



# TX Active Photocatalytic Concrete Technology



**Essroc**  
Italcementi Group

# AGENDA

- Introduction
- Photocatalysis
- Self-Cleaning
- De-Polluting
- Concrete in Practice
- Project Profiles
  - European*
  - USA*

# Pollution and it's Effects



# CAUSES OF POLLUTION

There are more than 120 primary organic and inorganic pollutants.  
(*Environmental Protection Agency*)

The main polluting agents are mostly produced by human activities:

- Cars emissions
- Power plants, industries, incinerators
- Heating from fossil fuel
- Pesticides
- Mining and agricultural operations



# POLLUTANTS MONITORED BY EPA



The EPA tracks emissions of six principal air pollutants considered to be significant factors in negatively impacting the quality of human health.

## Six Pollutants:

- Carbon monoxide
- Sulfur dioxide
- Particulate matter
- Volatile organic compounds
- Nitrogen oxides
- Lead

# POLLUTANTS MONITORED BY EPA



These air pollutants are responsible for our smog covered cities and the resulting migratory smog in rural areas.

# VISIBLE EFFECTS

The effects of pollution are visible on building exteriors throughout our cities and towns...



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...and cost thousands of dollars to remove.

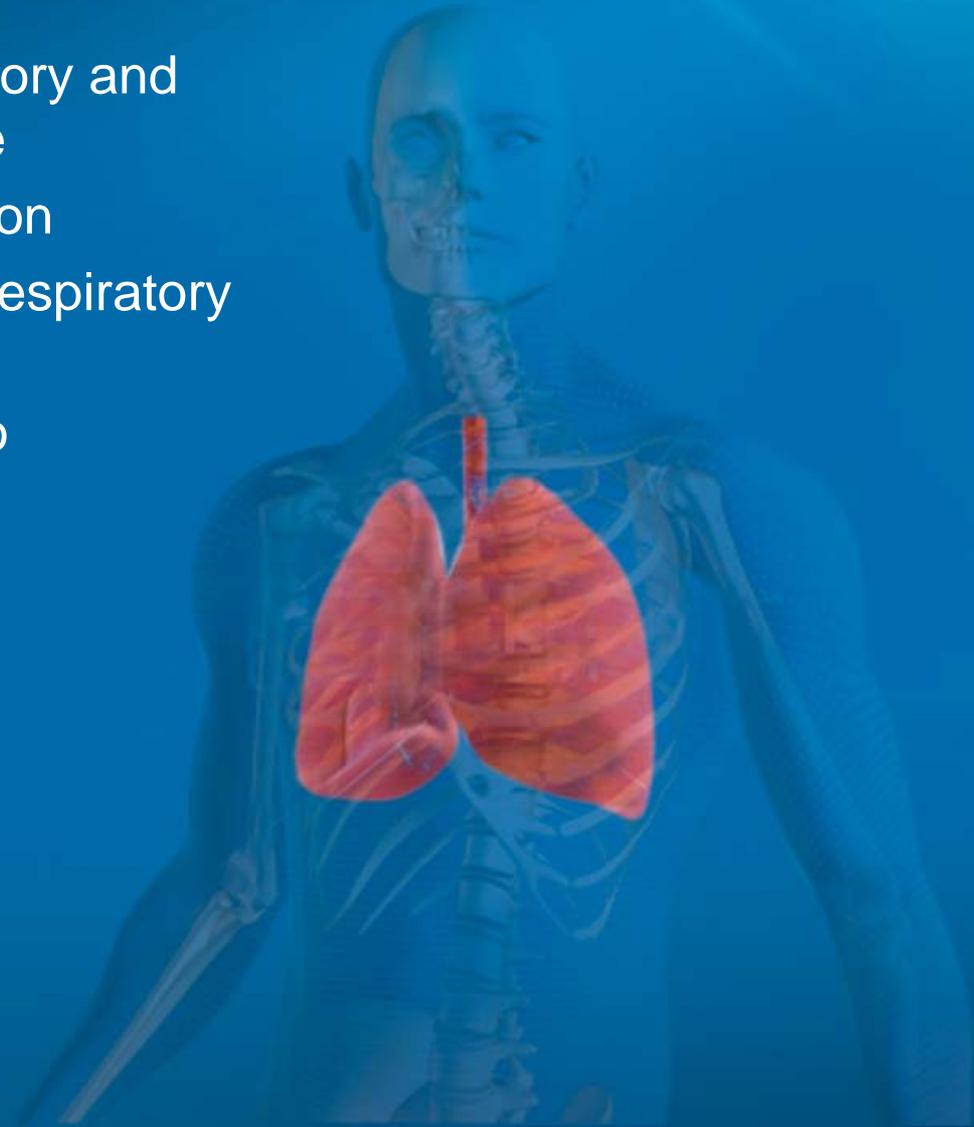


# HEALTH ISSUES



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- Aggravation of Respiratory and Cardiovascular Disease
- Decreased Lung Function
- Increased Severity of Respiratory Symptoms
- Greater Susceptibility to Respiratory Infections

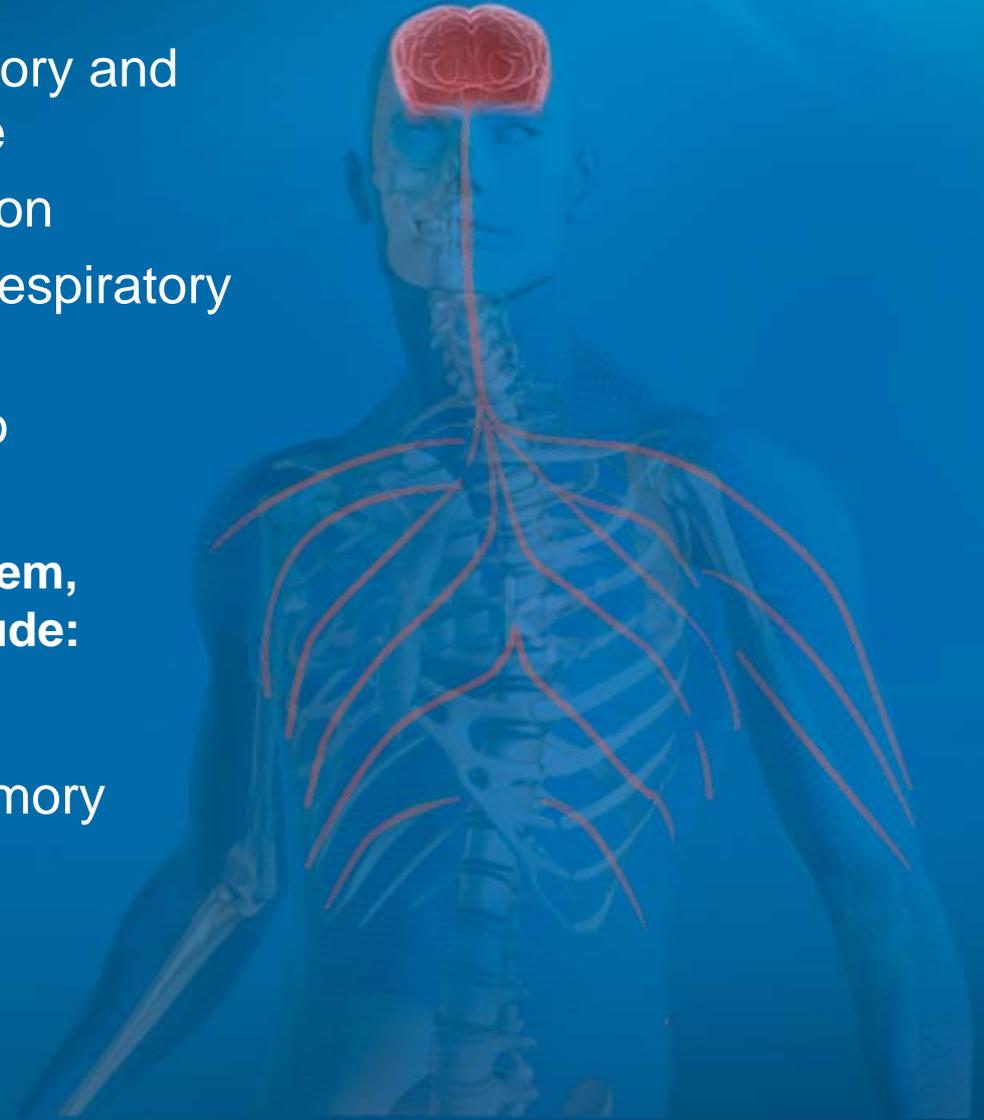


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**Effects on the Nervous System, specific to the brain, to include:**

- IQ Loss
- Impact on learning, memory and behavior

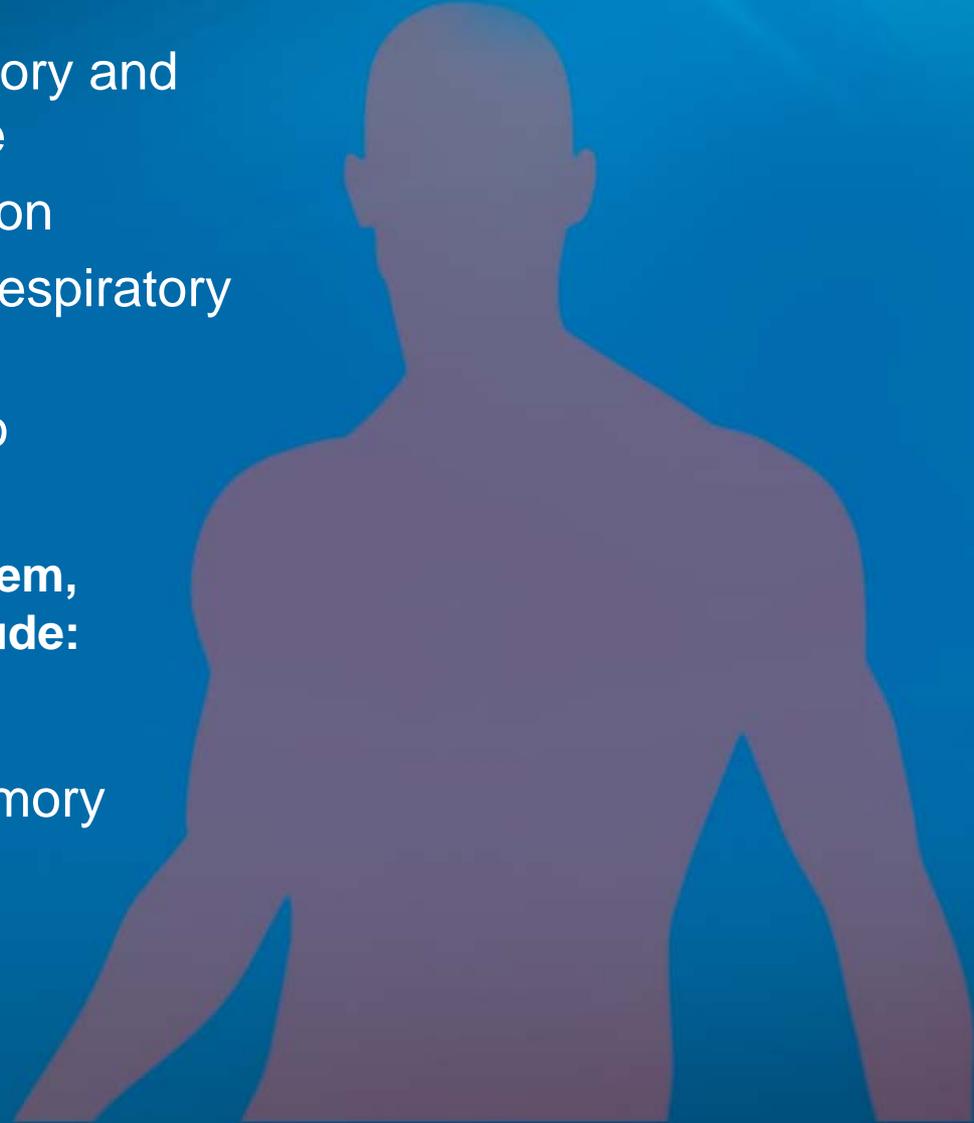


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## **Effects on the Nervous System, specific to the brain, to include:**

- IQ Loss
- Impact on learning, memory and behavior
- Cancer
- Premature Death



# ENVIRONMENTAL CONCERNS

- **Damage to vegetation** including reduced tree growth and crop yields
- **Acid rain** as a form of  $\text{SO}_2$  and  $\text{NO}_x$  deposition
- Concentrations of heat-forming **greenhouse gases** that may contribute to warmer global temperatures



# USE OF SUNLIGHT

**The solar energy reaching the earth surface is about 10,000 times the yearly worldwide energy consumption.**

**In the past, the sun was considered something to protect people from.**

**But now, through the development of photocatalytic cementitious materials, the sun's rays may represent one of the solutions to the pollution issue.**



# Photocatalysis



# WHAT IT MEANS

## Photocatalysis

- Prefix **Photo** – defined simply as light
- **Catalyst** – a substance that accelerates a process, increases the rate of a reaction, without being consumed in that process.

# CURRENT CATALYST

## Titanium Dioxide

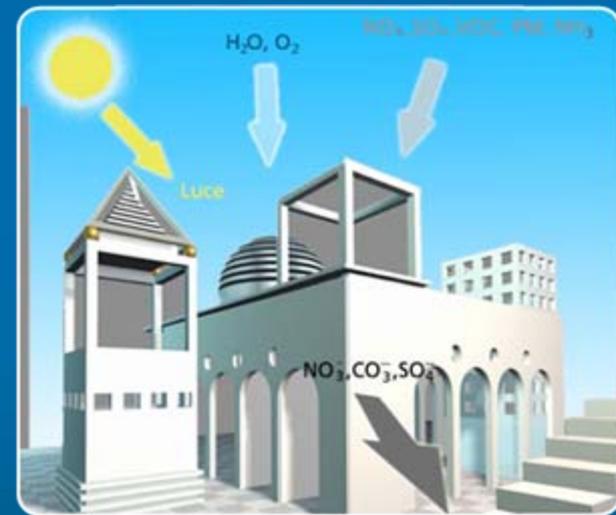
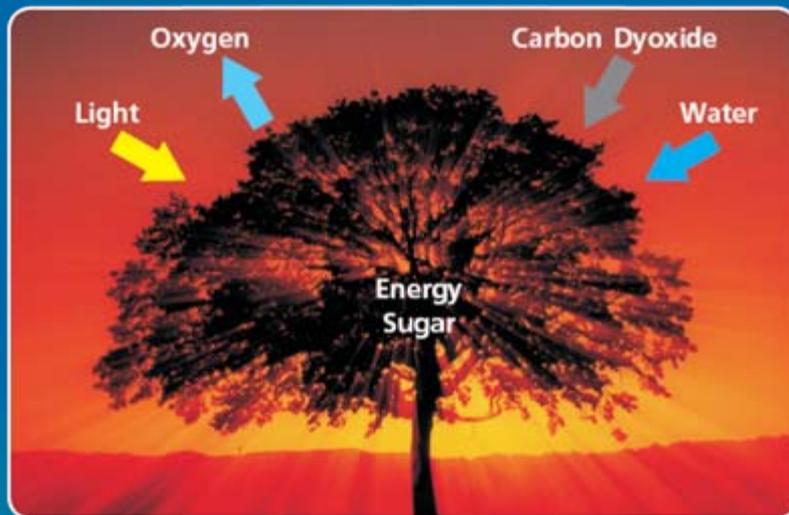
occurs in nature as the minerals rutile, anatase, and brookite. These oxides are the source of commercial titanium.

- Due to its brightness and high refractive index,  $\text{TiO}_2$  is the most widely used white pigment
- Approximately four million tons of pigmentary  $\text{TiO}_2$  are consumed annually worldwide
- Applications include paints, inks, coatings, plastics, papers, foods, medicine, and toothpaste



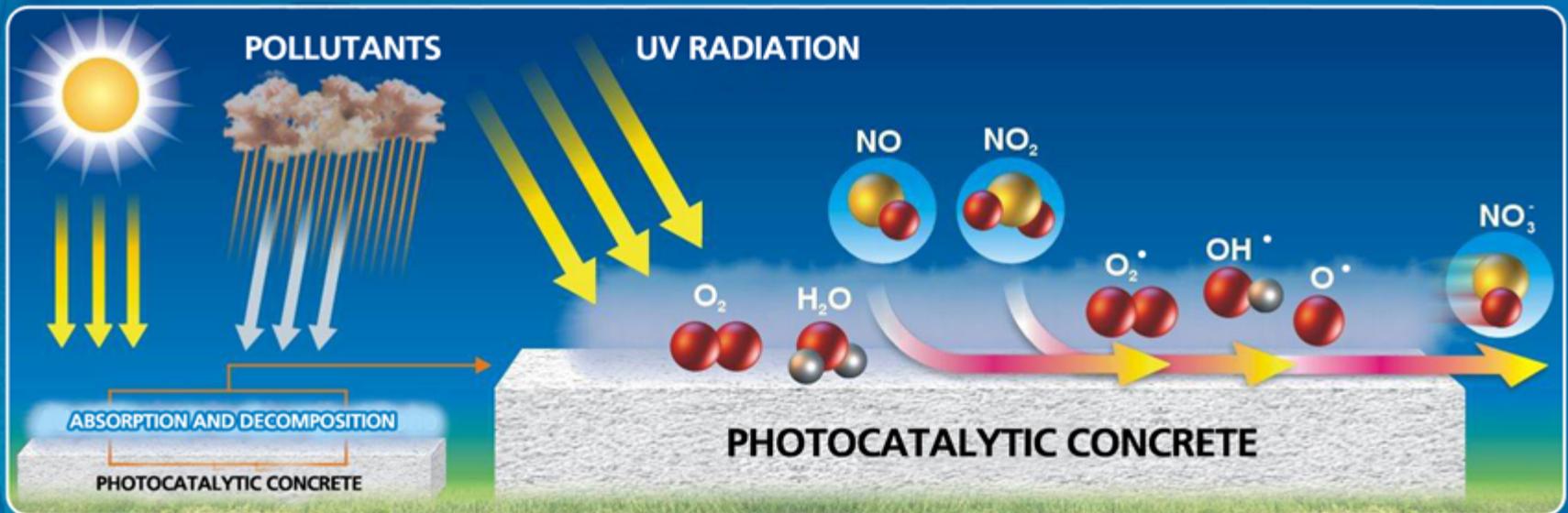
# PHOTOSYNTHESIS & PHOTOCATALYSIS

- **Photosynthesis:** A chemical reaction by which carbon dioxide and water combine producing oxygen and the sugars that plants need for growth.
- This is accomplished by light acting on light-sensitive pigments called chlorophylls.



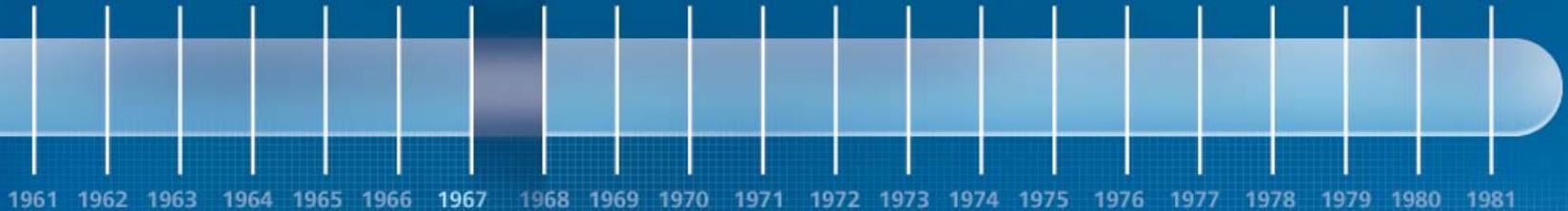
# PHOTOCATALYTIC ACTIVITY

The photocatalytic mechanism applied to cementitious materials



# TIMELINE

## Development of photocatalytic concrete technology



**1967**

The discovery of Titanium dioxide's photocatalytic properties



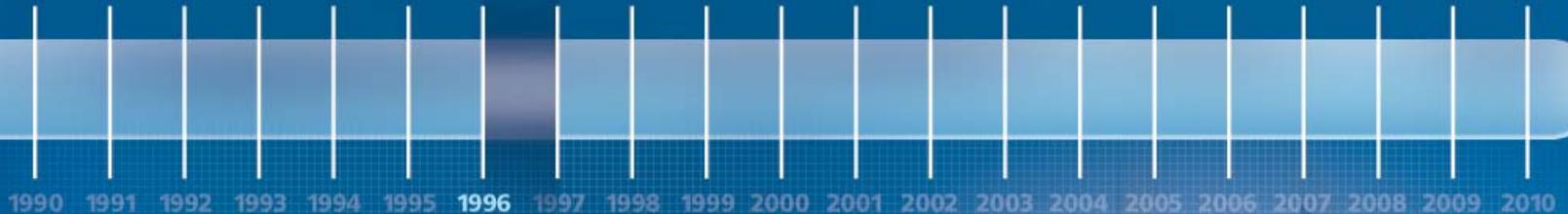
# PRODUCTS THAT UTILIZE THIS TECHNOLOGY

- Glass
- Ceramic tile
- And many more



# TIMELINE

## Development of photocatalytic concrete technology



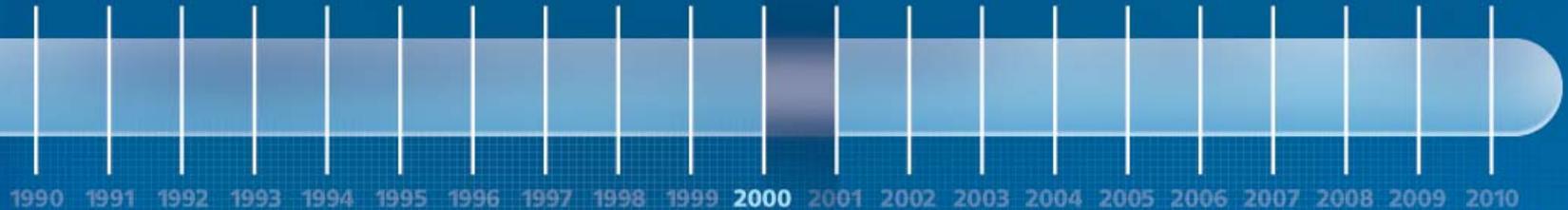
**1996**

European research into the self-cleaning benefits of photocatalytic concrete technology begins in response to a market need to construct the precast panels for the Dives in Misericordia Church Project.



# TIMELINE

## Development of photocatalytic concrete technology



**2000**

European research into the de-polluting benefits of photocatalytic concrete technology begins with the launching of the PICADA project.

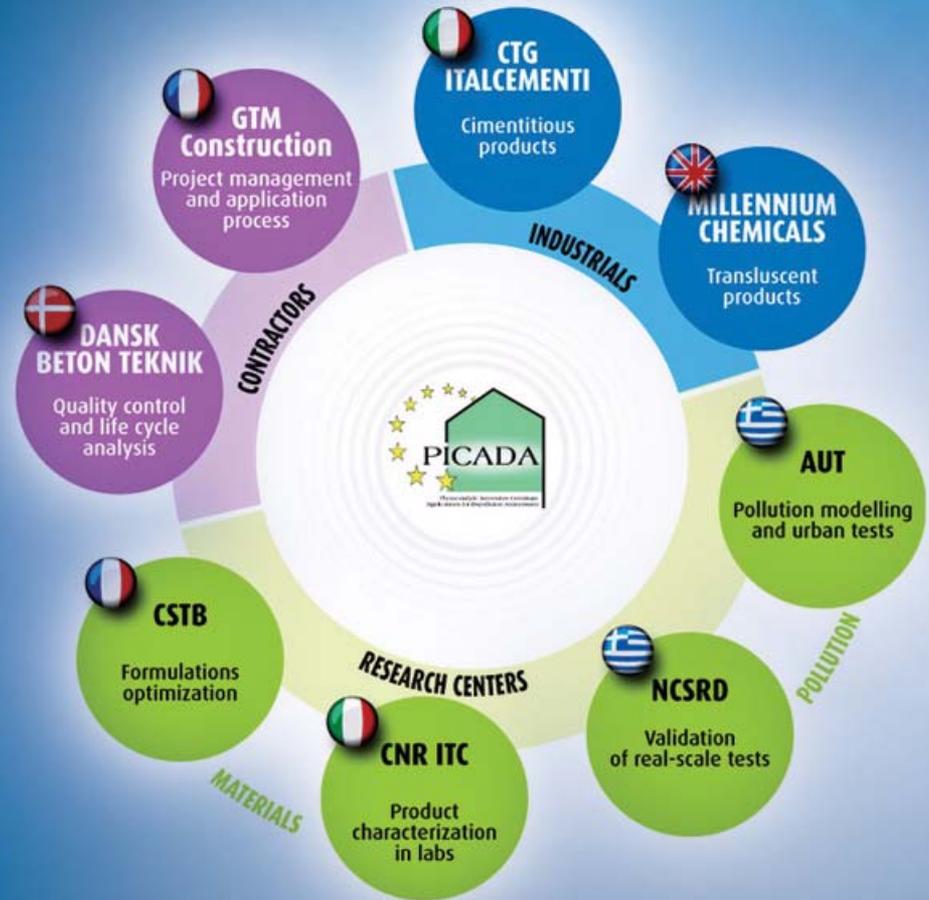
# PICADA

Photocatalytic  
Innovative  
Covering  
Applications for  
De-pollution  
Assessment

**Objective:** Develop and assess coverings for de-pollution based on photo-catalysis

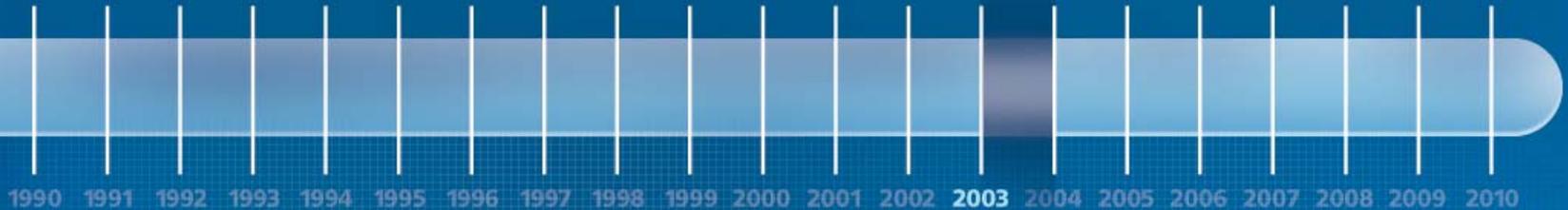
**Duration:** 2001-2005

[www.picada-project.com](http://www.picada-project.com)



# TIMELINE

## Development of photocatalytic concrete technology

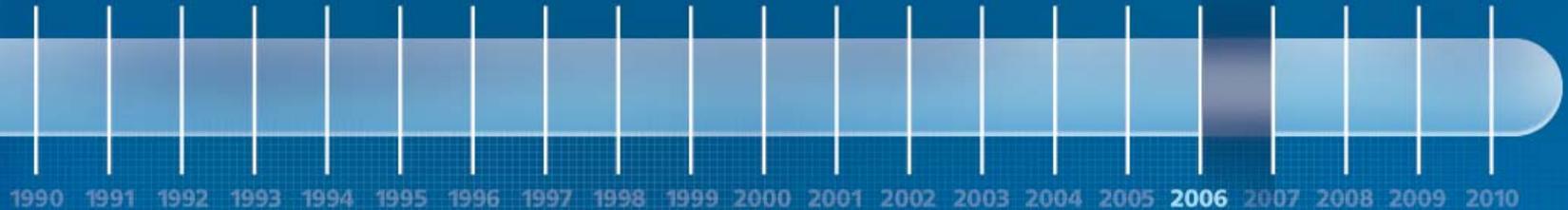


**2003**

First large scale field tests

# TIMELINE

## Development of photocatalytic concrete technology



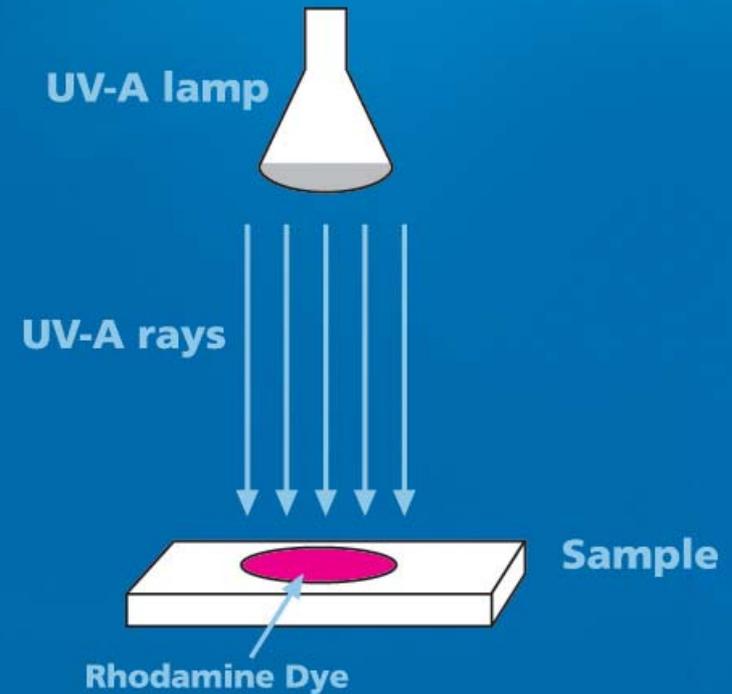
**2006**

Launch of a photocatalytic range of products

# Self-Cleaning Effect

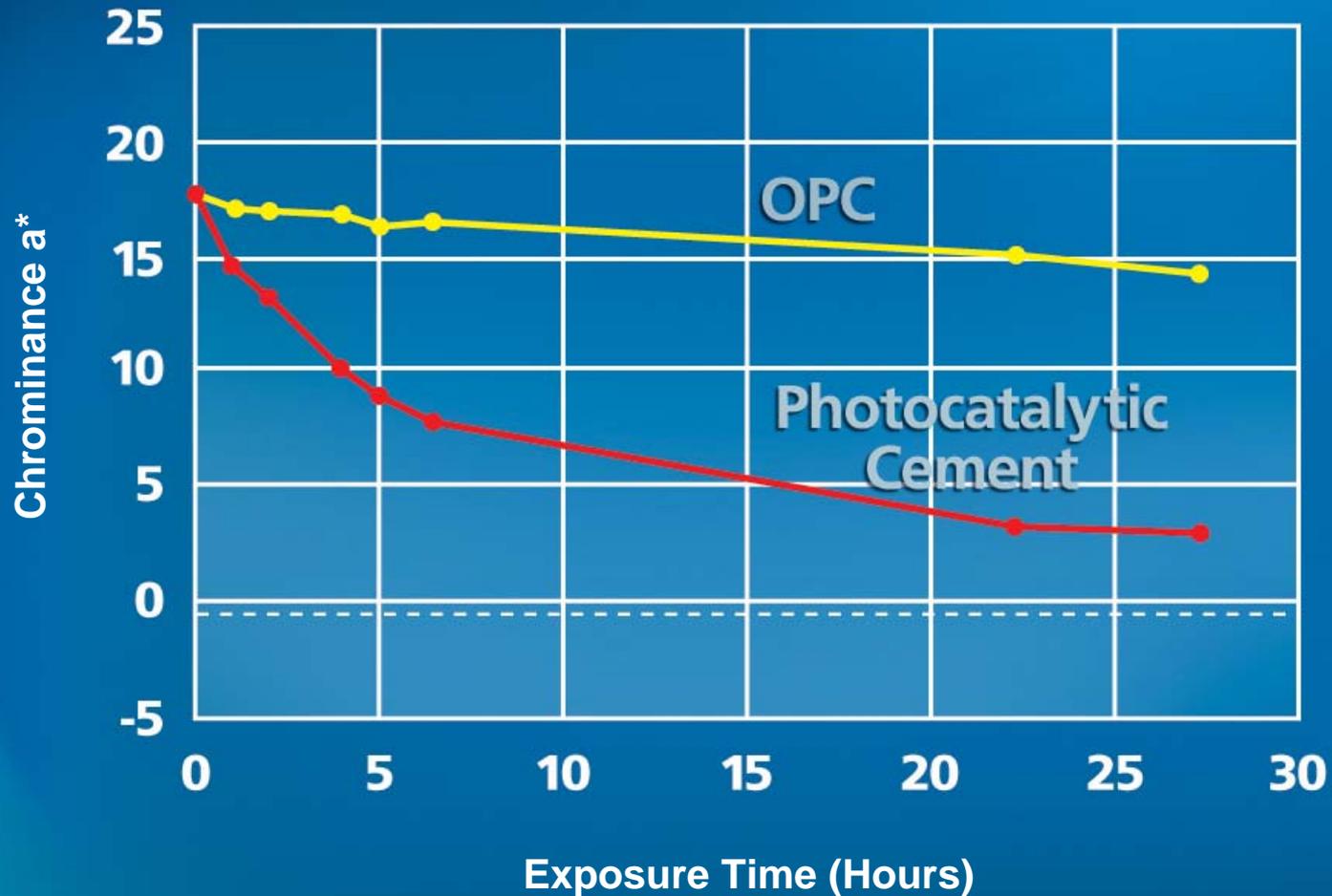


# HOW SELF-CLEANING IS MEASURED?

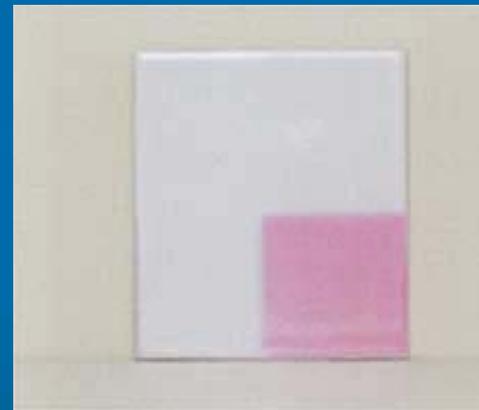
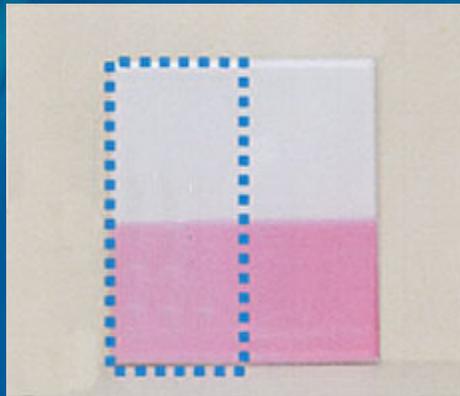


*Colorimetric method to determine the photocatalytic activity of hydraulic binders.*

# VISUAL RESULTS



# VISUAL RESULTS



# ACTUAL FIELD TRIAL

(VARIOUS CONTAMINANTS)



# ACTUAL FIELD TRIAL

(TIME LAPSED 6 HOURS)



# SELF-CLEANING IN PRACTICE

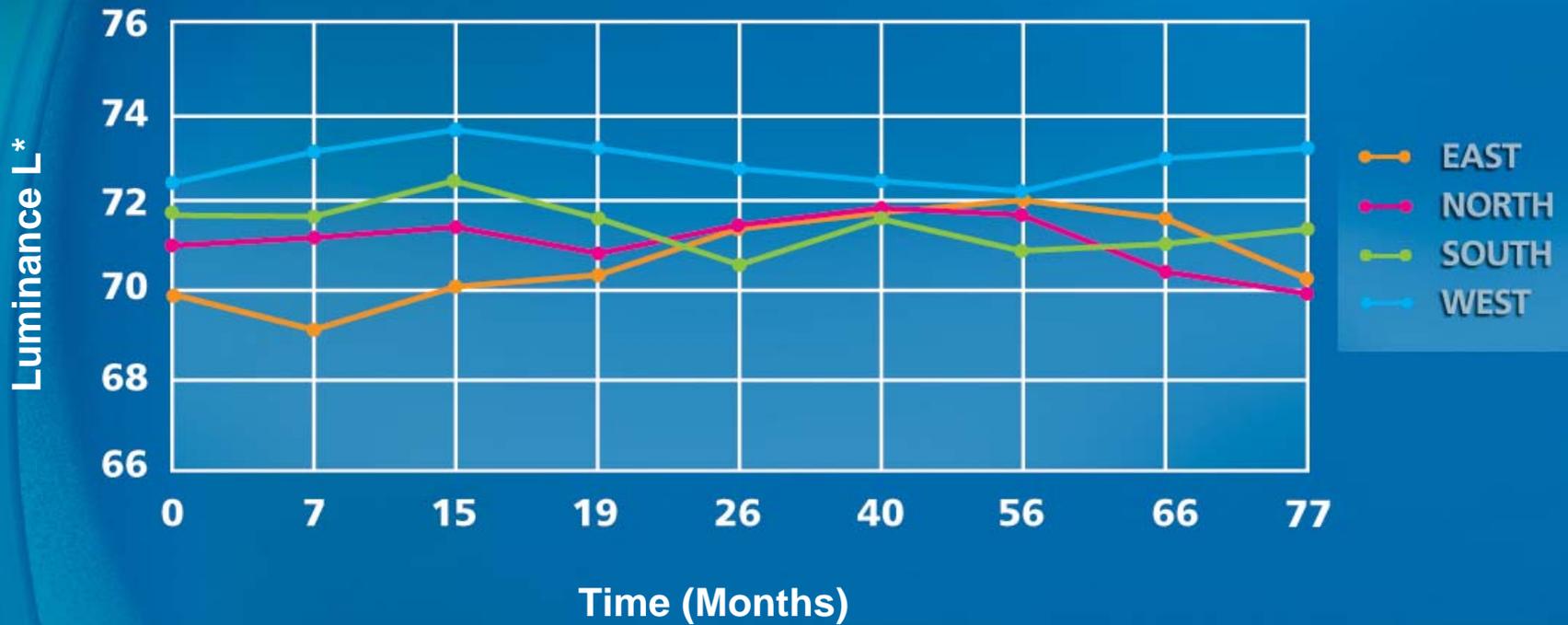
**Cite de la musique,  
Chambery, France**



# FIELD TESTING THE EFFECT OF UV DIFFUSION



# COLOR MONITORING



# ORDINARY CEMENT



# SELF-CLEANING CEMENT



# ORDINARY CEMENT



# SELF- CLEANING CEMENT

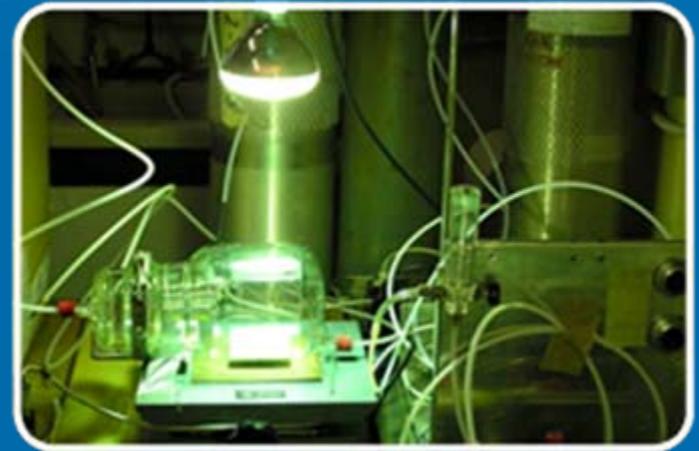
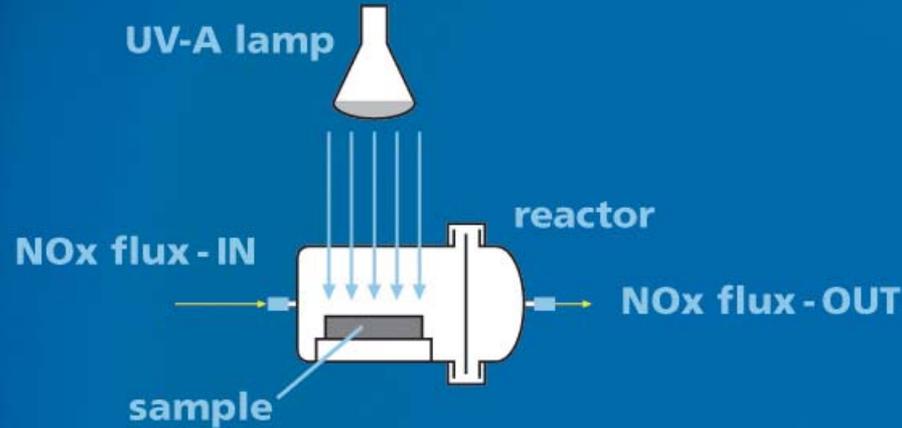


# De-Polluting Effect



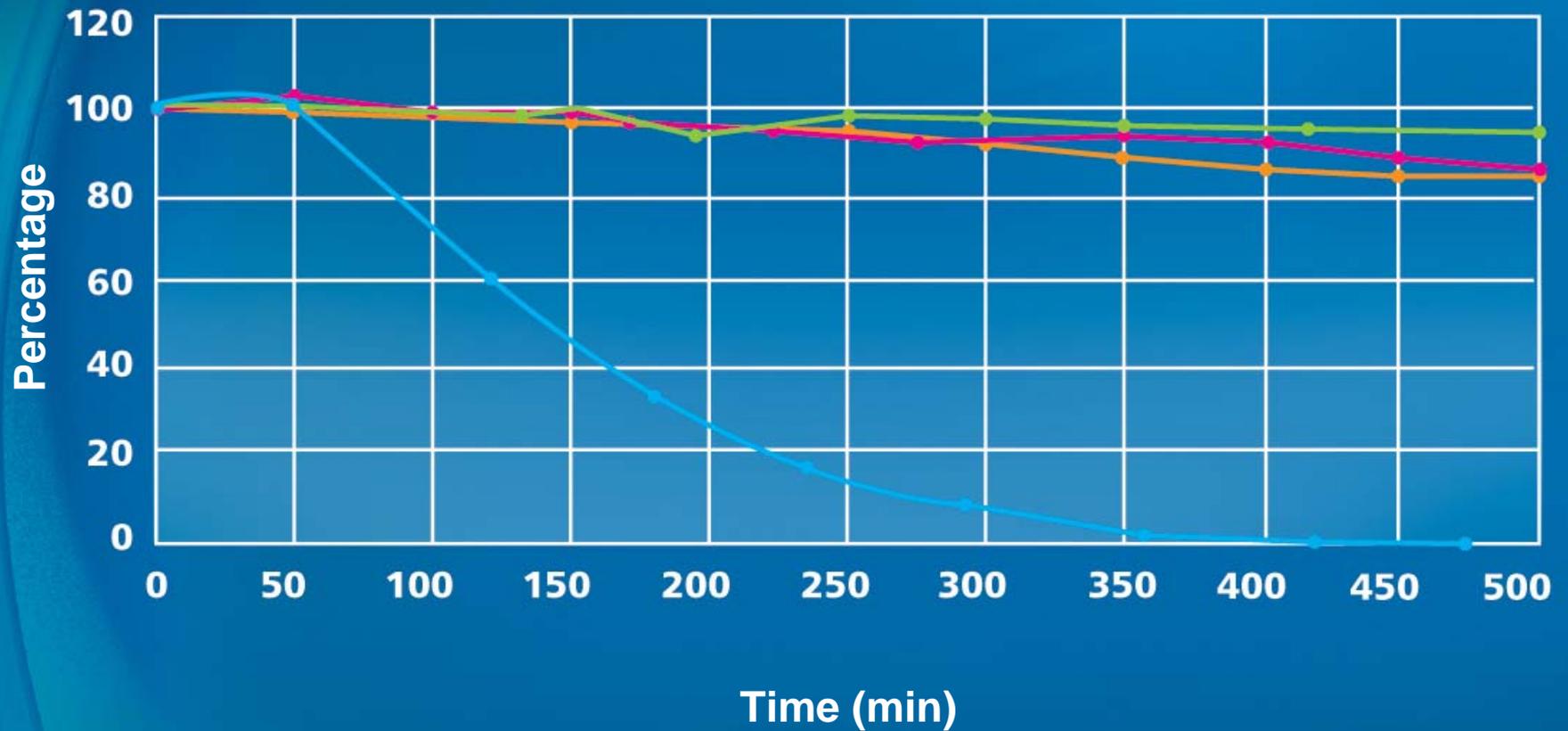
# HOW IT'S MEASURED

## Measuring Pollution Abatement

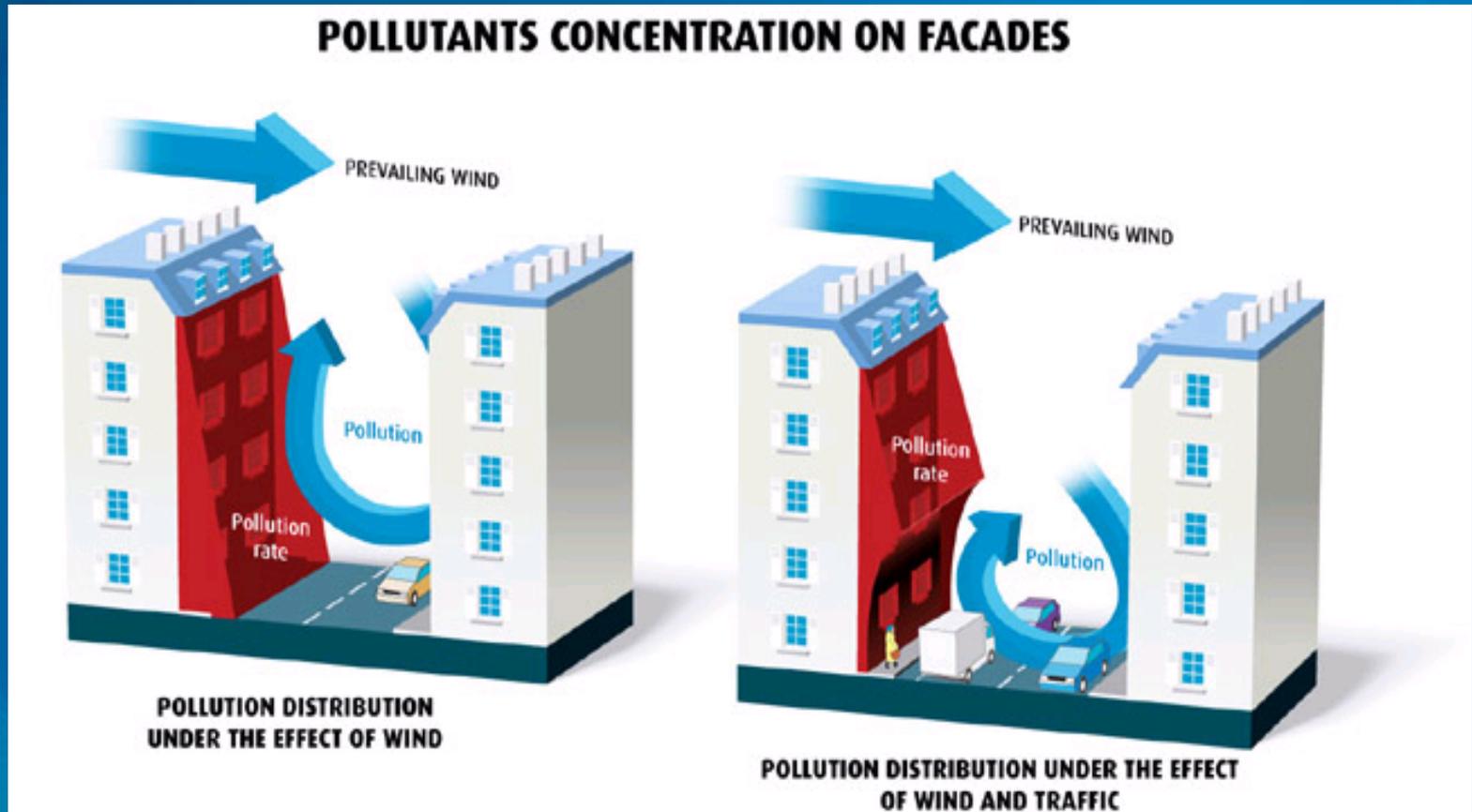


*Test for the measurement of the photocatalytic activity of cement-based or ceramic samples, by chemiluminescence analysis.*

# ISPRA NO<sub>x</sub> DESTRUCTION TEST RESULTS



# PICADA EXPERIMENT GUERVILLE, FRANCE 1/5 SCALE



Out door (real situation) efficiency evaluation and modeling

# PICADA EXPERIMENT GUERVILLE, FRANCE



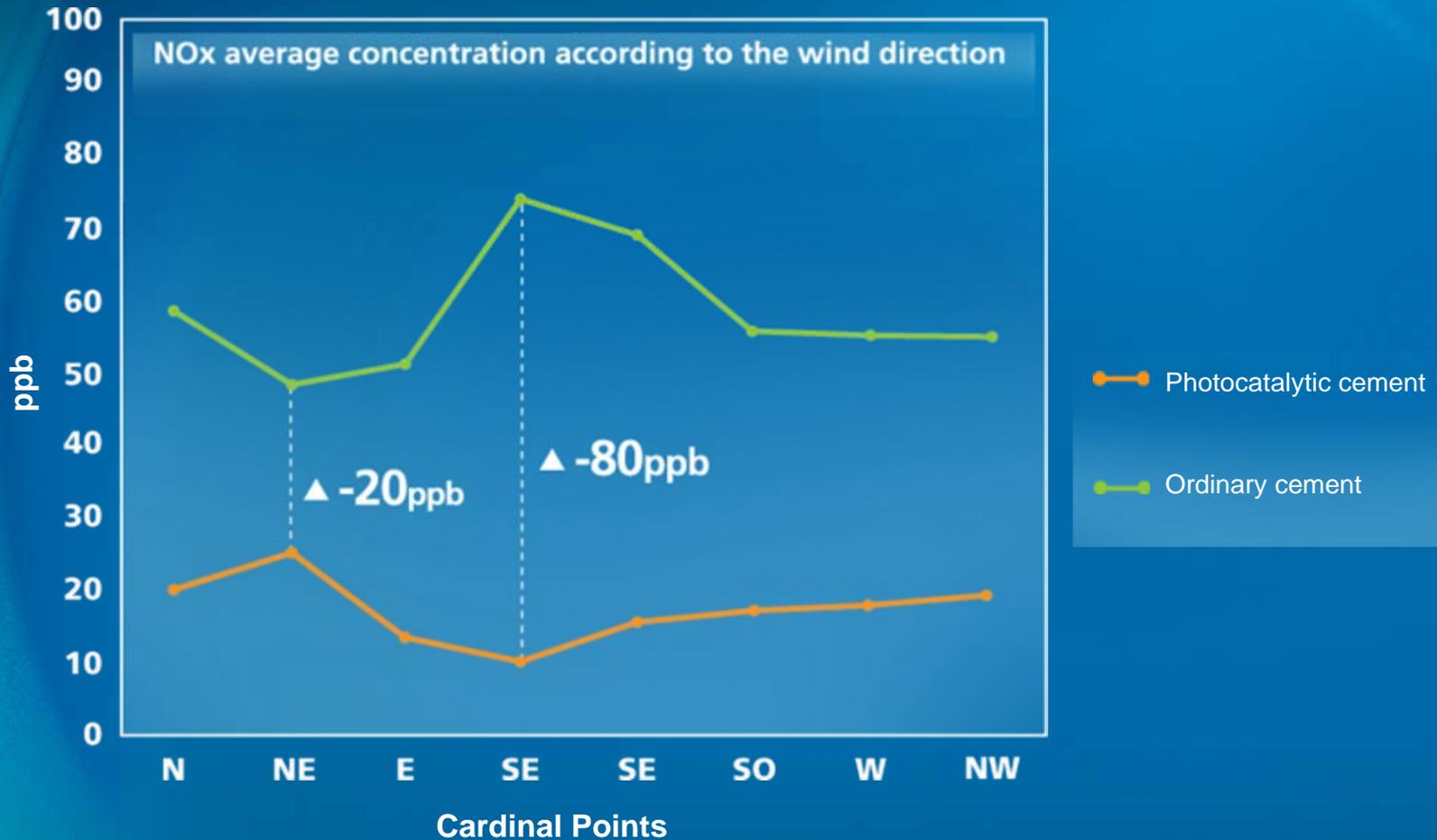
# PICADA EXPERIMENT GUERVILLE, FRANCE 1/5 SCALE



## Measurement Parameters

- Gas velocity, temperature, and composition from the pollution source.
- Continuous  $\text{NO}_x$  measurements on both treated and reference canyons.
- VOC's sampling twice daily.
- Background  $\text{NO}_x$  and  $\text{O}_3$  measurements at the top of the canyons.
- Meteorological parameters (WD, WS, T, RH, solar irradiation).

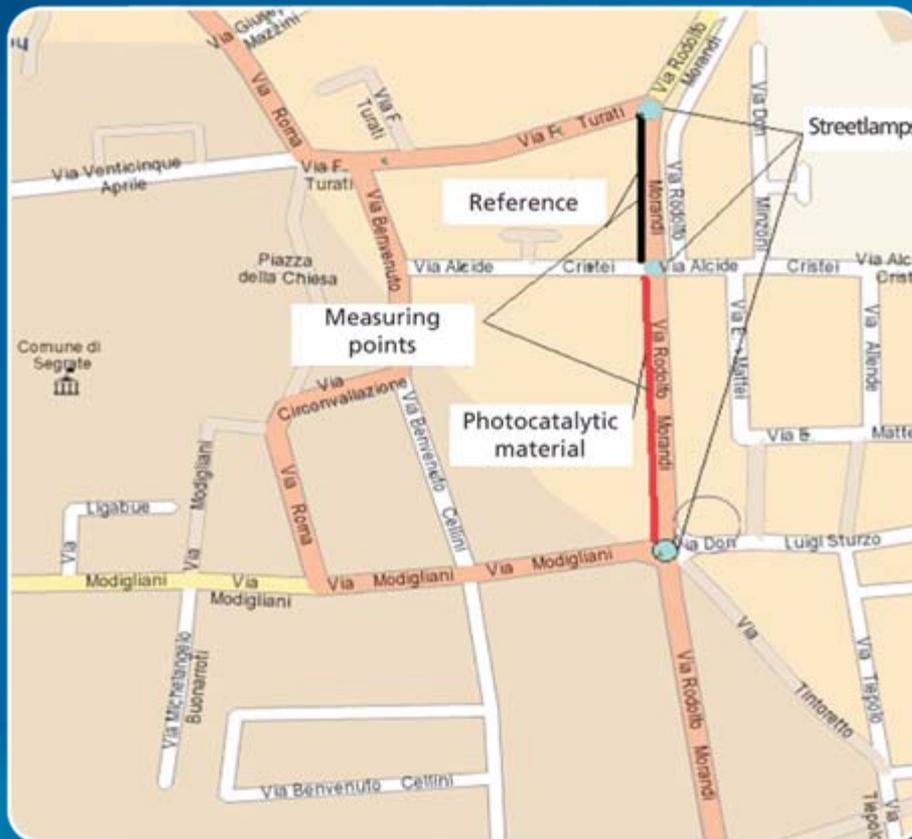
## ...RESULTS



**Several factors affect abatement rates including:**

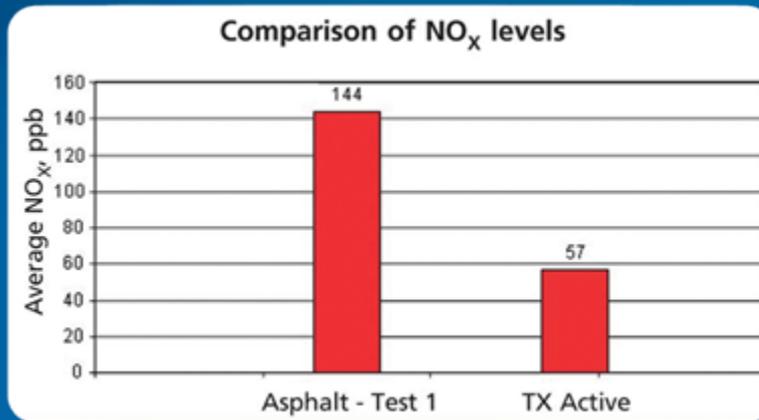
Solar irradiation, Pollutant concentration, Wind speed and Wind direction relative to the structure

# DE-POLLUTING ACTIVITY: SEGRATE (MILAN) 2002



- Heavily traveled two way road (1000 vehicles/hour).
- 10 meters wide in a residential area, sidewalks lined with trees.
- Thin layer of photocatalytic concrete applied to 230M long segment of bituminous road surface (total surface area of about 7000 M<sup>2</sup>).

## ...RESULTS: SEGRATE (MILAN) 2002



Reduction in NO<sub>x</sub> concentration in the photocatalytic treated area of the pavement was measured between 50%-60%.



# Concrete in Practice



# CEMENT PRODUCTION

**Photocatalytic cement is an ASTM C150 cement incorporating the “active” ingredient (catalyst) in a uniform homogenous manner.**



# CONCRETE PROPERTIES



## **Fresh Concrete Properties**

- Workability
- Rheology
- Heat generation
- Finishability

## **Hardened Concrete Properties**

- Compressive Strength
- Flexural Strength
- Durability
- Air Void System
- Permeability

# CONCRETE IN PRACTICE

## **Mix Designs:**

- Normal mix designs procedures are applicable to photocatalytic concrete...ACI 211, etc.
- Same attention as concrete produced with OPC.
  - Air content
  - Water cement ratio
  - Quality aggregates

## **Concrete Production:**

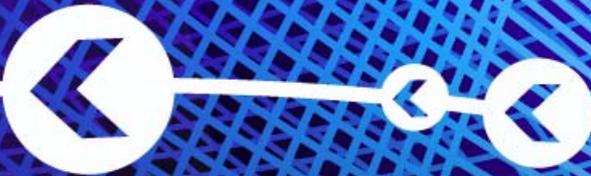
- Manufacturing procedures same as normal concrete, however extra care should be taken to avoid contamination.

## **Concrete Curing:**

- All concrete must be properly cured to attain maximum strength, reduce permeability, obtain durable concrete and attain desired properties – photocatalytic concrete is no different.

# Project Profiles

## Europe



# DIVES IN MISERACORDIA CHURCH • ROME, ITALY



# AIR FRANCE HEADQUARTERS • PARIS, FRANCE



# BORDEAUX POLICE DEPARTMENT • BORDEAUX, FRANCE



# BORGO PALLAZZO • BERGAMO, ITALY

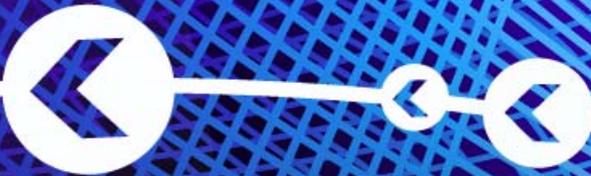


## JEAN BLEUZEN STREET • VANVES, FRANCE



# Project Profiles

## US/Canada



# LSU BASKETBALL PRACTICE FACILITY • BATON ROUGE, LA



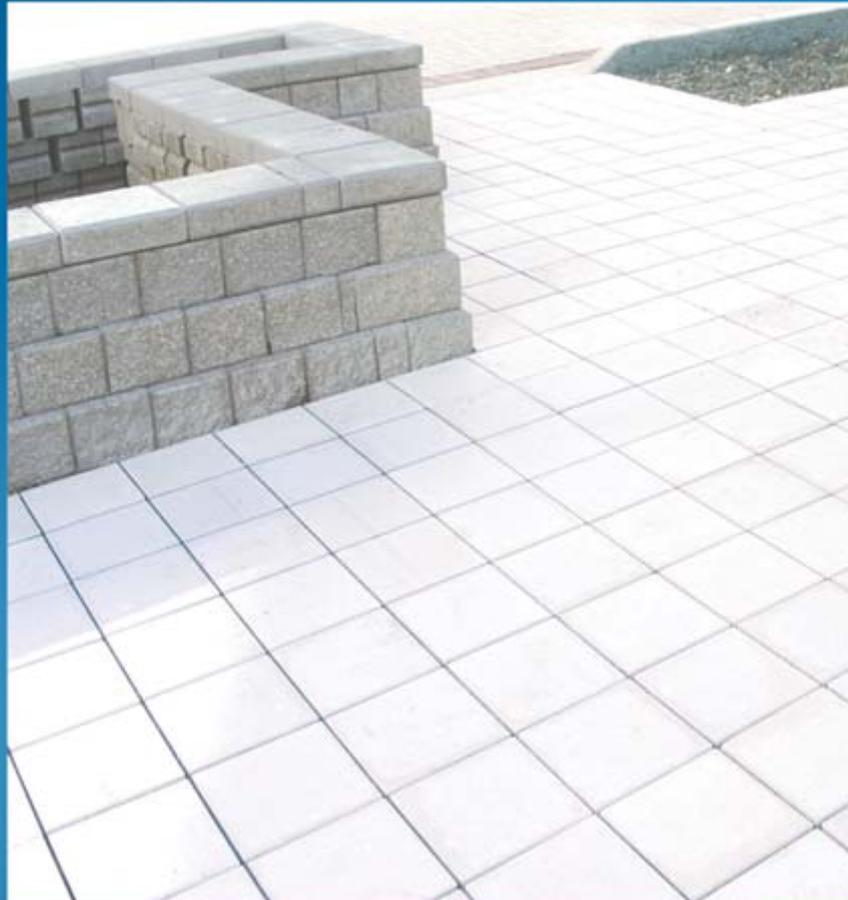
# THE BELL TOWER • DALTON, GEORGIA



# I-35 GATEWAY ELEMENTS • MINNEAPOLIS, MINNESOTA



## HYACINTH PLACE • HIGHLAND PARK, ILLINOIS



# THE YOGA STUDIO • CLARKE COUNTY, VIRGINIA



# GOVERNOR MIFFLIN SCHOOL • SHILLINGTON, PENNSYLVANIA



# SUN LIFE FINANCIAL • WATERLOO, ONTARIO



