Lightweight, modular & prefab formwork for renovating floors

Introduction – project aim

Conceptual design

Experimental component lay-out

Structural validation of a lightweight composite floor

Fire test on a lightweight composite floor

Challenges before market entry

Conclusions
Introduction – project aim

Conceptual design

Experimental component lay-out

Structural validation of a lightweight composite floor

Fire test on a lightweight composite floor

Challenges before market entry

Conclusions

Growing renovation market = new opportunities

Increase of Brussels population with 1,5 million (35%) by 2060

Number of renovations has surpassed new constructions

Renovations: weight, manoeuvrability and manual labour

Market for new structural systems designed for renovation
Industrialisation and prefabrication of building systems for retrofitting

Our aim:
Develop lightweight floor for renovation!

focus on construction stage
floor consists of prefab elements
minimize weight of individual elements

=> Construction: easy, fast, no heavy equipment, low nuisance

Introduction – project aim

Conceptual design

Experimental component lay-out

Structural validation of a lightweight composite floor

Fire test on a lightweight composite floor

Challenges before market entry

Conclusions
Industrialisation and prefabrication of building systems for retrofitting

The hybrid floor design is based on the existing beam-and-block system

- Steel reinforced concrete beams
- Concrete / terracotta blocks
- Concrete compression layer

Easy-installation: steel-concrete beams are transformed into hybrid beams

- No steel
- No tensile concrete
- Low-weight composite materials
Industrialisation and prefabrication of building systems for retrofitting

Easy-installation: concrete blocks are transformed into sandwich panels

Low-weight composite materials

Fibre Reinforced Polymers (FRPs) are needed for their stiffness

High specific strength and stiffness
Substitute for the longitudinal steel reinforcement
Use limited by fire issues

1.2 mm Carbon strips gratefully received from ECC-TRADECC
**Textile Reinforced Cement (TRC)**
Composites complement the FRPs

- Fire safe
- Heat resistant
- Environmental friendly

**Inorganic Phosphate Cement (IPC):**
a matrix for high fibre volume fraction TRCs

- Low cost E-glass fibres
- pH-neutral, fine grained IPC
- High fibre volume fraction TRC (> 20%)
Combining all materials and ideas leads to new concepts

LightComp: a lightweight-in-installation composite floor
Industrialisation and prefabrication of building systems for retrofitting

Introduction – project aim

Conceptual design

**Experimental component lay-out**

Structural validation of a lightweight composite floor

Fire test on a lightweight composite floor

Challenges before market entry

Conclusions

24 real scale beam tests determine the beam’s cross section

![Beam Test Image]
Variations in:

- type of loading
- amount of concrete (1)
- amount and type of reinforcement (2)

Together with LCA and fire simulation inputs, the beam’s cross section became:

- Concrete compression layer
- TRC (with IPC matrix):
  - 8 layers 2D random glass fibres
  - 4 layers UD carbon fibres
- TRC (with IPC matrix):
  - 8 layers 2D random glass fibres
- Rockwool core
- TRC (with IPC matrix):
  - 8 layers 2D random glass fibres
  - 8 layers UD carbon fibres
Industrialisation and prefabrication of building systems for retrofitting

EPS is chosen as core material for sandwich panels

TRC (with IPC matrix): 2 layers 2D random glass fibres
EPS core

Several finishing layers are added to the stay-in-place formwork
Industrialisation and prefabrication of building systems for retrofitting

Introduction – project aim

Conceptual design

Experimental component lay-out

Structural validation of a lightweight composite floor

Fire test on a lightweight composite floor

Challenges before market entry

Conclusions

4 real scale floor tests validate the structural feasibility
Industrialisation and prefabrication of building systems for retrofitting

ULS and SLS requirements are met

- Installation weight: 29 kg/m²
- \( M_{\text{max},\text{SLS}} = 8.4 \text{kNm} \)
- \( \delta_{\text{max},\text{SLS}} = 6 \text{ mm} \)

Failure by debonding
Industrialisation and prefabrication of building systems for retrofitting

Introduction – project aim

Conceptual design

Experimental component lay-out

Structural validation of a lightweight composite floor

Fire test on a lightweight composite floor

Challenges before market entry

Conclusions

1 real scale floor is tested under fire
Lightcomp floor resists fire for 40 min

Central deflection (mm)

Failure at 40min

0 10 20 30 40
Time (min)

Central deflection (mm)

Failure at 40min

0 10 20 30 40
Time (min)
Industrialisation and prefabrication of building systems for retrofitting

Lightcomp floor resists fire for 40 min

Central deflection (mm)

Time (min)

Failure at 40min

Lightcomp floor resists fire for 40 min

Central deflection (mm)

Time (min)

Failure at 40min
Industrialisation and prefabrication of building systems for retrofitting

Lightcomp floor resists fire for 40 min

Central deflection (mm)

Time (min)

Failure at 40min

Introduction – project aim

Conceptual design

Experimental component lay-out

Structural validation of a lightweight composite floor

Fire test on a lightweight composite floor

Challenges before market entry

Conclusions
Challenges

Increase fire resistance time
- New core material for sandwiches
- Better adhesion gypsum layer

Challenges

Improve production process
- Use of automated production techniques
Challenges

Increase fire resistance time
  - New core material for sandwiches
  - Better adhesion gypsum layer

Improve production process
  - Use of automated production techniques

Cost reduction
  - Industrial and automated production
  - Large quantity uptake of bulk materials

Introduction – project aim

Conceptual design

Experimental component lay-out

Structural validation of a lightweight composite floor

Fire test on a lightweight composite floor

Challenges before market entry

Conclusions
Conclusion