BUILDINGENERGY BOSTON

Breaking Thermal Bridges: A Guide to the Divide

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Ivan Lee, Stantec
Russ Miller-Johnson, Engineering Ventures, PC

Curated by Keihly Moore and Smit Nimesh Ajmera

Northeast Sustainable Energy Association (NESEA) | March 23, 2026

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For the next 90 Minutes…

Breaking Thermal Bridges: A Guide to the Divide

- Overview - Ivan
- Code Requirements - Ivan
- Cladding - Ivan
- Constructible Details - Jim
- Foundation Insulation - Jim
- Constructible Details - Russ
- Embodied Carbon - Russ
- Problem Solving
- Thermal Bridging Catalog - Ivan
- Resources

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Presenting Team

Ivan Lee	Jim DAloisio	Russ Miller-Johnson
Stantec	Klepper, Hahn & Hyatt	Engineering Ventures, Inc.
P.Eng. (BC)	P.E. (NY)	P.E. (VT, PA, WI, CO, MT, IA), GA [SE]
LEED AP	LEED AP	45 years structural engineering experience w/alternative materials
15 years building envelope experience and building science simulation	35 years' structural experience, 10 years' envelope experience	ASCE/SEI Sustainability Committee Thermal Bridging Working Group
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Overview

Breaking Thermal Bridges: A Guide to the Divide

Ivan

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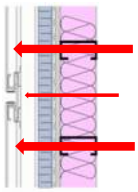
Structural Thermal Bridging



Thermal Bridging

- Heat flows through easiest and least resistant paths
- Components that increase heat flow beyond what is assumed in 1D is a 'thermal bridge'

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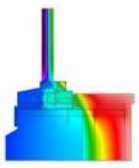
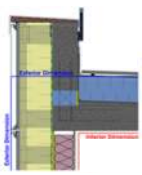
Thermal Bridging Types

Highly conductive material bypassing insulation



Mis-aligned, missing or reduced insulation



Increase heat loss due to greater exterior surface than interior surface areas

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Types of Thermal Bridges

Clear Field

U_o

heat loss per **area**
wall, floor, or roof assembly

Linear

Ψ

additional heat loss per **length**
window to wall, roof to wall, intermediate floor

Point

χ

additional heat loss per **point**
beam penetration, roof anchor

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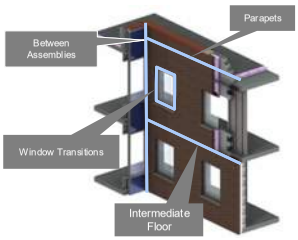
Thermal Bridging



Repetitive structural members
- studs, joists, lintels etc.

Major structural penetrations
- slabs, beams, columns, curbs, balconies

Junctions
- wall to roof, window to wall

Cladding support systems
- Brackets, ties, shelf angles

Edge of Walls and Floors

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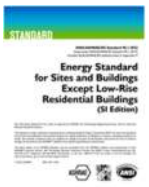
Code Requirements

2024 IECC



ASHRAE 90.1-2022

Requirements
- In addition to wall R-values and U-factors
- Climate zones 4+
- Linear and point thermal bridges with conductivity < 3.0 Btu.in/h.ft^2.°F are exempt
- Default/Compliant values for performance and trade-off calculations

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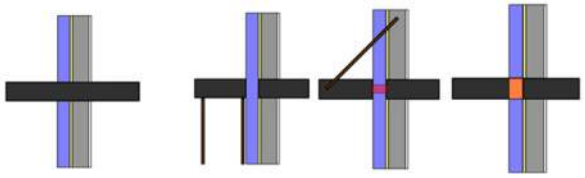
2024 IECC

C402.7.1: Balconies and Floor Decks



Non-Compliant
0.5 Btu/h.ft.°F

Compliant
0.2 Btu/h.ft.°F

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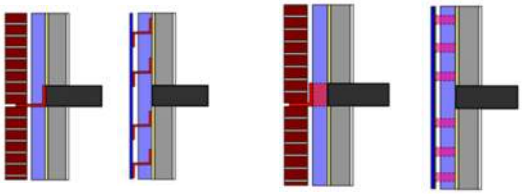
2024 IECC

C402.7.2: Cladding Supports



Non-Compliant
0.5 Btu/h.ft.°F

Compliant
0.3 Btu/h.ft.°F

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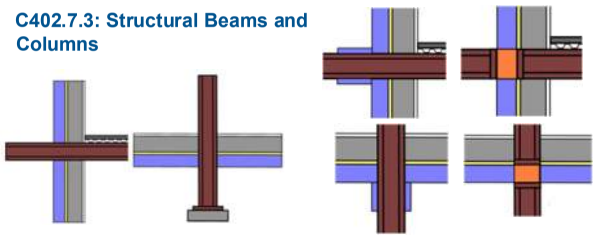
2024 IECC

C402.7.3: Structural Beams and Columns



Non-Compliant
1 to 2 Btu/h.°F

Compliant
0.3 to 1 Btu/h.°F

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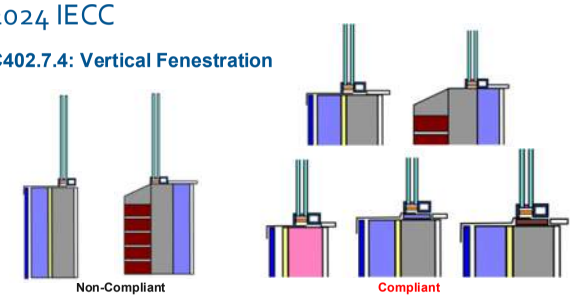
2024 IECC

C402.7.4: Vertical Fenestration



Non-Compliant

0.3 Btu/h.ft.°F

Compliant

0.15 Btu/h.ft.°F

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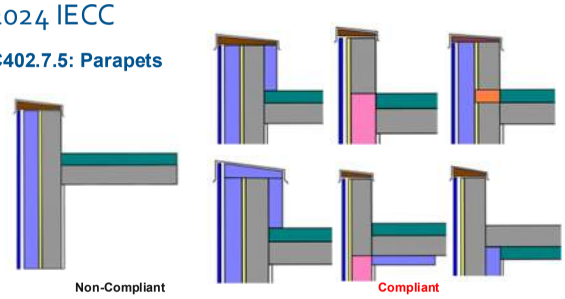
2024 IECC

C402.7.5: Parapets



Non-Compliant

0.4 Btu/h.ft.°F

Compliant

0.2 Btu/h.ft.°F

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Massachusetts Stretch Code

Passive House

TEDI Method

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Massachusetts Stretch Code

Passive House

- Performance based standards
- Thermal Bridge Free: Psi-values < 0.006 Btu/h.ft°F (0.01 W/mK)
- Common details
  - Foundation to wall
  - Grade beams and slab edges
  - Rim-joist / floor to wall
  - Wall to roof
  - Overhangs and exterior shading devices
- 2D thermal simulations (THERM, Flixo)

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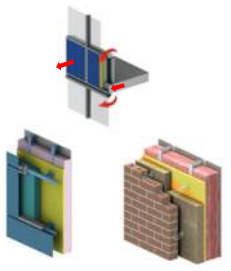
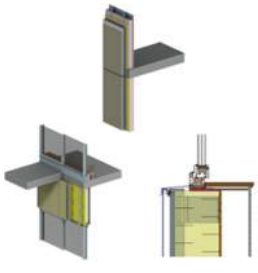
Massachusetts Stretch Code



Above Grade Walls



Linear Thermal Bridges

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Massachusetts Stretch Code

Above Grade Walls

- Derate continuous insulation
- Brick anchors:
  - 0.7 anchor derating factor
  - linear thermal bridge for shelf angle
- Cladding system derating
- Qualified thermal breaks:
  - 0.8 for < 3 Btu-in/h.ft2.F

Table 402.7.2.1.2 Cladding system derating factor

Thickness of R_c	Derating Factor
R_c is less than or equal to R-15	Derating Factor = 0.74 – 0.021 x R_c
R_c is greater than R-15	Derating Factor = 0.55 – 0.007 x R_c

C402.7.2.1.3 Cladding systems with qualifying thermal breaks. If plastic or fiberglass fasteners entirely comprised of material having thermal conductivity of 3 Btu-in/hr·ft²·F or less are used to support external cladding; or, if fasteners having thermal breaks which have a conductivity of 3 Btu-in/hr·ft²·F or less on both ends of the fastener are used to support external cladding, use Derating Factor of 0.8.

C402.7.2.2 Reference derating. Use pre-solved, derated continuous insulation values contained in Building Envelope Thermal Bridging Guide, version 1.6 or higher, published by BC Hydro Power Smart at https://www.bchydro.com

C402.7.2.3 Modeled derating. Use two or three dimensional finite element analysis heat transfer model to calculate derated value. A three-dimensional model shall be used when there are *point thermal bridges* or thermal bridging in multiple planes.

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Massachusetts Stretch Code

Spandrels

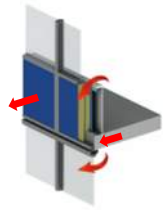

Table C402.7.4.1: Default R values for *spandrel sections*

Type	Default R-Value
Thermally broken	3.5
Non-thermally broken	2

C402.7.4.2 Reference R values. Use pre-solved opaque *spandrel sections* R values contained in Building Envelope Thermal Bridging Guide, version 1.6 or higher, published by BC Hydro Power Smart.

C402.7.4.3 Modelled R values. Use a two or three-dimensional finite element analysis to calculate R value of opaque *spandrel section*. A three-dimensional model shall be used when there are *point thermal bridges* or thermal bridging in multiple planes.

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Massachusetts Stretch Code

Linear Thermal Bridges

$$U_{derated} = \frac{PSI \times Length}{A_{wall}} + U_o$$

Where

$U_{derated}$ Derated wall U value (Btu/hr·ft²·F)

PSI Value from Section C402.7.3.1, C402.7.3.2, or C402.7.3.3 (Btu/hr·ft·F)

Length Length of linear *thermal bridge* (ft)

A_{wall} Area of derated wall (ft²)

U_o Wall or roof U value prior to *linear thermal bridge* derating

Table C402.7.3.1 Linear thermal bridge prescriptive PSI values

Type of Linear Thermal Bridge	PSI-value (Btu/hr · ft – F)
Balcony to exterior vertical wall intersection	1.00
Intermediate floor to exterior vertical wall intersection	0.60
Interior vertical wall to exterior vertical wall intersection	0.50
Fenestration to exterior vertical wall intersection	0.32
Parapet (vertical wall to roof intersection)	0.60
Brick shelf angle	0.35
Vertical wall to grade intersection	0.52
Vertical wall plane transition (building corners and other changes in vertical wall plane)	0.25

Reference Psi-values

- Building Envelope Thermal Bridging Guide

Modeled Psi-values

- 2D or 3D thermal simulations

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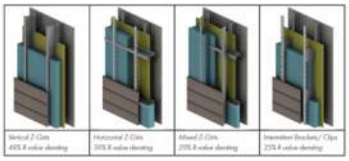
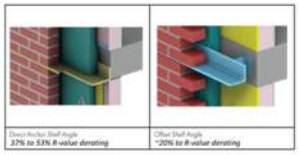
Thermal Bridging Solutions

Cladding Attachments





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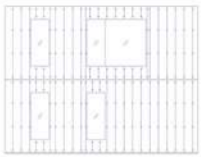
Thermal Bridging Solutions

Cladding Attachments

- Consider thermal and structural performance
- Girts vs Clips
- Mass Stretch Code: 27% to 63% de-rating values
- Properly designed system: ~10% de-rating



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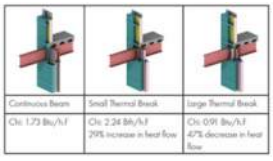
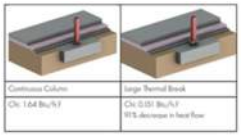
Thermal Bridging Solutions

Beams and Columns





1. Thickness matters
2. Stainless steel bolt > Steel bolts
3. Long-term Creep
4. Specifications

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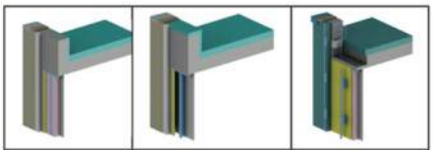
Thermal Bridging Solutions

Parapets



Partially Insulated Parapet	Fully Insulated Parapet	Thermally Broken Parapet
Psi: 0.260 Btu/h.ft.F	Psi: 0.186 Btu/h.ft.F 28% decrease in heat flow	Psi: 0.058 Btu/h.ft.F 78% decrease in heat flow

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Buildable Details

Breaking Thermal Bridges: A Guide to the Divide

Jim

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Durability Problems With Thermal Bridging

Condensation

- Cold spots
- Mold growth (Indoor Air Quality)
- Durability
- Moisture-related damage and deterioration

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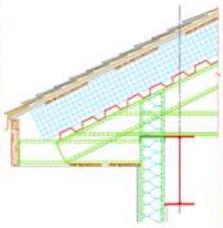
Clear Field – Cold-Formed Steel Roof Trusses



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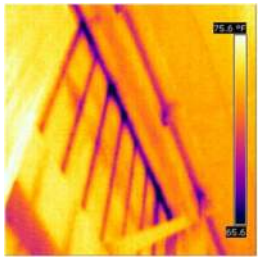
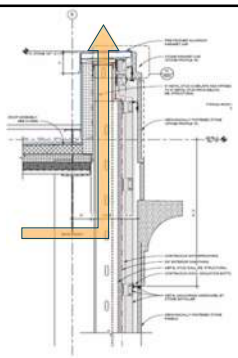
Clear Field – Steel Stud Parapets





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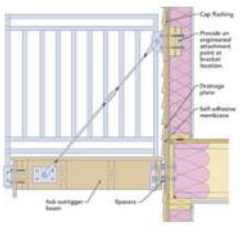
Structural Wood Balconies



https://www.finehomebuilding.com/2013/05/16/second-story-balconies

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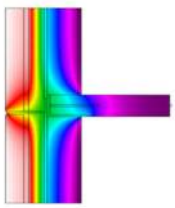
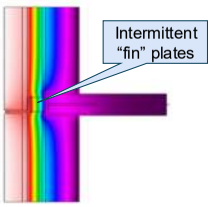
Linear Thermal Bridging – Relieving Angles





Unmitigated Detail:
U-Factor for 36" height = 0.44
240% INCREASE in conductive heat flow

Alternate Detail:
U-Factor for 36" height = 0.13
70% REDUCTION in conductive heat flow

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Linear Thermal Bridging – Relieving Angles

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Shelf Angle With Insulative Shims

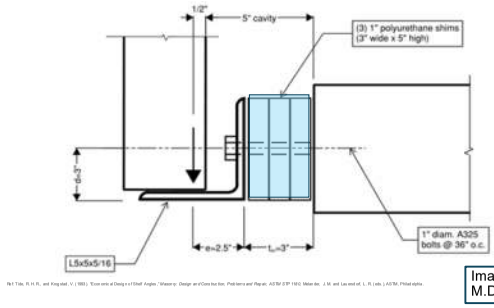

Image credit:
M.D. Webster, SGH

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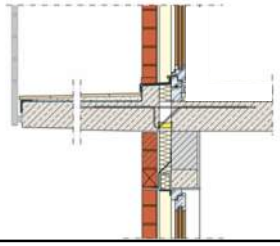
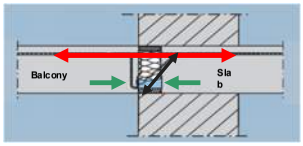
Manufactured Structural Thermal Break Assemblies (MSTBA's)

For CONCRETE



Images courtesy of Schock, Inc.



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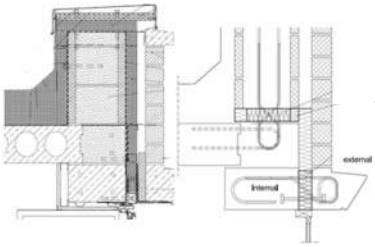
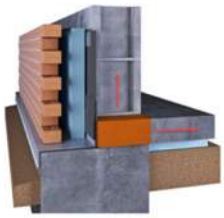
Masonry Parapets





Insulation Wrap
Courtesy Schock

Manufactured Structural Thermal Break Assembly
Courtesy Schock

Thermal Block
Courtesy Thermal Bridging Solutions

15 sep 22

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Manufactured Structural Thermal Break Assemblies (MSTBA's)

For STEEL

Images courtesy of Schock, Inc.

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Vernon-Verona-Sherrill CSD STEAM Addition MSTBAs

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Point Thermal Bridging – Low-Conductance Shims

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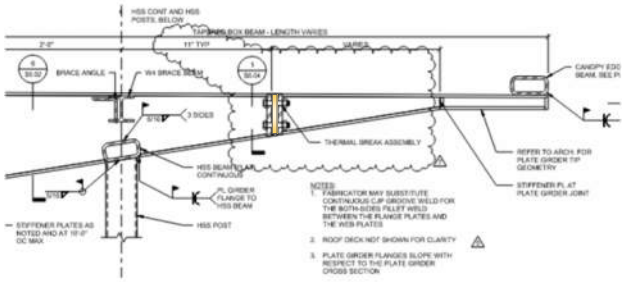
Low Conductance Shims - Thin is Worse Than Nothing!



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Insulative Coatings

Image courtesy of Greg Pope / Righter Group. Inc.

- Paint with aerogel insulation added for conductive resistance
- R-4.1 per inch, applied 25-50 mils = R-0.1 to 0.2 total
- Mainly used to reduce potential for condensation
- Requires surface prep, prime coat, and protection coat
- Apply to steel 24 inches out from insulation plane – on both interior and exterior sides
- Verify insulation properties of paint - there are imposters!

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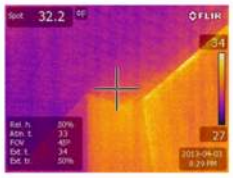
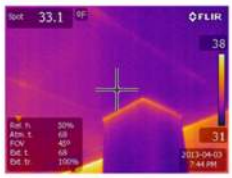
Insulated & Uninsulated Column Base Connection



Uninsulated Connection



Insulated Connection

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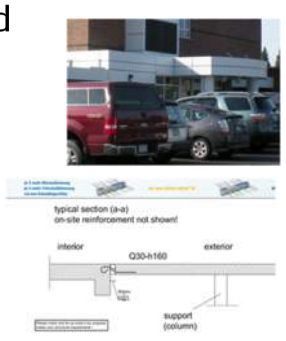
Insulating Extended Roof



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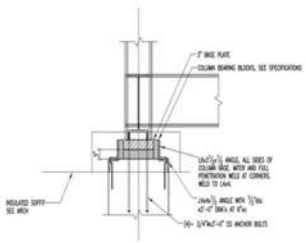
Insulating Above Open Parking



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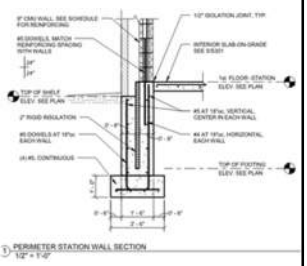
Insulating Within Foundation Wall



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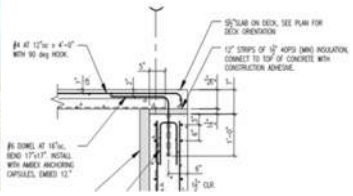
Insulating Above Foundation Wall



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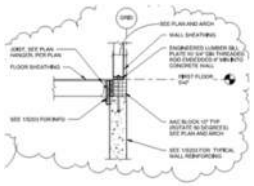
Insulating Above Foundation Wall



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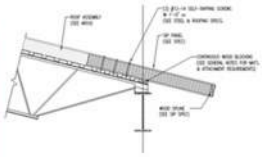
Insulated Roof Eave Framing



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Embodied Carbon

Breaking Thermal Bridges: A Guide to the Divide

Russ

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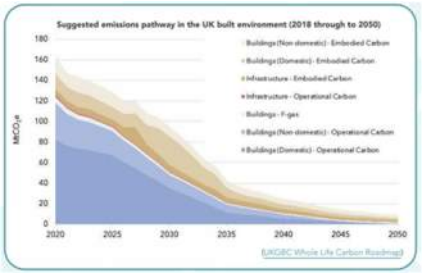
Embodied Carbon



Embodied Carbon as a Measurement of Environmental Impact & Comparison to Operational Energy

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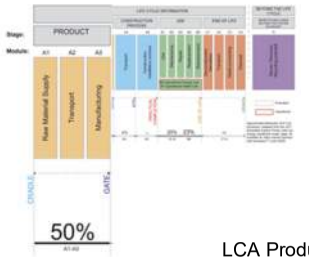
Embodied Carbon



GWP as kgCO2e
<u>or</u>
ODP
AP
EP
SFP
ADP

LCA Product Information from EPDs

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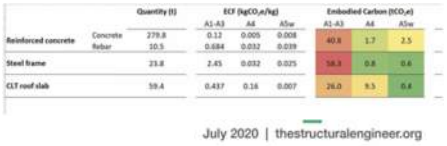
Embodied Carbon

GWP - Fossil	kg CO_2 eq.
GWP - Biogenic	kg CO_2 eq.
GWP - Luluc	kg CO_2 eq.
GWP - Total	kg CO_2 eq.

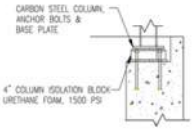


One pound of CO2
- *NRDC*

Overall GWP A1-A3 (IStructE's Quick Embodied Carbon Calculation)

50

Column Base Connection



FOAM COLUMN
BEARING BLOCK

99 kg CO2eq

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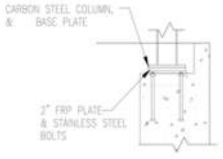
Column Base Connection



FRP & SS BOLT BASE

153 kg CO2eq

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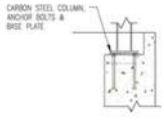
Column Base Connection



NO TB

151 kg CO2eq

53

Column Base Connection

Oak Block

50 kg CO2eq

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Beam Connection at Exterior Wall

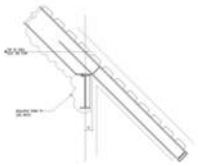
NO TB – 4 inch Swath

5 kg CO2eq

55

Beam Connection at Exterior Wall

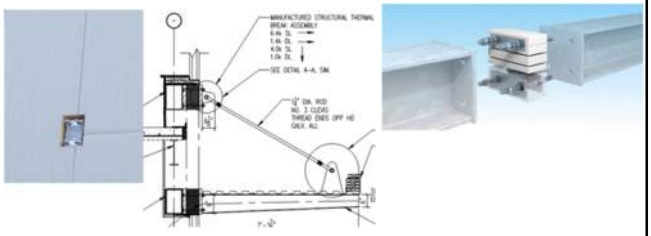
Interior Insulation



14 kg CO2eq

56

Beam Connection at Exterior Wall



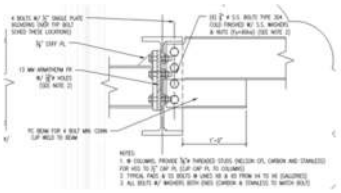
AAC w/ Foam & SS

25 kg CO2eq

57

Beam Connection at Exterior Wall

FRP & SS Bolts



27 kg CO2eq

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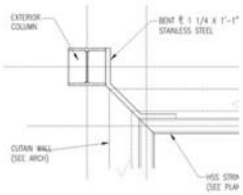
Beam Connection at Exterior Wall

Stainless Steel



7 kg CO2eq

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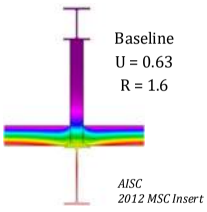
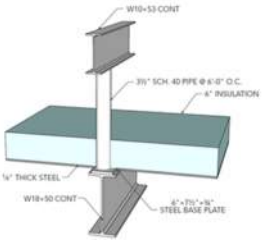
Roof Post



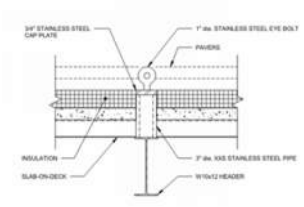
No TB



4 kg CO2eq

60

Roof Post

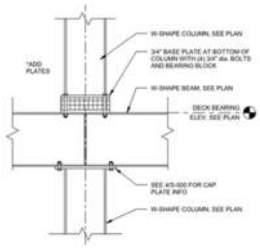


Stainless Steel

6 kg CO2eq

61

Roof Post



AAC w/ Foam & SS

16 kg CO2eq

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Other Pollution Metrics

Carbon Steel disturbs ~4x more EP by weight than Foams

ODP for Foams exponentially more by volume than steel

FRP 3x more WDP than AAC, by weight

Stainless Steel uses less energy to recycle than Carbon Steels

Carbon Steel ~ Stainless + FRP for GWP

GWP of Foam is ~1.5x more than Wood, by Mass

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General Ranking with Same Design Outline

Wood

Carbon Steel

Stainless Steel

Insulated Assembly

MSTBAs
- FRP w/ SS
- AAC w/ SS

Operational Assessments Due

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Problem Solving!

Breaking Thermal Bridges: A Guide to the Divide

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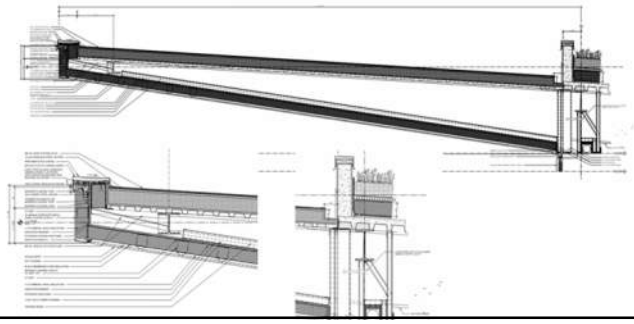
Soffit Detail



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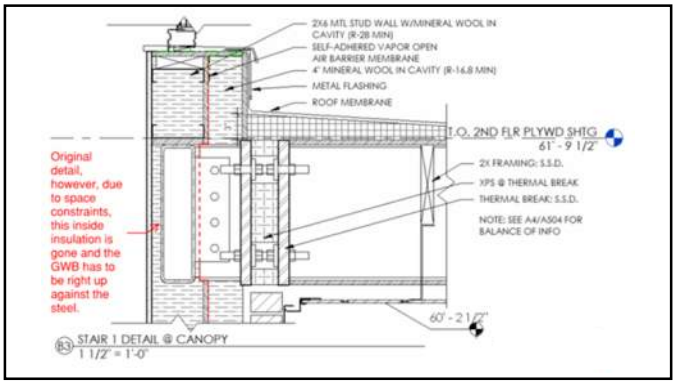

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Resources

Breaking Thermal Bridges: A Guide to the Divide

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Resources

Building Envelope Thermal Bridging Guide

- 700+ thermal bridging details

Construction Types

- Curtain wall, window wall
- Steel-frame
- Wood-frame
- Metal Buildings
- Mass Masonry
- Mass Timber

Thermalenvelope.ca

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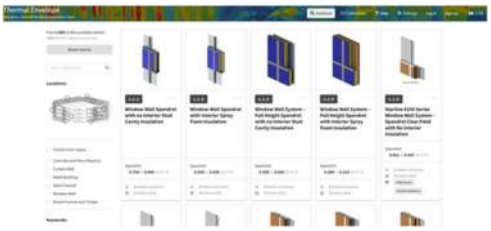
Themralenvelope.ca



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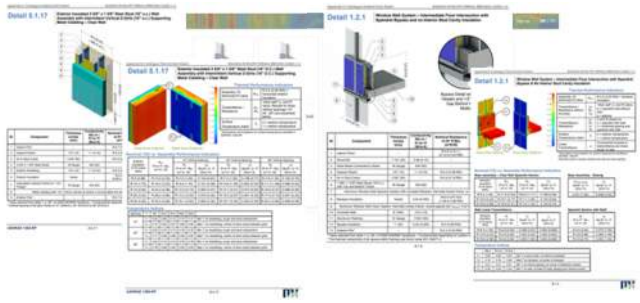

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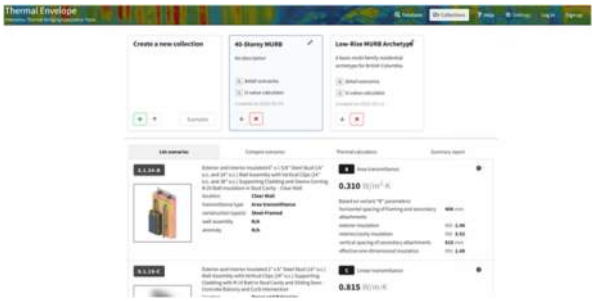

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SEI Sustainability Committee Thermal Steel Bridging Task Committee

Free!

http://structureandsustainability.blogspot.com/2012/03/pubs-5.html

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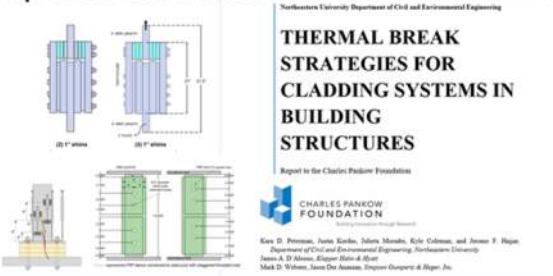
Pankow/AISC/ACMA/PIC – Sponsored Research



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Thank You!

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Breaking Thermal Bridges: A Guide to the Divide

Jim D'Aloisio, Klepper, Hahn & Hyatt (KHH)
Ivan Lee, Stantec
Russ Miller-Johnson, Engineering Ventures, PC

Curated by Keihly Moore and Smit Nimesh Ajmera

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