Minisymposia Summary

Topics:
A. Health monitoring / sensing / resilience (MS 001 - 020)
B. AI-ML-data driven modeling / testing (MS 021 - 036)
C. Cementitious / pavement / wood / bio-inspired materials (MS 037 - 050)
D. Structure stability / design / construction (MS 051 - 062)
E. Probabilistic methods / risk / uncertainty quantification (MS 063 - 073)
F. Wind / fire / flood / environment (MS 074 - 080)
G. Dynamics (MS 081 - 086)
H. Inelastic behavior of materials / multiscale modeling (MS 087 - 092)
I. Poromechanics / Geomechanics / Granular mechanics (MS 093 - 097)
J. Computational mechanics (MS 098 - 100)
K. Engineering education (MS 101 - 102)
L. Industry (MS 103)

MS 001. Smart Sensing and Artificial Intelligence for Advanced Civil Infrastructure Monitoring and Management

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Civil infrastructures that form the backbone of urban and rural communities, such as bridges, buildings, roads, railways, dams and levees, ports, transmission towers, etc., serve under continuous operational and environmental stresses, sometimes facing extreme hazardous loads. These factors contribute to deterioration and damage that can disrupt their intended services and potentially compromise public safety. Recently, smart sensing, accompanied by artificial intelligence (AI), has played a critical role in monitoring the integrity of civil infrastructures, supporting essential decision-making aimed at detection, diagnosis, and prognosis of infrastructure health conditions.

In recent years, we have witnessed significant advancements in smart sensing technologies, including wireless IoT sensors, mobile sensing, edge computing, cloud-based management. These innovations are further empowered by advanced signal processing, AI, and data science. Examples include artificial intelligence of things (AIoT), lightweight SHM systems, wireless large-area sensors for fatigue crack detection, agile sensing system for capturing sudden events, edge/cloud computing for sensor data anomaly detection, along with technologies designed to facilitate easy deployment and maintenance for practicing engineers, among others.

The objective of this mini-symposium is to foster discussions on the latest advancements in smart sensing and artificial intelligence for civil infrastructure health monitoring and management. Research involving real-world smart sensing applications is especially welcome. Topics of interest include, but are not limited to, visual data analytics, edge computing, energy harvesting, digital signal processing, sensor autonomous operations, sensor fault diagnosis and recovery, multimodal data fusion, mixed reality, structural damage diagnosis and prognosis, and predictive maintenance.

MS 002. Repurposing Urban Data Streams for Scalable Infrastructure Monitoring

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Aging infrastructure presents mounting challenges for modern societies, driven not only by physical deterioration but also by persistent gaps in structural response data and condition assessment. These blind spots heighten the risk of catastrophic failures and unexpected service disruptions, while deepening the infrastructure funding gap. Scalable monitoring of civil infrastructure is therefore essential for early warning, informed decision-making, and building resilience in a changing climate. Yet conventional monitoring systems, such as cameras and wireless sensor networks, are difficult to scale across cities due to their high costs, power demands, storage needs, and maintenance requirements. As urban areas expand, these limitations hinder the feasibility of large-scale deployment.

To overcome these challenges, researchers are increasingly repurposing vast data streams generated by existing urban systems, originally designed for transportation, utilities, and security, as unconventional yet powerful resources for assessing structural conditions. This special session will explore advances in harnessing such multimodal data for scalable, cost-effective bridge and network monitoring. The session will highlight diverse sensing approaches, including:

- Connected vehicles (e.g., vehicles equipped with sensors)
- Mobile devices (e.g., smartphones, wearables)
- Remote sensing (e.g., satellites)
- Stationary cameras (e.g., CCTV)
- Distributed fiber-optic sensing (e.g., existing fiber-optic cables)

Speakers will discuss algorithmic, integration, and governance challenges while identifying opportunities for cross-community collaboration.

MS 003. Robotics and automation for SHM and construction management

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Various robots and robotics have demonstrated great potential to solve challenging problems as automated systems in structural health monitoring (SHM) and construction management, leveraging advanced systems like UAVs, UGVs, swarm robotics, and cobots to enable precise, contactless inspections and efficient construction processes for civil infrastructure, including bridges, tunnels, and high-rise buildings. By integrating vision-based SHM, nonlinear ultrasonics, and reinforcement learning, these technologies enhance autonomous damage detection, lifecycle management, and sustainable construction practices in complex and hazardous environments. Key subtopics include:

- Intelligent Inspection Robots for Damage Detection: AI-driven robots for autonomous identification of cracks, corrosion, and structural anomalies in hard-to-access areas.
- UAVs and UGVs for Remote Monitoring: Drones and ground vehicles equipped with LiDAR and ultrasonic devices for real-time SHM in submerged or extreme environments, such as offshore structures.
- Robotic Systems for Advanced NDE: Automated platforms utilizing nonlinear ultrasonics and acoustic emission for high-resolution internal defect detection.
- Sustainable Robotic SHM Solutions: Energy-efficient robots with bionics-inspired designs for long-term, eco-friendly monitoring of infrastructure.
- Cobots and Humanoids for Construction Tasks: Collaborative robots for rebar tying, assembly, and welding, addressing labor shortages and enhancing site safety.
- AI-Enhanced Modular Construction Robotics: Automation for prefabrication and 3D printing, optimizing precision and reducing waste in modular building projects.
- Drones and Swarm Robotics for Site Management: Aerial and multi-agent robotic systems for surveying, progress tracking, and hazard mitigation, integrated with BIM for real-time insights.

Keywords: Robotics; Cobots and Humanoids; Automation in Construction; Infrastructure Inspection; Structural Health Monitoring

MS 004. Computer vision and vibration-based damage identification using machine and deep learning

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Advances in machine and deep learning are transforming structural health monitoring (SHM) of civil infrastructure such as bridges, buildings, tunnels, dams, and pipelines. This mini-symposium will explore recent breakthroughs in two complementary domains: vibration-based methods and computer vision. For vibration-based damage identification, emerging techniques in unsupervised learning, physics-informed models, and multi-sensor fusion enable automated, high-precision anomaly detection while addressing challenges such as environmental noise, limited labeled data, and real-time processing demands in safety-critical systems. In parallel, computer vision—augmented by deep learning—has become a powerful tool for automated damage assessment. Recent innovations in 3D LiDAR, depth sensing, and AI-driven image analysis are advancing crack detection, corrosion monitoring, and defect recognition across complex structures. By integrating predictive modeling, automated data processing, and scalable analytics, these approaches are reshaping SHM, enhancing disaster resilience, and improving long-term infrastructure management. Key subtopics include:

- Unsupervised / Semi-Supervised Learning & Anomaly Detection
- Physics-Informed Neural Networks (PINNs)
- Transfer Learning & Domain Adaptation
- Data Augmentation / Synthetic Data Generation
- Quantification: Severity, Location, Remaining Life
- Handling Environmental and Operational Variability
- Explainable AI (XAI) for Vibration Insights
- Multi-Sensor Fusion with Deep Learning
- Edge Computing and TinyML for Real-Time SHM
- Various GANs for Vibration Visual Data Augmentation
- Instance/Object Detection and Segmentation for Structural Damage
- 3D Vision, Depth Estimation, and Multi-View Reconstruction for Quantification
- Attention Mechanisms, Transformers, and Hybrid Architectures
- Real-Time, Edge, and Lightweight Models
- Quantification and Metrics of Damage
- Data Augmentation, Synthetic Data, and Domain Adaptation
- Automated Post-Disaster Assessment

MS 005. Advances in bridge health monitoring: Data-driven and machine learning methods, indirect monitoring, crowdsourced mobile sensing

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Vibration-based bridge condition assessment and monitoring are crucial for the efficient functioning and maintenance of transportation infrastructure. Conventional condition assessment usually occurs offline and relies on human visual inspection that cannot detect subtle changes in performance. Development of efficient schemes for response sensing, monitoring, modal identification, and life cycle assessment has recently witnessed immense interest. This helps asset engineers and public infrastructure owners initiate early countermeasures to avoid service disruption and structural failure. However, such techniques are still not an integral part of the bridge inspection, monitoring, and maintenance protocols, especially due to implementation challenges, limited field validation, and significant deployment and maintenance costs of dedicated fixed sensor networks.

This minisymposia deals with the theoretical and computational issues related to bridge health management and prognostics using robust real-time monitoring algorithms, crowdsourcing applications, citizen science, and indirect sensing approaches. The expected attendance of key players from both the development and application areas will offer a comprehensive commentary on recent advancements that will shape the future of bridge monitoring and ensure the development of smart and resilient transportation infrastructure networks.

Topics of interest include but are not limited to: (a) Crowdsourced mobile sensing techniques for bridge monitoring and modal identification; (b) Indirect monitoring methods - drone, UAV, satellite, camera-based, and remote sensing; (c) Applications of machine learning methods for use of sensing data for bridge monitoring; (d) Real-time bridge monitoring through machine learning, AI, and Internet of Things (IoT); and (e) Robustness of monitoring techniques towards operation and environmental conditions. Contributions that demonstrate field implementations, case studies, applications, and experimentation are particularly welcomed.

MS 006. Digital twins for SHM and infrastructure management

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This mini-symposium will advance theories and methods used for the creation, development, and application of digital twins for infrastructure systems, ranging from engineering and management of construction to life-cycle assessment and structural health monitoring (SHM). By integrating design and as-is conditions of a physical asset at a reasonable frequency, digital twins facilitate precise construction monitoring, condition assessment, and performance forecasting in support of sustainable and resilient infrastructure systems. The symposium will convene researchers, engineers, and industry leaders to present innovative methods, share case studies, and address challenges in scaling digital twin technologies for complex engineering systems. The goal of the session will be to establish current capabilities and help identify a road map for future research needs. Key topics will include 3D computer vision and reality mapping, AI-driven analytics, integration of physics-based models with real-time data, and long-term decision support systems.

Key subtopics include:

- Digitization, data modeling, interoperability & standards for twinning 2D and 3D design with as-is condition data
- 3D computer vision and reality mapping including NERF and Gaussian Splatting
- Geometry informed defect detection and characterization
- Physics-based models updated with real-time data
- AI-enhanced twins with AR/VR for monitoring infrastructure in harsh climates, such as offshore or seismic zones.
- Predictive data analytics
- New cloud architectures for digital twin platforms
- VR/AR for Construction Monitoring and Condition Assessment and Training: Immersive technologies for real-time structural visualization and workforce training in construction and SHM.
- Digital Twins for modular & reusable construction / Circular Economy
- Operational cost, scalability, practical deployment barriers

MS 007. Advances in Computer Vision, Deep Learning, & Artificial Intelligence for Structural Monitoring, Inspections, and Digital Twins

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This minisymposium invites contributions on the role of computer vision, deep learning, and AI in structural health monitoring (SHM), alongside advances in sensors, robotics, and digital twins. These technologies enhance traditional SHM, inspections, and nondestructive evaluation (NDE) methods. Topics include vision-based damage detection and assessment, robotics and sensors integration, synthetic data for training, AI, large and multi-modal models, virtual reality (VR) and augmented reality (AR), and digital twin development for condition assessment.

Vision-based damage detection and assessment leverage computer vision to detect visual damage and recover mechanical signals from deforming structures, enhancing SHM and NDE by enabling damage segmentation and quantification for digital twins. Robotics integration with vision-based SHM, including UAVs, UGVs, and swarm robotic systems, facilitates contactless, detailed inspections in complex environments. Advanced imaging techniques, such as 3D LIDAR and depth sensors, enable detailed scene reconstruction and structural analysis. Synthetic data generation and computer graphics simulations support structural identification, damage localization, and algorithm pre-training. AI, including large language models (LLMs), Vision-Language Models (VLMs) and multi-modal models, enhances SHM through advanced data interpretation, integrating text, imagery, and sensor data for robust decision support. VR, AR, and MR technologies provide immersive platforms for inspection, monitoring, and training, enhancing interaction between robotic systems and the built environment. Digital twin development, using techniques like Structure-from-Motion (SfM) and Building Information Modeling (BIM), enables real-time monitoring, performance forecasting, and predictive maintenance, offering a comprehensive approach to managing the health of civil infrastructure.

MS 008. Advances in AI-enabled Approaches, Robotic Inspection, and Smart Sensing for Civil Infrastructure

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Civil infrastructure faces growing demands for safety, resilience, and sustainability. Nevertheless, inspection and monitoring practices often remain labor-intensive, reactive, and costly. Emerging developments in artificial intelligence (AI), robotics, and smart sensing offer new opportunities to transform the way engineers assess, maintain, and manage critical assets. Robotic inspection platforms, such as UAVs, enable automated data collection in challenging environments, while self-powered sensors extend monitoring capabilities without increasing maintenance demands. Human-centered and generative AI tools further enhance condition assessment by improving accuracy and explainability, enabling inspectors and decision-makers to extract more actionable insights from multimodal data. These innovations are valuable not only for prognostic evaluation and routine management, but also for applications such as post-disaster recovery, where rapid inspection and practical guidance are crucial for restoring functionality and ensuring public safety. This mini-symposium highlights methods that make infrastructure inspection and monitoring smarter, more autonomous, and more effective for engineers and decision-makers. Relevant contributions are welcome including but not limited to:

- Advances in structural health monitoring self-powered sensing techniques
- Computer vision and robotic inspection methods for buildings, bridges, tunnels, and marine structures
- Generative AI for automated structural condition assessment and prognostic evaluation
- Copilot or human-centered AI for resilient infrastructure and post-disaster relieving
- Digital twin creation and updating from robotic and sensor data
- Data assimilation and hybrid physics–driven AI models

MS 009. Energy harvesting and intelligent sensing for sustainable structural health monitoring

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This mini symposium aims to bring together researchers working on the integration of energy harvesting technologies, smart sensing systems, and structural health monitoring (SHM) toward the development of self-powered and sustainable monitoring solutions for infrastructures.

Continuous SHM is essential for ensuring the safety and serviceability of critical structures. However, long-term monitoring often faces challenges related to power supply, maintenance, and data management. Energy harvesting offers a promising route to achieve autonomous operation of distributed sensing systems, while artificial intelligence (AI) and data-driven analytics enable efficient signal interpretation, anomaly detection, and decision support for condition assessment and damage diagnosis.

This session will emphasize recent advances in energy harvesting-enabled sensors, low-power wireless monitoring systems, and AI-assisted modeling or prediction approaches for assessing structural integrity. Contributions that address both fundamental mechanisms and practical implementations are highly encouraged.

Topics of Interest include but are not limited to:

- Energy harvesting mechanisms for SHM (piezoelectric, electromagnetic, triboelectric, photovoltaic, etc.)
- Self-powered sensing and wireless sensor networks
- Sustainable monitoring and maintenance strategies
- Low-power electronics and embedded data processing
- Structural diagnostics and damage detection
- Model-based and data-driven approaches for signal interpretation
- Multifunctional and adaptive sensing materials
- Integration with digital twin or life-cycle assessment frameworks
- Applications in civil, mechanical, and aerospace systems

MS 010. Digital Twin and AI Innovations in Smarter Civil Infrastructure Monitoring and Management

Yuguang Fu[1], Yasutaka Narazaki[2], Kareem Eltouny[3], Wenjun Cao[4]

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Critical civil infrastructure, encompassing bridges, roads, railways, dams, and power networks, forms the essential backbone of modern communities, yet faces persistent threats from operational demands, environmental stresses, and extreme hazard events. These challenges drive progressive deterioration that compromises structural integrity, disrupts vital services, and elevates public safety risks. In response, the emergence of the Digital Twin (DT) paradigm is fundamentally transforming infrastructure management practices. With bi-directional interactions with physical twins, digital twins can diagnose the current state of civil structures, predict their future performance, and make real-time decisions on future operations based on the information provided by the data.

Recent advances demonstrate significant progress in structural health monitoring, where AI-enhanced Digital Twins are enabling new capabilities for predictive maintenance and lifecycle management. Key developments include self-evolving digital replicas that continuously learn from operational data to improve forecasting accuracy, and cognitive maintenance systems that autonomously schedule interventions based on AI-driven risk assessments. These innovations are being implemented in bridge network management platforms that optimize inspection resources through predictive analytics, and in urban infrastructure systems that simulate real-time response to environmental changes. The convergence of Digital Twin with AI is proving particularly valuable for portfolio-level asset management, where these technologies support data-driven decision making across multiple infrastructure systems, enhancing both operational efficiency and long-term resilience while providing engineers with actionable intelligence for sustainable infrastructure stewardship.

The objective of this mini symposium is to foster discussions on the latest research and engineering applications at the intersection of Digital Twins and AI Innovations for civil infrastructure health monitoring and management. We aim to explore how these technologies are being integrated to create smarter, more resilient, and self-aware infrastructure systems. Topics of interest include, but are not limited to, AI-powered monitoring systems, digital twin development, distributed computing architectures, multi-source data integration, model calibration/updating, structural condition assessment, proactive maintenance strategies, immersive visualization interfaces, infrastructure resilience modeling, as well as supporting and decision-making optimization for maintenance and management. Research involving real-world implementations and validated case studies is particularly encouraged, e.g., digital twins for bridges, tunnels, buildings, and dams.

MS 011. Advanced Computing for the Resilience of Networked Critical Infrastructure Systems

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Networked critical infrastructure systems, also known as lifelines, including systems such as transportation, power, and water networks, are essential not only for supporting daily societal functions but also for enabling effective disaster response and recovery. While these systems share similarities of large-scale, interdependent networks, they also exhibit distinct characteristics and governing constraints shaped by their specific functions. Addressing these challenges demands advanced computational methods that can capture complexity, manage uncertainty, and support robust, data-driven decision making.

This mini symposium aims to foster interdisciplinary discussions on recent advances in sensing, modeling, and decision-making to assess and enhance the resilience and intelligence of such networked systems, either individually or in the form of system of systems. We invite contributions highlighting innovations in artificial intelligence and machine learning, quantum computing, uncertainty quantification, network science, digital twins, system modeling, and related fields, with applications across the broad spectrum of critical networked infrastructure.

Topics of this session include but are not limited to:

- Advancements in large-scale network sensing and surveillance.
- Methods for modeling and quantifying hazard impacts on networked systems.
- Innovative modeling of flow behavior within infrastructure networks.
- Digital twins and cyber-physical systems for critical infrastructure systems.
- Advanced decision-making algorithms for system's preparing for, responding to, and recovering from emergencies.
- System design and planning for mitigating and adapting to future hazards.

MS 012. Objective Resilience: Advancing Multi-Hazard Physical-Socio-Economic Community Resilience using Physics- and AI-based Modeling and Digital Technologies

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Communities across the U.S. are increasingly exposed to multi-hazard and compounding threats, particularly weather-related hazards (such as wind, storm surge, waves, flood, wind-borne debris, wind-driven rain,), geophysical hazards (such as earthquakes and tsunamis) and other natural and man-made hazards such as wildfires. These hazards amplify the socio-economic consequences for communities, placing greater stress on the built environment and critical infrastructure. In response to these escalating risks, advancing resilience has become imperative. To do so, it is critical to quantify the socio-physical performance of communities, enabling targeted investment in mitigation resources. Achieving this vision requires a new generation of resilience science and tools that leverage physics- and AI-based modeling alongside digital technologies to deliver high-resolution, real-time, and adaptive assessments. These approaches must capture interdependencies across infrastructure, social systems, and economic networks, while also accounting for spatial-temporal hazard variability, non-stationarity, and compounding or cascading impacts (e.g., storm surge combined with waves during hurricanes impacting interdependent community systems or wildfires intensified by wind events). Progress in this area depends on multi-scale quantification of hazard, exposure, vulnerability, risk, and post-hazard functionality, from the building to the system and community level. AI-driven models, immersive visualization, and digital twin ecosystems now open unprecedented opportunities for measuring, predicting, and communicating resilience in ways not possible before.

This session will explore state-of-the-art advances and case studies where digital technology and AI play a central role in resilience quantification, including:

- Multi-Hazard Life-Cycle Resilience and Cost Assessments: Advancing resilience modeling from traditional loss/damage assessment to functional recovery assessment, multi-hazard performance tracking, integrating predictive analytics and uncertainty quantification.
- AI-Enhanced Multi-Disciplinary Modeling and Optimization: Combining socio-economic, physical, and environmental data to reveal interdependencies and optimize recovery strategies.
- Digital Twin & Immersive Applications: Using AI-powered community-scale digital twins, real-time sensing, and visualization to simulate recovery and support decision-making.
- Community Engagement Platforms: Leveraging natural language processing, participatory simulations, and adaptive dashboards to integrate feedback and promote informed planning.
- Case Studies & Policy Integration: Highlighting best practices, lessons from recent disasters, and pathways for embedding science into design standards and policy.

By integrating AI modeling, digital innovation, and community participation into resilience measurement, this session will provide a forward-looking understanding of Objective Resilience. Discussions will emphasize both scientific advances and strategies for embedding these technologies into practice, ensuring that resilience planning, investment, and policy are guided by the best available tools to help communities withstand and recover from tomorrow's hazards.

MS 013. Advances in Digital Twins for Civil Infrastructure

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Civil infrastructure systems, including bridges, buildings, transportation networks, and utility systems, are the backbone of modern society, supporting public safety, economic vitality, and quality of life. Ensuring their resilience, adaptability, and long-term performance requires continuous monitoring, intelligent decision-making, and timely maintenance. In recent years, digital twin technologies have emerged as transformative tools for achieving these goals. By integrating real-time sensing, physics-based modeling, data analytics, and visualization in a dynamic virtual environment, digital twins enable more comprehensive, predictive, and data-driven management of civil infrastructure. Despite promising advancements, challenges remain in scaling digital twin implementations across asset types, integrating heterogeneous data sources, ensuring interoperability, and quantifying uncertainty. This mini-symposium aims to advance the state-of-the-art and practice of digital twins for civil infrastructure by bringing together the latest research on modeling frameworks, sensing technologies, data fusion, simulation techniques, and decision-support systems. Contributions that explore foundational methodologies, frameworks, innovative applications, real-world applied case studies, and cross-disciplinary innovations are especially encouraged.

We welcome contributions on topics including, but not limited to:

1. Emerging data collection and processing technologies for digital twin purposes.
2. Modeling and digitization workflows.
3. Solutions to existing challenges in the scalable and practical implementation of digital twins.
4. Digital twin case studies demonstrating applications to diverse civil infrastructure systems.

MS 014. Multi-Scale Digital Twins for Infrastructure Resilience Monitoring: Overcoming Data Scarcity and Multi-Hazard Degradation

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Infrastructure systems face increasing risks from aging, long-term weather patterns, and cascading multi-hazard events. Yet, decision-making is often constrained by limited data availability and the complex interactions that drive infrastructure deterioration along with human-centered response. Digital twins provide a promising pathway forward, as they are virtual information constructs that mimic the structure, context, and behavior of natural, engineered, or social systems. They are dynamically updated with data from their physical counterparts, possess predictive capabilities, and support bidirectional interaction between physical and virtual systems to inform decisions. As a result, they are emerging as powerful tools for monitoring and managing infrastructure and human-centered resilience.

Extending this concept to a multiscale framework enables the coupling of insights from component-, system-, network and community-level perspectives, which is critical for understanding resilience under complex hazard scenarios. A persistent challenge, however, is data scarcity, particularly the limited availability and uneven resolution of exposure data, infrastructure inventories, long-term monitoring records, and multi-hazard degradation (e.g., the compounding effects of earthquakes, wind, flooding, or aging). These gaps extend beyond physical systems to social exposure and response data, both of which are critical for capturing the full spectrum of resilience. Current artificial intelligence (AI) and machine learning (ML) approaches often require large datasets, limiting their immediate applicability to structural monitoring, collective human response, and risk assessment. This mini-symposium will focus on bridging this gap by exploring novel methods for data-efficient digital twins, including but not limited to:

- Digital twin-enabled resilience and cascading impact assessment.
- Fusion of heterogeneous sources (satellite and UAV imagery, crowdsourced data, structural health monitoring, physics-informed modeling).
- Multi-hazard modeling enhanced by AI/ML approaches to improve predictive accuracy in the face of uncertainty.
- Adaptive ML/DL models for sparse datasets.
- Practical applications for infrastructure resilience monitoring and recovery planning.
- Exploration of human-centered resilience models that can capture social capital and collective adaptive response.

By bringing together advances in digital twin theory, AI/ML, and practical monitoring applications, this mini-symposium aims to bridge foundational research gaps with actionable strategies for enhancing infrastructure and human-centered resilience under compounding hazards, supporting not only faster recovery but also stronger community-level adaptation in the face of future risks.

MS 015. Digital and sensing technologies for smart monitoring of infrastructure and buildings

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The rapid advancement of machine learning, computer vision, and sensing technologies is redefining how civil infrastructure is designed, constructed, and maintained. The integration of intelligent sensing, real-time data processing, and autonomous systems is enabling new paradigms in infrastructure monitoring and management, enhancing both efficiency and sustainability. These developments are driving the transition toward smarter and more resilient built environments through proactive, data-driven decision-making and automated interventions.

This mini-symposium focuses on recent progress and emerging multidisciplinary approaches in sensing, monitoring, digitalization and modeling for civil infrastructure and buildings. It aims to bring together researchers working at the intersection of structural engineering, sensing technologies, and artificial intelligence to explore methods that enhance performance, safety, and sustainability throughout the infrastructure lifecycle. Topics of interest include, but are not limited to, advanced sensing technologies and nondestructive evaluations; sensing data processing, integration, model updating, and digital twins; vision-based and data-driven damage assessment; extended reality and autonomous robotic inspections; 3D modeling of the built environment (semantic understanding and reconstruction); machine learning models for diagnostics, prognostics, and predictive maintenance.

MS 016. Decision-making towards resilience on complex, uncertain, and evolving socio-physical systems

Raul Rincon[1], Jamie E. Padgett[1], Mauricio Sanchez-Silva[2], Leonardo Duenas-Osorio[1], Dan M. Frangopol[3]

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Management decisions seek to prevent loss of infrastructure system functionality caused by progressive damage (e.g., due to aging and deterioration) or impacts from natural hazards, while keeping the operational costs and safety within acceptable ranges. Infrastructure management needs to consider the uncertain and evolving conditions during the infrastructure's lifetime, imposed due to other factors such as climate change, variations in population demographics, and technological shifts that drive changes in how users utilize and depend on the system. This mini symposium explores the new developments in formulation, algorithms, and computational modeling for understanding, designing, and operating infrastructure systems. To this end, this session discusses how dynamic decision-making has become a central approach for dealing with the pressures imposed by such evolving environments. Emphasis is given to methods that jointly integrate physical, social, and environmental risks during policy- and decision-making directed towards resilient and more equitable system performance. With relevance for regional-scale infrastructure systems, this session probes the benefits, strategies for implementation, and challenges of implementing adaptive management in complex systems (i.e., of networked systems, or systems-of-systems). Metrics capable of tracking the unequal infrastructure performance across diverse users (or sectors) are of interest for driving decision-making in these complex systems. We expect this mini symposium to promote and advance the analytical and computational modeling of management decision frameworks to achieve safer, resilient, and more equitable infrastructure system performance.

MS 017. Learning-Based Structural Health Monitoring Under Limited Damage Data: Adaptation, Transfer, and Unsupervised Approaches

Xiao Liang[1], Kareem Eltouny[2], Jian Li[3]

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[3] The University of Kansas

Structural Health Monitoring (SHM) is vital for ensuring the safety, longevity, and resilience of engineered systems spanning civil, aerospace, and mechanical domains. However, the scarcity of labeled data representing actual damage events remains one of the most persistent barriers to effective SHM model development and deployment. Structures rarely experience repeatable or well-documented damage scenarios, making it difficult to train data-hungry algorithms or validate generalizable diagnostic frameworks. This minisymposium focuses on advancing SHM in the face of limited damage-state data by leveraging innovative learning paradigms such as domain adaptation, transfer learning, and unsupervised learning.

The goal of this session is to bring together researchers and practitioners from diverse disciplines to share theoretical insights, computational methods, and field applications that tackle real-world SHM challenges. We warmly invite contributions that explore how models can learn from limited or unlabeled data, transfer knowledge across structures or environments, and improve robustness under varying operational and environmental conditions. Topics of interest include, but are not limited to:

- Cross-domain generalization
- Adaptive feature representation
- Unsupervised and self-supervised anomaly detection
- Multi-modal fusion under data scarcity
- Population-based and federated SHM strategies
- Physics-informed learning for interpretable and data-efficient diagnostics
- Experimental and field demonstrations validating generalization under real-world uncertainty
- Resilient SHM under extreme events and data loss
- Standardization, benchmarking, and datasets for SHM development

By fostering an open and inclusive environment, the session seeks to encourage dialogue among early-career scholars, established experts, and industry practitioners alike. Through this collaborative exchange, we hope to advance the next generation of learning-based SHM systems that can operate reliably despite limited damage data—paving the way toward practical, scalable, and intelligent infrastructure monitoring solutions.

MS 018. Electromagnetic Sensing and Imaging for Engineering Materials and Structures

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This mini symposium focuses on the theoretical formulation, numerical simulation, and physical experimentation of electromagnetic (EM) sensing and imaging techniques for engineering applications such as remote sensing, nondestructive testing/evaluation (NDT/E), and structural health monitoring (SHM) using ground penetrating radar (GPR) and synthetic aperture radar (SAR). Applicable engineering problems for EM sensing and imaging include but not limited to subsurface steel rebar corrosion inside concrete, subsurface concrete cracking, subsurface delamination in asphalt pavement, underground pipe/pipeline detection, sink hole detection, underground pipe leak detection, concrete hydration monitoring, detection of underground tank leak, and detection of underground water layers using EM waves in the RF spectrum (3kHz to 3,000 GHz).

Applications of different imaging modes in GPR (A-scan, B-scan, C-scan, and D-scan) and SAR (spotlight, stripmap, scan, dwell, inverse, and interferometric) on engineering materials (e.g., concrete, wood, composite, asphalt, soil, rock) and structures are acceptable. Numerical simulation works using the finite element method (FEM), finite difference of time domain (FDTD), boundary element method (BEM), discrete element method (DEM), Method of Moments (MoM), etc. applied to EM sensing and imaging are welcome to submit. Case studies with physical experimentation on laboratory specimens or field structures are also encouraged to submit.

MS 019. High-speed Railroad, Transportation Infrastructure, Lifelines, Structural Health Monitoring, and Management

Fernando Moreu[1], Hoon Sohn[2], Hae Young Noh[3], Jinwoo Lee[2], Yiqing Ni[4]

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This session is directed to the advancement of Structural Health Monitoring (SHM) for railroad infrastructure, railroad operations, AI and railroad engineering, algorithms, theory, modeling, with both freight and High-Speed Railroads (HSR). This session also covers multimodal sensing of highway and critical infrastructure. The session welcomes submissions on new technologies including Internet-of-Things (IoT) and their implementation, evaluation, and deployment. This session will also summarize experiences of railroad operations monitoring, assessing, and/or controlling train behavior and revenue traffic management and safety. Topics of interest include, but are not limited to: (1) understanding and modeling of railroad infrastructure responses induced by normal and unexpected operations; (2) understanding the interface between field data, modeling, simulations, and railroad management; (3) train-rail-infrastructure interfaces and theories in relation to railroad engineering; (4) practical applications on railroad management across the world, with an emphasis on railroad infrastructure including but not limited to rail, track, ballast; (5) analysis of high-speed rail data, behavior; and experience with performance, maintenance, and management; and (6) innovative applications, laboratory studies, and field validation in relation to SHM for railroads and HSR.

MS 020. Advances in Resilience Analytics and Sustainable Infrastructure: Bridging Theory and Practice

Arghavan Louhghalam[1], Aikaterini Kyprioti[2], MJ Qomi[3], Mazdak Tootkaboni[4]

[1] University of Massachusetts Lowell
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[3] University of California, Irvine
[4] University of Massachusetts Dartmouth

As we navigate an ever-changing climate and contend with the increasing frequency and severity of natural disasters, it becomes imperative to fortify our infrastructure against these adversities. This mini symposium will draw together researchers in the field of resilience analytics and quantitative sustainability to discuss state-of-the-art techniques and computational tools developed for assessing sustainability and resilience of engineering structures and infrastructure systems. Specifically, this MS covers latest contributions on developing theoretical, computational and data driven models as well as experimental field measurement and reconnaissance studies quantifying the impact of storms, tornadoes, floodings, hail, heat waves and extended droughts on civil infrastructure (buildings, road pavements, and engineering structures), assessing at the same time their energy efficiency and environmental footprint . Additionally, modeling of complex systems such as cities and transportation networks, incorporation of uncertainty in parameters affecting resilience and environmental footprint, application of big data analytics and AI/ML methods in developing predictive models as well as application of novel sustainable design tools in maintenance and design practices are invited. The MS topics include, but are not limited to, the following:

- modeling structural and non-structural elements
- damage and energy efficiency
- reliability analysis of systems/components
- fluid-structure interaction investigations
- pavement vehicle interaction and sustainability
- real time hazard modeling,
- rare and extreme event risk prediction,
- multi-hazard and/or cascading risk analysis,
- environmental and wind chamber measurements

This Mini-Symposium is sponsored by the EMI Objective Resilience Committee (ORC) and Probabilistic Methods Committee (PMC).

MS 021. Scientific Machine Learning for Computational Geosciences

Arash Fathi[1], Kami Mohammadi[2], Felix Herrmann[3], Somdatta Goswami[4], Kun Wang[1], Marcelo DallAqua[1], Dakshina Valiveti[1]

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[4] Johns Hopkins University

The synergy between scientific machine learning (SciML) and computational geosciences is transforming our approach to forward and inverse problems governed by complex partial differential equations. SciML provides a paradigm to merge measured data with physics, leveraging recent advances in computing hardware to solve parameter estimation problems within practical runtimes. Several formalisms have been proposed in recent literature, and progress in this area is rapidly evolving.

This session brings together experts from various disciplines – including geophysics, seismology, computational geomechanics and dynamics, flow in porous media, geological carbon storage and monitoring. It also engages the broader SciML community to explore cutting-edge methods and real-world applications in this interdisciplinary arena. The goal is to bridge the gap between traditional computational approaches and emerging AI-driven techniques in the modeling and analysis of problems that typically arise in the field of computational geosciences. We welcome contributions that leverage data-driven and physics-inspired machine-learning techniques to enhance the modeling, simulation, and interpretation in this domain. Topics of interest include, but are not limited to:
(1) Neural Operators: Advancements in neural operators, such as Deep Operator Networks (DeepONets) and Fourier Neural Operators (FNO) for efficient and accurate simulations.
(2) Physics-Informed Neural Networks (PINNs): Applications of PINNs in solving forward and inverse problems.
(3) Physics-Guided Generative Models: Leveraging diffusion and flow matching techniques to construct physically consistent models for PDE-governed systems, with emerging applications in probabilistic surrogate modeling and data-driven inference.
(4) Uncertainty Quantification: Developing machine learning methods to quantify, propagate, and mitigate uncertainties across simulations and predictions, thereby enhancing reliability and robustness.
(5) Cross-Disciplinary Applications: Innovative uses of SciML in related fields, such as acoustics and ultrasound imaging, elastodynamics, structural health monitoring, planetary seismology, environmental monitoring, natural hazard assessment, surrogate modeling, and digital twins.

We particularly encourage submissions that demonstrate how SciML techniques developed for computational geosciences can be adapted to, or inspire solutions in, adjacent fields, fostering the exchange of ideas and methodologies. This session provides a dynamic forum for attendees to discuss theoretical developments, share practical experiences, and identify future research directions that transcend traditional domain boundaries. Through these interactive exchanges, we aim to advance the capabilities of computational models and open new potentials in both scientific research and engineering applications.

MS 022. Integration of Physics-based Models with Data for Identification, Monitoring, Estimation, and Uncertainty Quantification

Yang Wang[1], Hamed Ebrahimian[2], Babak Moaveni[3], Haeyoung Noh[4]

[1] Georgia Institute of Technology
[2] University of Nevada, Reno
[3] Tufts University
[4] Stanford University

The goal of the minisymposium is to collect research and application studies that focus on integrating physics-based models with data for model updating, identification, estimation, and uncertainty quantification. Physics-based models often include unquantified uncertainties in forward simulation results associated with model class, model parameters, and/or model uncertainties. Infusing models with real-world measurement data provides the possibility to estimate the unknown model parameters and quantify the estimation uncertainties. To this end, we invite a diverse group of researchers and stakeholders working on this topic, including application practitioners, sensor experts, data scientists as well as researchers from computational mechanics fields. With such cross-domain experts, we aim to share the latest development and innovation in the topic area, as well as spur cross-domain discussions to generate ideas and directions for the next decades.

Topics relevant to this minisymposium are listed below. The minisymposium invites application from a wide-range of engineering and scientific fields including but not limited to Structural, Geotechnical, Mechanical, and Bio-Mechanical fields. Research studies that address experimental investigations and validation of theories or analytical approaches are especially welcome.

- Finite element model updating
- Data fusion
- Physics-informed machine learning
- Inverse modeling
- Model parameter estimation
- Data assimilation
- Bayesian inference for health monitoring
- Damage diagnosis and prognosis
- System identification
- Uncertainty quantification
- Service life prediction

MS 023. Towards Autonomous Resilience: Generative AI and Agentic Workflows for Infrastructure Systems

Debasish Jana[1], Jingxiao Liu[2], Furkan Luleci[3], Liangfu Ge[4], Valentina Giglioni[5], Zhenkun Li[6]

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[3] Louisiana State University
[4] Hong Kong Polytechnic University
[5] University of Perugia
[6] Aalto University

Civil infrastructure faces mounting risks from natural hazards such as wildfires, floods, landslides, and earthquakes, yet our ability to anticipate and monitor these threats remains constrained by data scarcity, fragmented sensor coverage, and the high cost of conventional monitoring systems. These blind spots increase vulnerability to cascading failures and slow, reactive decision-making. Traditional hazard models and inspection-based monitoring approaches, while valuable, struggle to keep pace with the scale, complexity, and dynamism of modern infrastructure systems.

Recent advances in generative artificial intelligence offer a transformative pathway forward. Deep generative models can synthesize high-fidelity hazard scenarios to augment limited datasets and stress-test resilience strategies. Large language models (LLMs) enable decision-making pipelines that integrate heterogeneous inputs—ranging from structural sensor networks and inspection logs to hazard forecasts and social data—while vision-language models (VLMs) extend this capacity to multimodal monitoring, aligning UAV, satellite, and ground imagery with semantic reasoning for damage detection and interpretation. A further paradigm shift comes from agentic AI, which leverages autonomous, goal-driven agents to couple generative reasoning with adaptive workflows for real-time hazard mapping, resource allocation, and prescriptive maintenance.

This special session will explore advances in generative AI and foundation models for hazard estimation and infrastructure monitoring. Topics will include:
1) Generative models for synthetic hazard simulation and resilience analysis
2) LLMs for decision support and risk-informed planning
3) VLMs for multimodal structural monitoring and interpretation
4) Agentic AI frameworks for adaptive, automated workflows in disaster and infrastructure management

Speakers will discuss algorithmic, integration, and governance challenges, highlighting opportunities for cross-disciplinary collaboration to build scalable, trustworthy, and adaptive resilience solutions.

MS 024. Experimental Mechanics in the Age of Big Data: Design, Sensing, and Integration

Yiwen Dong[1], Kostas Kalfas[2], Mehrdad Aghagholizadeh[3]

[1] University of Illinois, Urbana-Champaign
[2] Texas State University
[3] Loyola Marymount University

This mini-symposium addresses the paradigm shift in experimental mechanics driven by the confluence of advanced sensing technologies, Big Data, and the rise of the Digital Twin. As the complexity and scale of experimental data grow, a rigorous, first-principles approach to the design of experiments (DOE) is more critical than ever for generating reliable and impactful insights. We invite contributions that explore the frontiers of experimental methodology for physical structures, related to any of the three core pillars: (1) Design: Novel application of formal experimental design principles (e.g., factorial, adaptive, human-centered) for material, component, and system-level testing to ensure statistical rigor and repeatability. (2) Sensing: Deployment and validation of innovative instrumentation, including vibration sensors, strain gauges, distributed fiber optics, non-contact optical methods, wireless sensor networks, and UAV-based remote sensing, for high-fidelity data acquisition. (3) Integration: Methodologies for the fusion of heterogeneous data streams, physics-guided machine learning for real-time data interpretation, and the integration of physical testing with computational models to create robust Digital Twins. This symposium will provide a unique forum for researchers dedicated to advancing the foundational art and science of how we plan, execute, and learn from physical experiments in engineering mechanics.

MS 025. AI and Machine Learning for Risk, Uncertainty, and Resilience Assessment of Structural and Infrastructure Systems

Milad Roohi[1], Mohsen Zaker Esteghamati[2], Doeun Choe[3], John van de Lindt[4]

[1] University of Nebraska–Lincoln
[2] Utah State University
[3] New Mexico State University
[4] Colorado State University

Artificial Intelligence (AI), along with its subfields of Machine Learning (ML), Deep Learning (DL), Generative AI, and, more recently, Agentic AI, employs a combination of statistical methodologies and advanced computational techniques to analyze, process, interpret, and translate complex data into actionable insights. While their robust mathematical foundations enable the measurement and quantification of uncertainties in modeling and decision-making for engineering systems, a key limitation of uncertainties from AI methods remains in the aggregated nature of these uncertainties, which can reduce flexibility across applications. Among a few other persistent challenges, the field still faces the well-recognized deficiency of lacking sufficient physical insight in managing various structural and infrastructure systems. This mini-symposium focuses on cutting-edge research that addresses limitations in current AI developments to improve the resilience and management of infrastructure systems. It seeks the fundamental developments and application of AI and its subfields to advance our understanding of uncertainty, risk, and reliability assessment at various levels (e.g., system, components).

Topics of interest include, but are not limited to:
i) Structural and Infrastructure System Reliability Prediction: Applying ML and DL algorithms to predict the reliability and performance of different structural and infrastructure systems/components under varying conditions.
ii) Network Analysis of Infrastructure Systems: Leveraging AI techniques to model complex interactions within interconnected infrastructure networks
iii) Deterioration and Damage Prediction/Detection: Utilizing ML models for predictive maintenance by analyzing sensor data from infrastructure monitoring systems.
iv) Uncertainty Quantification: Developing AI-based probabilistic models to quantify uncertainties in structural performance, load conditions, and degradation rates of different infrastructure systems.
v) Infrastructure Resilience Assessment: Exploring methods to simulate and optimize maintenance and operational strategies under uncertainty, ensuring that resources are allocated efficiently to enhance the resilience of infrastructure networks.
vi) Data Ecosystems to Support Developing AI-Based Risk Tools: Developing data schema and data management frameworks to facilitate training and validation of AI-based models across different performance metrics and infrastructure assets.
vii) Decision-making Under Uncertainties: Use of emerging AI paradigms such as Agentic models to support the next generation of decision support systems under extreme conditions, and

viii) Interpretability and Generalizability: Exploring the epistemic uncertainties in AI algorithms and training data with the goal of improving model transparency and interpretation, and investigating AI algorithms' ability to extrapolate beyond the trained scenario.

This session will delve into addressing the current challenges in AI development for risk, uncertainty, and resilience assessment and how advanced data-driven technologies can contribute to developing innovative methodologies and practical solutions for enhancing the resilience, reliability, and management of infrastructure systems.

MS 026. Modeling of Materials with Interfaces and Scales Using Physics-Based and Machine-Learning Methods

Xiang Zhang[1], Pinlei Chen[2], Kamalendu Ghosh[3], Balavignesh Vemparala Narayana Murthy[4], Ravindra Duddu[5], Soheil Soghrati[6], Reza Abedi[7]

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[5] Vanderbilt University
[6] The Ohio State University
[7] University of Tennessee Space Institute

This mini-symposium aims to provide a forum for discussing novel computational methods and their applications that pertain to the mechanics of materials and structures.

In particular, contributions on the following topics are of significant interest:

- Multiscale modeling and methods for heterogeneous materials, including composites, earth materials, and others.
- Constitutive and numerical modeling of materials with interfacial/ surface properties, e.g, interface elasticity, surface tension, etc.
- Novel formulation and algorithm development for solids and materials, including interfacial FEM, phase field fracture, contact/friction, and other engineering problems.
- Computational methods for time-dependent material response (crystal plasticity, creep, fatigue, etc.).
- Application of deep learning in predicting the mechanical behavior of materials
- Model order reduction techniques and surrogate modeling for accelerating multiscale

MS 027. Bridging Numerical Modeling and Scientific Machine Learning for Next-Generation Computational Mechanics

Somdatta Goswami[1], Souvik Chakraborty[2]

[1] Johns Hopkins University
[2] Indian Institute of Technology Delhi

The emergence of Physics-Informed Machine Learning has established a powerful connection between data-driven approaches and fundamental engineering mechanics principles, resulting in accelerated computational tools for engineering applications. However, creating robust and scalable physics-informed ML systems presents significant obstacles, including substantial computational demands, absence of rigorous error bounds, and restricted transferability across engineering domains. This mini-symposium will explore the mutually beneficial relationship between classical numerical methods in engineering mechanics and machine learning techniques, where both disciplines enhance and strengthen each other. Our objective is to establish advanced computational frameworks that merge the mathematical rigor of established engineering methods with the adaptability of modern machine learning approaches.

Key topics include:

1. Core Developments in Physics-Informed ML: Creating new computational models that embed fundamental mechanical principles, structural constraints, and engineering physics to ensure interpretability and reliability in engineering applications.
2. Mechanics-Enhanced Learning Algorithms: Integrating advanced numerical techniques from engineering mechanics to enhance stability, computational efficiency, and convergence properties of machine learning training procedures.
3. ML-Accelerated Engineering Simulation: Merging physics-informed ML models with established computational mechanics solvers (including Finite Element Analysis, meshfree methods) to achieve superior performance in complex multiscale and coupled engineering problems.
4. Integrated Computational Approaches: Developing novel methodologies that combine traditional engineering mechanics algorithms with deep learning techniques to unlock innovative pathways for engineering analysis and design.

We encourage engineering researchers, industry practitioners, and graduate students to share their contributions at this dynamic convergence of computational mechanics and machine learning, advancing the frontiers of engineering computational modeling.

MS 028. Advances in Artificial Intelligence and Digital Twin Technologies for Resilient Infrastructure Systems

Herta Montoya[1], Tianzhi He[1]

[1] The University of Texas at San Antonio

The resilience of infrastructure systems is increasingly challenged by natural hazards, emerging cyber-physical disruptions, and progressive lifecycle degradation. Recent advances in artificial intelligence (AI) and digital twins (DTs) offer new opportunities to enhance health monitoring and decision-making, enabling next-generation resilient infrastructure that is adaptive, intelligent, and reliable under hazardous and uncertain conditions. This mini-symposium will highlight recent breakthroughs in integrating AI and DT technologies with physical infrastructure systems, advancing resilience capabilities in monitoring, prediction, and adaptive response. We welcome contributions spanning civil, mechanical, and aerospace infrastructure, with emphasis on critical system performance under multi-hazard and extreme event conditions, closed-loop autonomy, and the trustworthy deployment of AI and DT technologies.

Topics of interest include, but are not limited to:

- Methods and Models
    - Foundational methods, algorithms, and models driving DTs supporting infrastructure resilience
    - Machine learning, deep learning, reinforcement learning, and adaptive system control methods, leveraging multi-fidelity simulation and multi-modal data inputs
- Systems and Architecture
    - System architecture and design for next-generation infrastructure DTs
    - Frameworks extending physics-based modeling into actionable resilience strategies, such as integration, verification/validation, and trustworthy deployment
- Decision and Control
    - AI-driven autonomy and human–AI decision support for resilient performance under extreme and uncertain events
    - Human-AI teaming in infrastructure systems, including large language models (LLMs) and foundation models as interfaces between humans, data, and cyber-physical systems
- Application and Evaluation
    - Integration of physical infrastructure assets with sensor networks, real-time monitoring, and hybrid physics-data models
    - Data fusion and predictive/prognosis methods for rapid response and recovery strategies
    - Benchmarks, open datasets/simulators, and reproducible evaluation protocols for assessing AI- and DTs-enabled resilience approaches across domains

MS 029. Leveraging Artificial Intelligence for the Computational Modeling of Quasi-Brittle Infrastructure Materials

Gianluca Cusatis[1], Gilles Pijaudier-Cabot[2], M. Z. Naser[3], Mohammed Alnaggar[4], Giovanni Di Luzio[5]

[1] Northwestern University
[2] University of Pau and Pays de l'Adour
[3] Clemson University
[4] Oak Ridge National Laboratory
[5] Politecnico di Milano

This minisymposium will be a forum to disseminate and discuss the latest advancements on the adoption of Artificial Intelligence (AI) technologies in the field of computational modeling of quasi-brittle infrastructure materials. Quasi-brittle infrastructure materials, such as, but not limited to, concrete, masonry, wood, rocks, are ubiquitous in many civil engineering applications and their mechanical behavior, structural performance and long-term durability are influenced by the coupling of chemical reactions, mass transport and heat transfer, as well as fracture and other failure phenomena at multiple length scales. Hence, specific topics of interest for this minisymposium include, but they are not limited to, application of AI to material constitutive modeling, strain localization and fracture, durability, additive manufacturing, multiphysics problems, uncertainty quantification and model validation, computation accuracy and performance, dynamic response and fragmentation.

MS 030. Physics-based data-driven modeling and uncertainty quantification in computational science and engineering

Bahador Bahmani[1], Ramin Bostanabad[2], Johann Guilleminot[3], Michael Shields[4], Wei Chen[1], Lori Graham Brady[4]

[1] Northwestern University
[2] University of California Irvine
[3] Duke University
[4] Johns Hopkins University

Advances in physics-based modeling are responsible for the generation of massive datasets containing rich information about the physical systems they describe. Efforts in Uncertainty Quantification (UQ) serve to further enrich these datasets by endowing the simulation results with probabilistic information describing the effects of parameter variations, uncertainties in model-form, and/or their connection to and validation against physical experiments. This MS aims to highlight novel efforts to (A) Harness the rich datasets afforded by potentially multi-scale, multi-physics simulations for the purposes of uncertainty quantification; and (B) Develop physics-based stochastic models, solvers, and methodologies for identification, forward propagation, and validation. Submission may propose to: Merge machine learning techniques with physics-based models; Develop physics-based stochastic models and low dimensional representations of very high dimensional systems for the purposes of uncertainty quantification; Extract usable/actionable information from large, complex datasets generated by physics-based simulations; Develop active learning algorithms that exploit simulation data to inform iterative/adaptive UQ efforts; Develop stochastic solvers and sampling algorithms; Interpolate high-dimensional data for high-fidelity surrogate model development; Learn the intrinsic structure of physics-based simulation data to better understand model-form and its sensitivity; Develop new methodologies for model identification; Assess similarities/differences/sensitivities of physics-based models and validate them against experimental data.

MS 031. Physics Meets AI: Foundation Models for Multiscale Mechanics

Dibyajyoti Nayak[1], Dibakar Roy Sarkar[1], Somdatta Goswami[1]

[1] Johns Hopkins University

Recent advances in artificial intelligence have been propelled by foundation models, large-scale architectures trained on a multitude of datasets to simultaneously address multiple objectives through multitask learning paradigms, transforming scientific discovery. In computational mechanics, these models hold strong potential for learning solution fields that bridge spatiotemporal scales spanning orders of magnitude, from atomistic phenomena to continuum and structural systems. By learning transferable representations and capturing coupled multiscale, multiphysics behavior, foundation models can enable accelerated simulations, efficient inverse problem solving, uncertainty quantification, and autonomous design of complex multiscale systems. This mini-symposium explores how foundation models, including neural operators, transformers, graph neural networks, diffusion-based generative models, and multimodal architectures, both data-driven and physics-informed, can reshape mechanics research by synergistically combining physical priors with data-driven adaptability.

This mini-symposium welcomes contributions spanning the full spectrum of research at the intersection of foundation models and multiscale mechanics. We invite researchers from computational mechanics, applied mathematics, materials science, engineering, computer science, physics, and related disciplines to share work at all stages of development. Relevant contributions may include (but not limited to) novel architectures tailored to physical systems; applications of existing models to new emerging domains; hybrid methodologies combining data-driven learning with classical techniques; and theoretical investigations of approximation capabilities and generalization bounds. The symposium embraces methodological diversity, from classical statistical learning to modern deep learning, from supervised to unsupervised discovery of constitutive laws, and from purely data-driven approaches to physics-informed architectures embedding conservation laws and material symmetries. We particularly encourage work addressing multi-fidelity data integration, cross-system transferability, model interpretability, and computational efficiency.

The symposium encompasses applications across structural mechanics, computational materials science, fluid dynamics, geomechanics, and coupled multiphysics systems. Research objectives may span forward and inverse analysis, optimization, monitoring, predictive modeling, and real-time decision-making. We equally value fundamental research advancing theoretical and algorithmic foundations along with applied work demonstrating practical impact. This forum aims to catalyze cross-disciplinary dialogue, foster collaboration, and chart future directions for foundation models in mechanics. We welcome researchers, practitioners, and students from academia, national laboratories, and industry.

MS 032. Advances in Mechanics-Informed Machine Learning for Digital Twins

Mohamad Alipour[1], Zixin Wang[1], Zhidong Zhang[2], Furkan Lüleci[3]

[1] University of Illinois Urbana-Champaign
[2] University of Virginia
[3] Louisiana State University

Digital twins promise transformative capabilities for understanding, predicting, and optimizing the behavior of complex physical systems. A central challenge, however, is reconciling the gap between idealized simulations and the variability of real-world observations. Mechanics-informed machine learning has emerged as a powerful paradigm for addressing this challenge by combining the interpretability and generalizability of physical models with the adaptability of data-driven learning. This mini-symposium will bring together researchers at the intersection of computational mechanics, simulation science, and artificial intelligence to discuss advances in leveraging simulation data for real-world applications. Topics include, but are not limited to:

- Embedding governing equations into neural architectures
- Domain adaptation and transfer learning across simulation and reality
- Strategies for generating and calibrating synthetic training data
- Data assimilation for inverse problem-based applications
- Surrogate and reduced-order modeling
- Uncertainty quantification

Applications span diverse domains such as structural health monitoring, material parameter estimation, and information retrieval using either direct (fixed sensors) or indirect (remote dynamic sensors) sensing approaches, where the ability to bridge the sim-to-real divide is critical. Case studies across engineering and physical sciences will highlight how mechanics-informed machine learning accelerates the development of digital twins that are both scientifically rigorous and operationally useful. By convening experts across disciplines, the symposium will explore emerging pathways for creating AI models that are more generalizable and impactful in solving physics-driven problems.

MS 033. Nondestructive testing-based damage identification using machine and deep learning

Chanseok Jeong[1], Fernando Moreu[2], Hoon Sohn[3], Young-Jin Cha[4]

[1] Central Michigan University
[2] University of New Mexico
[3] Korea Advanced Institute of Science and Technology
[4] University of Manitoba

This mini-symposium will advance the integration of nondestructive testing (NDT) with machine and deep learning to enhance damage identification in complex engineering systems, including civil infrastructure like bridges, tunnels, dams, pipelines, and high-rise structures, as well as aerospace and mechanical systems. By harnessing NDT sensors of various modalities, such as thermography, eddy current techniques, ground-penetrating radar (GPR), ultrasonics, and acoustic emission, combined with advanced AI algorithms, these methods enable precise defect detection, lifecycle assessment, and predictive maintenance. Key subtopics include (but not limited to):

- Multimodal Fusion of NDT Methods
- Lightweight & Edge-Deployable Models
- Baseline-Free / Unsupervised Damage Detection & Localization
- 3D Volumetric & Tomographic Imaging + Deep Learning
- Higher Sensitivity: Fine / Micro-Damage, Early Detection
- Ultrasonic NDT
- Laser Ultrasonics & Non-contact Methods
- Thermography & Deep Learning
- Electrical Impedance Tomography
- Applications in Composite Materials / Aerospace / Critical Structures
- Machine Learning for Multi-Sensor Data Fusion
- Deep Learning for Anomaly Detection
- Automated Damage Prognostics
- Edge Computing and Internet of Things for NDT
- Cross-Domain Challenges and Innovations

MS 034. Machine Learning Applications in Natural Hazards Engineering for Enhancing Civil Infrastructure Resilience

Pedro Fernandez-Caban[1], Haifeng Wang[2]

[1] Florida A&M University-Florida State University (FAMU-FSU) College of Engineering
[2] Washington State University

This mini-symposium invites researchers integrating machine learning into natural hazards engineering to enhance civil infrastructure performance. Early-stage research contributions are encouraged to foster collaboration and stimulate discussion among experts in the field. All aspects of machine learning are welcome.

Natural hazards such as earthquakes, hurricanes, tornadoes, wildfires, and floods pose significant challenges to the resilience of civil infrastructure. These events involve complex, often nonlinear phenomena, requiring extensive modeling and simulation efforts that produce large datasets. Likewise, analyzing civil infrastructure performance under both normal and extreme conditions generates valuable data from experimental tests, field observations, and advanced simulations. Machine learning, with its potential to transform how these large, heterogeneous, and multi-modal datasets are utilized, is set to revolutionize the field, enabling more accurate predictions of infrastructure behavior under hazardous conditions. The development of deep learning models, especially multi-modality models, illuminates ways to leverage existing data more effectively and reduce repetitive physical testing.

By leveraging existing datasets and uncovering new patterns in hazard-related data, machine learning can accelerate the development of innovative strategies for mitigating risk and enhancing infrastructure resilience. This mini-symposium will highlight cutting-edge applications of machine learning in natural hazards research, including surrogate modeling, fragility estimation, early-warning systems, and decision-making assistance.

Participants will engage in presentations and discussions focused on the intersection of machine learning, natural hazard modeling and analysis, and infrastructure resilience, driving forward exploration in this emerging interdisciplinary field.

MS 035. Probabilistic Learning, Stochastic Optimization, and Digital Twins

Amir H Gandomi[1], Roger Ghanem[2], Christian Soize[3]

[1] University of Technology Sydney, Australia; Obuda University, Hungary
[2] University of Southern California, USA
[3] Université Gustave Eiffel, France

Engineering design problems in the real world are inherently complex, high-dimensional, and uncertain. The coexistence of discrete and continuous design variables, coupled with the stochastic nature of engineering systems, renders traditional deterministic and derivative-based optimization methods insufficient. Recent advances in probabilistic learning, stochastic optimization, and digital twins have provided new paradigms for tackling such challenges, enabling robust decision-making and adaptive system modelling under uncertainty. This Mini-Symposium aims to bring together leading researchers and practitioners to discuss recent developments and applications of these methods in engineering mechanics, structural systems, and applied sciences. The focus will be on integrating probabilistic reasoning, intelligent search algorithms, and data-driven approaches to improve the reliability, efficiency, and interpretability of computational models in design, monitoring, and control. Topics of interest include but are not limited to probabilistic deep learning, stochastic and robust optimization, evolutionary computation under uncertainty, statistical inverse problems, surrogate modelling, and digital twin technologies for both product and process engineering. By fostering interdisciplinary dialogue across computational mechanics, optimization, and artificial intelligence, this Mini-Symposium seeks to highlight emerging tools and theories that enable resilient, data-driven, and uncertainty-aware engineering systems for the next generation of intelligent design and maintenance frameworks.

MS 036. Human-Centered AI and Data-Driven Systems for Infrastructure and Community Resilience

Katherine Flanigan[1], Hadi Salehi[2]

[1] Carnegie Mellon University
[2] Louisiana Tech University

Resilient infrastructure is not solely a matter of structural performance—it depends on how humans, data, and decision systems interact before, during, and after disruption. As disruptions—such as climate-driven, social, and technological stressors—intensify, the need for adaptive, human-centered approaches to resilience has become paramount. Achieving this requires methods that explicitly link physical infrastructure with the social and informational systems it supports. Advances in sensing, cyber-physical systems, and artificial intelligence (AI) now enable measurement and modeling of how, for example, human decisions, mobility patterns, and social networks evolve under stress and, in turn, shape system recovery and adaptation. This can reveal latent dependencies between communities and infrastructure, support real-time decision making, and provide quantitative foundations for designing systems that learn and adapt alongside the people they serve. This mini-symposium explores emerging research that integrates, for example, AI, sensing, modeling, and participatory data systems to enhance community resilience and human-infrastructure coordination.

We invite contributions that examine resilience as a coupled human-cyber-physical phenomenon. Topics of interest include, but are not limited to: (1) data-driven and human-centered AI for community resilience; (2) cyber-physical-social systems and digital twins for adaptive decision making; (3) AI-driven socioeconomic and behavioral modeling for pre-disaster preparation and post-disaster recovery; (4) generative-AI co-pilots for situational awareness and community-aware incident assessment; (5) participatory and privacy-preserving sensing for resilience analytics; (6) value-of-information frameworks for resource allocation; (7) multi-scale modeling of interdependent infrastructure and social systems; and (8) human-in-the-loop learning frameworks for adaptive infrastructure operation and evaluation.

MS 037. Shaping Tomorrow: State-of-the-Art Innovations in Advanced Cementitious Materials and Concrete Technologies

Jianqiang Wei[1], Sung-Hwan Jang[2], Linfei Li[3], Yen-Fang Su[4]

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[2] Hanyang University ERICA
[3] Florida International University
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This mini-symposium aims to provide an interdisciplinary platform for scientists, researchers, and practitioners to present and discuss the latest challenges, innovations, and advancements in construction materials and emerging technologies in sustainable, high-performance, multifunctional, and resilient infrastructure materials. Topics of interest include, but are not limited to, the development of alternative cementitious binders, material sustainability and durability, multifunctional cementitious composites, artificial intelligence implementation, additive manufacturing, degradation analysis and service-life extension, non-destructive testing methods, and carbon-neutral or carbon-negative technologies in cement and concrete for a sustainable future. Contributions highlighting innovative approaches to enhance material performance and resistance against weathering action, chemical attack, and other aging processes, such as mechanical loads, corrosion, carbonation, freeze-thaw cycles, shrinkage, creep, deicing-salt attack, alkali-silica reactions, radiation, and sulfate attack, will be discussed. The symposium will also feature state-of-the-art experimental and computational efforts on evaluating and enhancing structural materials' performance, sustainability, and decarbonization. The following topics are specifically encouraged:

- Novel cementitious binders for next-generation concrete
- Ultra-high performance concrete (UHPC)
- Fiber-reinforced concrete
- Alternative cementitious materials
- New concrete derived from solid waste upcycling
- Recycled or functional aggregates
- Multifunctional cementitious composites (self-healing/self-sensing/self-cleaning, etc.)
- Additive manufacturing (3D printing) of cementitious composites
- Non-destructive testing methods
- Artificial Intelligence for concrete
- Nanoengineered concrete
- Degradation behavior of cement/concrete materials
- Durability improvement
- Chemical, physical, and mechanical properties of cement-based materials
- Repair and maintenance of existing concrete structures

MS 038. Mechanics and Modeling of Durable and Resilient Pavements

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Overview

The field of pavement mechanics is rapidly evolving due to advancements in materials science, computational methods, and the increasing demand for durable and resilient transportation infrastructure. This mini-symposium will focus on how pavement mechanics and modeling can tackle the dual challenge of ensuring long-term pavement performance while adapting to changing materials, traffic patterns, and environmental conditions.

Recent innovations in material characterization and numerical methods, such as finite element analysis, discrete element modeling, and coupled environmental-mechanical models, enable engineers to predict the performance of pavement systems more accurately under increasingly complex scenarios. Additionally, emerging challenges, including the increased use of electric vehicles, new requirements for friction and texture to enhance safety and reduce hydroplaning risk, and the effects of climate variability, necessitate fresh insights into pavement mechanics.

Objective

This mini-symposium will serve as a platform for researchers to explore innovative approaches in modeling, materials, and performance prediction, with the goal of delivering pavement systems that are technically sound and adaptable to future demands.

Topics of Interest:

- Advanced Pavement Modeling: Nonlinear finite element and other computational approaches to predict performance under varied loading, climate, and traffic conditions.
- Durability and Resilience of Pavements: Experimental and numerical approaches to improve long-term service life, with emphasis on factors such as moisture, temperature extremes, and interface behavior.
- Emerging Tire–Pavement Interactions: Novel insights into friction, texture, rolling resistance, hydroplaning, and the evolving effects of electric and connected vehicles on pavement performance.
- Coupled Environmental–Mechanical Models: Integration of environmental drivers (climate, flooding, heat, freeze–thaw) with mechanical performance to improve resilience predictions.
- Recycled and Alternative Materials: Performance modeling of pavements incorporating reclaimed asphalt, recycled aggregates, rubber, plastics, and other non-traditional materials without compromising durability.
- Life-cycle and Implementation Considerations: Incorporating life-cycle cost and

environmental assessments into mechanistic design and performance modeling to support decision-making.

MS 039. Architected Materials

Yunlan (Emma) Zhang[1], David Restrepo[2], Josephine Carstensen[3], Nilesh Mankame[4], Pablo Zavattieri[5]

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Controlling material architecture is one of the most promising ways to generate novel materials with properties that are unattainable by traditional monolithic solids. The past decade has seen an enormous upsurge of research works on architected materials with features that span multiple length scales, such as lightweight microlattices, multiphase composites, phase-transforming metamaterials, and origami structures, among others. These material systems have shown their potential to revolutionize modern engineering, with applications ranging from infrastructure and space structures to novel biomedical components and energy-storage devices. This symposium brings together several perspectives on the mechanics, optimization, and computational design of architected materials and will provide a forum to discuss the latest advances in the field with thematic sessions that include, but are not limited to:

· Multifuncitonal architected materials and structures for structural, acoustic, wave manipulation, thermal, mechanical, biomechanical, electromagnetic, and other applications
· Bioinspired, nanostructured, and hierarchical architected materials
· Knitted or woven architected materials and structures
· Adaptive, active, reconfigurable architected materials and structures
· Nonlinear behavior of architected materials
· Mechanics and design of fracture- and fatigue-resistant architected materials
· Methods for design of architected materials and structures
· Data-driven and machine learning techniques applied to architected materials
· Architected materials for extreme environments (hypersonic, radiation shielding, thermal shocks, etc.)
· Advanced synthesis techniques
· Coarse-grained and multiscale modeling techniques
· Unconventional applications of architected materials

MS 040. Mechanics of Wood and Wood-Based Materials

Markus Lukacevic[1], Eric Landis[2], Fiona O'Donnell[3], Luis Zelaya-Lainez[1], Josef Füssl[1]

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[3] Swarthmore College

Wood offers excellent advantages as a building material: in addition to being lightweight, economic, and strong, it is renewable, biodegradable, and carbon sequestering. As such, contemporary wood structures are revolutionizing the construction industry, rising to 18 stories and beyond. Yet despite these advances, the field of wood mechanics and associated computational modeling is still very much in its infancy stages. There is still much to explore and learn, for example, about wood's complex brittle and ductile failure modes, its variability and heterogeneity, as well as its dependencies on time, moisture, temperature, and size. Cutting-edge computational and experimental research in this regard will lead to new generations of wood products and applications, as well as help produce reliable engineering tools for the design and detailing of these new timber structures.

This symposium, entitled "Mechanics of Wood and Wood-Based Materials", is a forum for scientists and engineers working in these fields. The submitted contributions should address recent analytical, computational, and/or experimental advances on the mechanical behavior of wood and wood-based materials.

The primary topics of interest are:

- Mechanical response of wood and wood-based composites (e.g., time and moisture-dependent behavior)
- New and advanced modeling approaches (e.g., probabilistic, macroscopic constitutive modeling, micromechanics, and multiscale modeling)
- Analytical or numerical modeling of experiments, including interpretation and comparison of numerical and experimental results
- Geometric modeling of wood and wood-based materials (e.g., automated laser scanning and knot ID in 3D)
- Mechanical behavior of innovative timber connections
- Novel test setups for complex loading cases (e.g., biaxial, non-static, dynamic, moisture, temperature)

MS 041. Cementitious Materials: Experiments and Modeling Across the Scales

Bernhard Pichler[1], Gilles Pijaudier-Cabot[2], Günther Meschke[3], Christian Hellmich[1], Franz Josef Ulm[4]

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[2] Université de Pau et des Pays de l'Adour
[3] Ruhr University Bochum
[4] Massachusetts Institute of Technology

The objective of this symposium is to discuss recent advances in experimental oriented research and in modeling of cementitious materials across the scales, ranging from atomistic via molecular, nano, micro, and meso up to the macro scale, including also related applications in the field of engineering mechanics. Analytical and computational models for cementitious materials as well as related experimental techniques, addressing various length and time scales and physical phenomena relevant for the behavior of cementitious materials subjected to different environmental and loading conditions are welcome. Innovative approaches suitable to increase insight into complex phenomena as well as predictive models increasing safety, durability, and sustainability in practical applications are especially encouraged.

MS 042. 24th Symposium on Biological and Biologically Inspired Materials and Structures

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The Properties of Materials Committee, the Poromechanics Committee, and the Biomechanics Committee of the Engineering Mechanics Institute are proposing to organize a symposium on Biological and Biologically Inspired Materials and Structures for the 2026 EMI Conference being held in Boulder, Colorado. This symposium series has been organized continuously for 24 years and was the first symposium dedicated to the bio area at EMI/EMD conferences. The biologically inspired materials could include biomaterials, composite materials based on microarchitecture, or other nuances of biological materials. The symposium aims to bring together researchers working on various aspects of mechanics, micro, and nanostructure of biological materials, and the synthesis and processing of materials inspired by biology. The organizers invite abstracts in the area of biological and biologically inspired materials and structures, including but not limited to the following themes: modeling and simulation of mechanical properties of biological materials; materials design, synthesis, and processing based on biological materials; scale transition methods for bio-inspired or biological materials; nano and micro-scale characterization of interfaces in biological and bio-inspired materials; experimental investigation of bio-inspired or biological materials; poromechanical problems in bio-inspired or biological materials; constructs for tissue engineering; mechanobiological associations to diseases; biomechanics and other classical and emerging themes in this field.

MS 043. The Mechanics, Chemistry, and Physics for Cement and Concrete Decarbonization

MJ Qomi[1], Kemal Celik[2], Jiaqi Li[3], Konrad Krakowiak[4], Guoqing Geng[5], Mohsen Ben Haha[6]

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[5] National University of Singapore
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The decarbonization of concrete is opening new frontiers to envision scalable solutions to meet the global gigaton demand yearly while minimizing greenhouse gas emissions. Fueled by the climate crisis, industrial decarbonization has entered almost every aspect of cement and concrete production, from designing new clinkers and supplementary cementitious materials to designing eco-friendly kilns and machine-learned concrete mix designs. This mini-symposium aims to bring together researchers involved in all cement/concrete decarbonization aspects. We are interested in new cement and concrete formulations with low carbon footprints, magnesium-based cements, valorization of waste products through carbon sequestration, and sustainable pathways to produce construction materials through electrochemical processing and advanced separation technologies. We welcome submissions with both experimental and simulation focus on the mechanics (mechanical properties, durability, drying, shrinkage, fracture toughness, etc.), chemistry (hydration, carbonation, electrochemistry, separation, kinetics, etc.), and physics (mass and heat transport, etc.) of new cementitious and concrete materials.

MS 044. Mechanics and Modeling of Failure in Bi-Material Interfaces

Ayumi Manawadu[1]

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Bi-material interfaces are critical to the performance and durability of layered and composite systems in civil, aerospace, and mechanical engineering applications. Failure at these interfaces can be attributed to various reasons, including fracture, debonding, fatigue, or environmentally induced degradation, which often govern the service life of structural systems. Despite decades of research, predicting interface failure remains a significant challenge due to the coupled effects of material heterogeneity, geometry, environment, and multiscale fracture processes.

This mini-symposium will provide a platform to advance the mechanics, modeling, and simulation of failure in bi-material interfaces. Contributions are invited on the numerical and analytical modeling of bi-material interfaces, including fracture mechanics approaches, cohesive-zone and damage models, multiscale and multiphysics simulations, and emerging data-driven or machine learning techniques. Applications may include, but are not limited to, substrate–overlay concrete systems, composites, protective coatings, thin-film structures, and bonded repair materials.

This session aims to bring together researchers from structural engineering, materials science, and applied mechanics to identify advances and challenges in developing more realistic and computationally efficient simulations that accurately represent real-world applications. Discussions will encourage cross-disciplinary collaboration to enhance predictive models and support the design of durable interface systems under complex loading conditions.

MS 045. Materials Science and Mechanics of Earthen Construction

Samuel J. Armistead[1], Wil V. Srubar III[1]

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Earthen construction has been practiced for millennia, yet the underlying materials science and mechanics are only now beginning to be systematically explored, despite their critical importance for broader adoption. This mini symposium will bring together researchers from around the world to share state-of-the-art advances in the field. Contributions from materials science, civil engineering, and architecture are encouraged, focusing on process-structure-property relationships, constitutive behavior, and performance across a range of construction applications. By connecting fundamental materials science & mechanics, this symposium will highlight the potential of earthen construction in the built environment for the 21st century.

MS 046. Self-Healing Structural and Material Systems

Dryver Huston[1], George Voyiadjis[2], Sanhita Das[3]

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[2] Louisiana State University
[3] IIT Jodhpur

Self-healing is a ubiquitous phenomenon and key enabler of biological life. This mini-symposium will feature a series of presentations on recent progress toward incorporating the durability, damage recovery, and high-performance capabilities of self-healing into engineered structural and material systems. Potential presentation topics include modeling of self-healing structural and material systems, damage-induced load-path redistribution techniques, self-sealing walls, self-cleaning and regenerative surfaces, self-healing concretes, and metamaterial approaches.

MS 047. Mechanics and Data-Driven Innovations in Road Paving Materials

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Road pavements represent a cornerstone of civil engineering infrastructure. However, heavy traffic, climatic variability, site-specific stresses, and long-term degradation continually challenge their layered systems and materials. These factors lead to distresses such as cracking, rutting, fatigue, and moisture damage, which compromise durability and increase maintenance demands. In parallel, innovative materials and treatments, ranging from recycled aggregates and industrial by-products to bio-binders, polymers, and nano-modifiers, are being introduced to improve resilience and sustainability. Their adoption, however, introduces new complexities, as unconventional behaviors and multiscale interactions demand advanced mechanics, modeling, and data-driven strategies. This mini-symposium provides a forum for cross-disciplinary contributions at the interface of mechanics, experimental characterization, theory, and artificial intelligence/machine learning in road pavement research, fostering innovative solutions to extend pavement life, optimize performance, and reduce lifecycle costs. Topics of interest include (but are not limited to):

- Advanced mechanical testing and characterization of innovative paving materials.
- Reliability-based and probabilistic approaches to pavement performance.
- Fracture, fatigue, scaling, and failure mechanics in layered systems.
- Multiscale and computational modeling under coupled mechanical–environmental loads.
- Non-destructive testing, sensing, and structural health monitoring.
- Machine learning and AI for material design, property prediction, and asset management.
- Coupling of environmental stressors (thermal, moisture, freeze-thaw) with mechanical behavior.

We welcome contributions from academia, industry, and public agencies to share recent advances and promote a comprehensive understanding of how mechanics and data-driven methods can shape the next generation of pavement materials and structures.

MS 048. Mechanics and Modeling of Mass Timber Structures and Materials Subjected to Extreme Loads

David Roueche[1], Mark Weaver[2], Kadir Sener[1], Shiling Pei[3], Christian Viau[4], Mike Hillman[2]

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[4] Carleton University

Overview:
Mass timber products, such as Cross-Laminated Timber and Mass Plywood, have gained significant popularity over recent years as a sustainable and resilient construction material across a wide variety of structural typologies. Mass timber may be used as a primary structural system, or in hybrid and composite structural systems in combination with concrete or steel. Despite these advancements in its use, mass timber remains a relatively complex material to model and design with due to its being an organic and orthotropic material. This in turn introduces significant uncertainties in the fundamental material properties that can inhibit its use or lead to overly conservative designs. These uncertainties are magnified in extreme load scenarios, such as wind, earthquake, blast, and ballistics, where high strain-rate effects become more pronounced, and limited research has been conducted.

Objectives:
The objective of this mini-symposium is to present the state-of-the-art knowledge of the mechanical behavior of mass timber as a structural material under extreme loads, with particular emphasis on blast and other intermediate and high strain-rate loading mechanisms, and connect this knowledge with practical design considerations and existing design standards.

Topics of Interest:
- Simplified and Advanced Modeling Techniques for Mass Timber: Utilizing state-of-the-art modeling techniques, including traditional finite element approaches and mesh-free approaches, as well as simplified modelling methodologies such as the equivalent single degree-of-freedom (SDOF) method, to analyze the performance of mass timber structures under different loading conditions.
- Approaches for Handling Uncertainties in Mass Timber: Many of the advanced modeling techniques are computationally expensive and ill-suited to traditional probabilistic techniques for handling uncertainty such as Monte Carlo simulations. Methods are needed for understanding the need for and developing methods for integrating uncertainty and their effects on overall member or system behavior.
- Investigation of Mass Timber Response to Blast Loading: Experimental and numerical investigations of far-field and close-in blast effects on mass timber members and systems, including beams, columns, two-way bending panels, panels with openings, and more.
- Design for Blast and Other Extreme Loads: Translating the latest research and understanding of mass timber performance under extreme loads into appropriate design

methods.

- Response of Hybrid or Composite Mass Timber Systems to Extreme Loads: Materials such as wood and steel have very different sensitivities to high strain-rate roading yet are often used in conjunction in composite structures or in connections of timber-only structures. A better understanding is needed of how capacities, failure modes, and other fundamental response characteristics change in hybrid connections or assemblies under short-duration loading.

MS 049. Mechanics of Soft Synthetic and Biological Materials: Theory, Simulation, and Experiment

Berkin Dortdivanlioglu[1], Aditya Kumar[2], Raudel Avila[3]

[1] University of Texas at Austin
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[3] Rice University

Mechanics of soft materials continues to be an exciting field of research both from a theoretical and an applied perspective. On the theoretical side, nonlinear multiphysics behavior, interfacial behavior, fracture, and the capability of soft materials to adapt and evolve, particularly biological ones, present interesting challenges. On the applied side, a variety of novel technological applications like tissue-like materials, soft robotics, stretchable electronics, metamaterials, wearable sensors, and many bio-integrated medical applications have given renewed impetus to research in this area. The goal of this mini-symposium is to provide another avenue for soft materials researchers from diverse backgrounds to get together and exchange new knowledge in theoretical, computational, and experimental methods. The topics of interest include, but are not limited to:

- Fracture of soft materials: nucleation and propagation of cracks; characterization of fracture properties in biomaterials; fatigue; tougher and stronger material design; ratedependence of fracture properties
- Development of tissue-like materials: 3D printing techniques
- Coupled soft materials: flexoelectricity, stimuli responsive gels, electroactive polymers
- Functional adaptability: Growth, remodeling, and aging in biological materials
- Soft interfacial mechanics: adhesion, friction and contact; surface instabilities such as wrinkling and creasing; elastocapillary effects
- Size effects in soft materials: Surface energy in solids, lower-dimensional energetics, mechanics of biological membranes, strain-gradient materials
- Novel engineering/fabrication techniques, functional devices, and applications

MS 050. Mechanics of Network Materials: Linking Structure, Dynamics, and Function

Frank Vernerey[1], Nikolaos Bouklas[1], Trisha Sain[2], Noy Cohen[3]

[1] Cornell University
[2] Michigan Tech University
[3] Isreal Institute of Technology (Technion)

This minisymposium will focus on the mechanics of networked and disordered materials, emphasizing the link between micro- or meso-scale structure and emergent macroscopic behavior. Topics of interest include elasticity, viscoelasticity, damage, cavitation, degradation, fracture, and adaptive or responsive behaviors in both synthetic and biological networks. We welcome contributions spanning experiments, theoretical and computational modeling, and data-driven approaches, including AI and machine learning techniques, to uncover and predict structure-function relationships in complex networks. The goal is to create a forum where researchers studying polymer networks, hydrogels, cellular tissues, soft robotics, and other networked systems can share insights into how collective interactions determine mechanical response, durability, and functionality. Potential Topics:
Structure–property relationships in polymeric and biological networks
Viscoelastic and non-linear mechanics of disordered materials
Mechanisms of damage, fracture, and self-healing in networked systems
Data-driven modeling and AI for predicting network behavior
Experimental techniques to probe network mechanics across scales
Design principles for adaptive or responsive network materials

MS 051. Non-traditional reinforcement to the modern structures

Linfei Li[1], Eric Landis[2]

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[2] University of Maine

The objective of this mini-symposium is to provide an interdisciplinary platform for scientists, researchers, and practitioners to present and discuss the latest challenges, innovations, and advances in non-traditional reinforcement across various materials, designs, and combinations. Given the potential corrosion vulnerabilities and environmental concerns, new forms of reinforcement must be considered and implemented in the next generation of structures. Over the past decade, design codes such as ACI 318, AASHTO GFRP, ISO 18319, and CSA-S807 have increasingly accepted fiber-reinforced polymers (FRP) as alternatives to traditional steel reinforcement. This symposium will explore a broad range of topics, including but not limited to FRP, natural fiber reinforcement, nanomaterials reinforcement, magnetic and electrospun fiber reinforcement, hybrid reinforcement systems, reinforcement techniques for 3D-printed concrete, advanced corrosion mitigation technologies for steel reinforcement, smart reinforcement, optimized structural design, and fracture mechanics. Cutting-edge experimental research, theoretical frameworks, and computational modeling in the field of non-traditional reinforcement, applicable to various structures such as concrete and wood, will be highlighted. Contributions on the following topics are especially encouraged:

- Glass FRP and Carbon FRP reinforcement
- Polymer fiber and natural fiber reinforcement
- Installing reinforcement to the 3D printing structures
- Multi-functional reinforcement
- Hybrid reinforcement system
- Repair and maintenance of existing reinforced structures
- Advanced experimental fracture mechanics
- Multi-scale modeling development

MS 052. Stability of structures: Advances across time and scales

Noël Challamel[1], Hayder Rasheed[2], C.W. Lim[3], Stylianos Yiatros[4], Hyeyoung Koh[5]

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[2] Kansas State University, Kansas, USA
[3] City University of Hong Kong, P. R. China
[4] Cyprus University of Technology, Limassol, Cyprus
[5] Washington State University, Washington, USA

This symposium is supported by the ASCE EMI Stability Committee to provide a forum for reporting new advances in the area of instabilities and failure of nonclassical materials and nonlinear structures. This includes work that involves nonlinear behavior caused by structural instability, whether occurring naturally or by artificial means, where it leads either to ultimate failure of structural components, systems and materials, or where the instability may be harnessed to enhance performance by some mechanism. We would encourage contributions that are theoretical, experimental, data-driven or numerical in nature, or a combination thereof. Contributions investigating theories and applications for non-classical materials and nonlinear structures involving cross-disciplinary areas will be particularly encouraged and sought. The subjects include, but are not strictly limited to, the following topics:

- Stability of columns, beams, plates, shells and sandwich structures.
- Stability of structural elements made of metallic and composite materials.
- Stability of structures with linear or nonlinear elastic or inelastic materials.
- Post-buckling analysis including analytical/computational modelling and methods.
- Progressive cellular buckling, collapse and snaking.
- Development and applications of numerical continuation and generalized path-following techniques.
- Global-local buckling interactions in thin-walled structures.
- Buckling across the scales: nano, micro, thin film and lattice structures.
- Buckling in infrastructure elements (pipelines, rail) under mechanical and non-mechanical loads
- Adaptive, morphing and multistable structures; applications to design of smart structures.
- Instability-based failure mechanisms in various materials including cracks, delaminations and micro-buckling.
- Orthotropic and anisotropic material-related stability problems.
- Dynamic stability problems including energy absorption systems or crashworthiness analysis.
- Instability-related issues in layered and granular media including shear and kink band formation.
- Experimental techniques for structural and material stability mechanics.
- Non-local mechanics including stability in systems with non-local effects.
- Stochastic stability treatments with applications in performance-based design.
- Synergistic stability applications for improved functional performance.
- Stability application utilizing data-driven techniques and machine Learning.

Subject keywords

- Computational, Applied, Data-Driven, Experimental and Theoretical Mechanics
- Stability, Bifurcation, Chaos and Collapse
- Geometric and Material Nonlinearities
- Structural and Solid Mechanics
- “Buckliphilia” and stability-driven Design

MS 053. Tensegrity – Form finding, analysis, mechanical behaviour, control, and design of tensegrity and tensegrity-like systems

Landolf Rhode-Barbarigos[1], Muhao Chen[2], Ajay Harish[3]

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Tensegrity structures are lightweight, materially and mechanically efficient systems that use tension and compression to create stable, two- and three-dimensional shapes. They are made of interconnected cables (tension elements) and rigid struts (compression elements) that work together to maintain the system's form. The key to their strength lies in the carefully balanced tension and compression forces, which create a self-supporting structure. This prestressed state ensures the structure's stability and allows it to adapt to changing loads. Extensive research into tensegrity has revealed several advantages, including its high strength-to-weight ratio, structural robustness and redundancy, adjustable structure parameters, and significant morphing capabilities. More broadly, the concept of tensegrity can be applied to any field where stability arises from a careful balance of tension and compression. Tensegrity systems have been explored for a wide range of applications, including civil and aerospace structures, metamaterials, soft robotics, and as a model for cellular mechanics. This mini-symposium invites researchers from various fields to submit their findings on the form finding, analysis, mechanical behavior, control, and design of tensegrity and tensegrity-like systems.

MS 054. Geometries & Design: Opportunities for Sustainable Construction

Luis Zelaya-Lainez[1], Ann Sychterz[2]

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[2] University of Illinois Urbana-Champaign

Sustainable construction increasingly depends on understanding how geometry, topology, and defects influence the mechanical performance of construction materials. This minisymposium emphasizes experimental analysis and instrumentation across scales, from complex, novel experiments on heterogeneous materials at the nano- and micro-mechanical level to the behavior of components and deployable structures shaped by geometry. As experimental programs generate increasingly rich datasets, the use of rigorous designs of experiments and the integration of experimental observations with computational modeling frameworks are becoming essential for ensuring reproducibility and meaningful interpretation. By linking micromechanical mechanisms with structural performance, this minisymposium highlights how experimental approaches can drive material efficiency, innovative form finding, and sustainable design.

MS 055. Optimization in Civil Engineering: Methods, Challenges and Solutions

Yakov Zelickman[1], Edvard Bruun[2], Josephine Carstensen[3]

[1] Johns Hopkins University
[2] Georgia Institute of Technology
[3] Massachusetts Institute of Technology

Civil engineering offers tremendous opportunities for optimal design, yet it also presents distinctive challenges such as constructability requirements, environmental and architectural considerations, and strict compliance with building codes and provisions. Over the past two decades, research on optimization in civil engineering has become an active and dynamic field. Numerous methods and approaches have been developed to improve efficiency, reduce costs and environmental impact, and enhance safety.

This mini symposium aims to bring together researchers to share their latest work on optimization in civil engineering, fostering discussion, exchanging ideas, and cultivating new collaborations. We welcome contributions on all aspects of optimization in Civil-Engineering, including but not limited to:

- Structural optimization of concrete structures and elements
- Structural optimization of steel structures and elements
- Structural optimization of wood structures and elements
- Optimal design for seismic and wind loads
- Topology optimization for additive manufacturing
- Optimal design of bridges and other civil infrastructure
- Optimal design in geotechnical engineering
- Optimization methods in architectural engineering
- Gradient-based and heuristic approaches
- Data-driven optimization methods in civil engineering

MS 056. Load Combinations, Code Calibration, and Target Reliability in Structural Engineering

Seyed Hooman Ghasemi[1], Andrzej Nowak[2]

[1] University of Alabama at Birmingham
[2] Auburn University

Load combinations and target reliability indices form the backbone of modern structural codes, guiding design decisions that balance safety, serviceability, and economy. As hazards evolve and computational methods advance, there is a pressing need to reassess how combinations of loads are formulated, calibrated, and validated within structural design practice.

This mini-symposium will bring together researchers and practitioners to explore advances in load combination theory, probabilistic modeling, and code calibration. Topics of interest include derivation of target reliability levels for multihazard conditions, statistical and probabilistic calibration of design codes, and system-level reliability assessment of structural frames and bridges. Contributions that address performance-based and risk-informed design, progressive collapse under multiple load effects, and advanced computational approaches such as graph-theoretic or quantum-inspired reliability models are also welcome.

The session will provide a forum for discussing both theoretical developments and practical applications, including benchmarking studies and case histories. The overarching goal is to identify pathways for improving the consistency, transparency, and reliability basis of structural codes while fostering collaboration between academia, practitioners, and code-writing bodies.

MS 057. Performance Evolution and Control of Concrete Structures

Chao Jiang[1], Yao Wang[2], Jinliang Liu[3]

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[2] University of Texas at Arlington
[3] Northeast Forestry University

Under long-term environmental stressors, concrete structures typically undergo material deteriorations, component malfunction and structures deficiencies. Identifying the underlying mechanisms of deteriorations in concrete and reinforcing materials, as well as mechanical properties of degraded reinforced concrete (RC) components, is essential for developing strategies to control structural performance and extend service life. This mini symposium presents research which explores concrete and RC structures subjected to various environmental actions that lead to non-uniform spatial and/or temporal deteriorations. Topics of interest include, but not limited to, 1) durability of concrete, 2) corrosion of reinforcements embedded in concrete, 3) inspection methods for deteriorated RC components and structures, 4) mechanical performance of deteriorated RC components and structures, 5) hazard-resistance and/or resilience of deteriorated RC components and structures, 6) rehabilitation or strengthening measures for deteriorated RC components and structures, 7) probabilistic or reliability assessments of deteriorated and/or strengthened RC components and structures, and 8) performances of RC structures under climate change.

MS 058. Origami/Kirigami Inspired Structures and Metamaterials

Evgueni Filipov[1], John Brigham[2], Tanmoy Mukhopadhyay[3], Susmita Naskar[3], Mark Schenk[4], Martin Walker[5]

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[2] University of Pittsburgh
[3] University of Southampton
[4] University of Bristol
[5] University of Surrey

Thin folded sheets can enable novel engineering applications ranging in scale from adaptable metamaterials to large-scale deployable architecture. In particular, the principles of origami (folding thin sheets), and kirigami (cutting and folding) are now being used to enable self-assembly, deployment, reconfiguration, and tunable characteristics. The mechanics of the thin sheets can be harnessed to enhance their behaviors and achieve multi-functionality through motion or planned instabilities. This minisymposium, aims to bring together researchers working in the areas of origami/kirigami structures and metamaterials, and to emphasize the mechanics of these systems. Areas of interest include, but are not limited to:

- Folding systems inspired by concepts of origami and kirigami
- Deployable and reconfigurable structures and mechanisms
- Origami/kirigami-based metamaterials with tunable and programmable characteristics
- Facades and other architectural systems with adaptive properties (e.g. shading, thermal conductivity, etc.)
- Development, design, and optimization of adaptive structures
- Thickness accommodation techniques, material systems, and fabrication methods for origami/kirigami
- Analysis and physical testing of systems created from thin sheets (including kinematics, mechanics, multi-physical properties, etc.)
- Bi-stable and multi-stable structures and metamaterials
- Self-assembly and self-actuated systems

MS 059. Retrofitting, Inspection, and Repair for Resilient Infrastructure Systems

Emad Hassan[1], Hussam Mahmoud[2], Mohamed ElGawady[1], Genda Chen[1]

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The growing frequency and severity of natural and man-made hazards highlight the critical need to strengthen and modernize the nation's infrastructure. This session focuses on advancing the science and practice of retrofitting, inspection, and repair to improve the resilience, functionality, and longevity of civil infrastructure systems. Researchers and practitioners are invited to share recent advances in experimental testing, analytical modeling, and field implementation of innovative inspection and strengthening techniques. The session will also explore the integration of emerging technologies—such as digital twins, artificial intelligence, and sensor-based health monitoring—into resilience-informed retrofit design and decision-making frameworks.

By bridging material innovation, computational modeling, and data-driven infrastructure management, this session seeks to foster multidisciplinary collaboration and accelerate the transition from laboratory research to real-world implementation. The ultimate goal is to develop smarter, more adaptive, and more sustainable infrastructure capable of withstanding and recovering from extreme events.

Potential Topics Include:

- Advanced retrofitting and repair strategies for buildings, bridges, and lifelines
- Digital twin frameworks for infrastructure inspection, assessment, and adaptive maintenance
- AI and computer vision applications for damage detection and condition assessment
- Resilience-based design and retrofit strategies for multi-hazard environments
- Structural health monitoring systems integrated with decision-support tools
- Application of advanced and sustainable materials (FRP, SMA, ECC, nanomaterials) for retrofit and repair
- Numerical and experimental modeling of retrofitted or repaired systems
- Rapid and modular retrofit technologies for post-disaster recovery
- Lifecycle performance, durability, and cost-benefit assessment of retrofitted structures
- Policy, implementation, and technology transfer strategies for resilient infrastructure management

MS 060. Advancing a Functionality-Based Design Paradigm Grounded in Mechanics, System Modeling, and Decision Theory

Lisa Wang[1], Milad Roohi[2], Emad Hassan[3]

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The cascading failure of critical services—such as when a power outage triggers breakdowns in water, transportation, and communication networks—exposes a fundamental limitation of traditional infrastructure design: it focuses on structural safety but fails to ensure the continuity of the interconnected system of systems on which society depends. This session proposes a paradigm shift toward functionality-oriented design for the entire built environment, encompassing natural, man-made, and cyber-physical hazards, from individual buildings to lifeline networks, to enhance continuity and recovery of essential community functions.

This session aims to bring together researchers and practitioners from civil, structural, and infrastructure systems engineering to explore integrated modeling, design, and assessment frameworks. We will move beyond siloed analysis to focus on the critical interdependencies between the built environment (e.g., buildings, hospitals, schools) and lifeline networks (e.g., power, water, transport, communication). The session will highlight methods that integrate mechanics-informed simulation, performance-based engineering, optimization, and decision-support tools to ensure that communities and their essential functions can withstand and rapidly recover from disruptions. Our goal is to foster cross-disciplinary dialogue that bridges the gap between theoretical models and practical implementation for functional recovery.

Potential Topics Include:
Integrated System Design:
- Performance-based and functionality-oriented design frameworks for critical infrastructure and buildings.
- Modeling the interdependencies between building portfolio performance and the functionality of lifeline networks.
- Multi-criteria decision frameworks for prioritizing recovery and retrofit strategies across buildings and infrastructure assets.

Resilience Quantification and Recovery:
- Quantification of functional loss, recovery trajectories, and resilience metrics for coupled building-infrastructure systems.
- Decision-support and optimization tools for post-disaster restoration planning of interdependent systems.
- Data-driven, AI-assisted, and simulation-based frameworks for resilience assessment and recovery prediction.

Societal and Cross-Cutting Themes:
- Integration of stakeholder preferences, social vulnerability, and deep uncertainty in

function-based decision-making.

- Case studies demonstrate the application of recovery-based design principles in transportation, energy, water, and social systems.

Ultimately, this mini symposium seeks to help shape a new generation of performance-based methods that explicitly account for system interdependencies and functionality loss, ensuring that resilience is engineered, not assumed, across scales from components to communities.

MS 061. Topology Optimization: from Algorithmic Developments to Applications

Mazdak Tootkaboni[1], Chuan Luo[2], Josephine Carstensen[3], Shelly Zhang[4], James Guest[5]

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[4] University of Illinois at Urbana Champaign
[5] Johns Hopkins University

This special session of the EMI 2026 Conference will bring together researchers to discuss the latest advancements in topology optimization. Contributions discussing algorithmic developments in topology optimization, as well as novel applications in solid and structural mechanics, fluid flow, heat transfer, electro-magnetics and multi-physics problems are invited. Contributions focusing on topology optimization under uncertainty and its associated theoretical and computational challenges, and those pertaining to the design of material microarchitectures, devices and mechanisms are of particular interest. Contributions in manufacturing-aware topology optimization as well as topology optimization for additive manufacturing are especially welcome. This MS is sponsored by the EMI Computational Mechanics and Probabilistic Methods Committees.

MS 062. Analysis of Heritage Structures: Tools and Methods for Assessing Historic Monuments and Structures

Rebecca Napolitano[1], Linda Seymore[1], Branko Glisic[2], Admir Masic[3], Daniele Paulino[4]

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[2] Princeton University
[3] Massachusetts Institute of Technology
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Heritage structures constitute an important part of cultural legacy. Regardless of whether they are still standing, in or out of use, partially or completely collapsed, heritage structures represent important milestones in human cultural and engineering achievements, and in the scientific, political, economic, and artistic evolutions that left an everlasting impact on societies. However, while they are irreplaceable sources of knowledge and inspiration, often these structures are the most vulnerable within a community. Destruction of cultural heritage by both natural (e.g. earthquakes, extreme weather) and anthropogenic (e.g. war) means necessitates new and efficient methods of evaluation, repair, restoration, and safeguarding of such structures. Conversely, understanding how other structures remain standing and durable could provide insight for modern, sustainable construction. Historic and existing construction are crucial in surmounting engineering challenges like the design of sustainable infrastructure, space shortages, increased costs of construction, and the lowering life cycle costs. By reusing or recycling existing and historic structures, communities can reduce their carbon costs, decrease the amount of solid waste they contribute to landfills, and save on new construction materials. Before existing structures can be preserved or renovated, however, an assessment of the existing building must be completed. This process must comprise documenting where damages are, understanding how existing damages originated, and assessing the current capacity of a structure. This session aims to bring together experts in cultural heritage from an array of interdisciplinary fields, including civil engineering, archaeology, architecture, material science, geophysics, and computer science.

MS 063. Advanced Spatiotemporal Modeling and Risk Assessment of Natural Hazards for Resilient Infrastructure Systems

Abdollah Shafieezadeh[1], Yue Li[2], Hanbyeol Shin[1]

[1] The Ohio State University
[2] Case Western Reserve University

Accurate characterization and risk assessment of natural hazards are fundamental to designing and maintaining resilient infrastructure. While traditional risk assessment frameworks made significant strides in analyzing single, independent hazards, there is a growing recognition that this approach can be insufficient for capturing complex, real-world scenarios. The next frontier in risk assessment involves understanding compound hazards; multiple hazardous events interconnected in space and time. Scenarios such as hurricanes involving concurrent high winds, storm surge, and extreme precipitation, or earthquakes that trigger subsequent liquefaction and landslides, demonstrate that ignoring these dependencies can lead to a profound underestimation of system vulnerability and cascading failures. In light of the evolving nature of environmental threats and observed shifts in hazard patterns, developing robust frameworks to model both individual and interacting hazard is a paramount challenge.

This mini-symposium aims to bring together experts specializing in multi-hazard risk assessment, probabilistic dependence modeling (e.g., using copula theory), system-level reliability and resilience, coastal and geotechnical engineering, and the application of advanced data analytics and machine learning to hazard modeling/assessment. The session will provide a forum for discussing innovative approaches to address the challenges of compound hazard modeling. The focus will be on topics including, but not limited to:

- Advanced characterization and modeling of individual hazards, including their spatiotemporal variability and extreme value analysis.
- Novel frameworks for the spatiotemporal modeling of compound hazards, including the characterization of spatial and temporal correlations of hazard intensity measures.
- Probabilistic and statistical methods for quantifying the likelihood of compound events and modeling their dependency structures.
- Advanced computational tools and data-driven techniques for simulating the response of structures and infrastructure systems to sequential and concurrent loading.
- Development of multi-hazard fragility and vulnerability models that account for damage accumulation and interacting load effects.
- Application of compound hazard risk assessment to critical infrastructure, including transportation networks, energy systems, and coastal communities.

We invite contributions that advance theoretical foundations, computational tools, and practical applications of hazard and risk assessment. We welcome papers presenting novel methods at various scales, from individual components to entire infrastructure networks. We particularly encourage submissions that explicitly address the spatiotemporal nature of individual or compound hazards, bridge the gap between probabilistic modeling and engineering practice, or showcase interdisciplinary collaborations to enhance infrastructure resilience.

MS 064. Structural Identification and Damage Detection

Eleni Chatzi[1], Eleonora Tronci[2], Babak Moaveni[3], Costas Papadimitriou[4], Zhilu Lai[5]

[1] ETH Zurich
[2] New York University
[3] Tufts University
[4] University of Thessaly
[5] The Hong Kong University of Science and Technology

The mini-symposium focuses on structural identification methods and applications, as well as structural health monitoring (SHM) algorithms for damage detection and reliability prognosis. It brings together theoretical advances, computational developments, and practical applications across structural dynamics, earthquake engineering, mechanical and aerospace engineering, and related disciplines.

Key topics include:
- Data-driven and hybrid schemes for system identification
- Theoretical and experimental modal identification, including operational modal analysis
- Linear and nonlinear system identification methods
- Statistical approaches (e.g., maximum-likelihood, Bayesian inference) for parameter and state estimation
- Model updating, validation, and correlation
- Uncertainty quantification in model selection and parameter estimation
- Stochastic simulation techniques for state estimation and model class selection
- SHM and fault detection techniques
- Optimal strategies for experimental design, including optimal sensor and actuator placement
- Structural prognosis techniques, and updating of response and reliability predictions using data

Contributions addressing experimental investigations and validation of theoretical developments are especially encouraged.

This mini-symposium is organized under the auspices of the EMI Structural Health Monitoring and Control Committee and the Dynamics Committee.

MS 065. Advanced Computational Methods for Uncertainty Propagation and Risk Assessment in Engineering

Liuyun Xu[1], Meng-Ze Lyu[2], Seymour Spence[1], Jian-Bing Chen[3], Michael Beer[2]

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[3] Tongji University

In the engineering field, increasingly complex environmental changes and disturbance demand resilience-oriented decision-making in design, optimization and management of complex systems. Within this context, effective quantification and propagation of uncertainties arising from diverse sources (e.g., geometry, material, and loading conditions) are essential. To address these challenges, a wide range of computational approaches have been developed for robust probabilistic and risk assessment. However, practical applications in engineering often face substantial computational challenges, especially when dealing with high-dimensional problems and rare events involving small failure probabilities.

This mini-symposium seeks to bring together researchers, engineers, and practitioners to share the latest advances and explore pressing challenges in uncertainty quantification, propagation and risk assessment for engineering systems. We encourage submissions that span a broad range of topics, including but not limited to:

- New methods for full probabilistic quantification of non-Gaussian, non-Stationary random fields and stochastic processes.
- Novel methodologies for modeling and evaluating dynamic nonlinear systems, considering high-dimensional uncertainty.
- Advanced computational tools for probabilistic assessment, such as reliability, vulnerability, resilience, and sustainability of complex engineering systems.
- Efficient strategies for rapid uncertainty propagation and small failure probability estimation related to rare events.
- Emerging physics-informed/guided and data-driven artificial intelligence techniques for accelerating uncertainty characterization and propagation.
- Quantification and propagation of epistemic uncertainty.
- Intelligent and robust approaches for design and optimization of structures under uncertainty.
- Recent advances in risk-informed decision-making, resilience assessment, and lifecycle management for structural and infrastructural systems.

Through this symposium, we aim to foster innovative discussions and cross-disciplinary collaborations that advance our collective understanding of uncertainty quantification and risk assessment. We welcome contributions that highlight real-world engineering applications as well as pioneering theoretical and methodological innovations across multiple disciplines, such as civil, mechanical, automotive, aerospace, and energy engineering.

MS 066. Evaluating the Credibility of Computational Models and Digital Twins

Patrick Brewick[1], Pranav Karve[2], Kyle Neal[3], Sakaran Mahadevan[2]

[1] University of Notre Dame
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The scientific community has placed tremendous focus into harnessing the growing availability and capacity of computational tools to develop and create increasingly complex models of engineering systems. These advancements have directly contributed to the emergence of digital twins, i.e., virtual representations of a given system or structure that mirror all relevant aspects and features. However, these digital twins are the culminations of dozens, if not hundreds or thousands, of design decisions and assumptions, making them imperfect representations of the real system. While advanced verification and validation techniques have been developed to quantify the degree to which a predictive model is an accurate representation of the real world, the complexity of digital twins and other engineering models as well as the scarcity of test data make it difficult to fully validate all aspects of a complex model or a digital twin. Thus, even if the model can be validated under certain configurations with respect to some of the outputs, a larger question remains: How credible is the model?

This session invites talks interested in methodological developments related to quantifying and evaluating the credibility of digital twins and complex engineering models. This includes new techniques or advancements in model validation and falsification, assessments or evaluations of model confidence, as well as quantification of model risk. Of particular interest are talks that consider holistic approaches to model credibility and risk quantification, i.e., talks that attempt to quantify how domain expertise, engineering judgment, and/or human knowledge contribute to the confidence in a engineering model's representative ability.

MS 067. Computational statistics for natural hazards engineering: Advances in Uncertainty Quantification, Surrogate Modeling, and Dimension Reduction for Performance-based design of Structures and Systems.

Dimitris Giovanis[1], Somdatta Goswami[1], Bowei Li[2], Michael Shields[1], Seymour Spence[3], Alexandros Taflanidis[4]

[1] Johns Hopkins University
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[3] University of Michigan
[4] University of Notre Dame

Urbanization and climate change (for climatological hazards) have dramatically increased the intensity and/or impact on our communities of many natural hazards, such as tropical cyclones (hurricanes), extreme rainfall events, wildfires, earthquakes, and tsunamis. Such hazards pose a significant threat to most of the world's population, especially in areas where the (frequently aging) civil infrastructure falls short of providing adequate protection. For a better evaluation of the impact of such hazards as well as making intelligent decisions on optimal mitigative strategies, computer-aided simulations have emerged as critical. Recent advances in computational resources (hardware configurations and software) and numerical simulation methods, combined with large reservoirs of data, have dramatically improved the fidelity of these models, greatly improving their capabilities for evaluating and mitigating the catastrophic effects of natural hazards. However, as the resolution of numerical models grows, their computational complexity explodes, making predictive modeling and simulation of large complex and/or multiscale systems a challenging problem in natural hazards engineering. Moreover, inherent uncertainties- including randomness in the hazards, uncertainties stemming from data scarcity, incomplete or biased data, and uncertainties in the model form (epistemic uncertainties) add another level of complexity. To this end, Scientific Machine Learning may be utilized in conjunction with Uncertainty Quantification (UQ) methods and Bayesian Inference to accelerate UQ tasks and increase predictive confidence in natural hazards engineering.

This MS aims to bring together leading experts in the field of natural hazards engineering who combine scientific machine learning and data science with computational statistics tools to address uncertainty characterization and propagation in natural hazards engineering problems. Areas of interest include:

- Machine learning for natural hazards engineering.
- Surrogate modeling for accelerating UQ tasks in performance-based design of structures/systems.
- Data-driven dimensionality reduction of high-dimensional structures/systems
- Active learning and optimal experimental design using machine learning methods.
- Bayesian Inference in natural hazards engineering

MS 068. Surrogate Modeling for Uncertainty Quantification, Optimization, and Statistical Inference in Engineering Applications

Alexandros Taflanidis[1], Bruno Sudret[2], Abdollah Shafieezadeh[3], Gaofeng Jia[4], Min Li[5]

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[5] Rensselaer Polytechnic Institute

Computational models are widely used in many fields of engineering and science. However, accurate high-fidelity computational models are typically very time-consuming and expensive to run. Direct adoption of these high-fidelity models in the context of uncertainty quantification, optimization, and statistical inference is typically computationally prohibitive because of the large number of required model evaluations in these applications. To address these computational challenges, different types of surrogate models have been developed and adopted in many engineering applications to substitute the computationally demanding original models and facilitate uncertainty quantification, optimization, and statistical inference.

This mini-symposium will highlight new research in the field of surrogate modeling and its applications. Topics of interest include, but are not limited to: (1) strategies to support efficient surrogate model construction, e.g., adaptive design of experiments, dimension reduction techniques, multi-fidelity approaches, and physics-informed modeling, (2) development and use of different types of surrogate models, such as kriging/Gaussian process models, polynomial chaos expansion, neural networks and other machine learning-based surrogate models, and (3) application of surrogate models in uncertainty quantification (including but not limited to risk assessment, reliability analysis, sensitivity analysis), design optimization (e.g., reliability-based design and risk-informed design), and statistical inference (e.g., Bayesian inference).

MS 069. Uncertainty Quantification and System Reliability Methods for Regional Risk and Resilience Assessment

Sang-ri Yi[1], Ziqi Wang[2], Ji-Eun Byun[3], Alexandros Taflanidis[4]

[1] Rice University
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[4] University of Notre Dame

Advancements in computational modeling and probabilistic analysis techniques have enabled the assessment of natural hazards and their impacts on the built environment (buildings and lifelines) and communities with unprecedented scale and resolution. The outcomes of these analyses serve as invaluable inputs for guiding emergency response, assessing societal consequences, simulating recovery processes, and optimizing disaster policy and design decisions.

At the same time, efforts toward large-scale risk assessment present opportunities for researchers to address previously unexplored challenges. These challenges often pertain to the accurate and efficient management of uncertainty at scale and complexity. Addressing them requires systems thinking, advanced information theory, new computational methods, and interdisciplinary modeling.

This session is designed to showcase ongoing efforts within the research community to better understand, quantify, and mitigate the consequences of uncertainty in regional-scale risk and resilience analysis, ultimately fostering dialogue and encouraging collaboration among researchers. Topics of interest include, but are not limited to, surrogate modeling, system reliability analysis, sensitivity analysis, adaptive sampling, multi-fidelity approaches, dimension reduction methods, Bayesian inference, missing data imputation, real-time decision-making, and multi-objective optimization.

Applications to various hazard types (earthquakes, hurricanes, tsunamis, wildfires, multi-hazards, etc.) and target systems (hazards, individual structures, networks, communities, etc.) with the ultimate vision of exploring and addressing uncertainty in regional resilience analyses are all welcome.

MS 070. Probabilistic assessment, data-driven inference, and optimization for decision-making under uncertainty

Kostas G. Papakonstantinou[1], Charalampos P. Andriotis[2], Dan M. Frangopol[3], George Deodatis[4]

[1] The Pennsylvania State University
[2] Delft University of Technology
[3] Lehigh University
[4] Columbia University

Engineering systems are exposed to numerous uncertain operating conditions. Quantifying the impacts of deterioration, changing environmental loads and demands, as well as natural or humanmade hazards requires a sophisticated synergy of probabilistic methods for assessment, inference, and optimization. Such methods are also not to be seen in isolation of the decision- and control-theoretic considerations they eventually intend to support. In this regard, key computational constituents of engineering analysis, from the phase of design to that of operation and life-cycle planning, include stochastic modeling and simulation, uncertainty propagation and quantification, information processing and statistical learning, data-driven inference and model updating, together with mathematical and algorithmic approaches for decision-making optimization under stochastic objectives and risk constraints.

In this context, this mini-symposium aims to provide a comprehensive forum for discussion and exchange of ideas, focusing on new developments of stochastic methodologies in mechanics and engineering, and on how integration of traditional probabilistic and model-based engineering with advanced data-driven analytics, machine learning methods, and artificial intelligence techniques can further support optimal decisions in challenging settings characterized by diverse sources of uncertainty and complexity. Areas of interest thus include, but are not limited to:

- Stochastic optimization
- Reinforcement learning and Markov decision processes
- Value of information and structural health monitoring
- Multi-objective optimization
- Multi-criteria optimization in a life-cycle perspective
- Sequential decision-making under uncertainty
- Real-time and data-driven inference
- System identification methods
- Bayesian learning and inference
- Risk and reliability assessment
- Rare event probability estimation
- Sampling techniques
- Simulation of random processes and fields
- Uncertainty quantification and propagation
- Statistical learning, machine learning, and deep learning

- Stochastic dimensionality reduction
- Life-cycle infrastructure management
- Inspection and maintenance planning
- Resilient recovery and emergency response
- Probabilistic performance-based engineering
- Autonomous systems

MS 071. 5th Mini-Symposium on civil infrastructure in a changing climate: from nonstationary risk assessment to developing adaptation strategies

Eun Jeong Cha[1], Abdollah Shafieezadeh[2], Michele Barbato[3], Alexandros Taflanidis[4]

[1] University of Illinois at Urbana-Champaign
[2] Ohio State University
[3] University of California, Davis
[4] University of Notre Dame

Changing climate conditions have long been recognized as an important source of increasing risk associated with climate-driven hazards. These evolving climate conditions alter the environment to which built infrastructure is exposed, posing a major threat to its safety and functioning. To properly manage the risk to built infrastructure under future climate conditions, it is crucial to accurately assess the impacts of climate change on natural hazards and the physical vulnerability of infrastructure. Additionally, developing appropriate mitigation and adaptation strategies to enhance resilience against such hazards, has emerged as a key national and international priority.

This Mini-Symposium will bring together researchers to share the latest advances in climate change research for civil infrastructure and building adaptation. Topics of interest include, but are not limited to: (1) modeling methods for nonstationary risk assessment of infrastructure assets and systems, including physics-based, probabilistic, or data-driven modeling approaches for the impact on the patterns (i.e., intensity or frequency) of extreme weather or climate events (e.g., extreme precipitations, winds, heatwaves, droughts, wildfires), structural loads and structural vulnerability (e.g., through accelerated material degradation); (2) assessment of the climate change impact on the risk (failure and damage) and performance (serviceability, energy consumption, etc.) of civil infrastructure in different regions and at different temporal and spatial scales; (3) development of civil infrastructure adaptation strategies and implementation supports, such as the development of sustainable materials, investigation of structural design adaptation, performance-based engineering implementation, energy consumption reduction, and consideration of flexibility, etc.; and (4) development of support tools for decision-making under complex and uncertain conditions, including risk communication, consideration of risk perception, acceptability of adaptation strategies, deep uncertainty, and development of decision frameworks. Contributions that address conceptual, theoretical, computational, field-based, experimental, and/or methodological developments are all welcome.

MS 072. Reimagining Digital Twins through Artificial Intelligence and Probabilistic Reasoning for Infrastructure Resilience

Youngjun Kwon[1], Abdollah Shafieezadeh[1], Sang-ri Yi[2], Daniel Straub[3]

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[3] Technical University of Munich

Infrastructure resilience depends on how well we can understand and respond to the dynamic interactions between hazards and engineered systems. These interactions evolve over time through complex physical, operational, and human processes and are marked by deep uncertainty. Digital twins provide a promising foundation for capturing and reasoning about these evolving dynamics, yet their true potential lies in connecting data, models, and decisions rather than simply replicating system behavior. Integrating artificial intelligence with probabilistic reasoning allows digital twins to learn from observations, infer hidden states, and evaluate the reliability of predictive outcomes. Such approaches combine physics-based simulation, Bayesian inference, and data assimilation to represent uncertainty and improve situational awareness across diverse hazard environments. They enable infrastructure systems to move from reactive control to adaptive, risk-informed decision-making that considers multiple timescales and levels of uncertainty. This mini-symposium invites studies that advance these capabilities through probabilistic modeling, inverse analysis, dynamic simulation, and intelligent decision analytics. The overarching goal is to shape digital twins into continuously evolving systems that not only mirror infrastructure performance but also interpret changing conditions, anticipate cascading impacts, and collaborate with decision-makers to enhance the reliability, adaptability, and resilience of our built environment.

MS 073. Trustworthy AI and Uncertainty Quantification Methods for Infrastructure Risk, Deterioration, and Hazard Resilience

Aikaterini Kyprioti[1], Jize Zhang[2], De-Cheng Feng[3]

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Civil infrastructure systems are increasingly challenged by a convergence of stressors, including natural hazards, aging and deterioration, and the growing interdependence of life-line networks. At the same time, advances in artificial intelligence and machine learning are enabling unprecedented opportunities for monitoring, forecasting, and decision support. Yet the deployment of these methods in practice is often limited by issues of reliability, interpretability, and the absence of rigorous uncertainty quantification. This mini-symposium invites contributions that address these challenges by developing trustworthy, uncertainty-aware AI/ML frameworks for infrastructure resilience and risk assessment.

Some of the topics for this MS include but are not limited to:

- Early detection of structural damage, defects, or deterioration using computer vi-sion, sensing, and hybrid physics-informed ML approaches
- Robust AI methods for hazard impact forecasting (e.g. floods, wind, storm surge) with quantified confidence measures
- Uncertainty quantification and calibration techniques (Bayesian inference, ensembles, multi-fidelity surrogates) for decision support
- Integration of health monitoring data with physics-based models in digital twins for aging infrastructure
- Frameworks that explicitly account for noisy, incomplete, or shifting data environ-ments
- Applications spanning bridges, coastal systems, transportation networks, and community-scale infrastructure

The goal of this symposium is to highlight innovations that move beyond accuracy alone, toward reliable and interpretable AI solutions that support safe, resilient, and sustainable infrastructure management across its full life cycle.

MS 074. Innovations in CFD and FSI: Rigorous Methods with Practical Applications

Yuri Bazilevs[1], Ming-Chen Hsu[2], Artem Korobenko[3], Georgios Moutsanidis[4], Jinhui Yan[5]

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Computational Fluid Dynamics (CFD) is an established discipline with several decades of serious research and development. There are well established methodologies, implemented in the commercial and research codes, that are used in thousands, if not millions of daily calculations in the aerospace, marine, biomedical, and energy industries. Computational Fluid—Structure Interaction (FSI) as a discipline, on the other hand, is much newer, with unique challenges that make it hard to develop general-purpose solution across different industry sectors. The use of CFD and FSI in civil, structural, and environmental (CSE) engineering is perhaps not as established as in other disciplines. This is due to a combination of historical developments in these fields, funding landscape, and challenges that are unique to CSE. In the latter case, almost all applications of interest occur at large spatial scales, that of a tall building subjected to wind gusts or a bridge pylon under strong current conditions. In such scenarios, the surrounding flow is almost always turbulent, requiring the levels of accuracy, stability and robustness that are not present in many methods and software. The simulations are primarily carried out to deliver accurate structural loads on complex-geometry objects, which are challenging for turbulent flows. Many CSE applications involve free-surface flows interfacing with structures in the regime of high added mass, as in the case of floating offshore wind turbines, for which "non-invasive" loosely-coupled or even block-iterative approaches preferred by the practitioners simply do not work. Many problems of interest in CSE also involve coupling of free-surface flows, structures and soils, for which the community continues to develop methods and debate as to which ones work the best. The main goal of this minisymposium is to bring researchers working on advanced CFD and FSI modeling approaches and applications. Of particular interest are recent innovations in CFD and FSI, which are grounded on a solid theoretical foundation, and which enable effective solution of contemporary challenging problems in CSE and beyond.

MS 075. Wildfire Impacts and Resilience in WUI Communities: From Field Data to AI-Driven Future Planning

Serdar Selamet[1], Ertugrul Taciroglu[2], Negar Elhami-Khorasani[3], Sriram Narasimhan[2], Erica Fischer[4]

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[2] University of California, Los Angeles
[3] University at Buffalo New York
[4] Oregon State University

The 2025 Los Angeles wildfires destroyed over 16,000 structures, giving stark evidence of how extreme wildfire events can transition into devastating urban conflagrations once they enter the wildland–urban interface (WUI). These events underscored the vulnerability of both individual buildings and entire communities, as well as the cascading impacts that arise when fire spreads rapidly across densely built neighborhoods. Leveraging post-fire reconnaissance efforts supported by NSF and other research initiatives, our team undertook a comprehensive campaign to capture perishable data using aerial LiDAR, drone-based surveys, and ground-level inspections following the Los Angeles wildfires. These data collection efforts focused on documenting structural performance, ignition mechanisms, and fire spread pathways, with particular attention to how materials, building configurations, and spatial arrangements influenced outcomes. These datasets are being enhanced with AI-based image detection and recognition algorithms, which enable rapid identification of ignition-prone features, post-fire damage classification, and neighborhood-scale vulnerability mapping. Beyond immediate structural impacts, the reconnaissance sought to identify broader community-scale resilience factors—such as defensible space practices, infrastructure interdependencies, and the role of planning and code enforcement—that shaped survival or loss patterns. The findings highlight both the challenges of mitigating fire spread under extreme conditions. This mini-symposium will bring together engineers, scientists, and policy experts to share cross-disciplinary research on wildfire impacts. By integrating data-driven observations with engineering mechanics approaches, participants will explore new methods to couple fire dynamics, structural analysis, and catastrophe modeling. The goal is to translate field evidence into actionable strategies for mitigation and resilient rebuilding, encompassing a range of approaches from ignition-resistant building design and material selection to community-scale planning, infrastructure hardening, and policy innovation.

The topics of interest are (not limited to):
- Post-fire reconnaissance: aerial LiDAR, drone surveys, ground inspections, etc.
- Observed structure-to-structure fire spread and ignition factors
- Integrating reconnaissance data into predictive fire spread and structural models
- Linking ignition-resistant building design with community-scale resilience and policy strategies
- WUI wildfire risk assessment, fire spread modeling, etc.
- AI-enabled image detection and recognition for damage assessment and vulnerability mapping

MS 076. Advances in Modeling Wind and Its Effects on the Built Environment

Teng Wu[1], Catherine Gorle[2], Marco Giometto[3]

[1] University at Buffalo
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[3] Columbia University

The increasing global urbanization highlights the critical need for optimized urban planning to ensure quality of life while limiting adverse environmental effects. Wind plays an important role in this process, influencing urban resiliency, energy efficiency, citizen comfort, and public health. To support the optimal design of urban structures and infrastructure systems, it is essential to understand and correctly predict these complex, high-Reynolds number, bluff-body flows and their impacts on the built environment.

This mini-symposium aims to showcase recent progress in field measurements, wind tunnel experiments, and computational models of wind and wind effects on the built environment. In particular, the mini-symposium will cover:

- advances in measuring and modeling turbulent wind fields from meso- to micro-scale, considering both stationary and non-stationary effects;
- advances in modeling the effect of these wind fields on the built environment;
- advances in validation, uncertainty quantification, and data-driven approaches to wind modeling.

Submissions are encouraged to address both fundamental questions and applied research on topics such as wind loading, pedestrian wind comfort, urban wind resource assessment, pollutant dispersion, fluid-structure interaction, flow-induced motions, and bluff-body aerodynamics.

MS 077. Advanced Engineering Concepts, Designs, and Technologies for Aerospace and Extraterrestrial Applications (Sponsored by ASCE Aerospace Division)

Ramesh Malla[1], Robert Mueller[2], Kris Zacny[3], Yunlan (Emma) Zhang[4]

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This ASCE Aerospace Division (ASD) sponsored mini-symposium is being organized as a collaborative activity between ASD and the Engineering Mechanics Institute (EMI). The mini-symposium focusses on novel engineering concepts, designs and technologies with applications to aerospace, extraterrestrial exploration, and extreme environments. The symposium will cover a wide range of topics including, but not limited to, the following. Special consideration will be given to engineering and science topics that have potential for dual technology development and promote transfer of technologies and know-how in various civil engineering disciplines between terrestrial and extraterrestrial applications and between civil and other engineering and science areas. Presentations topics will include, but not limited, to the following:

Topics:
- 3-D Printing for aerospace and rapid deployable space structures
- Advanced materials and structures for aerospace applications
- Analytical, experimental, and computational methodologies for aerospace and extreme environments
- Autonomous robotic site preparation
- Dynamics and controls, sensors and condition monitoring of aerospace structures
- Extra-terrestrial civil engineering guidelines and best practices
- Extra-terrestrial exploration and development
- Geotechnical studies with lunar or Martian regolith simulants
- Green and high-performance materials for application in extreme environments
- Human and robotics space and planetary exploration
- Lunar infrastructure concepts and engineering designs
- Lunar seismic engineering
- Microgravity research, including those done in the International Space Station
- Mechanics of granular materials: empirical and analytical methods
- Regolith, mining, and drilling on Moon and Mars
- Space Engineering and construction, including human habitats on Moon and Mars
- Space Structures, Spacecraft, satellites, and propulsion
- Horizontal and vertical automated planetary and lunar construction methods using advanced robotics and regolith as a resource
- Other relevant topics in the areas of materials and structures related to aerospace,

extraterrestrial exploration, and extreme environments

MS 078. Wind, surge-wave, flooding and their impacts on infrastructure systems and coastal land

Chao Sun[1], Celalettin Ozdemir[1]

[1] Louisiana State University

Due to climate change, extreme tropical cyclone-induced coastal hazards (high winds, storm surge, waves, and flooding) have become increasingly frequent and severe, which has caused extensive damage to critical civil infrastructure systems, including buildings, electric power grids, bridges, and transportation networks. These escalating events have also accelerated coastal erosion and land loss, placing coastal communities under growing threat and underscoring the urgent need for effective mitigation and resilience strategies. To develop hurricane-resilient infrastructure and coastal communities, we need to better understand the characteristics of wind, surge, wave, and flooding and to accurately quantify their combined loading effects on structures. Additionally, it is essential to develop a clear understanding of the structural performance and failure mechanisms under single or multiple coastal hazards. This mini-symposium aims to provide a forum for discussions on the latest advances in computational modeling, experimental study, and post-event field reconnaissance study on tropical cyclone-induced single or multiple hazards and structural performance. Specific topics include, but are not limited to the following:

1. Computational modeling and experimental testing of wind, surge and/or wave loading on structures (buildings, bridges, energy systems, etc.);
2. Post-event reconnaissance study of community and regional level infrastructure systems;
3. Multi-scale multi-physics modeling of multi-phase flows;
4. Computational modeling of fluid-structure-interaction;
5. Nonlinear structural behavior and failure mechanism under single or multiple hazards;
6. Mitigation of tropical cyclone induced hazards.

This session is sponsored by the EMI Fluid Dynamics Committee.

MS 079. Assessing Human-Infrastructure Interactions and their Performance

Fernando Moreu[1], Haeyoung Noh[2], Katherine Flannigan[3], Yiwen Dong[4]

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[2] Stanford University
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Physical systems—such as aerospace, civil, marine, and mechanical structures—are designed to support and interact with humans and other living systems. Traditionally, these interactions have been treated as separate entities, with human and structural behaviors considered independently. However, there is growing recognition that the behavior of living systems (e.g., human operators) can significantly influence (or even jeopardize) structural performance and safety, and that the design, maintenance, and operation of physical systems can, in turn, affect living systems. By examining the interactions between these two systems, we can gain a more holistic understanding of both. Measuring and inferring structural responses induced by human behavior allows us to diagnose potential issues in both the structure and the human system. Similarly, assessing human-human and human-infrastructure interactions offers valuable insights into their interdependencies. To achieve optimal system performance and safety, as well as to promote human-centered (or "social") benefits, it is essential to sense and analyze these interactions, as they form critical input-output relationships between humans and the physical environment.

This session is soliciting contributions related to algorithms, theory, modeling, Internet-of-Things (IoT) technologies, implementation, evaluation, and deployment experiences of monitoring, assessing, or controlling human performance and human-induced structural responses. Topics of interest include but are not limited to: (1) understanding and modeling of physical system responses induced by humans or other living systems; (2) understanding the interface between humans, their decisions, and the built environment; (3) human experiences and human cognition of physical systems; (4) analysis of everyday and/or extreme activities of humans in physical systems; (5) wearable sensors and IoT technologies for monitoring human activity, behavior, health, and mental states; (6) augmented reality and virtual reality enabling human-infrastructure interfaces; (7) improving physical system performance through mitigating human effects; (8) enabling human-centric physical system management to improve human comfort, productivity, and other human-centered benefits; and (9) innovative applications, laboratory studies, and field validation.

MS 080. Failure Mechanisms and Health Assessment of Aging Hydraulic Structures under Future Environmental Conditions

Amin Hariri[1]

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Hydraulic structures such as dams, levees, and flood barriers are increasingly challenged by material aging, evolving boundary conditions, and intensifying environmental demands. Over extended service lives, complex chemo-thermo-mechanical interactions—such as creep, alkali–aggregate reaction, corrosion, and temperature gradients—modify the constitutive behavior of concrete and interfaces, leading to gradual stiffness loss, strength degradation, and altered failure pathways. These processes, when combined with dynamic hydraulic or seismic excitations, can induce nonlinear, path-dependent responses that depart from conventional limit-state assumptions.

This mini-symposium focuses on advancing the mechanics-based understanding of deterioration, damage localization, and failure evolution in aging hydraulic systems. Contributions are invited that (i) develop or validate constitutive and multiphysics models for degradation and fracture; (ii) investigate coupled hydro-mechanical and dynamic instabilities under multi-hazard conditions; and (iii) integrate structural health monitoring, inverse identification, and AI-enhanced model updating for prognosis and decision support. Studies bridging theory, computation, and field observations are especially encouraged. The session seeks to promote a unified framework for quantifying aging effects and ensuring the long-term safety and climate resilience of critical hydraulic infrastructure.

MS 081. Computational Methods for Stochastic Engineering Dynamics

Ketson dos Santos[1], Vasileios Fragkoulis[2], Ioannis Kougioumtzoglou[3], Antonina Pirrota[4], Athanasios Pantelous[5]

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[3] Columbia University
[4] University of Palermo
[5] Monash University

Ever-increasing computational capabilities, novel signal processing techniques, and advanced experimental setups have led to highly complex modeling of engineering systems and related excitations. Examples include nonlinear/hysteretic response behaviors and non-Gaussian, non-white, and non-stationary excitation modeling. In many cases, even the deterministic solution of such governing equations remains an open issue and an active research topic. Naturally, solving the stochastic counterparts of these equations becomes even more challenging, particularly for high-dimensional systems.

The objective of this MS is to present recent advances and emerging cross-disciplinary approaches in the broad field of computational methods for stochastic engineering dynamics problems, with a focus on uncertainty modeling and propagation. Of great interest are contributions related to both fundamental research and engineering applications of stochastic dynamics, as well as signal processing approaches in the modeling and solution processes. A non-exhaustive list of topics includes joint time-frequency analysis tools, sparse representation and compressive sampling methodologies, stochastic/fractional calculus modeling and applications, nonlinear stochastic dynamics, stochastic model/dimension reduction techniques, Monte Carlo simulation methods, and risk/reliability assessment applications.

MS 082. Innovations and Advances in Passive, Active, and Semi-active Structural Control

Nicholas Wierschem[1], P. Scott Harvey[2]

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Buildings, bridges, and other structures are subjected to service-level dynamic loads as well as extreme man-made and natural hazards. Additionally, the complexity of structures is increasing along with demands regarding their performance, resilience, and efficiency. Because of this, the continued development of structural control devices and techniques is crucial. This mini-symposium will serve as a gathering place for researchers and practitioners to present on and discuss recent innovations and advances in passive, active, and semi-active structural control. Of interest are presentations related to new or improved structural control devices including mass dampers, magnetorheological devices, cable-based devices, variable stiffness devices, base isolation systems, and other supplemental damping devices, including those which utilize innovative materials, inerters, nonlinear geometry, or nonlinear materials. Furthermore, of interest are advances related to the use of structural control devices to increase the sustainability, robustness, or resilience of structures. Additionally, advances in algorithms, optimization, or the implementation of control devices are of interest.

MS 083. Innovative Response Modification Methods and Devices for Resilient Structures and Infrastructure

Mehrdad Aghagholizadeh[1], Konstantinos Kalfas[2], Christian Málaga-Chuquitaype[3]

[1] Loyola Marymount University
[2] Texas State University
[3] Imperial College London

Recent advances in computational modeling, material development, and experimental capabilities have enabled engineers to design and assess innovative response modification strategies for structures and civil infrastructure. These include passive and active control systems, base and inter-story isolation, energy dissipation devices, tuned dampers, and rocking isolation. At the same time, emerging materials such as metamaterials, shape memory alloys, and eco-friendly hysteretic devices are opening new directions for sustainable and resilient design.

This mini-symposium invites contributions on experimental, analytical, and numerical studies of structural response modification methods and devices under seismic and other extreme hazards. Topics of interest include novel modeling frameworks, laboratory and large-scale experiments, and design strategies that advance the resilience and sustainability of the built environment. The goal is to bring together diverse perspectives and highlight recent advances that can shape the next generation of resilient structures.

MS 084. Recent Advances in Hybrid Simulation and Real-time Hybrid Simulation

Wei Song[1], Richard Christenson[2], Amirali Najafi[3]

[1] University of Alabama
[2] University of Connecticut
[3] Texas A&M University

Hybrid simulation (HS) is a novel, powerful and cost-effective experimental technique for examining the global behavior of complex, large-scale structural systems under realistic conditions. This technique is developed by coupling both physical and simulated components while enforcing the displacement constraints and force equilibrium as the simulation progresses. Real-time hybrid simulation (RTHS), a real-time extension of hybrid simulation, is developed to study structural systems with time-dependent behavior. Recent advances in HS and RTHS are offering better understanding to the fundamental issues in hybrid simulation, and enabling more efficient and cost-effective solutions to the investigation of global structural behavior under realistic conditions. The goal of this mini symposium is to provide a forum for researchers in HS and RTHS to exchange information, disseminate recent findings, and identify future key focus areas. This symposium invites papers related to the following topics:

- Novel enabling techniques, e.g., actuator control and compensation, numerical integration schemes, noise treatment, and machine learning based control design;
- Performance evaluation in HS and RTHS, e.g., stability analysis, assessment criteria, uncertainty quantification, and compensation/delay evaluations;
- Innovative HS and RTHS frameworks;
- Recent HS and RTHS implementations and applications, especially in hazard mitigation, multi-physics, and emerging applications;
- Tutorial materials to convey fundamental principles in HS and RTHS and encourage the broader community participation in HS and RTHS.

Keywords:
Hybrid simulation, real-time hybrid simulation, time integration, actuator control, delay compensation, stability analysis, machine learning

MS 085. Seismic Isolation and Energy Dissipation Systems: Mechanics, Experiments, and Innovations — In Honor of Professor James M. Kelly (1935–2025)

Dimitrios Konstantinidis[1], Nicos Makris[2]

[1] University of California, Berkeley
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This mini-symposium is dedicated to the memory of Professor James M. Kelly, whose pioneering work transformed earthquake engineering through the development of seismic isolation and supplemental energy dissipation technologies. Widely regarded as the Father of Seismic Isolation, Professor Kelly's contributions spanned from foundational mechanics to the analysis, design and experimental validation of innovative protective systems. His research bridged theory and practice, reshaping how engineers understand, model, and implement seismic protection for structures worldwide, with emphasis to high-performance and low-cost response modification devices.

In recognition of his visionary contributions, this mini-symposium aims to bring together researchers and practitioners to share advances in the mechanics, materials, modeling, and experimental evaluation of seismic isolation, supplemental energy dissipation, and other protective systems. Contributions with a strong mechanics foundation—reflecting Professor Kelly's enduring legacy in structural mechanics—are especially welcome. Equally encouraged are large-scale experimental investigations and applications demonstrating the transformative potential of isolation and damping systems in enhancing structural performance.

- Fundamental mechanics and constitutive modeling of isolation and damping devices
- Novel materials and adaptive concepts for isolators and energy dissipators
- Experimental characterization and full-scale testing of protective systems
- Hybrid simulation and system-level modeling of isolated and damped structures
- System-level performance and stability assessment
- Design optimization and performance-based assessment
- Multi-hazard and vertical response considerations
- Low-cost, sustainable, and regionally adaptable isolation and damping solutions
- Emerging technologies and innovative applications across buildings, bridges, and infrastructure

MS 086. Complex Dynamics Modeling and Vibration Control of Infrastructure Systems Under Single/Multiple Hazards

Chao Sun[1], Mariantonieta Soto[2], Zhen Sun[3], Zili Zhang[4]

[1] Louisiana State University
[2] Pennsylvania State University
[3] Southeast University
[4] Tongji University

Civil infrastructure systems are frequently impacted by single and/or multiple hazards like earthquakes, winds, waves, storm surge, current, ice, and collisions. Due to the combined loading effects, the structural dynamic behavior becomes increasingly complex and severe. Under certain conditions, structures can experience complex dynamic responses, such as chaos, bifurcations, jump, frequency lock-in, vortex induced vibrations, flutter, etc. These complex dynamic behaviors will inevitably undermine structural performance, damage the structural integrity, and cause potential loss of properties and lives. To prevent such damage and disasters, a better understanding of the complex dynamics as well as the corresponding vibration control strategies (active/semi-active/passive/hybrid) are required. Also, the emerging artificial intelligence (AI) and machine learning (ML) techniques, and metamaterials and metastructures provide new paradigms to efficiently model the complex dynamics of structures and mitigate the structures. This mini-symposium aims to advance open discussions on recent progress on complex dynamics modeling and mitigation of structures subjected to single and/or multiple hazards. Specific topics include, but are not limited to the following:

1. Dynamics modeling of mechanical/civil infrastructure under single/multiple hazards;
2. Leveraging AI/ML techniques to efficiently model complex dynamic responses;
3. Vibration control of buildings and bridges under single/multiple hazards;
4. Dynamics modeling and control of onshore and offshore wind turbines;
5. Hazard modeling and resilience enhancement of power transmission/distribution systems;
6. Dynamics modeling and control of cables/moorings and other flexible structures.
7. Novel metamaterials and metastructures for vibration mitigation applications.

This session is sponsored by the EMI Dynamics Committee and Structural Health Monitoring & Control Committee.

MS 087. 11th Symposium on Molecular Scale Modeling and Experimentation

Dinesh Katti[1], Sinan Keten[2], Nima Rahbar[3], Kalpana Katti[1], Steven Cranford[4], Wenjie Xia[5]

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[2] Northwestern University
[3] Worcester Polytechnic Institute
[4] Cell Press
[5] Iowa State University

The symposium will seek papers on topics pertaining to fundamental and applied research in the field of molecular-scale modeling and experimentation and their applications to engineering mechanics and materials characterization. Of particular interest are models and/or experimental techniques that enable atomistic control or assessment of mechanistic behavior or are based on novel mechanistic responses. Some of the topics included in the symposium, but not limited to, are: atomistic molecular dynamics simulations to evaluate the mechanical behavior of materials; molecular simulations of transport phenomena including diffusion, electrical and thermal transport, and coupled behavior; ab-initio and DFT computations for potential field development; techniques to bridge molecular-scale responses to higher length and time scales; hybrid modeling approaches, combining atomistic representations with non-atomistic elements; spectroscopy techniques to evaluate molecular-scale interactions and conformations; single molecule force spectroscopy, including atomic force microscopy, lateral force spectroscopy, etc.

MS 088. Advances in Damage Mechanics and Micromechanics - in Honor of the 2025 Blaise Pascal Medal in Engineering to Professor Jiann-Wen Woody Ju

Huiming Yin[1], Lizhi Sun[2], Glaucio Paulino[3], Yong-Rak Kim[4]

[1] Columbia University
[2] University of California Irvine
[3] Princeton University
[4] Texas A&M University

This minisymposium is dedicated to Professor Jiann-Wen Woody Ju in honor of the 2025 Blaise Pascal Medal in Engineering for his pioneering and exceptional contributions in the fields of damage mechanics and micromechanics of solids. At the same time, Professor Ju was recognized as a Fellow (Academician) of the prestigious European Academy of Sciences (EURASC) and honored among its distinguished Members. In addition to tributes from colleagues, former students, collaborators, and associates of Professor Ju are organizing this symposium to welcome contributions in the broadest context of recent advances in damage mechanics and micromechanics of materials and structures, especially those topics inspired and motivated by Professor Ju's seminal fundamental scientific work.

Modern engineering materials and structures are often subjected to multiple constraints, and the mechanics of materials and constitutive models of advanced engineering materials are critical to fulfill those multiple functions. This mini-symposium provides an excellent platform to exchange the cutting-edge results in theoretical, computational, and experimental methods from fundamental to applied research. Example topics of this mini-symposium can include but are not limited to the following:

- Micromechanical damage mechanics of brittle composites
- Micromechanics of random heterogeneous elastic and inelastic fibrous and particulate composites
- Microstructural damage, fracture, and healing mechanisms and modeling
- Continuum elastoplastic damage mechanics
- Plasticity and viscoplasticity theories and computational algorithms
- Advanced constitutive modeling of materials and tissues
- Nonlinear computational mechanics of composite materials and structures
- Nondestructive and destructive testing, durability, reliability, sulfate attack, and construction defects
- Multiscale multiphysics modeling of heterogeneous media subjected to coupled physics
- Advanced testing and modeling of heterogeneous media aided by AI/ML

MS 089. Microscopic Mechanisms of Plasticity in Amorphous Solids

Corey O'Hern[1], Mark Shattuck[2], Weiwei Jin[1]

[1] Yale University
[2] The City College of New York

Despite extensive research, the microscopic mechanisms governing plasticity in amorphous solids under an externally applied stress remain incompletely understood. This mini-symposium will focus on recent advances in identifying and characterizing the microscopic structural signatures, such as non-affine motion, shear transformation zones (STZs), and their collective organization into shear bands, that underpin plastic deformation in amorphous materials. A central goal is to elucidate how these structural features form, evolve, and interact, and how they contribute to the onset of shear localization and mechanical instability. These insights are essential for developing theoretical models and moving toward a unified framework for predicting the deformation and flow of amorphous solids.

We invite contributions from an interdisciplinary community of researchers in mechanics, physics, materials science, and engineering, including experimental, theoretical, and computational approaches. By bringing together diverse perspectives, this mini-symposium aims to foster new collaborations and accelerate progress toward understanding how microscopic structural ``defects'' govern the macroscopic mechanical response of amorphous solids.

MS 090. 10th Mini-Symposium on 4M (Modeling of Multiphysics, Multiscale, Multifunctional) Engineering Materials and Structures

Yong-Rak Kim[1], Huiming Yin[2], Chung Song[3], Jianqiang Wei[4]

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There has been increasing interest/foci and developments on the multiphysics, multiscale, multifunctional nature of materials research in many engineering and science disciplines. It is because many engineering materials and structures present multiple length/time scale-dependent behavior, which is often coupled with multiphysics phenomena (e.g., hydraulic, thermal, chemical, electromagnetic, etc.), and are increasingly targeted toward multifunctional characteristics. Even though multiphysics-multiscale problems have long been studied in Physics, Chemistry, Mathematics, and Mechanics, the current excitement is driven heavily by the use of advanced modeling in applied engineering and science. In addition, multifunctional materials are sought to meet specific requirements (functions) through tailored properties. Smart materials can be considered multifunctional materials that have the ability to react upon an external stimulus. The introduction of biomimetics in materials science allows the designing of materials with similar processes as nature does: building from molecules to complete structures (i.e., multiscale). Properly executed modeling of multiphysics, multiscale, and multifunctional engineering materials and structures can vastly improve accuracy and efficiency in solutions that were not quite feasible through conventional approaches, in many cases, with very reasonable experimental-computational costs.

Given the technological significance and increasing interest, we have continued this mini-symposium for the last nine years, and are excited to offer this 10th symposium at the EMI 2026 conference. More specifically, this mini-symposium will provide an interactive channel to discuss/introduce various (theoretical, computational, and experimental) approaches and their integration into the advanced modeling of multiphysics, multiscale, multifunctional materials and structures. Presentations from various fields are invited on the relevant topics including, but are not limited to:

Thrust 1: Multiphysics

- Coupled (multiphysical) modeling/simulation of engineering materials and structures
- Materials-structures interaction with environmental effects
- Multiphysics coupling of stimuli-responsive smart materials/structures
- Multiphysics testing and modeling aided by AI/ML

Thrust 2: Multiscale

- Quasi-continuum and equivalent continuum approaches
- Atomistic to continuum coupling
- Marriage of discrete medium and continuum mechanics

- Inelastic behavior and damage-fracture of materials in multiple length-time scales
- Effects of impurities (inclusions) on mechanical properties of composites
- Advanced nanocomposite-nanomaterials systems and nanomechanics
- Mechanics of bioinspired materials and structures with hierarchical structures
- Thermodynamic modeling and multi-scale approaches to bridge chemistry, microstructure, and bulk properties of cementitious composites
- Multiscale testing and modeling aided by AI/ML

Thrust 3: Multifunctional

- Multifunctional materials-structures and their constitutive/performance modeling
- Adaptive materials and structures that allow reconfiguration or readjustment of shape, functionality and mechanical properties in response to external stimuli
- Mechanics/modeling of self-healing materials (e.g., polymers, composites, and concretes)
- Mechanics of materials and structures with bioinspired functions
- Mechanics of multifunctional materials and structures aided by AI/ML

MS 091. Advances in Modeling of Material Damage and Fracture

Mostafa Mobasher[1], Lampros Svolos[2], Aditya Kumar[3], Georgios Moutsanidis[4], Alessandro Fascetti[5], Ravindra Duddu[6], Haim Waisman[7]

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[2] University of Vermont
[3] Georgia Institute of Technology
[4] Rutgers University
[5] University of Pittsburgh
[6] Vanderbilt University
[7] Columbia University

In recent decades, various computational methods have been developed for modeling damage and fracture in different materials across various applications. Despite significant progress, state-of-the-art methods still face challenges that impede the achievement of predictive and computationally efficient modeling of material and structural failure. Some examples of these challenges include modeling fracture initiation through damage, developing robust computational techniques for coupled phenomena, and implementing efficient solvers. These issues are particularly challenging under extreme loading conditions, such as those in impact and thermal shock experiments, hydraulic fracturing of geomaterials, and other multiphysics problems.

This minisymposium provides a forum for discussion on the challenges and advancements in computational methods for the reliable and efficient modeling of material damage and fracture. Topics of interest include, but are not limited to, the following: continuum damage approaches (e.g., local/non-local and cohesive zone models), phase-field models of fracture, constitutive modeling of failure mechanisms (e.g., void nucleation, microcracking, shear bands, and corrosion), failure in coupled problems (e.g., thermomechanical, electrochemical, fluid-driven fractures), advances in discretization methods (e.g., particle and material point methods) and solver technologies (e.g. staggered/monolithic schemes, and iterative methods), experimental validation of models capturing microstructural defects, reduced order modeling and machine learning techniques.

Example application areas are fracture and fatigue in both brittle and ductile materials, the dynamic response of polycrystalline materials, multiphysics problems (thermoelasticity and temperature-dependent viscoplasticity, hydraulic fracture), and rupture in soft materials.

MS 092. Fundamentals, Multiphysics, and Data-Driven Advances in Elasticity for Applied Mechanics

John Brigham[1], Berkin Dortdivanlioglu[2], Evgueni Filipov[3]

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[2] University of Texas
[3] University of Michigan

Elasticity remains a foundational pillar of applied mechanics, offering fundamental insights into material behavior and structural response. Beyond its classical role, elasticity now serves as a unifying framework for understanding multiphysical interactions—including coupled mechanical, thermal, electrical, and magnetic effects—as well as poroelastic and bioelastic phenomena. This mini-symposium, organized by the ASCE EMI Elasticity Committee, seeks contributions that advance the fundamental theory of elasticity, explore its role in multiphysics modeling, and integrate machine learning and data-driven methods to enhance predictive capabilities. Topics of interest include constitutive modeling, nonlinear and anisotropic elasticity, wave propagation in complex media, and elasticity-driven phenomena in multifunctional materials such as piezoelectric, magnetoelastic, and porous systems. We also welcome computational and experimental approaches that bridge scales, leverage AI for model discovery, and reveal new physical insights. By fostering dialogue across disciplines, this symposium aims to highlight how elasticity continues to evolve as a core tool for predicting and designing systems governed by coupled physical processes.

MS 093. ADVANCES IN GEOMECHANICS AND GEOPHYSICS FOR SUB-SURFACE TECHNOLOGY AND NATURAL HAZARD

Ghassan Shahin[1], John Rudnicki[2], Giuseppe Buscarnera[2]

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Rock systems are pivotal in addressing some of the most pressing societal challenges of our time, ranging from sustainable energy production and subsurface storage to the mitigation of natural hazards. The deformation of crustal rocks is challenging because of complexities such as a myriad of multiphysical phenomena, instabilities, disparate time and length scales, and coupling with pore fluid and thermal diffusion. For decades, these challenges have inspired active research, now further energized by the growing demand for subsurface technologies aimed at tackling climate change. This symposium seeks to foster interdisciplinary exchange on rock systems, showcasing the latest advancements in the field. We invite contributions on a broad spectrum of topics, including but not limited to:

1. Multiscale and multiphysics mechanics of porous rocks
2. Fault mechanics, fracture mechanics, and deformation banding
3. Field and laboratory methods
4. Constitutive, multiscale, and data-driven modeling approaches

MS 094. Mechanics and Physics of Granular Materials

Ryan Hurley[1], Marcial Gonzalez[2], Yimin Lu[3], Dawa Seo[4], Alessandro Rotta Loria[5], Ali Daouadji[6]

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[2] Purdue University
[3] Texas Tech University
[4] Wayne State University
[5] Northwestern University
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Nearly every product, commodity, or piece of infrastructure is constituted from, derived from, or supported by particulate materials which themselves are derived from mining, agriculture, and/or chemical processing. Granular materials are also featured in applications ranging from the development of novel composite materials with tailored properties to the construction of foundations and earthworks to the design of blast and penetration resistant structures. As ubiquitous constituents of industrial processes and geophysical phenomena, these materials operate in regimes extending from quasi-static deformation to rapid, collision-dominated flows. While systems composed of granular or bulk solids share common properties over a very wide range of particle sizes, their macroscopic behaviors are entirely dependent on the microstructural and micromechanical properties of their grains and their interactions.

This symposium focuses on the mechanics of granular systems over a broad range of scales and phase regimes. Contributions which examine, using theory, computation, or experiments, the mechanical and physical properties of granular materials as relevant to applications in geotechnical engineering, mining, manufacturing, and pharmaceutical production, among other industrial processes, are welcomed. Contributions which examine the origins of fundamental mechanical and physical phenomena in granular media without specific applications are also welcomed.

MS 095. Characterization and modeling of physical and chemical processes in porous materials across scales

Mostafa Mobasher[1], Pania Newell[2], Sara Abedi[3], Manolis Vevakis[4], Jean-Michel Pereira[5], Giuseppe Buscarnera[6], Yanni Chen[7], Ghassan Shahin[8], Rigoberto Moncada[9]

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[2] University of Utah
[3] Texas A&M University
[4] Duke University
[5] Univ Gustave Eiffel
[6] Northwestern University
[7] Zhejiang University
[8] Ecole Polytechnique Fédérale de Lausanne
[9] Lawrence Livermore National Laboratory

Poromechanics and physics of porous materials cover a wide range of applications including infrastructure integrity, energy, mining, manufacturing, and more. While significant research efforts have been established in the fields of characterization and modeling these processes, many challenges remain unresolved. Some of these challenges are stem from the difficulties in experimental characterization of the physical processes due to the multiscale and coupled nature of these processes. Other challenges are related to the modeling, such as the computational cost, the variability of material properties,, the difficulty of the development of representative constitutive laws, and the development of robust numerical solution algorithms to represent the multiphysics and multiscale phenomena. This MS aims at providing an opportunity to discuss the persisting challenges as well as the emerging advances in the field of porous materials characterization and modeling. The topics of interest include, but are not limited to the following:

• Innovative experimental characterization methods across scale, ranging from geotechnical engineering testing to advanced imaging of porous materials
• Experimental characterization attempting to capture multiphysical phenomena across scales
• Constitutive and phenomenological modeling, including the challenges associated with the calibration and validation of models
• Development of multiphysics analysis algorithms using numerical discretization methods such as finite elements, boundary elements, discrete elements, peridynamics, etc..
• Multiscale modeling and approaches attempting to bridge between scales
• Stochastic analysis, including the role and methodologies of uncertainty quantification and propagation
• Physics-informed and data-driven machine learning approaches, and reduced order modeling

We welcome contributions from students, postdocs, and researchers at different career stages to create a vibrant mini-symposium, where we all can exchange knowledge of porous media.

MS 096. Coupled Multi-Physics Mechanics of Geomaterials for Energy and Environmental Applications

Angelica Tuttolomondo[1], Anne-Catherine Dieudonné[2]

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[2] Delft University of Technology (TU Delft)

Current challenges in the energy transition and environmental management demand a deeper understanding of geomaterials under complex coupled conditions. This minisymposium will highlight recent advances in coupled multi-physics mechanics of geomaterials, bridging fundamental processes with practical applications in energy and environmental geotechnics. Topics include, but are not limited to, thermo-hydro-mechanical-chemical (THMC) interactions in subsurface systems such as CO_2 storage, hydrogen storage, geothermal applications, and nuclear waste repositories. Contributions addressing experimental investigations at multiple scales, from laboratory to in situ, as well as advanced constitutive modeling and computational frameworks, are particularly welcome. Special emphasis will be given to experiments that reveal and quantify relevant coupled processes, and to theoretical or numerical frameworks grounded in a physical understanding of these interactions. The minisymposium will provide a platform for cross-disciplinary exchange and showcase recent strategies to better characterize and design geomaterials for energy and environmental applications.

Keywords: Geomaterials, THMC interactions, Multi-physics, Experimental investigations, Theoretical and computational frameworks

MS 097. From Noisy Construction to Stable Structures in Soft and Granular Media

Atanu Chatterjee[1], Florence Müller[2], Qinglin Wu[1], Saad Bhamla[1]

[1] Georgia Institute of Technology and University of Colorado Boulder
[2] California Institute of Technology

Noisy builders, such as ants and termites excavate and cement soil to create robust, functional environments without centralized control or fixed blueprints. Their assembly rules are local, yet the media they shape are heterogeneous, history-dependent, and can be locally fragile, particularly during deposition and prior to curing. Engineering such processes requires a mechanics framework that quantifies how stochastic sensing, signaling, and actuation couple to deposition, curing, and load transfer in the host medium.

We are especially interested in materials whose microstructure can be deliberately tuned during construction, allowing noise to act as a design knob rather than a liability. By studying how biological collectives achieve reliable engineering under uncertainty, we aim to transfer these principles into swarm robotics, enabling autonomous systems to construct resilient, adaptive structures from the bottom up.

This mini-symposium aims to establish a framework for understanding the engineering and mechanics of blueprint-free construction using granular and soft materials as non-biological, synthesizable model systems. A key objective is to connect noise-driven local agent-level rules and microscale fluctuations to mesoscale rheology and macroscopic performance through constitutive models, mean-field approaches, and phase-field descriptions.

Topics of interest include mechanistic laws for stochastic deposition, hydrodynamic and poromechanical feedback during excavation and printing processes, and the scaling relations and dimensionless groups that govern pattern selection and structural stability. We will also examine residual stresses and memory-of-flow in yield-stress materials as designable features connected to process history (thixotropy), which have implications for post-deposition stability and service performance. Additionally, we will explore control-in-the-loop strategies that leverage noise to enhance reliability. Here, stochastic control can be coupled with in situ rheometry and process monitoring to guide real-time curing and load transfer.

We invite contributions in theory, computation (including Discrete Element Method (DEM), hybrid Computational Fluid Dynamics (CFD)-DEM, phase-field models, stochastic Partial Differential Equations (PDEs), and learned surrogates), and experimental studies related to bio-inspired systems, soft robotics, autonomous swarms, and the additive manufacturing of particulate and gel-based media. To connect with biofabrication practices, we particularly welcome work that integrates construct modeling, bioink selection and rheology, deposition strategy and path planning, and printed construct characterization, using stochastic mechanics that bridge agent policies with print fidelity and structural performance.

MS 098. Meshfree, Peridynamic, and Particle Methods: Advancements and Applications

Sheng-Wei Chi[1], Jiun-Shyan (JS) Chen[2], Mike Hillman[3], Pablo Seleson[4], Tsung-Hui (Alex) Huang[5], Kuan-Chung Lin[6]

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Simulations involving the mechanics of fracture, localization, shocks, and fluid-like plastic flow require a departure from traditional Lagrangian finite elements. Meshfree, peridynamic, and particle methods have proven successful in these challenging problems. Here, additional flexibility is obtained by using a point-based approximation without fixed mesh connectivity. When constructed in the current physical domain, they provide a natural framework for solving challenging engineering problems that would otherwise require erosion, mesh movement, and remeshing with mesh-based methods.

The approximations employed in meshfree and particle methods also allow for controllable orders of continuity and completeness, offering significant flexibility in incorporating enrichments to capture the physical characteristics of the problem at hand. Similarly, peridynamic methods have been proposed to model systems with or without discontinuities, and they share many features with meshfree and particle methods. All these methods provide new paradigms for solving mechanics problems without being restricted to Galerkin-type procedures and are versatile enough to naturally embed and couple machine learning techniques.

This session aims to promote collaboration among academia, government/national labs, and industry in the development and application of meshfree, peridynamic, and particle methods to share recent advances and lessons learned, as well as to transfer knowledge. This mini-symposium will solicit all subjects related to the development of these methods, which include, but are not limited to, the following:

- Fundamental theoretical developments
- Industry and lab applications where meshfree, peridynamic, and particle methods provide an advantage over conventional methods, such as natural disasters, manufacturing processes, and bio-mechanics
- One-to-one comparisons of meshfree and mesh-based methods in challenging applications
- Integration of machine Learning and meshfree methods
- Treatment of strong and weak discontinuities, e.g., for strong shock dynamics, crack propagation, and material interfaces
- Methods and algorithms to treat extreme material distortion, fragmentation, contact, and impact

- Applications involving structural failure and/or combined fluid-structure interaction in extreme events such as blast, impact, and penetration
- Novel and/or flexible discretization techniques for challenging problems, such as composite microstructural analysis
- Treatment of material instability
- Enhanced and/or stabilized nodal integration methods
- Variationally consistent integration and other approaches to quadrature
- Strong form collocation meshfree methods
- Rank stability, kernel stability, and other stability issues
- Parallel computing, including GPUs, scalable algorithms, and large-scale simulations
- Multiple and coupled physics
- Multiple time and/or length scales
- Multi-phase (solid, fluid, and gas) interactions

MS 099. Computational Generalized Continua, Gradients, and Nonlocal Mechanics

Richard Regueiro[1], Remi Dingreville[2], Alexander Dummer[1], Christian Linder[3], Nathan Miller[1], Matthias Neuner[4], Leong Hien Poh[5]

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Higher order continuum theories involving additional field variables (generalized continua), gradients of fields or internal state variables, or nonlocal integral representations, have been developed over the past century in an attempt to capture underlying microscopic material scale behavior within macroscale continuum field theories while also modeling localized deformation. With the development of advanced experimental diagnostics (such as ultrafast computed tomography) achieving higher spatial and temporal resolution, as well as advances in Machine Learning (ML) and Artificial Intelligence (AI) to sample microstructural response, these theories have become richer in their representation of underlying microscale behavior and thus have gained more applicability in multiscale analysis as well as simulating localized deformation and failure in solids. Various challenges with these theories remain such as: (i) suitable numerical methods for implementing such theories computationally, (ii) application of boundary conditions, (iii) overlapped couplings for upscaling underlying direct numerical simulation data, (iv) communication between non-overlapping micro and macro domains, (v) adaptive spatial and temporal resolution, (vi) continuity requirements, and (vii) demonstration of spatial discretization independence for simulating localized deformation, to name a few. Thus, this minisymposium provides a venue for researchers interested in any aspect of generalized continua, gradients, and nonlocal mechanics to present their recent work and interact with other researchers also working in the area.

MS 100. Computational Geomechanics

Hyoung Suk Suh[1], Shabnam Semnani[2], Jinhyun Choo[3], WaiChing Sun[4], Craig Foster[5], Richard Regueiro[6], Ronaldo Borja[7]

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This mini-symposium will serve as a forum for the presentation and discussion of both cutting-edge research and practical advancements in computational geomechanics. Topics of interest include, but are not limited to: (1) development, implementation, and validation of advanced constitutive models in geomechanics; (2) particle-based numerical methods (DEM, MD, Peridynamics, and related approaches); (3) computational models and algorithms for multiscale and multiphysics problems; (4) numerical modeling of fracture, damage, and fragmentation processes; (5) local/nonlocal theories and models (mesh-based and mesh-free appraoches); (6) implementation and case studies of numerical methods in geo-energy, geo-hazards, and geo-environmental applications; (7) validation and verification of numerical models and algorithms in geomechanics; (8) machine learning and data-driven approaches in geomechanics; and (9) new challenges and opportunities (geomechanics in extraterrestrial exploration, nature-inspired geomechanics, metamaterials, etc.).

MS 101. Engineering Education: New Trends, Opportunities, and Experiences

Rebecca Napolitano[1], Fernando Moreu[2], Roya Nasimi[3], Wesley Reinhart[1], Shahlaa Al Wakeel[4]

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Higher education is being shaped by rapidly evolving technologies, shifting student expectations, and new insights into the science of learning. To meet these challenges, educators across all engineering mechanics disciplines are seeking innovative and effective ways to enhance their teaching and deepen student engagement. This session provides a dynamic forum for instructors, researchers, and administrators to share tangible, evidence-based approaches to educational excellence in engineering mechanics. Through a series of presentations, speakers will explore practical strategies and thoughtful frameworks for creating more impactful, inclusive, and relevant learning experiences for today's engineering mechanics students. The talks presented in this session can cover a range of themes:

- Presentations can showcase creative pedagogical approaches and the development of adaptable learning materials. These talks could explore how new teaching strategies and course content, from project-based learning to incorporating digital tools, can be effectively integrated into established courses to enrich the student experience.
- Recognizing that instructor development is key to educational excellence, another set of talks could explore successful models for faculty support. This includes case studies on fostering collaborative teaching communities, effective peer-mentorship programs, and creating shared resource libraries to help educators thrive in a changing academic landscape.
- Presentations can also examine how to create more cohesive and impactful educational pathways for students. Presenters can share strategies for integrating core concepts across multiple courses, ensuring that foundational knowledge is built upon and applied in diverse contexts, thereby deepening student understanding and long-term retention.
- Moving beyond individual classrooms, presentations can explore frameworks that cover innovative methods for assessing student learning beyond traditional exams, as well as strategies for evaluating program effectiveness and securing institutional support for new initiatives.

This session is ideal for educators, academic leaders, and instructional support staff from all engineering mechanics subdisciplines who are passionate about the future of teaching and learning. Attendees will leave with actionable strategies for their own practice and a connection to a broader community of innovators dedicated to shaping a more effective and meaningful future for higher education

MS 102. Embedding AI in Structural Mechanics for Undergraduate Engineers

Jieun Hur[1]

[1] Ohio State University

The rapid emergence of Artificial Intelligence (AI) is reshaping how civil and structural engineers design, analyze, and manage infrastructure systems. This mini-symposium will highlight innovative and practical approaches to embedding AI education into undergraduate and graduate programs in structural engineering and engineering mechanics. Emphasis will be placed on equipping future civil engineers with hands-on experience in AI tools for modeling, simulation, design optimization, and decision support. Presentations will showcase classroom and laboratory modules, project-based learning, and curriculum models that connect core engineering principles with emerging AI applications. The session aims to bridge theory and practice, fostering the development of data-informed, adaptive engineers prepared to lead in an AI-driven profession.

MS 103. Industry Challenges in Engineering Mechanics (ICiEM)

Kundan Goswami[1], Gourab Ghosh[2], Rudraprasad Bhattacharyya[3]

[1] Protection Engineering Consultants, LLC
[2] Hexagon Manufacturing Intelligence
[3] Cronus Technology

The purpose of this mini-symposium is to foster the connection between research in academia and applications in the private sector. Industry practitioners will be invited to present ongoing and emerging engineering mechanics challenges from their respective areas, such as automotive, energy, civil infrastructure, and aerospace. No proprietary or sensitive specific information is expected to be presented. Rather, practical problems will be posed as fundamental engineering mechanics problems. Each presenter will talk about one or two technical challenges of interest to their company that would benefit from outside expertise or collaboration. While we envision a total of approximately thirty to forty minutes of five-minute talks followed by a relaxed discussion.

We aim to strengthen the bridge between industry practitioners and researchers in academia. Based on the industry challenges presented, researchers will have a chance to help solve exciting and challenging industry problems, with a potential for applying their research tools developed in an academic setting to practical problems. Meanwhile, industry practitioners will have the opportunity to receive intellectual support from academia, and insight into advanced and emerging engineering tools. This MS is not intended to guarantee research funding. However, the industry-academia session is expected to help for instance, with organic partnerships, as well as joint future applications for federal or state-based research funding, such as SBIRs and STTRs, NSF TIP.