Department of Civil and Environmental Engineering

Cullen College of Engineering

Graduate Seminar Series Spring 2023

CIVE 6111

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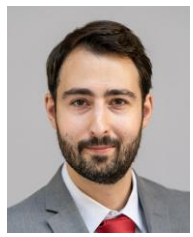

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From Bridge Structure to Intermodal Network Scale: Resilience Modeling of Transportation Infrastructure

Jamie E. Padgett, Professor and Department Chair
Department of Civil and Environmental Engineering
Rice University

Friday, January 20, 2023
2:45pm-3:45pm
Classroom Business Building (CBB) - Room 104
Zoom:https://uh-edu-cougarnet.zoom.us/j/94589160391

Abstract

Our structures and infrastructure systems are exposed to an array of threats throughout their lifetime, including both chronic and acute stressors that pose a risk of damage and cascading consequences to social, environmental and economic systems. These stressors include aging and deterioration, increased demand by a growing population, and natural hazards that may become more frequent with climate change. This presentation provides an overview infrastructure resilience modeling considering exposure to multiple hazards. Emphasis is placed on transportation infrastructure, given its vulnerability in past hazard events, as well as its essential role in supporting both emergency response as well as long term recovery of a region. Recent advances in multi-hazard vulnerability modeling and hybrid metrics of resilience are described. Case studies are leveraged to illustrate key input to the resilience modeling framework, such as fragility models and restoration functions, and to quantify indicators of infrastructure resilience. These case studies cut across hazards, systems and scales—from bridges to intermodal transportation networks subjected to earthquakes, floods, or hurricane hazards—to demonstrate model integration and probe alternative practical questions of design, management and risk mitigation. We conclude with a discussion of challenges and opportunities to propel the field toward smart and equitable resilience modeling in hazard prone communities.

Bio

Jamie E. Padgett is the Stanley C. Moore Professor and Department Chair of Civil and Environmental Engineering at Rice University. She received her PhD from Georgia Tech and BS from the University of Florida both in Civil Engineering. Padgett is a structural engineer whose research is focused on multi-hazard risk and resilience modeling of structures and infrastructure systems, while understanding their impacts on communities. Padgett is a Fellow of ASCE's Structural Engineering Institute (SEI) and the founding Chair of its technical committee on Multiple Hazard Mitigation. Among other advisory and professional service roles, Padgett serves on Editorial Boards for such journals as the ASCE Journal of Structural Engineering, Natural Hazards Review, and Sustainable and Resilient Infrastructure. Padgett serves in leadership roles within several large national research efforts including the NIST funded Center of Excellence for Risk-based Resilience Planning, the NSF funded Natural Hazards Engineering Research Infrastructure (NHERI) Cyberinfrastructure "DesignSafe-CI", and the Severe Storm Prediction Education and Evacuation from Disasters (SSPEED) Center. She is the Faculty Director of the inaugural Gulf Scholars Program at Rice University funded by NASEM's Gulf Research Program.

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Regional Hazard Risk Assessment through High-Performance Computing, Computer Vision, and Machine Learning

Ertugrul Taciroglu, Department Chair
Department of Civil and Environmental Engineering
UCLA

Friday, January 27, 2023
2:45pm-3:45pm
Classroom Business Building (CBB) - Room 104
Zoom: https://uh-edu-cougarnet.zoom.us/j/94589160391

Abstract

There is a perfect convergence of key tools and technologies that are now enabling civil engineers to assess risk and resilience at the system level, which will illuminate the true hazard exposure in unprecedented ways. In this talk, I will provide a summary of various workflows that our research group has generated for regional seismic risk and loss assessment for various hazards. These workflows feature building and bridge inventories generated using expert systems, computer vision, machine learning algorithms, and tools for automated generation of fragility functions.

Bio

Ertugrul Taciroglu earned a B.S. degree in 1993 from Istanbul Technical University, and MS and PhD degrees from the University of Illinois at Urbana-Champaign (UIUC) in 1995, and 1998, respectively. After a stint at the Center for Simulation of Advanced Rockets (UIUC) as a postdoctoral research associate, he joined the Civil & Environmental Engineering Department at UCLA in 2001 where he is currently the department chair. His research interests span the disciplines of theoretical & applied mechanics, and structural & geotechnical earthquake engineering. He is conducting projects on regional performance-based risk assessment of civil infrastructure, structural health and performance monitoring, soil-structure interaction, and simulation of structural response under extreme loads. Dr. Taciroglu is the recipient of a 2006 National Science Foundation CAREER award, and the 2011 Walter Huber Prize of the American Society of Civil Engineers (ASCE). He was elected to become a Fellow of the ASCE Engineering Mechanics Institute (EMI) in 2015, and serves on the EMI Board of Governors. He serves on the editorial boards of several journals, including ASCE Journal of Structural Engineering, EERI Earthquake Spectra, Soil Dynamics & Earthquake Engineering, and Structural Control & Health Monitoring. He became the inaugural chief editor of ASCE Open: Multidisciplinary Journal of Civil Engineering in 2022.

What Yields the Best Performance? The Design and Repair of Lap Splices with a View on Deformability

Kinsey C. Skillen, Assistant Professor
Department of Civil & Environmental Engineering at Texas A&M University

Friday, February 03, 2023
2:45pm-3:45pm
Classroom Business Building (CBB) - Room 104
Zoom: https://uh-edu-cougarnet.zoom.us/j/94589160391

Abstract

It is evident that splices which fail prior to, or soon after yielding are not reliable. Demands from earthquake, blast, wind or settlement can result in bar strains that exceed the yield strain by large margin. The reliability of the splice should not be based on stress values alone, but rather strains. Achieving large strains, or adequate deformability without splice failure should be the emphasis for design. The real question is how much deformability a lap splice should have. For seismic applications, for instance, all the evidence considered suggests that it would be prudent to expect strain demand to exceed drift ratio. Given a) current design target drift ratios as high as 2.5%, b) uncertainties involved in estimating drift demands for phenomena that require the most ductility (earthquake and blast) and c) the potentially fatal consequences of splice failure, it is hard to envision situations in which drift or rotation targets would not exceed 2 or 3%. The verdict is simple: unconfined lap splices in critical regions of critical structural elements pose high risk and need strengthening and/or retrofit.

In the investigation presented, a series of beam and coupon specimens containing a pair of spliced Gr. 60 #11 reinforcing bars were tested. A splice length of 56-bar diameters and the same cross-section were used in twenty-four specimens. In twelve specimens the spliced bars were unconfined while the remaining twelve specimens were confined by post-installed epoxied anchors. Conclusions regarding the behavior of the spliced bars and the effects of the epoxied anchors are discussed from the perspective of both strength and deformability.

Bio

Kinsey C. Skillen is an Assistant Professor of Civil & Environmental Engineering within the Construction, Geotechnical, and Structures Division at Texas A&M University. He also holds a joint appointment as an Assistant Research Scientist of Major Highway Structures for the Texas A&M Transportation Institute (TTI). He obtained his BSCE from Montana State University in 2015, MSCE from Purdue University in 2017, and PhD in Civil Engineering from Purdue University in 2020. He conducts research on topics related to bond and anchorage of steel reinforcement, the development of early-high-strength & eco-efficient cementitious mortars, and hyper-velocity impact behavior of concrete materials. He is a voting member of ACI committee 408 – Bond and Development of Steel Reinforcement and associate member of ACI committees 351 – Joints and Connections and 441 – Columns.

Development of Eco-Filament for 3D Printing in Construction and CO2 sequestration

Hee-Jeong, Professor
Department of Civil and Architectural Engineering and Mechanics at the University of Arizona

Friday, February 10, 2023
2:45pm-3:45pm
Classroom Business Building (CBB) - Room 104
Zoom: https://uh-edu-cougarnet.zoom.us/j/94589160391

Abstract

We face a key challenge global warming and CO2 cause greenhouse effects to promote climate change. Each nation is trying to reach net-zero greenhouse gas (GHG) emissions by 2050. The cement industry accounts for 8% of global CO2 emissions, and the United States has a significant cement production. This seminar will discuss how construction material research can play a significant role in Carbon Capture, Utilization, and Storage (CCUS). In addition, the future of the construction industry such as 3D concrete printing and lunar concrete will be discussed.

Bio

Hee-Jeong Kim is an assistant professor in the Department of Civil and Architectural Engineering and Mechanics at the University of Arizona. She received a B.S., M.S. and Ph.D. in civil and environmental engineering, all from the Korea Advanced Institute of Science and Technology (KAIST) and did her postdoctoral research at the Department of Civil and Environmental Engineering, MIT. Her area of expertise is the multi-scale chemo-mechanical characterization of advanced materials in civil engineering. Kim's research involves designing and developing new construction materials based on advanced multi-scale computational modeling and experimental characterization, improving the sustainability and resilience of civil infrastructure, utilization of digital fabrication, including large-scale printing in the development and application of new construction.

Advances in Real-time Cyber-Physical Simulation: Enhancement of Performance-Based Engineered Structural Systems for Multi-Natural Hazards

James M. Ricles, Bruce G. Johnston Professor of Structural Engineering
Department of Civil & Environmental Engineering
Lehigh University

Friday, February 17, 2023
2:45pm-3:45pm
Zoom: https://uh-edu-cougarnet.zoom.us/j/94589160391

Abstract

Stakeholders are demanding that the performance of the built civil infrastructure be more resilient to natural hazards in order to reduce their impact on society. Performance-based engineering is a means to attempt to meet performance objectives associated with prescribed levels of hazards. A viable technique to meet validation requirements for performance-engineered structural systems is to use real-time hybrid simulation to perform cyber-physical experiments. The complete system is involved in these simulations, where selected components of the system are modeled physically while others are numerically using computational models. The modeling of the former in the physical domain is required because accurate computational models do not exist for these components. In such studies the response modification devices can be coupled to a system and the system subjected to a prescribed hazard with a specific return period, enabling system performance under prescribed levels of realistic hazard demands to be investigated. The talk will present results from recent efforts that the presenter and his research team have completed to advance large-scale multi-directional real-time hybrid simulation. Topics of the talk include the development of model-based unconditionally stable dissipative explicit direct integration algorithms, explicit state-determination force-based fiber elements, and adaptive servohydraulic actuator control algorithms. The talk will conclude with applications of these developments to perform real-time hybrid simulations of nonlinear structural systems subjected to earthquake and wind hazards, including extensions to perform real-time aeroelastic hybrid simulations of a tall building.

Bio

James Ricles works in the area of structural engineering and mechanics as well as large-scale experimental simulations. His research includes the development and implementation of computational frameworks for large-scale multi-directional real-time hybrid simulations applied to complex structural systems. He is the principal investigator and director of the NSF Natural Hazards Engineering Research Infrastructure (NHERI) Experimental Facility located at Lehigh University. He is also a registered professional engineer in the State of California and serves on the Editorial Advisory Board for the International Journal of Earthquake Engineering and Structural Dynamics. James is the recipient of the NSF Presidential Young Investigators Award, the ASCE Raymond C. Reese Research Prize and AISC Special Achievement Award for his work in innovations in structural resiliency.

Decision Support Tool for Cost Estimating of Conventional and Accelerated Bridge Construction Methods

El-Rayes, Professor
Department of Civil & Environmental Engineering at University of Illinois at Urbana-Champaign

Friday, February 24, 2023
2:45pm-3:45pm
Classroom Business Building (CBB) - Room 104
Zoom: https://uh-edu-cougarnet.zoom.us/j/94589160391

Abstract

Accelerated bridge construction (ABC) methods have been increasingly used for bridge rehabilitation and replacement projects in recent years. ABC methods use innovative planning, design, materials, and construction methods in a safe and cost-effective manner to reduce the onsite construction time. The main advantages of ABC method over conventional staged construction include reduced impact on traffic and mobility caused by onsite bridge construction, lane closures, and detours. Despite these advantages, ABC methods often require a higher initial cost and more planning, design coordination, and increased construction lead time. Decision makers need to accurately estimate total and life cycle costs of the two bridge construction methods to identify the most-cost effective method for different bridge construction projects. This presentation focuses on the development of a decision support tool (DST) for estimating the total and life cycle cost of conventional and accelerated bridge construction methods such as prefabricated elements, lateral slide, and self-propelled modular transporter. The DST is designed to provide DOT decision makers with much-needed support to generate accurate Rough Order of Magnitude cost estimate during the early project planning and engineering phases. The cost estimating DST was developed in six tasks that were designed to (1) collect historical cost data of various bridge projects constructed using both conventional staged construction and ABC methods; (2) create a database of all collected bridge cost data; (3) develop a construction cost module that enables DOT planners to develop rough order of magnitude estimates for each bridge construction method; (4) implement a road user cost module that estimates the cost to the travelling public resulting from detours and traffic delays during bridge construction; (5) develop a life cycle cost module that includes construction, road user, maintenance, and replacement costs; and (6) compare the construction, road user, and life cycle costs for each bridge construction method.

Bio

Khaled El-Rayes is a Professor of Construction Engineering and Management and Associate Head of the Department of Civil and Environmental Engineering at the University of Illinois at Urbana-Champaign. El-Rayes has more than 30 years of professional experience in both academia and the construction industry. He taught numerous graduate and undergraduate construction engineering and management courses, and he was repeatedly selected in the "List of Teachers Ranked as Excellent by their Students" at the University of Illinois. He also served as PI and Co-PI on numerous research projects with budgets totaling more than $12 Million that were funded by the National Science Foundation, Illinois Department of Transportation, and National Center for Supercomputing Applications. The outcome of his research projects was published in more than 175 articles including more than 100 journal papers. The contributions of his research have also been recognized nationally and internationally, receiving many research awards including the "Best Conference Paper Award" from the ASCE Construction Research Congress in 2012, the "Best Journal Paper Award" in 2010 from the ASCE Journal of Construction Engineering and Management, and the "ASCE Thomas Fitch Rowland Prize" in 2007; the "NSF CAREER Award" from the National Science Foundation in 2003. El-Rayes supervised the research work of more than 30 Ph.D. students, including 22 former Ph.D. students who are currently holding faculty Positions in the University of Illinois, Purdue University, Columbia University, University of Colorado, US Air Force Institute of Technology, Florida International University, University of Santa Clara, University of Alexandria, Kuwait University, King Fahd University of Petroleum and Minerals, and King Saud University. El-Rayes served as the Secretary, Vice-Chair and Chair of the ASCE Construction Research Council, which is widely recognized as the premier national forum for Construction Engineering and Management research and it includes in its membership more than 200 professors and scholars.

Modifying Existing Buildings

Doug Antwiler, PE, SE
Senior Structural Forensic Specialist
IMEG Corp.

Friday, March 03, 2023
2:45pm-3:45pm
Classroom Business Building (CBB) - Room 104
Zoom: https://uh-edu-cougarnet.zoom.us/j/94589160391

Abstract

This presentation explores current building code requirements for making modifications to existing buildings. Several real-world examples of proposed modifications to buildings are presented and the impact of these modifications on the final building design are discussed. Finally, general guidance on how to begin an evaluation or modification of an existing structure is provided.

Bio

Doug serves as Senior Structural Forensics Specialist for IMEG in Houston. He has 27 years of experience as a structural engineer, specializing in the forensic investigation, testing, analysis, repair and modification of existing concrete, steel, wood and masonry structures. His expertise includes historical and industrial structures within refining, chemical processing and manufacturing facilities, as well as commercial, retail, parking and educational facilities. Doug's comprehensive assessments lead to innovative, cost-effective and buildable solutions.

Parametric Studies of Structures via Model Reduction

Ruda Zhang, Assistant Professor
Department of Civil & Environmental Engineering at University of Houston

Friday, March 10, 2023
2:45pm-3:45pm
Classroom Business Building (CBB) - Room 104
Zoom: https://uh-edu-cougarnet.zoom.us/j/94589160391

Abstract

Complex structures in civil engineering require large-scale finite element models to analyze their dynamic characteristics. With degrees of freedom over a million, and sometimes hundreds of millions, it is costly to study structural responses under various loading conditions. The challenge deepens when the models need to be adjusted in various parameters, for purposes of design, structural health monitoring, and uncertainty quantification. To make these analyses feasible, the original models are usually replaced with ones that are approximate but faster to solve. In this talk, I will first review traditional methods and recent development for reduced order modeling (ROM) of structural systems. All these methods follow modal analysis and build reduced models using eigenmodes. However, structural engineers have largely ignored decades of ROM research in systems theory. I will compare three classes of structural ROM methods and introduce a new method that offers the best accuracy and computational complexity. For parametric studies, a data-driven, machine learning method for probabilistic subspace prediction is combined with the physics-based reduced order model, to construct fast and accurate parametric models. We apply our method to emulate the dynamics of a multilevel structure for spent nuclear fuel, and study the effect of parameter uncertainty on structural response. Compared with the state-of-the-art methods, our approach is more data efficient and computationally efficient, and gives smooth predictions with uncertainty quantification.

Bio

Dr. Ruda Zhang is an Assistant Professor in the Department of Civil and Environmental Engineering at the University of Houston (UH), where he leads the Uncertainty Quantification (UQ) Lab. He received his B.E. degree in Engineering Structure Analysis from Peking University, Beijing, China, and master's degree in Economics and Ph.D. degree in Civil Engineering from the University of Southern California, Los Angeles, CA. Before joining UH in Fall 2022, he was a Phillip Griffiths Assistant Research Professor in the Department of Mathematics at Duke University.

His research combines machine learning (ML) and uncertainty quantification (UQ) for structural engineering, and more broadly, for computational and data-enabled science and engineering (CDS&E). His current focus is on dimension reduction and emulation of computational models, using Gaussian processes, deep neural nets, and data-driven methods. His recent awards include the 2021 INFORMS Quality, Statistics & Reliability (QSR) best paper award, and the SIAM Early Career Travel Award.

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Humans, Rivers, and Climate Change

Bart Nijssen, Allan & Inger Osberg Professor and Department Chair
Department of Civil & Environmental Engineering at the University of Washington

Friday, March 24, 2023
2:45pm-3:45pm
Classroom Business Building (CBB) - Room 104
Zoom: https://uh-edu-cougarnet.zoom.us/j/94589160391

Abstract

The effects of climate change are strongly felt in the hydrological cycle, where changes in extremes, volumes, timing, and water quality pose challenges for water resources management. Most hydrological projections under climate change rely on computer models that do not adequately represent the role of humans as active agents in the hydrological cycle. Two case studies are presented to illustrate the need to account for water resources management in assessing climate change impacts on hydrology. Both studies rely on a complex model chain to estimate climate change impacts with and without the effects of water resources management. One study is focused on streamflow and stream temperature in the southeastern United States. The other examines streamflow in the Columbia River, which is the main source of hydropower in the Pacific Northwest.

Bio

Bart Nijssen is the Allan & Inger Osberg Professor and Chair of Civil and Environmental Engineering at the University of Washington, Seattle. His research career has focused on the development and application of models and analytical techniques to better understand and predict hydrologic processes near the land surface and to better understand how our planet will respond to change. He has contributed to the development, maintenance and distribution of hydrologic models (e.g. DHSVM, VIC, and SUMMA) that are widely used in the hydrology community and has championed the use of standard software development methods in hydrological research to promote reproducibility. In 2021, he was awarded the Edward A. Flinn III Award from the AGU in recognition for his work in developing and sharing open-source models and datasets.

Emerging Technologies for Mitigating Climate Change

Dr. Mahmoud Reda Taha, PE, FACI, F. ASCE,
Distinguished Professor & Chair
Department of Civil, Construction & Environmental Engineering at The University of New Mexico, USA

Friday, March 31, 2023
2:45pm-3:45pm
Classroom Business Building (CBB) - Room 104
Zoom: https://uh-edu-cougarnet.zoom.us/j/94589160391

Abstract

The last few decades observed a noticeable increase in natural and man-made hazards, including climate change, scarce resources, and increased energy challenges and demands. The continuous upward trend of greenhouse gas emissions demands new developments to mitigate the emissions and create new materials with a low carbon footprint. In civil infrastructure, the frequent occurrence of disasters and the challenges associated with maintaining the performance of critical infrastructure is an issue of great concern for professional societies and policymakers. Over the years, traditional materials and classical design philosophies have proven unyielding to resilient systems and incapable of meeting the challenges to combat climate change. Advancements in materials science and robotics introduced nanotechnology and additive manufacturing, widely known as 3D printing, to infrastructure. This development has created opportunities that were not possible a decade ago. Using such emerging technologies (ETs) appears as a robust solution to mitigate climate change and improve infrastructure resilience.

In this presentation, I will discuss research investigations carried out by my research group at the University of New Mexico on developing a new generation of polymers, polymer concrete, and polymer composites that are nanomodified and/or 3D-printable with superior performance to mitigate climate change. Three distinct categories of ETs with great potential for impacting our efforts to limit global climate events will be identified, namely, smart materials, additive manufacturing technology, and advanced sensing technology. I will showcase recent advancements of select ETs and their roles in new materials developed to minimize the impacts of global warming, including newly invented nanomodified polymers used to seal abandoned oil wells to prevent methane emission, new nanomodified pultruded rebar and 3D-printed composites with improved performance, super ductile textile reinforced polymer concrete, biopolymer concrete with low carbon footprint, and cognizant fiber reinforced polymer (FRP) composites incorporating artificial intelligence components. Additionally, nanomodified composite joints and viscoelastic dampers will be demonstrated as unique structural features that can enhance the resilience of infrastructure during extreme loading events. I will conclude with a roadmap for the current state and field implementation of ETs in the infrastructure and energy sectors.

Bio

Dr. Mahmoud Reda Taha, PE, is a Distinguished Professor, Regents' Lecturer, and Chairman of the Department of Civil, Construction & Environmental Engineering at the University of New Mexico, USA where he has worked for the past 20 years. He was the founding director of the UNM Resilience Institute. He authored and co-authored more than 370 papers in refereed journals and conference proceedings; he has eleven issued US-Patents and has advised more than 50 students toward their MS and PhD degrees. He is a Fellow of the American Concrete Institute, a Fellow of the American Society of Civil Engineers, Chairman of the ACI Committee on Nanotechnology, Chairman of the ASCE Infrastructure Resilience Division, and Section Editor of ASCE Journal of Materials. He is a licensed professional engineer in the US and Canada, and an entrepreneur. He received his BS (Honors) and MS in Structural Engineering from Ain Shams University, Egypt, and his Ph.D. in Civil Engineering from the University of Calgary, Canada.

Highly Ductile Concrete Materials in Seismic Applications: Transitioning from Component Behavior to System-Level Performance

Matthew J. Bandelt, Ph.D., P.E. Associate Professor
Department of Civil & Environmental Engineering
New Jersey Institute of Technology

Friday, April 7, 2023
2:45pm-3:45pm
Zoom: https://uh-edu-cougarnet.zoom.us/j/94589160391

Abstract

Highly ductile concrete materials known as high-performance fiber-reinforced cementitious composites (HPFRCCS) have been developed to improve the resilience and sustainability of civil infrastructure. To date, proof-of-concept studies on seismic structural applications of these materials has shown improvements in the strength, damage tolerance, and ductility of individual structural components and sub-assemblies. Relatively little, however, is known about how HPFRCCs influence the response of structural systems from seismic ground shaking. This presentation will discuss ongoing research related to the seismic response of building systems using highly ductile concrete materials. First, experimental data of reinforced HPFRCC members will be presented to highlight the unique structural response and failure characteristics of HPFRCC components. Then, computational modeling approaches to predict the behavior of HPFRCC elements including collapse. The behavior and design of various archetype structures using these materials will then be presented along with considerations for design of structural systems. Future research directions on developing seismic design criteria for structures utilizing these new materials will be discussed.

Bio

Dr. Bandelt joined the John A. Reif, Jr. Department of Civil and Environmental Engineering at NJIT in July 2015 after serving as a National Science Foundation Graduate Research Fellow at Stanford University. His background and experience are in the behavior and modeling of ductile cement-based materials, performance of recycled aggregate concrete, and durability of reinforced concrete structures. Dr. Bandelt teaches graduate and undergraduate courses in the areas of structural engineering, mechanics, and materials. His research has been supported by the National Science Foundation, the New Jersey Department of Transportation, the Federal Highway Administration, the USDOT Region 2 University Transportation Center, and others. Recent research focus has included: experimental testing and simulation of ductile fiber-reinforced cementitious materials such as ultra-high performance concrete and others, numerical simulation of service life and ultimate limit states of reinforced concrete structures, and behavior of recycled aggregate concrete. Dr. Bandelt is a licensed professional engineer (PE) in New Jersey and Pennsylvania, and is heavily involved in the American Concrete Institute, holding voting positions on numerous committees.

AFM-Based Mechanical Characterization of Nanomembranes

Yifan Rao, PhD Candidate
Department of Aerospace Engineering & Engineering Mechanics, The University of Texas at Austin

Friday, April 14, 2023
2:45pm-3:45pm
Classroom Business Building (CBB) - Room 104
Zoom: https://uh-edu-cougarnet.zoom.us/j/94589160391

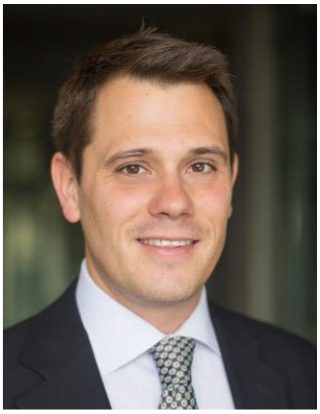
Abstract

Nanomembranes are slender structures with a nanoscale thickness (from a few ångströms to a few hundred nanometers) and with a giant aspect ratio (i.e., lateral size is 2~3 orders of magnitude greater than thickness). The category of structures has aroused tremendous research interest as the principal building block of basically all living organisms, micro-/nano- electromechanical systems (MEMS/NEMS), and epidermal/implantable bio-electronic/photonic devices. For the application of nanomembranes in nanotechnology, it is essential to develop research to characterize the interfacial (adhesion strength and slippage ability) or mechanical (Young's modulus, Poisson's ratio, and bending stiffness) properties of nanomembranes. In the talk, I will start with recent advances in state-of-the-art measurements of nanomembranes based on the atomic force microscopy (AFM) technique, including bulge testing, spontaneously formed blister testing, and nanoindentation testing. Next, I will discuss several recent studies on AFM-based nanomembrane characterization: 1) Shape characteristics of 2D crystal blisters. At 2D crystal interfaces, we observed a unique pattern where satellite nanoblisters surround a parent microblister. AFM revealed that the blister shape transits from self-similar to size-dependent as its base radius decreases. We theoretically explained that the blister shape characteristics are governed by 2D crystal behaviors (membrane vs. plate) and interface behaviors (Griffith type vs. cohesive zone type). By conducting coarse-grained molecular dynamics (CG-MD) simulations, we verified the significance of the size of the process zone of van der Waals (vdW) interactions between 2D crystals and substrates in small sized blisters. We also found a limiting blister height corresponding to one molecular layer of confined substances through CG-MD simulation results, suggesting a transition of confined substances' phases from the liquid state to the monolayer-lattice state. 2) Nanoindentation of freestanding nanomembranes. Extracting precise knowledge of the shear stress between nanomembranes and substrates from the AFM based nanoindentation data is challenging. For this purpose, we established a theoretical model including the AFM-tip/nanomembrane and the nanomembrane/supporting-substrate interactions. Theoretical studies found that the influence of the AFM tip vanishes when tailoring the deflection of nanomembranes in nanoindentation measurements. I will conclude the talk with challenges and perspectives on the mechanical characterization of nanomembranes.

Bio

Yifan Rao is a Ph.D. candidate in engineering mechanics, at the University of Texas at Austin (UT Austin), working under Professor Nanshu Lu. Her research interests are in the mechanics of nanomembrane characterization, assembly, and application. Throughout her dissertation, she investigates how blistering occurs in a wide range of nanoscale films, including ultra-stiff and ultra-soft films. She addresses the following key questions: 1) how wettability affects blister shape and size? 2) how to bridge the gap between the blister model based on film/substrate molecule interactions and that based on the adhesion strength of film/substrate interfaces? The findings benefit the metrology of interfacial properties and nanomembrane properties, as well as the strain engineering of nanomembranes. She is currently working on probe measuring and manipulating nanomembranes/nanoblisters to explore potential applications. For the past four years, Yifan Rao has taught seminars in two undergraduate-level courses: Statics and Mechanics of Solids. She organized the Lu research group activities in Explore UT, which are open to the general public. Her research has been published in, among others, Journal of the Mechanics and Physics of Solids, International Journal of Solids and Structures, Matter, and Nature Communications. She has two papers forthcoming in Journal of the Mechanics and Physics of Solids and Chemical Reviews. Prior to arriving at UT Austin, Yifan Rao holds B.S. and M.S. degrees in engineering mechanics from Tongji University, China.

SOIL-STRUCTURE INTERACTION IN ENERGY PILES IN CHALLENGING SOIL DEPOSITS



John S. McCartney, Ph.D., P.E., F.ASCE, Professor and Department Chair
Department of Structural Engineering University of California San Diego

Friday, April 21, 2023
2:45pm-3:45pm
Classroom Business Building (CBB) - Room 104
Zoom: https://uh-edu-cougarnet.zoom.us/j/94589160391

Abstract

Drilled shaft foundations with embedded geothermal heat exchangers (energy piles) have gained attention by employing the same materials to provide structural support and improve the energy efficiency of building heating and cooling systems. Data from two case histories of instrumented energy piles beneath buildings in Colorado will be presented, focusing on their thermo-mechanical and thermal performance. The results from the case studies indicate that there are no adverse effects of heat exchange on the performance of drilled shaft foundations in heavily overconsolidated soils or rock, confirming that energy piles are a sustainable solution for new building construction. Challenging issues that could not be evaluated in field case studies were investigated in a series of centrifuge model experiments, which were used to calibrate a thermo-mechanical load-transfer analysis that can be used for the thermo-mechanical design of energy piles. These include energy piles in soft clay, where heat transfer leads to soil volume change and an increase in pullout capacity, and energy piles in unsaturated soil layers, where coupled heat transfer and water flow lead to an increase in axial capacity. The presentation will conclude with a summary of future research needs for incorporating geothermal heat exchangers in civil engineering infrastructure.

Bio

John S. McCartney is a Professor in the Department of Structural Engineering at UCSD, where he also serves as Department Chair. He received BSCE and MSCE degrees from the University of Colorado Boulder and a PhD degree in civil engineering from the University of Texas at Austin. Dr. McCartney's research interests include unsaturated soil mechanics, geosynthetics, and thermally active geotechnical systems like energy piles. He has received several research awards, including the R.M. Quigley award from CGS in 2020, Walter L. Huber Civil Engineering Research Prize in 2016, the J. James R. Croes medal from ASCE in 2012, the DFI Young Professor Award in 2012, the NSF Faculty Early Development (CAREER) Award in 2011, and the IGS and Young IGS Award from the International Geosynthetics Society in 2018 and 2008, respectively. He is currently the Past-President of the International Geosynthetics Society-North America Chapter (IGS-NA). He is an Editor of the Journal of Geotechnical and Geoenvironmental Engineering and Computers and Geotechnics and is on the editorial boards of several other journals. Homepage: http://mccartney.eng.ucsd.edu.

Future Floods and Changing Flood-producing Mechanisms Across the Delaware River Basin

Ning Sun, Senior Scientist
PNNL

Friday, April 28, 2023
2:45pm-3:45pm
Classroom Business Building (CBB) - Room 104
Zoom: https://uh-edu-cougarnet.zoom.us/j/94589160391

Abstract

Analysis of historical flow records across the Delaware River Basin (DRB) revealed considerable variability in flood characteristics and flood seasonality across the basin, highlighting the complexity and diversity of underlying flood-producing mechanisms. Despite the critical implications for coastal flood adaptation development, future flood hazards and how flood mechanism may change across the hydroclimatic gradients of DRB are not yet well understood. As part of the Integrated Coastal Modeling (ICoM) project, this talk will present a flood attribution analysis through process-based modeling of the DRB hydrological system, which provides physical consistency between the upstream hydrometeorological processes and each consequential flood event. Flood mechanisms are determined for each sub-basin of DRB among the following classes: snowmelt, rain-on-snow (ROS), and short and long rainfall that are further classified by dry/wet antecedent soil moisture condition. The outcomes of this research suggest changing spatial patterns of flood vulnerability in future climate due to a shift of dominant FPM that is most pronounced for historically ROS-dominated areas. Changing soil moisture in response to changing climate also plays an important role in modulating rain-induced flood characteristics.

Bio

Dr. Ning Sun is a senior scientist in the Earth System Science Division of the Energy & Environment Directorate at the Pacific Northwest National Laboratory (PNNL). She is specialized in multi-scale hydrological modeling in the context of changing climate and extreme events, combined with human-induced perturbations such as land use and land cover change and reservoir operations. Before joining PNNL, Dr. Sun earned her Ph.D. in the State University of New York College of Environmental Science and Forestry. Her PhD research focused on urban hydrology and modeling green infrastructure in mitigating urban sewer overflows. She then joined University of Washington Civil and Environmental Engineering as a postdoc, working on modeling of urban hydrology and water quality. At PNNL, she is a lead developer of regional hydrological model (Distributed Hydrology Soil Vegetation Model, DHSVM). She also leads several projects and project tasks focused on modeling and attribution analysis of extreme events, such as flood including coastal compound floods, and drought.