DANISH TECHNOLOGICAL INSTITUTE

CONCRETE CENTRE NEWSLETTER – June 2011

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Photocatalyis at the concrete surface induced by visible light - PhoEnICs

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PhoEnICs project is an example of how concrete, the most used construction material in the modern era, can be used as a unique vehicle to exploit innovative technologies in the field of material chemistry that can contribute to tackle the dramatic issue of climate change that societies are facing. In particular:

- Within the European Union, buildings account for 40 % of total energy consumption and a third of CO2 emissions (Directive 2010/31/EU). In the effort of tackling climate change by reducing carbon footprints and saving resources, reduction of energy consumption in buildings is a paramount objective to target.

- It has been demonstrated that climate change highly depends on air pollution too (J. H. Seinfeld, Atmospheric chemistry and physics: from air pollution to climate change, 1 edn., Wiley, New York, 1998), hence the need to improve air quality in European Countries has been identified as a major requirement to be achieved within the next decade (Directive 2008/50/EC).

Photocatalytic concretes, i.e. concretes with exposed surfaces modified with TiO2 photocatalysts, have shown ability to reduce air pollution mainly caused by nitrogen oxides (NOx), sulphur oxides (SOx) and volatile organic compounds (VOCs) once irradiated by sunlight and in the presence of atmospheric moisture. They are also able to provide self-cleaning effect through the light induced super-hydrophilic nature of light irradiated TiO2 surfaces and ability to degrade compounds causing dirt and stains.

In this project highly visible light active TiO2 photocatalysts are implemented into concrete in order to provide air depollution effect to the final material surface. Furthermore, novel encapsulated PCMs will be introduced so as to optimise energy efficiency in buildings where the photocatalytic concrete will be used. The combination of such processes (photocatalysis and energy storage) will therefore offer a chance to produce sustainable innovative, multifunctional concretes with enhanced structural, depolluting, self-cleaning and energy saving properties.

The PhoEnICs project is co-financed by the European Commissions FP7 Marie Curie Actions.

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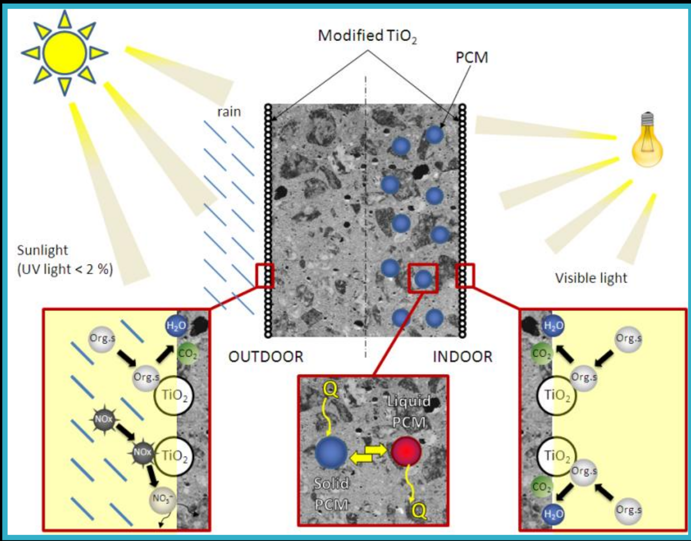
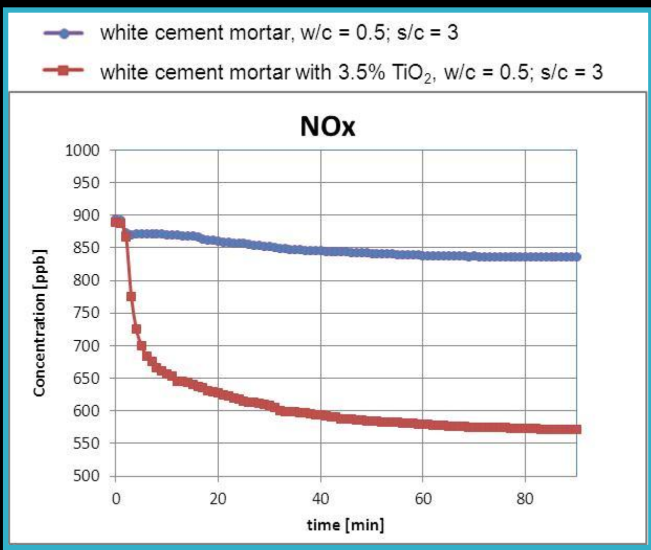
PhoEnICs



Schematic diagram of PhoEnICs working principle.



Nitrogen oxides (NOx = NO + NO2) abatement provided by mortar specimens containing TiO2 under irradiation.

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SFRC Consortium – First demonstration project was a success

The SFRC Consortium (steel fiber reinforced concrete) is an innovation consortium which was initiated in January 2010 and is set to run for 3½ years. The consortium consists of 17 partners in total including larger industrial companies, research institutions and engineering consultancy firms of which The Danish Technological Institute is the overall project leader.

The project is funded by the participating partners and the Danish Agency for Science, Technology and Innovation.

The main purpose of the project is to enhance the sustainability of concrete structures by improving working environment, productivity and aesthetics through increased usage of steel fiber reinforced concrete.
This purpose is fulfilled by carrying out the necessary research activities needed to form the basis for the preparation of a pre-normative document containing guidelines for design, production and execution of steel fiber reinforced concrete structures.

A more specific goal is to develop well documented and applicable solutions for selected load bearing construction parts. In this project these are:

- In situ foundations (e.g. slabs)
- In situ walls
- Prefabricated pre-stressed beams

It is anticipated that a considerable amount of these load bearing construction parts utilizing only traditional reinforcement will be replaced by a steel fiber solution within a 5 year frame from the completion of the project.

The project is divided into 5 work packages:

1. Simulation of form filling and mechanical properties of steel fibre reinforced self-compacting concrete (SFRSCC)
2. Material development and testing
3. Design guide
4. Execution control and methods
5. Demonstration and knowledge transfer

The first demonstration project has now been carried out in Aalborg, Denmark (Eternitgrunden). Here the bottom slab for a large rainwater bassin was cast as a slab on grade using SFRSCC. Using steel fibres it was possible to reduce the amount of conventional reinforcement and obtain savings of approximately 30 %.
A total of 380m^3 of SFRC was used and the entire casting took 13 hours to complete.

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Trial castings were carried out to optimise the flow properties and casting procedure. By using SFRSCC the total amount of steel could be reduced. Right: Beam with 16mm rebars and no fibers. Left: Beam with 10mm rebars and 30kgs RC-80/60 BN steel fibres.

The bassin slab is 900m^2 in total and 40cm thick. Reinforcement needed to withstand high water pressure from underneath, due to a high groundwater table. Due to the use of SFRSCC a lot less steel had to be placed manually which in itself is a clear cut bonus for the working environment.

Target slump flow for the mix design was 550mm. Strict control of the concrete rheology and slump flow was kept using the 4C-Rheometer. Slump flow below 500mm made the SFRSCC very difficult to place and slump flows higher than 600mm made the concrete front more difficult to control and increased the risk of segregation.

Resource recovery from municipal waste incinerator bottom ashes

The municipalities of Eastern Denmark through their jointly owned company AFATEK has initiated a research and development project together with the Danish Technological Institute, the Technical University of Denmark, IBF A/S that over the next 3-4 year period will explore the potential for recovery and use of the resources in municipal waste incinerator bottom ash.

The incineration of municipal waste in Denmark leaves approximately 20% bottom ash consisting of minerals, metals, unburned organics as a wet granular material.

The ash typically contains 3-4% of metal which represents a significant and valuable resource. With the increasingly improved sorting/separation technologies high efficiency in metal recovery seems possibly making available essentially "metal free" mineral size fractions that may be used in the production of concrete.

The project has three technical workpackages dealing with:

- Recovery of metals
- Recovery of minerals and their use in concrete
- Environmental aspect – e.g. LCA and leaching

In the "concrete" workpackage the available size fractions 0-2 mm, 2-8 mm, 8-16 mm and 16-50 mm will be characterized in terms of their physical and chemical properties including variations over an extended production period.

Subsequently, the use of the bottom ash as aggregate in C25/30 and C35/45 slump concrete as well as in zero slump concrete pavers will be documented by mixing and casting concrete using the industrial batch plant at DTI. The performance of the bottom ash concrete in the fresh and hardened states will be tested and compared to reference concrete.

Based on the performance of the bottom ash in the concrete as well as a screening of relevant European standards one application of the bottom in concrete will be selected for full scale implementation at a production site of IBF A/S.

Sample of bottom ash from incinerated municipal waste.

One of four danish AFATEK storage facilities for bottom ash. Processing and removal of metals is performed locally.

Pavers produced with zero slump concrete containing bottom ash.

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Conspacers - Next generation of concrete spacers

Concrete spacers is an indispensible part of every construction project and the demand for high quality spacers is increasing.

In today´s major civil engineering works specifications for the spacers are drawn up specifically for each single project. These specifications concern constituents, geometry, strength etc. This means that production facilities and moulds have to been adjusted or manufactured for each individual project. This is both extremely expensive and time consuming.

The Danish Technological Institute (DTI) have recently completed a preliminary study in order to determine the overall quality of the most common concrete spacers used today in Northern and Eastern Europe. The results made it clear that the quality had to be improved and that research into a method of creating a stronger more dense bonding between spacer and concrete matrix is required.

The European Union annually spends billions of Euros in the maintenance and repair of its infrastructural network including bridges, tunnels harbours etc. In order to postpone the deterioration process by reducing corrosion, the spacers used in supporting the reinforcement needs to be of a guaranteed high quality and problems with e.g. high chloride ingression must be solved.

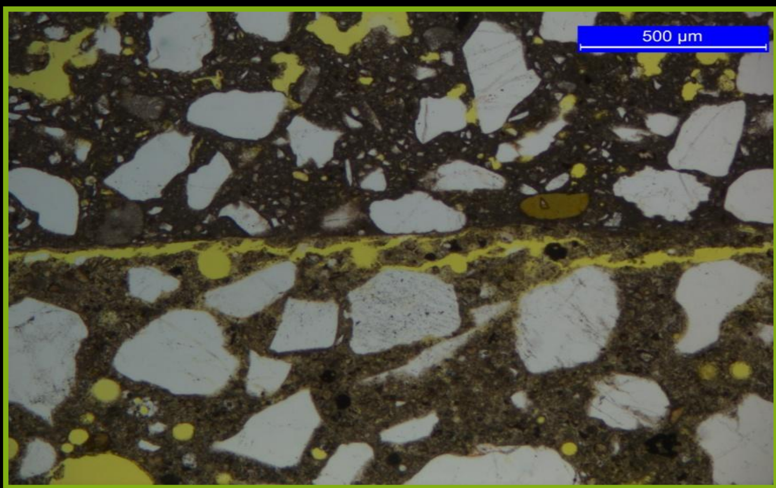
Based on the findings in the preliminary tests the Danish Technological Institute has initiated a 3 year Eurostars project, *Conspacers,* to develop high quality and competitive spacers for major civil engineering constructions. The project is funded through the EUREKA and the EU Seventh framework programme with a budget of €0,65 mio.

The project will develop a cement-based reinforcement spacer with improved bonding to the surrounding concrete, minimising penetration of chloride ions along the interface. This is to be obtained by utilising an active surface on the spacers capable of ensuring a superior bonding by interacting with the surrounding concrete. This will reduce corrosion on the concrete structure thereby prolonging service life and reducing maintenance and repair costs.

Bone shaped concrete spacer tested by DTI

Experimental setup. Testing of various techniques to obtain a superior bonding between spacer and concrete.

Chloride migration tests was performed on the spacers.The silver nitrate used for the test has penetrated much farther into the spacer than anticipated indicating a very porous structure.



Microscopy analysis of the interface between spacer and the surrounding concrete. The bonding zone is clearly visible.

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