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Enhancing Seismic Resilience of Reinforced Concrete and Modular Steel Structures Using Shape Memory Alloys

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Abstract

The increasing frequency and intensity of seismic events worldwide have brought urgently needed innovative and advanced strategies to improve infrastructure resilience. While widely adopted in modern construction, conventional **reinforced concrete (RC)** and **modular steel structures (MSSs)** often reveal vulnerabilities under seismic loading due to material limitations and design constraints. This keynote presentation highlights the transformative potential of **Shape Memory Alloys (SMAs)** in revolutionizing seismic performance and structural resilience, particularly in RC and MSS systems.

SMAs exhibit unique properties such as **superelasticity** and **self-centring**, which allow structural elements to undergo large deformations during seismic events and return to their original configuration upon unloading. The lecture will explore how these alloys can be effectively incorporated into critical structural components, such as **beam-column joints, shear walls, beams**, and **modular connections**, to enhance performance. Drawing from an extensive body of research—encompassing **experimental investigations**, **numerical simulations**, and **analytical modelling**—this presentation will demonstrate how SMAs can enhance **ductility**, improve **energy dissipation**, and significantly reduce **residual deformations** in structures subjected to seismic forces.

For **RC structures**, integrating SMAs into **beam-column joints** and **shear walls** has shown significant improvements in **ductility** and **self-centring behaviour**. This leads to reduced structural damage and enhanced post-earthquake operability. In **beam applications**, SMAs can facilitate **plastic hinge relocation** and enhanced **deflection control**, protecting critical regions and ensuring structural integrity. Additionally, combining SMAs with **corrosion-resistant materials** offers a sustainable solution to extending the lifespan of RC structures in seismic-prone regions.

In the context of **MSSs**, SMAs offer cutting-edge solutions to mitigate seismic vulnerabilities in **modular connections**. Integrating **SMA braces** and **bolts** in MSSs enhances energy dissipation, significantly reducing **inter-story drifts** and residual displacements. Furthermore, recent research into **SMA-enhanced steel tubular columns** with **shear-key connectors** has demonstrated increased **axial compression performance**, effectively addressing stability concerns in modular designs subjected to seismic loads.

This presentation will also explore **practical considerations** for implementing SMAs in construction, such as **mechanical anchorage techniques**, **design guidelines**, and **cost-benefit analyses**. Through an in-depth review of **case studies** and **experimental results**, participants will gain valuable insights into the **real-world applications** of SMAs and their potential to improve seismic resilience in both RC and MSS systems dramatically.