Université Gustave Eiffel

LABORATOIRE MIT
MATÉRIAUX POUR
INFRASTRUCTURES
DE TRANSPORT

High Performance Concrete Carpet

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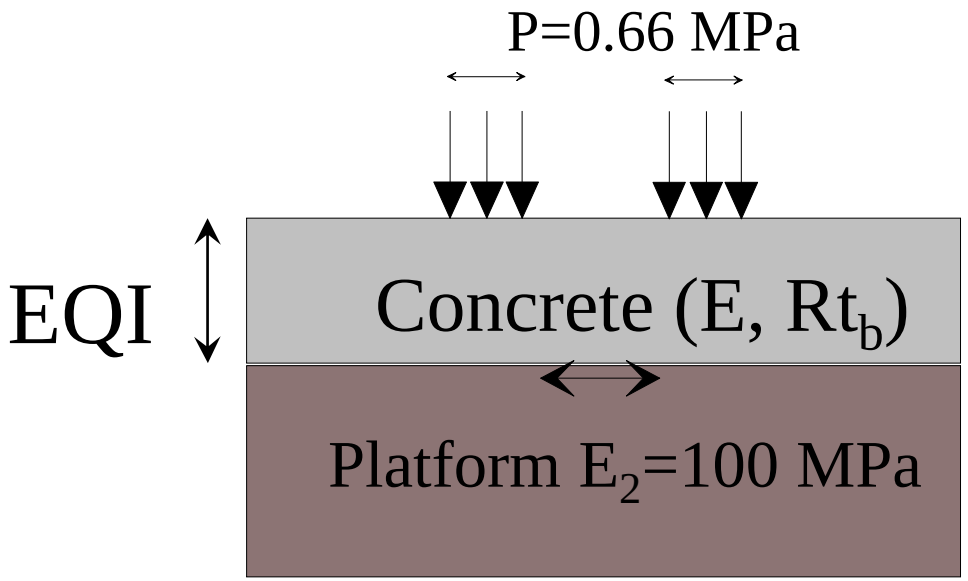
Introduction

- Is it worth using high or ultra high performance concrete (HPC or UHPC) in traditional concrete pavement structure?

- A simplified approach to compare different materials accounting for the fatigue resistance of the materials
  - Concept of equivalent quality index
  - Used in the French Pavement Design Method to classify the materials

Introduction

- EQI Equivalent Quality Index
  - thickness allowing 10^6 cycles in a simplified case of structure
  - accounts for E and R_{tb}
- Calculations assumptions
  - Poisson coefficient ν=0,25
  - σ_6 / R_{tb} =1



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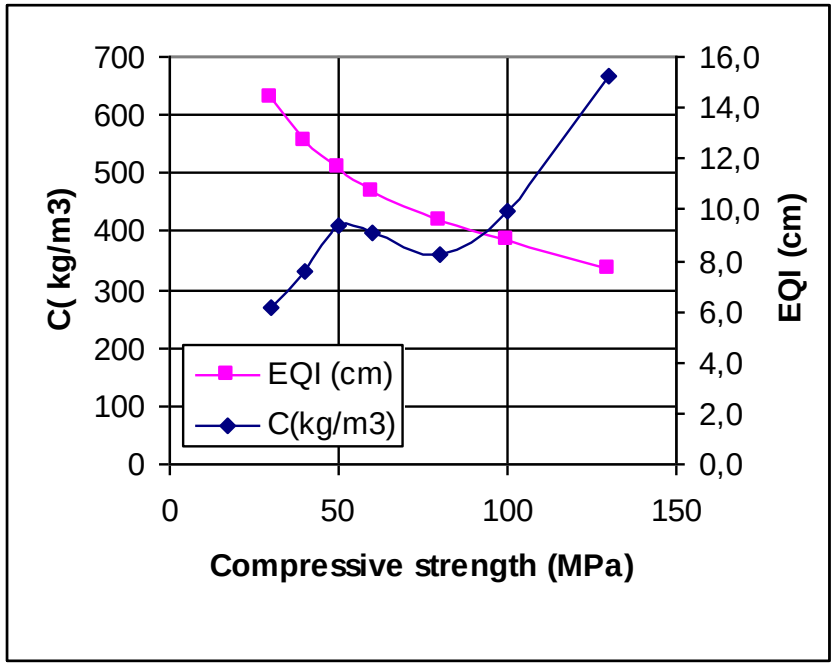
Introduction

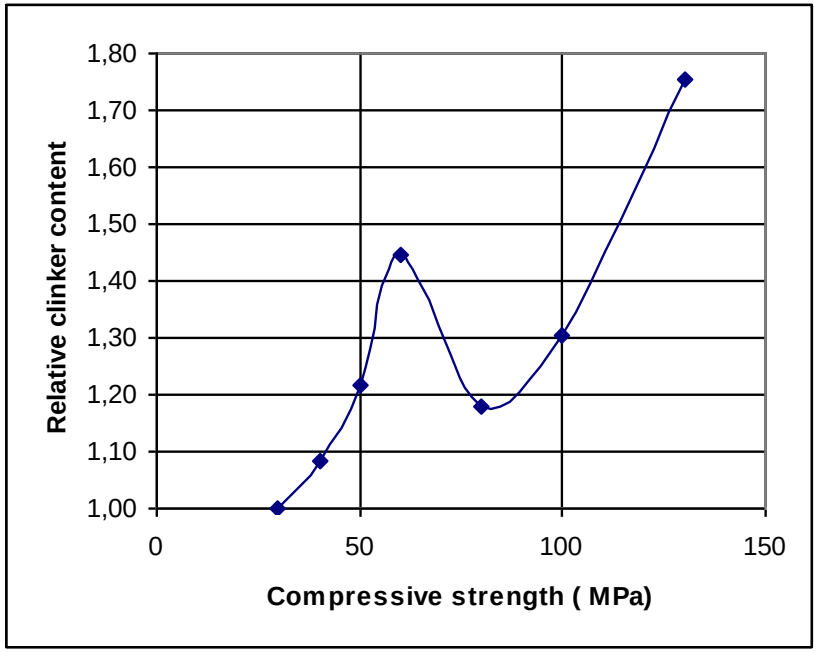
- Calculations of EQI for concrete with increasing strength
  - Mixes simulated with BetonlabPro software from 30 to 130 MPa
    - From 30 à 50 MPa: CEM II 42,5 (25% limestone) slump=3 cm, Dmax=20 mm, air=4%
    - At 60 MPa:CEM I 52,5 slump=18, Dmax=12,5 mm
    - Higher than 80 MPa CEM I 52,5 + 10% SF, slump=18 cm, Dmax=12,5 mm

- EQI x cement content of the mix ➔ calculation of clinker content in the structure

Introduction

- For the same fatigue based performance of the pavement structure the clinker need per meter of road increases with the strength of the concrete





Introduction

- In traditional pavement structures, HPC and UHPC may be of limited interest considering:
  - this increasing clinker demand per length of pavement
  - the sharper quality control needed to ensure a good placement as higher viscosity and/or thixotropy are expected with these concrete
  - the higher risk of plastic shrinkage at early age

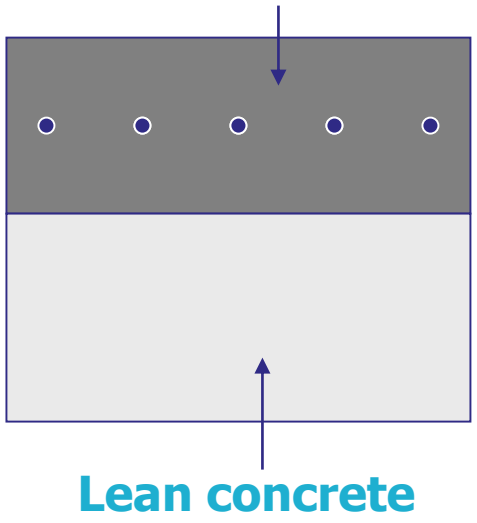
- For fast track repair, high early age strength of HPC/UHPC may justify their use

Introduction

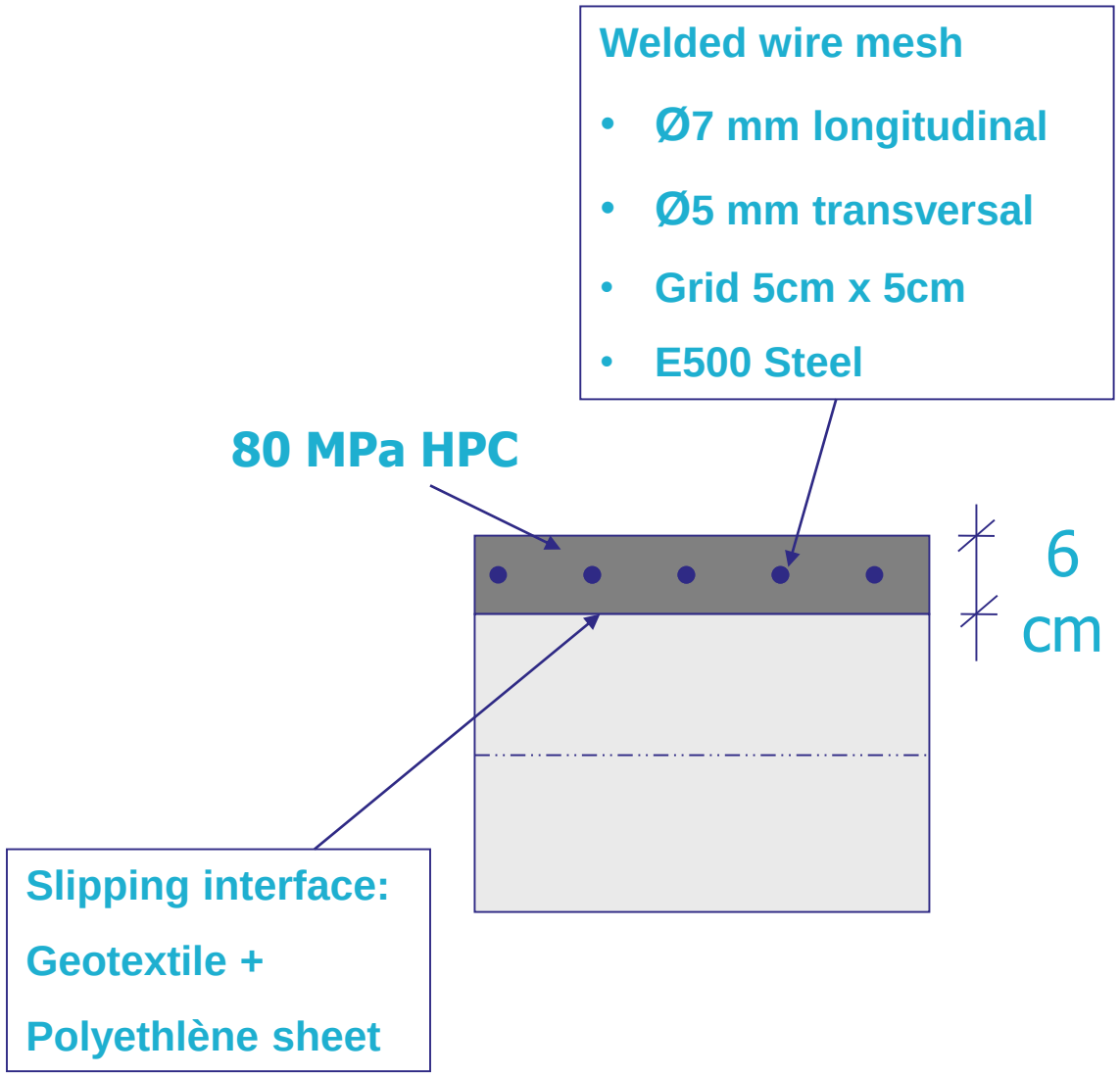
- ➔ It is then necessary to develop new long lasting concepts to benefit the high quality of HPC/UHPC such as high durability, high resistance to wearing

- In that context, University G. Eiffel (ex LCPC) has participated to the development of the High Performance Concrete Carpet (HPC)
  - under the direction of F. de Larrard (at LCPC and then Lafarge Holcim)
  - since the last 90'

The concept



Classical concept



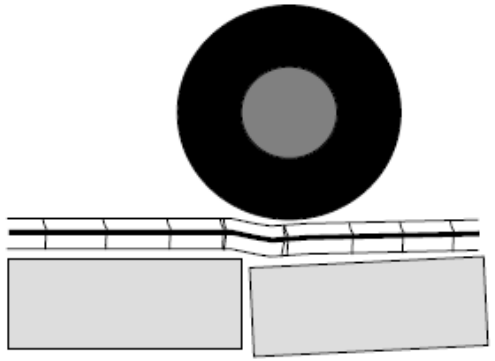
New concept

The concept: main ideas

- Separate the role of each layer and have a high quality long lasting wearing course➔ concentrate the high-value materials in an upper thin layer with:
  - High wearing resistance
  - High durability
  - Low rolling noise (exposed aggregate with $D_{max} \leq 10$ mm, or brushed surface)
  - ➔ The thickness is not designed by the fatigue behavior but by the limitation of corrosion of wire mesh (cover > 20 mm in presence of deicing salt)
- Avoiding the reflective cracking from the bottom layers ➔ slipping conditions

The concept : main ideas

- Accept thin cracking pattern controlled in both directions by welded wire mesh:
  - ➔ good water tightness expected ➔ protection of the foundation
  - ➔ increased flexibility of the wearing course which would adapt itself without degradation, like a coat of mail
  - ➔ could be used for new pavements as well as for repairs of rigid or semi-rigid old pavements



The concept : main ideas

- Avoiding the risk of buckling by hot weather:
  - a minimal level of shrinkage is specified to add some tension in the layer and counteract the effect of thermal expansion
  - the wearing layer must be anchored by transverse beams inserted in the foundation (end day joints)
- Expected savings of materials compared to CRCP:
  - Cement: -34%
  - Steel: -35%
  - High quality aggregates for wearing course: -71%

A long way to the final solution

- 10 m experimental slab for fatigue tests in **2001-2002** at LCPC
- 100 m site test (Villeurbanne) in **2003** in the entrance of a concrete plant: up to now, good behavior (fine and distributed cracks), but slow traffic
- 300 m site test on A26 highway (SANEF) in **2007** but technical problems with slip-form incorrect flow of the concrete through the welded wire mesh ➔ presence of voids under the layer ➔ failure after the first days ➔ rapid deconstruction

Auxerre experiment

- A 200 m section near Auxerre
- On an access road between two national roads
- Experimental construction followed by:
  - Owner: Dir CE (Road inter departmental agency)
  - Companies: Agilis and Lafarge
  - Public research intitutes: CEREMA, Univ. Eiffel (ex Ifsttar)

- Construction in june 2015

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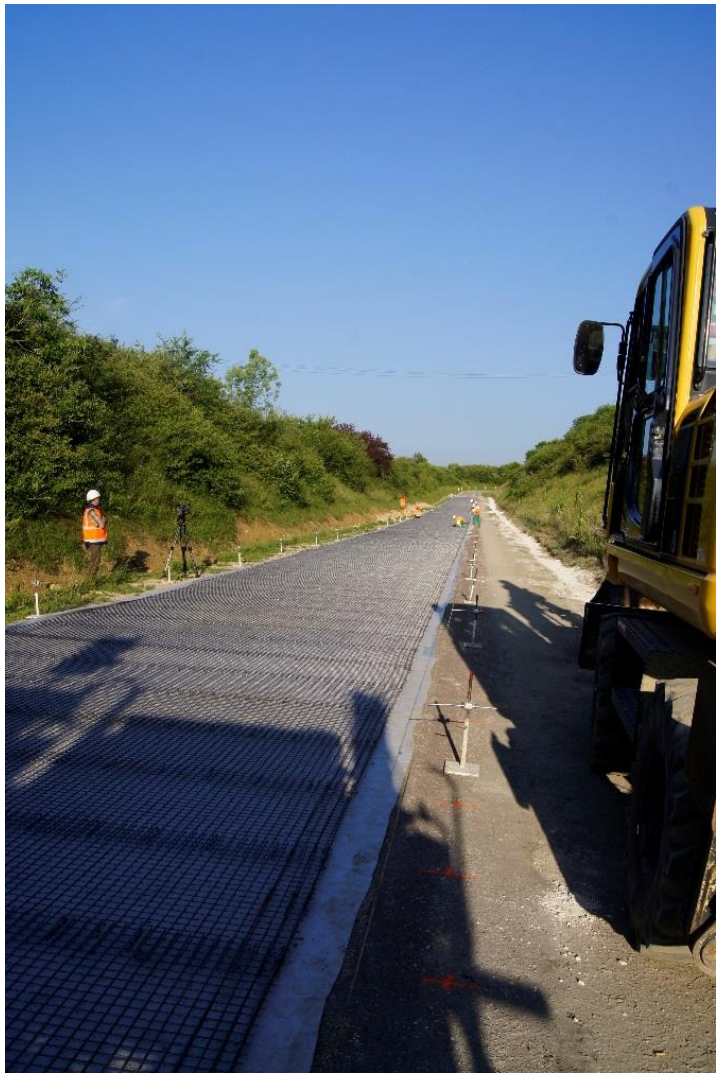
Auxerre experiment



Auxerre experiment

Casting of edge beams

Auxerre experiment

Auxerre experiment

- In october 2022 (7 years after construction)
  - Approx. 325 trucks per day
  - Good global mechanical behavior (fine and distributed cracks)
  - Skid resistance of the brushed surface: decreasing with time and at the limit of acceptable values, but can be tackled
  - Same noise as the bituminous layer connected to the section

Conclusion

- Promissing concept
- Some key points:
  - HPC with a low slump (around 5 cm) to ensure evenness
  - The workability must be very well controlled and adapted to the slipform speed ➔ use of high amount of retarder
  - No long stops between two edge beams
  - High quality of mesh laying to ensure concrete cover ➔ use of mesh panels

- And now:
  - Monitoring will continue (next in 2024)
  - New operational site is seeked

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