University of Luxembourg

20 years dedicated to students, research & society

Partnerships @ FSTM – FEDIL Meet up 05/02/2025

FSTM Research - KEY FIGURES

- **5 departments/disciplines**
  Computer science, Life sciences, engineering, physics, mathematics
- **585 researchers**
- **12 ERC grants**
- **21 million euros external grants (2022)**
- **2.7 million euros industrial collaborations (2022)**
- **39 study programmes**
- **2250 students & 80 teachers**

FSTM Partnerships & Megatrends team

Stefanie Oestlund
Megatrends

Cristina Marinho
Education

Bertrand Dessart
Partnerships

Johnatan Pecero
Partnerships

Partnerships examples - Partners

- Arcelor Mittal
- Euro composite
- Good Year
- ACL
- Rotarex
- Ceratizit
- Hydac
- Honda
- Prefalux
- Meersteter
- Paul Wurth

- MetOffice
- Carraro
- Imatec
- Steffen Holzbau
- Daiwa
- Phinia
- Brugpipes
- ArianeGroup
- Kiswire
- CFL
- Megeno

- RSS Hydro
- Luxenergie
- Luxplan
- TR Engineering
- CDCL
- AWS
- Amazon
- Bradford Space
- Rafinex
- RBC Luxembourg

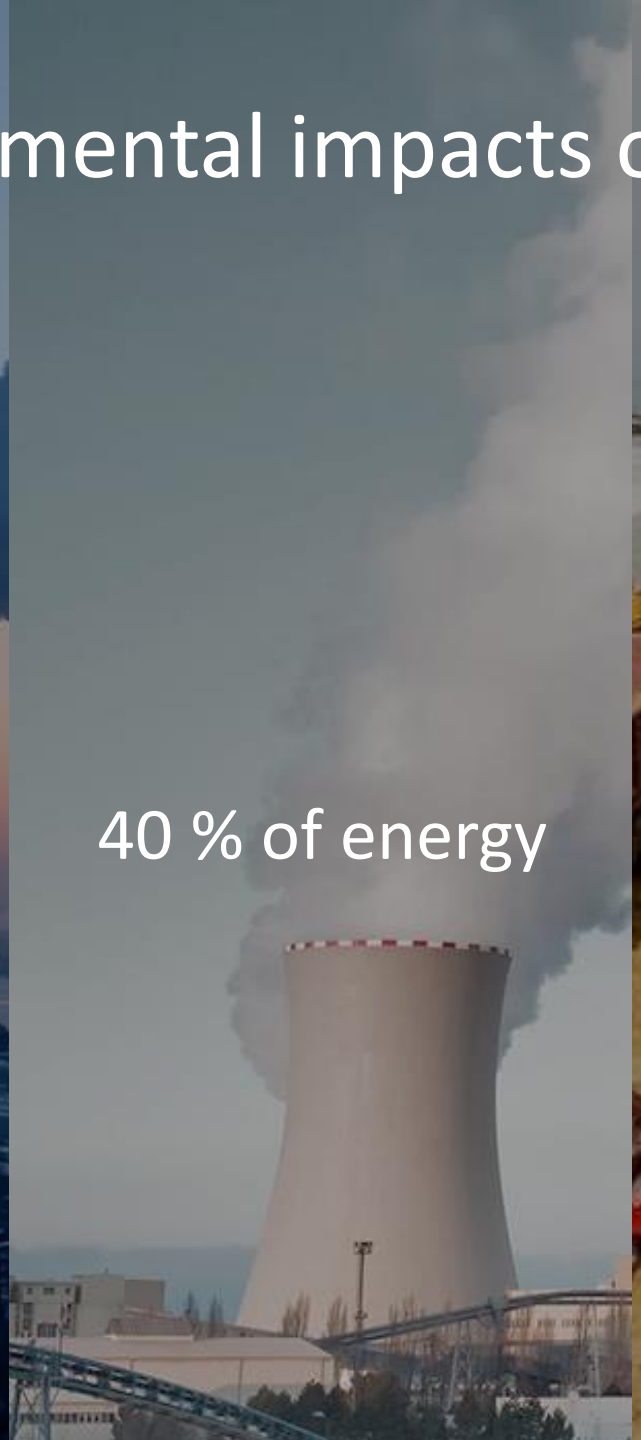
Bridging Sustainability and Concrete Structures

Prof. Numa Bertola

05.02.25
FEDIL

Environmental impacts of the built environment

40 % of emissions



40 % of energy

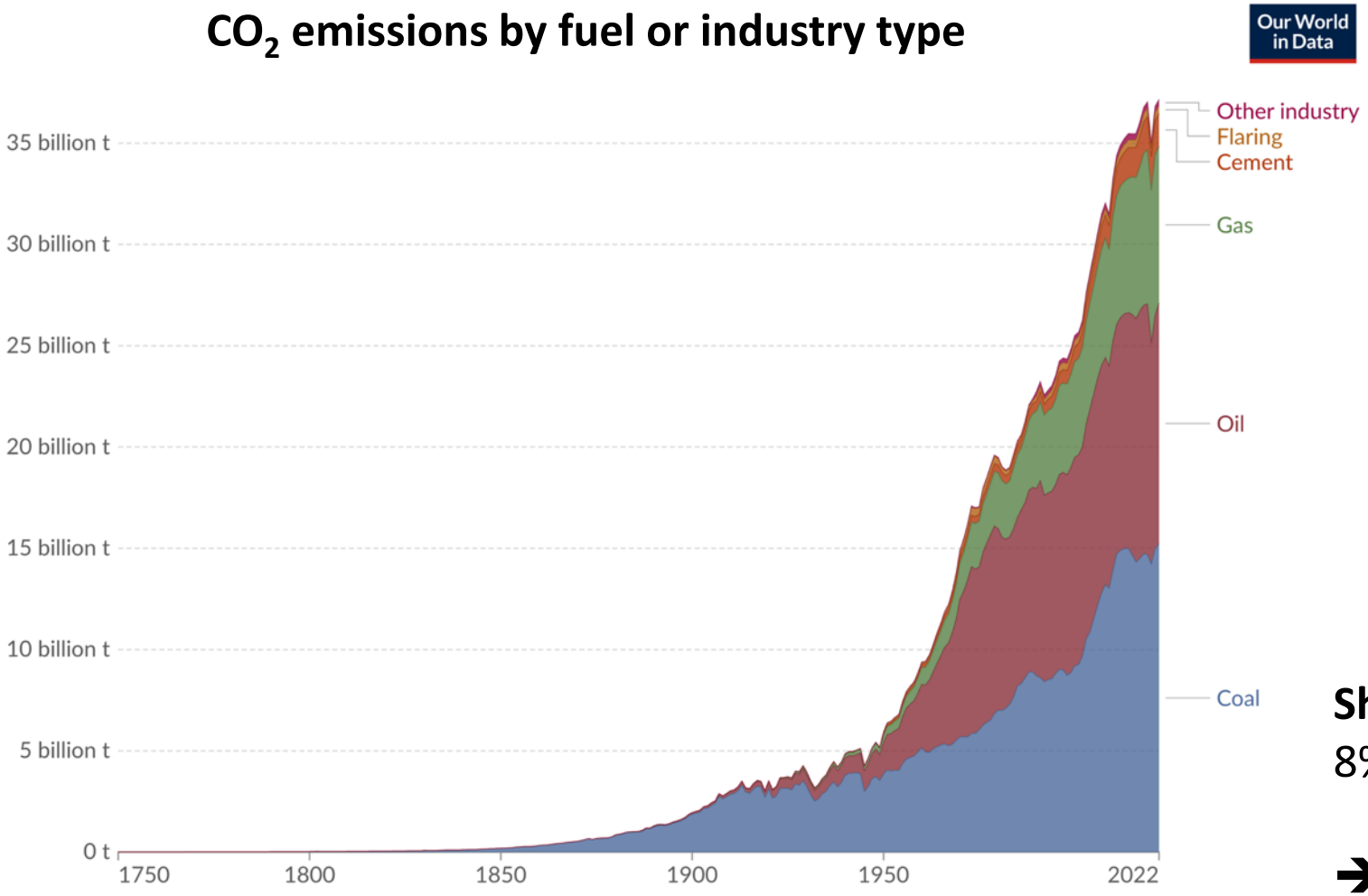
40 % of resources

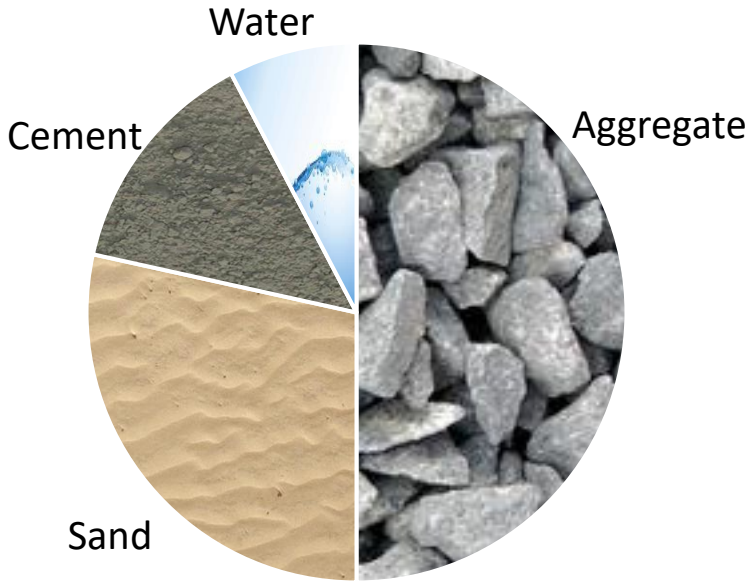
40 % of waste

Source: BRG (ETH)

Carbon footprint of concrete industry

CO_2 emissions by fuel or industry type

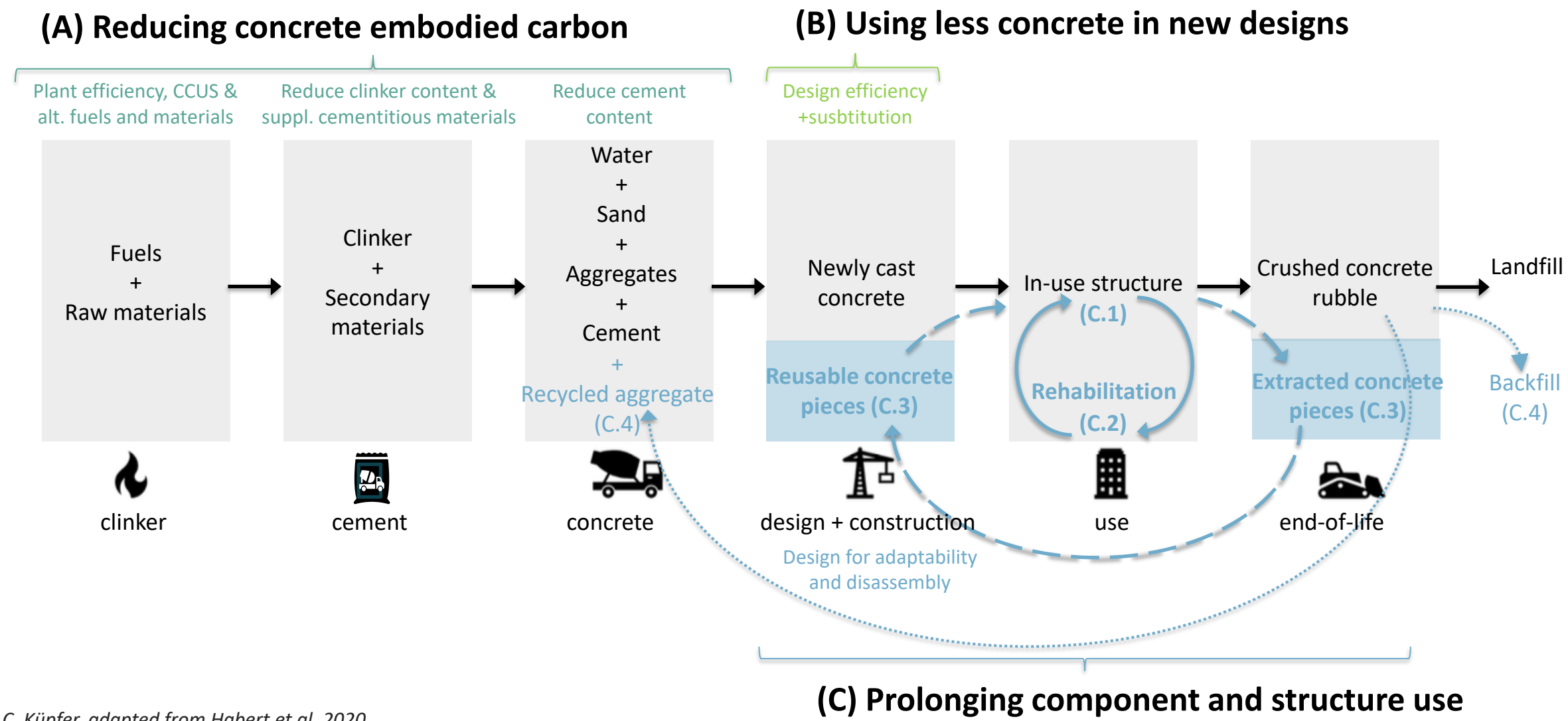




Share of cement in CO_2 emissions
8% (chemical reaction + energy use)

➔ **Concrete is $\approx 10\%$ of global CO_2 emissions**

Decarbonization of concrete industry



Credit: C. Küpfer, adapted from Habert et al. 2020

Sustainable management of existing structures

1. Structural performance monitoring

Sensing technologies

+

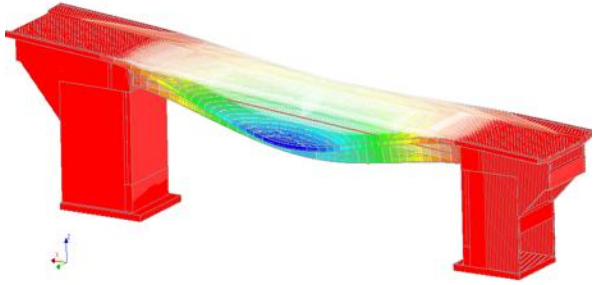
Data science

+

Finite-element modelling

=

Robust digital twin



2. Ultra-high-performance fibre-reinforced concrete

Material science

+

Structural design

+

Advanced modelling

=

Durable intervention

3. Concrete reuse

Structural engineering

+

Material testing

+

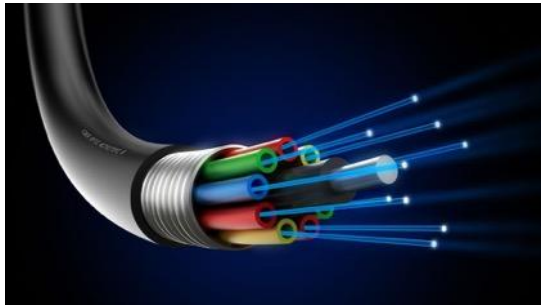
Demountable connections

=

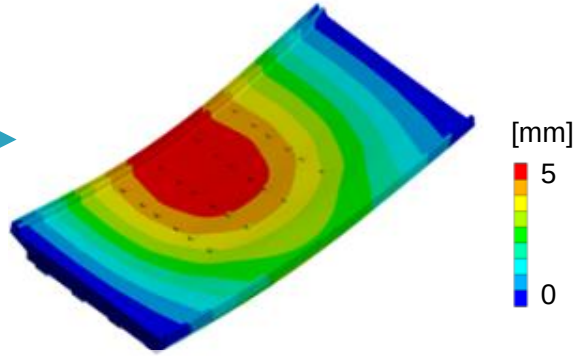
Sustainable design

Structural health monitoring

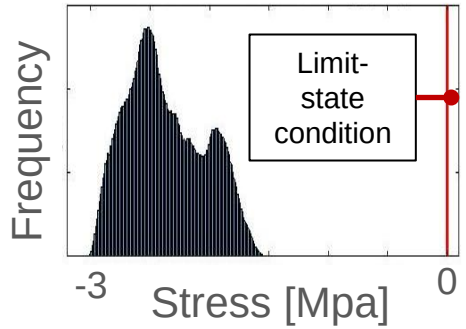
Sensing technologies



Model updating



Structural-safety assessment



Crêt de l'Anneau, Switzerland

+108 % of reserve capacity

Rockingham, Australia

+15 % of reserve capacity

Girarde, Switzerland

+22 % of reserve capacity

Flyover, Singapore

+23 % of reserve capacity

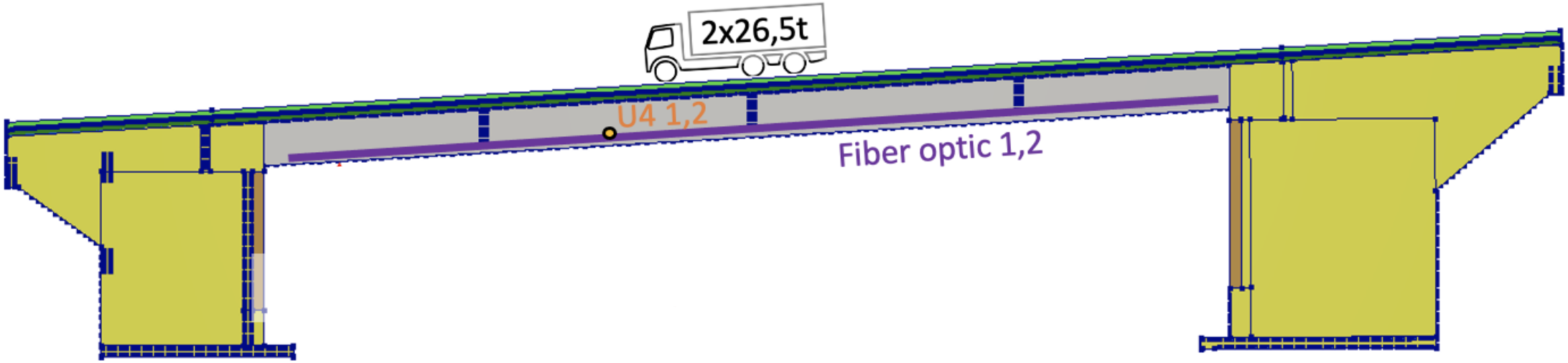
Exeter Bascule, UK

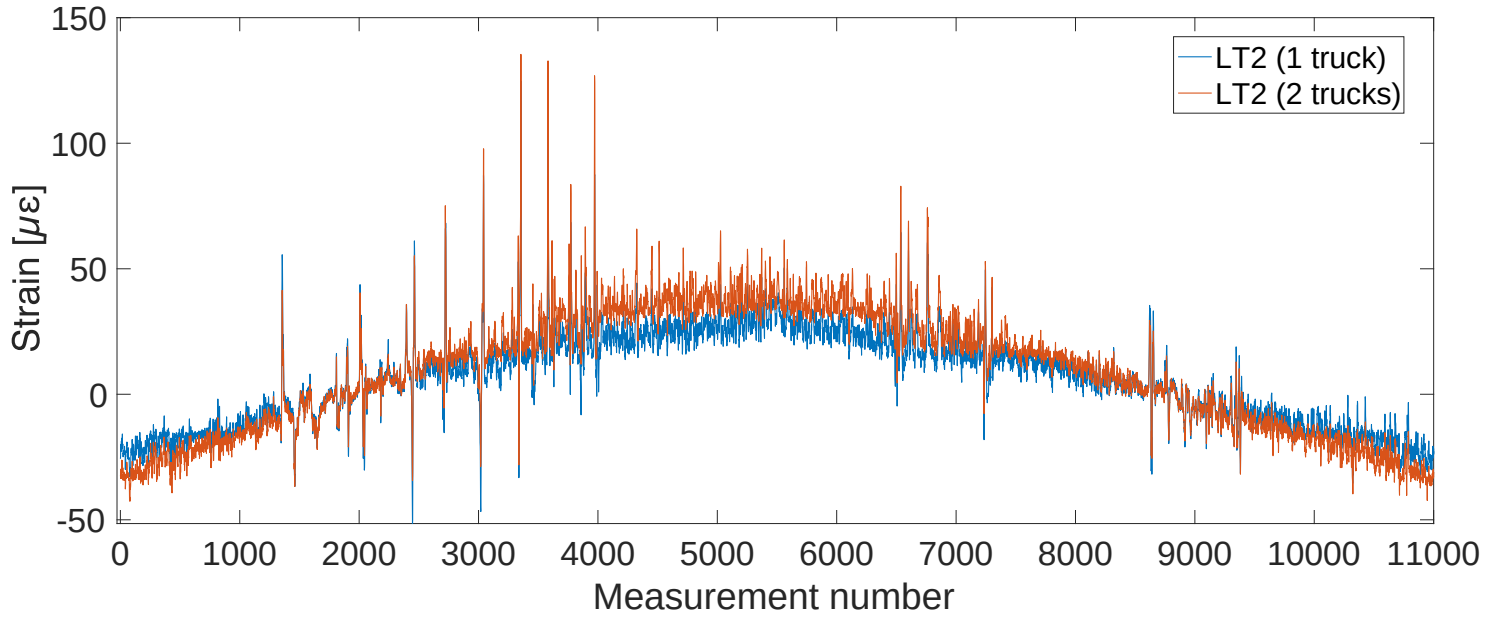
+38 % of reserve capacity

Powder Mill, USA

+33 % of reserve capacity

Fiber optic measurements

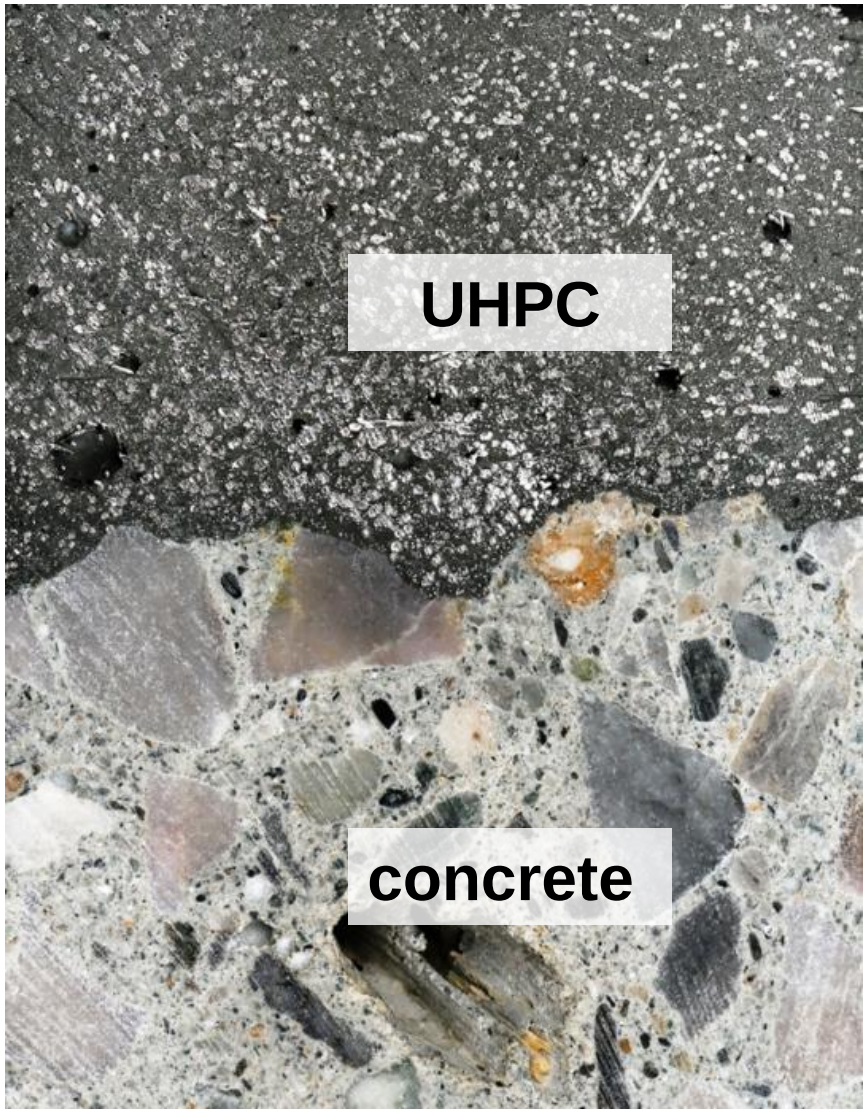




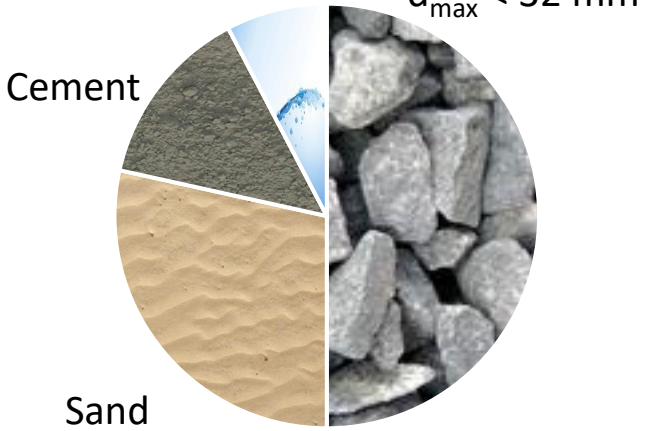
Continuous strain measurements (every 3 mm)
➔ 11'000 measurement points on a 35-meter bridge girder

Goals

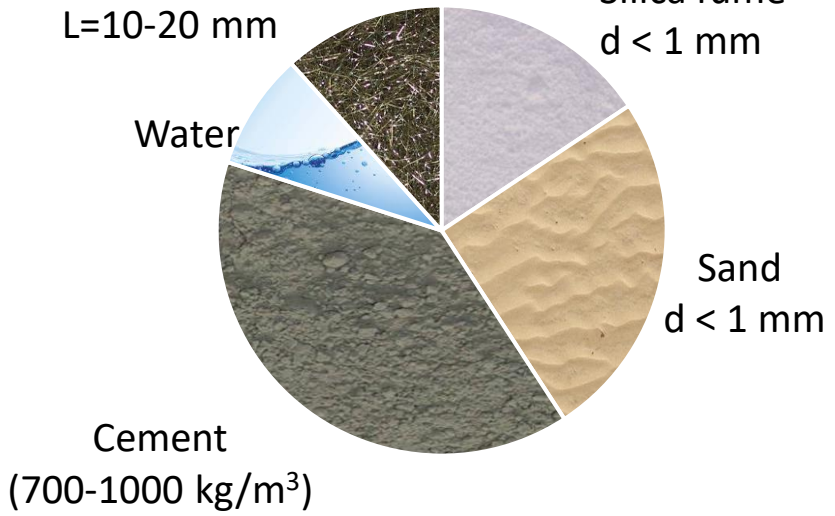
- Obtain the curvature profile of the bridge
- Detect cracks in the concrete elements



Concrete



UHPC



Properties

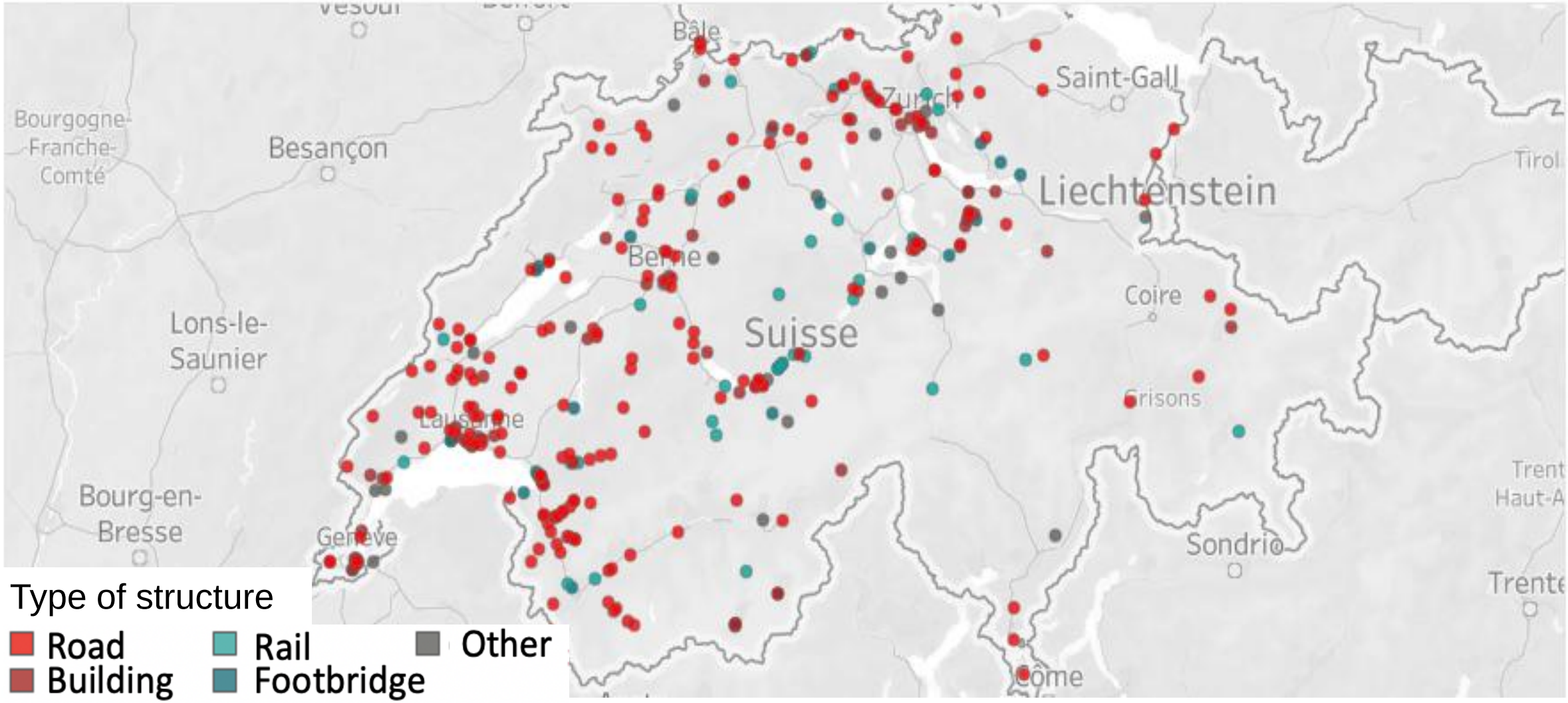
- Low permeability under service conditions
- higher mechanical properties than concrete (4-5 times)

UHPFRC application

UHPFRC map

450 applications since 2003, mostly bridge strengthening

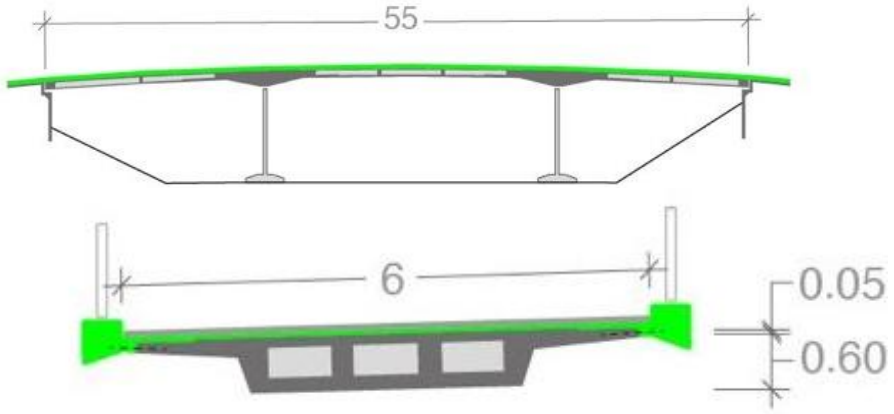
19000 m^3 since 2003



UHPFRC environmental impact

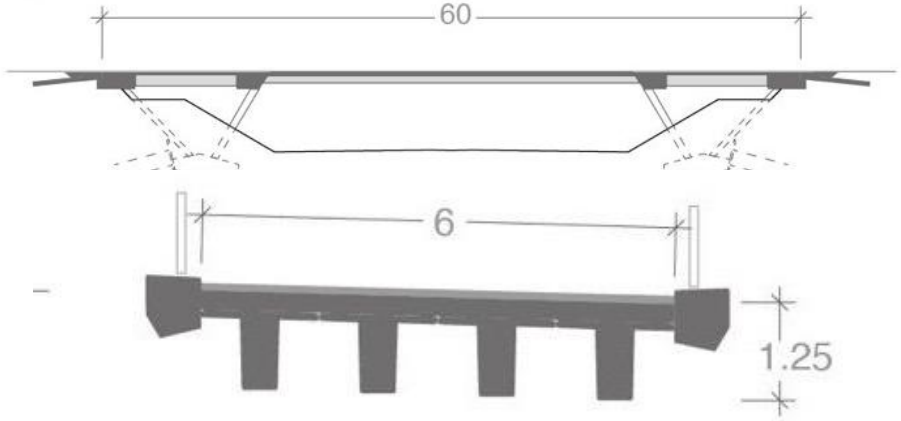
UHPFRC intervention

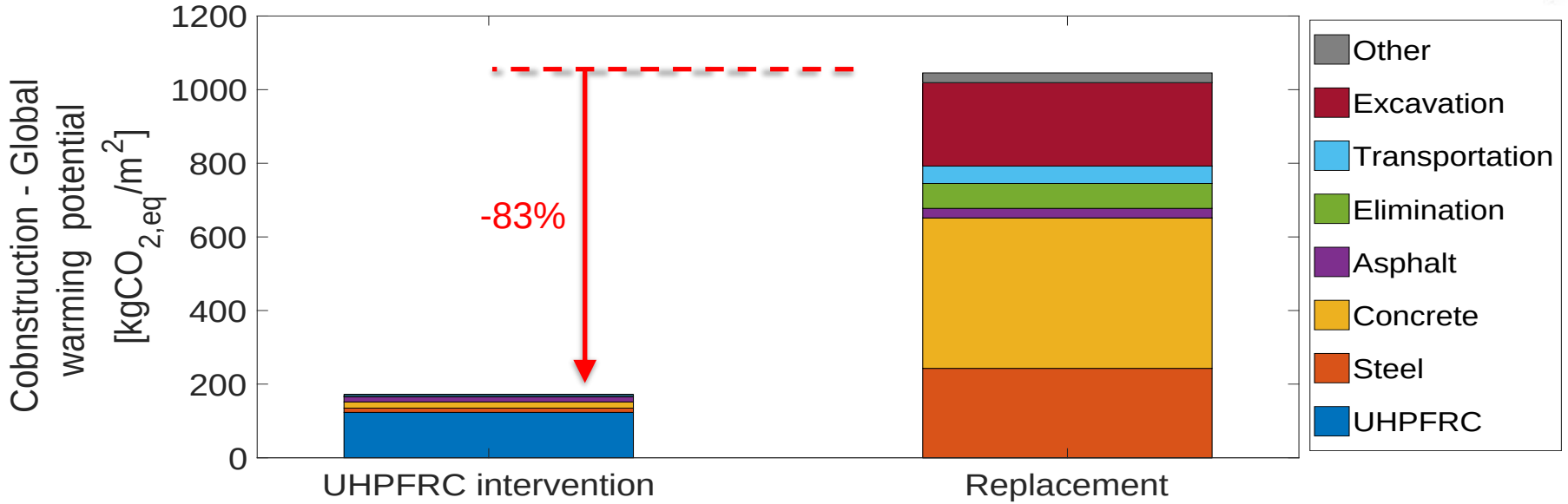
≈2500 CHF /m²



Bridge replacement

≈ 10'000 CHF /m²



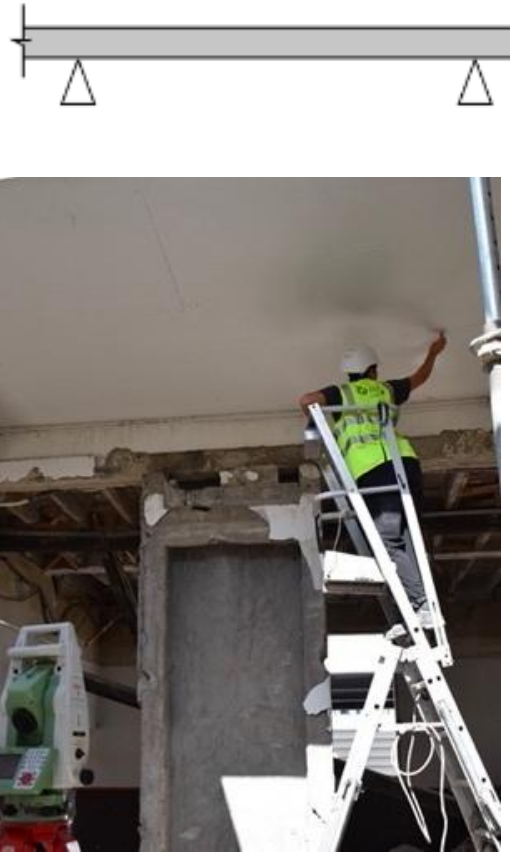


Fruttli Bridge

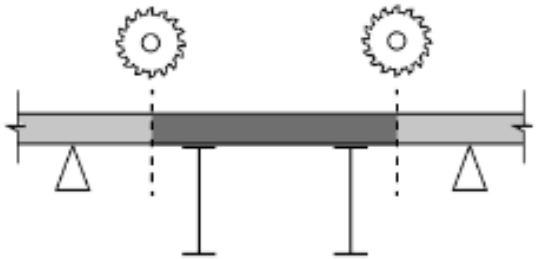
Photo: E. Kälin

Concrete reuse

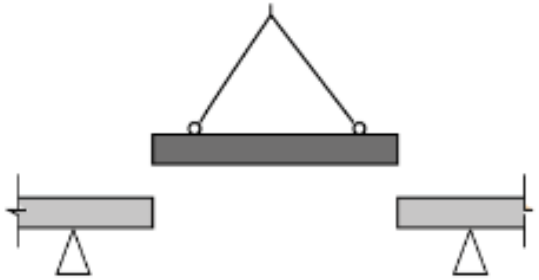
1) Donor structure



2) Sawing

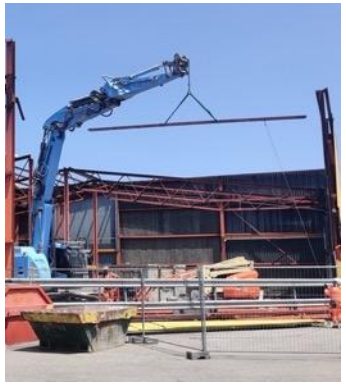


3) Lifting

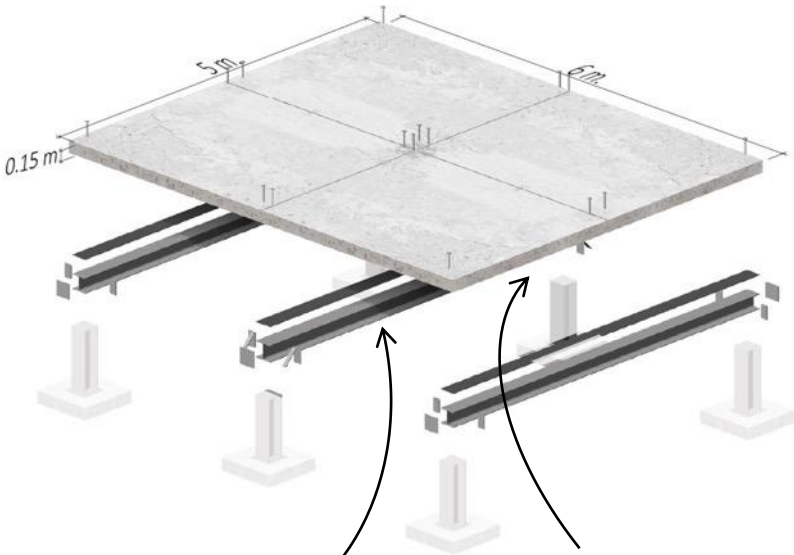


4) New structure

Flo:Re prototype

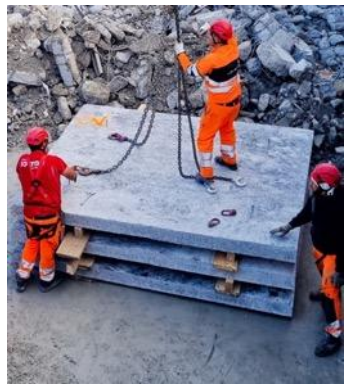


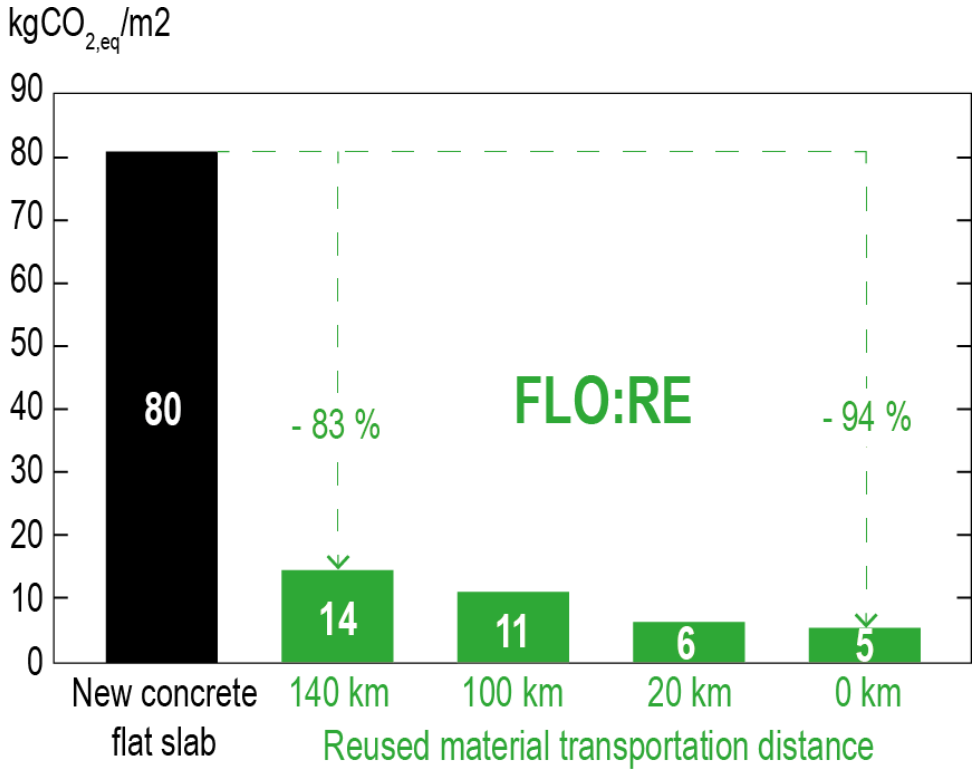
1:1 office-building floor mock-up



Reused steel profiles

Cut RC pieces from a cast-in-place roof slab





Credit 2401 Cooperative

Conclusions

1. Conventional **concrete** is responsible for large environmental impacts that must be **reduced in the future**

2. The **monitoring** of infrastructure leads to **better understanding** of structural behavior, leading to **more sustainable** infrastructure management

3. **UHPFRC** offers new perspective for infrastructure management with **improved lifespan and performance**

4. **Reusing** instead of recycling **concrete** has tremendous potential for sustainable and circular built environments

5. The **future of concrete** involves a **better** use of **existing structures**, more **efficient designs**, and new composite structures with **low-carbon materials**

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