University of Connecticut

Center for Resilient Transportation Infrastructure

The Fourth Annual DHS University Network Summit
Panel 22 - Transportation System Resiliency
Enabling Technologies for Resilient Transportation

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NTSCOE NATIONAL TRANSPORTATION SECURITY CENTER OF EXCELLENCE

U.S. DEPARTMENT OF HOMELAND SECURITY

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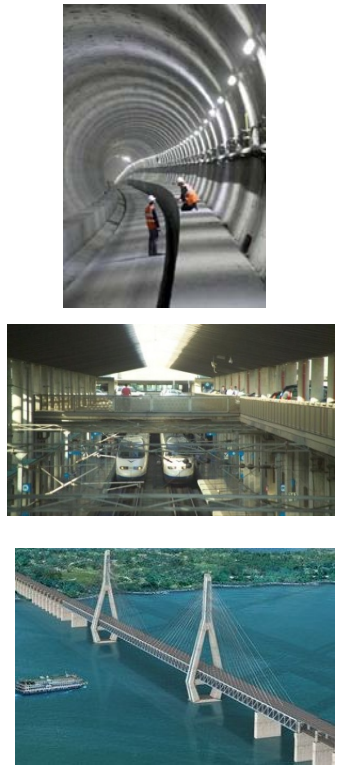
The Transportation Security Challenge

- Large interconnected networks with many infrastructure components
- Potential cascading effects due to loss of a single component
- Requires integrated risk assessment & management at both the network & component levels

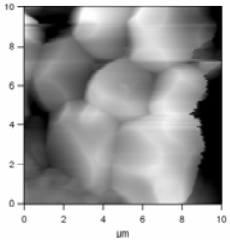
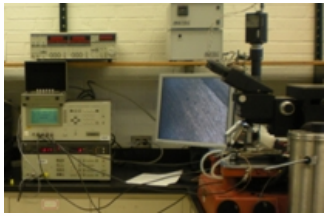
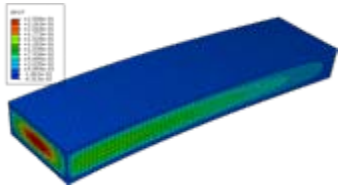
Transportation Networks



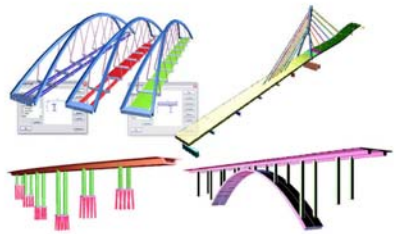
Transportation Infrastructure Components

Enabling Technologies

1. Advanced Materials
- Material synthesis
- Material characterization
- Material level modeling

2. Network & Structural Modeling & Simulation
- Verification & validation
- All-hazards modeling
- Predictive capabilities

3. Network & Structural Monitoring
- Sensor technology
- Sensor network design
- Damage detection


What are existing capabilities & gaps? What are short and long term goals?

Enabling Technologies & Security = Prevent + Protect + Respond + Recover

Protect
- Transportation network simulation to design networks for maximum resiliency
- Verified simulation capability for all-hazards design of infrastructure components
- Hardening of strategic infrastructure components via advanced materials
- Optimized sensor networks at both the network & component levels

Respond
- Network sensing provides real-time information for network level decision making
- Structural monitoring & sensing provides real-time assessment of damage
- Reliable real-time information for evacuation and emergency response
- Integrate network & structural simulations with real-time sensing

Recover
- Post incident assessment of network adaptability & structural damage
- Integrate network sensing & simulation to evaluate & verify recovery strategies
- Integrate structural sensing & simulations to verify damage assessment
- Perform simulation to evaluate and implement structural repairs

Transportation Network Vulnerability - Modeling, Sensor Deployment & Data Routing

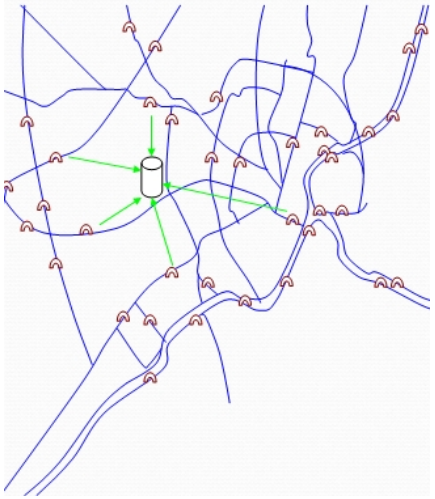
R. Ammar, S. Rajasekaran and N. Lownes

Goal: Maximize transportation network resiliency through real-time monitoring and intelligent response.

Objectives: Model vulnerability, optimize sensor placement, develop data routing strategies.

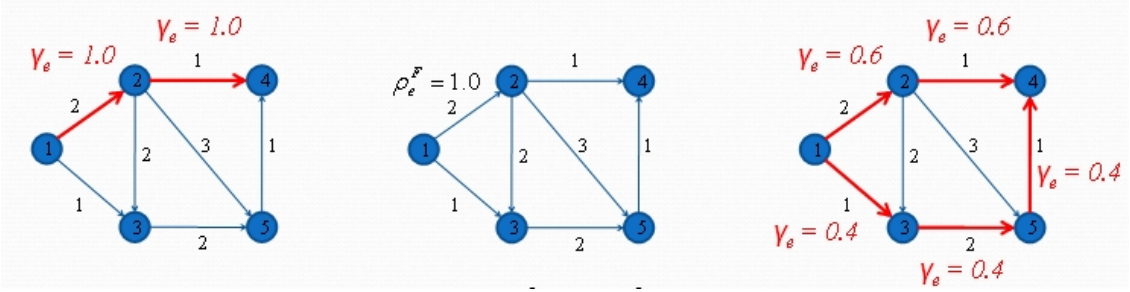
Approach

1. Vulnerability-Driven Sensor Placement
- Vulnerability Modeling - Assess the risk level of each link
- Sensor Placement - Utilize this information in optimizing sensor locations
2. Data Routing
- Route collected data to appropriate stations



Network, Sensors & Data Routing

Game Theory Based Vulnerability Analysis



Strengthening and Modeling of Earth Embankments Under High Loads

M. Chrysochoou, D. Basu and A. Bagtzoglou

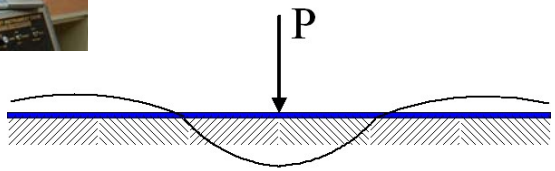
Motivation: Soil-structure interaction important in many applications

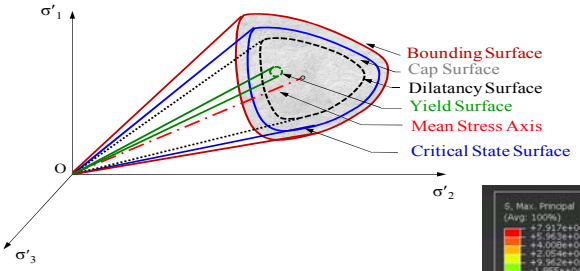
Goal: Soil strengthening & soil modeling for extreme loads

Approach:

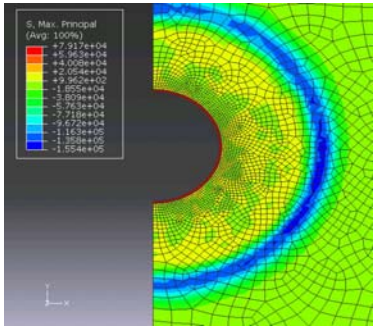
- Chemical strengthening with fly ash (under utilized material) + quantitative mineralogy = predictive design & enhanced properties (+500%)
- Soil constitutive model + material characterization = soil-structure interaction modeling for high rate loads

Soil Strengthening





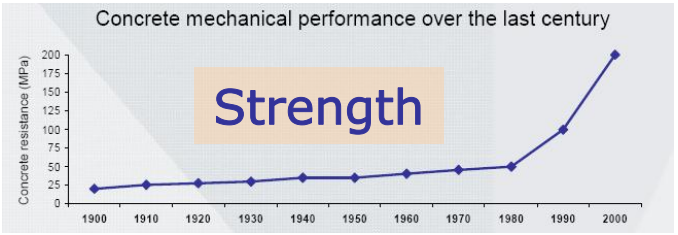
Soil Constitutive Model & Simulations



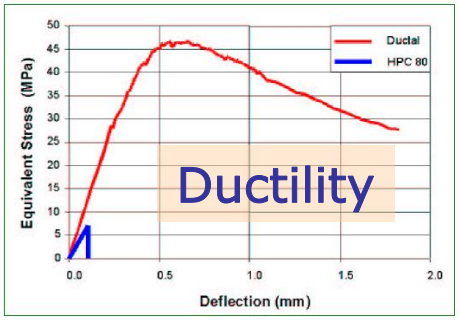
Mechanical Characterization of UHPC for Resilient Transportation Infrastructure

A. Zofka, M. Accorsi and J. Mahoney

Motivation: Revolutionary advances in concrete technology in last decade
Goal: Develop modeling & simulation capabilities for thermo-mechanical behavior of ultra-high performance concrete (UHPC) structures
Approach: Thermo-mechanical testing + constitutive modeling



Revolutionary Advances



Structures subjected to fire

LAFARGE Ductal®

LS-DYNA

Regular Concrete

Ductal UHPC

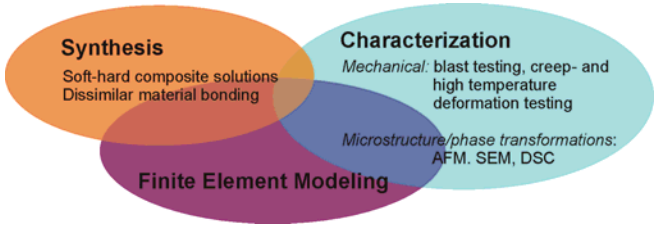
Advanced Composite Materials for Blast and Fire Resistance

R. Hebert, B. Huey, G. Rossetti, J.H. Kim - University of Connecticut
Richard Riman - Rutgers University
Arun Shukla - University of Rhode Island

Motivation: Existing solutions for blast loading are not suitable for elevated temperatures; conversely, existing solution for fire resistance are not blast resistant.

Goal: Development of new composite sandwich materials with combined blast & fire resistance.

Approach: Metallic, oxide & ceramic materials & sandwich architectures, material synthesis and characterization, microstructural analysis, high temperature & blast loading, material level modeling



Synthesis, Characterization & Modeling

Shock Tube Testing at URI

Integrated Sensing and Control System Development for Bridge Structures

R. Christenson and J. Tang

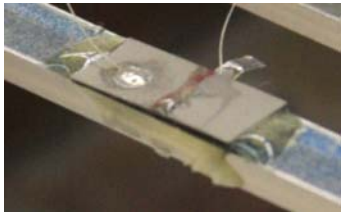
Goal: Develop and demonstrate an integrated framework of sensing and control of bridge structures

Approach: Integrated sensing & control methodology, scaled bridge test bed, novel impedance sensor system, magneto-rheological fluid dampers (control), modal & impact testing, numerical modeling & simulation

Bridge Test Bed

- **Impedance Sensors**
- **MRF Dampers**
- **Permanent Magnet Shaker**
- **Drop Weight Testing**

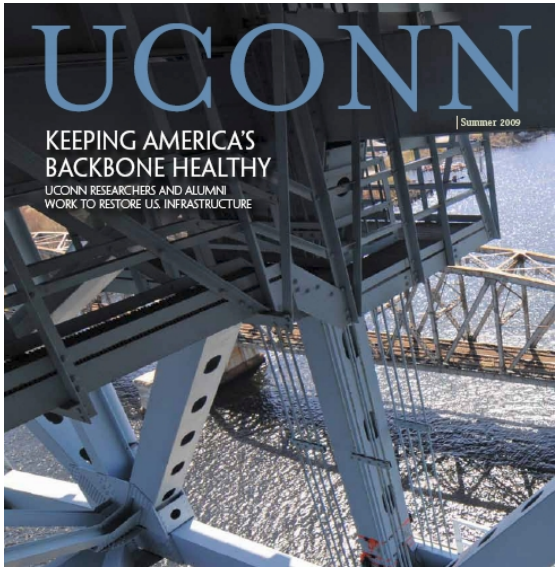
Impedance Sensors



MRF Dampers

Conclusions:

- Strong national need for next-generation resilient infrastructure
- Utilize existing and emerging technologies
- Strong need for basic research and development
- Area that is ripe for innovation!



Thank you