Composite UHPFRC
Concrete construction for CO_2 savings

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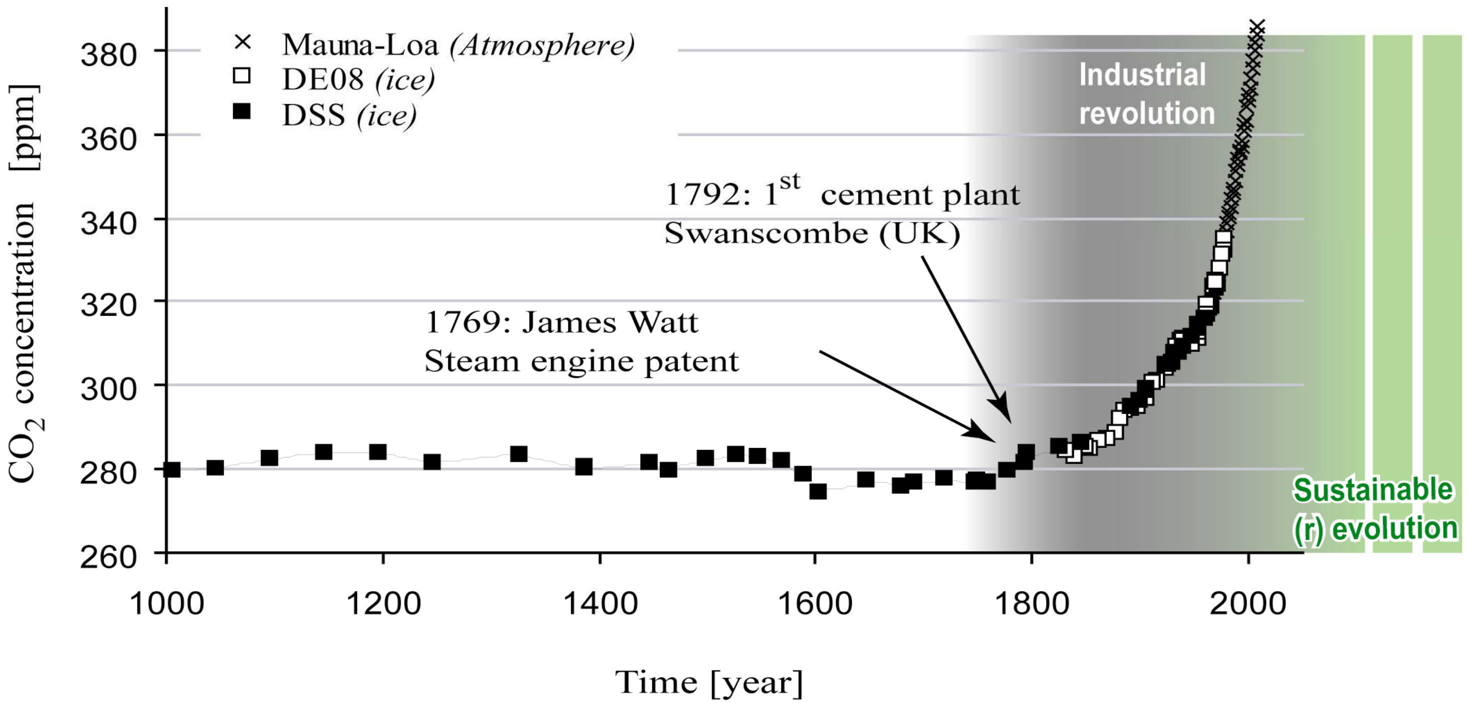
OUTLINE

1. Motivation
2. Presentation of Life Cycle Assessment method
3. Environmental evaluation of Log Čezsoški bridge rehabilitation
4. Comparison with traditional rehabilitation
5. Conclusion and perspectives

1. Motivation



CO_2 emissions from cement industry: 7 % of total CO_2 emissions

Need for CO_2 savings

2. Life Cycle Assessment method

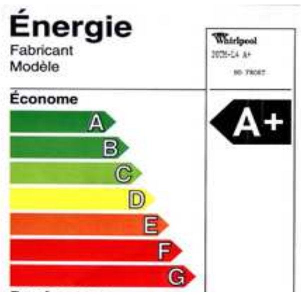
- Principles
  - Functional Unit definition
  - System boundaries and Inventory
  - Environmental impact calculation

- References
  - ISO 14040: Environmental management - Life cycle assessment - Principles and framework

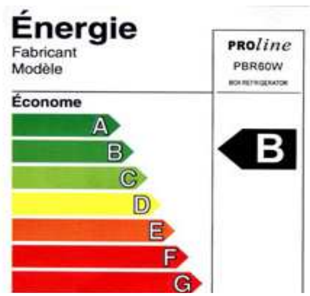
2. Life Cycle Assessment method

- Principles
  - Functional Unit definition

American fridge



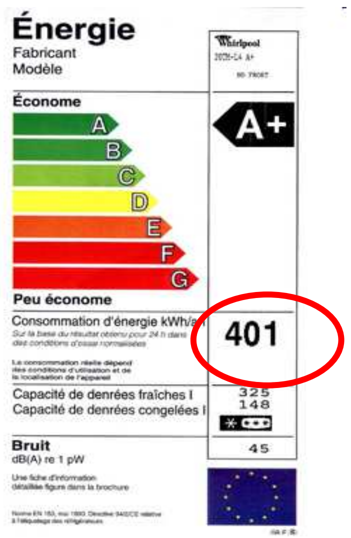
Small fridge



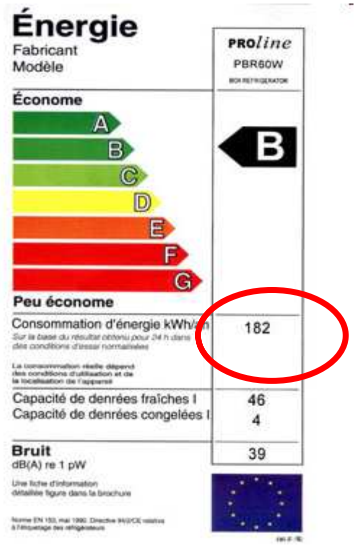
If the functional unit is 1 cooled m^3, then
A+ product consumes less than B product to cool 1 m^3

- Principles
  - Functional Unit definition

American fridge



Small fridge



If the functional unit is 1 fridge, then
Fridge on the left consumes more than the one on the right

2. Life Cycle Assessment method

- Principles
  - Functional Unit definition

Bridge beams comparison

	Prestressed Ductal©	Prestressed concrete	Reinforced concrete
Weight (kg)	140	467	530
CO_2 intensity (kg)	24	55	49

[Lafarge, Sustainable report, 2006]

Different evaluation if the functional unit is 1 m^3 of concrete or 1 linear meter of beam

2. Life Cycle Assessment method

- Principles
  - Functional Unit definition
  - System boundaries and Inventory
    - Depending on the boundaries of the system
      - » Energy for fridge use
      - » Energy and materials for fridge production
      - » Energy and materials for extraction and refining of Oil and Aluminium

- References
  - Ecoinvent (Swiss Life Cycle Inventory)

    Database that gives Inventory with all indirect and hidden flows

2. Life Cycle Assessment method

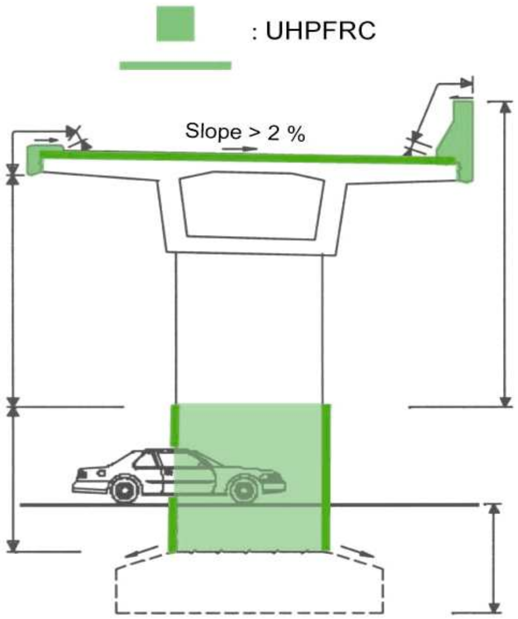
- Principles
  - Functional Unit definition
  - System boundaries and Inventory
  - Environmental impact calculation
    - Transformation of the list of input and output of the system into environmental impacts

Ex: The Global Warming Potential indicator

1 kg CO_2 + 1 kg CFC-11 → 3401 kg CO_2 equivalent

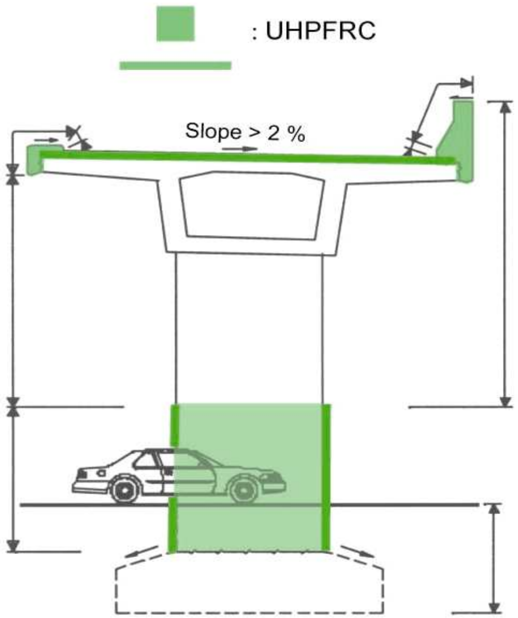
- References
  - CML01 (Guinee et al., 2002)

3. Environmental evaluation



- System = materials and processes involved in the rehabilitation
- Boundaries = All processes involved from extraction of raw materials
- Inventory = Data from Ecoinvent, 2009; Kawai et al., 2008 and Chen et al., 2009
- Indicator = GWP_{100} (CML01)

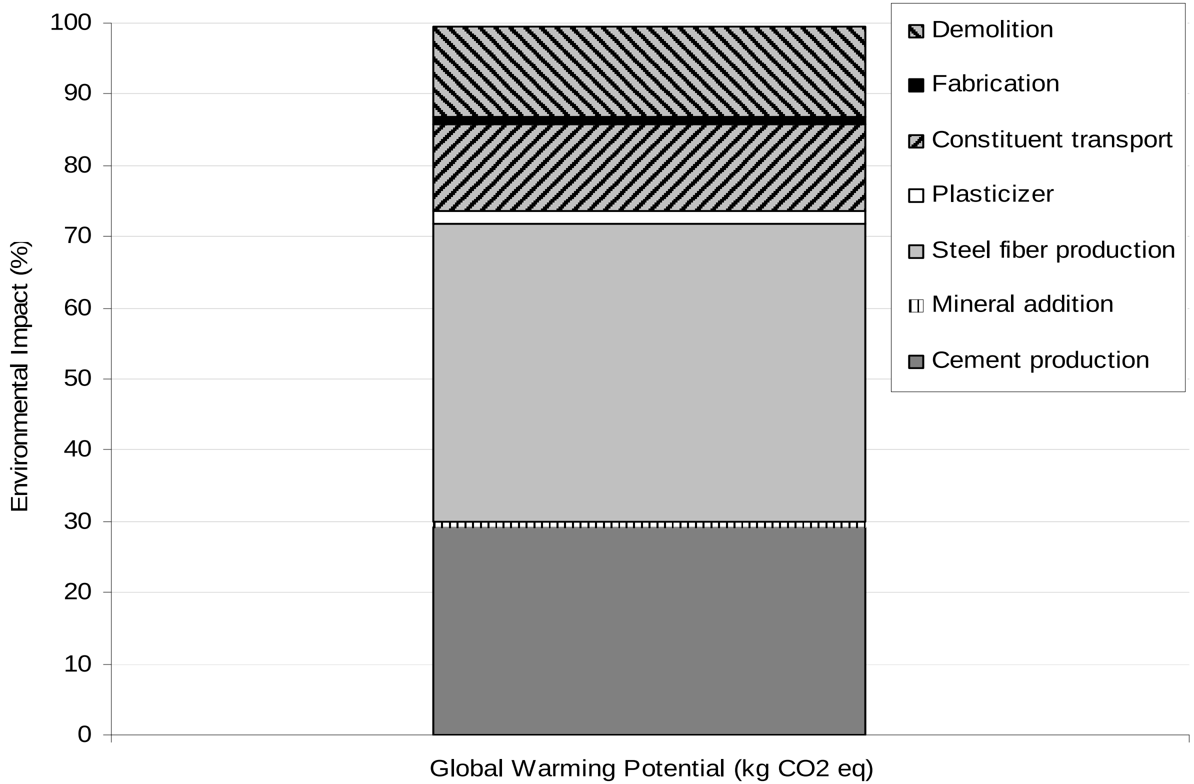
3. Environmental evaluation



log čezsoški bridge rehabilitation

	Material type	Distance
Demolition work		
Cleaning *concrete upper surface with high water pressure*		
Removal *of existant asphalt and waterproofing mambrain* ***& permanent disposal***	*Asphalt + Waterproofing membrane*	*30 km*
Repair works		
Delivery and casting ***UHPFRC concrete***	*Concrete*	*5 km*
Delivery and building ***asphalt pavement***	*Asphalt*	*5 km*
Material production	*(kg/m^3)*	
Concrete		*5 km*
Cement	*765*	*51 km*
Mineral addition	*765*	*200 km*
Microsilice	*153*	*540 km*
Steel fibers	*707*	*700 km*
Super plasticizer	*55*	*2 km*
Water	*224*	
Asphalt		*5 km*

3. Environmental evaluation



[Data from: EcoInvent, 2009; Sakai, 2007; Chen et al., 2009. Using CML01 calculation and Simapro sofware]

-Main impacts from production of materials (vs fabrication and transport)

- Steel fibers represent a larger part than cement

4. Traditional rehabilitation comparison

- Comparison with a traditional rehabilitation

  In addition to work done with UHPFRC

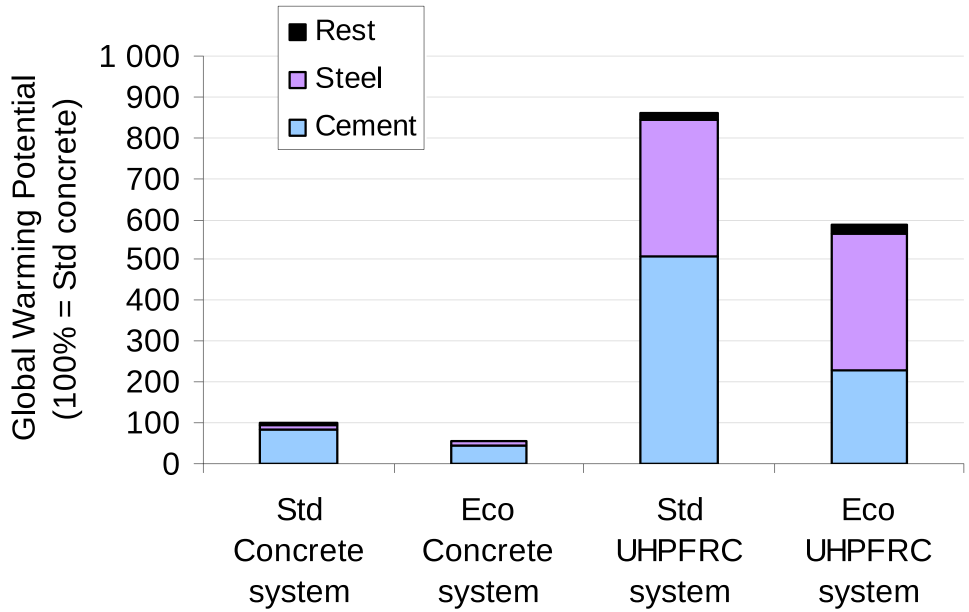
  - Procedure
    - Removal and disposal of concrete
    - Delivery and building of bitumen sealing
  - Material
    - Concrete C30/37
    - Reinforcement steel

4. Traditional rehabilitation comparison

- Four rehabilitation systems have been compared
  - Traditional rehabilitation
    - With Standard Concrete (CEM I)
    - With « Eco Concrete » (CEM I + mineral additions)
  - UHPFRC rehabilition
    - With Standard UHPFRC
    - With « Eco UHPFRC » (CEM I + mineral additions)
- Four levels have been studied
    - 1 cubic meter materials
    - Effective material volumes per system
    - All rehabilitation work
    - All rehabilitation work considering life cycle

4. Traditional rehabilitation comparison

- Comparison for 1 cubic meter of materials

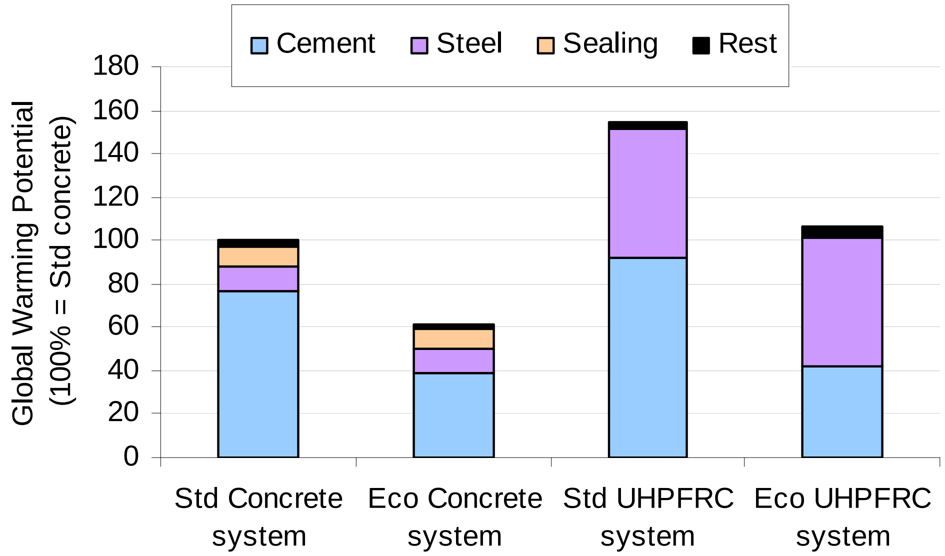


-Traditional systems involve materials with much lower impact per cubic meter

-Cement represents the larger part of CO_2 emission except for Eco-UHPFRC

4. Traditional rehabilitation comparison

- Comparison for effective material volumes per system

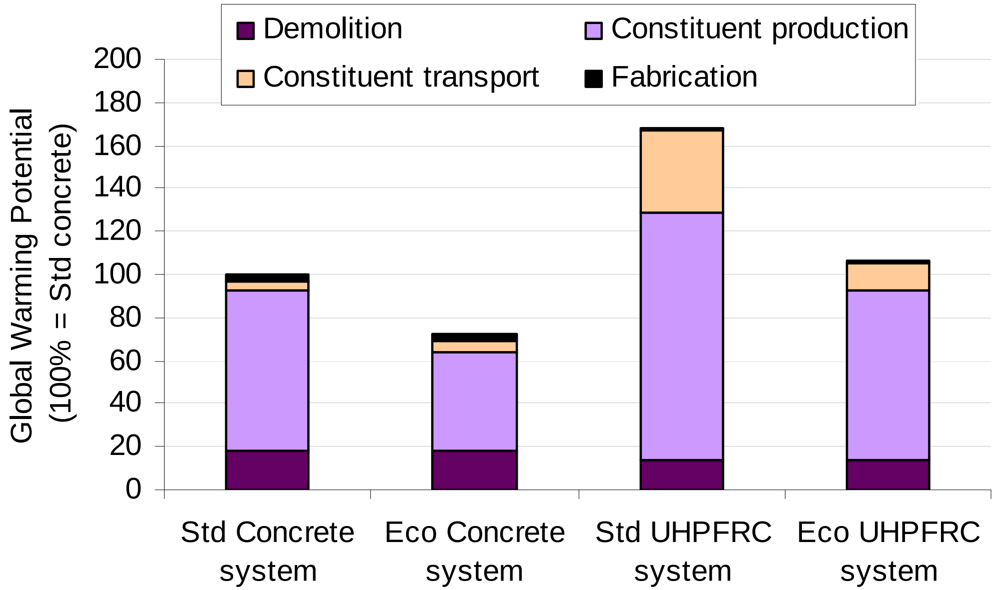


- Eco UHPFRC has similar impact than traditional system with standard concrete

- Waterproofing membrane = 10% of traditional systems

4. Traditional rehabilitation comparison

- Comparison for the different rehabilitation work



-Eco UHPFRC = similar impact than traditional system with standard concrete

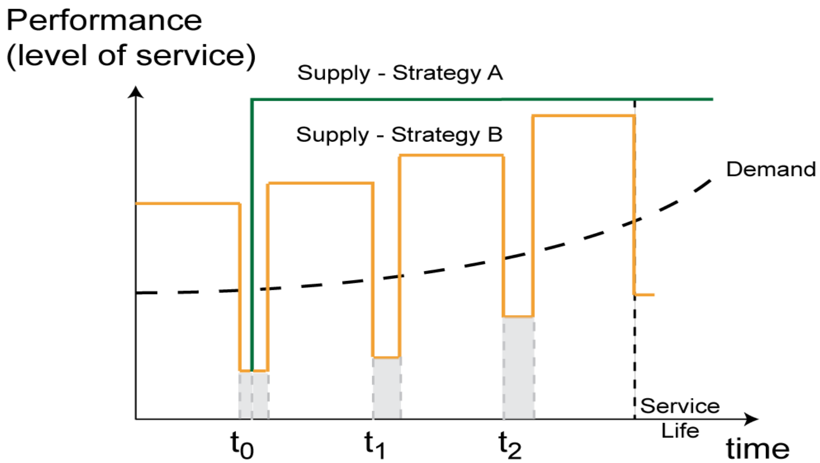
- Impacts from material production dominate

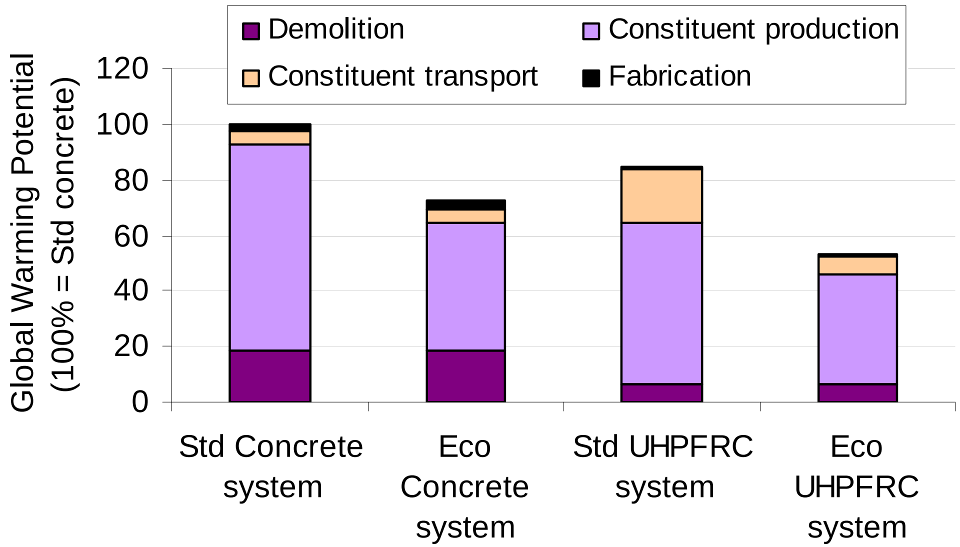
Transport impacts lower than 10% except for Std UHPFRC

4. Traditional rehabilitation comparison

- Comparison for the different rehabilitation system considering Life cycle

Durability of UHPFRC = twice concrete durability





Eco UHPFRC has lower impact than traditional system with Eco concrete

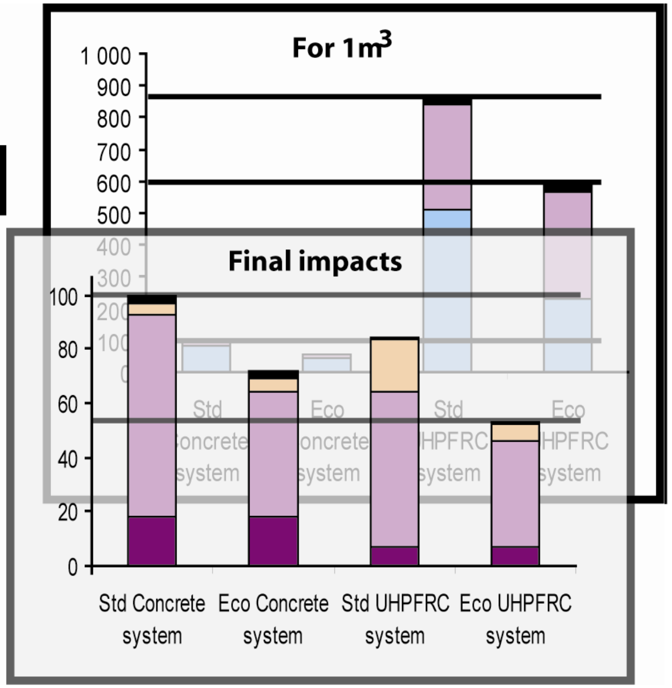
Even Std UHPFRC has similar impact than traditional solutions

4. Traditional rehabilitation comparison

- Synthesis
  - Impacts related to material production dominate
  - The main parameters to take into account are:
    - Impact per unit of volume
    - Effective volume used for the different systems
    - Durability of the system

	Std Concrete	Std UHPFRC	eco UHPFRC
Impact per unit volume	1	9	6
Volume used	1	0.2	0.2
Durability	1	2	2
Total	**1**	**0.9**	**0.6**

$$\textbf{Total} = \frac{\textbf{Impact per volume x Volume}}{\textbf{Durability}}$$



Some figures…

Log Čezsoški bridge rehabilitation

Eco UHPFRC (Arches)	Traditional solution
23 tons CO_2	21 tons CO_2

Car emissions

Yearly emissions from 1 car = 1-3 tons CO_2

Rehabilitation work = yearly emissions from 8 cars

Impacts from traffic deviations

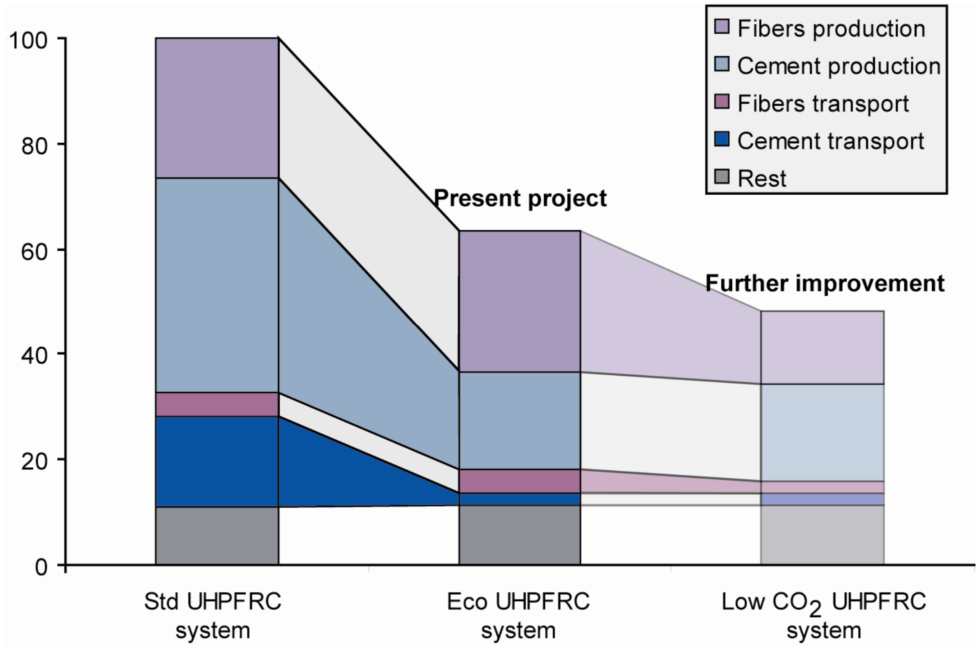
During site work, deviation travels:

- Deviation distance: 15 km (30 km return trip)
- Traffic: 100 cars a day

3 days of site work represents
yearly CO_2 emissions for 1 car

5. Conclusion and perspectives

- UHPFRC system
  - Use less materials and have similar impacts than traditional systems
  - Use easy-to-implement technics
- Eco UHPFRC developped in Arches project
  - Use local cement and reduce transport impacts
  - Use less cement without compromising mechanical and protective properties of UHPFRC



Further improvement:

Fibers with lower impact

Thank your for attention !

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