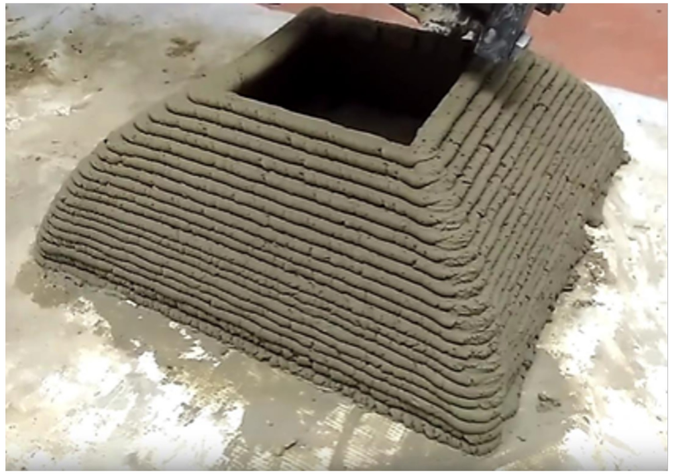
16th GeopolymerCamp

Geopolymer development for 3D printing in Kazakhstan

Timur Mukhametkaliyev

Back in 2021



Back in 2021

GEOPOLYMER
INSTITUTE

2021-Geopolymer development

Fly ash:

- Power plant Karaganda
- Power plant Aksu

GGBS

- Temirtau (Arcelormittal)

Raw kaolin clay:

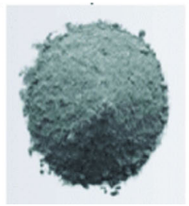
- Kokshetau
- Tomsk

Geopolymer concrete fabrication

2021-Geopolymer development

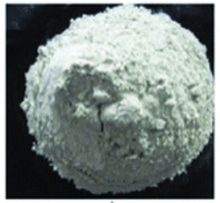
1

Aluminosilicates



Fly ash

Metakaolin



GGBS

or

Raw calcined kaolin clay

2

Sodium silicate

Use some of this materials

Cement

3

Sand

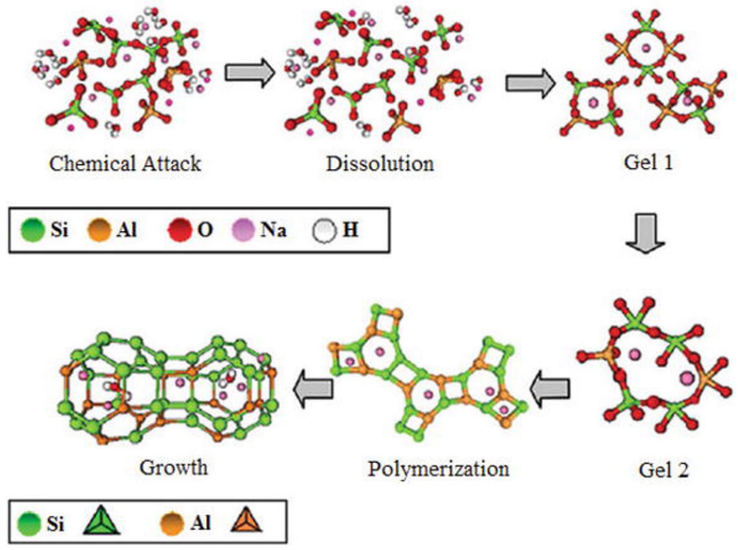
Gravels

Fibers

Mix binder with selected fillers

4

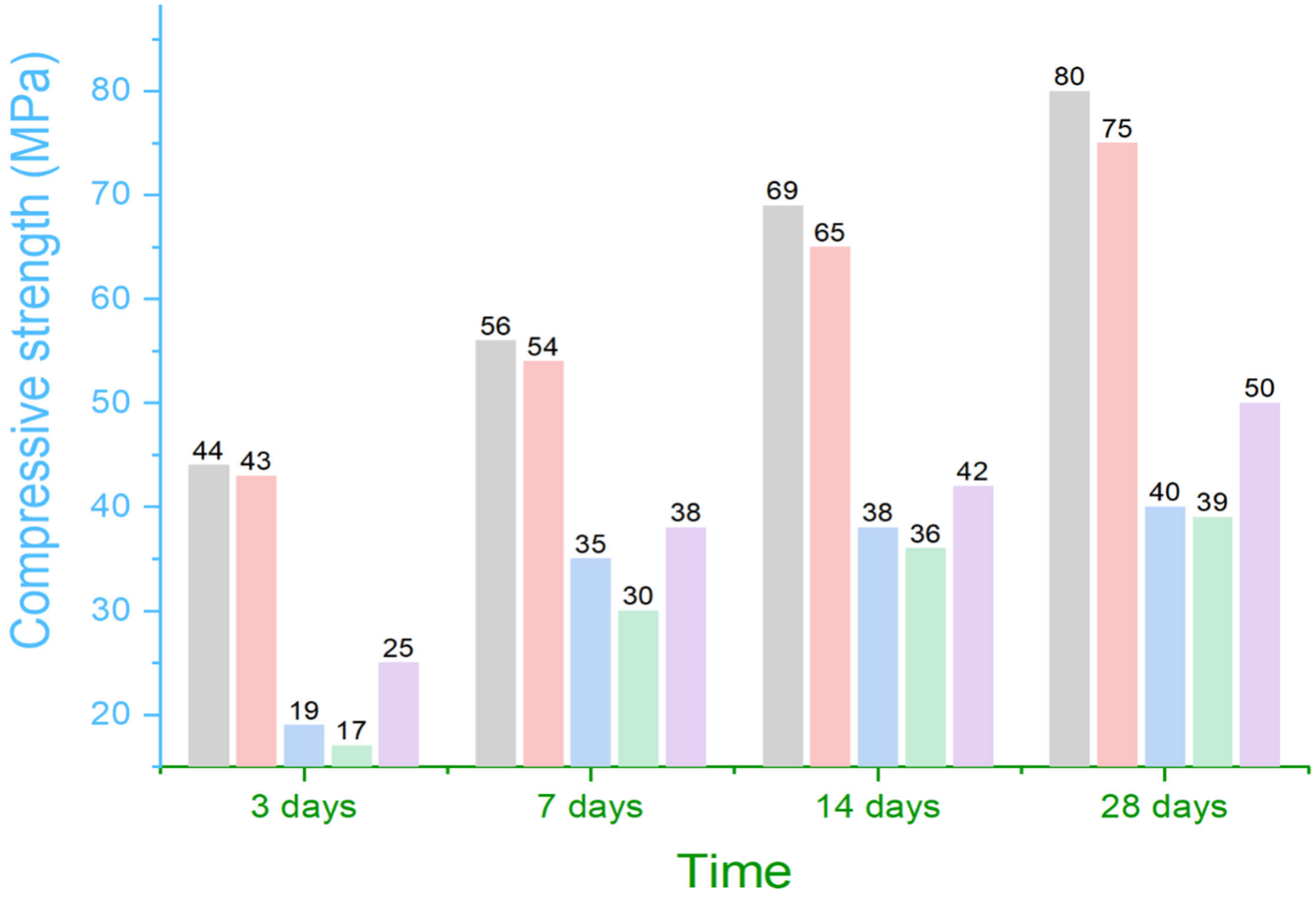
Geopolymerization process



Geopolymer concrete

2022-Geopolymer development

Compressive strength of Geopolymer concrete



Calcined kaolin clay **(1)** (Kokshetau)
Calcined kaolin clay **(2)** (Tomsk)
Fly ash **(1)** (Karaganda)
Fly ash **(2)** (Aksu)
Fly ash **(3)** (Tomsk)

Maximum compressive strength 80 MPa

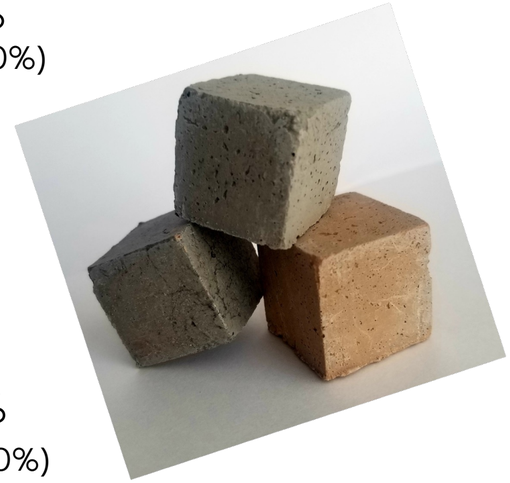
Maximum flexural strength 12 MPa

Calcined kaolin cement mix:

Silica fume - 12%
NaOH - 12%
GGBS - 6%
Calcined kaolin clay - 70%
(Kaolinite amount in clay ~ 30-40%)

Fly ash cement mix:

Silica fume - 9%
NaOH - 9%
GGBS - 5%
Fly ash - 45%
Calcined kaolin clay - 32%
(Kaolinite amount in clay ~ 30-40%)



2022-Geopolymer chemistry

polymers

MDPI

Article

Influence of Mixing Order on Synthesis of Geopolymer Concrete

Timur Mukhametkaliyev[1], Md. Hazrat Ali [1]*, Viktor Kutugin [2], Olesya Savinova [2], and Vladimir Vereschagin [2].

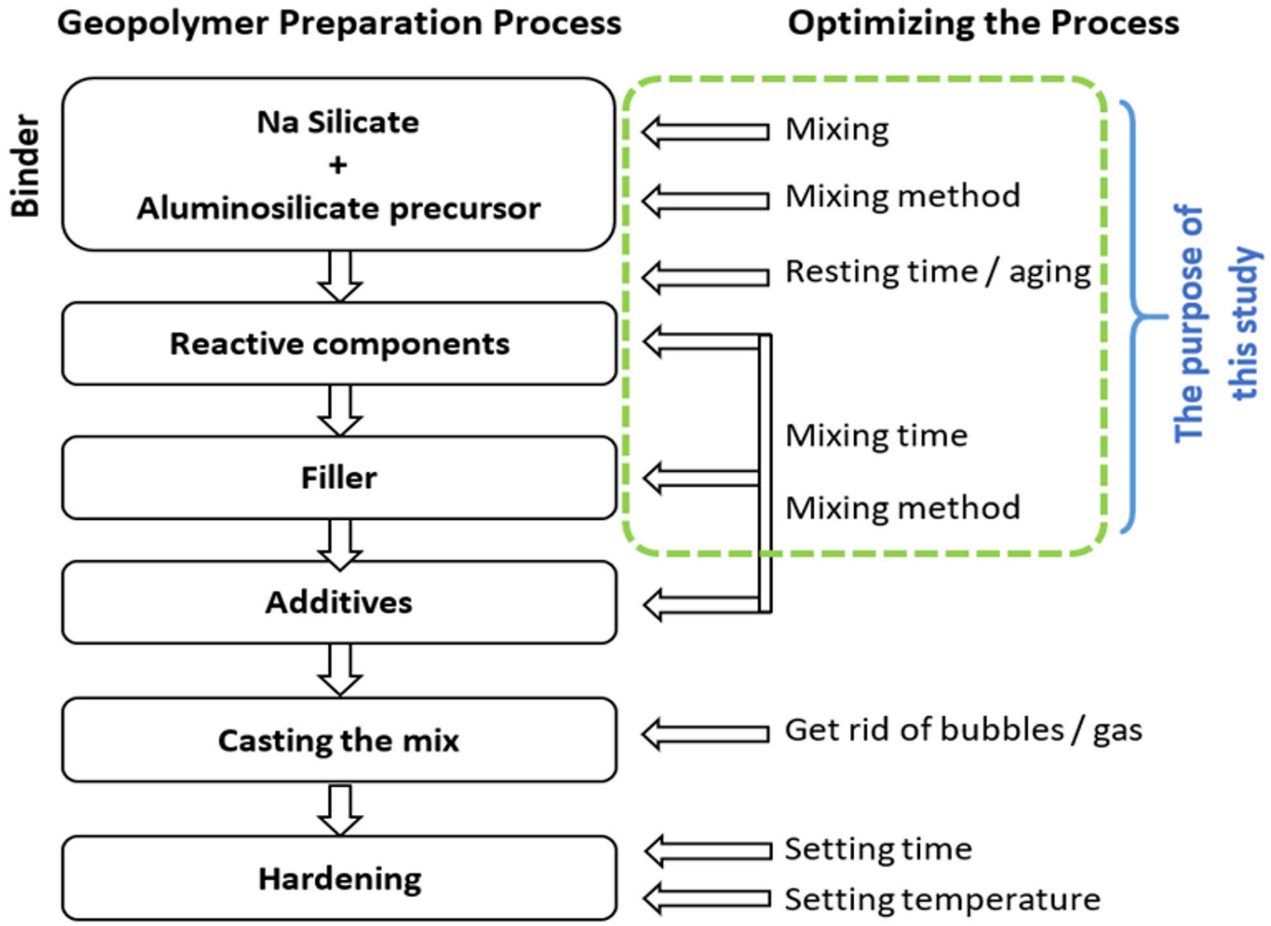
[1] Department of Mechanical and Aerospace Engineering, Nazarbayev University, Nur-Sultan, Kazakhstan; md.ali@nu.edu.kz
[2] National Research Tomsk Polytechnic University, 30 Lenin Ave., Tomsk, Russian Federation
* Correspondence: md.ali@nu.edu.kz;

Abstract: Geopolymers are high-performance, cost-effective materials made from industrial wastes that ideally fit the needs of construction 3D printing technology. The present work investigates methods to mix geopolymer concrete from such industrial materials as fly ash (FA) class F, ground granulated blast furnace slag (GGBS), and raw calcined kaolin clay (RCKC) to determine the mixing procedure which provides the best mechanical strength and structural integrity. The experimental results show that aluminosilicates with different reaction parameters when mixed one after another provide the optimal results while the geopolymer concrete possesses the highest compressive strength and the denser structure. The results demonstrated that the reactivity of GGBS, FA, and RCKC increased for different depolymerization speeds of selected aluminosilicates. This research will provide results on how to improve the mixing order for geopolymer synthesis for 3D printing demands.

Keywords: Geopolymer; Inorganic polymer; Clay; Concrete; Fly Ash; Slag.

Citation: Mukhametkaliyev T., Ali Md. H., Kutugin V., Savinova O.,

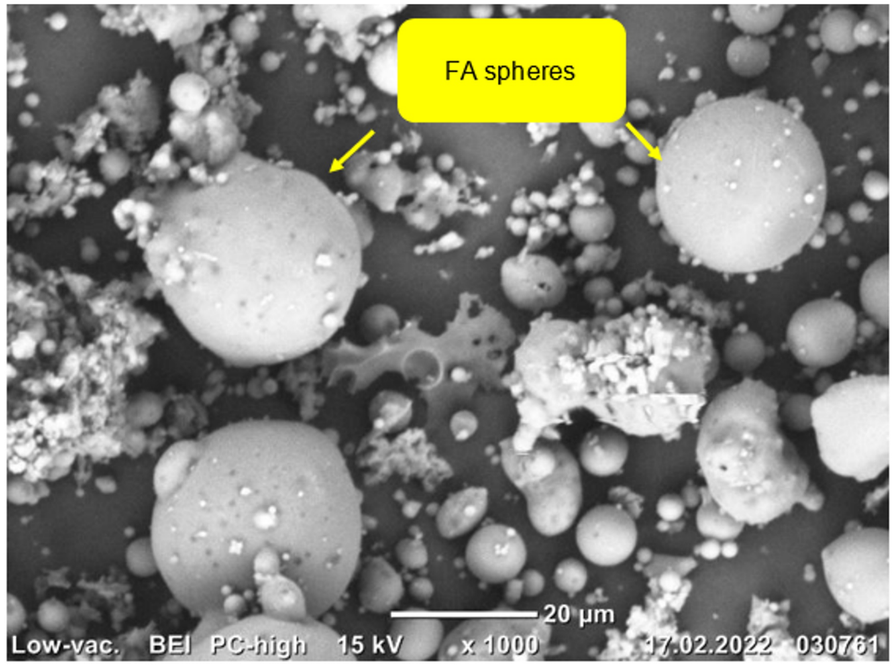
2022-Geopolymer chemistry

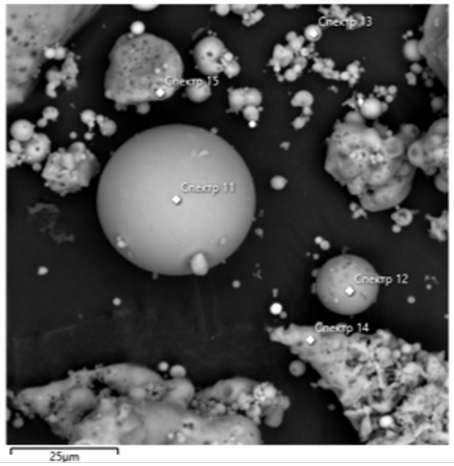


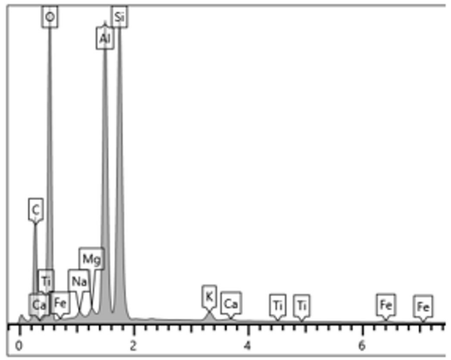
The casting of the specimens was performed as follows:

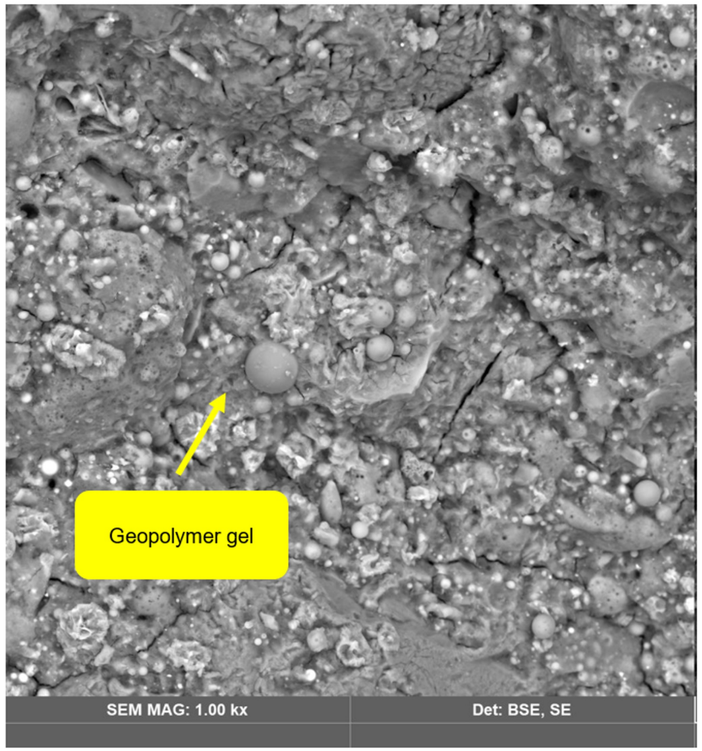
- Mix 1. FA was mixed with an alkaline solution for 10 min, and then followed by the addition of raw calcined kaolin clay (RCKC) that was mixed for 5 min, then GGBS was added which had to be mixed for 3 min, and the last step was to add sand and mix for 3 min;
- Mix 2. All aluminosilicates (FA, RCKC, GGBS) were mixed with the alkaline acti-vator in one step for 18 min and after that, the standard sand was introduced to the mixture which then was mixed for 3 min;
- Mix 3. All aluminosilicates (FA, RCKC, GGBS) and sand were mixed simultane-ously with an alkaline activator for 21 min.

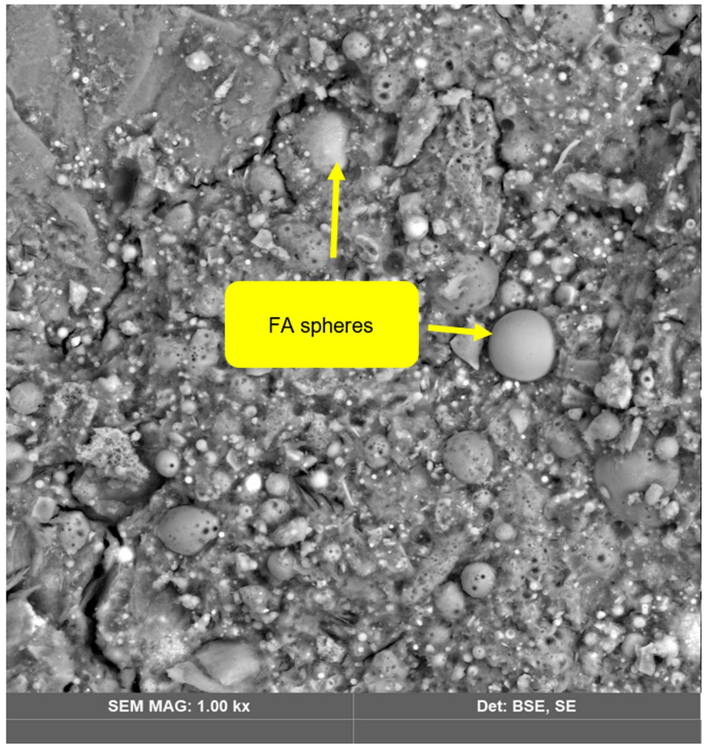
2022-Geopolymer chemistry











2022-Geopolymer chemistry

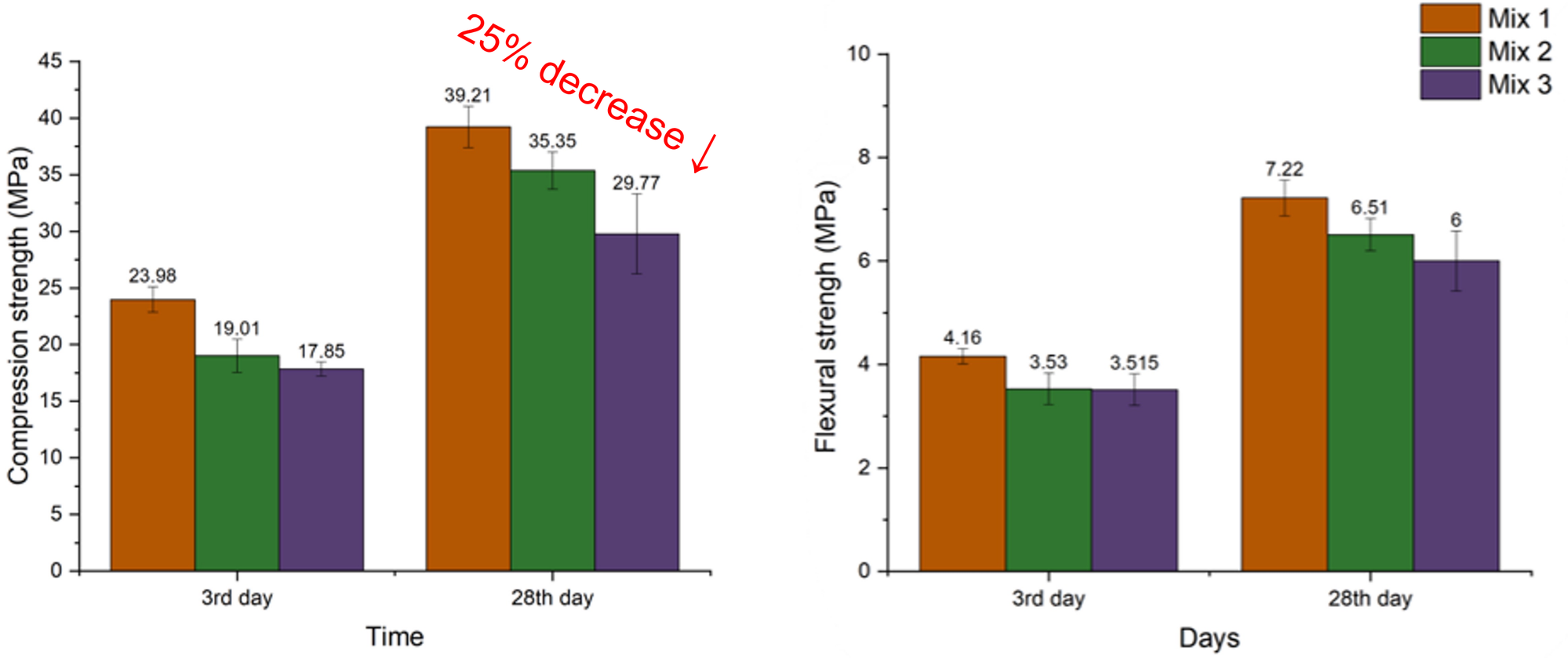
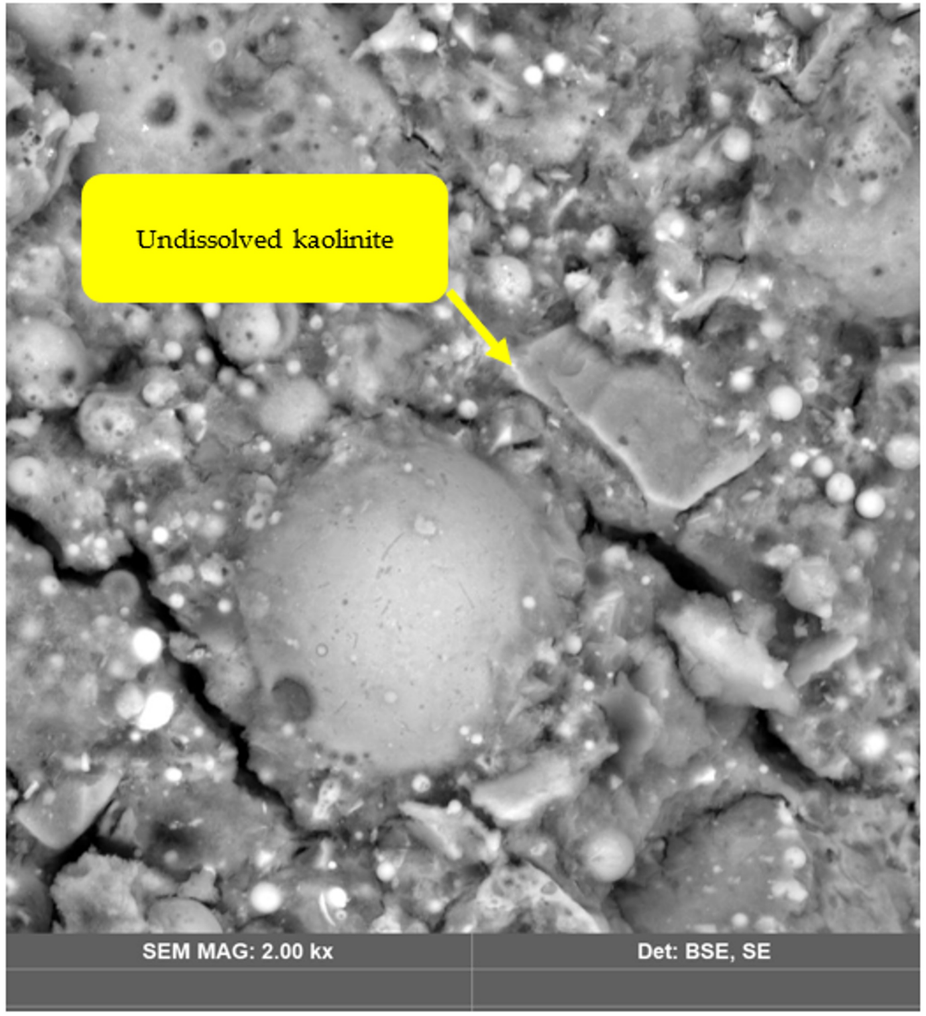
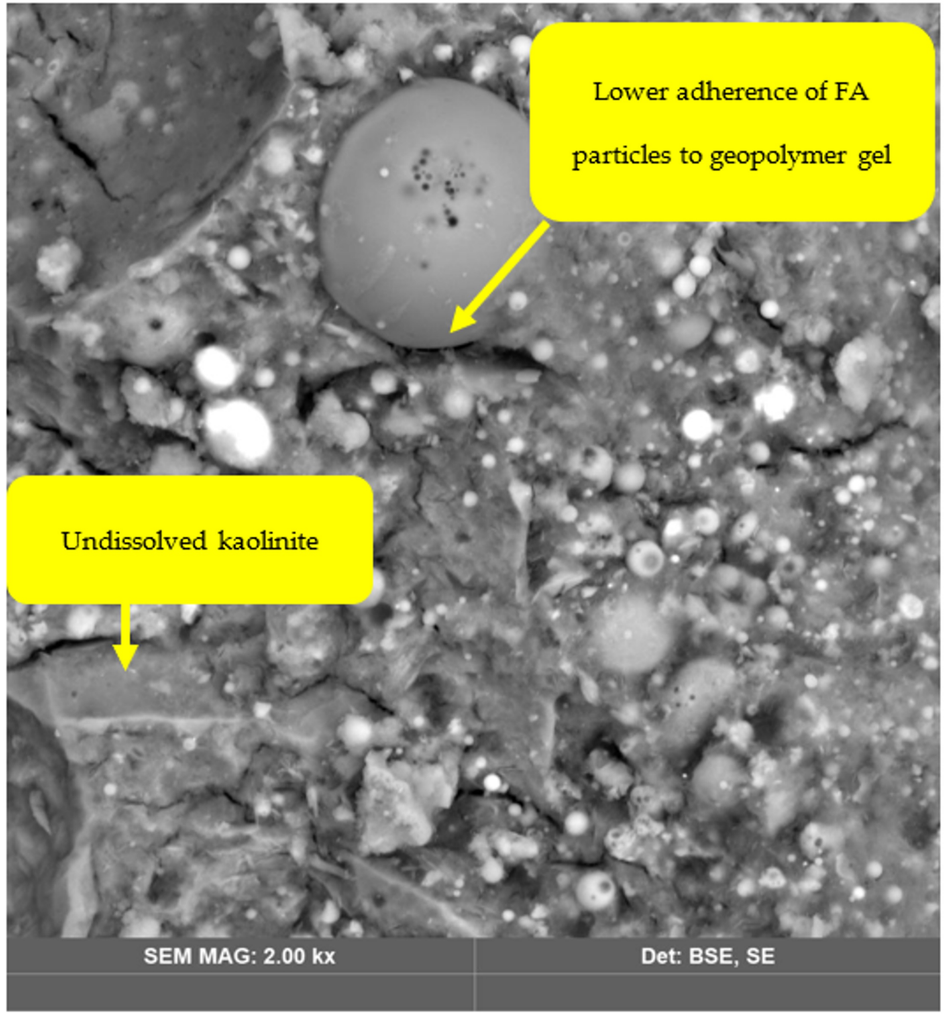


Figure 2. Compression strength and flexural strength. (**a**) Compressive strength; (**b**) Flexural strength.

2022-Geopolymer chemistry





2022-Research grant at NU

Research grant at Nazarbayev University to develop construction 3D printing system for geopolymers

Oven for clay calcination

Autoclave for sodium or potassium silicate

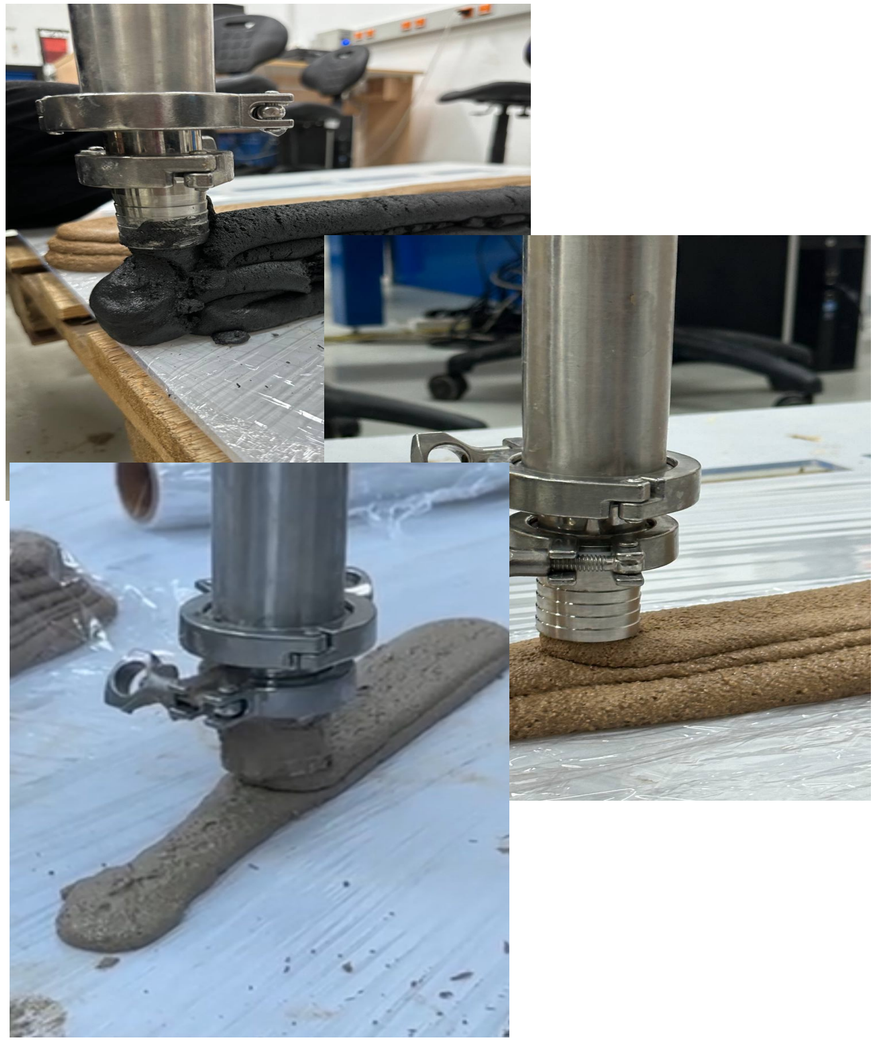
Ball mill

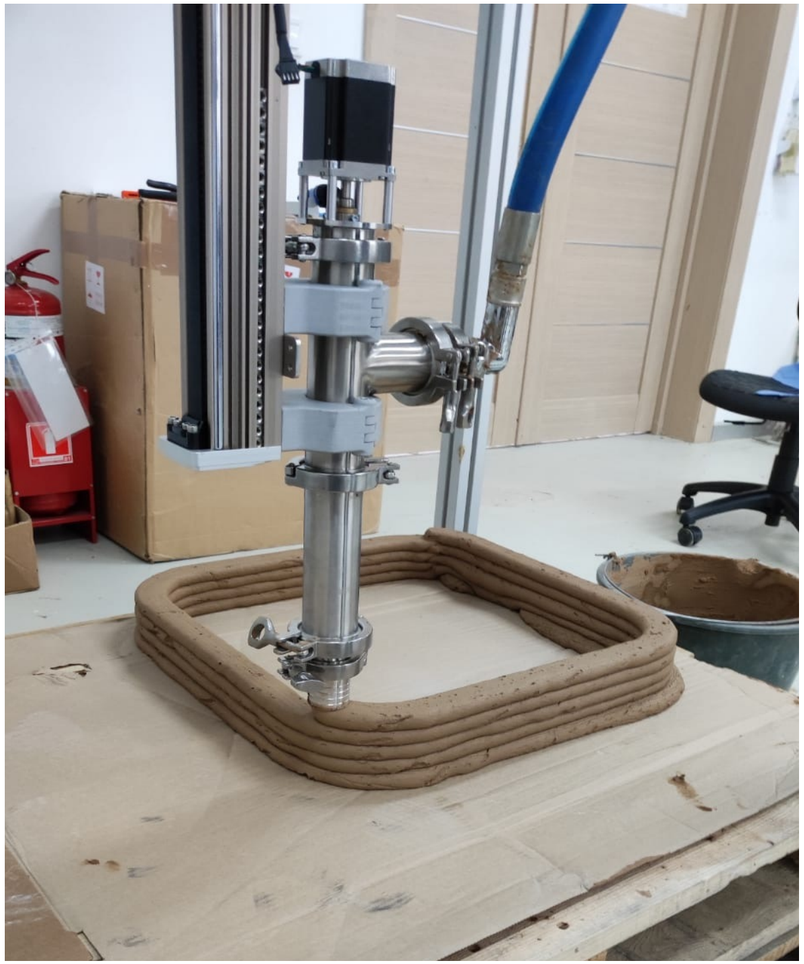
Concrete mixer

Drying machine

Construction 3D printing system

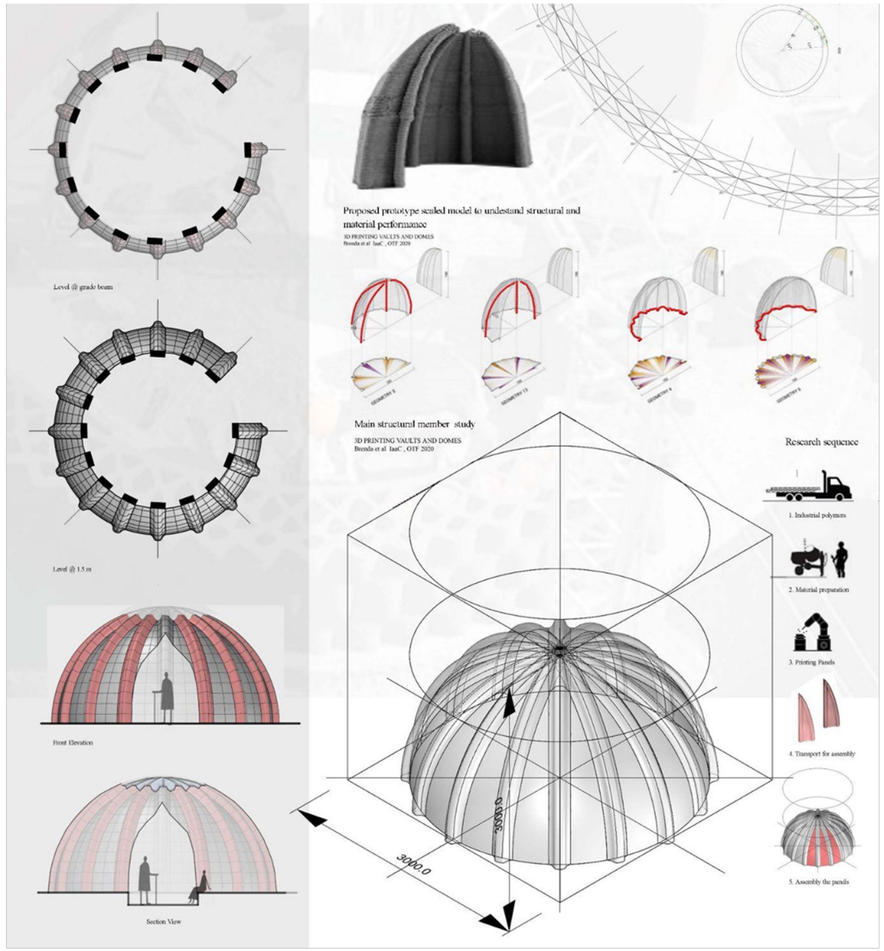
2023-2024 Research grant at NU





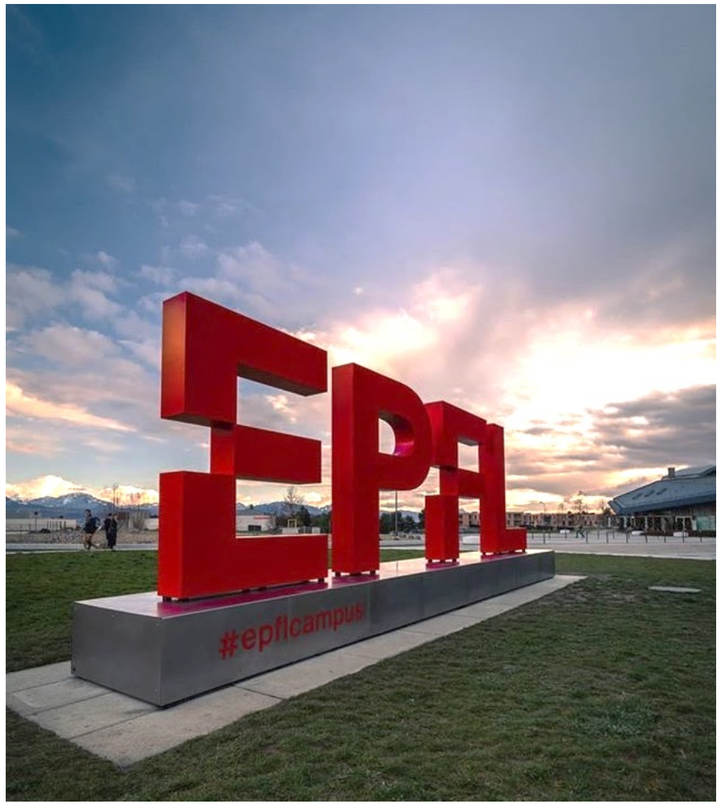
2023-2024 Research grant at NU

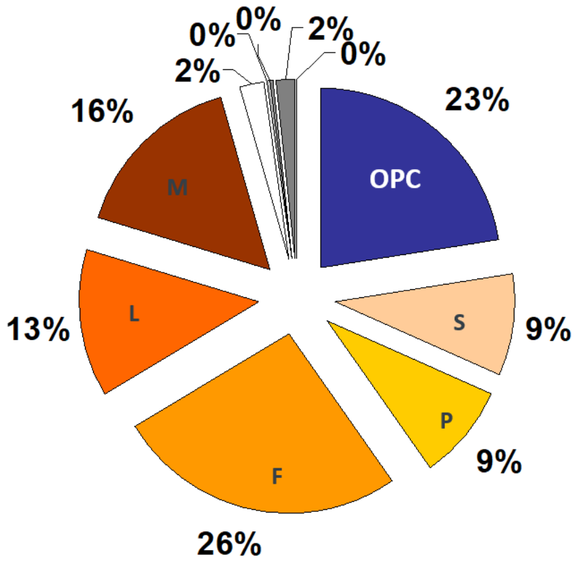
2023-2024 Research grant at NU



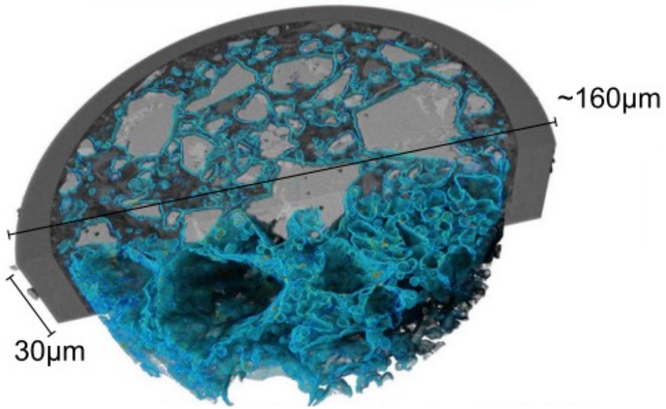
2023-2024. Geneva. Switzerland

2023-2027 PhD in Cement chemistry. EPFL





S Slag Cement
P Pozzolan Cement
F Fly Ash Cement
L Limestone Cement
M Multiple Blend Cement
Masonry Cement



C-S-H

Metakaolin + slag

0% - PC
38% - Calcined clay
52% - potassium silicate
(MR 1.7, user-friendly)
10% - slag

K:Al = 1
Si:Al = 2, 3

Metakaolin

0% - PC
48% - MK or calcined clay
52% - potassium silicate
(MR 1.7, user-friendly)
0% - slag
80°C curing for 24 hours

K:Al = 1
Si:Al = 2, 3

Alkali-activated slag

0% - PC
67% - Slag
33% - potassium silicate
(MR 1.7)

Thank you!

+41 774 226 499

mtmtimur@gmail.com