Northwestern | CENTER FOR ENGINEERING SUSTAINABILITY AND RESILIENCE

2020 Seed Funding Awards Announced to Support Innovative, High-Risk, and/or Enabling Collaborative Research to Enhance Engineering Sustainability and Resilience

Four interdisciplinary teams of faculty members have been awarded $60,000 each to support 18-month collaborative research projects. All four projects represent new collaborations among the faculty members and provide support for graduate student(s) and/or postdoctoral fellow(s). Results from these projects will be presented at a Center for Engineering Sustainability and Resilience poster session in spring 2022 and will provide preliminary data to support proposals for funding from federal agencies, foundations and/or industry.

Executive summaries for the selected projects are listed below alphabetically by PI last name:

Physics-based assessment of societal risks due to the collapse of mining waste disposal facilities

Lead-PI: Giuseppe Buscarnera
Associate Professor
Department of Civil and Environmental Engineering

Co-PI: Petia Vlahovska
Professor
Department of Engineering Sciences and Applied Mathematics

Unsustainable mining produces vast amounts of residues and the proliferation of waste disposal facilities, such as tailing dams. Due to their high toxicity and marked vulnerability to rainfall, such earthen structures constitute a major risk for the environment. Evidence from recent failures shows that tailing dams may suffer fluidization after long periods of apparent inactivity, which culminate in high velocity, long runout and loss of human life. The pervasive distribution of tailing dams around the world, combined with well-known trends of population growth and increasingly severe weather, give compelling arguments to address this problem with rigorous scientific tools. For this purpose, this project aims to formulate an innovative conceptual model bridging the pre-failure regime of tailing dams with their post-failure dynamics. By doing so, it will develop physics-based indicators of impending instability to monitor and retrofit waste disposal facilities. The outcomes of this project can therefore inspire the formulation of the next-generation of risk assessment tools to decommission facilities with intolerable hazard levels, as well as to design early warning systems increasing the resilience of communities and ecosystems to climate-induced geohazards.

ViSER (VIsualizing Suspension Electro-Rheology): a new tool for interrogating microstructure in fast-flowing suspensions

Lead-PI: Jeffrey J Richards
Assistant Professor
Department of Chemical and Biological Engineering

Co-PI: Michelle Driscoll
Assistant Professor
Department of Physics

In this seed proposal the co-PI's, Michelle Driscoll and Jeff Richards, seek to develop a new apparatus (ViSER) to image particle-laden, high-velocity flows. Such flows are encountered in emerging electrochemical technologies and existing battery technologies that seek to reduce the cost of renewable electricity. In this seed proposal, the PI's will focus their efforts on the development of the apparatus and obtaining experimental data from suspensions that are subjected to complex deformation that mimics realistic operating conditions. By visualizing the particles within the suspension under these conditions, the PI's seek to bridge a gap in knowledge between predicting performance and measuring material properties in idealized laboratory settings. Successful completion of the seed proposal will pave the way to new scientific discoveries and accelerate the transition to a sustainable energy economy.

Community Vulnerability Index: Examining resilience to overlapping hazards

Lead-PI: Amanda Stathopoulos
Assistant Professor
Department of Civil and Environmental Engineering

Co-PI: Emőke-Ágnes Horvát
Assistant Professor
Department of Communication Studies

It is well known that socially vulnerable populations are disproportionately impacted when disasters strike. Specifically, social vulnerability factors such as lacking social capital, or neighborhood cohesion, cause households to have less resources to deal with emergencies like tornadoes, flooding or heat waves. The COVID-19 pandemic adds a new layer of vulnerability to communities coping with hazards due to devastating health impacts and risk of contagion. Existing agency emergency management plans designed for a 'general population' of people who can access resources, comply with directions, and move out of harm's way rapidly are not prepared for this new reality. Notably, disasters and emergencies occurring in tandem with the COVID-19 crisis generate new challenges for evacuation communication, transportation and logistics.

Research is needed to define community vulnerability and examine how households behave when a public health crises overlaps with acute emergencies. Our team brings together transportation engineering, social science theories and network analysis to provide a leap forward in our understanding of community resilience to simultaneous crises. We use detailed surveys coupled with crowd-sourced data to tackle three research objectives: 1) define a community resilience index accounting for social embeddedness of decision makers, 2) examine the impact of overlapping hazards, and 3) study the effect of overlapping pandemic and emergency hazards on critical decisions to comply with official guidance, timing and mode of evacuation. This proof-of-concept research promises new insight to help agencies ensure social equity in mitigation, response, and recovery from emergencies by highlighting the crucial role played by the social fabric of American communities.

Connecting microscopic reprocessing to macroscopic properties for a circular plastics economy

Lead-PI: Muzhou Wang
Assistant Professor
Department of Chemical and Biological Engineering

Co-PI: Julia A. Kalow
Assistant Professor
Department of Chemistry

Co-PI: Jeffrey J. Richards
Assistant Professor
Department of Chemical and Biological Engineering

Thermosetting plastics represent a $92.4B market, but since these materials are largely landfilled or downcycled at end of use, they impose a >50 megaton environmental burden. Within the past decade, many compelling solutions to the plastics pollution crisis have emerged based on materials that can be recycled by reconfiguring their chemical bonds. In principle, these dynamic bonds allow repair and reprocessing of used or damaged material, greatly extending the overall service life. However, the most fundamental steps of reprocessing remain invisible to standard experimental techniques, and the integrity of recycled materials is not tested under realistic conditions. Identifying highly recyclable elastomers and efficient reprocessing conditions requires insight that bridges disparate length scales. This project combines innovative materials design, next-generation microscopy, and advanced mechanical characterization to address this gap. For example, what engineering parameters during the recycling process determine whether the recycled and re-formed material has the same overall properties? What is happening at the molecular length scale to enable this recovery in macroscopic properties? This project will directly observe the recycling process at the unprecedented nanoscale, and correlate this to bulk mechanical properties. By visualizing the motion of individual polymers in real time, we can understand the underlying dynamic mechanisms near the interface between re-forming pieces, and how mechanical properties recover to their original state. This fundamental knowledge will help us understand which elastomers can be rendered recyclable and why, minimize the energy required to reprocess them, and maximize the retention of properties after recycling.