CHARLES PANKOW FOUNDATION

# Thermal Performance of Spandrels

BEST6 Conference

March 20, 2024

# Speakers

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CHARLES PANKOW FOUNDATION

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$15M Funded

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37 Organizations

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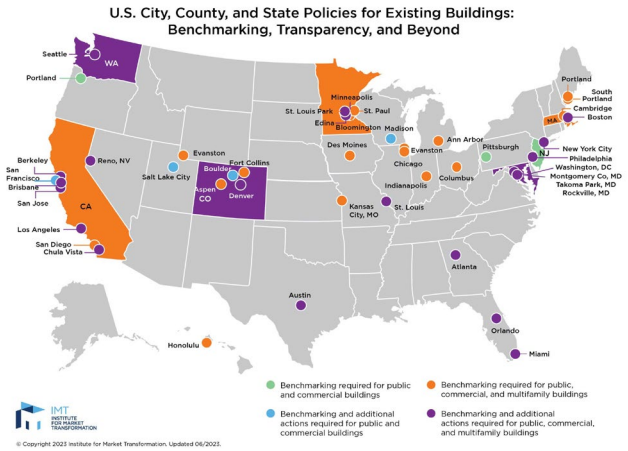
# Agenda

## Spandrels

What, Where, Why Spandrels?




## Codes & Standards

What do the codes say?

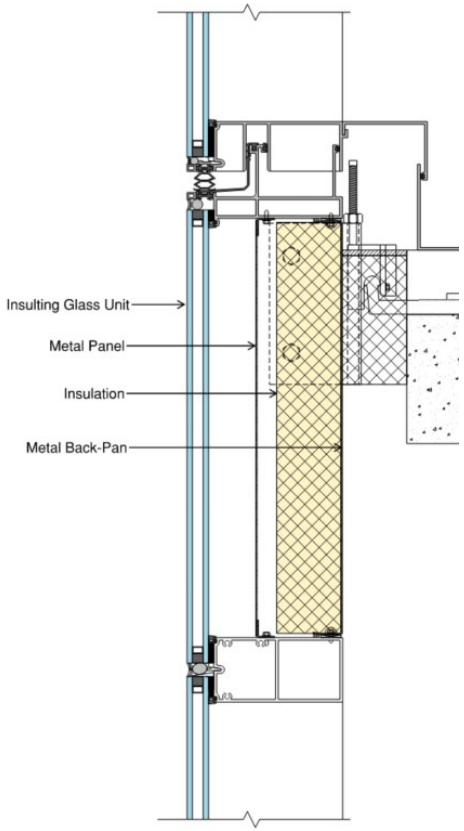
## Research & Testing

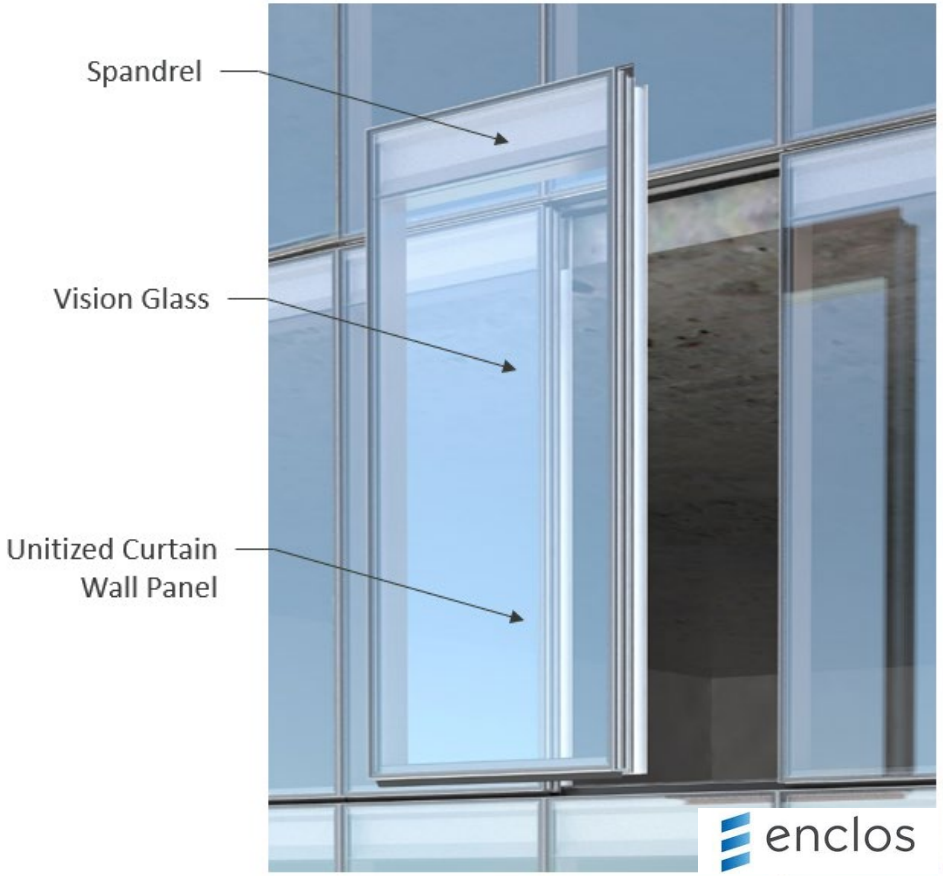
Closing the Performance Gap

# Spandrels

What, Where, Why
Spandrels?

# Glazed Wall Spandrel Systems




A non-vision application of a fenestration product; typically used to hide or obscure features of the building structure or used for visual effect. **(NFRC 100)**

North American Glass Curtain Wall Market estimated
**> $8.4 Billion in 2023**

*(Stellar Market Research, 2023)*

QA + QC

Aesthetics

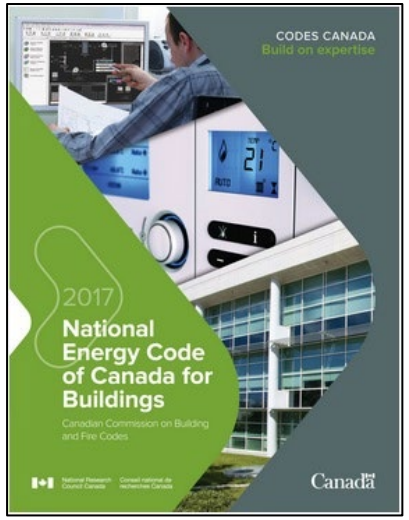
Customization

Speed of Construction

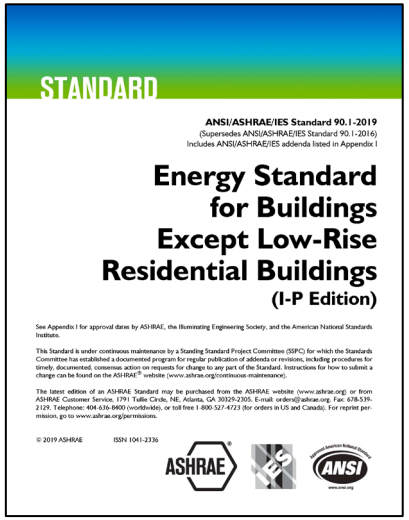
# Codes & Standards

What do the codes say?

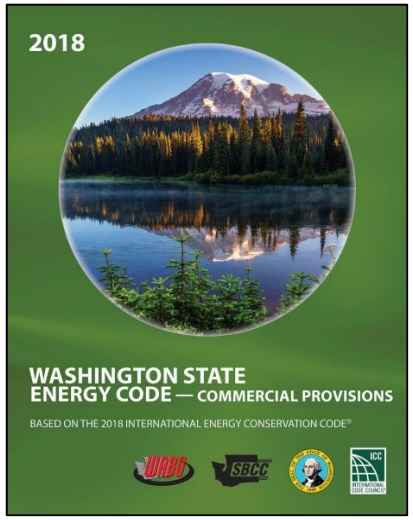
# What is a Spandrel?



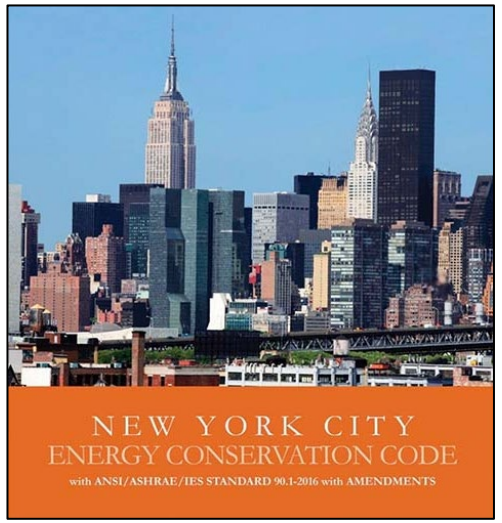


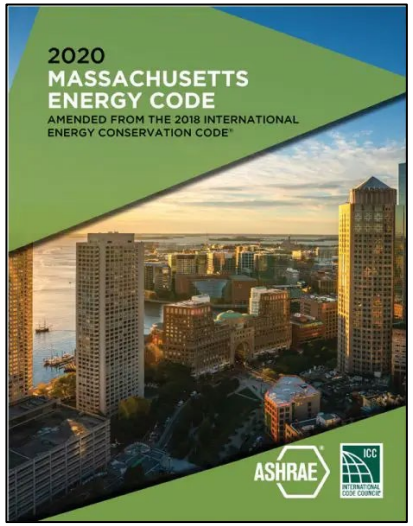



**National Level**



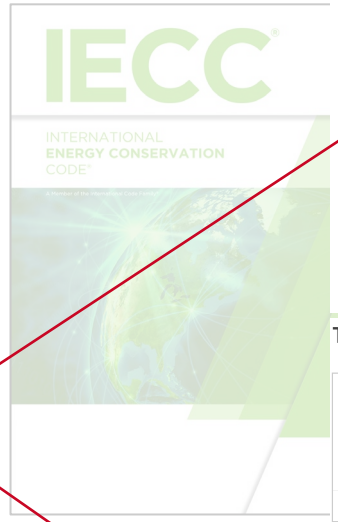





**State Level**

# What is a Spandrel?


**OTHER?**



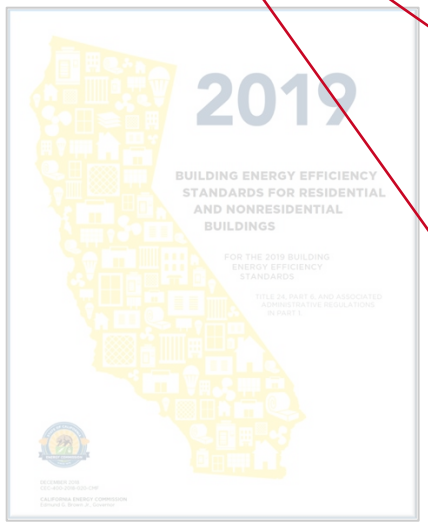






TABLE 170.2-A ENVELOPE COMPONENT PACKAGE – Multifamily Standard Building Design

| Multifamily | | Climate Zone | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Walls | Metal-Building, any fire rating | 0.061 | 0.061 | 0.061 | 0.061 | 0.061 | 0.061 | 0.061 | 0.061 | 0.061 | 0.061 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 |
| | Framed (wood, metal) and other >1hr fire rating | 0.059 | 0.059 | 0.059 | 0.059 | 0.059 | 0.065 | 0.065 | 0.059 | 0.059 | 0.059 | 0.051 | 0.059 | 0.059 | 0.051 | 0.051 | 0.051 |
| | Framed (wood, metal) and other, ≤1hr fire rating[3] | 0 | | | | | | | | | | | | | 0.051 | 0.051 | 0.051 |
| | Mass Light [4,5] | U 0.077 R 13 | U 0.077 R 13 | U 0.077 R 13 | U 0.077 R 13 | U 0.077 R 13 | U 0.077 R 13 | U 0.077 R 13 | U 0.077 R 13 | U 0.077 R 13 | U 0.077 R 13 | U 0.077 R 13 | U 0.077 R 13 | U 0.077 R 13 | U 0.077 R 13 | U 0.077 R 13 | U 0.059 R 17 |
| | Mass Heavy | 0.253 | 0.650 | 0.650 | 0.650 | 0.650 | 0.690 | 0.690 | 0.690 | 0.690 | 0.650 | 0.184 | 0.253 | 0.211 | 0.184 | 0.184 | 0.160 |

**R-16 to R-20**

TABLE C402.1.4 OPAQUE THERMAL ENVELOPE ASSEMBLY MAXIMUM REQUIREMENTS, *U*-FACTOR METHOD[a, b]

| CLIMATE ZONE | 0 AND 1 | | 2 | | 3 | | 4 EXCEPT MARINE | | 5 AND MARINE 4 | | 6 | | 7 | | 8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Gr |
| Walls, above grade | | | | | | | | | | | | | | | | |
| Mass[f] | U-0.151 | U-0.151 | U-0.151 | U- | U- | U- | U- | U- | U- | | U- | U- | U- | U-0.071 | U-0.037 | U- |
| Metal building | U-0.079 | U-0.079 | U-0.079 | | | | | | | | | | | U-0.039 | U-0.039 | U- |
| Metal framed | U-0.077 | U-0.077 | U-0.077 | | | | | | | | | | | U-0.042 | U-0.037 | U- |
| Wood framed and other[c] | U-0.064 | U-0.064 | U-0.064 | U-0.064 | U-0.064 | U-0.064 | U-0.064 | U-0.064 | U-0.051 | U-0.051 | U-0.051 | U-0.051 | U-0.051 | U-0.051 | U-0.032 | U- |

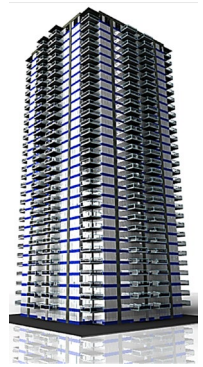
**R-15 to > R-30**

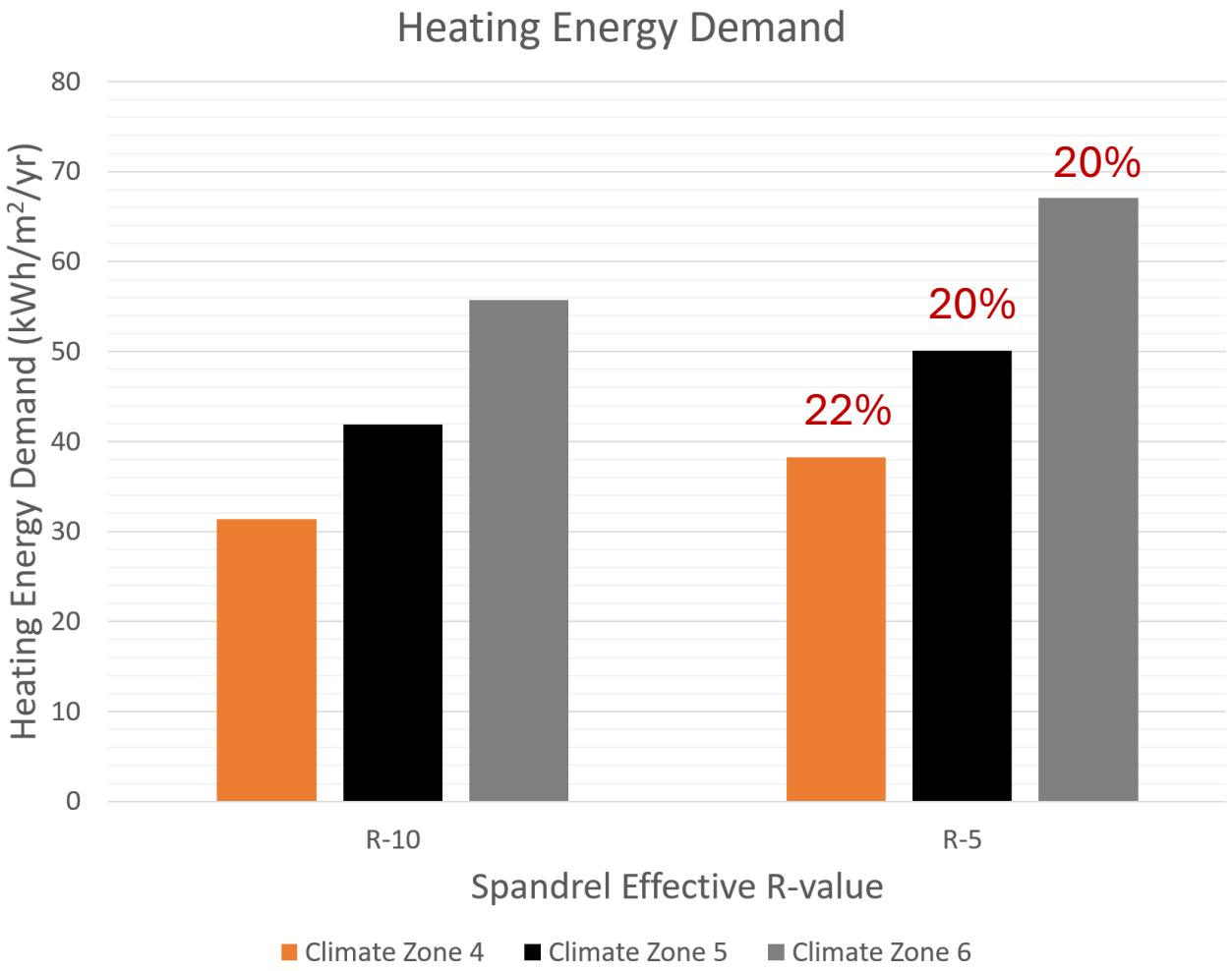
Table 5.5-4 Building Envelope Requirements for Climate Zone 4 (A,B,C)*

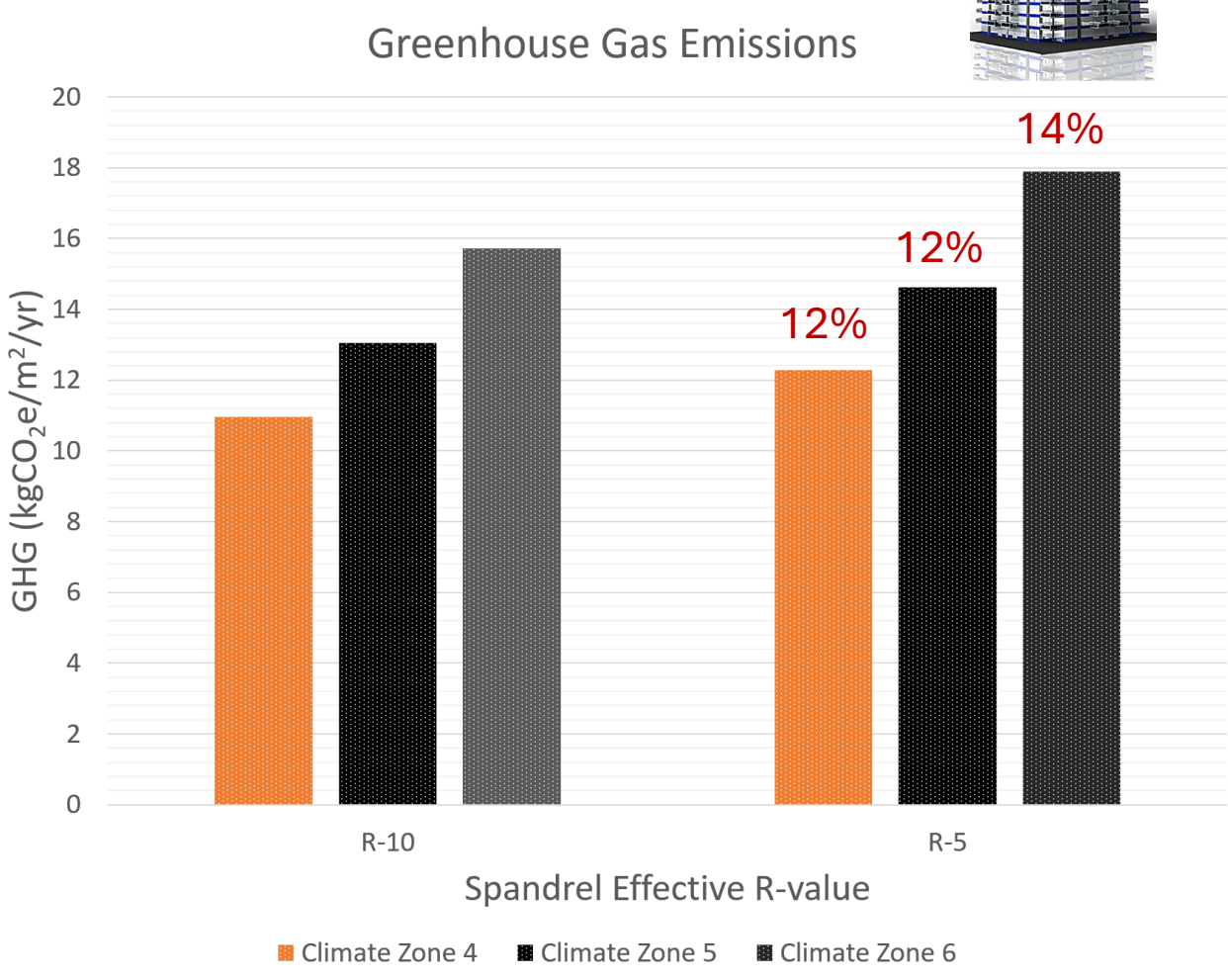
| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|---|---|---|---|---|---|---|
| | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value | Assembly Maximum | Insulation Min. R-Value |
| *Walls, above Grade* | | | | | | |
| *Mass* | U-0.592 | | | | | |
| *Metal building* | U-0.341 | | | | | |
| *Steel-framed* | U-0.365 | | | | | |
| *Wood-framed and other* | U-0.365 | R-2.3 + R-0.7 *c.i.* or R-3.5 | U-0.365 | R-2.3 + R-0.7 *c.i.* or R-3.5 | U-0.504 | R-2.3 |

**>R-15**

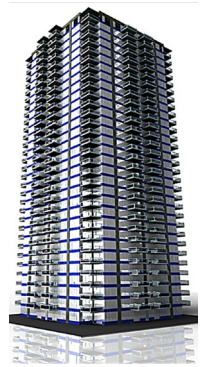
# Building Energy Performance

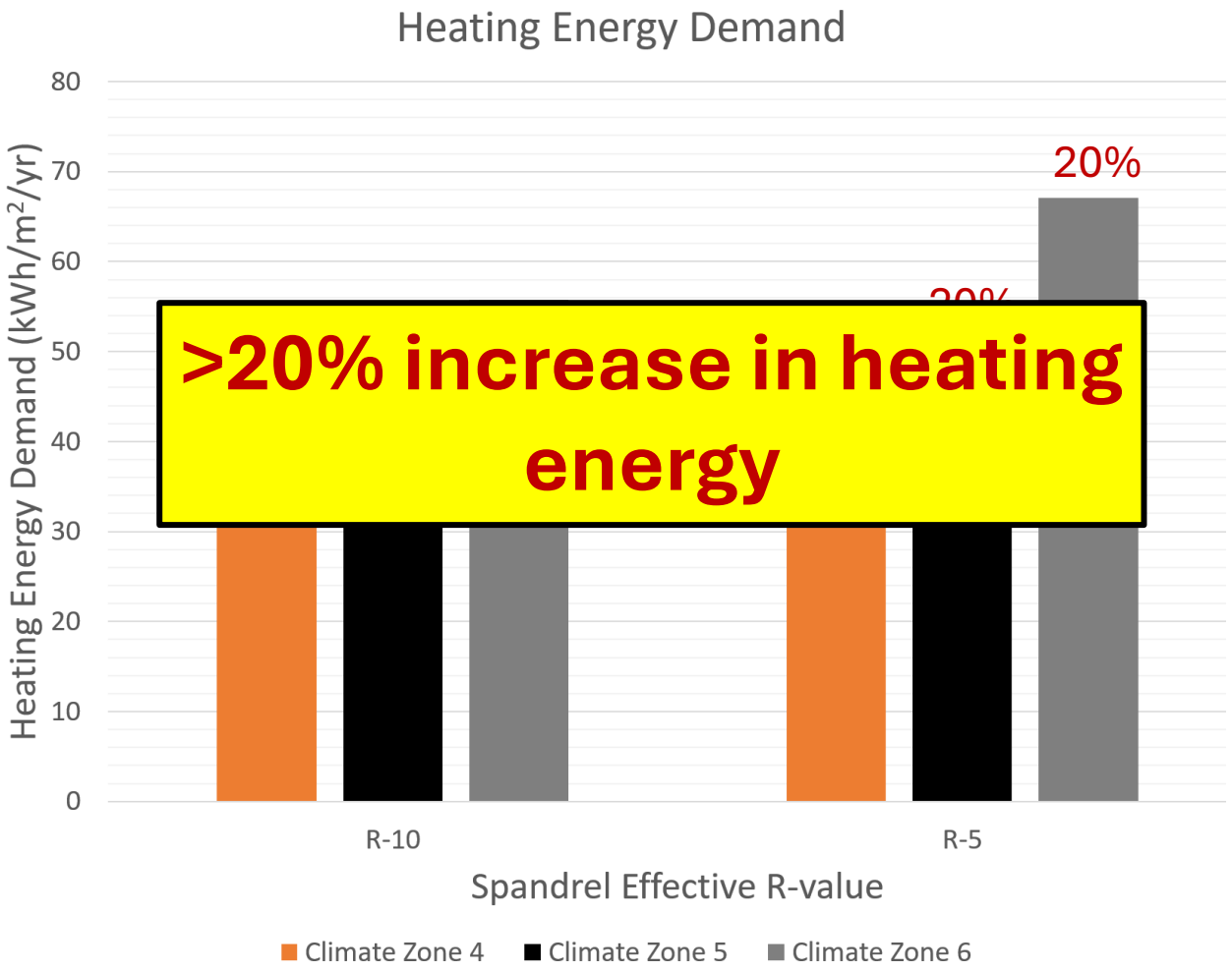


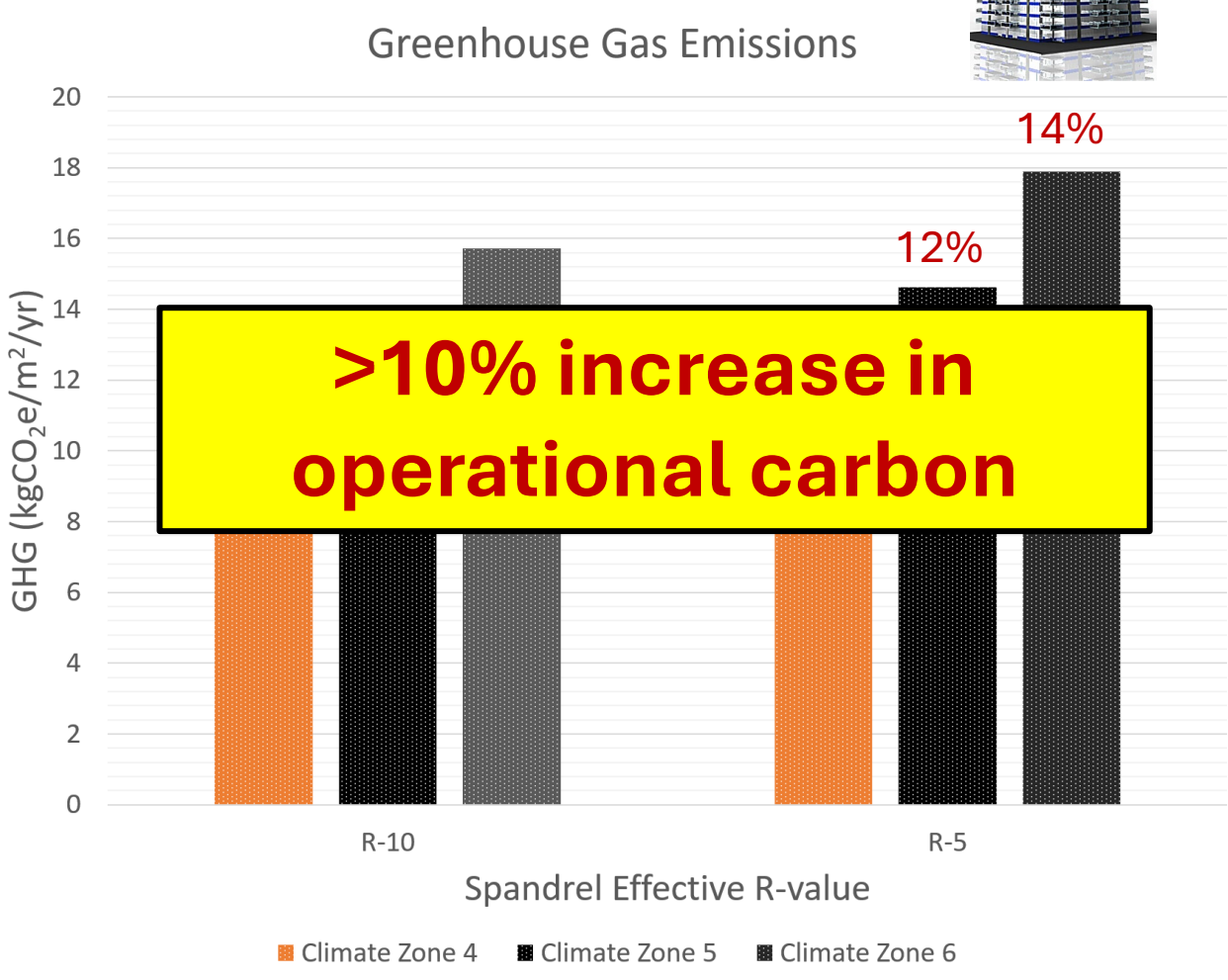


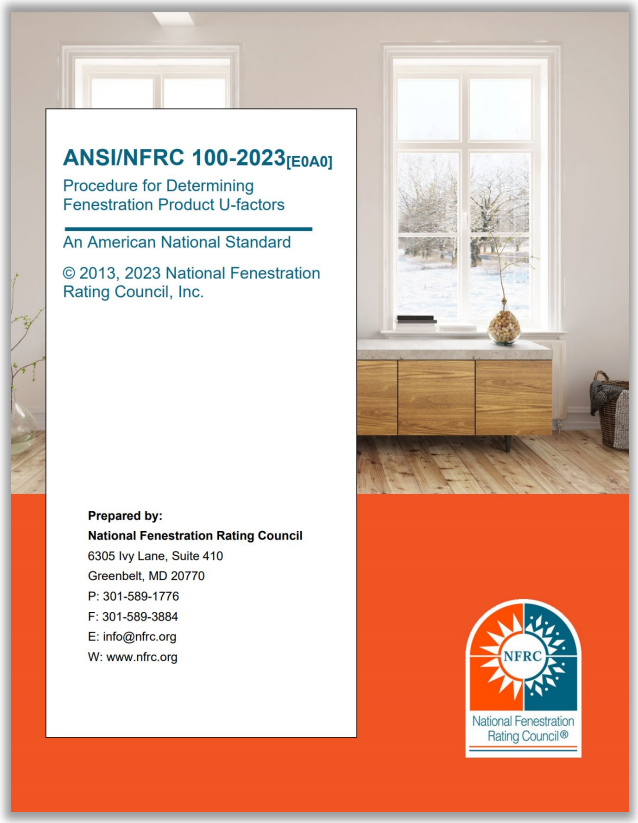
# Building Energy Performance

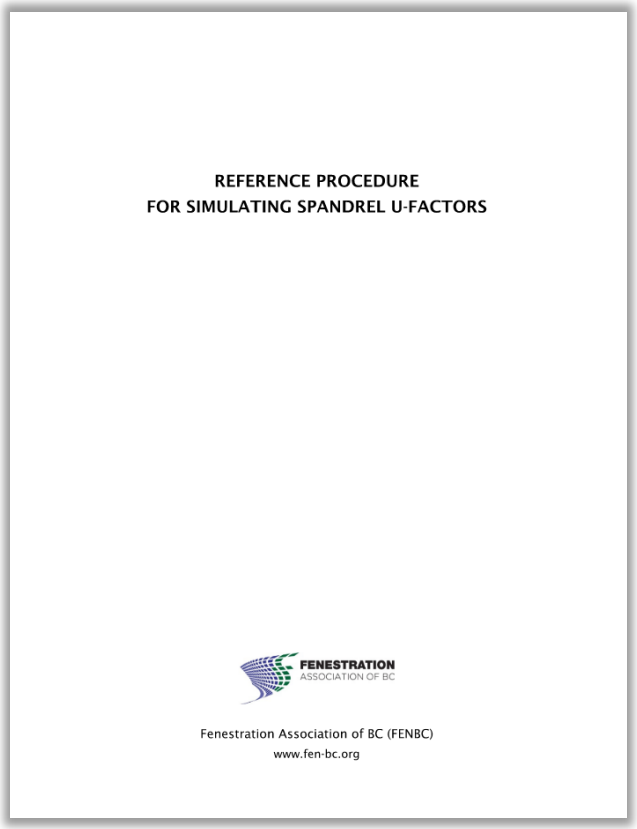


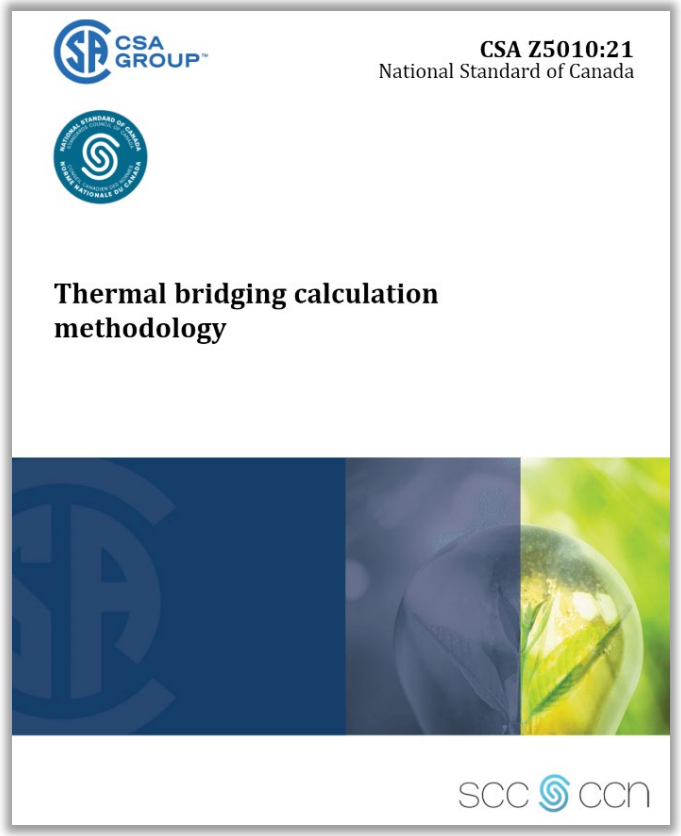


# Uncertain Thermal Performance



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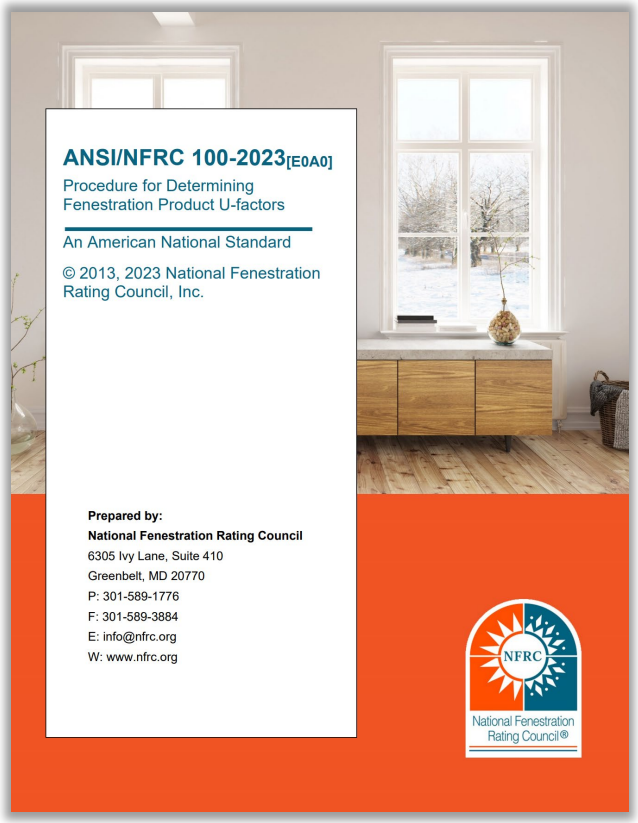
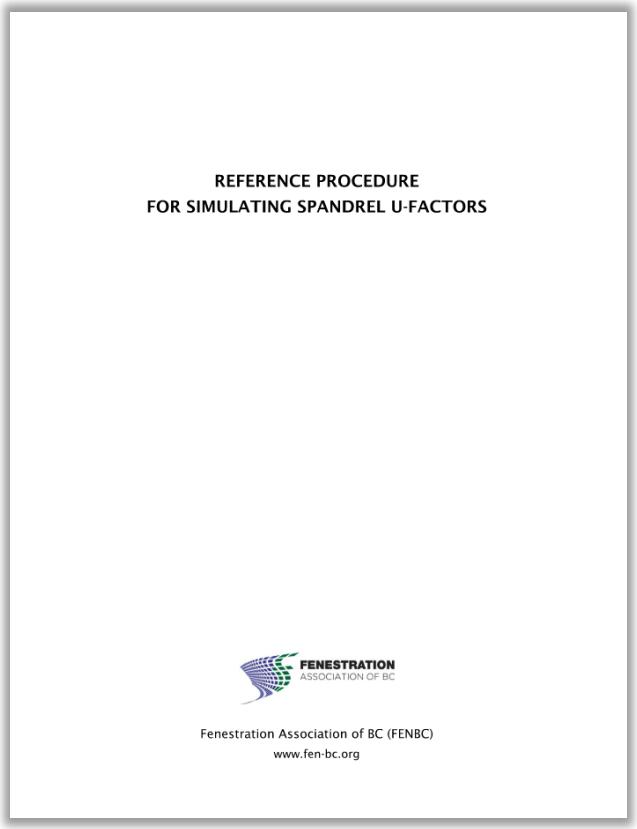
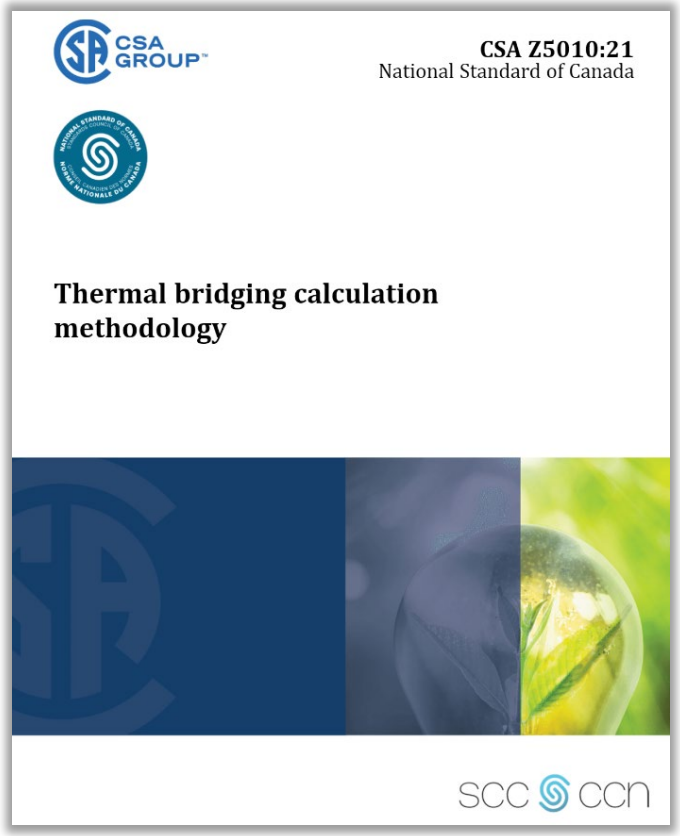
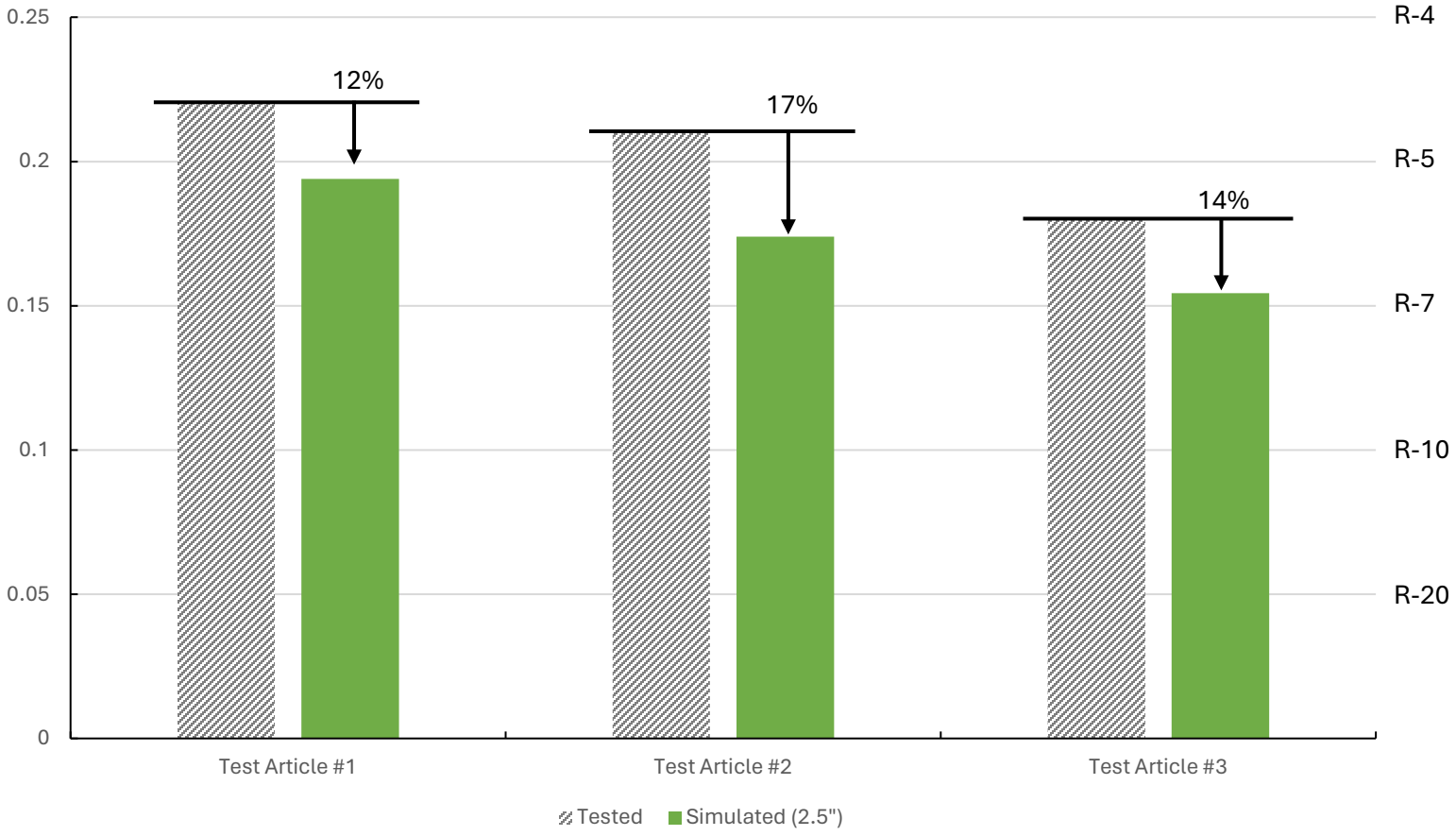



**No Consensus**

# **NFRC Spandrel Task Group |** Sim. vs. Testing



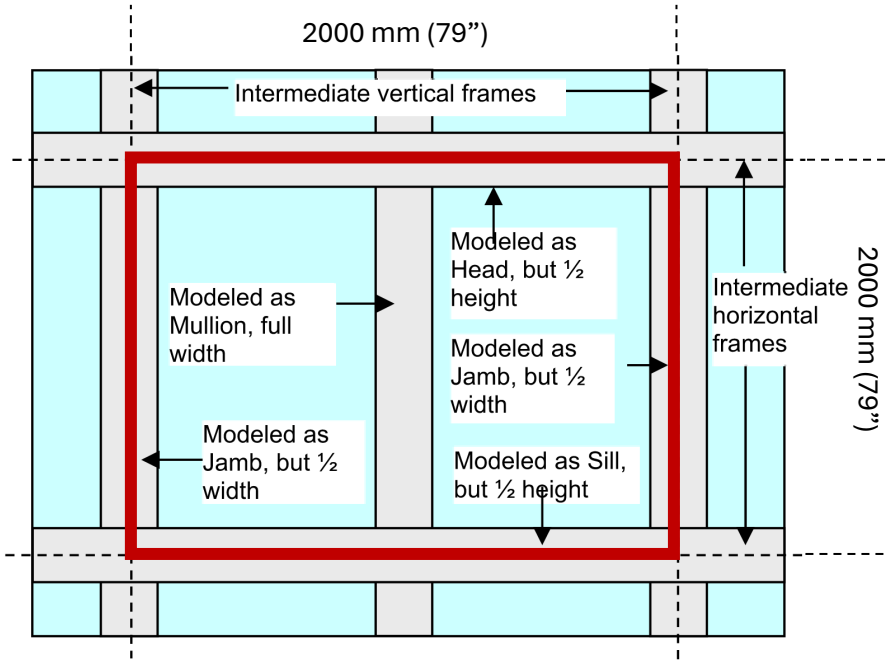
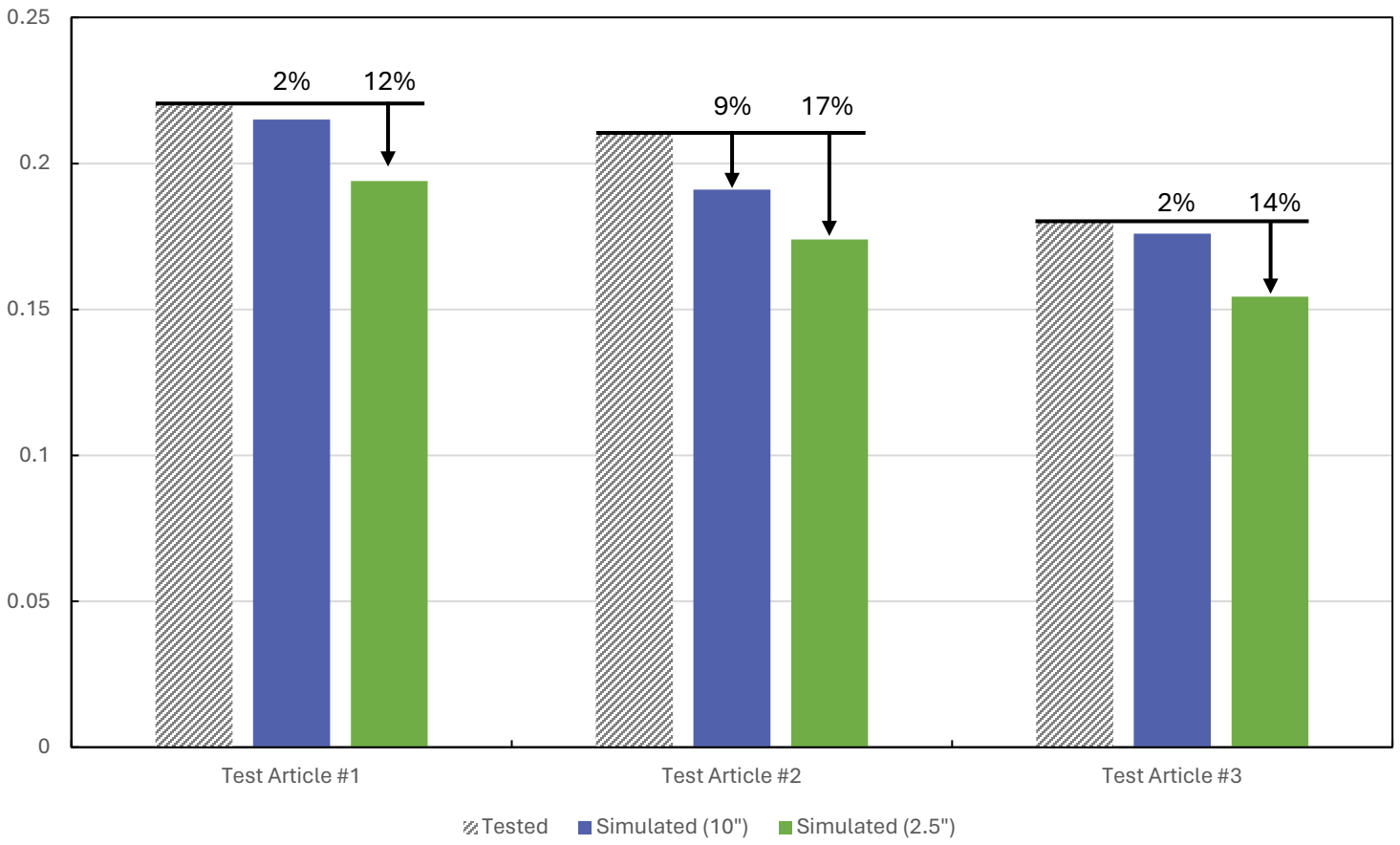




*Figure 8-86. Curtain Wall Modeling Method*

# **NFRC Spandrel Task Group |** Sim. vs. Testing




R-4

R-5

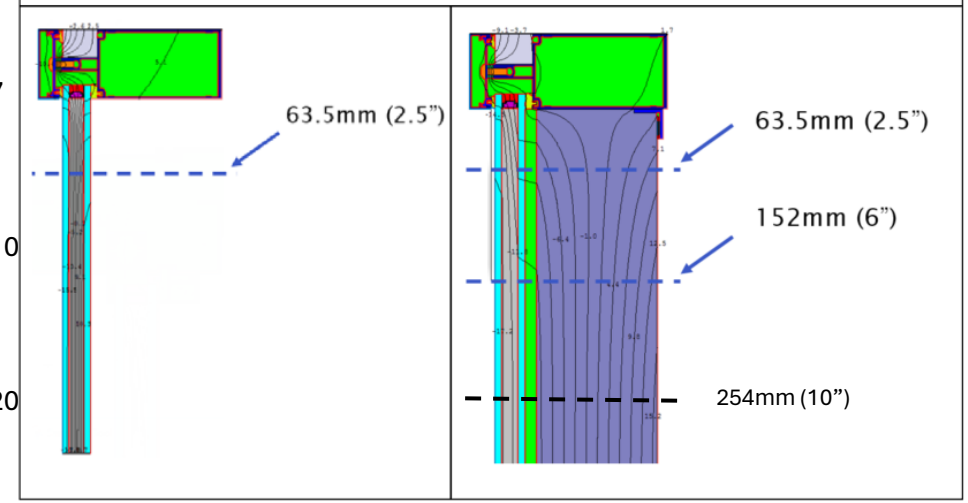
R-7

R-10

R-20

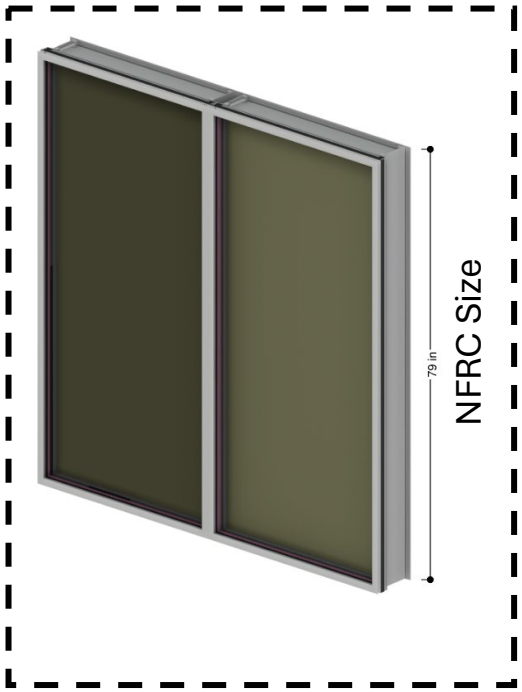
**Figure 2.1: 2D simulations of a typical double glazed curtain wall IGU (left) and spandrel (right).**

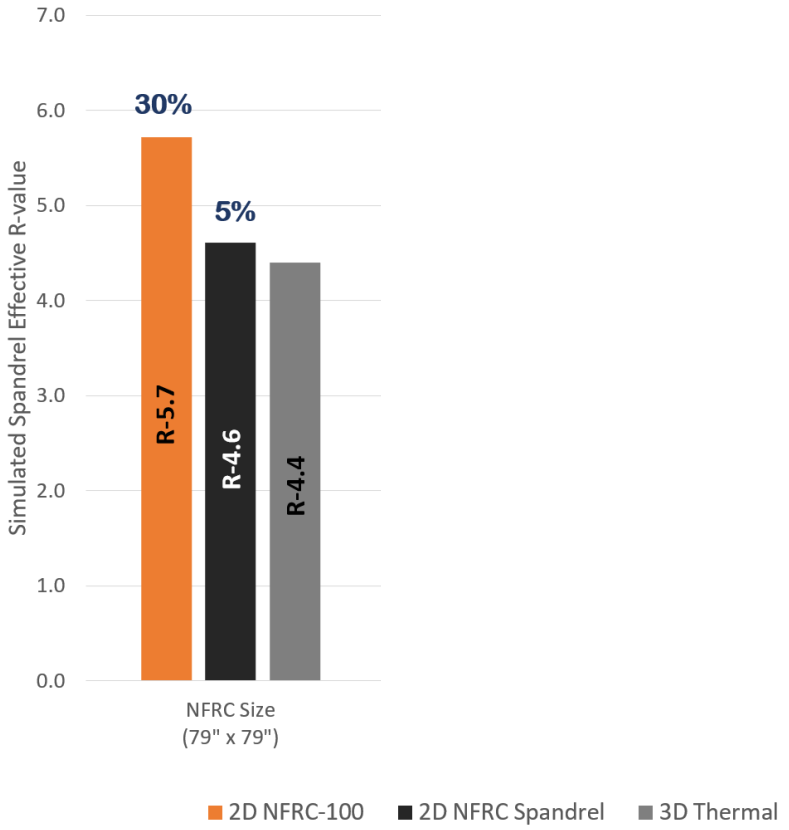
Where the isotherms converge to become parallel the center of glass/panel performance is achieved. For spandrels, similar to the simulation shown, this condition often occurs at a greater edge distance than is specified for glass infill.



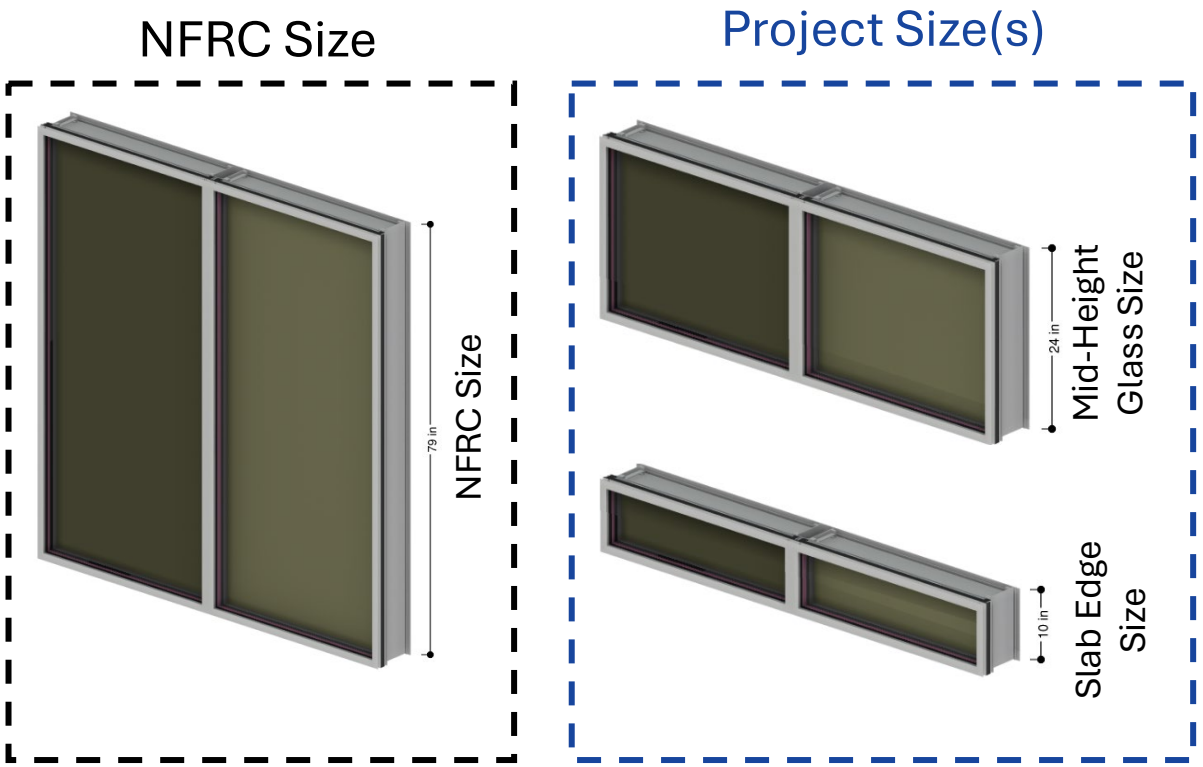
# Uncertain Thermal Performance

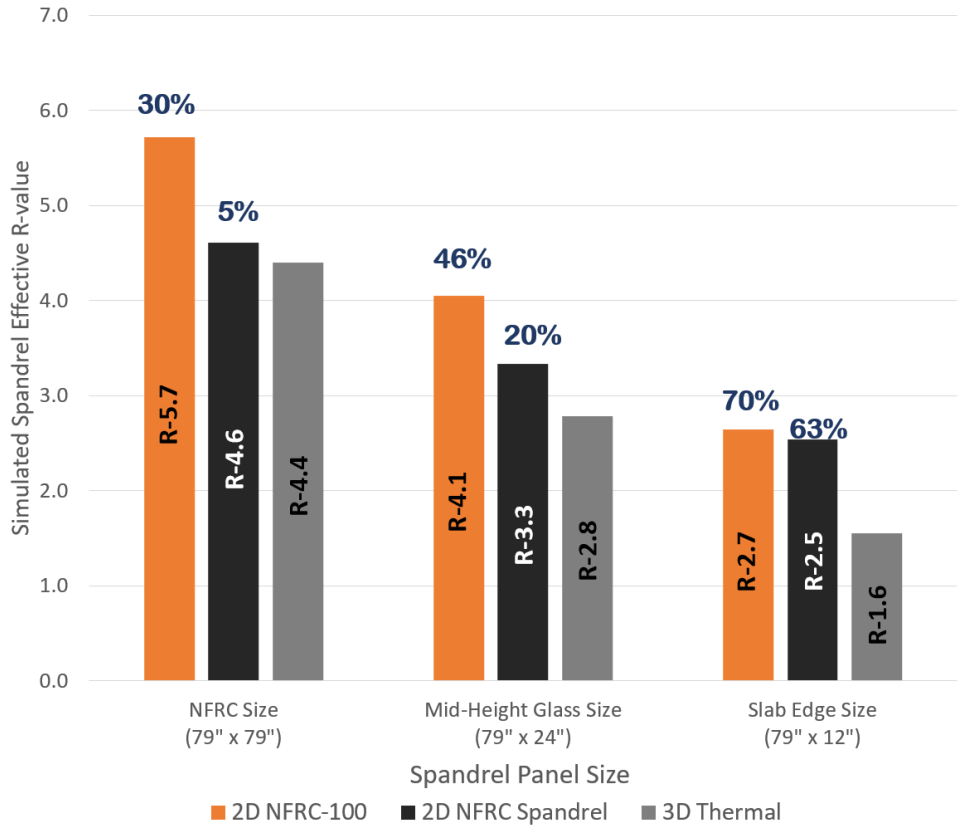
NFRC Size



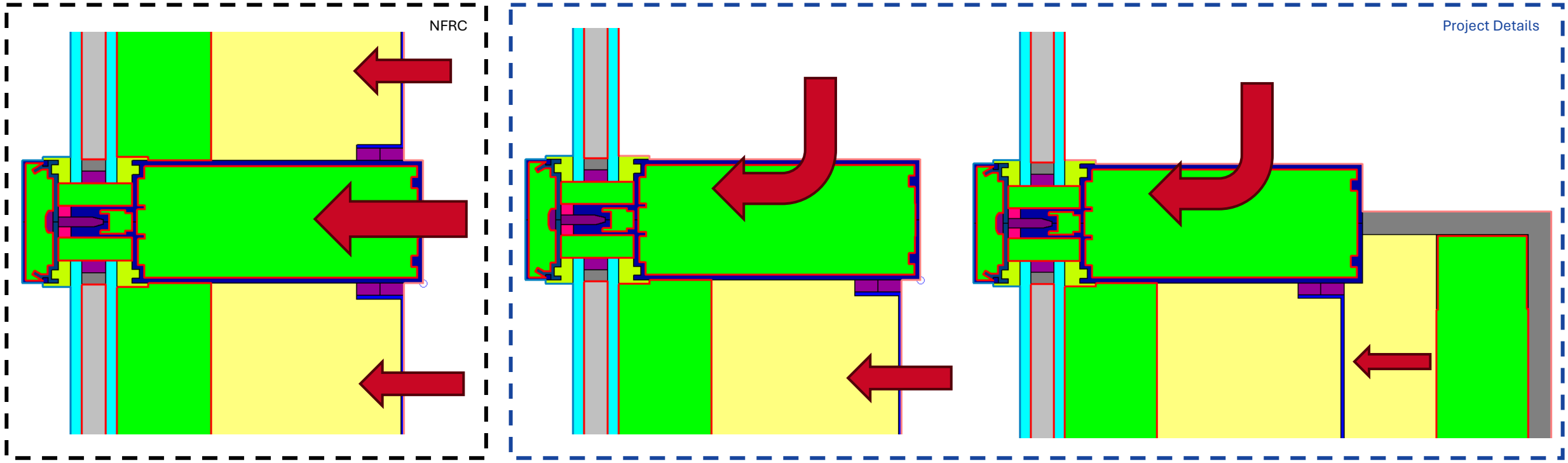
# Uncertain Thermal Performance




Thermal performance is dependent on size similar to fenestration (windows and doors)

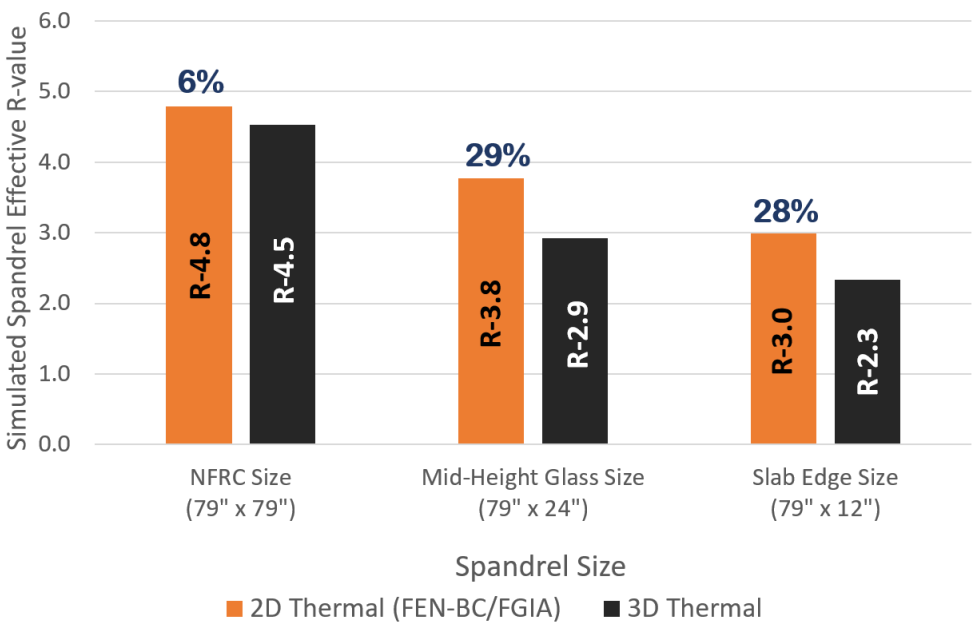
# Impact of Adjacent Assemblies

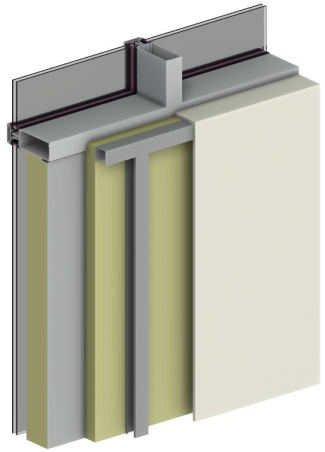



Adjacent assemblies may impact spandrel heat flow

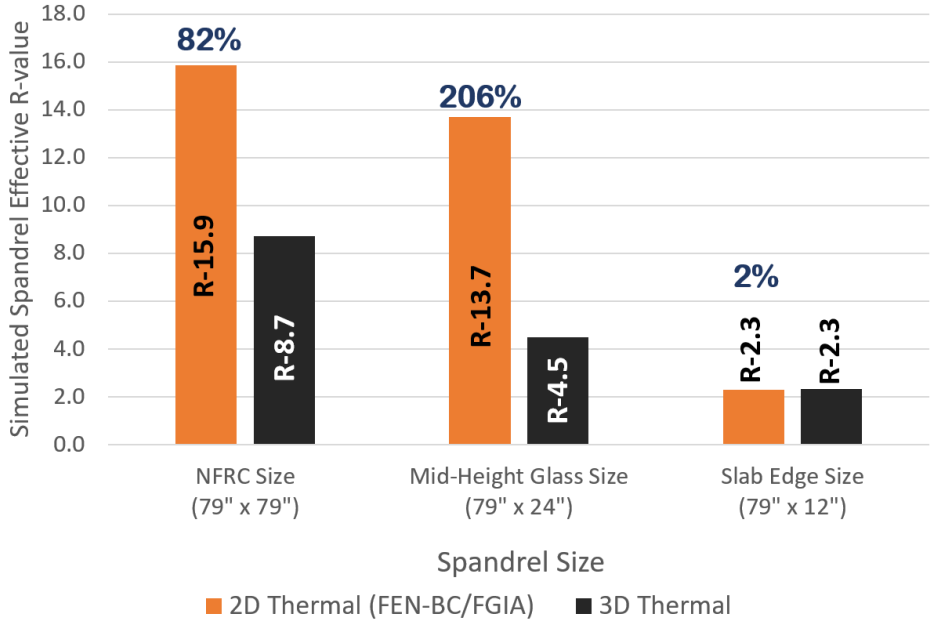
# Spandrel Thermal Performance Adjacent to Glazing

Spandrel with R-16.8 insulation adjacent to double glazed IGU

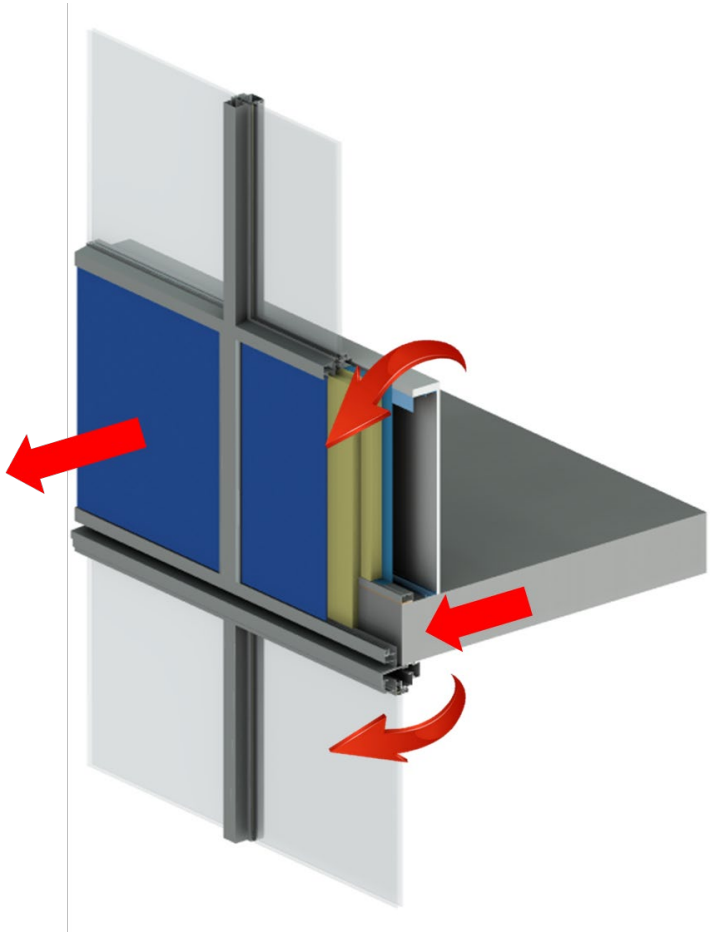


Spandrel with R-16.8 insulation and R-8.4 interior insulation and furring adjacent to double glazed IGU



# Uncertain Thermal Performance

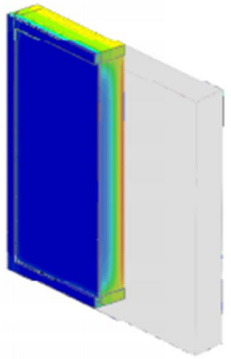


Derated performance due to thermal bridging

Spandrel with R-16.8 insulation

'Actual' **R-6.5!**

Hotbox Lab Measurement



3D Analysis

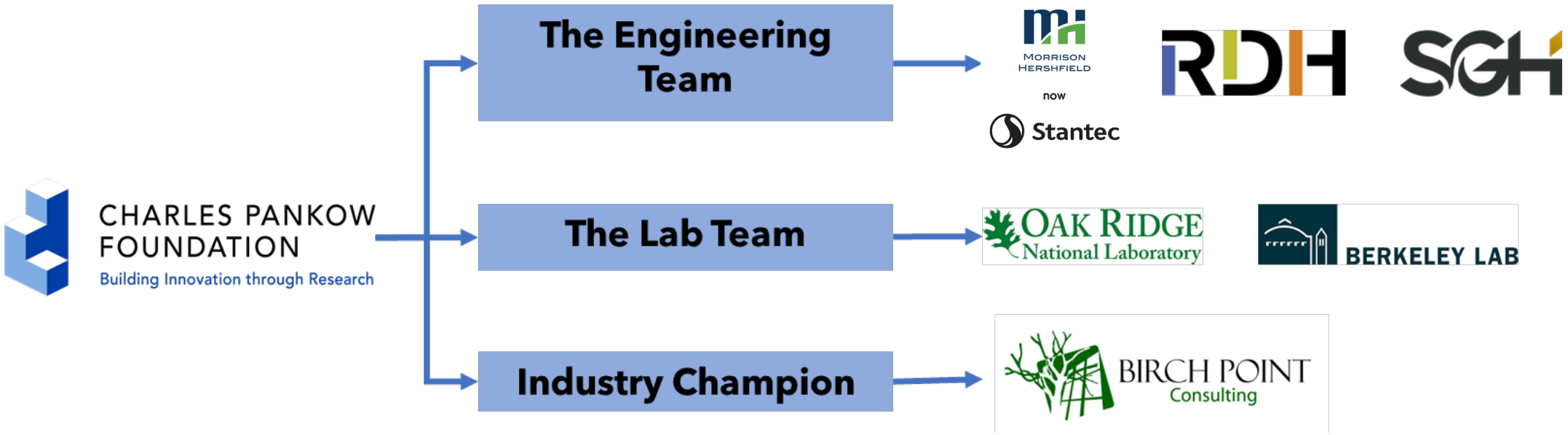
2D Analysis

| Approach | Thermal Transmittance $W/m^2K$ ($BTU/ft^2hr°F$) | Effective R-value $m^2K/W$ ($ft^2hr°F/BTU$) | Percent Difference Compared to Hotbox Measurement |
|---|---|---|---|
| **Hotbox Measurement** | **0.87 (0.153)** | **1.2 (6.5)** | - |
| 3D Analysis | 0.87 (0.153) | 1.2 (6.5) | 0% |
| 2D NFRC-100 | 0.63 (0.111) | 1.6 (9.0) | 32% |
| 2D NFRC Modified | 0.68 (0.120) | 1.5 (8.3) | 24% |

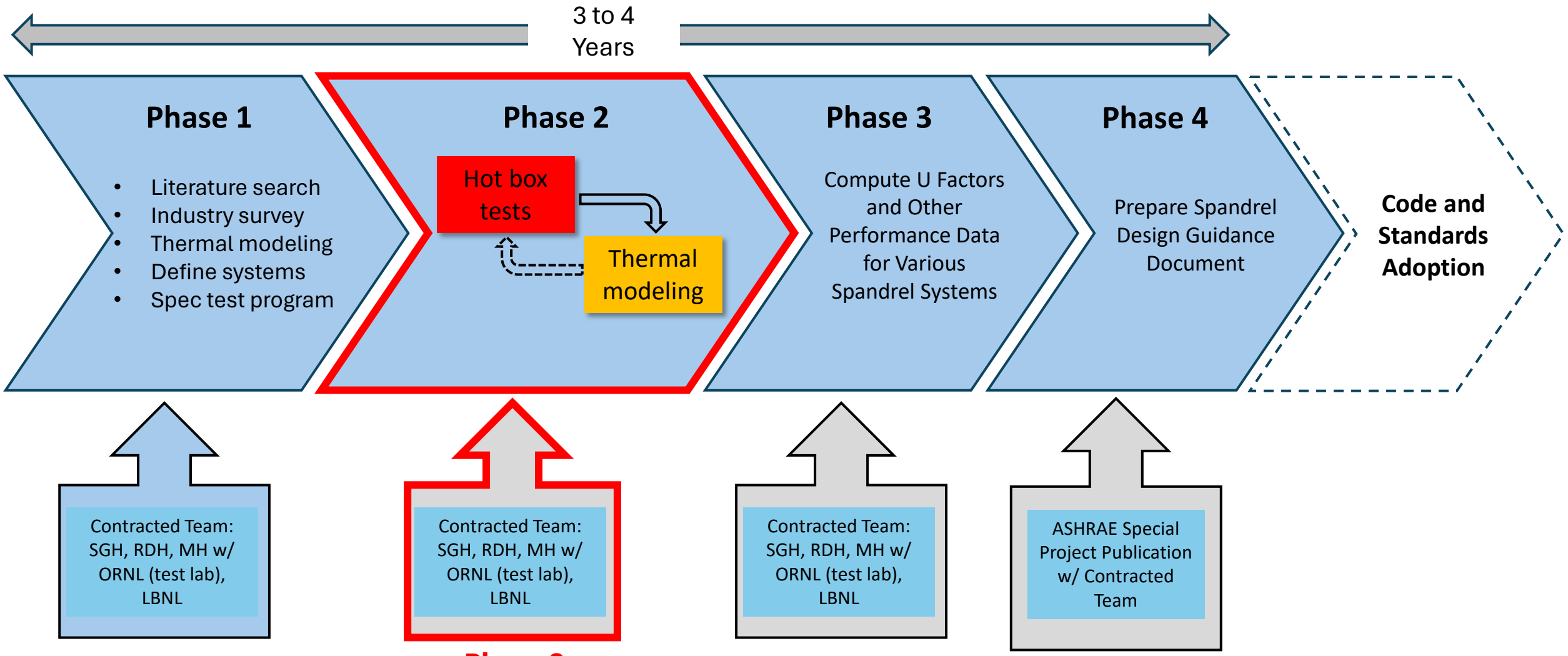
# Research & Testing

Closing the performance gap

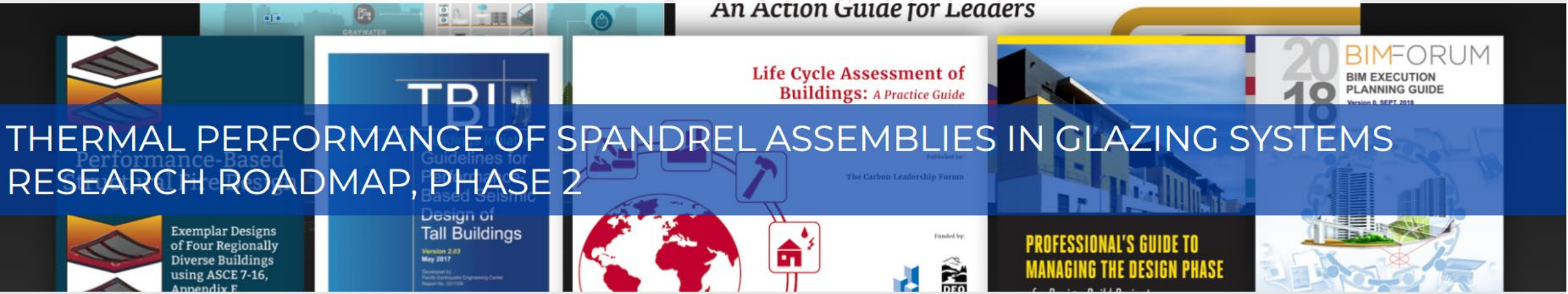
# Thermal Performance of Spandrels



# Research Timeline




**Phase 2**
**Started Summer 2023**




# THERMAL PERFORMANCE OF SPANDREL ASSEMBLIES IN GLAZING SYSTEMS RESEARCH ROADMAP, PHASE 2



## RESOURCES / DOWNLOADS

RGA #04-22 Thermal Performance of Spandrel Assemblies in Glazing Systems Research Roadmap, Phase 1
Phase 1 Report

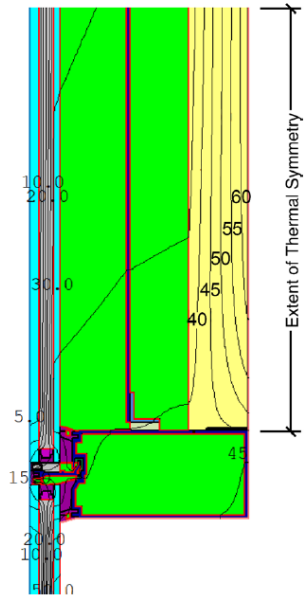
Thermal Performance of Spandrels: Sustainable Development, Leadership, and Investment Opportunities
August 2023 Webinar

Webinar Recording: Thermal Performance of Spandrels
Recording of the webinar presented on Tuesday, 8 August 2023

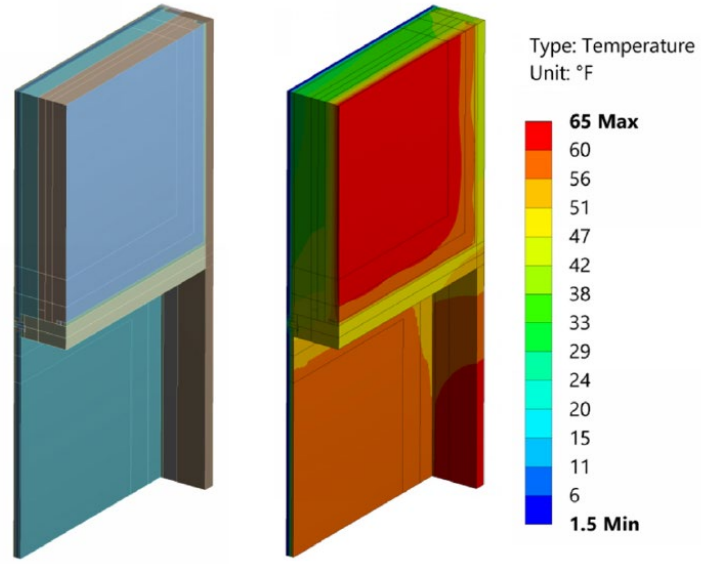
# Close the Knowledge Gap

Physical thermal “hot box” testing
Oak Ridge National Laboratory

2-D modeling

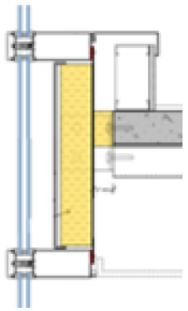
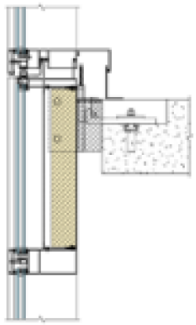
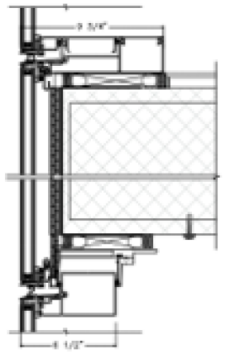
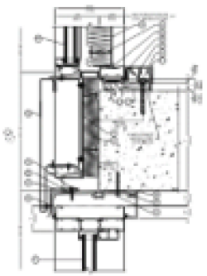
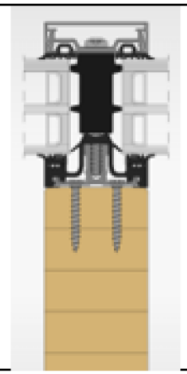
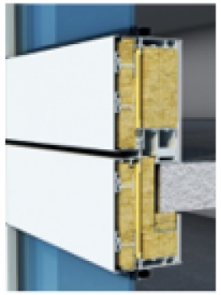



3-D modeling

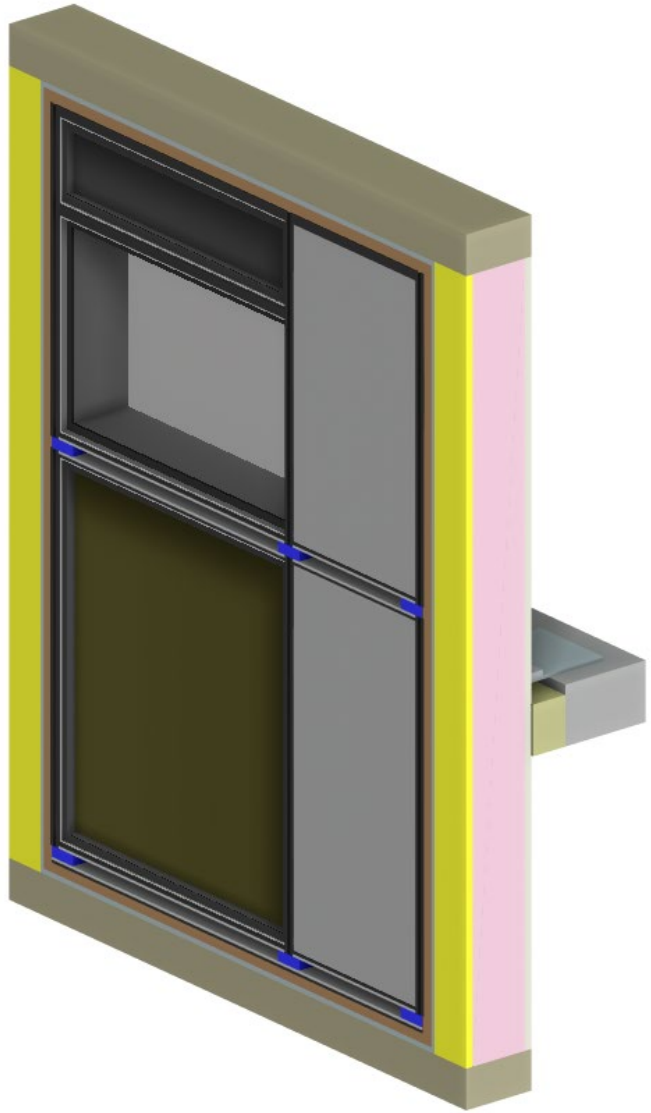



Result: detailed data set on heat flow through various components of spandrel assemblies

# Test Articles

| | | | |
|---|---|---|---|
|  | **Stick-Built Curtain Wall**<br>• Thermally-broken aluminum captured system<br>• Commonly used in industry<br>• Individual components installed on site |  | **Unitized Curtain Wall**<br>• Thermally-broken aluminum structural glazed (SSG) system<br>• Commonly used in industry<br>• Prefabricated panels shipped to and assemblies on site |
|  | **Window Wall (US)**<br>• Thermally-broken aluminum captured system<br>• Supported on slab edge, mullion above and below slab<br>• Greater integration with intermediate floor slab, less space available for insulation leading to greater heat loss |  | **Window Wall (Canadian)**<br>• Thermally-broken aluminum captured system<br>• Significant integration with intermediate floor slab (more than US window wall system)<br>• More space for insulation outboard of slab, but still high heat loss |
|  | **Veneer System**<br>• Captured system with wood or steel mullions<br>• Alternative to typical curtain wall systems with potentially less heat loss<br>• Individual components installed on site |  | **Nex Generation High Performance System**<br>• Industry state of the art high performance systems<br>• Thermally-broken aluminum systems with insulation (R-40+) |

Test Article #1



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# Thank You!