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How Modern Manufacturing and Construction Are Converging to Build Better

Written by: Markkus Rovito, Content Marketing Specialist, Autodesk

The words "manufacturing" and "construction" are thesaurus-confirmed synonyms. The industries bearing these names are also similar pursuits of making things — often exceedingly complicated things. However, the manufacturing and construction industries have approached adopting advanced technology a bit differently. Manufacturing has a major lead on construction in taking digital transformation journeys that digitize operations and find multiple efficiencies based on collecting and analyzing operational data. Construction for the most part has been slower to digitize, but that's changing at an accelerating rate. By applying some of the lessons and techniques of smart manufacturing, construction is becoming more digital and also more efficient, safe, and sustainable.

WHAT'S THE DIFFERENCE BETWEEN CONSTRUCTION AND MANUFACTURING?

Manufacturing and construction are similar industries in that both involve the creation of an object. Construction is focused on the process of making buildings, bridges, tunnels, and more. Manufacturing is largely focused on creating goods, such as tables or smartphones.

In the third decade of the 21st century, the construction industry has begun to transition toward 3D printing, prefabrication, modular construction, and other manufacturing techniques to circumvent labor shortages and build faster, more cost-effectively, and with fewer materials than traditional methods.

MODERN MANUFACTURING INDUSTRY

The modern manufacturing industry has embraced Industry 4.0, characterized by intelligent automation based on insights from operational data and AI-driven data analytics. Core to Industry 4.0 is the digital transformation to smart manufacturing and smart factories, which digitize all areas of manufacturing from product design to sales, including the supply chain, production, and distribution.

In a full-fledged smart factory, an Industrial Internet of Things (IIoT) network collects massive amounts of data from many thousands of sensors embedded throughout the production line and factory floor. That data feeds into cloud-connected software platforms, where AI and machine learning technology analyzes it to provide actionable insights enabling predictive maintenance of machinery and improving production efficiency, quality assurance, supply chain management, and more.

Robotics systems and other automation tied to smart factory operation execute on the data-derived insights to optimize areas like efficiency and worker safety. Often a digital twin of the entire smart factory provides a virtual window into the real-time monitoring and managing of the entire operation.

Smart manufacturing offers many benefits to businesses, such as higher productivity, cost savings, quality improvements, and the flexibility and scalability to identify and act upon new business opportunities like mass customization or manufacturing as a service (MaaS).

In addition, smart factories lead to more sustainable manufacturing by reducing waste and promoting efficient use of energy and materials — at the same time maintaining or increasing production output and product performance. Sustainability in manufacturing is important due to increasing demands from customers and governments for sustainable products, as well as the cost-cutting competitive advantages associated with reducing waste.

Modern manufacturing software provides sustainability tools that, for example, can outline the total carbon management of a product across its entire lifecycle, including material selection, manufacturing techniques, and end-of-life disposal, as well as additional sustainability factors like material toxicity. Total carbon management is also available to estimate and reduce the carbon footprint across the entire design and manufacturing enterprise, including both embodied and operational carbon.

CONSTRUCTION INDUSTRY INNOVATIONS

Traditionally, the construction industry has been slower to adopt the same advanced technologies that have led manufacturing into Industry 4.0. However, the increasing integration of several technologies into construction workflows has been modernizing construction just in time for the industry to address simultaneous demands for completing projects faster and more sustainably.

Beginning with the 3D model, building information modeling (BIM) software improves collaboration and decision-making during the planning and pre-construction stages, when making early, well-informed decisions can save time, money, and resources.

Other advancements in industrialized construction have improved the efficiency and quality of building projects off the construction site. Industrialized construction harnesses the power of advanced manufacturing and applies it to construction by standardizing and automating the offsite manufacturing of various building products, which are then brought to the jobsite for easier, safer assembly. This includes the prefabrication of a variety of building components or larger assemblies like MEP (mechanical, electrical, and plumbing) systems. The modular construction approach prefabricates entire modules of a building, such as rooms, apartments, and more, which are transported to the construction site for efficient, highly systematized assembly.

Prefabrication, including modular construction, shifts a certain amount of construction site work to highly organized, controlled facilities, which greatly increases safety and efficiency and makes change management easier. It reduces rework and accelerates project timelines. It also allows the construction industry to benefit from the innovations that Industry 4.0 advanced manufacturing is known for, including automation, flexibility/scalability, and a focus on sustainability.

Additive manufacturing, or 3D printing, has particularly benefitted construction both offsite and onsite. It can handle the offsite production of certain standardized building products, as well as more complex architectural structures like facades. The precision of 3D printing can help reduce waste, and eco-friendly materials are often available. And 3D printing is becoming an increasingly viable option for the onsite creation of entire building structures. Companies like Apis Cor are innovating in 3D-printed construction to produce reliable, affordable housing and other buildings with extruded concrete mixtures.

Combining these advanced construction technologies can amplify their benefits. For example, BIM paired with modular construction could capture all the data from each module into a digital twin for monitoring, managing, and improving them.

INTEGRATION OF MANUFACTURING AND CONSTRUCTION

Industrialized construction, BIM, and digital twins have blurred the boundaries between manufacturing and construction. However, construction remains a unique industry with its own needs. As it becomes a more efficient and digitized version of manufacturing's Industry 4.0, it still requires tools particularly suited to its needs. For example, just as smart manufacturing relies on software platforms to design and make manufactured goods, construction has software to facilitate creating digital twins or prefab building products. Industrialized construction may use some of the same automation and robotics in offsite facilities as manufacturers, but construction robotics are also transforming jobsites with machines like bricklaying and drywall-installing robots or automated surveying drones.

While some of these tools for the two industries differ, the benefits of advanced manufacturing practices are largely the same whether applied to consumer goods or to constructed buildings. Integrating smart manufacturing with construction to produce prefabricated components and modules reduces construction time and material waste while improving quality control. Sophisticated BIM and digital twins ease decision-making and project management with real-time data insights. Offsite construction with robotics and automation boosts precision and consistency while relieving workers of dangerous or repetitive stress-inducing tasks.

Lean construction has also integrated principles from lean manufacturing, such as just-in-time delivery. This delivers prefabricated building products to the jobsite just-in-time for installation, keeping inventory costs low and construction sites free from clutter. A well-run just-in-time schedule can reduce timeline delays and rework.

Optimizing prefabrication and modular construction with integrated techniques from smart manufacturing gives architects and builders greater flexibility to scale projects up or down as needed. It also can significantly cut back on material waste and energy use from more traditional onsite construction methods. Industrialized construction combined with an advanced construction software platform opens up great possibilities to use the most sustainable production practices and materials.

INDUSTRIALIZED CONSTRUCTION: PREFABRICATION PLUS PRODUCTIZATION AND DFMA

Industrialized construction is the application of manufacturing principles to the built environment, especially the principle of connecting the "design" stage with the "make," or construction, stage. The industrialized construction framework combines prefabrication and productization with design for manufacture and assembly (DfMA).

In this context, "prefabrication" refers to the method of physical output, which happens away from the jobsite in a controlled environment taking advantage of advanced manufacturing's various efficiencies. "Productization" points to the standardization of building products into repeatable and configurable units. In construction, productization has led to the standardization of, for example, wall panel systems, bathroom pods, and volumetric modules.

"DfMA" is a rules-based design approach that aims from the outset to customize products for the best fit into a building project. It includes comprehensive product data in the building design process, which means that the prefabrication of those building products doesn't have to occur in isolation; manual rework is significantly lessened; and ultimately, DfMA could progress to configuration at the building level.

EXAMPLES OF THE CONVERGENCE OF MANUFACTURING AND CONSTRUCTION

These six examples show how the convergence of construction and manufacturing improves efficiency, worker safety, and construction-project sustainability.

1. The Project Phoenix modular housing development addresses affordability and sustainability

MBH Architects set out to revitalize an underused area in West Oakland, California, with Project Phoenix, a 300-unit housing complex addressing the necessity of creating affordable and sustainable housing. To achieve the level of efficiency needed for both carbon neutrality and an accelerated timeline for completion, MBH employed a modular design and a generous amount of offsite construction. Factory OS's warehouse-built apartment units fit together "like LEGOs" for quick construction onsite. MBH also made use of innovative carbon-sinking mycelium insulation. Generative design also optimized building placement for levels of sound, wind, and sunlight.

2. Bryden Wood maximizes the potential of DfMA

Some of London's most important transportation arteries have turned to the design and engineering house Bryden Wood to make efficient additions and improvements. The pioneering firm deftly practices design for manufacturing and assembly (DfMA), a methodology for designing building products that are easy to manufacture offsite and, once manufactured, easy to assemble. DfMA optimizes the use of manufactured products and prefabricated assemblies in construction — reducing costs, time, complexity, and environmental impact.

To improve traffic at London's Heathrow and Gatwick airports, Bryden Wood manufactured corridor sections offsite and quickly pieced them together onsite. For the Forge office building, Bryden Wood developed a platform construction system similar to the platforms used by automotive manufacturing to produce multiple cars from the same chassis. Bryden Wood's product-based, standardized offsite construction platform manufactured columns, beams, and other components based on digital modules and then brought them onsite, where they basically snap together to assemble.

3. BamCore multiplies its impact with sustainable materials and prefabrication

Prefabricating building products for onsite construction inherently improves the efficiency of onsite installation. BamCore goes several steps further by manufacturing its wall panels offsite with a mix of bamboo and certain species of eucalyptus — two of the most regenerative botanical fibers in nature — and printing the panels with numbers and installation instructions, making building framing much faster and less expensive.

BamCore's prefab wall panels reduce carbon emissions while also providing superior thermal and sound insulation. The company further simplifies onsite installation by using unified 3D BIM data to workers on smartphones or any other device.

4. The history of prefabrication

Prefabrication, the efficient application of manufacturing techniques to construction, has been around since at least the ancient Roman Empire. 17th-century wood panel homes, the Eiffel Tower, and 20th-century industrialized catalog housing all utilized the principles of prefabrication, where building products are manufactured offsite in a factory or workshop and brought to a construction site for easier assembly.

Modern technology like robotics and automation, BIM, and 3D printing has started a prefab revolution, where prefabrication in construction has reached new heights in efficiency, quality, style, and sustainability.

5. CCEED's towering achievement using prefab construction and BIM

The Tianjin Chow Tai Fook Financial Center was the largest project to date for the China Construction Eighth Engineering Division Corp., Ltd. (CCEED) — a 103-story, super-efficient skyscraper housing its own mini-city of offices, luxury apartments, retail, and a five-star hotel. To reach its goal of LEED Gold Certification for the project, the firm chose efficient technology at every turn, including QR codes for tracking components, virtual reality simulations for testing, drones for site monitoring, and most importantly, building information modeling (BIM). By combining meticulous cloud-hosted BIM models with offsite construction, CCEED manufactured prefab components with the utmost precision, greatly reducing material waste. More than 184,000 total components were catalogued in over 1,000 BIM models. This offered real-time data sharing, boosting efficiency through effective collaboration and reduced errors.

6. Factory OS creates true housing affordability through industrialized construction

To address the affordable housing shortage, Factory OS looks at the entire building process, from the supply chain to onsite construction. In short, the Northern California company seeks a lower final price by finding efficiencies everywhere it can. Its number one method is applying manufacturing techniques to offsite construction.

Factory OS industrializes housing construction by building as much of a housing unit as it can in its offsite facilities and then bringing those modular components to construction sites for assembly. Its systems can reduce waste by as much as 70% and reduce building time by 40–50% compared to traditional methods.

About the Author

Markkus Rovito joined Autodesk as a contractor six years ago and joined the team full-time as a content marketing specialist focusing on SEO and owned media. Since his time with Autodesk, he's developed a great appreciation for exciting emerging technologies that are changing the world of design, manufacturing, architecture, and construction.

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