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Journal of Risk and Uncertainty in Engineering Systems, Part B: Mechanical Engineering

Editorial

Developing Climate Resilience Technologies for Infrastructure: Perspectives on Some Strategic Needs in Mechanical Engineering

Infrastructure plays a crucial role in our society, supporting our communities with mechanical systems providing critical functions related to energy generation and distribution, heating and air conditioning, communication, control, aviation, railroads, biomedical and other devices, mechanics, water and wastewater, transportation including vehicles, railroad cars, people movers, elevators, escalators, etc. These systems are interconnected and rely on America's infrastructure that has been assessed annually in 17 categories with a school report card style A to F grading system [1]. For example, the ASCE's 2021 Infrastructure Report Card on freight rail and passenger rail with approximately 140,000 rail miles operated by freight's Class I, II, and III railroads; and Amtrak operating over a 21,400-mile network, 70% of which is owned by other railroads, also known as host track. The freight and passenger rail being part of an integrated system, stark differences exist in the challenges faced by the two rail categories. Freight maintains a strong network largely through direct shipper fees with investment on the average of over $260,000 per mile; however, passenger rail requires government investment and has been plagued by a lack of federal support, leading to a current state of good repair backlog at $45.2 billion. Along our nation's busiest passenger rail corridor, the Northeast Corridor, infrastructure-related issues caused 328,000 train-delay minutes, or the equivalent of roughly 700 Northeast Regional train trips from Boston, Massachusetts, to Washington, DC [1].

Each year, governments and the private sector additionally invest trillions of dollars in infrastructure that may face greater risks from future extreme weather and climate events due to inadequate design. These investments should utilize technologies for reducing emissions and contributing toward a sustainable future. As discussed by Ayyub and Hill [2], these infrastructure investments represent public and private expenditures that exceed $1 Trillion dollars annually, noting that the Value of Construction Put in Place for 2020 is estimated by the U.S. Census Bureau [3] to exceed $1.3 Trillion. According to the Bureau of Labor Statistics, over seven million employees were involved in U.S. Construction as of May of 2020 [4]. Given the importance, infrastructure plays in the economy, and the increasing risk it faces from extreme events, it's understandable that the bi-partisan *Infrastructure Investment and Jobs Act of 2021* include provisions for addressing climate change. Infrastructure elements with a relatively long-life cycle, such as highway, power, and communication systems, must be resilient to the effects of a changing climate, including weather extremes and other related hazards.

The 2021 Intergovernmental Panel on Climate Change [5] affirmed its earlier finding that warming of the climate system is unequivocal and concluded that human-induced climate change is the primary driver. The congressionally mandated Fourth National Climate Assessment [6,7] depicts these increasing trends of anthropogenic greenhouse gas (GHG) emissions. Since the 1950s, GHG emissions have driven many of the observed changes, which are unprecedented over decades and even millennia. Consequently, the overall projected changes in global climate over the next 50 years [5,6] remain valid and call for action to reduce the potential for the negative impacts associated with these changes. Failure to account for future anthropogenically forced changes in the Earth's climate during the design and construction of various components of civil and environmental infrastructure will result in significant maladaptation, and increased losses due to fire, flood, and other natural disasters that are projected to increase in frequency and magnitude as a result of the changing climate.

While awareness of the importance of climate resilience is growing among the professional communities of practice involved in the siting, design, financing, and construction of the built environment, significant challenges to systematic and well-informed action remain. Chief among these is the development of technologies for mechanical systems for reducing emissions, contributing toward climate mitigation and a sustainable future. Additionally, a well-documented gap between the current understanding of the evolution of the probability of relevant weather and climate extremes and engineering practice (for example, Refs. [8] and [9]). While this "gap" takes many forms, one of the most illustrative is the lack of systematic treatment of climate change in most codes and standards in the United States and abroad. Recent work by the International Codes Council concluded that, globally, "Climate data is frequently only updated on a 10-year cycle on average, so as the weather becomes more severe from year to year, the underlying data simply does not accurately reflect the risk to the building of these extreme weather-related events." [10].

Central to the success in addressing infrastructure needs and challenges is a significant fiscal and intellectual investment in climate-resilient infrastructure for all systems that support communities. To help the Nation achieve these twin goals, promoting the development of climate-resilient technologies spanning both mitigation and adaptation is of strategic importance. Formal collaborations between public and private agencies are on advancing the use of climate science and understanding within the engineering practice for the design and construction of climate-resilient technologies for infrastructure as presented and offered by ASCE, such as Refs. [8] and [9]. Private and public investments in infrastructure for this purpose should be strategic and equitable. Scientists, planners, and engineers have central roles in this pursuit where innovation in technology development is necessary and ongoing to address related challenges. According to the USGCRP [6], our "Nation's aging and deteriorating infrastructure are further stressed by increases in heavy precipitation events, coastal

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flooding, heat, wildfires, and other extreme events, as well as changes to average precipitation and temperature. Without adaptation, climate change will continue to degrade infrastructure performance over the rest of the century, with the potential for cascading impacts that threaten our economy, national security, essential services, and health and well-being." There is a dire need to innovatively develop technologies for climate-resilient infrastructure not only for adaptation but also contributions by infrastructure toward mitigation by reducing GHG emissions.

The ASCE-ASME *Journal of Risk and Uncertainty in Engineering Systems* was established in 2014 by Professor Bilal M. Ayyub as its founding Editor-in-Chief to address core issues related to hazards, risks, and associated economics, finance, and decision making [11]. The journal has established itself as a leading archival journal in the civil and mechanical engineering risk and uncertainty field. This significant achievement for our research and engineering community is indicative of the importance of the scope and pursuits of the journal in meeting societal and professional needs and constructing knowledge to inform decision and policy-making processes. Pursuing climate-resilient technology broadly and creatively is encouraged where the term technology means the application of scientific knowledge for practical purposes, such as climate resilience, including the development of physical products (e.g., materials, sensors, robots), cyber products (e.g., software, databases, blockchain, crypto-technologies), processes/methods for intelligent decision (e.g., manuals, standards) [12].

As the founding editor concludes his term at the end of 2021 and passes the editorship to Professor Michael Beer, the editor is taking this opportunity to highlight in this editorial strategic need to help guide the intellectual pursuits of our community for the service of our society by focusing on the development of technology for climate-resilient infrastructure.

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