

**Platform Design for** Manufacture & **Assembly (P-DfMA):** Optimizing **Construction of** Manufactured **Buildings** CHRIS HOLLAND SALES MANAGER

SMART MODULAR CANADA



# Agenda





- Introduction to Platform Design for Manufacture & Assembly (P-DfMA)
- History of P-DfMA
- Why P-DfMA?
- Examples of P-DfMA in Application
- When Should P-DfMA be Applied?
- P-DfMA at Smart Modular Canada
- Developing P-DfMA Standards
- The future of P-DfMA in Construction

# Introduction to P-DfMA

P-DfMA: Optimizing Construction of Manufactured Building

# An Introduction

#### Modern Methods of Construction (MMC)

- Processes which focus on off-site construction techniques, such as mass production and factory assembly as alternatives to traditional building
- Drives innovation and change within the construction industry

**Platform Design for Manufacture & Assembly** 

- Aims to streamline design, manufacturing & assembly by utilizing standardized components, kits & modules in off-site, factory construction for easy on-site assembly
- A single aspect of MMC that is central to the methodology

#### **Goals Achieved Using P-DfMA**

#### **Mass Customization**

- Finding ways to increase design standardization & also retain sufficient flexibility to maintain individuality from project to project
- Manufacturers standardize wherever possible

#### **Increased Efficiency**

 Optimizes processing, reduces construction time, minimizes on-site disruptions & delivers cost-effective solutions

#### **Decreased Pollution**

Minimizes construction waste, optimizes material usage, reduces on-site noise disturbance & promotes use of sustainable materials

5

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#### Early 20<sup>th</sup> Century

- In the early 1900's, companies like Sears and Roebuck &Co. were selling mail order houses with pre-fab parts
- Significant increase of pre-fab and mass production in WWII



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Prices Buildert to Change.



#### MODERN HOME NO. 668

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Read about the construction of Cur Houses on Page 21

| BITE FOR LATEST | QUOTATION | S ON LUNSER | FOR THIS | HOUSE |
|-----------------|-----------|-------------|----------|-------|
|-----------------|-----------|-------------|----------|-------|

#### Price of Material

| Lorenter, Lock, Shingles, Monthlings, Windows a     | ad Des | en fglated | 1212.45 |
|---|--------|------------|---------|
| Paint, State for Walls and Skingles, subrise sells, | 105    | Windows    | 83.78   |
| Manderate   |        |            | 88.71   |
| Subs  | 1.00   | -          | 15.05   |
| Building Paper                                      | 1.1    |            | \$4.40  |
| Total   |        |            | 1118.81 |

#### Price of Hot Air Heating Plant

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Write as for Prices on Steam and Hot Water Heating

#### **Price of Plumbing Material**

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A page from an Eaton Co. mail order house catalogue from 1917

Fast Taing

#### **Post-War Era**

- Adoption of pre-fab methods continued to develop
- In the first decade after WWII, nearly
   500,000 permanent homes were constructed with prefab



The AIROH house, one of many post-war pre-fab designs, being assembled on site

#### Late 20<sup>th</sup> Century

- Modular construction & pre-fab gained more traction in residential and commercial projects
- P-DfMA principles are integrated into design process to optimize manufacturing & assembly



A pre-fab style restaurant module, popular along the East Coast, instantly recognizable by its long, rectangular shape which made shipping by rail extremely easy

#### **21st Century**

- New BIM technology further developed P-DfMA techniques
- Design-build approach
- Growing environmental awareness encouraged pre-fab to reduce waste and energy consumption



#### Now

- Greater benefits of P DfMA are now being recognized
- Increased use of BIM allows for better coordination & integration of pre-fab design



A graphic outline of some benefits that result from P-DfMA construction techniques

11

#### **Recent Advancements in P-DfMA**

#### **Technological Advancements**

- Advancements in robotics, automation & digital technologies continues to further accelerate P-DfMA adoption
- Also including 3D printing, robotics in manufacturing & advanced materials

#### **Current Trends**

- Today, P-DfMA continues to be a growing trend in construction
- Focused on integrating technology, sustainability & efficiency into the pre-fab process



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#### Efficiency, Savings & Control

#### **Increases Efficiency**

 The controlled environment inside a factory allows for better cost management, reduced material waste & increased economy of scale

#### **Time Savings**

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Pre-fab components can be manufactured concurrently with site preparations reducing project timelines significantly

#### **Quality Control**

Factory conditions promote precision and consistency, reducing errors and defects

#### Safety, Consistency & Innovation

#### **Safety Improvements**

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- Potential for accidents is minimized with reduced need for on-site assembly work and controlled manufacturing environment
- Standard manufacturing processes promotes consistency across multiple projects
- This can lead to improved efficiency, easier project management & better understanding of costs
- Fosters collaboration among architects, engineers, manufacturers & contractors

**Consistent Standards Innovation & Collaboration** 

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#### World Population Growth



United Nations suggest that the world's population could grow to around 8.5 billion in 2030 and 9.7 billion in 2050; it is projected to reach a peak of around 10.4 billion people during the 2080s and to remain at that level until 2100.

 Nearly 25% population growth in just 25 years

# **World Population Growth**

P-DfMA offers efficient, scalable & sustainable solutions tailored to diverse housing needs

P-DfMA can speed up construction, enhance quality & optimize resources making it a valuable approach in the context of population growth and housing needs





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The Ford Model T production line, invented by Henry Ford in 1913



A graphic showing differing end-products created on identical platforms using interchangeable components

### **Automotive Industry**

- In 1913, Henry Ford introduced the worlds first production line
- Combined interchangeable parts with subdivided labour in specialized areas
- Resulted in productivity gains and price reductions
- Inspired manufacturers in many industries to adopt the innovative production method

### IKEA

Uses standardized components across different product lines to simplify manufacturing and assembly

Flat-pack design minimizes packaging space, reduces cost of transport & allows end-user assembly



An IKEA furniture factory, where components are manufactured and packaged





A prefabricated wall panel is craned into place on-site



The factory at Smart Modular Canada where prefabrication occurs

# **Modular Construction**

- Pre-fab Modular builds embrace platform design principles where engineered modules are fabricated in an off-site factory and assembled onsite
- Results in faster construction, reduced cost & reduced environmental impact

### **Electronic Devices**

- Companies like Apple & Samsung have implemented P-DfMA principles in their product design & assembly
- Common components and manufacturing processes are used across multiple devices





Electronic devices are assembled from bins of commonly used components on a production line



These 14 LEGO blocks can be rearranged and interchanged to form a vast number of end-products



One iteration of the blocks created a 3-storey home with 2 car garage

# **LEGO Blocks**

- Highly versatile, modular, quick & easy to assemble
- Many permutations possible from same base components

# When to Apply P-DfMA

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# **Project Inception**

- Should be implemented as early as inception and the conceptual design phase
- Considerations such as project complexity will affect the potential for pre-fabrication



# **During Construction**

A P-DfMA methodology can pick up on design & construction challenges during the fabrication process

Realizing these challenges at this time is an important step in the iterative process of improvement



### **Project Wrap-Up & Completion**

- Feeds back challenges and potential solutions into next design iteration
- Collaborative multidisciplinary meeting should happen at this stage to ensure all challenges are captured

# P-DfMA at Smart Modular Canada

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Operating the CNC router table to manufacture cabinets for pre-assembly at SMC



# **P-DfMA** at SMC

- Many aspects of P-DfMA are integrated into design and construction at Smart Modular Canada
- Developed list of approved standard building components and equipment
- Iterative process that is always improving project to project
- Batch ordering large quantities for multiple
  projects instead of long lead times

#### **Pods: A Standard Room Plan**

- Pods are standardized room layouts complete with walls, fixtures & equipment
- Fit together like building blocks to form a floor plan
- Multiple permutations of the same room to fit an array of customer preferences



A standard Pod Bath/Utility room combination



This single wide module design is quickly created by placing a standard kitchen pod next to a bath/utility room pod



Webbed floor trusses complete with mechanical chase are a new standard being implemented in floor construction at SMC



LVL timbers are used for rim beams as a standard in floor construction at SMC

#### **Standard Floor Construction**

- Webbed floor truss system including a mechanical chase
- Allows for 3 standard widths of modules 12', 14' & 16'
- Ordered in large batches for multiple concurrent projects avoiding long lead times and increasing economy of scale

# **Standard Fixtures & Equipment**

- Standard fixtures & equipment used in most applications where repeatability is possible
- All fixtures & equipment go through an approval process
- Including but not limited to HRV's, casework, electrical panels, appliances & lighting fixtures



Fixtures, equipment & furniture options are standardized across multiple projects



Equipment controls are also standardized for use with specific equipment



The CNC router table deployed by SMC to cut cabinets from CAD files



The CNC component saw at SMC which cuts using a program linked with Revit

# **Factory Automation**

- CNC router table for fabricating custom cabinet components
- CNC component saw cuts wood framing members to length from BIM floor & wall panels

# **Standard On-Site Assembly**

- Developed a procedure to assemble completed modules on-site
- Procedure remains the same for all modules fitted together side-by-side



# Developing P-DfMA Standards

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### **Clearly Define Objectives**



#### DEFINE INTENTION OF DEVELOPMENT OF STANDARD DESIGN ELEMENTS

IMPROVE EFFICIENCY, EASE OF ASSEMBLY, REPEATABILITY, REDUCED COST & SUSTAINABILITY

# **Define Design Constraints**





Specify constraints like space, power requirements, structural requirements, manufacturing tolerances & other technical details This also includes adherence to codes, regulations and standards

# **Multidisciplinary Engineering**



Include professionals and advisors from design, engineering, manufacturing, construction & quality control from the start of design process



Ensures comprehensive approach to design that considers various perspectives



# **Outline Assembly Strategy**

| Create      | Create clear & complete assembly instructions                               |
|-------------|---|
| Sequence    | Sequence of assembly, connections & other relevant details for on-site work |
| No Guessing | Leave nothing to guess work or interpretation                               |

### **Create 1st Iteration**





Implement standardized component into a design and construct for the first time Paying close attention to challenges in both manufacturing & assembly

### **An Iterative Improvement Process**

As challenges are identified, standardized components can be redesigned to eliminate those challenges through an iterative design process

Further challenges will likely result from changing the design

The iterate and build cycle can go on for some time until arriving at a final solution

# **Standard Components Catalogue**



Components are added to a catalogue of approved standard components to be used in design, manufacturing & assembly



If a component becomes unavailable, the process begins again with a new standard



An approved substitute should always be in place in case of supply shortage or unavailability

# The Future of P-DfMA

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#### **P-DfMA is the Future of Construction**

- A continued evolution towards more efficient, sustainable
   & technologically advanced practices
- P-DfMA is poised to play a central role in shaping the future landscape of construction methodologies



"Innovation is the calling card of the future. From the complexities of design to the simplicity of a nail, each innovation is a step forward in the grand story of construction."

FRANK LLOYD WRIGHT

ARCHITECT, DESIGNER & WRITER



# Thank you!

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