

Vulnerability - Engineering

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**WORKSHOP FOR A CROSS-DISCIPLINARY
PROGRAM FOR DISASTER RESILIENCE,
VULNERABILITY AND RISK REDUCTION**

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Objective



- Present the engineering perspective on interdisciplinary research in disaster vulnerability

Outline

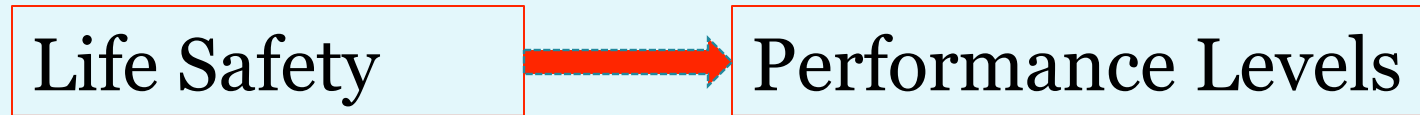


- State of science
- Research opportunities
- Limitations

State of the Science



- Fundamental paradigm shift



- New definitions of vulnerability
 - **Vulnerability = non-performance levels**
 - Example: immediate occupancy performance level implies that structure should have only cosmetic damage and will have all lifeline functionality available to it
 - This definition requires a systems approach to vulnerability definition!

State of the Science



- Advanced vulnerability assessment methods – relate to performance levels— PBEЕ - earthquake primarily
 - Building structural system
 - Non-structural components
 - Contents
 - Lifeline systems
 - ✦ Transportation
 - ✦ Water/sewer
 - ✦ Power
 - ✦ Communications
 - ✦ Gas

Primary current focus

Performance models
in their infancy

Research Opportunities



- Bring performance modeling for other hazards in line with earthquake performance definitions
- Multi-hazard performance evaluations - this should be within the context of the digital city concept
 - E.g. hurricane wind force, storm surge and flood levels
 - E.g. earthquake and tsunami plus technological hazards – earthquake of March 11, 2011 in Tohoku, Japan
- Define performance levels within the context of social and economic requirements for functionality and resiliency
- Building and other structure specific models – need for better understanding of structural response such as the behavior of materials when subjected to extreme loads

Research Opportunities



- Study and develop methods for evaluating and modeling
 - Interaction/dependence between
 - ✦ Structure – vulnerability correlation of similar structures
 - ✦ Lifeline systems
 - ✦ Social components
 - ✦ Economic components
- Time-dependent modeling - consideration of aging and deterioration in performance assessment as well as population and infrastructure growth
- Consider life-cycle issues and sustainability – reusable/new materials that are also hazard resistant

Research Opportunities – cont'd



- Need for technologies that connect vulnerability models with regional risk assessment – high data, high computation
- Need for multi-scale models that go across the structural, social and economic components – these are typically data intensive, and computationally very intensive
- Data and other information collection:
 - Single structure instrumentation for
 - ✦ Performance assessment – - pre- and post event evaluation
 - ✦ Design development
 - ✦ Instrumentation that integrates structural performance, energy consumption and environmental conditions
 - Regional data collection
 - ✦ Inventory compilation for all hazards
 - ✦ Develop technologies for automated inventory compilation
 - ✦ Technologies for continuous updating – such as direct link to building permitting process and visualization tools (e.g. google earth, remote sensing, video cameras, etc.)
 - ✦ Post-event regional damage evaluation methods – using remote sensing

Research Opportunities – cont'd



- Develop new materials and systems for
 - New structures
 - Retrofit purposes
 - Rapid reconstruction
- } Include social and economic implications in the design of these materials
- Special designs for evacuations & temporary housing
 - Address individual hazards – hurricane, tornado, floods, tsunamis
 - Identify common themes
 - Include the following in evacuation strategies
 - ✦ Multicultural social environments
 - ✦ Economic conditions – government and individual – correlate to social status
 - Relationship between vulnerability and resiliency of a region
 - Need for demonstration projects – similar to the southern California earthquake scenario – for other hazards and for multiple hazards

Constraints



- Very limited funding
- Limited communication between the fields – engineering, social and economic sciences
- Lack of appreciation of the cross-disciplinary issues by all the fields