BUILDING SCIENCE LIVE
JUNE 3, 2020

Going Modular: Lessons Learned from High Performance Affordable Housing

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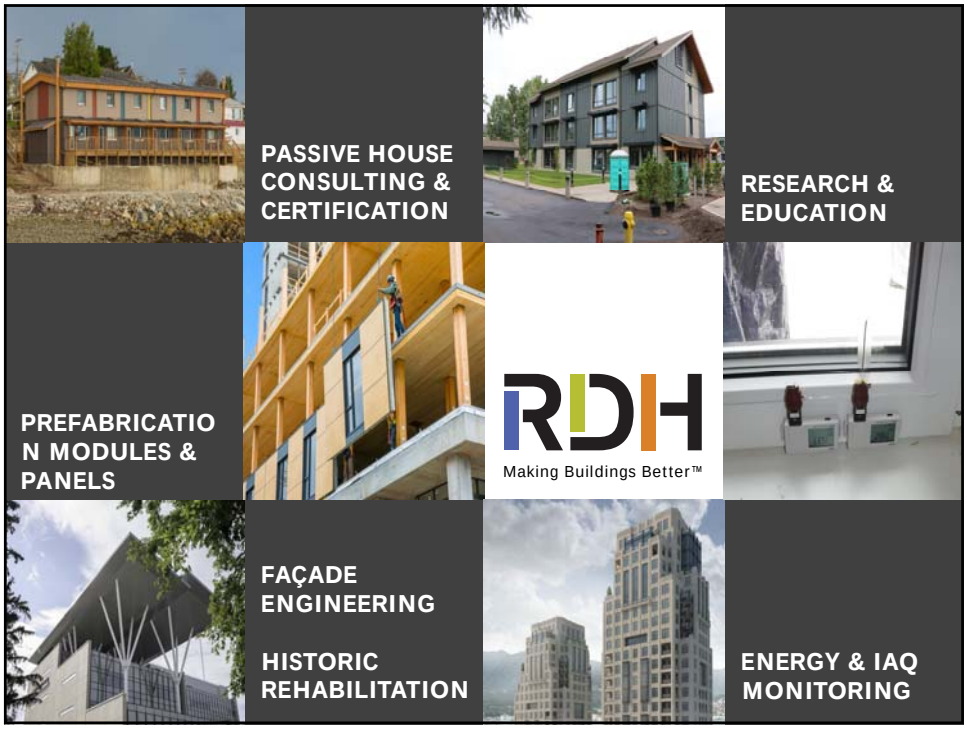
PASSIVE HOUSE CONSULTING & CERTIFICATION
RESEARCH & EDUCATION
PREFABRICATIO N MODULES & PANELS
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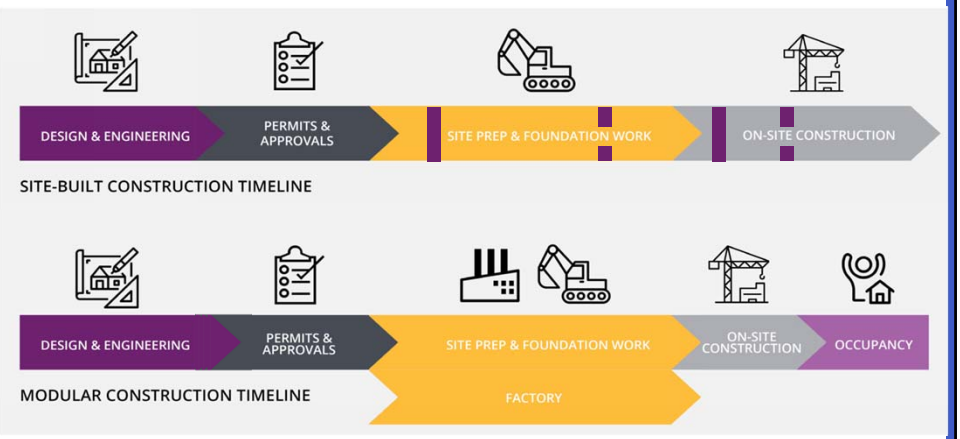
Making Buildings Better™
FAÇADE ENGINEERING
HISTORIC REHABILITATION
ENERGY & IAQ MONITORING


Prefabrication:
Modular Construction

Why Prefabricate?

- Faster (with planning)
- Cheaper (in some cases)
- Sustainable (depending on how you count it)
- Less time on site
- Less weather sensitivity
- Better quality control
- Availability of local labor

Typical Project Timelines



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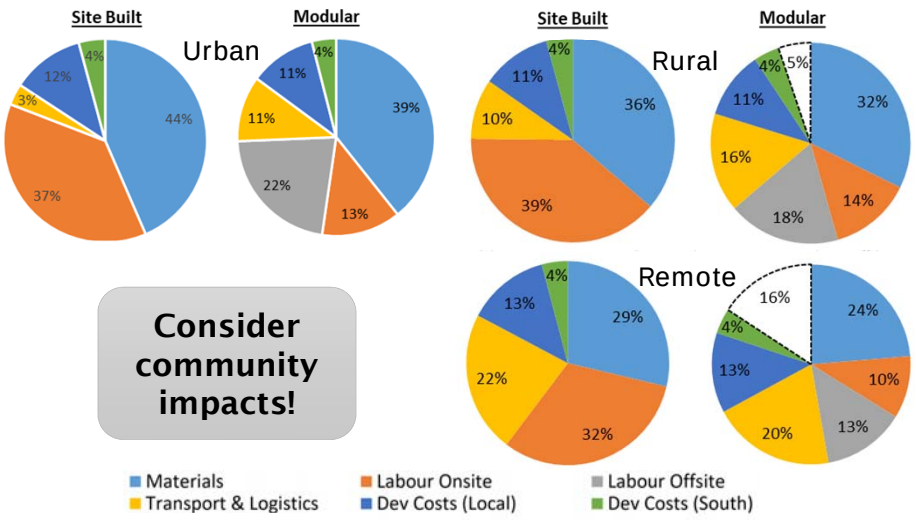
Potential Cost Advantage



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Designing for Modular

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Repetition Brings Cost Down

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Fast, affordable, sustainable housing?

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Solution – Modular Construction?

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Case Studies

- Rapid Response Housing
  - Challenging timeline
  - Near net zero energy code targets
  - Considerations for overheating
- Coastal Staff Housing
  - Remote, wet coastal climate
  - Wood-frame Passive House
  - Shift in modular detailing practices
- Remote Steel Modular Hotel
  - Remote location & long-distance shipping
  - Short building season & local labour shortage
  - High thermal performance with large steel frames

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Case Study #1: Rapid Response Housing

Image provided by Metric Modular

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Project Overview

- **Building type**: Temporary Transitional Housing
- **Location**: Abbotsford, BC
- **Construction year**: 2019
- **Manufacturer/Builder**: Metric Modular
- **Energy Code Target**: Step 3, near net zero

BC HOUSING

ENERGY STEPCODE BUILDING BEYOND THE STANDARD

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Challenges

- Fast project timeline to provide temporary transitional housing
- Stringent comfort control & overheating requirements
- High performance, approaching near net zero energy target

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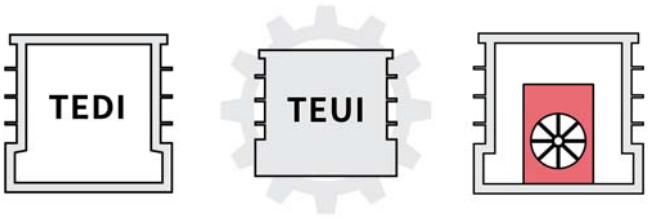
Performance Based Metrics
BC Energy Step Code (Near Net Zero)



	Building Envelope & Ventilation	Whole Building Energy Consumption	Airtightness
STEP 3 →	30 kWh/m²/yr	120 kWh/m²/yr	Whole Building: 2.0 L/s-m² @ 75 Pa Suites: 1.2 L/s-m² @ 50 Pa

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Energy Efficiency Design Strategy

- **Heat recovery ventilation**: in all suites and common spaces
  - 70% SRE
- **Wall assemblies**: split insulated wood frame
  - 1.5" exterior mineral wool or 1" XPS (multiple projects)
- **Window performance**: double glazed with vinyl frames
  - U-value of 0.26 Btu/(hr-F-ft²), SHGC 0.3
- **Airtightness**: Energy Code & BC Housing requirements
  - Whole building better than 2.0 L/s-m² @ 75 Pa (0.4 cfm/ft²)

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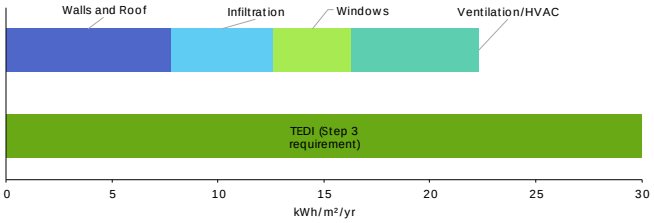
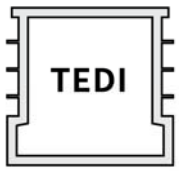
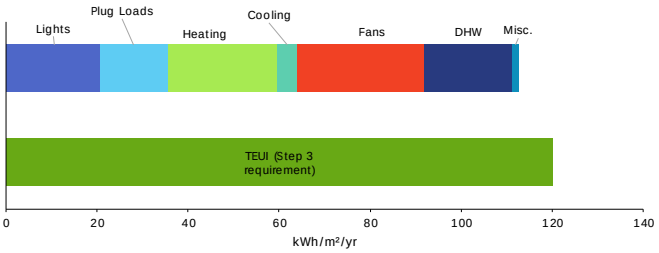
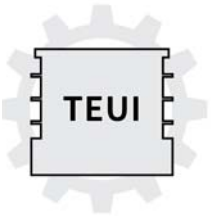
Energy Modelling





Building Envelope & Ventilation





Whole Building Energy Consumption

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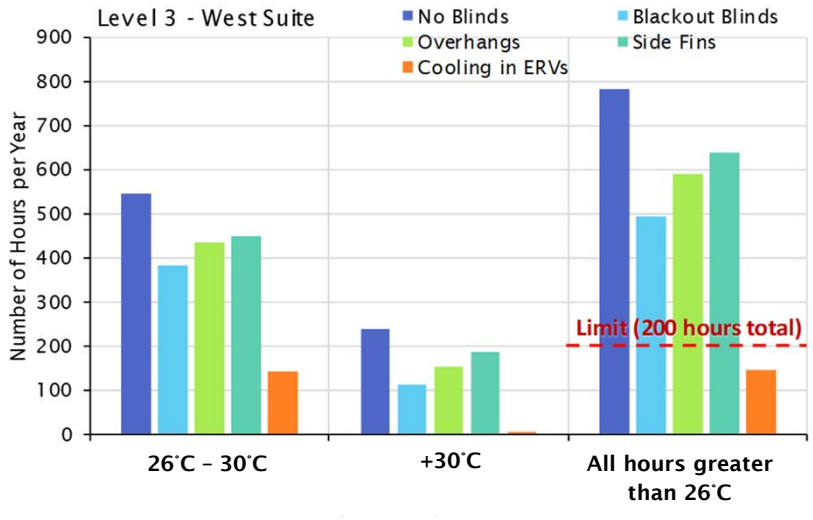
Considerations for Overheating



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Typical Project Timelines

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Modular Lessons

- Opportunity
  - Rapid Response to Homelessness
  - High Performance Energy Code (approaching net zero ready)
- Lessons Learned
  - Engage with local jurisdictions to facilitate permitting (early)
  - Use energy analysis to help guide the design approach
  - Consider overheating in design (mechanical cooling may be necessary)
- Benefits
  - Temporary housing can still be energy efficient and airtight!
- Scaling Up
  - Several projects with similar design

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Scaling Up…

Case Study #2: Coastal Staff Housing

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Project Overview

- **Owner/Operator**: Vancouver Coastal Health
- **Building type**: 6-unit staff accommodations
- **Location**: Bella Bella, BC
- **Construction year**: 2015
- **Designer/Manufacturer/Builder**: Mobius Architecture/Metric Modular (formerly Britco)/Spani Developments
- **Energy Target**: Passive House

Vancouver Coastal Health

Passive House Institute

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Apartment fire in 2014

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Challenges

- 6 month timeline
- Wet coastal climate with barge only access
- Remote site with limited materials and local labor
- First Passive House project for the design, modular, and construction team

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YUKON
NORTHWEST TERRITORIES
Yellowknife
Whitehorse
Juneau
Canada
MANITOBA
Fort McMurray
ALBERTA
SASKATCHEWAN
BRITISH COLUMBIA
Edmonton
Saskatoon
Winnipeg
Bella Bella
Regina
Calgary
NORTH DAKOTA
Vancouver
Victoria
Seattle
WASHINGTON
MONTANA
SOUTH DAKOTA
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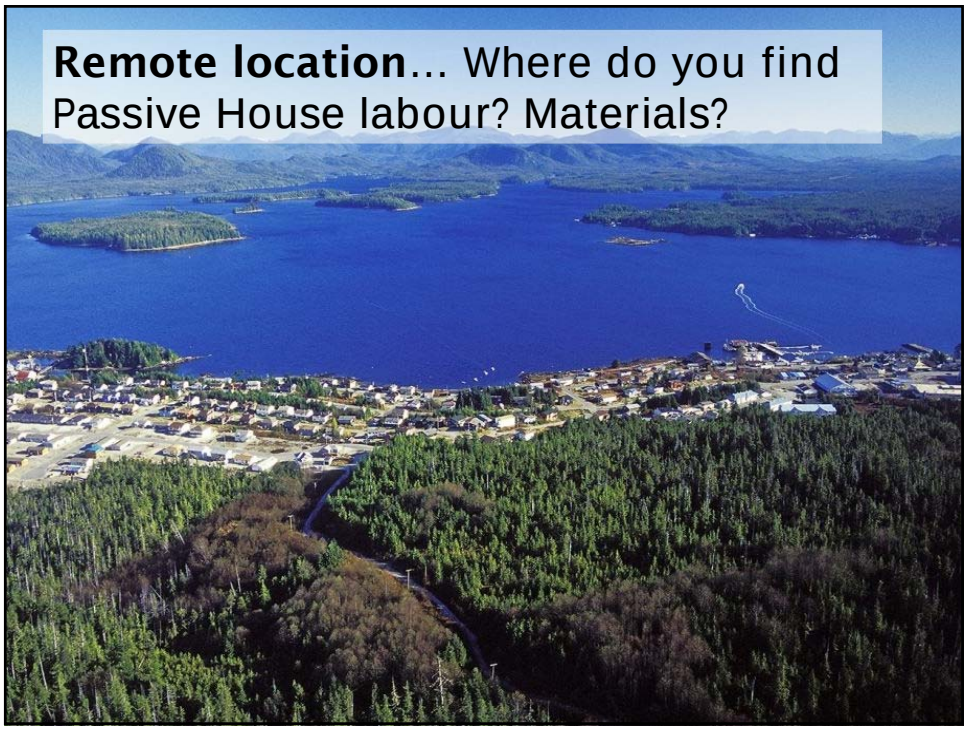
Portland

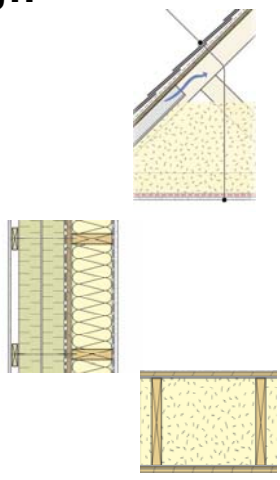

Vision: First Modular Passive House


2 storey
6plex


Remote location... Where do you find
Passive House labour? Materials?

Building Enclosure Design Challenges

- Passive house R-values (R-35, R-100, R-80) & very good air-sealing (0.6 ACH50)
- Rapid design time – needed proven assemblies and simple trainable details
- Was the first "higher-performance" building enclosure for this wood-frame modular building manufacturer
- Materials, assemblies and details had to work within existing factory line
- Had to be cost effective to fit the tight budget
- Very wet climate



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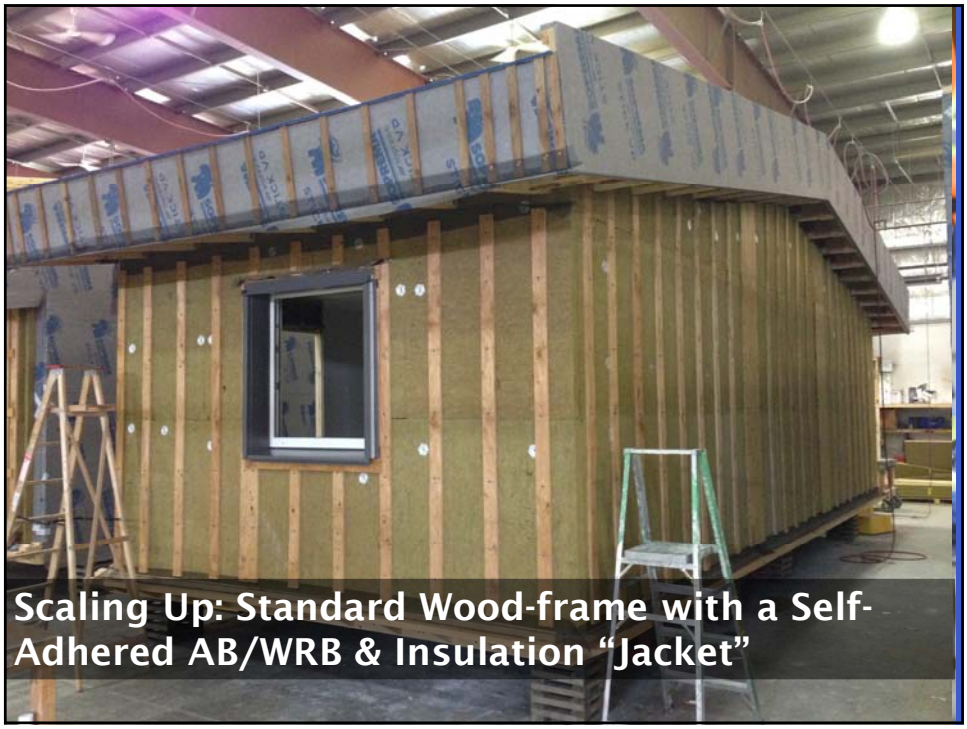
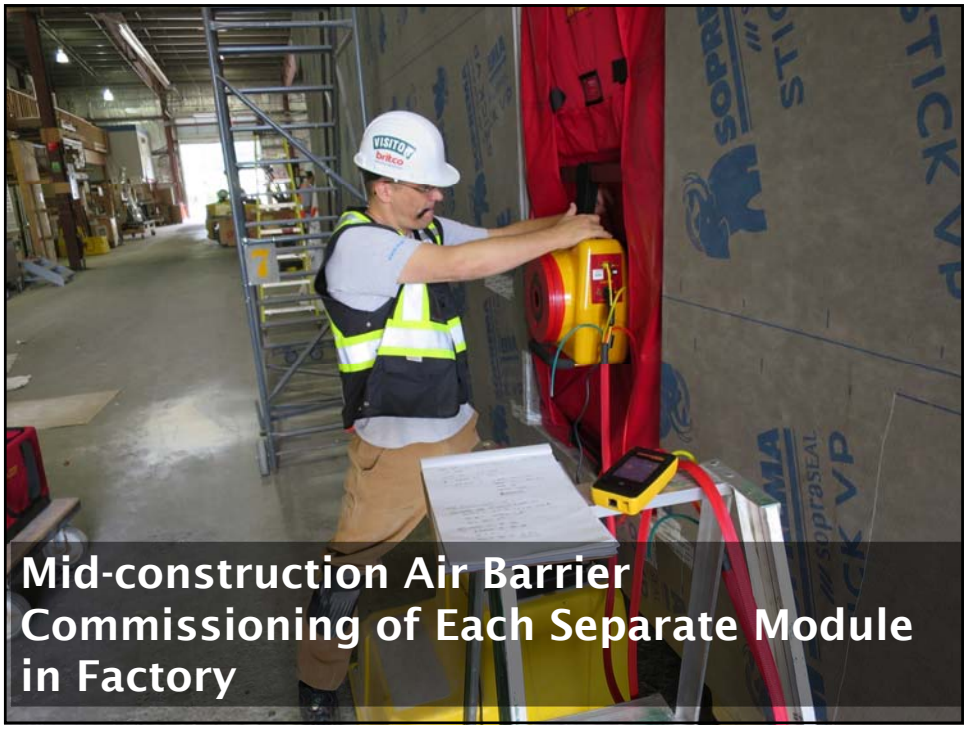
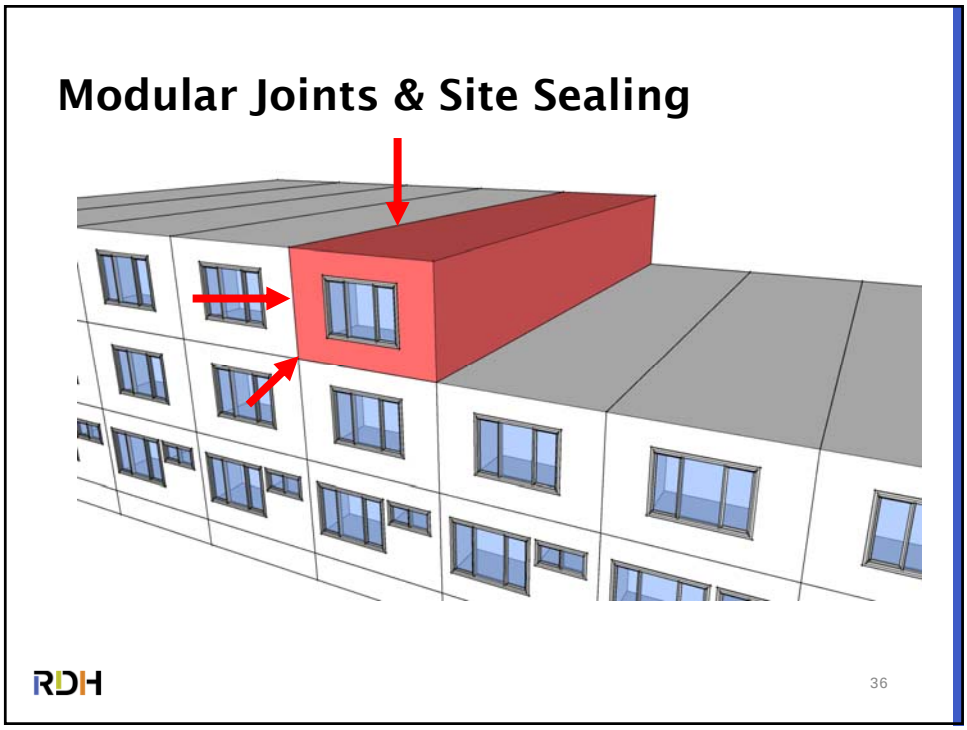

Scaling Up: Standard Wood-frame with a Self-Adhered AB/WRB & Insulation "Jacket"


Train the Trades in the Factory on New Higher Performance Building Techniques
STICK
sopraSEAL
STICK VP


Mid-construction Air Barrier Commissioning of Each Separate Module in Factory


Modular Joints & Site Sealing
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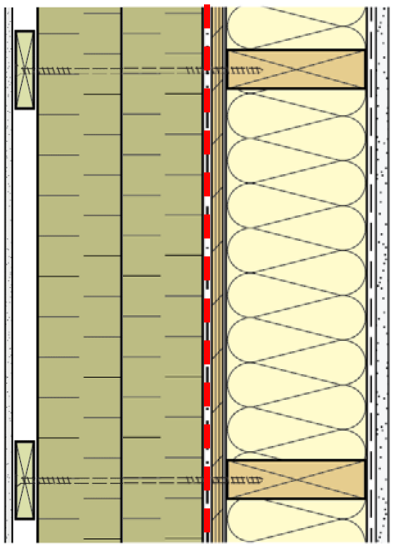
Modular Wall Joints

- 2x6 framing with 6" exterior insulation
- Self-adhered air and water resistive barrier at the sheathing plane behind insulation in middle of assembly
  - Need to access connection onsite but want to finish as much in the factory as possible...



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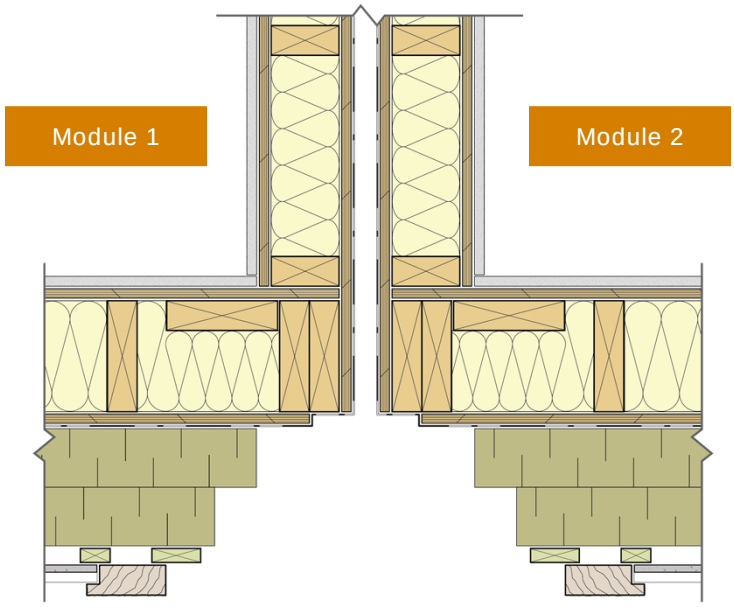

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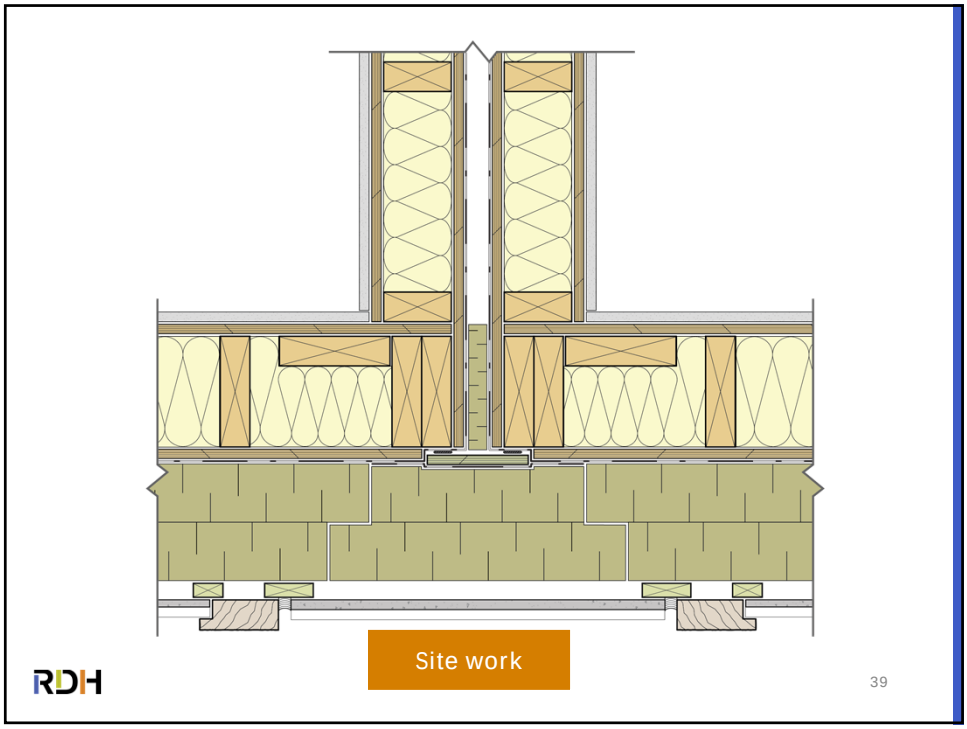
Site work
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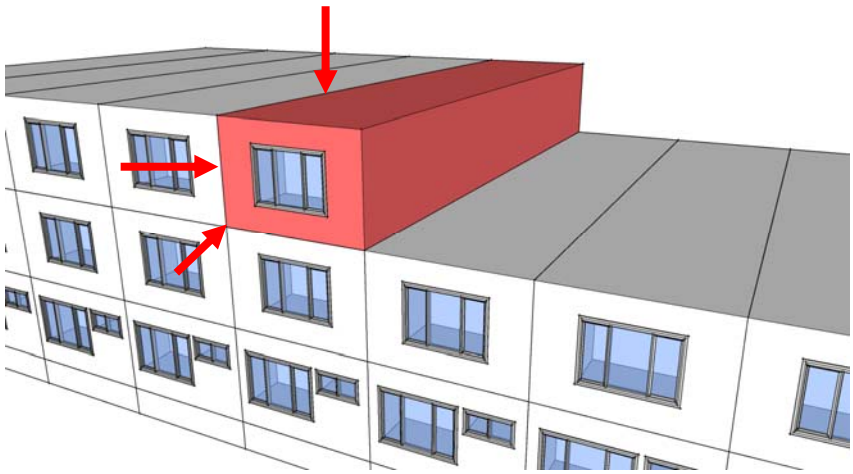
Everything including the kitchen sink…
and all the utensils


Shipping by ocean demands robust water protection on all sides


Foundation and site prep work
during manufacturing & shipping

Modular Joints & Site Sealing



EPDM (Temporary & removed here) on top of lower modules, vapor permeable underside of floor. Offers good short term protection against rain, though want to assembly dry to keep low RH in-service

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Done!

But How is it Performing?

Same tenants, new building

Six-unit Passive House replaced six apartments built to former code

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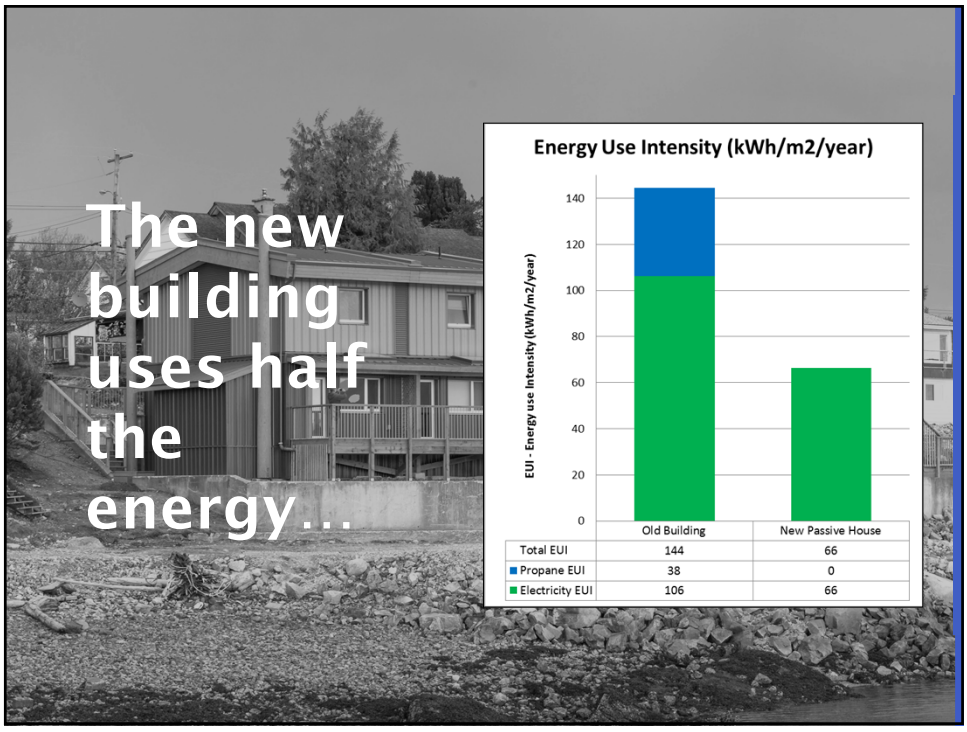
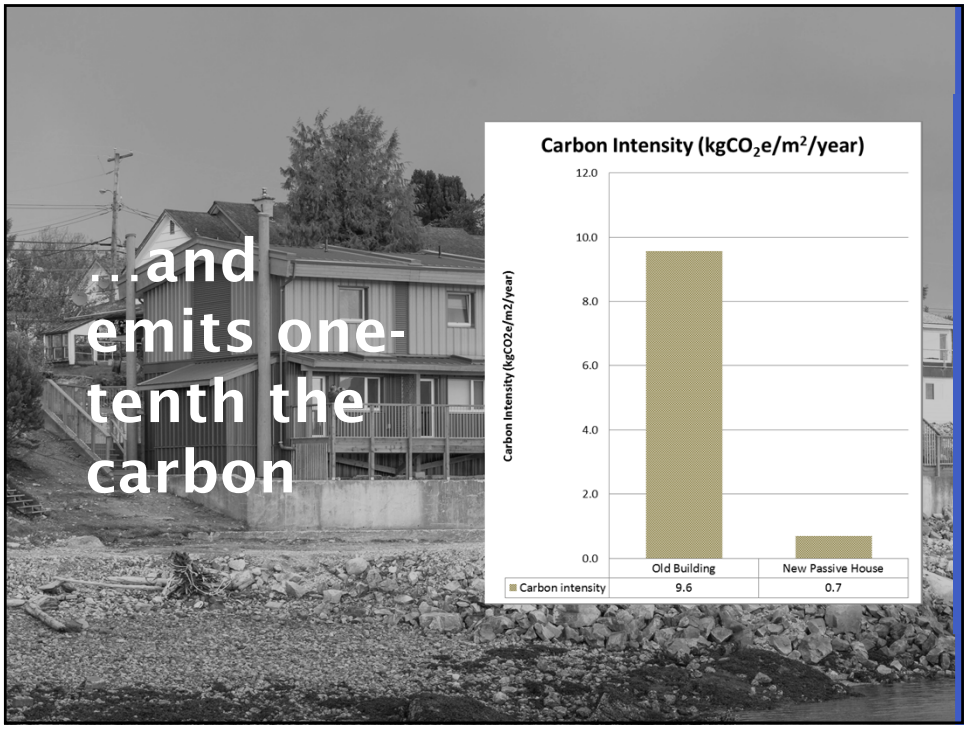
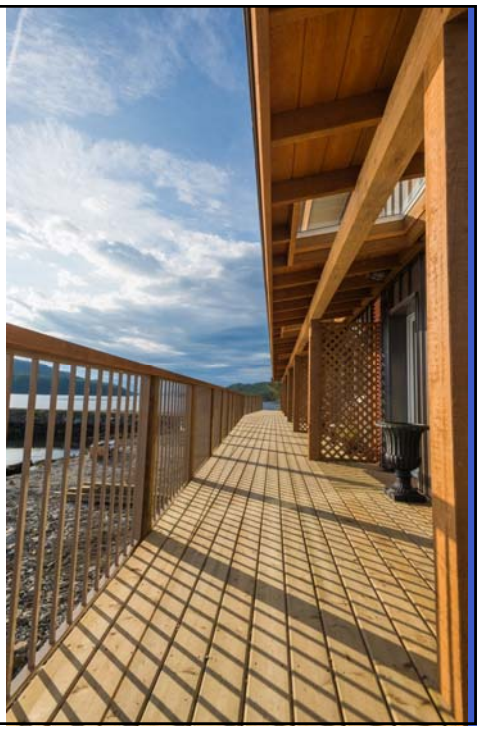




Modular Success

- Opportunity
  - Remote Location
  - Passive House
- Design Lessons
  - Details must be finalized prior to manufacturing – change in design focus from construction delivery
  - Moisture management approach critical to maintaining schedule
- Benefits
  - Site labour & shipping cost savings exceed Passive House premium
  - Community was happy with the short disruption
- Scaling up
  - The project has been replicated!




Improve & Repeat – V2.0 – Local Site


Improved: Rigid Ceiling Air Barrier
SIGA-Wigluv


Improved: Module to Module Air Barrier
Detailing for Site Sealing

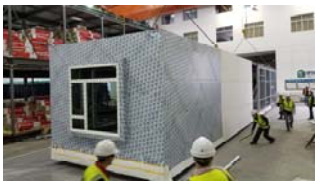

V2.0 = 0.52 ACH @ 50 Pa
≈ 0.20 L/s·m² (0.05 cfm/ft²)
at 75 Pa

Case Study #3: Remote Steel Modular Hotel

RDH BIRD STACK MODULAR

Project Overview

- **Building type**: Steel framed hotel and conference centre
- **Location**: Iqaluit, NU
- **Construction year**: 2018-2020
- **Designer/Manufacturer/ Builder/Owner**: Livingston Architecture/ Stack Modular/ Bird Construction/ Qikiqtaaluk Corporation
- **Energy Target**: National Energy Code of Canada+



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Steel Framed Modular For All Climates

- Building Enclosure Challenges
  - Steel Framed
  - Energy code target >R-30 effective walls (arctic)
  - Robust air, vapor & water-tightness for shipping and site
  - Indoor moisture control during shipping
- Modular Manufacturing Challenges
  - Designed in Canada / Manufactured in China to North American Standards & Codes
  - Very large modules, spanning two suites & corridor
  - Shipping from Shanghai to Iqaluit
  - Rapid erection in limited construction window
  - Site sealing and finishing

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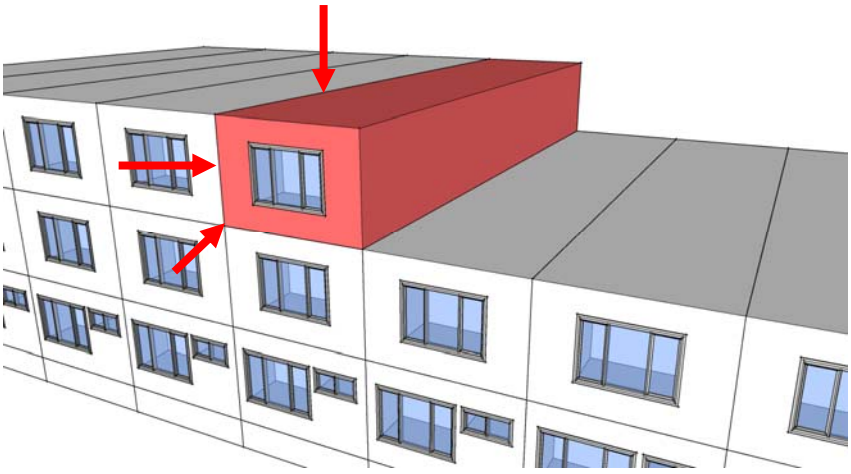
Modular Joints & Site Sealing



steel lid and floor, no moisture sensitive materials exposed – seal quickly to avoid trapping water

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SOPREMA
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Improved: Factory Installed Exterior Insulation and Cladding
Protecto Wrap
STACK MODULAR

Lessons Learned

- Opportunity
  - Remote with challenging logistics
  - Manufactured overseas and shipped around world
  - Modular design saved 1 year of schedule and several million dollars vs site built option
- Design
  - Fully wrapped self-adhered membrane over all boxes – works in cold or hot climates
  - Exterior insulated steel stud with thermally efficient cladding attachment to maximize R-value for climate
  - Lesson: factory applied exterior insulation and cladding a further cost savings and address remote site labor challenges

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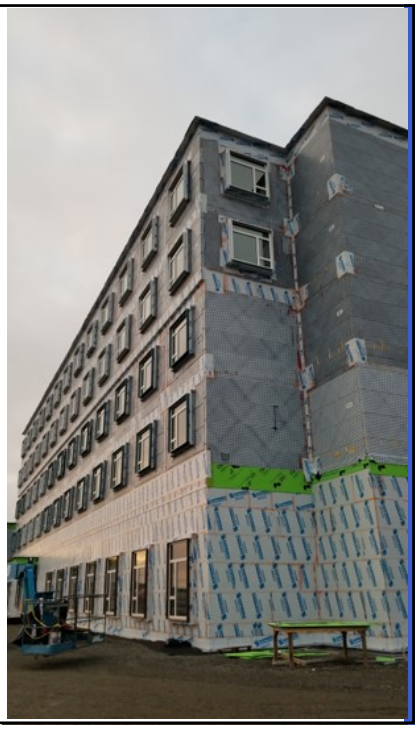

Engagement & Site Selection

- Municipalities:
  - Streamline permitting
  - One building inspector
- Project Team:
  - Engage with site servicers early-on
  - Consider site storage capacity

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Design & Manufacturing

- Front-loaded design work (no changes later)
- Consider shipping constraints & protection

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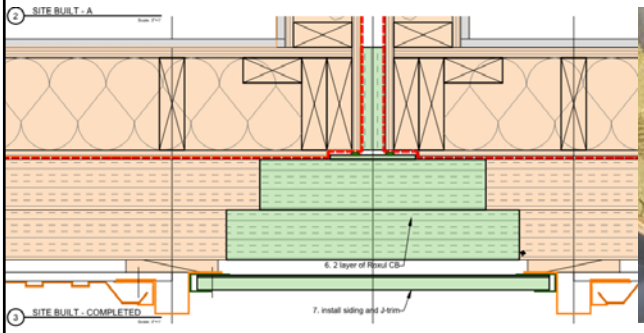
Design Details

- What will be done in plant vs. on site?
- Design for adjustability and seal in poor weather



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Transportation

- Wrap & protect all 6 sides – wind, water, dirt during transport
- Seal & support all openings
- Careful with shrinkwrap as primary protection – damage & drain

Construction

- Proactively manage moisture prior to and during erection
- Connect and seal module joints immediately, in particular on horizontal surfaces

Fast, sustainable, affordable housing with Modular Construction?

- **FAST**: if everything goes as planned
- **SUSTAINABLE**: with intentional design
- **AFFORDABLE**: with scale, simple design, and in remote locations

- Also, housing for underserved communities:
  - Solution for remote locations

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Resources – Technical Bulletin

www.rdh.com/resource-type/technical-bulletins/

Or search:

"*RDH Technical Bulletins*"

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Resources – 2-pager

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Additional Course

- https://www.learnbuildingscience.com/courses/prefabricated-construction
- Instructor: John Straube | Principal, Senior Building Science Specialist

Course Description

There is renewed attention being paid to expedited building processes using prefabricated and modular components. The drive to manage moisture during construction, accelerate construction cycles, and minimize construction waste has sharpened interest in prefab. Alas, there is much unjustified "prefabulous" hype. What can building science tell us about the different prefab options? How are they different and how are they the same as traditional construction? What do you need to know to avoid problems and use prefab options successfully?

GOING MODULAR:
LESSONS LEARNED FROM HIGH PERFORMANCE AFFORDABLE HOUSING

Discussion + Questions

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