Demonstration of the use of mine tailings in cement and concrete: From bin to big-bag

The NEMO project has received funding from the European Union's EU Framework Programme for Research and Innovation Horizon 2020 under Grant Agreement No 776846

EIT Raw Materials Week November 2022, Brussels

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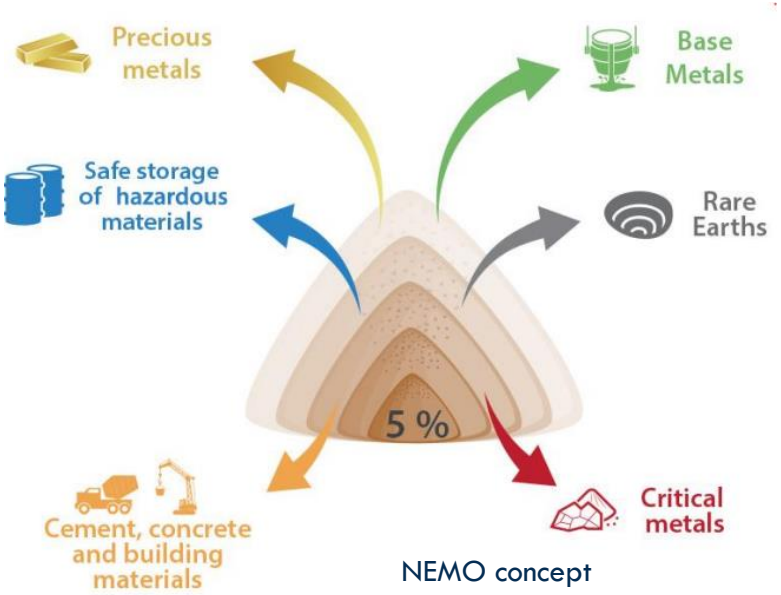
Tailings: a matrix to valorize

- 700 Mt/y of resource is wasted
  - Metals needed for our society
    - Base, precious, rare earths
  - 85-99 wt% = mineral matrix
- 700 x 90% = 630 Mt/y still wasted without matrix valorization

➔ Applications needed for large volume of minerals



NEMO concept

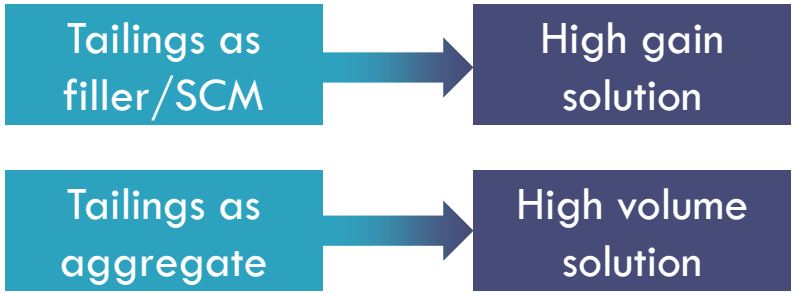
Tailings in construction materials

- Construction sector = largest mineral consumer
  - e.g. EU: aggregates 2900 Mt/y vs. tailings 700 Mt/y
- Construction materials are as variable as tailings
  - Aggregates
  - Cement clinkers
  - Supplementary cementitious materials
  - Alkali-activated materials
  - Ceramics (bricks, tiles)

Pires Martins et al. (2021)

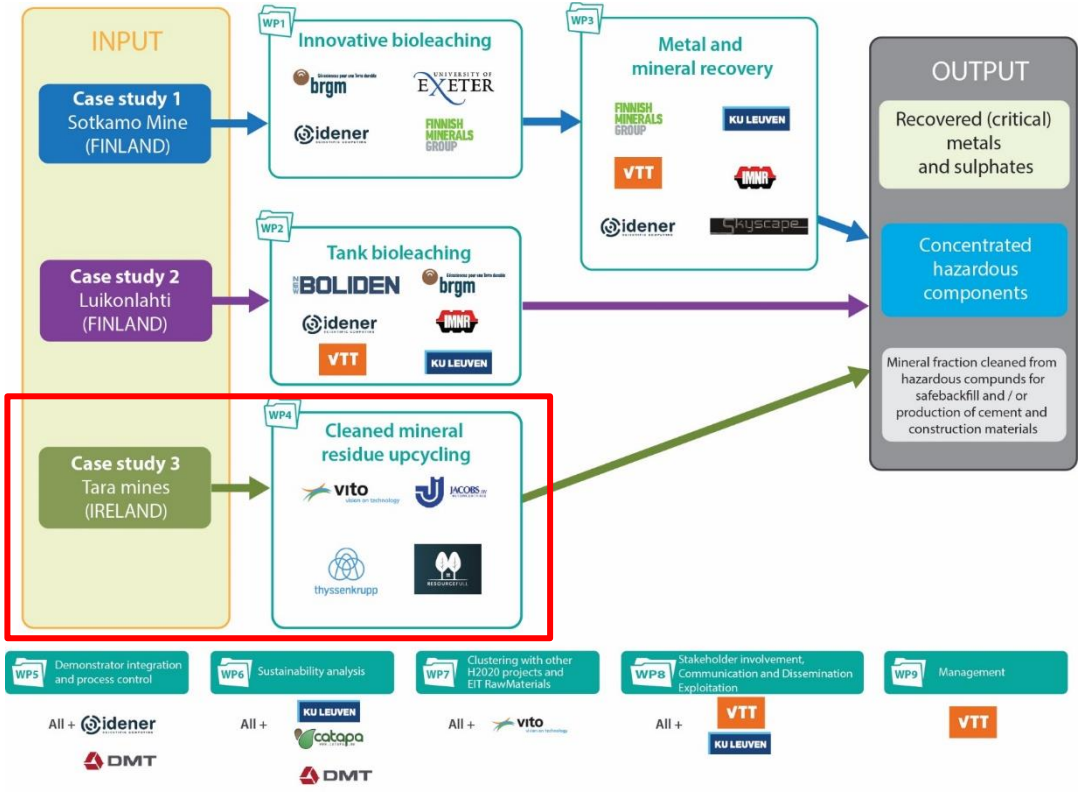
Tailings in cement and concrete

- Tailings = fine powder ➔ use as filler or supplementary cementitious material to replace cement partially
  - Cement replacement = avoiding CO_2 (in line with vision of cement sector towards 2050)
- Use as aggregate? ➔ agglomeration process needed
  - Volume of tailings > consumption of cement << consumption of aggregates



NEMO Matrix valorization

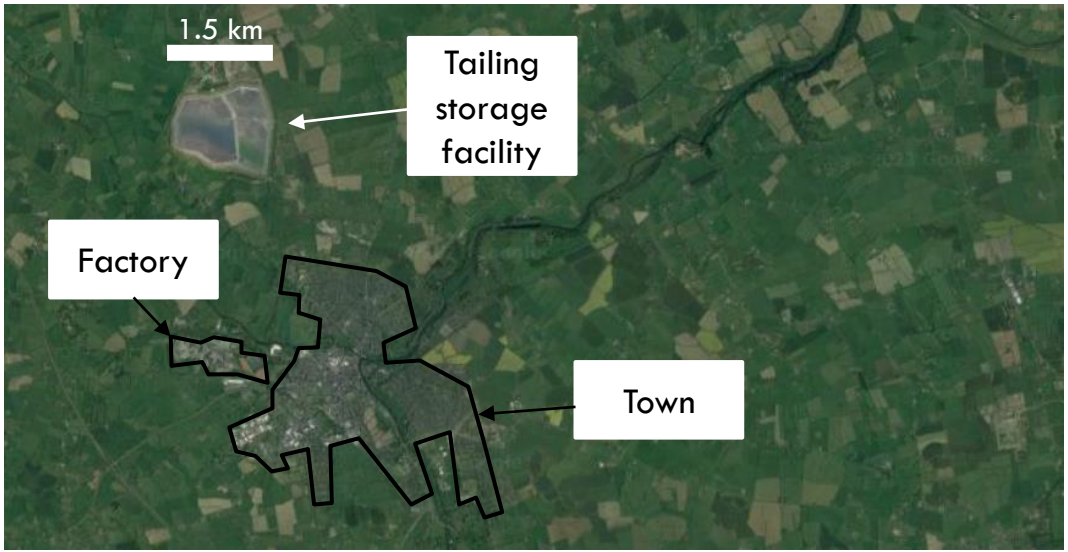
Clean Tara mine tailings upcycling in cement and concrete



The Tara mine, Boliden

Current Operation:

- Underground Zn-Pb mine
- Tailings produced after lead and zinc flotation stages
- Coarse tailings fraction used for back-fill
- Fine tailings fraction - tailings slimes - sent to tailings management facility = NEMO feed material.



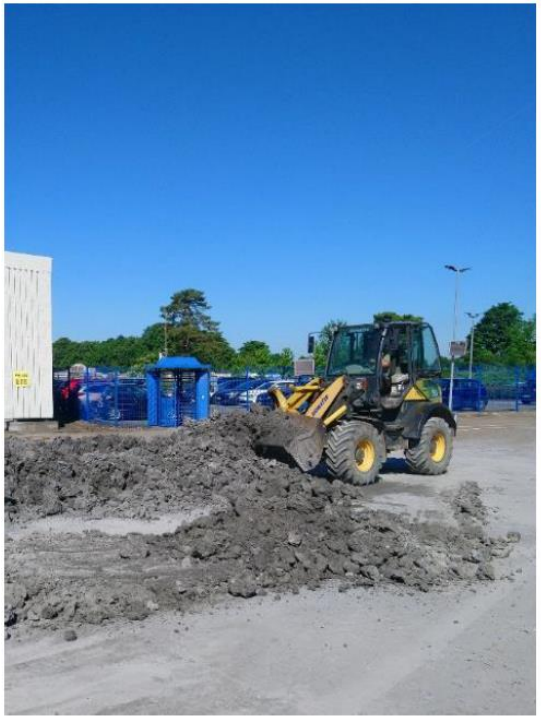
Source: https://www.boliden.com/

Sourcing at pilot scale

- Collection, homogenisation (Boliden, Tara)

Sourcing at pilot scale

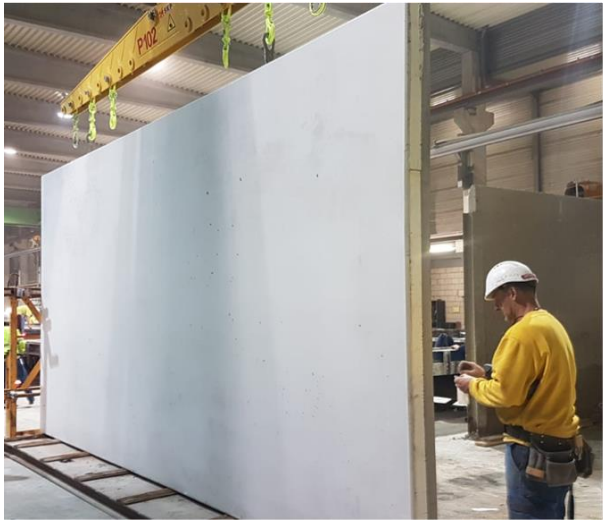
- Drying, bagging (Thyssenkrupp)



Use of Tara tailings in demos

NEMO objectives:

- Use of tailings slimes (fine fraction of tailings) for production of cement & concrete
  - artificial aggregates by granulation of tailings
  - novel composite cement by flash-calcination of tailings
  - demonstration of ready-mix concrete production and application and pre-cast concrete element production at an industrial scale



Example of industrially produced sandwich paneln one of the concrete products that will be produced in NEMO (Source: Resourcefull)

Artificial aggregates by granulation

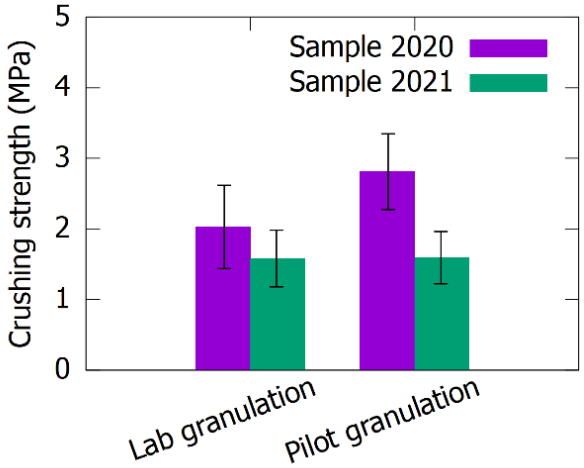
NEMO outcomes:

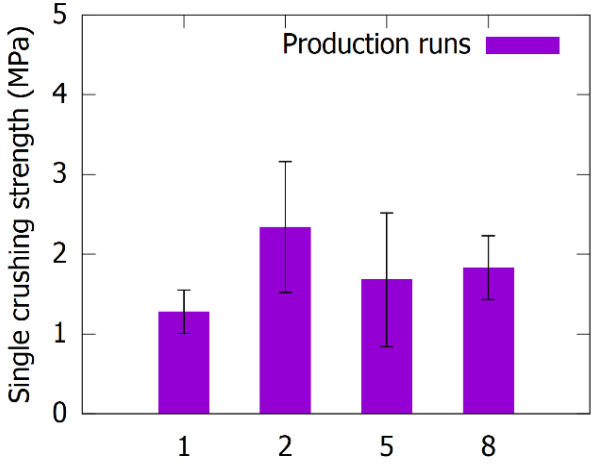
- Target TRL7 production capacity reached: 1 t/d
- No decrease in technical performance vs. lab

Artificial aggregates by granulation

NEMO outcomes:

- No decrease in technical performance vs. lab
- Variability needs to be taken into account (heating up/wetting of mixer in subsequent production runs





Flash calcination pilot trials

- Presence of pyrite (FeS_2) in tailings in unwanted for cement
- Flash calcination of the material at 550°C to obtain fine filler
  - Enables oxidation of **FeS_2** while Barite is still stable
  - Avoids decarbonation of Calcite and Dolomite

		Before FC	After FC
Quartz	Mass.-%	26	28
Orthoclase	Mass.-%	2	2
Plagioclase	Mass.-%	5	6
Pyrite	**Mass.-%**	**3**	**0**
Calcite	Mass.-%	40	38
Dolomite	Mass.-%	11	11
Muscovite	Mass.-%	7	6
Hematite	Mass.-%	0	2
Barite	Mass.-%	5	5
Gypsum	Mass.-%	1	0
Anhydrite	Mass.-%	0	2
Lime	Mass.-%	0	1

Concrete Introduction

Traditional concrete

NEMO concrete

Concrete development

3 Types of concrete will be validate in this project:

Prefab – Pressed Paver

Ready Mix

Prefab – SCC

Concrete development

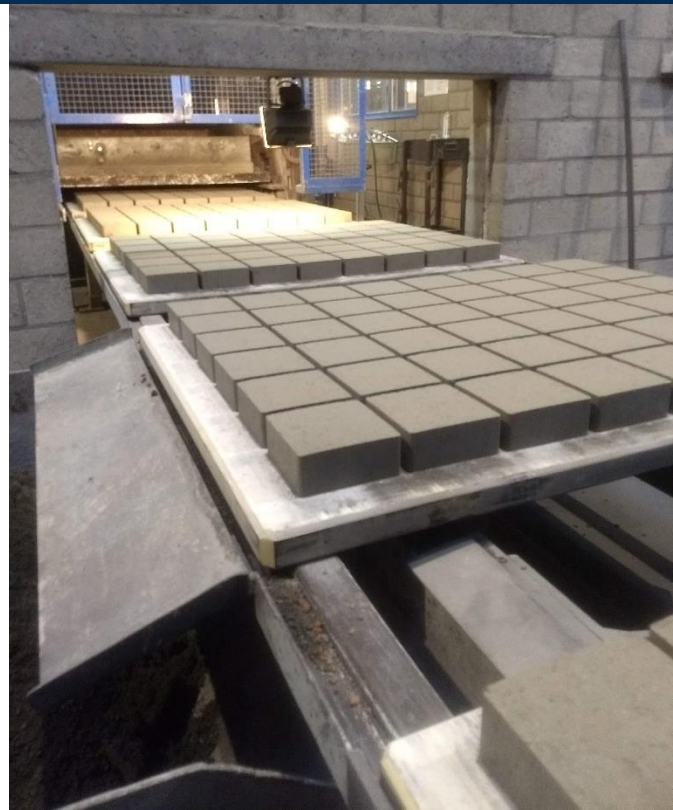
Pavers: pressed concrete in 148 X 148 X 60 mm^3 - units
800 pavers were produced

Production of earth moist concrete:

- Binder = 225 kg CEM I + 75kg GGBFS per m^3
- w/b = 0,37

Production of with NEMO filler:

- Binder= 210 kg CEM I + 90 kg NEMO per m^3
- w/b = 0,37



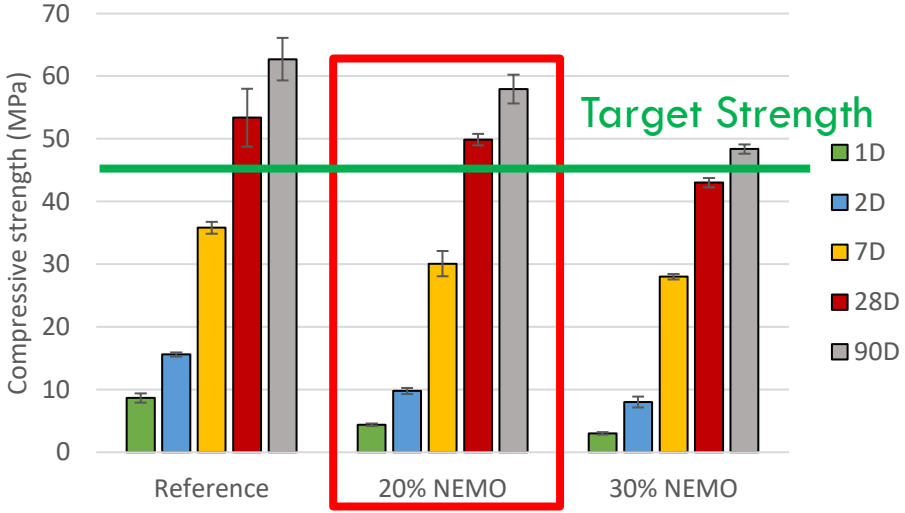
Concrete development

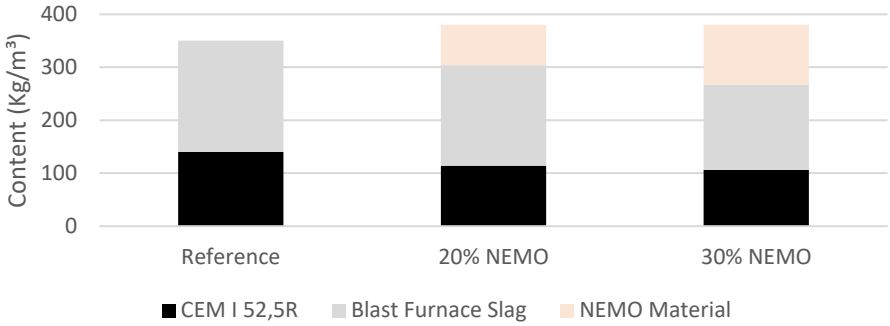
Ready Mix concrete: C30/37 EE3 – S4 castable:

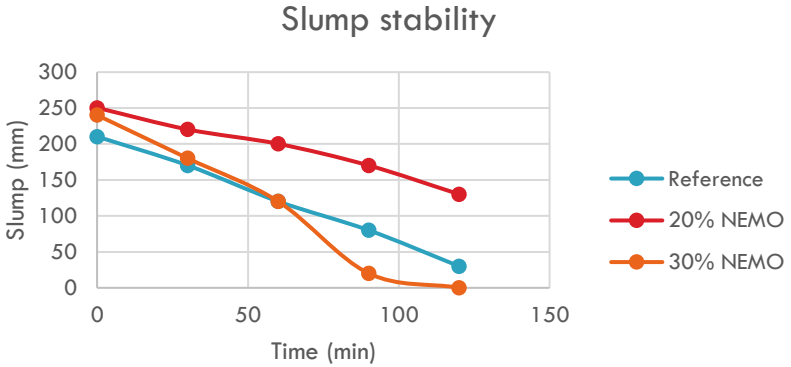
Target strength: 45 MPa at 28 days

Workability over 120 min in 35°C

Conform EE3 durability class







Concrete development - Pilot

NEMO material in self-compaction C30/37 EE3 – class concrete for ready-mix

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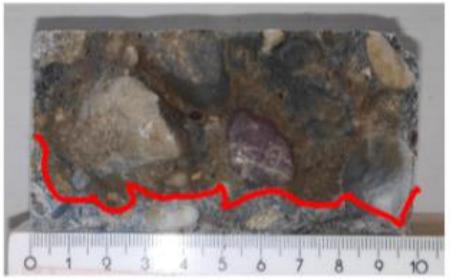
Concrete development

Extensive Durability study following equivalent concrete performance:

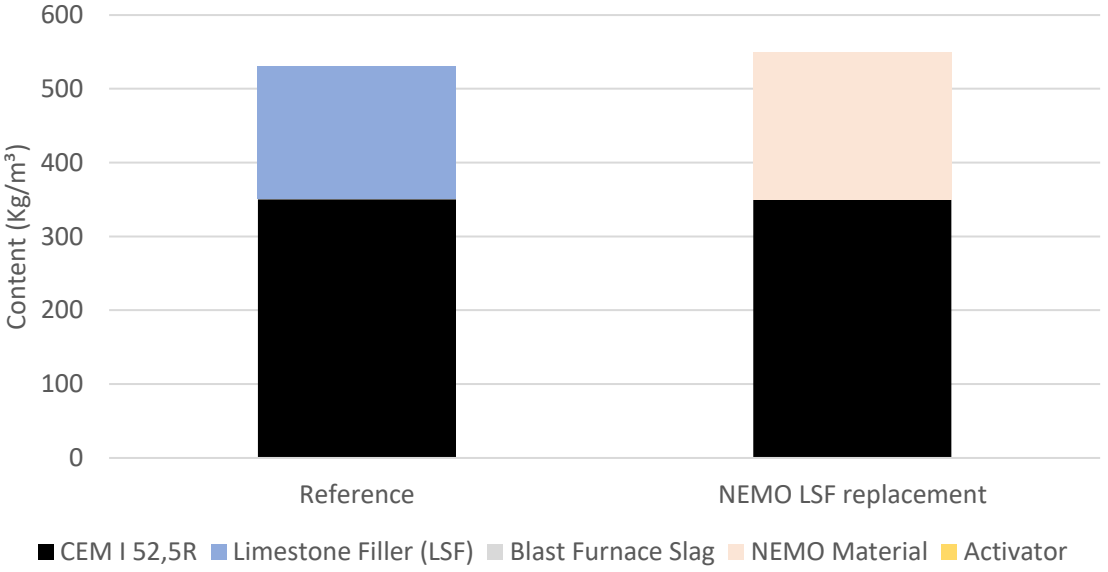
Slump stability	EN 12350-2	DONE	Fresh properties
Fresh density	EN 12350-6	DONE	
Air content	EN 12350-7	DONE	
Compressive strength	EN 12390-3	DONE	Mechanical properties
Flexural strength	EN 12390-5	DONE	
Freeze and thaw - Scaling	EN 12390-9	DONE	Durability properties
Water absorption	NBN B 15-215	DONE	
Shrinkage	EN 12390-16	DONE	
Carbonation	EN 12390-12	DONE	
Chloride Migration	NT Build 492	DONE	



Concrete development

NEMO material in self-compaction C30/37 EE3 – class concrete for prefab:

- (1) as replacement for the lime stone filler
- (2) as additional fine filler in combination with alternative binder



Concrete development

- Pilot is completed – Production finalized on 12/04/22
- 5,6 m³ (13,2 tons) of prefab concrete produced containing 840kg of calcined Tara tailings

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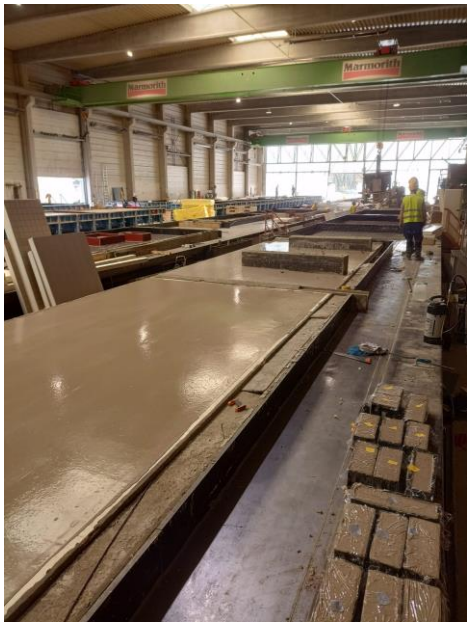

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