
reconstruct
Circular Territorial Solutions for the Built Environment

reconstruct

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WHAT

A **research project**, funded by

- European Union, HORIZON 2022
- UK Research and Innovation

Central objective

- a circular future for concrete
- generate fewer emissions
- lowering primary resource consumption and waste production

Timing

- June 2023 - May 2027

HOW

Three innovation strategies

- low-carbon concrete compositions
- design for deconstruction
- digitalisation as a support to close the material loop

Learning by doing

- 2 pilots
- in Brussels and Barcelona

WHO

16 partners from across the continent,

- both industry and research
- coordinated by **ITeC** (ES)

2 stakeholder clusters

- in Brussels and Barcelona

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Material innovation

- Replacing ordinary Portland cement with **low-carbon, alkali-activated alternatives**.
- Replacing steel bars in concrete with **textile or bio-based reinforcement**.
- Manufacturing concrete components incorporating **recycled materials** (aggregates, slag, etc.)

Design for deconstruction

- Integrating the **deconstruction process** from the buildings initial design phase.
- The construction of structures concept as a **kit of parts**, made of prefabricated modular components that are easy to assemble and dismantle.
- From demolition and recycling of materials to **deconstruction** and **reuse of components**.

Digitalisation

- AI-based **geolocalisation** and **image processing** technology for material sourcing.
- Tracking and tracing with **product passports** and **digital twinning** in BIM.
- **Market places** for the **reuse/resale** of the reclaimed components and materials.

Two demo buildings

BARCELONA

BRUSSELS

Two demo buildings

BARCELONA

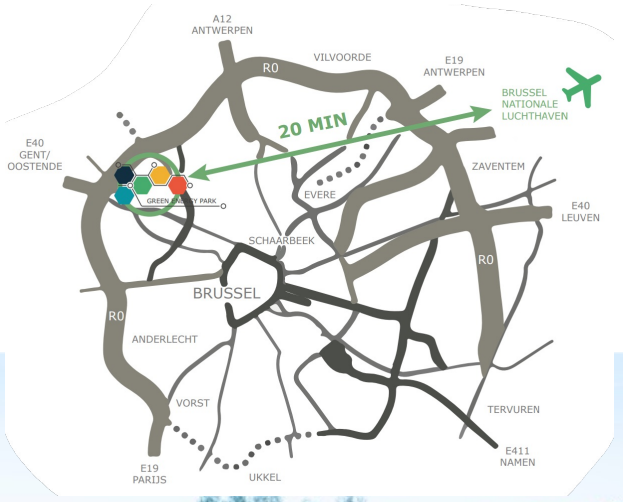
BRUSSELS

Client
Green Energy Park

Research partners
Vrije Universiteit Brussel (ARCH, MEMC, FYSC)

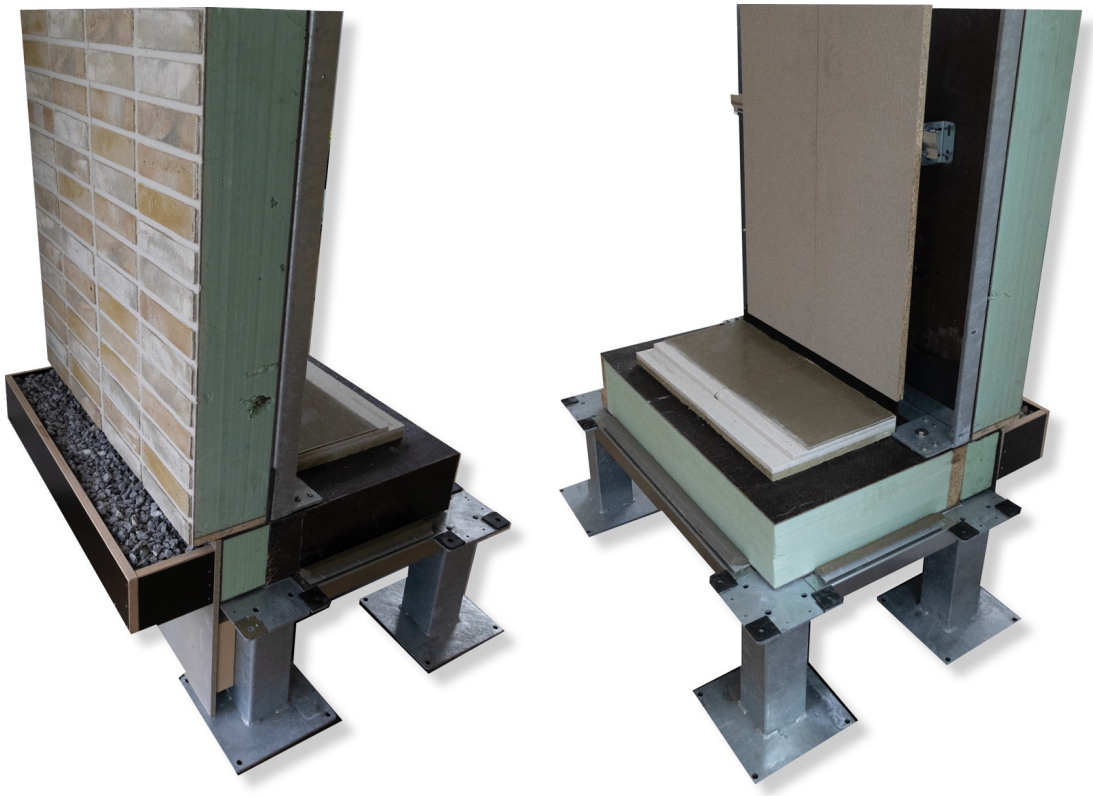
Industrial partners
Holland Composites, Ecocem, Silmaco, Poraver

Demo site | Green Energy Park



The Qbix System | Holland Composites

Model of the current Qbix building system, showing the foundation concept and the hybrid façade structure.



Lightweight structural frame made of steel beams and columns, resting on concrete blocks. Wall panels that can be replaced without compromising the structural integrity of the frame.

The Qbix System | Holland Composites

THE SYSTEM

The **Duplicor façade panels**

- are 150 mm thick sandwich elements
- with a U-value of 0,23 W/m^{2}K.

combining

two 3 mm Duplicor **laminate shells**,

- made of **glass fibre** and **bio-resin**

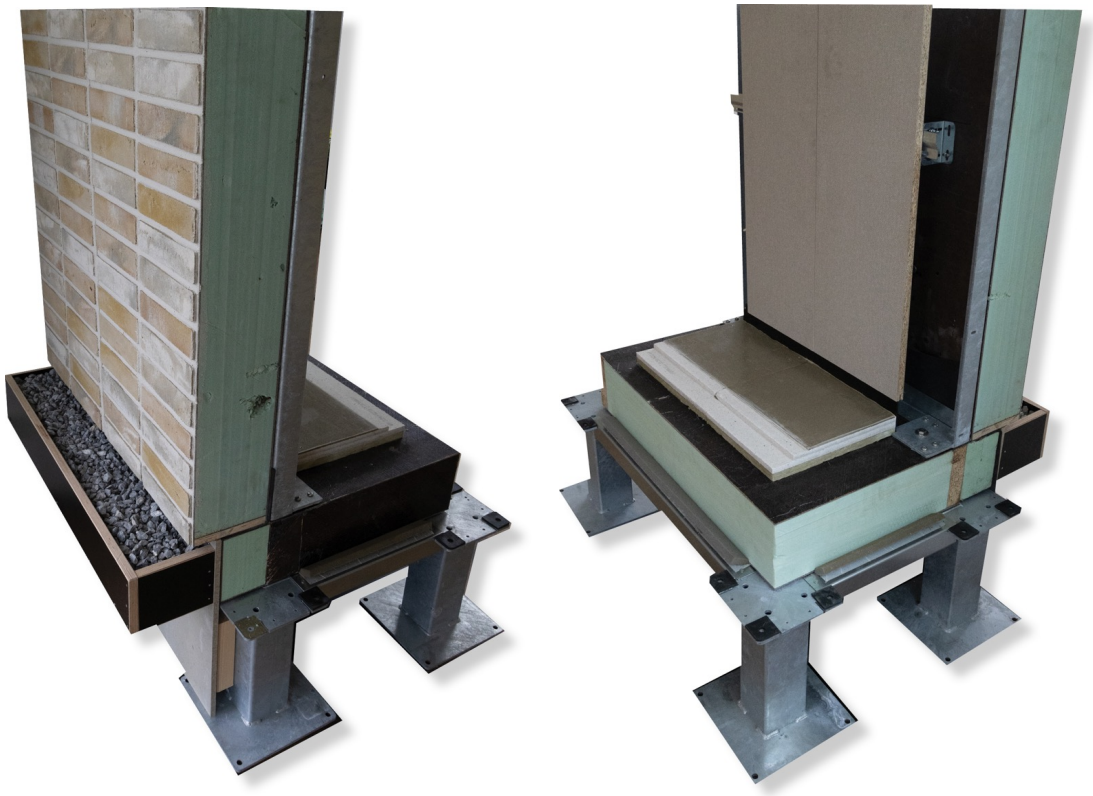
with a 150 mm **core**

- made up of 3 layers of **ArmaPET** Eco50 closed cell insulation foam

THE CHALLENGE

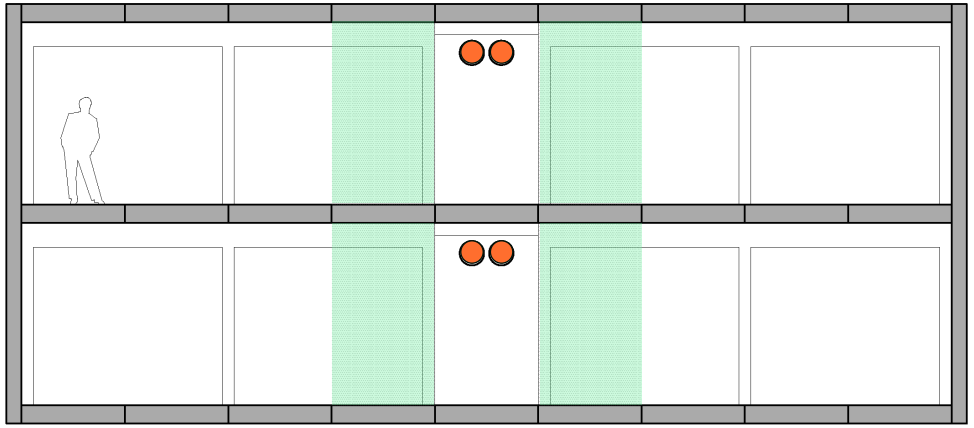
The system is designed for **single-storey residential** use.

For use in **tertiary, multistorey buildings**, more mass is needed to fulfill the structural, acoustic and fire safety requirements → concrete



Lightweight structural frame made of steel beams and columns, resting on concrete blocks. Wall panels that can be replaced without compromising the structural integrity of the frame.

Design for change

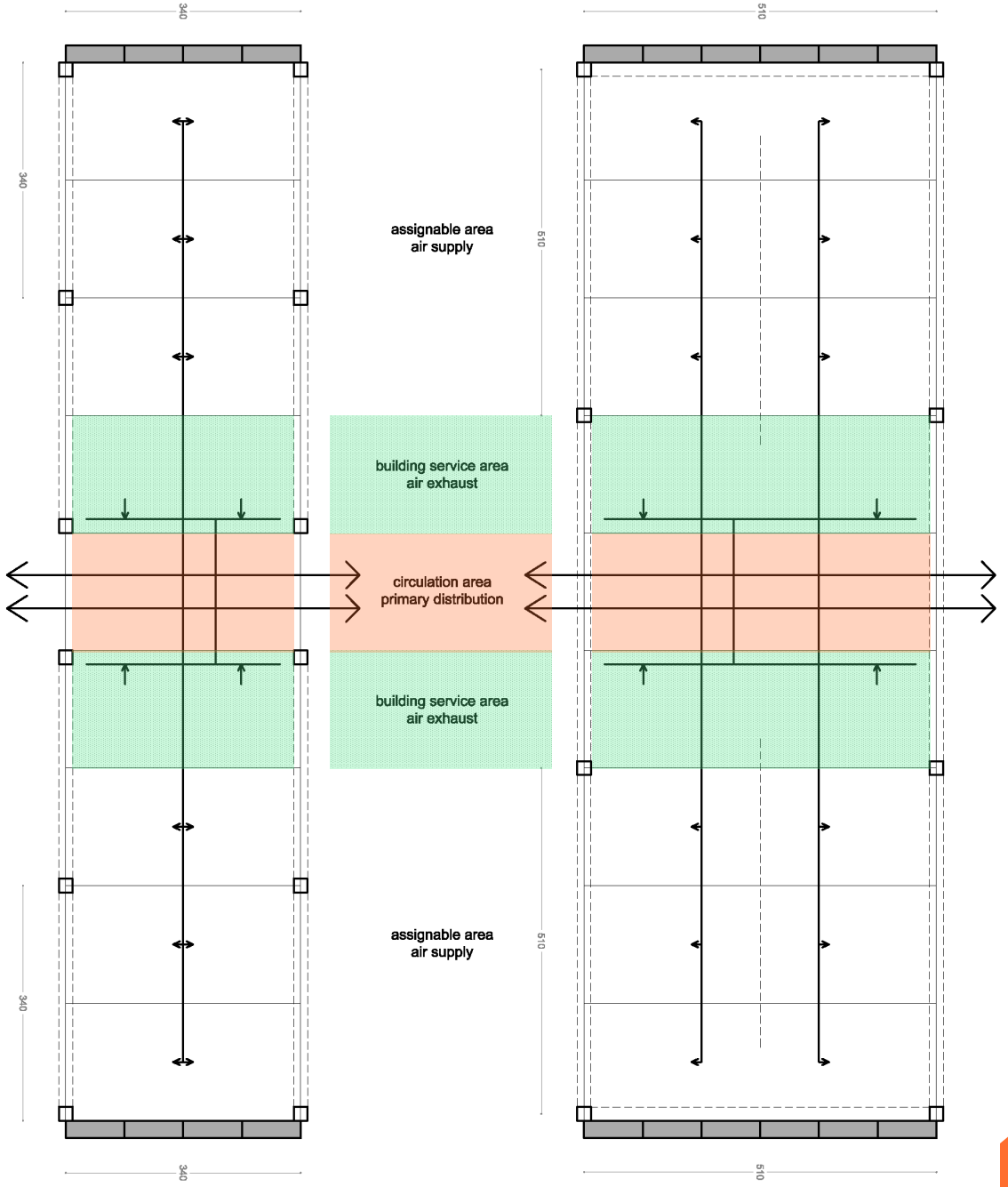


GRID SYSTEM

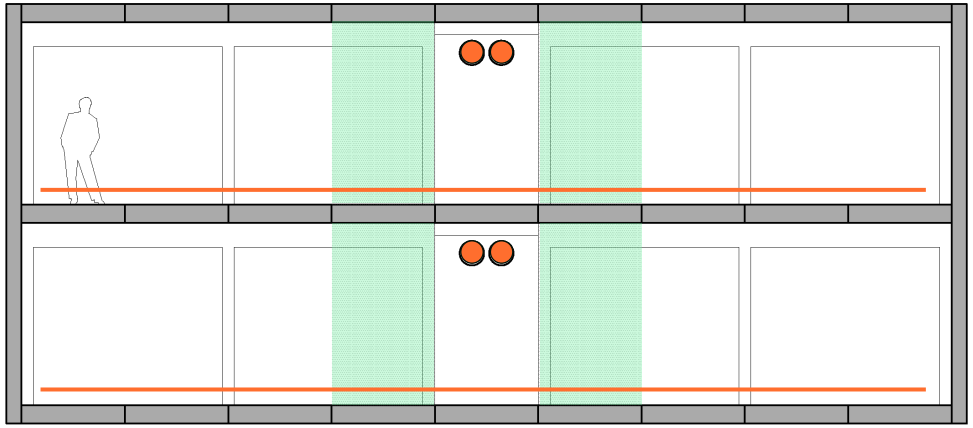
2 design options to upscale the Qbix system for **zoned, tertiary use**, exploring **spatial adaptability** and **functional layering**

- based on the **Qbix grid system**, with
  85 cm façade elements and 340x170 cm floor elements

- using a **primary structure** of
  340x340 cm or 510x510 cm



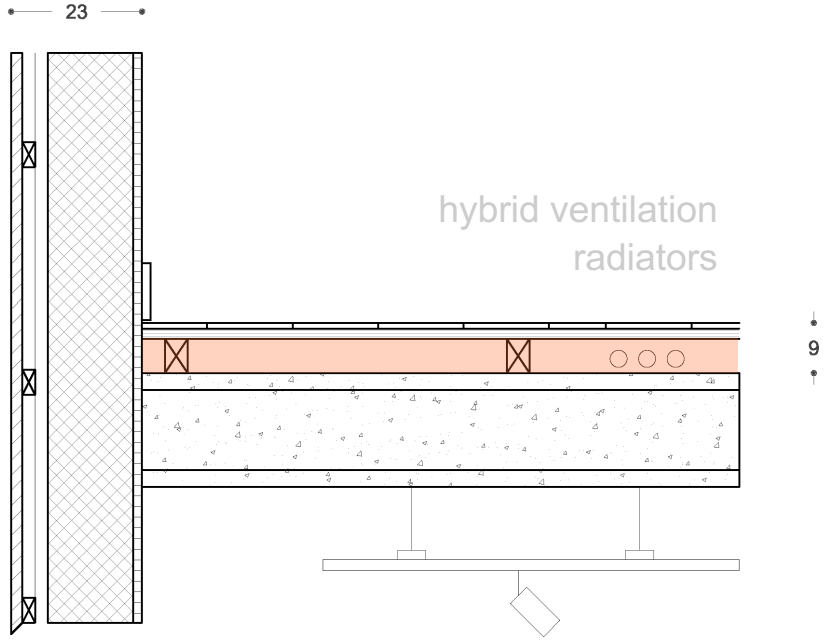
Design for change

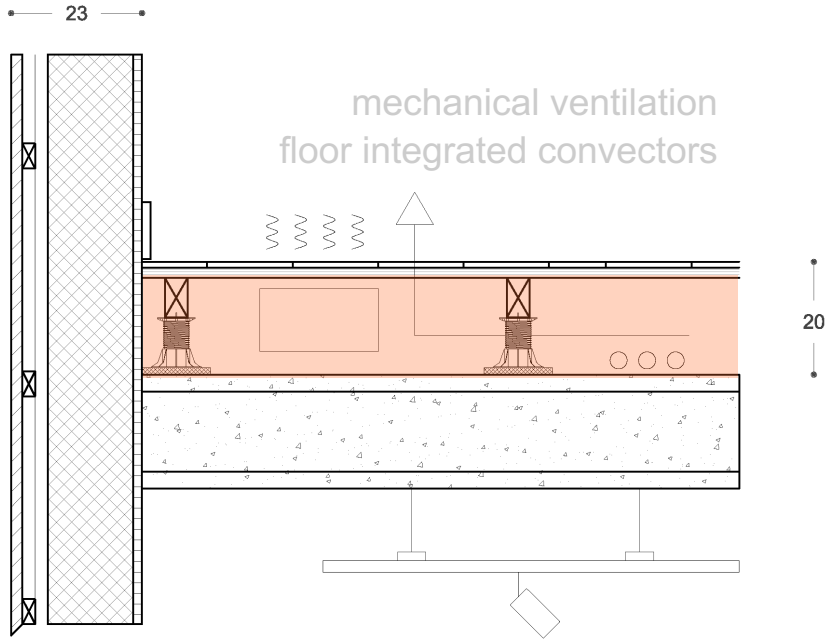


SUPPORT AND INFILL

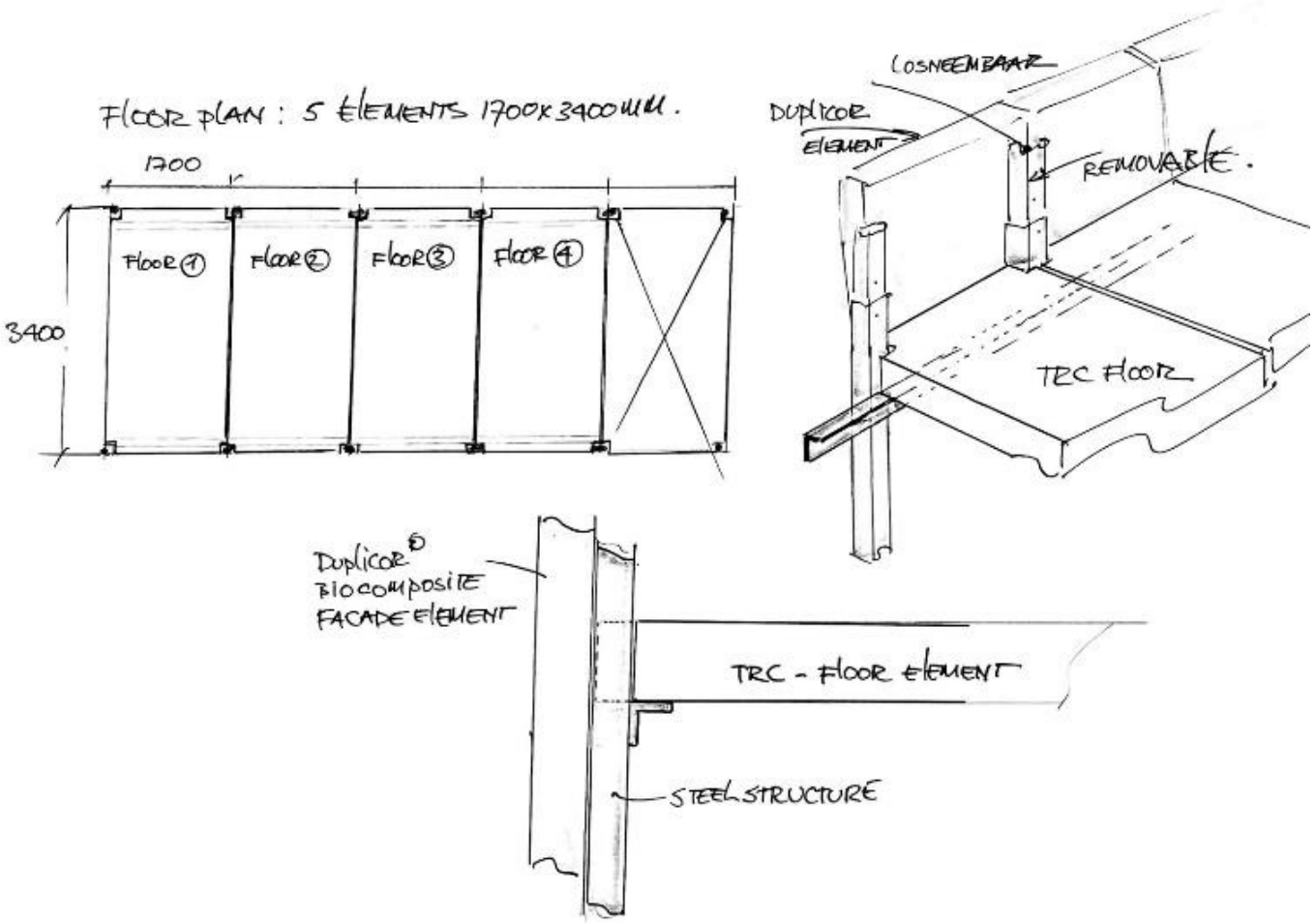
2 design options to upscale the Qbix system for **zoned, tertiary use**, exploring **spatial adaptability** and **functional layering**

- proposing dry construction, **technical flooring solutions** for low- and high-volume building services
- enabling **transformations** from tertiary to residential uses and back





Design for deconstruction



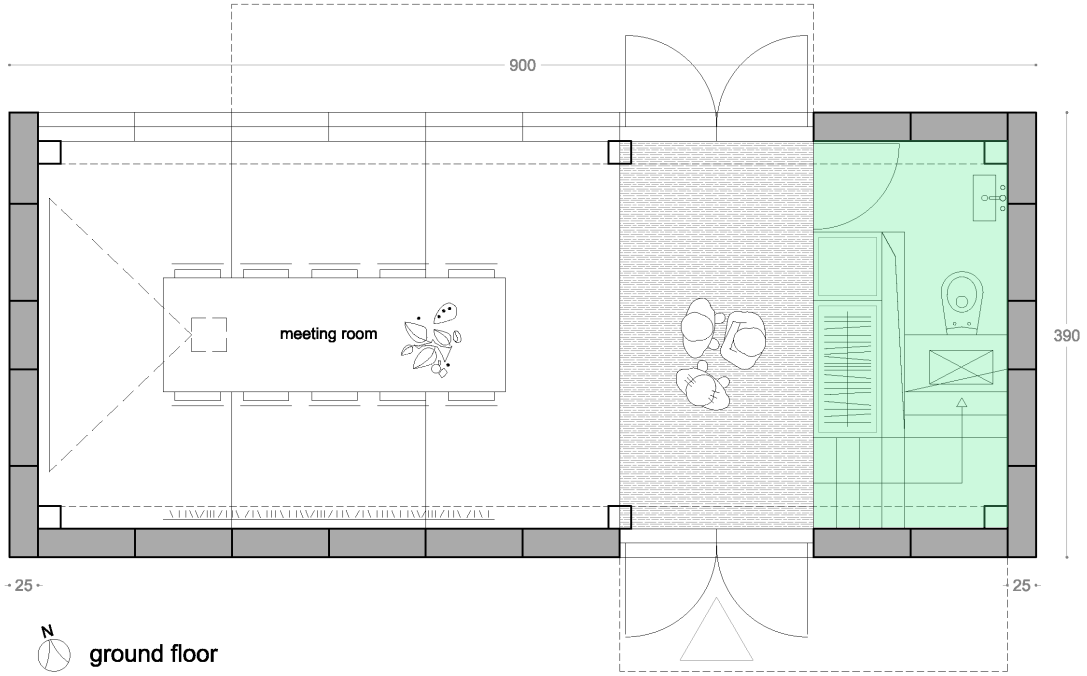
STRUCTURAL HIERARCHY

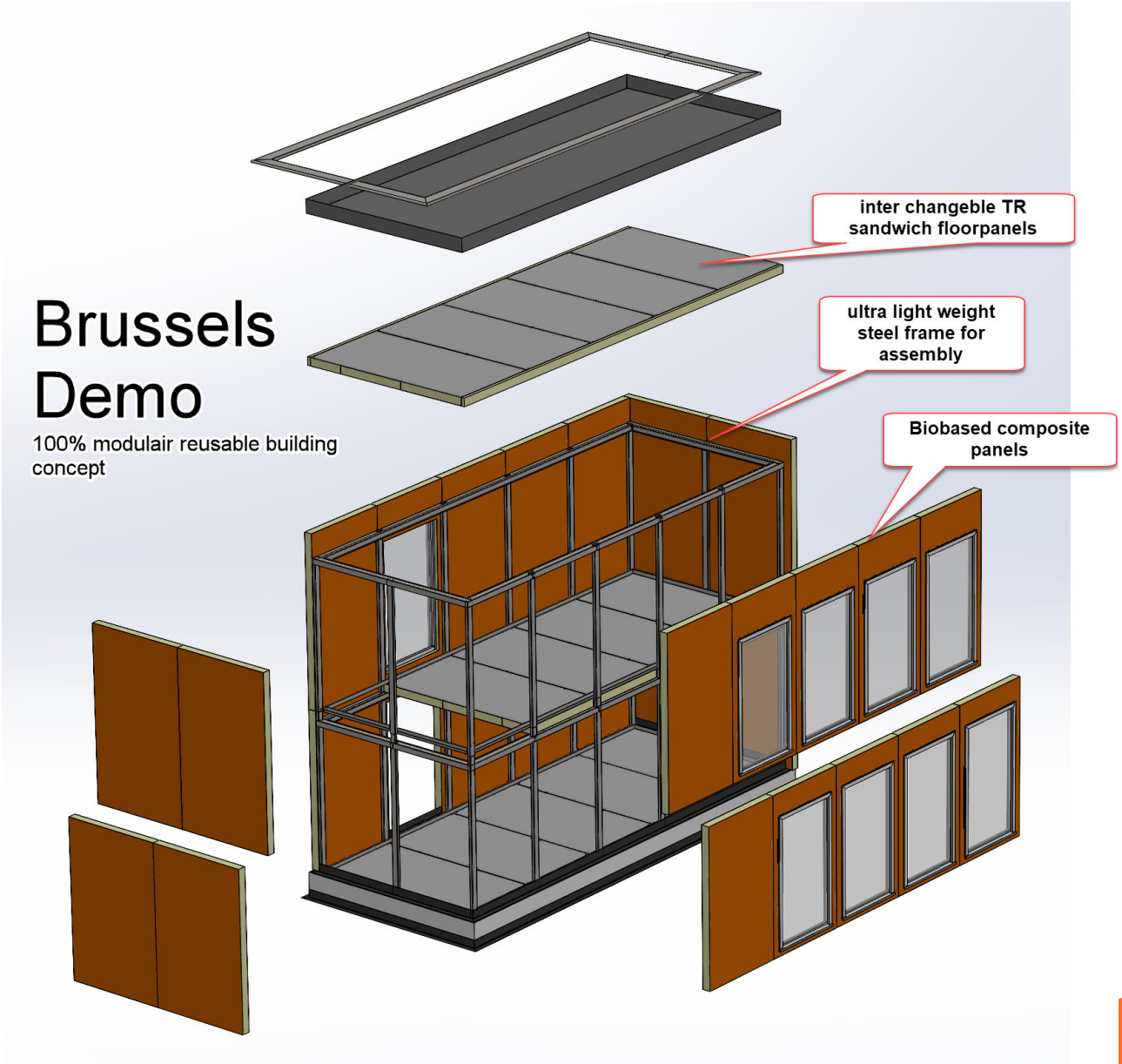
To allow **changing the plan layout**
and enable **reuse** at the end of life,
we made the storey floors **removable.**

To do this, the **structural logic** was adapted from

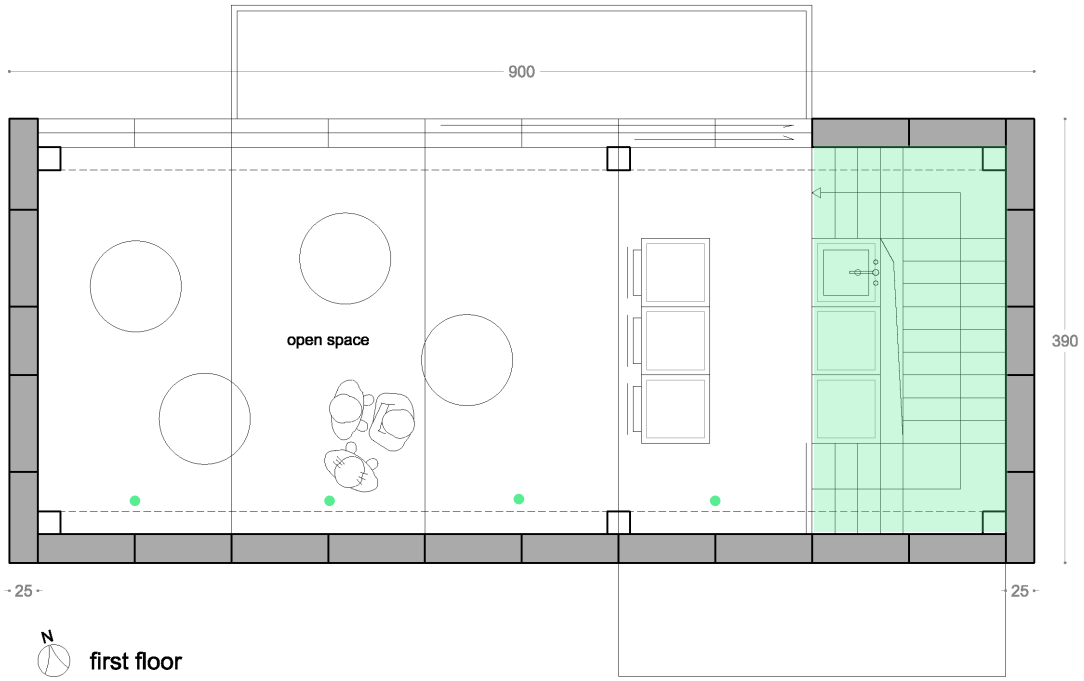
- a **stack** approach**,** with columns standing on the floor elements
- to an **infill** approach**,** with continuous columns and floors resting on horizontal beams between them

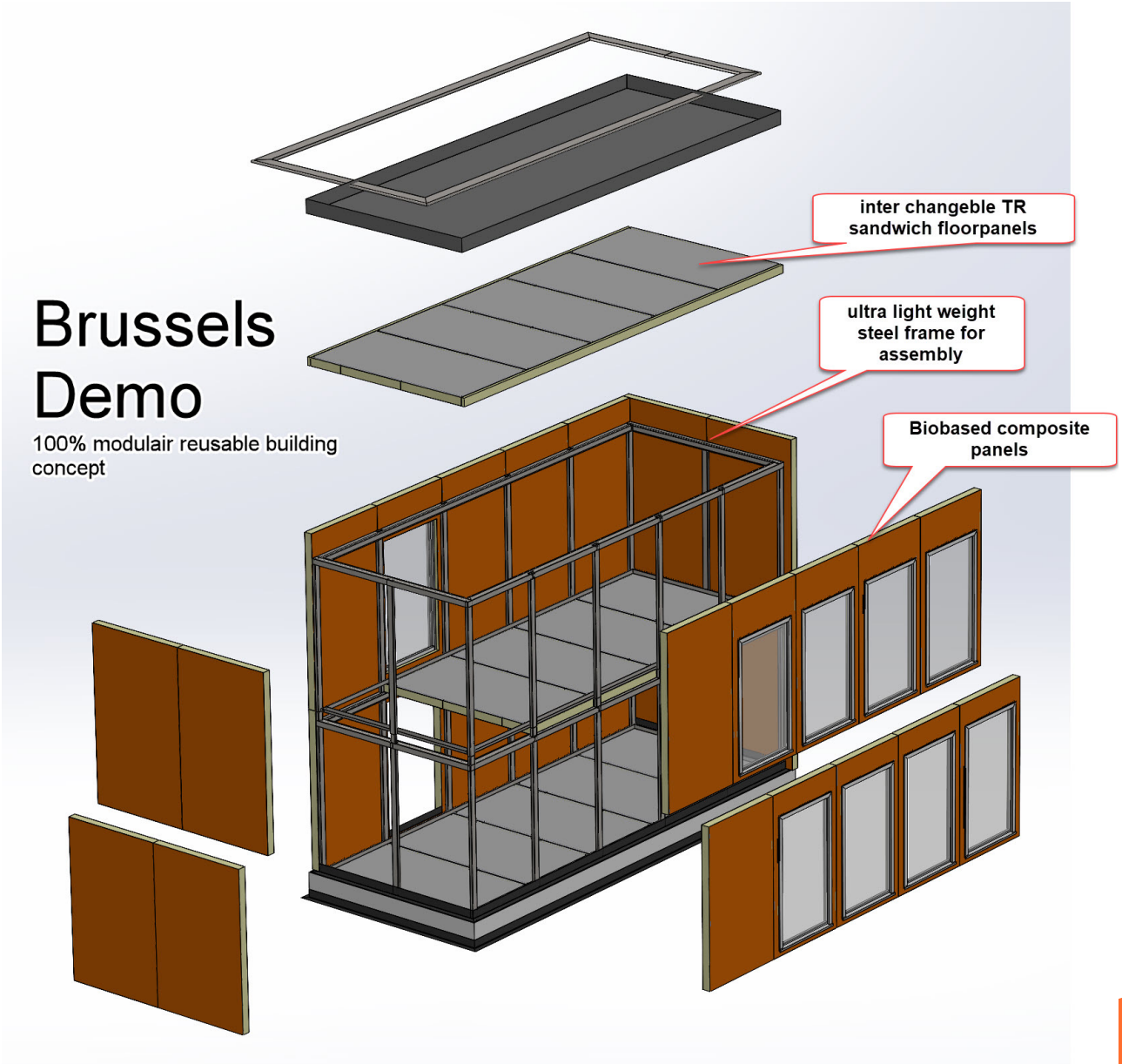
The demo


900
meeting room
390
25
25
N
ground floor


Brussels
Demo
100% modulair reusable building concept
inter changeble TR sandwich floorpanels
ultra light weight steel frame for assembly
Biobased composite panels

The demo


900
open space
390
25
25
N
first floor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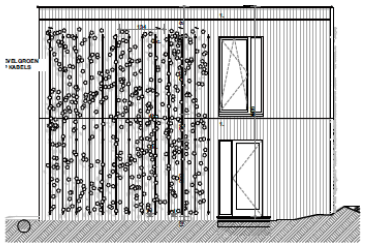
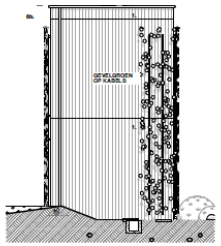
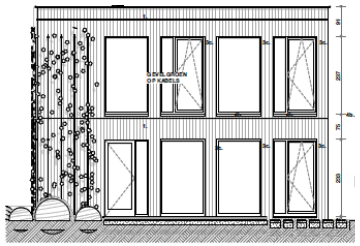


GEVEL R1 - ZUID



GEVEL R2 - OOST

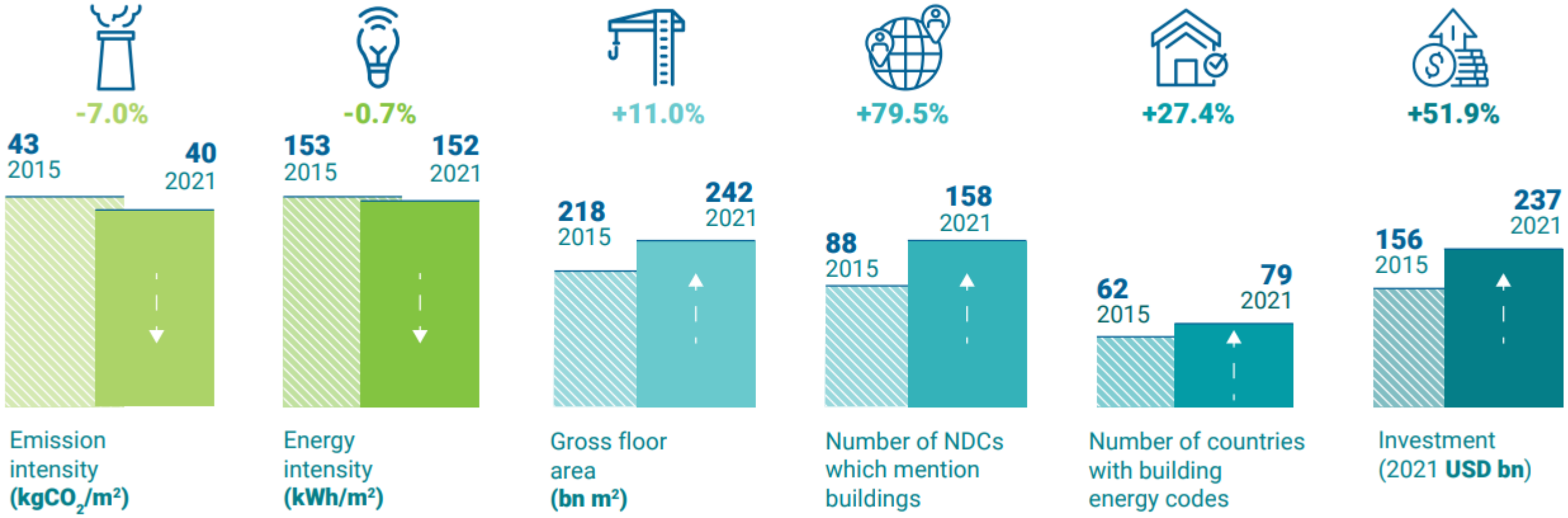


GEVEL R3 - NOORD

Lightweight resource-efficient floor system

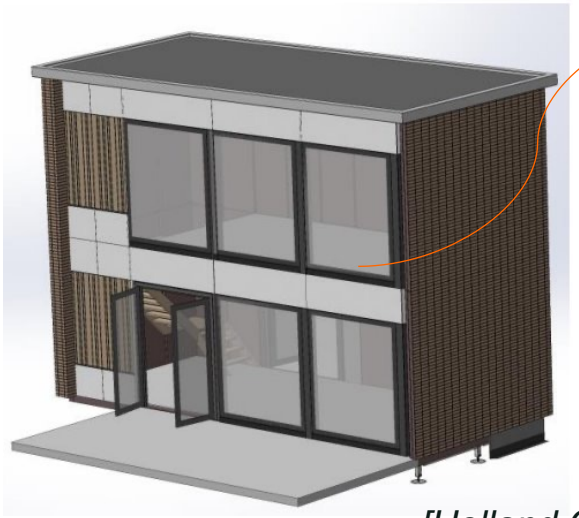
FOCUS ON EMBODIED CARBON

Energy efficiency investments overruled by increasing floor area

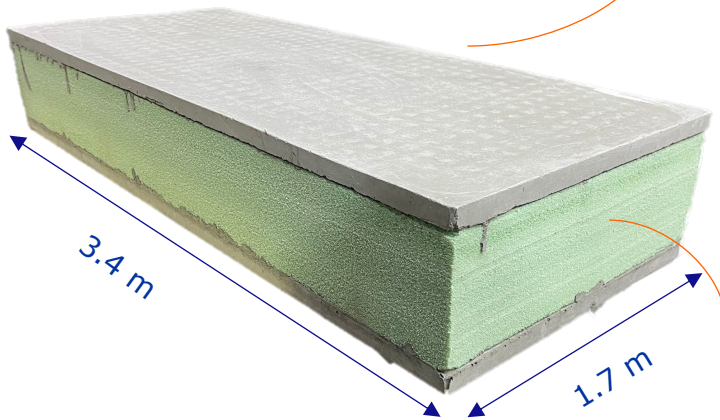


[UNEP Global Status Report for Buildings and Construction 2022]

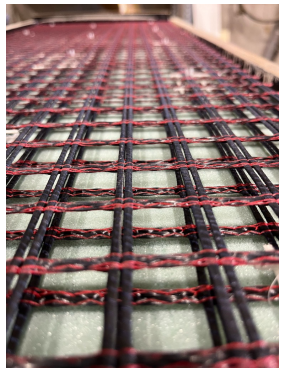
Development of a lightweight and modular TRC sandwich floor system



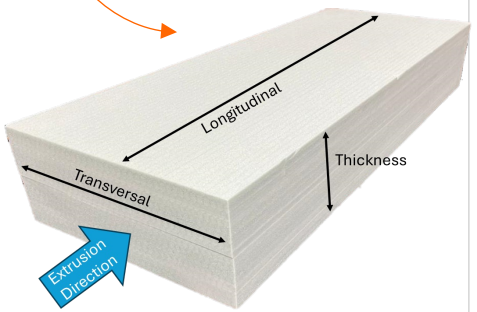
[Holland Composites]

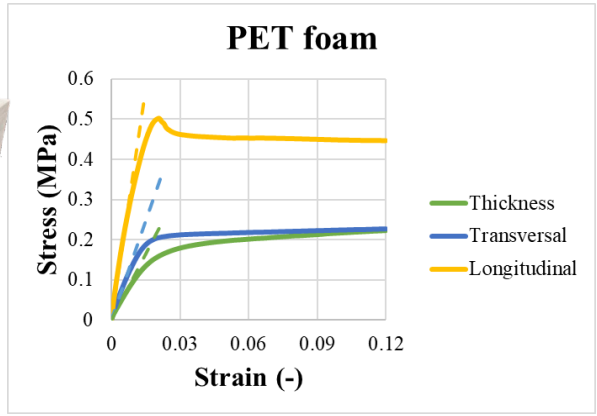


Lightweight modular TRC sandwich floor system



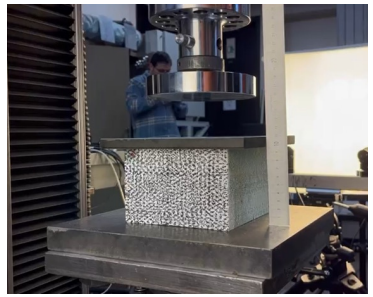
Only 22 mm thickness
(carbon) fibre textile reinforcement
No steel reinforcement

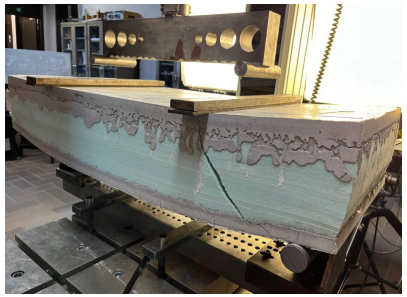


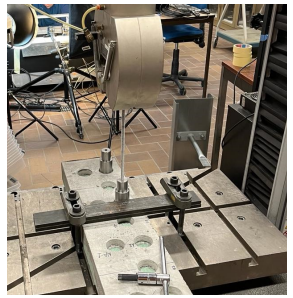


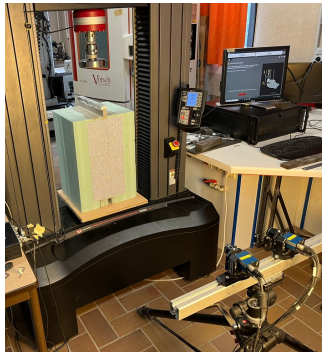
Recycled PET foam

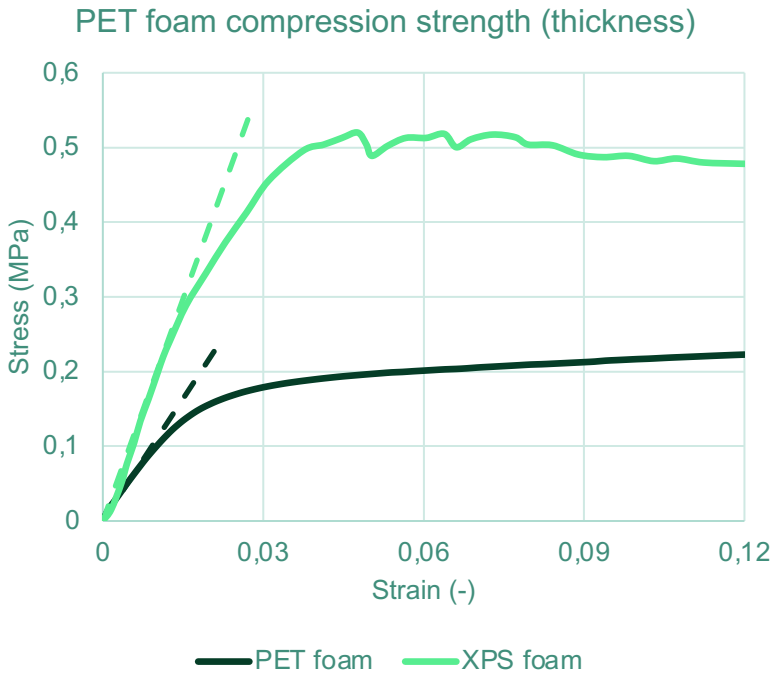
Challenges using recycled PET foam core vs. XPS

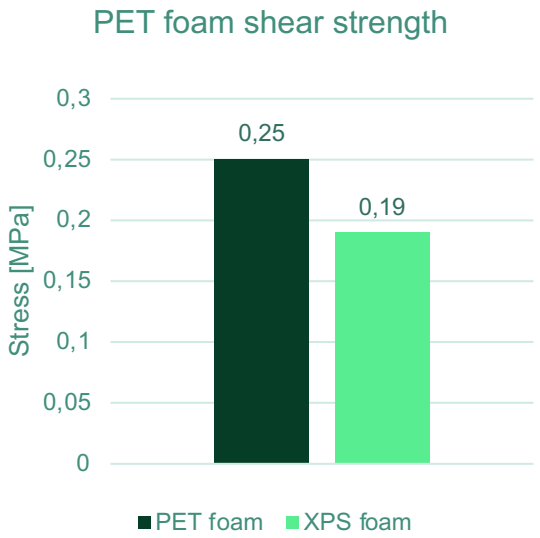


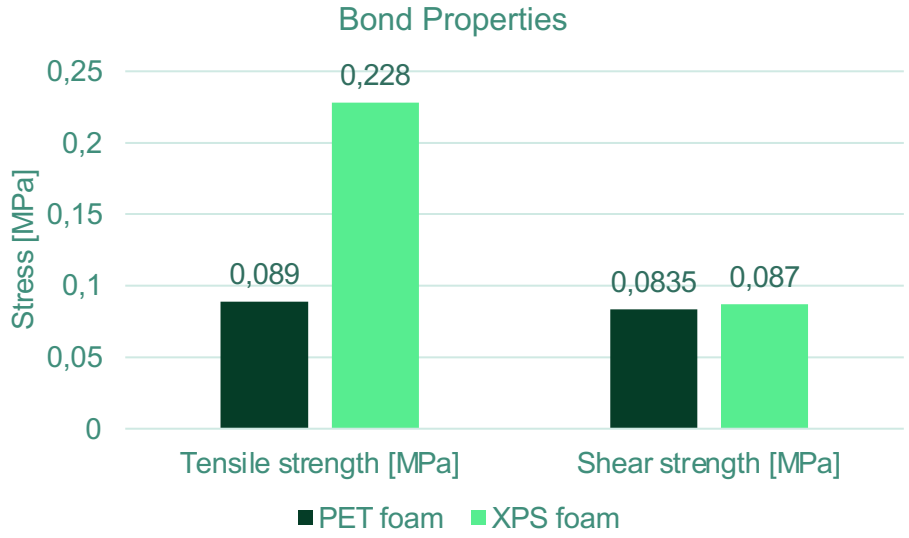










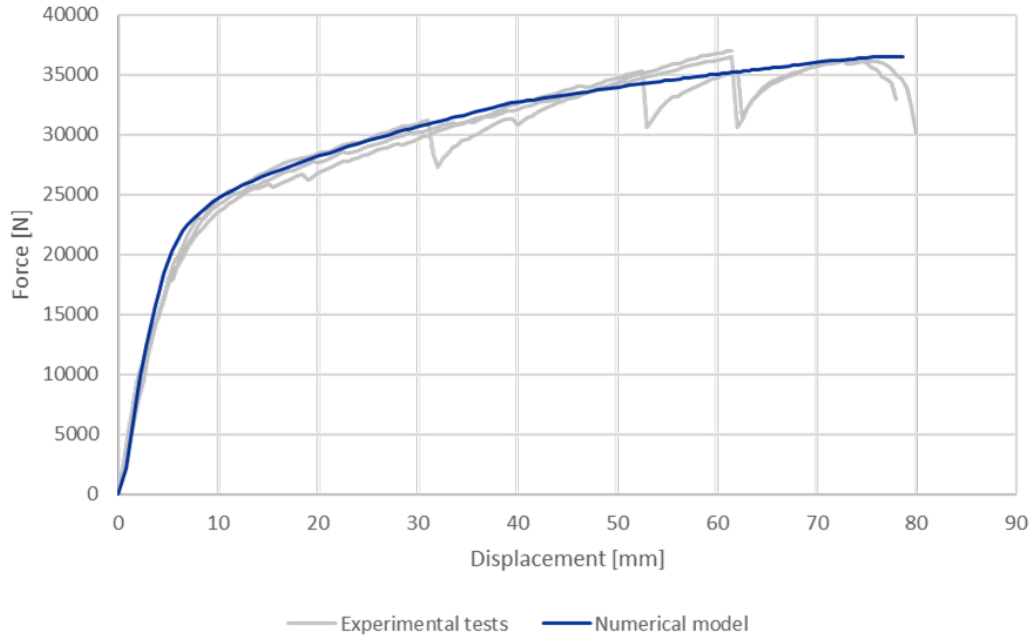


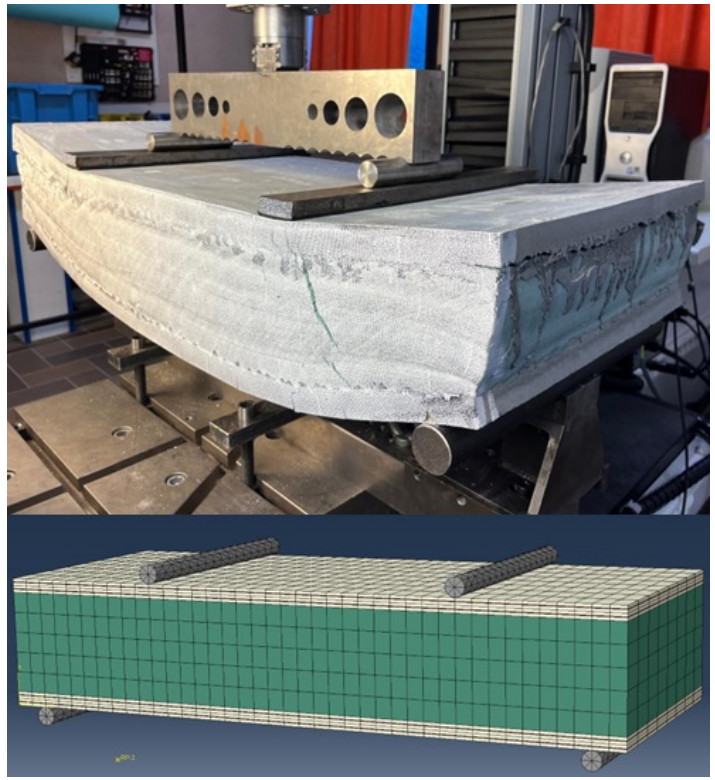
XPS foam density = 33.5 Kg/m³ [Vervloet, 2019]
PET foam density = 58.8 kg/m³

Development of a lightweight and modular TRC sandwich floor system

Model input & definition

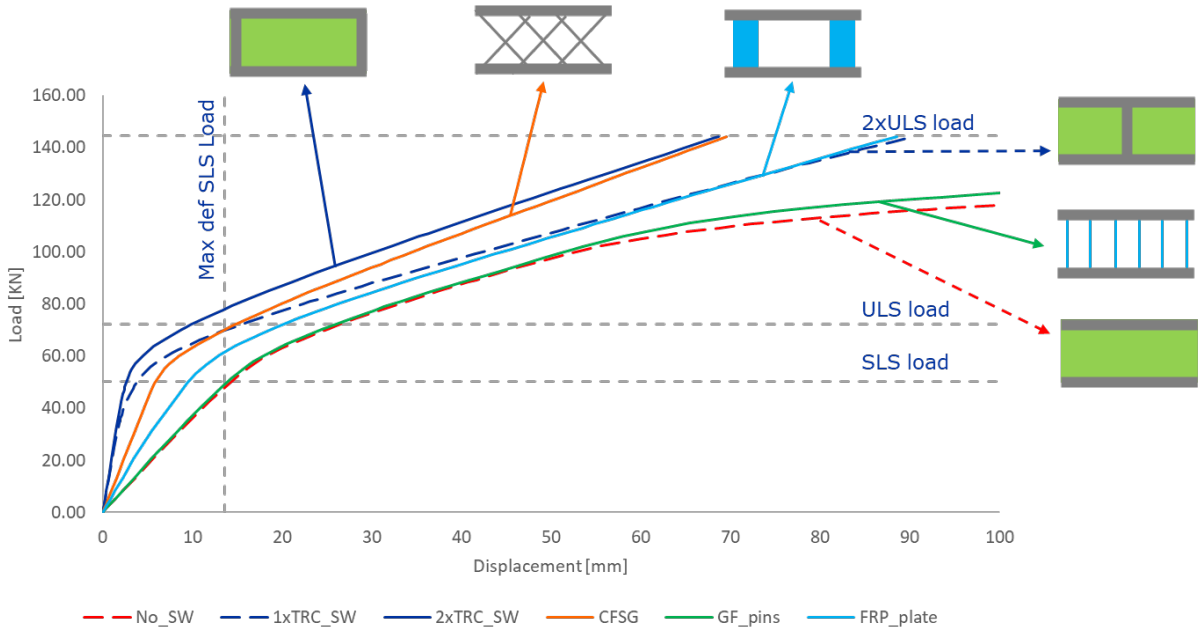
- Recycled Pet foam characterisation
- Numerical modeling definition
- Lab-scale testing and comparison with NM





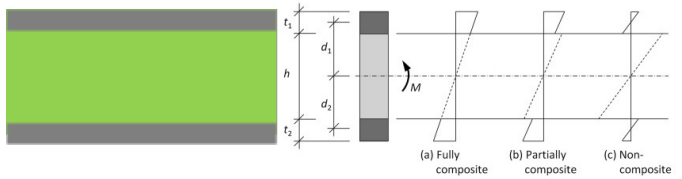
Parametric study on TRC sandwich floor system: towards a ribbed concrete floor

SHEAR TRANSFER ELEMENTS ANALYSIS



SANDWICH PANEL COMPOSITE ACTION

Sandwich panel	α	Def. SLS [mm]
	0.058	14.35
	0.060	13.94
	0.090	9.59
	0.149	5.89
	0.231	3.83
	0.339	2.63

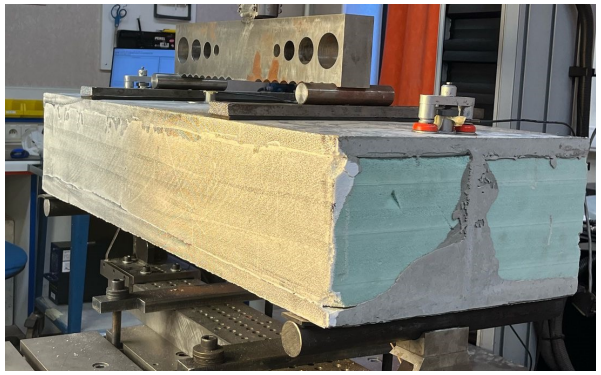


[Portal, 2017]

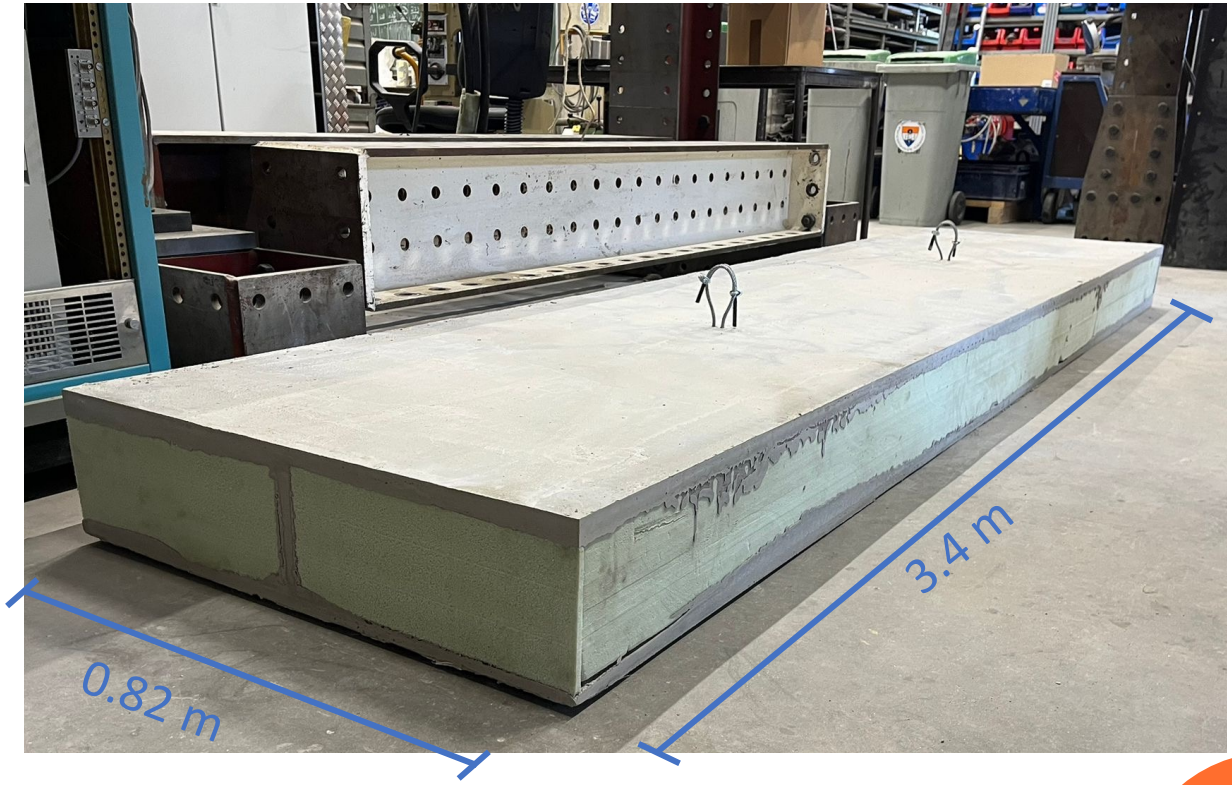
$$EI_{SP} = \underbrace{\left(E_c \frac{2bt_c^3}{12}\right) + \left(E_f \frac{bt_f^3}{12}\right)}_{EI_1} + \underbrace{\alpha(2E_c btd^2)}_{EI_2} \rightarrow \alpha = \frac{EI_{SP} - EI_1}{EI_2}$$

Development of a lightweight and modular TRC sandwich floor system

SHEAR TRANSFER ELEMENTS TESTING

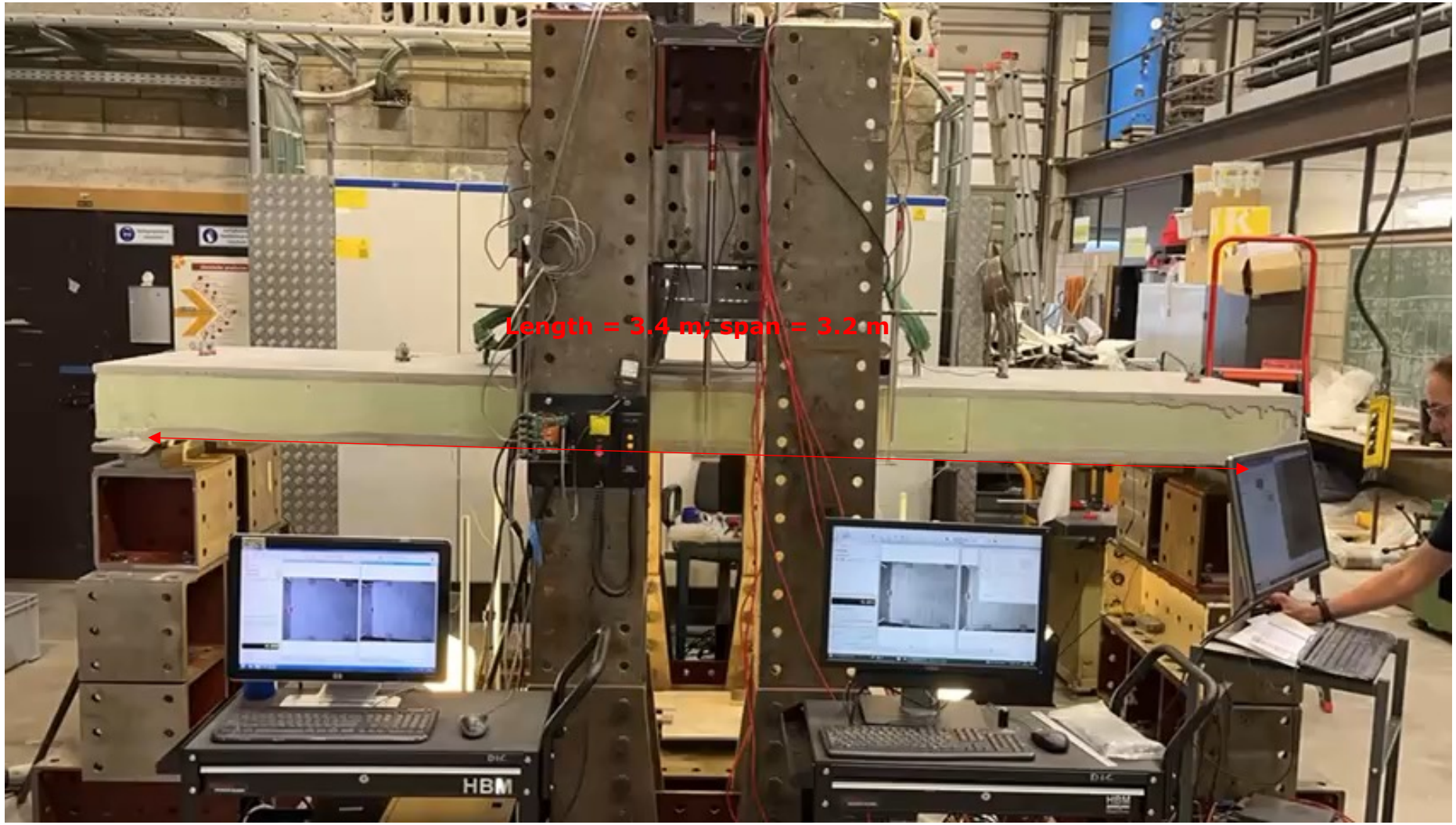


EXP. TESTING OF FULL-SCALE SAMPLE

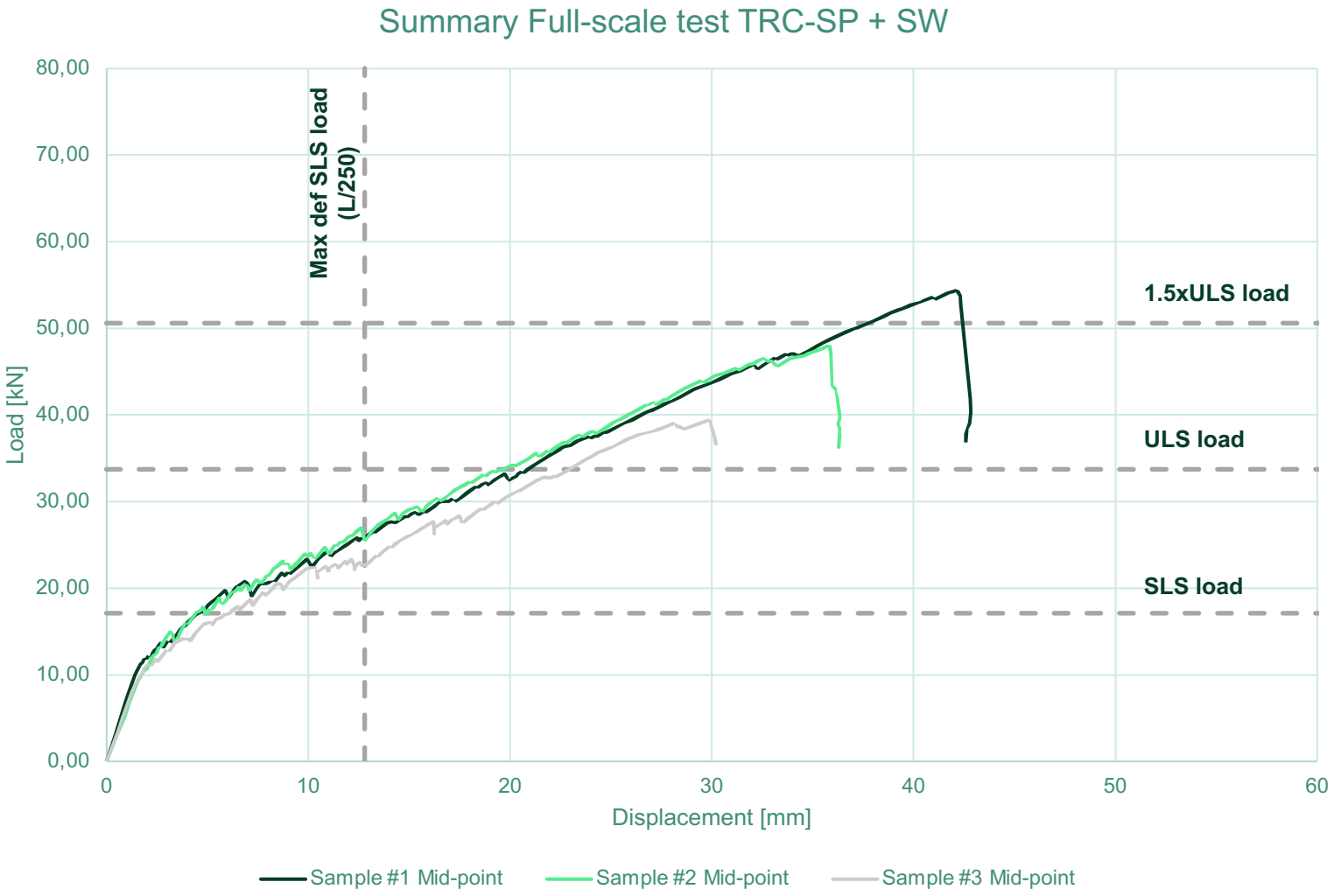


Casting full size prototype

Testing loadbearing capacity



Test results loadbearing capacity

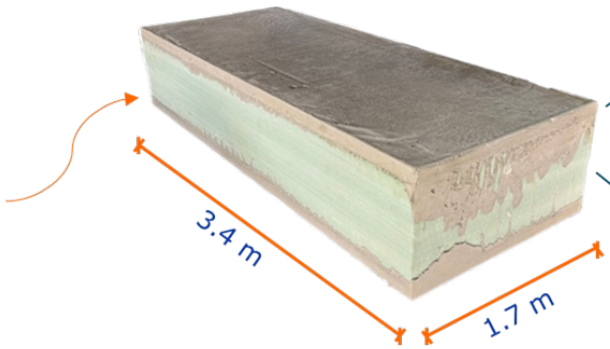


- **Surface area (2.8 m²)**
  - Length: 3.4 m (span 3.2 m)
  - Width: 0.822 m
  - Height: 0.204 m
  - **Weight: 120 kg/m²**
- **Permanent loads (*1.35)**
  - Selfweight: 1.18 kN/m²
  - Top layer: 1.0 kN/m²
  - False ceiling: 1.5 kN/m²
- **Variable loads (*1.5)**
  - Service load: 5 kN/m²

Project phase II: Replacement of one floor module with panel integrating recycled materials

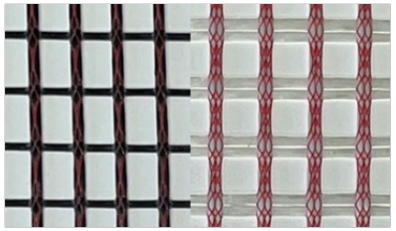
Collaboration with VUB dept. FYSC on material research

[Holland Composites]

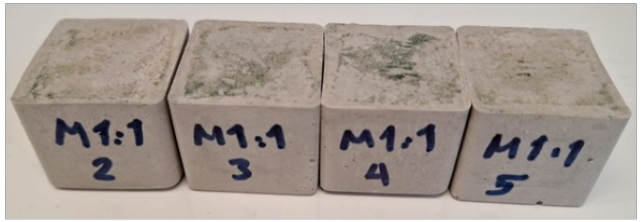


Lightweight modular TRC sandwich floor system

TRC faces



Carbon and Glass fiber textiles



alkali-activated cement-based concrete

Core alkali activated GGBFS and glass beads

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Circular Territorial Solutions for the Built Environment

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UK Research and Innovation