# New Road Construction Concepts: towards reliable, green, safe&smart and human focused infrastructures in Europe
# The european project NR2C

Brigitte MAHUT

LCPC Laboratoire Central des Ponts et Chaussées
L'esprit de recherche au cœur des réseaux

# NR2C

1. What will the European road system look like in 2040 ?

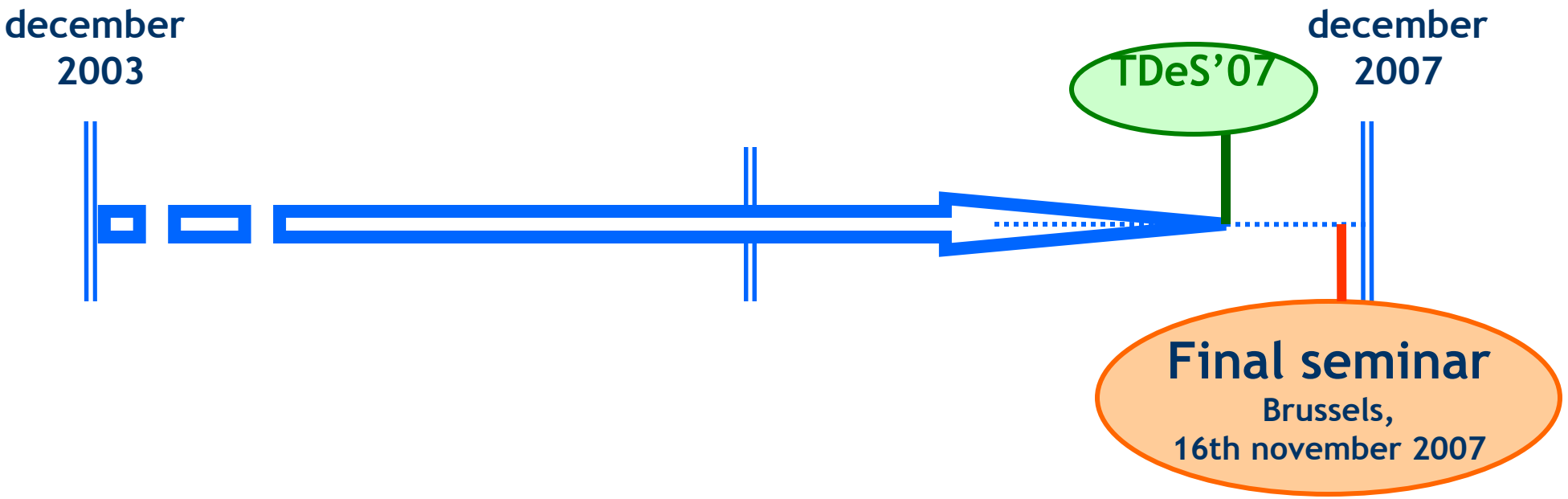
2. How can innovation deliver solutions to the challenge of the future ?

# NR2C « New Road Construction Project »

## STREP of the FP6

Priority 6 : Sustainable development, global change

**Duration : 4 years**



# NR2C partners

- **Laboratories**

| | |
|---|---|
| LCPC | France (coordinator)<br>(joint unit research :DREIF/LROP, CETE de Lyon) |
| FEHRL | + « umbrella » : DRI Denmark, KTI Hungary, ZAG Slovenia, VTI Sweden |
| BRRC | Belgium |
| DWW | Netherlands |
| EPFL | Suisse |

- **Engineering and design consultants**
  **Road industry**

| | |
|---|---|
| Greisch | Belgium |
| Eurovia | France |
| JMI | France |

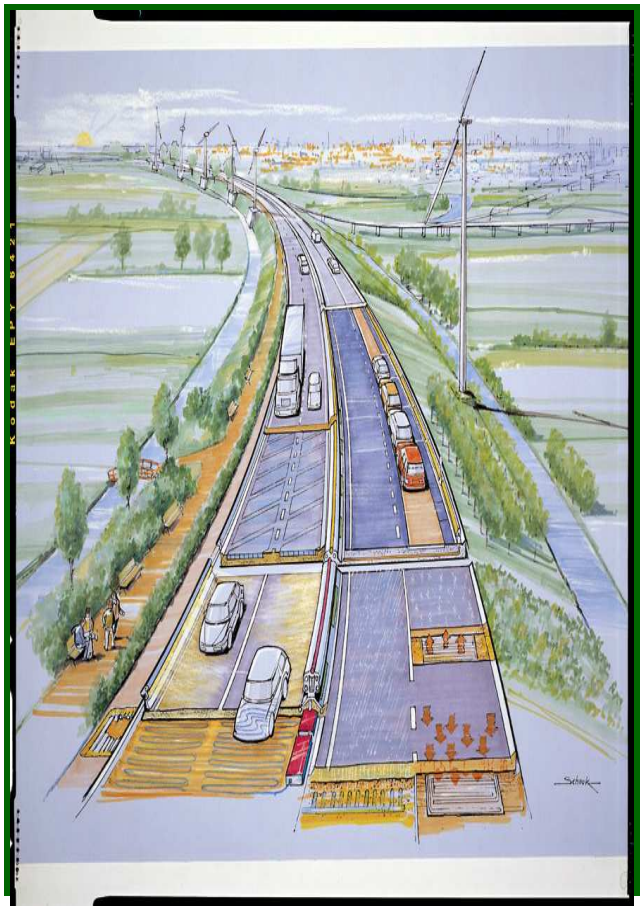
- **Infrastructure owner**

| | |
|---|---|
| Autostrade | Italy |

# Objectives of NR2C 1/2

1. Develop **new concepts** for the road of the future

- comfortable and safer
- high quality,
- environmentally friendly
- low resources
- nuisance mitigating
- low maintenance
- always accessible to traffic
-…cost effective



**Long term vision horizon 2040**

# Objectives of NR2C 2/2

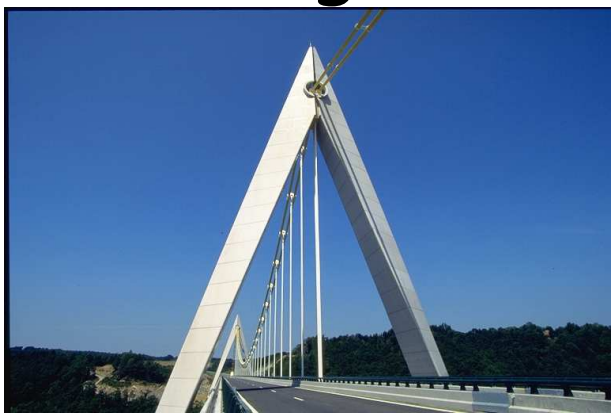
❷ Develop **specific innovations**

to support and progressively implement these concepts and answer to future needs and expectations

## Urban

## Interurban

## Bridges



**Shorter term Vision**

The project NR2C is supported through the Sixth Framework Programme of the European Union.

FEHRL

NEW ROAD CONSTRUCTION CONCEPTS: VISION 2040

# The NR2C Vision 2040

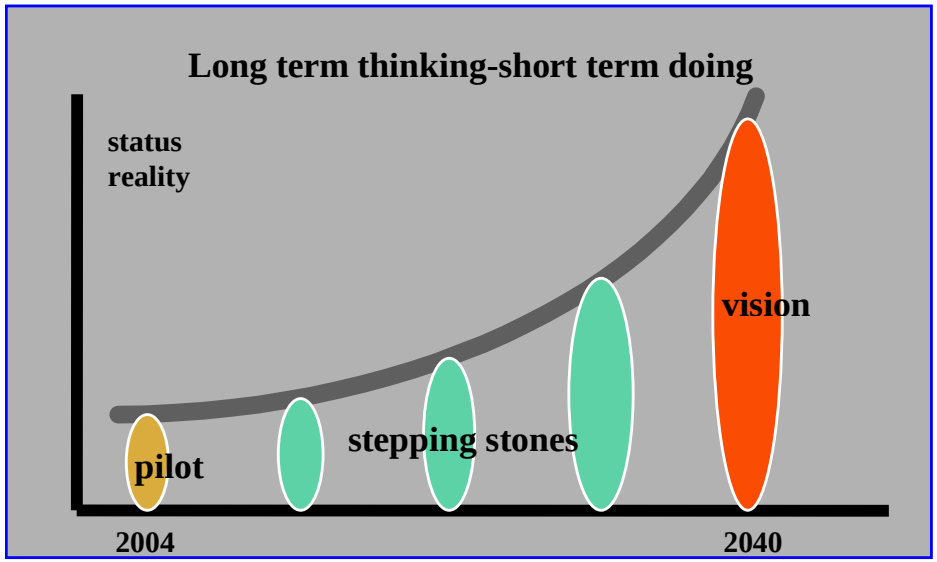
**Published by FEHRL (2006)**

**Available on website :**

**www.fehrl.org/nr2c**

FEHRL

# NR2C why a Vision ? why 2040 ?




## Visions

**Mobility and Transport**
**ERTRAC**
**2020**

**Road Transport**
**FEHRL**
**2025**

**Construction**
**(buildings and networks)**
**ECTP**
**2030**

**Road and streets engineering**
**NR2C**
**2040**

# NR2C, a european vision

- **Generic developments :**
  - Shortage of clean environment
  - shortage of energy
  - shortage of space

  -Increased demand for mobility

- **postulates :**

  -Road transport and cars will continue to be the predominant transport mode (to be nuanced in urban area)

  -Infrastructure engineering and technologies reduce nuisance due to road traffic

# Vision NR2C : 4 concepts

**Reliable**

***"Reliable"*** *: includes* ***reliability, durability, serviceability***
*<=> infrastructure durable, high quality, easy to maintain with low traffic disturbance; road must remain accessible.*

**Green**

***"Green"****: covers* ***environmental impact reduction*** *: insertion in the landscape* ***nuisance reduction*** *(noise, air pollution, water pollution, vibrations),* ***energy economy, preservation of rare natural resources, use of new materials***

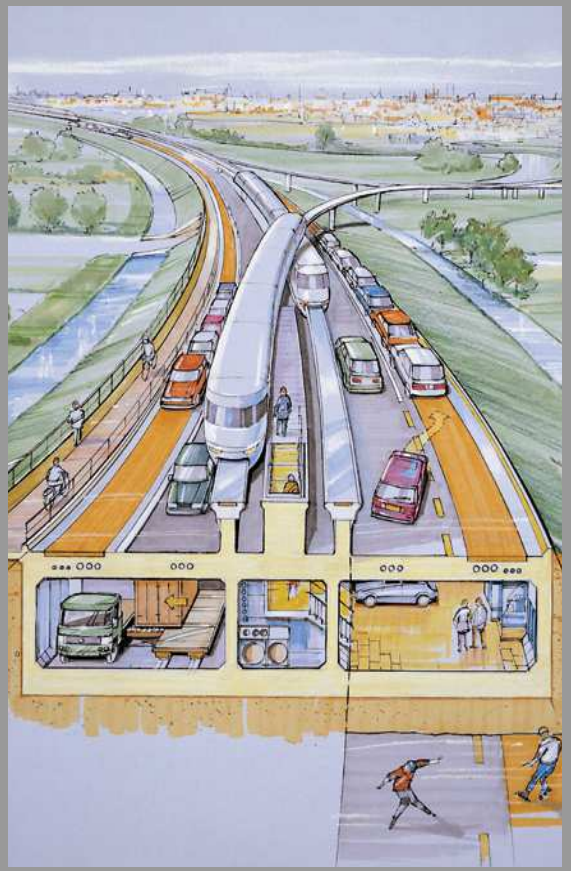
**Smart, safe**

***"Smart and safe" :*** *infrastructure equipped with devices which give information on traffic, on infrastructure condition, able to interpret, to decide, to act, for* ***the benefit*** *of* ***users (all categories)*** *for safe and comfortable travels, and as a maintenance support tool for the* ***infrastructure owner****..*

**Human**

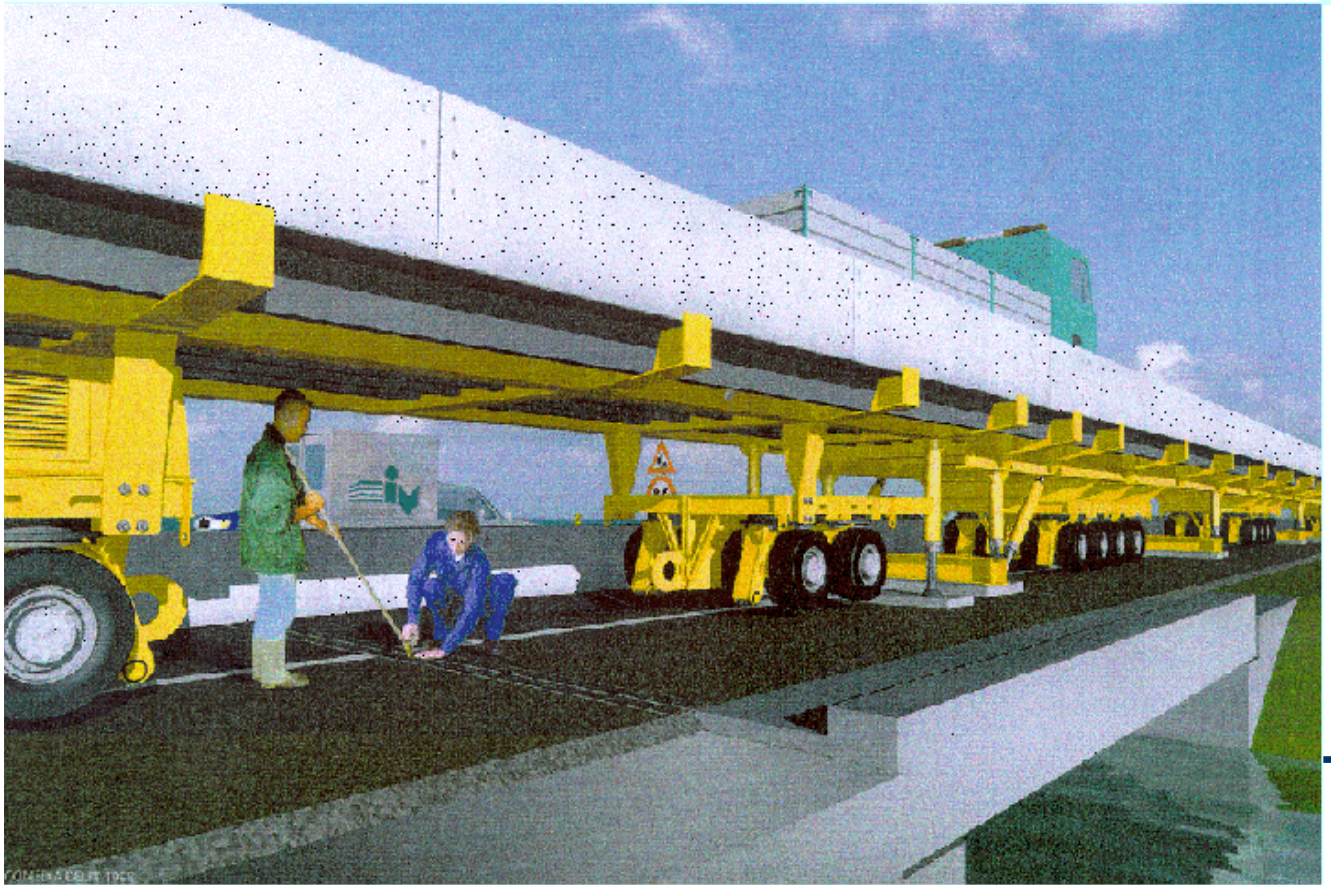
***"Human"*** *: includes* ***multi-fonctionality****,* ***multi-use.*** *And also : space arrangements where one feels safe , in accordance with* ***human dimension.***

# From Vision …to direction of solutions

| Vision 2040 | Characteristics | Construction Concepts | Directions of solutions |
|---|---|---|---|
|  | Available<br>Durable<br>Reliable | **Reliable Infrastructure** | • Lifetime engineering<br>• Fast, hindrance-free maintenance<br>• Balancing demand and capacity<br>• Asset management tools |
| | Energy efficient<br>Sustainable<br>Environment | **Green Infrastructure** | • Saving natural resources<br>• Emission Control |
| | Accessible<br>Smart<br>Safe | **Safe & Smart Infrastructure** | • Safe design<br>• Smart design<br>• Smart communication<br>• Smart monitoring |
| | Multi-functional<br>Multi usable<br>Public security | **Human Infrastructure** | • Public security<br>• Multi-functional use<br>• Human design |

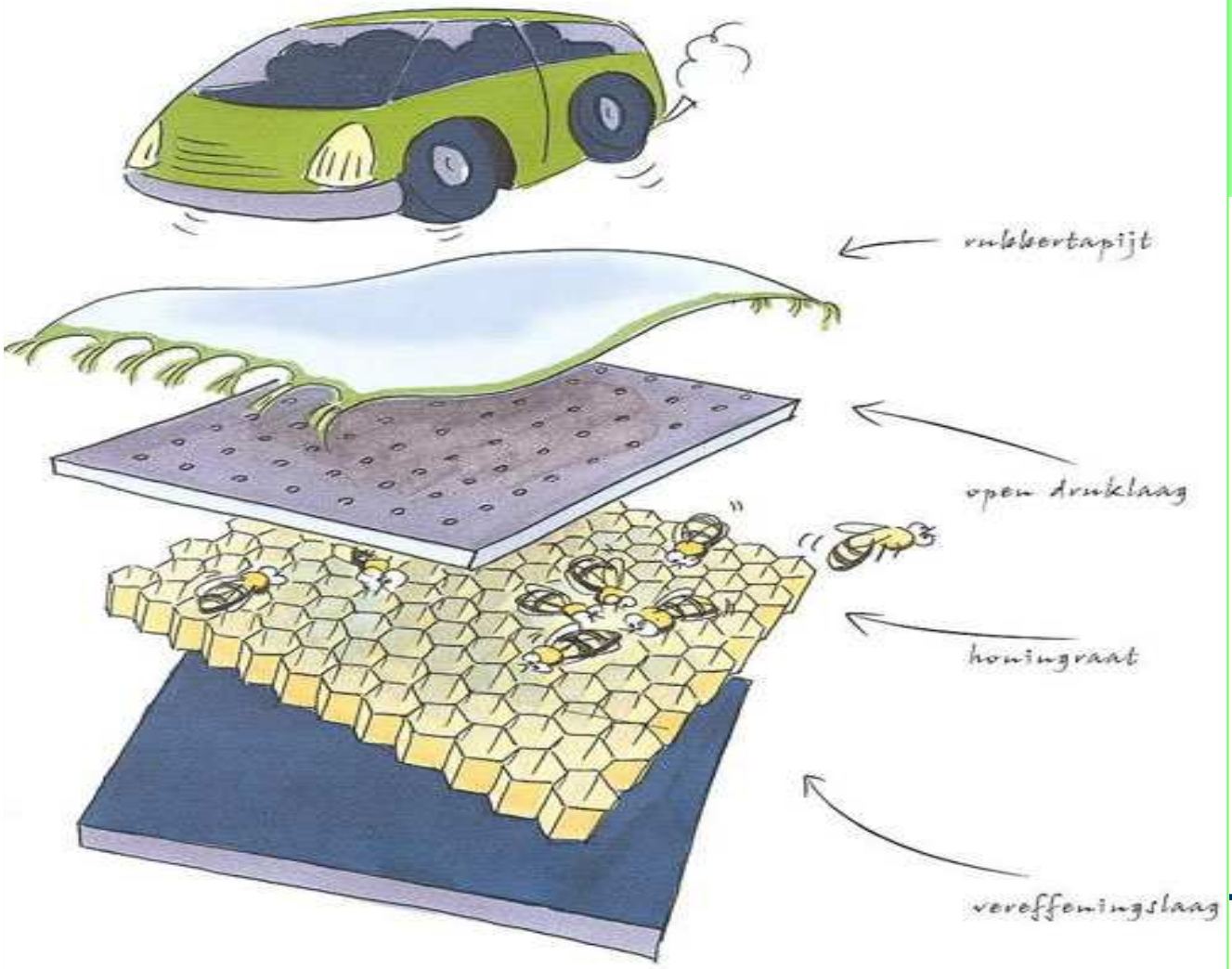
# Reliable infrastructure

## Direction of solution



- Low maintenance
- Balancing demand and capacity
- **Fast and hinderance free maintenance**
- Asset management tools

# Green Infrastructure

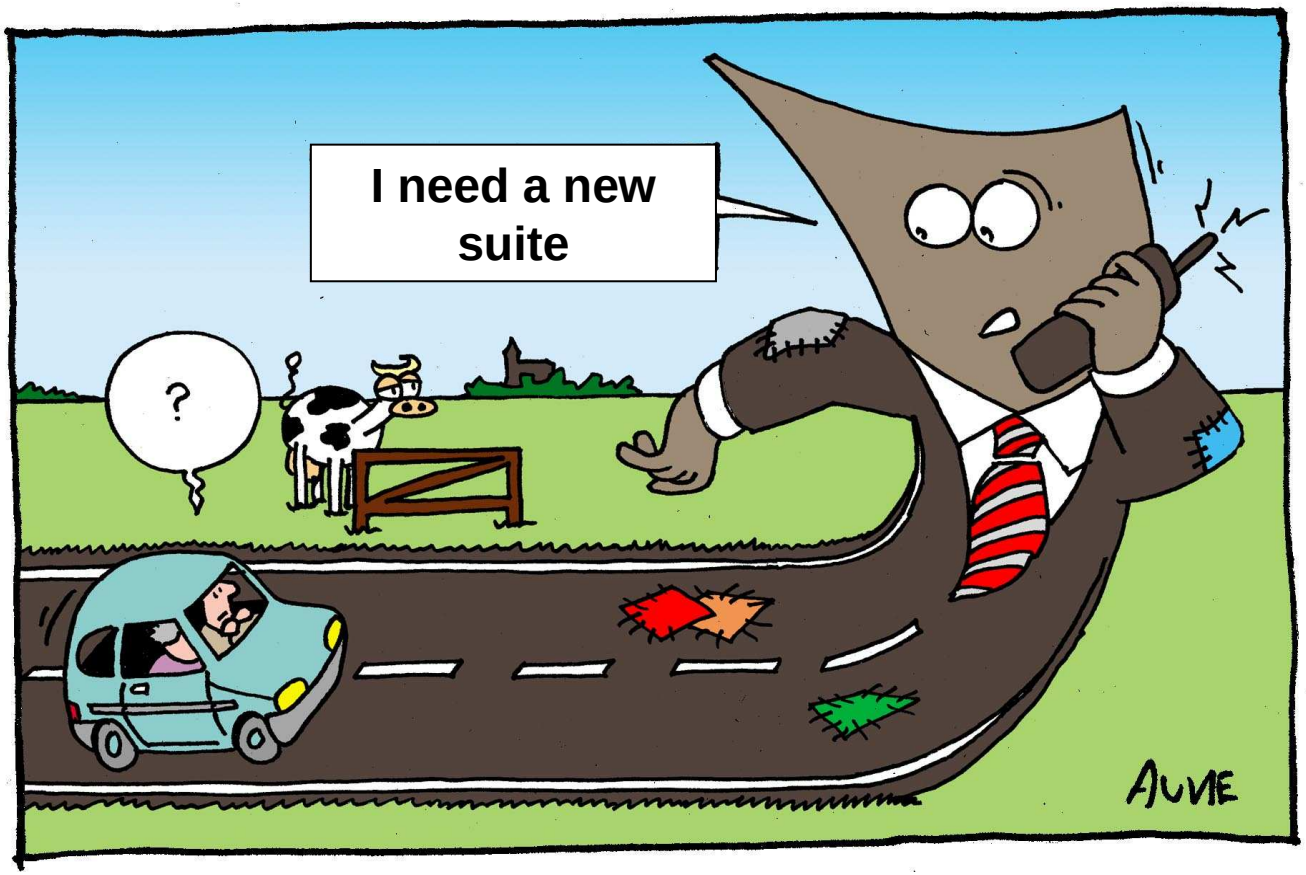



## Directions of solution

- saving natural resources
- **emission reducing constructions**

# Smart, safe infrastructure

## Direction of solution




- User-friendly
- User-supporting design
- **Smart, detective road**

New Road Construction Concepts

Nr2c

# Human infrastructure

## Direction of solution


- Secure place to stay
- Multi-functional
- **Multi-usable**
- Grand design

# *Examples of Specific innovations developed in NR2C*

*Towards more human infrastructure,*

# *....Design models for multimodal streets*

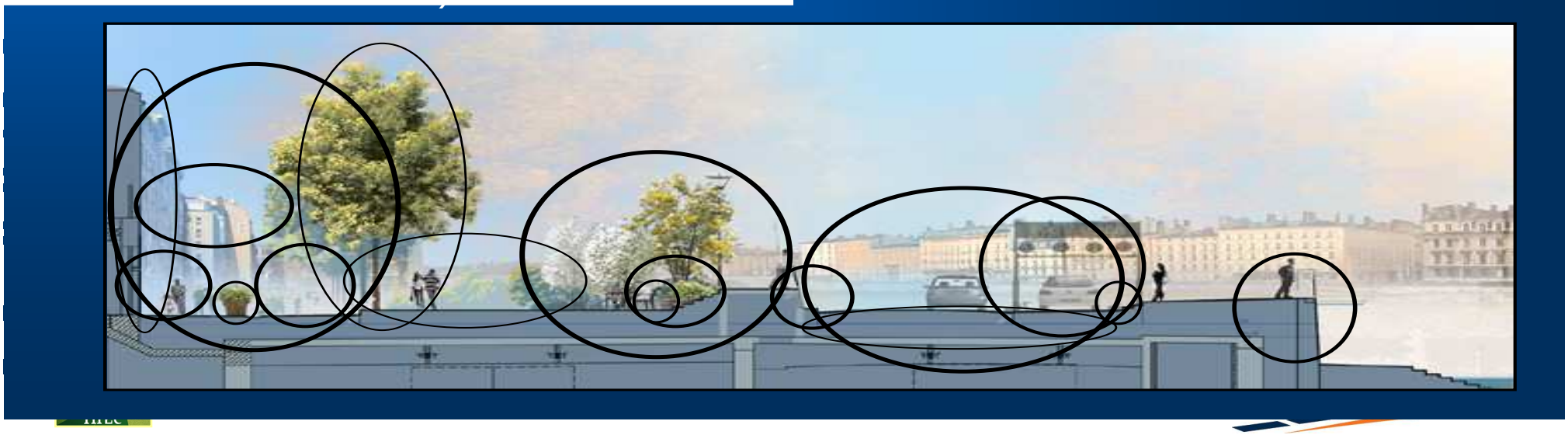
## Urban infrastructure

# Design models for multi-modal streets

**Human**

***a creative tool for the design of streets,***
***and a support in the dialogue between persons involved***

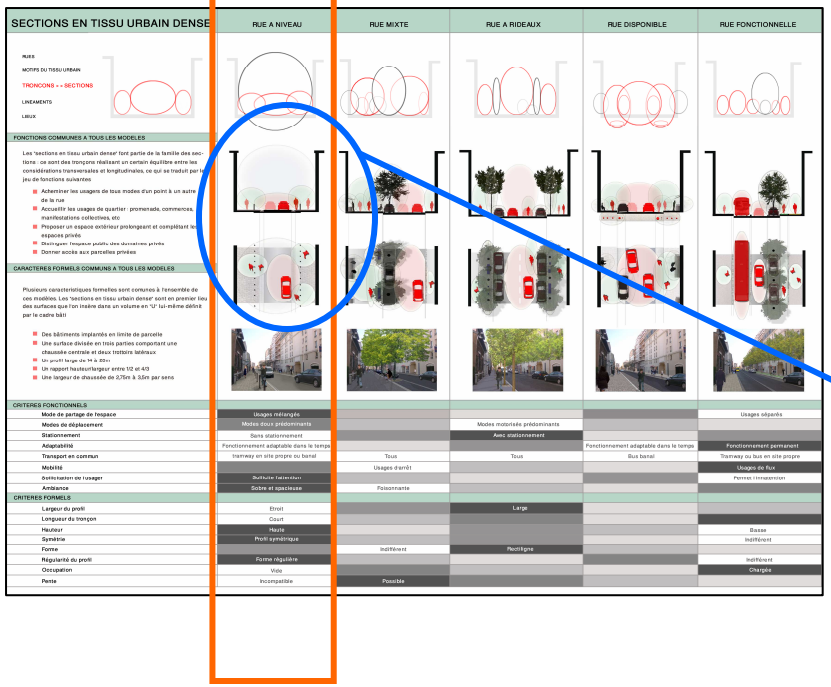
**(LROP - France)**

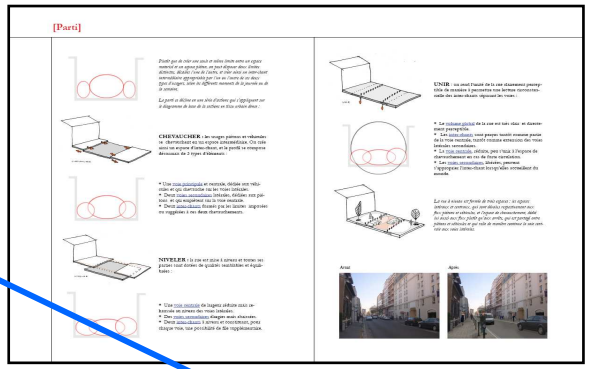


# What is a design model ? an explicit tool

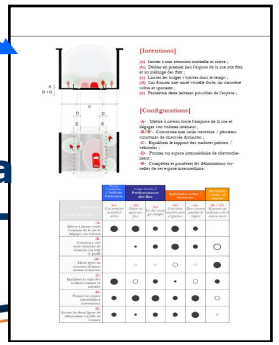
**Human**

Depending on the given street,
depending on the programme (what you intend to do)
⇒choice of the most appropriate
design model
⇒solution


**Force/criteria**



***Example : depending on the objective, and therefore on the design model chosen it can results solutions where the space of the street is differently shared between pedestrians and vehicles***

***with the design model chosen :***

**Possible solution**

**Before**

La rue Jean Bleuzen a Vanves

## *If other design models, other possible solutions ...*




## Main issues

**Human**

- 20 design models have been finalised
  - for direct use
- Methodology to develop new design models has been developed
  - for specialists
  - based on reflexion on qualities of streets
- Implementation under progress in Wattrelos (France)

***Towards greener infrastructure,***
***reduction of traffic nuisance***

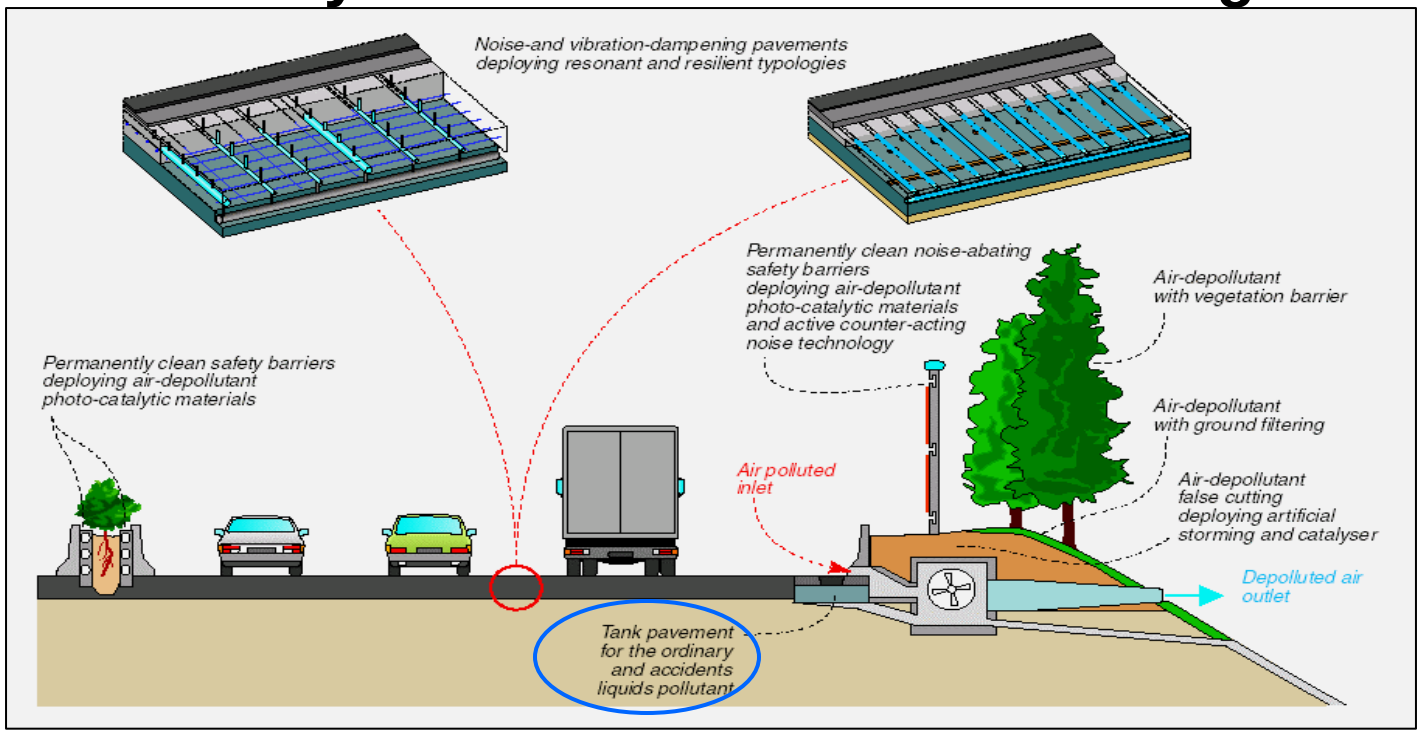
# ..... Ecotechnic Road Systems,

## Urban and periurban infrastructure

# Ecotechnic Road Systems

**Green**

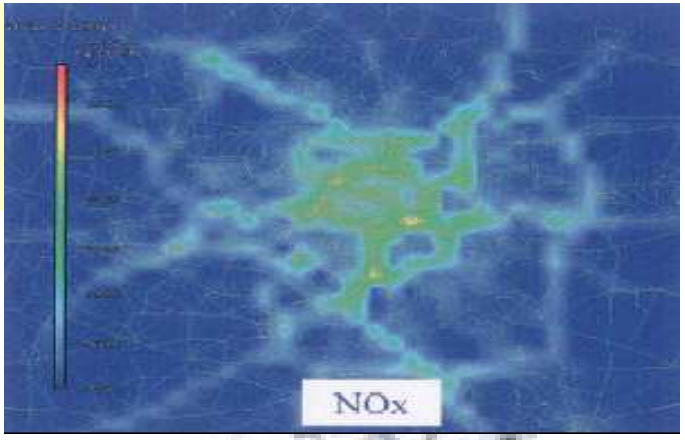
**(Autostrade – Italy + contribution BRRC –Belgium on Ti O2)**




***Integrated infrastructure based on the most innovative technologies for a global reduction of nuisance (noise, vibrations, air pollution and water pollution).***

3 subsystems :
- Pavements (resilient, resonant, and reservoir pavement)
- Barriers (anti-noise, air depollutant, safety and green barriers)
- Auxiliary subsystem (air cleaning unit, ventilation unit, ground catalyser, photocatalytic material and TiO2 coating)

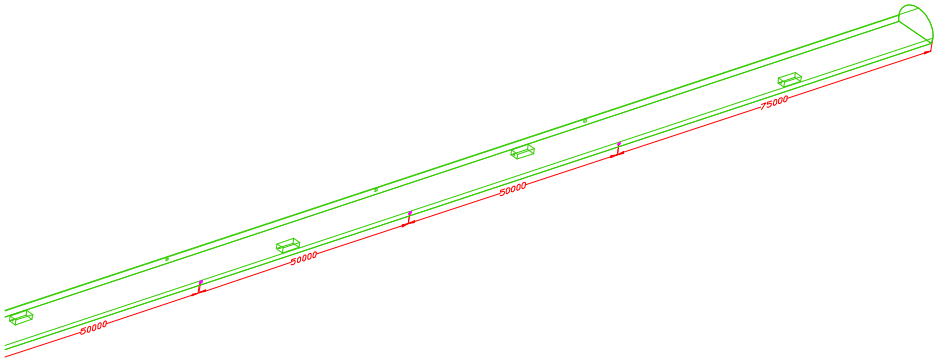
# Air pollution

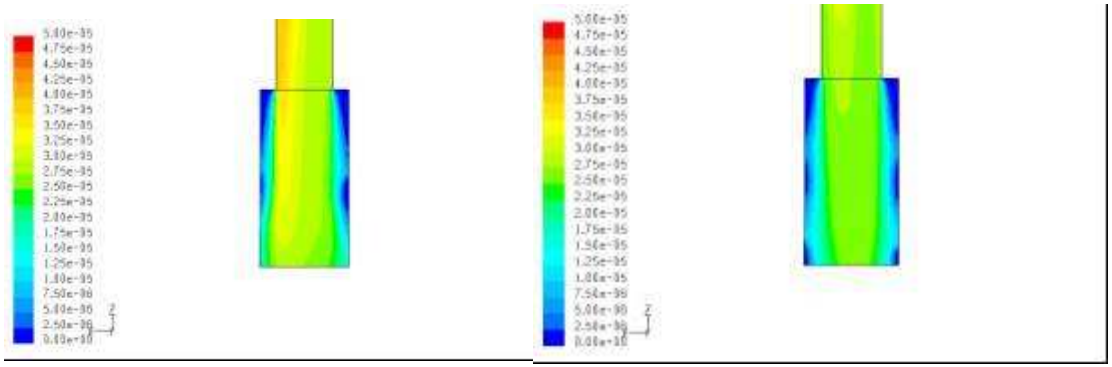


# Air pollution

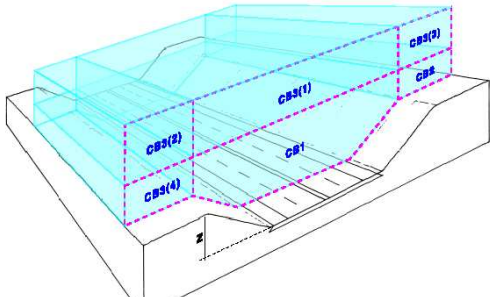
## Tunnel , Road- cutting and embankment

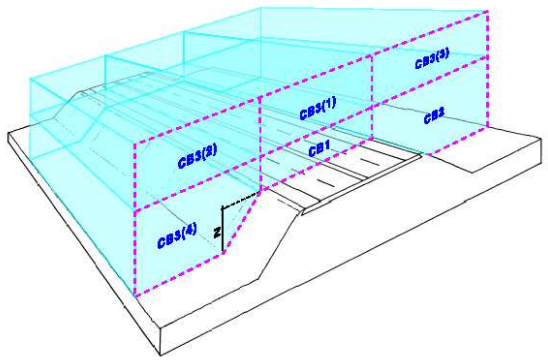
**Green**

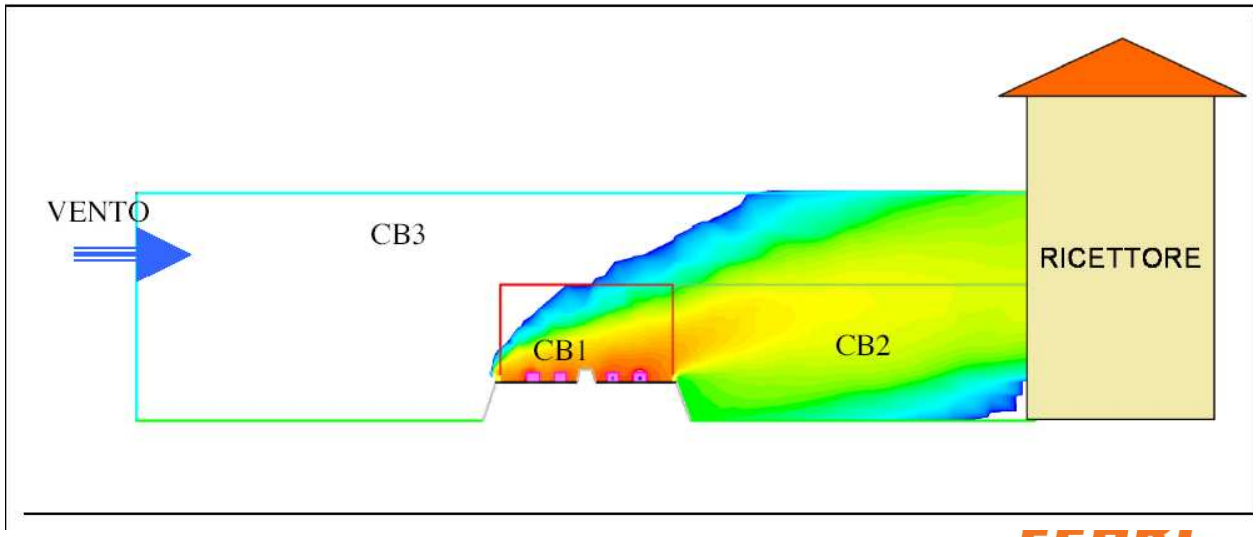




**Mass fraction CO without (left side) and with (right side) ACSU [h = 0 m (upper)]**



# Main results

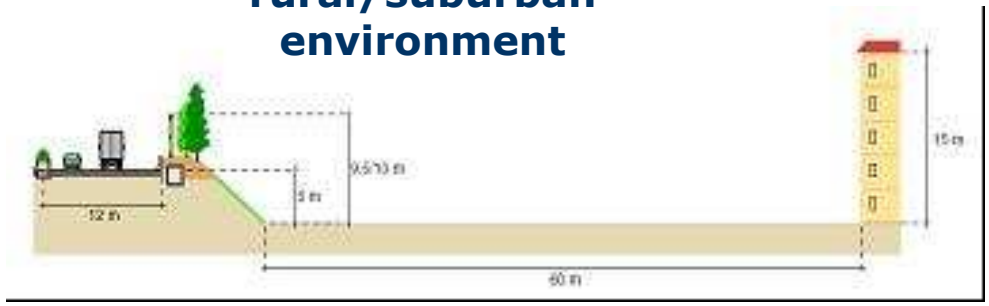
**Green**

- Nuisance reduction : possible solutions

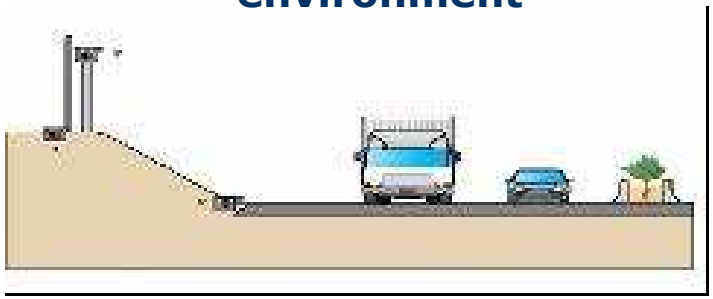
**Noise** : till 12 dBA – road 3 to 6 dBA and barriers till 8 dBA
**Water** : reservoir pavement defined storage capacity till 2 days
**Air pollution** : embankments 9 %, cuttings 8 % (average values for different traffics, winds,etc)

- Global environmental performance of 2 innovative solutions

**Solution 1 rural/suburban environment**

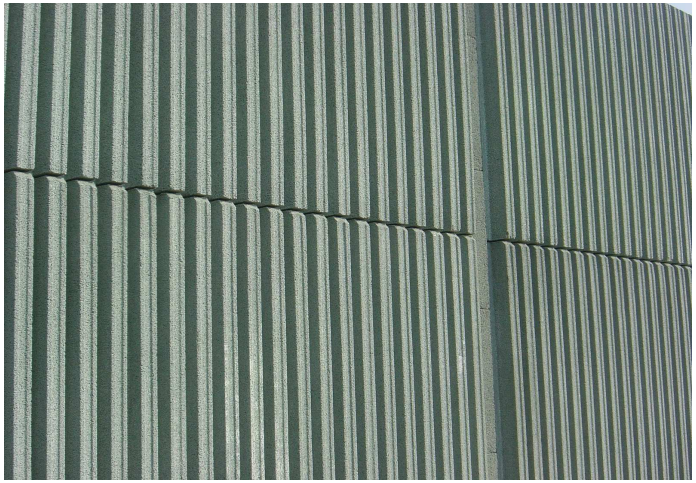


**Solution 2 urban environment**



# Combined functions
# Noise, air pollution reduction

**Green**



**+ TiO2**
***(BRRC - Belgium)***

*Example of $TiO_2$ application in Anvers*

***Towards greener infrastructure,***

***also***

***..... low noise pavement***

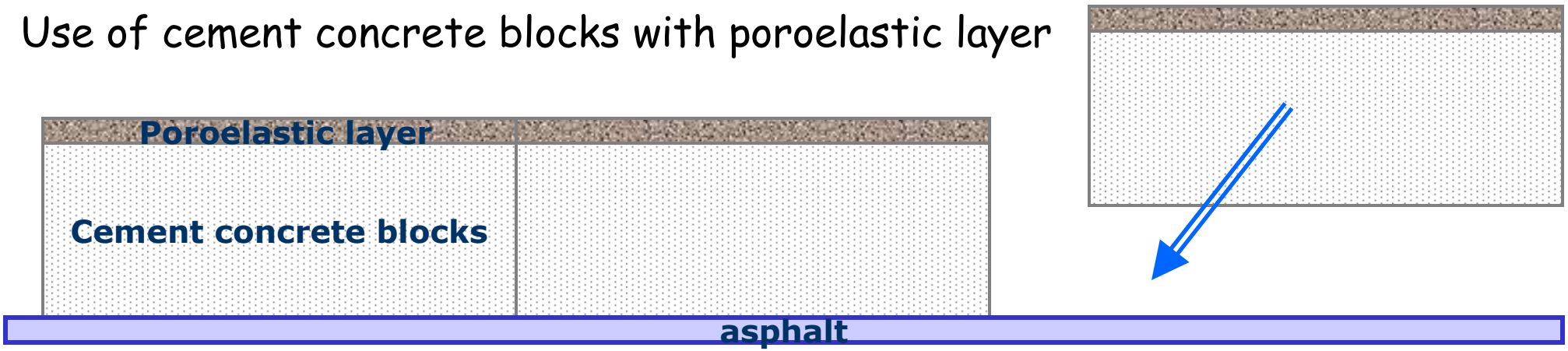
# Low Noise Pavement

Green

(ZAG -Slovenia + VTI - Sweden)

- Synergy with Silence project

Use of cement concrete blocks with poroelastic layer




***Towards greener infrastructure,***
***reduction of rare resources consumption***

***.....recycling***

# High performance underlayers with low cost materials and high percentage of re-us

**Green**

## (BRRC – Belgium + EPFL – Switzerland, and VTI - Sweden)

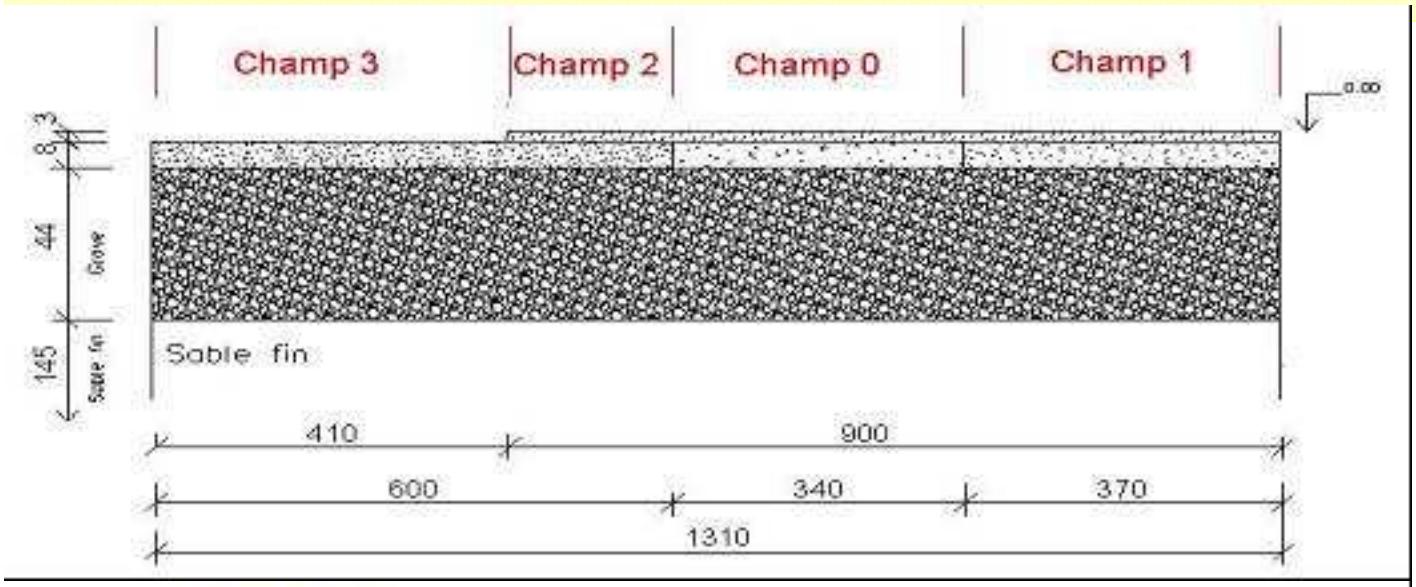
**materials studied :**
**Belgium and Swiss materials**

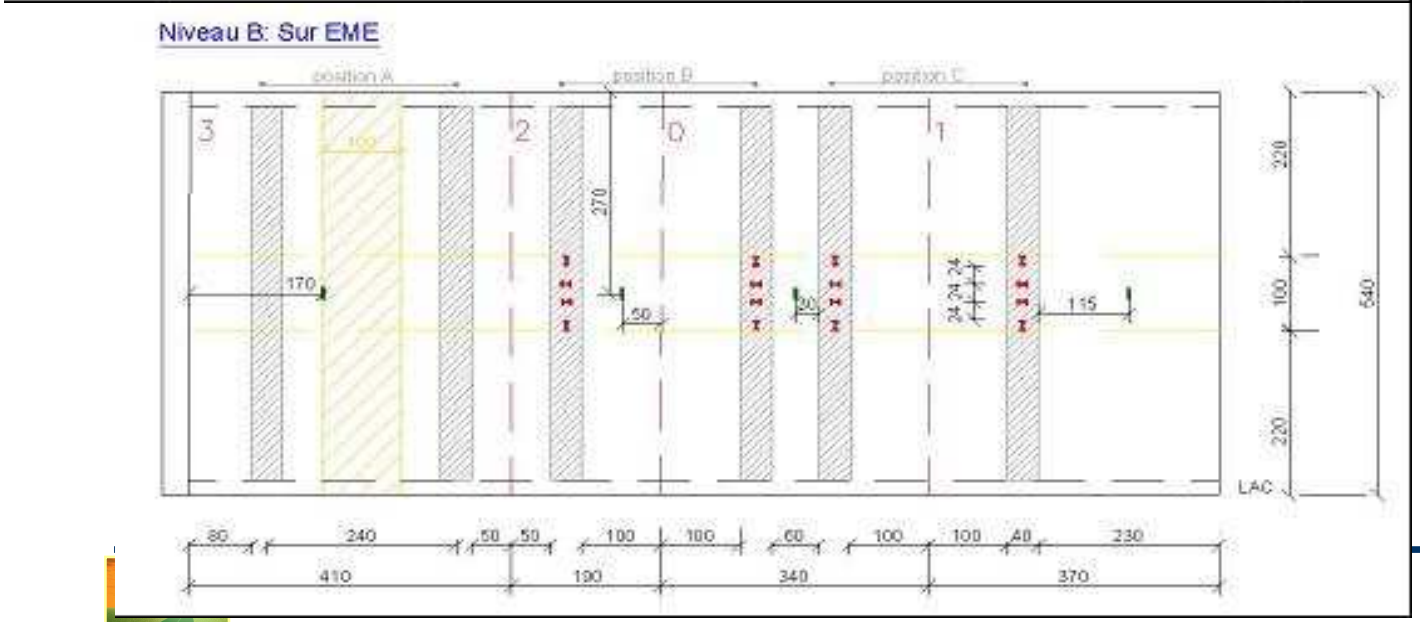
**with 0%, 25% and 40 %**
**of Reclaimed Asphalt**

**ALT –EPFL facilities**

# Main results

**Green**




**-> OK even with 40 % RA,**

-difficulty to predict precisely behaviour-> analysis of binders

FEHRL

***Towards greener infrastructure,***

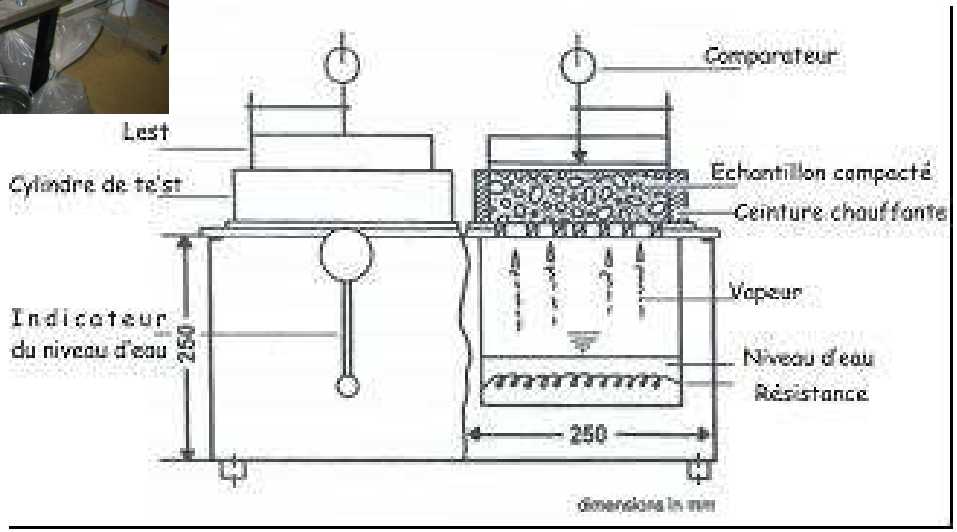
***also***

***..... crack free semi-rigid pavement***

# Crack free semi-rigid pavement (LCPC)

**Green**

incorporating by products => controlled swelling (Feasability study )




**Difficulty : device to be used for accelerated measurement**

*Towards more reliable infrastructure,*

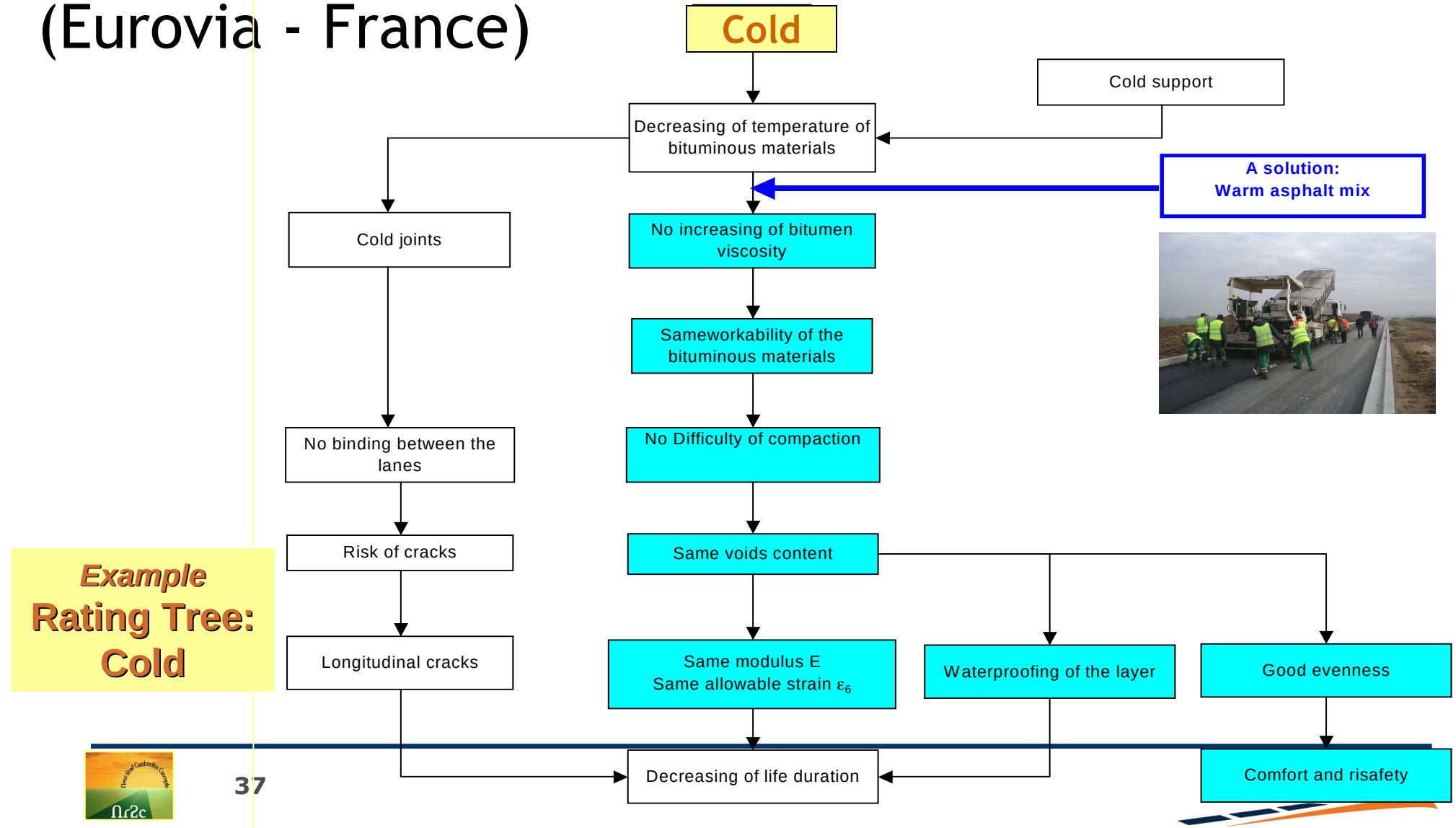
*..... road maintenance*
*innovative solutions*
*under bad weather condition*

# New maintenance methods

(optimised process regarding influence climatic parameters)

**Reliable** **Green**

## (Eurovia - France)




***Example***
**Rating Tree: Cold**

# From rating tree to technical solution

**Reliable** **Green**

## Example of laying of high modulus asphalt mixes with low outside temperature

Outside temperature : 6°C and wet atmosphere

Two layers of high modulus asphalt mix 0/14 laid at a temperature **of 126°C instead of 170-180°C**

**Addition of an additive like a zeolite** (natrium aluminium silicate) with around 21% of crystalline water, which is released (like a foam) in order to maintain the workability of the asphalt mix during the laying and the compaction.

*Towards more reliable infrastructures,*

*..... New bridge design,*

*Bridges durable, light, easier and quicker to build*

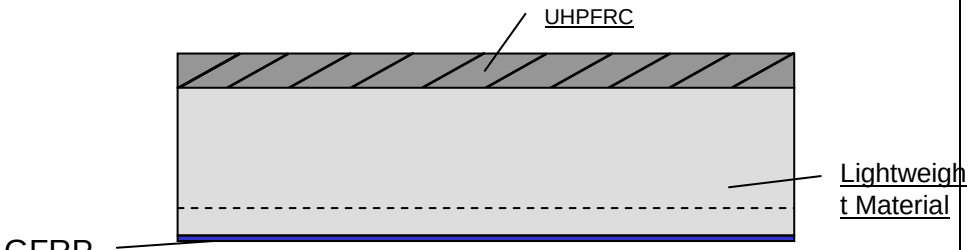
# Innovative slab bridges

**Reliable** **Green**

(JMI, LCPC,LCPC/LAMI, CETE de Lyon, Greisch, EPFL,ZAG)

**> 90% of bridges are current bridges**

## Small spans




## Slab element :

Light, durable, easy to put in place and assemble on site

combining and optimizing performance of new materials

## Longer spans

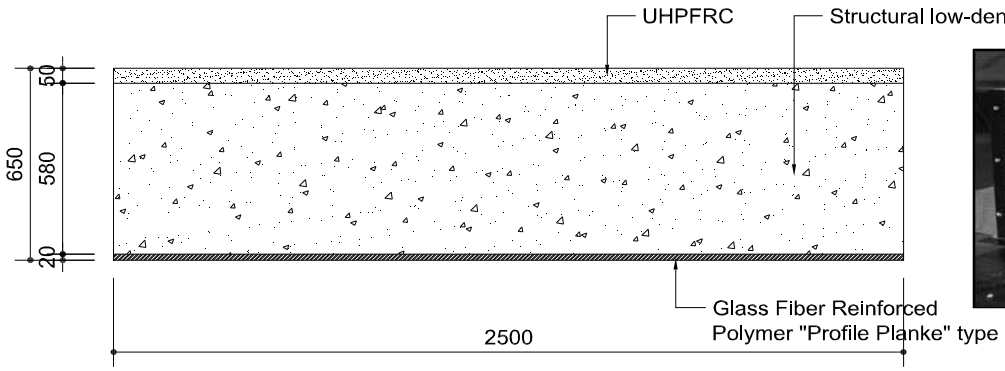
These segments could be used :

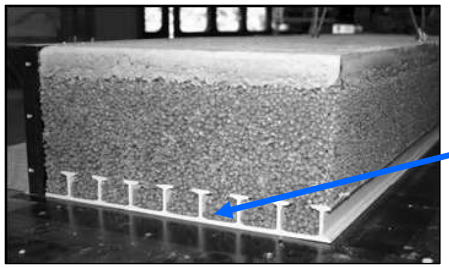
- alone for small span (10 or 25 m)
- themselves supported by structural elements (in new materials) for longer span

# 1 - Sandwich slab tested at EPFL

**Reliable**

## UHPFRC, Lightweight concrete, GFRP

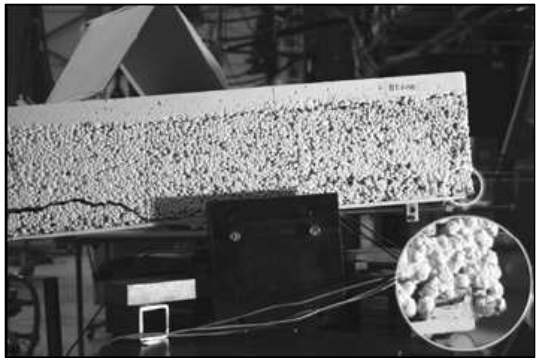


**4 beams configuration** studied:

- 2 types of Light concrete
- 2 interfaces FRP/LC(bond or not)

Typical failure of unbonded beam



Push out of lightweight concrete for unbonded beam

**Main Results** :
The ultimate loads of the beams increased by 100% on average due to bonding. However, the beam failure mode changed from ductile failure to a brittle behaviour. The beams using a LC of higher density exhibited a significant increase of the ultimate load.

# 2 – Design of UHPFC solutions (CETE de Lyon)

**Reliable**

## (+ prestressing and/or FRP, or + steel plates)

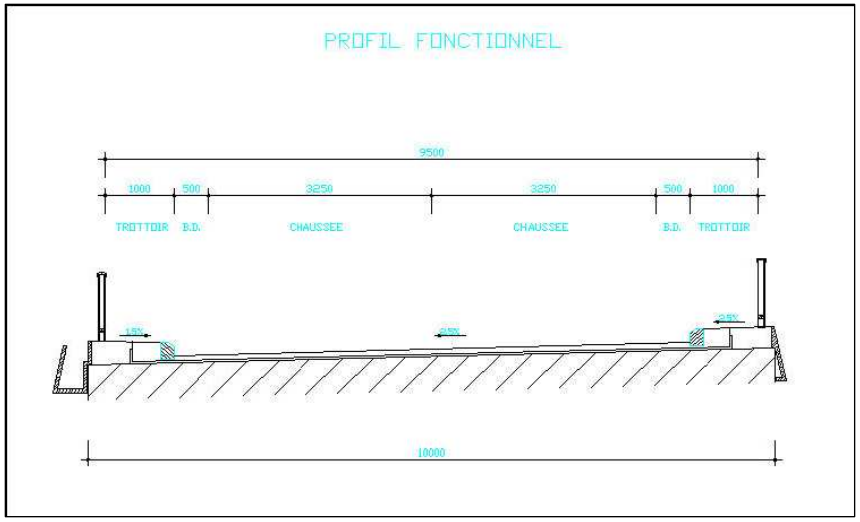
**Cases studied :**

**Span 10 m - UHPFC with prestressing**
Span 10 m – UHPFC + FRP
**Span 10 m – UHPFC + steel plates**

**Span 25 m – UHPFC with prestressing**
Span 25 m – UHPFC + FRP
Span 25 m – UHPFC with prestressing + FRP

Span 25 m – UHPFRC truss + FRP
Span 25 m - UHPFRC + steel plates

Typical transverse profile studied

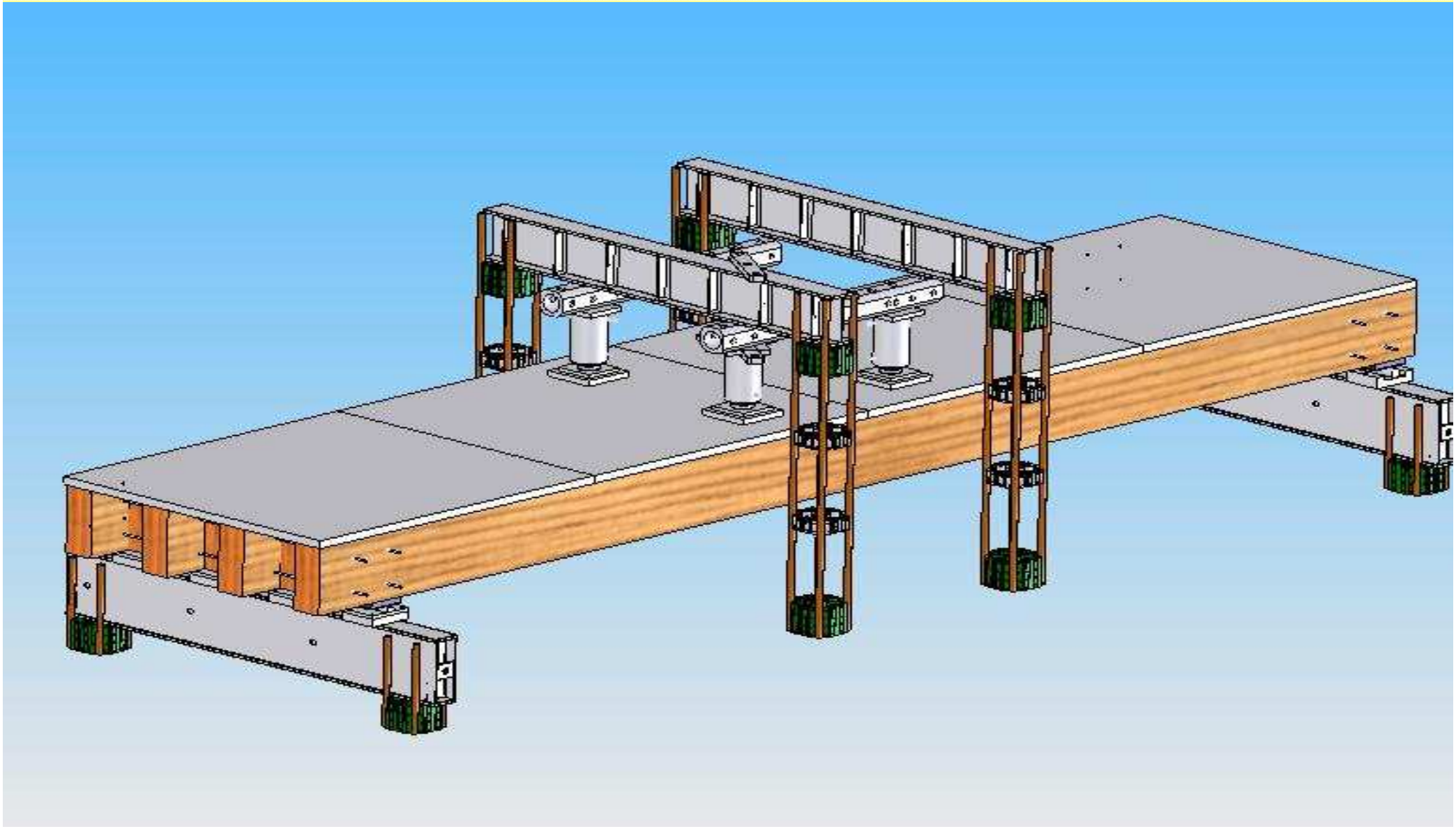



**In each case : specific Design provided + general economical considerations**

# 3 - Structural element tested at LCPC

Reliable

## (UHPFC, wood, FRP)



***Towards safer infrastructure,***

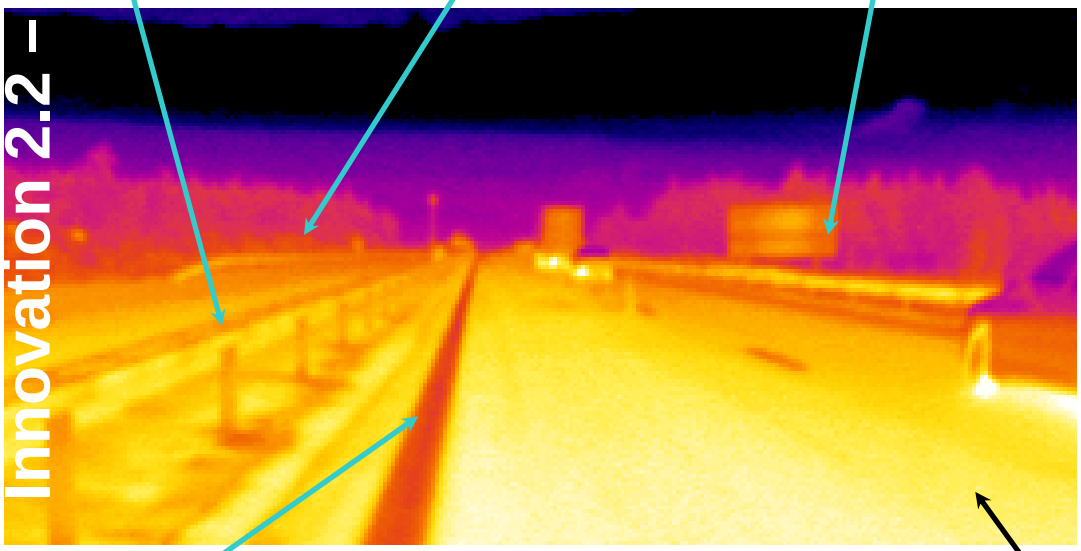
***….. Infra-red***
***to improve vision***

**Use of infra-red materials characteristics**
to improve visibility under bad conditions
(LCPC -France)

**Safe**

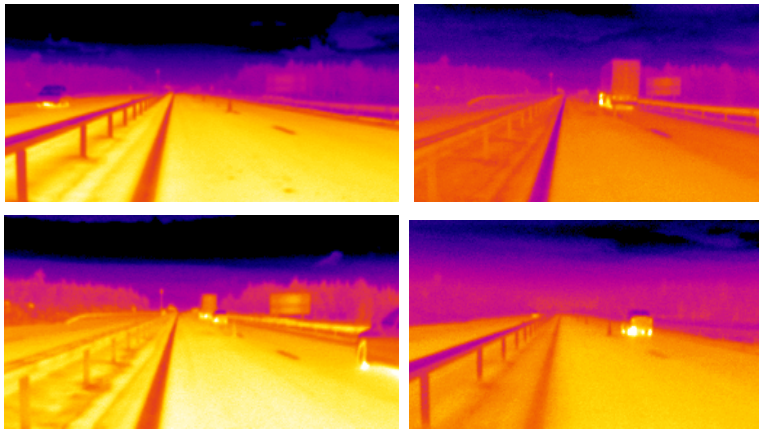
# Infrared vision and roads

- **Infrared images at different time**




Infrared images from LRPC Clermont-Ferrand

View of the test site



# As a conclusion, NR2C

- **support innovation**
- **for a best service to the user,**
  benefit for all actors : decision makers, owners, road and civil engeering industries and consultants
- in accordance with **sustainable development** requirements

- **share will to innovate**
- **involvement of all actors**

**2040 will be what we will build**

***"The most exciting aspect of the future is that we can determine it ourselves".***

**(Charles Handy: *The Age of Unreason*)**

Illustrations and acknowledgements :Thanks Studio WnT, T. Maagdenberg, M.S. Sule, Blanche Koelensmid, JP. Christory, M. Luminari, A. Beeldens, J. Dumoulin, JM. Tanis, T. Keller, E. Schaumann

information :

www.fehrl.org/nr2c

**Final seminar,**

**Brussels, 16th november 2007**