



Part two:

Photocatalytic technology for pavements and roads



Outline

- ✓ Introduction
- ✓ Design approach
- ✓ Products: laboratory tests (NO_x)
- ✓ Products: in-service performances
- ✓ Photocatalytic pavements: performances
- ✓ Case histories
- ✓ Other photocatalytic solutions for roads and tunnels
- ✓ Conclusions

Abatement of gases - NOx and CO2

Mean value of NOx abatement, for a cement-based surface:

30 gNOx/year/m²

- **for 1000 m², we can determine a NOx removal of 30 kg/NOx/year**
- **for 10000 m² of pavement, we can determine a NOx removal of 300 kg/NOx/year**

An Euro4 vehicle (car) can produce in 360 days/year, 0,5gNOx/km.

Passing along a road, 100 long, a vehicle can produce 0,05gNOx/passing time

Referred to 1000m², we can abate the pollution of $30.000/0,5=600.000$ passing vehicles per year

This corresponds to a daily abatement of: $600.000/365 = \underline{1644 \text{ car/day}}$

Abatement of gases - CO2 reduction

An even more significant contribution may come from the use of photocatalytic cementitious materials which can not only reduce the “urban heat island” effect, but also keep surfaces clear over time (self-cleaning) and further reduce air pollution (depolluting).

This is one of the reasons why TX Active® has been successful not only in architectural applications but also on roads and sidewalks.

Using a photocatalytic surface, it is possible to compensate a global heating effect produced by an equivalent value of 70-140 kg of CO₂.

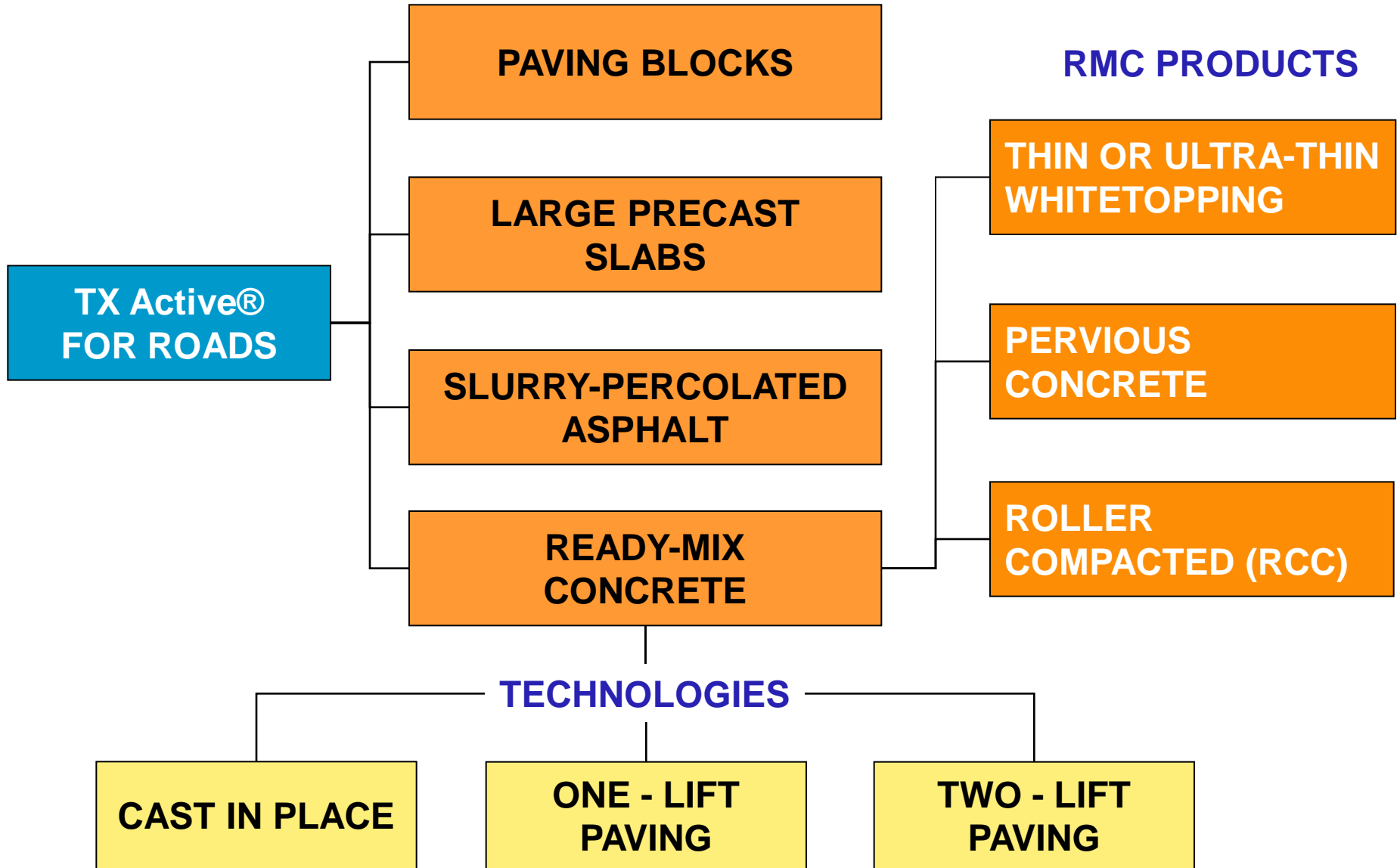
Generally speaking, with a reflecting white surface of 15 m² it is possible to compensate the heating effect of 1 ton/year of CO₂.

For vertical surfaces, we can consider: 10 m² → 1 ton, that is:

1000 m²: 100 ton/yr

10.000 m²: 1000 ton/yr

TX Active solutions for roads and pavements



Examples of applications

- Roadways, Highways
- Parking Lots
- Walkways
- Bike paths
- Bus stops
- Pedestrian area
- Industrial And Commercial Floorings
- Ports and airports

Colors: white, grey or colored (pigmented)

Requirements to be considered

- STRUCTURAL ASPECTS (SERVICE LOADS)
- QUALITY AND AESTHETIC ASPECTS
- DURABILITY, from the points of view of both photocatalytic and mechanical performances (as to the expected service life)

Design approach

In the preliminary phase it is fundamental to consider:

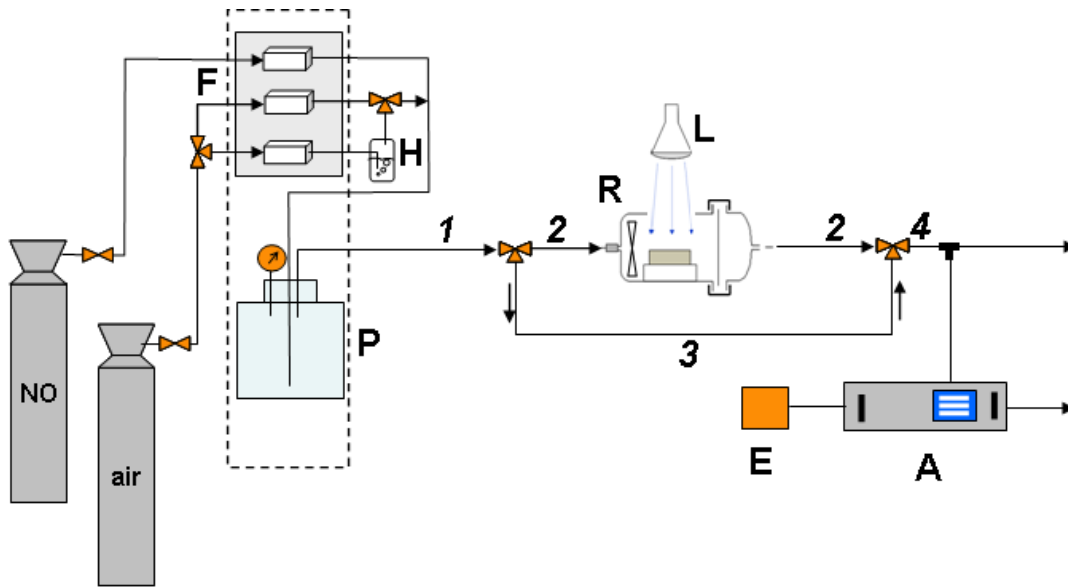
- ✓ architect's requirements
- ✓ engineer's recommendations
- ✓ technologist's constraints

In Italy, Politecnico di Milano (prof. Maurizio Crispino) supports Italcementi in pavement design and in research and development about photocatalytic pavements

Photocatalytic materials: laboratory tests for certification

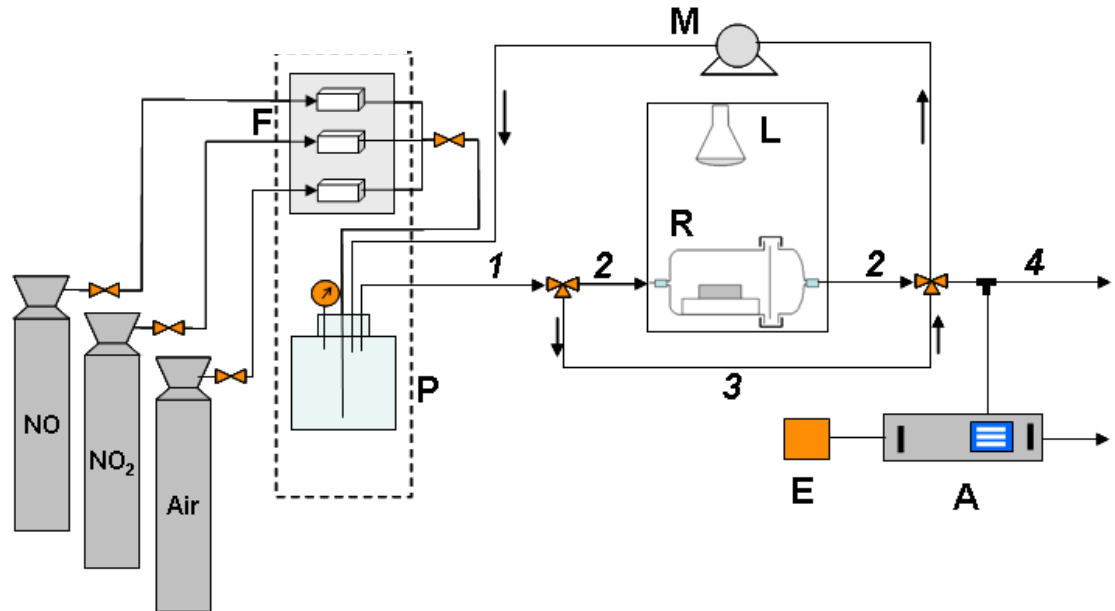
According to Italcementi Group's approach, each photocatalytic building material produced with TX Active cements, is **tested** according to well-established test methods (standards) and **certified** as to its photocatalytic performances.

Depolluting tests (NOx)



**Flow-through test
(continuous)
UNI 11247-2010
(CEN draft standard)**

**Recirculation test
draft UNI standard**



Depolluting applications: from the laboratory to the real situation

The problem is **to evaluate in a real situation/scale** the effect induced by the use of products, whose photocatalytic performances have been already assessed at laboratory scale.

Early experiences in Europe (2002-):

- ✓ PICADA European Project – Street Canyon
- ✓ SEGRATE, CALUSCO, BERGAMO
- ✓ ROME (Tunnel)
- ✓ Others...

PICADA experiment - Guerville, France



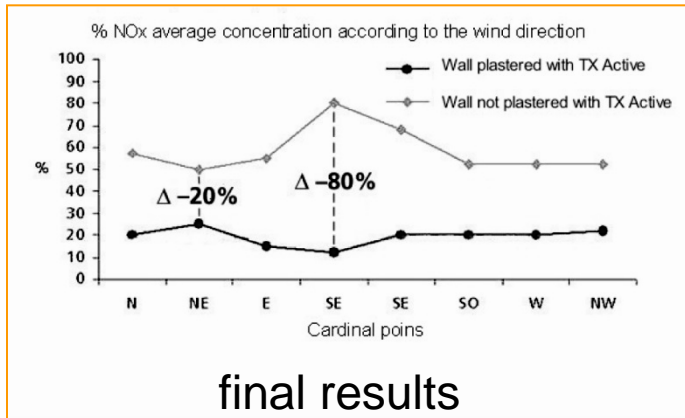
test site



weather station

NO_x, VOC monitoring

pollution source (engine)



www.picada-project.com

Scale 1:5

Main results of some experiences

On the basis of long monitoring campaigns – carried out in different pilot projects – it was possible to demonstrate the “in situ” efficacy of TX products. For example:

➤ **PAVING BLOCK PAVEMENT in BERGAMO, ITALY**

Differences of NOx values between those of photocatalytic zone and those of asphalt zone (reference) **vary between 20% and 60%**, as a function of both weather and traffic conditions.

➤ **UMBERTO I TUNNEL in ROME (only vaults)**

NOx abatement **higher than 20%** (ante/post operam) as absolute values, but **corresponding to about 50%** if referred to the pollution situation in the city of Rome, in the same days

From pilot scale to real projects

In these more recent years, some **demonstration projects** have been completed and some corresponding monitoring campaigns were carried out, in order to confirm photocatalytic performances of installed materials.



Rome (2007)

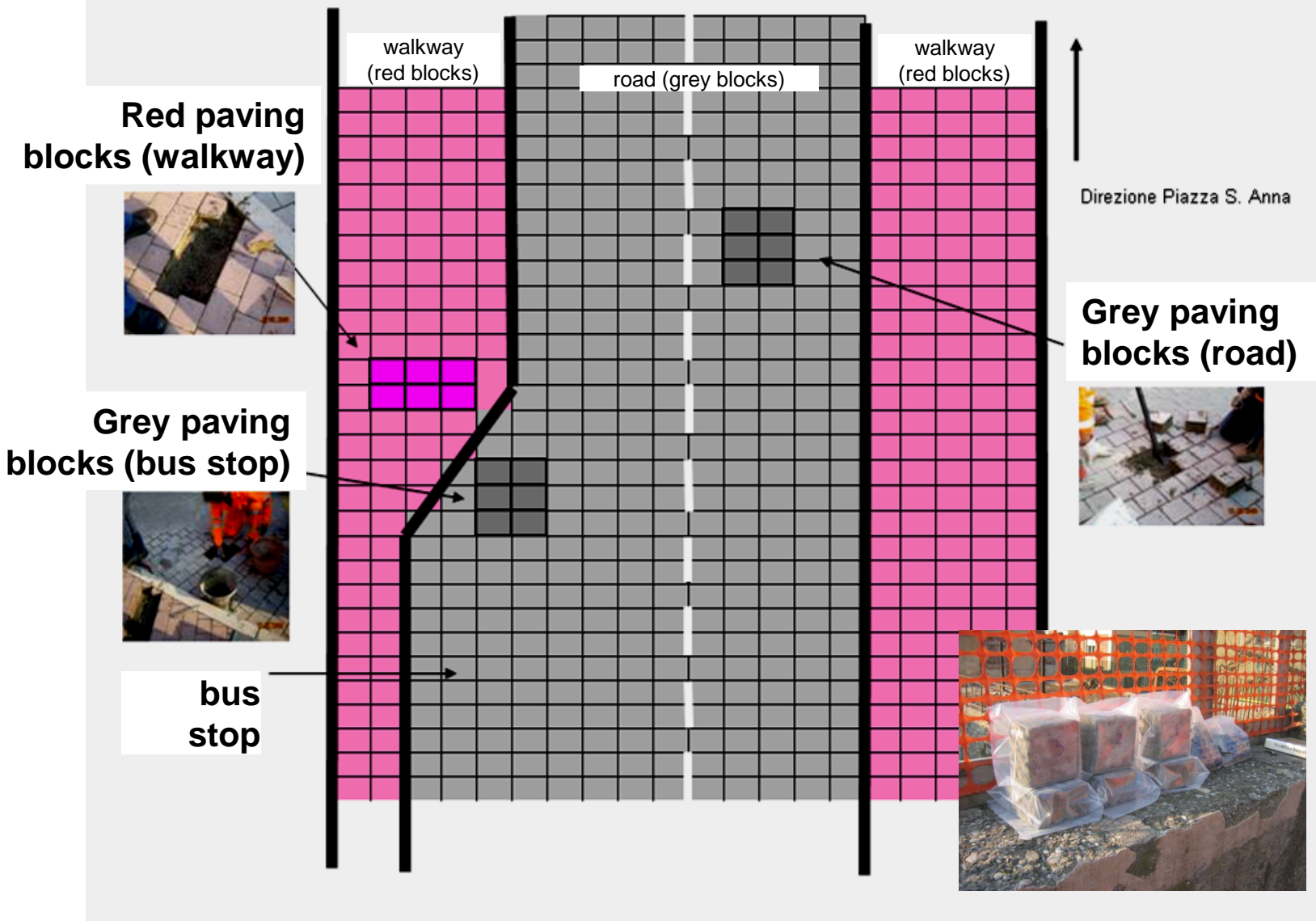


Bergamo (2006-7)



Paris (2007-9)

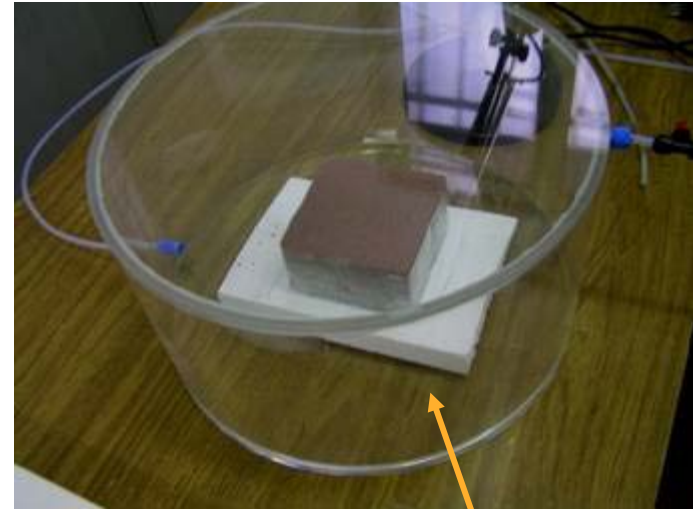
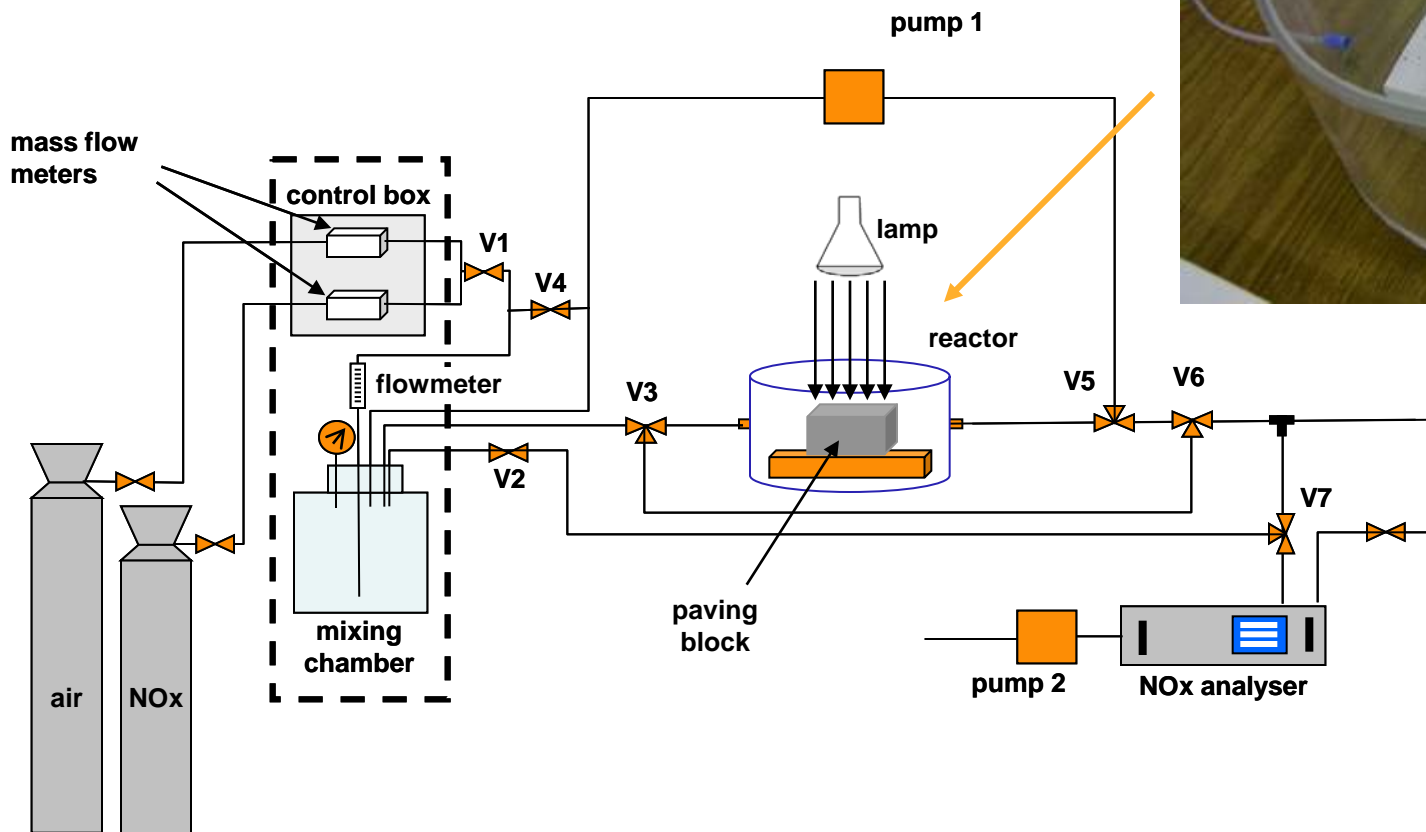
In-service performances



In-service performances

Laboratory control

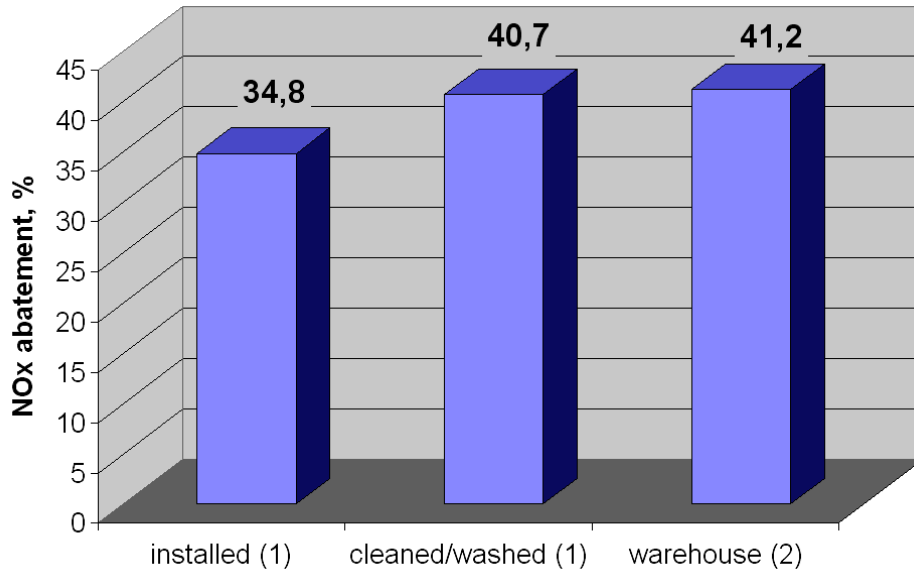
The same experimental set-up used for NO_x depollution tests (ITC Group – reference method)



Only the reactor was substituted to test a block, instead of a specimen (non-destructive test)

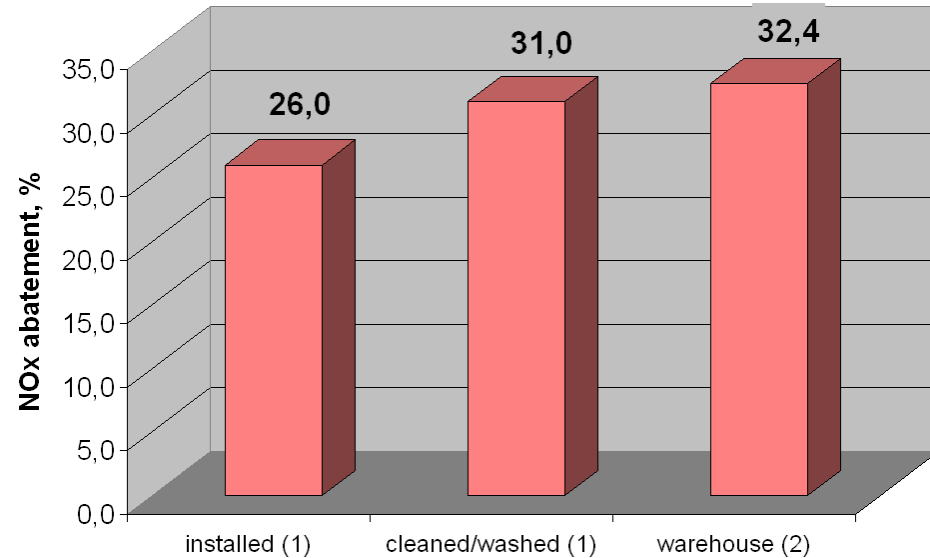
Depolluting activity of paving blocks

Grey block (road): 147x147x88 mm



(1) average values for 12 blocks - (2) average value for 10 blocks

Red block 120x120x60 mm



(1) average values for 6 blocks - (2) average value for 7 blocks

installed: blocks extracted and tested “as is” (dusty blocks)

cleaned/washed: test repeated on the same blocks, cleaned, washed and dried

warehouse: test on paving blocks available for substitution (stock)

BFT (Betonwerk Fertigteil-Technik), 5/2009 - G.L. Guerrini

TX Active solutions for roads and pavements

✓ already tested or marketed

PAVING BLOCKS ✓

LARGE PRECAST SLABS

SLURRY-PERCOLATED ASPHALT ✓

READY-MIX CONCRETE

RMC PRODUCTS

THIN OR ULTRA-THIN WHITETOPPING ✓

PERVIOUS CONCRETE ✓

ROLLER COMPACTED (RCC)

TECHNOLOGIES

CAST IN PLACE ✓

ONE - LIFT PAVING ✓

TWO - LIFT PAVING

TX ACTIVE[®] FOR ROADS

Paving blocks



Railway stations



Reduced speed zones



Decorated concrete



Streets and walkways



Shopping centers



Sport centers



Parking buildings

One-lift paving application



Site

Rue Jean Bleuzen – Porte de Vanves (Paris - France) - 13.000 cars/day

Geometry

- length: 300m (photocatalytic)
- total photocatalytic surface: about 6000 m²

Upper surface

exposed aggregate concrete overlay
(retarding admixture)

Technology

Vibrofinishing (one-lift paving)

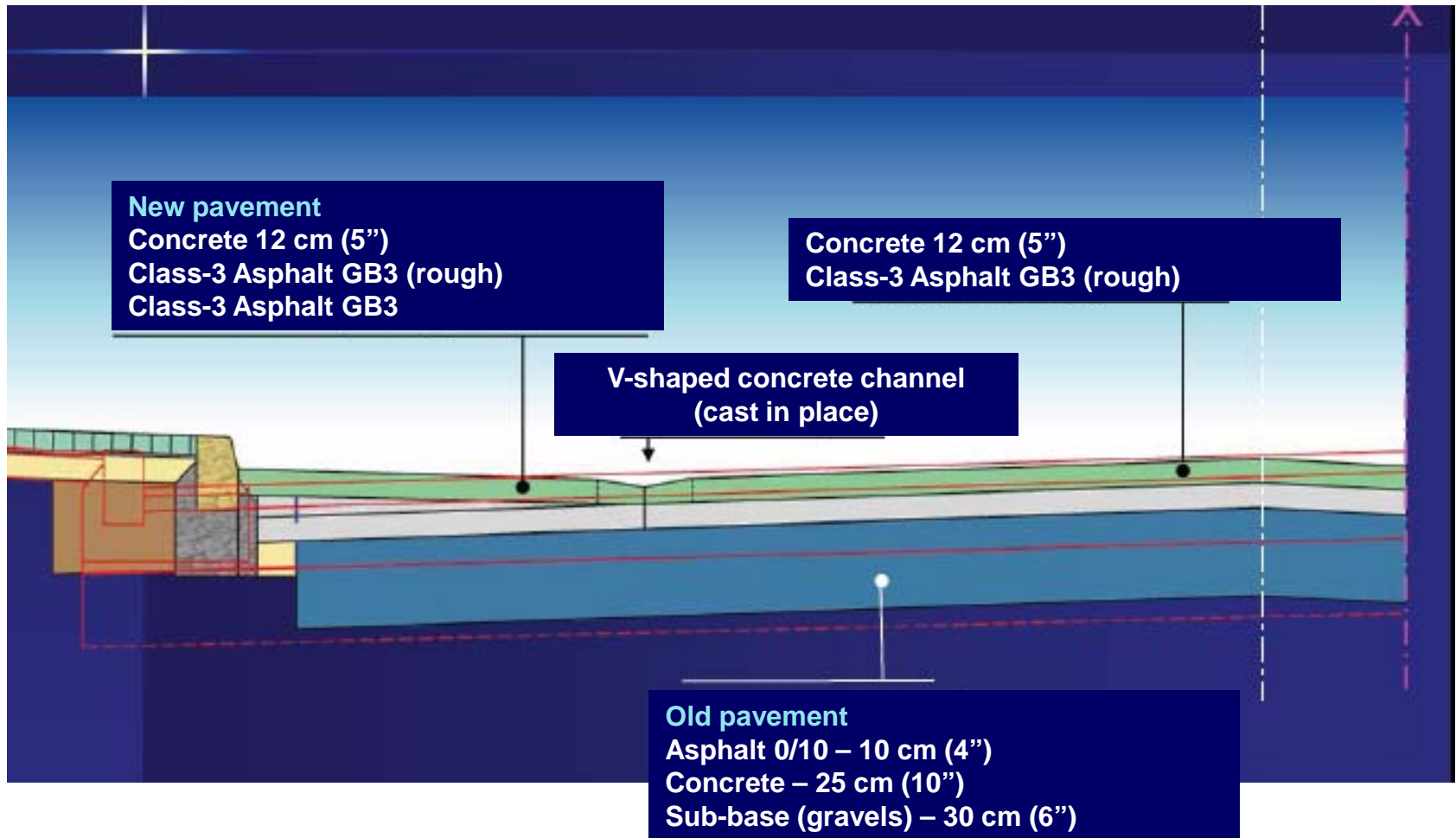
Sidewalks

Photocatalytic precast paving flags and curbs

NOx monitoring campaign

carried out by LROP (Western Paris Regional Transport Research Laboratory)

Cross-section pavement



Some construction phases

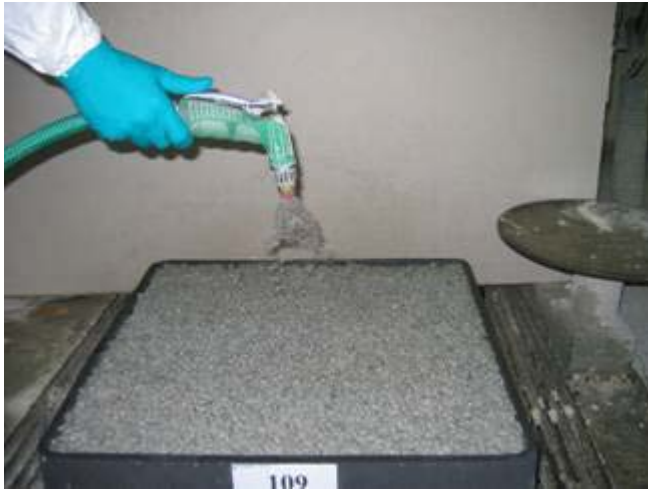


Historical cities (Italy) - Pavements



Architectural concrete (bush-hammered)

Pervious concrete



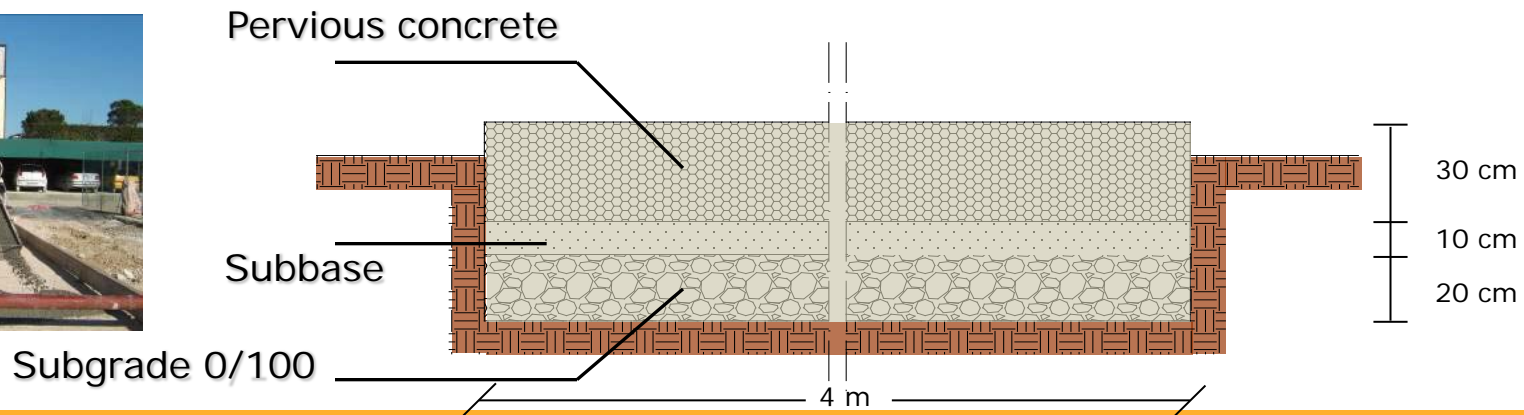
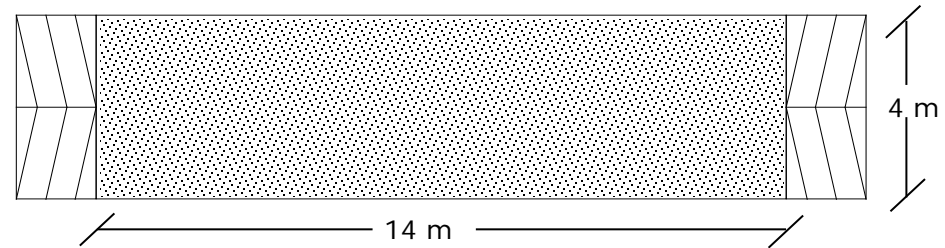
from the laboratory...

...to the field

Pervious concrete

Construction of an experimental road

University of Ancona – prof. G. Moriconi



Pervious concrete

Casting and curing phases

MIX DESIGN:

w/c 0,35

a/c 4,5

Void content 15%

Slump: 21,5 cm

Consistency S5 (superfluid)

PHASES:

- Casting
- Placing
- Levelling
- Strips removal
- Compaction
- Finishing
- Concrete protection



TX Active for tunnels

The use of TX Active products in tunnels allows to obtain:

- better fire endurance
- better environmental conditions (reduced pollution)
- better visibility (clearer surfaces)
- reduced maintenance costs (prolonged maintenance of clear surfaces, extended cleaning cycles)

Available cement-based solutions

- **concrete precast panels (lining)**
- **thin-walled precast panels (lining)**

e.g. GRC – Glass Reinforced Cement or Fiber Reinforced Cement sheets

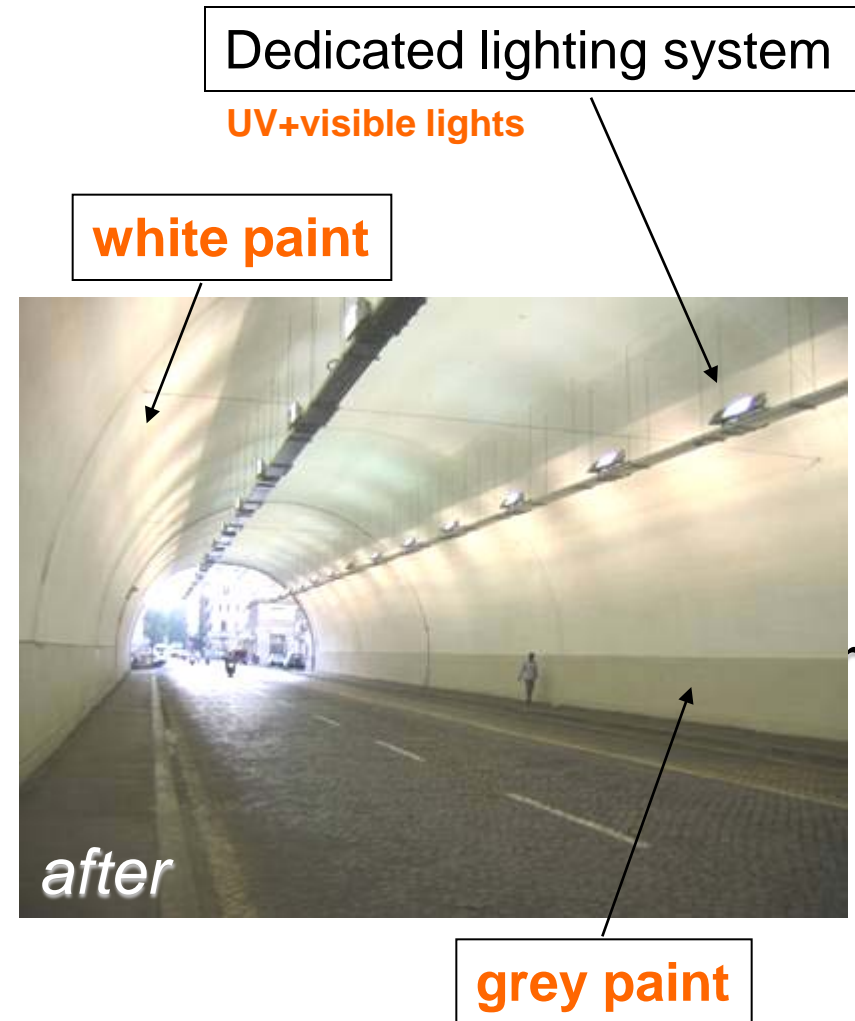
The use of traditional cement-based solutions coated with photocatalytic solutions (containing TiO₂ particles) are not suggested, due to the weak adhesion to the substrate, the poor durability, when subjected to washing cycles.

Further, a release of TiO₂ particles in the environment is almost certain.

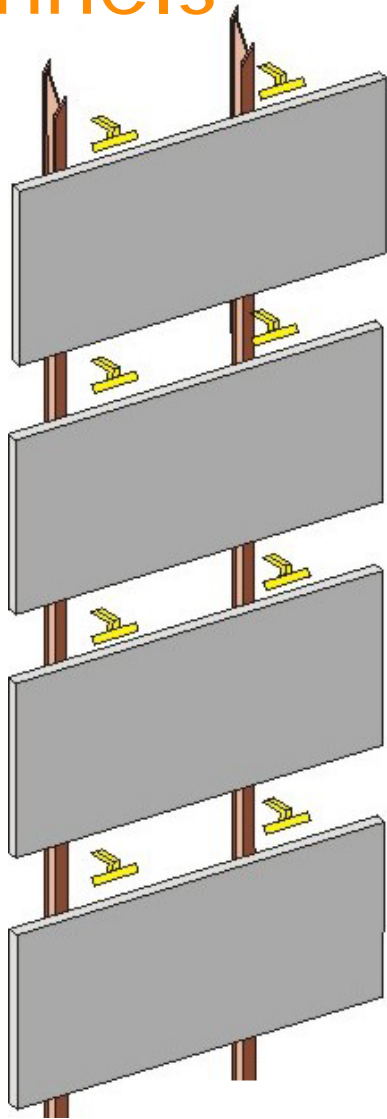
“Umberto I” tunnel – Rome: indoor



- ✓ Galleria “Umberto I” – Rome, Italy
- ✓ Length: 350 m
- ✓ Renovation of vaults, using white and grey photocatalytic cement-based paints (9000 sq.meters) duration: 1 month
- ✓ Completed in August 2007



Examples of precast concrete panels for tunnels

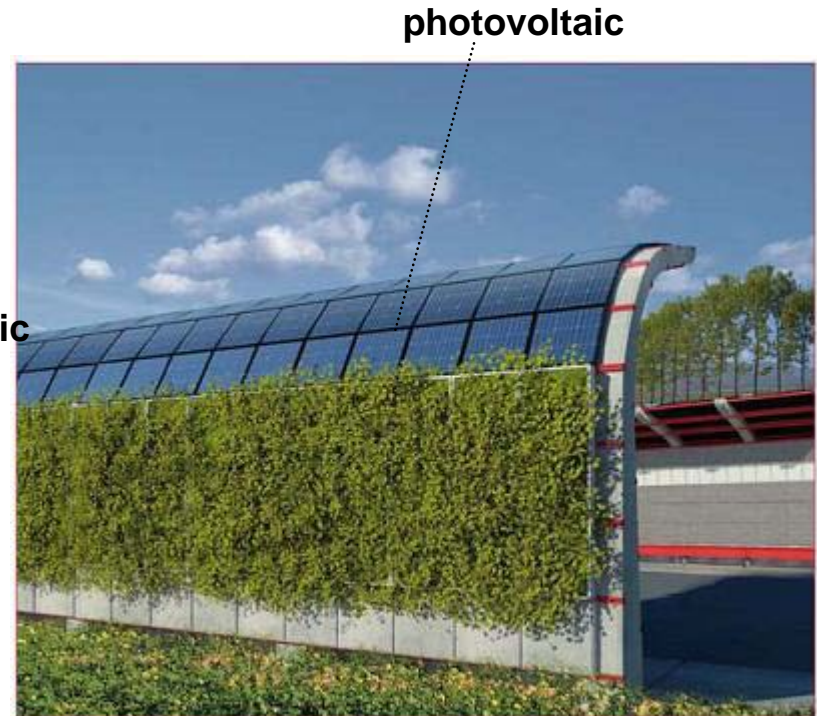
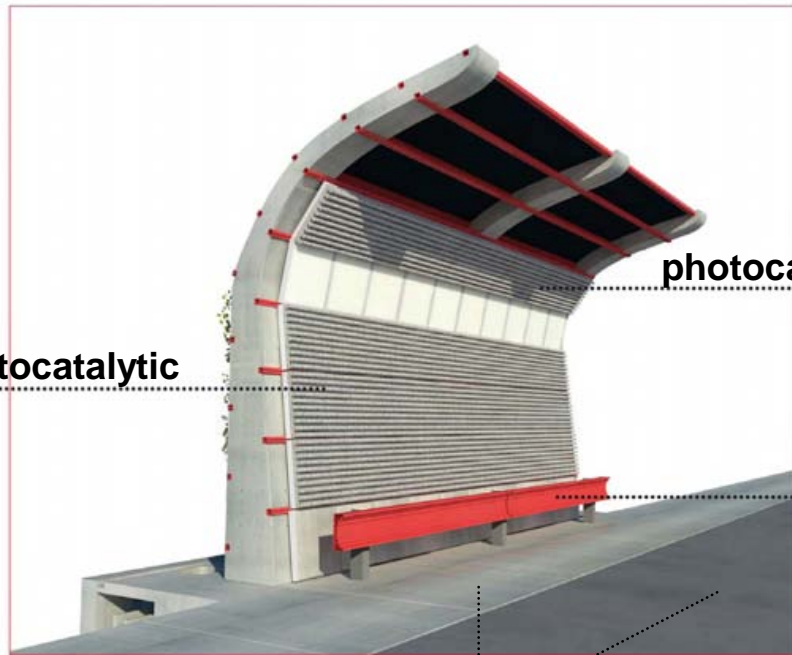


GRC panel (tunnels)



Monoskin ribbed panels or fiber-reinforced panels

KMZEROROAD concept



photocatalytic

An innovative Italian project for a new type of “sustainable road”, energetically active with a reduced environmental impact

One team of several partners for an integrated solution, considering construction/use/maintenance/management of the infrastructure

Examples of sound-absorbing panels (roads)



Precast concrete sound-absorbing elements can be produced:

- a) by using photocatalytic cements (in bulk);
- b) by applying photocatalytic precast concrete tiles on concrete walls

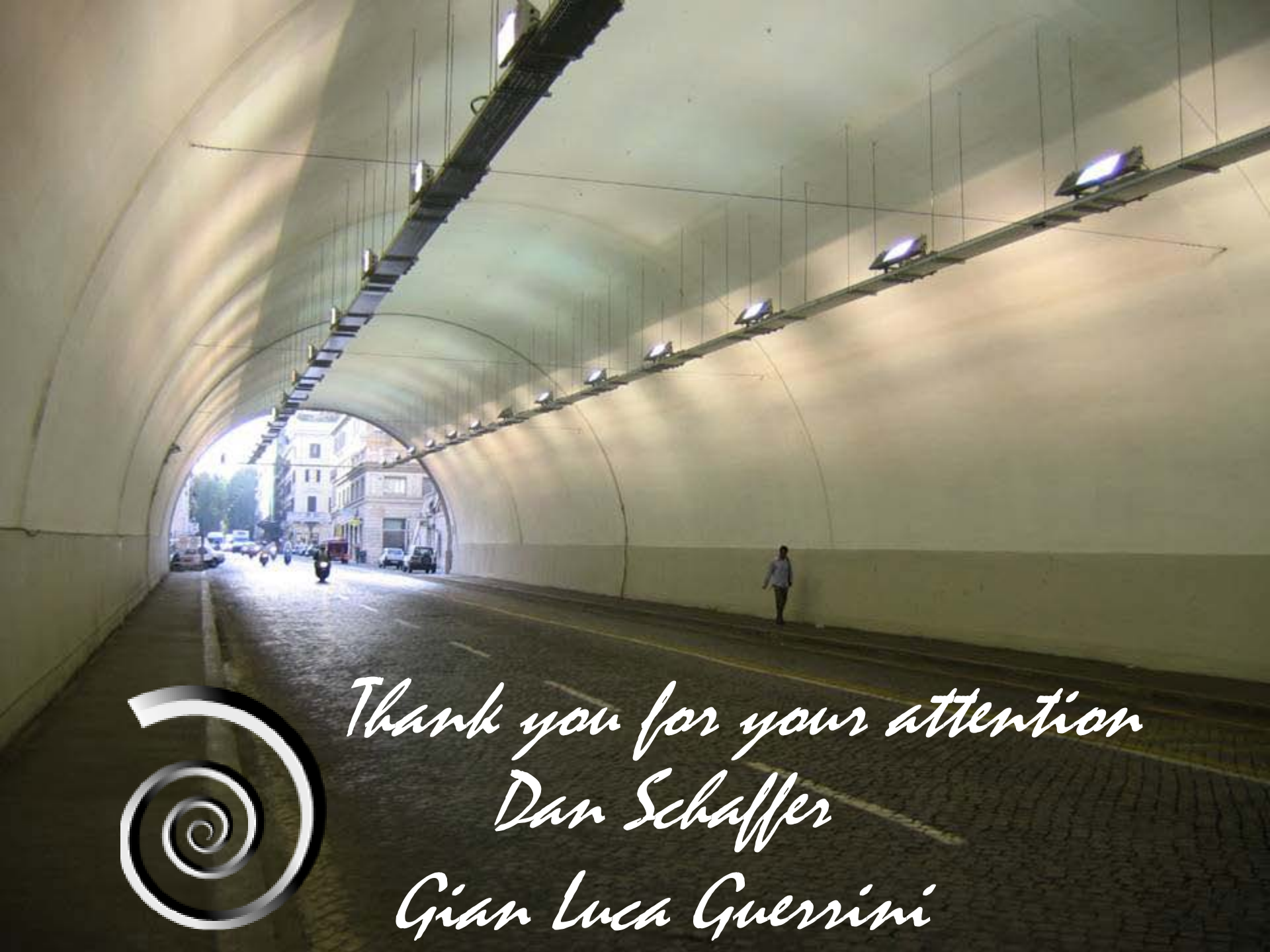
Conclusions

Photocatalytic cement-based pavements have completed the testing step and they are by now real applications.

The research activity is continuing in order to evaluate the transfer feasibility to the large works.

High expectations are on pervious concrete as it should allow to obtain a draining pavement possessing several advantages:

- a) laying cold, (bituminous pavement is a hot solution)
- b) light colored (cool pavement, reduction of heat island effect)
- c) long lasting durability in terms of photocatalytic performances (due to the presence of photocatalyst, in bulk)
- d) aesthetic solution



*Thank you for your attention
Dan Schaffer
Gian Luca Guerrini*

