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 Infrastructure

Professor Michael L. Accorsi
University of Connecticut

NTSCOE NATIONAL TRANSPORTATION SECURITY CENTER OF EXCELLENCE

U.S. DEPARTMENT OF HOMELAND SECURITY

This material is based upon work supported by the U.S. Department of Homeland Security under Award Number 2008-ST-061-TS0002-01. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Department of Homeland Security.

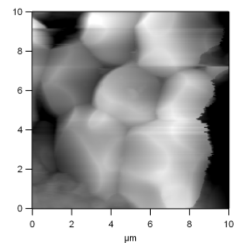
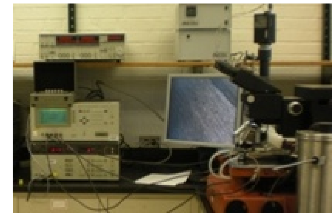
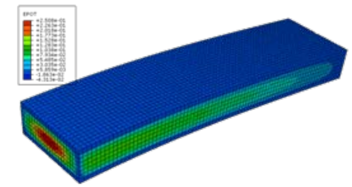
The Transportation Security Challenge

- 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
- UConn focus = network analysis and physical infrastructure

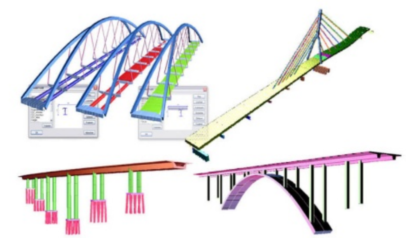
Transportation Networks

Transportation Infrastructure Components

Enabling Technologies – Engineering Perspective

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

2. Network & Structural Modeling & Simulation
- All-hazards modeling capability
- Model validation
- Validated predictive tools


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 Perspective

Resilience = Prevent + Protect + Respond + Recover

Protect

- Network Simulation = design transportation networks for maximum resiliency
- Structural Simulation = integrated all-hazards design of infrastructure components
- Advanced Materials = strategic hardening of infrastructure components
- Sensor Networks = Optimize design at both the network & component levels

Respond

- Network Sensing = real-time information for network level decision making
- Structural Sensing = real-time assessment of structural damage
- Simulation = integrate network & structural simulations with real-time sensing

✓ Reliable real-time information for evacuation and emergency response

Recover

- Integrated Network Sensing & Simulation
  = robust information for post incident, network level, decision making
- Integrated Structural Sensing & Simulation
  = robust information for post incident structural repair

University of Connecticut

Center for Resilient Transportation Infrastructure

Transportation Network Vulnerability - Modeling, Sensor Deployment & Data Routing

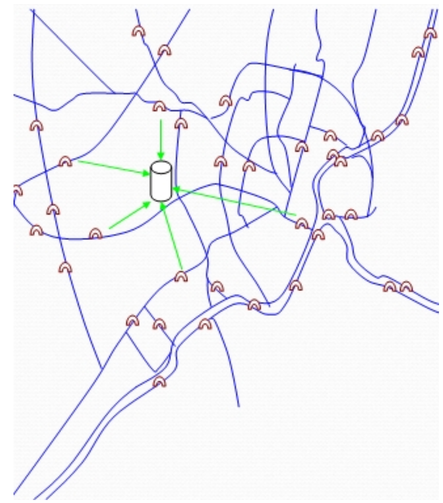
R. Ammar, S. Rajasekaran and N. Lownes

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

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

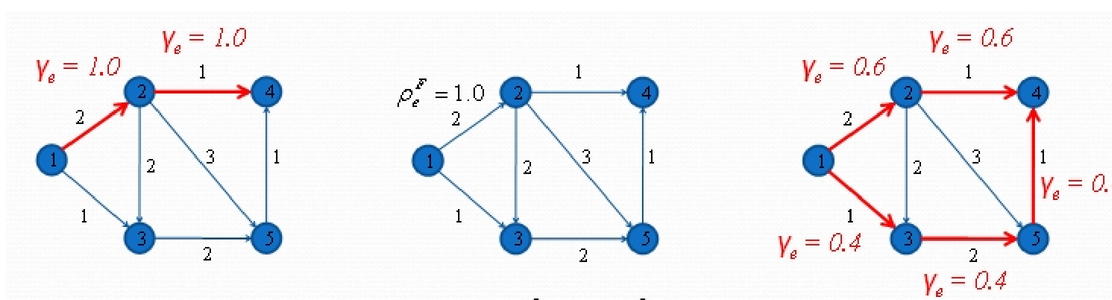
Approach

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



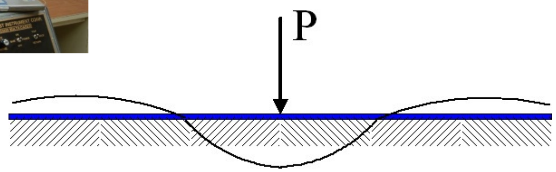
Strengthening and Modeling of Earth Embankments Under High Loads

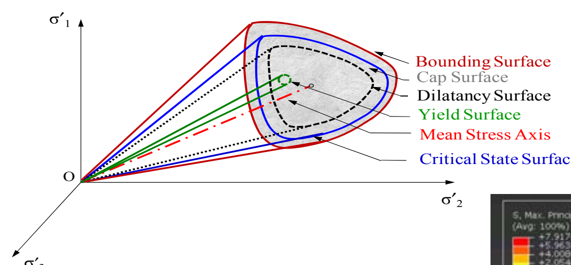
M. Chrysochoou, D. Basu and A. Bagtzoglou

Motivation: Soil-structure interaction important in many infrastructure applications
Goal: Soil strengthening & soil modeling for extreme loads
Approach:

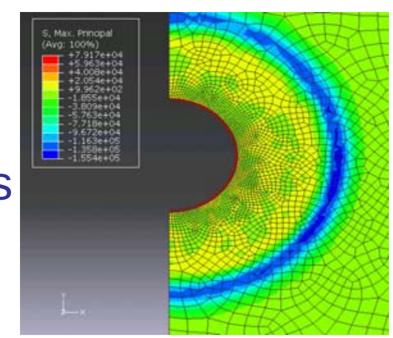
- Chemical strengthening with fly ash (under utilized material) + quantitative mineralogy = predictive design & enhanced properties (+500%)
- Soil constitutive model + material characterization = soil-structure interaction modeling for high rate loads

Soil Strengthening





Soil Constitutive Model & Simulations



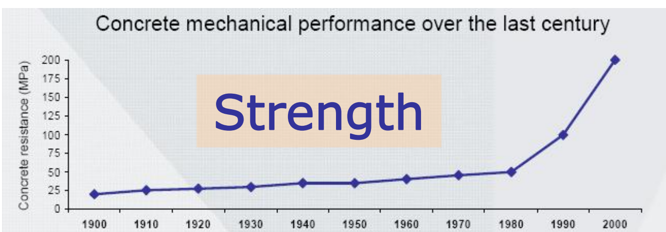
Mechanical Characterization of UHPC for Resilient Transportation Infrastructure

A. Zofka, M. Accorsi and J. Mahoney

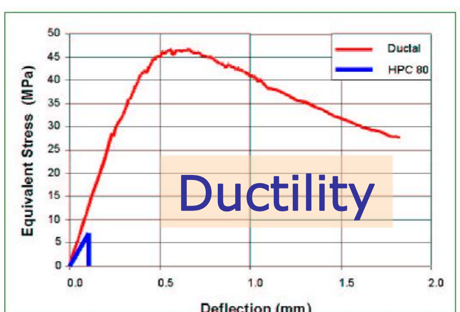
Motivation: Revolutionary advances in concrete technology in last decade

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

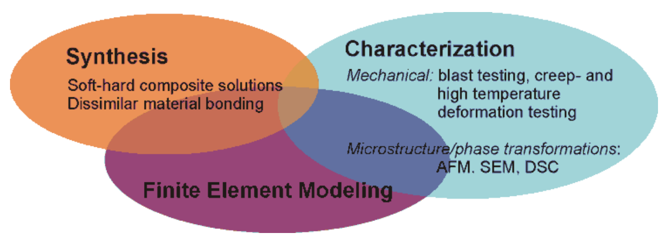
Advanced Composite Materials for Blast and Fire Resistance

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

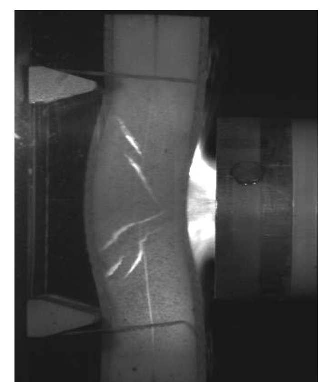
Motivation: Existing solutions for blast loading are not suitable for elevated temperatures; conversely, existing solution for fire resistance are not blast resistant.

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

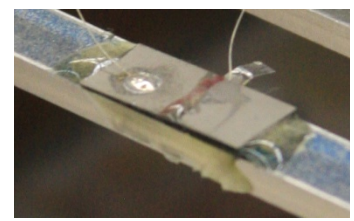
Goal: Develop and demonstrate an integrated framework of sensing and control of bridge structures

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**

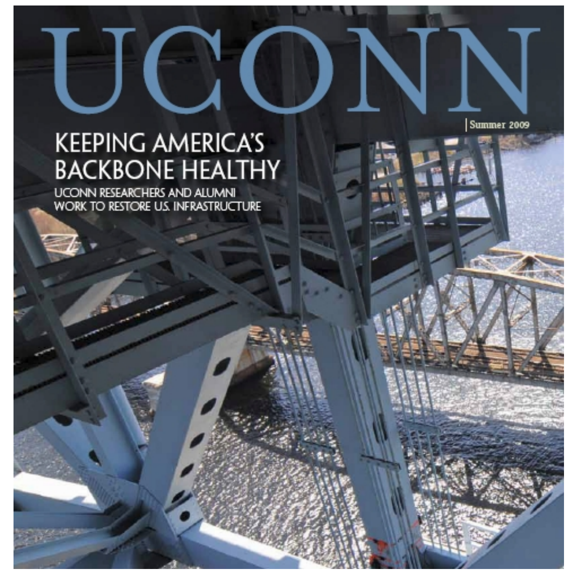
Impedance Sensors



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

Integrated Technologies
Advanced Materials
Modeling & Simulation
Sensors & Monitoring
Hardening & Control
All-Hazards Analysis

→

Technology Implementation
- **Infrastructure Protection**
- **Risk Assessment & Management**
- **Response & Recovery**

→

- **Sustainable & Resilient Infrastructure**