REU SITE PROJECTS FOR 2022 SUMMER: RESEARCH EXPERIENCE FOR UNDERGRADUATES IN ADVANCED INFRASTRUCTURE MATERIALS
(UNIVERSITY OF LOUISIANA AT LAFAYETTE)

Polyethyleneimine beads for Perfluorooctanoic acid (PFOA) Removal: Characterization, Adsorption, and Adsorption Mechanism

Advisor/Mentor: Dr. Daniel Gang, PhD.

Project Summary: This study is aimed at developing a novel material that can remove PPOA efficiently from drinking water. PFOA issue has gained great attention due to its widespread existence, long-term persistence, and potential environmental threats. Available techniques for remediation of PFOA from water include adsorption, degradation, filtration, sonochemical destruction, bioremediation, membrane separation, and reverse osmosis. Among these technologies, adsorption has gained a huge attention due to its high efficiency, low cost, and simple operations. Various adsorbents have already been reported for PFOA removal, such as granular activated carbon (GAC), powdered activated carbon (PAC), carbon nanotubes (CNTs), and ordered mesoporous carbon (OMC). However, these materials have not been widely used due to the limited adsorption capacity. In this study, polyethyleneimine beads will be used to increase the adsorption capacity in PFOA removal. This study aims to: (1) demonstrate the concept for removing PFOA; and (2) to understand the effects of adsorption time, pH, and background cations on the adsorption. The results will prove the concept and possibility provide a highly efficient adsorbent for PFOA removal from drinking water.

Performance-Based Design and Testing of Cross Laminated Timber Connections under Cyclic Loadings

Advisor/Mentor: Dr. Trung Do, PhD.

Project Summary: Timber is a traditional, environmentally friendly material for buildings and other structures. Recent development of timber material is cross laminated timber (CLT) which glued smaller lumber panels and is consider as a solution to build high-rise building out of wood. While the CLT panel itself is light weight, better seismic and thermal performance than other conventional building materials, the weakest points of CLT structures are usually the connections. The most comment method to connect the CLT panels is using metal crews/nails and brackets/plates and the performance of CLT structure is heavily dependent on these metal connections. This project will evaluate different performance levels of CLT connections under cyclic loadings using the Materials Testing Systems (MTS). Results from this study is the key contribution to overall performance-based design of CLT structures.

Physical Model of Coastal Structures under Wave Loadings

Advisor/Mentor: Dr. Trung Do, PhD.

Project Summary: Wave and surge in addition to high wind speed create severe damage to coastal communities during hurricane. This project is going to develop a testing system for coastal structures including coastal protection structures, buildings and other elevated structures. A small scale of wave flume to for shallow water wave generation will be constructed to quantify wave loadings on structures under different wave heights and wave types. Wave forces on coastal structures will be monitored and compared with conventional wave equations. Finally, a transform function to estimate wave loading structure will be constructed to estimate wave loadings from different wave conditions. This project encourages students with computer programing skills, signal processing and lab experience.

Self-Healing Asphalt Composites using Alginate-Encapsulated Rejuvenators

Advisor/Mentors: William M. Chirdon, PhD and Mohammad Jamal Khattak, PhD, P.E.

Project Summary: Failure of asphalt mixtures in our infrastructure are costly in terms of maintenance, replacement, and the causation of vehicle damage and accidents. While the bitumen in asphalts has an innate ability to self-heal, it gradually loses this ability over time, primarily due to the loss of lower molecular-weight components due to weathering and leaching. As a result, these materials also tend to be more brittle with increasing propensity for crack propagation leading to failure.

This project seeks to facilitate the self-healing of these asphalt mixtures by using alginate to encapsulate rejuvenators for incorporation into the composite formulation. These rejuvenators soften the bitumen so as to promote the closure of micro-cracks (self-healing). Some objectives in this project include the development and understanding of the process through which alginate-encapsulated rejuvenators can be made, investigating the effect of the rejuvenator on the asphalt rheology, assessing the effectiveness of the alginate beads for mitigating crack propagation under cyclic loading conditions, and determining the effect of the additive on the conventional structural properties of the asphalt composite.

FRP Composite for Strengthening Damaged Reinforced Concrete Beam

Advisor/Mentors: Dr. Li Hui, PhD.

Project Summary: Reinforced concrete (RC) bridges play an important role in the economic activities and services of society. However, according to the 2021 Report Card for America's Infrastructure, 42% of all bridges are at least 50 years old and 7.5% of the nation's bridges are considered structurally deficient. The rehabilitation of existing reinforced concrete (RC) bridges becomes necessary due to aging, corrosion of steel reinforcement, defects in construction/design, demand for increased service loads, and improvement in the design guidelines. It has been shown through some experimental and analytical studies that the external-boned fiber-reinforced polymer (FRP) composites can be applied to improve structural performance and the durability of the members. This project focuses on evaluating the performance of FRP in strengthening the RC beams. Several parameters, such as surface preparation, adhesive curing, failure modes of RC beams retrofitted with FRP, and load capacity of beams, will also be evaluated in this project.

Advanced Pavement Materials Using Crumb Rubber and Microfibers

Advisor/Mentors: Mohammad Jamal Khattak, PhD, P.E.

Project Summary: This study focuses on the development of advanced hot mix asphalt pavement surface material for mitigating flexible pavement's high temperature permanent deformation and rutting distress. Long-term performance and sustainability of the pavements could be achieved by augmenting asphalt mixtures with optimum dosages of microfiber and crumb rubber. Addition of the fibers will significantly increase the stiffness, strength, and fracture toughness under traffic loading. Higher dosages of crumb rubber, which is the product of recycled tire industry, could also be used as dry process to improve the resilience and viscoelastic properties at medium to high temperatures. Development of such novel composite 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 proposed 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:

Production of Adhesives from Waste Protein Sources

Advisor/Mentor: Dr. Mark E. Zappi, PE, Executive Director of the UL Energy Institute of Louisiana and BORSF Chair in Bioprocessing, Professor of Chemical Engineering, UL

Project Summary: The global adhesive industry is quickly adopting green adhesives as a major component of their commercial offerings. The use of proteins from waste sources are a particularly attractive green option because of greatly reduced costs, improved environmental stewardship, and novel chemical matrices that can be developed. UL is working on the development and commercialization of green adhesives, with a focus on fiberboard and furniture manufacturing. An exciting research opportunity is in place to help UL researchers explore these options. Several input waste are being evaluating and their respective products being tested. Investigation into governing mechanisms and impacts of feedstock protein matrices are of prime interest. The students involved in this project will also have opportunities for technical presentations and very likely co-authorship on peer-reviewed papers.

Production of Microalgae Industrial Feedstocks from Human-Derived Waste Within the Mars Human Space Camp

Advisor/Mentor: Dr. Mark E. Zappi, PE, Executive Director of the UL Energy Institute of Louisiana and BORSF Chair in Bioprocessing, Professor of Chemical Engineering, UL

Project Summary: The researchers at UL are working with NASA to integrated microalgae culturing as a means of locking carbon dioxide produced by humans within the future Mars human space camp. This novel reactor system will capture cabin air to exchange the carbon dioxide for oxygen (replenishing cabin atmosphere) along with producing numerous materials of interest such as lipids, proteins, and whole cells. Additionally, the incorporation of the microalgae reactors with wastewater management is being studied where the concern does exist that the bacteria within the bioreactors may overwhelm the microalgal population within the photobioreactors thereby ceasing critical photosynthesis. An opportunity exists to assist with optimizing the design and operation of numerous candidate reactor designs with both carbon conversion and resulting product quality being of interest. The students involved in this project will also have opportunities for technical presentations and very likely co-authorship on peer-reviewed papers.

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.