Photocatalytic concrete products

Evaluation of air-purifying abilities

Subject

Motivated by the promising results of the research on photocatalytic materials and their application in building materials, various products for air purification have been introduced onto the European market. A comprehensive scientific description is often limited to the advertised product and comparative tests under equal conditions are missing for concrete paving blocks. Therefore, a suitable measuring technique for evaluating the efficiency of concrete products containing photocatalytic materials for air purification was developed at the UT. The described test setup allows studying the influence of boundary conditions like irradiation, relative humidity, etc. on the degradation rate. Based on the laboratory observations, recommendations in regard to the practical execution of evaluating tests as well as their analysis can be given. By means of the described measuring technique, a representative profile of available air purifying concrete products of the European market was tested regarding their air purifying abilities. The results of the survey help potential customers with their selection of suitable air purifying concrete products.

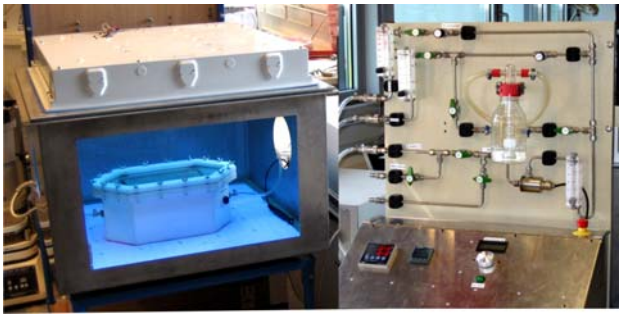

Figure 1: Test setup incl. reactor cell (l) and gas supply (r).

Goals

The research is focused on photocatalytic concrete products for the degradation of inorganic air pollutants like nitrogen oxide (NO_x). Here, the evaluation of air-purifying abilities and the optimum use of photocatalytic powder is of major concern.

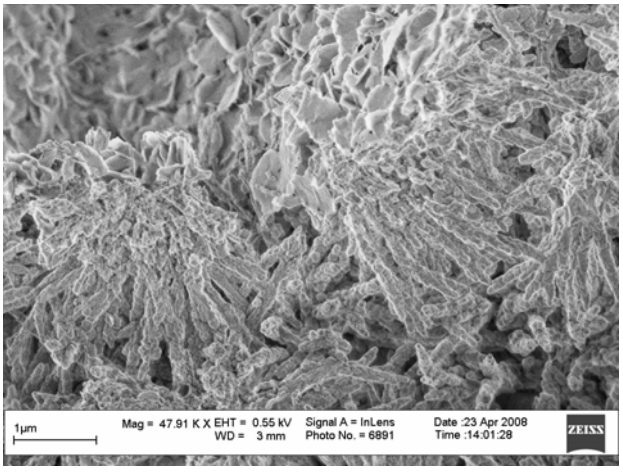

Figure 2: TiO_2 covered CSH-phases and phases of calcium aluminate hydrate in the background.

Goals

The knowledge about the influence of boundary conditions on the degradation of nitric oxide (NO) are used for the formulation of a standardized measuring principle for photocatalytic concrete products which helps comparing different products regarding their effective degradation. (cp. Figure 4).

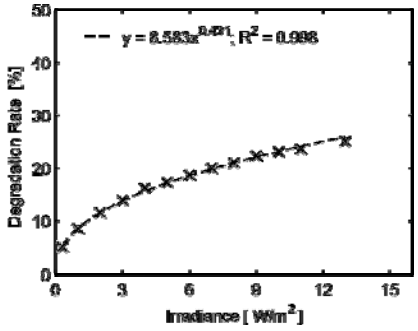

Figure 3: Influence of the irradiance on the degradation rate.

Furthermore, the data obtained in the lab will be used to model the degradation process. The results of the modeling will be compared with measurements under practical conditions in a later state.

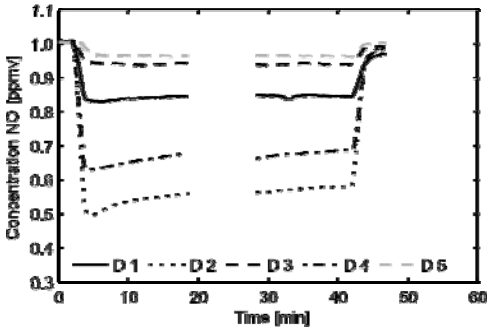

Figure 4: Degradation of nitric oxide for different products.

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Use of Stone Waste Materials in Earth-Moist Concrete (EMC)

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Subject

The use of natural resources in consideration of ecological and economical aspects forms the foundation for sustainable development. Low energy consumption during production and the use of by-products and waste materials of the production process are necessary to avoid environmental as well as financial impacts.

Goals

So far, stone waste materials are not considered a suitable ingredient for concrete production although the use of industrial by-products like fly ash and blast furnace slag is an approved method in concrete production. This research project will show the potential of stone waste materials for the production of concrete mass products made of earth-moist concrete (EMC) and its environmental and financial benefits.

For the development of innovative concrete products, stone waste materials will be applied together with photocatalysts (titanium dioxide) to combine sustainable use of primary raw materials and air-purifying abilities in the end product.

Research Question

- Development of a theoretical model for EMC
- Performance based mix design concept for EMC based on particle packing ideas
- Use of stone waste materials in EMC mixes
- Application of photocatalytic materials in concrete mass products (paving blocks) considering new types of titanium dioxide
- Improvement of air-purifying abilities of the functional top layer of paving blocks

Strategy

In the first instance, particle packing ideas will be studied and applied for developing a performance based mix design concept. The new mix design concept forms the basis for further investigation and evaluations on EMC. The results of the investigation on EMC mixes are used to formulate a theoretical model for earth-moist concrete. Furthermore, the mode of action of photocatalytic materials in cementitious materials is investigated. New insights in the working mechanisms of photocatalytic materials in cementitious materials are the starting point for developing new types of functional concrete products. This new type of functional concrete products is using cost-efficient photocatalytic powders to stimulate the use of air-purifying concrete products in critical areas.

Expected Results

By means of an optimized particle packing, stone waste materials will be used for the production of earth-moist concrete mixes. These mixes are characterized by low cement contents which will meet mechanical and durability requirements.

Preferred Partners Applications / Sponsors

The research project is sponsored by the integrated project for SMEs (EU 6th FP): “Re-engineering of natural stone production chain through knowledge-based processes, eco innovation and new organizational paradigms” (Acronym: I-STONE) and the user/sponsor group “Cement-Immobilisates-Concrete research” at the University of Twente.

Prime Publication / Prototyping

- G. Hüsken, M. Hunger, H.J.H. Brouwers, Comparative study on cementitious products containing titanium dioxide as photocatalyst. Proceedings of the International RILEM Symposium on Photocatalysis, Environment and Construction Materials, Florence, Italy, October, 2007
- G. Hüsken, H.J.H. Brouwers, Earth-moist concrete: application of a new mix design concept, Cement and Concrete Research 38, 1246-1259 (2008).
- G. Hüsken, M. Hunger and H.J.H. Brouwers (2008), Comparative study on air-purifying concrete products/Eine vergleichende Untersuchung von luftreinigenden Betonprodukten, BFT International – Betonwerk + Fertigteil-Technik (4)12-18.
- M. Hunger, G. Hüsken and H.J.H. Brouwers (2008), Photocatalysis applied to concrete products - Part 1: Principles and test procedure, ZKG 61(8):77-85.
- M. Hunger, G. Hüsken and H.J.H. Brouwers (2008), Photocatalysis applied to concrete products - Part 2: Principles and test procedure, ZKG 61(10):76-84.
- G. Hüsken, H.J.H. Brouwers, Air purification by cementitious materials: evaluation of air purifying properties, Proceedings 7th International Conference on Construction and Building Technology Volume A: Emerging Technology in Construction Materials, 16-20 June, Kuala Lumpur, Malaysia, 263-274, Eds. H.M.A. Al-Mattarneh, M.F. Nuruddin and K.N. Mustapha, International Association for Construction Technology/UPENA, Kuala Lumpur, Malaysia (2008).
- G. Hüsken, H.J.H. Brouwers, Development of eco earth-moist concrete, International Conference Excellence in Concrete Construction through Innovation, 9-10 September 2008, London, United Kingdom, 97-105, Eds. M.C. Limbachiya and H.Y. Kew, CRC Press/Balkema, Leiden, The Netherlands (2009).

Research Period

2005 - 2009