

ARCHITECTURE, ENGINEERING & CONSTRUCTION

PREFABRICATION AND

INDUSTRIALIZED CONSTRUCTION



INTRODUCTION

As part of a larger trend toward the industrialization of construction, prefabrication is a powerful strategy for reducing cost, risk, and waste in the Architecture, Engineering & Construction (AEC) industry. In this paper, we explore various aspects of prefabrication and present some real-world examples of how prefabrication is used in the field.

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1: TYPES OF WORK SUITED FOR PREFABRICATION

Prefabrication is an important tool for those practicing industrialized construction.

But not everything on a project is delivered more efficiently with prefabrication. Some components or elements of a building are more suited for prefab than others.

Standardized building systems, complex assemblies, and repetitive subcomponents of a building are three examples of applications likely to be successful with prefab.

“Unnoticed” Building Systems

Commodity assemblies—parts mostly required by code—often go unnoticed. These building systems don’t make or break the finished project, and so they are more price-sensitive than other systems.

Fire stairs, elevators, plumbing, heating and cooling, and ADA-compliant spaces are examples of building systems that could easily be prefabricated, ordered directly by the owner, and delivered to the worksite ready to be installed.

Complex Systems

High-end, intricate elements of a building, for example a unique façade system or other stand-alone component, may be more successfully installed if panelized and prefabricated off the job site.

Components of a Building

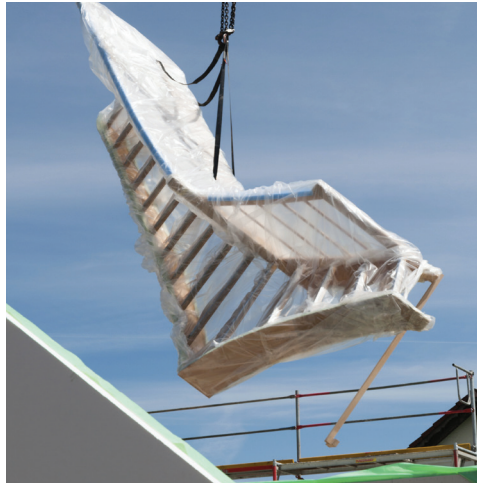
Repetitive subcomponents can make up 75 percent of a project in some types of buildings.

For example, patient rooms in hospitals, guest bathrooms and kitchenettes in hotels, classrooms in schools, and labs in research facilities are subcomponents that are replicated over and over again within the building.

Components that make up certain building types can be built offsite more efficiently at scale, and installed on site more quickly.

When planning a project, be careful not to assume that prefab is an all or nothing proposition. Some parts of a building are much better suited to offsite fabrication than others.

These prefab components will end up being delivered in less time at much higher quality with as much as 30 percent savings.



A prefabricated stairway installation in progress.

2: ADVANTAGES OF PREFABRICATION FOR AEC

Where prefabrication is possible, a number of benefits make these systems attractive to building owners.

Prefabricated systems can lead to reduced labor costs, safer projects, and fewer delays—and often results in an overall higher quality product than can be achieved with traditional stick-built projects.

Reduced Labor Costs

Prefabricated systems simplify the installation process, requiring fewer workers onsite to complete a task.

Because the most complex components are assembled in a specialized manufacturing environment, prefabrication reduces the need for skilled laborers. Skilled trade people need only be used onsite for the final connection of systems, such as wiring or ductwork.

Improved Safety

Not only does prefabrication lower labor costs, but by shortening the amount of time spent onsite, laborers are able to get in and out more safely.

Laborers working in a controlled factory environment don't have to brave jobsite hazards such as ice or winter chills, unsafe access to electricity, or dangerous heights. A factory-controlled environment also makes it possible to supply components and equipment where the worker needs it, rather than having workers moving parts through an active jobsite.



Workers construct a modular structure in a manufacturing facility. *@iStock.com/EdStock*

Minimized Delays

Sequencing for stick-built projects follows a typical pattern: each trade moves in to complete its portion of the building once the previous trade has completed its work. That means an unexpected delay in ductwork installation can push back wall framing, which then moves the schedule for the electricians who are already working around another project, and so on.

Prefabrication minimizes the need for coordination among subcontractors because electrical, ductwork, and other necessary components are installed within the wall as it's being fabricated, requiring minimal onsite coordination.

What's more, because the majority of work is done inside, there is no need for delays due to weather, and shift work can be performed around the clock.

Improved Quality of Finished Project

Prefabrication work is typically completed in a specialized, centralized factory. Suppliers might use a permanent location or a temporary warehouse close to the jobsite to reduce the logistics of transporting finished products.

A major advantage of working in this enclosed environment is that it allows for greater quality control than is possible on a typical jobsite. Producing these complex systems in a manufacturing environment keeps jobsite dust, dirt, and other contaminants out of sensitive systems. It allows for more oversight of each step of the process.

Once completed systems arrive onsite, surveying devices such as transits help installers to precisely locate where each component needs to be installed. Expert tradesmen must simply connect the final pieces.

Expanding Benefits

While not every project—or every system within a project—may be able to take advantage of prefabrication, today's new technology allows even highly custom systems to take advantage of these benefits to workers and building owners.

FEATURED ARTICLE: PREFABRICATION PRODUCTIVITY

By Vicki Speed

[Originally published in *Compass* magazine from Dassault Systèmes]

From a residential high-rise in New York City to low-cost hotels in Europe, the application of prefabricated and modular objects and systems continues to capture the interest of owners, architects, contractors, fabricators, and product manufacturers in the building industry.

Around the world, prefabrication proponents are finding ways to apply offsite construction techniques that go way beyond repeatable systems, such as bathroom pods or mechanical pipe rack, to more volumetric, pioneering, semi-customized solutions that address a wide range of common construction challenges.



"In some parts of the world, like Japan and the United Kingdom, owners and project teams have necessarily moved to offsite construction methods because of land prices and the cost of labor," said Ryan Smith, associate professor and director in the College of Architecture + Planning at the University of Utah (USA), and chairman of the National Institute of Building Sciences Off-Site Construction Council (OSCC). "Amortizing land is prohibitive in these countries, so owners favor methods that facilitate faster construction schedules. Labor is more expensive, also necessitating quick turnaround on construction duration."

However, he added, the greater interest and application of offsite construction methods in recent years is largely driven by two ongoing challenges in the global construction industry: the need to improve construction productivity and skilled-labor shortages in some parts of the world.

North American Methods Shifting

Concerns about labor shortages are one of the primary reasons for increased interest in offsite construction in North America.

In its 2014 U.S. Markets Construction Overview, FMI, a global provider of management consulting, investment banking, and research to the engineering and construction industry, predicts that modularization and prefabrication will play an increasingly vital role in the U.S. construction value chain because emerging demand is outrunning the availability of skilled tradespeople.

Meanwhile, many international contractors are looking to their European or Asian counterparts for ideas.



Modular construction at the
Corrections Corporation of
America's detention facility in
Otay Mesa, California
© Sundt Construction,
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"In our experience, prefabrication and modularization are primarily driven by our need to be more competitive and deliver a project at the lowest cost and schedule certainty —and the mechanical, electrical, and plumbing (MEP) subcontractors have taken the lead in delivering effective solutions for good reason," said Don Goodrich, director of preconstruction services at Sundt, a construction company based in Phoenix, Arizona (USA). "The MEP trades are facing a considerable labor shortage. The increasing use of Building Information Modeling (BIM) helps bring the prefabrication conversation to the forefront as well."

Deciding when to use a prefab approach is based on the challenges of a specific project, Goodrich said. "We're translating prefab and modular techniques that we learn from one job to other jobs as much as possible," he said.

In one case, Sundt transferred the modular technology approach from a private prison construction project to a much larger state prison project.

Global Multi-Trade Opportunities

Similarly, U.K.-based Balfour Beatty, an international infrastructure lifecycle services company, relies on prefabrication and modular methods to construct a number of different structures to achieve considerable value.

Some phases of the Queen Elizabeth Hospital in Birmingham, England, for example, were completed a year early. Likewise, Belgium-based Inter IKEA Group, parent company of the IKEA furniture brand, teamed with Marriott International, a hospitality company headquartered in Bethesda, Maryland (USA), to create low-cost prefabricated hotels in Europe.

FMI Senior Consultant Ethan Cowles expects the use of prefab and modularization to grow quickly in health care, lodging, and education, as it already has done in the fast-food market.

OSCC's Smith agrees. "We see full volumetric prefabricated construction mostly with owners of smaller structures, some housing, and some industrial markets," he said. "Owners of fast-food franchises, automotive service centers, daycare, data centers, hospitals, multi-family and mid-rise structures, and others with repeatable structural requirements are becoming more engaged in design-build and integrated delivery, and are not so dependent on open bid requirements."

Looking ahead, Cowles and Smith point to growing interest and demand for multi-trade prefabrication and modularization.

"The success of a multi-trade scenario will depend on the owner seeing value and capable contractors coming together contractually to maximize the benefits," Cowles said.

Rethinking Conventional Practices

Despite the promise that prefabrication and modularization holds for the building industry, the approach is not without wrinkles—as witnessed by the lawsuits related to New York's B2 Tower project.

Cowles and Smith noted that offsite approaches inherently require early coordination and decision-making to maximize the value. Offsite construction also requires that owners, architects, and contractors rethink the conventional processes that have been industry standards for decades.

"The building technology and methodology for offsite construction is not mysterious," Smith said. "There's very little technical challenge or complexity to the process, very little intellectual property, relatively speaking, in comparison to other manufacturing industries. The challenge has more to do with tacit knowledge related to the social, political, regulation, and economic context in which offsite construction unfolds."

Integrating prefabrication and modularization into the construction build cycle adds value, but it's not a panacea, Smith said. "I don't see these methods adopted on every project; but, most certainly, as components of an overall project build to minimize labor, increase productivity, and improve schedules—in short, to add value."

3: WHO WILL LEAD THE PREFABRICATION MOVEMENT?

The shift toward prefabrication means embracing a new project delivery method. While the use of prefabrication offers clear advantages on many project types, the construction industry is notoriously slow to adapt to new business models.

Widespread adoption of prefabrication is being seen from two drivers in particular: building product manufacturers and subcontractors.

Building Product Manufacturers

During the latest construction downturn, a handful of building product manufacturers flourished by consolidating with and/or acquiring a range of related building product companies.

The result is a handful of suppliers that are now able to deliver multiple building systems to a single project. This delivery system promotes a move toward prefabricated systems since it allows the supplier to move more products.

Take for example United Technologies, which manufactures both elevators and air conditioners. Such suppliers are more motivated to sell a complete system directly to the building owner, avoiding the battle to get each individual component specified by the designer or selected by the general contractor.

Subcontractors

For some time, subcontractors seeking to secure bigger contracts have looked to become a resource to architects in the design phase. These design-build partners are able to advise architects on product selection, and consequently lock in their preferred products and services.

However, many of these companies are focusing on a new advantage of selling directly to the building owner. With today's focus on sustainability, more building owners are taking a long-term view of new construction; the future operation of systems is now a greater part of design considerations.

The emergence of design-build-operate-maintain contracts means subcontractors earn not only installation work but also a contract to provide maintenance work over the life cycle of their system.

Take again the case of United Technologies. While the supplier may only earn a small profit margin for installing its elevators, its labor force can earn as much as three times that by managing the operation of that elevator for the duration of its existence.

That movement toward lifecycle maintenance is a major motivator for installers to be part of the early specification process—although building owners win as well with a more efficiently delivered product.

Next Steps

Forward-thinking suppliers and subcontractors already are promoting this new method of project delivery. As more building owners buy into the benefits of prefabrication, more members of the construction industry may find themselves adapting to this new reality.



Workers build a floor on a chassis at a factory.

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FEATURED ARTICLE: ***CUSTOMIZED EFFICIENCY—AN INTERVIEW WITH PERMASTEELISA GROUP***

By Vicki Speed

[Originally published in *Compass* magazine from Dassault Systèmes]

The Permasteelisa Group, based in Italy, is a leading worldwide contractor in the engineering, manufacture, and installation of architectural envelopes and interior systems. Compass spoke to Permasteelisa IT project manager Federico Momesso and communication manager Massimiliano Fanzaga about how the company is adopting more standardized technologies and processes to better meet the construction industry's growing demand for customized building systems on short timelines.



The Permasteelisa Group, based in Italy, is a leading worldwide contractor in the engineering, manufacture and installation of architectural envelopes and interior systems.

Compass: What challenges do you face in meeting client expectations?

FEDERICO MOMESSO: Every building project is unique, requiring multiple companies — owners, architects, engineers, contractors, subcontractors, and suppliers with different skills to come together. It's a fragmented industry that does not yet apply the same advanced level of 3D modeling to move from concept to completion as other markets, such as the automotive or aerospace industry.

Part of this is because of the inherent differences. In the automotive industry, one design is modeled and reproduced many times; in the building industry, every design is distinctive.

MASSIMILIANO FANZAGA: As well, projects are increasingly complex, as are the shapes of the interior/exterior elements. Even though every project is different, owners, architects, and contractors want projects engineered, executed, and built much quicker than ever before.

Permasteelisa has the added challenge of adapting its services to meet the needs of a diverse range of customers from different cultures, each with very different expectations, resources, and awareness.

What is your most common workflow?

FANZAGA: It has changed considerably over the years. Increasingly, the industry is shifting to an early-stage design review, similar to the front-loaded design process in the automotive industry, to improve communication and collaboration between all parties, especially the architect and contractor.

Ideally, we work hand-in-hand with the owner and project team at the earliest onset of design to engineer a technical solution that best meets the needs and budget of the project.

MOMESSO: One of the biggest challenges in developing our technology framework is to find a (3D modeling) solution that is able to work with all the different modeling systems our global customers use.

We must have the ability to capture more information and functionality to shorten lead-time, reduce waste and rework, and maintain our expectation of high quality. It's a continually improving process.

How has technology helped meet market demand?

MOMESSO: We've relied on virtual design and 3D technology for many years. One of the company's first applications of 3D modeling was on Frank Gehry's golden fish sculpture for the 1992 Olympics in Barcelona, Spain. In those early days, the benefits of 3D modeling were primarily internal to Permasteelisa.

Our project engineers and designers relied on the system capabilities for clash detection and quality production checks. Today, Permasteelisa uses the virtual model to communicate and share design concepts with customers as a way to help them visualize design intent and balance costs throughout the process.

FANZAGA: Our strength is our ability to apply the best resources for any job anytime, anywhere to meet the customized requirements of every project. Not that long ago, every one of our 50 offices would have used different CAD and other design technologies and approaches to complete a job.

Today, we're all speaking the same language thanks to 3D, regardless of geographic location. We have reached a point where all design/engineering are relying on a standardized IT environment, which allows anyone to work on any project at the same time. We're also finding ways to pre-customize elements or use the same module on multiple projects.

How do you communicate to the installers which piece goes where?

MOMESSO: For every project, we provide detailed work instructions about how to install different modules, as well as installation maps that show the correct installation sequence for each floor/façade.

What if something goes wrong on site?

FANZAGA: Clearly, the world is not as perfect as we would like it to be and some problems can arise on site. In these rare events, our site managers decide the best way to adapt the modules to fit to the concrete structure of the building or, in the worst case, ask for new modules to be produced and shipped onsite. Luckily, those events are very rare!

How are you looking to advance your processes?

MOMESSO: For installation, we have been testing the possibility of using radio-frequency identification (RFID) tags to precisely indicate where each unit has to be installed, which would minimize the risk of an incorrect installation sequence.

We're also looking to extend the benefits of 3D to our customers and suppliers. Since those early days of 3D modeling in the building industry, you can see considerable improvements, especially with the application of Building Information Modeling (BIM). As well, our clients are asking us to deliver solutions that can be connected to their 3D models.

We are currently implementing product lifecycle technologies. They provide a collaboration-based project backbone that enables centralized project management, which helps us to expand our online creation and collaboration capabilities as well as to foster lean construction methods.

CONCLUSION

Dassault Systèmes **3DEXPERIENCE®** platform offers robust PLM applications for the AEC industry, with powerful applications for innovative prefabrication processes. Cloud solutions and process implementation support are also available.

Dassault Systèmes, the **3DEXPERIENCE** Company, is the world leader in 3D Design, Digital Mock-Up (3D-DMU), and Product Lifecycle Management (3D-PLM).

Learn more about the Dassault Systèmes **3DEXPERIENCE** platform and AEC applications at www.3ds.com/aec.

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With over 30 years of AEC experience, Mr. Mays is part of the core team driving the AEC industry strategy at Dassault Systèmes. Mr. Mays was the General Manager for North America at Graphisoft and served as CIO at NBBJ Architects, where he led the firm's transition to Building Information Modeling (BIM) in the 1990s.

Featured articles reprinted from *Compass—The 3DEXPERIENCE Magazine* published by Dassault Systèmes

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