The Northridge Experience and CUREE-Caltech Woodframe Project

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Northridge 20 Symposium - January 17, 2014
Casualties: 24 of the 25 fatalities in the Northridge Earthquake that were caused by building damage occurred in woodframe buildings (1)

Property Loss: Half or more of the $40 billion in property damage was due to damage to wood buildings; approximately. $15 billion in insured loss (2)

Functionality: 48,000 housing units, almost all of them in woodframe buildings, were rendered uninhabitable by the earthquake (3)

(1) EQE and Calif. OES, 1995
(2) Charles Kircher et al., 1997, and Robert Reitherman, 1998
(3) Jeanne B. Perkins, et al., 1998
Property and functional loss

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Property and functional loss
life safety

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Woodframe Project Goal

- Advance the (seismic) engineering of woodframe buildings and improve the efficiency of their construction for targeted performance levels
Advisory Committee
Frank Beall (UC FPL), Jay Crandell (NAHRB RC), Nic Delli Quadri (LA), Daniel Dolan, (VPI) Greg Foliente (CSIRO), Robert Hanson (FEMA), Eric Kough (Kaufman & Broad), Philip Line, (AFPA) Michael Mahoney (FEMA), Gary Mochizuki (SEAOC), Andy Petrow (OES), James Russell (IBHS), Daniel Shapiro (CSSC), Edward Takehashi (CCAIA)

1. Testing and Analysis
   - Prof. André Filiatrault
     Manager (UCSD)
   - Prof. Chia-Ming Uang
     Asst. Manager (UCSD)

2. Field Investigation
   - Prof. G.G. Schierle
     Manager (USC)
   - Prof. Frieder Seible
     Asst. Manager (UCSD)

3. Building Codes & Standards
   - Kelly Cobeen, S.E.
     Manager (GFDS Engineers)
   - John Coil, S.E.
     Asst. Manager (Coil & Welsh)

4. Economic Applications
   - Thomas Tobin
     Manager (Tobin & Assoc.)
   - James Russell, P.E.
     Asst. Manager (Bldg. Codes Consultant)

5. Education and Outreach
   - Jill Andrews
     Manager (SCEC)

Project Organization Chart

John Hall
Project Manager (Caltech)

Robert Reitherman
Project Director (CUREE)

 Gregg Brandow
Senior Advisor & Representative (Brandow & Johnston)
Element 1: Testing and Analysis

- 23 CUREE reports are available from 22 testing and analysis tasks
Analysis and Experimental Components

1.1.1 Single-Family House (UC-San Diego)

1.1.2 Apartment Building (UC-Berkeley)
- 1.2 International Benchmark (UC-San Diego)
- 1.3.1 Rate of Loading + Loading Protocol Effects (UC-San Diego)
- 1.3.2 Testing Protocols (Stanford)
- 1.3.3 Dynamic Characteristics (Caltech)
- 1.4.1 Anchorage (WJE, USC)
- 1.4.2 Diaphragms (Virginia Tech)
- 1.4.3 Cripple Walls (UC-Davis)
- 1.4.4 Shear Walls (UC-Irvine)
- 1.4.6 Wall Finish Materials (Stanford, San Jose State)
- 1.4.7 Innovative Systems (Washington State)
- 1.4.8 Connections (Brigham Young) (UC-Irvine) (Washington State)
- 1.5.1 Analysis Software (UC-San Diego)
- 1.5.2 Demand Aspects (Stanford)
- 1.5.3 Reliability Analysis (Oregon State)
- 1.5.4 Analysis of Index Buildings (UC-San Diego)

1.1.3 Simplified Model (British Columbia)
Element 2: Field Investigations


Element 3: Codes & Standards

Element 4: Loss Estimation

Element 5: Education & Outreach

- Video Updates
- Newsletters
- Museum Displays
- Coordination of Media Information
W-06: Shake Table Tests of a Two-Story Woodframe House

D. Fischer; A. Filiatrault; B. Folz; C.-M. Uang; and F. Seible, UC San Diego
Designer: K. Cobeen, S.E.
W-19: Seismic Evaluation of an Asymmetric Three-Story Woodframe Building


Designer: Bret Lizundia, S.E.
W-14: Anchorage of Woodframe Buildings: Laboratory Testing Report

J. Mahaney and B. Kehoe
Wiss, Janney, Elstner, and Assoc.
W-15: Seismic Performance of Gypsum Walls: Experimental Test Program

K. McMullin and D. Merrick
San Jose State University
W-17: Seismic Behavior of Level and Stepped Cripple Walls

R. Chai, T. Hutchinson, and S. Vukazich
UC Davis
W-02: Development of a Testing Protocol for Woodframe Structures

H. Krawinkler, F. Parisi, L. Ibara, A. Ayoub, and R. Medina
Stanford University
W-09: Northridge Earthquake Field Investigations: Statistical Analysis of Woodframe Damage

G. G. Schierle
University of Southern California
Task 1.1.1 - Phase 9 Test Structure

3-D Model of Task 1.1.1 Test Structure

B. Folz and A. Filiatrault
UC San Diego
W-04: Woodframe Project: Case Studies

Edited by G. G. Schierle
University of Southern California
Future Needs

Goal: Advance the (seismic) engineering of woodframe buildings and improve the efficiency of their construction for targeted performance levels

Update: Ability to predict performance, move towards improved performance are key

Question: What happens if we do nothing:

• New buildings similar to recent
• Existing buildings
• Future mid-rise/ larger buildings
Future Needs

• Research
• Design
• Implementation
• Quality control
• Evaluation and retrofit of existing buildings
• Evaluation and repair of damaged buildings
Future Needs – Research

• Close gap between state of the art analysis tools and full building performance to provide reliable prediction of strength, deflection, and collapse
  – Large scale component testing with realistic boundary conditions, new and archaic material
  – Full building testing to collapse for analysis validation
  – Analytical studies of existing buildings with known earthquake performance
  – Analysis tool development and validation with all available information
Future Needs – Design

• Simplified design tools that capture actual building behavior and performance
  – For new buildings
  – For evaluation and retrofit of existing buildings
  – To understand performance
  – To aid in day-to-day design decisions
  – To inform trends in structural design
  – To inform development of proprietary components
Future Needs – Implementation

• Screening tools to quickly identify vulnerable building configurations that rise to the level of requiring detailed evaluation
• Broad estimates of performance and cost benefits of retrofit to encourage above-code construction
• Tools to communicate anticipated performance to nontechnical community in a responsible and realistic fashion
Future Needs – Quality Control

• Quality of construction and resulting performance issues remains significant concern in engineering community
  – Training of construction industry
  – Oversight
Future Needs – Evaluation and Retrofit of Existing Buildings

• Better understanding of when and why buildings become vulnerable
  – Realistic evaluation of performance
  – How weak is too weak
  – Construction quality influence
  – Deterioration influence?

• Efficient methods to improve performance
Future Needs – Evaluation and Repair of Damaged Buildings

• Better understanding of performance implications of damage
  – Technical understanding
  – Guidance for building evaluators
  – Guidance for repair design

• Efficient methods of repair
Acknowledgements

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Questions, Comments?