A Workshop of the U.S. National Committee on Theoretical and Applied Mechanics

Materials and Material Systems Research in Structural Protective Design

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Disaster Reduction – So Much is at Stake

Casualty of Recent Nature and Man-made Disaster

- 2.7 million people affected worldwide due to Nature Hazard between 2000-2011 (landslide, earthquake, tsunami etc.).
- 2977 death toll of September 11 attack.
- ~ 585,000 death toll of War on Terror 2000-2013.
- 863 fatalities due to airplane crash in 2014.

Economic Impact of Recent Nature and Man-made Disaster

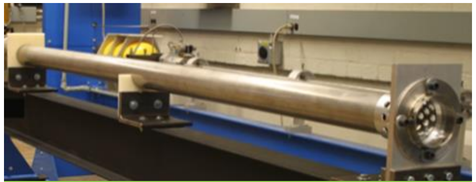
- $1.3 trillion loss worldwide due to Nature Hazard between 2000-2011 (landslide, earthquake, tsunami etc.).
- $123 billion estimated economic loss in the first 2-4 weeks after September 11 attack.
- $60 billion estimated WTC site and surrounding infrastructure loss.





Fundamentals and Transformative Technology Gaps

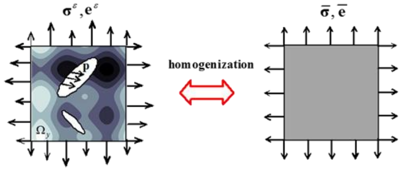
Material and material system responses to high-rate shock loads



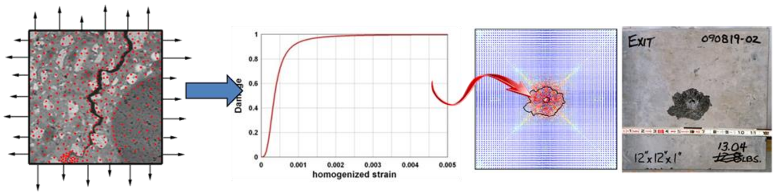
Tests at extreme damage rates is challenging

Active material systems for extreme loadings

Multiscale approaches for shock dynamics

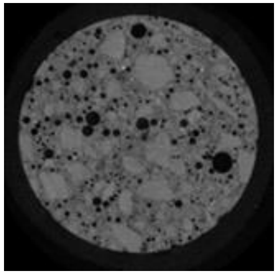


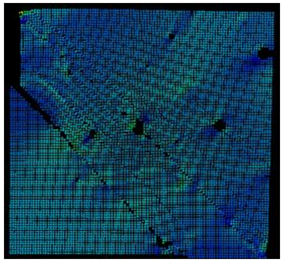
High strain rate?



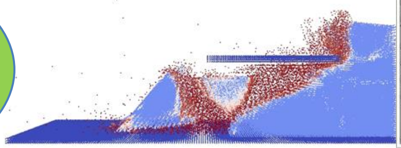
An Integrated Protective System for Disaster Reduction

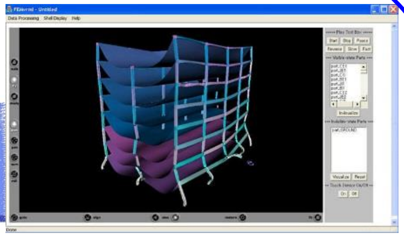
Before Disaster





Computational Science and Engineering

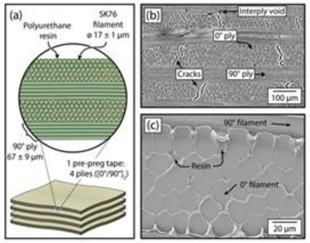




Materials & material systems

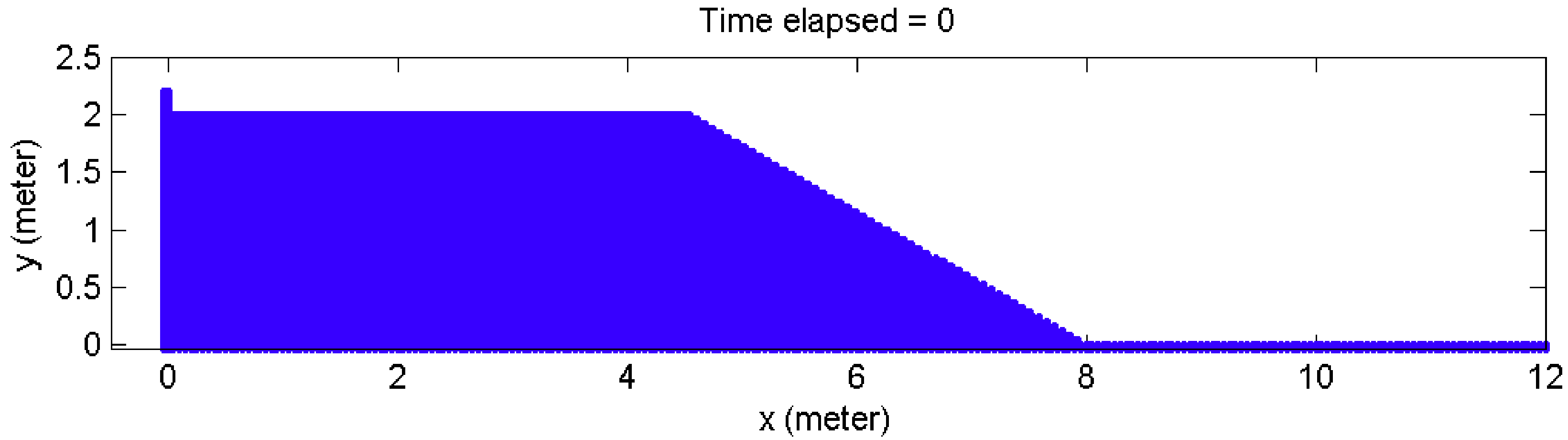
Failure Prediction & Protective Structural Design

Construction & manufacturing



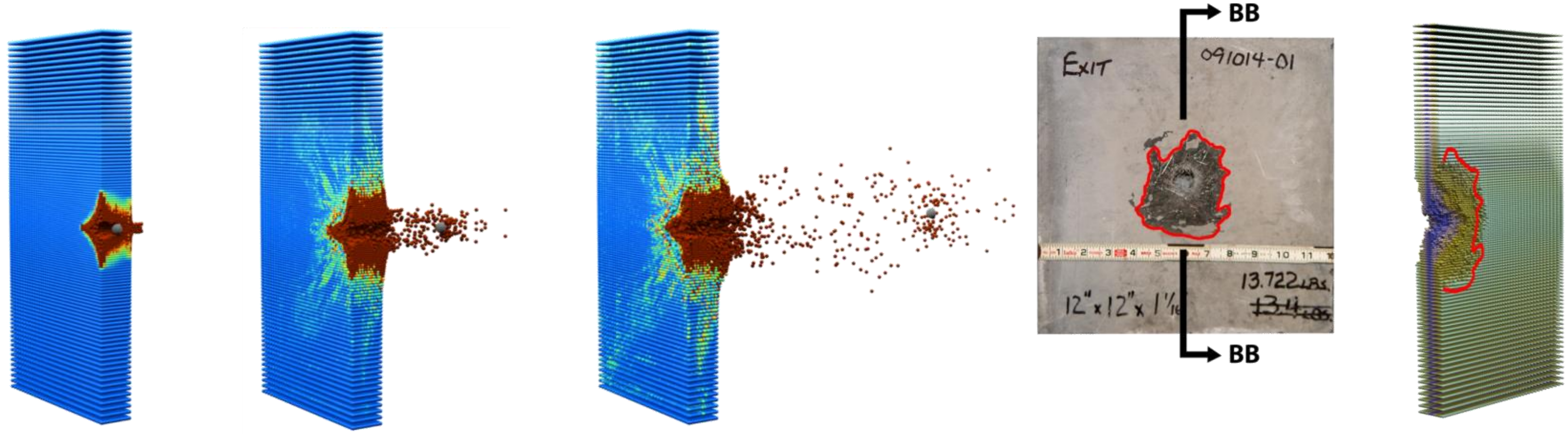
Lab damage characterization

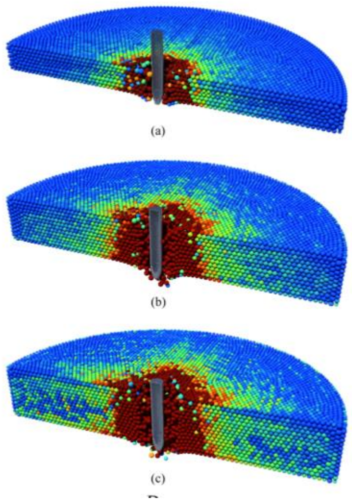
Landslide

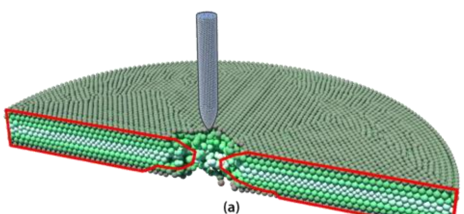


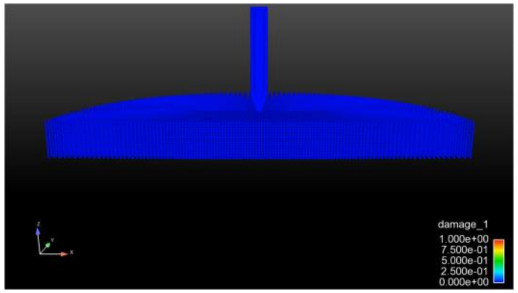
Displacement history:
San Fernando Earthquake, (1971)
Source : 34.40N 118.40W Depth 8.4 km
peak ground acceleration: 1.251g
Measured at Pacoima Dam

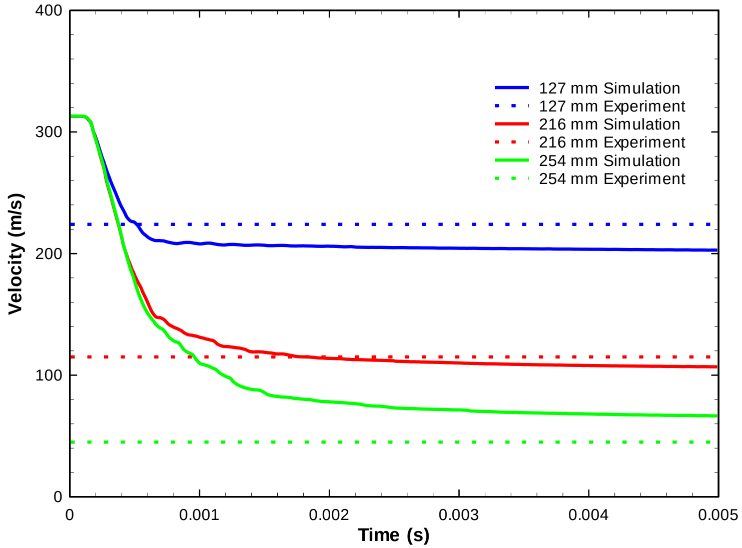
Concrete Plate Penetration




(a)
(b)
(c)


(a)



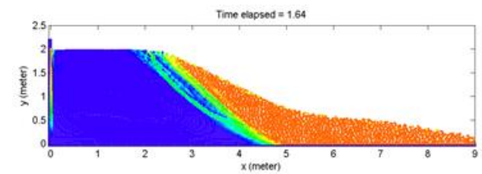


Courtesy of Jesse Sherburn, Army ERDC

An Integrated Protective System for Disaster Reduction


After Disaster


Computational Science and Engineering

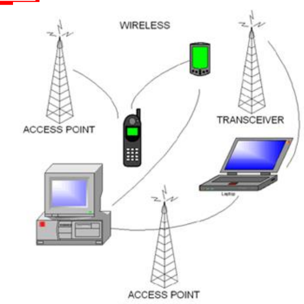


Sensing & systems diagnostics

Fast Assessment, Damage Mitigation and Retrofit Designs

Information & communication technologies

Imaging processing

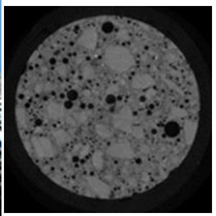


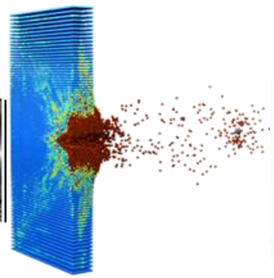
Center for Extreme Events Research

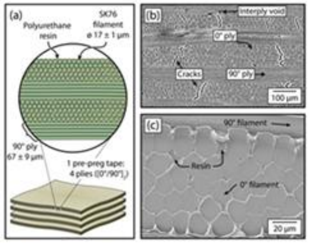
UC San Diego
Jacobs School of Engineering

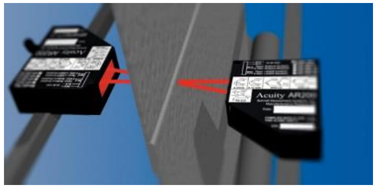
Workshop on Materials and Material Systems Research in Structural Protective Design

Goals





NSF, DOD, DOE, DHS, DOI, DOT, University, Industry

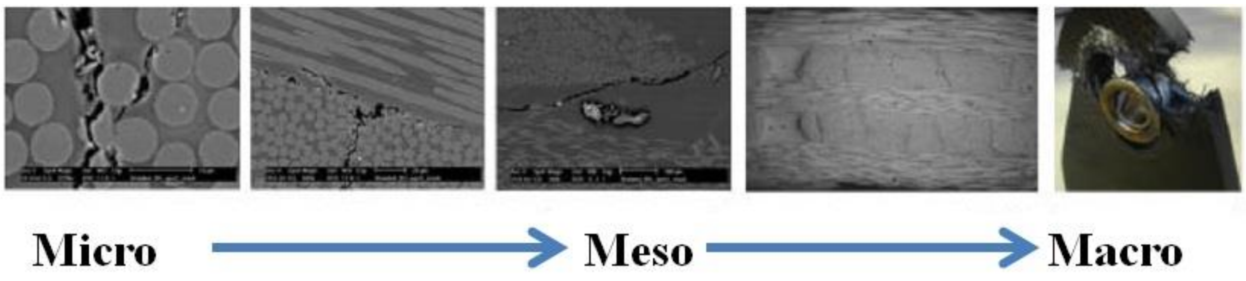
Center for Extreme Events Research

UC San Diego Jacobs School of Engineering

Objectives of the Workshop

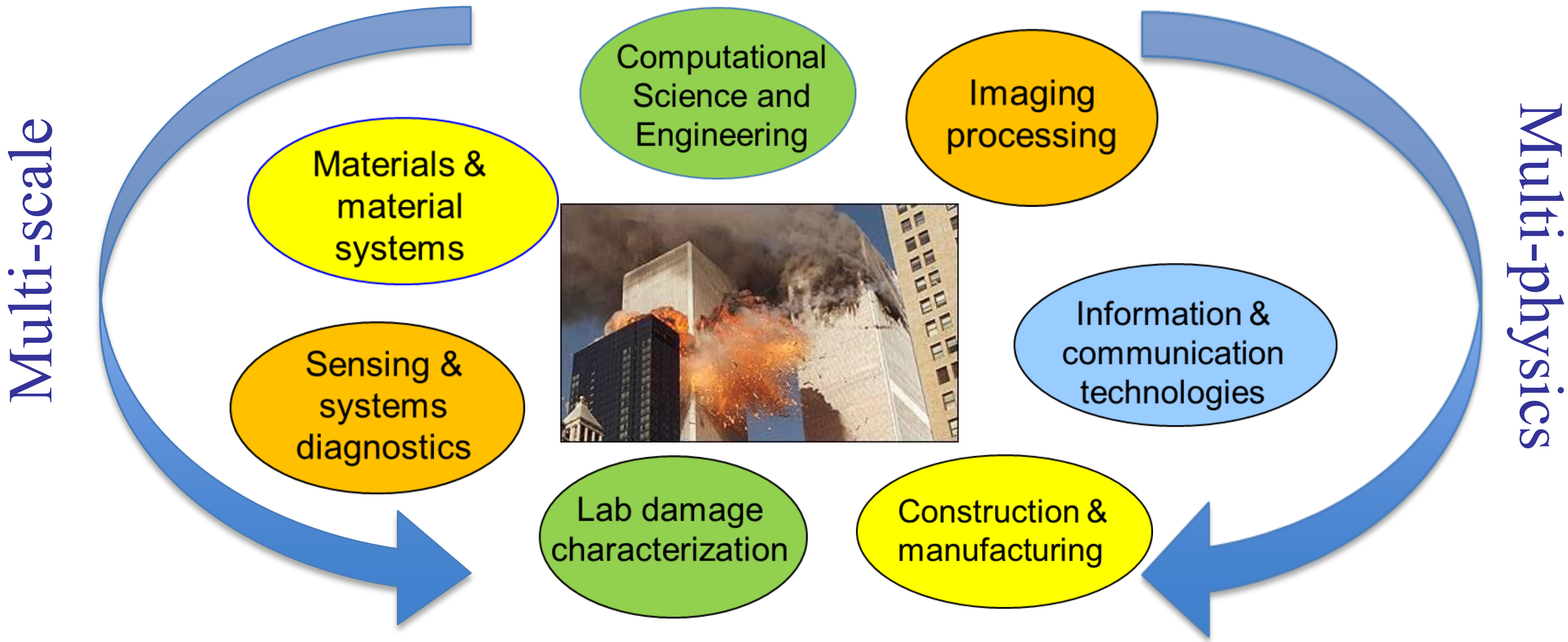
Identify challenges in

- damage assessment and correlation to structural integrity and failure processes,
- design and manufacturing of new materials and material systems for structural protection, and disaster/accident recovery.



Objectives of the Workshop

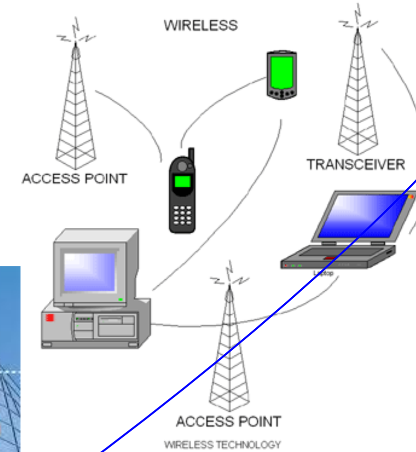
Provide better insight into the interdisciplinary relationships between complementary technologies.

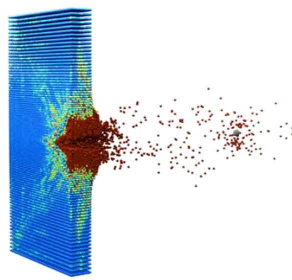


Broaden fundamental knowledge critical to extreme loading conditions for protective infrastructural designs.

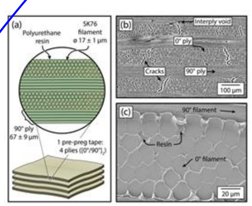
Objectives of the Workshop

academic & research communities
+
First responders





Research traineeship program for graduate education training.



Workshop Format and Agenda

- A 2.5-day workshop to be held during the spring period, such as May, 2016.
- The first day schedule consists of 3 panel discussions, each is facilitated by 5~6 panelists.
- The panelists will include prominent individuals with diverse background from academia, industry, DOD and DOE Labs, and program managers of funding agencies.
- The next 1 1/2 days will be discussions on the writing of the report to be led by the NAS writers.
- Computational Solid Mechanics/Structural Dynamics of Sandia National Laboratories has offered to provide $50,000.00 to support travel for the speakers/panelists and other Workshop costs.

Technical Areas to be Addressed in the Workshop

1. Damage measurement technologies: systems diagnostics, device capabilities, imaging, information and communication technologies,
2. Materials and material systems: mechanics of materials damage/failure, construction/manufacturing, materials and system design optimization,
3. Analytic and computational methods: material damage and structural damage modeling, fast assessment,
4. Experimental methods: characterization, validation of analytic and computational techniques, fast assessment,
5. Technologies integrating combinations of 1-4 above.
6. Education program: undergraduate and graduate programs.

Panel Discussion Topics

Topic 1: What are challenges currently faced in key science and technology developments critical to damage measurement and assessment?

- What structural identification techniques can be of use?
- What damage identification techniques can be of use?
- What different damage types are of interest?
- How efficient are current sensors and placement strategies in detecting and locating damage? Can such detection be done in real time?
- How would/could damage identification methods relay damage information to first responders?
- What types of sensors and/or sensor outputs are needed?
- Are pre-damaged sensor responses needed to establish a baseline?

Panel Discussion Topics

Topic 2: What are the fundamental relationships between damage and failure/serviceability necessary to create new materials and material systems for structural protection and disaster/accident recovery?

- Can the Representative Volume Elements (RVE) connected in many multiscale approaches accurately capture high-rate shock propagation at subscales?
- Can active/sensitive structural material systems function in a safe and sufficiently fast manner for extremely high loading rates?
- Do current damage and numerical models accurately transition from high-rate loading/overmatch conditions to steady-state levels of damage necessary to predict progressive collapse and structural system integrity?

Panel Discussion Topics

Topic 3: What are the benefits and challenges to using computational mechanics and information technology to provide better information for protective infrastructure?

Topic 4: What are the necessary test methods to characterize damage, and how to perform sub-scale and near full-scale experimental investigation of damage mechanisms at coupon, component, and system levels, for a thorough understanding of damage initiation, propagation, and total collapse?

Topic 5: How to provide fast assessment of damages after disastrous events using simplified and reduced order computational and experimental techniques with the aid of available sensor data and visualization information?

Panel Discussion Topics

Topic 6: Can topics 1-5 above be combined into an integrated research area?

- Could damage model validation procedures also benefit from better sensor interpretation methods?
- Can sensor data be combined with computational models to predict failure?

Topic 7: How to encourage development of education program on structural protection?

- Programs in high-rate mechanics and materials in addition to ones in structural and mechanical engineering?