7th Edition

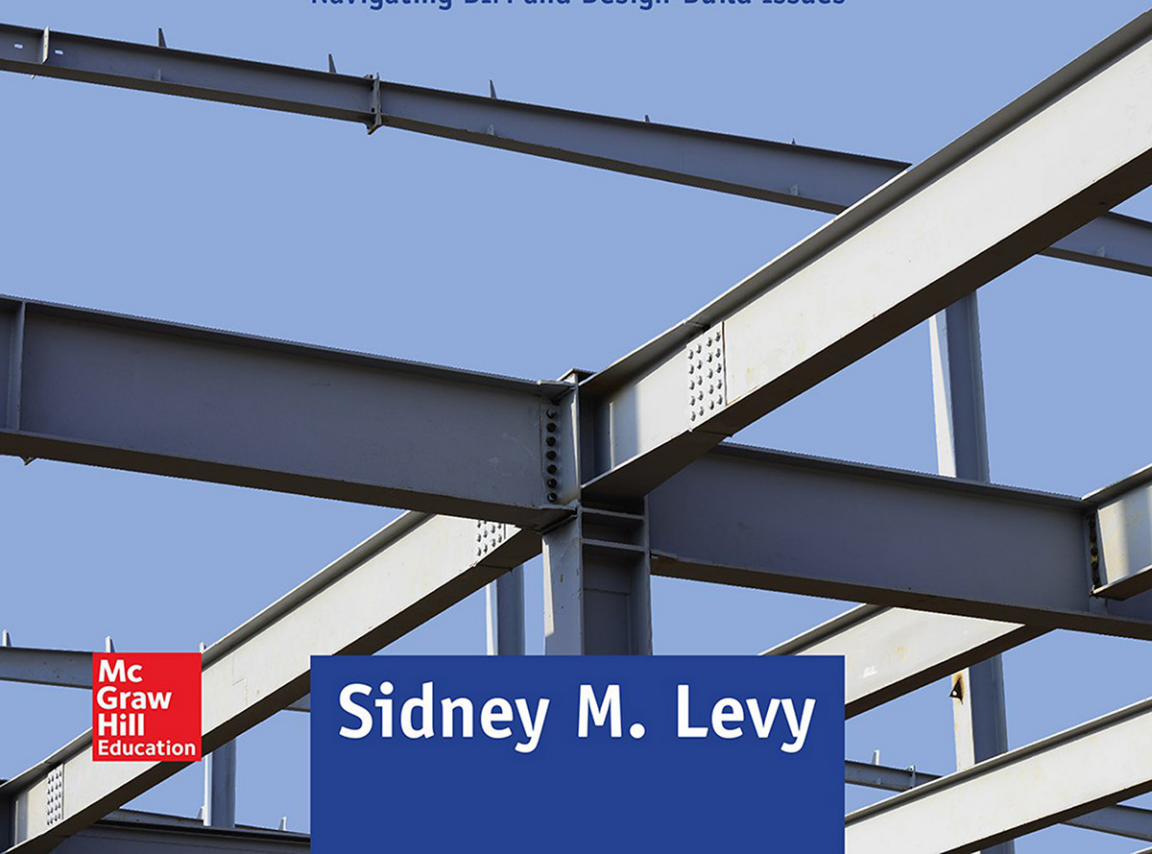
PROJECT MANAGEMENT IN CONSTRUCTION

Avoiding Pitfalls with New Collaborative Contracts

Dealing with OSHA's "Fatal Four"

Going Green in New Markets

Navigating BIM and Design-Build Issues



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Project Management in Construction

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Preface

The project manager on a construction site can be likened to the hub in a spoked wheel around which all the on-site managerial activities revolve. He or she is the focus for the project's owner, its architect, its engineer, and the construction team of subcontractors and material and equipment vendors. Government agencies, whether the local building department, the OSHA inspector, or myriad officials when working on public works projects, must also be dealt with, and dealt with effectively, by the project manager.

The journey from Point A to Point B is rarely a smooth one, often with roadblocks, detours, and sometimes sinkholes and the need to change direction quickly; this task falls to the project manager.

Along with having technical knowledge, the project manager must be adept at getting people to work together harmoniously, have some knowledge of the legal world, and be an accountant at times and father confessor on other occasions. But all of these efforts and challenges seem to be worth it as we see the structure rising from the ground, advancing toward project completion, and finally turned over to an expectant owner. Then we move on to another project, but when passing that old job, we say to ourselves, "I built that."

In the end, project management is an exercise in control—control over quality, schedule, costs. Each one, by itself, is a full-time job, yet all fall under the responsibility of the project manager.

Project Management in Construction, Seventh Edition, examines many of the basic tenets involved in managing a construction project, dealing with the forces that will most likely be met and suggesting ways to overcome these forces and move on.

I have been associated with the construction industry for more than 40 years and have seen the many facets of that business, from working summers in high school and college as a laborer and a time clerk to full-time employment starting as assistant superintendent and graduating to project manager, and finally to executive vice-president of a major New England general contractor. Upon retirement I became a construction consultant

engaged with many project owners as well as general contractors and subcontractors. Through this work, I gained the perspective of each one of the participants, which has helped me to help them resolve the concerns and disagreements that usually arise in the complex process of the design and construction of a building or structure.

I pass this knowledge on to you, the reader, and quote an anonymous old-timer's sage advice: "Smart men learn from experience; wise men learn from the experience of others." I hope *Project Management in Construction,* Seventh Edition, will provide you with some of those worthwhile experiences.

Sidney M. Levy

Project Management in Construction

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Chapter

1

The Construction Industry

The construction industry, like so many basic American businesses, is being transformed to meet the demands of the twenty-first century; these demands affect and impact all of us in that industry.

Construction is a mighty economic engine; the 650,000 construction companies in the United States employ about 6 million people. In April 2016, the Federal Reserve Bank of St. Louis reported that it was projected that all construction activity in the United States would amount to approximately $1.15 trillion. Add to that the amount of money spent on furniture, fixtures, and equipment (FFE) by commercial construction, new hospitals and schools, public buildings, and residential construction and you can add another $1 trillion to that figure.

The construction industry is in the midst of the information technology (IT) era that shows no indication of slowing down.

This Information Technology Thing

An easy definition of information technology (IT) is that it consists of a set of tools, methodologies, and procedures such as data conversion, storage, dissemination, and retrieval. It is a system for analysis and design; it is devices to collect, process, and present data via various types of algorithms; it is a process that allows a computer to perform calculations, data processing, and/or automated reasoning tasks.

We now have a basket full of mobile devices for communication, transmittal of photographs, collection and storage of data, and rapid distribution to concerned parties.

With so many of us using smart phones and iPads to access the Internet, going "online" takes on a different meaning, allowing us to communicate, transfer data, and obtain data wirelessly and seamlessly.

But with advances in technology, another problem has been growing—an unsecure network requiring protection from hacking. Cybersecurity is of concern to all companies—imagine having a competitor "hack" into your bid proposal to a major client.

Use of software in the construction industry for invitations to bid, estimating, scheduling, budgeting, cost control, and building information modeling (BIM) is now an everyday affair. BIM is being widely used by the architectural and engineering design teams providing the transition from two-dimensional (2D) paper documents to 3D technology, allowing them to link up digitally.

Cloud Computing: Impacting the Way We Communicate and Transmit Data

The National Institute of Standards and Technology (NIST) defines cloud computing as "a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction."

For those of us who can't understand government jargon, cloud computing is simply a storage and data transmission service that is available anywhere, anytime, on any type of device, and in any capacity or location desired. You don't have to wait to go online with your service provider.

Taking the 3D concept further, we now have organizations such as the Bartlett School of Architecture in London developing a method of using 3D printing to create concrete structural elements. We have a prominent U.S. general contracting firm using lasers to accurately provide dimensions in buildings being renovated, rather than having to physically measure areas after their existing surfaces had been removed by demolition, thereby developing very accurate "as builts."

The "scan" created by the laser can capture the shape and appearance of the selected structure or its components and direct these dimensions through the Cloud to the BIM model.

What Do the Experts See for Construction Down the Road?

According to the World Economic Forum (WEF) at its 2016 meeting, productivity, in general, has stagnated over the past 40 years. WEF claims that the future is here but it is not widely distributed—and it hasn't trickled

down to the small, local construction companies from the large international builders.

Digital technology ranging from BIM to estimating to smart equipment technology is here and has become more mainstream in the past five years. The goal for design and construction in the coming decades, according to WEF, can be stated very simply, taking shape in three areas:

- Economics—increasing the speed and lowering the costs of the construction project
- Social Impact—how new construction impacts the local community including the new roads and expanded utilities required to service these buildings
- Environment—creating structures that are energy efficient, environmentally friendly, and utilizing sustainable materials wherever possible

The increasing use of BIM has resulted in a more rapid design-construct cycle along with a reduction in errors and omissions and conflicts created by closer coordination among the various design disciplines. All of the benefits created by BIM result in savings to the owner, architect, and contractor.

The communities where new construction is being planned are being scrutinized by local activist groups who feel they should to have some say in the process that will take place when new construction is planned for their neighborhoods. We will all see these concerns being given more attention by developers and building owners. WEF, in its paper "What's the Future of the Construction Industry?", predicted that full-scale digitization in the design-construct industry would lead to savings of 13% to 21% in the design and engineering professions and 10% to 17% in construction. Based on results experienced by owners, architects, engineers, and contractors in the past couple of years these savings appear to be real.

National Institute of Standards and Technology

NIST, along with other governmental, professional, and trade organizations, points to key challenges facing the design-construct industries and like most, sees the need to increase productivity. How to get there is another matter, but most solutions seem to involve more IT.

NIST lists the following activities with the potential for breakthrough improvements:

- Widespread use of interoperable technology applications and BIM. Interoperability of software systems, so everyone is "speaking" the same software "language." This will allow all parties to communicate more rapidly through the Cloud with unlimited memory capacity.

- Improved job-site efficiency through more effective interfacing and collaboration of people, processes, materials, equipment, and IT.
- Greater use of prefabrication, pre-assembly, modularization, and off-site fabrication and processes.
- Innovative demonstration installations to show that the schemes on paper can actually be transformed into workable, efficient products or assemblies.
- Effective performance measures to drive efficiency and support innovation.

All of these NIST observations along with others that follow seem to change that "one brick at a time" thinking to an industrial/manufacturing frame of mind.

National Institute of Building Sciences

The National Institute of Building Sciences (NIBS) foresees a steady growth in modular and off-site construction, which it categorizes into four directions:

1. Prefabricated construction (prefab) that can encompass the off-site prefabrication of building components, sub-assemblies, or volumetric units that fit perfectly into the building's on-site structural framework.
2. Modular construction: This is viewed as a method to reduce complexity while offering customized products or units. The Modular Building Institute (MBI) defines modular construction as that being performed in a factory setting producing 3D modules that will be transported to the site and assembled at the building's location.
3. Industrial building systems (IBS) is actually the term that encompasses the use of prefabrication, off-site manufacturing of components, and the "industrialization" of the construction industry, that is, applying manufacturing techniques to what was once a stick-by-stick industry. Emphasis is being placed upon improved productivity, improved quality, and improved safety.
4. Open building manufacturing (OBM) is a concept based on applying the productivity method to construction, utilizing standardized components that can be assembled to build the end product. This OBM approach to construction decouples building parts in order to determine which types are most likely to be designed and produced as a manufactured component.

Gensler, an international design, planning, and consulting group

Gensler, an international design, planning, and consulting group with offices in the United States, Latin America, the Middle East, and the Asia Pacific region, published its list of the "six mega trends" that it sees as impacting the world economy by the year 2025. These trends, if they do develop, will have a significant effect on the way we design and build.

> Trend #1: The digital world we experience today will become more of an integral part of our working and leisure lives. We will interact with this stream of digital data to improve our work life and home life.
>
> Trend #2: The world around us will become smarter. Buildings, products, and services will be more integrated, offering us more connectivity to people and places, and access to goods at an astoundingly faster pace.
>
> Trend #3: Time is money. Business and personal purchases will expect no "dead time." Construction projects, both design and build, will undoubtedly fit into this category, more so than today. Schedule commitment will become sacrosanct.
>
> Trend #4: Urban centers will be connected by human networks. Real estate in urban areas will innovate in both form and means to meet new lifestyles. Transit-served hubs will allow for new growth and incorporate what are now suburban areas.
>
> Trend #5: Neo-industrial cities will transition to centers where innovation is the key to growth. These cities will support digital and artisanal cultures, freelance innovators, and the tools and the environment to speed new products and ideas to market.
>
> Trend#6: Health and safety will take a leading role in protecting individuals or an entire city. Disasters created by nature or those man-made that urban areas often face, along with security threats, epidemics, and pandemics, will be managed by a government mind-set armed with data and the tools necessary to deal with these issues. Smart cities will be prepared to engage and deal with matters related to wellness.

Associated General Contractors of America

In its study "The Challenges Facing a Growing Industry: The 2016 Construction Hiring and Business Outlook," the Associated General Contractors of America (AGC) sees workforce shortages as one of the major concerns in the near future.

The AGC is heartened by what it sees as contractors' investments in IT as a way to increase the efficiency of their overall operations. It also sees in

the years ahead a continued growth that will come with challenges such as recruitment of qualified workers and experienced superintendents. Sixty-five percent of general contractors in the study were worried about the performance of their subcontractors and particularly the poor safety and health performance of their employees which impact the overall project. The AGC lists the following reasons for their concerns that enough qualified construction workers will join the industry's labor pool:

1. The dismantling of public vocational schools and technical education programs, and more emphasis at the high school level urging graduates to continue on to college. Community colleges continue to offer some types of "trade school" programs to augment the loss of vocational schools.

   Not mentioned in the AGC report but a hot topic in most local newspapers are the scams in these so-called for-profit technology schools offering courses in welding, auto mechanics, plumbing, and the like. And after charging excessive fees, they often fail to place graduates in a job, and these new "graduates" leave the program with no employment prospects in sight, but owing the "school" thousands of dollars. The government has recently seen the need to look into these problems and besides cutting off government monetary support, has taken to warning prospective students to be very careful before deciding to enroll in some "for-profit" universities and assume the burden of paying off their student loans.
2. The decline in union membership has resulted in the decline of new members being enrolled in their apprenticeship programs, further contributing to the shortage of skilled workers. Besides providing the book learning with on-the-job training with experienced tradesman, some unions have gone further. The International Union of Bricklayers & Allied Craftworkers and its component the International Masonry Institute (IMI) have teamed up with 50 architecture and engineering colleges and universities to include the basics of masonry and concrete design and construction in their curriculum.
3. Immigration has become a political football, and restrictions on the numbers and types of persons allowed permission to enter the United States has been limited, even though there are shortages of highly skilled and educated people in many fields.

One of the ways in which builders were looking to compensate for these shortages of skilled and unskilled labor is to find a way to reduce the amount of on-site labor needed, and that leads to increased interest in constructing modular components off-site that could just be set in place

when arriving at the project by trailer. Another similar approach is to look for ways to prefabricate portions of the structure instead of assembling them piece-by-piece on-site.

The Off-Site Movement: Modular and Prefab

The Off-Site Construction Council (OSCC) in 2015 conducted a survey to find out what type of off-site prefabrication was most utilized by the 22 participants in that survey. The survey not only identified the components but also the effectiveness of the software that permitted this off-site work to be fitted into the on-site structure. Prefabbed HVAC, plumbing, and electrical risers and assemblies were employed by 66.67% of the respondents, not too surprising because these components lend themselves to being fabricated either on-site or off-site and installed as a pre-assembled module. Structural steel assemblies were installed 61.9% of the time, also not too surprisingly because the American Institute of Steel Construction (AISC) back in 2004 initiated its CIM Steel Integration Standards Version 2 (CIS/2), a design software system that was compatible with several BIM software developers.

Precast concrete structures were purchased by 61.9% of those surveyed, curtain wall assemblies by 47.6%, prefabricated exterior wall assemblies by 38.1%, and service pods (bathrooms, utility rooms, etc.) by 33.3%.

NIBS and the OSCC found that 93 percent of the architects, engineers, contractors, and owners they contacted had implemented some form of off-site construction process in the years leading up to 2015. Not much attention had been focused on these practices in the past, but the necessity to increase overall productivity, the need to speed up the completion schedule and increase in profits using some form of product made off-site, and that nagging concern about labor shortages made contractors start to check things out.

Let's look at one of these off-site-oriented projects

The new Exempla Saint Joseph Hospital in Denver, Colorado, completed in 2014, utilizing prefabricated components, gives us a look into the future. This 840,000-square-foot hospital, eight stories high with 350 patient rooms, 24 operating rooms, laboratories, and office space, showed significant savings in costs and scheduling, along with increased productivity and safety, by applying many of the off-site practices.

The total construction budget for the project was $360 million. All bathrooms, some 440, were prefabricated off-site and included the installation of all finishes, towel bars, mirrors, toilet-paper holders, and fixtures.

Shipped to the site, these modules were set in place in depressed floor slabs where all utility rough-in connections had been installed, making final connection rather simple.

According to the general contractor, this procedure alone resulted in a schedule reduction of 52 work days, indirect cost savings of $3.1 million, and resulted in only four safety incidents. The upper four floors of the structure used prefabricated exterior wall panels that came complete with framing, brick ledge, sheathing, air barrier, brick ties, and spray-foam insulation. The general contractor reported a schedule reduction of 41 work days, indirect costs savings of $42.4 million, a reduction of 5,000 worker hours, and only two reported safety incidents occurred by the use of these prefabbed components.

The general contractor (GC), in collaboration with the design team, made extensive use of BIM to work through the prefabrication and modular unit process with site-interfacing and placement schedules. Although these savings in costs, manpower, time, and profits on this project may be the exception rather than the rule, the application of off-site fabrication certainly points to a movement that will continue to grow.

Another new technology that is just coming into its own and has unlimited potential is the use of 3D printing.

3D Printing and the Construction Industry

Another technology that promises to impact the way we do business is the 3D printer that can now "print out" concrete footings and walls leaving cavities for plumbing and electrical risers. The earliest 3D printers were built in the late 1980s, first patented by Dr. Kodama from the Nagoya Municipal Research Institute in Japan. He built a solid, printed object using photopolymers that built up this 3D product in layers. Charles Hull invented the first stereolithography apparatus (SLA)—a 3D printer. They key to stereolithography is the material, which is an acrylic-based polymer.

When hit with a UV laser beam this polymer will "grow" into a solid piece of hard plastic molded into the shape of the desired 3D object.

Other printer improvements have since been made, and other patents issued. Today we have one printer capable of using a special concrete mixture, thicker than conventional ready mix, that allows it to build a self-supporting foundation wall as additional layers are added. A Chinese company, Winsun, is using this technology to build single-family houses. Working with 3D BIM, and as the technology and operational skills improve, the limits of 3D printing have not been established.

The Green Building Movement

The U.S. Green Building Council (USGBC) reported, as of January 2016, more than 74,500 commercial projects in the United States constructed using the Leadership in Energy and Environmental Design (LEED) certification. The LEED rating system evaluates the environmental performance of a building and assigns points for achieving various levels of that performance, ranging from Certified (40–49 points) to Silver (50–59 points) to Gold (60–79 points), to the highest level, Platinum (80–110 points). Different LEED ratings have been assigned by USGBC to new construction and major renovations, to commercial interiors, to schools, retail space, health care, and neighborhood development, the latter a program now in its pilot stage.

The federal government has wholeheartedly embraced the green building movement. In 2010, the General Services Administration (GSA) moved to require all new federal buildings and major renovations to meet USGBC Gold standards. Starting in 2011, the U.S. Treasury Building in Washington, D.C., believed to be the oldest building in the world to receive LEED Gold Certification, has been estimated to have saved the government about $3.5 million per year in energy and lease cost savings.

Sustainable Structures

The need to conserve materials in a world where urban areas will continue to expand and areas devoted to the production of food and raw materials may be limited places more emphasis on reduction of waste and increased use of materials that can be replenished without endangering the environment.

Sustainable design and construction rely on the ability to design and build a structure that is not only environmentally responsible but also resource efficient throughout the life cycle of the building. Sustainable building incorporates not only concern about return-on-investment but also the costs over the entire life cycle of the building, from selection of materials to cost to dispose of materials once the structure exceeds its life cycle.

Construction in the United States contributes significantly to the disposal of waste it creates as well as generating pollution and wastewater discharge. The U.S. Environmental Protection Agency (EPA) estimates that construction and building operations in this country result in:

- The addition of 25–40 percent to municipal waste disposal
- The generation of 50 percent of emissions of CFCs (chlorofluorocarbons), a derivative of methane, ethane, and propane
- The generation of 30 percent of CO_2 production

A sustainable building is one that takes into account not only the materials that go into a building but also the public health, not only of the occupants of the building but also the surrounding community.

What Is New in Contract Format?

A few new contract formats were issued in the period 2010 to 2016 and reflect the trend toward avoidance of adversarial relations among all parties to the construction process. These new contracts represent a new approach to the relationship between owner, architect, construction manager, general contractor, and subcontractor. The key words are "integration" and "collaboration" as well as "risk sharing" and "reward sharing."

ConsensusDOCS® is a contract format developed by a diverse group of members from the design and construct community. Their purpose was to incorporate "best practices" and yield better results with less disagreements and disputes, hence the name ConsensusDOCS.

The American Institute of Architects (AIA) Integrated Project Delivery (IPD) agreement is another document that encouraged this collaborative movement. The trend toward involving all parties, design consultants, general contractors, subcontractors, and vendors in the formation of a "team" early in the project's inception appears to be growing, and such a relationship proving valuable. Lean construction contracts, based on the production line practices developed by Toyota, invite comments and suggestions from all levels of the manufacturing process—from supervisors to line workers. This same procedure applied to the design and build community has shown positive results.

Building Information Modeling

BIM is revolutionizing the construction industry by working in 3D (design), 4D (as in virtual schedules), and 5D (quantity take-offs and estimating). This process has substantially decreased errors and omissions, shortened the time from design to construction to occupancy, and saved both time and money for all parties. Some federal government agencies have adopted BIM as their prime project delivery choice and other sectors of our economy will follow. For the project manager encountering BIM for the first time, the challenges may be formidable, but will need to be conquered since it looks like this 3D world is here to stay.

Laser scanning has also entered mainstream construction as scanning equipment has become less cost prohibitive. Being able to convert field measurements into digital form precisely creates "as built" conditions and is a proven tool accurately measuring areas to be renovated; laser scanning

joins the other new technologies vastly improving the quality of construction projects.

Life Cycle Analysis

This is another term that project managers will be hearing more frequently. Life cycle analysis (LCA) is a method used to evaluate the environmental impact of processes and products that begins during the design stage and continues through the construction cycle and onto the building's operation. LCA looks at energy usage, materials used in construction, along with the waste and pollutants generated during the life of the building. This process can stop at the analysis of the construction and building operations once the building has been completed or can be expanded to include the project's entire life cycle, generally considered to be 60 years of operation. The latter will continue to assess maintenance and replacement of key equipment.

Although LCA is a function of creating value for future design and construction, the project manager should be acquainted with the term, especially if he is involved in green building construction where owner–architect discussions may include collection of data relating to environmental efficiencies.

What Do Owners Think?

The Construction Management Association of America (CMAA) conducted an owner's survey in 2010 and updated it in 2015. It asked owners what were their major challenges and what were their "important but secondary" challenges, and lastly, what issues were not a problem. Since these are the people we deal with on an everyday basis, the results of these surveys are worthy of our consideration.

The most urgent challenges were as follows:

- The high cost of change orders, indicating that contractors need to scrutinize these costs more closely before submitting them to the owner.
- Too many change orders (which might be a reflection of the next item below).
- Poor quality of the design documents—plans and specifications.
- Inadequate budgets (not really a contractor concern unless requests for payments are slow in coming).
- Lack of innovation in the industry and new ideas. [This seems to be being addressed by new contract formats (i.e., IPD), BIM, more prefabrication and off-site assembly, etc.]

The least urgent challenges were as follows:

- Adopting lean technologies.
- Safety programs, and attention to safety in general.
- Fluctuation in prices of materials and equipment.
- Cybercrime and security of stored data.
- Meeting sustainable goals in design and construction.

The CMAA also asked its respondents what they foresee as changing the most in the construction industry over the period 2013 to 2018. Some of their answers were noteworthy.

- Increase in more preconstruction services, at added costs, involving owner, designers, and contractors to work more closely to eliminate errors, omissions, conflicts, and duplication in documents so that the potential for a "no change order" construction cycle can be accomplished
- Better control over budgets, schedules, and having contractors assume more risk in getting work done with minimal change orders
- Searching for contractors that will be more creative in design-build projects at more competitive pricing
- Using BIM on all projects regardless of the size to determine the best constructability for the project and also using BIM for life-cycle and building management purposes
- Although a majority of the owner respondents indicated they have had experience with BIM modeling, they have had much less experience with 4D (scheduling) and 5D (cost data modeling). Only 63% said they had no 4D experience and 74% indicated no 5D experience

We will experience sea changes in the way we do business in the coming years because of the impact of existing and new technologies. Relationships between owner, architects, engineers, builders, and their subcontractors will change with the recognition that working together to solve problems is certainly less stressful and more cost effective than the old adversarial relationships.

But many things will not change: the need for professionalism in our work, the ability to form a team that works together, and relationships that recognize that we can learn from each other if we listen and really try.

This is an exciting time to be in the construction business and take on the responsibilities of a project manager—I sure wish I was there with you.