Available Projects for Summer 2019

Development of High Performance Hot mix Asphalt Mixtures

Mentor: Dr. Khattak Jamal Mohammad, Department of Civil Engineering

This study focuses on the development of high performance asphalt composite for mitigating flexible pavement cracking such as fatigue, transverse and reflective cracks. Long-term performance and sustainability of the pavements could be achieved by augmenting asphalt mixtures with optimum dosages of microfiber. Addition of the fibers will significantly increase the stiffness, strength, and fracture toughness under traffic loading. Such novel composites could enhance the life-cycle cost of pavements and save taxpayers money. The asphalt mixtures are used over 94% of all pavements in US, and accounts for $45 billion/year of national transportation spending. The potential economic impact is significant if the pavement life-cycle cost could be decreased due to the high performance asphalt mixture. In order to develop advanced high performance asphalt composite, several mix parameters will be studied and optimized in relation to mechanical and durability characteristics. The developed the mixture will hold high prospective of commercialization and implementation potential by federal, state, and private industry due to the following characteristics:

- Enhanced stiffness, strength, and fracture toughness due to microfiber addition *(High Performance, Durable, Sustainable)*
- Reduced life-cycle costs of pavement due to high performance and low maintenance costs *(Economical)*

Innovative reinforcing materials for 3D concrete printing

Mentor: Dr. Qian Zhang, Department of Civil Engineering

Recent advancement in 3D concrete printing has enabled printing of structure elements, e.g. bridge girders and bridge decks, that are suitable for use in transportation infrastructures. 3D printing of concrete structures offers many advantages in the construction of transportation infrastructure, including improved construction quality control due to fully automated process, significantly reduced construction time and cost, and improved work safety. However, one of the major challenge of 3D concrete printing is the difficulty to add reinforcement. Since the printed concrete does not have adequate structural capacity on its own, most 3D printed concrete structures require external reinforcement such as post-tensioning rebars. Placement of such external reinforcement makes the construction process less automated and less efficient. This project aims at developing a high strength and high ductility concrete mixture that can be printed using 3D printing technology and the printed structure will have adequate structural capacity without the need of external reinforcement.

Adsorptive Removal of Pb(II) Using CS2 Modified Graphite Oxide: Characterization, Adsorption Performance, and Adsorption Mechanism

Mentor: Dr. Daniel Gang, Department of Civil Engineering

This research focused on exploring a novel material with high adsorption capacity for Pb(II) removal from drinking water. Pb(II) contamination attributable to the drinking water is creating considerable concern due to its non-biodegradable nature. Accumulation of this metal in living organisms can cause detrimental effects to health. Many materials, such as modified ordered mesoporous carbon, activated carbons, Turkish kaolinite clay, and palm kernel fiber have been prepared as adsorbents for adsorptive removal of Pb(II) from aqueous solutions. However, these materials have not been widely used due to their limited adsorption capacity and slow adsorption kinetics. UL Lafayette proposes a novel CS2 modified graphite oxide for Pb(II) removal with fast adsorption kinetics. The objectives are to (1) develop a novel material with fast adsorption kinetics; (2) achieve a conspicuous increment of the Pb(II) adsorption capacity; (3) understand the adsorption mechanism. Through a planned series of experiments, the proposed research will examine the effects of pH, effects of background cations, adsorption kinetics, adsorption isotherm, and adsorption thermodynamics, and its ability to be regenerated and reused. This research will advance the drinking water treatment in Pb(II) removal from drinking water.

Urbanization and the Hydraulic Failure Potential of Roadway Drainage Structures

Mentor: Dr. Robert Miller, Department of Civil Engineering

The objective of this project is to conduct a case study which informs the development of a methodology aimed at quantifying the impact of urbanization on the hydraulic failure potential of roadway drainage crossings. The student working on this project will participate in field visits to inspect and document hydraulic conditions at various culvert and bridge locations in the study area. The student will also be introduced to basic design concepts including advanced hydraulic analysis procedures, flood risk assessments, and regulatory requirements.

Comparison of Material Properties of Reverse Osmosis Membranes from Additive Manufacturing Using a Novel Injection Method and Electrospraying

Mentor: Lulin Jiang, Department of Mechanical Engineering

Interfacial polymeriazation has been used for producing extremely thin and permeablemembranes for reverse osmosis (RO) for years. However, the conventional technology is limited to the its production process of self-terminating reaction between an aqueous phase amine and an organic phase acid chloride monomer. The traditional method hinders the controllability of the membrane thickness and material properties including roughness that are significant for liquid flow optimization and fouling reduction in many applications such as desalinization. Recently, additive manufacturing by electrospraying has shown promise of research breakthrough in RO membrane redesign and production with less power input and less proneness to fouling. Electro-injection generates a charged jet that breaks down into fine droplets downstream, enabling controlling of the thickness and property of the printed membrane. The current project aims to utilize the recently developed multi-phase novel sprayer at UL Lafayette to 3-D print membranes of various materials and thicknesses by comparing to that of an electro injector. The novel injector has shown greatly enhanced atomization efficiency in terms of less power input and fine droplet and spray generation with uniform size distribution at the injector immediate exit, rather than a typical liquid jet as of other sprayers. Due to the fine atomization capability, it has been proved to be highly effective for material of various properties and sizeable for multi-applications. With the high material flexibility, scalability, spraying efficiency and uniformness, the novel injector is expected to generate comparable and/or further improved performance of RO membrane printing, compared to that of electrospraying which generates a jet first.

Nanoscaled Oxides for Thin Film Gas Sensors
Mentor: Dr. Xiaodong Zhou, Department of Civil Engineering

The aim of this project is to employ our recently developed oxides, doped $(Pr,Nd)_2NiO_4$ (PNNO) and mesoporous ceria, as the thin film gas sensors. These gas sensors differ from the conventional ones which are operated on the galvanic cell principle by using a solid-state electrolyte with a high ionic conductivity. Here, the electrical conductivity of gas sensors based on doped PNNO and ceria are extremely atmosphere sensitive. As a result, the reaction kinetics are dependent on the physical nature of both electronic and ionic species at the electrode/electrolyte interfaces. Doped PNNO and ceria therefore exhibit mixed ionic-electronic conductivity upon changing gas compositions.

Our previous work showed that the oxygen stoichiometry of praseodymium nickelate (Pr_2NiO_4) is very sensitive to the gas atmosphere and therefore is an active oxygen reduction electrode, but it undergoes phase transition at elevated temperatures. The understanding of the phase transition has remained obscure, but is of great importance in developing desirable microstructures of sensors or electrodes. The REU student will work with graduate students, Yudong Wang and Josh Wilson, investigate the size dependence of oxygen nonstoichiometry, phase transition kinetics and translate this knowledge to better tune the microstructures for gas sensors and fuel cells. The REU student will carry out electrical and electrochemical measurements to understand the mechanisms for the dependence of electrical conductivity on gas compositions and to develop a better microstructure to improve the performance of sensors and electrodes. The second aim of this REU project is to study mesoporous ceria, which exhibits similar sensitivity as doped PNNO. The student is expected to gain experience in synthesis, sensors and fuel cell research. In the past, each REU student of the PI's group has participated in at least one peer-reviewed journal publication. We expect the incoming REU student will be co-authoring manuscript(s) with the graduate student.

Activities

Seminar series and an educational field trip will be offered during the 10-week program to help participating students learn how to conduct research, improve their presentation and writing skills, and prepare them for graduate school and advanced career in the engineering field.

Seminar Series:

Grand Challenges of US Infrastructure - An half-hour presentation will be given to the participating students to introduce them the current status of US infrastructure, the grand challenges our infrastructure is facing, and the importance of research in infrastructure materials to overcome these difficulties.

Research Methods and Ethics – 1-2 1-hr seminars will be given to the participating students to introduce them the basics of the research process. The seminar will introduce what research is, safety procedures and required training for working in different labs, literature search tools, and the importance of research ethics.

Technical Writing and Presentation Skills – 1-2 1-hr seminars will be offered by an experienced tutor from the Writing Center at UL Lafayette on technical writing and presentation tips and advice.

Graduate School Life and Application Process – A 1-hr seminar on graduate school application followed by a 1-hr panel discussion on graduate school life and experience will be offered to the participating students during the REU program. Past and current graduate students with diverse backgrounds from both engineering and science disciplines will share their experience with participating students on graduate school application process, life as a graduate student in STEM and discuss why they chose to attend graduate school.

Careers in STEM – A 2-hr seminar on potential career paths and development in STEM fields will be given. Senior engineers from industries will be invited to speak at the seminar and offer their advice to participating students on career development. Recent graduates from UL Lafayette will also be invited to share his/her experience as a young engineer.

Field trips:

Two field trips will be help during the 10-week program.

LUMCOM Trip

A two-day weekend field trip to Louisiana Universities Marine Consortium (LUMCON, Figure 1) will be organized during the REU program. LUMCON was formed in 1979 to increase society's awareness of the environmental, economic and cultural value of Louisiana's coastal and marine environments by conducting research and education programs directly relevant to Louisiana's needs in marine science and coastal resources and serving as a facility for all Louisiana schools with an interest in marine research and education. Part of LUMCON's mission is to increase society's awareness of important Louisiana coastal issues. LUMCON is located within the coastal landscape and is close to the Mississippi and Atchafalaya rivers, where a number of largest Louisiana's coastal bridges are located. LUMCON is in possession of multiple vessels, Marine Center, Library and Environmental Monitoring Stations which will be available for use to the REU site. The Marine Center is a modern, 75,000 square foot complex of research, instructional, housing, and support facilities completed in 1986. The Center includes 26,000 net usable square feet of laboratory, classroom, office, and library space. Eight laboratories are equipped with running seawater. Six additional laboratories are reserved for dry applications and instrumentation and are used for both research and teaching.

Louisiana Universities Marine Consortium

LTRC trip

Another educational field trip will be a tour to Louisiana Transportation Research Center (LTRC) research lab to learn about the advanced research conducted by Louisiana Department of Transportation related to advanced infrastructural materials.