CIAMTIS REU

Project 1

Durability of Composites Derived from Renewable Resources

Mentor: Dr. Jovan Tatar

Overview:
Fiber-reinforced polymer (FRP) composites have become an essential and widely used construction material. While FRP composites offer significant advantages over concrete and steel—such as higher strength-to-weight ratio, improved durability and faster construction—these materials are produced from non-renewable fossil fuel feedstocks with a substantial carbon footprint. This research examines novel recyclable composite materials manufactured from renewable sources, like natural fibers and biomass-derived epoxy. The specific objective is to investigate the fundamental degradation mechanisms of bio-based composites when exposed to outdoor environments typical for transportation infrastructure (e.g., wet/dry cycles, freeze/thaw, UV, etc.) The project employs sensitive materials characterization techniques and mechanical testing of aged composite samples to elucidate the environmental effects on the material performance.

Suggested Coursework: Construction Materials, Construction Materials Lab, Mechanics of Materials, Mechanics of Materials Lab. Equivalent courses are acceptable.

Project 2

Improving the Performance of Externally Bonded Carbon Fiber Reinforced Polymer Composite Repairs in Concrete Structures with U-wrap Anchors

Mentor: Dr. Jovan Tatar

Overview: Over 7.5% of national bridges are in poor condition, many of them being concrete bridges. Thus, a reliable strengthening technique, such as anchored externally bonded CFRP, has potential to rapidly address some of the deficient bridge inventory. The objectives of the research are twofold: (1) to develop a test method for quantifying the effectiveness of U-wrap anchors for externally bonded CFRP reinforcement; and (2) to elucidate the effect of anchor design variables on the performance improvement of externally bonded CFRP. This research is expected to greatly impact the development of American Concrete Institute (ACI) design guidelines for implementation in the design practice.

Suggested Coursework: Structural Analysis, Mechanics of Materials, Mechanics of Materials Lab, Construction Materials, Construction Materials Lab, Reinforced Concrete Design. Equivalent courses are acceptable.

Project 3

Passive Strain Sensor Using Retroreflective Sheeting Materials

Mentor: Dr. Tripp Shenton

Overview:
Retroreflective Sheeting Materials (RRSM), commonly used in making highly reflective traffic signs, have been shown to be sensitive to strain, which opens the possibility of using these materials as passive sensors for Structural Health Monitoring (SHM). Retroreflectivity can be measured using a portable, easy to use, retroreflectometer which DOTs typically already own and know how to operate. This research will expand on work already conducted to better understand how and why the reflectivity of RRSM changes when subjected to strain. It will involve microscopic imaging, experimental testing, and finite element modeling. The ultimate goal of this research is to provide a simple and easy way to monitor the conditions of bridges and detect the early evidence of deterioration of the structure.

Suggested Coursework: Solid Mechanics, Mechanics of Materials. Equivalent courses are acceptable.

Project 4

Use of Photo Recognition Tools to Reduce Subjectivity in Bridge Inspection

Mentor: Dr. Jennifer McConnell

Overview:
Bi-annual bridge inspections are federally mandated for nearly all bridges in the United States. This represents a significant expenditure of labor and equipment resources. Yet, the information generated during these inspections is largely based on visual assessments that are qualitative and subjective. A recently completed pilot study explored the use of artificial intelligence to quantify the percent of rusting and paint loss on deteriorated painted steel laboratory specimens, similar to real-world corrosion of bridges, and yielded promising results. The project will build on existing successes to transition the laboratory-proven techniques to the field. Real-world bridge inspections will be shadowed with trained inspectors performing traditional inspections and researchers performing inspections using photography and AI. The results will be compared to assess the potential of the innovative method and to provide best practices for the use of photography in this application by considering variables such as scale, lighting, and color correction.

Suggested Coursework: Introductory computer programming. Equivalent courses are acceptable.

Project 5

Assessment of Saltwater Intrusion in Coastal Infrastructure

Mentor: Dr. Jennifer McConnell

Overview:
Sea level rise has the potential to greatly increase the volume and rate of saltwater intrusion in natural and built systems. One specific concern caused by this is saltwater intrusion in concrete infrastructure, which can cause premature and / or unexpected corrosion and structural failures. This is a particular concern in Delaware, which has the 4th highest coast-to-area ratio in the United States, but also affects the 40% of the US population that lives along a coastline. The project will consider the causes and / or effects of sea level rise and saltwater intrusion. Possible avenues of research include quantification of the airborne and groundwater salinity in different locations, sampling of concrete near the coastline to assess the depth to which chlorides have been absorbed in concrete members, and investigation of concrete mix designs that are more resistant to chloride permeation.

Suggested Coursework: Civil Engineering Materials, Chemistry. Equivalent courses are acceptable.

Project 6

An investigation into fracturing of asphalt pavement surfaces using tillage radishes

Mentor: Dr. Haritha Malladi

Overview:
The United States has large tracts of unused impervious surfaces that are paved with asphalt including old subdivisions, parking lots, and disused roads. The paved surfaces exacerbate the urban heat island effect, impair water percolation, and cause detrimental effects from rapid temperature fluctuations in nearby streams. Due to the lack of economic incentives to mill up these paved surfaces, they generally lay abandoned, sometimes for decades. Tillage radishes, which have been used in agriculture to relieve soil compaction, could be used to unseal soils beneath pavements. This study involves research into the mechanics of using tillage radishes to intentionally fracture unused asphalt pavement surfaces. Based on the availability of field-testing opportunities, this study will test the factors of radish planting that affect the fracturing of asphalt pavements such as planting distance, size, shape, and angle of holes drilled into the pavement to plant the radishes. The study can also involve performing a life cycle assessment to quantify the inputs required to achieve pavement fracturing.

Suggested Coursework: Solid Mechanics, Construction Materials, Construction Materials Lab, Probability and Statistics for Engineers. Equivalent courses are acceptable.

Project 7

Evaluation of Bond Strength of Tack Coat

Mentor: Dr. Haritha Malladi

Overview:
An asphalt concrete pavement is constructed in multiple layers. To promote bonding between these layers, a thin layer of liquid—tack coat—is applied between each layer. Tack coats are also used in resurfacing existing asphalt concrete pavements with an overlay. Adequate bonding between pavement layers and especially between the existing road surface and an overlay is critical for the completed pavement structure to behave as a single unit and provide adequate strength. Inadequate bonding leads to delamination (debonding) followed by distresses that greatly reduce pavement life. This project involves working with the Delaware Department of Transportation (DelDOT) to randomly sample cores from newly pavement location and determine the bond strength between the layers. The specific objective is to evaluate what a good end-result bond strength is based on proper application of tack. This research will help DelDOT develop a specification for bond strength for tack coat applications.

Suggested Coursework: Solid Mechanics, Construction Materials, Construction Materials Lab, Probability and Statistics for Engineers. Equivalent courses are acceptable.