KEEP THE HEAT INSIDE

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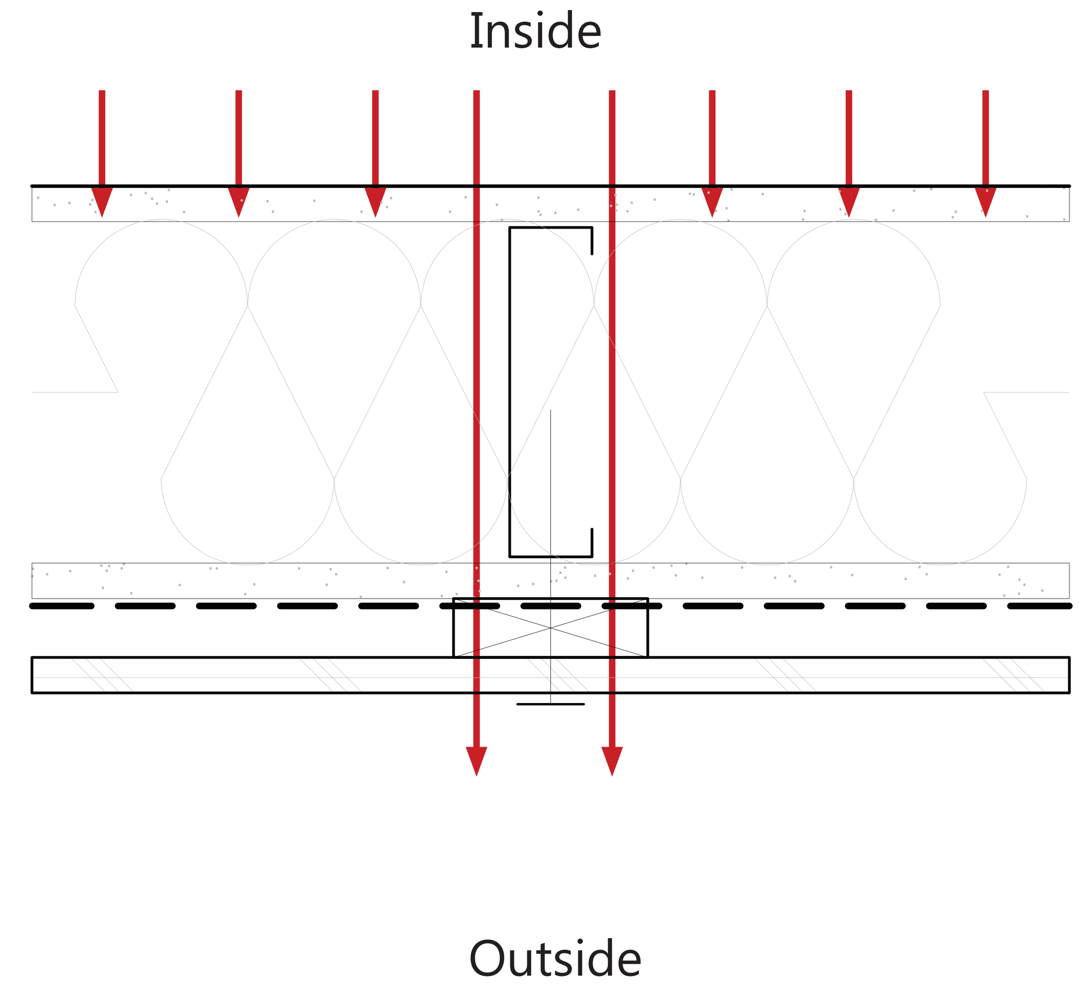
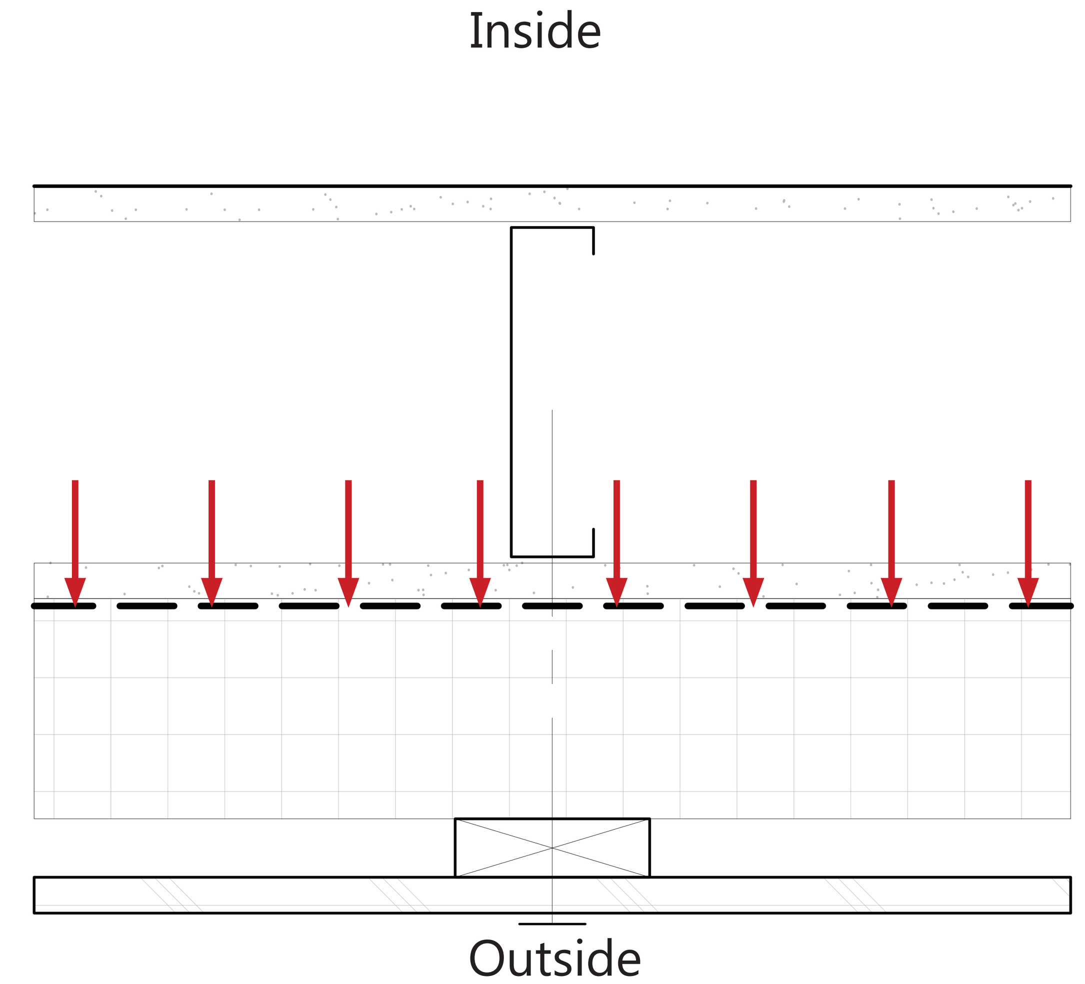
A Quantitative Methodology for the Evaluation of Thermal Bridges in Buildings

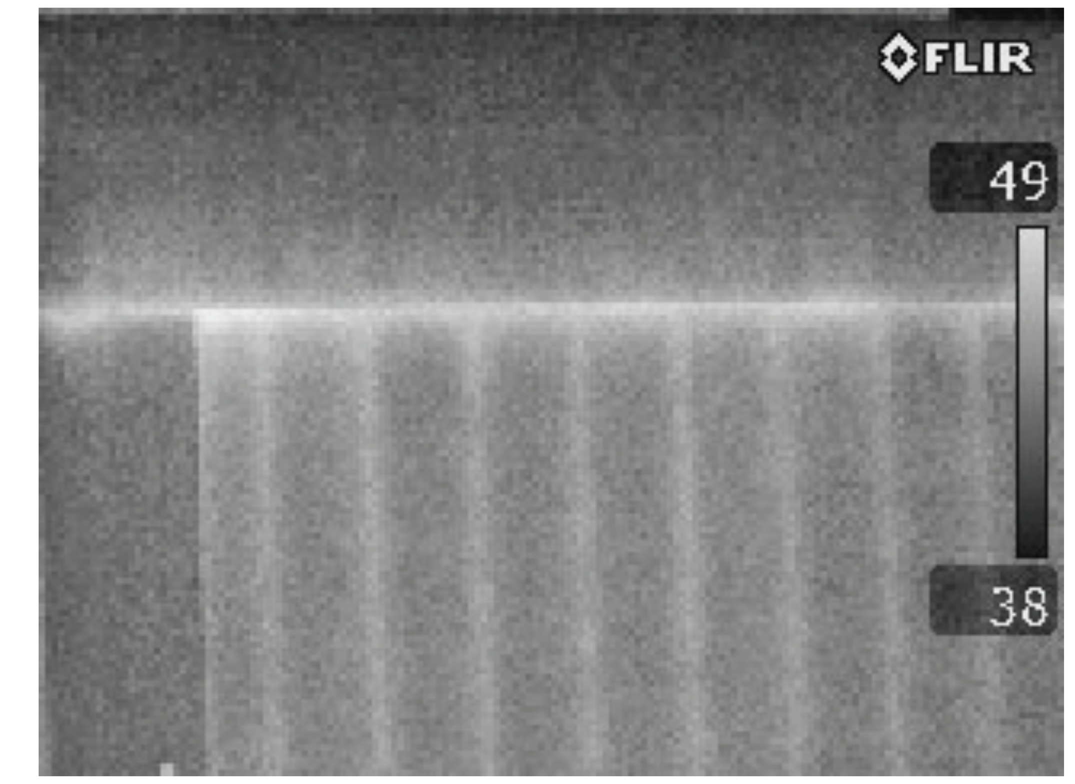
A thermal bridge is essentially a short circuit in the insulation (R-value) of a building. Common examples include steel or wood studs in the insulation cavity, or structural connections that extend completely through the insultation. Thermal bridges result in a significant increase in energy use, and can also cause moisture problems due to condensation within the wall assembly. Some contemporary detailing strategies can dramatically reduce the amount of thermal bridging in buildings, so architects could benefit from a tool that quantifies the intensity of thermal bridging in their designs. This research proposes a methodology that utilizes infrared thermography and the algoritmic scripting program *Grasshopper* to analyze the intensity of thermal bridging in a wall assembly.



Thermal bridge through metal stud



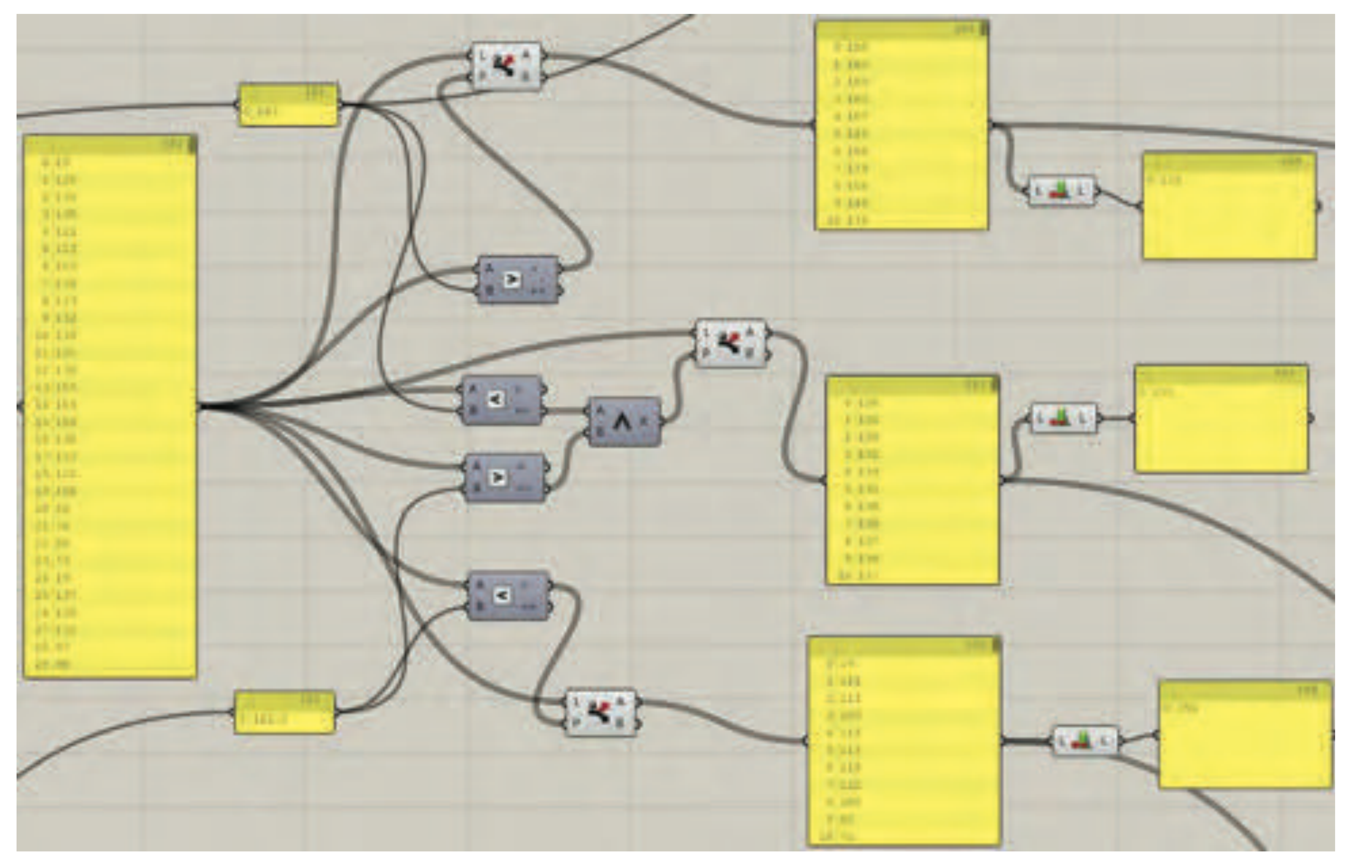
Better detail with continuous insulation



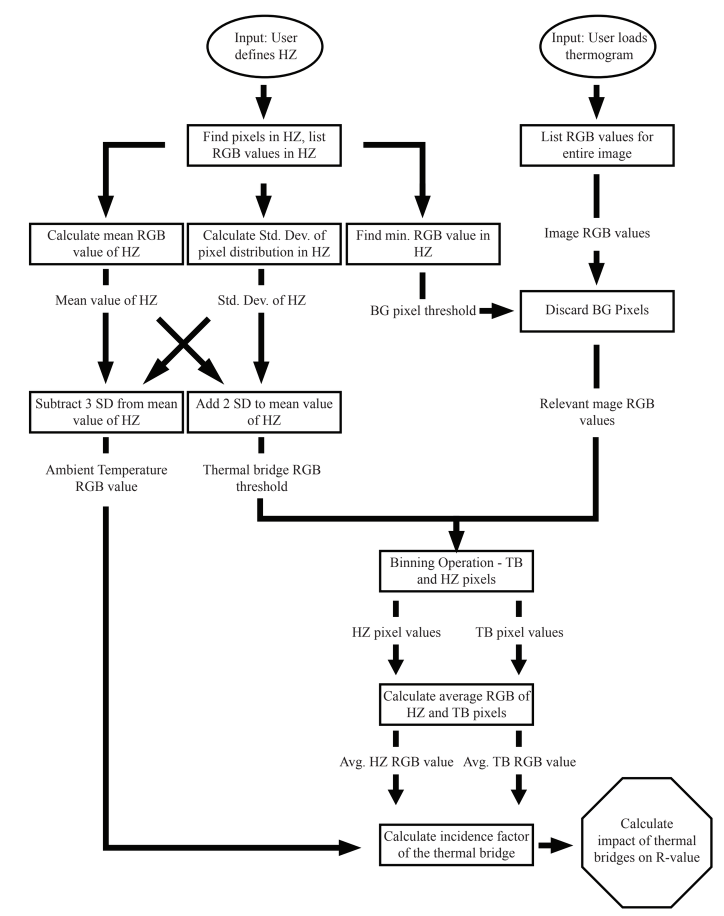
Infrared thermogram of thermal bridging through metal studs

WHAT IS A THERMAL BRIDGE?

Grasshopper is now used by many architecture firms to create adaptive solutions to design problems, so it is an ideal platform to dissemenate knowledge across the field. Infrared thermography is another emerging field in the profession, since it visually represents heat loss patterns. Therefore, combining these techniques presents an opportunity to incorporate quantitative study of building performance into the practice of architecture. A *Grasshopper* script was created to calculate the intensity of thermal bridging, the effective R-value in the thermogram, and the percent reduction in performance due to thermal bridging. The script was tested against thermography analysis software, and test images were generated to verify that the calculations were correct. These tests show that the *Grasshopper* script is highly accurate, and is an effective means of analyzing thermograms for the intensity of thermal bridging.



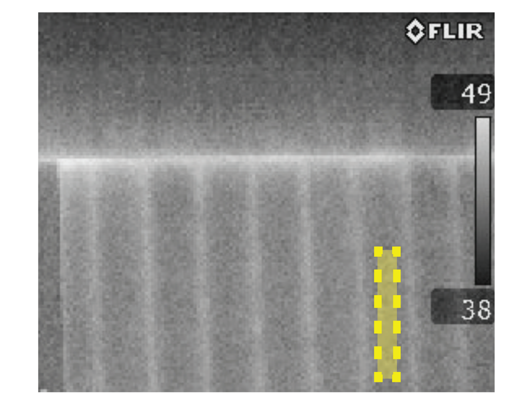
Screenshot of *Grasshopper* script



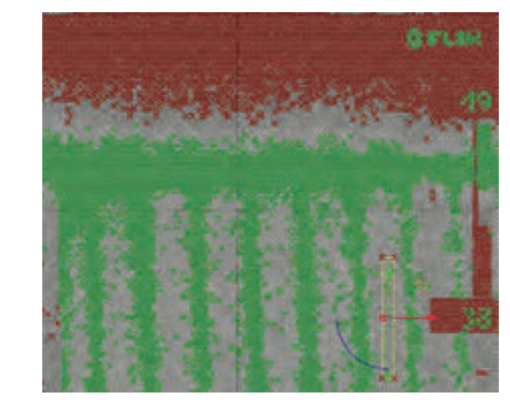
Flowchart of *Grasshopper* function

Inputs

Provide thermogram



Define baseline



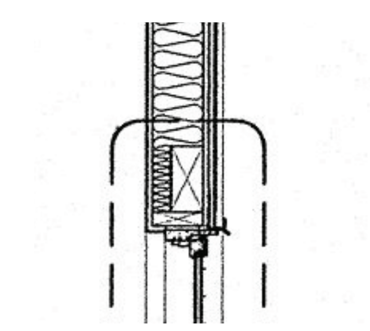
Define R-value of baseline

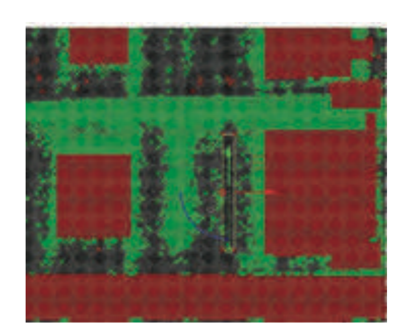
Outputs

Incidence factor of the thermal bridge: 1.60
Effective R-value of the wall shown in thermogram: 12.5
Percent reduction in R-value due to thermal bridging: 38%

METHODOLOGY

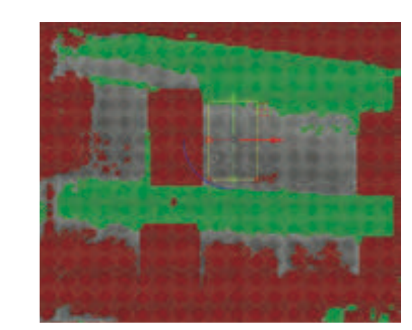
Case studies were conducted to illustrate the use of the *Grasshopper* script, and to demonstrate the impact that thermal bridges can have on a building's energy use. Four buildings were sampled in multiple locations, and results were averaged to balance the inherent variation in infrared thermography. Results show that wood studs can reduce the building's R-value by 31%, and that a comparable steel-framed building would see a 39% reduction in R-value. These values are consistent with computer simulation precedents. The most serious thermal bridge was an uninsulated concrete beam, which reduced the performance of the wall by 49-62%. These case studies show that different detailing strategies can have significant impact on a building's performance. They also illustrate a workflow that architecture firms can utilize to study the performance of their buildings, thereby providing information to improve detailing practices in future projects.



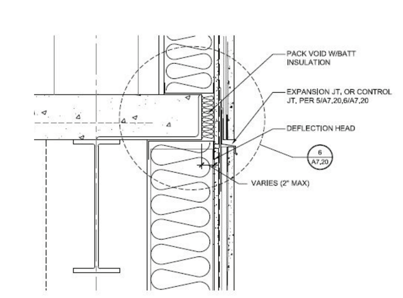
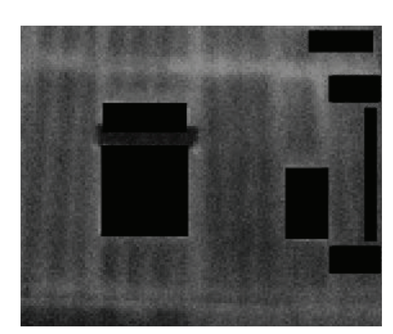
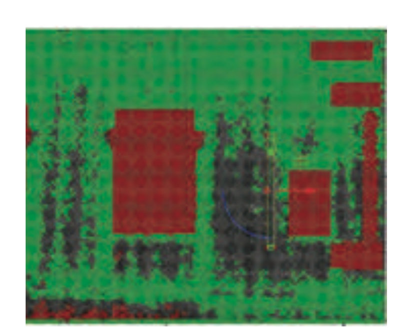
31% Reduction in R-value

Thermal bridging through wood studs



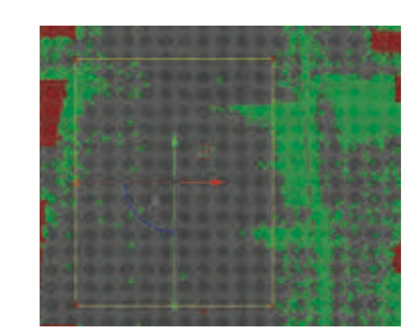
57% Reduction in R-value

Thermal bridging through uninsulated structure

39% Reduction in R-value

Thermal bridging through metal studs

16% Reduction in R-value

The highest-performing building

RESULTS AND CASE STUDIES