Thermal Bridges:
Understanding, Identifying, Reviewing & Mitigating

July 14, 2026

phius

Event Approved for Phius CEUs

July Webinar: Thermal Bridges

Earn 1.0 CEU

XXXXX

Self Report Code Coming Later

Self Report @

www.phius.org/certifications/professionals/maintain-credentials

Agenda

1. Concepts
2. Examples & Mitigation Strategies
3. Common Misconceptions
4. References / Links
5. Questions

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Thermal Bridge - Concepts

Thermal Bridge Definition

A difference in energy transfer.

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2 Types of Thermal Bridges

Construction Material

A difference in energy transfer is created due to a difference in conductivity between two materials.

Linear (psi / Ψ-value) OR
Point (chi / X-value)

Geometric

A difference in energy transfer is created due to an interior to exterior surface area ratio ≠ 1.

Linear (psi / Ψ-value)

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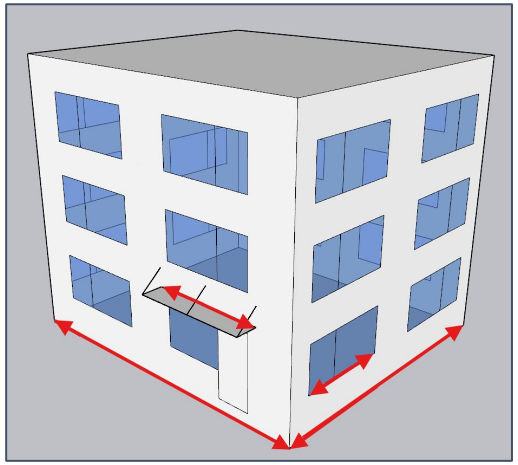
Quantifying Thermal Bridges

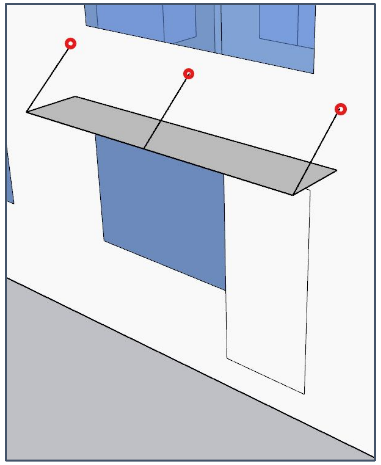
Linear Thermal Bridges (Ψ-value)

Coefficient of additional energy transfer along a line, seam or joint between assemblies.



Point Thermal Bridges (Χ-value)

Coefficient of additional energy transfer at a penetration such as a fastener, anchor, pipe or column.



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Positive vs Negative/Neutral Thermal Bridges

Positive Thermal Bridges

The total energy transfer accounted for in WUFI Passive or METr is less than the actual energy transfer of the specific condition.

Positive: Any calculated psi-value >0.006 Btu/hr.ft/F

Negative / Neutral Thermal Bridges

The total energy transfer accounted for in WUFI Passive or METr is greater than or equal to the actual energy transfer of the specific condition.

Neutral: Any psi-value that calculates ≥0 but ≤0.006 Btu/hr.ft.F

Negative: Any psi-value that calculates <0 Btu/hr.ft.F

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Why do we care?

Why do they matter?

- Total energy transfer accounting
- Mold & moisture risk
- Occupant comfort

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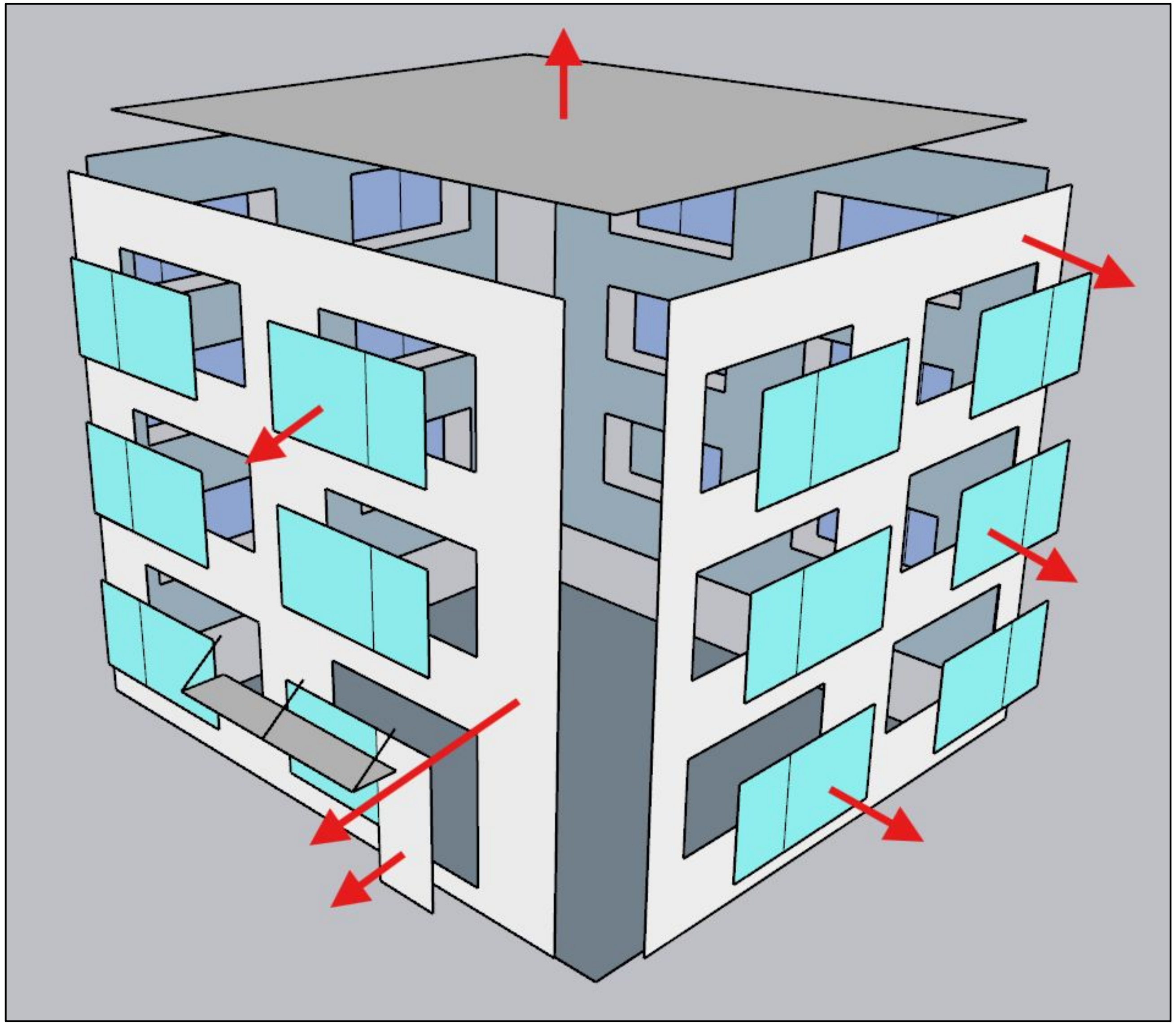
Total energy transfer accounting

Phius' space conditioning targets (annual and peak heating/cooling) are based on whole-building energy modeling.

WUFI Passive / METr: Performs a basic transmission energy transfer calculation per surface that does not account for assembly connections or material fasteners etc...

$q_{trans} = q_{trans,roof} + q_{trans,wall} + q_{trans,window}$ etc…

Thermal bridges can lead to undercounting energy transfer and inaccurate space conditioning results.



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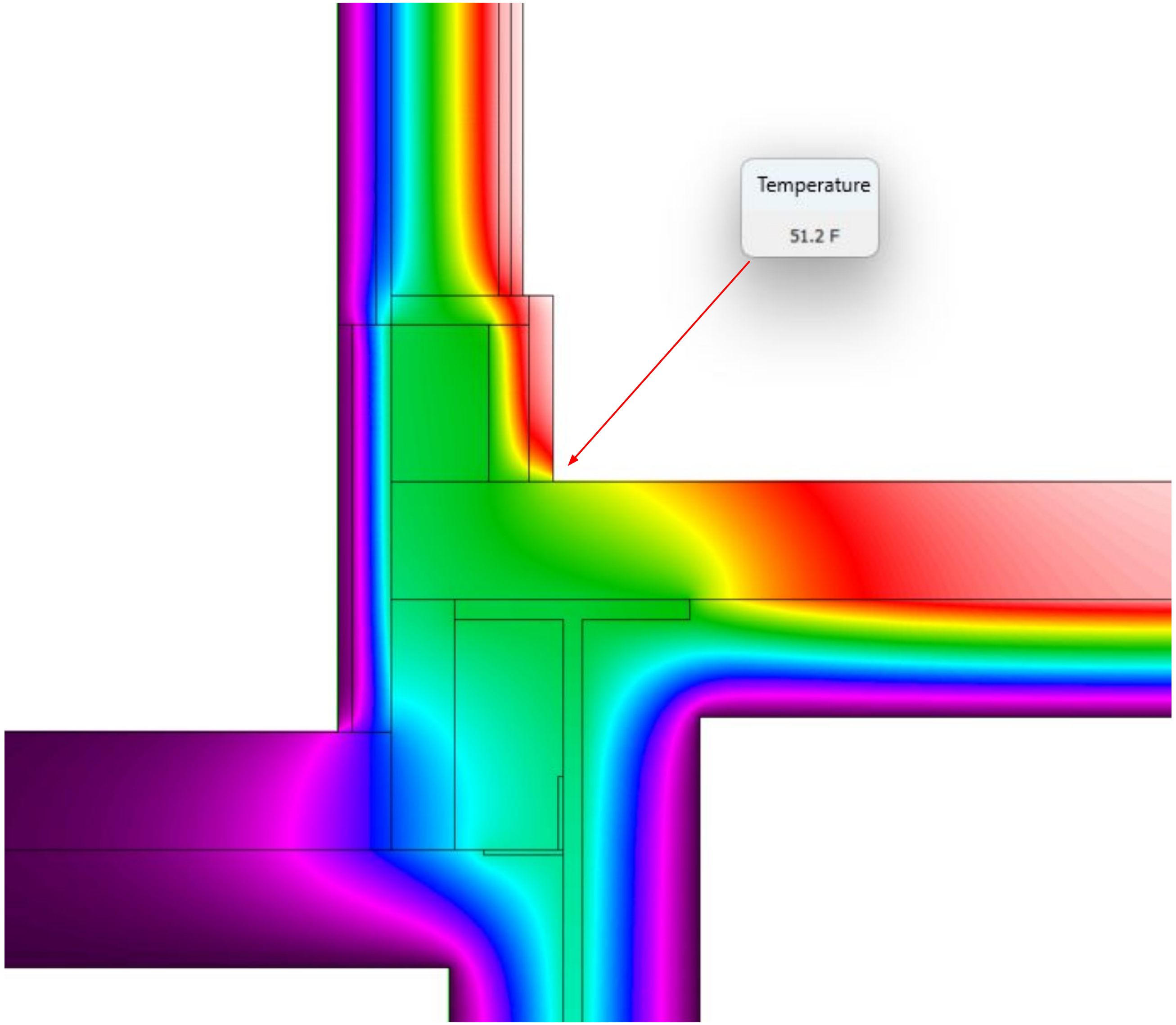
Mold & moisture risk

Thermal bridges can lower the interior surface temperature and present a risk of surface mold or condensation.

Occupant comfort

Thermal bridges can lower the interior surface temperature and create thermal discomfort for occupants.



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Positive Thermal Bridges

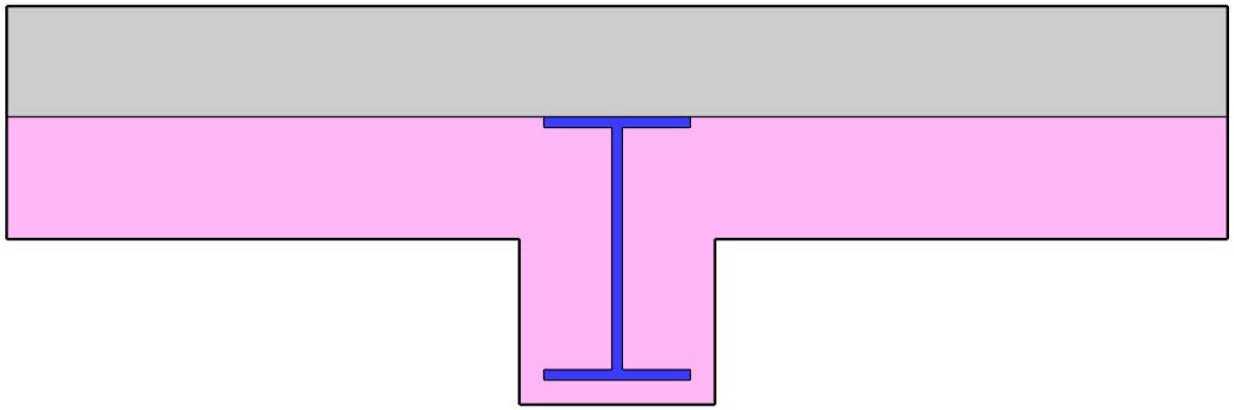
Steel Beams (Overhang/Podium Floors)

Type: Construction Material & Geometric

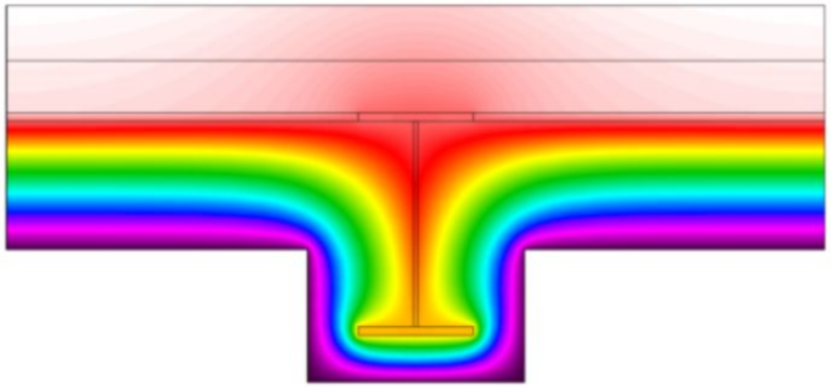
- Linear (Ψ)

Concern: Energy transfer accounting, moisture risk

Inside



Outside / Garage



Psi-Value = 0.076 Btu/hr.ft.F

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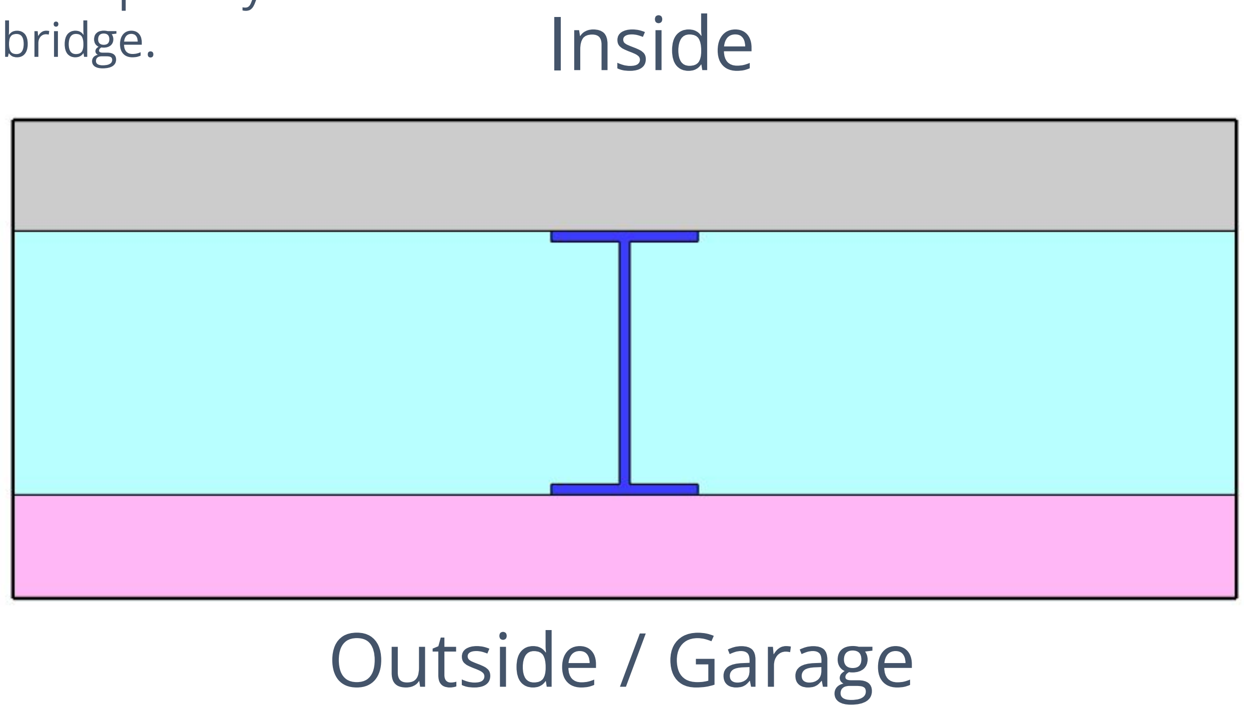
Steel Beams (Overhang/Podium Floors)

Potential Mitigation Strategy:

Locate insulation below the structure, keeping it entirely within the thermal boundary. This solution completely eliminates the thermal bridge.

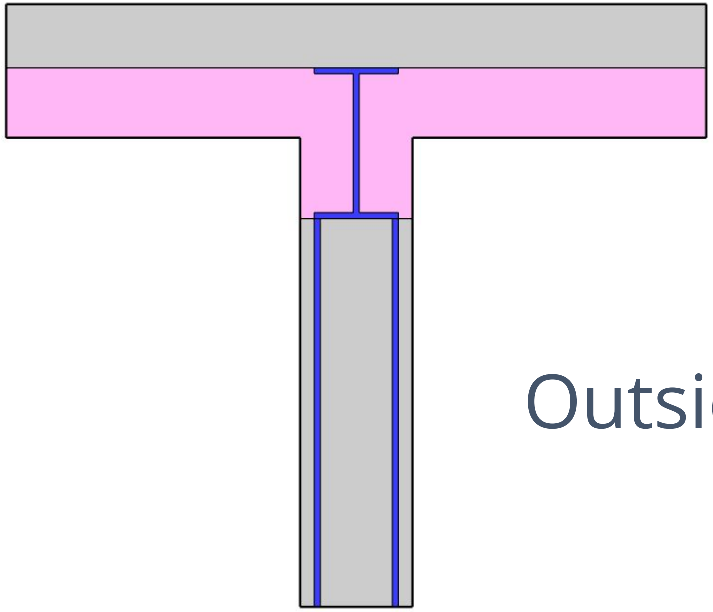


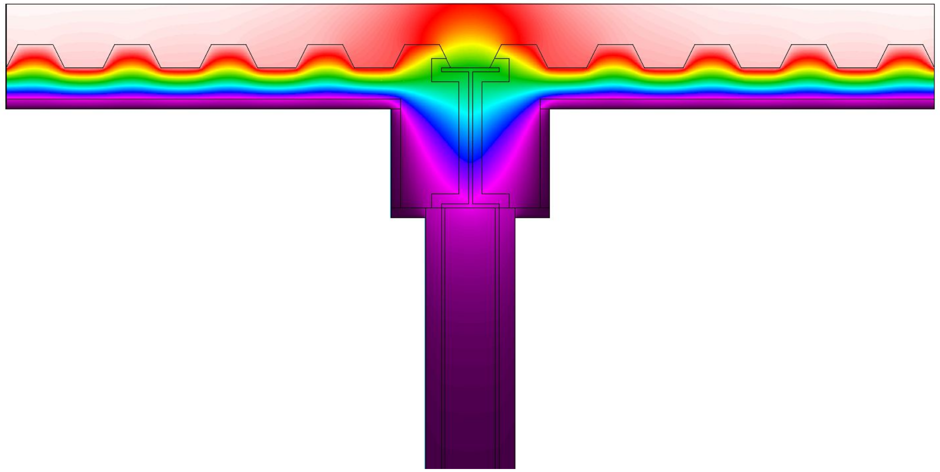
Column to Floor Connection (Podium)

Type: Construction Material

- Linear (Ψ) or Point (X)

Concern: Energy transfer accounting, moisture risk





Psi-Value = 0.197 Btu/hr.ft.F

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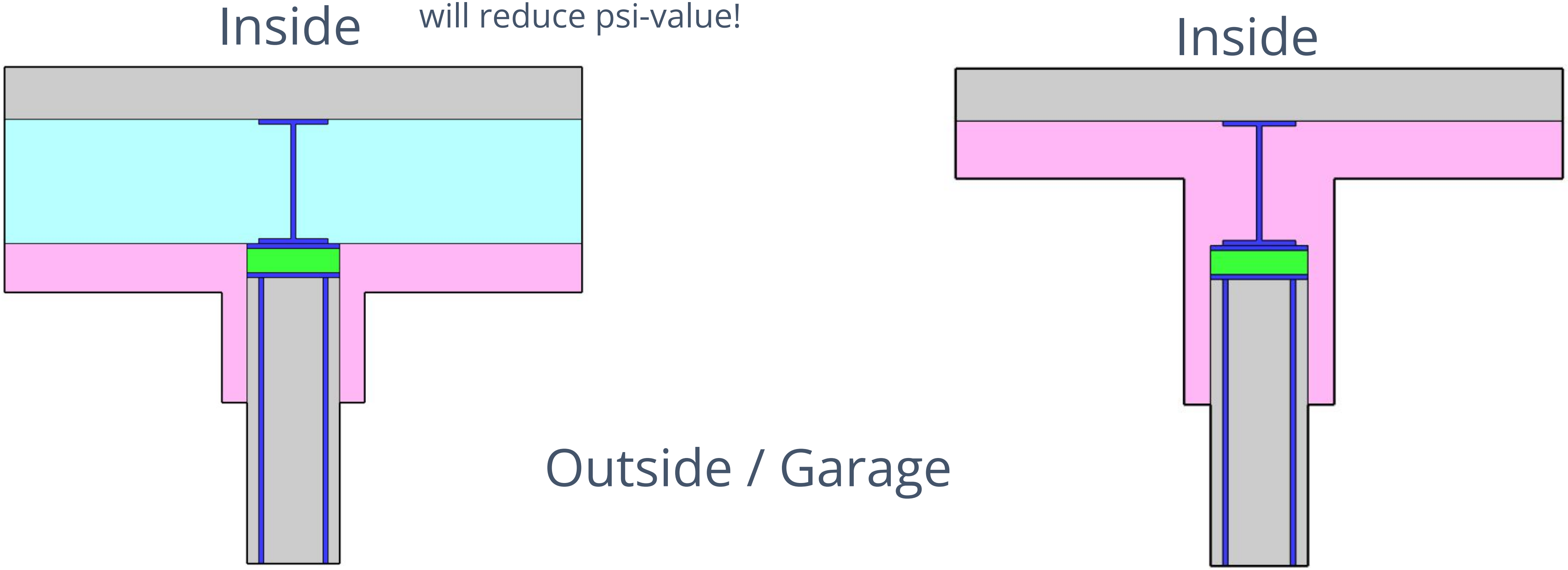
Column to Floor Connection (Podium)

Potential Mitigation Strategies:

Locate insulation below the structure, extend insulation down face of column, separate column & beam with a thermal break pad. Still a TB but will reduce psi-value!

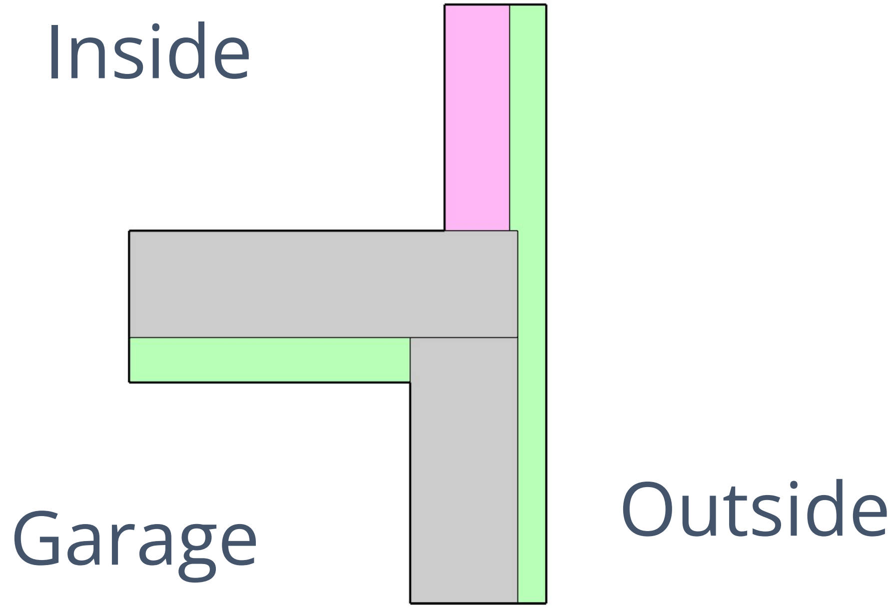


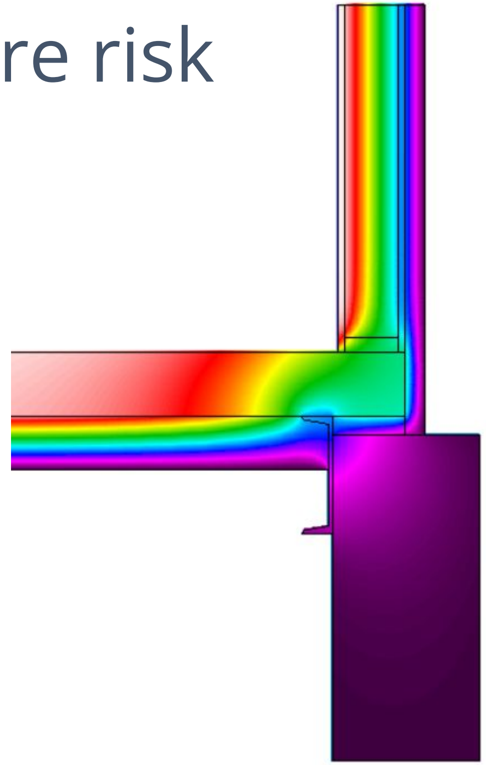
Podium Perimeter

Type: Construction Material

- Linear (Ψ)

Concern: Energy transfer accounting, moisture risk





Psi-Value = 0.469 Btu/hr.ft.F

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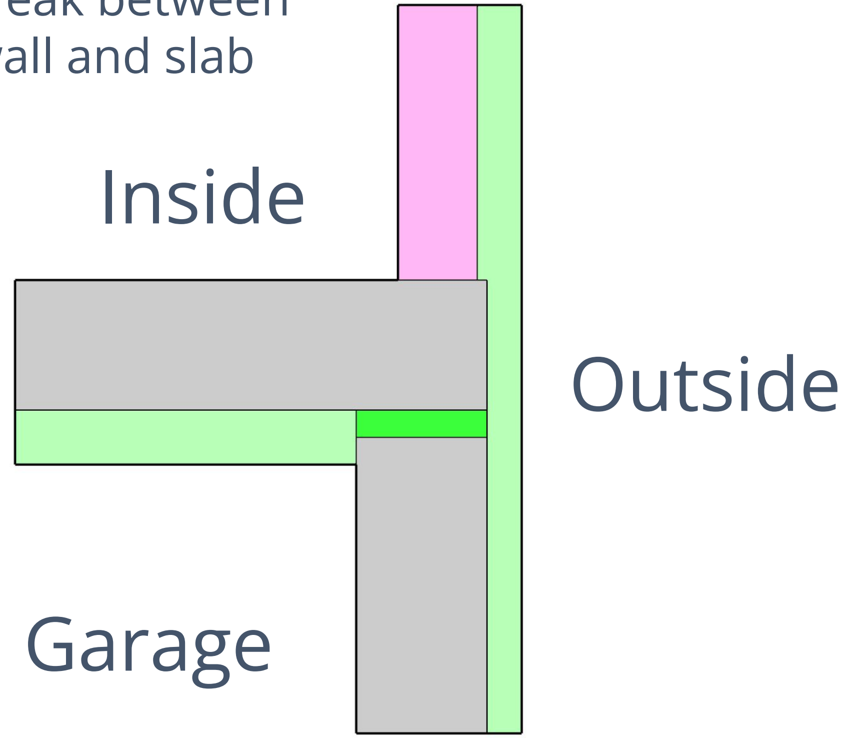
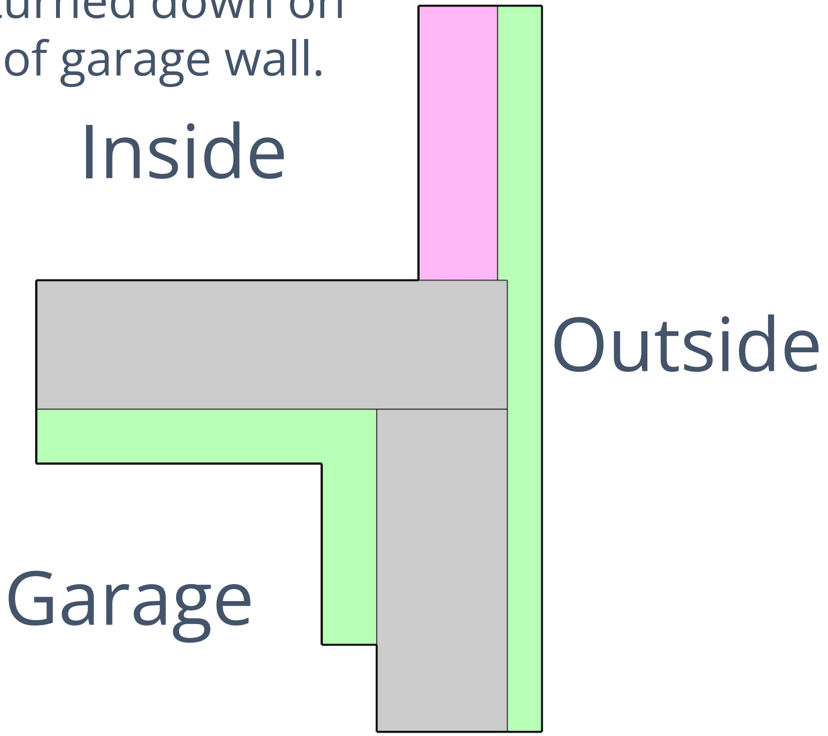
Podium Perimeter

Potential Mitigation Strategies:

Thermal break between concrete wall and slab



Insulation turned down on inside face of garage wall.



Either approach will reduce psi-value, but may not fully mitigate the thermal bridge

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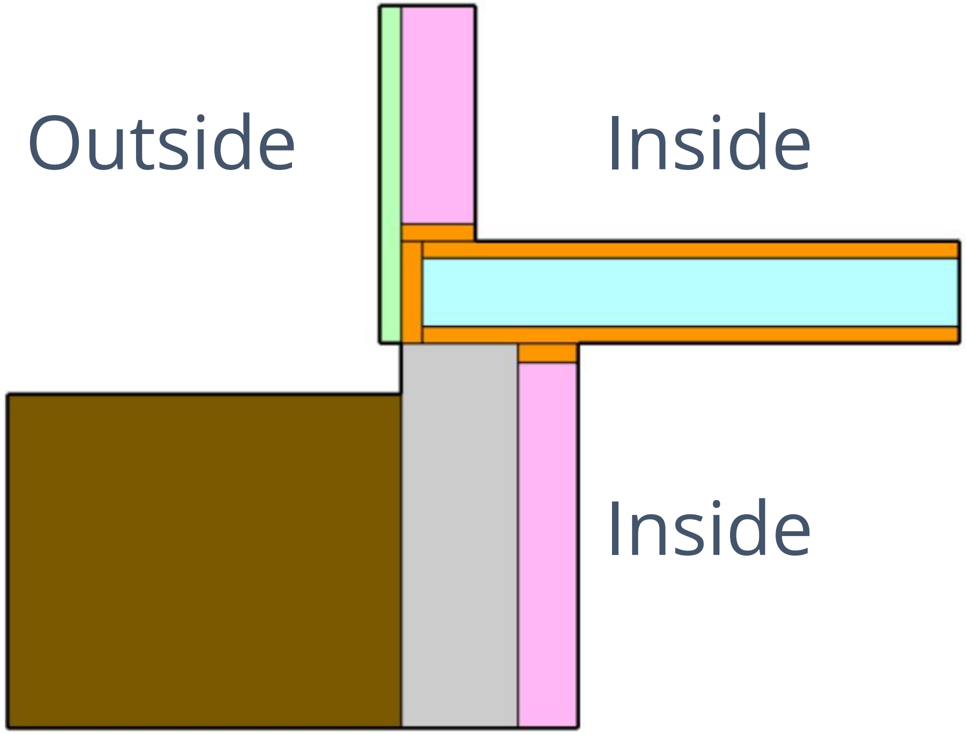
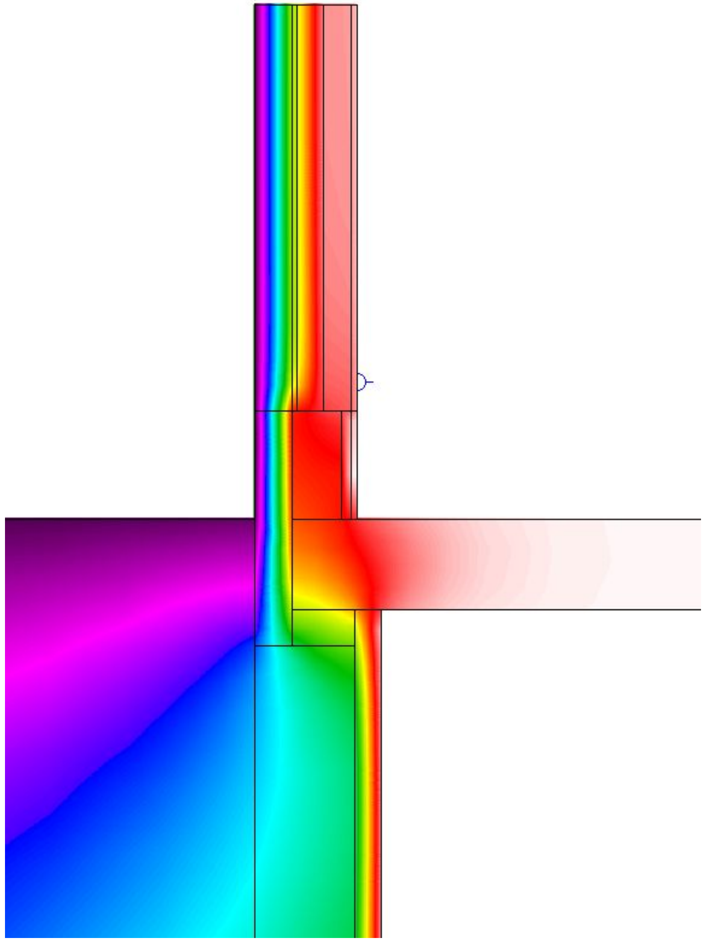
Above Grade to Basement Wall

Type: Construction Material

- Linear (Ψ)

Concern: Energy transfer accounting





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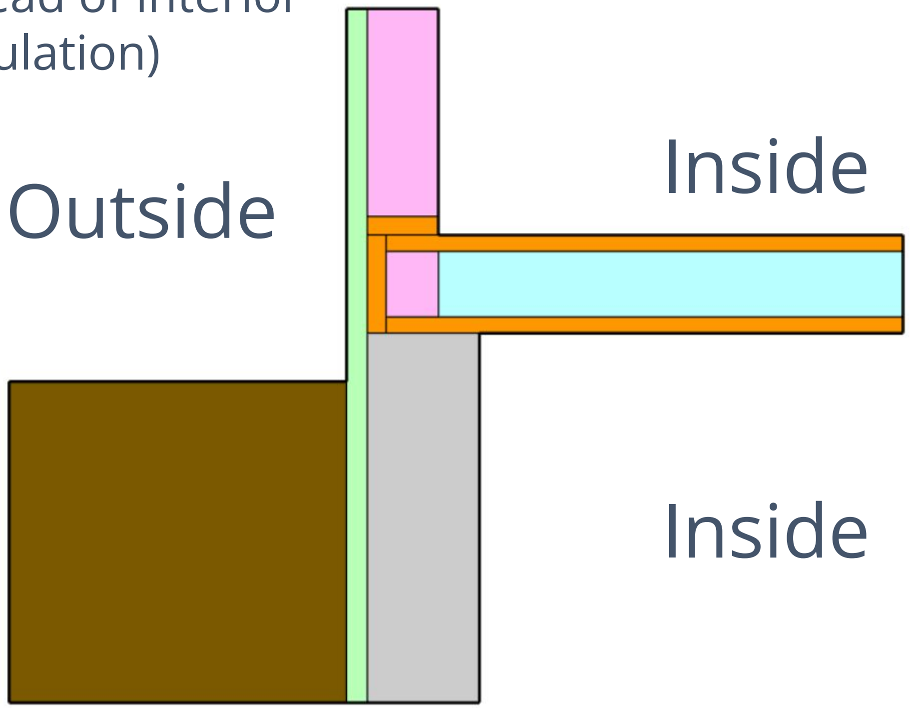
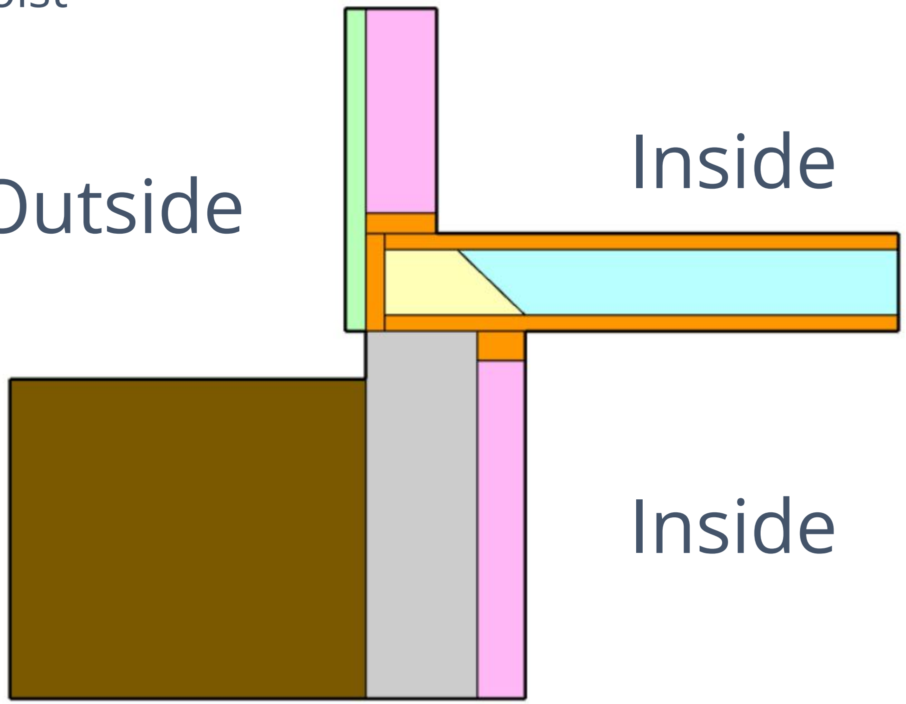
Above Grade to Basement Wall

Potential Mitigation Strategies:

Maintain CI on basement wall (instead of interior cavity insulation)



Spray foam/insulation in floor joist

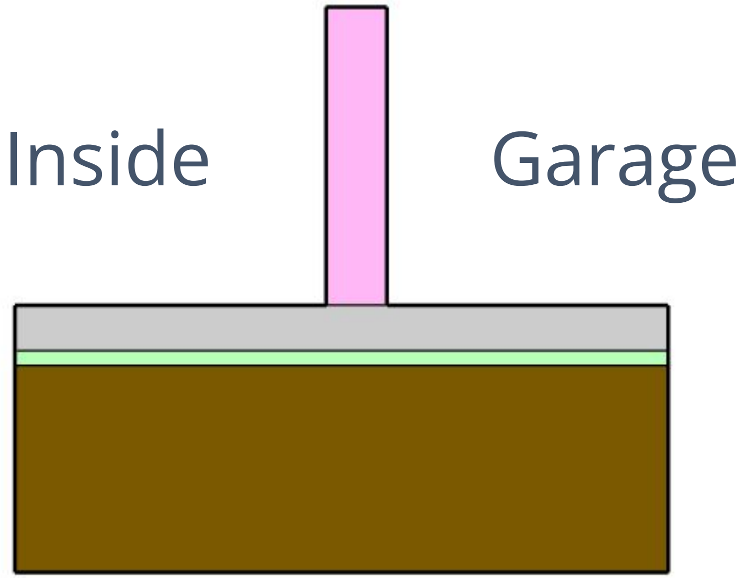


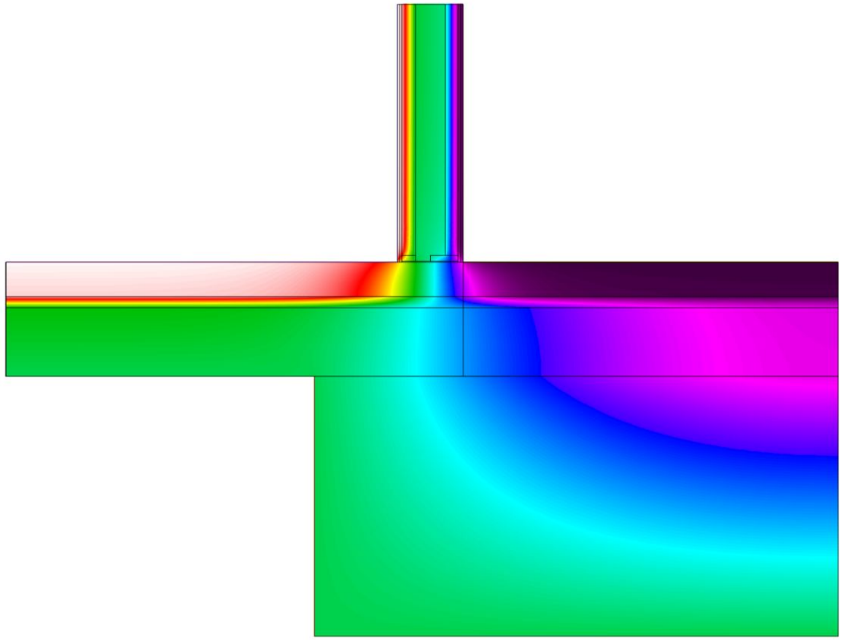
Garage Floor to Conditioned Space

Type: Construction Material

- Linear (Ψ)

Concern: Energy transfer accounting





Psi-Value = 0.132 Btu/hr.ft.F

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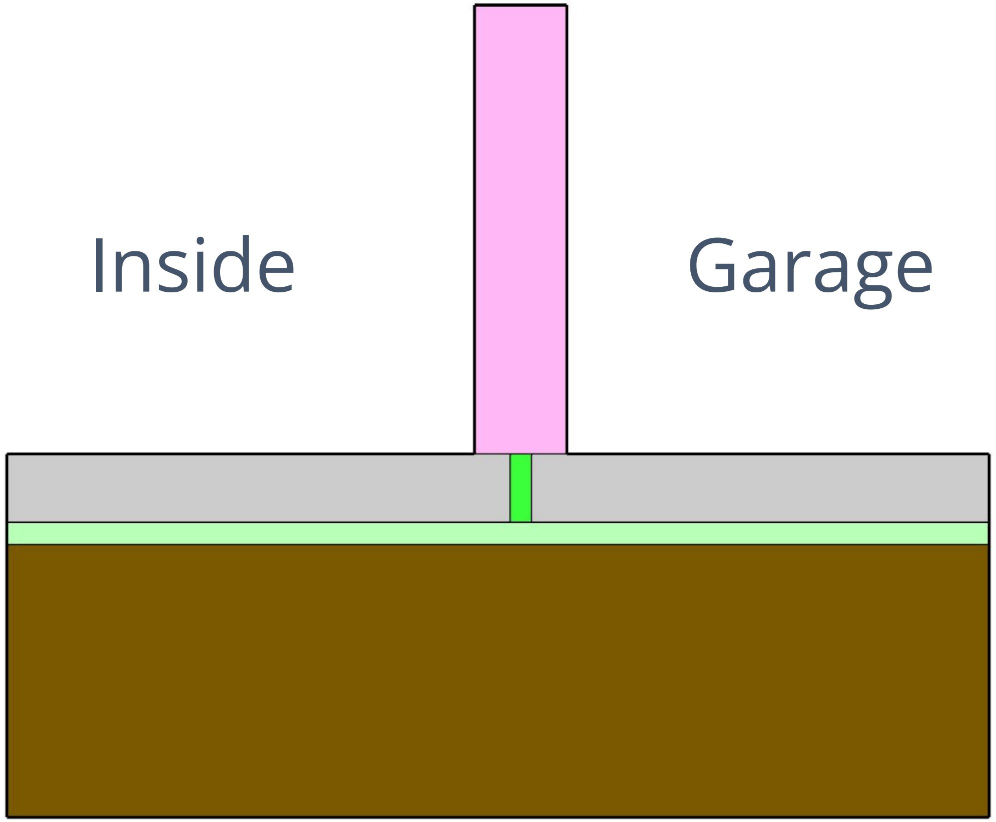
Garage Floor to Conditioned Space

Potential Mitigation Strategies:

Thermal break between conditioned space slab and garage floor slab



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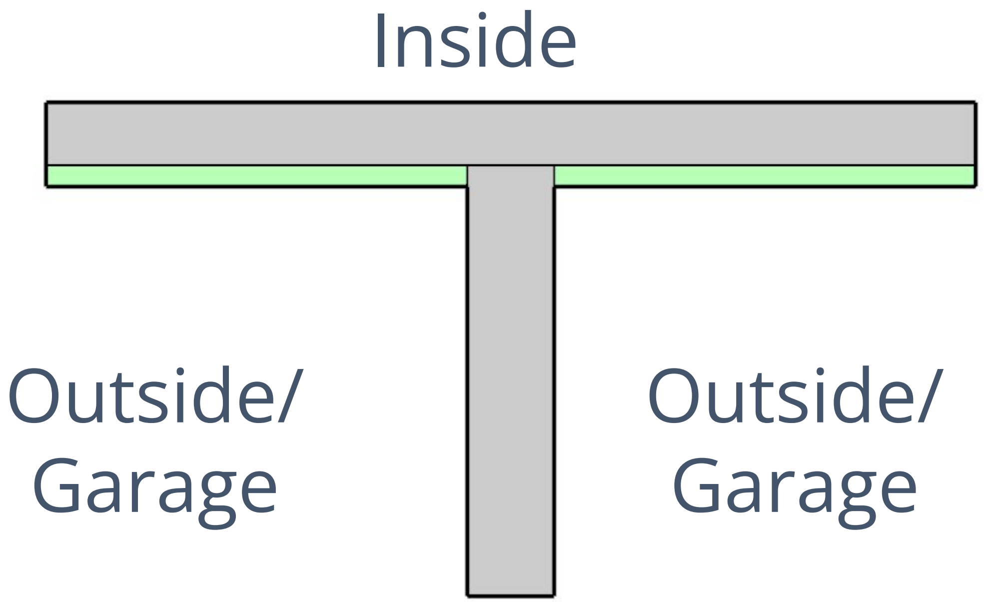
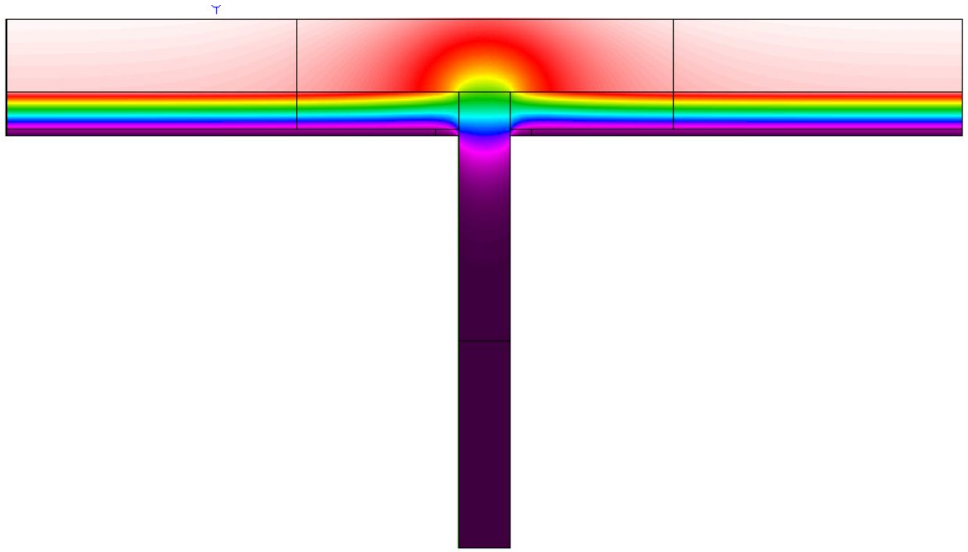
Garage Level Walls to Cond. Space (Plan View)

Type: Construction Material

- Linear (Ψ)

Concern: Energy transfer accounting





Psi-Value = 0.410 Btu/hr.ft.F

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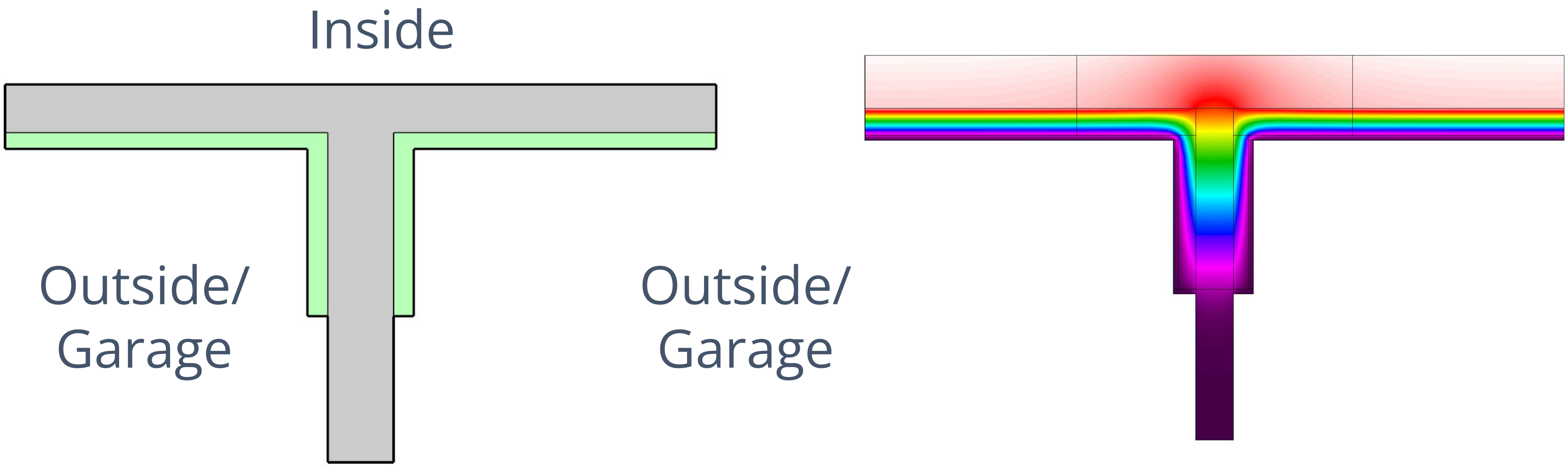
Garage Level Walls to Cond. Space (Plan)

Potential Mitigation Strategies:

Extend insulation down both faces of wall (similar to slide 14), lengthening heat transfer path



Psi-Value = 0.165 Btu/hr.ft.F

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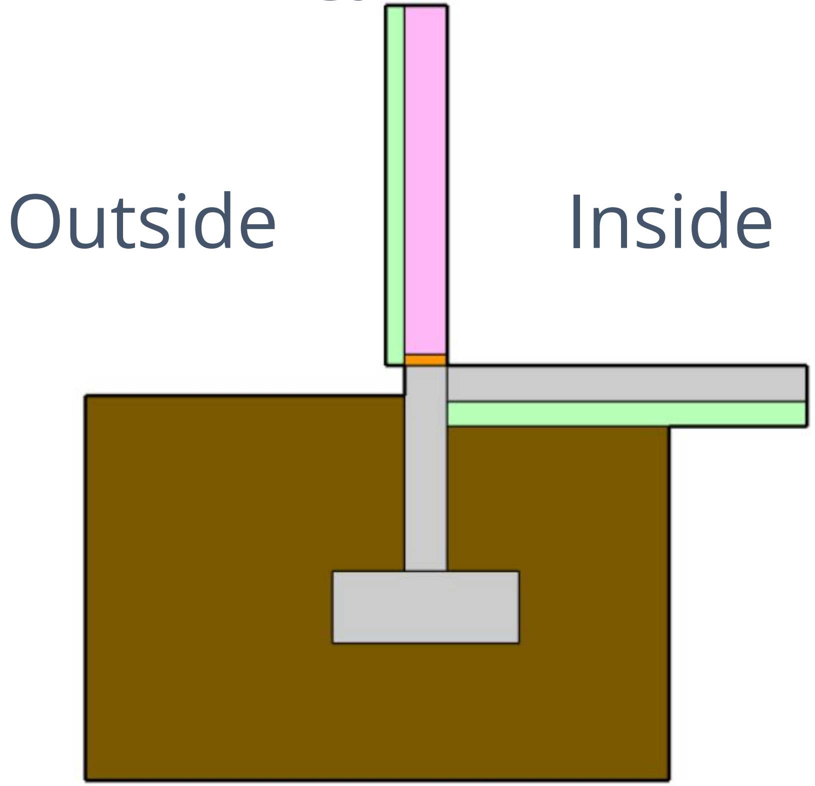
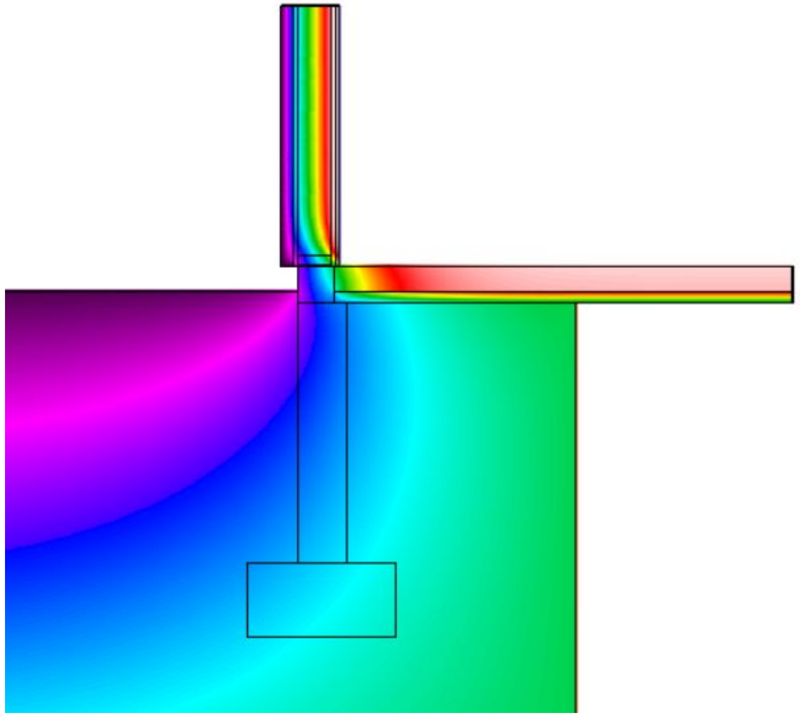
Footings (perimeter)

Type: Construction Material

- Linear (Ψ)

Concern: Energy transfer accounting, moisture risk



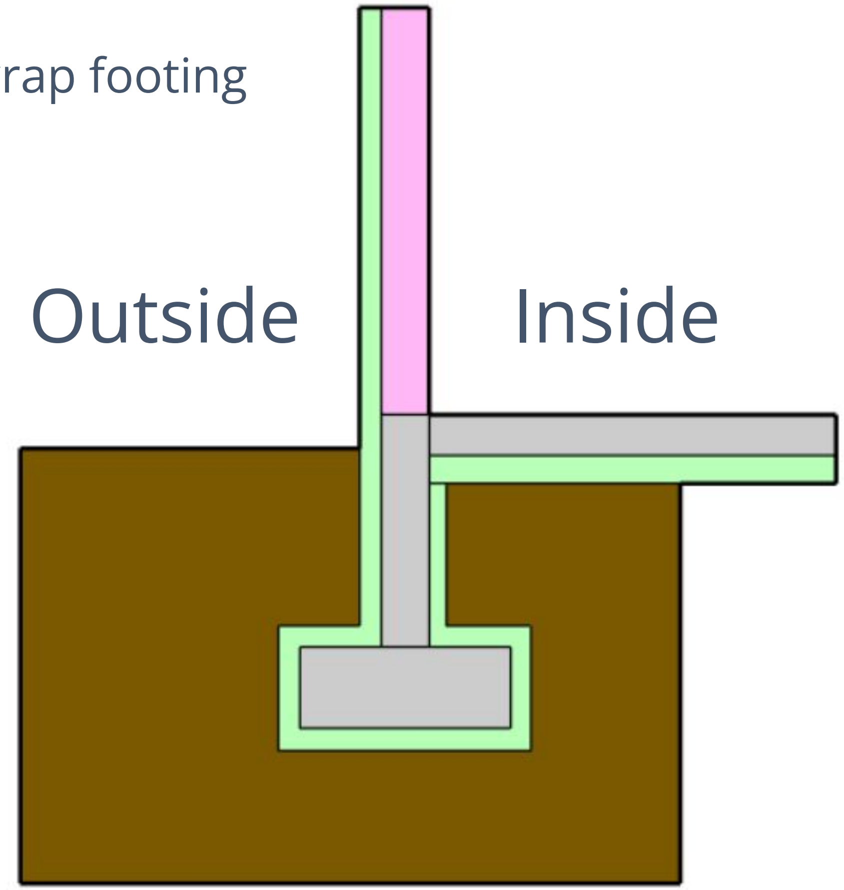


Psi-Value = 0.234 Btu/hr.ft.F

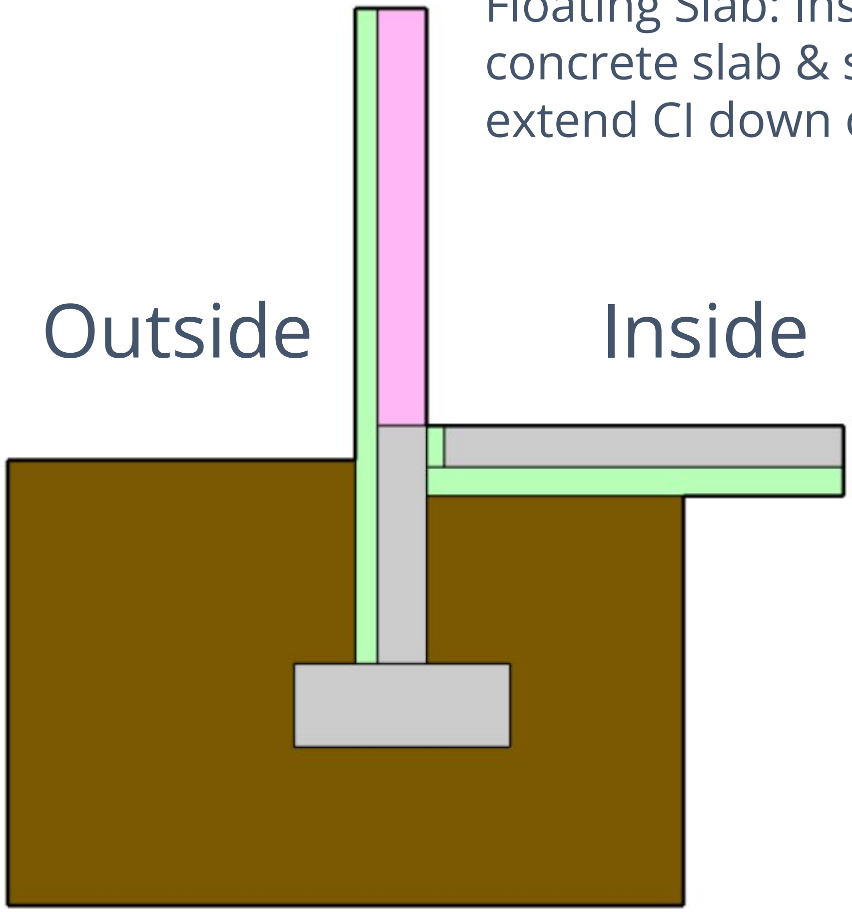
Footings (perimeter)

Potential Mitigation Strategies:

Fully wrap footing



Floating Slab: Insulate between concrete slab & stem wall & extend CI down outer face



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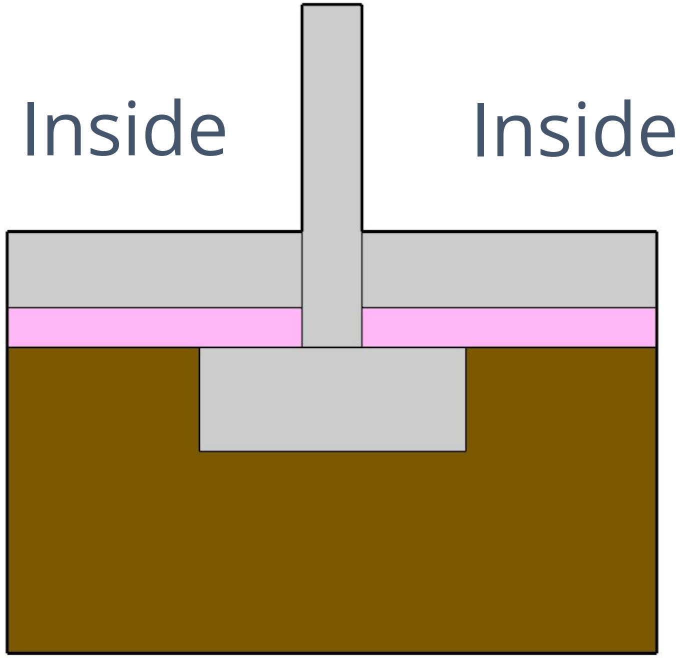
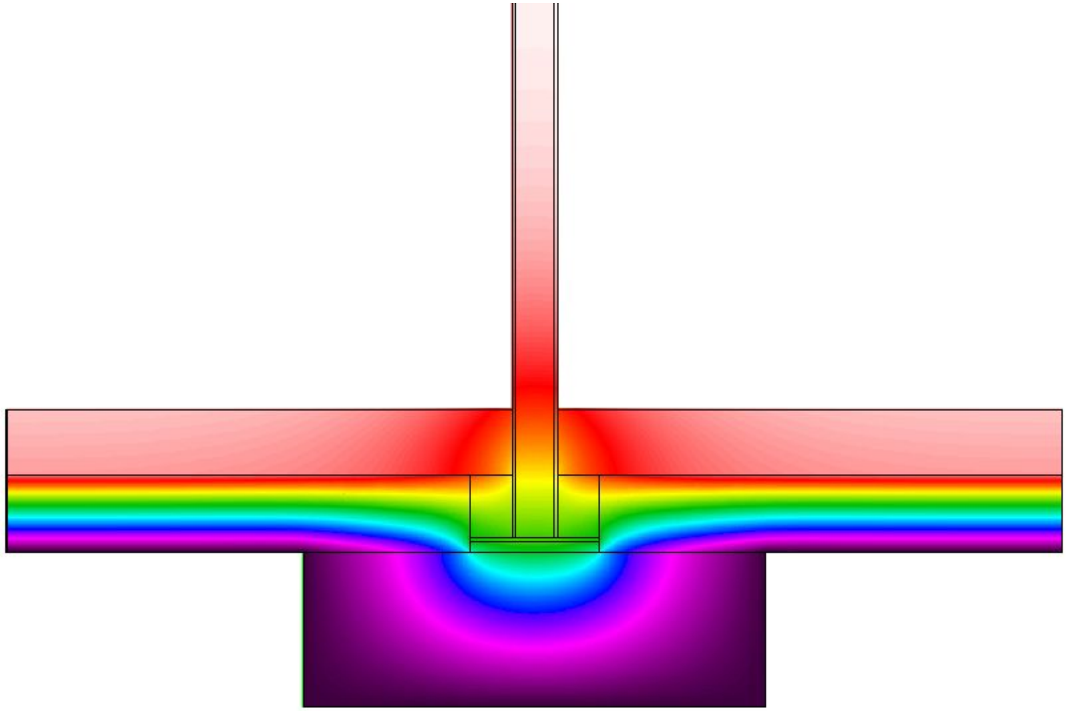
Footings (interior, column)

Type: Construction Material

- Linear (Ψ)

Concern: Energy transfer accounting





Psi-Value = 0.424 Btu/hr.ft.F

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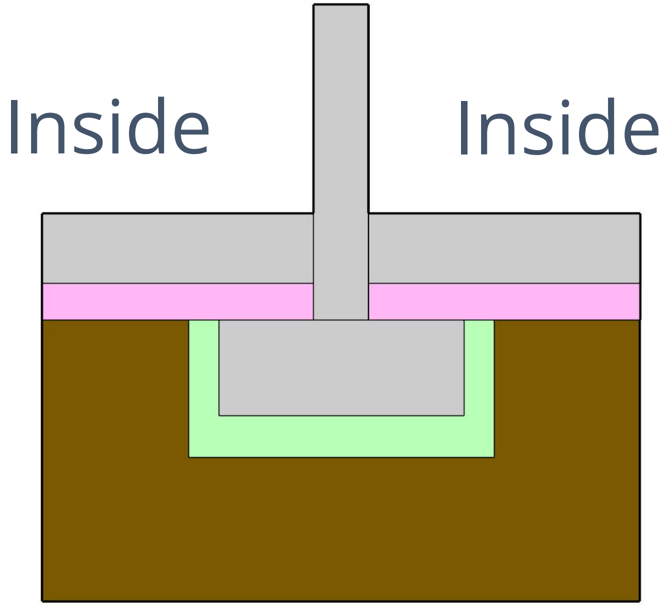
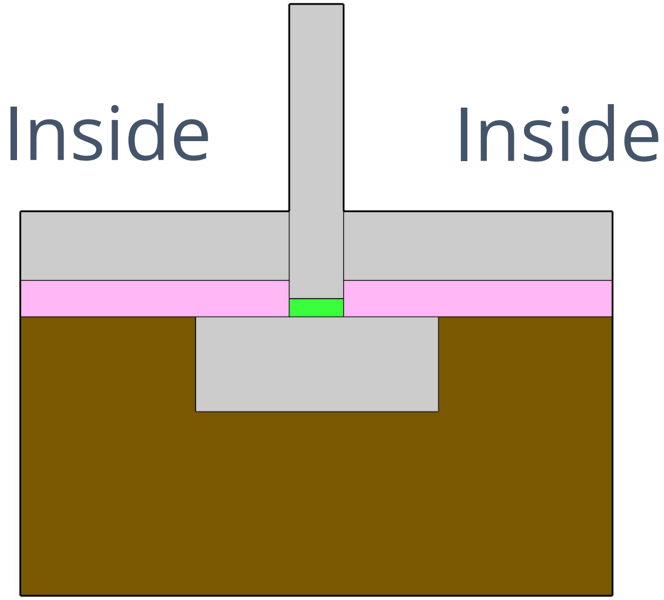
Footings (interior, column)

Potential Mitigation Strategies:

Fully wrap footing



Thermal break pad between column and grade beam



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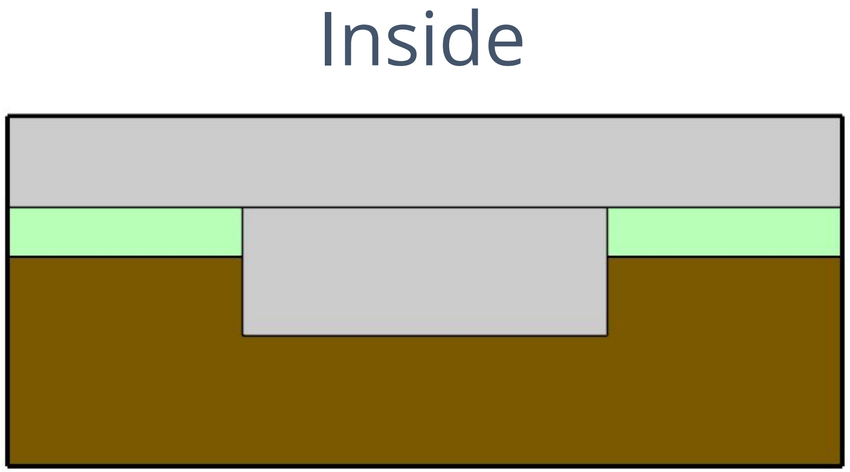
Grade Beams

Type: Construction Material

- Linear (Ψ)

Concern: Energy transfer accounting

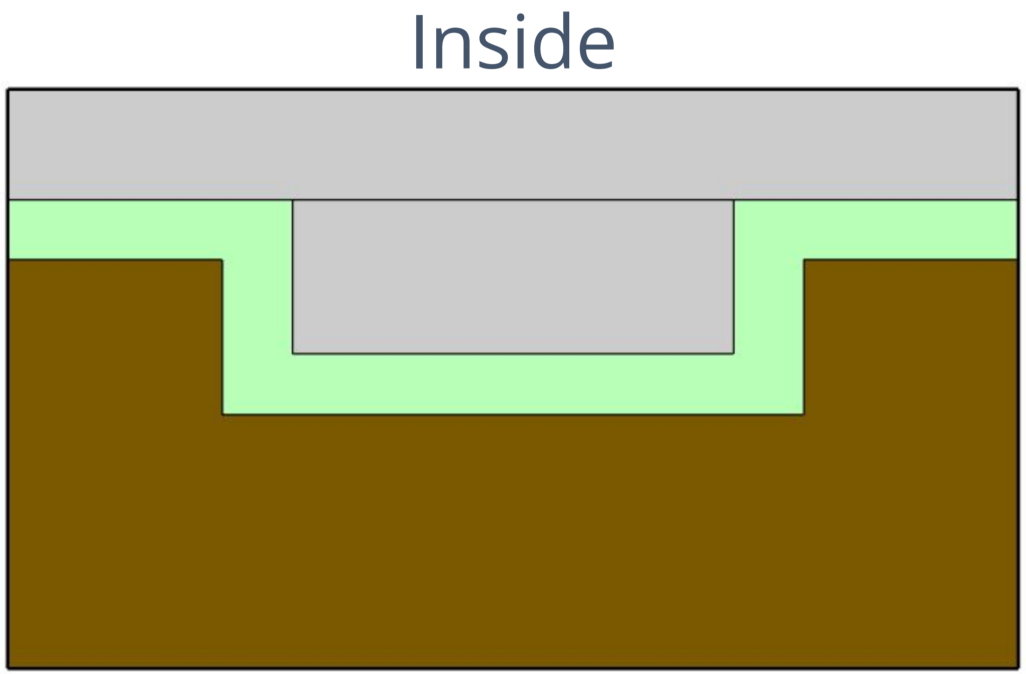


Psi-Value = 0.030 Btu/hr.ft.F

Grade Beams

Potential Mitigation Strategies:

Fully wrap grade beam



Do an independent THERM study to see how much insulation it takes to mitigate!

Dimensions of Grade Beam Concrete		Insulation Thickness (in)	Psi-value
Width (in)	Depth (in)		
24	1	2	-0.004
	2		0.001
	5		0.030
	10		0.073
	20		0.133
	1	4	-0.005
	2		-0.004
	5		0.009
	10		0.04
	20		0.092

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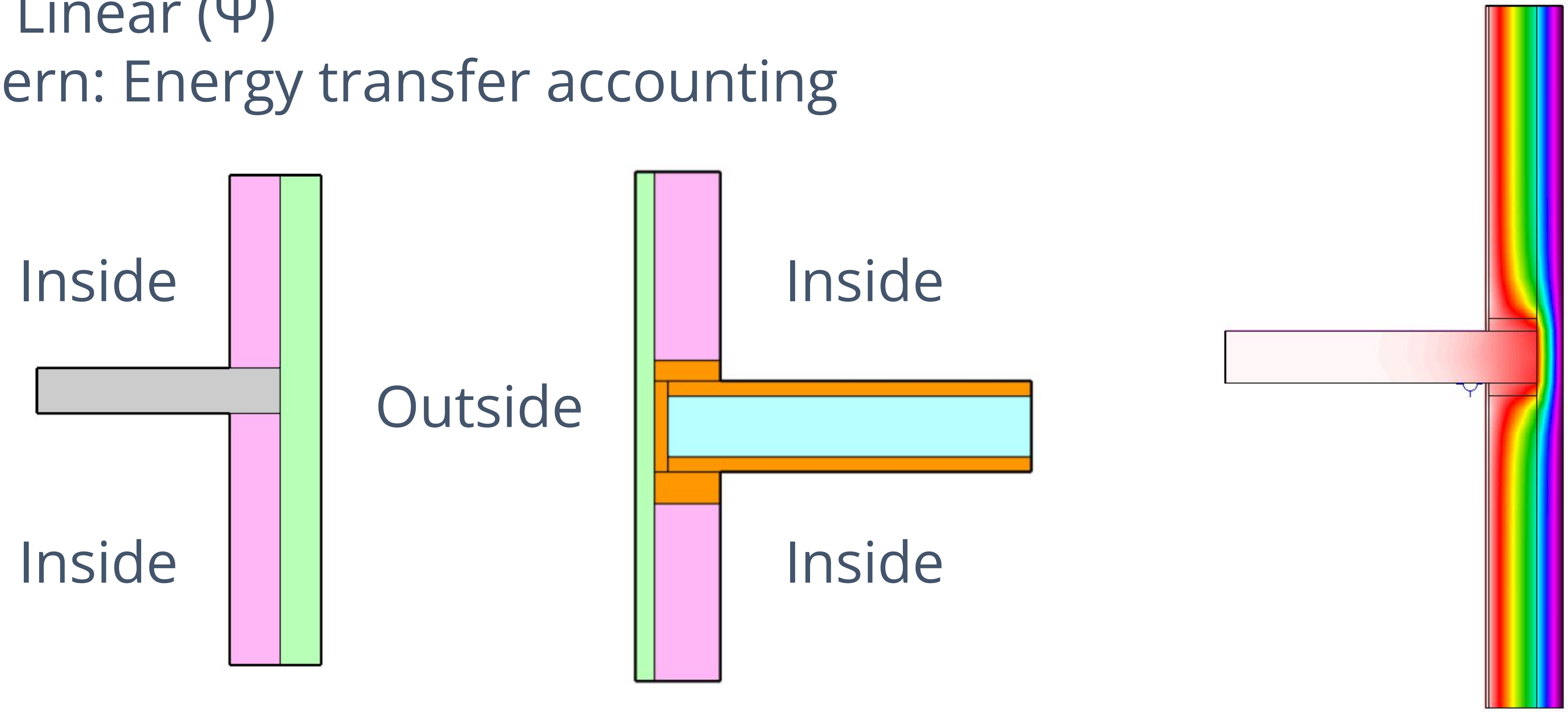
Floor Transition ("rim joist")

Type: Construction Material
- Linear (Ψ)

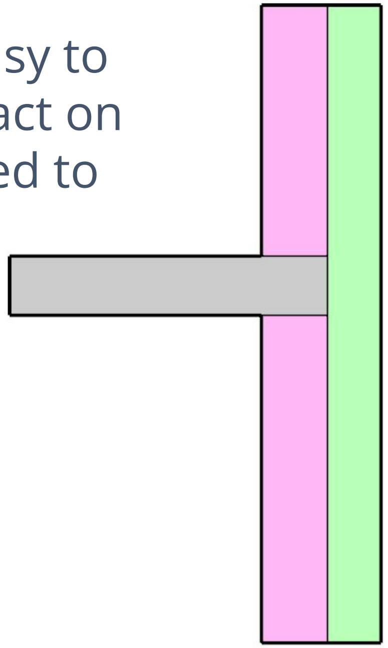
Concern: Energy transfer accounting



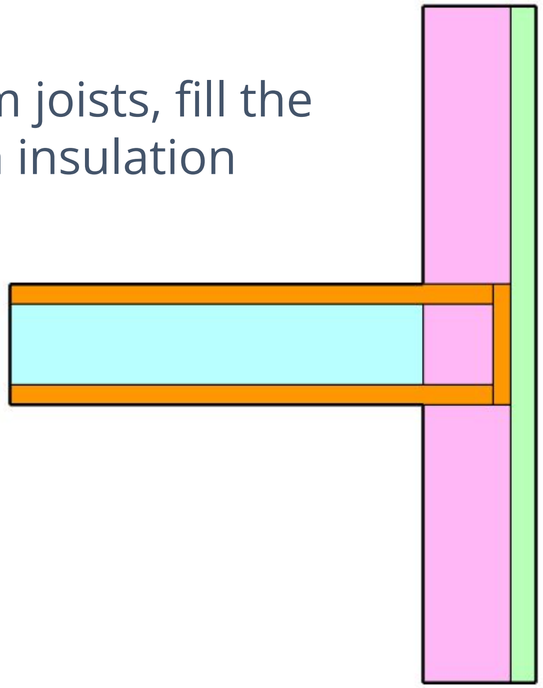
Floor Transition ("rim joist")

Potential Mitigation Strategies:

Concrete slab edges not easy to mitigate. Typically low impact on large buildings, but still need to account for it



In wood-framed rim joists, fill the rim joist cavity with insulation



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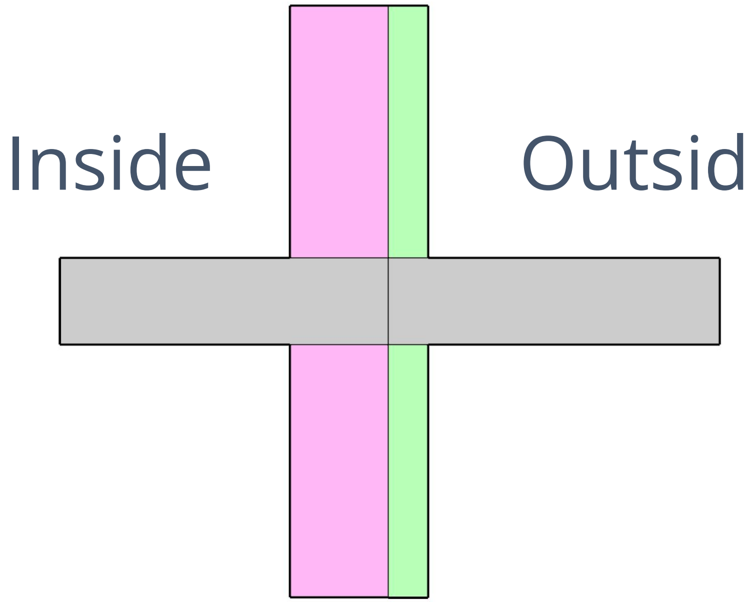
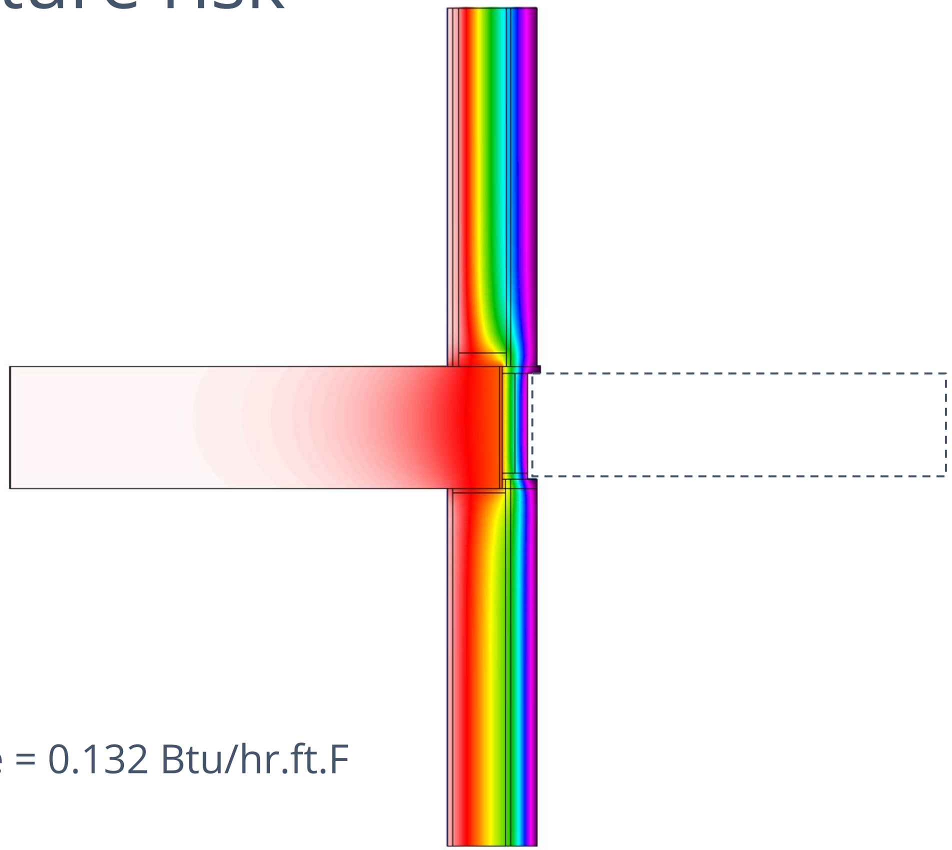
Canopies/Overhangs/Balconies

Type: Construction Material

- Linear (Ψ)

Concern: Energy transfer accounting & moisture risk



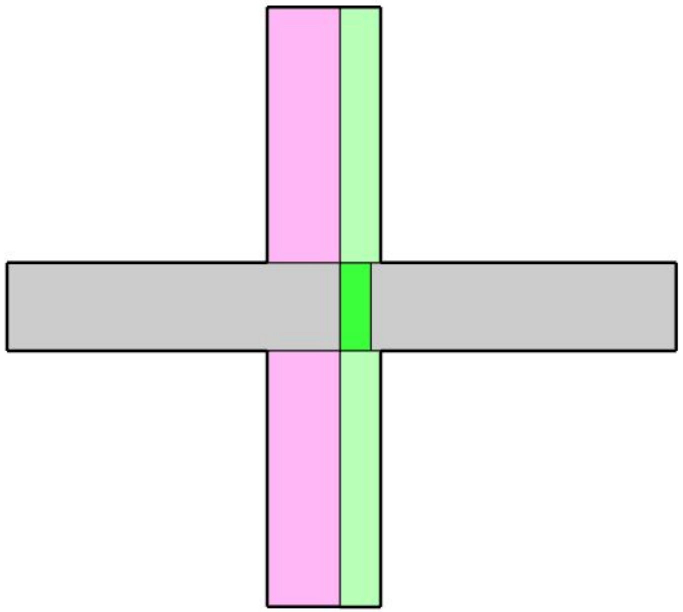


Psi-Value = 0.132 Btu/hr.ft.F

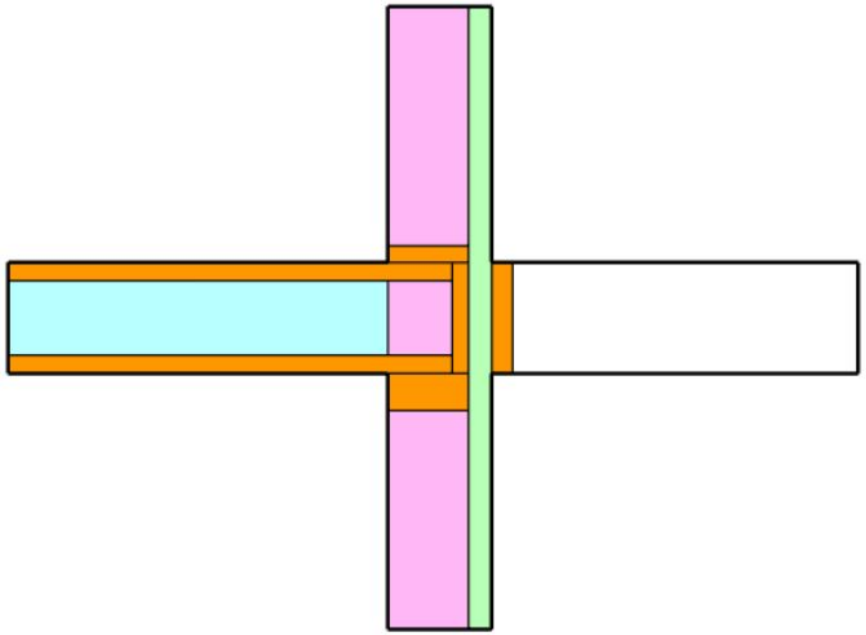
Canopies/Overhangs/Balconies

Potential Mitigation Strategies:

Add thermal break at attachment location. This will reduce the psi-value but may not fully eliminate the thermal bridge



Install ledger board outboard of CI material, fill joist cavity



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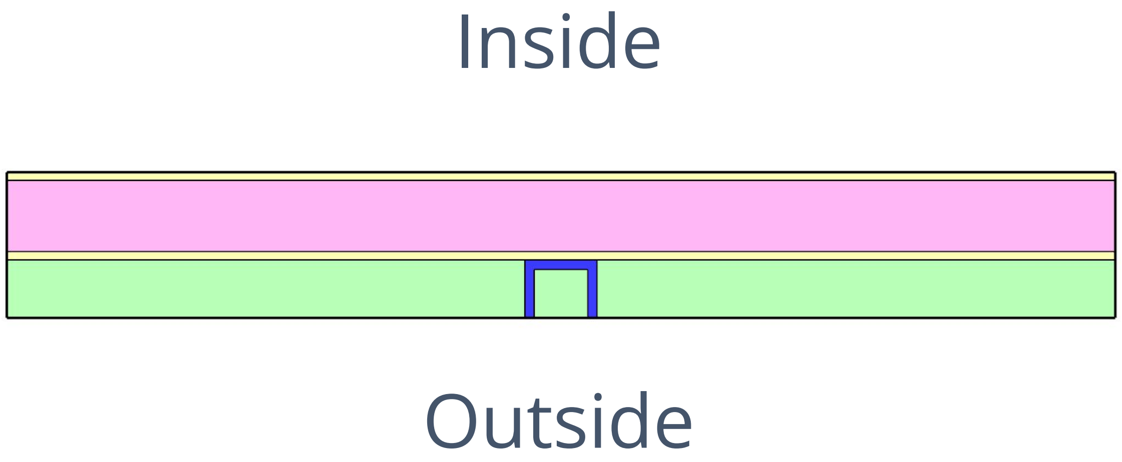
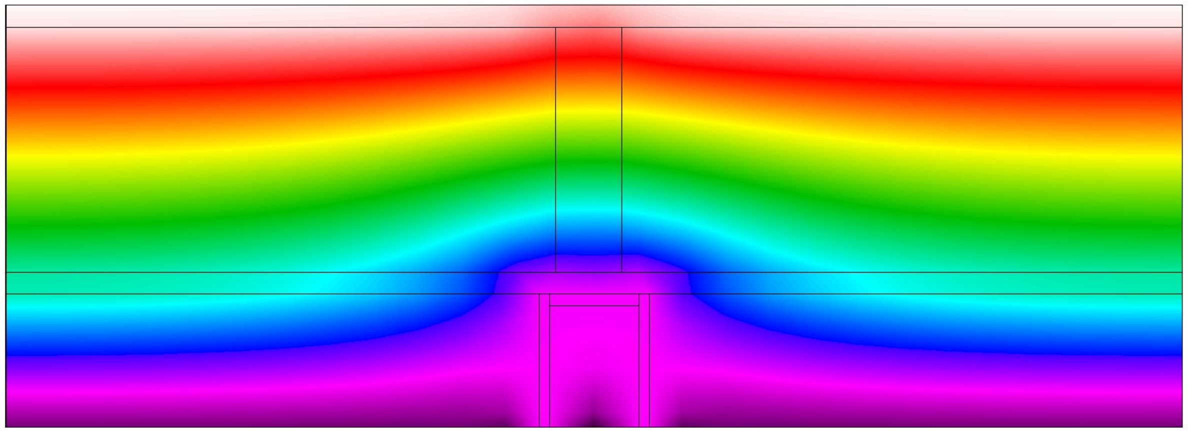
Knife Plates / Cladding Attachments

Type: Construction Material

- Point (X)

Concern: Energy transfer accounting

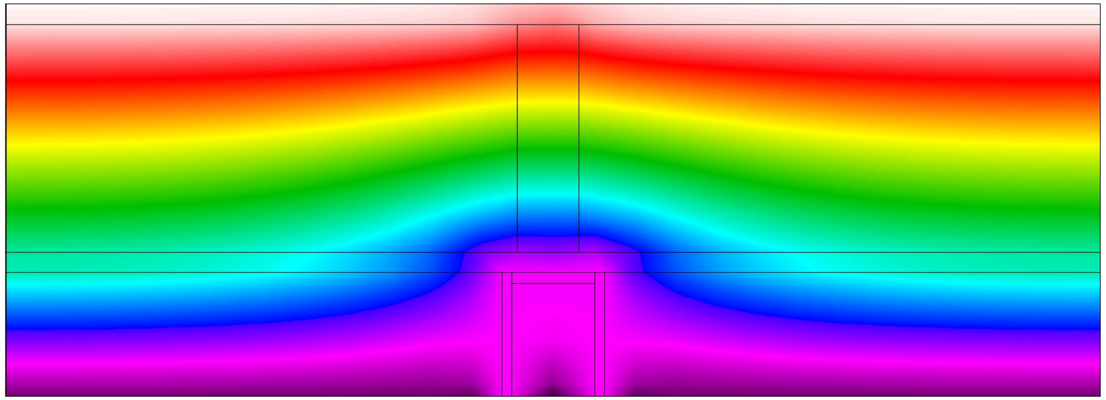




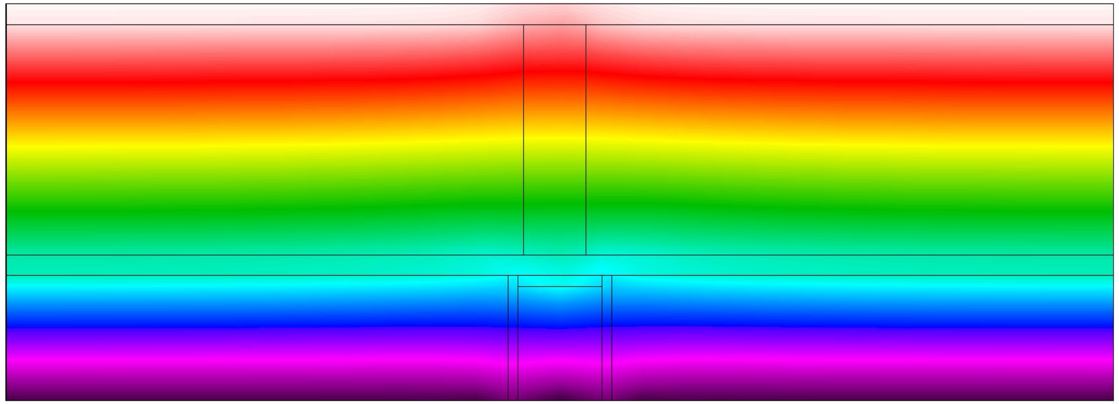
Knife Plates / Cladding Attachments

Potential Mitigation Strategies:

- Low(er) conductivity materials (fiberglass or stainless steel)
  - This will reduce the psi-value but may not fully eliminate the thermal bridge



Steel



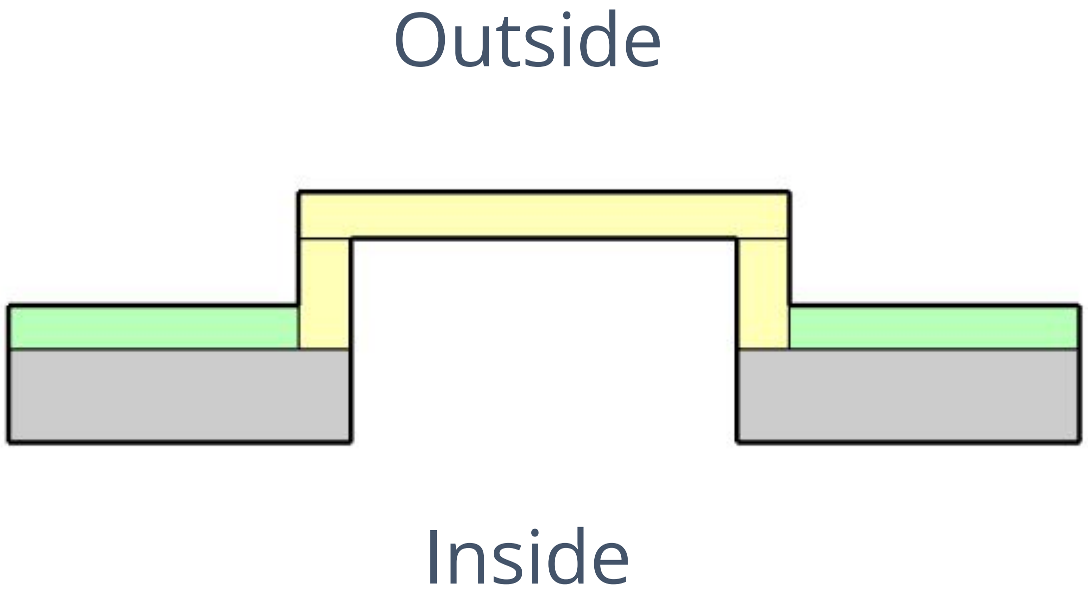
Fiberglass

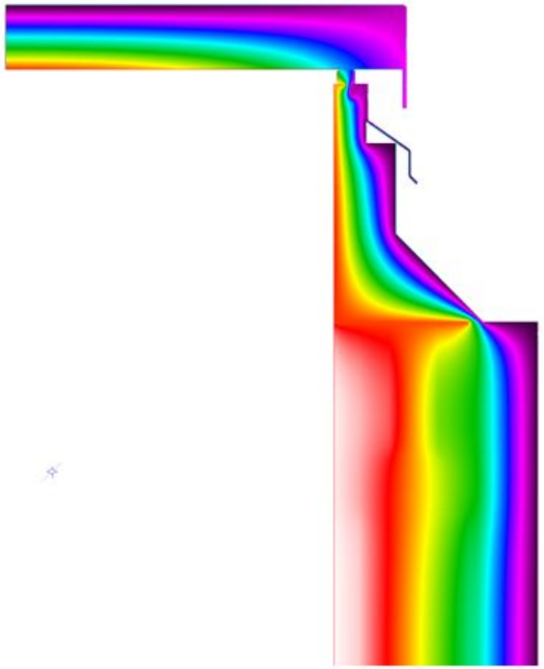
Roof Hatches

Type: Geometric

- Linear (Ψ)

Concern: Energy transfer accounting





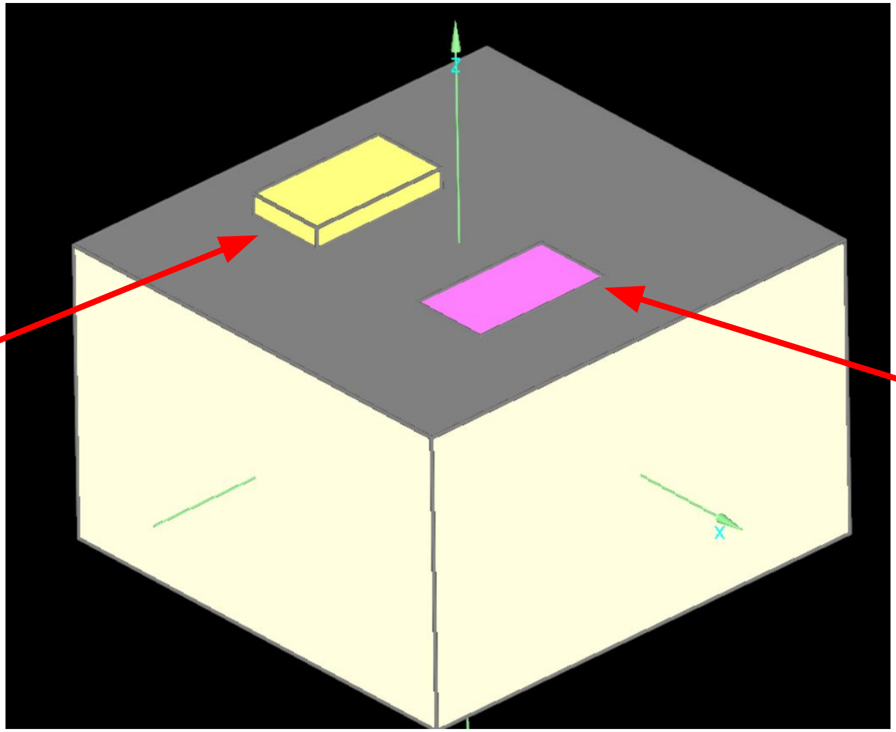
Roof Hatches

Potential Mitigation Strategies:

- n/a

Acceptable modeling approaches for roof hatches & curbs:

Model the curb wall + hatch directly in building geometry



Model flush with roof geometry + calculate geometric thermal bridge, enter a linear TB in WUFI/METr

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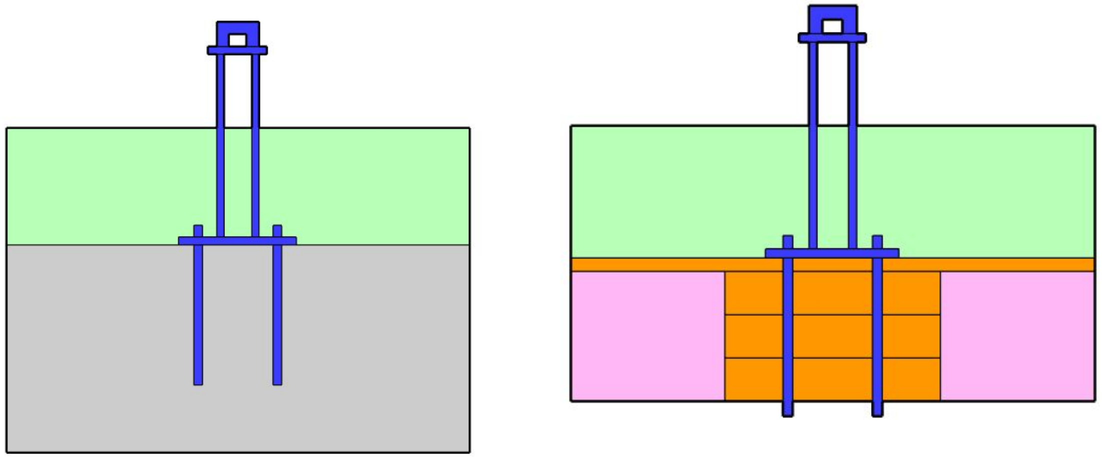
Roof Anchors and Posts or Fences

Type: Construction Material

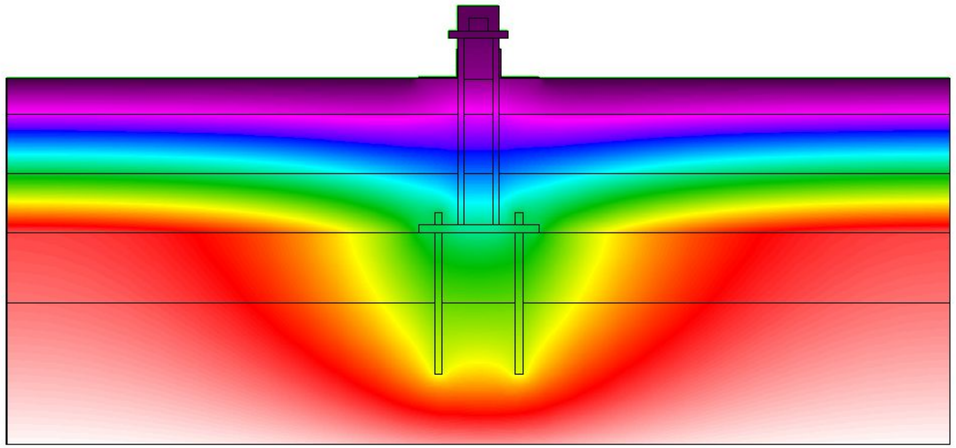
- Point (X)

Concern: Energy transfer accounting & moisture risk

Outside



Inside



Psi-Value = 0.316 Btu/hr.ft.F

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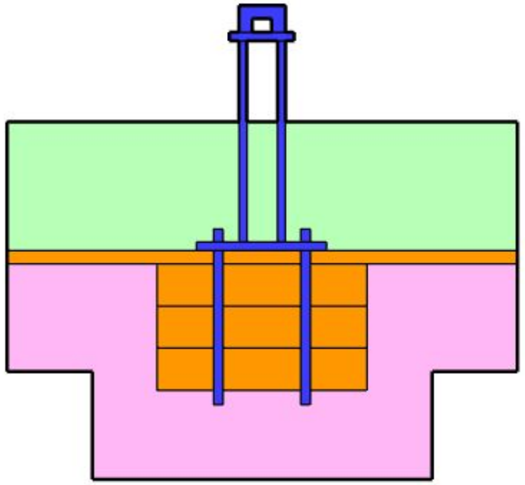
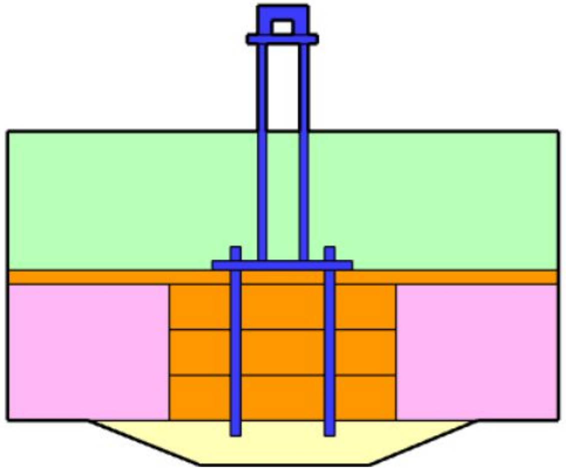
Roof Anchors and Posts or Fences

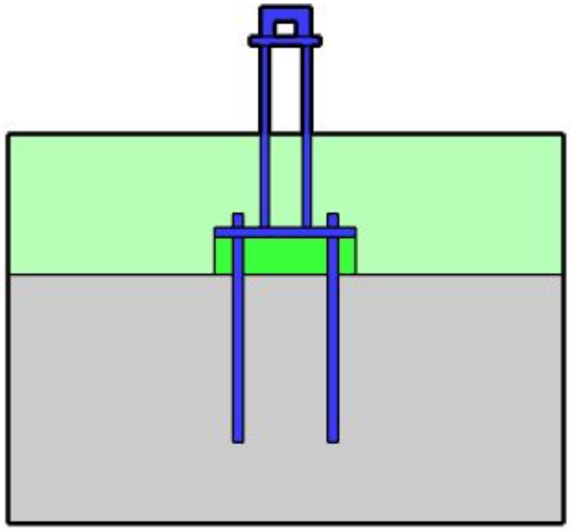
Potential Mitigation Strategies:

Increase insulation under attachment/spray foam bolts





Add thermal break at attachment location

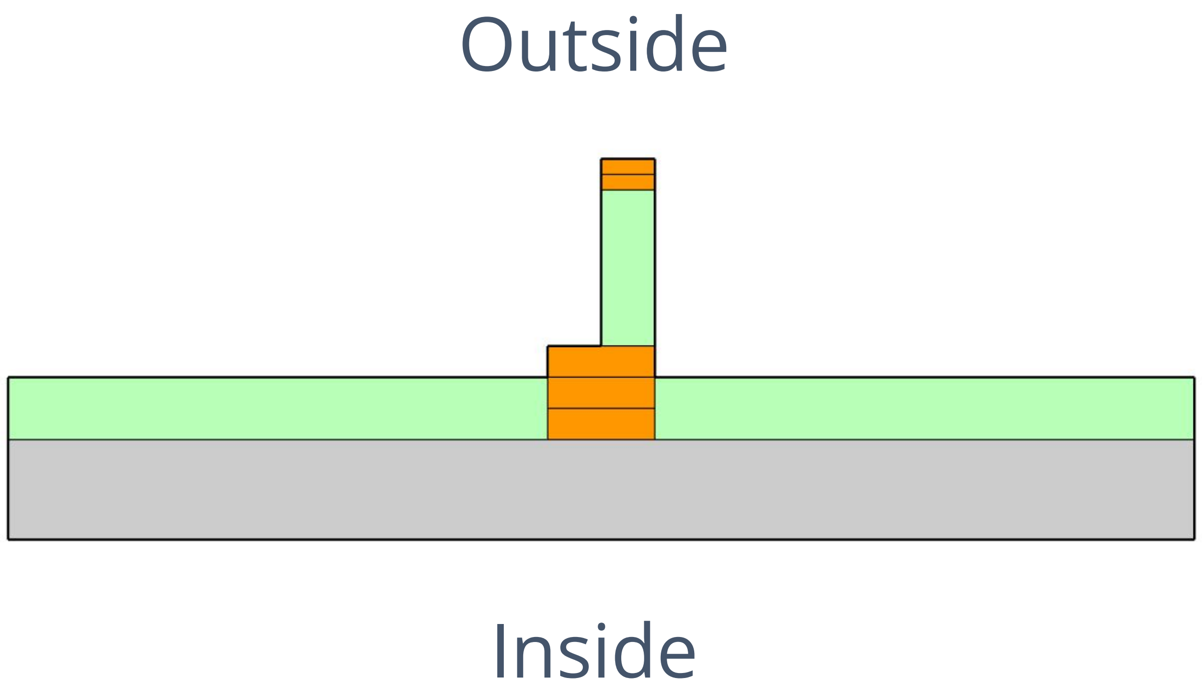


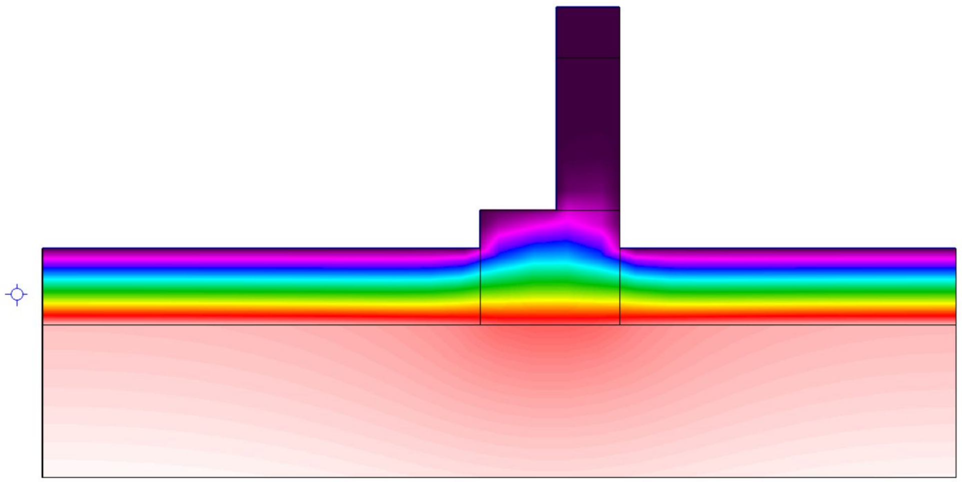
Mechanical System Curbs

Type: Construction Material

- Linear (Ψ)

Concern: Energy transfer accounting, moisture risk

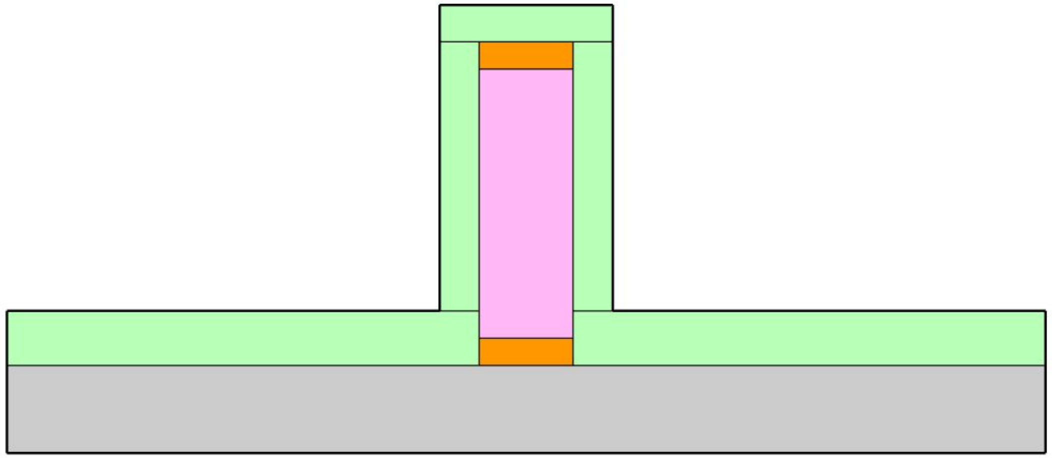




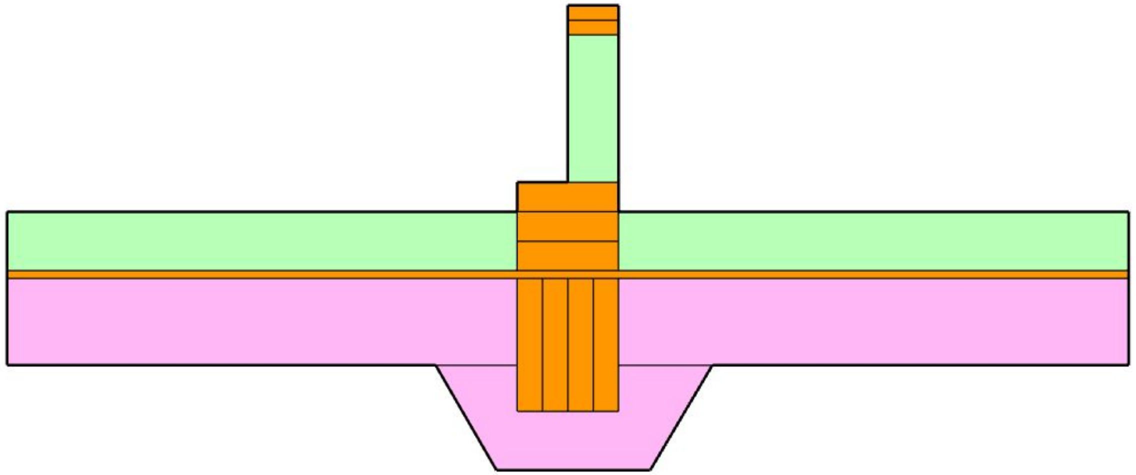
Mechanical System Curbs

Potential Mitigation Strategies:

Wrap outside with CI and insulate within curb cavity



Increase insulation around interior structure at attachment



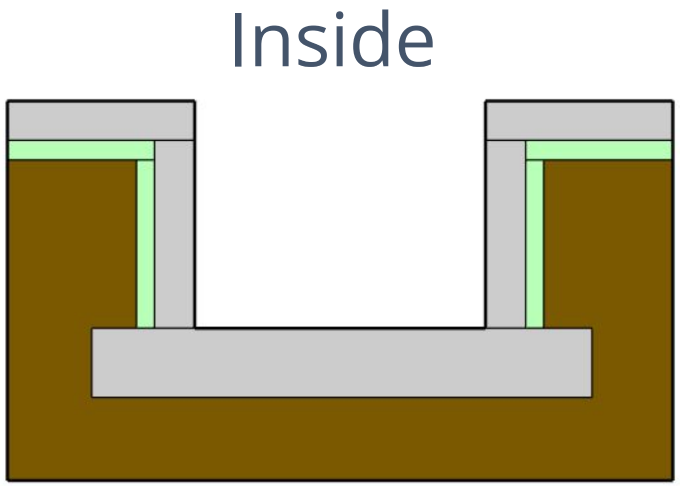
Neutral / Negative Thermal Bridges

Elevator Pit

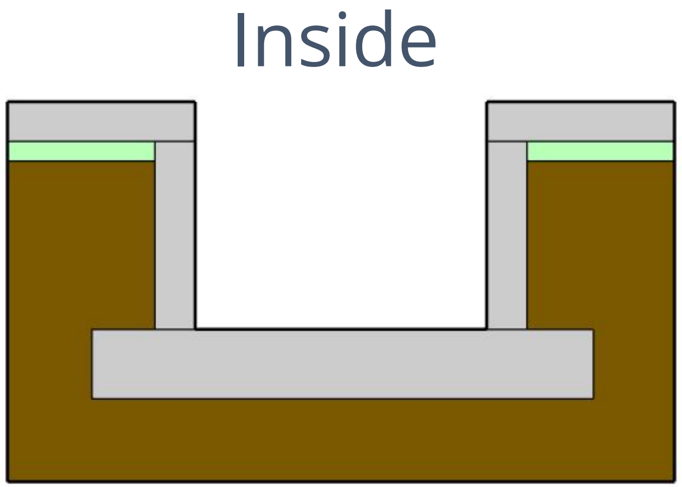
Type: Geometric

- Linear (Ψ)

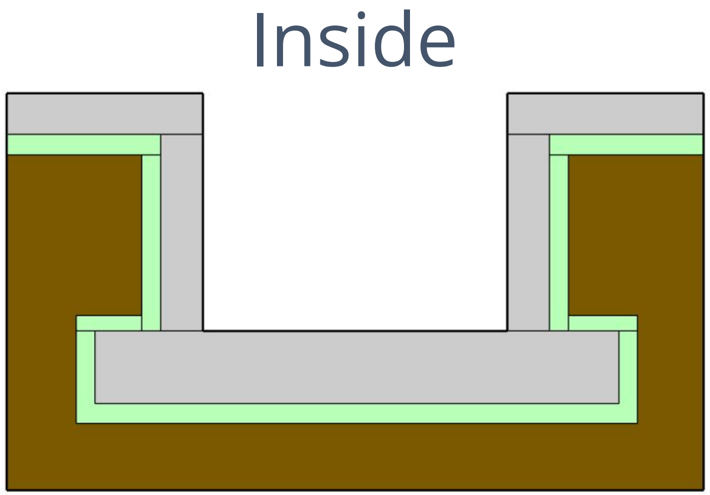
Concern: Model correctly in WUFI Passive / MEtr



- Main Slab: Insulated assembly
- Pit Walls: Insulated assembly
- Pit Slab: Uninsulated concrete



- Main Slab: Insulated assembly
- Pit Walls: Uninsulated concrete
- Pit Slab: Uninsulated concrete



- All: Insulated assembly

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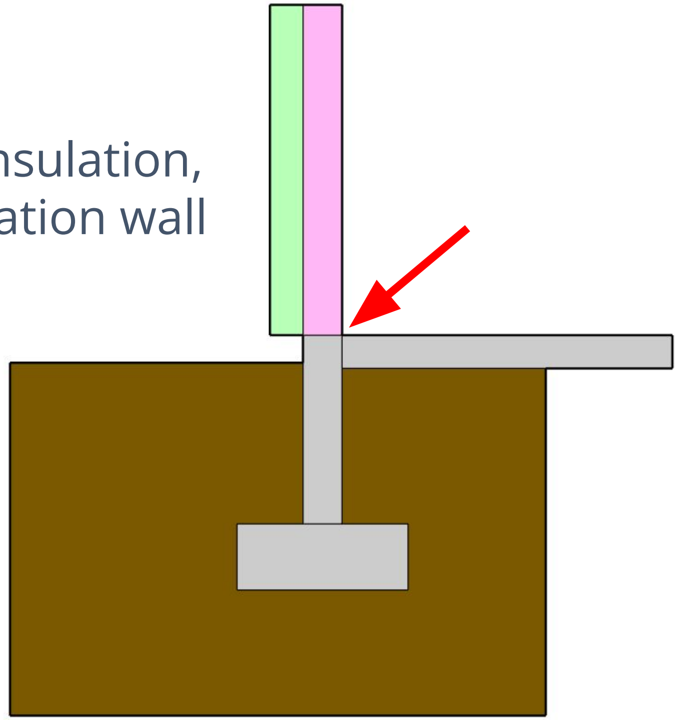
Uninsulated Slab

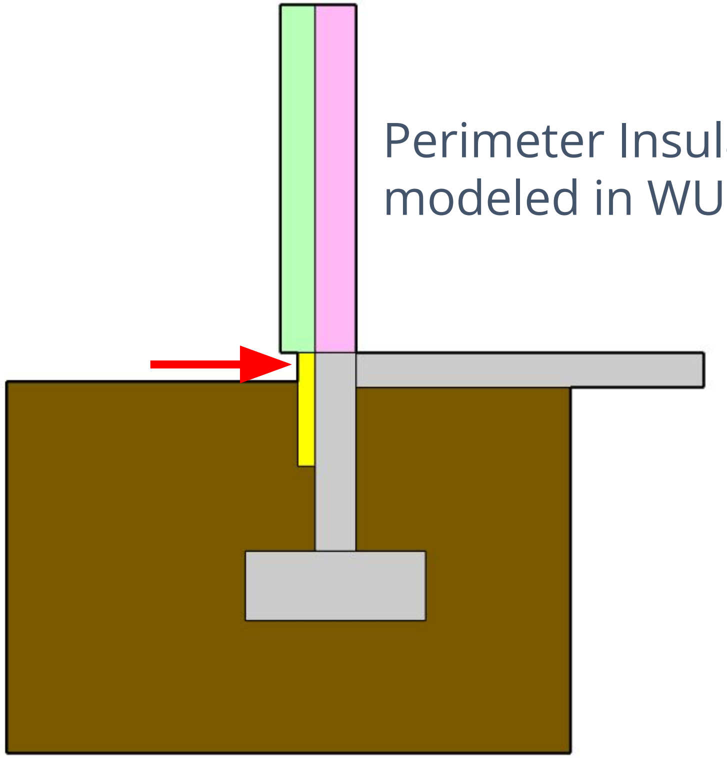
Type: Construction Material

- Linear (Ψ)

Concern: Moisture risk

No perimeter insulation, exposed foundation wall

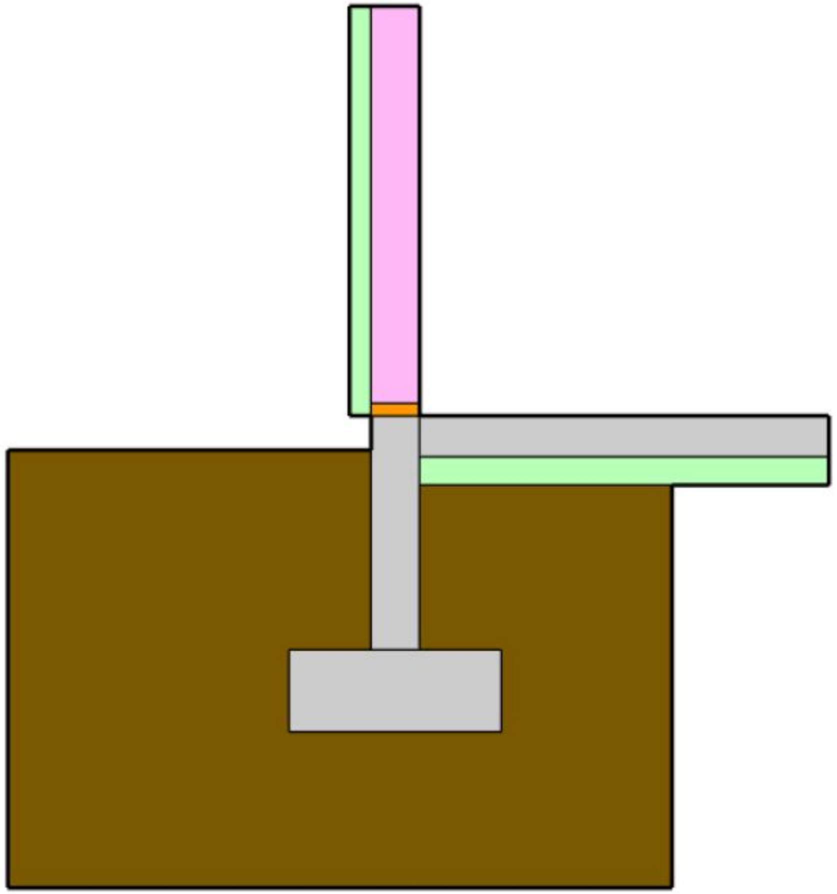


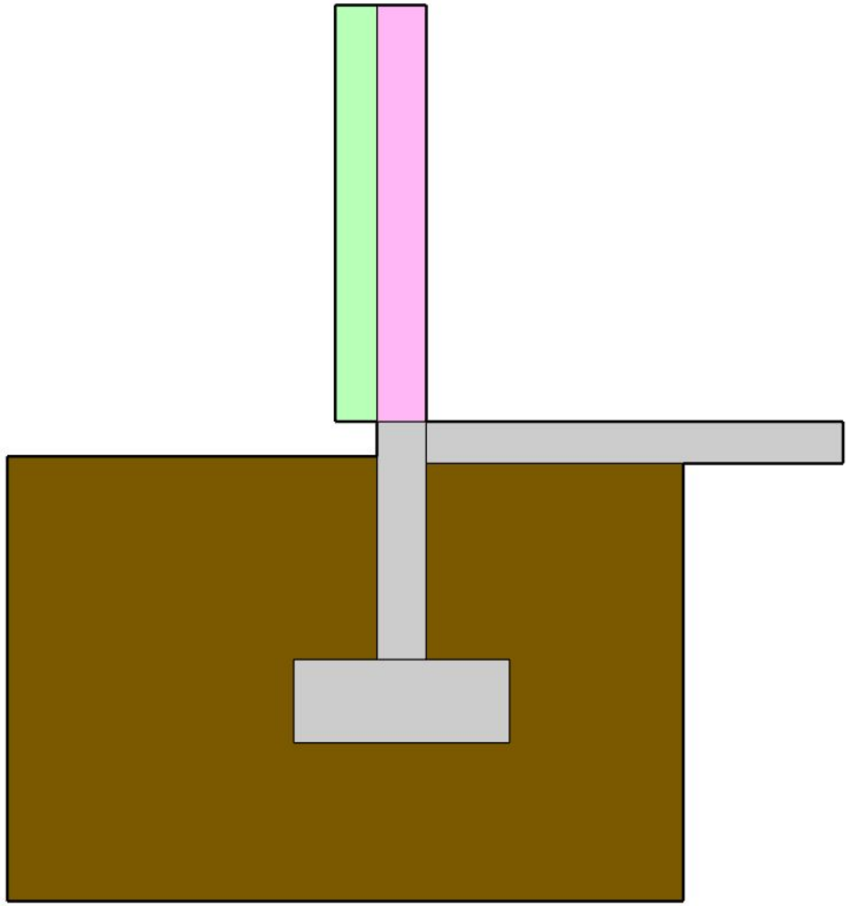


Perimeter Insulation may be modeled in WUFI/METr

Uninsulated Slab - Explanation

Why no concern with energy transfer for the detail on the right?





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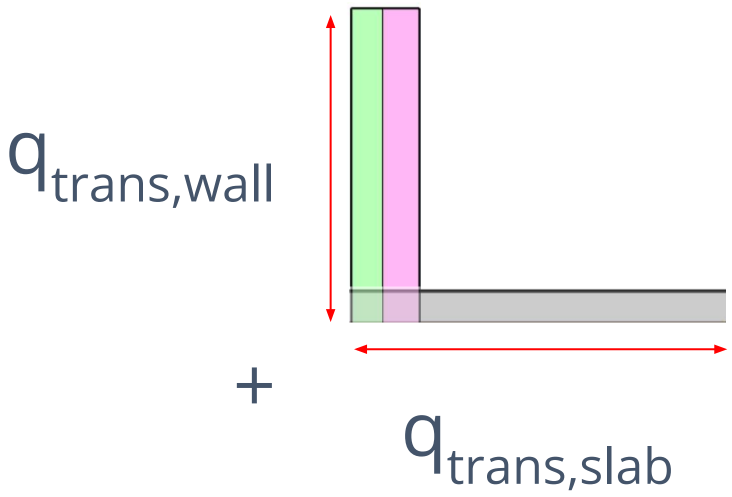
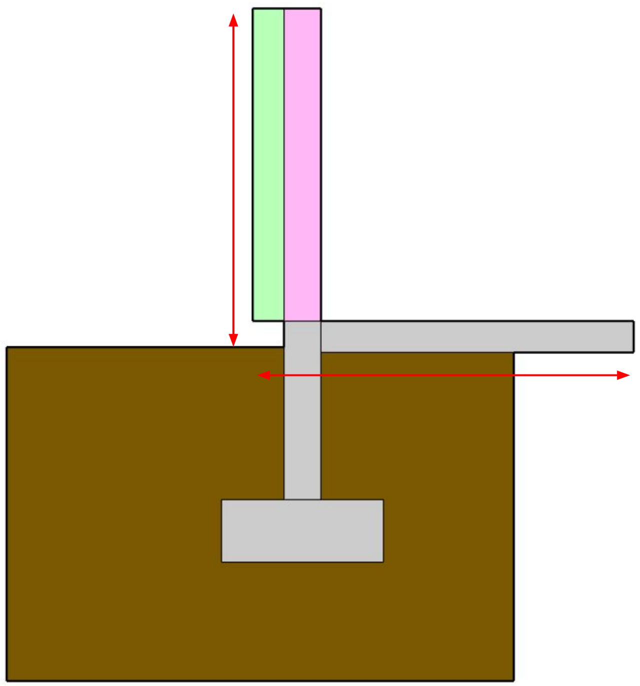
Uninsulated Slab - Explanation

WUFI Passive & METr conservatively accounts for the energy transfer of the uninsulated slab with energy transmission equation built into the software: $q_{trans} = q_{trans,wall} + q_{trans,slab}$





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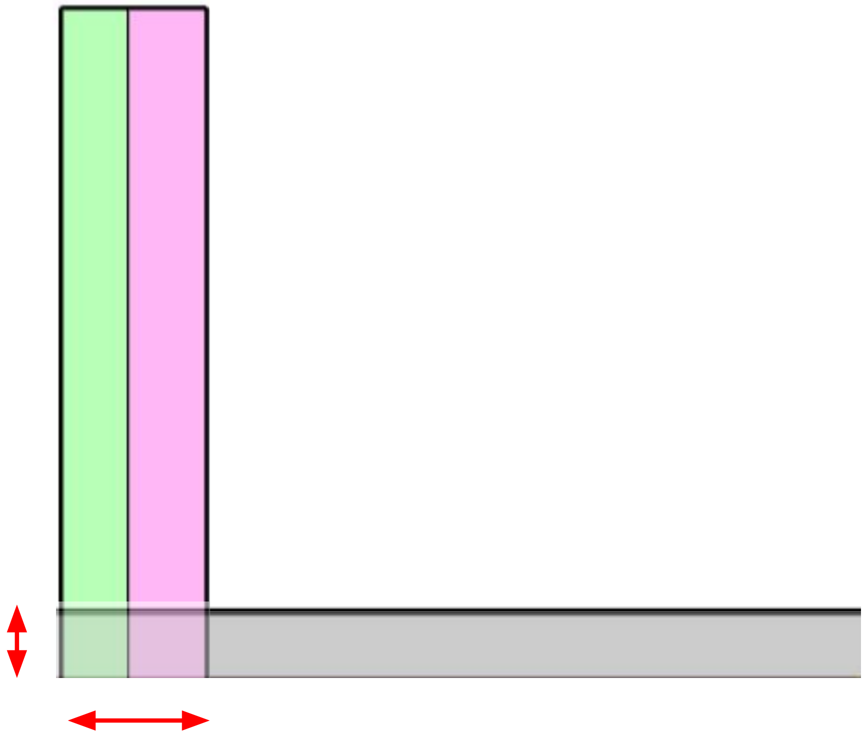
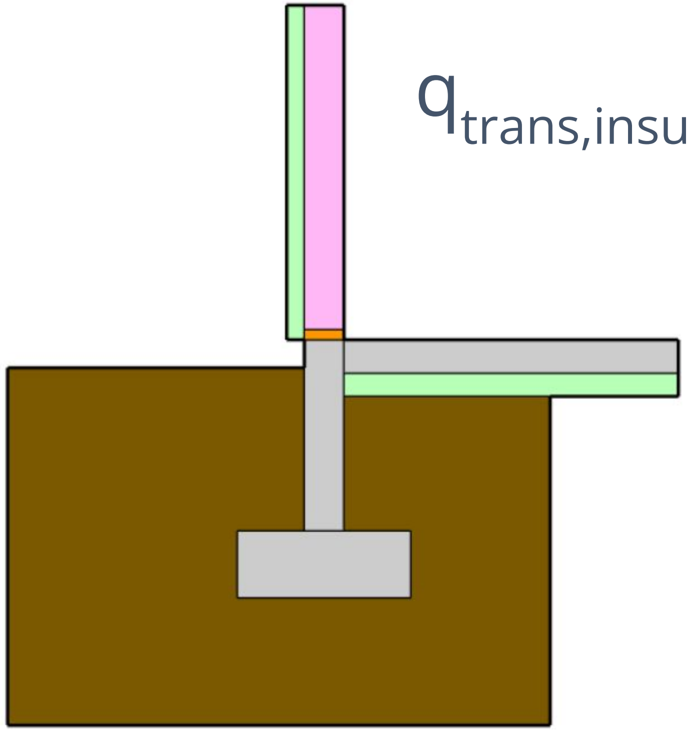
Uninsulated Slab - Explanation

Calculating a psi-value for this condition will always result in a negative or neutral thermal bridge due to the double-counted area at the corner where the wall and slab edge meet.

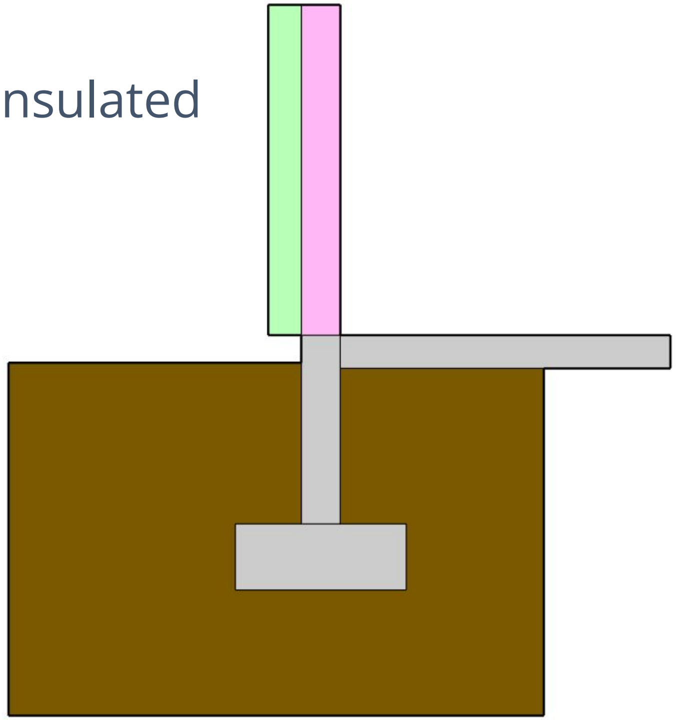


Uninsulated Slab - Explanation

An insulated slab + thermal bridge will still have less energy transfer than an uninsulated slab.

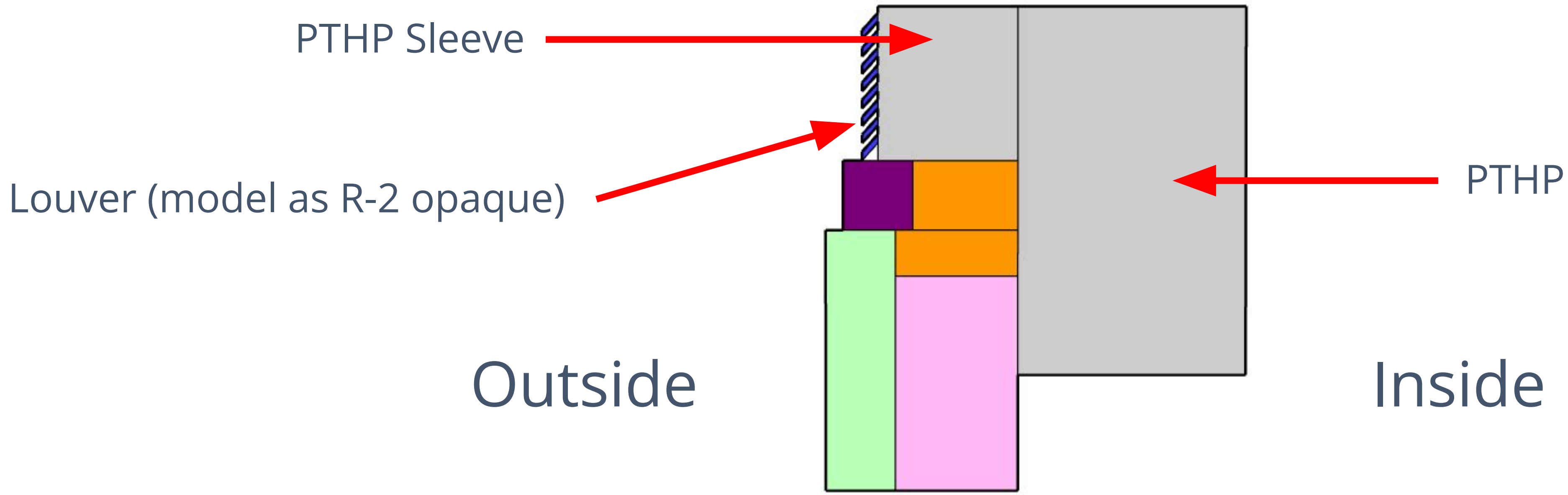


$$q_{trans,insulated} + \Psi_{perimeter} \leq q_{trans,uninsulated}$$



PTAC Units

- No longer requiring TB model.
  - Model in WUFI/METr as generic R-2 opaque assembly
- Not concerned with comfort or moisture risk **<u>if</u>** the through-wall unit does **both heating and cooling**



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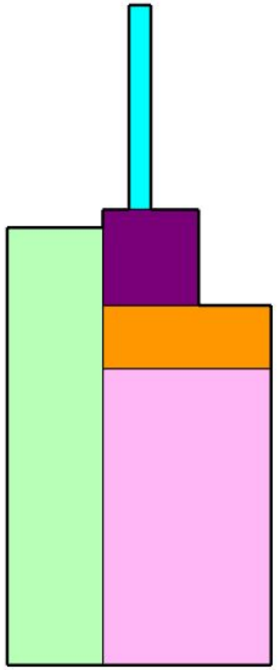
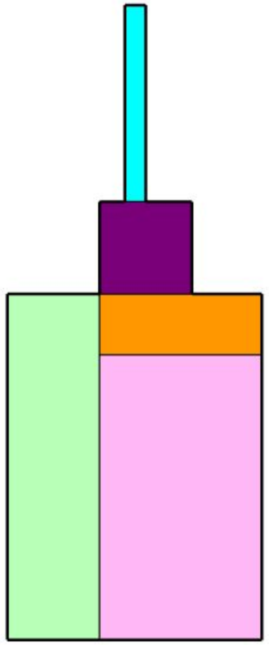
Window Psi-Install Defaults vs Calculations

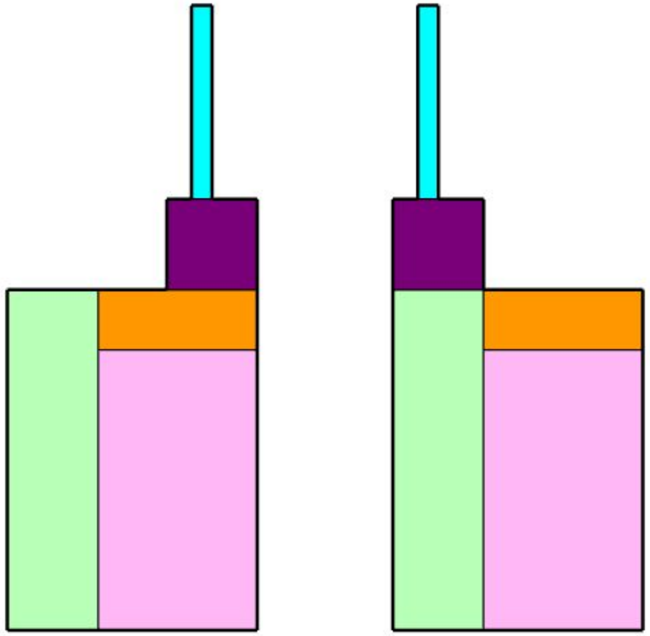
Best --► Worst



Mid Mounted + Over Insulated
Psi-Install = 0.015 Btu/hr.ft.F



Mid Mounted
Psi-Install = 0.02 Btu/hr.ft.F



Outer/Inner Mounted
Psi-Install = 0.03 Btu/hr.ft.F

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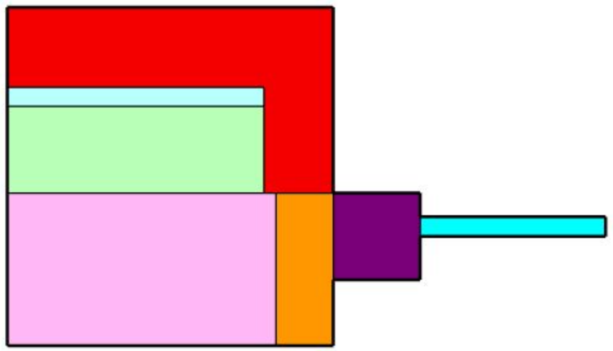
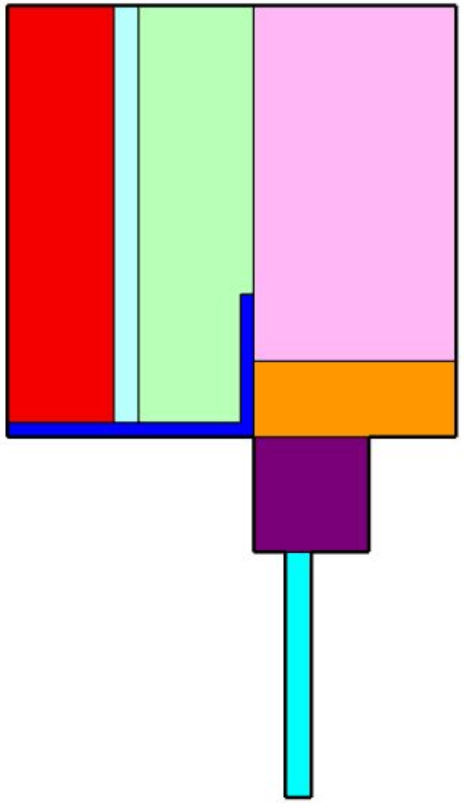
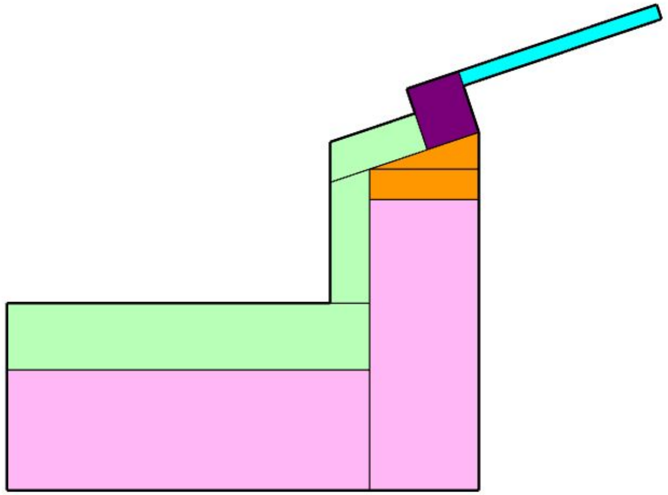
Window Psi-Install Defaults vs Calculations



Brick Returns
(typically in plan view)



Brick Relieving Angle
(typically at window header)



Skylights
Default Psi-Install = 0.06 Btu/hr.ft.F

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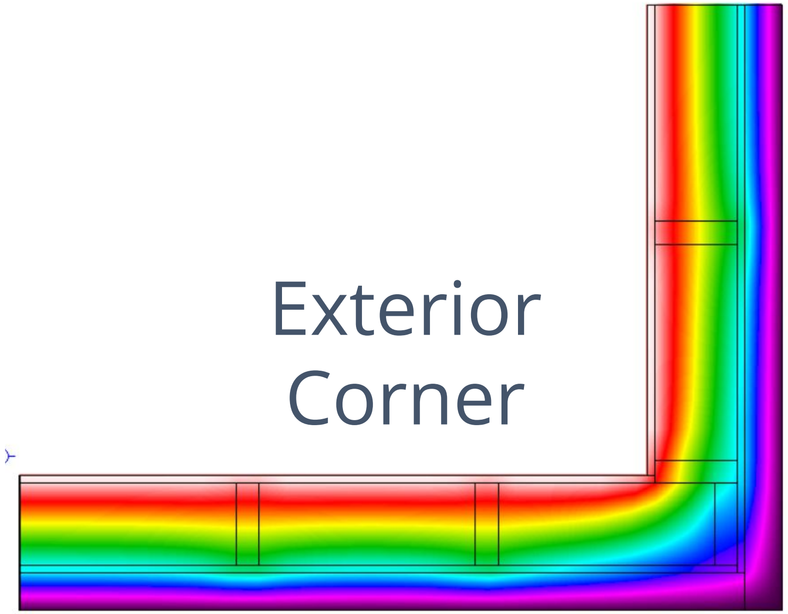
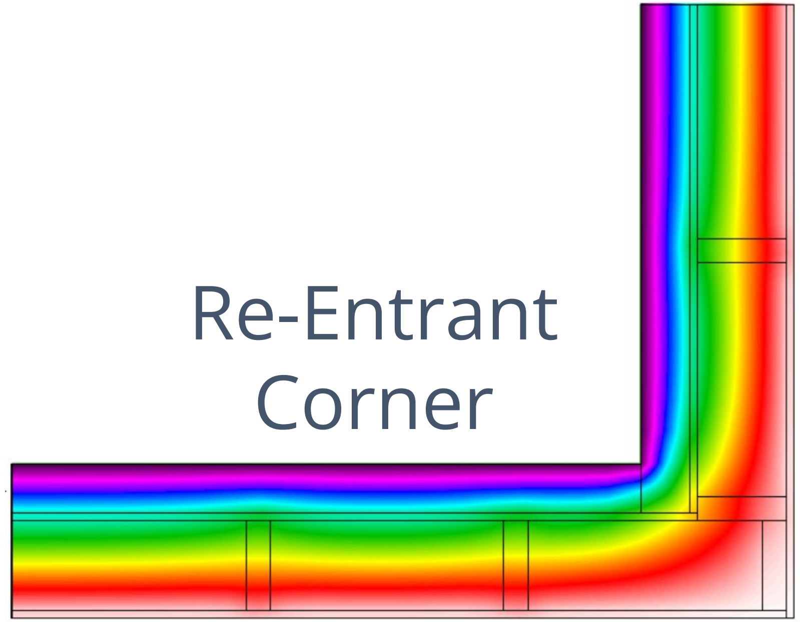
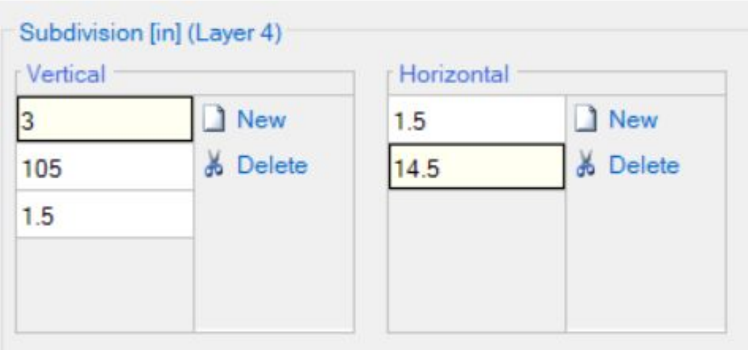
Exterior & Re-entrant (interior) Corners

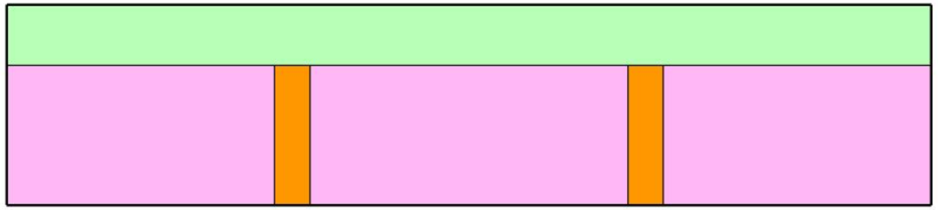
- Geometric thermal bridges like these are not a concern
  - Exterior corners (negative) and re-entrant corners (positive) typically cancel each other out



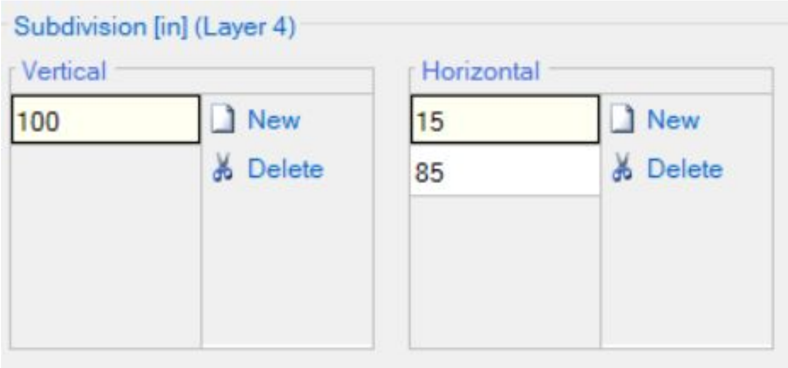


Wood Framing (studs)





<u>Typical On-Center Framing + CI</u>
Model using subdivision layers in WUFI/METr



<u>Typical On-Center Framing **NO** CI</u>
Model 25% (16” oc) or 15% (24” oc) framing factor in WUFI/METr using subdivision layers

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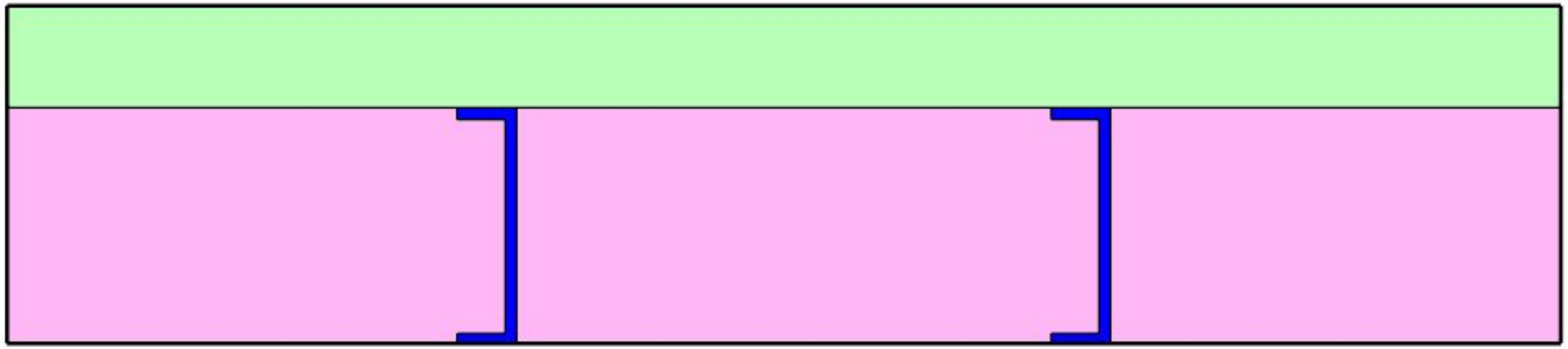
Metal Framing (studs)



<u>Metal Framing Deration Methods:</u> Choose one method below whenever metal framing is used.

Simple Method:

33% x R-value/in of the cavity insulation for 16” o.c. assemblies

39% x R-value/in of the cavity insulation for 24” o.c. assemblies

ASHRAE Method:

Apply a deration to the insulation layer containing metal framing in accordance with ASHRAE 90.1 Table A.

aka 67% deration (R/in * 0.33)

aka 61% deration (R/in * 0.39)

DO NOT Model steel framing using subdivision layers in WUFI/METr!

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Point Fasteners

Table I-3.1.0 Fastener Correction Derations		
Fastener Material	**Continuous Insulation Thickness**	**Deration Requirement**
Stainless Steel	<4"	Derate R/in by 10%
	≥4"	Derate R/in by 15%
Mild Steel	<4"	Derate R/in by 25%
	≥4"	Derate R/in by 35%
Plastic or Thermally Broken Z-Girts	Any	Derate R/in by 8%
Plastic or Thermally Broken Point Fasteners	No fastener correction required	
Aluminum	Fastener Correction Calculator required.	

OR

Phius Point Fastener Correction Calculator v26.1.0 (2026.01)			Instructions and Notes
			Required input cells / **Calculated**
			Required dropdown menu inputs / **Results**
Inputs for WUFI Passive or METr		**Units**	
Adjusted Insulation R-value per inch:	-	R-value/in [hr.ft².F/Btu.in]	**Adjusted thermal resistance per inch** of the insulation layer penetrated by point fasteners. (R-value/inch of the insulation should be adjusted in WUFI Passive to align with this value.)
Adjusted Insulation R-Value [$R1_a$]	-	R-value [hr.ft2.F/Btu]	Adjusted thermal resistance of the insulation layer containing point fasteners at the typical depth. (Informational)
Fastener Information		**Units**	
Recessed Fasteners?	< Select >	True or False	Choose 'True' if the point fasteners start below the surface of the exterior insulation if not, choose 'False'.
Fastener Material	< Select >		Input the material from which the point fastener is made and provide documentation to confirm.
Fastener Diameter [D_f]		Inches [in]	Nominal diameter of the point fastener.
Area of Fastener [A_f]	0.000	Square Inches [in²]	Cross sectional area of one point fastener. (For a screw, bolt or nail, this area is calculated using the diameter of the fastener. $A = \pi \times (D/2)^2$)
Density of Fasteners		**Units**	
Assembly Area		Square Feet [sf]	Area of assembly being assessed. (If a typical 4'x8' section of material is being analyzed, input 32 sf)
Fastener Count		Quantity	Number of point fasteners used in the area being assessed.
Fastener Density [nf]	-	Quantity/sf	Point fastener density based on the area of the assembly being assessed and the number of fasteners.
Assembly Information		**Units**	
Depth of Insulation [d0]		Inches [in]	Thickness of the insulation layer containing point fasteners.
Insulation R-value per inch		R-value/in [hr.ft².F/Btu.in]	Thermal resistance per inch of the insulation containing point fasteners.
Insulation R-Value [R1]	0.0	R-value [hr.ft2.F/Btu]	Thermal resistance of the insulation layer penetrated by the point fasteners. (Based on d1)
Depth of Fastener [d1]		Inches [in]	Length of the point fastener that penetrates the insulation layer. (d1 can be greater than the thickness of the insulation layer if the fastener passes through it at an angle.)
Homogenous R-Value [RTh]		R-value [hr.ft2.F/Btu]	Total thermal resistance of the assembly ignoring any thermal bridging. (The sum of the resistance layers, ignoring framing.)

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Common Misconceptions

Misconceptions

A thermal bridge will disqualify my project from certification.

Not Always

Many projects can accommodate some thermal bridging, but the magnitude of the thermal bridge (ie. psi/chi-value and length/quantity) are critical factors in determining if the space conditioning targets can be met.

Thermal bridges with potential moisture risk must be resolved to avoid disqualification from certification.

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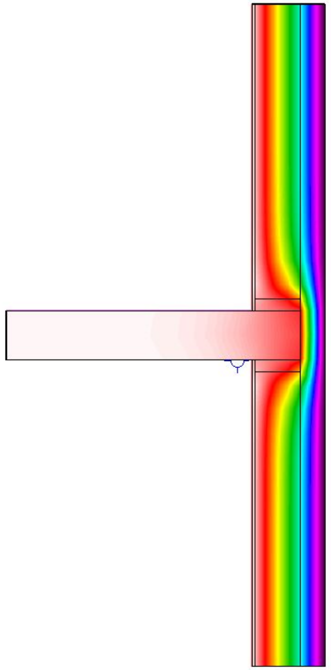
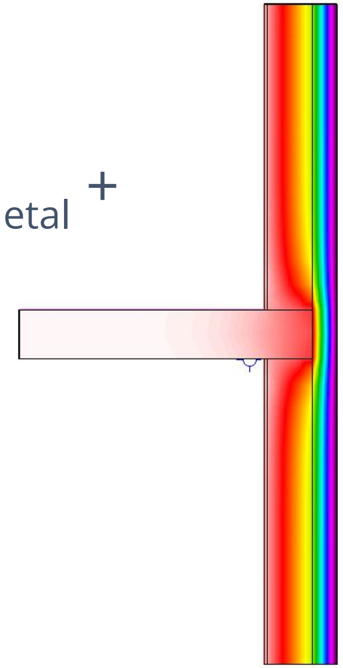
Misconceptions

Increasing the R-value of my assembly will reduce or eliminate the thermal bridge.



Wood Stud

$$q_{wood} + \Psi_{wood} < q_{metal} + \Psi_{metal}$$



Metal Stud

Not always

In the example on the left, a wood stud wall has better insulative value than a steel stud. This means that the concrete impacts the effective R-value of the cavity more and results in a higher psi-value in the wood stud wall than the steel stud wall.

However, the total energy transfer through the wood stud condition is still less than the steel stud.

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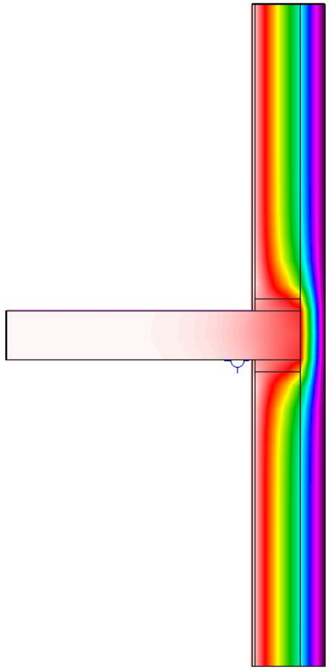
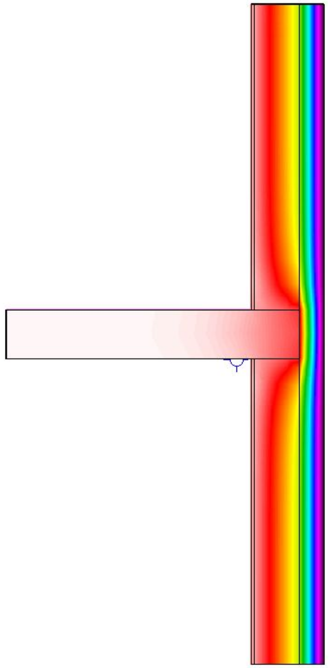
Misconceptions

Increasing the R-value of my assembly will reduce or eliminate the thermal bridge.



Wood Stud



Metal Stud

What would help?

More continuous exterior insulation in both scenarios would reduce the thermal bridge created by the concrete slab.

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Misconceptions

Phius needs every juncture and detail to be modeled.

Incorrect

Phius' concern is with visually identifiable construction material thermal bridges and proper accounting of geometric thermal bridges with high conductivity materials that pose additional energy transfer and/or moisture risk.

(ie. concrete grade beams, steel members etc..)

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References / Links

References & Links

- Phius Psi-Value Calculator
  - Linear thermal bridge accounting
  - Accepted softwares: THERM, Flixo and HT Flux
- Critical Interior Surface Temp Calculator
  - Moisture risk analysis
  - ISO 13788
- Phius Point Fastener Correction Calculator
  - Point thermal bridge accounting
  - or Use defaults per Table I-3.1.0 per Certification Guidebook
- Phius Psi-Install Modeling Protocol
  - Window installation
- Phius Project Details Library

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Questions?

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