DS-4: Vulnerability Functions

Ty Stokes
University of South Carolina
REU 2004, University of Illinois Urbana-Champaign
Advisor: Professor Y.K. Wen
Outline

• Overview of DS-4
• What are Vulnerability Functions?
• How do we develop them?
• Why do we care?
• My Role
Project DS-4

- Part of the Mid-America Earthquake Center’s Damage Synthesis (DS) group
- Related to other projects (DS-1,6-9; CM-1, 4, 7)
- Deals with Buildings (Reinforced Concrete, Steel, Masonry)
Describing Vulnerability Functions

• Essentially, relate ground motion intensity to probability
• Easily understood, visual representation of the likelihood of limit states being reached
• Gives a clear relationship between various structures in terms of safety
Memphis Buildings Vulnerability Curves

Sample Vulnerability Curves

Immediate Occupancy (IO)
Life safety (LS)
Incipient Collapse (IC)

RC-IO
RC-LS
RC-IC
S-MD
S-LT
Wood-LS
URM-IO
URM-LS
URM-IC
Developing Vulnerability Functions

• Necessary to accurately describe the structure in question

• Analysis of response to ground motion

• Probability formulae are used to find final Vulnerability functions
Visual examples of development steps

\[ y = 1.8414x^{0.7189} \]
Significance of Vulnerability Functions

- Clear models, easily understood by stakeholders
- Limit states correspond to building codes for immediate occupancy (IO), or other states of structural integrity
- Stakeholders include Insurance companies, city officials, facility operators, and the general public
- Saves money and lives
My Role

• Describing nature of typical Unreinforced Masonry Structures
• Finding details of connections
• Recommending model configuration
Resources

• Memphis Test Bed (project DS-2)
• Library Research
• Internet Research
• Expert Assistance
• Visual Evidence
Useful Information

- **Memphis Test Bed**
  - Number of stories of buildings
  - Age of buildings
  - Use of buildings

- **Library Research**
  - Connection details

- **Internet Research**
  - Alternate connection details
  - Possible retrofit connectors
Visual Discoveries
Typical URM Structures

- Less than 5 stories (99%), preferably one story (70%)
- Most structures constructed prior to 1980
- Fire-cut Joists with possible metal strap connections
- Built-up brick columns support large floor beams
- Most structures less than 2,500 square feet
Project DS-4’s Future

• Researchers at UIUC are collaborating with researchers at Georgia Tech and Texas A&M to define the population of structures in Memphis in terms of Fragility, Damage, and Loss

• Submit probability-based tools to other projects to help decide on the benefits of retrofitting
Thank you

(Questions?)