Impact of Binder Modification on PCM Concretes Properties

Richa Bhardwaj[1] , Jeffery R. Roesler[2]

[1] Ph.D. Candidate, Civil and Environmental Engineering, University of Illinois at Urbana-Champaign, richa2@illinois.edu

[2]Ernest Barenberg Professor, Civil and Environmental Engineering, University of Illinois at Urbana-Champaign, jroesler@illinois.edu

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Introduction

Why PCMs in Concrete ??

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Thermoregulation due to latent heat capacity at transition temp

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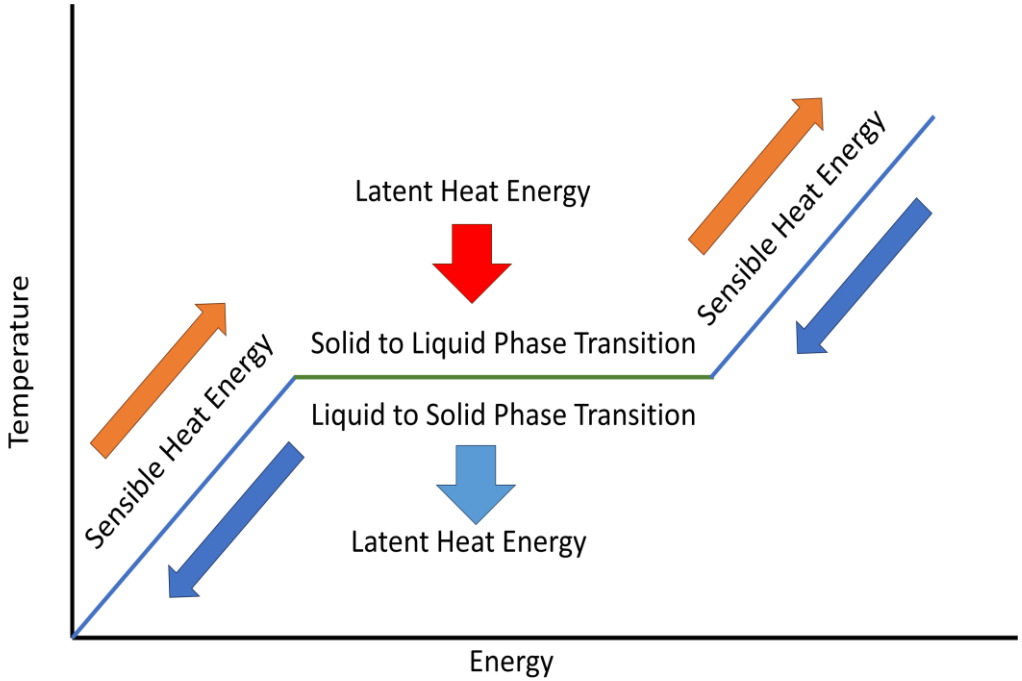
Urban overheating mitigation, thermal stress relief, freeze thaw durability etc.



Challenges :

- Lowered mechanical strength
- Lowered thermal conductivity

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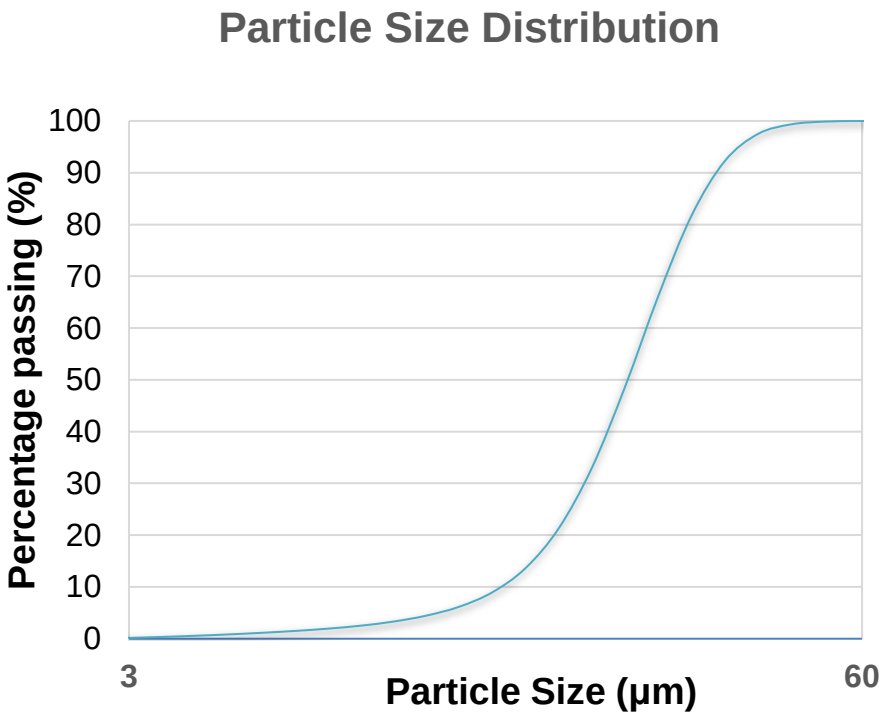
Objectives

- Develop PCM concretes for horizontal surfaces through binder modification
- Analyze the compression and fracture properties of these PCM concretes for application as horizontal surfaces

Materials

Microencapsulated PCMs



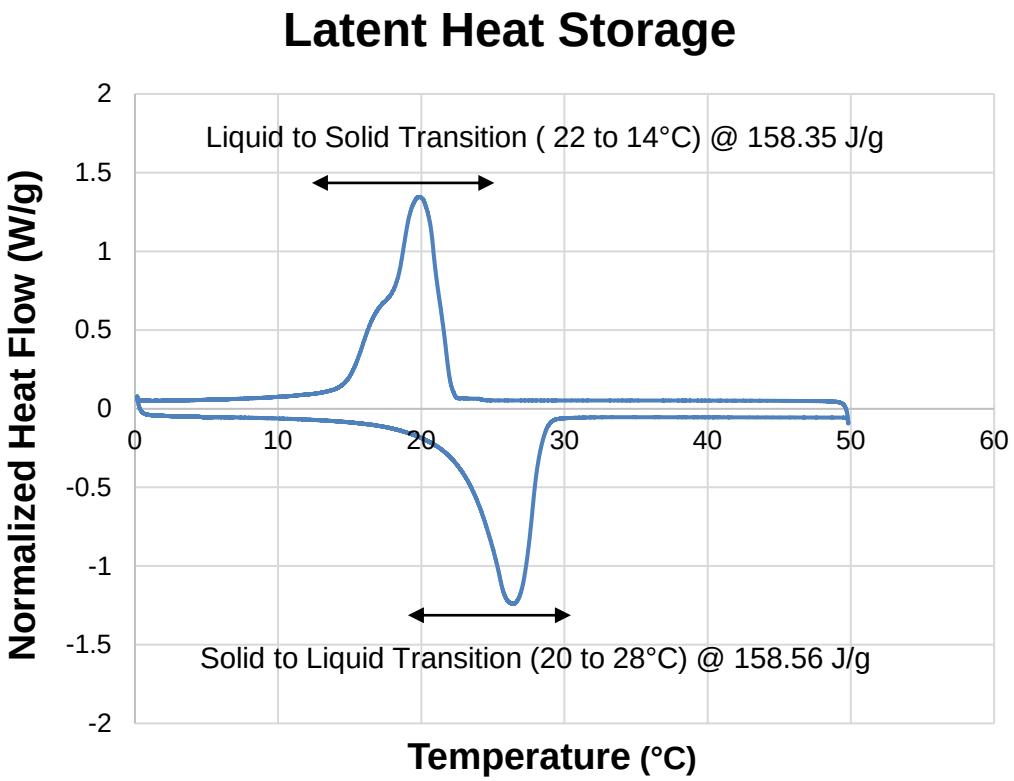
Powder Form

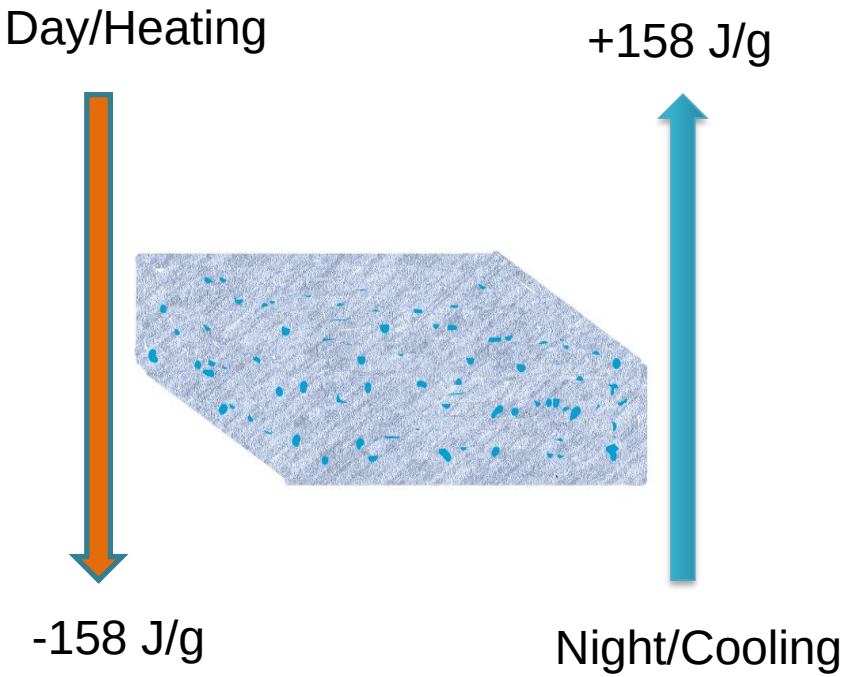
Particle size (3μm to 50 μm)

Melamine-formaldehyde shell (10-15 wt.%)
Paraffin wax core(85-90 wt.%)

Materials

Microencapsulated PCMs





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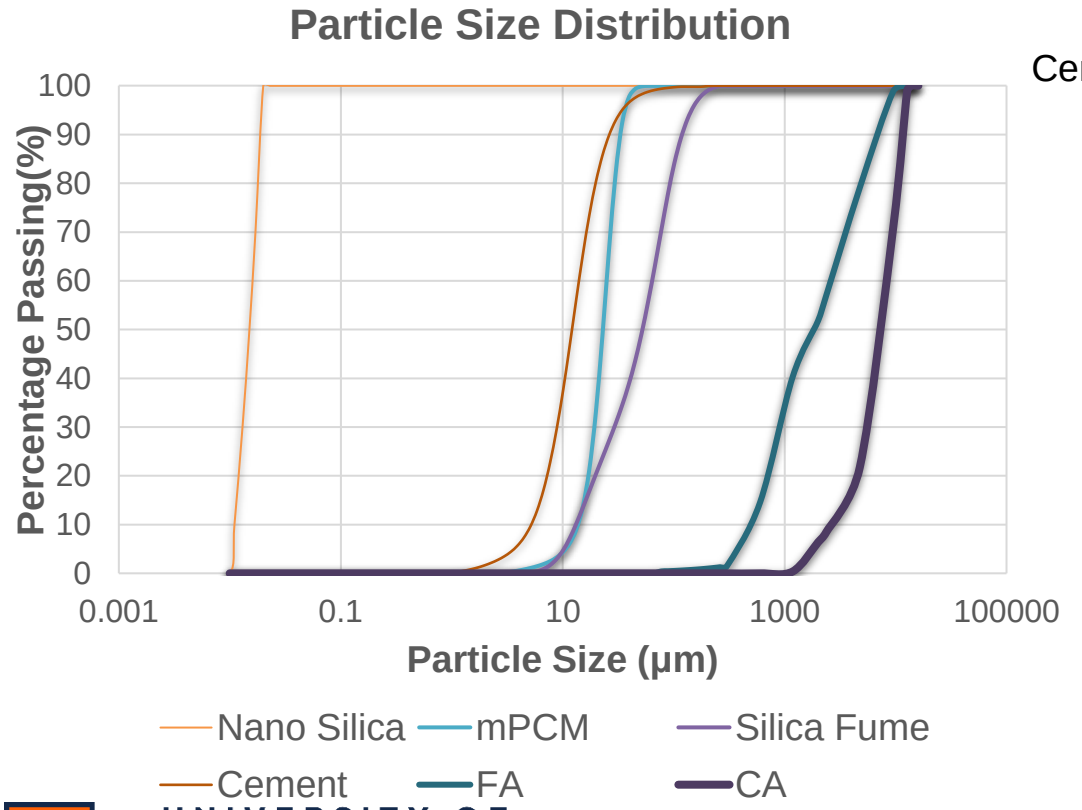
Materials

Mix Design

Densifying the matrix through progressive filling with additives while keeping paste content constant



Cement + Water + Aggregate

- **P0**
- + PCM microcapsules → **P10**
- + Silica Fume → **P10S**
- + Nano Silica → **P10nS**
- + Steel Fibers (l = 25mm, d=0.50mm) → **P10nSF**

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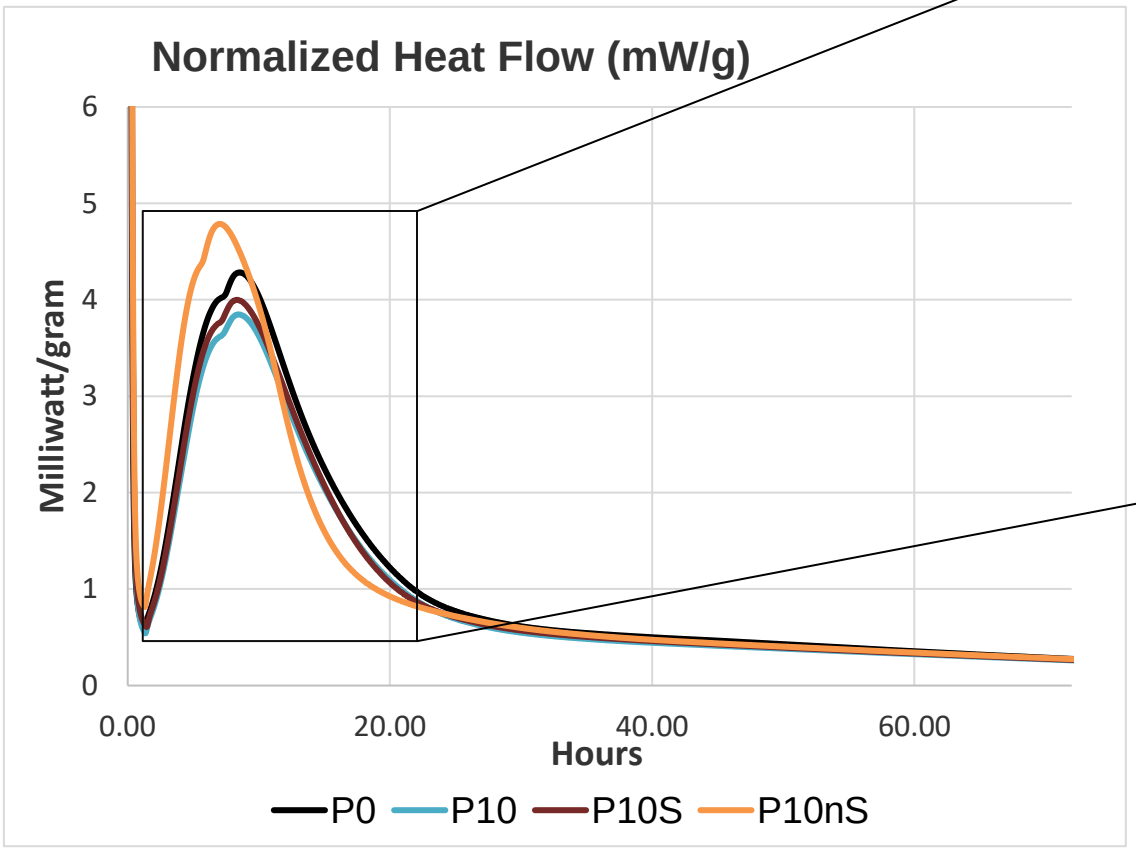
Materials

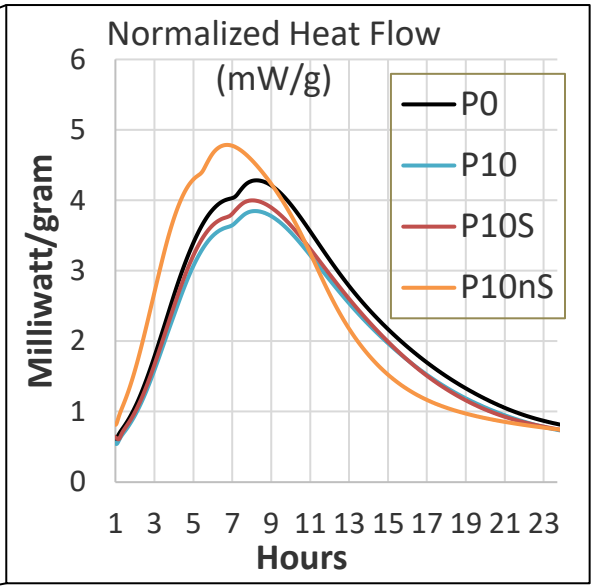
Mix Design

	Mix P0	Mix P10	Mix P10S	Mix P10nS	Mix P10nSf
Cement	550 kg/m^3	550 kg/m3	522.5 kg/m3	517.5. kg/m3	525 kg/m3
Silica Fume	0	0	27.5 kg/m3	27.5 kg/m3	25 kg/m3
Nano Silica	0	0	0	5.5 kg/m3	5.5 kg/m3
mPCM	0	10% by vol	10% by vol	10% by vol	10% by vol
Fine Aggregate	600 kg/m3	475 kg/m3	475 kg/m3	475 kg/m3	475 kg/m3
Coarse aggregate	600 kg/m3	600 kg/m3	600 kg/m3	600 kg/m3	600 kg/m3
w/c	0.45	0.45	0.45	0.45	0.45
Steel fibers	0	0	0	0	1% by vol

Methods & Results

Isothermal Calorimetry





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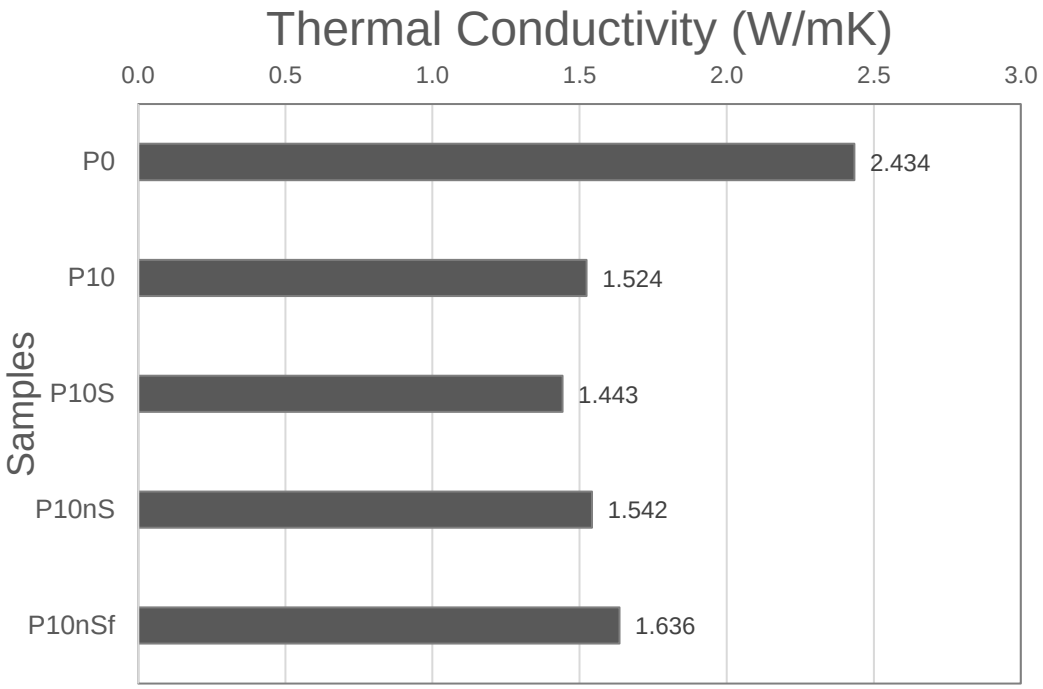
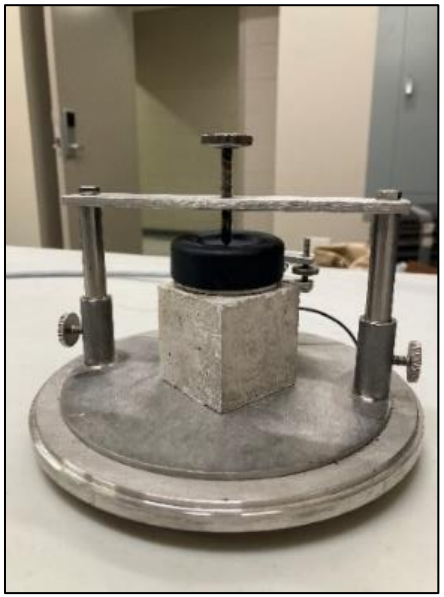
Methods & Results

Thermal Conductivity

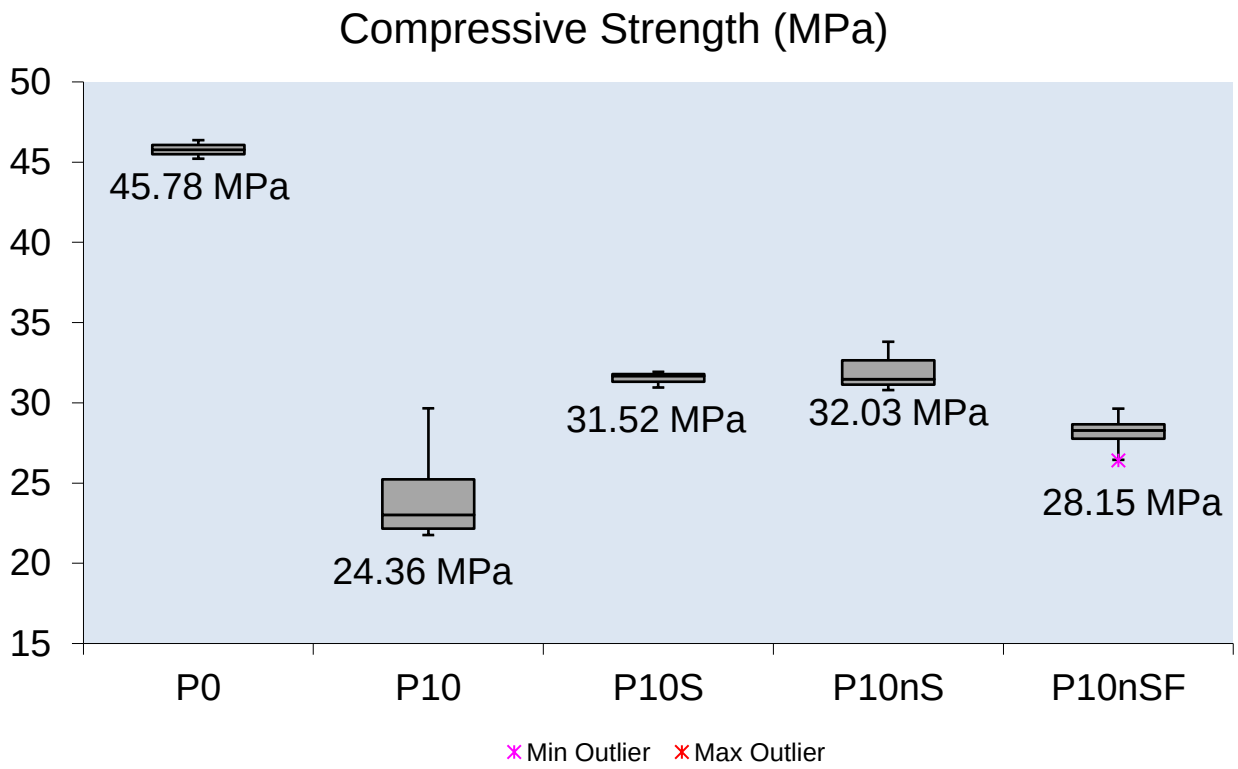




Transient plane sensor

Methods & Results

Compressive strength (MPa)



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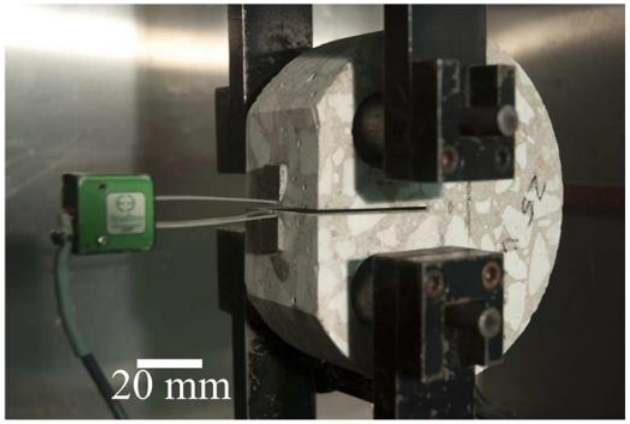
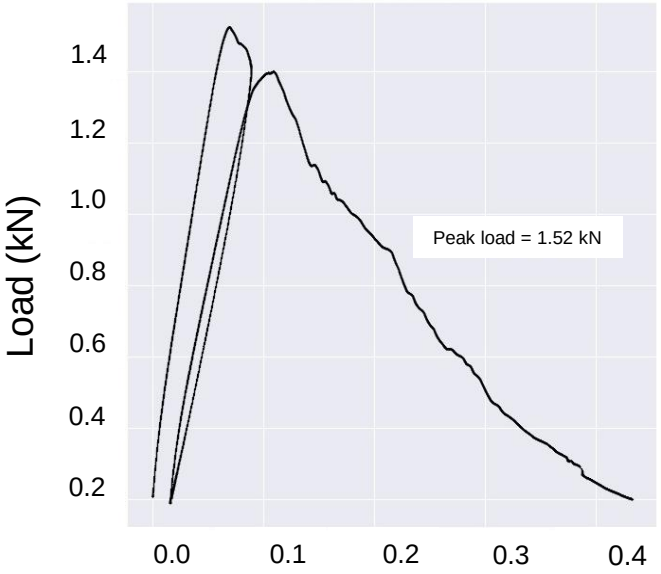
Methods & Results

Fracture Properties



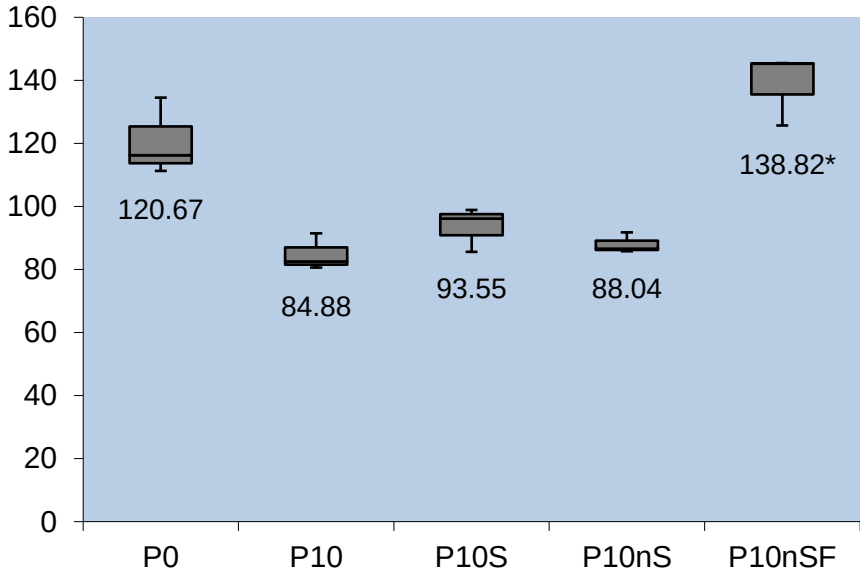
DCT testing setup
(Image Courtesy : Amirkhanian et al (2011)



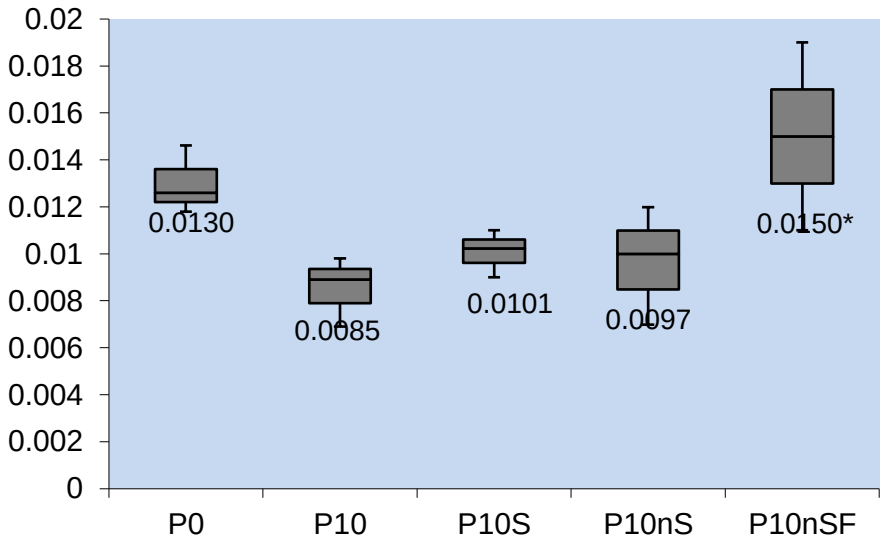
Methods & Results

Fracture Properties

Total Fracture Energy - G_F (N/m)



Critical Tip Opening Displacement – $CTOD_C$ (mm)



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* For steel fibers test was ended at CMOD chosen arbitrarily.

Conclusions

- No significant impact of additives on thermal conductivity
- Reduction in compressive strength (51%) > Reduction in fracture energy (30%)
- Silica based additives : potential solutions for compressive strengths comparable to low volume traffic roads
- Steel fibers : potential solution for fracture energy enhancement

Acknowledgements

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Thanks for your attention

For further communication : richa2@illinois.edu

Questions ??

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