School of Construction and the Environment

Building Science Education from a Canadian Perspective:

The BCIT Experience

Presentation Outline

- Introduction to BCIT and its building science curriculum
- The British Columbia (BC) and Canadian context for Building Science
- Master’s degrees in building science
- A success story

Introduction

- Many Canadian institutions offer one or more courses in Building Science
- Established centres of excellence at Concordia University and the University of Waterloo
- Substantial new programming at Ryerson University and the British Columbia Institute of Technology (BCIT)

Introduction to BCIT

- 18,000 full time students
- 28,000 part-time enrolments
- Over 2,000 faculty & staff
- One main campus & several satellite campuses

Introduction to BCIT - History

- 1960's Known for trades & technology programs
- 1988 Applied research mandate
- 1996 Bachelor's degree granting status
- 2002 Master's degree granting status
  - » First master's in building science
- Credentials offered include
  - Certificates
  - Diplomas
  - Degrees (e.g. B.Tech., B.Eng., B.Sc., M.A.Sc., M.Eng.)

Introduction to BCIT - Schools

- School of Business
- School of Computing and Academic Studies
- School of Construction & the Environment
- School of Energy
- School of Health Sciences
- School of Transportation

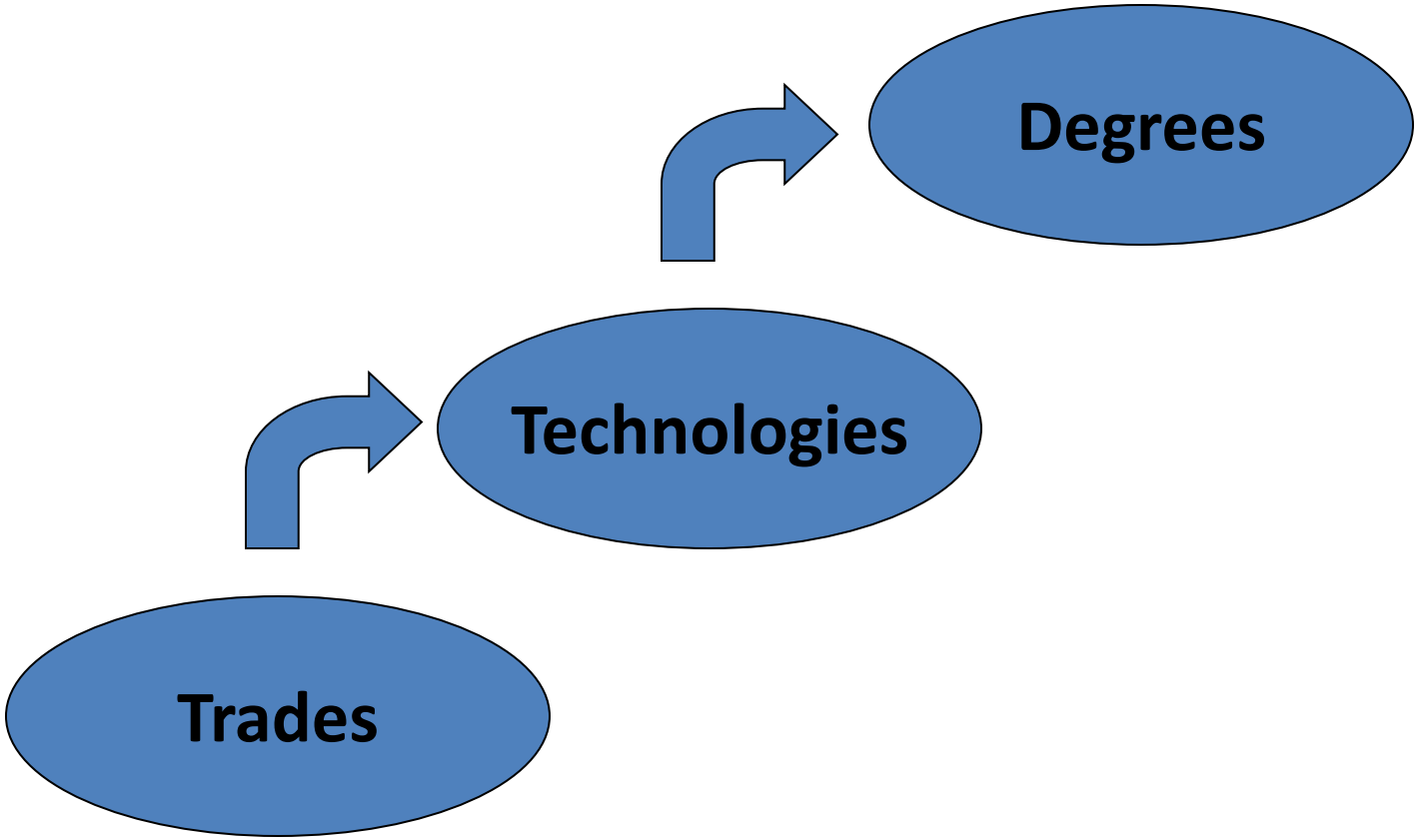
Introduction to BCIT: Some Building-Related Programs

- **Trades**
  - Carpentry
  - Sheet Metal
  - Construction Estimating
  - Construction Operations & Supervision
  - House Inspection
  - HVAC Technician
- **Technologies**
  - Architectural & Building
  - Interior Design
- **Degrees**
  - Building Science
  - Structural Engineering
  - Mechanical Engineering
  - Electrical Engineering
  - Architectural Science
  - Construction Management

Introduction to BCIT—Program Characteristics

- Laddering and life-long learning
- Flexible delivery
- Vertically integrated curriculum

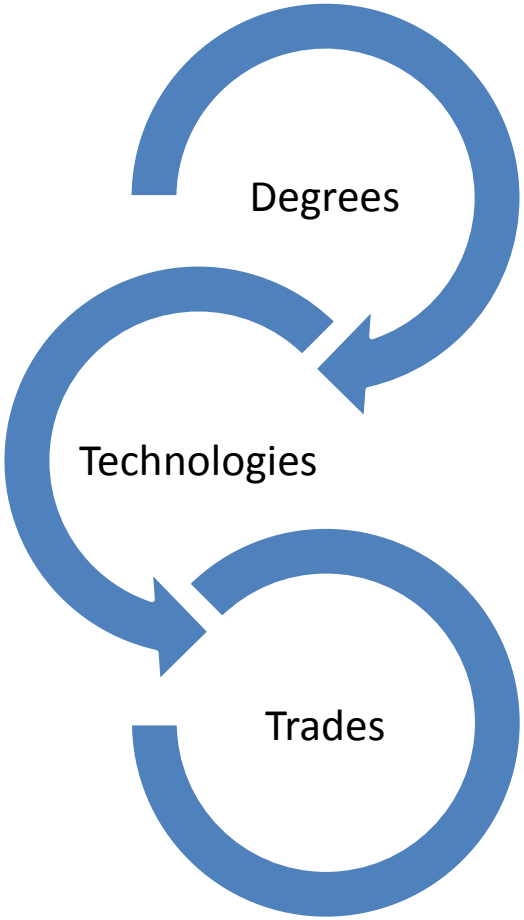
Introduction to BCIT – Program Laddering



Introduction to BCIT - Flexible Delivery

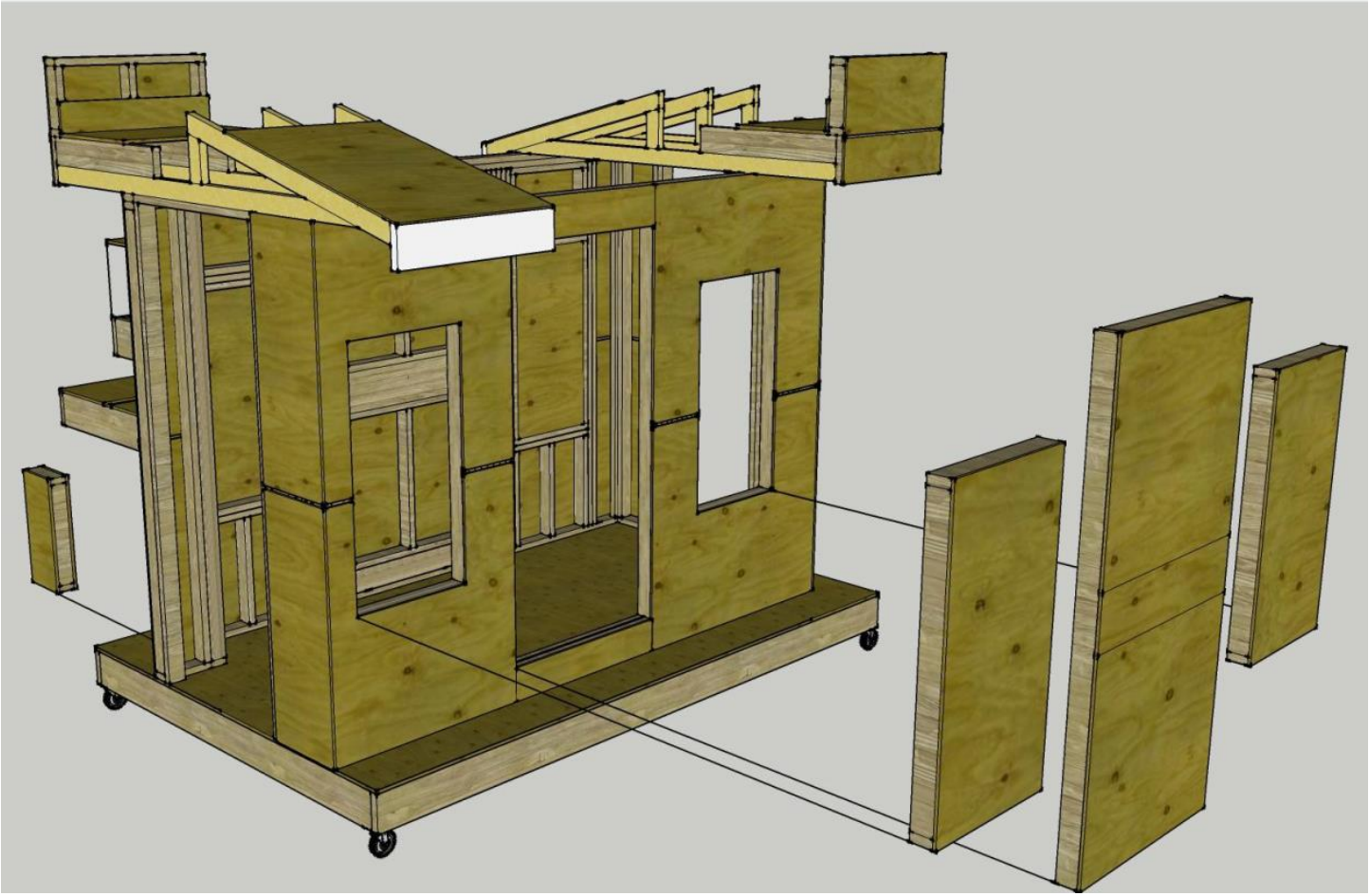
- Part-time studies
- Distance learning
- Prior learning assessment

Introduction to BCIT - Vertically Integrated Curriculum



Vertical Integration - Teaching Huts

Hands-on Building Enclosure Construction and Detailing




Tyve

Introduction to BCIT - Building Science courses at diploma through degree levels

Diploma in Architectural & Building Technology (ABT) – 120 Students

- Introduction to Building Science
  - 20 lecture hours
  - 20 lab hours

Diploma in ABT – Building Science Elective – 40 Students

- Building Science 1
  - 30 lecture hours
  - 60 lab hours
- Building Science 2
  - 40 lecture hours
  - 80 lab hours
    - Industry-sponsored capstone project
  - 40 hour Industry Practicum

Bachelor of Technology in Architectural Science – 24 Students

- Environmental Separators
- Building Envelope Performance
- Building Envelope Lab
  - Bridging courses required to continue into masters level
  - 45-70 lecture & lab hours

Master of Applied Science/Engineering in Building Science – 20 Students

- Building Science 1
- Building Materials
- Building Envelope 1
- Building Energy Performance
  - Core courses shown
  - 45 lecture/lab hours

Introduction to BCIT - Building Science courses at trades and certificate levels

Casual Part-time studies < 20 Students

- Building Envelop Solutions
  - 36 lecture/lab hours

Certificate in Architectural and Building Technology – 40 Students

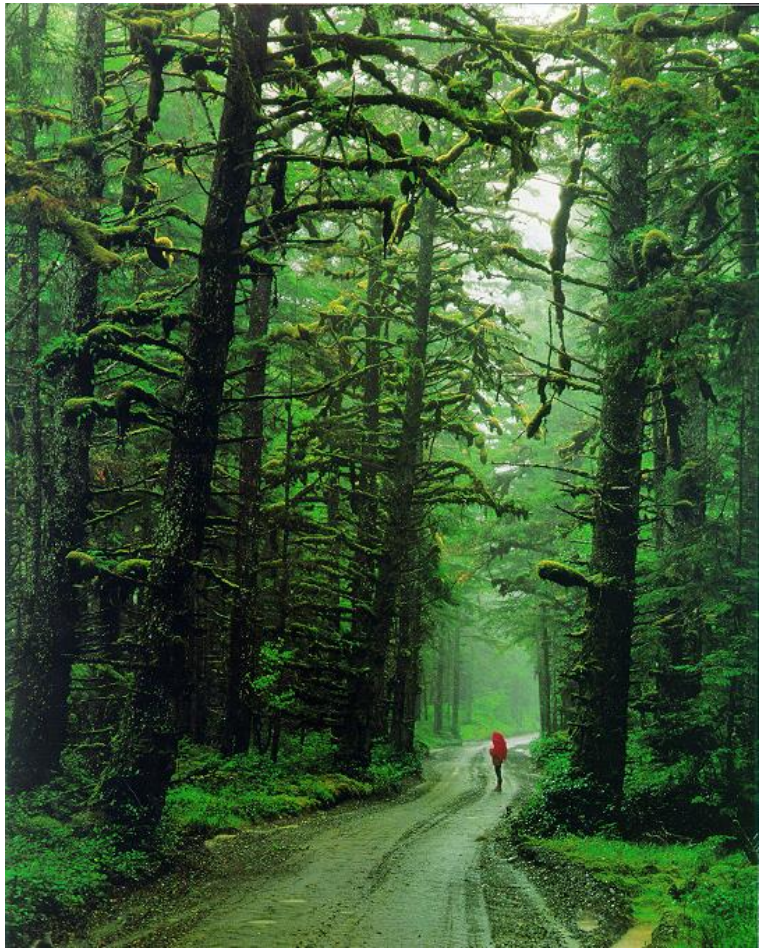
- Building Envelop Performance
  - 36 lecture hours
- Building Envelope Lab
  - 36 lab hours

How did we get here?

The BC Context: “Leaky Condo Crisis”

- Condo’s, or Condominiums, are multifamily residential housing units
- In the 1990’s, coastal BC experiences a dramatic systemic failure of building envelope systems costing billions of dollars
- Many types of buildings were affected by this failure, any many were Condo’s

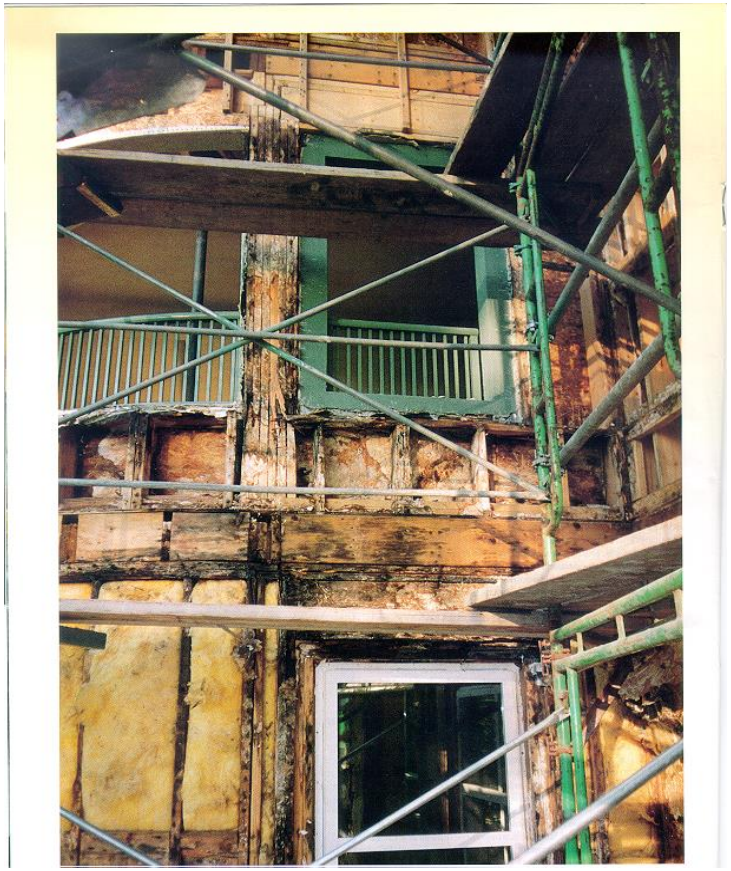
Coastal BC - a temperate rain forest climate



Characteristics of the temperate rainforest climate

- Moderate temperature
- High frequency of rain and wind-driven rain during the winter season
- Low sunshine during periods of highest rain fall

The “leaky condo crisis”: Premature building envelope failure



Systemic building envelope failure

Commission of Inquiry

In 1998 the Government of British Columbia appointed Dave Barrett to undertake a Commission of Inquiry into the Quality of Condominium Construction in British Columbia.

The Durability Problem
Consequences

- Financial hardship for owners
- Loss of public trust
- Loss of consumer confidence
- Emotional strain on owners and occupants
- Health compromise to occupants

The Durability Problem

Cost

WALL SYSTEM COST COMPARISONS						
Project	**Wall Area (sq. ft.)**	**Cost Rebuild**	**Cost Original**	**Cost Correctly**	**S.H.**	**Cladding/Framing**
Project A	14,000	$51.70	$22.50	$25.85	8	Concrete
Project B	28,300	$25.72	$13.25	$15.50	14	Stucco/Concrete
Project C	10,000	$26.80	$9.30	$11.25	3	Stucco/Wood

The Durability Problem

Cost

Residential Real Estate Sales BC

1983-1997

Quote from the inquiry

"In addition to economic pressures, climatic conditions, and a systemic failure of the building process, building science also played a role in bringing about this crisis of confidence."

– Barrett (1998)

Factors related to building science include:

- (i) a poorly interpreted building code;
- (ii) municipal by-laws that can lead to inappropriate design, exacerbated by architects, who do not understand the implications of their designs;
- (iii) the use of new materials without an understanding of how they will be affected by our climate;
- (iv) a loss of collective memory, and lack of conventional wisdom, among inspectors, architects, engineers, developers, and contractors regarding the requirements for effective building; and
- (v) ineffective communication and transfer of knowledge among the professionals and business people (who understand the issues), to others involved in the building process.

The Durability Problem
Cost

- The cost to repair the problem facing residential homeowners will be between $500 million and $800 million
  - Barrett (1998)
- Concern of a repeat without better application of widely-understood and endorsed building science principles

The Commissioner's report included a long list of recommendations

Recommendation #14: That training provided through educational institutions…clearly identify the special requirements for multi-family building envelopes in British Columbia.

One final quote from the Inquiry

"It should be made clear that the research and knowledge necessary to avoid the current problems have been known for more than thirty years, and that the principles of building envelope science (or enclosure design), as laid out in National Research Council studies, are built into Section 5 of the Building Code."

National Research Council of Canada (NRC)

- Late 1940's
  - Division of Building Research studies construction problems (now the IRC)
    - Emphasis on control of heat, air and moisture flow
- 1960's and 70's
  - Canadian Building Digests published
- 1985
  - Neil Hutcheon and Gus Handegord wrote textbook that summarized the "new discipline" of building science.
- 1995
  - Gus Handegord publishes a guide for teachers and students of building science.

The Utility of Building Science

"Knowledge about building, called, for convenience, building science, is valuable largely because it is useful in predicting the outcome or the result of some building situation. The prediction may involve the thermal pattern resulting from a particular wall construction in a given climate or the service to be expected from a particular kind of brick used in a given way in a particular location. The situation may be real, if the building already exists, or it may be posed in a hypothetical way in the normal course of building design. Rational design is possible only when there is the capability to establish, each time a choice is made, the probability of a particular result."

- Hutcheon (1971) The Utility of Building Science
- Published as the opening paper to the Fifth Conference on Building Science and Technology in Toronto in March 1990

- The systemic failure of building envelopes in coastal BC created the impetus to develop building science programming, and
- the vision of early researchers at the NRC provided the direction.

Masters Degree in Building Science

- Launch of first-of-a-kind Building Science program in BC & western Canada – Sept. 2010
  - Master of Engineering (M.Eng.) in Building Science
  - Master of Applied Science (M.A.Sc.) in Building Science
- First intake
  - 8 M.Eng. (4 FT and 4 PT)
  - 7 M.A.Sc. (6 FT and 1 PT)
- Three practicing Engineers

Acknowledgements

- BCBEC
- HPO
- BC Housing
- CMHC
- FP Innovations
- UBC
- Concordia University
  - Dr. Paul Fazio & Dr. Hua Ge
- RDH
- RJC
- BC Masonry Institute
- NSERC, CRC, CFI, BCKDF and WED

Program Structure: Two Degree Programs

- Master of Engineering in Building Science
  - One Year Full-Time
  - Course-based
    - More Coursework
    - Industry/Research Project
  - 33 Credits
- Master of Science in Building Science
  - Two Years Full-Time
  - Thesis-based
    - Less Coursework
    - Research Thesis
  - 36 Credits

Course Credit Comparison

M.Eng.	M.A.Sc.
Core Technical Courses	
15 credits	9 credits
Elective Technical Courses	
6 or 9 credits	6 or 9 credits
Elective Outside Program	
3 or 0 credits	3 or 0 credits
Graduate Seminar	
0 credits	0 credits
Research	
9 credits	18 credits
Total	
33 credits	36 credits

Courses

- Building Science I *
- Building Materials *
- Building Envelope I*
- Building Envelope II **
- Building Energy Performance**
  - * Core courses for M.Eng./M.A.Sc.
  - ** Core courses for M.Eng.
- Building Science II
- Advanced Acoustics
- Ventilation & IAQ
- Modeling Heat and Mass Transfer in Buildings
- Graduate Seminar
- Research Methods

Program Map: M.Eng.

M.Eng. Program Cluster	Term 1 Sept-Dec 15 weeks	Term 2 Jan-Apr 15 weeks	Term 3 May-Aug 15 weeks	Credit Totals
Core Technical courses (15 credits)	Building Science 1 BSCI 9000 3 credits Building Materials BSCI 9020 3 credits	Building Envelope 1 BSCI 9110 3 credits Building Energy Performance BSCI 9130 3 credits	Building Envelope 2 BSCI 9210 3 credits	**15**
Elective technical courses (students select two courses for in-depth study)	Advanced Acoustics BSCI 9060 3 credits	Building Science 2 BSCI 9100 3 credits Ventilation & IAQ BSCI 9170 3 credits	Modeling Heat and Mass Transfer in Buildings BSCI 9240 3 credits	**6**
Elective outside of the program	Outside of the program 3 credits	Outside of the program 3 credits	Outside of the program 3 credits	**3**
Graduate seminar 0 credits	Graduate Seminar series BSCI 9055			**0**
Research 9 credits	Research Methods BSCI 9050 3 credits	Industry/Research Project BSCI 9750 6 credits		**9**
				33

Program Map: M.A.Sc.

M.A.Sc. Program Cluster	Term 1 Sept-Dec 15 weeks	Term 2 Jan-Apr 15 weeks	Term 3 May-Aug 15 weeks	Term 4 Sept-Dec 15 weeks	Term 5 Jan-Apr 15 weeks	Term 6 May-Aug 15 weeks	Credit Totals
Core Technical courses (9 credits)	Building Science 1 BSCI 9000 3 credits Building Materials BSCI 9020 3 credits	Building Envelope 1 BSCI 9110 3 credits					**9**
Elective technical courses (students select two or three courses for in-depth study)	Advanced Acoustics BSCI 9060 3 credits	Building Energy Performance BSCI 9130 3 credits Building Science 2 BSCI 9100 3 credits Ventilation & IAQ BSCI 9170 3 credits	Building Envelope 2 BSCI 9210 3 credits Modeling Heat and Mass Transfer in Buildings BSCI 9240 3 credits				**6 or 9**
Approved Elective from outside of the program (max. of one course)	Outside of the program 3 credits	Outside of the program 3 credits					**3 or 0**
Graduate Seminar series 0 credits	Graduate Seminar series BSCI 9055						**0**
Research 18 credits	Research Methods BSCI 9050 3 credits		Research Proposal BSCI 9650 3 credits	Research Thesis BSCI 9850 12 credits			**18**
							36

Program Entry Requirements

- M.Eng.
  - Bachelor's degree in an engineering field
- M.A.Sc.
  - Bachelor's degree in an engineering field or architecture
  - Bachelor degree in a science field and completion of the Architectural and Building Technology (ABT) diploma with Building Science option or Industry practice

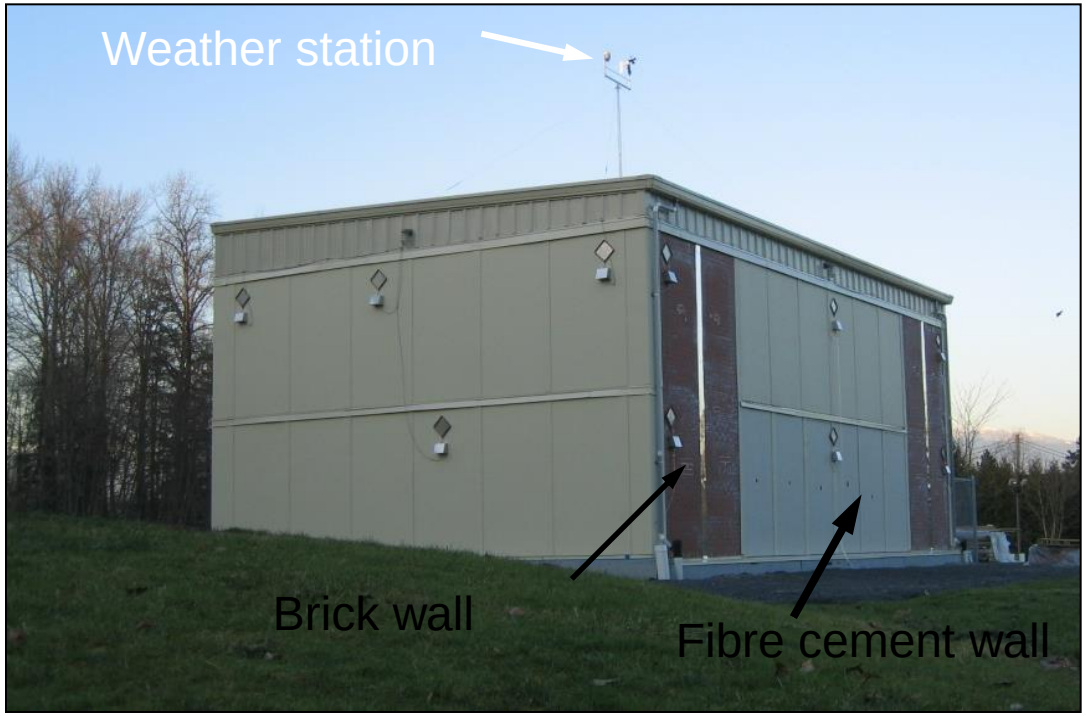
Program Entry cont'd

- Advanced mathematics in differential equations and linear algebra
- English language proficiency
- Applicants who completed post-secondary studies outside of Canada, United States or England will require a comprehensive evaluation of their credentials by the International Credential Evaluation Service (ICES).

Research Infrastructure

- Building envelope field experimental facility
- Material Properties and Instrumentation laboratory
- Computer models: Building envelope HAM, Energy and Whole-Building Hygrothermal & IEQ models
- Field monitoring
- Whole-Building performance research laboratory
- Full-scale environmental chamber (under development)
- Green Roof Research Facility
- Sound transmission suite and reverberation chamber

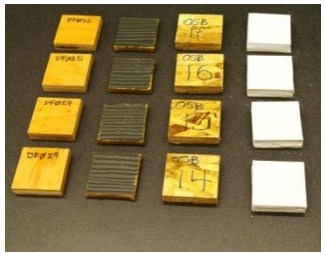
Building Envelope Test Facility

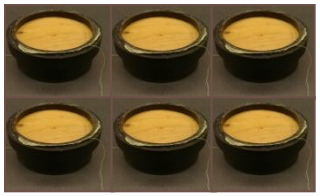


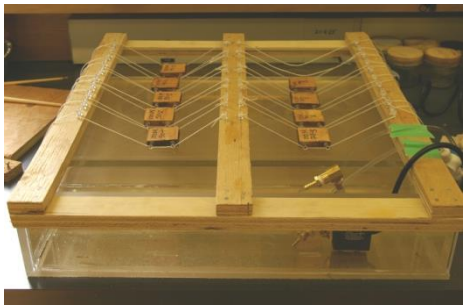
- Dimensions
  - 44’ x 28’
- Test
  - Walls
  - Roof
  - Windows
- Accommodates
  - 62 Panels

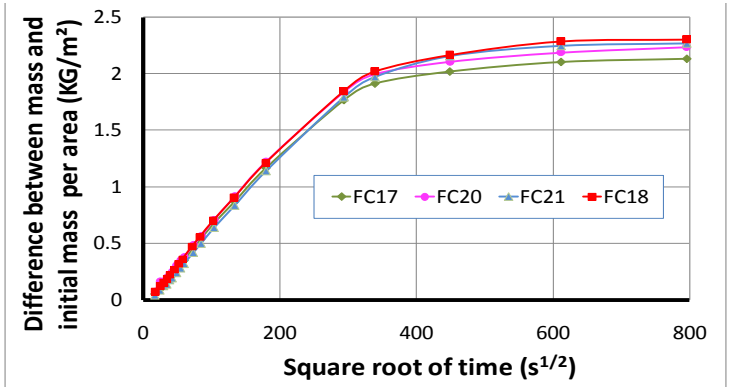
Material Property Measurements

- Moisture sorption isotherm
- Vapour permeability
- Water absorption coefficient
- Thermal conductivity

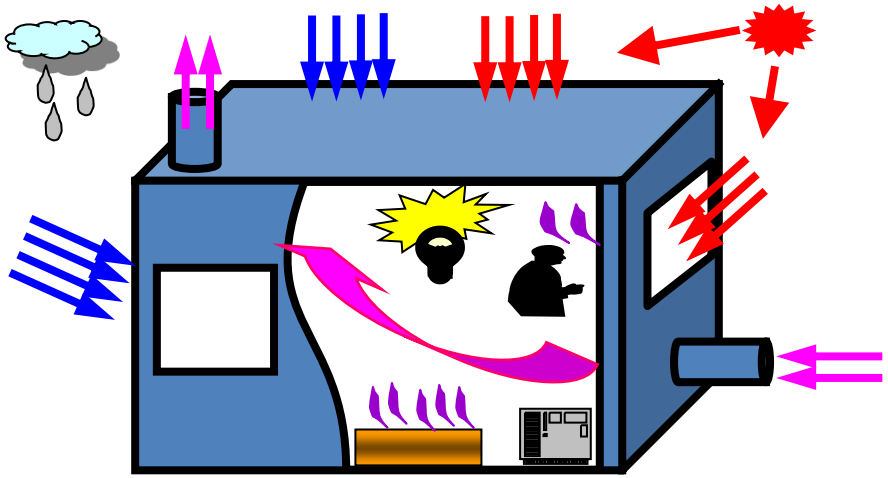




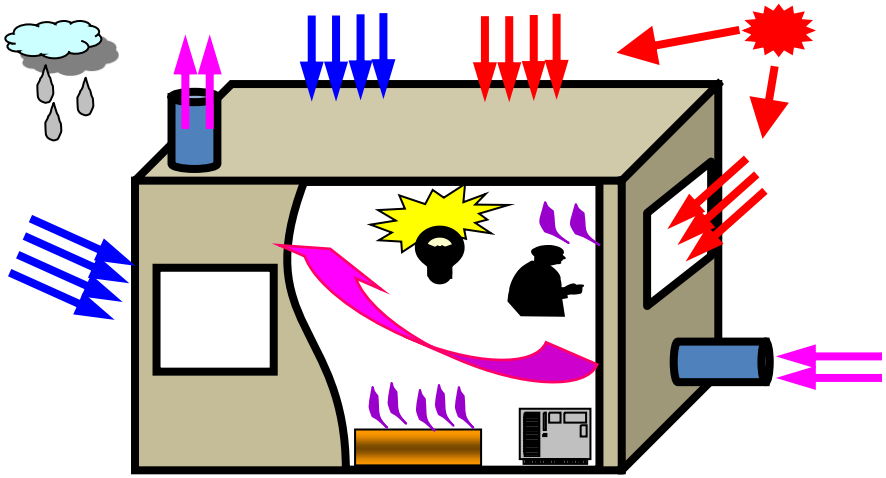




Whole-Building Performance Research Laboratory



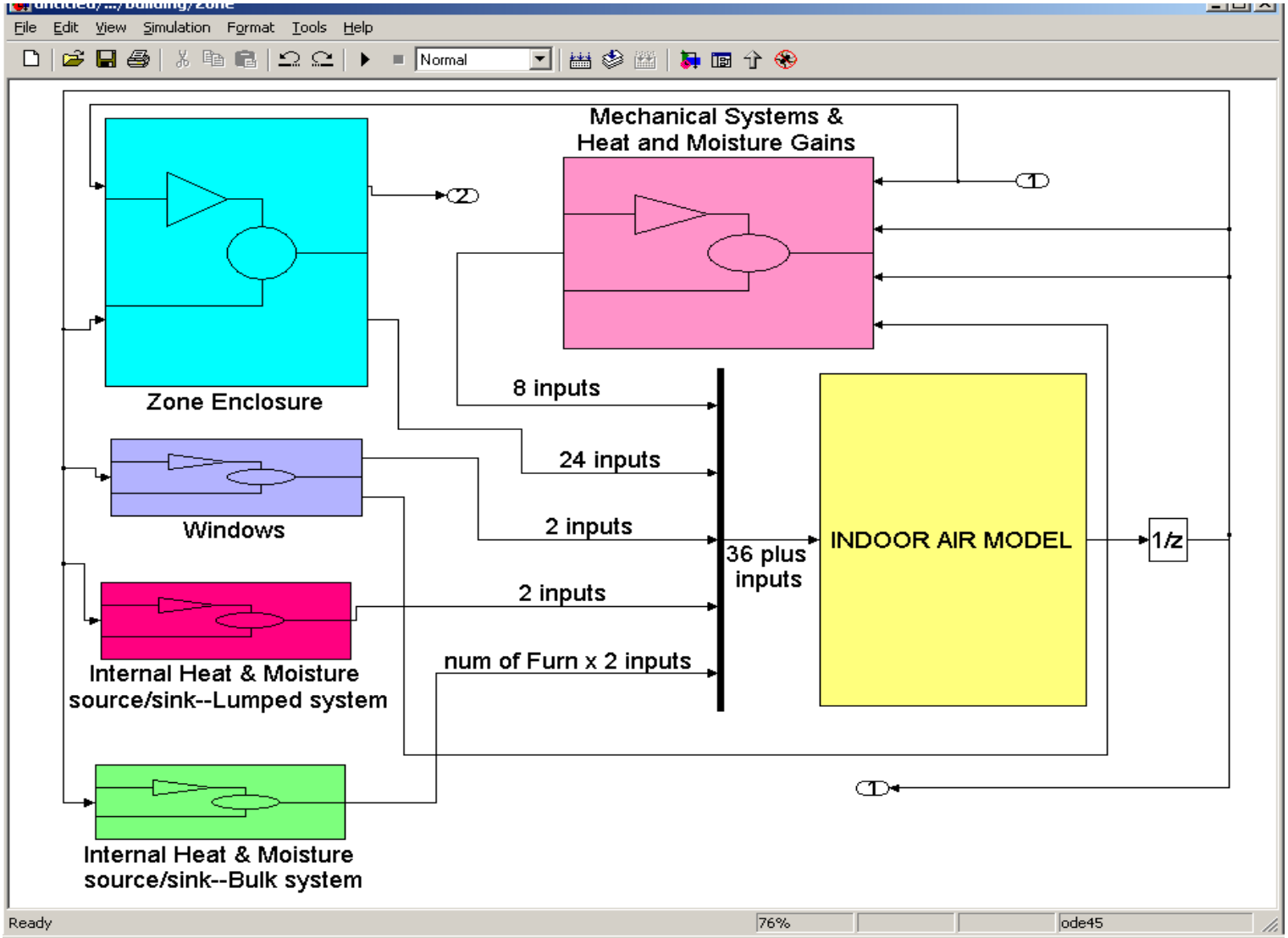
Reference Building



Test Building

Whole-Building Performance Research Laboratory (WBPRL)

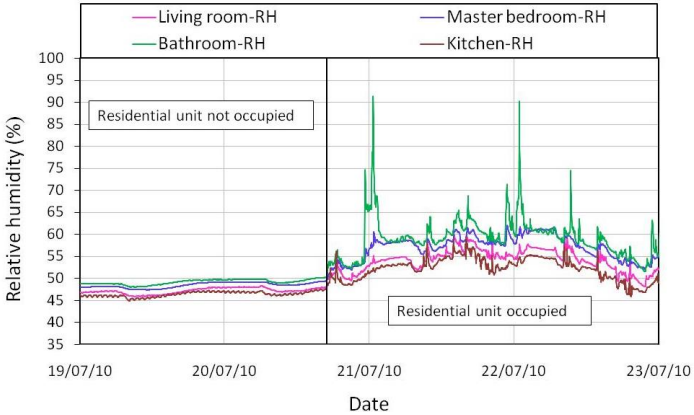
Whole-Building Hygrothermal Modeling



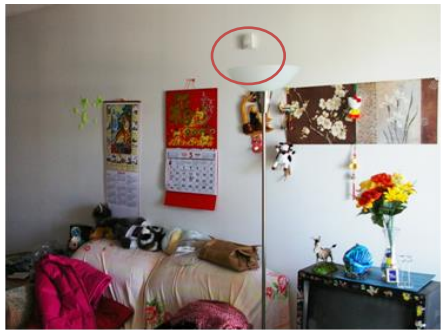
Indoor Climate Load Analysis

The residential building for indoor climate testing in Vancouver

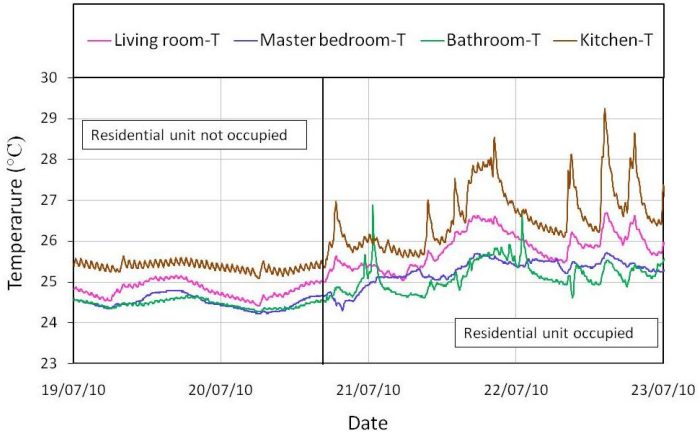
The HOBO data logger use measurement



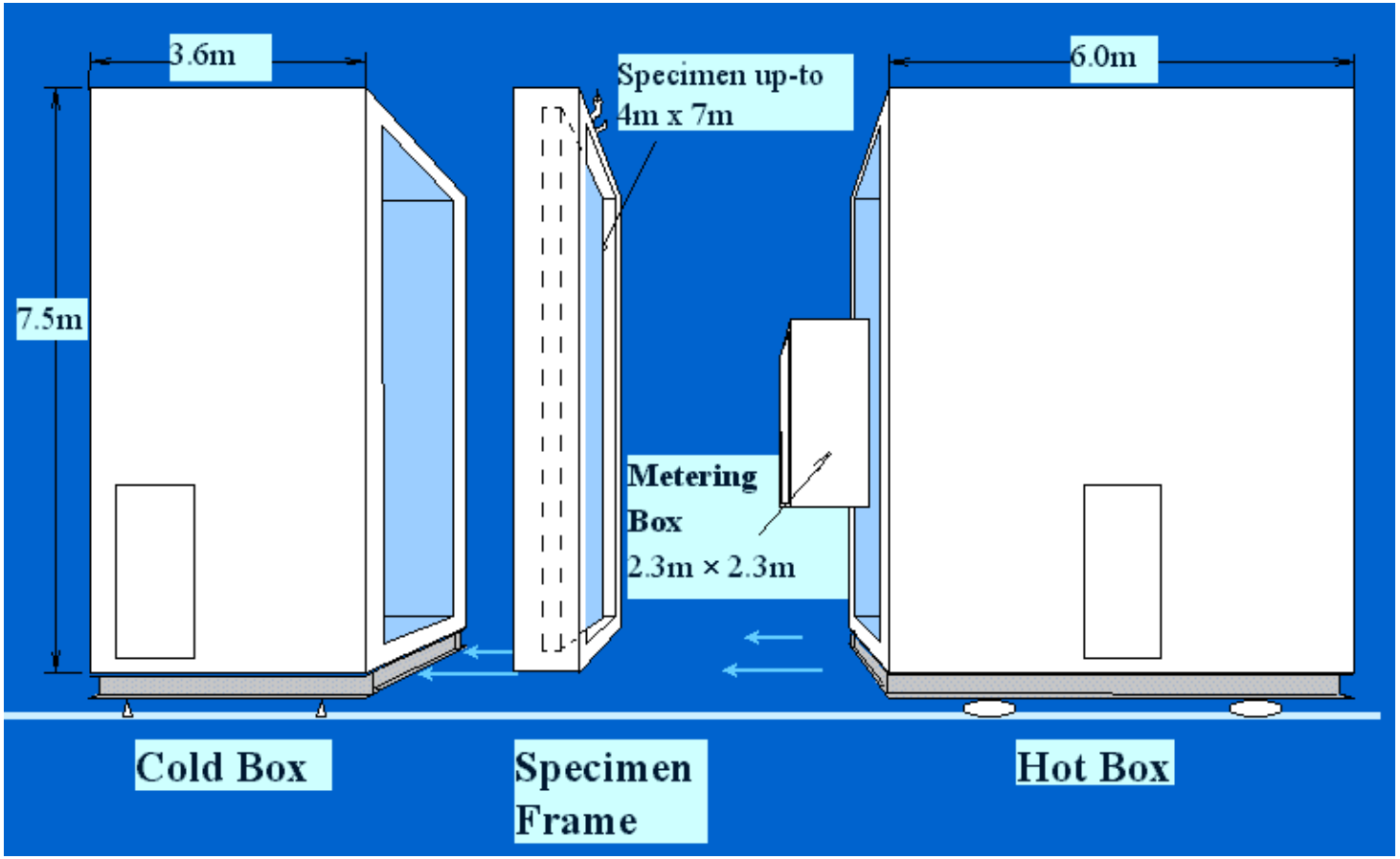
A HOBO data logger installed in kitchen



A HOBO data logger installed in living room



Under development: Full Scale Environmental Facility

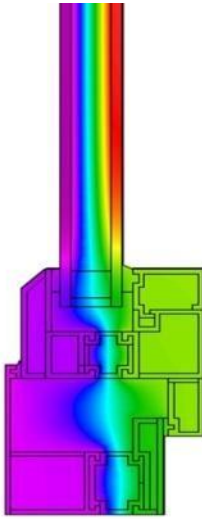


Indoor-Outdoor sound Transmission Suite

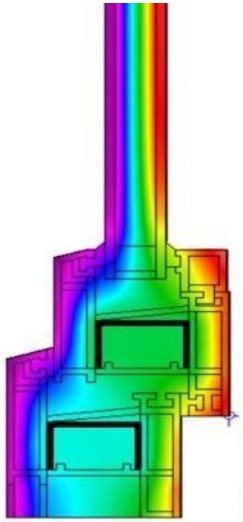
A success story

Bullitt Center
Seattle, WA

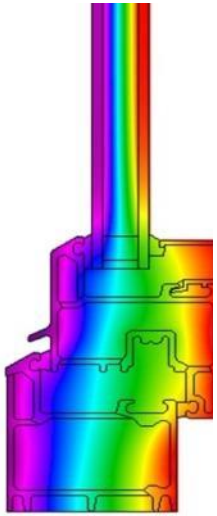
Fiberglass frames – dimensionally stable and thermally efficient



THERMALLY BROKEN ALUMINUM FRAME



REINFORCED VINYL FRAME

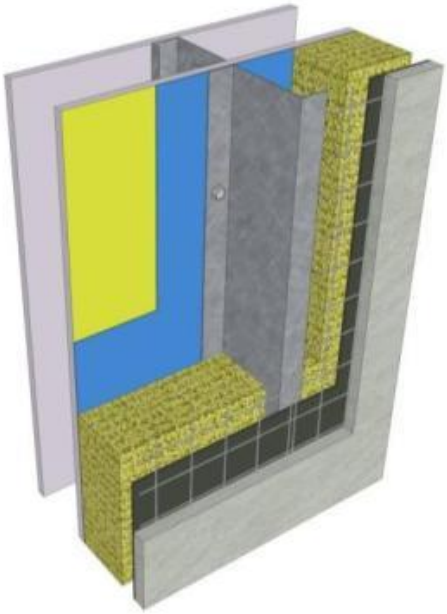


FIBERGLASS FRAME

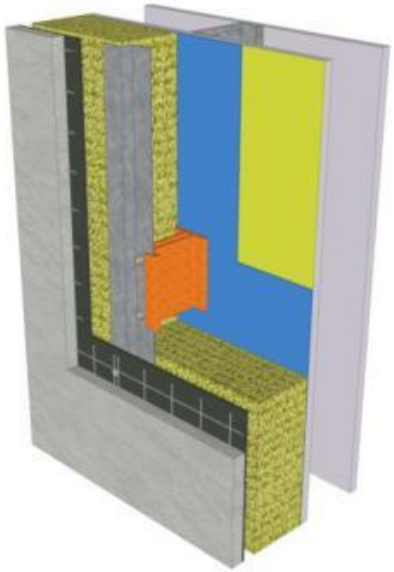
Outstanding Quality Assurance Measures


Linfield
College

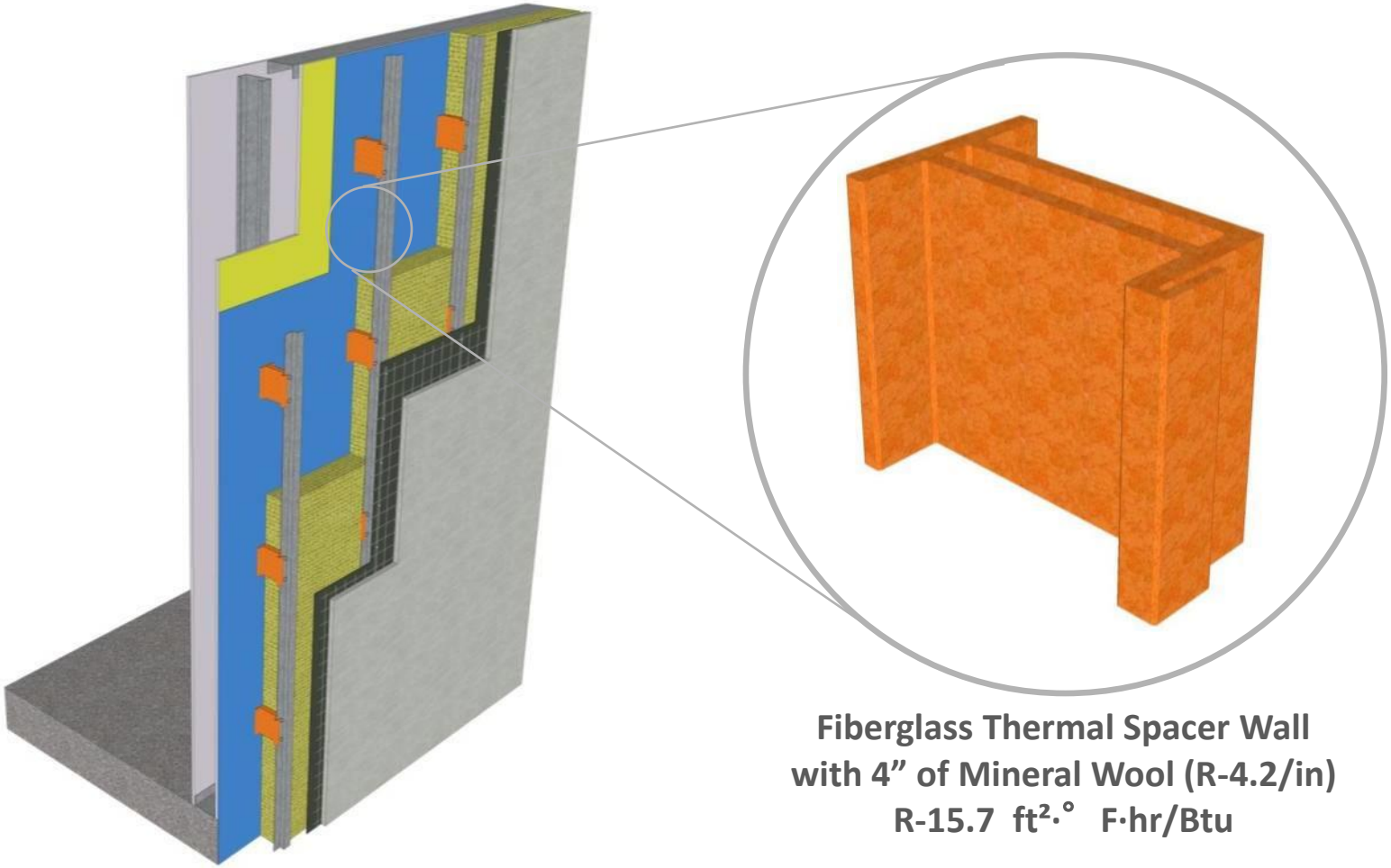

16




ASHRAE STANDARD
Energy Standard for Buildings Except Low-Rise Residential Buildings



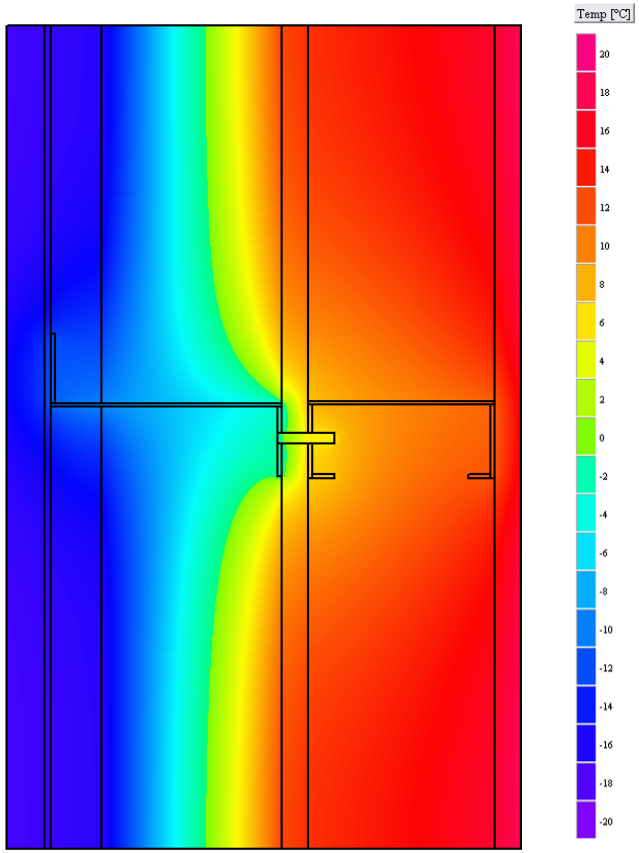
Cascadia Clip - Fiberglass Thermal Spacer



Fiberglass Thermal Spacer Wall
with 4” of Mineral Wool (R-4.2/in)
R-15.7 ft²·° F·hr/Btu

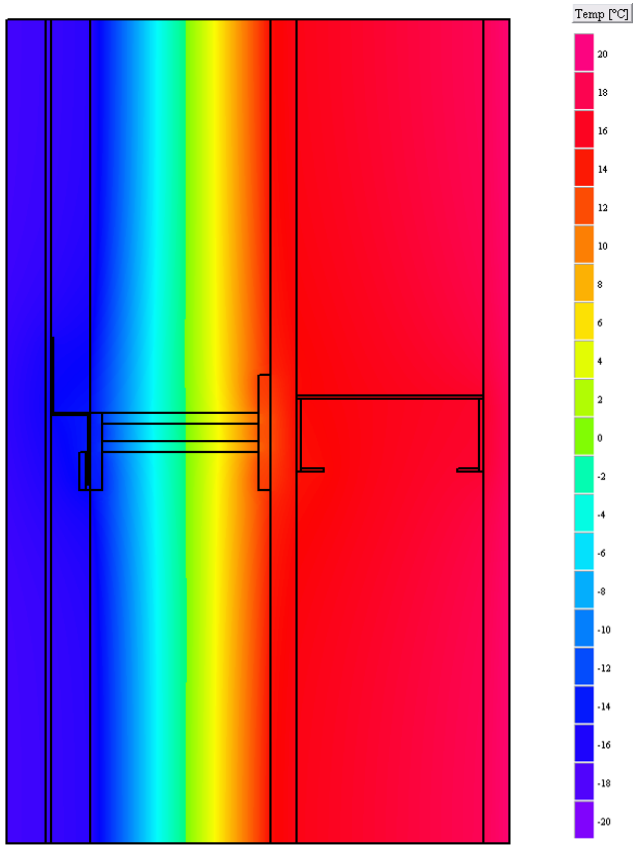
Low-conductivity fiberglass material reduces thermal bridging and improves the effective thermal performance of the wall.

Fiberglass Thermal Spacer



R-7.0

Common wall with exterior steel girts; not ASHRAE 90.1 compliant
(needs to meet R-15.6 effective)



R-15.7

Exceeds the ASHRAE 90.1 minimum prescriptive requirement of R-15.6 $ft^2 \cdot {}^\circ F \cdot hr/Btu$ for steel frame walls

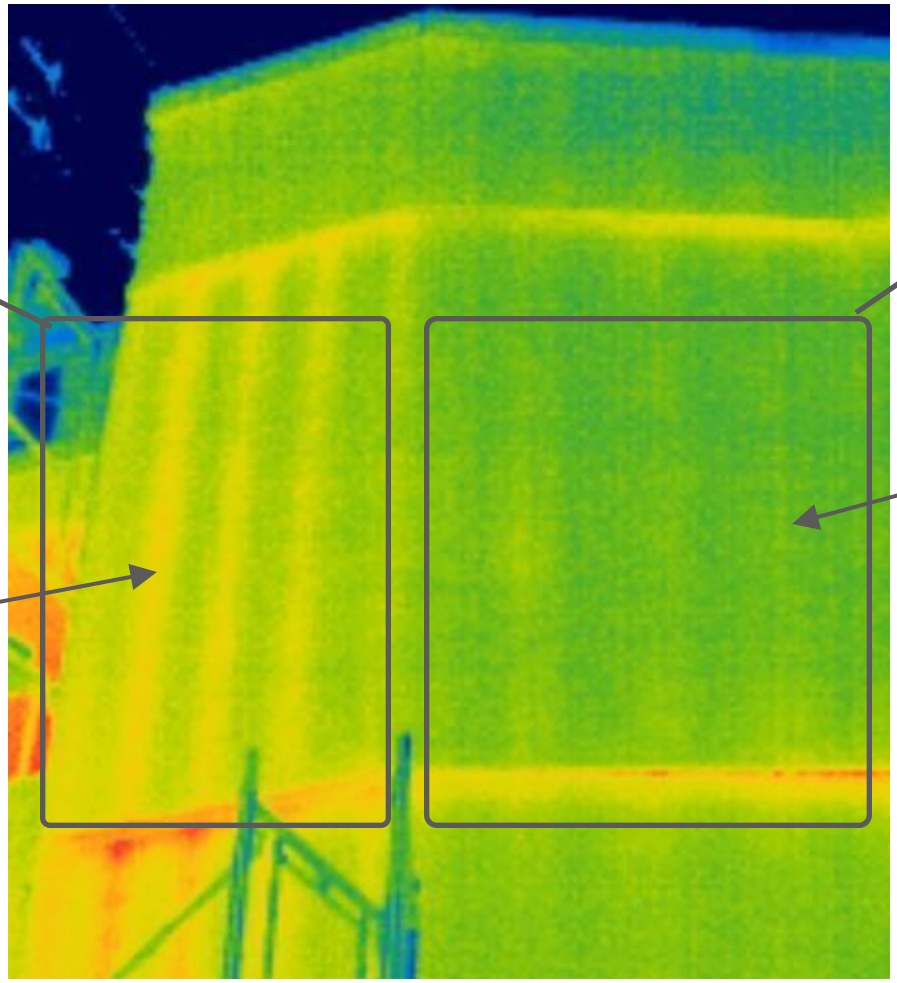

CASCADIA CLIP™
FIBERGLASS
THERMAL SPACER

Fiberglass Thermal Spacer

Field Comparison of Vertical Z-Girt and Fiberglass Girt Spacer System

Vertical Z-Girt Wall System

Warm areas visible on exterior wall that correspond with the conductive Vertical Z-girts.



Fiberglass Thermal Spacer Wall System

Essentially no warm areas visible on exterior wall because fiberglass spacers limit the heat flow.

Infrared Image of Exterior Wall

Awards

- This has been getting some attention…

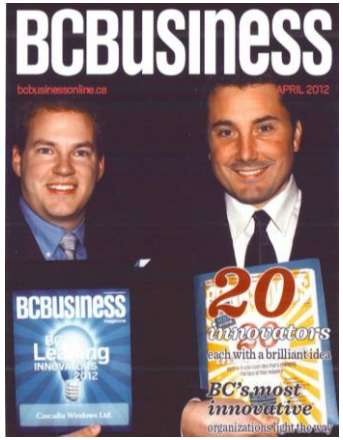
GLOBE-Net

CASCADIA WINDOWS & DOORS

the GREEN innovators in B.C.

VRCA

Awards of Excellence 2011
Sustainable Construction and Innovation
SILVER Award



Cascadia in Top 10 Most Innovative Companies

THE WTN
THE WORLD TECHNOLOGY NETWORK

BC EXPORT AWARDS 2012 WINNER

FORTUNE CNN TIME