Building Energy Education for Architects – Thermal Envelope

3.18.2021

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Providing effective energy strategies for buildings and communities

ICC Preferred Provider # 2396
ICC Course # 27293

AIA Illinois

Stacey Pfingsten

Executive Vice President

Presentation Education Credits

SEDAC is a Preferred Education Provider with the International Code Council (ICC). Credits earned on completion of this program will be reported to ICC for ICC members. Certificates of Completion will be issued to all participants.

ICC PREFERRED EDUCATION PROVIDER

This workshop is approved for 1.5 LU/HSW CES credits from the American Institute of Architects (AIA). Credits earned on completion will be reported for AIA members.

AIA Continuing Education Provider

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Who We Are

The Smart Energy Design Assistance Center (SEDAC) is an applied research program at University of Illinois.

Our mission: Reduce the energy footprint of Illinois and beyond.

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Building Energy Education for Architects

Comprehensive energy efficiency training.
Learn how to design for efficiency.

Learn more and register at

smartenergy.illinois.edu/events

Training delivered by the University of Illinois Smart Energy Design Assistance Center (SEDAC) in partnership with the American Institute of Architects Illinois

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AIA Illinois

3/18/2021, 1-2:30 pm: Thermal Envelope

4/15/2021, 1-2:30 pm: Lighting & Electrical

5/20/2021, 1-2:30 pm: Indoor Air Quality & Comfort

SEDAC Program Contacts

- Technical support
  sedac-info@illinois.edu
  800.214.7954
- Online resources at https://smartenergy.illinois.edu/
  - Blog Posts on current issues in efficiency and sustainability
  - Energy Smart Tips
  - Technical Notes

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www.smartenergy.Illinois.edu/energy-code/

TRAINING AND SUPPORT SERVICES

Workshops

Webinars

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Technical support

ENERGY CODE RESOURCES

What is the Illinois Energy Conservation Code?

Frequently asked questions

Useful websites

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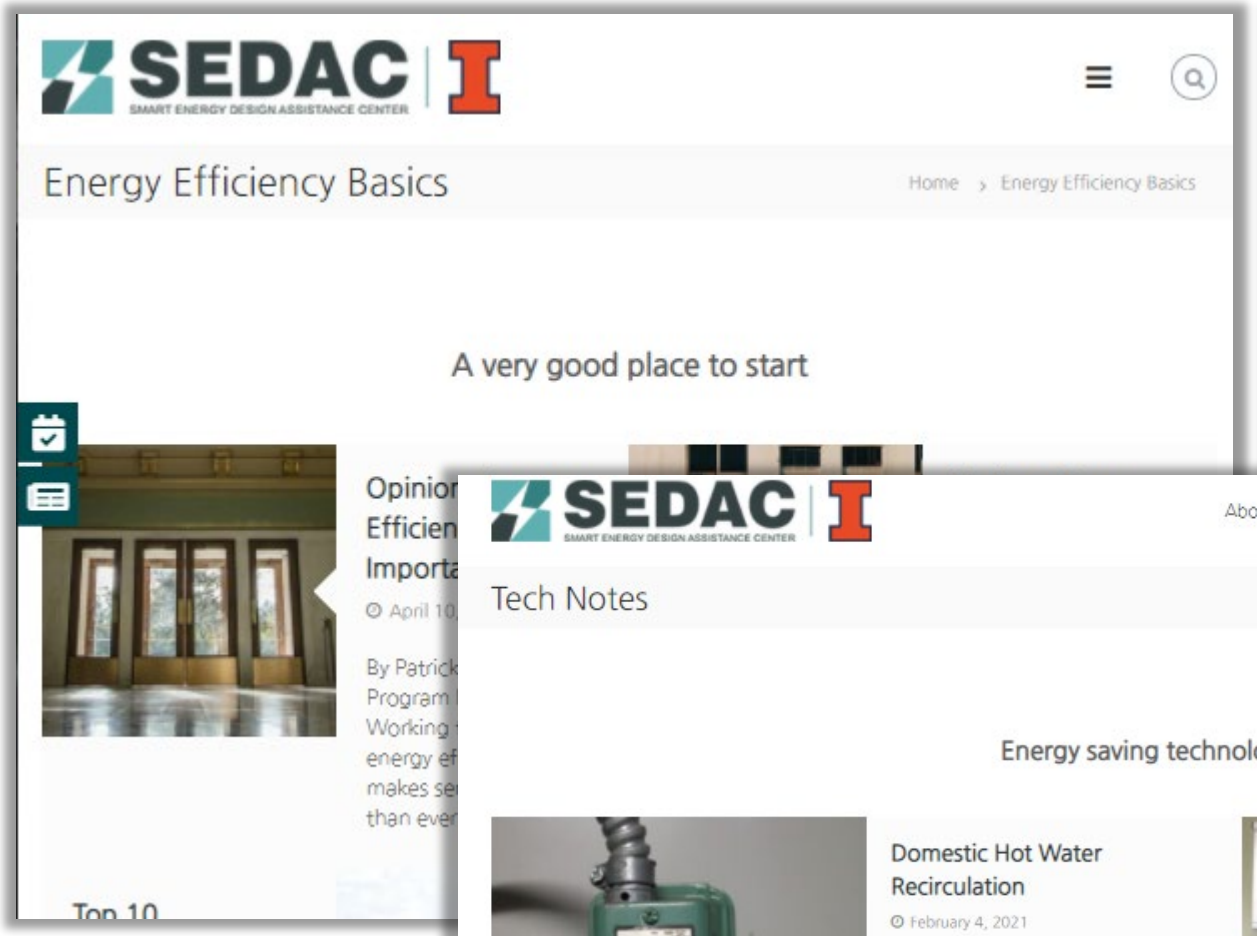
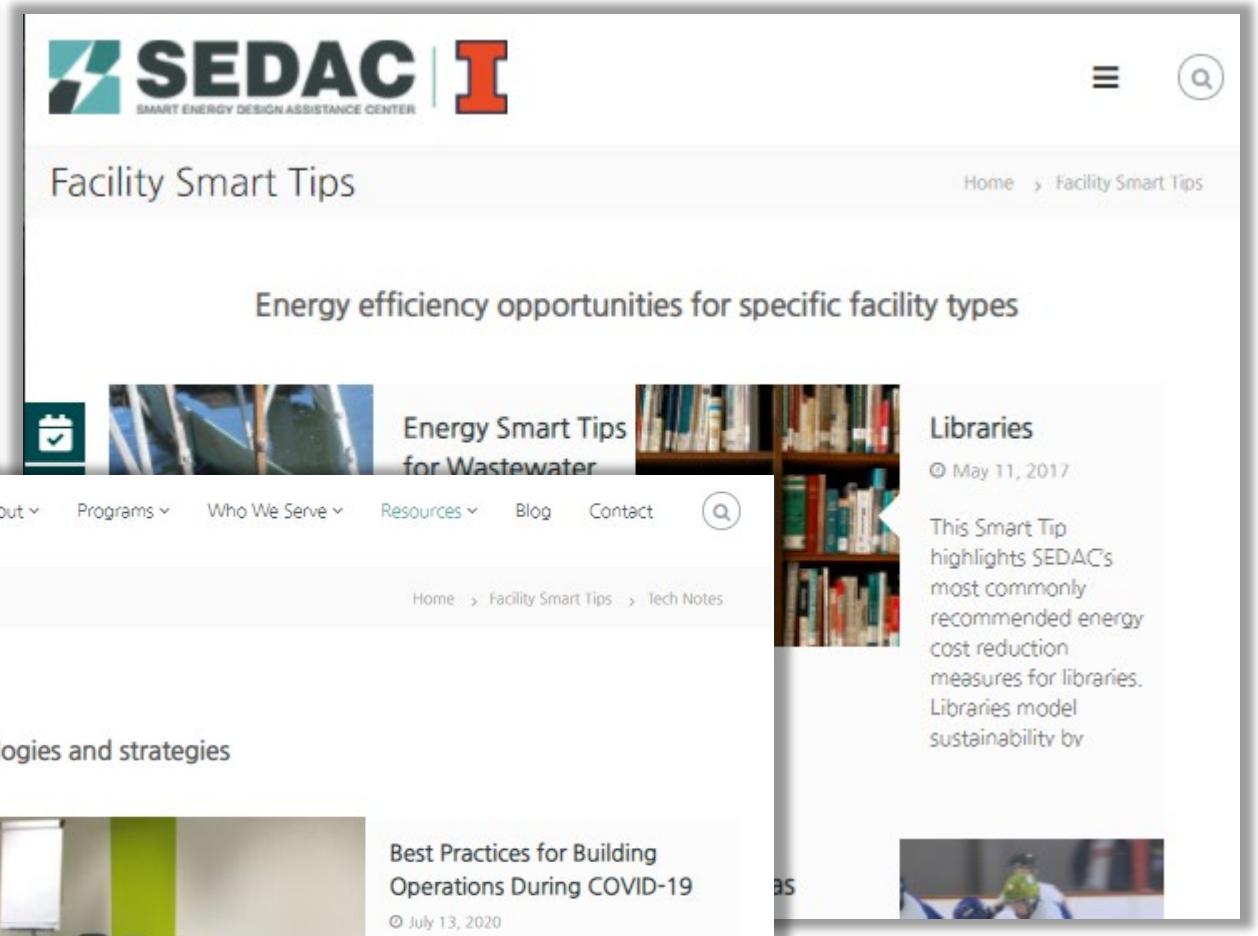
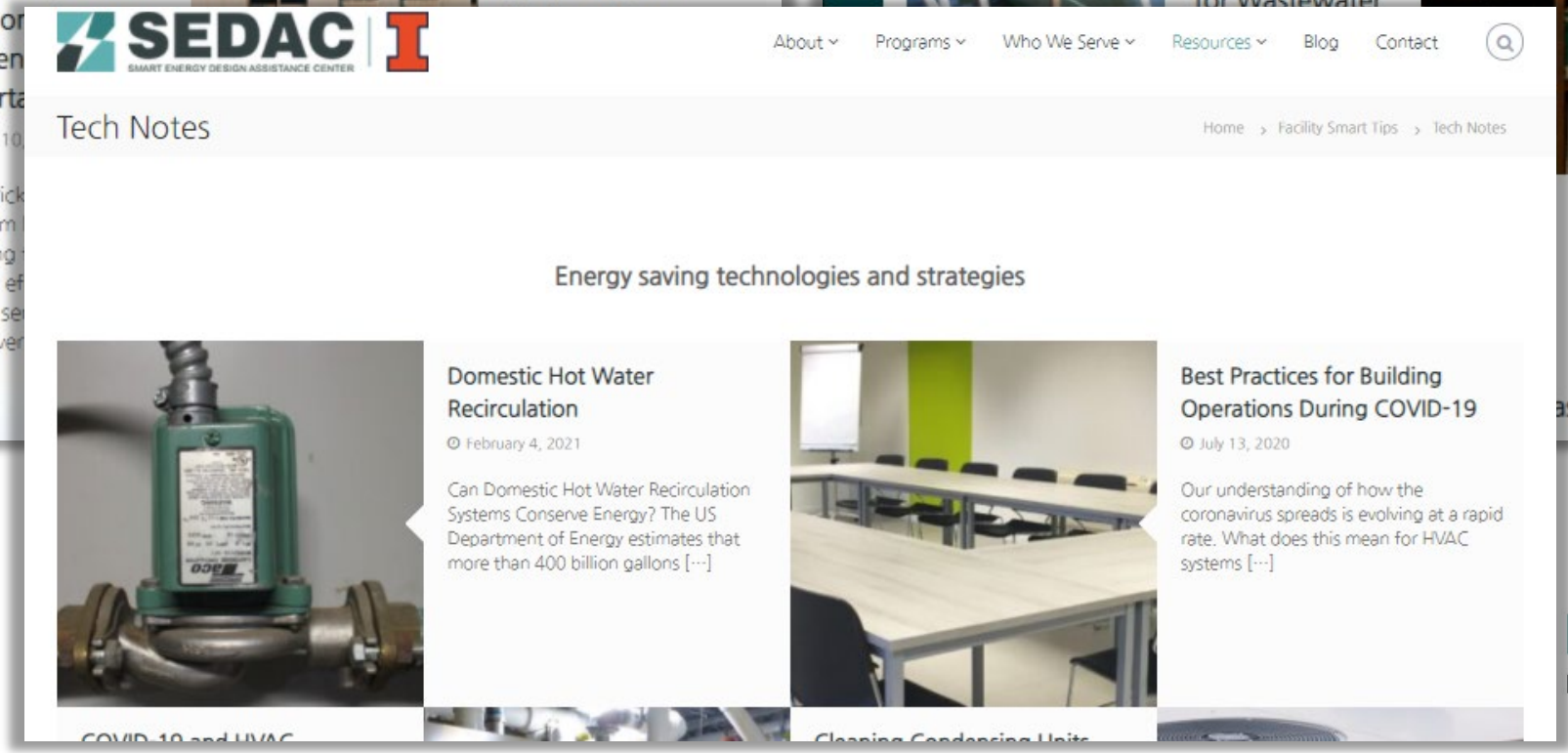
SEDAC Building Energy Resources







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Learning Objectives

1. Understand the building as a whole system and the thermal envelope's role in energy efficiency and comfort.
2. Learn about schematic and massing studies for thermal envelope efficiency.
3. Identify problems and solutions of envelope details based on heat transfer methods.
4. Understand how to comply with the current Illinois Energy Conservation Code for envelope design and installation.

Understanding Envelope Energy Impacts

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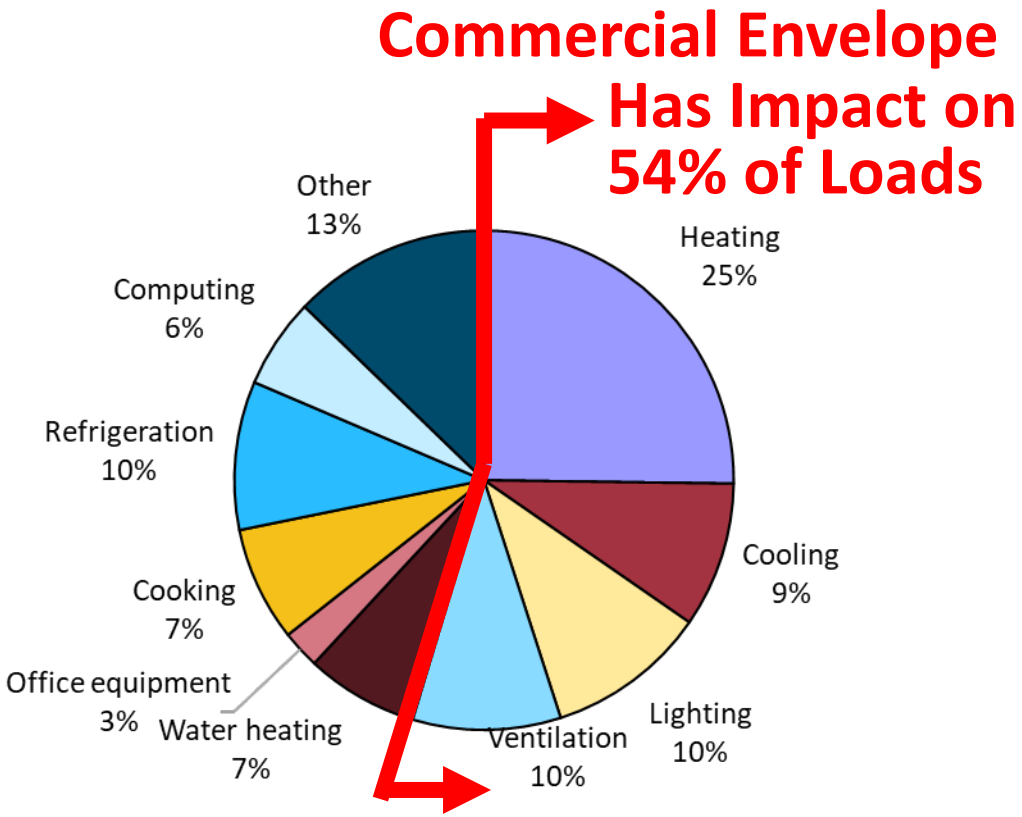
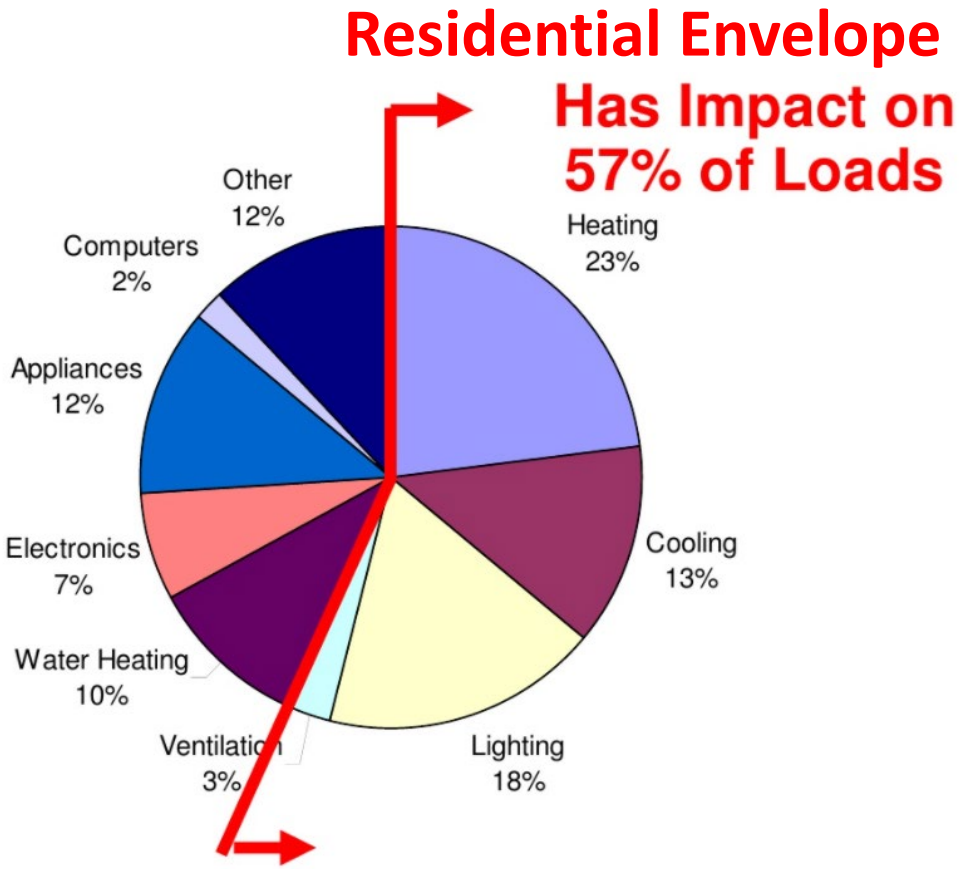
Envelope Has Major Impact on Building Systems



Commercial Loads Breakdown

https://www.eia.gov/consumption/commercial/data/2012/index.php?view=consumption#e1-e11



Residential Loads Breakdown

https://gaia.lbl.gov/btech/CSI_BPMAlliance/EnergyPolicies.pdf

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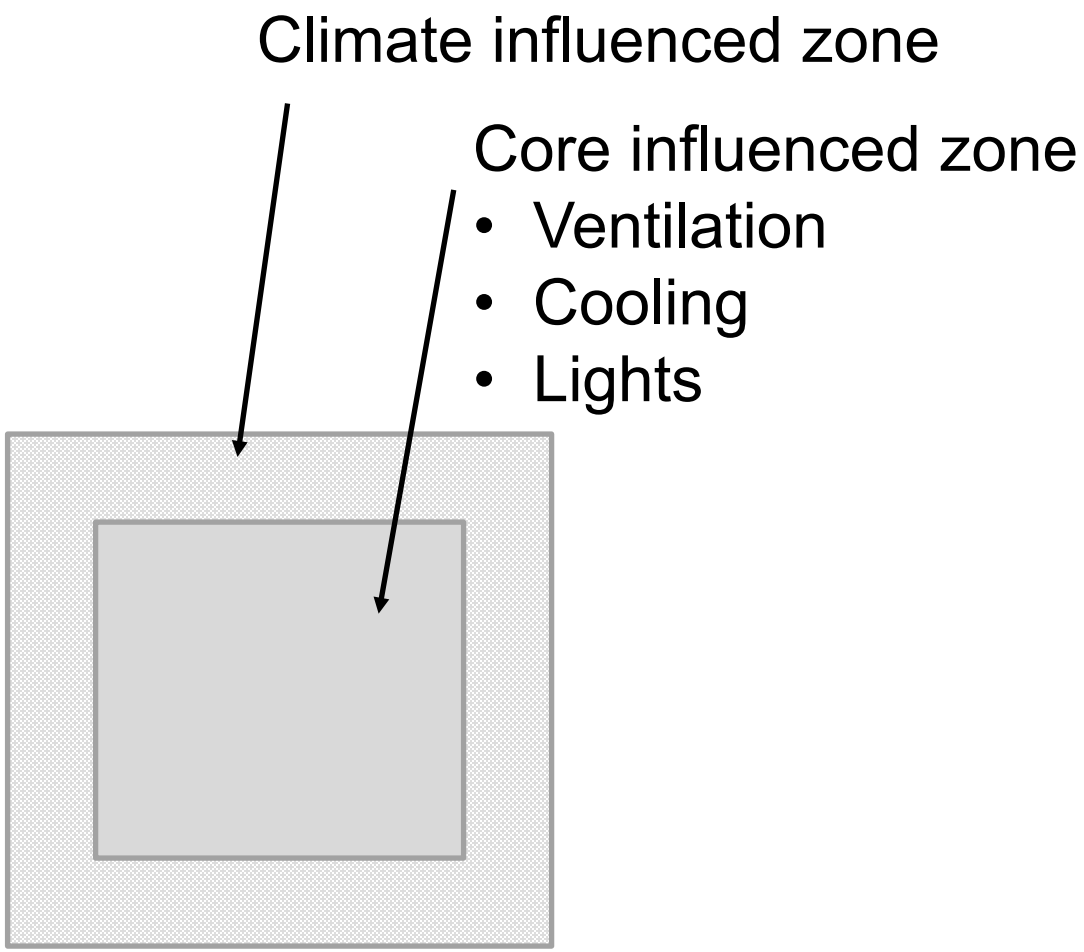
Envelopes Have Two Primary Building Interactions

Envelope (skin loads) Dominated Buildings

- Usually smaller buildings with a large surface area to volume ratio
- Consumption dominated by climate

Core (internal loads) Dominated

- Usually larger buildings with small surface area to volume ratio
- Consumption impacted by ventilation requirements rather than envelope loads



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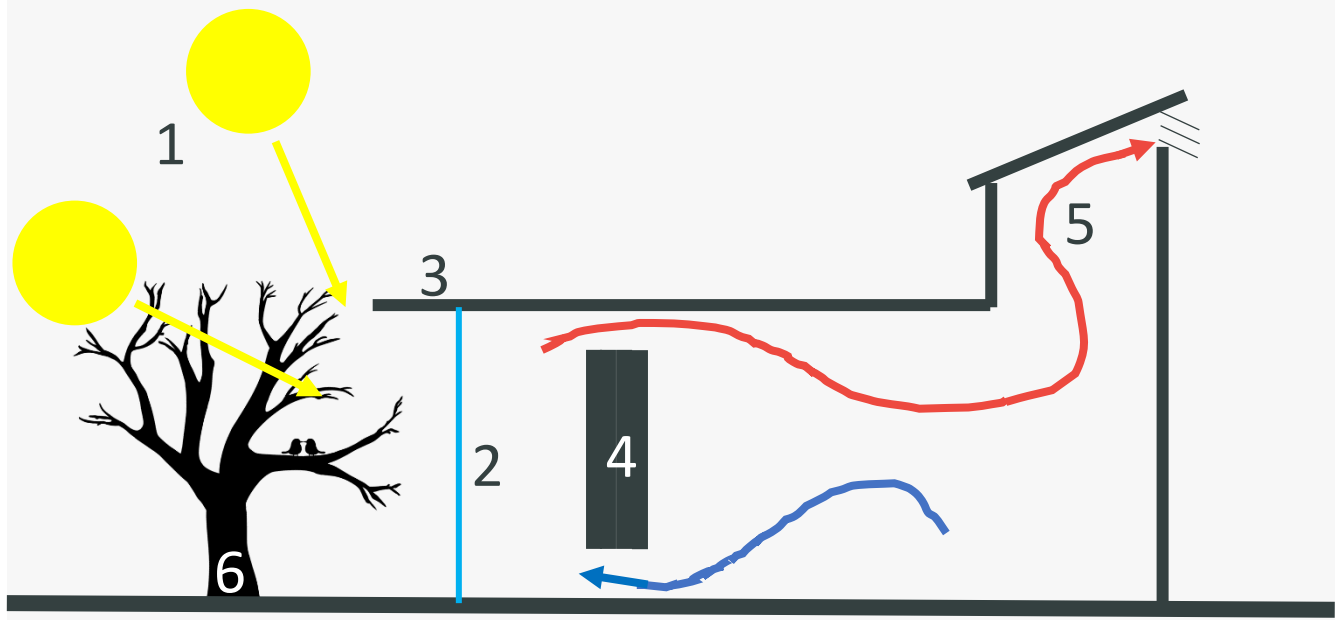
Passive Design Principles Reduce Envelope Loads

- Solar loads and thermal massing reduce HVAC loads
- Reduced loads reduce size of HVAC components
  - Can trade cost reductions in HVAC for envelope improvements
  - Can trade space requirements for envelope improvements
- Envelope is semi-permanent component of the building system
  - Most design choices for envelope stay with building for life of structure

Incorporate Passive Designs for Resilience

1. Building orientation
2. Passive solar heating
3. Shading/Daylighting
4. Thermal massing
5. Natural ventilation
6. Landscape/Natural Shade



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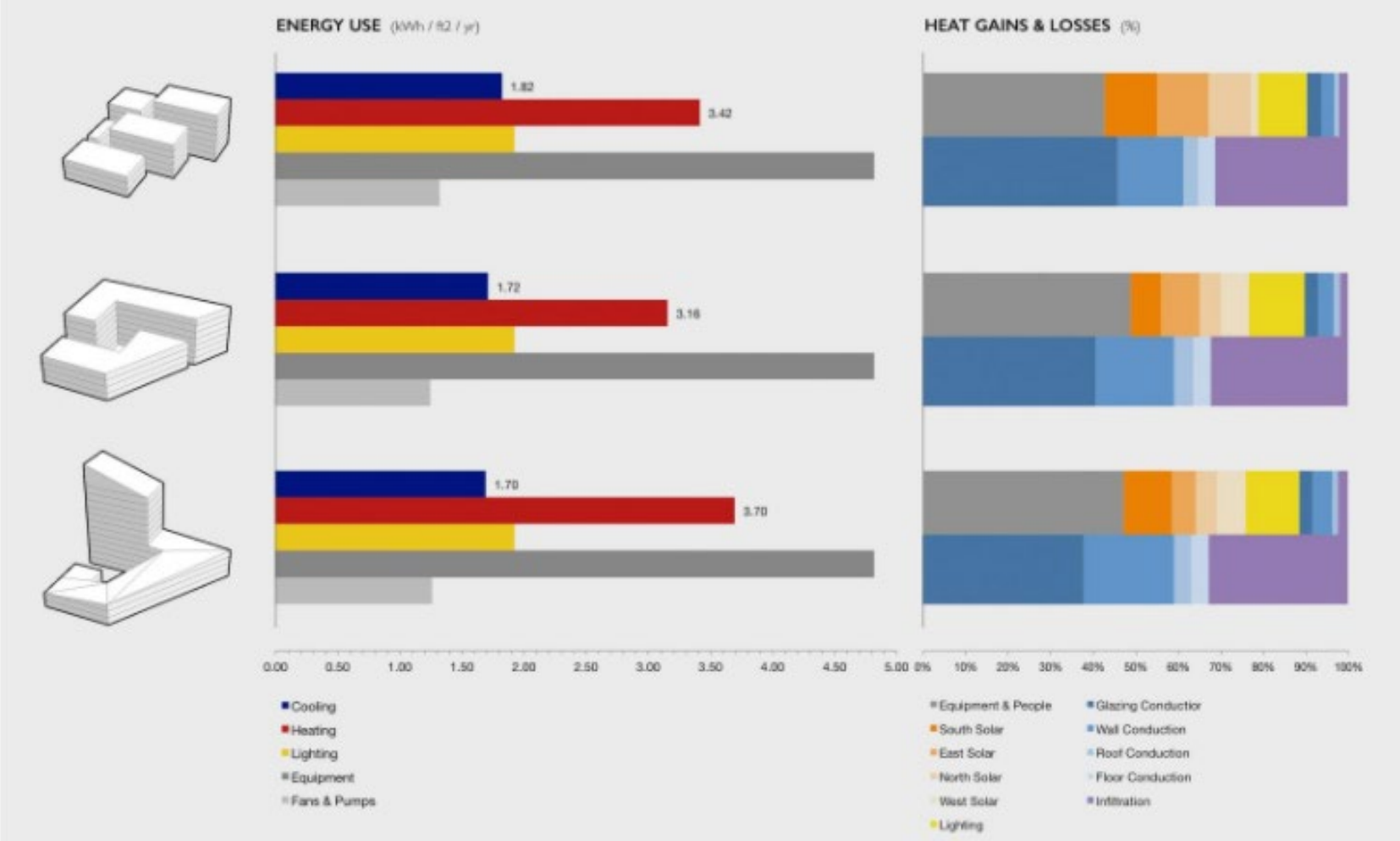
Identify Passive Opportunities Early in Design

Changing layouts, thermal mass locations, orientation, fenestration levels, shading, etc… in simple model parametric runs can identify potential for optimizing passive features in envelopes

Even if passive design isn't focus of envelope, optimization reduces energy and improves resiliency



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Detailing Envelope Continuity for Improved Performance

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Keys to Managing Envelope Loads

- Get Control Layers Right! Thermal, Water, Vapor and Air
- All must work together effectively and form continuous layers.
- Detailing <u>continuity</u> is biggest challenge for efficient envelope design.
- Focus on detailing around building joints
  - Wall to roof
  - Floor to wall
  - Window to wall
  - Foundation to wall

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Confirm Continuity Detailing

- ORNL field study showed that most commercial facilities use similar materials, area-to-volume ratios, number of penetrations for services and equipment.
- Biggest difference in performance was installation workmanship
  - Starts with detailing!
  - Good detailing leads to proper installation, limits confusion and errors
  - Consider integrated-layer products to help simplify detailing: SIPS, EIFS, etc… provide air, water, and thermal barriers in one kit

Building Envelope Design Guides

- National Institute of Building Sciences Whole Building Design Guide website has multiple articles and resources for envelope design and efficiency
- US DOE Better Buildings Solution Center hosts multiple articles, webinars, and toolkits.
- Architecture and Construction Continuing Education Center hosts a library of courses, including envelope continuity, efficiency, and sustainability.

WBDG Whole Building Design Guide

Better Buildings®
U.S. DEPARTMENT OF ENERGY

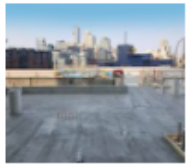
CONTINUING EDUCATION CENTER
ARCHITECTURE + CONSTRUCTION

April 6, 2021 at 2:00 PM EDT
Building Sustainably with Metal Roofs and Walls

Read more...

Sponsored by Petersen Aluminum

April 8, 2021 at 2:00 PM EDT
Proactively Address Moisture in Roof Assemblies

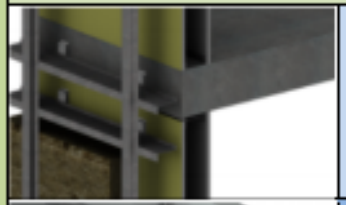
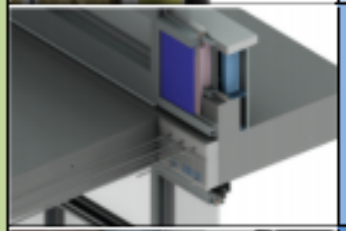
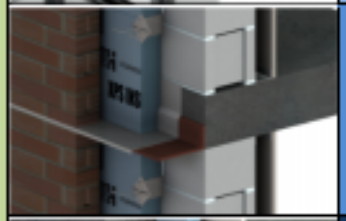


Read more...

Sponsored by ISE Logik Industries

Resources for Continuity Design

- BC Hydro produces a [Building Envelope Thermal Bridging Guide]() that has helpful diagrams and best-practice details for multiple building transitions.

FLOOR AND BALCONY SLABS	Performance Category	Description and Examples	Linear Transmittance	
			Btu / hr ft F	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

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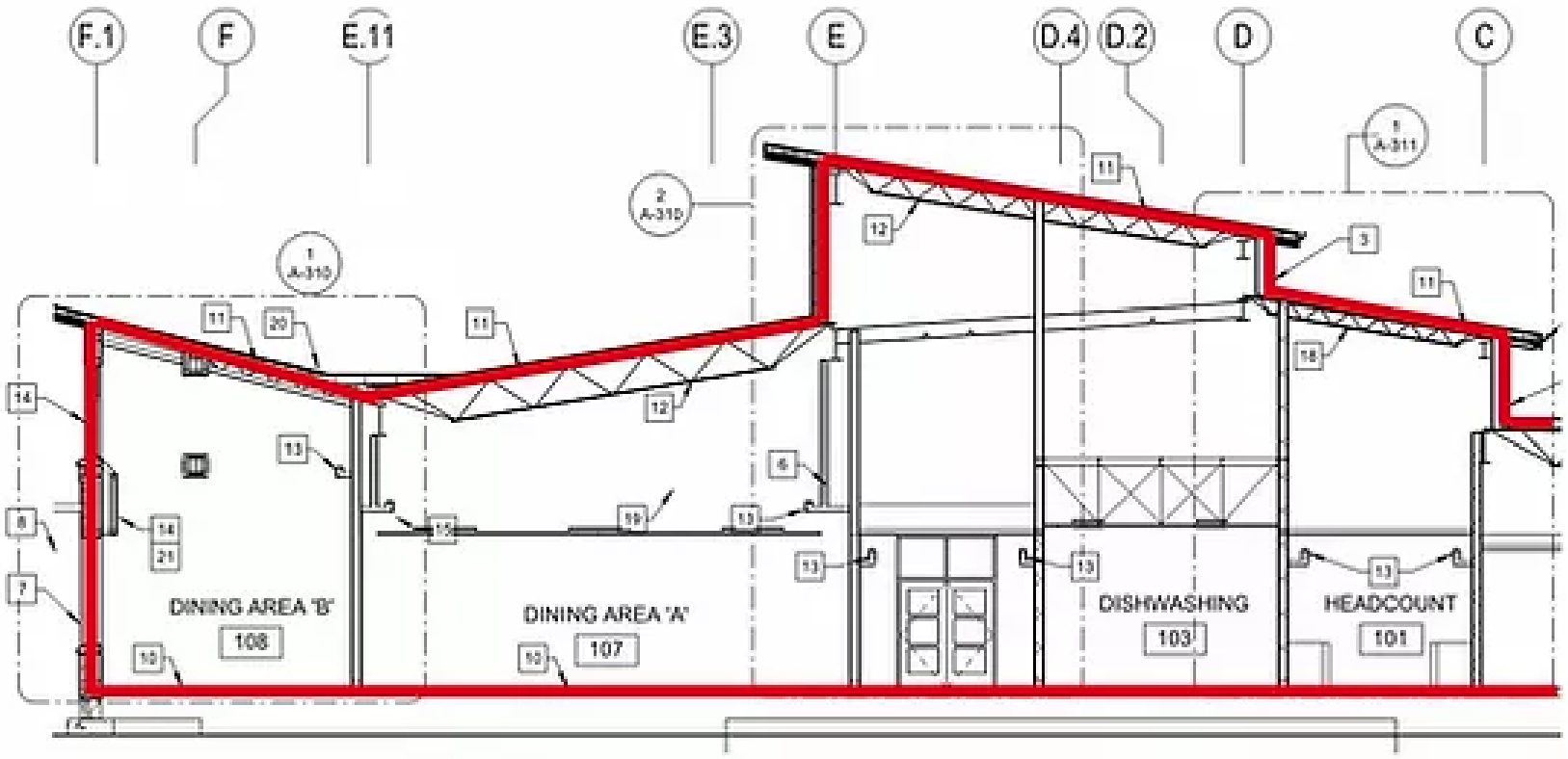
Identify Potential Envelope Issues Using Pen Test

Joining different building assemblies is a common location for errors in control layers of the envelope.



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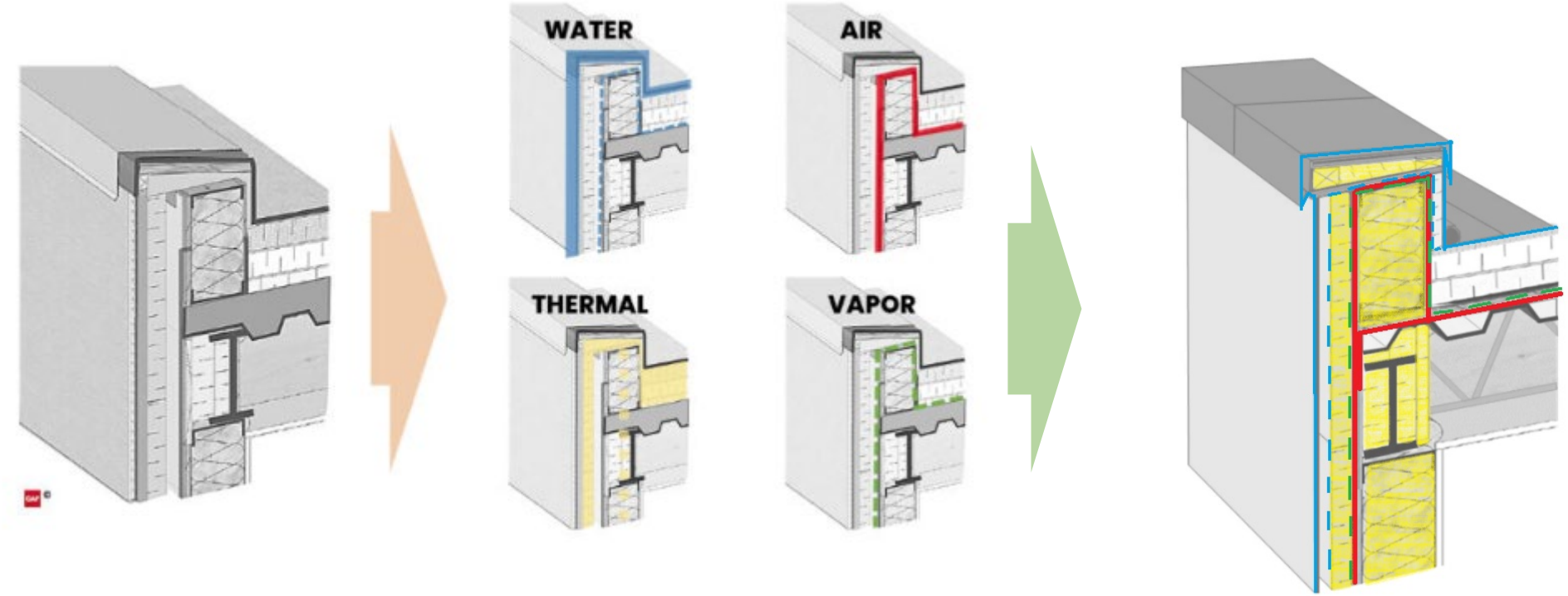
Four Control Layers Need to Align and Be Continuous

- Alignment of thermal barrier between wall and above-deck roof insulation often a difficult detail. Again, call out sealing between differing materials and joints between assemblies.



Source: https://blog.gaf.com/parapets-part-3-an-example-of-complexity/

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Parapet Wall – Optimal Design

Important to **plan for complex joints** and detail envelope continuity around these joints.

Note in image to right, thermal and air barriers consist of same materials or **closely aligned control layers**

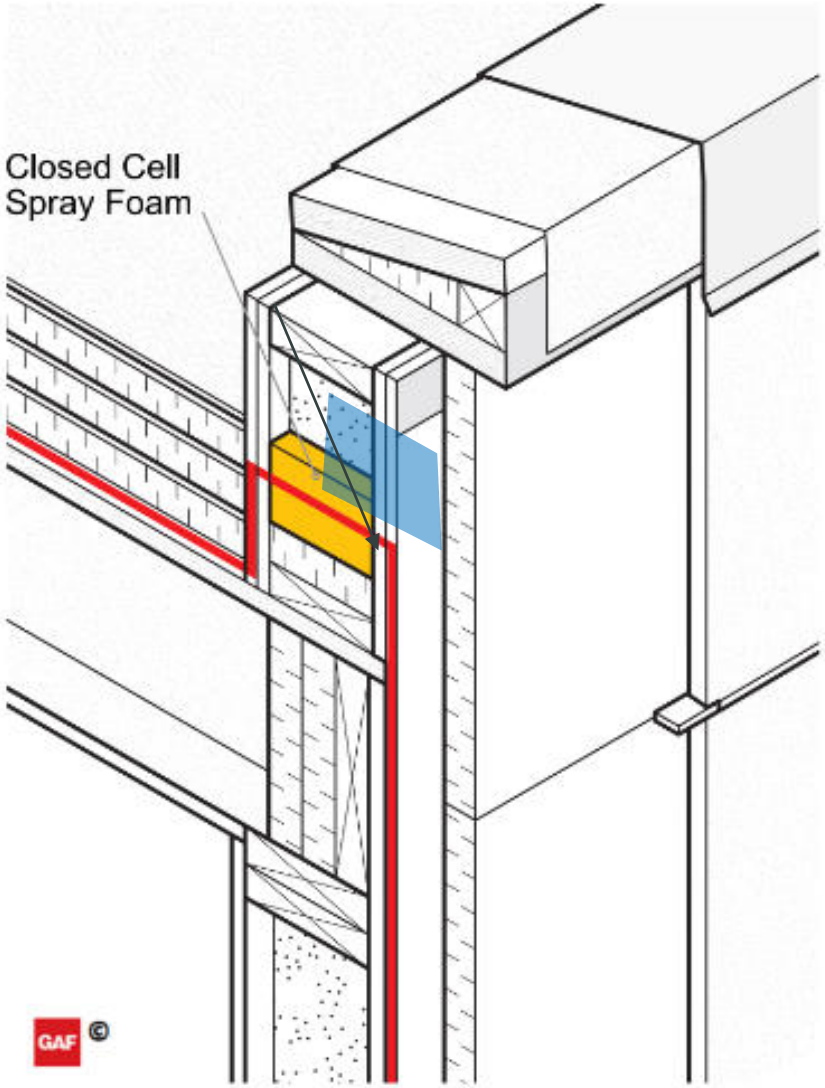

Image source:
https://continuingeducation.bnpmedia.com/courses/gaf/parapets-continuity-of-control-layers/2/

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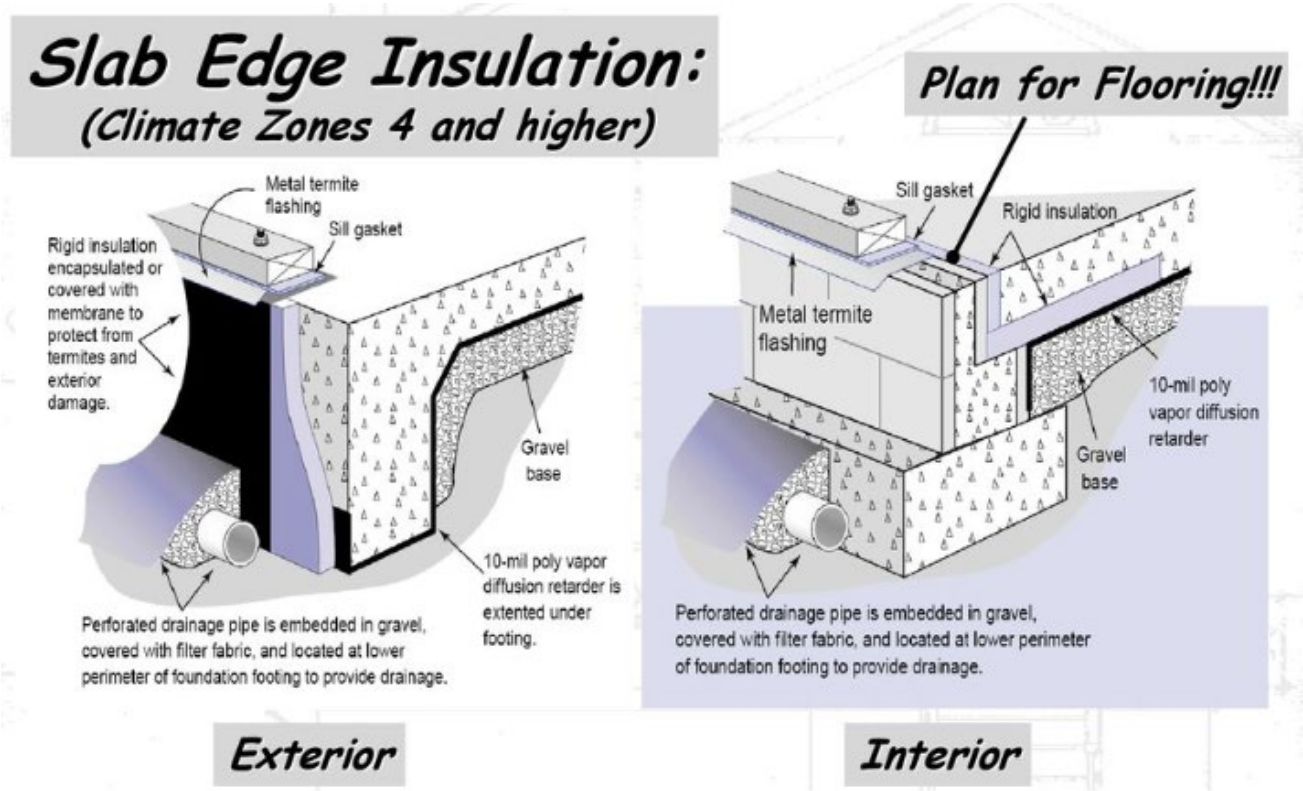
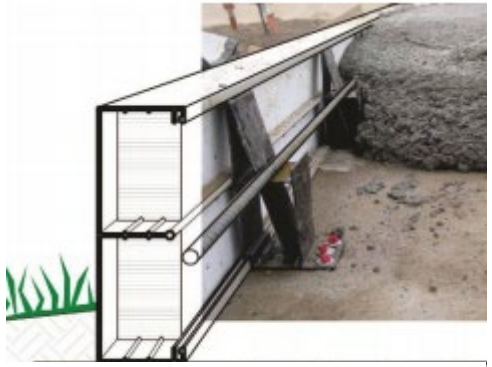
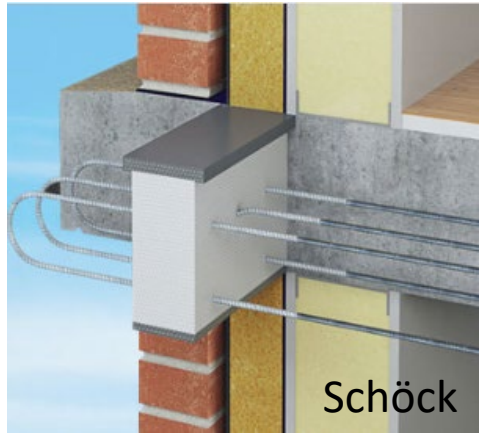
Slab Edge Should Detail Thermal Breaks

- R-10 for slab edge, R-5 under heated (hydronic or electric) slab on grade.
- Structural thermal breaks are available for cantilevered slabs and heavy-traffic slab loads





Energy Edge®



Schöck

ENERGY STAR Thermal Bypass Checklist: http://slideplayer.com/slide/15071129/

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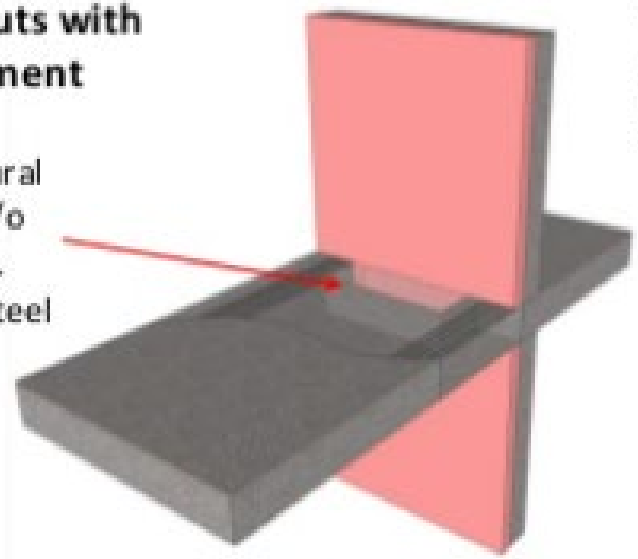
Ensure no Thermal Bridging

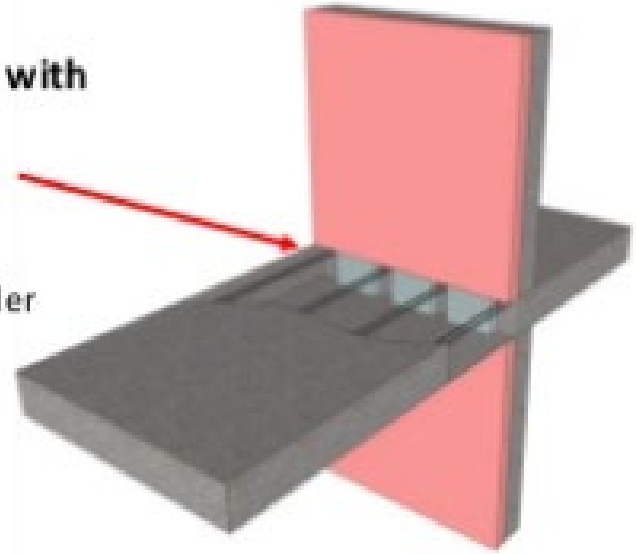
Structural cut-outs with beam reinforcement

60% length structural cut-out (w/ and w/o exterior insulation. Extra reinforcing steel in remainder to support slab.
Approx. Cost $50/ft



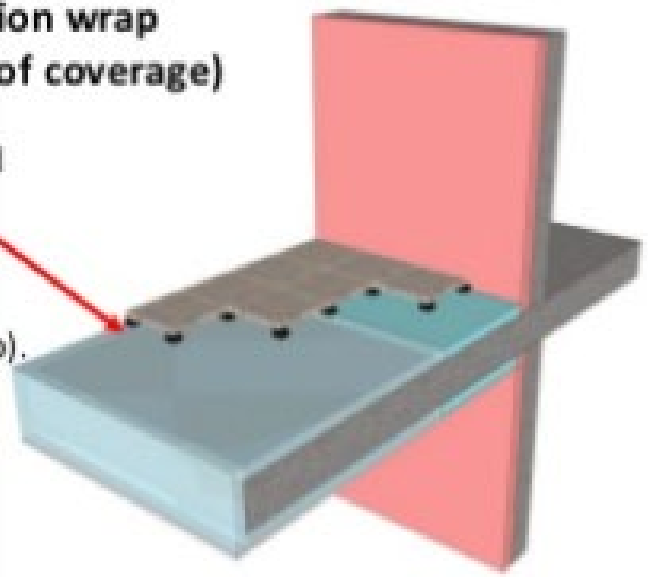
Concentrated reinforcement with insulation

Concentrated reinforcement within 40% of length (remainder insulation).
Approx. Cost $ 25/ft



Balcony Insulation wrap (varying depth of coverage)

2" (R-10) extruded polystyrene (XPS) insulation wrap (coverage 2', 4' 6' and full edge wrap).
Approx. Cost $200-$250/ft



Manufactured slab edge / balcony thermal break

Manufactured balcony thermal break within slab separating interior from exterior.
Approx. Cost $50-$80/ft

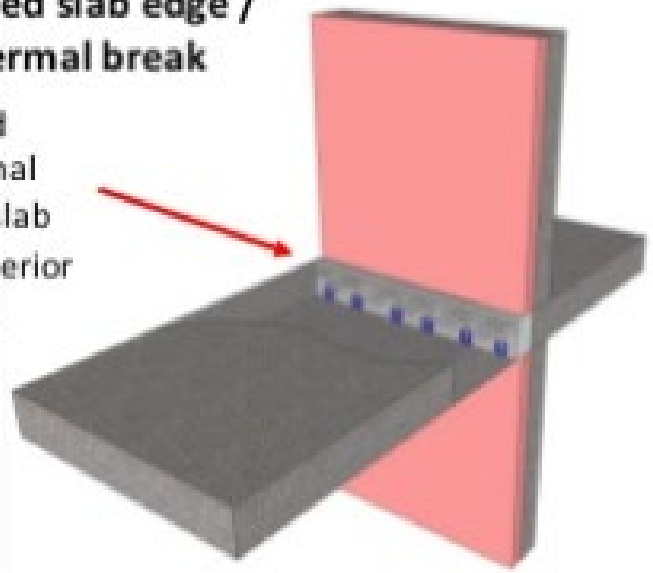


Image source: NBEC 2014 conference presentation: https://www.slideshare.net/RDHBuildings/nbec-2014-balcony-thermal-bridging-gf-final-oct-2314

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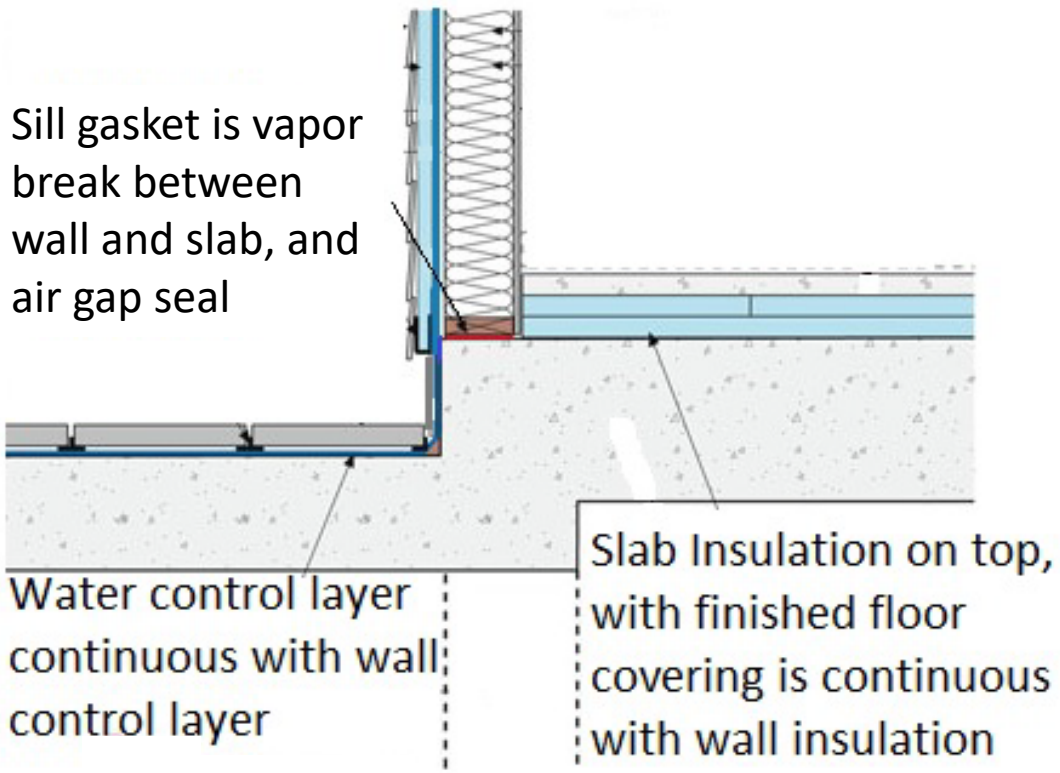
Podium Slab Thermal Break Option 1

Podium slabs (common for condos/apartments over a parking structure) are a difficult joint to detail

- Durable floor finish needed over interior insulation for fire and mechanical damage protection
- Thermal continuity ensured as floor insulation connects directly to exterior wall insulation
- Water barrier laps up under wall barrier for continuity



Images adapted from https://www.buildingscience.com/documents/insights/bsi-059-slab-happy

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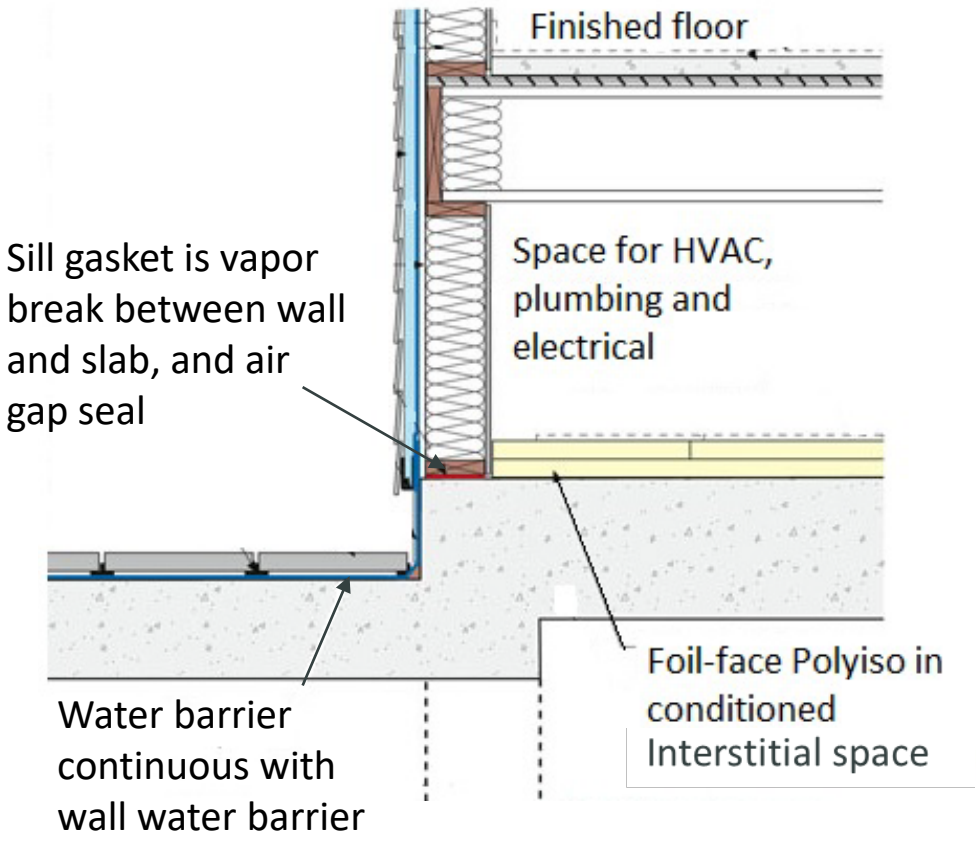
Podium Slab Thermal Break Option 2

Podium slabs (common for condos/apartments over a parking structure) are a difficult joint to detail

- Interstitial space must be compartmentalized for fire safety
- No thermal breaks as floor insulation connects directly to exterior wall insulation
- Wall water barrier connects to plaza slab water barrier



Images adapted from https://www.buildingscience.com/documents/insights/bsi-059-slab-happy

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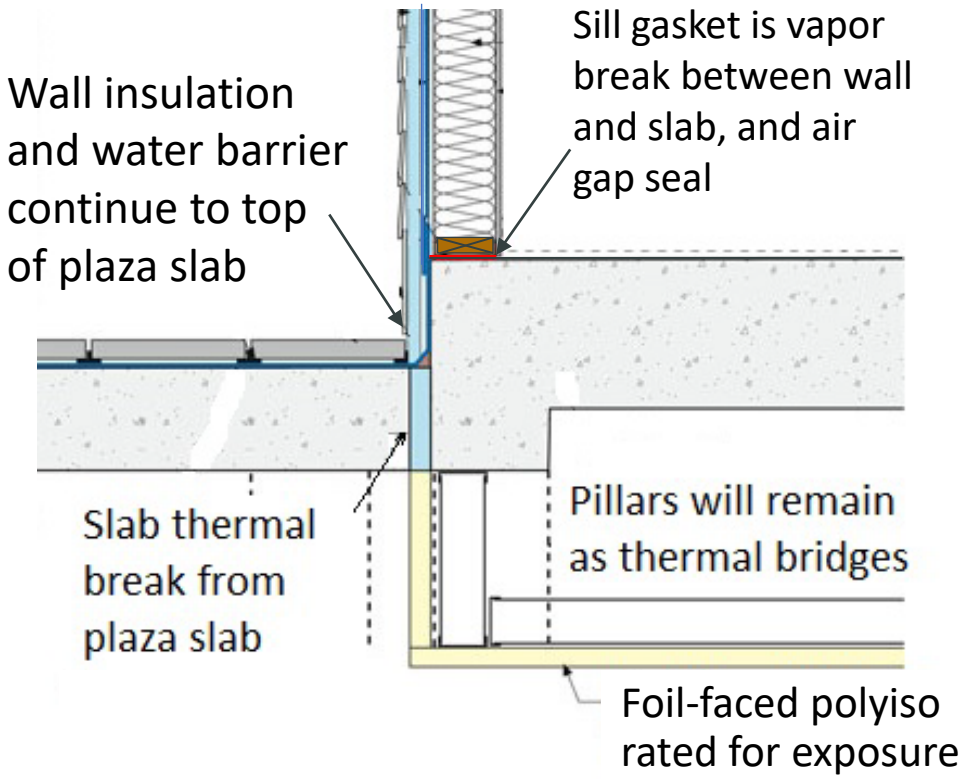
Podium Slab Thermal Break Option 3

Podium slabs (common for condos/apartments over a parking structure) are a difficult joint to detail

- Exterior and interior slab must be thermally broken by structural thermal break
- Supporting pillars will always be thermal bridge, usually compensated with heat tape or small heaters, if needed
- Interstitial space is more accessible below slab



Images adapted from https://www.buildingscience.com/documents/insights/bsi-059-slab-happy

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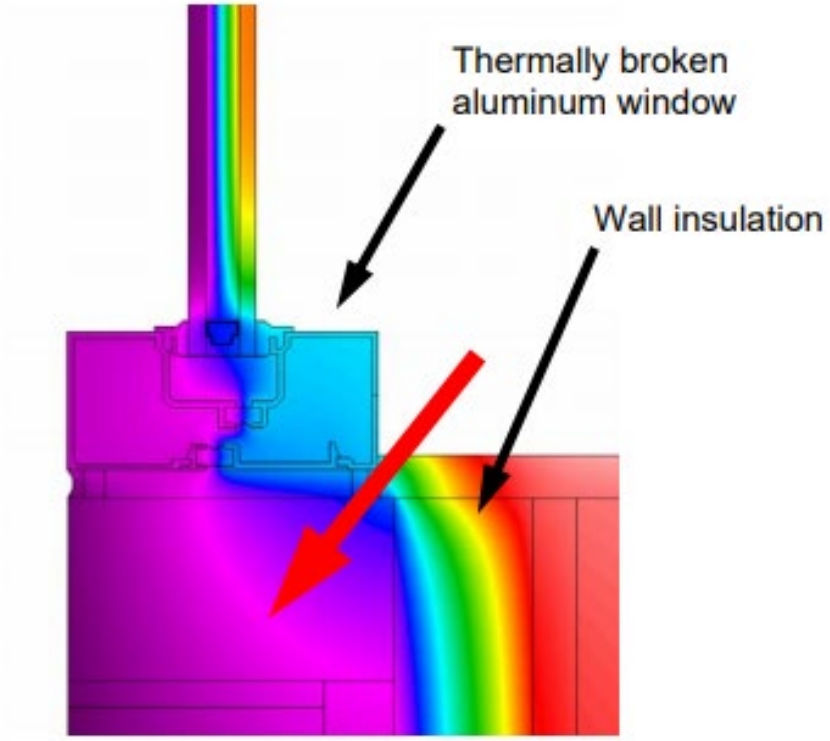
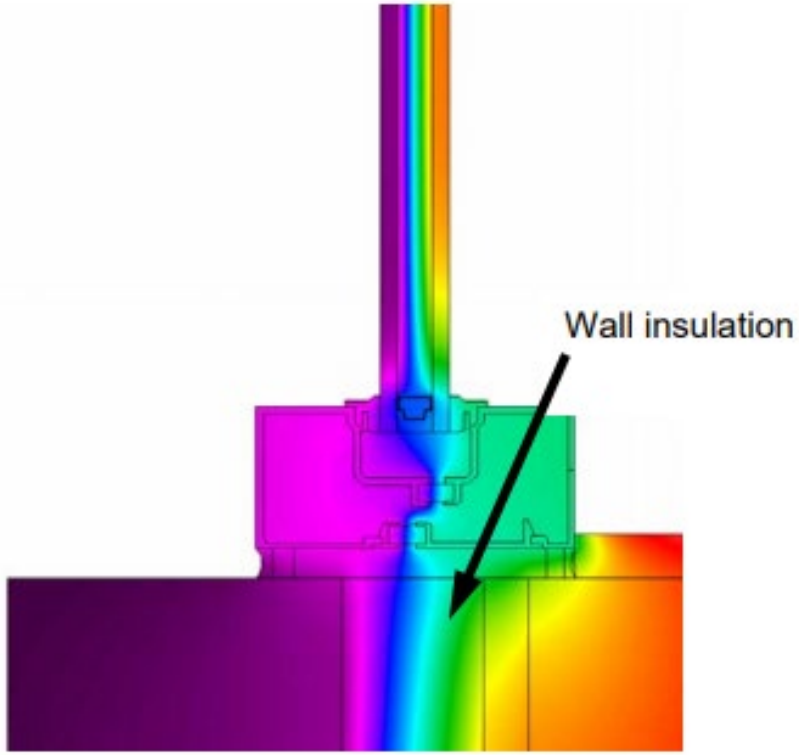
Pay Attention to Control Layer Alignment

When placing building component assemblies, pay attention to the locations of the thermal, vapor and air barriers to ensure continuity.





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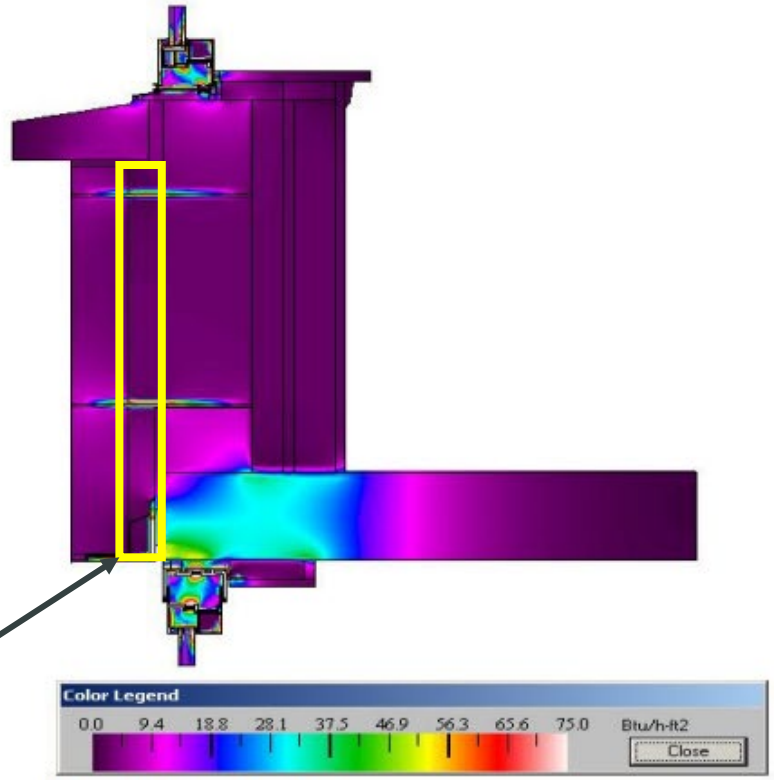
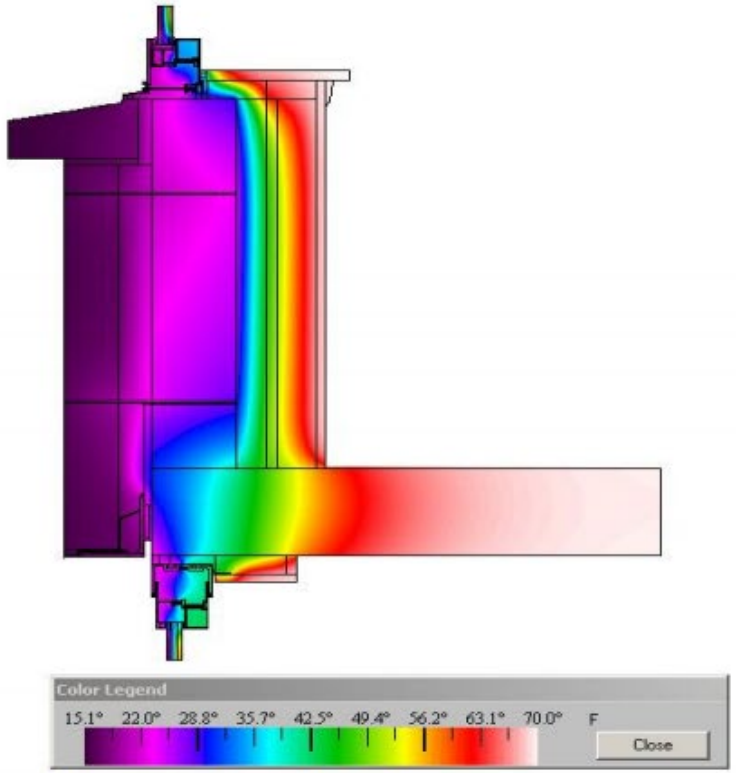
Window/Floor Combined Joint Thermal Bridge

Continuous insulation? Not quite



Heat Flux Profile



Temperature Profile

Calculated R-Value = 5.6

Images courtesy: NYC Commercial Envelope Training Module

Base wall R-value is R-22, reduced to <R-6, about 74.5% reduction!

Continuous insulation covers slab face, but window frame provides bridge

Leave header space above windows to provide thermal break for floor slabs

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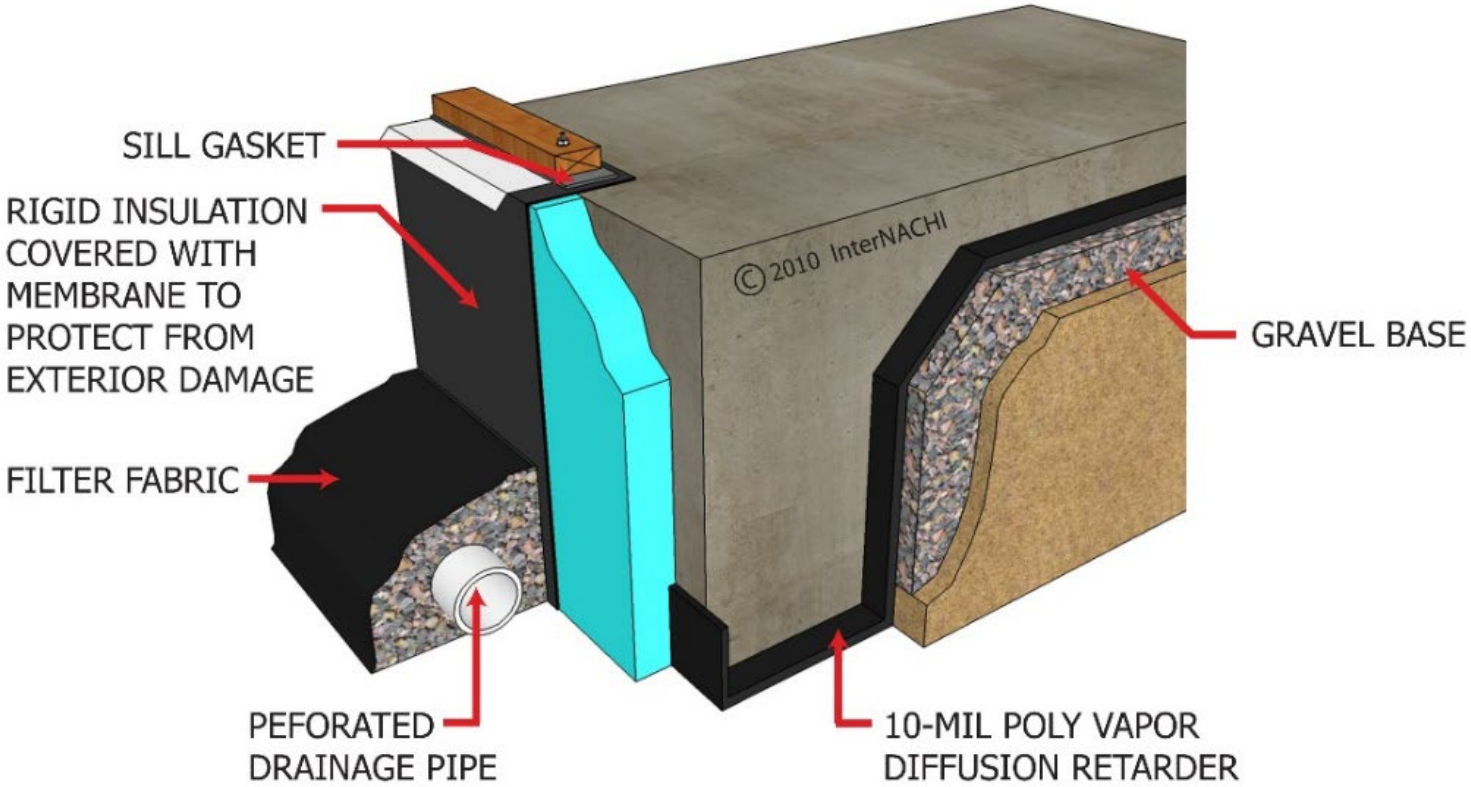
Foundation Control Layers Are a Little Tricky

- Insulation provides thermal barrier
- Masonry is the air barrier, except at joints!
- Damp proofing and soil drainage provide water “barrier” on exterior.
- Vapor retarders under slabs prevent vapor diffusion through slab into space.
- Sill gaskets perform vapor and air barrier roles.
- Exposed insulation needs protection from elements.



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Addressing Problematic Detailing

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R402.4 Air Barrier Construction Table Can Help Catch Issues

The sealing methods between dissimilar materials shall allow for differential expansion and contraction.

Be sure to include appropriate detailing for building joints and fenestration. (See table R402.4.1.1)

TABLE R402.4.1.1
AIR BARRIER AND INSULATION INSTALLATION[a]

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
General requirements	A continuous air barrier shall be installed in the building envelope. The exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier shall be sealed.	Air-permeable insulation shall not be used as a sealing material.
Ceiling/attic	The air barrier in any dropped ceiling or soffit shall be aligned with the insulation and any gaps in the air barrier shall be sealed. Access openings, drop down stairs or knee wall doors to unconditioned attic spaces shall be sealed.	The insulation in any dropped ceiling/soffit shall be aligned with the air barrier.

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Buildings With Thermal Bridging at Slabs Can Be Radiators!

Fins on Aqua Tower add interesting aesthetic, but have consequences

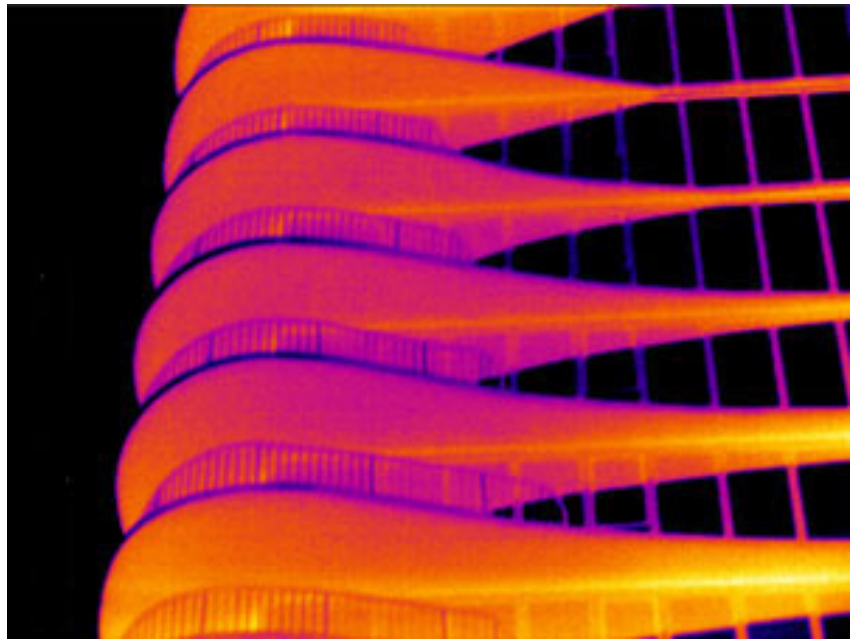

Image source: https://www.buildingscience.com/documents/insights/bsi062-thermal-bridges-redux

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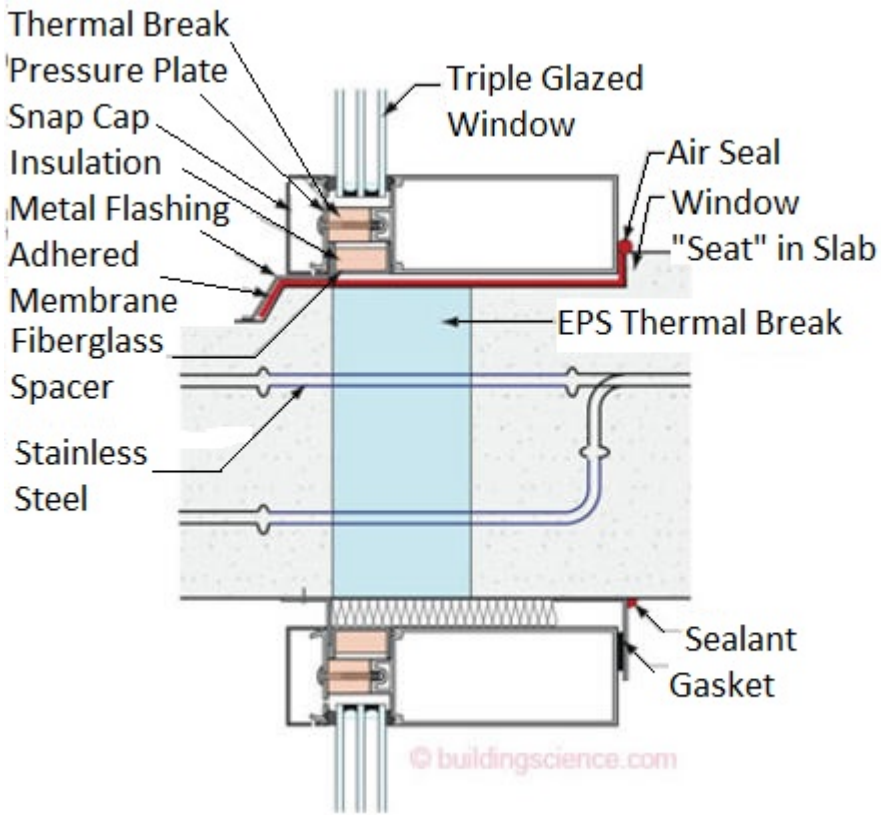
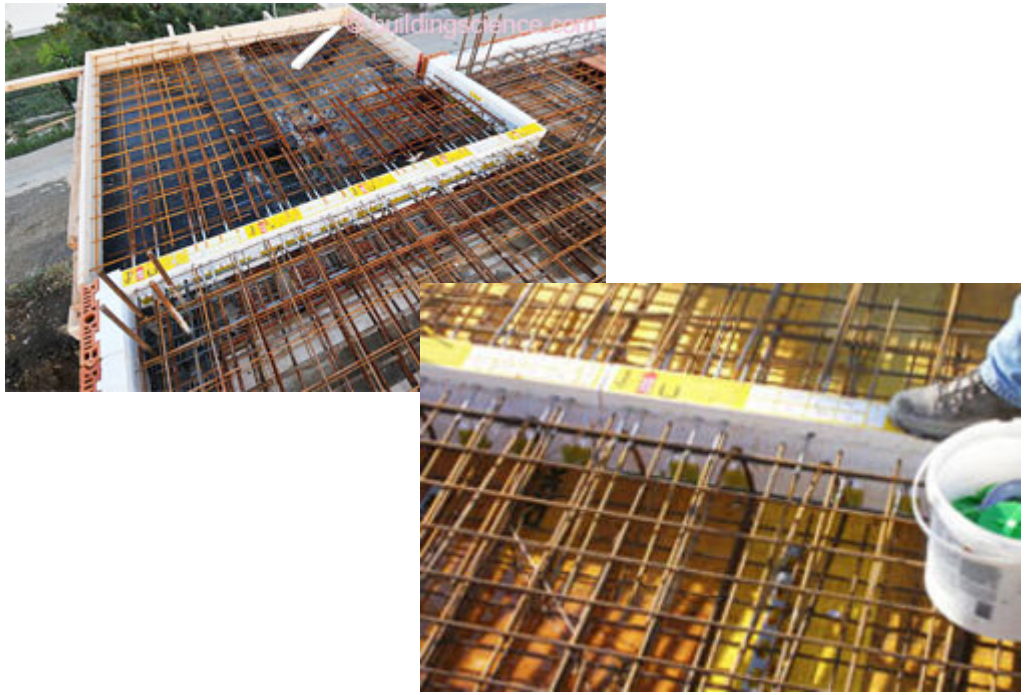
Cantilevered Slab Structural Thermal Breaks Need to be Detailed

- Without proper detailing, thermal breaks are likely in the construction phase.
- Design for efficiency from the start!





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How To Detail Insulation When Slab Need Support?

How do you insulate the perimeter of a heated slab that will experience heavy loads from vehicle traffic?

- Heavy traffic can damage perimeter insulation that is unsupported, particularly if slab is heated and R-15 (about 3” of EPS) insulation is needed at the perimeter. That’s a big gap!

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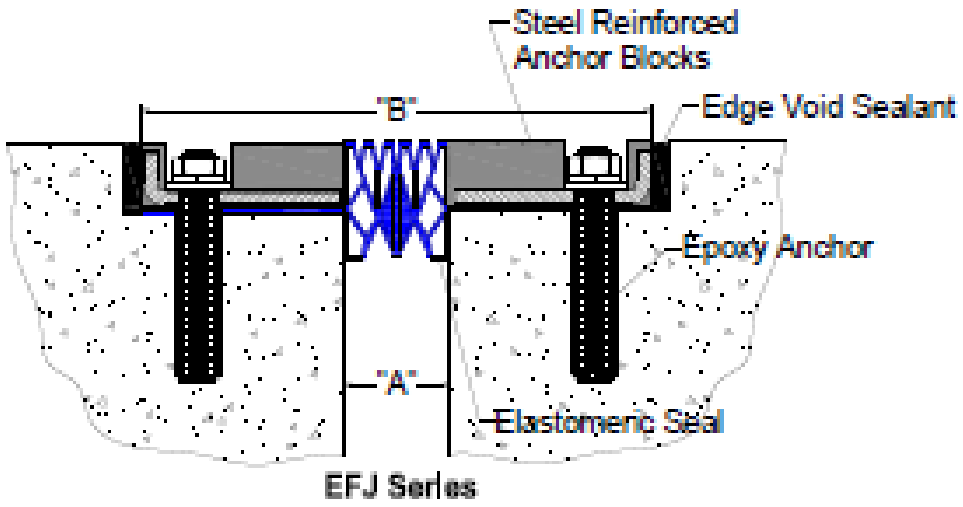
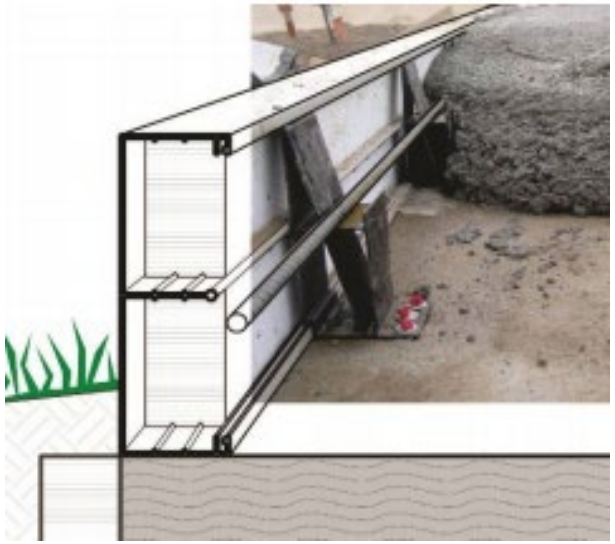
Solutions Exist for Problem Locations

Specify materials with added support, or designed to fill heavy traffic expansion joints and use to cover edge insulation



Expansion joints can cover insulation gaps.



Energy Edge® is PVC-reinforced slab edge insulation product

Schock

Air Barrier Continuity Needs Verified at Complex Joints

Ensure that all building joints, material changes, and openings have proper air sealing in place.

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Verifying Control Layers On Site

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Foundation Errors Can Hold Up Project-Check Early

- Ensure any exterior insulation is protected from damage.
- If necessary, ensure termite shield in place.
- For horizontal exterior insulation, ensure minimum 10” below grade for protection, or under pavement.
- Soils around foundation must be free draining and sloped away from building to prevent trapping water

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Heated Slabs Must be Verified Earlier

- Under-slab insulation for heated slabs must be continuous R-5
- Check before pouring for continuity and proper R-value.

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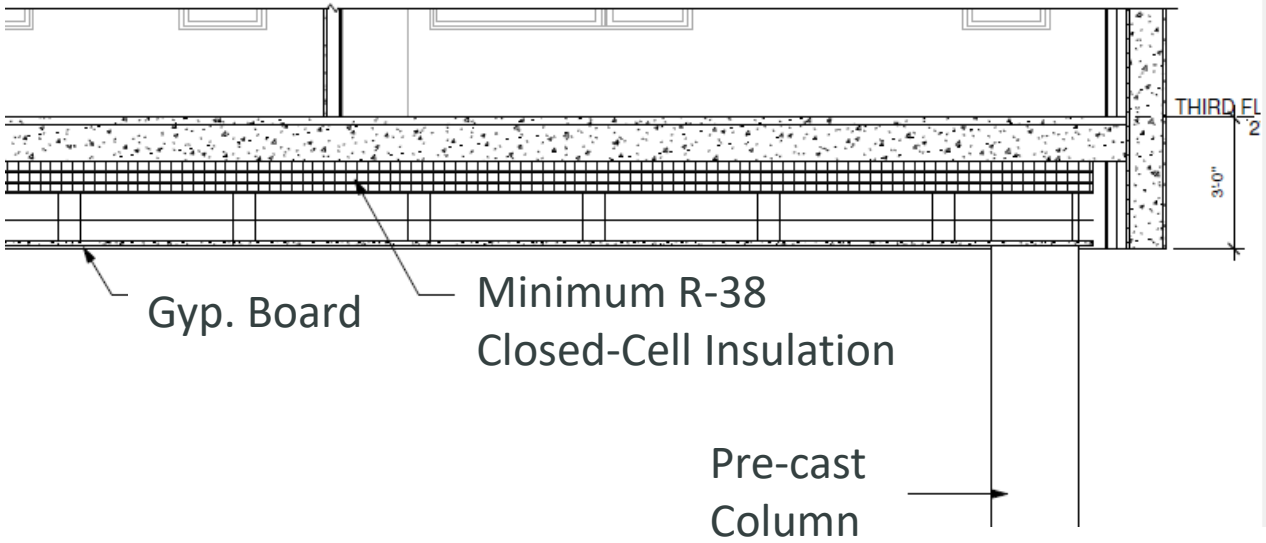
Floor Insulation Must Be Held in Place

- Insulation needs to maintain permanent contact with the subfloor decking to provide rated R-value



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Verify Fenestration Performance with NFRC Labels

- For factory-assembled windows, look for the NFRC-400 tag.
- For site-built and curtain-wall assemblies, construction documents should have report from NFRC CMA computer program.

Figure 3-12A - NFRC - CMA Label Certificate Page 2

PRODUCT LISTING

FOR CODE COMPLIANCE

LABEL CERTIFICATE ID: ***XYZ-001*** **Issuance Date:** mm/dd/yyyy

NFRC CERTIFIED PRODUCT RATING INFORMATION:*

The NFRC Certified Product Rating Information listed here is to be used to verify that the ratings meet applicable energy code requirements.

PRODUCT LISTING:

						CERTIFIED Performance Rating at NFRC Model Size		
CPD ID	Total Area	Name	Framing Ref	Glazing Ref	Spacer Ref	U**	SHGC**	VT**
	ft^2					Btu/ $hr \cdot ft^2 \cdot {}^\circ F$	-	-
P-PL-010	88.89	PL-2200 / PL-2210	FA-PL2210	GA-TT-001	SA-AM-001	0.53	0.58	0.66
P-PL-005	192.67	PL-3400 / PL-3401	FA-PL3401	GA-TT-001	SA-AM-002	0.56	0.57	0.65
P-PL-012	382.22	PL-5700 / PL-5720	FA-PL5720	GA-TO-002	SA-AM-001	0.52	0.21	0.30
P-PL-002	60.00	PL-1100 / PL-1152	FA-PL1152	GA-TT-001	SA-AM-001	0.42	0.51	0.62
P-PL-022	525.00	PL-9900 / PL-9915	FA-PL9915	GA-TO-003	SA-AM-002	0.45	0.15	0.19

NFRC
National Fenestration Rating Council®
CERTIFIED

World's Best Window Co.
Series "2000"
Casement
Vinyl Clad Wood Frame
Double Glazing•Argon Fill•Low E
XYZ-X-1-00001-00001

ENERGY PERFORMANCE RATINGS

U-Factor (U.S. / I-P)	Solar Heat Gain Coefficient
0.35	**0.32**

ADDITIONAL PERFORMANCE RATINGS

Visible Transmittance	Air Leakage (U.S. / I-P)
0.51	**≤0.3**
Condensation Resistance	
51	**–**

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. NFRC does not recommend any product and does not warrant the suitability of any product for any specific use. Consult manufacturer's literature for other product performance information.
www.nfrc.org

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Verify all Control Layers for Window Assemblies

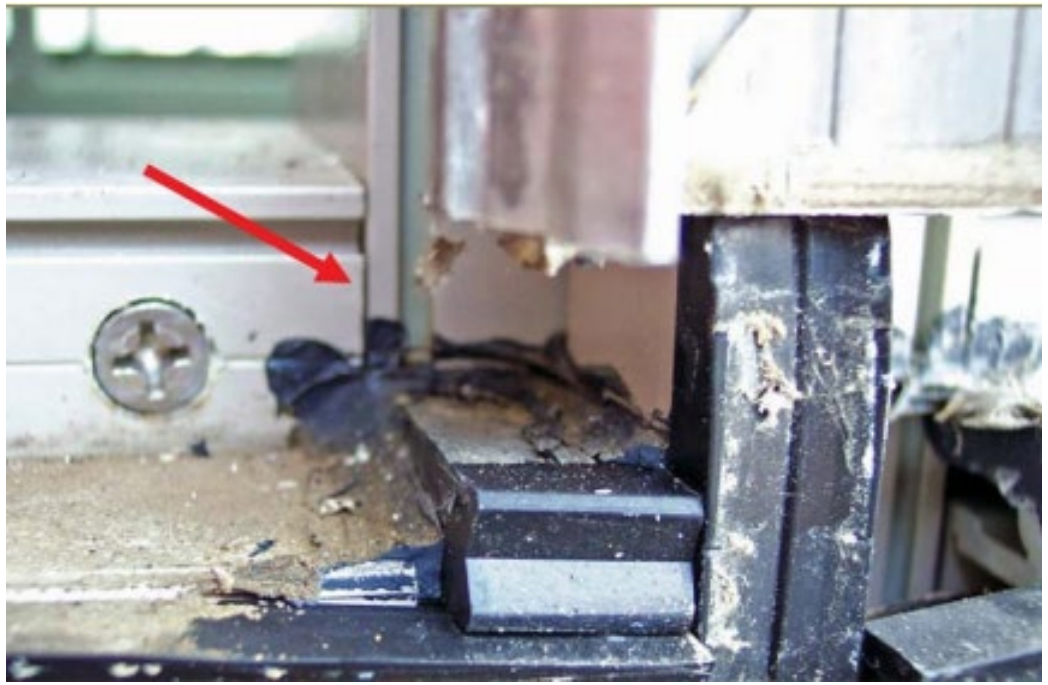

Image source: https://iibec.org/wp-content/uploads/2011-03-mccowan-kivela.pdf

- End dams properly installed to direct water to weep holes
- Sealant applied to joints and gaps between glazing units and between windows and walls
- Avoid too much sealant, which can plug weep holes
- Proper flashing around openings for fenestration – particularly check for shingle-style installation

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Wall Cavity Insulation Most Common Source of Issues

Insulation must maintain contact with approved air barrier.
Fibrous cavity insulation should fill cavity with no gaps.
Spray insulation needs to be proper depth & even thickness.

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Inspect Roof Layers for Continuity

- Verify above-deck insulation has at least 2 layers with lapped joints to minimize air leakage.

- If insulation is above dropped ceiling/inside building, ensure it maintains contact with the air barrier surface (roof deck) and is not set on ceiling tiles or have gaps in the insulation.

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Housewrap Needs Careful Installation to be Effective Air/Water Barrier

- Ensure continuity of air barrier
- Ensure joints/seams sealed so they won't dislodge or fail in the future
- For wraps, ensure proper spacing of fasteners per manufacturer's instructions.

Image © Ecohome

Image courtesy FineHomebuilding.com

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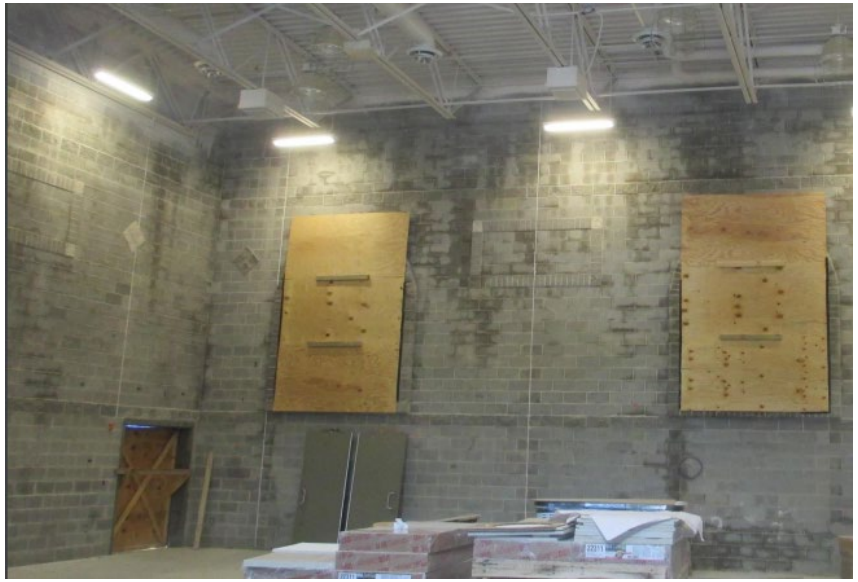
Use Proper Air Barrier Materials for Continuity

- Ensure materials used in air barrier assembly are air barrier materials listed in C402.5.1.2.1.
- Most common issues
  - non-air barrier material in gaps (fibrous insulation)

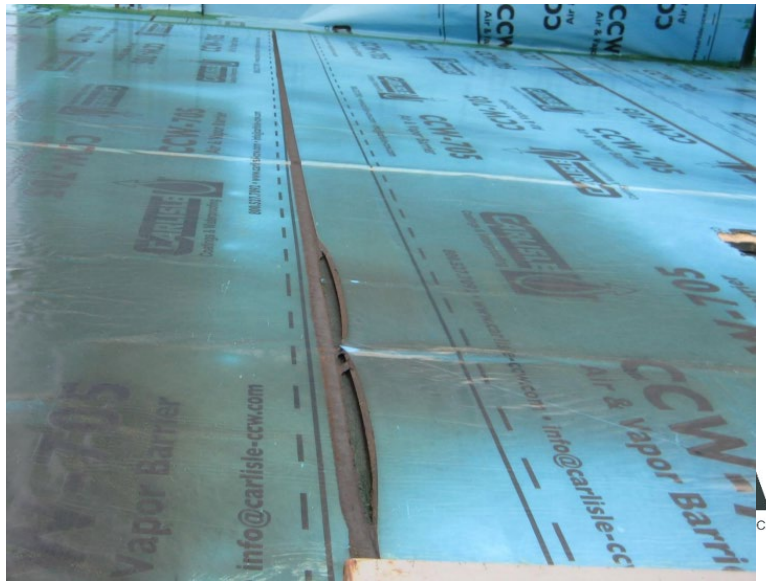
Material	Thickness (minimum)
Plywood	3/8 in.
Oriented strand board	3/8 in.
Extruded polystyrene insulation board	½ in.
Foil-faced urethane insulation board	½ in.
Closed cell spray foam minimum density of 1.5 pcf	1-1/2 in.
Open cell spray foam density between 0.4 and 1.5 pcf	4.5 in.
Exterior gypsum sheathing or interior gypsum board	½ in.
Cement board	½ in.
Built up roofing membrane	
Modified bituminous roof membrane	
Fully adhered single-ply roof membrane	
A Portland cement/sand parge, stucco, or gypsum plaster	5/8 in.
Cast-in-place and precast concrete	
Sheet metal or aluminum	
Solid or hollow masonry constructed of clay or shale masonry units	

Check Air Barriers Carefully for Continuity!

Fluid applied barrier pinholes allow air & moisture transmission – common in cinderblock applications

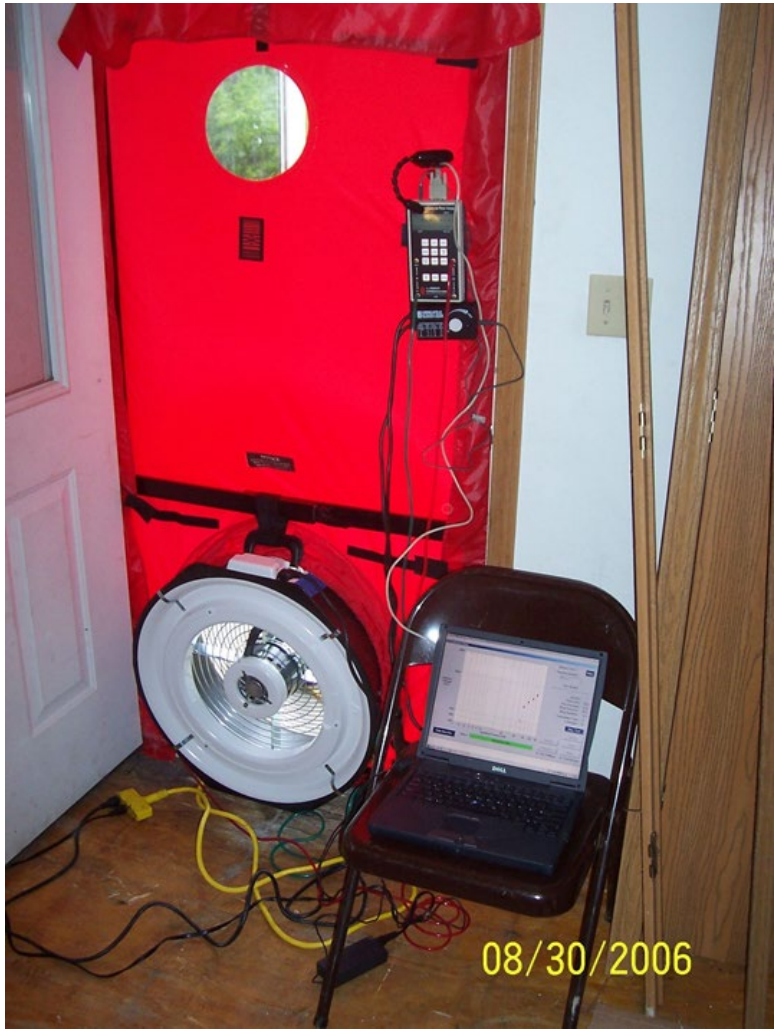


Self-adhered membranes should follow installer instructions to avoid over-exposure to heat and wrinkles that create gaps



Pressure Testing For Residential Ensure Air Barrier Performance

- **Mandatory** for residential construction
- Residential air leakage rate not to exceed 4 air changes per hour @ 50 pascals
- Where required by code official, testing shall be conducted by an approved third party.
- Testing performed after creation of all penetrations of the building thermal envelope



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Commercial Pressure Testing is Possible with Smaller/Tighter Buildings

- Though rarely done, smaller commercial buildings can be pressure tested with multiple blower doors
- Larger buildings can be pressure tested using HVAC systems
- Must seal all intentional openings (vents, fans not used for pressurization test, gravity dampers, etc…)
- Ideal means to verify integrity of the air barrier

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Documenting Envelope Code Compliance

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C103 – Lists Construction Documents for Compliance

- Construction documents must be provided to code official, prepared by registered design professional where required by local statutes.
- C103.2 Information on Construction Documents
  - Drawn to scale, clearly depict details, and provide sufficient detail on building systems and features.
  - Right-hand list contains required details

Envelope documentation requirements

1. Insulation materials and R-value
2. Fenestration U-factor and SHGC
   1. Area weighted factors if used
3. Air sealing details
4. Building thermal envelope depiction

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Properly Reference Between Drawings, Spec. Manual, and Any Software Used

- Best to have all code-compliance references in a single location to avoid missing documentation, including conflicting data, or the chance it may be missed by the reviewer.
- Can be in the specification manual, plan drawings, or both. If in both, include cross references to aid in speed of review.
- Plan drawing keys for assemblies should be used to reference assembly components in specification manual as well
  - Also helpful to reference between plans and entries in software programs

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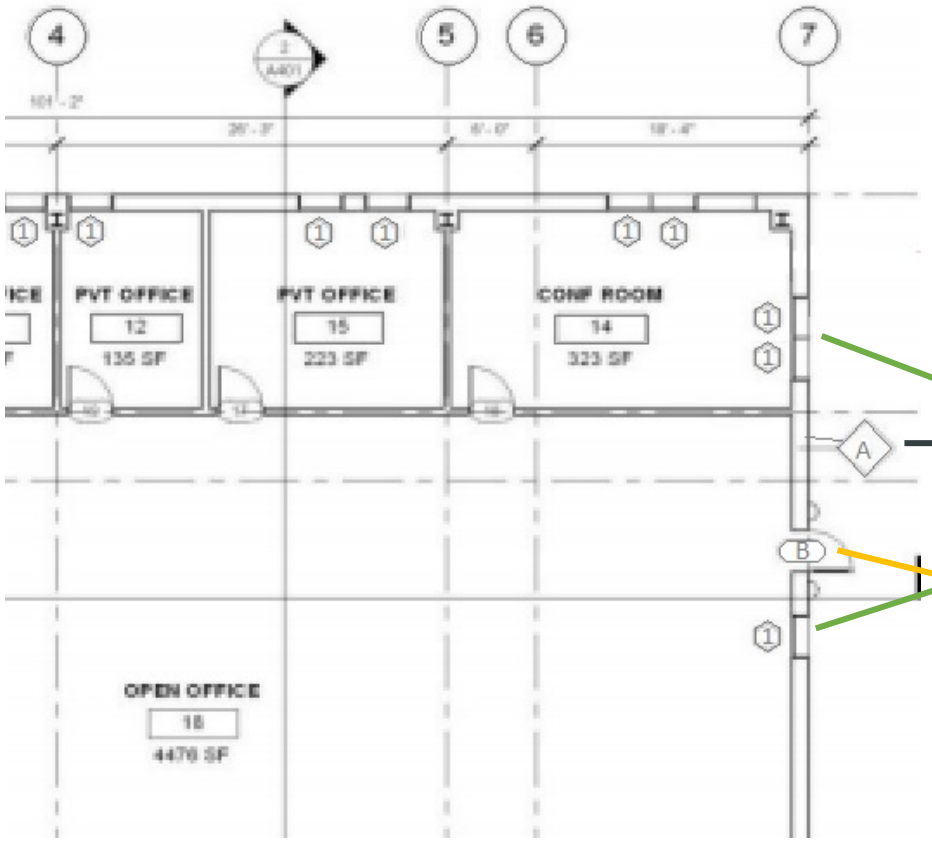
Assembly References Should Match in All Documentation

- Names for building assemblies should match plan drawing nomenclature for easy reference between output reports and plan documentation.



[redacted] - COMcheck 4.0.7.2 Review Code: 2016 New York City Energy Conservation Code

File Edit View Options Code Help

Project | Envelope | Interior Lighting | Exterior Lighting | Mechanical | Requirements

Roof | Skylight | Exterior Wall | Window | Door | Basement | Floor

	Component	Assembly
	Building	
1	Roof Type A	Insulation Entirely Above Deck
2	Window 4 - Skylight	Metal Frame:Glass, With Curb
3	Floor Type A	Slab-On-Grade:Unheated
4	Abv-Grade Wall Assembly Type A	Concrete Block:12", Partially Grouted, Cells Empty
5	Window 1-2	Metal Frame with Thermal Break
6	Window 1-2 - w/overhang	Metal Frame with Thermal Break
7	Window 3A-3D - Storefront	Metal Frame with Thermal Break
8	Window 3A-3D - Storefront, ovhg.	Metal Frame with Thermal Break
9	Door A - Ext Dbl Glass Door	Glass (> 50% glazing):Metal Frame, Entrance Door
10	Door B - Insulated Hollow Metal	Insulated Metal
11	Door C - Roll-up Overhead	Insulated Metal
12	Abv-Grade Wall Assembly Type B	Steel-Framed, 16" o.c.
13	Window 1-2	Metal Frame with Thermal Break
14	Window 1-2 - w/overhang	Metal Frame with Thermal Break
15	Window 3A-3D - Storefront	Metal Frame with Thermal Break
16	Window 3A-3D - Storefront, ovhg.	Metal Frame with Thermal Break

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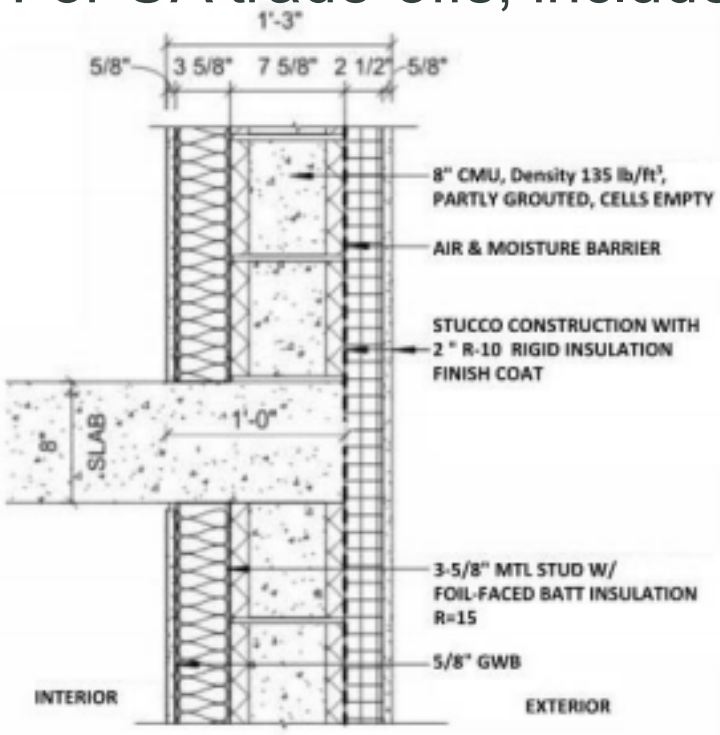
Include Insulation Materials and Specifications

- Summary of R-values and U-factors in table, or on section view drawing showing calculated assembly U-factor
- Specifications should detail any installation requirements: Types of hangers, spacing, joint treatments, etc…
- Detail drawings should display continuity plan for complex joints or joining with dissimilar materials

Plan Sections Should Summarize Thermal Layer Properties

- In architectural plan summary page, include table with insulation summary
  - Code required R-value/U-factor, Design values, and applicable areas
  - For fenestration, also include code and design SHGC.
- For UA trade-offs, include minimally compliant UA vs calculated UA



E7 TYPICAL STUCCO–8" CMU WALL
TOTAL WALL R VALUE = 16.73 1"= 1'-0"

WALL TYPE E7	
Wall Assembly	**R-Value**
2" R-10 Rigid Insulation	10
8" CMU, Partly Grouted, Cells Empty	1.83 [a]
3-1/2 " R-15 Foil-faced Batt Insulation	4.9 [b]
Total R-Value of Wall Assembly	16.73
U-Factor of Wall Assembly (= 1/16.73)	**0.060**
(a) Assembly R_U for Concrete Block Walls from ASHRAE Table A3.1-3	
(b) Effective R-Value from ASHRAE Table A3.1-4	
Slab Assembly	**R-Value**
2 " R-10 Rigid Insulation	10
12"-Thick Solid Concrete Wall (Density: 144 lb/ft³)	1.60 [c]
Total R-Value of Slab Assembly	11.60
U-Factor of Slab Assembly (=1/11.60)	**0.086**
(c) Assembly R_U for Concrete from ASHRAE Table A3.1-2	

Area-Weighted Assembly U-factor Calculation for the Unit Wall			
Typical 10'-6" floor to floor height (8" slab + 9'-10" wall height)			
Assembly	**U-Factor**	**Height (in)**	**UA**
Wall Assembly	**0.060**	118	7.053
Slab Assembly	**0.086**	8	0.690
Total		126	7.743
Area-Weighted Assembly U-factor (=7.743/126)			0.061
Code-Allowed Maximum U-Factor (ASHRAE Table 5.5-4)			*0.090*

Source: https://www1.nyc.gov/assets/buildings/pdf/h2g_all.pdf

Helpful When Schedule Sheets Refer to Compliance Values

WINDOW AND DOOR SCHEDULE										IL-ECC 2018 REQUIREMENT		
TAG	TYPE	MATERIAL	NOMINAL DIM. (WXH)	PROJECTION FACTOR	MANUF-MODEL NO.	ASSEMBLY U-FACTOR	SHGC	VT	AIR LEAKAGE RATE (CFM/SF)	CODE U-FACTOR	CODE SHGC FOR GIVEN PF	CODE AIR LEAKAGE (CFM/SF)
W1	FIXED	ANNO. ALUM.	7'0" x 7'0"	0.15	ABC WINDOW-D999 SERIES OR EQUAL	0.33	0.38	0.51	0.16	0.38	SEW: 0.38, N:0.51	0.20
W1A	FIXED & CASEMENT	ANNO. ALUM.	7'0" x 7'0"	0.15	ABC WINDOW-D999 SERIES OR EQUAL	0.35	0.39	0.51	0.18	0.38	SEW: 0.38, N:0.51	0.20
W2	CASEMENT	ANNO. ALUM.	4'6" x 2'3"	0.15	ABC WINDOW-D999 SERIES OR EQUAL	0.42	0.39	0.51	0.18	0.45	SEW: 0.38, N:0.51	0.20
SW1	SKYLIGHT	ANNO. ALUM.	2'10" x 5'2"	0.00	SKLT CO - TH123 OR EQUAL	0.40	0.38	0.53	0.18	0.50	0.40	0.30
W5	STOREFRONT FIXED	ANNO. ALUM.	SEE PLAN A301-A305	0.15	SFT CO. - CW123 OR EQUAL	0.36	0.38	0.53	0.05	0.38	SEW: 0.38, N:0.51	0.06
D1	STOREFRONT - ENTRY DOOR	GLASS/ METAL	3'0" - 7'6"	0.15	SFT CO. - DW321 OR EQUAL	0.60	0.38	0.53	0.18	0.77	SEW: 0.38, N:0.51	1.00
D2	OPAQUE SWINGING DOOR	METAL	3'0" - 7'6"	0.15	AMERICAN DOOR - #89 OR EQUAL	0.35	N/A	N/A	0.18	0.37	N/A	N/A

Sample fenestration schedule with added code-compliance summary

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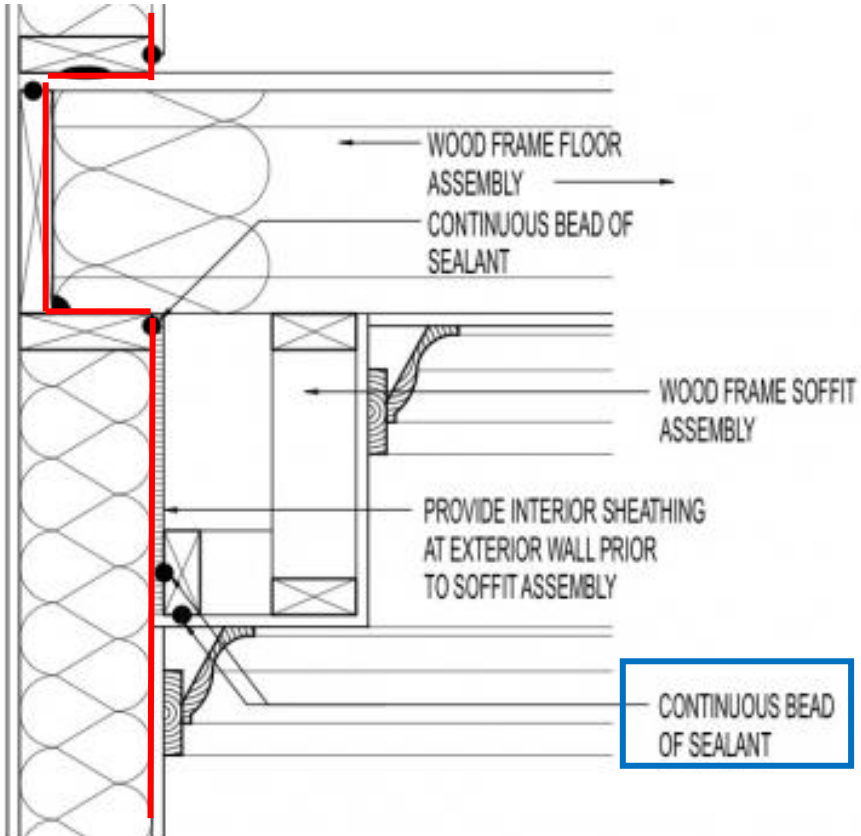
Air/Thermal Control Layer Details Should be Clear

- Section views of walls and details of joints between dissimilar materials should show the continuity of the thermal and air barriers clearly.
- Show sealing compounds between joints/materials, too.



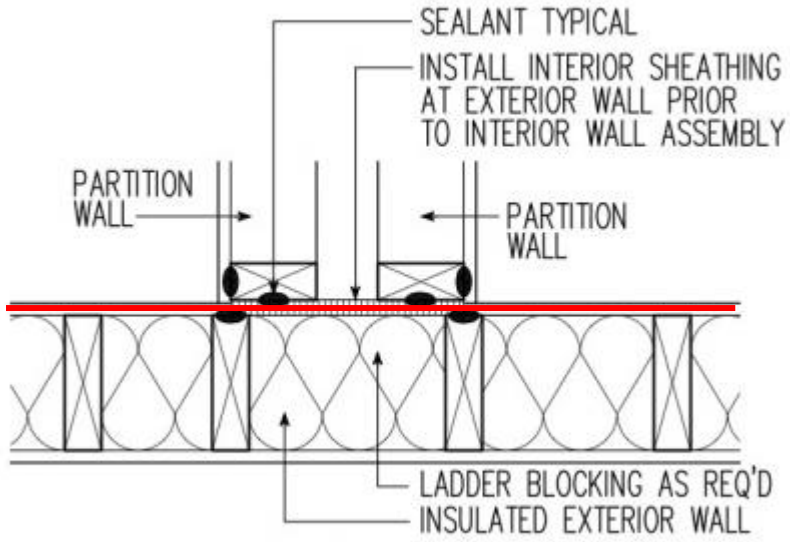


Image Source: https://basc.pnnl.gov/cad-files

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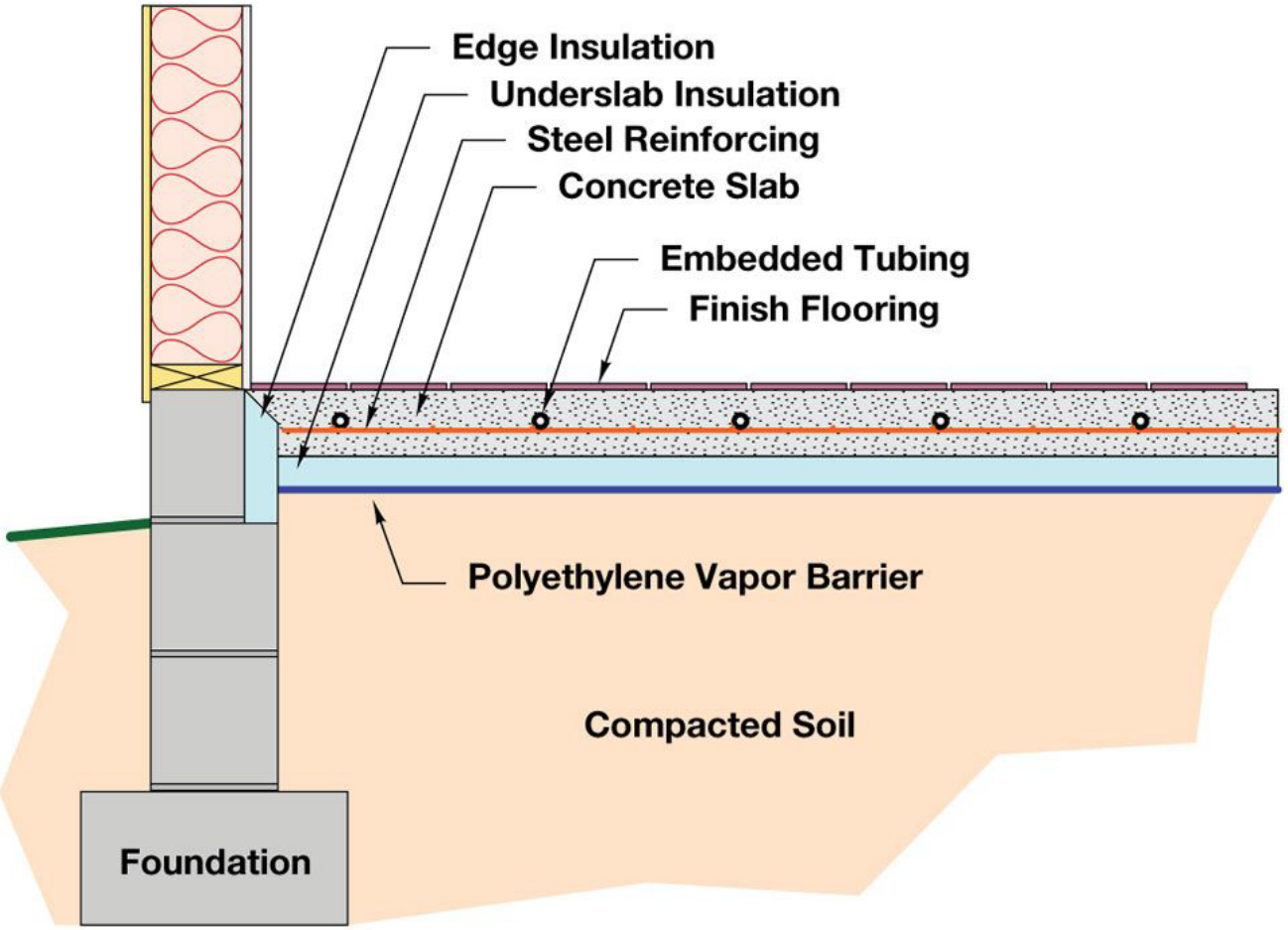
Heated Slabs Need Insulation Detail Under the Slab



- Detailing insulation gap for edge at doorways can be difficult, often leads to thermal bridges.
- R-10 for unheated slab (2” gap), R-15 for heated slab (3” gap).
- Heated slab needs R-5 underneath as well.

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ENERGY STAR Thermal Bypass Checklist: http://slideplayer.com/slide/15071129/

Insulation Summary in Notes/Details

- In architectural plan summary page, include table with insulation summary
  - Code required R-value/U-factor, Design values, and applicable areas
  - For fenestration, also include code and design SHGC.
- For UA trade-offs, include minimally compliant UA vs. calculated UA

Compliance: Fails using UA trade-off

Compliance: **87.5% Worse Than Code** Maximum UA: **335** Your UA: **628**

The % Better or Worse Than Code Index reflects how close to compliance the house is based on code trade-off rules.
It DOES NOT provide an estimate of energy use or cost relative to a minimum-code home.

Envelope Assemblies

Assembly	Gross Area or Perimeter	Cavity R-Value	Cont. R-Value	U-Factor	UA
Ceiling: Flat Ceiling or Scissor Truss	960	23.0	0.0	0.043	41
Wall: Wood Frame, 16" o.c.	2,418	15.0	0.0	0.077	147
Door: Solid Door (under 50% glazing)	40			0.300	12
Window 1: Metal Frame	18			1.000	18
Window: Vinyl Frame	450			0.300	135
Basement: Solid Concrete or Masonry Wall height: 7.0' Depth below grade: 5.0' Insulation depth: 0.0'	854	0.0	0.0	0.322	275

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Software Used for Compliance Should Report Assembly Thermal Properties

- Code official will check wall assembly U-factors in program against U-factor assemblies in plan drawings.

	Construction	Reflectance	U-Factor with Film (W/m2-K)	U-Factor no Film (W/m2-K)	Gross Area (m2)	Azimuth (deg)	Tilt (deg)	Cardinal Direction
WALL-1PF	WALL-1	0.22	0.384	0.41	18.30	210.00	90.00	S
WALL-1PR	WALL-1	0.22	0.384	0.41	9.12	120.00	90.00	E
WALL-1PB	WALL-1	0.22	0.384	0.41	18.30	30.00	90.00	N
WALL-1PL	WALL-1	0.22	0.384	0.41	9.12	300.00	90.00	W
TOP-1	ROOF-1	0.35	0.268	0.28	463.60	210.00	0.00	
FRONT-1	WALL-1	0.22	0.384	0.41	73.20	210.00	90.00	S
F1-1	FLOOR-SLAB-1	0.35	1.454	2.25	99.16	30.00	180.00	

Example report from Energy Plus.

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Questions?

energycode@illinois.edu
800-214-7954