



Building a sustainable future

Assessment and Optimization of European CDW Streams for Geopolymer Mortars



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Saint-Quentin, France



GEOPOLYMER
INSTITUTE



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 Galicia, Spain.

- We develop R&D&I PROJECTS and Technological Services of high added value.

- Our main capabilities are focused on:

- Advanced Manufacturing
- Sustainability
- Process Digitalization
- Materials Development



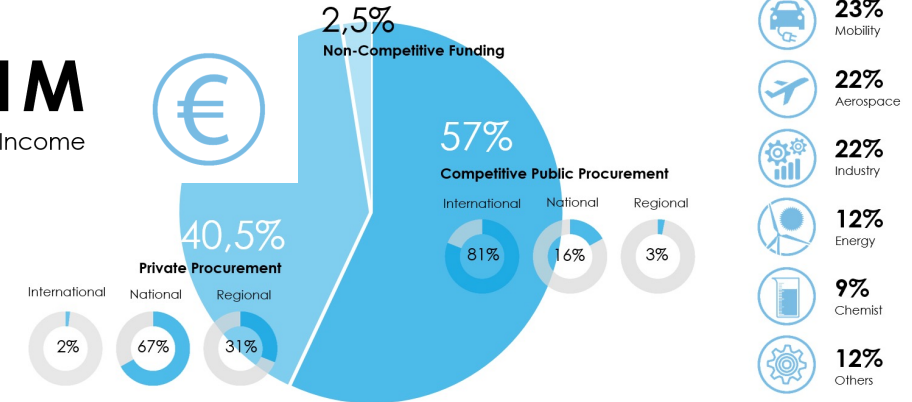
3 facilities

In O Porriño

+10.000 m²

of scientific-technological infrastructures

>21M
Annual Income



Geopolymers at AIMEN

- Projects



2015

2026

Sustainable Construction laboratories



BUILDING SECTOR



Constructive module: 4m x 3m x 3m

Geopolymer Bricks



GeoCel

Facade elements



IRON AND STEEL SECTOR

Foundry molds



CIRCUM

Refractory Geopolymers



ENVIRONMENTAL SECTOR

Adsorbent geopolymers



Radioactive waste management

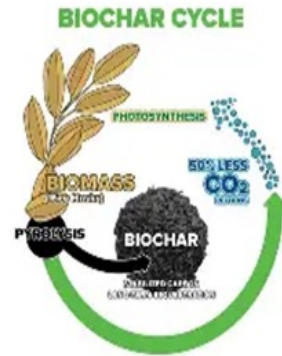


FUNCTIONALITY

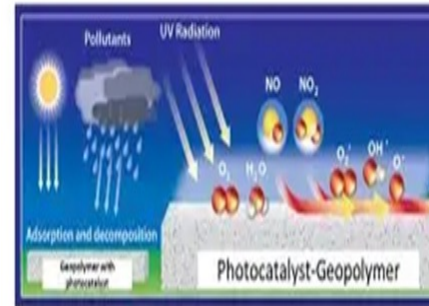
Electric conductivity



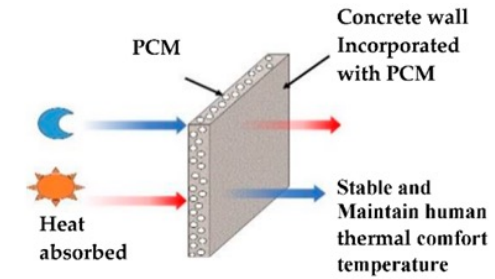
CO2 adsorption



Photocatalysis GP



Thermal confort



BIOGEMSE

3D PRITING



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

CORAL



Digital Platform

- Budget: 12,8 M € (HORIZON)
- Objectives:
 - **Sustainability** (Geopolymers)
 - **Digital solutions**
 - **Advanced logistics**
- Partners:
 - HOLCIM INNOVATION CENTER (waste supplier)
 - AIMEN (material developer)
 - NTUA (aggregate processor)
 - TECNALIA (technology developer)
 - TUE (aggregate processor)



·A preliminary evaluation of the best source will be carried out among the following 6 origins:

- Avenches Mix (CH)
- Avenches Ceramic (CH)
- Dortmund Mix(DE)
- Bürglen Mix (CH)
- Retznei Mix (AT)
- VOLBAS Mix (SP)

·Optimizing a geopolymer formula starting from 2 liquid reagents (Ksil, NaSil) and 3 different solid-liquid ratios (2.5, 2, 1.5). Minitab statistical software.

·Manufacture a final mortar with an aggregate treated by TUE's SMART CRUSHER (pure concrete fraction).



·Each sample is dried for 24 hours and grinded to a particle size of less than 500 µm.

·Once grinded, the samples are characterized by DRX, BET, XRF and laser granulometry.

·After characterization, preliminary tests are performed: setting time, efflorescence and cracking (7 days), integrity in water (after curing for 7 days) and workability.

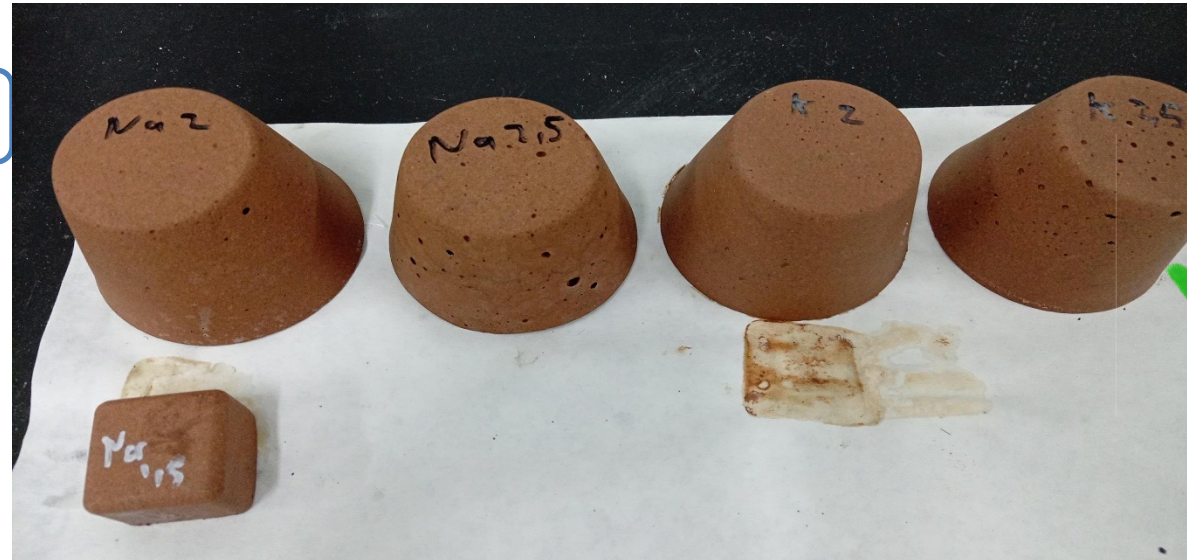
Binder Optimization

-Setting time

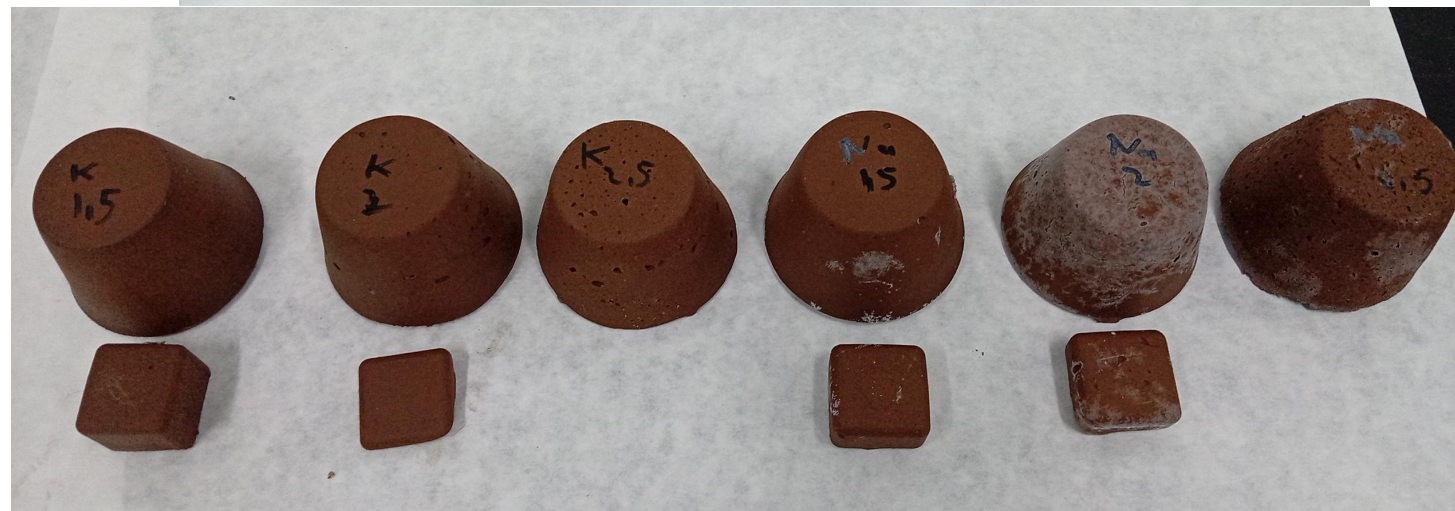
-Workability of fresh paste

-Efflorescence

-Cracks



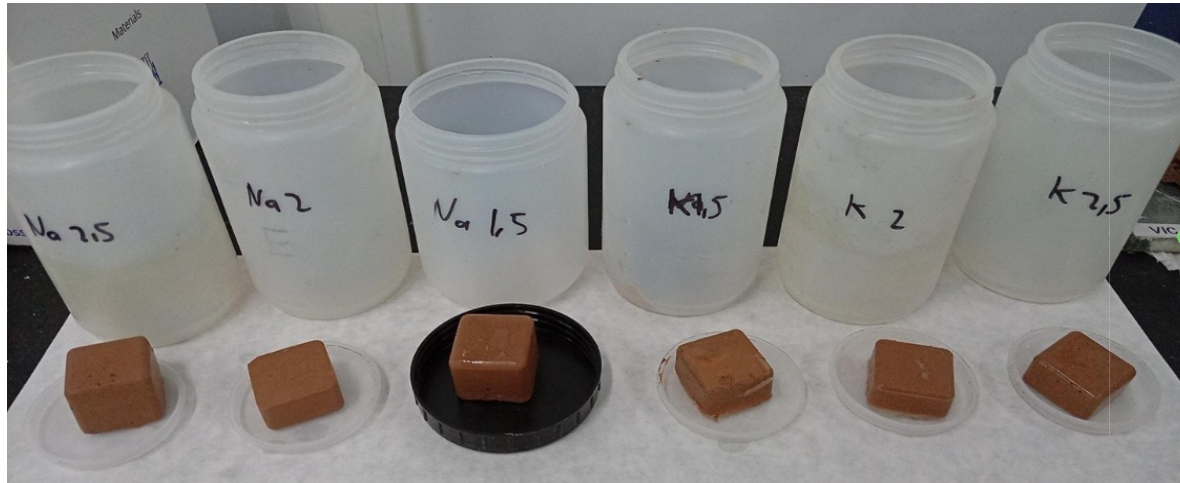
Avenches CH mix



Retznei AT mix

Binder Optimization

-Structural integrity in water (7 days)



Avenches CH mix



*Avenches CH
ceramic*

Design of Experiments Results

Origin	S/L Ratio	Reagent	Workability	Cracks	Setting Time	Efflorescence (7 days)	Structural Integrity in Water (7 days)
Avenches Mixed	2,5	KSil	Low	No	6-24h	Very few	Good
	2		Fluid	No	6-24h	Very few	Good
	1,5		Very fluid	-	No setting (>24h)	-	A little broken on the surface
	2,5	NaSil	Very low	No	6-24h	No	Good
	2		Low	No	6-24h	No	Good
	1,5		Fluid	No	No setting (>24h)	No	Some cracks
Bürglen	2,5	KSil	Low	No	4h	Few	Good
	2		Medium	No	7h 35min	Few	Good
	1,5		Fluid	No	8-24h	Some	A little broken
	2,5	NaSil	Low	Few	5h	No	Good
	2		Low	No	8-24h	No	Good
	1,5		Medium	No	8-24h	No	Good
Retznei	2,5	KSil	Very low	No	3h 30min	No	Broken
	2		Low	No	8h 30min	No	Cracks
	1,5		Fluid	No	8-24h	No	Cracks
	2,5	NaSil	Very low	No	5h	Yes	Good
	2		Low	Some	8-24h	Many	A little broken
	1,5		Medium	Some	8-24h	Yes	Broken

Design of Experiments Results

Origin	S/L Ratio	Reagent	Workability	Cracks	Setting Time	Efflorescence (7 days)	Structural Integrity in Water (7 days)
Dortmund	2,5	KSil	Low	No	8-24h	Some	Ok
	2		Fluid	No	8-24h	Few	Ok
	1,5		Very fluid	-	>48h	-	Very degraded
	2,5	NaSil	Very low	No	8-24h	No	Broken
	2		Low	Some	8-24h	No	Some cracks
	1,5		Fluid	no	>24h	No	Some cracks
Avenches Ceramic	2,5	KSil	Not dissolve	-	-	-	-
	2		Dry	No	>24h	No	Degraded
	1,5		Fluid	No	>24h	No	Degraded
	2,5	NaSil	Not dissolve	-	-	-	-
	2		Dry	No	8-24h	No	Degraded
	1,5		Low	no	8-24h	no	Degraded
VOLBAS	2,6	NaSil	Dry	No	30 min	Few	Degraded
	2,3		Medium	No	1h 20 min	Few	Ok
	2		Medium	No	2h 30 min	Few	Ok
	2,6	KSil	Dry	No	1h	Few	Degraded
	2,3		Fluid	no	20 min	few	ok

Design of Experiments Results (modelled)

Origin	S/L Ratio	Reagent	Workability	Cracks	Setting Time	Efflorescence (7 days)	Structural Integrity in Water (7 days)
Avenches Mixed	2,5	KSil	1	0	4	1	5
	2						
	1,5		4	0	4	1	5
			5	-	6	-	4
	2,5	NaSil	0	0	4	0	5
	2		1	0	4	0	5
	1,5		4	0	6	0	3
Bürglen	2,5	KSil	0	0	3	1	5
	2		3	0	4	1	5
	1,5		4	0	4	2	3
	2,5	NaSil	0	1	3	0	5
	2		1	0	4	0	5
	1,5		3	0	4	0	5
Retznei	2,5	KSil	0	0	2	0	2
	2		1	0	4	0	5
	1,5		5	0	4	0	3
	2,5	NaSil	0	0	2	3	5
	2		0	1	4	4	5
	1,5		3	2	4	3	2

Design of Experiments Results (modelled)

Origin	S/L Ratio	Reagent	Workability	Cracks	Setting Time	Efflorescence (7 days)	Structural Integrity in Water (7 days)
Dortmund	2,5	KSil	0	0	4	2	5
	2		4	0	4	1	5
	1,5		5	-	6	-	1
	2,5	NaSil	0	0	4	0	2
	2		0	1	4	0	4
	1,5		4	0	6	0	4
Avenches Ceramic	2,5	KSil	0	-	-	-	-
	2		0	0	4	0	1
	1,5		4	0	6	0	1
	2,5	NaSil	0	-	-	-	-
	2		0	0	4	0	1
	1,5		1	0	4	0	1
VOLBAS mix	2,5	NaSil	0	0	0	2	2
	2		3	0	1	2	5
	1,5		5	0	2	0	5
	2,5	KSil	0	0	0	2	2
	2		4	0	1	0	5
	1,5		5	0	3	0	5

Minitab Results

-Response optimizer results

Curing conditions: 20°C, 95% RH
(No heating curing!)

Need to improve
mechanical strengths-> MK
temPozz® C90

Origin	Reagent	Optimized S/L ratio	Desirability global	Setting time	Compression strength MPa	Flexural strength MPa
Avenches CH mix	KSil	2	0,89	6-24h	1,22	0,85
Dortmund DE	KSil	2	0,78	6-24h	0,8	0,4
Burg CH	NaSil	1,5	0,84	6-24h	1,75	0,75
Avenches CH ceramic	KSil	2	0,50	>24h	-	-
Retznei AT	KSil	2	0,73	8h 30 min	2,1	0,65
VOLBAS mix	Ksil	1,65	0,68	1 h 20 min	7,87	3,5

Binder Optimization



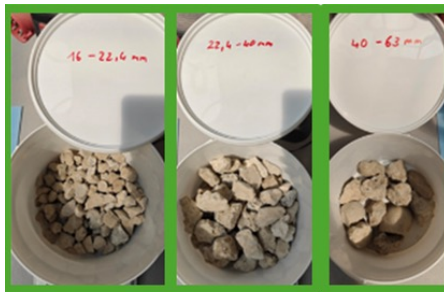
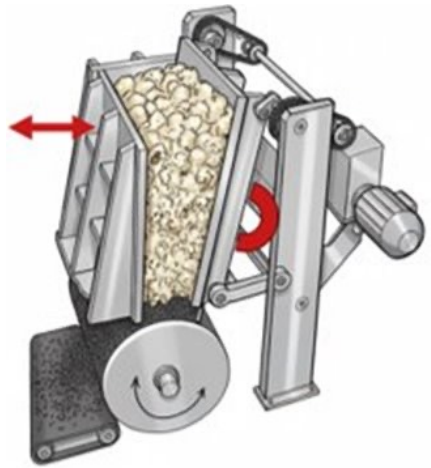
- Metakaolin (MK) anhydrous calcinated clay from Kaolinite. Its addition allows to significantly rise the strengths of geopolymers
- Smallest possible amount of additive, prioritizing a higher content of recycled waste materials.

Origin	Reagent	precursor/ liquid ratio	MK content	Flex strength 7d (Mpa)	Compression strength 7d (Mpa)
Avenches Mix	KSil	2	0%	0,85	1,22
Avenches Mix	KSil	2	5%	2,55	12,75
Avenches Mix	KSil	2	10%	4,5	29,65

- Acceptable mechanical resistances, that would presumably go higher with the addition of aggregate

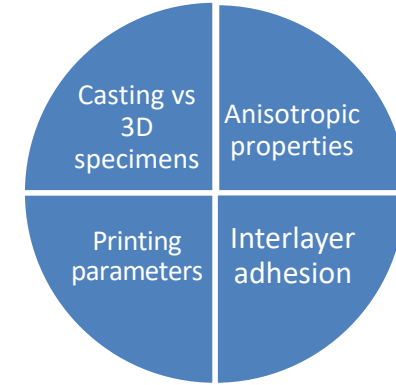
Next Steps

- Aggregate from Tue SMART CRUSHER
- Mechanical tests of mortar (for casting)



Functionalization: 3D printing

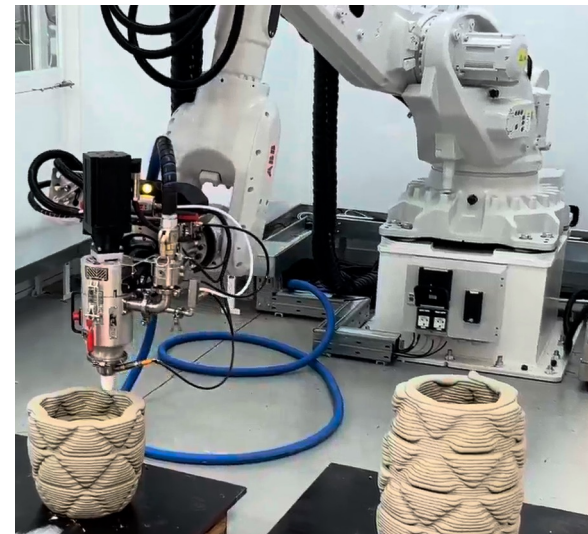
Lab-scale test



DELTA WASP 40100 LDM



Scale-up ?





Thanks for your attention

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