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

Life Safety	→	Performance Levels

- 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–– PBEE - <u>earthquake primarily</u>
  - 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 <u>social and economic requirements</u> 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 – re-usable/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