aimen
CENTRO TECNOLÓGICO

Building a sustainable future

GeoS²·3D

3D printing of landfill waste-based geopolymers
for Smart and Sustainable Construction

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Saint Quentin, France

GEOPOLYMER
INSTITUTE

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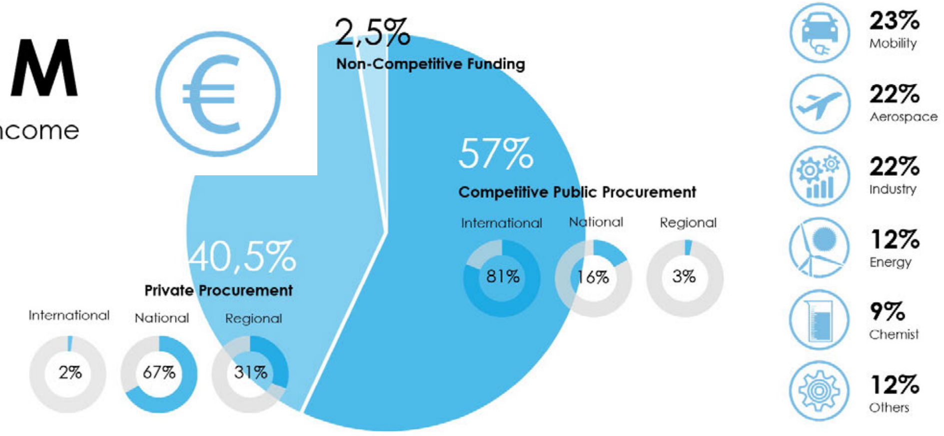
AIMEN Technology Center

Staff: **300** ***(50% in R&D)***

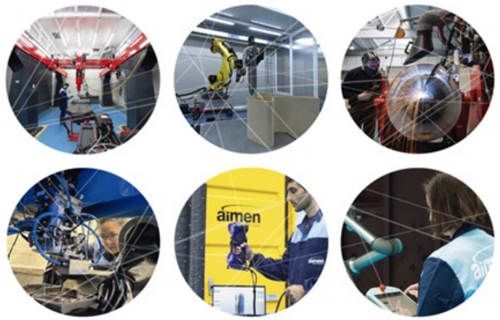
- AIMEN is a 100% private, non-profit, multi-sectoral Technology Center, established in 1967, located in Spain, Galicia.
- We develop R&D&I PROJECTS and Technological Services of high added value..
- Our main capabilities are focused on **Materials Development**, **Advanced Manufacturing, sustainability** and **Process Digitalization**.
- Our facilities are equipped with state-of-the-art scientific and technological equipment.

>21M
Annual Income



2 facilities
In O Porriño

9.500 m²
of scientific-technological infrastructures



Geopolymers at AIMEN

Projects

eGEO

GEOPOLAR

NEWSLAG

GeoCel

PREDIS

LIFE GREEN ADAPT

CIRCOM

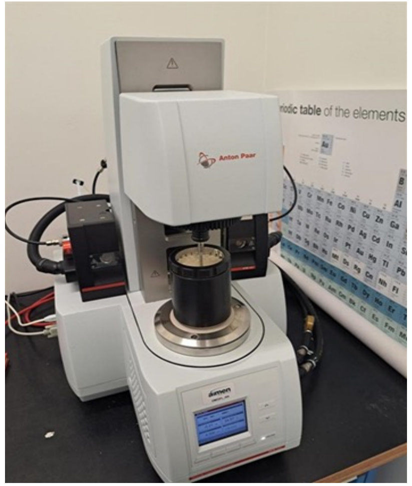
GeoS²·3D
3D printing of landfill waste-based geopolymers for Smart and Sustainable Construction

CIRCULESS

2015 ⟷ 2024

Construction laboratory

3D Printing laboratory



Geopolymers at AIMEN

Building modules

Pavements

Radioactive waste managment

Precast insulating panels

Electrical conductive

Adsorbent geopolymers

GeoS²·3D project

GeoS²·3D
3D printing of landfill waste-based geopolymers for Smart and Sustainable Construction

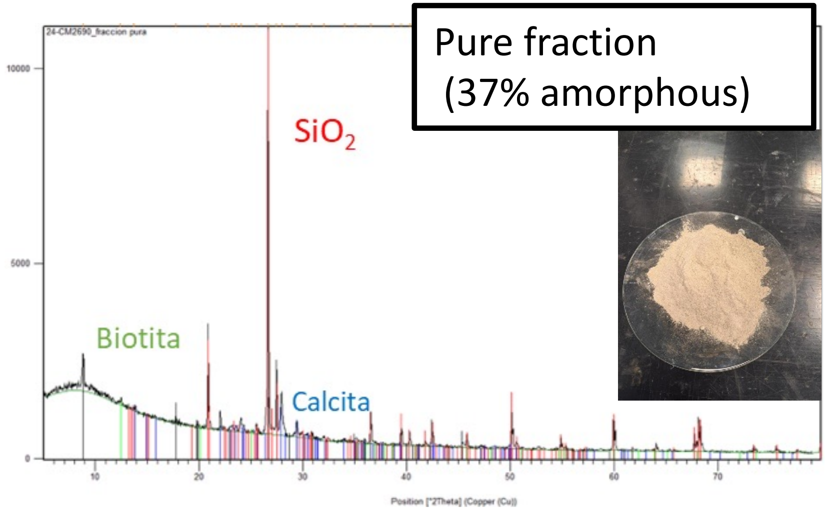
- **Budget**: 900.000 € (next generation)
- **Start date**: 1st January 2024
- **Objective**: Printable CDW-based geopolymers
- **Benefits**:
  - Sustainability (Geopolymers)
  - Modernity (Additive manufacturing)
- **Partners:**
  - RECINOR (waste manager)
  - AIMEN (material developer)
  - BeMore 3D (demonstrators)
  - CyE (technical validation)

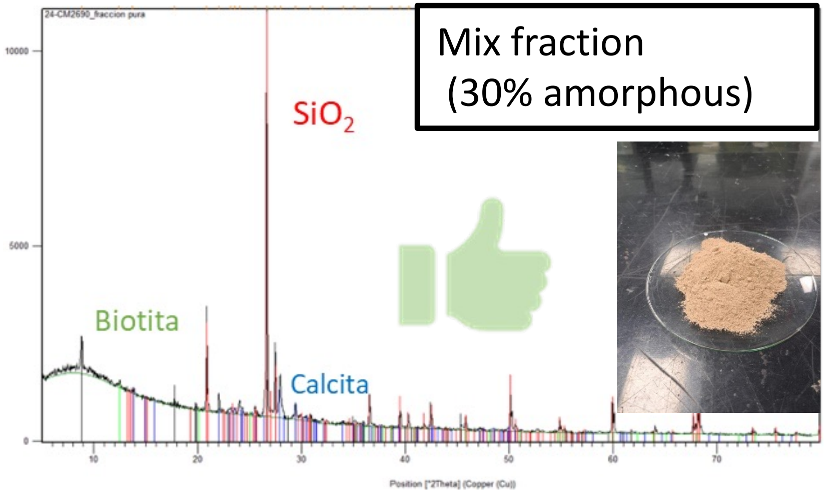
Binder optimization

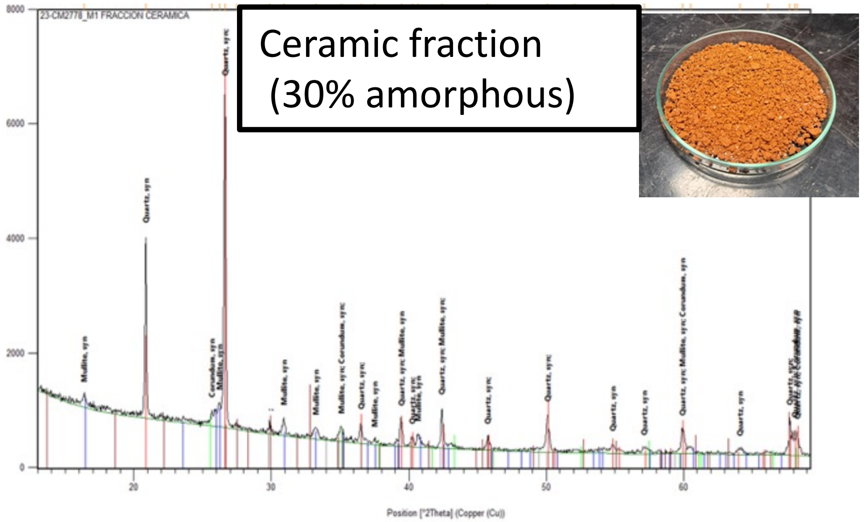
2024

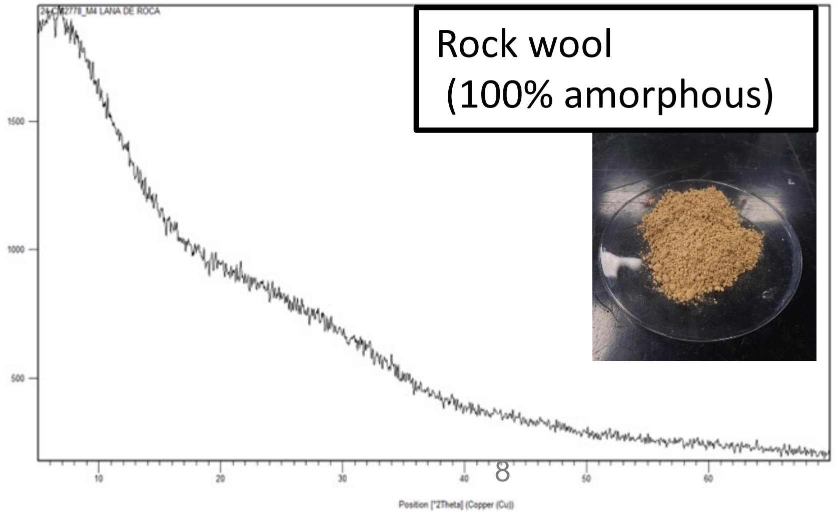
CDW selection

Waste selection → Crushing → Sieving → XRD and XRF Characterization









Initial selection criteria

- Fast setting (50min-2h)
- Open time (20-40min)
- Water integrity
- Mechanical strength (>10MPa)

Mix fraction activation

S/L = 2,5

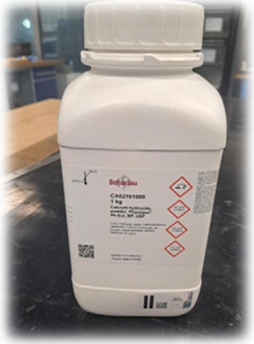
	% $Ca(OH)_2$					
	0	0,5	1	2	4	6
Na-Sil	100% Na-Sil			50-50% Na-Sil:Water		
K-Sil	100% K-Sil			25%-75% K-Sil:Water		

Flash setting

Alkaline reagents

Na and K GEOSIL

$Ca(OH)_2$

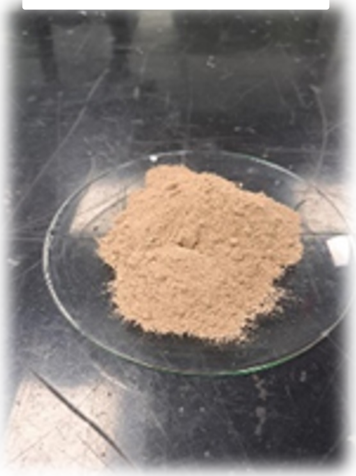


↑ MS
↑ consistency /buildability
↓ Setting time

+

Solid precursor

Mix fraction



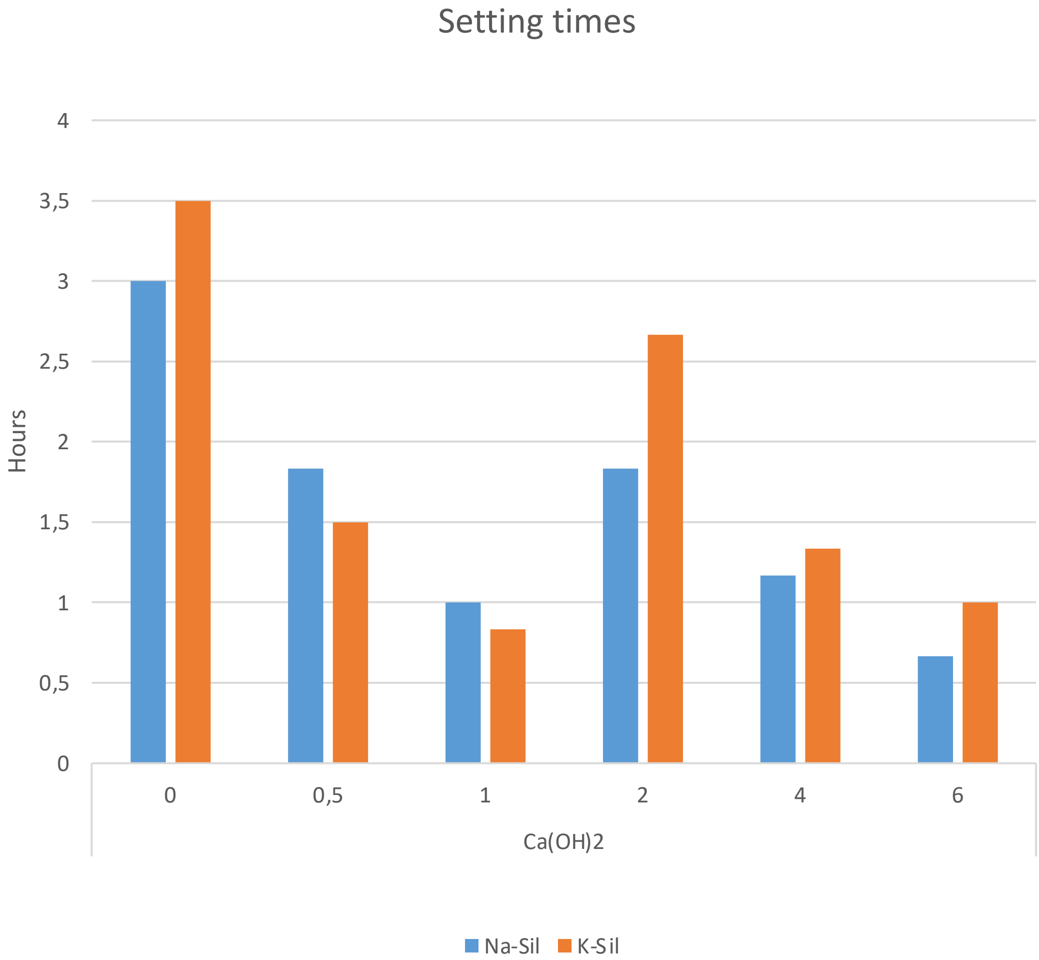
→

Geopolymer

Physical-chemical characterization

Water integrity

Setting time



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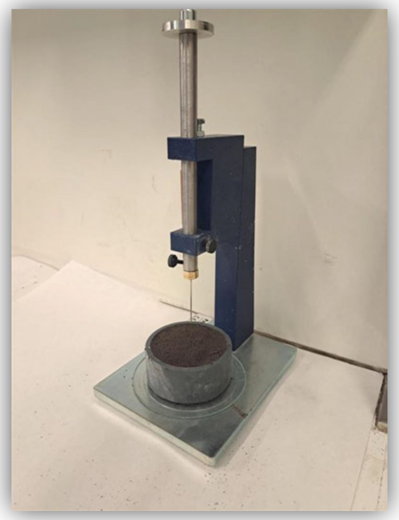
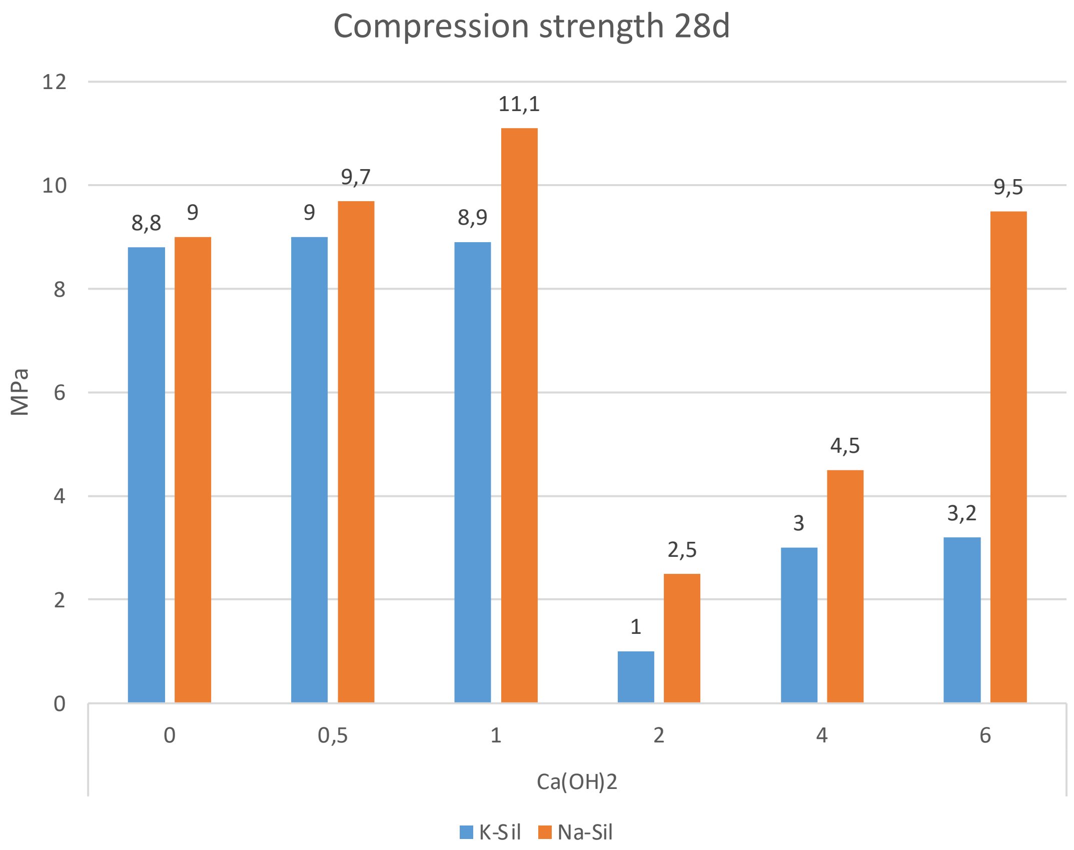
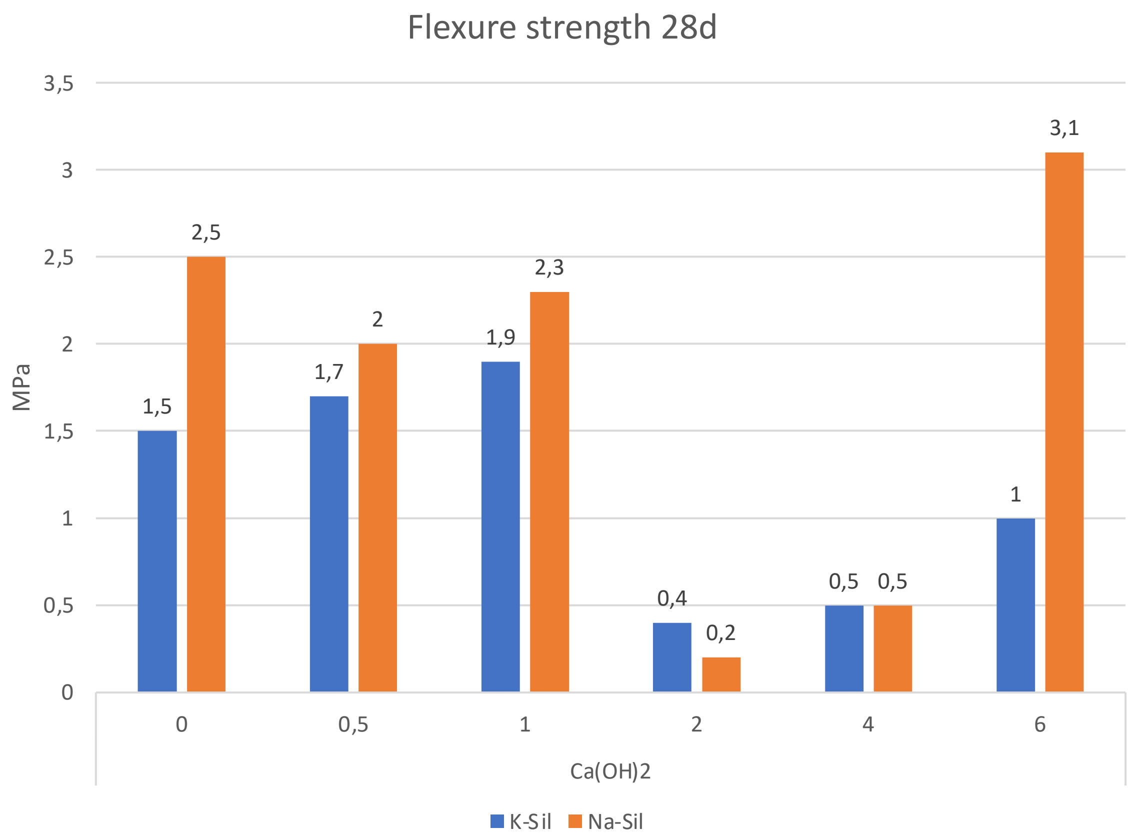


- ❑ Mostly <2h (3D Printing)
- ❑ ↑ Ca ↓ setting time

Mechanical strengths





- ❑ ↑ MS beetwen (0-1% Ca) than (2-6% Ca)
- ❑ Na-Sil > K-Sil
- ❑ ↑Ca ↑ MS

Selected binders:

- Na-Sil (1% Ca)
- Na-Sil (6% Ca)

Advanced Characterization Techniques for 3D printing optimization

Flow table test

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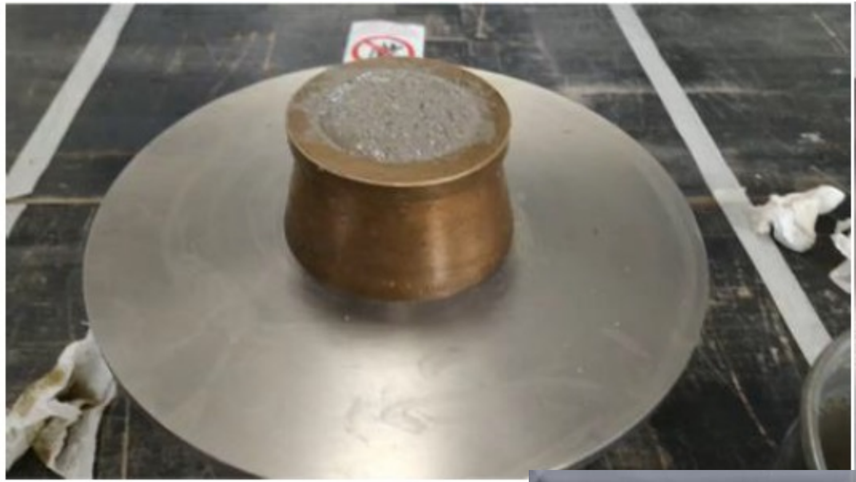
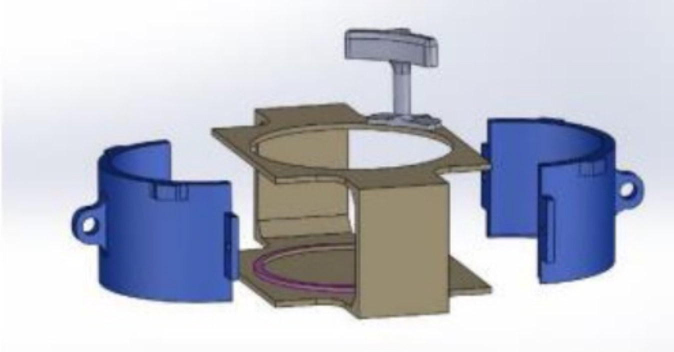


Requirements 3D:
Before shaking (10-11cm)
After 15 shocks (14-16cm)

aimen TECHNOLOGY CENTRE

Shape stability test



Requirements 3D:
1 kg (0-2 cm)
2 kg (2-5 cm)

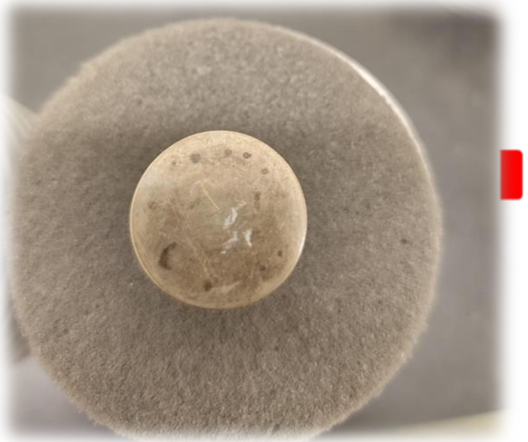
Rheology

Accesories

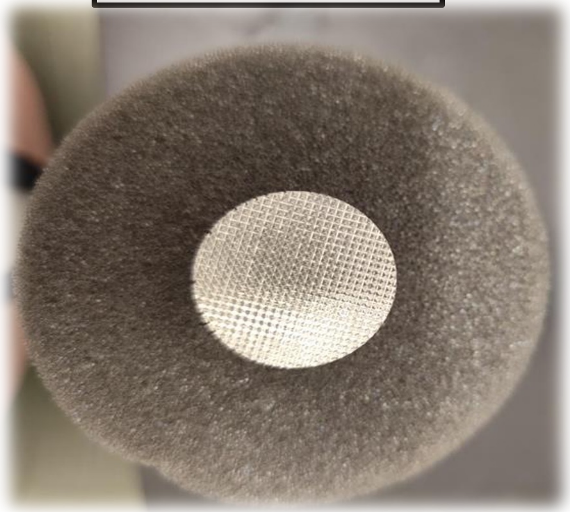
Rotational rheometer MCR 102e

Building Material Cell

Smooth plates



Profiled plates

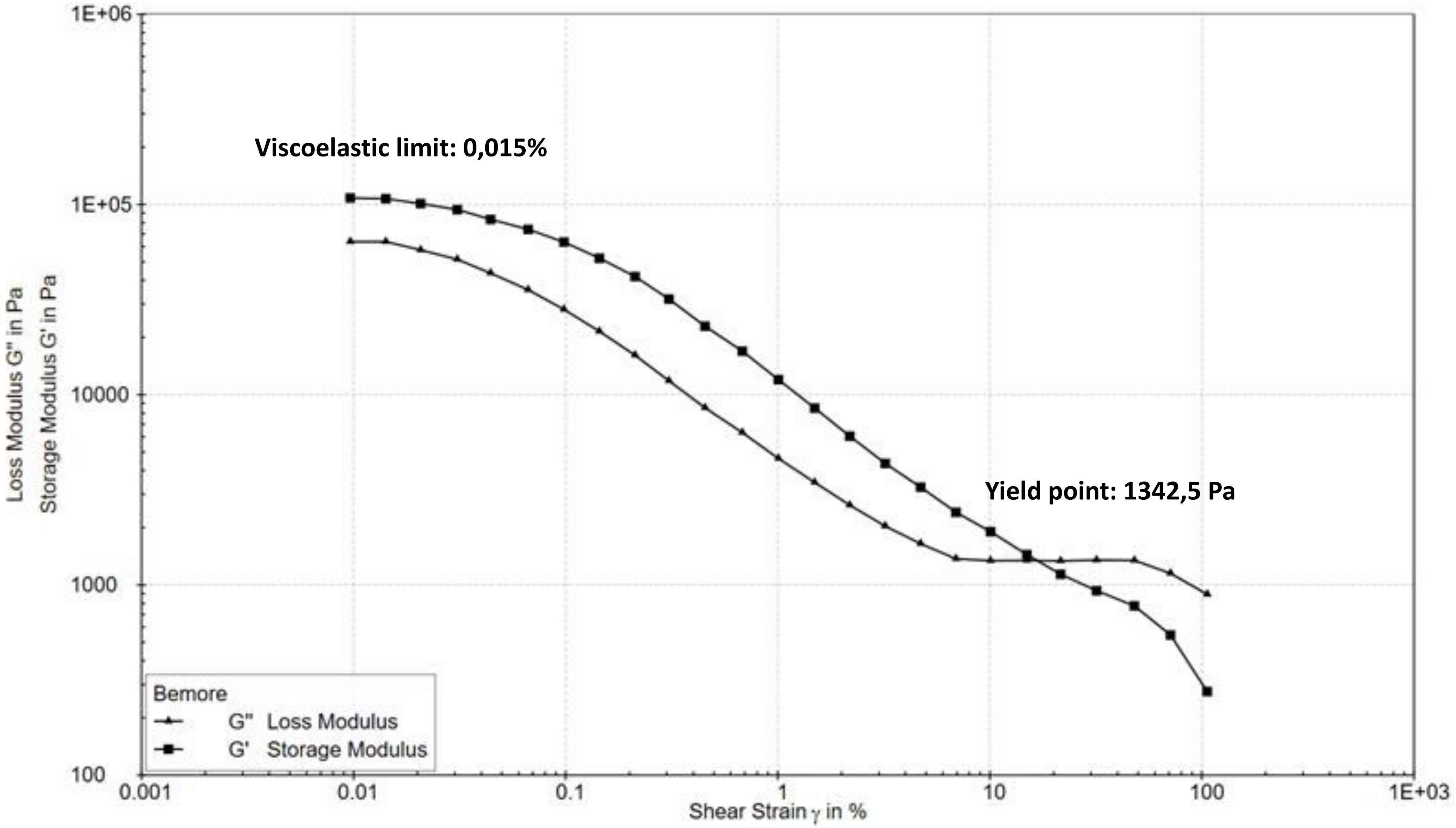


Tests:

- Amplitud sweep
- Thixotropics analysis
- Relaxation modulus

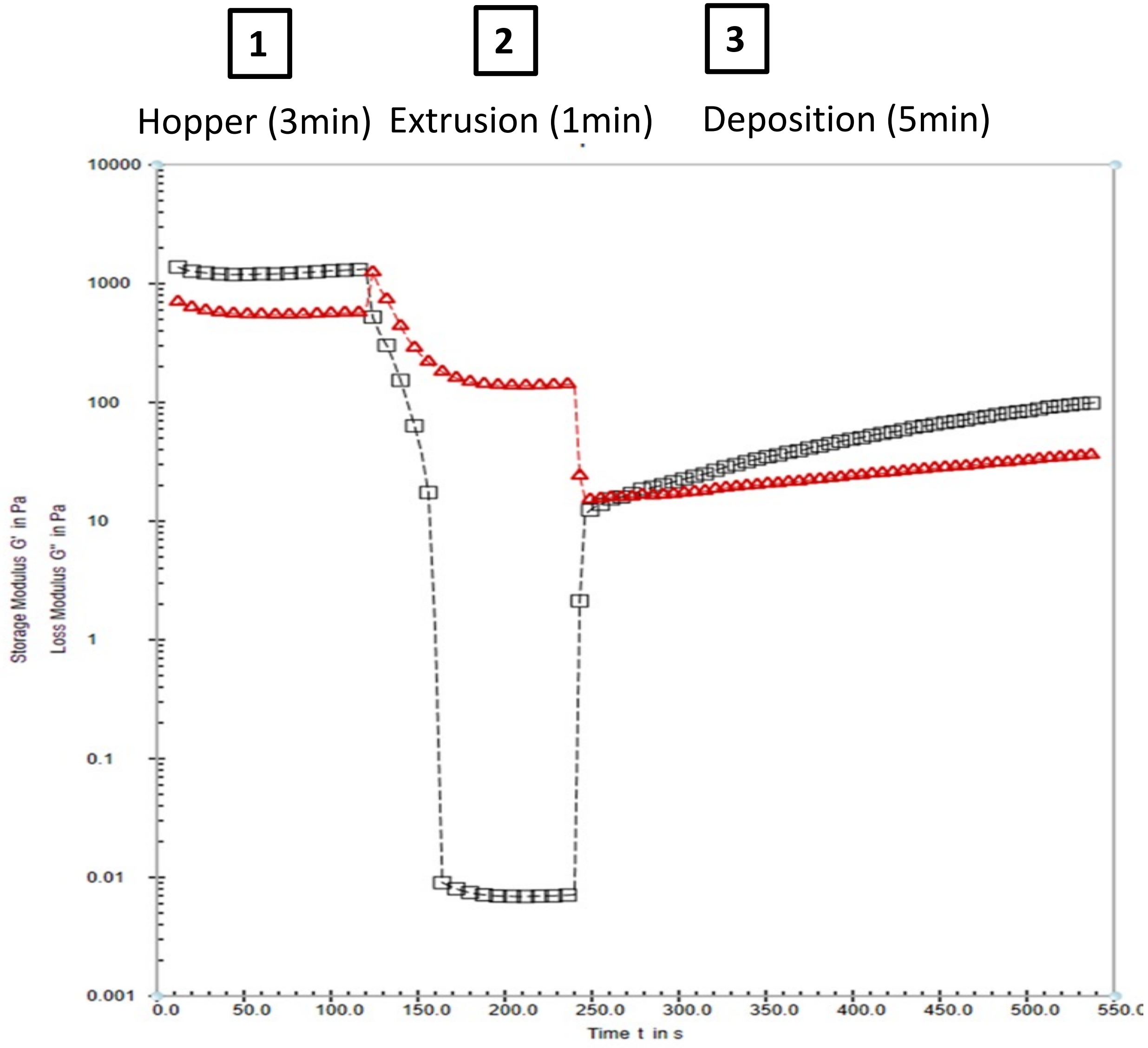
Rheology

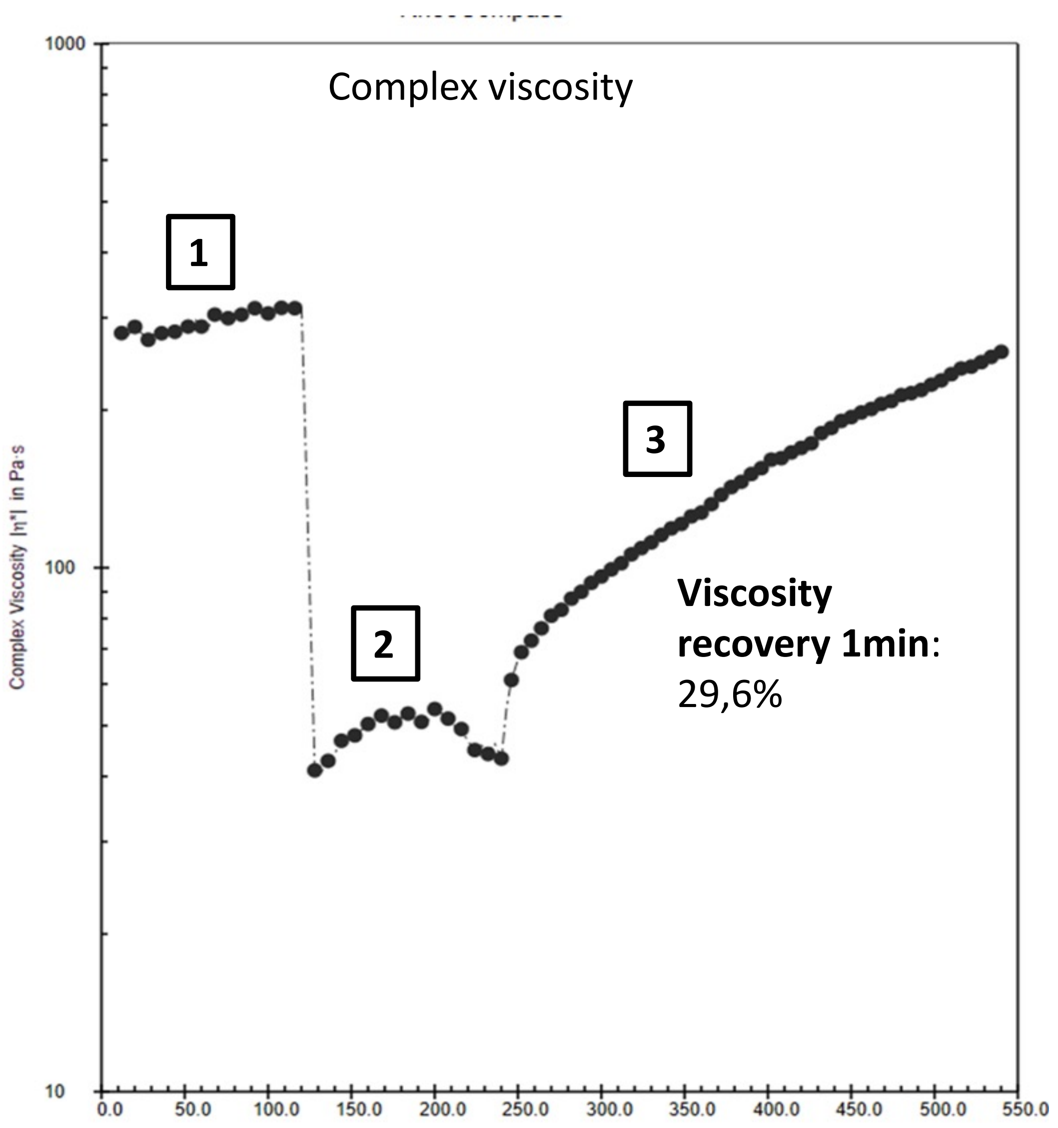
Amplitud sweep test



Rheology

Thixotropic analysis (3-Interval test)





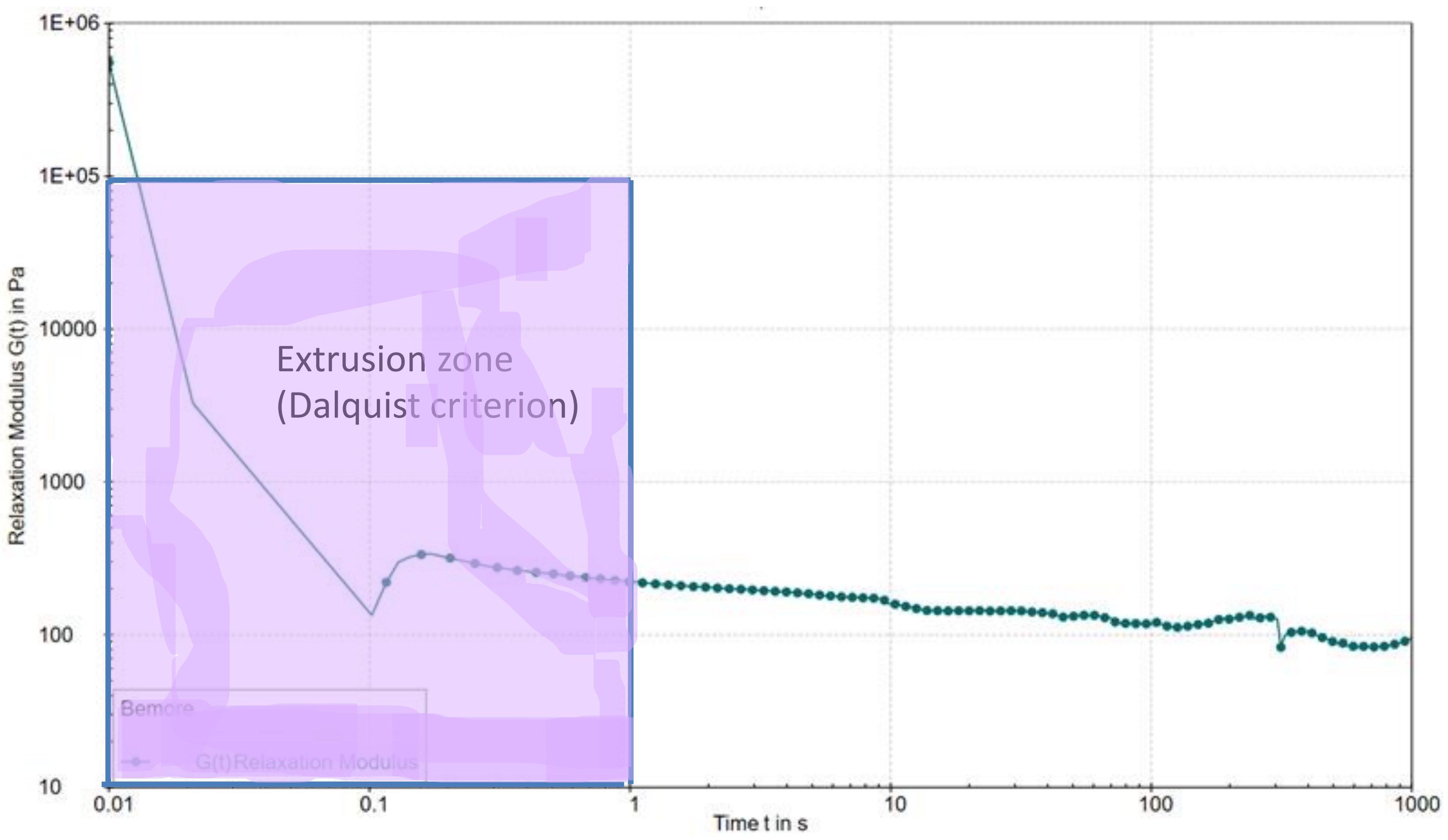
Rheology

Relaxation modulus

- Constant amplitude
- Relaxation modulus

Dahlquist criterion

- 10^5 Pa deformation in 3D Printing
- 1s extrusión time



Conclusions

Overview

- Mix fraction best CDW to make geopolymers
- $Ca(OH)_2$ improves the setting and mechanical strength
- K-Sil showed lower mechanical strength than Na-Sil.
- 1% and 6% of Ca with Na-Sil best binders
- Flow table, shape stability and rheology tests could predict printability

Next steps

- Mix the optimized binders with fibers, aggregates and additives.
- Printability will be optimized with advanced 3D characterization techniqes:
  - Flow table
  - Shape stability
  - Rheometer
- Start with the first lab-scale prints

Thanks for your attention

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