



WalDeCoViet II Project

Wallonia-Brussels International/Vietnam

USE OF RECYCLED SAND FOR 3D PRINTING

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RESEARCH MOTIVATION

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01. Research motivation

OVER-EXTRACTION OF SAND

Sand demand: **50 billion tons** per year

The Earth is running out of sand, despite it being a seemingly abundant resource.

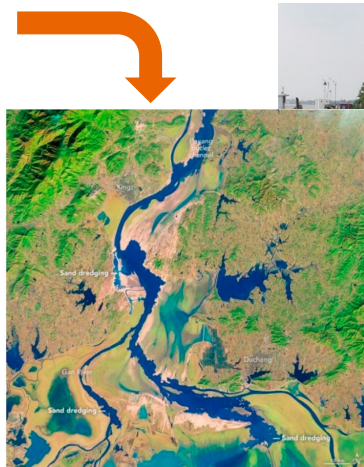
Consequences of over-extraction:

- Riverbank erosion
- Increased risk of flooding
- Loss of biodiversity ...

Alternative materials ?



Nedeljkovic et al., 2021



<https://moitruongxaydungvn.vn/>

CONSTRUCTION AND DEMOLITION WASTE

Construction and demolition waste generates approximately **10 billion tons** per year.

- It comes from the demolition, construction, and renovation of buildings.
- It causes environmental damage, including soil, water, and air pollution.



<https://nld.com.vn>



<https://rowconrecycling.com.au>

01. Research motivation

3D PRINTING TECHNOLOGY FOR CONSTRUCTION

A new construction technology using additive-manufactured formwork: instead of traditional formwork, **a printer** builds structural components **layer by layer**.

Some advantages:

- Fast construction time
- Lower construction costs
- Environmentally friendly (reduced CO₂ emissions)
- Unique architecture (no limits in design)
- Great potential for future application



<https://www.heidelbergmaterials.com>



“Applying recycled sand in 3D printing for construction”



02

RESEARCH APPROACH



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02. Research approach

DESIGNING A NEW 3D-PRINTING MORTAR FORMULATION WITH RECYCLED SAND

Materials:



Cement CEM III A 52.5



Natural sand 0-2 mm



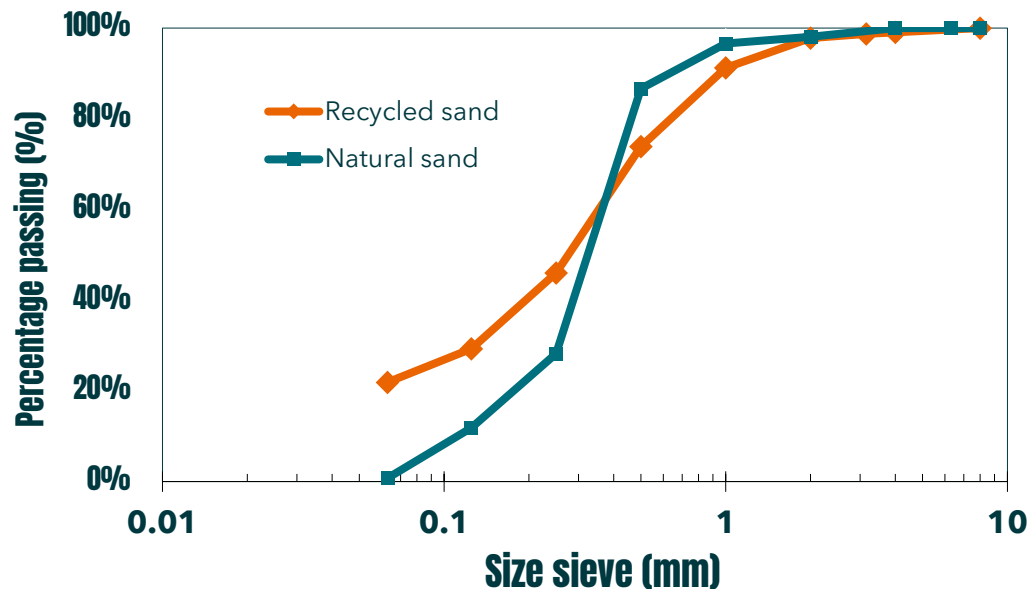
Recycled sand 0-2 mm



Recycled crushed fine 0-60 µm



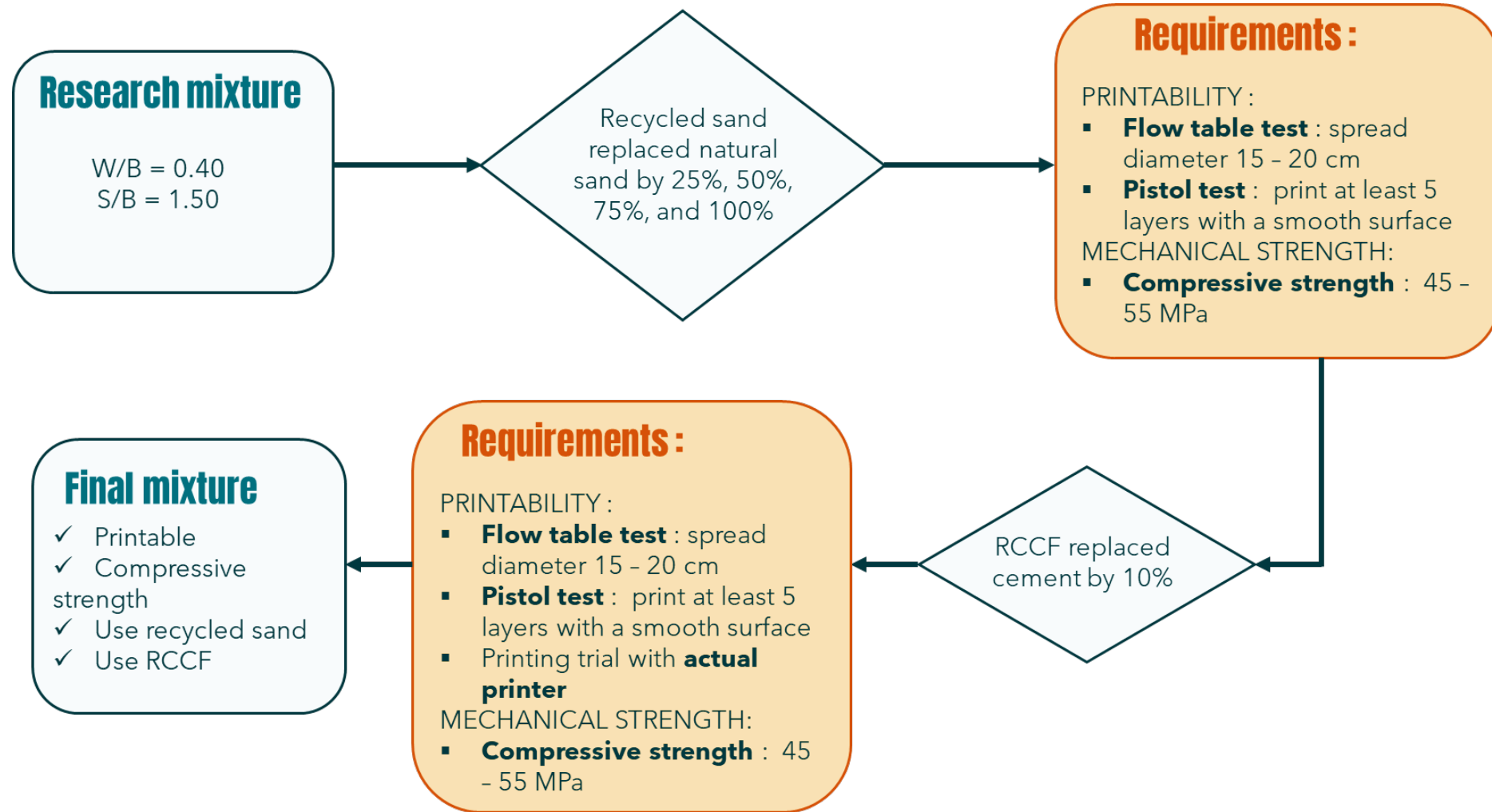
Superplasticizer
Sika betonverflüssiger BV 3 M



Fine Aggregate	Density (kg/m ³)	Maximum particle size (mm)	Water absorption(%)
Natural sand	2650	2	0.18
Recycled sand	2400	2	14.0

02. Research approach

DESIGNING A NEW 3D-PRINTING MORTAR FORMULATION WITH RECYCLED SAND



02. Research approach

DESIGNING A NEW 3D-PRINTING MORTAR FORMULATION WITH RECYCLED SAND

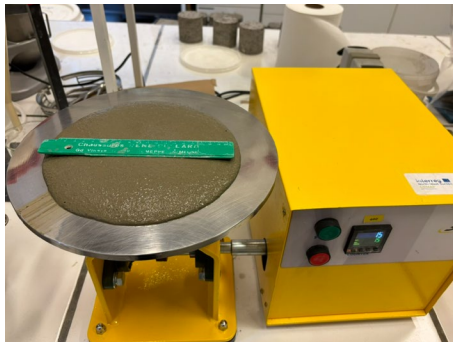
Requirements:

- Compressive strength : 45 – 55 MPa
- Printable: extrudability – pumpability – buildability

EXTRUDABILITY - PUMPABILITY - BUILDABILITY

Standard: EN 13395-1: 2002

Flow table test



Measure the diameter of the sample (cm)
Repeat the test 4 times (0, 10, 20, 30 min)
Optimal spread diameter: 15 – 20 cm

Standard: (none)

Pistol test



Print 5 layers of material without deformations
Repeat the test 4 times (0, 10, 20, 30 min)

Standard: (none)

Actual 3D printer



Print trial on an actual 3D printer to evaluate the printability

02. Research approach

DESIGNING A NEW 3D-PRINTING MORTAR FORMULATION WITH RECYCLED SAND

Research mixtures:

					Quantities (kg/m ³)					
Mixture	W/B	S/B	%NS	%RS	Cement	NS	RS	Water	Added water	Superplastizicer (%wob)
RS 07	0.40	1.50	75%	25%	770	866	289	308	40	0.99
RS 08	0.40	1.50	50%	50%	761	571	571	304	79	1.35
RS 09	0.40	1.50	25%	75%	753	282	847	301	117	1.51
RS 10	0.40	1.50	0%	100%	744	0	1117	298	155	1.70

NS: natural sand ; RS : recycled sand ; W/B: water to binder ; S/B : sand to binder ; Added water : balance the water which are absorb by the RS ; wob: weight of binder

03

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RESULTS

Test results achieved



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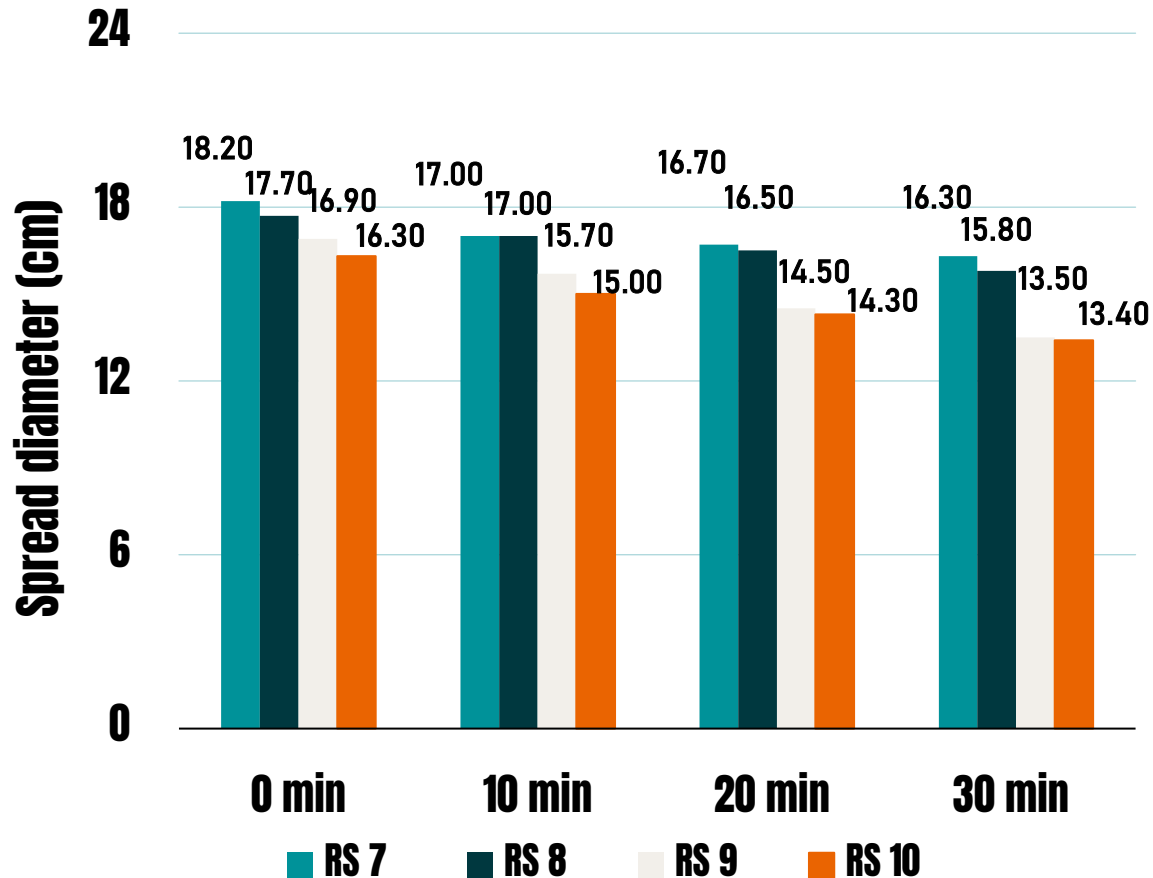
2

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03. Results

EVALUATING THE PRINTABILITY WITH FLOW TABLE TEST

Flow table test results



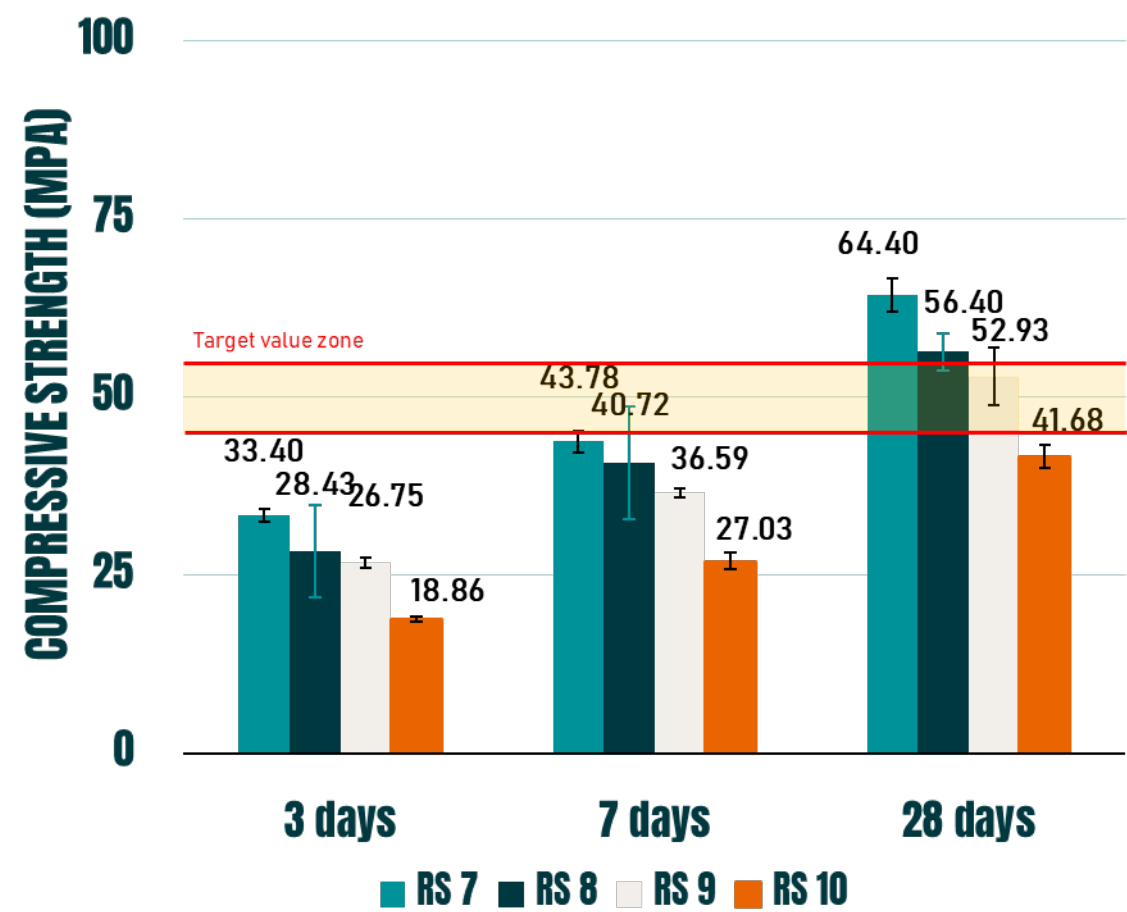
All 4 mixture have a great potential for 3D printing technology.

The spread diameter of the 4 mixtures is within the optimal range

	%NS	%RS
RS 07	75%	25%
RS 08	50%	50%
RS 09	25%	75%
RS 10	0%	100%

03. Results

COMPRESSIVE STRENGTH



Mixture RS 10 fails to satisfy the required compressive strength

Mixtures RS7, RS8, and RS9 achieve the required compressive strength.

	%NS	%RS
RS 07	75%	25%
RS 08	50%	50%
RS 09	25%	75%
RS 10	0%	100%

03. Results

EVALUATING THE PRINTABILITY WITH PISTOL TEST

All 3 mixtures have great printability.

5 layers without deformations- smooth

surface – stable buildability

Printability decreases with time.

%NS

%RS

RS 07

75%

25%

RS 08

50%

50%

RS 09

25%

75%

RS 07



5 min



10 min



20 min



30 min

RS 08



5 min



10 min



20 min



30 min

RS 09



5 min



10 min



20 min



30 min

03. Results

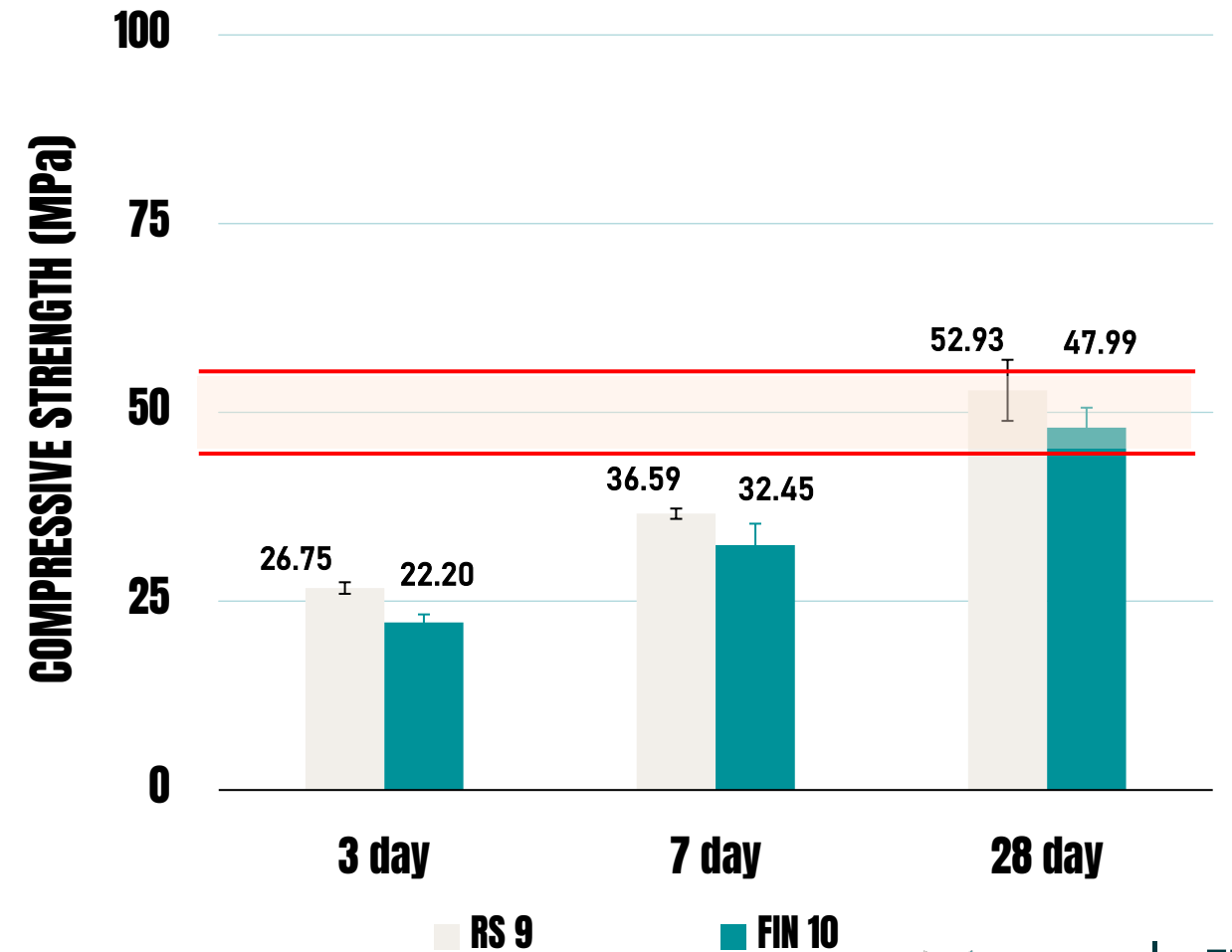
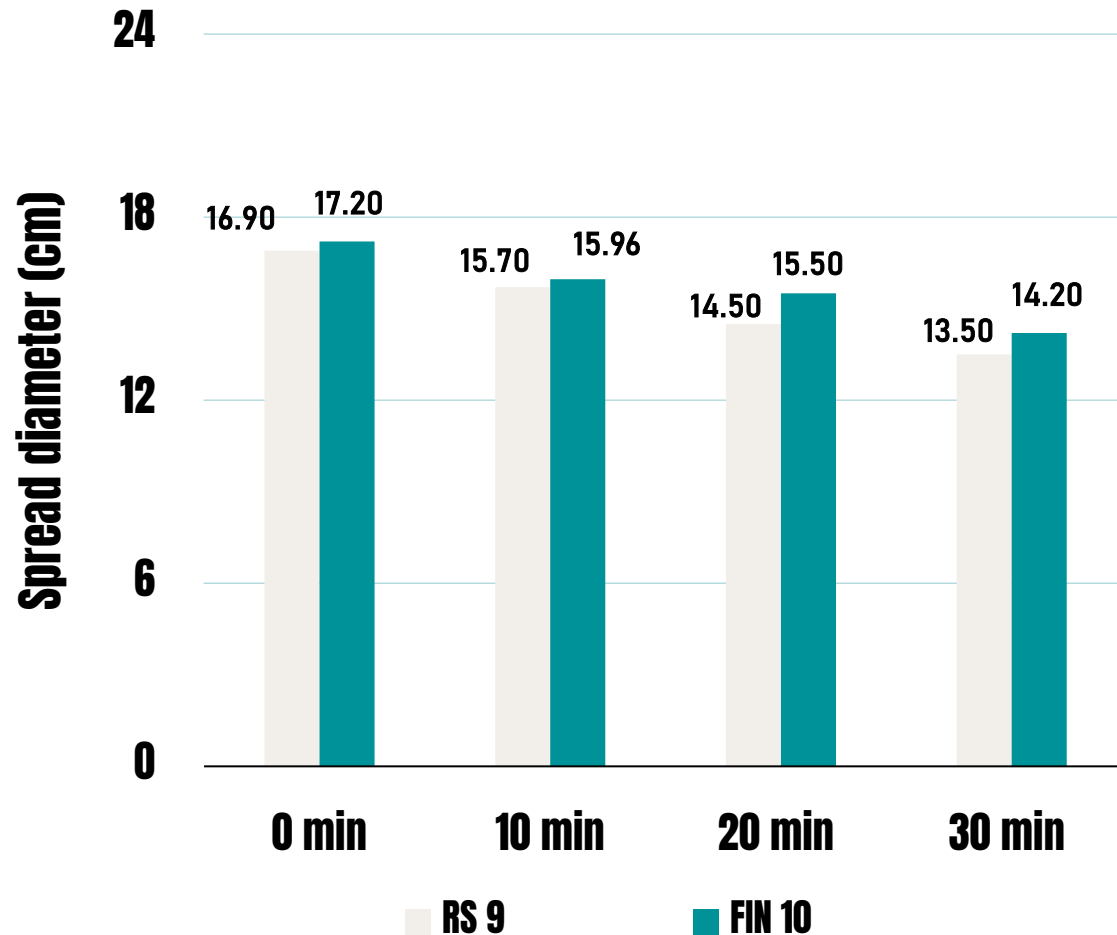
					Quantities (kg/m³)					
Mixture	W/B	S/B	%NS	%RS	Cement	NS	RS	Water	Added water	Superplastizicer (%wob)
RS 07	0.40	1.50	75%	25%	770	866	289	308	40	0.99
RS 08	0.40	1.50	50%	50%	761	571	571	304	79	1.35
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NS: natural sand ; RS : recycled sand ; W/B: water to binder ; S/B : sand to binder ; Added water : balance the water which are absorb by the RS ; wob: weight of binder; **RCCF : Recycled Crushed Concrete Fine**

							Quantities (kg/m³)							
Mixture	W/B	S/B	%Cement	%RCCF	%NS	%RS	Binder	Cement	RCCF	NS	RS	Water	Added water	Superplastizicer (wob)
FIN 10	0.40	1.50	90%	10%	25%	75%	747	672	75	280	840	299	116	1.51

03. Results

EVALUATING THE PRINTABILITY AND COMPRESSIVE STRENGTH



03. Results

EVALUATING THE PRINTABILITY WITH PISTOL TEST

The mixture FIN 10 have great printability.

5 layers without deformations- smooth surface – stable buildability

FIN 10



5 min



10 min



20 min

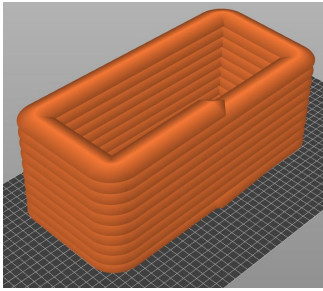


30 min

Next step: Conduct a **printing trial** on the **actual 3D printer**

03. Results

EVALUATING THE PRINTABILITY WITH AN ACTUAL PRINTER



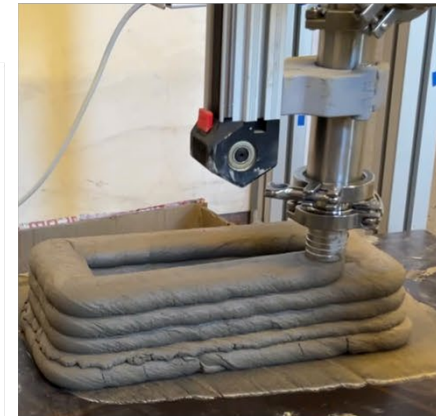
STL file -> G- code



Prepare the G-code



Mix the material, deliver it to the pump



Begin the printing process

03. Results

EVALUATING THE PRINTABILITY WITH AN ACTUAL PRINTER

Pumpability: The material can be transported easily through the printing pipeline.

Extrudability: The printed line is clean, neat, continuous, and smooth.

Buildability: Multiple layers can be stacked without deformation.



04

DISCUSSION



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04. Conclusion

KEY CONCLUSIONS FROM THIS STUDY INCLUDE:

- Fully **recycled sand** can be used in 3D printing technology, with the potential to **replace** up to **75% of natural sand**.
- The **compressive strength** requirements of the material **are met**.
- The **rheological requirements** for 3D printable concrete are also **satisfied**.
- **Recycled crushed concrete fine** can be added to reduce cement usage.

<https://www.heidelbergmaterials.com>



THANK
YOU
for your attention

DO YOU HAVE ANY QUESTION ?

