ICPIC 2023
WARSAW 17-20 SEPTEMBER 2023
17TH INTERNATIONAL CONGRESS ON POLYMERS IN CONCRETE 2023
Concrete-Polymer Composite in Circular Economy

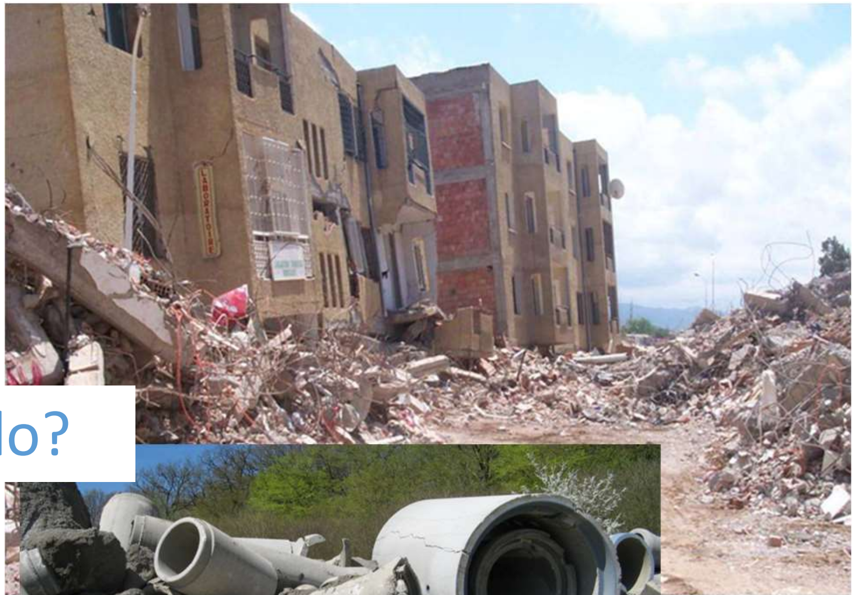
Recycling brick fines for new alcali-activated binders

A. Grellier, D. Bulteel, L. Courard
University of Liège (Belgium), IMT Nord Europe (France)

contact@icpic23.org
www.icpic23.org

Context

What to do?



Context

Flow of brick waste: 1-2% of C&DW in BE/North of France

Valorization

- Reuse of bricks
- Aggregates: landfilling/recycling for backfilling
- Brick fine particles

Objectives

Brick fine particles treatment

- Increase specific surface
- Activate amorphous characteristics

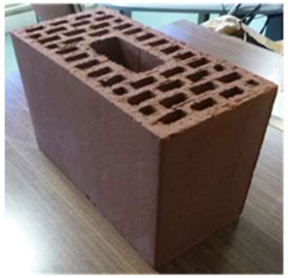
Two ways of valorisation

- Supplementary cementitious material
- Alcali-activated material

Investigations on paste

Objectives

Brick fine particles treatment



Bloc 238x138x138 mm

crushing

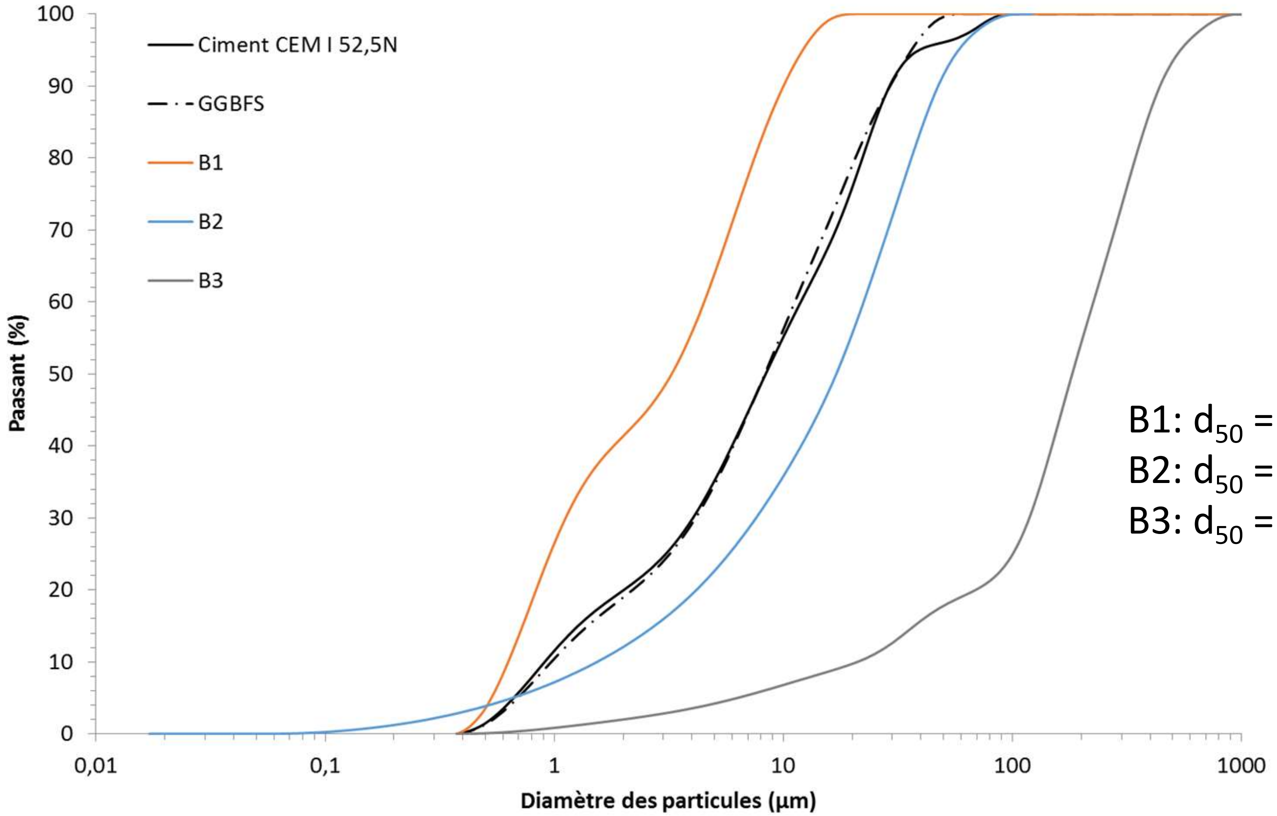
Jaw crusher

grinding

Impact crusher

Preparation

Brick fine particles/GGBFS granulometry



B1: d_{50} = 3.3 µm
B2: d_{50} = 20 µm
B3: d_{50} = 190 µm

Preparation

Brick fine particles

3 types of granulometry

- B1: d_{50} = 3.3 µm (with supplementary cyclogrinding)
- B2: d_{50} = 20 µm
- B3: d_{50} = 190 µm

Ground Granulated Blast Furnace Slag

	Brick fines B2	GGBFS
Specific surface, BET (m^2/kg)	833	1
Water absorption (%)	1.1	-
Granulometry (µm)		
d10	1.95	1
d50	19.1	8.5
d90	56.6	30
$Ca(OH)_2$ quantity fixed (mg/g brick fines)	394	-

ICPIC 2023
WARSAW 17-20 SEPTEMBER 2023

Preparation

Brick fine particles/GGBFS mineralogy

Oxides (%)	CaO	SiO_2	Al_2O_3	Fe_2O_3	K_2O	Na_2O	MgO	TiO_2	Total
Brick fine	1.7	62.8	10.4	16.3	2.1	0.6	2.2	2.4	99.3
GGBFS	42.9	38	10.8	0.5	0.3	-	6.5	0.7	99.5

Mineral (%)	Brick fine
Quartz SiO_2	58.6
Hematite Fe_2O_3	12.8
Albite $NaAlSi_3O_8$	3.9
Microline $KAlSi_3O_8$	6.0
Cristobalite SiO_2	2.8
Amorphicity	15.9

ICPIC 2023
WARSAW
17-20 SEPTEMBER 2023

Preparation

Alcali Activated Material production

Brick fine particles
B2

GGBFS

Alcali-Activating Solution

Soda (NaOH)
Sodium Silicates (Na_2SiO_3)
(SiO_2/Na_2O: 1.45)

Substitution
10, 20, 30 and 50 %

Characterization at
7 and 90 days

Preparation

Two hypothesis

- **BL : brick fines = mineral addition**
  - Concentration of the alcali-activating solution calculated versus GGBFS mass

- **BLM** : **brick fines = precursor like GGBFS**
  - Concentration of the alcali-activating solution calculated versus GGBFS+brick fines mass

Preparation

Two hypothesis

Control 100% GGBFS	GGBFS

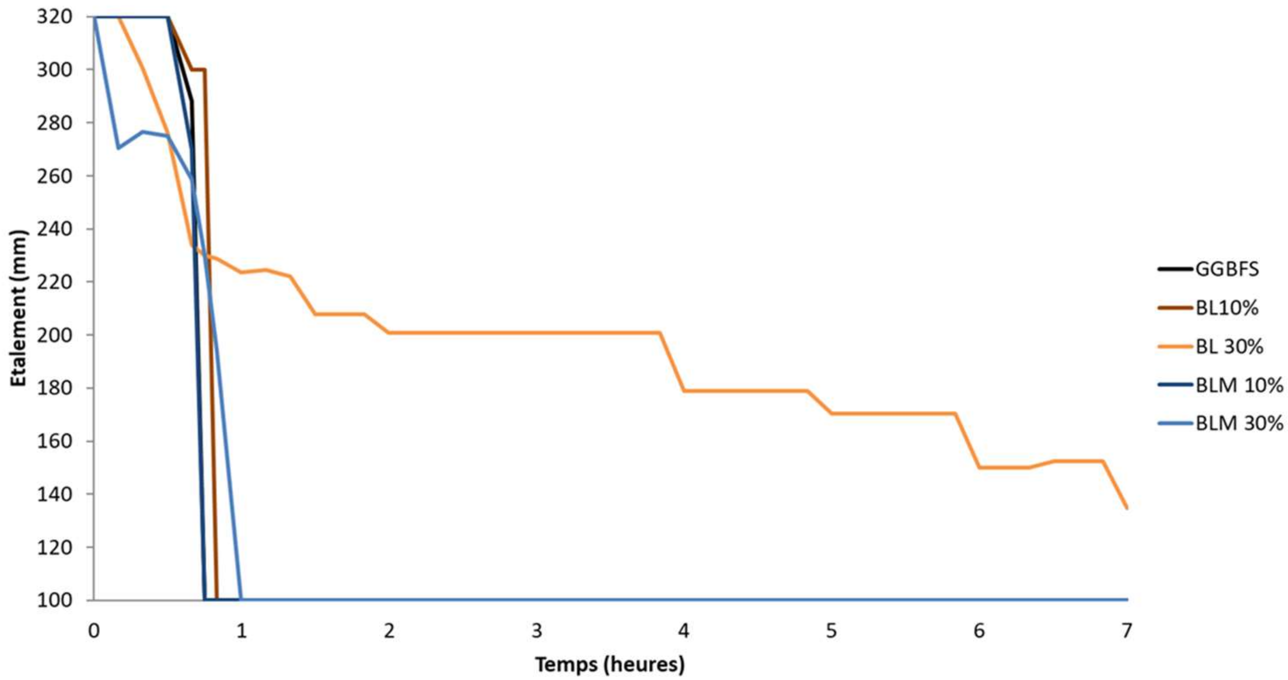
BL	**BLM**
Concentration ↘	Constant Concentration
BL 10%	BML 10%
BL 20%	BML 20%
BL 30%	BML 30%
BL 50%	BML 50%

Results

Evolution of spread with time

Short time of maniability with AAM

Slowing down of “stiffening” with continuous mixing on BL 30% mix



ICPIC 2023
WARSAW 17-20 SEPTEMBER 2023

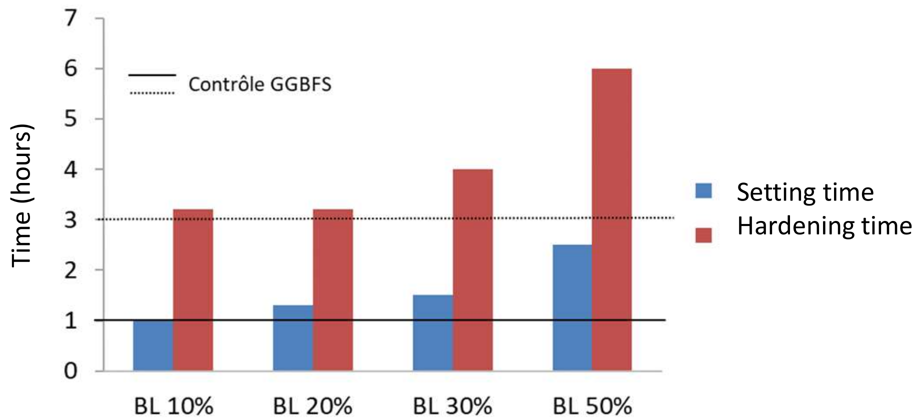
Results

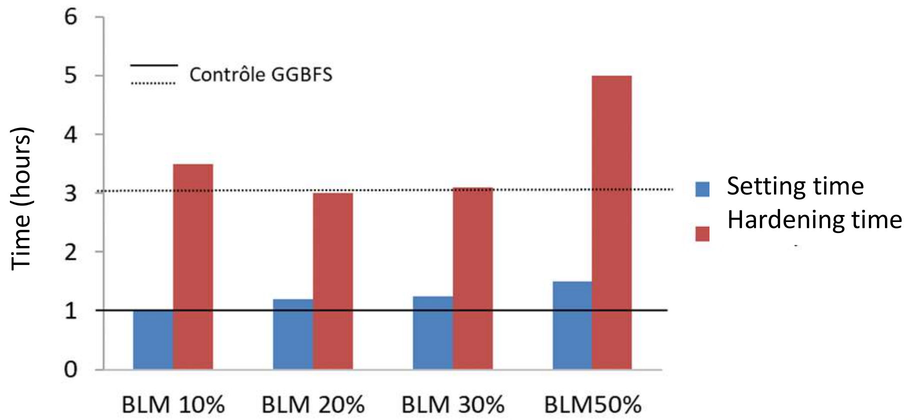
Evolution of setting time

Setting time usually lower with AAM

BL: hardening time ↗ from 30 % substitution

BLM: hardening time ↗ from 50 % substitution





Results

Development of hydrates (TGA) – loss of mass

Impact on phase precipitation from 50% substitution

BL more impacted than BLM

Samples	C-A-S-H (%)		Hydrotalcite (%)		Total mass loss (%)	
	7 days	90 days	7 days	90 days	7 days	90 days
GGBFS	**4,9**	**6,4**	**3,9**	**4,2**	**8,7**	**10,6**
BL 10%	4,4	5,7	3,7	3,5	8,1	9,1
BLM 10%	4,7	6,1	3,4	4,6	8	10,6
BL 50%	2,8	3,5	4,5	2,8	7,3	6,3
BLM 50%	4,1	4,4	3,5	3,1	7,6	7,6

Results

Development of hydrates (TGA) – loss of mass

BLM: brick fines react with AA solution → compensation of GGBFS

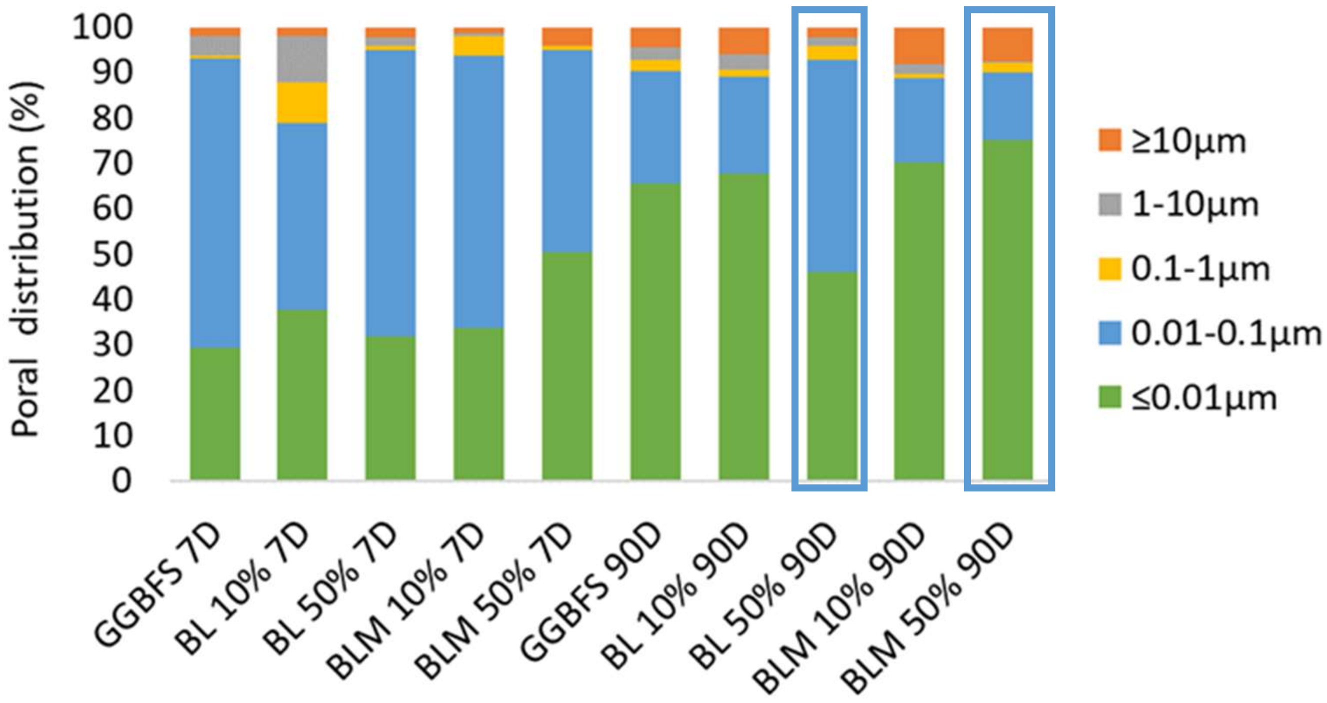
Samples	C-A-S-H (%)		Hydrotalcite (%)		Total mass loss (%)	
	7 days	90 days	7 days	90 days	7 days	90 days
GGBFS	**4,9**	**6,4**	**3,9**	**4,2**	**8,7**	**10,6**
BL 10%	4,4	5,7	3,7	3,5	8,1	9,1
BLM 10%	4,7	6,1	3,4	4,6	8	10,6
BL 50%	2,8	3,5	4,5	2,8	7,3	6,3
BLM 50%	4,1	4,4	3,5	3,1	7,6	7,6

Results

Poral distribution

Finer porosity with time for all the mixes

Finer porosity with BLM 50% than BL 50

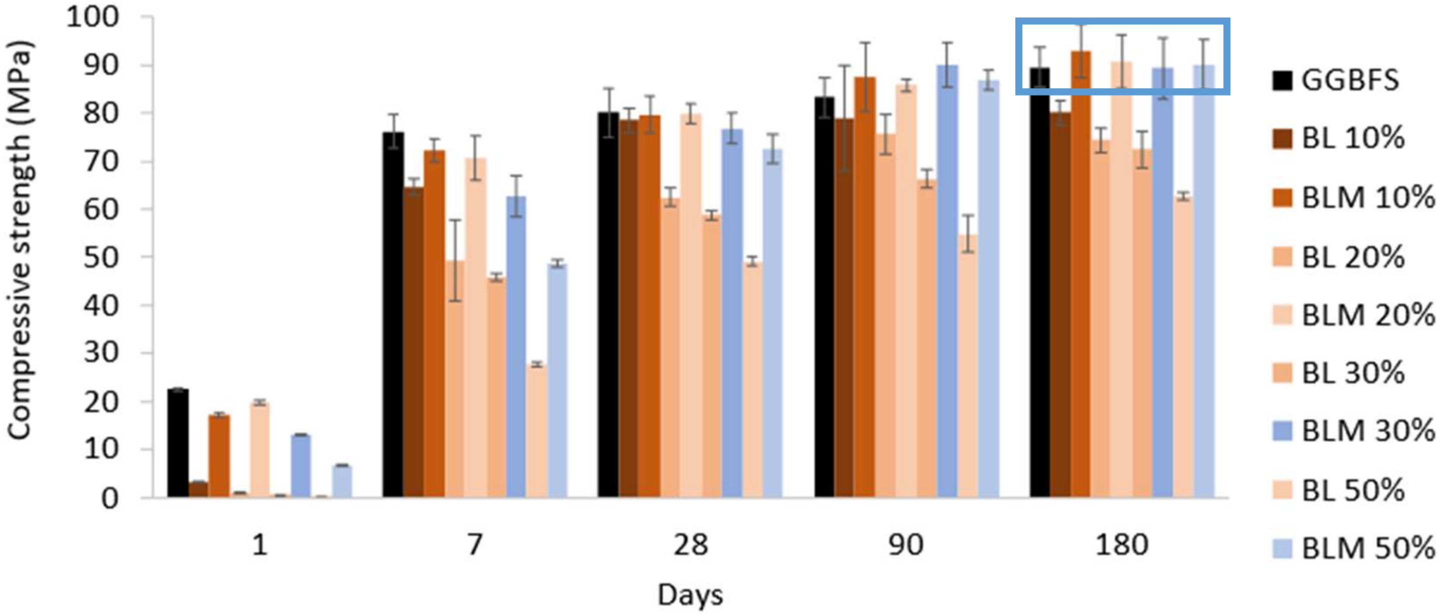


Results

Mechanical strength

BL: slower kinetics – Rc ↓ when [brick fines] ↑

BLM: quicklier kinetics - Rc ≥ GGBFS from 90 days



ICPIC 2023

WARSAW

17-20 SEPTEMBER 2023

Results

BL : brick fines = mineral addition

↗ Substitution 30 % ↗ Workability if continous mixing ↘ stiffening time

↗ [Brick fines] ↗ time for casting

↘ compressive strength but not proportional to substitution rate

→ *Economy on activator*

BLM : brick fines = precursor = GGBFS

↗ [Brick fines] → Workability and consistency constant

↗ alcali-activation kinetics and hydrates production

compressive strength at 90 days ≥ GGBFS

→ *Economy on precursor*

ICPIC 2023
WARSAW
17-20 SEPTEMBER 2023

Acknowledgements

IMT Lille Douai
École Mines-Télécom
IMT-Université de Lille

Université de Lille

LIÈGE université

Interreg
France-Wallonie-Vlaanderen
UNION EUROPÉENNE
EUROPESE UNIE

VALDEM