UMR
UNIVERSITY OF MISSOURI-ROLLA

CENTER FOR INFRASTRUCTURE ENGINEERING STUDIES

Mapei Scholar Program

By

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16. Abstract

During the summer of 2006, six University of Naples "Federico II" (UniNa) students will come to UMR to conduct supervised research under the advisement of UMR faculty members and funding from Mapei.

- The research work will be compiled by each student into a thesis (English language) for obtaining the second level engineering degree (laurea specialistica = US master equivalent) in the fields of Materials and Civil Engineering at UniNA with UMR faculty serving as co-advisors.
- The research topical areas will be jointly selected by UniNA and UMR faculty and will be of interest to Mapei.
- Immediately after completion of the thesis, the students will make a presentation of their work at Mapei Headquarters in Milan, Italy, and will provide Mapei with a copy of their thesis report.
- It is envisioned that this program will be continued over the years.

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MAPEI SCHOLAR PROGRAM – SUMMER 2006

University of Naples Federico II (UniNa) and University of Missouri-Rolla (UMR)

Student	UMR Thesis Co-advisor	Thesis Topic*
Alessandro Borrelli abpp5@umr.edu	Dr. Rajiv Mishra rsmishra@umr.edu	Setup of a testing procedure for micro-tensile and micro-fatigue analysis of nanocomposite micro-specimens
Rosa Colasanto rc4k3@umr.edu	Dr. Michael Van-De-Mark mvandema@umr.edu	Silane adhesion promoters effect on adhesion and abrasion for epoxy resin systems
Vincenzo Capuano vc989@umr.edu	Dr. K. Chandrashekhara chandra@umr.edu	Synthesis and characterizaction of epoxy-clay nanocomposites
Antonio De Luca adzp9@umr.edu anto_deluca@tiscali.it	Dr. Antonio Nanni nanni@umr.edu	Validation of structural strengthening of concrete members with composite systems by means of in situ load testing
Rossella Mafalda Ferraro rmf8wf@umr.edu rossellamafalda.ferraro@virgilio.it	Dr. Richard Brow brow@umr.edu	Mechanical properties of high strength/high-alkaline resistant Fe-Phosphate glass fibers as concrete reinforcement
Carolina Maliardo cm432@umr.edu	Dr. Greg Hilmas ghilmas@umr.edu	Ceramic coating for a composite steam manhole to resist high temperature

*The following pages include the thesis abstracts for the six 2006 Mapei scholars.

SETUP OF A TESTING PROCEDURE FOR MICRO-TENSILE AND MICRO-FATIGUE ANALYSIS OF NANOCOMPOSITE MICRO-SPECIMENS

By Alessandro Borrelli

Advised by Prof. Giuseppe Mensitieri (UniNa) and Dr. Rajiv Mishra (UMR)

Abstract

The present study is initiated to cater to the increasing demand for smaller and lighter industrial products. Nanocomposite materials would most likely be suitable to satisfy these demands. However, the mechanical properties of these materials should be known to ensure the performance quality of the final product.

The major objective of this work was to analyze the influence of wt% composition on mechanical properties. For this purpose, the existing micro-testing machine was revamped and debugged. The machine encloses two modules—one for micro-tensile testing and the other for micro-fatigue testing.

Mechanical behaviors of different nanocomposites like polyepoxy with varying silica content (0wt% - 3 wt% - 7wt%), unfilled polypropylene, 5wt% cloisite filled polypropylene, 40wt% talc filled polypropylene, and 50 wt% glass fiber filled polypropylene were tested and evaluated.

The results obtained for all the nanocomposites showed an increasing trend in yield strength and ultimate strength but a decreasing tendency in elongation at failure with increasing strain rate. For polyepoxy silica nanocomposites with increasing silica content, yield strength increases. For polypropylene, elastic modulus increases with cloisite, talc, and glass fiber content; yield strength decreases with talc content, but it increases with cloisite and glass fiber content. The S-N curve (fatigue life) was obtained for epoxy-silica nanocomposite.

SILANE ADHESION PROMOTERS EFFECT ON ADHESION AND ABRASION FOR EPOXY RESIN SYSTEMS

By Rosa Colasanto

Advised by Dr. Michael Van De Mark (UMR) and Prof. Acierno Domenico (UniNa)

Abstract

This work of thesis covers the major attributes affected by the interaction of a pigment, titanium dioxide, with the epoxy resin in the presence of an adsorbed dispersant. The dispersant acts to stabilize the pigment in a liquid media through adsorption on its surface, however, it can alter the interaction of the resin with the pigment. The adhesion of the dispersant to the pigment and the adhesion of the dispersant and/or pigment to the resin are critical to the performance of the coating, adhesive, composite or sealant. The dispersant can cause a substantial change in the tensile and abrasion resistance of these materials. To obtain better results in terms of adhesion and abrasion resistance, silane was added to the pigment-dispersant-resin system. Through different kind of tests, it was possible to verify the increase of the epoxy resin systems' adhesive and abrasive properties.

SYNTHESIS AND CHARACTERIZATION OF EPOXY-CLAY NANOCOMPOSITES

By Vincenzo Capuano

Advised by Dr. K. Chandrashekhara (UMR) and Prof. C. Carfagna (UniNa)

Abstract

Nanocomposites are a relatively new class of materials with ultra fine phase dimension typically in the range of 1–100 nm. Because of their unique phase morphology and their improved interfacial properties, nanocomposites usually exhibit better physical and mechanical properties than their micro-counterparts.

Layered silicate clay is attracting great attention owing to its potential in the preparation of organic-inorganic nanocomposites. By intercalation and in situ polymerization of monomers, layered silicate can be induced to exfoliate into nanoscale layers, which disperse in the polymer matrices uniformly. In this work nanocomposites materials consisting of an epoxy resin matrix with two different curing agents and silicate clay particles have been processed and characterized morphologically and mechanically.

The clay was a commercial available product, modified with a quaternary ammonium salt; the clay particles were mixed with the epoxy resin in low concentration and sonicated, then mixed with the curing agent, deareated and cured.

The process used result in a exfoliation and the characteristic of the nanocomposites were assessed by X-ray diffraction and mechanical tests. Result from these observation show that the basal spacing of clay platelets increased from an initial pre-processing value of 1,85 nm to a final value higher than 8,8 nm, the detection limit of XRD analysis.

Enhancement of mechanical properties was measured by flexural and tensile testing of nanocomposites. Young's module increases of 24% over that the unfilled epoxy were measured for clay concentration of 1.5 wt%.

VALIDATION OF STRUCTURAL STRENGTHENING OF CONCRETE MEMBERS WITH COMPOSITE SYSTEMS BY MEANS OF IN SITU LOAD TESTING

By Antonio De Luca

Advised by Dr. Antonio Nanni (UMR) and Prof. Gaetano Manfredi (UniNa)

Abstract

The current role of testing within structural engineering has gained increasing importance, as it can now be applied to every phase of the structure's life because of innovative materials and new design approaches. By focusing on either the preliminary testing of a new structure or the necessary control checks prior to assessing the strength of an existing one, in-situ load testing can determine the real behavior of the structure under the existing loading conditions. Accordingly, researchers can have an overall, accurate understanding of the mechanical properties of the structural members.

In the United States of America, the current American Concrete Institute (ACI) 318 Building Code provides requirements for load testing of concrete structures. ACI Committee 437 proposes a diagnostic cyclic load testing procedure consisting of the application of patch loads in a quasi-static way to the structural member according to loading and unloading cycles. Patch load magnitude and distribution shall simulate the uniformly distributed load defined in the ACI 318 Building Code.

The objective of this work is to showcase to an engineer who is considering performing a diagnostic cyclic load test a theoretical procedure for determining the patch load, which when applied to a two-way slab floor system would generate internal forces at critical locations equal to those resulting from the uniformly distributed load. This procedure should also help the practitioner to define a representative model of the structure and to update the magnitude of the target load at the end of each loading and unloading cycle by means of a real-time evaluation of boundary conditions and slab stiffness. The slab to be tested is thought modeled by Finite Differences Method (FDM).

Sample slabs under different load and boundary conditions have been studied. Each case of study has been solved with the FDM and with commercial Finite Element Method (FEM) software (SAP2000) at the same time. The solution obtained by using the FDM has been compared with the one obtained with the FEM. The idea is to show that the FDM can be employed in the routine mentioned above.

Finally, the diagnostic load test performed on Notre Dame University Football Stadium (South Bend, IN) have been outlined. It is the first time that two whole parts of a structure has been tested: a vertical-load test to check the capacity of sections of typical concrete tread and riser affected by deterioration; a lateral-load test to determine the ability of the lateral-load system affected by the removal of portions of infill masonry walls.

MECHANICAL PROPERTIS OF HIGH-STRENGTH/HIGH-ALKALINE RESISTANT FE-PHOSPHATE GLASS FIBERS AS CONCRETE REINFORCEMENT

By Rossella Mafalda Ferraro

Advised by Dr. Richard Brow (UMR) and Prof. Domenico Acierno (UniNa)

Abstract

Alkaline-resistant (AR) glass fibers are used in glass fiber reinforced composites (GFRCs). Current commercial AR glass fibers are based on high-zirconia (15–20 wt%) silicate compositions and are manufactured by foreign companies, such as, CemFILTM (St. Gobain, France), which manufactures NEG ARGTM (Nippon Electric Glass Co. Japan). These commercial fibers often degrade after about six months in cement environments. Optimizing the glass composition is one way to address the problem of embrittlement with aging and to improve the long-term performance of GFRCs. The objective of this program is to develop alkaline-resistant, iron-phosphate glass fibers for reinforcing concrete and cement products and for replacing silica-based, alkali-resistant glass fiber. The iron-phosphate glass fiber offers the potential for saving 40–60 percent of the energy used to manufacture the higher melting zirconia-silica-based, alkaline-resistant glass fiber. The lower temperature viscosity characteristics of iron-phosphate glass fiber offer the added advantage of saving considerable energy costs associated with manufacturing more refractory commercial alkaline-resistant, zirconia-containing, silicate glass fibers.

The topic of my work at UMR is to understand the possibility of using Silica-Iron-Phosphate (SIP) fibers instead of Calcium-Iron-Phosphorate (CFP) fibers, by using chemical and mechanical tests. In particular, the chemical stability of candidate glasses has been evaluated and compared to Cem-FIL™ (a commercial alkaline-resistant glass fiber manufactured by the St. Gobain Group in France), E-glass, and NEG glass fibers. In addition to using short and long corrosion resistance tests, we also mixed iron phosphate fibers of selected composition with cement and qualitatively monitored the behavior of the fiber. The mechanical properties have been evaluated by testing several kinds of composites by flexural and splitting tensile tests.

CERAMIC COATING FOR A COMPOSITE STEAM MANHOLE TO RESIST HIGH TEMPERATURE

By Carolina Mallardo

Advised by Dr. Greg Hilmas (UMR) and Prof. Domenico Acierno (UniNa)

Abstract

The scope of this project is to identify one or more materials to be used as a coating on the fiber reinforced plastic (FRP) composite being used for the F-95 manhole product produced by Fibrelite.

The goal of the project is to provide an adherent coating that can be applied to the bottom surface of a composite steam manhole cover in order to provide adequate insulation from high temperatures, while also providing protection against high temperature steam. Tests will be performed both at the coupon and structural level in order to provide complete characterization of the final product. Also the performance of the manholes under sustained loads at high temperatures will be studied. Thermal diffusivity of coated and uncoated samples was determined.

Coatings were realized using ceramic filler in epoxy novolac vinyl ester resin, a refractory coating, Vipel coating, a commercial coating designed for high temperature resistance, two commercial paint.

The Fibrelite manhole cover F-95 is made up of a composite material. The cover is E glass with a vinyl ester resin(Vipel® F086) and a P.U. (polyurethane) foam insert. It was manufactured (in accordance with BS EN ISO 9001) with a resin transfer molding process.