Break it, or Lose it: Thermal Bridging in Building Envelopes

NESEA BuildingEnergy 16

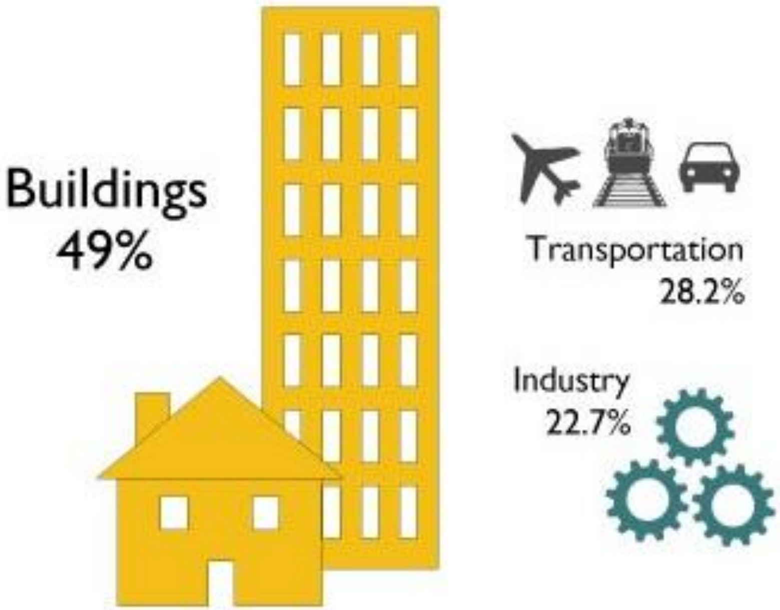
March 9, 2016

PAYETTE

INTRODUCTION | Learning Objectives

1. Learn the significance that thermal bridges can have on decreasing the design intended R-value in commercial building facades.
2. Will know common problems areas in the thermal performance of building envelopes which can be used to identify potential problems in future designs.
3. Learn a methodology for evaluating thermal bridges through thermal imaging that can be used to evaluate building during and after construction.
4. Will learn the limitations of current processes for evaluating heat flows through building envelopes and an easily applied simulation technique to correctly evaluate it.

INTRODUCTION | Building's Environmental Impact



U.S. Energy Consumption by Sector

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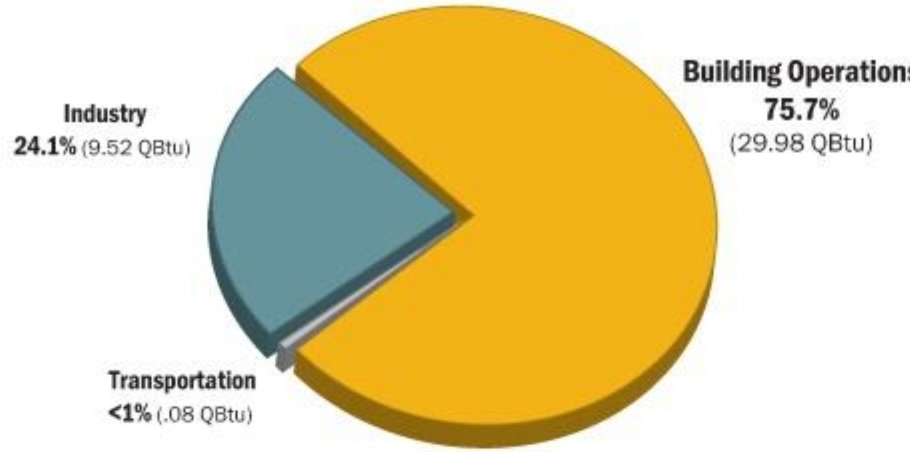
Data Source: U.S. Energy Information Administration (2009).



U.S. Electricity Consumption by Sector

Source: ©2011 2030, Inc. / Architecture 2030. All Rights Reserved.
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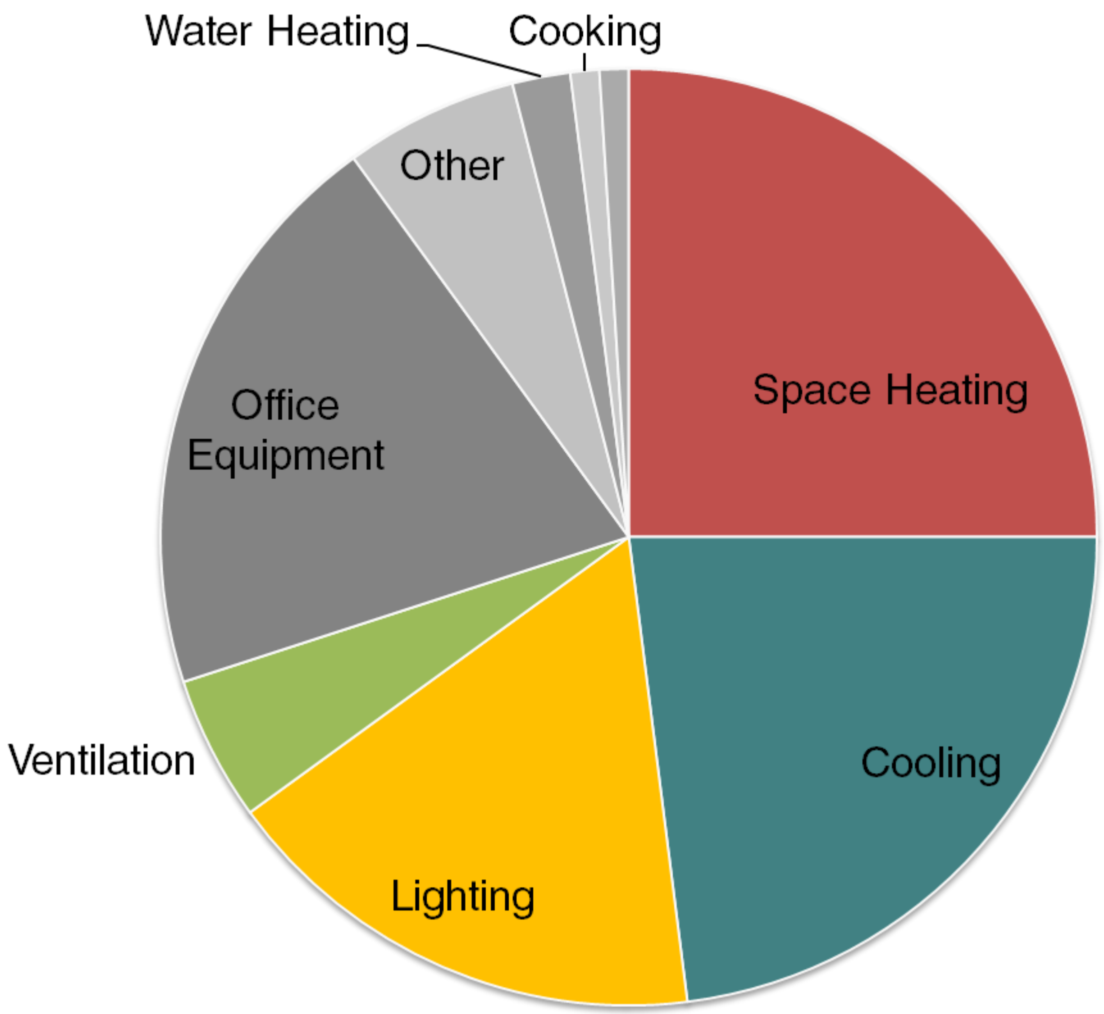
INTRODUCTION | Architect's Influence on Energy Usage



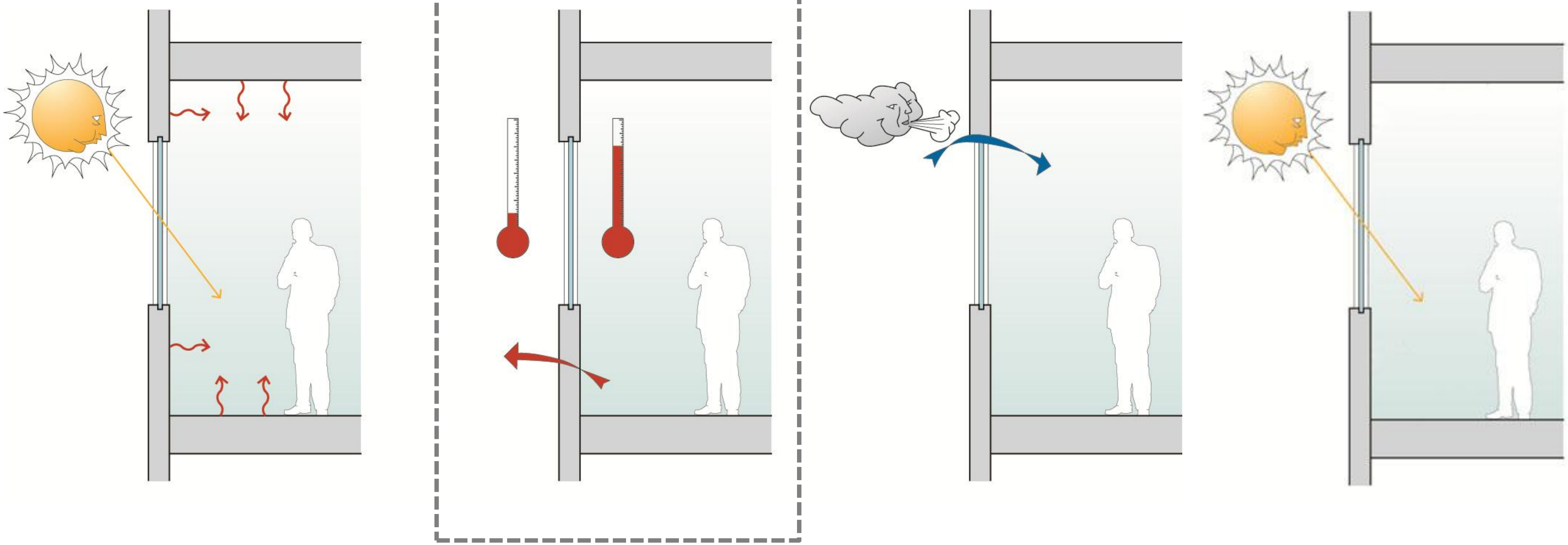
70%

of commercial building's energy is impacted by the design of the envelope

CBECS, 2003

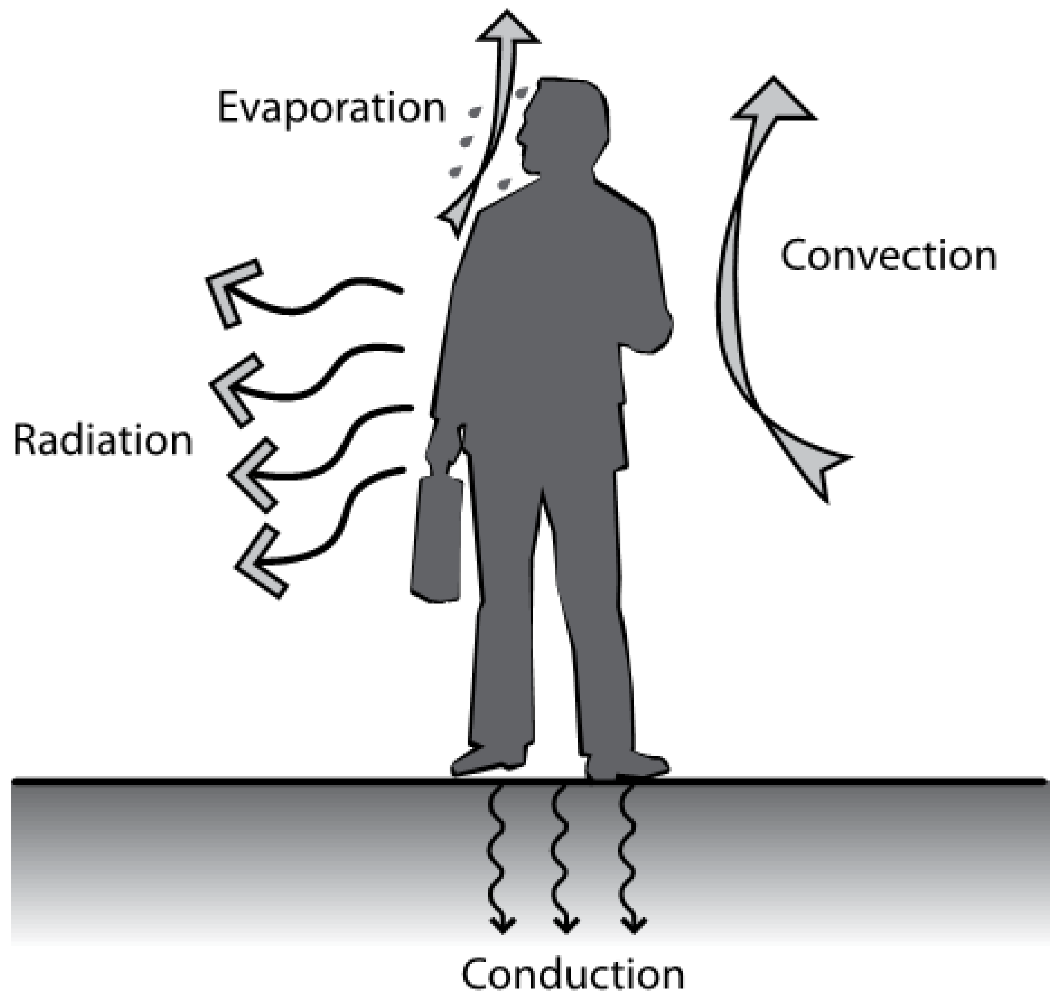
INTRODUCTION | Envelope's Impact on Energy

Thermal Mass | **Thermal Resistance** | **Infiltration** | **Glazing Visual Transmittance & Solar Heat Gain**



Modes of Heat Transfer:

- Conduction
- Convection
- Radiation



Heat flow through the building envelope (Q)

$$Q = A \times U \times \Delta T$$

(in Btu/hr or W)

A = area of surface

ΔT = difference in temperature between inside & out

U = heat transfer coefficient

- **R-value** – measure of thermal resistance - h·ft^2·°F/Btu or m^2·°K/W

  (bigger the better)

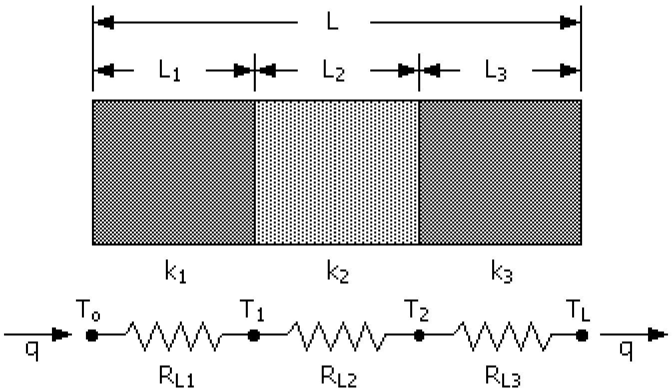
- **U-value** – heat transfer coefficient; measure of how well the building conducts heat - Btu/h·ft^2·°F or W/m^2·°K

  (smaller the better)

$$U = \frac{1}{R} = \frac{material \quad conduct.}{material \quad width} = \frac{heat \quad transfer \quad per \quad unit \quad area}{temperature \quad difference}$$

INTRODUCTION | Thermal Bridges

How we think about it in design:



1D Heat Flow

INTRODUCTION | Thermal Bridges

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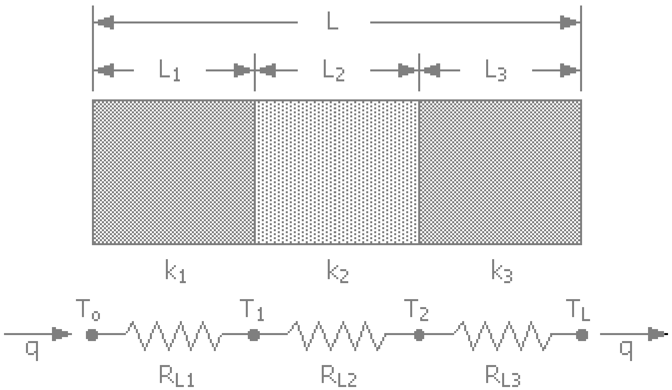
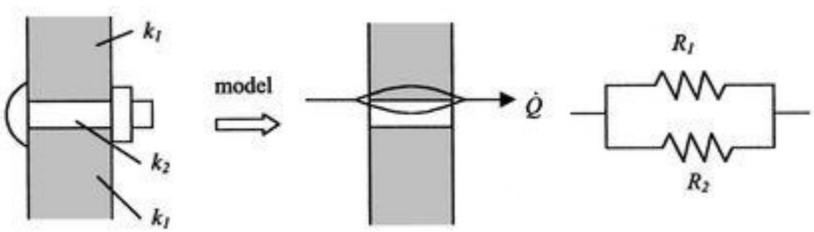


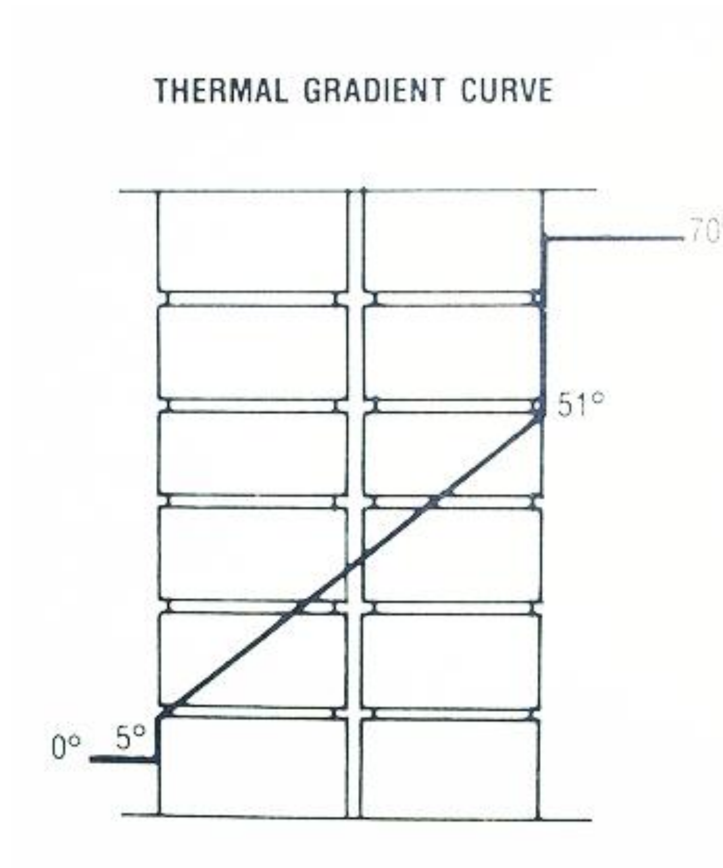
1D Heat Flow

How it is in reality:



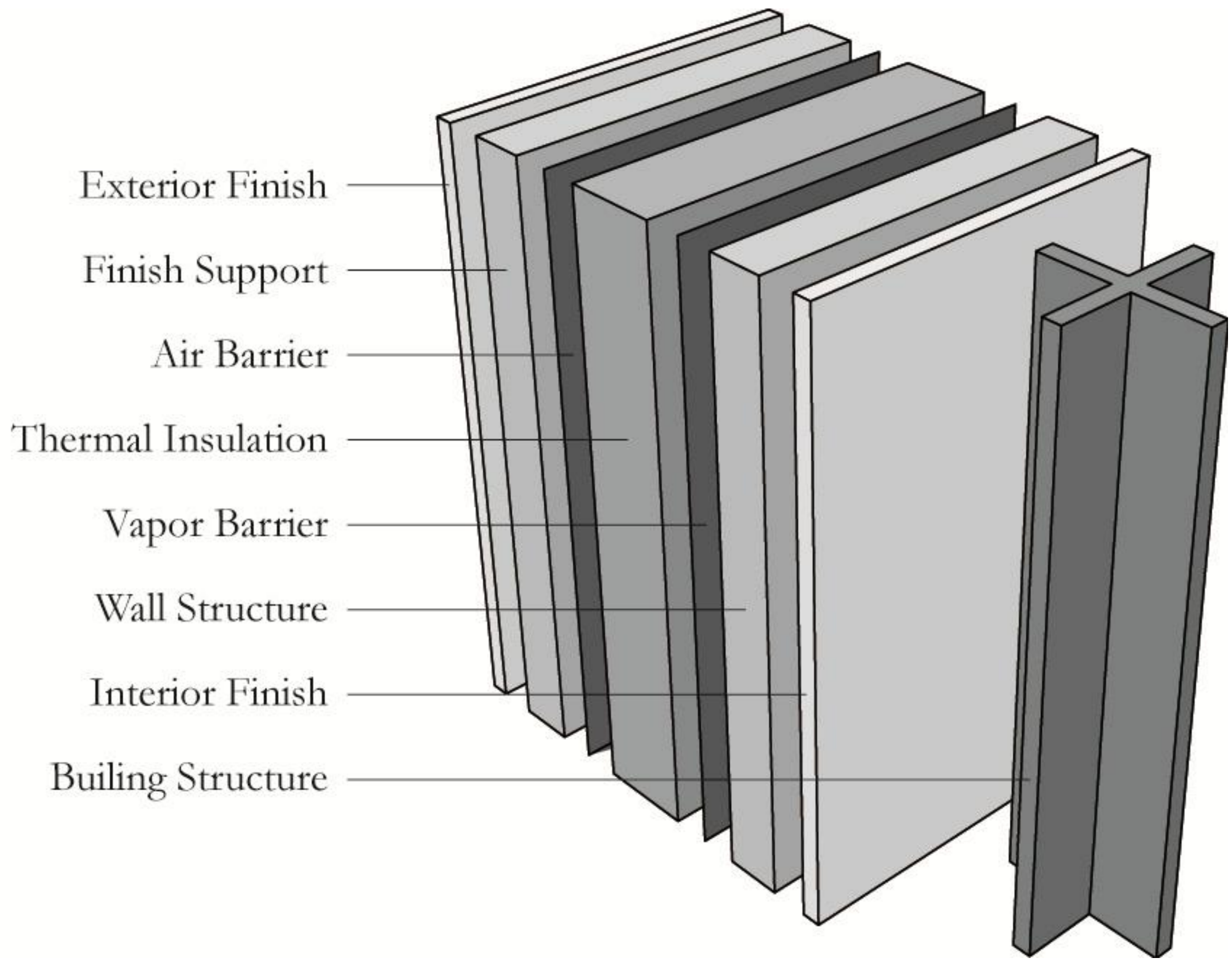
2D & 3D Heat Flow

INTRODUCTION | Historic Envelopes

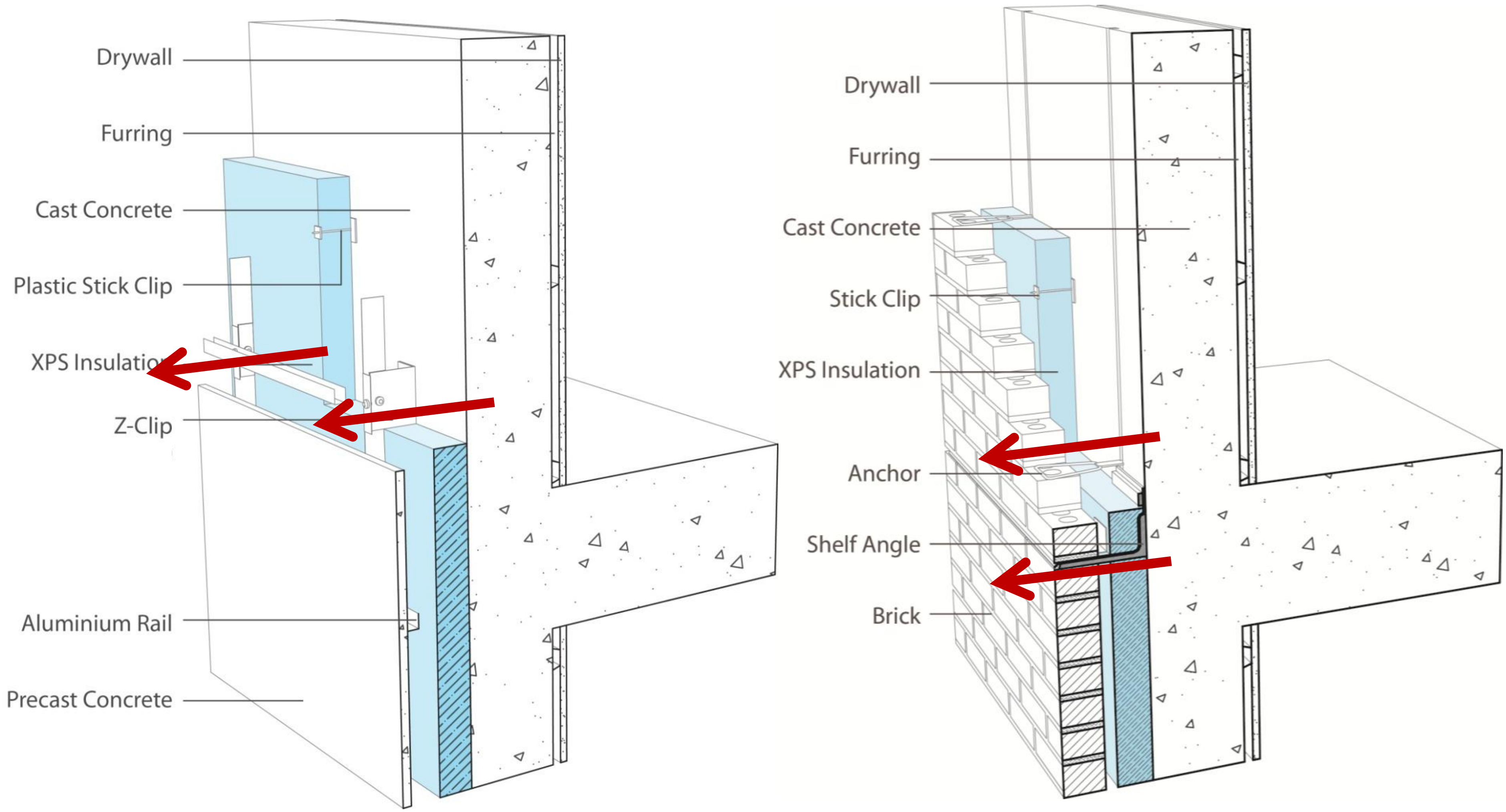


Monadnock Building in Chicago, IL

INTRODUCTION | Modern Envelopes



INTRODUCTION | Modern Envelopes



INTRODUCTION | Code Requirements

- Specify Minimum R-values

From ASHRAE 90.1-2007

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

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.119	R-7.6 c.i.
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above-Grade						
Mass	U-0.090	R-11.4 c.i.	U-0.080	R-13.3 c.i.	U-0.151[a]	R-5.7 c.i.[a]
Metal Building	U-0.113	R-13.0	U-0.057	R-13.0 + R-13.0	U-0.123	R-11.0
Steel-Framed	U-0.064	R-13.0 + R-7.5 c.i.	U-0.064	R-13.0 + R-7.5 c.i.	U-0.124	R-13.0
Wood-Framed and Other	U-0.064	R-13.0 + R-3.8 c.i.	U-0.051	R-13.0 + R-7.5 c.i.	U-0.089	R-13.0
Walls, Below-Grade						
Below-Grade Wall	C-0.119	R-7.5 c.i.	C-0.119	R-7.5 c.i.	C-1.140	NR
Floors						
Mass	U-0.074	R-10.4 c.i.	U-0.064	R-12.5 c.i.	U-0.137	R-4.2 c.i.
Steel-Joist	U-0.038	R-30.0	U-0.038	R-30.0	U-0.052	R-19.0
Wood-Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-0.051	R-19.0

INTRODUCTION | Code Requirements

- **Continuous insulation** – insulation that is continuous across all structural members without thermal bridges other than fasteners and service openings.

INTRODUCTION | Code Requirements

- **Continuous insulation** – insulation that is continuous across all structural members without thermal bridges other than fasteners and service openings.

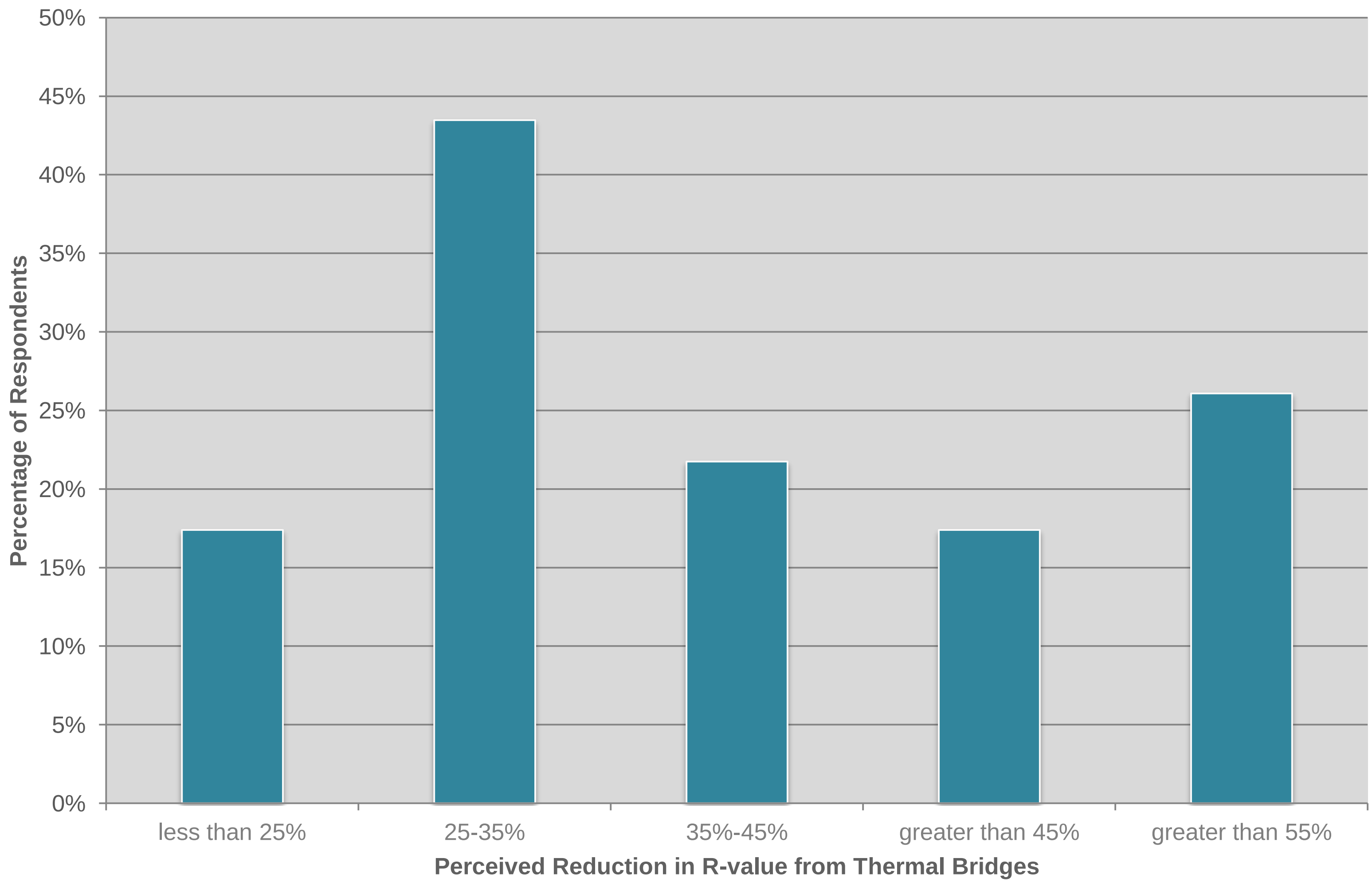
- Structural Members – IE studs, Z-girts, clips

- Fasteners – IE screws & nails

How many facades meet these requirements?

HYPOTHESIS | Survey

What is the impact on the R-value of thermal bridges in commercial assemblies?

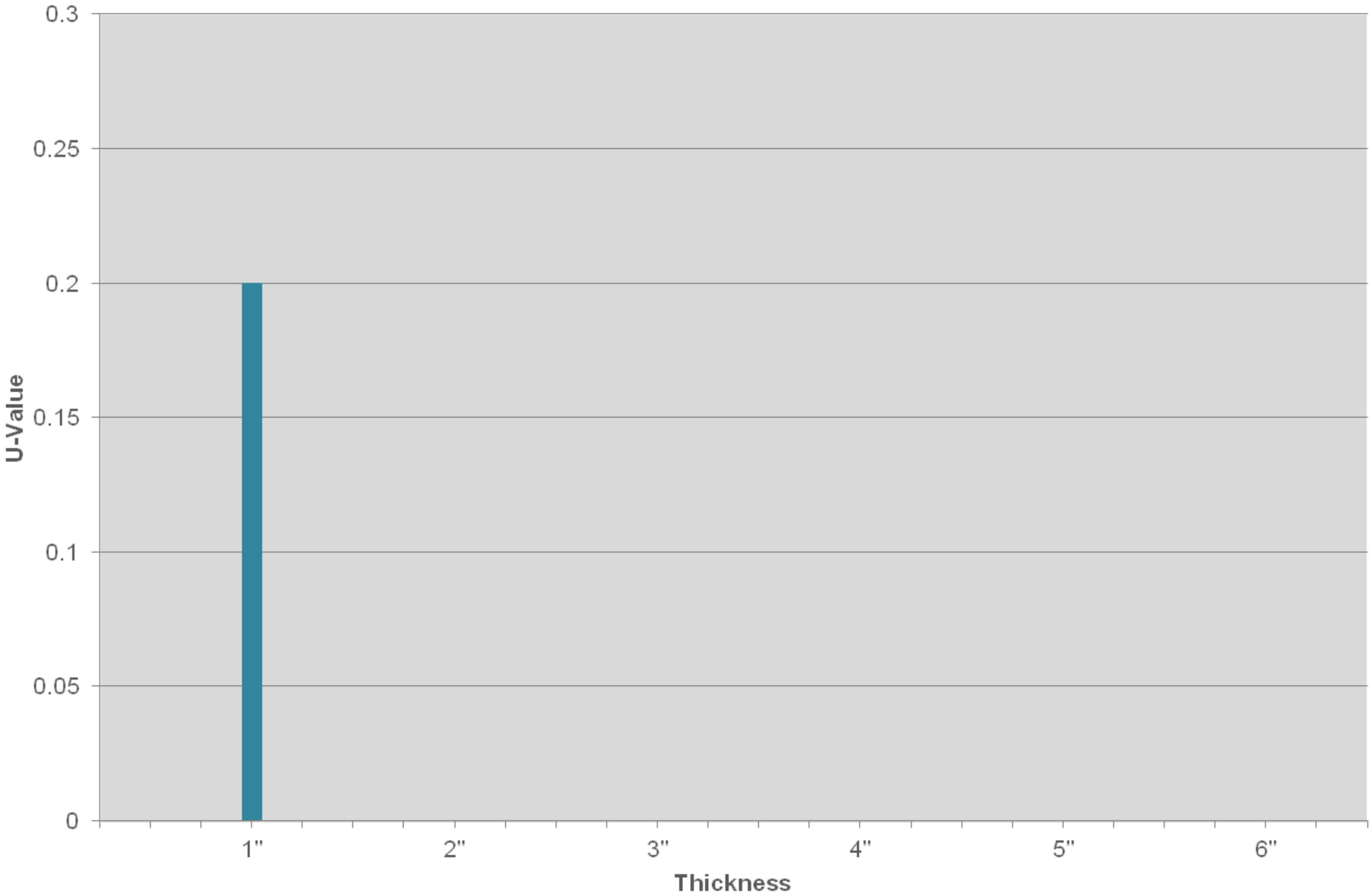


HYPOTHESIS | Existing Literature

What is the impact on the R-value of thermal bridges in commercial assemblies?

- Very little literature exists, but those that do suggest they can have a significant impact

HYPOTHESIS | Why Thermal Bridges Matter



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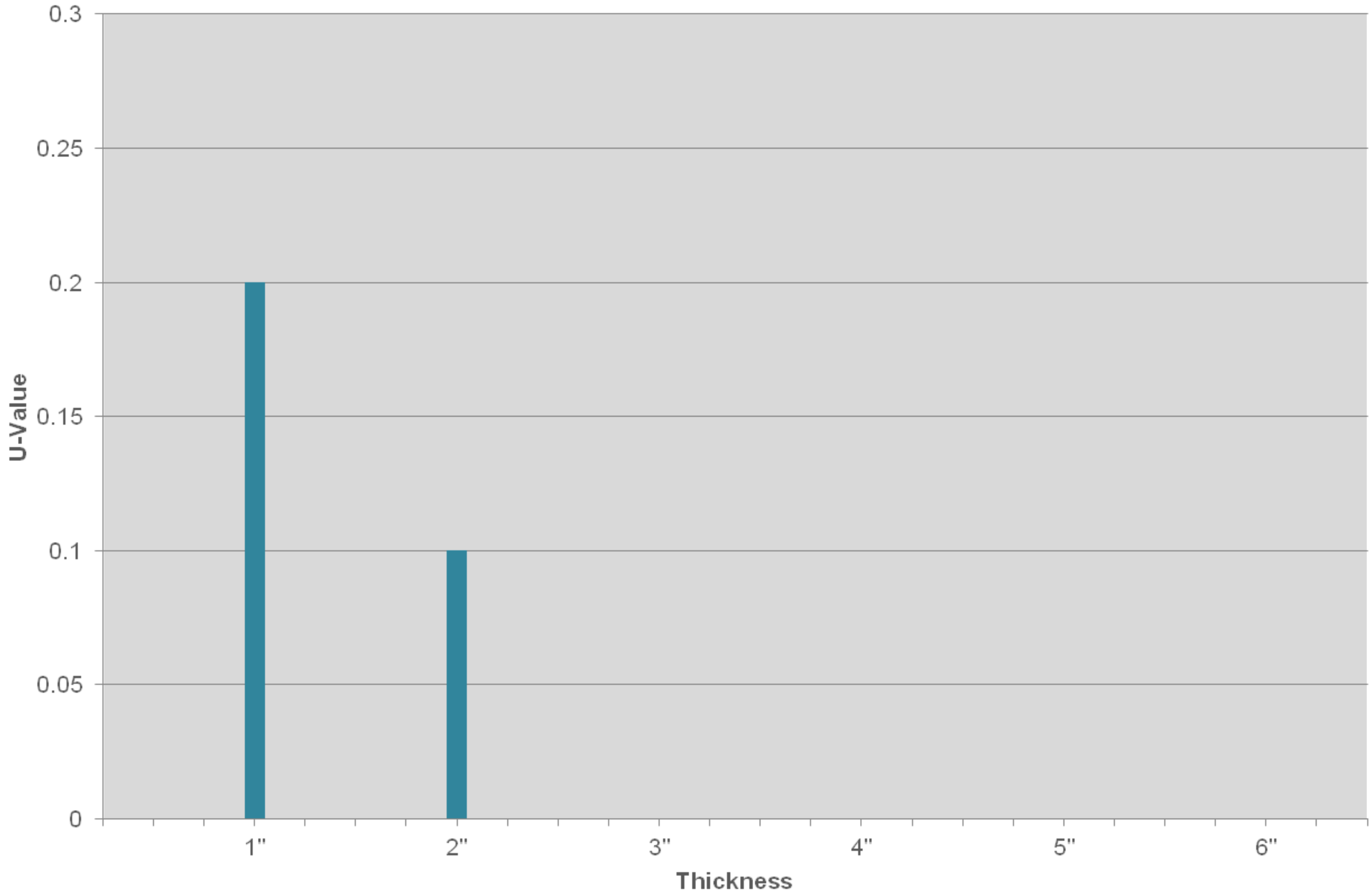

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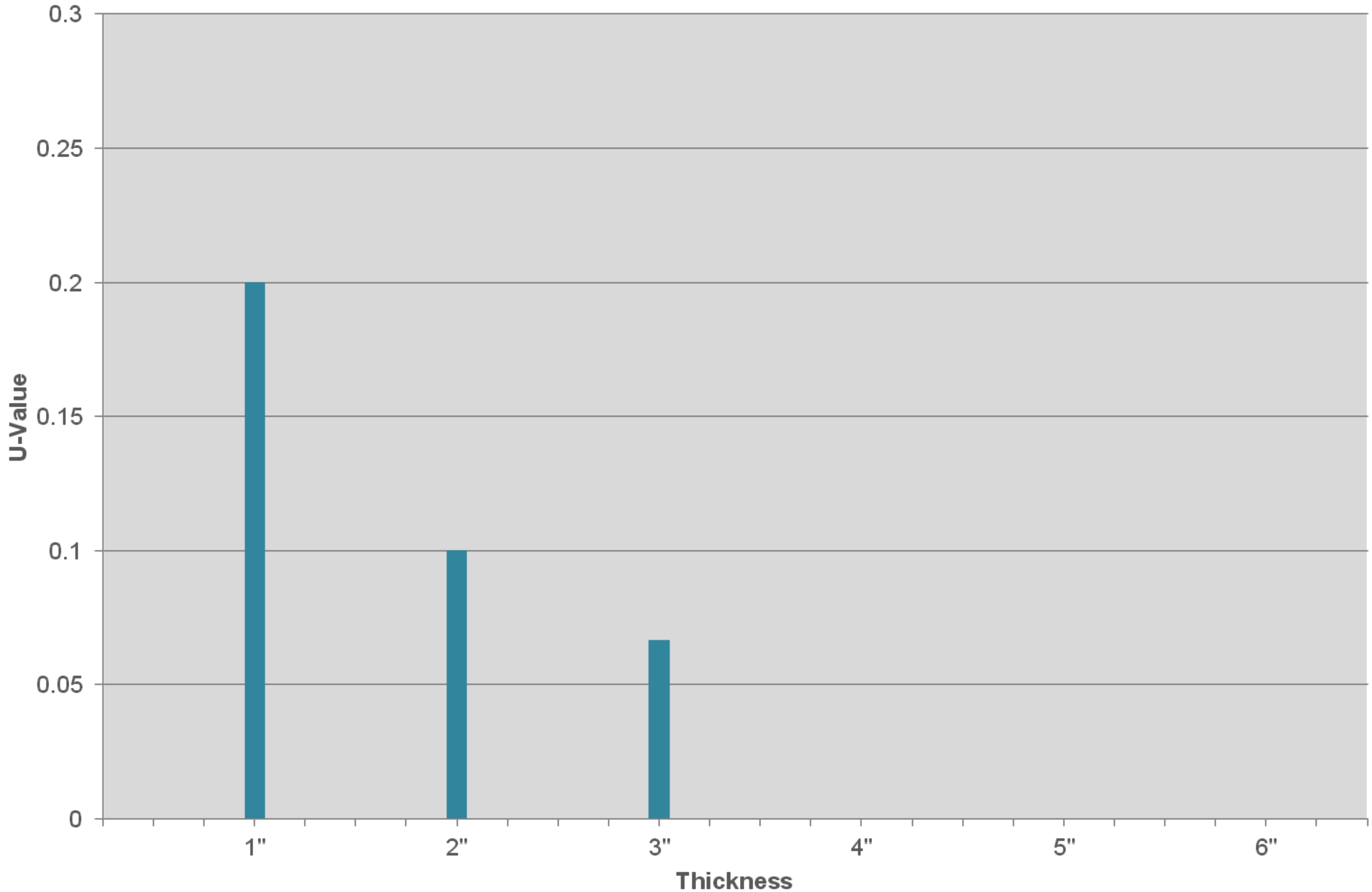

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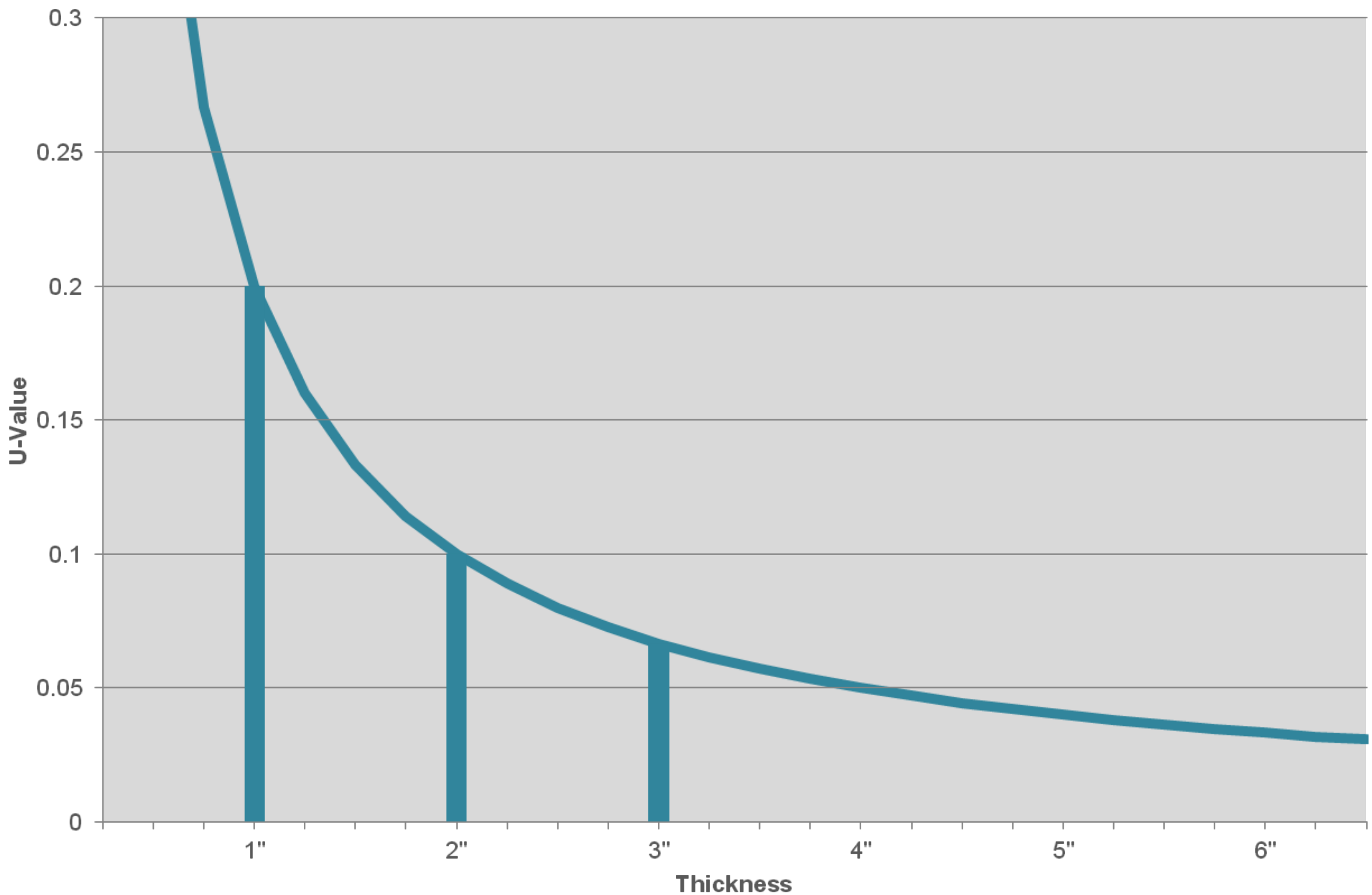

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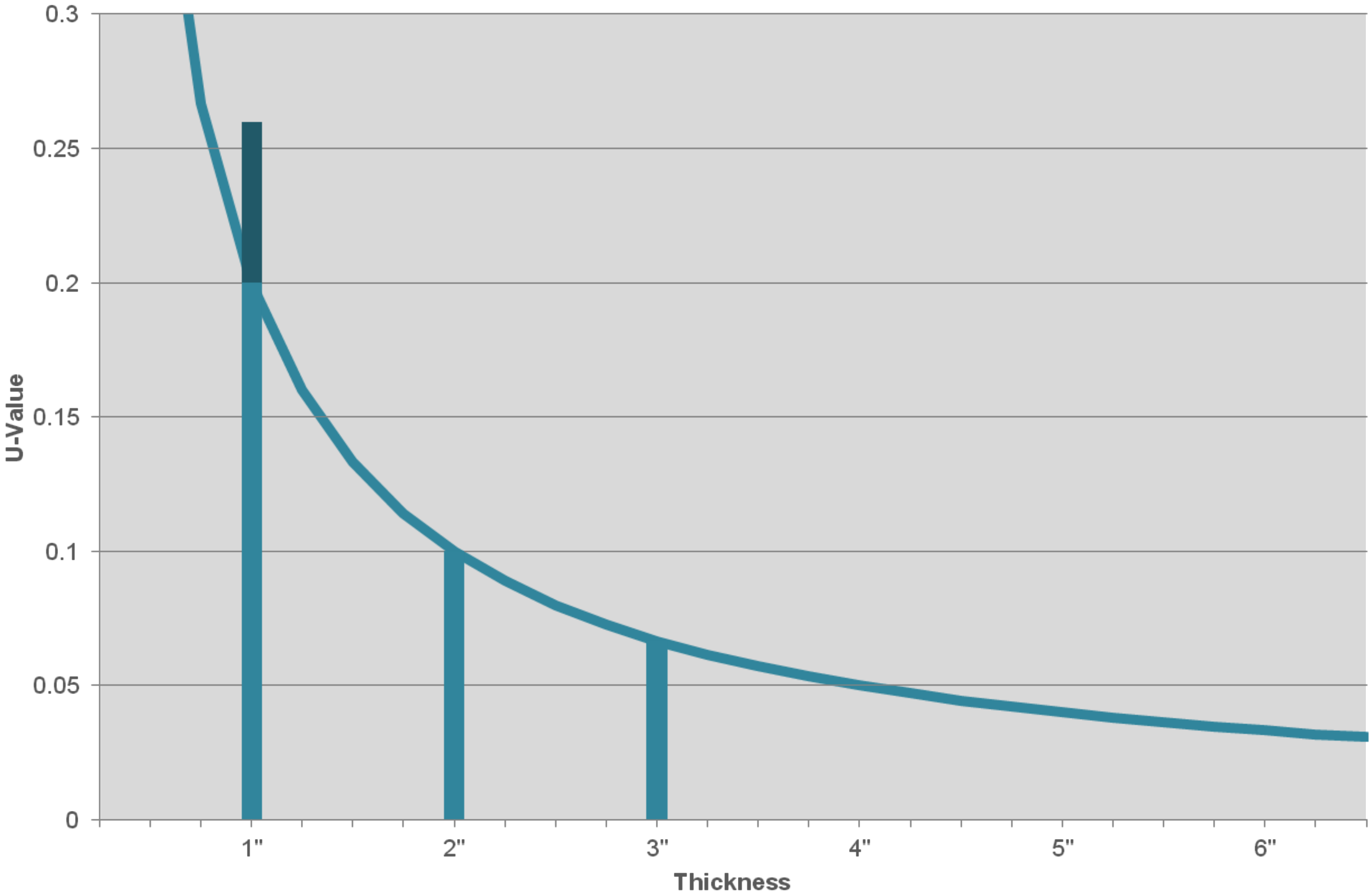

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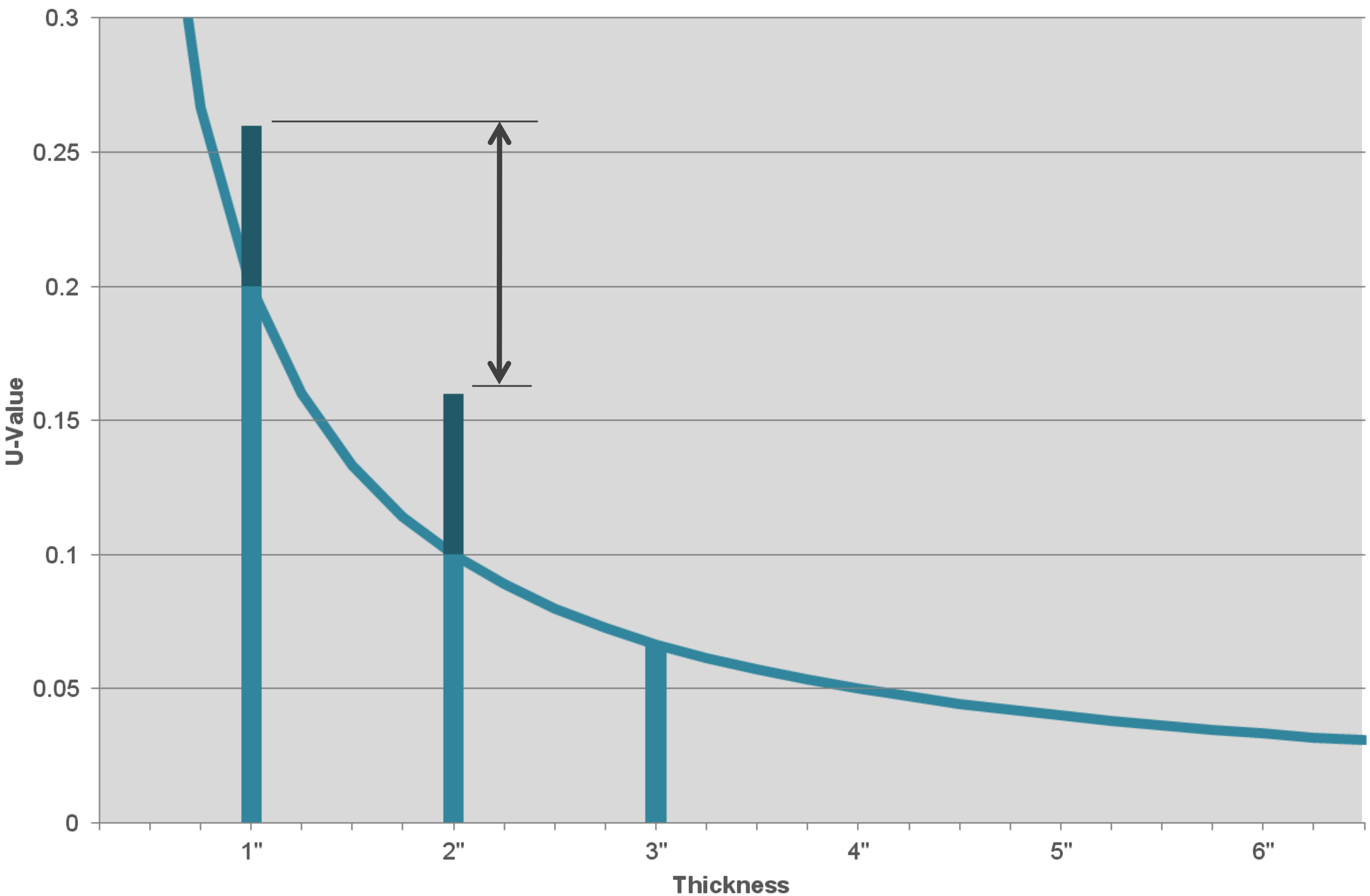

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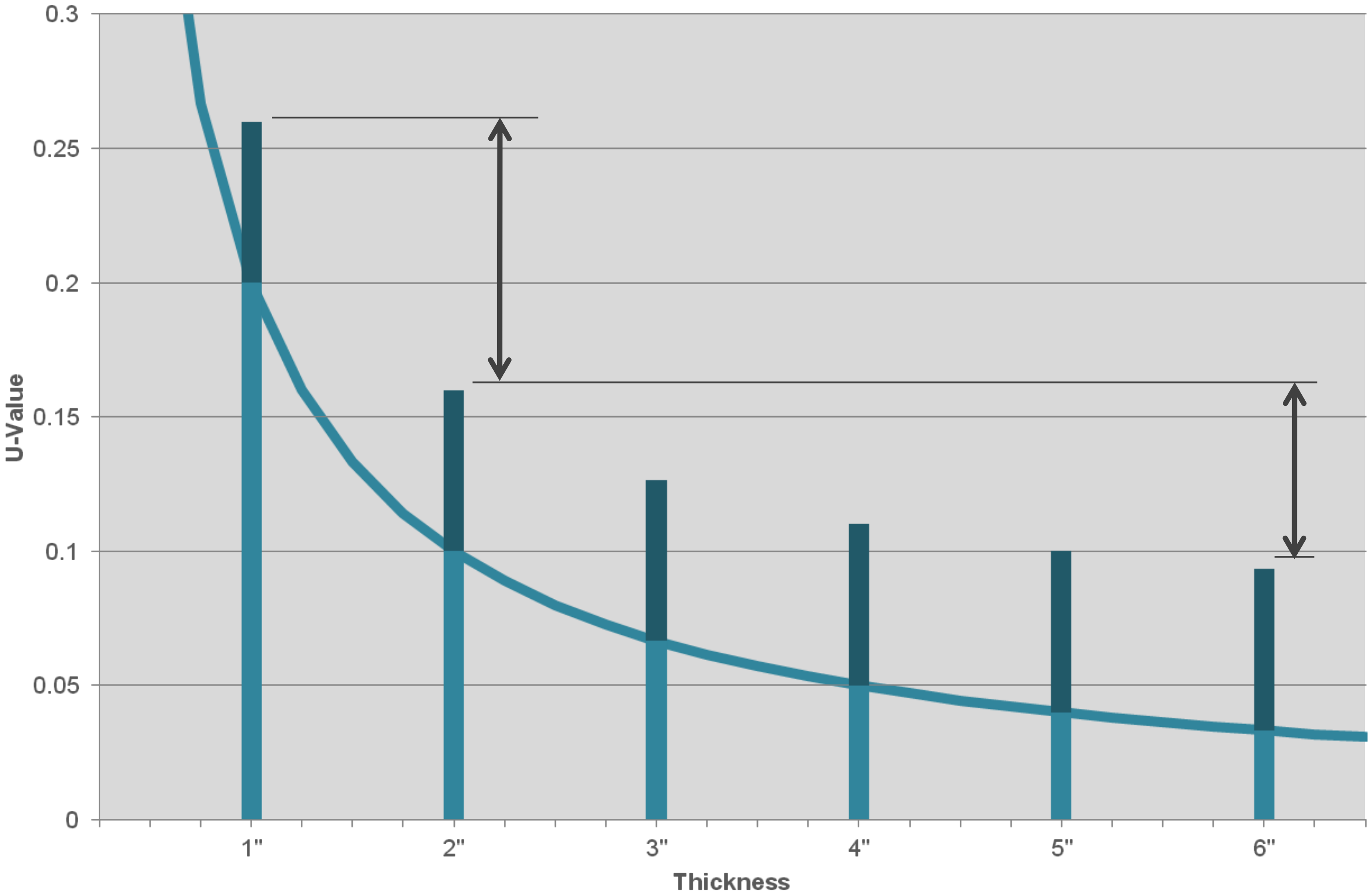

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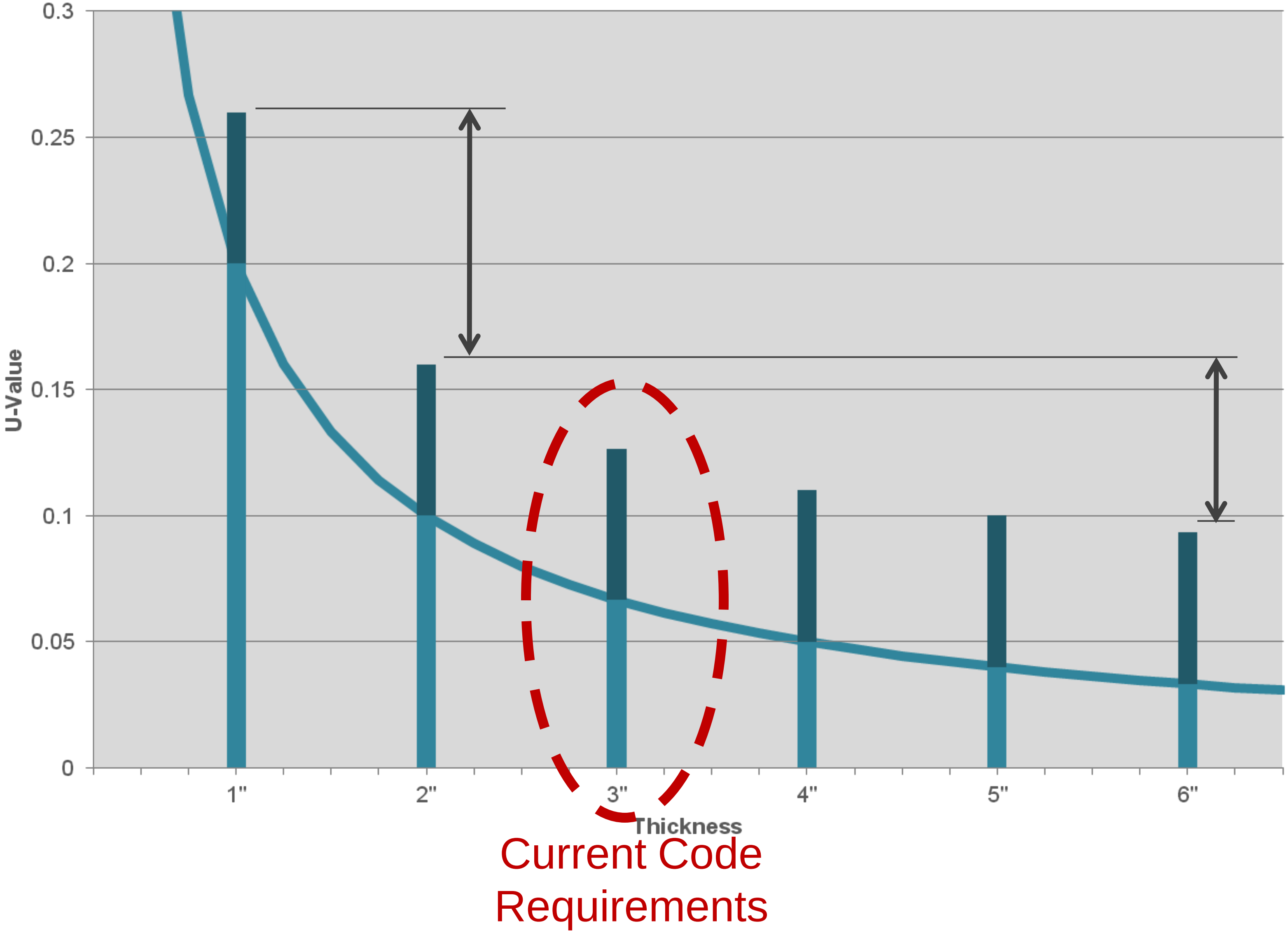
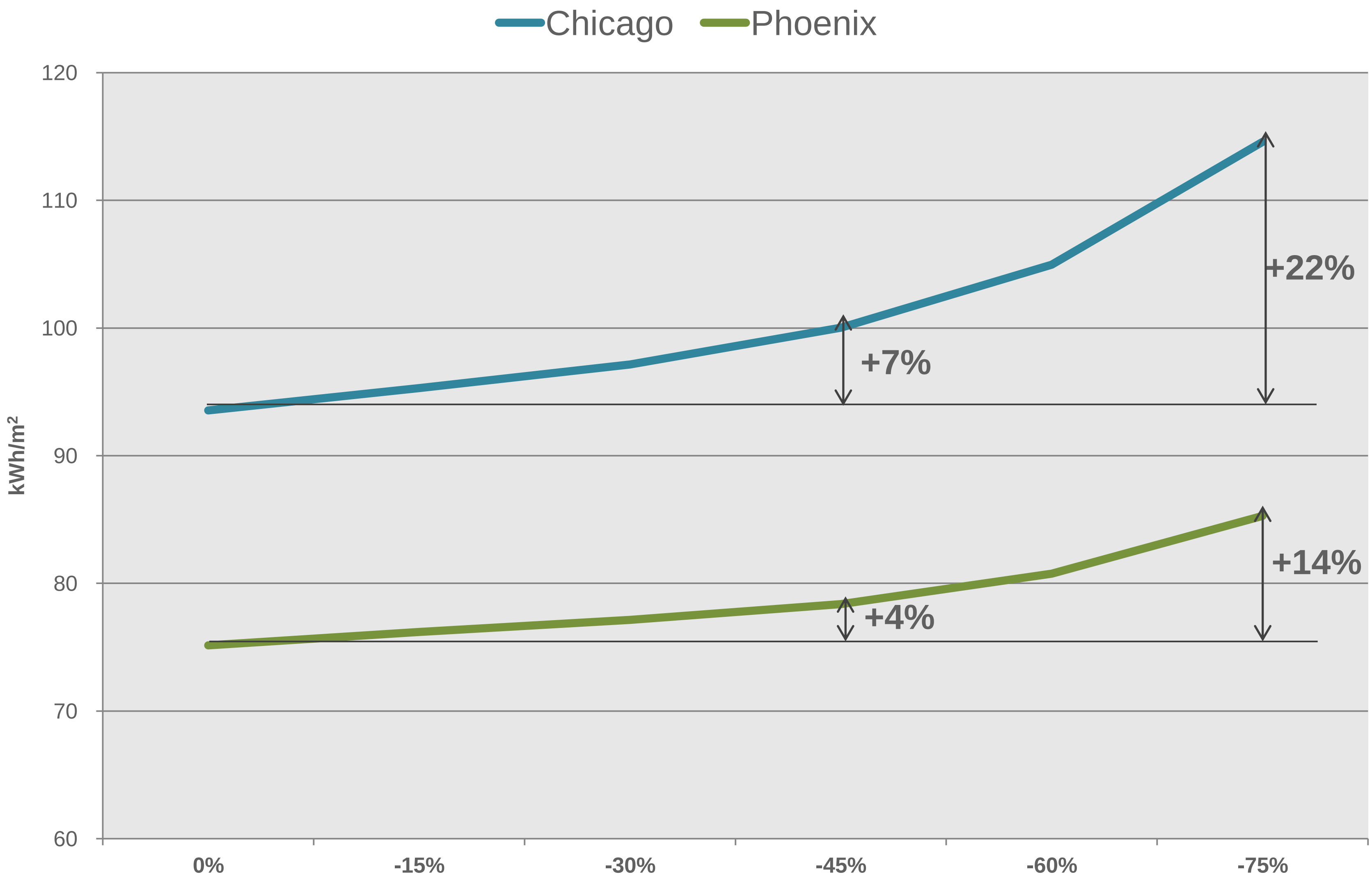


HYPOTHESIS | Decrease in R-value's Impact on Energy

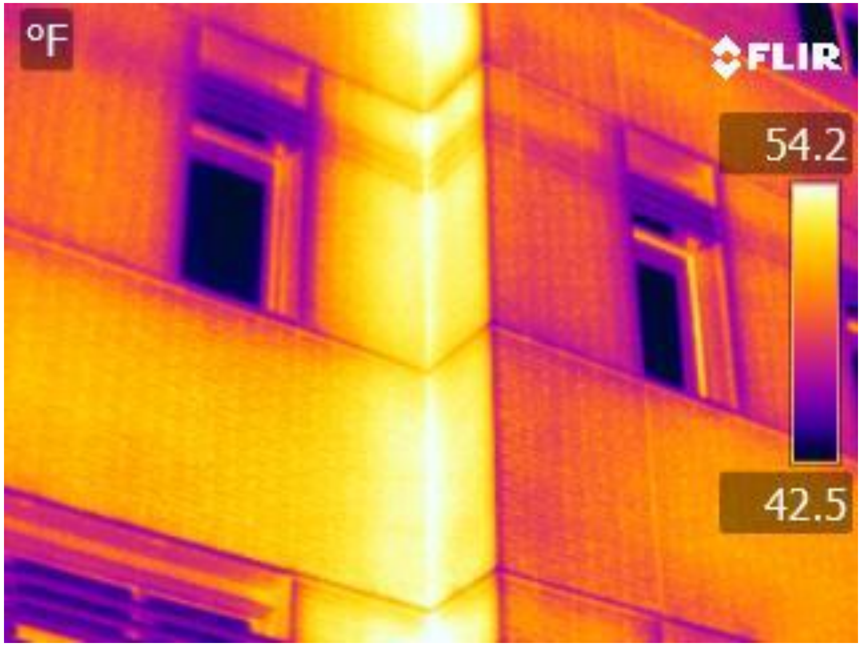


Energy Model Based on DOE Benchmark Model for Large Office Building Updated to High Performance Building (ASHRAE 90.1-2010)

HYPOTHESIS | Hypothesis

Thermal bridges have a big impact on the thermal performance of our facades. Changing how we design our envelope will have a biggest impact in improving their thermal performance.

- Quantify how walls are really performing and understand the impact of thermal bridges
- Identify if any observed decreases in thermal performance is resultant from design decisions or construction practices
- Identify good (and bad) design details for thermal performance

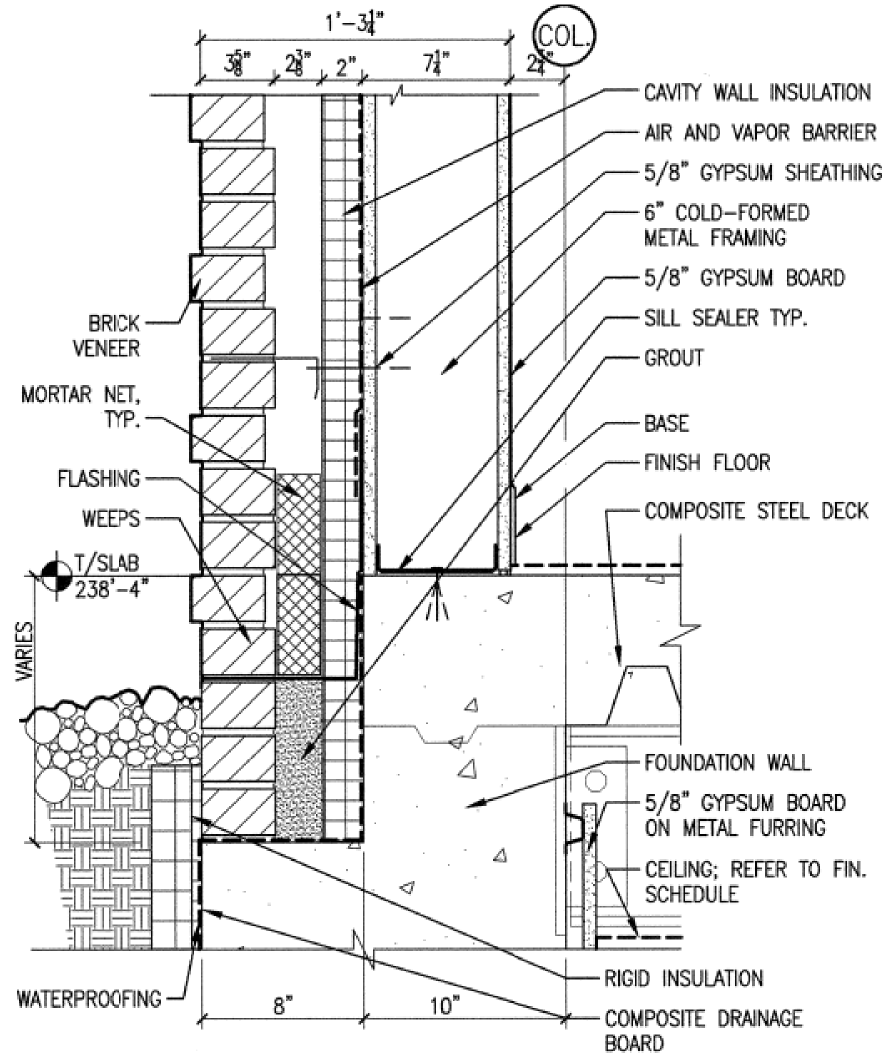


RESEARCH PROCESS | Baseline R-Value

- Manual calculation based on design - Doesn't account for thermal bridges and is viewed as "best case scenario"

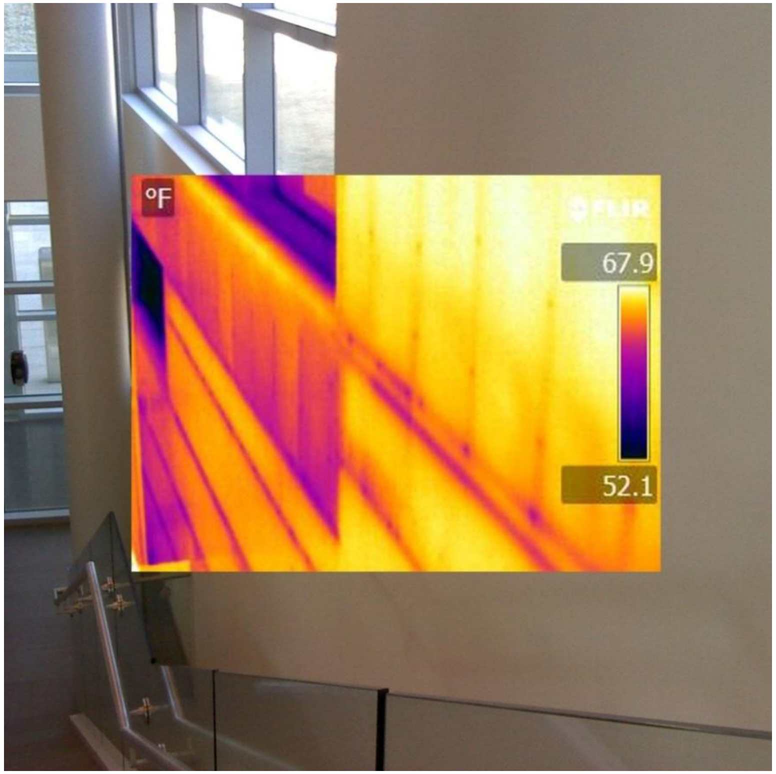
Material	Thickness	k	R-value
Ext. Air	NA	-	0.17
Brick	3.625	6.4	0.56
Air Space	2.375	-	0.91
XPS	2	0.2	10.00
Gypsum	0.625	1.1	0.57
Studs	6	-	1.36
Gypsum	0.625	1.1	0.57
Int. Air	NA	-	0.68

R-value = 14.82



RESEARCH PROCESS | Observed Performance

- Use thermal imaging camera to document actual performance in 15 buildings
- Creates color infrared image of surface temperature

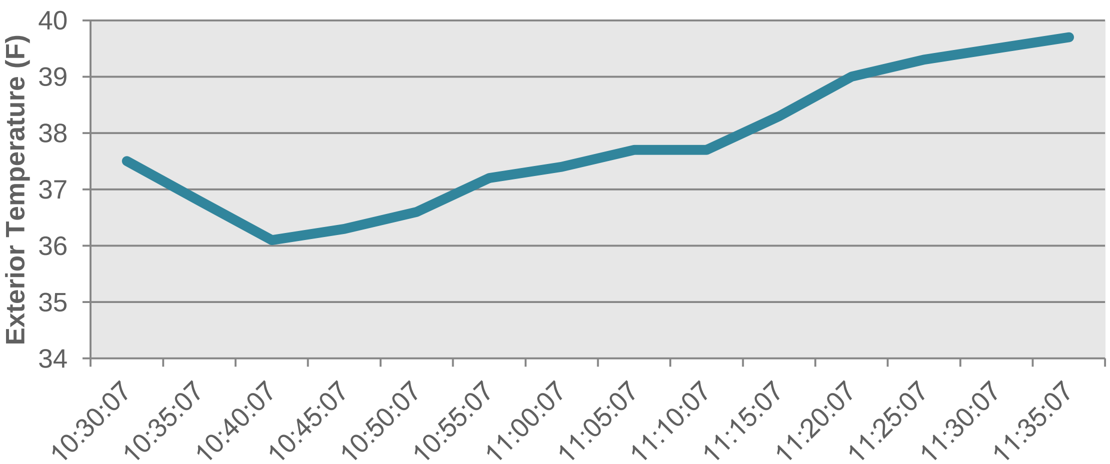


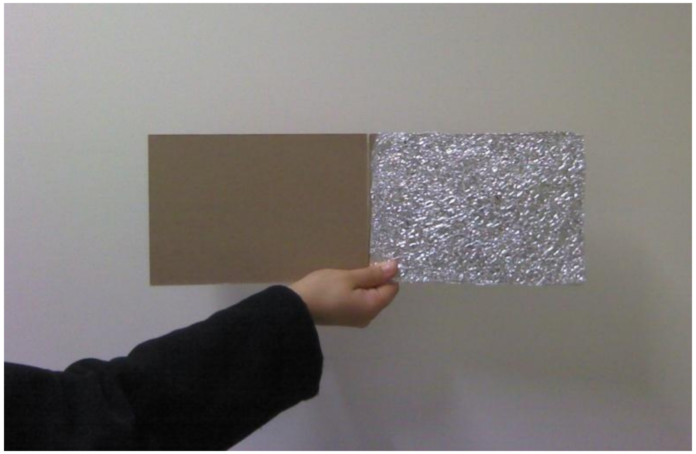
RESEARCH PROCESS | Observed Performance

- Calculate R-value from thermal images

- Calculation based on difference between wall surface and inside air temperature, inside surface and radiant temperature, and inside surface and exterior temperature.

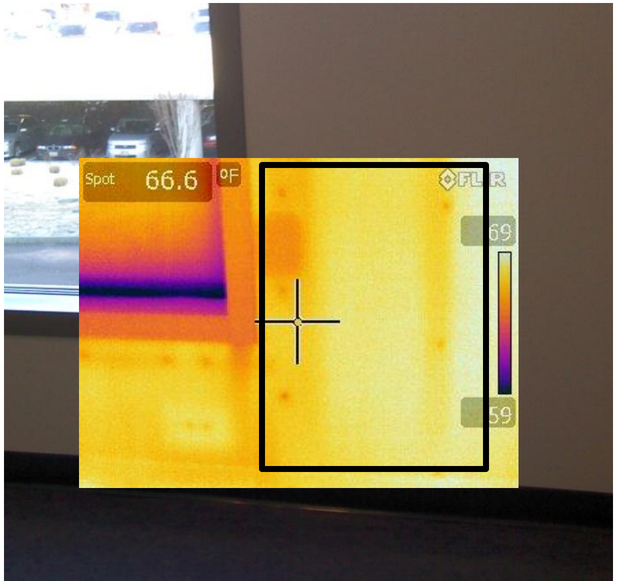
- Need to also find out:
  – Outside Air Temperature
  – Inside Air Temperature
  – Inside Radiant Temperature

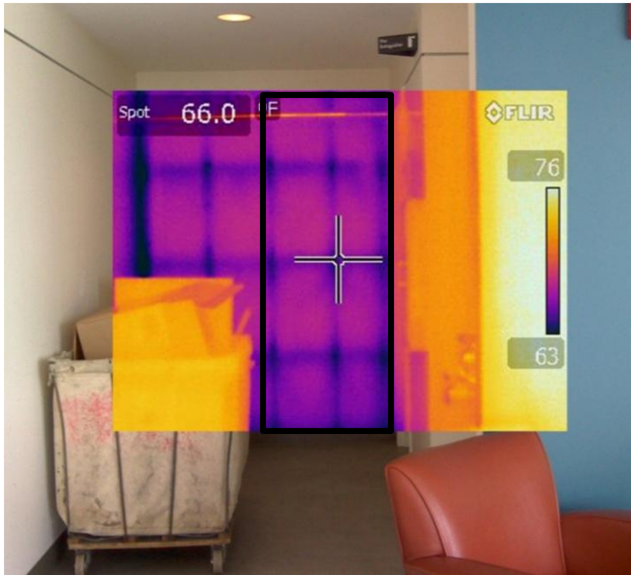




RESEARCH PROCESS | Limitation of Thermal Image

- R-value only of designated area
- Calculated only from interior
- Doesn’t work on glass because it is a specular reflector
- Can only take images in winter (in the northeast) when there is a larger temperature difference between interior & exterior



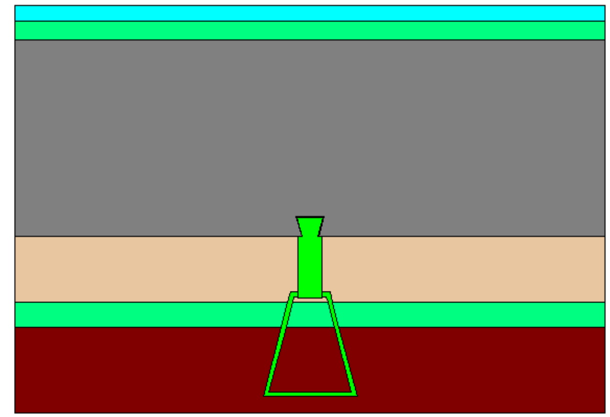


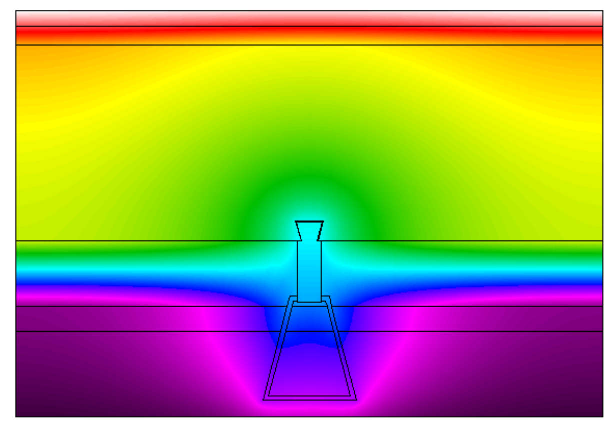
RESEARCH PROCESS | Heat Flow Simulation

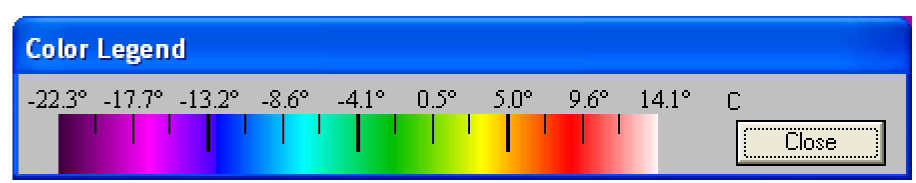
- Use THERM – 2D heat flow simulation program to match model with image to better understand what is causing decrease in R-value

- Validated model allows for testing of alternative designs

- Provides results of U-value along specified surface, surface temperatures and images of temperature gradient through model







RESEARCH PROCESS | Heat Flow Simulation

How to make a 2D program simulate a 3D world:

Table 22: Average Surface Temperature Results Comparision (Griffith 1997)

	Measured	Parallel Path		Isothermal Planes		Averaged	
	°C	°C	% Different	°C	% Different	°C	% Different
Nylon, 229mm	12.4	11.5	*-7.3%*	11.5	*-7.3%*	11.5	*-7.3%*
Stainless,457mm	11.0	11.3	*+2.7%*	10.5	*-4.5%*	10.9	*-0.9%*
Stainless,305mm	10.8	11.2	*+3.7%*	10.1	*-6.5%*	10.7	*-0.9%*
Stainless,229mm	10.7	11.1	*+3.7%*	9.8	*-8.4%*	10.5	*-1.9%*
Stainless,152mm	10.5	10.9	*+3.8%*	9.2	*-12.4%*	10.1	*-3.8%*
Stainless, 76mm	9.4	10.3	*+9.6%*	7.9	*-16.0%*	9.1	*-3.2%*
Steel, 229mm	8.8	11.1	*+26.1%*	7.7	*-12.5%*	9.4	*+6.8%*
Average			±*8.1%*		*-9.7%*		± *3.5%*

RESEARCH PROCESS | Heat Flow Simulation

Parallel Path Method

- Weighted average of 2 simulations

$$U_P = F_B * U_B + F_N * U_N$$

Whereas, U_P = U-value parallel path

F_B = Fraction of bridging element

U_B = U-value from THERM with bridging element

F_N = Fraction of clear wall

U_N = U-value from THERM of clear wall

Isothermal Planes Method

- 1 simulation with a weighted average of the conductivities

$$k_{eff} = F_B * k_B + F_N * k_N$$

Whereas, U_I = U-value from THERM using isothermal planes method

k_B = effective conductivity

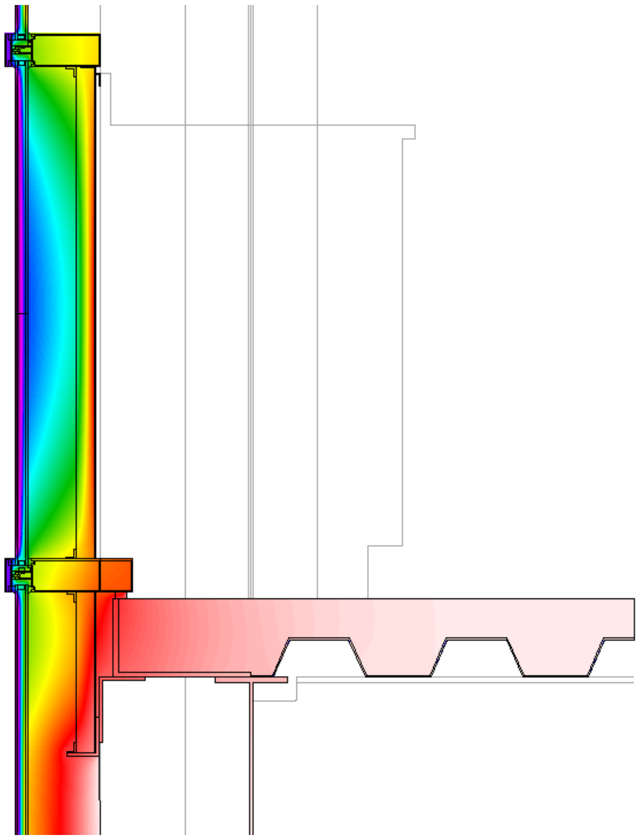
k_B = conductivity of bridging element

k_N = conductivity of non-bridging element

RESEARCH PROCESS | Identified Commonalities

- Identified 16 common areas for further investigation

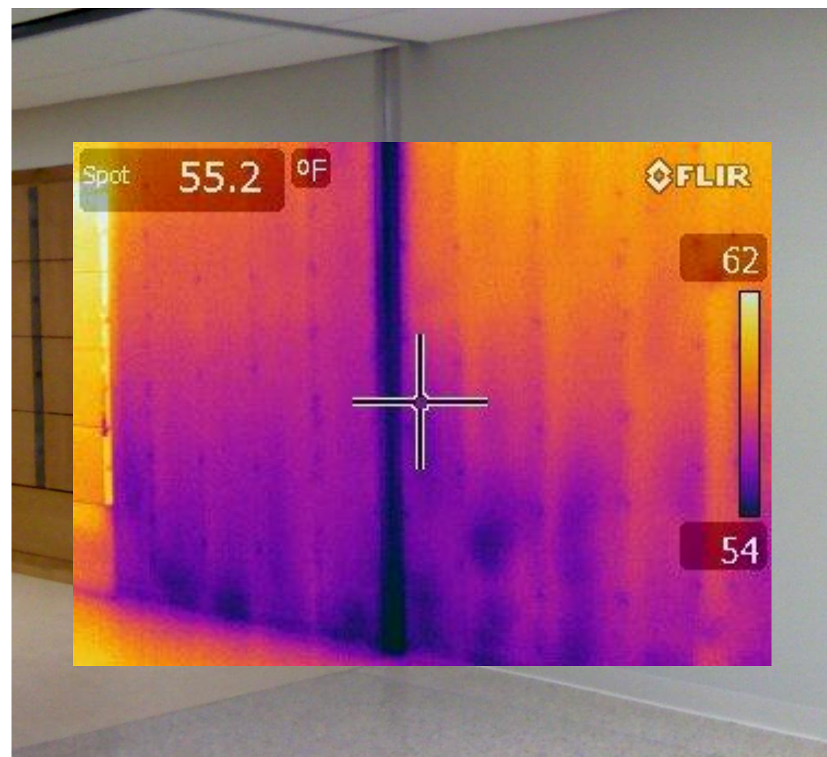
- Cladding Support Systems
  - Existing building façade renovations
  - Masonry wall systems
  - Metal panel wall systems
  - Curtain wall systems
  - Rain screens wall systems



RESEARCH PROCESS | Identified Commonalities

- Identified 16 common areas for further investigation

- Transitions and Penetrations
  - Transitions between new and existing facades
  - Transitions between different wall systems
  - Transition between windows and walls
  - Foundation to wall transitions
  - Roof to wall transitions
  - Roof parapets
  - Soffits
  - Roof penetrations
  - Seismic & movement joints
  - Louver openings



RESEARCH FINDINGS | Existing Masonry Wall Assemblies

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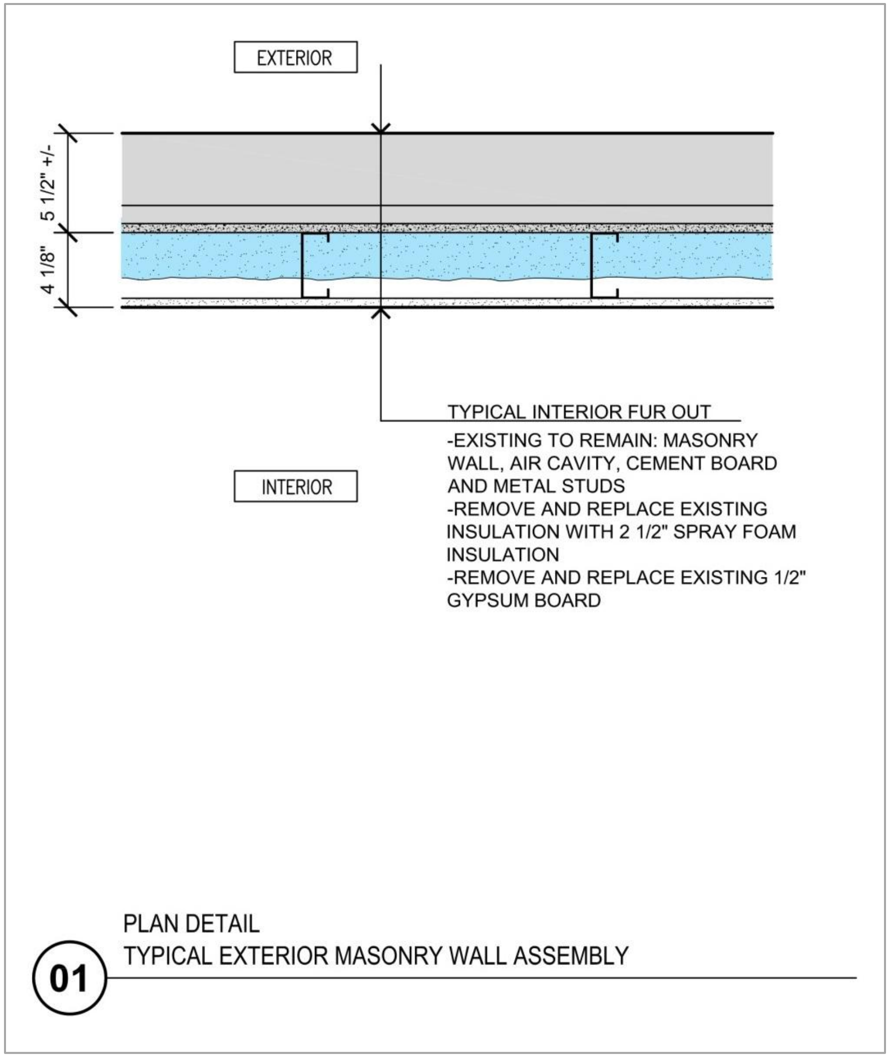
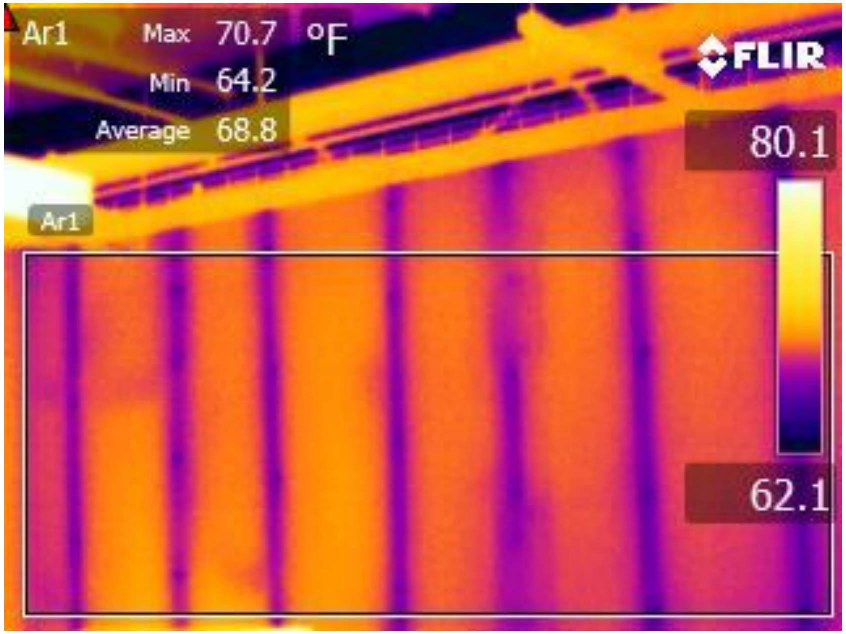
Building 1- studs directly attached to existing wall → resulting in a decrease of 59% of baseline R-value





Baseline R-Value= 19.53

Observed R-Value= 4.15

Simulated R-Value= 8.05

-59%

RESEARCH FINDINGS | Existing Masonry Wall Assemblies

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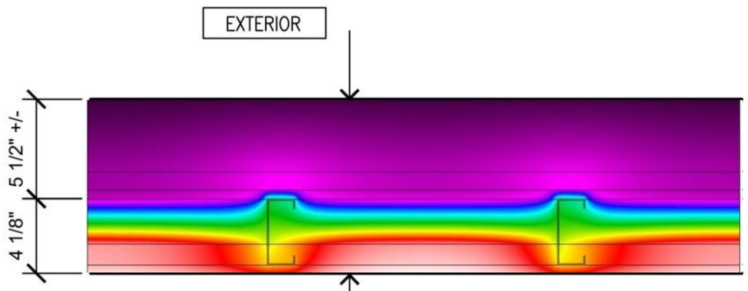
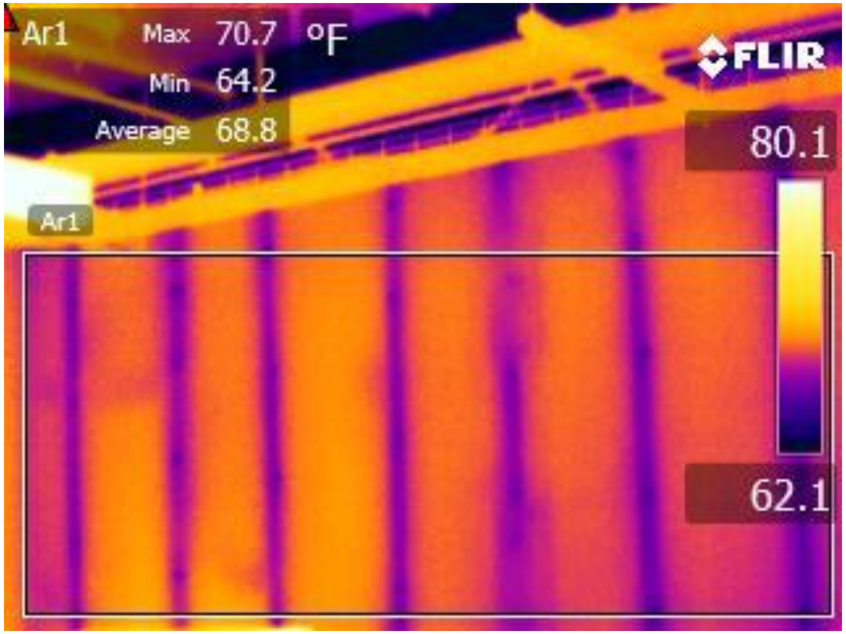


TYPICAL INTERIOR FUR OUT
-EXISTING TO REMAIN: MASONRY WALL, AIR CAVITY, CEMENT BOARD AND METAL STUDS
-REMOVE AND REPLACE EXISTING INSULATION WITH 2 1/2" SPRAY FOAM INSULATION
-REMOVE AND REPLACE EXISTING 1/2" GYPSUM BOARD

01 PLAN DETAIL
TYPICAL EXTERIOR MASONRY WALL ASSEMBLY



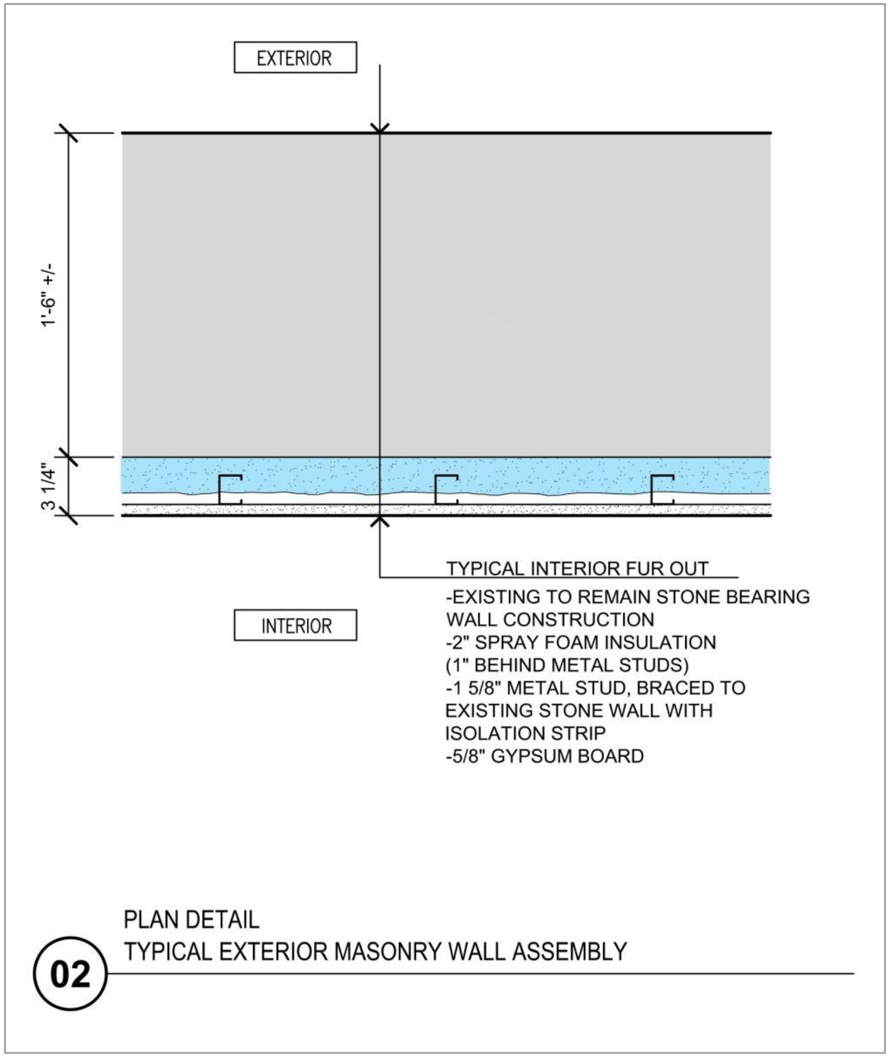
Calculated R-Value= 19.53

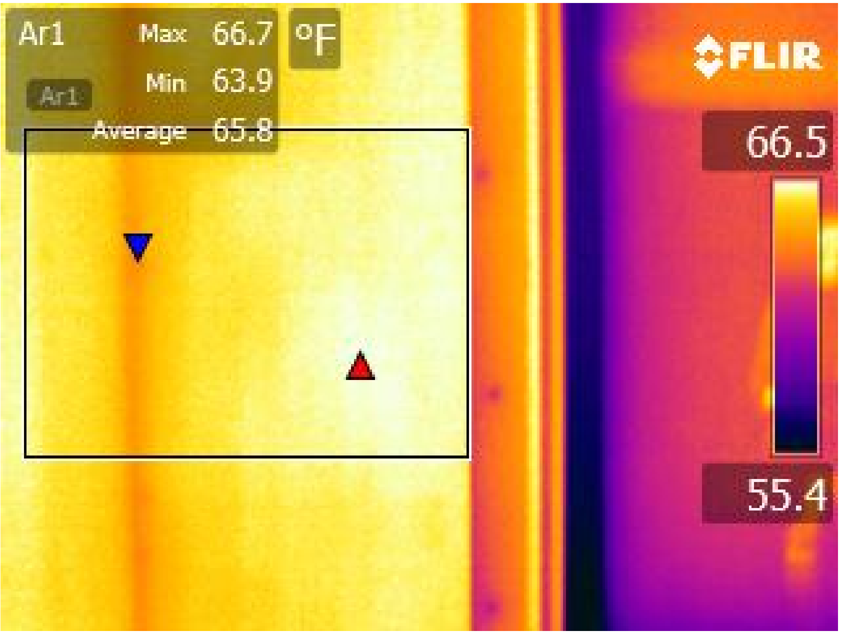
Observed R-Value= 4.15

Simulated R-Value= 8.05 -59%

RESEARCH FINDINGS | Existing Masonry Wall Assemblies

Building 2- studs pulled 1” back from existing wall → results in a decrease of 16% of baseline R-value





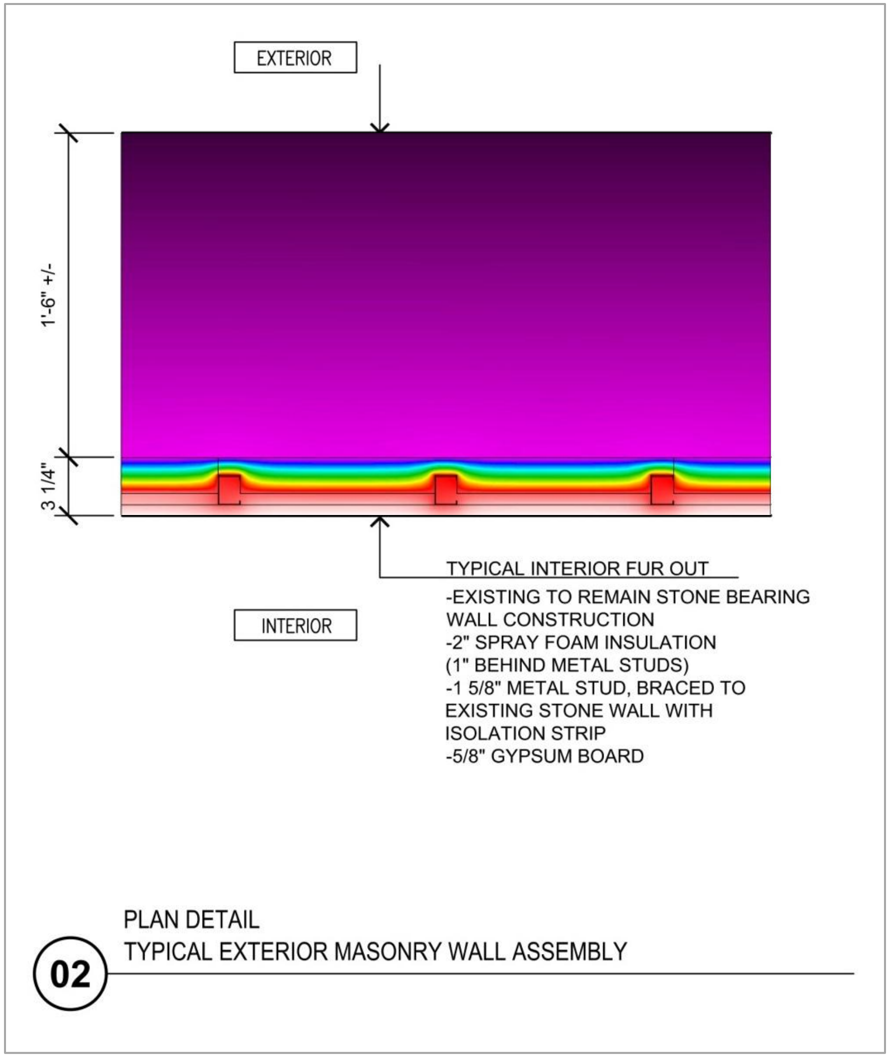
Baseline R-Value= 16.84

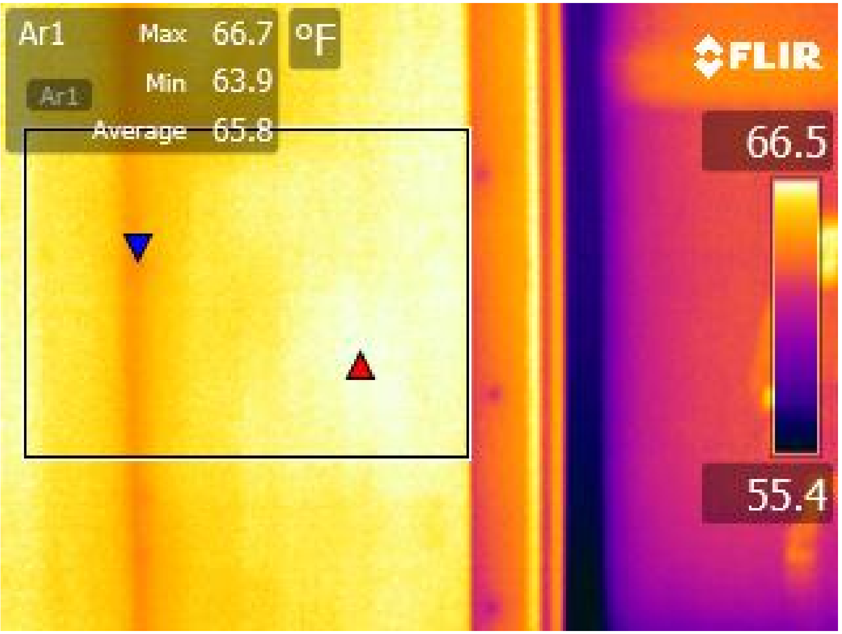
Observed R-Value= 12.44

Simulated R-Value= 14.11 -16%

RESEARCH FINDINGS | Existing Masonry Wall Assemblies

Building 2- studs pulled 1” back from existing wall → results in a decrease of 16% of baseline R-value





Baseline R-Value= 16.84

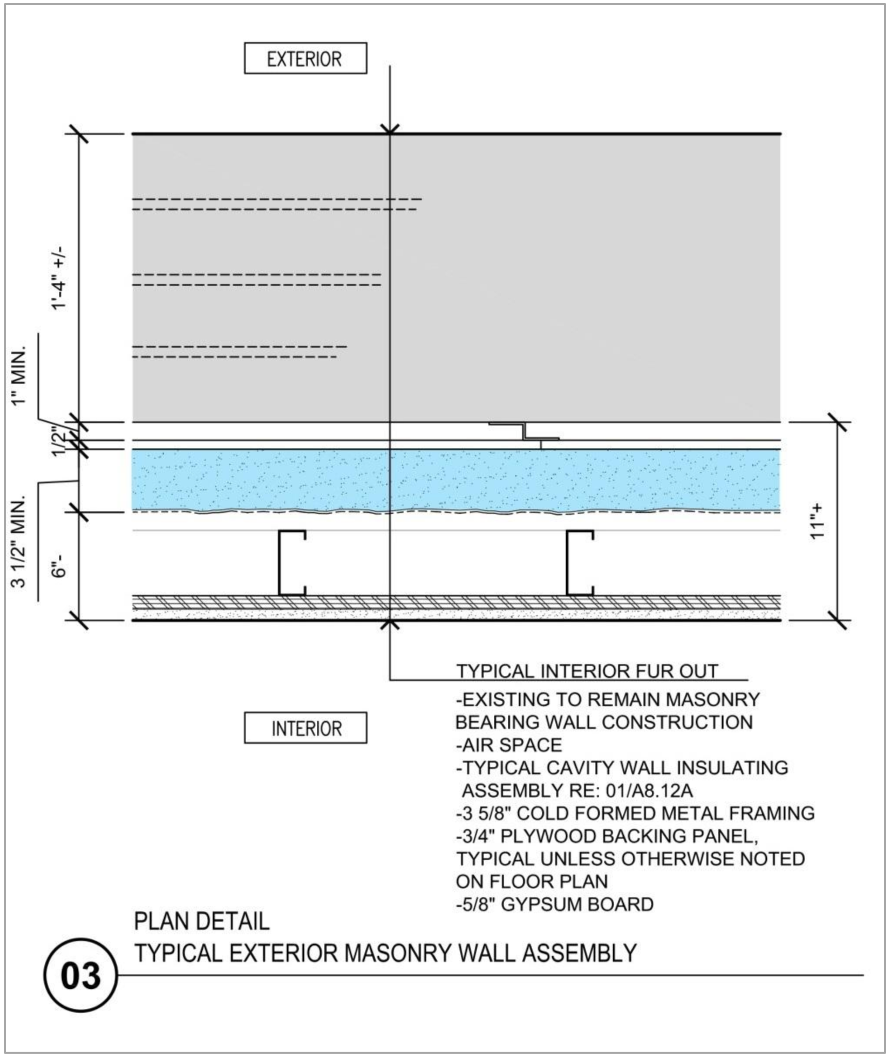
Observed R-Value= 12.44

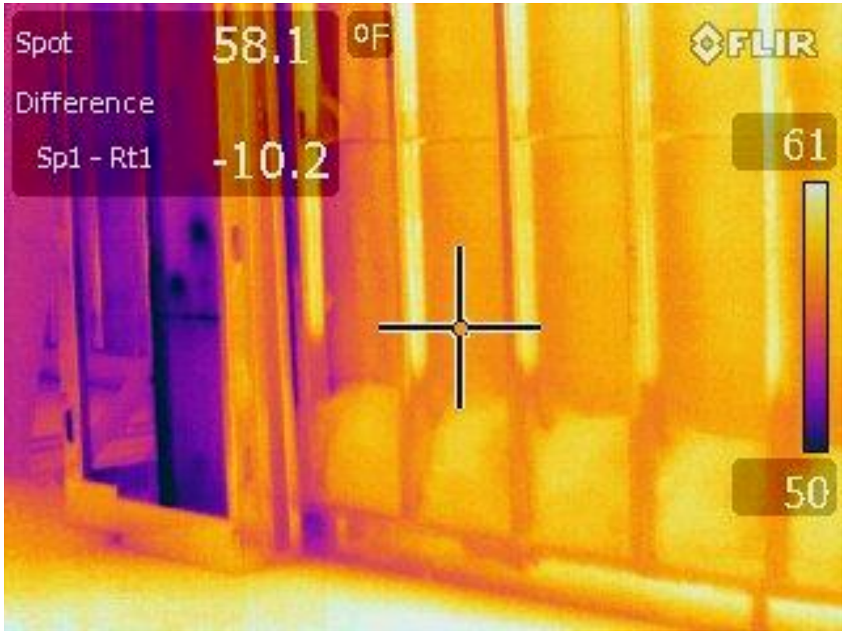
Simulated R-Value= 14.11

-16%

RESEARCH FINDINGS | Existing Masonry Wall Assemblies

Building 3- studs separated from insulation → resulted in a decrease of 2% of baseline R-value





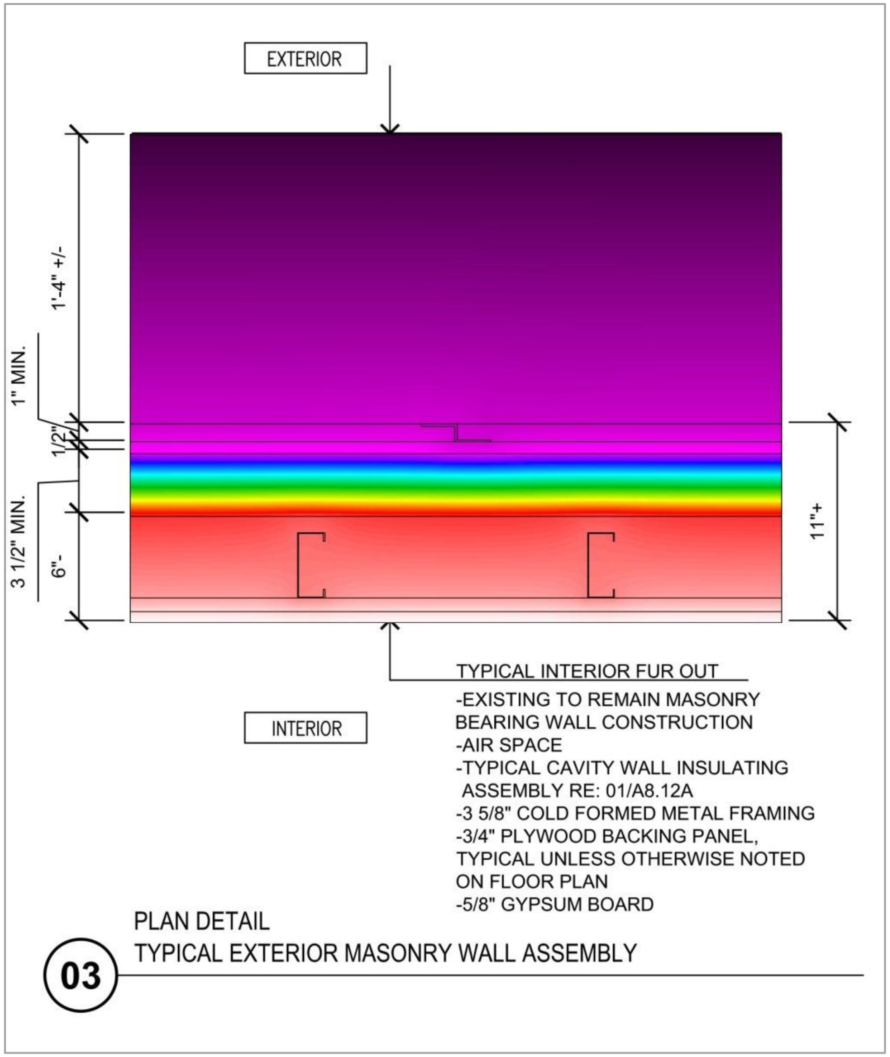
Baseline R-Value= 29.23

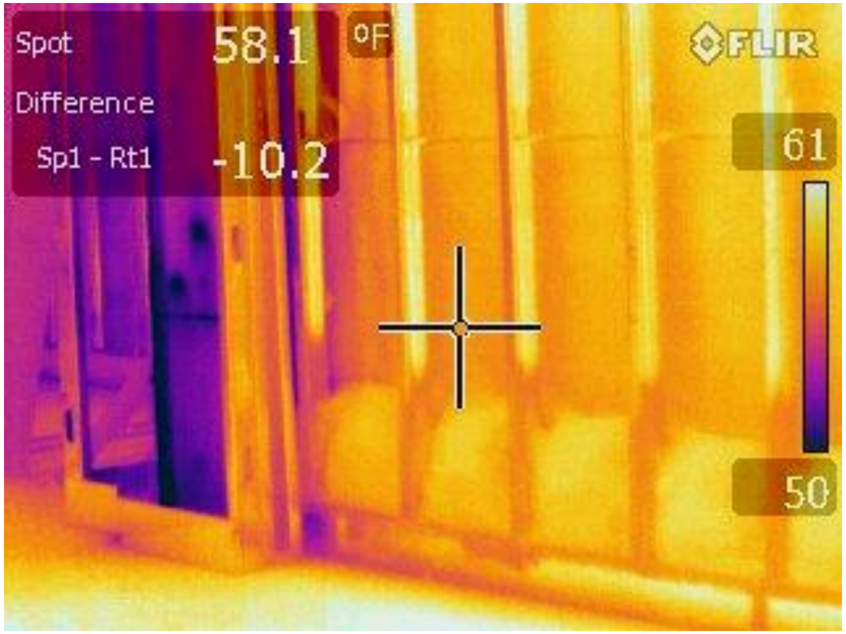
Observed R-Value= 20.16

Simulated R-Value= 28.78 -2%

RESEARCH FINDINGS | Existing Masonry Wall Assemblies

Building 3- studs separated from insulation → resulted in a decrease of 2% of baseline R-value



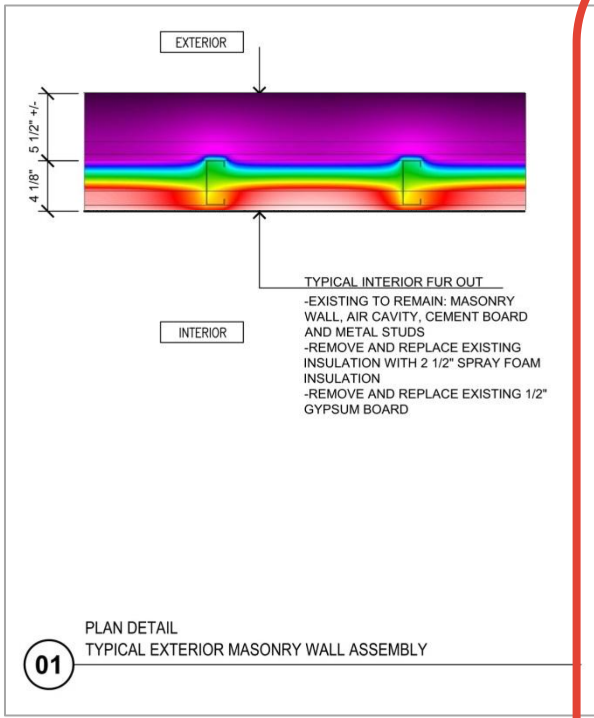


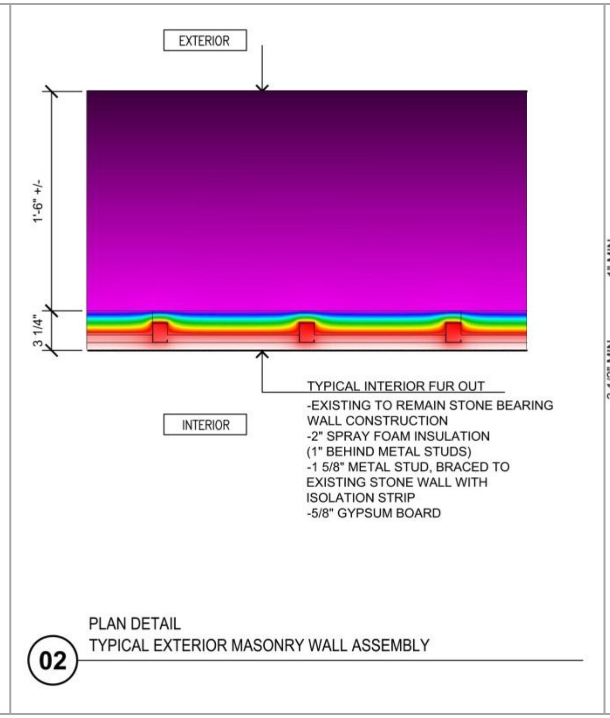
Baseline R-Value= 29.23

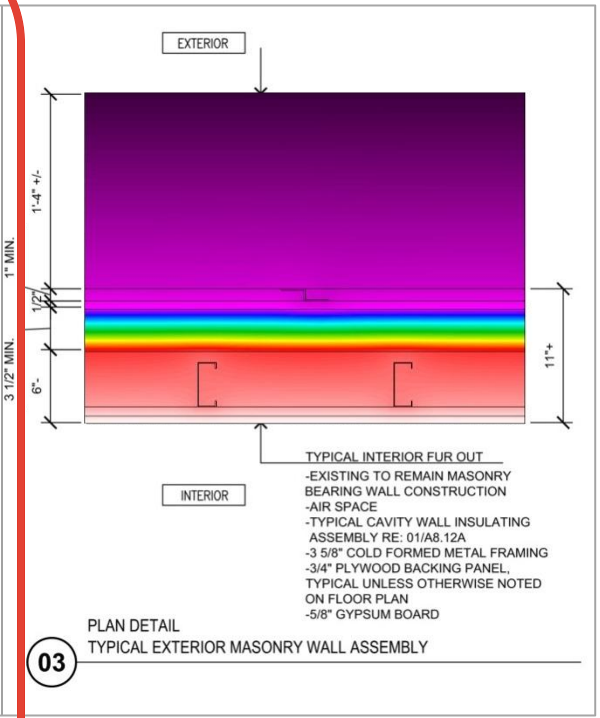
Observed R-Value= 20.16

Simulated R-Value= 28.78 -2%

RESEARCH FINDINGS | Existing Masonry Wall Assemblies







41%
of Baseline R-Value

84%
of Baseline R-Value

98%
of Baseline R-Value

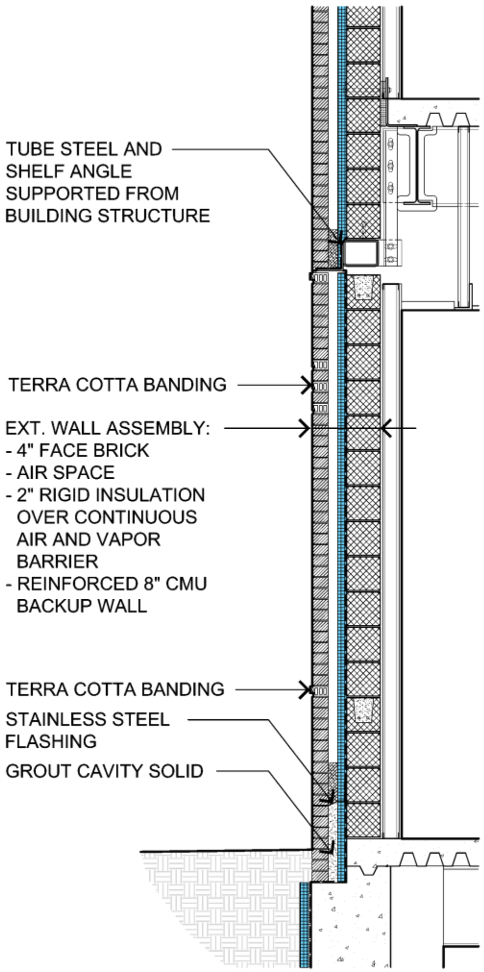
RESEARCH FINDINGS | Masonry Veneer Support Connections

RESEARCH FINDINGS | Masonry Veneer Support Connections

- Main areas of thermal bridging:
  - Brick ties (one every 2.67 square feet)
  - Shelf angle

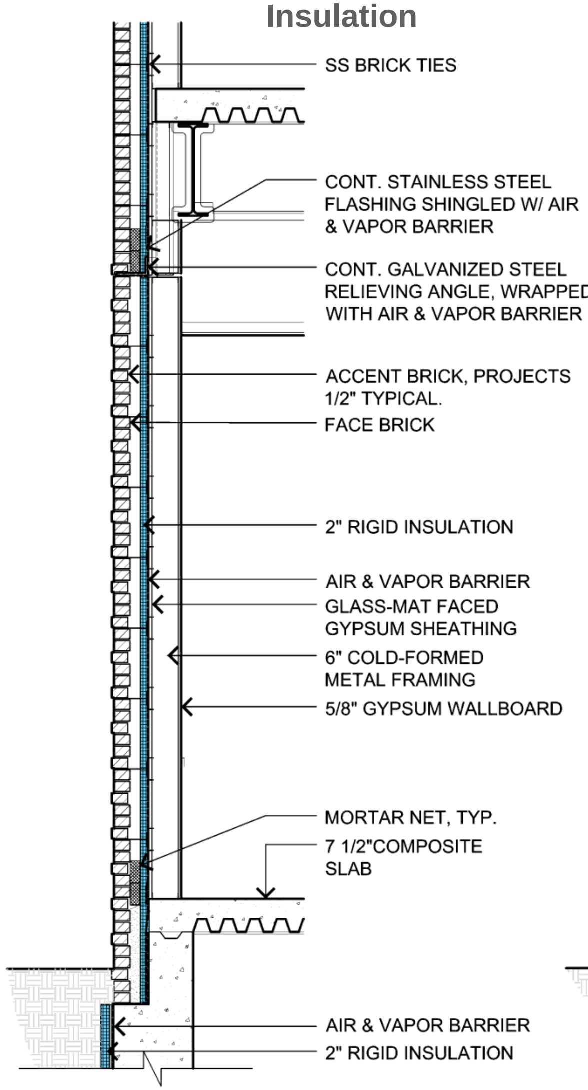
RESEARCH FINDINGS | Masonry Veneer Support Connections

CMU Back Up Wall with 2" Rigid Insulation



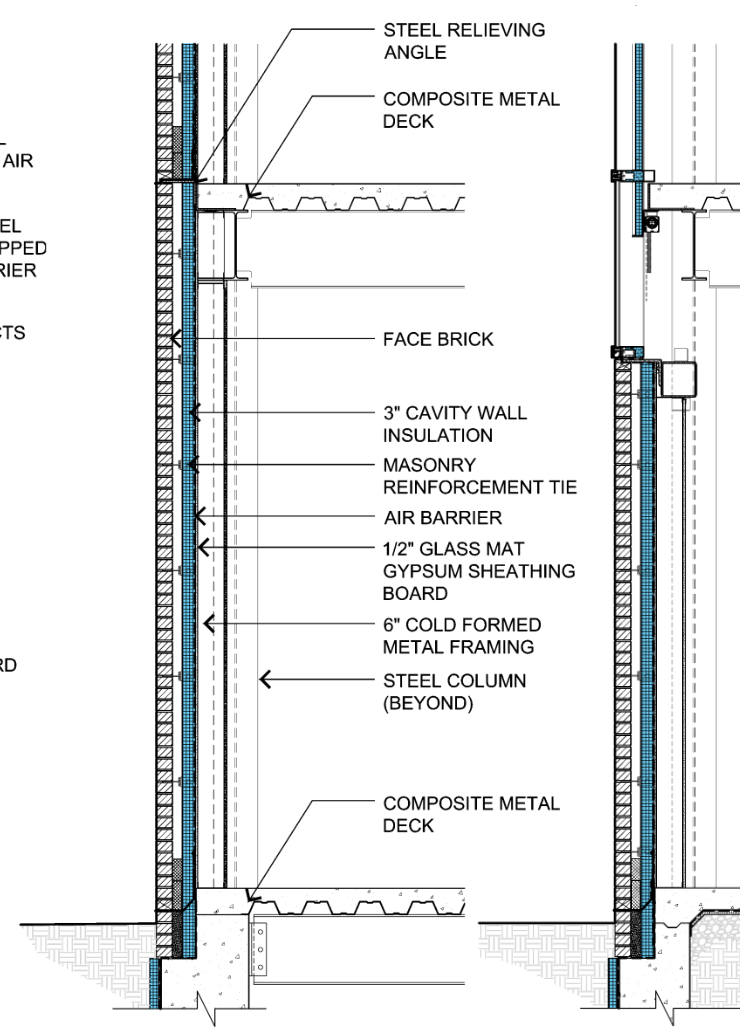
R-16.1

Stud Back Up Wall with 2" Rigid Insulation



R-16.2

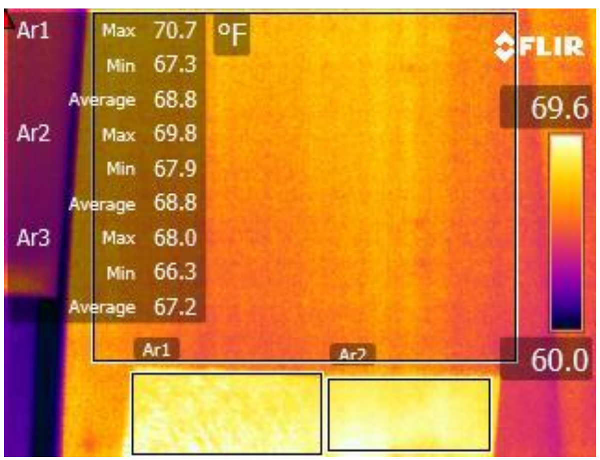
Stud Back Up Wall with 3" Mineral Wool insulation



R-19.1

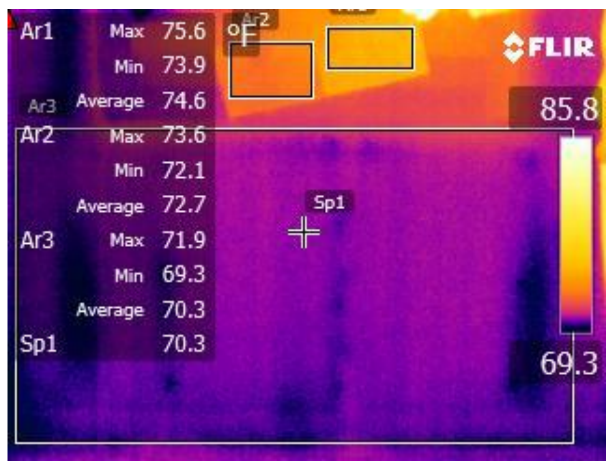
RESEARCH FINDINGS | Masonry Veneer Support Connections

CMU Back Up Wall with 2" Rigid Insulation



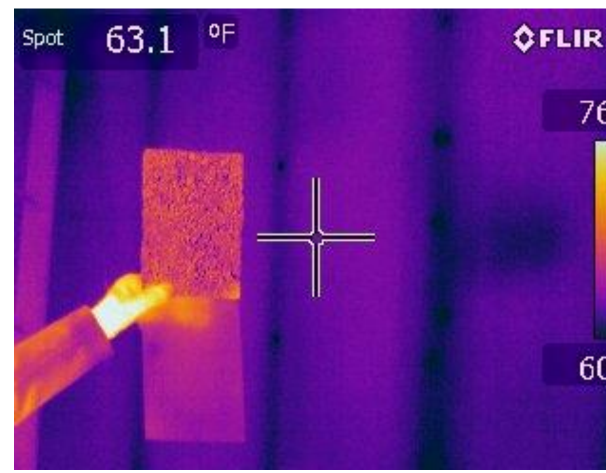
R-12.3 **-24%**

Stud Back Up Wall with 2" Rigid Insulation



R-6.5 **-60%**

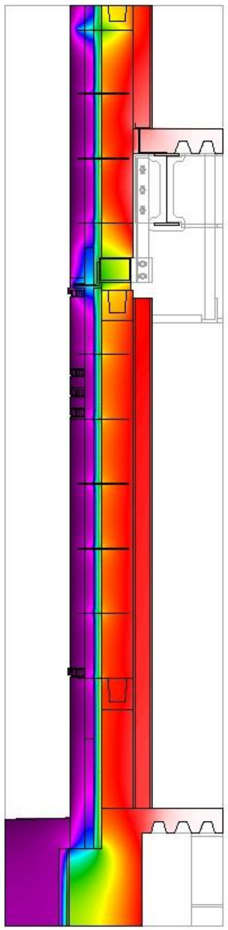
Stud Back Up Wall with 3" Mineral Wool insulation



R-8.42 **-56%**

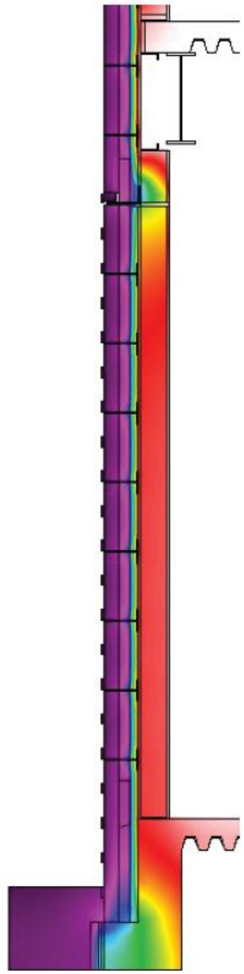
RESEARCH FINDINGS | Masonry Veneer Support Connections

CMU Back Up Wall with 2" Rigid Insulation



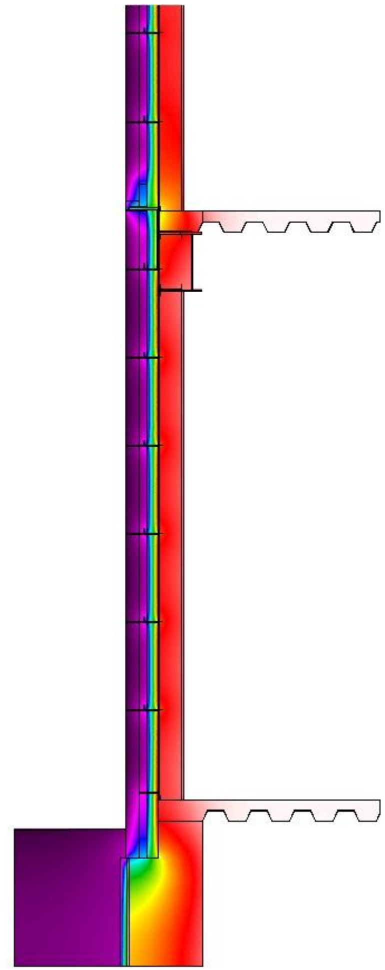
R-13.3 -17%

Stud Back Up Wall with 2" Rigid Insulation

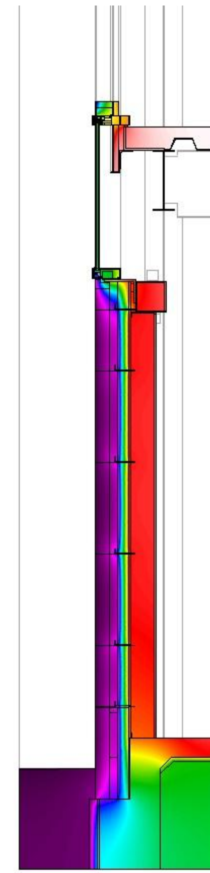


R-9.3 -43%

Stud Back Up Wall with 3" Mineral Wool insulation



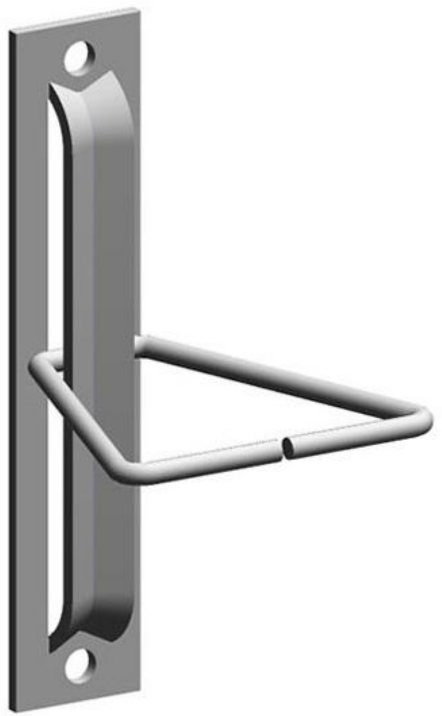
R-14.2 -25%



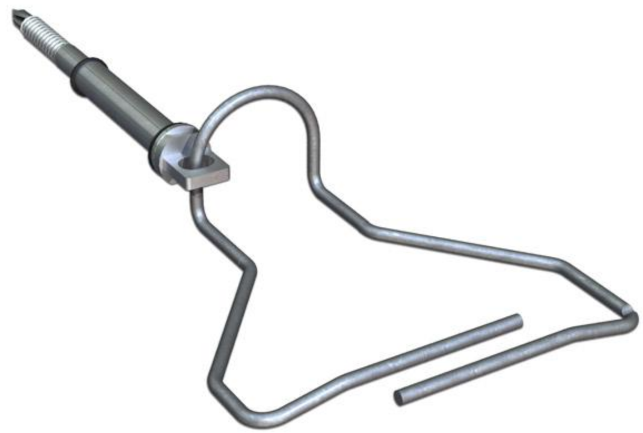
R-14.4 -25%

RESEARCH FINDINGS | Masonry Veneer Support Connections

Screw On (S)



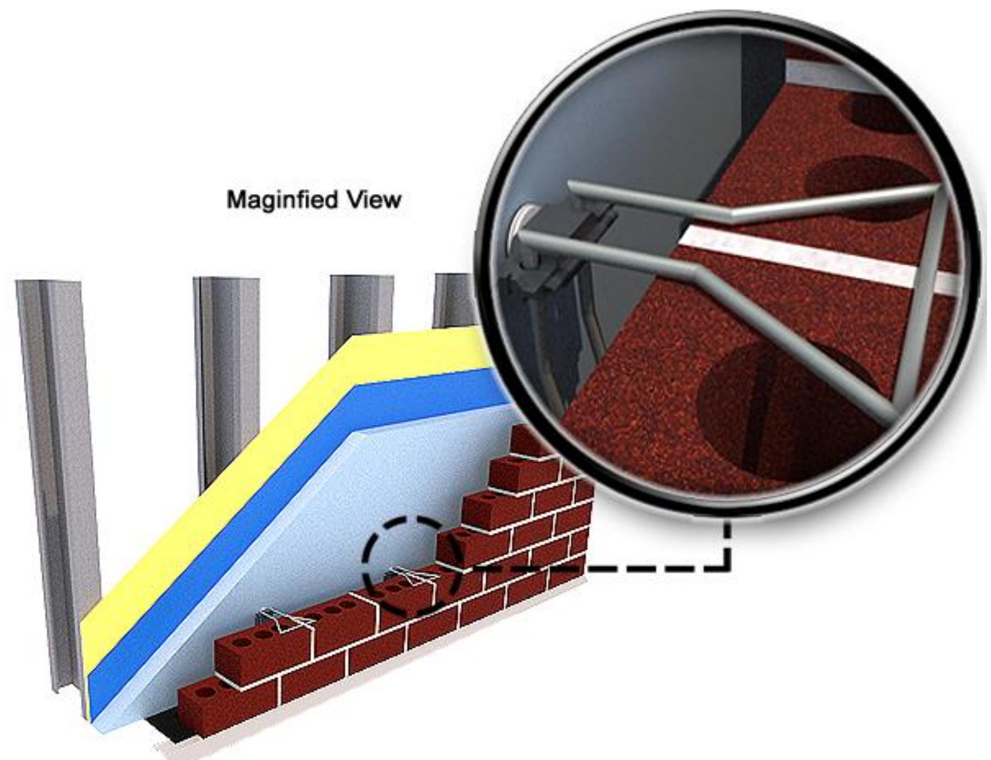
Posities Barrel (B)



Eye and Pintle

RESEARCH FINDINGS | Masonry Veneer Support Connections

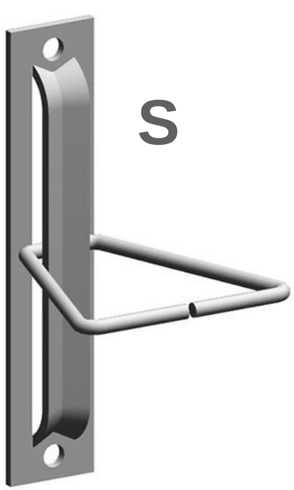
Thermal Brick Tie (T)

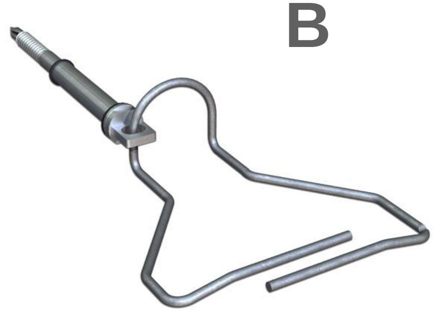


RESEARCH FINDINGS | Masonry Veneer Support Connections

LOSS %			-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13	-14	-15
TIE SPACING	16 X 16	B							▲								●
		S			▲						●						
		T														●	
	16 X 24	B					▲							●			
		S		▲					●								
		T					▲				●						
	R 14.75 (BASE WALL NO TIES)																

● GALVANIZED ▲ STAINLESS

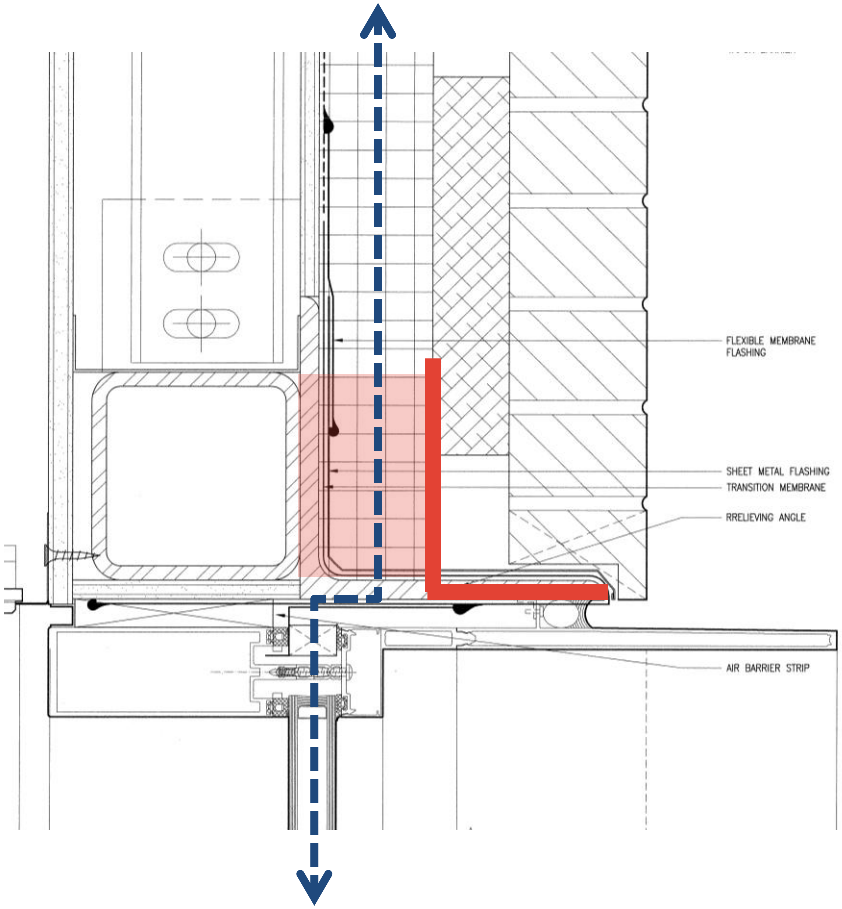

S

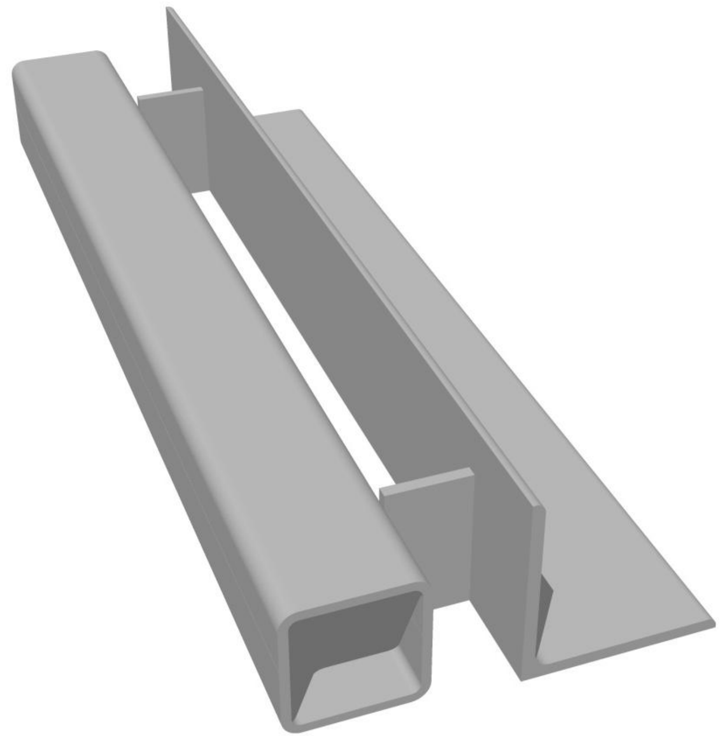

B

T

RESEARCH FINDINGS | Masonry Veneer Support Connections

RESEARCH FINDINGS | Masonry Veneer Support Connections



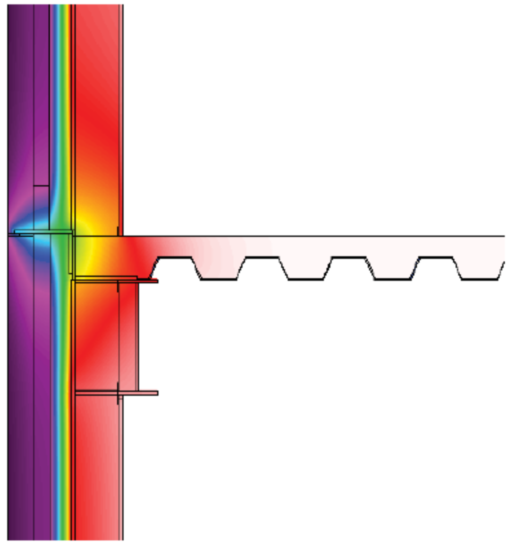


RESEARCH FINDINGS | Masonry Veneer Support Connections

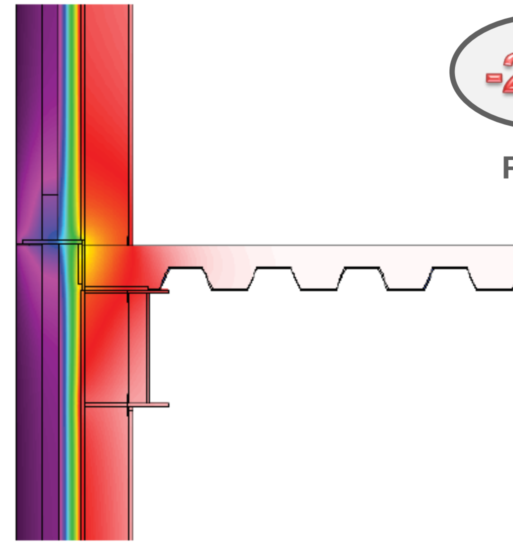
Continuous Galvanized Shelf Angle

-35%

R-12.0



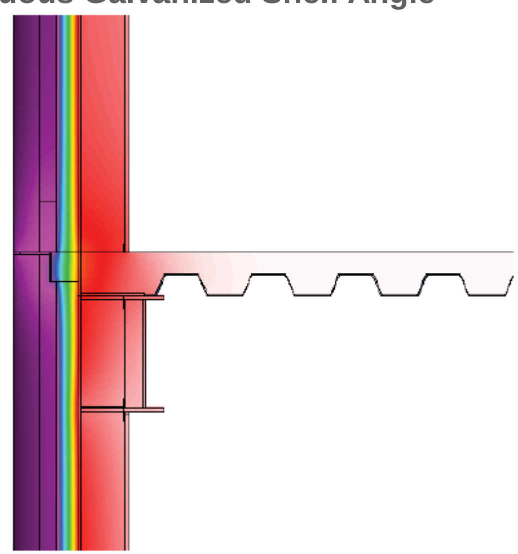
Continuous Stainless Steel Shelf Angle



-29%

R-13.0

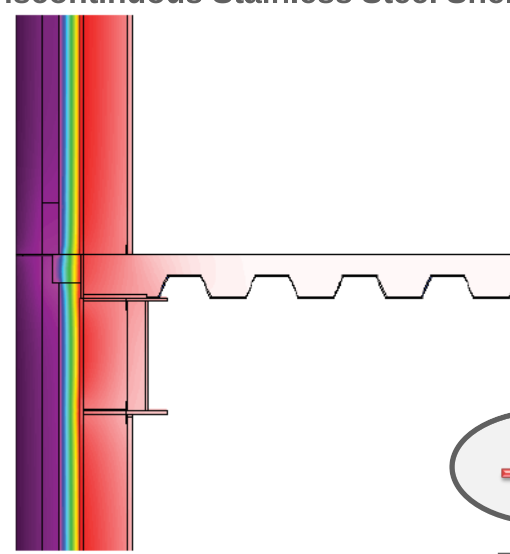
Discontinuous Galvanized Shelf Angle



-12%

R-16.0

Discontinuous Stainless Steel Shelf Angle

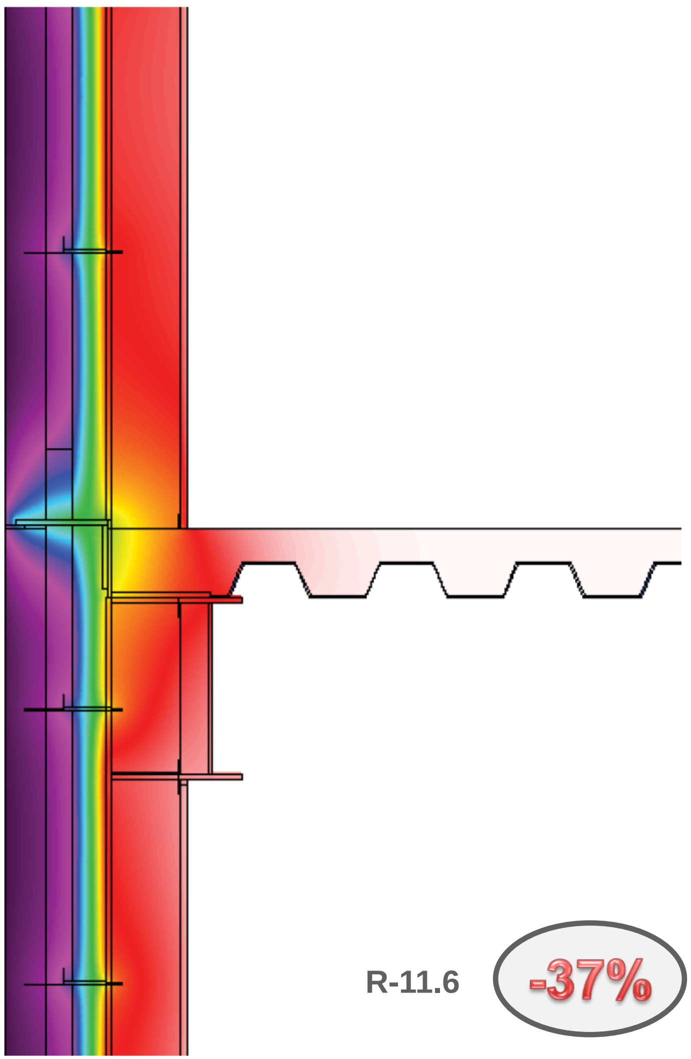


-3%

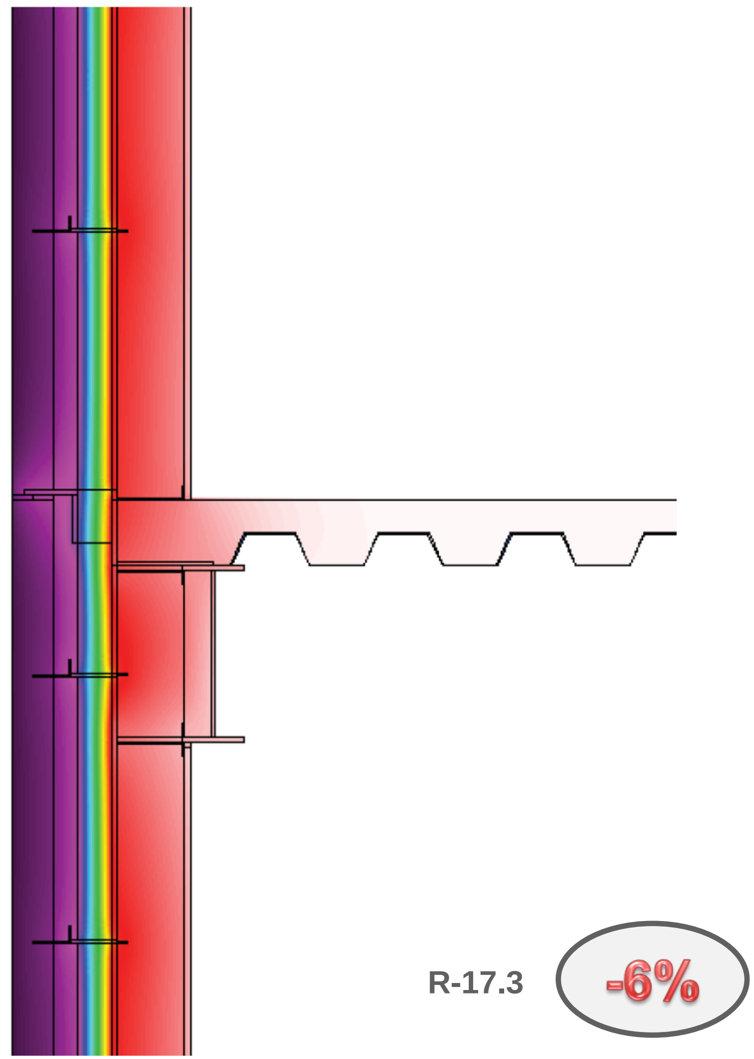
R-17.6

RESEARCH FINDINGS | Masonry Veneer Support Connections

Traditional Masonry Wall with Galvanized Barrel Ties and a Continuous Galvanized Shelf Angle



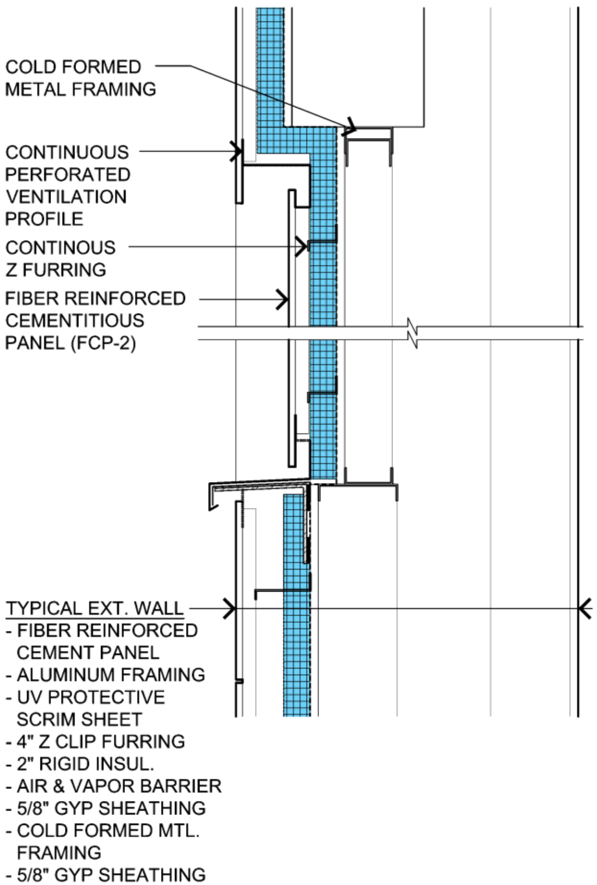
Improved Masonry Wall with Stainless Steel Screw Ties and a Discontinuous Stainless Steel Shelf Angle

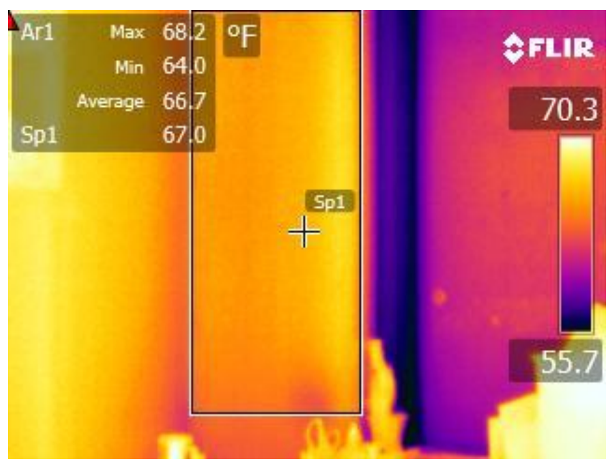


RESEARCH FINDINGS | Rainscreens

RESEARCH FINDINGS | Rainscreens

Horizontal Z-Girt Supports





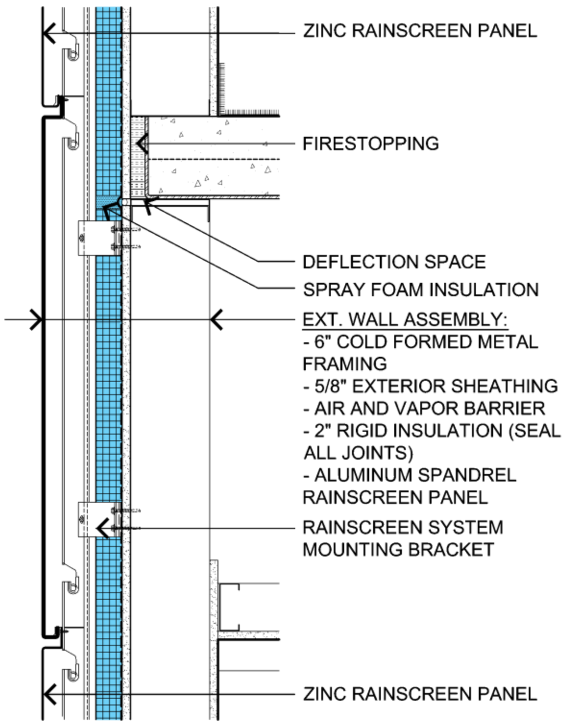
R-14.1

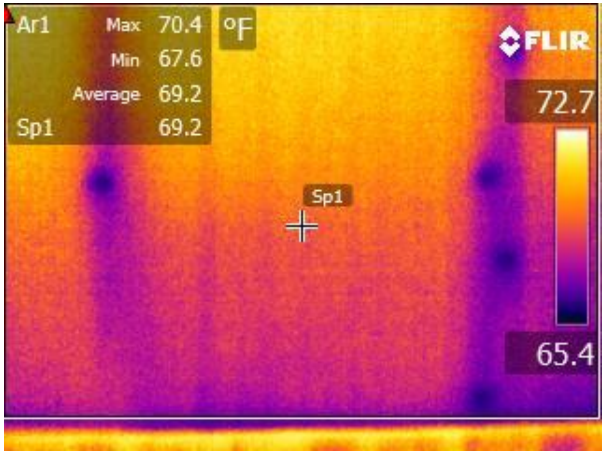
R-6.2 -56%

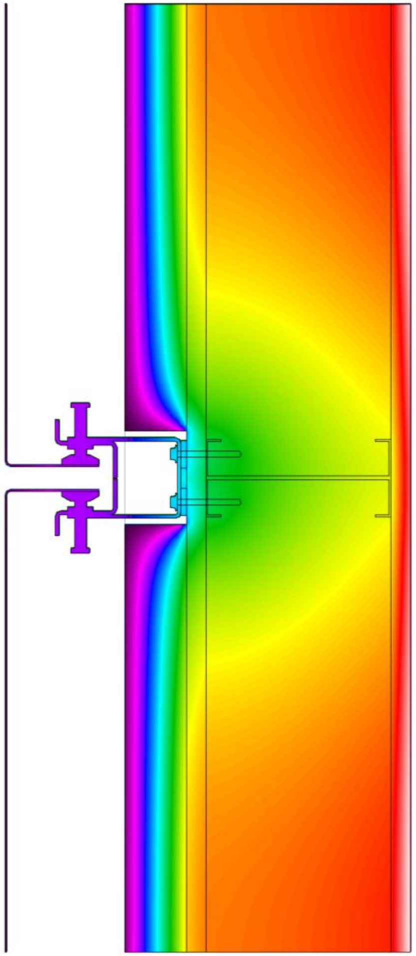
R-5.6 -60%

RESEARCH FINDINGS | Rainscreens

Clip Supports







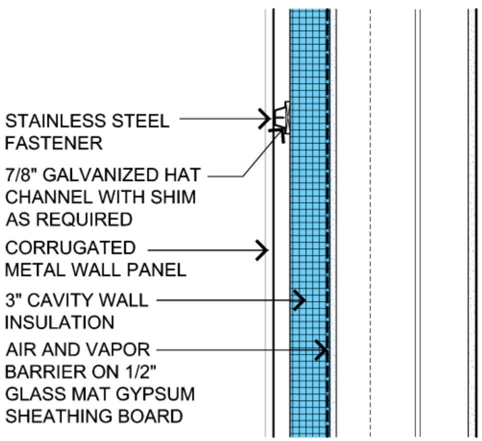
R-12.6

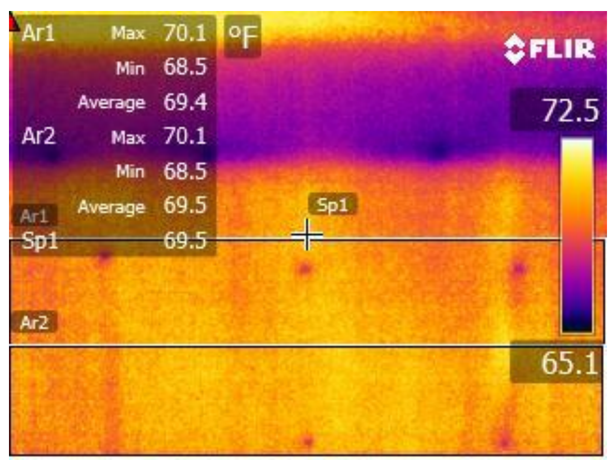
R-9.7 -23%

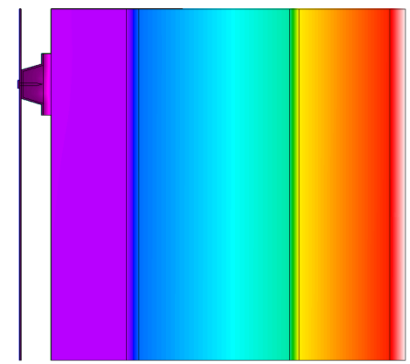
-14%

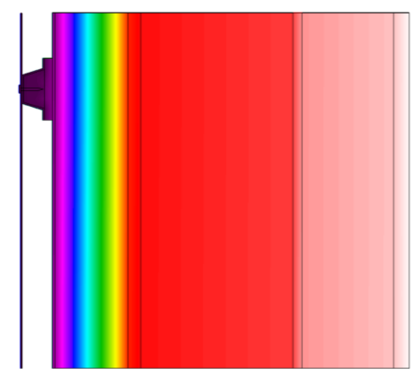
RESEARCH FINDINGS | Rainscreens

Vertical Z-Girt Supports









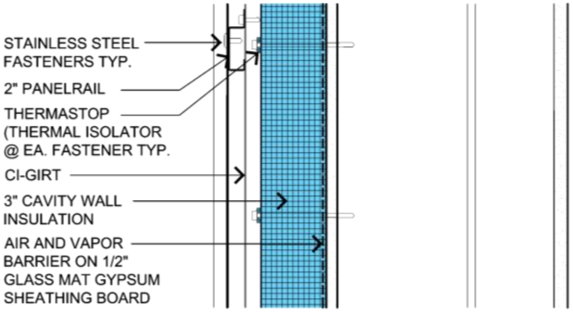
R-16.9

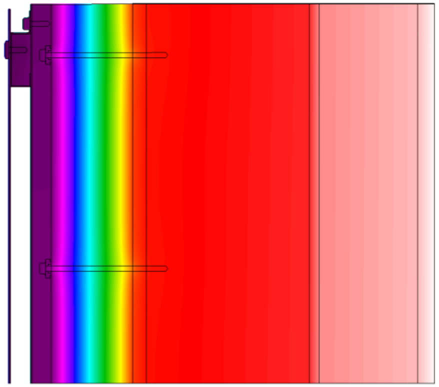
R-9.2 -46%

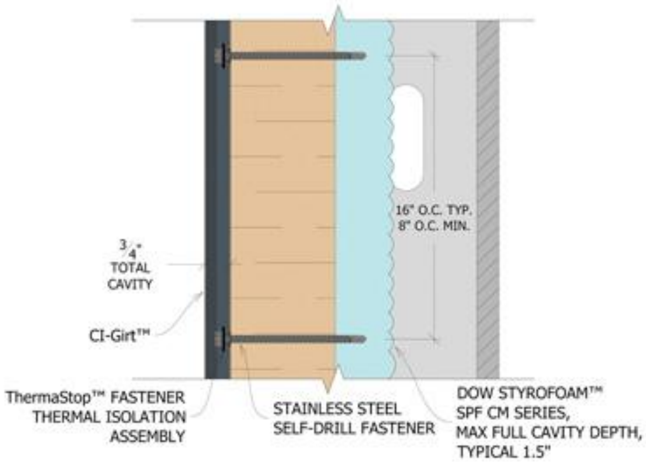
R-11.1 -34%

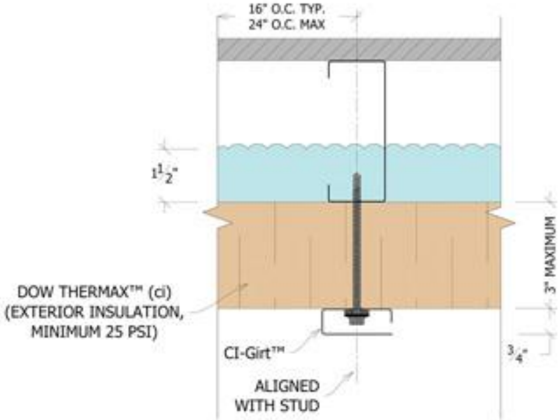
RESEARCH FINDINGS | Rainscreens

Continuous Rainscreen System







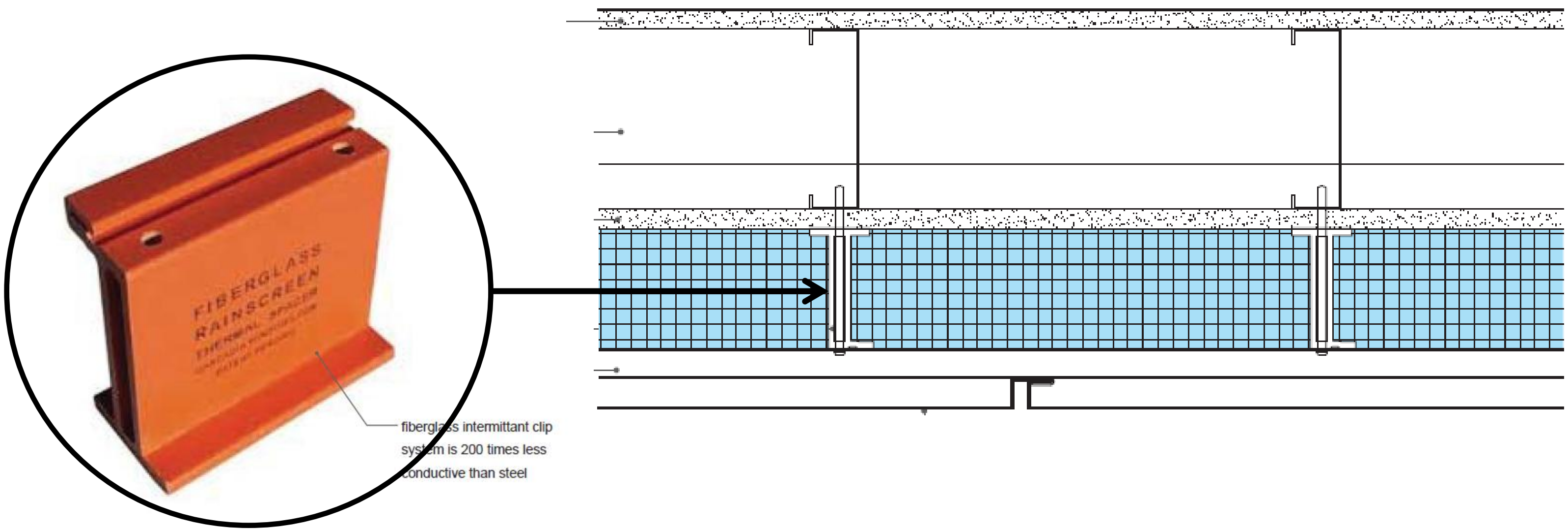


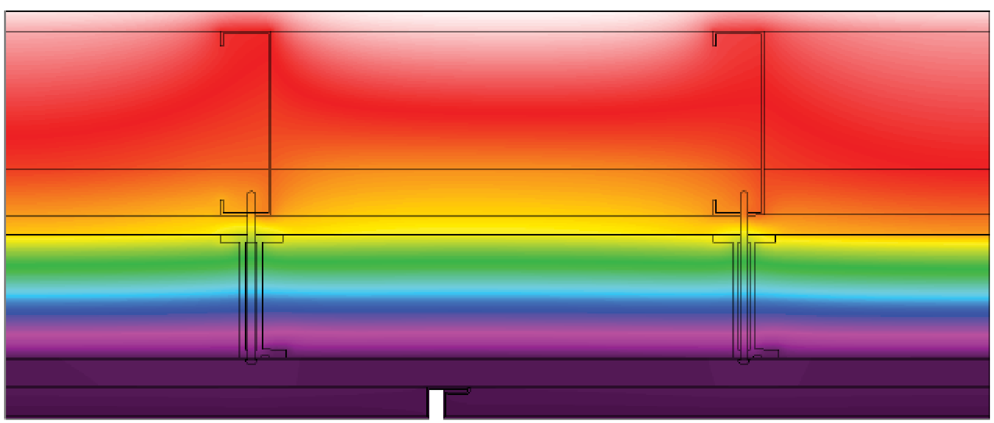
R-16.2

-4%

RESEARCH FINDINGS | Rainscreens

Examples of existing thermally broken products on the market



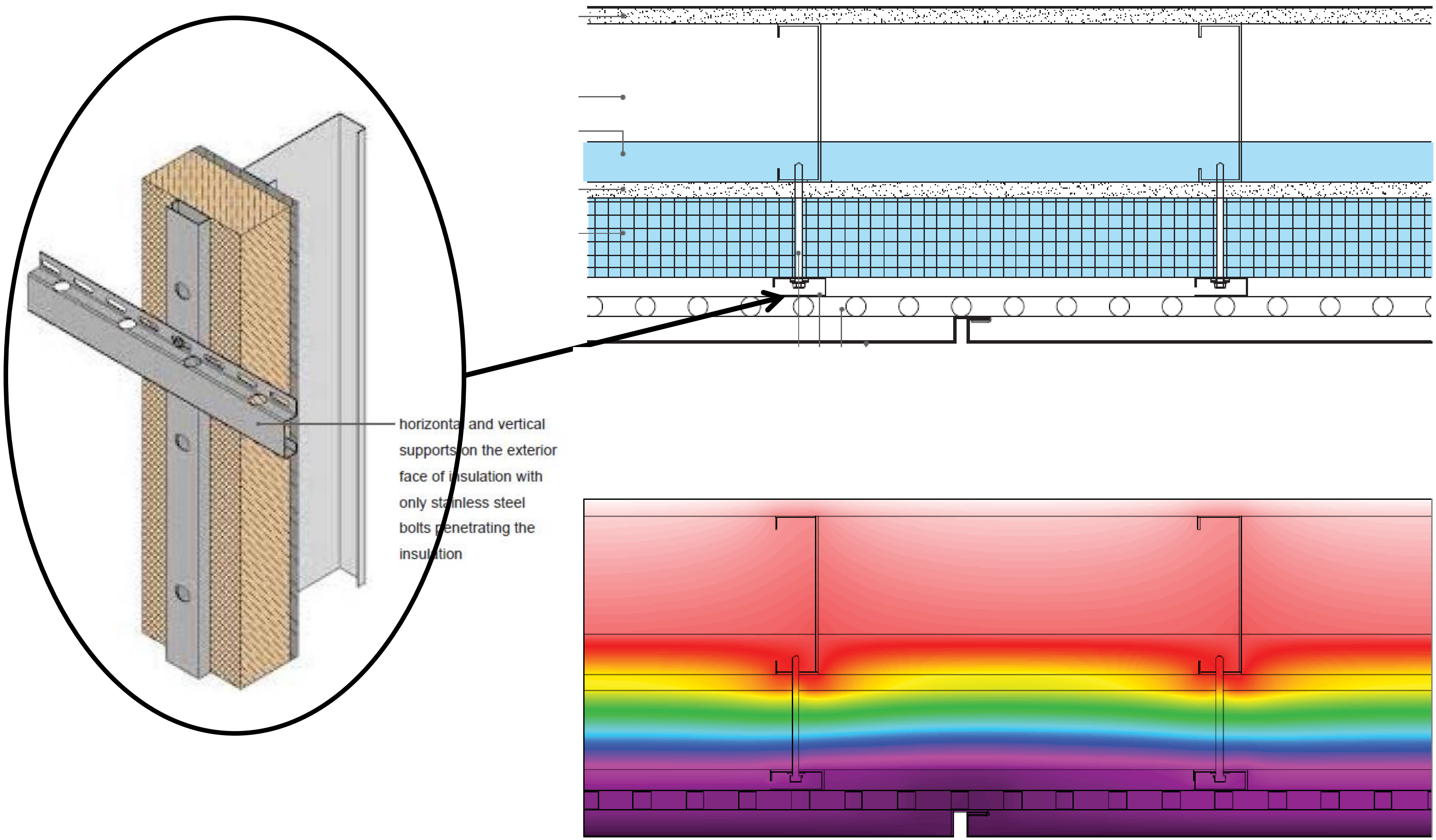


R-16.8

-20%

RESEARCH FINDINGS | Rainscreens

Examples of existing thermally broken products on the market

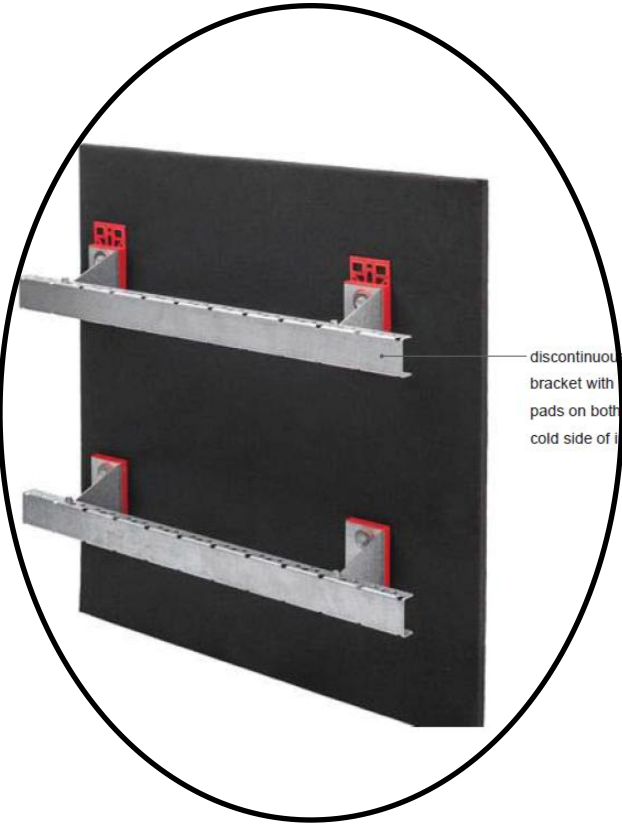


R-21.4

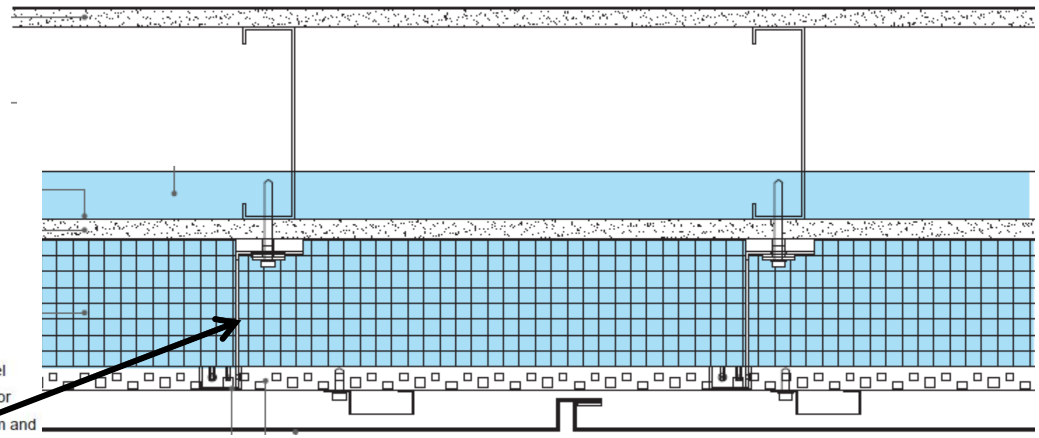
-10%

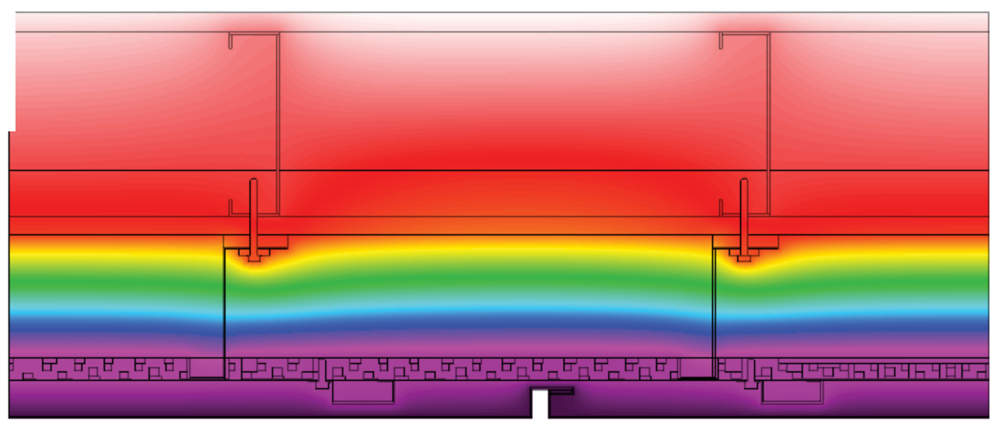
RESEARCH FINDINGS | Rainscreens

Examples of existing thermally broken products on the market



discontinuous steel bracket with isolator pads on both warm and cold side of insulation

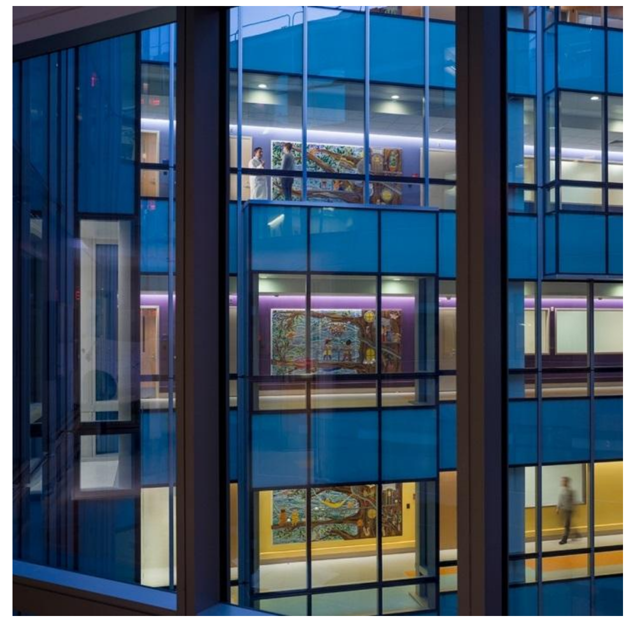




R-22.5

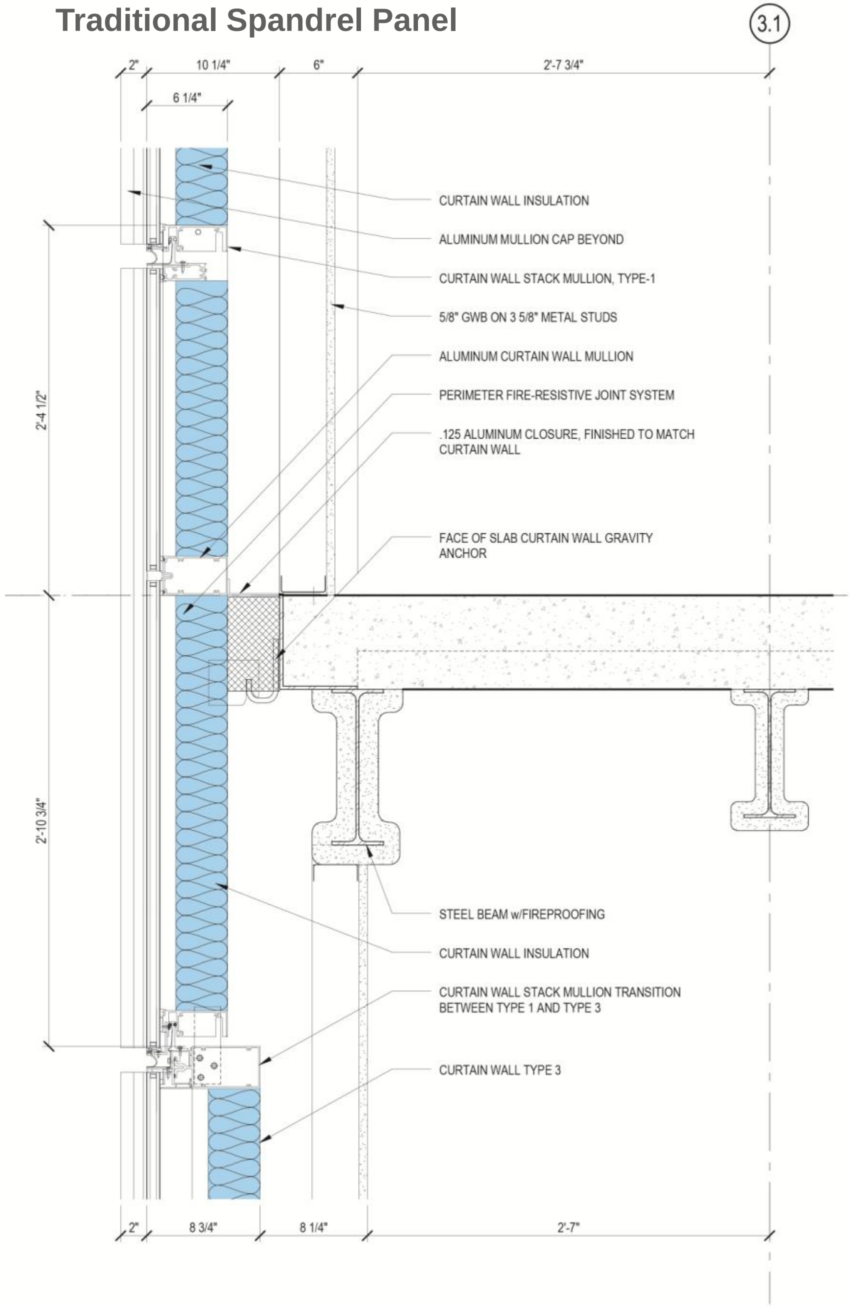
-25%

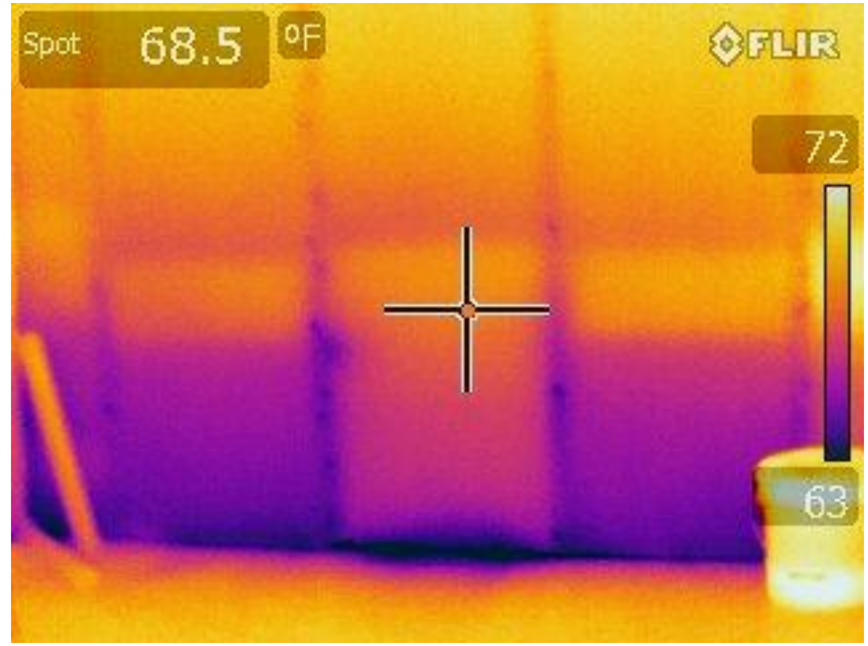
RESEARCH FINDINGS | Curtain Walls



RESEARCH FINDINGS | Curtain Walls

Traditional Spandrel Panel



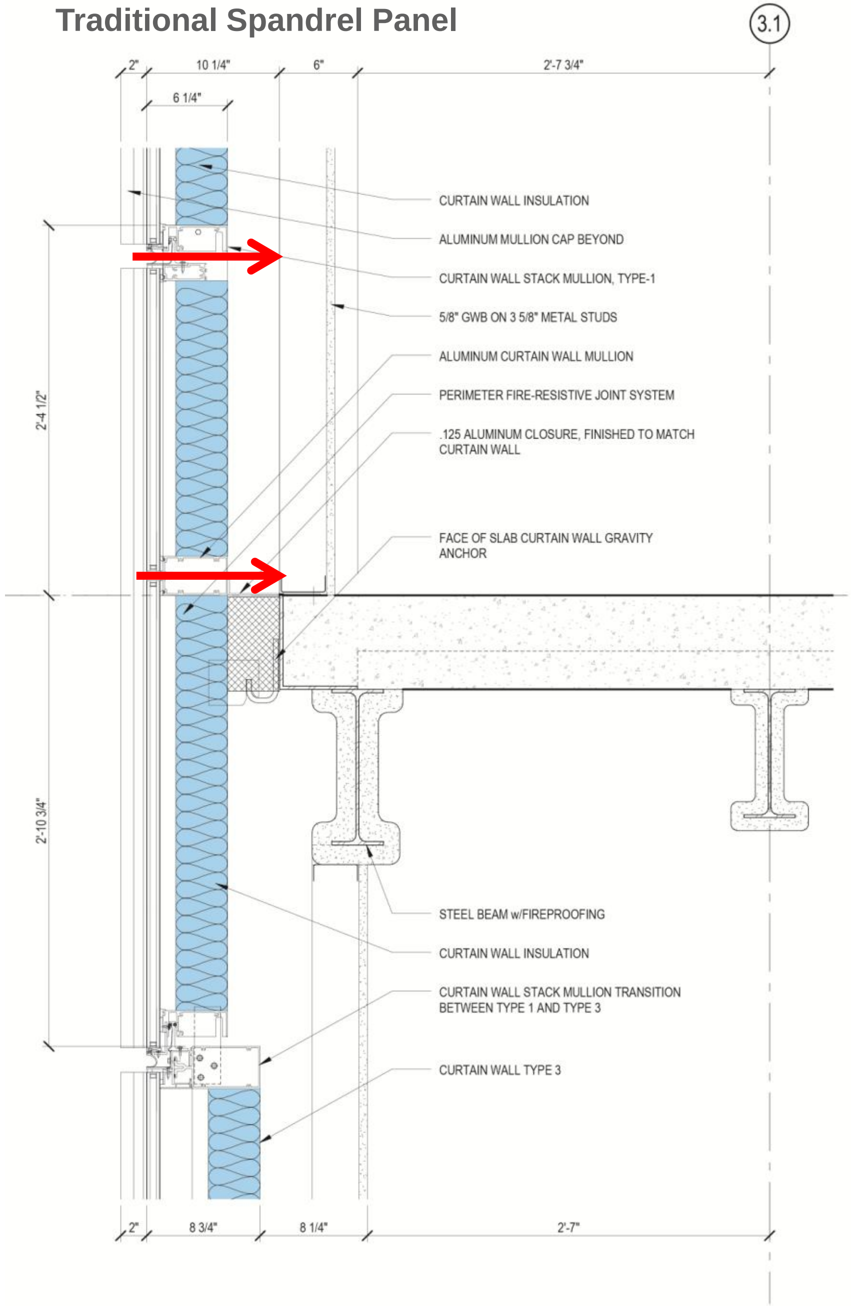


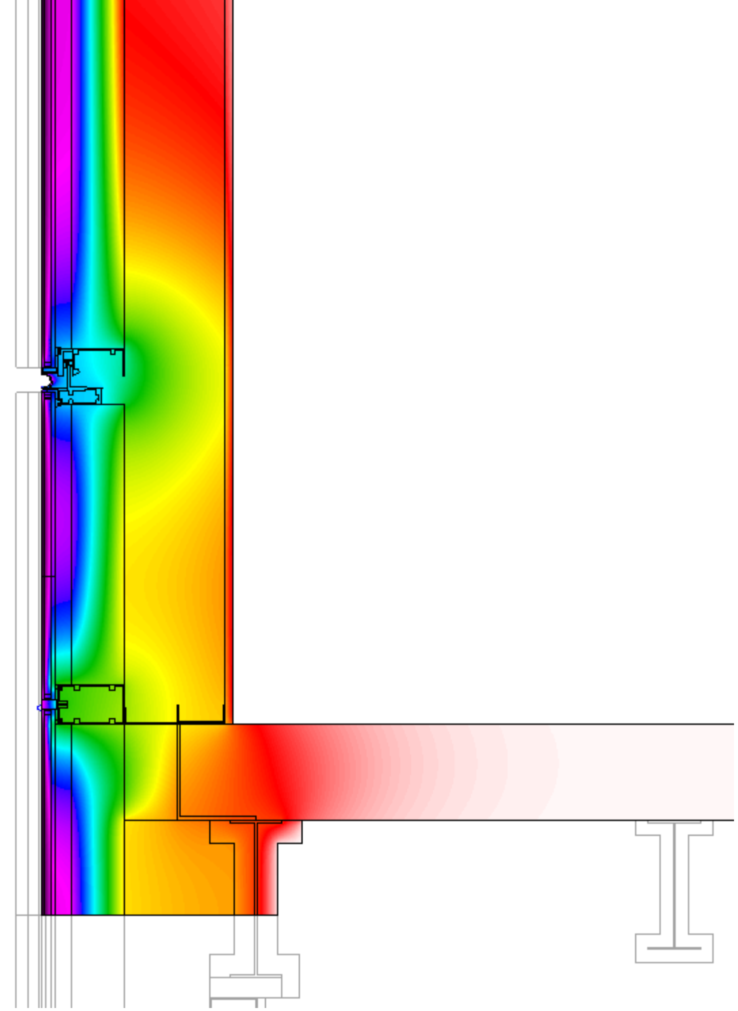
-72%

Baseline R-Value: 20.4
Observed R-Value: 5.8

RESEARCH FINDINGS | Curtain Walls

Traditional Spandrel Panel



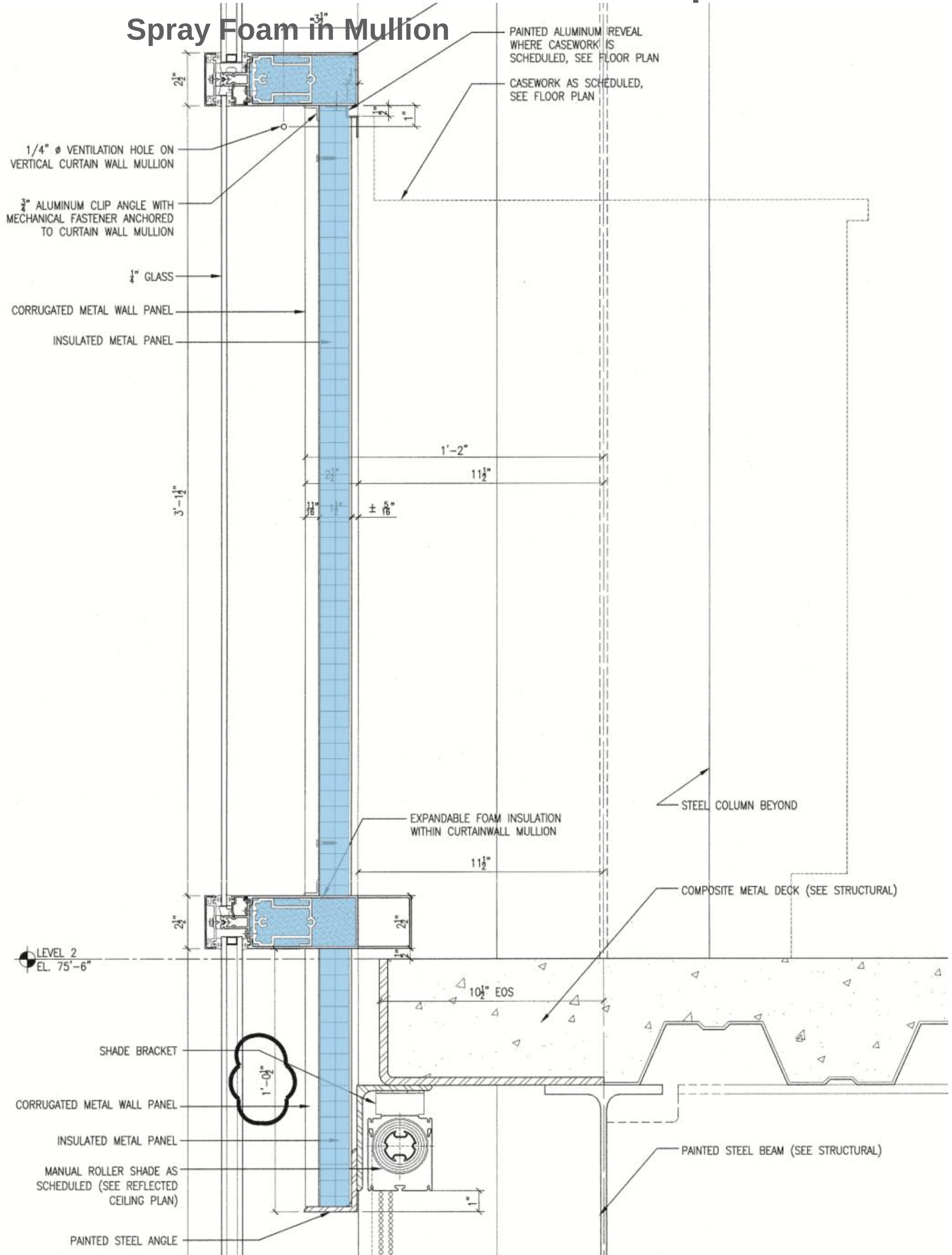


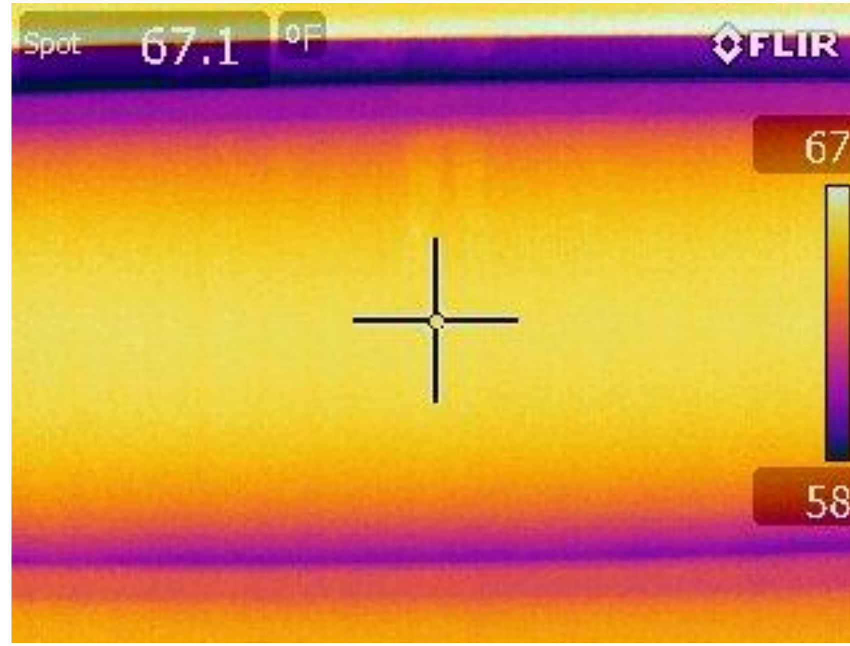
-70%

Baseline R-Value: 20.4
Simulated R-Value: 6.2

RESEARCH FINDINGS | Curtain Walls

Spray Foam in Mullion

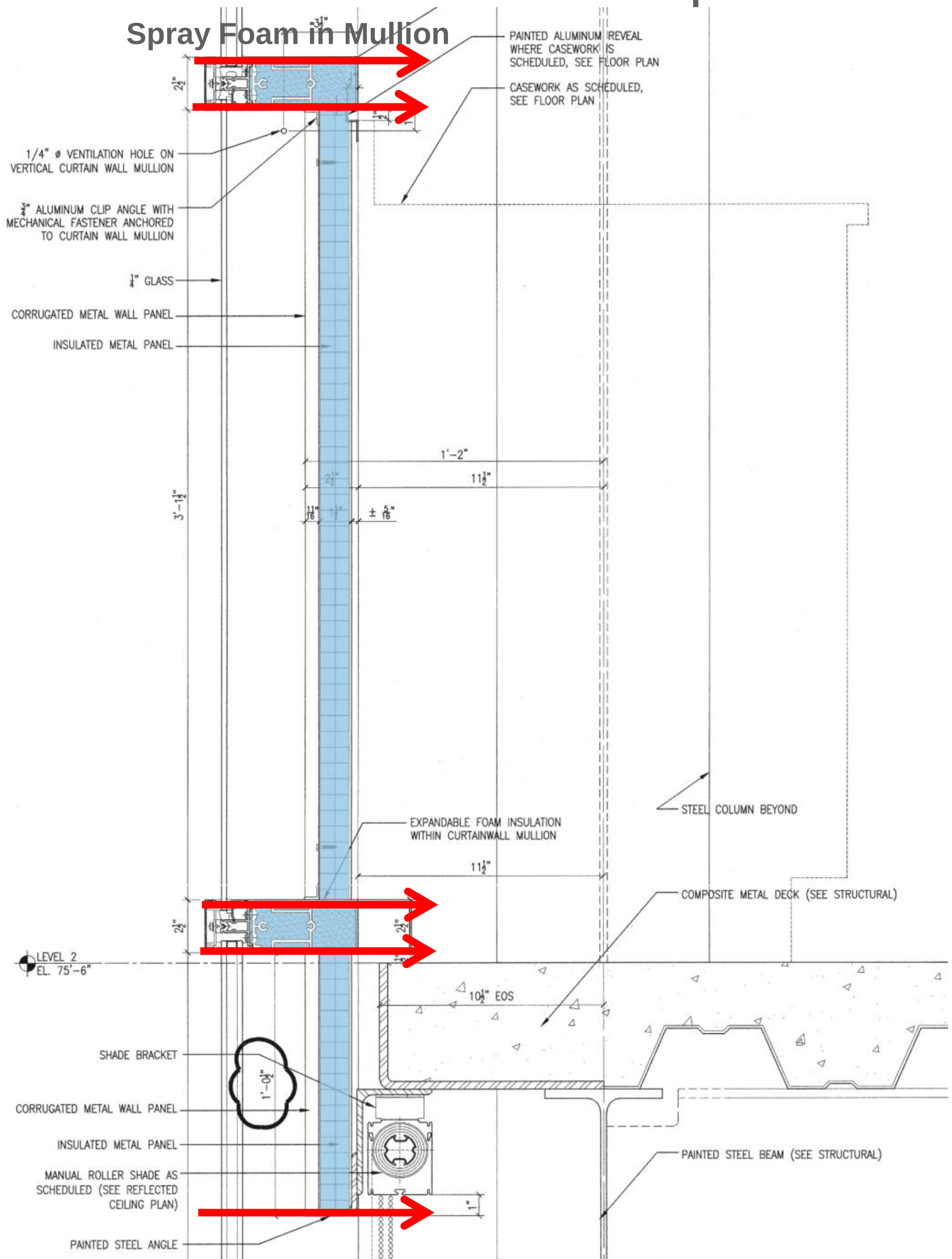


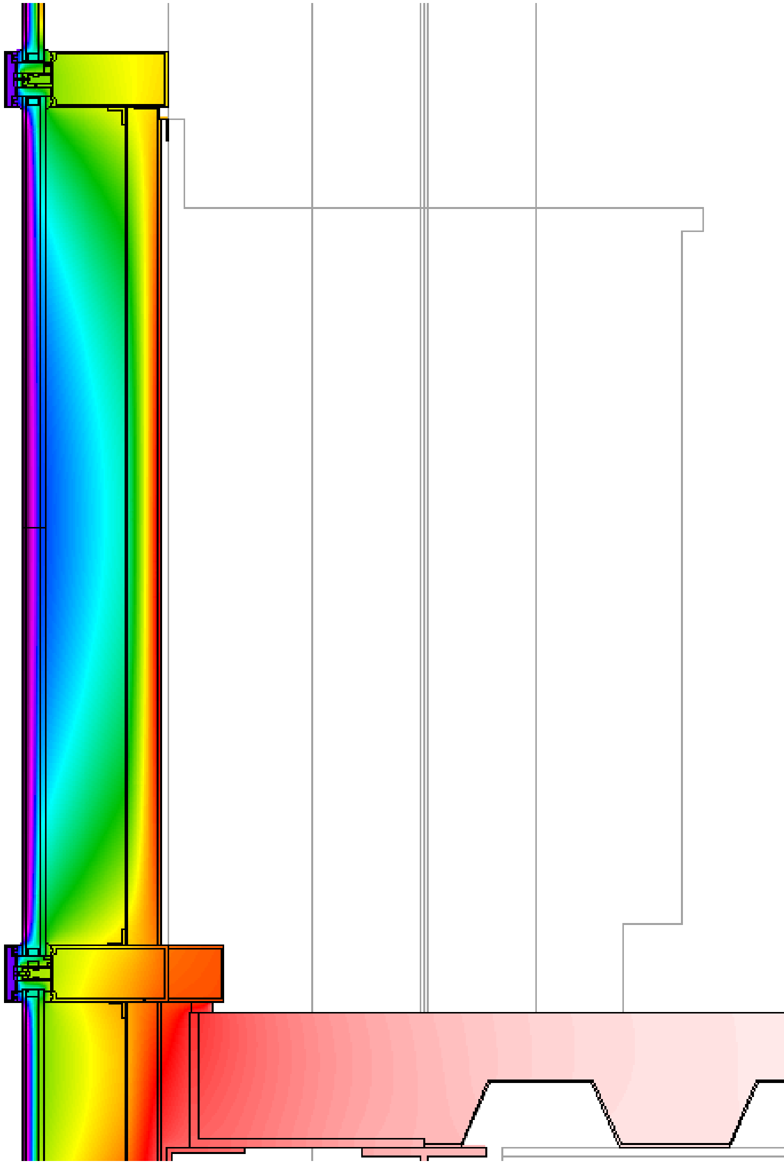


-56%

Baseline R-Value: 14.2
Observed R-Value: 6.2

RESEARCH FINDINGS | Curtain Walls



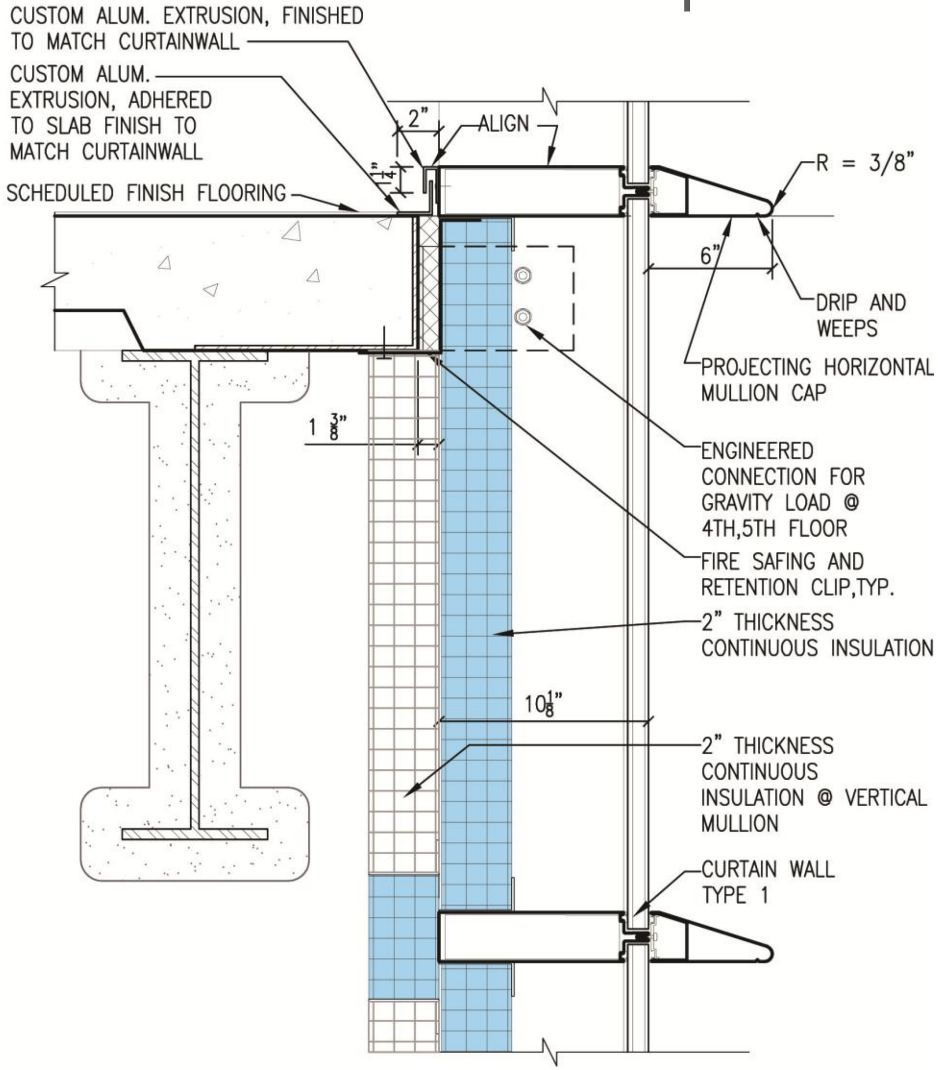


-65%

Baseline R-Value: 14.2

Simulated R-Value: 4.9

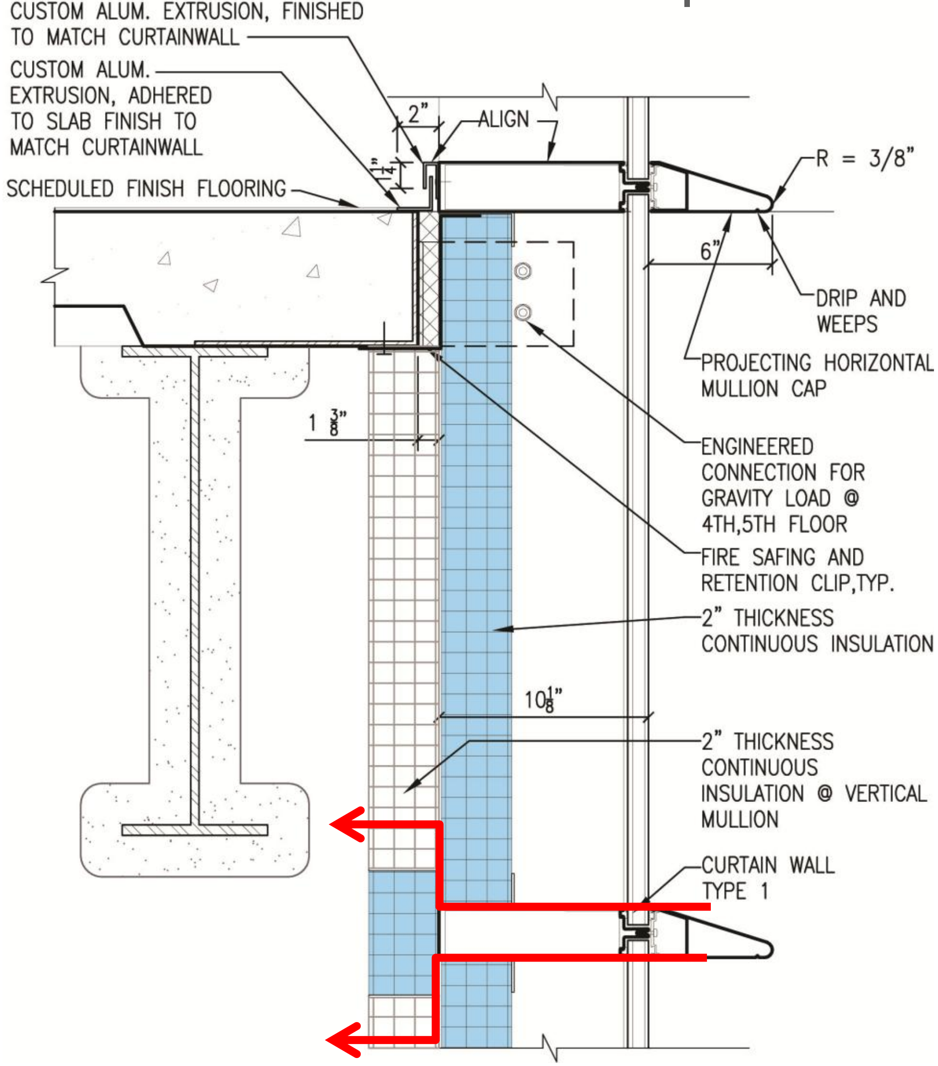
RESEARCH FINDINGS | Curtain Walls



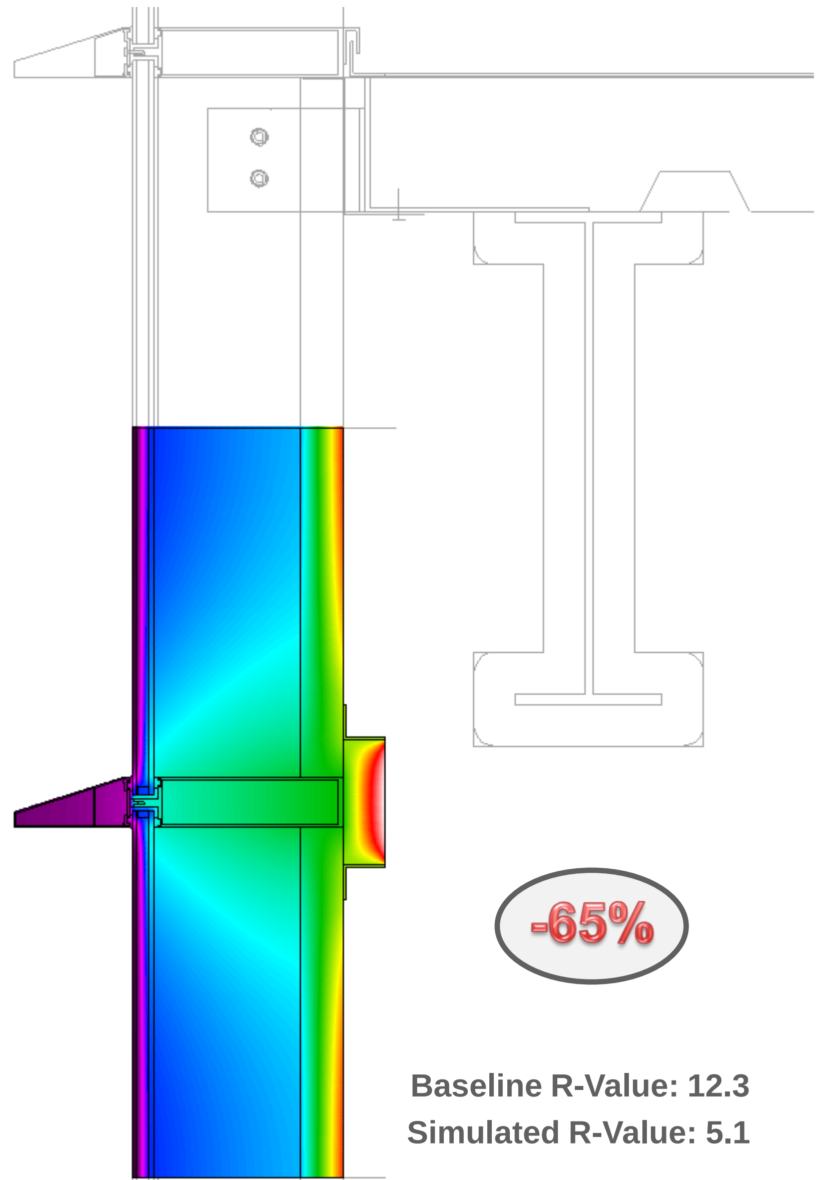
Wrapped Mullion

Baseline R-Value: 12.3

RESEARCH FINDINGS | Curtain Walls



Wrapped Mullion with Back Pan

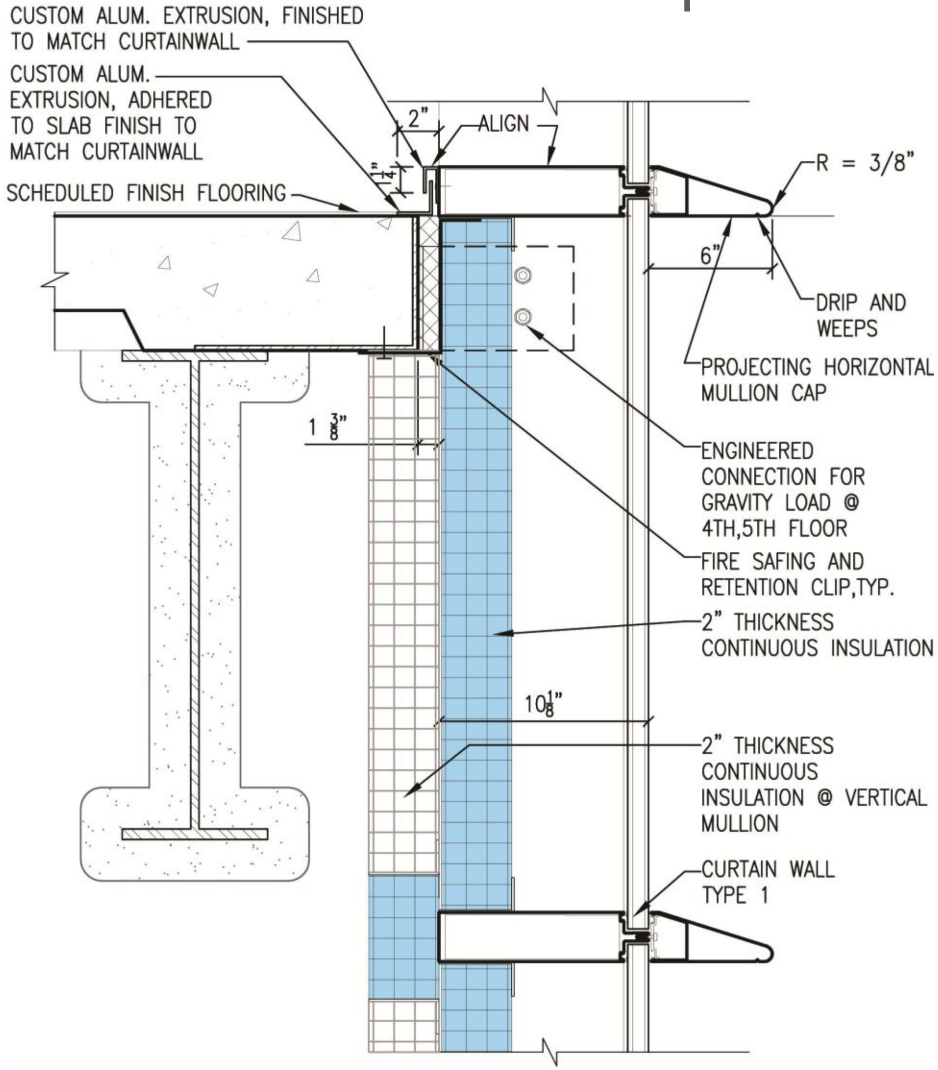


-65%

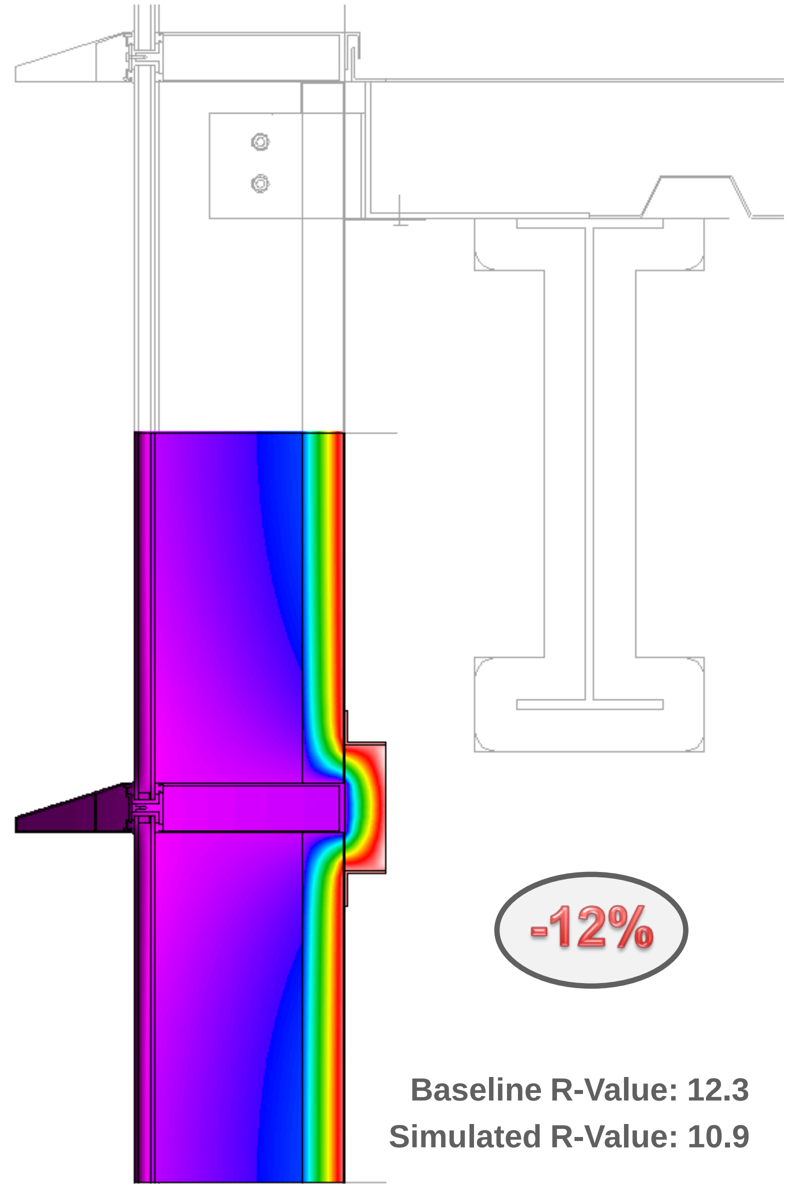
Baseline R-Value: 12.3

Simulated R-Value: 5.1

RESEARCH FINDINGS | Curtain Walls



Wrapped Mullion without Back Pan

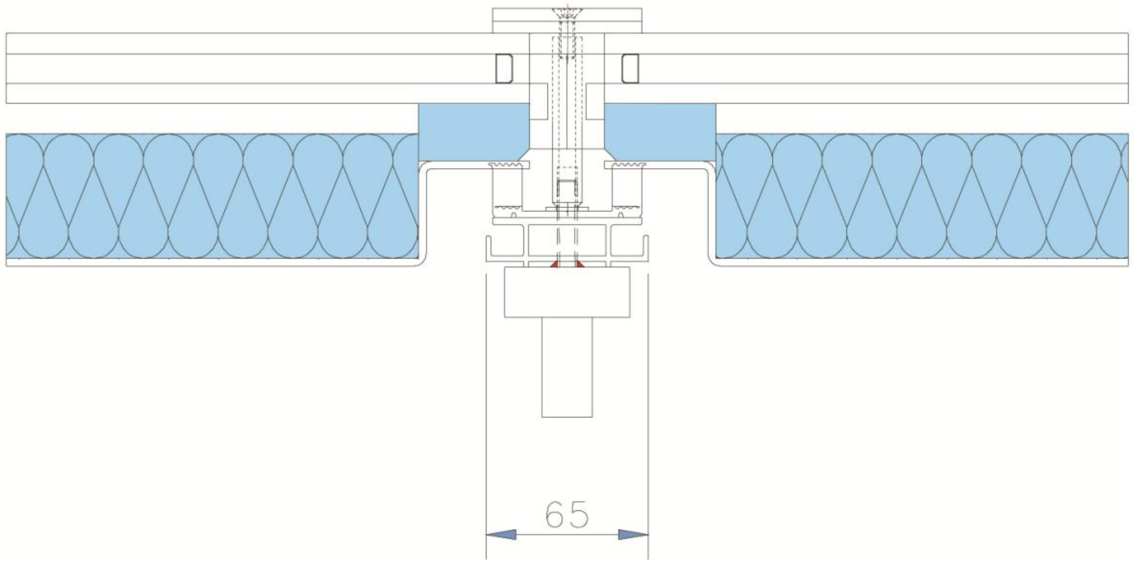


Baseline R-Value: 12.3

Simulated R-Value: 10.9

RESEARCH FINDINGS | Curtain Walls

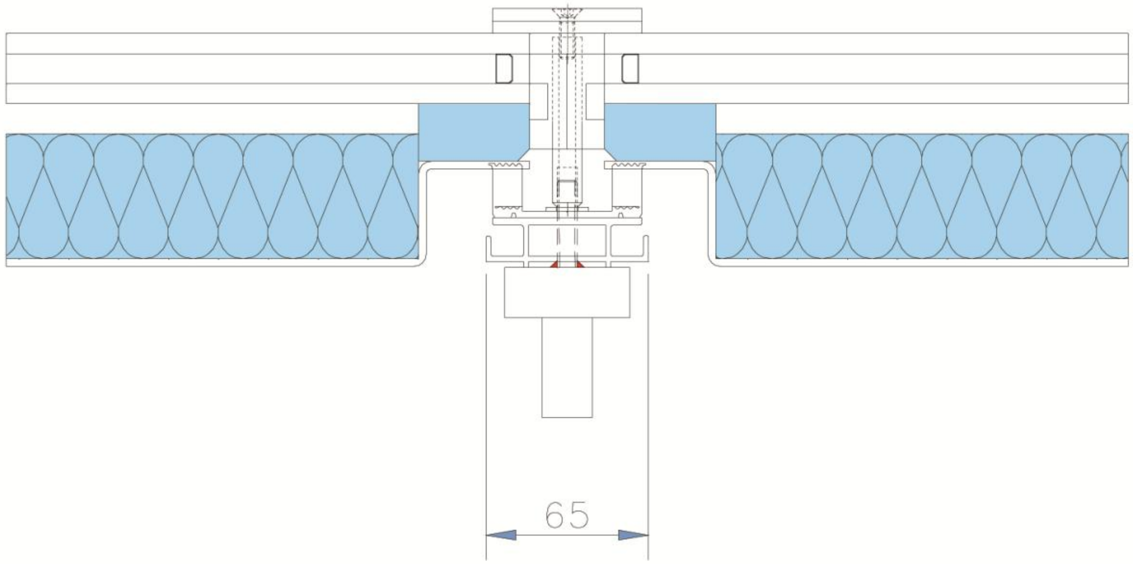
Glazed in Spandrel Panel

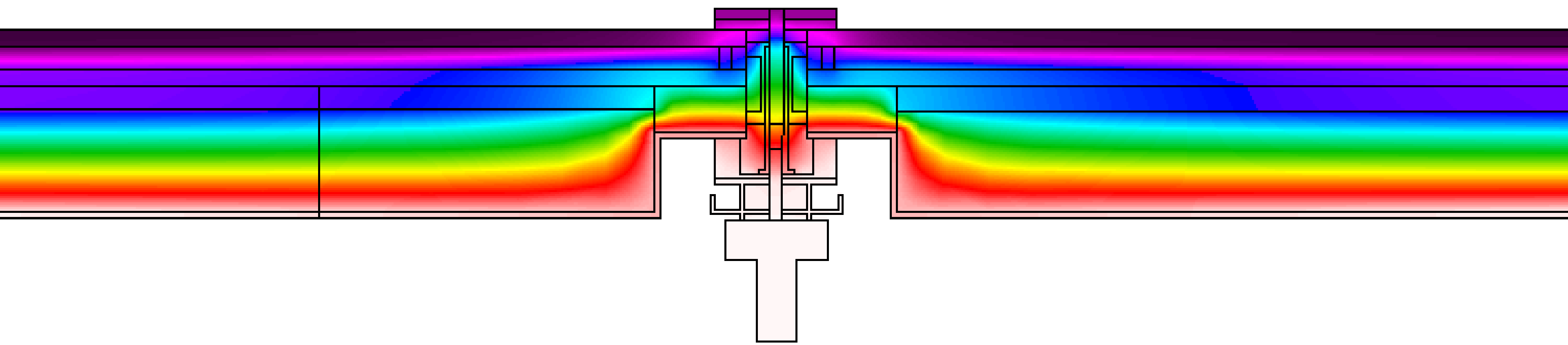


Baseline R-Value: 10.6

RESEARCH FINDINGS | Curtain Walls

Glazed in Spandrel Panel





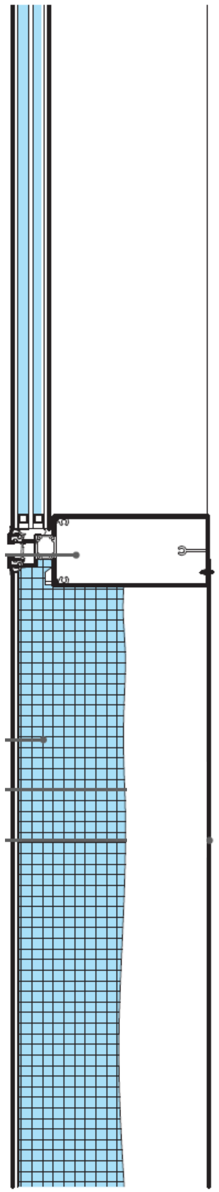
-24%

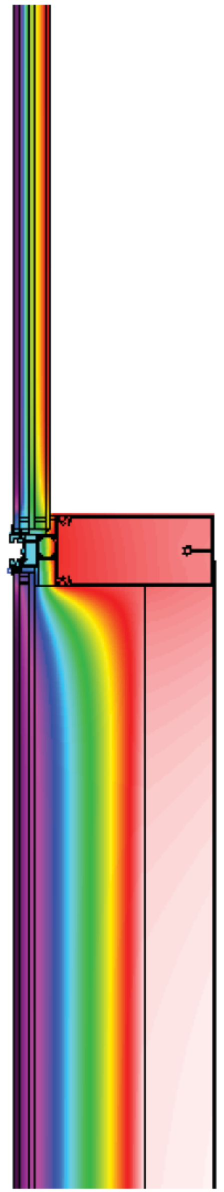
Baseline R-Value: 10.6

Simulated R-Value: 8.1

RESEARCH FINDINGS | Curtain Walls

Glazed in Spandrel Panel





-29%

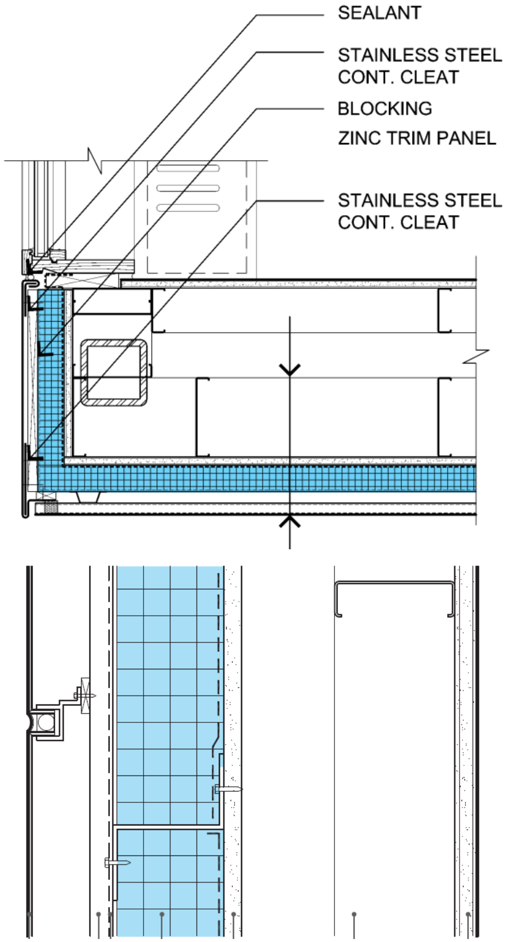
Baseline R-Value: 21.2

Simulated R-Value: 15.1

RESEARCH FINDINGS | Metal Panels

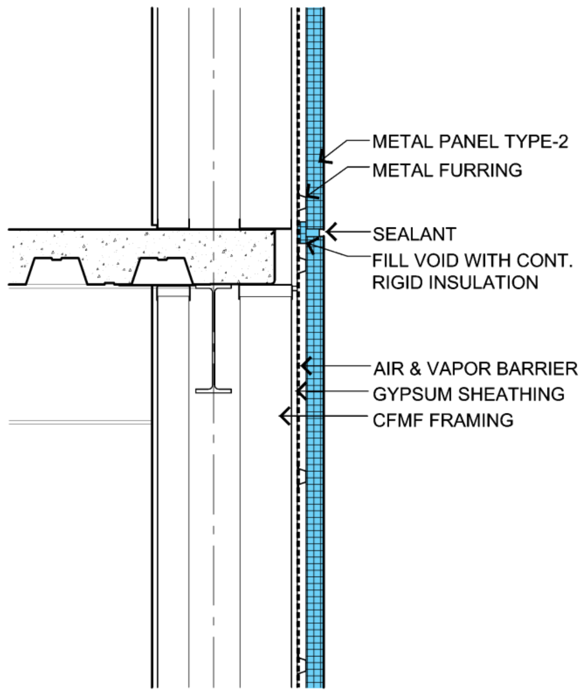
RESEARCH FINDINGS | Metal Panels

Uninsulated Panel with Back Up Insulation



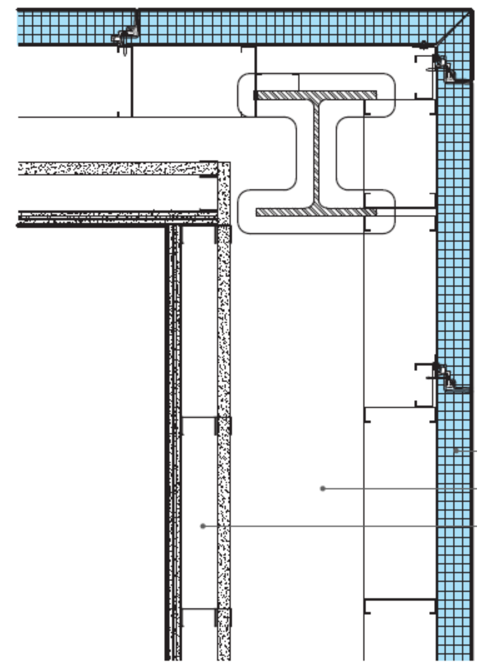
R-19.8

2” Insulated Panel



R-19.2

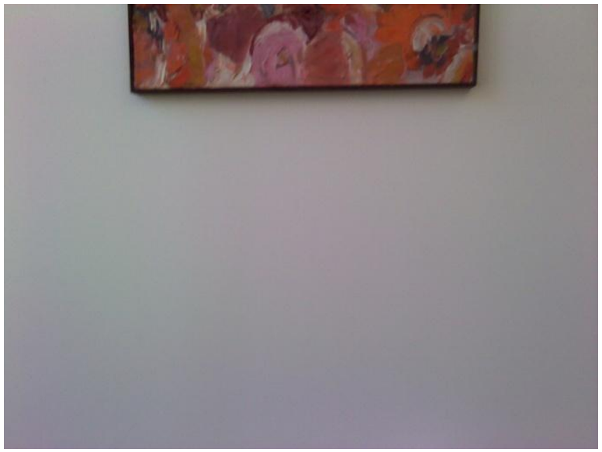
3” Insulated Panel

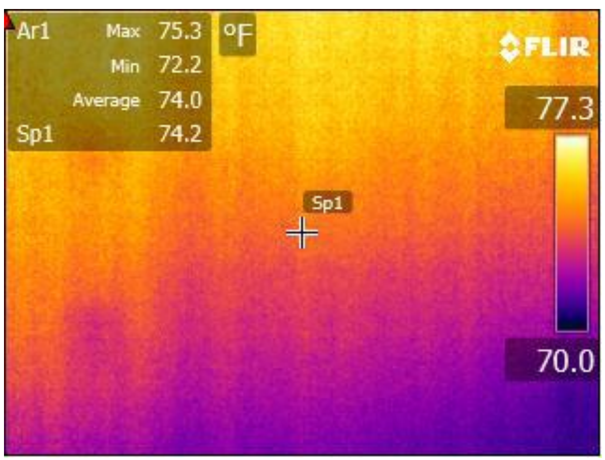


R-20.5

RESEARCH FINDINGS | Metal Panels

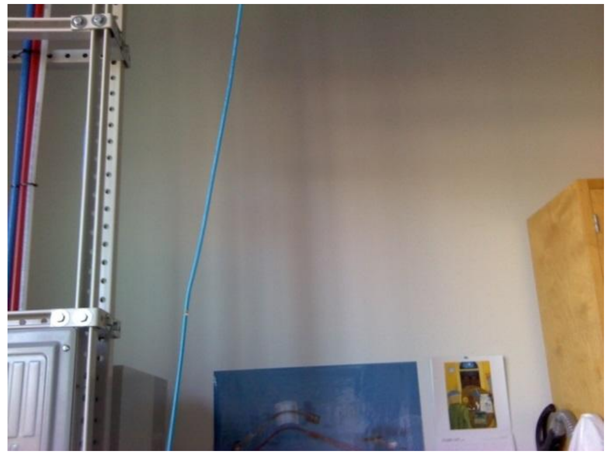
Uninsulated Panel with Back Up Insulation

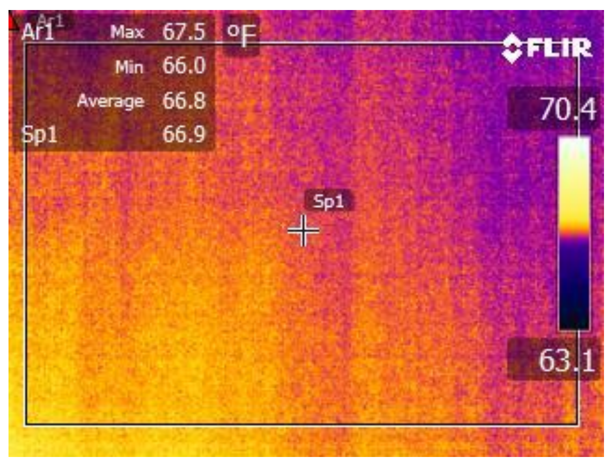




R-6.0 -70%

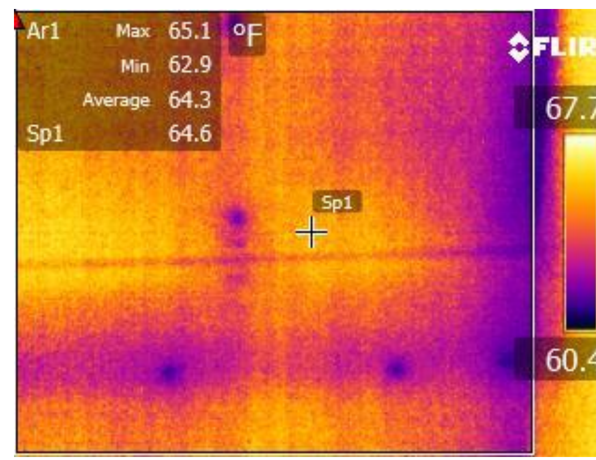
2" Insulated Panel





R-18.7 -3%

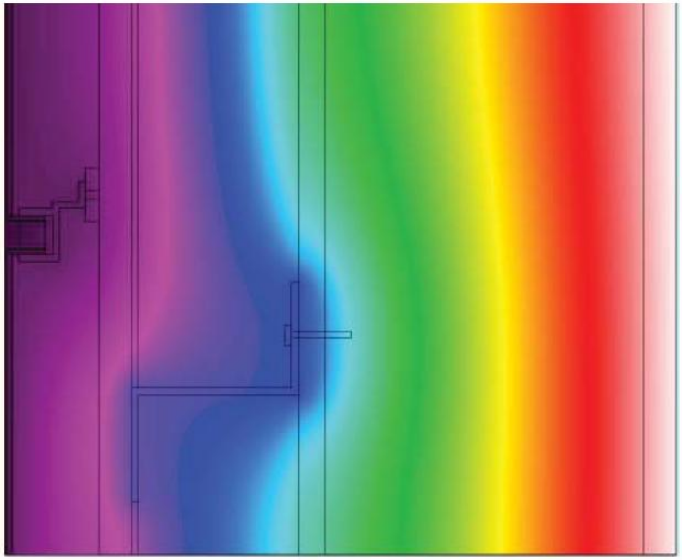
3" Insulated Panel



R-6.8 -67%

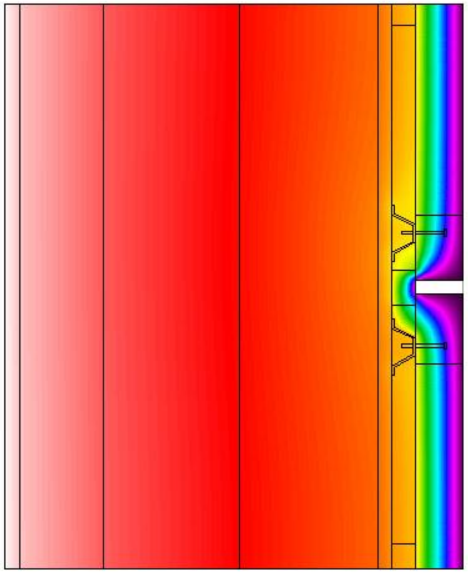
RESEARCH FINDINGS | Metal Panels

Uninsulated Panel with Back Up Insulation



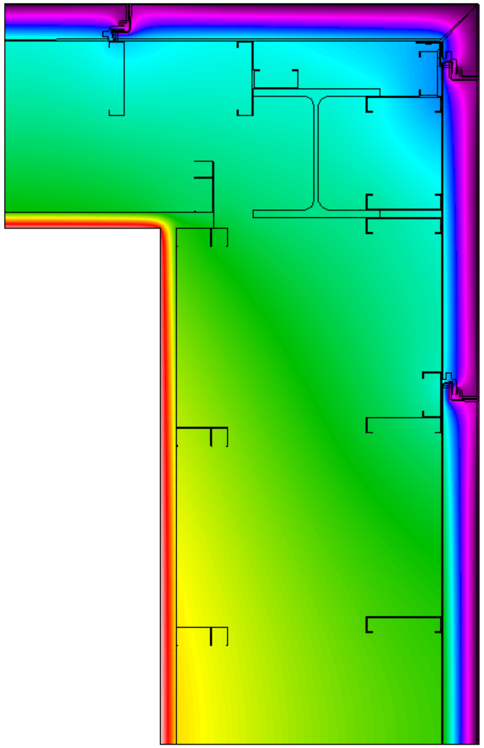
R-9.7 **-51%**

2” Insulated Panel



R-17.6 **-5%**

3” Insulated Panel



R-4.3 **-80%**

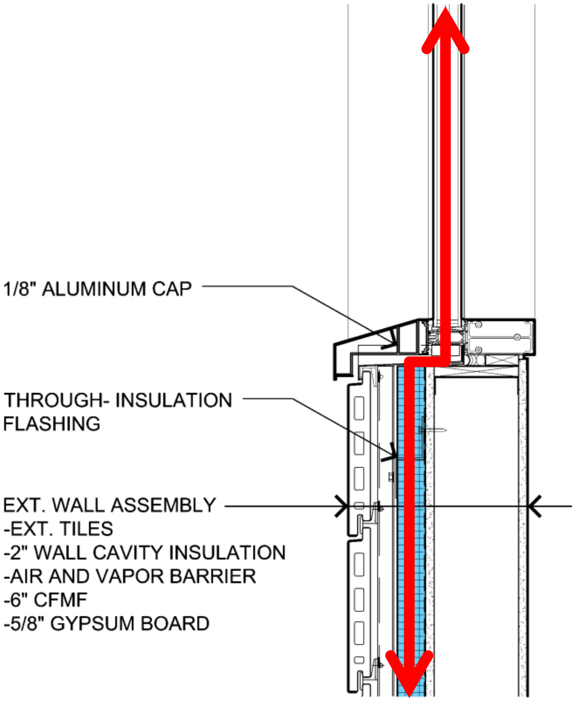
RESEARCH FINDINGS | Window Openings

Inline

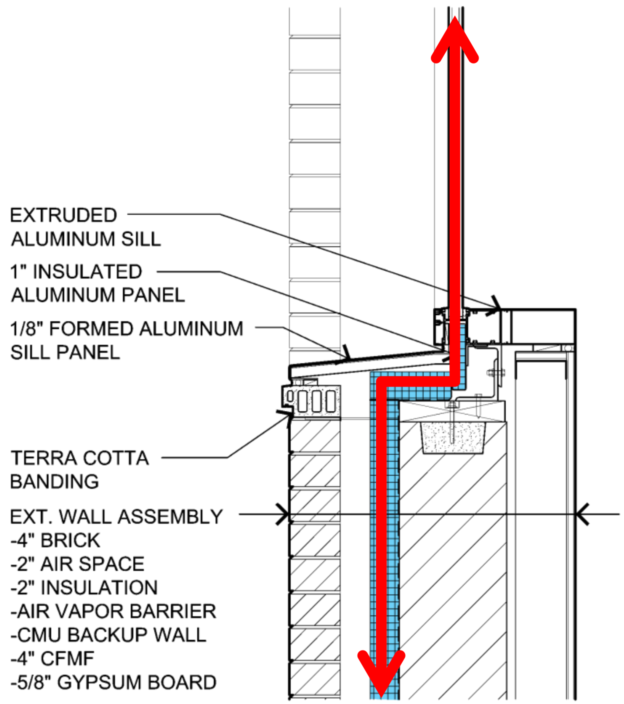
Recessed

Proud

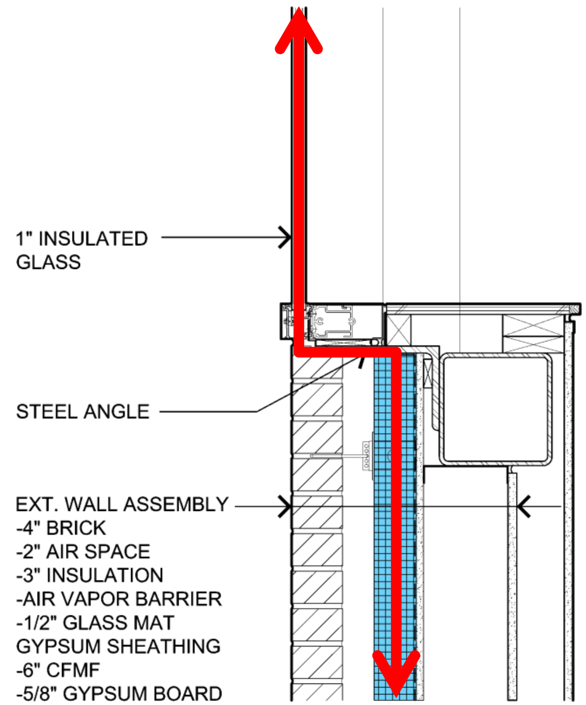
RESEARCH FINDINGS | Window Openings – Thermal Barrier



Aligned

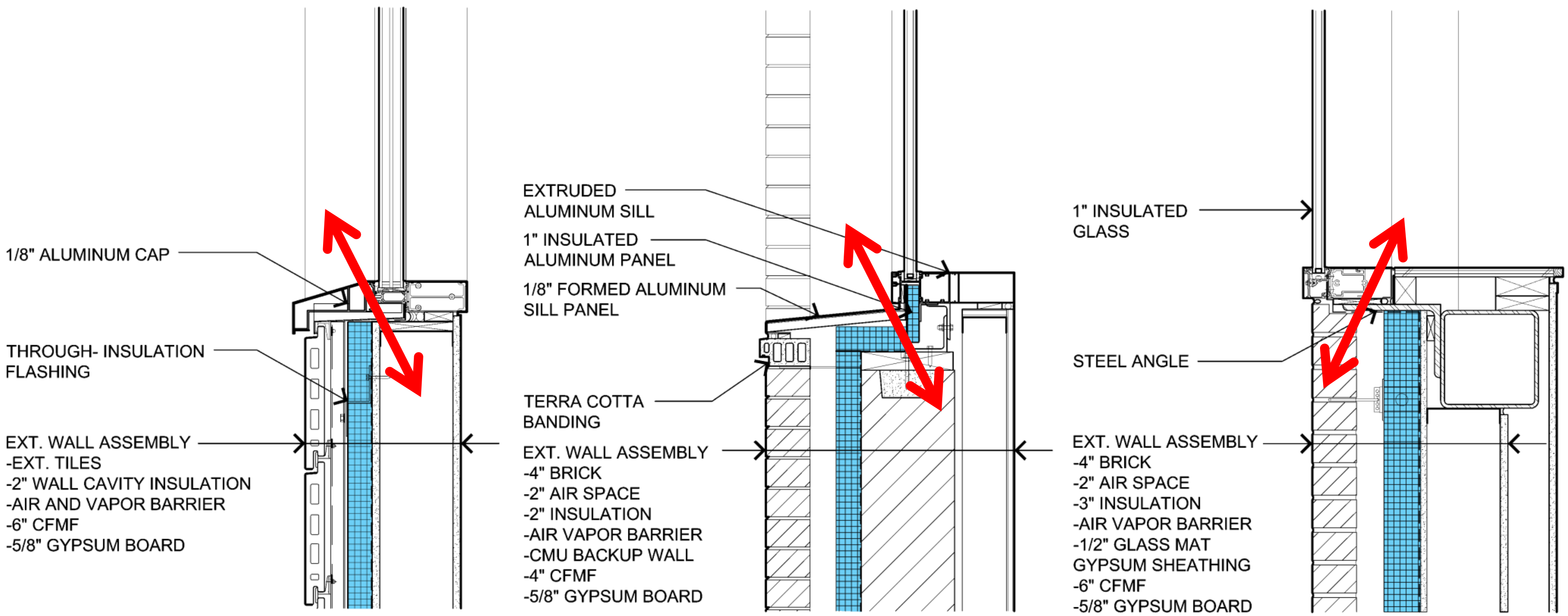


Recessed



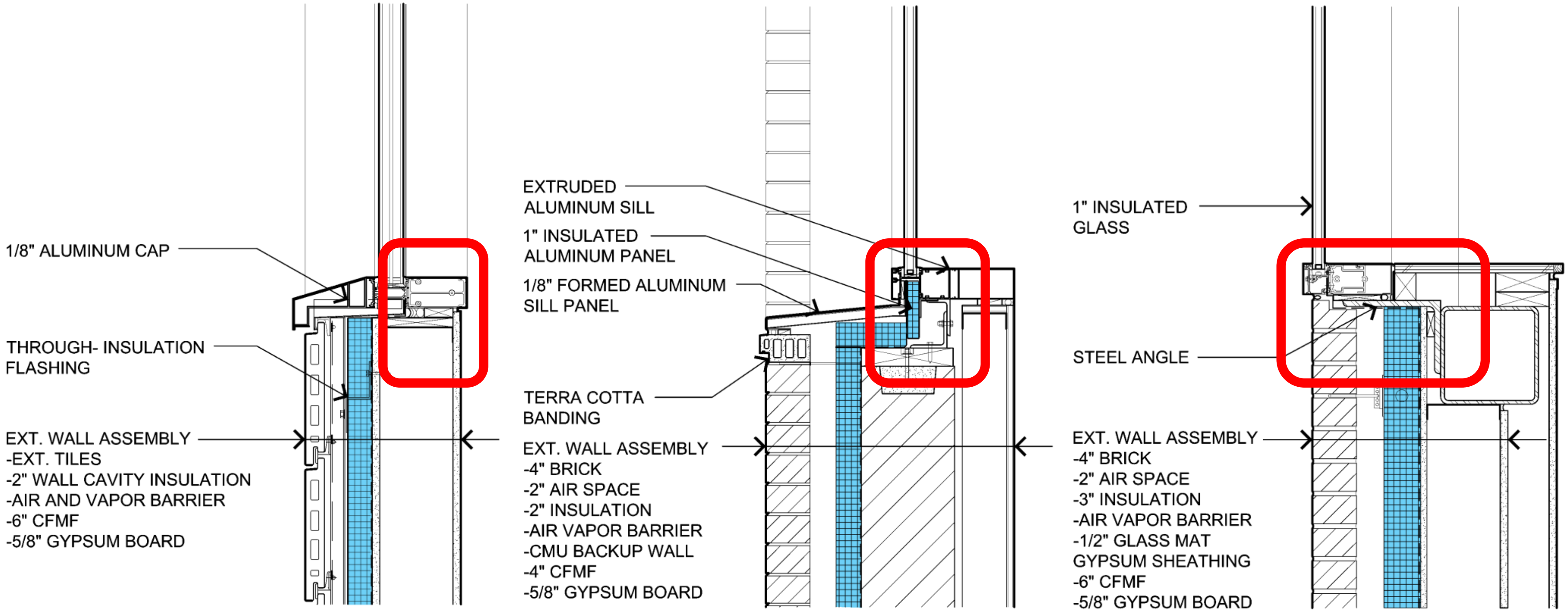
Proud

RESEARCH FINDINGS | Window Openings – Flanking Loss



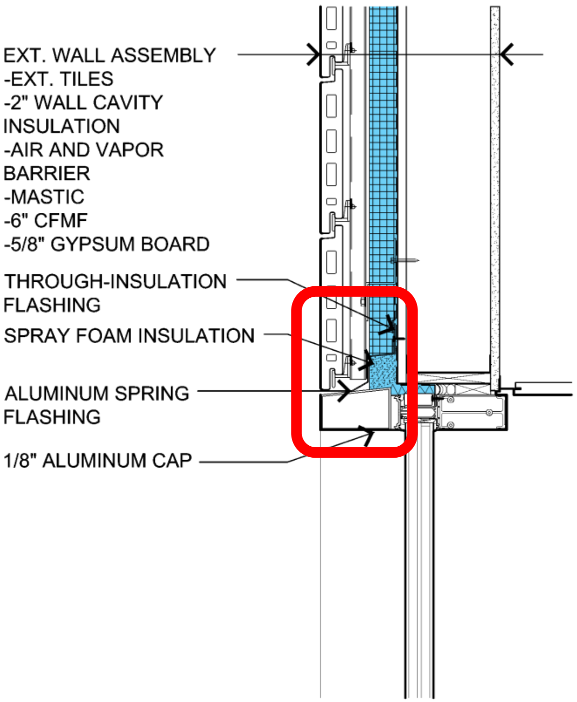
Aligned **Recessed** **Proud**

RESEARCH FINDINGS | Window Openings – Structural Support

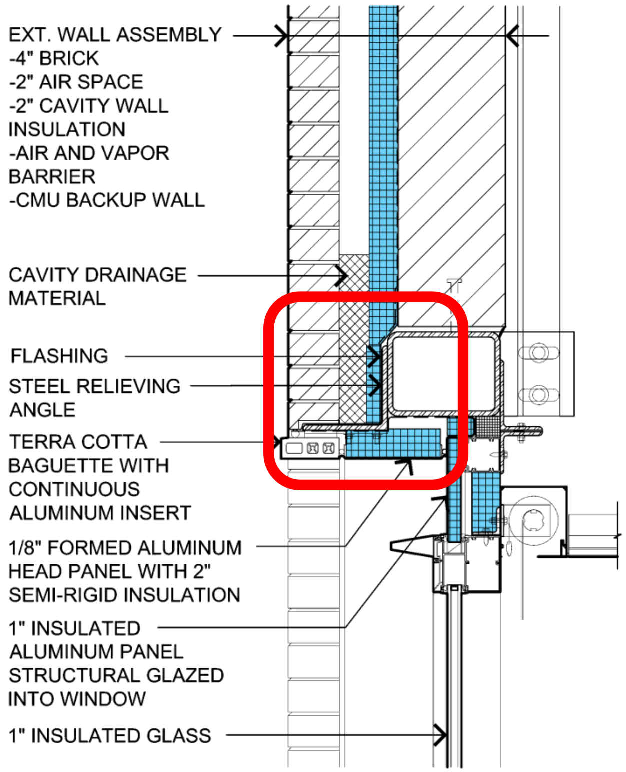


Aligned **Recessed** **Proud**

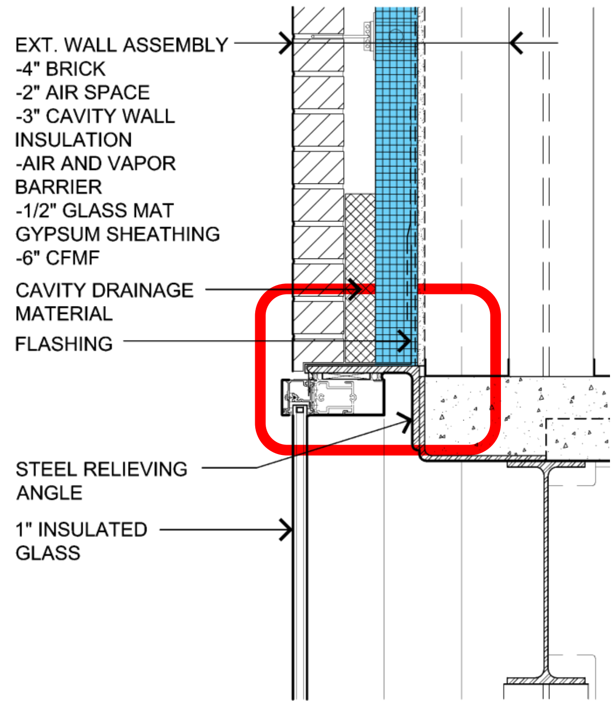
RESEARCH FINDINGS | Window Openings – Structural Support



Aligned

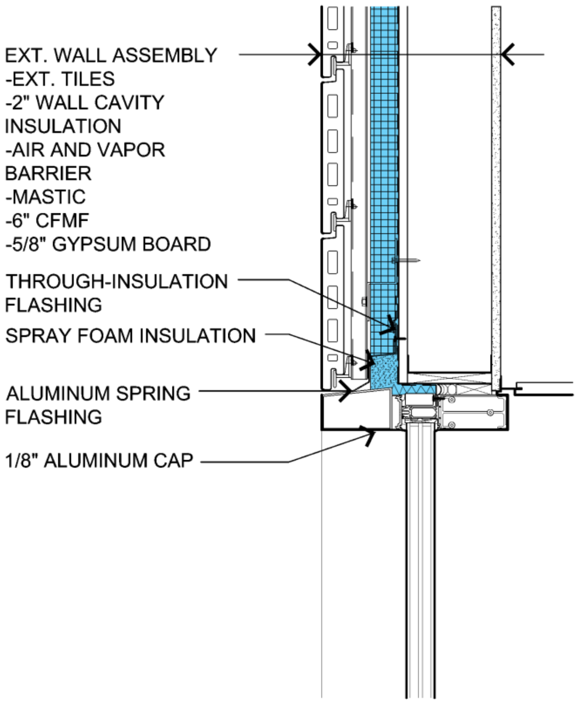


Recessed

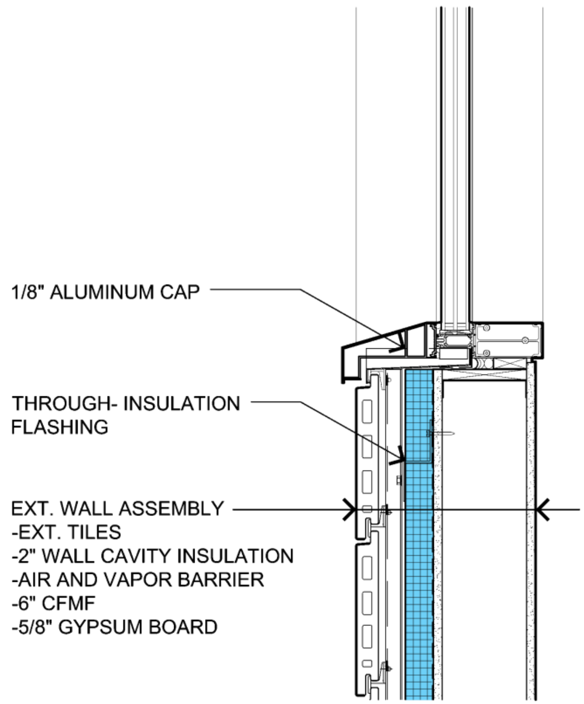


Proud

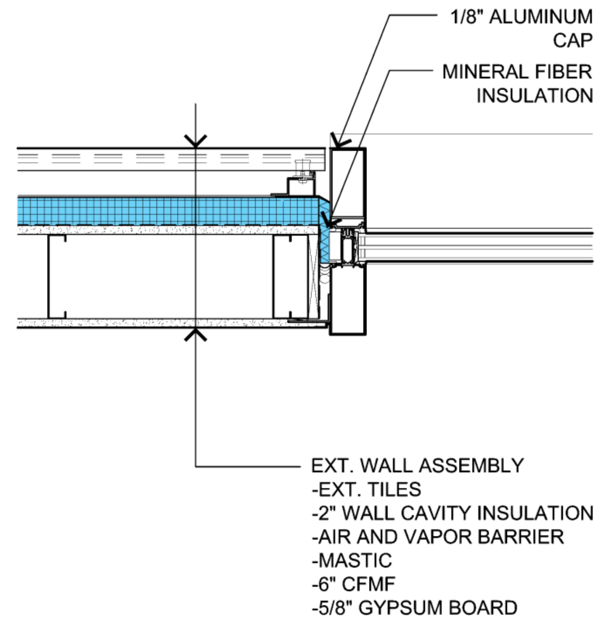
RESEARCH FINDINGS | Window Openings – Inline Relationship



Window Head



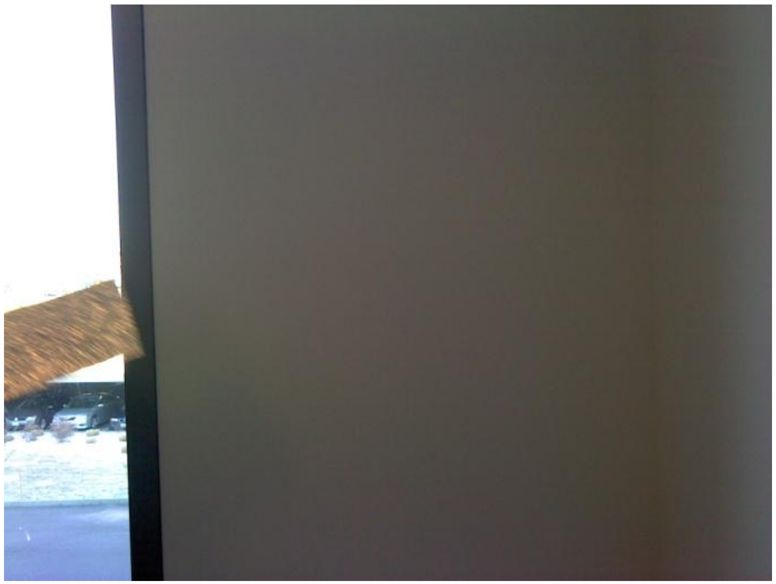
Window Sill



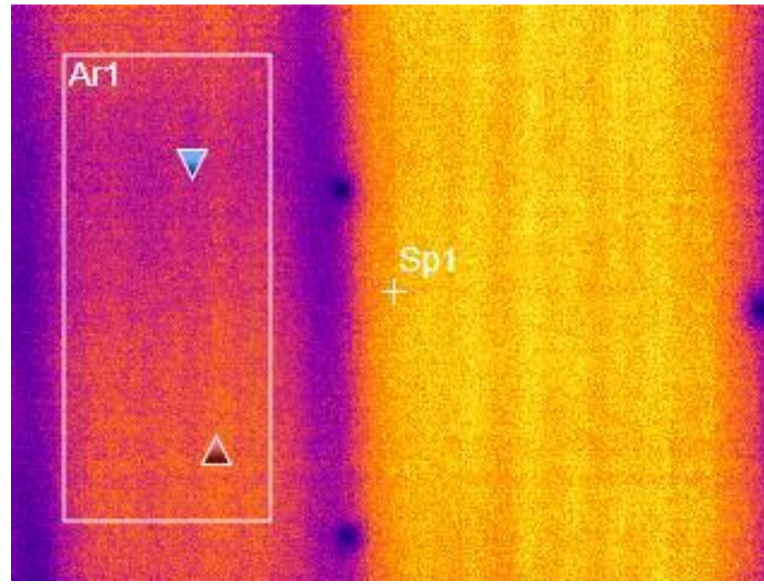
Window Jamb

Baseline R-Value: 13.86

RESEARCH FINDINGS | Window Openings – Inline Relationship



Window Jamb

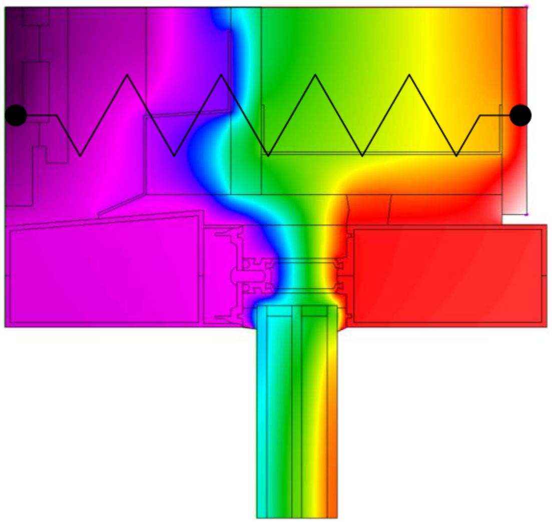


Window Jamb

R-7.50

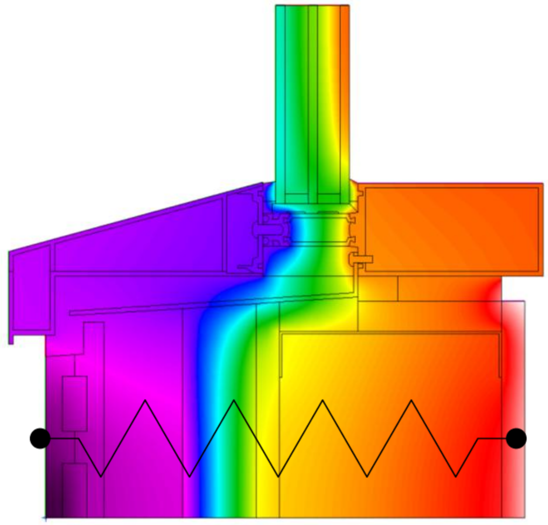
-46%

RESEARCH FINDINGS | Window Openings – Inline Relationship



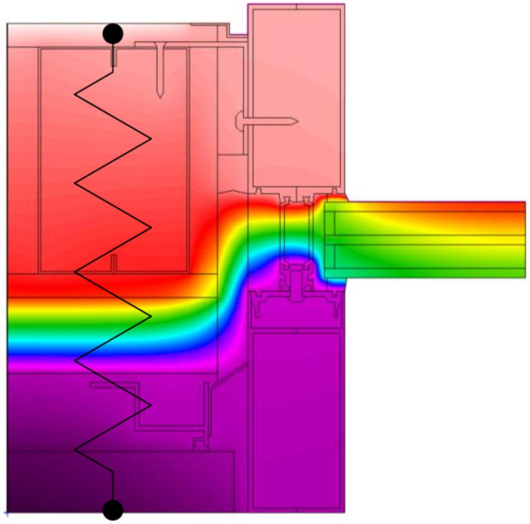
Window Head

R-6.46 -53%



Window Sill

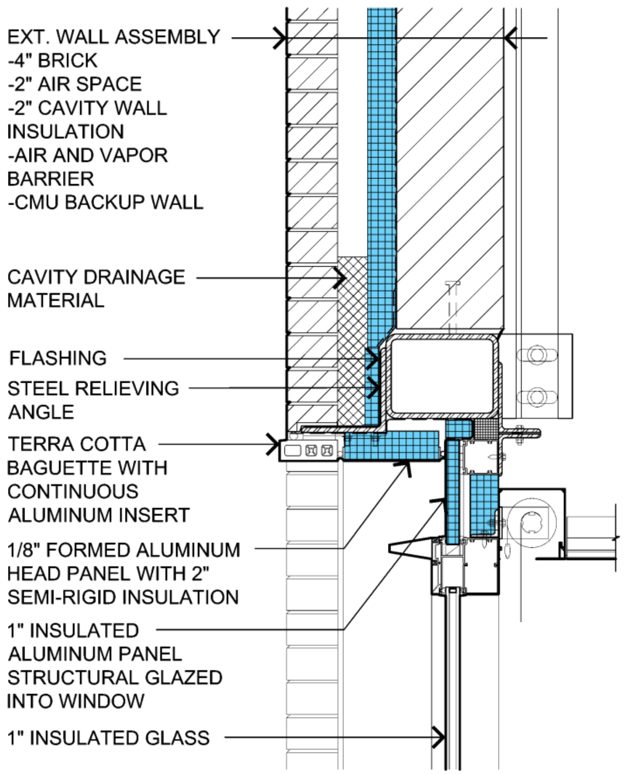
R-6.46 -53%



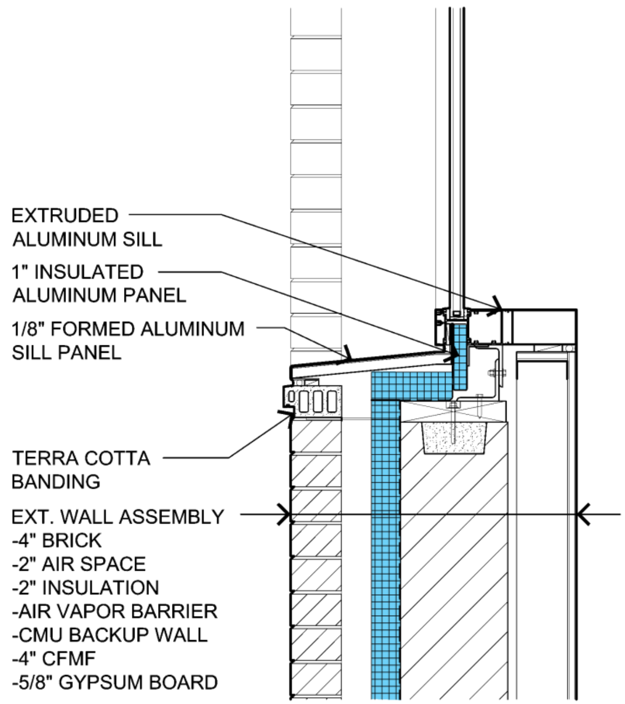
Window Jamb

R-7.65 -45%

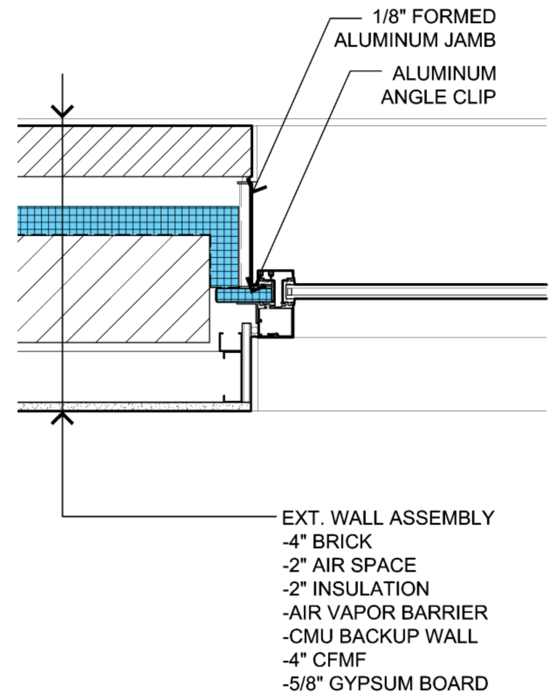
RESEARCH FINDINGS | Window Openings – Recessed Relationship



Window Head



Window Sill

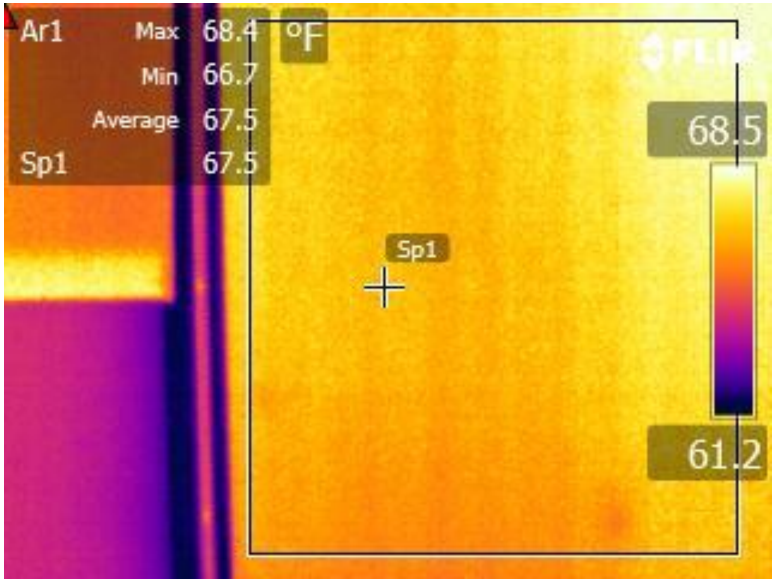


Window Jamb

Baseline R-Value: 15.39

RESEARCH FINDINGS | Window Openings – Recessed Relationship

Window Jamb

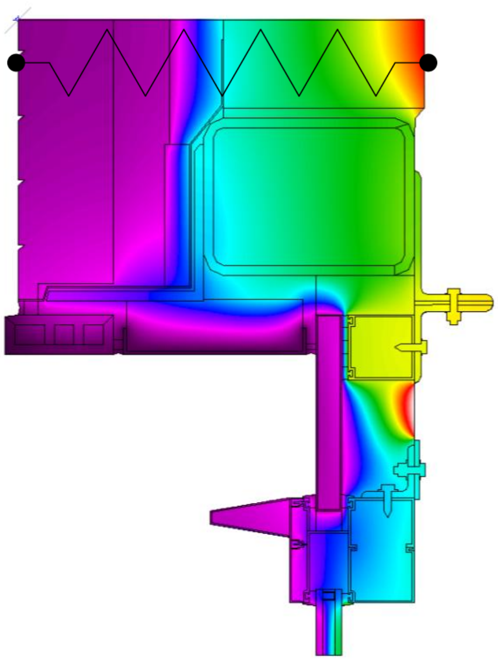


Window Jamb

R-6.58

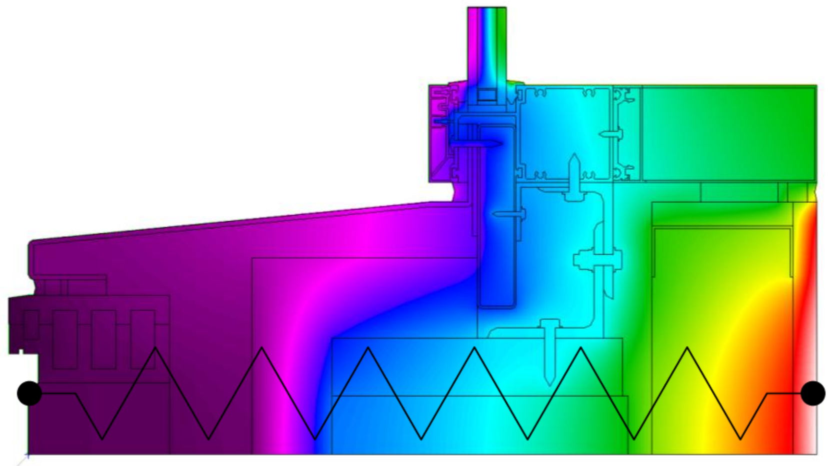
-57%

RESEARCH FINDINGS | Window Openings – Recessed Relationship



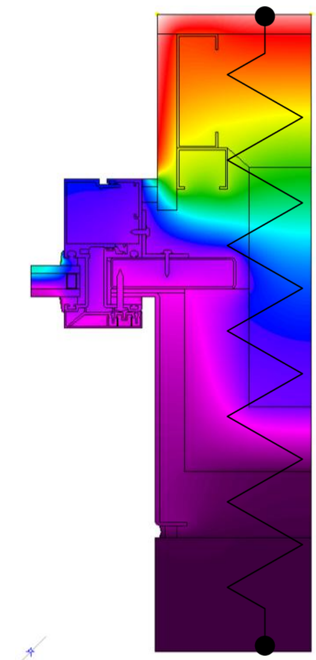
Window Head

R-6.46 -58%



Window Sill

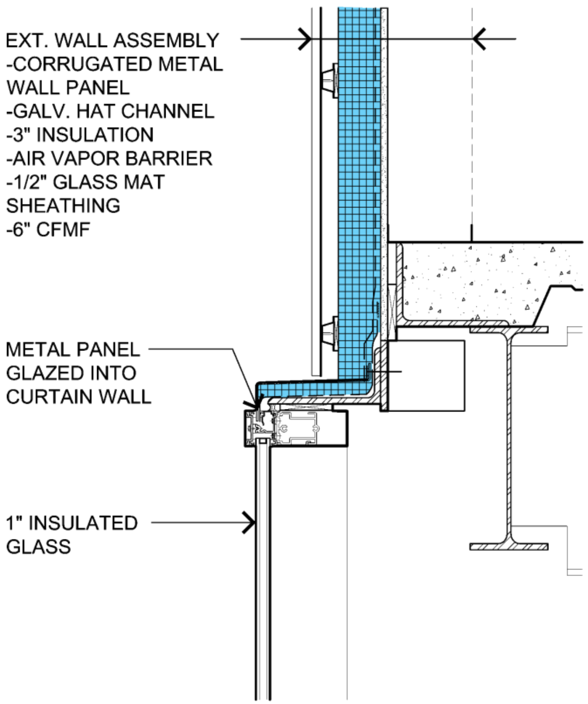
R-4.60 -70%



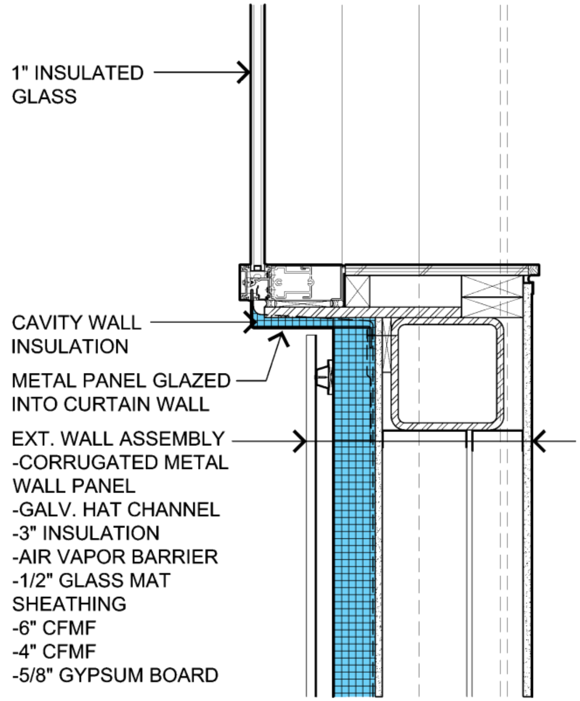
Window Jamb

R-6.58 -51%

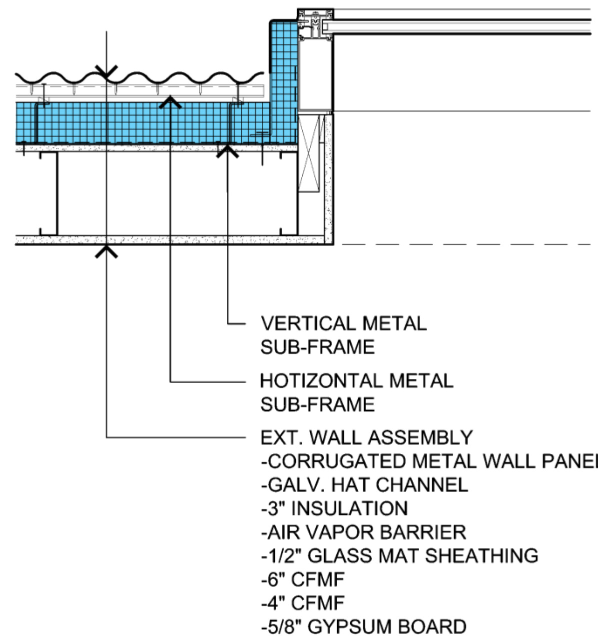
RESEARCH FINDINGS | Window Openings – Proud Relationship



Window Head



Window Sill

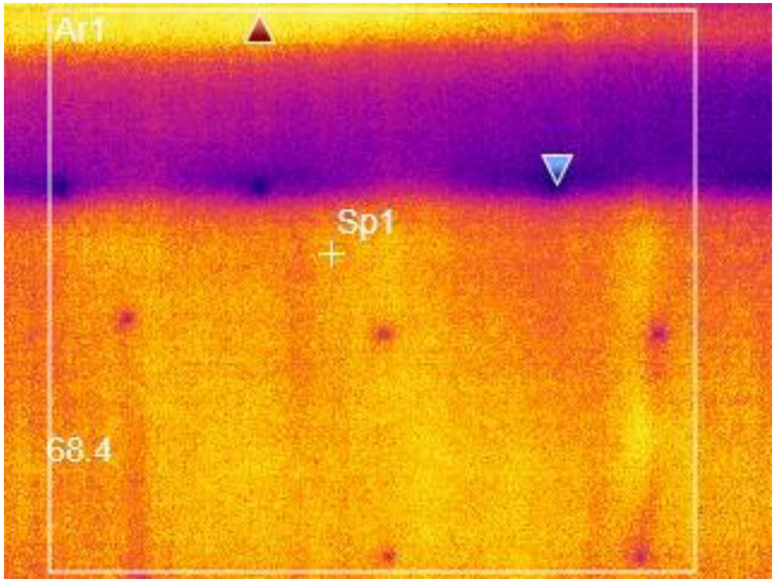


Window Jamb

Calculated Clear Wall R-Value: 18.78

RESEARCH FINDINGS | Window Openings – Proud Relationship

Window Sill

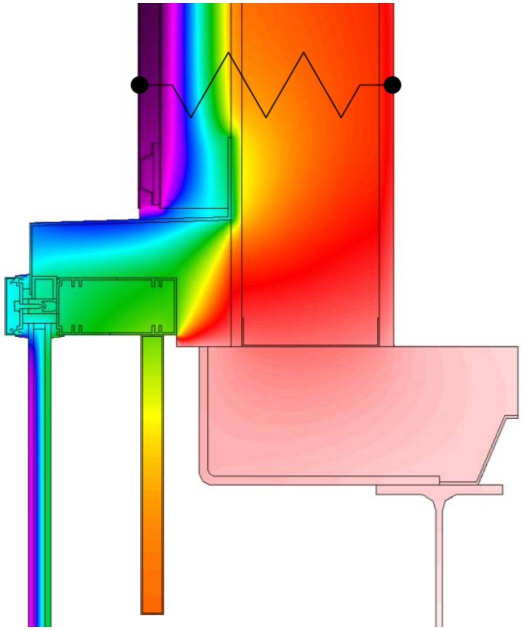


Window Sill

R-8.58

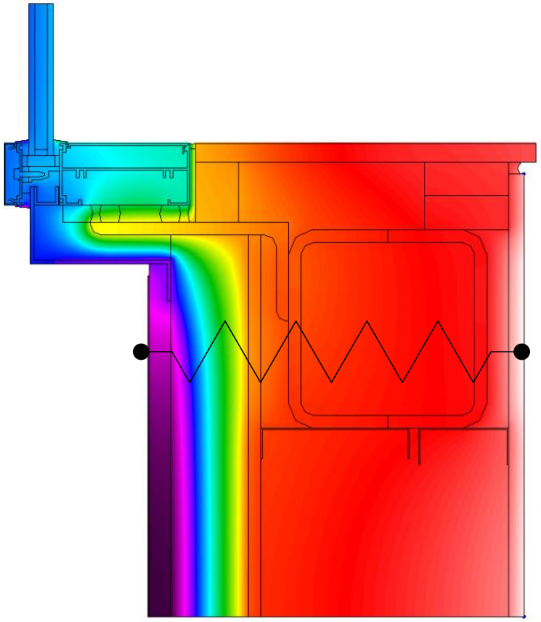
-54%

RESEARCH FINDINGS | Window Openings – Proud Relationship



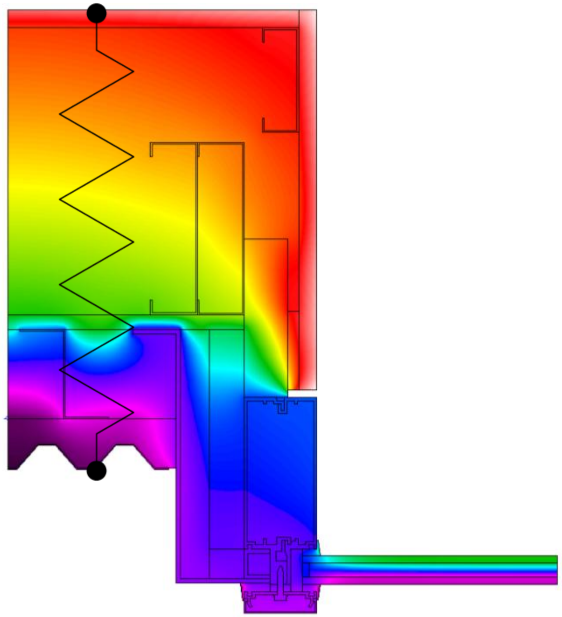
Window Head

R-10.48 -44%



Window Sill

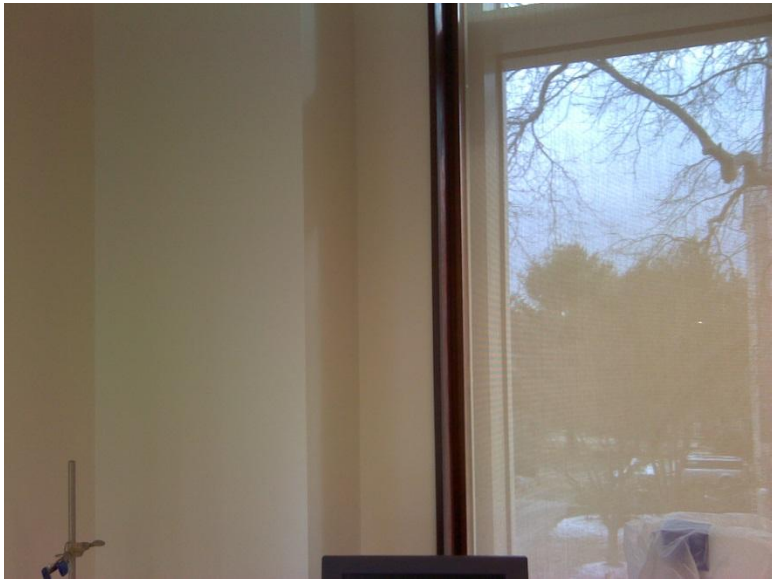
R-10.39 -45%



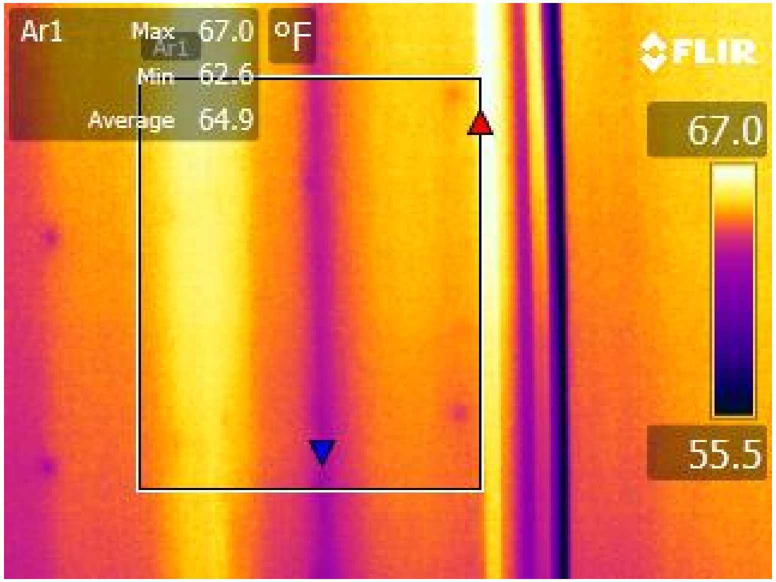
Window Jamb

R-9.36 -50%

RESEARCH FINDINGS | Window Openings – Aligned



Window Jamb



Window Jamb

R-7.94

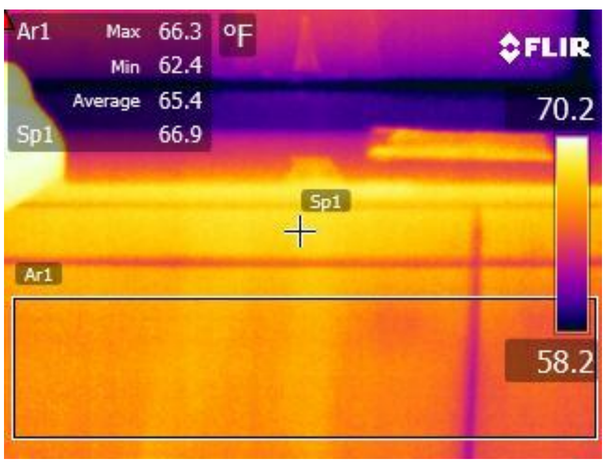
-62%

Baseline R-Value: 20.93

RESEARCH FINDINGS | Foundation Walls

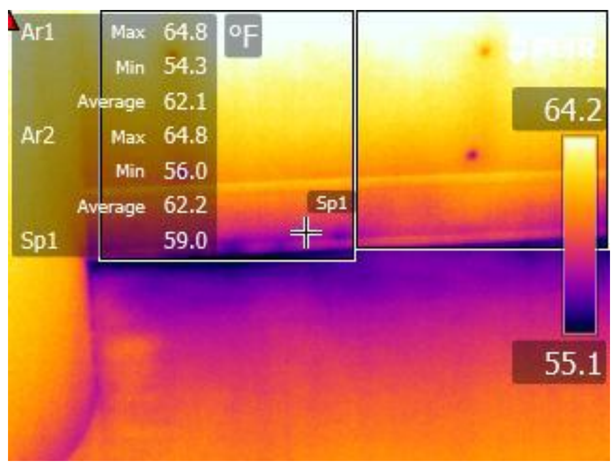
RESEARCH FINDINGS | Foundation Walls

Exterior Insulation



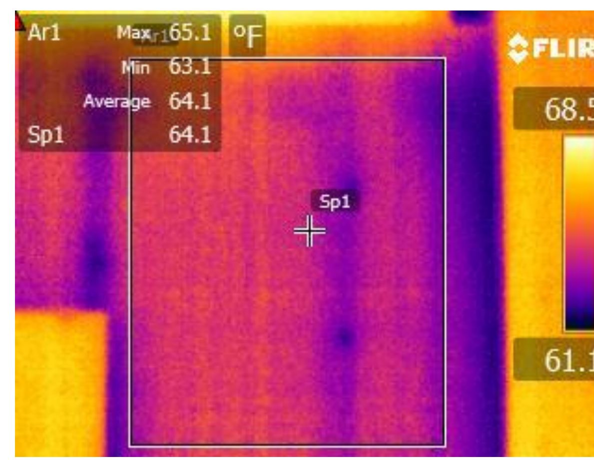
R-4.1 -70%

Interior Insulation



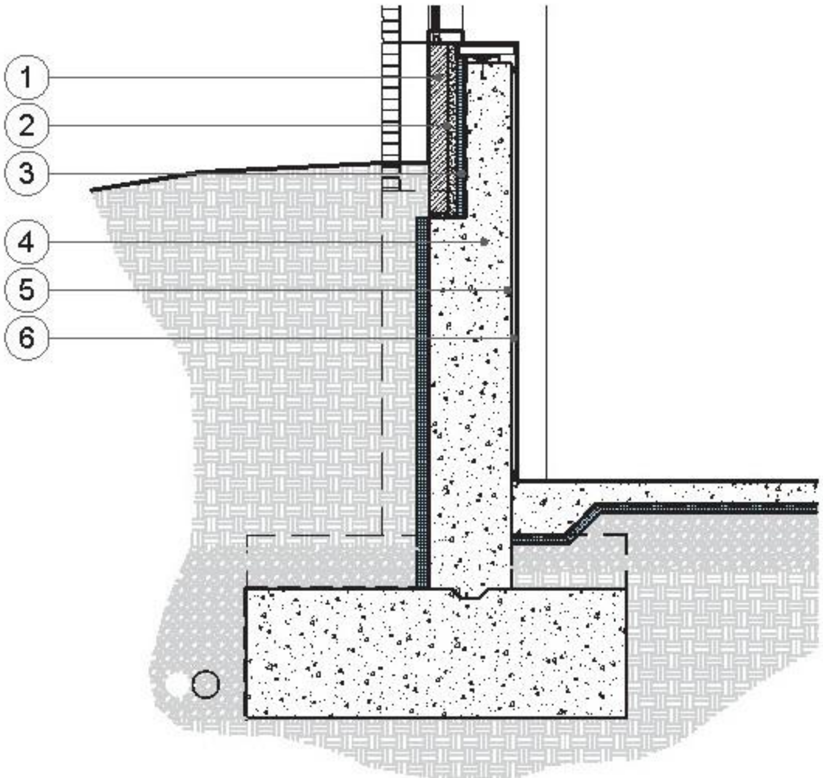
R-3.5 -72%

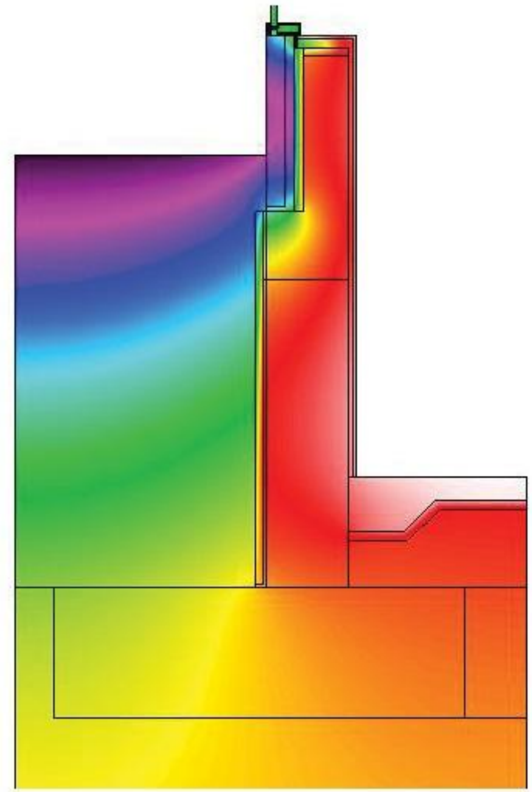
Exterior Insulation



R-3.71 -75%

RESEARCH FINDINGS | Foundation Walls

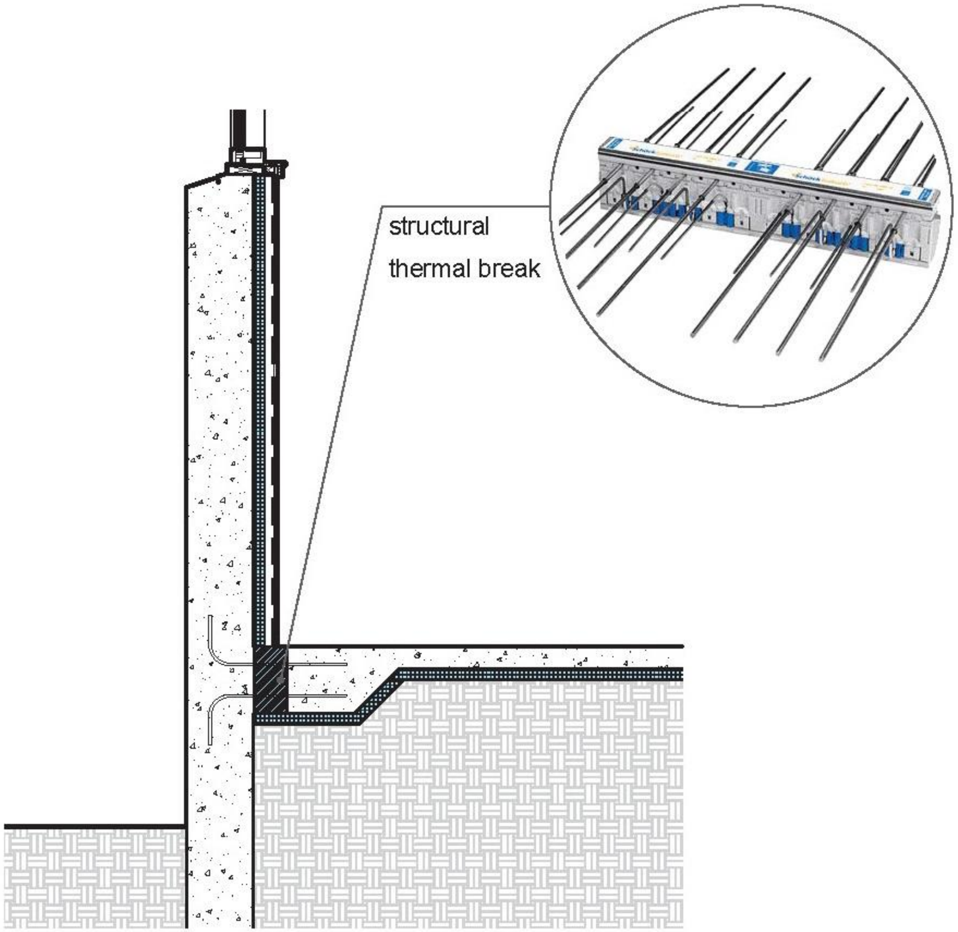




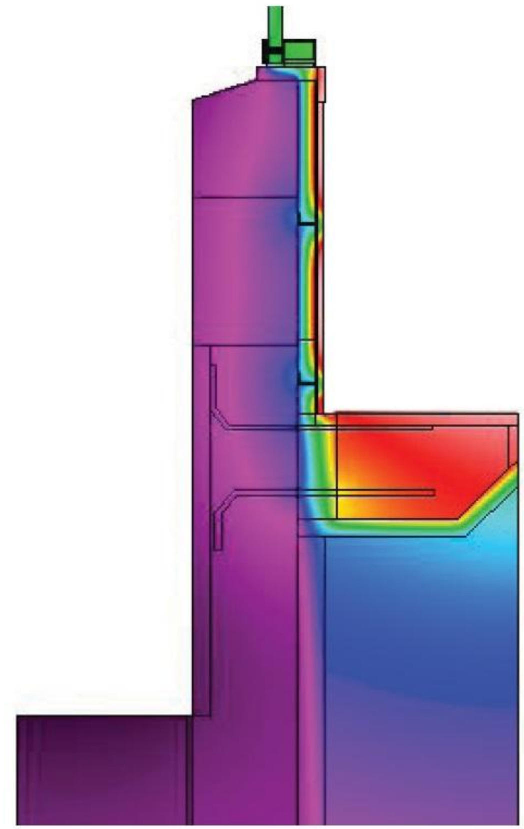
Simulated R-Value: 8.39

-40% Baseline R-Value: 14.01

RESEARCH FINDINGS | Foundation Walls



Thermally Improved Condition

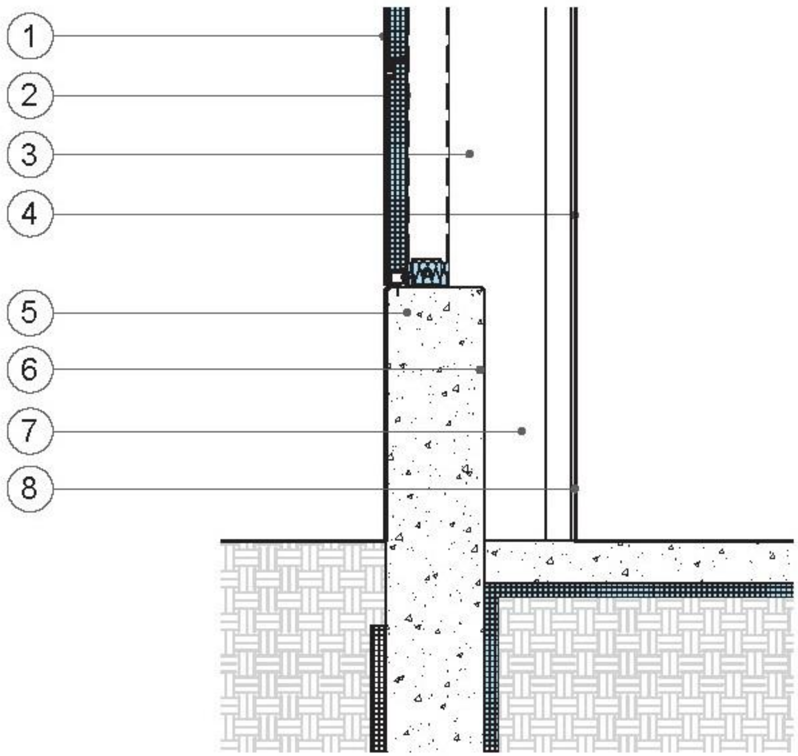


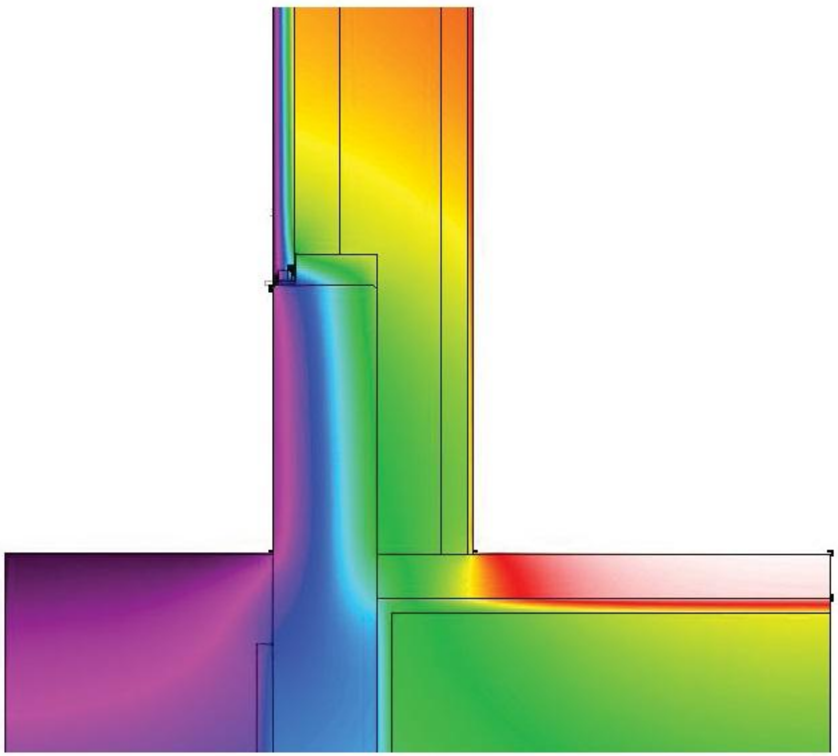
Simulated R-Value: 6.1

-56% **Baseline R-Value: 13.74**

RESEARCH FINDINGS | Foundation Walls

As-Built Condition



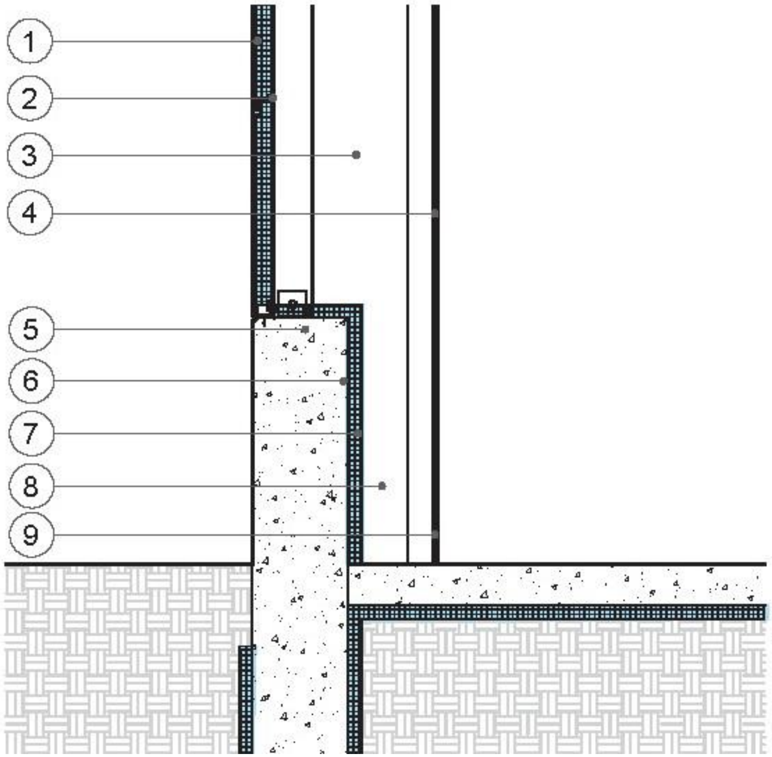


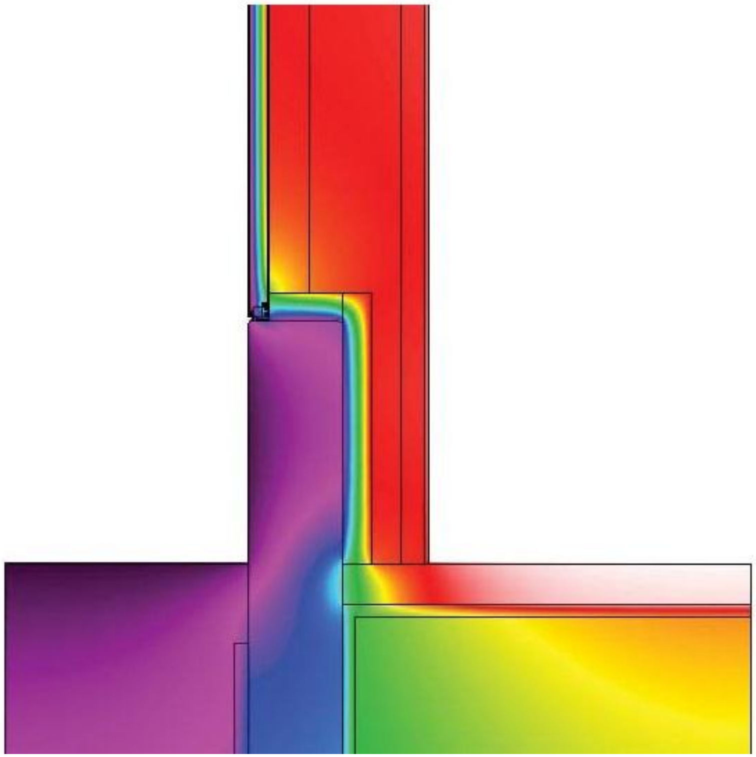
Simulated R-Value: 4.10

-69% **Baseline R-Value: 13.38**

RESEARCH FINDINGS | Foundation Walls

Thermally Improved Option A

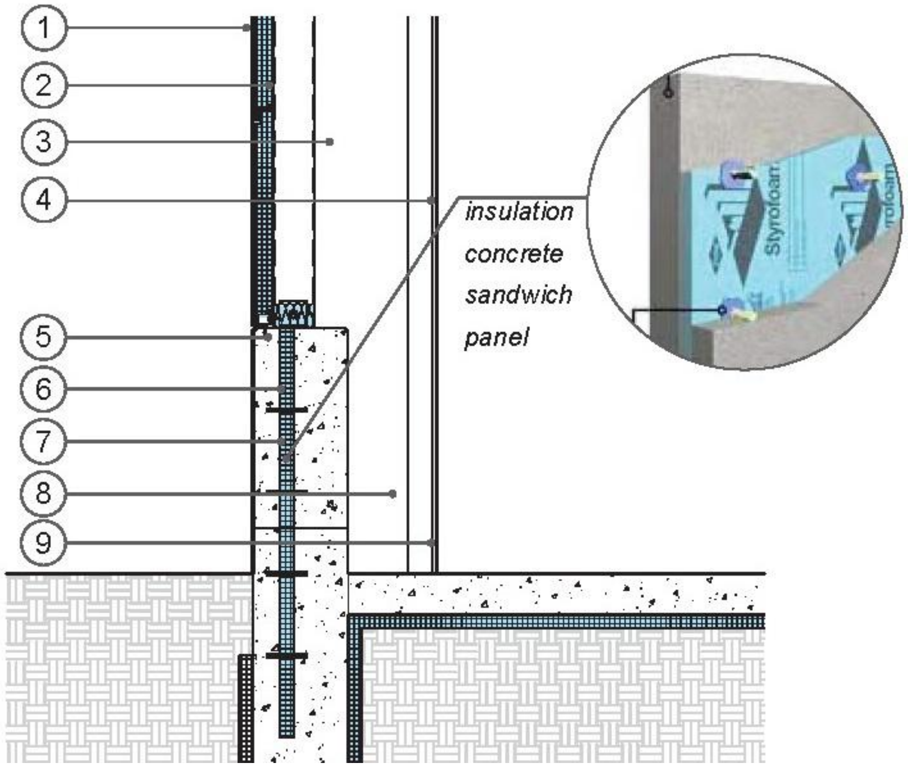




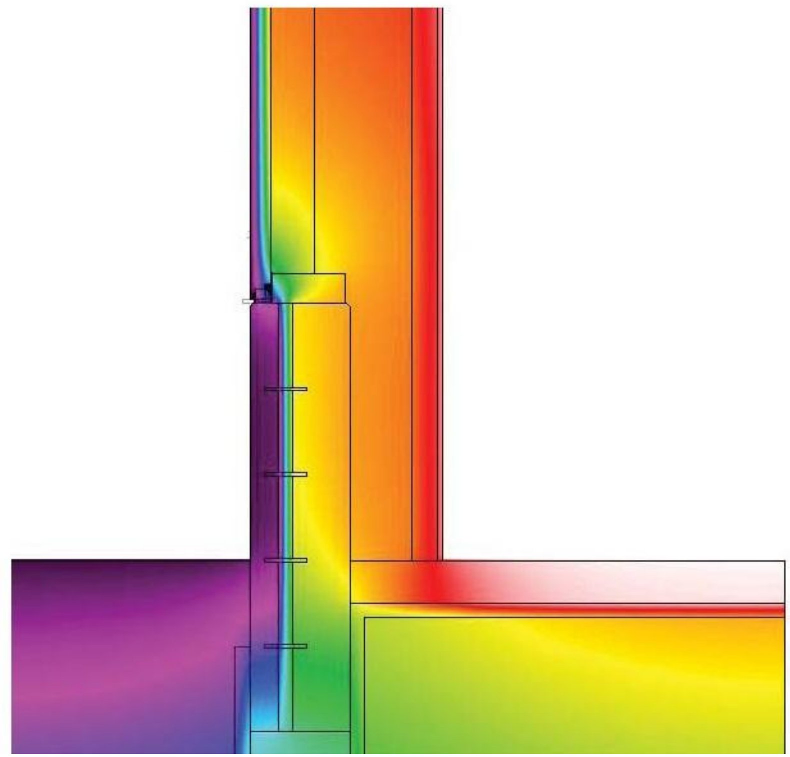
Simulated R-Value: 8.59

-36% **Baseline R-Value: 13.38**

RESEARCH FINDINGS | Foundation Walls



Thermally Improved Option B

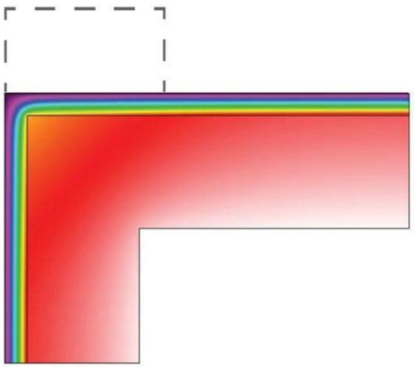


Simulated R-Value: 9.82

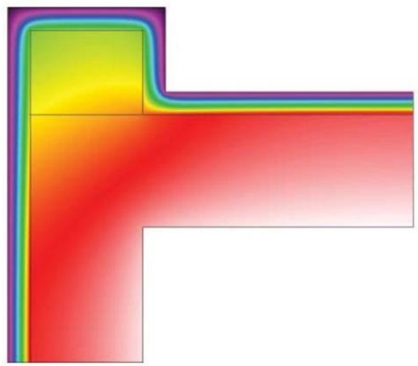
-27% **Baseline R-Value: 13.38**

RESEARCH FINDINGS | Roof Parapets

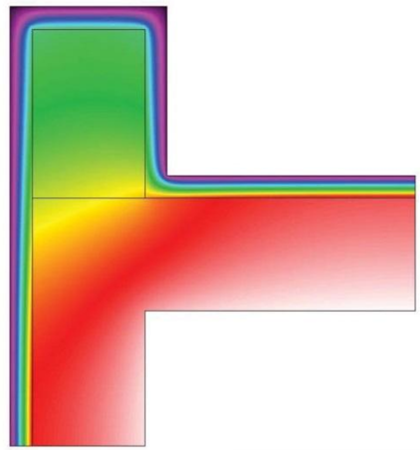
RESEARCH FINDINGS | Parapets



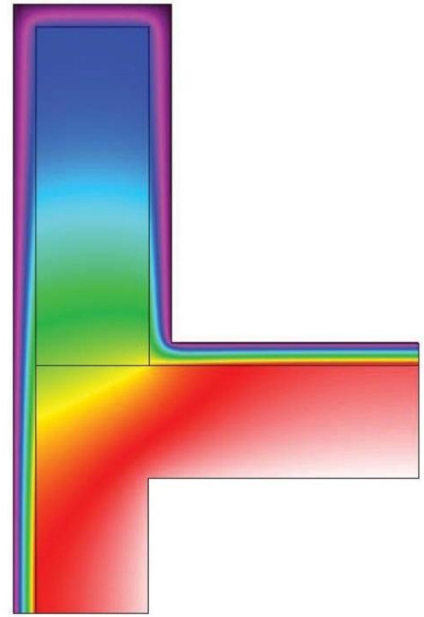
R-15.33
Insulating beneath parapet



R-13.42
Insulating around 1'-3" tall parapet



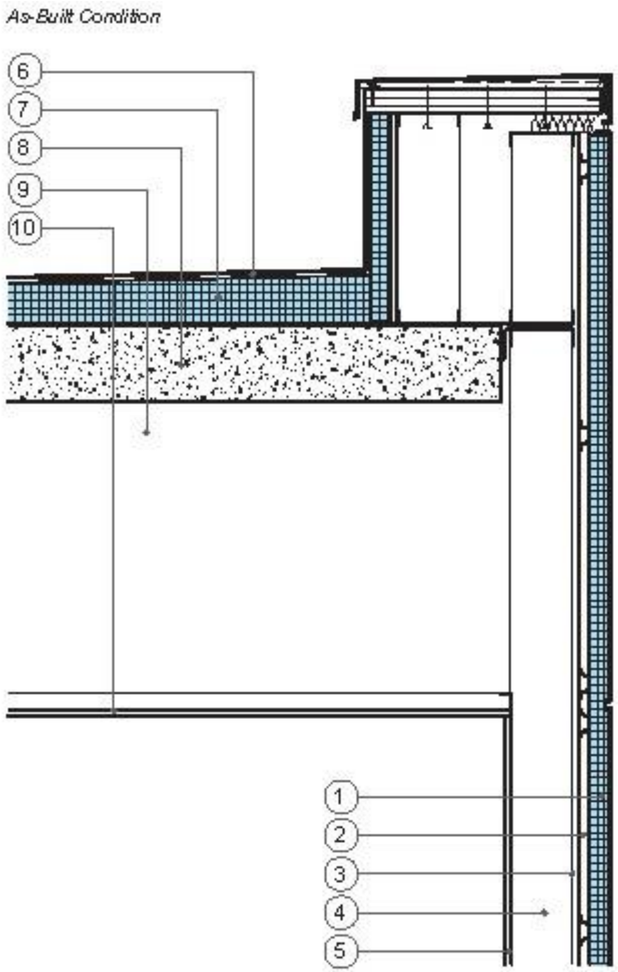
R-12.25
Insulating around 2'-6" tall parapet

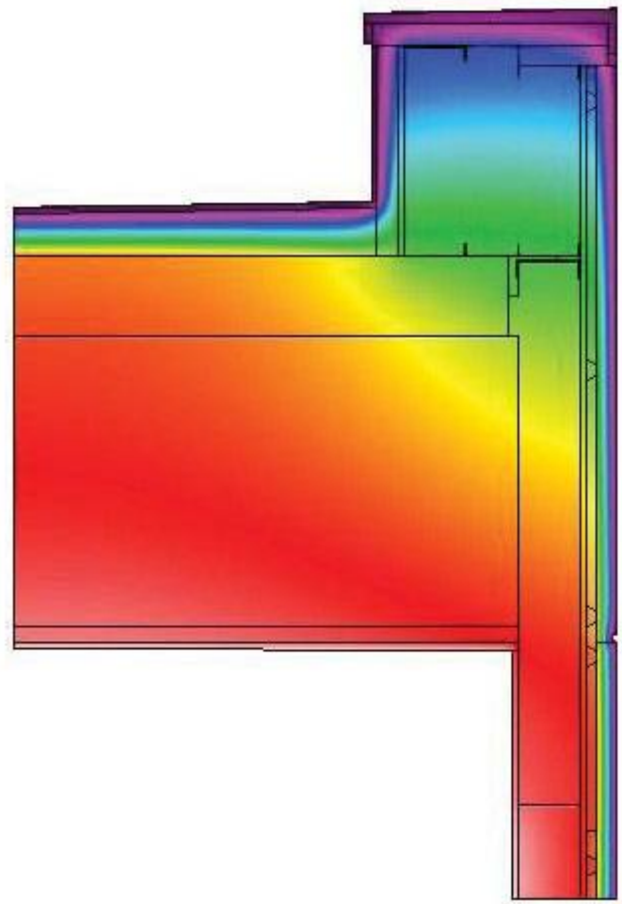


R-11.27
Insulating around 5'-0" tall parapet

as the height increases, the R-value decreases

RESEARCH FINDINGS | Parapets

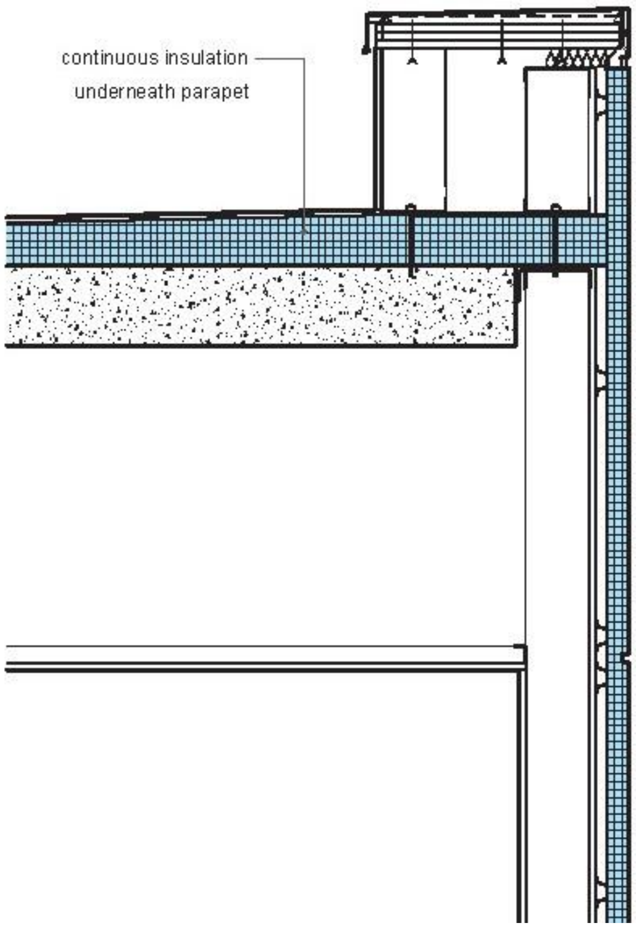


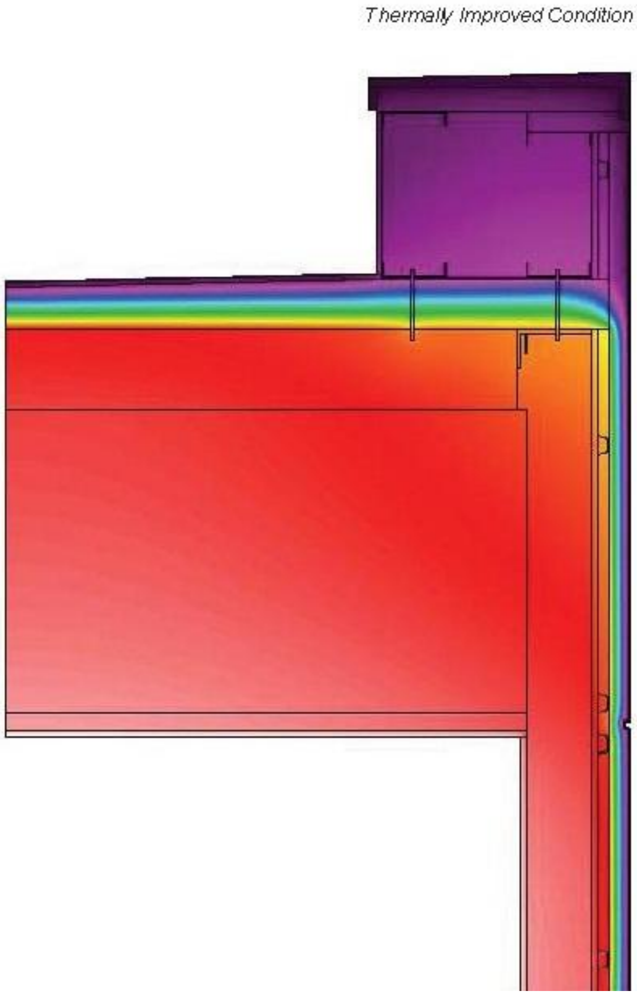


Simulated R-Value: 8.57

-62% Baseline R-Value: 22.34

RESEARCH FINDINGS | Parapets





Simulated R-Value: 10.65

-52% **Baseline R-Value: 22.34**

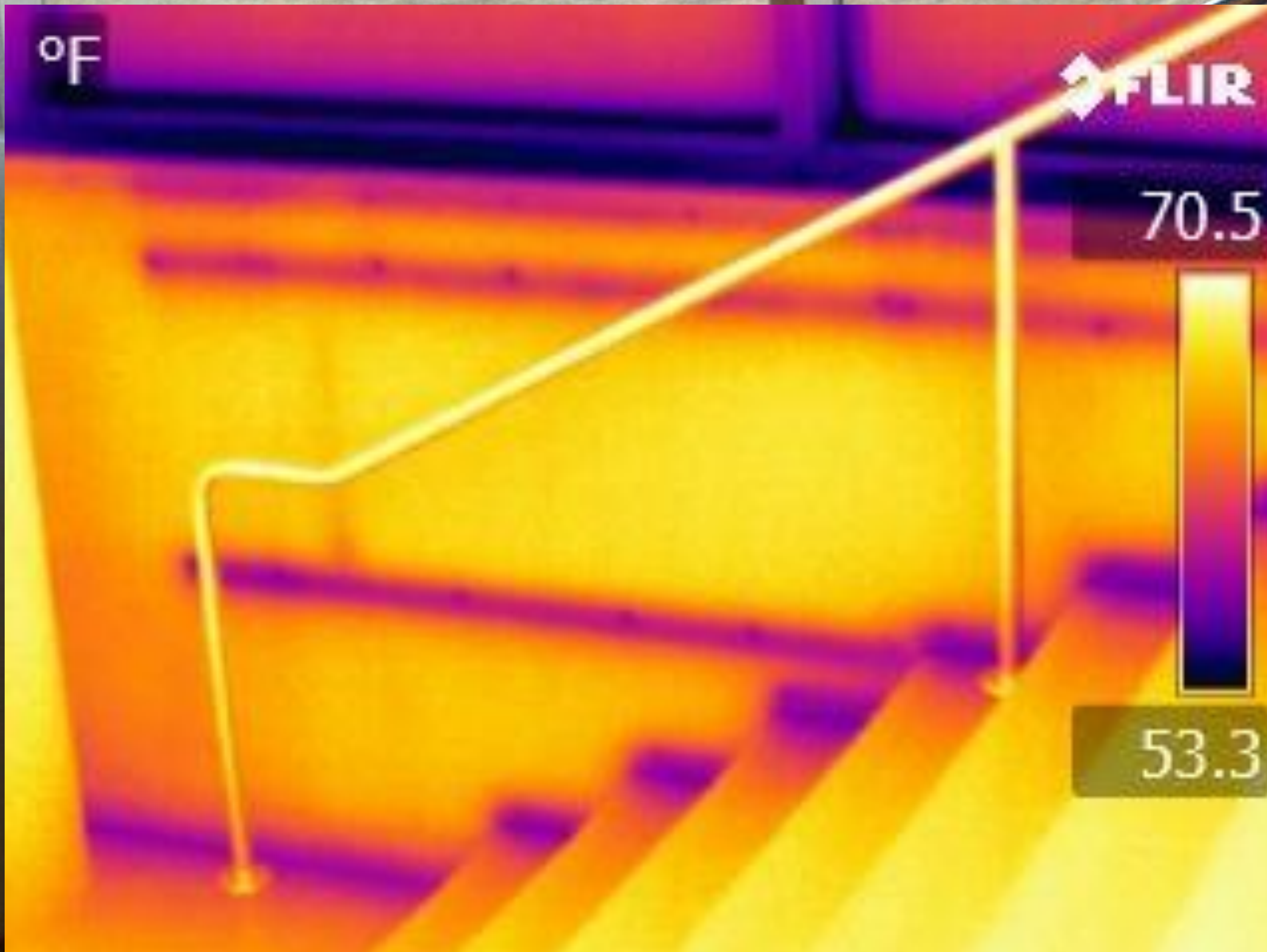
CONCLUSION | Full Report

- Report available on Payette's website

Projects
↓
Research @ Payette
↓
Thermal Performance of Façades

CONCLUSION | Observations

- Thermal bridges are significantly decreasing the thermal performance of our building envelopes
- There are numerous thermal bridges all over our buildings
- Careful detailing and attention to the issue can improve their performance
- More awareness and education is needed on the sources of thermal bridges in our details
- We should shift the dialog from the R-value of insulation to the performance as R-value of assembly
- CONTINUITY of insulation barrier key to good thermal performance



Questions?

INTERACTIVE WORKSHOP | Finding Solutions to Thermal Bridges

- Break into Groups (20 Minutes)
  - Review your typical building envelope detail
  - Identify the thermal break(s)
  - Develop your own solution(s)

- Share you Findings and Proposed Solutions (10 Minutes)

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1) Transitions Between Systems
2) Soffits
3) Roof to Wall Transitions
4) Roof Penetrations / Seismic Joints
5) Louvers
6) Exist. Bldg. Slab & Beam Conx.