Worcester Polytechnic Institute is hosting a Research Experience for Undergraduates site sponsored by the National Science Foundation. Students participating in this site will carry out scientific research in the Department of Civil and Environmental Engineering on the broad topic of sustainable infrastructure materials. The program runs from May 31st to August 5th, with participants receiving a stipend of $500 per week.

Eligibility
Participants must be citizens or permanent residents of the United States or its possessions, and must be in their first three years of college or university study. Students from backgrounds that are traditionally underrepresented in STEM are particularly encouraged to apply, including: females, members of underrepresented ethnic and racial groups, and veterans.

Application Instructions
A cover sheet is provided on page four of this document. Applicants should:

1. Complete all sections of the application cover sheet, remembering signature and date at the bottom;
2. Provide a one-page resume;
3. Provide an academic transcript from their college or university (unofficial copies, such as those printed from bannerweb or a similar service, are acceptable);
4. Provide a one-page personal statement, describing their motivation, background, interest in sustainable infrastructure materials, what they can provide to the REU site, and what they expect to gain from participation in the site;
5. Provide verification of status as citizen or permanent resident of the US or its possessions (i.e., a photocopy of passport, birth certificate, or consular report of birth abroad); and,
6. Arrange for a letter of recommendation (limited to one page in length) to be emailed directly to irsim@wpi.edu by the writer of the letter.

Items one through five should be combined into a single adobe PDF document and emailed to irsim@wpi.edu as an attachment; the letter of recommendation should be emailed directly to irsim@wpi.edu by the writer of the letter. Students with questions about the application process are encouraged to contact the site director at irsim@wpi.edu.

The deadline for applications is March 1st. Students will be notified of acceptance (or placement on a standby list) by April 1st. When students are notified of acceptance, they will be provided with a list of potential research projects, and asked to rank their preferences. While we will attempt to match students with their preferred projects, no guarantee is made. A list of example projects is provided on pages two and three of this document.

Aaron Sakulich, REU Site Director
Worcester Polytechnic Institute

Example projects

Reduced chloride diffusion in alternative binders
A variety of alternatives to Ordinary Portland Cement (OPC) have been developed in attempts to lower the environmental impact of the built environment. Two of the most promising alternative binders, alkali-activated slags (AAS) and geopolymers, have not seen widespread adoption in part due to high levels of shrinkage. The chemistries of these binders render conventional shrinkage reducing admixtures ineffective. Autogenous shrinkage, cause by the menisci in partially-filled pores 'pulling' the pore walls together, can be a primary cause of shrinkage in AAS and geopolymer systems. Internal curing, in which reservoirs such as lightweight aggregates provide a supply of water that keeps pores filled, has been shown to effectively eliminate autogenous shrinkage in OPC binders; preliminary results by Sakulich and Bentz suggest that internal curing is also effective in alternative binders. Internal curing may have one additional benefit that has not yet been investigated. Water from internal curing may densify the matrix/aggregate interfacial transition zone (ITZ) and/or lead to a higher degree of hydration, thus refining the matrix pore structure. Either of these effects would reduce the ability of aggressive media such as chlorides to migrate through the binder, in turn improving resistance to corrosion. This project will investigate the ability of internal curing not only to reduce shrinkage in alternative binders, but to improve corrosion resistance.

Linking asphalt microstructure and mechanical properties
Although asphalt binders are composed of thousands of organic hydrocarbons with very complex microstructures, asphalt binders are most often characterized as homogeneous materials. The microstructure of an asphalt binder varies depending on the nature of the saturate, aromatic, resin, and asphaltene pseudo-components (SARAs) of which it is made. The spatial distribution of SARA components, degree of heterogeneity, interactions between individual SARAs, etc. play important roles in the mechanical properties of asphalt binders. The study of asphalt microstructure remains a significant technical challenge. A variety of (sometimes contradictory) opinions about the microstructural composition of asphalt binders are found in the literature. The results of the AFM-based study of surface topography of asphalt binders by Pauli et al. also indicate that much of the observed microstructure, including the well-known 'bee structures', is largely due to the interactions between crystallizing paraffin waxes and no-wax asphalt components. Furthermore, topographic images can only provide very limited information about chemical composition of the binders. The feasibility of mapping the microstructural morphology of asphalt binder based on the spatial distribution of mechanical properties will be explored through AFM-based adhesion measurements.

Rejuvenation and recycling of asphalt materials
The 4 million miles of asphalt roadways in the US are not immune to the growing infrastructure maintenance crisis. As a result of dwindling resources, fluctuating asphalt costs, and increasing maintenance demands, recycling has become a top priority for many departments of transportation. Commercially available recycling agents are able to recover roughly 25% of the hydrocarbons that make up the binder in asphalt. This technology, however, cannot process standard grade asphalt. Further, to be economically viable, the percentage of recovered hydrocarbons must be increased to nearly 50%. Innovative materials, capable of recovering a greater fraction of asphalt from waste sources, would significantly reduce energy use and raw material consumption, while increasing the amount of roadwork that could be performed during a given period.

Structural damage mitigation of civil structures
There are significant uncertainties associated with the design of impact resistant structures. Two main sources of uncertainty are the definition of the high impact excitation itself and inadequate characterization of the properties of the structure. For important structures (e.g. impact-resistant bridge

piers) it is standard to perform detailed impact risk analyses requiring sophisticated models. However, using detailed models is impractical if reliable data on the properties of aged or damaged structures is not available. The minimum information needed is the stiffness and damping of structures at very low strains (in the linear range) and their variation with material properties. When an impact-resistant structure is designed, the basic assumption has been that the relative variations of the stiffness and the damping would be the same in the laboratory tests and in the field. More recent studies cast some doubt on the validity of this assumption but, until now, it has been nearly impossible to measure stiffness and damping for different levels of excitation in the field. This is particularly true for excitations of high magnitude, such as those that occur in truck/pier collisions. Therefore, this project will develop real time, adaptive, bio-inspired smart controllers for impact resistant structures.

Biomimetic structural materials

Biological materials have been shown to have superior properties in comparison to conventional structural materials. Bamboo's strength:weight ratio is higher than those of steel and concrete. Such materials show promise as structural materials in low-capacity applications. Local natural materials can also help developing countries avoid reliance on cement and steel. Bamboo, as a fast growing, renewable material with a simple production process, is expected to be a sustainable alternative to the more traditional structural materials, like concrete, steel, and timber. Bamboo can also be used in combination with other materials to create low-cost, light composite structures. Hence, analyzing bamboo as a model natural material has two significant impacts in materials engineering and design. First, bamboo may possibly be used as an eco-friendly alternative material in many areas as a strong candidate for locally available, low-cost structural material. Second, inspired by the knowledge of the mechanical behavior of bamboo as a natural functionally graded material, advanced composites with robust mechanical properties can be designed. Therefore, the main purpose of this task is to study the mechanical behavior of bamboo, particularly the role of fiber gradation on the deformation and toughening mechanism, quasi-static and dynamic fracture properties, fatigue mechanisms and adhesion between bamboo fibers and the matrix, as a model sustainable eco-friendly functionally graded material.

APPLICATION COVER SHEET

Application Checklist:

[ ] Coversheet
[ ] Resume (one page limit)
[ ] Academic transcript (unofficial copies are acceptable; no page limit)
[ ] Personal statement (one page limit)
[ ] Verification of status as citizen or permanent resident of the US or its possessions (photocopy of passport, birth certificate, or other official document)
[ ] One letter of recommendation (one page limit; emailed directly to irsim@wpi.edu)

Applicant Information:

Applicant Name: _____

Email address: _____

Phone number: _____

Complete mailing address: _____

Home institution: _____

Academic Major(s): _____

Year in School: _____

Are you a U.S. Citizen? [ ] YES [ ] NO

If not, are you a Permanent Resident with a valid Green Card? [ ] YES [ ] NO [ ] N/A

Are you willing to abide by the conduct policy? [ ] YES [ ] NO
(The conduct policy is provided on the next page for your review)

Are you available for the entire 10-week period? [ ] YES [ ] NO: _____
(The REU site runs from 31 May to 5 August, 2016)

The following questions are optional. Your responses are confidential.

Race: _____
(i.e. American Indian/Alaskan Native, Asian, Black or African American, Caucasian, Hawaiian/Pacific Islander, etc.)

Ethnicity: _____
(i.e. Hispanic or non-Hispanic if Caucasian)

Gender: [ ] Female [ ] Male [ ] Other: _____

Are you a member of an underrepresented group? [ ] NO [ ] YES: _____
(If yes, indicate which group. "Female" counts as an underrepresented minority.)

Are you a veteran? [ ] NO [ ] YES: _____
(If yes, indicate branch of service and dates. Please indicate if registered as a conscientious objector.)

SIGNATURE: _____

DATE: _____

REU PARTICIPANT CODE OF CONDUCT

Participants in the 2015 Research Experience for Undergraduates site at Worcester Polytechnic Institute are expected to conduct themselves in a manner consistent with their status as visiting researchers. This includes abiding by the terms of all local and national laws as well as abiding by the terms of:

The WPI Campus Code of Conduct:
http://www.wpi.edu/offices/policies/judicial/sect4.html

The WPI Drug and Alcohol Policy:
http://www.wpi.edu/offices/policies/judicial/sect7.html

The WPI Academic Integrity Policy, as it relates to research:
http://www.wpi.edu/offices/policies/judicial/sect5.html

The WPI Anti-Harassment Policy:
http://www.wpi.edu/offices/policies/judicial/sect8.html

The WPI Intellectual Property Policy, if appropriate:
http://www.wpi.edu/offices/policies/judicial/sect14.html

REU participants are also expected to abide by the safety policies established by the particular laboratory of facility in which they are working. At a minimum, this includes appropriate attire (long trousers and closed-toe shoes, regardless of weather, and safety eyewear when in the laboratory), proper handling of chemicals and maintenance of MSDS sheets, and carrying out research as instructed by the participant's advisor.

Finally, REU participants are expected to actively work on their projects for the duration of the program. Holidays, sick days, etc. are discouraged and should be arranged ahead of time with the participant's project advisor.

Successful applicants chosen for participation in the REU site will be asked to a sign a copy of this Code of Conduct on the first day of the program.