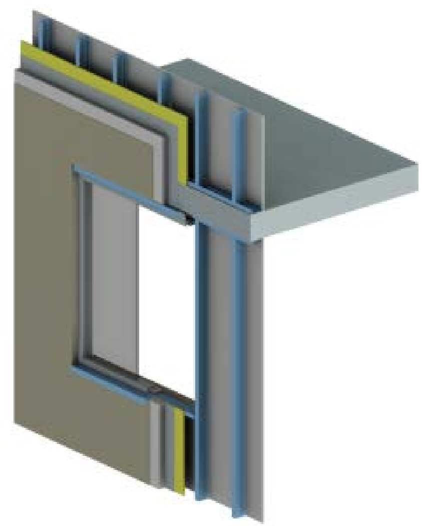
MORRISON HERSHFIELD

REPORT

Thermal and Whole Building Energy Performance of Exterior Insulated Finishing Systems Assemblies



Presented to:

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TABLE OF CONTENTS

1. BACKGROUND

Morrison Hershfield Ltd. (MH) was retained by the EIFS Council of Canada (EIFS Council) to evaluate the thermal and energy performance of EIFS details and systems from a component and whole building energy use perspective and the cost benefit of minimizing thermal bridging. The objective of this study is to provide direct comparisons between generic EIFS systems to other common wall assemblies that are part of the Building Envelope Thermal Bridging Guide (Thermal Bridging Guide) and leverage this larger body of work[1]. This report summarizes the findings specific to EIFS. Detailed explanation of the methodology of the thermal and cost benefit analysis can be found in the Thermal Bridging Guide.

Section 2 summarizes the thermal analysis of the evaluated EIFS wall assemblies and details. The EIFS assemblies included EPS insulation with a 6 mm Geometrically Defined Drainage Cavity (GDDC) and 13% open area with adhesive attachment. EIFS assemblies included EIFS with a steel stud and poured-in-place concrete back-up walls. The thermal analysis included analysis of the base (clear field) wall assemblies and at the interface to a concrete floor slab, punched window opening, curtain wall, parapet, and corner.

Section 3 summarizes the significance and insights, specific to EIFS, leading from the cost benefit analysis completed for the Thermal Bridging Guide. Energy savings related to EIFS systems compared to competing assemblies were evaluated for current market conditions in British Columbia, for eight archetype buildings, two glazing ratios and three climate zones. The cost benefit of EIFS systems compared to competing assemblies was evaluated using a simple payback based on the incremental construction costs and energy savings.

2. THERMAL ANALYSIS OF DETAILS

The results of the thermal analysis are presented as U-values or “Effective” R-values for the clear field assemblies and as linear transmittance for the incremental heat flow at interface details. Linear transmittance might be foreign to some readers but the Thermal Bridging Guide provides a detailed explanation of how to use these values and values that should be expected for different types of interface details, such as window transitions, parapets, and floor slabs.

Temperature indices have been provided at locations where condensation may be a concern. The temperatures are presented as a non-dimensional temperature index, which is a ratio between any given inside and outside temperature difference. This is further explained in Appendix A.

Model images including dimensions and a list of material properties are shown in datasheets in Appendix B for each scenario. The complete set of results including U-values, R-values and temperature profiles are shown in Appendix C.

[1] Morrison Hershfield Ltd, “Building Envelope Thermal Bridging Guide”, 2014. Available for download at morrisonhershfield.com

Highlights of the thermal analysis follow. Comparisons of the EIFS values to competing assemblies with regards to energy use and construction costs are covered in section 3.

2.1 Clear Wall Assembly

Three clear wall assemblies were evaluated for various thicknesses of EIFS; a fully exterior insulated steel stud assembly, a split insulated steel stud assembly, and an exterior insulated concrete wall assembly. Figures 1 and 2 show a fully exterior insulated steel stud wall and an exterior insulated poured-in-place concrete wall assembly. Table 1 summarizes the clear wall U-values and effective R-values of the three clear wall assemblies. The exterior insulated EIFS systems are very efficient because there is essentially no thermal bridging and the insulation is continuous. More insulation levels were evaluated as part of this study and the results can be found in Appendix C.

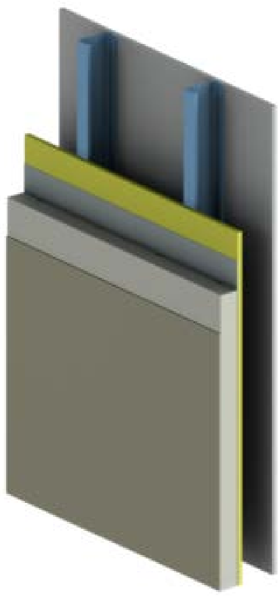


Figure 1: Exterior Insulated EIFS Steel Stud Clear Wall Assembly

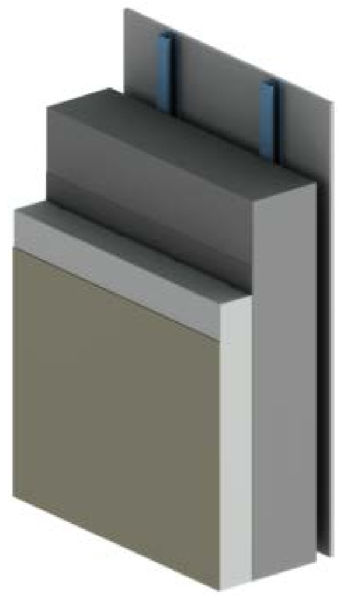


Figure 2: EIFS Concrete Clear Wall Assembly

Table 1: Clear Wall U-values of Fully Exterior and Split Insulation EIFS Assemblies

Assembly Type	Exterior Insulation Nominal R-Value hr.ft^2.°F/BTU (m^{2}K/W)	Nominal Assembly R-Value (R-1D) hr.ft^2.°F/BTU (m^{2}K/W)	Assembly U-Value BTU/hr.ft^2.°F (W/m^{2}K)	Effective R-Value hr.ft^2.°F/BTU (m^{2}K/W)
Steel Stud wall with EIFS Exterior Insulation	R-15 (2.64)	R-17.7 (3.12)	0.057 (0.33)	R-17.4 (3.06)
Steel Stud with EIFS and R-12 batt insulation in stud cavity	R-7.5 (1.32)	R-21.7 (3.83)	0.060 (0.34)	R-16.6 (2.93)
Steel Stud with EIFS and R-12 batt insulation in stud cavity	R-15 (2.64)	R-29.2 (5.15)	0.042 (0.24)	R-24.0 (4.23)
Pour-in-place concrete wall with EIFS	R-15 (2.64)	R-18.0 (3.17)	0.057 (0.32)	R-17.6 (3.10)

2.2 Floor Slab Interface

Floor slab interface details were evaluated for the three wall assemblies. Examples of the floor slab intersection are shown in Figures 3 and 4. Table 2 summarizes the results. EIFS is particularly effective at reducing the heat floor at slab interfaces compared to other types of assemblies because the insulation is not interrupted by the floor slab. Accordingly, the linear transmittances are very small for the EIFS assemblies.

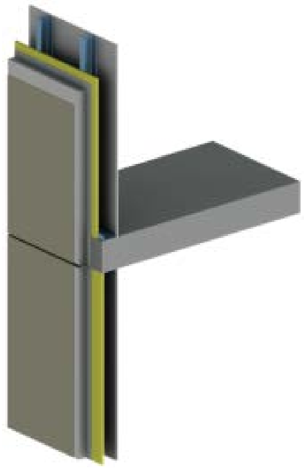


Figure 3: Fully Exterior Insulated EIFS Steel Stud Floor Slab Intersection

Figure 4: EIFS Concrete Wall Floor Slab Intersection

Table2: Linear Transmittance of Floor Slab Interface Details

Assembly Type	Exterior Insulation Nominal R-Value hr.ft^2.^{o}F/BTU (m^{2}K/W)	Linear Transmittance BTU/ft.hr.^{o}F (W/mK)
Steel Stud wall with EIFS	R-15 (2.64)	0.012 (0.022)
Steel Stud with EIFS and R-12 batt insulation in stud cavity	R-7.5 (1.32)	0.076 (0.132)
Pour-in-place concrete wall with EIFS	R-15 (2.64)	0.013 (0.023)

2.3 Curtain Wall Transition

For the curtain wall interface detail, the glazing system is on the Kawneer 1600 series with double glazed IGU and warm-edge spacer. The double glazed IGU centre-of-glass U-value is U-0.32 (USI 1.82). Images of the curtain wall to wall transition detail are shown in Figures 5 and 6. The curtain wall transition was simulated with and without insulation adjacent to the curtain wall jamb as shown in Figures 7 and 8. Linear transmittance values are summarized in Table 3.

The linear transmittances at the curtain wall interfaces are generally low to moderate for the EIFS interface details. There is potential to improve performance by insulating between the curtain wall frame and the back-up wall.

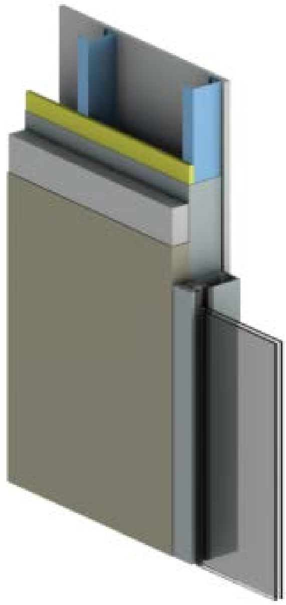


Figure 5: Fully Exterior Insulated EIFS Steel Stud Wall to Curtain Wall Transition

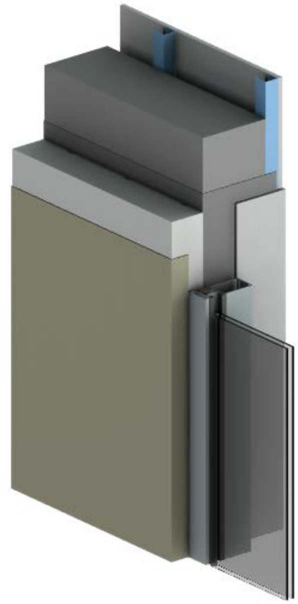


Figure 6: EIFS Concrete Wall to Curtain Wall Transition

Figure 7: Curtain Wall Transition without Insulation between the Frame and Back-up Wall

Figure 8: Curtain Wall Transition with Insulation

Table 3: Linear Transmittance of Curtain Wall Interface

Assembly Type	Exterior Insulation Nominal R-Value hr.ft^2.°F/BTU (m^{2}K/W)	Linear Transmittance BTU/ft.hr.°F (W/mK)	
		without insulation	with insulation
Steel Stud wall with EIFS	R-15 (2.64)	0.051 (0.088)	0.023 (0.041)
Steel Stud with EIFS and R-12 batt insulation in stud cavity	R-7.5 (1.32)	0.043 (0.074)	0.026 (0.044)
Pour-in-place concrete wall with EIFS	R-15 (2.64)	0.059 (0.103)	0.035 (0.060)

2.4 Punched Windows

The interface between a thermally broken aluminum framed window and a punched EIFS wall opening was evaluated for the three wall assemblies. The window is based on Starline 9000 series window, with a double glazed IGU and warm-edge spacer. The double glazed IGU centre-of-glass U-value is U-0.32 (USI 1.82). Images of the curtain wall to wall transition detail are shown in Figures 9 and 10.

Linear transmittance values for the details are summarized in Table 4. The linear transmittance values for common window installation are moderately high for the EIFS window interface details. This is because the thermal break of the window is typically not well aligned with the thermal insulation, which allows for heat to easily flow around the thermal break of the window. The extra heat flow associated with the window interface can be significantly reduced by aligning the thermal break of the window with the thermal insulation, providing a thermal break, or by bringing insulation into the opening. This concept is illustrated below for a window sill detail for both steel stud assemblies.

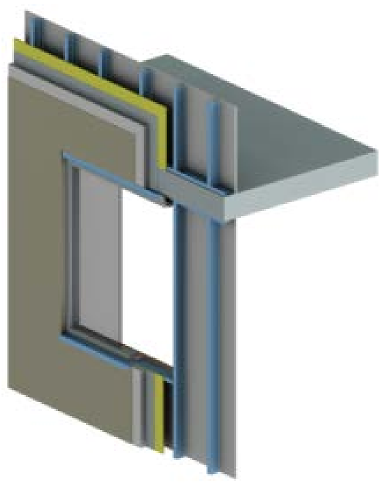


Figure 9: Exterior Insulated EIFS Steel Stud Punched Window Detail

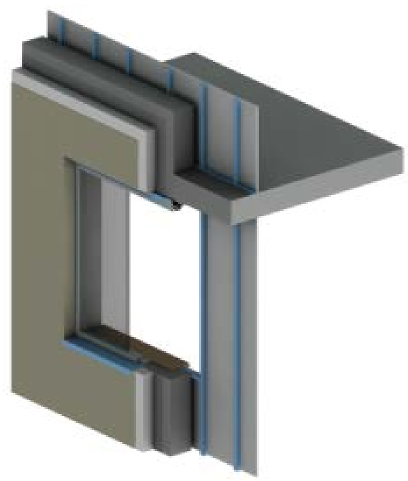
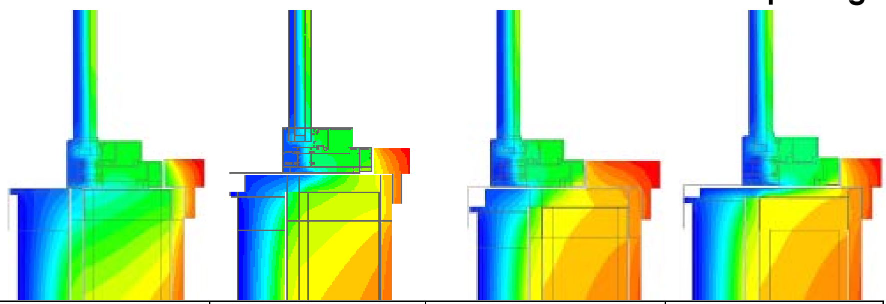


Figure 10: EIFS Concrete Wall Punched Window Detail

Table 4: Linear Transmittance of Punched Window Transition Detail of Fully Exterior Insulated and Split Insulated EIFS Assemblies

Assembly Type	**Exterior Insulation Nominal R-Value** hr.ft^2.°F/BTU (m^{2}K/W)	**Linear Transmittance** BTU/ft.hr.°F (W/mK)
Steel Stud wall with EIFS	R-15 (2.64)	0.187 (0.324)
Steel Stud with EIFS and R-12 batt insulation in stud cavity	R-7.5 (1.32)	0.136 (0.236)
Pour-in-place concrete wall with EIFS	R-15 (2.64)	0.106 (0.184)

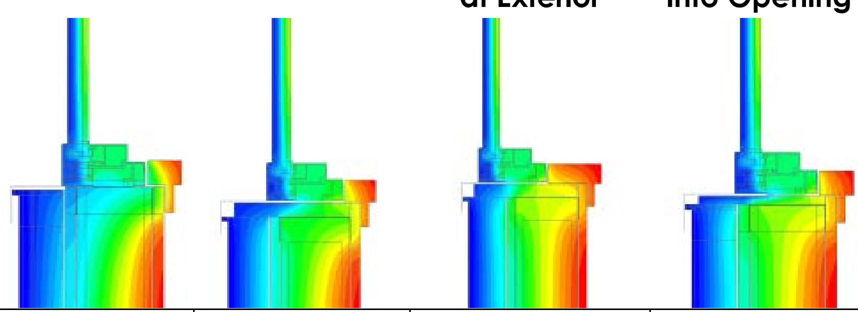
The following example highlights the relative impact of introducing a wood liner, moving the window position, and insulating the window opening for an aluminum framed window in a punched steel stud opening with exterior insulation for only a sill condition.



	Base Case	**Plywood Liner**	**Plywood Liner with Window at Exterior**	**R-4 Insulation Wrapped into Opening**
Linear Transmittance (W/m K)	0.41	0.24	0.21	0.21
Glass Temperature Index at Edge (-)	0.465	0.464	0.460	0.456
Frame Temperature Index (-)	0.503	0.505	0.499	0.485

When comparing the base case to the R-4 Insulation wrapped into the opening, **for the entire window interface**, the linear transmittances are 0.32 and 0.19 respectively. This difference can translate to a notable impact on energy consumption, which is discussed in section 3.

Interestingly, the linear transmittances for the same interface details, but with R-12 batt insulation in the stud cavity, are less. The difference is explained by the fact that the insulation in the stud cavity provides resistance to heat flow resulting in less thermal flanking at the interface for poorly positioned windows. Nevertheless, significant improvements can still be made for split insulated assemblies as summarized below.



	Base Case	**Plywood Liner**	**Plywood Liner with Window at Exterior**	**R-4 Insulation Wrapped into Opening**
Linear Transmittance (W/m K)	0.23	0.11	0.10	0.09
Glass Temperature Index at Edge (-)	0.465	0.457	0.456	0.453
Frame Temperature Index (-)	0.503	0.492	0.491	0.490

2.5 Parapets

All of the parapet interface details included an eight inch thick pour-in-place concrete parapet and roof deck with R-20 exterior roof insulation. The base parapets were evaluated with only one inch of insulation (R-5) on the inside face of the parapet. A best practice detail was also evaluated where the parapet was fully insulated to the same levels as the wall assembly. Configurations of the partially and fully insulated parapets are shown in Figures 11 and 12. Linear transmittance values are summarized in Table 5. Fully insulating the parapet reduces the linear transmittance by as much as 45%.

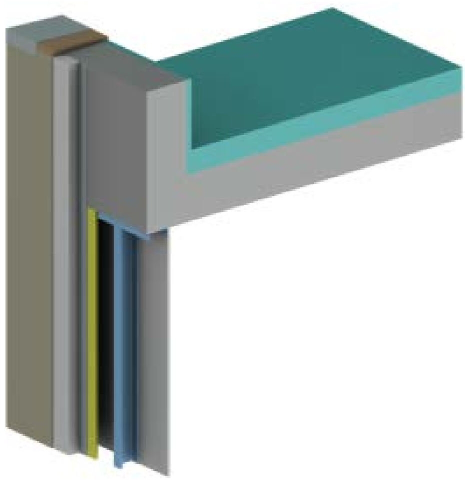


Figure 11: Under-Insulated Parapet

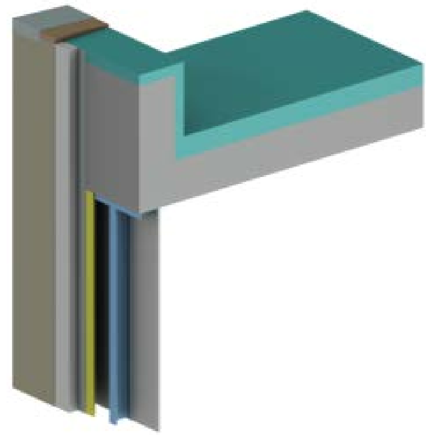


Figure 12: Fully Insulated Parapet

Table 5: Linear Transmittance of Parapet Detail of Fully Exterior Insulated and Split Insulated EIFS Assemblies

Assembly Type	Exterior Insulation Nominal R-Value hr.ft².°F/BTU (m²K/W)	Linear Transmittance BTU/ft.hr.°F (W/mK)	
		Under-Insulated	Fully Insulated
Steel Stud wall with EIFS	R-15 (2.64)	0.263 (0.456)	0.138 (0.238)
Steel Stud with EIFS and R-12 batt insulation in stud cavity	R-7.5 (1.32)	0.297 (0.514)	0.225 (0.390)
Pour-in-place concrete wall with EIFS	R-15 (2.64)	0.231 (0.400)	0.125 (0.217)

2.6 Outside Corners

Outside corner configurations are shown in Figures 13 and 14 with results presented in Table 6. Similar to floor slab intersections, EIFS is particularly effective at reducing the linear transmittance of outside corners when compared to other assembly types since it is able to provide continuous insulation without interruptions. Accordingly, the linear transmittance values are low.

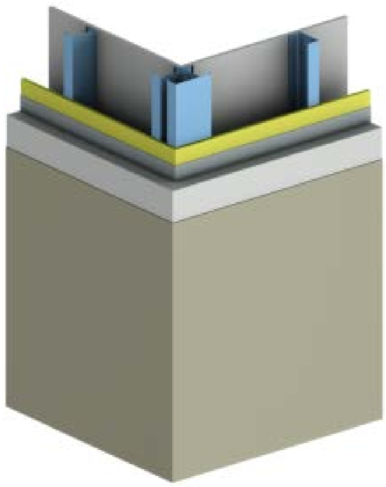


Figure 13: Outside Corner for Steel Stud Wall

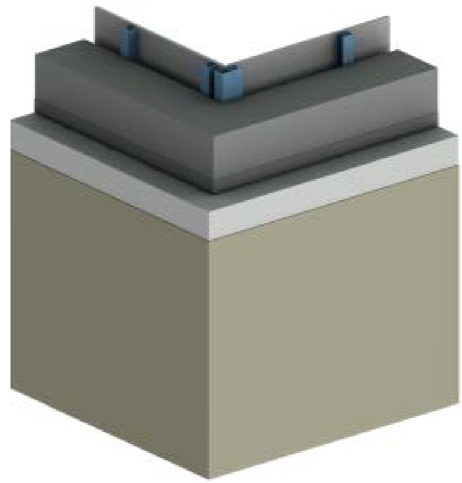


Figure 14: Outside Corner for Concrete Wall

Table 6: Linear Transmittance of Outside Corner Transition with Fully Exterior Insulated and Split Insulated EIFS Assemblies

Assembly Type	Exterior Insulation Nominal R-Value hr.ft².°F/BTU (m²K/W)	Linear Transmittance BTU/ft.hr.°F (W/mK)
Steel Stud wall with EIFS	R-15 (2.64)	0.044 (0.076)
Steel Stud with EIFS and R-12 batt insulation in stud cavity	R-7.5 (1.32)	0.039 (0.067)
Pour-in-place concrete wall with EIFS	R-15 (2.64)	0.085 (0.147)

2.7 EIFS Interface Details Compared to other Details

The following tables show how the EIFS interface details evaluated for this study compare to the range of expected values for the same type of interface detail.

Table 7: Expected Range of Transmittances for Floor and Balcony Slabs

	Performance Category		Description and Examples	Linear Transmittance Btu / hr ft F	Linear Transmittance W / m K
FLOOR AND BALCONY SLABS		Efficient	**Fully insulated with only small conductive bypasses** Examples: exterior insulated wall and floor slab. **The EIFS floor slab details are in this category.**	0.12	0.2
		Improved	**Thermally broken and intermittent structural connections** Examples: structural thermal breaks, stand-off shelf angles.	0.20	0.35
		Regular	**Under-insulated and continuous structural connections** Examples: partially insulated floor (i.e. firestop), shelf angles attached directly to the floor slab.	0.29	0.5
		Poor	**Un-insulated and major conductive bypasses** Examples: un-insulated balconies and exposed floor slabs.	0.58	1.0

Table 8: Expected Range of Transmittances for Glazing Transitions

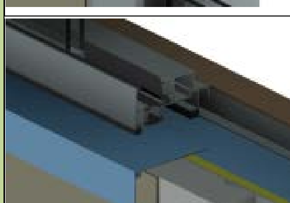
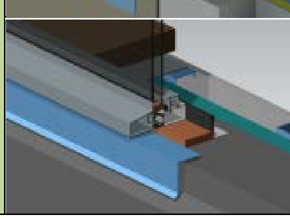
	Performance Category		Description and Examples	Linear Transmittance Btu / hr ft F	Linear Transmittance W / m K
GLAZING TRANSITIONS		Efficient	**Well aligned glazing without conductive bypasses** Example: wall insulation is aligned with the glazing thermal break. Flashing does not bypass the thermal break. **The EIFS interface with the curtain wall is in this category.**	0.12	0.2
		Regular	**Misaligned glazing and minor conductive bypasses** Examples: wall insulation is not continuous to thermal break. **The EIFS punched window details, without improvements, are in this category.**	0.20	0.35
		Poor	**Un-insulated and conductive bypasses** Examples: metal closures connected to structural framing. Un-insulated concrete opening (wall insulation ends at edge of opening).	0.29	0.5

Table 9: Expected Range of Transmittances for Parapets

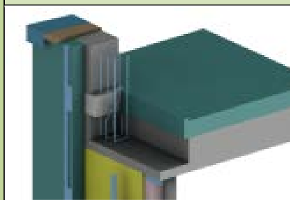
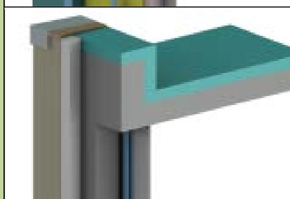
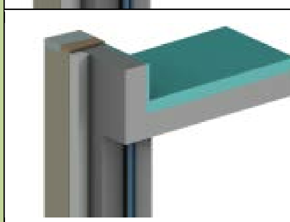
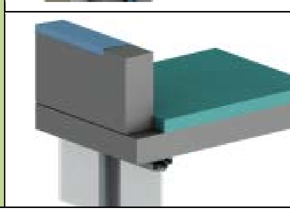
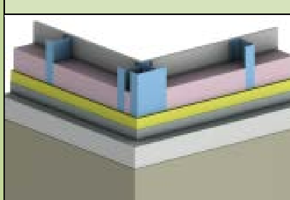
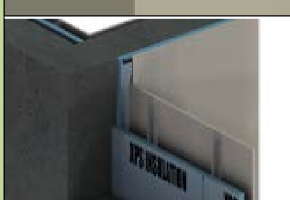
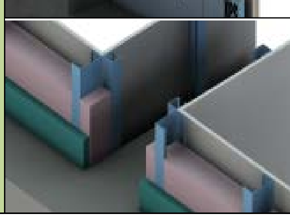
	Performance Category		Description and Examples	Linear Transmittance Btu / hr ft F	Linear Transmittance W / m K
PARAPETS		Efficient	**Roof and Wall Insulation Meet at the Roof Deck** Example: structural thermal break at roof deck, wood-frame parapet.	0.12	0.2
		Improved	**Fully Insulated Parapet** Example: insulation wraps around the parapet to the same insulation level as the roof and wall. **The EIFS parapet details are in this category for full insulation.**	0.17	0.3
		Regular	**Under-insulated Parapets** Examples: concrete parapet is partially insulated (less than roof insulation), insulated steel framed parapet, concrete block parapet. **The EIFS details are in this category for exterior insulated assemblies without full parapet insulation.**	0.26	0.45
		Poor	**Un-insulated and major conductive bypasses** Examples: exposed parapet and roof deck. **The EIFS details are in this category for the steel stud assembly with batt insulation and without full parapet insulation.**	0.46	0.8

Table 10: Expected Range of Transmittances for Parapets

	Performance Category		Description and Examples	Linear Transmittance Btu / hr ft F	Linear Transmittance W / m K
OTHER INTERFACE DETAILS		Efficient	**Minor Thermal Bridging at Miscellaneous Details** Examples: extra framing at corners of steel framed walls, wood-frame to foundation wall interface. **The EIFS corners are in this category.**	0.12	0.2
		Regular	**Moderate Thermal Bridging at Miscellaneous Details** Examples: insulation returns into a concrete shear wall, exterior insulated wall at interface with insulated footing.	0.26	0.45
		Poor	**Major Thermal Bridging at Miscellaneous Details** Examples: un-insulated concrete shear wall, exposed footing at exterior insulated wall with insulation below floor slab.	0.49	0.85

3. ENERGY SAVINGS AND COST BENEFIT

3.1 Overview

We acknowledge and emphasize that this section steps beyond a strict 3rd party evaluation and discussion of EIFS systems. This section discusses the results from our perceived viewpoint of the EIFS industry. The objective of this discussion is to help the EIFS industry focus on the positive messages that follow from the larger body of work that went into the Thermal Bridging Guide.

The energy and cost benefit analysis completed for this study followed the methodology outlined in the Building Envelope Thermal Bridging Guide and is specific to construction and climates in BC. However, the methodology is applicable to any jurisdiction and the findings highlight how EIFS can provide high performance building envelopes and how EIFS naturally excels for minimizing thermal bridging at interface details. Refer to the Thermal Bridging Guide for the background and more detailed explanation of the energy and cost benefit analysis methodology.

The Thermal Bridging Guide includes whole building energy analysis of eight archetype buildings that cover current market conditions in BC. The buildings cover sectors divided by use; commercial office, high-rise multi-unit residential (MURB), hotels, institutional, low-rise multi-unit residential, non-food retail, recreation centre, and secondary school. Each building was evaluated for two glazing ratios, which varied by sector, and three climate zones in BC. The climate zones are: Lower Mainland of BC (Zone 5, cool-marine climate), Interior BC – Okanagan (Zone 5, cool-dry climate), and Northern BC (Zone 7, very cold climate). The buildings included mechanical and lighting systems that represent current market conditions and code minimums.

Energy savings were evaluated for many envelope scenarios using curves for each building scenario where the energy use is expressed as a function of the opaque wall assembly U-value. An example of a curve for a 40% glazed high-rise MURB in Vancouver follows.

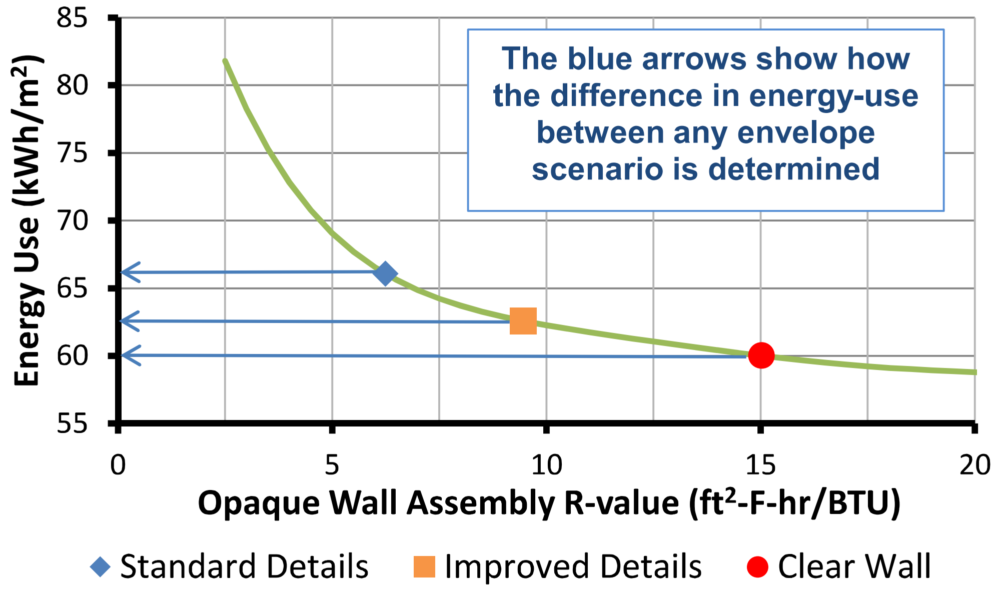


Figure 15. Annual Total Heating Energy for a 40% Glazed High-Rise MURB in Vancouver, Heated with Electric Baseboards

The way to interpret this graph is that there are three wall effective R-value scenarios, each a separate point on the curve:

- The energy-use associated with only the clear wall assembly performance (red circle)
- The energy-use if both the clear wall and interface details are considered for common construction (blue diamond)
- The energy-use if both the clear wall and interface details are considered for improved construction (orange square).

The same graphs and procedures are used to compare the difference between competing assemblies. EIFS naturally has better interface details than other assemblies where thermal bridging is not effectively controlled, such as interior insulated poured-in-place architectural concrete walls. For this case, EIFS would be the scenario with improved details and the architectural concrete wall would be the case with common details. Nevertheless, EIFS is not exempt from thermal bridging and there is still a difference between the clear field thermal performance of an EIFS wall and the performance that includes the impact of details.

This next section highlights the significance and insights with regard to energy savings and benefits of using EIFS.

3.2 Significance and Insights

In the past, EIFS was more commonly installed in BC because EIFS is inexpensive and provides thermally efficient wall assemblies. EIFS systems have evolved since they were first introduced to the market to be more durable yet still offer a cost effective and thermally efficient alternative to other types of types of claddings.

In many respects, EIFS is the only wall assembly that is close to the notion of continuous insulation many in the building industry believe is important. However, even the performance of EIFS is subject to interface details like window flashings, concrete balconies, and discontinuous insulation at-grade. The additional heat flow associated with thermal bridging at interface details can add up to be quite a bit of the total heat flow through a wall assembly. Nevertheless, EIFS systems and improved details can result in significant energy savings. Figure 16 shows how poured-in-place concrete walls with "continuous" insulation in board of the concrete structure compares to true continuous (EIFS) insulation outboard the concrete structure. The sole act of selecting an efficient system improves the performance by approximately 60%. However, there are still more energy savings that can be realized by improving details, such as thermally broken balconies, parapets, and detailing at window interfaces.

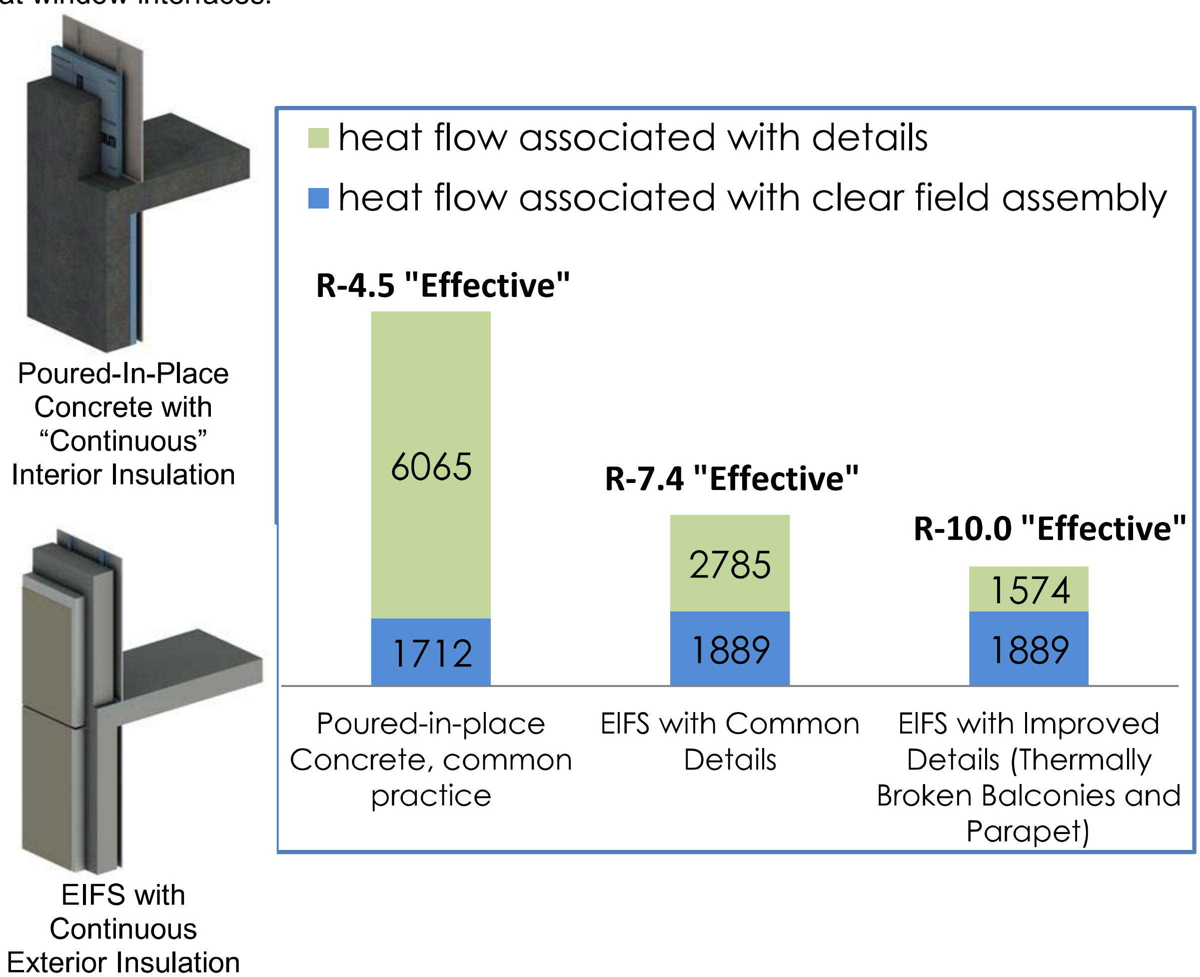


Figure 16. Comparison of Poured-in-place Concrete Walls with "Continuous" Insulation to EIFS Wall Assemblies with Actual Continuous Insulation

In terms of energy savings, the differences are significant because the assemblies are within the "steep" part of the energy curve, shown in Figure 15, where small changes in "effective" R-value translate to significant energy savings. Electricity energy savings of 10 ekW/m^2

were determined for the high-rise MURB with 40% glazing with EIFS on concrete and thermally broken balconies compared to common construction (Scenario 2, Case 2A in Appendix E in the BC Thermal Bridging Guide). However, there is currently no incentive to realize these savings because continuous insulation can be installed inboard of poured-in-place concrete walls and comply with code. Installing insulation inboard of the concrete is made ineffective because it is bypassed by concrete floor slabs. This is an example where current energy codes and standards are dampening the benefits of systems such as EIFS.

The poured-in-place concrete example demonstrates a case where EIFS is actually more expensive than common practice. There is room for debate whether this type of construction would be common practice for concrete construction in BC if energy code and standards effectively addressed thermal bridging, but what is clear is that changes would make this type of construction more expensive. This example highlights the need for industry to move past the idea that the only thing a designer or authority having jurisdiction needs to think about and check is how much insulation is provided, if consistent outcomes will be realized for large buildings. This is largely an issue with ASHRAE 90.1 -2010 and not NECB 2011. NECB 2011 has already moved beyond this line of thinking and is based exclusively on effective U-values. Even if “continuous” insulation, insulation that is only interrupted by service openings, existed in practice, such as EIFS without flashing, then parapets and balcony slabs would have to be wrapped with insulation. This is possible for exterior insulated steel stud assemblies, but this is not reality for interior insulated poured-in-place architectural concrete walls that are ubiquitous in BC construction. This is not a reality because floor slabs bypass the thermal insulation for this type of construction, and actual continuous insulation cannot be achieved. Despite the intent of the continuous insulation concept, to make it simple and not require calculations, this approach has created confusion in industry and enforcement challenges.

EIFS is very cost effective compared to other exterior insulated walls and the cost to improve the interface details is often less than the cost difference between competing assemblies. This means that a truly effective building envelope can be provided, with “expensive” technology, less than the costs for common wall assemblies BC without effectively addressing thermal bridging. Table 11 demonstrates this concept by comparing the costs and performance of two exterior insulated steel stud assemblies, metal panel and EIFS. The EIFS assembly has slightly better performance than the metal panel assembly for the same level of exterior insulation (R-15) for this example, but costs less. The difference in cost between the assemblies is far more than the cost to provide thermally broken balconies and parapets.

Table 11: Cost and Performance Comparison of Two Types of Steel Stud Assemblies

Type of Steel Stud Wall Assembly	Interface Detail Scenario	U-Value (W/m^2K)	Incremental Costs	Energy Cost Savings	Payback
Metal Panel	Common	0.95	-	-	-
	Improved	0.60	$144,576	$10,019	14
EIFS	Common	0.92	$(2,136,608)	$965	0
	Improved	0.51	$ (1,697,075)	$12,453	0

Decisions regarding the selection of assemblies are not just made by architects; entire design teams and owners will need to get onboard to improve practice related to building envelope performance. This circles back to the importance of the codes and standards to set the bar so that industry is on a level playing field.

Regulators and designers are starting to realize that they need to focus on improving glazing performance because glazing U-values are assumed to be so much higher than what is assumed will be provided by the opaque building envelope. Unfortunately, analysis covered by the Thermal Bridging Guide is showing that when interface details are taken into account, the overall U-value of the opaque building envelope may not be that much higher than the vision areas. Also, the opaque areas do not have the potential of providing solar heat gain in the winter or daylighting. Upgrading windows may be important but not at the expense of ignoring the performance of opaque elements.

EIFS with improved details compared to a baseline metal panel steel stud assembly, with common details, relates to energy savings in the similar order of magnitude as the energy savings that can be realized by improving the glazing performance from double to triple glazing for the multi-unit residential building with 40% glazing. Table 12 summarizes the cost and performance comparison of triple glazing for the High-Rise MURB with 40% glazing compared to improving performance with EIFS and improved detailing.

From a payback perspective, the triple glazing is expensive in comparison to the EIFS scenarios. Addressing the interface details and improving the glazing together have the potential to make the biggest reductions in heating energy use. The fact that there are opaque envelope solutions that provide similar gains in terms of reducing energy consumption, but cost less, should provide more incentive for industry to pay attention to improving the opaque building envelope thermal performance.

Table 12: Cost and Performance Comparison to Triple Glazing for High-rise MURB with 40% Glazing

Wall Assembly	Glazing Assembly	Interface Detail Scenario	U-Value (W/m^2K)	Incremental Costs	Energy Cost Savings	Pay Back
Baseline: R-10 Exterior and R-12 Interior Insulated Steel Stud Assembly	Double Glazing	Common	0.95	-	-	-
R-7.5 EIFS and R-12 Interior Insulated Steel Stud Assembly	Double Glazing	Common	0.92	$(2,136,608)	$965	0
R-15 EIFS Steel Stud Assembly	Double Glazing	Improved	0.51	$(1,697,075)	$12,453	0
R-10 Exterior and R-12 Interior Insulated Steel Stud Assembly	Triple Glazing	Common	0.95	$346,125	$11,678	30
R-15 Exterior Insulated Steel Stud Assembly	Triple Glazing	Improved	0.60	$492,177	$21,053	23

A final important and significant insight of the work completed for the Thermal Bridging Guide related to EIFS assemblies is the importance of detailing around windows to reduce thermal bridging. Section 2.4 highlighted the possible ranges in linear transmittances due to thermal bridging at window interfaces of punched windows. A difference in linear transmittance between the base case and R-4 wrapped into the opening has notable impact on energy consumption.

For example, when comparing the base case to the R-4 Insulation wrapped into the opening, **for the entire window interface**, the linear transmittances are 0.32 and 0.19 respectively. For the high-rise MURB with 40% glazing for the EIFS with improved details scenario (Scenario 1, Case 2A in Appendix E in the BC Thermal Bridging Guide), the difference between these two interface details translates to an “Effective” R-values of 9.1 versus 11.2 and a difference in electricity energy savings of approximately $2,900. This amount of energy savings is more than the difference between the base case with common details, U-value of 0.35 W/m^{2}K (ASHRAE 90.1-2010 prescriptive requirement for zone 5) and an assembly with an additional R-10 exterior insulation or U-value of 0.28 W/m^{2}K (NECB 2011 prescriptive requirement for zone 5).

Figure 17: An example of thermal bridging at the interface between assemblies that is NOT captured by wall schedules (not an issue for EIFS)

The EIFS industry should get onboard and actively promote a holistic approach to dealing with thermal bridging. EIFS has natural advantages, but EIFS systems are not immune from thermal bridging at interface details, such as misaligned windows. Moreover, improvements are easily made to EIFS assemblies in comparison to other types of assemblies. For example, metal panel assemblies do a good job, as well as EIFS, at addressing thermal bridging at floor slabs and parapets. However, metal panel assemblies typically require closures at window interfaces. Metal closures introduce thermal bridging, which is not an issue for EIFS assemblies.

The examples above consistently highlight the performance of EIFS for the 40% glazed multi-unit residential buildings. The same story applies to the other buildings types as well. Figure 18 illustrates the gap between the performances of standard concrete construction with interior insulation to EIFS on concrete for all the 30 to 40% glazing archetype buildings. The difference is significant and there is still room for improvement. For example, the low-rise buildings, such as the non-food retail or recreation centre, have a lot of heat loss associated with the at-grade interface. However, the analysis did not consider improvements to minimize the thermal bridging at this location. This example also did not include other improvements or synergies, such as thermally broken balconies, improved parapet, improved window transitions, and improved spandrel sections.

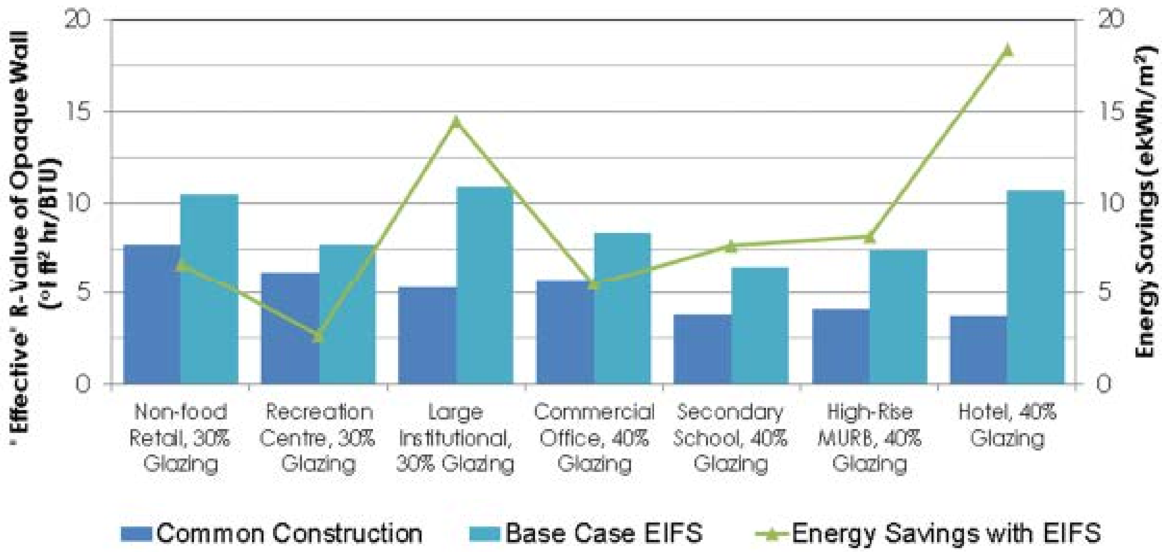


Figure 18. Comparison of Poured-in-place Concrete Walls with "Continuous" Insulation to the Base Case EIFS Wall Assemblies for all the Archetype Buildings for Vancouver (Except Low-rise MURB)

For exterior insulated steel assemblies, EIFS does not have a significant advantage in terms of thermal performance and energy savings because large thermal bridges can be insulated with any exterior insulated assembly. However, there are inherent savings and EIFS is more cost effective than exterior insulated assemblies with cladding. Therefore, the "expensive" costs to improve the overall performance, such as addressing balconies and spandrel sections, can be more than offset by the savings related to a cost effective assembly such as EIFS. This is true for all the building sectors as shown in Figure 19. Again, further improvements are still possible, such as more thermally efficient at-grade transitions.

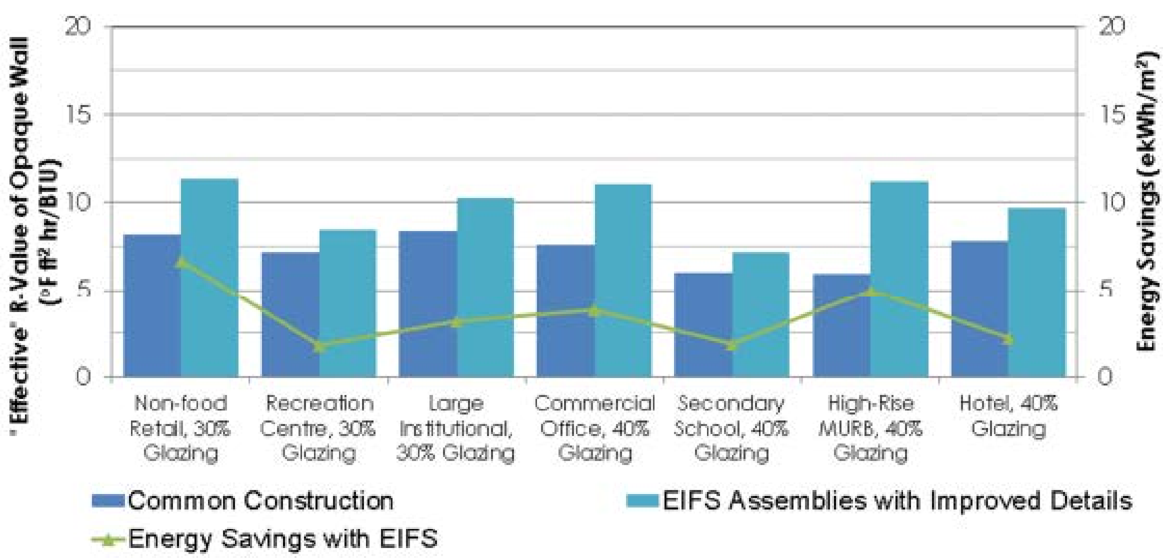


Figure 19. Comparison of Common Exterior Insulated Steel Stud Walls to the EIFS Wall Assemblies with Improved Details for all the Archetype Buildings for Vancouver (Except Low-rise MURB)

4. CONCLUSIONS

This report summarizes the findings specific to EIFS details and systems from a larger body of work focused on minimizing thermal bridging in construction. This work confirms what many in industry already know – EIFS is cost effective and provides thermally efficient wall assemblies. However, this work also highlights some concepts that less talked about:

1. EIFS is not the cost effective choice for poured-in-place concrete construction, but offers significant improvements to performance. This form of construction is very ubiquitous in BC. There is plenty of room for debate, whether current practice would be so ubiquitous if energy standards and codes thoroughly addressed thermal bridging and was strictly enforced in practice.

2. EIFS is the only wall assembly that is close to the notion of continuous insulation many in the building industry believe is important. However, even the performance of EIFS is subject to interface details like window flashings, concrete balconies, and discontinuous insulation at-grade. Improvements can be realized by paying more attention to interface details and better design.

3. For exterior insulated assemblies, EIFS offers a very cost effective solution compared to common practice in BC. The cost difference between competing assemblies more than pays for any extra costs associated with addressing major thermal bridges at balconies and parapets. There might be synergies for EIFS manufacturers to promote holistic approaches that might also rely on other technologies.

In our opinion, EIFS industry should get onboard and actively promote a holistic approach to dealing with thermal bridging, since EIFS has natural advantages that go beyond the notion of continuous of insulation. This report highlights these advantages. The Thermal Bridging Guide provides a deeper conversation as to how industry can effectively deal with thermal bridging and realize energy savings. The Thermal Bridging Guide should be consulted to better assess how EIFS fits into the bigger picture of addressing thermal bridging in construction.

If you have any questions or comments related to the above, please do not hesitate to contact the undersigned.

Yours truly,

Morrison Hershfield Limited

Ivan Lee, M.A.Sc.
Building Science Consultant

Patrick Roppel, P.Eng.
Building Science Specialist

APPENDIX A – THERMAL ANALYSIS METHODOLOGY

A.1 General Modeling Approach

For this report, a steady-state conduction model was used. Air cavities were assumed to have an effective thermal conductivity which includes the effects of cavity convection. Interior/exterior air films were taken from Table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundaments depending on surface orientation. The thermal analysis methodology used in this report was based on the procedures and approach developed in ASHRAE 1365-RP. From the calibration in ASHRAE 1365-RP, contact resistances between materials were modeled. The temperature difference between interior and exterior was modeled as a dimensionless temperature index between 0 and 1 (see Appendix A.3). These values, along with other modeling parameters, are given in ASHRAE 1365-RP, Chapter 5.

A.2 Thermal Transmittance

The methodology presented in ASHRAE 1365-RP separates the thermal performance of assemblies and details in order to simplify heat loss calculations. For the assemblies, a characteristic area is modeled and the heat flow through that area is found. To find the effects of thermal bridges in details (such as slab edges), the assembly is modeled with and without the detail. The difference in heat loss between the two models is then prescribed to that detail. This allows the thermal transmittances to be divided into three categories: clear field, linear and point transmittances.

The clear field transmittance is the heat flow from the wall or roof assembly, including uniformly distributed thermal bridges that are not practical to account for on an individual basis, such as structural framing, brick ties and cladding supports. This is treated the same as in standard practice, defined as a U-value, Uo (heat flow per area). For a specific area of opaque wall, this can be converted into an overall heat flow per temperature difference, Qo.

The linear transmittance is the additional heat flow caused by details that can be defined by a characteristic length, L. This includes slab edges, corners, parapets, and transitions between assemblies. The linear transmittance is a heat flow per length, and is represented by psi (Ψ).

The point transmittance is the heat flow caused by thermal bridges that occur only at single, infrequent locations. This includes building components such as pipe penetrations and intersections between linear details. The point transmittance is a single additive amount of heat, represented by chi (χ).

With these thermal quantities the overall heat flow can be found simple by adding all the components together, as given in equation 1.

$$Q = \Sigma\, Q_{thermalbridge} + Q_o = \Sigma\,(\Psi \cdot L) + \Sigma\,(\chi) + Q_o$$

EQ 1

Equation 1 gives the overall heat flow for a given building size. For energy modeling, or comparisons to standards and codes, often it is more useful to present equation 1 as a heat flow per area. Knowing that the opaque wall area is A_{total}, and $U=Q/At_{otal}$, equation 2 can be derived.

$$U = \frac{\Sigma(\Psi \cdot L) + \Sigma(\chi)}{A_{Total}} + U_o \qquad \text{EQ 2}$$

Since the linear and point transmittances are simply added amounts of heat flow, they can be individually included or excluded depending on design requirements.

A.2 Temperature Index

For condensation concerns, the thermal model can also provide surface temperatures of assembly components to help locate potential areas of risk. In order to be applicable for any climate (varying indoor and outdoor temperatures), the temperatures can been non-dimensionalized into a temperature index, T_i, as shown below in Equation 3.

$$T_i = \frac{T_{surface} - T_{outside}}{T_{inside} - T_{outside}} \qquad \text{EQ 3}$$

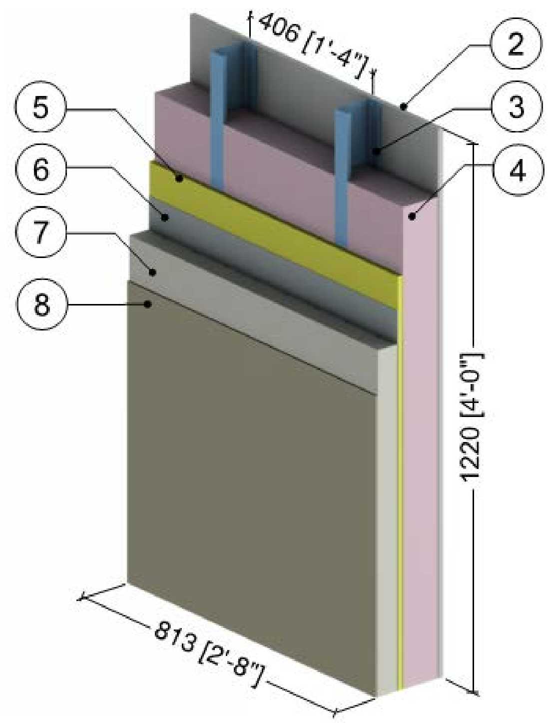
The index is the ratio of the surface temperature relative to the interior and exterior temperatures. The temperature index has a value between 0 and 1, where 0 is the exterior temperature and 1 is the interior temperature. If T_i is known, Equation 3 can be rearranged for $T_{surface}$.

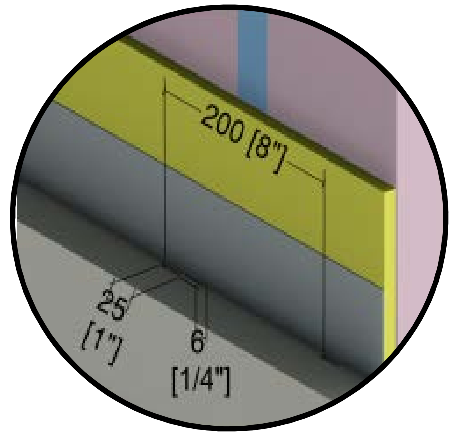
Temperature profiles for the assemblies and details modeled in this report are shown in Appendix C.

APPENDIX B – ASSEMBLY DATASHEETS

Detail 1

Exterior and Interior Insulated 3 5/8” x 1 5/8” Steel Stud (16” o.c.) Drained EIFS Wall Assembly – Clear Wall





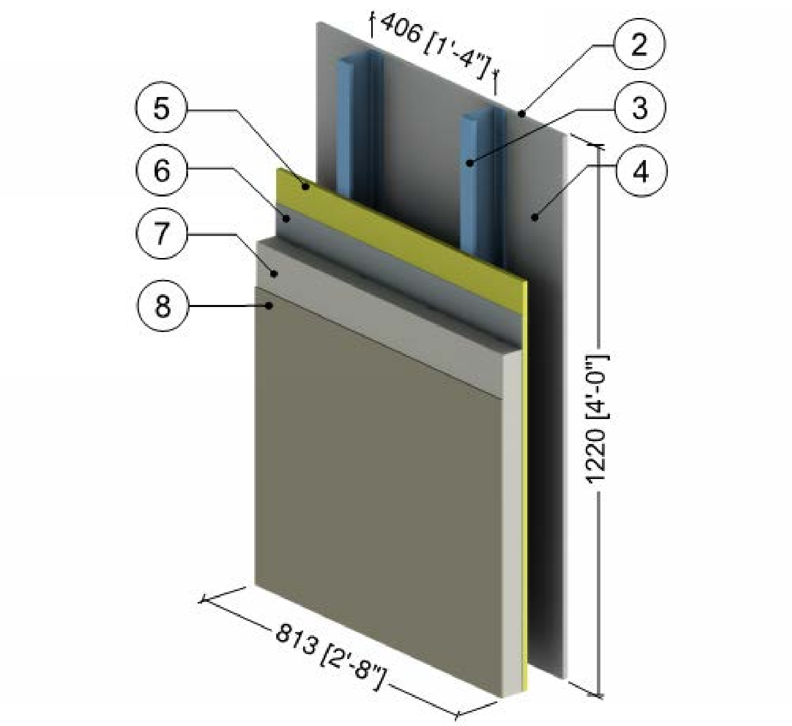
1” (25 mm)
Drained EIFS
Detail

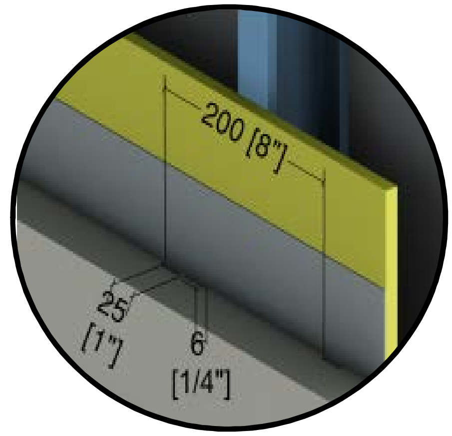
ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	3 5/8” x 1 5/8” Steel Studs (16”o.c.)	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Fiberglass Batt Insulation	3 5/8” (92)	0.29 (0.042)	R-12 (2.1 RSI)	0.9 (1.1)	0.17 (710)
5	Exterior Sheathing	1/2” (13)	1.1 (0.16)	R-0.5 (0.09 RSI)	50 (800)	0.26 (1090)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	2” (50) to 4” (100)	0.27 (0.039)	R-7.5 (1.32 RSI) to R-15 (2.64 RSI)	1 (16)	0.35 (1470)
8	Lamina	1/8” (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail 1a

Exterior Insulated 3 5/8” x 1 5/8” Steel Stud (16” o.c.) Drained EIFS Wall Assembly – Clear Wall





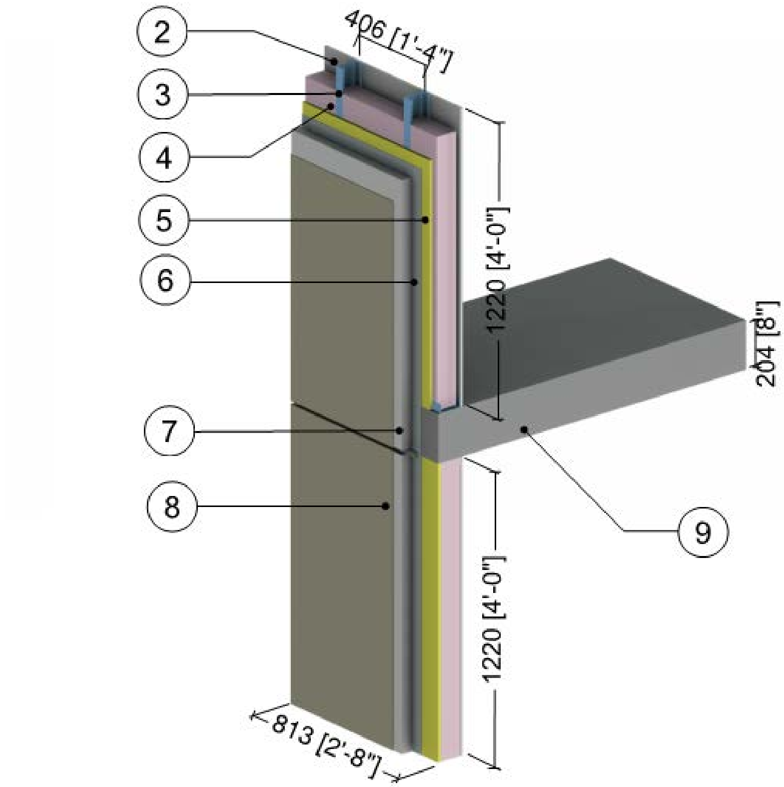
1” (25 mm)
Drained EIFS
Detail

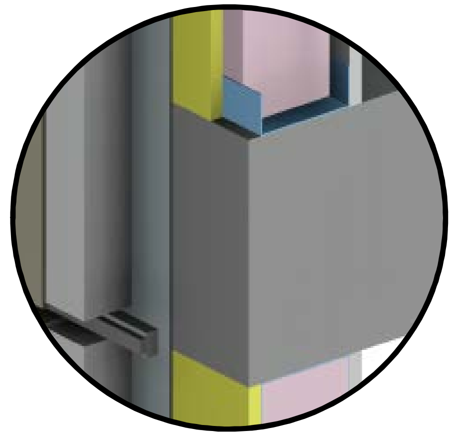
ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	3 5/8” x 1 5/8” Steel Studs (16”o.c.)	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	3 5/8” (92)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
5	Exterior Sheathing	1/2” (13)	1.1 (0.16)	R-0.5 (0.09 RSI)	50 (800)	0.26 (1090)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	2” (50) to 4” (100)	0.27 (0.039)	R-7.5 (1.32 RSI) to R-15 (2.64 RSI)	1 (16)	0.35 (1470)
8	Lamina	1/8” (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail 2

Exterior and Interior Insulated 3 5/8” x 1 5/8” Steel Stud (16” o.c.) Drained EIFS Wall Assembly – Floor Slab Intersection





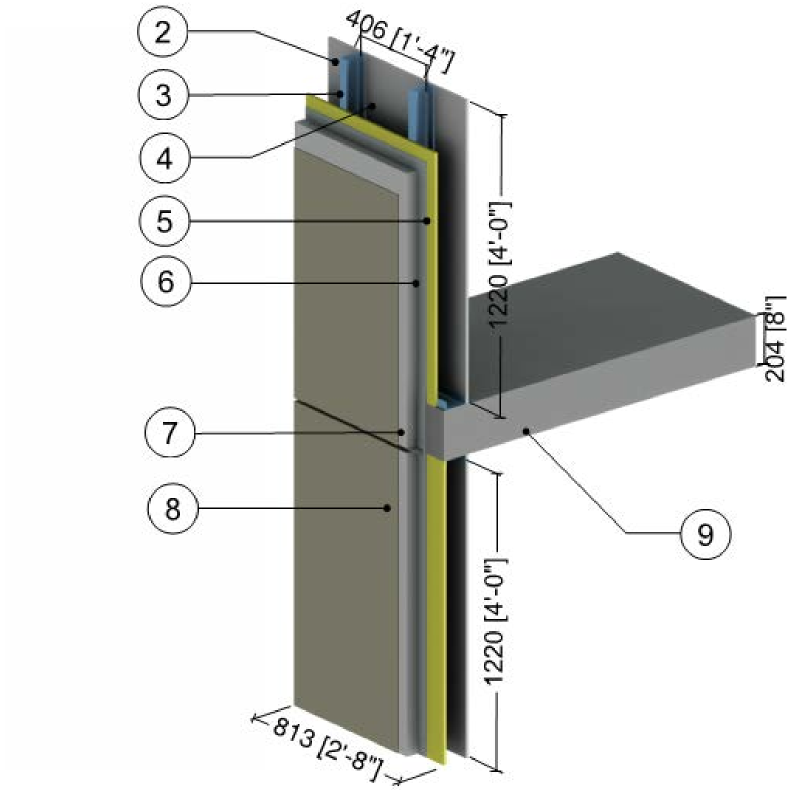
1” (25 mm)
Drained EIFS
at Slab Detail

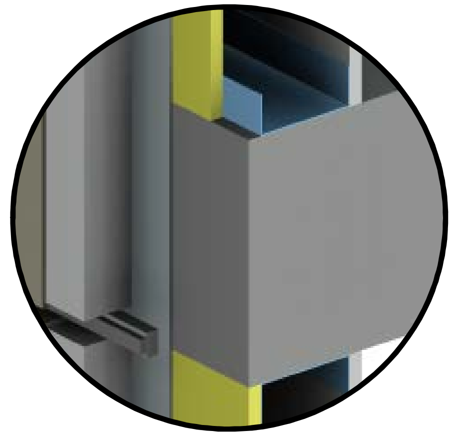
ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI) to R-0.9 (0.16 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	3 5/8” x 3 5/8” Steel Studs (16”o.c.) with Top and Bottom Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Fiberglass Batt Insulation	3 5/8” (92)	0.29 (0.042)	R-12 (2.1 RSI)	0.9 (1.1)	0.17 (710)
5	Exterior Sheathing	1/2” (13)	1.1 (0.16)	R-0.5 (0.09 RSI)	50 (800)	0.26 (1090)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	2” (50) to 4” (100)	0.27 (0.039)	R-7.5 (1.32 RSI) to R-15 (2.64 RSI)	1 (16)	0.35 (1470)
8	Lamina	1/8” (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Concrete Slab	8” (203)	12 (1.8)	-	140 (2250)	0.20 (850)
10	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail 2a

Exterior Insulated 3 5/8” x 1 5/8” Steel Stud (16” o.c.) Drained EIFS Wall Assembly – Floor Slab Intersection





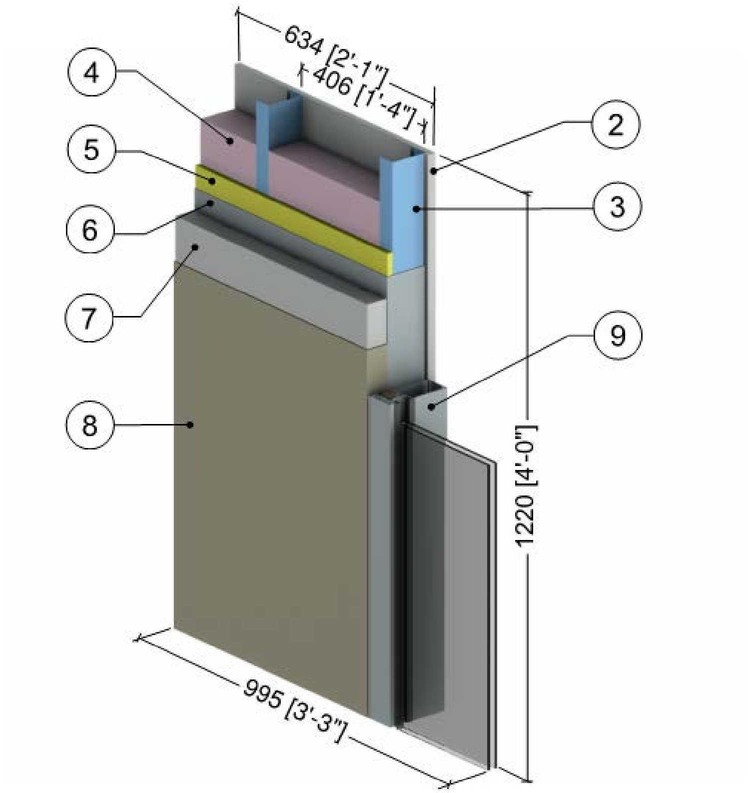
1” (25 mm) Drained EIFS at Slab Detail

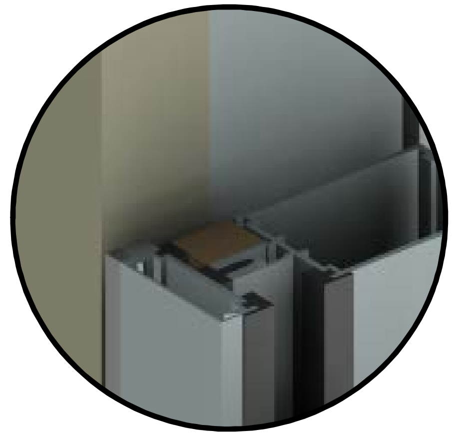
ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI) to R-0.9 (0.16 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	3 5/8” x 3 5/8” Steel Studs (16”o.c.) with Top and Bottom Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	3 5/8” (92)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
5	Exterior Sheathing	1/2” (13)	1.1 (0.16)	R-0.5 (0.09 RSI)	50 (800)	0.26 (1090)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	2” (50) to 4” (100)	0.27 (0.039)	R-7.5 (1.32 RSI) to R-15 (2.64 RSI)	1 (16)	0.35 (1470)
8	Lamina	1/8” (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Concrete Slab	8” (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
10	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail 3

Exterior and Interior Insulated 3 5/8" x 1 5/8" Steel Stud (16" o.c.) Drained EIFS Wall Assembly – Conventional Curtain Wall Transition





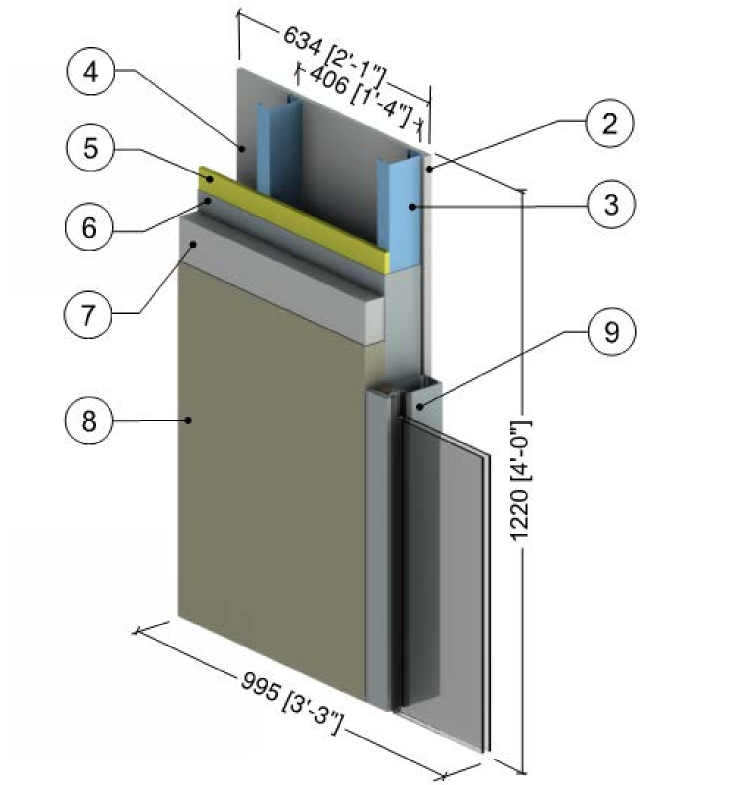
Curtain Wall
Jamb Detail

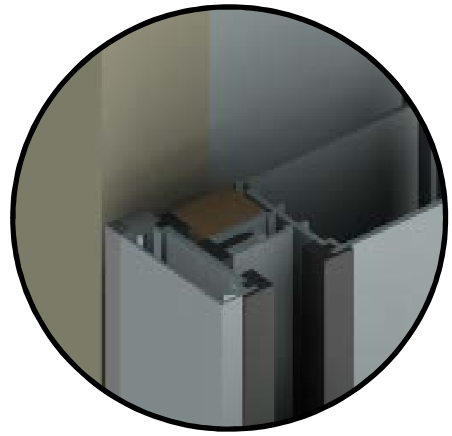
ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI) to R-1.1 (0.20 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	3 5/8" x 1 5/8" Steel Studs (16"o.c.)	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Fiberglass Batt Insulation	3 5/8" (92)	0.29 (0.042)	R-12 (2.1 RSI)	0.9 (1.1)	0.17 (710)
5	Exterior Sheathing	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	Varies	0.27 (0.039)	R-7.5 (1.32 RSI) to R-15 (2.64 RSI	1 (16)	0.35 (1470)
8	Lamina	1/8" (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Conventional curtain wall system: double glazed with minimal thermal break, double glazed IGU U_{IGU}= 0.32 BTU/hr·ft2·oF (1.82 W/m2K) [2]					
10	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation
[2] The thermal conductivity of air spaces within framing was found using ISO 100077-2

Detail 3a

Exterior Insulated 3 5/8" x 1 5/8" Steel Stud (16" o.c.) Drained EIFS Wall Assembly – Conventional Curtain Wall Transition





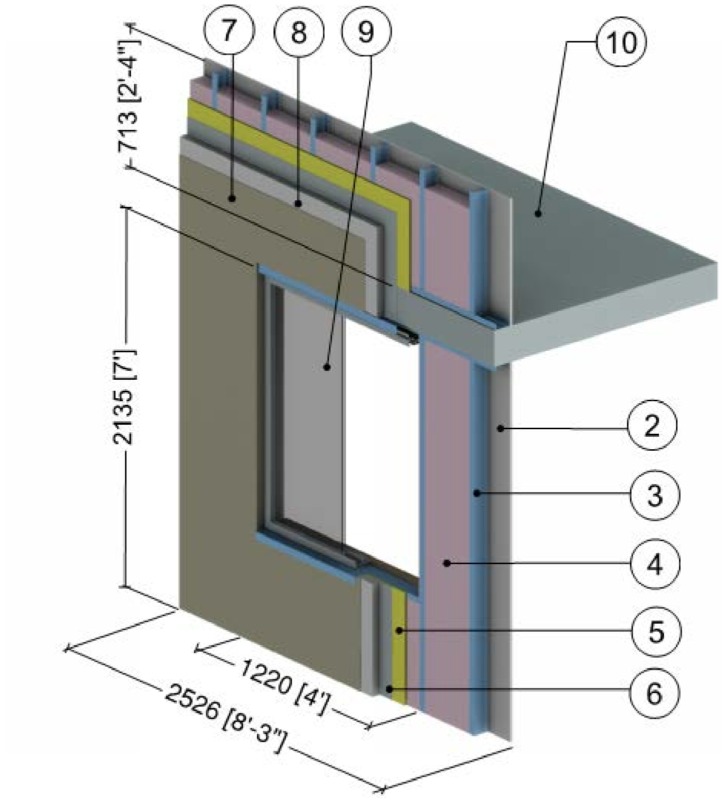
Curtain Wall
Jamb Detail

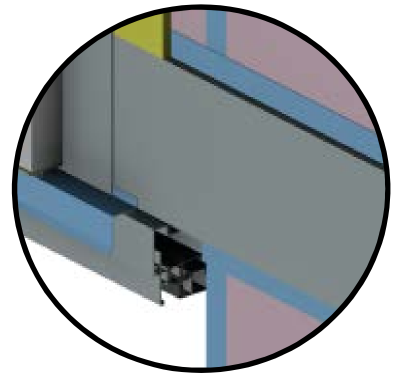
ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft^2·hr·°F (W/m K)	Nominal Resistance hr·ft^2·°F/Btu (m^2K/W)	Density lb/ft^3 (kg/m^3)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI) to R-1.1 (0.20 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	3 5/8" x 1 5/8" Steel Studs (16"o.c.)	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	3 5/8" (92)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
5	Exterior Sheathing	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	Varies	0.27 (0.039)	R-7.5 (1.32 RSI) to R-15 (2.64 RSI	1 (16)	0.35 (1470)
8	Lamina	1/8" (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Conventional curtain wall system: double glazed with minimal thermal break, double glazed IGU U_{IGU}= 0.32 BTU/hr·ft2·oF (1.82 W/m2K)[2]					
10	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation
[2] The thermal conductivity of air spaces within framing was found using ISO 100077-2

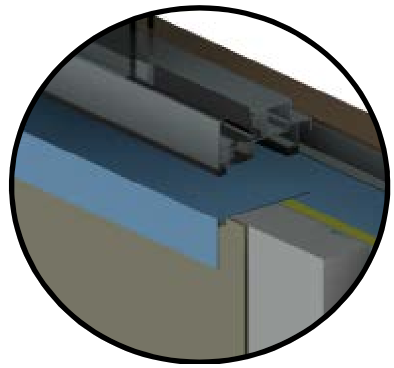
Detail 4

Exterior and Interior Insulated 3 5/8" x 1 5/8" Steel Stud (16" o.c.) Drained EIFS Wall Assembly – Window and Floor Slab Intersection





Window Head Detail



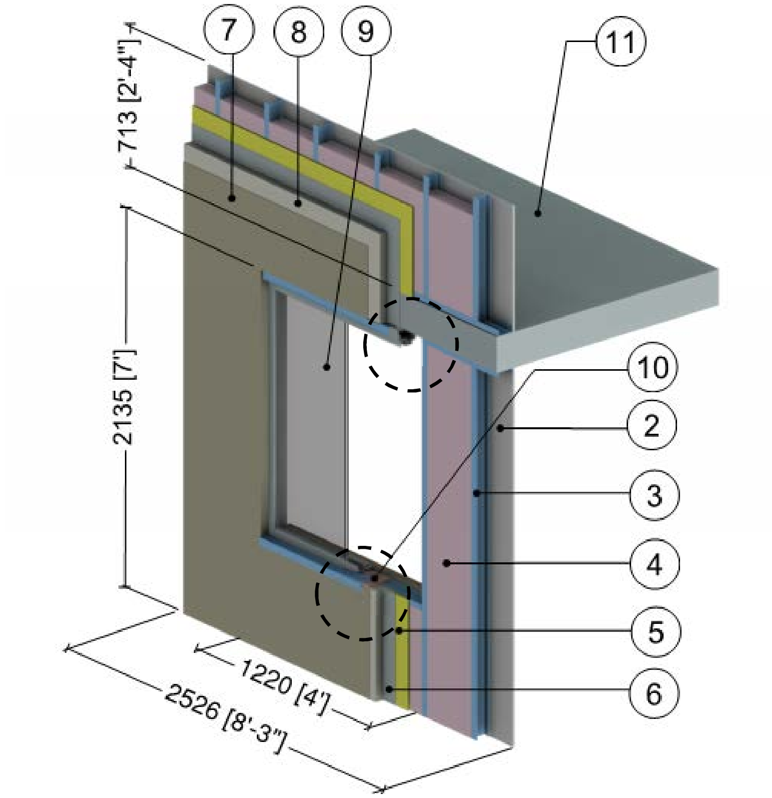
Window Sill Detail

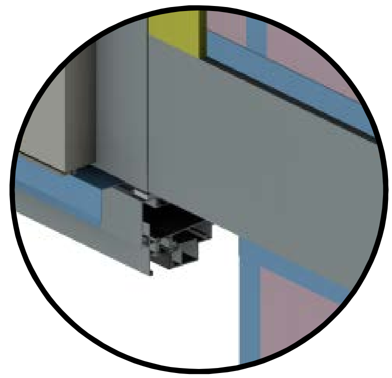
ID	Component	Thickness Inches (mm)	Conductivity Btu·in / $ft^2 \cdot hr \cdot {}^oF$ (W/m K)	Nominal Resistance $hr \cdot ft^2 \cdot {}^oF/Btu$ (m^2K/W)	Density lb/ft^3 (kg/m^3)	Specific Heat $Btu/lb \cdot {}^oF$ (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI) to R-1.1 (0.20 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	3 5/8" x 1 5/8" Steel Studs (16"o.c.) with Top and Bottom Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Fiberglass Batt Insulation	3 5/8" (92)	0.29 (0.042)	R-12 (2.1 RSI)	0.9 (1.1)	0.17 (710)
5	Exterior Sheathing	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Lamina	1/8" (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
8	Insulation Board	Varies	0.27 (0.039)	R-7.5 (1.32 RSI) to R-15 (2.64 RSI)	1 (16)	0.35 (1470)
9	5' (1.5m) x 6' (1.8m) Aluminum window: double glazed & thermally broken, double glazed IGU U_{IGU} = 0.32 BTU/hr.ft^2.^{o}F (1.82 W/m^{2}K) [2]					
10	Concrete Slab	8" (203)	12 (1.8)	-	140 (2250)	0.20 (850)
11	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation
[2] The thermal conductivity of air spaces within framing was found using ISO 100077-2

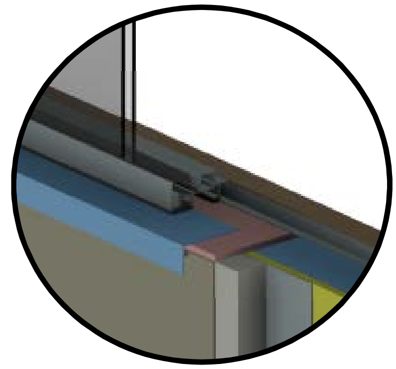
Detail 4i

Exterior and Interior Insulated 3 5/8" x 1 5/8" Steel Stud (16" o.c.) Drained EIFS Wall Assembly – Window with Aerogel and Floor Slab Intersection





Window Head Detail



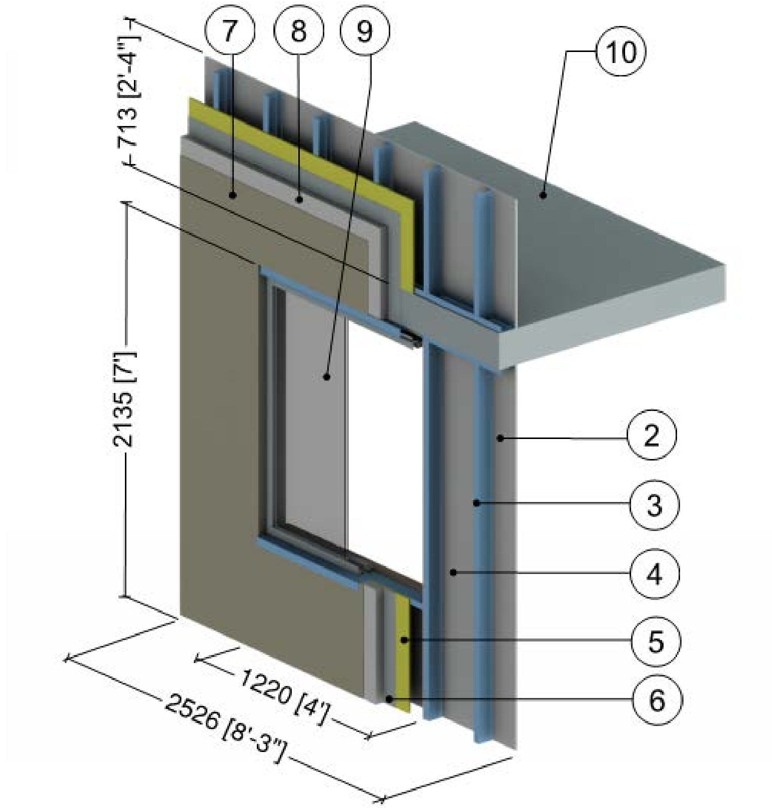
Window Sill Detail

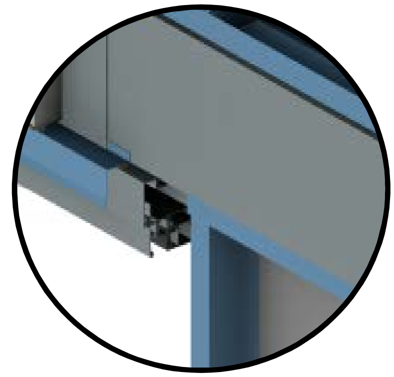
ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft2·hr·oF (W/m K)	Nominal Resistance hr·ft2·oF/Btu (m2K/W)	Density lb/ft3 (kg/m3)	Specific Heat Btu/lb·oF (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI) to R-1.1 (0.20 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	3 5/8" x 1 5/8" Steel Studs (16"o.c.) with Top and Bottom Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Fiberglass Batt Insulation	3 5/8" (92)	0.29 (0.042)	R-12 (2.1 RSI)	0.9 (1.1)	0.17 (710)
5	Exterior Sheathing	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Lamina	1/8" (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
8	Insulation Board	Varies	0.27 (0.039)	R-7.5 (1.32 RSI) to R-15 (2.64 RSI)	1 (16)	0.35 (1470)
9	5' (1.5m) x 6' (1.8m) Aluminum window: double glazed & thermally broken, double glazed IGU U_{IGU} = 0.32 BTU/hr.ft^2.°F (1.82 W/m^{2}K) [2]					
10	Aerogel Blanket	3/8" (10)	0.086 (0.015)	R-3.8 (0.67 RSI)	-	-
11	Concrete Slab	8" (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
12	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation
[2] The thermal conductivity of air spaces within framing was found using ISO 100077-2

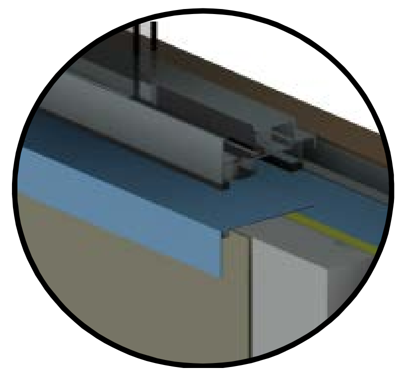
Detail 4a

Exterior Insulated 3 5/8” x 1 5/8” Steel Stud (16” o.c.) Drained EIFS Wall Assembly – Window and Floor Slab Intersection





Window Head Detail



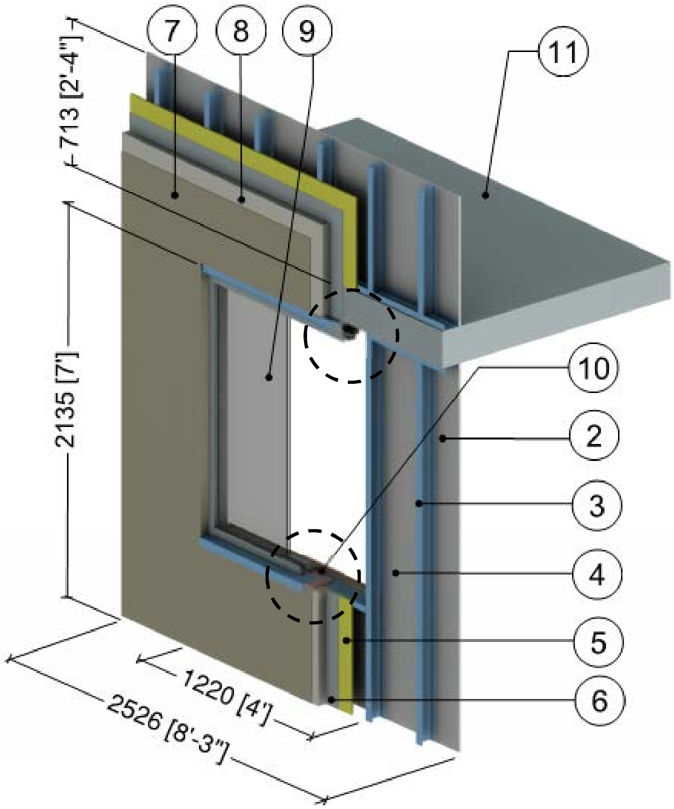
Window Sill Detail

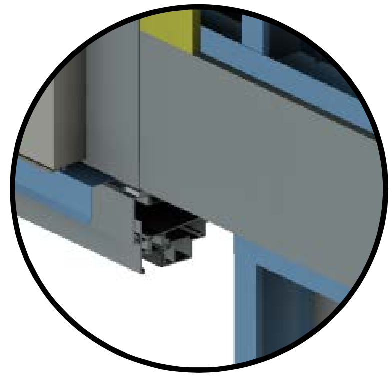
ID	Component	Thickness Inches (mm)	Conductivity Btu·in / $ft^2 \cdot hr \cdot {}^oF$ (W/m K)	Nominal Resistance $hr \cdot ft^2 \cdot {}^oF/Btu$ (m^2K/W)	Density lb/ft^3 (kg/m^3)	Specific Heat $Btu/lb \cdot {}^oF$ (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI) to R-1.1 (0.20 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	3 5/8” x 1 5/8” Steel Studs (16”o.c.) with Top and Bottom Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	3 5/8” (92)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
5	Exterior Sheathing	1/2” (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Lamina	1/8” (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
8	Insulation Board	Varies	0.27 (0.039)	R-7.5 (1.32 RSI) to R-15 (2.64 RSI)	1 (16)	0.35 (1470)
9	5’ (1.5m) x 6’ (1.8m) Aluminum window: double glazed & thermally broken, double glazed IGU U_{IGU} = 0.32 $BTU/hr.ft^2.{}^oF$ (1.82 W/m^2K) [2]					
10	Concrete Slab	8” (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
11	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation
[2] The thermal conductivity of air spaces within framing was found using ISO 100077-2

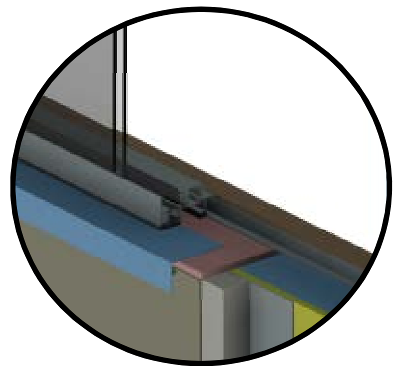
Detail 4ai

Exterior Insulated 3 5/8" x 1 5/8" Steel Stud (16" o.c.) Drained EIFS Wall Assembly – Window with Aerogel and Floor Slab Intersection





Window Head Detail



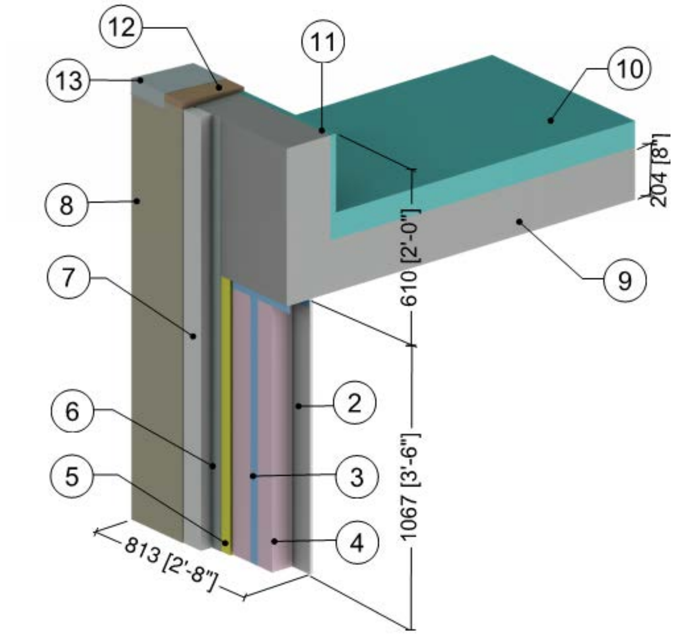
Window Sill Detail

ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI) to R-1.1 (0.20 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	3 5/8" x 1 5/8" Steel Studs (16"o.c.) with Top and Bottom Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	3 5/8" (92)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
5	Exterior Sheathing	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Lamina	1/8" (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
8	Insulation Board	Varies	0.27 (0.039)	R-7.5 (1.32 RSI) to R-15 (2.64 RSI)	1 (16)	0.35 (1470)
9	5' (1.5m) x 6' (1.8m) Aluminum window: double glazed & thermally broken, double glazed IGU U_{IGU} = 0.32 BTU/hr.ft².°F (1.82 W/m²K) [2]					
10	Aerogel Blanket	3/8" (10)	0.086 (0.015)	R-3.8 (0.67 RSI)	-	-
11	Concrete Slab	8" (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
12	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation
[2] The thermal conductivity of air spaces within framing was found using ISO 100077-2

Detail 5

Exterior and Interior Insulated 3 5/8" x 1 5/8" Steel Stud (16" o.c.) Drained EIFS Wall Assembly – Concrete Parapet & Slab Intersection

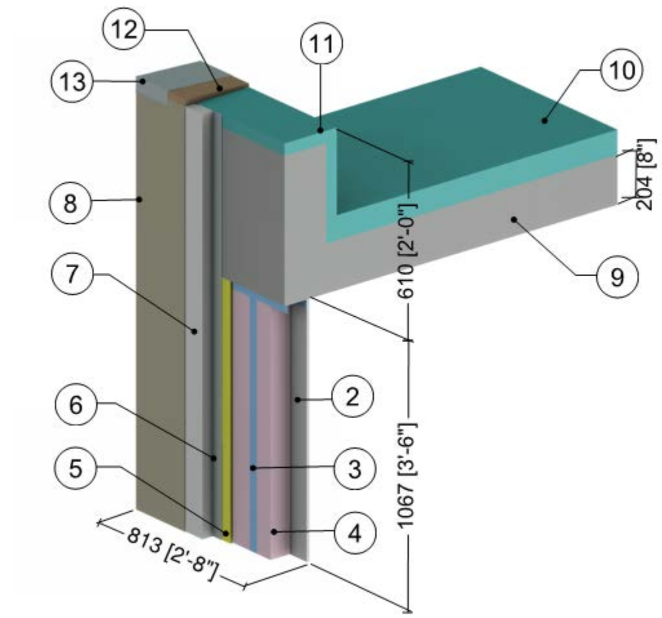


ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI) to R-0.9 (0.16 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	3 5/8" x 1 5/8" Steel Studs (16"o.c.) with Top Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Fiberglass Batt Insulation	3 5/8" (92)	0.29 (0.042)	R-12 (2.1 RSI)	0.9 (1.1)	0.17 (710)
5	Exterior Sheathing	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	Varies	0.27 (0.039)	R-7.5 (1.32 RSI) to R-15 (2.64 RSI)	1 (16)	0.35 (1470)
8	Lamina	1/8" (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Concrete Slab & Parapet	8" (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
10	Roof Insulation	4" (100)	-	R-20 (3.5 RSI)	1.8 (28)	0.29 (1220)
11	Parapet Insulation	1" (25)	-	R-5 (0.88 RSI)	1.8 (28)	0.29 (1220)
12	Wood Blocking	5/8" (16)	0.63 (0.09)	-	27.8 (445)	0.45 (1880)
13	Flashing & roof finish material are incorporated into exterior heat transfer coefficient					
14	Exterior Film[1]	-	-	R-0.2 (0.03 RSI) to R-0.7 (0.12 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail 5i

Exterior and Interior Insulated 3 5/8" x 1 5/8" Steel Stud (16" o.c.) Drained EIFS Wall Assembly – Insulated Concrete Parapet & Slab Intersection

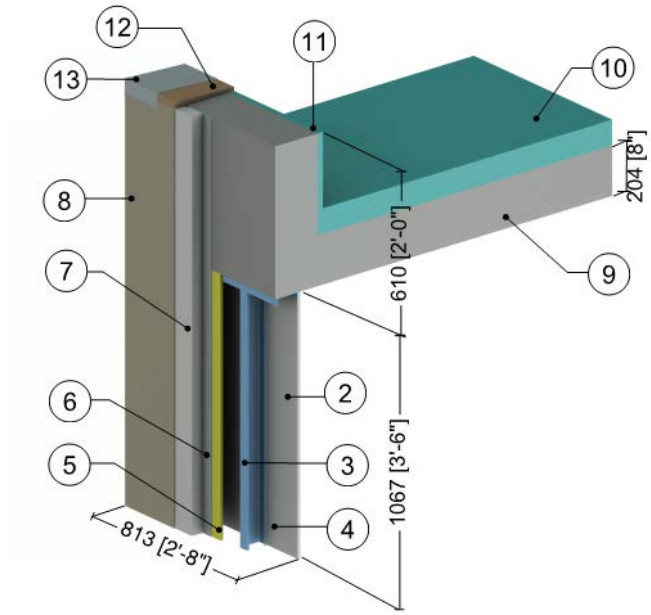


ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft^2·hr·°F (W/m K)	Nominal Resistance hr·ft^2·°F/Btu (m^{2}K/W)	Density lb/ft^3 (kg/m^3)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.12 RSI) to R-0.9 (0.16 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	3 5/8" x 1 5/8" Steel Studs (16"o.c.) with Top Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Fiberglass Batt Insulation	3 5/8" (92)	0.29 (0.042)	R-12 (2.1 RSI)	0.9 (1.1)	0.17 (710)
5	Exterior Sheathing	1/2" (13)	1.1 (0.16	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	Varies	0.27 (0.039)	R-7.5 (1.32 RSI) to R-15 (2.64 RSI)	1 (16)	0.35 (1470)
8	Lamina	1/8" (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Concrete Slab & Parapet	8" (203)	12 (1.8)	-	140 (2250)	0.20 (850)
10	Roof Insulation	4" (100)	-	R-20 (3.5 RSI)	1.8 (28)	0.29 (1220)
11	Parapet Insulation	Varies	-	R-10 (1.76 RSI) to R-20 (3.52 RSI)	1.8 (28)	0.29 (1220)
12	Wood Blocking	5/8" (16)	0.63 (0.09)	R-1 (0.18 RSI)	27.8 (445)	0.45 (1880)
13	Flashing & roof finish material are incorporated into exterior heat transfer coefficient					
14	Exterior Film[1]	-	-	R-0.2 (0.03 RSI) to R-0.7 (0.12 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail 5a

Exterior Insulated 3 5/8” x 1 5/8” Steel Stud (16” o.c.) Drained EIFS Wall Assembly – Concrete Parapet & Slab Intersection

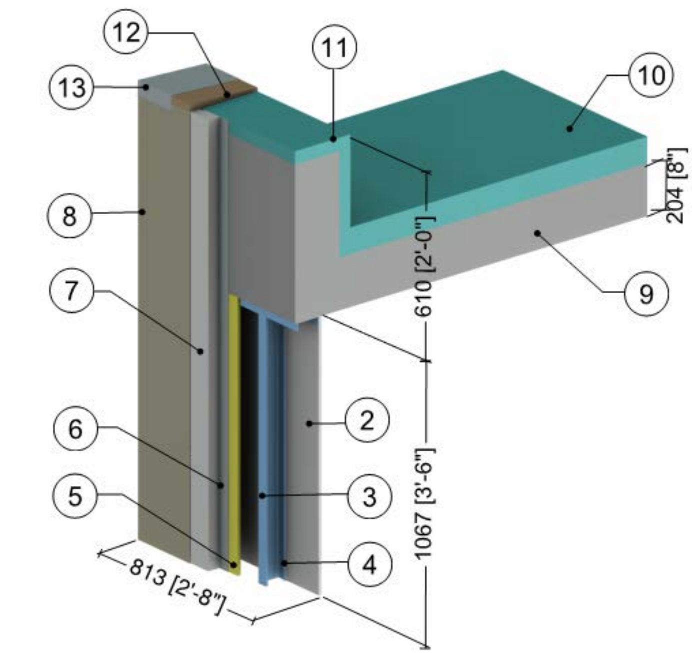


ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI) to R-0.9 (0.16 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	3 5/8” x 1 5/8” Steel Studs (16”o.c.) with Top Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	3 5/8” (92)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
5	Exterior Sheathing	1/2” (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	Varies	0.27 (0.039)	R-7.5 (1.32 RSI) to R-15 (2.64 RSI)	1 (16)	0.35 (1470)
8	Lamina	1/8” (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Concrete Slab & Parapet	8” (203)	12 (1.8)	-	140 (2250)	0.20 (850)
10	Roof Insulation	4” (100)	-	R-20 (3.5 RSI)	1.8 (28)	0.29 (1220)
11	Parapet Insulation	1” (25)	-	R-5 (0.88 RSI)	1.8 (28)	0.29 (1220)
12	Wood Blocking	5/8” (16)	0.63 (0.09)	-	27.8 (445)	0.45 (1880)
13	Flashing & roof finish material are incorporated into exterior heat transfer coefficient					
14	Exterior Film[1]	-	-	R-0.2 (0.03 RSI) to R-0.7 (0.12 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail 5ai

Exterior Insulated 3 5/8" x 1 5/8" Steel Stud (16" o.c.) Drained EIFS Wall Assembly – Insulated Concrete Parapet & Slab Intersection

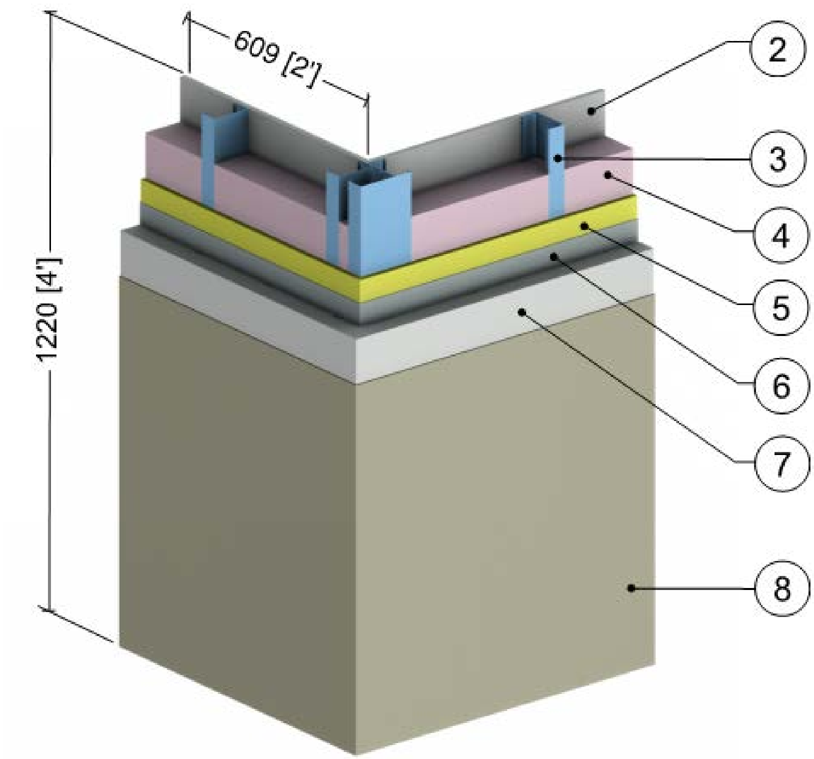


ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.12 RSI) to R-0.9 (0.16 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	3 5/8" x 1 5/8" Steel Studs (16"o.c.) with Top Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	3 5/8" (92)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
5	Exterior Sheathing	1/2" (13)	1.1 (0.16	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	Varies	0.27 (0.039)	R-7.5 (1.32 RSI) to R-15 (2.64 RSI)	1 (16)	0.35 (1470)
8	Lamina	1/8" (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Concrete Slab & Parapet	8" (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
10	Roof Insulation	4" (100)	-	R-20 (3.5 RSI)	1.8 (28)	0.29 (1220)
11	Parapet Insulation	Varies	-	R-10 (1.76 RSI) to R-20 (3.52 RSI)	1.8 (28)	0.29 (1220)
12	Wood Blocking	5/8" (16)	0.63 (0.09)	-	27.8 (445)	0.45 (1880)
13	Flashing & roof finish material are incorporated into exterior heat transfer coefficient					
14	Exterior Film[1]	-	-	R-0.2 (0.03 RSI) to R-0.7 (0.12 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail 6

Exterior and Interior Insulated 3 5/8” x 1 5/8” Steel Stud (16” o.c.) Drained EIFS Wall Assembly – Corner Intersection

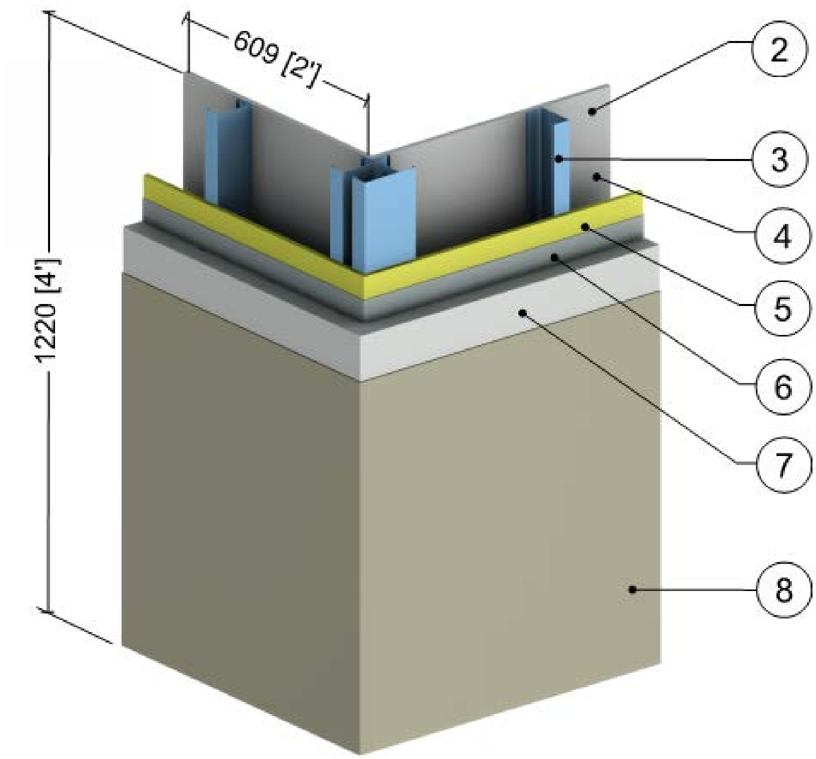


ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	3 5/8” x 1 5/8” Steel Studs (16”o.c.)	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Fiberglass Batt Insulation	3 5/8” (92)	0.29 (0.042)	R-12 (2.1 RSI)	0.9 (1.1)	0.17 (710)
5	Exterior Sheathing	1/2” (13)	1.1 (0.16)	R-0.5 (0.09 RSI)	50 (800)	0.26 (1090)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	Varies	0.27 (0.039)	R-7.5 (1.32 RSI) to R-15 (2.64 RSI)	1 (16)	0.35 (1470)
8	Lamina	1/8” (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail 6a

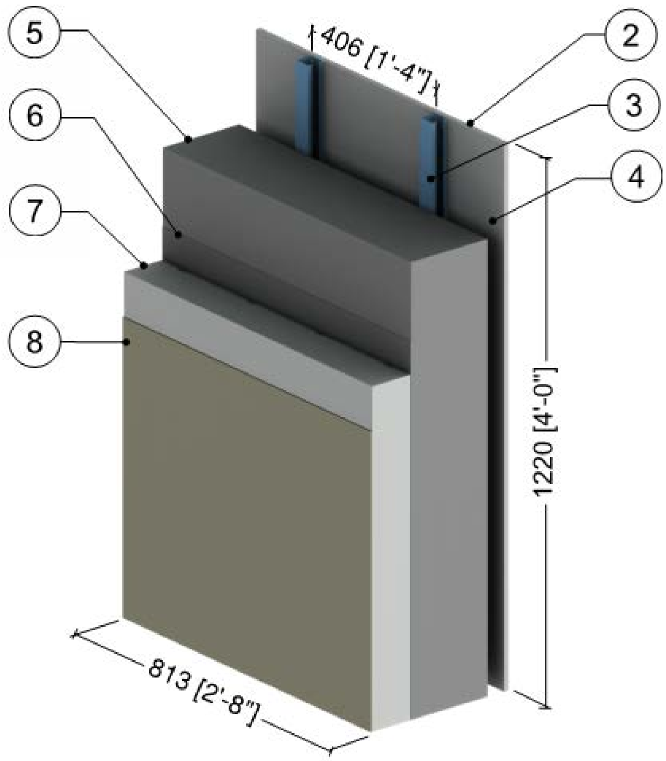
Exterior and Interior Insulated 3 5/8” x 1 5/8” Steel Stud (16” o.c.) Drained EIFS Wall Assembly – Corner Intersection

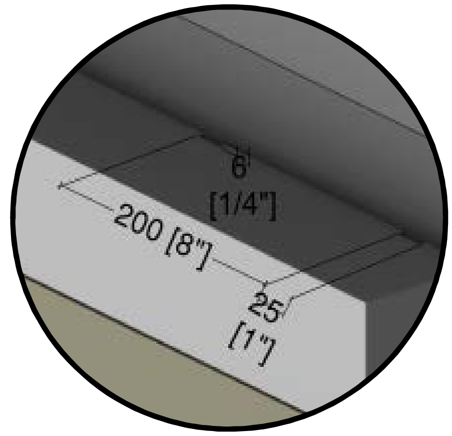


ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft^2·hr·^{o}F (W/m K)	Nominal Resistance hr·ft^2·^{o}F/Btu (m^{2}K/W)	Density lb/ft^3 (kg/m^3)	Specific Heat Btu/lb·^{o}F (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	3 5/8” x 1 5/8” Steel Studs (16”o.c.)	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	3 5/8” (92)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
5	Exterior Sheathing	1/2” (13)	1.1 (0.16)	R-0.5 (0.09 RSI)	50 (800)	0.26 (1090)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	Varies	0.27 (0.039)	R-7.5 (1.32 RSI) to R-15 (2.64 RSI)	1 (16)	0.35 (1470)
8	Lamina	1/8” (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail 7 | Exterior Insulated Concrete Drained EIFS Wall Assembly – Clear Wall





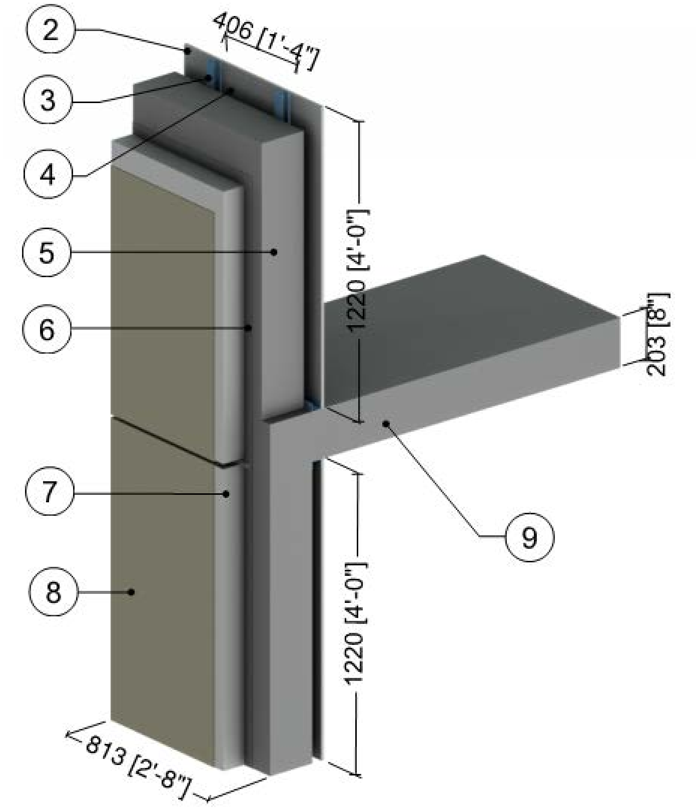
1” (25 mm) Drained EIFS Detail

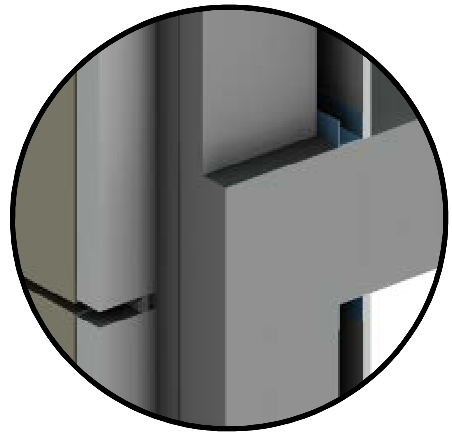
ID	Component	Thickness Inches (mm)	Conductivity Btu·in / $ft^2 \cdot hr \cdot {}^oF$ (W/m K)	Nominal Resistance $hr \cdot ft^2 \cdot {}^oF/Btu$ (m^2K/W)	Density lb/ft^3 (kg/m^3)	Specific Heat $Btu/lb \cdot {}^oF$ (J/kg K)
1	Interior Film[1]	-	-	R-0.6 (0.11 RSI)	-	-
2	Gypsum Board	1/2” (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	1 5/8” x 1 5/8” Steel Studs (16” o.c.)	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	1 5/8" (41)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
5	Concrete Wall	8” (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	4” (100)	0.27 (0.039)	R-15 (2.64 RSI)	1 (16)	0.35 (1470)
8	Lamina	1/8” (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail 8

Exterior Insulated Concrete Drained EIFS Wall Assembly – Floor Slab Intersection





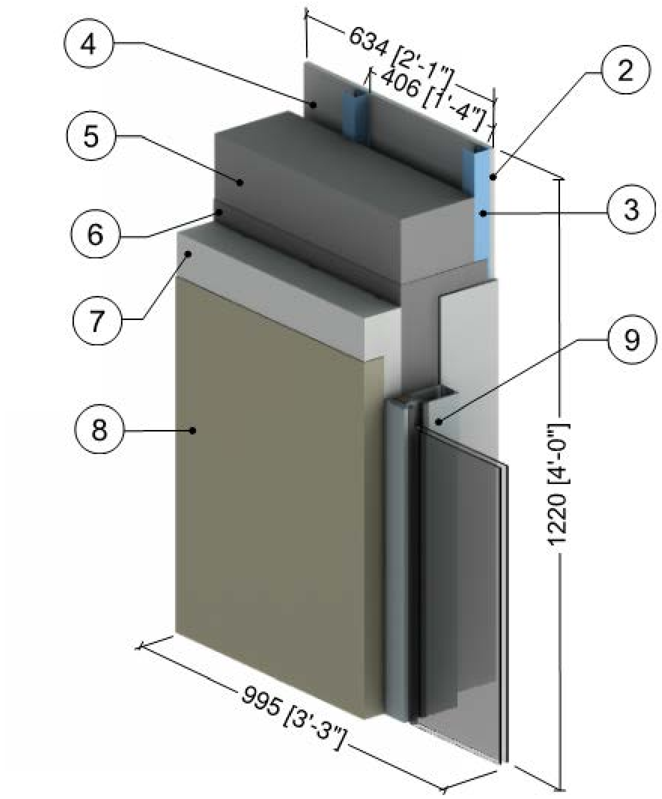
1" (25 mm)
Drained EIFS
at Slab Detail

ID	Component	Thickness Inches (mm)	Conductivity Btu·in / $ft^2 \cdot hr \cdot ^oF$ (W/m K)	Nominal Resistance $hr \cdot ft^2 \cdot ^oF/Btu$ (m^2K/W)	Density lb/ft^3 (kg/m^3)	Specific Heat $Btu/lb \cdot ^oF$ (J/kg K)
1	Interior Films [1]	-	-	R-0.6 (0.11 RSI) to R-0.9 (0.16 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	1 5/8" x 1 5/8" Steel Studs (16"o.c.) with Top and Bottom Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	1 5/8" (41)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
5	Concrete Wall	8" (203)	12 (1.8)	-	140 (2250)	0.20 (850)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	4" (100)	0.27 (0.039)	R-15 (2.64 RSI)	1 (16)	0.35 (1470)
8	Lamina	1/8" (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Concrete Slab	8" (203)	12 (1.8)	-	140 (2250)	0.20 (850)
10	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail 9

Exterior Insulated Concrete Drained EIFS Wall Assembly – Conventional Curtain Wall Transition



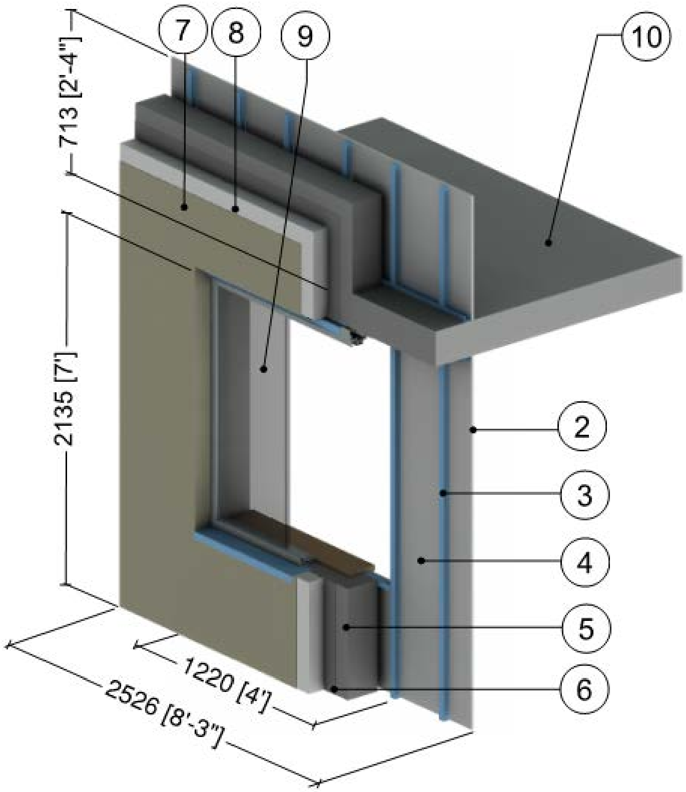
Curtain Wall
Jamb Detail

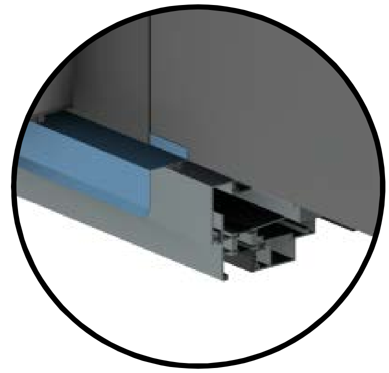
ID	Component	Thickness Inches (mm)	Conductivity Btu·in / $ft^2 \cdot hr \cdot {}^oF$ (W/m K)	Nominal Resistance $hr \cdot ft^2 \cdot {}^oF/Btu$ (m^2K/W)	Density lb/ft^3 (kg/m^3)	Specific Heat $Btu/lb \cdot {}^oF$ (J/kg K)
1	Interior Films [1]	-	-	R-0.6 (0.11 RSI) to R-1.1 (0.20 RSI)	-	-
2	Gypsum Board	1/2" (30)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	1 5/8" x 1 5/8" Steel Studs (16" o.c.)	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	3 5/8" (92)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
5	Concrete Wall	8" (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	4" (100)	0.27 (0.039)	R-15 (2.64 RSI)	1 (16)	0.35 (1470)
8	Lamina	1/8" (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Conventional curtain wall system: double glazed with minimal thermal break, double glazed IGU U_{IGU} = 0.32 $BTU/hrft^2F$ (1.82 W/m^2K) [2]					
10	Exterior Film (left side)[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation
[2] The thermal conductivity of air spaces within framing was found using ISO 100077-2

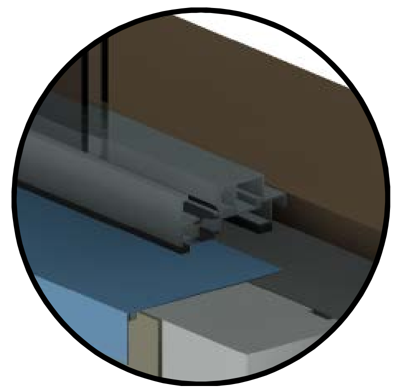
Detail 10

Exterior Insulated Concrete Drained EIFS Wall Assembly – Window and Floor Slab Intersection





Window Head Detail



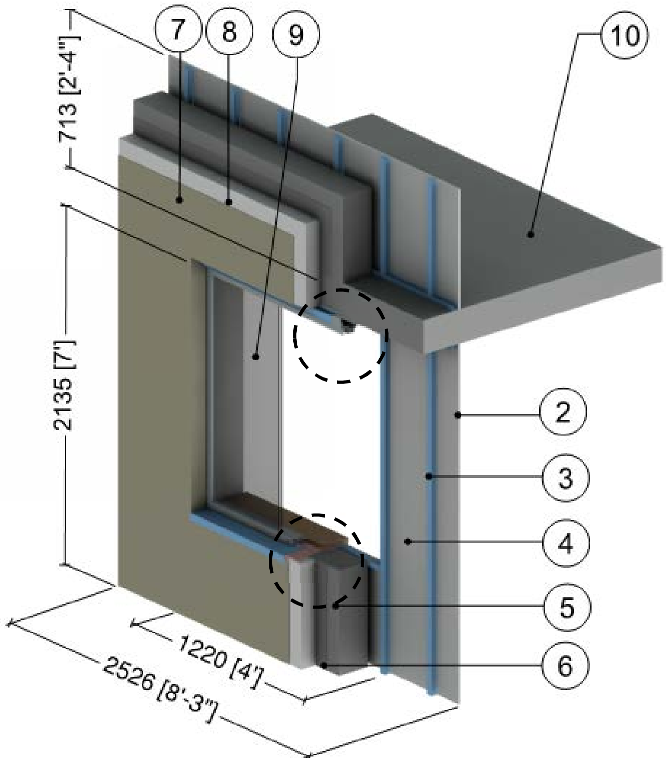
Window Sill Detail

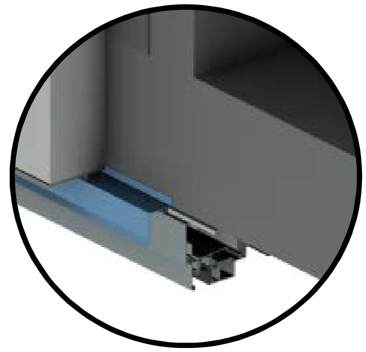
ID	Component	Thickness Inches (mm)	Conductivity Btu·in / $ft^2 \cdot hr \cdot {}^oF$ (W/m K)	Nominal Resistance $hr \cdot ft^2 \cdot {}^oF/Btu$ (m^2K/W)	Density lb/ft^3 (kg/m^3)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films [1]	-	-	R-0.6 (0.11 RSI) to R-0.9 (0.16 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	1 5/8" x 1 5/8" Steel Studs (16"o.c.) with Top and Bottom Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	1 5/8" (41)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
5	Concrete Wall	8" (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Lamina	1/8" (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
8	Insulation Board	4" (100)	0.27 (0.039)	R-15 (2.64 RSI)	1.2 (20)	0.35 (1470)
9	5' (1.5m) x 6' (1.8m) Aluminum window: double glazed & thermally broken, double glazed IGU U_{IGU} = 0.32 $BTU/hr.ft^2.{}^oF$ ($1.82\ W/m^2K$) [2]					
10	Concrete Slab	8" (203)	12 (1.8)	-	140 (2250)	0.20 (850)
11	Exterior Film (left side)[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation
[2] The thermal conductivity of air spaces within framing was found using ISO 100077-2

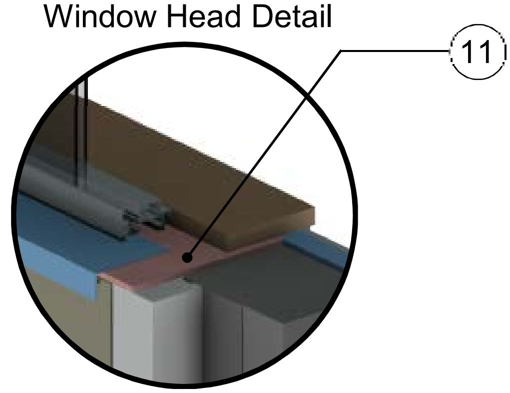
Detail 10i

Exterior Insulated Concrete Drained EIFS Wall Assembly – Window with Aerogel and Floor Slab Intersection





Window Head Detail



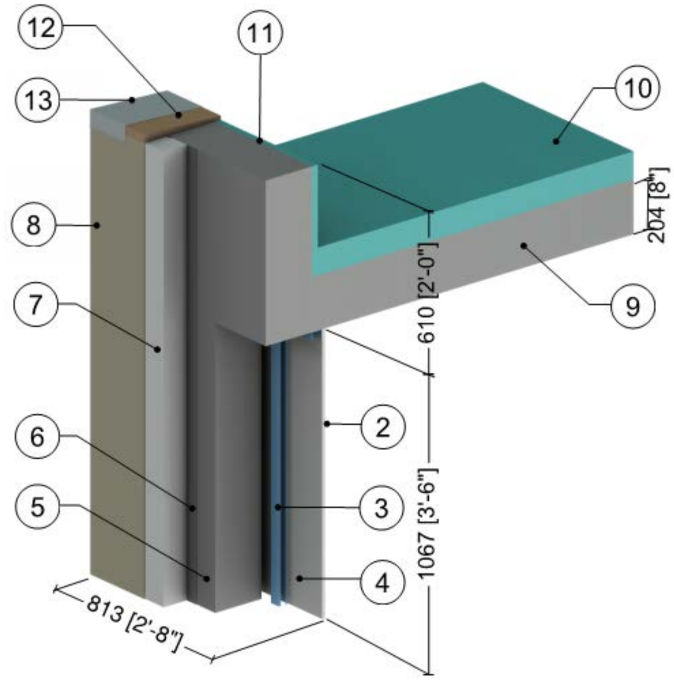
Window Sill Detail

ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft^2·hr·°F (W/m K)	Nominal Resistance hr·ft^2·°F/Btu (m^{2}K/W)	Density lb/ft^3 (kg/m^3)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI) to R-0.9 (0.16 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	1 5/8" x 1 5/8" Steel Studs (16"o.c.) with Top and Bottom Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	1 5/8" (41)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
5	Concrete Wall	8" (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Lamina	1/8" (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
8	Insulation Board	4" (100)	0.27 (0.039)	R-15 (2.64 RSI)	1.2 (20)	0.35 (1470)
9	5' (1.5m) x 6' (1.8m) Aluminum window: double glazed & thermally broken, double glazed IGU U_{IGU} = 0.32 BTU/hr.ft^2.°F (1.82 W/m^{2}K) [2]					
10	Concrete Slab	8" (203)	12 (1.8)	-	140 (2250)	0.20 (850)
11	Aerogel Blanket	3/8" (10)	0.1 (0.015)	R-3.8 (0.67 RSI)	-	-
12	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation
[2] The thermal conductivity of air spaces within framing was found using ISO 100077-2

Detail 11

Exterior Insulated Concrete Drained EIFS Wall Assembly – Concrete Parapet & Slab Intersection

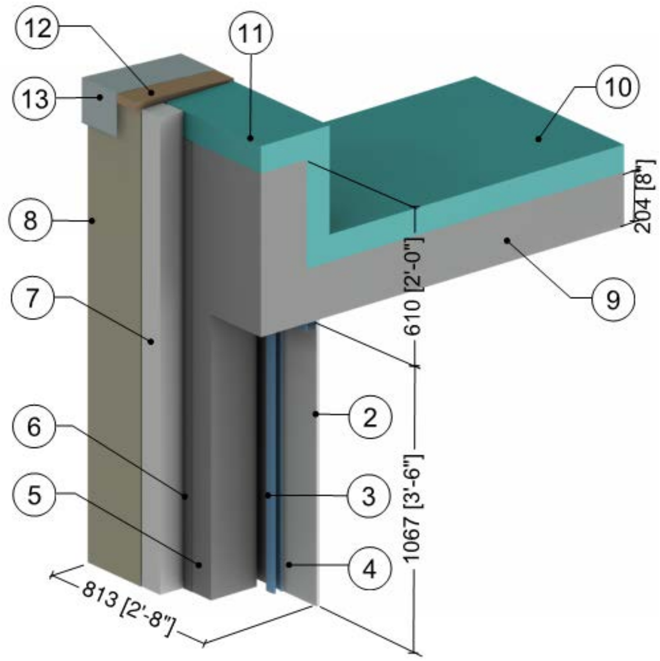


ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft^2·hr·°F (W/m K)	Nominal Resistance hr·ft^2·°F/Btu (m^2K/W)	Density lb/ft^3 (kg/m^3)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI) to R-0.7 (0.12 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	1 5/8" x 1 5/8" Steel Studs (16"o.c.) with Top Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	1 5/8" (41)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
5	Concrete Wall	8" (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	4" (100)	0.27 (0.039)	R-15 (2.64 RSI)	1 (16)	0.35 (1470)
8	Lamina	1/8" (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Concrete Slab & Parapet	8" (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
10	Roof Insulation	4" (100)	-	R-20 (3.5 RSI)	1.8 (28)	0.29 (1220)
11	Parapet Insulation	1" (25)	-	R-5 (0.88 RSI)	1.8 (28)	0.29 (1220)
12	Wood Blocking	5/8" (16)	0.63 (0.09)	-	27.8 (445)	0.45 (1880)
13	Flashing & roof finish material are incorporated into exterior heat transfer coefficient					
14	Exterior Film[1]	-	-	R-0.2 (0.03 RSI) to R-0.7 (0.12 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail 11i

Exterior Insulated Concrete Drained EIFS Wall Assembly – Insulated Concrete Parapet & Slab Intersection

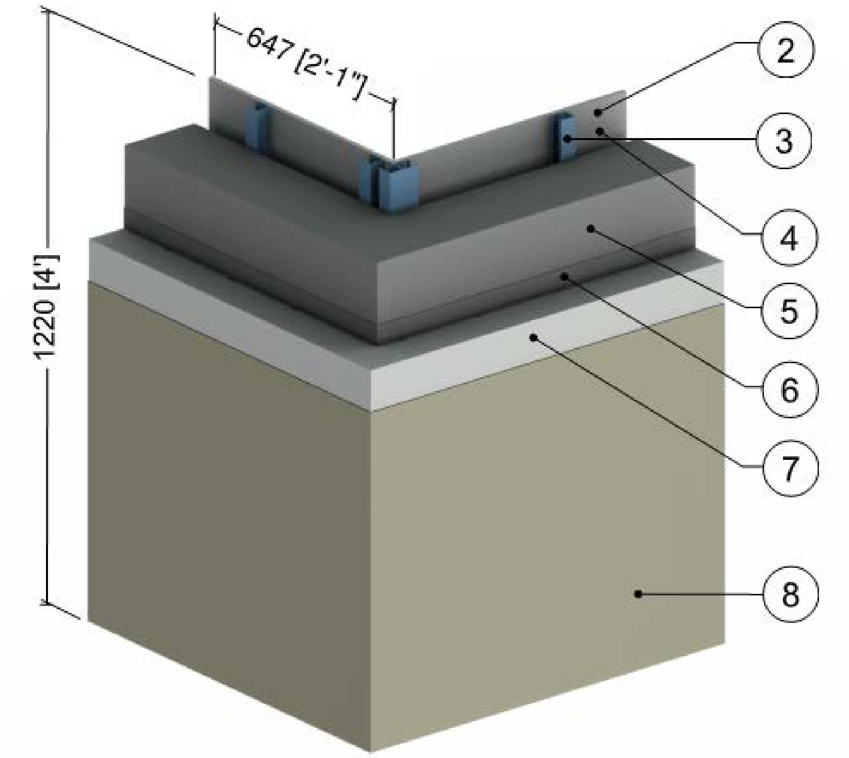


ID	Component	Thickness Inches (mm)	Conductivity Btu·in / $ft^2 \cdot hr \cdot {}^oF$ (W/m K)	Nominal Resistance $hr \cdot ft^2 \cdot {}^oF/Btu$ (m^2K/W)	Density lb/ft^3 (kg/m^3)	Specific Heat $Btu/lb \cdot {}^oF$ (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI) to R-0.7 (0.12 RSI)	-	-
2	Gypsum Board	1/2” (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	1 5/8” x 1 5/8” Steel Studs (16”o.c.) with Top Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	1 5/8” (41)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
5	Concrete	8” (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	4” (100)	0.27 (0.039)	R-15 (2.64 RSI)	1 (16)	0.35 (1470)
8	Lamina	1/8” (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Concrete Slab & Parapet	8” (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
10	Roof Insulation	4” (100)	-	R-20 (3.5 RSI)	1.8 (28)	0.29 (1220)
11	Parapet Insulation	Varies	-	R-10 (1.76 RSI) to R-20 (3.52 RSI)	1.8 (28)	0.29 (1220)
12	Wood Blocking	5/8” (16)	0.63 (0.09)	-	27.8 (445)	0.45 (1880)
13	Flashing & roof finish material are incorporated into exterior heat transfer coefficient					
14	Exterior Film[1]	-	-	R-0.2 (0.03 RSI) to R-0.7 (0.12 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail 12

Exterior Insulated Concrete Drained EIFS Wall Assembly – Corner Intersection



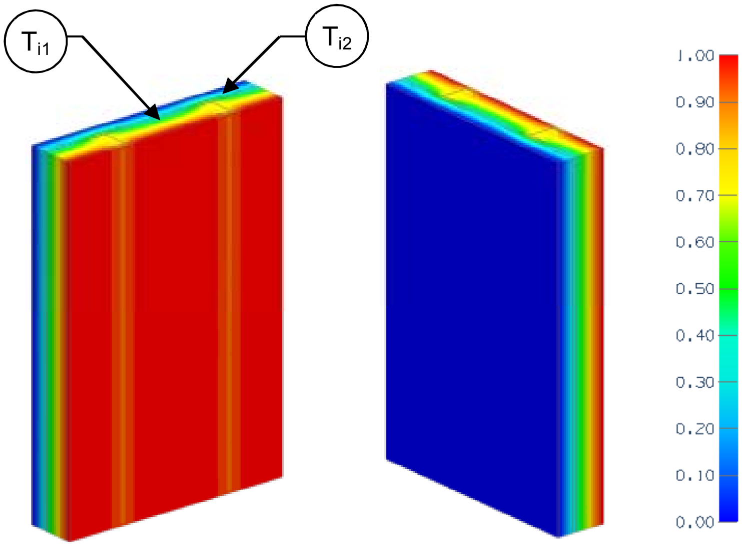
ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films[1]	-	-	R-0.6 (0.11 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	1 5/8" x 1 5/8" Steel Studs (16"o.c.)	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	1 5/8" (41)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
5	Concrete Wall	8" (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
6	Weather Resistive Barrier with Adhesive	-	-	-	-	-
7	Insulation Board	4" (100)	0.27 (0.039)	R-15 (2.64 RSI)	1 (16)	0.35 (1470)
8	Lamina	1/8" (4)	6 (0.9)	R-0.04 (0.01 RSI)	120 (1922)	0.20 (850)
9	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

APPENDIX C – SIMULATION RESULT SHEETS

Detail 1

Exterior and Interior Insulated 3 5/8" x 1 5/8" Steel Stud (16" o.c.) Drained EIFS Wall Assembly – Clear Wall



View from Interior   View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-14.2 (2.51 RSI) + exterior insulation
Transmittance / Resistance	U_o, R_o	"clear wall" U- and R-value
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

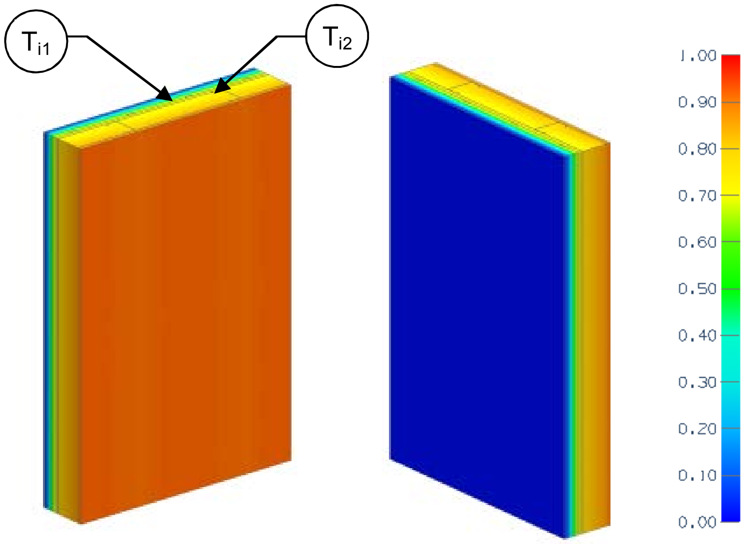
Exterior Insulation 1D R-Value (RSI)	R_{1D} ft^2·hr·^{o}F / Btu (m^2 K / W)	R_o ft^2·hr·^{o}F / Btu (m^2 K / W)	U_o Btu/ft^2 ·hr ·^{o}F (W/m^2 K)
R-7.5 (1.32)	R-21.7 (3.83)	R-16.6 (2.93)	0.060 (0.34)
R-15 (2.64)	R-29.2 (5.15)	R-24.0 (4.23)	0.042 (0.24)

Temperature Indices

	R7.5	R15	
T_{i1}	0.40	0.58	Min T on sheathing, between studs
T_{i2}	0.68	0.77	Max T on sheathing, along studs

Detail 1a

Exterior Insulated 3 5/8" x 1 5/8" Steel Stud (16" o.c.) Drained EIFS Wall Assembly – Clear Wall



View from Interior   View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-2.7 (0.47 RSI) + exterior insulation
Transmittance / Resistance	U_o, R_o	"clear wall" U- and R-value
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

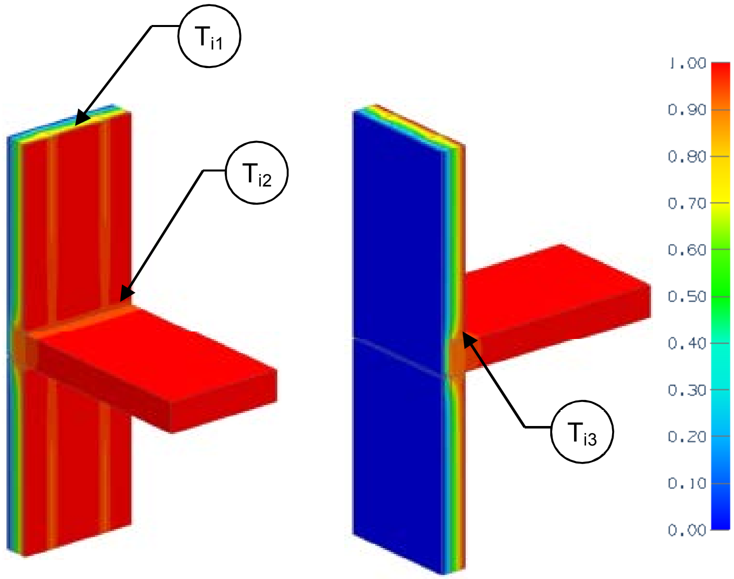
Exterior Insulation 1D R-Value (RSI)	R_{1D} ft²·hr·°F / Btu (m² K / W)	R_o ft²·hr·°F / Btu (m² K / W)	U_o Btu/ft² ·hr ·°F (W/m² K)
R-7.5 (1.32)	R-10.2 (1.80)	R-10.0 (1.76)	0.100 (0.57)
R-11.3 (1.98)	R-13.9 (2.46)	R-13.7 (2.41)	0.073 (0.41)
R-15 (2.64)	R-17.7 (3.12)	R-17.4 (3.06)	0.057 (0.33)

Temperature Indices

	R7.5	R11.3	R15	
T_{i1}	0.80	0.85	0.88	Min T on sheathing, between studs
T_{i2}	0.82	0.86	0.89	Max T on sheathing, along studs

Detail 2

Exterior and Interior Insulated 3 5/8" x 1 5/8" Steel Stud (16" o.c.) Drained EIFS Wall Assembly – Floor Slab Intersection



View from Interior   View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-14.2 (2.51 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_o, R_o	"clear wall" U- and R-value without slab
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of slab

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

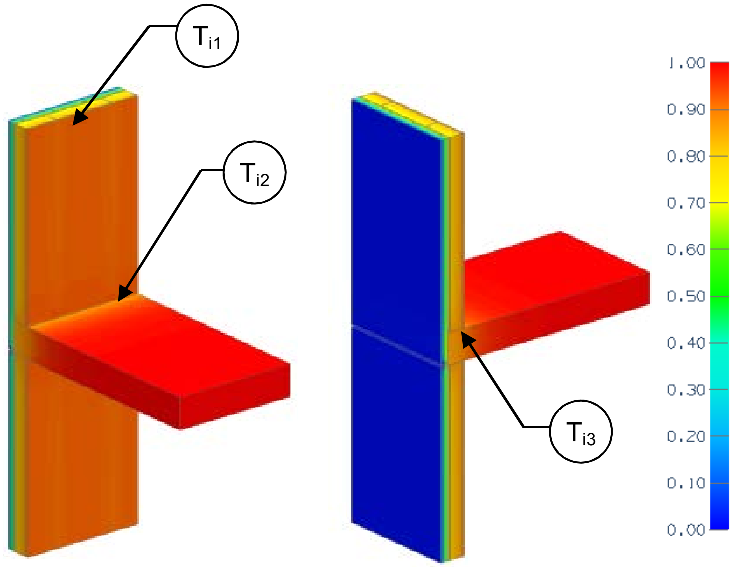
Exterior Insulation 1D R-Value (RSI)	R_{1D} ft^2·hr·°F / Btu (m^2 K / W)	R_o ft^2·hr·°F / Btu (m^2 K / W)	U_o Btu/ft^2 ·hr ·°F (W/m^2 K)	R ft^2·hr·°F / Btu (m^2 K / W)	U Btu/ft^2 ·hr ·°F (W/m^2 K)	ψ Btu/ft^2 ·hr ·°F (W/m^2 K)
R-7.5 (1.32)	R-21.7 (3.83)	R-16.6 (2.93)	0.060 (0.34)	R-14.5 (2.55)	0.069 (0.39)	0.076 (0.132)
R-15 (2.64)	R-29.2 (5.15)	R-24.0 (4.23)	0.042 (0.24)	R-22.0 (3.88)	0.045 (0.26)	0.032 (0.056)

Temperature Indices

	R7.5	R15	
T_{i1}	0.41	0.58	Min T on sheathing, between studs
T_{i2}	0.85	0.91	Max T on sheathing, along steel track at slab
T_{i3}	0.90	0.94	Min T on slab, at edge interior drywall, exposed to interior air

Detail 2a

Exterior Insulated 3 5/8” x 1 5/8” Steel Stud (16” o.c.) Drained EIFS Wall Assembly – Floor Slab Intersection



View from Interior

View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-2.7 (0.47 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_o, R_o	“clear wall” U- and R-value without slab
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of slab

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

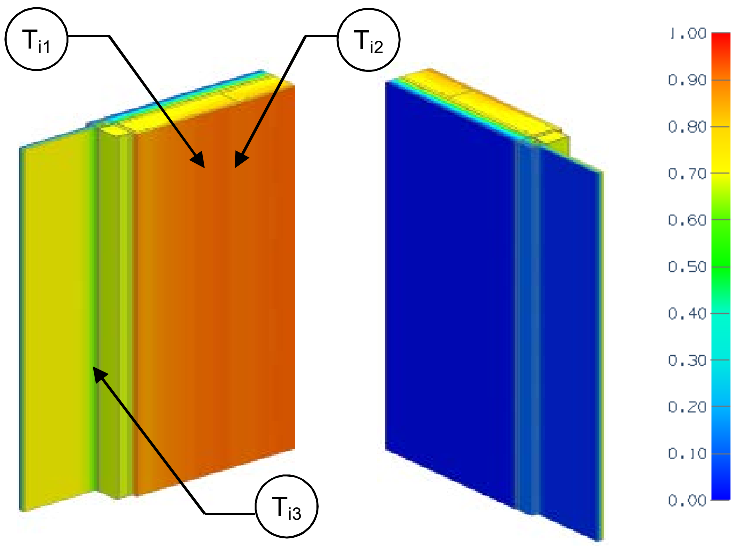
Exterior Insulation 1D R-Value (RSI)	R_{1D} ft^2·hr·^{o}F / Btu (m^2 K / W)	R_o ft^2·hr·^{o}F / Btu (m^2 K / W)	U_o Btu/ft^2 ·hr ·^{o}F (W/m^2 K)	R ft^2·hr·^{o}F / Btu (m^2 K / W)	U Btu/ft^2 ·hr ·^{o}F (W/m^2 K)	ψ Btu/ft^2 ·hr ·^{o}F (W/m^2 K)
R-7.5 (1.32)	R-10.2 (1.80)	R-10.0 (1.76)	0.100 (0.57)	R-9.7 (1.70)	0.104 (0.59)	0.032 (0.055)
R-11.3 (1.98)	R-13.9 (2.46)	R-13.7 (2.41)	0.073 (0.41)	R-13.3 (2.35)	0.075 (0.43)	0.018 (0.032)
R-15 (2.64)	R-17.7 (3.12)	R-17.4 (3.06)	0.057 (0.33)	R-17.0 (2.99)	0.059 (0.33)	0.012 (0.022)

Temperature Indices

	R7.5	R11.3	R15	
T_{i1}	0.80	0.85	0.88	Min T on sheathing, between studs
T_{i2}	0.86	0.90	0.93	Max T on sheathing, along steel track at slab
T_{i3}	0.91	0.94	0.95	Min T on slab, at edge interior drywall, exposed to interior air

Detail 3

Exterior and Interior Insulated 3 5/8" x 1 5/8" Steel Stud (16" o.c.) Drained EIFS Wall Assembly – Conventional Curtain Wall Transition



View from Interior View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-14.2 (2.51 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_g, U_w, R_w	"clear wall" U- and R-value for: g = curtain wall and glazing w = steel stud assembly
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of curtain wall transition

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Exterior Insulation 1D R-Value (RSI)	R_{1D} $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	R_o $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	U_o Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)
R-7.5 (1.32)	R-21.7 (3.83)	R-16.6 (2.93)	0.060 (0.34)
R-15 (2.64)	R-29.2 (5.15)	R-24.0 (4.23)	0.042 (0.24)

Base Assembly – Curtain Wall Glazing

$U_{centre\ of\ glazing}$ Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)	U_g Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)
0.321 (1.82)	0.476 (2.7)

Curtain Wall Transition Linear Transmittance

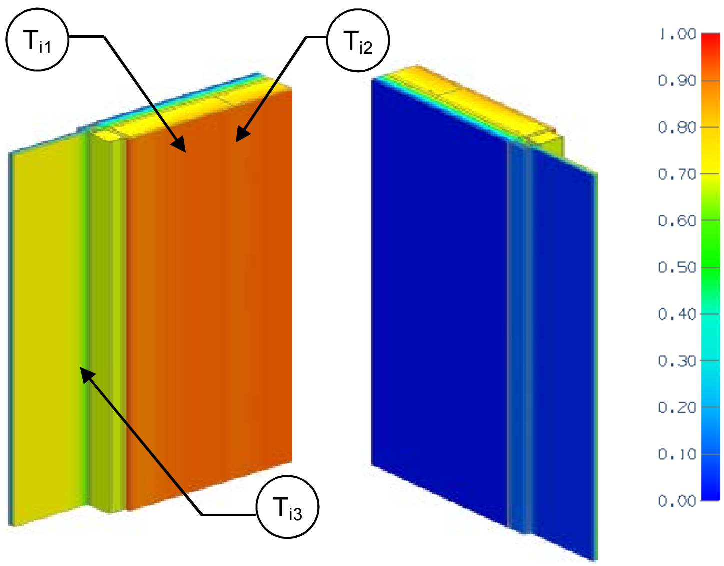
Jamb Transition	Exterior Insulation 1D R-Value (RSI)	R $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	U Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)	ψ Btu/ft hr ^oF (W/m K)
Without Insulation	R-7.5 (1.32)	R-4.5 (0.79)	0.224 (1.27)	0.043 (0.074)
	R-15 (2.64)	R-4.7 (0.83)	0.211 (1.20)	0.039 (0.067)
With Insulation	R-7.5 (1.32)	R-4.6 (0.81)	0.219 (1.24)	0.026 (0.044)
	R-15 (2.64)	R-4.9 (0.86)	0.205 (1.16)	0.019 (0.033)

Temperature Indices

	R7.5	R15	
T_{i1}	0.40	0.57	Min T on sheathing, between studs
T_{i2}	0.66	0.77	Max T on sheathing, along studs
T_{i3}	0.55	0.56	Min T on frame, at edge of frame at glass

Detail 3a

Exterior Insulated 3 5/8” x 1 5/8” Steel Stud (16” o.c.) Drained EIFS Wall Assembly – Conventional Curtain Wall Transition



View from Interior   View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-2.7 (0.47 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_g, U_w, R_w	“clear wall” U- and R-value for: g = curtain wall w = steel stud assembly
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of curtain wall transition

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Exterior Insulation 1D R-Value (RSI)	R_{1D} ft²·hr·°F / Btu (m² K / W)	R_o ft²·hr·°F / Btu (m² K / W)	U_o Btu/ft² ·hr ·°F (W/m² K)
R-7.5 (1.32)	R-10.2 (1.80)	R-10.0 (1.76)	0.100 (0.57)
R-11.3 (1.98)	R13.9 (2.46)	R-13.7 (2.41)	0.073 (0.41)
R-15 (2.64)	R-17.7 (3.12)	R-17.4 (3.06)	0.057 (0.33)

Base Assembly – Curtain Wall

$U_{centre\ of\ glazing}$ Btu/ft² ·hr ·°F (W/m² K)	U_g Btu/ft² ·hr ·°F (W/m² K)
0.321 (1.82)	0.476 (2.7)

Curtain Wall Transition Linear Transmittance

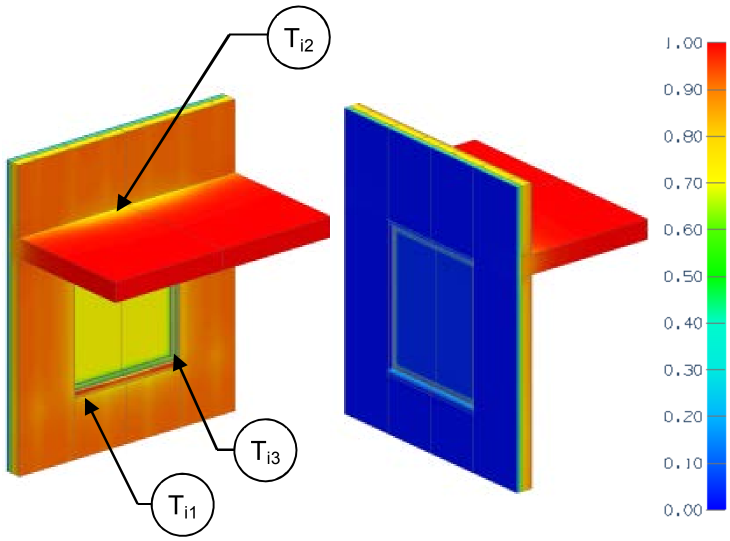
Exterior Insulation 1D R-Value (RSI)	Jamb Transition without Insulation			Jamb Transition with Insulation		
	R ft²·hr·°F / Btu (m² K / W)	U Btu/ft² ·hr ·°F (W/m² K)	ψ Btu/ft hr °F (W/m K)	R ft²·hr·°F / Btu (m² K / W)	U Btu/ft² ·hr ·°F (W/m² K)	ψ Btu/ft hr °F (W/m K)
R-7.5 (1.32)	R-4.0 (0.70)	0.250 (1.42)	0.045 (0.079)	R-4.1 (0.72)	0.24 (1.38)	0.024 (0.042)
R-11.3 (1.98)	R-4.3 (0.75)	0.234 (1.33)	0.049 (0.084)	R-4.4 (0.77)	0.23 (1.29)	0.027 (0.047)
R-15 (2.64)	R-4.4 (0.78)	0.225 (1.28)	0.051 (0.088)	R-4.6 (0.81)	0.22 (1.23)	0.023 (0.041)

Temperature Indices

	R7.5	R11.3	R15	
T_{i1}	0.62	0.64	0.65	Min T on sheathing, between studs
T_{i2}	0.81	0.86	0.89	Max T on sheathing, along studs
T_{i3}	0.56	0.56	0.57	Min T on frame, at edge of frame at glass

Detail 4

Exterior and Interior Insulated 3 5/8" x 1 5/8" Steel Stud (16" o.c.) Drained EIFS Wall Assembly – Window and Floor Slab Intersection



View from Interior   View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-14.2 (2.51 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_o, R_o	"clear wall" U- and R-value, without slab and window
Transmittance / Resistance	U_s, R_s, U_g	U and R-values for s = wall + slab g = glazing
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ_s, ψ_g	Incremental increase in transmittance per linear length of s = slab g = glazing transition

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Exterior Insulation 1D R-Value (RSI)	R_{1D} ft^2·hr·^{o}F / Btu (m^2 K / W)	R_o ft^2·hr·^{o}F / Btu (m^2 K / W)	U_o Btu/ft^2 ·hr ·^{o}F (W/m^2 K)
R-7.5 (1.32)	R-21.7 (3.83)	R-16.6 (2.93)	0.060 (0.34)
R-15 (2.64)	R-29.2 (5.15)	R-24.0 (4.23)	0.042 (0.24)

Base Assembly - Glazing

$U_{centre\ of\ glazing}$ Btu/ft^2 ·hr ·^{o}F (W/m^2 K)	U_g Btu/ft^2 ·hr ·^{o}F (W/m^2 K)
0.321 (1.82)	0.400 (2.27)

Slab Linear Transmittance

Exterior Insulation 1D R-Value (RSI)	R_s ft^2·hr·^{o}F / Btu (m^2 K / W)	U_s Btu/ft^2 ·hr ·^{o}F (W/m^2 K)	ψ_s Btu/ft^2 ·hr ·^{o}F (W/m^2 K)
R-7.5 (1.32)	R-14.5 (2.55)	0.069 (0.39)	0.076 (0.132)
R-15 (2.64)	R-22.0 (3.88)	0.045 (0.26)	0.032 (0.056)

Window Transition Linear Transmittance

R ft^2·hr·^{o}F / Btu (m^2 K / W)	U Btu/ft^2 ·hr ·^{o}F (W/m^2 K)	ψ_g[2] Btu/ft hr ^{o}F (W/m K)
R-5.6 (0.98)	0.180 (1.02)	0.136 (0.236)
R-6.1 (1.07)	0.165 (0.94)	0.155 (0.268)

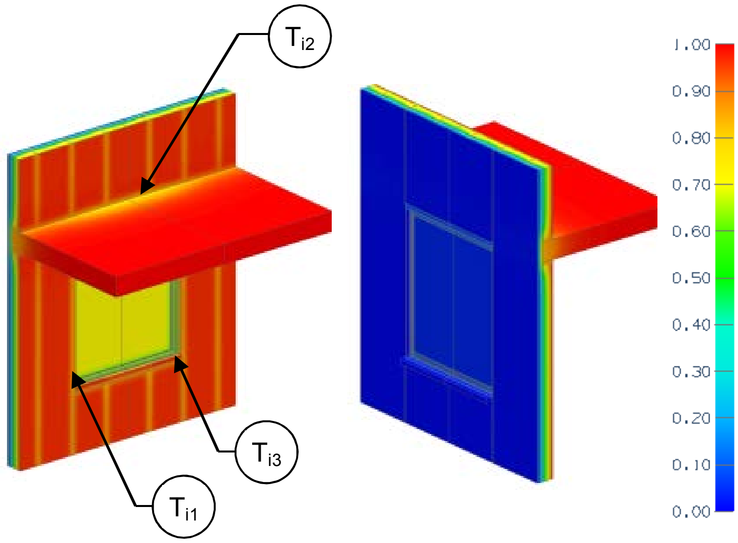
Temperature Indices

	R7.5	R15	
T_{i1}	0.25	0.26	Min T on sheathing, below window sill between studs
T_{i2}	0.84	0.89	Max T on sheathing, along steel tracks at slab
T_{i3}	0.52	0.53	Min T on window frame, at corner of window at glass

[2]For the linear transmittance, use the window perimeter

Detail 4i

Exterior and Interior Insulated 3 5/8" x 1 5/8" Steel Stud (16" o.c.) Drained EIFS Wall Assembly – Window with Aerogel and Floor Slab Intersection



View from Interior

View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-14.2 (2.51 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_o, R_o	"clear wall" U- and R-value, without slab and window
Transmittance / Resistance	U_s, R_s, U_g	U and R-values for s = wall + slab g = glazing
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ_s, ψ_g	Incremental increase in transmittance per linear length of s = slab g = glazing transition

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Exterior Insulation 1D R-Value (RSI)	R_{1D} ft^2·hr·^{o}F / Btu (m^2 K / W)	R_o ft^2·hr·^{o}F / Btu (m^2 K / W)	U_o Btu/ft^2 ·hr ·^{o}F (W/m^2 K)
R-7.5 (1.32)	R-21.7 (3.83)	R-16.6 (2.93)	0.060 (0.34)
R-15 (2.64)	R-29.2 (5.15)	R-24.0 (4.23)	0.042 (0.24)

Base Assembly - Glazing

$U_{centre\ of\ glazing}$ Btu/ft^2 ·hr ·^{o}F (W/m^2 K)	U_g Btu/ft^2 ·hr ·^{o}F (W/m^2 K)
0.321 (1.82)	0.400 (2.27)

Slab Linear Transmittance

Exterior Insulation 1D R-Value (RSI)	R_s ft^2·hr·^{o}F / Btu (m^2 K / W)	U_s Btu/ft^2 ·hr ·^{o}F (W/m^2 K)	ψ_s Btu/ft^2 ·hr ·^{o}F (W/m^2 K)
R-7.5 (1.32)	R-14.5 (2.55)	0.069 (0.39)	0.076 (0.132)
R-15 (2.64)	R-22.0 (3.88)	0.045 (0.26)	0.032 (0.056)

Window Transition Linear Transmittance

R ft^2·hr·^{o}F / Btu (m^2 K / W)	U Btu/ft^2 ·hr ·^{o}F (W/m^2 K)	ψ_g[2] Btu/ft hr ^{o}F (W/m K)
R-6.0 (1.05)	0.168 (0.95)	0.083 (0.144)
R-6.5 (1.15)	0.154 (0.87)	0.103 (0.178)

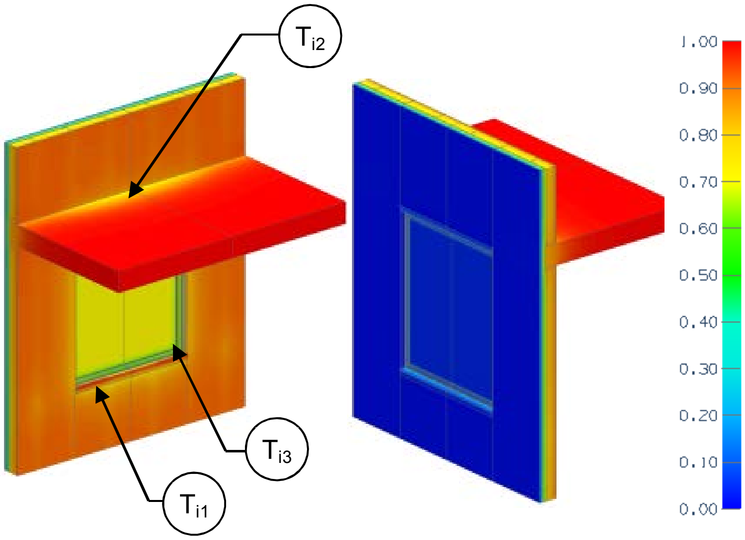
Temperature Indices

	R7.5	R15	
T_{i1}	0.39	0.51	Min T on sheathing, below window sill between studs
T_{i2}	0.85	0.90	Max T on sheathing, along steel tracks at slab
T_{i3}	0.56	0.57	Min T on window frame, at corner of window at glass

[2]For the linear transmittance, use the window perimeter

Detail 4a

Exterior Insulated 3 5/8” x 1 5/8” Steel Stud (16” o.c.) Drained EIFS Wall Assembly – Window and Floor Slab Intersection



View from Interior View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-2.7 (0.47 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_o, R_o	“clear wall” U- and R-value, without slab and window
Transmittance / Resistance	U_s, R_s, U_g	U and R-values for s = wall + slab g = glazing
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ_s, ψ_g	Incremental increase in transmittance per linear length of s = slab g = glazing transition

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Exterior Insulation 1D R-Value (RSI)	R_{1D} $ft^2·hr·^oF$ / Btu (m^2 K / W)	R_o $ft^2·hr·^oF$ / Btu (m^2 K / W)	U_o Btu/ft^2 ·hr ·^oF (W/m^2 K)
R-7.5 (1.32)	R-10.2 (1.80)	R-10.0 (1.76)	0.100 (0.57)
R-11.3 (1.98)	R-13.9 (2.46)	R-13.7 (2.41)	0.073 (0.41)
R-15 (2.64)	R-17.7 (3.12)	R-17.4 (3.06)	0.057 (0.33)

Base Assembly - Glazing

$U_{centre\ of\ glazing}$ Btu/ft^2 ·hr ·^oF (W/m^2 K)	U_g Btu/ft^2 ·hr ·^oF (W/m^2 K)
0.321 (1.82)	0.400 (2.27)

Slab Linear Transmittance

Exterior Insulation 1D R-Value (RSI)	R_s $ft^2·hr·^oF$ / Btu (m^2 K / W)	U_s Btu/ft^2 ·hr ·^oF (W/m^2 K)	ψ_s Btu/ft^2 ·hr ·^oF (W/m^2 K)
R-7.5 (1.32)	R-9.7 (1.70)	0.104 (0.59)	0.032 (0.055)
R-11.3 (1.98)	R-13.3 (2.35)	0.075 (0.43)	0.018 (0.032)
R-15 (2.64)	R-17.0 (2.99)	0.059 (0.33)	0.012 (0.022)

Window Transition Linear Transmittance

R $ft^2·hr·^oF$ / Btu (m^2 K / W)	U Btu/ft^2 ·hr ·^oF (W/m^2 K)	ψ_g[2] Btu/ft hr ^oF (W/m K)
R-4.8 (0.84)	0.210 (1.19)	0.160 (0.277)
R-5.2 (0.92)	0.192 (1.09)	0.175 (0.303)
R-5.5 (0.97)	0.182 (1.03)	0.187 (0.324)

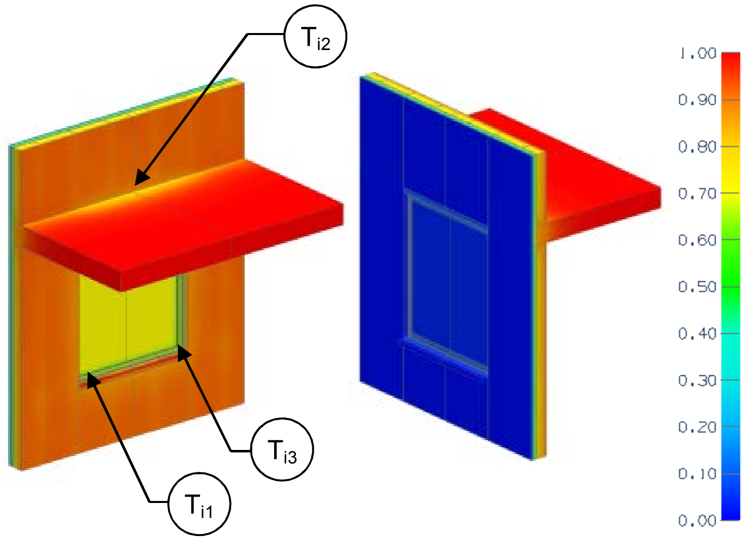
Temperature Indices

	R7.5	R11.3	R15	
T_{i1}	0.33	0.33	0.34	Min T on sheathing, below window sill
T_{i2}	0.86	0.89	0.91	Max T on sheathing, at slab intersection away from window
T_{i3}	0.55	0.56	0.56	Min T on window frame, at corner of window at glass

[2]For the linear transmittance, use the window perimeter

Detail 4ai

Exterior Insulated 3 5/8” x 1 5/8” Steel Stud (16” o.c.) Drained EIFS Wall Assembly – Window with Aerogel and Floor Slab Intersection with Aerogel



View from Interior View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-2.7 (0.47 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_o, R_o	“clear wall” U- and R-value, without slab and window
Transmittance / Resistance	U_s, R_s, U_g	U and R-values for s = wall + slab g = glazing
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ_s, ψ_g	Incremental increase in transmittance per linear length of s = slab g = glazing transition

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Exterior Insulation 1D R-Value (RSI)	R_{1D} ft²·hr·°F / Btu (m² K / W)	R_o ft²·hr·°F / Btu (m² K / W)	U_o Btu/ft² ·hr ·°F (W/m² K)
R-7.5 (1.32)	R-10.2 (1.80)	R-10.0 (1.76)	0.100 (0.57)
R-11.3 (1.98)	R-13.9 (2.46)	R-13.7 (2.41)	0.073 (0.41)
R-15 (2.64)	R-17.7 (3.12)	R-17.4 (3.06)	0.057 (0.33)

Base Assembly - Glazing

$U_{centre\ of\ glazing}$ Btu/ft² ·hr ·°F (W/m² K)	U_g Btu/ft² ·hr ·°F (W/m² K)
0.321 (1.82)	0.400 (2.27)

Slab Linear Transmittance

Exterior Insulation 1D R-Value (RSI)	R_s ft²·hr·°F / Btu (m² K / W)	U_s Btu/ft² ·hr ·°F (W/m² K)	ψ_s Btu/ft² ·hr ·°F (W/m² K)
R-7.5 (1.32)	R-9.7 (1.70)	0.104 (0.59)	0.032 (0.055)
R-11.3 (1.98)	R-13.3 (2.35)	0.075 (0.43)	0.018 (0.032)
R-15 (2.64)	R-17.0 (2.99)	0.059 (0.33)	0.012 (0.022)

Window Transition Linear Transmittance

R ft²·hr·°F / Btu (m² K / W)	U Btu/ft² ·hr ·°F (W/m² K)	ψ_g[2] Btu/ft hr °F (W/m K)
R-5.1 (0.90)	0.196 (1.11)	0.093 (0.160)
R-5.7 (1.00)	0.176 (1.00)	0.103 (0.178)
R-6.0 (1.06)	0.166 (0.94)	0.112 (0.194)

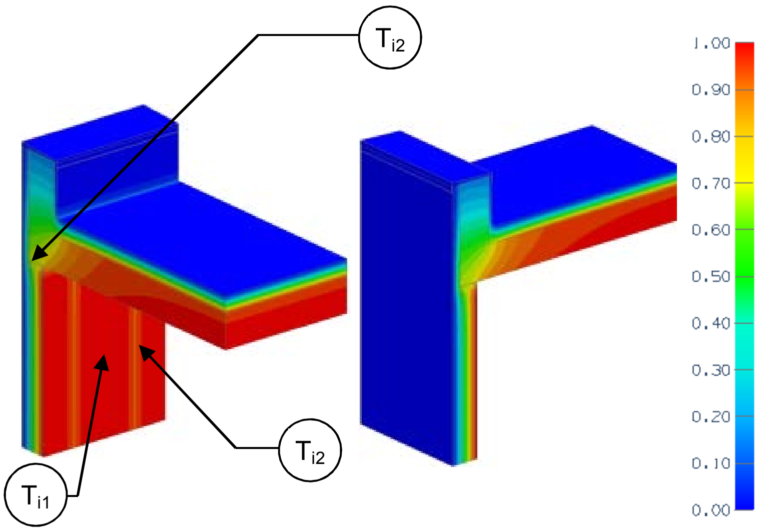
Temperature Indices

	R7.5	R11.3	R15	
T_{i1}	0.60	0.62	0.63	Min T on sheathing, below window sill
T_{i2}	0.87	0.90	0.92	Max T on sheathing, at slab intersection away from window
T_{i3}	0.59	0.59	0.59	Min T on window frame, at corner of window at glass

[2]For the linear transmittance, use the window perimeter

Detail 5

Exterior and Interior Insulated 3 5/8" x 1 5/8" Steel Stud (16" o.c.) Drained EIFS Wall Assembly – Concrete Parapet & Slab Intersection



View from Interior   View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1Dw}	R-14.2 (2.51 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_r, R_r, U_w, R_w	"clear field" U- and R-values for: r = roof w = wall
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of parapet

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Exterior Insulation 1D R-Value (RSI)	R_{1Dw} $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	R_w $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	U_w Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)
R-7.5 (1.32)	R-21.7 (3.83)	R-16.6 (2.93)	0.060 (0.34)
R-15 (2.64)	R-29.2 (5.15)	R-24 (4.23)	0.042 (0.24)

Base Assembly - Roof

Roof Insulation 1D R-Value (RSI)	R_r ft^2 hr ${}^oF$ / Btu (m^2 K / W)	U_r Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)
R-20 (3.52)	R-21.9 (3.86)	0.046 (0.26)

Parapet Linear Transmittance

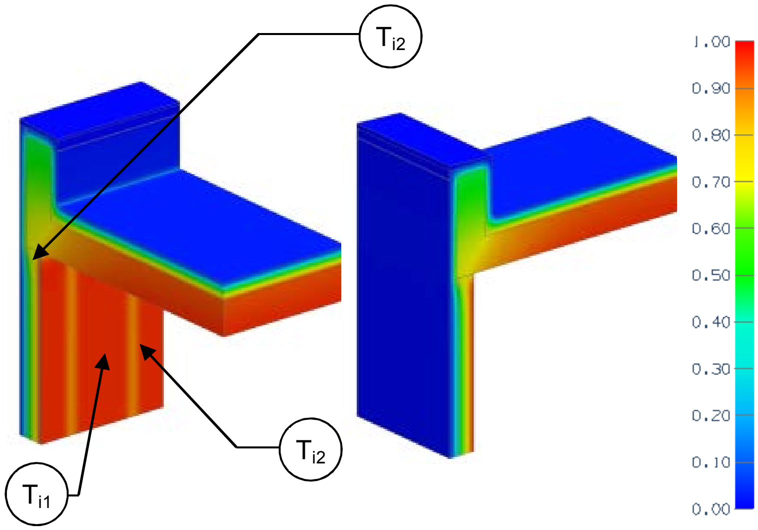
Exterior Insulation 1D R-Value (RSI)	R $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	U Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)	ψ Btu/ft hr ${}^oF$ (W/m K)
R-7.5 (1.32)	R-7.7 (1.35)	0.130 (0.74)	0.297 (0.514)
R-15 (2.64)	R-8.9 (1.57)	0.112 (0.64)	0.260 (0.451)

Temperature Indices

	R7.5	R15	
T_{i1}	0.41	0.58	Min T on sheathing, between studs
T_{i2}	0.68	0.77	Max T on sheathing, along steel studs
T_{i3}	0.75	0.78	Min T on concrete ceiling, at drywall intersection, exposed to interior air

Detail 5i

Exterior and Interior Insulated 3 5/8” x 1 5/8” Steel Stud (16” o.c.) Drained EIFS Wall Assembly – Insulated Concrete Parapet & Slab Intersection



View from Interior   View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1Dw}	R-14.2 (2.51 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_r, R_r, U_w, R_w,	“clear field” U- and R-values for: r = roof w = wall
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of parapet

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Exterior Insulation 1D R-Value (RSI)	R_{1Dw} $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	R_w $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	U_w Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)
R-7.5 (1.32)	R-21.7 (3.83)	R-16.6 (2.93)	0.060 (0.34)
R-15 (2.64)	R-29.2 (5.15)	R-24 (4.23)	0.042 (0.24)

Base Assembly - Roof

Roof Insulation 1D R-Value (RSI)	R_r ft^2 hr ${}^oF$ / Btu (m^2 K / W)	U_r Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)
R-20 (3.52)	R-21.9 (3.86)	0.046 (0.26)

Parapet Linear Transmittance

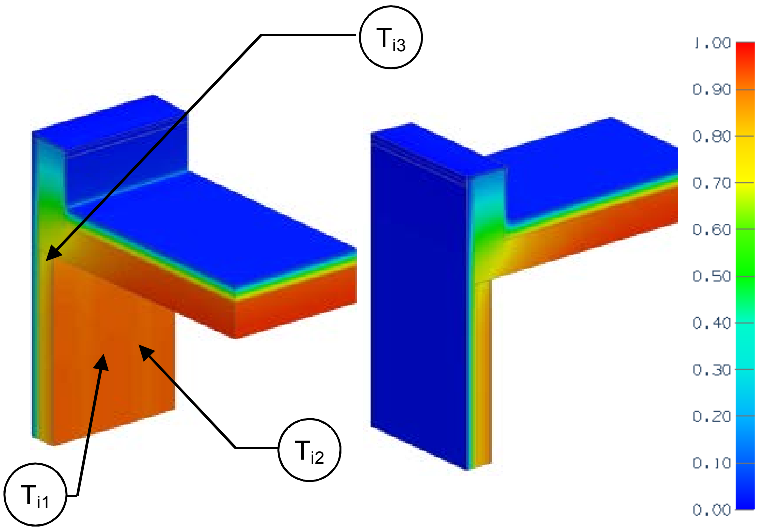
Exterior Insulation 1D R-Value (RSI)	R $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	U Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)	ψ Btu/ft hr ${}^oF$ (W/m K)
R-7.5 (1.32)	R-8.5 (1.50)	0.118 (0.67)	0.225 (0.390)
R-15 (2.64)	R-10.1 (1.78)	0.099 (0.56)	0.186 (0.323)

Temperature Indices

	R7.5	R15	
T_{i1}	0.41	0.51	Min T on sheathing, between studs
T_{i2}	0.72	0.78	Max T on sheathing, along steel studs
T_{i3}	0.75	0.84	Min T on concrete ceiling, at drywall intersection, exposed to interior air

Detail 5a

Exterior Insulated 3 5/8" x 1 5/8" Steel Stud (16" o.c.) Drained EIFS Wall Assembly – Concrete Parapet & Slab Intersection



View from Interior   View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1Dw}	R-2.7 (0.47 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_r, R_r, U_w, R_w	"clear field" U- and R-values for: r = roof w = wall
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of parapet

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Exterior Insulation 1D R-Value (RSI)	R_{1Dw} ft²·hr·°F / Btu (m² K / W)	R_w ft²·hr·°F / Btu (m² K / W)	U_w Btu/ft² ·hr ·°F (W/m² K)
R-7.5 (1.32)	R-10.2 (1.80)	R-10.0 (1.76)	0.100 (0.57)
R-11.3 (1.98)	R-13.9 (2.46)	R-13.7 (2.41)	0.073 (0.41)
R-15 (2.64)	R-17.7 (3.12)	R-17.4 (3.06)	0.057 (0.33)

Base Assembly - Roof

Roof Insulation 1D R-Value (RSI)	R_r ft² hr °F / Btu (m² K / W)	U_r Btu/ft² ·hr ·°F (W/m² K)
R-20 (3.52)	R-21.9 (3.86)	0.046 (0.26)

Parapet Linear Transmittance

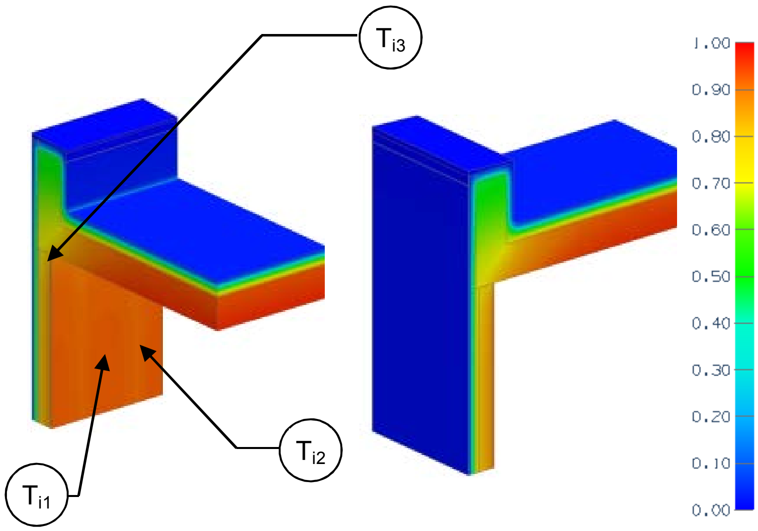
Exterior Insulation 1D R-Value (RSI)	R ft²·hr·°F / Btu (m² K / W)	U Btu/ft² ·hr ·°F (W/m² K)	ψ Btu/ft hr °F (W/m K)
R-7.5 (1.32)	R-6.5 (1.14)	0.155 (0.88)	0.295 (0.511)
R-11.3 (1.98)	R-7.5 (1.31)	0.134 (0.76)	0.273 (0.472)
R-15 (2.64)	R-8.1 (1.43)	0.123 (0.70)	0.263 (0.456)

Temperature Indices

	R7.5	R11.3	R15	
T_{i1}	0.71	0.74	0.76	Min T on sheathing, at roof slab
T_{i2}	0.82	0.87	0.89	Max T on sheathing, along steel studs away from slab
T_{i3}	0.77	0.79	0.81	Min T on concrete ceiling, at drywall intersection, exposed to interior air

Detail 5ai

Exterior Insulated 3 5/8” x 1 5/8” Steel Stud (16” o.c.) Drained EIFS Wall Assembly – Insulated Concrete Parapet & Slab Intersection



View from Interior

View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1Dw}	R-2.7 (0.47 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_r, R_r, U_w, R_w	“clear field” U- and R-values for: r = roof w = wall
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of parapet

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Exterior Insulation 1D R-Value (RSI)	R_{1Dw} $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	R_w $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	U_w Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)
R-7.5 (1.32)	R-10.2 (1.80)	R-10.0 (1.76)	0.100 (0.57)
R-11.3 (1.98)	R-13.9 (2.46)	R-13.7 (2.41)	0.073 (0.41)
R-15 (2.64)	R-17.7 (3.12)	R-17.4 (3.06)	0.057 (0.33)

Base Assembly - Roof

Roof Insulation 1D R-Value (RSI)	R_r ft^2 hr ${}^oF$ / Btu (m^2 K / W)	U_r Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)
R-20 (3.52)	R-21.9 (3.86)	0.046 (0.26)

Parapet Linear Transmittance

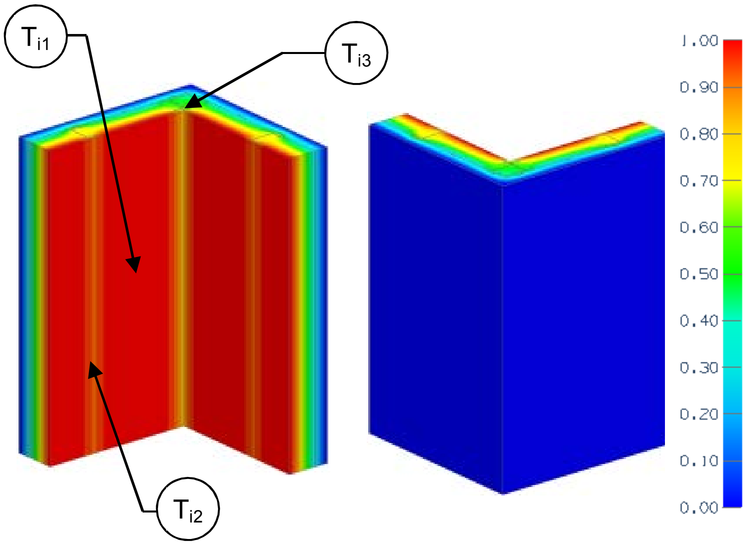
Exterior Insulation 1D R-Value (RSI)	R $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	U Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)	ψ Btu/ft hr ${}^oF$ (W/m K)
R-7.5 (1.32)	R-7.1 (1.24)	0.141 (0.80)	0.220 (0.380)
R-11.3 (1.98)	R-8.7 (1.53)	0.115 (0.66)	0.168 (0.291)
R-15 (2.64)	R-10.0 (1.76)	0.100 (0.57)	0.138 (0.238)

Temperature Indices

	R7.5	R11.3	R15	
T_{i1}	0.75	0.81	0.84	Min T on sheathing, along roof slab
T_{i2}	0.82	0.87	0.89	Max T on sheathing, along steel studs away from slab
T_{i3}	0.81	0.85	0.87	Min T on concrete ceiling, at drywall intersection, exposed to interior air

Detail 6

Exterior and Interior Insulated 3 5/8” x 1 5/8” Steel Stud (16” o.c.) Drained EIFS Wall Assembly – Corner Intersection



View from Interior   View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-14.2 (2.51 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_o, R_o	“clear wall” U- and R-value, without corner
Transmittance / Resistance	U, R	U- and R-values for the overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of corner

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

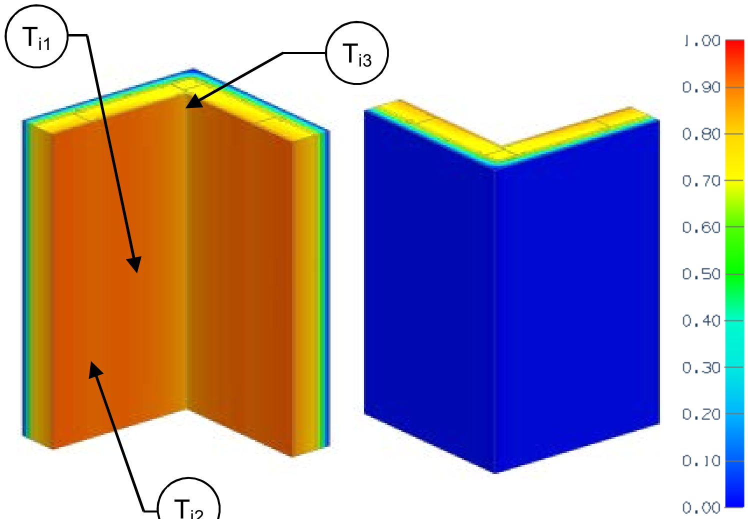
Exterior Insulation 1D R-Value (RSI)	R_{1D} ft²·hr·°F / Btu (m² K / W)	R_o ft²·hr·°F / Btu (m² K / W)	U_o Btu/ft² ·hr ·°F (W/m² K)	R ft²·hr·°F / Btu (m² K / W)	U Btu/ft² ·hr ·°F (W/m² K)	ψ Btu/ft hr °F (W/m K)
R-7.5 (1.32)	R-21.7 (3.83)	R-16.6 (2.93)	0.060 (0.34)	R-14.3 (2.52)	0.07 (0.40)	0.039 (0.067)
R-15 (2.64)	R-29.2 (5.15)	R-24.0 (4.23)	0.042 (0.24)	R-20.2 (3.56)	0.05 (0.28)	0.031 (0.054)

Temperature Indices

	R7.5	R15	
T_{i1}	0.39	0.56	Min T on sheathing, between studs
T_{i2}	0.66	0.77	Max T on sheathing, along studs away from corner
T_{i3}	0.75	0.81	Min T on drywall, at corner

Detail 6a

Exterior Insulated 3 5/8" x 1 5/8" Steel Stud (16" o.c.) Drained EIFS Wall Assembly – Corner Intersection



View from Interior   View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-2.7 (0.47 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_o, R_o	"clear wall" U- and R-value, without corner
Transmittance / Resistance	U, R	U- and R-values for the overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of corner

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

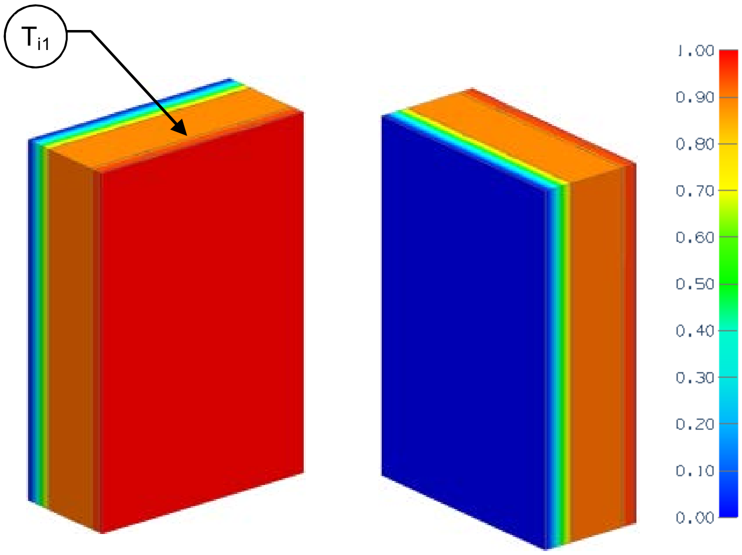
Exterior Insulation 1D R-Value (RSI)	R_{1D} $ft^2·hr·^oF$ / Btu (m^2 K / W)	R_o $ft^2·hr·^oF$ / Btu (m^2 K / W)	U_o Btu/ft^2 ·hr ·^oF (W/m^2 K)	R $ft^2·hr·^oF$ / Btu (m^2 K / W)	U Btu/ft^2 ·hr ·^oF (W/m^2 K)	ψ Btu/ft hr ^oF (W/m K)
R-7.5 (1.32)	R-10.2 (1.80)	R-10.0 (1.76)	0.100 (0.57)	R-8.7 (1.53)	0.120 (0.65)	0.060 (0.105)
R-11.3 (1.98)	R-13.9 (2.46)	R-13.7 (2.41)	0.073 (0.41)	R-11.7 (2.05)	0.090 (0.49)	0.051 (0.088)
R-15 (2.64)	R-17.7 (3.12)	R-17.4 (3.06)	0.057 (0.33)	R-14.6 (2.57)	0.070 (0.39)	0.044 (0.076)

Temperature Indices

	R7.5	R11.3	R15	
T_{i1}	0.64	0.71	0.76	Min T on sheathing, between studs
T_{i2}	0.81	0.86	0.89	Max T on sheathing, along studs away from corner
T_{i3}	0.83	0.87	0.90	Min T on drywall, at corner

Detail 7

Exterior Insulated Concrete Drained EIFS Wall Assembly - Clear Wall



View from Interior

View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-3.0 (0.53 RSI) + exterior insulation
Transmittance / Resistance	U_o, R_o	"clear wall" U- and R-value
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

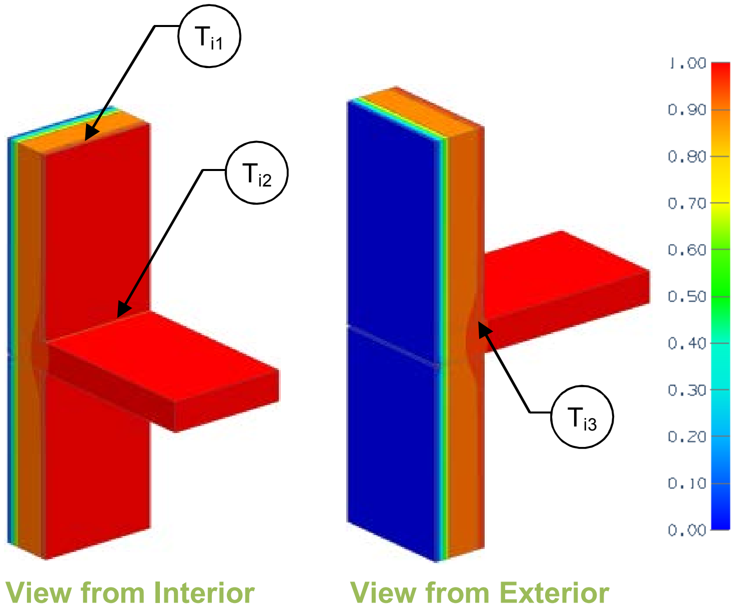
Exterior Insulation 1D R-Value (RSI)	R_{1D} ft^2·hr·^{o}F / Btu (m^2 K / W)	R_o ft^2·hr·^{o}F / Btu (m^2 K / W)	U_o Btu/ft^2 ·hr ·^{o}F (W/m^2 K)
R-15 (2.64)	R-18.0 (3.17)	R-17.6 (3.10)	0.057 (0.32)

Temperature Indices

T_{i1}	0.89	Consistent temperature along interior concrete surface

Detail 8

Exterior Insulated Concrete Drained EIFS Wall Assembly – Floor Slab Intersection



Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-3.0 (0.53 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_o, R_o	“clear wall” U- and R-value without slab
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of slab

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

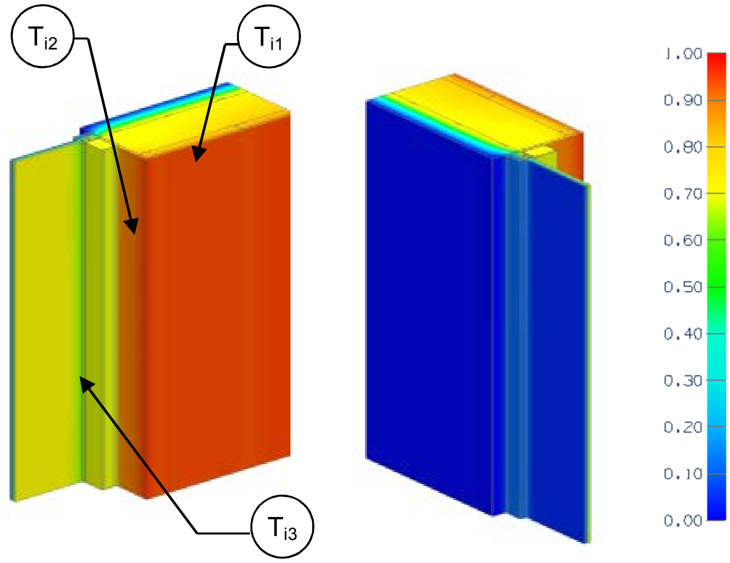
Exterior Insulation 1D R-Value (RSI)	R_{1D} ft^2·hr·^{o}F / Btu (m^2 K / W)	R_o ft^2·hr·^{o}F / Btu (m^2 K / W)	U_o Btu/ft^2 ·hr ·^{o}F (W/m^2 K)	R ft^2·hr·^{o}F / Btu (m^2 K / W)	U Btu/ft^2 ·hr ·^{o}F (W/m^2 K)	ψ Btu/ft^2 ·hr ·^{o}F (W/m^2 K)
R-15 (2.64)	R-18 (3.17)	R-17.6 (3.10)	0.057 (0.32)	R-17.1 (3.02)	0.058 (0.33)	0.013 (0.023)

Temperature Indices

T_{i1}	0.89	Min T on concrete wall, between studs away from floor slab
T_{i2}	0.92	Max T on concrete, along steel track of floor slab
T_{i3}	0.94	Min T on slab, at edge interior drywall, exposed to interior air

Detail 9

Exterior Insulated Concrete Drained EIFS Wall Assembly – Conventional Curtain Wall Transition



View from Interior   View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-3.0 (0.53 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_g, U_w, R_w	"clear wall" U- and R-value for: g = curtain wall glazing w = concrete assembly
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of curtain wall transition

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Exterior Insulation 1D R-Value (RSI)	R_{1D} ft²·hr·°F / Btu (m² K / W)	R_o ft²·hr·°F / Btu (m² K / W)	U_o Btu/ft² ·hr ·°F (W/m² K)
R-15 (2.64)	R-18 (3.17)	R-17.6 (3.10)	0.057 (0.32)

Base Assembly – Curtain Wall

$U_{centre\ of\ glazing}$ Btu/ft² ·hr ·°F (W/m² K)	U_g Btu/ft² ·hr ·°F (W/m² K)
R-1.2 (0.21)	0.476 (2.70)

Curtain Wall Transition Linear Transmittance

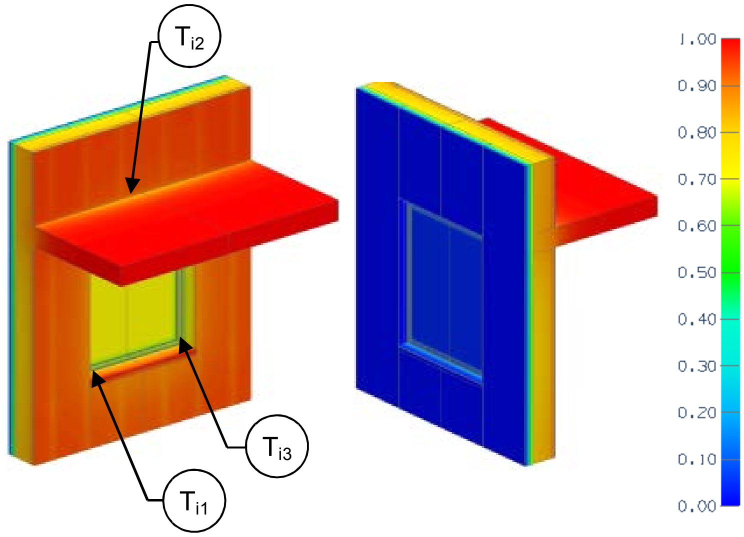
Jamb Transition	Exterior Insulation 1D R-Value (RSI)	R ft²·hr·°F / Btu (m² K / W)	U Btu/ft² ·hr ·°F (W/m² K)	ψ Btu/ft hr °F (W/m K)
Without Insulation	R-15 (2.64)	R-4.4 (0.78)	0.227 (1.29)	0.059 (0.103)
With Insulation	R-15 (2.64)	R-4.6 (0.81)	0.216 (1.23)	0.035 (0.060)

Temperature Indices

	Without Insulation	With Insulation	
T_{i1}	0.79	0.88	Min T on concrete interior face, between steel studs
T_{i2}	0.87	0.91	Max T on concrete, at drywall return
T_{i3}	0.58	0.56	Min T on curtain wall, at glass

Detail 10

Exterior Insulated Concrete Drained EIFS Wall Assembly – Window and Floor Slab Intersection



View from Interior

View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-3.0 (0.53 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_w, R_w, U_g	"clear wall" U- and R-value: w = wall without slab g = glazing
Transmittance / Resistance	U_s, R_s, U_t, R_t	U and R-values for s = wall + slab t = combined wall + slab + window
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ_s, ψ_g	Incremental increase in transmittance per linear length of: s = slab g = glazing transition

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Exterior Insulation 1D R-Value (RSI)	R_{1D} ft^2·hr·^{o}F / Btu (m^2 K / W)	R_o ft^2·hr·^{o}F / Btu (m^2 K / W)	U_o Btu/ft^2 ·hr ·^{o}F (W/m^2 K)
R-15 (2.64)	R-18 (3.17)	R-17.6 (3.10)	0.057 (0.32)

Base Assembly - Glazing

$U_{centre\ of\ glazing}$ Btu/ft^2 ·hr ·^{o}F (W/m^2 K)	U_g Btu/ft^2 ·hr ·^{o}F (W/m^2 K)
0.321 (1.82)	0.400 (2.27)

Slab Linear Transmittance

Exterior Insulation 1D R-Value (RSI)	R_s ft^2·hr·^{o}F / Btu (m^2 K / W)	U_s Btu/ft^2 ·hr ·^{o}F (W/m^2 K)	ψ_s Btu/ft^2 ·hr ·^{o}F (W/m^2 K)
R-15 (2.64)	R-17.1 (3.02)	0.058 (0.33)	0.013 (0.023)

Window Transition Linear Transmittance

R_t ft^2·hr·^{o}F / Btu (m^2 K / W)	U_t Btu/ft^2 ·hr ·^{o}F (W/m^2 K)	ψ_g[2] Btu/ft hr ^{o}F (W/m K)
R-6.1 (1.07)	0.164 (0.93)	0.106 (0.184)

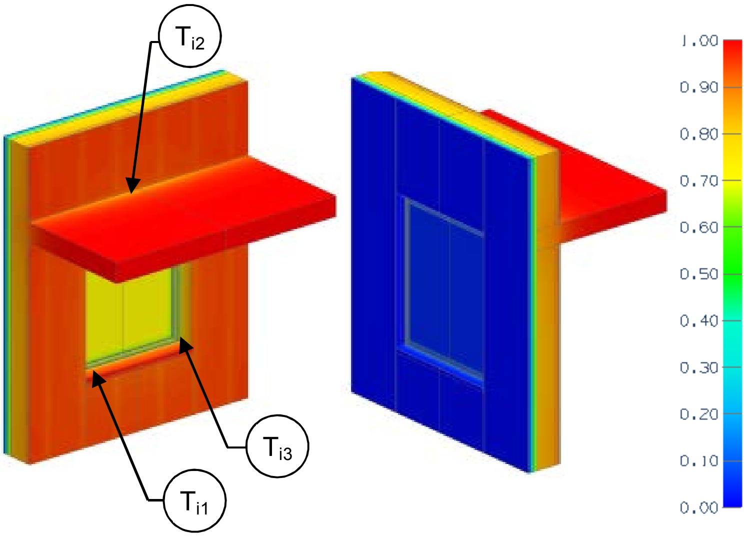
Temperature Indices

T_{i1}	0.73	Min T on concrete interior surface, below window sill between studs
T_{i2}	0.89	Max T on concrete, at floor slab intersection away from window
T_{i3}	0.60	Min T on window frame, at corner of glass

[2]For the linear transmittance, use the window perimeter

Detail 10i

Exterior Insulated Concrete Drained EIFS Wall Assembly – Window with Aerogel and Floor Slab Intersection



View from Interior   View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-3.0 (0.53 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_w, R_w, U_g	"clear wall" U- and R-value: w = wall without slab g = glazing
Transmittance / Resistance	U_s, R_s, U_t, R_t	U and R-values for: s = wall + slab t = combined wall + slab + window
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ_s, ψ_g	Incremental increase in transmittance per linear length of s = slab g = glazing transition

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Concrete Clear Wall

Exterior Insulation 1D R-Value (RSI)	R_{1D} ft^2·hr·^{o}F / Btu (m^2 K / W)	R_w ft^2·hr·^{o}F / Btu (m^2 K / W)	U_w Btu/ft^2 ·hr ·^{o}F (W/m^2 K)
R-15 (2.64)	R-18.0 (3.17)	R-17.6 (3.10)	0.057 (0.32)

Base Assembly - Glazing

$U_{centre\ of\ glazing}$ Btu/ft^2 ·hr ·^{o}F (W/m^2 K)	U_g Btu/ft^2 ·hr ·^{o}F (W/m^2 K)
0.321 (1.82)	0.400 (2.27)

Slab Linear Transmittance

Exterior Insulation 1D R-Value (RSI)	R_s ft^2·hr·^{o}F / Btu (m^2 K / W)	U_s Btu/ft^2 ·hr ·^{o}F (W/m^2 K)	ψ_s Btu/ft^2 ·hr ·^{o}F (W/m^2 K)
R-15 (2.64)	R-17.1 (3.02)	0.058 (0.33)	0.013 (0.023)

Window Transition Linear Transmittance

R_t ft^2·hr·^{o}F / Btu (m^2 K / W)	U_t Btu/ft^2 ·hr ·^{o}F (W/m^2 K)	ψ_g[2] Btu/ft hr ^{o}F (W/m K)
R-6.1 (1.07)	0.164 (0.93)	0.106 (0.184)

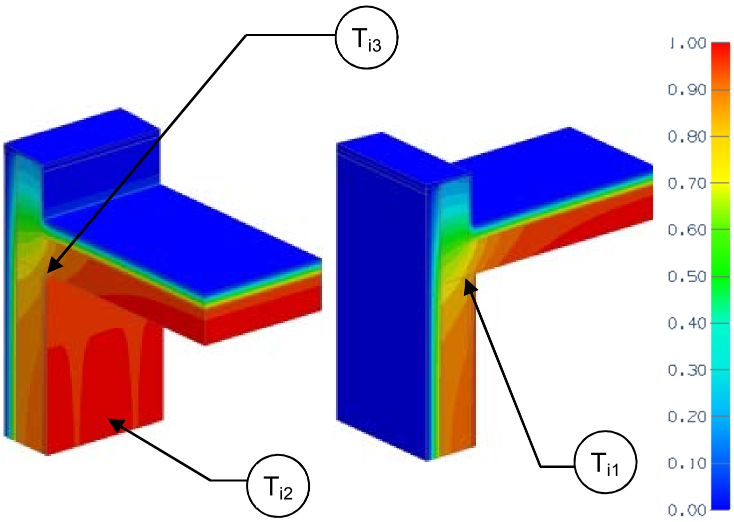
Temperature Indices

T_{i1}	0.82	Min T on concrete interior surface, below window sill between studs
T_{i2}	0.91	Max T on concrete, at floor slab intersection away from window
T_{i3}	0.59	Min T on window frame, at corner of glass

[2]For the linear transmittance, use the window perimeter

Detail 11

Exterior Insulated Concrete Drained EIFS Wall Assembly – Concrete Parapet & Slab Intersection



View from Interior   View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1Dw}	R-3.0 (0.53 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_r, R_r, U_w, R_w	"clear field" U- and R-values: r = roof w = wall
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of parapet

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Exterior Insulation 1D R-Value (RSI)	R_{1Dw} ft²·hr·°F / Btu (m² K / W)	R_w ft²·hr·°F / Btu (m² K / W)	U_w Btu/ft² ·hr ·°F (W/m² K)
R-15 (2.64)	R-18.0 (3.17)	R-17.6 (3.10)	0.057 (0.32)

Base Assembly - Roof

Roof Insulation 1D R-Value (RSI)	R_r ft² hr °F / Btu (m² K / W)	U_r Btu/ft² ·hr ·°F (W/m² K)
R-20 (3.52)	R-21.9 (3.86)	0.046 (0.26)

Parapet Linear Transmittance

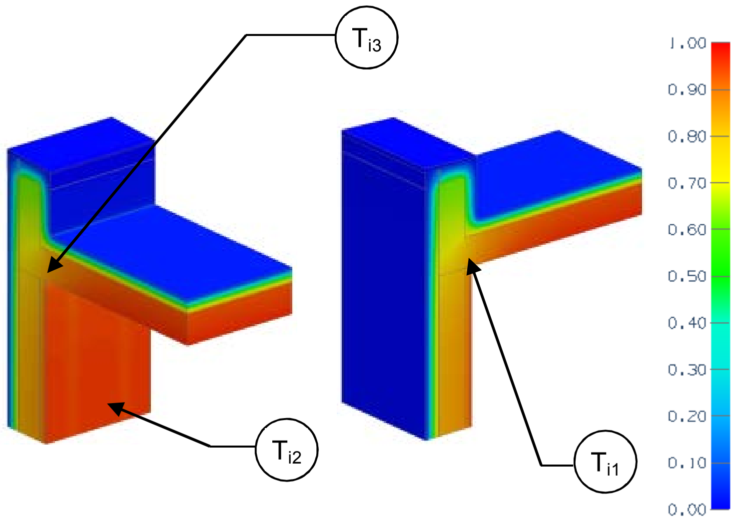
Exterior Insulation 1D R-Value (RSI)	R ft²·hr·°F / Btu (m² K / W)	U Btu/ft² ·hr ·°F (W/m² K)	ψ Btu/ft hr °F (W/m K)
R-15 (2.64)	R-8.6 (1.51)	0.117 (0.66)	0.231 (0.400)

Temperature Indices

T_{i1}	0.77	Min T on concrete interior surface, at concrete roof slab intersection
T_{i2}	0.88	Max T on concrete interior surface at mid-wall
T_{i3}	0.82	Min T on concrete ceiling, at drywall intersection, exposed to interior air

Detail 11i

Exterior Insulated Concrete Drained EIFS Wall Assembly – Insulated Concrete Parapet & Slab Intersection



View from Interior **View from Exterior**

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1Dw}	R-3.0 (0.53 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_r, R_r, U_w, R_w	"clear field" U- and R-value: r = roof w = wall
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of parapet

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Exterior Insulation 1D R-Value (RSI)	R_{1Dw} $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	R_w $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	U_w Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)
R-15 (2.64)	R-18.0 (3.17)	R-17.6 (3.10)	0.057 (0.32)

Base Assembly - Roof

Roof Insulation 1D R-Value (RSI)	R_r ft^2 hr ${}^oF$ / Btu (m^2 K / W)	U_r Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)
R-20 (3.52)	R-21.9 (3.86)	0.046 (0.26)

Parapet Linear Transmittance

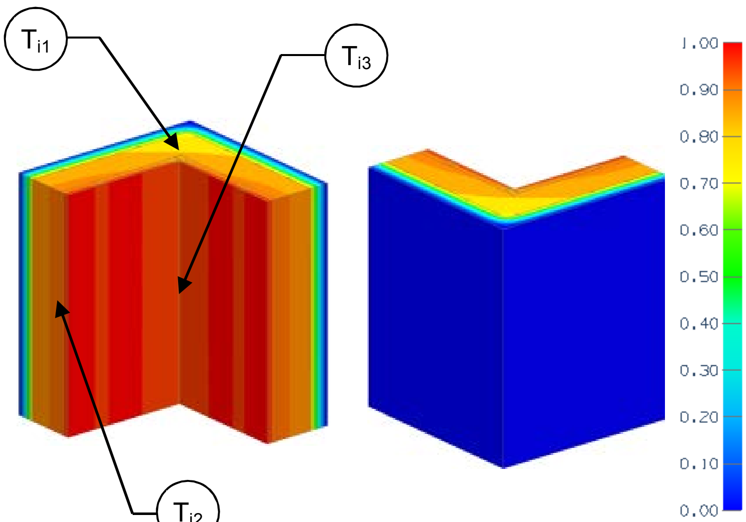
Exterior Insulation 1D R-Value (RSI)	R $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	U Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)	ψ Btu/ft hr ${}^oF$ (W/m K)
R-15 (2.64)	R-10.2 (1.80)	0.098 (0.55)	0.125 (0.217)

Temperature Indices

T_{i1}	0.83	Min T on concrete interior surface, at concrete roof slab intersection
T_{i2}	0.89	Max T on concrete interior surface, at mid-wall
T_{i3}	0.87	Min T on concrete ceiling, at drywall intersection, exposed to interior air

Detail 12

Exterior Insulated Concrete Drained EIFS Wall Assembly – Corner Intersection



View from Interior

View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-3.0 (0.53 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_o, R_o	“clear wall” U- and R-value, without corner
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of corner

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

Exterior Insulation 1D R-Value (RSI)	R_{1D} ft²·hr·°F / Btu (m² K / W)	R_o ft²·hr·°F / Btu (m² K / W)	U_o Btu/ft² ·hr ·°F (W/m² K)	R ft²·hr·°F / Btu (m² K / W)	U Btu/ft² ·hr ·°F (W/m² K)	ψ Btu/ft hr °F (W/m K)
R-15 (2.64)	R-18.0 (3.17)	R-17.6 (3.10)	0.057 (0.32)	R-13.1 (2.30)	0.08 (0.43)	0.085 (0.147)

Temperature Indices

T_{i1}	0.81	Min T on concrete interior surface, at corner
T_{i2}	0.87	Max T on concrete interior surface, between studs away from corner
T_{i3}	0.89	Min T on drywall, at corner