Resilient & Advanced Infrastructure Laboratory

The research in the Resilient and Advanced Infrastructure Laboratory (RAIL) focuses on applying smart technologies and interdisciplinary expertise to the development of resilient and sustainable civil infrastructure systems. The actively pursued areas are: (1) development of innovative structural systems and design strategies to enhance the performance and safety of structures; (2) application of advanced materials for disaster resistant design of structures as well as repair and retrofit of deficient and aging civil infrastructure; (3) development of damage detection and non-destructive evaluation techniques for structural health monitoring of civil infrastructure systems.

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"Working to increase the long-term sustainability and resilience of the infrastructure we already have, and that which we plan to build."

UNIVERSITY of VIRGINIA
ENGINEERING

Shape Memory Materials for Structural Engineering Applications

The term "smart materials" usually refers to materials that have unique and interesting characteristics and can be employed in conventional structural design to improve performance of the structure. Shape memory alloys (SMAs) are a smart class of metals that exhibit several extraordinary properties. This research focuses on developing a multiscale framework for experimental characterization and constitutive modeling of SMAs and investigates their potential for applications in civil engineering. Currently we are exploring the development and application of iron (Fe)-based superelastic shape memory alloys that would be a cost-effective alternative to most commonly used nickel-titanium (NiTi)-based alloys.

Innovative Materials for Repair and Retrofit of Existing Structures

We are exploring novel materials and low cost techniques to incorporate them into structural systems for optimal retrofit and maintenance of existing infrastructures.

Design of Novel Structural Control Devices and Systems

Passive or controllable devices can be successfully incorporated to structures to minimize damages caused by natural disasters. We are working to develop new devices and systems that can be implemented into large-scale civil infrastructures such as bridges, buildings and nuclear power plants to guarantee their integrity and safety against multi-hazard threats. Emphasis is placed on the use of smart materials in the design of control devices.

Development of Intelligent and Adaptive Control Strategies

One of the challenges associated with the implementation of controllable devices is the use of an appropriate control algorithm to determine the command signal sent to the device. This research focuses on developing robust and reliable control methods and algorithms for vibration control of civil structures. This includes application of soft computing techniques, such as fuzzy logic, neural networks and evolutionary computation along with adaptive control strategies.

Nondestructive Evaluation Technologies for Structural Health Monitoring

This research aims to develop and apply nondestructive evaluation technologies for health monitoring and condition assessment of civil infrastructure systems such as bridges, buildings, tunnels and pipelines through field and laboratory investigations.

Development and Application of Hybrid Loading Test Methods

Although performance tests enable one to characterize the mechanical response of a control device, they do not directly correspond to the response of the structural system to be evaluation. The goal of this research is to develop and apply real-time hybrid loading test methods for the performance validation of structural control devices and systems installed into full-scale structures.

RECENT RESEARCH DEVELOPMENTS

- Shape memory alloy cables for structural applications
- Feasibility of self-prestressing concrete members using shape memory alloys
- A superelastic viscous damper for enhanced seismic performance of steel frame structures

RECENT GRANTS

- Multi-hazard resilient design of buildings with high strength and damping capacity shape memory alloy mitigation of bridges - NSF
- FRP wraps for next generation sustainable and cost-effective rehabilitation of coastal transportation infrastructure in the mid-Atlantic region, - Mid-Atlantic Transportation Sustainability Center
- Load rating strategies for bridges with limited or missing as-built information - Virginia Center for Transportation Innovation and Research

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