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Effect of Modeling Parameters on Collapse Behavior of RC Building

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16th U.S.-Japan-New Zealand Workshop on the Improvement of Structural Engineering and Resiliency
Nara, Japan, 27-29 June 2016

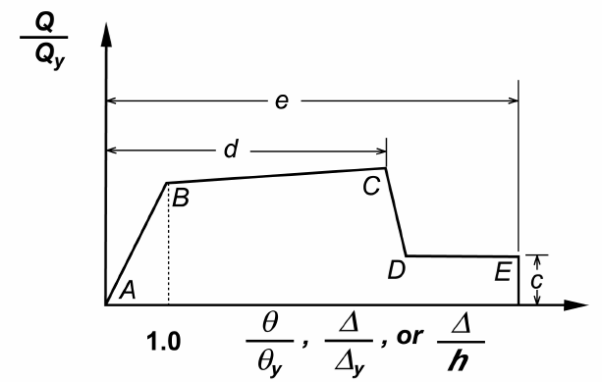
Rehabilitation Objective

Earthquake Hazard Level		Operational Performance Level (1-A)	Immediate Occupancy Performance Level (1-B)	Life Safety Performance Level (3-C)	Collapse Prevention Performance Level (5-E)
		Target Building Performance Levels			
	50%/50 year 72 yrs	a	b	c	d
	20%/50 year 225 yrs	e	f	g	h
	BSE-1 474 yrs (~10%/50 year)	i	j	k	l
	BSE-2 2475 yrs (~2%/50 year)	m	n	o	p

Maximum **C**onsidered **E**arthquake

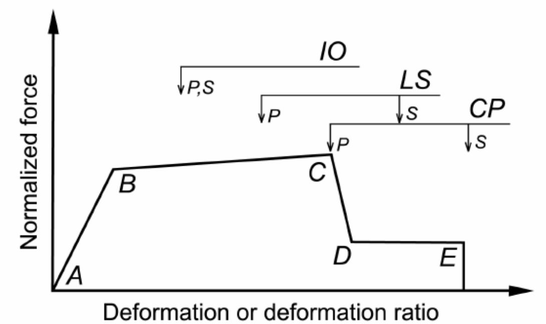
ASCE-41 Standard

Modeling Parameters



(b) Deformation ratio

Acceptance Criteria



(c) Component or element deformation acceptance criteria

FEMA P695 Methodology

Equivalent safety against collapse for buildings with different seismic force resisting systems

Collapse Safety Margin → Design Criteria for Building Codes (i.e. R, C_d, and Ω_0 seismic performance factors)

Median Collapse: One-half of the structures have some form of collapse

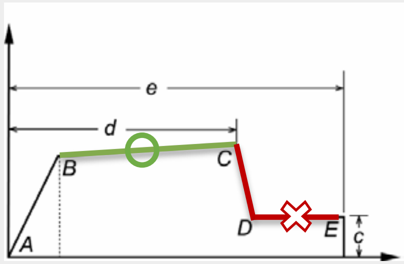
Local Instability

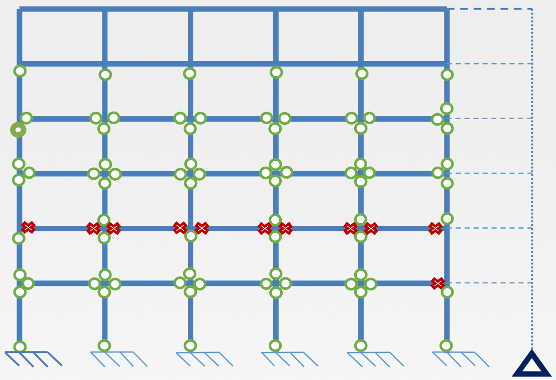
Global Instability

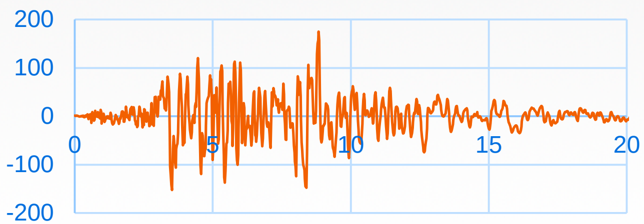
$$\text{Collapse Margin Ratio, } CMR = \frac{SA \text{ Median collapse-level ground motions}}{SA \text{ of } MCE \text{ ground motions}}$$

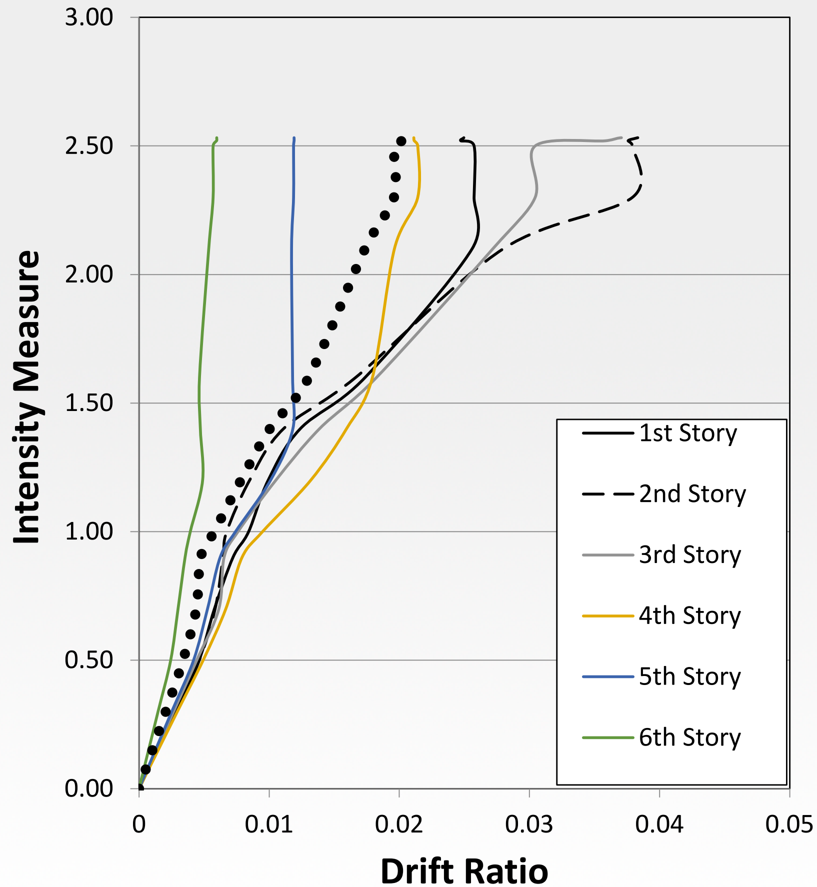
NEHRP: Structure should have a low probability of collapse for *MCE* (1.5 times the design level earthquake)

CMR is established through Incremental Dynamic Analysis



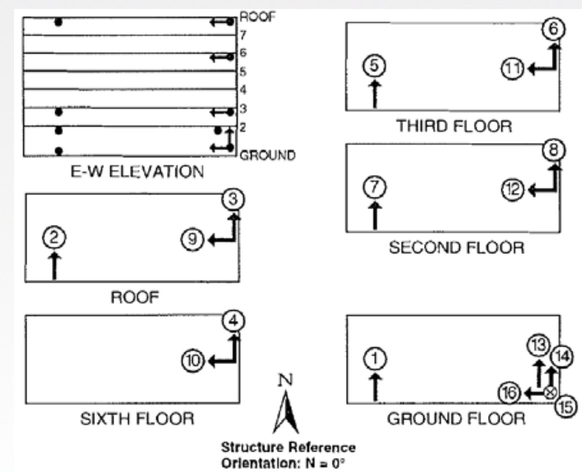


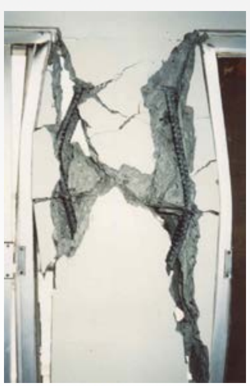




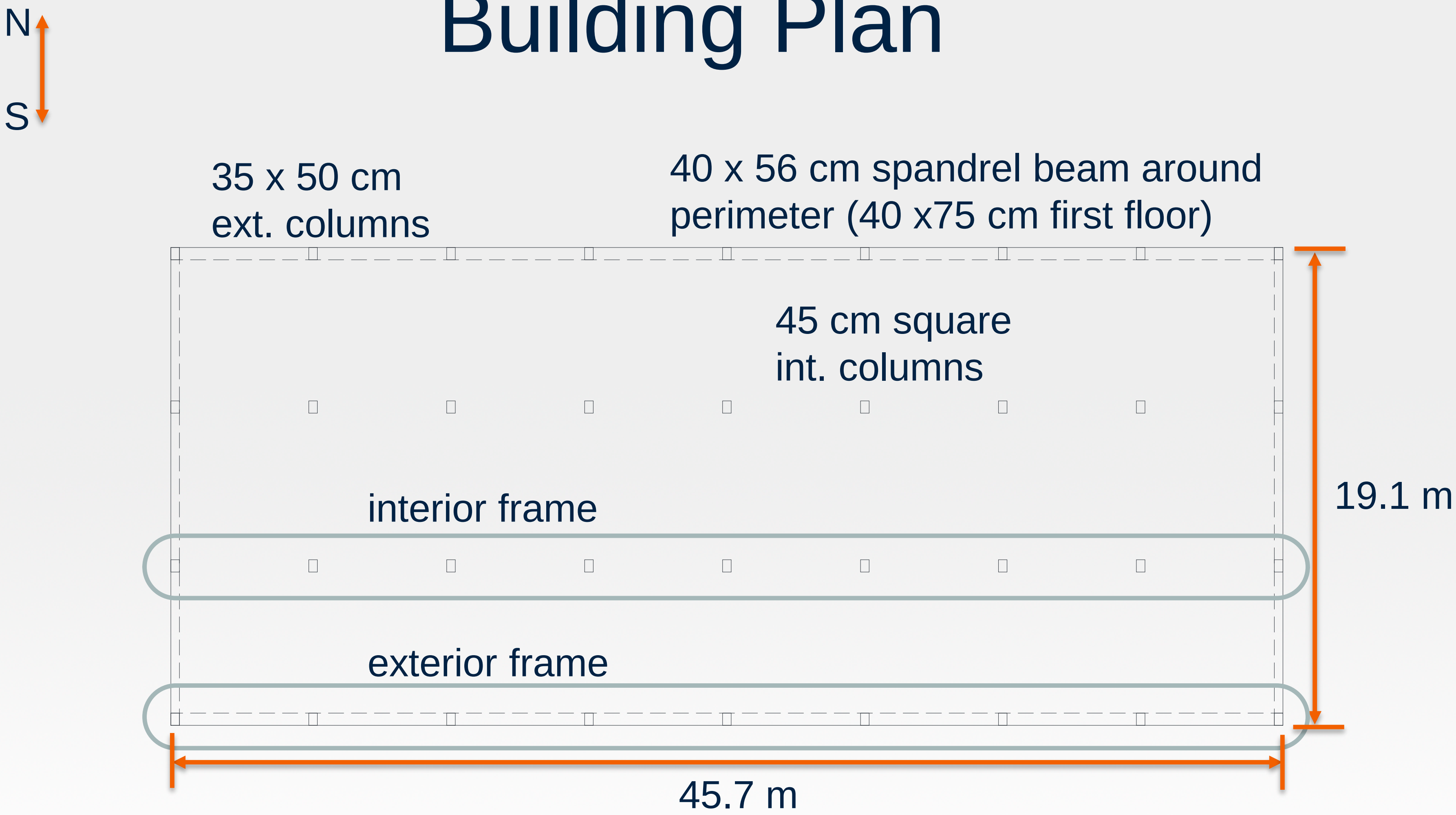
Building Description

- Seven-story RC Building in Van Nuys, CA
- Designed in 1965 and constructed in 1966
- Exterior moment-resisting frames
- Interior gravity load flat slab system
- Strong motion records from:
  - 1971 San Fernando
  - 1987 Whittier
  - 1990 Upland
  - 1992 Sierra Madre
  - 1994 Northridge
- Light structural damage during the 1971 San Fernando Earthquake, severe column damage during the 1995 Northridge earthquake.

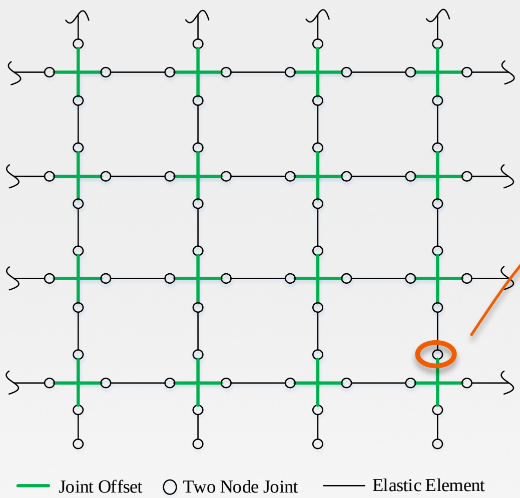


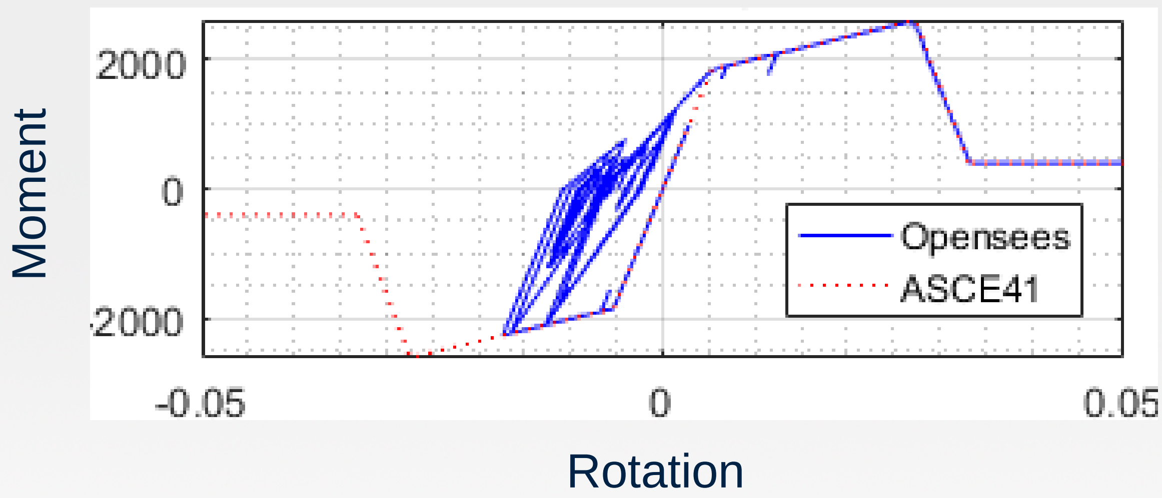


Building Plan



Lumped Plasticity Model for Frame Structure



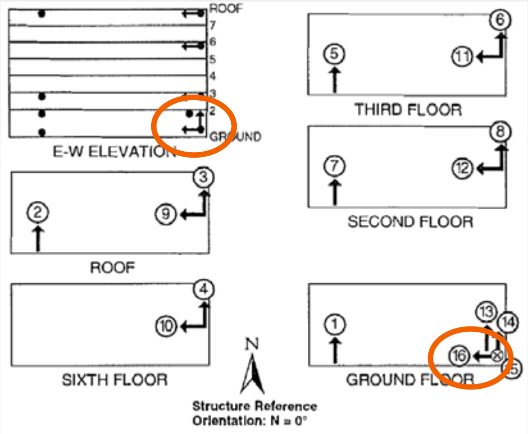


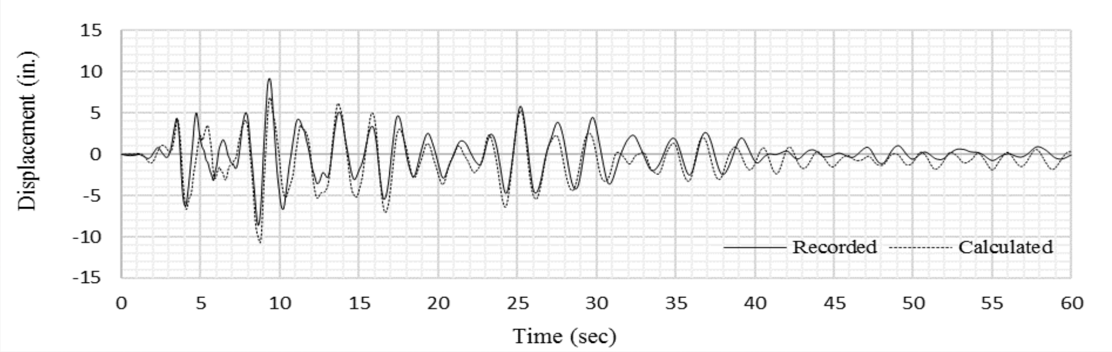
Moment rotation relationship for nonlinear rotational spring of second story column of RC Building

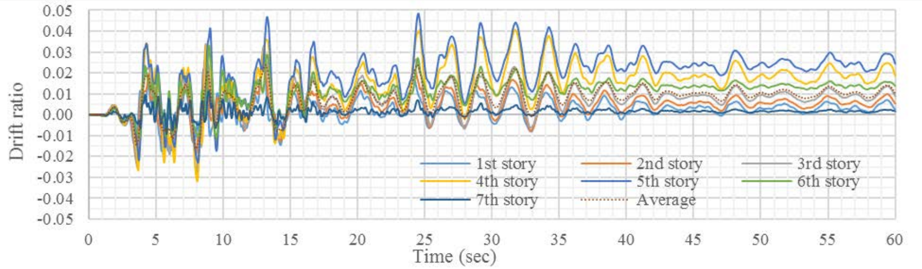
Evaluation Ground Motion

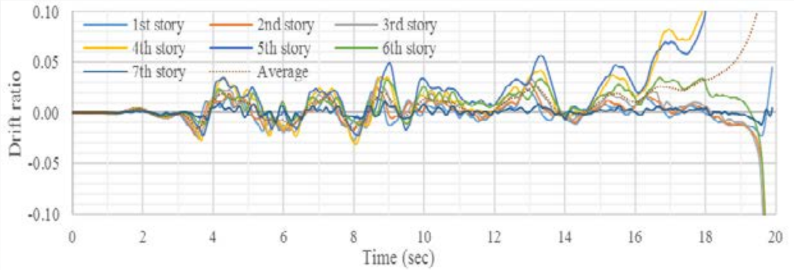
- 1994 Northridge record SE Corner E-W
- PGA 0.45 g

IM 1.0





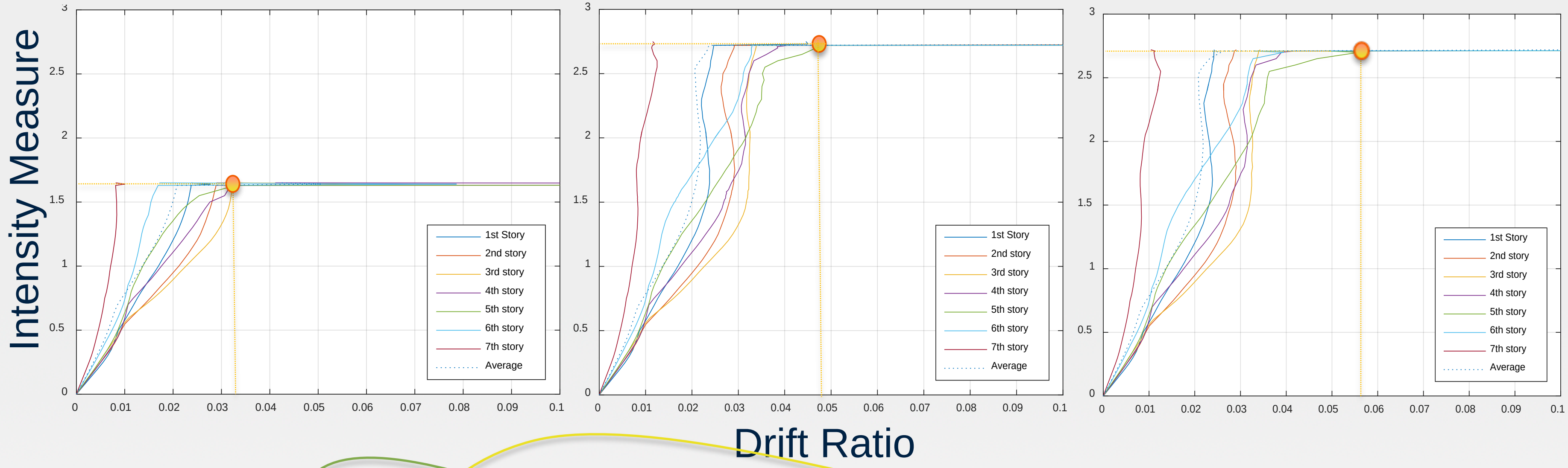


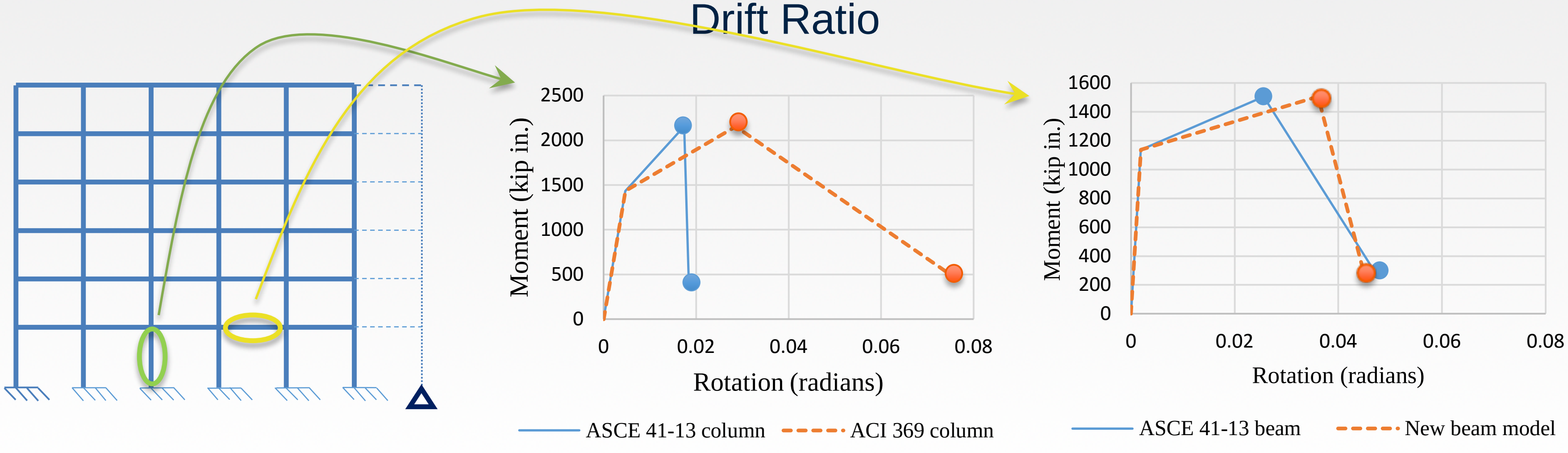


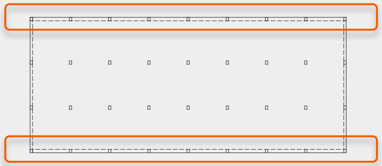
IM 2.72

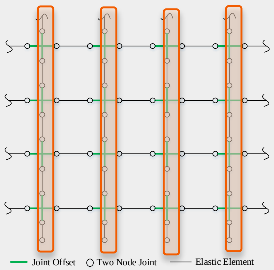
IM 2.73

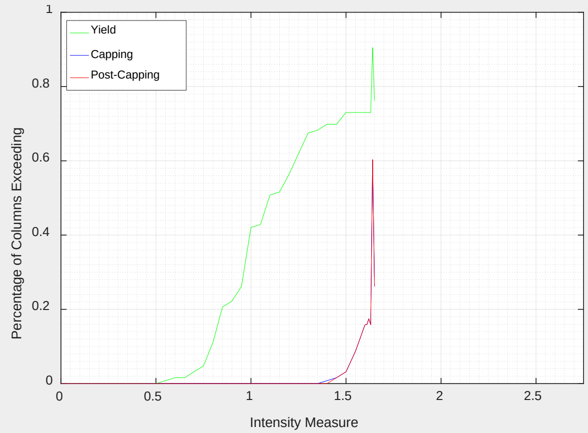
Collapse Simulation Results EW Direction

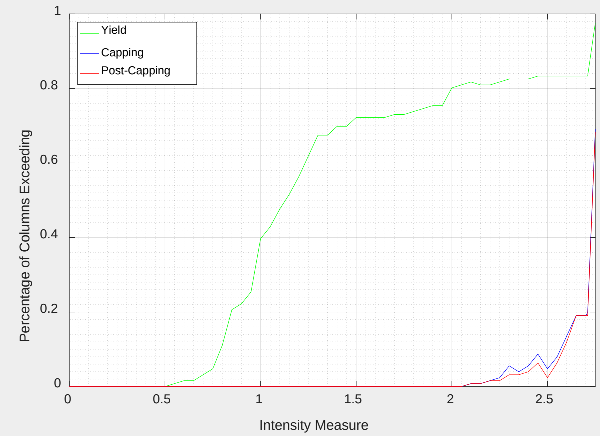


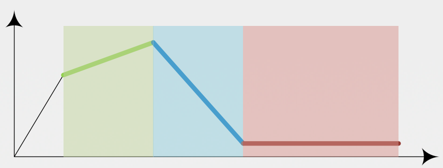


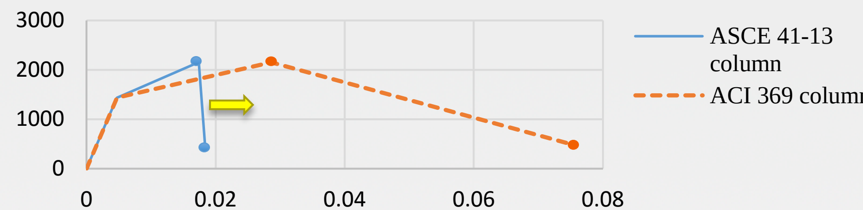


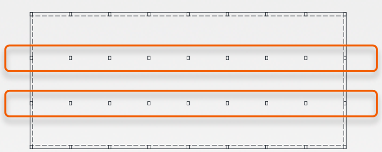


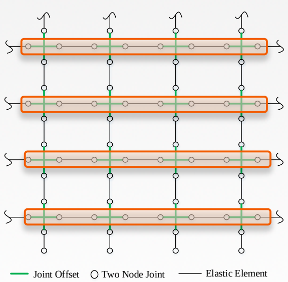


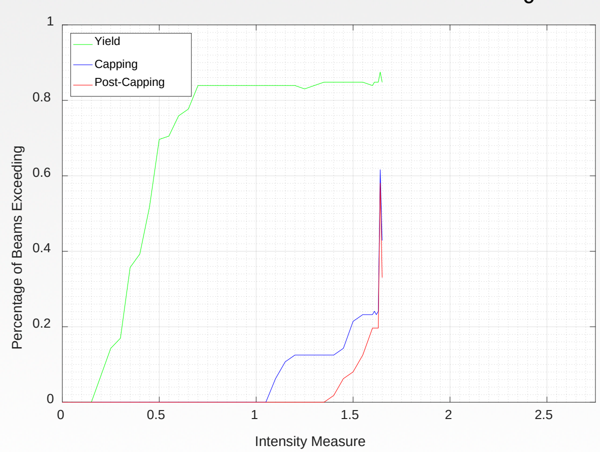


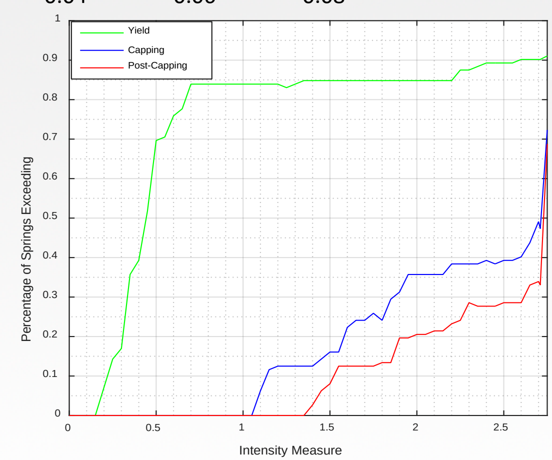












ASCE 41-13

ACI 369

Conclusions

- Changes in modeling parameters for beams and columns affected the distribution of damage of the case-study building.
- The intensity measure corresponding to lateral instability for the model with ASCE 41-13 modeling parameters was 1.63 (0.77 g), whereas the maximum intensity measure for the model with ACI 369 modeling parameters was 2.71 (1.27 g).
- The effect of beam modeling parameters on the intensity measure corresponding to lateral instability was not significant for the case-study building, although the maximum story drift ratios before lateral instability did increase by approximately 1%.
- While the intensity corresponding to lateral instability increased significantly by adopting modeling parameters representative of the mean response of component tests, the level of damage expected to occur in gravity-load frames increased significantly as well.