

Hospital Seismic Rehabilitation Industry – University Partnerships

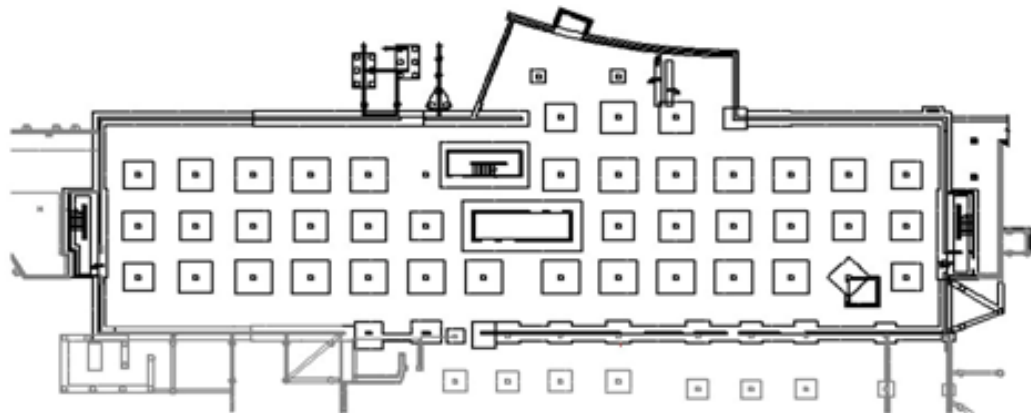
John Gavan, KPFF and John Wallace, UCLA



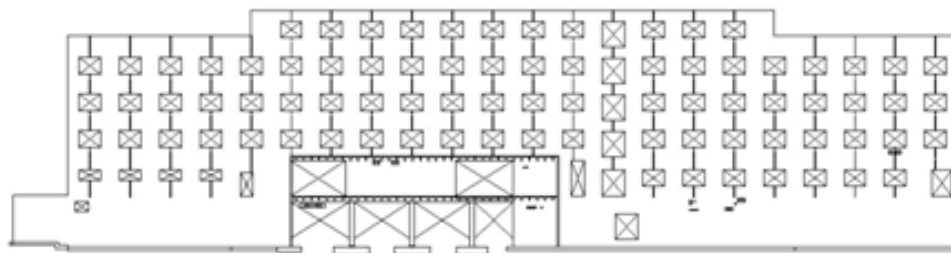
January 16-17, 2014 - University of California, Los Angeles

Project Background

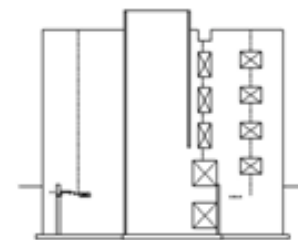
- Perimeter, perforated walls (1962)
 - St Joseph's Health System, Orange CA



Foundation Plan



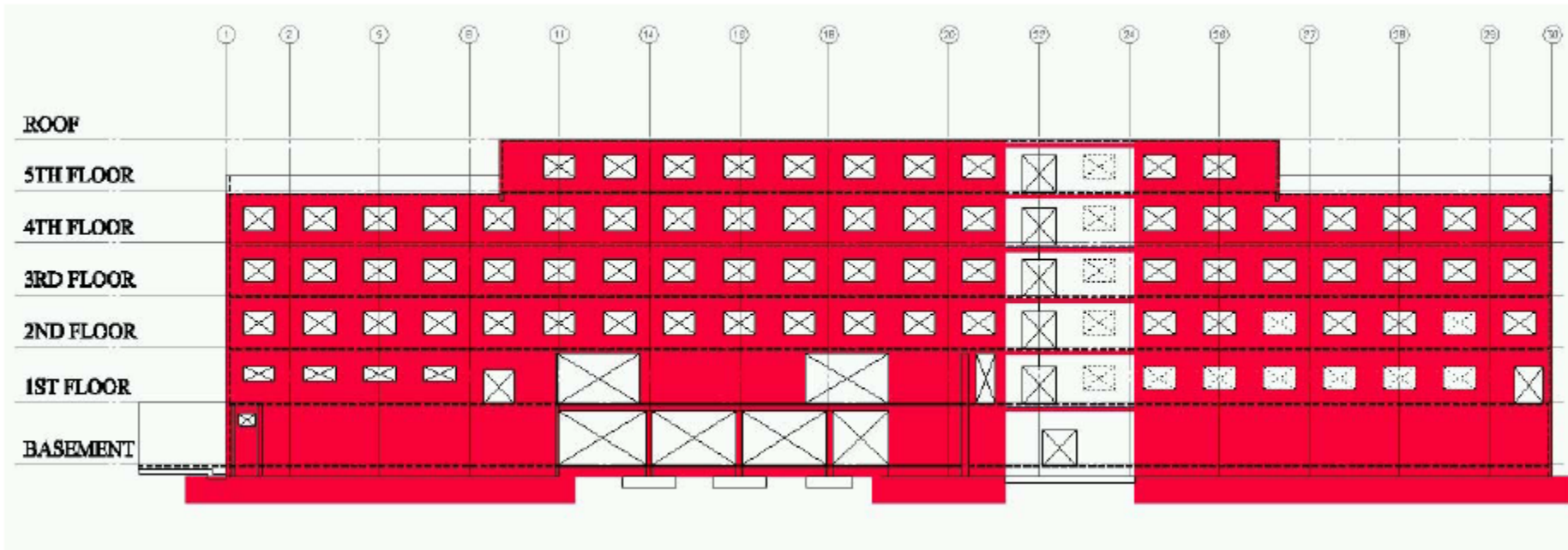
Long Wall



End Wall

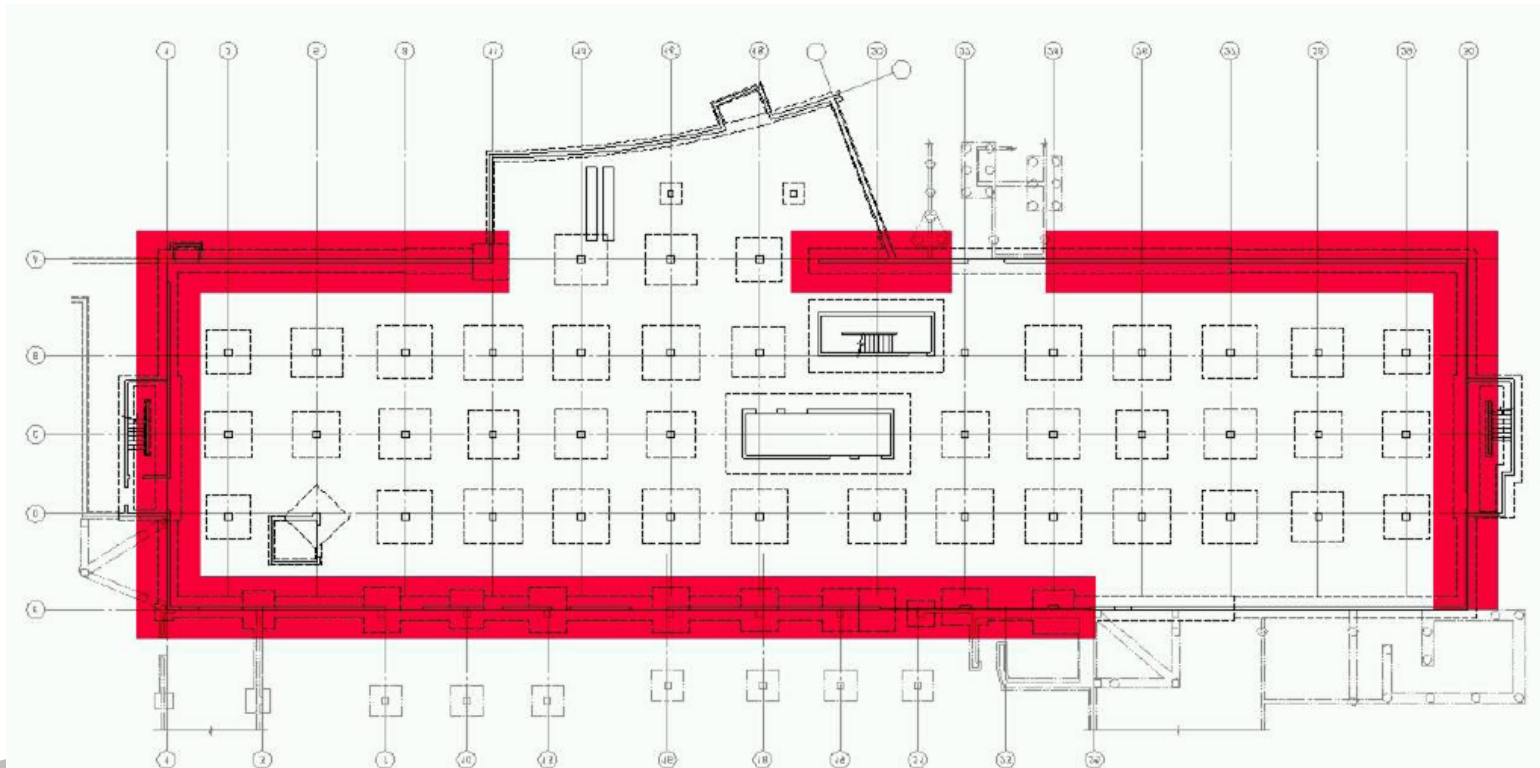
Project Background

- FEMA 356 – Linear Static Procedure
 - New perimeter walls



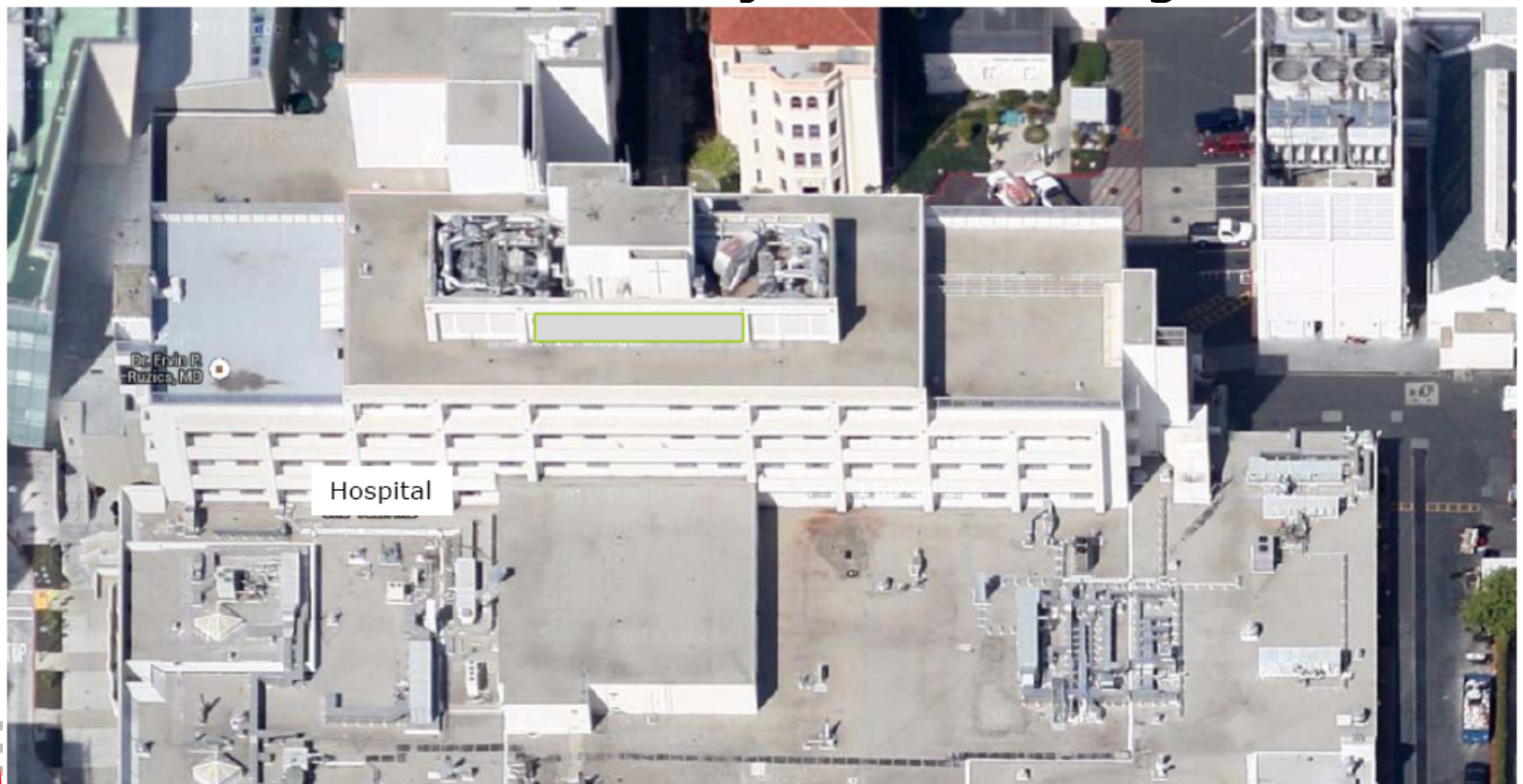
Project Background

- FEMA 356 – Linear Static Procedure
 - New Foundations



Project Background

- FEMA 356 – Linear Static Procedure
 - Need to “cut-back” adjacent buildings



Project Background

- St John's Hospital – Santa Monica
 - Observations from Northridge Earthquake



Project Inception – MTB Ride

Practice – University Collaboration: The value of getting to know your peers



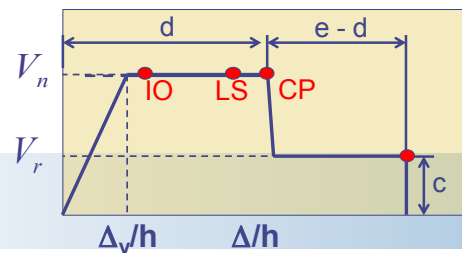
Project Overview

- FEMA 356 – Linear Procedures
 - Costly, disruptive, and overkill
- FEMA 356 – Nonlinear Static Procedure
 - Six-story, stiff building, no torsional issues
 - Backbone relations – Do they apply to this building

Table 6-19 Modeling Parameters and Numerical Acceptance Criteria for Nonlinear Procedures—Members Controlled by Shear

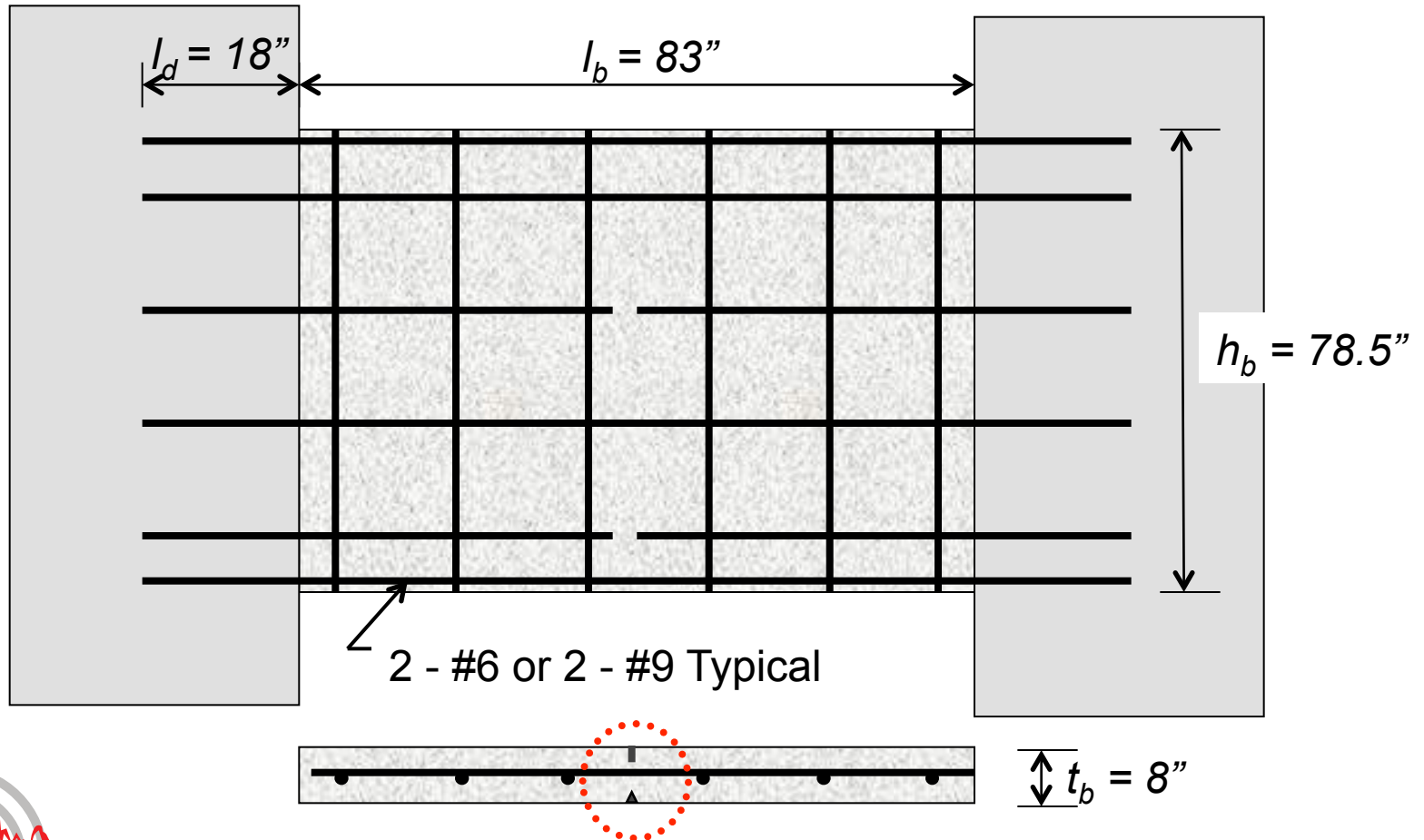
Conditions	Total Drift Ratio (%) or Chord Rotation (radians) ¹		Residual Strength Ratio	Acceptable Total Drift (%) or Chord Rotation (radians) ¹				
				Performance Level				
	d	e	c	IO	Component Type			
					Primary		Secondary	
				LS	CP	LS	CP	
i. Shear walls and wall segments								
All shear walls and wall segments ²	0.75	2.0	0.40	0.40	0.60	0.75	0.75	1.5

One Row



Wall Spandrel Reinforcing Details

- Typical Spandrel: Cut bars, weakened plane

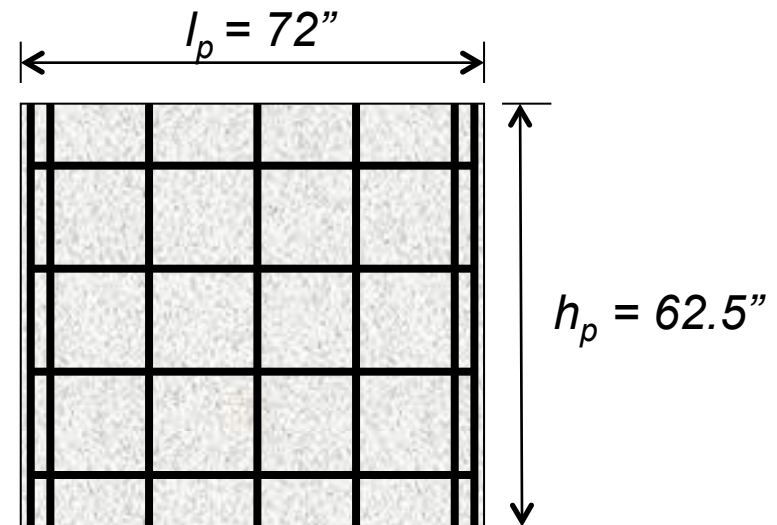


Wall Segment Reinforcing Details

- Weakened plane joint (Spandrel)



- Typical Pier



$$\rho_v = \sim 0.25\%$$

$$\rho_h = \sim 0.35\%$$



Single curtain, no hooks (field survey)
No support for boundary vertical bars

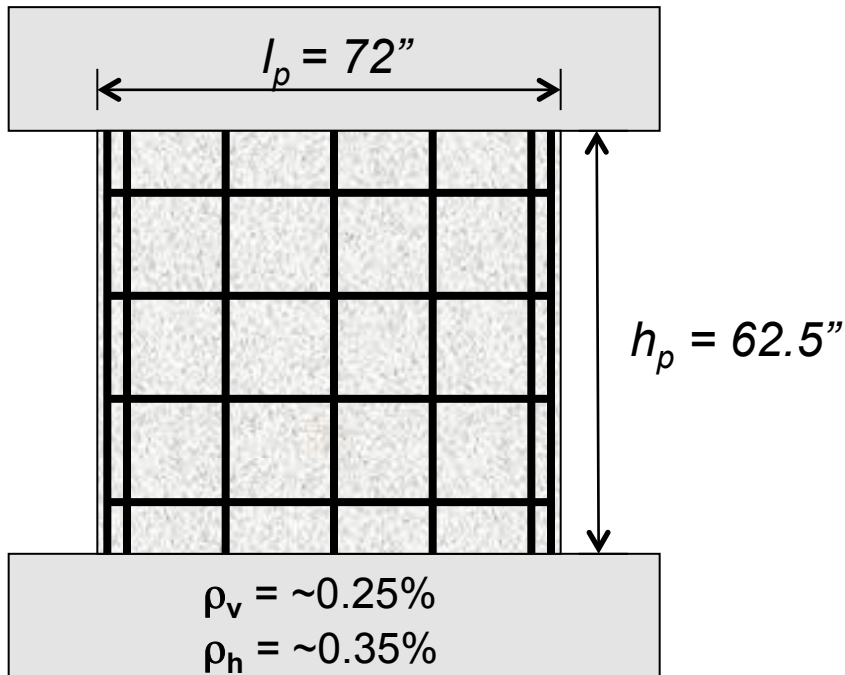
Component Testing

- Testing Criteria developed
 - Piers ($P=0, 0.05, 0.10A_gf'_c$)
 - Spandrels – two details



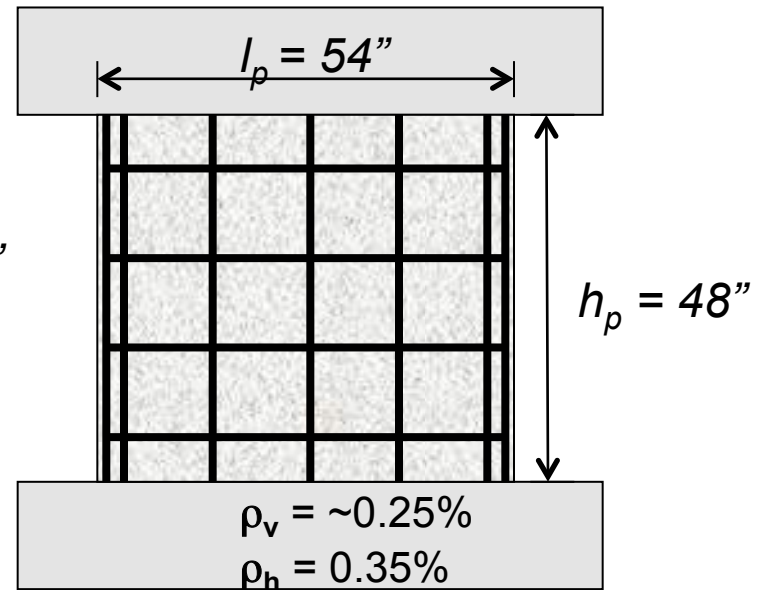
Test Specimens – Piers

Prototype (Actual Building)



3/4 Scale Test Specimen

To reduce costs and test more configurations



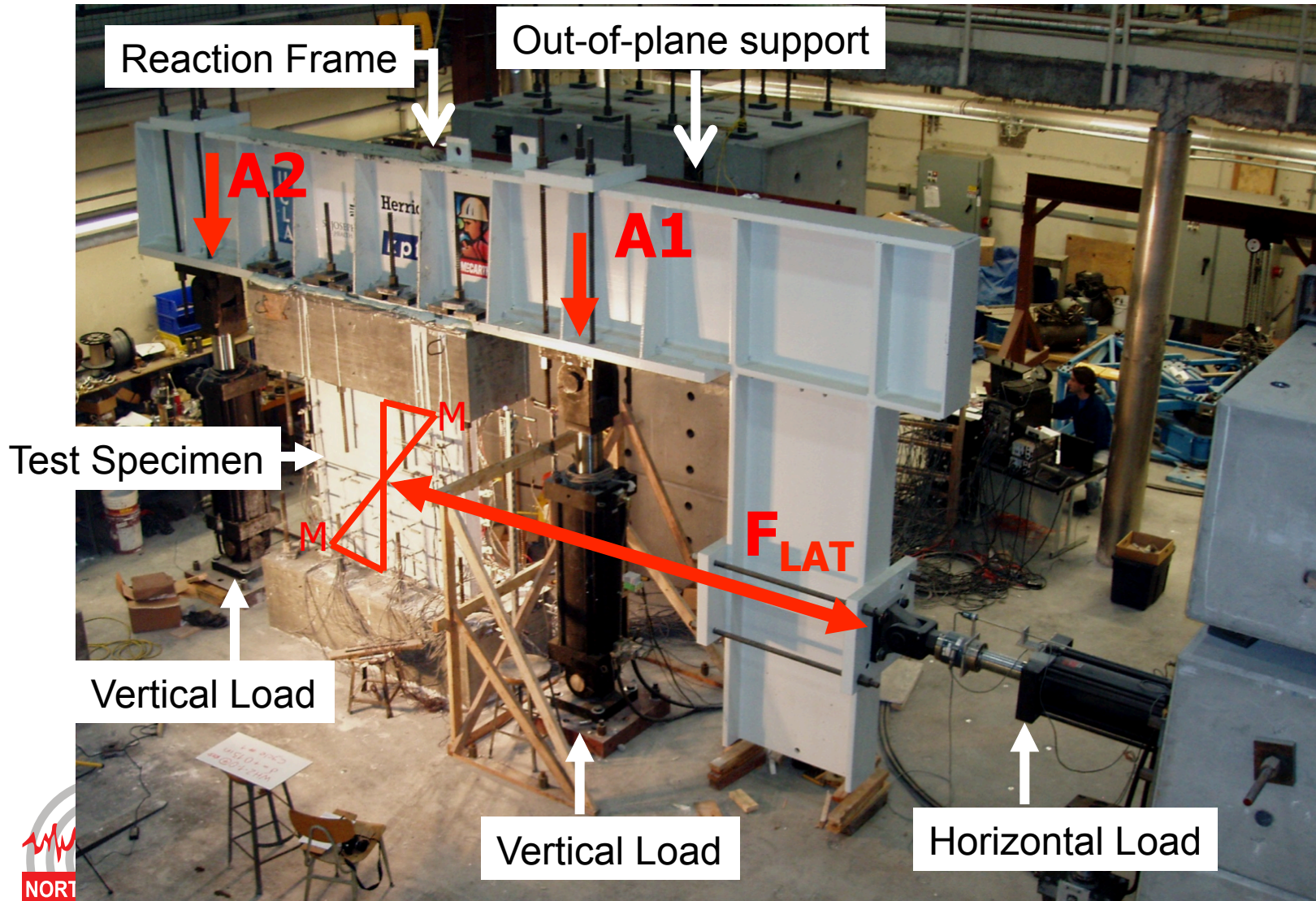
Test Specimens – VWS



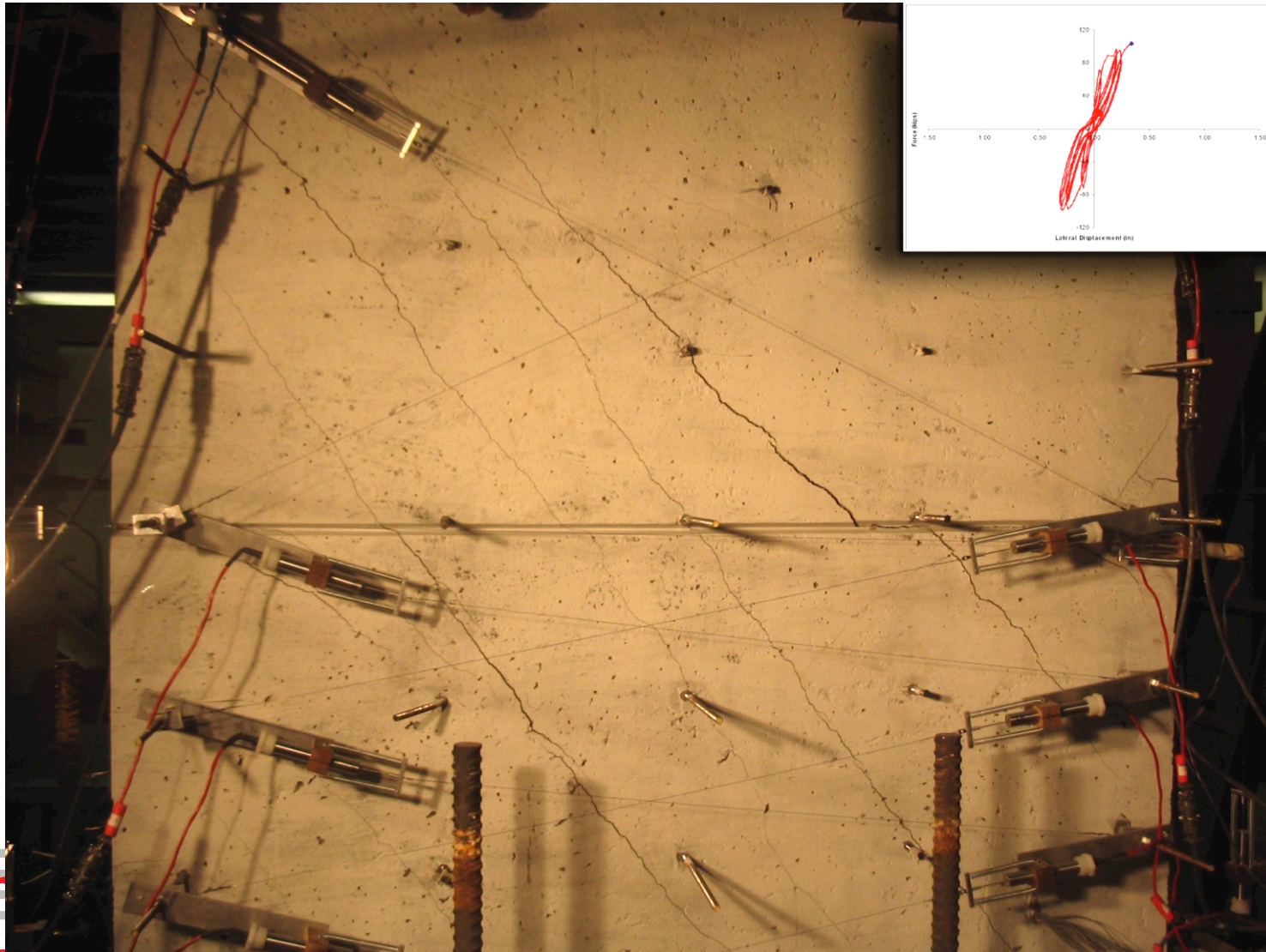
Hooks removed

Specimen ID	Geometry (inches)			Reinforcement ³			$P/A_g f'_c$ ⁴ (kips)	Specimens (#)
	Height	Length	Thickness	Edge ¹	Vert. Web ²	Horiz. Web ²		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
WP1-1-10	48	54	6	2 - #4	0.26%	0.35%	0.10	2
WP2-1-05	48	54	6	2 - #4	0.26%	0.35%	0.05	2
WP3-1-00	48	54	6	2 - #4	0.26%	0.35%	0.00	2
WH1-1-0	60	60	6	1-#4 1-#5	0.35%	0.26%	0.0	2
WH2-1-0	60	60	6	4 - #5	0.35%	0.26%	0.0	2

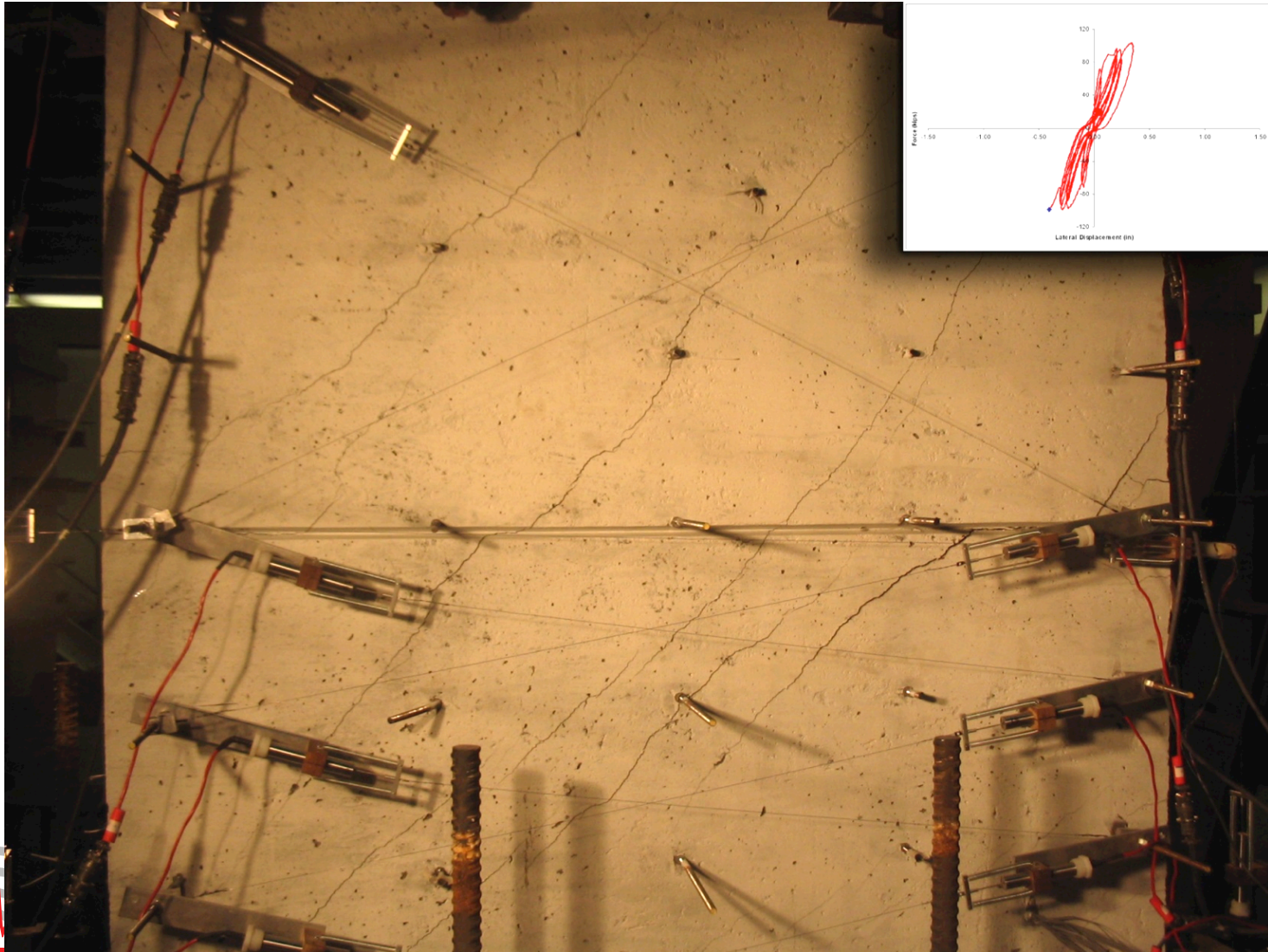
Test Program - Setup



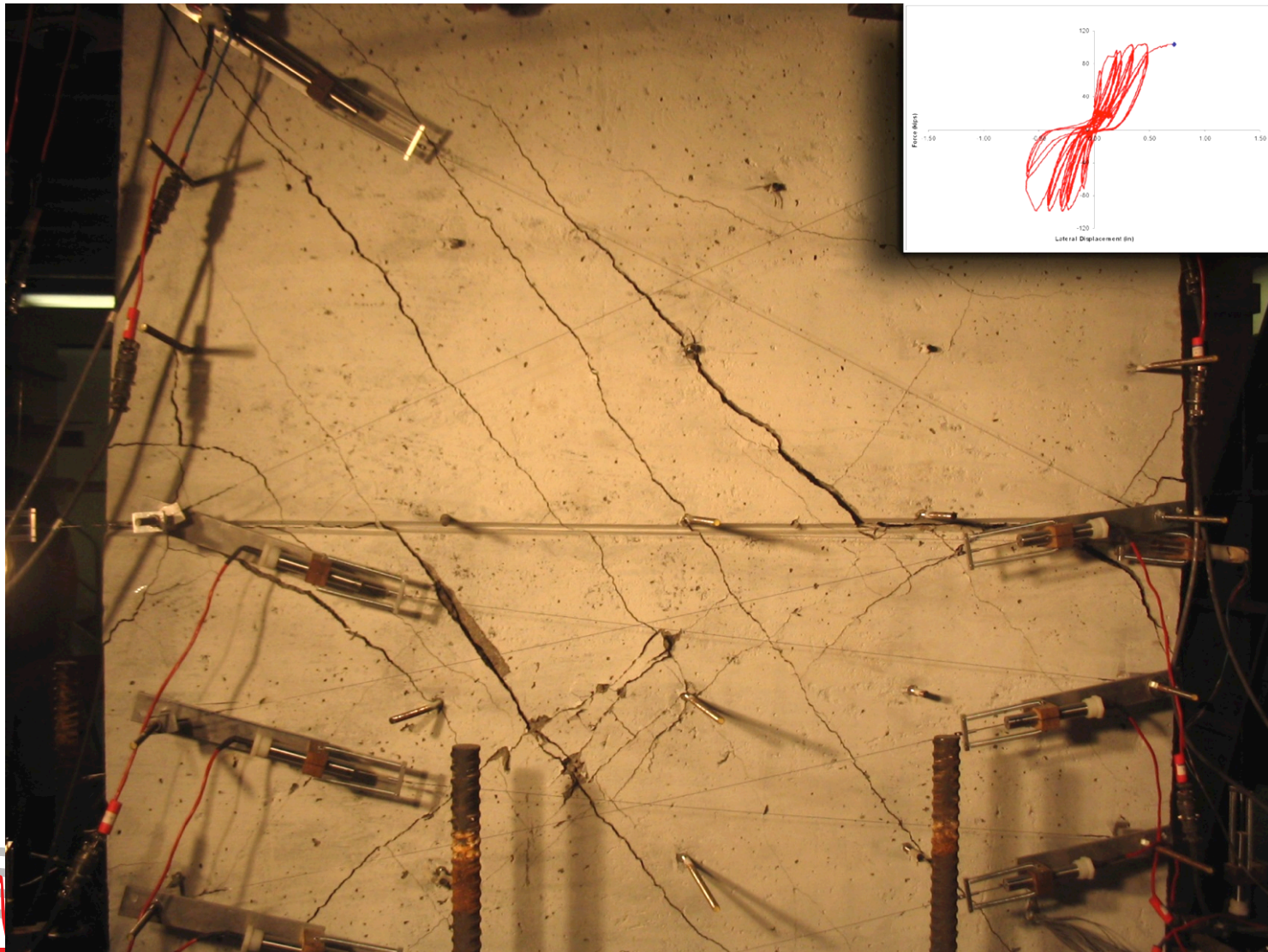
Test Result - Spandrel



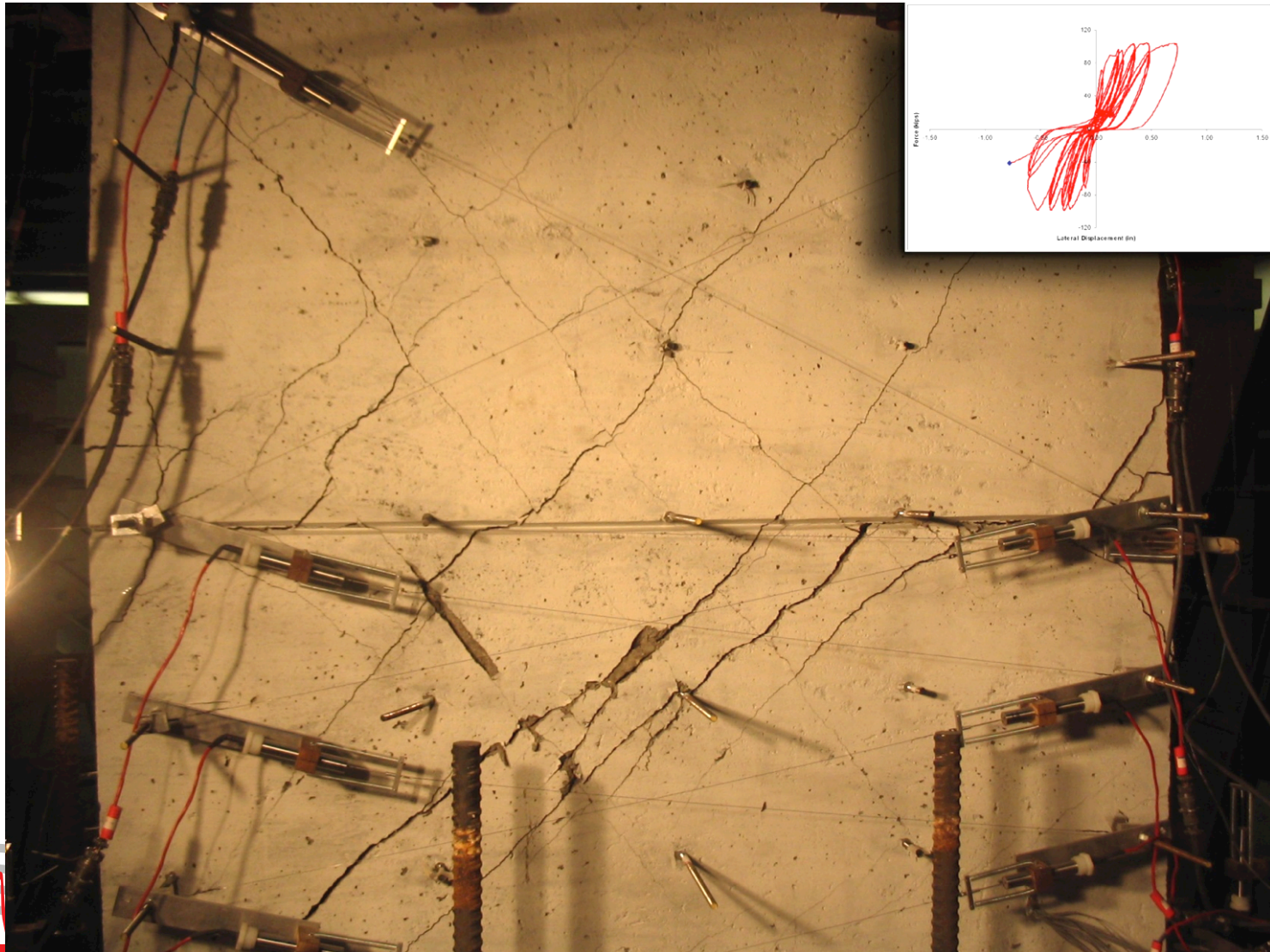
Test Result - Spandrel



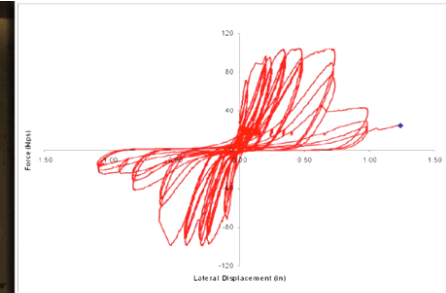
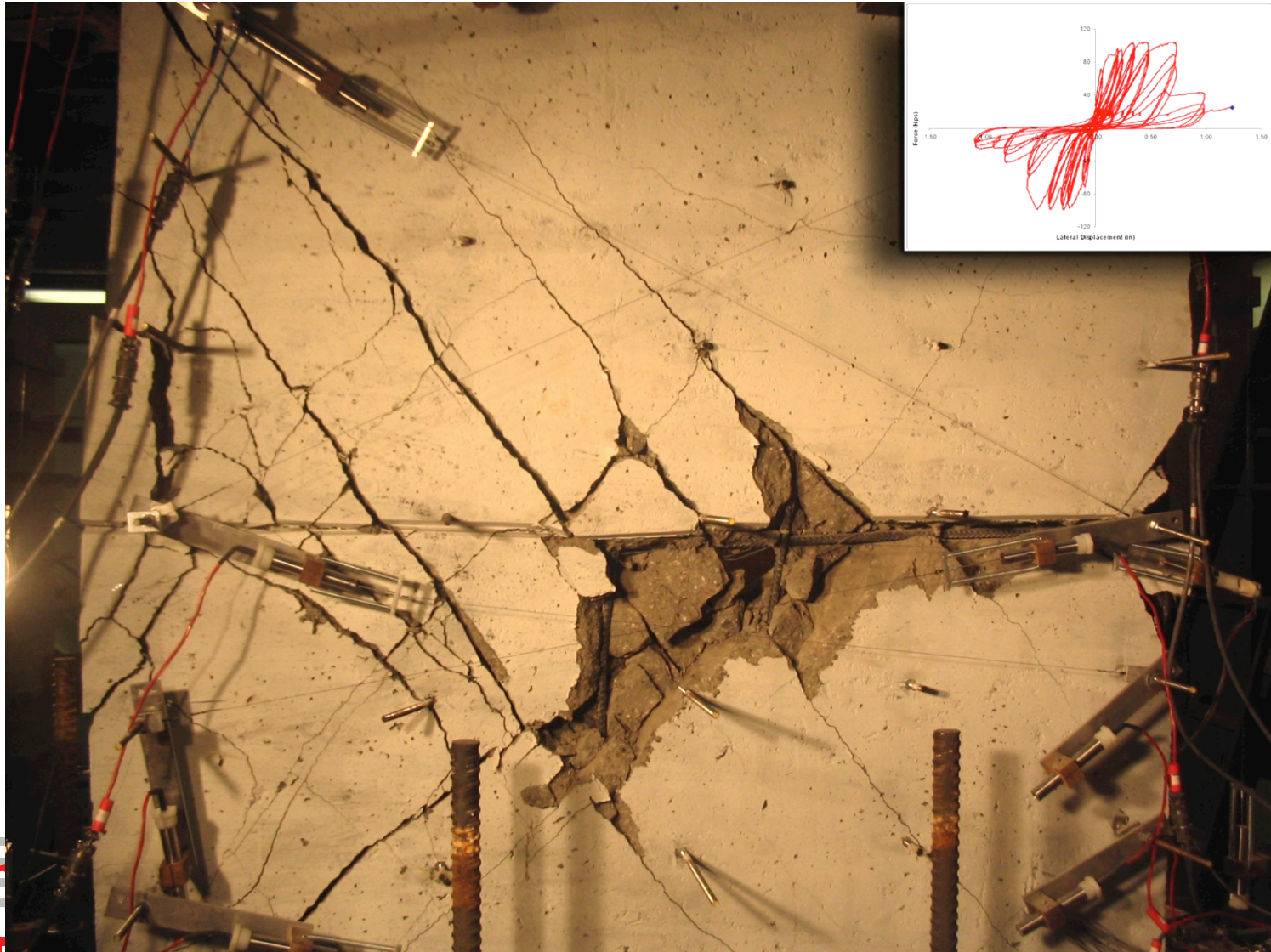
Test Result - Spandrel



Test Result - Spandrel



Test Result - Spandrel

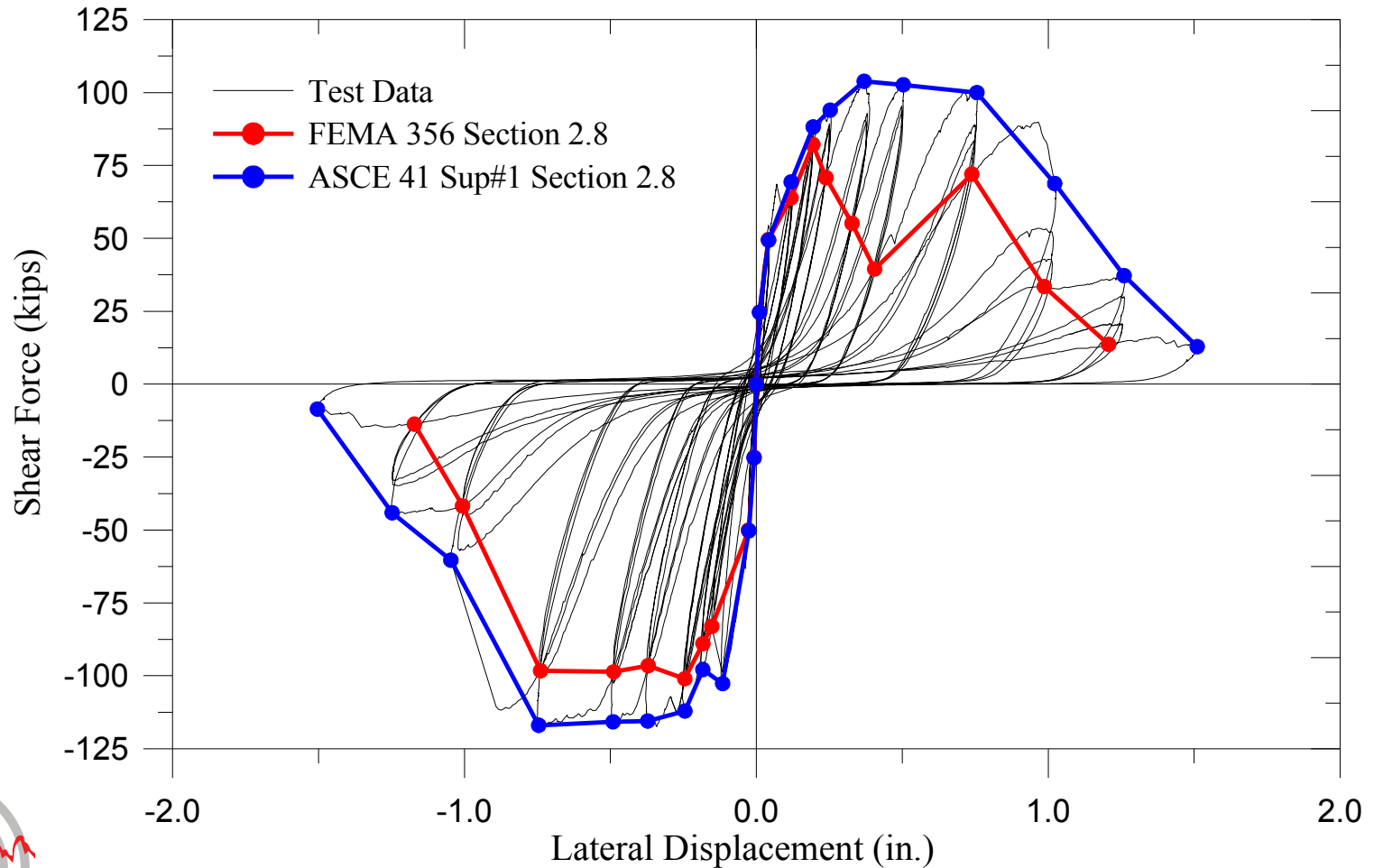


Test Result - Spandrel



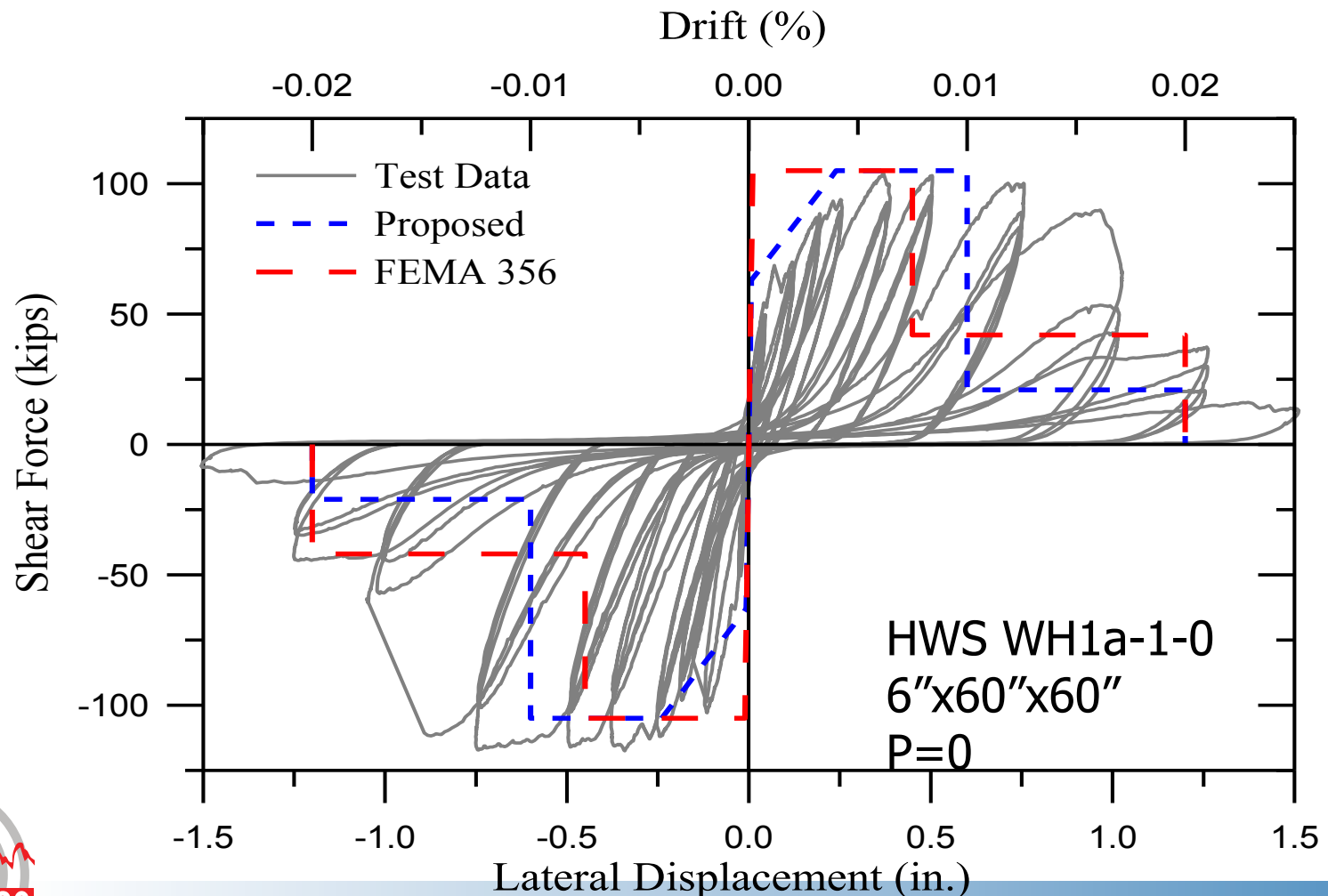
Project Contributions: ASCE 41 S#1

- Modify determination of test backbone relation



Project Contributions: ASCE 41 S#1

- New backbone relation with shear cracking



Project Contributions: ASCE 41 S#1

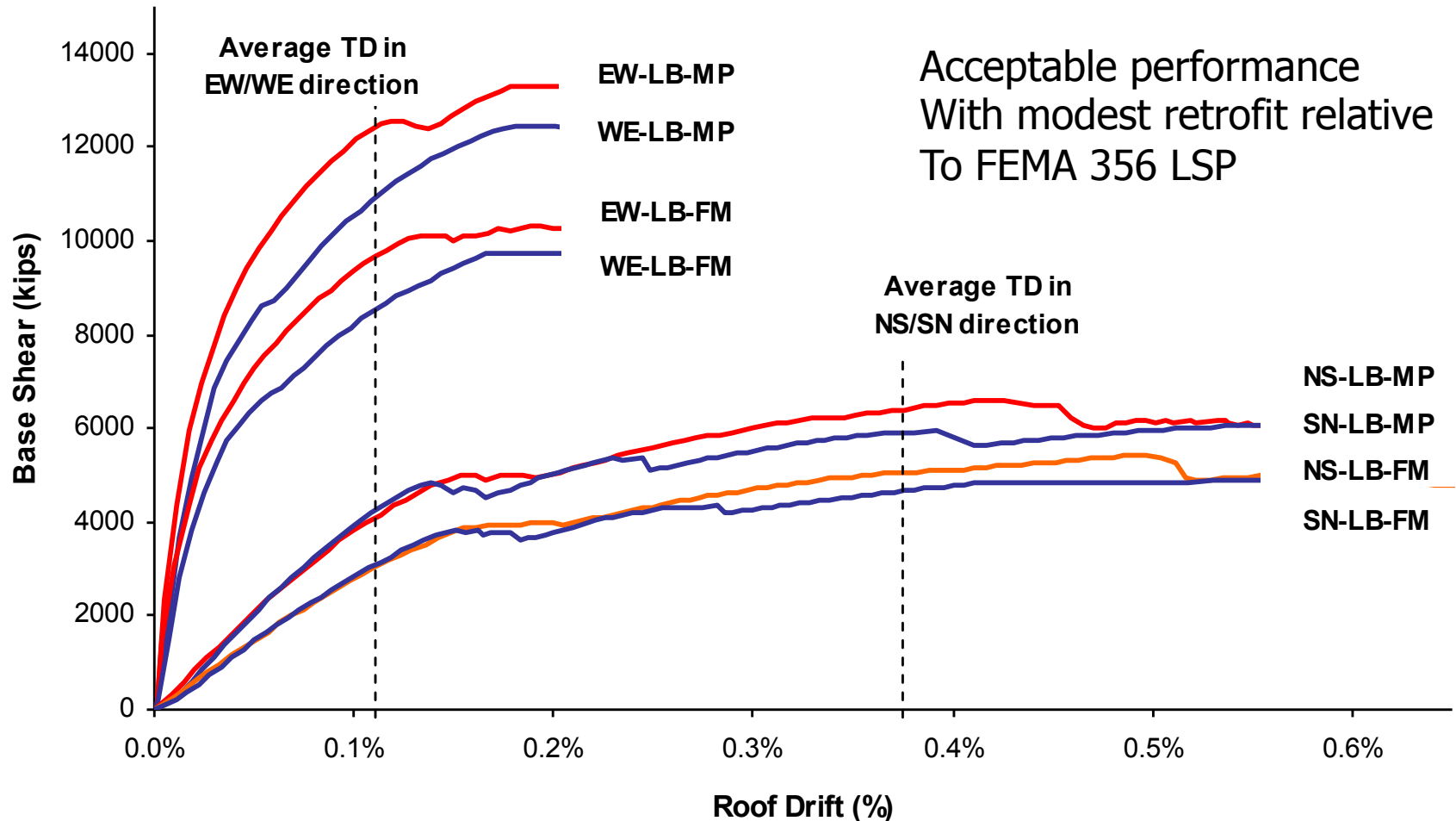
■ Backbone Relations: Modified Table 6-19

Table 6-19 Modeling Parameters and Numerical Acceptance Criteria for Nonlinear Procedure R/C Shear Walls and Associated Components Controlled by Shear

Conditions	Total Drift Ratio (%), or Chord Rotation (radians) ¹			Strength Ratio		Acceptable Total Drift (%) or Chord ⁵ Rotation (radians) ¹				
						Performance Level				
	d	e	g	c	f	IO	Component Type			
							Primary		Secondary	
						LS	CP	LS	CP	
i. Shear walls and wall segments²										
$\frac{(A_s - A'_s) f_y + P}{t_w l_w f'_c} \leq 0.05$	1.0	2.0	0.4	0.20	0.6	0.40	0.75	1.0	1.5	2.0
$\frac{(A_s - A'_s) f_y + P}{t_w l_w f'_c} > 0.05$	0.75	1.0	0.4	0.0	0.6	0.40	0.55	0.75	0.75	1.0

Project Results: Pushover Relations

Final Pushover Curves - Lower Bound Soil Case



Acceptable performance
With modest retrofit relative
To FEMA 356 LSP

Project Outcomes - Lessons

- St Joseph's Healthcare
 - Project cost (value) and disruption



- KPFF

- Cutting edge rehabilitation project
- Educational value
- Higher fee, but also better value for their client



- UCLA

- Educational value (research/teaching)
- Value of project specific test programs



- Profession: ASCE 41 Supplement #1



Win – Win – Win – Win



Project Outcomes - Lessons

■ Education and Outreach

- EERI Technical Seminar Series - 2006
- EERI Annual Meeting – February 2007
- ASCE Structures Congress – May 2007
- SEAOC Convention, Lake Tahoe – September 2007

■ Research Findings

- ASCE 41-06 Supplement #1 (2007); EERI Spectra (2007)
 - New backbone relations
 - Revised testing criteria
- ASCE Structures Journal (2008)
 - Axial failure model
- ACI Structures Journal (2009a; 2009b)
 - Wall shear strength
 - Nonlinear wall shear modeling

Acknowledgements

■ Collaborators

■ KPFF-LA

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■ Host of undergraduates

■ NEES@UCLA & CEE Staff

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- H. Kasper (CEE UCLA)

