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Evaluating Suggested Lengths used for Cut-off Planes using The Effective Length Calculation Procedure.

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Research Officer NRC (2019-Present)

- Investigating steady state effects of thermal bridges
- Exploring effects of simplifications made in thermal performance simulations
- Performing effective length calculations to confirm effects of thermal bridges are being captured in thermal performance simulations

Master’s degree in mechanical engineering from Carleton University

- Investigation of service life for vacuum insulation panels using accelerated ageing
- Designed, built and calibrated a guarded hot plate apparatus

Expertise

- Heat transfer, simulations, linear thermal transmittance, vacuum insulation panels, Mechanical engineering

Thermal performance of building envelopes

Building codes are attempting to reduce space heating and cooling loads by increasing the minimum insulating levels.

As higher insulation levels are used, the effects of thermal bridging become more important.

The additional heat flow from all the thermal bridges can become a large portion of total energy loss from a structure.

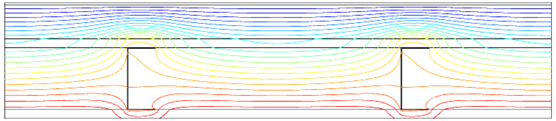
(National Research Council Canada, 2019)

What is a thermal bridge

Thermal bridge is a term used to describe a feature within a building façade which facilitates the transport of thermal energy through the envelope at a higher rate compared to the surrounding construction (ISO 10211, 2017).

Thermal bridges can be found where there are changes in material properties or geometries that result in discrepancies in material thicknesses.

Eg. Window frames, studs in walls, slab edges, metal fasteners



Ways to calculate thermal performance

Hand calculations (ASHRAE, 2017) (National Research Council Canada, 2011)

- Isothermal planes, Parallel path, Modified Zone, Thermal transmittance

Guarded Hot Box testing (ASTM C-1363, 2019)

In-Situ testing

Computer simulations (ISO 10211, 2017)

- 2D and 3D simulations

Thermal transmittance

$$U = \frac{\sum(\psi L) + \sum(\chi)}{Area} + U_O$$

U = Thermal transmittance of assembly with thermal bridges (W/m^2•K)

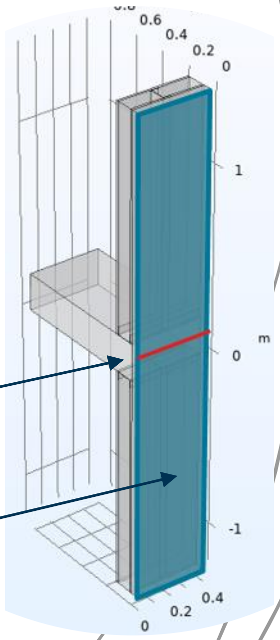
U_O = Thermal transmittance of assembly without thermal bridge (W/m^2•K)

ψ = Linear thermal transmittance (W/m•K)

L = Length of linear thermal bridge (m)

χ = Point thermal transmittance (W/K)

Area = Surface area (m^2)



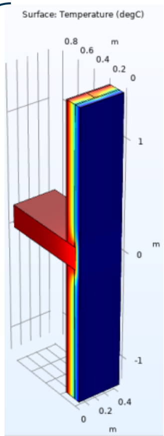
Linear thermal transmittance

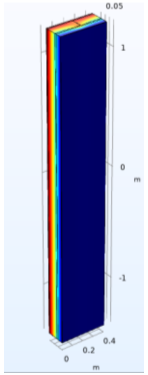
$$U = \frac{\Sigma(\psi L) + \Sigma(\chi)}{Area} + U_O$$

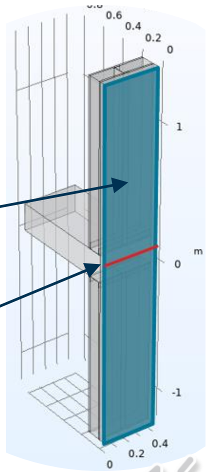
Assuming no point thermal bridges,

Rearranging for ψ

$$\psi = \frac{\{\ \text{[image 1]} - \text{[image 2]}\ \}\ Area}{L}$$

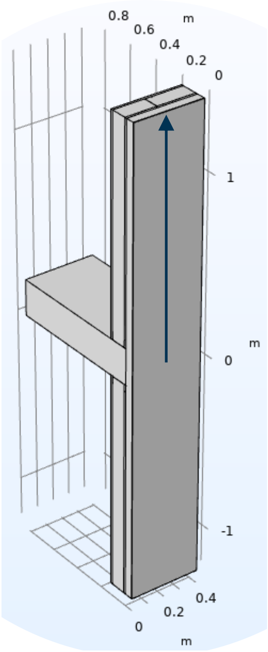






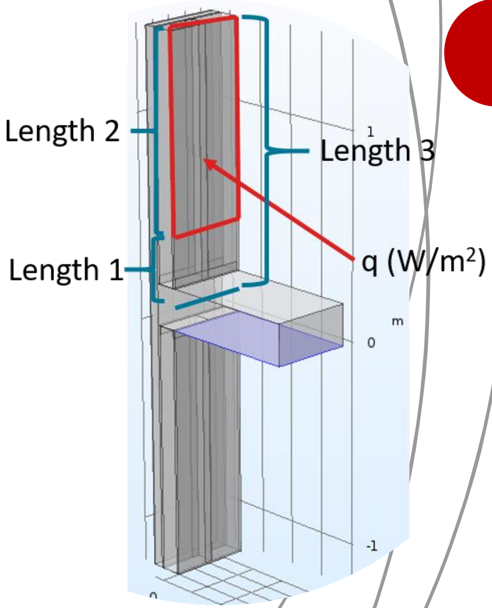
Cut-off lengths

Suggested Cut-off Length	
Length (m)	**Reference**
0.915	(ASHRAE, 2011)
Greater of 1 m or 3 times thickness of flanking element	(ISO 10211, 2017)
1.2	Used in this study

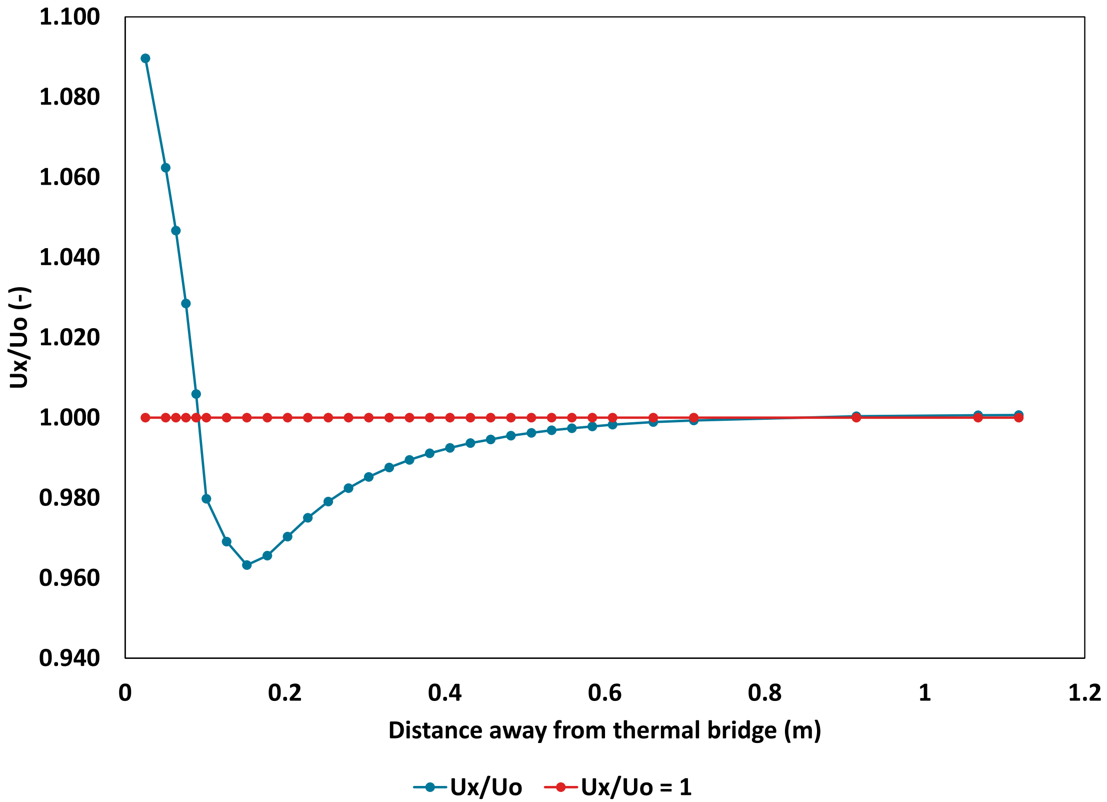


Effective length procedure

- Incrementally increase the length of Length 1 starting “x” distance from center of thermal bridge
- Evaluate the average heat flux (W/m^2) and subsequent thermal transmittance “U_X” (W/m^2 K) value through the remaining area (Length 2 x Width)
- Calculate the ratio between the obtained U_X value and the clear field U_O value or U_X/U_O
- U_O or Clear field thermal transmittance (assembly without thermal bridge)
- Looking for the length away from the thermal bridge where the resulting ratio U_X/U_O converges to 1

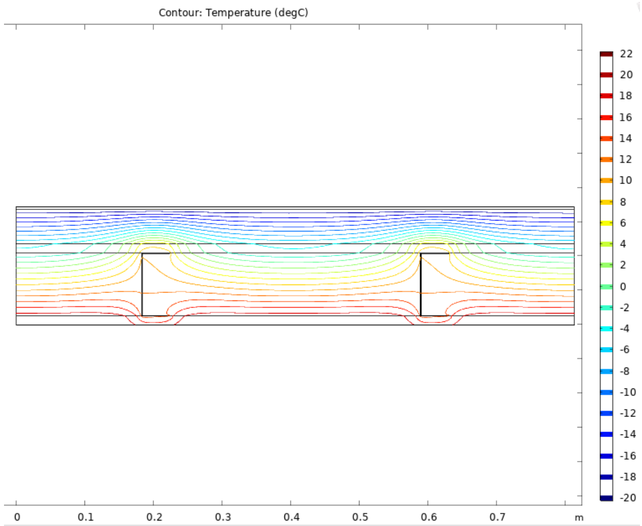


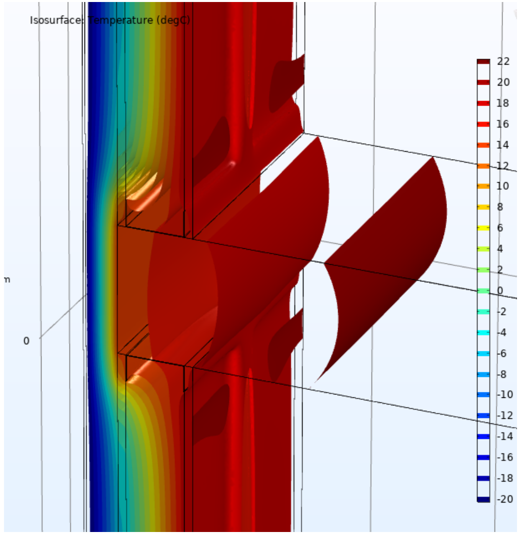
Effective length plot

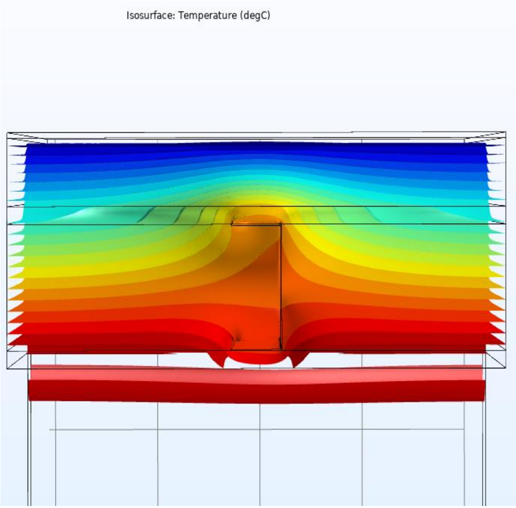


- Ratio of $U_X/U_O = 1$ is when heat flux resembles that of clear field wall.
- As distance away from center of thermal bridge increases, the effects of thermal bridge decrease.

Isotherms from COMSOL







Conclusions

- Effective length in example was found to be 0.7 m
- Recommended cut-off lengths would be sufficient
- Linear thermal transmittance ψ is dependant on modeled area

Acknowledgements

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