# The Role of Mechanics, Infrastructure Materials, and Structural Design for the Decarbonization and Resilience of the Built Environment

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## Abstract:

The built environment, buildings, urban spaces, roads, energy infrastructure, etc., is the most important component of human life; its protection and sustainable development are quintessential for the wellbeing and survival of billions of people on earth. Material harvesting and manufacturing, construction processes, operation of civil infrastructure are energy intensive and contribute significantly to the global greenhouse gas (GHG) emissions, which lead to current planet mean temperature rise and increased frequency of extreme weather conditions. Hence, there exists a compelling need to design, construct, maintain, operate, and eventually recycle components of the built environment that minimize GHG emissions while adapting to future climate and societal changes. The first part of this presentation will introduce a vision for a research program that will establish the fundamental multidisciplinary knowledge base, the relevant technological and computational tools, and the necessary policy changes making possible management of the built environment that maximizes performance, minimizes environmental and economic costs, enables justice and equity, and protects public health during its entire lifetime. In particular, the role of mechanics, infrastructure materials, and structural design will be highlighted. The second part of the presentation will discuss (a) the details of recent research achievements and future goals in the specific area of aging and deterioration of concrete structures as well as (b) its relevance to decarbonization and resilience of the built environment. A novel multiscale/multiphysics computational framework for the simulation of aging and deterioration of concrete structures will be presented. The overall framework is centered on the so-called Lattice Discrete Particle Model (LDPM). LDPM is a discrete fine-scale model of concrete that can accurately describe the behavior of concrete during elastic, fracturing, softening, and hardening regimes. The LDPM technology has been proven to supersede by far most of other available computational techniques for the simulation of concrete, especially for applications where the description of material internal structure and the link among different length scales is important. The use of these novel approaches is demonstrated in relation to a variety of applications spanning several different themes relevant to infrastructure aging and deterioration.

## Bio:

Prof. Cusatis is a faculty member of the Civil and Environmental Engineering Department at Northwestern University from August 2011. Prior to joining Northwestern, he worked at Rensselaer Polytechnic Institute for 6 years. He performs research in the field of experimental, computational and applied mechanics, with emphasis on heterogeneous and quasi-brittle infrastructure materials. His work on constitutive modeling of concrete through the adoption of the so-called Lattice Discrete Particle Model (LDPM), one of the most accurate and reliable approaches to simulate failure of materials experiencing strain-softening, is known worldwide.

He is a member of ASCE and ACI and active in several technical committees. He held leadership positions in ASCE EMI, ACI 446, ACI 209, IA-ConCreep, and IA-FRAMCOS. In 2018 he was awarded the prestigious EMI Fellow membership grade. Since September 2021, he has been serving as Program Director for the CMMI ECI program at the National Science Foundation.

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1310 Yeh Student Center