The Future of High-Performance Window Installations

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Agenda

1. Case Study: 825 Pacific Artist Hub

2. Post Construction Research Study

3. Window Install Optimization

BEST6

Case Study:
825 Pacific Artist Hub

Case Study: 825 Pacific Artist Hub

825 Pacific Artist Hub

Building Enclosure Façade: What did it take?

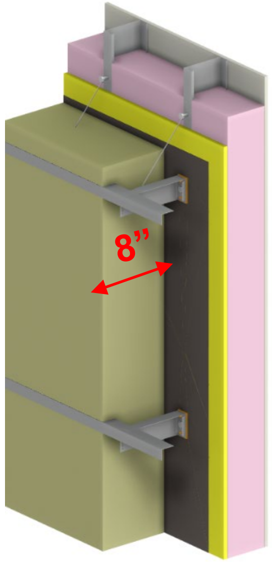
- **Windows:** R-7.8 effective (installed window average)
  - Cascadia Universal Series PH (cool temperate)
- **Walls Above Grade:** R-42 effective (clear field)
  - 17-inch total thickness
- **Optimized Thermal Bridge Detailing**
- **Airtightness:** 0.19 ACH @ 50 Pa

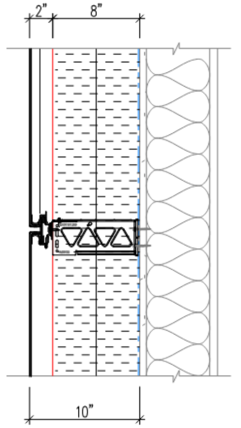
825 Pacific Artist Hub

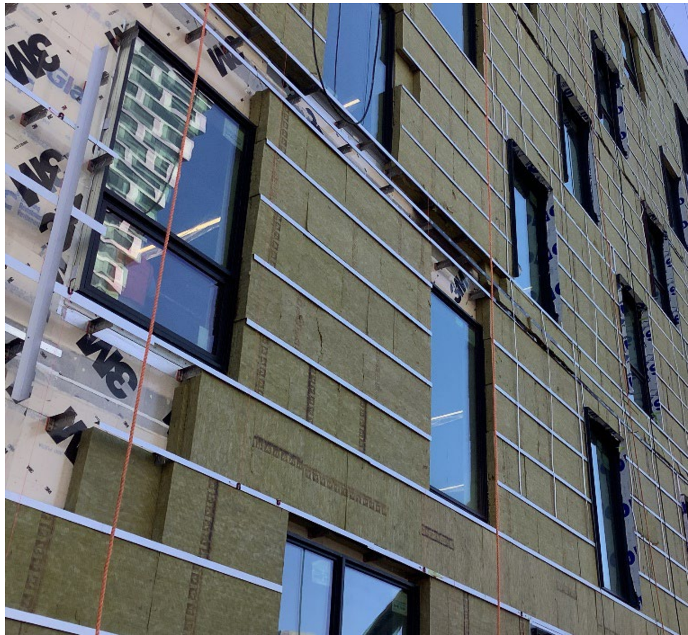
Building Enclosure Façade: Walls Above Grade

Walls Above Grade: R-42 effective (clear field)

- 8-inch exterior mineral wool insulation (Rockwool CavityRock)
- EJOT K1 200 Crossfix (bracket) w/ horizontal cladding attachment system
- R-22.5 mineral wool batt insulation (Rockwool ComfortBatt) in steel stud cavities

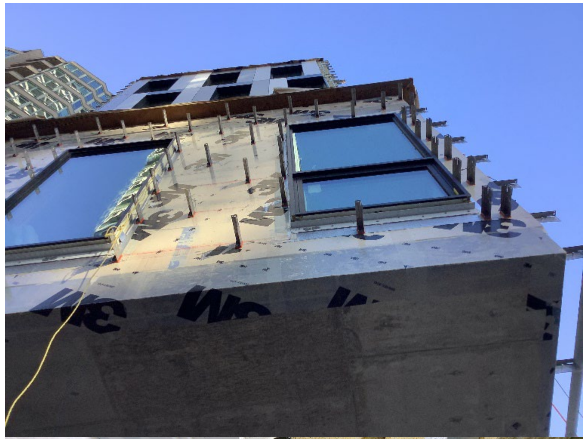


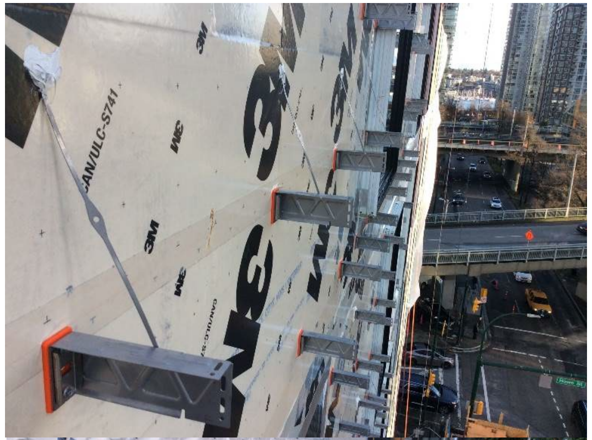


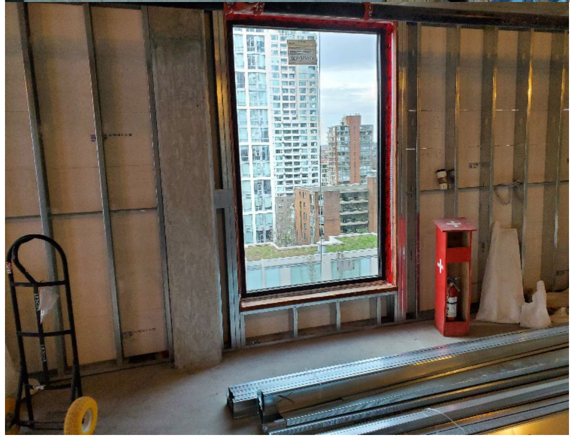


825 Pacific Artist Hub

Building Enclosure Façade: Walls Above Grade

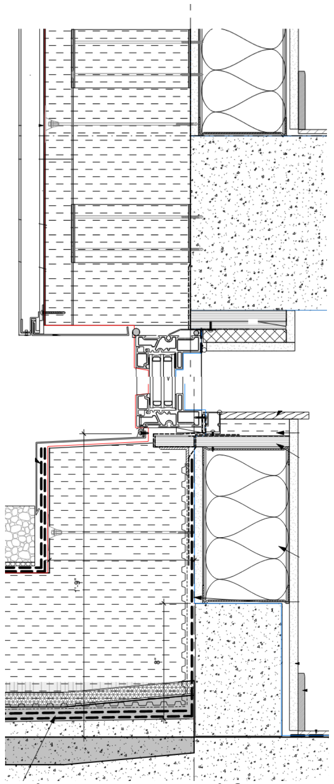




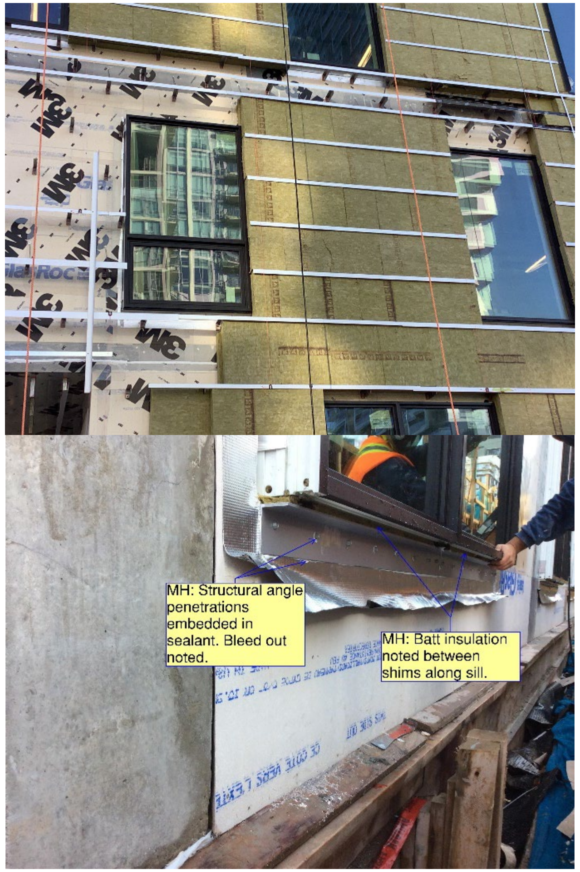


825 Pacific Artist Hub

Building Enclosure Façade: Windows



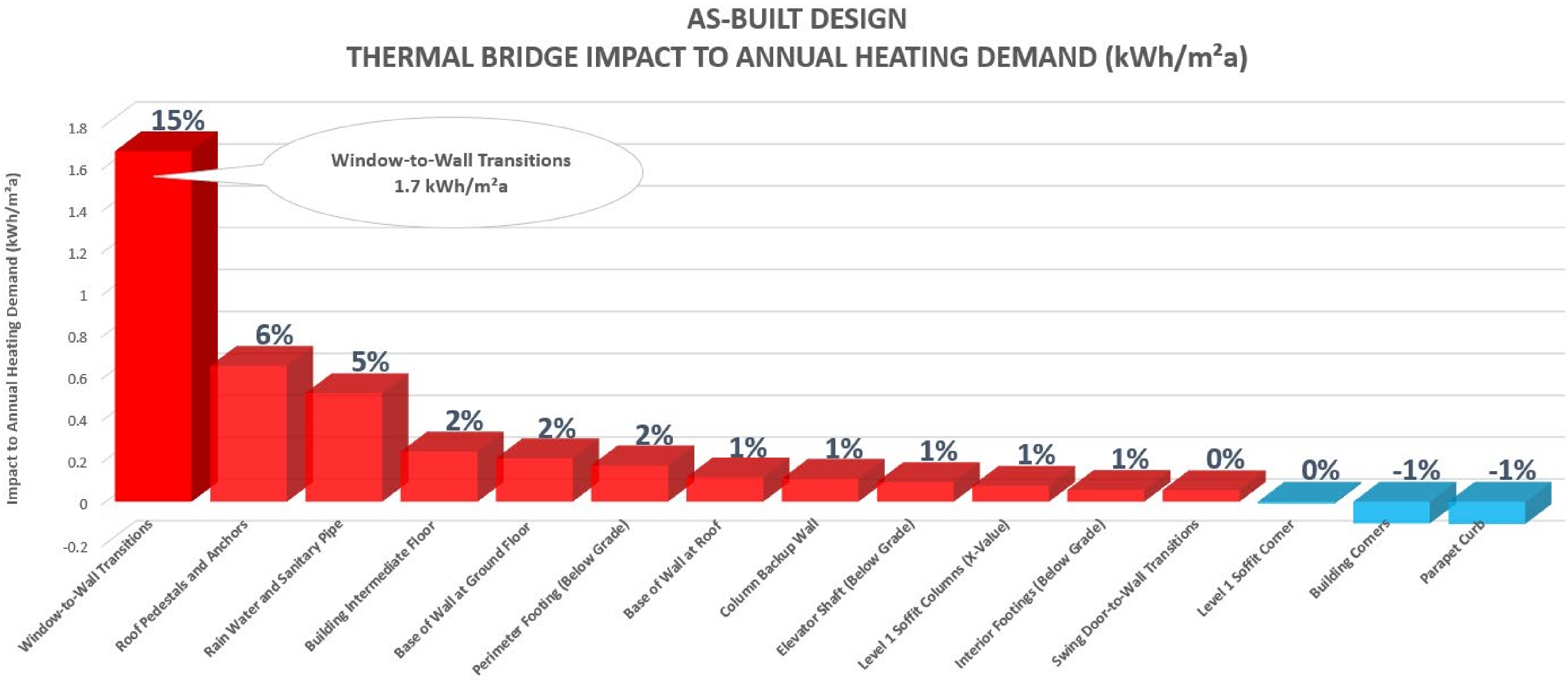
Schematic Detail for illustrative purposes only



825 Pacific Artist Hub

Building Enclosure Façade: Thermal Bridging Heat Loss

- Where are the high impact thermal bridges?



825 Pacific Artist Hub

Building Enclosure Façade: Thermal Bridging Heat Loss

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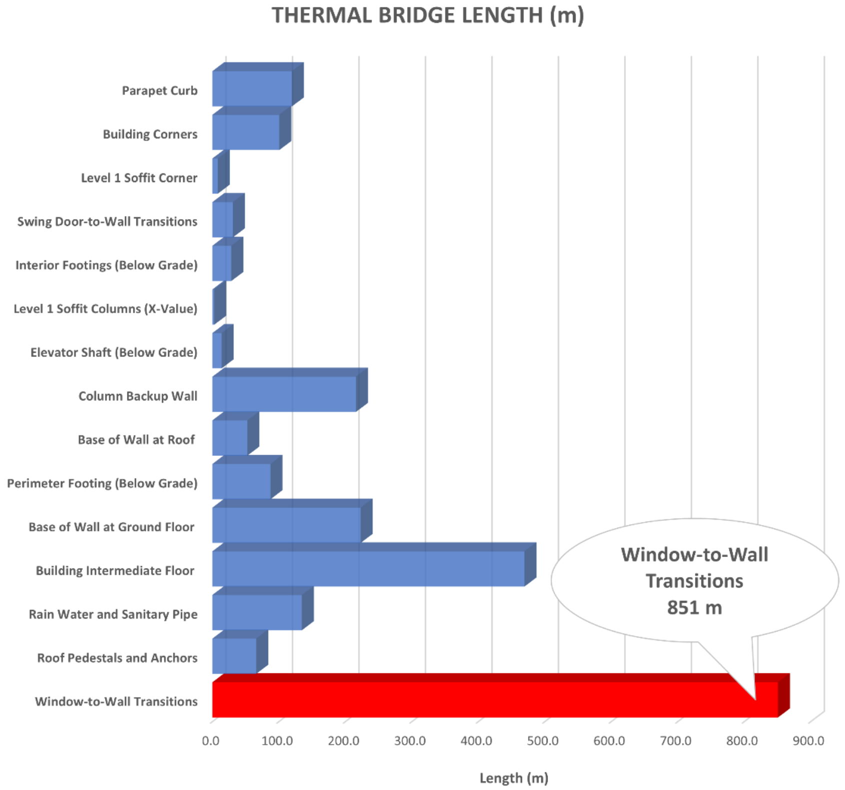


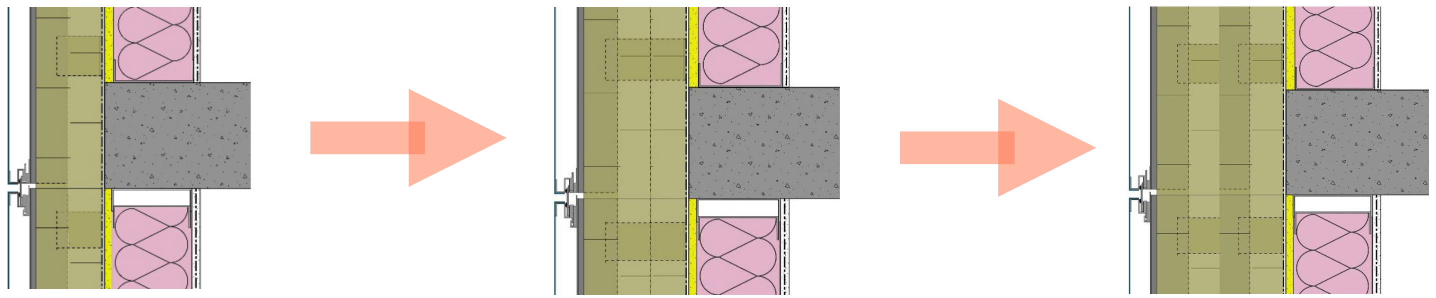
Post Construction Research Study: Optimized Window Installation at 825 Pacific Artist Hub

Post Construction Research Study: Optimized Window Installation at 825 Pacific Artist Hub

The Problem: Common Energy Conservation Measure (ECM)

Adding excessive insulation to external walls to compensate for heat loss borne from high impact thermal bridges – is this the best ECM approach?

- Lowering operational carbon, while increasing embodied carbon
- Potentially diminishing marketable floor area due to thicker walls

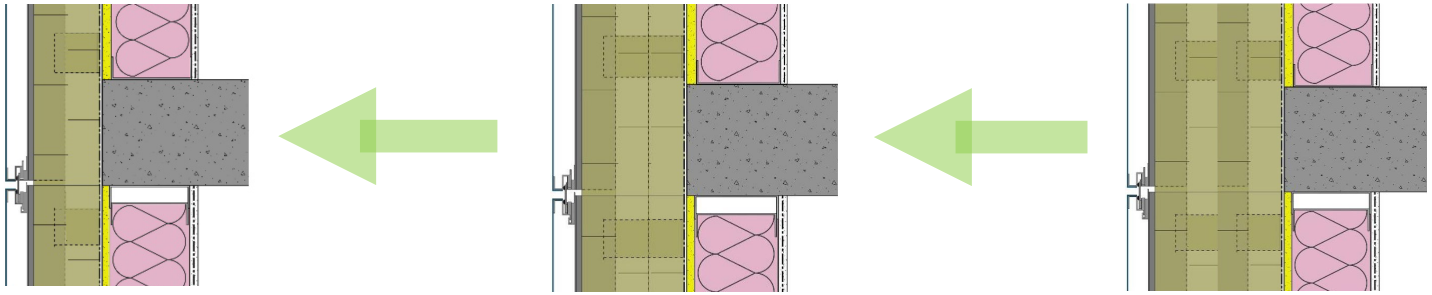


Post Construction Research Study: Optimized Window Installation at 825 Pacific Artist Hub

The Solution: Effective Energy Conservation Measure (ECM)

How to make high-rise Passive House walls thinner:

- Eliminate conservative assumptions at high impact thermal bridges
- Allocate resources to optimize high impact thermal bridges

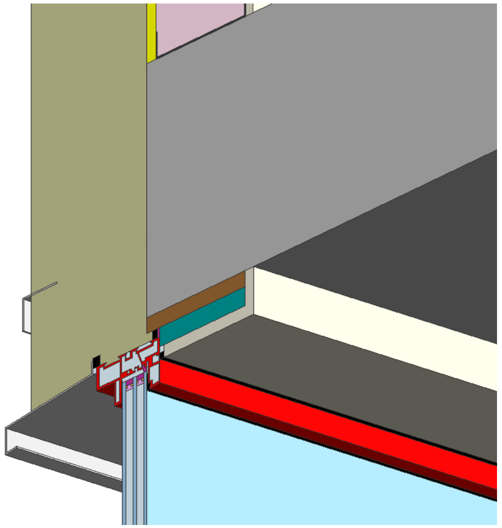


Post Construction Research Study: Optimized Window Installation at 825 Pacific Artist Hub

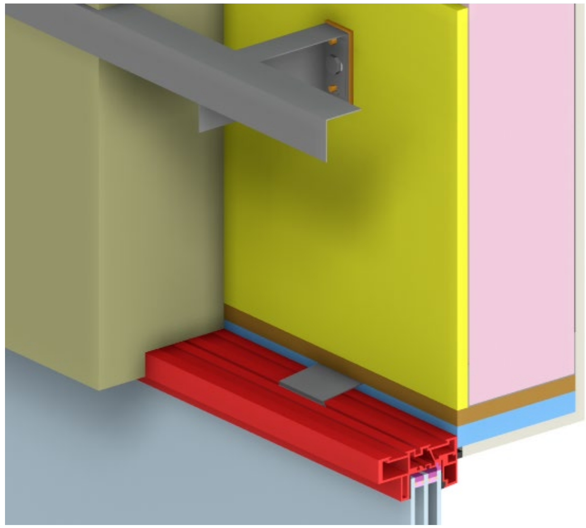
Objective

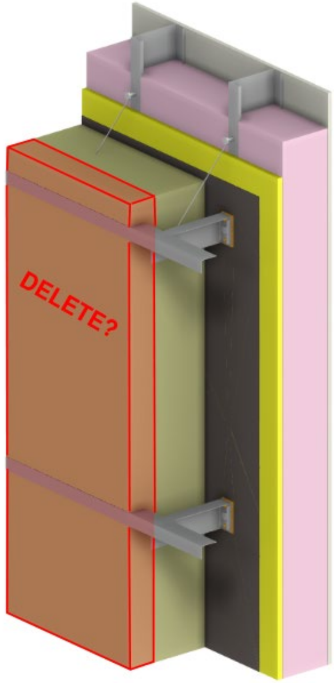
Determine if the high impact thermal bridges at window-to-wall transitions can be optimized to provide a trade-off opportunity with the external walls to reduce its 17-inch thickness

As-Built



Optimized



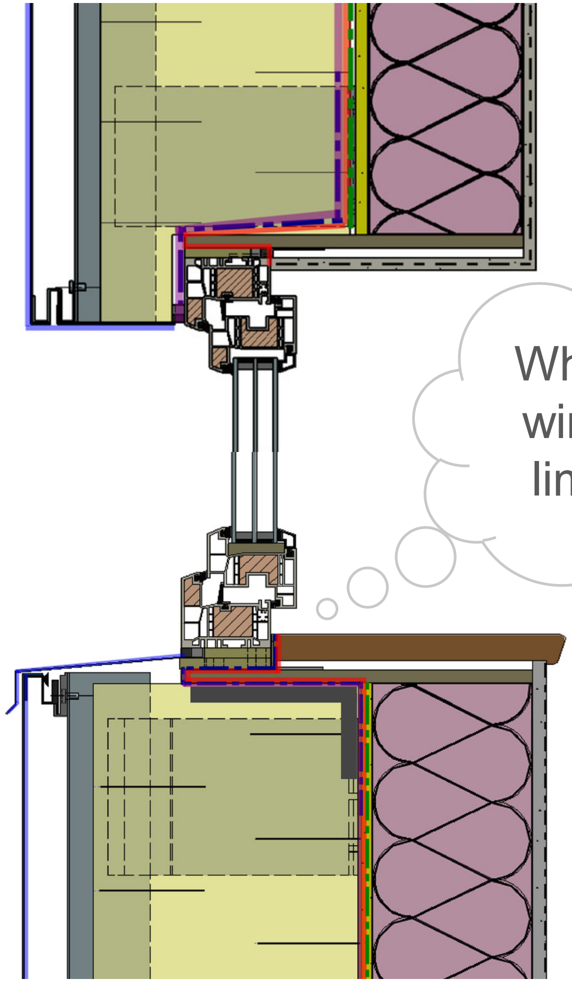


Post Construction Research Study: Optimized Window Installation at 825 Pacific Artist Hub

How do you optimize a window installation?

What reference documents are publicly available?

1. ThermalEnvelope.ca – Detail 5.3.22



What are the window size limitations?

ψ_{Head} Btu/ft·hr·°F (W/m K)	ψ_{Sill} Btu/ft·hr·°F (W/m K)	ψ_{Jamb} Btu/ft·hr·°F (W/m K)
0.027 (0.047)	0.057 (0.099)	0.063 (0.109)

Post Construction Research Study: Optimized Window Installation at 825 Pacific Artist Hub

How do you optimize a window installation?

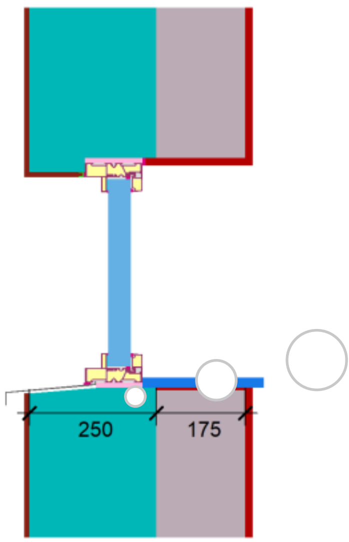
What reference documents are publicly available?

1. ThermalEnvelope.ca – Detail 5.3.22
2. PassiveHouseComponents.org – Component-ID 1256fx03

Is the thermal bridge reference acceptable to the Passive House Building Certifier?

Exterior insulation and finishing system (EIFS) (fixed glazed)

$U_{Wall} = 0.13\ W/(m^2 \cdot K)$



$\Psi_{install}$	$W/(m \cdot K)$
Top	0.008
Side	0.008
Bottom	0.016

$U_{W,installed} = 0.80\ W/(m^2 \cdot K)$

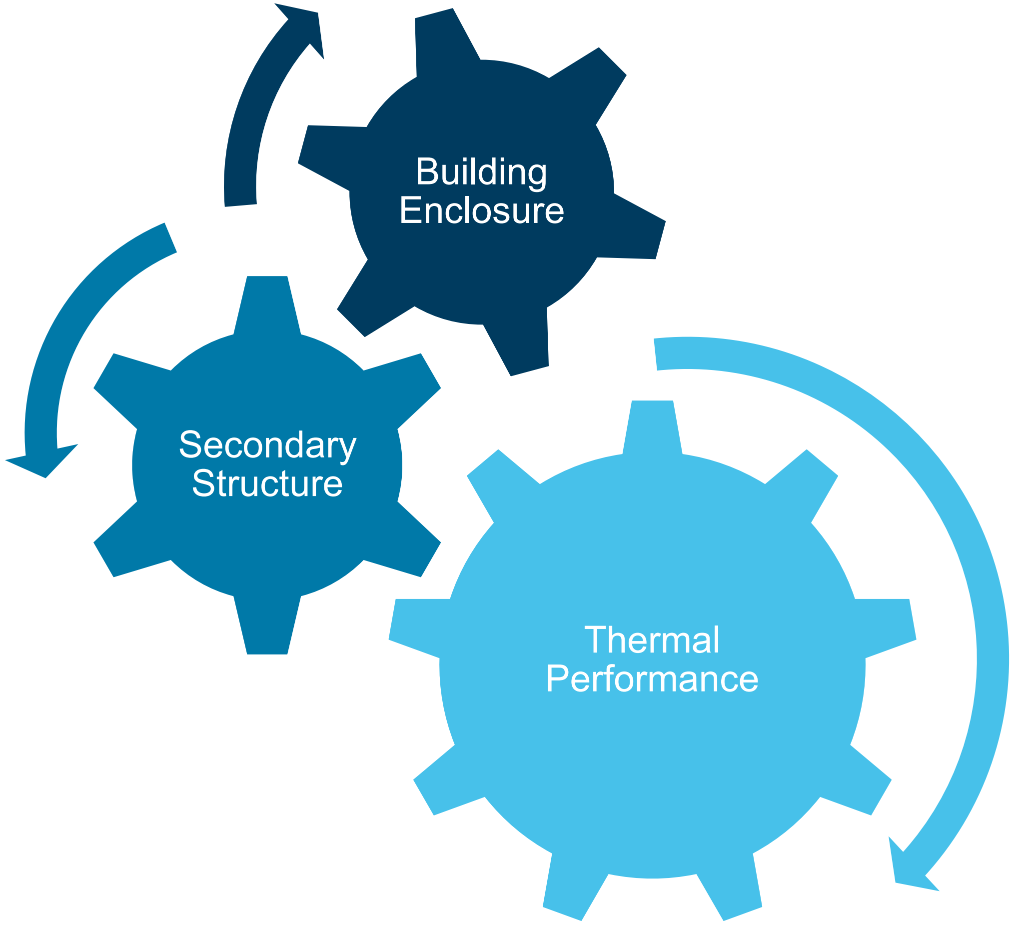
How is this window structurally supported?

Post Construction Research Study: Optimized Window Installation at 825 Pacific Artist Hub

How do you optimize a window installation?

Solution if reference documents are not available:

- Retain qualified consultant team to develop a solution customized to suit your project



2023 BC Housing Building Excellence Research & Education Grant

How do you optimize a window installation?

Morrison Hershfield (now Stantec) was awarded a Building Excellence Research & Education Grant from BC Housing in March 2023 to develop high-performance window-to-wall transition details intended for use in larger low energy/low carbon buildings in all climate zones within BC to be added to ThermalEnvelope.ca

2023 BC Housing Building Excellence Research & Education Grant

Project Team

Inventor: Cody Akira Belton, AScT, PTech, CPHD: Passive House Specialist & Building Enclosure Consultant

Harold Louwerse, P.L.Eng., RRO: Department Manager – Building Science Vancouver

Jameson H. Vong, P.Eng.: Building Envelope Specialist & Technical Manager

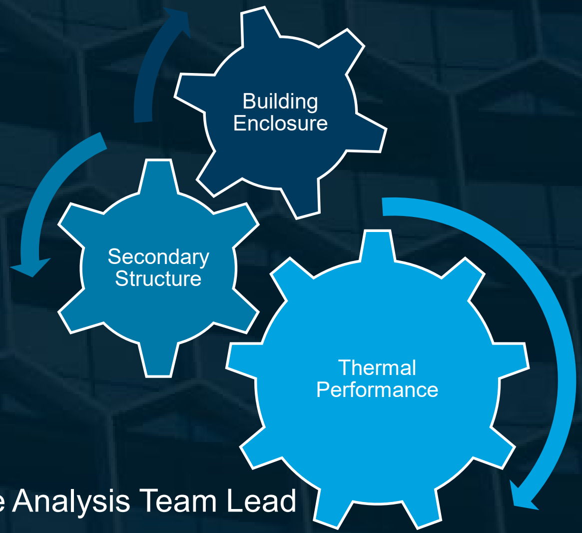
Brett Pattrick, P.Eng.: Façade Specialist & Secondary Structures Team Lead

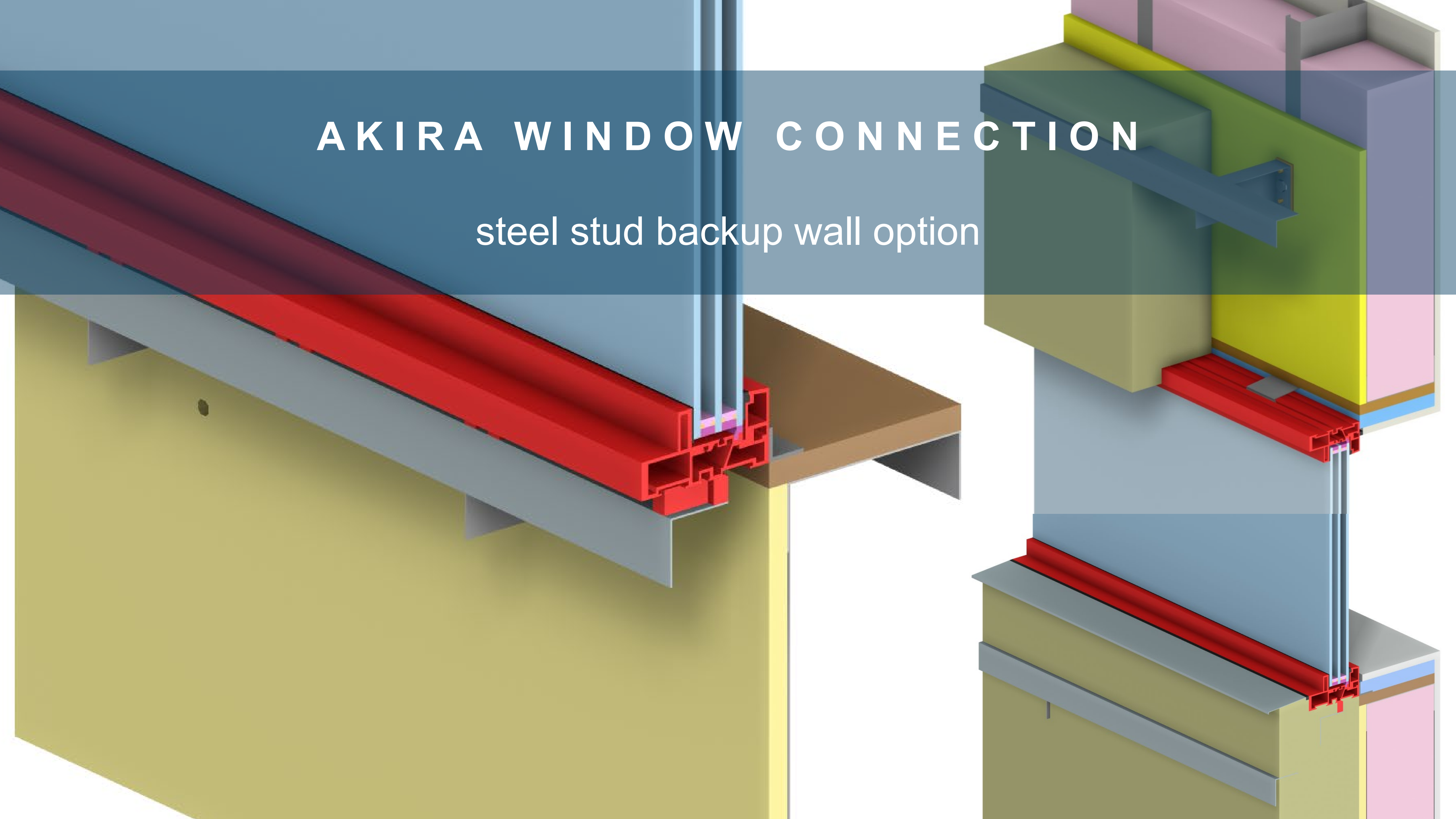
Qing Li, E.I.T.: Façade Consultant

Ivan Lee, P.Eng., M.A.Sc., LEED AP BD+C: Building Science Engineer & Building Performance Analysis Team Lead

Felipe Merino Gordo, M.A.Sc.: Building Science Consultant

Shahima Rahmatipour, M.Sc., P.Eng., PMP, CEM: Building Science Consultant




AKIRA WINDOW CONNECTION
steel stud backup wall option

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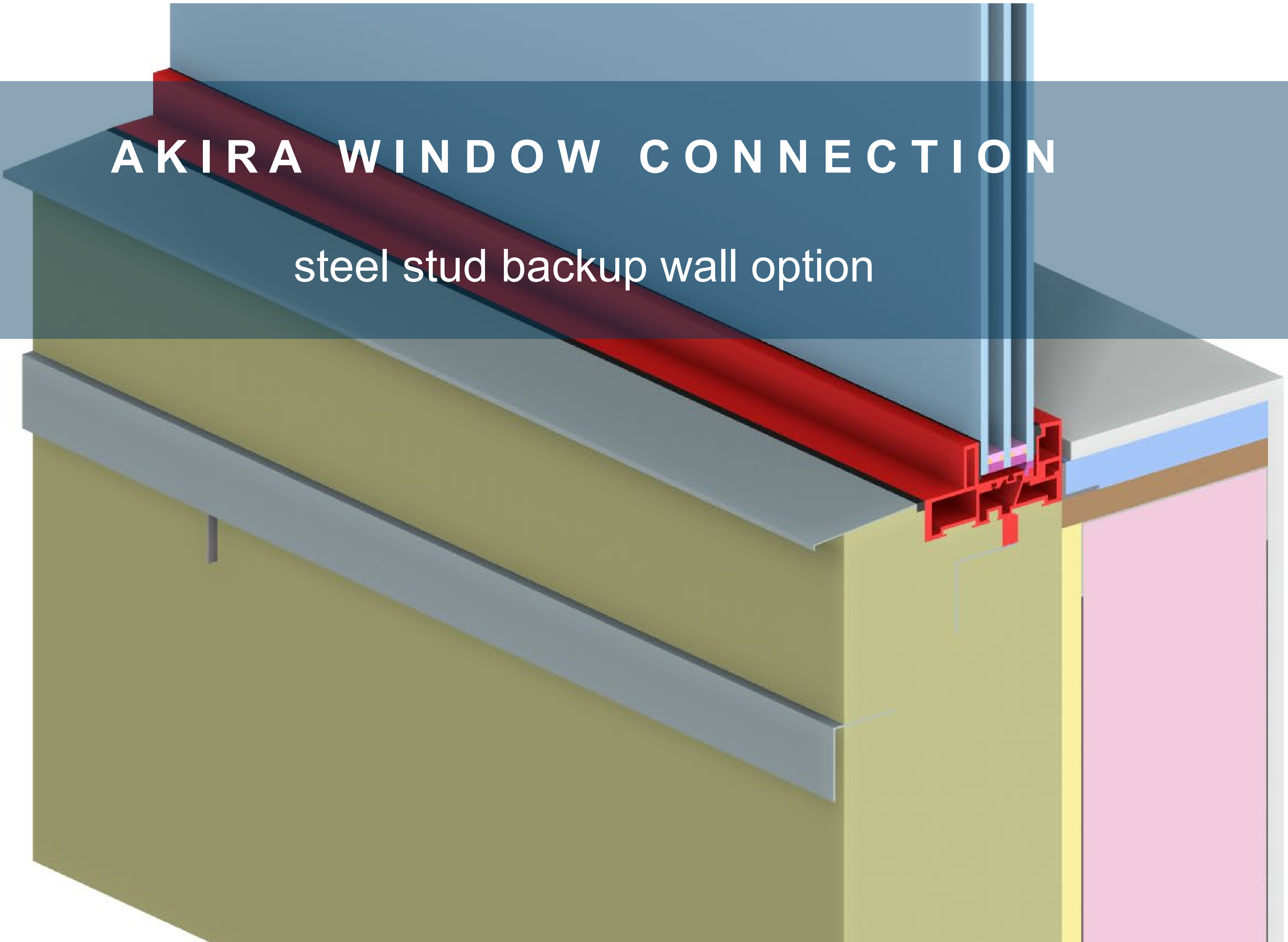

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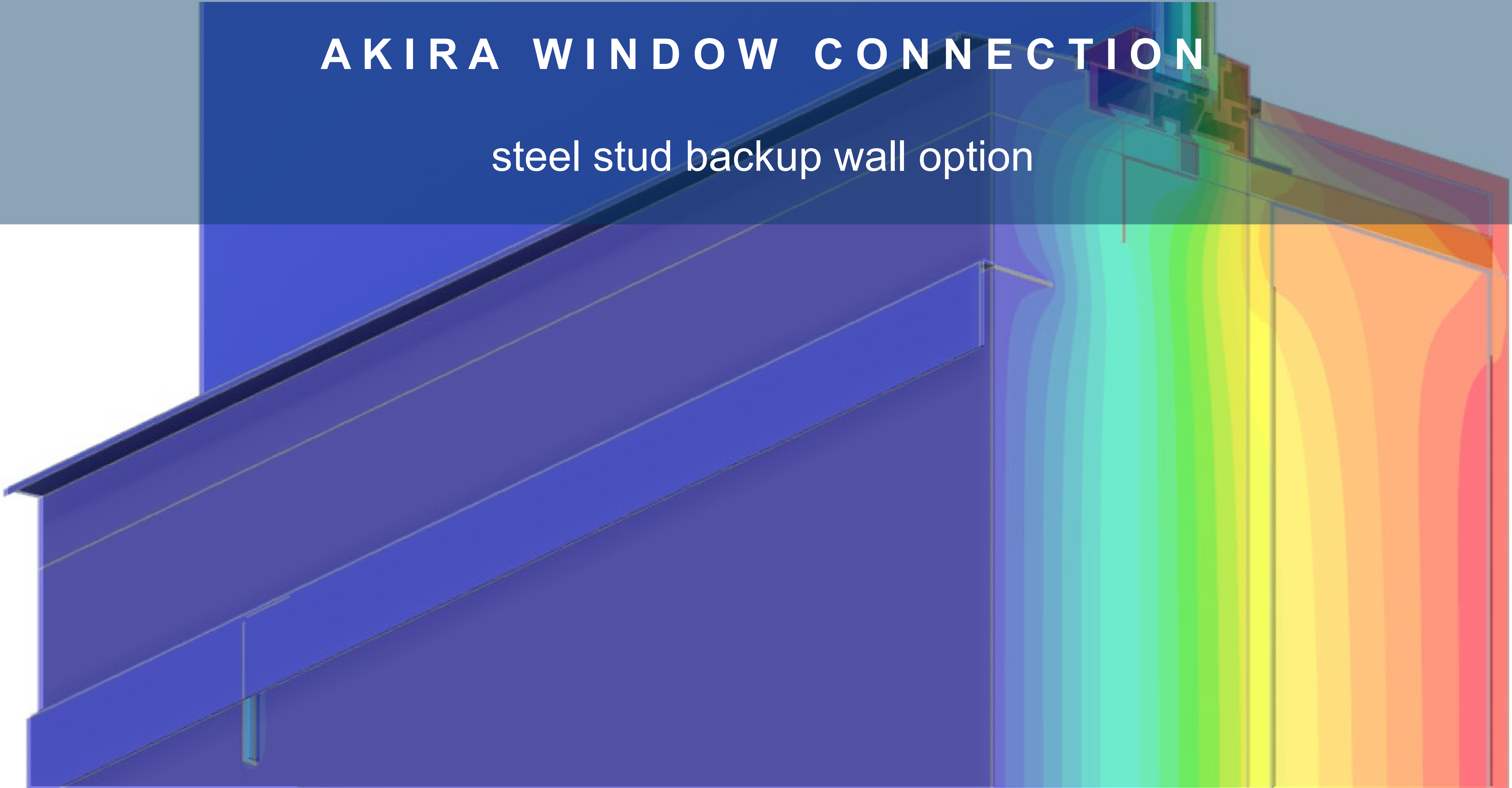

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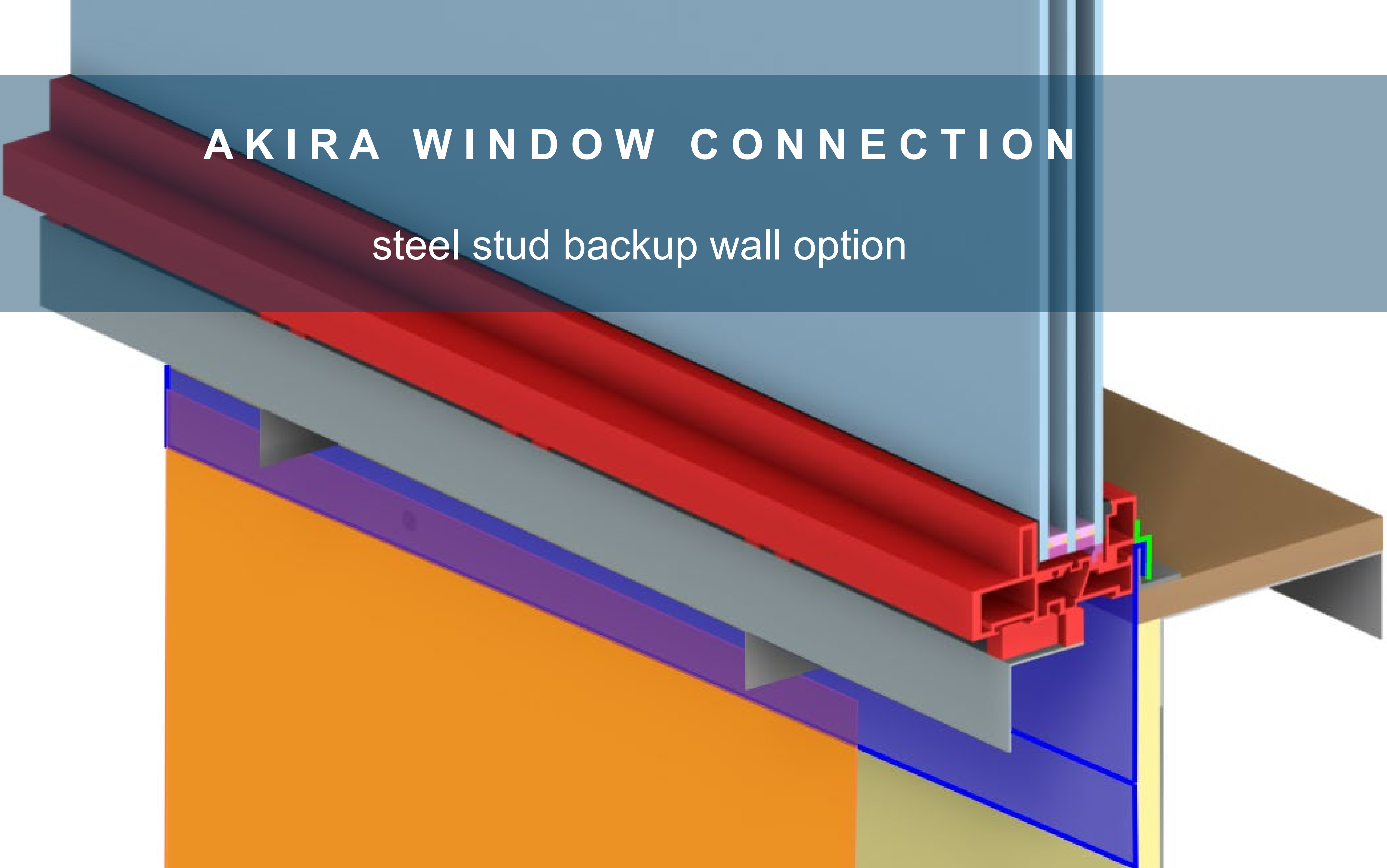
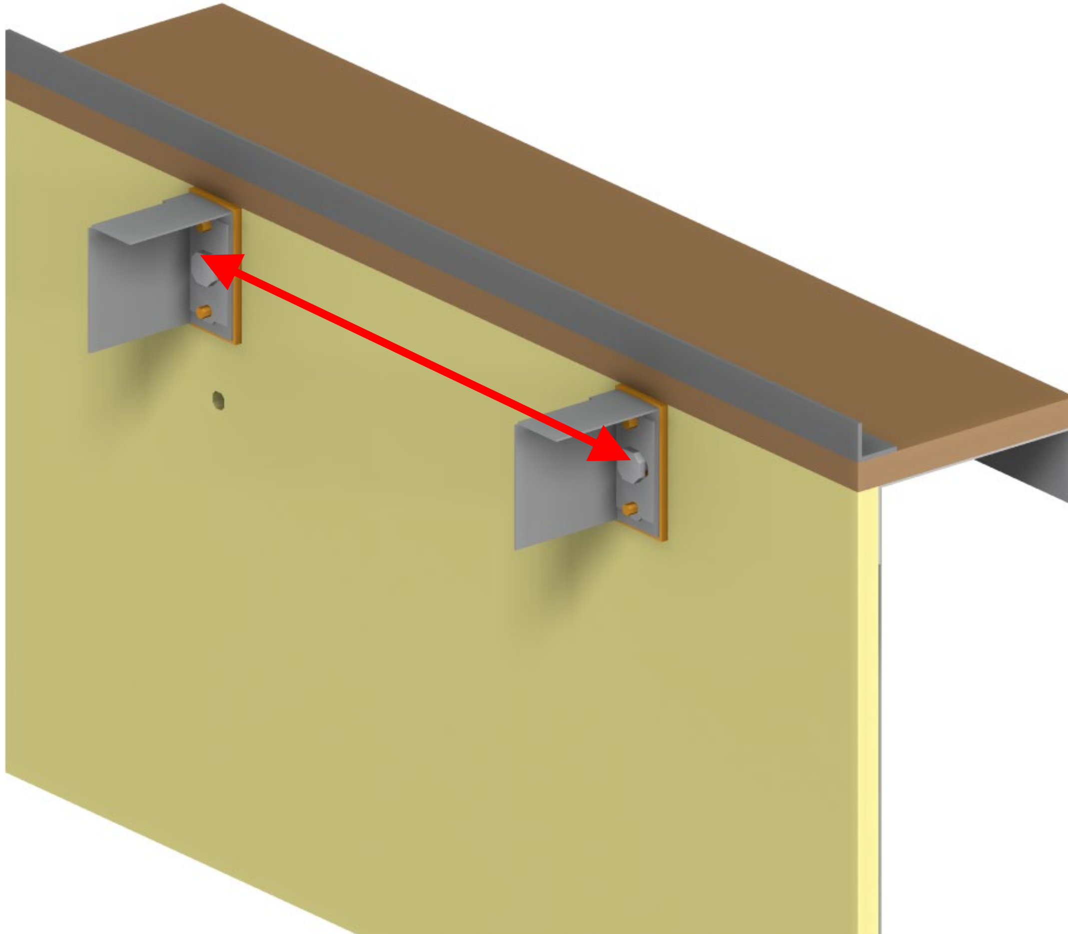


Akira Window Connection
Steel Stud Backup Wall Option @ Window Sill

Structural Analysis:

Table 1: Akira Window Connection by MH Dead Load Support System Maximum Intermittent Bracket Spacing

Window Height (inch)		48	84	115	144
Window Dead Load Support System Max. Intermittent Bracket Spacing (inch)	Without Wood Blocking at Steel Studs	32	32	24	16
	With Wood Blocking at Steel Studs	32	32	24	24



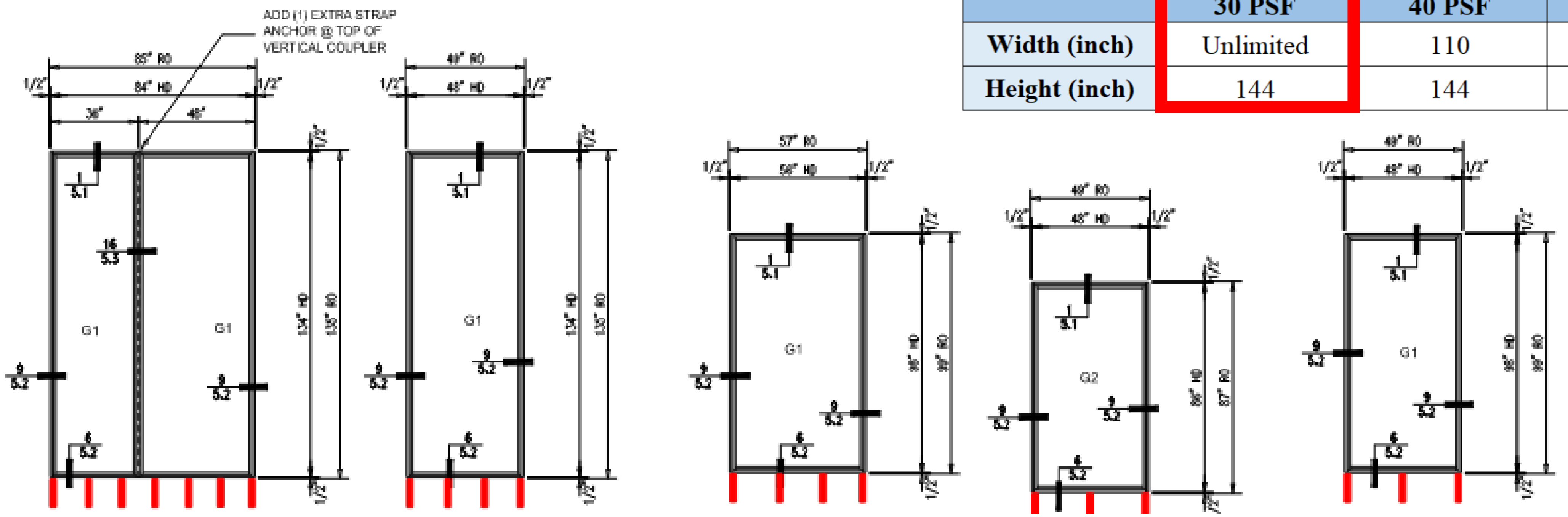
Akira Window Connection

Steel Stud Backup Wall Option @ Window Sill

Structural Analysis:

Table 2: Akira Window Connection by MH Maximum Window Size

Dimension	For Building Less Than 10 Storey (<30 m) Wind Load: 30 PSF	For Building Less Than 30 Storey (<100 m) Wind Load: 40 PSF	For Building Less Than 50 Storey (<150 m) Wind Load: 50 PSF
Width (inch)	Unlimited	110	90
Height (inch)	144	144	144



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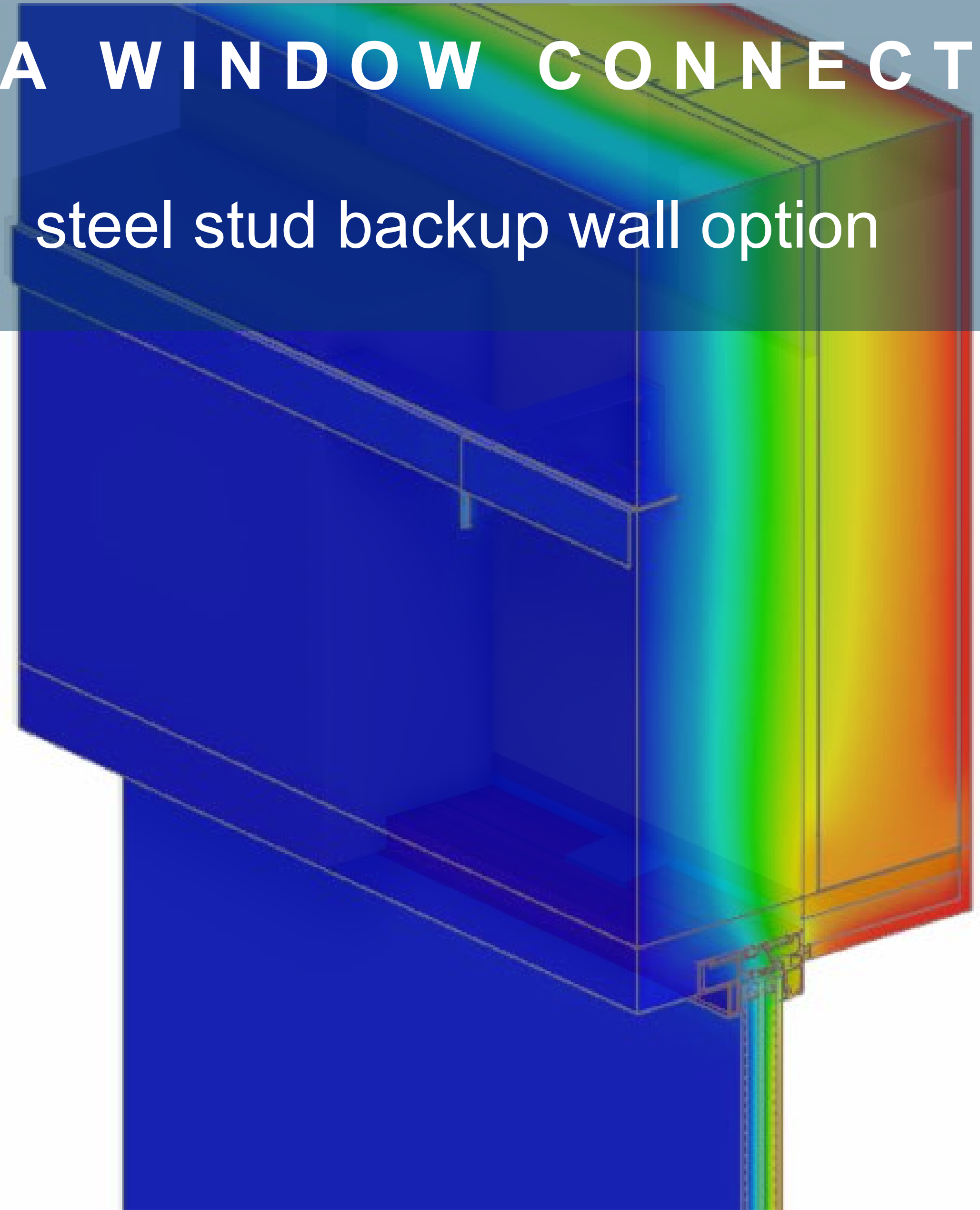

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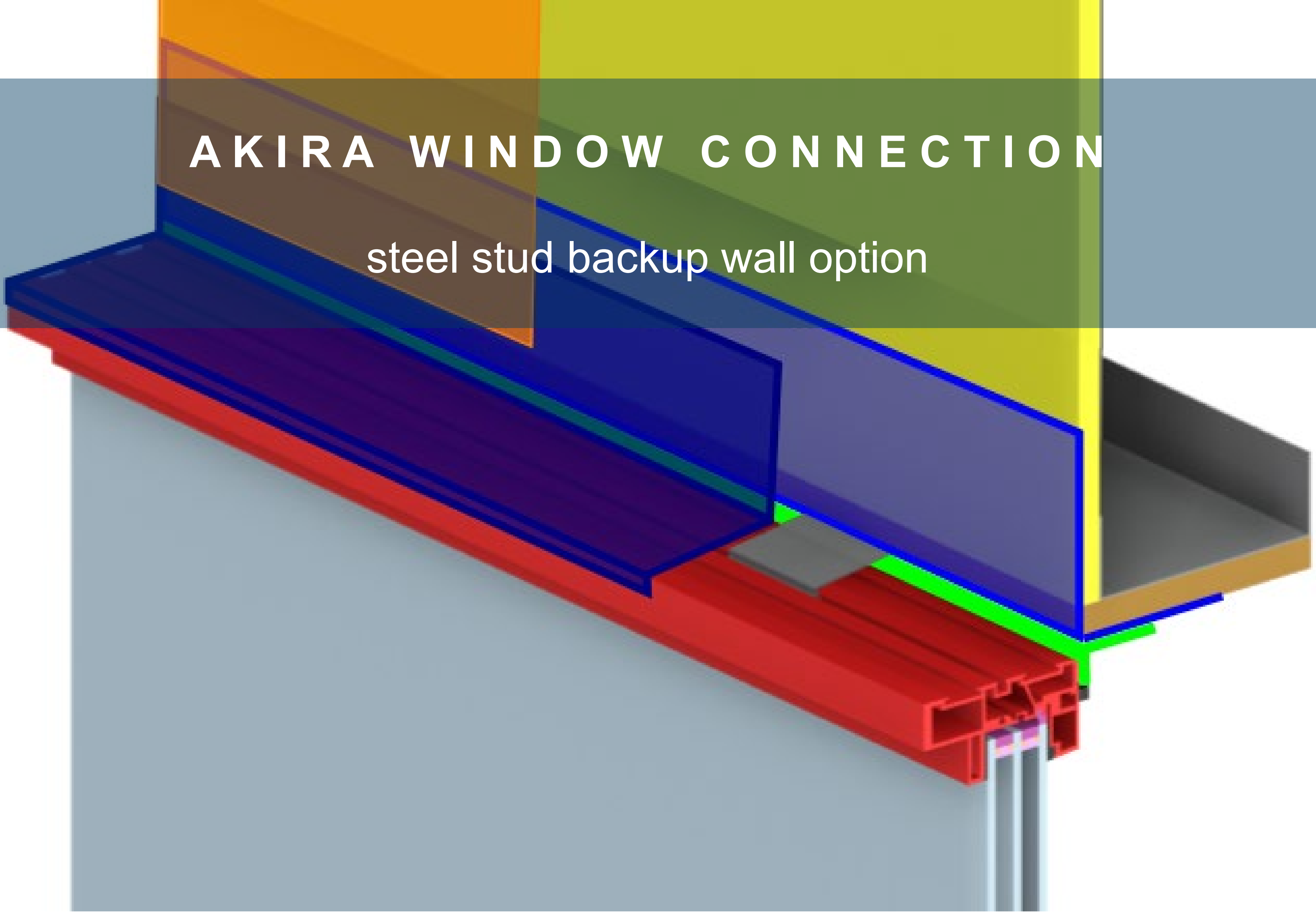
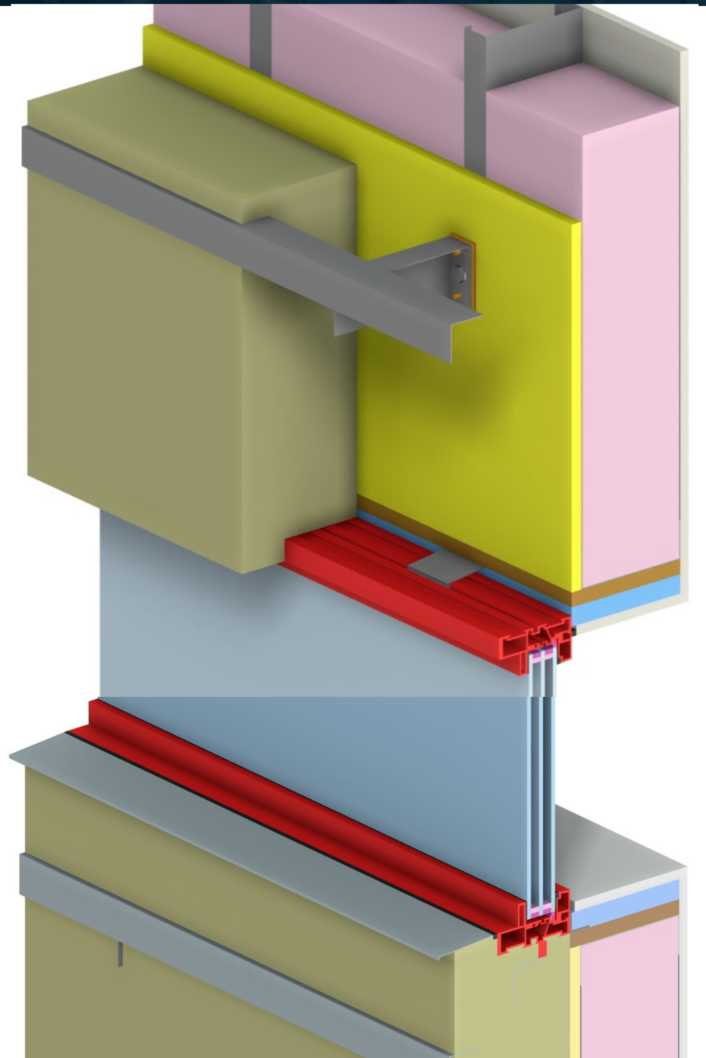


Post Construction Research Study: Optimized Window Installation at 825 Pacific Artist Hub

Optimized Window Install

1. Q: What is the impact to energy performance?

2. Q: Does window install provide design flexibility?



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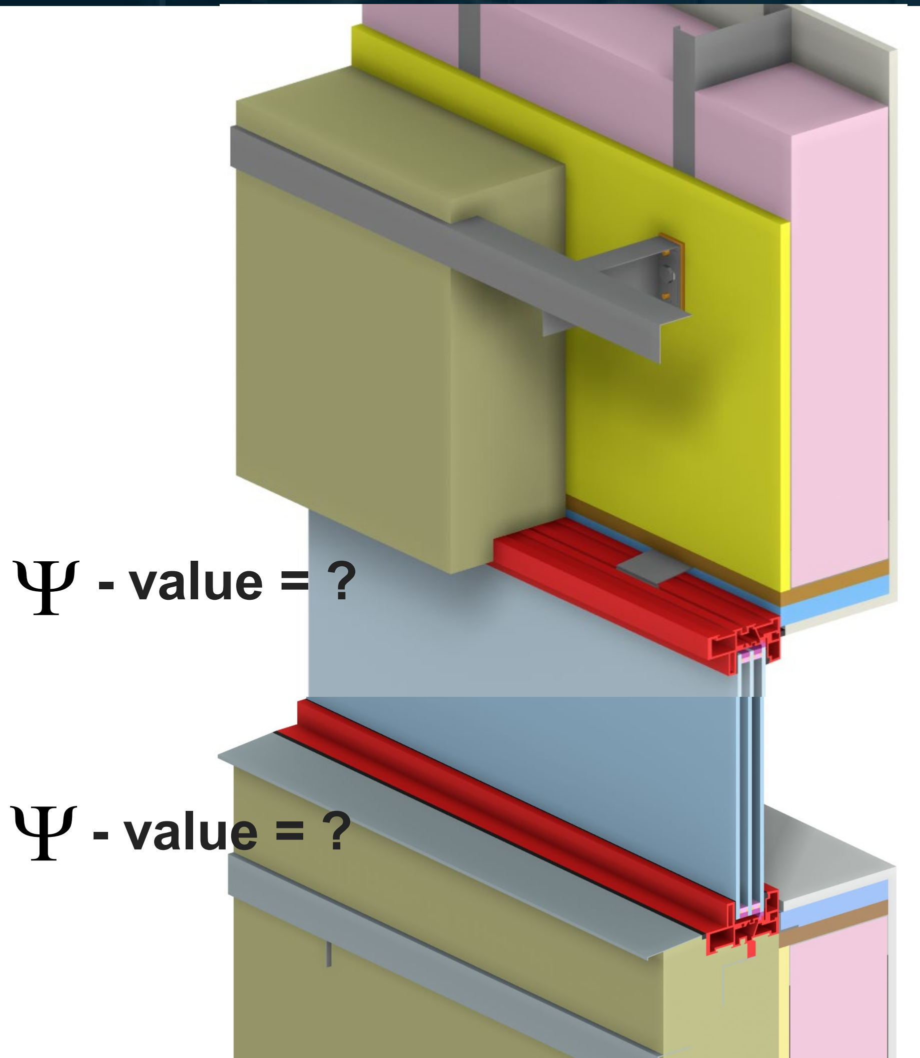
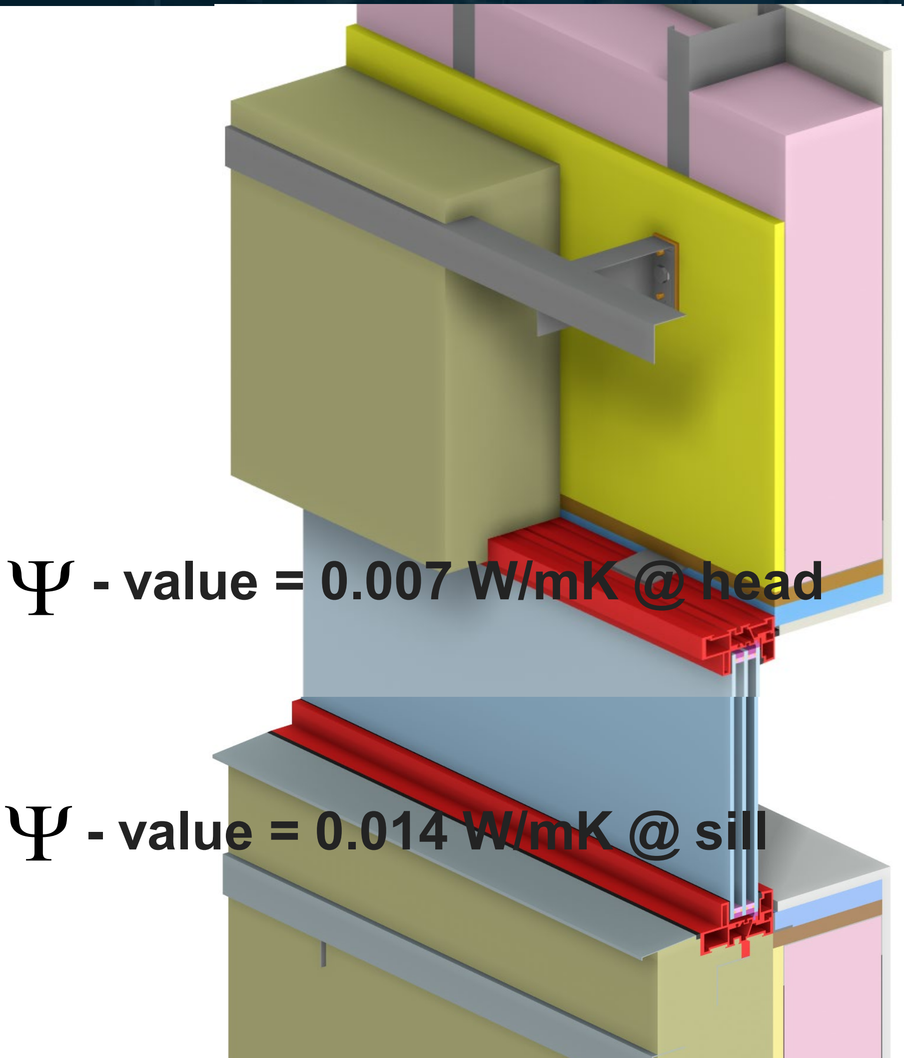


Post Construction Research Study: Optimized Window Installation at 825 Pacific Artist Hub

Optimized Window Install: Thermal Bridging Heat Loss Effect

Table 4: Akira Window Connection Thermal Bridge Psi-values at Window Transitions

Location	Window Position Description	Window Dead Load Support System	Exterior Wall Material Description	Transmittance Type	ψ-value (W/mK)
Akira Window Connection @ HEAD	window frame interior edge aligned with wall sheathing exterior	continuous angle + intermittent brackets	7-inch mineral wool with 7-inch bracket	linear thermal bridge	0.007
Akira Window Connection @ JAMB	window frame interior edge aligned with wall sheathing exterior	continuous angle + intermittent brackets	7-inch mineral wool with 7-inch bracket	linear thermal bridge	0.019
Akira Window Connection @ SILL	window frame interior edge aligned with wall sheathing exterior	continuous angle + intermittent brackets	7-inch mineral wool with 7-inch bracket	linear thermal bridge	0.014



Post Construction Research Study: Optimized Window Installation at 825 Pacific Artist Hub

Optimized Window Install: Thermal Bridging Heat Loss Effect

- Energy conservation savings (buffer) = more design flexibility

Table 5: Akira Window Connection Energy Performance Comparison

Scenario	PER Demand Effect compared to As-Built (kWh/m²a)	Space Heating Demand Effect compared to As-Built (kWh/m²a)	Space Heating Load Effect compared to As-Built (W/m²)	Space Cooling & Dehum. Demand Effect compared to As-Built (kWh/m²a)	Space Cooling Load Effect compared to As-Built (W/m²)	Heating Period Window Energy Balcance compared to As-Built (kWh/a)	Passive House Classic?
Akira Window Connection (7-inch ext. insulation)	-0.40	-0.86	-0.32	0.30	0.24	-3138	YES
Akira Window Connection (6-inch ext. insulation) [1]	0.18	0.29	0.19	0.24	0.25	-3289	YES

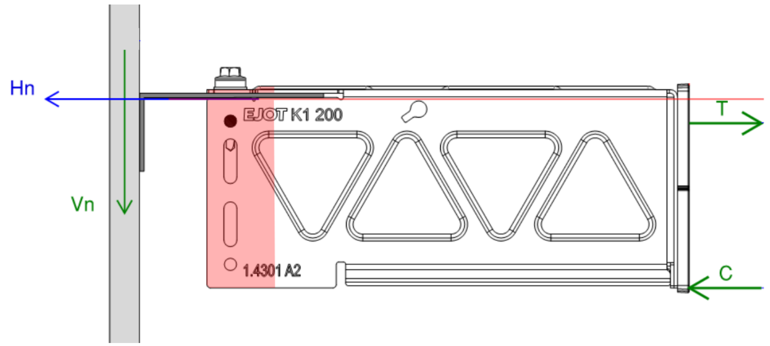
Note:

1. Psi-values at window transitions with 6-inch and 8-inch exterior insulation at walls assumed to match psi-values for scenario with 7-inch exterior insulation.

Post Construction Research Study: Optimized Window Installation at 825 Pacific Artist Hub

Optimized Window Install: Thermal Bridging Heat Loss Effect

- Energy conservation savings (buffer) = more design flexibility
- Alternate wall design with reduced insulation potential benefits:
  - Decrease wall thickness
  - Increase cladding attachment options
  - Decrease embodied carbon emissions
  - Decrease wall construction costs



Post Construction Research Study: Optimized Window Installation at 825 Pacific Artist Hub

Optimized Window Install: Thermal Bridging Heat Loss Effect

Total Cost Analysis:

Table 7: Akira Window Connection & Exterior Wall Material Cost Comparison

Scenario	Window Position Description	Window Dead Load Support System	Window Dead Load Support System Material Cost [1]	Exterior Wall Material Description	Exterior Wall Material Cost	Total Material Cost	Cost Savings Compared to As-Built
As-Built (8-inch ext. insulation)	window frame interior edge recessed 16 mm into rough opening	2"x3"x0.125" aluminum angle	$2,637	8-inch mineral wool with 8-inch bracket	$252,297	$254,934	
Akira Window Connection (7-inch ext. insulation)	window frame interior edge aligned with wall sheathing exterior face	2"x2"x0.05" galvanized steel + intermittent metal brackets	$5,509	7-inch mineral wool with 7-inch bracket	$228,114	$233,623	$21,311
Akira Window Connection (6-inch ext. insulation)	window frame interior edge aligned with wall sheathing exterior face	2"x2"x0.05" galvanized steel + intermittent metal brackets	$5,509	6-inch mineral wool with 6-inch bracket [2]	$202,672	$208,180	$46,753

Post Construction Research Study: Optimized Window Installation at 825 Pacific Artist Hub

Optimized Window Install: Akira Window Connection

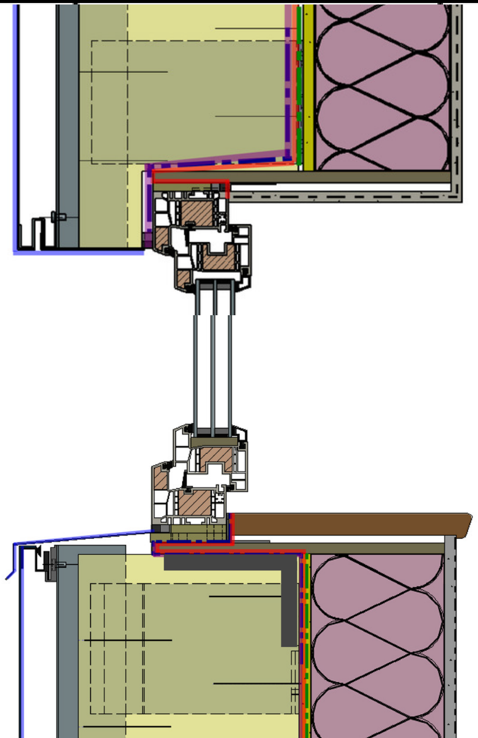
Research Findings Summary:

- Decrease external wall thickness → 2-inch
  - Walls Above Grade: ~~R-42~~ R-33 effective (clear field)
  - ~~17-inch~~ 15-inch total thickness
- Decrease embodied carbon → 5.3 imperial tons of carbon dioxide equivalent
- Decrease exterior wall insulation and cladding bracket size → $46.7K CAD ($35K USD) savings in material

Constructability

Detail 5.3.22

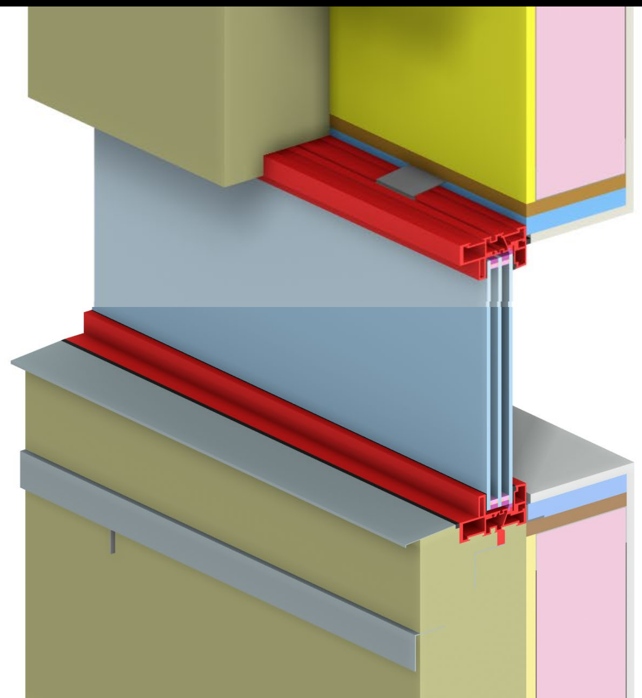
ψ_{Head} Btu/ft ·hr ·°F (W/m K)	ψ_{Sill} Btu/ft ·hr ·°F (W/m K)	ψ_{Jamb} Btu/ft ·hr ·°F (W/m K)
0.027 (0.047)	0.057 (0.099)	0.063 (0.109)



vs.

Detail 5.3.26

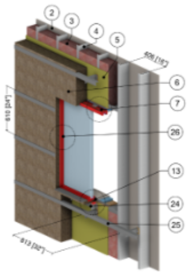
ψ_h Btu/ft ·hr ·°F (W/m K)	ψ_l Btu/ft ·hr ·°F (W/m K)	ψ_j Btu/ft ·hr ·°F (W/m K)
0.004 (0.007)	0.008 (0.014)	0.011 (0.019)

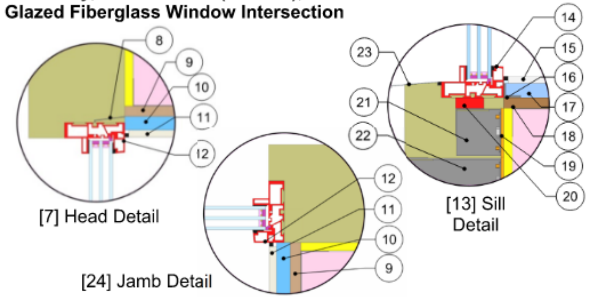


ThermalEnvelope.ca – Detail 5.3.26

Detail 5.3.26

Akira Window Connection at Exterior Insulated Steel Stud Wall Assembly, 6" Steel Stud (16" o.c.), Fiberglass in cavity – Triple Glazed Fiberglass Window Intersection



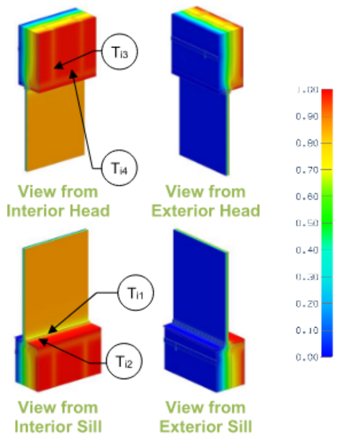


ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Film[1]	-	-	R-0.7 to R-1.1 (0.12 RSI to 0.20 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	Fiberglass Batt in Stud Cavity	6" (152)	0.30 (0.043)	R-20 (3.52 RSI)	0.075 (1.2)	0.24 (1000)
4	6" x 1 5/8" Steel Studs with Tracks	18 Gauge	430 (62)		489 (7830)	0.12 (500)
5	Exterior Sheathing	5/8" (16)	1.1 (0.16)	R-0.6 (0.10 RSI)	50 (800)	0.26 (1090)
6	Exterior Mineral Wool Insulation	7" (178)	0.24 (0.034)	R-29.4 (5.18RSI)	4 (64)	0.20 (850)
8	Intermittent metal strap anchor	18 Gauge	1110 (160)	-	489 (7830)	0.12 (500)
9, 18	Wood liner (plywood)	1/2" (13)	0.69 (0.10)	-	27.8 (445)	0.45 (1880)
10, 17	Insulation at sill, head and jamb (XPS)	1" (25)	0.20 (0.029)	-	1.55 (25)	0.29 (1220)
11, 15	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
12, 14	Fiberglass window: triple glazed IGU, U_{IGU}-0.156 Btu/hr·ft²·°F (0.888 W/m²K)[2]					
16	Sill Angle (Aluminum)	0.13" (3.2)	1110 (160)	-	489 (7830)	0.12 (500)
19	Thermal break (Polyamide)	0.2" (5)	2.2 (0.32)	-	69 (1100)	0.36 (1500)
20	Plastic shims (Polyethylene)	3/4" (19)	2.1 (0.3)	-	69 (1100)	0.36 (1500)
21	Intermittent brackets (stainless steel)(16" horizontal spacing)	16 Gauge	118 (17)	-	499 (8000)	0.12 (500)
22	Cladding support system (Stainless steel) (24"vertical – 36" horizontal spacing)	16 Gauge	118 (17)	-	499 (8000)	0.12 (500)
23	Flashing	14 Gauge	1110 (160)	-	489 (7830)	0.12 (500)
24	Horizontal girt that supports the window (Galvanized steel)	18 gauge	430 (62)	-	489 (7830)	0.12 (500)
25	Rail (Galvanized steel)	0.08" (2)	430 (62)	-	489 (7830)	0.12 (500)
	Cladding with 1/2" vented airspace incorporated into exterior heat transfer coefficient					
27	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 5.3.26

Akira Window Connection at Exterior Insulated Steel Stud Wall Assembly, 6" Steel Stud (16" o.c.), Fiberglass in cavity – Triple Glazed Fiberglass Window Intersection.



Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-22.3 (3.93 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_w, R_w, U_g	"clear wall" U- and R-value: w = wall g = glazing
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ_h, ψ_l, ψ_j	Incremental increase in transmittance per linear length of: h = head l = sill j = jamb

[1]Assumptions and limitations for surface temperatures identified in ASHRAE 1365-RP

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Clear Wall

Exterior Insulation 1D R-Value (RSI)	R_{1D} 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-29.4 (5.18)	R-51.7 (9.10)	R-38.1 (6.70)	0.026 (0.15)

Base Assembly - Glazing

$U_{centre\ of\ glass}$ Btu/ft² ·hr ·°F (W/m² K)	U_g Btu/ft² ·hr ·°F (W/m² K)
0.156 (0.888)	0.110 (0.625)

Window Linear Transmittance

Exterior Insulation 1D R-Value (RSI)	ψ_h Btu/ft ·hr ·°F (W/m K)	ψ_l Btu/ft ·hr ·°F (W/m K)	ψ_j Btu/ft ·hr ·°F (W/m K)
R-29.4 (5.18)	0.004 (0.007)	0.008 (0.014)	0.011 (0.019)

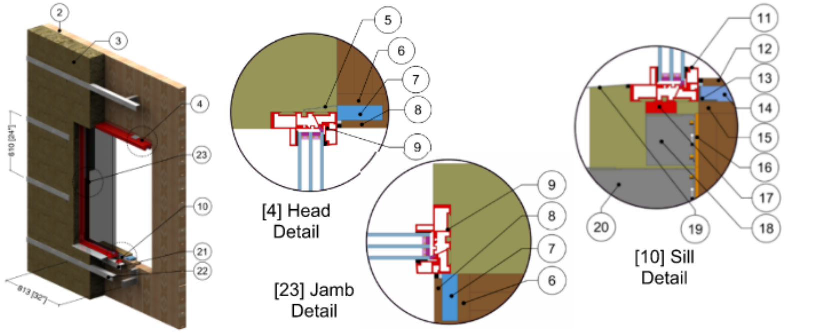
Temperature Indices

	Description	Head	Sill	Jamb
T_{i1}	Min T on window glass, next to frame	0.75	0.74	0.76
T_{i2}	Min T on window frame, next to head, sill or jamb	0.83	0.81	0.82
T_{i3}	Min T on wall, at studs	0.95	0.94	0.95
T_{i4}	Max T on wall, between studs at head or sill	1.00	1.00	0.99

ThermalEnvelope.ca – Detail 8.3.24

Detail 8.3.24

Akira Window Connection at Exterior Insulated CLT back up wall – Triple Glazed Fiberglass Window Intersection

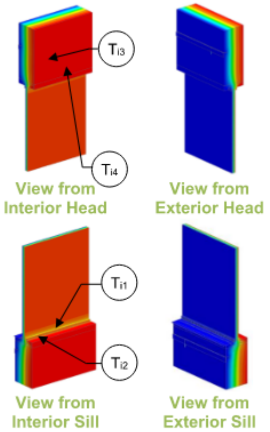


ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Film[1]	-	-	R-0.7 to R-1.1 (0.12 RSI to 0.20 RSI)	-	-
2	CLT	3 1/2" (89)	0.83 (0.12)	R-4.2 (0.74 RSI)	50 (800)	0.26 (1090)
3	Exterior Mineral Wool Insulation	7" (178)	0.24 (0.034)	R-29.4 (5.18RSI)	4 (64)	0.20 (850)
5	Intermittent metal strap anchor	18 Gauge	1110 (160)	-	489 (7830)	0.12 (500)
6, 15	Wood liner (plywood)	1/2" (13)	0.69 (0.10)	-	27.8 (445)	0.45 (1880)
7, 14	Insulation at sill, head and jamb (XPS)	1" (25)	0.20 (0.029)	-	1.55 (25)	0.29 (1220)
8, 12	Wood trim	1/2" (13)	0.69 (0.10)	R-0.5 (0.08 RSI)	50 (800)	0.26 (109
9, 11	Fiberglass window: triple glazed IGU, U_{IGU}-0.156 Btu/hr·ft²·°F (0.888 W/m²K) [2]					
13	Sill Angle (Aluminum)	0.13" (3.2)	1110 (160)	-	489 (7830)	0.12 (500
16	Thermal break (Polyamide)	0.2" (5)	2.2 (0.32)	-	69 (1100)	0.36 (150
17	Plastic shims (Polyethylene)	3/4" (19)	2.1 (0.3)	-	69 (1100)	0.36 (150
18	Intermittent brackets (stainless steel)(16" horizontal spacing)	16 Gauge	118 (17)	-	499 (8000)	0.12 (500
19	Flashing	14 Gauge	1110 (160)	-	489 (7830)	0.12 (500
20	Cladding support system (Stainless steel) (24"vertical – 36" horizontal spacing)	16 Gauge	118 (17)	-	499 (8000)	0.12 (500
21	Horizontal girt that supports the window (Galvanized steel)	18 gauge	430 (62)	-	489 (7830)	0.12 (500
22	Rail (Galvanized steel)	0.08" (2)	430 (62)	-	489 (7830)	0.12 (500)
	Cladding with 1/2" vented airspace incorporated into exterior heat transfer coefficient					
24	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 8.3.24

Akira Window Connection at Exterior Insulated CLT back up wall – Triple Glazed Fiberglass Window Intersection



Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-5.57 (0.98 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_w, R_w, U_g	"clear wall" U- and R-value: w = wall g = glazing
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	Ψ_h, Ψ_l, Ψ_j	Incremental increase in transmittance per linear length of: h = head l = sill j = jamb

[1] Assumptions and limitations for surface temperatures identified in ASHRAE 1365-RP

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Clear Wall

Exterior Insulation 1D R-Value (RSI)	R_{1D} 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-29.4 (5.18)	R-5.6 (0.98)	R-32.3 (5.70)	0.031 (0.18)

Base Assembly - Glazing

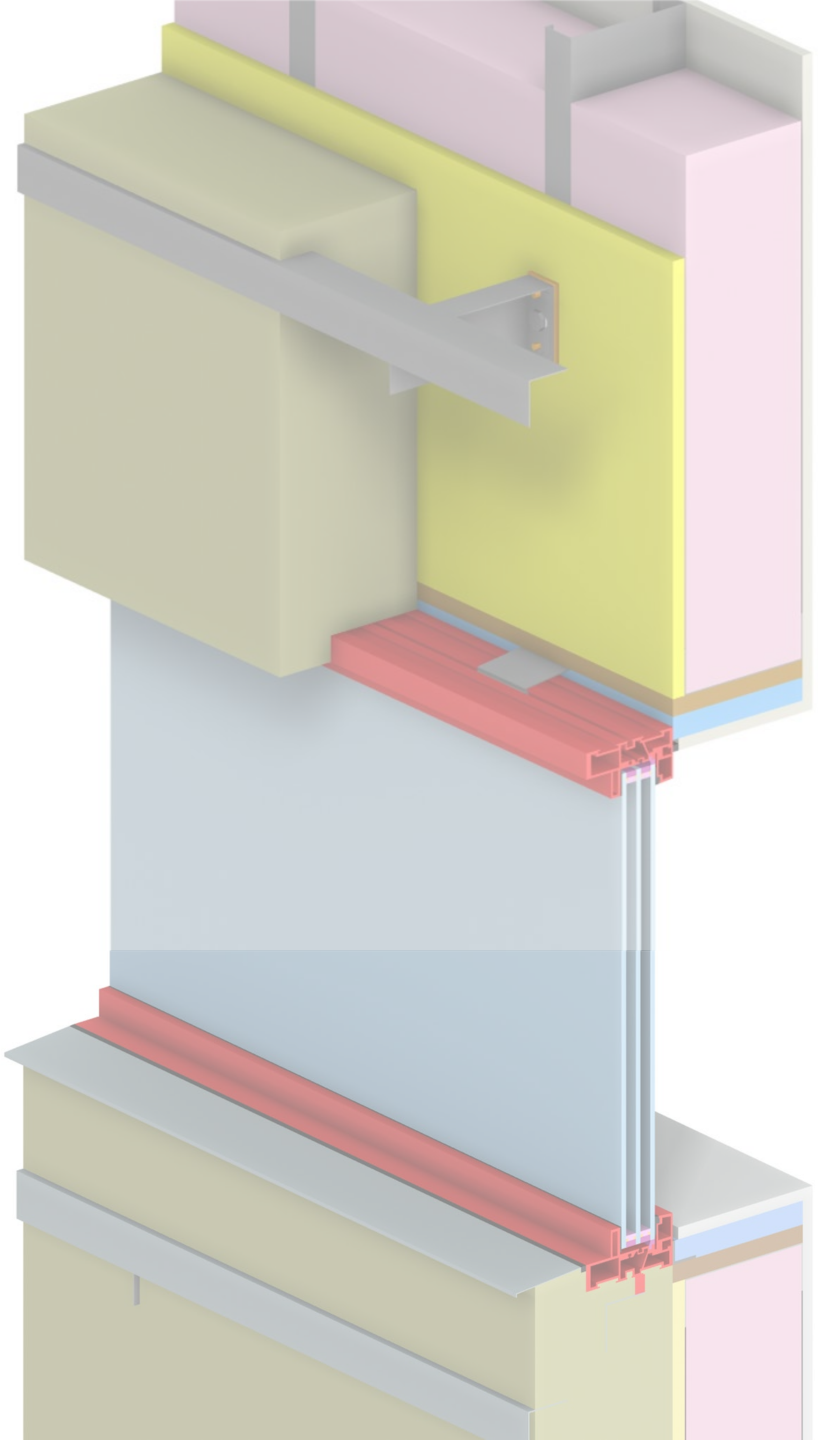
$U_{centre\ of\ glass}$ Btu/ft² ·hr ·°F (W/m² K)	U_g Btu/ft² ·hr ·°F (W/m² K)
0.156 (0.888)	0.110 (0.625)

Window Linear Transmittance

Exterior Insulation 1D R-Value (RSI)	Ψ_h Btu/ft ·hr ·°F (W/m K)	Ψ_l Btu/ft ·hr ·°F (W/m K)	Ψ_j Btu/ft ·hr ·°F (W/m K)
R-29.4 (5.18)	0.0008 (0.001)	0.004 (0.006)	0.004 (0.007)

What’s next?

- Detailing Akira Window Connection into your next project
    - new construction
    - retrofits
    - prefabricated wall systems
    - modular systems



Structural Analysis

- Akira Window Connection with Cascadia Clip
  - 16 Ga. Steel Stud Wall
  - 18 Ga. Steel Stud Wall
  - 6-inch Concrete Wall
- Thermal Analysis for all backup wall types are in progress for head, jamb and sill

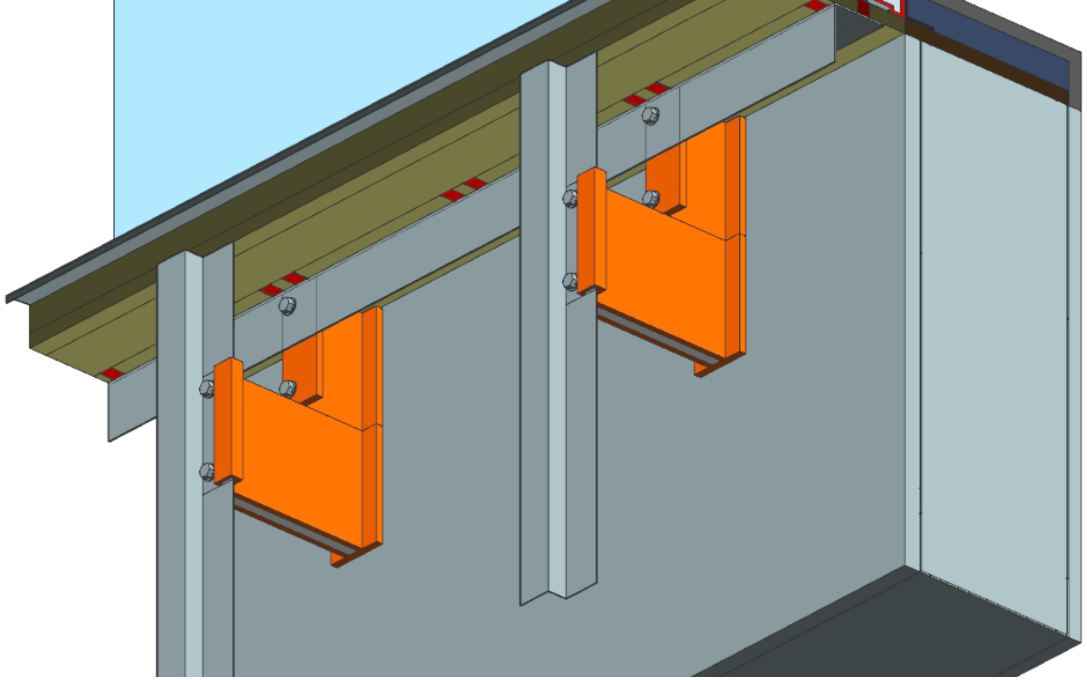


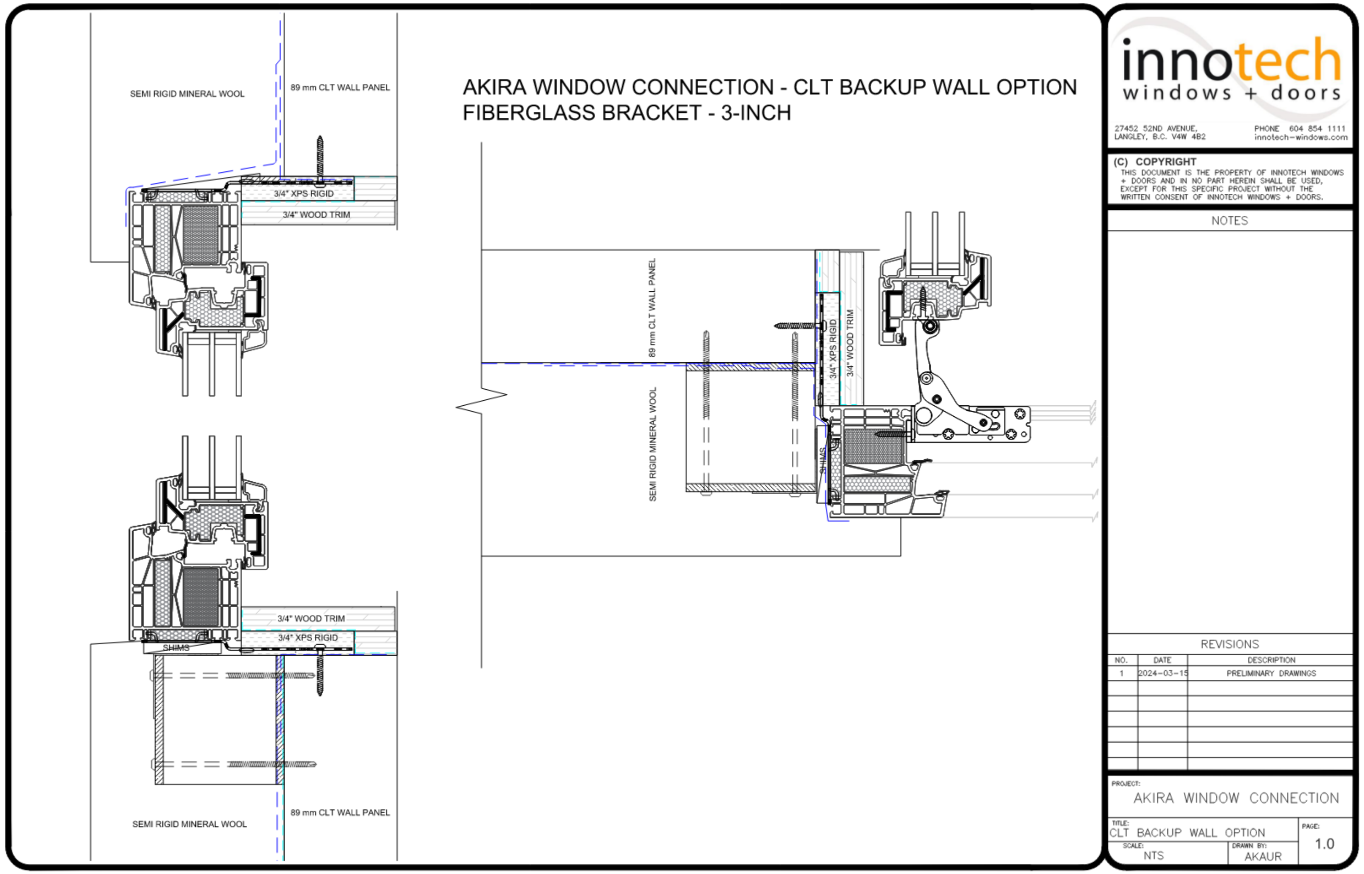
Table 3
Maximum Window Height

Maximum Window Height (in)				
Backup Wall Type	Dead Load (PSF)	Clip Horizontal Spacing (in)		
		16	24	32
16 Ga. Steel Stud	12	204	136	102
18 Ga. Steel Stud	12	134	89	67
Concrete Wall	12	192	128	96

The table is intended to be used for estimation purposes only. Project-specific engineering to be performed for all projects and the responsibility for the design shall remain with the Engineer of Record for each specific project.

Mass Timber Mock-up

- Akira Window Connection with Defender PH88+ PRO (tilt & turn) by Innotech Windows + Doors
  - CLT wall mock-up will be on display at the International Mass Timber Conference in Portland, OR



INTERNATIONAL MassTimber CONFERENCE

Thank You

Get in touch

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