Evaluation and Repair of Earthquake Damage in Woodframe Buildings

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Agenda

• Introduction & Background
• Damage Assessment References
• The CUREE Woodframe Damage Assessment Project
• Research to-date
• Guidelines
• ATC-43 Comparison
Purpose of Post-EQ Damage Assessment

- Confirm safety assessment
- Document damage
- Determine significance of damage
- Provide basis for decision on what to do about damage
Need for Guidelines

Engineering issues following Northridge

• **What is damage?**

• **What constitutes an adequate inspection?**
  – What to look for
  – Where to look
  – When to look for concealed damage

• **What constitutes appropriate repair**
  – Do nothing - accept damage
  – Restore to pre-event condition
  – Upgrade to a better condition
  – Demolish as uneconomical to repair

• **Problem for steel, concrete, & woodframe buildings**
**Damage Assessment References**

- **Pre-Northridge**
  - ATC-20 – 1989

- **Post-Northridge**
  - SAC Steel Moment Frame Project – 1995-2001
  - CUREE - CalTech Woodframe Project 1998-2003
  - CUREE Earthquake Damage Assessment Project 1998-2007?
Earthquake Damage Assessment and Repair for Woodframe Residential Construction (EDA)

Objective to develop guidelines to be used by engineers, contractors, owners, insurance industry, building officials, and others for post-earthquake damage assessment and repair

Applies to residential woodframe construction

Modeled on ATC-20 and ATC-43

In progress
Research to-date:

- **Damage assessment and repair of walls where shear resistance is provided only by stucco and drywall**
  - refining understanding of damage mechanisms
  - establishing correlations between visible damage and structural response
  - assessing the efficacy of repair techniques for common types of earthquake damage

- **Potential for earthquake-induced cracking of concrete slabs-on-grade and foundations at sites that are geotechnically stable**

- **Efficacy of epoxy repair of cracks in unreinforced concrete slabs-on-grade and foundations**

- **Refined understanding of seismic compression of fills**
Stucco & Drywall Shearwalls

• Researchers: Chia-Ming Uang, Andre Filiatrault, & Andrew Arnold, UCSD

• Publications
  – EDA-03 - *Cyclic Behavior and Repair of Stucco and Gypsum Sheathed Woodframe Walls Phase I*
  – EDA-07 - *Cyclic Behavior and Repair of Stucco and Gypsum Sheathed Woodframe Walls Phase II*
Section 6 – Wall Elements

Photo Credits: CUREE
Section 6 – Wall Elements

(a) 0.2% Drift

(b) 0.4% Drift

(c) 0.7% Drift

(d) Failure

Diagram Credit: CUREE
Stucco & Drywall Shearwalls

Drift (in)
Load (kips)

(a) Wall 3d
Surface Strains

• Workshop Panel:
  – Bruce Bolt
  – Paul Somerville
  – Norman Abrahamson
  – Aspasia Zerva

• Publication:
  – EDA-04 – *Workshop Proceedings: Effect of Earthquake-Induced Transient Ground Surface Deformations on At-Grade Improvements*, A. Gupta, ed.
Surface Strains

- The magnitude of earthquake-induced transient ground surface strains at an arbitrary site can be reasonably estimated given the current state-of-science.
- The effect of surface strains on at-grade improvements would be inconsequential, except perhaps in the near fault region where large transient peak ground displacements may occur.
- The reported observations of visible waves on the ground surface during strong ground shaking cannot be explained from a seismological perspective. Under special circumstances where the ground is extremely soft, it may be possible to observe the surface waves, however these waves would likely not be damaging to at-grade improvements, as the wavelength of these waves would be much larger than the dimensions of the at-grade improvements.
Epoxy Repair

• **Contractor:**
  - Jay Crandall, National Association of Home Builders Research Center

• **Report:**
  - EDA-01 – *Testing and Assessment of Epoxy Injection Crack Repair for Residential Concrete Stem Walls and Slabs-on-Grade*
Seismic Compression

• **Researcher:**
  – Jon Stewart, UCLA

• **Publication:**
  – EDA-05 – *Seismic Compression of As-Compacted Fill Soils with Variable Levels of Fines Content and Fines Plasticity*
EDA-02 - General Guidelines for the Assessment and Repair of Earthquake Damage in Residential Woodframe Buildings

- Section 1 – Introduction
- Section 2 – Working with Engineers
- Section 3 – Characterization of Ground Motion Damage Potential and Structural Vulnerabilities (in progress)
- Section 4 – Geotechnical Aspects (in progress)
- Section 5 – Foundations and Slabs-on-Grade
- Section 6 – Wall Elements
- Section 7 – Floors, Ceilings, and Roofs (in progress)
- Section 8 – Fireplaces and Chimneys (in progress)
- Section 9 – Mechanical Systems (in progress)
- Section 10 – Glossary (in progress)
CUREE EDA General Guidelines

Wall Elements - Typical Chapter Outline

- **Quick Guide**
  - What to look for
  - Where to look
  - When to call an engineer
  - Repair guidelines

- **Summary**

- **Limitations**

- **Description of typical wall construction**

- **Non-earthquake sources of wall damage**
  - Stucco
  - Drywall
  - Lath & Plaster
  - Doors & windows
  - Wood trim

- **Earthquake-induced wall damage**
  - Stucco
  - Drywall
  - Lath & Plaster
  - Doors & windows

- **Assessment guidelines and methodology**
  - Exterior
  - Interior
  - Engineering assessment
  - Establishing the cause and age of cracks

- **Repair methodologies**
  - Crack repair
  - Construction joints
  - Engineered repairs
  - Upgrades and Betterment
EDA-06 - Engineering Guidelines for the Assessment and Repair of Earthquake Damage in Residential Woodframe Buildings

- Section 1 – Introduction
- Section 2 – Client Interactions & Reporting
- Section 3 – Characterization of Ground Motion Damage Potential and Structural Vulnerabilities
- Section 4 – Geotechnical Aspects (completed)
- Section 5 – Foundations and Slabs-on-Grade
- Section 6 – Wall Elements
- Section 7 – Floors, Ceilings, and Roofs
- Section 8 – Fireplaces and Chimneys
- Section 9 – Mechanical Systems
- Section 10 - Glossary
Geotechnical Aspects - Typical chapter outline

• Introduction
• Reconnaissance of Permanent Ground Deformation
  – Examples of seismically-induced permanent ground deformation
  – Site investigation
• Surface Fault Rupture
  – Description
  – Methods of investigation
  – Damage, repair, and mitigation
• Soil Liquefaction
• Seismically-induced landslides
• Seismic Compression
• EQ-induced deformation of retaining Walls
• Overview of non-seismic ground deformation processes
  – Consolidation settlement
  – Immediate settlement
  – Hydro-compression settlement
  – Expansive soil movement
  – Slope creep
• References
ATC-43/CUREE EDA Commonalities

- Characterization of ground motions & damage potential
- Investigation methodologies
- Guidelines for distinction between pre-existing conditions and earthquake damage
- Damage documentation guidelines
- Damage classification
- Component performance information
- Correlation between visible damage and structural behavior
- Repair alternatives
ATC-43/CUREE EDA Differences

- **Construction type**
  - ATC-43 – concrete & masonry walls
  - CUREE EDA – woodframe

- **Components**
  - ATC-43 – lateral load resisting wall elements
  - CUREE EDA – all building components, structural & non-structural
• **Publications:**
  - ATC: [www.atcouncil.org](http://www.atcouncil.org)
  - CUREE: [www.curee.org](http://www.curee.org)

• **Presenter:**
  - John Osteraas: [osteraas@exponent.com](mailto:osteraas@exponent.com)
  - Business card for CUREE EDA Project mailing list
Questions?