Use of pozzolans and CDW-fines in temPozz M92-based geopolymers

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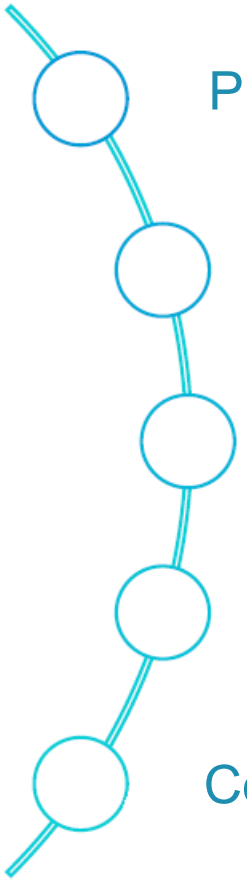
Geopolymer Camp 2026, Saint-Quentin

Thursday 9 July 2026

GEOPOLYMER INSTITUTE

Presentation overview



Problem statement

Construction and Demolition Waste (CDW) fines

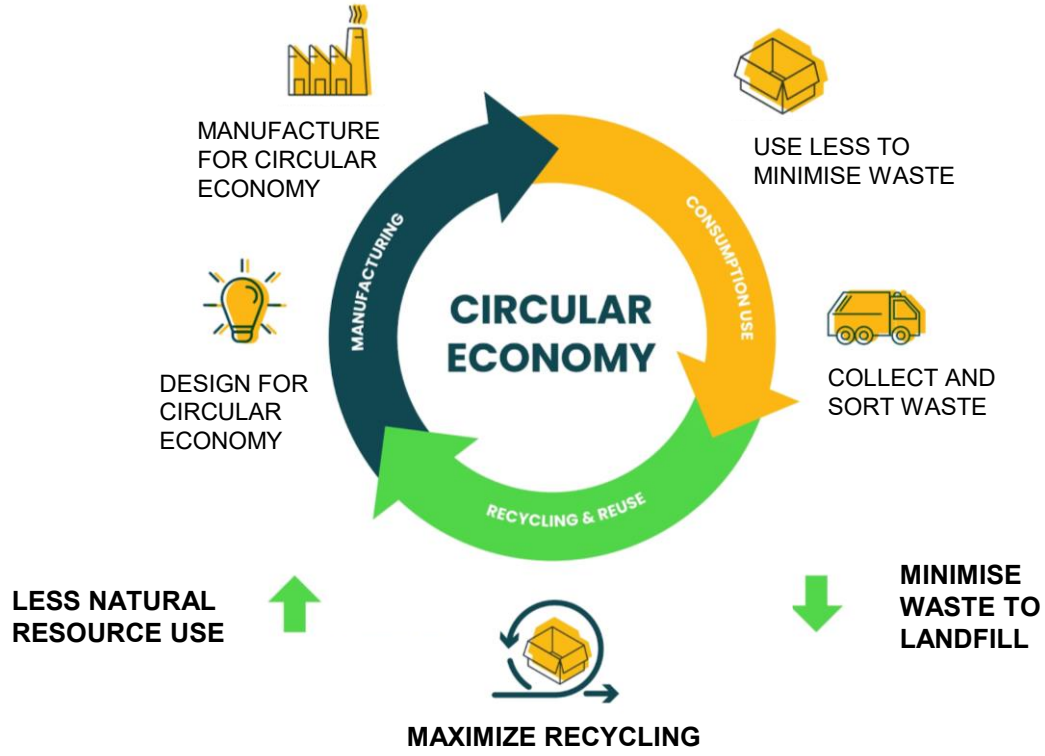
Materials and methodology

Results

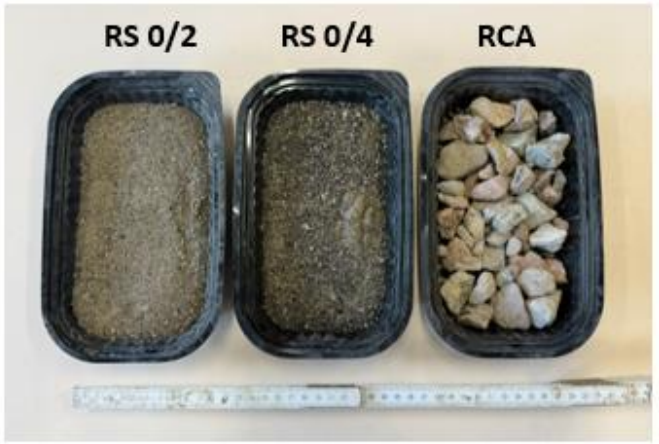
Conclusions

Problem statement

- Construction and demolition waste (CDW)
- Circular economy
- Recycling of CDW constituents
  - Coarse fraction (> 4 mm)
  - Fine fraction (0-4 mm)
  - Fines / Powders (< 125 µm)



Construction and demolition waste (CDW)



Recycled coarse and fine aggregate (RA)

~ 90%

Recycled powder (RP)

~ 10%

Low reactivity

Recycling of CDW fines (< 125 µm)

Recycled concrete powder (RCP)

Recycled brick powder (RBP)

Material properties – precursors

temPozz M92

Temcon solutions gmbh

White, amorphous aluminosilicate · very high precursor efficiency

Lava powder

VVM cement

Volcanic · van nature reactief · puzzolaan

Recycled Concrete Powder (RCP)

AC Materials

Filter cake from concrete crushing installations · CaO-rich

Recycled Brick Powder (RBP)

Ploegsteert

Crushed powder from cutting process during brick manufacturing · SiO_2-rich

RCP = Recycled Concrete Powder
RBP = Recycled Brick Powder

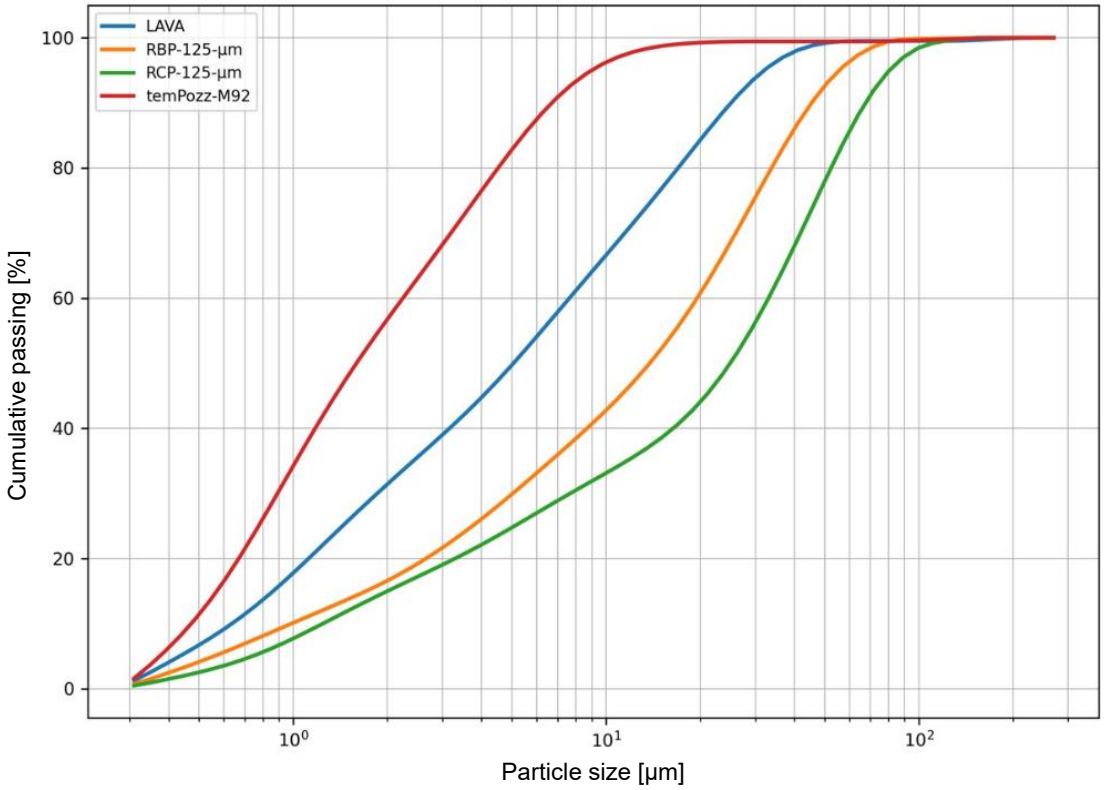
Material properties – precursors

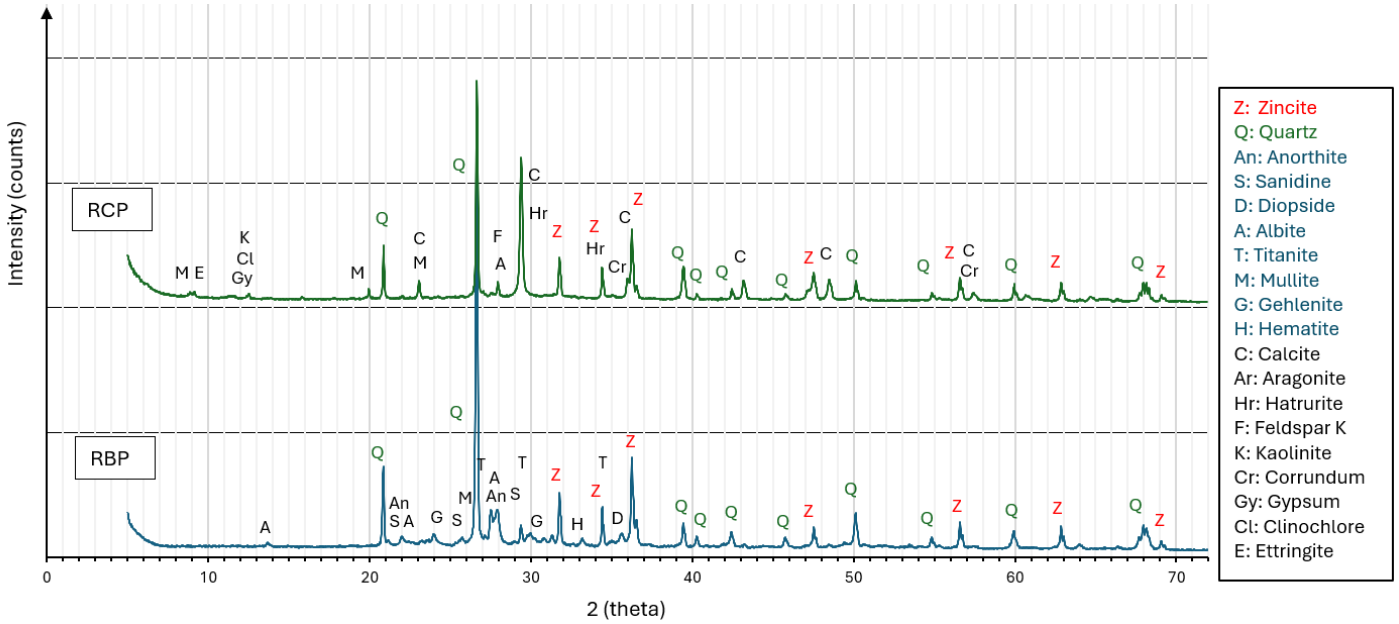
PSD analyzer - Fritsch Analysette 22

XRF spectrometer Bruker S8 TIGER

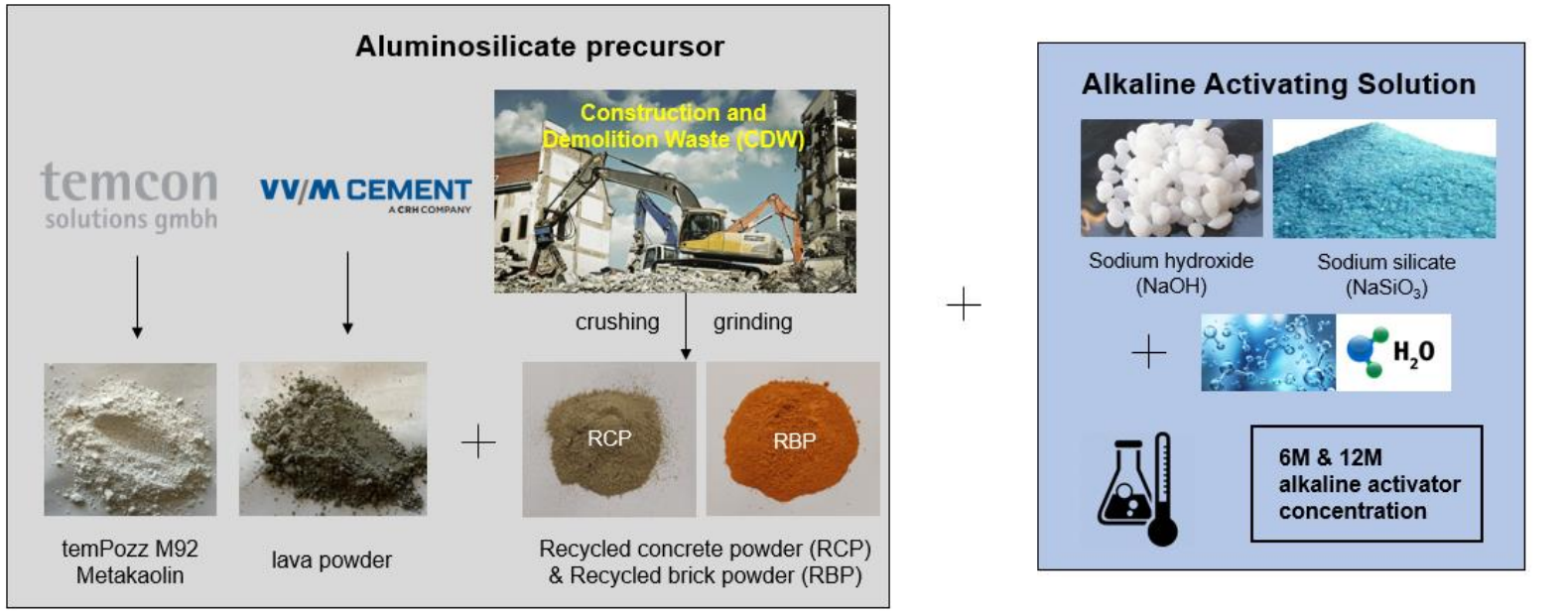
Bruker D2 Phaser

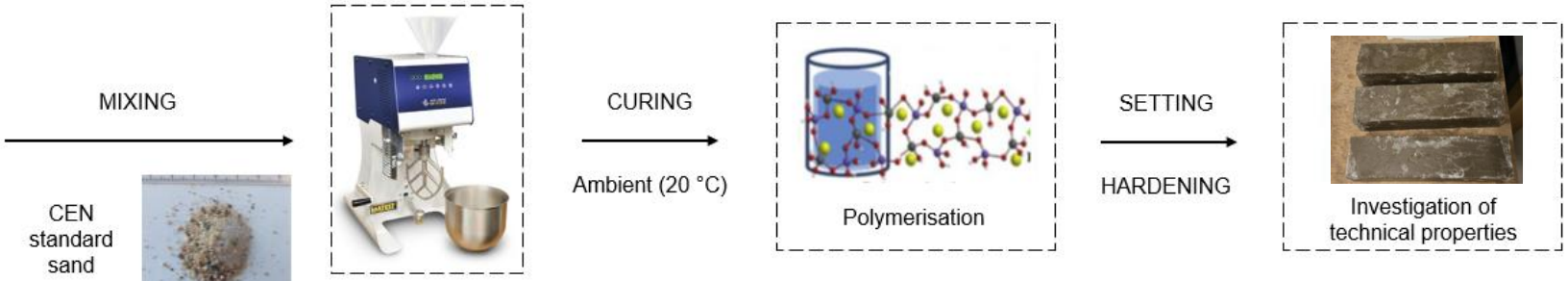
Precursors	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	Others
temPozz M92	54.0	43.0	<1.00	<0.50	-	-	-	-
lava powder	56.1	15.3	7.70	9.86	5.73	1.62	2.80	0.89
RBP	63.2	13.0	4.58	10.8	1.83	2.72	1.89	2.0
RCP	38.3	7.02	5.41	42.4	1.59	1.21	0.42	3.7



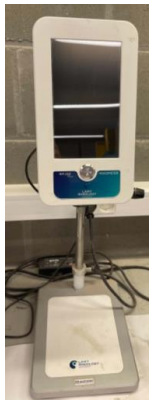


Research methodology – overview

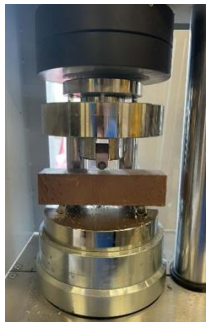




- **Rheological behaviour (NBN EN 3219-1 & -2), Vicat test (NBN EN 196-3), mini slump (NBN EN 1015-3)**



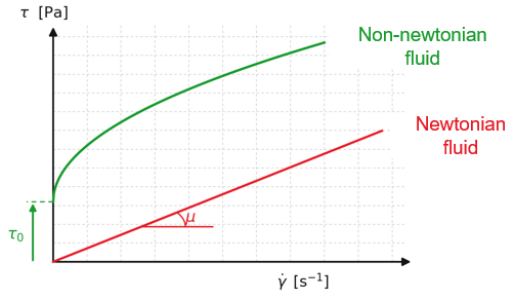
- **Flexural & compressive strength (NBN EN 196-1)**

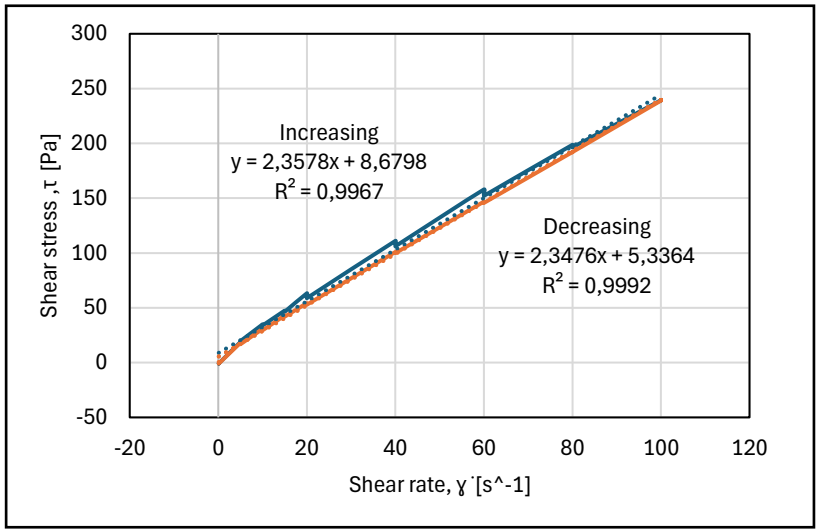


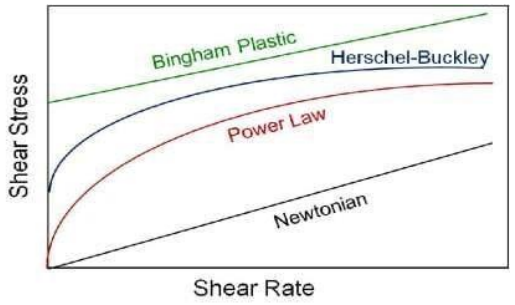
Rheology (NBN EN 3219-1 & -2)

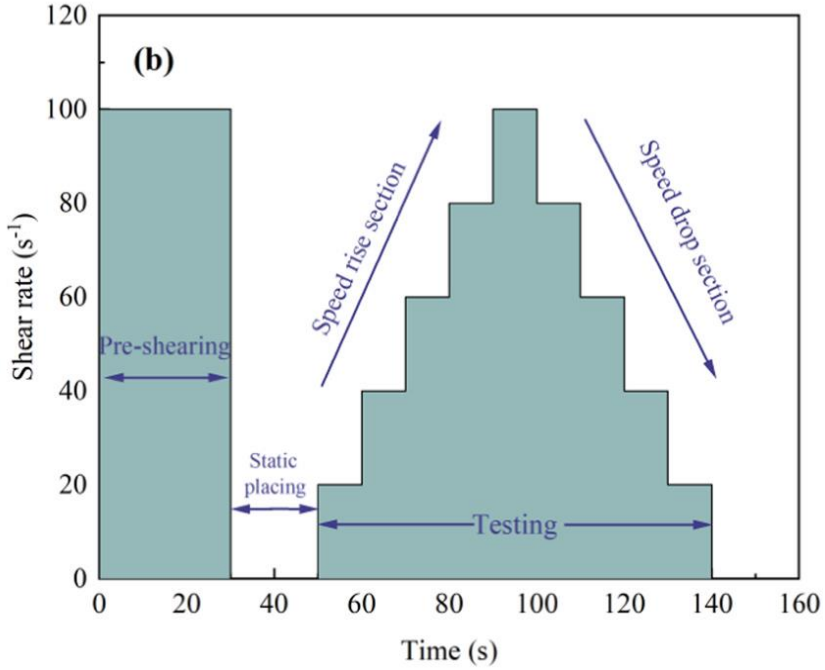
- Insight in flow behaviour
  - Dynamic yield stress τ_0
  - Plastic viscosity μ_p
- Coaxial Lamy Rheometer
  → “Searle principe”
- Use of Herschel Bulkley model for data analysis

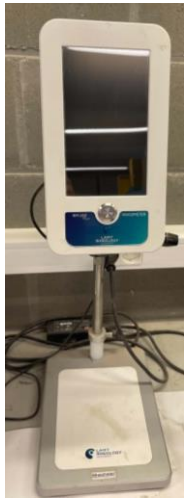
$$\tau = \tau_0 + K * \dot{\gamma}^n$$









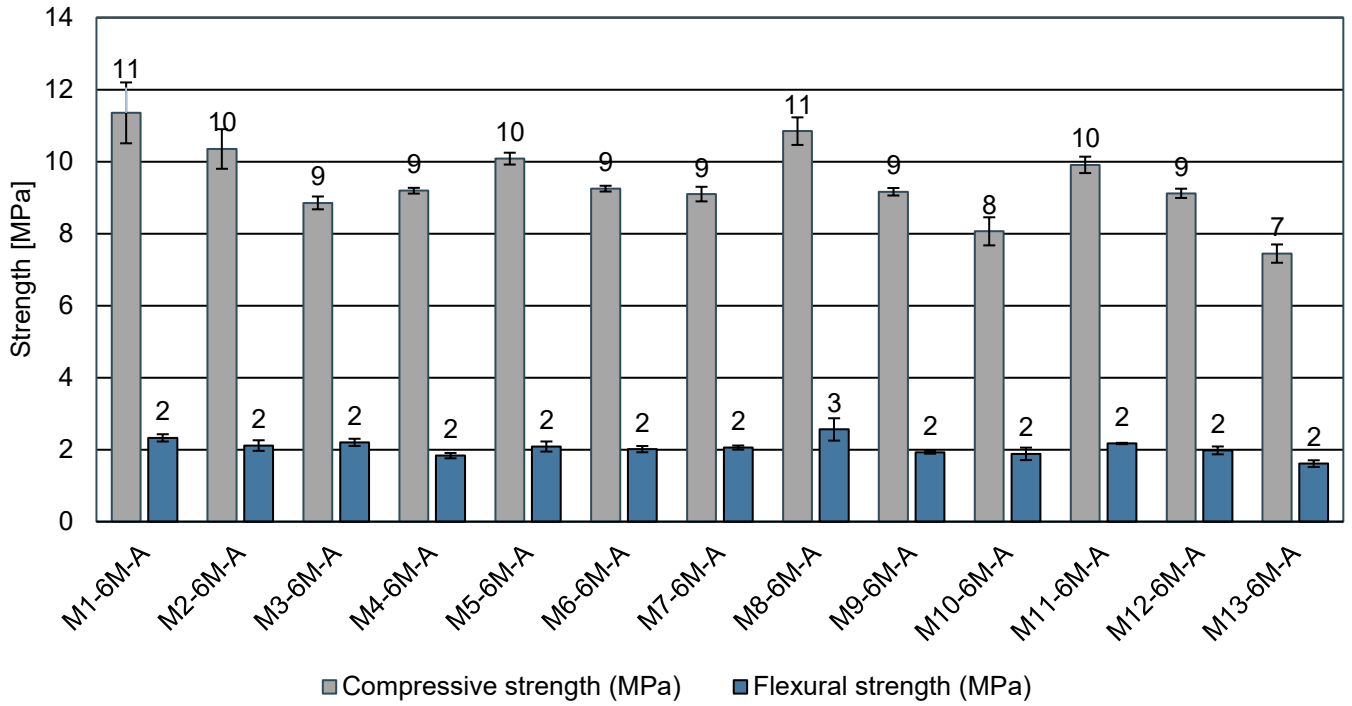


[1] D. Zhang, T. Zhu, Q. Yang, V. Vandeginste, en J. Li, ‘Influence of ground granulated blast furnace slag on recycled concrete powder-based geopolymer cured at ambient temperature: Rheology, mechanical properties, reaction kinetics and air-void characteristics’, Construction and Building Materials, vol. 438, p. 137190, aug. 2024

Strength results – 6M concentration

- temPozz M92 replacement: 0-20 wt.%
- 6M alkaline activator concentration: best results for higher RCP contents
  - $f_{c,7d}$: 7-11 MPa
  - $f_{fl,7d}$: 2-3 MPa

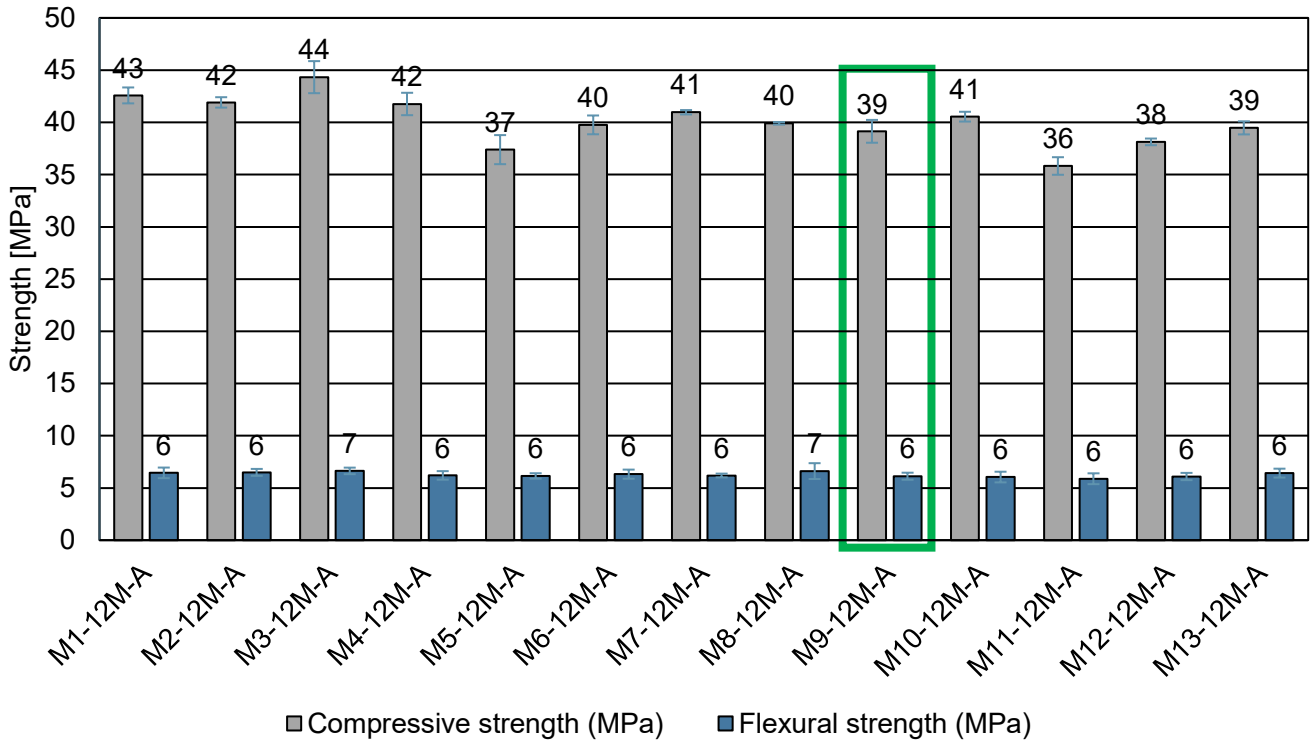
Mixture No.	Replacement percentage [%]	temPozz M92 [%]	RCP [%]	RBP [%]
M1	0	100	0	0
M2	5	95	5	0
M3	5	95	2,5	2,5
M4	5	95	0	5
M5	10	90	10	0
M6	10	90	5	5
M7	10	90	0	10
M8	15	85	15	0
M9	15	85	7,5	7,5
M10	15	85	0	15
M11	20	80	20	0
M12	20	80	10	10
M13	20	80	0	20



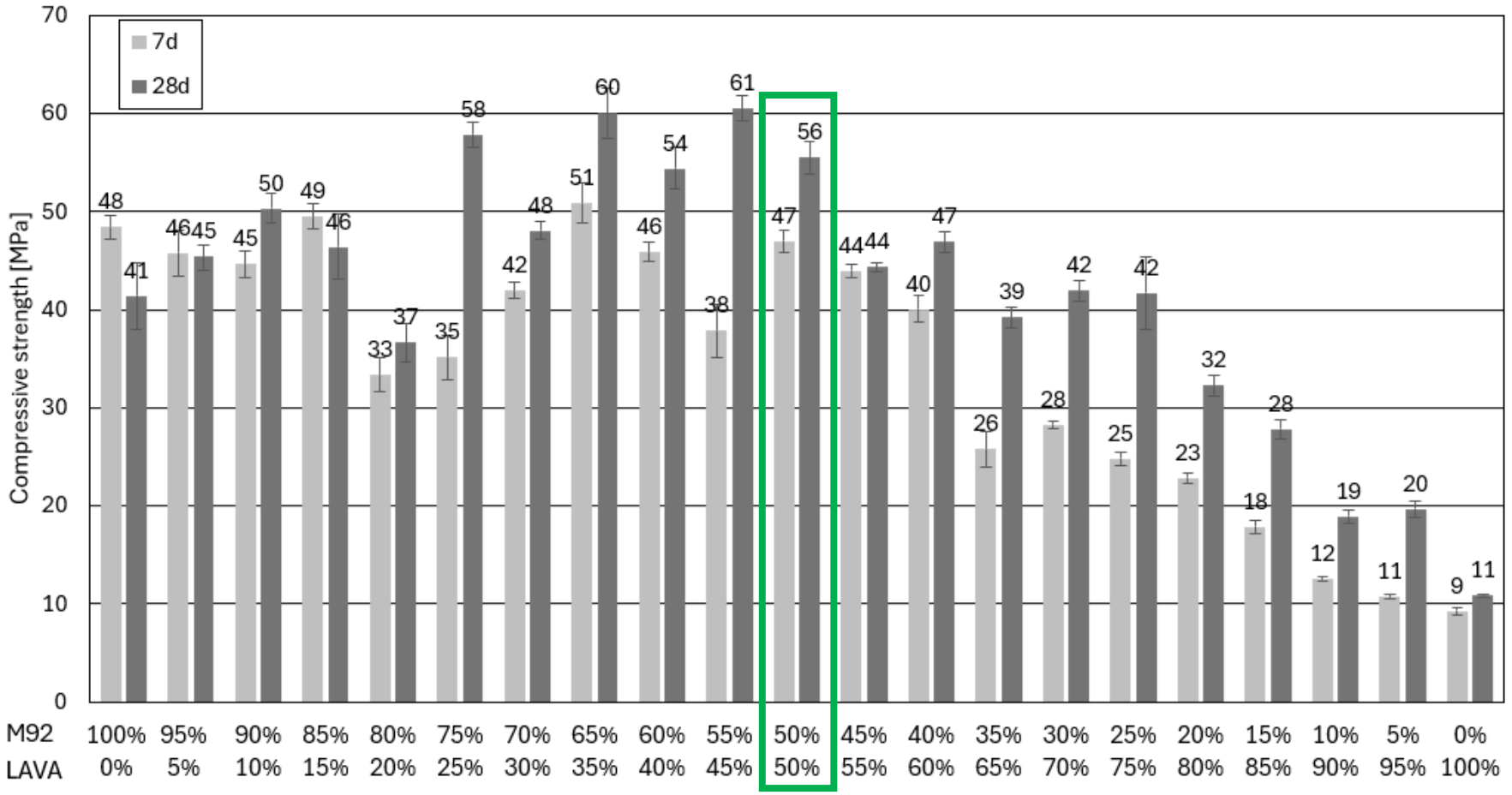
Strength results – 12M concentration

- temPozz M92 replacement: 0-20 wt.%
- 12M alkaline activator concentration: best results for higher RBP contents
  - $f_{c,7d}$: 36-44 MPa
  - $f_{fl,7d}$: 6-7 MPa

Mixture No.	Replacement percentage [%]	temPozz M92 [%]	RCP [%]	RBP [%]
M1	0	100	0	0
M2	5	95	5	0
M3	5	95	2,5	2,5
M4	5	95	0	5
M5	10	90	10	0
M6	10	90	5	5
M7	10	90	0	10
M8	15	85	15	0
M9	15	85	7,5	7,5
M10	15	85	0	15
M11	20	80	20	0
M12	20	80	10	10
M13	20	80	0	20



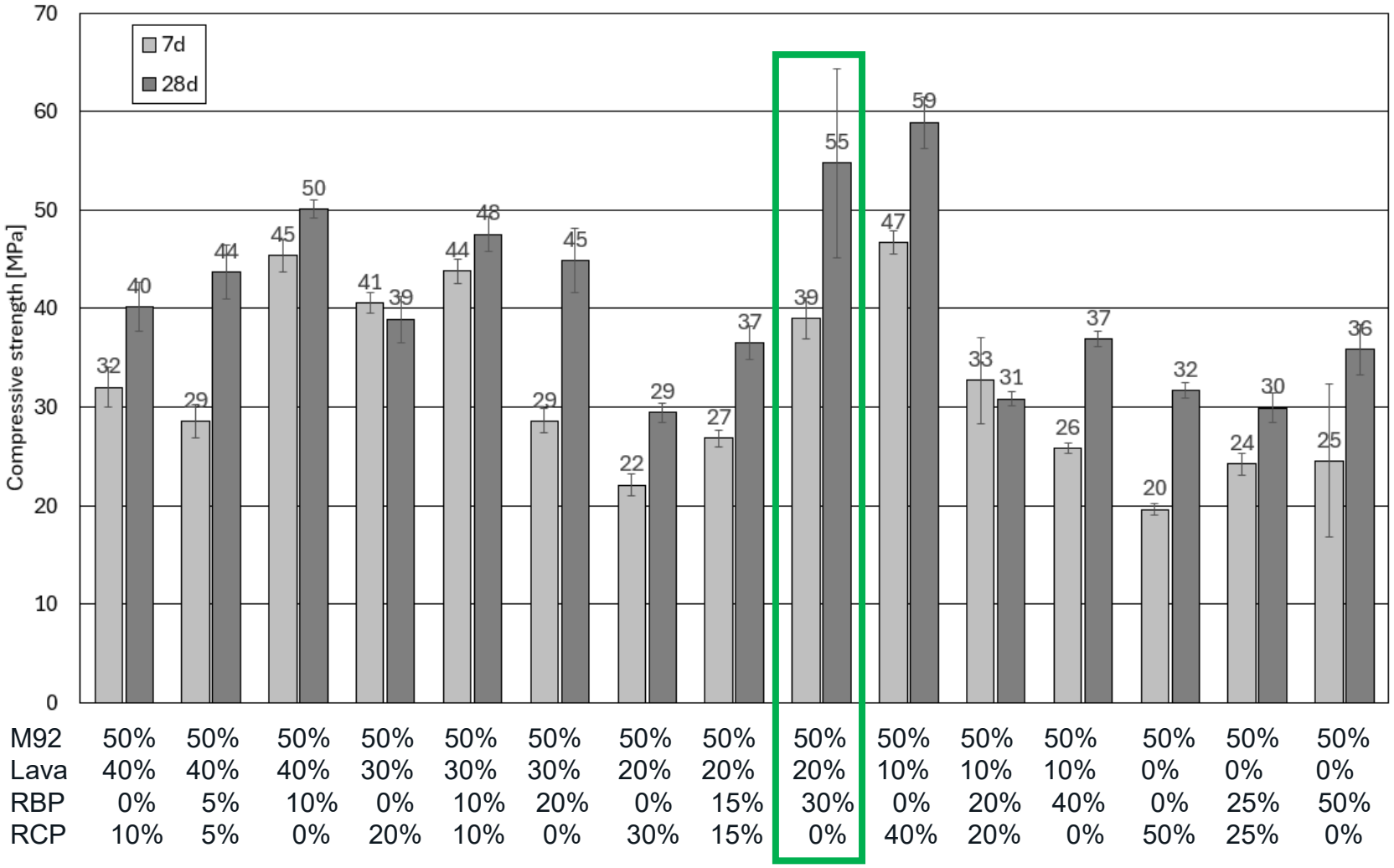
Compressive strength (EN 196-1)



M92 lava powder

- Lava powder contributes to strength between 30-50 wt.% replacement rate
- Compressive strength drops significantly when replacement rate > 55 wt.% of lava powder

Compressive strength (EN 196-1)

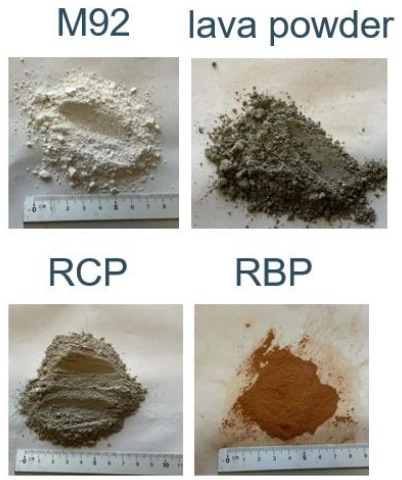


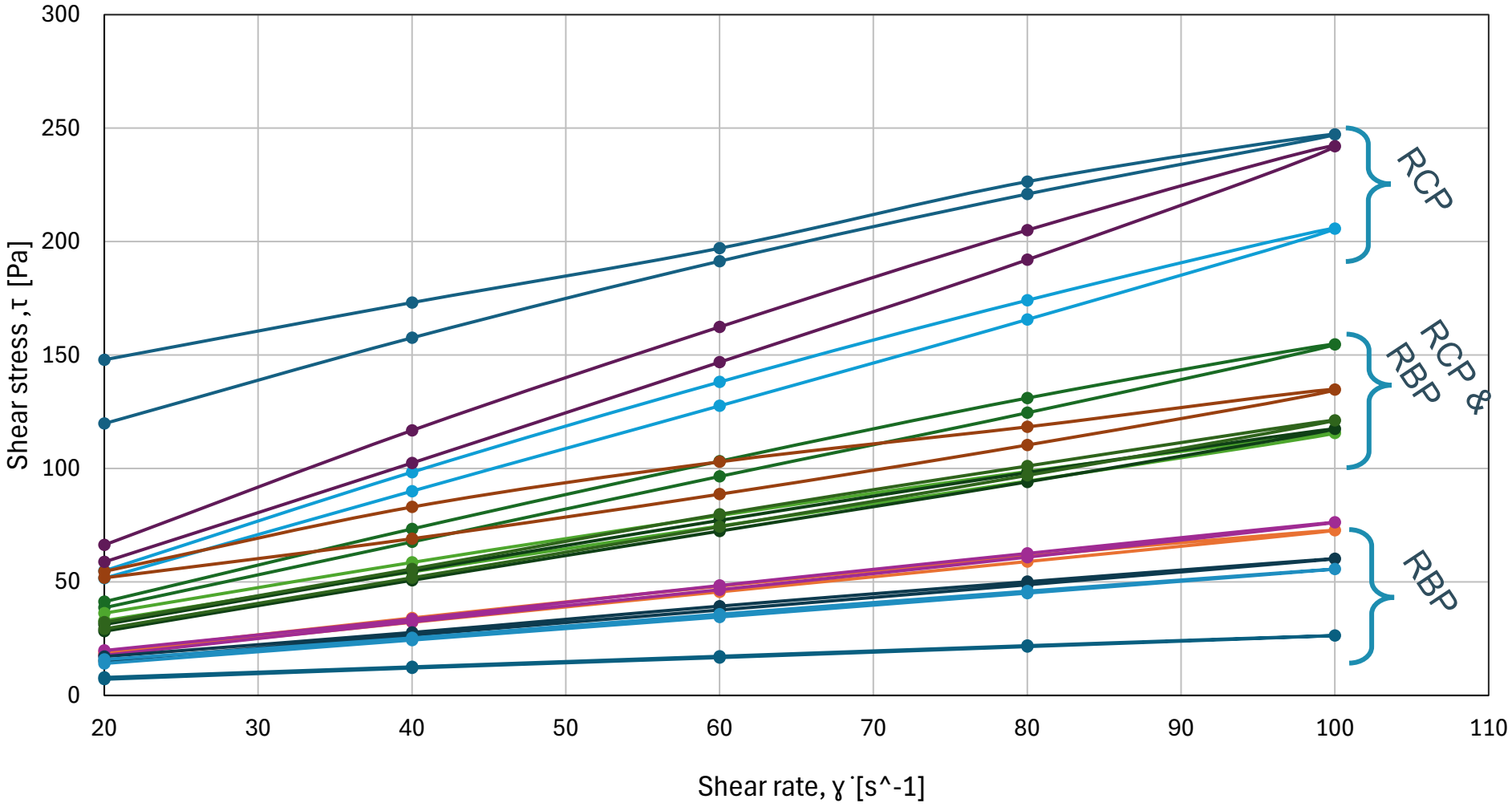
M92 lava powder

RCP RBP

- 20% lava / 30% RBP → $f_{c,28d}$ = 54,8 ± 9,61 MPa
- Strong strength drop when lava content < 20% (mainly with RCP)
- Lava powder contributes to strength in hybrid system

Rheological analysis (NBN EN 3219-1 & -2)

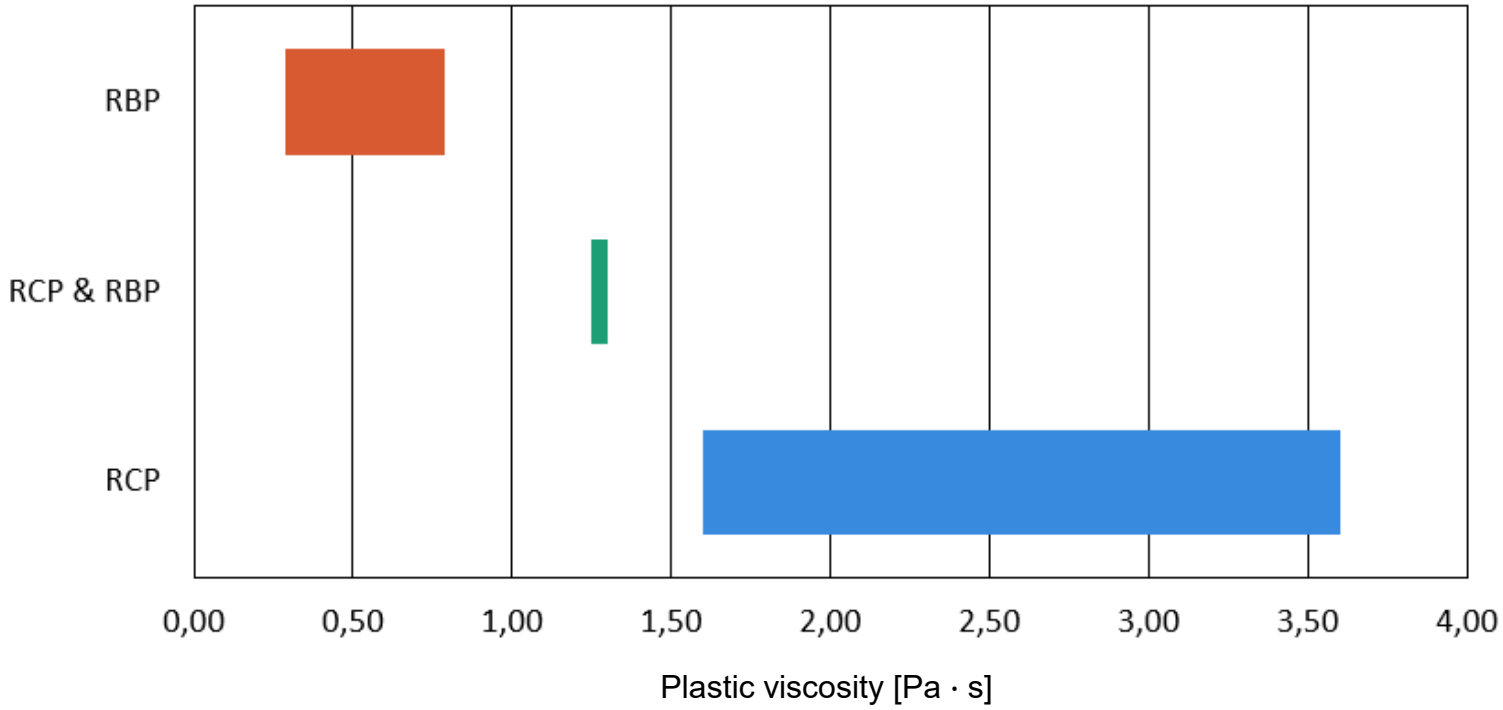




- RCP-mixtures exhibit highest shear stress
- RBP-mixtures exhibit lowest shear stress
- RCP addition increases plastic viscosity

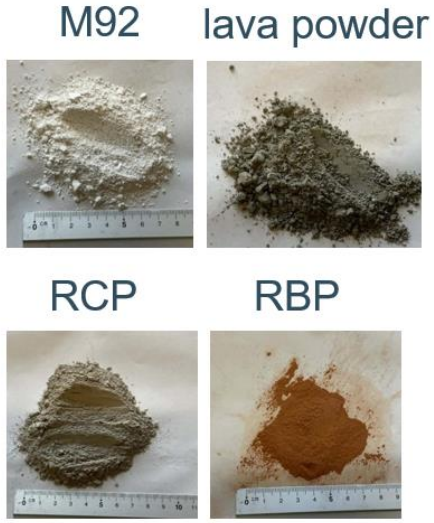
Rheological analysis (NBN EN 3219-1 & -2)

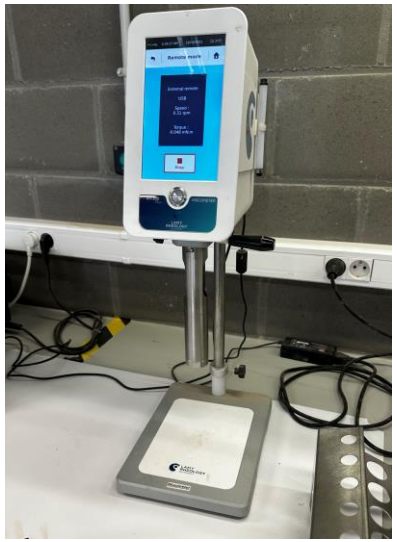
- RCP
  - ➢μ = 3,65 – 1,66 Pa.s
- RBP & RCP
  - ➢μ = 1,30 – 1,24 Pa.s
- RBP
  - ➢μ = 0,79 - 0, 29 Pa.s



Conclusions

- Most optimal mixture:
  - 50% MK, 20% Lava & 30% RBP
  - 12M alkaline activator concentration
- Compressive strength:
  - $f_{c,7d}$ = 39,0 ± 2,09 MPa
  - $f_{c,28d}$ = 54,8 ± 9,61 MPa
- Flexural strength:
  - $f_{fl,7d}$ = 7,67 ± 0,61 MPa
  - $f_{fl,28d}$ = 9,23 ± 0,86 MPa
- Mini slump: 20,5 ± 0,3 cm
- Vicat setting time: 90 minutes
- Plastic viscosity: 1,67 Pa.s





Thank you for your attention!

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