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Thermal Bridging: It Can Be Done Better

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1090 Vermont Avenue, NW, Suite 700
Washington, DC 20005-4905
Phone: (202) 289-7800
Fax: (202) 289-1092
nibs@nibs.org
www.nibs.org

PRESIDENT
Henry L. Green, Hon. AIA

CHIEF OPERATING OFFICER
Earle W. Kennett

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Please return all undeliverable addresses to:
5190 Neil Road, Suite 430
Reno, NV 89502
Phone: (866) 999-1299
Fax: (866) 244-2544

PRESIDENT & CEO
Jack Andress

CHIEF OPERATING OFFICER
Jessica Potter
jpotter@matrixgroupinc.net

PUBLISHER
Peter Schulz

EDITOR-IN-CHIEF
Shannon Savory
ssavory@matrixgroupinc.net

EDITOR
Alexandra Walld

FINANCE/ACCOUNTING & ADMINISTRATION
Shoshana Weinberg, Pat Andress, Nathan Redekop
accounting@matrixgroupinc.net

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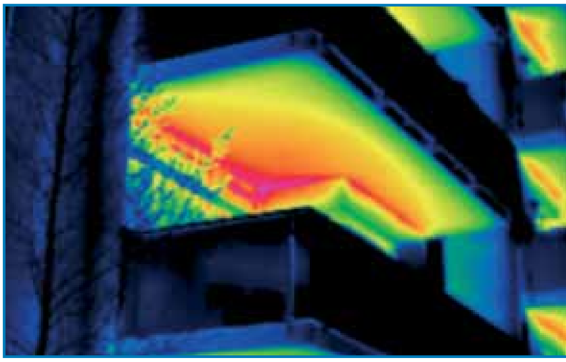

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Thermal Bridging: It Can Be Done Better

On the cover: The Centre for Interactive Research on Sustainability (CIRS), located at the University of British Columbia, is one of the greenest buildings on earth… and provides a great example of thermal bridging done right.

Thermal Bridging: Ignorance is not Bliss

By Mark Lawton and Neil Norris

ACROSS NORTH AMERICA, THE INDUSTRY is facing more stringent thermal requirements in building codes, and designers are responding by increasing the amount of insulation in walls, all in an attempt to increase energy efficiency in buildings. But how effective are these changes on building energy use when the impacts of 3D heat flow in transition building components (for example, exposed concrete slabs, window flashings and un-insulated parapets), are ignored? What if the building components that are neglected have a much greater impact on energy than first realized? And how will that affect the decisions that are currently made regarding the building envelope?

Thermal bridging cannot be completely avoided since many of these transition components, such as shelf angles and canopy penetrations, are required for structural purposes. The building industry has long struggled with how to deal with analyzing these components from a thermal perspective. The current thought process is: "If these structural members have to be there, they are small compared to the total wall area AND the energy impacts are difficult to calculate, so they can be ignored and focus can be put elsewhere." This has resulted in codes and standards increasing the thermal resistance requirements of walls and windows (lowering maximum wall U-values), while largely neglecting heat flow between transitional components.

More often than not, this increase in thermal requirements is interpreted as: "More insulation in the walls means proportionally better energy-efficiency in the building." The reality is, the industry is doing things wrong and as a result, bad decisions are being made. Simply adding more insulation to the walls will not necessarily decrease the energy use of your building if most of the heat flow bypasses the insulation through poor details anyway. This will leave you with diminishing returns as you add more insulation.

As an analogy, the building envelope can be thought of as a leaky water bucket with several holes. You may keep trying to plug one spot (for example, stuffing more insulation into the walls) but the hole right beside it is still leaking. If you want to achieve real energy savings AND minimize costs, you should consider the impact of these thermal bridges from transitional components in our analysis **(FIGURE 1 AND FIGURE 2)**.

Recent studies, such as ASHRAE 1365-RP *Thermal Performance of Building Envelope Details for Mid- and High-rise Buildings*, have shown that thermal bridges in transitional components can be significant contributors to heat flow through the envelope and cannot be ignored. The results show that lateral heat flow from studs or other bridging elements in the wall assembly connect to the bridging elements of the transition components. This creates 3D heat flow paths that allow heat to bypass the insulation of "high R-value" walls through the transition components, negating the benefits of having more insulation in the walls.

Having common details, like exposed slabs and metal flashings around windows, can more than double the expected heat flow. By ignoring these components, the unaccounted for heat flow is passed on as extra heating and cooling costs, oversizing of mechanical equipment and impacts on condensation and thermal comfort that are not fully realized. Let's also not forget about the cost of adding more insulation.

Fortunately, there are sensible ways to account for the effects of these thermal bridges. The method of linear transmittance, as outlined in ASHRAE 1365-RP, has been around for a while but not widely used in North America. Now, with relevant data to support the method, there is an opportunity to integrate this approach to improve current practices.

Essentially, this method allows transitional details to be characterized by the amount of extra heat flow they add to the wall assembly. For example, the linear transmittance of a slab edge is the added amount of heat flow from the slab per linear foot of the slab across the building. This approach also works for point transmittances, like steel canopy penetrations.

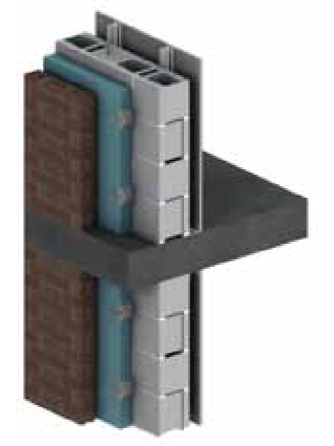

Figure 1. Brick veneer assembly with flush slab.

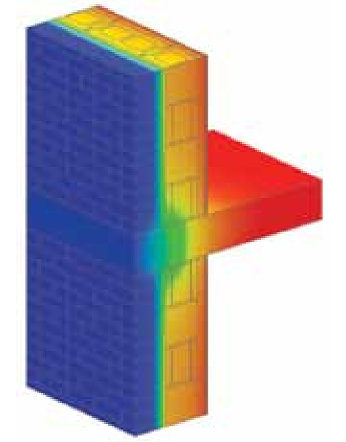

Figure 2. Thermal profile showing heat flow bypassing the insulation through the slab.

TABLE 1: SUMMARY OF FLOOR SLAB LINEAR TRANSMITTANCES

Floor Slab Detail	Wall Assembly	Linear Transmittance Btu/hr·ft °F (W/m K)	Category
Exterior Insulated Z-Girt Framing at Concrete Slab	Exterior Insulated Steel Stud Wall	0.02 to 0.06 (0.03 to 0.11)	Efficient
Insulated Metal Panel at Structural Steel Framed Floor	Horizontal Insulated Metal Panel System	0.02 (0.03)	Efficient
Exterior Insulated Z-Girt Framing at Structural Steel Framed Floor	Exterior Insulated and Interior Insulated Cavity Steel Stud Wall	0.07 to 0.18 (0.12 to 0.31)	Efficient to Average
Thermally Broken Concrete Slab Extension	Exterior Insulated Brick Veneer Wall with Concrete Block Back-up	0.12 (0.2)	Efficient
Insulated Metal Panel at Structural Steel Framed Floor	Vertical Insulated Metal Panel System with Metal Stacked Joint	0.19 (0.32)	Average
Pre-Cast Concrete with Steel Anchors at Concrete Slab	Sandwich Panel with no Interior Insulation	0.12 (0.21)	Efficient
	Precast Concrete Panel with “Continuous” Interior Insulation between Panel and Drywall Framing	0.22 (0.38)	Average
	Precast Concrete Panel with Interior Insulation Interrupted by Steel Stud Framing	0.29 (0.50)	Poor
Stand-off Shelf Angle Attached to Concrete Slab with Continuous Metal Flashing	Exterior Insulated Brick Veneer Wall with Concrete Block Back-up	0.19 (0.33)	Average
	Exterior Insulated Brick Veneer Wall with Steel Stud Back-up and Cavity Insulation	0.18 (0.31)	Average
Standard Shelf Angle Attached to Concrete Slab with Continuous Metal Flashing	Exterior Insulated Brick Veneer Wall with Steel Stud Back-up and Cavity Insulation	0.26 (0.45)	Poor
	Exterior Insulated Brick Veneer Wall with Concrete Block Back-up	0.29 (0.51)	Poor
Un-insulated Concrete Slab Extension	Exterior Insulated Brick Veneer Wall with Concrete Block Back-up	0.34 (0.59)	Poor
	Exterior Insulated Steel Stud Wall	0.43 (0.75)	Poor
	Interior Insulated Concrete Mass Wall	0.47 (0.81)	Poor
Un-insulated Concrete Slab with Exterior Slab Face Flush with Brick	Exterior Insulated Brick Veneer Wall with Concrete Block Back-up	0.36 (0.62)	Poor

This allows details to be categorized from poor to efficient in terms of the additional heat flow they produce (examples for floor slabs are shown in **TABLE 1**).

By characterizing the heat flow through transitional details in this manner, designers can more accurately make informed decisions when designing energy-efficient building envelopes. For example, the heat flow through a poor-performing detail, like an exposed concrete slab edge, could account for over 40 percent of the heat flow through the building envelope. This amount alone is surprising when you consider that it is typically ignored in calculations.

In comparison, a thermally efficient detail, such as an insulated slab edge, could contribute less than 10 percent. Insulating the slab edge could be much more cost-effective than trying to add more insulation to a wall assembly. By addressing transition components along with wall and window assemblies, a designer can more accurately evaluate what the best way is to improve overall U-values.

In order to change current practice for dealing with thermal bridging in transition components, communication between all members of the design team is essential. Increasing the accuracy of the U-values of walls will affect other aspects of the building design. Previously, heating, ventilation and air conditioning (HVAC) equipment had to be oversized with a significant safety factor because thermal bridging was difficult to quantify. Now, with the inclusion of an easy way to determine this heat flow, HVAC load calculations can be evaluated with more confidence.

Moving forward, understanding and integrating these thermal performance methods into practice is required by all parties involved in the building industry. For the architect, this is identifying efficient details over poor details in design. For the HVAC engineer, this is understanding the impact of accurate wall U-values on load calculations. For the energy modeler, this is using overall U-values that include thermal bridging in whole building energy simulations, as well as recognizing the sensitivity of wall U-values on simulated energy use. Most importantly, for governing bodies and standards associations, this is acknowledging thermal

THERMAL BRIDGING ON CIRS

The Centre for Interactive Research on Sustainability (CIRS), located at the University of British Columbia, is a good example of thermal bridging done right. In fact, in order to achieve a high level of energy efficiency with the building envelope, thermal bridging was minimized during the design of this building.

The main structure is wood frame, using glulam beams and some concrete sections. The cladding is connected to the structure using intermittent clips, which significantly reduced the thermal bridging compared to continuous girts. This also allows the exterior insulation to be run more continuously, especially over slab edges and rim joists. The roof insulation is run outboard of the structure with few penetrations. Additionally, the curtain wall was also aligned with the plane of the exterior insulation to minimize heat loss at curtainwall transitions.

bridging and providing incentives for better practice.

These governing bodies set the framework for industry to find the most efficient solutions. If thermal bridges in transition components are not recognized by the codes and standards, then there will not be a level playing field for designers. Accounting for heat flow through these transition components will make the building appear to be worse off than if they were just ignored. In reality, if the transition components are recognized and addressed, the building will have a much better thermal resistance. This creates a bizarre situation where you are rewarded for being less accurate. If there are no consequences for bad practice, or no recognition of good practice, then there is no incentive to improve on what is currently being done.

If there are real gains of improving overall building U-values to be made, then the governing bodies and standards associations will have to include accounting for thermal bridging in transition components in their compliance paths.

As architectural designs become more complex and demands for energy-efficiency increase, it will be up to industry to ensure that current practice sufficiently reflects reality. All members of the design team must be aware of these issues to ensure thermal bridging is recognized when it does make a difference. Otherwise, as energy costs rise, the industry will find out pretty quickly that ignorance is not bliss. ■

Mark Lawton, B.A.Sc., P.Eng. and Neil Norris, MASc., are with Morrison Hershfield, Ltd., based out of Vancouver, British Columbia.