Seattle Fault Earthquake Scenario

Conference

February 28, 2005

Seattle Emergency Management

University of Washington

CREW

USGS science for a changing world

Structural Engineers Association Washington

ASCE Seattle Section Geotechnical Group

Earthquake Engineering Research Institute

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Buildings

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SEAW and MRP Engineering, LLC

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Agenda

- SEAW team
- Performance methodology
- Local building stock
- Building code history
- HAZUS damage estimates
- Vulnerable structure types and mitigation options
- Performance-based structural engineering
- Conclusions/Actions

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SEAW Buildings Team

Structural Engineer	Task	Organization
Greg Gilda, PE, SE	Residential Structures	DCI Engineers
John Headland, PE, SE	Tilt-up Structures	Shutler Consulting Engineers
Dr. Greg MacRae, PE	Industrial Facilities	University of Washington
Mark Moorleghen, PE, SE	Commercial Buildings	DCI Engineers
Mark Pierepiekarz, PE, SE	Task Leader	MRP Engineering
Joseph Shutler, PE, SE	Tilt-up Structures	Shutler Consulting Engineers
Peter Somers, PE, SE	Hi-rise Structures	Magnusson Klemencic Associates
Doug Wilson, PE	Building Code History	Reid Middleton
Michael Valley, PE, SE	Hi-rise Structures	Magnusson Klemencic Associates
Kylie Yamatsuka, PE, SE	Unreinforced Masonry	Reid Middleton
Tom Xia, PE, SE	Commercial Buildings	DCI Engineers

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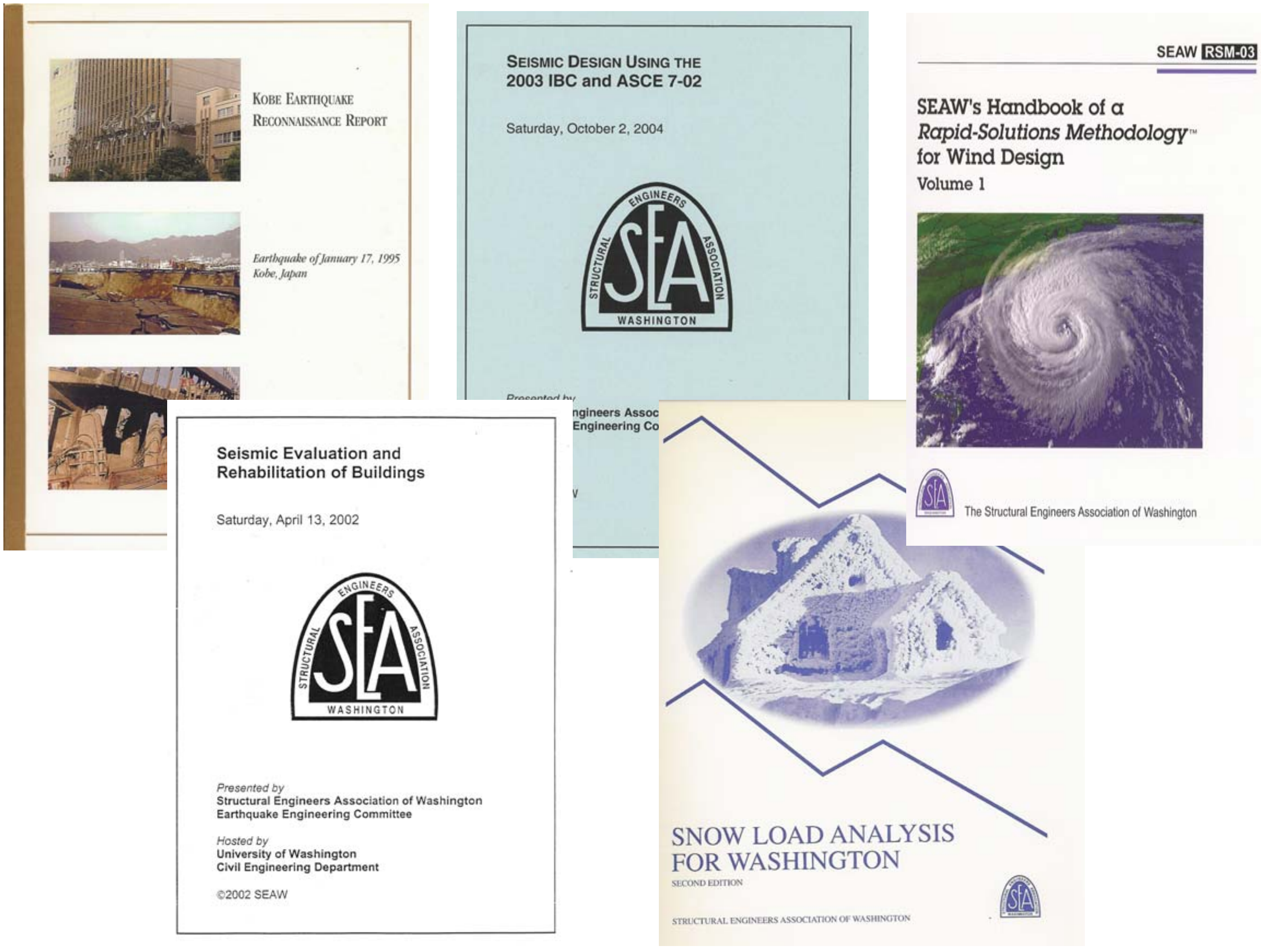
Who is Structural Engineers Association of Washington?



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Performance Methodology

- Scenario ground motions
- Building code history
- Local building stock and structural engineering practice
- Lessons learned in recent earthquake investigations
- HAZUS “regional” damage estimates
- Vulnerable structure types
- Resulting impacts and conclusions

M6.7 Scenario Ground Motions

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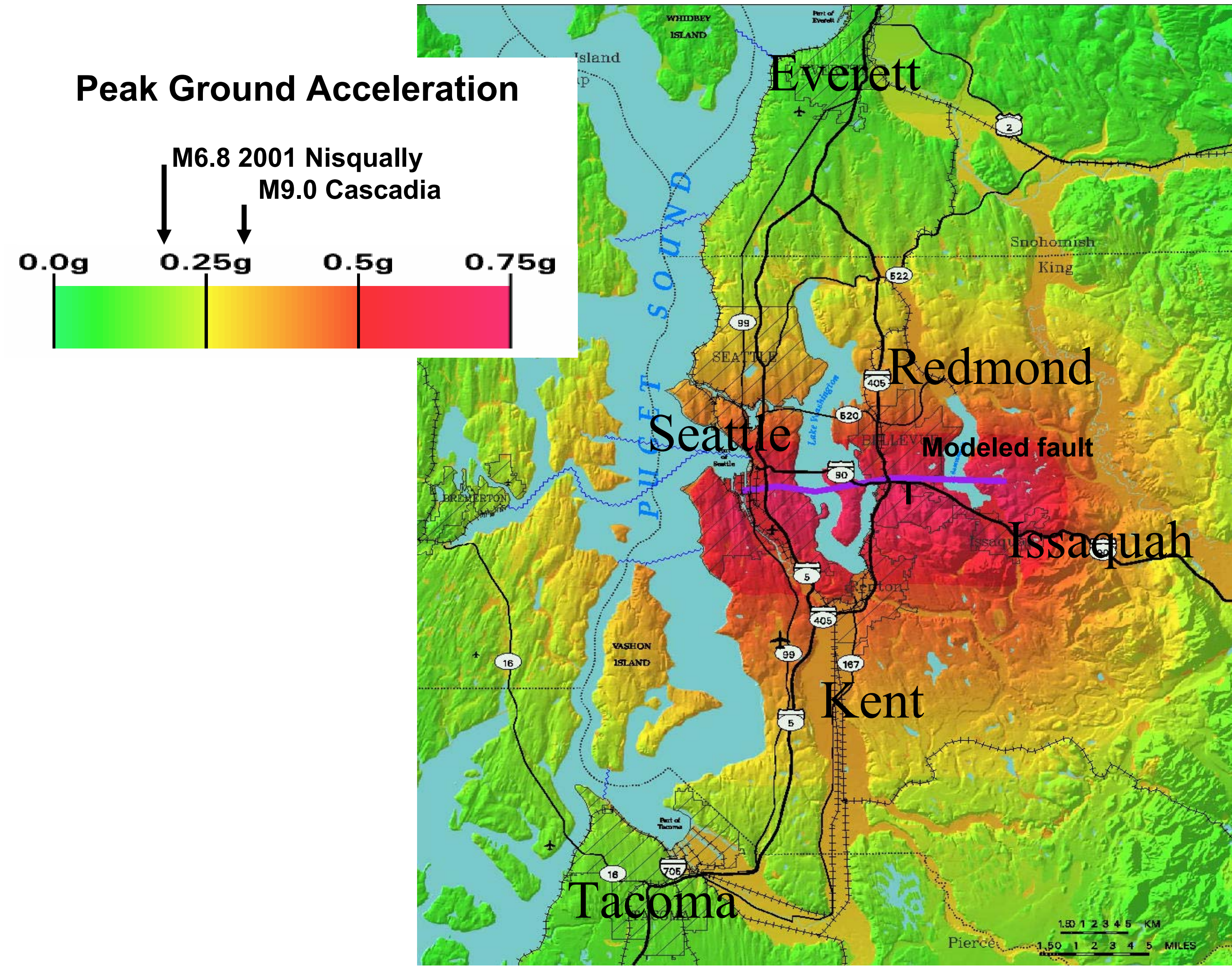

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Building Codes History

The intent of earthquake design provisions in building codes for <u>new</u> construction is safeguarding human life, not damage prevention.

Year	Building Code Development (for <u>new</u> construction)
1894	First building code published for Seattle
1946	Earthquake requirements added to Seattle building Code
1953	Earthquake design level increased in the Seattle following the 1949 Olympia earthquake
1955	State law mandates earthquake design for newly constructed hospitals, schools, assembly, and public buildings in Western Washington
1974	1973 Uniform Building Code made the minimum standard throughout the state
2004	The 2003 edition of the International Building Code adopted by the State Building Code Council

Most seismic retrofits are currently voluntary.
There is currently no requirement for seismic retrofit of <u>existing</u> vulnerable buildings, unless significant renovation is proposed.




Local Building Stock

Local Building Stock

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E.Q. Performance Factors

- Type of system (tilt-up, pre-cast, shear wall)
- Primary material (steel, concrete, wood)
- Year designed/built (year and code)
- Type of soil (soft soil vs. rock)
- Layout
  - Geometry (Rectangular, L-shaped)
  - Openings above grade (windows/garages)
- Quality of design and construction

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Scenario Damage Estimates

- Very strong ground motions near the fault
- 4,000 (27%) commercial structures with significant damage:
  - Unreinforced masonry (URM's)
  - Reinforced concrete Tilt-ups
  - Pre 1970-vintage reinforced concrete frame buildings
- Significant damage to structures founded on poorly consolidated soils
- 46,000+ households displaced
- Long-term impact on industry and economy

HAZUS Damage Projections




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Building Type	Damage Level		
	Moderate	Extensive	Complete
Commercial	3,352	2,245	1,275
Industrial	361	232	121
Multi-Family	20,281	8,290	2,538
Single Family	130,312	18,488	5,699




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Unreinforced Masonry (URM's)

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Retrofitted URM Building

Pre-1970 Tilt-Up Concrete

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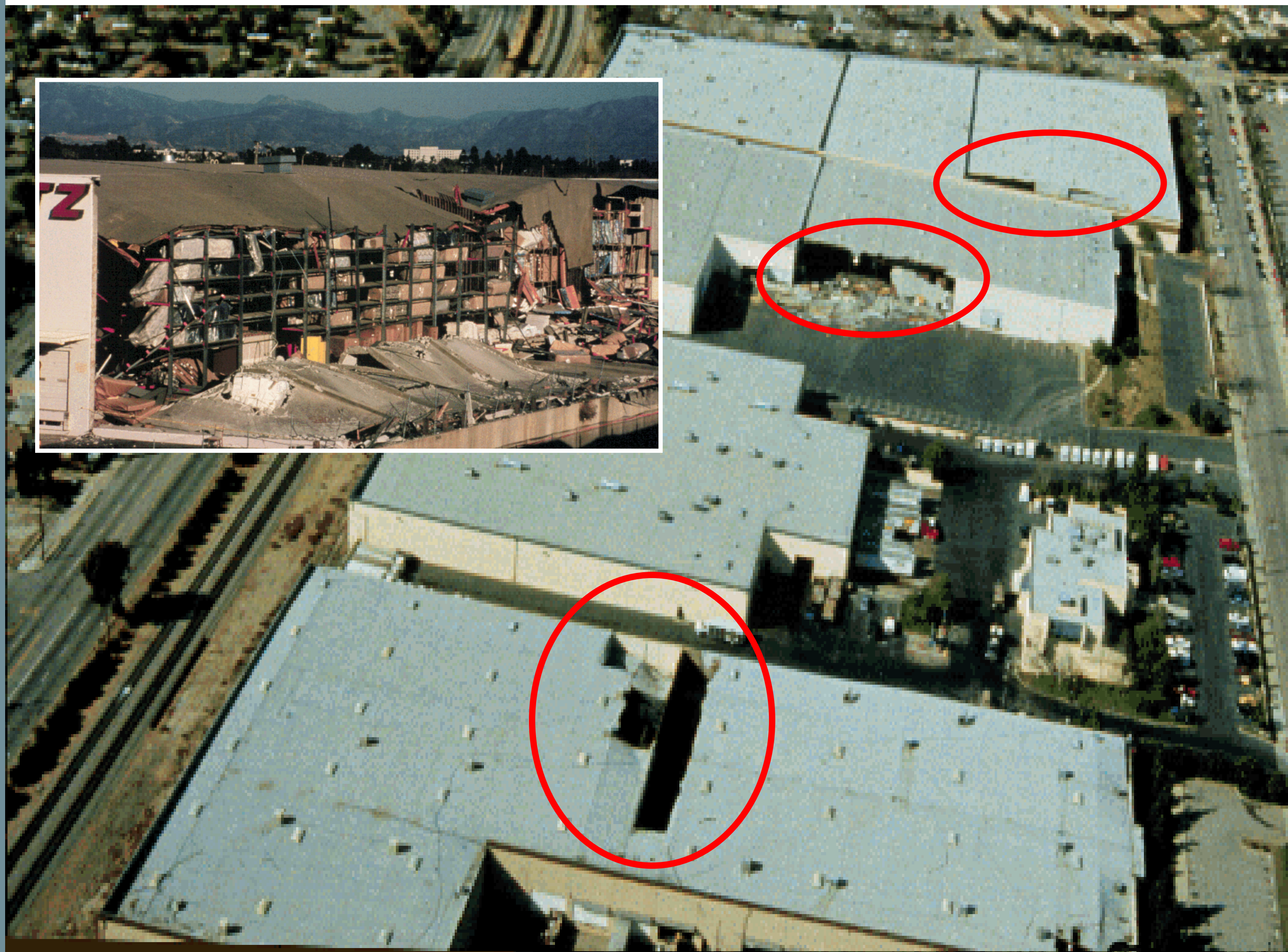

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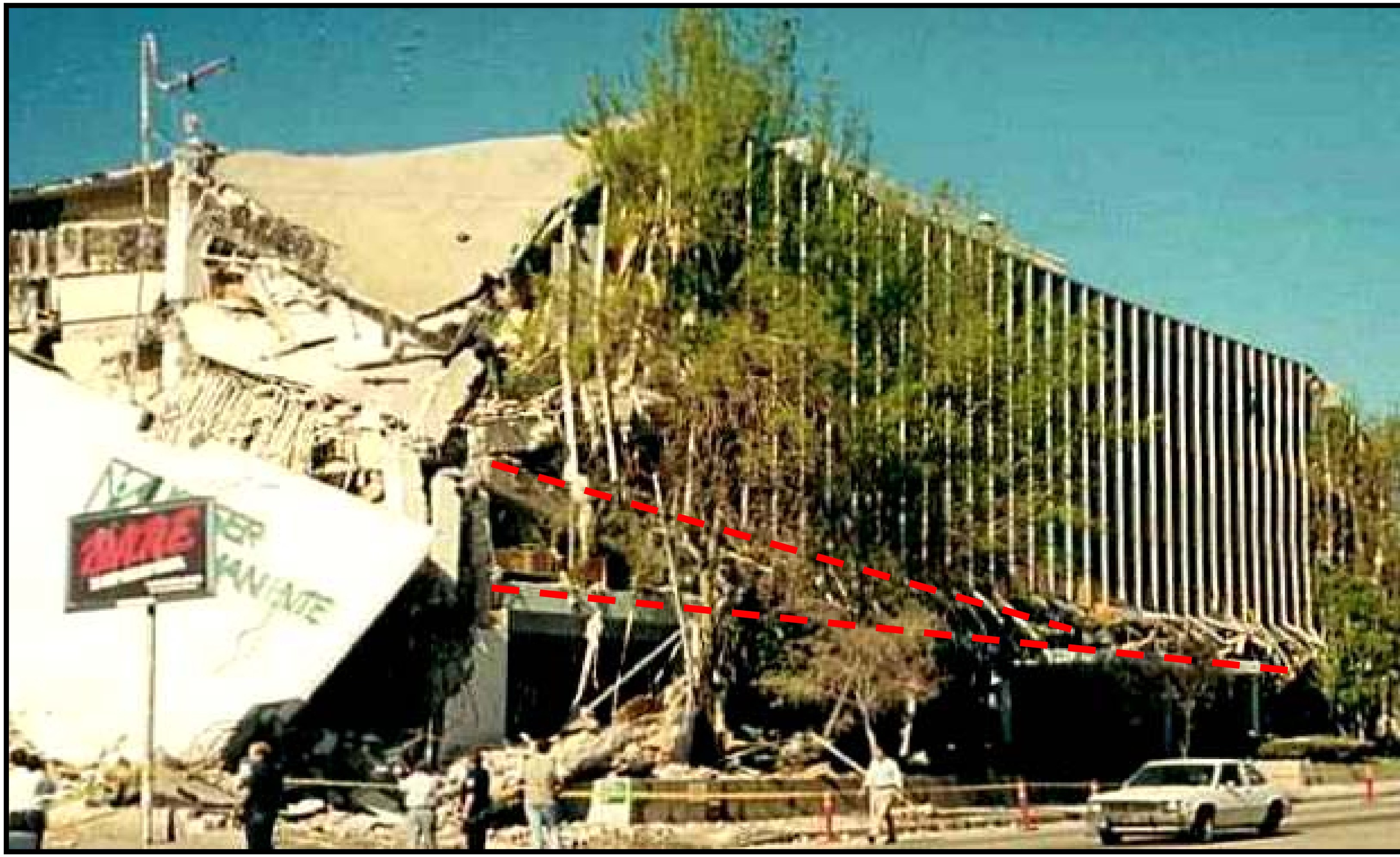
Pre-1970 R/C Concrete Frames



The collapse occurred in an unoccupied building at about 5 AM.
At noon this medical office building would have been full of people.

Nonstructural Bracing

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HAZUS Projections: Household Loss of Occupancy

% of Displaced Households	Time to Reoccupy
50% to 60%	2 Weeks
25% to 35%	Less than 3 months
15%	More then 6 months

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Residential Structures




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Industrial Facilities




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Industrial Facilities Performance

- In addition to strong ground shaking, soil settlement and liquefaction would result in damage to structures, machinery, and buried utilities.
- Significant impacts to storage racks, tanks, piping, conveyors, and inventory.
- Potential for hazardous chemical release.
- Long-term impact on local economy since functioning industry will be required in rebuilding efforts.

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New Trends: Performance-Based Earthquake Engineering

HAZUS Damage State	Performance Level	Expected Post-Earthquake Damage State
None to Slight	Operational	Very little damage. Backup utility services maintain function.
Slight to Moderate	Immediate occupancy	Minor repairs. The building is safe to occupy.
Moderate to Extensive	Life Safety	Structure remains stable. Hazardous non-structural damage is controlled.
Extensive to Complete	Collapse Prevention	The building remains standing, but only barely.




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Conclusions

- Scenario ground motions would be significantly greater than in recent local earthquakes.
- Modern structures would survive with varying degrees of damage.
- Many older existing structures would experience significant damage with some collapses.
- Building owners should assess potential risks and make practical improvements.

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