

# 3D FINITE ELEMENT MODELING OF RECYCLED GLASS CULLETS IN ASPHALT SHINGLES

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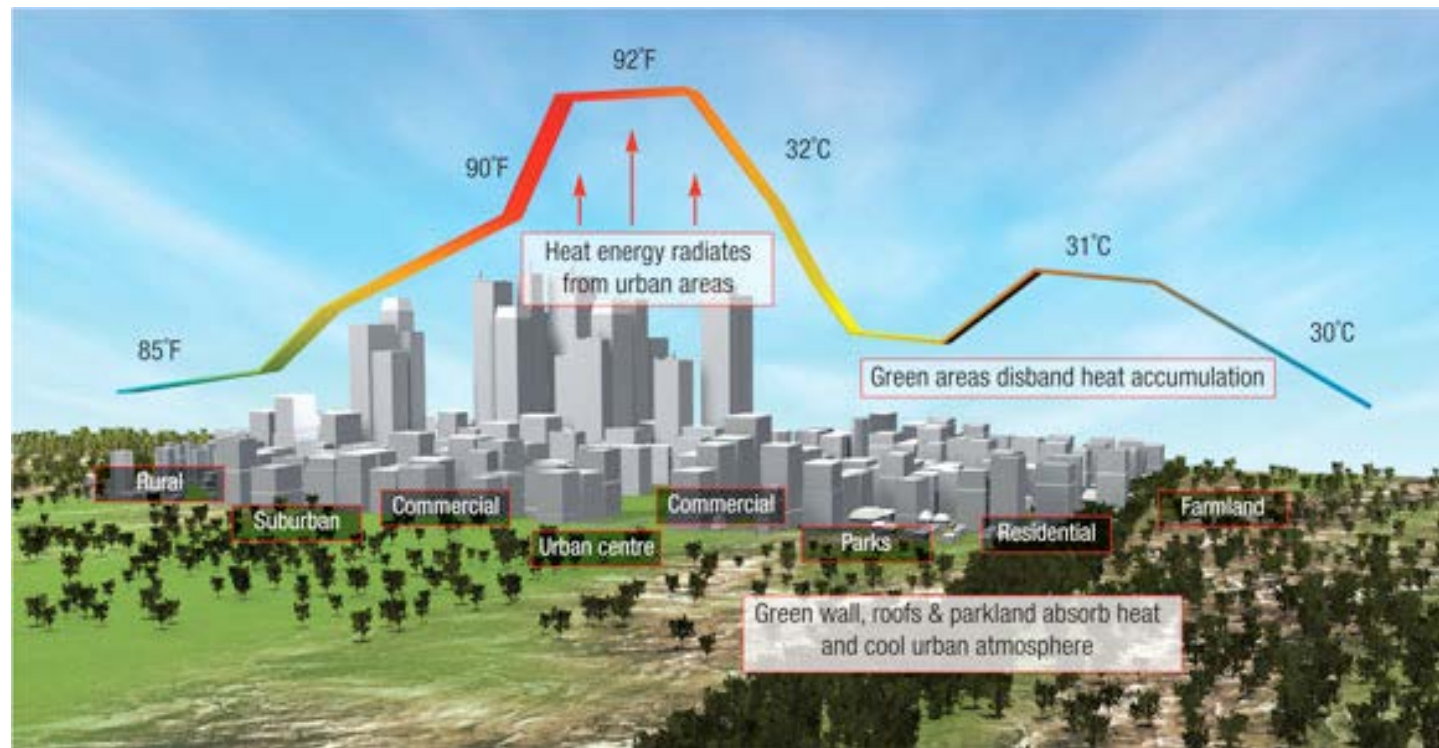


# Introduction

- Building sector in most countries represent about one third of the total energy consumption.
- Many cities world-wide with populations that equal or exceed 1 million people experience an increase in annual mean air temperature of 1 to 3°C compared to their surroundings.
- Evening differences as high as 12°C.

# Introduction

## Heat Island Effect



# Background

- High albedo coatings and urban greening
- Cool roofs



# Objective

- ❑ Investigates the application of recycling of broken and waste glass cullet in the production of asphalt shingles to reduce energy consumption in residential buildings
- ❑ Mitigate heat island effects by increasing the solar reflectance index (SRI) of the roof asphalt shingles.





# EXPERIMENTAL PROGRAM

Asphalt shingle with/without glass cullet



# Solar Reflectance Index

## Solar Reflectance Index of Common Asphalt Shingles

Type of the asphalt shingle	SRI	Type of the asphalt shingle	SRI
White	21	Black	1
Gray	4	Weathered Wood	4
Green	18	Dark Brown	4
Antique Silver	19	Beachwood Sand	19

# Solar Reflectance Index

## Solar Reflectance Index of prepared Asphalt Shingles

ID	Material Composition		SRI
	Top Surface	Filler	
X1	Control 1: Ceramic Coated Granules	Limestone	0
X2	Control 2: Ceramic Coated Granules	Clear Glass 1	0
A	Green Glass	Limestone	3
B	Clear Glass 1	Limestone	5
C	Green Glass	Green Glass	3
D	Clear Glass 1	Clear Glass 1	5
C1	Green Glass & Pigments	Green Glass	28
D1	Clear Glass 1 & Pigments	Clear Glass 1	27
G1	Clear Glass 2 & Pigments	Clear Glass 2	30

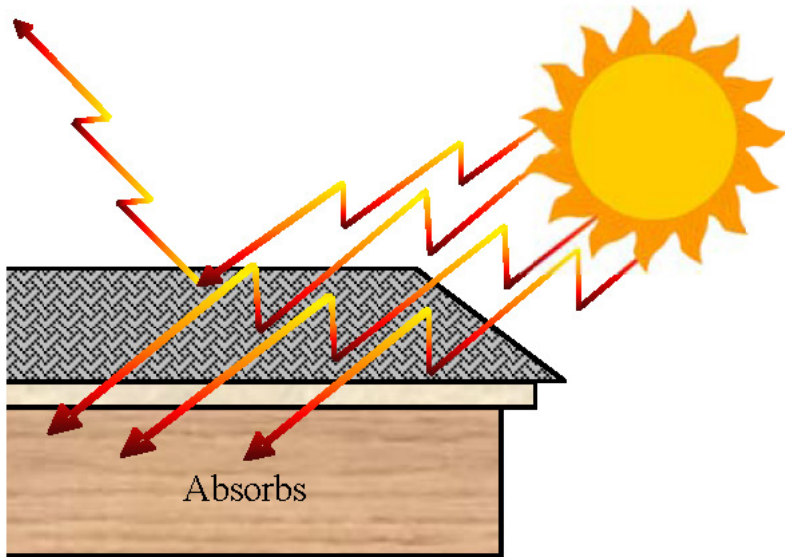


# CLIMATE REGIONS IN THE UNITED STATES

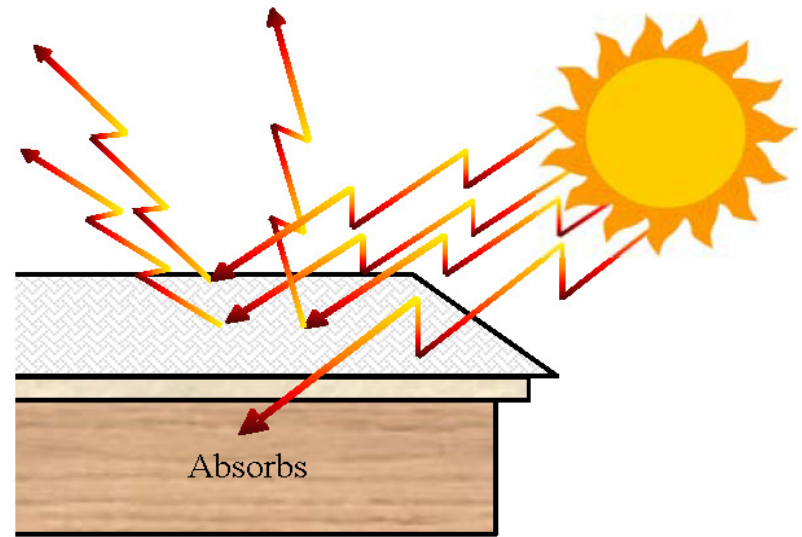
The latitude and longitude of the selected cities for the simulations

City, State	Latitude (°)	Longitude (°)	Cooling Degree Days (°C)
Miami, FL	25.82	80.28	2645
Charlotte, NC	35.22	80.93	1105
Kansas City, MO	39.32	94.72	1110

# Operation of conventional and reflective roofs

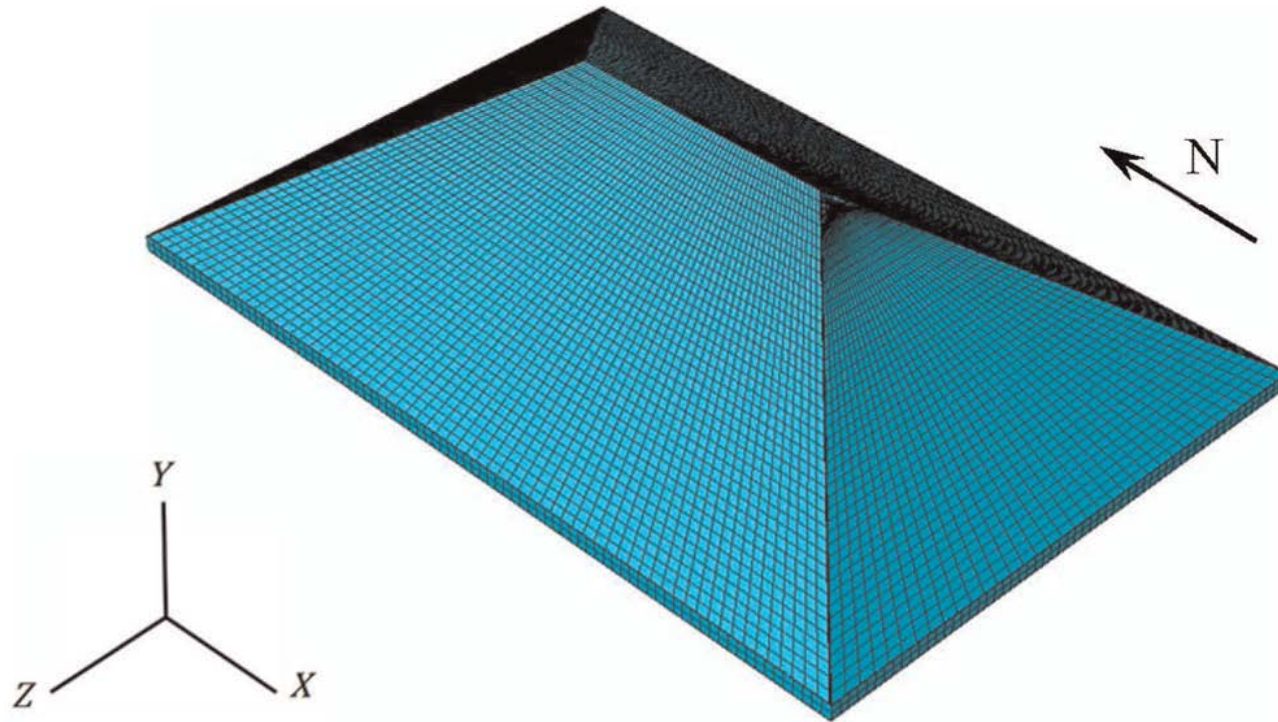


**Conventional roof**



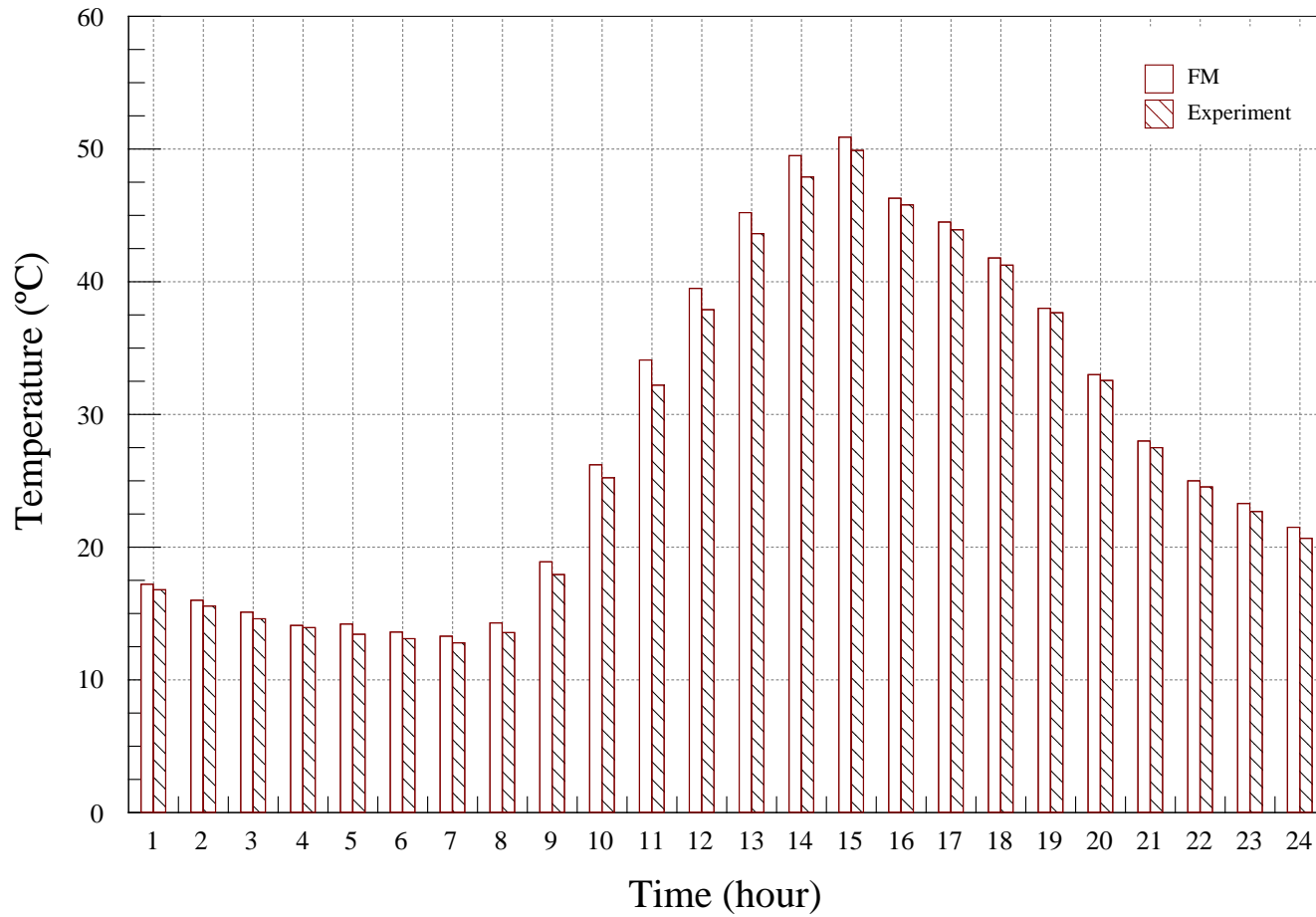
**Reflective roof**

# Finite Element Model



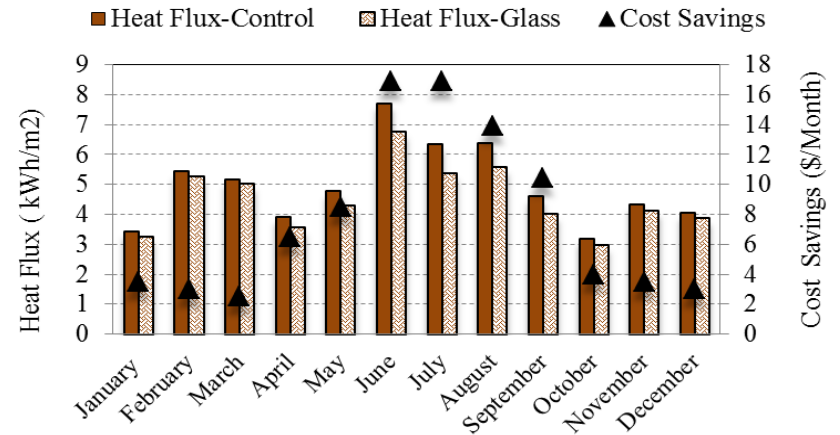
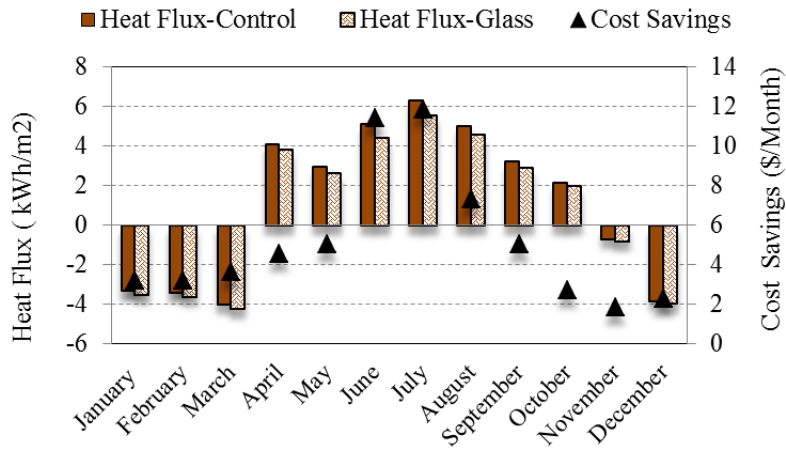
Finite Element Mesh

# Results and Discussions



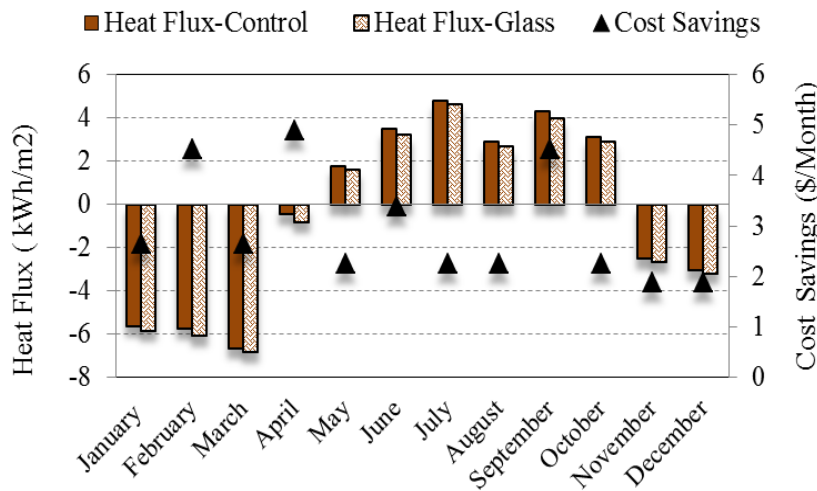
Model validation

# Results and Discussions



Zone 4: Charlotte

Zone 5: Miami



Zone 3: Kansas

Required heating and cooling load in 3 climate regions in the US

# Conclusions

- A typical black ceramic coated asphalt shingle has a very low SRI.
- The addition of a white pigment mixed together with the top surface granules increased the SRI to 30 for clear glass.
- FE results indicated that the application of asphalt shingle containing glass cullet in the roof can reduce energy consumption from 7.8 kwh/m<sup>2</sup> to 6.9 kwh/m<sup>2</sup> in June in Miami-FL and save approximately \$16.



# Conclusions

- Results showed that increasing the SRI of a roof is characteristically more advantageous in hot climate regions where cooling load dominates most of the year.
- This study provides evidence that roofs covered with asphalt shingles containing glass cullet are effective strategies for urban heat island mitigation.
- The increased SRI of these roofs effectively reduces their surface temperature and decreases sensible flux into the urban atmospheric system.



**Thank You for Your Attention**