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High Performance Building Material for Structural and Energy Efficiency

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2017 Research and Creative for Undergraduate Students (RCEU) Proposal

TITLE: HIGH PERFORMANCE BUILDING MATERIALS FOR STRUCTURAL AND ENERGY EFFICIENCY

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Project Summary

Construction materials form the foundation of the reliable and sustainable performance of architectural substances. Traditionally, the selection of material alternatives for building design has been primarily focused on the mechanical performance, while their thermophysical properties (e.g., thermal conductivity, heat capacity) have significant impact on a building's life-cycle energy consumption. Future designs of building structures desire solutions that holistically consider materials' properties towards both structural resilience and energy efficiency. This RCEU research explores the linkage between mechanical and thermal properties of construction materials (e.g., concrete) at multiple length scales. Through a combination of experimental and analytical approaches, the effects of cement chemistry, hydration (or chemical-activation),

material constituents, and microstructural evolution (Fig. 1) on material's mechanical and thermophysical properties will be studied.

This research investigates the mechanical and thermal properties of building materials (e.g., concrete, fired brick) and their impacts on building structural robustness and energy efficiency. Students will have opportunity to work on research both at material and large-scale structural levels.

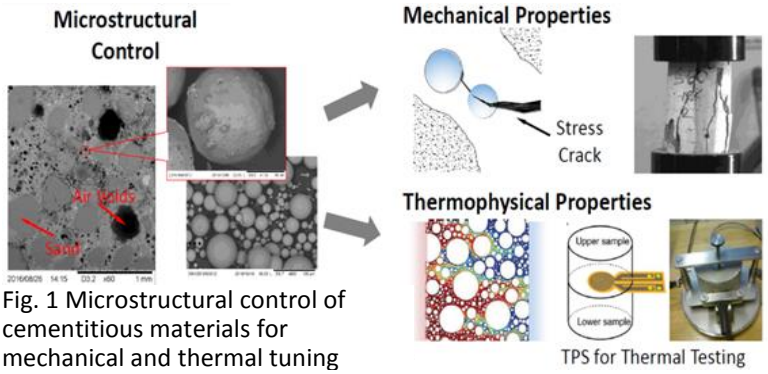

Fig. 1 Microstructural control of cementitious materials for mechanical and thermal tuning

Research Plan

We propose to study the constituents, microstructure, and processing of building materials including concretes, brick, and masonry materials using state-of-the-art characterization techniques including scanning electron microscopy (SEM), X-ray diffraction (XRD).

The mechanical properties of the material, including strength, modulus of elasticity, and fracture toughness, will be tested using servo-hydraulic testing equipment at the PI's lab. In addition, the thermal properties of the materials will be tested using a state-of-the-art Transient Plane Source (TPS) source method. Training will be provided to student on the working principal the test procedure for the TPS test and how it is applied to building materials.

If the schedule permits, the student will learn to perform post-damage characterization and evaluation of samples using SEM.

Student Duties

Prepare material samples; learn to perform mechanical and thermophysical experiments for building materials. Learn to set up experiments and instrumenting samples with sensors. Learn to process and analyze experimental data.

Tentative 10-week Schedule

(1) Weeks 1-2, familiarize with the lab environments, safety training, learn to prepare materials (i.e., concrete, fire bricks etc.);
(2) Weeks 3-4, design experimental test matrix and fabricate the material samples needed for mechanical and thermal testing;
(3) Weeks 5-6, learn and perform mechanical and thermal experiments in the laboratories;
(4) Weeks 7-8, analyze the experimental data;
(5) Weeks 9-10, refine the experimental process and generate presentation materials.

Expected Student Background and Requirements

Students should have good background in general physics, materials; knowledge of mechanics of materials and civil engineering materials is advantageous; typically students with a major in Civil Engineering, Mechanical and Aerospace Engineering, or Chemical Engineering should be ok. Pre-exposure to analytical instrumentation is a plus.

It is expected that the students will work full-time (32-40 hrs/week) for 10 weeks during summer 2017. Students who consider pursuing the RCEU program may not register more than 6

credit hours of class during smr 2017 (i.e., two classes over the summer, or one class each mini-semester). Office space located in Technology Hall (OKT) and computers will be made available to the enrolled students. The students will have access to the newly established structural hazard mitigation and intelligent materials laboratory located in the high-bay area of Tech Hall.

Results and Deliverables

Students will learn state-of-art characterization techniques for building materials. Students are expected to be exposed to a combination of experimental and analytical techniques, including SEM, XRD, TPS, accelerated durability testing and finite element analysis (FEA) software.

Mentor Supervision and Interaction

The faculty mentor will oversee the project throughout the performance period, including supervising the student and design the testing protocols associated with this project to ensure all project objectives are achieved. The mentor will examine all student's work and provide the assistance and resources needed. The student will report (in written or oral format) to the mentor periodically on a weekly base, and the mentor will ensure the student is progressing as planned. It is expected that a brief research report will be generated towards the end of the project.