

Thermal Bridging: Ignorance is not Bliss

Reconciling Reality with Practice in Building Envelope Thermal Performance

By Neil Norris

Across North America we are seeing 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 we ignore the impacts of 3-dimensional heat flow in transition building components, like exposed concrete slabs, window flashings and un-insulated parapets. What if these building components we neglect have a much greater impact on energy than we realize? And how will that affect the decisions we currently make on 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, we can ignore them and focus somewhere else'*. 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, we are doing things wrong and as a result, we are making bad decisions. Simply adding more insulation to your 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 (ie: stuffing more insulation into the walls), but the whole right beside it is still leaking. This approach can result in throwing money away on something that has no practical effect on energy use. If we want to achieve real energy savings AND minimize costs, we should consider the impact of these thermal bridging from transitional components in our analysis.

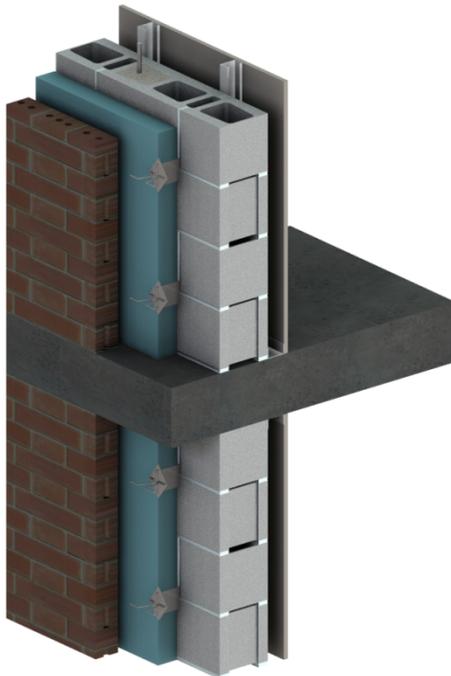


Fig 1: Brick Veneer Assembly with Flush Slab

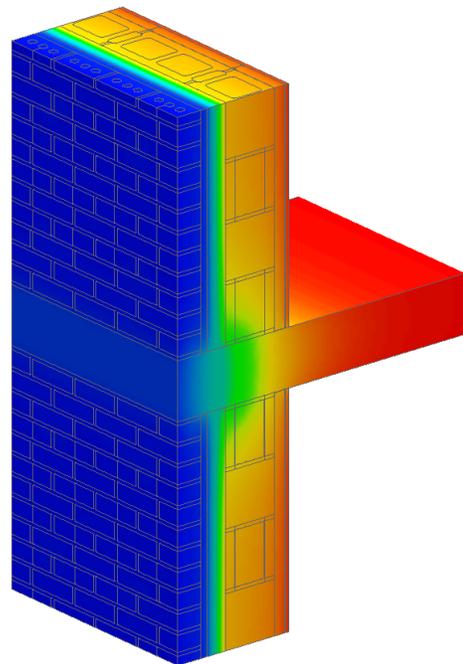


Fig 2: Thermal profile showing heat flow bypassing the insulation through the slab

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 costs of additional insulation in the wall assembly which could be better spent on improving other building elements that could have more impact.

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. 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% 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%. 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 is the best way to improve overall U-values.

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

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 wall U-values will affect other aspects of the building design. Previously, 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 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. Therefore practitioners cannot be blamed for thinking '*well if I'm not required to account for these thermal bridges, why should I voluntarily penalize myself?*' 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 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, we will find out pretty quickly that ignorance is not bliss.

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