RESEARCHER PROFILE
MILAD ROOHI

Dr. Milad Roohi is an Assistant Professor in the **Charles W. Durham School of Architectural Engineering and Construction** at the University of Nebraska–Lincoln (UNL) and the director of the SiRIUS lab.

He specializes in structural engineering and mechanics, risk, reliability, and resilience engineering, infrastructure sensing and monitoring. His research has been funded by US federal agencies (including NSF, NIST, and HUD) and on Service Corporation, and he has published/presented his research findings in leading journals (e.g., by ASCE, Wiley, Elsevier, and Springer), international conferences, and at the US institutions as an invited speaker.

Enhancing Resilience through Multidisciplinary Research: Milad Roohi's Contributions to IN-CORE

Milad Roohi's journey with the IN-CORE (Interdependent Networked Community Resilience Modeling Environment) platform and the National Institute of Standards and Technology (NIST) funded Center for Risk-based Community Resilience Planning began in 2019 when he joined as a postdoctoral fellow at Colorado State University. Since then, he has made significant strides in advancing resilience modeling, particularly in seismic resilience, and has played a significant role in the platform's development and community engagement. Roohi completed his postdoc in 2021 and remained with IN-CORE as a research affiliate. In 2022, Roohi joined the University of Nebraska-Lincoln (UNL), where he is a tenure-track Assistant Professor in the Charles W. Durham School of Architectural Engineering and Construction and director of the Smart Resilient Infrastructure and Urban Systems (SiRIUS) lab.

From Postdoctoral Fellow to Leading Resilience Research

Roohi's initial role focused on seismic resilience testbeds, particularly the Memphis Metropolitan Statistical Area (MMSA), where he collaborated with social and economic scientists to integrate engineering models with economic and social models. "My role was mainly working on seismic resilience testbeds. Our first study involved quantifying resilience metrics in Shelby County, Tennessee," he said. This collaboration led to Roohi's first major co-authored publication, demonstrating the successful integration of engineering, social, and economic systems.

Roohi's work extended beyond model development. He was instrumental in making IN-CORE accessible and practical for communities, which involved developing initial interfaces for the platform. "One of my major contributions was to study the Community Resilience Planning Guide Playbook from NIST. I worked with NCSA [the National Center for Supercomputing Applications] to implement the interface," Roohi explained. His efforts culminated in the development of tailored community apps, including one for Salt Lake City, which he presented at various conferences to disseminate IN-CORE's capabilities.

Pushing the Boundaries of Resilience Modeling

Roohi's contributions to IN-CORE have not been limited to seismic resilience. His work has expanded into enhancing the platform's design and usability, linking scientific developments directly to community needs. "I worked with NCSA to enhance the design for the web interface of IN-CORE," Roohi noted, highlighting his efforts to make the platform more user-friendly for broader audiences.

One advancement Roohi has promoted is integrating machine learning into resilience modeling. He described how he and his team have worked with the center's economic and data scientists on applying machine learning algorithms to develop efficient data-driven economic models to estimate resilience metrics using engineering metrics directly. "We brought the economic science model in terms of a CGE [Computable General Equilibrium] model... there was interest in implementing a machine learning algorithm for chaining the engineering models with the CGE model to reduce the modeling and computational efforts in qualifying resilience metrics," Roohi said, reflecting his commitment to pushing the boundaries of resilience modeling.

Community Engagement and Real-World Applications

Roohi's involvement with IN-CORE's Salt Lake City Partner Community project has been a highlight of his work. He recounted his first meeting with community officials, held virtually, where they discussed the challenges faced by the city's infrastructure, particularly concerning seismic resilience. "It was an eye-opening meeting for us... they presented challenges such as developing mitigation strategies to retrofit unreinforced masonry buildings," Roohi said. This engagement led to developing a community app that allows local stakeholders to run various resilience analyses, including cost-benefit comparisons of different mitigation policy options.

The positive reception of these tools was evident during a workshop in April 2024, where Roohi observed participants actively using the IN-CORE platform. "They were generating earthquakes, going through the process of resilience modeling... excited to use this platform to help them write proposals to government agencies," Roohi shared.

Expanding IN-CORE's Reach to New Hazards and Sectors

Roohi's move to the University of Nebraska-Lincoln has opened new avenues for applying IN-CORE, particularly in flood resilience modeling for bridge and transportation networks. Roohi and colleague Dr. Christine Wittich, also at UNL, successfully received a grant funded by the Nebraska Department of Transportation (NDOT); this project aims to prioritize maintenance and improve resilience against future flooding events. "We are going to develop an IN-CORE model for the transportation network in Nebraska... the goal is to understand how we can improve the resilience of transportation network in Nebraska," Roohi explained. The project brought together various departments in the NDOT and demonstrated the value of IN-CORE in integrating multiple dimensions into decision-making processes.

Roohi's success in securing funding has extended to a collaborative project with the Omaha Indian Reservation and the University of Nebraska-Omaha (UNO) through a National Science Foundation (NSF) Civic Innovation Challenge (CIVIC) Grant. This initiative will focus on integrating AI into resilience modeling for governance and risk mitigation, further demonstrating Roohi's commitment to leveraging IN-CORE for diverse community needs.

Educational Impact and Workforce Development

Roohi's commitment to education is evident in his development of a new course, "Infrastructure and Community Resilience," at the University of Nebraska. The course heavily utilizes IN-CORE, allowing undergraduate and graduate students to engage in real-world resilience modeling projects. "Each student defined their own final project... one student developed a seismic resilience model for

San Francisco, while another focused on flood resilience for bridges in Nebraska," Roohi noted, emphasizing the course's impact on student skills in resilience modeling.

The course has strengthened students' technical skills and inspired them to pursue resilience planning and modeling careers. Roohi reflected on how his students have leveraged IN-CORE to explore complex challenges. "Three of my undergraduate students each received a $3,600 award from UNL's Undergraduate Creative Activities and Research Experience [UNL UCARE] to conduct undergraduate research on infrastructure resilience using IN-CORE." Highlighting the platform's potential to inspire the next generation of engineers and scientists, Roohi shared, "One of my master's students got really excited about wildfire resilience modeling... he spent time reading papers and meeting with experts to understand the challenges."

IN-CORE'S Role in Career Trajectory

Working with IN-CORE has been instrumental in shaping Roohi's early career work as a researcher and academic. He noted that working with IN-CORE has increased his visibility in the field, provided opportunities to work with many "amazing minds," and contribute back to society. He stresses the importance of "making actual contributions to help people" and ensuring that the knowledge created moves beyond research papers. "For me, during the past almost five years, it's been quite exciting because this was the first time I was part of a big multi-university team of researchers and scientists. This opened my eyes to all these opportunities and great collaborations as part of this type of multidisciplinary collaboration. And now I see the same for my students." Roohi currently works with PhD students who plan to connect their work with the IN-CORE platform to help "produce multidisciplinary metrics that go through optimization, recovery planning, and help communities to better prepare for hazards."

Future Directions and Industry Applications

Roohi envisions a broader application of IN-CORE in consulting and industry sectors, particularly in insurance and reinsurance. He pointed out that traditional catastrophe models often fail to account for interdependencies between infrastructure systems, a gap that IN-CORE can fill. "One of the capabilities that IN-CORE can offer for insurance and reinsurance is to go beyond the metrics they can produce and enhance the accuracy of these models," Roohi noted, suggesting the potential for collaboration to address emerging challenges related to climate change.

Through his work, Milad Roohi has demonstrated the powerful impact of multidisciplinary research on resilience modeling, community engagement, and education. His contributions to IN-CORE have advanced the platform and helped bridge the gap between cutting-edge science and practical, real-world applications toward making communities more resilient in the face of future challenges.

Recent and Relevant Publications

Roohi, M., Ghasemi, S., Sediek, O., Jeon, H., van de Lindt, J. W., Shields, M., ... & Cutler, H. (2024). Multi-disciplinary seismic resilience modeling for developing mitigation policies and recovery planning. *Resilient Cities and Structures*, *3*(2), 66-84.

> *The multi-disciplinary data and information available at a community level comprise the foundation of natural hazard resilience modeling. These data enable and inform mitigation and recovery planning decisions before and following damaging events such as earthquakes. This paper presents a multi-*

disciplinary seismic resilience modeling methodology to assess the vulnerability of the built environment and economic systems that can assist decision-makers with developing effective mitigation policies to improve the seismic resilience of communities.

Sediek, O. A., **Roohi, M.,** & van de Lindt, J. W. (2024). A Decision Support Methodology for Seismic Design Requirements of Buildings to Achieve Community-Level Resilience Metrics. *ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering*, *10*(3), 04024038.

Communities can face devastation from earthquakes, including loss of lives, destruction of infrastructure, and damage to buildings. By implementing rigorous standards, communities can ensure that new and existing structures are designed and retrofitted to withstand seismic forces. While current building codes prioritize life safety during earthquakes, they may not fully consider buildings' post-disaster functionality and usability. Consequently, this paper introduces a novel simulation-based approach that promotes resilience-informed decision-making related to seismic design requirements for individual buildings within a community. This multidisciplinary approach considers the interdependencies between the physical and social systems in the community in terms of population dislocation after earthquakes. The methodology produces cost estimates for implementing seismic design upgrades.

Sediek, O. A., **Roohi, M.,** & van de Lindt, J. W. (2024). A genetic algorithm framework for seismic retrofit of building portfolios to enhance community resilience. *International Journal of Disaster Risk Reduction*, *108*, 104570.

Earthquakes can impose significant human, societal, and economic burdens, emphasizing the necessity of community preparedness, including mitigation. Seismic retrofitting, a key preparedness measure, seeks to enhance structural resilience against earthquakes. Despite the effectiveness of community-level plans, challenges persist in quantifying their effectiveness and optimizing resource allocation. This paper introduces a genetic algorithm (GA) framework designed to address these challenges to optimize seismic retrofitting communities' building portfolios to achieve community-level resilience goals. The proposed framework, part of a simulation-based approach, probabilistically models building damage and post-earthquake functionality of the community.

Access IN-CORE tools to run analyses that model the impact of natural hazards on your community and that assess community resilience at https://incore.ncsa.illinois.edu/

For more information about IN-CORE's work in communities and to request assistance, go to https://in-core.org