Prefabrication and modular construction have become increasingly significant in building design and construction management. BIM (Building Information Modeling) combined with fabrication has enabled integrated architecture and engineering workflows that can embrace these technologies. In industrialized production, the digital model becomes the product. For architecture and engineering professionals, drawing sets rely on symbology and design intent, not on specifics of construction and fabrication. This class will present best practices and procedures for modular off-site fabrication. Focused workflows will be demonstrated using the architectural design and documentation capacity of Autodesk software. The digitally fabricated model produced by Inventor software directly informs both the architectural design and the computer numerical control (CNC) components.
Modular Prefabricated Constructions

Prefabricated construction, this term leads most of us to think about complete structures being built in a factory and then transported to the site and set on a foundation. To a great extent, this notion is quite correct.

To put in simpler terms, Prefab or prefabrication is the practice of bringing together components of a structure in a factory or other manufacturing site and then transporting the complete assemblies to the construction site where the structure is planned to be located. This technique controls construction costs by economizing time, wages, and materials. Prefabricated units may include doors, wall panels, floor panels, stairs, window, walls, roof trusses, room-sized components, and sometimes even entire buildings.

This building method has been gaining a lot of popularity and builders across the world are using factory precision and efficiencies to construct quality structures.

The Prefab Concept

Prefabricated construction is a combination of great design with up-to-date high-performance mechanisms and quality-controlled manufacturing procedures. The work is carried out in mainly two stages,

1) **Manufacturing of the components**: Which takes place in the factories or a location that is other than its final location.

2) **Erection of the structure** in the final position.

The different prefabricated sections are produced in huge quantities and then shipped to various construction sites. The precast concrete units are hardened and cast before it is used in the construction. However, sometimes, builders cast components at the construction site and hoist them into the actual location after they harden.
With prefab techniques, bad weather conditions no more hinder the construction process, in fact, it helps in reducing waste in time and materials at the site. This technique also ensures speedy erection of the structures.

**Prefab Modular System**

These systems use all prefab styles and create a whole building structure typically made from factory-constructed units. The buildings are transported to the final construction site and then simply connected to a prepared foundation.

Prefabrication demands the cooperation of architects, builders, and suppliers, regarding the size and specification of basic modular units.

**Advantages**

Prefabricated construction is fetching more popularity, improving in quality and is now available in a variety of different budgets. Let’s now take a look at the advantages of prefabricated construction for both businesses and customers

1. **Construction Time:** The off-site fabrication process takes place in the factory; hence the site preparation activities can go on in parallel. This can significantly help in reducing the overall construction time of a project.

2. **Quality:** Factory controlled processes ensure the products are of a predetermined quality. Also, the indoor environment protects the buildings and the components from climate extremes and destruction.
3. **Safety:** In factory settings, controlling health and safety is much easier

4. **Value:** Faster time to completion of projects can generate income for the clients earlier and also lead to lower site outlays due to less time on site

5. **Sustainability:** Least site disturbance, closely managed material flow and construction waste, and pre-planned assembly/disassembly can help in cutting down the environmental impact of construction. Pre-fab structures are very sustainable because they reduce the amount of waste produced.

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**Decrease in Project Schedule**

- Decrease by 4 Weeks or More, 37%
- Decrease by 3 weeks, 12%
- Decrease by 2 weeks, 15%
- Decrease by 1 week, 8%
- No Change, 22%
- Increase, 6%

**% OF RESPONDENTS**

- Decrease by 4 Weeks or More
- Decrease by 3 weeks
- Decrease by 2 weeks
- Decrease by 1 week
- No Change
- Increase

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**Decrease in Project Budget**

- Decreased 1%–5%, 15% (Contractors), 16% (Engineers), 12% (Architects)
- Decreased 6%–10%, 15% (Contractors), 15% (Engineers), 12% (Architects)
- Decreased 11%–20%, 18% (Contractors), 16% (Engineers), 9% (Architects)
- Decreased more than 20%, 5% (Contractors), 6% (Engineers), 5% (Architects)

**% OF RESPONDENTS**

- Decreased 1%–5%
- Decreased 6%–10%
- Decreased 11%–20%
- Decreased more than 20%

**Source:** Smart Market Report - McGraw Hill Construction - 2015
Integration of BIM Workflow in Modular System

BIM evolved as a superset of the 3D model of a building, containing parametric information supplemented with object relationships, which can support the simulation of a building virtually, permitting experimentation, by modification of design parameters.

A designer will be able to use Modular Coordination (MC) standards to size and locate building objects in a modular reference frame. Integration of rules of MC with BIM authoring tool will enhance the design process and allow designers to automate some complex modelling/documentation activities requiring no design expertise.

The development of rule-based BIM objects exploits the parametric modelling capabilities of BIM authoring tools in addition to visual programming tool to automate the modelling process. The research first explains development of rule based BIM objects which is extended to streamline the overall design process.

In the prototype system, the designer is guided by specific rules and constraints while providing sufficient options to develop variegated configuration. The integration of design rules of MC standards with BIM application will be influential to increase radical use of BIM for built environment especially in the prefabrication industry.

Why BIM for Modular System?

1) Preparing a building component or assembly for fabrication is a time consuming process that depends on numerous complex factors. BIM facilitates a variety of related design/construction activities, including digital fabrication and Shop drawings of building components.

2) BIM enables digital design-to-fabrication workflows for all building disciplines.

3) The fact is that if we use prefab elements or that just need to be assembled in the final location, there are changes during the workflow. That is, you have to choose the elements much earlier and the manufacturer, download them and start the modeling. The architecture studio and the other agents are able to make more precise decisions.

Well, the BIM allows visualizing virtual reproductions of the building or making 3D models that help to correct problems or better choose the materials and, above all, reduce execution costs.
BIM allows to make prefab or modular construction with more efficient workflows than in traditional construction.

A. Example of BIM Workflow [Pre-Cast Concrete Panel fabrication and Installation]

3D Model of Pre-Cast Concrete by BIM Platform

3D Model of Tilt up Panel by BIM Platform
Kit of Parts of Tilt-Up Panel by BIM platform

Individual Tilt-Up Panel Shop drawing by BIM Platform
Panel Production Process in Factory

Assembly Line Panel Installation
B. Example of BIM Workflow [ MEP Assembly in Module & and Installation]

The 3d Modular System Is Where the “True Integration” Really Occurs

Modeling of Module racks and fixing their connection and dimensions

Services accommodation and connections
Connection Process at Site

- **Duct Connectors To Be Used At The End Of Module To Attach With Other Duct of Another Module**

- **Couplings For Connecting Pipes With One Module To Another**

- **Duct Or Pipe Will Be Connected At Site By Coupling Or Welding Or Duct Connector**

Panel Production Process in Factory
BIM is making a shift by industrializing construction

Industrialization in construction means on a high level the use of state of the art on- and off-site production technologies and the standardization of products, elements and modules used. The industrialization of manufacturing processes has already been implemented in other industries, such as automotive, airlines long ago and to some extend as well more recently in plant engineering. And there is a trend that more and more construction companies are looking at manufacturing industries to see if there are principles, processes or tools that can be applicable for the construction industry. So the ideas around the term Building Information Modeling (BIM) get more and more prominent in the industry.

The idea of BIM is to maintain an integrated repository of all the information relevant to a building or construction project throughout the different phases of the project lifecycle. This repository facilitates storing, integrating, checking and visualizing the entire data emerging throughout the project lifecycle. So with other words we talk about a virtual digital model of the physical building or facility. In the past with regards to BIM often the main focus was on just the 3D geometry and the people directly working with the 3D model. More and more the scope of BIM has evolves from just being 3D visualization models to a concept that can help the industry stakeholders in carrying out 360 degree analysis of construction project even before a single brick is laid on the ground.

BIM will support the industrialization because it provides the required granularity to apply on- and off-site production technologies, allowing better reuse of standardized products, elements and modules and on the same time providing customers one-of-a-kind designs. BIM holds great value for the industrialization of the construction phase itself and facility management in the post construction phase. Having a lifecycle focus where information is reused from early design, through construction into maintenance is where the real improvement lies. 4D project scheduling and 5D cost estimation are prominent process examples in which information from 3D models are populated and combined with additional information to drive improvements and to change the way of working. In the future we will see much more additional processes which will be applied as well like,

- Model-Driven Prefabrication
- Model-Driven Sourcing and Procurement
- Model-Driven Operation and maintenance
- Virtual job site planning and logistics
- Virtual Project Execution
- Safety planning / training
- Work packaging and on & off-site construction planning
- Improve Building Performance Through BIM Optimized Facilities Management

So facilitated by the idea of building information modeling the industry moves into an end to end digitalization in construction.

This will help to overcome one of the major problems currently facing project delivery like securing a coordinated, reliable and ongoing flow of information between all parties.
Understand the challenges and critical success factors

1. Typically 100% of modularizing a project is not possible, we want to maximize the areas we can.
2. Changes in design during manufacturing - difficult & expensive to accommodate
3. Geographic location of the factory
4. Specific dimension or loading limitations due to transportation constraints
5. The nature of the construction industry has multiple stakeholders with different mindsets and practices.
6. The increased demand for very effective coordination & communication among participants
7. Manufacturer – quantity of prefabricated components is essential to meet cost effectiveness

Summary

Rapid economic development requires a healthy and sustainable construction industry to meet the demand for facilities and infrastructure. After decades of limited development in industrialization of construction, the widespread adoption of BIM has been seen as a way to accelerate growth of modular and industrialized construction in both the technical and management fields. BIM in the construction industry in the near future, will unearth more benefits of modular and industrialized construction.