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Novel Climate Resilient and Earthquake Resistant Concrete Elements with Hybrid FRP and SMA Reinforcements

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Abstract - **Abstract**: This study advances the development of climate-resilient, earthquake-resistant concrete structures by investigating bridge piers with hybrid longitudinal reinforcements. Two systems are examined:

SMA–FRP Hybrid Beam–Column Joints: Conventional steel reinforcement suffers from costly corrosion issues, while Fibre Reinforced Polymer (FRP) offers superior durability but lacks ductility in seismic events. Nickel–Titanium (Ni–Ti) Shape Memory Alloy (SMA) combines corrosion resistance with super-elasticity, enabling self-recovery after deformation. A hybrid system, which places SMA bars in plastic hinge regions and FRP elsewhere, was tested under cyclic loading. Results show that drift, rotation, and energy dissipation are comparable to those of steel joints, making it suitable for seismic regions.

Double-Confined Hybrid (DCH) Bridge Piers: While double-confined steel (DCS) reinforcement ensures ductility and post-yield stiffness, corrosion remains a challenge. The proposed DCH system replaces the outer steel layer with glass FRP (GFRP), shielding the inner steel from environmental damage while improving durability. Featuring three confinement zones—unconfined cover, singly confined zone, and doubly confined core, DCH balances ductility and long-term durability. Comparative cyclic tests of DCS and DCH piers assessed load capacity, damage progression, and energy dissipation.

The presentation also evaluates effective flexural stiffness for varying axial loads and demonstrates a performance-based design example, providing practical insights into hybrid reinforcement strategies for seismic and climate resilience.