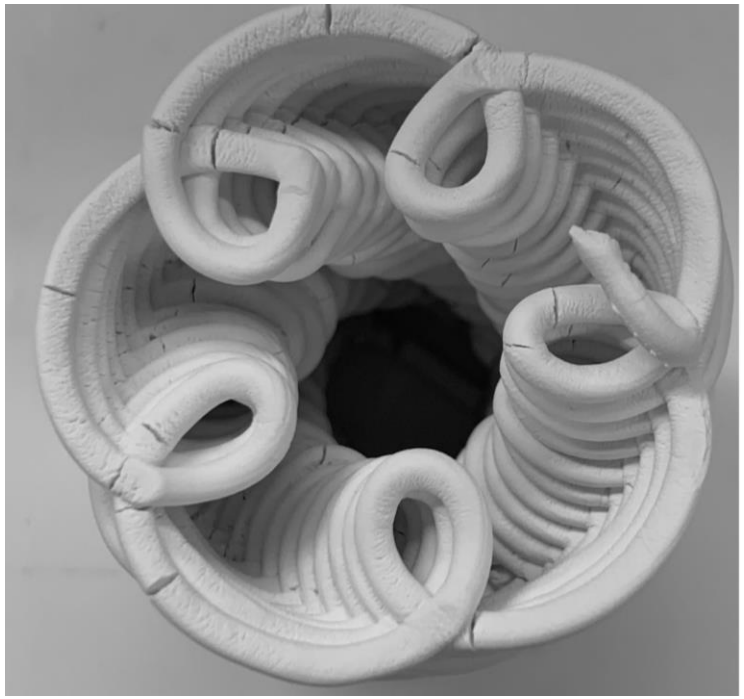
Enhanced Carbon-Intake of MgO Paste Structures via 3D Printing



Ala Eddin Douba

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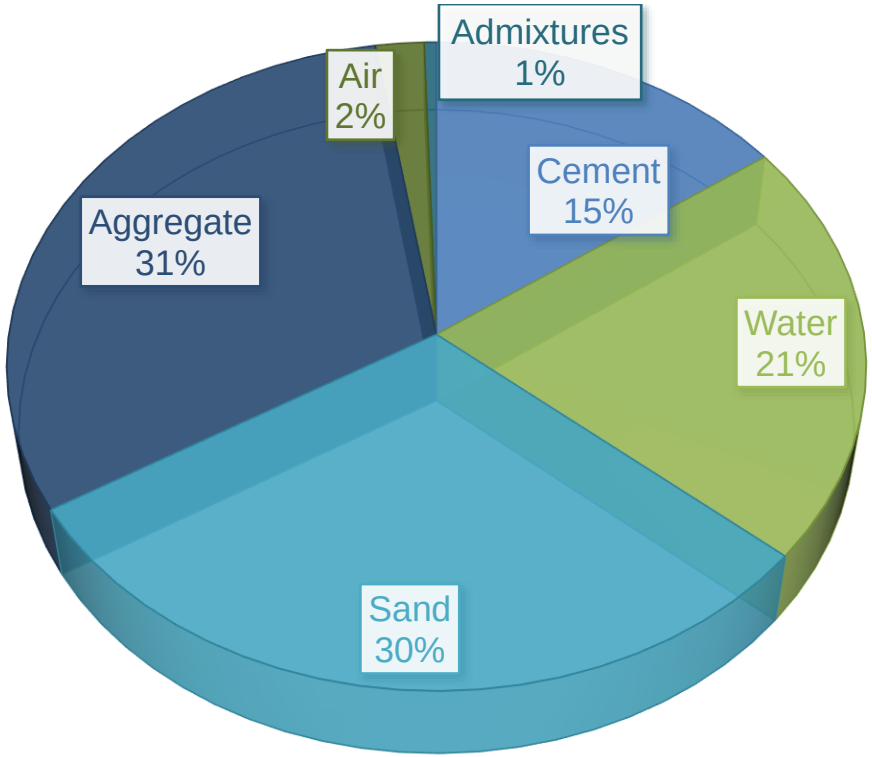
ACI Spring 23 Convention. San Francisco, CA April 1-5

aci CONCRETE CONVENTION

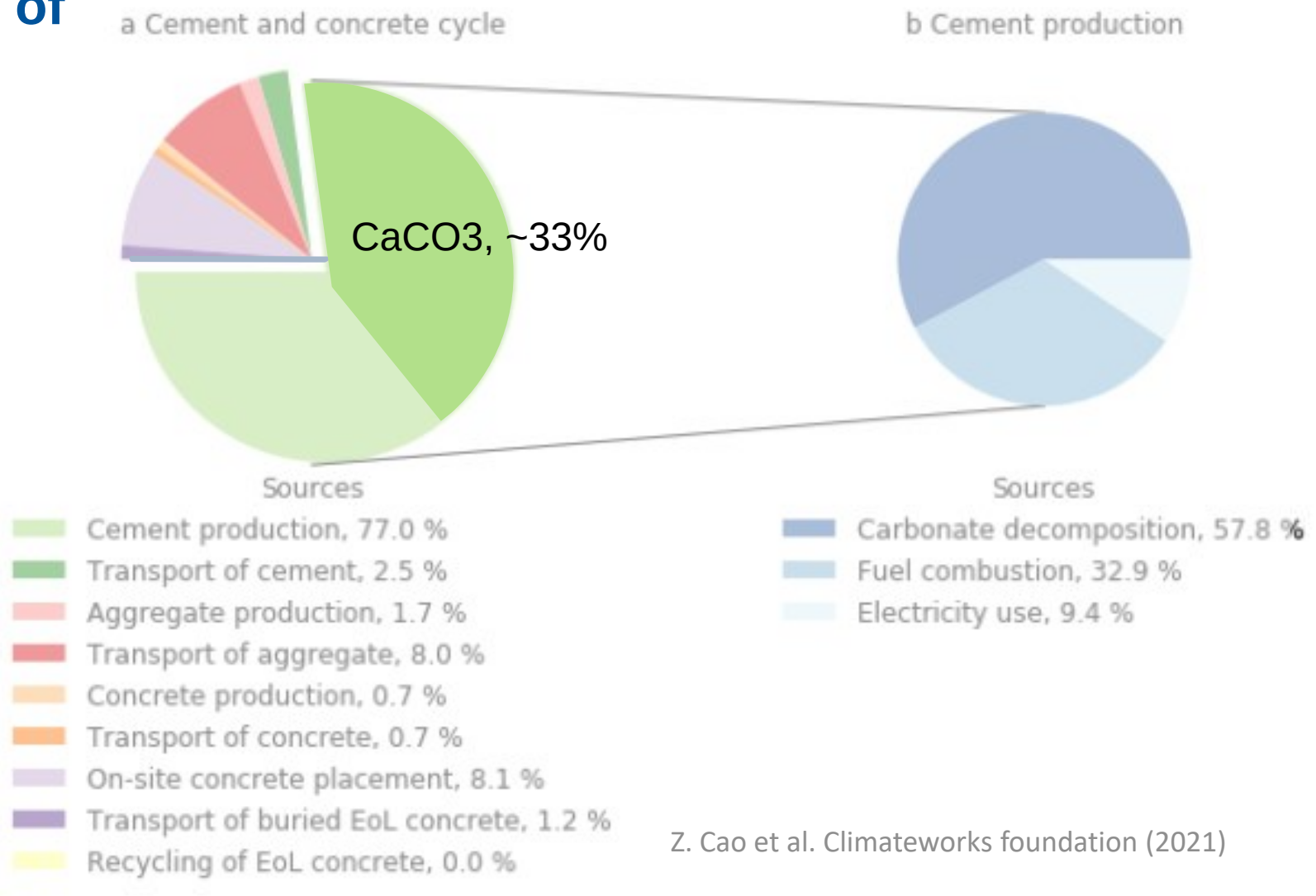
Concrete is the second most consumed material on earth after water



Concrete composition by volume

Carbon footprint of concrete

Global Cement and Concrete Association aims to reach carbon neutrality of cement and concrete by 2050



Z. Cao et al. Climateworks foundation (2021)

Magnesia

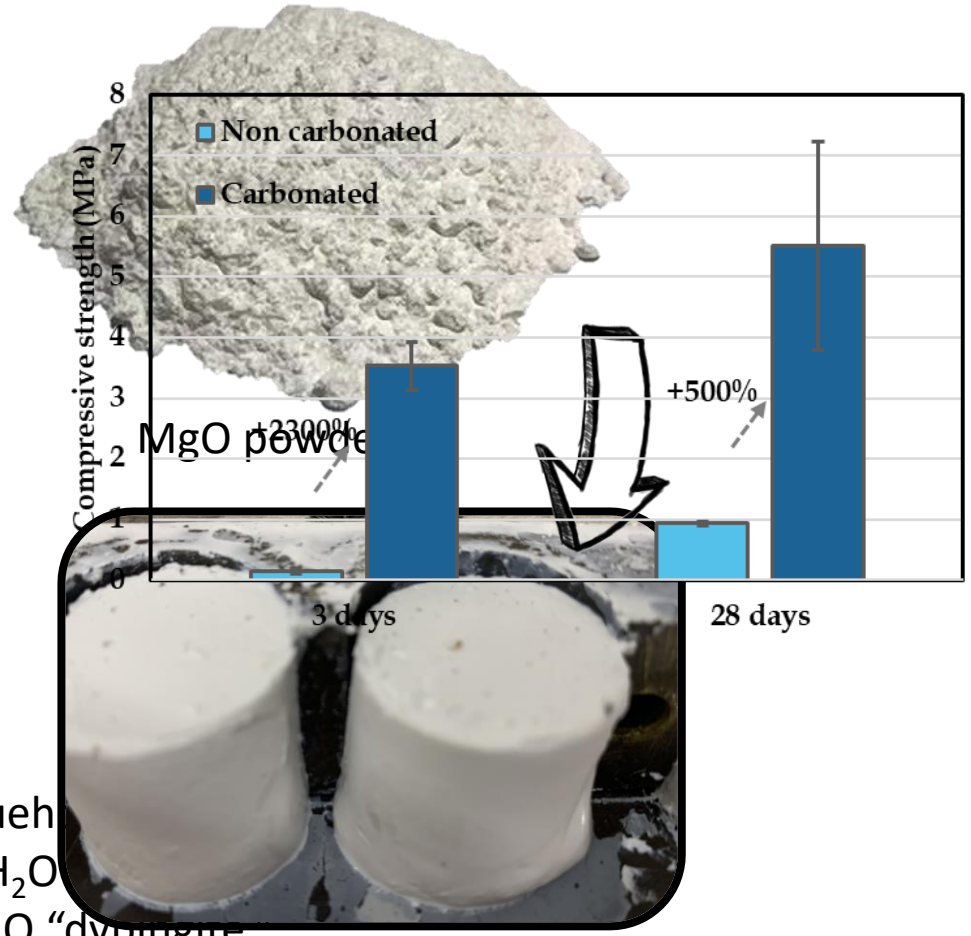
MgO

Hydration

$Mg(OH)_2$
"Brucite"

Carbonation

$MgCO_3 \cdot 3H_2O$ "Nesqueh
$4MgCO_3 \cdot Mg(OH)_2 \cdot 4H_2O$
$MgCO_3 \cdot Mg(OH)_2 \cdot 5H_2O$ "dypingite
$MgCO_3 \cdot Mg(OH)_2 \cdot 3H_2O$ "artinite

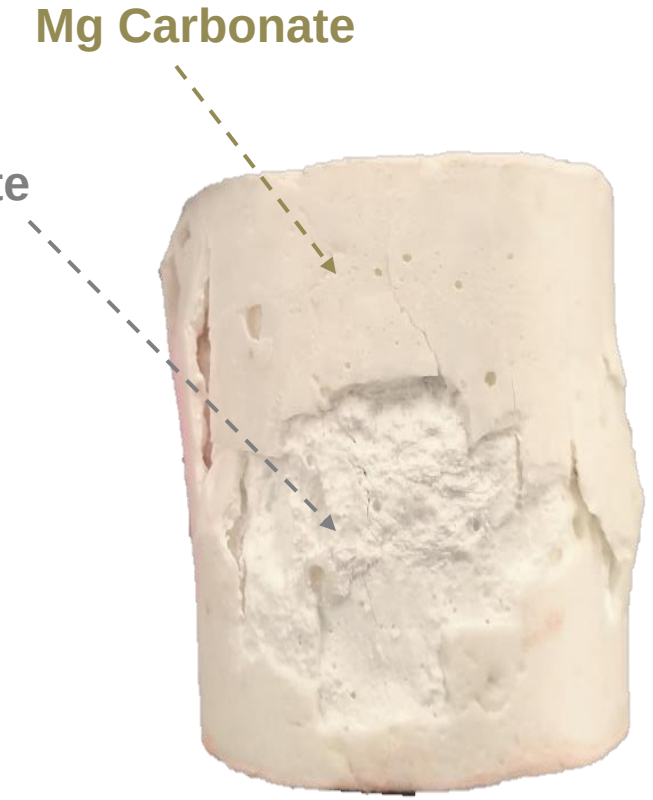


Atmospheric Carbonation

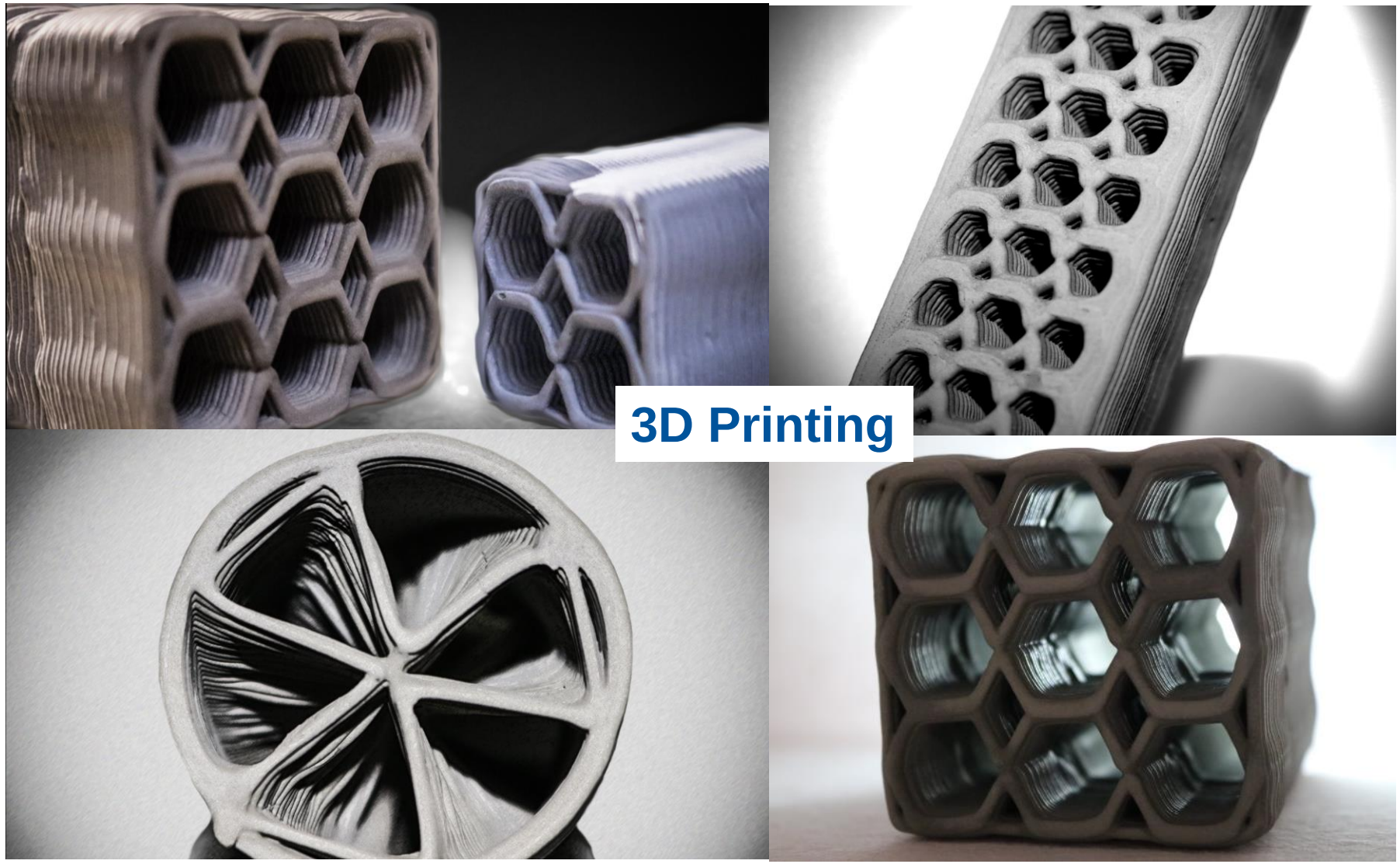
Low-pressure carbonation

Outside-in process

Carbonated specimen



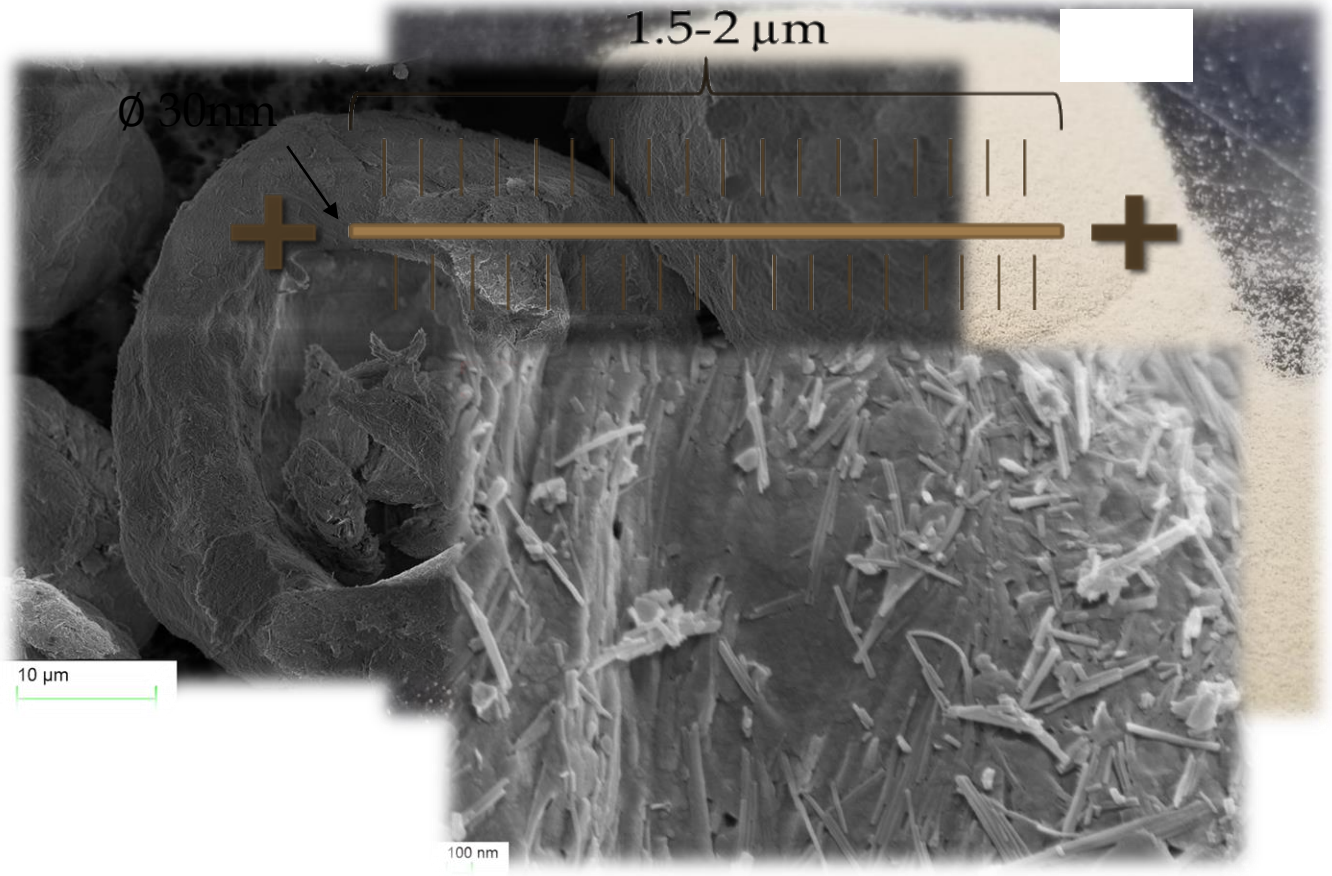
Uncarbonated weak core



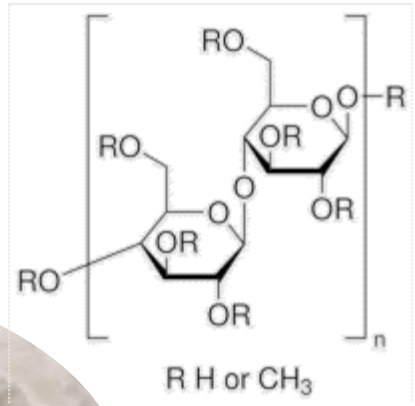
3D Printing

Materials

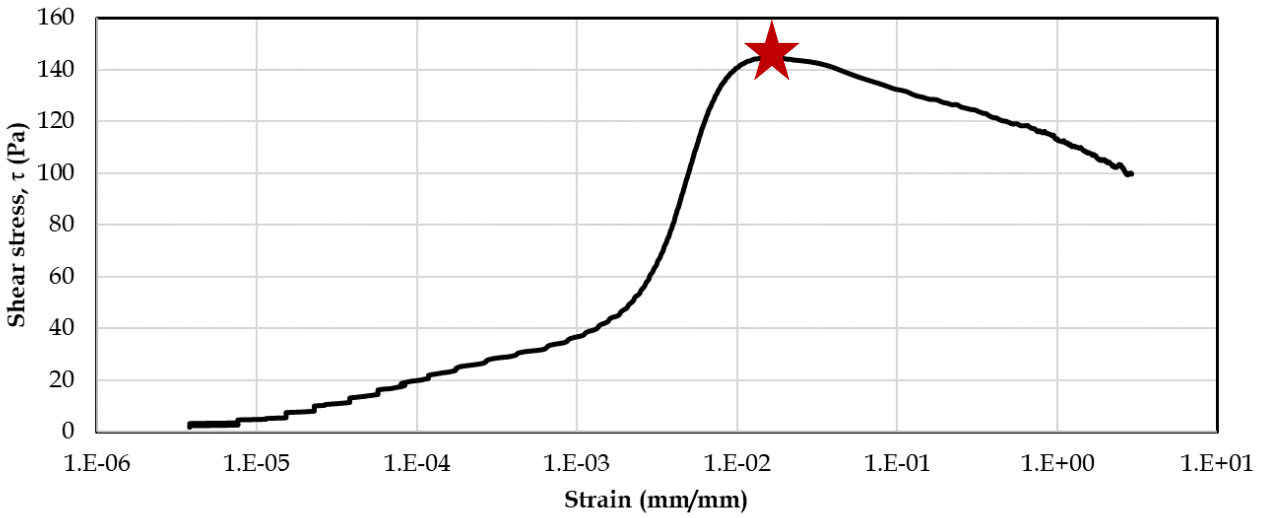
1. Nanoclays (NC)
- Attapulgite nanorods made of purified Magnesium Aluminosilicate



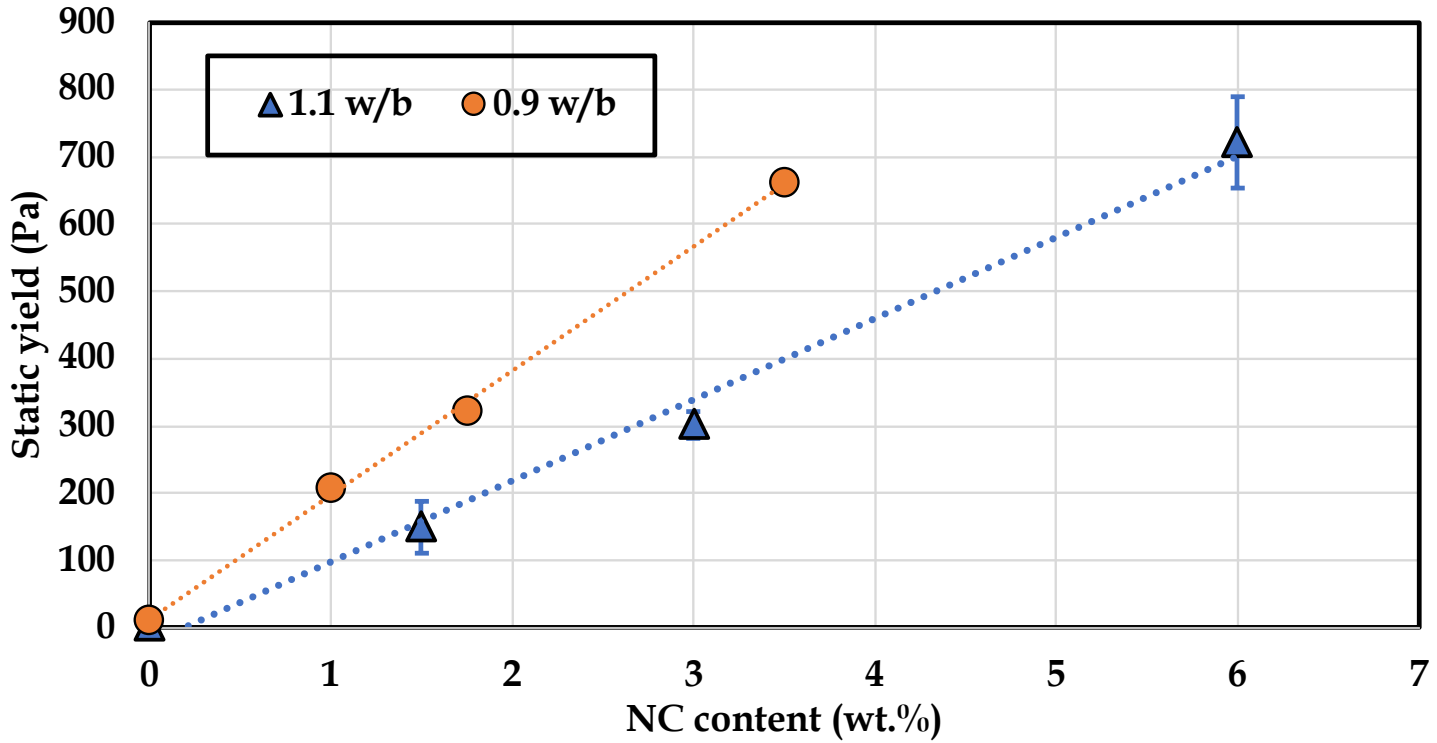
2. Methyl Cellulose (MC)
- 15,000 molecular weight viscosity modifying admixture (VMA)



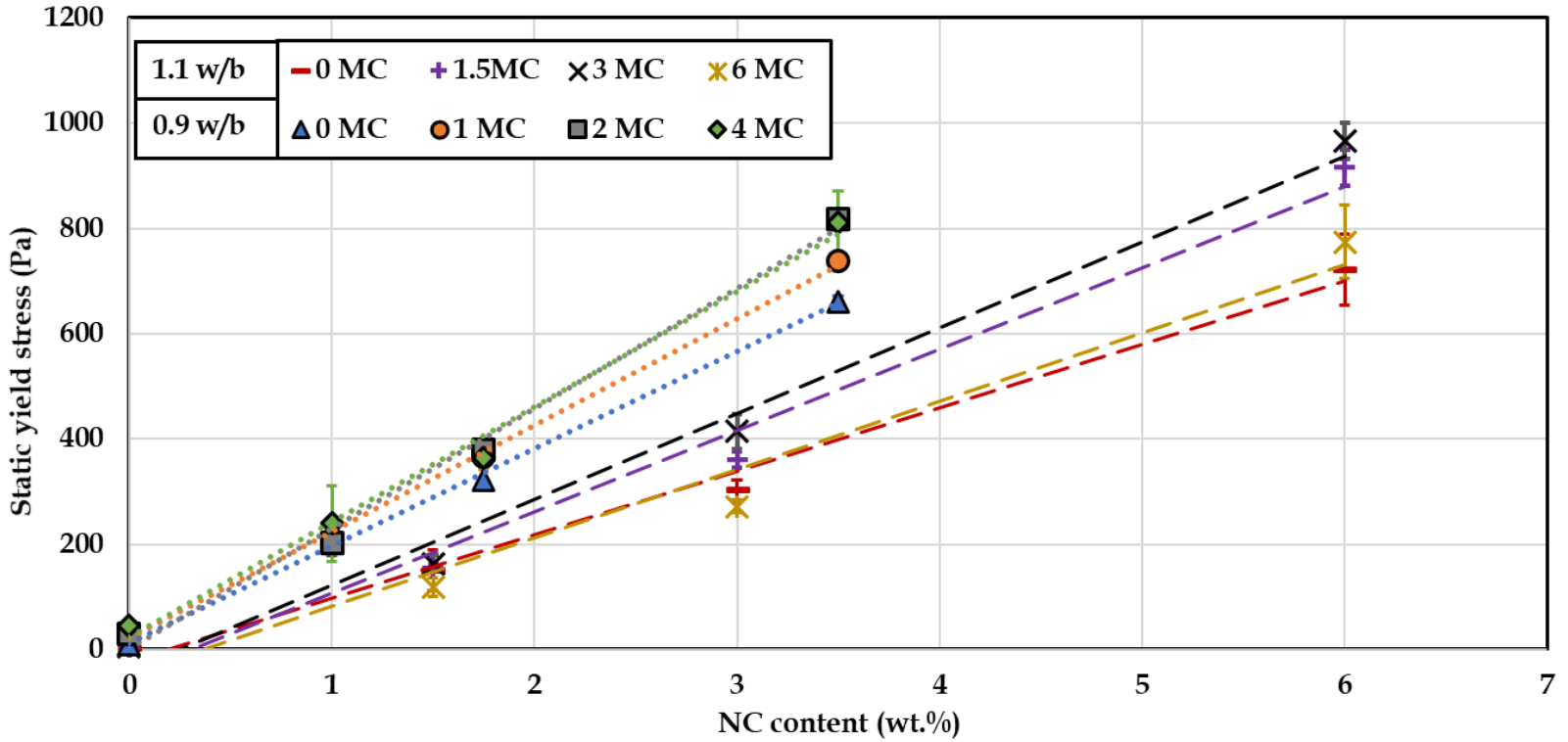
Rheological characterization



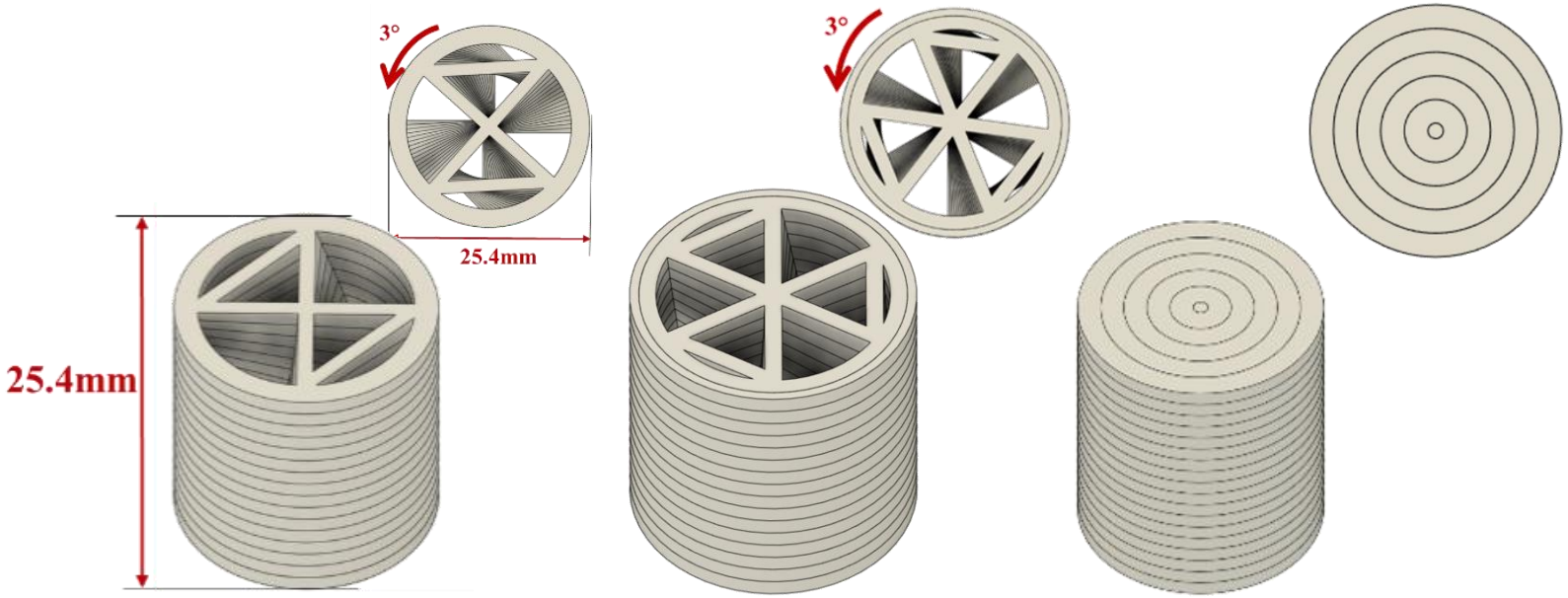
Rheology


900
800
700
600
500
400
300
200
100
0
Static yield (Pa)
1.1 w/b
0.9 w/b
0
1
2
3
4
5
6
7
NC content (wt.%)

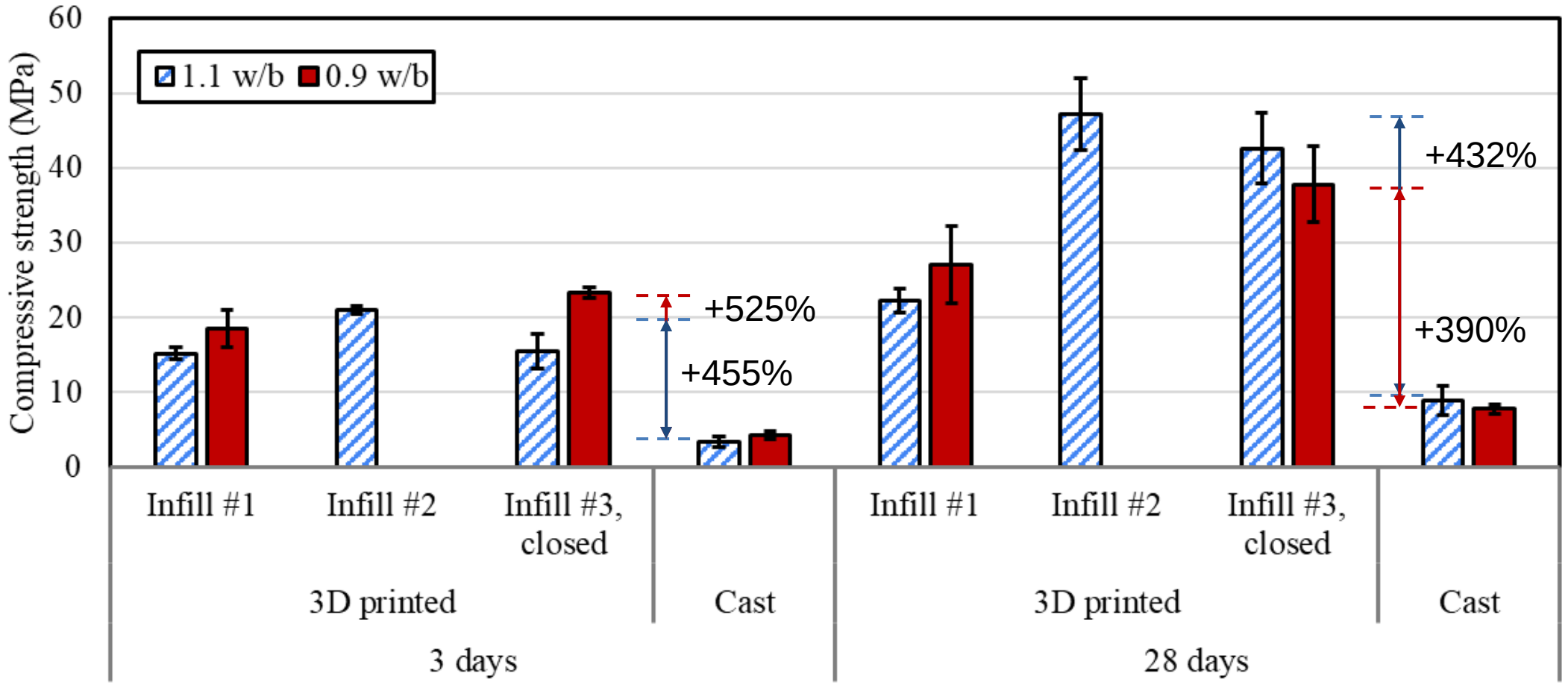
Rheology



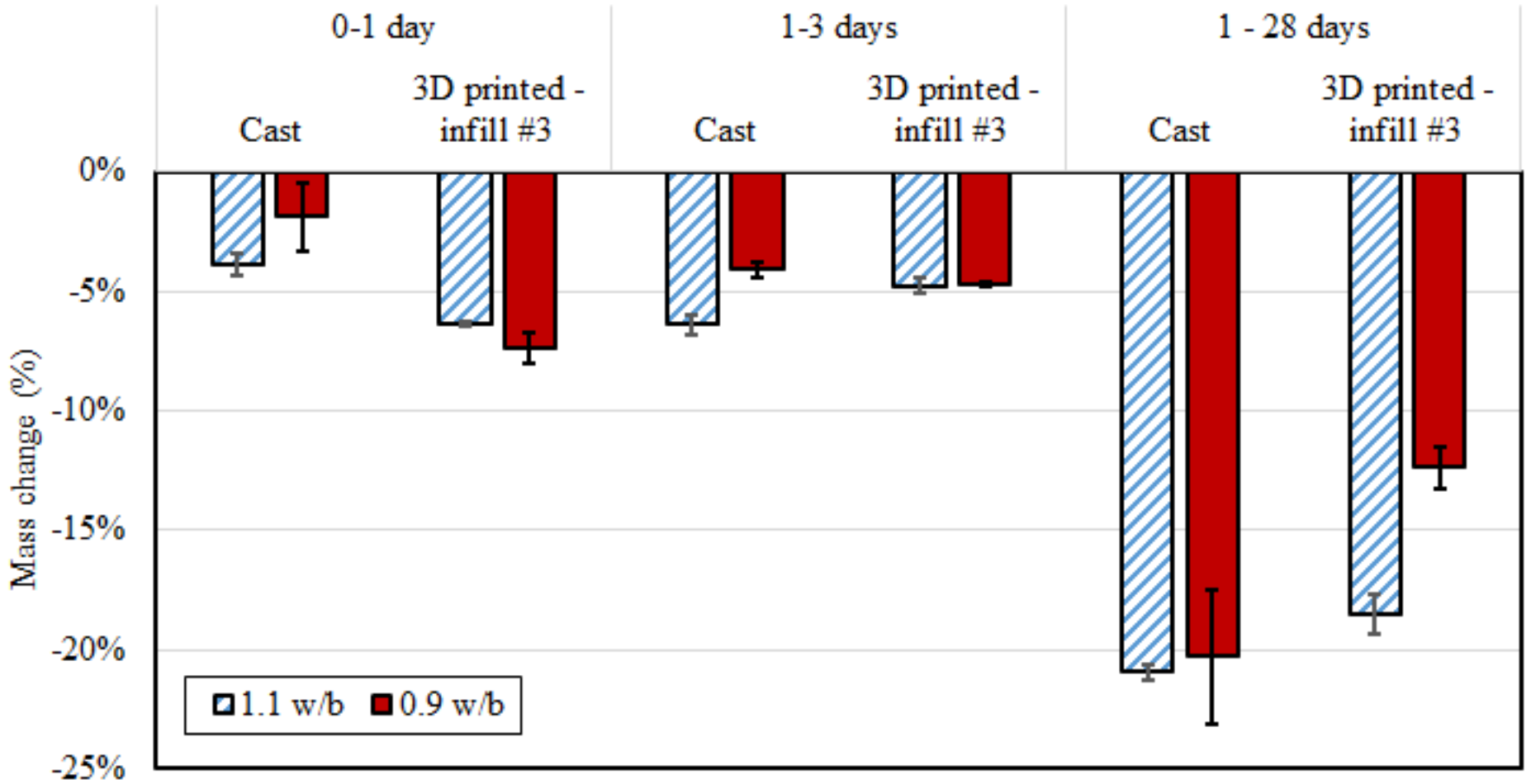
3D Printing Program



Compressive Strength



Mass Change



Conclusion

- **Nanoclays** can increase the **structuration** of MgO to **enable** 3D printing
- 3D printing can increase MgO **compressive strength** reaching **40-60 Mpa**
- The **higher water evaporation** due to lack of protective formwork **increased porosity** which in term **enhanced carbon intake**
- 3D printed **MgO** is a promising new construction material with **neutral** or **negative carbon footprint**

Acknowledgement

Dr. Shiho Kawashima's Lab

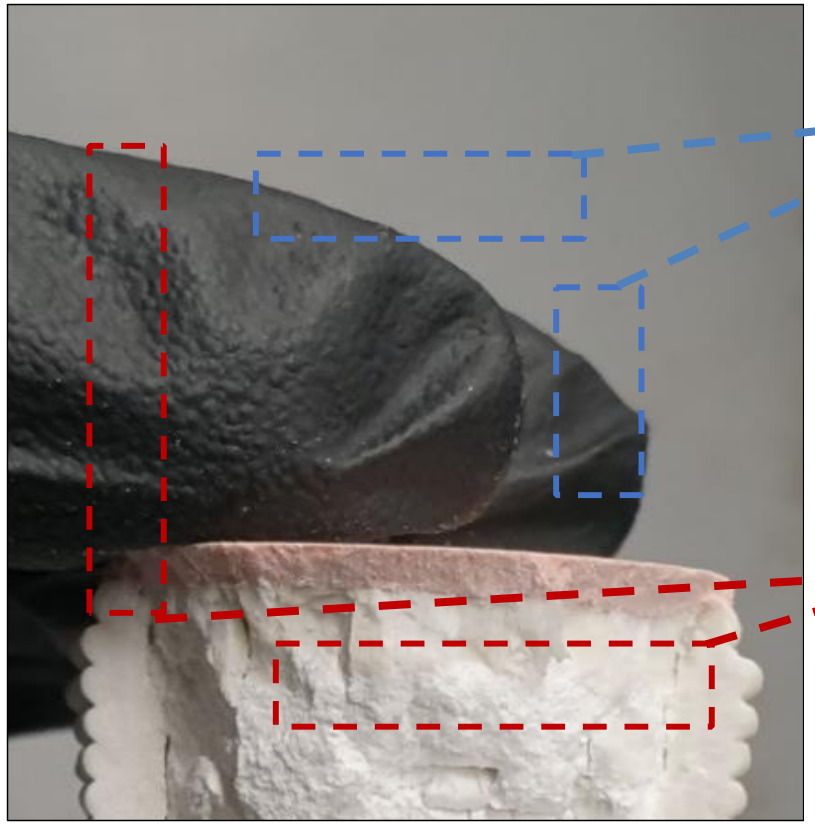
Dr. Jan Olek's Lab

A.Douba, P. Badjatya, S. Kawashima, **Enhancing carbonation and strength of MgO cement through 3D printing**, *Construction and Building Materials*, Volume 328, 2022, 126867,ISSN 0950-0618,

CAREER: (**NSF** 1653419)

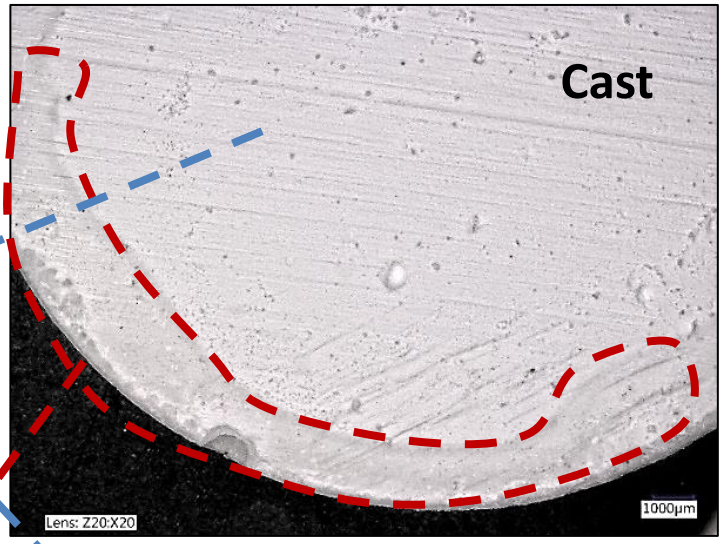
Follow up: adouba@purdue.edu

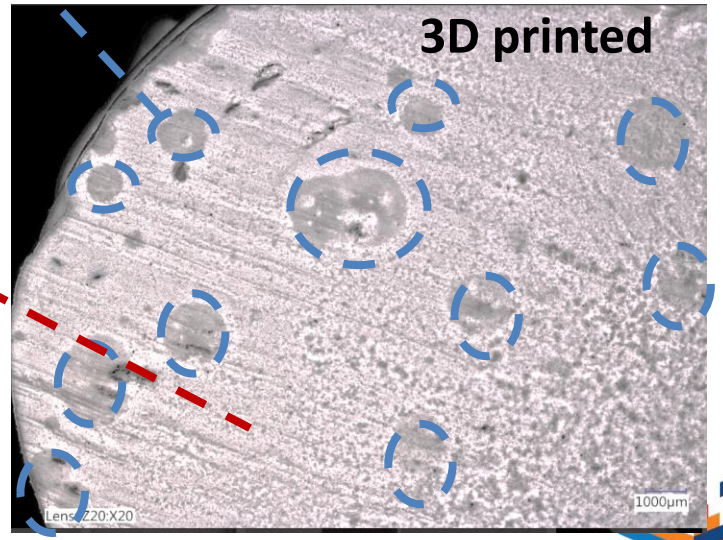
Microstructure



Unhydrated MgO or Brucite

Magnesium carbonates





XRD