Thermal Bridging Concepts for Structural Engineers

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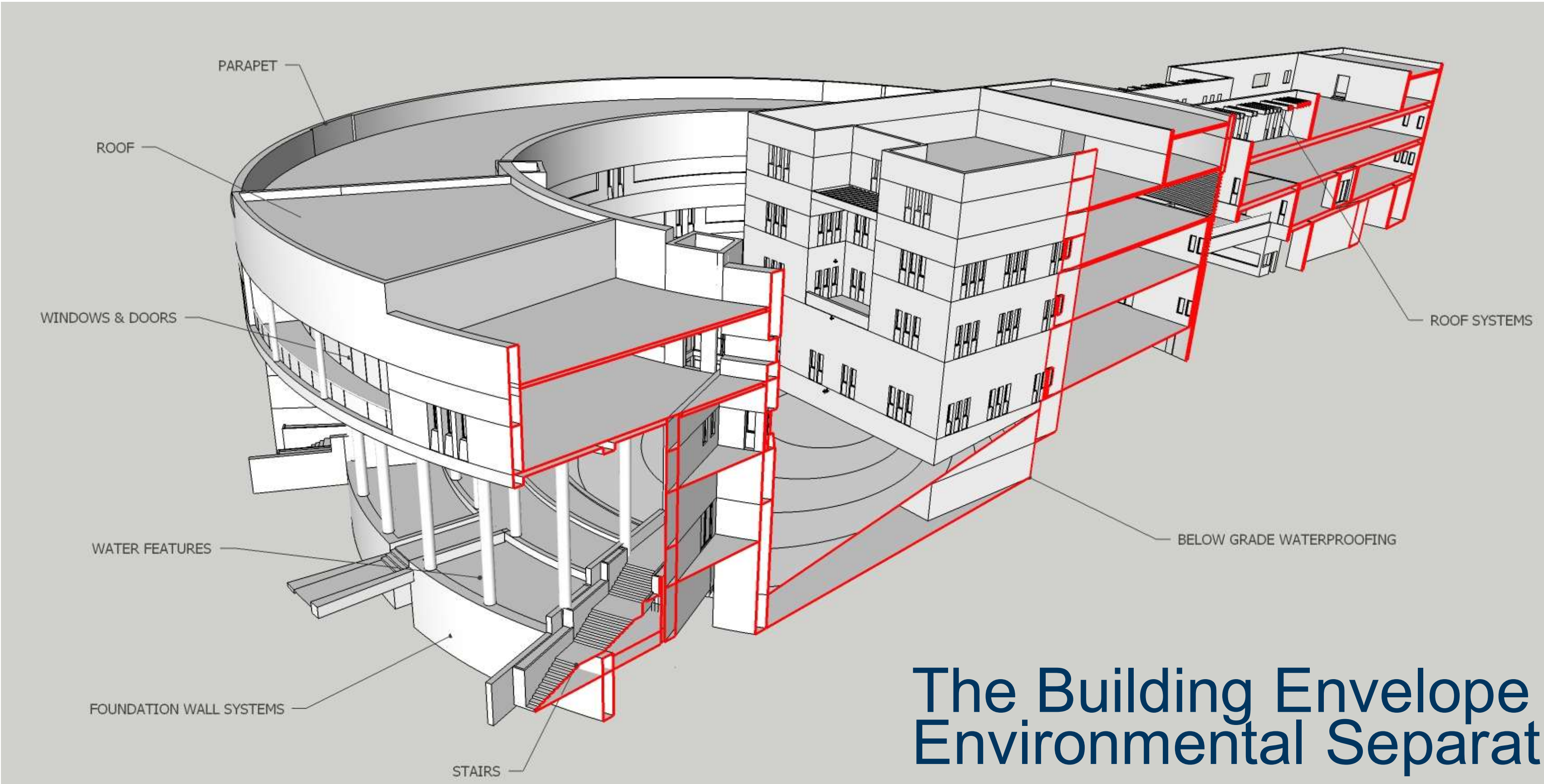
Outline

- Understand the fundamental concepts of building envelope thermal bridging.
- Review thermal bridging conditions and the impact on thermal and condensation resistance.
- Identify typical methods used to mitigate thermal bridges at structural conditions.

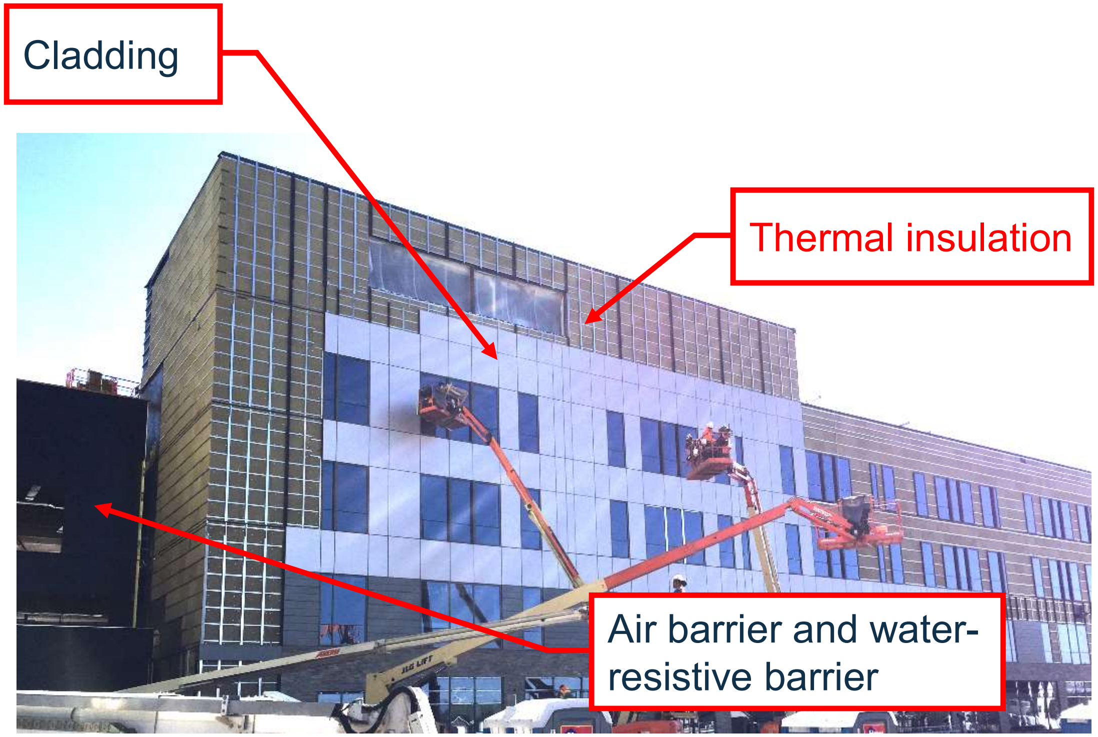
Building Envelope and Thermal Performance

The Building Envelope



The Building Envelope = Environmental Separation

Building Envelope Control Layers



Environmental Separation

- Control rain
- Limit air leakage
- Mitigate heat transfer
- Control vapor diffusion

Thermal Performance

Quantifying Thermal Performance

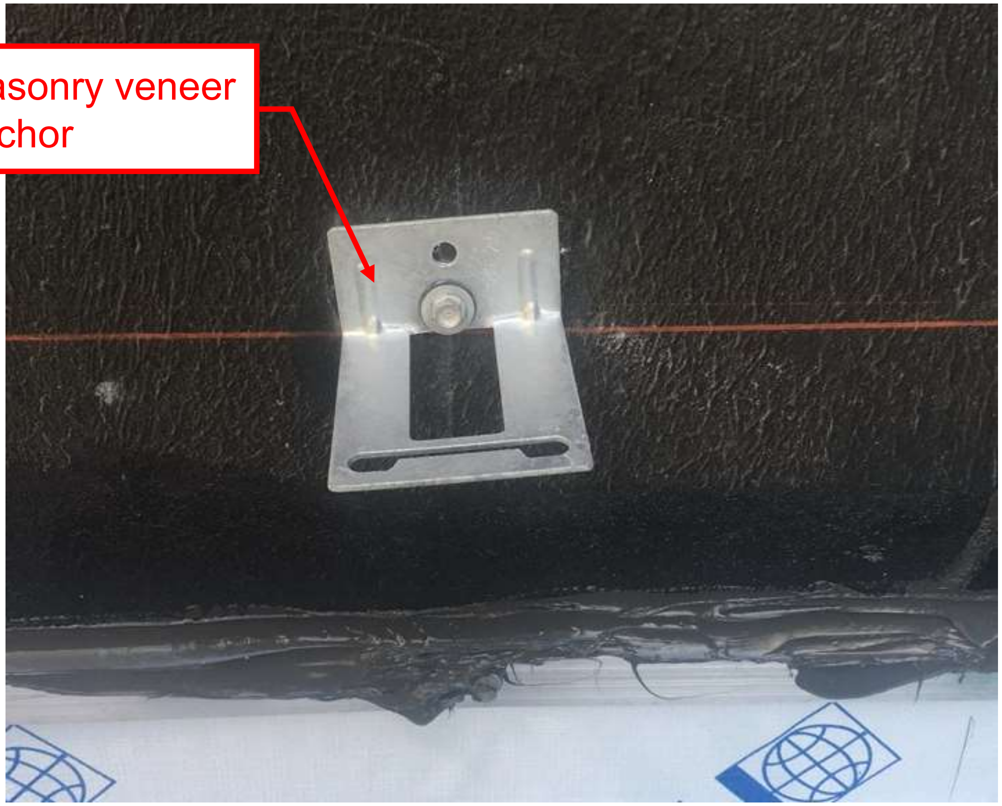
- U-Factor: Coefficient of heat transmission through a building component or assembly

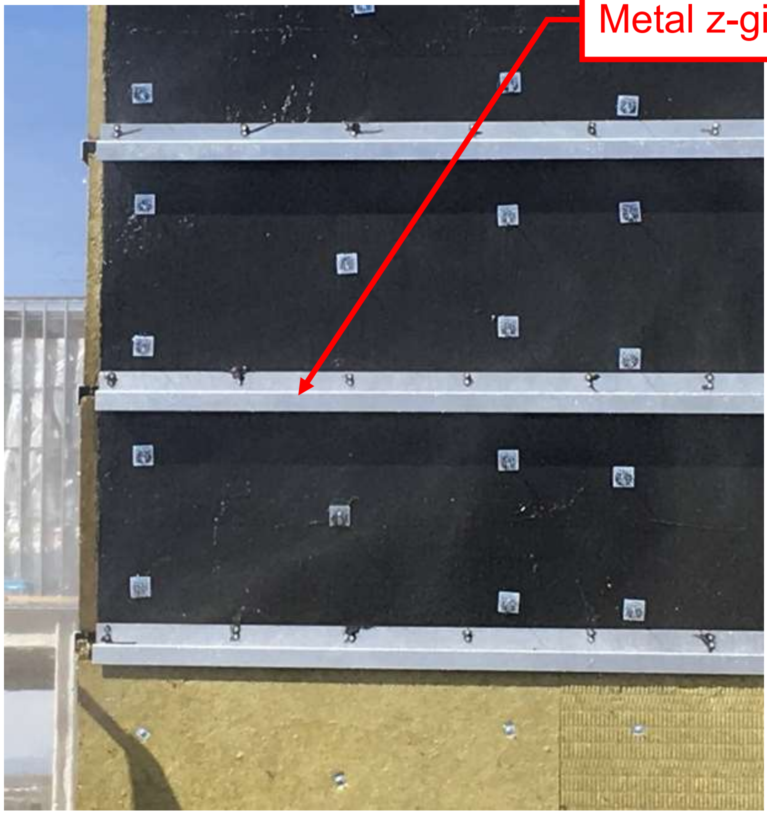
- R-Value: The inverse of heat flow (resistance)

Thermal Bridging

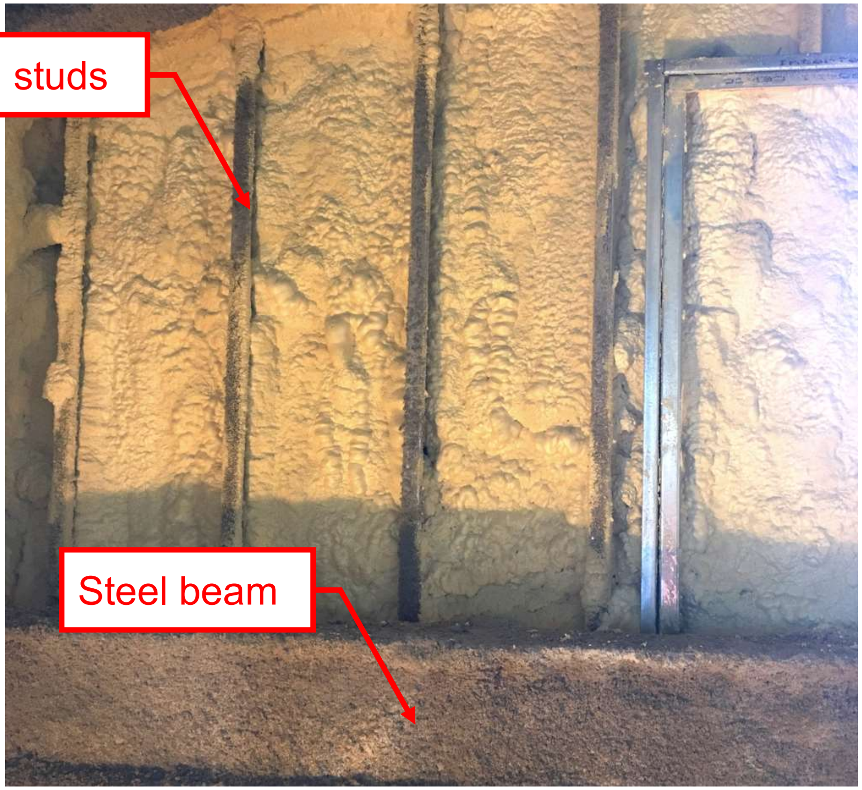
- Highly conducting material that bypasses an insulation layer
- Relative high heat transfer
- Potentially a significant impact on thermal performance (nominal vs. effective)
- Can allow condensation to occur

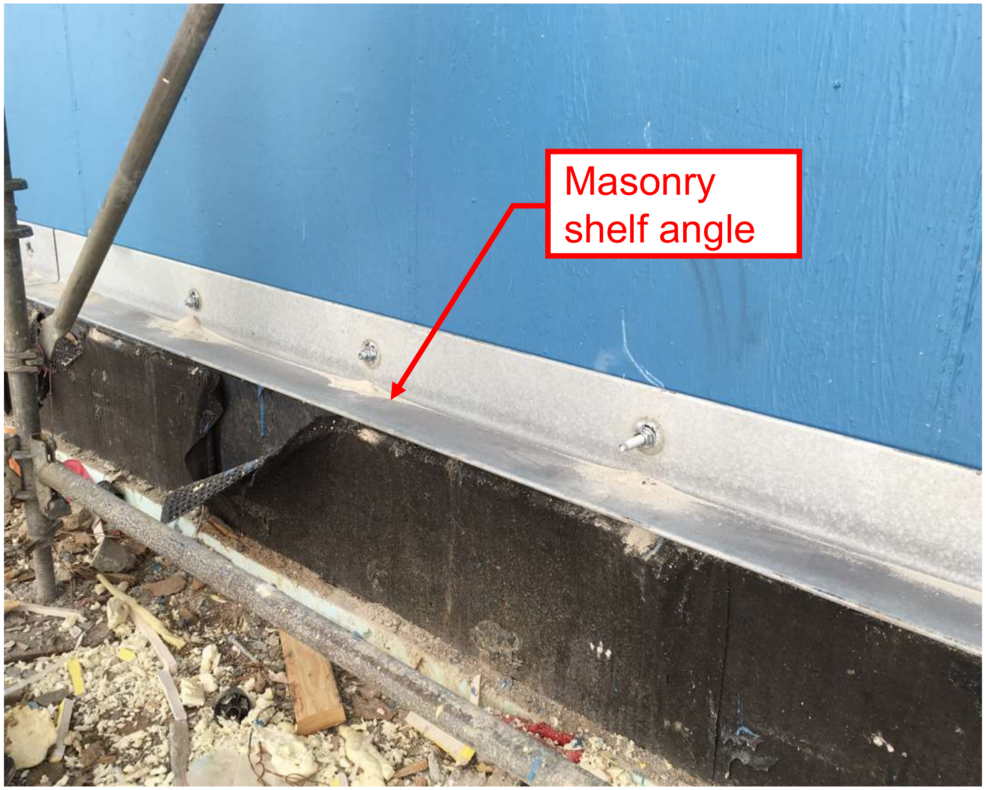
Thermal Bridging



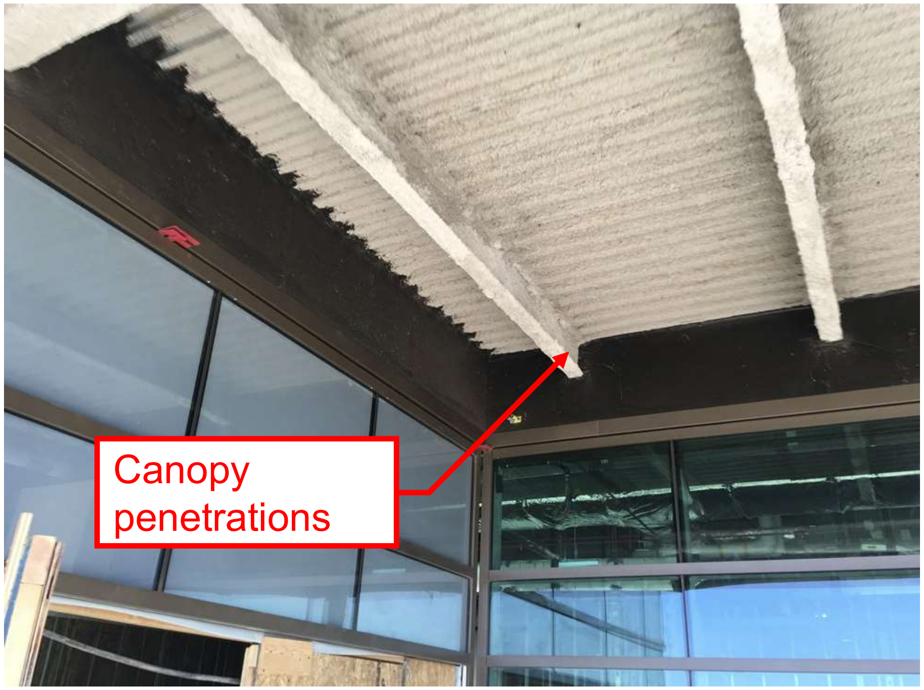


Thermal Bridging





Thermal Bridging

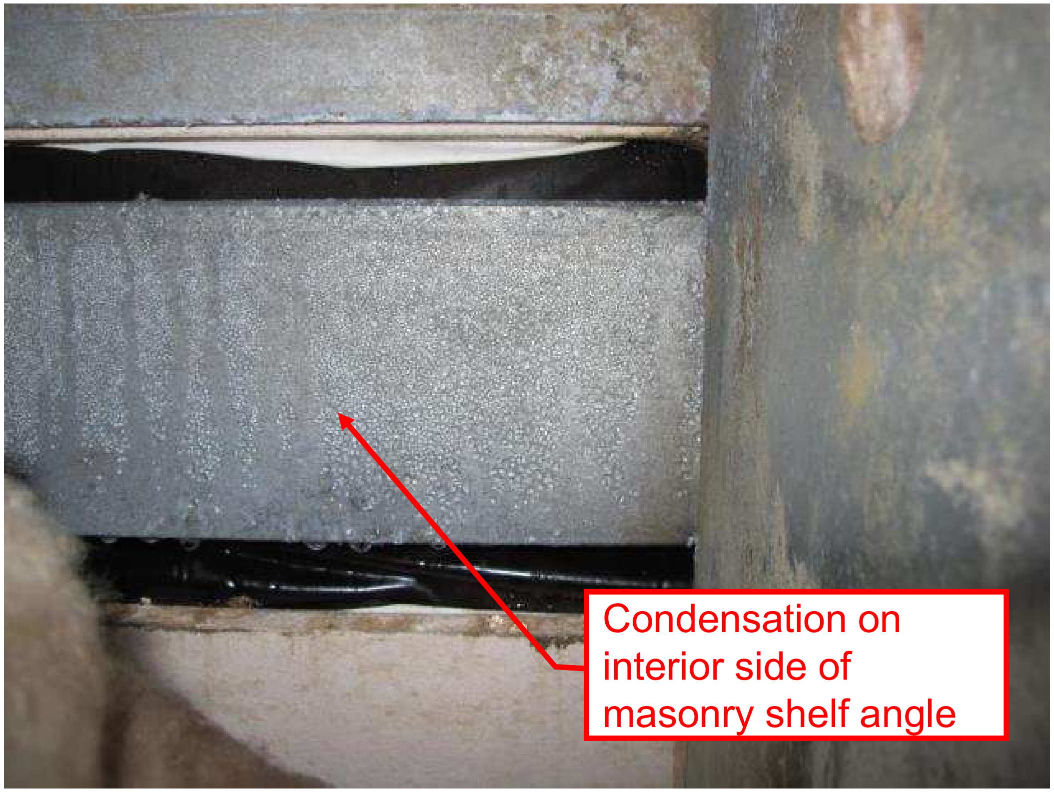


Thermal Bridging

Thermal Bridging

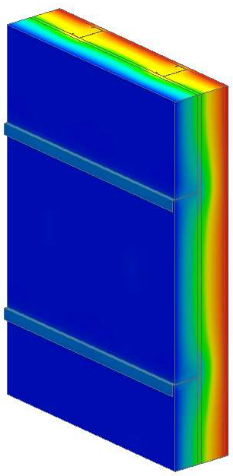
Thermal Bridging Consequences

- Condensation can occur surfaces that are below the dew point temperature
- A function of exterior temperature, surface temperatures, interior relative humidity



Thermal Bridging Concepts

Thermal Transmittance Types



Clear Field

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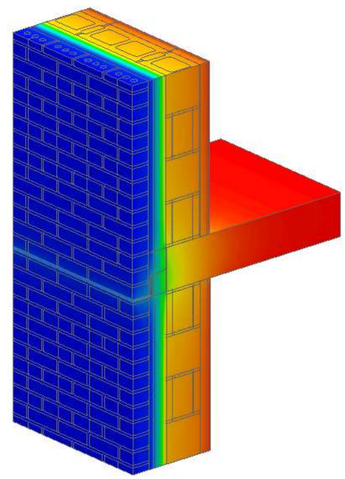

Linear

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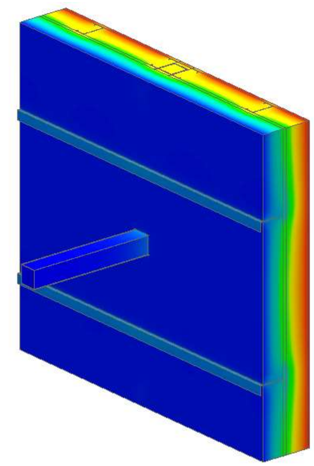

Point

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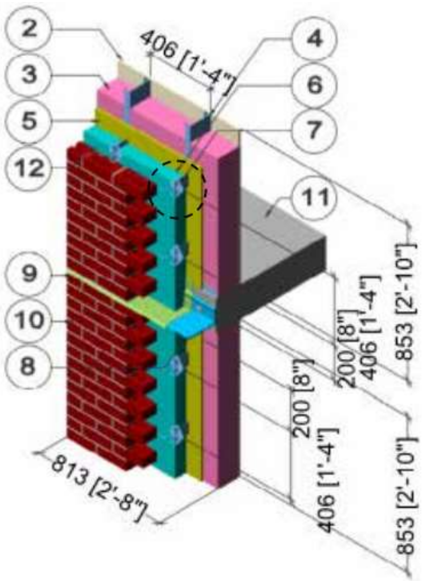
Unless otherwise noted, modelling excerpts are from the Building Envelope Thermal Bridging Guide developed by BC Hydro, BC Housing, Canadian Wood Council, Fortis BC, FPInnovations, and Morrison Hershfield

Thermal Bridging



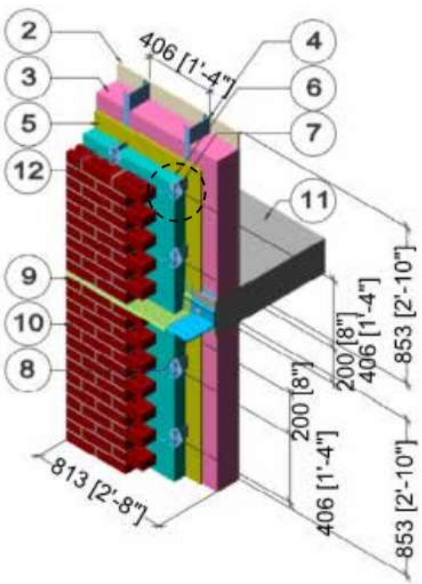
Brick Tie Detail

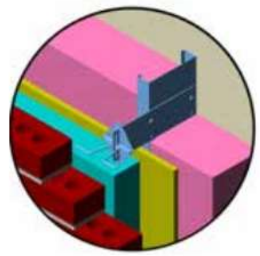
Quantifying Thermal Performance

- Wall assembly: R-17 (nominal)
- Area: 200 sf
- Assembly with shelf angle: R-13.5

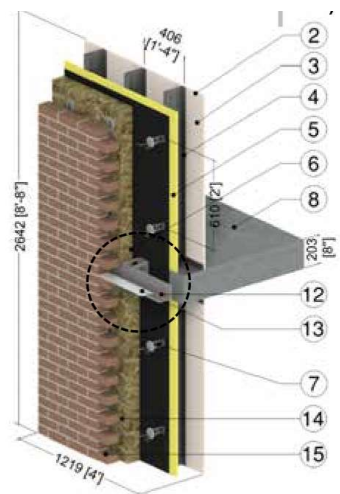
The shelf angle accounts for 21% of the heat flow through the assembly

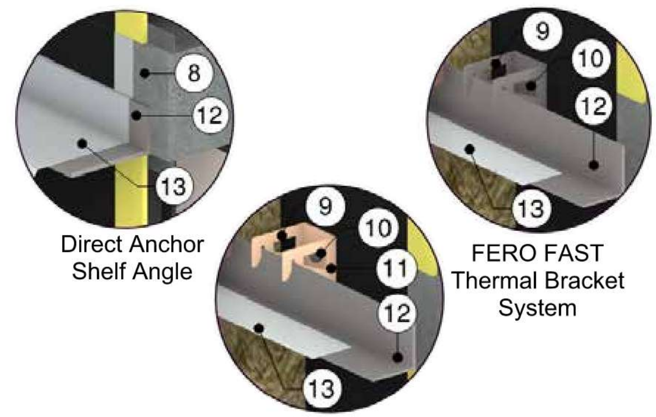
Thermal Bridge Mitigation





Brick Tie Detail





Direct Anchor Shelf Angle

FERO FAST Thermal Bracket System

FERO FAST Thermal Bracket System with Aerogel Coating

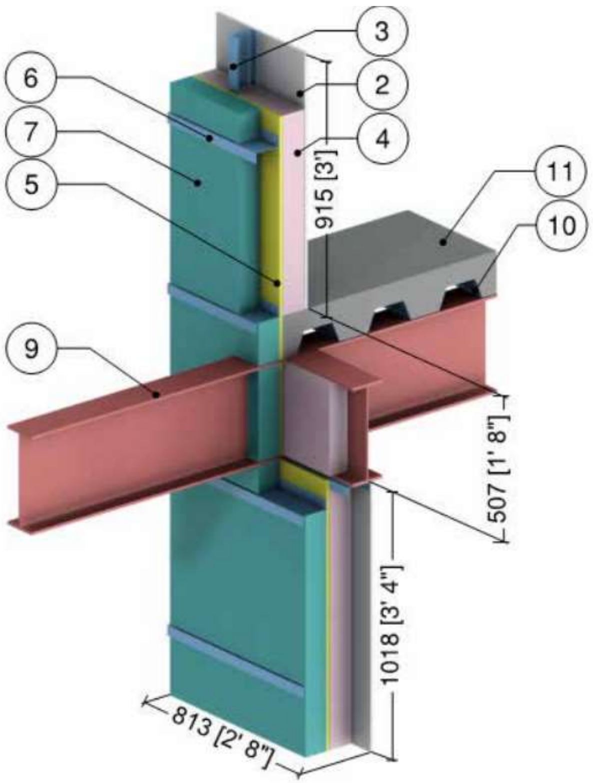
Shelf Angle

- R-14 effective (R-17 nominal)
- Max 50% interior RH

Shelf Angle with Thermal Bracket

- R-16.4 effective (R-17 nominal)
- Max 75% interior RH

Thermal Bridging

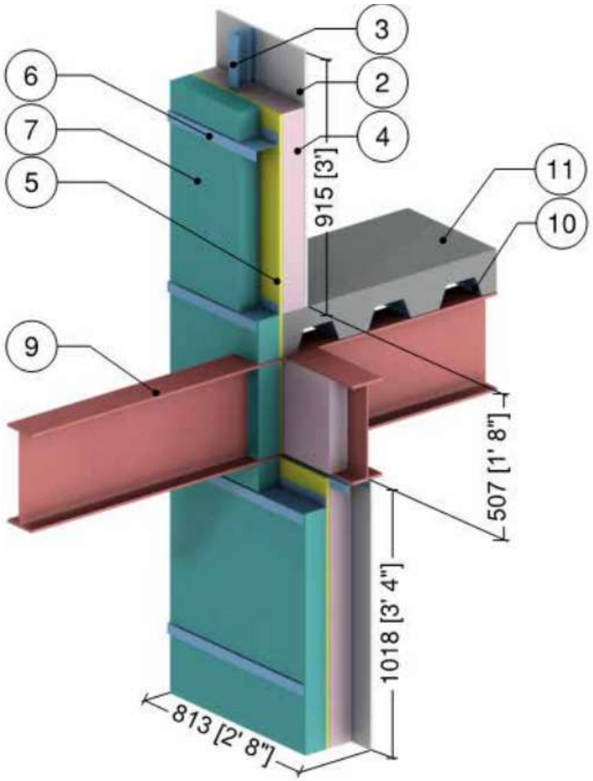


Quantifying Thermal Performance

- Wall assembly: R-18.5 (nominal)
- Area: 100 sf
- Assembly with beam penetration: R-14.0

The beam penetration accounts for 24% of the heat flow through the assembly

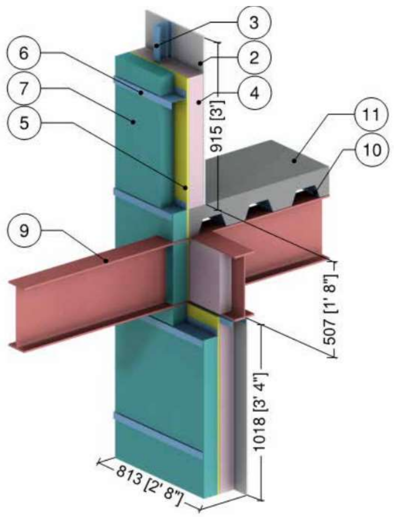
Thermal Bridging



Condensation Risk

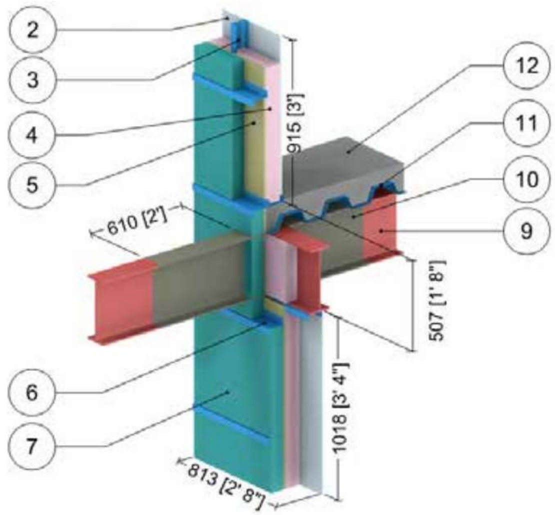
- Surface temperature may get as low as 46 deg. F (20 deg. F outside)
- Condensation may occur at 46% interior RH

Thermal Bridge Mitigation



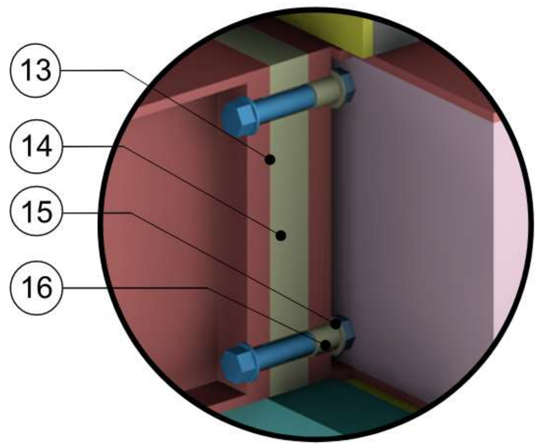
Beam Penetration

- R-14 effective
- Max 46% interior RH



Thermal Coating

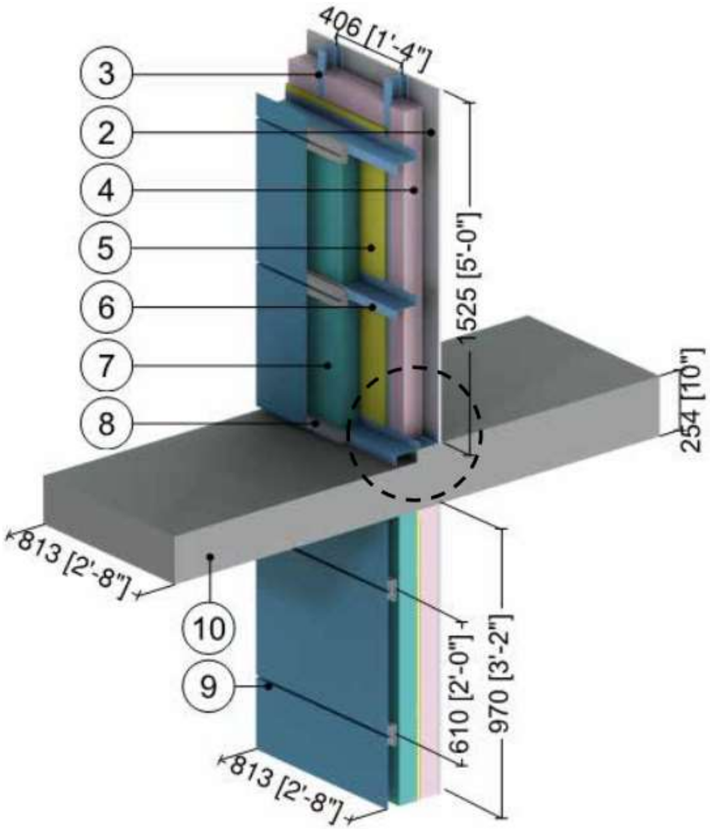
- R-15.2 effective
- Max 49% interior RH



Thermal Break

- R-16.3 effective
- Max 70% interior RH

Thermal Bridging

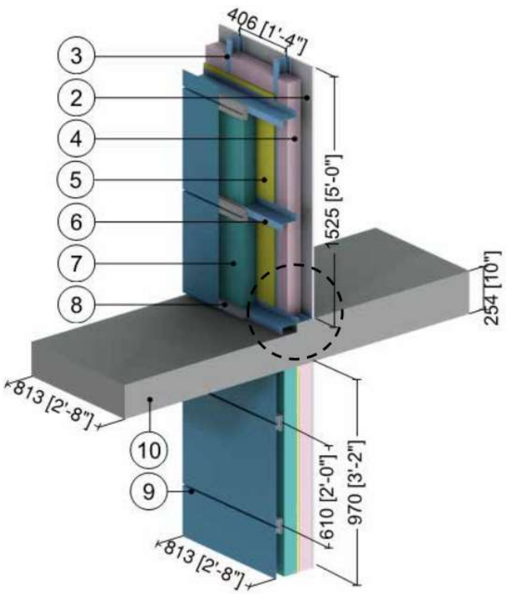


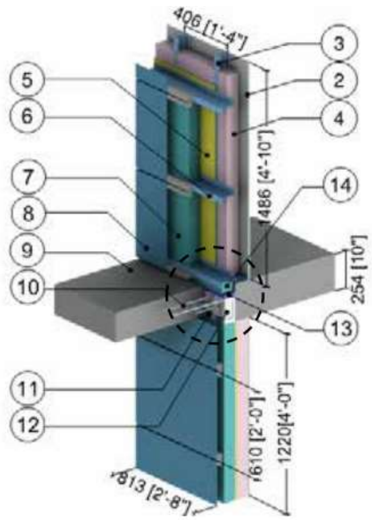
Quantifying Thermal Performance

- Wall assembly: R-18.5 (nominal)
- Area: 200 sf
- Assembly with slab: R-11.8

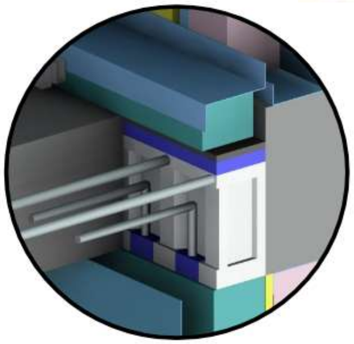
The slab accounts for 36% of the heat flow through the assembly

Thermal Bridge Mitigation





Schöck
Innovative Building Solutions



Thermally Broken Slab Detail
(Isokorb CM20)

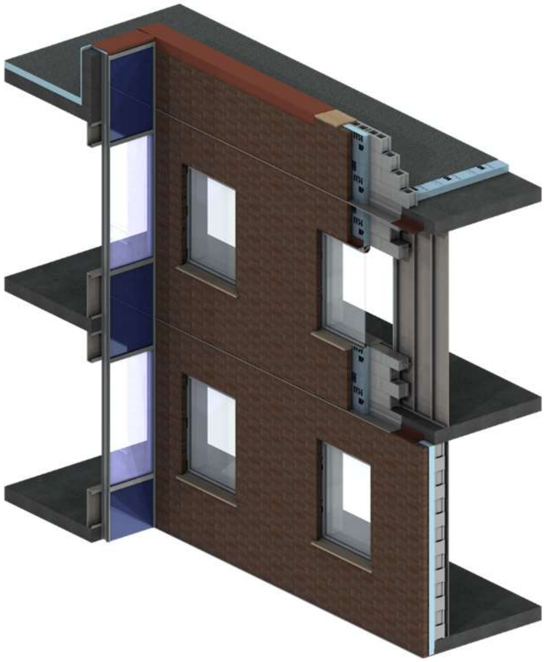
Slab Penetration

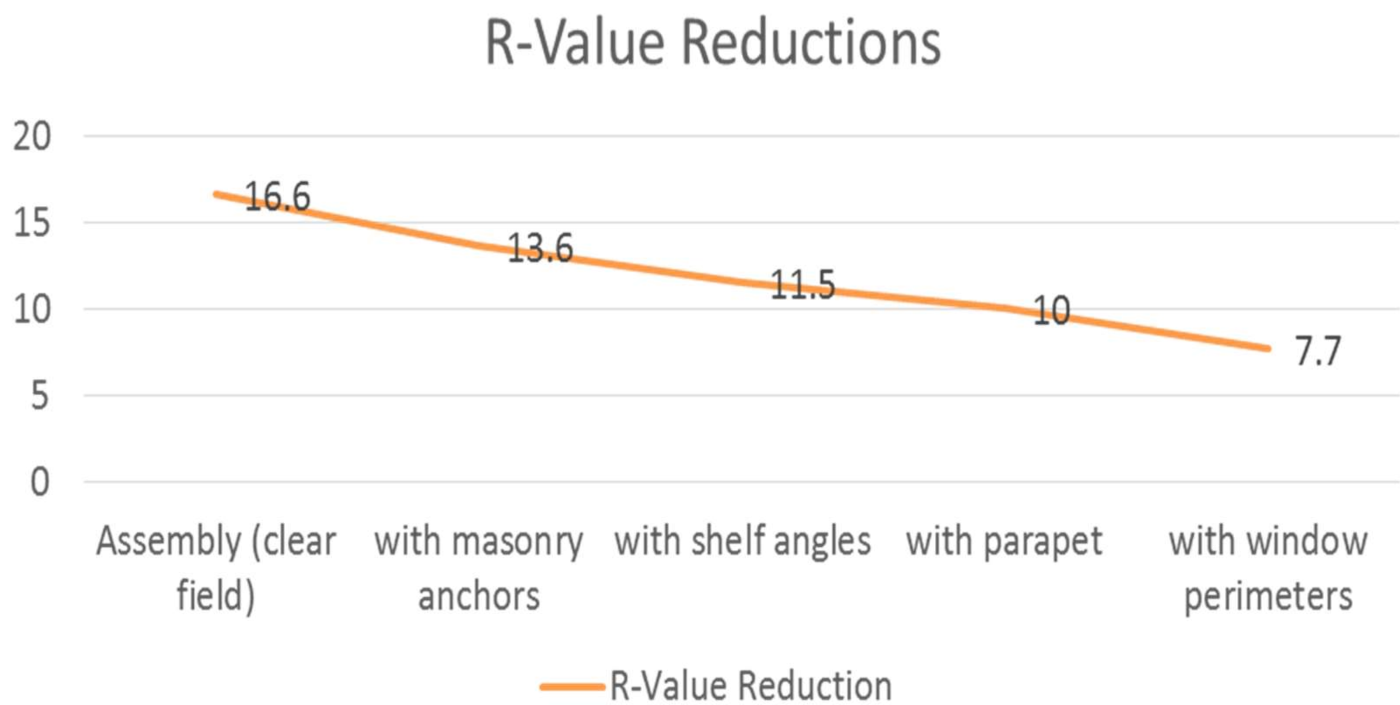
- R-11.8 effective (R-18.5 nominal)
- Max 53% interior RH

Thermally Broken Slab

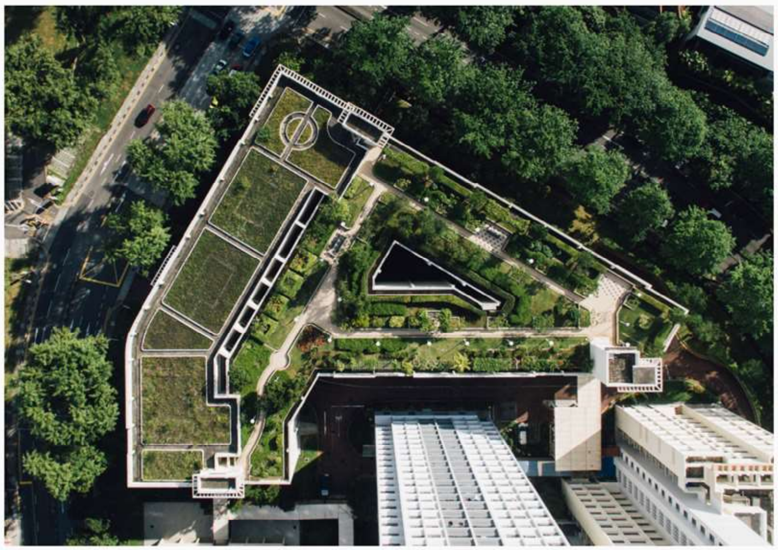
- R-15.8 effective (R-18.5 nominal)
- Max 75% interior RH

Thermal Bridging





Thermal Bridging



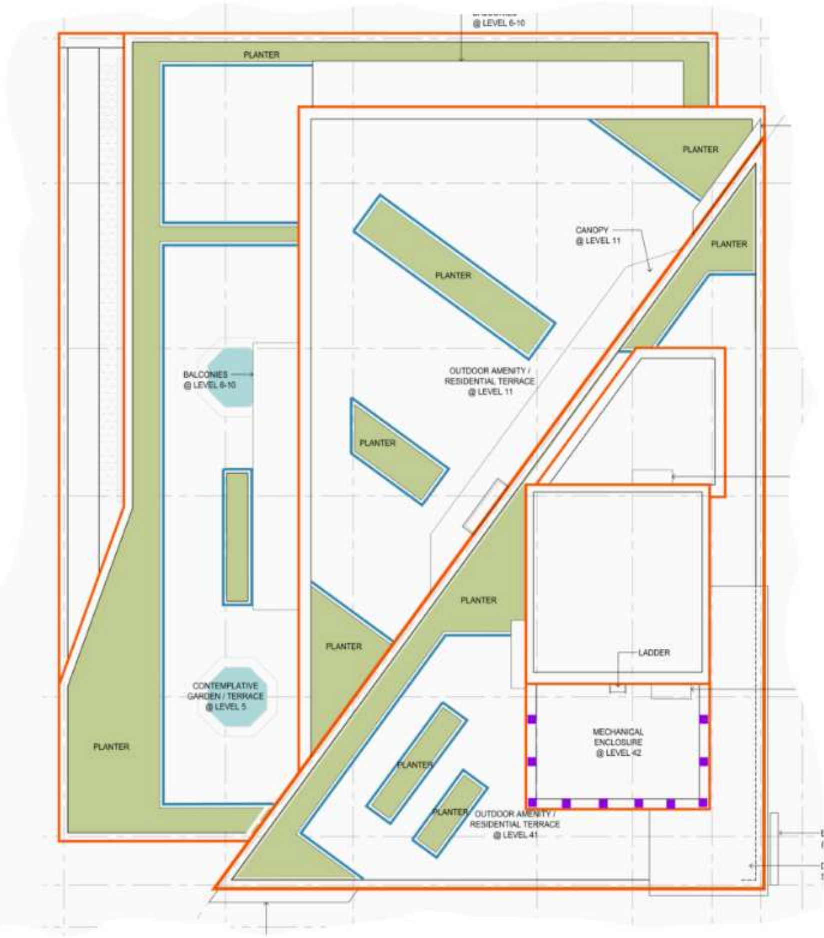


Figure 1. Roof Deck Plan

Roof plan showing parapet walls, planter with concrete curbs, and pedestals.

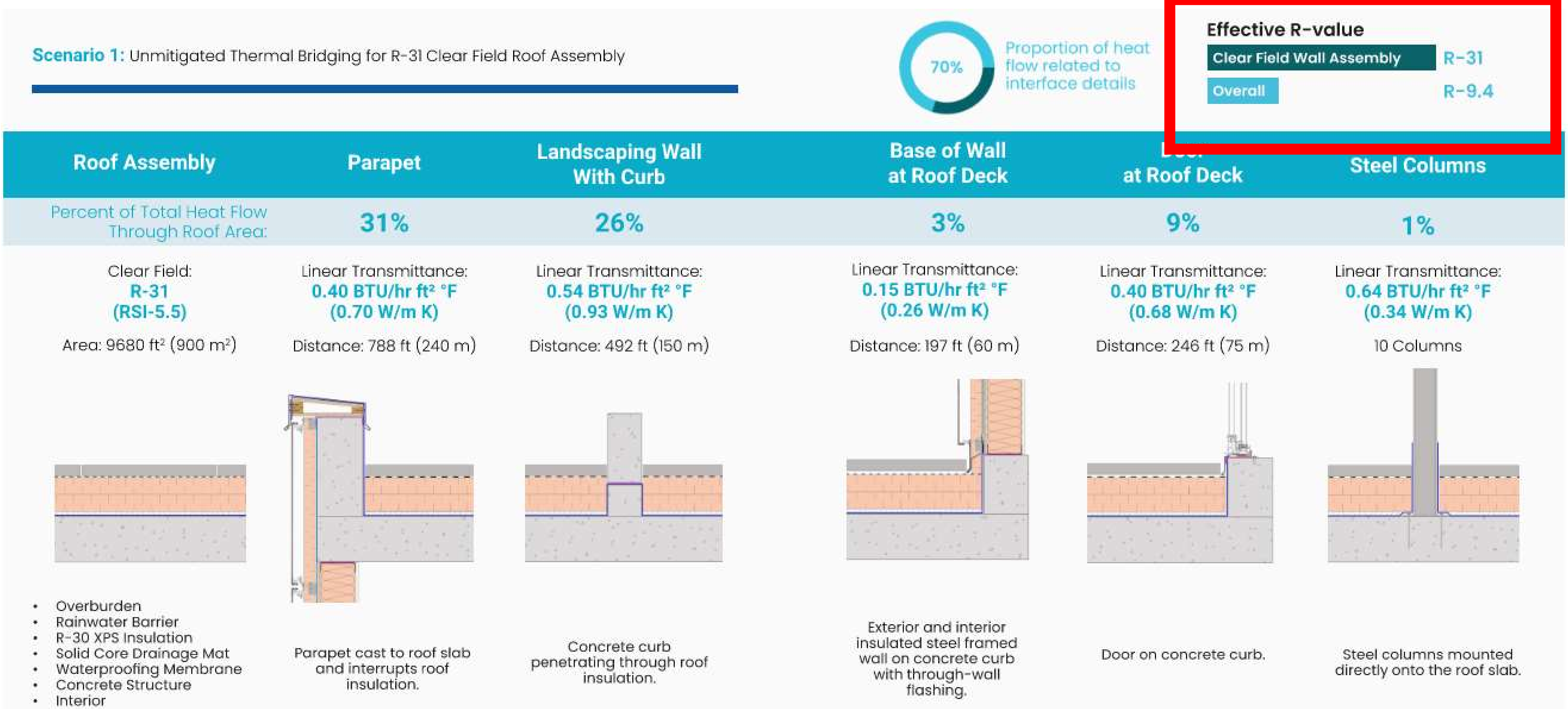
Orange = Parapets (240 m)

Blue = Planter Walls (150 m)

Purple = Columns (10)

Guide to Mitigating Thermal Bridging at Roof Decks – BC Housing (Prepared by Evoke)

Thermal Bridging



Guide to Mitigating Thermal Bridging at Roof Decks – BC Housing (Prepared by Evoke)

Thermal Bridging

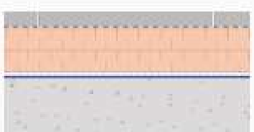
Scenario 3: Highly Mitigated Thermal Bridging for R-31 Clear Field Roof Assembly

Proportion of heat flow related to interface details

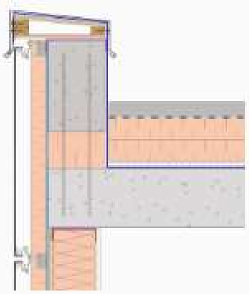
Effective R-value

Clear Field Wall Assembly	R-31
Overall	R-21.9

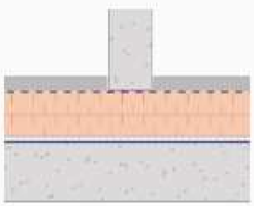
Roof Assembly	Parapet	Landscaping Wall	Base of Wall at Roof Deck	Door at Roof Deck	Steel Columns
Percent of Total Heat Flow Through Roof Area:	18%	0%	7%	5%	0%
Clear Field: **R-31 (RSI-5.5)**	Linear Transmittance: **0.144 BTU/hr ft² °F (0.250 W/m K)**	Linear Transmittance: **0 BTU/hr ft² °F (0 W/m K)**	Linear Transmittance: **0.15 BTU/hr ft² °F (0.26 W/m K)**	Linear Transmittance: **0.10 BTU/hr ft² °F (0.17 W/m K)**	Linear Transmittance: **0.171 BTU/hr ft² °F (0.090 W/m K)**
Area: 9680 ft² (900 m²)	Distance: 788 ft (240 m)	Distance: 492 ft (150 m)	Distance: 197 ft (60 m)	Distance: 246 ft (75 m)	10 Columns



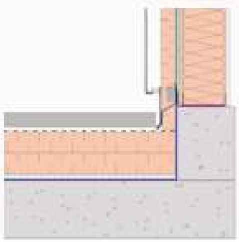
- Overburden
- Rainwater Barrier
- R-30 XPS Insulation
- Solid Core Drainage Mat
- Waterproofing Membrane
- Concrete Structure
- Interior



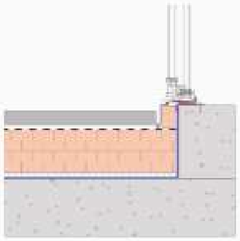
Parapet wall with manufactured thermal break.



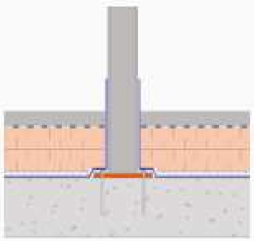
Concrete curb "floats" over the insulation.



Exterior and interior insulated steel framed wall on concrete curb with through-wall flashing.



Curb is exterior insulated.

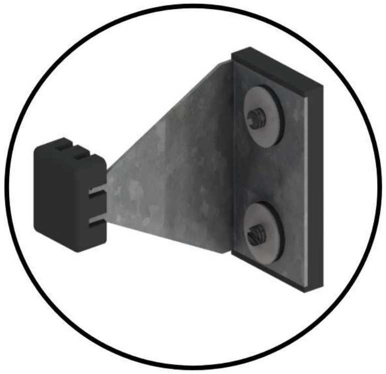


Steel columns mounted with thermal break.

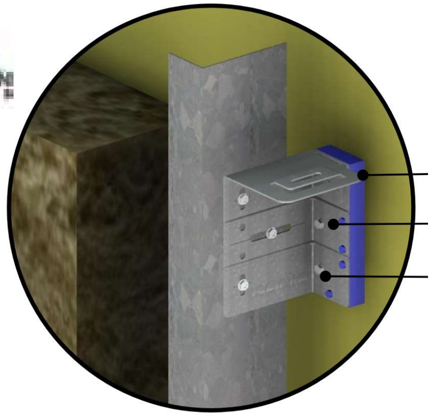
Guide to Mitigating Thermal Bridging at Roof Decks – BC Housing (Prepared by Evoke)

Structural Considerations

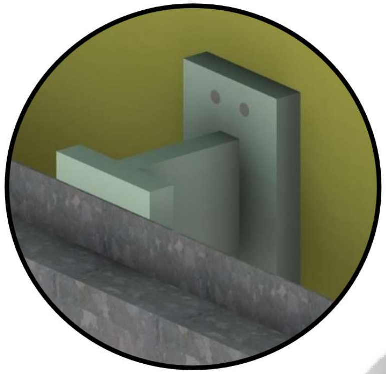
Thermal Break Options



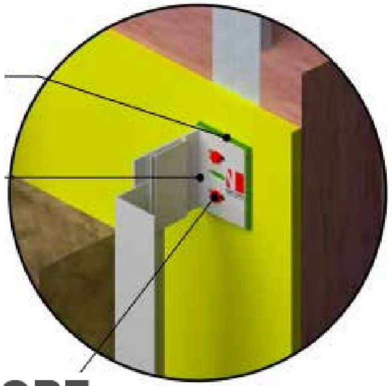
ThermaBracket Detail



ISO Clip Detail

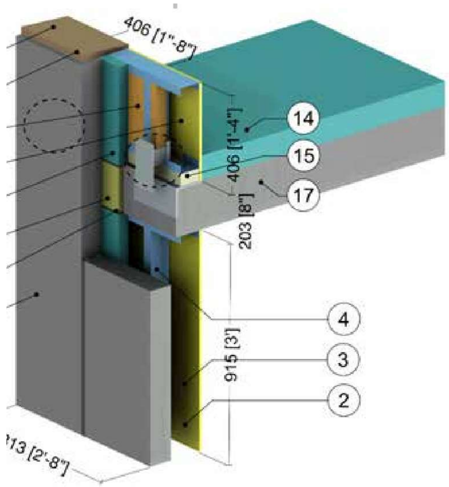


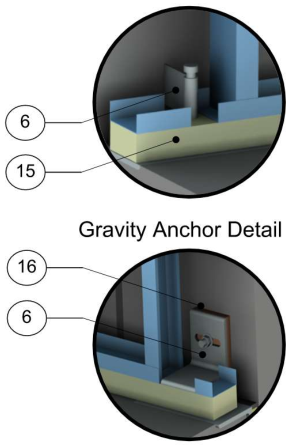
Fiber Reinforced
Clip Detail



NVI Clip Detail

Thermal Break Options



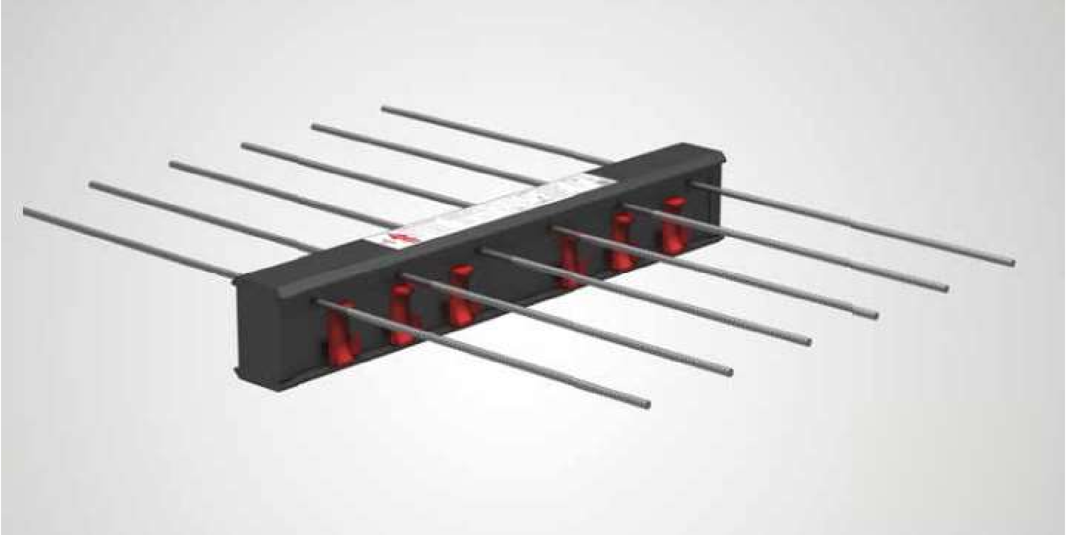


Gravity Anchor Detail

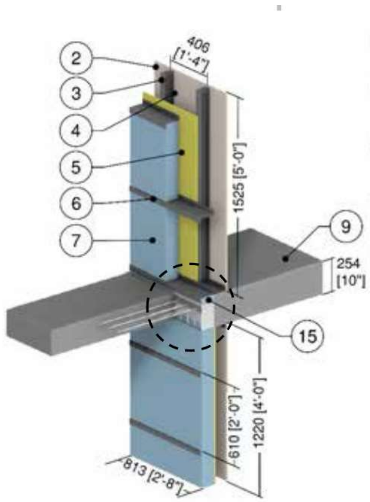
Slot Anchor Detail

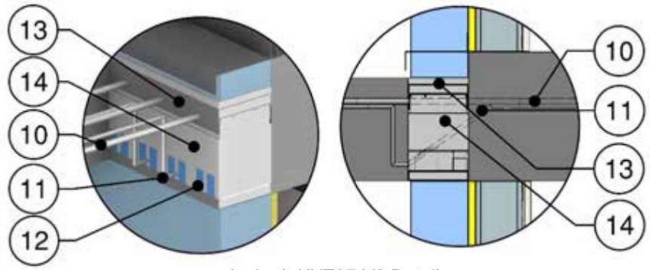
ARMATHERM™
THERMAL BREAK SOLUTIONS

HALFEN

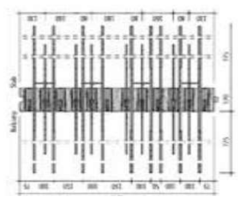


Thermal Break Options





Isokorb KXT65-V8 Detail



Isokorb KXT65-V8
Rebar Arrangement

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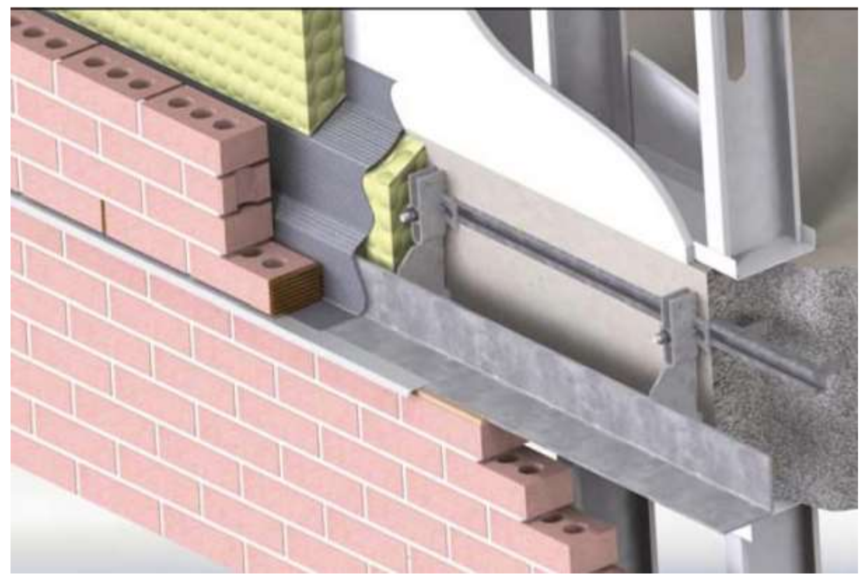
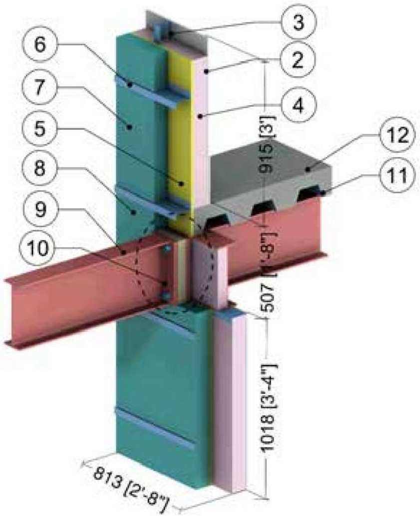
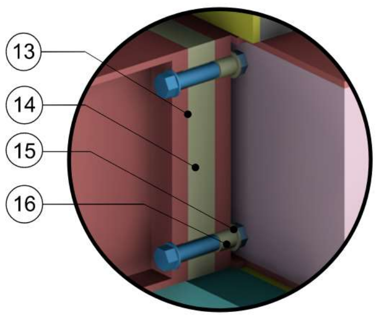
YOUR BEST CONNECTIONS

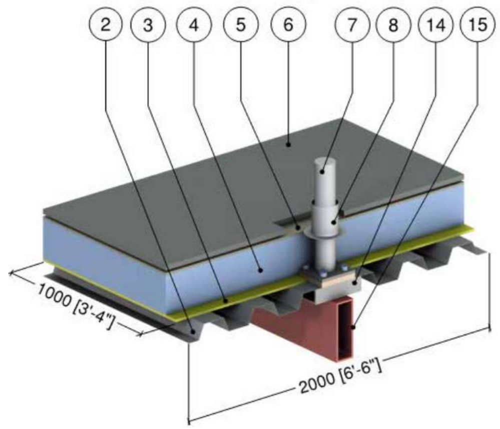


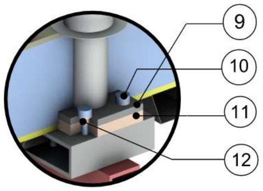
Thermal Break Options



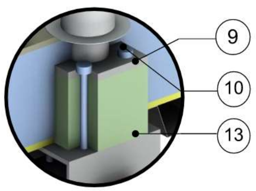


Beam Thermal Break





Armatherm FRR Roof Anchor Thermal Break



Armatherm 500 Roof Anchor Thermal Break

Conclusions

- Thermal breaks are (probably) going to be used more often, including in mild climates
- Thermal performance and condensation mitigation should be thoughtfully developed during design (quantified)
- Design teams will need to coordinate more and better
- Be prepared to work through field issues with the contractors