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Preface

Preface to special issue on: Nanotechnology in construction

This issue of Cement and Concrete Composites is devoted to the rapidly advancing field of Nanotechnology in Construction. It contains 18 papers written by eminent experts in the field. All papers were presented at the "4th International Symposium on Nanotechnology in Construction", (NICOM4), held in Agios Nikolaos in Crete, Greece, May 20–22, 2012 organized by the Center for Multifunctional Nanocomposite Construction Materials of the Democritus University of Thrace. The First International Symposium on Nanotechnology in Construction, (NICOM1) was held in Paisley in 2003, organized by the Scottish Center for Nanotechnology in Construction Materials. LABEIN-Tecnalia took on the responsibility of organizing the 2nd International Symposium on Nanotechnology in Construction, (NICOM2) held in Bilbao in November 2005. The 3rd symposium, (NICOM3), was held in Prague, Czech Republic in June 2009 under the auspices of the Czech Technical University. NICOM4 was the fourth international gathering of world leading experts from academia, industry and government, interested in all aspects of applications of nanotechnology in construction.

Nanotechnology in construction is already identified as a novel field, mature enough to revolutionize construction and its materials. It is the objective of this issue to present the current state of the art in this area, and to cover the latest trends and future directions on the use and implementation of nanotechnology in construction materials and structures. These trends may be grouped as follows: nanostructured modified construction materials-use of nanoparticles and nanosized fibers; advanced characterization techniques and tools at the nanoscale; nanomechanical characterization of nanostructures; atomic scale computational materials modeling; application of TiO_2 photocatalysis on construction materials; nanomaterials in cultural heritage buildings and monuments; and nanomechanical properties of cement based materials.

The paper by *Schmidt* et al. provides a detailed overview of the nanotechnological improvement of structural materials and introduces its impact on material performance and structural design.

Three papers present state of the art research on nanostructured modified materials and the use of nanoparticles and nanosized fibers in cement based materials: The paper of *Kawashima* et al. studies the modification of the fresh-state and hardened properties of cement-based systems with nanoclays, nano$CaCO_3$ and nanoSiO_2. The rheological properties of nanoclay-modified cement-based materials are investigated to further understand the influence of nanoclays on fresh-state stiffening and formwork pressure. Also an in-depth study on the mechanisms underlying the influence of nanoSiO_2 on the compressive strength gain of fly ash cement systems is discussed. *Jayapalan, Lee and Kurtis* investigate the effect of chemically inert nano and microparticles (i.e., titanium dioxide (TiO_2) and calcium carbonate) on the early age properties and behavior of cement-based materials, through heat of hydration studies, measurement of chemical shrinkage, surface area and pore size distribution. *Metaxa, Konsta-Gdoutos and Shah* compare the reinforcing efficiency of four different Carbon Nanoscale Fibers (CNFs) with different morphology and subjected to different debulking processes. The paper presents an optimization of the authors' CNF dispersion method, followed by an experimental determination of the mechanical properties and nanostructure of cementitious nanocomposites, reinforced with CNFs at an amount of 0.048 wt.% of cement.

In the same context the paper of *Maravelaki-Kalaitzaki* et al. present a study on nanomaterials specifically designed for use in monument restoration. The authors study the effect of 4.5–6% w/w of binder nano-titania in the hydration and carbonation of binders widely used in the design of restoration mortars, with a special emphasis given to mortars tailored to ensure adhesion of fragments of porous limestones from the Acropolis monuments in Athens, Greece.

Five papers present the latest research on advanced characterization techniques and tools used to evaluate the chemical and mechanical properties of advanced cement based materials at the nanoscale: *Glotzbach, Stephan and Schmidt* study the forces between silica surfaces using Atomic Force Microscopy (AFM). Their experimental approach involves two spherical particles in a closed cell flooded with different additive solutions. The forces acting between the particles were measured in a fluid environment that could be adapted to simulate a real mortar. In the paper of *Peled, Castro and Weiss* two major nanotechnology tools, the Atomic Force Microscopy (AFM) and Lateral Force Microscopy (LFM), were used to examine and better understand the nano- and microstructure of cement paste phases and ITZ of mortars. The paper of *Provis* et al. provides a case study outlining the value of advanced beamline techniques, such as Synchrotron Infrared Microscopy, X-ray Fluorescence Microscopy, and X-ray Tomography in the development, nanostructural characterization and optimization of a new class of environmentally beneficial cements and concretes. The paper of *Kim, Foley and Reda Taha* provides insight on the nanoscale mechanical characteristics of C–S–H. Dried C–S–H powders were chemically characterized using X-ray diffraction analysis (XRDA), and ^{29}Si magic angle spinning (MAS) nuclear magnetic resonance (NMR) spectroscopy. The specimens then underwent nanoindentation for a detailed nanomechanical characterization. *Trtik* et al. report results using the recently established Ptychographic X-ray Computed Tomography (PXCT) technique on epoxy-resin impregnated hardened cement paste. The method was successfully used to quantify the electron density of material phases and to derive the mass density of the phases based on an estimation of their chemical composition.

Two papers provide an insight in atomic scale computational materials modeling and finite element simulations. The paper of *Sarris and Constantinides* presents a computational study of the

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indentation response of a rigid axisymmetric indenter on a semi-infinite elasto-plastic material of the Mohr–Coulomb type. The finite element method is used to quantify the effect of material properties (E, c, φ) and contact friction (μ) on the indentation response of C–S–H phases. In their paper *Němeček, Králík and Vondřejc* employ Nanoindentation for the determination of phase properties at grid points at the scale below one micrometer for cement paste, gypsum and aluminum alloy. Statistical approach and deconvolution methods are applied to assess intrinsic phase properties.

Five papers are dealing with the photocatalytic activity and performance of TiO_2 as well as of new inorganic–inorganic nanocomposite photocatalysts in construction materials. In the first paper *Maury-Ramirez* et al. evaluate the self cleaning and antimicrobial properties of TiO_2 containing cements and coatings as strategies to avoid algal fouling on new and existing buildings. The paper by *Gou, Ling and Poon* studies the photocatalytic NO degradation and bacteria inactivation performances of TiO_2 coated glass and self compacted glass mortars, obtained by two different dip coating methods. The work of *Kamaruddin and Stephan* deals with the synthesis of quartz-titania composites, using ground quartz as the core material. The self cleaning properties of these photocatalytically modified core–shell composites were evaluated and presented. *Bianchi* et al. study the photocatalytic properties of vitrified tiles prepared with a commercial micro-sized TiO_2. The paper by *Vulic* et al. studies the use of new inorganic–inorganic nanocomposite photocatalyst based on layered double hydroxides (LDH) associated to TiO_2. The results show that the synergetic effect between $TiO_{2,}$ as a traditional photocatalytic semiconductor, and Zn–Al–LDH contributes to the overall photocatalytic performance, improving also the compatibility of the photocatalytic active phase with the mortar matrix.

Last but not least *Revel* et al. study the development of innovative nanobased coatings with improved Near InfraRed reflecting capabilities. The paper regards the improvement of NIR reflectance on paints (for building roofs and façades) and ceramic tiles (for building façades) by working on the coating nanoscale, tuning the particle size of selected nanostructured oxides.

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