List of Poster Abstracts

Correlation between the composition and the morphology of pulp fibers and their internal curing capacity

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Since the use of saturated lightweight aggregates (LWA) and superabsorbent polymers (SAPs) for internal curing have been well studied over the past ten years, current studies are focusing more on the implementation of these internal curing agents on large scale applications. Alternative to LWA and SAPs cellulose or pulp fibers demonstrated recently can be used as an absorptive material for internal curing. While many studies showed the abilities of cellulose fibers to reduce autogenous shrinkage and provide additional resistance to shrinkage-induced cracking, the mechanisms underlying the internal curing efficiency of pulp fibers remain unclear.

In this study, with an aim to clarify the complex roles playing in providing internal curing of pulp fibers, five treatments of Eucalyptus camaldulensis fibers' unbleached soda pulp, bleached soda pulp, unbleached kraft pulp, bleached kraft pulp, and semi-chemical pulp were evaluated. The cross-sectional analysis of those fibers assessed by performing an image analysis of scanning electron micrographs and the chemical composition determined by measuring the weight change of sample during thermogravimatric analysis will be reported and discussed, to further substantiate the observed autogenous shrinkage reduction of the fiber-cement pastes. This basis understanding would make the selection of type and dosage of pulp fiber in mortar and concrete more precise.

From wheat straw and rice straw to supplementary cementitious materials

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Agricultural residues ashes (ARA) are good candidates for SCMs in many locations because of their pozzolanic behavior, low cost, and availability. The influence of hydrothermal and thermochemical pretreatments on the pozzolanic reactivity of ARA was studied. Thermal degradation of pretreated wheat straw and rice straw was explored. It was shown that pretreatments are effective in partial removal of hemicellulose and alkali metals out of both wheat straw and rice straw leading to ARA with lower LOI, higher internal surface area, and higher amorphous silica content than that of unpretreated ARA. Although oxygen availability decreased carbon content, it did not significantly improve the amorphous silica content of the ash. When used at a cement replacement rate of 20% by mass, pretreated ARA accelerated the hydration of paste samples while unpretreated ARA retarded the cement hydration. ARA increased compressive strength or mortar samples by 25% when used as 20% replacement of cement in the samples.

The effect of microorganism on compressive strength of mortar

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This study investigated the effect of microorganism on compressive strength development of Portland cement mortar. The microorganism, which belongs to the Bacillus species that was isolated from Manjang cave in Jeju, S-Korea, and used for this study. This microorganism was capable of microbial induced calcite precipitation (MICP). Four different cell concentrations were selected ranging from 10 to 107 per ml. Urea-CaCl2 liquid medium and distilled water were employed as mixing water. From experimental results, mortar with microorganisms showed higher strength gain compared with reference mortar at earlier ages. From DTA/TGA analysis, more calcium hydroxide was observed in the mortar with microorganisms. The degree of hydration of the mortar with microorganisms, evaluated by measuring non-evaporable water contents in mortar, was also higher than that of reference mortar. It is very likely that the strength improvement is due to acceleration of hydration process caused by the metabolism of microorganisms. Further investigation is in progress to identify the specific mechanisms which is responsible for the improvement of compressive strength in early ages.

Elastic properties of C–S–H with inclusions of Na+ and K+ predicted by molecular dynamics simulation: validation by nanoindentation

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It is important to understand the relationship between the structure and the mechanical properties of the CSH, since it has been found that the spatial array of the atoms in the structure has a direct impact on the macroscopic properties of concrete. The effect of the alkalis in the structure of the CSH is still not clear, but it is certain that how easy the CSH incorporates them is influenced by the Ca/Si relation and increases linearly with the concentration of ions in the pore solution.

To identify the changes in the structure and elastic properties of the CSH generated by the inclusion of Na+ and K+ the 1.1 nm tobermorite simulation cell was built and the elastic properties of the system were calculated once the energetic values of the system were identified. The structure of the CSH was modified by the alkalis mainly due to their positive charge, which is attracted by the negative charge of the silicate layers, this displaces the molecules of water and moves the oxygen atoms away from the silica tetrahedra and closer to the calcium ions. The elastic properties of the CSH, specifically the Young's modulus showed increases up to 100% with the inclusion of Na+ and up to 150% with the inclusion of K+ for a Ca/Si relation of 1.2, these results are validated experimentally on this work via nanoindentation on CSH samples sintetized in the laboratory and included with alkalis.

Photocatalytic cement exposed to nitrogen oxides: Effect of oxidation and binding

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Photocatalytic cement is increasingly being adopted due to its ability to improve air quality through both NOx and VOC binding, as well as due to its self-cleaning and biocidal capabilities. In this study, the photocatalytic efficiency was experimentally examined and compared for NO and NO2. Also, their adsorptivity on cement-based materials was examined. Cement paste samples containing nano-TiO2 were prepared at different water-to-cement ratio (w/c), and the samples were exposed to test gas in a UV reactor. The photocatalytic reactivity and gas adsorptivity were determined by changes of the concentration of the test gas. From these experiments, it was shown that the rate of oxidation was similar for the NO and NO2 after 3 hours of UV exposure. In case of the NO, it was shown that the w/c affects the early oxidation rate, possibly due to high surface area available for NO adsorption. The adsorption experiments results indicate that NO2 was highly bound in cementitious materials compared to NO. With same number of wet samples, the NO2 concentration was decreased by 38% whereas the NO concentration decreased by 9%. These results suggest that photocatalytic cement-based materials could improve air quality not only through photocatalytic NOx oxidation, but also by adsorbing NO2. The great potential of the NO2 gas to be adsorbed onto cement-based materials suggests that cement itself can be considered as an environmentally friendly construction material that could bind atmospheric harmful NO2 gas.

Evaluation of rheological properties and microstructure of cement paste

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In the rheological study of the fresh state concrete, cement paste is an important criterion to understand entire concrete system. As a suspension of cement particles in water, cement paste experiences various shear forces. The goal of this study is identifying the influence of mixing intensity on rheological properties of cement. Based on the different mixing distributions, two different mixing intensities were applied and microstructure of cement paste and rheological properties were observed. The results show that the different mixing intensities affects the formation of the microstructure and rheological properties of cement paste.

Set on demand concrete

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The authors present a new type of concrete whose fresh state rheological properties can be controlled without the use of any admixtures. Based on the principles of magneto-rheology, when an external magnetic field is applied to the material, the magnetic particles present in the paste respond instantaneously and cause for a stiffening behavior. Using small dosages of carbonyl iron powder, it was found that as the magnitude of magnetic field was increased the cement paste displayed more solid-like behavior. A similar trend was observed with increasing the amount of magnetic particles. This new innovative type of concrete can potentially be used in civil engineering applications to act as a "set on demand" material, thus allowing the user greater control over the processing (e.g. mixing, casting, pumping, etc) of the concrete and application of loads. Such a material can be useful in applications in which controlling the fresh state behavior of the material is critical, including but not limited to oil well cementing, self-consolidating concrete casting, and underwater concrete casting.

Improving the robustness of self consolidating concrete

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According to ACI 237R, Self-consolidating concrete (SCC) is defined as a "highly flowable, nonsegregating concrete that can spread into place, fill the formwork, and encapsulate the reinforcement without any mechanical consolidation". Although SCCs have been around for a while, concerns due to the robustness issues still exist and thus has limited wide spread use in cast-in-place applications. Robustness is the ability of SCC to maintain its fresh state properties between successive batches. SCC might be more susceptible to changes than ordinary concrete because of its complex low yield stress and viscosity. In this research, we investigate the possibility of using small amounts of clays to increase the stability of SCC. Several mixes with varying amounts of water are tested. We measure robustness based on fresh state properties such as slump, visual stability index, dynamic segregation, static segregation and viscosity of concrete.

Geothermal silica waste as an addition to synthesize metakaolin-based geopolymers

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The concrete made of Portland cement is the second material more used after water. Several authors indicate that the production of one ton of Portland cement accounts for about one ton of CO2 released to the atmosphere, contributing with approximately 5-7% of the emissions of this harmful Greenhouse Gas due to human activities. In view of this, the search for environmentally friendly construction materials is important, in order to mitigate this problem. Nowadays, the development of geopolymers which are free of Portland cement is pursued. In this work, the effect of additions of nanometric geothermal silica waste on the mechanical properties, the microstructure and the formation of reaction products of geopolymers exposed at room temperature and up to 800°C was analyzed. The geothermal silica waste was diluted in alkaline solution, to avoid agglomeration, and also to adjust the SiO2/Al2O3 ratio needed for the activation. Geopolymers were synthesized with molar ratios of SiO2/Al2O3= 2.8, 3.0 and 3.2, Na2O/SiO2= 0.32 and H2O/Na2O= 10, with 0 to 20% of geothermal silica waste and a solution of sodium silicate and sodium hydroxide was used to activate metakaolin. The compression strength of the geopolymers was evaluated after 3 to 60 days of curing. Characterization of the materials was conducted by means of X-ray diffraction, Fourier transformed infrared spectroscopy, and scanning electronic microscopy. Additionally, the thermal stability of the geopolymers was evaluated in experiments that involved exposure to temperatures ranging from 200 to 800°C for 2 hours. The X-ray diffraction results showed the amorphous halo displacement associated with geopolymeric gel formation. A shift in the characteristic band of aluminosilicates in infrared spectra was also observed as evidence of the geopolymerization process. The greatest mechanical performance for the materials studied was obtained with a ratio of SiO2/Al2O3=3.2 and 0% of geothermal silica waste. Observations in the scanning electron microscopy revealed an increment in the porosity of the specimens when the amount of geothermal silica waste content in the system increased, which was also responsible for the low compressive strength of the geopolymers when exposed to high temperature.

Micromechanical properties of carbon nanofiber/cement-based composites

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Carbon nanofibers (CNFs) have the potential to be excellent nanoscale reinforcement for cement-based composites due to their high aspect ratios and extraordinary strength. However, the dispersion and uniform distribution of CNFs in cement-based composites has shown to be a challenge due the strong van der Waals self-attraction and high hydrophobicity of the CNFs that cause them to agglomerate and form bundles. As a result, the presence in the composite of areas with a high density of individual CNFs (CNF-rich regions) and areas with few to no CNFs (CNF-poor regions) as well as the presence of microscale CNF agglomerates have been identified. The objective of the study presented here was to determine the effects of CNFs and CNF microscale agglomerates on the micromechanical properties of cement pastes.

Nanoindentation was paired with scanning electron microscopy (SEM) to study the mechanical properties of representative major cement phases in cement pastes with up to 1% CNFs by weight of cement. SEM was used to identify the location of specific indents, and SEM coupled with energy dispersive x-ray spectroscopy (EDS) was used for phase identification and study of the local microstructure. The hardness and elastic modulus of CNF-rich and CNF-poor areas and microscale CNF agglomerates will be presented.

Early age hydration of $C_4A_3\hat{S}$

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Suspensions of $C_4A_3\hat{S}$ in a saturated gypsum and calcium hydroxide solution were examined in-situ in a wet cell by soft x-ray transmission microscopy and ex-situ by scanning electron microscopy. The most voluminous hydration product observed was ettringite. Ettringite commonly displayed acicular, filiform, reticulated, and stellate crystal habits. Additionally, cement pastes with $C_4A_3\hat{S}$, 15% $C\hat{S}H_2$, and varying amounts of CH were prepared and examined with x-ray diffraction (XRD) and isothermal calorimetry. The XRD experiments showed that with increasing CH more AFM type phases were formed with a variety of interlayer ions including SO_4^{2-}, CO_3^{2-}, and OH^-. Calorimetry indicated that increasing CH reduced the time till the maximum rate of heat evolution and the maximum rate of heat evolution increases with 1% CH compared to no CH and subsequently decreases with increasing CH.

Preparation and microstructual analysis of UHPCC material

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Over the last two decades, remarkable advances have been made in the research and application of Ultra High Performance Cementitious Composites (UHPCC) which exhibit superior mechanical properties and excellent durability. In this study, by virtue of using fly ash and river sand to substitute for expensive quartz powder and quartz sand, a cost-effective UHPCC material was designed at Southeast University, China, and was applied to produce pavement coverplates which are used in China's high-speed railway project. In order to understand the underlying mechanisms that govern the superior performance of the material at macroscopic level, the microstructure and the micro-mechanical properties of the material were investigated by MIP and nanoindentation. The result from MIP showed that UPHCC had a very dense microstructure, in terms of the total porosity of less than 5% and the average pore diameter of about 15 nm. Nanoindentation examinations revealed that the hydration products in UHPCC were governed by high stiffness C-S-H gel and that there was strong mechanical bond in both the steel fiber-matrix interfacial zone and the aggregate-matrix interfacial zone, which contributed to the outstanding performance of UHPCC at macro-scale.

Alternative cementitious materials for sustainable and high performance infrastructure: Research by the US Army Engineer Research and Development Center

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Recent interest in the areas of green/sustainable cements has lead to the development of a variety of different alternative cementitious materials (ACMs) that have become the subject of much research with limited implementation. Researchers at the US Army Engineer Research and Development Center (ERDC) are engaged in research on ACMs in a variety of areas including: (1) full-scale construction of roads and parking areas using alkali-activated geopolymers that incorporate local materials and benign activating solutions, (2) bio-inspired nanocomposites fabricated using geopolymeric gel phases and high aspect ratio particulate fillers, and (3) ACMs for the rapid repair of damage in airfields and pavements. These efforts span from materials development, optimization, testing, and characterization, to field implementation in demonstration projects and the development of specifications and standardized testing protocols. This poster will provide an overview of these research programs, the materials developed, and our vision for the future of ACMs for the construction of sustainable and high-performance civil and military infrastructure systems.

Predicting frost damage in concrete due to D-cracking susceptible aggregates

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When the temperature of concrete is reduced below the freezing point, D-cracking susceptible aggregates within the concrete may undergo cryo-deformation due to freezing of pore water and associated pore water pressure, causing tensile stress gradient in the aggregate and the surrounding cement paste matrix. A poroelastic model has been developed that can successfully predict damage in concrete under freezing conditions caused by aggregates with undesirable combination of geometry and constitutive properties. A sensitivity of the damage growth to the aggregate and matrix properties has been assessed using this model. The proposed model uses material properties that are directly used in the concrete mixture design procedure, and successfully predicts pore pressure, stresses and strains generated within the structure that may occur in the field. It is expected that incorporation of this theory into the mixture design process will help selecting appropriate materials which in turn will improve the durability of the structure.

Measuring in situ loading conditions in the rail seat for the understanding of concrete abrasion

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To adequately satisfy the demands placed on railway infrastructure through ever increasing freight tonnages and the development of high speed rail, the design and performance of concrete crossties and elastic fastening systems must be improved. This study encompasses a full-scale field test program to determine the parameters within the crosstie-fastener system necessary to conduct a mechanistic design. The most significant failure mode widely seen in the industry is rail seat deterioration (RSD), which is the degradation of concrete material at the rail seat of the tie, just below the rail pad. This is widely considered to be a product of abrasion. The abrasion occurs when there is relative movement between the crosstie and the rail pad. This study will investigate the mechanistic loading conditions of the rail seat. Utilizing strain gage measurements on the rail surface, lateral and vertical loads being transferred into the rail seat can be determined. Embedded load cells in the concrete and matrix-based tactile surface sensors (MBTSS), which will give a distribution of stresses across the rail seat, will also be used to gather vertical load data. Linear potentiometers will be mounted to the crosstie in order to understand the lateral and rotational movement of the rail. With this characterization of loading conditions and relative movement, testing can be used on a simulated lab model at an accelerated rate and in computational modeling to further understand the reasons for abrasive RSD.

Early-age behavior of expansive cements: A closer look

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This study presents a detailed investigation of critical parameters influencing the early-age expansion responsible for residual stress-development in expansive concretes. Two different cements: 1) calcium sulfoaluminate-based, and 2) lime-based were used to replace a set percentage of Portland cement. The unrestrained expansion is measured using corrugated tube (ASTM C 1698), and is compared to the restrained expansion of concrete, monitored by ASTM C 878. The study highlights the difference in the rate of expansion of ettringite and portlandite-based system. Furthermore, the changes in the pore solution chemistry due to the addition of expansive components are monitored.

The effect of mineral admixtures such as fly ash and silica fume on unrestrained and restrained expansion of cement paste/concrete is also investigated. These mineral admixtures are commonly used in concrete to improve durability, however, they also modify the composition of hydration products, the setting characteristics and bulk properties (e.g., stiffness), and are expected to alter the expansion during the early-age.

Effect of recycled aggregate on moisture state in concrete

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Internal curing in concrete is gaining interest in recent years due to increased use of low w/c concrete mixtures and new developments in microstructural modeling. Typically internal curing is achieved by using presoaked lightweight aggregates such as expanded shale which act as reservoirs to provide additional water to the concrete after the free mix water has been consumed. In this study, we considered the potential of using recycled concrete aggregates (RCA) as a “green” alternative to lightweight aggregates. RCA is generally less porous than lightweight aggregates but more porous than virgin aggregates. The absorption characteristics of the RCA were measured and compared to the other aggregates. The performance in concrete was also measured using internal relative humidity sensors, free shrinkage and weight loss in prisms. The study concluded that the RCA maintained a higher internal relative humidity than the virgin aggregates. It is believed that RCA shows promise as a sustainable alternative to normal internal curing practices.

Investigating setting, strength, and stiffness in alkali diffusion-controlled geopolymeric reactions

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Geopolymer materials are gaining interest as an alternative binder system to ordinary Portland cement concrete, but its adoption in industry has been slow due to its unpredictability in setting time and thermal cracking. The rate of setting in geopolymers is largely controlled by numerous factors including the mix and curing temperature, the alkalinity of the system, and the soluble Si/Al ratio. As such, it is postulated that the intimate mixing of powders and solutions can be replaced by a system in which alkali-soaked absorptive aggregates are incorporated into an alkali-deficient geopolymer mix. In doing so, the reaction kinetics can be slowed and controlled through diffusion processes, instead. A research program was developed to investigate low-calcium fly ash-based geopolymers with varying concentrations of alkali-soaked expanded shale aggregate. Preliminary results suggested that setting time and strength are affected by varying binder-to-soaked-aggregate concentrations as well as the degree of soaking of the aggregates. Additional experiments utilized varying scales of indentation to measure the relative stiffness of the hardened geopolymer paste as a function of distance from a soaked-aggregate wall.

The effect of heat treatment on the reactivity of natural zeolite used as a supplementary cementitious material

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The influence of six sources of naturally occurring clinoptilolite zeolite on cement hydration reactions was studied along with the pozzolanic reactivity of the zeolites. Pastes and mortars with 0% and 20% cement replacement with zeolites were tested using isothermal calorimetry, mortar cube compressive strength, and the Chappelle test for pozzolanicity. The natural zeolites were found to interfere with initial cement reactions. The materials were then heated for 5 hours at 300, 400, 500, 600, 700 and 800 Â°C and studied using the same methods. Heat treatment resulted in an increase in the early reactivity of all zeolite-cement blends, with higher temperatures generally yielding greater reactivity.

Exploring very early age hydration using a solution-phase continuum model

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Recent experiments indicate that the onset of Stage III hydration in alite is inhibited at some point by additional water. Such suggests that Stage I hydration events which lead to very slow dissolution and dormancy must be accurately modeled and that through solution mechanisms must be included for accurate early age kinetic predictions. A simple dissolution-precipitation model was developed using continuum considerations which accounts very early age hydration from the point of mixing with water until the end of Stage I . The model accounts for dissolution of alite, for formation of aqueous intermediates including H2SiO4-2, Ca+2 and OH- and the precipitation of calcium-silicate-hydrate (C-S-H) and calcium hydroxide (CH). This model provided the opportunity to test both a recent hypothesis which suggests that alite dissolution slows as the result of solution phase concentration induced changes in the dissolution mechanism and to consider older experimental datasets which describe the detailed evolution of pore solution chemistry. While some quantitative differences are noted, qualitatively it appears that such models are helpful for discrimination between mechanistic alternative hypothesis and were found to mimic very early age solution phase behavior as well as the strong dependence of water-to-cement ratio on the rate of early age hydration.

An image-analysis approach to probabilistic modeling of air void networks in hardened concrete

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Entrained air voids serve as hardened concrete's principle defense against freeze-thaw damage: a problem which is far from restricted to the northern United States. While air void distribution data is useful for the design and control of concrete mixes subject to freeze-thaw cycles, it is also crucial from a fracture mechanics standpoint, where air voids serve as stress concentrators in emerging models of concrete's behavior under high rates of strain. Detailed descriptions are difficult to extract, and performing ASTM C-457, the standard test method for microscopical determination of parameters of the air void system in hardened concrete, is tedious and provides only a limited description of the material's void network. The methodology presented herein synthesizes various techniques that have been developed in the study of random heterogeneous materials which allow for a statistical three-dimensional reconstruction of the void network from two-dimensional planed sections. The approach offers a more detailed description of the size distribution and spatial arrangement of the air voids than is offered by simple point-counting techniques, thereby providing a more robust metric to assess a concrete mix (e.g. efficacy of SCMs).

Two parameter fracture testing of Portland cement mortar containing silica functionalized carbon nanotubes

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Several recent articles have documented the potential for carbon nanotubes (CNTs) to substantially improve the mechanical properties of Portland cement mortar and concrete. Typical tensile and flexural strength increases range from 20-50% over a control mixture. The flexural strain to failure can improve as much as 100% over a control

mixture. However, most of the literature reports on the poor dispersion of CNTs in the cement paste matrix and the unstable nature of ultrasonically processed CNT suspensions. One solution is to modify the surface of the CNTs to both improve dispersion and encourage interfacial bonding between the CNTs and hydrated cement matrix, an important factor which is often ignored. Several researchers have incorporated hydroxyl and carboxyl functional groups to a varying degree of success. We have shown in another publication that silica functionalization greatly improves the dispersion of CNTs in water and extends suspension stability to 24 hours and beyond. In this study, mortar beams containing CNTs with or without silica functionalization were cast along with control specimens to investigate the mechanical effects of the functionalization at 7 days of hydration age. Notched beam bending tests were controlled by crack mouth opening, so the problems of size effect and roller punching in typical flexural strength tests of small specimens were eliminated. The two parameter fracture model of Jenq and Shah was used to determine any changes in flexural strength, fracture toughness, and critical crack tip opening displacement as a result of modifying the interfacial bond efficiency between the matrix and the CNT reinforcement. Comparisons were made between both the control mixtures and mixtures containing pristine CNTs. Another round of mixtures incorporating silica fume examined the importance of pore size refinement as it relates to the enhancement of overall mechanical properties by CNTs and silica functionalization.

The effect of particle size on the performance of pumice as a supplementary cementitious material

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The demand for high quality Class F Fly Ash is soon predicted to exceed its supply in the US, because of impending environmental restrictions and increased usage of coal sources that do not produce Class F Fly Ash in power plants. The widespread usage of Class F Fly Ash for improving concrete durability and preventing alkali-silica reaction, sulfate attack, and thermal cracking makes it imperative to look into alternative materials that can act as supplementary cementitious materials (SCM) and provide similar benefits to concrete mixtures as Class F Fly Ash. This study examined how different pumices with varying particle size distributions behaved in cementitious mixtures, including early reactivity, pozzolanic reactivity, setting time, compressive strength, drying shrinkage, and resistance to alkali-silica reaction compared to mixtures with cement only or cement with an equivalent replacement amount of Class F fly ash.

Long-term shrinkage prediction using improved ACI 209 model for local materials

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Drying shrinkage is regarded as a major cause contributing to the complex cracking issue in concrete. It is important to develop proper prediction models. In addition to the attempt of modeling dying shrinkage, previous research has addressed that the prediction models should be updated when different materials were used compared to those used to develop the proposed prediction models. In this research, ten different HPC mixture using local aggregates and internal cured by LWFA and/or SRA were casted and its free shrinkage stain was monitored by ASTM C157 test. The data collected was used to evaluate six existing shrinkage prediction models, namely, ACI 209 model, CEB 90 model, AASHTO model, B3 model, GL 2000 model and ALSN model. The study found that the GL 2000 model shows the best overall performance in predicting shrinkage strain for internally cured HPC. However, more accurate long-term shrinkage prediction can be achieved combining current ACI 209 model with experimental measurements (ASTM C157) with the local materials. This proposed improvement enables the current ACI 209 model to predict shrinkage more accurately for most given concrete mixture by monitoring experimental measurements up to 50 day. A procedure was proposed and its reliability was discussed.

Monitor fresh cement hardening by measuring resonance of bender element

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Previous studies by the authors have shown that the shear wave velocity is an effective parameter to monitor setting and hardening process of fresh cement and concrete. Shear wave ultrasonic transducers and piezoelectric bender elements were proposed to measure shear waves in fresh cement paste. The low-cost benders were found especially effective for shear wave generation and measurement in cement paste at very early age. However, the shear wave test setup using two benders (one source and one receiver) requires relatively large sample size in lab tests, and also requires accurate measurement of sensor spacing which may not always be possible in field applications. In this study, we propose a resonance test method that requires only one bender to be embedded in cement paste. The resonant frequency and vibration amplitude of an embedded bender are functions of mechanical properties of the bender and the surrounding material. With the increase of stiffness and age of cement paste, the bender's resonant frequency increases but amplitude decreases. Shear modulus and damping ratio of the cement paste can be derived from the resonance measurement of bender. The results are compared to shear wave ultrasonic measurements.

Smart stress-sensing carbon nano- / PVA- fiber reinforced composites for stress and chloride detection

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Existing methods for nondestructive observations of concrete are not always reliable and often expensive for implementation on new or existing structures. Finding a new, more effective monitoring method of concrete structures is very important. This paper describes the exploration of the self-sensing capabilities of fiber reinforced concrete (FRC) by the addition of electrically conductive carbon nanofibers (CNF). The CNFs were dispersed in water with a surfactant to prevent clumping during batching.

Monitoring of the crack propagation in specimens was conducted using resistivity measurements of the samples using the two probe method. Prior to testing the samples were subjected to either water or 2% chloride solution for 24 hours. To improve the flexural and tensile response of the specimen, the polyvinyl alcohol (PVA) fibers were used. Changes in resistivity were observed and analyzed using integral and differential relative conductivity calculations. Strong correlation between cracking and changes in the relative conductivity were detected leading to successful crack monitoring. Addition of carbon nanofibers allowed for more effective crack detection. The addition of CNFs increased chloride detection potential of PVA-FRC proving this technique as a viable option for nondestructive monitoring.

Characterization of calcium aluminosilicate hydrate

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Synthesis of calcium aluminosilicate hydrate (C-A-S-H), in which alumina substitutes for some of the silica in tetrahedral sites, was conducted by precipitation. Samples with various levels of alumina substitution were synthesized. The synthesized material was characterized by powder X-ray diffraction (XRD), X-ray fluorescence

(XRF), 29Si magic-angle-spinning nuclear magnetic resonance (MAS NMR), and 27Al MAS NMR. The effects of alumina substitution for silica in the tetrahedral sites on the nano-scale structure of a defect-tobermorite model of C-S-H were observed. Specifically, the degree of polymerization of the silicate/aluminate chain and the ability for chains to connect through the bridging tetrahedra (cross-linking) were examined. The nano-scale structure of C-A-S-H is expected to play a critical role in the mechanical properties of concrete. Progress will continue into the effects of the nano-scale structure on mechanical properties, specifically creep.

Assessment of reutilization options for concrete debris in the Caribbean

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The Caribbean is a region with an unusually high exposure to both earthquakes and hurricanes. It is also a region which is resource-constrained in terms of the availability of materials. Together, these realities present important challenges for reconstruction after a natural disaster occurs in this region. It is proposed that debris material produced during such an event or cascading events can be safely and economically reused in rebuilding efforts. Here, the use of concrete debris is examined in two applications: (1) use of coarsely crushed material as aggregate in concrete and (2) use of fine residues as a component in the cementitious binder in concrete. Because of the relatively low strength of the local concrete, attention to processing is a critical step in ensuring adequate strength and durability when used as aggregate in new concrete. While recycling concrete as a coarse or fine aggregate has received considerably more attention, less attention has been given to the reuse of fine residues resulting from the concrete crushing to produce aggregate, despite the difficulty in disposing and storing these by-products. Calorimetry curves for cement paste and compressive strengths for mortar cubes with varying w/cm and replacement ratios of recycled fines will be computed to assess the feasibility of recycling the concrete fines as a component of the binder.

Leaching of Heavy Metals from Lime-Fly Ash Cements

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The lime stabilization of fly ash is one potential methods to convert coal combustion by-products into useful construction materials. This research presents results for heavy metals leaching potential of lime-fly ash cements for one low loss on ignition (LLOI) and one high loss on ignition ash (HLOI). Leaching was studied using three different test methods: (1) a standard shaken (stirred) extraction test; (2) a modified shaken extraction test; and (3) a modified EP-TOX test. novel hydration time-based test sequence was used to explore the relationship between formation of hydration product and sequestration potential. As-receive fly ashes and lime-fly ash samples were cured for 0, 7, 28 and 84 d at 40ºC. The curing results suggested that curing time sequences can be used to study the rate of sequestration by the hydration product relative to the rate of leaching from the ash. X-ray diffraction (XRD) was used to characterize hydration reaction products of the lime-fly ash cements. In addition, the rate of hydration reaction was compared using isothermal calorimetry at 25ºC and 40ºC. The leaching results suggested that some of the tested heavy metals are greatly dependent on leachant pH and test method. Additionally, formation of hydration products during leaching does appear to partially sequester some tested heavy metals. X-ray diffraction peaks indicated that ettringite and an unidentified calcium aluminosilicate hydrate (CASH) phase are major hydration products, depends upon fly ash sources. Furthermore isothermal calorimetry results suggests that hydrations of LLOI fly ash is measureable at 40°C but slow at 25°C, while HLOI fly ash hydrates with much slower yet detectable rates.

Microstructure of Class C fly ash geopolymer

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High calcium fly ash (Class C) is being studied as a geopolymer precursor. A key advantage is the development of a high early strength even at room temperature. The strength depends on the specific raw material and mix design. The objective of this study is to explore the microstructure of high calcium fly ash geopolymers using scanning electron microscopy (SEM) and X-ray diffraction (XRD). Three variables were used: the SiO2/Al2O3 molar ratio (S/A 3.0 and S/A 3.2), curing temperature (60oC and room temperature), and curing time (in oven for 3h and 24h). Of these variables, the one with the greatest effect on morphology was the SiO2/Al2O3 molar ratio. Only difference of 0.2 of S/A leads to the relative difference of morphology. The microstructural analysis will play a basic role in designing geopolymers for future engineering applications.