

# Lightweight, modular & prefab formwork for renovating floors

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Vrije  
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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

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## 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

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## 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

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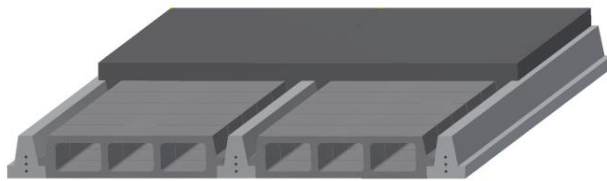
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## The hybrid floor design is based on the existing beam-and-block system

Steel reinforced concrete beams

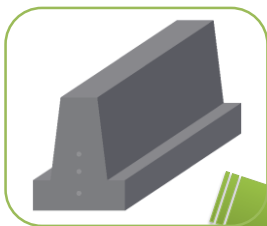
Concrete / terracotta blocks

Concrete compression layer



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



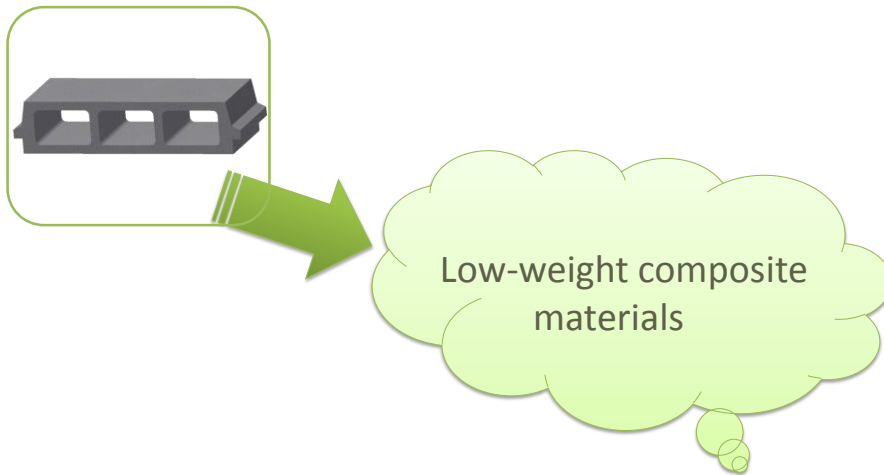
No steel

No tensile concrete

Low-weight composite materials

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Easy-installation: concrete blocks are transformed into sandwich panels



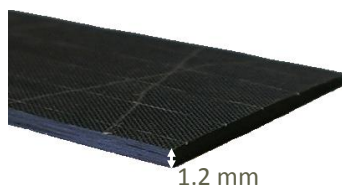
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**Fibre Reinforced Polymers (FRPs)** are needed for their stiffness

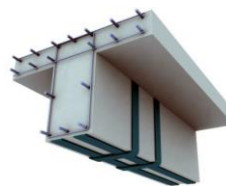
High specific strength and stiffness

Substitute for the longitudinal steel reinforcement

Use limited by fire issues



Carbon strips gratefully received from ECC-TRADECC



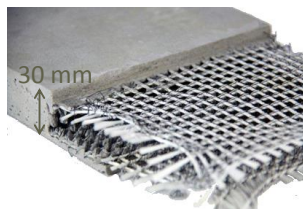
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## Textile Reinforced Cement (TRC) Composites complement the FRPs

Fire safe

Heat resistant

Environmental friendly



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

Low cost E-glass fibres



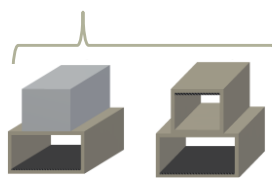
pH-neutral, fine grained IPC



High fibre volume  
fraction TRC (> 20%)

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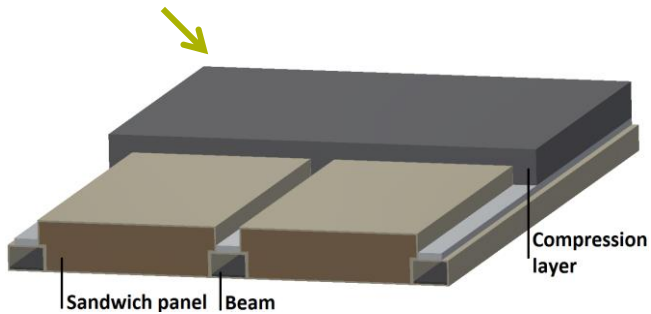
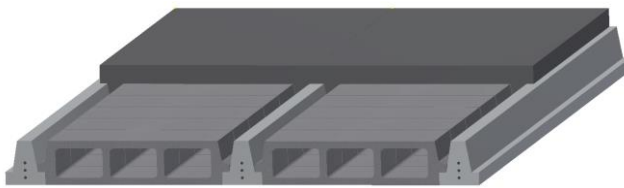
Combining all materials and ideas leads to new concepts



■ GFR,IPC    ■ Concrete, precast  
■ CFRP    ■ Steel bars

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LightComp: a lightweight-in-installation composite floor



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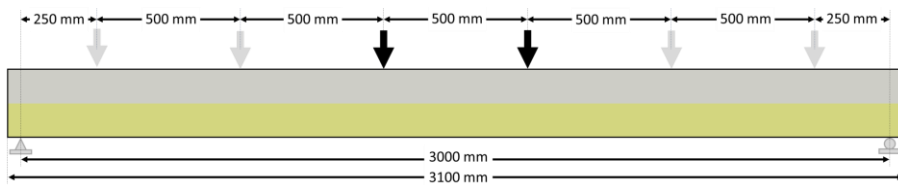
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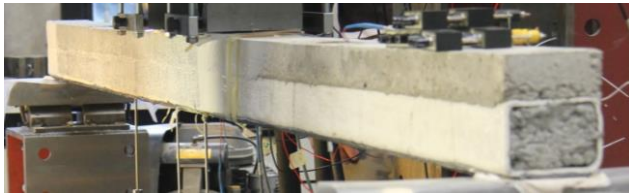
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24 real scale beam tests determine the beam's cross section



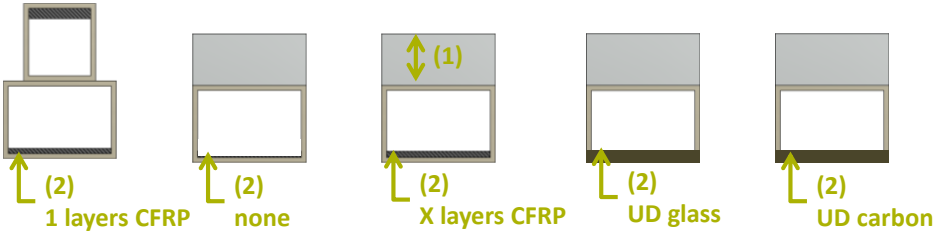
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Variations in:

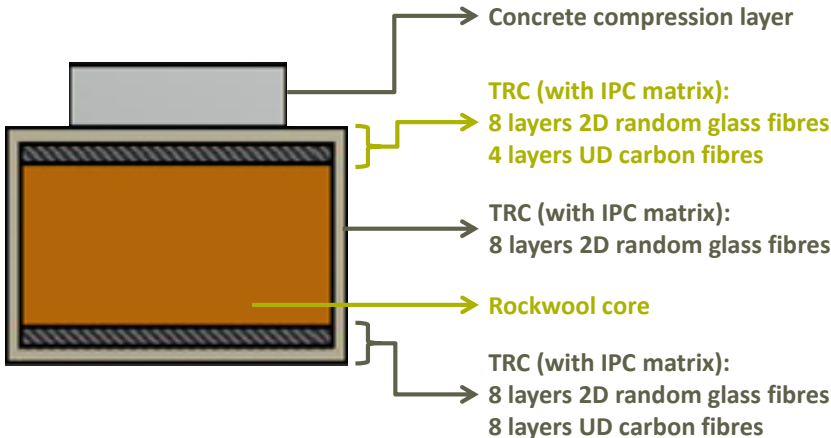
- type of loading
- amount of concrete (1)
- amount and type of reinforcement (2)



(2) 1 layers CFRP    (2) none    (1) X layers CFRP    (2) UD glass    (2) UD carbon

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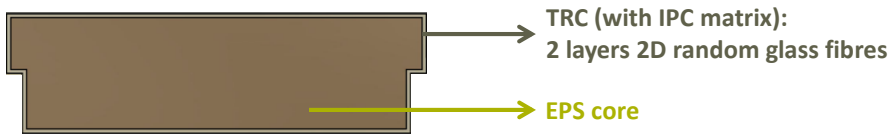
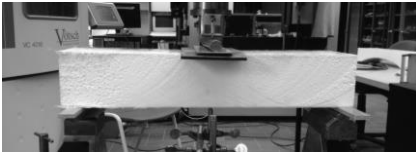
Together with LCA and fire simulation inputs, the beam's cross section became:



- 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

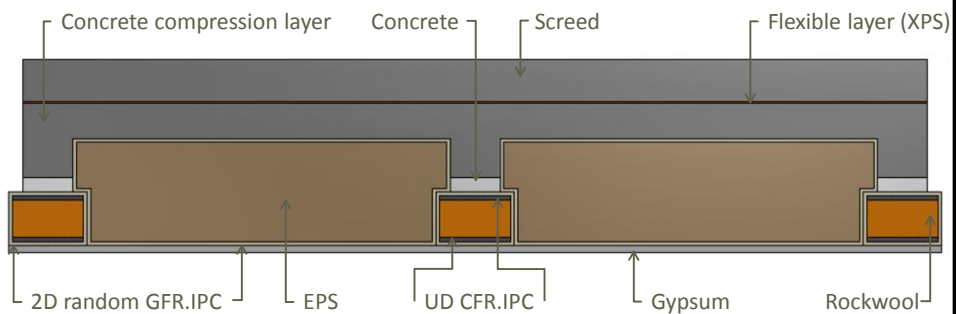
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## EPS is chosen as core material for sandwich panels



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## Several finishing layers are added to the stay-in-place formwork



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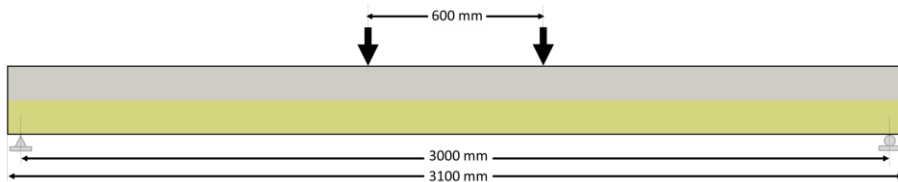
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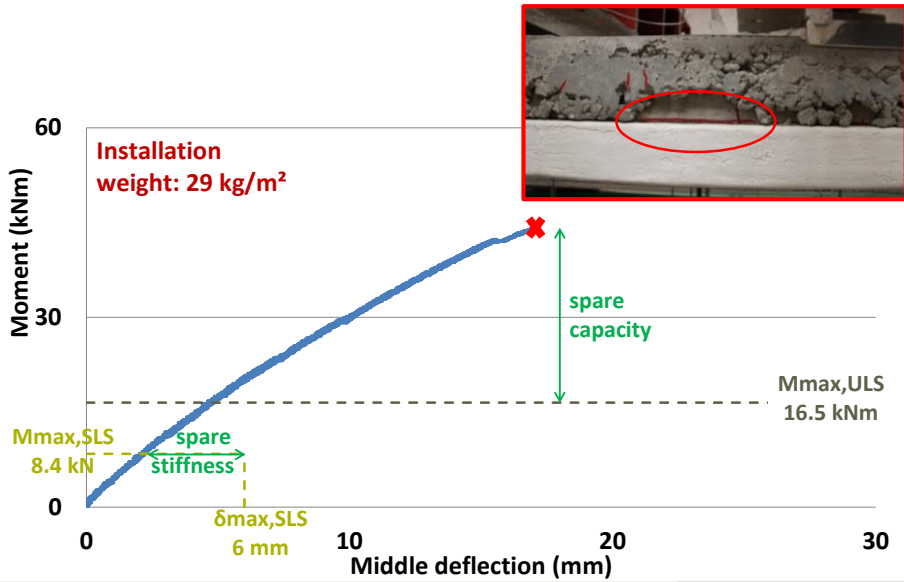
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4 real scale floor tests validate the structural feasibility



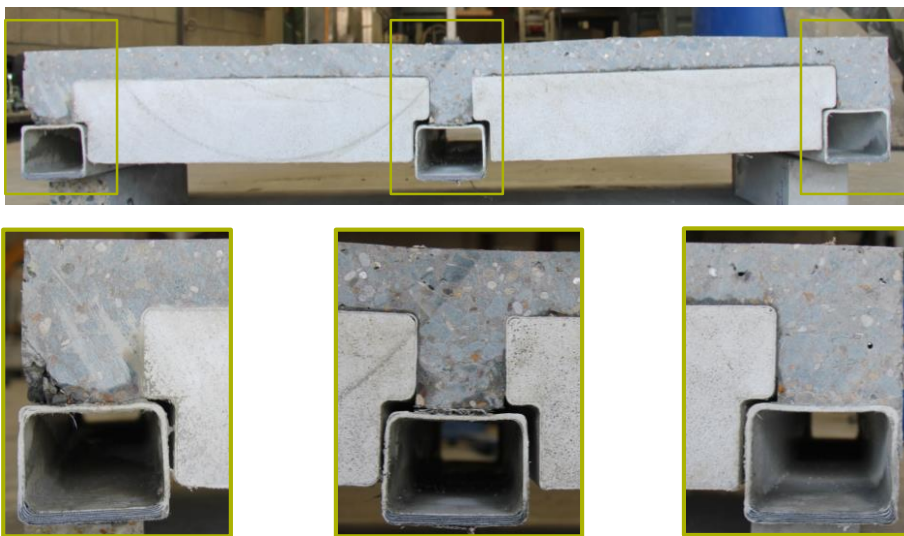
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## ULS and SLS requirements are met



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## Failure by debonding



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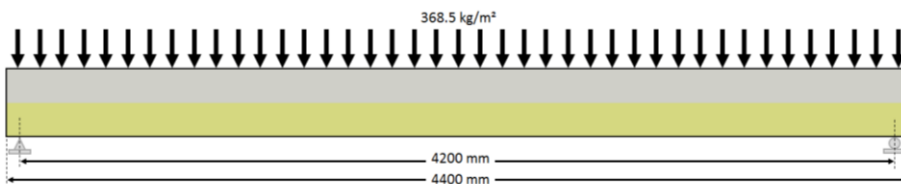
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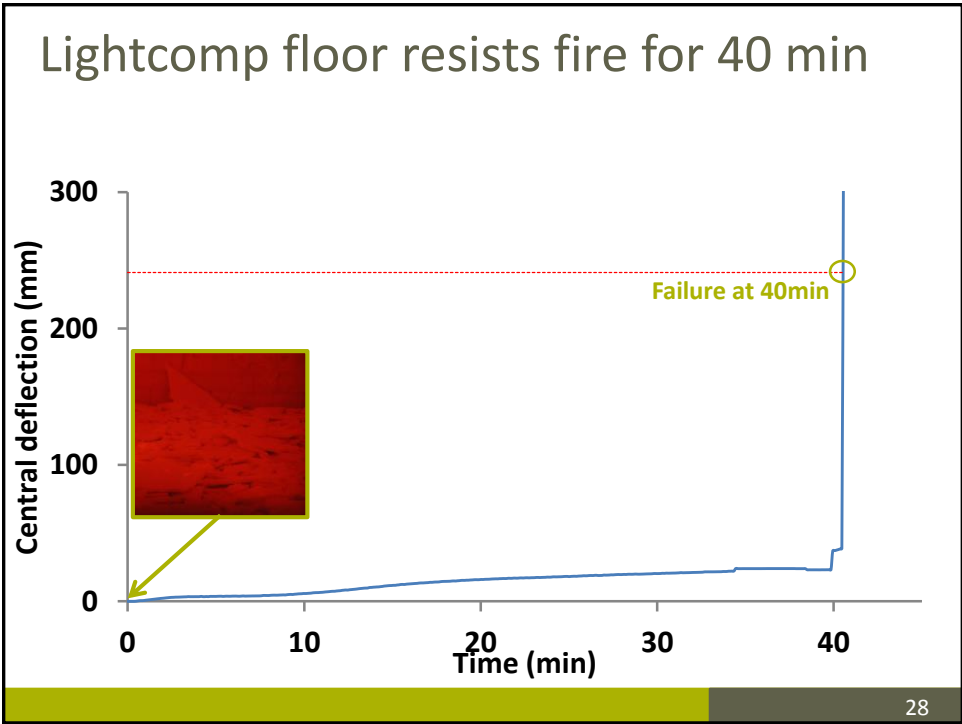
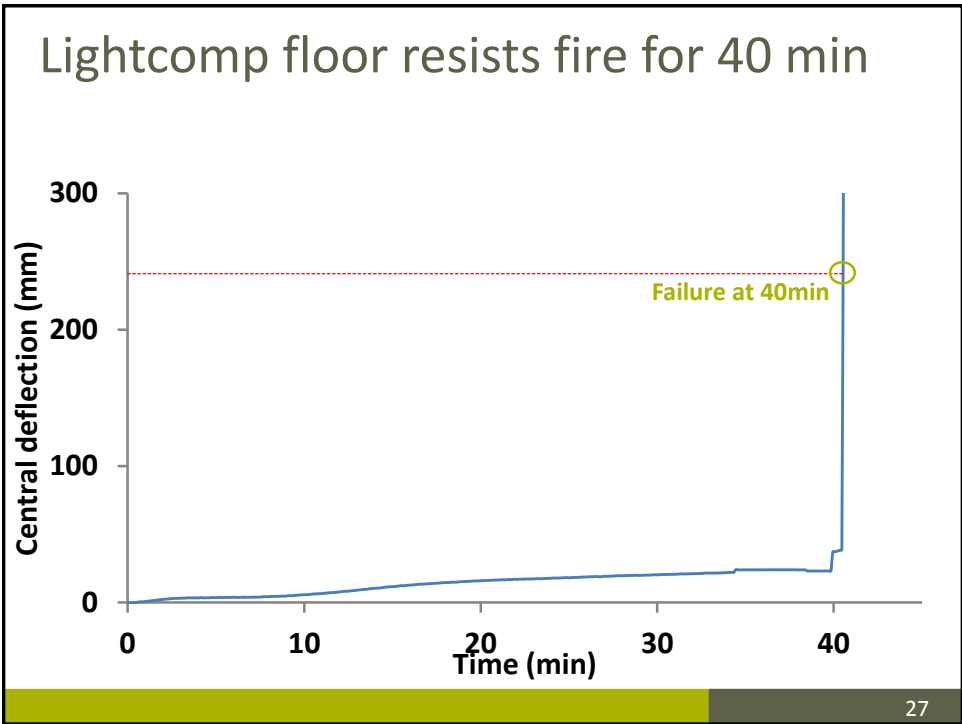
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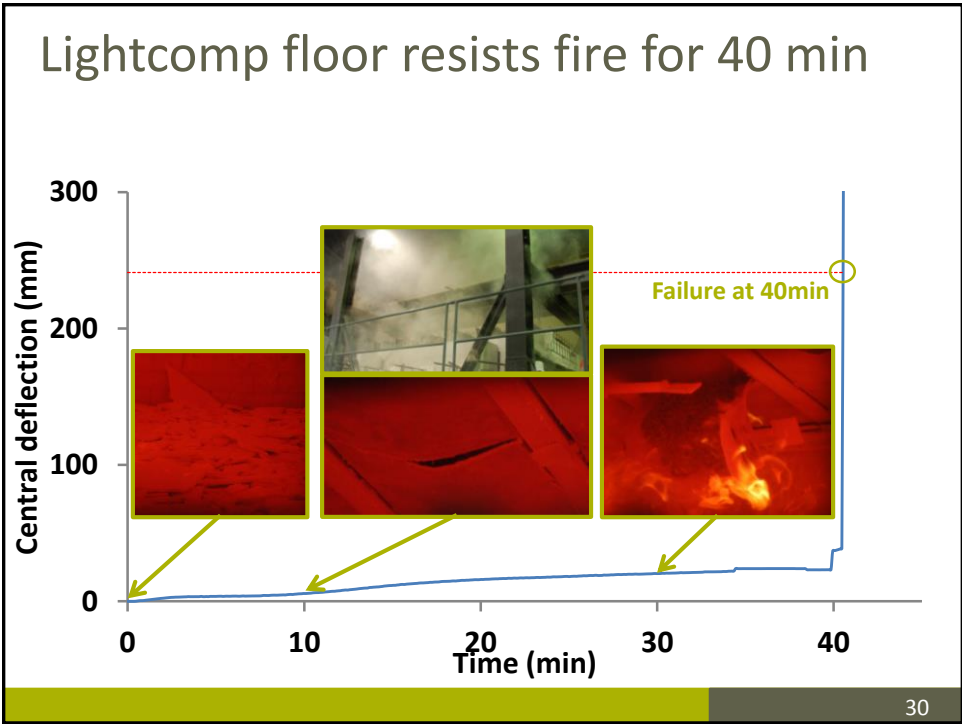
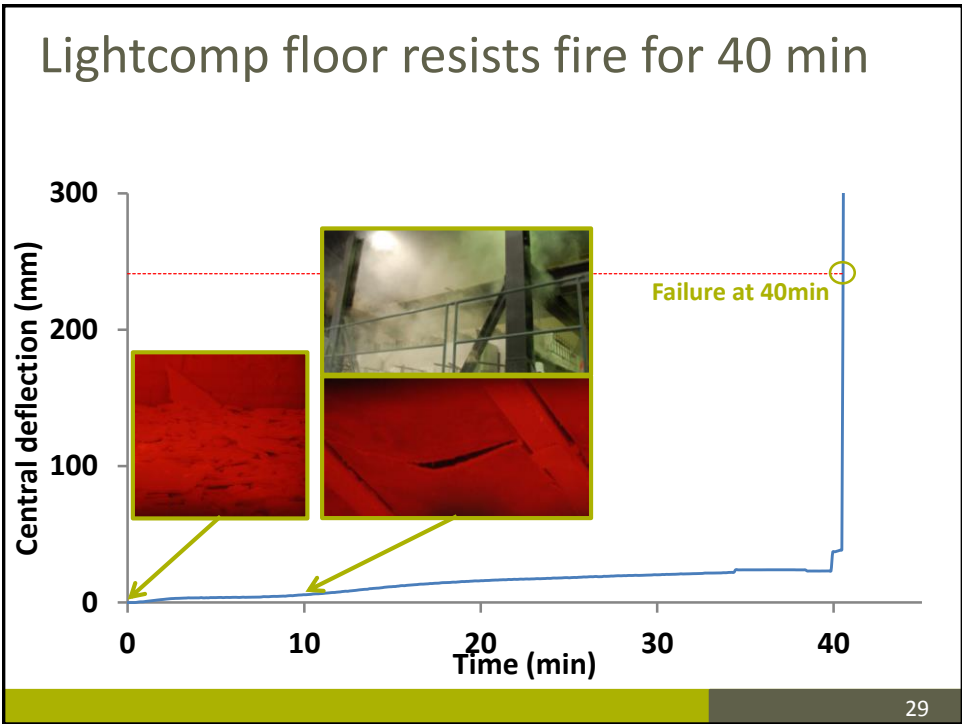
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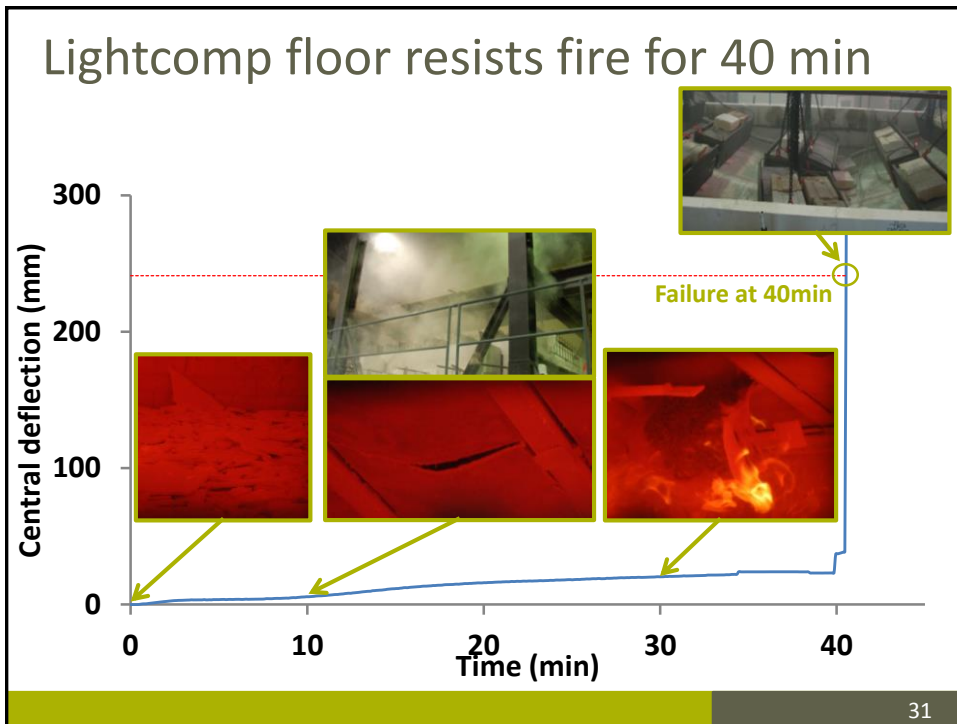
## 1 real scale floor is tested under fire



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## Challenges

Increase fire resistance time

New core material for sandwiches

Better adhesion gypsum layer

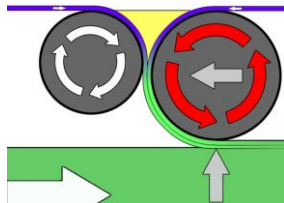


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## Challenges

Improve production process

Use of automated production techniques



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## 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

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### Conclusion

The diagram illustrates a retrofitting system. At the top, a grey beam with a corrugated profile is shown. Below it, two inset images show a cross-section of a sandwich panel (left) and a dark grey compression layer (right). A yellow arrow points from these insets to a larger 3D model of the beam with the sandwich panels and compression layer installed. Labels at the bottom of the model identify the 'Sandwich panel', 'Beam', and 'Compression layer'.

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**BRUSSELS**  
**RETROFIT**  
INNOVIRIS STRATEGIC PLATFORM  
ENVIRONMENT

The slide features the logos of Vrije Universiteit Brussel and the Brussels Retrofit platform. Below the logos is a 3D diagram of the retrofitting system, identical to the one on slide 37. At the bottom, a photograph shows a physical model of the system on a laboratory table, with various sensors and supports attached to it.

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