Thermal Bridge Modeling for Architects

Friday, October 25, 2019. 1-5 PM



Acknowledgements/Credits

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Course / Learning Objectives

- Build a foundation for understanding thermal bridging in buildings and how excess heat loss impacts building energy consumption, durability, and health.
- Learn how to use the free software LBNL THERM to execute typical architectural-envelope simulations on areas such as steel-stud assemblies, corner details, and balcony penetrations.
- Compare details and material thermal properties, learn how to examine details for common thermal bridges, and how to classify and calculate detail 'PSI-Values' for your own projects.
- Study effective thermal bridge mitigation techniques, and learn how to solve common design problems through iteration and simulation.



Outline

- Introduction to Thermal Bridges
- THERM Libraries, Underlays, Geometry
- THERM Materials & Boundary Conditions
- THERM Simulations
- Calculating Psi-Values:
 - Outside Corners
 - Parapets
 - Windows
 - Slab on Grade
 - Heated Basement



From ISO 10211

"thermal bridge: part of the building envelope where the otherwise uniform thermal resistance is significantly changed by full or partial penetration of the building envelope by materials with a different thermal conductivity, and/or a change in thickness of the fabric, and/or a difference between internal and external areas, such as occur at wall/floor/ceiling junctions"

Thermal bridges, which in general occur at any junction between building components or where the building structure changes composition, have two consequences compared with those of the unbridged structure:

1. a change in heat flow rate, and

2. a change in internal surface temperature.

Although similar calculation procedures are used, the procedures are not identical for the calculation of heat flows and of surface temperatures.



Any place in the building envelope where the otherwise uniform thermal resistance is significantly changed due to:



full or partial penetration of the insulating layers by materials with a different thermal conductivity



and/or

a change in thickness of the insulating layers



and/or

a difference between internal and external areas, such as occurs at wall/floor/ceiling junctions.



Simulating Thermal Bridges





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https://windows.lbl.gov/tools/therm/software-download

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THERM Model

A model is made of the construction assembly and the conductivities / resistances are added for the relevant materials

The model is overlaid with a mesh and all elements are calculated. The thermal behavior of the construction elements can be calculated according to the 'grain' or scale of the mesh.





ISO Reference Standards

LIN INSTITUTE OF TECHNOLOGY, 19/10/2014, Uncontrolled Copy, © BSI	BRITISH STANDARD Thermal bridges in building construction — Heat flows and surface temperatures — Detailed calculations (ISO 10211:2007)	BS EN ISO 10211:2007	LIN INSTITUTE OF THEINOLOGY, 19/10/2014, Uncontrolled Copy, © BET	BRITTSH STANDARD Thermal performance of buildings — Heat transfer via the ground — Calculation methods (ISO 13370:2007)	BS EN ISO Interpreting Comparing Merce 2009	BS EN ISO 13788:2012 BI Standards Publication Mygrothermal performance puilding components and puilding elements — Internal surface temperature to avoid critical surface humidity and interstitial condensation — Calculation methods (ISO 13788:2012)
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ISO 10211

• Thermal bridges in building construction.

ISO 13370	
Heat transfer	via
the ground.	

ISO 13788

• Hygrothermal performance of components



Fen-BC Window Guide

AIA

New York

bldgtyp

http://www.fen-bc.org/uploads/BC Reference Procedure PHPP Window Values Using THERM (1.1).pdf



How much to model?

ISO 10211 Section 5.2.2 and 5.2.3 have detailed rules about how far to model, and where to 'cut' the model in order to ensure accurate simulation results.

- at least 3-ft from the central element if there is no nearer symmetry plane
- at a **symmetry plane** if this is less than 3-ft from the central element
- 'Rule of thumb': use at least 3x the wall thickness for length of the detail





Materials and Conductivity Values



ISO 10456

 Building Materials and Products

ISO 6946

Thermal resistance and thermal transmittance



2x6 Stud Wall (Typ.)

For the 'normal' clear field assembly, we use THERM to give us an effective whole assembly U-Factor. This takes into account the effect of the repeating bridges (studs).

Our energy model's Transmission Heat Loss calculations are all executed using this value.



U-Factor = 0.0570 (Btu / hr·ft²·F)



Structural Steel Thermal Bridge

EXAMPLE: For structural reasons, at several locations in the building the engineering team wants to insert steel columns in the walls which support beams above. They propose adding $\frac{1}{2}$ of XPS foam to the exterior as a thermal break. What is the impact of adding these columns to the wall?



Bridged Assembly

'Typical' Assembly



Calculating the PSI-Value

The PSI-Value (Ψ) accounts for the actual heat loss at the detail vs. the 'Typical' assembly – the one we used in the numerical energy model

The steel columns' disruption to this 'typical' construction will mean additional heat loss at this area



Actual Heat Loss - 'Typical' Heat Loss = Psi-Value



Setting Up THERM Libraries

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Conductivity?

Note: Conductivity (k) is a measure of the material properties measured over 1 inch of thickness, measured in Btu-in/hr-ft²-F

By default Therm uses 1D Conductivity values, rather than the 2D Transmittance values (k) we are probably more familiar with. You'll need to convert all your materials to a 1D value to be able to input them into a new Therm material.



Note: In order to use in THERM, first convert your material R/in values to a conductivity value, then divide by **12 inch / foot** to correct the units



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Use the underlay to help you create all the elements with the rectangle and polygon tool

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