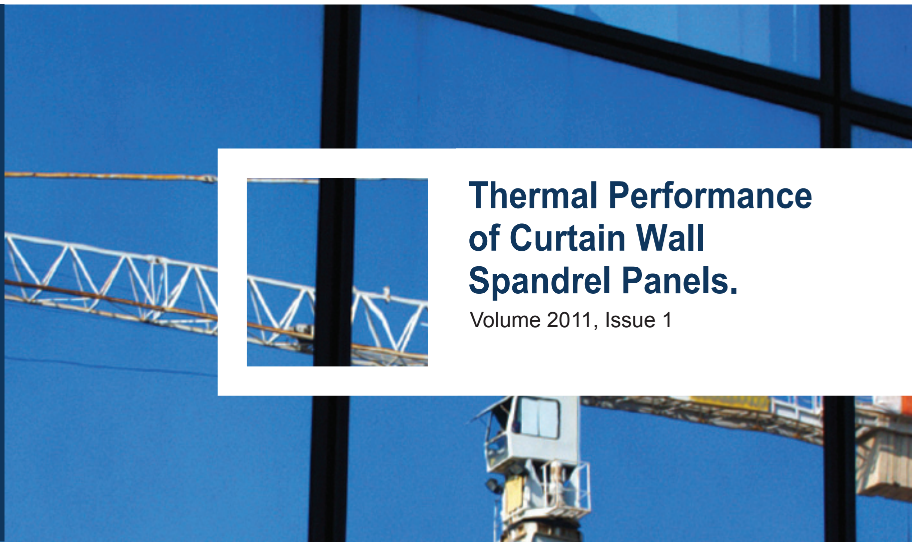
Morrison Hershfield

SOLUTIONS

BUILDINGS



Thermal Performance of Curtain Wall Spandrel Panels.

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Leading the way to a Sustainable Future.

Spandrel panels constituent of glazing systems are a widespread architectural element of mid- and high-rise buildings. Designers long for spandrel panel sections to match the requirements of energy standards for opaque elements. Regrettably there is not an available insulation that can be packed into the back-pan of typical spandrel panel sections to meet the requirements of current energy standards for opaque elements for mild and cold climates. This situation often leads designers to consider adding insulation inboard of spandrel sections to improve their performance.

The Questions

Two questions arise from the evaluation of the thermal performance of adding insulation inboard of spandrel panel back-pan:

1. **How does the overall thermal transmittance (U-value) compare between the two scenarios (un-insulated stud cavity behind back-pan and spray foam in stud cavity behind back-pan)?**

2. **How much is the condensation resistance of the glazing system compromised by adding insulation inboard the metal back-pan?[1]**

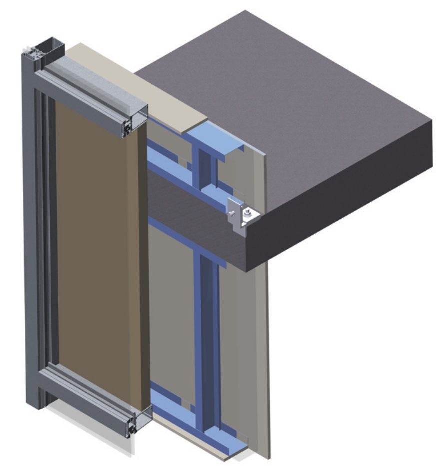
These questions are best answered by a calibrated three dimensional (3D) thermal model.[2 3] A 2D model cannot effectively model this scenario to answer these questions because of the complex three dimensional heat flow paths and the need to evaluate surface temperatures.

The Solution

A solution to these questions for a conventional curtain wall system was found as part of ASHRAE Research Project 1365 "Thermal Performance of Building Envelope Details for Mid- and High-Rise Buildings".[4] A conventional curtain wall system at a floor slab intersection with an un-insulated stud cavity was compared to the same system with 50 mm (2 inches) of closed cell spray foam in the stud cavity. Both systems were completed for varying levels of insulation in the back-pan, R-5 to R-25.

Thermal Transmittance (U-value)

Adding insulation into the back-pan has a similar diminishing rate of return for both systems since the aluminum structural members bypass the back-pan for both scenarios. Adding spray foam inboard of the back-pan results in an 80% to 115% improvement in overall thermal transmittance (U-value) but still falls short of the performance typically expected from opaque elements for mild and cold climates. Furthermore, adding R-11.5 (2 inches of foam) of insulation to the system only resulted in an increase in overall (effective) thermal resistance of about R-4. This is disappointing but not surprising given the significant amount of heat flow that can flow through elements bypassing the thermal insulation; slab, anchors, and perimeter stud framing.



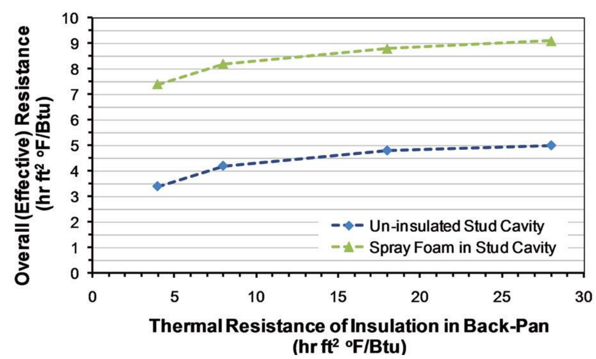


Figure 1: Diminishing Rate of Return of Spandrel Section Overall Thermal Reaction.

Table 1: Overall Thermal Transmittance of Curtain Wall Spandrel Section [Btu/hr ft^2 ^{o}F (W/m^2 K)]

	Back-Pan Insulation R-Value (RSI)			
	R-4	R-8	R-18	R-28
Un-insulated Stud Cavity	0.29 (1.66)	0.24 (1.35)	0.21 (1.19)	0.20 (1.14)
Spray Foam in Stud Cavity	0.14 (0.77)	0.12 (0.69)	0.11 (0.64)	0.11 (0.63)

Condensation Resistance

Indexed surface temperatures[5] provide designers a means for a quick check of condensation risk for any design condition and target any potential problem areas. Further analysis can then be targeted to areas where the risk of condensation does not appear to be effectively minimized.[6] The temperature index of glass and frame was reduced by 10% and 15% respectively by adding the spray foam to the back-pan.

For evaluation of the system based on coldest surface temperature, the condensation resistance dropped from a temperature index of 0.48 to 0.43. This is a 1° to 3°C difference in surface temperature or a 2 to 4% RH difference in maximum indoor RH without the risk of condensation for mild and cold climates. These results indicate that the difference in condensation resistance is acceptable for when indoor moisture levels are controlled but needs closer examination for spaces with uncontrolled indoor humidity (most residential buildings).

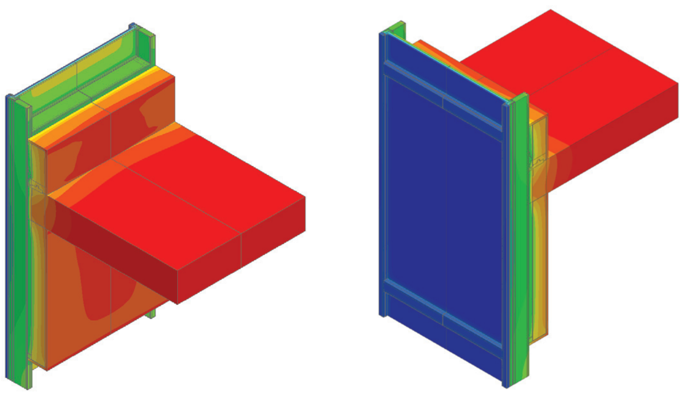


Figure 2: Temperature Profile of a Conventional Curtain Wall Spandrel Section at a Concrete Floor Slab

Closing

Often evaluation of glazing systems does not require 3D heat transfer modeling. Techniques utilizing component modeling of 2D sections is well established in our industry; procedures developed over many years to evaluate the thermal performance of glazing systems provide sufficient accuracy for building design. This MH solution highlighted an exception where more complex procedures are necessary.

This example provided insight into the relative performance between a conventional curtain wall spandrel panel with insulation only in the metal back-pan and a composite system with insulation also provided inboard of the back-pan. Definite solutions for specific systems and framing spacing can be done using the same procedures. A higher performing glazing system with a significant thermal break can likely improve the performance closer to the expected performance for opaque elements with steel framing.

We believe our experience and resources to do complex 3D modeling efficiently and without limitations set us apart from our peers.[7] Furthermore the judgment of our modeling team gained by extensive field experience allows us to effectively apply solutions that are relevant to the design, construction and operation of the built environment.

Supplementary Notes

1. The provision of insulation inboard of the metal back-pan and vertical curtain wall members of the spandrel section will lower the interior surface temperature of the frame of the vision section since vertical curtain wall members are continuous. Condensation resistance can be compromised because many systems rely on the interior air to keep interior surfaces marginally warmer than the interior air dewpoint of some conditioned spaces.

2. The only other viable alternative is guarded hot-box test measurements, which can be a difficult and costly proposal if considering the thermal bridging effects of intersections of spandrel panels with other building elements, for example concrete floor slabs.

3. Part of MH's resources is a 3D heat transfer model that was extensively calibrated and validated as part of ASHRAE Research Project 1365.

4. Final Report was finalized in July, 2011 and is available from ashrae.org.

5. Surface temperatures presented using temperature indices allow the surface temperatures to be applicable to any set of indoor and outdoor conditions. A value of 0 is the outdoor air temperature and 1 is the indoor air temperature.

6. Surface temperatures at boundary layers exposed to air are highly sensitive to variable boundary conditions. There is the potential for condensation to occur in practice at some localized areas (for example, due to screws, surface resistances variations, moisture variations, etc), nevertheless the design criteria in most codes, stated or implied, and design practice is to minimize condensation and not totally eliminate the risk of condensation.

7. We have the resources readily available to analyze the combination of time sensitive and dynamic effects, radiation through air spaces, complex geometries (objects not necessarily parallel to the x-y-z axis), phase changes, and conduction as required to provide constructive solutions.

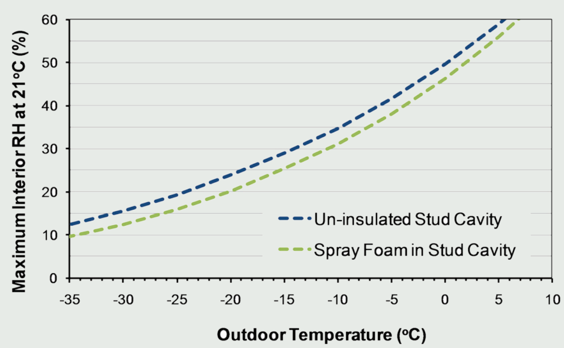


Figure 3: Maximum Indoor RH without the Risk of Condensation for a Range of Outdoor Design Temperatures.

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