MODULAR BUILDING INSTITUTE

Improving Construction Efficiency & Productivity with **Modular Construction**

Prepared by

The Modular Building Institute
944 Glenwood Station Lane, Suite 204
Charlottesville, VA 22901 USA

with Excerpts from:

"Advancing the Competitiveness and Efficiency of the U.S. Construction Industry," a report issued by the National Research Council

Recently, the National Institute of Standards and Technology (NIST) requested that the National Research Council (NRC) appoint an ad hoc committee of experts to provide advice for advancing the competitiveness and productivity of the U.S. construction industry. The committee's specific task was to conduct a workshop to identify and prioritize technologies, processes, and deployment activities that have the greatest potential to advance significantly the productivity and competitiveness of the capital facilities sector of the U.S. construction industry in the next 20 years. The committee identified five breakthroughs to improve the efficiency and productivity of the construction industry, including breakthrough number three: "Greater use of prefabrication, preassembly, modularization, and off-site fabrication techniques and processes."

The modular construction industry has made significant advances in implementing processes and materials to build and deliver more sophisticated and complex facility types. More and more customers are turning to modular for multi-story, steel framed structures, health care facilities, educational structures, and large scale military projects. Always known for its time saving advantages, modular is now being recognized for being a more resource-efficient, inherently greener process.

This report includes portions of "Advancing the Competitiveness and Efficiency of the U.S. Construction Industry," a NIST/NRC study, along with supplemental supporting information, reprinted with permission by the National Academies Press.

Overview

U.S. industries have experienced almost continuous productivity growth for the past several decades. The one anomaly has been the construction industry, for which overall productivity declined from 1995 to 2001 (Triplett and Bosworth, 2004). For industries other than construction, improved productivity could be attributed to advances in and increased usage of information technologies, increased competition due to globalization, and changes in workplace practices and organizational structures (Triplett and Bosworth, 2004).

Studies focusing on construction efficiency, in contrast to productivity, have documented 25 to 50 percent waste in coordinating labor and in managing, moving, and installing materials (Tulacz and Armistead, 2007); losses of $15.6 billion per year due to the lack of interoperability (NIST, 2004); and transactional costs of $4 billion to $12 billion per year to resolve disputes and claims associated with construction projects (Federal Facilities Council (FFC), 2007).

Because the concept of productivity can be difficult to define, measure, and communicate, the NRC committee determined that it would focus on ways to improve the efficiency of the capital facilities sector of the construction industry. It defines efficiency improvements as ways to cut waste in time, costs, materials, energy, skills, and labor. The committee believes that improving efficiency will also improve overall productivity and help individual construction firms produce more environmentally sustainable projects and become more competitive.

To gather data for this task, the Committee on Advancing the Competitiveness and Productivity of the U.S. Construction Industry Workshop commissioned three white papers by industry analysts and held a 2-day workshop to which 50 additional experts were invited. A range of activities that could improve construction productivity were identified in the papers, at the workshop, and by the committee itself. From among these, the committee identified five interrelated activities that could lead to breakthrough improvements in construction efficiency and productivity in 2 to 10 years, in contrast to 20 years.

If implemented throughout the capital facilities sector, these activities could significantly advance construction efficiency and improve the quality, timeliness, cost–effectiveness, and sustainability of construction projects. Following are the five activities, which are discussed in the section that follows.

Opportunities for Breakthrough Improvements

The NRC Committee chose the following five breakthroughs from among dozens of potential ideas, concepts, processes and practices as potentially having the most significant impact on the construction industry efficiency and productivity.

1. Widespread deployment and use of interoperable technology applications, also called Building Information Modeling (BIM);

2. Improved job-site efficiency through more effective interfacing of people, processes, materials, equipment, and information;

3. Greater use of prefabrication, preassembly, modularization, and off-site fabrication techniques and processes;

4. Innovative, widespread use of demonstration installations; and

5. Effective performance measurement to drive efficiency and support innovation.

Contents

"Manufacturing building components off-site provides for more controlled conditions and allows for improved quality and precision in the fabrication of the component."

– Advancing the Competitiveness and Efficiency of the U.S. Construction Industry; National Research Council

The five activities are interrelated, and the implementation of each will enable that of the others. Deploying these activities so that they become standard operating procedures in the capital facilities sector will require a strategic, collaborative approach led by those project owners who will most directly benefit from lower-cost, higher-quality sustainable projects, namely, the large corporations and government agencies that regularly invest hundreds of millions of dollars in buildings and infrastructure in order to conduct their operations. However, these owners cannot effect widespread change without the collaboration and support of large contractors, subcontractors, architects, engineers, and researchers. The committee suggests a path forward for implementing the changes required to advance the competitiveness and efficiency of the U.S. construction industry significantly in the 21st century.

The quality of life of every American relies in part on the products of the U.S. construction industry—houses, office buildings, factories, shopping centers, hospitals, airports, universities, refineries, roads, bridges, power plants, water and sewer lines, and other infrastructure. Construction products—buildings and infrastructure—provide shelter, water, and power, and they support commerce, education, recreation, mobility, and connectivity. They also have significant environmental impacts, annually accounting for 40 percent of primary energy use in the United States and 40 percent of the U.S. greenhouse gas emissions linked to global climate change. Each year, new construction projects in this country account for 30 percent of the raw materials and 25 percent of the water used, and for 30 percent of the materials placed in landfills (National Science and Technology Council (NSTC), 1995).

The construction industry itself is a major generator of jobs and contributes an important component of the gross domestic product (GDP). In 2007, almost 11 million people, about 8 percent of the total U.S. workforce, worked in construction. The value of the buildings and infrastructure that they constructed was estimated to be $1.16 trillion (U.S. Census Bureau, 2008a). The construction industry accounted for $611 billion, or 4.4 percent of the GDP, more than many other industries, including information, arts and entertainment, utilities, agriculture, and mining (Bureau of Economic Analysis, 2009). Construction's portion of the GDP would increase to 10 percent if the equipment, furnishings, and energy required to complete buildings were included (NSTC, 2008).

Construction productivity—how well, how quickly, and at what cost buildings and infrastructure can be constructed—directly affects prices for homes and consumer goods and the robustness of the national economy. Construction productivity will also affect the outcomes of national efforts to renew existing infrastructure systems; to build new infrastructure for power from renewable resources; to develop high-performance "green" buildings; and to remain competitive in the global market. Changes in building design, construction, and renovation, and in building materials and materials recycling, will be essential to the success of national efforts to minimize environmental impacts, reduce overall energy use, and reduce greenhouse gas emissions (NSTC, 2008).

However, industry analysts differ on whether construction industry productivity is improving or declining. Some analyses for the industry as a whole indicate that productivity has been declining for 30 years or more. Other studies document improved productivity for construction projects and construction tasks (e.g., the laying of pipe or concrete).

One note of agreement is that there is significant room for improvement. Studies focusing on construction efficiency, in contrast to productivity, have documented 25 to 50 percent waste in coordinating labor and in managing, moving, and installing materials (Tulacz and Armistead, 2007); losses of $15.6 billion per year due to the lack of interoperability (NIST, 2004); and transactional costs of $4 billion to $12 billion per year to resolve disputes and claims associated with construction projects (FFC, 2007).

A key message of the present report is that advances in available and emerging technologies offer significant opportunities to improve construction efficiency substantially in the 21st century and to help meet other national challenges, such as environmental sustainability. From among many suggestions, the committee identified five interrelated activities that could result in breakthrough improvements in the capital facilities sector of the construction industry in the next 2 to 10 years. Following is a brief discussion of each activity.

1. Widespread deployment and use of interoperable technology applications, also called Building Information Modeling (BIM). Interoperability is the ability to manage and communicate electronic data among owners, clients, contractors, and suppliers, and across a project's design, engineering, operations, project management, construction, financial, and legal units. Interoerability is made possible by a range of information technology tools and applications including computer-aided design and drafting (CADD), three– and four–dimensional visualization and modeling programs, laser scanning, cost-estimating and scheduling tools, and materials tracking.

Effective use of interoperable technologies requires integrated, collaborative processes and effective planning up front and thus can help overcome obstacles to efficiency created by process fragmentation. Interoperable technologies can also help to improve the quality and speed of project related decision making; integrate processes; manage supply chains; sequence work flow; improve data accuracy and reduce the time spent on data entry; reduce design and engineering conflicts and the subsequent need for rework; improve the life–cycle management of buildings and infrastructure;

and provide the data required to measure performance. Barriers to the widespread deployment of interoperable technologies include legal issues, data-storage capacities, and the need for "intelligent" search applications to sort quickly through thousands of data elements and make real-time information available for on-site decision making.

2. Improved job-site efficiency through more effective interfacing of people, processes, materials, equipment, and information. The job site for a large construction project is a dynamic place, involving numerous contractors, subcontractors, trades people, and laborers, all of whom require equipment, materials, and supplies to complete their tasks. Managing these activities and demands to achieve the maximum efficiency from the available resources is difficult and typically not done well. Time, money, and resources are wasted when projects are poorly managed, causing workers to have to wait around for tools and work crews' schedules to conflict; when work crews are not on–site at the appropriate time; or when supplies and equipment are stored haphazardly, requiring that they be moved multiple times.

Greater use of automated equipment (e.g., for excavation and earthmoving operations, concrete placement, pipe installation) and information technologies (e.g., radio-frequency identification tags for tracking materials, personal digital assistants for capturing field data), process improvements, and the provision of real–time information for improved management at the job site could significantly cut waste, improve job–site safety, and improve the quality of projects. A primary barrier to more effective use of such technologies is the segmentation and sequencing of planning, design, engineering, and construction processes. Improved job–site efficiency also requires a skilled labor force with communication, collaboration, and management skills as well as technical proficiencies.

3. Greater use of prefabrication, preassembly, modularization, and off-site fabrication techniques and processes. Prefabrication, preassembly, modularization, and off–site fabrication involve the fabrication or assembly of systems and components at off-site locations and manufacturing plants. Once completed, the systems or components are shipped to a construction job site for installation at the appropriate time. These techniques offer the promise (if used appropriately) of lower project costs, shorter schedules, improved quality, and more efficient use of labor and materials. Various obstacles stand in the way of the widespread use of such technologies, including building codes that hinder innovation as well as conventional design and construction processes and practices.

4. Innovative, widespread use of demonstration installations. Demonstration installations are research and development tools that can take a variety of forms: field testing on a job site; seminars, training, and conferences; and scientific laboratories with sophisticated equipment and standardized testing and reporting protocols. Greater and more collaborative use of demonstration installations can be used to test and verify the effectiveness of new processes, technologies, and materials and their readiness to be deployed throughout the construction industry. By allowing determinations to be made about whether innovative approaches are mature enough for general use, demonstration installations can help to mitigate innovation–related risks to owners, contractors, and subcontractors.

5. Effective performance measurement to drive efficiency and support innovation. Performance measures are enablers of innovation and of corrective actions throughout a project's life cycle. They can help companies and organizations understand how processes or practices led to success or failure, improvements or inefficiencies, and how to use that knowledge to improve products, processes, and the outcomes of active projects. The nature of construction projects and the industry itself calls for lagging, current, and leading performance indicators at the industry, project, and task levels, respectively.

Prefabrication, Preassembly & Modular Construction

Construction workers typically are exposed to high levels of noise, dust and airborne particles, adverse weather conditions, and other factors that can cause fatigue and injuries and thereby reduce efficiency and productivity. New types of equipment can make an activity physically easier to perform, easier to control, more precise, and safer for construction workers. Similarly, changes in materials can reduce the weight of construction components, which in turn can make them easier to handle, move, and install. Manufacturing building components off–site provides for more controlled conditions and allows for improved quality and precision in the fabrication of the component.

Prefabrication, preassembly, modularization, and off-site fabrication involve the assembly or fabrication of building systems and/or components at off–site locations and plants. Once completed, the systems or components are shipped to a construction job site for installation at the appropriate time. One study that examined the relationship between changes in material technology and construction productivity based on 100 construction–related tasks found the following:

- Labor productivity for the same activity increased by 30 percent where lighter materials were used; and
- Labor productivity also improved when construction activities were performed using materials that were easier to install or were pre–fabricated (Goodrum et al., 2009).

Prefabrication and related techniques allow for the following:

- **More controlled conditions** for weather, quality control, improved supervision of labor, easier access to tools, and fewer material deliveries (Construction Industry Institute, 2002).
- **Fewer job-site environmental impacts** because of reductions in material waste, air and water pollution, dust and noise, and overall energy costs, although prefabrication and related technologies may also entail higher transportation costs and energy costs at off–site locations;
- **Compressed project schedules** that result from changing the sequencing of work flow (e.g., allowing for the assembly of components off-site while foundations are being poured on–site; allowing for the assembly of components off-site while permits are being processed);
- **Fewer conflicts in work crew scheduling** and better sequencing of crafts persons;
- **Reduced requirements for on-site materials storage**, and fewer losses or misplacements of materials; and
- **Increased workers safety** through reduced exposures to inclement weather, temperature extremes, and ongoing or hazardous operations; better working conditions (e.g., components traditionally constructed on-site at heights or in confined spaces can be fabricated off-site and then hoisted into place using cranes) (Construction Users Roundtable, 2007).

Prefabrication and related techniques are commonly used in the construction of industrial projects, but they are also used, if less frequently, for commercial and infrastructure projects. The committee believes that greater use and deployment of these techniques (if used appropriately) can result in lower project costs, shorter schedules, improved quality, more efficient use of labor and materials, and improved worker safety.

Read the full report from the National Research Council here:
www.modular.org/marketing/documents/NRC_USConstructionIndustry_Report.pdf

Definition of Modular Construction: A resource efficient, off-site delivery method to construct code-compliant buildings in a quality-controlled setting.

Resource Efficiency

The impact of construction and demolition (C&D) debris on the environment is staggering. More than 135 million tons of debris from construction sites is brought to U.S. landfills every year, making it the single largest source in the waste stream.

Figures developed by the U.S. Environmental Protection Agency (EPA) are helpful to building owners, designers and contractors in understanding the magnitude of C&D waste. In commercial construction, a typical new building generates an average of 3.9 pounds of waste per square foot of building area. To put this in perspective, a new building of 50,000 square feet – a typical college residence hall or mid-size suburban office building – will produce 195,000 pounds, or almost 100 tons of waste.

Change the activity to demolition and the figures increase dramatically. In this case, commercial buildings yield an average of 155 pounds per square foot of building area. Turn the same 50,000 square foot building in to a demolition project and the result will be almost 4,000 tons of waste (www.modular.org/marketing/documents/USGBC_WhitePaper_PlanningConstructionWasteReduction.pdf).

Modular construction by nature is material and resource efficient. One of the great economies of modular construction is the ability to assemble repetitive units in controlled conditions. Another is to minimize material waste associated with conventional construction due to weather intrusion and construction site theft. Whole modular units – largely finished prior to arriving at the construction site – can significantly limit construction waste generated at the site and contribute directly to construction site waste management.

Modular construction capitalizes on the ability to move product in controlled manufacturing conditions, and on tight inventory control and project schedules. It is inherently waste conscious and can have minimum site impact if delivered carefully and strategically with respect to site constraints.

Using off–site manufacturing processes can help the construction industry reduce waste, according to a report published by the U.K. group WRAP (Waste & Resources Action Programme). Off site manufacture already offers the construction industry benefits in terms of time and cost predictability, health and safety and skills. However, this work shows that there is the potential to make a significant difference to the amount of waste the industry produces. Some of the biggest waste streams in traditional construction are packaging (up to 5%), timber (up to 25%) and plasterboard (up to 36%). Up to a 90% reduction can be achieved by reducing wastes such as wood pallets, shrink wrap, cardboard, plasterboard, timber, concrete, bricks and cement by increasing the use of off-site manufacture and modern methods of construction (www.modular.org/marketing/documents/WRAP_ModernMethodsConstruction_Report.pdf).

The U.S. Green Building Council (USGBC) also recognizes the inherent materials advantages using prefabrication and off-site construction techniques. In its Leadership in Energy and Environmental Design (LEED) for Homes rating system, the USGBC awards points under its materials and resources sections MR 1.2 and MR 1.3. "Projects with a precut framing package (e.g. modular homes, kit homes) are awarded MR 1.2 and MR 1.3 (detailed framing documents) automatically." Additionally, LEED for Homes includes a credit specifically for off-site fabrication – MR 1.5. MR 1.5 states "this credit should only be awarded if the walls, roof, and floors are fabricated off-site." www.modular.org/marketing/documents/USGBC_LEEDforHomesRatingSystem.pdf

Design for Reuse and Deconstruction

The EPA recently hosted its third Lifecycle Building Challenge to address the pressing need to address the impact construction activity has on the environment. According to the EPA, "Lifecycle building is the design of building materials, components, information systems, and management practices to create buildings that facilitate and anticipate future changes to and eventual adaptation or dismantling for recovery of all systems, components, and materials."

The competition is intended to spur innovation and highlight best practices that could be put to use by the building industry in ways to help it reduce the more than 88 million tons of construction – and demolition-related debris sent to U.S. landfills each year, according to EPA estimates.

The winners of the third annual awards were chosen by EPA representatives along with the American Institute of Architects, West Coast Green, the Collaborative for High Performance Schools, and StopWaste.Org. The common theme among this year's winners was modular construction:

In the professionally designed building category – the Arboretum and Research Visitors' Center in Charlottesville, VA., won the award. Designed by Kira Gould of William McDonough + Partners, the building makes use of reconfigurable connections and modules, allowing it to be adapted to other uses.

David Fleming from the University of Cincinnati won the award for the student-designed building with his "[Un] Modular Design for Deconstruction" shown here. His adaptable structural system can change almost any element of the building, and shows the potential for a building that can evolve with time and innovations in materials and styles change.

Winner of the Best Professional Product award – The ENVY Modular Wall System developed by Douglas Spear and Aaron Barnes is made of panels and extruded joining parts that are recyclable, reusable and can be recycled into new products with zero waste. The EPA estimates that the ENVY wall system saves 1 ton of landfill waste for every 70 linear feet of wall used.

The prize for Best School design went to the School M.O.D. designed by Yosuke Kawai and Ikue Nomura at the University of Pennsylvania in Dayton, Ohio. M.O.D. in this case means modular, open and dual–structural, and is a prototype building method that emphasizes flexible construction methods using whatever materials are locally available.

Full details, including photos and full descriptions of the buildings, are available at http://2009.lifecyclebuilding.org.

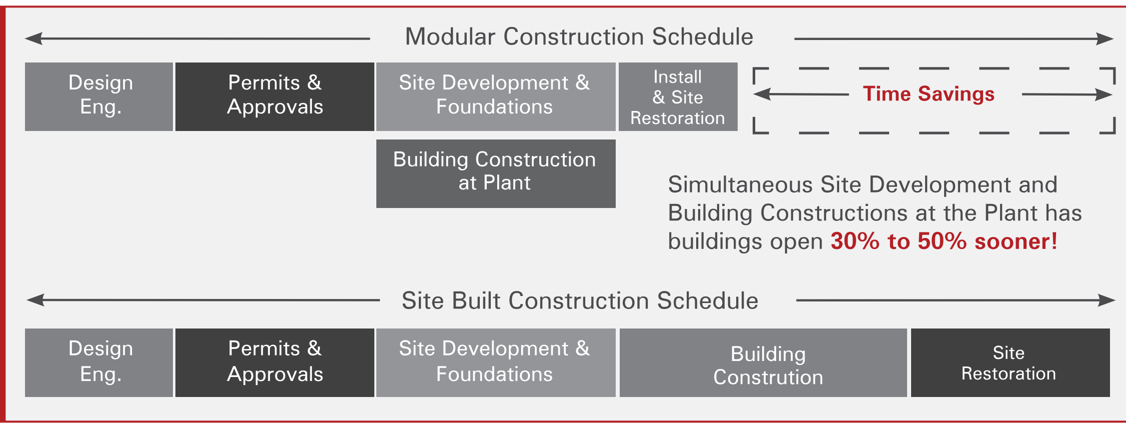
Of course, the modular construction industry has for many years been practitioners of flexible design and reuse. At its annual Awards of Distinction competition, the Modular Building Institute hosts a category for best "renovated reuse" of an existing building. Renovated reuse is defined as a reconfiguration of an existing factory-built commercial structure to meet the needs of an application that is different from its original design.

Before (left) and after (right and below) pictures of the Brookfield Homes Sales Office in Kona, HI

Streamlined Construction Process

Primarily, four stages make up factory-built construction. First, design approval by the end-user and any regulating authorities; second, assembly of module components in a controlled environment; third, transportation of modules to a final destination; and fourth, erection of modular units to form a finished building. Unique to modular construction, while modules are being assembled in a factory, site work is occurring at the same time. This permits earlier building occupancy and contributes to a much shorter construction period, reducing financing and supervision costs. Saving even more time and money, nearly all design and engineering disciplines are part of the manufacturing process.

Also unique to modular, is the ability to simultaneously construct a building's floors, walls, ceilings, rafters, and roofs. During site–built construction, walls cannot be set until floors are in position, and ceilings and rafters cannot be added until walls are erected. On the other hand, with modern modular methods of construction, walls, floors, ceilings, and rafters are all built at the same time, and then brought together in the same factory to form a building. This process often allows modular construction times of half that of conventional, stick–built construction.



The U.S. Department of Veteran Affairs (VA) has incorporated modular construction processes in its development of new hospital construction. Known as the "VA Hospital Building System," this system was developed by the VA for use in the design and construction of new hospital buildings; characterized by modular design and the use of systems approach to the integration of building services and functional planning modules. Faced with rising costs, lengthy periods between programming and occupancy, accelerating obsolescence and inadequate building performances, VA decided to study the application of systems integration to a prototype design for new hospitals. Since then, the VAHBS has been used successfully on many VA projects (www.modular.org/marketing/documents/VA_HospitalBuildingSystem.pdf).

Evaluation Criteria in U.S. Army Corps of Engineers Request for Proposals: "The Government places a higher value on an offer that provides proposed methods to streamline construction, manage labor and other resource constraints in an effort to reduce costs and support an aggressive schedule, including such things as fast tracking, using factory built modules or assemblies, panelization, pre-cast, tilt-up, standard designs, etc. The government will also consider whether the approach reduces on-site craft labor and susceptibility to inclement weather delays."

The U.S. Department of Education's Impact Aid program is also a proponent of "alternative construction techniques" including the modular construction processes. Under section 8007 (b), competitive construction grants are awarded to local school districts that educate high percentages of certain federally connected children – both children living on Indian lands and children of members of the uniformed services. Among other criteria, grantees are awarded points for:

The extent to which the new design and proposed construction utilizes non-traditional or alternative building methods to expedite construction and project completion and maximize cost efficiency; and the feasibility of project completion within 24 months from award.

Proposals utilizing alternative construction techniques including modular were awarded higher points than those utilizing conventional methods to encourage the use of these alternative construction methods in efforts to streamline the construction process. *(Pictured: Milestones Middle School in Phoenix, AZ)*

Quality Controlled Setting

A report from the American Institute of Architects (AIA) called "External Issues & Trends Affecting Architectural Firms, and the AIA" from February 2008 was prepared because "The AIA wants to keep abreast of elements that are known to impact or that may in the future have an impact on the architecture profession and the American Institute of Architects." The report states:

"The life expectancy of modular construction is the same as conventional, and in a world where sustainability is gaining momentum each day, there are also several basic principles intrinsic to the modular construction process that make it more eco-friendly than conventional construction. They spend significantly less on-site time, a result of a shortened construction cycle, (the outcome of the simultaneous activities of on-site development and off-site building construction), notably minimizes the overall impact on a site. And finally, modular construction methods and materials allow a building to be more readily "deconstructed" and moved to another location should the need arise, so complete building reuse or recycling is an integral part of the design technology."

After Hurricane Andrew hit in 1992, Federal Emergency Management Agency's (FEMA) Mitigation Assessment Team conducted a study of various building types and how well they weathered the storm. In their summary the Mitigation Assessment team concluded that "in general, it was observed that masonry buildings and wood-framed modular buildings performed relatively well."

The report went on to state that "overall, relatively minimal structural damage was noted in modular housing developments. The module–to-module combination of the units appears to have provided an inherently rigid system that performed much better than conventional residential framing." www.modular.org/marketing/documents/FEMA_HurricaneAndrew_Report.pdf

Type II vs. Type V – Wood (Construction Type V) and light gage steel frame (Construction Type II) are long respected methods of construction that have been used in many buildings throughout the United States. Both methods are fully code compliant and due to the competitive cost, each provides a great value as a long-term building solution. The modular construction process can be efficiently utilized to deliver **both** Type II and Type V facilities. Additionally, facilities constructed off–site can be designed to meet ATFP blast resistant standards.

Modular construction methods have been shown to be inherently advantageous in several major areas:

Less Materials Waste – Pre-fabrication makes it possible to optimize construction material purchases and usage while minimizing on-site waste and offering a higher quality product to the buyer. Bulk materials are delivered to the manufacturing facility where they are stored in a protected environment safe from theft and exposure to the environmental conditions of a job site.

Less Material Exposure to Inclement Weather – Many of the indoor air quality issues identified in new construction result from high moisture levels in the framing materials. Because the modular structure is substantially completed in a factory-controlled setting using dry materials, the potential for high levels of moisture being trapped in the new construction is eliminated.

Less Site Disturbance – The modular structure is constructed off–site simultaneous to foundation and other site work, thereby reducing the time and impact on the surrounding site environment, as well as reducing the number of vehicles and equipment needed at the site.

Safer Construction – Modular construction is a safer alternative. Conventional construction workers regularly work in less than ideal conditions dealing with temperature extremes, rain, wind, or any combination of natural conditions. This, by its very nature, is a much more challenging environment to work safely in. Additionally, the potential for injury including falls, the most common work site risk, is much higher. In a factory controlled setting, each worker is typically assigned to a work station supplied with all the appropriate equipment needed to provide the safest work environment possible. Off-site construction also eliminates the hazards associated with materials, equipment and an incomplete construction processes typical of construction sites that can attract curious and unwelcome "visitors" (i.e. students on a school expansion project).

Flexibility – When the needs change, modular buildings can be disassembled and the modules relocated or refurbished for new use, reducing the demand for raw materials and minimizing the amount of energy expended to create a building to meet the new need. In essence, the entire building can be recycled in some cases.

Adaptability – Modular buildings are frequently designed to quickly add or remove one or more "modules," minimizing disruptions to adjacent buildings and surroundings.

Built to Code With Shorter Build Times – The bottom line is that with modular construction you can get a facility built to the same local codes with construction quality as good as or better than a comparable site built building in much less time. Additionally, the abbreviated construction schedule allows you to get a return on your investment sooner, while minimizing the exposure to the risks commonly associated with protracted construction schedules.

High Tech High in Chula Vista, CA

Summary

As cited in this report, the following agencies and organizations have embraced and acknowledged many of the advantages of the modular construction process:

National Institute of Standards and Technology
National Research Council
Environmental Protection Agency
American Institute of Architects
U.S. Green Building Council
U.S. Department of Veterans Affairs
U.S. Department of Education Impact Aid Program
U.S. Army Corps of Engineers

In addition, most major universities now offer courses on modular construction as part of their construction management or architecture programs.

Regardless of the type of construction selected, alternative construction methods, specifically modular construction, offer compelling advantages in terms of quality, cost, durability, and environmental impact.

Improving Construction Efficiency & Productivity with **Modular Construction**

Committee on Advancing the Competitiveness and Productivity of the U.S. Construction Industry

Theodore C. Kennedy, BE&K (retired), Birmingham, Alabama, *Chair*
Parviz Daneshgari, MCA, Inc., Flint, Michigan
Patricia D. Galloway, Pegasus-Global Holdings, Inc., Cle Elum, Washington
James O. Jirsa, University of Texas, Austin
Behrokh Khoshnevis, University of Southern California, Los Angeles
Feniosky Pena-Mora, Columbia University, New York, New York
Benedict Schwegler, Jr., Walt Disney Imagineering Research and Development, Glendale, California
David A. Skiven, General Motors Corporation (retired), Brighton, Michigan
Jorge A. Vanegas, Texas A&M University, College Station
Norbert W. Young, Jr., McGraw-Hill Construction, New York, New York

About the MBI Educational Foundation (MBIEF)

The MBI Educational Foundation is the only organization established to provide educational opportunities in the form of training and scholarships to individuals with an interest in commercial modular construction. Since 2001, the Foundation has trained over 1000 industry professionals through its popular "Essentials of Commercial Modular Construction" educational series, begun intensive development of a modular buildings installation certificate program, and awarded student scholarships. The foundation also spear-heads industry research and recently published a report on modular building and the USGBC's LEED v3.0 Building Rating System.

MBI also has a Canadian Foundation (MBICF) based in Toronto, Ontario. To learn more about MBI's educational foundations, visit:

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Modular Building Institute
944 Glenwood Station Ln. Ste. 204
Charlottesville, VA 22901 USA
888-811-3288
434-296-3361 fax
www.modular.org

Address all inquiries to:
Tom Hardiman
888.811.3288 x 158
tom@modular.org

Founded in 1983, the Modular Building Institute is the only, international, non–profit trade association serving non–residential modular construction. Our regular membership includes wholesale manufacturers, direct manufacturers, and dealers of commercial modular buildings, while our associate members are companies supplying building components, services, and financing to the industry. It is MBI's mission to grow the industry and its capabilities by encouraging innovation, quality, and professionalism through communication, education, and recognition. MBI also administers an educational foundation. For more information, visit modular.org.