



CONCRETE BUILDINGS

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Seismic Risk and Rehabilitation of Older Concrete Buildings

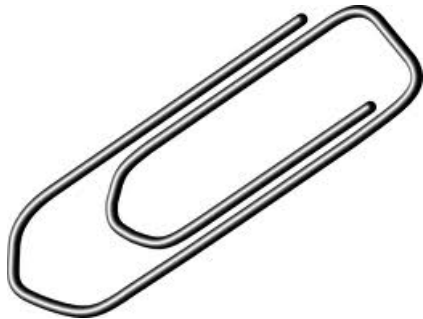
- Deficiency of concrete buildings
- Examples of building seismic performance
- How buildings are strengthened
- Recent developments and research
- Ordinances for compulsory seismic retrofit
- Recommendations for risk reduction

Effect of earthquake on buildings



First mode

Second mode



Bends (Ductile)



Breaks (Brittle)

Brittle columns



1971 San Fernando



1994 Northridge

Steel reinforcement ties (cage) make brittle concrete behave as ductile



Olive View Hospital, 1971 San Fernando

Deficiency: Brittle Columns



Barrington Building



Champaign Tower



Kaiser Permanente Building

Ductility of Reinforced Concrete



Exterior columns are ductile. Brittle interior elements caused collapse of CSUN parking structure in 1994

Deficiency: Weak Story



Olive View Hospital, 1971



Weak story (wood), 1994

Deficiency: Discontinuous Walls



Imperial County Services building, 1979



Discontinuous Walls

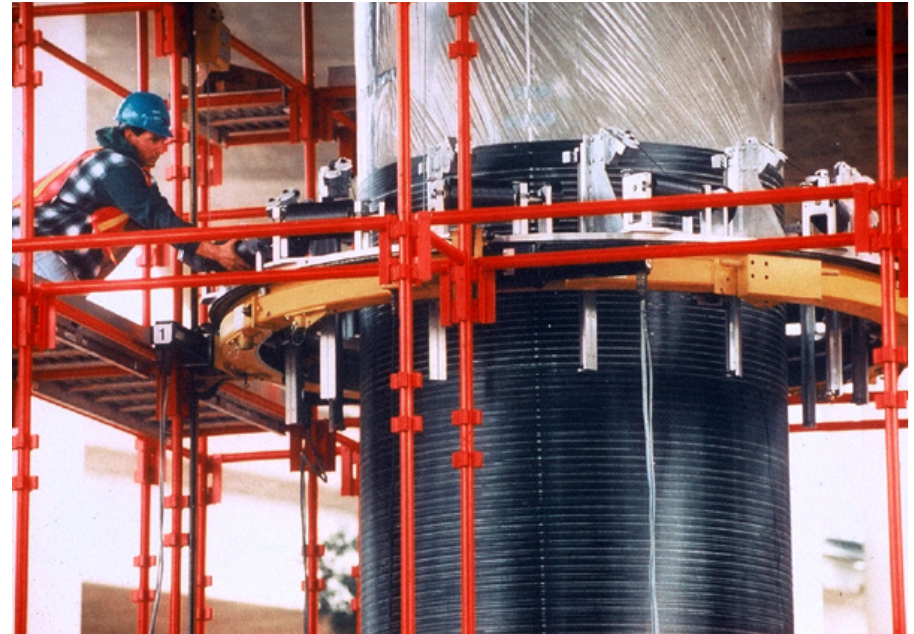


Olive View Hospital, 1971

Retrofit of brittle columns: Wrap Columns



Steel Wrap



Fiber Wrap

Retrofit of weak-story deficiency



Retrofit : Add Bracing or Concrete Walls



Development in the past 20 years

- Code changes for new buildings
- SB1953 for existing hospitals
- PEER (Pacific Earthquake Engineering Research Center)
- CUREE (Consortium of Univ. Research in EE)
- MCEER (Multidisciplinary Earthquake Engineering Research Center, Buffalo)
- ATC (Applied Technology Center)
- NEES Grand Challenge, Concrete Coalition
- LA inventory

Laboratory Tests



Development of Guidelines/Standards (FEMA and ASCE)

1970-1990 : **Linear** analysis (code method)

1990-2010 : **Non-linear** analysis
(performance based)

2010-Now : **Probabilistic** analysis

City Mandated Seismic Retrofits

Building Type	Deficiency Identified	LA City ordinance	Completed
Un-reinforced Masonry (URM)	1933 Long Beach	1980's	1990's
Tilt-up	1971 San Fernando	1990's	2000's
Wood, soft story	1971 San Fernando 1989 Loma Prieta 1994 Northridge	Currently Being Considered	-----
Concrete Buildings	1971 San Fernando 1994 Northridge Guam, Turkey, Taiwan, Kobe, etc.	None	-----

Recommendations for Risk Reduction

- Support efforts on development of seismic evaluation and retrofit standards
- Prepare ordinance for “incremental” retrofit
 - Limited retrofit in 10 years
 - Full Retrofit in 25 years
- Promote standardization of a “Building Rating System” (similar to LEED certification) for property transfer, insurance, and mortgage.
- Promote financial incentives for retrofit and eliminate requirement for ADA, etc. as part of a seismic retrofit program.

THANK YOU

