Treatment of residual cementitious fines obtained through innovative recycling for the replacement of primary cement

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URBAN MINE

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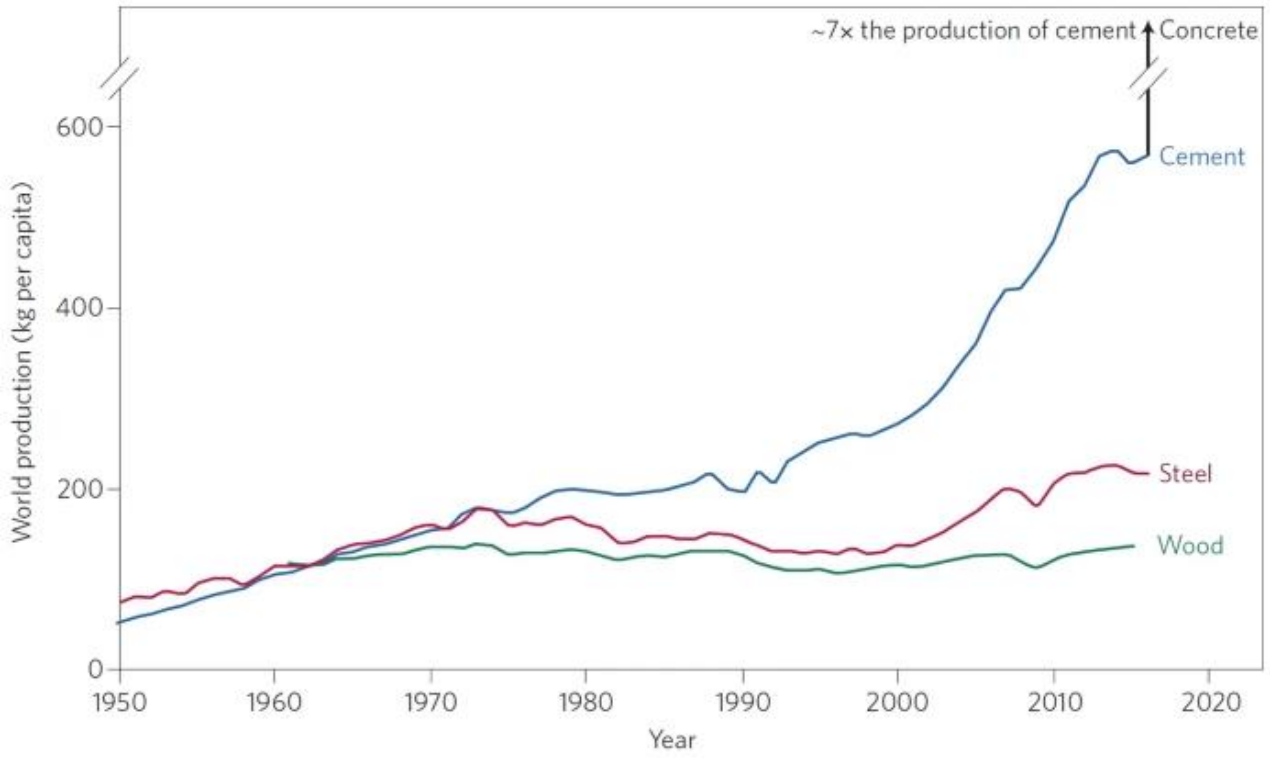
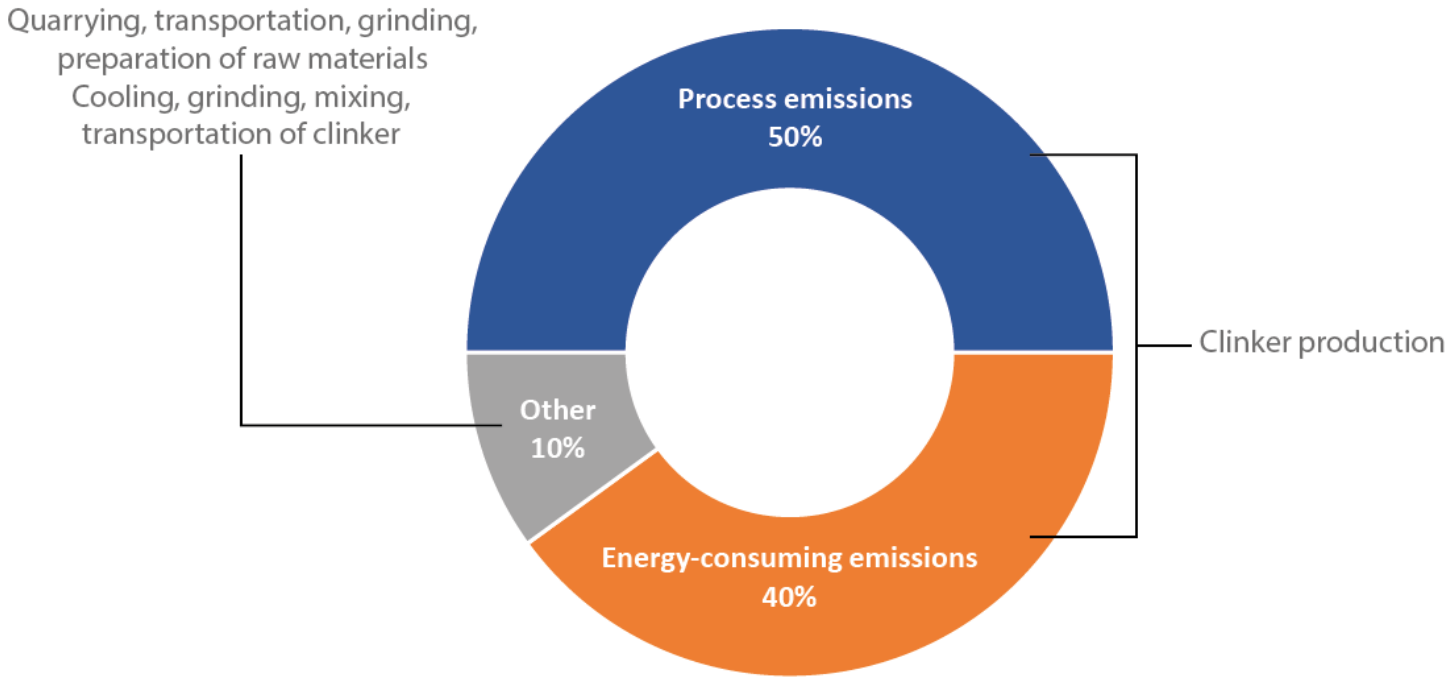
The need for circular concrete



- World population continues to grow
  - Expanding urban areas
  - Improving and increasing existing structures
  - Need for construction materials

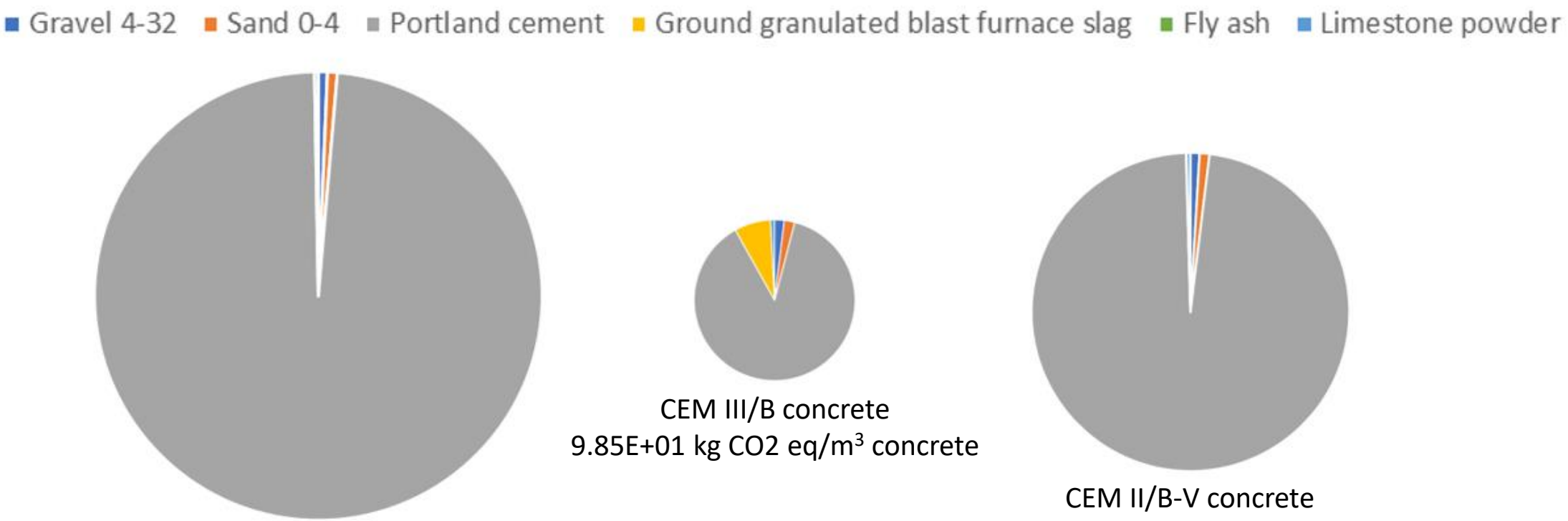
- Increasing demand construction materials
  - Concrete largest growth rate
  - Already visible in the demand of cement
  - Consequences for resource depletion and CO2 emissions

The need for circular concrete



- Concrete is responsible for 8% of the greenhouse gas emissions
  - Main contributor: production of cement
    - 90% of these emissions come from the clinker production
      - Process emissions
      - Energy-consuming emissions

Global warming potential



CEM I concrete
2.93E+02 kg CO2 eq/m^3 concrete

CEM III/B concrete
9.85E+01 kg CO2 eq/m^3 concrete

CEM II/B-V concrete
2.07E+02 kg CO2 eq/m^3 concrete

Traditional versus innovative recycled materials

Fractions
Traditional recycling

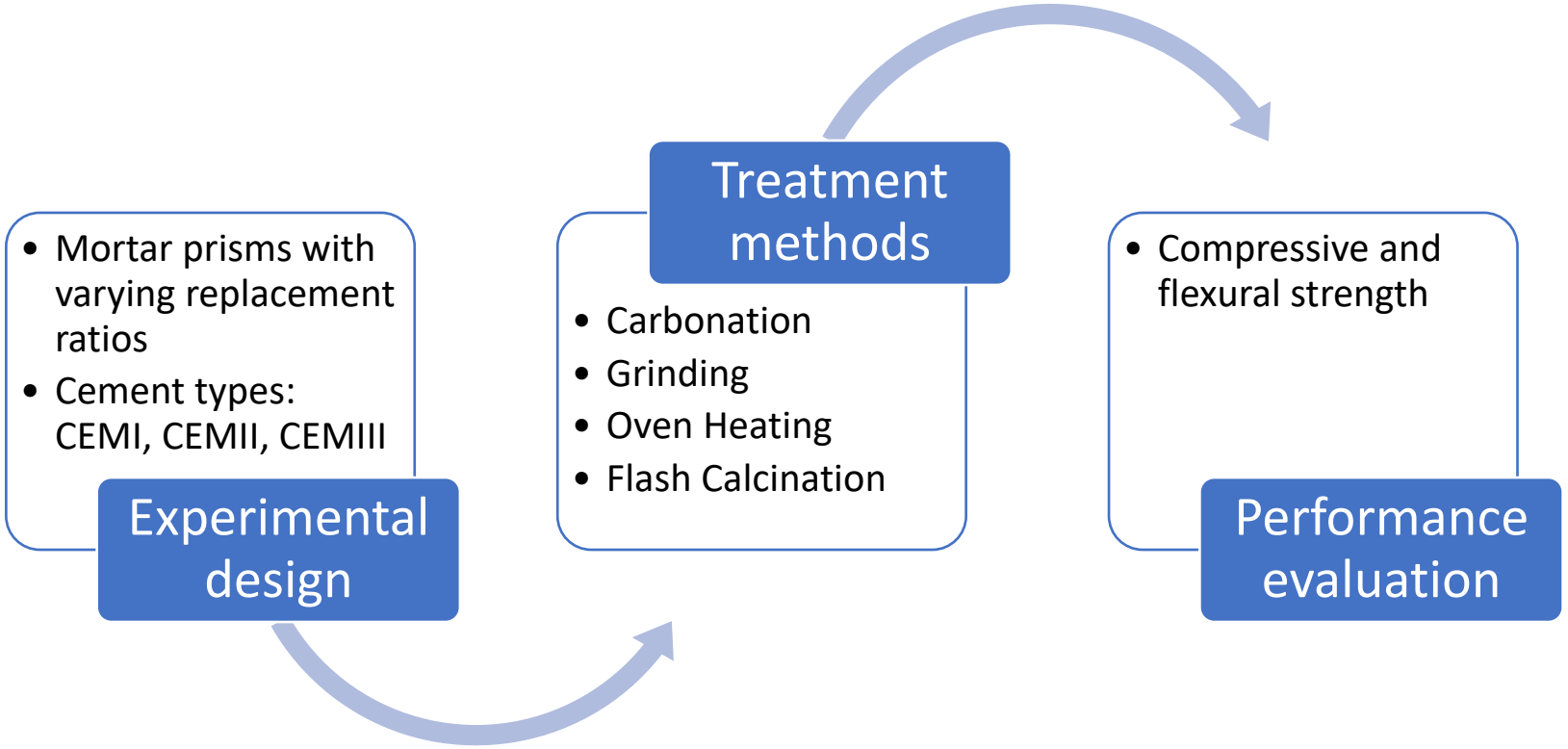
Fractions
Innovative recycling

- Traditional concrete recycling
  - Support materials in road foundations and other infrastructure
  - Two fractions
    - Coarse aggregate
    - Fine aggregate

- Innovative concrete recycling
  - Potential to replace primary materials
  - At least three fractions
    - Secondary gravel
    - Secondary sand
    - Concrete fines (old binder)

Research aim

Determine the potential of various treatment methods for the upcycling of residual cementitious fines to replace cement.



Mortar mixtures

Type	Replacement [%]	OPC [g]	Fly ash [g]	GGBS [g]	RCF [g]	Sand [g]	Water [g]
CEM I	0	450	0	0	0	1350	225
	50	225	0	0	225	1350	225
	75	112.5	0	0	337.5	1350	225
	100	0	0	0	450	1350	225
CEM III/B	0	135	0	315	0	1350	225
	50	67.5	0	315	67.5	1350	225
	75	33.75	0	315	101.25	1350	225
	100	0	0	315	135	1350	225
CEM II/B-V	0	315	135	0	0	1350	225
	50	157.5	135	0	157.5	1350	225
	75	78.75	135	0	236.25	1350	225
	100	0	135	0	315	1350	225

Treatment methods for upcycling

Grinding

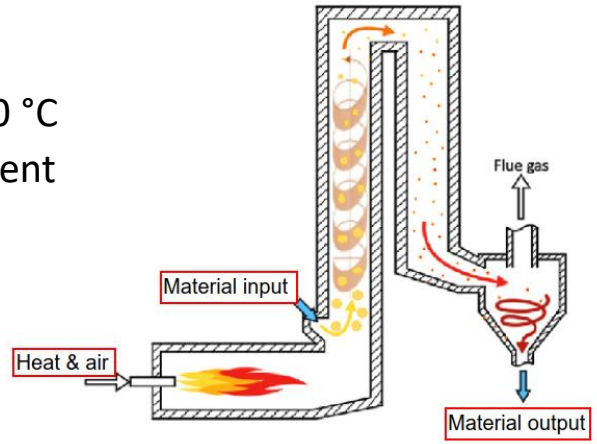
- From 0-63 µm to 0-32 µm
- Higher specific surface area
- Unreacted cement cores

Carbonation

- High CO_2 concentration
- Carbon capture
- Reactive silica-gel

Oven Heating

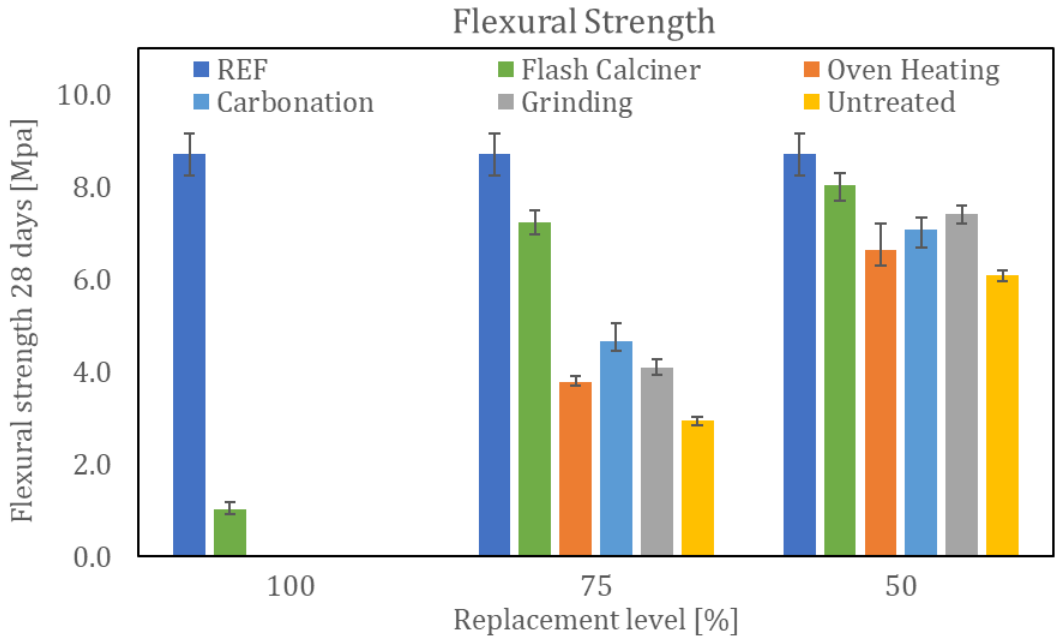
- Temperature: 900 °C
- Dehydration cement



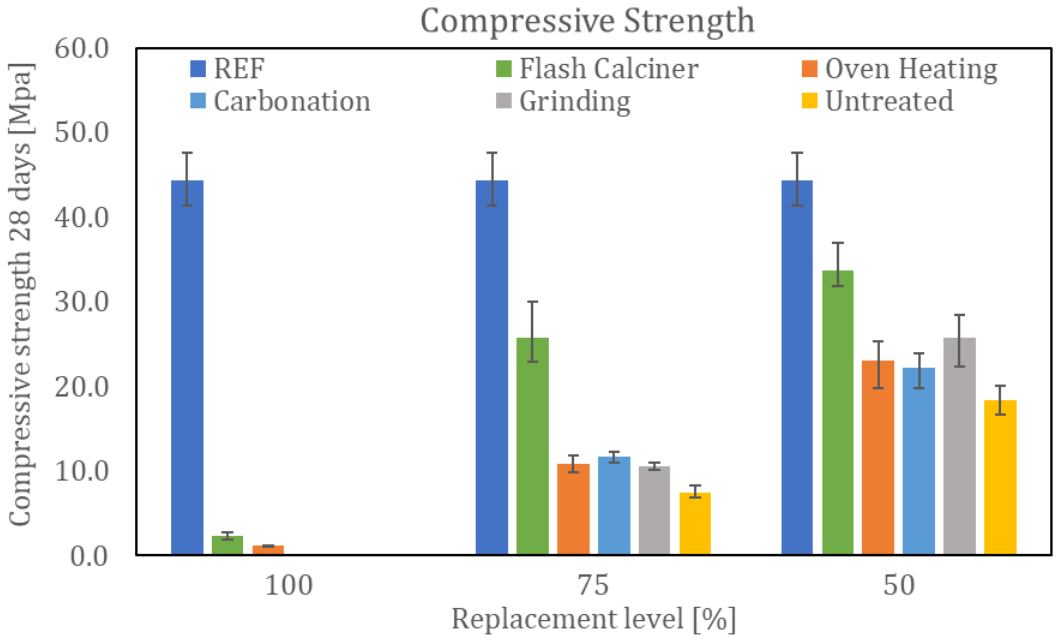
Flash Calcination

- Temperature: 750 °C
- Fast heating and cooling

Results – CEM I based mortar

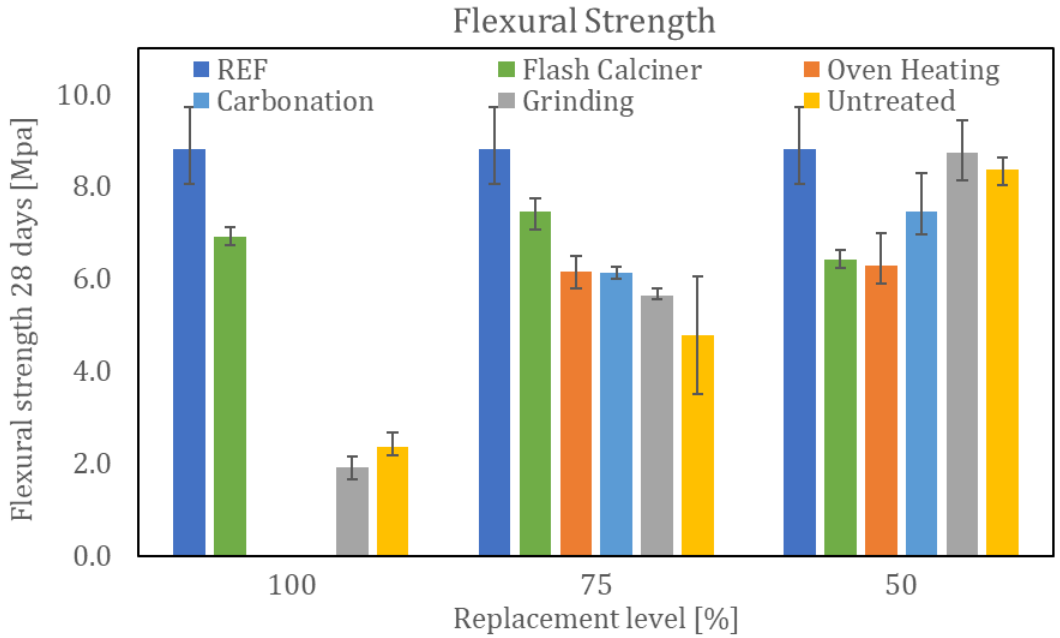


	100	75	50
REF	100%	100%	100%
Untreated	0%	34%	70%
Grinding	0%	47%	85%
Carbonation	0%	54%	81%
Oven Heating	0%	43%	76%
Flash Calciner	12%	83%	92%

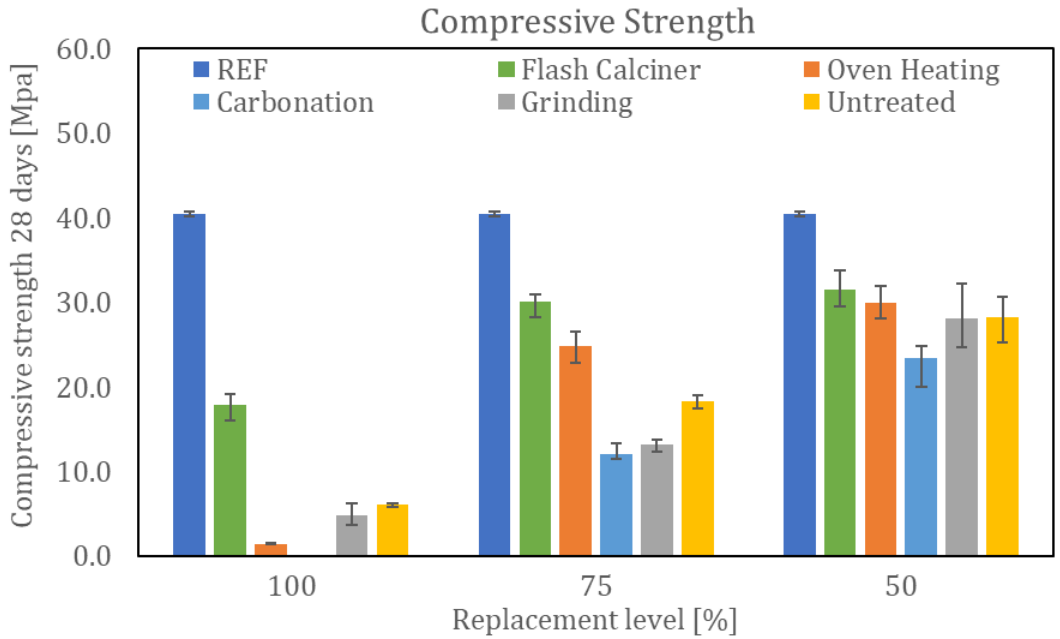


	100	75	50
REF	100%	100%	100%
Untreated	0%	17%	42%
Grinding	0%	24%	58%
Carbonation	0%	26%	50%
Oven Heating	3%	24%	52%
Flash Calciner	5%	58%	76%

Results – CEM III/B based mortar

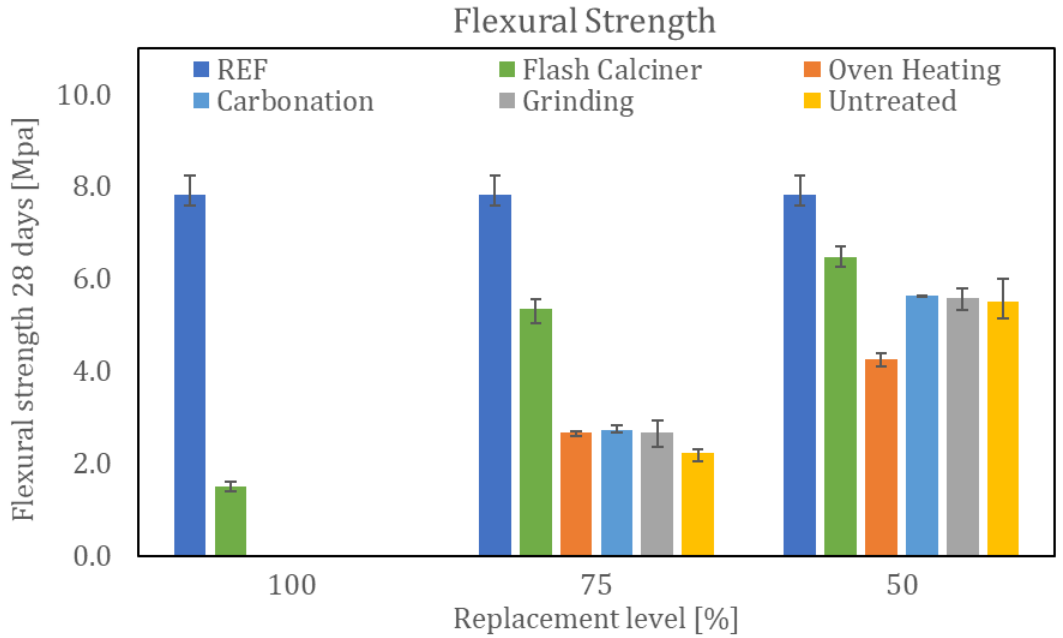


	100	75	50
REF	100%	100%	100%
Untreated	27%	54%	95%
Grinding	22%	64%	99%
Carbonation	0%	70%	85%
Oven Heating	0%	70%	72%
Flash Calciner	78%	85%	73%

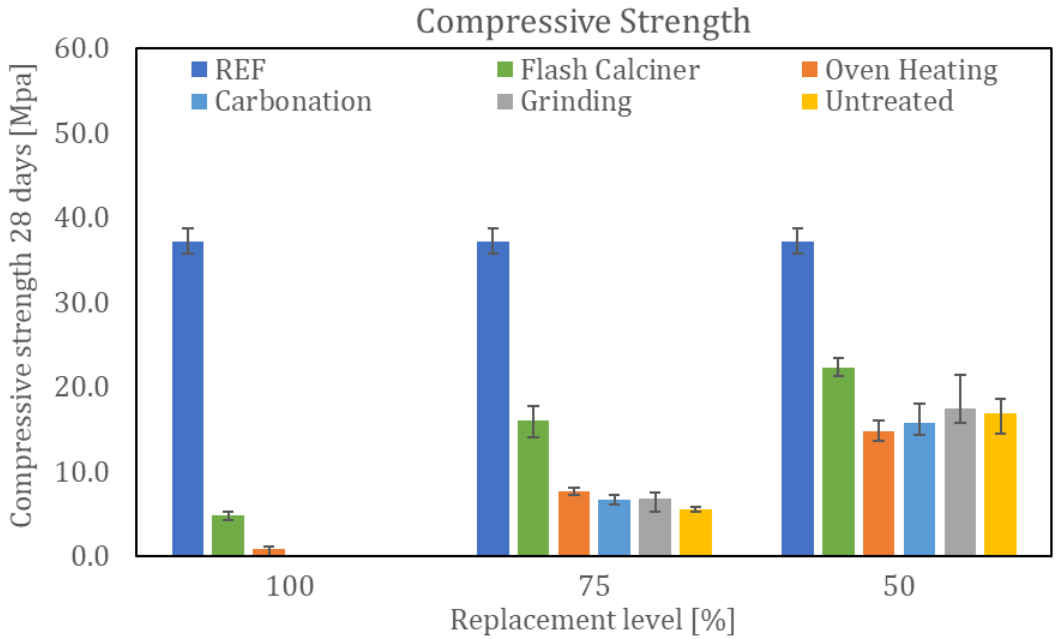


	100	75	50
REF	100%	100%	100%
Untreated	15%	45%	70%
Grinding	12%	33%	70%
Carbonation	0%	30%	58%
Oven Heating	4%	62%	74%
Flash Calciner	44%	74%	78%

Results – CEM II/B-V based mortar



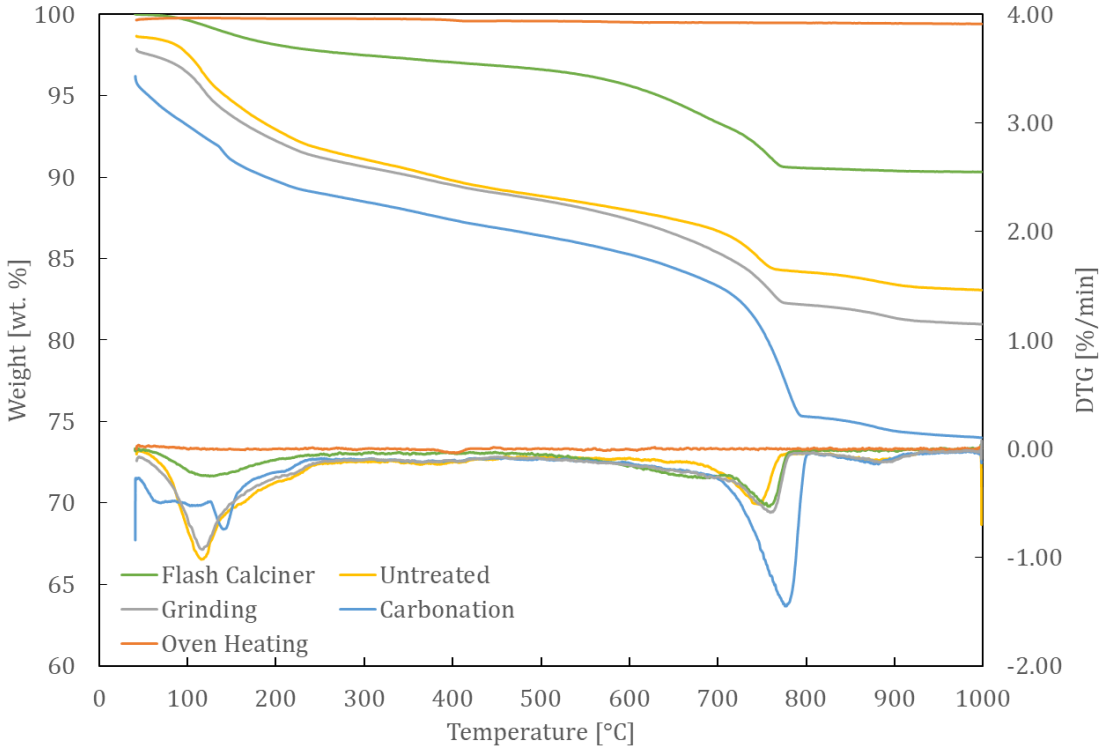
	100	75	50
REF	100%	100%	100%
Untreated	0%	28%	70%
Grinding	0%	34%	71%
Carbonation	0%	35%	72%
Oven Heating	0%	34%	55%
Flash Calciner	19%	69%	83%



	100	75	50
REF	100%	100%	100%
Untreated	0%	15%	46%
Grinding	0%	18%	47%
Carbonation	0%	18%	43%
Oven Heating	2%	21%	40%
Flash Calciner	13%	43%	60%

Characterisation

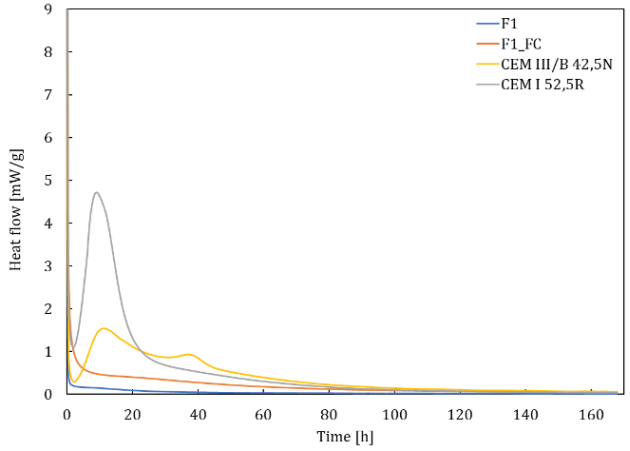
TGA of treatment methods

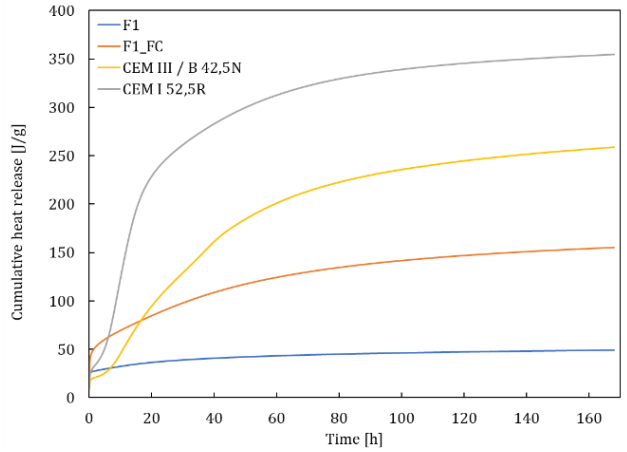


Flash Calcination – Density and particle size

Material	Density [g/cm³]	D(10) [µm]	D(50) [µm]	D(90) [µm]
F1	2.332	13.42	48.67	84.78
F1_FC	2.677	9.46	36.72	69.06
CEM I	3.067	4.57	19.12	36.68

Flash Calcination - Isothermal Calorimetry

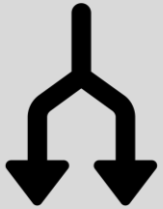




Conclusion

The recycling process should shift from the current traditional to innovative recycling techniques with a focus on producing high-quality residual cementitious fines due to its potential to fully replace primary clinker.

For all mortar mixtures, Flash Calcination shows the highest potential as a technique for the upcycling of residual cementitious fines to replace primary Portland cement in new mixtures.



CEM III/B based mortar obtained the best results. Reduction in compressive strength was the lowest for these mortars.

Thank you for your attention!
Questions?