Abstract

Engineering Resilient and Sustainable Structures: From Fundamental Mechanics to Real-World Implementation

The increasing demand for infrastructure that can withstand extreme events while remaining functional, repairable, and sustainable has fundamentally reshaped the objectives of structural engineering. This seminar presents an overview of Professor Alessandro Palermo's research program, developed over two decades across Italy, New Zealand, and currently the United States, focusing on the development of resilient structural systems that integrate advanced mechanics, innovative construction technologies, and performance-based design.

The presentation will discuss the evolution of low-damage seismic design, from the development of post-tensioned self-centering timber and concrete systems to resilient bridge technologies employing controlled rocking and replaceable energy-dissipating devices. These research developments have resulted in internationally recognized design methodologies, multiple patented technologies, and their successful implementation in numerous buildings and bridges worldwide. The seminar will highlight the underlying mechanics, experimental validation through large-scale testing, including full-scale shake table experiment and nonlinear analytical approaches that have enabled the transition of these concepts from research to engineering practice.

Building on these foundations, the seminar will present recent advances in sustainable structural engineering, including hybrid structural systems, digital fabrication through 3D concrete printing, recycled materials for seismic protection, non-metallic reinforcement. Ongoing research on resilient bridge systems, advanced construction technologies, and long-term structural performance will also be discussed, together with the role of close collaboration with industry and government agencies in accelerating technology transfer and implementation.

The seminar concludes by outlining a future research vision in which resilience, sustainability, digital construction, and advanced computational methods converge to enable the next generation of structural systems capable of minimizing damage, reducing lifecycle costs, and enhancing the long-term performance of buildings and infrastructure subjected to natural and man-made hazards.

Biosketch

Professor Alessandro Palermo is Professor of Structural Engineering at the University of California San Diego (UC San Diego), where he leads the RISE Structures Laboratory (Resilient, Innovative, Sustainable and Enduring Structures). His research focuses on performance-based earthquake engineering, low-damage structural systems, sustainable construction technologies, and the durability and resilience of buildings and bridges subjected to natural and man-made hazards.

Professor Palermo received his Laurea, postgraduate specialization, and Ph.D. in Structural Engineering from Politecnico di Milano, Italy. Before joining UC San Diego in 2023, he was Professor of Civil Engineering at the University of Canterbury, New Zealand, where he developed internationally recognized research in seismic resilience, mass timber engineering, and innovative structural systems.

His research has made significant contributions to the development of post-tensioned self-centering structural systems for timber, concrete, and bridge applications. He is a co-inventor of pioneering technologies that have been implemented in buildings and bridges in New Zealand, North America, and elsewhere, including the internationally recognized PRES-LAM (Prestressed Laminated Timber) system. His work combines fundamental structural mechanics, large-scale experimental testing, nonlinear numerical modeling, and close collaboration with industry to accelerate the transfer of research into engineering practice.

Professor Palermo has authored more than 120 peer-reviewed journal papers, over 260 conference publications, and holds five patents. Since joining UC San Diego, he has secured three research projects with the California Department of Transportation (Caltrans) totaling more than US$2 million, supporting research on resilient bridge systems, fatigue life prediction of reinforced concrete bridge decks, and next-generation hybrid bridge columns. He is also leading the development of a new multidisciplinary timber research centre at UC San Diego, bringing together expertise in structural engineering, architecture, materials, manufacturing, and sustainability to advance the future of timber construction.

Professor Palermo is a Fellow of the International Association for Bridge and Structural Engineering (IABSE) and a Fellow of the International Federation for Structural Concrete (fib), two of the highest international professional recognitions in structural engineering. He serves on several international technical committees, including the ACI 440 Seismic Subcommittee, and has delivered more than 30 keynote and invited lectures worldwide. His current research integrates seismic resilience, sustainability, digital fabrication, artificial intelligence, and advanced materials to develop the next generation of high-performance buildings and infrastructure.