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Coastal Restoration, Protection Projects Help Reduce Disaster Losses

By Steven J. Storts
Dublin, Ohio

LAST year's flooding and storm-battering of several Southern and Eastern seaboard states serves as a reminder of how fragile coastal and river shoreline ecosystems can be during extreme weather conditions. Natural disasters, though, can also serve as viable proving grounds for the construction challenges of shoreline restoration and erosion mitigation.

At $17 billion, the total flood loss in 2016 was six times greater than the overall flood damage experienced in 2015, according to CoreLogic, Inc., property information analysts based in Irvine, Calif. Five major events in 2016 shared the bulk of that devastation: the Louisiana flood in August; Hurricane Matthew in October; the Sabine River Basin flood in East Texas and Louisiana in March; the Houston flood in April; and West Virginia's flash and riverine flooding in June.

CoreLogic further states that overall hurricane activity in the Atlantic coastal region was slightly higher than average in 2016, with 15 named storms, including eight tropical storms and seven hurricanes. Three of the latter were major hurricanes identified as Category 3 or greater.

ConstructionDive.com notes that the residential construction market has continually researched and developed methods to mitigate the impact of severe weather and natural disasters. For instance in December, researchers at the Massachusetts Institute of Technology Concrete Sustainability Hub showcased an estimating tool for developers that helps in determining initial investments when designing structures to be more resilient and to lower the risk of future natural disaster damage. Another measure aimed at reducing the risk of weather-related damage includes a plan announced last summer by the U.S. Federal Emergency Management Agency. It proposes that most federally funded construction projects be constructed two feet above a 100-year floodplain in the wake of flooding damage from hurricanes Katrina and Sandy in 2005 and 2012, respectively.

In a regional resource report issued by the Southern Legislative Conference of the Council of State Governments, SLC policy analyst Anne Roberts points out that since the throes of Hurricane Katrina, much attention has focused on the rehabilitation of the area's homes, businesses, and infrastructure, but less attention has been directed toward the reconstruction of the coastlines of Alabama, Mississippi, and Louisiana.

"In order to maintain a sustainable Gulf Coast, investments in sound redevelopment and restoration practices, balancing the critical natural resources of the Gulf Coast with the equally vital economic drivers in the region, are critical to full recovery and necessary to weakening future natural disasters," she contends. The report, *SLC State Efforts to Rebuild the Coastline*, highlights recent projects undertaken by southern states to rebuild their coastlines, specifically the communities of Dauphin Island, Alabama; Pascagoula, Mississippi; and the metropolitan area of New Orleans.

Roberts says that although levees and structural protections are important components of mitigating damage from hurricanes and floods, they are most effective when coupled with natural forms of mitigation. In the wake of Hurricane Katrina, many coastal communities have turned to coastal and wetland restoration as an additional mitigation measure, she adds.

"Though Alabama, Mississippi, and Louisiana are Gulf Coast neighbors with similar resources, they have prioritized different forms of economic development and have divergent hurricane mitigation approaches," Roberts explains. Louisiana and, specifically, the New Orleans metropolitan area, has long relied on a series of levees for protection from river- and hurricane-related floods, she says, whereas Alabama and Mississippi have emphasized structural protection, such as seawalls and elevated buildings, that do not impede oceanfront access.

For example, in Alabama, building codes require beachfront structures to be built high on pilings. Hurricane mitigation trends also include installing hard structures, such as bulkheads, seawalls, or "rip-rap" on the shoreline to protect waterfront property from erosion and storm surge. Rip-rap is simply a foundation or sustaining wall of stones or chunks of concrete amassed without order. In Mississippi, Roberts notes, experiences with storms prior to Hurricane Katrina have resulted in modifications to building codes and land use specifications, including the early creation of a 26-mile, 10-foot-high seawall designed to act as a storm barrier.

Spearheading restoration and protection projects in Louisiana is the Coastal Protection and Restoration Authority, which has identified specific projects that address the root causes of land loss. Since 2007, the state has increased its financial commitment to the coastline, yielding substantial progress. CPRA has built or

improved about 250 miles of levees — benefitting more than 25,700 acres of coastal habitat — and secured $18 billion in state and federal funding for protection and restoration projects. Also noteworthy, the agency has moved more than 150 projects into design and construction, constructed projects in 20 parishes, and constructed 45 miles of barrier islands and berms.

CPRA's targeted projects encompass bank stabilization, barrier island/headland restoration, channel realignment, waterway diversions, hydrologic restoration, marsh creation, oyster barrier reefs, ridge restoration, and shoreline protection. The latter comprises near-shore rock breakwaters to reduce wave energies on shorelines in open bays, lakes, sounds, and bayous, in addition to project work on navigation channels. CPRA's protection projects utilize concrete walls, earthen levees (both linear and circular in design), floodgates, and pumps for enclosed-risk reduction systems.

The agency also addresses structural resiliency as an essential part of coastal restoration and protection, focusing primarily on the options of elevation and flood-proofing. The elevation option involves raising residential structures so that their lowest floors are higher than projected flood depths, ranging from three feet to 14 feet. The other option refits structures so they can be resistant to flood damages; commercial flood-proofing has been considered for areas with projected flood depths of three feet or less.

NOLA.com and *The Times-Picayune* report that Louisiana could spend $663 million on coastal restoration and levee projects in fiscal year 2018, with 56 percent of the money used for construction, according to a draft annual plan under consideration by CPRA. The proposal would also create 800 square miles of additional coastal wetlands over a 50-year period. CPRA's annual plan acts as the budget for the state's master plan for coastal restoration and hurricane storm surge protection, both of which will be subject to public hearings across Louisiana.

January 2017

New Standards, Research Address Mitigation of Natural Disaster Damage

By Steven J. Storts
Dublin, Ohio

IN the aftermath of natural disasters such as hurricanes, earthquakes, and floods, construction professionals are often called upon to assess property damage and assist with initial recovery operations. While these immediate tasks do serve a greater good toward public health and safety, the ongoing advancements made in construction research, methodology, and techniques aimed at mitigating or reducing extensive damage from natural disasters should not be overlooked, either.

For instance, national safety standards were recently announced by the American Society of Civil Engineers (ASCE 7-16) that address for the first time in the United States the structural risks posed by tsunamis. Developed by ASCE, this latest edition of the standards is in addition to chapters relating to seismic, wind, and flood hazards. However, they apply only to steel-reinforced concrete buildings in "inundation zones," not wood-frame structures.

The ASCE 7-16 standards are in effect for six years and will become part of the International Building Code. Individual states, though, have the option in deciding whether to adopt new codes in their entirety, partially in a modified format, or not at all.

The new standards were based in part on research from Oregon State University's O. H. Hinsdale Wave Research Laboratory, according to Dan Cox, Ph.D., a professor of civil and construction engineering at OSU and one of about 20 engineers on the ASCE subcommittee that developed ASCE 7-16. The committee began its work in late 2010, a few months before the March 2011 earthquake and tsunami that devastated Japan.

The large wave flume at the Hinsdale lab played a major role in producing the data used in developing the tsunami standards. "One of the big projects was debris," Cox notes. "What force does debris have, and how can you build a column to keep a building in place if debris were to strike it? Now we have equations to use to size that column to withstand a large piece of debris, like a shipping container."

Already underway on the new standards, Cox and other subcommittee members went to Japan after the 2011 tragedy to study what had worked and what didn't. "We got enough information to estimate hydraulic forces and understand damage patterns, and we used this to validate what we were doing," Cox explains. "It was independent, real-world experience to check on whether our approach was valid. These standards are built on lab work, field observation, and engineering practice. We used all of the tools available to come up with these standards."

Cox points out that the tsunami standards will have the most impact on engineers designing and building structures five stories high or less. Above five stories, even-stronger building codes will take precedence over codes to protect smaller structures from tsunamis. Although there would be some added expense to the cost of a two- or three-story building, the additional amount would be comparatively small.

"The structural cost of a building is less than 10 percent," Cox adds. "It will be more expensive, but it doesn't triple the cost. When you make a building twice as strong, it doesn't cost twice as much."

Another construction field gaining attention is the use of alternative materials in seismic hazard design. In lieu of using specially detailed reinforced steel, is it possible to build a structure in less time and at lower cost, yet still exhibit the same required deformation capacity? According to the American Concrete Institute (ACI), researchers at the University of Michigan and the University of Wisconsin-Madison believe such a possibility exists and are examining the use of fiber-reinforced concrete (FRC) in earthquake-resistant construction.

FRC refers to concrete that has short fibers mixed evenly throughout the material. The research team used 1.2 inch-long steel fibers with a diameter of 0.02 inches made out of a high-strength steel wire. The fibers were mixed into the fresh concrete before it was poured into the formwork. The short fibers are randomly disbursed throughout the mixture, acting like distributed reinforcement which holds the concrete together upon cracking.

The research team focused its study on the use of FRC in walls and coupling beams. Tests were conducted on large-scale models to evaluate the performance of walls constructed in a manner consistent with current practice using reinforced steel versus walls constructed with FRC. The models were built to about one-third of full-scale and then subjected to reversing lateral displacements to simulate earthquake loading. The test results showed that when walls and coupling

beams are constructed with FRC, reinforcing steel can be reduced significantly in the walls and coupling beams (by up to 40 percent in coupling beams) without compromising behavior. The FRC members had the same or better deformation capacity and showed less damage after testing than the members constructed without FRC.

ACI cites the plausibility for future use of FRC, contending that its deployment will allow for the use of less and simpler steel reinforcement, while maintaining good structural behavior and potentially reducing the amount of post-earthquake repair. Such results should lead to a less-expensive way to construct safe buildings with reduced life-cycle costs for the owner, ACI adds.

On a related front across the Pacific in Singapore, engineers and scientists from the JTC Industrial Infrastructure Innovation Centre at Nanyang Technological University have invented a new type of concrete called ConFlexPave. The material is bendable, yet stronger and longer lasting than regular concrete, which is heavy and brittle by nature and can break under tension.

The innovation is targeting the formation of slim precast pavement slabs for quick installation, reducing by half the time needed for repairing roadworks and placing new pavements. ConFlexPave, which is also touted as being more sustainable and requiring less maintenance, will undergo further scaled-up testing during the next three years.

As explained by the research center, the typical concrete mixture results in a hard and strong material, but it does not yield or promote flexibility, in essence making it more brittle and prone to cracks if too much weight is applied. ConFlexPave, on the other hand, is specifically engineered to have certain types of hard elements mixed with polymer microfibers. The inclusion of these special synthetic fibers, aside from allowing the concrete to flex and bend under tension, also enhances skid resistance.

Concrete is also the subject of current research at the Massachusetts Institute of Technology, aimed at finding a new formula for concrete or viable alternatives to Portland cement, the primary binding ingredient of concrete. As their mission, researchers are looking into the biological composition of natural materials such as bones, shells, and deep-sea sponges as a sustainable blueprint.

October 2016

Innovative Construction Technologies Require Tempering With Experience

By Steven J. Storts
Dublin, Ohio

AS INVITING as construction innovations may be, there are always potential issues or possible tradeoffs with the advent of newer technologies. For instance, one of the most frequently cited criticisms of innovative technologies is the displacement of employees or workers. While this perception pervades almost all U.S. industries to some degree, the construction industry can sometimes find itself in a public relations conundrum.

For more than a decade due to a shortage of skilled labor, there have been ongoing promotional campaigns in radio and television media, high schools, vocational schools, community colleges, and some four-year universities touting the benefits of employment and careers in construction.

Equally publicized, both print and electronic media continually report on the numerous advances being made in the construction industry through computerization, robotics, drones, and intelligent transportation equipment to increase productivity and safety by eliminating some of the human element — occasionally prone to personal injury and errors in judgment. The result can sometimes be a mixed, confusing message to a younger audience seeking job security.

For many businesses and professions, though, the line is already blurred between job creation and technological advancements, exhibiting a paradoxical trend. In fact, two management academics from the Massachusetts Institute of Technology, Erik Brynjolfsson and Andrew McAfee, opine that technology is behind both the healthy growth in productivity and the weak growth in jobs. "It's a startling assertion because it threatens the faith that many economists place in technological progress," says the *MIT Technology Review* in an online report.

The *Review* further points out that Brynjolfsson and McAfee still believe that technology boosts productivity and makes societies wealthier, but they think it can also have a dark side, namely, that technological progress is eliminating the need for many types of jobs and leaving the typical worker worse off than before.

During their research into the extent and speed of recent digital advances, Brynjolfsson and McAfee learned that the same technologies making many jobs safer, easier, and more productive were also reducing the demand for many types of human workers, the *Review* reports.

"It's the great paradox of our era," says Bryn-jolfsson. "Productivity is at record levels, innovation has never been faster, and yet at the same time, we have a falling median income and we have fewer jobs. People are falling behind because technology is advancing so fast and our skills and organizations aren't keeping up." Therein rests one of the major challenges — implementing new technology.

For any innovation to succeed, according to the *Harvard Business Review*, an implementation team must include the following: a sponsor, usually a fairly high-level person who ensures the project receives financial and manpower resources and who is wise about the politics of the organization; a champion, who is salesperson, diplomat, and problem-solver for the innovation; a project manager, who oversees administrative details; and an integrator, who manages conflicting priorities and molds the group through communication skills. Because these are roles, not people, more than one person can fulfill a given function, and one individual can take on more than a single role.

Also, as the deskilling potential for new computerized technologies increases, the *Review* notes that unions are pursuing the retraining of their members for whom automation would otherwise displace. "Many companies are upgrading the status of their workers who are forced to trade hard-earned manual skills for the often dreary routine of button pushing," the *Review* adds. "Although the problem is far from being resolved, it has at least merited recognition."

On a different front, the Construction Financial Management Association contends that while the engineering and construction fields unquestionably boast some of the most industrious, innovative, and creative professionals nationwide, there is still a lack of technological innovation in construction methods.

"After all, the basic inputs to the construction process — wood, stone, steel, and craftsmanship — have existed for centuries and will likely remain consistent for some time," says CFMA. "However, it is clear that construction tools and technology are changing dramatically. Broadband mobile communication and handheld processing power are radically altering the way general contractors deliver projects."

Technology adoption in the field is inarguably altering the expectations of

services that contractors provide to owners, CFMA notes, adding that the sheer efficiency with which information can be shared and processed demands that businesses change. However, for construction market participants and the financial managers who lead them, "there is not as much emphasis on finding the next best technology" as the more important issues "relate to the culture and structure of an organization and its flexibility to incorporate technology that ultimately improves the value proposition for customers," the organization points out.

CFMA suggests that construction professionals need to decide if any new technology under consideration will do the following: improve the building process for owners; increase coordination with upstream and downstream subcontractors and trade partners; and provide a stimulating environment for innovation. The pace of technological change in construction services will only quicken in the years ahead, the organization forecasts, and construction businesses must be prepared to address how change will impact the services they provide to project owners.

New methods of contracts and project management are becoming more widespread in the construction industry, too. Among the emerging trends in construction management techniques and technology are integrated project delivery, building information modeling, prefabrication, lean construction, robots and drones, and collaboration software. Construction Dive.com observes that with that growth comes the question of whether the new techniques will actually result in fewer disputes — a common goal in the industry.

With these new technologies and techniques, Christopher Payne, executive vice president of McDonough Bolyard Peck, says he expects the industry to deal with fewer disputes in the future, according to Construction Dive. However, when disputes do arise, they will be more complex and difficult to resolve because they will involve uncharted territory, he predicts.

ConstructionDive also cites Ron Pennella, construction project manager at Structure Tone and adjunct professor at the Polytechnic Institute of New York University, who points out, "We keep hearing about the difference with technology, but it can't replace experience . . . . These machines have a usefulness, but it's like a ruler or a hammer. You have to know how to use them." He adds, "As a construction leader, my responsibility is to advocate for completion of the project, for the client, for the design team, for the subcontractor, for everyone else affected. It's all about people."

July 2016

Evolving Construction Technologies Offer an Array of Functions, Options

By Steven J. Storts
Dublin, Ohio

ALTHOUGH evading technology is really not an option for most construction companies these days, keeping up with technological trends is no small task, either. However, staying on the cusp of new technologies does help organizations and their employees better adapt to change, albeit gradually, making the change process more manageable and less complex.

Still, are all technological innovations useful for the construction professionals, particularly in an industry where a majority of the actual work is outdoors, often under remote or rugged conditions or in rural environments? For the most part, the answer is yes, but with some caveats.

Depending on an organization's culture and its workforce diversity, construction management should not shy away from technological advancements or become too discouraged if lagging behind the technology curve. Instead, the focus should be on scrutinizing, setting financial priorities, and then deciding which technologies best suit a project site or its field offices. Some of the fledgling construction trends that began only a few years ago have now become more mainstream and will continue to expand in the future.

Today's innovative standouts, some still under testing, include advanced construction robotics, 3-D printed building components, driverless vehicles at work zones, permeable or flexible concretes, and "phablets" (the merging of a smartphone and a tablet). Other construction technologies or trends that have already gained a foothold and increased use are integrated project delivery, building information modeling (BIM), lean construction, sustainable (green) construction, prefabricated building components, and aerial drone surveillance.

Some tech-minded advocates categorize the field of emerging construction technologies into three elements: Internet applications, digital fabrication, and "real-time" environments. In an article published by ConstructionExecutive.com, author Paul Doherty emphasizes that smartphones and tablets are offering unprecedented access to updated project information aimed toward reducing errors, thereby increasing efficiency. "Apps, 3-D visualization, and real time data are just some of the next-generation tools that construction professionals are enjoying in the field," he adds.

Doherty contends that the commercial exemption for use of aerial drones at construction sites will bring "enormous benefits in the form of increased safety, security, and operational efficiencies to construction job sites throughout the United States."

For example, smartphones can be attached to drones and then directed into hard-to-reach areas under construction to record pictures or videos of potential problems — all set up for later use in hands-free video conferencing with engineers or architects. Doherty further points out that sensor technologies, which provide inexpensive, automated solutions for jobsite access to information, are also gaining attention for use in "location awareness" of personnel, equipment, materials, and tools.

On a different front, Doherty observes as the pricing of computer numerical control-enabled machinery continues to fall and the training of construction professionals to use these machines increases, the use of digital fabrication is becoming more commonplace, providing better quality and increased profits for firms using this production and procurement methodology. He notes that digital fabrication is already being widely deployed in the homebuilding industry.

Finally, the gaming industry has developed sophisticated graphic technologies that allow developers to create virtual worlds that act as "stage sets" for their customers, according to Doherty. "The A/E/C industry has adopted gaming technologies and is quickly discovering a solution that emancipates their design and construction data from expert system authoring tools, such as BIM, and allows their data to become open and flexible to be used in other ways," he says. "Because of gaming technologies' levels of detail for 3-D visualized objects and the ability to place objects in a highly accurate geospatial manner, the use of gaming technologies is exploding in A/E/C."

Moreover, distributing A/E/C data into various facility management software solutions is no longer a laborious effort and offers tremendous value for building operators, Doherty adds. "A lasting effect of this new process is that authenticated data is now associated with a physical building," he says, "providing the opportunity to have buildings communicate with each other."

What about emerging communication technologies? For the last several years, construction companies have

frugally invested in either smartphones or tablets for their on-site and field personnel.

The introduction of phablet devices can now provide the best of both worlds, according to structural engineer Lauren Hasegawa, co-founder of Bridgit, a developer of mobile-first solutions for on-site project management issues. She notes that a "phablet" is basically a smartphone with a screen that is intermediate in size between that of a typical smartphone and a tablet computer. With Apple's continual upgrades and launches of its iPhone series, she predicts a steady rise in phablet sales, with other manufacturers and brands following suit.

Hasegawa has other predictions, too. In an article published by For ConstructionPros.com, she says, "Augmented reality technologies, such as Google Glass, allow the user to see a digital image beside or on top of their view of the world. The use of these technologies in construction has the potential to make virtual design and construction and the use of BIM more accessible on-site." By using GPS capabilities already present in most augmented reality technologies, she explains, a user could sync his or her location data to a BIM model. In doing so, the user would have the ability to see the 3-D virtual view of the construction overlaid on the real-world view of the job site with just the click of a button.

A rising popularity of near-field communications at the job site is another forecast of Hasegawa's. NFC is a secure form of data exchange that allows data to be transferred from physical tags to NFC-enabled devices and is frequently discussed in relation to mobile payments from smartphones. "As NFC begins to grow as a popular form of data exchange, we can expect to see many uses for it in construction, especially with materials tracking, prefabrication, and workforce management," she says.

For example, Hasegawa points out that NFC can be used to track prefabricated sections of large structures as they arrive at the project site. Tracking these prefabricated materials can help quickly identify if an incorrect section has been delivered, or if parts are missing, prior to installation — saving time and labor costs.

April 2016

Women, Minorities Remain at Forefront Of Current Labor Recruitment Efforts

By Steven J. Storts
Dublin, Ohio

ONE of the nationwide celebrated events every March is Women in Construction Week, an observance aimed at raising awareness of the opportunities available for women in the construction industry and emphasizing the growing role of women in the industry. Sponsored by the National Association of Women in Construction (NAWIC), the event's core purpose is to enhance the success of women employed in construction.

By comparisons from decades ago, progress has been made in the advancement of women and minorities in the construction industry, attributed in part to federal, state, and local equal opportunity employment statutes, and in some cases, affirmative action requirements. For instance, the Office of Federal Contract Compliance Programs requires construction contractors to "engage in a self-analysis for the purpose of discovering any barriers to equal employment opportunity" and to take good faith steps to increase the utilization of women and minorities in the skilled trades.

On a different front, the Federal Highway Administration On-the-Job Training Program requires state transportation agencies to establish apprenticeship and training programs to move women, minorities, and disadvantaged individuals into journey-level positions. The mission is to ensure that a competent workforce is available to meet highway construction hiring needs and to address the historical underrepresentation of these groups in highway construction skilled crafts.

State and local governments are also committed to bolstering the employment of women and minorities in construction. In 2012, public officials and labor leaders in Newark, N.J., announced a $300,000 grant program to train local residents for apprenticeships in the building and construction trades. Funding was provided by the New Jersey Builders Utilization Initiative for Labor Diversity, which addresses employment programs for women and minorities.

Also in 2012, the St. Louis mayor released an executive order extending existing workforce goals on city public works projects $1 million or larger. Among those goals, 25 percent of labor hours were to be performed by minorities, with five percent of those labor hours addressed by women.

More than five years ago, the Philadelphia Mayor's Advisory Commission on Construction Industry Diversity issued numerous recommendations to help increase inclusion of women and minorities in the local region's construction workforce. Among minority men, a long-term goal of 32 percent participation was suggested. An initial goal of seven percent for the participation of women was also strongly recommended, but once reached, that goal should likely be raised.

Interestingly, the advisory commission recommended the reintegration of vocational and technical education options into local middle school and high school systems, rather than as stand-alone schools. The commission also challenged educators to help recruit qualified female and minority candidates for inclusion in the building and construction trades, with emphasis on entering apprentice programs after graduating from high school.

In 2013, KARE-TV in Minneapolis reported on a series of meetings addressing the planned construction of the new sports stadium for the Minnesota Vikings. The initial meeting, hosted by Mortenson Construction and the Minnesota Sports Facilities Authority, provided subcontractors with details on the work bidding process, in addition to the required composition of the workforce. The stated overall labor goal was 11 percent women-owned businesses and nine percent minority-owned businesses, with workforce participation being 32 percent minority and six percent women during the construction phase.

"They are challenging goals," said John Wood, senior vice president with Mortenson Construction. "I think everybody acknowledges that. They are higher than what has ever been achieved on a major project before." He emphasized that the goals transcend the stadium project, stating, "It's about creating a pipeline of workers of the future that are going to make up the men and women of the Minnesota construction industry in the years to come."

More recently in January, ConcreteConstruction.net highlighted Alise Martiny, business manager of the Greater Kansas City Building and Construction Trades Council. She entered the concrete industry in 1982 as a concrete finisher apprentice and then advanced to regular project work for commercial con-

crete contractors in the Kansas City area, eventually focusing mostly on decorative concrete installations. Today, she serves in more of a training and recruiting role, as showcased by her MAGIC (Mentoring a Girl in Construction) program. Sponsored by NAWIC, her initiative targets girls at a young age, promoting construction as a viable ambition.

Martiny points to the necessity to "get outside the box about who to hire." Labor goals in Kansas City on projects over $300,000 call for the desired workforce to be at least two percent female. "There's going to be a lot of work in this town over the next year" she says, "and my goal is that the workforce on those projects should look like the community in which they are being built, so we have to recruit females and minorities." She further notes, "We've got to market ourselves better and let young people know there are opportunities. We've got to change the mindset."

Perhaps one of the more comprehensive recruiting programs for women and minorities is spearheaded by Turner Construction Company. Although women comprise only 2.2 percent of construction labor, according to the Center for Construction Research and Training, Turner says federal census figures indicate that the future growth of the nation's workforce will be attributed primarily to women and minorities. Consequently, the company has developed and expanded outreach activities and programs that encourage, promote, train, and sustain minorities and their construction businesses.

One of the organization's major outreach initiatives is The Turner School of Construction Management, a program started in 1969 to enhance the technical, administrative, and managerial skills of minority and women business executives in both the public and private sectors. Today, the program is offered in more than 70 cities across the country. Instructional classes are held two evenings per week and typically run from six to 10 weeks. Participants learn the essentials of managing a business, including how to develop a business plan, estimate and bid larger jobs, obtain bonding, enforce safety principles, and establish and manage credit.

To date, the program has been a catalyst in helping Turner achieve success in awarding more than 52,000 contracts valued in excess of $18 billion to minority- and women-owned business enterprises.

April 2015

Construction Industry Reaping Major Dividends from Investment in BIM

By Steven J. Storts
Dublin, Ohio

THERE is little doubt that the Digital Age is carving its brand on the construction industry, particularly in the area of building information modeling. And why not? For those organizations taking advantage of what BIM brings to the project table, the future may be brighter.

In a study released last year by McGraw Hill Construction, contractors in nine of the world's top construction markets using BIM reported that digital modeling helps them to improve productivity, efficiency, quality, and safety on their projects, in addition to boosting their own competitiveness. *The Business Value of BIM for Construction in Major Global Markets* reveals that businesses in markets with well-established BIM use — including Canada, France, Germany, the United Kingdom, and the United States — are seeing a positive return on their technology investments.

Moreover, the study notes that construction markets that are still in the initial stages of BIM adoption — Australia/New Zealand, Brazil, Japan, and South Korea, for example — are experiencing benefits, too, such as reduced errors and omissions, improved collaboration among project team members, and an enhanced organizational image.

Through digital information networking and management in a team environment, BIM creates measureable value by combining the efforts of project stakeholders, process, and technology. Essentially, BIM is a clearinghouse for every component of the built structure, making it possible for any project team member to access information for any purpose. The process integrates different aspects of the project design more effectively, reducing the potential risk for mistakes, discrepancies, or conflicts during the delivery process. As its core advantage, BIM data can be used to illustrate a building's entire life-cycle from inception and design to demolition and materials reuse. Spaces, systems, products, and sequences can be exhibited and compared in relative scale to each other and, in turn, relative to the entire project.

The McGraw Hill study demonstrates that businesses deploying BIM achieve more benefits and realize a stronger return on their technology investment than those less engaged. Half of those organizations highly engaged in BIM report returns in excess of 25 percent on their technology investment. Much of that return on investment is due to significantly reduced rework on projects. The study results also forecast exponential growth in BIM use in the near future. Over the next two years, contractors expect the percentage of their work involving BIM to increase by 50 percent on average.

In a separate analysis, Massachusetts-based Fast Market Research Inc., an online aggregator and distributor of market research and business information, forecasts the BIM market to grow from $2,640.12 million in 2013 to $8,646.47 million by 2020 at a compound annual growth rate of 16.72 percent. FMR points out that newer applications and uses are continuously being devised for this technology, which will further propel the market in the coming five years, with much of the expected growth due to the expanding industrial sector for the BIM market.

"As greater industry demands unfold, BIM is emerging as a vital process to promote efficiency and leaner operations throughout a construction project's life-cycle," says Lisa Campbell, vice president of industry strategy and marketing at Autodesk, the McGraw Hill study's premier partner. She further notes that construction organizations with very high BIM engagement levels are heavily investing in mobile devices, demonstrating that BIM's future for contractor use lies in getting it more widely used in the field.

Additionally, the study demonstrates the broad range of BIM use globally, including how use varies by specific markets. For example, while 82 percent of U.S. contractors use BIM for multitrade coordination, leading the global market in this area, Brazilian contractors notably lag in this area, with only 25 percent using BIM for the purpose. On the other hand, contractors from Brazil lead in the integration of 4-D scheduling, a practice only used by 21 percent of U.S. firms. Aside from the project construction phase, BIM is gaining attention in the preconstruction and postconstruction phases. One emerging area is project management for the owner beyond closeout, a trend showing strength in Asia and Europe but only moving slowly in North America.

In actual practice, a BIM object can be a combination of many things: information content that defines a product; product properties; or ge-

ometry representing a product's physical characteristics. Among its more familiar functions, BIM provides 3-D visualization data giving an object a recognizable appearance and exhibits functional data, enabling an object to be positioned or repositioned and then viewed throughout various applications.

Many construction stakeholders are coming to the realization that BIM technology may be far superior to shop drawings in terms of actual building representation. Because 3-D objects are machine readable, spatial conflicts in a building model can be tracked automatically. And by integrating this capability at all phases of project delivery, errors, omissions, and change orders due to internal causes can be greatly reduced. Proponents also contend that BIM improves overall productivity due to easier retrieval of information and increases coordination of construction documents, thereby increasing speed of delivery and reducing delay costs. To that end, BIM quickly embeds and links vital information into its model, including suppliers for specific materials, location details, and the quantities required for estimation and procurement.

National Building Specification, an informative arm of RIBA Enterprises Ltd., which is wholly owned by the Royal Institute of British Architects, publishes annual research into BIM adoption in the United Kingdom. A survey of 1,000 U.K. construction professionals last year revealed that BIM engagement had increased from 13 percent in 2011 to 54 percent in 2014.

NBS suggests that organizations interested in pursuing or honing BIM strategies need to perform five initial tasks: establish an existing BIM maturing level (knowledge base and/or learning curve); examine current client base needs for best practices; review technological nature of current projects; forecast future work sector plans and ambitions; and assess the skill sets of existing staff. Regarding the latter, NBS emphasizes that BIM encompasses more than just knowledge about the latest 3-D imaging or CAD software; a wide range of technical, communicative, and leadership skills is required for a successful BIM project.

January 2015

Matters of Ethics Remain a Continuing Challenge for Construction Industry

By Steven J. Storts
Dublin, Ohio

PROFESSIONAL engineers are no stranger to the pursuit of ethical prowess, but how do the ethical cards stack up on an industrywide basis, in particular, within the construction community?

Survey results released in November by the Ethics Resource Center indicate that when compared to the national averages, employees in the U.S. nonresidential construction industry are facing more pressure to compromise standards (18 percent), and that they are witnessing more misconduct (53 percent). ERC further notes that 37 percent of construction employees are significantly more likely to experience retaliation by managers or co-workers after reporting issues of misconduct.

Among the more positive findings of ERC's *National Business Ethics Survey of the U.S. Construction Industry* were the reporting rates for misconduct. Nearly 75 percent of construction employees said they reported workplace misconduct, a number that is higher than any other group of employees in all 19 years of *NBES* research. As a comparison, the 2011 national average was only 65 percent.

Located in Arlington, Va., ERC is America's oldest nonprofit organization dating back to 1922. Its operation is devoted to independent research and the advancement of high ethical standards and practices in public and private institutions. More specifically, ERC researchers analyze current and emerging issues and produce new ideas and benchmarks aimed at the public trust. Sponsors of ERC's recent research include the Construction Industry Ethics and Compliance Initiative, Reed Construction Data, American Society of Civil Engineers, American Road and Transportation Builders Association, Associated General Contractors of America, Travelers Indemnity Company, and Bechtel Corporation.

"No industry in America is immune to ethics challenges," ERC points out. "In truth, certain industries are just inherently more at risk for facing ethical issues depending on the kind of work they do. The construction industry is one such industry, especially given the contexts in which companies conduct business, the safety risks that are inherent to their work, and the performance pressures they face."

ERC emphasizes, however, that when companies come together to identify and address their ethics concerns, their collective efforts can and do make a difference. For example, in 2005 a group of 17 companies within a single industry agreed to use ERC's metrics to identify their ethics/compliance challenges. Once data was collected, the group regularly met to compare results and discuss best practices. They continued to collect data within their individual organizations and benchmarked against each other. Each company learned from their peers, and together they raised the bar for their industry. Over time, the industry was able to reduce perceived misconduct by 24 percent.

NBES research demographics are also noteworthy because over the years, ERC has polled and reported findings on more than 23,000 employees. Participants in the recent *NBES* research were 18 years of age or older, currently employed at least 20 hours per week for their primary employer, and working for a nonresidential construction company based in the United States. Self-employed general contractors, project managers, and self-employed subcontractors working in an office were screened out from the survey to ensure that data were reflective of individuals in organizations that potentially could support an ethics and compliance program or individuals that would be expected to adhere to ethics and compliance programs maintained by an organization hiring or contracting with them. Data were weighted according to three factors — age, education, and sex — aligned with methods established by ERC in 2007 and per their representation in the civilian labor force defined by census reporting of the U.S. Bureau of Labor Statistics.

Key findings of ERC's 2011 survey revealed that misconduct witnessed by U.S. workers is at historic lows, while reporting of misconduct is at near highs. Additionally, retaliation against employee whistleblowers rose sharply, and the percentage of employees who perceived pressure to compromise standards in order to do their jobs climbed five points from 2009 to 13 percent. The share of companies with weak ethics cultures also climbed to near record levels. Not surprising, two influences stood out in the unusual shift in trends: the economy and the unique experiences of those

actively using social networking at work.

Both past and recent *NBES* research continues to show that companies can react differently during economic shifts. For instance, during economic difficulties, the decisions and behaviors of their organizational leaders are perceived by employees as a heightened commitment to ethics.

Consequently, employees personally adopt higher standards of conduct in the workplace. As the economy improves — and companies and employees become more optimistic about their financial futures — it seems likely that misconduct will rise and reporting will drop, mirroring the growth in pressure and retaliation that have already taken place and conforming to historic patterns.

In 2011, active social networkers reported far more negative experiences in their workplaces. ERC's findings point out that as a group, social networkers are much more likely to experience pressure to compromise ethics standards and to experience retaliation for reporting misconduct than co-workers who are less involved with social networking. This group also shows a higher tolerance for certain activities that could be considered questionable.

Construction organizations, of course, still need to explore both the positive opportunities as well as the pitfalls of social networking within their own employee ranks. *NBES* social networking research focuses on U.S. workers who participate on at least one social networking site. The objective is to capture the awareness and opinions of these employees at all levels within companies to reveal real-life views of what is happening within business cultures and the ethical risks confronted by these employees.

ERC reports that almost three out of four social networkers (72 percent) spend at least some time of their workday on social networking sites, and more than 25 percent indicate that such activity adds up to an hour or more of every workday. One third of those employees also admit that none of that activity is work related. As cited earlier, the more active the social networker, the more likely they are to encounter ethical risks, such as witnessing misconduct, feeling pressure to compromise standards, and experiencing retaliation for reporting misconduct.

Moreover, ERC emphasizes that despite what many perceive, social networks are not just for younger employees. Although 47 percent of active social networkers are under the age of 30, not far behind are the 40 percent between the ages of 30 and 44.

January 2014

Improving Construction Inspection Advances Overall Project Quality

By Steven J. Storts
Dublin, Ohio

ONE of the most unheralded yet vital tasks of the construction community is the responsibility of project inspection. However, excellent performance is too often considered routine, expected, and is generally unrecognized for its success. Failure, on the other hand, or any misstep in inspection protocol can sometimes result in serious threats to public safety.

Competent, qualified construction inspectors require common sense, honed powers of observation, and excellent communication and organizational skills. Equally important, they must understand basic engineering principles and be knowledgeable about con-struction materials and methods. In public works inspection alone, these requisites need to be applied in the following areas: contracts, plans, and specifications; soils fundamentals; water and sewerage systems construction; concrete and asphalt pavement systems; highway, street, and bridge construction; dredging operations and dam construction; erosion control techniques; and work zone traffic control.

Outside of the context of residential home inspections, many of those in the general public are usually not aware of the broad scope of construction inspection duties. Typically, inspectors ensure that new construction, changes, or repairs comply with local and national building codes and ordinances, zoning regulations, and contract specifications. To perform their duties, inspectors must be adept at using surveying instruments, metering devices, and testing equipment to verify level, alignment, and elevation of structures and fixtures, and they are obligated to issue violation notices and stop-work orders until compliance is satisfied.

According to the U.S. Bureau of Labor Statistics, the employment of construction and building inspectors is expected to grow 18 percent from 2010 to 2020, about as fast as the average for all occupations. With concern for public safety and a desire to improve construction quality spurring this growth, those who are professionally certified and can multi-task their inspection duties are expected to have the edge in employment opportunities in both the public and private sectors.

Indeed, one of the interesting construction trends is how inspection teams are diversifying. For instance, construction inspectors that traditionally have checked the structural quality and general safety of buildings are now expanding into specific areas of structural steel and reinforced-concrete structures. Other inspection teams are focusing more individually on electrical, elevator, mechanical, plumbing, and fire and sprinkler systems. More recently, some inspection activities have diversified specifically into examining plans and specifications to determine whether compliance with building codes is satisfactory and to ensure that services performed are according to an owner's design specifications.

As noted earlier, professional certification will become increasingly desirable in the future. To that end, in 1984 the American Construction Inspectors Association created the Board of Registered Construction Inspectors to establish a program to set minimum standards for general engineering inspectors, general building inspectors, public works inspectors, and for different categories of specialty inspectors. Today, RCI receives and processes numerous applications for registration, conducts examinations, and registers construction inspectors who successfully meet all the specified requirements. Registrations may be renewed, conditional upon payment of renewal fees and verification of completing a minimum of 24 units of continuing education.

Of course, at the core of any viable construction inspection program — whether managed internally by a company's project staff or outsourced to certified professionals — is the use of inspection forms, checklists, and other documentation, such as photographs, drawings, and digital or taped recordings. Well-organized documentation on paper or through use of mobile or online technology cannot be overstated. Not only is this prudent business-wise, but it is an excellent precautionary move to ward off or mitigate potential legal claims that might arise during construction or after project closeout.

First Time Quality L.L.C., a developer of construction quality and safety products based in Crofton, Md., cites five important ways that inspection checklists can improve project quality. First, inspection forms that list critical quality concerns can be used to build consensus among project stakeholders. Next, as the various phases of construction begin, contractors

can use their checklists as reminders for important items to remember and as verification of completion of their work tasks. Third, inspection checklists serve to verify compliance to quality control protocol and adherence to relevant construction specifications. Fourth, because any stakeholder can use the same inspection form to inspect work, these forms are a good vehicle for identifying commonly cited issues for improvement. Finally, project owners, construction managers, and general contractors can use inspection checklist data for deciding which subcontractors provided the best "return on investment," a tool that can be used for monitoring future project performance.

Two other resources for improving construction inspection quality are at the fingertips of construction stakeholders, one in NSPE's own backyard. A few years ago, the Professional Engineers in Construction interest group of NSPE released an online publication, *A Field Guide for Inspection of Sewerage and Drainage Construction*. The 156-page guide is designed for use by construction inspectors serving on sewerage and drainage projects for small to mid-size municipalities or private owners. The document's purpose is to help advance the mission of high-quality construction standards by providing a series of proven policies, established procedures and techniques, and helpful resources, including inspection checklists, applicable to construction projects on any size scale.

The second useful resource, the seventh edition of the *Construction Inspection Manual*, is available at Contractor-Books.com. The 358-page manual provides recognized guidelines for construction inspectors and includes comprehensive checklists for field inspection. Cited in the document's foreword, the field manual's goal is to assist the construction industry in improving the inspection procedures on all types of construction work and to achieve a consensus among owners, architects, engineers, contractors, and construction inspectors as to the best methods and practices.

Finally, for inspection of public works projects in the transportation industry, the Federal Highway Administration offers the *Construction Program Management and Inspection Guide*. Among its diverse content, the 196-page guide defines the purposes of construction inspection reports and discusses the various types and scope of inspections. Specifically, the guide teaches how to prepare for inspection activities, including how to conduct reviews, collect and evaluate data, write field inspection reports, process and distribute reports, and how to control and expedite information sharing and technology transfer, as it pertains to construction program management.

October 2013

Researchers Continue Pursuit of Construction Technology Innovations

By Steven J. Storts
Dublin, Ohio

AS a late spring thaw finally gives way to new construction activity, innovations in building technologies — materials, methods, and processes — are also moving to the forefront of the construction community.

Recently, a joint research program between the Indiana Department of Transportation and Purdue University's Pankow Materials Laboratory yielded successful test results for an "internally cured" high-performance concrete. The new material will be used for maintenance projects on four bridge decks this year in the state, following a review of product specifications for construction use.

The researchers assisted Monroe County (Indiana) in the specification of internally cured concrete used in a bridge built in 2010, adjacent to a bridge built the same year using conventional concrete. According to Purdue civil engineering and materials science professor Jason Weiss, the control bridge has developed three cracks, but no cracks have developed in the internally cured bridge. Tests also indicate that the internally cured concrete is about 30 percent more resistant to salt ingress. As further field data are collected, Weiss anticipates broader deployment of this concrete specification.

Traditionally, curing is promoted by adding water on top of the bridge deck surface. The new technology for internal curing provides additional water pockets inside the concrete, enhancing the reaction between the Portland cement and water, which adds to strength and durability. The water pockets are formed by using a lightweight, fine aggregate to replace some of the sand in the mixture. A key step in the process is to pre-wet the lightweight aggregate with water before mixing the concrete, Weiss points out. He also notes that the internal curing process allows engineers to reduce the amount of Portland cement used in the concrete by replacing a portion of it with supplementary or waste stream materials, such as limestone, silica fume, and fly ash.

On a different front, a new structural building system resistant to earthquakes was successfully tested a few years ago at the Hyogo Earthquake Engineering Research Center in Miki City, Japan. Spearheaded by researchers from Stanford University and the University of Illinois, an engineering team designed a construction technique that not only secures a multistory building during a violent earthquake, but returns the structure to its original stance on its foundation following the seismic activity, with damage confined to a few easily replaceable parts. During final testing, the system survived simulated earthquakes in excess of magnitude 7, which is greater than either the 1994 Northridge earthquake or the 1989 Loma Prieta earthquake in California.

This new construction method dissipates energy through the movement of steel-braced frames that are located around the building's core or along exterior walls. The frames can be part of a building's initial design or incorporated into an existing building undergoing seismic retrofitting. They are economically feasible to build from materials commonly used in construction today, and all the parts can be made using existing fabrication methods.

Unlike most conventional systems, though, the steel-braced frames actually "rock off" of their foundation under large earthquakes and are free to move up and down within steel "shoes" secured at their base. To control the rocking and return the frame to vertical when the shaking stops, steel tendons run down the center of the frame from top to bottom. The tendons are each made of seven high-strength steel cable strands twisted together and designed to remain elastic during shaking. When shaking is over, they rebound to their normal length, pulling the building back into proper alignment. At the bottom of the frame rest steel "fuses," designed keep the rest of the building from sustaining damage.

Professional engineer Greg Deierlein, a professor of civil and environmental engineering at Stanford who led the research team, explains, "The idea of this structural system is that we concentrate the damage in replaceable fuses," which are built to flex and dissipate the shaking energy induced by the earthquake, thereby confining the damage. Like electrical fuses, the steel fuses are easily replaced when they "blow out."

Deierlein further notes that while various researchers have been working for more than a decade on some of the ideas and techniques incorporated in the new structural system, this is the first time anyone has put

them all together and demonstrated their performance. The structural technology developed is applicable to steel-framed buildings up to about 15 stories tall, but Deierlein contends that the general approach could be modified for other types of buildings and possibly applied to alternate materials and configurations as well.

The National Institute for Standards and Technology is also pursuing a number of innovations of potential interest to the construction industry. For instance, NIST has developed a climate suitability software tool that helps ventilation design teams evaluate the suitability of a local climate for cooling a prospective building with natural ventilation or whether a hybrid system will be required for supplying supplemental cooling capacity.

Additionally, the institute has prototyped a framework for evaluating and implementing sustainability standards for green projects. Advocacy for sustainability practices has expanded considerably the last five years, and with the NIST-customized framework, stakeholders can view individual sustainability standards from their particular perspective, such as that of a manufacturer, services provider, software supplier, regulator, or consumer. Complex standards are broken down into six different levels of detail, from the contextual view of a planner down to the actual data to collect and use.

Along environmental lines, NIST and Virginia Tech researchers are also developing a promising approach for checking the accuracy of measurements of hazardous indoor air pollutants. Such a measurement tool would prove useful to testers of indoor air quality or volatile organic compounds and to manufacturers and suppliers of paints, floor coverings, cleaners, and other building and construction products, in addition to planners, architects, and design engineers. The researchers conclude that their prototype could significantly reduce costly, time-consuming interlaboratory studies and variability in testing results.

Finally, although thermoplastic composite, known as "plastic lumber," may not be a new concept, the U.S. Army Corps of Engineers' Construction Engineering Research Laboratory (CERL) has found new ways to utilize the material for high-capacity load structures, such as bridges, large decks, docks, seawalls, wharves, and railroad bridges. Inherently resistant to rot, insects, bacteria, and rodents without the need for chemical treatments, thermoplastic composite rarely cracks or splinters, is weather- and graffiti-resistant, provides great shock-absorption, and requires no waterproofing, staining, or regular maintenance.

CERL researchers are also addressing state-of-the art and emerging technologies to remotely monitor the condition of bridges and overpasses. The engineering goal is to integrating durable, low-cost sensor systems with software to provide advance warning of growing structural problems due to corrosion and materials degradation or events such as earthquakes.

April 2013

The Dynamic Paradigm of Construction Quality Management

By Steven J. Storts
Dublin, Ohio

WHAT is the value of construction quality? The answers to this question are as varied as the interpretations of the word "quality," and within the construction community, the term remains subjective in meaning or definition. For some, quality is simply a measure of the degree to which a constructed project meets the expectations of the client. For others, quality may be more complex, representing strict adherence to project requirements, free of deficiencies or limited to few standard variations from projected outcomes.

The subtle trend in construction quality for nearly a decade has been a honing of traditional quality control and assurance methods, marked with a renewed commitment to manage organizational resources and tools to achieve benchmark performance levels in all facets of business operations — not just the constructed project. Quality becomes more than a perception when it harnesses everyone's cooperation in reaching zero defects, controlling costs, and continually satisfying customer requirements.

There are several benefits to hosting a comprehensive construction quality management program, including increased employee morale, enhanced project efficiency and reliability, improved organizational image, and expanded revenue streams.

Moreover, an efficient quality program is relatively simple to develop and initiate, particularly for smaller construction organizations with limited financial resources. And it all begins with a focus on three quality concepts: competence and integrity in the constructed work; compliance with documents, drawings, and specifications; and timely project completion according to the client's scheduling requirements.

Quality control and quality assurance have always been key components for addressing these quality concepts. More recently, though, quality improvement has been added as an essential element to the traditional QC/QA approach. This component can assume many faces — Total Quality Management, Six Sigma, lean construction methodology, or adoption of ISO 9001 quality management system standards — but they all subscribe to a core belief that quality should be oriented toward the process, not the end result, and that the bottom line follows quality, not vice versa.

Quality improvement programs share other commonalities, too, such as customer focus, highlighting process development techniques for continual improvement, innovation, leadership from top management, education and training of employees, teamwork, two-way feedback mechanisms, recognition and rewards for outstanding performance, and evaluation of all organizational goals and initiatives.

Of course, a viable quality management system also requires review of QC/QA directives. Misronet Construction Information Services, an online data provider, suggests an approach to quality control through proper planning in five stages:

- Setting the quality standard or quality of design and construction required by the client;
- Planning how to achieve the required quality, construction methods, equipment, materials, and personnel to be employed;
- Constructing the project correctly the first time;
- Immediately correcting any quality deficiencies; and
- Providing for long-term quality control through development of a quality culture within the organization.

Misronet also points to the costs of quality, noting that quality is always proportional to the costs associated with any construction process, and that these costs need to be identified early on in the planning process in order to make proper management decisions.

The online information service places quality costs in three categories, the first being failure costs, those associated with demolition and rebuilding and the loss of production time due to delays and change orders. There are also appraisal costs, which are necessary for inspection and testing purposes. Finally, there are prevention costs, which can be regarded in a positive, forward-thinking sense because they are aimed at providing better designs and more training to reduce failure costs or unnecessary maintenance overhead.

From a slightly different perspective, Donald Neff, president and CEO of La Jolla Pacific Ltd., a construction services firm located in Irvine, Calif., regards quality control as just one component of quality assurance. He contends that quality control is more short-term, limited

to specific project considerations and generally addressing budget issues or expense reductions. Quality assurance, on the other hand, he explains, should be expansive to encompass all elements of a quality management program, addressing all levels of work and performance and focusing on greater value-added benefits.

Clients often look to quality assurance as a measure of reassurance that they will receive an optimum project outcome without undue quality problems. To help accomplish this, Neff says ongoing organizational interventions are usually required, such as process training in design, purchasing, construction, and delivery; technical training in all field risk elements; incentive benefit structures for both the office and in the field; and proactive document retention and archiving.

So, how does an organization develop a construction quality management system of value? The preferred method is to personalize a program using the expertise and resources already accessible within business operations, without the need to retain an outside consultant, if possible. Some construction firms download templates at a reasonable cost from providers on the Internet and then tailor the specifics to their organizational structure. Through personalization or the customization approach, staff personnel gain an intimate understanding of the quality management program and feel more confident in implementing it.

Regardless of how a quality management program is developed, it's necessary to build in safeguards. Neff emphasizes that new challenges in the construction industry pose new risks, including new technologies, innovative building practices, and increased expectations from project owners and tenants. There are risks specific to construction, too, he says, citing entity management, design direction, governing documents, the construction process, and maintenance obligations.

However, under an effective quality management system, risks can be avoided, Neff adds. For instance, project "unknowns" can be eliminated or mitigated by establishing expectations and specific performance standards in the project specification manuals. Also, regular insurance reporting throughout the construction process can play a vital role in risk avoidance, in addition to providing regular e-mail communications among project stakeholders as a continuous thread in quality assurance.

October 2012

Cleanroom Construction Projects Offer Unique Engineering Challenges

By Steven J. Storts
Dublin, Ohio

CLEANROOM construction is nothing new in the literal sense, dating back more than a hundred years to hospital environments. The process was later applied to industrial manufacturing during World War II as a means for safeguarding instrumentation during the production of munitions, tanks, and aircraft. However, the evolution of cleanroom construction and the expanded applications for these projects today have helped create a renaissance business, equal in stature to sustainable design and green construction.

The cornerstone of cleanroom development is, of course, the control of contamination, specifically airborne particulate matter that naturally occurs, such as dust, dirt, pollen, bacteria and other microorganisms, and even sea mist. Industrial functions, office activity, and workplace personnel, too, contribute significantly to airborne contamination, including particulates generated from combustion processes, chemical vapors, and friction in manufacturing equipment and contaminate particles emitted in the form of skin flakes, lint, cosmetics, and respiratory gases.

In most instances, the required standard of cleanliness of a room area depends on its purpose. Federal Standard 209E, considered the benchmark for cleanliness for many industries, defines a cleanroom as that in which the concentration of airborne particles is controlled to a specified maximum number of particles 0.5 microns in size per cubic foot (or cubic meter) of sampled air. Usually, cleanroom cleanliness is expressed in terms of classification areas or numbers, such as Class 100 or Class 100,000. For example, those classifications would denote there should be no more than 100 or 100,000 particles, respectively, larger than 0.5 microns per cubic foot of air during the sampling period.

The more susceptible a product or procedure is to contamination, the more stringent the FS 209E requirements become. And as technology advances, the purposes for cleanrooms increase, too. Aside from hospital health care, cleanroom construction has carved niches into numerous other industries: electronics, semiconductors, micromechanics, optics, biotechnology, pharmaceuticals, medical devices, and food and beverages.

Today, a substantial number of manufacturing or production processes require that area spaces be designed and constructed to control particulate and microbial contamination, while maintaining reasonable installation and operating costs. Not surprising, the key stakeholders in modern-day cleanroom construction have become the mechanical engineers who must design and build HVAC systems sophisticated enough to satisfy FS 209E requirements.

Professional engineer Abraham Marinelarena, a specialist in cleanroom development and senior mechanical engineer for Bath Consulting Corp., of El Paso, Texas, notes that cleanrooms have evolved into two major types, differentiated by their method of ventilation — turbulent air flow and laminar air flow. The general method of ventilation used in turbulent air flow cleanrooms is similar to that found in general building and plant construction, with air supplied by an air-conditioning system through diffusers in the ceiling structure. However, a cleanroom differs from an ordinary ventilated room in three ways: increased air supply, use of high-efficiency particulate air filters, and room pressurization.

Laminar air flow, Marinelarena explains, is used when low airborne concentrations of particles or bacteria are required. This air flow pattern is in one direction, usually horizontal or vertical and at a uniform speed of between 60 to 90 feet per minute throughout the entire cleanroom area. The air velocity must be sufficient to remove relatively large particles before they settle onto surfaces and must take into account practical situations, such as room obstructions and personnel moving around. Any contaminant released into the air can be immediately removed by laminar air flow, whereas turbulent air flow ventilation relies on mixing and dilution to remove contamination.

Although air flow design is critical, Marinelarena emphasizes that it alone does not guarantee that cleanroom conditions will be satisfied. “Construction finishes, personnel and clothing, materials and equipment, and points of egress are other sources of particulate contamination that must also be controlled,” he says. In particular, room construction and material finishes are a significant part of cleanroom design, he points out, because not only is it vital to exclude outside contaminants,

it is also important that material finishes not contribute to particle generation in the cleanroom space itself.

Benchmark Engineering Group Inc., of Toledo, Ohio, recognized cleanroom consultants, also stresses the importance of carefully selected construction materials and products that meet cleanroom standards, including walls, floors, ceiling tiles, lighting fixtures, doors, and windows.

Benchmark's clean construction guidelines cite the maintenance of ventilation as paramount, noting, "Contamination of the existing house ventilation can be prevented by isolating supply air dampers in the construction areas to prevent a positive pressure within the construction space." Maintaining construction in a state of negative pressurization should always be the primary goal.

"A cleanroom requires the highest standards of construction," says Space Industries Ltd., of Christchurch, England. "The construction materials used to build cleanrooms can differ greatly from those used in non-cleanroom construction." For example:

- A cleanroom should be built with an airtight structure.
- The internal surface finish should be smooth and suitable for cleaning.
- The internal surface finish should be sufficiently tough to resist chipping or powdering when impacted or abraded.
- Some process chemicals, cleaning agents, disinfectants, and water may attack or penetrate conventional finishes.
- In some cleanrooms, electro-dissipative construction materials will be required.
- In some cleanrooms, construction materials that give a minimum of "outgassing" will be necessary.

Additionally, materials that are used for cleanroom construction should be smooth on the surface facing the inside of the cleanroom, and all butts and joints as seen from the inside of the cleanroom should not show openings that may harbor, and then disperse, dirt.

All cleanrooms, as expected, have their own specific protocols for construction and operation. When designing and constructing a pharmaceutical cleanroom, for instance, the *International Journal of Pharmaceutical Compounding* says several critical factors must be considered, such as policies and procedures, employee training, aseptic technique and process validation, ongoing environmental monitoring, facility maintenance, and compliance auditing.

If these factors are not properly addressed, problems of quality, operation, or maintenance will result. It is often suggested that professional independent consultants be retained who can serve as project managers for constructing clean-rooms for specific industries.

July 2012

Constructing for Fire Safety Remains a Major Focus for Research

By Steven J. Storts
Dublin, Ohio

THE annual observances of the September 11 terrorist attacks on the World Trade Center in New York serve as a constant reminder to the engineering community that building construction is often key to human survival in any natural or man-made disaster. As investigative analyses have shown, the major root cause for the structural collapse of the WTC twin towers in 2001 was excessive heat levels generated through the fiery explosion of projectile aircraft and their unspent fuel reserves.

During the course of the WTC investigations, construction industry and fire protection professionals began new research aimed at curbing or preventing mass structural failure from heat levels at elevated temperatures. Since 2009, the National Institute of Standards and Technology's Engineering Laboratory has been examining the adhesion properties of spray-applied fire resistive materials (FRMs) for structural steel. The performance of these materials—specifically their dislodging upon impact from a debris field—was identified as a key factor in the failure of the steel framework of the twin towers.

NIST points out that the adhesion properties of FRMs at high temperatures, which are vital for modeling and performance predictions, were not available in 2001. Providing this necessary measurement science infrastructure for FRMs will ultimately allow the forecasting of their performance during standardized testing by the American Society for Testing and Materials (ASTM) and actual fire exposures, in addition to the adoption of performance-based code requirements based on science and engineering.

For the NIST Engineering Laboratory, this project poses major challenges. FRMs change dramatically during exposure to high temperatures, including mass losses, dimensional changes (shrinkage and expansions), chemical reactions, and microstructural modifications effecting modifications in mechanical properties. To expedite research, attention is being focused on applying a NIST-developed fracture mechanics approach to FRM adhesion at elevated temperatures. Building on the success of a recently completed consortium where the new adhesion test methods were developed and commissioned, these techniques will be adapted to measure FRM temperature dependence.

Another NIST research project, also initiated in 2009, is looking at the total building envelope in terms of fire resistance design. Although current building codes specify fire ratings of individual building components and assemblies from standard fire endurance tests, such as ASTM E-119, NIST contends that there are no accepted scientific measurement tools to evaluate the fire performance of entire structures—including connections—under realistic fire scenarios. "The state of the art in measurement science to predict structural performance to failure under extreme loading conditions, such as during an uncontrollable fire, is lacking," agency officials admit.

As an alternative to current prescriptive design methods, NIST recommends the development of performance-based standards and code provisions to enable the design and rehabilitation of structures to resist actual building fire conditions, in addition to the development of tools, guidelines, and test methods necessary to evaluate the fire performance of the constructed project as a whole system.

For instance, the agency says a key recommendation resulting from the WTC investigations was that careful consideration should be given to the possibility that certain design features, such as long-span floor systems and connections that cannot accommodate unusual thermal effects, may adversely affect the performance of the entire structural system under abnormal or excessive fire conditions.

NIST's new technical approach is incorporating a broad range of knowledge concerning fire load, material response, and overall structural response to elevated temperatures. Building layout, windows and ventilation, construction materials, passive and active fire protection systems, and the amount and location of combustibles will be included in this approach. Recent technical advances will also aid in this research by providing the ability to forecast both the development and propagation of building fires and structural system performance at elevated temperatures.

Another closely aligned initiative, the Whole Building Design Guide, a program of the National Institute of Building Sciences, is addressing the

need for new facilities and renovation projects to be designed to incorporate efficient, cost-effective passive and automatic fire protection systems—systems that are effective in detecting, containing, and controlling or extinguishing a fire event in the early stages. At the core of WBDG is the mission to creatively and efficiently integrate code requirements with other fire safety measures and design strategies to achieve a balanced facility that will provide desired levels of safety.

According to WBDG, the major components necessary for developing a successful fire protection design include: the design team; design standards and criteria; site requirements; building construction requirements; egress requirements; fire detection and notification system requirements; fire suppression requirements; emergency power, lighting, and exit signage; and special fire protection requirements.

At a minimum, all building construction requirements should address the following elements: construction type, allowable height, and area; exposures and separation requirements; fire ratings, materials, and systems; occupancy types; interior finishes; and exit stairway enclosures.

An advocate for whole building design, professional engineer Morgan Hurley, fellow and technical director of the Society of Fire Protection Engineers, advises, "It is beneficial to involve fire protection engineers in a design at the earliest stages of planning, generally at the feasibility or concept design stage." He cites the benefits: greater design flexibility; innovation in design, construction, and materials; equal or better fire safety; and maximization of cost/benefit.

"Designing from a 'whole building' approach does not require that design be on a performance basis," Hurley explains. "It is necessary, however, that the design of fire protection-related systems be coordinated with each other and with other building systems and the overall building design."

October 2011

Integrated Project Delivery Sets New Construction Team Objectives

By Steven J. Storts
Dublin, Ohio

ONE of the more general misconceptions about Integrated Project Delivery is the assumption that IPD is just an expanded version of the design-build concept. While design-build principles may be closely aligned with the fundamentals of IPD, the latter actually pitches a larger tent; design-build simply shares space under that tent.

Construction industry sources point out that design-build procurement and management methods can differentiate among projects and may or may not include the owner to varying degrees. If design-build moves more toward a procurement process or a project management that does not include the owner, it also begins to move away from the fundamental principles of IPD. Conversely, when design-build is used according to its best practices, it also aligns with the best practices of IPD. This is where the two concepts are sometimes inadvertently considered synonymous.

In its 2007 report *Integrated Project Delivery—A Working Definition*, the Integrated Project Delivery Task Force released its now widely accepted statement: IPD is a project delivery approach that integrates people, systems, business structures, and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction.

The IPD Task Force, an interdisciplinary group sponsored by McGraw-Hill Construction and the American Institute of Architects/California Council, notes that within the ideal IPD and design-build models, the owner, designers, and builders work jointly cooperate *from a project's inception* to mutually establish the performance, budget, and schedule within the constraints of the owner's business model. Moreover, IPD principles can also be applied to a variety of contractual arrangements, with project teams including members beyond the basic triad of owner, engineer/architect, and contractor—all aimed at a life-cycle approach toward constructed facilities.

As part of its core definition, IPD is a "deeply collaborative process that uses best available technologies, but it goes beyond merely the application of digital tools, such as Building Information Modeling (BIM)," the task force report notes. Unless all parties are committed to a set of essential principles, integrated practice will not succeed, the task force emphasizes. These principles include mutual respect, mutual benefit, early goal definition, enhanced communication, clearly defined standards, appropriate technology, and high performance.

To some, thoe principles may sound reflective of the construction partnering process. However, the AIA/California Council contends that partnering is purely *aspirational*, with project stakeholders signing a non-binding agreement that supports joint and open interaction. "Partnering does not, however, change the basic contract and liability relationships, nor does it create incentives and consequences that flow from achieving or ignoring the collaborative goals," the council explains.

In contrast, IPD is a value-driven process, where project goals are reinforced through shared risk (appropriate liability allocation) and reward based on the best interests of the project as a whole rather than individual performance.

Noteworthy, too, the council says that acceptance of IPD's essential principles does not necessarily guarantee project success. "Although integrated projects can proceed using various business models, some approaches are better suited to an integrated project than others," according to the IPD Task Force, which represents the interests of architects, engineers, contractors, subcontractors, owners, and attorneys.

For instance, under the more traditional design-bid-build approach, key participants cannot be identified until bids are received—too late to meaningfully participate in developing the integrated design, resulting in a likely failure to achieve the efficiency and performance benefits of an integrated process, the task force points out. For this reason, progressive design-build delivery methods have the potential to be more consistent with the integrated approach.

If a business model is a good fit for IPD, there are eight primary sequential phases that comprise the integrated approach, the task force reports:

- **Conceptualization** (traditionally known as pre-design): the be-

ginning of determining what is to be built.

- **Criteria Design** (traditionally known as schematic design): where the project begins to take shape.
- **Detailed Design** (traditionally known as design development): concludes the what-is-being-created phase of the project.
- **Implementation Documents** (traditionally known as construction documents): where the focus shifts from *what* is being created to documenting *how* it will be implemented.
- **Agency Review**: use of digital technologies such as BIM, early involvement, and validation by agencies to shorten the final permitting process.
- **Buyout**: complete buyout of remaining contracts.
- **Construction**: where the benefits of the integrated model are realized.
- **Closeout**: delivery of an intelligent 3-D model to the project owner.

For construction organizations considering an IPD approach, proponents recommend business models that promote early involvement of key participants; equitably balance risk and reward; have compensation structures that reward best-for-project behavior or provide incentives related to project success; clearly define responsibilities without discouraging open communication and risk taking; and implement management and control structures built around team decision making.

November 2010

Use of BIM Creating New Paradigm In Construction Project Delivery

By Steven J. Storts
Dublin, Ohio

MUCH of the engineering design and construction community has been introduced in some manner to Building Information Modeling — the process of generating and managing computerized multi-dimensional models linked to databases containing design specifications, schedules, and other documents related to a construction project. When used, BIM is a digital representation of the building process itself, making it easier for construction firms to accelerate construction, lower costs, and manage facility operation throughout a project's lifecycle.

Virtual building, virtual design and construction, and integrated practice are all synonymous terms for this emerging technology that is trending toward being the next-generation tool for project delivery. Regardless of terminology preference, BIM's mission is not to replace traditional or modern forms of project delivery; rather, the process aims to dramatically increase productivity and efficiency in the construction industry.

Although the academic origins of BIM can be traced back to the late 1970s, it took more than decade for information modeling to achieve wider acceptance in the building industry itself.

BIM gained further ground in 2004 following the release of a report entitled *Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry*. Published by the National Institute of Standards and Technology (NIST), the report concluded that nearly $16 billion is lost annually by the U.S. construction industry due to inadequate inter-operability, including the highly fragmented structure of the overall industry, continued paper-based business practices, lack of standardization, and inconsistent technology use among project team members.

Today, adopted in principle by more than 20 construction industry organizations, BIM overcomes many of the barriers cited in the NIST report. Proponents tout it as a process that offers improved visualization, better coordination of construction documents, and greater productivity due to easy retrieval of information. Because BIM embeds and links vital data such as suppliers of specific materials, location of details, and quantities required for estimation and procurement, it also increases speed of delivery and reduces overall costs.

By its own nature, BIM represents a new approach in architectural and engineering design. Digital representations of the actual components used to construct a building can be created, and the quantities and shared properties of materials can be extracted easily. Scopes of work can be isolated and defined, and the systems, assemblies, and work sequences can be shown in a relative scale within the entire project or just a group of facilities.

"BIM provides all parties involved on a project with shared up–to–date project data," the Associated General Contractors points out, "subsequently allowing for a richer design process, increased budget control through predictions about the project's construction process, and fewer surprises with respect to potential design and scheduling conflicts among trades — long before ground is even broken."

AGC's perspective is shared with Terry Cook, president of the Construction Owners Association of America. "The challenge in the design and construction process isn't to expand our horizons but to fix the seams," he says. "BIM is an important conduit for information to flow from concept through design, construction, operations, and back to concept for the next project."

The structural steel industry has also demonstrated the viability of BIM in today's marketplace, according to the American Institute of Steel Construction. "The accomplishment of vertical integration has motivated other specialty contractors to begin the process of replicating these successes in their vertical project supply chain," AISC notes.

"At the same time, the marketplace continues to move toward a horizontal integration of design software where the sharing of coordinated 3-D design models between architects and engineers brings further advantages."

In an industry that can sometimes be slow to embrace change, what is the future role of BIM in building documentation and project delivery?

The *SmartMarket Report on Building Information Modeling: Transforming Design and Construction to Achieve Greater Industry Productivity*, published by McGraw-Hill Construction in December 2008, found that BIM use on construction projects is growing rapidly. In fact, 62 percent of users surveyed indicated they would be using BIM on more than 30 percent of their projects in 2009. The research findings also showed that 82 percent of those using BIM believe it is having a very positive impact on their organizations' productivity.

As part of its market summary, McGraw-Hill says BIM is being broadly accepted by the construction industry, with more than 50 percent of each survey segment — architects, engineers,

contractors, and owners — utilizing the technology tools at moderate levels or higher. Architects are the heaviest users of BIM; contractors are the lightest users, although they expect to see the greatest rise in BIM use in the future. Engineers see their BIM use increasing but not as much as that of other project team members; owners expect to see moderate increases.

"This powerful trend points to an unstoppable wave of adoption and creative implementation that will redefine project delivery and affect every company in the construction industry," the McGraw-Hill report contends.

As with any new or emerging technology, some legal uncertainties may be associated with using BIM. To address these potential legalities, in 2008 an addendum was added to the ConsensusDOCS catalog, which addresses contractual agreements among all forms of project delivery. The BIM addendum provides a tool to utilize the process from start to finish, thereby allowing contractors to more closely integrate project delivery with owners and design professionals.

ConsensusDOCS — a collaborative effort of 22 leading organizations representing owners, contractors, subcontractors, sureties, and designers — contains more than 70 construction contracts aimed at identifying and employing best practices that allocate risk fairly among all contractual parties. The addendum expects to serve as a catalyst for acceptance of BIM in many sectors of the industry.

"BIM is changing how construction projects are planned, coordinated, and documented, and that means contracts must change accordingly," says E. Colette Nelson, executive vice president of the American Subcontractors Association. "ASA endorses the addendum, a truly pioneering effort to help construction team members define their business relationships on projects that use BIM."

July 2010

Skilled Labor Shortages Still Problematic For General Construction Industry

By Steven J. Storts
Dublin, Ohio

"BUILD it, and they will come!" This approach to project planning worked well, of course, in the popular movie *Field of Dreams*. But in the current construction marketplace, fielding a skilled labor workforce is beginning to pose greater challenges for project owners and members of the construction team.

One of the core principles that evolved out of a long-term campaign of The Business Roundtable's Construction Committee—the Construction Industry Cost Effectiveness Project—emphasizes that good personnel management enables people to make their maximum contribution, develops their potential, and ensures that skilled craftsmen are used only in those tasks where their skills are required.

Although construction workers are usually contractor employees, the Roundtable notes, it is in the owners' interest to require that they be managed and used effectively and to accept the associated costs. Unfortunately, recent survey and census data from numerous organizations point toward a growing shortage of skilled workers in construction and heavy equipment industries.

The growth rate of the construction workforce has been steadily declining since the 1970s. Also, both the U.S. Census Bureau and reports from private consulting firms indicate the workforce will begin to experience a negative growth rate beginning in 2015. Census estimates further project that by 2020 one out of every two people in the U.S. will be older than 50. Many of these older workers, however, are willing to stay in the workforce longer or even re-enter it after retirement.

In March 2008, the Construction Labor Research Council conducted a survey of more than 6,000 contractors nationwide and found that the largest expansion in decades in industrial construction is causing significant shortages in the workforce within single and multiple trades. The findings come from a study, *The 2008 Construction Industry Conditions Survey,* which was sponsored by construction industry unions to determine the impact of increased job demand within various sectors of the construction market. According to the survey results, those trades most often associated with labor shortages include boilermakers, pipefitters, ironworkers, operating engineers, and electricians.

With the availability of an adequate supply of skilled trade labor becoming less certain, construction stakeholders are responding by adopting nontraditional work practices, which in some cases increase labor costs beyond the contractual wage and fringe rate. In fact, to cope with temporary labor shortfalls, many contractors are posting weekly work schedules of more than 40 hours; some have schedules exceeding 70 hours weekly. Additionally, supplemental payments that are $1 to $3 above scale are being made on a project-by-project basis in order to attract sufficient and adequately skilled trade workers.

However, construction professionals point out that real solutions to labor shortages must be long-term in their approach and address both the recruitment and retention of a skilled workforce. To that end, the Construction Industry Institute formed a research team more than a decade ago to examine the U.S. Department of Labor's forecasted workforce shortages for the new millennium. The research team's early findings still hold true today: contractors that experience an employee retention rate of 80 percent or better realize profits on more jobs, complete more projects on or ahead of schedule, and experience better safety performance.

Based on its research, CII recommends that owners should prequalify contractors according to these factors: employee wages and benefits; overall trade worker retention rates; attributes used to attract and retain trade workers; and efforts in craft training, assessment, and certification to enhance the employee's career development process.

Recommendations to contractors include the following: providing competitive wage and benefit packages; monitoring and using retention rates to diagnose company field staffing trends; providing a safe workplace; implementing a skill assessment process; enhancing permanent employment opportunities; adopting certification programs to ensure qualified trade workers; and treating employees with respect.

March 2010

Shortfalls in Cement Supplies Draw Much Concern in Construction Industry

By Steven J. Storts
Dublin, Ohio

THE Portland Cement Association's predictions of tight supplies of cement and even shortfalls in some regions of the U.S. are proving all too true for many stakeholders in the construction industry.

In its May survey of cement suppliers, PCA reported tight supplies in 23 states. Among those, 10 indicated tight supplies in only portions of the state, typically surrounding large metropolitan areas. The states most affected were located in the Southwest, Southeast, and Northeast, with the exception of the New England region.

But PCA also cautioned, "Fragile market balances prevail in several other areas currently not characterized by tight supplies." That fragile nature has now reached critical stages in Arkansas, Florida, Idaho, Missouri, Montana, Nevada, New Mexico, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

Citing delays in construction projects and hoping to mitigate further shortages of cement supplies, governors in four Western states recently forwarded a letter to U.S. Commerce Secretary Carlos Gutierrez, urging the federal government to immediately end a trade policy that restricts cement imports from Mexico.

The letter, signed by Governors Mike Rounds of South Dakota, Kenny Guinn of Nevada, Bill Richardson of New Mexico, and Jon Huntsman of Utah, stated, "The effects of the shortage are rippling through the construction industry. Concrete producers are being forced to reduce their allotments to their customers, meaning the possibility of costly delays or even the cancellation of construction contracts."

The governors cited further concerns. "If this shortage continues, thousands of jobs and millions of dollars in broken contracts will be at risk, and many small construction businesses could be forced out of business," they noted. "Public projects will increase in cost, while failing to meet construction schedules."

Additional letters to Gutierrez have also been sent by Governors Jeb Bush of Florida and Rick Perry of Texas, and by Steven Sandherr, president of the Associated General Contractors of America.

According to Richardson's office, the U.S. instituted a tariff in 1990 to prevent Mexican cement manufacturers from dumping their product on U.S. markets below domestically produced prices. AGC reports that domestic cement production is now falling short of demand, and the antidumping duty, which is "essentially a tax of up to 80%," is preventing Mexican cement from entering the U.S. market.

PCA has also adjusted upwardly its demand forecast for this year from a 3% increase to 5%. Tight supplies are primarily the result of record demand for cement, the organization explains. Cement consumption in the U.S. grew to 119.9 million metric tons in 2004, an increase of 6.8% over 2003 and a record year for cement consumption. Through the first quarter of 2005, cement consumption has increased 7% over the very strong 2004 levels.

Because mortgage rates have remained near historic lows, home building continues to be very strong. In addition, nonresidential and public construction is also expected to increase as the economy improves, PCA forecasts. "Price hikes for other construction materials have also increased demand for concrete," the organization explains. "Overall, concrete price increases have been slight—and relatively stable—compared to increases in steel and lumber prices."

Shortages of fly ash, used as a supplementary cementing material in concrete mixes, have further increased the demand for cement in some regions of the U.S., PCA points out.

Sandherr's letter to Gutierrez in June warned the Commerce Department about possible cement shortages. Since then, he says the number of states where significant shortages or tight supplies of cement are reported has risen to 30, plus Washington, D.C. "The long-awaited enactment of surface transportation and energy bills . . . will add to cement demand, at a time when construction spending has already risen 9% from last year, while domestic cement production has barely budged," Sandherr contends.

The AGC president says domestic suppliers are currently selling all they can produce, rationing existing customers, and turning down new customers. "It is high time for other cement producers to admit they are not being 'injured' by Mexican cement imports and to agree . . . to a suspension of the 15-year-old antidumping duty on those imports," Sandherr emphasizes. "The duty is causing needless hardship for contractors and concrete suppliers in states all across the country."

Cement companies are currently taking both near- and long-term measures to prevent and resolve regional shortages by operating at full capacity, expanding domestic capacity, and

importing more cement when possible, PCA reports. In fact, it is expected that the imports' share of total U.S. consumption will exceed 25% during 2005 through 2007, a rise of more than 4% since 2003.

"U.S. cement plants are operating at maximum levels, as they did throughout 2004," PCA notes. "To meet market demand last year, cement producers drew four million tons from inventory. This year, inventory levels are at historic lows and a further draw-down is not likely."

According to the organization, U.S. cement manufacturers have announced plans to spend about $3.5 billion to build new plants and expand existing ones to produce an additional estimated 14.5 million tons of annual capacity by 2010, which represents a 15% increase over 2004 domestic capacity levels.

October 2005

Industry Consortium Issues Challenge For Construction Productivity Measures

By Steven J. Storts
Dublin, Ohio

A NATIONAL building industry consortium is calling on the U.S. Bureau of Labor Statistics to establish standard productivity measurements in the domestic construction industry.

In May, the Building Futures Council released a white paper that documents the inadequacy of current productivity measures for the construction industry and encourages BLS to continue its efforts to improve measurement.

BFC says these efforts, including future studies, should pay close attention to recent industry innovations—increased offsite fabrication, new materials, and improved communications—and attempt to gauge the effect of these innovations on construction productivity.

BFC, a national, nonprofit organization comprising building and construction industry stakeholders, addresses the challenges and rewards of the built environment. The consortium operates as a think tank to identify critical issues encountered in the building and construction process, and then analyzes, discusses, and advocates guidelines and criteria for improving efficiency in the process.

The value of construction put in place equals nearly 9% of the U.S. gross domestic product, yet despite its importance, BLS has not developed any standard productivity measures for the construction industry. Consequently, there are difficulties in measuring outputs, inputs, and prices, although BLS will begin publishing its first index for finished structures—warehouses—this summer.

Aside from the difficulties of establishing suitable measurements, BFC suggests that BLS develop, publish, and monitor adequate benchmarks that the construction industry could use to better evaluate, improve, and, most importantly, identify the valuable contributions the industry brings to the U.S. economy.

"It is essential to establish uniform measurements of inputs and outputs," notes Derish Wolff, BFC vice chairman and chairman of Berger Group Holdings in East Orange, New Jersey. "Without proper measurement and reporting of productivity, the U.S. construction industry will continue to be wrongly perceived by some as resistant to innovation and change."

The effect of this perception on the public is significant, BFC emphasizes. The construction industry is often criticized as unprogressive, archaic, and conservative. This perception is unfounded, and in many ways, discourages the very talent needed to properly fuel growth and productivity, the organization adds.

"Collectively, the industry has made significant strides in recent years in developing safer work sites, shorter construction time lines, and more resilient products and systems that make the built environment more productive and efficient for the industries that occupy the facilities built," says Wolff.

If suitable measurements for construction productivity can be identified, then industry productivity and the effect of improved technologies can be better evaluated and understood, Wolff contends. "This will enhance the industry's efficiency while contributing to the economy, and performance against other major sectors will be more accurately measured," he adds.

The BFC white paper *Measuring Productivity and Evaluating Innovation in the U.S. Construction Industry* points out that, in general, detailed construction productivity measurement has been avoided by U.S. government analysts due to a lack of adequate data and professional and academic consensus on measurement techniques and their significance.

Statistics on long-term productivity trends are available for many industries in the U.S., particularly in goods-producing sectors such as mining and manufacturing. "The same cannot be said for the construction industry," the white paper reports. "This discrepancy is primarily due to the measurement difficulties regarding real inputs and outputs unique to the construction industry. Most of the problem involves measurements of output, particularly the problem of controlling for the change in quality in the inflation indices."

BFC says the use of proxy indices in construction also adds to the problem, such as using the Census Housing Index to deflate commercial and military construction.

While the input data is measured in hours worked by BLS, output is measured by the U.S. Census Bureau. In comparison to other industrial sectors, it appears that a number of analysts believe, even in the absence of agreed measurable data, that construction productivity growth was above average in the 1960s and early 1970s, and below average in the 1990s, according to BFC researchers.

There have been few studies aimed at accurately quantifying construc-

tion productivity growth, the white paper notes. Therefore, BFC recommends that any future studies should focus on analyzing—and perhaps redefining—the unique characteristics of the diverse subsectors of the construction process and establishing appropriate measurements of inputs and outputs.

National estimates of costs of labor, material, and equipment compared to the price of the finished products may not, given the complexity of the sector, produce the most accurate or beneficial productivity data, BFC explains, noting that productivity factors should, where practical, be qualified by categories such as geography, types of products or services, and materials.

July 2005

CMAA Study Confronts Issue of What a Construction Manager Does

By Steven J. Storts
Dublin, Ohio

A RECENT study by the Construction Management Association of America pinpoints the key functions of a construction manager, including the tasks and responsibilities that most realistically define the job as it is actually practiced in the market.

CMAA contends that the real definition of a professional CM is often not correctly understood. Part of the misunderstanding arises from confusing terms, with people applying different job titles such as owner's representative, project manager, and program manager to this critical function.

"We see an urgent need for clarity in describing and defining the content of the professional construction manager's job," says CMAA Executive Director Bruce D'Agostino.

The organization surveyed its own individual, corporate, and owner members, in addition to certified construction managers and certification candidates. More than 500 professional CMs responded to the survey. Participants were asked to rank 120 common project responsibilities according to their importance in a CM's work and the frequency in which they actually engaged in the activities.

The CM project responsibilities fell into seven broad functional areas: project management planning, cost management, time management, quality management, contract administration, safety management, and CM professional practice.

Survey respondents ranked project management planning as the most important of all project-specific functional areas. Overall, CMs and owners ranked maintenance of professional practice as their primary ongoing concern, including adherence to ethical standards and providing leadership to their firms.

Among specific project management tasks, CMs assigned the highest value to defining the responsibilities and structure of the project management team. Second place went to "organizing and leading the project team by implementing project controls, defining roles and responsibilities, and developing communication protocols." Third place was assigned to identifying the elements of project design and construction that were most likely to give rise to disputes and claims.

CMs reported that their most frequent tasks—functions they perform on a daily or almost-daily basis—include prequalifying designers, developing and managing a selection process, creating project procedures manuals, and developing trade contractors' scope of work definitions for contract agreements.

The next most important functional category cited in the survey was time management, where CMs said their most important task is to develop a master construction schedule, followed by developing and managing a critical path schedule for the project, and reviewing detailed short-term schedules with contractors.

CMs noted that they perform these duties on at least a monthly basis, with the greatest frequency being reported for "developing project scheduling requirements and systems," followed by "developing a project program schedule" and "reviewing acquisition plan and design documents to verify constructability within established performance periods."

A number of quality management functions were also identified in the survey as being central to a CM's role. Chief among these tasks is to "manage conformance of work to contract documents during the construction phase." Tied for second in importance are "monitoring risk management and implementation of safety plans" and "ensuring review comments are adequately addressed during the design phase."

Survey respondents reported performing these tasks on a monthly basis. Other duties performed on a monthly or weekly basis include preparing a quality management plan, selecting and leading a QM team, conducting design reviews on behalf of the owner, and monitoring the effectiveness of contractors' QM/QC teams.

Contract administration is also a central CM function, the survey found. CMs attached the highest value to monitoring contractor compliance with contract requirements, developing scope-of-work documents for bid packages, and organizing team interactions. The most frequently performed tasks include defining the partnering process, developing a contract procurement plan, establishing contractor prequalification procedures, and developing requirements for occupancy and startup.

Construction management also focuses heavily on project costs. In the area of cost management, the survey found CMs and owners defining the budget development process as their most important duty, followed by reviewing design documents for conformity with budget and scope re-

quirements, and monitoring costs as the design is developed.

In addressing safety management, CMs said their most valued function is to establish project emergency plans, including coordination of police, fire, rescue and other emergency services. Assessing job-site risks, defining the responsibilities of on-site employers, and reviewing contractor safety programs are also considered highly important.

"This survey clearly demonstrates that both CMs and project owners see a large number of important, specific jobs that must be performed by the CM at every stage of a project," says Agostino. "The most important functions identified by respondents, as well as those they report performing most often, are equally distributed across the design, construction, and project delivery stages."

June 2005

Crom Corporation Takes Construction Of Elevated Tanks to New Heights

By Steven J. Storts
Dublin, Ohio

FROM a distance, a water tower's angular, yet smooth, domelike shape sitting atop a narrow pedestal resembles a landed spaceship of sorts. Others simply describe the sighting as a gigantic golf tee, slightly rounded on top. Either description satisfies the engineering creativity that emanates from The Crom Corporation, a Gainesville, Florida-based construction firm specializing in prestressed composite tanks.

A longtime sustaining firm of the National Society of Professional Engineers' Construction Practice Division, Crom has become a recognized builder of prestressed concrete water storage tanks. In fact, when the time comes for your community to build a newer, improved water storage facility, there's a good chance Crom will be there. And with it will come its proven expertise in constructing elevated prestressed concrete tanks.

Professional Engineer James Neff, senior vice president of Crom, notes, "The design and construction of these tanks are unique compared to typical construction projects. Building a water-containing, leak-free concrete structure of this type is difficult at best. The techniques used in our construction eliminate many of the problems inherent in satisfactorily building such a structure."

In addition to Crom's more than half-a-century of design and construction experience that is the cornerstone of these newer, elevated storage tank structures, key features include concrete construction throughout, adding to the structure's long life span; water containment within a vessel in permanent compression; and a low-silhouette, free-span dome roof with no submerged interior columns. All of these features complement the aesthetic appeal of the facility that sports an attractive texture with smooth outside lines.

"Concrete has long been recognized as a building material with great durability," Neff notes. "It stands to reason that it has become the preferred material for construction of water storage structures throughout the U.S. and worldwide."

The Crom executive further points out that elevated prestressed concrete tanks provide long-range economy for any owner. "Because exterior painting is not required, and the fact that interior coatings or linings aren't necessary, maintenance costs are almost negligible," Neff explains. "Also, the inconvenience of service interruptions is minimal, and in many cases, is avoided entirely."

Murfreesboro, Tennessee, is the latest home to one of these innovative, elevated storage tank systems. Just recently completed, the $4.2 million, 180-foot-high tower structure will hold two million gallons of water for customers of the Murfreesboro Water and Sewer Department. The community also plans to replace an older 500,000-gallon steel storage tank with one of Crom's two-million-gallon systems, estimated at a cost of $3.8 million. Crom has also constructed elevated prestressed concrete tank towers in Frankfort, Kentucky, and Boynton Beach, Florida.

The company's unique construction method employs a specially designed, self-supporting concrete formwork system that eliminates all through-wall ties, essential for water impermeability. Horizontal and vertical prestressing keeps the concrete in the vessel walls and the dome roof in permanent compression, both of which ensure a watertight structure that will provide many years of service.

The elevated prestressed concrete tank structure starts with a floor foundation constructed with heavily reinforced concrete. Resting on that foundation is the tank pedestal, cast using the jump-formed method. From that point, the exterior forms for the conical concrete vessel wall are erected. When the ring is complete the forms are self-supporting.

Reinforcing steel and prestressing ducts are then placed for the conical vessel wall, followed by the installation of the interior formwork system in preparation for casting the conical vessel wall. Interior shutter boards are placed one row at a time and concrete is cast in 22-inch-high lifts to assure good consolidation. A hydraulic jack is used to tension the prestressing elements for the vessel wall, which overall is put in permanent compression using both horizontal and vertical prestressing.

The concrete cylindrical vessel wall and the free-span dome roof are then cast and prestressed, followed by the tank's completion, consisting of adding stairs, ladders, accessories, and painting of the exterior surfaces.

Crom's years of experience in building more than 2,600 prestressed composite tanks—the majority of which are still in service—have perfected the composite system for tank wall design and construction. These improvements have included the use of ready-

mixed concrete and pneumatically applied shotcrete in combination with a steel shell diaphragm; high-strength prestressing wire; and various epoxies for sealing the steel shell membrane.

Of the major developments in prestressed composite system design and construction, Crom engineers cite the steel shell diaphragm as the most effective means for making the tank's core wall watertight. Also, shotcrete, with its high cement factor and low water-to-cement ratio, has been found to have greater corrosion inhibition, impermeability, and strength as compared to conventional concrete.

"Our more recent move toward elevating some of our water storage tank structures is, in effect, a culmination of many of these improvements in construction materials and techniques within the industry," Neff points out. "When it comes to prestressed composite systems, Crom's mission is to provide a turnkey design and construction service stressing good workmanship, structural integrity, and pleasing aesthetics that result in expanded longevity with low maintenance costs."

Over the last two decades, The Crom Corporation has been nationally recognized for technological expertise, construction excellence, and architectural and environmental aesthetics by the Portland Cement Association, with 12 major awards spanning the 1980s and 1990s.

July 2004

Survey Finds Security Issues Taking Forefront in Hiring of Executives

By Steven J. Storts
Dublin, Ohio

A RECENT survey of construction CEOs indicates that the events of September 11, 2001, and the resulting nationwide response to terrorism have brought about permanent change in construction executive hiring.

More than 500 construction CEOs and industry executives, responding to a ConstructionExecutive.com survey, show that since 9/11, more emphasis has been placed on candidate screening for executive hiring, including increased demands for third-party reference checking, detailed background checks, assessment testing, fee-based company research, and probationary hires.

Construction Executive is a career advancement and leadership development center for CEOs and industry executives in the architectural, engineering, and construction communities. Through its emphasis on human capital services, the New Orleans-based firm maintains one of the largest, offline, private profiles database of employed or contracted A/E/C executives and is a leading information provider of construction salary surveys, construction career trends, construction demographics, and other A/E/C employment data.

Kevin Carney, marketing director for Construction Executive, says that 9/11 forever changed the way construction executives are hired. "Most CEOs believed they were hiring smarter and being more careful with candidate screening this year than in previous years," he reports. "Even the construction executives we heard from (who accepted new positions), felt they were much more cautious and had performed more company research prior to accepting a job offer."

One of the survey's findings points toward an increase in probationary hiring of executives. The survey shows that 16% of all executive hires over the last 12 months involved a probationary or trial period. This figure has risen 12% from 2002 figures, after climbing 9% from the previous year when a similar survey was conducted.

Although probationary hiring may make sense for cautious employers and executives who prefer to test the waters before jumping in, it could be a smart move statistically for risk-takers as well, Carney observes. "Our studies indicate that most new executive hires that fail usually fail within the first 90 days," he says. "However, we found that employers who implemented a 90-day probationary period had a lower failure rate and were more likely to retain their hires longer than employers who did not."

Employers without probationary hiring showed an 18% failure rate (due to termination or resignation) for new hires within the first 90 days, while employers with probationary hiring showed a 15% failure rate.

"We also found that executives and employers who consider probationary hiring usually are more diligent with their research and qualifying efforts," Carney adds, "and more likely to put forth their best efforts to accommodate each other throughout the probationary period. Probationary hiring acts like an extended courtship giving everyone a chance to work cooperatively together over a longer term before making a permanent commitment."

Overall, the survey indicates a general change in attitude and approach to hiring for construction employers and executives, including changes in hiring practices at the corporate governance level. "Since 9/11, we have experienced a significant rise in demand for our third-party reference checks, e-background checks, assessment testing, and company research services," Carney points out.

The hiring of company executives is not the only practice undergoing change within the construction industry. Building project owners and building management officials are placing greater emphasis on security, which is resulting in higher operating costs.

Larry Soehren, president of Building Owners and Managers Association International, testified earlier this year before a congressional subcommittee that oversees funding allocations for the General Services Administration. The BOMA International official told lawmakers and GSA officials that building operating costs for both private and public sector buildings have steadily increased about 10% annually over the past five years.

Chief among those operating costs are security measures, Soehren points out. "In these times, most office buildings—whether private or public, urban or suburban—have no alternative but to increase the security in buildings," he explains. "Whether the threat is real or perceived, tenants are demanding more secure workplaces, and owners and managers are responding."

In a survey conducted last year by CEL & Associates on behalf of BOMA International and the Urban Land Institute, the results indicated that most building owners, managers, and devel-

opers have improved security systems and procedures since 9/11 by adding security cameras, increasing security personnel, and either installing or more rigidly enforcing card-access systems. The basic security enhancement procedures used most frequently include more accurate vendor identification and check-in and more comprehensive employee background checks by vendors.

"It is clear that, in today's environment of terrorism and war, building owners and managers in both private and public sector buildings must continue to meet new standards of safety in office buildings," Soehren contends. He encouraged subcommittee members to give GSA more flexibility in its management and development of the buildings in its federal portfolio and to enact legislation that would "allow GSA and private sector companies to enter into public-private partnerships."

BOMA International is generally supportive of the "lease-back" concept of public-private partnerships. Under this arrangement, the government engages a private entity to assume economic control of a building and its renovation. The government, though, still retains a first-refusal option to lease the building back for a rent that includes a return on building improvements. Soehren notes there are also opportunities in leasing outright some government-owned buildings to the private sector.

September 2003

Automated Garage Parking System Premieres in Hoboken, New Jersey

By Steven J. Storts
Dublin, Ohio

PARKING a vehicle in Hoboken, New Jersey, just got a little easier and safer. The nation's first modular and fully automated parking garage opened this fall—a 56-foot-high structure resting on a lot just 100 feet square, accommodating 324 cars. But really, automated parking? Sounds too good to be true.

Modestly described, Robotic Parking's new facility is an elaborate system of lifts and rails that place, move, and retrieve cars among any of the parking bays on any floor level—all without the assistance of a vehicle owner or parking attendant. Those wanting to park simply leave their locked car on a pallet at the entrance bay and let the computerized system take it through a series of lifts and carriers to a vacant parking space. When it's time to retrieve the vehicle, the car owner inserts an e-card and the automated pallet fetches the vehicle in minutes.

Robotic Parking's automated parking systems can park twice as many cars in the same space (or use half the space for the same number of vehicles) as a conventional garage. It offers the highest level of security possible in a parking structure, all with the convenience of a valet service but without the valet. The fact that no one enters the parking garage itself virtually eliminates any danger of vandalism, scratches, dents, or theft of a vehicle.

More importantly, the risk of personal injury or robbery that can occur in conventional parking areas is dramatically reduced because drivers remain safely outside the building at all times. Additionally, the facility has all the convenience of ground-level access, eliminating the need to take elevators or walk up and down stairs.

Less than a decade ago, Gerhard Haag, president of Robotic Parking, had a vision to provide a smart solution for urban planners in major metropolitan areas. Why plan all that space for traditional parking when it could be more efficiently utilized for other purposes, with the added benefit of increased aesthetics. That vision is being realized today, Haag observes, adding, "Our unique, patented technology offers a revolutionary alternative to conventional parking where space is limited. This technology is truly the wave of the future."

The founder of the Clearwater, Florida-based company has more than 27 years experience in engineering and construction. Haag, who holds an advanced degree in engineering, has been involved in designing, planning, manufacturing, supervising, and constructing several major projects in Europe, particularly in Germany, including a Volkswagen factory, a Hitachi chip fabrication plant, a Mercedes automobile assembly plant, a BMW paint plant, a launch test frame for European Rocket Ariane 4, and MUC II, Munich's newest airport.

In addition to his engineering and construction successes, Haag's management skills are evidenced by his purchase and subsequent turnaround of Krupp's Steel Manufacturing Division in Stuttgart, Germany, growing the company by nearly 200%.

Established in 1994, Robotic Parking is the designer, manufacturer, and operator of a complete line of automated, modular parking systems that can accommodate from 10 to more than 5,000 cars, wherever garage space is limited. With more than 60 years cumulative automation experience, the company has pioneered the field of automated parking to the point where it can serve a variety of markets that are dependent upon parking requirements that can't be easily satisfied with a conventional garage, such as condominium or apartment complexes, recreational facilities, hotels, or small office building development projects.

Robotic Parking's expanded product line comprises four different models—RPS 1000, RPS 100, RPS 20W, and RPS 20L—to accommodate various parking needs, particularly building size and location and projected uses. The RPS 1000 line, for example, can accommodate from 200 to more than 5,000 cars and can be built on lot sizes as small as 60 feet square. The other three model series, beginning with the RPS 100 line, can accommodate as many as 200 vehicles and as few as 10, and all have the option to add more parking modules to expand capacity.

All models have flexible, modular designs that are well-suited for independent applications, above ground or underground, or can be adapted to an already existing structure, such as inside, underneath, or on top of a building. The facades are flexible, too, and can be designed to blend in with neighboring buildings with a look that is contemporary, historic, or traditional. Materials used in the facade are versatile as well, including concrete, wood, brick, stone, aluminum, or other composite building materials.

Both the RPS 1000 and 100 models provide high levels of redundancy—

backup systems for all major components and early warning signals to help ensure uninterrupted operation and minimize any downtime. According to Robotic Parking, no single failure will ever result in its system being inoperable, due to a patent pending "Human Machine Interface," a sophisticated system of advance diagnostics.

Underground applications of Robotic Parking's automated parking systems also provide further financial incentive. Because only half the space is needed, an owner can realize as much as 50% cost-savings on the excavation alone. Also, due to lower lighting and ventilation requirements, lower insurance costs, lower personnel expenses, and savings in land purchase, the overall development costs can be significantly lower than for a conventional garage.

December 2002

Construction of UPS Worldport Facility Raises Bar on Project Cooperation

By Steven J. Storts
Dublin, Ohio

WITH a looming presence that can only be described as mammoth when seen from the air or on the ground, the new UPS Worldport air express delivery hub in Louisville, Kentucky, takes technological advancement, project management, and business creativity to new horizons.

Not to be understated, the 4 million-square-foot, $1.1 billion expansion project at the Louisville International Airport, completed last September, is considered the most advanced sorting facility in the world, serving as the nerve center of UPS's international air operations. Spanning more than 80 football fields, Worldport is the largest capital project in the company's 96-year history. The addition more than doubles the size of its former domestic air express hub and sorting complex.

Although actual construction of the all-points air facility began in 1999, its planning was initiated in 1995. The project's monumental scale required more than 200 contractors, 21 different trade groups, and an unprecedented project labor agreement with the Greater Louisville Building and Construction Trades Council to eliminate the potential for untimely contract expirations during construction.

Moreover, to help ensure a safe workplace, UPS forged a partnering agreement with GLBCTC and the Kentucky Occupational Safety and Health Program to provide on-site safety training and education in an effort to avert injuries or fatalities during the 4.5 million construction hours at Worldport.

UPS officials tout their billion dollars' worth of lessons learned in the design and construction of Worldport as something applicable to planners and executives from any industry. The proof is a finished product that translates to more than 75 million pounds of steel, 122 miles of conveyers, and nearly 4,500 miles of fiber optic cable.

Undoubtedly, the technological advancements leading to Worldport's expanded capacity, cutting-edge package and document handling, greater reliability, and faster transit times for customers are partially responsible for UPS recently receiving the inaugural American Business Award for "Most Innovative Company." The Atlanta-based enterprise, which serves more than 200 countries and territories worldwide, was selected from 18 finalists for its outstanding leadership, innovation, perseverance, creativity, teamwork, and integrity.

"Worldport exemplifies the amazing technological capabilities of UPS, which enable us to move our customers' critical business information around the world as precisely as we move their goods," says Jack Blaisdell, Worldport program manager, who oversaw the design and construction of the expanded facility that will eventually create up to 6,000 new full- and part-time jobs. UPS currently employs more than 15,000 people in Louisville.

Constructed with engineering ergonomics in mind to reduce the physical demands of the package-sorting jobs, the automation technology of Worldport increases the package sorting capacity to 304,000 packages per hour—more than 84 packages every second. Still, UPS admits that it's capable of expanding the system to process up to 500,000 packages per hour or 140 packages every second.

Customers' express shipments speed through 122 miles of conveyors—enough to stretch from Louisville to Cincinnati—in as little as eight minutes. A sophisticated system of cameras read detailed information encoded in UPS "smart labels," triggering a network of computer-activated sorting and tracking devices that process some 59 million database transactions every hour. The system not only provides split-second visibility of packages, but it also reduces manual package handling from six times to only two.

The smart labels are considered key to Worldport's automation system. Most UPS customers already have the ability to produce the machine-readable labels using special software provided by UPS.

Last year, the company also announced its agreement to participate in the U.S. Customs Service's Trade Partnership Against Terrorism initiative. C-TPAT is a joint government-business initiative aimed at strengthening overall supply chain and border security. Through the program, Customs officials can offer the highest level of security through close cooperation with the direct owners of the supply chain—importers, carriers, brokers, warehouse operators, and manufacturers.

Worldport has already provided Customs officials with updated computer software to track and stop potentially dangerous or illegal imports. Inspectors can use the new software and other automated tools to filter through shipping manifests using any search query they choose, including the name of the shipper or recipient, the description of the goods, their weight, or declared value.

As a result of this innovative technology, UPS has saved nearly $70 million by eliminating the need for a separate customs facility. The entire Worldport hub now qualifies as a "controlled building," according to regulations issued by the Federal Aviation Administration and Transportation Security Administration.

"We've poured every technological and practical innovation we've learned during 90 years in the logistics and distribution business into the design of this new hub, and our customers will directly benefit," notes Tom Weidemeyer, UPS Airlines president and chief operating officer. "This is certainly the largest construction project ever undertaken by our company. But it's much more than that. It's leadership."

Part of that leadership is attributed to current UPS Chairman and CEO Mike Eskew, an industrial engineer who joined the company in1972. Credited as one of the architects of UPS's technology strategy, Eskew was group vice president for engineering before becoming executive vice president in 1999 and assuming his current post in January 2002.

July 2003

Arizona Finally Moves Forward On Delayed Football Stadium Project

By Steven J. Storts
Dublin, Ohio

AFTER nearly a year-and-a-half of jurisdictional disputes and a land development lawsuit that went all the way to the state's high court, the Arizona Cardinals can look forward to having their new football stadium built.

Located in the Glendale community of Phoenix, the $355 million multipurpose stadium facility had its groundbreaking ceremony in March and is slated as the largest single construction project in the state since the Palo Verde Nuclear Generating Station. The stadium, to be owned and operated by the Arizona Tourism and Sports Authority, will generate 3,500 new construction jobs and is expected to reduce the state's budget deficit by $20 million over the next three years.

The Cardinals will contribute a minimum of $85 million toward the construction cost and have guaranteed to pay the difference between the original total cost estimate of $331 million and the most recent $355 million price tag. Most of the construction funding will come from bonds marketed by Arizona TSA and paid off with revenues generated by hotel bed taxes and rental car surcharges in Maricopa County.

As unveiled by world renown architect Peter Eisenman, the future landmark takes its basic form from a barrel cactus, resulting in dramatic vertical slots that are in contrast to the smooth outside panels. Even under a closed-roof condition, the roof fabric will still allow light inside.

Built on a 160-acre site, which also provides parking for general seating, premium seating, buses, team personnel, and operations and maintenance, the multipurpose stadium will have a seating capacity of more than 63,000 and include 88 luxury suites. The operable (retractable), natural grass playing field, the first to be used in the U.S., provides for the optimum football playing surface, while serving as a multipurpose venue for other public events.

The field will support more than 94,000 square feet of natural grass and will weigh more that 7,500 tons. The flexibility benefits of the operable field are twofold, allowing the grass quality time outdoors to receive maximum sun for proper growth and maintenance, while providing a concrete floor base within the facility for multipurpose events.

The roof will have two, large, retractable panels that will completely expose the entire playing field, while providing maximum sun-shading for fans. During the hot months, the roof will be closed, with the entire facility air conditioned, In cooler months, the roof will remain open, taking advantage of the Arizona sunshine.

Arizona voters approved a new stadium law (Proposition 302) in November 2000. It enacted a 30-year hotel bed tax and rental car surcharge to pay for stadium construction, in addition to providing for Arizona tourism promotion activities, improvements to Arizona's Cactus League baseball facilities, and construction of youth sports facilities in the Phoenix metro area.

As reported in the *Arizona Republic*, local developer John Long asserted that the law was an unconstitutional "special law" because it applied only to Maricopa County, and that provisions allowing the sports authority to pledge its tax revenues to pay off stadium-construction bonds violated Arizona's constitutional restrictions on public debt. After the state's attorney general rejected his legal claims, Long filed a lawsuit in September 2001. Those same claims eventually were dismissed by a Maricopa County Superior Court judge, but Long took his arguments to the Arizona Court of Appeals.

The appellate court, in a ruling issued last August, rejected most of the developer's claims but agreed that certain income taxes dedicated to the project violated the state constitution, according to the *Republic*. Rather than invalidate the entire law, the court severed the unlawful portion from the rest and ruled the bulk of the law as constitutional.

Long took his case to the Arizona Supreme Court when the appellate panel declined to reconsider its action at his request. Long's final setback occurred in early December when the high court determined that it would not take the lawsuit under further review, allowing Arizona TSA to move forward on all fronts of the stadium project.

Although the court decision clears the way for construction, it remains unclear whether the successive project delays can be overcome to complete the facility by the start of the fall 2005 National Football League season as originally planned.

June 2003

Historic Preservation Offers Inviting Challenges for Construction Industry

By Steven J. Storts
Dublin, Ohio

IS HISTORIC preservation becoming a lost art for the construction industry? Not according to Forest City Enterprises Inc. The Cleveland, Ohio-based development company thrives on transforming functionally obsolete urban areas into vibrant housing and mixed-use properties.

The restoration and adaptive reuse of historic buildings are both a passion driven by a sense of community identity and a significant economic development opportunity for cities, says Ronald Ratner, president and chief executive officer of Forest City's Residential Group.

"We have a real passion for this kind of work," Ratner notes. "As a developer, I am sometimes asked if we would ever be willing to sacrifice profitability to achieve excellence in historic preservation. My answer is, that's a false choice. Using technical and financial creativity and working in public-private partnerships, we can have it all, including economic return."

The Forest City executive's observations are based on a portfolio of experience that includes interests in retail centers, apartment communities, office buildings, and hotels. His company has pursued the adaptive reuse and historic preservation of urban landmarks in Washington, D.C., and cities such as Boston, Cleveland, Denver, Los Angeles, New York City, Philadelphia, Providence, and Richmond.

Drawing parallels to the environmental movement, Ratner urges engineering planners, construction companies, developers, project owners, policy makers, and other historic preservation stakeholders to think in terms of "sustainable development." He emphasizes, "We need to think more about adaptive reuse opportunities. That's how we can balance historic preservation and economic reality."

Ratner, a keynote speaker at a national preservation conference last fall, addressed four issues or challenges in historic preservation: the broad context of urban fabric, public-private partnerships, understanding economic realities, and the future.

"We cannot focus on a single building," he explains. "There is a much broader context of neighborhood, district, city, and region. No matter how skillfully done, a building must be part of a vibrant urban fabric if it is to maintain its value and provide a return on financial and civic investment."

Supporting his stance for reassessing historic tax credit requirements and expanding public-private partnerships, Ratner says cooperation must extend well beyond the conventional areas of economic assistance and regulatory and code cooperation to include marketing and urban planning.

"Private investment is the only way to achieve some of these things. Without it and without the commitment and leadership of the public sector, it just won't happen," he claims. "Historic rehabilitation introduces costs and complexities that are not associated with new construction. Bringing old buildings into compliance with new needs, codes, and demands is very complex and expensive."

Ratner says a 20% federal historic tax credit can bring some economic relief, but in most cases, it barely offsets the premium costs of doing historic rehabilitation. Economic challenges must be addressed through a combination of financial creativity and physical or technical creativity, he adds, noting that state historic tax credits, where available, can be very helpful as an additional layer of benefit beyond federal credits.

To illustrate his major themes, Ratner cites the many challenges that Forest City had to overcome—fire and safety code problems, narrow corridors, nonworking elevators, and existing tenants—in renovating the former Drake Hotel in Philadelphia to create 280 prestigious apartment units.

In New York City's Times Square, Forest City completed a technical marvel by using rollers to move the landmark Empire Theater—all 37,000 tons of it—168 feet down the street to accommodate the lobby of the new AMC Theaters and open up space for additional commercial development in the area.

Highlighting Cleveland's Tower City Center mixed-use project, Ratner says the redevelopment of the former downtown train station was completed, despite not receiving National Park Service approval for historic tax credits.

"This was a wonderful project that in and of itself was a tremendous adaptive reuse/historic preservation success story," he reflects. "I will accept that under the [current] rules, the National Park Service's decision (to not grant tax credits) was correct, although it was purely academic . . . . [However,] if the decision was correct within the rules and guidelines that currently exist, then we need to rethink the rules."

Looking toward the future, Ratner says the time has come for a comprehensive reassessment of the laws and

regulations governing the federal historic tax credit program. In particular, he contends that the onerous, resource-intensive requirements in applying for tax credits are detrimental to small projects.

"After years of experience, we have learned a lot—as developers, as public officials, as citizens," he points out. "We need greater flexibility in the law. I do not believe that the current standards or process that are in place to review and approve projects for historic tax credits allow for a creative balance of historic needs and economic realities."

March 2003

Engineers Release Preliminary Findings On Trade Center's Structural Collapse

By Steven J. Storts
Dublin, Ohio

A TEAM of 25 leading structural and fire protection engineers report that the World Trade Center's towers could have remained standing indefinitely following the terrorist attacks if fire had not overwhelmed the weakened structures.

According to a study conducted by the Federal Emergency Management Agency and the American Society of Civil Engineers, this finding is significant. W. Gene Corley, head of the ASCE/FEMA Building Performance Study Team, explains that because extreme events such as the ones on September 11 are generally not considered in building design, the fact that WTC structures were able to successfully withstand such damage is noteworthy.

Among the significant findings from the *World Trade Center Building Performance Study: Data Collection, Preliminary Observations, and Recommendations*, the study team noted that much of the jet fuel on board the hijacked planes that plowed into the towers burned off in fireballs outside the buildings. Instead of causing the fires to burn at extremely high temperatures, as was widely speculated, the role of the jet fuel was to ignite other combustible materials over several floors simultaneously. Those fires eventually weakened the structural steel, leading to the collapse of the twin towers.

WTC Building 7 was the focus of another finding by the study team. The building, which sustained no significant structural damage and collapsed on September 11 after burning uncontrolled for seven hours, was the first protected steel structure ever known to collapse solely due to fire.

The team also found that some connections between the structural steel beams failed in the fires. This was most apparent in WTC Building 5, where the fireproofing didn't protect the connections, leading to a partial collapse. Engineers point out that the design and construction of this structure is typical of many steel-framed high-rises and cite the building's collapse as the first major one caused by failure of connections due to fire damage.

The ASCE Structural Engineering Institute, which began putting together building performance assessment teams within hours of the terrorist attacks on the WTC complex and the Pentagon, says these investigations have frequently served as the basis for evolutionary development of the nation's building codes. In fact, as a direct result of congressional interest in the ASCE/FEMA study, particularly from the House Science Committee, lawmakers have taken the first step in establishing building performance study protocol.

The National Construction Safety Team Act of 2002, recently introduced in the House (H.R. 4687) and Senate (S. 2496), would require the National Institute of Standards and Technology (NIST) to dispatch professional experts to a disaster site within 48 hours. The investigative team would have similar authorities to the National Transportation Safety Board, including early access to the disaster site, subpoena power to retrieve key information, and guaranteed funds up to $25 million annually over a three-year period.

Based on observations of how the twin towers and the surrounding buildings performed in the aftermath of the attack, Corley says his study team recommends that the following be considered in the design and construction of buildings deemed potential targets of terrorist attack:

- Buildings should be designed with sturdy, backup structural supports to bear the weight held by the primary supports when damage to the building occurs;
- Fireproofing needs to adhere under impact and fire-induced steel deformation, so that the protective coatings remain on the steel and provide the intended protection;
- The connecting structural elements (nuts, rivets, and plates) need to be analyzed to better understand how they fare under sudden impact and fire;
- When sprinkler systems are a critical part of a building's fire protection system, the water supply should be reliable and abundant;
- Stairwells, including transfer floors and stair spacing and locations, should be evaluated for multiple alternate routes of escapes and strength in order to provide safe and clear evacuation routes when the building is damaged; and
- Fire protection ratings and safety factors for structural transfer systems should be evaluated for their adequacy relative to the role of transfer systems in building stability.

Corley points out that while the ASCE/FEMA study team does not call for immediate changes to existing building codes, it does strongly urge the continuing study into building collapses, which could eventually

lead to code revisions. Already, NIST researchers are expected to spearhead the next round of studies into how the WTC buildings performed. Their findings are scheduled for release within two years.

July 2002

High-Tech Engineering Tools Find Their Way to the Construction Site

By Steven J. Storts
Dublin, Ohio

THE once-familiar car advertising slogan, "This is not your father's Oldsmobile!" could well describe what is waiting around the corner for the construction industry. High-speed computer communications, laser technologies, and electronically generated graphics are beginning to evolve into tools that can effectively reduce project delivery time and offer a significant competitive edge to engineers, contractors, and owners.

More than 5% of the labor costs in a typical construction project are spent on activity monitoring. For example, workers monitor the state of excavation, the presence of raw materials, the status of change orders, and the reporting of "as-built" information about the project. Researchers at the National Institute of Standards and Technology are developing measurement and automation tools that can reduce this time-consuming and costly burden.

Conducted primarily by the NIST Construction Metrology and Automation Group, the current automation research is focused on using information technologies to make construction activities more productive and qualitative in their evaluation. Much of the group's R&D mission targets real-time spatial metrology in unstructured applications such as construction sites and includes development of position/orientation tracking systems, sensor interface protocols for construction data telemetry, and construction site simulation.

Fundamental to the group's approach is what it calls "closing the information loop," which involves gathering relevant information (construction plans, site measurements, and schedule changes), maintaining coherent models of what has been built versus the original design, and providing expedient information to the people and machines doing the actual building.

An example of this might be a "smart hardhat" that could display to a worker—with an overlay on the field of view—the desired location for a girder and to signal (perhaps with a color change) when the girder was correctly placed.

The group emphasizes, however, that any approach toward achieving its R&D objectives hinges on improving and automating construction-site metrology, particularly real-time measurement, which is the foundation for feedback and automation. Current metrology research includes the development of a real-time, non-line-of-sight surveying system that can "see through wall" and the use of global positioning system satellite signals for precise, relative position measurements in open environments.

NIST's most successful research to date has been the development of standard methods for tracking the movement of manufactured parts at the construction site. The new tracking program encompasses three-dimensional laser metrology, wireless communications, interactive Web browsers, and a remote time-based project database to provide quick access to materials and parts activity at both the job site and remote offices.

The impending impact of this development is evident to structural research engineer Geraldine Cheok, who notes, "Construction managers will eventually be able to use this technology to determine the current status of their projects and automatically maintain accurate as-built documents."

Cheok cites construction excavation as another area of focus for NIST engineers and scientists. Researchers are currently developing methods and procedures that would enable the use of a laser scanner—a LIDAR (light detection and ranging)—to determine the status of excavation activities. Briefly explained, the LIDAR first scans the project site. The resulting set of 3-D points is then used to generate visualization models for use by off-site contractors, engineers, and designers.

"The idea is to be able to calculate any volume changes in excavation material between any two dates," says Cheok. However, she notes that some issues still have to be addressed, including the ability to:

- Easily define the area of interest and determine a suitable scan location;
- Identify and remove objects such as equipment or landscaping from the scene with little user intervention;
- Register the scans with little user intervention; and
- Include uncertainties associated with the laser scanner itself and any derived values such as volume calculations.

"NIST's eventual goal is to use LIDAR technology to obtain cut-and-fill requirements in both a precise and timely manner, in addition to reporting the quantities and rates of material placed or removed at the project site," Cheok points out.

Other institute projects include the development of test prototypes for evaluating construction automation

techniques, standards, and software; representation standards for construction machinery and components; and standards for wireless data telemetry.

Cheok reports that NIST's advanced construction initiatives have drawn industry interest, resulting in several planned collaborative research projects with U.S. construction companies.

January 2002

Rebuilding of Tall, Futuristic Structures Draws Mixed Reviews Among Experts

By Steven J. Storts
Dublin, Ohio

FORMER U.S. Sen. Daniel Moynihan (D-N.Y.) has noted that the best defense against attacks on America's free society is to "concentrate, not scatter," and move ahead with thoughtful rebuilding and reinvigoration of urban areas.

A widely recognized urban design expert, Moynihan was recently presented the Urban Land Institute's (ULI) J. C. Nichols Prize for Visionary Urban Development during the institute's annual fall meeting in Boston. The retired senator was honored for his lifelong dedication to excellence in urban design, public building architecture, and community revitalization issues.

"This is a moment not to be intimidated. The only way they [terrorists] can win is if we change the way we live, and a lot of us live in cities," Moynihan told his audience. "What we did once [in reviving lower Manhattan], we can do again, and this time, we can do it even better. These acts won't change our civilization."

Still, planners and developers are questioning the future and need for tall buildings. Is the skyscraper obsolete in America? ULI researchers point out that the demand for taller office structures of 100-plus floors could lessen; 50-story buildings offering a mixture of uses could see a rise in popularity.

While opinions vary on the future allure of working in downtown sites, most participants at the institute's annual meeting generally agreed that "mega towers" are past their prime and will be increasingly passed over by businesses seeking buildings that have fewer floors and serve more than one function.

ULI reports that a trend toward less tall towers, which had begun long before the terrorist attacks on the 110-story towers of the World Trade Center, is due both to market conditions that have made such buildings hard to fully lease and to technology allowing people to work from a variety of locations and telecommute.

"The high density and mass urbanization resulting from skyscrapers are not necessary or desirable," says Frank Feather, president of Global Marketing Consultants in Aurora, Ontario. According to the marketing analyst, the ability to telecommute via the Internet has created a situation in which the majority of people who work in downtown office space "do not actually have to be there." As a result, he notes that the events of September 11 have escalated changes in working patterns—such as telecommuting—that were already taking place.

"Uses of existing buildings will change," Feather predicts. "We will see more 24-hour, multiuse projects offering employees amenities such as full-service business centers and medical facilities, and which provide space that is communal, flexible, and easily adaptable." Also, more working space is likely to be provided in horizontal, campus-like settings near the edge of cities, which are likely to be perceived as safer locations than downtown areas, he contends.

While attending ULI's annual meeting, Eugene Kohn, president of Kohn, Pedersen and Fox Associates, P.C., of New York City, noted that when the economy slows pace, building design historically becomes more conservative and simpler. Given the current economic instability and uncertainty, a tendency toward structures of more moderate height is understandable, he observed.

However, Kohn added, "The high-rise is not dead. Everyone is re-examining tall buildings, but I do believe in them. They are key to providing density and allow people to commute by foot, not by car. They are important for cities."

According to Kohn, the building codes in the U.S. are among the most lenient for tall building construction; Asia, by comparison, has among the most stringent codes. For instance, Kohn cited skyscrapers constructed in Shanghai that would likely withstand the impact, fire, and heat of a jetliner explosion. In addition, he explained that building design in Asia includes fireproof elevators dedicated for firefighters, more exit stairwells, and fire-resistant "refuge levels" on every 15 floors.

In areas with scarce land, "we need tall buildings, and we need them to be safe," Kohn said, noting that if the space in the World Trade Center towers had been spread over 10-floor and 20-floor structures, they would have covered 30 acres. However, he pointed out that tall buildings do "fare much better" in the event of car and truck bombs, and while there is no market in the U.S. for "super tall" buildings, Kohn reaffirmed that 70-story structures are still "quite doable."

December 2001

Bengals Stadium Project Scores High In Construction Project Safety

By Steven J. Storts
Dublin, Ohio

THE Cincinnati Bengals may not often post a winning season in the NFL, but their new football stadium certainly ranks high when it comes to construction project safety.

The Occupational Safety and Health Administration recently noted that the number of job site injuries and illnesses incurred during construction of the Bengals' Paul Brown Stadium is significantly lower than the national median average for such projects. Area workplace safety consultants are crediting a voluntary program for the low incidence rate.

Through a cooperative partnership with contractors and the Hamilton County government, OSHA's Cincinnati area office developed a voluntary initiative to enhance overall construction job site safety of the stadium project. The partnership, known as the Mobilized Alliance for Safety, Teamwork, Education, and Results (MASTER), was designed to increase employee involvement, joint labor and management job site safety oversight, teamwork, and education of workers at construction sites.

Paul Brown Stadium, heralded as the first visible sign of Cincinnati's plan to dramatically refashion its river front, employed as many as 1,000 workers daily during construction up until last June when the Bengals' coaches and staff moved into their new 65,600-seat stadium. In just under two years, the 40-acre site (including parking and pedestrian access areas) along the western bank of the Ohio River was transformed into the Bengals' third home since the team's inception in 1968.

The stadium project achieved some other unique benchmarks: the design phase alone required more than 1,700 architectural and engineering drawings, which, if pasted together would cover almost a half acre; more than 11,000 tons of steel bars were used to reinforce the cast-in-place concrete, which, if placed end to end, would total 1,560 miles; about 95,000 cubic yards of concrete were placed and more than 9,100 tons of structural steel were erected; and nearly 330 miles of electrical wire were installed through and around 1,438,000 square feet of drywall.

While the construction benchmarks of Paul Brown Stadium are noteworthy, the ensuing safety record is equally impressive. The lost workday injury and illness rate for the project is 0.95 as compared to the national rate of 4.0 for the construction industry. The national rate is based on the U.S. Department of Labor's Bureau of Labor Statistics survey for 1998, which is the most recent data.

Hamilton County indicates that more than $4 million has been saved through reduced workers' compensation and general liability costs due to the project's low injury and illness rate.

The MASTER program, which emphasizes the utilization of fall protection, was implemented at the start of the stadium project and remained in place until completion. A labor and management safety team provided continuous oversight and monitoring of job site safety performance.

The MASTER initiative at the Paul Brown Stadium is unique because it includes county government stakeholders in addition to construction firm partners Turner/Barton, Malow/DAG Joint Venture, and contractor and employee representatives.

The agency's voluntary construction safety program is being tested at other construction sites in the Cincinnati area, including the Cincinnati Reds' new Great American Ball Park Stadium, which is slated for completion in 2003. OSHA also plans to expand the safety program this year to include all of Ohio.

February 2001

Artificial Islands: No Ordinary Challenge in Waterway Projects

By Steven J. Storts
Dublin, Ohio

AS you drive along the engineering wonder that crosses over and under open waters where the Chesapeake Bay meets the Atlantic Ocean, you hardly even notice that the ends of the Chesapeake Bay Bridge-Tunnel are anchored on man-made islands. And yet, from a construction engineering perspective, the most challenging aspect of the project was the creation of these four artificial structures that provide a transition from the trestle roadway to the tunnel tubes.

The man-made islands—each eight acres of new land rising 30 feet above the surface of the open sea—comprise some of the more unique structural features of the 17.6 mile-long bridge-tunnel complex.

Built in water ranging from 35 to 45 feet deep, each of the four man-made islands is roughly the size of Yankee Stadium or about as large as five football fields (1,500 feet long and 230 feet wide at the top). Each contains about 1.5 million tons of sand and 300,000 tons of rock. In addition to providing a base for approach ramps to the tunnels, the islands also serve as areas for garages, emergency equipment, and tunnel ventilation buildings.

The four islands represent some of the most expensive real estate in the world. They cost about $5 million apiece to build, or $625,000 an acre. Nevertheless, even this price is considered reasonable when the complex and painstaking construction methods for adding this new geography to the earth's surface are examined more closely.

First, huge derrick barges laid a low, outer formation of rocks on the bay bottom. These formed the first outside dimensions of each island. A hydraulic dredge then pumped down sand to fill the hollow island core. This process was repeated time after time—an outer shell of rock filled with an inner core of sand—until the island base, now the shape of a pyramid with its top leveled off, heightened to about 17 feet below bay surface. A mixture of sand and water was then pumped into the undersea island until it surfaced.

Thirty-four thousand carloads of heavy boulders—some weighing as much as 32 tons—hold the islands securely in place. Beginning on the bay bottom, these boulders were placed with precision to form the islands' tough outer shells. Still, more multiton boulders form a protective armor around the islands. Moreover, each island has a 12-foot-high concrete "splash wall," designed to resist the forces of hurricanes with 105-miles-per-hour velocity.

In addition to the man-made islands, construction of the bridge-tunnel complex required undertaking a project of more than 12 miles of low-level trestle, two one-mile tunnels, two bridges, almost two miles of causeway, and 5-1/2 miles of approach roads, totaling 23 miles. Although the individual components are not the longest nor largest ever built, the bridge-tunnel is unique in the number of different types of structures it includes and the way it was constructed.

December 2000

Mt. Rushmore: A Technically Skilled, Creative Release for a Restless Soul

By Steven J. Storts
Dublin, Ohio

TO gaze upon the majestic granite facade of Mt. Rushmore nestled in the Black Hills of South Dakota, one would not suspect that its sculptor, Gutzon Borglum, bore a restless youth. But this is often the case with creative genius. He once said, "American art ought to be monumental in keeping with American life, and Rushmore ought to be colossal in keeping with American achievements."

Borglum, too, was colossal. When he died suddenly in 1941 at the age of 74, he left a lasting legacy of creating more art displayed in the nation's capital than any other artist. As another sign of his artistic prominence, Borglum designed the flickering flame on the Statue of Liberty's torch. Not only a prolific and talented artist, he was also an active political figure throughout his life.

Born in 1867 to Danish immigrants on the untamed frontier near Bear Lake, Idaho, Borglum became fiercely independent and rebellious at a young age. His restless spirit found peace only when he discovered his father's artistic abilities at the age of 14. When Borglum arrived in the Black Hills in the early 1920s, he was 57 years old, but he fell in love immediately with the area, pointing out that the granite in the mountains was "exactly what he was looking for."

Wanting to prepare something that future generations forever would be able to enjoy, the carving of Mt. Rushmore became the focus of his life for 17 years until his death. In fact, he died as the final dedication of the monument was being planned. Borglum's son Lincoln, who oversaw the carving when his father was away, completed the monument upon Borglum's death.

America's shrine to democracy was carved in stone as a record and celebration of the nation's achievement, growth, and spirit. The four presidents chosen—George Washington, Thomas Jefferson, Abraham Lincoln, and Theodore Roosevelt—symbolized the birth and growing pains of a new nation, each representing a different stage of development. The mountain chosen for the monument's construction was dedicated on August 10, 1927. The groundbreaking ceremony was symbolized by a set of drill bits handed to Borglum by President Calvin Coolidge.

The original surface of the mountain was soft and cracked, and nearly half-a-million tons of rock had to be removed to reach granite solid enough to begin carving. The actual carving time of Mt. Rushmore was six-and-half years spread over a 14-year period. Work was halted when funds diminished, or when weather became too severe.

Borglum developed the engineering techniques for mountain carving while working on the Confederate Memorial at Stone Mountain, Georgia. On both carvings, measurements of models were multiplied by a factor of 12 and transferred to the mountain via a boom and plumb line. Nine models were made before a grouping was found that would not be affected by the granite's deep cracks. For example, Borglum originally specified Jefferson's head to be on the left side of Washington's (looking toward the monument) instead of his right. Also, Washington's nose had to be modified slightly, carved a little longer than earlier planned. And Roosevelt is tucked away in the corner of the monument because of the solid granite located there.

Still considered by many as an unsurpassed feat of technical skill, nearly 90 percent of Mt. Rushmore was carved using dynamite. During construction, most of the workers hung over the side of the mountain face in a type of chair with a swing-seat and harness, using their drills, air-hammers, and chisels. They were raised and lowered from the top of the mountain by cables attached to a winch. As workers neared completion, the surface of the rock was honeycombed with holes that weakened the surface rock, making it easier to knock off large sections of rock to do the final shaping of the monument faces with hand chisels. Air-hammers and grinders later helped to make the final surface smooth like a sidewalk.

According to original specifications, Mt. Rushmore was to display full-bust figures of the four presidents, but when Borglum died unexpectedly and Lincoln took over the project, it was decided that future blasting should be halted to avoid any damage to what already had been carved. Therefore, shortly after Borglum's death in 1941, the monument was officially dedicated. And in what perhaps could be regarded as a final tribute to Gutzon Borglum and his engineering prowess, no fatalities were incurred while constructing Mt. Rushmore, only a few minor accidents with no serious injury.

October 1997