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

- Degrees
- Technologies
- Trades
Introduction to BCIT - Flexible Delivery

• Part-time studies
• Distance learning
• Prior learning assessment
Introduction to BCIT - Vertically Integrated Curriculum

Degrees

Technologies

Trades
Vertical Integration - Teaching Huts
Hands-on Building Enclosure Construction and Detailing
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 Envelope Solutions
- 36 lecture/lab hours

Certificate in Architectural and Building Technology – 40 Students
- Building Envelope 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

<table>
<thead>
<tr>
<th>Project</th>
<th>Wall Area (sq. ft.)</th>
<th>Cost Rebuild</th>
<th>Cost Original</th>
<th>Cost Correctly</th>
<th>S.H.</th>
<th>Cladding/Framing</th>
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<tr>
<td>Project A</td>
<td>14,000</td>
<td>$51.70</td>
<td>$22.50</td>
<td>$25.85</td>
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<td>Concrete</td>
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<td>Project B</td>
<td>28,300</td>
<td>$25.72</td>
<td>$13.25</td>
<td>$15.50</td>
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<td>Stucco/Concrete</td>
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<tr>
<td>Project C</td>
<td>10,000</td>
<td>$26.80</td>
<td>$9.30</td>
<td>$11.25</td>
<td>3</td>
<td>Stucco/Wood</td>
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</tbody>
</table>
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

<table>
<thead>
<tr>
<th></th>
<th>M.Eng.</th>
<th>M.A.Sc.</th>
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</thead>
<tbody>
<tr>
<td><strong>Core Technical Courses</strong></td>
<td>15 credits</td>
<td>9 credits</td>
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<tr>
<td><strong>Elective Technical Courses</strong></td>
<td>6 or 9 credits</td>
<td>6 or 9 credits</td>
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<td><strong>Elective Outside Program</strong></td>
<td>3 or 0 credits</td>
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<tr>
<td><strong>Graduate Seminar</strong></td>
<td>0 credits</td>
<td>0 credits</td>
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<tr>
<td><strong>Research</strong></td>
<td>9 credits</td>
<td>18 credits</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>33 credits</td>
<td>36 credits</td>
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</table>
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.

<table>
<thead>
<tr>
<th>M.Eng. Program Cluster</th>
<th>Term 1 Sept-Dec 15 weeks</th>
<th>Term 2 Jan-Apr 15 weeks</th>
<th>Term 3 May-Aug 15 weeks</th>
<th>Credit Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Technical courses (15 credits)</td>
<td>Building Science 1 BSCI 9000 3 credits</td>
<td>Building Envelope 1 BSCI 9110 3 credits</td>
<td>Building Envelope 2 BSCI 9210 3 credits</td>
<td>15</td>
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<tr>
<td></td>
<td>Building Materials BSCI 9020 3 credits</td>
<td>Building Energy Performance BSCI 9130 3 credits</td>
<td></td>
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<tr>
<td>Elective technical courses (students select two courses for in-depth study)</td>
<td>Advanced Acoustics BSCI 9060 3 credits</td>
<td>Building Science 2 BSCI 9100 3 credits</td>
<td>Modeling Heat and Mass Transfer in Buildings BSCI 9240 3 credits</td>
<td>6</td>
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<tr>
<td></td>
<td></td>
<td>Ventilation &amp; IAQ BSCI 9170 3 credits</td>
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<td>Elective outside of the program</td>
<td>Outside of the program 3 credits</td>
<td>Outside of the program 3 credits</td>
<td>Outside of the program 3 credits</td>
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<tr>
<td>Graduate seminar 0 credits</td>
<td>Graduate Seminar series BSCI 9055</td>
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<tr>
<td>Research 9 credits</td>
<td>Research Methods BSCI 9050 3 credits</td>
<td>Industry/Research Project BSCI 9750 6 credits</td>
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<tr>
<td>M.A.Sc. Program Cluster</td>
<td>Term 1 Sept-Dec 15 weeks</td>
<td>Term 2 Jan-Apr 15 weeks</td>
<td>Term 3 May-Aug 15 weeks</td>
<td>Term 4 Sept-Dec 15 weeks</td>
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<tr>
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</tr>
<tr>
<td>Core Technical courses</td>
<td>Building Science 1 BSCI 9000 3 credits</td>
<td>Building Envelope 1 BSCI 9110 3 credits</td>
<td>Building Materials BSCI 9020 3 credits</td>
<td>Building Energy Performance BSCI 9130 3 credits</td>
</tr>
<tr>
<td>Elective technical courses</td>
<td>Advanced Acoustics BSCI 9060 3 credits</td>
<td>Building Science 2 BSCI 9100 3 credits</td>
<td>Ventilation &amp; IAQ BSCI 9170 3 credits</td>
<td>Building Energy Performance BSCI 9130 3 credits</td>
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<tr>
<td>Approved Elective from outside of the program (max. of one course)</td>
<td>Outside of the program 3 credits</td>
<td>Outside of the program 3 credits</td>
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<td>Graduate Seminar series</td>
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<td>Graduate Seminar series BSCI 9055</td>
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<td>Research 18 credits</td>
<td>Research Methods BSCI 9050 3 credits</td>
<td>Research Proposal BSCI 9650 3 credits</td>
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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

Features:
- Weather station
- Brick wall
- Fibre cement wall
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 (WBPRRL)
Whole-Building Hygrothermal Modeling
Indoor Climate Load Analysis

The residential building for indoor climate testing in Vancouver

A HOBO data logger installed in kitchen

A HOBO data logger installed in living room

The HOBO data logger used for the measurement

Relative humidity (%)

<table>
<thead>
<tr>
<th>Date</th>
<th>Living room-RH</th>
<th>Bathroom-RH</th>
<th>Master bedroom-RH</th>
<th>Kitchen-RH</th>
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</thead>
<tbody>
<tr>
<td>19/07/10</td>
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<td>20/07/10</td>
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<td>21/07/10</td>
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<td>23/07/10</td>
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</tbody>
</table>

Residential unit not occupied

Residential unit occupied

Temperature (°C)

<table>
<thead>
<tr>
<th>Date</th>
<th>Living room-T</th>
<th>Master bedroom-T</th>
<th>Bathroom-T</th>
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<td>23/07/10</td>
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</tr>
</tbody>
</table>

Residential unit not occupied

Residential unit occupied
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
Outstanding Quality Assurance Measures
Cascadia Clip - Fiberglass Thermal Spacer

Fiberglass Thermal Spacer Wall with 4” of Mineral Wool (R-4.2/in)
R-15.7 $ft^2 \cdot ^\circ F \cdot hr/Btu$

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

R-15.7
Exceeds the ASHRAE 90.1 minimum prescriptive requirement of R-15.6 ft²·° F·hr/Btu for steel frame walls

R-7.0
Common wall with exterior steel girts; not ASHRAE 90.1 compliant (needs to meet R-15.6 effective)
Fiberglass Thermal Spacer

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

Vertical Z-Girt Wall System

Fiberglass Thermal Spacer Wall System

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

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

- This has been getting some attention…

Cascadia in Top 10 Most Innovative Companies