DETERMINATION OF SEIMIC VULNERABILITY USING AMBIENT AND FORCED VIBRATION TESTS

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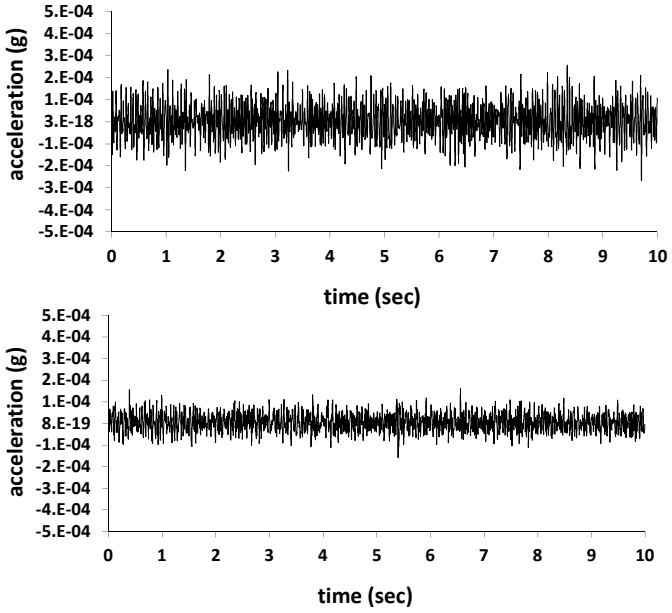
Outline

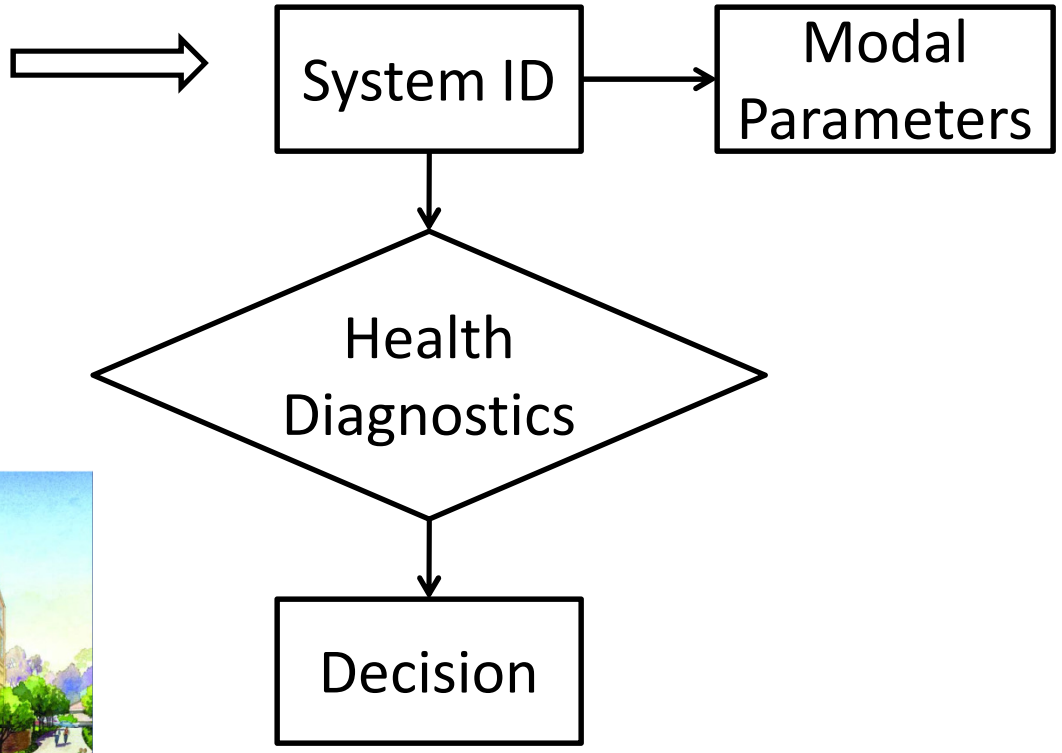
- Motivation
- Seismic Retrofitting of the Building
- Ambient Vibration Test
- Forced Vibration Test
- Seismic Vulnerability Assessment
- Conclusions

Seismic Vulnerability

- How confidently do we predict the actual performance/reliability by the current practice?
- Modal period and damping ratios are critical to determine especially for non-ductile buildings.

Vibration-Based Health Monitoring





Motivation

- Determination of modal parameters
- Determination of change in the modal parameters due to increase in the applied force to the structure
- FEM updating using identified modal parameters
- Determination of seismic vulnerability of the structure

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Seismic Retrofitting

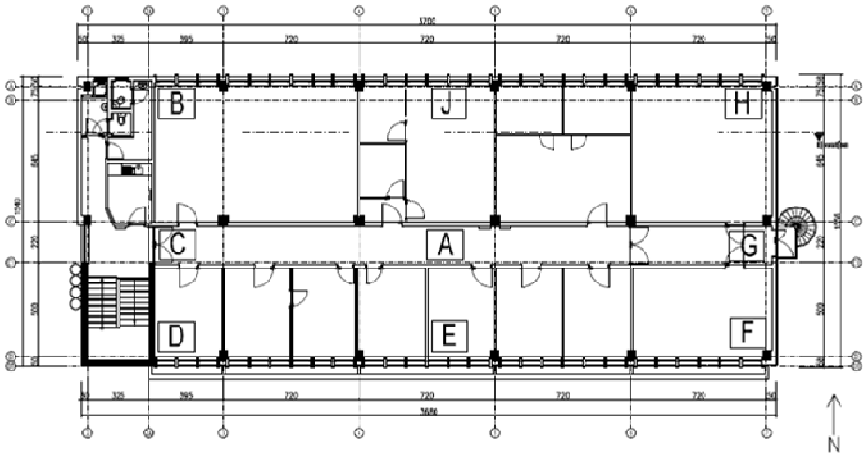
Columns

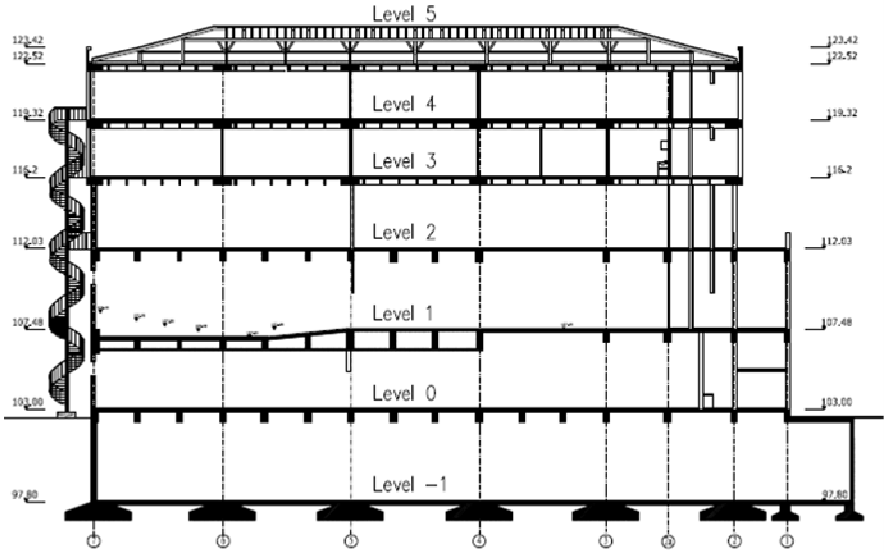
Before Retrofit		After Retrofit	
Dimension (cm × cm)	Number	Dimension (cm × cm)	Adet
40 × 60	13	70 × 75	9
		55 × 75	2
		70 × 90	1
		65 × 90	1
Ø60	2	90 × 90	2
60 × 50	1	90 × 80	1
50 × 60	1	80 × 90	1
30 × 30	2	30 × 30	2
30 × 50	2	30 × 50	2
		70 × 90	1

Shear Walls

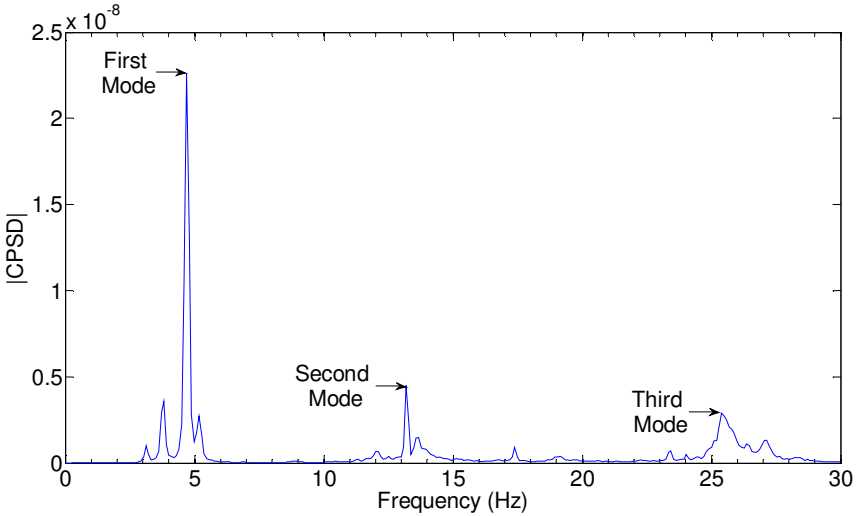
Before Retrofit			After Retrofit		
Dimension (cm × cm)	#	Direction	Dimension (cm × cm)	#	Direction
			650 × 45	1	E-W
			635 × 40	1	E-W
			40 × 345	1	N-S
			40 × 620	2	N-S
325 × 30	1	E-W	325 × 30	1	E-W
30 × 470	2	N-S	30 × 470	2	N-S

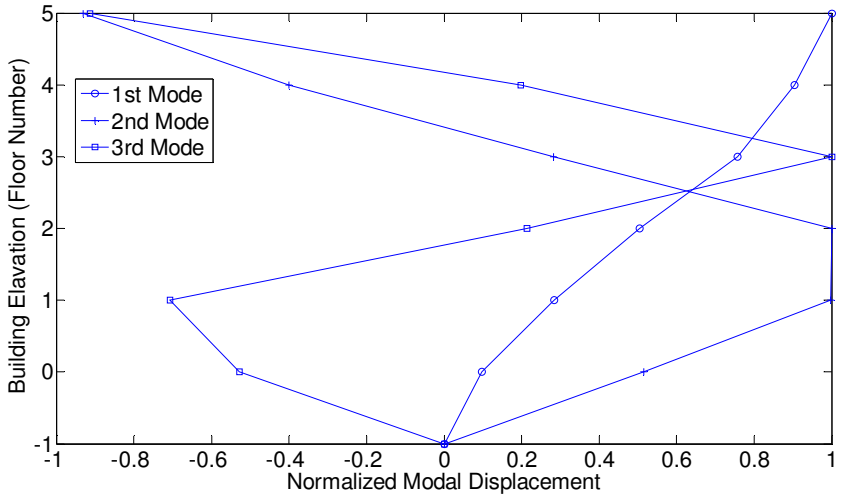
Instrumentation



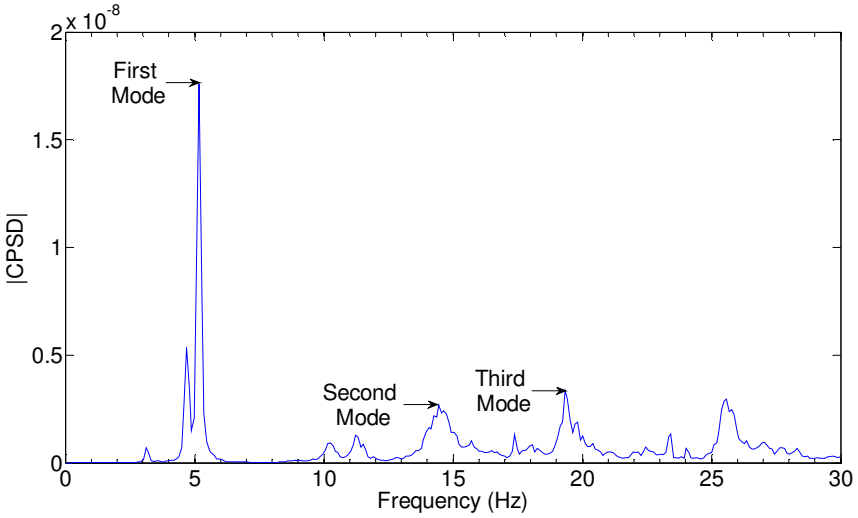


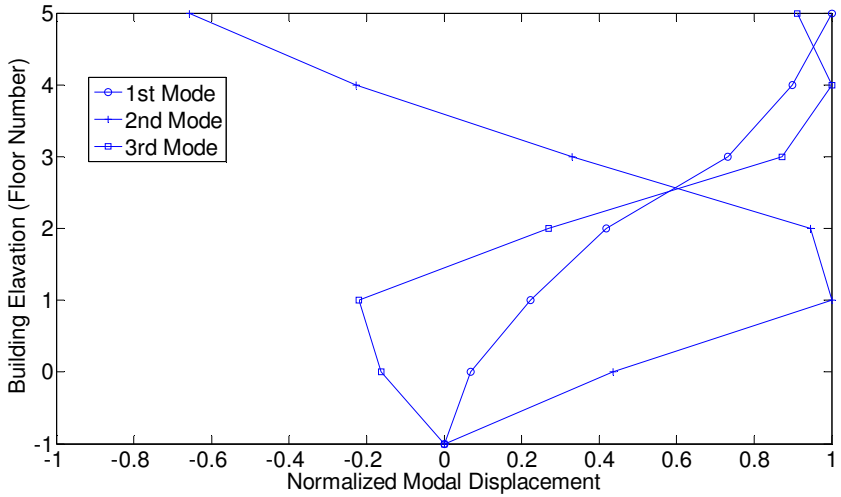
Ambient Vibration Test





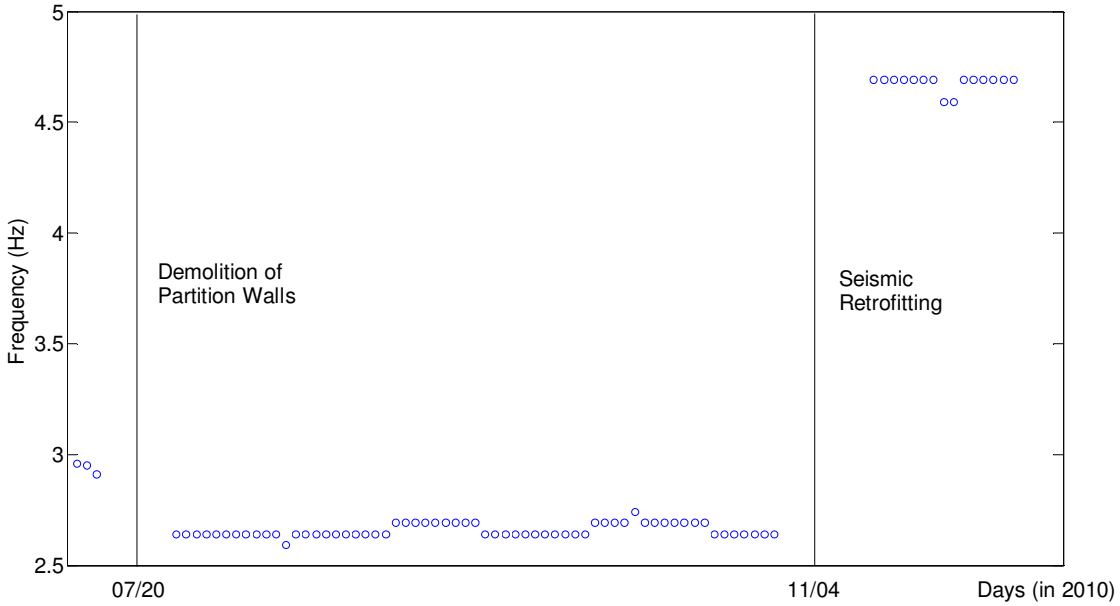
Modal Frequencies and Shapes in E-W Direction



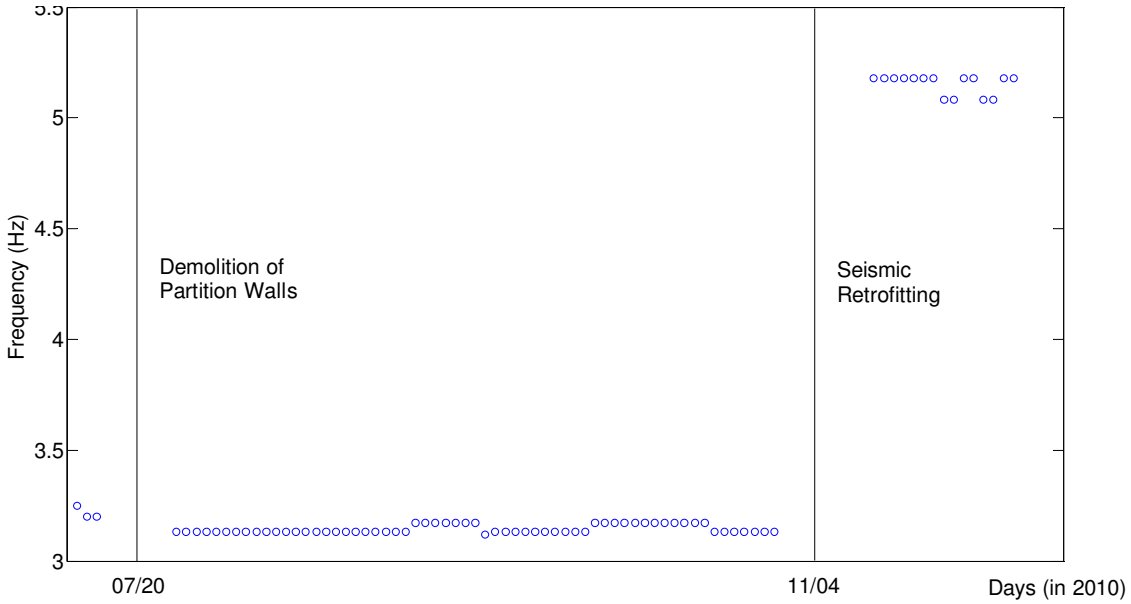


Modal Frequencies and Shapes in N-S Direction

Change in Modal Frequencies by Time



First mode in E-W



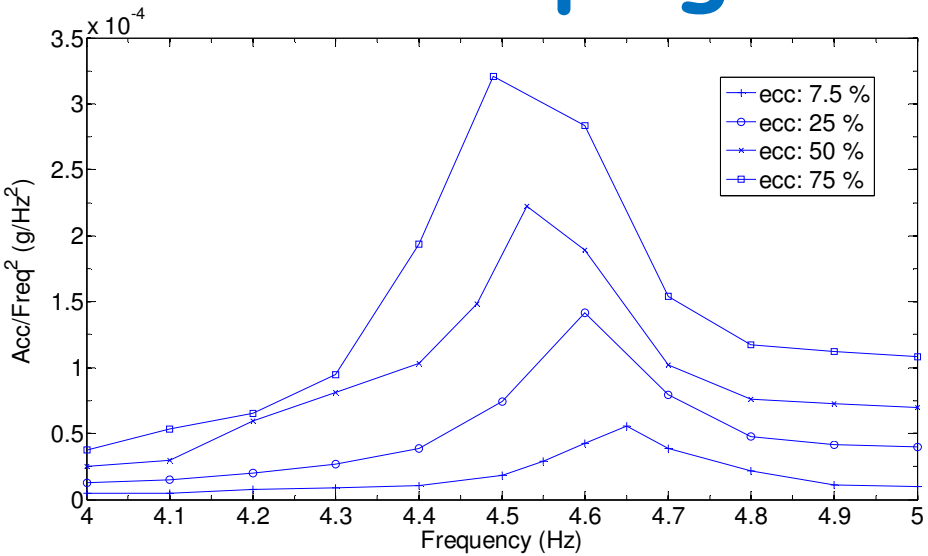
First mode in N-S

Forced Vibration Test-1

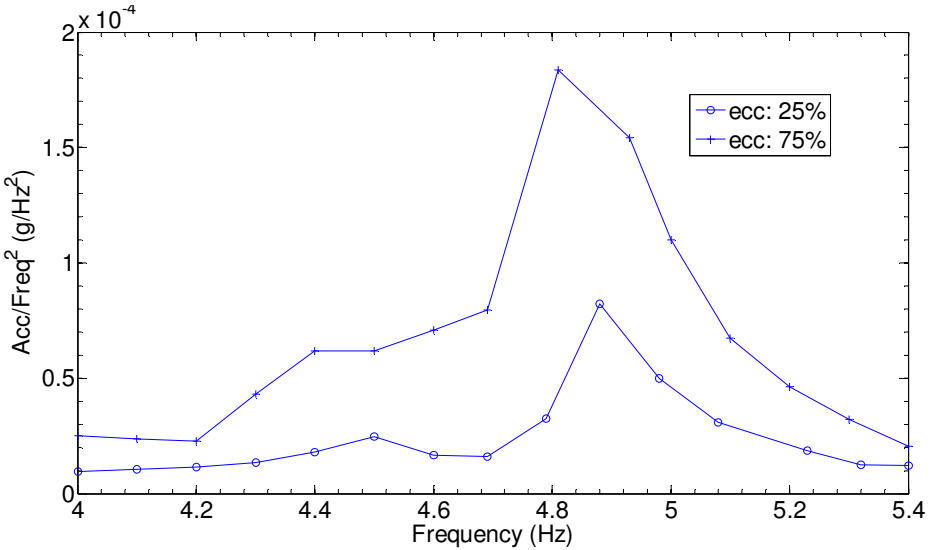
Eccentricity (%)	Frequency (Hz)	Force (kN)
25	4.5	3.70
50	4.5	7.39
75	4.5	11.1
25	6.5	7.71
50	6.5	15.4
75	6.5	23.1

Forced Vibration Test-2

Change in Modal Frequencies and Damping Ratios by Force

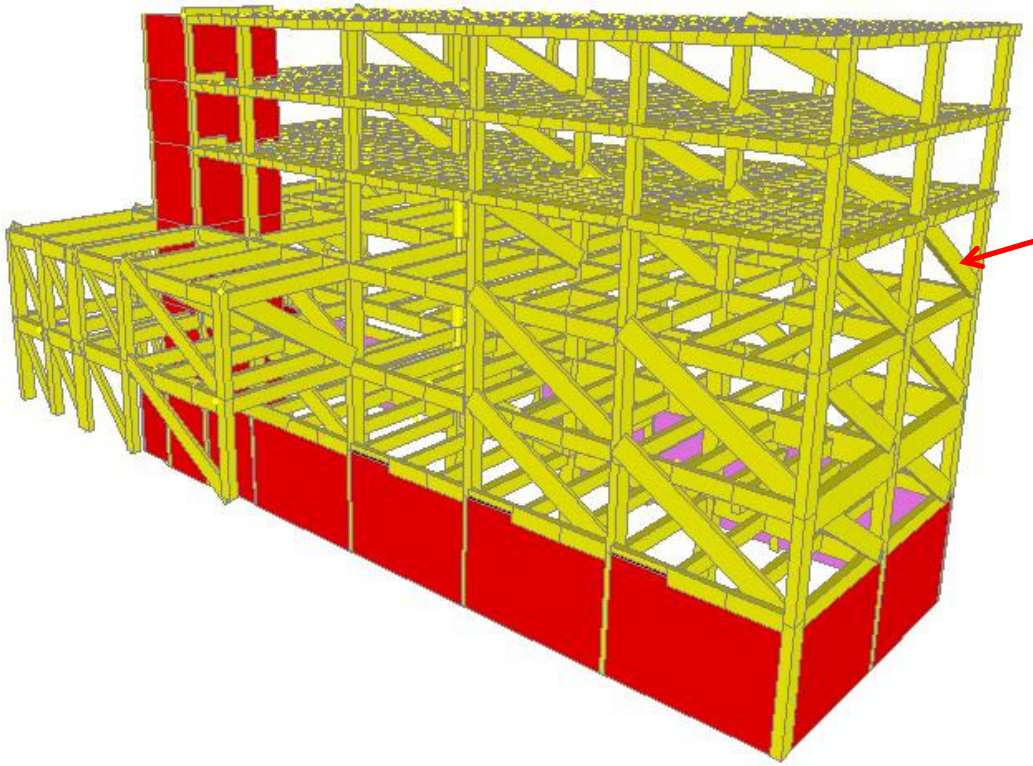


Ecc. (%)	Frequency (Hz)	Damping Ratio (%)
7.5	4.65	1.1
25	4.60	1.3
50	4.53	1.8
75	4.49	2.3



Ecc. (%)	Frequency (Hz)	Damping Ratio (%)
25	4.88	1.1
75	4.81	2.3

Finite Element Model



	FEM	Experimental
1. Modal Frequency	2.35 Hz	2.94 Hz
2. Modal Frequency	3.11 Hz	3.22 Hz
3. Modal Frequency	4.96 Hz	3.76 Hz

Seismic Vulnerability Assessment-1

Methodology:

• Obtain the distribution of max. story drifts obtained from the time-history analysis using 10 input motions such as

PGA (g)	MAGNITUTE	NAME
0.55	6.1	BINGOL (03)
0.81	7.2	Marmara - BOLU (November.99)
0.27	6.2	CEYHAN (98)
0.48	7.4	Marmara - DUZCE (Agust.99)
0.47	6.1	ERZINCAN (92)
0.18	6.7	VAN (11)

• Obtain the exceedance probability using a limit state for the story drifts

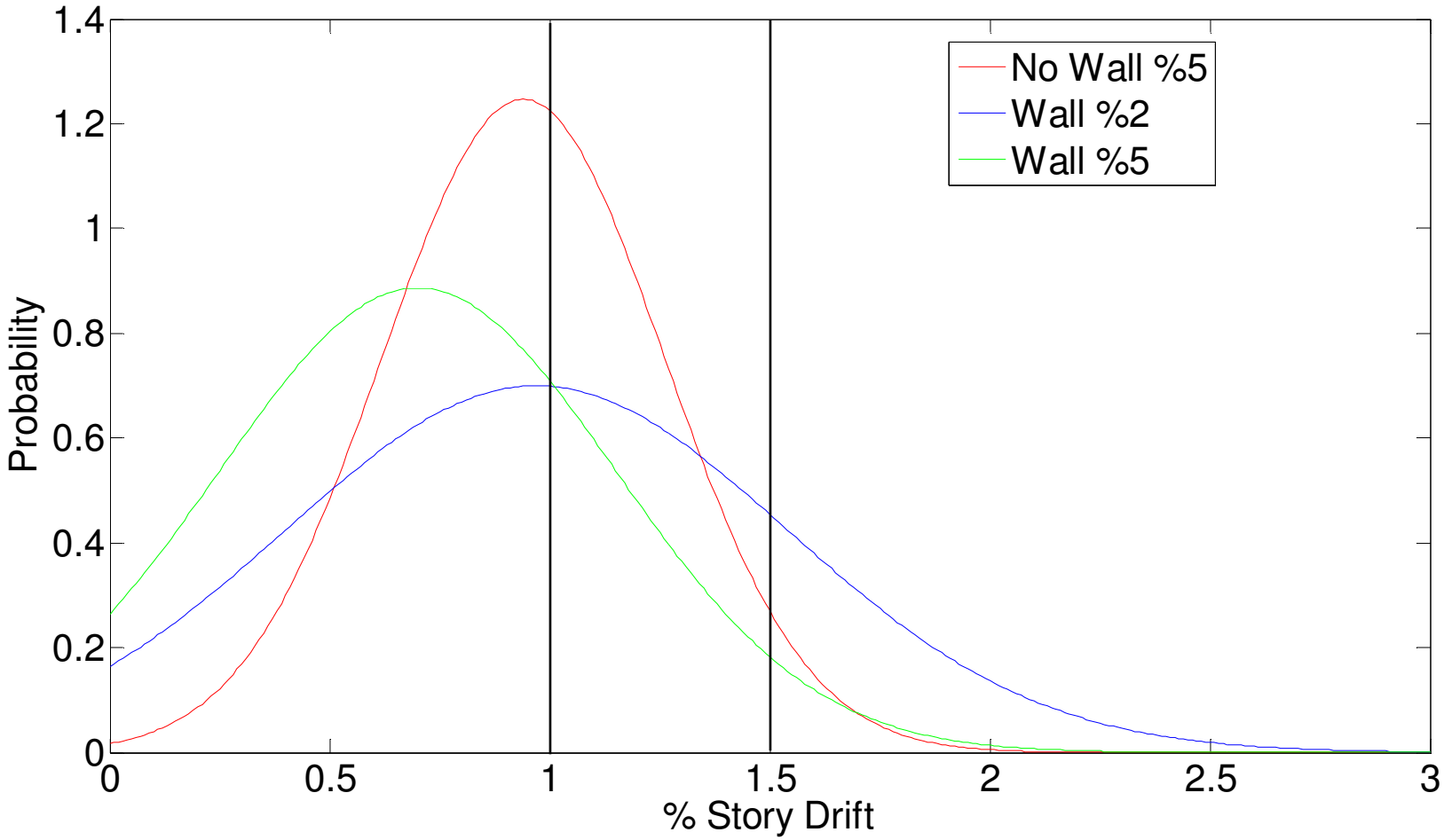
Cases Considered:

•W/O Infill Walls / %5 Damping

•W Infill Walls / %5 Damping

•W Infill Walls / %2 Damping

Seismic Vulnerability Assessment-2



Seismic Vulnerability Assessment-3

Story DriftThreshold %1		
Case	Damping Ratio (%)	Prob. Failure (%)
Without Wall	5	43
With Wall	5	25
With Wall	2	48
Story DriftThreshold %1.5		
Case	Damping Ratio (%)	Prob. Failure (%)
No Wall	5	4
With Wall	5	4
With Wall	2	18

Conclusions

- Due to infill walls the first structural frequency decreased by 10 %.
- Modal damping ratio increases almost linearly with the applied force to structure.
- Seismic vulnerability may change significantly if updated (identified) parameters rather than non-updated (code suggested) parameters are used.
- Vibration-based identification of actual modal parameters may be critical for the seismic vulnerability assessment of non-ductile buildings.

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SERIES Committee