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

Source: ©2010 2030, Inc. / Architecture 2030. All Rights Reserved.

U.S. Electricity Consumption by Sector

Source: ©2011 2030, Inc. / Architecture 2030. All Rights Reserved.
70% of commercial building’s energy is impacted by the design of the envelope.
INTRODUCTION | Envelope’s Impact on Energy

Thermal Mass

Thermal Resistance

Infiltration

Glazing Visual Transmittance & Solar Heat Gain
INTRODUCTION | Heat Flow Basics

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
\( \Delta T = \) difference in temperature between inside & out
U = heat transfer coefficient
INTRODUCTION │ Heat Flow Basics

• **R-value** – measure of thermal resistance - $h \cdot \text{ft}^2 \cdot \degree \text{F}/\text{Btu}$ or $m^2 \cdot \degree \text{K}/\text{W}$
  
  (bigger the better)

• **U-value** – heat transfer coefficient; measure of how well the building conducts heat - $\text{Btu}/h \cdot \text{ft}^2 \cdot \degree \text{F}$ or $W/m^2 \cdot \degree \text{K}$
  
  (smaller the better)

\[
U = \frac{1}{R} = \frac{\text{material conduct.}}{\text{material width}} = \frac{\text{heat transfer per unit area}}{\text{temperature difference}}
\]
How we think about it in design:

1D Heat Flow
INTRODUCTION  |  Thermal Bridges

How we think about it in design:

1D Heat Flow

How it is in reality:

2D & 3D Heat Flow
INTRODUCTION │ Historic Envelopes

Monadnock Building in Chicago, IL
### 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)***

<table>
<thead>
<tr>
<th>Opaque Elements</th>
<th>Nonresidential</th>
<th>Residential</th>
<th>Semihheated</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Assembly Max.</td>
<td>Insulation Min. R-Value</td>
<td>Assembly Max.</td>
</tr>
<tr>
<td><strong>Roofs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation Entirely above Deck</td>
<td>U-0.048</td>
<td>R-20.0 c.i.</td>
<td>U-0.048</td>
</tr>
<tr>
<td>Metal Building</td>
<td>U-0.065</td>
<td>R-19.0</td>
<td>U-0.065</td>
</tr>
<tr>
<td>Attic and Other</td>
<td>U-0.027</td>
<td>R-38.0</td>
<td>U-0.027</td>
</tr>
<tr>
<td><strong>Walls, Above-Grade</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>U-0.090</td>
<td>R-11.4 c.i.</td>
<td>U-0.080</td>
</tr>
<tr>
<td>Metal Building</td>
<td>U-0.113</td>
<td>R-13.0</td>
<td>U-0.057</td>
</tr>
<tr>
<td>Steel-Framed</td>
<td>U-0.064</td>
<td>R-13.0 + R-7.5 c.i.</td>
<td>U-0.064</td>
</tr>
<tr>
<td>Wood-Framed and Other</td>
<td>U-0.064</td>
<td>R-13.0 + R-3.8 c.i.</td>
<td>U-0.051</td>
</tr>
<tr>
<td><strong>Walls, Below-Grade</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Below-Grade Wall</td>
<td>C-0.119</td>
<td>R-7.5 c.i.</td>
<td>C-0.119</td>
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<tr>
<td><strong>Floors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>U-0.074</td>
<td>R-10.4 c.i.</td>
<td>U-0.064</td>
</tr>
<tr>
<td>Steel-Joist</td>
<td>U-0.038</td>
<td>R-30.0</td>
<td>U-0.038</td>
</tr>
<tr>
<td>Wood-Framed and Other</td>
<td>U-0.033</td>
<td>R-30.0</td>
<td>U-0.033</td>
</tr>
</tbody>
</table>
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?

[Bar chart showing the perceived reduction in R-value from thermal bridges across different percentage ranges.]
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
HYPOTHESIS │ Why Thermal Bridges Matter

![Graph showing thickness vs. U-value]

- The graph illustrates the relationship between thickness and U-value.
- It shows that as thickness increases, the U-value decreases, indicating improved thermal performance.
- The data suggests that thermal bridges are critical in energy efficiency, affecting how well a building maintains its temperature.
HYPOTHESIS | Why Thermal Bridges Matter
HYPOTHESIS | Why Thermal Bridges Matter
HYPOTHESIS | Why Thermal Bridges Matter

![Graph showing the relationship between thickness and U-value](image)
HYPOTHESIS | Why Thermal Bridges Matter
HYPOTHESIS │ Why Thermal Bridges Matter

Current Code Requirements
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”

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness</th>
<th>k</th>
<th>R-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ext. Air</td>
<td>NA</td>
<td>-</td>
<td>0.17</td>
</tr>
<tr>
<td>Brick</td>
<td>3.625</td>
<td>6.4</td>
<td>0.56</td>
</tr>
<tr>
<td>Air Space</td>
<td>2.375</td>
<td>-</td>
<td>0.91</td>
</tr>
<tr>
<td>XPS</td>
<td>2</td>
<td>0.2</td>
<td>10.00</td>
</tr>
<tr>
<td>Gypsum</td>
<td>0.625</td>
<td>1.1</td>
<td>0.57</td>
</tr>
<tr>
<td>Studs</td>
<td>6</td>
<td>-</td>
<td>1.36</td>
</tr>
<tr>
<td>Gypsum</td>
<td>0.625</td>
<td>1.1</td>
<td>0.57</td>
</tr>
<tr>
<td>Int. Air</td>
<td>NA</td>
<td>-</td>
<td>0.68</td>
</tr>
</tbody>
</table>

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

**Table 22: Average Surface Temperature Results Comparison (Griffith 1997)**

<table>
<thead>
<tr>
<th></th>
<th>Measured</th>
<th>Parallel Path</th>
<th>Isothermal Planes</th>
<th>Averaged</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>°C</td>
<td>°C</td>
<td>% Different</td>
<td>°C</td>
</tr>
<tr>
<td>Nylon, 229mm</td>
<td>12.4</td>
<td>11.5</td>
<td>-7.3%</td>
<td>11.5</td>
</tr>
<tr>
<td>Stainless, 457mm</td>
<td>11.0</td>
<td>11.3</td>
<td>+2.7%</td>
<td>10.5</td>
</tr>
<tr>
<td>Stainless, 305mm</td>
<td>10.8</td>
<td>11.2</td>
<td>+3.7%</td>
<td>10.1</td>
</tr>
<tr>
<td>Stainless, 229mm</td>
<td>10.7</td>
<td>11.1</td>
<td>+3.7%</td>
<td>9.8</td>
</tr>
<tr>
<td>Stainless, 152mm</td>
<td>10.5</td>
<td>10.9</td>
<td>+3.8%</td>
<td>9.2</td>
</tr>
<tr>
<td>Stainless, 76mm</td>
<td>9.4</td>
<td>10.3</td>
<td>+9.6%</td>
<td>7.9</td>
</tr>
<tr>
<td>Steel, 229mm</td>
<td>8.8</td>
<td>11.1</td>
<td>+26.1%</td>
<td>7.7</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
RESEARCH PROCESS │ Heat Flow Simulation

Parallel Path Method
   – Weighted average of 2 simulations

\[ U_P = F_B \times U_B + F_N \times U_N \]

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
RESEARCH PROCESS | Heat Flow Simulation

Isothermal Planes Method
- 1 simulation with a weighted average of the conductivities

\[ k_{\text{eff}} = F_B \cdot k_B + F_N \cdot k_N \]

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

\( k_B = \text{effective conductivity} \)

\( k_B = \text{conductivity of bridging element} \)

\( k_N = \text{conductivity of non-bridging element} \)
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
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
RESEARCH FINDINGS | Existing Masonry Wall Assemblies

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

Building 1- studs directly attached to existing wall \(\rightarrow\) resulting in a decrease of 59% of baseline R-value

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%
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%
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
• 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

- TUBE STEEL AND SHELF ANGLE SUPPORTED FROM BUILDING STRUCTURE
- TERRA COTTA BANDING
- EXT. WALL ASSEMBLY:
  - 4” FACE BRICK
  - AIR SPACE
  - 2” RIGID INSULATION OVER CONTINUOUS AIR AND VAPOR BARRIER
  - REINFORCED 8” CMU BACKUP WALL
- TERRA COTTA BANDING
- STAINLESS STEEL FLASHING
- GROUT CAVITY SOLID

Stud Back Up Wall with 2” Rigid Insulation

- SS BRICK TIES
- CONT. STAINLESS STEEL FLASHING SHINGLED W/ AIR & VAPOR BARRIER
- CONT. GALVANIZED STEEL RELIEVING ANGLE, WRAPPED WITH AIR & VAPOR BARRIER
- ACCENT BRICK, PROJECTS 1/2” TYPICAL
- FACE BRICK
- 2” RIGID INSULATION
- AIR & VAPOR BARRIER
- GLASS-MAT FACED GYPSUM SHEATHING
- 6” COLD-FORMED METAL FRAMING
- 5/8” GYPSUM WALLBOARD
- MORTAR NET, TYP.
- 7 1/2” COMPOSITE SLAB
- AIR & VAPOR BARRIER
- 2” RIGID INSULATION

Stud Back Up Wall with 3” Mineral Wool insulation

- STEEL RELIEVING ANGLE
- COMPOSITE METAL DECK
- FACE BRICK
- 3” CAVITY WALL INSULATION
- MASONRY REINFORCEMENT TIE
- AIR BARRIER
- 1/2” GLASS MAT GYPSUM SHEATHING BOARD
- 6” COLD FORMED METAL FRAMING
- STEEL COLUMN (BEYOND)
- COMPOSITE METAL DECK
RESEARCH FINDINGS │ Masonry Veneer Support Connections

CMU Back Up Wall with 2” Rigid Insulation

Stud Back Up Wall with 2” Rigid Insulation

Stud Back Up Wall with 3” Mineral Wool insulation

R-12.3 -24%
R-6.5 -60%
R-8.42 -56%
RESEARCH FINDINGS | Masonry Veneer Support Connections

CMU Back Up Wall with 2” Rigid Insulation

-17%

Stud Back Up Wall with 2” Rigid Insulation

-43%

Stud Back Up Wall with 3” Mineral Wool insulation

-25%

R-13.3

R-9.3

R-14.2

R-14.4
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)

Magnified View
## RESEARCH FINDINGS | Masonry Veneer Support Connections

<table>
<thead>
<tr>
<th>LOSS %</th>
<th>-1</th>
<th>-2</th>
<th>-3</th>
<th>-4</th>
<th>-5</th>
<th>-6</th>
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<th>-10</th>
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<th>-12</th>
<th>-13</th>
<th>-14</th>
<th>-15</th>
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<td>TIE SPACING</td>
<td>16</td>
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</tbody>
</table>

R 14.75 (BASE WALL NO TIES)

- **S**: GALVANIZED
- **B**: STAINLESS
- **T**:
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

R-11.6 -37%

R-17.3 -6%
RESEARCH FINDINGS │ Rainscreens
RESEARCH FINDINGS | Rainscreens

Horizontal Z-Girt Supports

- COLD FORMED METAL FRAMING
- CONTINUOUS PERFORATED VENTILATION PROFILE
- CONTINUOUS Z FURRING
- FIBER REINFORCED CEMENTITIOUS PANEL (FCP-2)
- TYPICAL EXT. WALL
  - FIBER REINFORCED CEMENT PANEL
  - ALUMINUM FRAMING
  - UV PROTECTIVE SCRIM SHEET
  - 4" Z CLIP FURRING
  - 2" RIGID INSUL
  - AIR & VAPOR BARRIER
  - 5/8" GYP SHEATHING
  - COLD FORMED MTL. FRAMING
  - 5/8" GYP SHEATHING

---

R-14.1  R-6.2  -56%  R-5.6  -60%
Clip Supports

ZINC RAINSCREEN PANEL

FIRESTOPPING

DEFLECTION SPACE
SPRAY FOAM INSULATION
EXT. WALL ASSEMBLY:
- 6" COLD FORMED METAL FRAMING
- 5/8" EXTERIOR SHEATHING
- AIR AND VAPOR BARRIER
- 2" RIGID INSULATION (SEAL ALL JOINTS)
- ALUMINUM SPANDREL RAINSCREEN PANEL
- RAINSCREEN SYSTEM MOUNTING BRACKET

R-12.6

R-9.7

-23%

-14%

FLIR Image:
- Max 70.4°F
- Min 67.6°F
- Average 69.2°F
- Sp1 69.2°F

Temperature Map:
- 72.7°C
- 65.4°C
RESEARCH FINDINGS  |  Rainscreens

**Vertical Z-Girt Supports**

- Stainless Steel Fastener
- 7/8” Galvanized Hat Channel with Shim as Required
- Corrugated Metal Wall Panel
- 3” Cavity Wall Insulation
- Air and Vapor Barrier on 1/2” Glass Mat Gypsum Sheathing Board

**Thermal Imaging**

- Ar1 Max: 70.1°F
- Ar1 Min: 68.5°F
- Ar1 Average: 69.4°F
- Ar2 Max: 70.1°F
- Ar2 Min: 68.5°F
- Ar1 Average: 69.5°F
- Sp1: 69.5°F

**R-values**: R-16.9, R-9.2, R-11.1
RESEARCH FINDINGS │ Rainscreens

Examples of existing thermally broken products on the market

Continuous Rainscreen System

STAINLESS STEEL FASTENERS TYP.
2” PANELRAIL
THERMASTOP (THERMAL ISOLATOR @ EA. FASTENER TYP.
CI-GIRT
3” CAVITY WALL INSULATION
AIR AND VAPOR BARRIER ON 1/2” GLASS MAT GYPSUM SHEATHING BOARD

DOW THERMAX™ (C)
(EXTERIOR INSULATION, MINIMUM 25 PSI)

ThermaStop™ FASTENER THERMAL ISOLATION ASSEMBLY
STAINLESS STEEL SELF-DRILL FASTENER
DOW STYROFOAM™ SPF CM SERIES, MAX FULL CAVITY DEPTH, TYPICAL 1.5”

CI-Girt™

3/4” TOTAL CAVITY

16” O.C. TYP., 8” O.C. MIN.

1/2”

16” O.C. TYP., 24” O.C. MAX

3” MAXIMUM

ALIGNED WITH STUD
Examples of existing thermally broken products on the market
Examples of existing thermally broken products on the market
Examples of existing thermally broken products on the market.
RESEARCH FINDINGS  │ Curtain Walls
Baseline R-Value: 20.4
Observed R-Value: 5.8
RESEARCH FINDINGS │ Curtain Walls

Traditional Spandrel Panel

Baseline R-Value: 20.4
Simulated R-Value: 6.2
RESEARCH FINDINGS │ Curtain Walls

Baseline R-Value: 14.2

Observed R-Value: 6.2
RESEARCH FINDINGS │ Curtain Walls

Spray Foam in Mullion

Baseline R-Value: 14.2
Simulated R-Value: 4.9

-65%
RESEARCH FINDINGS │ Curtain Walls

Custom Alum. Extrusion, Finished to Match Curtainwall

Custom Alum. Extrusion, Adhered to Slab Finish to Match Curtainwall

Scheduled Finish Flooring

Wrapped Mullion

Baseline R-Value: 12.3
RESEARCH FINDINGS │ Curtain Walls

- Baseline R-Value: 12.3
- Simulated R-Value: 5.1

Wrapped Mullion with Back Pan

CUSTOM ALUM. EXTRUSION, FINISHED TO MATCH CURTAINWALL
CUSTOM ALUM. EXTRUSION, ADHERED TO SLAB FINISH TO MATCH CURTAINWALL
SCHEDULED FINISH FLOORING

R = 3/8"

DRIP AND WEEPS
PROJECTING HORIZONTAL MULLION CAP
ENGINEERED CONNECTION FOR GRAVITY LOAD @ 4TH,5TH FLOOR
FIRE SAFING AND RETENTION CLIP, TYP.
2" THICKNESS CONTINUOUS INSULATION

2" THICKNESS CONTINUOUS INSULATION @ VERTICAL MULLION
CURTAIN WALL TYPE 1

-65%

Baseline R-Value: 12.3
Simulated R-Value: 5.1
RESEARCH FINDINGS │ Curtain Walls

Baseline R-Value: 12.3
Simulated R-Value: 10.9

Wrapped Mullion without Back Pan
RESEARCH FINDINGS │ Curtain Walls

Glazed in Spandrel Panel

Baseline R-Value: 10.6
RESEARCH FINDINGS | Curtain Walls

Glazed in Spandrel Panel

Baseline R-Value: 10.6
Simulated R-Value: 8.1

-24%
RESEARCH FINDINGS  |  Curtain Walls

Glazed in Spandrel Panel

Baseline R-Value: 21.2
Simulated R-Value: 15.1

-29%
RESEARCH FINDINGS │ Metal Panels
RESEARCH FINDINGS │ Metal Panels

Uninsulated Panel with Back Up Insulation

- SEALANT
- STAINLESS STEEL CONT. CLEAT
- BLOCKING
- ZINC TRIM PANEL
- STAINLESS STEEL CONT. CLEAT

2” Insulated Panel

- METAL PANEL TYPE-2
- METAL FURRING
- SEALANT
- FILL VOID WITH CONT. RIGID INSULATION
- AIR & VAPOR BARRIER
- GYPSUM SHEATHING
- CFMF FRAMING

3” Insulated Panel

- R-19.8
- R-19.2
- R-20.5
RESEARCH FINDINGS │ Metal Panels

Uninsulated Panel with Back Up Insulation

2” Insulated Panel

3” Insulated Panel

Uninsulated Panel with Back Up Insulation

2” Insulated Panel

3” Insulated Panel

R-6.0 -70%  
R-18.7 -3%  
R-6.8 -67%

Ar1  Max  75.3  Min  72.2  Average  74.0  Sp1  74.2

Ar1  Max  67.5  Min  66.0  Average  66.8  Sp1  66.9

Ar1  Max  65.1  Min  62.9  Average  64.3  Sp1  64.6

Ar1  Max  77.3  Min  70.0  Average  70.0

Ar1  Max  67.7  Min  63.1  Average  64.6

Ar1  Max  60.4  Min  57.7  Average  59.0

RESEARCH FINDINGS │ Metal Panels

Uninsulated Panel with Back Up Insulation

2” Insulated Panel

3” Insulated Panel

R-9.7 -51%

R-17.6 -5%

R-4.3 -80%
RESEARCH FINDINGS | Window Openings

Inline

Recessed

Proud
RESEARCH FINDINGS | Window Openings – Flanking Loss

Aligned

1/8" ALUMINUM CAP
THROUGH-INSULATION FLASHERING
EXT. WALL ASSEMBLY
-EXT. TILES
-2" WALL CAVITY INSULATION
-AIR AND VAPOR BARRIER
-6" CFMF
-5/8" GYPSUM BOARD

RECESSED

EXTRUDED ALUMINUM SILL
1" INSULATED ALUMINUM PANEL
1/8" FORMED ALUMINUM SILL PANEL
TERRA COTTA BANDING
EXT. WALL ASSEMBLY
-4" BRICK
-2" AIR SPACE
-2" INSULATION
-AIR VAPOR BARRIER
-CMU BACKUP WALL
-4" CFMF
-5/8" GYPSUM BOARD

PROUD

1" INSULATED GLASS
STEEL ANGLE
EXT. WALL ASSEMBLY
-4" BRICK
-2" AIR SPACE
-3" INSULATION
-AIR VAPOR BARRIER
-1/2" GLASS MAT
GYPSUM SHEATHING
-6" CFMF
-5/8" GYPSUM BOARD
RESEARCH FINDINGS │ Window Openings – Structural Support

Aligned

- Extruded Aluminum Sill
- 1" Insulated Aluminum Panel
- 1/8" Formed Aluminum Sill Panel
- Terra Cotta Banding
- Ext. Wall Assembly
  - Ext. Tiles
  - 2" Wall Cavity Insulation
  - Air and Vapor Barrier
  - 6" CFMF
  - 5/8" Gypsum Board

Recessed

- 1" Insulated Glass
- Steel Angle
- Ext. Wall Assembly
  - 4" Brick
  - 2" Air Space
  - 3" Insulation
  - Air Vapor Barrier
  - CMU Backup Wall
  - 4" CFMF
  - 5/8" Gypsum Board

Proud

- Extruded Aluminum Sill
- 1" Insulated Aluminum Panel
- 1/8" Formed Aluminum Sill Panel
- Terra Cotta Banding
- Ext. Wall Assembly
  - Ext. Tiles
  - 2" Wall Cavity Insulation
  - Air and Vapor Barrier
  - 6" CFMF
  - 5/8" Gypsum Board
Window Openings – Inline Relationship

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

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

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

Window Sill

Window Jamb

R-10.48 -44%
R-10.39 -45%
R-9.36 -50%
RESEARCH FINDINGS │ Window Openings – Aligned

Window Jamb

Window Jamb

R-7.94

Baseline R-Value: 20.93

-62%
RESEARCH FINDINGS │ Foundation Walls
RESEARCH FINDINGS │ Foundation Walls

Exterior Insulation

Interior Insulation

Exterior Insulation

R-4.1 -70%

R-3.5 -72%

R-3.71 -75%
Baseline R-Value: 14.01
Simulated R-Value: 8.39

-40%
RESEARCH FINDINGS │ Foundation Walls

Baseline R-Value: 13.74

Simulated R-Value: 6.1

-56%

Baseline R-Value: 13.74
RESEARCH FINDINGS │ Foundation Walls

As-Built Condition

Baseline R-Value: 13.38

Simulated R-Value: 4.10

-69%
Baseline R-Value: 13.38
RESEARCH FINDINGS | Foundation Walls

Baseline R-Value: 13.38

Simulated R-Value: 8.59

-Thirty-six percent (36%) improvement

Baseline R-Value: 13.38
RESEARCH FINDINGS │ Foundation Walls

Baseline R-Value: 13.38

Simulated R-Value: 9.82

-27%

Baseline R-Value: 13.38
RESEARCH FINDINGS │ Roof Parapets
as the height increases, the R-value decreases
Baseline R-Value: 22.34
Simulated R-Value: 8.57
-62%
RESEARCH FINDINGS | Parapets

Baseline R-Value: 22.34
Simulated R-Value: 10.65

-52% Baseline R-Value: 22.34

Simulated R-Value: 10.65
CONCLUSION  |  Full Report

- Report available on Payette’s website
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)

1) Transitions Between Systems
2) Soffits
3) Roof to Wall Transitions
4) Roof Penetrations / Seismic Joints
5) Louvers