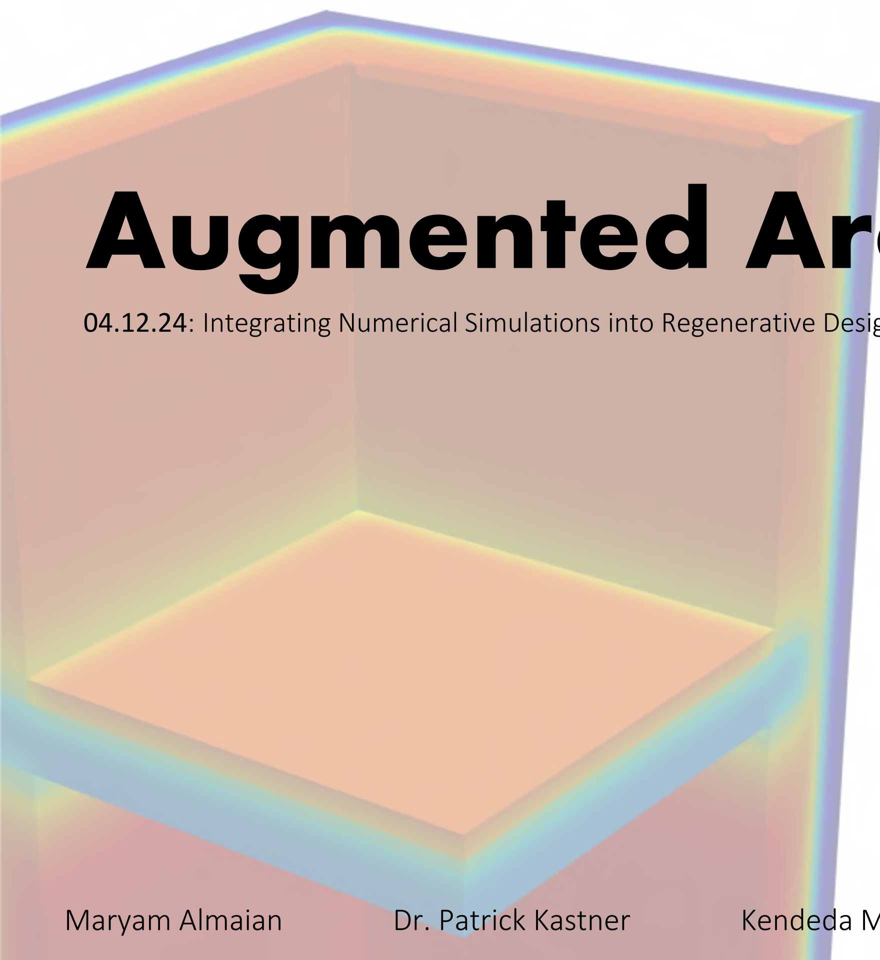


Augmented Architecture

04.12.24: Integrating Numerical Simulations into Regenerative Design

Maryam Almaian Dr. Patrick Kastner Kendeda Microgrant Symposium

Georgia Tech

Overview

Research Question

Motivation

Research Gap

Methodology

Experiment

Conclusion

Research Question

How do we build and validate a tool that can simulate 3D heat transfer?

We needed heat flux sensors to validate the tool further, so, we applied for the Kendeda microgrant to receive funding and purchase the sensors.

U-Value and Heat Flux Measurement Kit

★★★★★ (1 review) Write a Review

1,949.00CHF

Product: gSKIN® KIT-2615C (calibrated)

Article Number: A-163479

GSKIN® KIT Includes (For More Details Consult The Datasheets Of The Individual Products): Sensor: gSKIN®-XO 67 7C (30mm x 30mm), Logger: gSKIN® DLOG-4231 and double sided mounting tape (MOUNT-1235)

Heat Flux Range Min / Max [W/M²]: ±300

Heat Flux Resolution [W/M²]: <0.22

Temperature Accuracy [°C]: ±0.5 (-10...+46 °C) ±2.0 (-55...+125 °C)

Min. Sensor Sensitivity (S) [MV/(W/M²)]: 7.0 (sensor calibration data already loaded onto logger for simple and fast plug-and-play measurements).

Data Storage Capacity [# Measurements]: >2'000'000

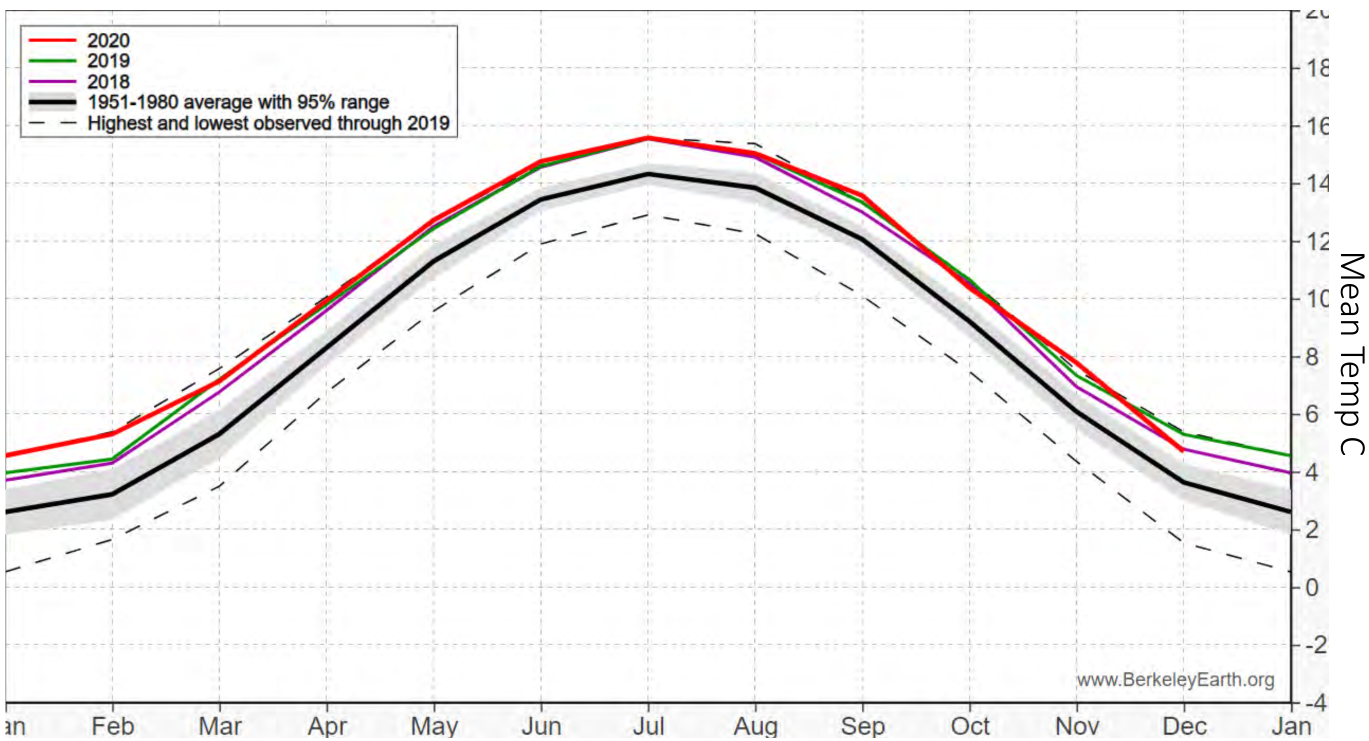
Battery Lifetime [Days]: >30 at lowest measurement frequency (2/d). Rechargeable.

Motivation

Climate Change

Rate of warming is 40% higher than warming since 1970

Global Land



https://berkeleyearth.org/temperature-region/global-land

Motivation

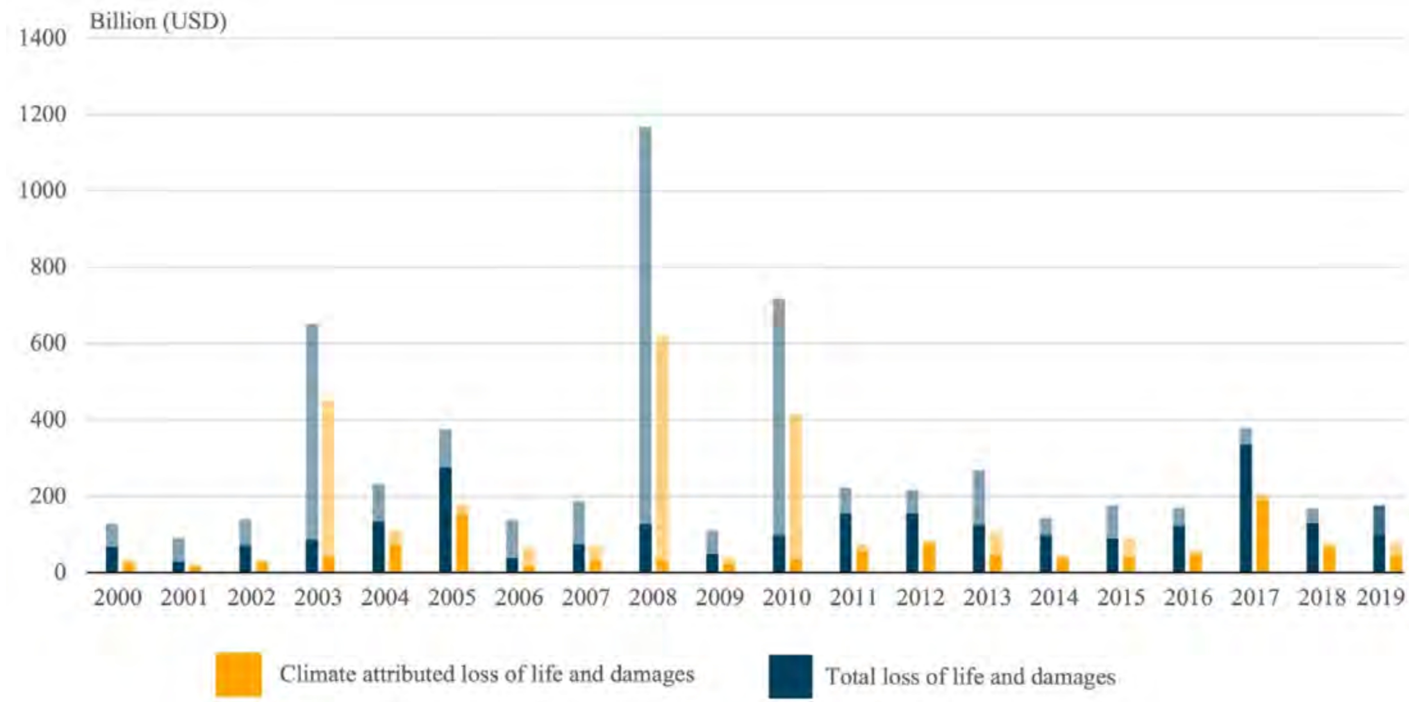
Climate Change

Rate of warming is **40% higher** than warming since 1970

Climate Crisis Cost

$16m/hr in extreme weather damage

Climate change- attributed loss of life and damages from extreme weather events



From: The global costs of extreme weather that are attributable to climate change
https://www.nature.com/articles/s41467-023-41888-1

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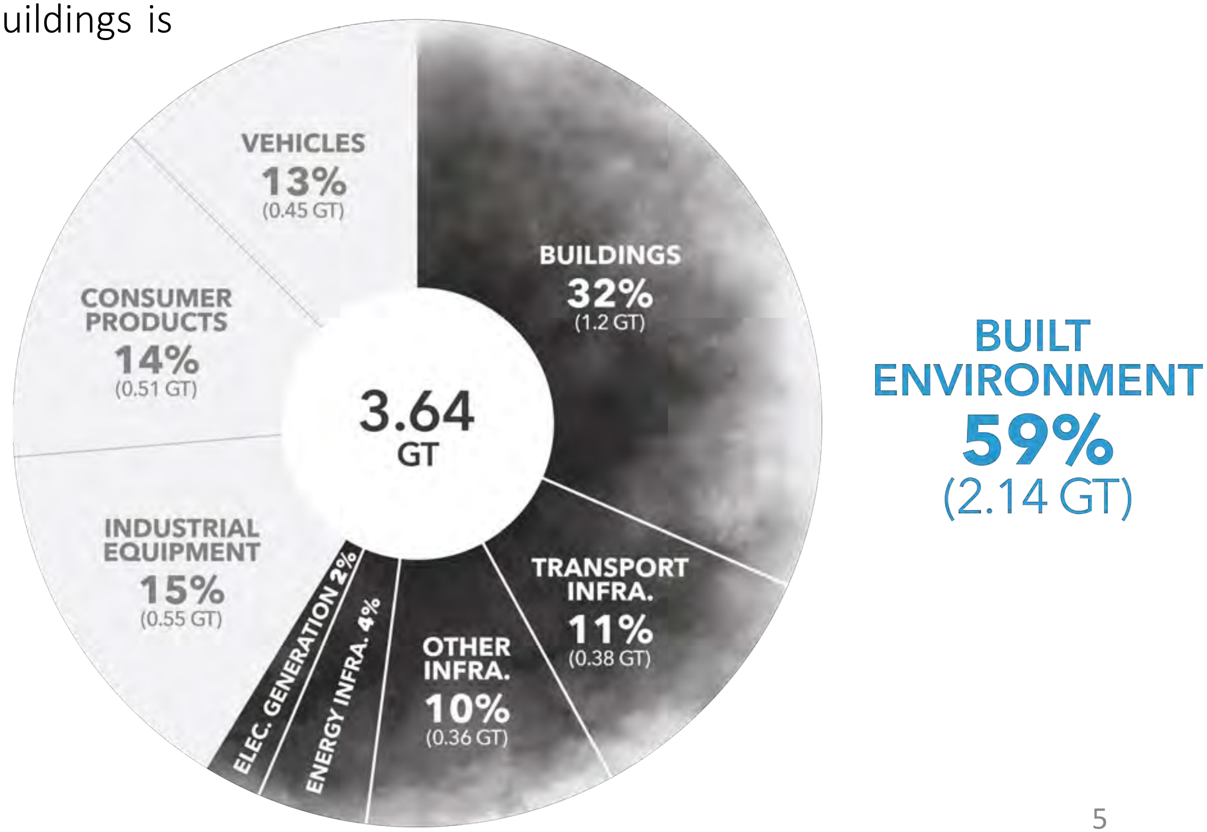
Carbon Emissions

Global emissions from buildings is 59%



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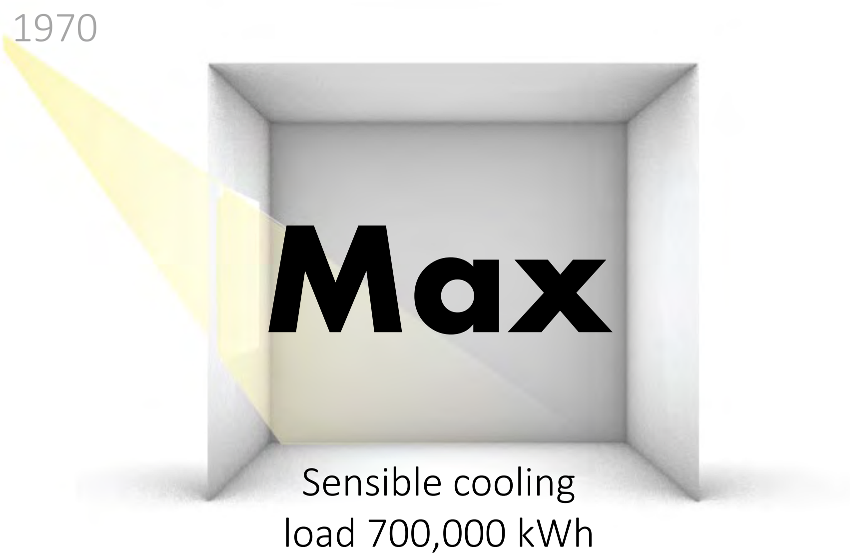
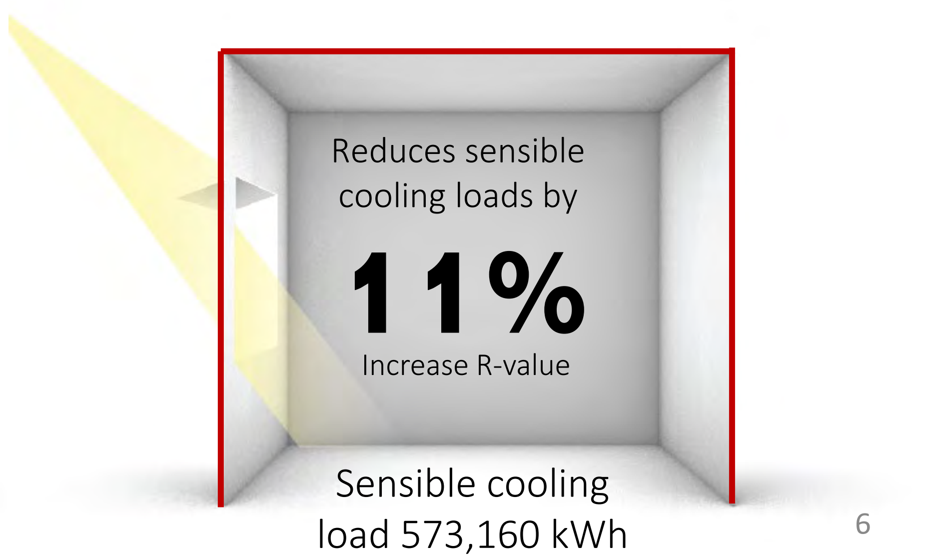
Critical in Building Design

Design decisions are connected to 3d heat transfer such as orientation and shading





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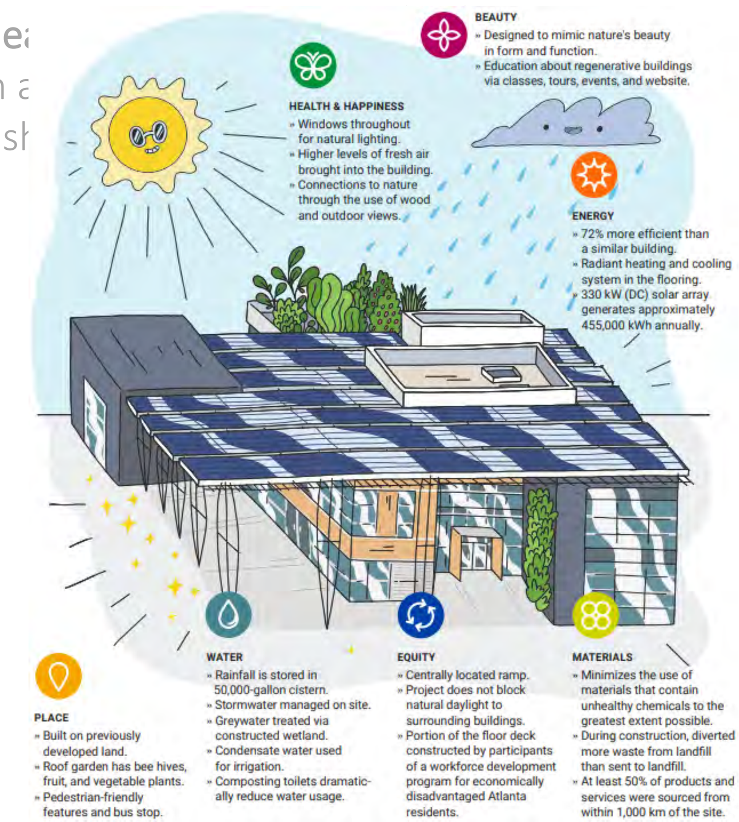
such a
and sh

Kendeda

Kendeda regenerative building design



https://livingbuilding.gatech.edu/key-living-building-details

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Kendeda

Kendeda regenerative building design

Current Software

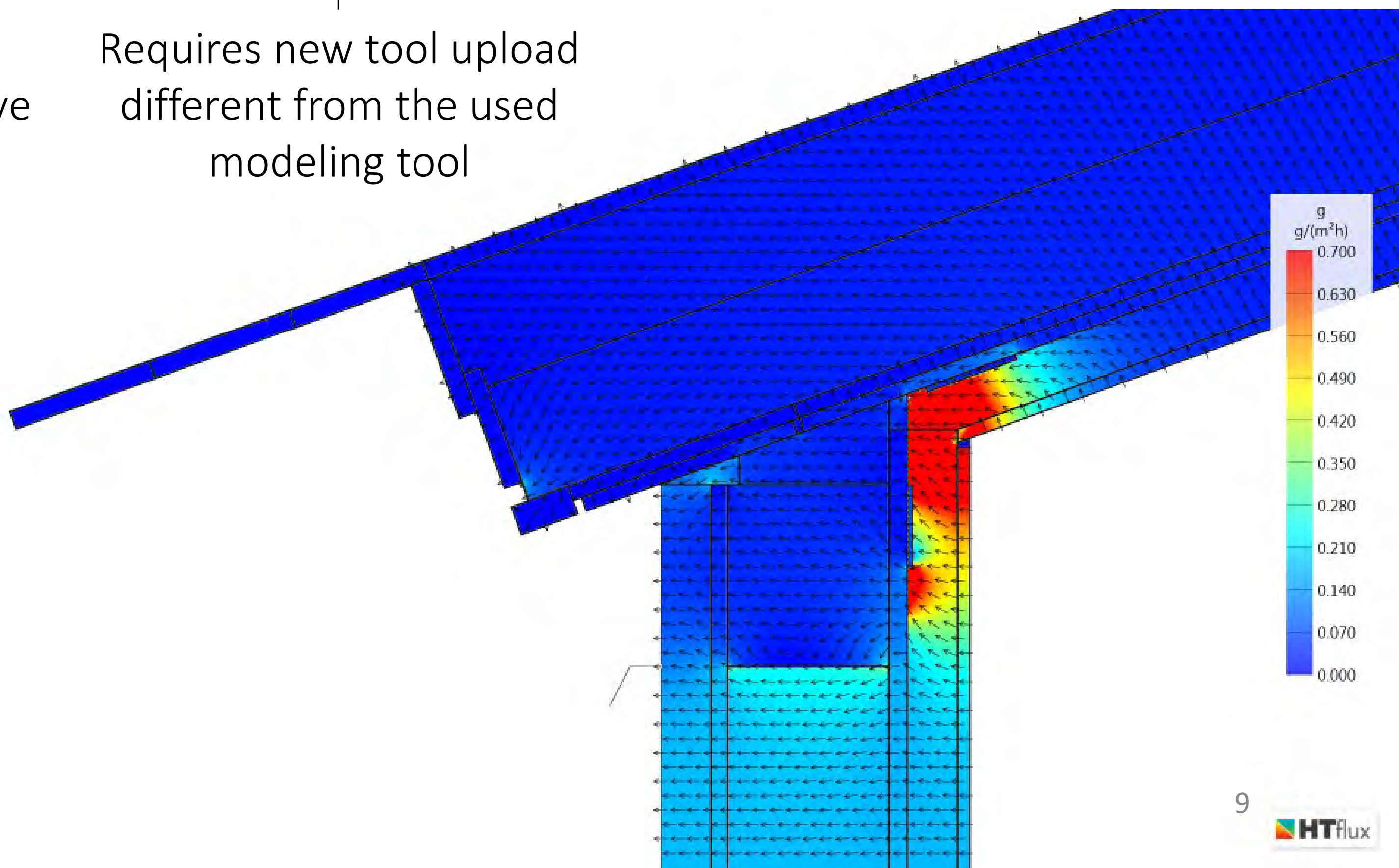
Current 3D heat transfer simulation tools are limited and cost effective

Research Gap

Current software and problems

Current software and simulation tools in the architectural field are limited

- 2D Heat transfer
- Cost Effective
- Requires new tool upload different from the used modeling tool



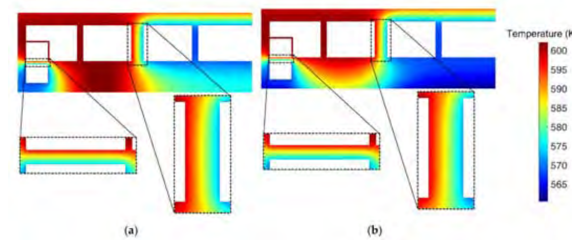
https://www.htflux.com/en/

Methodology

Validation Case

EN ISO 10211:2007 Thermal bridges in building construction. Test case A.3 validation

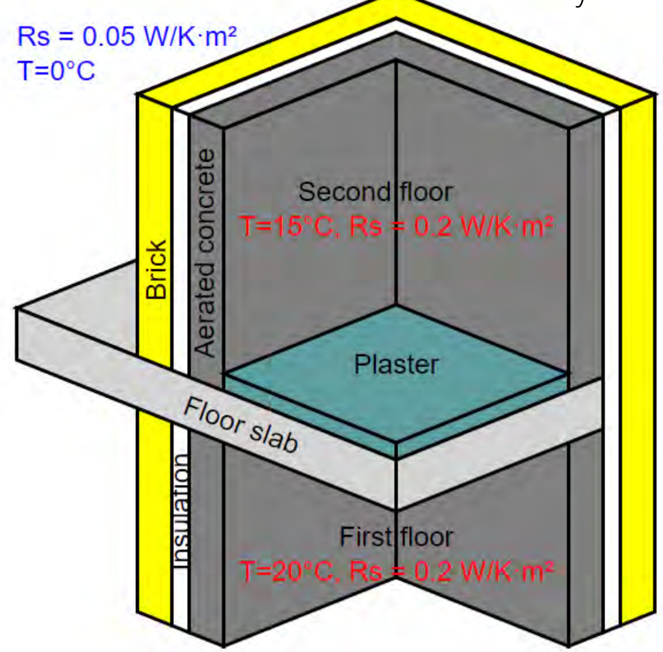
Quickfield



Most of the found cases for validation were 2D heat transfer cases and not 3D.

https://www.mdpi.com/1996-1073/13/14/3525

Geometry

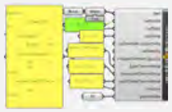


Icon	Material	K [W/mk]	Cp [j/kgK]	P [kg/m^3]
	Concrete Slab	2.5	1000	2300
	Brick	1	920	710
	Insulation	0.04	1450	35
	Plaster	1	1000	2300

Methodology

Rhino

Grasshopper

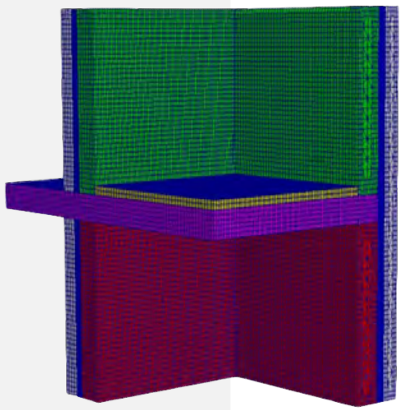


Materials Construction

Boundary Conditions

→ Pre-Processing

OpenFOAM



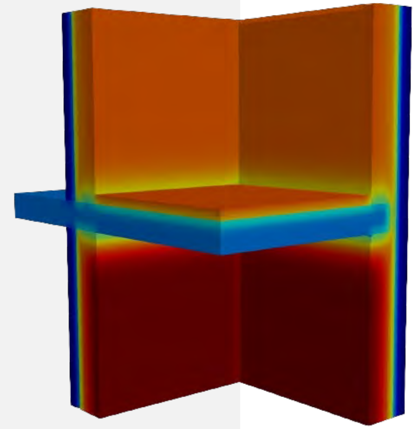
Mesh Creation

Simulation

Numerical Simulation

Post-Processing

ParaView



Temp Distribution

Visual Representation

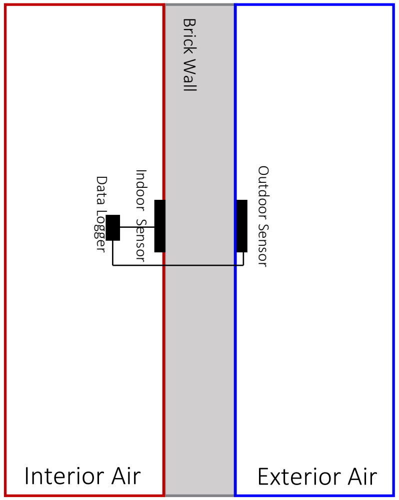
Validation

Validation

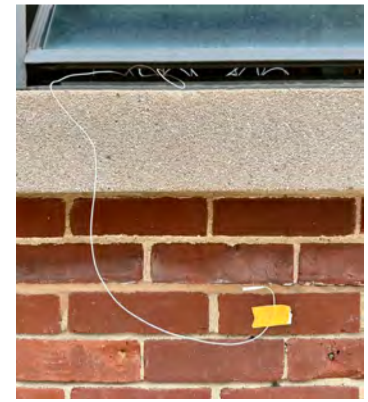
Applied for Kendeda Microgrant to receive funding, buy the sensors, and validate via experiment

Experimental Design

Geometry Section



Indoor Sensor



Outdoor Sensor

Experiment

Real-time measurement

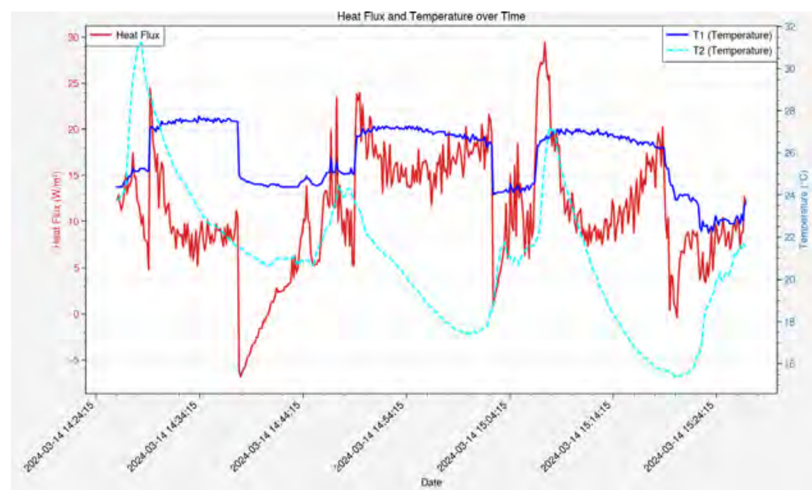
U-Value and Heat Flux Measurement Kit

Calibration Accuracy [±%]: 3

Temperature Accuracy [°C]: ±0.5

Duration: 74 hrs

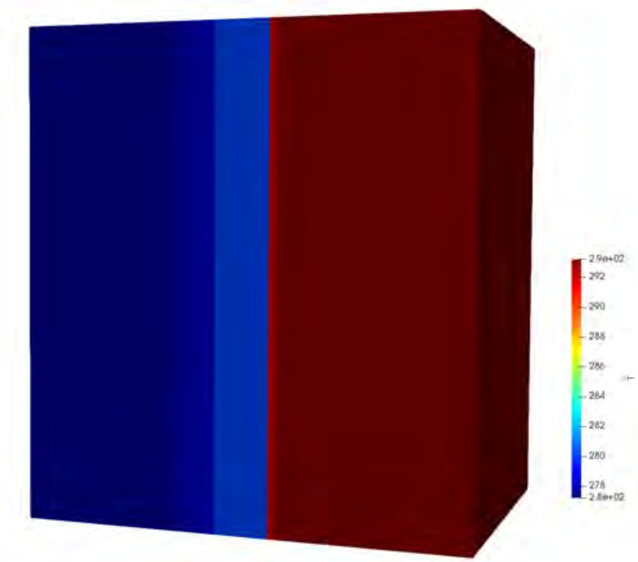
Purchased from GreenTEG company, $2,157



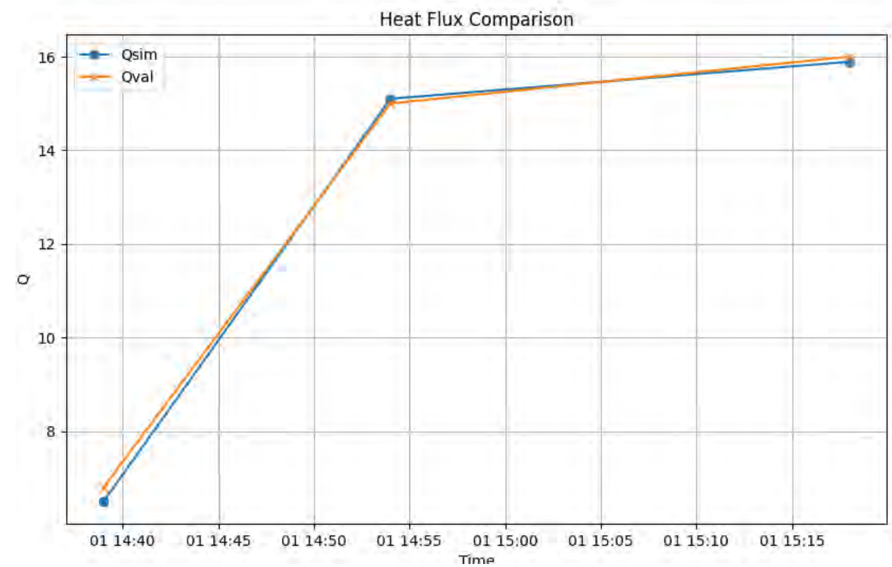
Sensors temp and heat flux output

Experimental Design

Simulation



Simulation results visualized in ParaView



Heat flux in W/m2 comparison between the simulation and the validation experiment from the sensors

Icon	Material	K [W/mk]	Cp [j/kgK]	P [kg/m3]
■	Brick wall	1	920	710

Case	Inside Temp (T1) C	Outside Temp (T2) C
Validation	25.8	21
Simulation	24.85	21.85

Percentage of error 0.8%

Thank You!

Questions? Connect!

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