

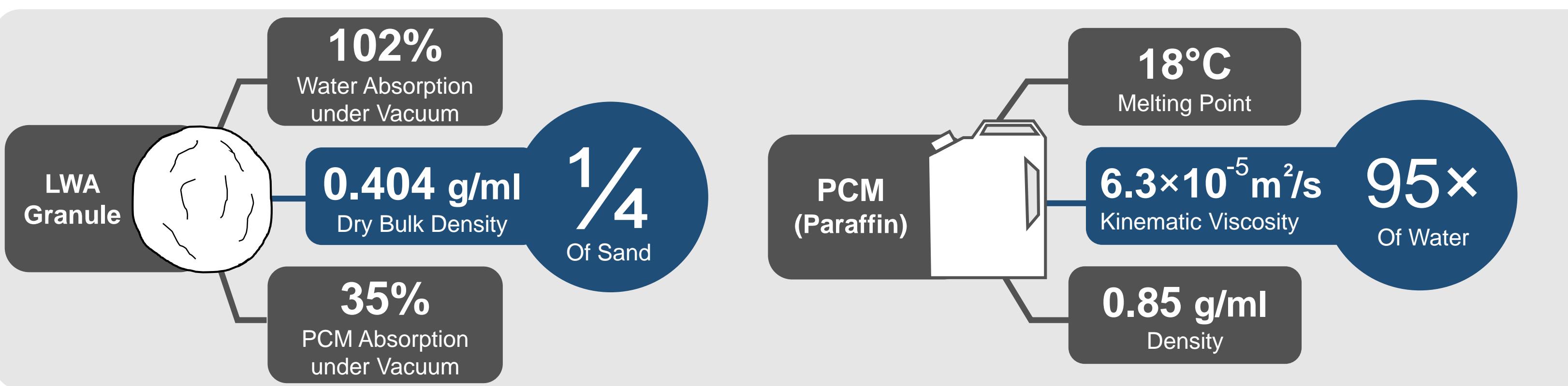
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Introduction

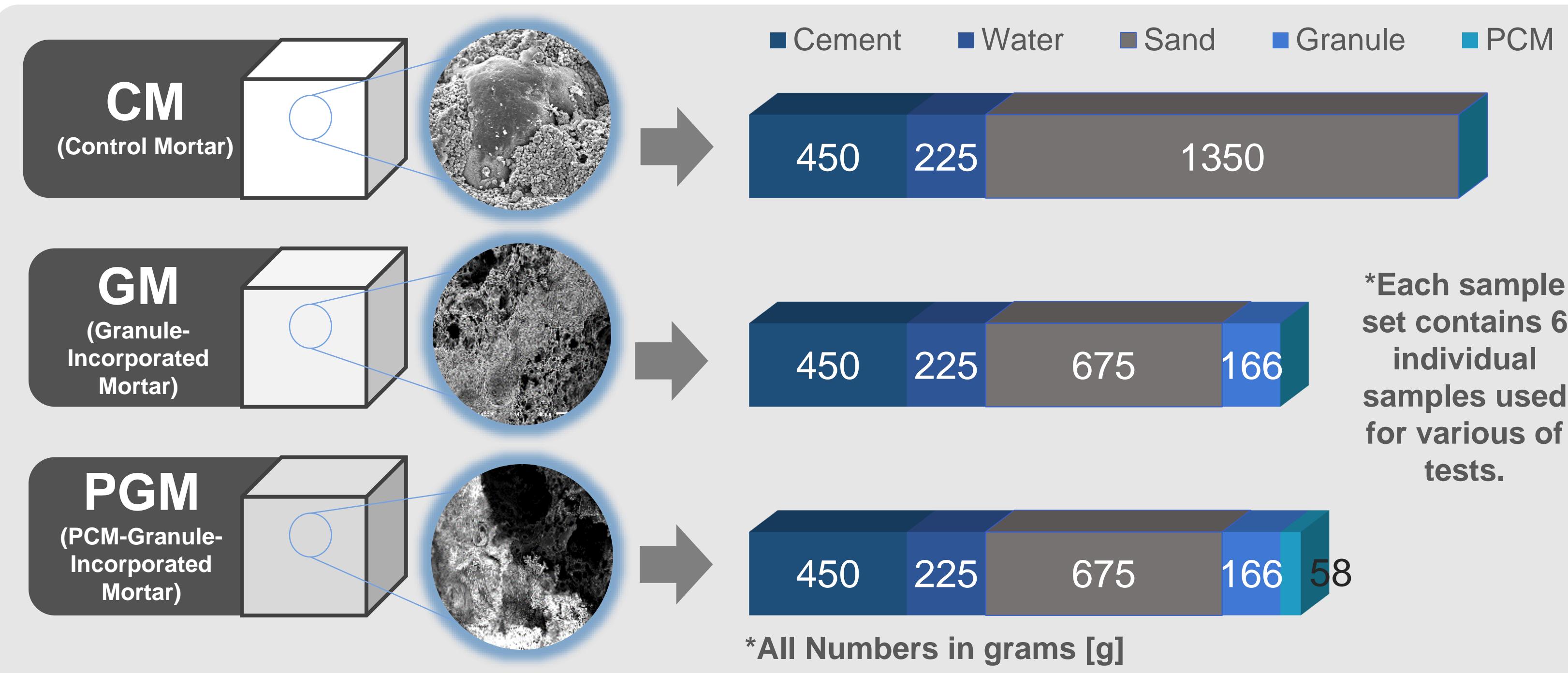
A new category of insulation is being developed and they use a type of material called **phase change materials (PCM)**. PCM is a substance that changes its physical state at a particular temperature by absorbing or releasing large amount of thermal energy, thereby stalling temperature changes to create a form of insulation. However, many PCM incorporations are not integrated into the construction materials, and that leads to this project of looking at the possibilities of using a **lightweight aggregate (LWA)** based on recycled glass, to encapsulate the PCM therefore it can be mixed in mortar.

LWA Granules & PCM

To produce the granules, *Eirich EL1 Mixer-Granulator* and *Rotary Kiln* were used.

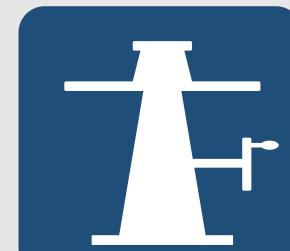


Mortar Sample Sets



Tests & Results

Workability



- PGM is 1.5× higher than CM.
- PGM is 1.1× higher than GM.
- GM is 1.3× higher than CM.

Compressive Strength



- PGM is 50% lower than CM.
- PGM is 28% lower than GM.
- GM is 30% lower than CM.

Open Porosity & Water Absorption



- CM & PGM have the same open porosities.
- GM has 24% higher open porosity than CM & PGM.
- GM has 51% higher water absorption than CM and 29% higher than PGM.

Scanning Electron Microscope (SEM)



- CM has strong bonding at interfaces due to the large surface area of the sand grains provide for crystallisation.
- GM has good amount of cement hydration inside the granules. The extra hydration provides the additional bonding when it comes to the compressive strength test.
- PGM almost has no cement hydration inside the granules, as cement particles are incompatible with the PCM. However the granule encapsulated the PCM very well, resulting in the clean boundary seen in the image.

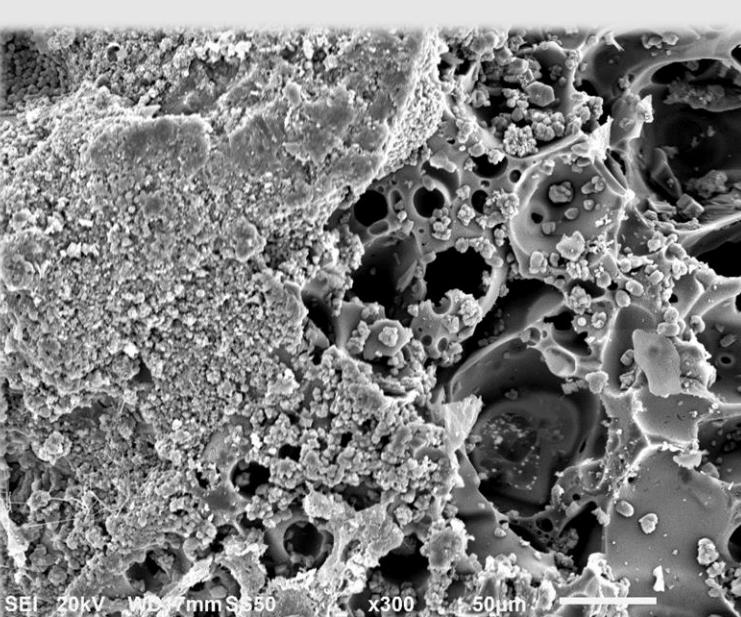


Figure: GM at 50µm

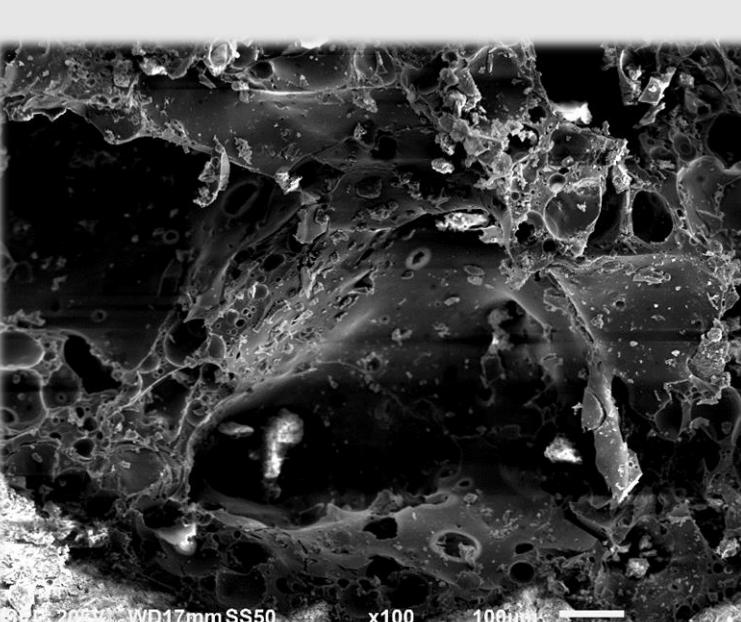


Figure: PGM at 100µm

Setting Time



- PGM takes 1.2× longer than CM.
- PGM takes 1.1× longer than GM.
- GM takes 1.07× longer than CM.

Dry Bulk Density



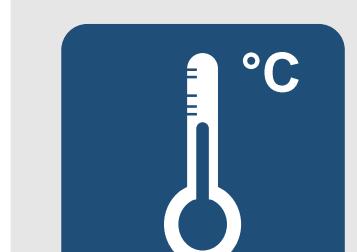
- PGM and GM are both 18% lighter than CM.
- Meaning that the PCM added was negligible in weight

Plane Source Thermal Conductivity



- CM is 35% higher than both PGM & GM.
- This is largely due to the increased air content and lower thermal conductivity of granules compared with sand grains.

Thermal Performance



- Samples' surface temperatures are monitored within an hour while being moved from one temperature environment to the other.

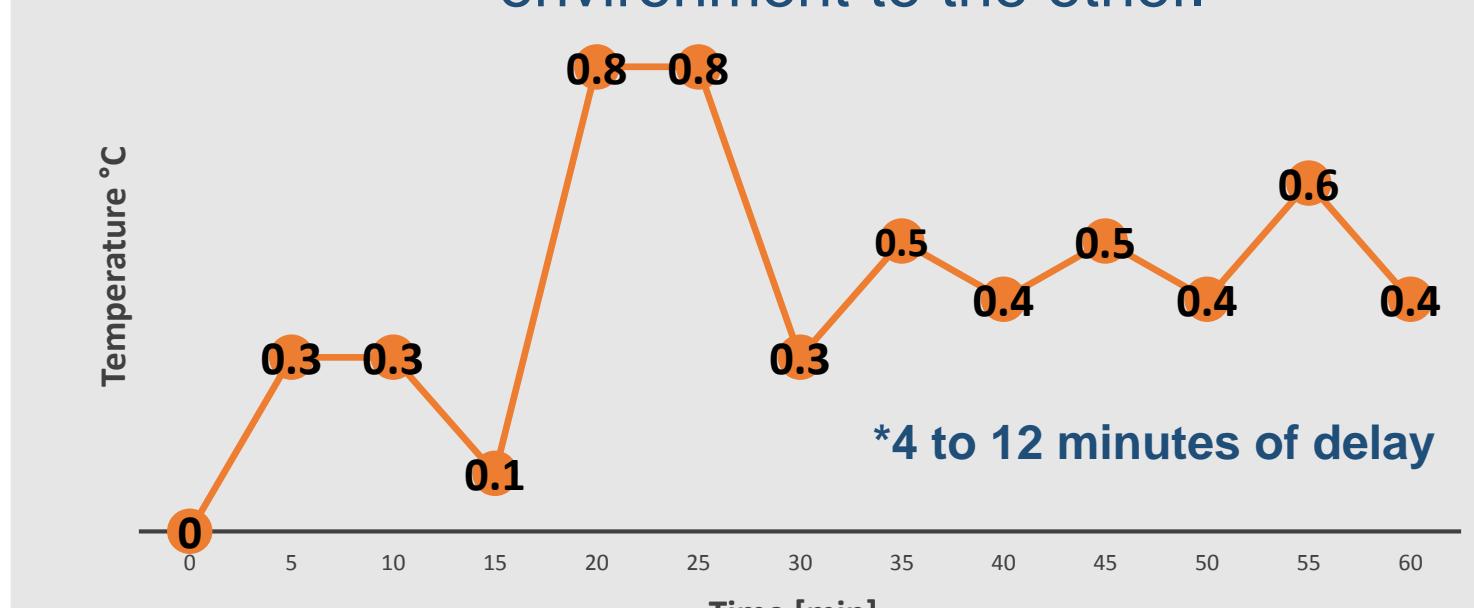


Figure: PGM over CM from High to Low temperature environments

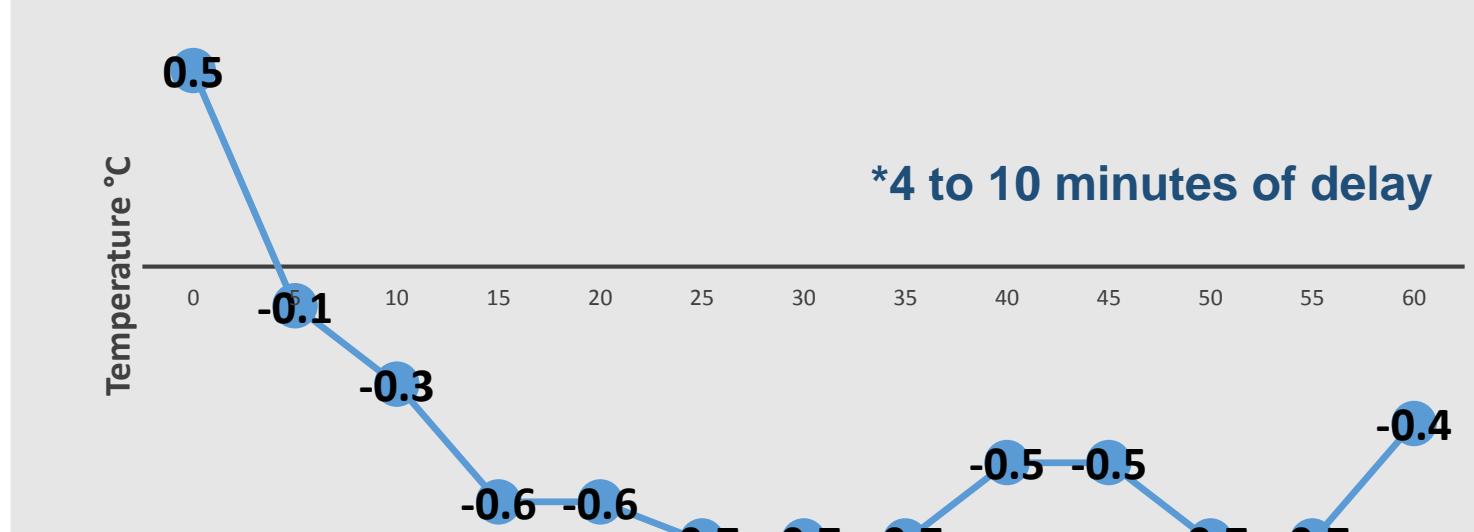


Figure: PGM under CM from Low to High temperature environments

Conclusions

Overall, the glass based granules demonstrated excellent potentials when used as an PCM encapsulation device, and the PGM sample manifested its superior insulating properties compared with the control mortar. For future works on this topic, purer composition of PCM and the introduction of a coating for the granules are recommended.

Acknowledgement

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