

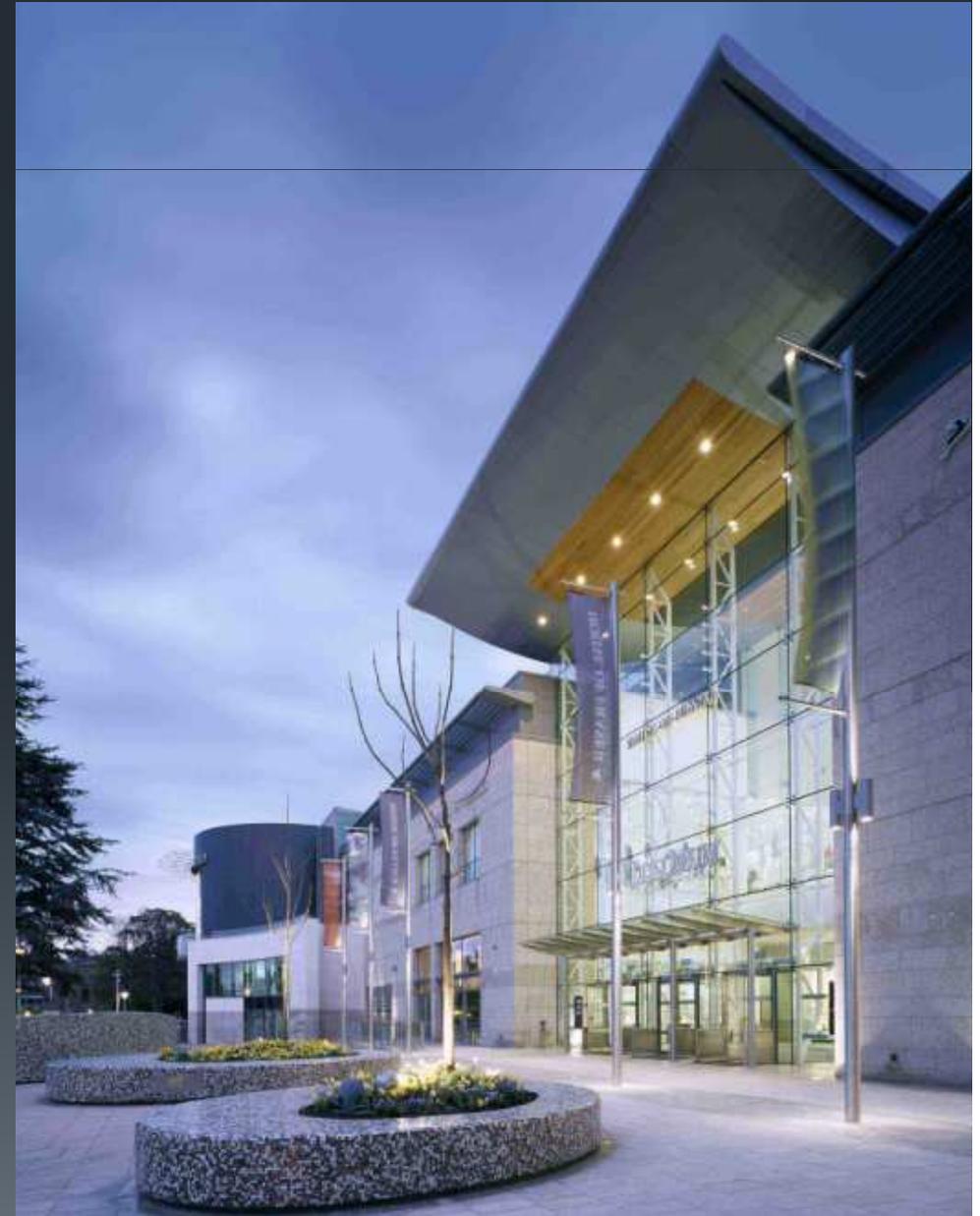
# Numerical Assessment of the Thermal Performance of Structural Precast Panels

J Keenahan, K Concannon, D Hajializadeh & C McNally  
UCD School of Civil, Structural &  
Environmental Engineering  
Email: [ciaran.mcnally@ucd.ie](mailto:ciaran.mcnally@ucd.ie)



# Description

- Precast sandwich panels – widely used in building facades
- 3 layers
  - Concrete
  - Insulation
  - Concrete



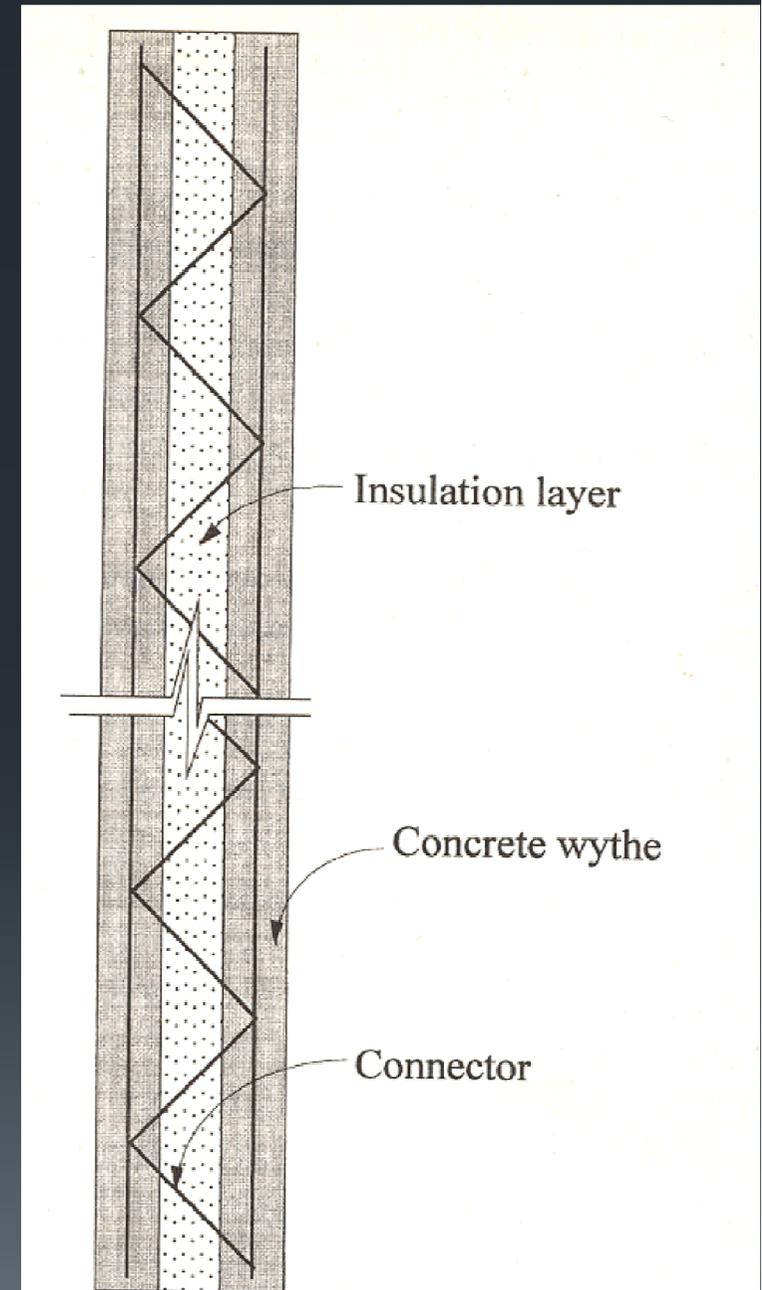
# Industrial Relevance



- New building regulations will specify a much lower U-value for sandwich panels
- Expected to go from 0.25 to 0.15 W/m<sup>2</sup>K
- Significant implications for industry
- Concern over structural connectors

# Structural Connectors

- Needed for all panels
- Traditionally made of steel
- Also available in FRP
- Potential thermal weakness



# Structural Connectors

- FRP more expensive, but will they give the required U-value?
- 3 panel types studied
- Determined using
  - Numerical methods (ASHRAE)
  - Hot-box testing (Experimental)
  - FEA analysis

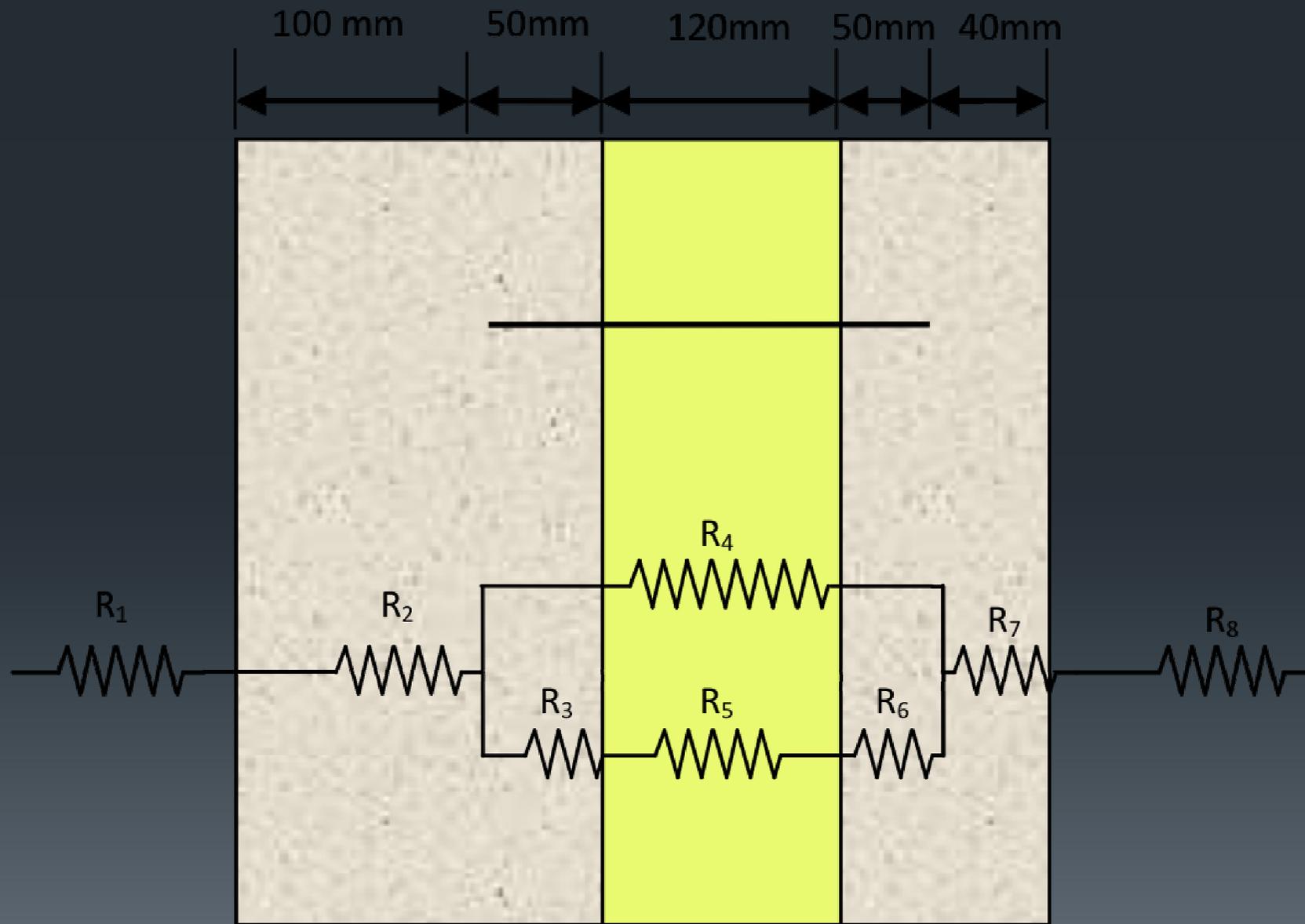
$$U = \frac{1}{\sum RA}$$

$$U = \frac{\dot{Q}}{\Delta T}$$

# Numerical Analysis

- ASHRAE: American Society for Heating, Refrigeration and Air-Conditioning Engineers
- U-value: inverse of the resistances of a material
- Theoretical approach
- Thermal resistances  electric resistances
  - Parallel
  - Series
  - Combination

# Numerical Analysis



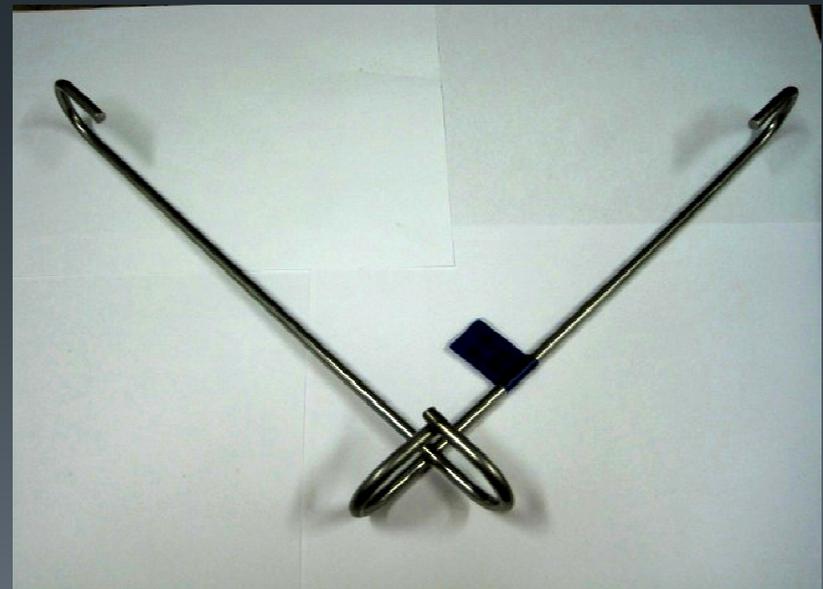
# Hot-box Testing

- Build insulated room around a series of precast concrete sandwich panels
- Install heater inside the room
  - Thermostat to control temperature
- Sensors to measure temperature (internal & external) and heat flux
- Monitor using thermal imaging camera
- 30°C Temperature gradient
- Tests duration: 48 hours
- EN 1946-4 (2000)

# Hot-box Testing

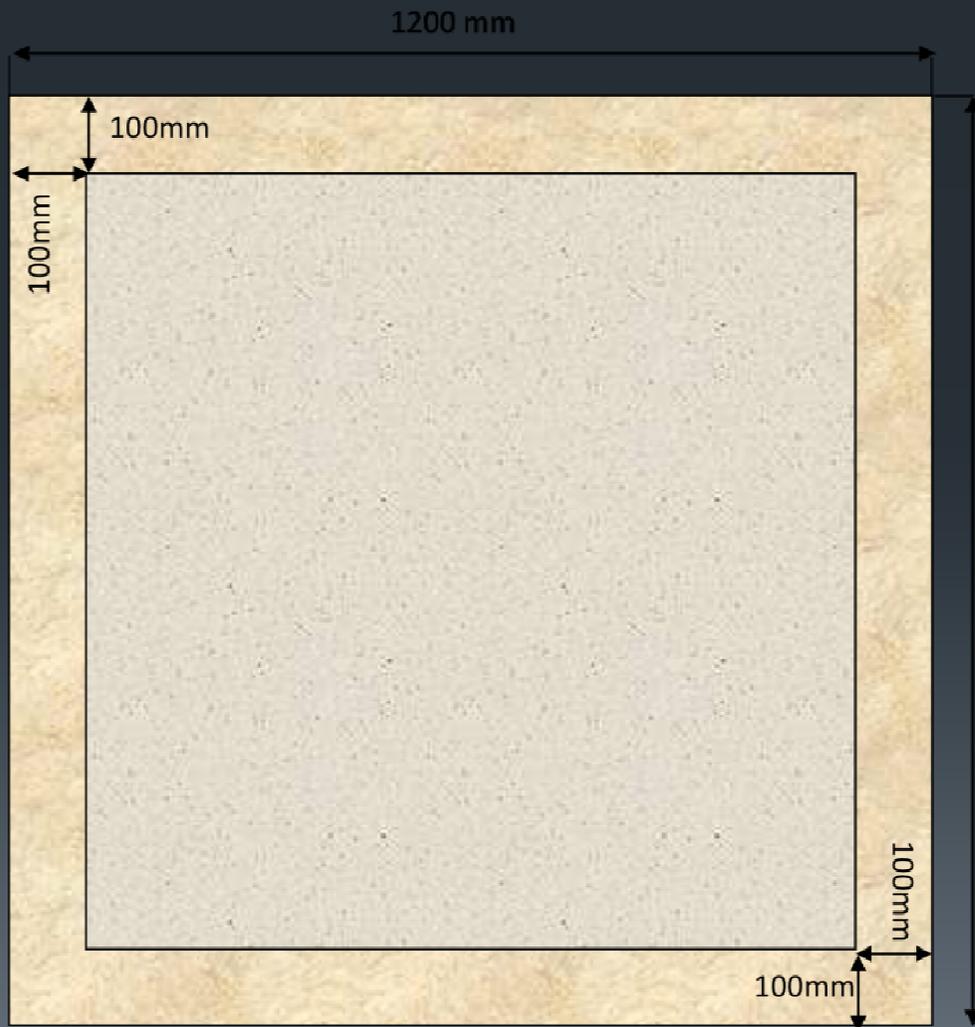
Materials used:

- Insulation (120 mm)
- FRP connectors (9)
- Steel connectors (3)



# Hot-box Testing

## Thermal Imaging

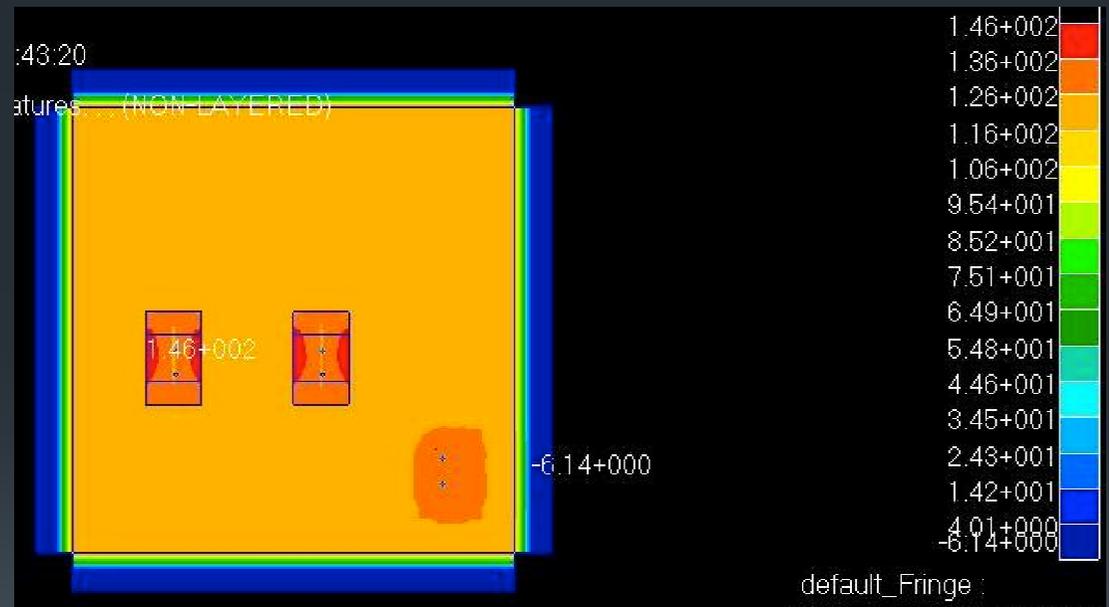
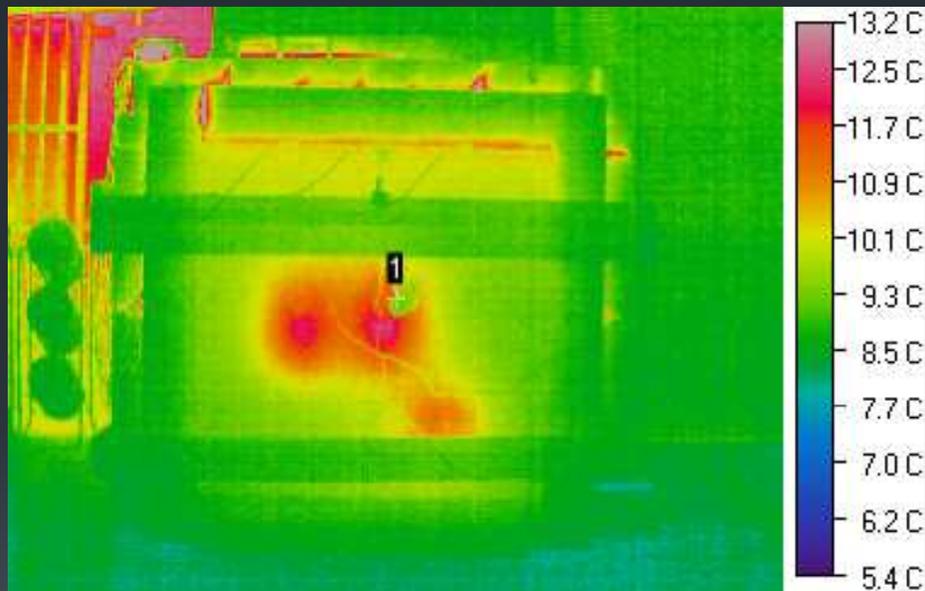


# FE Analysis

- Conducted using MSC Patran
- 3-D FE solid model (hex elements)
- 2 DOF per node (Temp & heat flux)
- Boundary conditions to mirror hot-box testing
  - Internal temp 40°C
  - External temp 10°C
  - Internal convection coefficient 8.29 W/m<sup>2</sup>K
  - External convection coefficient 34 W/m<sup>2</sup>K
- Patran *Connector* function
- Transient analysis

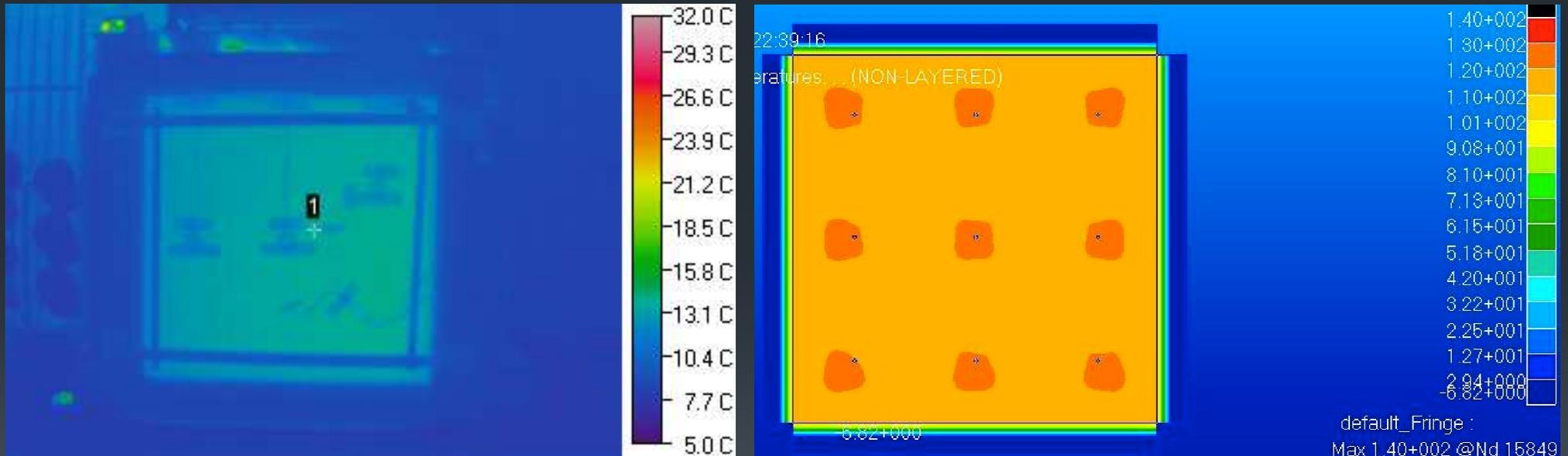
# FE Analysis

## Sample results: steel connectors



# FE Analysis

## Sample results: FRP connectors



# Results

	U-Values (W/m <sup>2</sup> K)		
Connector Type	ASHRAE	Hot-box	FEA
Steel	0.288	0.260	0.286
FRP	0.169	0.150	0.149
Control	0.168	0.139	0.145

# Conclusions

- Choice of connectors has a very significant impact on achievable U-values
- Simple numerical analysis surprisingly good, but insufficient for low U-values
- FEA verified as offering significant benefits in product development of such panels

# Acknowledgement

Ergon Structural Concrete



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