A Comparison of Thermal Break Solutions for Structural Steel

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Steel is a highly thermal conductive building material (k = 50 W/mK), thus incredibly efficient in transferring heat energy. What happens when steel is used as the structural member for cantilever assemblies like canopies and sunshades that extend from the interior of a building to the exterior?

Since these steel beams penetrate the exterior wall insulation, this creates a thermal bridge in the building envelope. Thermal bridges are detrimental to the energy performance of a building, which results in high energy loss, thermal discomfort, and low temperatures on the internal surface of the structural element. The latter creates a potential situation for condensation, mold growth and premature maintenance costs.

The solution is a thermal break connection for steel assemblies. The primary function of a thermal break is the reduction in heat loss and thermal conductivity through the building envelope. Yet, equally important to energy efficiency is the structural integrity of the thermally broken connection. An effective thermal break for steel cantilever structures must be able to transfer significant moment and vertical shear forces from the exterior assembly to the interior structure.

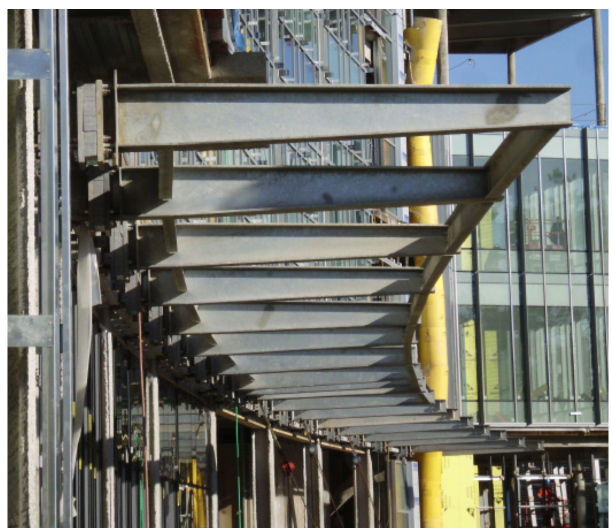
With various thermal break options for steel in the market place, how does a design team determine the most viable and structurally sound solution?

In the short time I'd been with Schöck, I found most architects and engineers in the Pacific Northwest were familiar with various types of thermal insulation materials (TIM) or 'thermal pads' which consists of PTFE or fabric reinforced composite. However, most designers were not familiar with the Schöck Isokorb Type S22, a complete structural thermal break solution for cantilevered steel construction that facilitates the thermal separation of steel structures while transferring high loads at the same time.

To properly understand the differences between 'thermal pads' and the Schöck Isokorb Type S22, we will examine the structural and thermal properties separately.

Structural Differences

'Thermal pads' or thermal insulation materials (TIM) are non-load bearing and have no proven structural integrity except for high compressive strength.



Schöck Isokorb® S22 structural thermal breaks installed at canopy connections, Life Science Laboratory, UMASS, Amherst, MA.

Tensile and shear forces are resisted by the steel bolts holding the thermally broken connection together. The vertical shear forces at the connection along with the gap (thickness of the thermal pad) create bending moments at the bolts - the thicker the thermal pad or the gap, the greater the bending moments at the bolts. If any creep deformation occurs in the pad over time, this creates extra stresses and increases the buckling potential of the bolts in the compression zone. Additional deflection of the steel member also needs to be taken into consideration if the pads deform. Due to the uncertainty about the creep deformation potential in the insulation pad, precise connection stiffness cannot be guaranteed with this solution. In addition, thermal pad suppliers do not normally provide the engineering design of the connection. The Engineer of Record (EOR) for the project or the steel fabricator is responsible for the engineering of the connection. This should cause concern as there are no standardized material data for such a structurally critical connection.

Schöck Isokorb® Type S22 modules are manufactured thermal breaks designed to transfer moment forces in constituent tension and compression, as well as shear forces. The load bearing elements in the Schöck Isokorb Type S22 modules constructed of stainless steel are the head-plates, threaded rods, and an internal HSS (hollow structural section) core that can transfer the vertical shear forces into the interior members. Unlike the thermal pads, Schöck Isokorb Type S22 modules provide precise connection stiffness making the deflection calculations straightforward. The Schöck Isokorb solution *includes* the delegated engineering connection design along with an independent Professional Engineer's seal and signature for all structural thermally broken connections.

Thermal Differences

Any solutions claiming to be a structural thermal break should be able to provide a thermal modelling analysis of the connection. This is something the design team should inquire about to differentiate between legitimate solutions vs. smoke and mirror claims.

The load bearing elements in the Schöck Isokorb® Type S22 modules are all made of stainless steel (k = 15 W/mK). Stainless steel is 70% less thermally conductive as carbon steel (k = 50 W/mK). These load bearing components are then encased with 3.15" (80mm) of superior insulation material, BASF's Neopor™, a graphite enhanced expanded polystyrene (k = 0.031 W/mK). The graphite acts as a thermal absorber and reflector of radiation heat providing a higher thermal resistance compared to regular white EPS.

Schöck Isokorb® S22 structural thermal breaks for steel-to-steel connections

'Thermal pad' solutions often range from thicknesses of ½" to 1-½".

There have been a few independent studies that show that 'thermal pads' are NOT an effective thermal break solution for steel. As a matter of fact, there had been two prominent studies that show 'thermal pads' can increase the thermal bridging effect compared to a continuous steel beam with no thermal break solution. The first study was performed by Oxford Brookes University, Oxford Institute for Sustainable Development (OISD Technology) in their Report 060814SCH updated December 18, 2012, "Thermal Performance of Steel Beam Junctions using Different Connection Methods" and the second was by Morrison Hershfield in their Report No. 5131042.00 dated August 1, 2014 , "Thermal Break Technology for Various Construction Types." The thermal findings in Morrison Hershfield's report were also included in their well-received "Building Envelope Thermal Bridging Guide: Analysis, Applications, and Insights (Version 1.1 – 2016)".

2.1.3 Steel to Steel Connection

Table 9: Thermal transmittance of Structural Steel Beam Penetrations through Steel Stud Walls

Scenario		Description	Clear Wall U-value Btu/ft²·hr·°F (W/m²K)	Overall U-value Btu/ft²·hr·°F (W/m²K)	X Btu/hr·°F (W/K)	% Reduction in Heat Loss
Conventional Construction	C01-CC	Uninterrupted steel beam	0.054 (0.31)	0.146 (0.83)	1.73 (0.92)	-
Thermal Isolator Pad	C02-TI	5 mm isolator pad, stainless steel bolts	0.054 (0.31)	0.167 (0.95)	2.17 (1.15)	-26%
		5 mm isolator pad, steel bolts	0.054 (0.31)	0.170 (0.97)	2.24 (1.19)	-30%
		5 mm pad, stainless steel bolts, R-10 outboard of flanges	0.054 (0.31)	0.156 (0.89)	1.80 (1.03)	-12%
		10 mm isolator pad, stainless steel bolts	0.054 (0.31)	0.150 (0.85)	1.82 (0.97)	-5%
		10 mm isolator pad, steel bolts	0.054 (0.31)	0.153 (0.87)	1.89 (1.00)	-9%
		19 mm isolator pad, steel bolts	0.054 (0.31)	0.145 (0.82)	1.71 (0.91)	1%
		25 mm isolator pad, steel bolts	0.054 (0.31)	0.140 (0.80)	1.61 (0.86)	7%
Manufactured Thermal Break (Isokorb S22)	C03-SA	Steel beam separated by Isokorb S22 thermal break	0.054 (0.31)	0.107 (0.61)	0.91 (0.48)	48%

The table to the left from the Morrison Hershfield study shows a steel beam separated by a Schöck Isokorb Type S22 thermal break solution can reduce heat loss by 48% compared to a continuous steel beam with no thermal break solution. Unfortunately, the study also shows damaging results for 'thermal pad' solutions under a 1" in thickness where it can intensify the thermal bridging effect. This is caused by a larger surface area at the end plates as well as concentrated heat flow through the bolts holding the connection.

3" (75mm) and thicker 'thermal pads' start becoming a legitimate competitor in terms of thermal performance. However with the thicker pads, this requires more engineering faith in the bending moment capacity and buckling strength of the bolts.

For more information on our Schöck Isokorb® Type S22 structural thermal break solutions, please feel free to contact me directly at Patrick.Chan@schock-na.com or +1 604 363 4212. You can also visit the Schöck North America website http://www.schock-na.com.

ON THE COVER: Steel canopy connections at the Life Science Laboratory at the University of Massachusetts in Amherst, MA, insulated with Schöck Isokorb® S22 structural thermal breaks,

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