Sustainability Fellowship
Flood-induced Roadway Damage Risk Analysis

UNH Center for Infrastructure Resilience to Climate
Durham, NH

About the Sustainability Fellows Program:
UNH Sustainability Fellowships pair exceptional students from across the U.S. with municipal, educational, corporate, and non-profit partners in New England to work on transformative sustainability initiatives each summer. Sustainability Fellows undertake challenging projects that are designed to create an immediate impact, offer a quality learning experience, and foster meaningful collaboration. Fellows work on-site with their mentors at partner organizations during the summer, supported by a network of Fellows, partners, alumni, and the UNH Team. Graduate students, exceptional undergraduate students, and recent graduates from any accredited college or university are eligible to apply.

A detailed description of one Fellowship follows. To learn more about the other Fellowships offered this year, and for application instructions, see: www.sustainableunh.unh.edu/sustainability-fellows.

About the Host Organization:
The UNH Center for Infrastructure Resilience to Climate (UCIRC) is dedicated to accelerating and advancing the development of new methods and approaches to planning, design, and operation and maintenance of climate and weather resilient transportation and building infrastructure systems. The Center brings together UNH faculty and students for interdisciplinary, collaborative research to tackle these multi-dimensional issues. UCIRC builds on the leading-edge work conducted by the Infrastructure and Climate Network (ICNet).

About the Fellowship:
Flooding is a challenge for many roadways (e.g. coastal roads) in New England, however flooding is often neglected in conventional pavement design. In locations where flooding is frequent or will become more frequent in the future (e.g. due to changes in climate or sea level rise), priority should be given to risk quantification associated with flood-induced damage and adaption of road design to local flooding impacts. On one hand, this requires information on local frequencies of flooding and their magnitudes. On the other hand, it is important to quantify flood-induced damage, given different flooding magnitudes.

In general, flooding of a greater magnitude is expected to do more harm to a roadway. For decades, FEMA and the US Army Corps of Engineers (ACOE) have used depth-damage functions to estimate the damage to civil infrastructure (particularly for buildings and their contents) based on the depth of flood waters. These estimates are based on field assessments of damage following flooding events. These depth-damage functions for riverine flooding have been codified in the FEMA Hazus tool and have been used locally to estimate damages to buildings associated with flooding in the Lamprey River. More recently the North Atlantic Coast Comprehensive Study (NACCS) examined damage to buildings resulting from Hurricane Sandy and developed depth-damage relationships for coastal storm events, and critically included damage from waves as well as high water. These updated depth-damage relationships have been used by a group of engineers and coastal managers to develop the Coastal Environmental Risk Index (CERI) which provides an objective and quantitative assessment of the risk to individual buildings and specific infrastructure from storm surge and sea level rise. However, potential damage to road infrastructure from flooding is clearly missing from CERI results and other assessment tools. For accurate assessments of damage associated with flooding, it is critical to develop local damage functions for roadways and use the functions to quantify the risks of flood-induced damage.

During flooding, moisture levels in a pavement can increase significantly and weaken pavement structure. After flooding, high levels of moisture can be trapped in the pavement structure and it can remain weakened for a long time. In those periods when moisture levels are high, rapid damage can occur and the traffic bearing capacity of the roadway can reduce significantly. This leads to a reduced pavement service life and loss of asset economic values. It has been discovered in many roadway surveys that severe pavement distress can occur after flooding and such consequence needs to be accounted for in the flood-induced damage risk assessment. Therefore, the component of time needs to be included in the determination of the amount of damage that a roadway will experience due to a particular flooding event.

This multi-disciplinary project investigates an urgent topic regarding pavement flood resilience. It is important to quantify the flood-induced damage risk on roadways with respect to both time and depth so that expected economic loss due to flooding can be assessed. The assessment can be used by road authorities to claim for repair/reconstruction budgets after flooding.

The goal of this project is to build upon existing research on roadway flooding resilience at the University of New Hampshire Center for Infrastructure Resilience to Climate (UCIRC) to develop an approach to quantify the cost of flooding induced damage on roadways.

Outcomes:
The approach will include a literature survey, data collection, finite element modeling of flooded pavements, and cost assessment. In addition, this study will identify key knowledge gaps and new research that is critical for adaptation of roadways to flooding. The anticipated outcomes include presentations and contribution to peer-reviewed publication(s) to present the findings of this study. This study will also generate pilot data for future proposals.

Impact:
The Sustainability Fellow will learn how to model flooded pavements using the finite element method (FEM), perform pavement evaluations, and cost assessments. The skills/expertise can be applied to a variety of engineering problems, add will a unique perspective on infrastructure climate resilience to the Fellow's portfolio.

We expect this project will serve as the foundation to emphasize that urgent changes in roadway pavement design are needed to account for flood resilience. The findings of this project are expected to provide road agents with a tool to project the degree of roadway damage relative to a range of potential flooding events. It is our hope that this work will lead to the routine incorporation of flood resilience into roadway pavement design, and subsequently increase the resilience of pavements to climate change.

Desired Qualifications:

- BS degree in Civil Engineering
- Fundamental knowledge in civil engineering materials, geotechnical engineering, and hydrology
- Background knowledge of pavements and finite element method (FEM)
- Strong interest and desire for multi-disciplinary research, experience an advantage but not a requirement
- Broad interest in climate resilience generally to engage with other sustainability fellows working in different areas of climate resilience
- Ability to work collaboratively and independently
- Good writing and communication abilities
- Programming skills (in R, Python, or VBA) are an advantage but not a requirement

Work Location: UNH Center for Infrastructure Resilience to Climate, Kingsbury Hall, UNH, Durham, NH

Mentor:
Dr. Jo E. Sias, Professor, UNH Department of Civil and Environmental Engineering

Compensation: $6500
(taxable and distributed on a two-week payroll cycle over the course of the fellowship)

Expectations:
Fellows are expected to be primarily dedicated to their assigned projects throughout the summer, and also participate in a variety of networking activities, professional development opportunities, and presentations coordinated by UNHSI. Specifically, Fellows are expected to:

- Attend a mandatory orientation at UNH prior to the start of the fellowship term, **May 26-28, 2020**. (Travel scholarships may be available for students traveling from outside New England.)
- Work full-time on-site at the partner organization, **June 1 - August 14, 2020**

- Complete 400 hours of work, including work at host site as well as UNHSI activities, between May 26 – August 14, 2020.
- Complete a fellowship project according to the work plan (with adjustments as necessary).
- Participate in weekly webinars or advisory group meetings.
- Present work at mid-term and final poster sessions at UNH on **July 10** and **August 7**. (Travel support available.)
- Engage in additional professional development, networking, and advisory activities as offered.
- Provide and receive feedback at the end of the fellowship.

Apply by February 10 at www.sustainableunh.unh.edu/sustainability-fellows.

Questions may be addressed to megan.carney@unh.edu.