Thermal Bridging and Energy Standards
2014 BOABC Education Conference

November 27, 2014

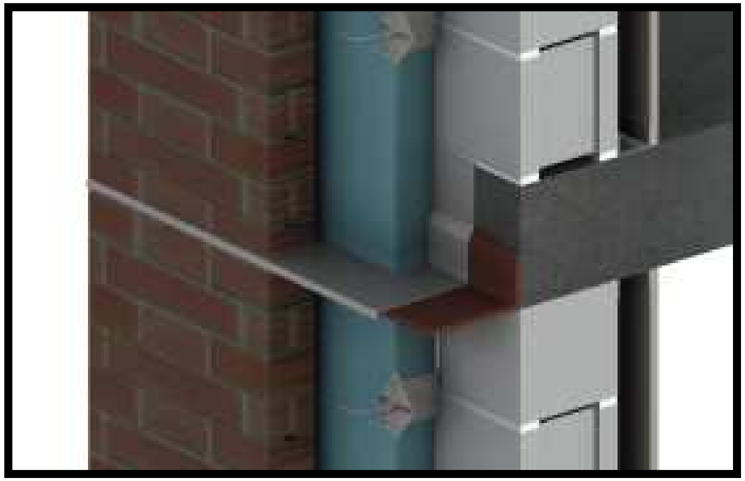
Morrison Hershfield

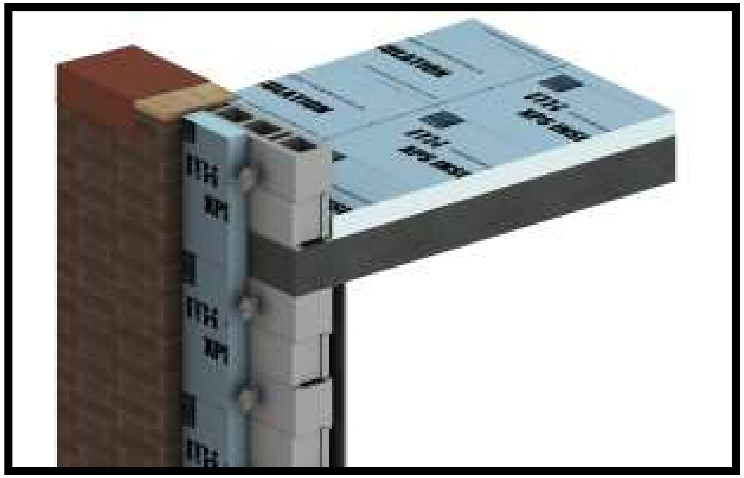
Current Energy Standards vs. Research Insights

- **Building Envelope Thermal Bridging Guide**
  - Overview
  - Significance, Insights, and Next Steps
- **Current Energy Codes and Standards**
  - Overview
  - Development
- Q & A

What is Thermal Bridging?

- Highly conductive material that by-passes insulation layer
- Areas of high heat transfer
- Can greatly affect the thermal performance of assemblies

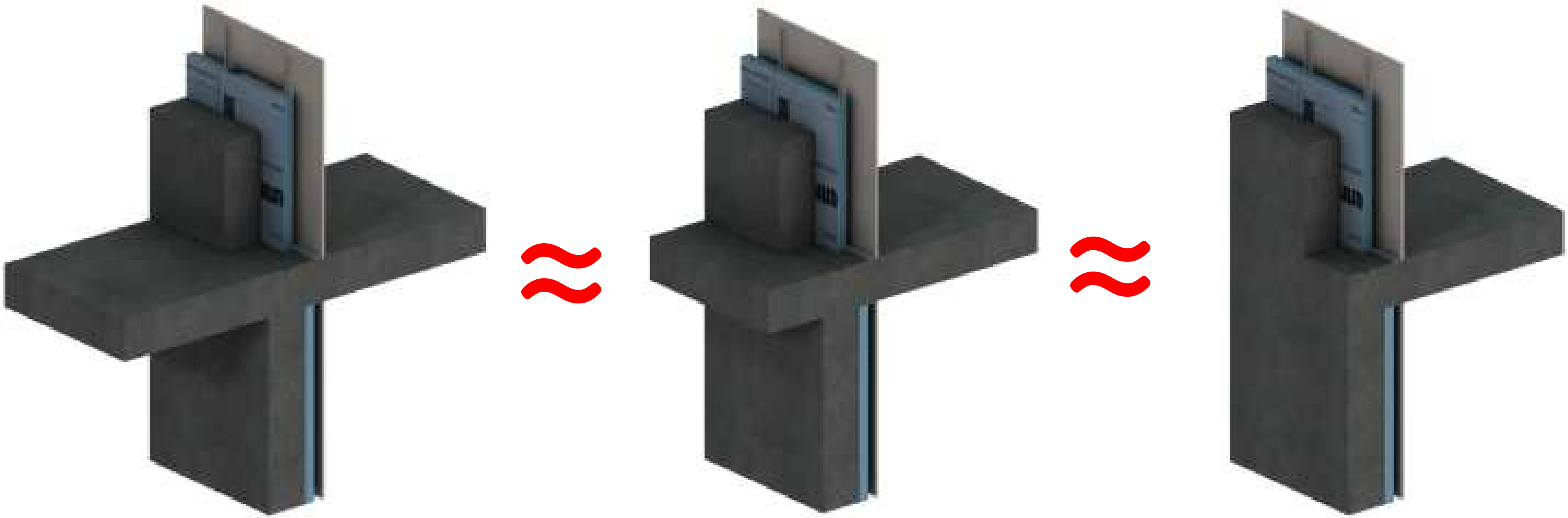




Why Care about Thermal Bridging?

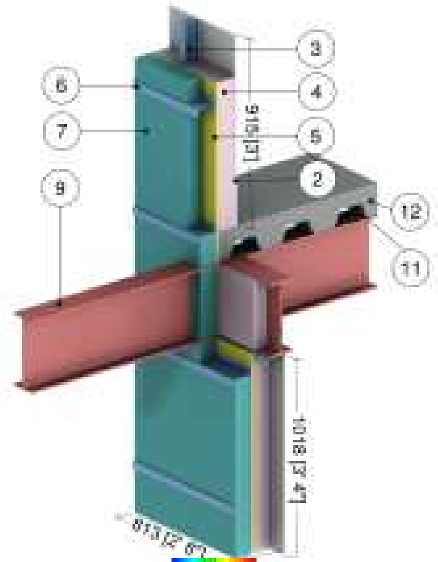
CBC

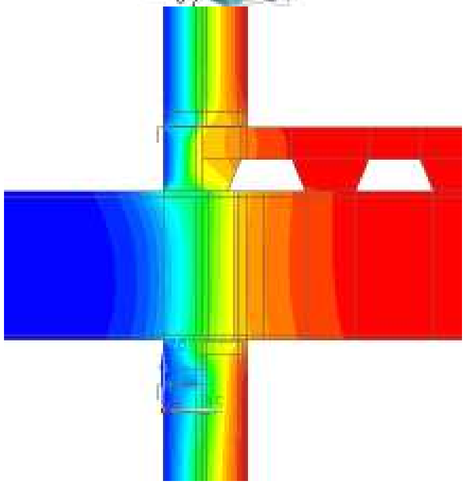
Exposed Floors



Why Care about Thermal Bridging?

- Heat flows determine:
  - Heating and cooling system capacity
  - Purchased energy requirements
  - Compliance with energy codes
  - Compliance with voluntary energy programs
- Arrangement of materials determine:
  - Surface temperatures
  - Condensation and moisture collection
  - Durability
  - Mold growth and health issues



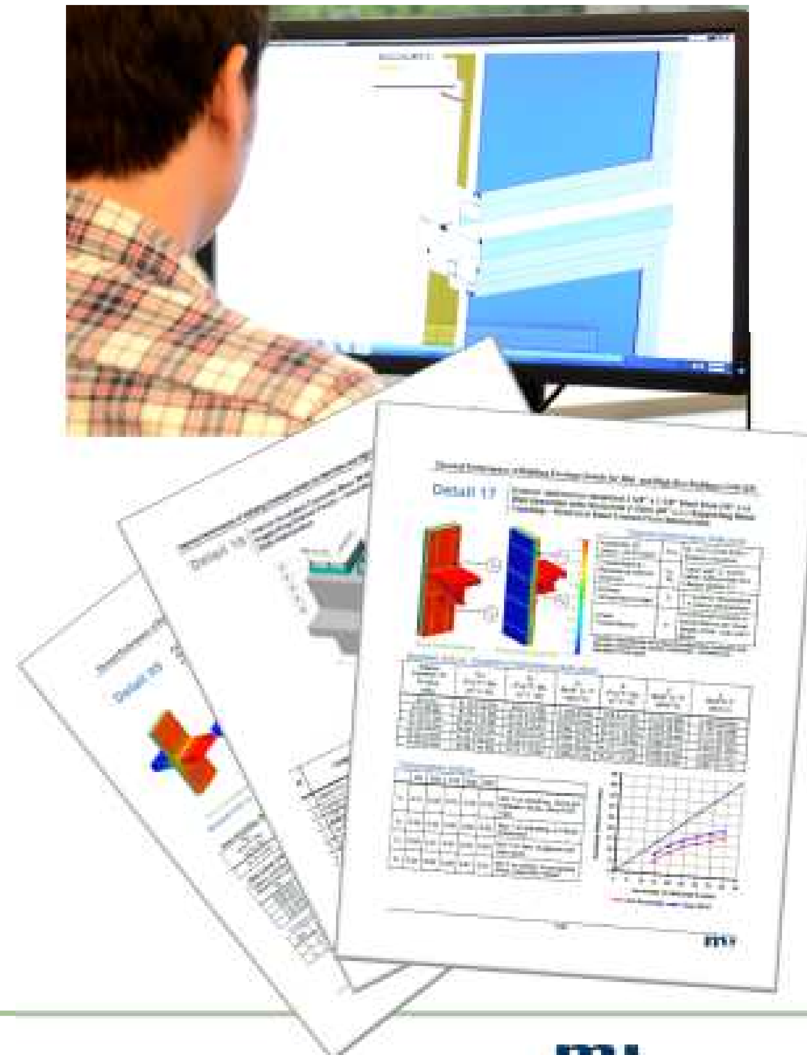


Five Years Ago…

ASHRAE

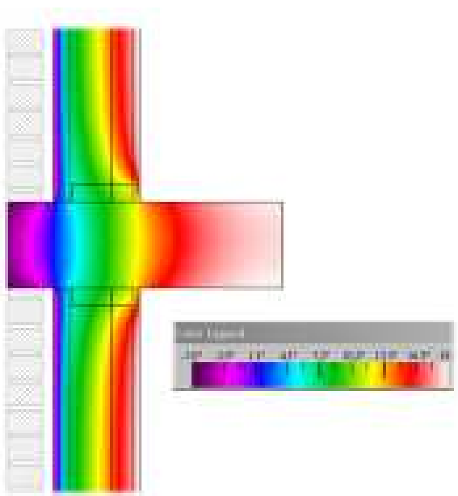
Research Project 1365-RP

- We went 3D with serious software
- Validated our model and procedures to measured data
- Borrowed a methodology from Europe and applied to North American practice
- Started a catalogue of thermal performance data

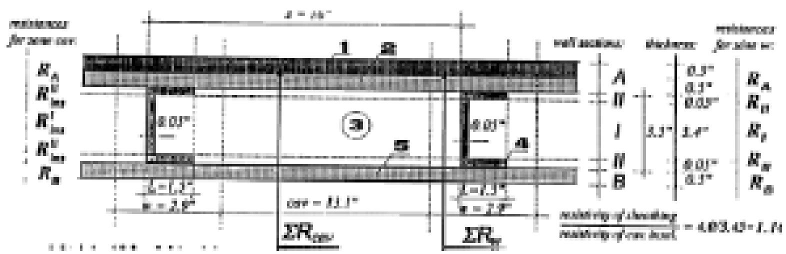


Five Years Ago…

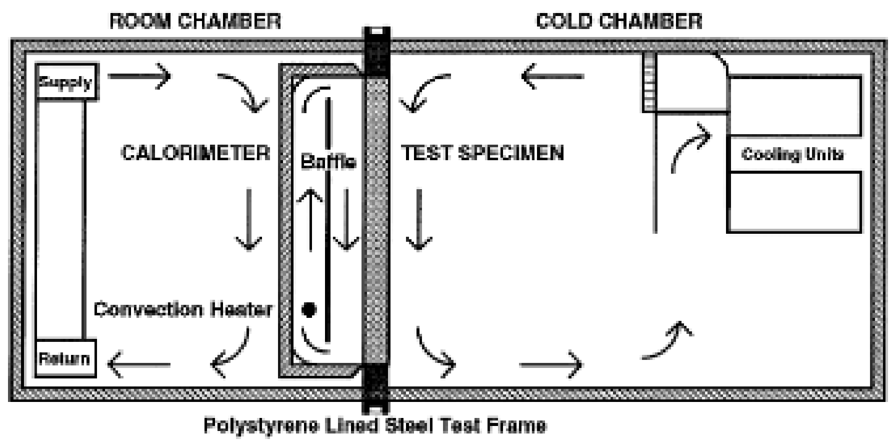
North American Data and Procedures in Energy Standards Pre-date 1365-RP



Computer Modeling

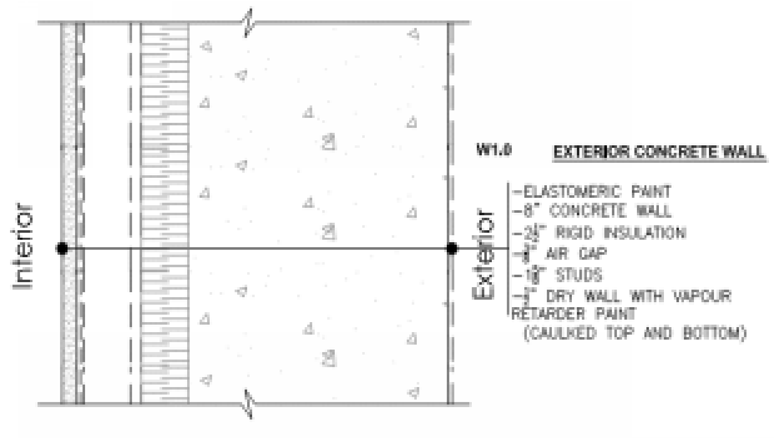


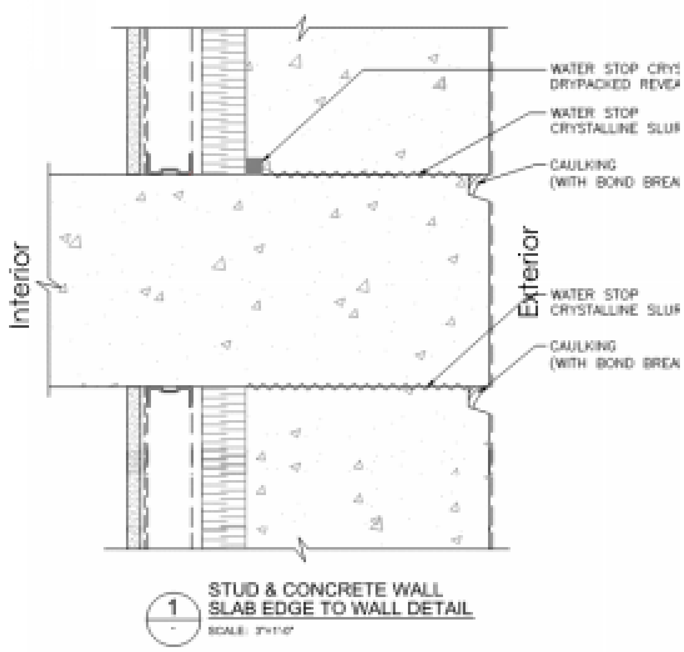
Hand Calculations



Lab Measurement

Interface Details

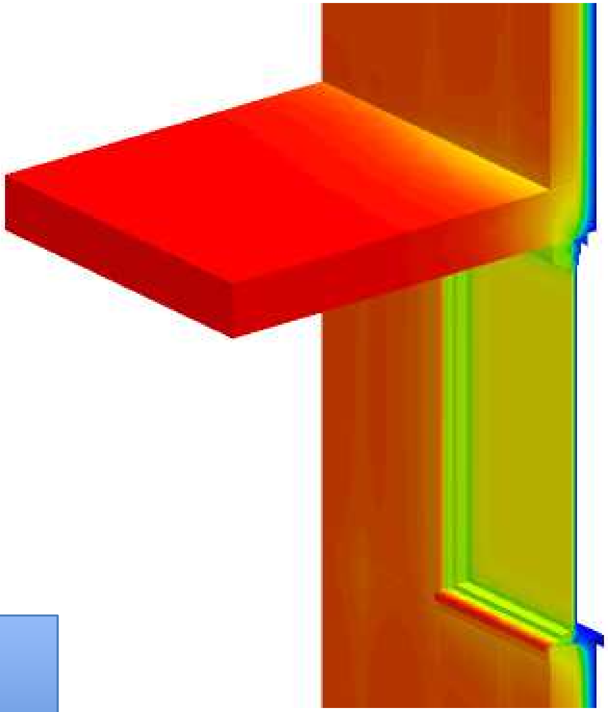




A Clear Field Assembly

A Interface Detail

Interface Details



Building Envelope Thermal Bridging Guide

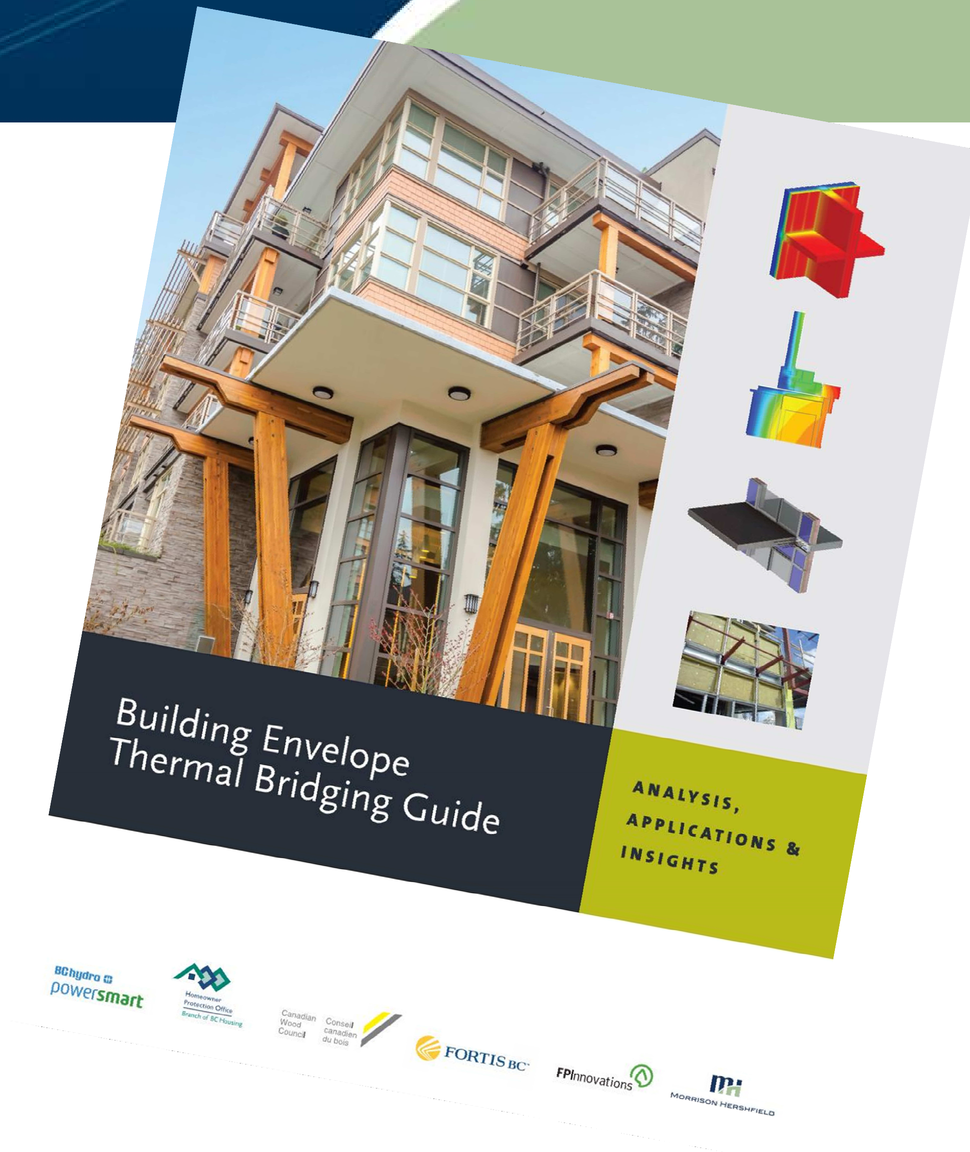
BC hydro powersmart

Homeowner Protection Office
Branch of BC Housing

FORTIS BC

Canadian Wood Council
Conseil canadien du bois

FPInnovations



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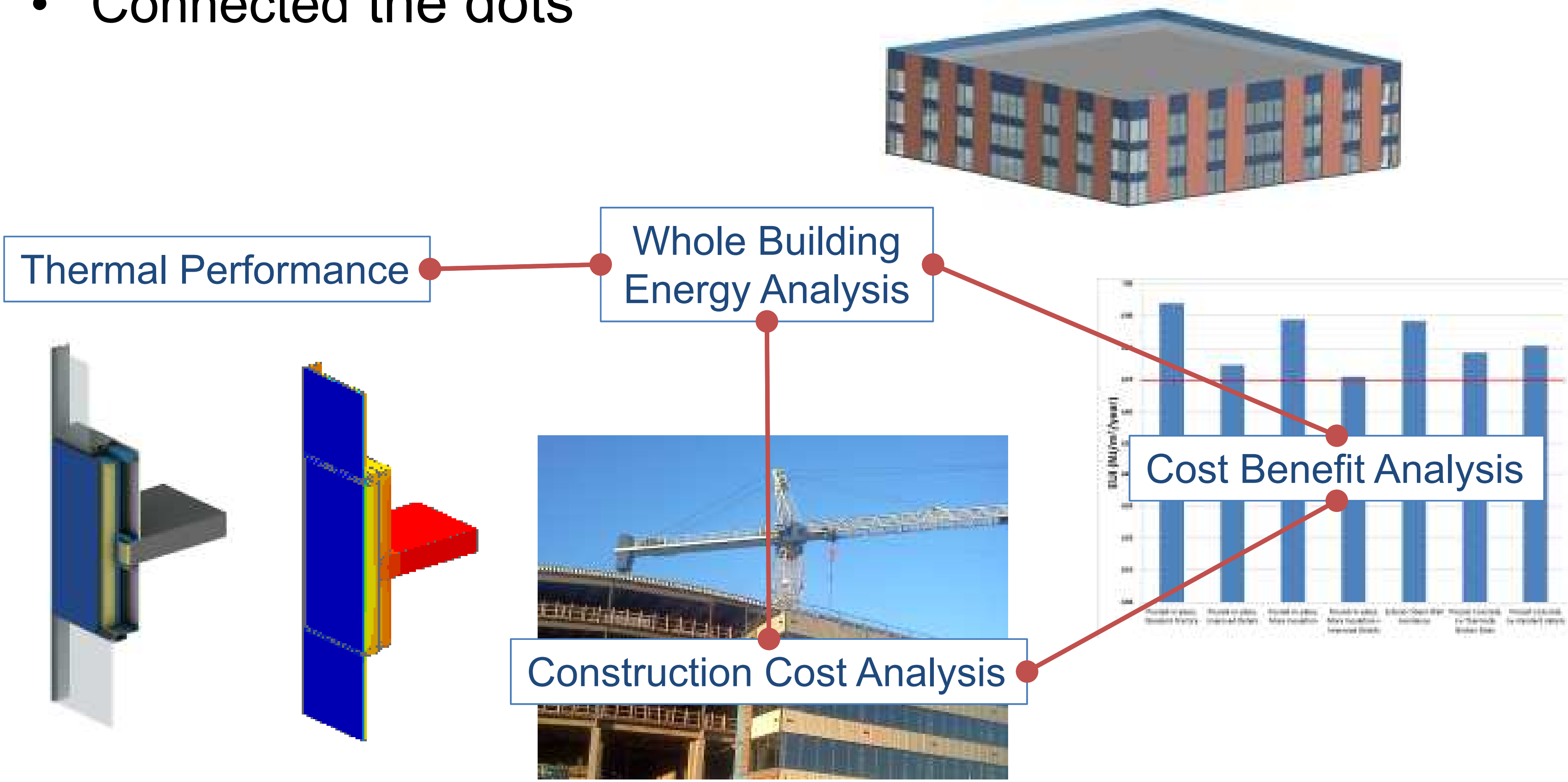
1365-RP and Beyond

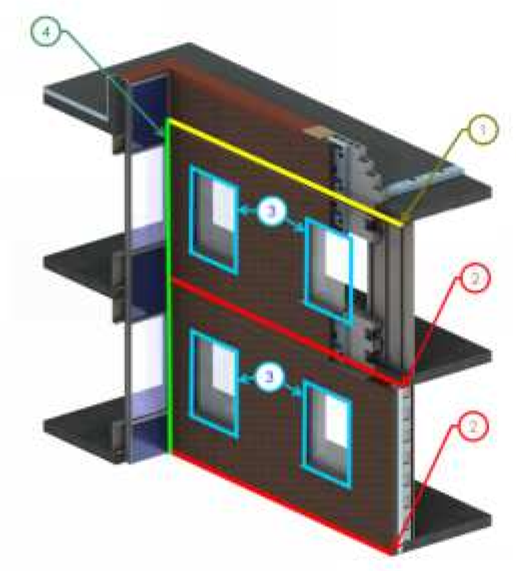
- Connected the dots



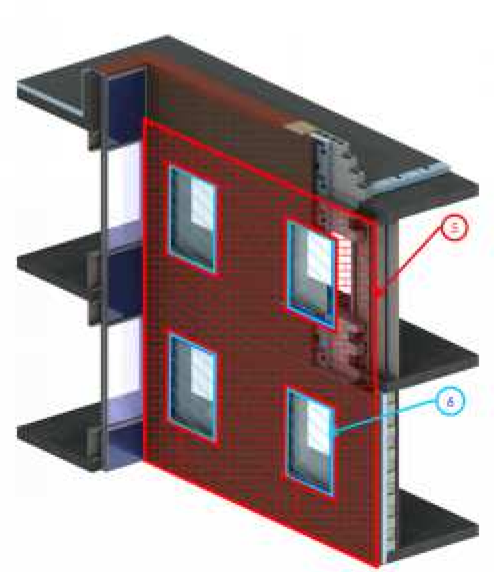
Guides within a Guide

Introduction	
Part 1	Building Envelope Thermal Analysis (BETA) Guide
Part 2	Energy and Cost Analysis
Part 3	Significance, Insights, and Next Steps
Appendix A	Material Data Catalogue
Appendix B	Thermal Data Catalogue
Appendix C	Energy Modeling Analysis and Results
Appendix D	Construction Costs
Appendix E	Cost Benefit Analysis

Part 1: Building Envelope Thermal Analysis (BETA)



1. Parapet Length
2. Slab Lengths
3. Wall to Window Transition Lengths

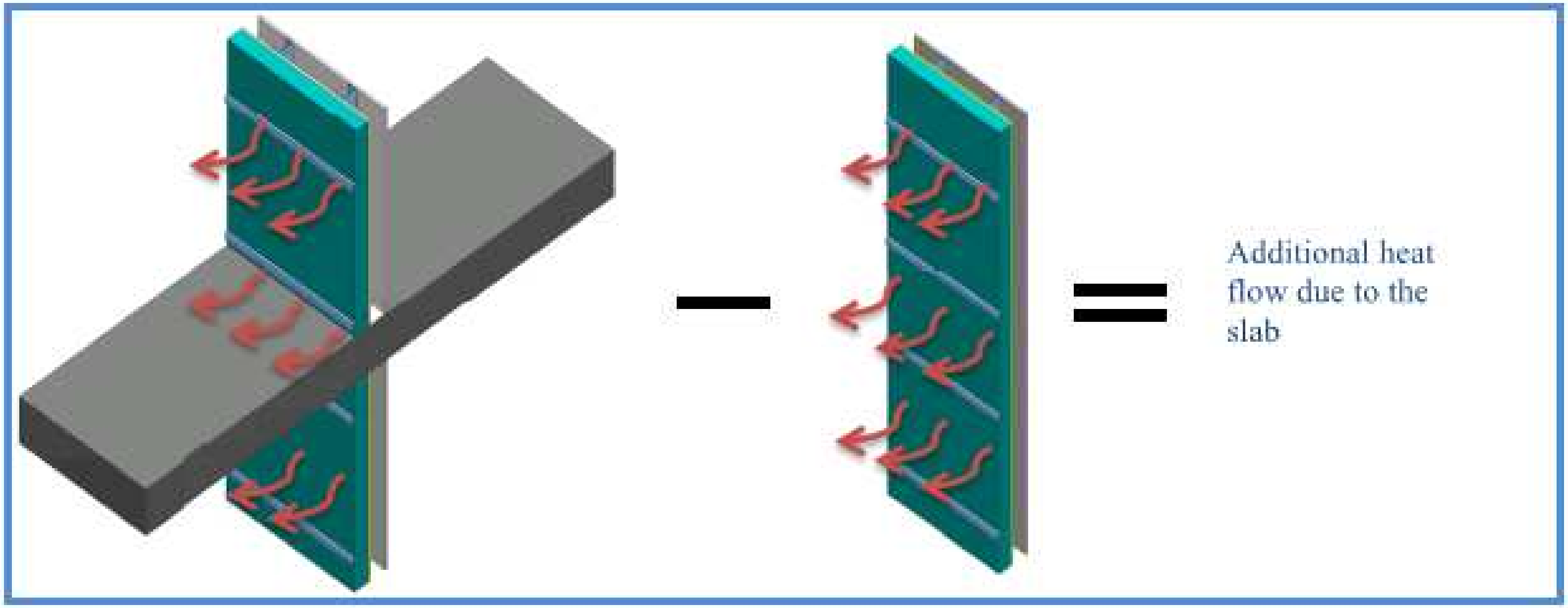


4. Corner Length
5. Opaque Brick Wall Area
6. Glazing Area

- BETA Method
- Catalogue Summary
- Utilization
- Energy Model Inputs

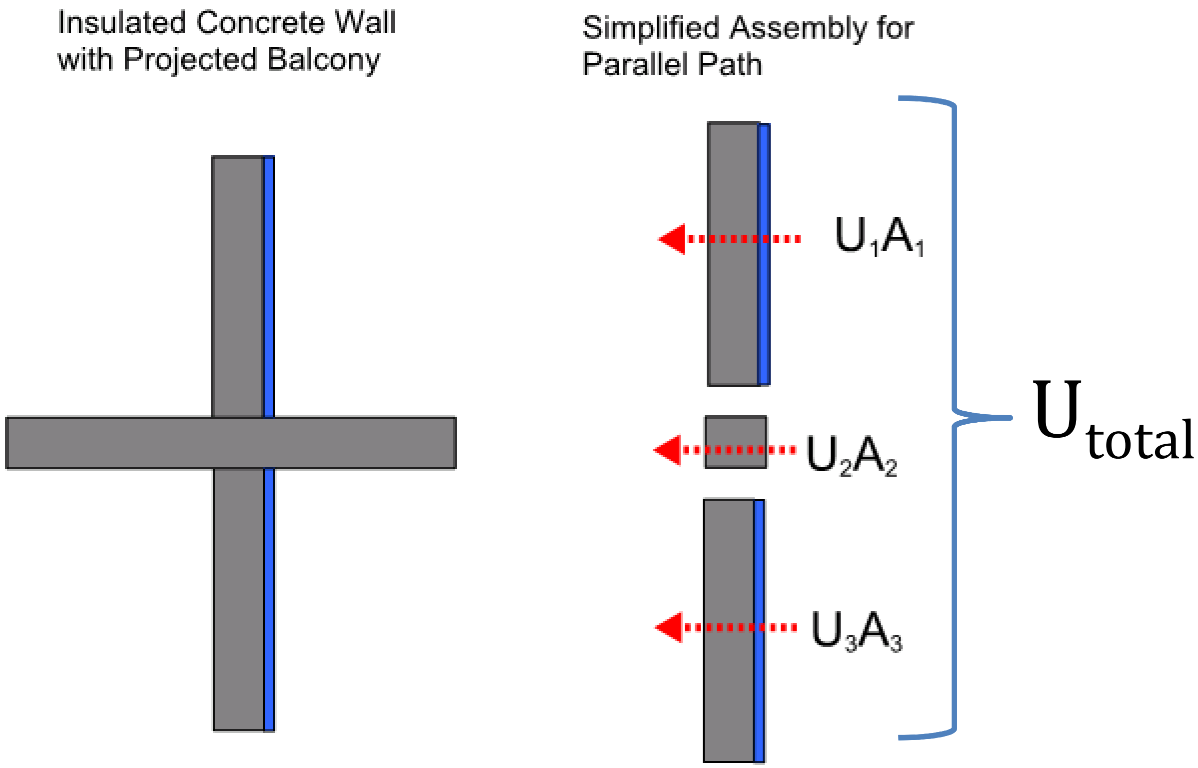
Part 1: Building Envelope Thermal Analysis (BETA)

- Refines ASHRAE 1365 Methodology
- Step by Step examples
- Now called the BETA method



Beyond parallel path assumptions

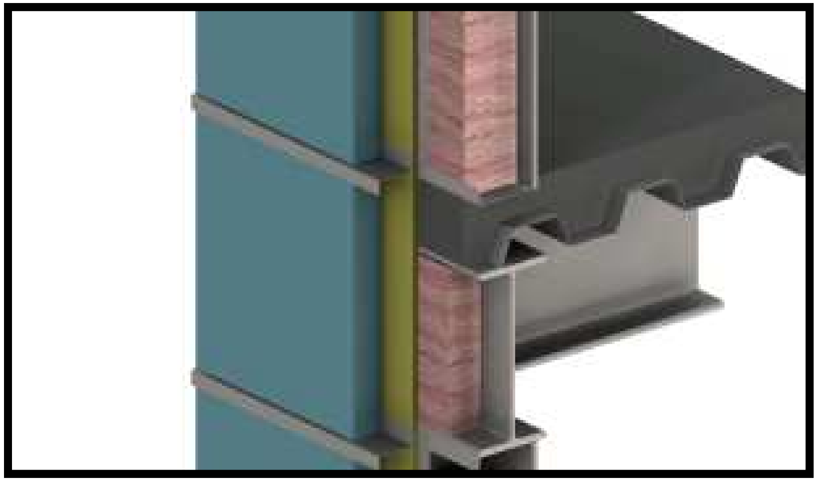
- Assumes heat flows are separate and do not influence each other
- Averages overall heat flow/resistance based on the areas of components

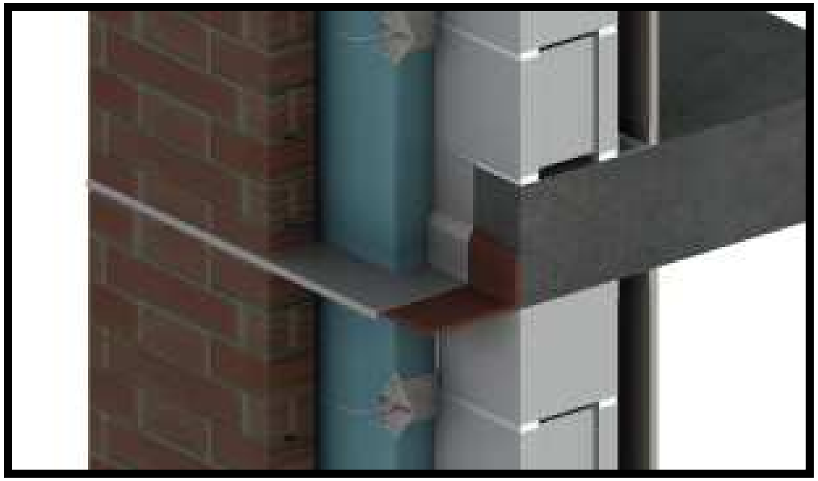


$$U_{total} = \frac{(U_1A_1 + U_2A_2 + U_3A_3 \dots)}{(A_1 + A_2 + A_3 \dots)} \cdot \Delta T$$

Why moving beyond this is a good thing

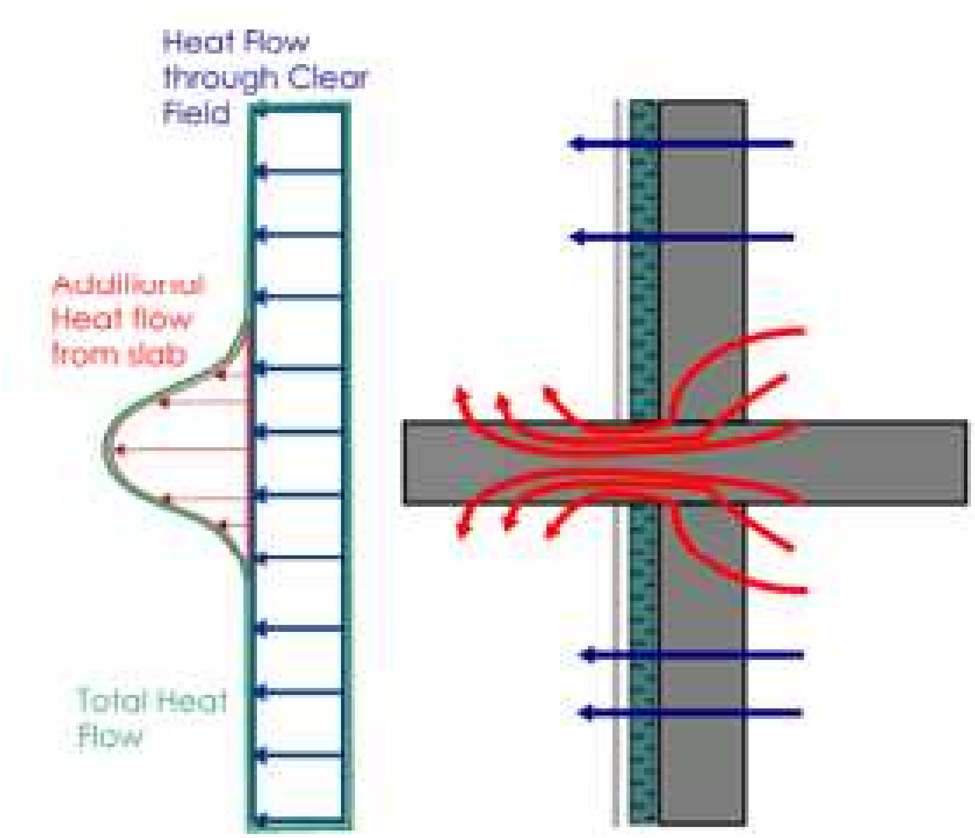
- Parallel path doesn't tell the whole story
- Many thermal bridges don't abide by "areas"
- There is an easier way to account for details across the board
- Level playing field will be created when all thermal bridges are thoroughly evaluated





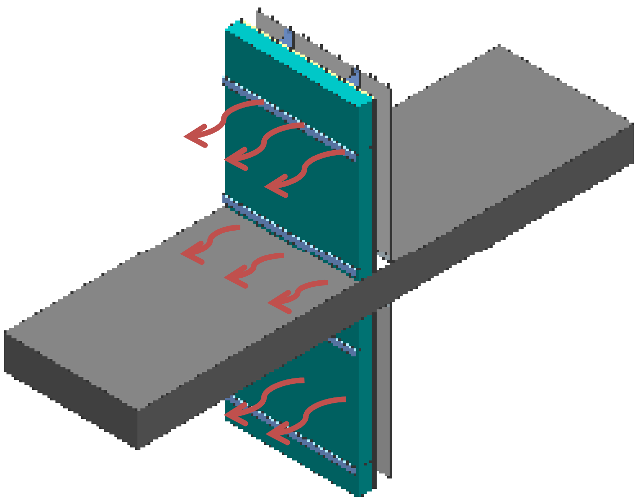
Part 1: Building Envelope Thermal Analysis (BETA)

- Part 1 shows how to translate heat flows (clear field, linear and point transmittances) into overall U-values



Overall Heat Loss

$$Q - Q_o = Q_{slab}$$



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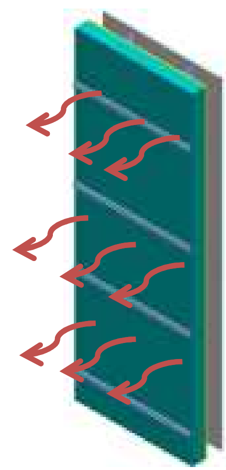

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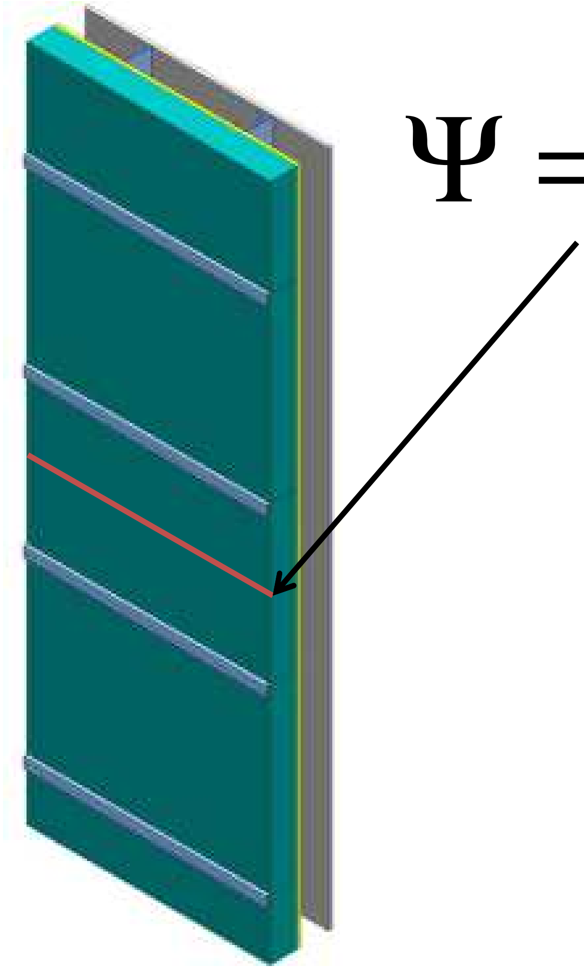
Additional heat loss due to the slab

Overall Heat Loss

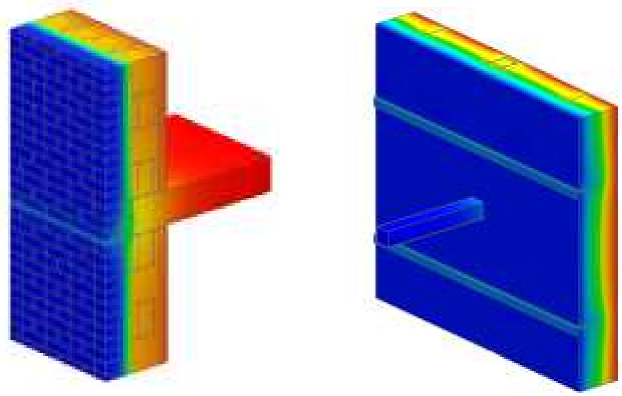


$$\Psi = Q_{slab} / L$$

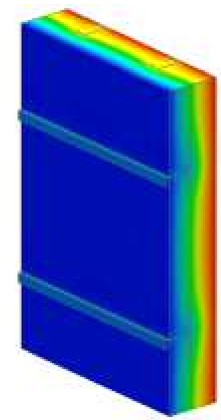
linear transmittance represents the additional heat flow because of the slab, but with area set to zero

Overall U-value (aka “Effective” R-value)

Interface Details



Clear Field Assembly

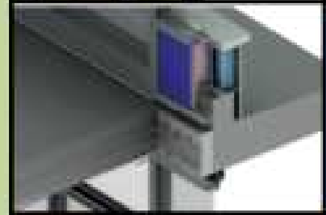


Total Heat flow per area through the overall assembly = (Heat flow through linear transmittances + Heat flow through point transmittances) / Total Area of assembly + Heat flow per area through clear field assembly

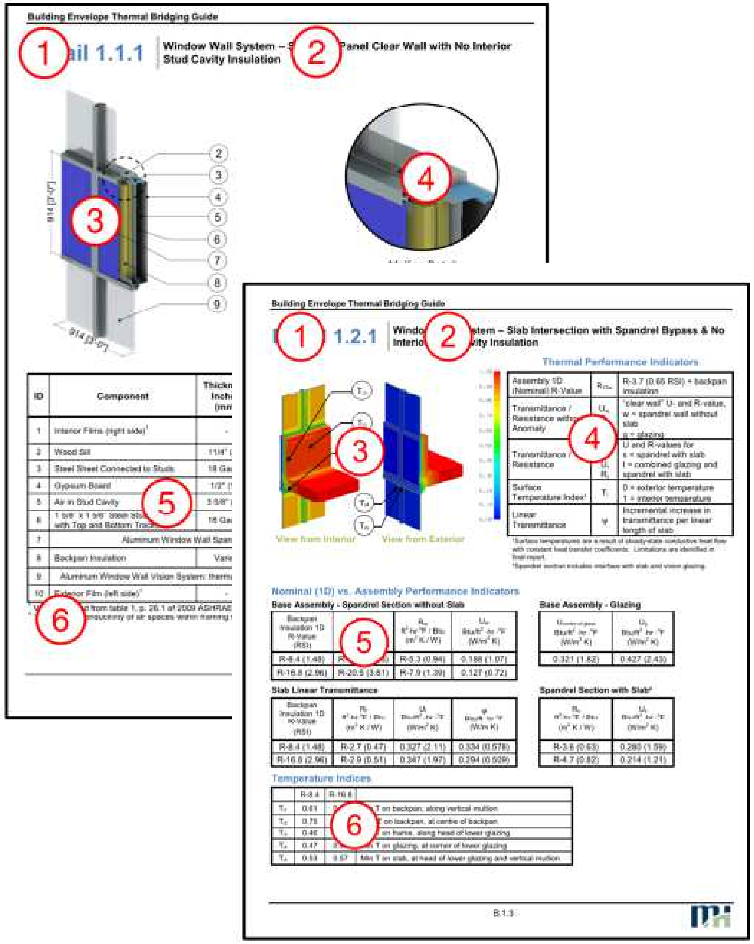
$$U_T = \frac{\Sigma(\Psi \cdot L) + \Sigma(\chi)}{A_{Total}} + U_o$$

Range of Transmittances

FLOOR AND BALCONY SLABS

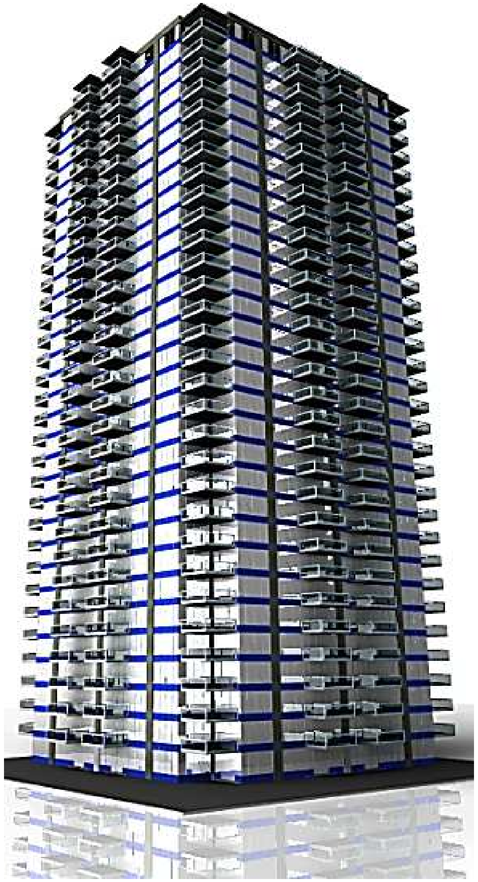
Performance Category		Description and Examples	Linear Transmittance Btu/hr ft F	Linear Transmittance W/m K
	Efficient	**Fully insulated with only small conductive bypasses** Examples: exterior insulated wall and floor slab.	0.12	0.2
	Improved	**Thermally broken and intermittent structural connections** Examples: structural thermal breaks, stand-off shelf angles.	0.20	0.35
	Regular	**Under-insulated and continuous structural connections** Examples: partial insulated floor (i.e. firestop), shelf angles attached directly to the floor slab.	0.29	0.5
	Poor	**Un-insulated and major conductive bypasses** Examples: un-insulated balconies and exposed floor slabs.	0.58	1.0

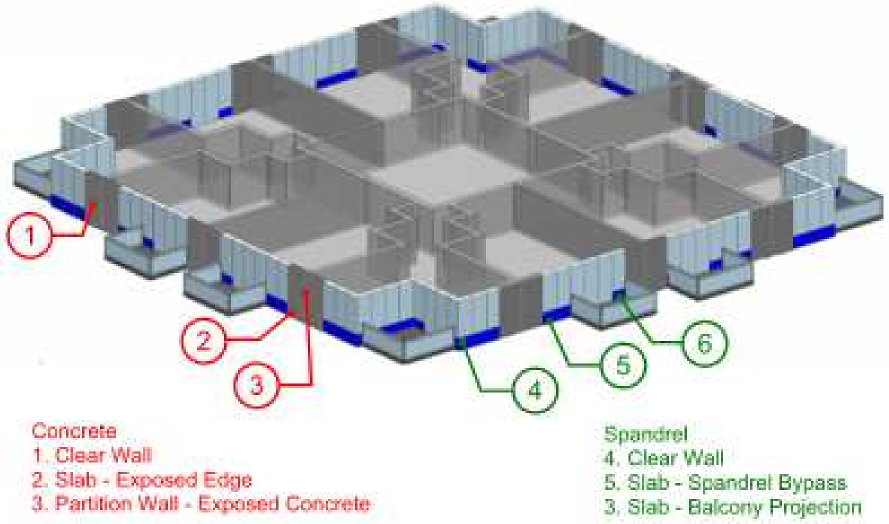
Appendix A and B



CATALOGUE INDEX

Example from the Guide





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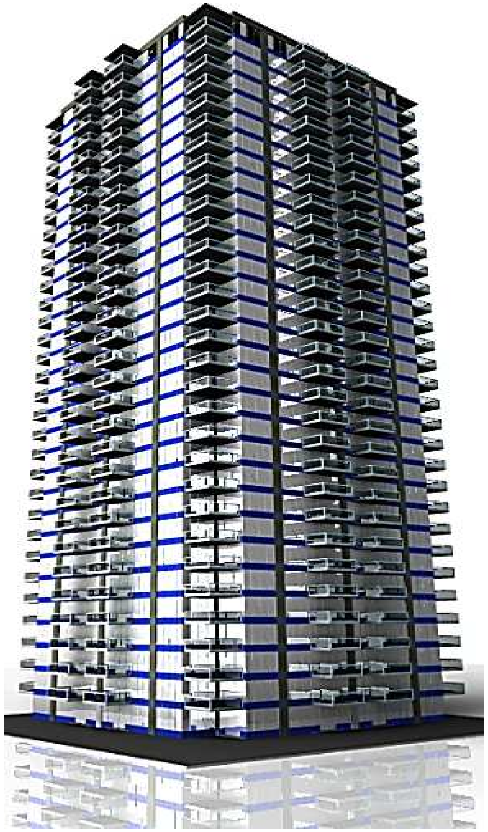
Example from the Guide

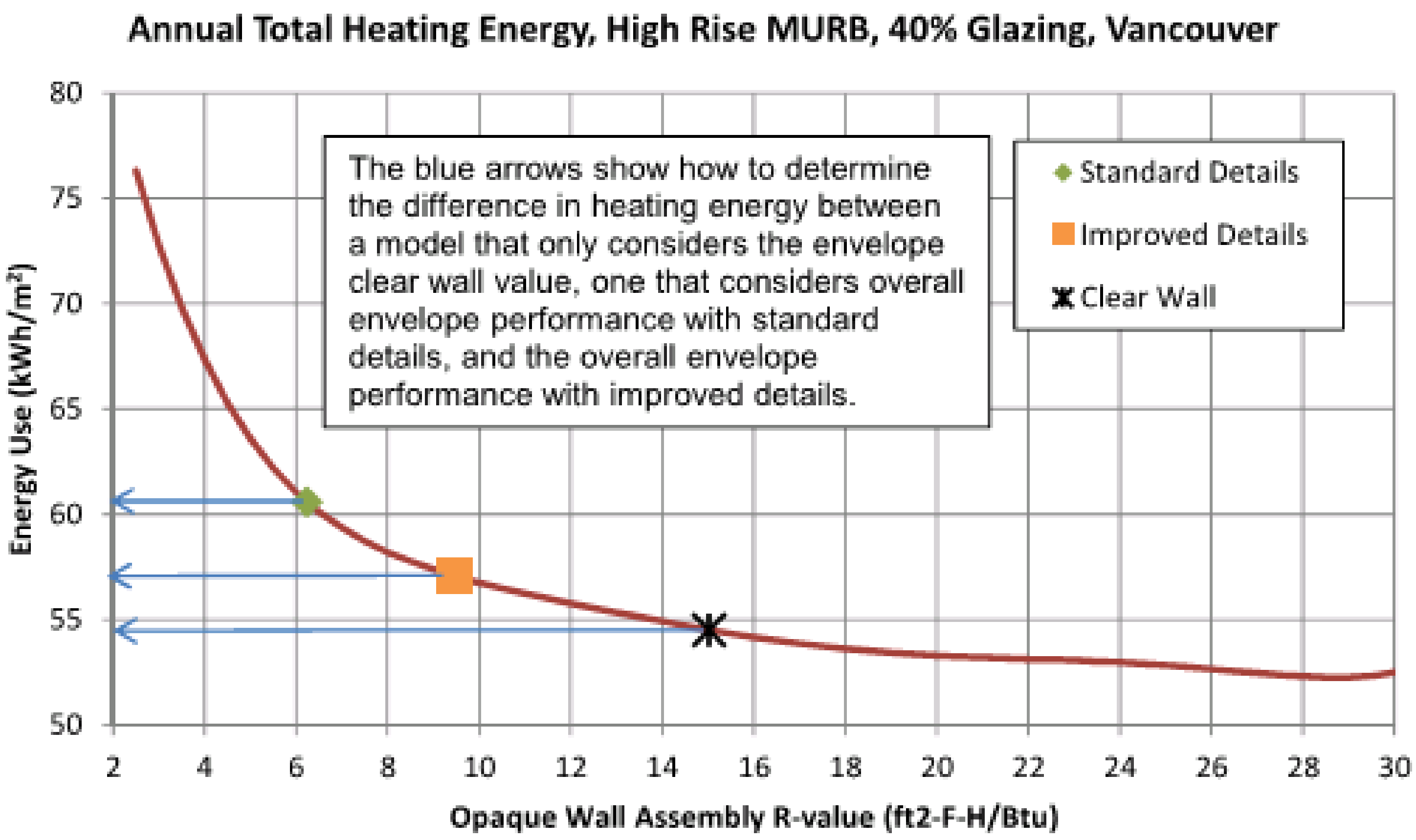
Step 1-2	Step 3	Step 4	Step 5		Step 6-7	
Transmittance Type		Quantity	Detail Ref.	Transmittance	Heat Flow (W/K)	% of Total Heat Flow
Concrete Wall	Clear Field	2987 m^2	6.2.2	0.42 W/m^2K	1254	16%
	Parapet	27 m	6.5.3	0.78 W/mK	21	<1%
	Exposed Floor Slab	1090 m	6.2.5	1.00 W/mK	1085	14%
	At Grade Transition	27 m	ISO-14863	0.75 W/mK	20	<1%
	Partition Wall	1315 m	6.2.2	0.67 W/mK	876	11%
Overall Concrete Wall U-value, BTU / hr ft^2 °F (W/m^2K)					**0.192 (1.09)**	
Overall Concrete Wall R-value, hr ft^2 °F/ BTU (m^2K/W)					**5.2 (0.92)**	
Window-wall Spandrel	Clear Field	1792 m^2	1.1.1	1.07 W/m^2K	1917	24%
	Parapet	82 m	1.3.2	0.72 W/mK	59	<1%
	Slab Bypass	1635 m	1.2.1	0.58 W/mK	945	12%
	Balcony Slab	1635 m	8.1.9	1.11 W/mK	1815	23%
	At Grade Transition	82 m	2.5.1 (est.)	0.86 W/mK	70	<1%
Overall Spandrel Wall U-value, BTU / hr ft^2 °F (W/m^2K)					**0.472 (2.68)**	
Overall Spandrel Wall R-value, hr ft^2 °F/ BTU (m^2K/W)					**2.11 (0.37)**	
Total (W/K)					**8063**	**100%**
Overall Opaque Wall U-value, BTU / hr ft^2 °F (W/m^2K)					**0.297 (1.68)**	
Overall Opaque Wall R-value, hr ft^2 °F/ BTU (m^2K/W)					**3.4 (0.59)**	



Part 2 – Energy and Cost Analysis

- Whole Building Energy Use
- Construction Costs
- Cost Benefit

Part 2 – Energy and Cost Analysis



Part 2 – Energy and Cost Analysis

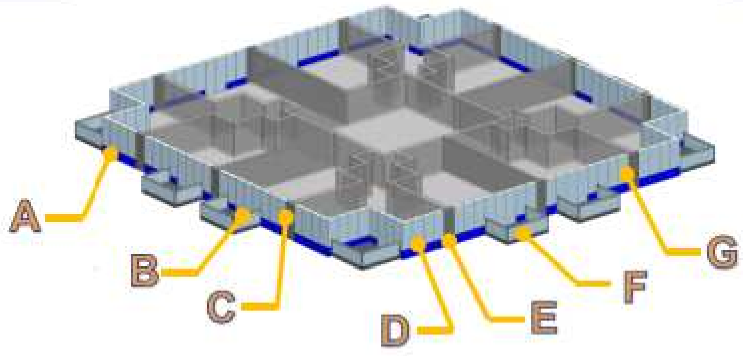
Construction Costs

- Broad order of magnitude estimates, +-50%
- Not arrived at for a specific building nor is there a comprehensive list of requirements to base assumptions
- Construction costs vary quite widely in practice, even with detailed designs

Part 2 – Energy and Cost Analysis

Cost Benefit Analysis

- The Impact of Interface Details
- Thermal Bridging Avoidance
- The Effectiveness of Adding More Insulation
- Ranking of Opaque Thermal Performance

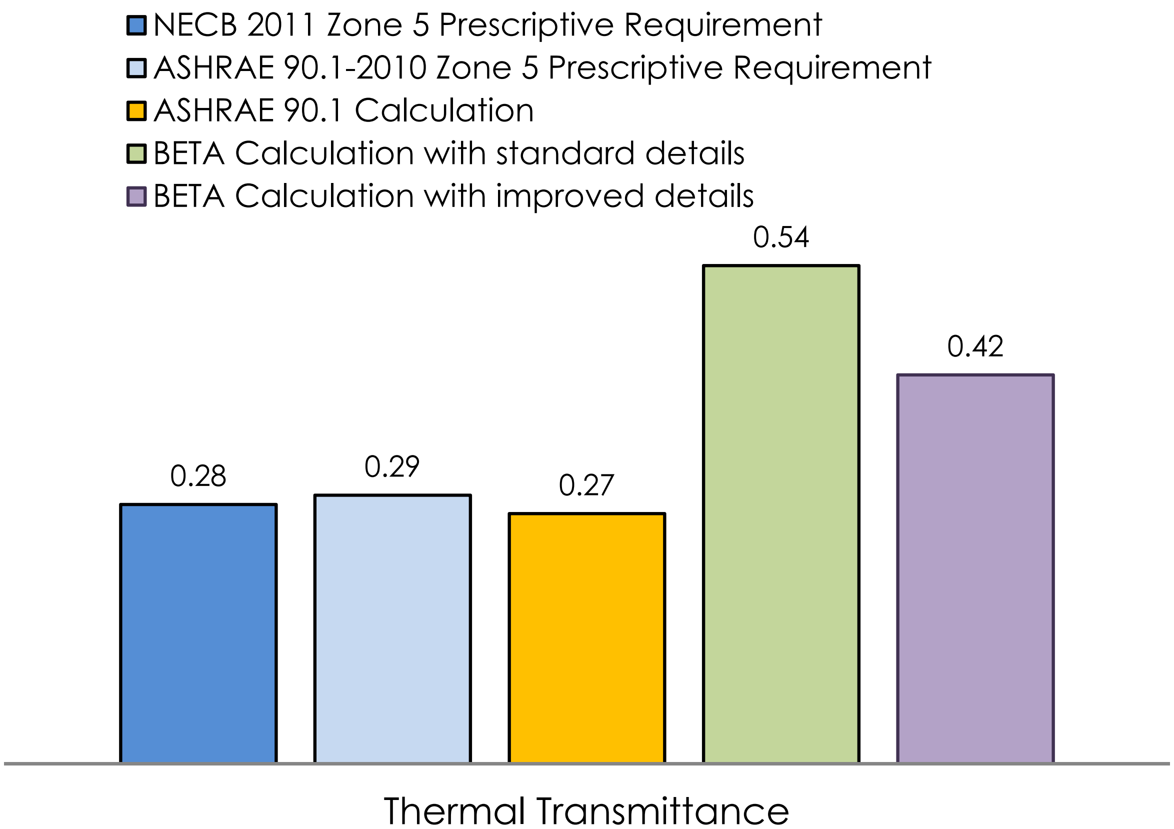


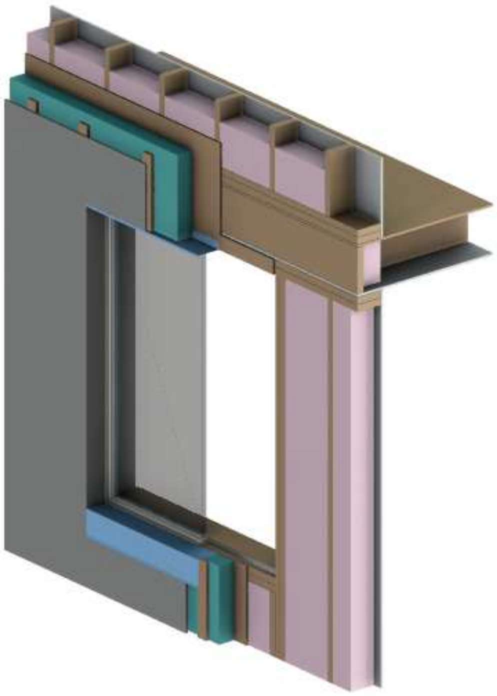
Opaque wall area
A. Window-wall spandrel
B. Curb at sliding door
C. Concrete wall
Floor slab interface detail
D. At window-wall spandrel bypass
E. At concrete wall
F. At balcony
Glazing interface detail
G. Vertical

Building Envelope Thermal Bridging Guide (BETB Guide)

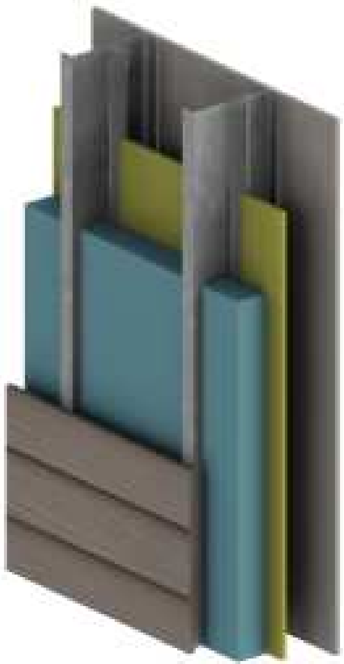
Insights

Building Envelope Thermal Bridging Guide (BETB Guide)

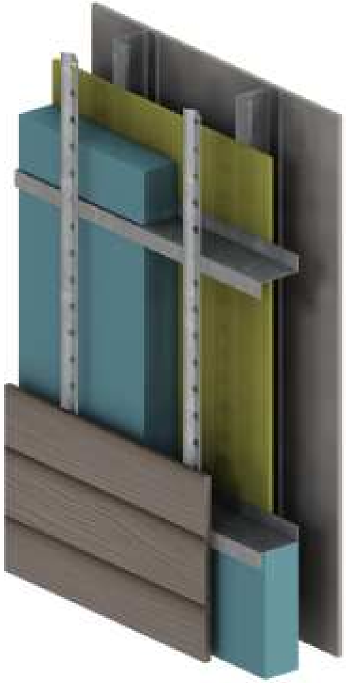




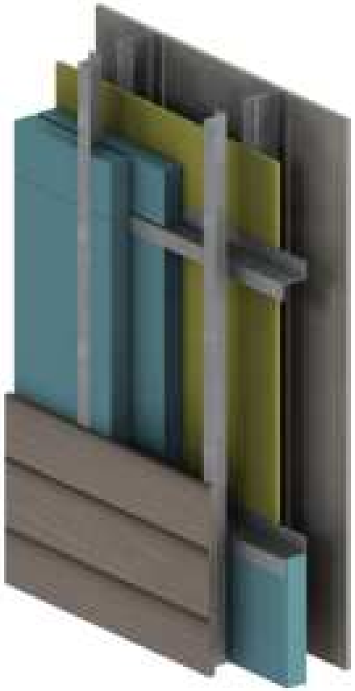
Market Transformation



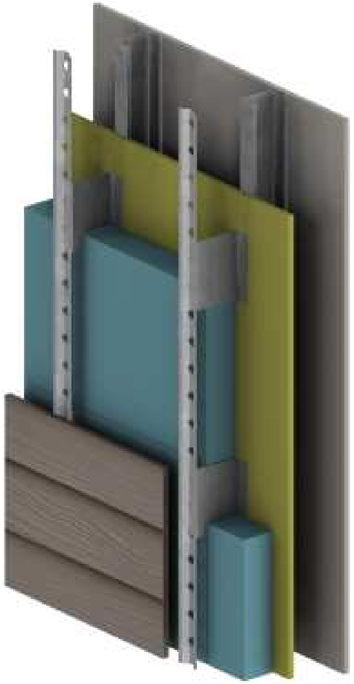
Vertical Z-Girts



Horizontal Z-Girts



Mixed Z-Girts

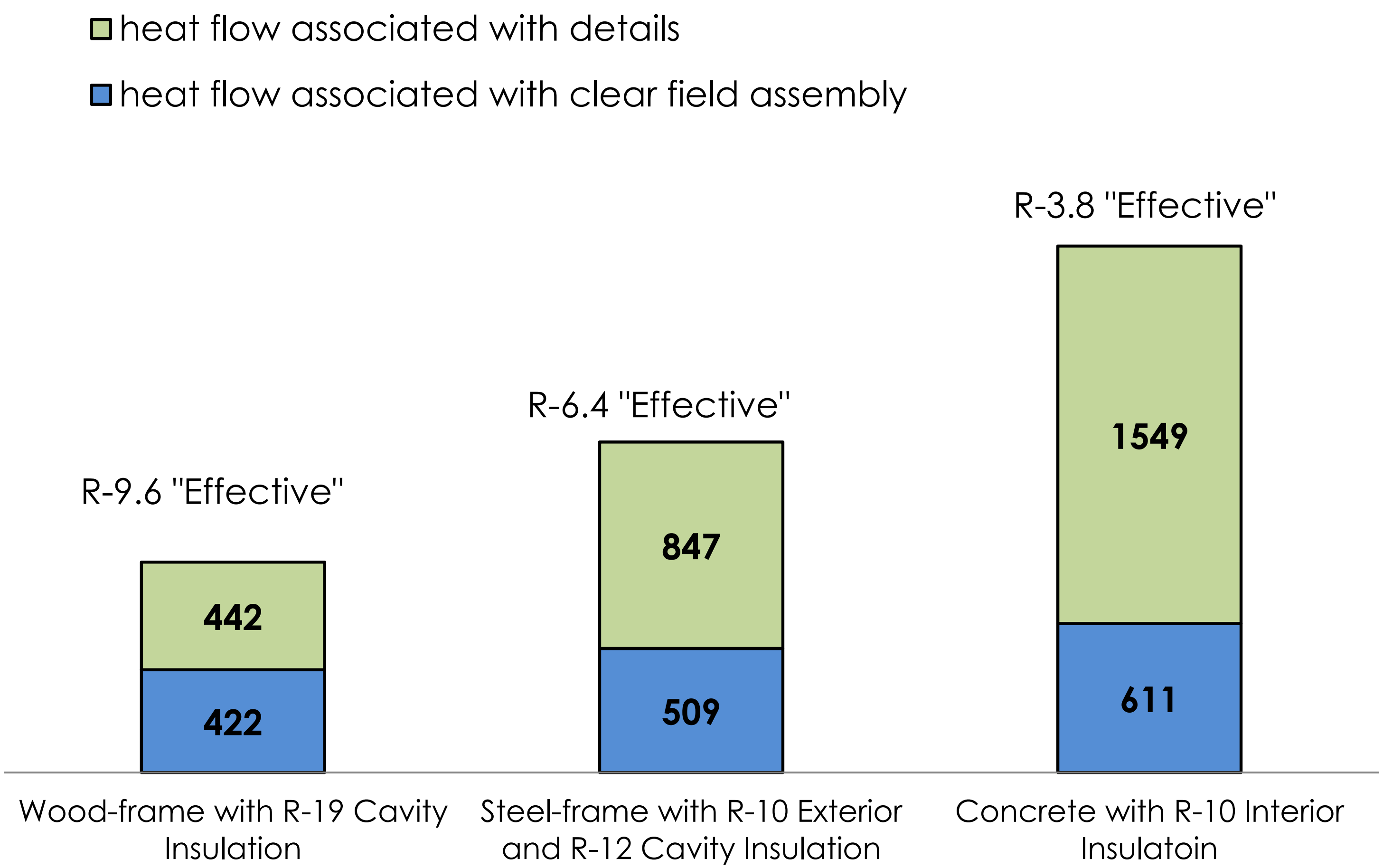


Intermittent Z-Girts

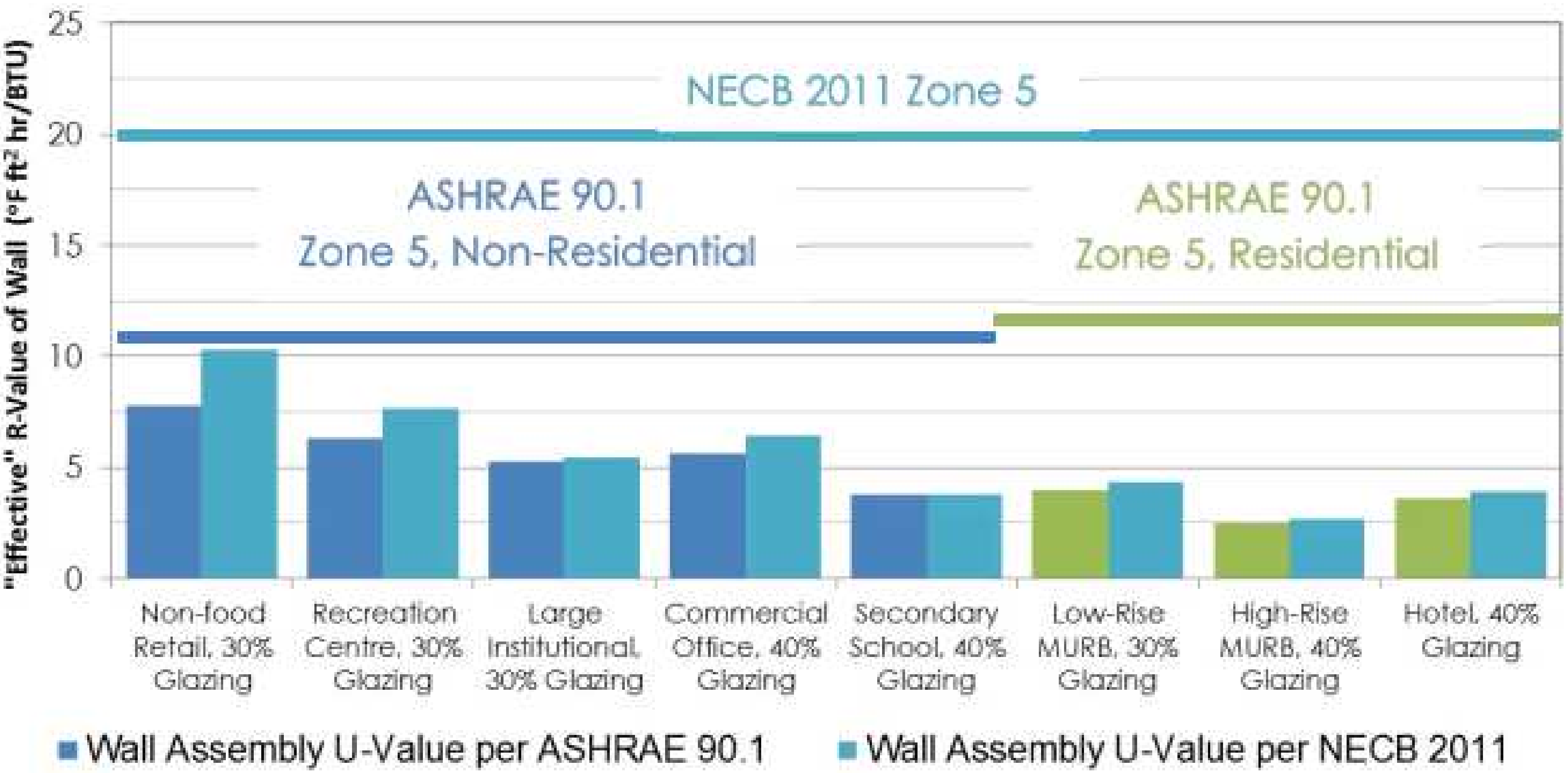
Origins of Improved Systems

Continuous Girts are Now Discrete Systems

Interface Details are Significant



Interface Details are Significant

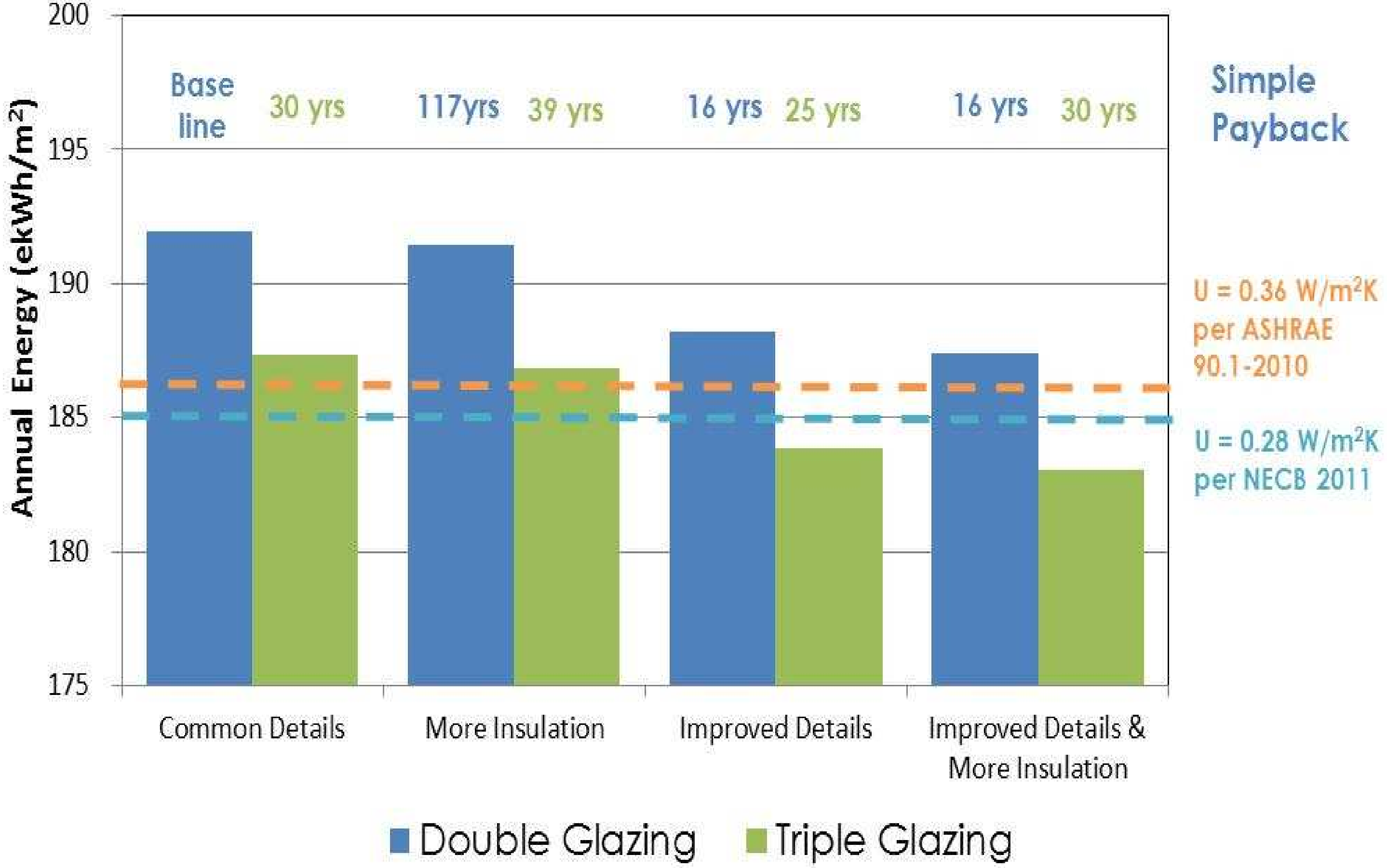


Interface Details are Significant

Building Type	NECB 2011 Zone 5 U-Value	BETA Calculation Value	% Incr. U-Value	Total Energy Difference ekWh/m²	Energy Cost Difference $/m²
Commercial Office	0.28	1.02	263%	14	$ 0.51
High-Rise MURB	0.28	1.54	663%	16	$ 1.39
Hotel	0.28	1.45	418%	22	$ 0.64
Large Institutional	0.28	1.07	283%	36	$ 1.21
Low-Rise MURB	0.28	1.31	369%	14	$ 1.24
Non-Food Retail	0.28	0.55	96%	12	$ 0.34
Recreation Centre	0.28	0.74	165%	7	$ 0.34
Secondary School	0.28	1.50	436%	15	$ 0.53

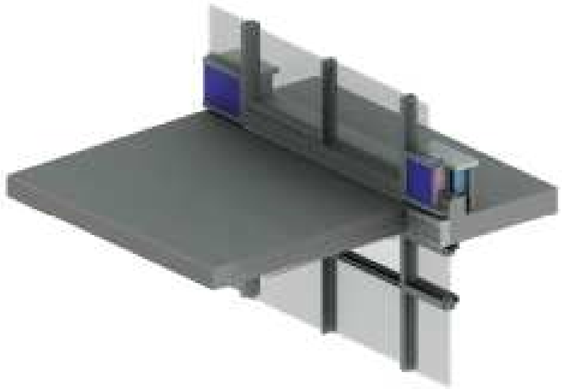
Interface Details are Significant

High-Rise MURB with 40% Glazing in Vancouver



The Effectiveness of Adding More Insulation

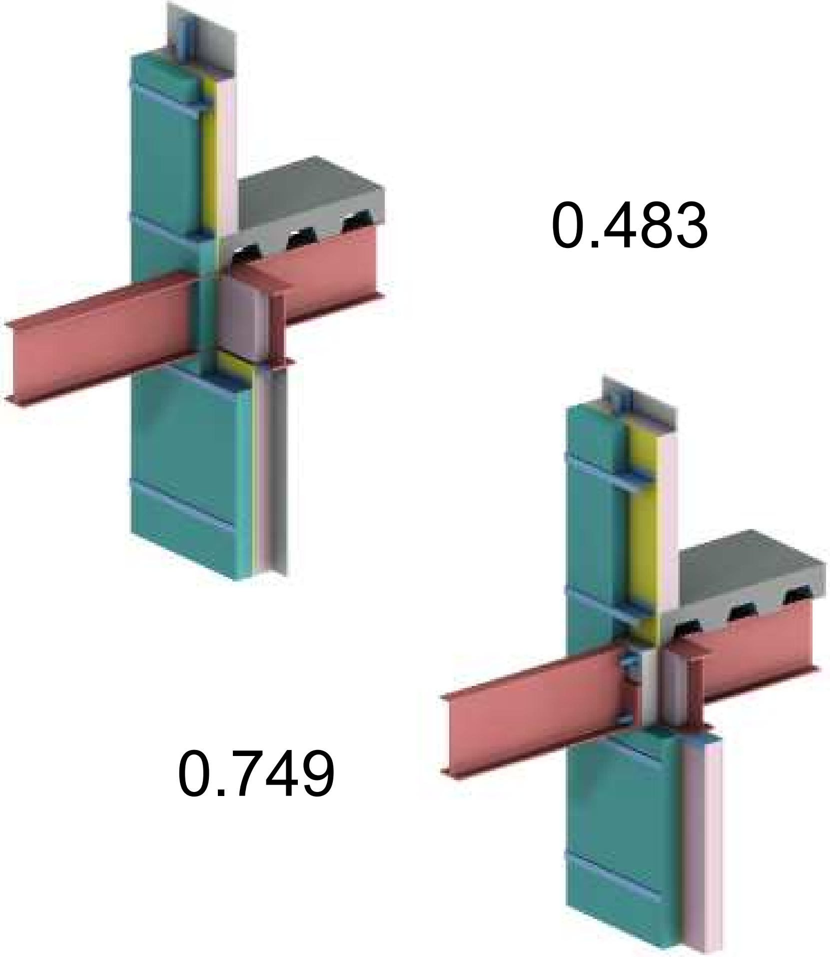
- Even some “expensive” options look attractive when compared to the cost effectiveness of adding insulation
- The cost to upgrade to thermally broken balconies and parapets for the high-rise MURB with 40% glazing may require **two to three times the cost** of increasing effective wall assembly R-value from R-15.6 to R-20
- **Seven times more energy savings**
- Better details AND adding insulation translates to the most energy savings and the best payback period



Exterior Insulation Finish Systems (EIFS)

- EIFS with improved details is a 69% improvement in U-value
- A savings of 14 ekW/m^2 in electricity energy was determined for the high-rise MURB with 40% glazing
- An example where EIFS is more expensive
- There is currently no incentive to realize these savings

Condensation

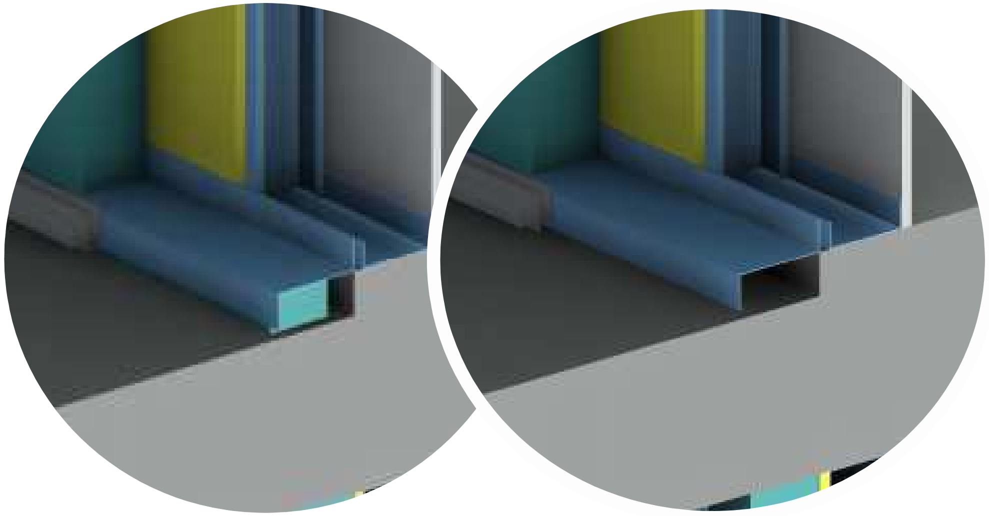


0.483

0.749

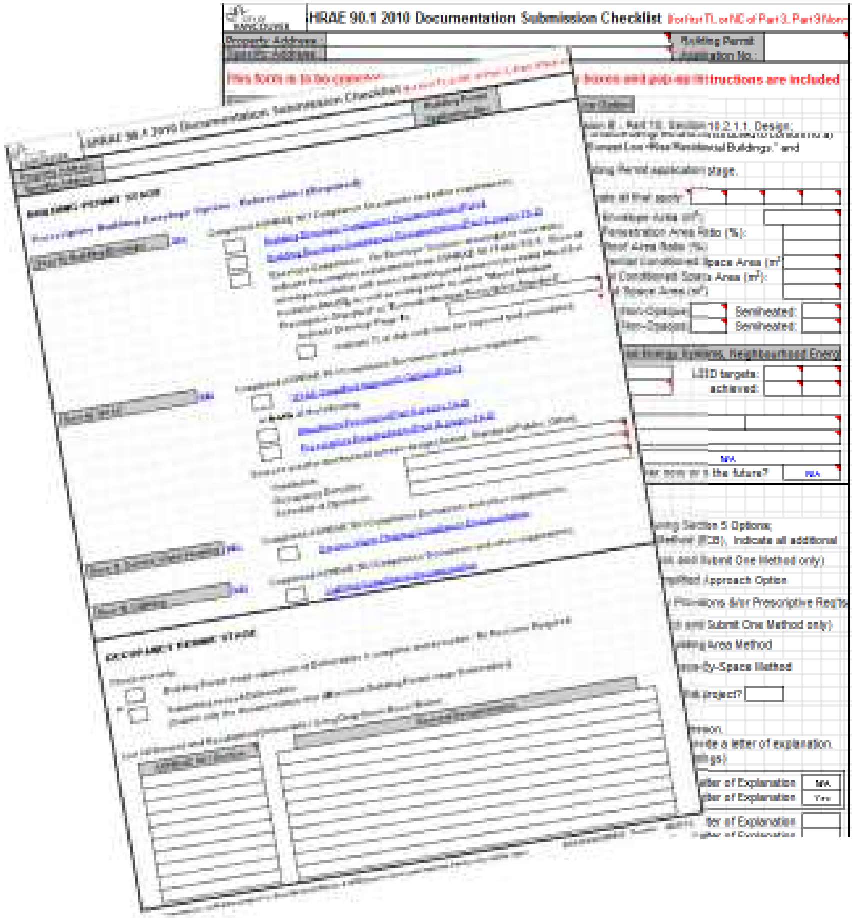
The Bottom Line

- More attention needs to be paid to minimizing thermal bridging at interface details for all buildings
- More energy savings can be realized with improving details than simply adding more insulation
- Sometimes a small amount of insulation in a gap makes a difference



Role and Challenges of the AHJ

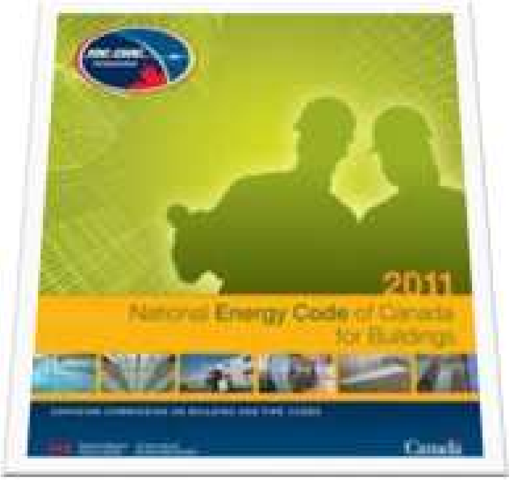
- Move past only checking insulation levels
- Differences and silence on thermal bridges at interface details has created confusion and enforcement challenges
- Enforcement requires understanding of the differences between the reference standards

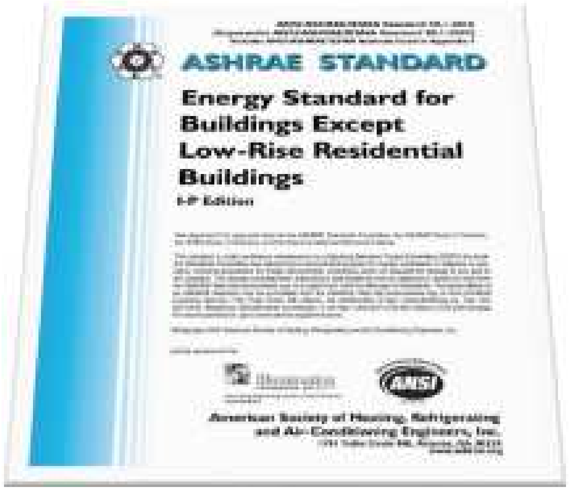


Energy Codes and Standards

Overview

- ASHRAE Standard 90.1
- NECB
- 9.36





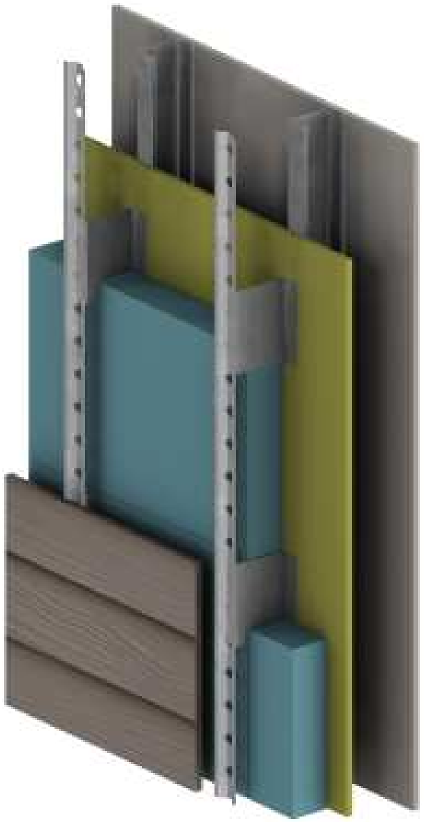
Energy Standards

Thermal bridges at transitions is currently not captured

- Not punished
- Or rewarded to implement feasible solutions to mitigate thermal bridging at interface details

Continuous Insulation vs. Insulation Continuity

- Despite the intent of the continuous insulation concept, to make it simple and not require calculations, this approach does effectively deal with thermal bridging
- NECB 2011 (and now 9.36) is based exclusively on effective U-values, but has many relaxations for accounting for thermal bridging



Envelope Requirements

	ASHRAE 90.1 2010	NECB 2011
Mandatory requirements	Yes, for all methods	Not for energy modeling
Prescriptive requirements	Generally less demanding R values	Stringent, specific
• Framing	Accounted	Accounted
• Structure	Not clear	Specific
• Cladding attachments	Accounted	Only if repetitive
• Service penetrations	Ignore	Specific
• Walls	More categories	Less categories
• Fenestration & doors	More categories	Less categories
Trade-off methods	Complex, no benefit if FDWR <40%	Simple or software Benefit if FDWR <40%

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ASHRAE 90.1 Overview

ASHRAE 2004
Baseline

ASHRAE 2007
Increased BE requirements

ASHRAE 2010
No major changes in BE requirements

ASHARE 90.1 – Thermal Bridging

- Similar to NECB for wall assemblies, but with a lot less clarity
- Balcony slabs are uninsulated mass walls?
- Difficult to enforce for other common thermal bridges at interface details

continuous insulation (c.i.): insulation that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the building envelope.

ASHRAE 90.1 - Prescriptive Opaque areas

TABLE 5.5-5 Building Envelope Requirements for Climate Zone 5 (A, B, C)*

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.119	R-7.6 c.i.
Metal Building[a]	U-0.055	R-13.0 + R-13.0	U-0.055	R-13.0 + R-13.0	U-0.083	R-13.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above-Grade						
Mass	U-0.090	R-11.4 c.i.	U-0.080	R-13.3 c.i.	U-0.151[b]	R-5.7 c.i.[b]
Metal Building	U-0.069	R-13.0 + R-5.6 c.i.	U-0.069	R-13.0 + R-5.6 c.i.	U-0.113	R-13.0
Steel-Framed	U-0.064	R-13.0 + R-7.5 c.i.	U-0.064	R-13.0 + R-7.5 c.i.	U-0.124	R-13.0
Wood-Framed and Other	U-0.064	R-13.0 + R-3.8 c.i.	U-0.051	R-13.0 + R-7.5 c.i.	U-0.089	R-13.0

For multiple assemblies within a single class of construction for a single conditioning space, can be combined using a weighed average

Above Grade Walls

NECB 2011 Above-Grade Walls

Assemblies	Any Occupancy				
	R values (effective)				
	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
Walls	18	20.4	23	27	31
Roofs	25	31	31	35	40
Floors	25	31	31	35	40

Mass	**11.4**
Metal Building	14.5
Steel-framed	15.6
Wood-framed and other	19.6

ASHRAE 90.1 – 2010 Above-Grade Walls Residential

Appendix A

TABLE A3.3 Assembly U-Factors for Steel-Frame Walls

Framing Type and Spacing Width (Actual Depth)	Cavity Insulation R-Value: Rated (Effective Installed [see Table A9.2B])	Overall U-Factor for Entire Base Wall Assembly	Overall U-Factor for Assembly of Base Wall Plus Continuous Insulation (Uninterrupted by Framing)							
			Rated R-Value of Continuous Insulation							
			R-1.00	R-2.00	R-3.00	R-4.00	R-5.00	R-6.00	R-7.00	R-8.00
Steel Framing at 16 in. on center										
3.5 in. depth	None (0.0)	**0.352**	0.260	0.207	0.171	0.146	0.128	0.113	0.102	0.092
	R-11 (5.5)	**0.132**	0.117	0.105	0.095	0.087	0.080	0.074	0.069	0.064
	R-13 (6.0)	**0.124**	[illegible]	.100	0.091	0.083	0.077	0.071	0.066	0.062
	R-15 (6.4)	**0.118**	0.106	0.096	0.087	0.080	0.074	[illegible]	[illegible]	[illegible]

= R-8

= R-8 + R-8

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Acceptable calculation methods

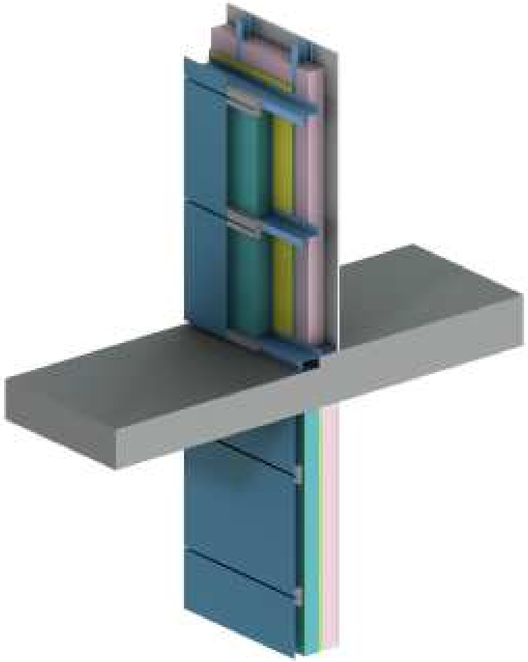
Construction Classes		Testing or Modeling	Series calculation method	Parallel path calculation method	Isothermal planes method
Roofs	Insulation above deck	✓	✓		
	Attic (wood joists)	✓		✓	
	Attic (steel joists)	✓			✓
Walls	Mass	✓			✓
	Steel framed	✓			✓
	Wood framed	✓		✓	

ASHRAE 90.1 Prescriptive - Fenestration

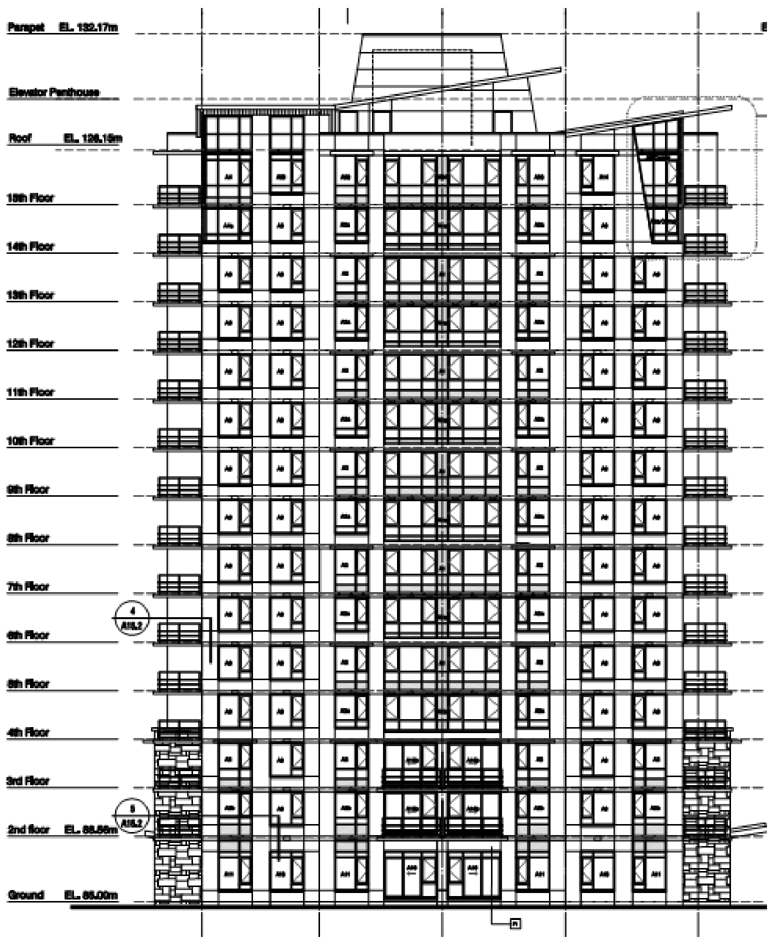
Components	Zone 5					
	Residential		Non-Residential		Semi-Heated	
	U factor	SHGC	U factor	SHGC	U factor	SHGC
Non-Metal Framing	0.35	0.40 for all	0.35	0.40 for all	1.20	0.40 for all
Metal Framing (curtain wall and storefront)	0.45		0.45		1.20	
Metal Framing (entrance doors)	0.80		0.80		1.20	
Metal Framing (operable and fixed windows, non-entrance doors)	0.55		0.55		1.20	

Silence and Ambiguity Leads to an Un-level Playing Field

Can a Concrete Balcony and Steel-Frame Wall comply with the Prescriptive Path?



ASHRAE 90.1 Trade-off



Axis – Raymond Letkeman Architects

Need to :

- Do take-offs for all the different BE components i.e. floor, roof, wall and fenestration assemblies for <u>every space-conditioning category</u> and <u>every orientation</u>.
- Evaluate the U values of each component including SHGC and VT for fenestration.
- Enter all the numbers into a series of equations that you can find in normative Appendix C*.

* COMcheck (Now has Canadian climate data).

COMcheck

COM*check* Software Version 3.9.4

Envelope Compliance Certificate

Section 2: General Information

Building Location (for weather data):	**Vancouver, British Columbia**
Climate Zone:	**5c**
Building Space Conditioning Type(s):	**Nonresidential**
Vertical Glazing / Wall Area Pct.:	**17%**

Building Type	Floor Area
Retail	4152

Section 3: Envelope Assemblies

Envelope FAILS: Design 2% worse than code.

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ASHRAE Code (ECB) vs. LEED (App G)

Section 11: Energy Cost Budget

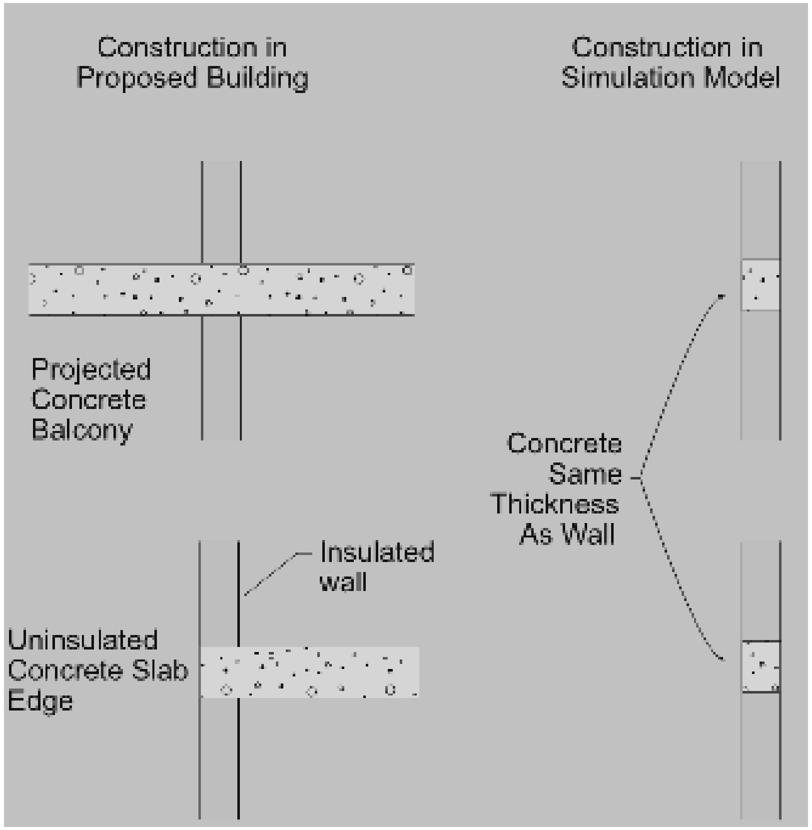
Any envelope assembly that covers less than 5% of the total area of that assembly type (e.g., exterior walls) need not be separately described. If not separately described, the area of an envelope assembly must be added to the area of the adjacent assembly of that same type.

Appendix G

All uninsulated assemblies (e.g., projecting balconies, perimeter edges of intermediate floor stabs, concrete floor beams over parking garages, roof parapet) shall be separately modeled….
Any other envelope assembly that covers less than 5% of the total area of that assembly type (e.g., exterior walls) need not be separately described provided that it is similar to an assembly being modeled.

Silence and Ambiguity Leads to an Un-level Playing Field

Appendix G: Slab Edges



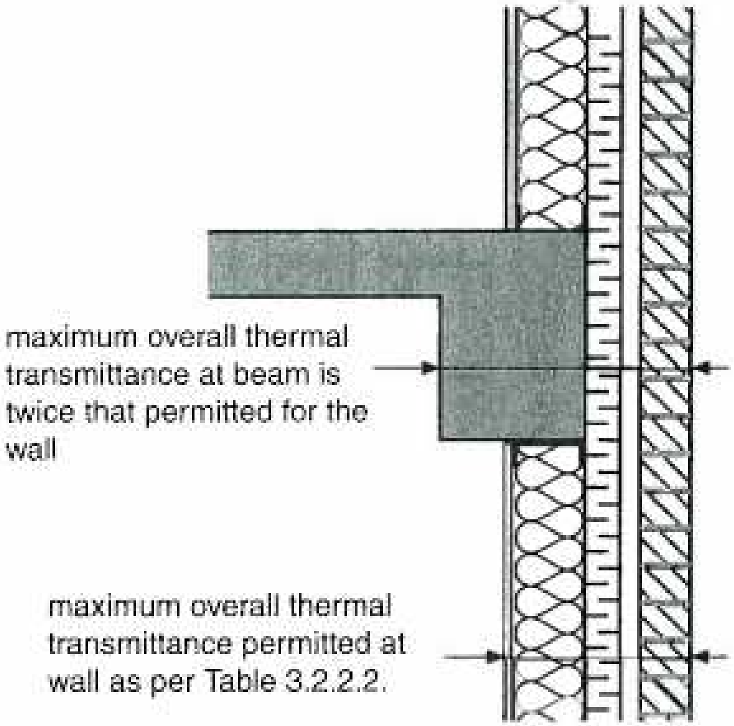
NECB (9.36) - Thermal bridging

Clear Field Assembly

The thermal bridging effect of closely spaced repetitive structural members (e.g. studs) and of ancillary members (e.g. sill and plates) should be taken into account.

Floor Slab Interface Detail

The thermal bridging of major structural elements that are parallel to the building envelope can be ignored, provided that they do not increase the thermal transmittance to more than twice than permitted.



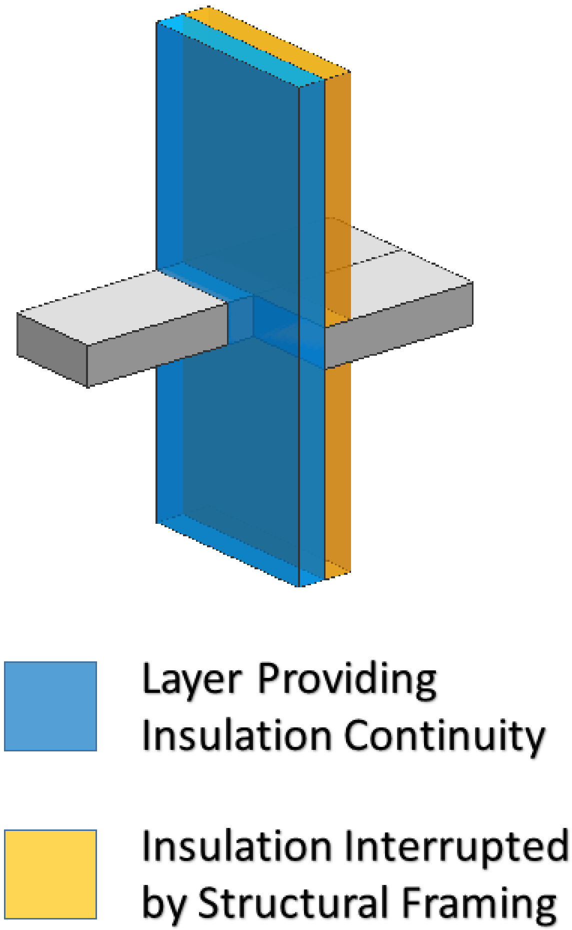
NECB (9.36) - Thermal bridging

Clear Field Assembly

The thermal bridging effect of closely spaced repetitive structural members (e.g. studs) and of ancillary members (e.g. sill and plates) should be taken into account.

Balconies Interface Detail

The thermal bridging of major structural elements that must penetrate the building envelope need not be taken into account, provided that the sum of the areas is less than 2% of the above ground building envelope.



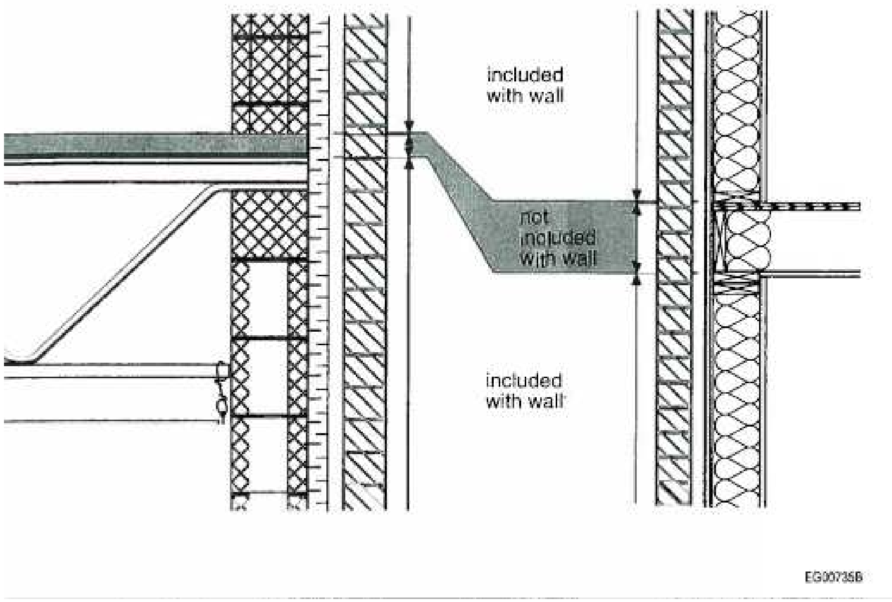
NECB (9.36) - Thermal bridging

Clear Field Assembly

The thermal bridging effect of closely spaced repetitive structural members (e.g. studs) and of ancillary members (e.g. sill and plates) should be taken into account.

Clear Field and Interface Details?

..pipes, ducts, equipment with through-the-wall venting…shelf angles, anchors and ties and associated fasteners, and other minor structural members that must completely penetrate the building envelope to perform their intended function need not be taken into account



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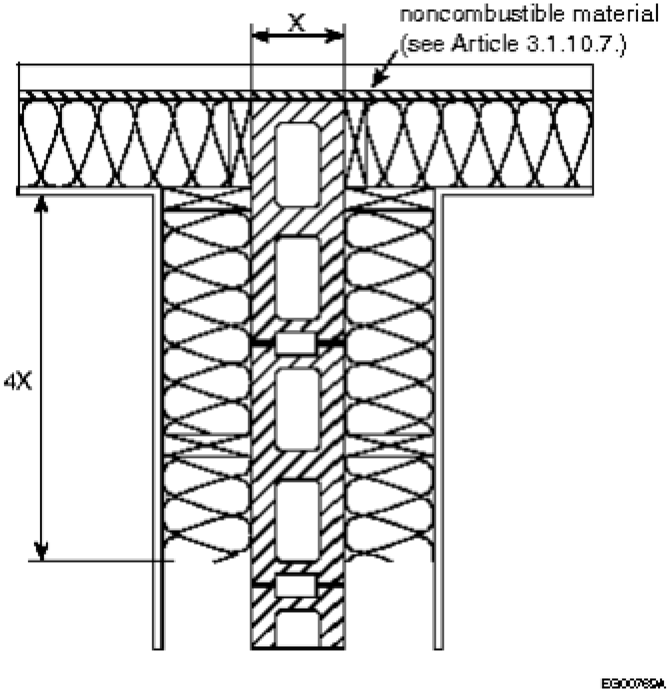
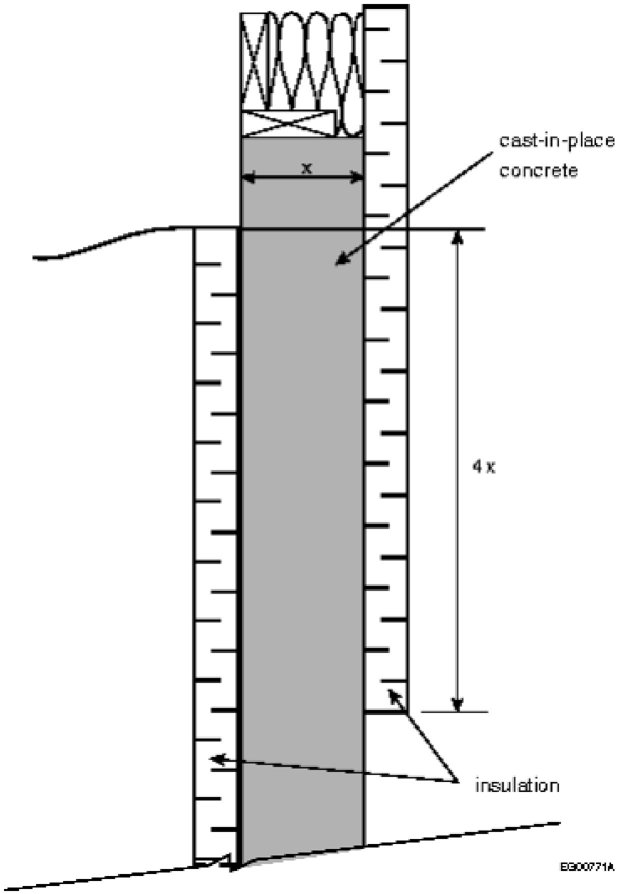
NECB (9.36) Insulation Continuity





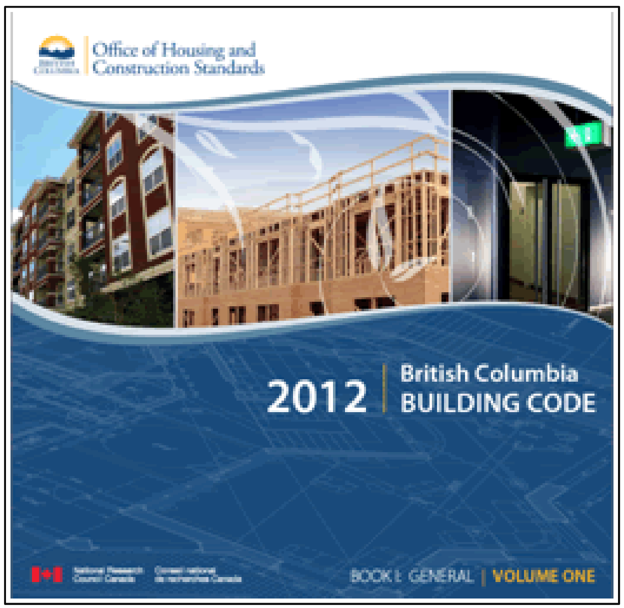
2012 BCBC - Enforcement

10.2.1.1. Design

1) Except as provided for in Sentence (2) or (4), all *buildings* shall be designed and constructed to conform to

a) ANSI/ASHRAE/IESNA 90.1, "Energy Standard for Buildings Except Low-Rise Residential Buildings", or

b) NRCC 54435, "National Energy Code of Canada for Buildings."



ARCHITECTURAL

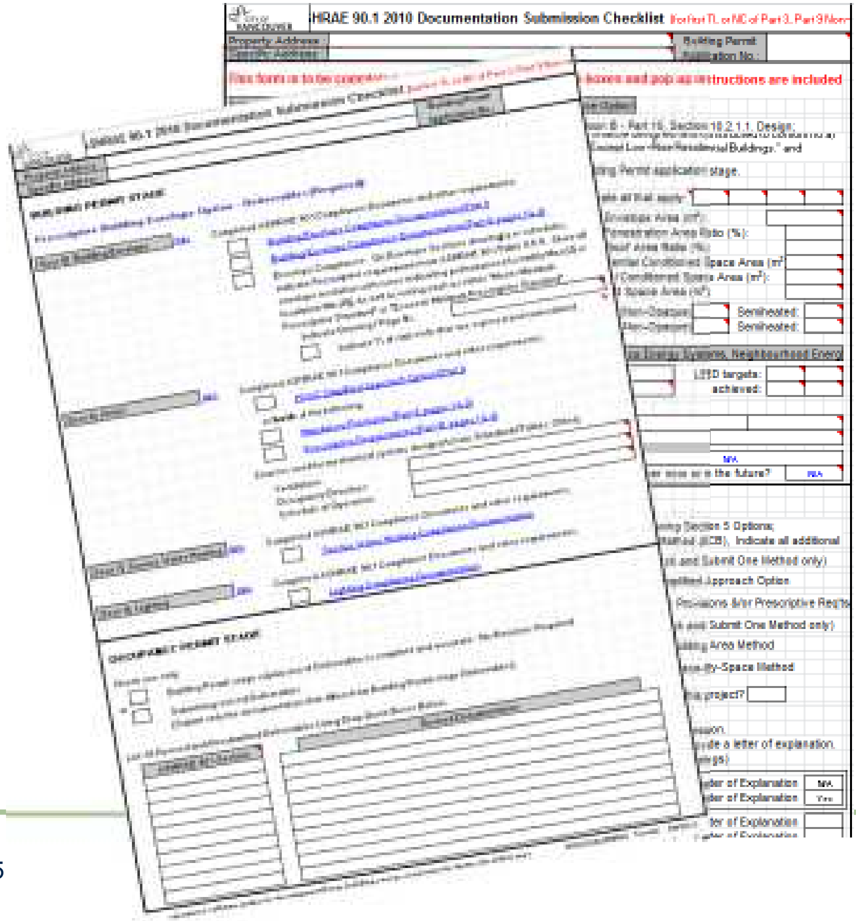
1.1 Fire resisting assemblies
1.2 *Fire separations* and their continuity
1.3 *Closures*, including tightness and operation
1.4 Egress systems, including *access to exit* within *suites* and *floor areas*
1.5 Performance and physical safety features (guardrails, handrails, etc.)
1.6 Structural capacity of architectural components, including anchorage and seismic restraint
1.7 Sound control
1.8 Landscaping, screening and site grading
1.9 Provisions for fire fighting access
1.10 *Access* requirements for *persons with disabilities*
1.11 Elevating devices
1.12 Functional testing of architecturally related fire emergency systems and devices
1.13 Development Permit and conditions therein
1.14 Interior signage, including acceptable materials, dimensions and locations
1.15 Review of all applicable shop drawings
1.16 Interior and exterior finishes
1.17 Dampproofing and/or waterproofing of walls and slabs below *grade*
1.18 Roofing and flashings
1.19 Wall cladding systems
1.20 Condensation control and cavity ventilation
1.21 Exterior glazing
1.22 Integration of building envelope components
1.23 Environmental separation requirements (Part 5)
1.24 Building Envelope, Part 10/ASHRAE Requirements

(Professional's Seal and Signature)

Vancouver Building by-law

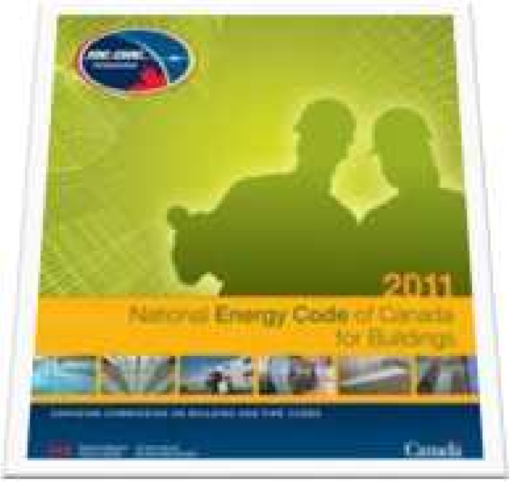
Energy standards and conditions

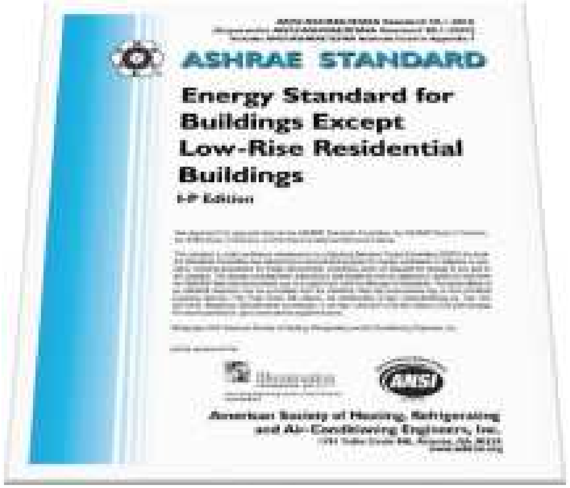
Effective January 21, 2014, the Vancouver Building Bylaw requires the use of the energy standard ASHRAE 90.1-2010 or the energy code, National Energy Code of Canada for Buildings (NECB) 2011, in place of ASHRAE 90.1-2007. The standard and code have been implemented without additional addenda or errata.



Energy Codes and Standards

Development





Reduce the Confusion

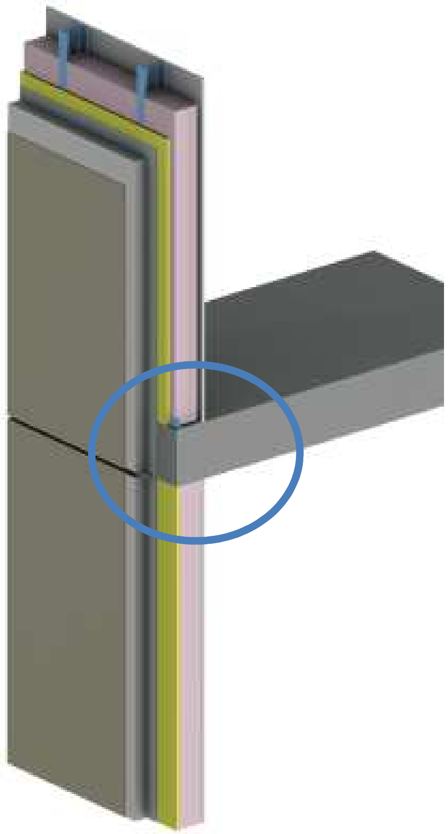
- We no longer need to ignore thermal bridging and apply haphazard exceptions based on assumptions that are no longer valid
- The BETB Guide provides a straightforward approach supported by a lot of data
- Straightforward to amend NECB and 9.36, but will require a detailed U-value calculation
- ASHRAE 90.1 is a little more complicated

Next Steps

- Improve the ability to enforce the code and level the playing field by adding clarity
- Replace "exceptions" based on wall areas with metrics that represent heat flow like linear transmittance or remove all exceptions
- Create incentives and reward improved details when practical
- Use the guide to help policy and authorities implement programs that are more enforceable

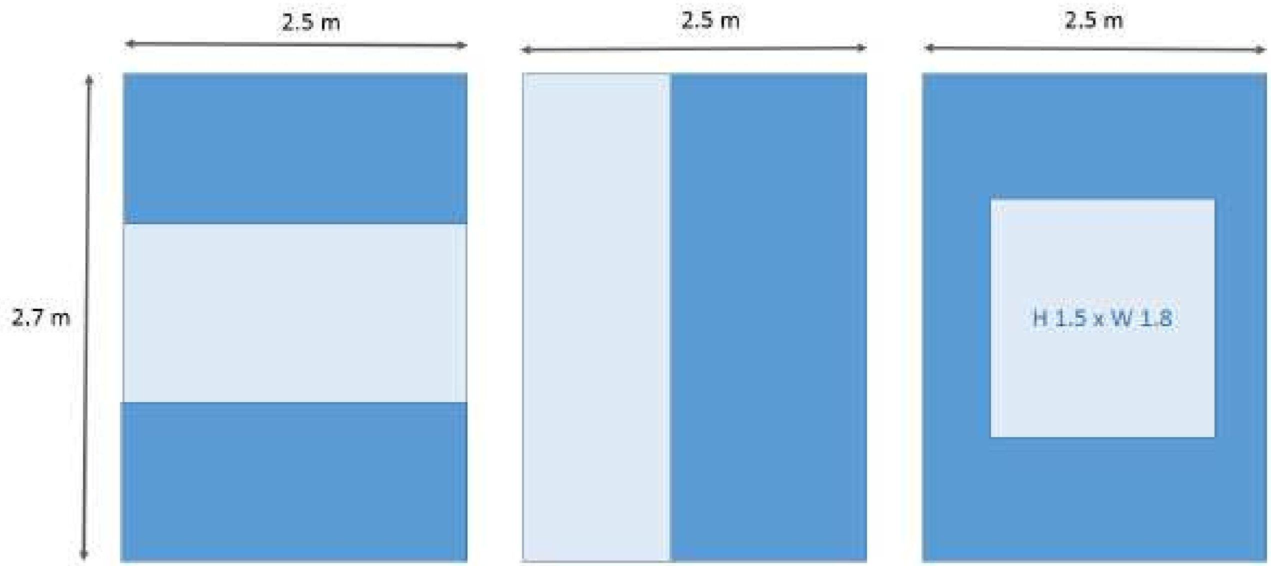
Challenges

- Thermal bridging not recognized by the standards has always existed
- All the compliance paths reference the prescriptive requirements.
- Thermal bridging has to be carried through for all the compliance paths
- U-value requirements likely need to be relaxed if accounting for all thermal bridges



Challenges

- Window transitions are a big deal



Horizontal Strip Glazing with Two Glazing Interfaces

Interface length = 5 m

Vertical Strip Glazing with one Glazing Interface

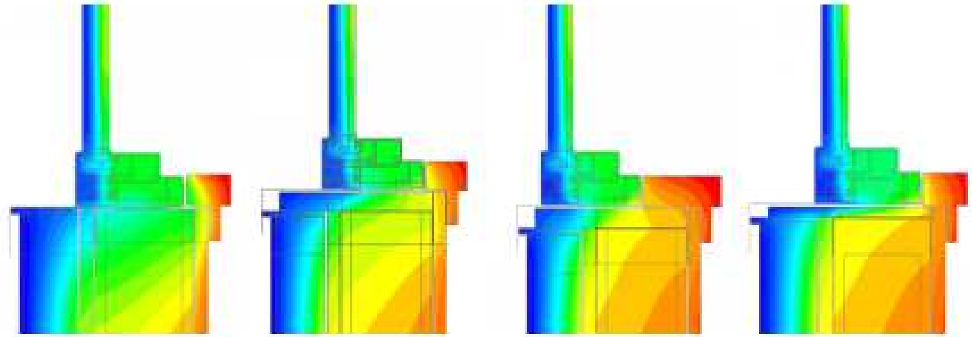
Interface length = 2.7 m

Punched Window Opening with Several Glazing Interfaces (Jambs, Sill, Head)

Interface length = 6.6 m

Challenges

- Window transitions are a big deal



	Base Case	Plywood Liner	Plywood Liner with Window at Exterior	R-4 Insulation Wrapped into Opening
Linear Transmittance (W/m K)	0.41	0.24	0.21	0.21
Glass Temperature Index at Edge (-)	0.465	0.464	0.460	0.456
Frame Temperature Index (-)	0.503	0.505	0.499	0.485

Tools will help the process

Select Area Calculation (Choose One)	Area	Units
Sum of Active Clear Field Areas (Default)	0	m^2
User Defined Area	Enter User Defined Opaque Area	m^2

Overall Opaque Wall Thermal Performance Values	
Opaque U-Value (W/m^2K)	-
Effective R-value (m^2K/W)	-

Add/Remove Detail	Transmittance Type	Include	Transmittance Description	Area, Length or Amount Takeoff	Units	Transmittance Value	Units	Source Reference	Heat Flow W/K	% Total Heat Flow
								Totals	0	0%
Add Clear Field	Clear Field	☑	Enter Description Here	Enter Area Here	m^2	Enter Clear Field U-Value Here	W/m²K	Enter Source Here	-	-
Add Linear Interface Detail	Linear Interface Detail	☑	Enter Description Here	Enter Length Here	m	Enter Psi-Value Here	W/mK	Enter Source Here	-	-
Add Point Interface Detail	Point Interface Detail	☑	Enter Description Here	Enter Amount Here	#	Enter Chi-Value Here	W/K	Enter Source Here	-	-

Conclusion

- Details such as slab penetration are easy to account for in calculation
- Codes do not yet take into account details such as window transitions
- It will likely become increasingly more difficult to ignore thermal bridging at intersections of assemblies
- Move beyond simply adding “more insulation”

Questions?

Thank You

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