Northridge Earthquake + 25 years

UCLA ENGINEERING
Civil and Environmental Engineering

Accomplishments + Challenges
Design + Retrofit of Buildings


Joseph Sohm / Shutterstock.com

John W. Wallace
University of California, Los Angeles

Contributions: SA Abdullah, A Safdari, K Kolozvari, TA Sabol

NSF aci American Concrete Institute Always advancing CHARLES PANKOW FOUNDATION Building Innovation through Research MAGNUSSON KLEMENCIC ASSOCIATES FOUNDATION UCLA Samueli School of Engineering

Observations
Accomplishments
Challenges

Observations (1) - Retrofit

- Column Shear Failure

Photo: Joseph Sohm / Shutterstock.com

- Joint Failure

Photo, J. Wallace, UCLA

3

Observations (1) – Retrofit/Repair

- Slab-column Punching shear

Photo: J. Wallace, UCLA

- Epoxy Injection

CSUN Oviatt Library, Special Collection

4

Observations (2) - Diaphragms

Photo: AP Photo: Reed Saxon (from The Atlantic)

5

Observations (3) – Gravity Systems

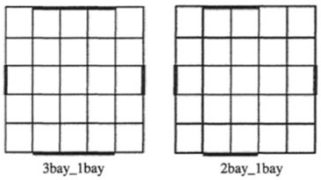
Photo: USGS.gov

Photo: Perry C. Riddle (see LA Times, March 10, 2015)

6

Observations (4): Other

- Redundancy



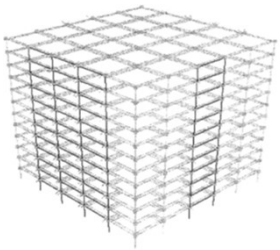
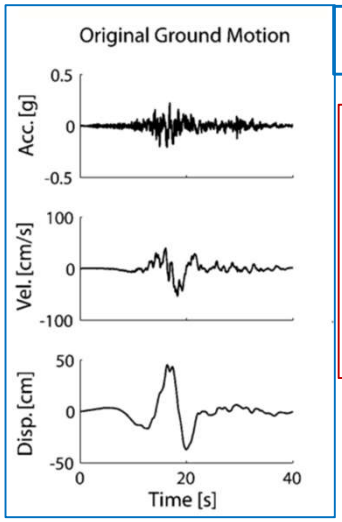
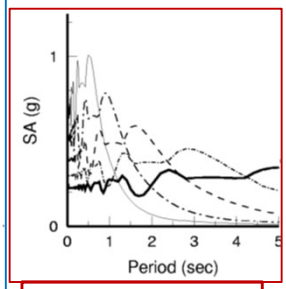


Figure: Liao& Wen, UIUC SRS 636, 2004

- Near fault ground motions



Landers 1992
From Baker (2007)



Somerville (2005)

7

Observations (6) – Wood Structures

- Tuck-under parking

Damage from the 1994 Northridge quake is shown. (Credit: Boris Yaro / Los Angeles Times).

- Wood houses

Photo: Joe Pugliese/Los Angeles Times via Getty Images

8

Observations (7) – Steel Structures

- Steel moment frames

Photo: NIST GCR 9-917-3

- Brittle fractures

Photo provided by: Jim Malley, Degenkolb

9

Observations (7) – Steel Structures

- Steel moment frames

Photos: Provided by Tom Sabol, UCLA

- Steel braced frames

9

Accomplishments

11

Accomplishments (1) - Retrofit

- Need for retrofit

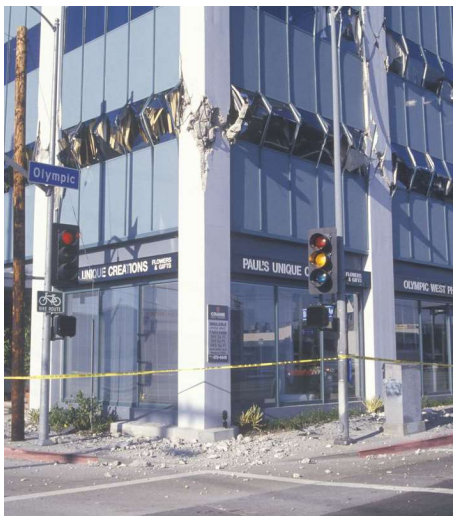
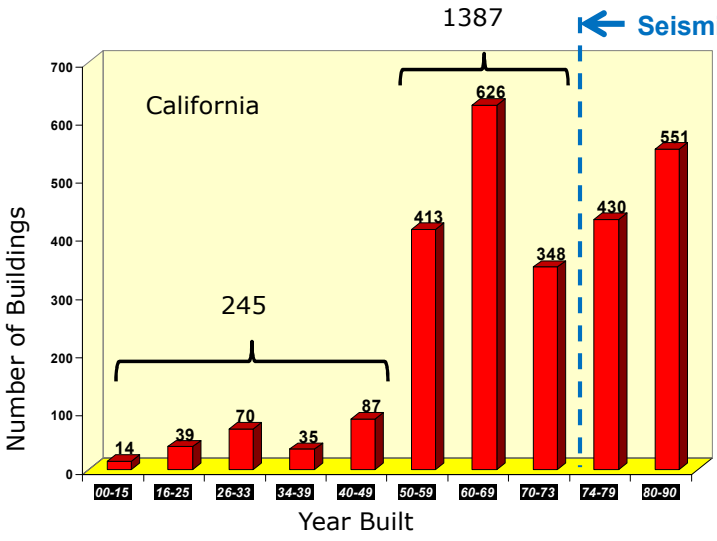


Photo: Joseph Sohm / Shutterstock.com

- Available tools
  - FEMA Guidelines
    - 273/274 Guidelines (1997)
    - FEMA 356 Pre-Standard (2000)
    - FEMA 351 Steel Moment Frames (2000)
  - PEER Research (1997-2007)
    - Columns/Joints/Analysis tools
    - Performance-based design
    - NEES Grand Challenge
  - ASCE 41-06/13/17
    - ACI Committee 369
  - ATC Projects
    - ATC 78 Ranking Approach (2017)
    - ATC 140 Updates (ongoing)

12

Accomplishments (2) – Hospitals



- SB 1953
  - FEMA 356/ASCE 41
  - Nonlinear Procedures
  - Laboratory Testing

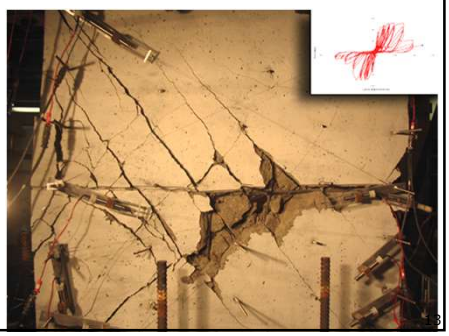


Photo: J. Wallace, UCLA

Accomplishments (3) - Retrofit

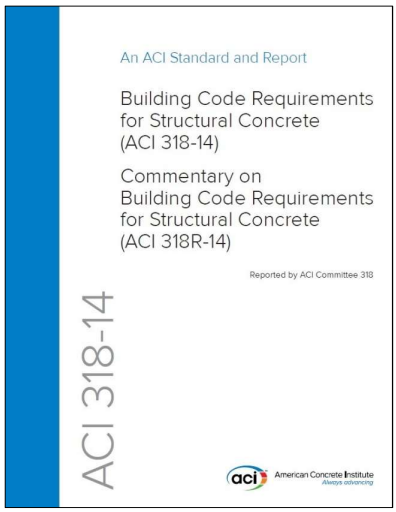
Accomplishments (3) – LA Ordinance

MILESTONE	REQUIREMENT
Begin Process	Order received by building owner
3 Years after Order	Submit one of the following: 1. Proof that the structures meets the ordinance requirements, or 2. Plans for retrofit, or 3. Plans for demolition
10 Years after Order	Obtain one of the following: 1. Permit for retrofit, or 2. Permit for Demolition
25 Years after Order	Complete one of the following: 1. Construction/retrofit, or 2. Demolition

15

Accomplishments (4) – New Design

- ACI 318-19

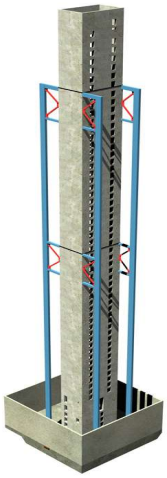


- 318-95 Chapter 21: 24 pages
  - Introduction (21.1 – 21.2; 4 pp)
  - Frames (21.3 – 21.5; 10 pp)
  - Walls and diaphragms (21.6; 5 pp)
  - Gravity Systems (21.7; 1+ pp)
  - Moderate seismic (21.8; 4 pp)
- 318-14 Chapter 18: 52 pages
  - Ordinary + Intermediate Moment frames
  - Special Moment Frames
  - Special walls, wall piers, coupling beams (pp 292 – 303)
  - Diaphragms (18.12; pp 304-310)
  - Foundations (18.13)
  - Gravity systems (18.14)

16

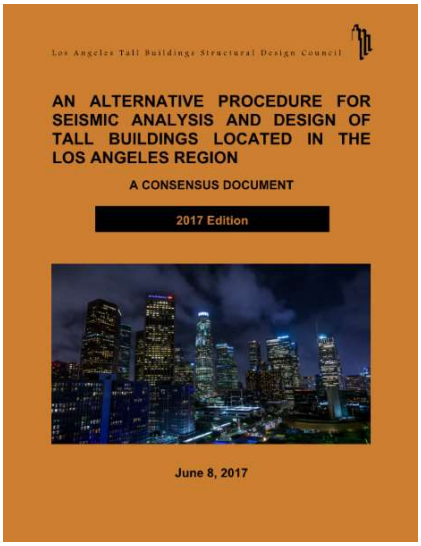
Accomplishments (5) – New Design

- Tall Buildings



Renderings: MKA, Seattle, WA

- LATBSDC + PEER TBI



17

Accomplishments (6): Collaboration

- Practice + Research

kpff UCLA

oshpd Office of Statewide Health Planning & Development

Photo: J. Wallace, UCLA

- International
  - Japan, New Zealand
  - China, Taiwan, Korea
  - Europe, etc
  - Modeling, databases testing…

Photo: J. Wallace, UCLA; Video: E-Defense, Miki, Japan

18

Accomplishments (7) – Steel Structures

- Steel moment frames
  - Improved detailing
  - Multiple beam-column connection choices
  - Stricter welding requirements for material toughness
  - Improved inspection requirements
- Steel braced frames
  - Capacity-based analytical and design requirements
  - Stricter member proportioning requirements
  - Alternative system choices (e.g., buckling-restrained braced frames)

Photo: NIST 09-917-3

Photo: Tom Sabol, UCLA

19

Challenges

20

Challenges (1): New + Existing Construction

- System level response

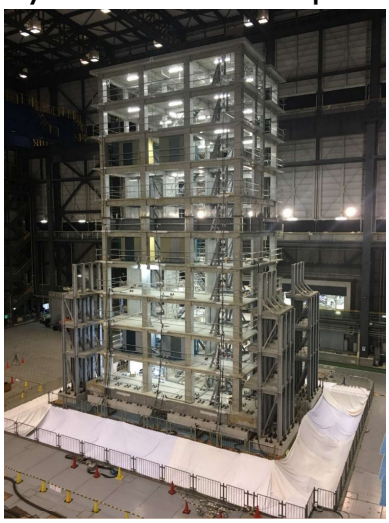


Photo: J. Wallace, UCLA

- Shake Table Tests
  - E-Defense, UCSD, other
- Challenges
  - Test cost
    - Large-scale, 3D, instrumentation
  - Damage level
    - Collapse level information
  - System complexity
    - Foundation, soil, non-structural
  - Data sharing
    - Time/effort
  - Funding Sources

21

Challenges (2): New + Existing Construction

- System level response

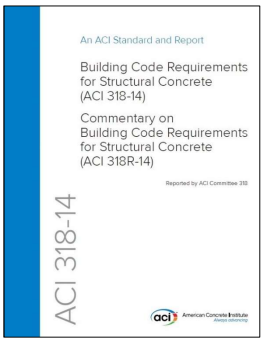
Photo: Hunter Kerhart, from NABE

- Instrumented Buildings
  - City of Los Angeles program
  - Other programs (e.g., CSMIP)
- Challenges
  - Data sharing
  - Triggered vs continuous data
  - Data sharing/access
  - Instrumentation density
    - 24 to 40 channels
  - Instrumentation diversity
    - Acceleration vs displacements
- Opportunities

22

Challenges (3): New + Existing Construction

- Performance Goals



- Design objectives
  - Limit damage (SLE)
  - Life-safety (DE)
  - Collapse prevention (MCE)
- Challenges (Societal impact)
  - Chile 2010 (0.3%)
  - New Zealand 2011 (185/115)
  - California 20XX
- Revise Goals
  - Target higher performance
  - Existing buildings
  - Communication

23

Challenges (4): Repair

- Moderate damage

Photo: J. Wallace, UCLA

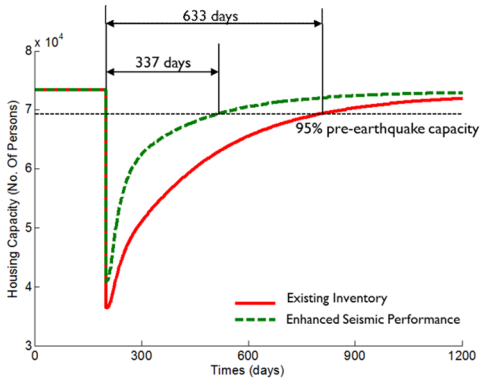
- Repair performance

CSUN Oviatt Library, Special Collection

24

Challenges (5): System Interactions/Resilience

- Resilience



Henry Burton, UCLA

- Resilience
  - Resilience by Design (2016)
  - Promote as an objective
  - Improve/measure resilience
- Problem Complexity
  - Single/multiple structure
  - Interactions
    - Transportation systems
    - Water, electricity, etc
- Collaboration
  - PEER, CA, US, International
- Funding

25

Outlook

Optimist/Pessimist/Realist

26