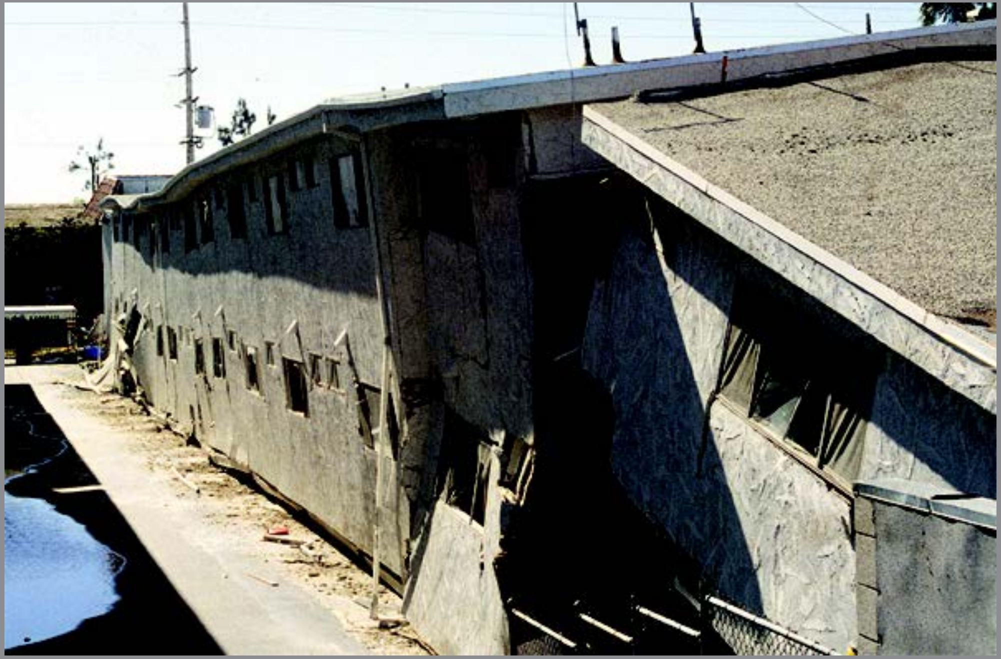
The Northridge Experience and CUREE-Caltech Woodframe Project



Kelly Cobeen, Wiss Janney Elstner & Associates

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

Property and functional loss

life safety

Woodframe Project Goal

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

Project Organization Chart

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)

John Hall
Project Manager (Caltech)

Robert Reitherman
Project Director (CUREE)

Gregg Brandow
Senior Advisor & Representative (Brandow & Johnston)

1. Testing and Analysis

Prof. André Filiatrault
Manager (UCSD)

Prof. Chia-Ming Uang
Asst. Manager (UCSD)

2. Field Investigations

Prof. G.G. Schierle
Manager (USC)

Prof. Frieder Seible
Asst. Manager (UCSD)

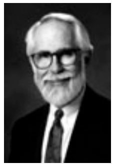
3. Building Codes & Standards

Kelly Cobeen, S.E.
Manager (GFDS Engineers)

John Coil, S.E.
Asst. Manager (Coil & Welsh)

James Russell, P.E.
Asst. Manager (Bldg. Codes Consultant)

4. Economic Applications



Thomas Tobin
Manager (Tobin & Assoc.)

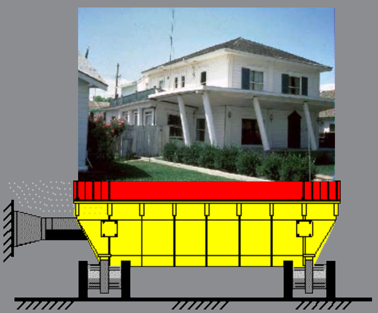
5. Education and Outreach

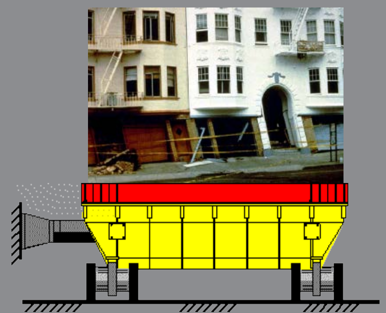
Jill Andrews
Manager (SCEC)

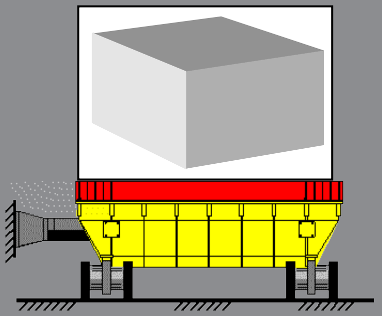
Element 1: Testing and Analysis

- 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)

1.1.3 Simplified Model (British Columbia)

- 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 (Bringham 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)

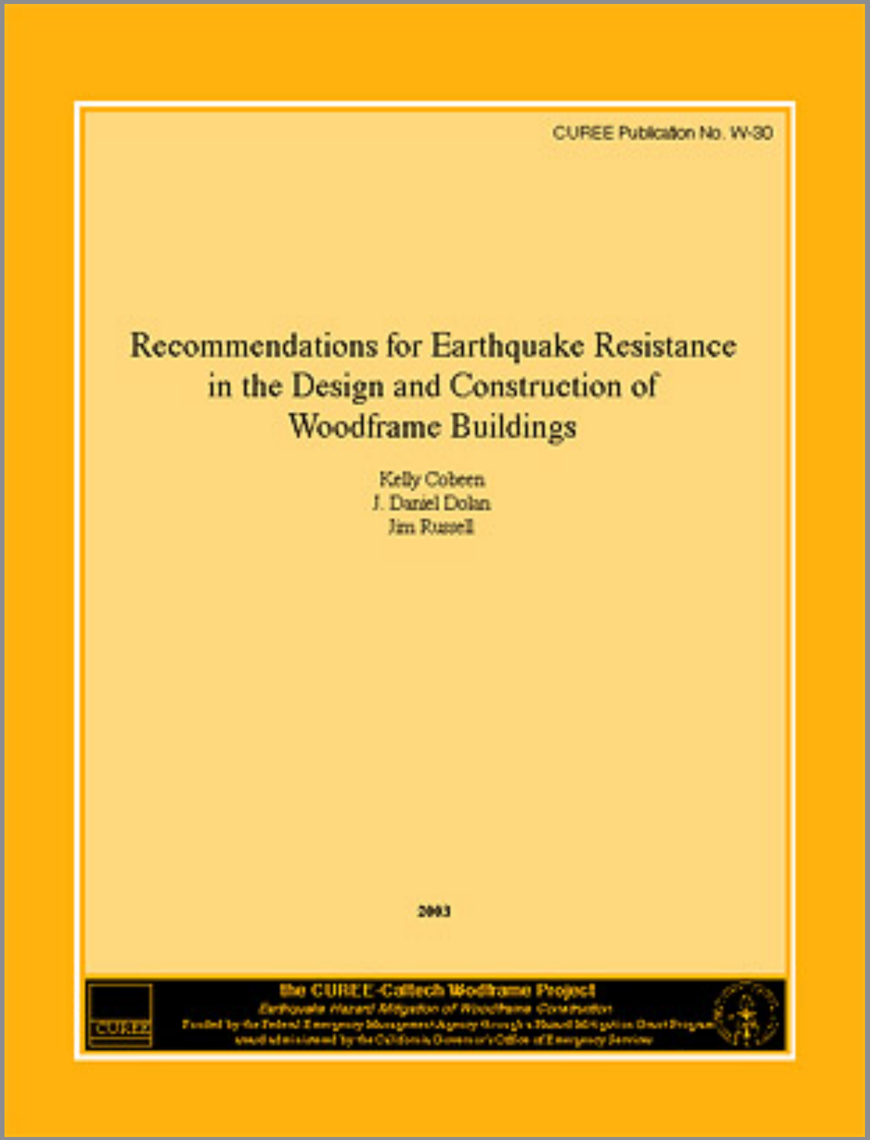
Element 2: Field Investigations

- CUREE Pub. W-04: Woodframe Project Case Studies, ed. by G.G. Schierle

- CUREE Pub. W-09: Northridge Earthquake Field Investigations: Statistical Analysis, G.G. Schierle

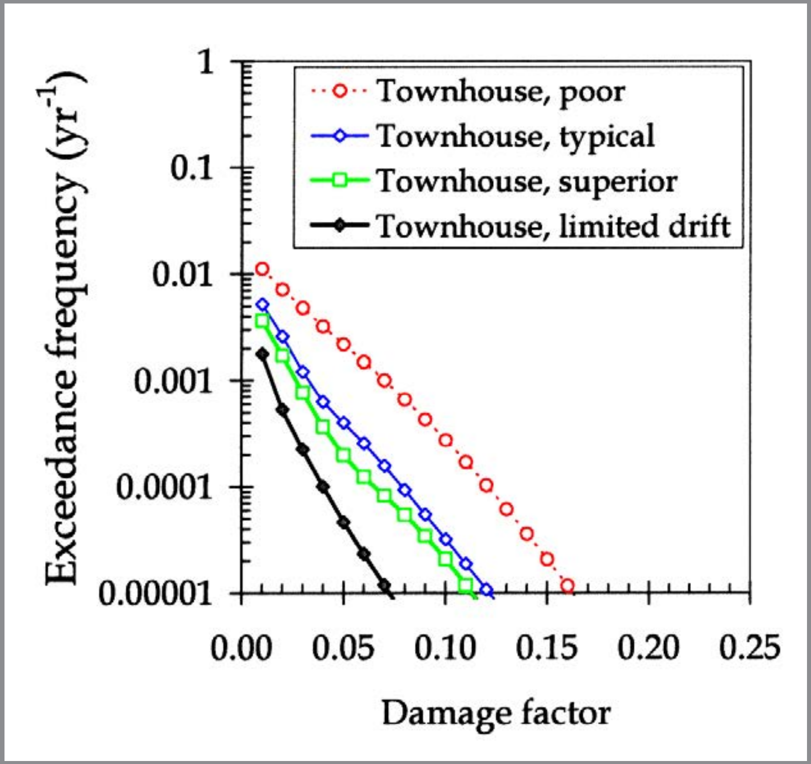
Element 3: Codes & Standards

- CURÉE Publication W-30: Recommendations for Earthquake Resistance in the Design and Construction of Woodframe Buildings, Parts I and II



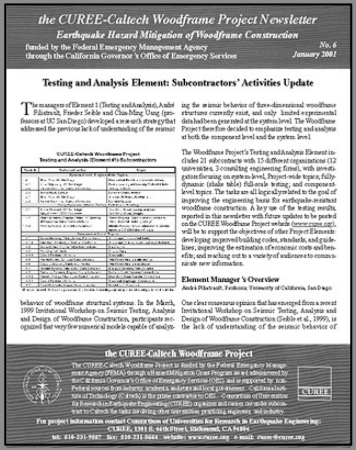
Element 4: Loss Estimation

- CUREE Report W-18: Improving Loss Estimation for Woodframe Buildings, Porter et. al.



Element 5: Education & Outreach

- Video Updates
- Newsletters
- Museum Displays
- Coordination of Media Information



the CUREE-Caltech Woodframe Project Newsletter

Earthquake Hazard Mitigation of Woodframe Construction

funded by the Federal Emergency Management Agency
through the California Governor's Office of Emergency Services

No. 6
January 2001

Testing and Analysis Element: Subcontractors' Activities Update

The managers of Element 1 (Testing and Analysis), André Filiatrault, Frieder Seible and Chia-Ming Uang (professors at UC San Diego) developed a research strategy that addressed the previous lack of understanding of the seismic behavior of woodframe structural systems. In the March, 1999 Invitational Workshop on Seismic Testing, Analysis and Design of Woodframe Construction, participants recognized that very few numerical models capable of analyzing the seismic behavior of three-dimensional woodframe structures currently exist, and only limited experimental data had been generated at the system level. The Woodframe Project therefore decided to emphasize testing and analysis at both the component level and the system level.

CUREE-Caltech Woodframe Project
Testing and Analysis (Element #1) Subcontractors

The Woodframe Project's Testing and Analysis Element includes 21 subcontracts with 15 different organizations (12 universities, 3 consulting engineering firms), with investigators focusing on system-level, Project-wide topics; fully-dynamic (shake table) full-scale testing; and component-level topics. The tasks are all logically related to the goal of improving the engineering basis for earthquake-resistant woodframe construction. A key use of the testing results, reported in this newsletter with future updates to be posted on the CUREE Woodframe Project website (www.curee.org), will be to support the objectives of other Project Elements: developing improved building codes, standards, and guidelines; improving the estimation of economic costs and benefits; and reaching out to a variety of audiences to communicate new information.

Element Manager's Overview

André Filiatrault, Professor, University of California, San Diego

One clear consensus opinion that has emerged from a recent Invitational Workshop on Seismic Testing, Analysis and Design of Woodframe Construction (Seible et al., 1999), is the lack of understanding of the seismic behavior of

the CUREE-Caltech Woodframe Project

The CUREE-Caltech Woodframe Project is funded by the Federal Emergency Management Agency (FEMA) through a Hazard Mitigation Grant Program award administered by the California Governor's Office of Emergency Services (OES) and is supported by non-Federal sources from industry, academia, and state and local government. California Institute of Technology (Caltech) is the prime contractor to OES. Consortium of Universities for Research in Earthquake Engineering (CUREE) organizes and carries out under subcontract to Caltech the tasks involving other universities, practicing engineers, and industry.

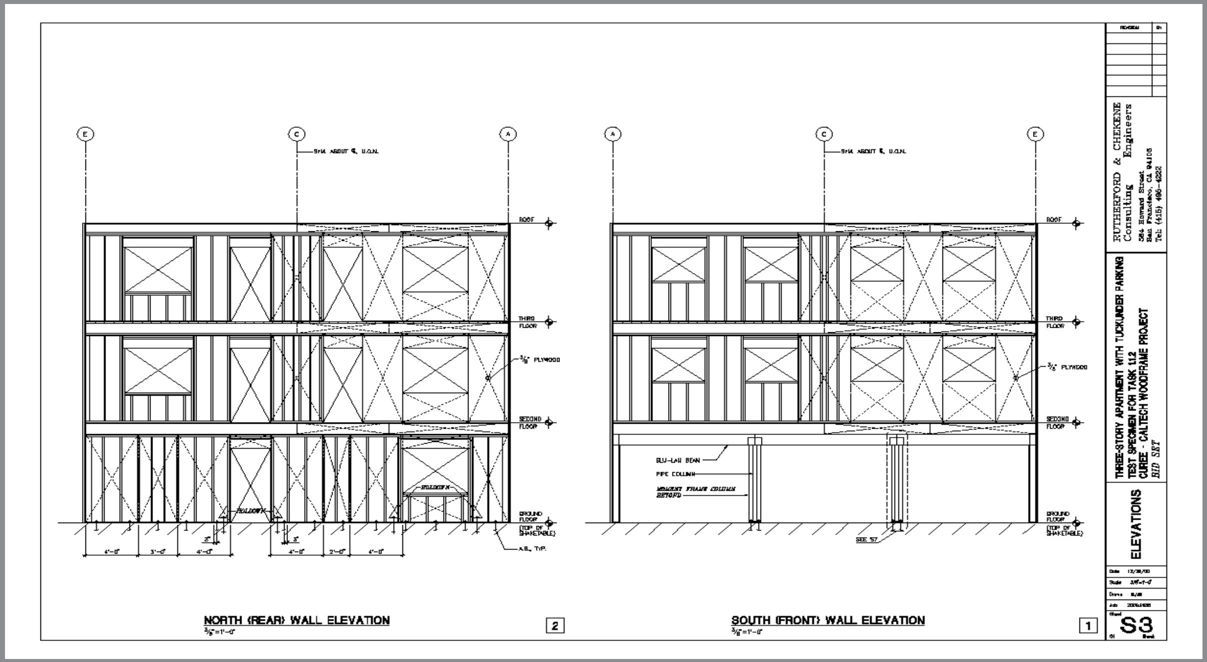
For project information contact Consortium of Universities for Research in Earthquake Engineering:
CUREE, 1301 S. 46th Street, Richmond, CA 94804
tel: 510-231-9557 fax: 510-231-5664 website: www.curee.org e-mail: curee@curee.org

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



K. M. Mosalam, C. Machado, K.-U. Gliniorz
C. Naito, E. Kunkel, and S. Mahin, *UC Berkeley*
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


CUREE Publication No. W24

Seismic Behavior of Base-Level Diaphragm Anchorage of Hillside Woodframe Buildings

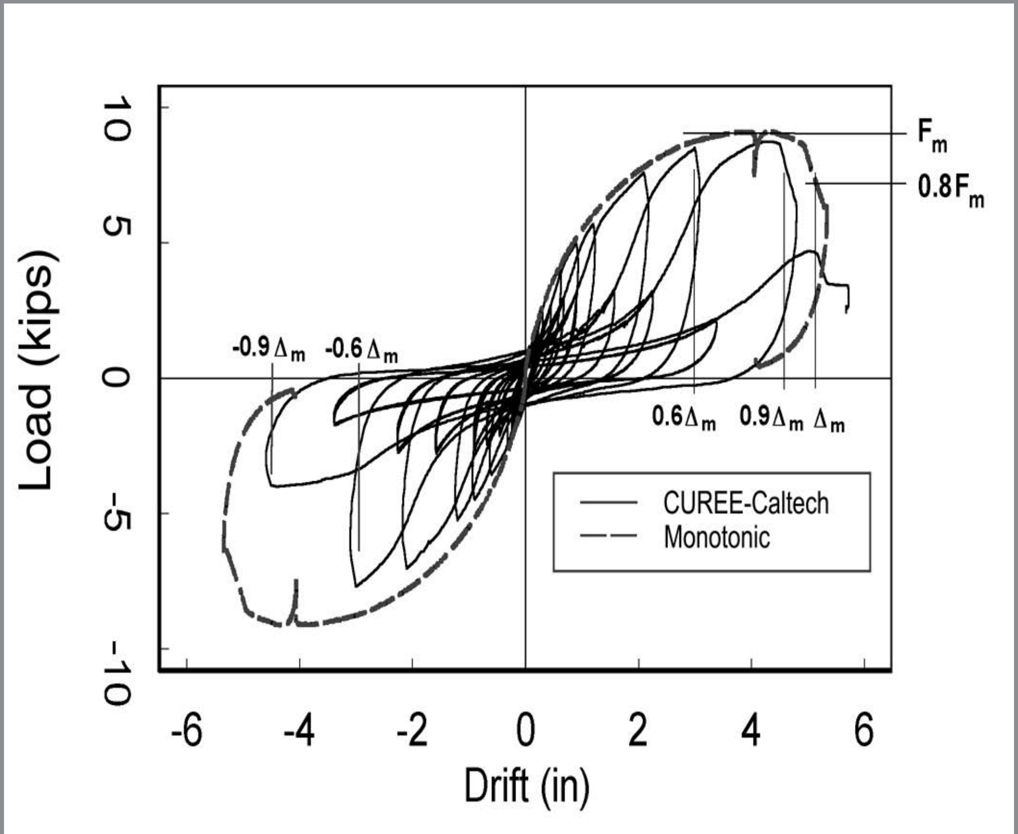
Yan Xiao
Li Xie

2003

the CUREE-Caltech Woodframe Project
Earthquake Hazard Mitigation of Woodframe Construction

R. Chai, T. Hutchinson, and S. Vukazich
UC Davis

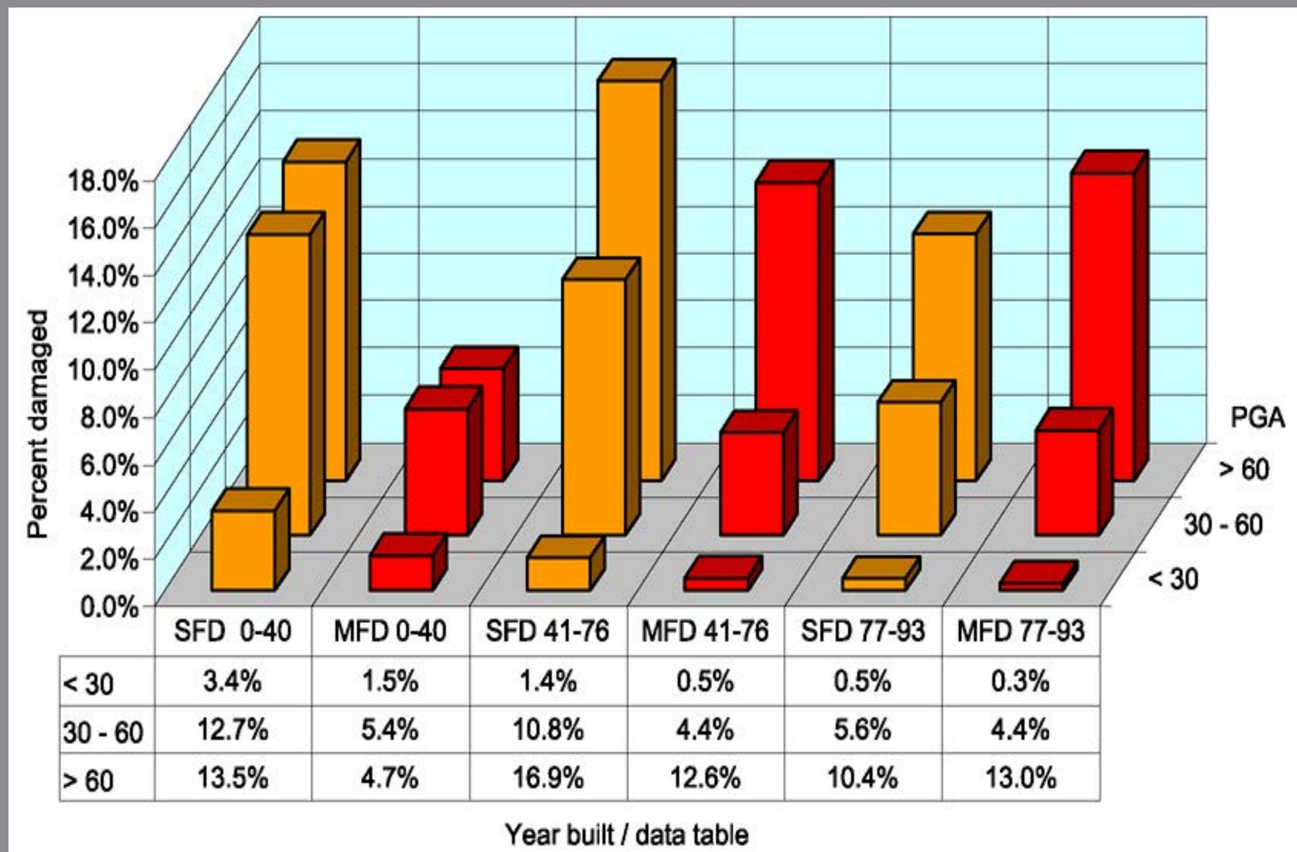
W-02: Development of a Testing Protocol for Woodframe Structures



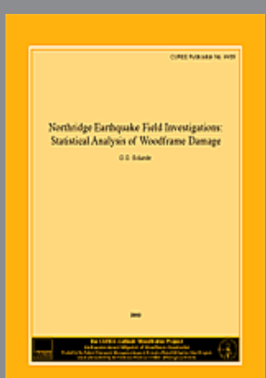
H. Krawinkler, F. Parisi, L. Ibara, A. Ayoub, and R. Medina

Stanford University

W-09: Northridge Earthquake Field Investigations: Statistical Analysis of Woodframe Damage



	SFD 0-40	MFD 0-40	SFD 41-76	MFD 41-76	SFD 77-93	MFD 77-93
< 30	3.4%	1.5%	1.4%	0.5%	0.5%	0.3%
30 - 60	12.7%	5.4%	10.8%	4.4%	5.6%	4.4%
> 60	13.5%	4.7%	16.9%	12.6%	10.4%	13.0%

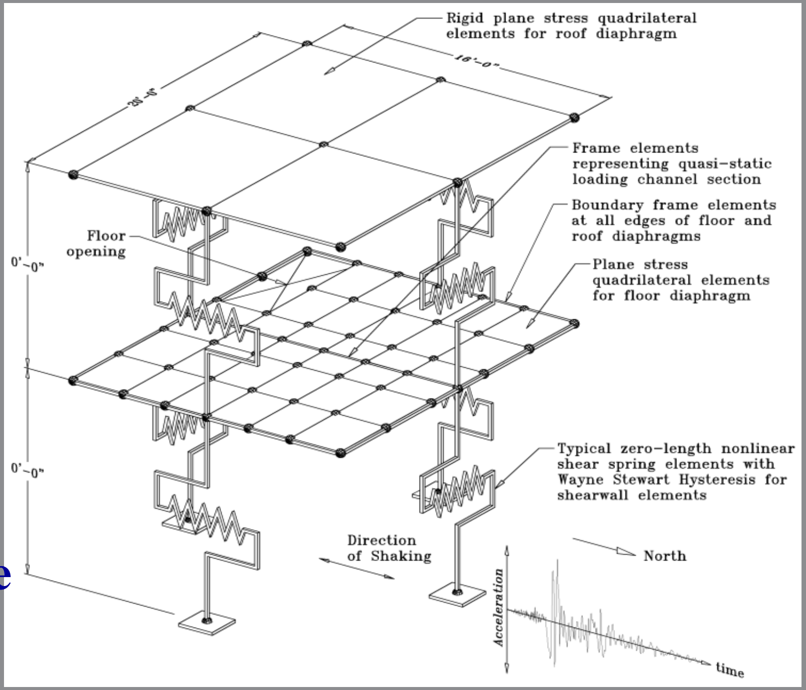


G. G. Schierle

University of Southern California

W-21: SAWS – Version 1.0 – A Computer Program for the Seismic Analysis of Woodframe Shearwalls

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

- CUREE-Caltech Woodframe Project Funding: Provided primarily by the Federal Emergency Management Agency (FEMA) under the Hazard Mitigation Program, Section 404 of the Robert T. Stafford Act (Public Law 93-288 as revised), through a California Governor's Office of Emergency Services (OES) Hazard Mitigation Grant award.

Questions, Comments?