

MODULAR CONSTRUCTION

Council



Conseil de la
CONSTRUCTION MODULAIRE

**Canadian
Home Builders'
Association**

**Association
Canadienne
Des Constructeurs
D'Habitations**



Photo courtesy of: Royal Homes



Photo courtesy of: Triple M Housing



Photo courtesy of: Triple M Housing



Photo courtesy of: Royal Homes, Kohn Shnier Architects

WORKING WITH MODULAR

CHBA Webinar Series 2022/2023

chba.ca/modular

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D'Habitations**

- 1. MODULAR CONSTRUCTION 101 (APR 28 2022)**
- 2. MODULAR AND THE ENVIRONMENT (MAY 26 2022)**
- 3. THE FACTORY-BUILT PROCESS (DEC 15 2022)**
- 4. CODE COMPLIANCE FOR MODULAR (JAN 2023)**
- 5. FINANCING FOR FACTORY-BUILT (MAR 2023)**
- 6. INDUSTRY TRENDS, DATA & SHOWCASE (TBD)**



Photo courtesy of: Royal Homes



Photo courtesy of: Triple M Housing



Photo courtesy of: Triple M Housing



Photo courtesy of: Royal Homes, Kohn Shnier Architects

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THE FACTORY-BUILT PROCESS

- 1 The factory process step-by-step
- 2 Analysis of the factory process



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THE FACTORY-BUILT PROCESS

Today's Guest Speakers:

- Simarjit Bains & Rick Weste, Triple M Housing
- Dr. Mohamed Al-Hussein, University of Alberta





How does the factory process work?

- “Overview”
- Step-by-Step Factory Process
- Schedule & Savings





Before we go in ...

Triple M Housing, Lethbridge, AB

- 31 acres
- Main Plant: 192 000 ft²
- 12 000 ft² Sawshop & Welding Shop
- Over 400 employees
- Day & night shifts
- 21 workstations
- 12 drywall stations
- Avg. floor size: 20' x 76'
- Max. floor size: 30' x 76'
- 10-21 days to completion
- Various building types





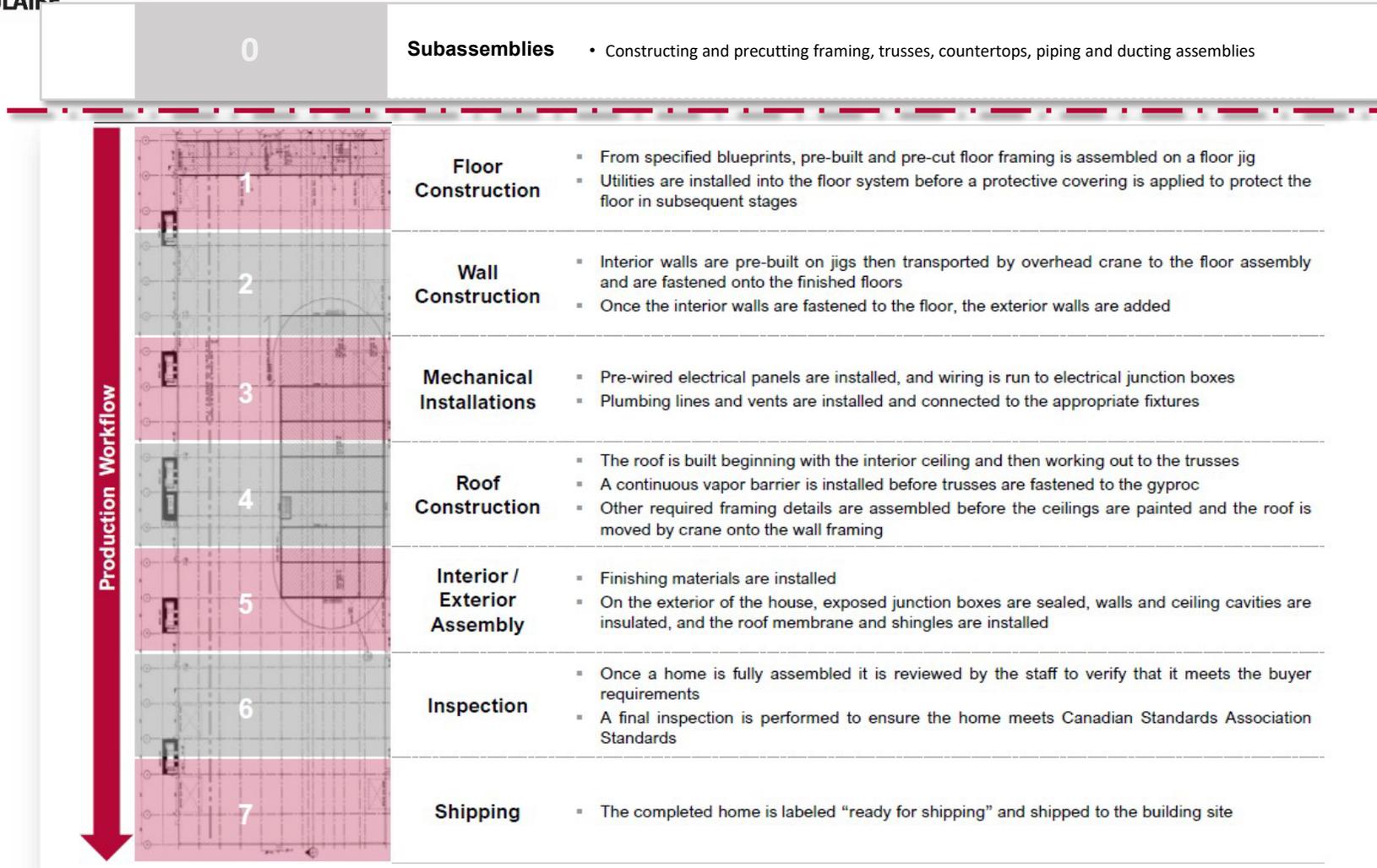
Before we zoom into every step ...

Modular Construction

- Built inside-out vs outside-in
- Construction process lends itself to creating airtight building
- If change is requested, factory setting allows for a solution to be properly implemented without compromising building envelope
- Factory is temperature-controlled



Step-by-Step – Factory Process Flow





Step-by-Step – Subassemblies

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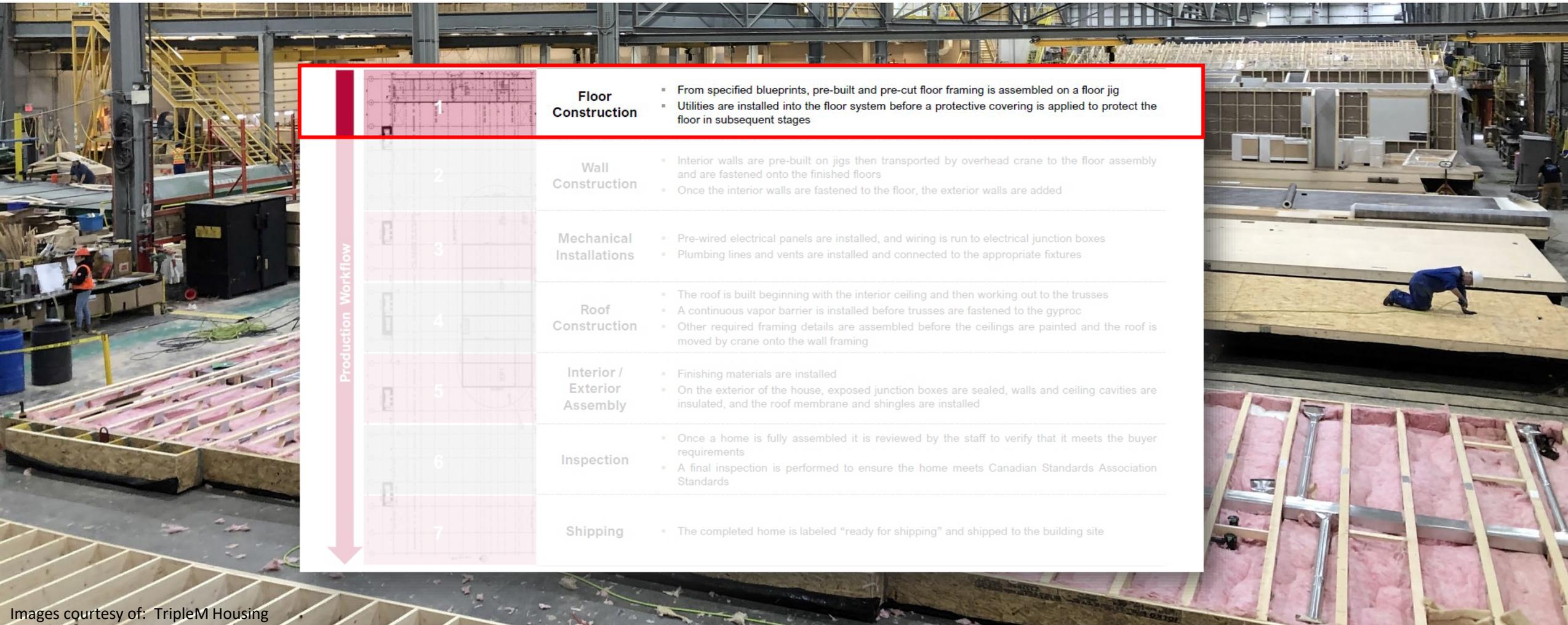
Subassemblies • Constructing and precutting framing, trusses, countertops, piping and ducting assemblies



Images courtesy of: TripleM Housing



Step-By-Step – Floor Construction



Production Workflow	1	Floor Construction	<ul style="list-style-type: none"> From specified blueprints, pre-built and pre-cut floor framing is assembled on a floor jig Utilities are installed into the floor system before a protective covering is applied to protect the floor in subsequent stages
	2	Wall Construction	<ul style="list-style-type: none"> Interior walls are pre-built on jigs then transported by overhead crane to the floor assembly and are fastened onto the finished floors Once the interior walls are fastened to the floor, the exterior walls are added
	3	Mechanical Installations	<ul style="list-style-type: none"> Pre-wired electrical panels are installed, and wiring is run to electrical junction boxes Plumbing lines and vents are installed and connected to the appropriate fixtures
	4	Roof Construction	<ul style="list-style-type: none"> The roof is built beginning with the interior ceiling and then working out to the trusses A continuous vapor barrier is installed before trusses are fastened to the gyproc Other required framing details are assembled before the ceilings are painted and the roof is moved by crane onto the wall framing
	5	Interior / Exterior Assembly	<ul style="list-style-type: none"> Finishing materials are installed On the exterior of the house, exposed junction boxes are sealed, walls and ceiling cavities are insulated, and the roof membrane and shingles are installed
	6	Inspection	<ul style="list-style-type: none"> Once a home is fully assembled it is reviewed by the staff to verify that it meets the buyer requirements A final inspection is performed to ensure the home meets Canadian Standards Association Standards
	7	Shipping	<ul style="list-style-type: none"> The completed home is labeled "ready for shipping" and shipped to the building site

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Step-by-Step – Floor Construction



Step-by-Step – Floor Construction

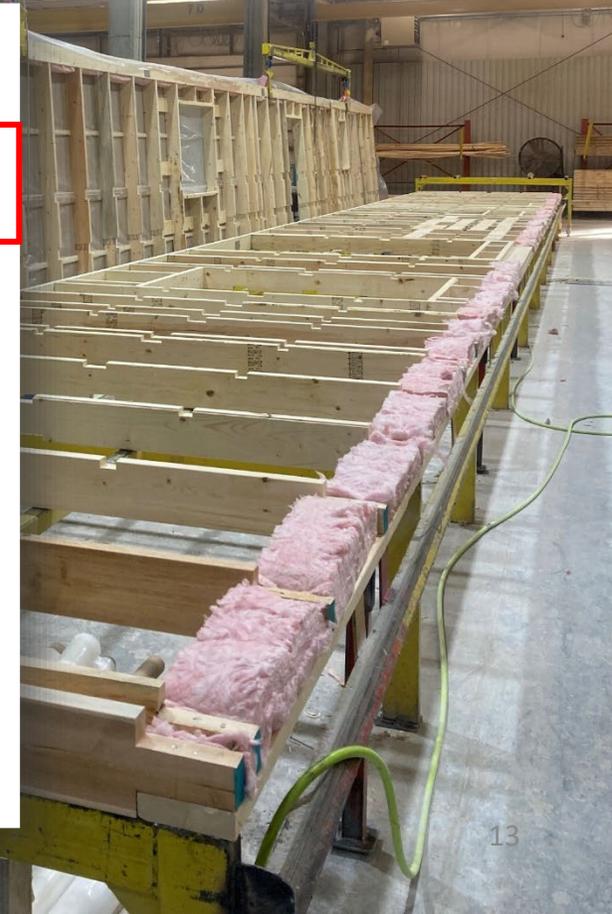




Step-by-Step – Wall Construction



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Step-by-Step – Wall Construction



Images courtesy of SRI Kelowna

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Step-by-Step – Wall Construction



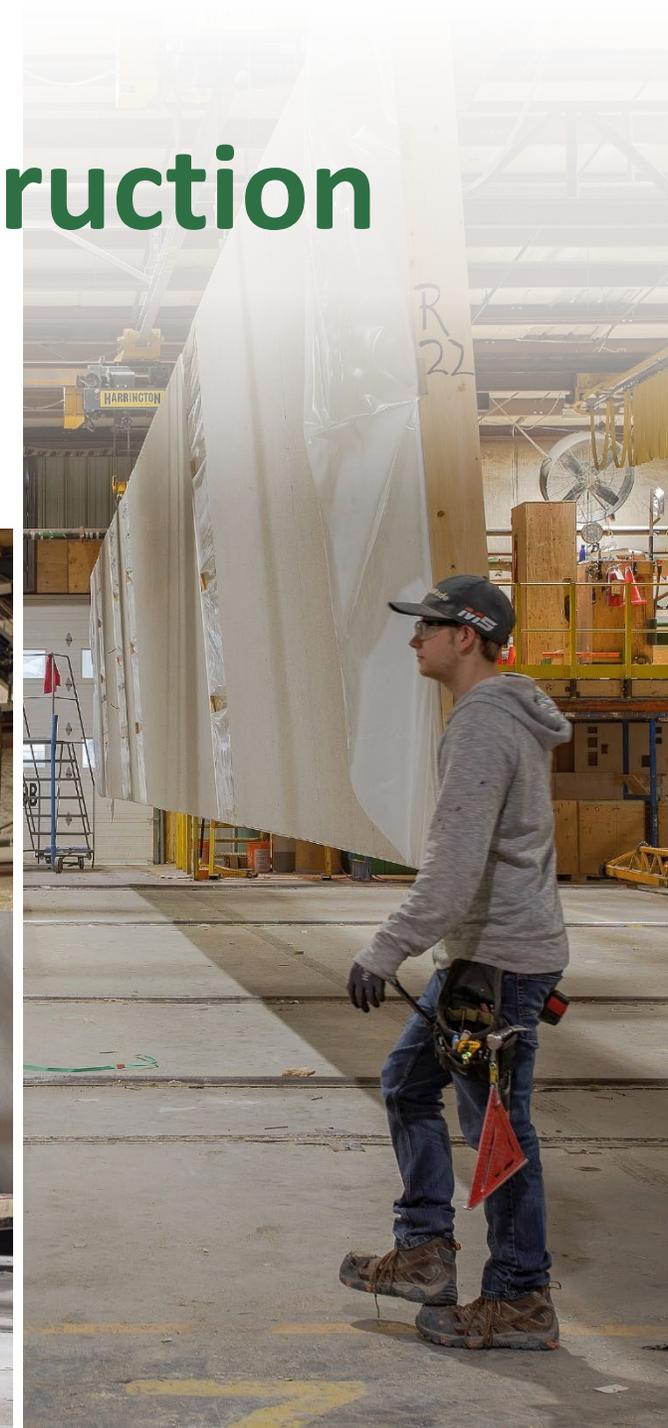
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Step-by-Step – Wall Construction



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Step-by-Step – Wall Construction





Step-by-Step – Mechanical Installations

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Step-by-Step – Mechanical Installations





Step-by-Step – Roof Construction

Production Workflow	1	Floor Construction	<ul style="list-style-type: none"> From specified blueprints, pre-built and pre-cut floor framing is assembled on a floor jig Utilities are installed into the floor system before a protective covering is applied to protect the floor in subsequent stages
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Step-by-Step – Roof Construction



Images courtesy of: TripleM Housing

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Step-by-Step – Roof Install

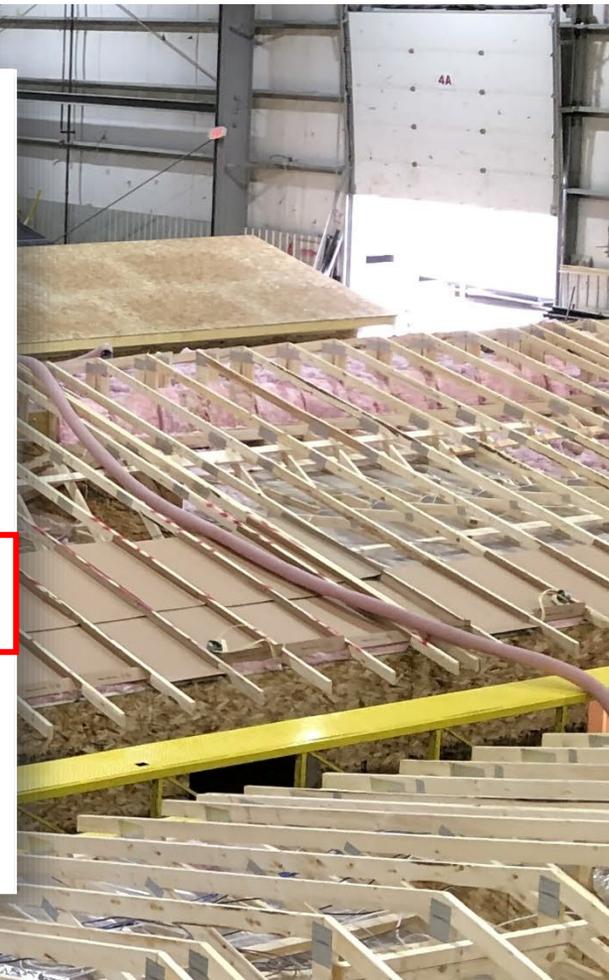


Images courtesy of SRI Kelowna



Step-by-Step – Exterior Assembly

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Step-by-Step – Exterior Assembly



Images courtesy of: TripleM Housing

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Step-by-Step – Interior Assembly

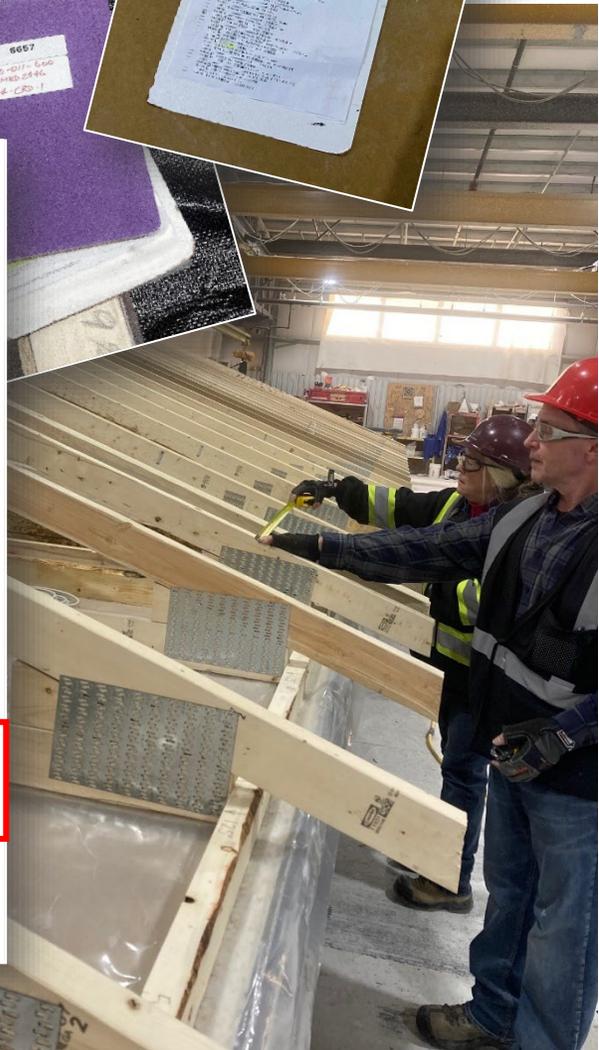
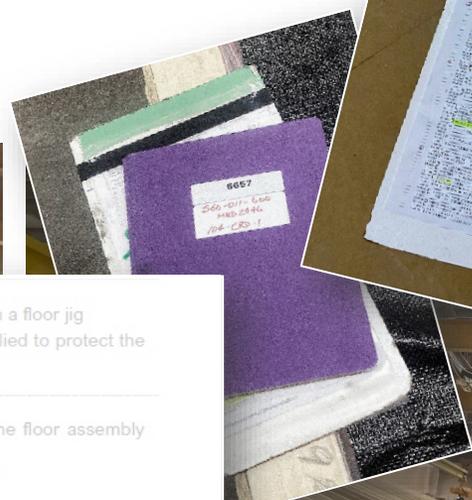


Step-by-Step – Interior Assembly

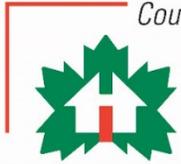




Step-by-Step – Inspection



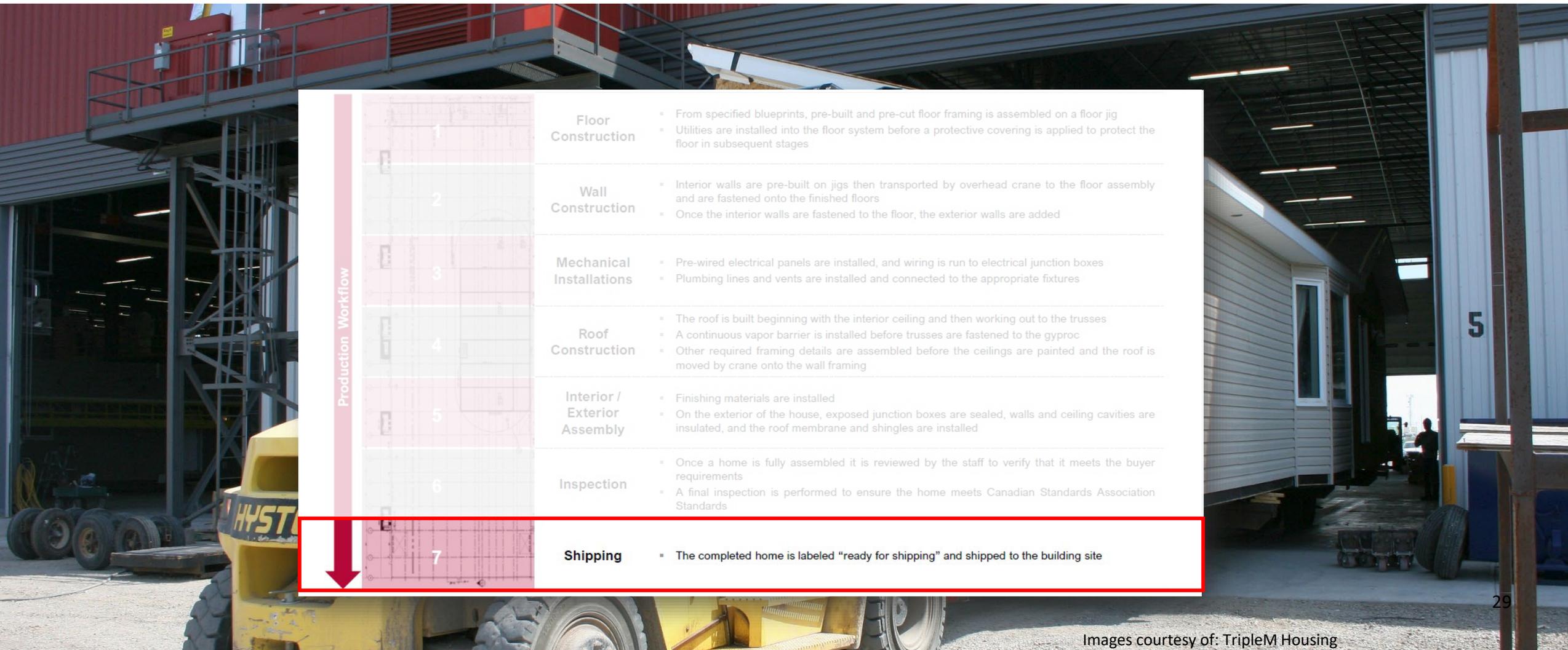
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Step-by-Step – Inspection



Step-by-Step – Shipping



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Step-by-Step – Shipping Package



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Step-by-Step – Shipping



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Step-by-Step – Non-disruptive Siting



Step-by-Step – Transport and Siting



Images courtesy of: Big Block Construction through NRCan funded "Affordable, Replicable, Marketable Net Zero MURB" project

Step-by-Step – Install



Image courtesy of: Big Block Construction through NRCan funded “Affordable, Replicable, Marketable Net Zero MURB” project

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Step-by-Step – Finished Product



Royal Homes



Triple M Housing



Grandeur Housing



Royal Homes

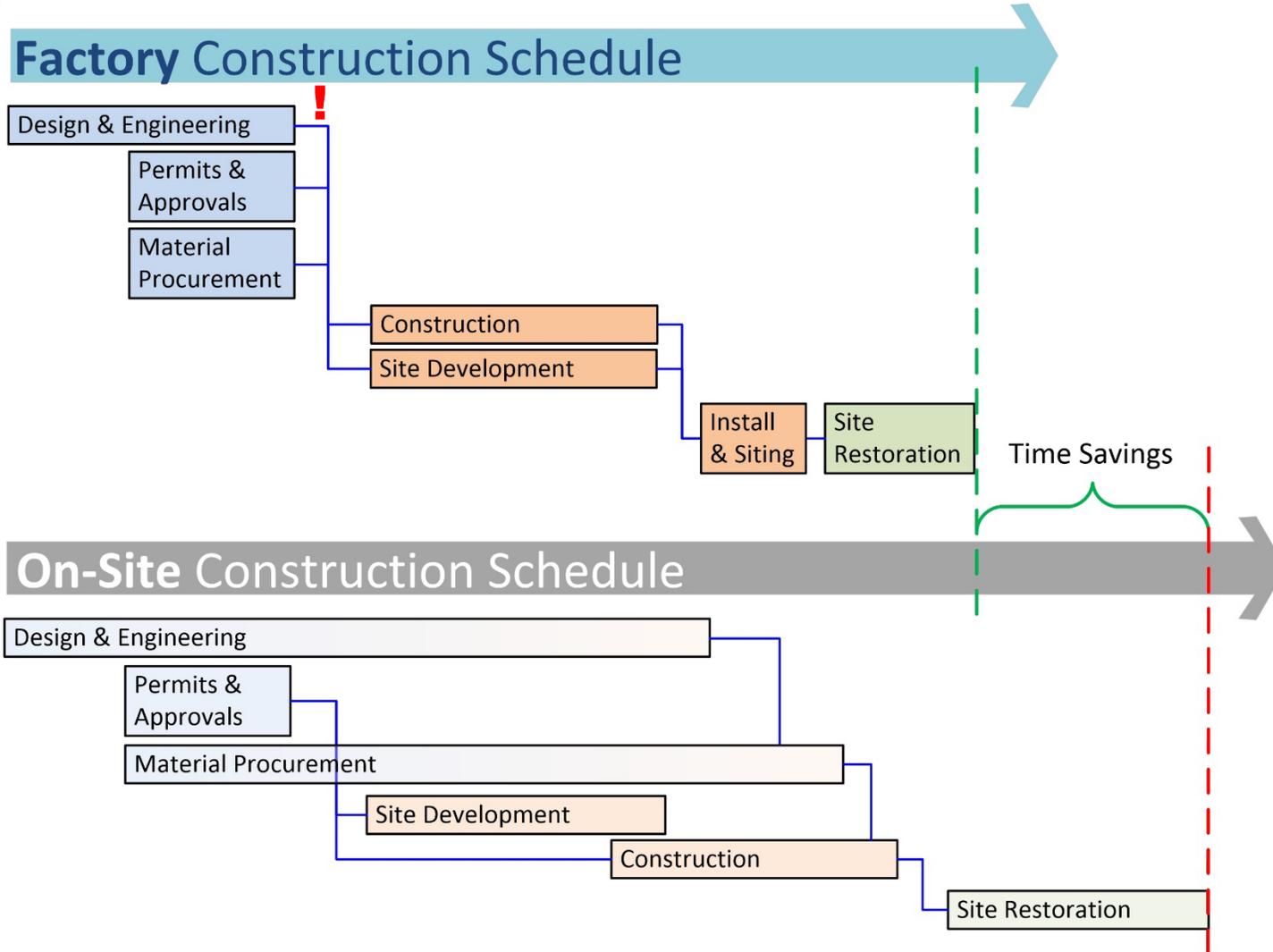


Guildcrest



Brookside

Construction Schedules





Analysis of the factory process

- Efficiencies in the factory process
- Transformation from on-site to off-site (case study)



Transformation from Conventional to Panelized Construction

Factory Efficiency: the quest to predictability

Mohamed Al-Hussein

Email: malhussein@ualberta.ca



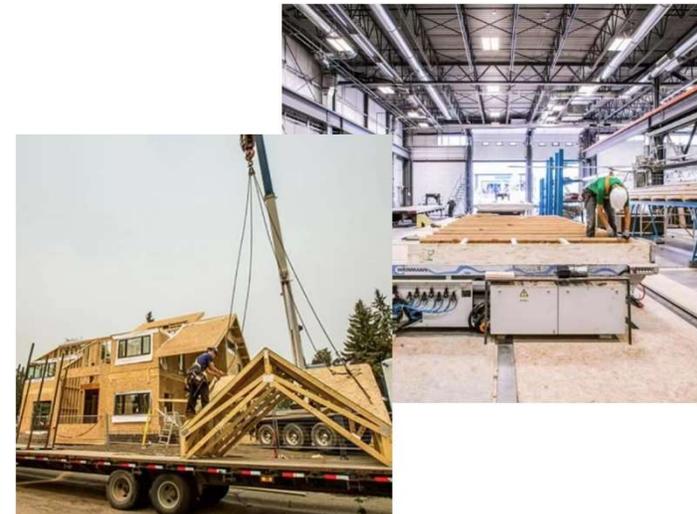
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ALBERTA



THE CASE OF A PRODUCTION BUILDER FROM (100%) CONVENTIONAL FOR 35 YEARS TO (100%) PANELIZED CONSTRUCTION

BACKGROUND

Landmark, which has around 44-years' history, is a well-known residential home builder in Alberta. It started changing from conventional (stick-build) construction method to panelized construction method since 2005. Until 2012 it has built a completely panelized production line. By comparing Landmark's previous production with the current, we find that this kind of transformation will lead to a highly improvement on production rate and a reduction in CO2 emissions and operation fees.



**(100%) CONVENTIONAL
CONSTRUCTION FOR 35
YEARS**



**(100%) PANELIZED
CONSTRUCTION**

LIST OF HYPOTHESES



Number of Superintendents



Production Rate



Invoices



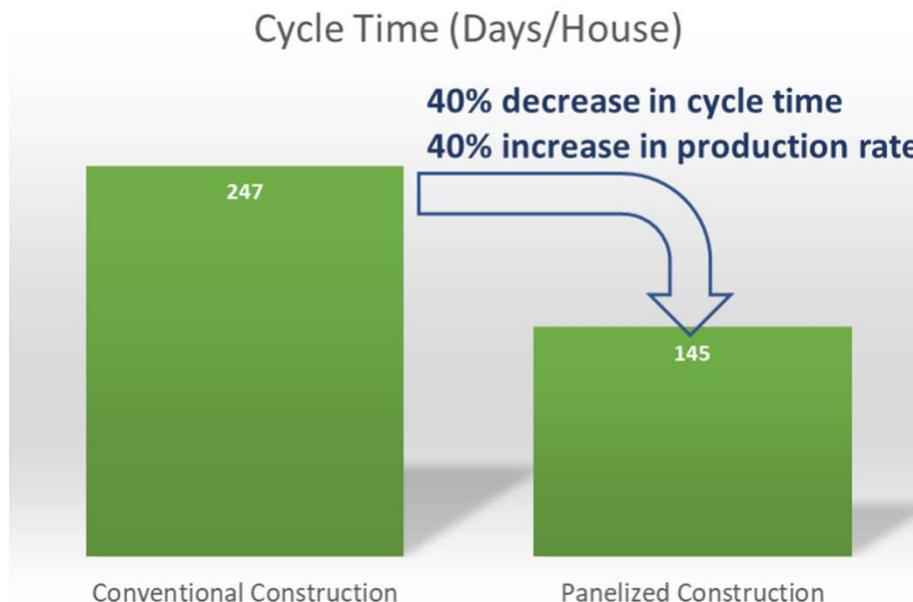
Inspections



Office Space vs Plant Space

PRODUCTION RATE

Comparing with conventional construction method, the cycle time of panelized construction will **decrease about 97 days**, changing **from 247 days** per house **to 145 days** per house.



Cycle time reduced by:

- Less uncertainties related to the hand-off to different trades
- Smoother turnover from house to house
- Higher predictability

NUMBER OF SUPERINTENDENTS

The required number of superintendents will reduce from **46** to **27**.

For building **1000 houses / year**:

Conventional

Panelized

Average cycle time:

247 Days/ House

145 Days/House

Turn over rate:

$365 / 247 = 1.478$ Batches / year

$365 / 145 = 2.517$ Batches / year

Average number of houses one superintendent can manage at the given cycle time:

15 houses/batch/superintendent

15 houses/batch/superintendent

Number of the completed houses per superintendent per year:

$1.478 * 15 = 22.17$ houses/superintendent/year

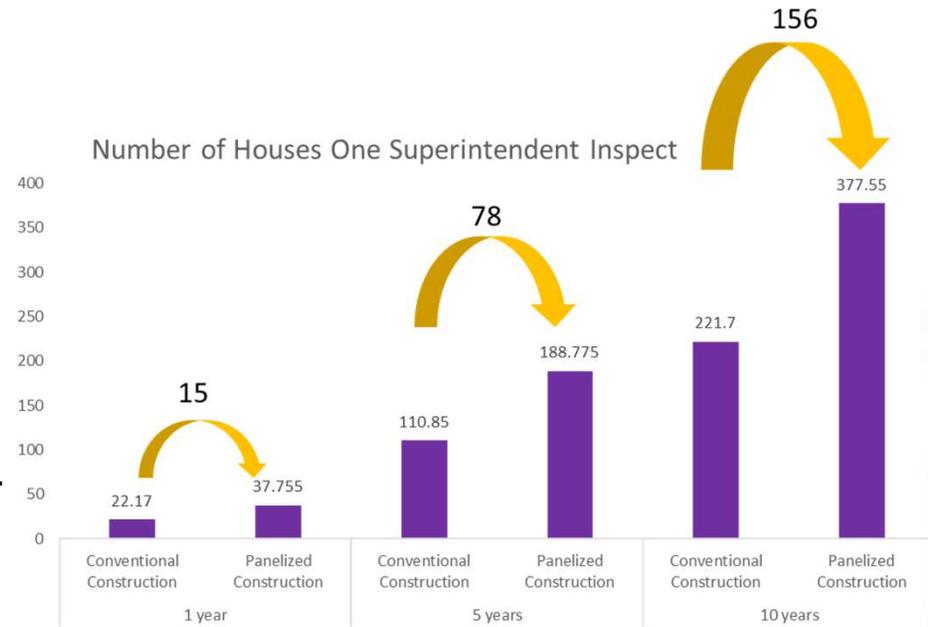
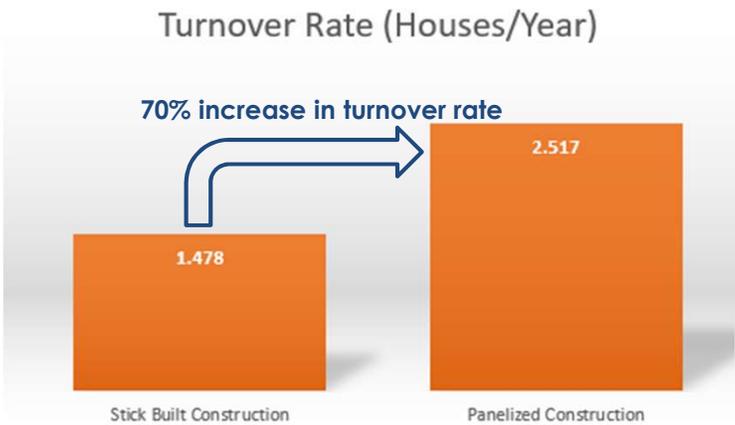
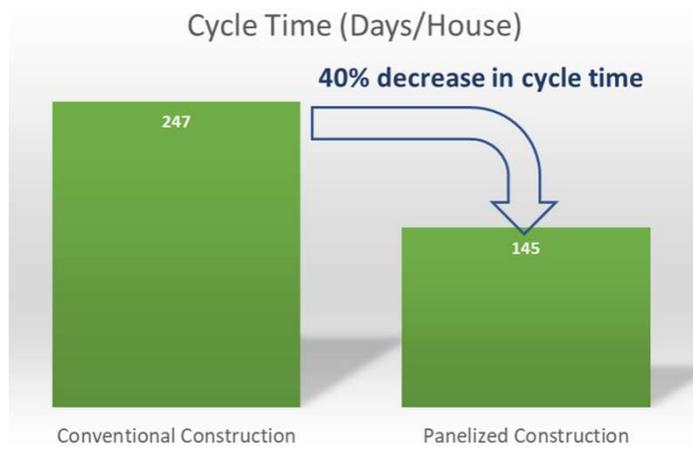
$2.517 * 15 = 37.75$ houses/superintendent/year

Number of the required superintendents:

$1000 / 22.17 = 46$ superintendents

$1000 / 37.75 = 27$ superintendents

NUMBER OF THE MANAGED HOUSES PER SUPERINTENDENT

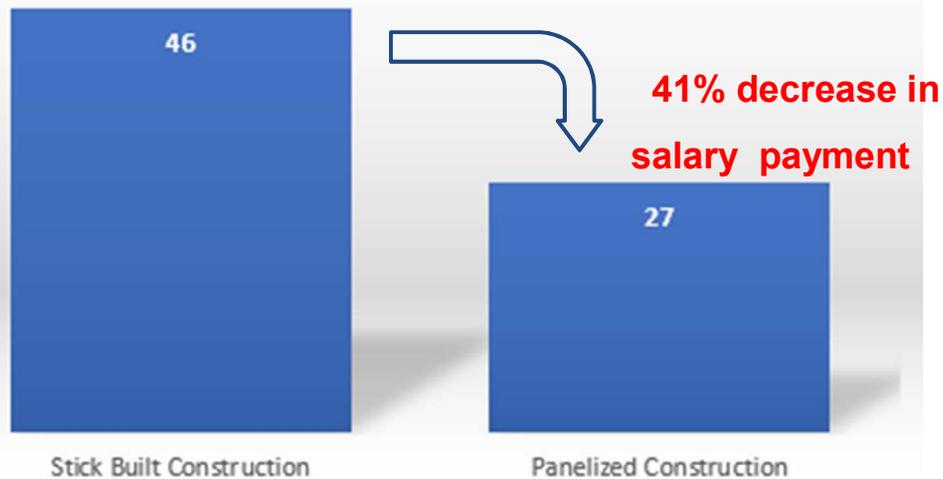


With the application of panelized construction, the number of the houses one superintendent can inspect per year will increase by 15 (5 years increase by 78, 10 years increase by 156).

NUMBER OF SUPERINTENDENTS

For building 1000 houses per year, the required number of superintendents will reduce from **46** to **27**.

Number of Superintendents



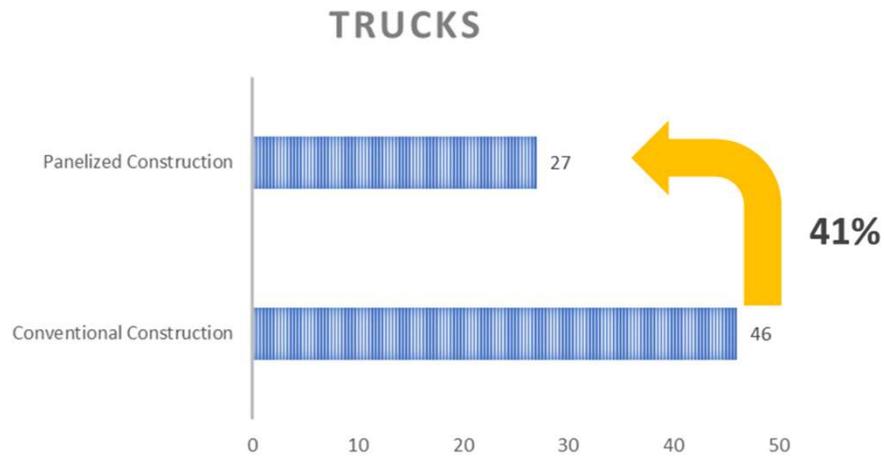
For building **1000** houses / year



Further Effect

- Number of pickup trucks
- Oil consumption
- CO2 Emission

NUMBER OF SUPERINTENDENTS - PICKUP TRUCKS

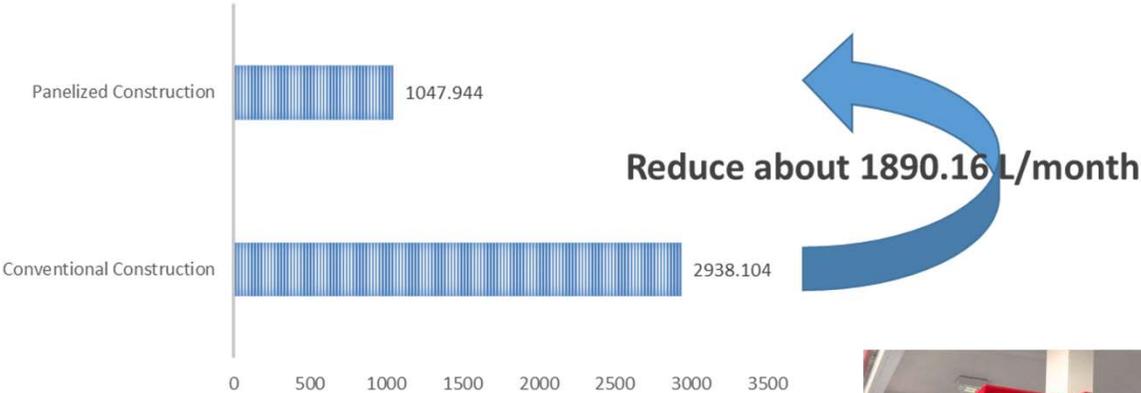


The reduction of superintendents will lead to about 41% reduction on pickup trucks.



NUMBER OF SUPERINTENDENTS - FUEL CONSUMPTION

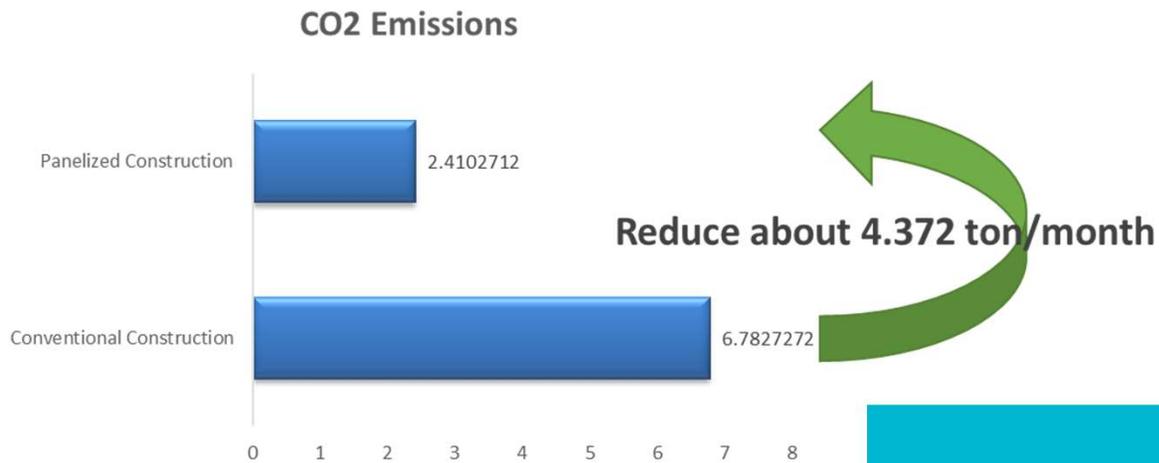
FUEL CONSUMPTION / MONTH



The reduction of trucks will reduce fuel consumption 1890.16 Litres/month which is 22,681.92 L/year



NUMBER OF SUPERINTENDENTS - CO2 EMISSIONS



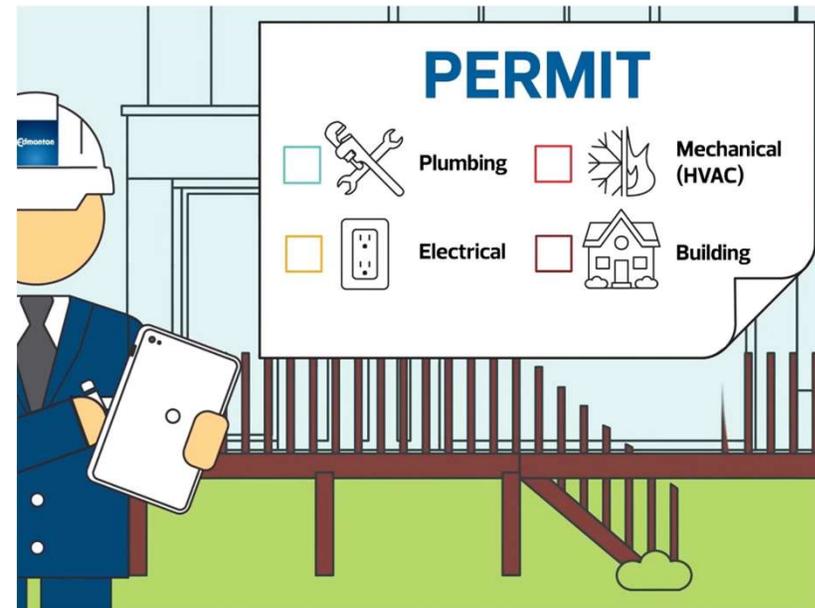
The reduction of trucks will lead to 4.37 ton less CO2 emissions per month, 52.46 ton less per year



INSPECTIONS

The city of Edmonton conducts inspections in the following areas:

- Heating, Ventilation, and Air Conditioning (Mechanical HVAC)
- Plumbing and gas
- Electrical
- Building



A fee of \$270 is charged for every reinspection after failing to correct previously detected deficiencies.

Source: https://www.edmonton.ca/residential_neighbourhoods/safety-codes-permits-and-inspections

INSPECTIONS - STICK BUILT VS PANELIZED CONSTRUCTION

Stick-Build Construction

Average of two additional inspections for each area

Total Additional Inspections: 8

Total Additional Cost of Inspections: \$2,160



Panelized Construction

No additional inspections are required

Total Additional Inspections: 0

Total Additional Cost of Inspections: \$0



Source: https://www.edmonton.ca/residential_neighbourhoods/safety-codes-permits-and-inspections

INVOICES

The average cost of issuing one invoice is 60\$



The 10% decrease in the number of invoices being issued is a result of the framing method related to panelized construction

John Doe
128 First Avenue
Sydney, New South Wales 2251
Australia

Construction Invoice

Bill To Henry Higgins
1 Main St.
Melbourn, Victoria 3035
Australia

Invoice no. 0000
Date 2019/12/11

Description	Quantity	Unit price	Amount
Construction Materials	100	\$150.00	\$15000.00
Construction labourers	9	\$300.00	\$2700.00
Total			\$17700.00

Stick Built Construction → **160 invoices issued**

Panelized Construction → **150 invoices issued**

INVOICES

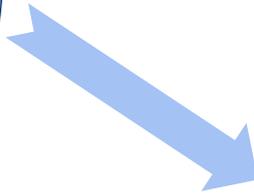
Material
Purchase
Order

- Lumber package
- Window & Doors
- Roof Trusses
- joists
- Stairs

Labour
Purchase
Order

- ❖ Framer
- ❖ Siding Contractor
- ❖ Roofing Contractor
- ❖ Deck Contractor

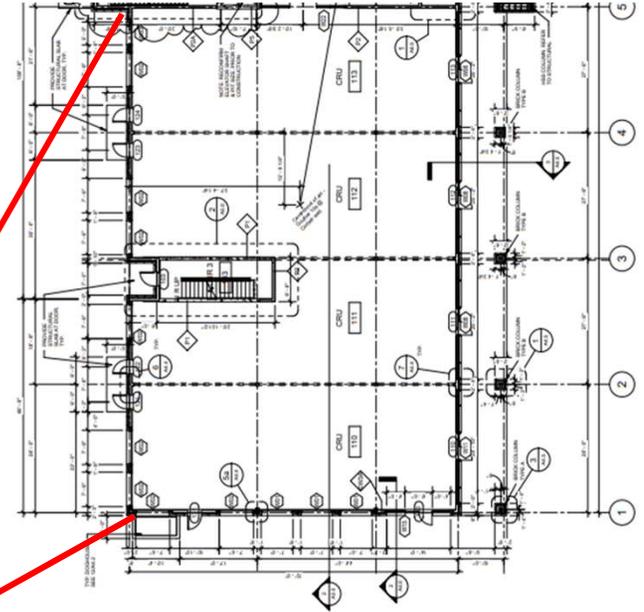
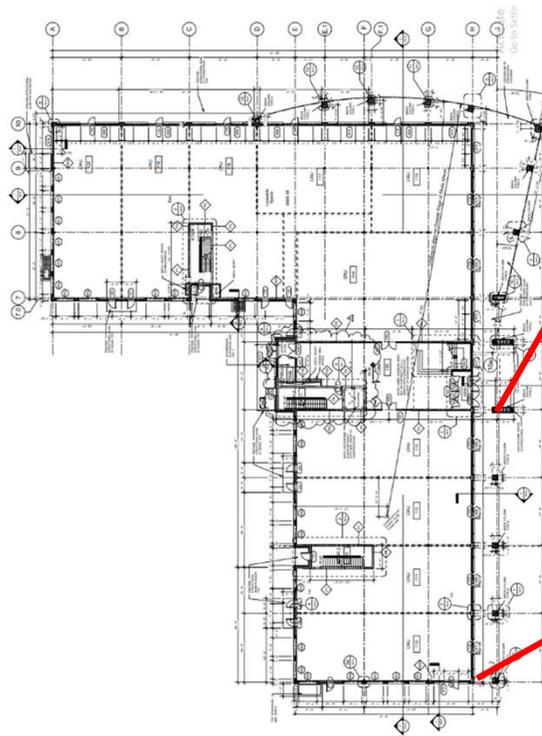
**Stick Built
Construction**



Combine **9**
purchase order into
1 purchase order

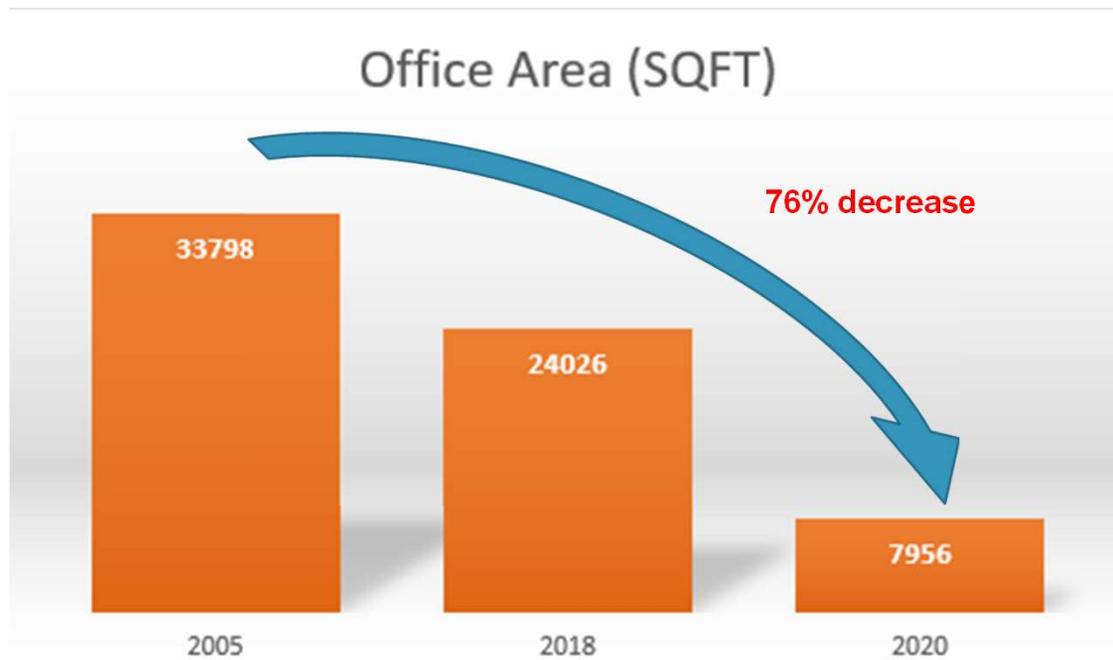
**Panelized
Construction**

OFFICE AREA CHANGE



OFFICE AREA CHANGE

The required office area will reduce from to 33798 SQFT 7956 SQFT →



Transformation from Conventional to Panelized Construction

Factory Efficiency: the quest to predictability

Mohamed Al-Hussein

Email: malhussein@ualberta.ca



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BUILDING INDUSTRIALIZATION

2



BUILDING INFORMATION MODELING (BIM)

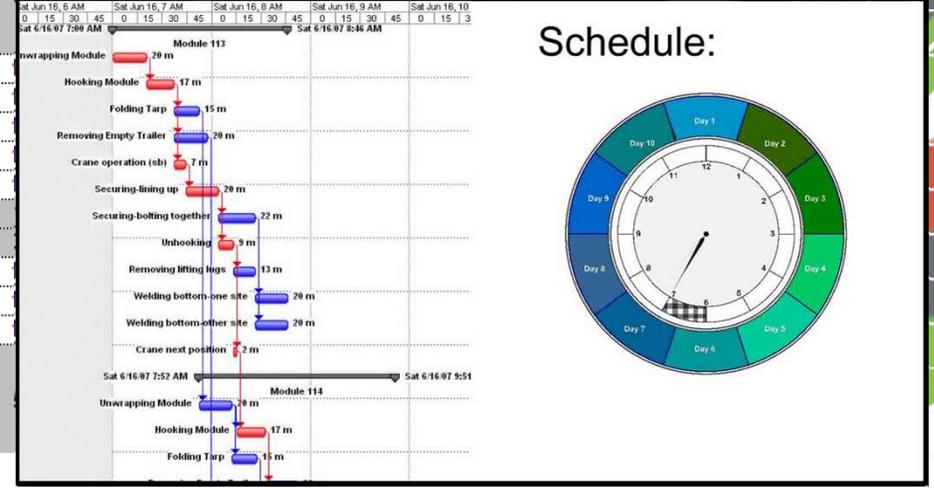
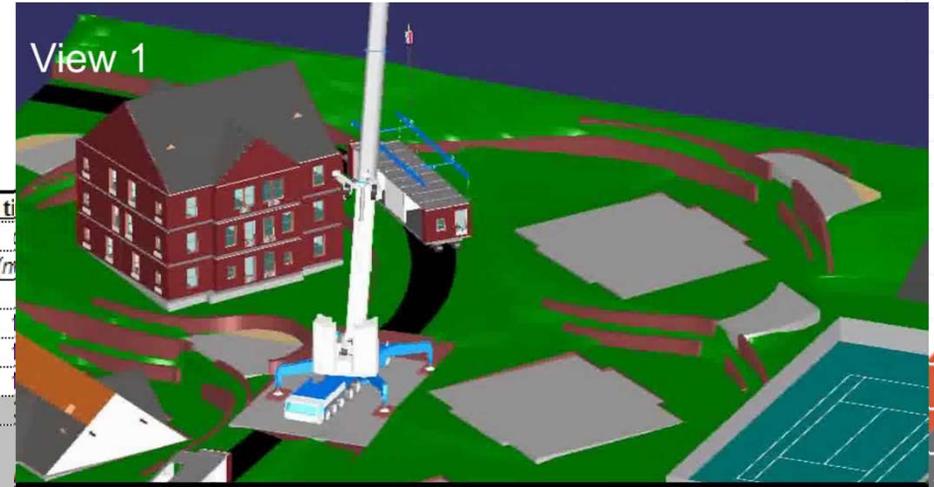
SIMULATION AND POST-SIMULATION 3D-VISUALIZATION AND ANIMATION



RESEARCH OBJECTIVE SEVEN

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oper code	activity/operation	module	place		workers/crane time		
			start	crew	p (min)	m (min)	t (min)
13-Jun-07							
K1	unwrapping module	113	B1	4	25	20	
K1	hooking module	113	B1	4	20	17	
K1	folding tarp for next module		B1	4	25	15	
T1	removing empty trailer		B1		7	5	
C-sb	load hoisting up	113	B1				
C-sb	load booming up	113			10	7	
C-sb	load swing	113					
C-sb	load hoisting down	113					
K2	securing-lining up	113	PB1-1	1	30	20	
K2	securing-bolting together	113	PB1-1	2	30	22	
K2	unhooking-remove lift lugs	113	PB1-1	2	25	22	
K3	welding bottom - one side	113	PB1-1	1	30	20	
K3	welding bottom - other side	113	PB1-1	1	30	20	
C-sb	return to next position		PB1-1		3	2	
T2	placing trailer module for lifting	114	-		7	5	
K1	unwrapping module	114	B1	4	25	20	
K1	hooking module	114	B1	4	20	17	
K1	folding tarp for next module		B1	4	25	15	
C-sb	load hoisting up	114	B1				
C-sb	load booming up	114			10	7	
C-sb	load swing	114					
C-sb	load hoisting down	114					



FLOOR ASSEMBLY (WHAT CAN YOU DO TO REDUCE THE TIME BY 50% AND THE HUMAN EFFORT BY 80%; USING THE SAME TOOLS)



7 WASTES IN LEAN THEORY



Motion

Transportation

Defects

Overproduction

Waiting

Inventory

Over-processing



ELIMINATING WASTE IN PRODUCTION

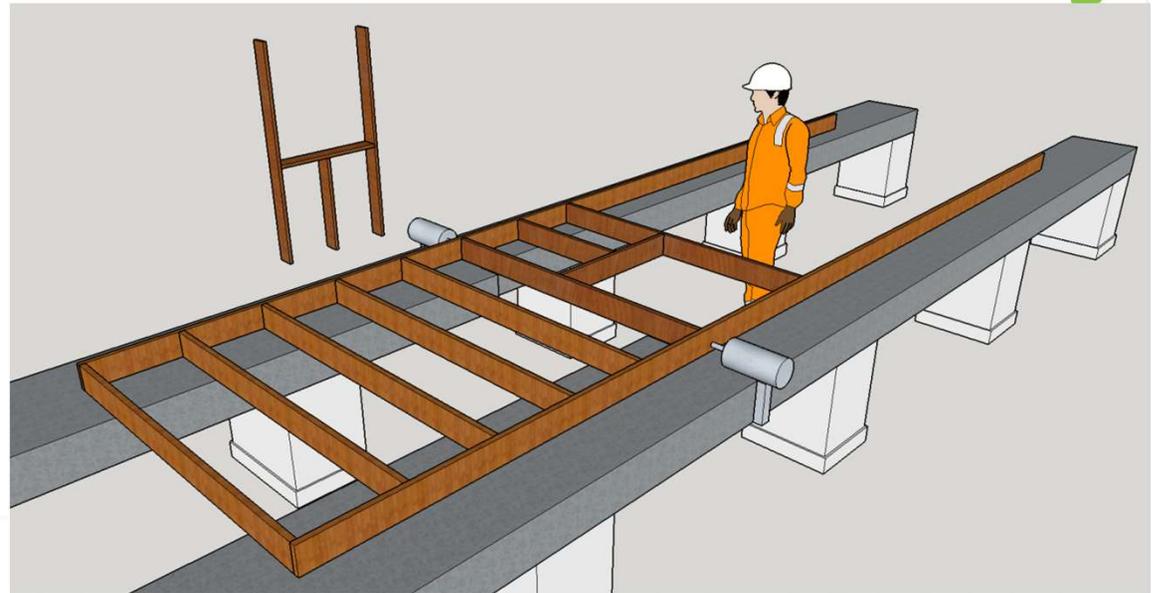
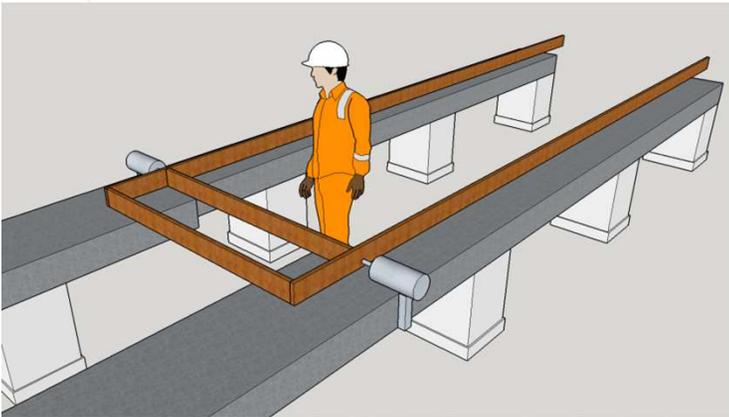
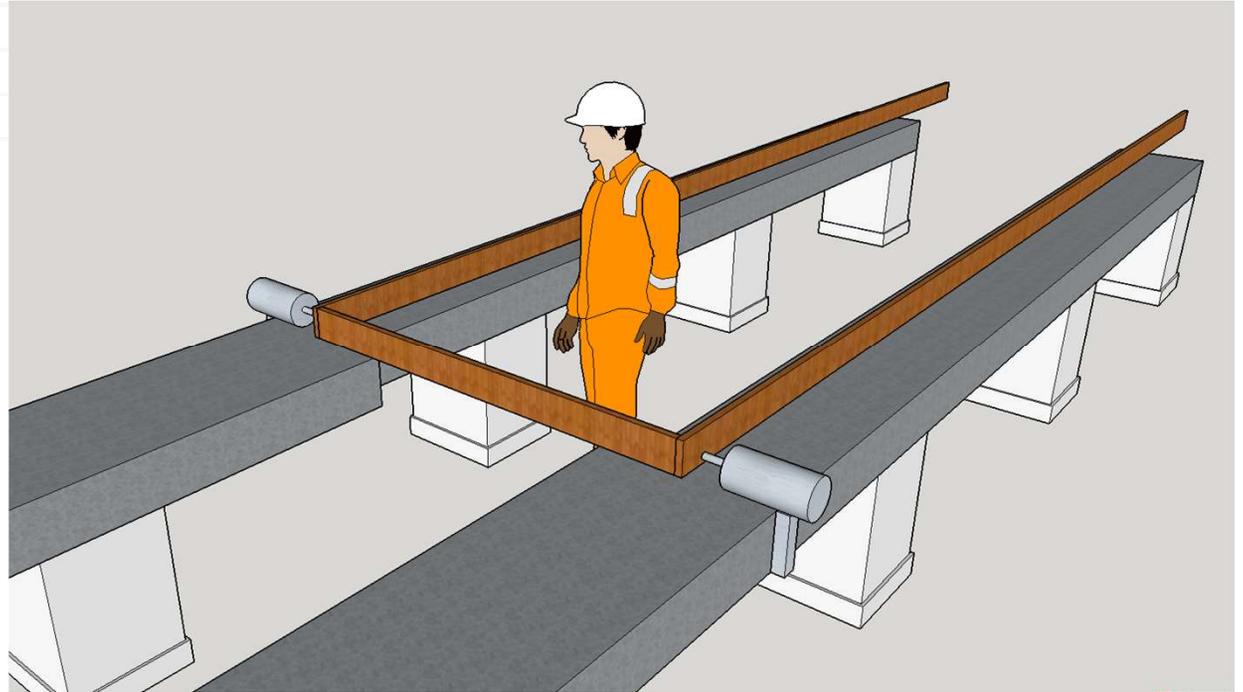


ELIMINATING WASTE IN PRODUCTION

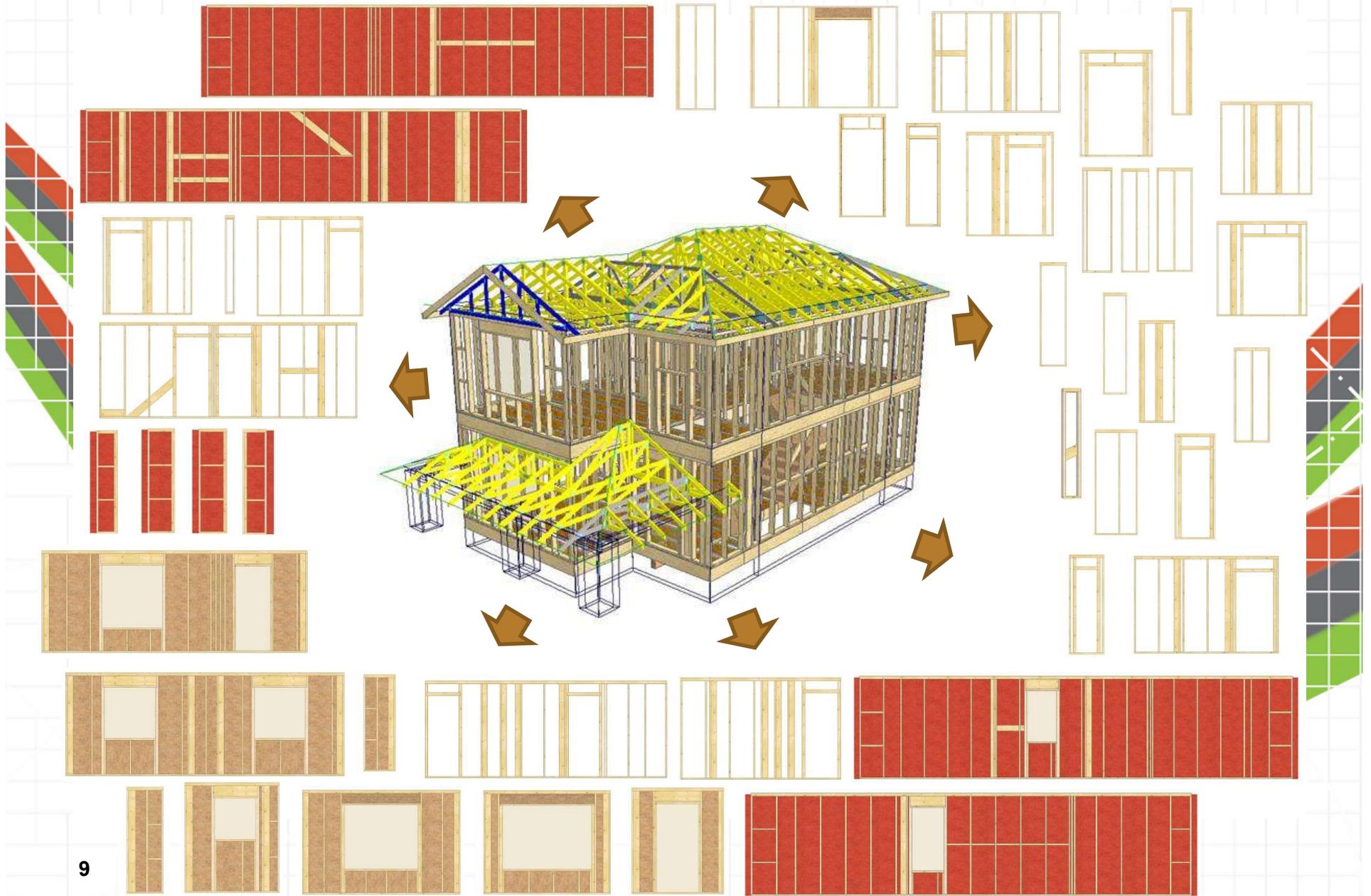


A BETTER WAY

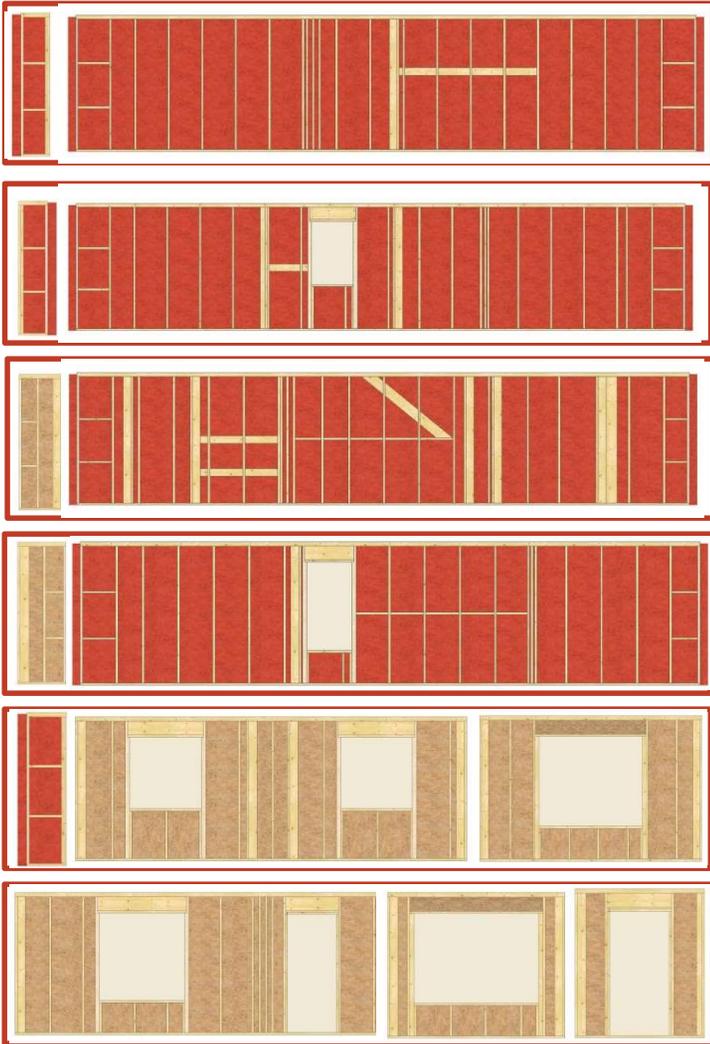
Products move
People & Tools are fixed



DIFFERENT PANELS' TYPES IN PANELIZED CONSTRUCTION



MULTI-PANELS IN PANELIZED CONSTRUCTION



Exterior Multi-Panels

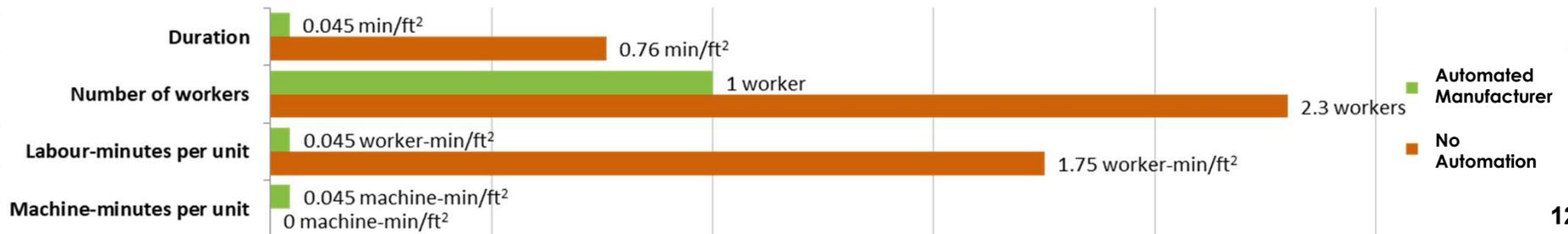


Interior Multi-Panels

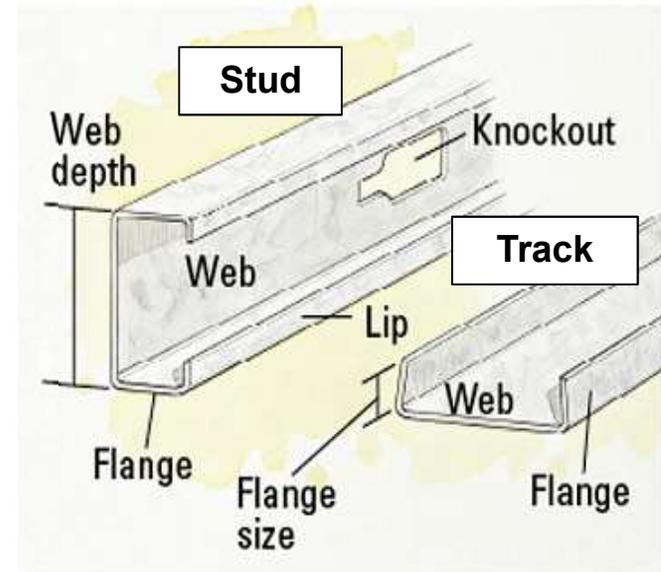
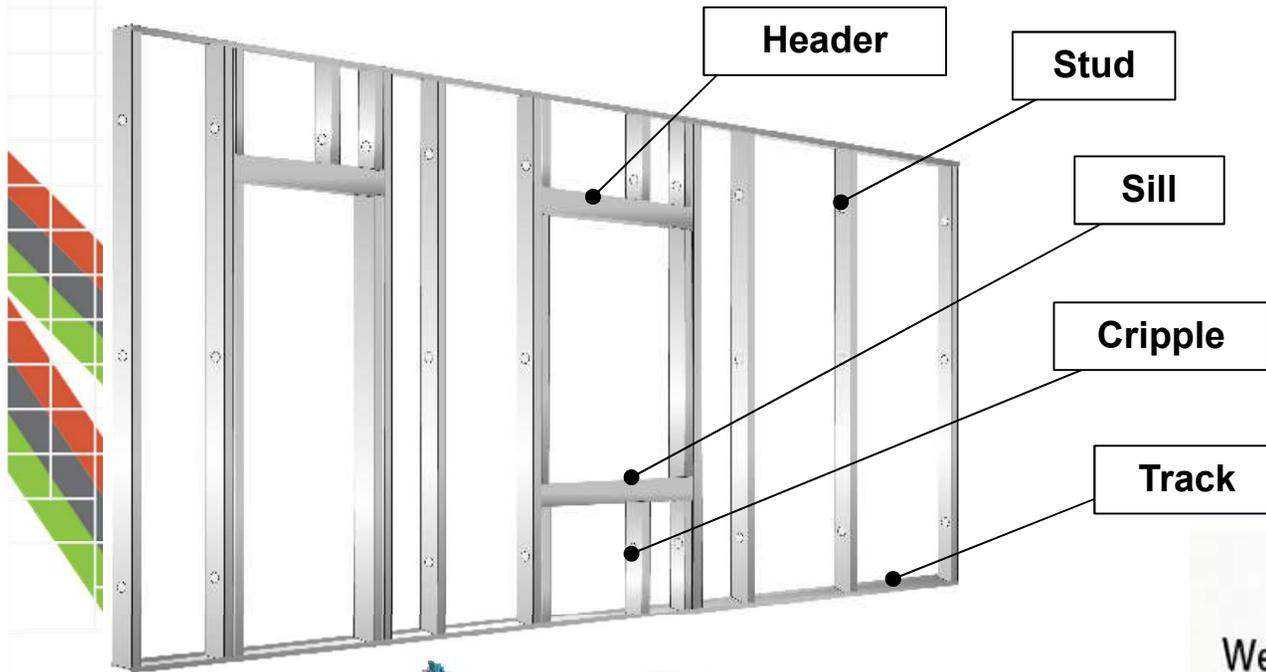


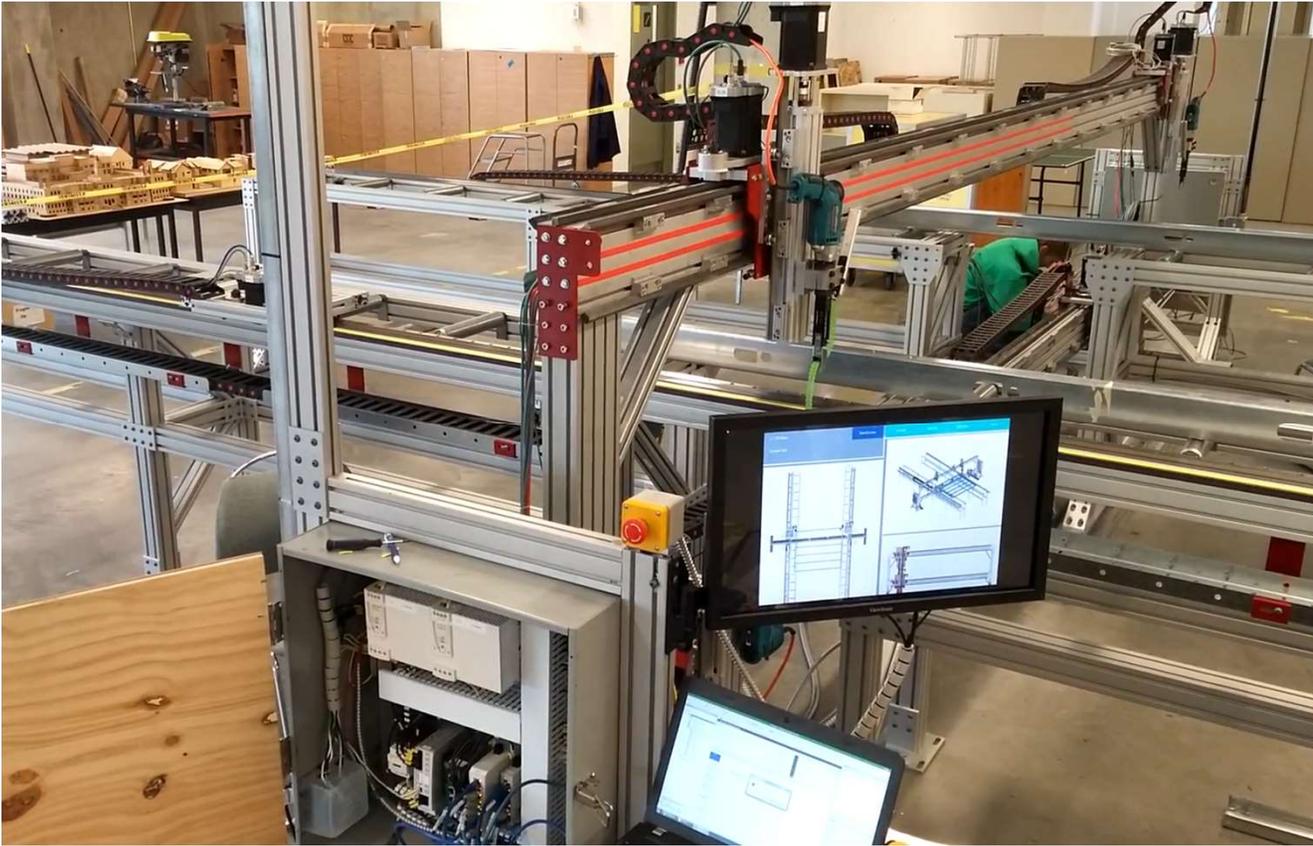
PRODUCTIVITY ANALYSIS

➤ Wall framing



LIGHT GAUGE STEEL FRAMING



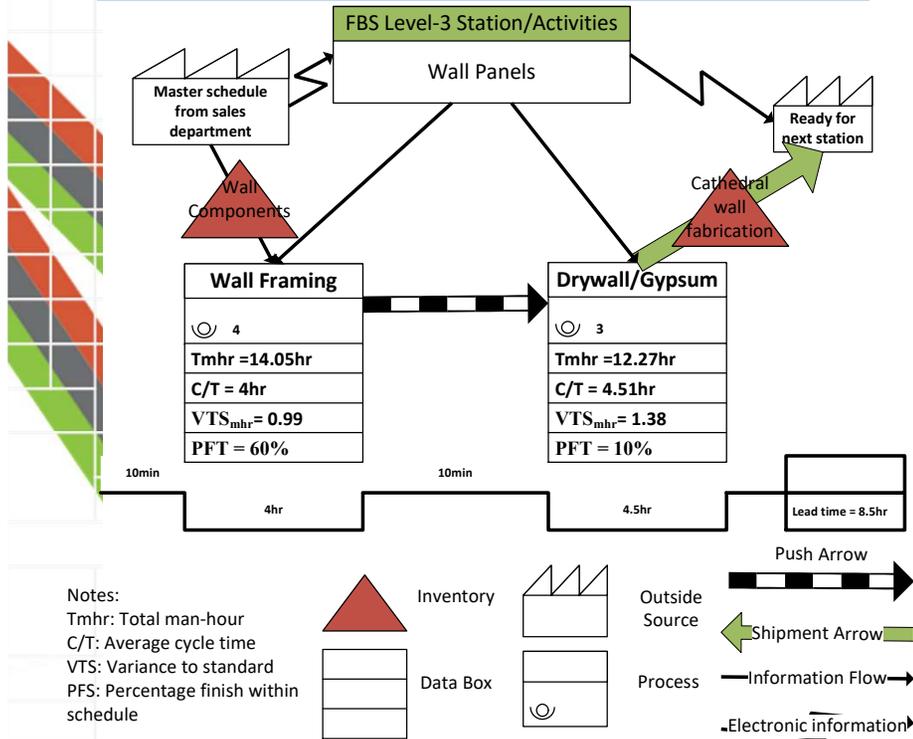


STEEL FRAMING TABLE



CASE STUDY 2—WALL PANEL AND MAIN PRODUCTION LINE WORK LOAD ADJUSTMENT

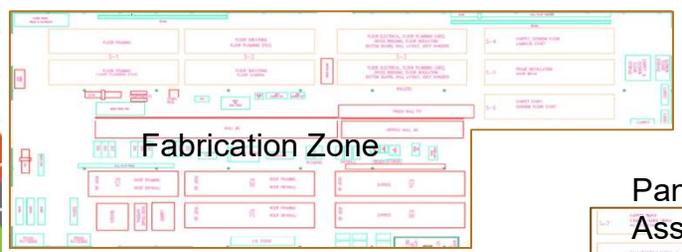
Overall work station performance at wall line



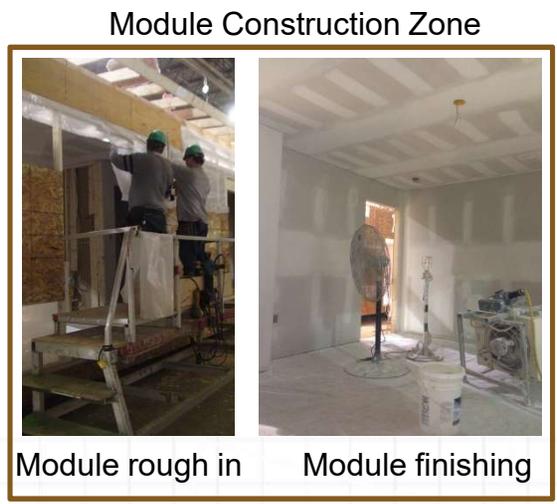
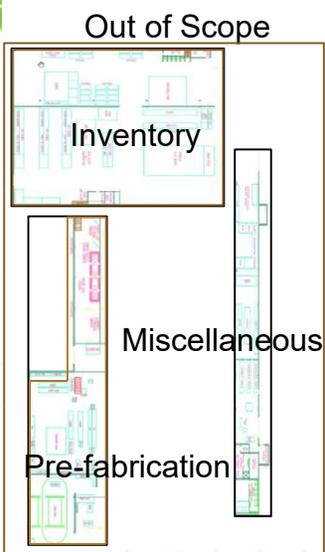
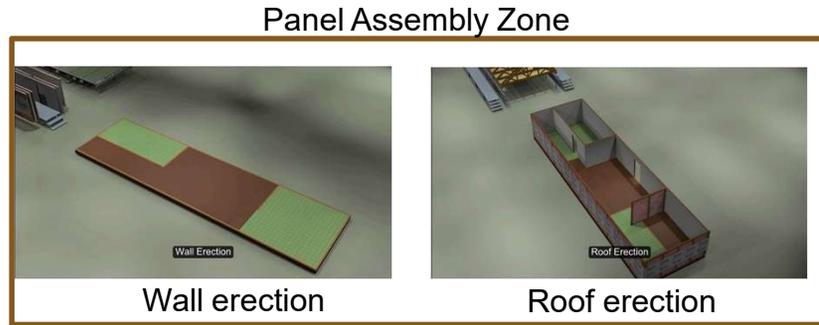
IMPROVEMENT PROCESSES HIGHLIGHT —MULTI-STATIONS/ACTIVITIES IMPROVEMENT

Level-2: Production line zone

Level-3: Building components

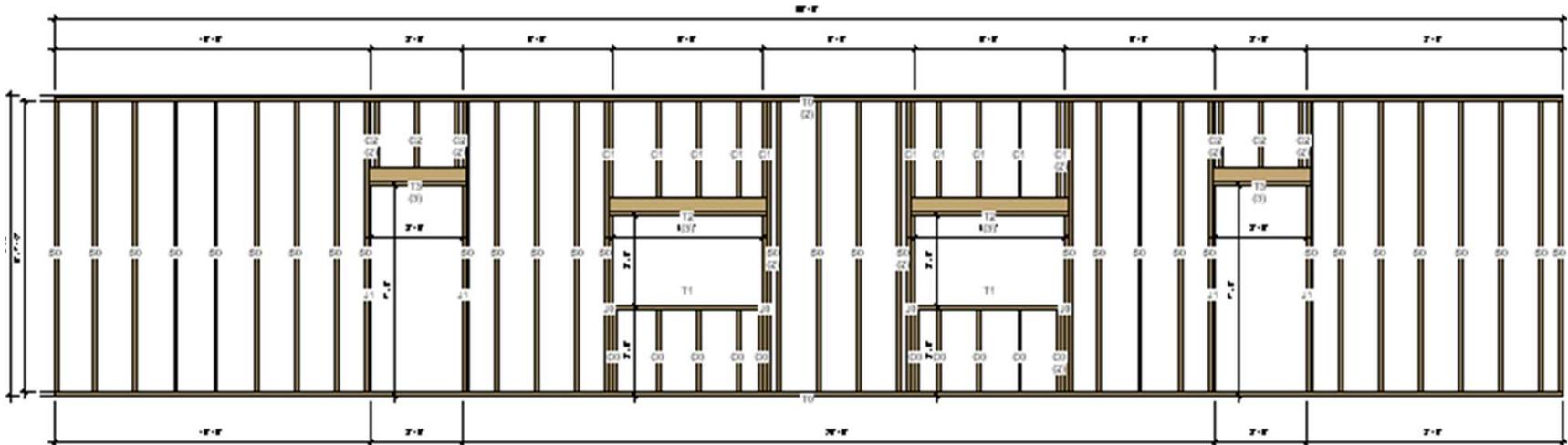
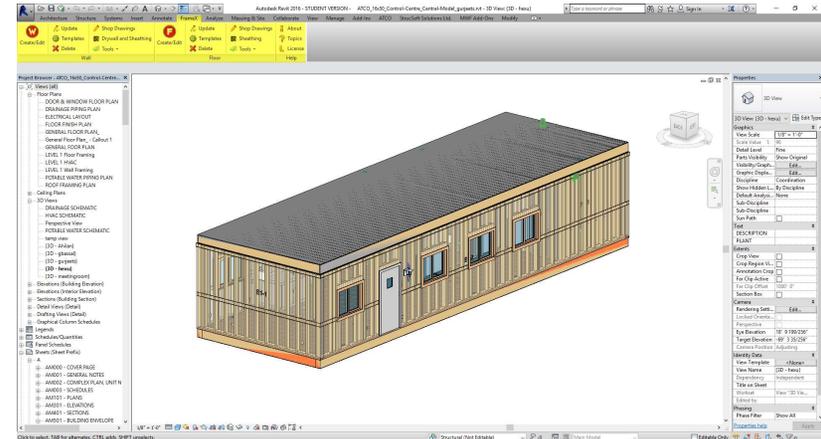


Panel Assembly Zone

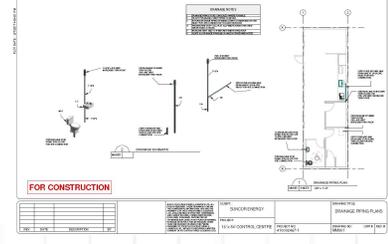
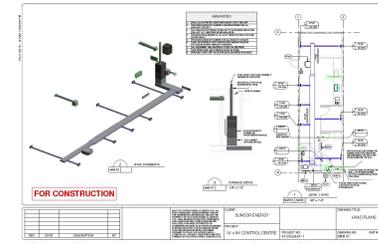
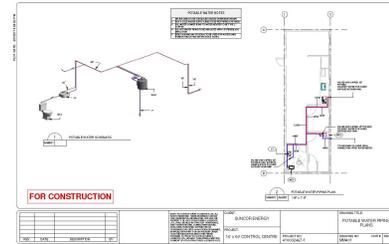
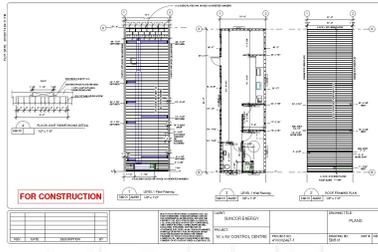
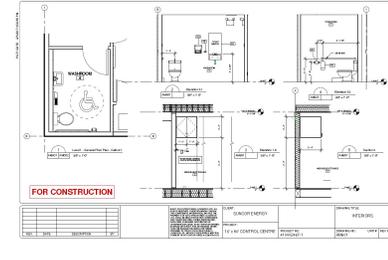
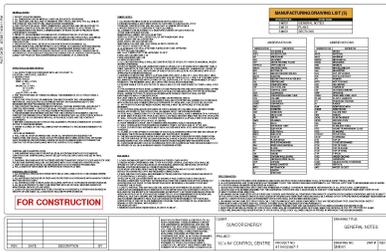
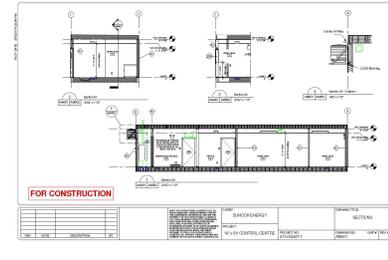
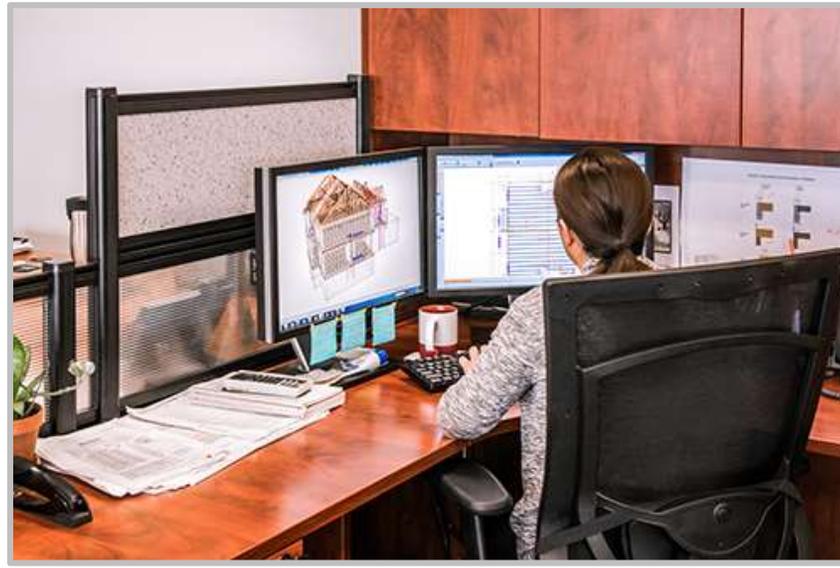
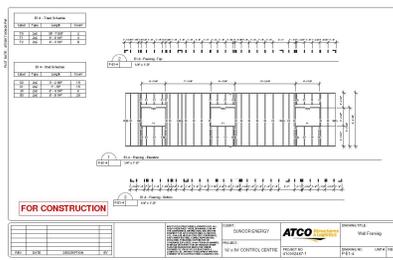
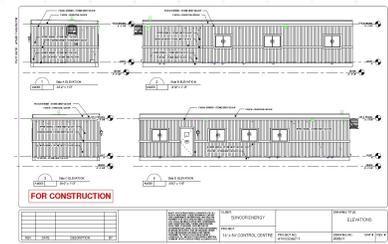
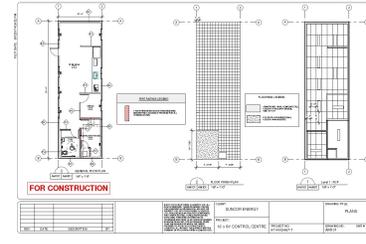
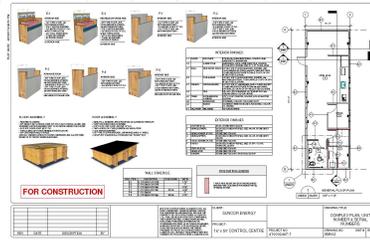
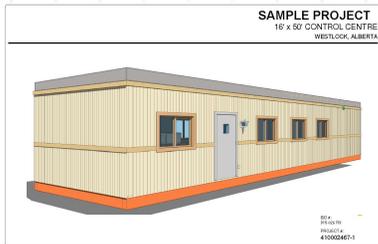


WHAT IS EXPECTED FROM A SOFTWARE

- Studs 16" o/c
- Wall Length is 50'
- 2 doors and 2 windows

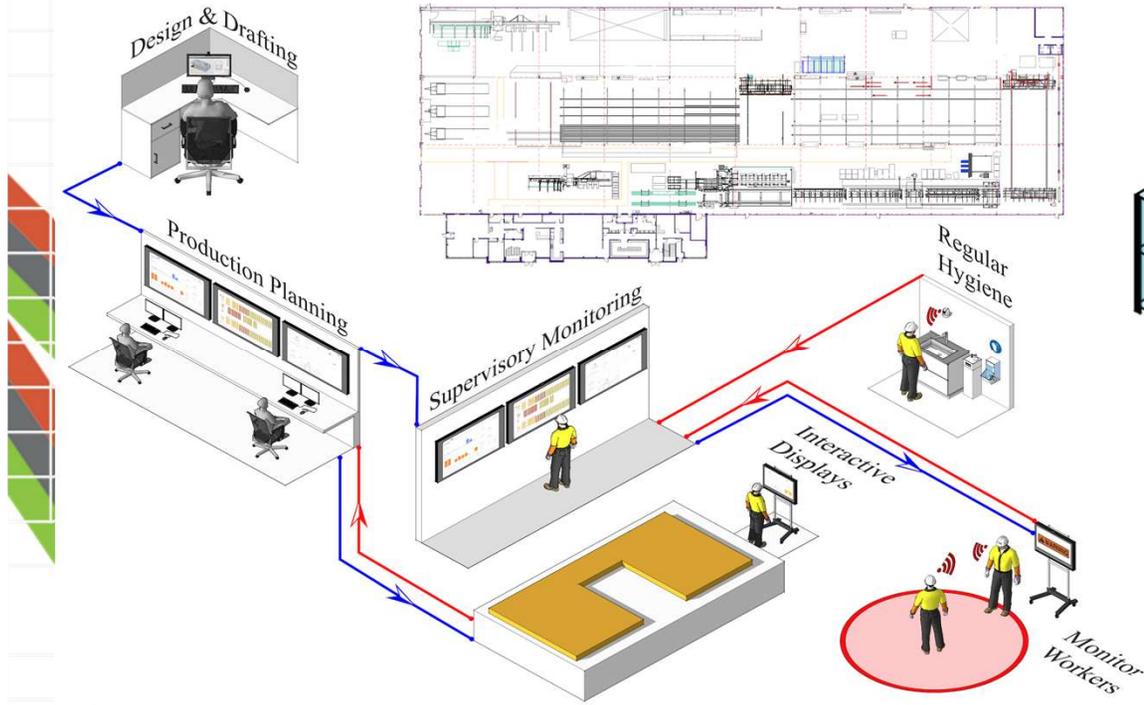


WHAT IS EXPECTED FROM A SOFTWARE

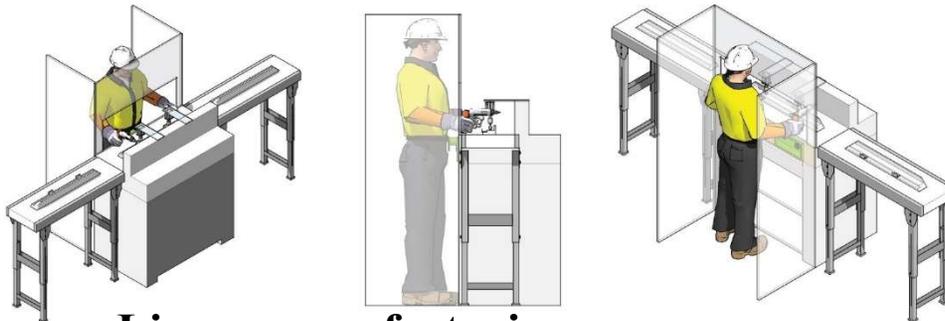
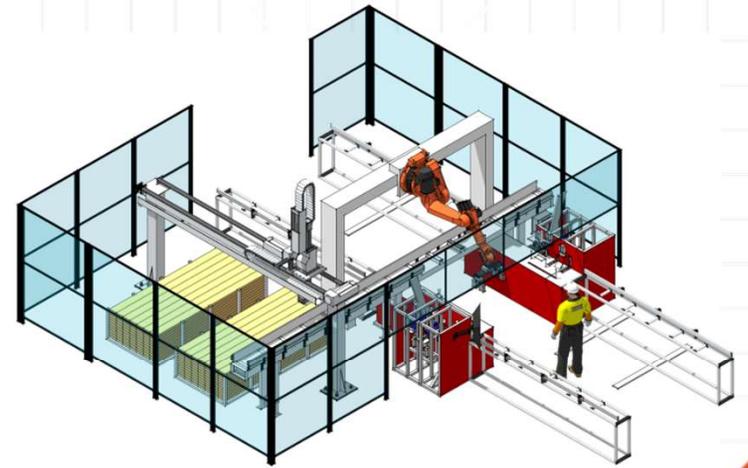


Digitization of manufacturing process

Digital Twin



Advanced robotic technologies



-- Linear manufacturing process

Virtual Reality (VR) platform

MODULAR CONSTRUCTION

Council



Conseil de la
CONSTRUCTION MODULAIRE

**Canadian
Home Builders'
Association**

**Association
Canadienne
Des Constructeurs
D'Habitations**

QUESTIONS?

chba.ca/modular

Photo courtesy of: Triple M Housing

Photo courtesy of: Royal Homes

Photo courtesy of: Triple M Housing

WORKING WITH MODULAR

CHBA Webinar Series 2022



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