Modern Building Enclosures: Implementing the New Energy Standards

SESSION T151 - THE BUILDINGS SHOW - TORONTO, ON
DECEMBER 1, 2016
PRESENTED BY ALEX LUKACHKO, PRINCIPAL
The Big Story in Brief

1. Our industry is in a period of rapid change as we integrate “performance” into design and construction

2. We should pay special attention to changing energy efficiency codes and standards

3. There are implications for architecture – we will be designing and building different buildings.
→ New materials and systems
→ Faster construction & design cycles
  → All weather construction, efficient material use
→ Congested sites
  → i.e., urban & additions to existing buildings
→ More High-rise & Multi-use
→ Better energy performance
→ Climate Change & Resiliency
→ Design for Maintenance & Renewal
How is this change different than in the past?

1. The rate of change has increased
   - availability of different materials and systems
   - new properties and applications for old materials
Evaluation of Membranes and Substrate Movement

Liquid applied membranes

Self-adhered sheet applied membranes

Liquid applied membranes
How is this change different than in the past?

1. The rate of change has increased
2. Owner/occupant expectations have changed:
   - Operate buildings differently – AC, pressure
   - (some) owners asking for:
     - more energy efficiency
     - better indoor environmental quality
     - more durable buildings
     - lower ecological impact
1. The rate of change has increased
2. Owner/occupant expectations have changed
3. Performance requirements address the whole building
   → Changes can no longer be done through specs only
      – Energy performance is a SYSTEM and DESIGN issue not a material issue (e.g., air barrier systems, mechanical/enclosure integration)
   → Measured performance is a game changer
      – Models vs reality
      – Code compliance vs performance
How is this change different than in the past?

1. The rate of change has increased
2. Owner/occupant expectations have changed
3. Performance requirements address the whole building

→ These have fundamental implications for how buildings will look and how they will be built
   (i.e., these changes will change the architecture)
Let’s look at the energy efficiency of buildings

Today’s Energy Use of Canadian Buildings – By Year of Construction

- Energy consumption is for year 2009
- Most older building have been renovated with newer HVAC
- Not getting much better!

Ref: Survey of Commercial and Institutional Energy Use – Buildings 2009, NRCAN
Today’s Energy Use of USA Buildings
– By Year of Construction

Ref: Commercial Building Energy Consumption Survey 2003 – US DOE
Where are energy codes going?

This graph is illustrative only.
Energy Codes over time

This graph is illustrative only
→ Architecture 2030
  → sets benchmarks for progress to zero (circa 2006)
  → adopted by the AIA before 2010
→ LEED
  → aimed at broad industry buy-in to a broad platform of building-related issues; now deepening approach

→ ENERGY STAR
  → in the U.S. leads code change by developing and testing new technology, and establishing acceptance in the market
→ ASHRAE 90.1, USACE regulations
From: Standing Committee on Energy Efficiency of Buildings

To: Executive Committee to the Canadian Commission on Building and Fire Codes (CCBFC)

The memo formed part of a recommendation from the Standing Committee on Energy Efficiency of Buildings and should not be considered as direction from the Canadian Commission of Building and Fire Codes (CCBFC) or the Provinces and Territories.

- A policy paper/strategy is still in the works but is not yet available.
Possible Long-term Energy Improvement Values

- Change to compliance based on performance
- 100 ekWh/m²/year considered the threshold for “net zero ready”
- Achievable between 2025 – 2030 with strategies that are considered workable.
Where might these improvements come from?

- Most savings from mechanical systems, then building enclosure
- Language to describe energy targets switches to EUI

And other consider added:
- objectives related to health and greenhouse gas in NECB
- don’t count renewables in base compliance
- commissioning, certification, and testing

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| Savings over NECB2011      | 2.5% | 15%  | 31%  | 46%  | 57%  |
| ekW-h/m²/year              | 195  | 170  | 138  | 108  | 86   |
Bullitt Center
Seattle, Washington

Architect: The Miller Hull Partnership

50 – 50 = 0
(16 kBtu/ft²)
By 2025, every building in Canada will need this kind of performance

Architect: The Miller Hull Partnership
key energy changes

1. increase insulation
2. address thermal bridging
3. increase whole building airtightness
4. windows

→ For each, examine trends and potential impacts
→ Will conclude with summary of implications for architecture
Increase insulation

- obvious connection to reducing heat flow
  - big impact in a cold climate
  - hard to go wrong with this passive approach
→ **Rated R-value**
   
   → The *theoretical* R-value of the insulation. Sometimes called the Nominal or Advertised R-value. E.g., “R-13 batt” or “R-6/inch”

→ **Total R-value**

   → The actual R-value of the wall assembly including not only the Effective R-value of the insulation but also the R-values for other wall system components such as materials, air spaces, air films, etc.
Traditional R-value Calculations

Dr. Ted Kesik, University of Toronto
→ **Rated R-value**
  
  → The *theoretical* R-value of the insulation. Sometimes called the Nominal or Advertised R-value. E.g., R-13 batt; R-6/inch

→ **Total R-value**
  
  → The actual R-value of the wall *assembly* including not only the Effective R-value of the insulation but also the R-values for other wall system components such as materials, air spaces, air films, etc.

→ **Effective R-value**
  
  → The *functional* R-value of the insulation as installed in the wall assembly, de-rated if necessary due to thermal bridging at framing members.
Find the thermal bridge
Best-case R-values for Wood and Steel Stud Walls

**Steel Studs @ 16" o.c.**

**Wood Studs @ 16" o.c.**

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Source: ASHRAE 90.1-2007, Table A9.2B. CI denotes a layer of continuous insulation with no framing penetrations.
Adding Insulation to Frame Walls

Baseline
2x6 w/ R-22 batts = ~R-16 effective

Exterior Insulation:
R-20 to R-40+ effective
- Constraints: cladding attachment, wall thickness
- Good durability

Deep or Double Stud:
R-20 to R-40+ effective
- Constraints wall thickness
- Fair durability, sensitive to air/vapour

Split Insulation:
R-20 to R-40+ effective
- Constraints: cladding attachment
- Good durability with proper design
Complete prefab high-performance enclosure
Increase insulation

→ challenges:
  → cladding attachment
  → total wall thickness
  → trim, windows, doors

→ other options:
  → thicker frame walls
    › less expensive, more risk
  → precast and IMP
    › more expensive, different risk, application for high-rise
2 Address thermal bridging

- impacts of thermal bridging:
  - heat flow (energy and comfort problems)
  - localized moisture problems

- major thermal bridges
  - framing (see effective R-value)
  - windows (more on that later)
  - balconies and other projecting structural elements
  - cladding attachment (esp. heavy cladding)
Structural Penetrations with High Heat Flow

→ Balconies, exposed slab edges, etc.
Balcony thermal bridge options

Zeidler Partnership Architects; image: Norman Li AG+I
Address thermal bridging

→ impacts:
  → heat flow (energy and comfort problems)
  → localized moisture problems

→ major thermal bridges
  → framing (see effective R-value)
  → windows (more on that later)
  → balconies
  → cladding attachment (esp. heavy cladding)

→ compliance tightening up
Attention to thermal bridging

→ LEED® Canada 2009 Supplementary Energy Modelling Guidelines (emphasis added):

“All of the energy modelling submittal pathways referenced by the LEED Canada rating systems require that thermal bridging in envelope assemblies (e.g. fenestration, opaque walls, roofs, etc.) be reasonably accounted for when determining the overall thermal transmittance of envelope components of the Proposed building . . . However, the energy modeller should be aware that the state of the art is continually advancing, especially as new tools and references reduce the level of effort of determining the overall thermal transmittance of envelope construction. It is the responsibility of the modelling professional to understand the validity of the source of information and/or the limitations and assumptions associated with any references, tools or resources used to determine overall envelope assembly thermal transmittance.”
LEED® Canada 2009 Supplementary Energy Modelling Guidelines, continued:

“Through the LEED Canada certification review process the CaGBC has noticed that thermal bridging in the following envelope assemblies are often overlooked. These assemblies must have their overall thermal performance evaluated to account for thermal bridging, according to the standards referenced by LEED Canada. Example assemblies include, but are not limited to, the following:

- Spandrel panel sections in window wall and curtain wall
- Fenestration in general
- Z-girt walls
- Balcony slabs, uninsulated slab edges

Note: The above list is not meant to be a complete list of envelope assemblies the modeller needs to evaluate to account for thermal bridging—it is only a list of commonly overlooked assemblies.”
Analysis method and catalogue of thermal bridge details.
Expanded catalogue of thermal bridge details and more specific information on how to use this information in design.
Information specifically for designers comparing thermal performance of a range of methods.
Examines common details in existing buildings and explains how to use the information in energy models.
Increase whole building airtightness

- Requirements for an Air Barrier System
  - Continuous (most important)
  - Strong
  - Stiff
  - Durable
  - Air Impermeable (least important)

- Energy impacts are significant:
  - 16% of heating and cooling for office buildings
  - 24% for multi-unit residential buildings
  - and the impacts increase for well insulated buildings
Large Building Airtightness Study

A basis for future code changes – is it possible to have whole building air leakage targets and testing in the code?
Airtightness Trends in Mid-Rise Construction

Seattle & WA State Requirement = 0.40 cfm/ft^2 @75Pa
Who is responsible for the connections?
Often exterior air barrier is only practical solution
Airtightness is not a “spec” change

1. **Design**
   - Set performance targets
   - Choose assemblies and materials
   - U.S. Army Corps of Engineers target is 0.25 cfm/ft$^2$ at 0.3” H$_2$O (1.3 l/s/m$^2$ at 75 Pa)

2. **Inspection**
   - confirmation of materials and systems
   - confirmation of assembly sequence

3. **Testing**
   - whole building test common for small and mid size buildings
   - testing of mock-up common for mid-size and large buildings
Air Leakage Testing

Infiltration test
ASTM E779

image: Building Science Corporation
→ glazing has a very significant impact on whole building thermal performance

→ not as simple as other changes
  → contributes to view, daylighting, ventilation
  → passive solar heating, but also unwanted heat gain
  → strongly related to marketing / identity of buildings
Impact on overall thermal performance?

**Overall Thermal Performance**
- **Current building**: R-2.5
- **Current OBC SB-10 target**: R-5.8
- **Future target**: R-10+

**“Centre of Glass”**
- Flanking through window frame

**“Spandrel”**
- Flanking through window frame

- “Edge of glass” – flanking through spacer

*Less than R-4 overall*
Wall system (wall + windows) overall R-value is strongly affected by WWR.
Problems of perception with WWR

- Doesn’t have to look like this!
- And it’s not all about how much glass
Architect: The Miller Hull Partnership
Steve Kemp (RDH): “Great envelopes enclosures enable great HVAC”

New Hlfx Condo
Tower
R-4 spandrel,
60% WWR of U-0.40

NECB
R-19 wall
40% WWR of U-0.39

What we want:
R-18 Walls,
40% WWR of U-0.16

Typ. Limit of 180F Baseboard

Typ. Limit of Infloor Radiant

Typ. Cost Effective VRF Heat Pumps
implications
Implications for how buildings will look

→ different approach to glazing
  › 50% or less? “inside – out” thinking is required
  › daylight and passive ventilation will be more important
  › we may have new buildings that look like old buildings

→ thicker walls, experimentation with cladding
  › better insulation quality, increased quantity = thicker
  › challenges for cladding attachment, fit to site

→ different approach for structural projections
  › balconies most obvious but parapets, canopies, etc.
→ our design and construction process will change:
  → design thermal and air control before structure?

  → whole building performance goals will drive system and material selection
    › rather than traditional component specification

  → more integration between enclosure and mechanical design
    › must do this to have low load buildings

→ measurement and verification will be the norm
  › require increased attention to quality assurance program
  › whole building airtightness is one example
Case Study: UBC Ponderosa Commons

→ High-rise university residence
  → 54,000 m²
  → Both phases complete by 2015

→ Architects:
  → KPMB Architects (Toronto), in JV with
  → HCMA Architecture + Design (Vancouver)

→ Contractor:
  → Ledcor
→ Unique and challenging design requirements:
  → **Effective** cladding R-Value of R15
  → Exposed textured concrete cladding with randomly shifting panels and colours
  → High performance air & moisture management strategy
  → Economically installed on par with residential window-wall
  → Very short construction schedule to full occupancy
  → Durable lifecycle & expected “hard university residence use”
  → LEED Gold
Starts with Computer Simulation
Proof of Concept Mock-up
Placing Insulation
Consistent angle for precast and windowwall
Membrane
Insulation (compressible and fire resistant)
Joints caulked (allowing for drainage; rainscreen)
Actual panel installation
Flashing and membrane
Window unit installation
Interior Finish – To be painted
# Lessons Learned - Cost

<table>
<thead>
<tr>
<th>Scheme A - Sandwich</th>
<th>BLDG TOTAL</th>
<th>Contact SF</th>
<th>Contact Rate</th>
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<tr>
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## Lessons Learned - Cost

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<td><strong>Scheme B</strong></td>
<td><strong>Window Wall</strong></td>
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<tr>
<td>Curtail Wall (SM)</td>
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<td>11001</td>
<td>$76</td>
<td>$838,262</td>
<td>8%</td>
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</tr>
<tr>
<td>Metal Panel (SM)</td>
<td>153</td>
<td>1647</td>
<td>$61</td>
<td>$100,296</td>
<td>1%</td>
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</tr>
<tr>
<td>Precast</td>
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<td>$56</td>
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<td><strong>Scheme C</strong></td>
<td><strong>Tactyl</strong></td>
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<tr>
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<td>$76</td>
<td>$838,262</td>
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<tr>
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<td>$61</td>
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<tr>
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<tr>
<td>Window Wall (SM)</td>
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<td>$52</td>
<td>$2,283,319</td>
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<tr>
<td>Tactyl in lieu of Window Wall (SM)</td>
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<td><strong>Scheme D</strong></td>
<td><strong>Brick</strong></td>
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<td>$2,283,319</td>
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<tr>
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</tr>
<tr>
<td>Solid (%)</td>
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</table>
Case Study: UBC Orchard Commons

→ High-rise university residence
  → almost 50,000 m²
  → Complete by 2016
→ Architect:
  → Perkins + Will

→ Similar precast and windowwall approach but more sculptural qualities
What will modern building enclosures look like?

Zeidler Partnership Architects; image: Norman Li AG+I
key take-aways

→ energy codes (and associated standards) are creating a fundamentally different approach to performance
→ these are whole building changes . . .
→ need new architectural language and process
  → Bullit Center is the best, but what approach for every building?
  → need experimentation with form and process
→ integration difficult but architects are well-positioned to address the challenges
  → long history of doing environmental separation with the building – with little or no additional energy
Discussion + Questions

FOR FURTHER INFORMATION PLEASE VISIT

→ rdh.com | buildingsciencelabs.com

RDH Building Engineering Ltd. and Building Science Consulting Inc. have merged. Effective November 1, 2015, we now operate as one integrated firm. The merger brings two of the leading building science firms in North America together to provide a combination of cutting-edge research with leading design and implementation capabilities. The result is a unique offering for our clients—an ability to explore new and innovative ideas based on science and our practical knowledge of what can be built. We are excited about the possibilities as we launch the new firm.