Vulnerability-Based Assessment and Retrofit of Dwellings: Performance Needs and Expectations

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- **Project Steering Committee**
Project Vision and Deliverables

Vulnerability-Based Seismic Assessment and Retrofit of One- and Two-Family Dwellings

Volume 1 - Prestandard

PRESTANDARD (IN REVIEW) + PLAN SETS (SOON) + BACKGROUND DOCUMENTS (SOON)
Scope

- Cripple Wall Dwelling
- Living-Space-Over-Garage
- Hillside Dwelling
  + Chimneys & Fireplace Surrounds
Why a Retrofit Prestandard?
Why a Retrofit Prestandard?

[Image of damaged and undamaged houses]
Why a Retrofit Prestandard?
1. Develop performance criteria

2. Develop retrofit design methodology, estimate design parameters

3. Design archetype buildings with and without retrofit

4. Use NLRHA numerical studies to judge improved performance with retrofit
Performance Criteria

Primary:
- Probability of collapse at $\text{MCE}_R$ – FEMA P-695

Secondary:
- Indicator of level of repair – probability of exceeding 0.75% drift at 0.4 $\text{MCE}_R$ – FEMA P-58 Fragilities, CUREE EDA-02
- Indicator of safety for continued occupancy – probability of exceeding 1.5% drift at 2/3 $\text{MCE}_R$ – CUREE EDA-02, FEMA P-807 Appendix D.9
Numerical Studies
Numerical Study - Qualifications

- Best available tools used
- Understood to provide approximate indication of performance, likely overestimate probability of collapse
- Approximate nature of results considered when making decisions based on analytical results
- Emphasized as a predictor of relative performance rather than absolute performance
Crawlspace Dwelling
Vulnerability & Performance Questions

1. What seismic design forces should be used for retrofit to achieve performance target?
2. Will retrofit increase damage to occupied stories above?
Median Home Study
Quantifying Strength in Occupied Stories

- 21 one-story homes (84 combinations)
- 14 one-story homes (56 combinations)
Performance and Design Criteria
Cripple Wall Retrofit

2' Cripple Wall Summary

- **Primary Performance Criteria - Adjusted Probability of Collapse at MCE**
- **Cripple Wall - Secondary Criterion 2 (1.5% at DE)**
- **Cripple Wall - Secondary Criterion 1 (0.75% at 0.4 MCE)**
- **Superstructure - Secondary Criterion 2 (1.5% at DE)**
- **Superstructure - Secondary Criterion 1 (0.75% at 0.4 MCE)**

![Graph showing probability of exceedance of primary and secondary criteria for different criteria levels (R=4.0, R=3.0, R=2.5, R=2.0).]
Living-Space-Over-Garage Dwelling
Vulnerability & Performance Questions

1. What seismic design forces should be used for retrofit to achieve performance target?
2. Will retrofit increase damage to occupied stories above?
3. Are room-over garage dwellings as vulnerable as house-over-garage?
Performance and Design Criteria
House Over Garage Retrofit

- Existing
- Cantilever Column, R=4
- Cantilever Column, R=3
- Cantilever Column, R=2
- Wood Structural Panel, R=4
- Proprietary R=3

Primary Performance Criteria – Adjusted Probability of Collapse at MCE_R
- Yellow: First Story – Secondary Criteria 1 (0.75% @ 0.4MCE_R)
- Blue: First Story – Secondary Criteria 2 (1.5% @ DE)
- Red: Second Story – Secondary Criteria 1 (0.75% at 0.4 MCE_R)
- Light Gray: Second Story – Secondary Criteria 2 (1.5% at DE)
Hillside Dwelling
Vulnerability & Performance Questions

1. Where does the transition from cripple wall behavior to hillside dwelling behavior occur?
2. What seismic design forces should be used for retrofit design to achieve performance target?
Performance and Design Criteria
Hillside Dwelling Retrofit

Model and Performance Criterion

- Primary Criterion - FEMA P695 Adjusted Prediction
- Cripple Walls - Secondary Criterion #1 (0.75%)
- Cripple Walls - Secondary Criterion #2 (1.5%)
- Upper Story Walls - Secondary Criterion #1 (1%)
- Upper Story Walls - Secondary Criterion #2 (1.5%)

P[C|MCE] or Probability of Exceedance (%)

EXISTING
SECONDARY ONLY
PRIMARY AND SECONDARY
PLUS SHEATHING
PRIMARY ONLY
EXTRA SECONDARY
PLUS SHEATHING

ATC-110: Development of a Prestandard for the Assessment and Retrofit of One and Two Family Light Frame Residential Buildings
Final Choice of Retrofit Informed by Numerical Studies of Performance Objectives

- Improve Collapse Performance
- Mitigate damage migration
- Constructability
- Final Retrofit
Questions?