Østfold University College

Investigating the mechanical properties of geopolymer concrete with micro-encapsulated phase change materials

Shima Pilehvar

Micro-encapsulated phase change materials in concrete

Interdisciplinary project - several external partners

- University of Castilla-La Mancha (Spain)
- University of Birmingham (UK)
- University of Murcia (Spain)
- Norwegian University of Life Sciences (Ås)
- University of Oslo
- Technical University of Cartagena (Spain)
- Mapei
- University of Bergen
- Østfold University College

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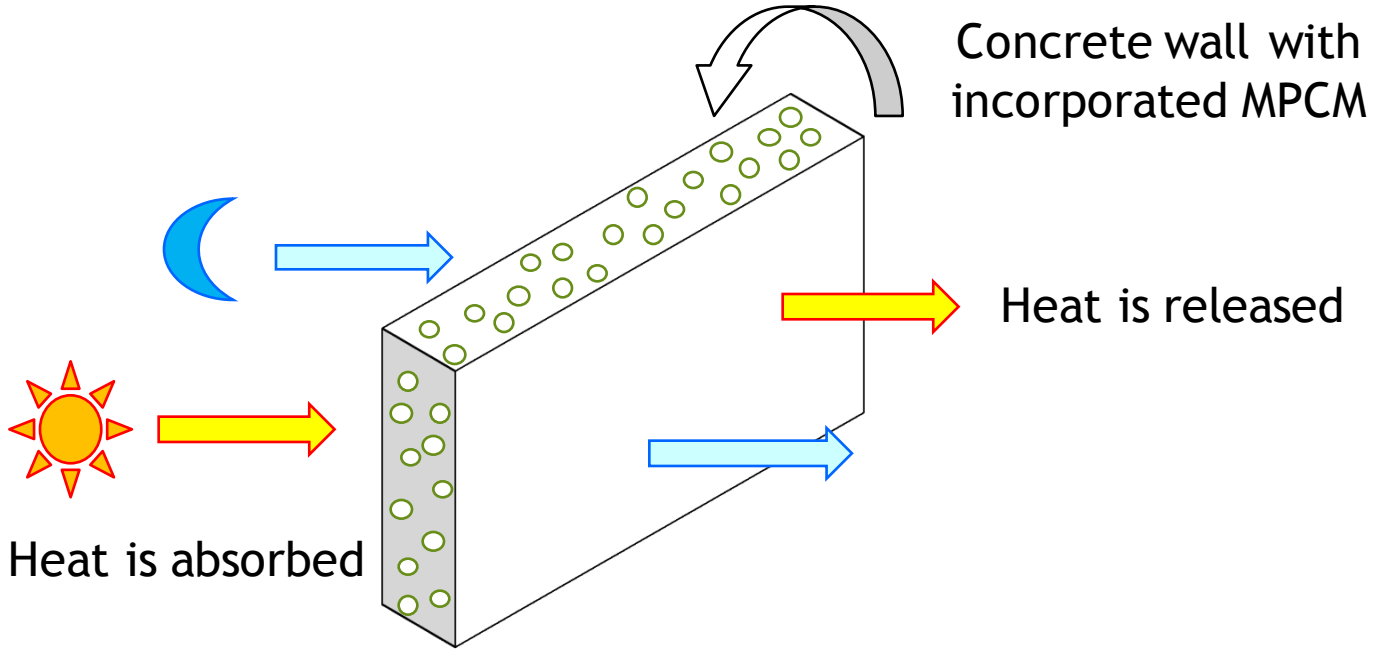
Function of Micro-encapsulated phase change material (MPCM) in building materials



save the excess daytime energy by melting

release it back at night by decreasing the temperature

Concrete with incorporated MPCM

Advantage

- Reducing thermal conductivity of concrete
- Increasing heat capacity of concrete

Disadvantage

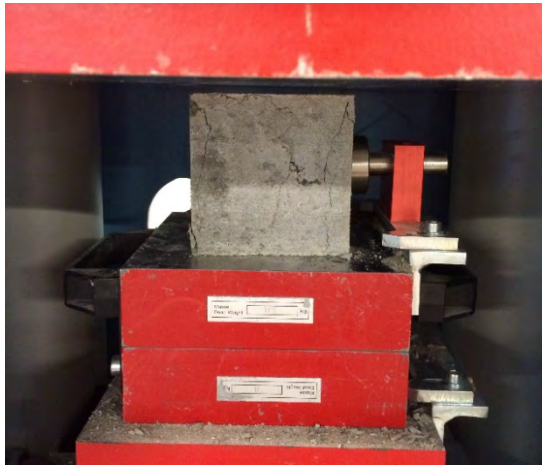
- Reducing mechanical properties such as compressive strength

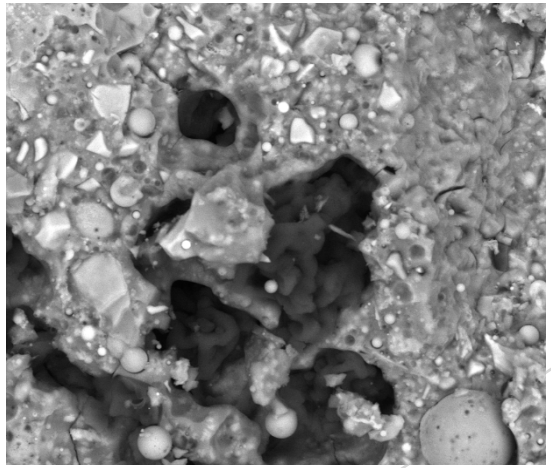
Hypothesises for the compressive strength reduction of concrete after adding MPCM

Destroying MPCMs during mixing process with concrete

Low stiffness of MPCMs compared to sand

Destroying microcapsules while concrete is under the pressure of compressive strength machine

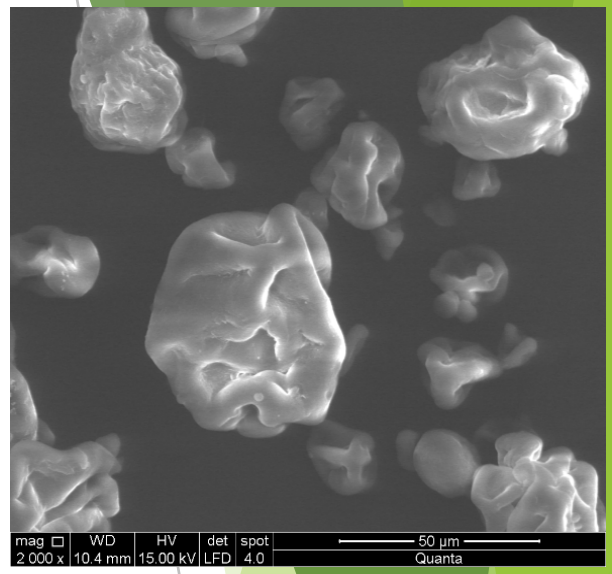




Adhesion and bonds between MPCM and concrete matrix

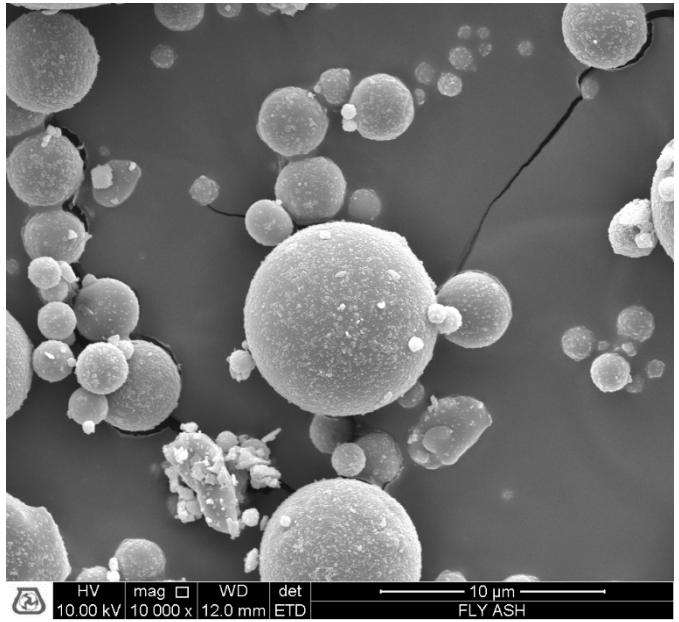
MPCM in the current experiment

- ✓ Microcapsules prepared by Spray drying (SD) technique
- ✓ A polymeric shell of low density polyethylene(LDPE) and Ethylvinylacetate (EVA) copolymer
- ✓ paraffin wax Rubitherm®RT27 as core material



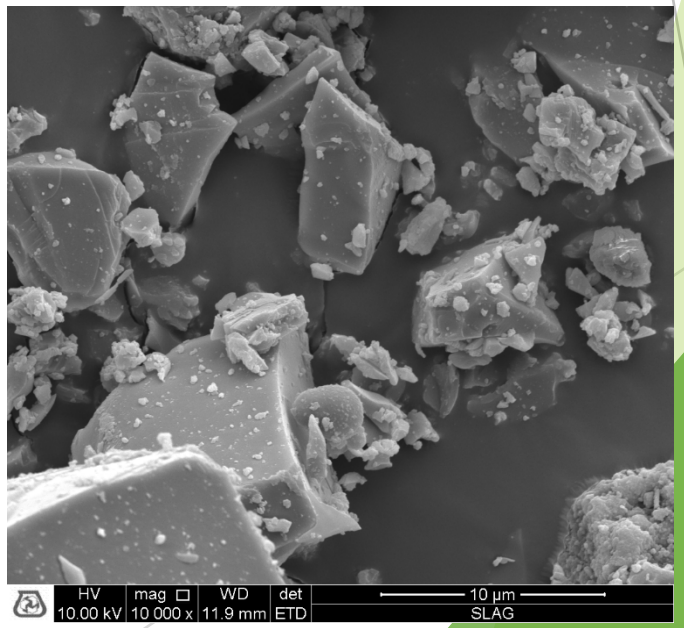
properties	
appearance	white
Form	powder
Capsule composition	40-50 wt.% PCM, 50-60 wt.% polymer shell
Shell material	LDPE and EVA
Core material	Paraffin wax Rubitherm®RT27
Mean particle size (µm)	5
Melting point (°C)	28.40 ± 0.90

Geopolymer concrete (GPC)



Fly ash

Slag



Details of GPC mixtures per 1 liter

Recipe	hardner(g)	Water (g)	Fly ash (g)	Slag (g)	Sand (g)	Aggregate (g)
GPC	161.6	56.4	242.6	161.4	893.1	868.6

Recipe	Sodium hydroxide (g)	Water (g)	Sodium silicate (g)
hardner	16.8	29.4	115.4

Replacing different percentage of sand by MPCM

GPC	MPCM (%)	Sand (g)	PCM (g)
1	0	893.1	0
2	5	848.6	15
3	10	803.8	30
4	20	714.5	60

Preparing specimens

Preparing alkaline solution

Blending fly ash and slag

Mixing together

Introducing the binder into the sand

Adding aggregate to the mixture

Adding MPCM as last component

Casting

3 cubes for each measurement $10 \times 10 \times 10\ cm^3$

Viberating

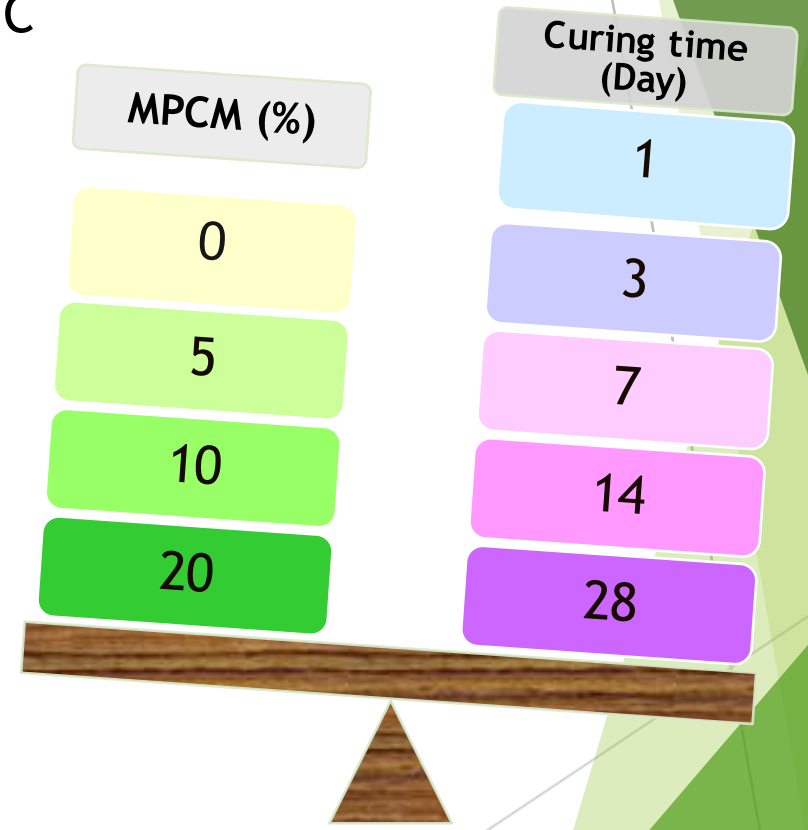
One day precuring

Variables

Curing temperatures:

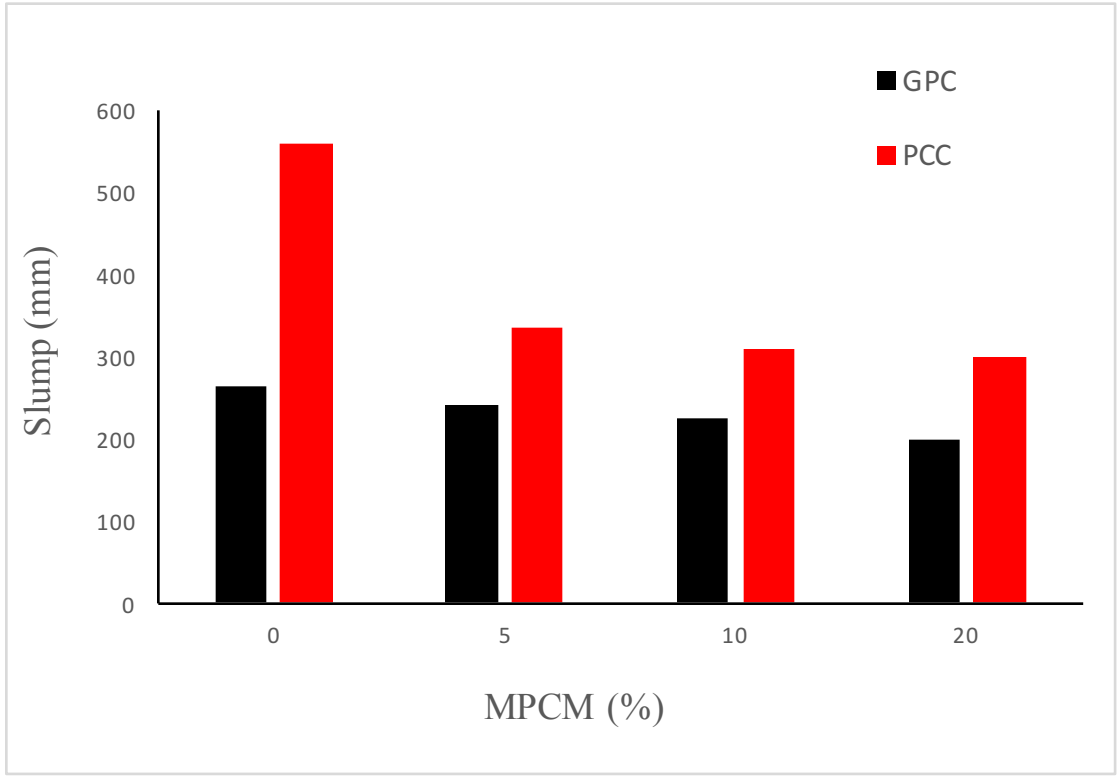
Curing some specimens in water at 20 °C
Curing some specimens in thermal bath at 40 °C

To investigate the effect of MPCM
in solid and liquid states
on the properties of GPC



Slump flow test

In order to determine the effect of MPCM addition on the workability of fresh GPC and PCC



Compressive strength (CS) test

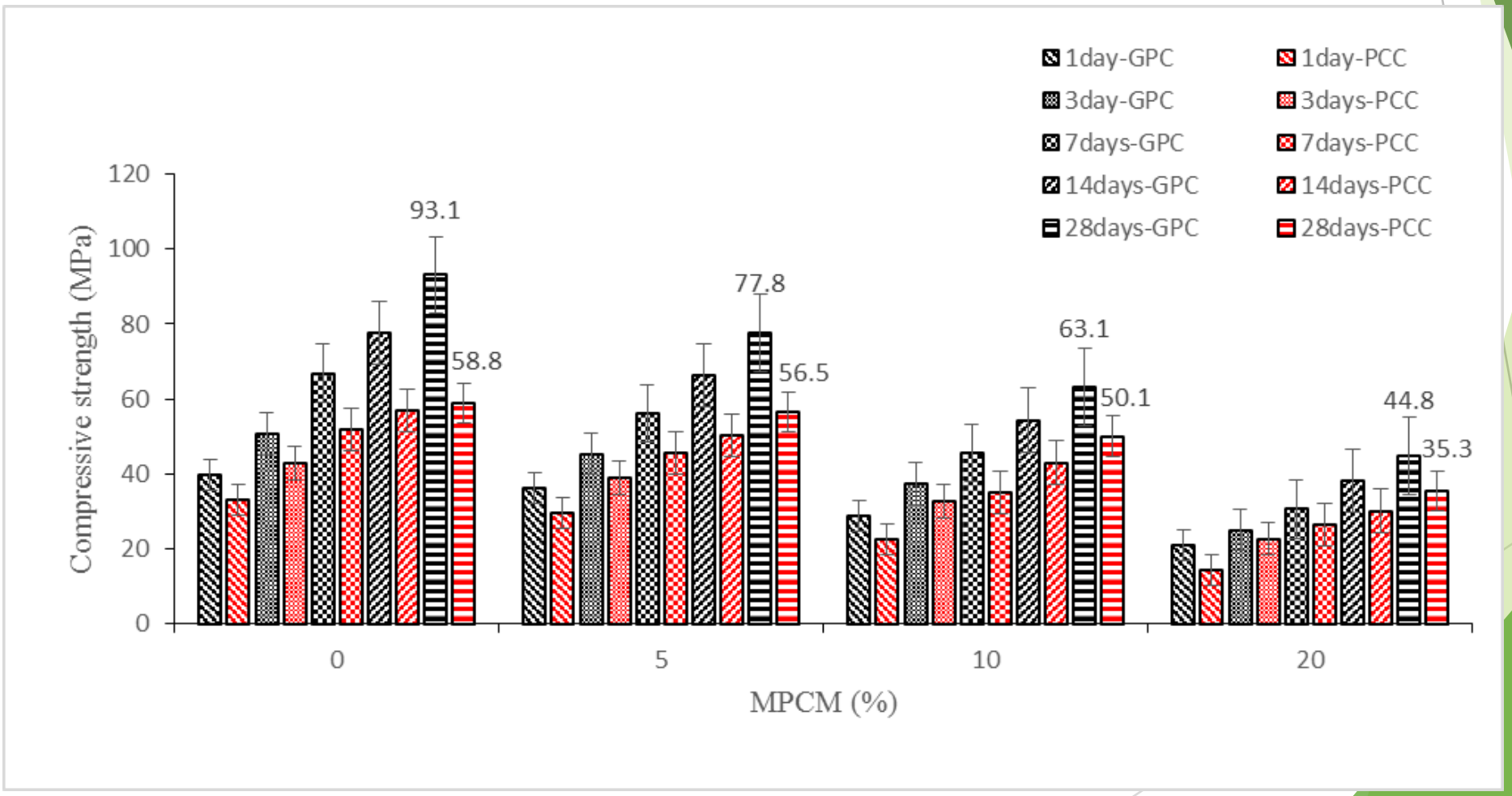
At 20° C:

- ✓ Drying and weighing specimens
- ✓ Measuring CS by CS test machine

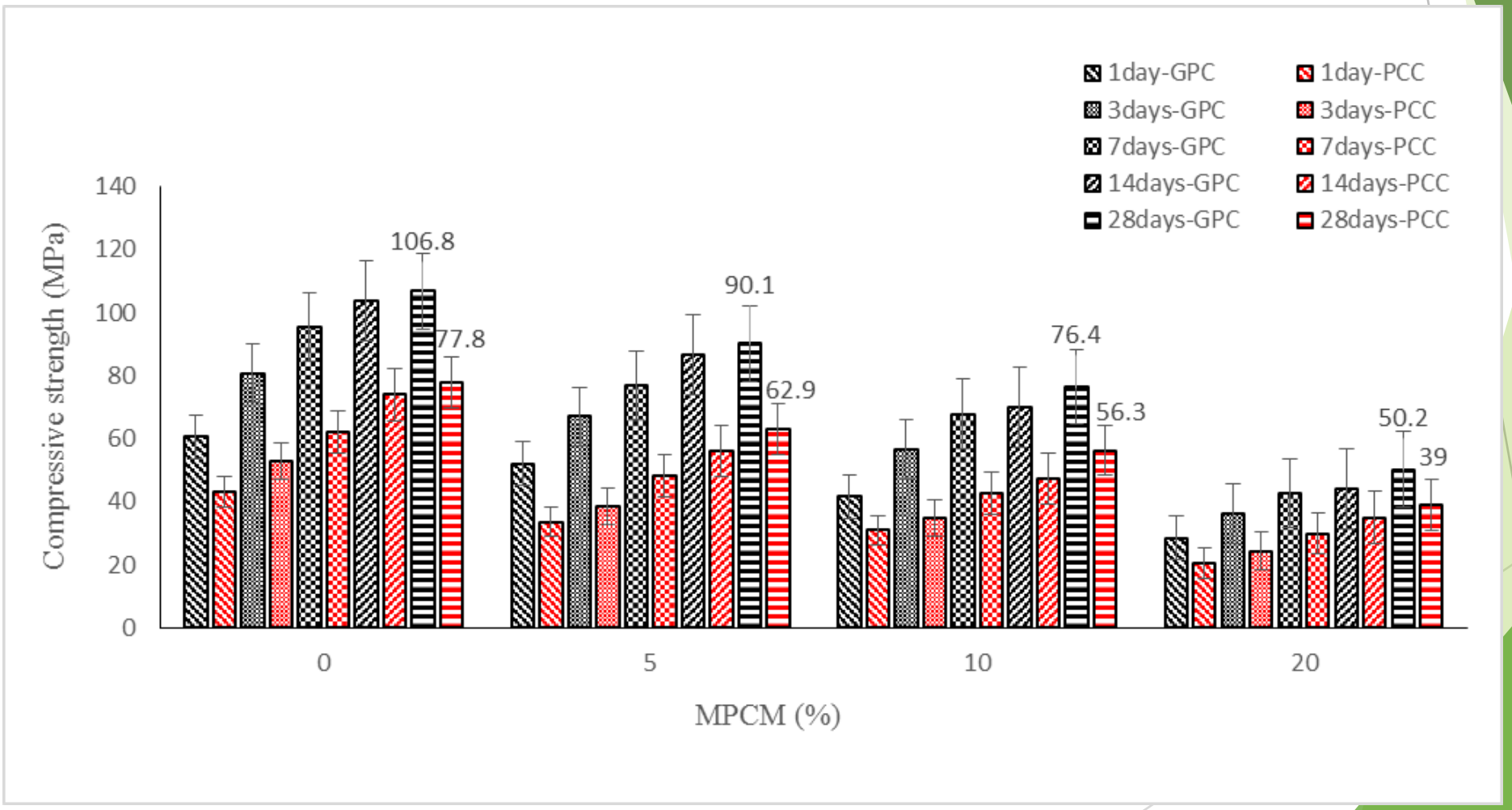
At 40° C:

- ✓ Isolating CS test machine thermally
- ✓ Connecting machine to a heating chamber by an isolated tube → to keep the temperature constant during testing
- ✓ Keeping MPCMs in liquid state during measurement
- ✓ Measuring CS by CS test machine

The compressive strength of GPC and PCC versus MPCM at 20 °C

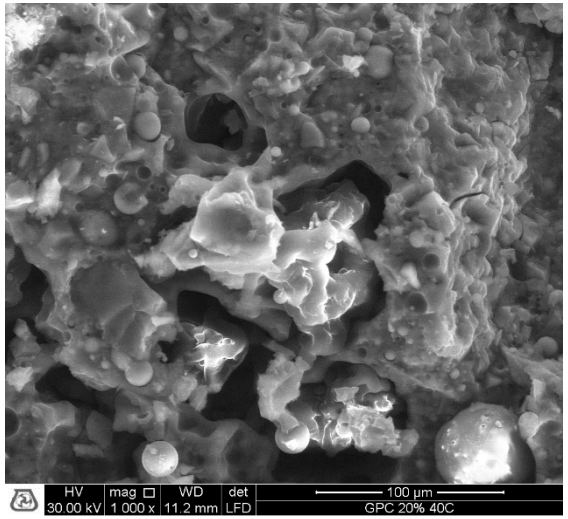


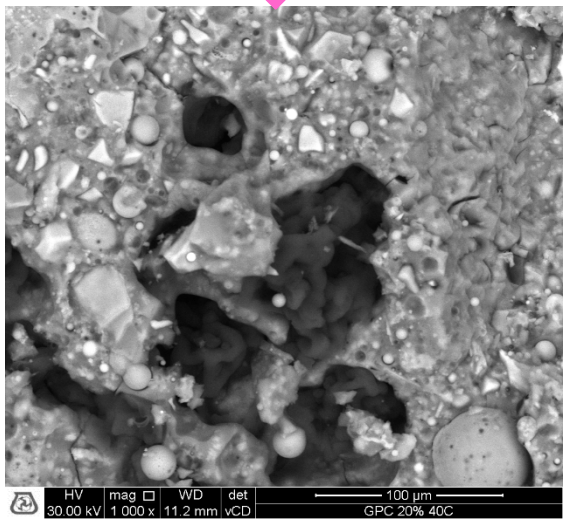
The compressive strength of PCC and GPC versus MPCM at 40°C



SEM imaging with LFD and vCD methods

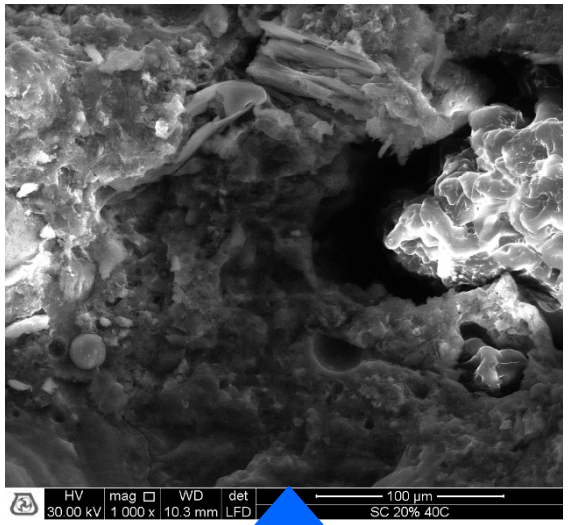
GPC





vCD LFD

PCC



vCD LFD

problems

- After adding MPCM to the geopolymer concrete → the workability decreases noticeably → working with higher percentage of MPCM is impossible
- Standards for shrinkage of geopolymer concrete containing MPCM


Thank you for your attention
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