Resilience of Critical Infrastructure and Facilities (Hospitals, Highways & other Structures)

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MULTIDISCIPLINARY CENTER FOR EARTHQUAKE ENGINEERING RESEARCH

A National Center of Excellence in Advanced Technology Applications

Mitigation to Break the Cycles of Destruction-Reconstruction

(Photo Credit: Chauncey Hinman)

Richelieu Apartments Before Hurricane Camille

Mitigation to Break the Cycles of Destruction-Reconstruction

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Richelieu Apartments After Hurricane Camille

Mitigation to Break the Cycles of Destruction-Reconstruction

Rebuilt 1995 (Winn Dixie Supermarket) Destroyed by Katrina

Owners of land (Cress Realty Group) future plans for "prime" location is to wait until the coast economy rebounds, then re-build—probably a condominium complex.

The Four Fundamental Properties of Resilience

robustness

redundancy

resourcefulness

rapidity

DHS Definitions

- "Critical infrastructure" are "systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters." (US Patriot Act 2001).

The Protection Challenge

"National Strategy for the Physical Protection of Critical Infrastructures and Key Assets" – White House 2003

- Agriculture and Food: 1,912,000 farms; 87,000 food-processing plants
- Water: 1,800 federal reservoirs; 1,600 municipal waste water facilities
- Public Health: 5,800 registered hospitals
- Emergency Services: 87,000 U.S. localities
- Defense Industrial Base: 250,000 firms in 215 distinct industries
- Telecommunications: 2 billion miles of cable
- Energy: (Electricity: 2,800 power plants; Oil and Natural Gas: 300,000 producing sites)
- Transportation
  - Aviation: 5,000 public airports
  - Passenger Rail and Railroads : 120,000 miles of major railroads
  - Highways, Trucking, and Busing: 590,000 highway bridges
  - Pipelines: 2 million miles of pipelines
  - Maritime: 300 inland/costal ports
  - Mass Transit: 500 major urban public transit operators
- Banking and Finance: 26,600 FDIC insured institutions
- Chemical Industry and Hazardous Materials: 66,000 chemical plants
- Postal and Shipping: 137 million delivery sites
- Key Assets:
  - National Monuments and Icons: 5,800 historic buildings
  - Nuclear Power Plants: 104 commercial nuclear power plants
  - Dams: 80,000 dams
  - Government Facilities: 3,000 government facilities
  - Commercial Assets: 460 skyscrapers

"Critical"

- "Criticality" is in the eyes of the beholder
  - DHS: Macro-level (National security or health)
  - Community Resilience: Focus on infrastructure that population will need to rely upon following a disaster (e.g. Hospitals, power grid, water distribution system, transportation)
  - Stakeholders see "critical" in terms of their business continuity/survival

Past MCEER Work

Robustness

- Highway short to long-span bridges, culverts, tunnels, geotechnical works
- Transformer stations
- Hospitals (foundations, structure, non-structural systems, organizational structure, operational requirements, etc.)
- Others

MCEER Solutions

Robustness

- Base Isolation
- Dampers
- Active Control
- Semi-Active Control
- Steel Plate Shear Walls
- Advanced Materials
- New Design Approaches

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Seizing the Opportunity:
Meeting New and Emerging Needs

- State of California SB 1953
  - Seismic Safety Act for Hospital Facilities
    - Decision Support Systems
    - Engineering Studies
      - Structures
      - Equipment & Contents
    - Retrofit Techniques
      - Knowledge, Tools & Technologies
    - Public Policy Studies
  - OSHPD & Industry Input
  - Publications & Continuing Education

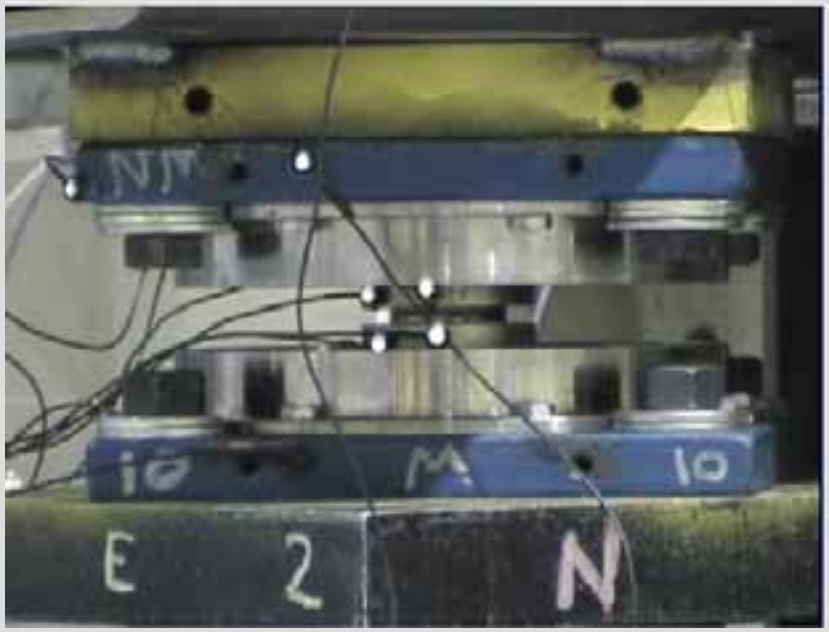
Solutions for Hospitals

Non-Structural Components

- Resilience of Hospital Depends in a highly integrated way on Performance of Non-Structural Components (testing of systems, development of numerical models and fragility data)

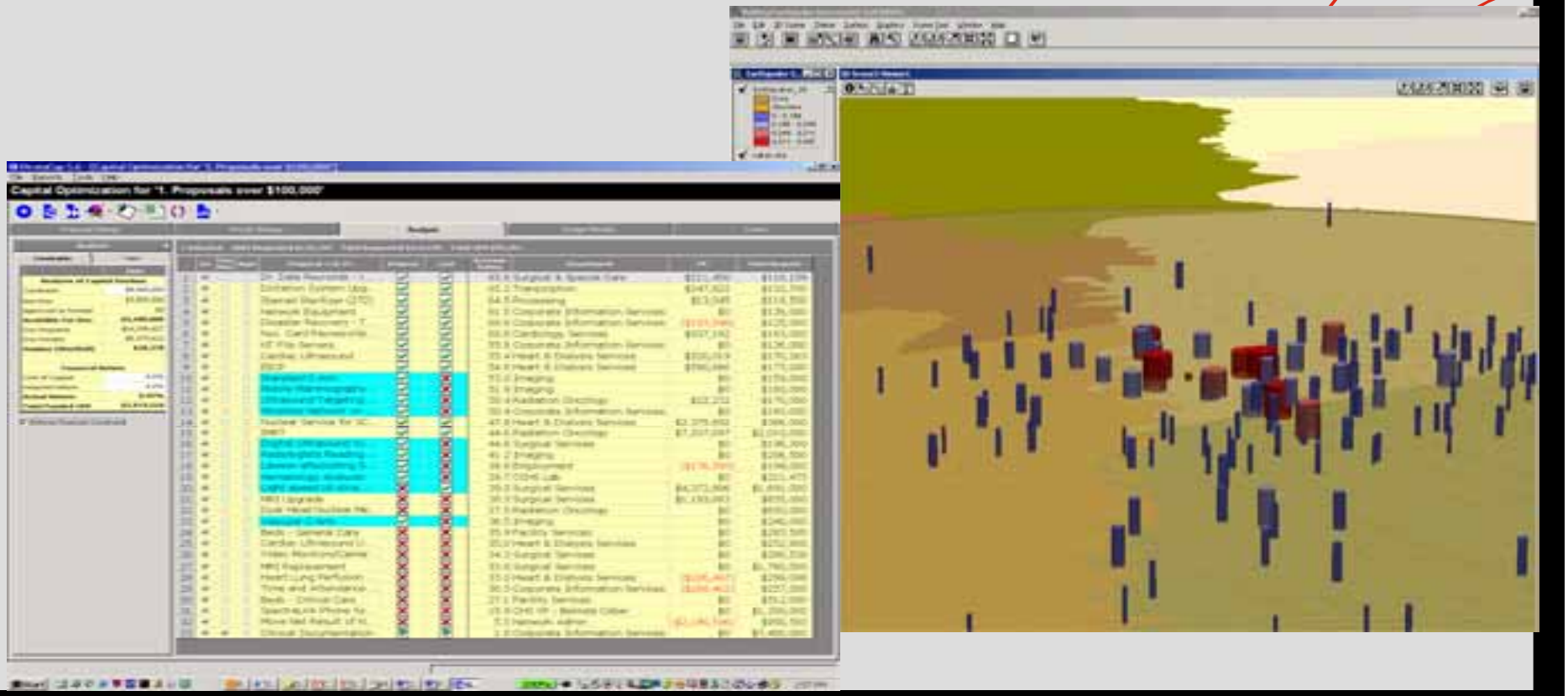
Impact of Structural Performance on Non-Structural Components

- Advanced technologies concepts elaborated based on how they impact structural AND non-structural performance
- Case studies on MCEER Demonstration Hospital using MCEER Ground Motions



Decision Analysis / Decision Models

- Development of risk module and integration of fragility results and models in capital allocation software
- Evolutionary methodologies for decision support



Development of Effective Policy Implementation, Healthcare Decision Making

- Review and continued monitoring of SB 1953 in California
- Study addressing discontinuity between structural and nonstructural design in hospitals
- Complete empirically-based healthcare decision making model

Past MCEER Work

Robustness

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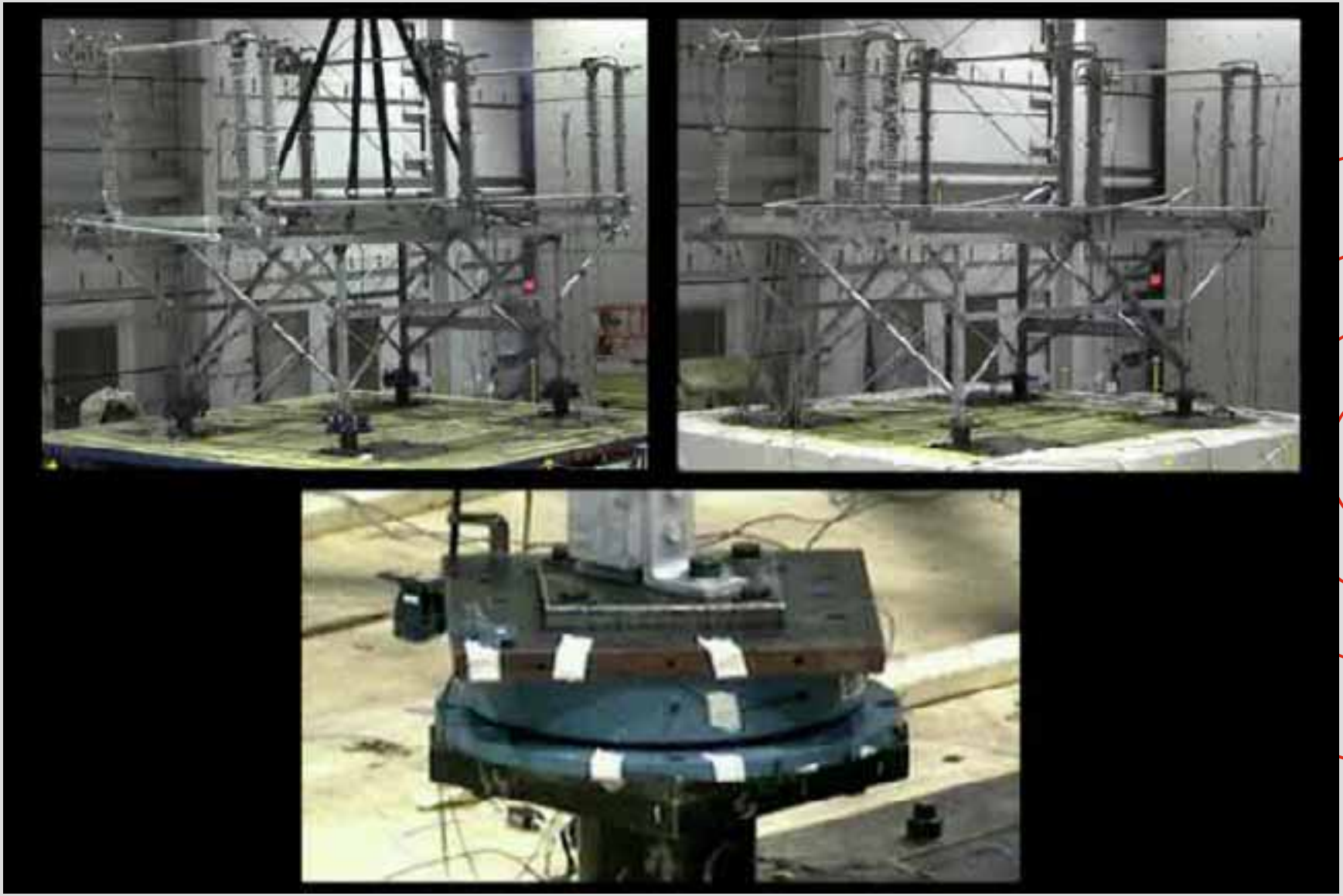
- Others

Federal Highway Research

- Task B: Loss Estimation
- Task C: Special Structures
- Task D: Response Modification
- Task E: Geotechnical
- Task F: Special Studies
  - Design Examples
  - Seismic Monitoring
  - NDE
- Task G: Tech Transfer

Base Isolated Disconnect Switch



Industry Collaboration

- Engage manufacturing, practitioner, and end-user communities related to each of MCEER's research thrusts
- Further interaction, research, education, knowledge, and technology transfer
- Increase collaboration and support of Center research, education and outreach endeavors
- Advance Center and mutual goals

From Earthquake Engineering to Multi-Hazard Engineering

- What are the opportunities to leverage the extensive earthquake engineering knowledge and advances to provide enhance the resilience against a broader spectrum of hazards?

Steps to Enhance Resilience Spectrum of Needs

Pre-Event

- Risk and vulnerability assessment, including the development of risk and vulnerability assessment methodologies, to prioritize the allocation of limited resources;
- System analysis and design, to investigate the ultimate behavior of systems and foster capacity-design principles for fail-safe outcomes;
- Improved materials, devices, or systems, to enhance the ability of infrastructure components and systems to withstand hazards;
- Retrofitting prior to an event.

Steps to Enhance Resilience Spectrum of Needs

During Event

- Sensing technologies, for structural health monitoring, with possible applications for detection, surveillance and prevention

Steps to Enhance Resilience Spectrum of Needs

Post-Event

- Post-event assessment, including the use of remote sensing (airborne or satellite-based) to rapidly locate areas impacted by a disaster, the type of damage suffered, and rapid assessment of losses;
- Post-event on-site screening methodologies, to assess safety of structures after an event using simple tools based on expert knowledge;
- Advanced technologies for repair and restoration following an event;
- Evaluation test-beds, to test and validate new technologies proposed to achieve above objectives.

Steps to Enhance Resilience

- In that perspective, much research results from the field of earthquake engineering could be modified to contribute to this objective. Earthquake engineering research has provided practical solutions to address a number of needs that are similar (although not identical) for a number of hazards.

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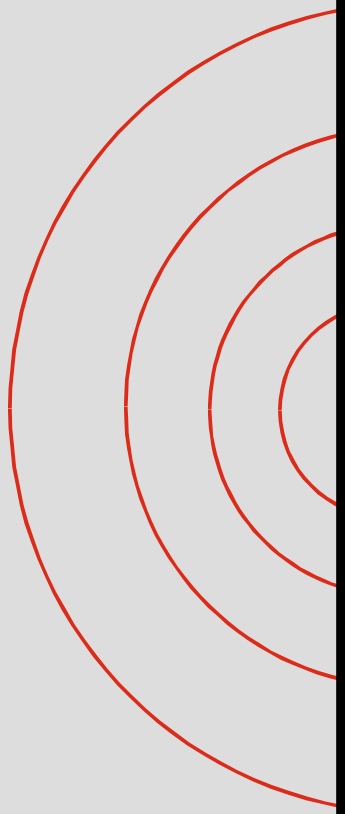
RESEARCH

Mitigation Prior to an Extreme Event

Real-time Monitoring During an Extreme Event

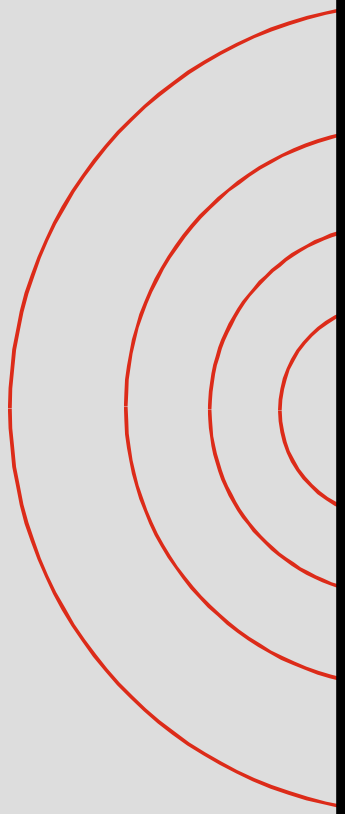
Post-event Response and Recovery Issues




HAZARD/THREATS
Earthquake
Blast
Hurricane
Tornado
Fire
Flood / Scour
Chemical
Infectious Agent
Radioactive Agent
. . . . .

CRITICAL INFRASTRUCTURE

- Hospitals / Medical Facilities
- Emergency Facilities
- Stadiums / Arenas / Theaters
- Industrial Facilities
- Bridges
- Transportation Systems
- Utilities



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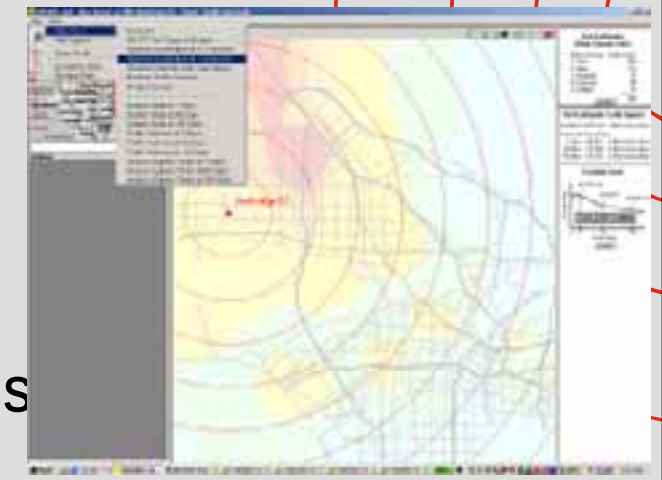
Risk Analysis/Decision Support

- MCEER Software for Seismic Risk Analysis of Highway Systems
  - MCEER-Federal Highway Administration REDARs public-domain software
  - Caltrans project of Bay Area Highway Network
  - Validation/calibration to Northridge Earthquake
  - Modules to develop for other hazards

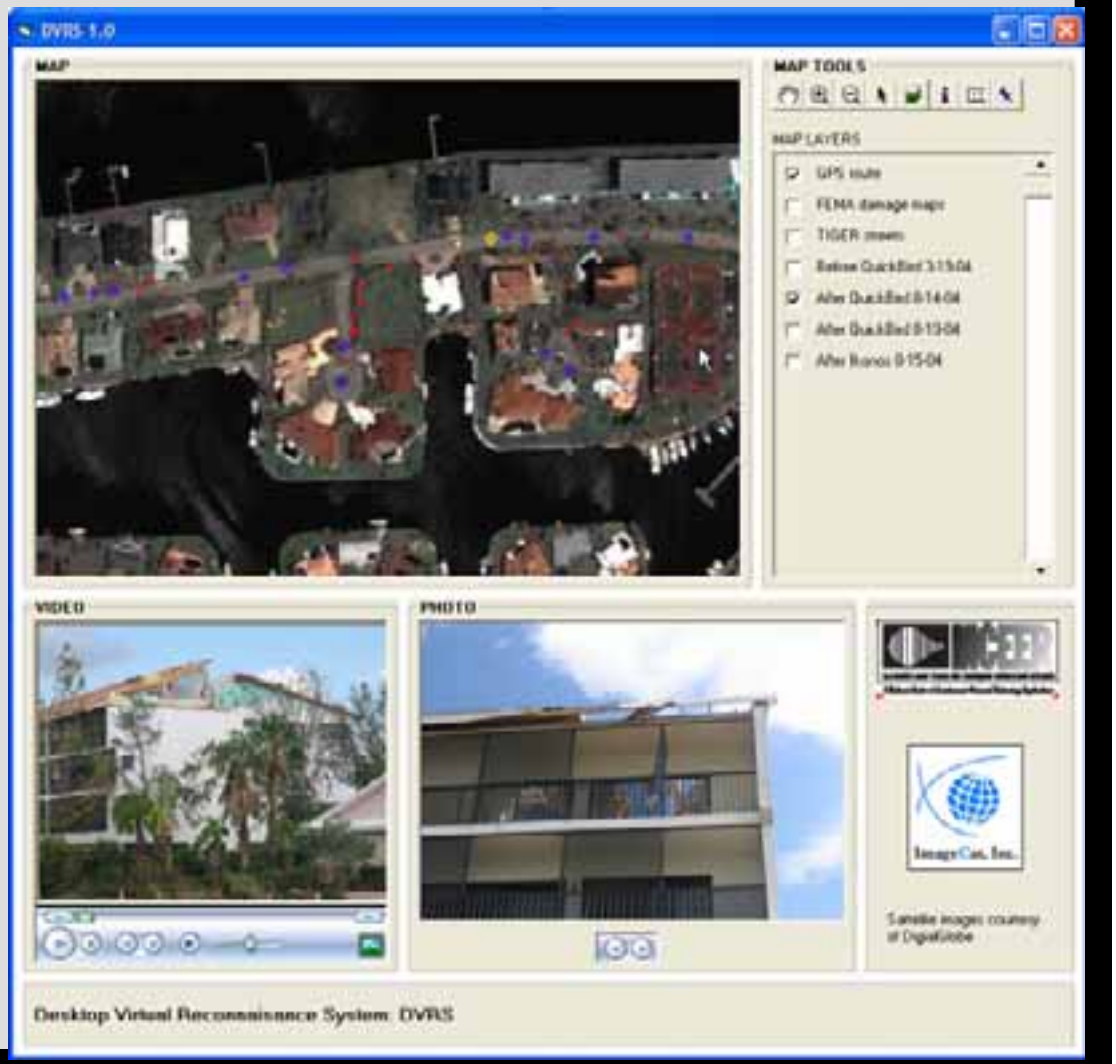


World Trade Center Research

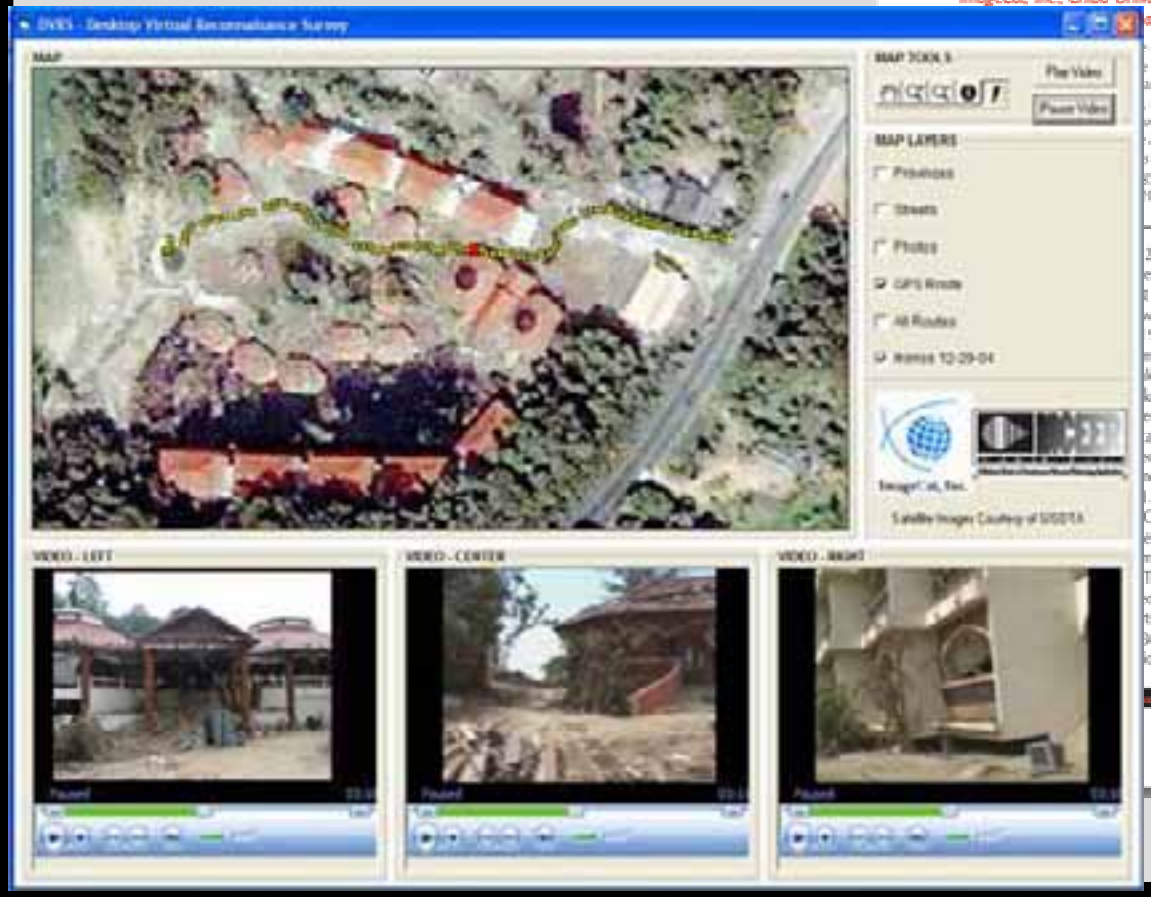
- Comparing and Contrasting Natural and Human-Induced Disasters
  - Data analysis will advance the conceptualization and quantification of a community's resilience to disasters
  - Engineering and social science knowledge to address the impact of major urban earthquakes

Major Accomplishment

- Hurricane Charley Reconnaissance Report
  - Satellite-Referenced Building Damage Information in the Aftermath of Hurricane Charley



December 2004 Tsunami



MCEER RESPONSE

A Summary of Reconnaissance Efforts of the Multidisciplinary Center for Earthquake Engineering Research

Post-Tsunami Urban Damage Survey in Thailand Using the VIEWS® Reconnaissance System

Shubharoop Ghosh, Beverley J. Adams, Charles K. Huyck, Michael Mio, Ronald T. Eguchi, Fumio Yamazaki and Masashi Matsuoka

ImageCat, Inc., Chiba University and the Earthquake Disaster Mitigation Research Center, National Research and Disaster Prevention

of December 26, 2004, and the tsunamis that it generated, were events of unprec- of the number of populated areas that were exposed to the disaster, the immediate and umis are being considered as one of the most significant in the history of mankind. This undertaken in some of the hardest hit areas in southwestern Thailand, presented the e opportunity to collect perishable damage data, with the aim of increasing the effective- assessment activities. The data collected will help decision makers better understand the of the event, and will support future research to improve disaster response using satel- gy. High-resolution satellite images collected before and after the tsunamis were used for tsunami reconnaissance efforts, and the data may ultimately help develop a preliminary

2004, 00:58:53 UTC, earthquake occurred of northern Sumatra, was located beneath the 95.9-47°E. The earthquake mis in the region that long thousands of miles ked as one of the most ent times, the earthquake caused significant damage: d in over 200,000 deaths, ndered homeless, or left amenities.

Center for Earthquake ed a multi-lateral Thai-Jap- to investigate the effects Thailand. Of the affected cted as the destination ts of destruction at mul- 300 deaths, and >US$500 ion's shrimp industry; and

(2) a preliminary assessment of potential casualties in the region by ImageCat, using remote sensing data.

Figure 1 shows results of the preliminary assessment, using satellite imagery to identify areas of potential devastation. This figure was developed by cross referencing population data from NOAA's (National Oceanic and Atmospheric Administration) DMSP sensor (in yellow and orange) with wave height modeled by Vasily Titov (NOAA, 2005) and proximity to the coastline. The resulting zones of potential damage (in red) were used to prioritize areas for field investigation, and the acquisition of high-resolution satellite images from DigitalGlobe.

The main objective of this post-tsunami field deployment was to collect perishable information about building and lifeline damage characteristics. In the aftermath of a catastrophic event like the Indian Ocean tsunamis, the rapid collection, evaluation, and dissemination of information regarding the spatial extent and severity of damage is of

sance Efforts of the Multidisciplinary Center for Earthquake Engineering Research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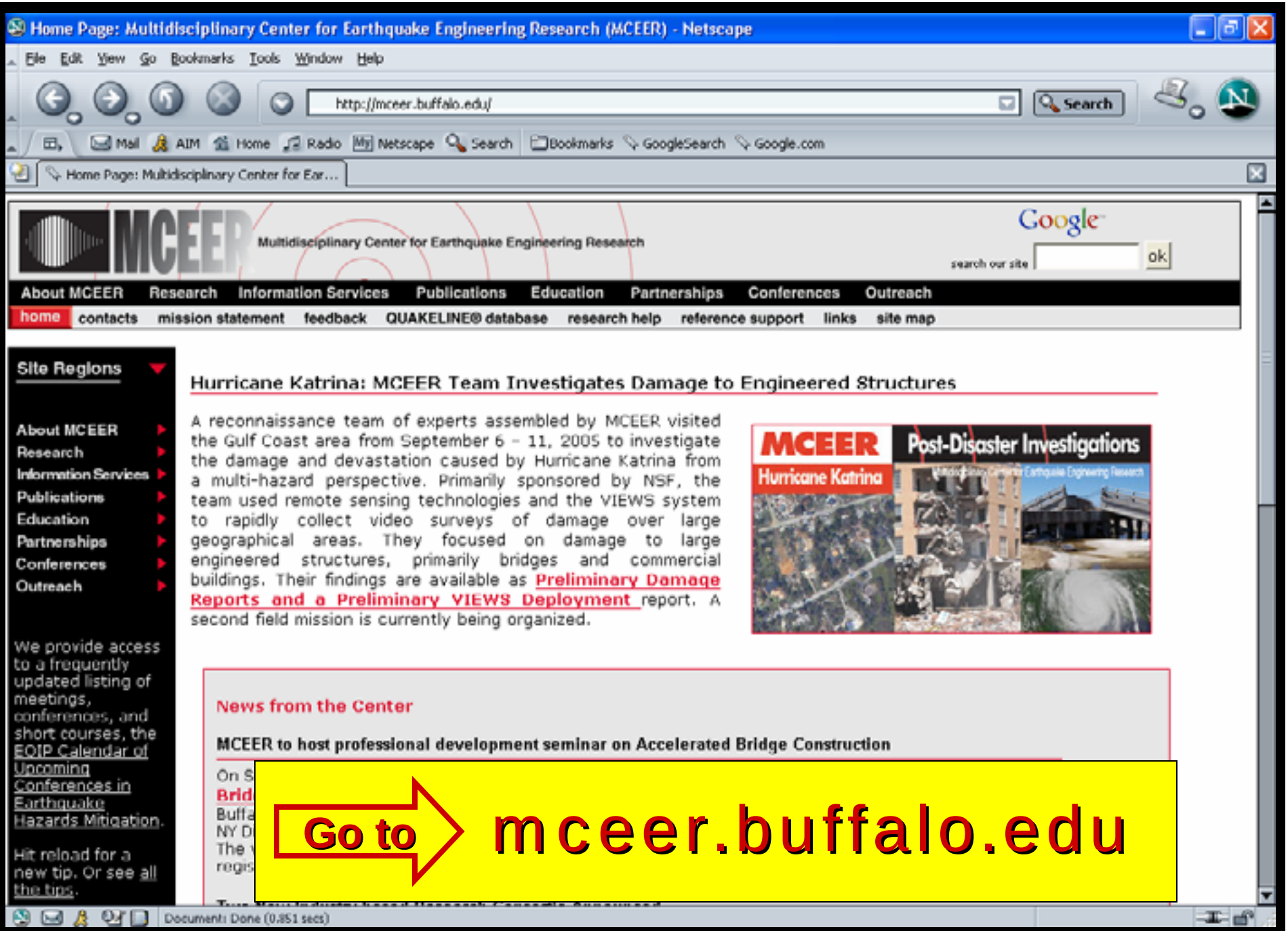
Post-Disaster Investigations
Hurricane Katrina
Multidisciplinary Center for Earthquake Engineering Research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We provide access to a frequently updated listing of meetings, conferences, and short courses, the EQIP Calendar of Uncoming Conferences in Earthquake Hazards Mitigation.
Hit reload for a new tip. Or see all the tips.
Hurricane Katrina: MCEER Team Investigates Damage to Engineered Structures
A reconnaissance team of experts assembled by MCEER visited the Gulf Coast area from September 6 - 11, 2005 to investigate the damage and devastation caused by Hurricane Katrina from a multi-hazard perspective. Primarily sponsored by NSF, the team used remote sensing technologies and the VIEWS system to rapidly collect video surveys of damage over large geographical areas. They focused on damage to large engineered structures, primarily bridges and commercial buildings. Their findings are available as Preliminary Damage Reports and a Preliminary VIEWS Deployment report. A second field mission is currently being organized.
MCEER
Post-Disaster Investigations
Hurricane Katrina
News from the Center
MCEER to host professional development seminar on Accelerated Bridge Construction
Go to mceer.buffalo.edu
Document: Done (0.851 secs)


US 90 Eastbound
Pass Christian to Bay St. Louis, Mississippi

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15 ft.

Kobe 1995

Blast-Resistant Bridge Bent Design

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Results

- Reached target ductility
- No breaching
- Able to resist gravity loads
- Optimal Seismic/Blast Design

Conclusions

- Innovative and integrated solutions are key to enhance the resilience of infrastructure against extreme events (natural disasters, technological disasters, and acts of terrorism against our society)
- MCEER already working to expand “single-hazard solutions” to satisfactorily address multiple hazards (without incremental costs)

Thank you!

Questions?