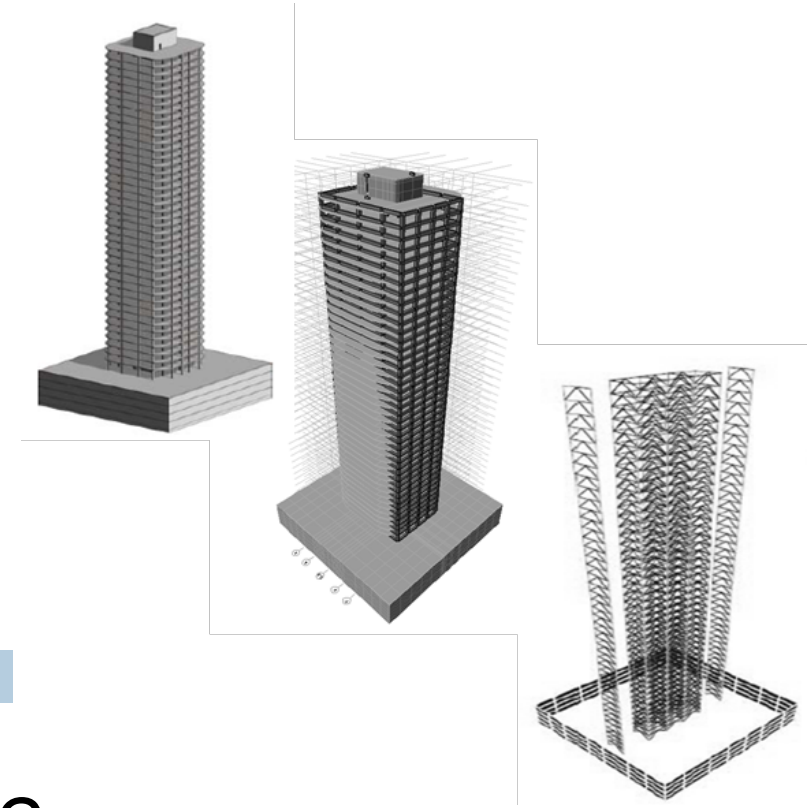
PEER Tall Building Seismic Design Guidelines



Case Studies Performance Assessment

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PEER

SEAW

November 30, 2010

TBI thanks

- Sponsors
  - CSSC – F. Turner, A. Sadre, D. McCarthy
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  - RMS – N. Shome, M. Rahnama, P. Seneviratna; H. Aslani


Sierra Madre
(San Fernando)
San Andreas
Sierra Madre
(Cucamonga)
Verdugo
TBI
Raymond
Santa
Monica
Hollywood
Elsinore
(Whittier)
Elsinore
(Chino)
Newport-Inglewood-Rose Canyon
1.5Km, Puente Hills
7.3Km, Hollywood
8.8Km, Raymond
11.5Km, Santa Monica
24.5Km, Elsinore
40.0Km, Sierra Madre
56Km, San Andreas
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image County of San Bernardino
Image U.S. Geological Survey
©2009 Google
Imagery Dates: Mar 16, 2006 - Nov 16, 2009
34°02'17.04" N 118°10'05.62" W elev 288 ft
Eye alt 67.25 mi

Record selection and scaling

- All the usual challenges for tall buildings
  - Long fundamental period
  - Multiple contributing periods
- … and more
  - Three different buildings
  - Interest in extreme hazard (> 2500-year return period

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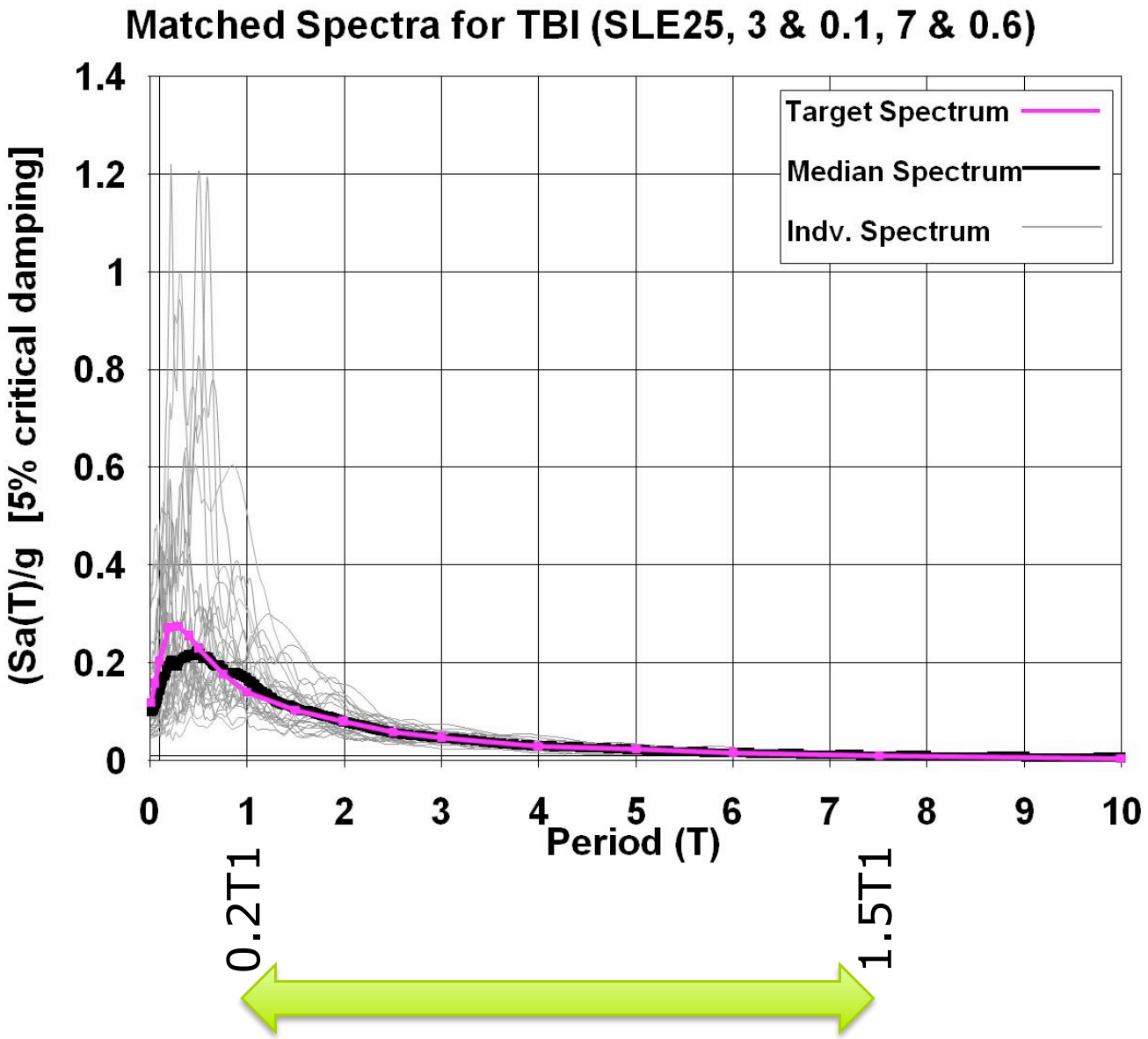
Response Spectra SLE25 (25 year)



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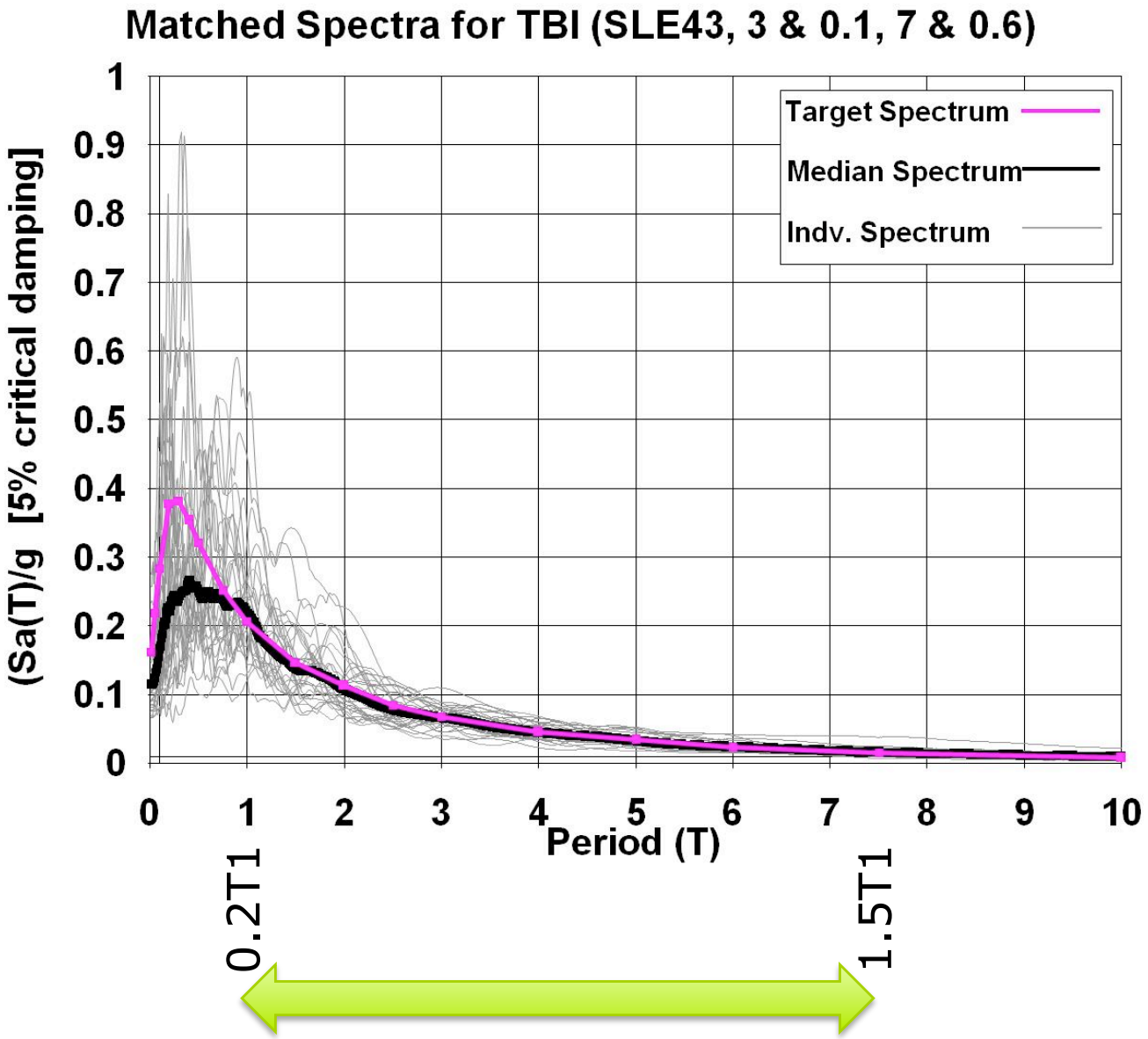
Response Spectra SLE43 (43 year)



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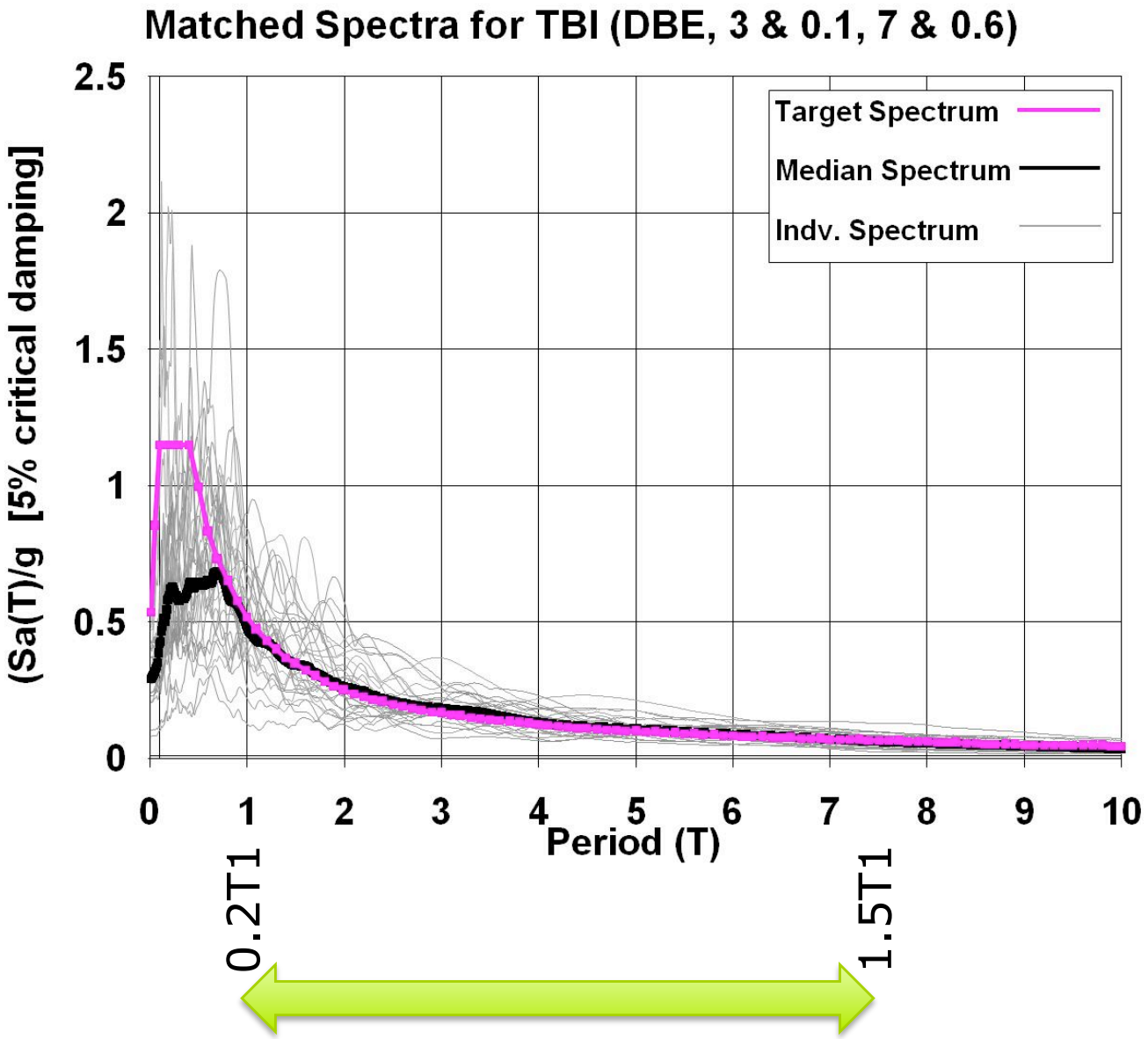
Response Spectra DBE (475 year)



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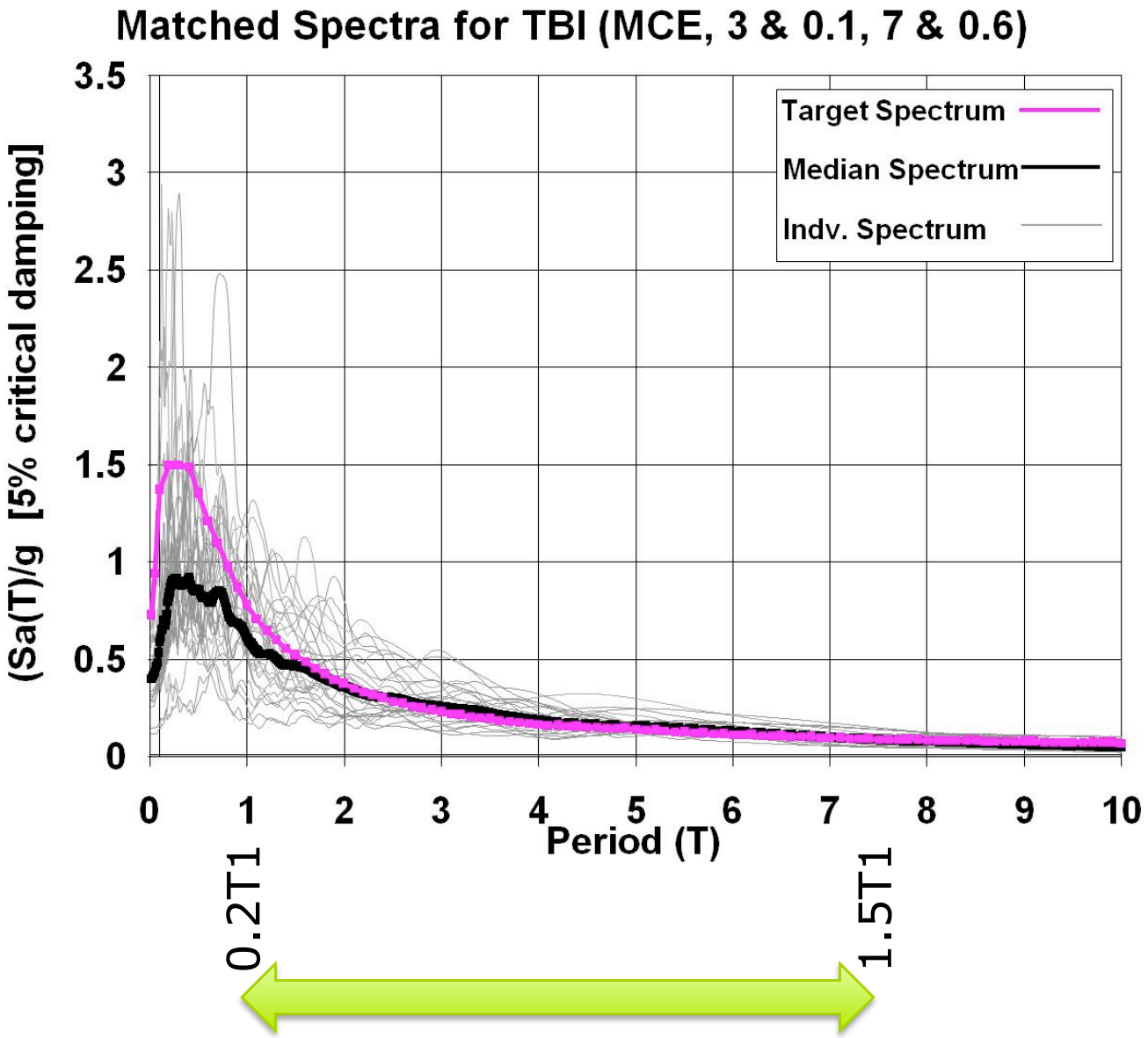
Response Spectra MCE (2475 year)



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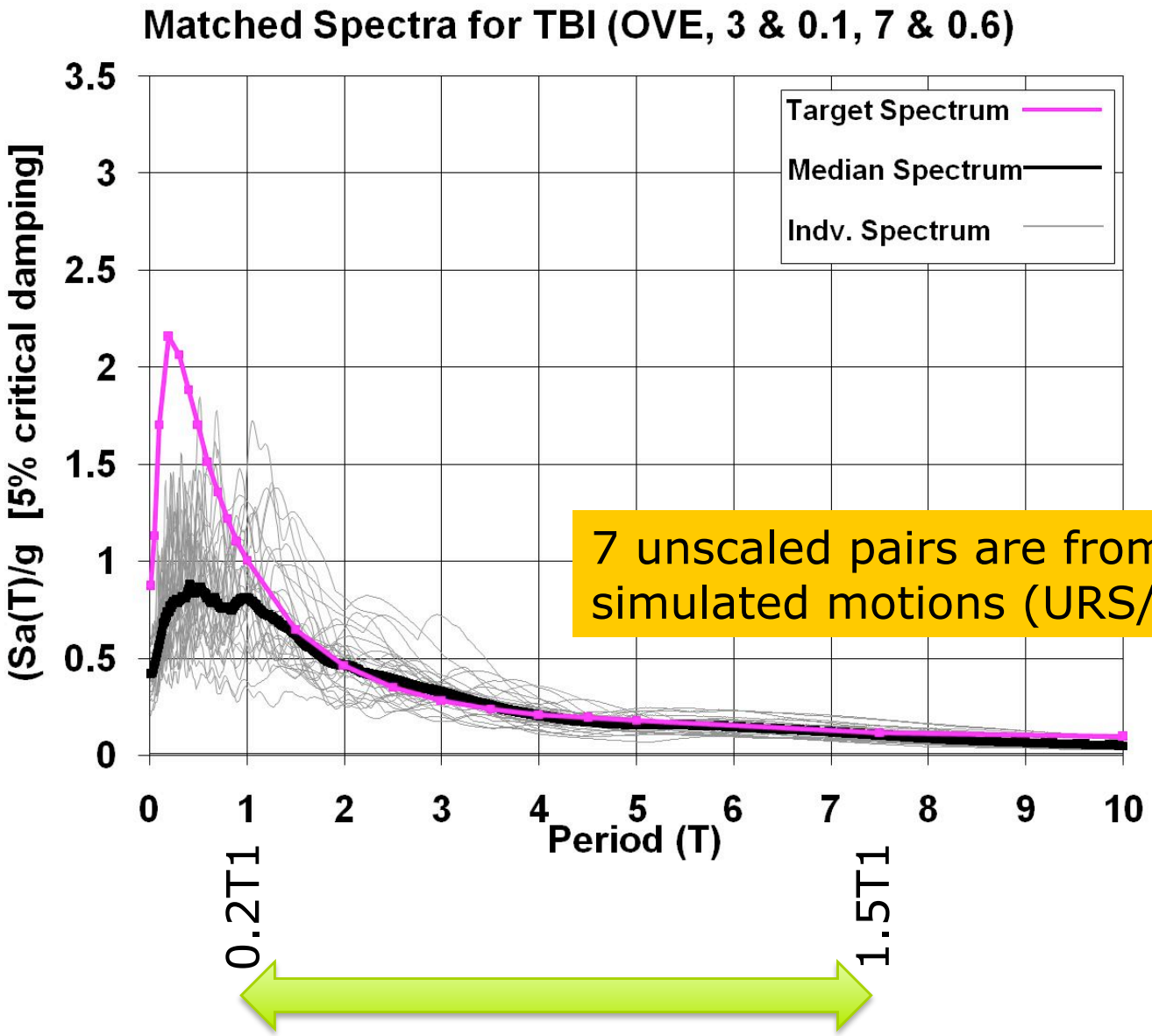
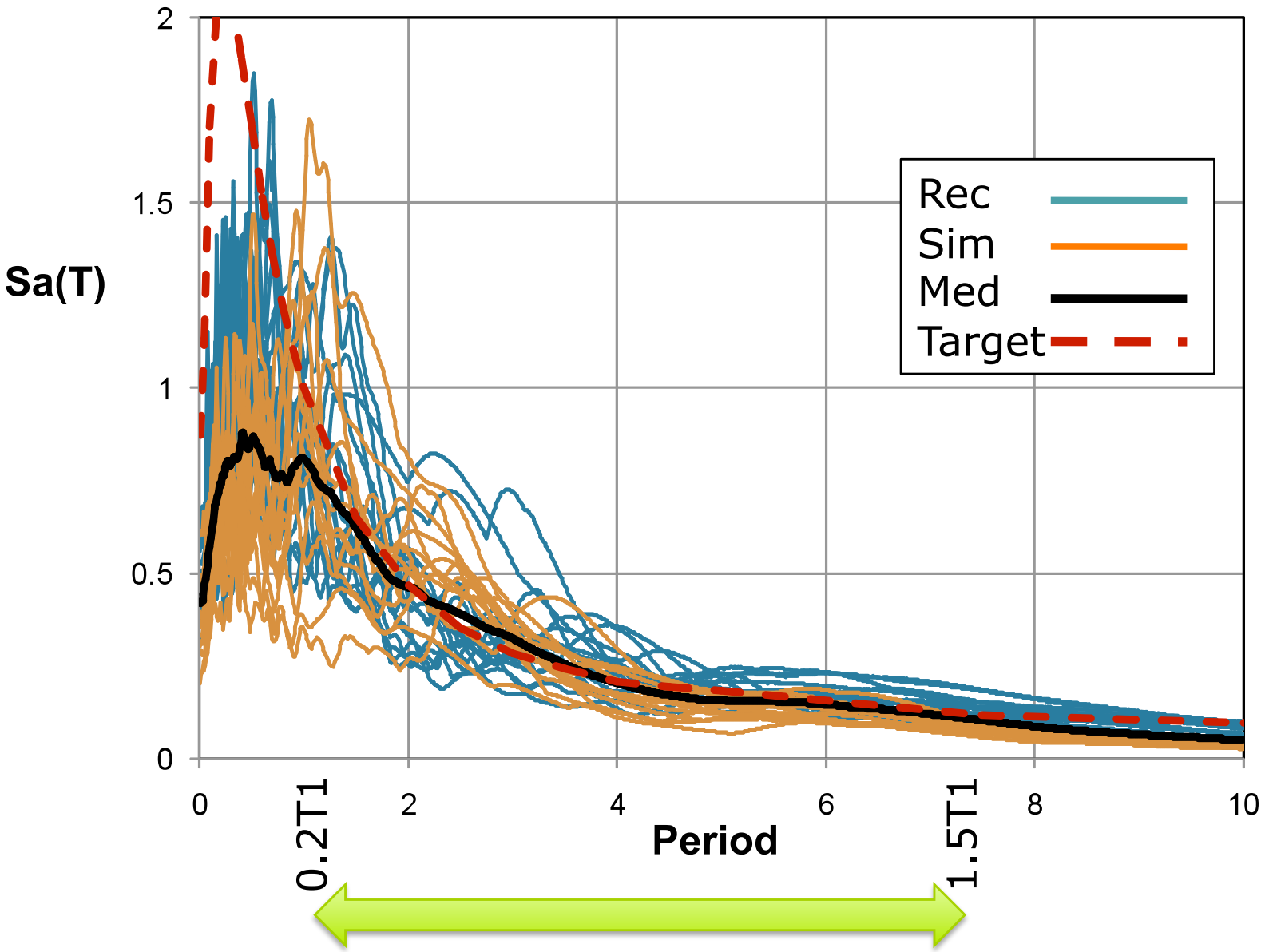
Response Spectra OVE (4975 year)



7 unscaled pairs are from simulated motions (URS/SCEC)

PEER

Response Spectra OVE (4975 year)



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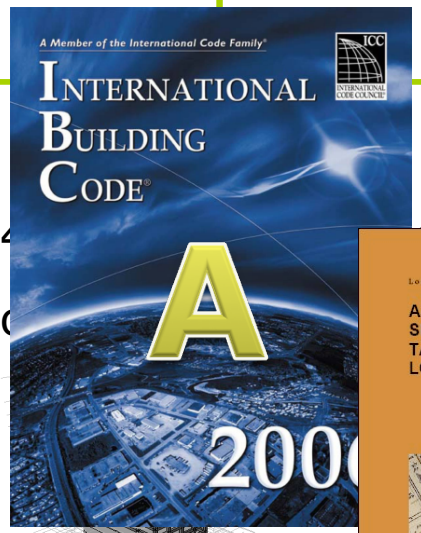
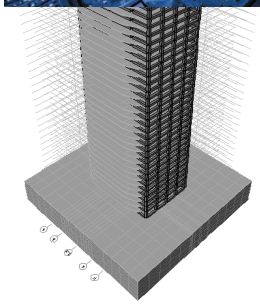
Building Design and Modeling

Three Building Systems

42-story reinforced concrete core wall

1





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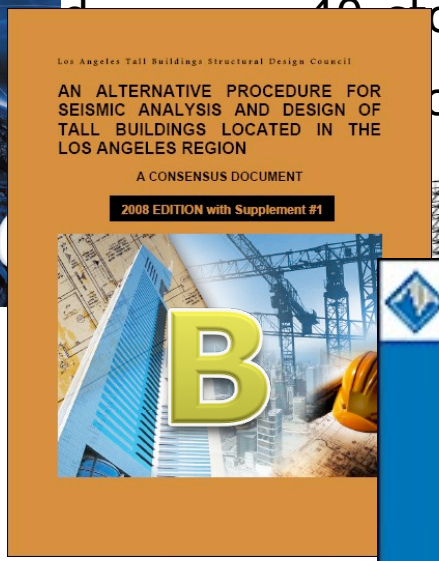
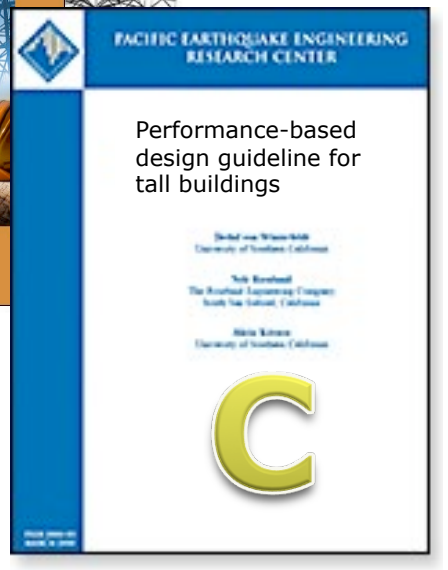
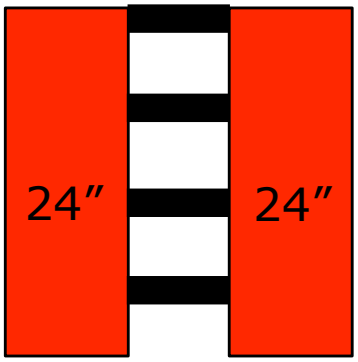




42-Story Concrete Core Wall

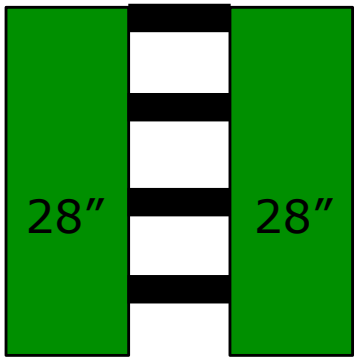
Building Design Comparison

1A: Code



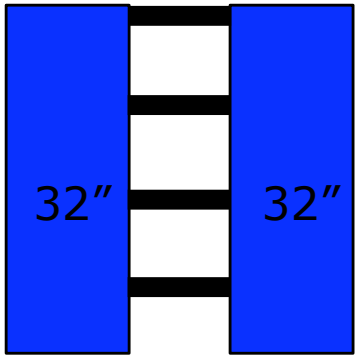
T_{1EW} = 5.2 sec

1B: PBEE



T_{1EW} = 4.8 sec

1C: PBEE+



T_{1EW} = 4.6 sec

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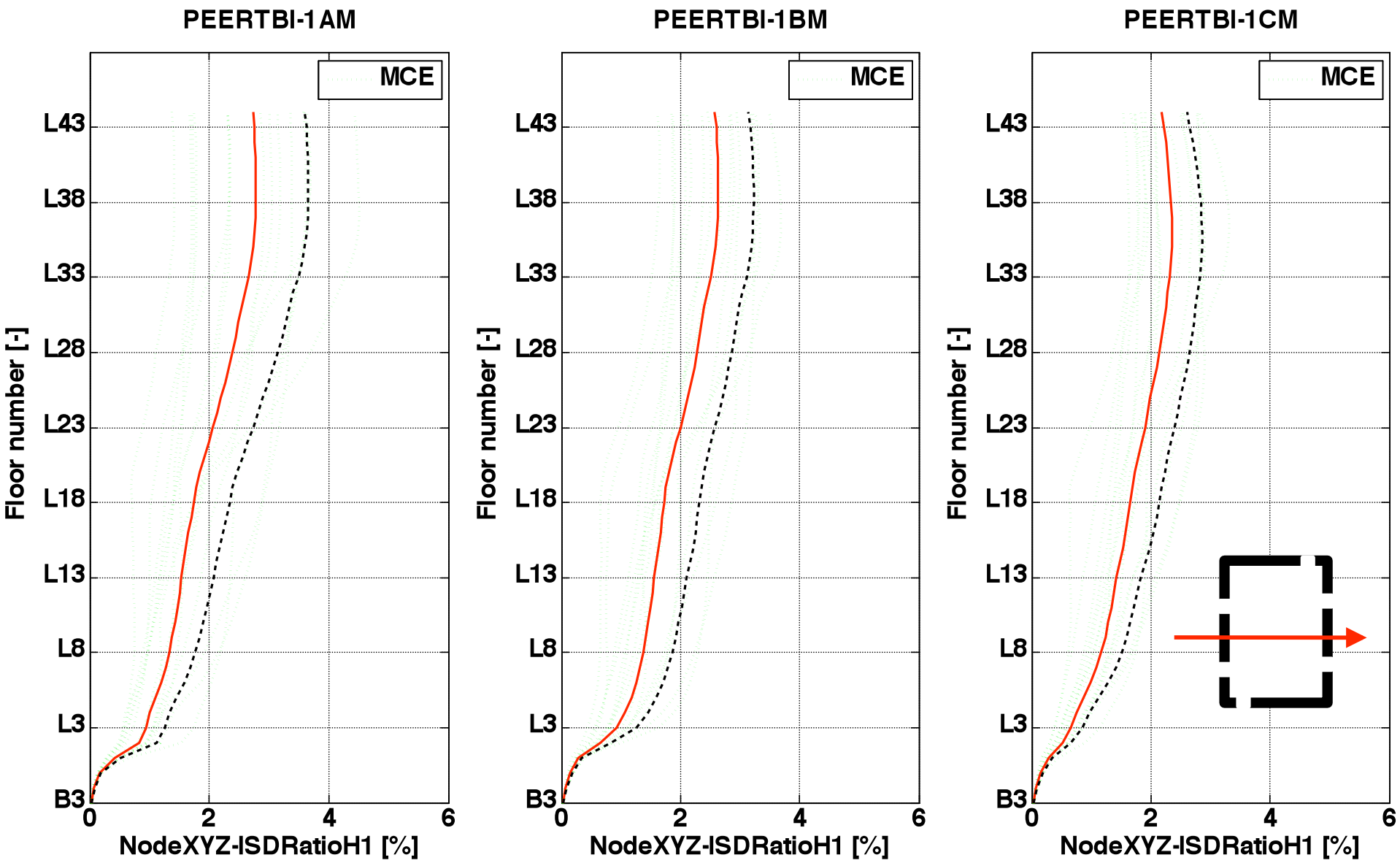
42-Story Concrete Core Wall

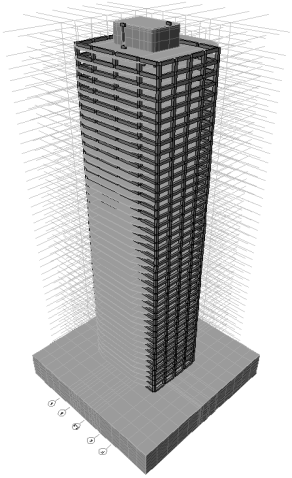


Building Design and Modeling

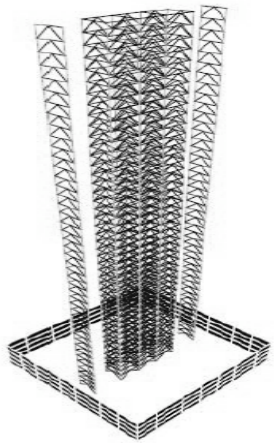
Three Building Systems

42-story reinforced concrete core wall

42-story reinforced concrete dual system



40-story steel special moment-frame



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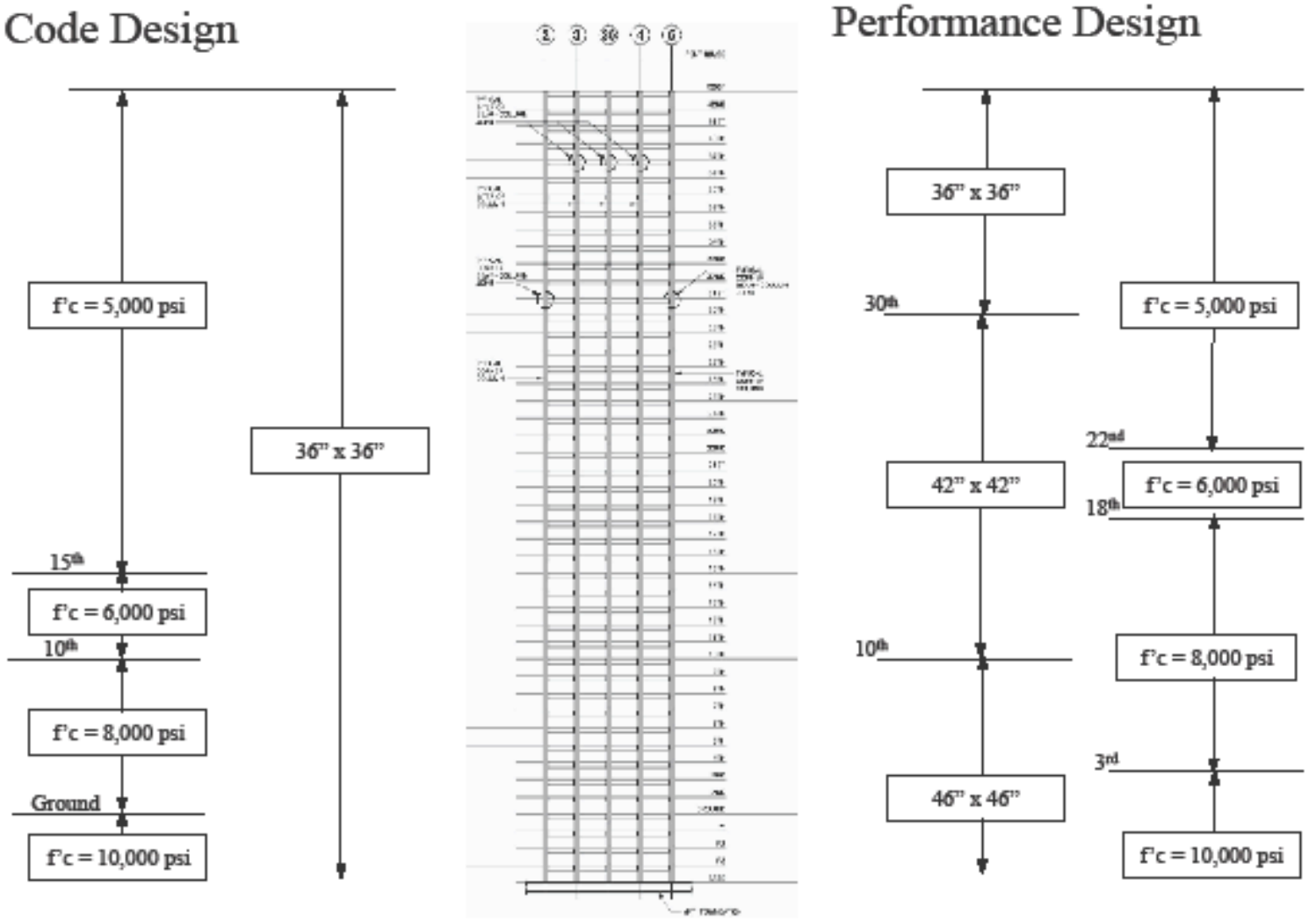
42-Story Concrete Dual System

Corner Column Concrete Strength and Size Comparison



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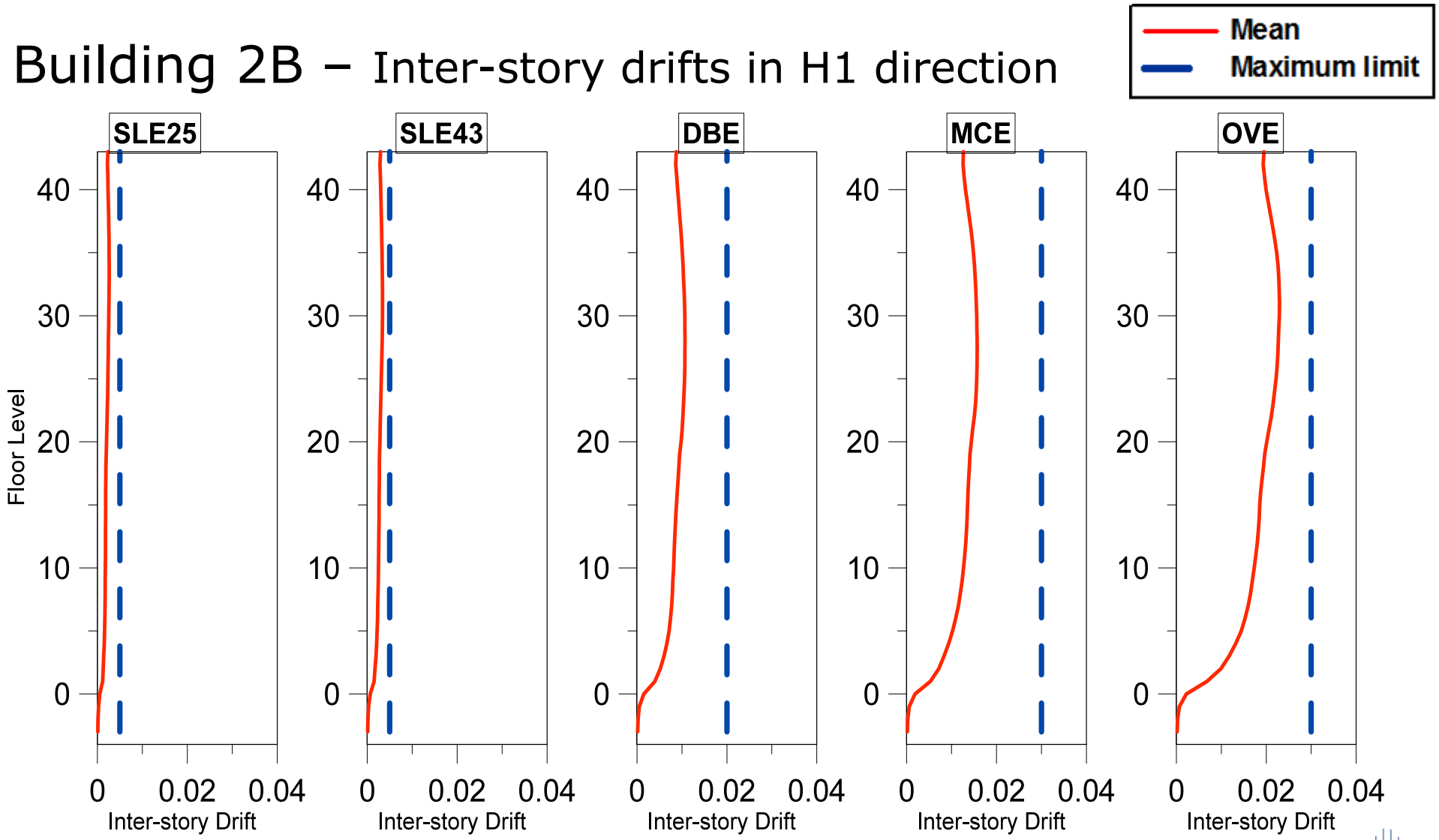
42-Story Concrete Dual System

Building 2B – Inter-story drifts in H1 direction



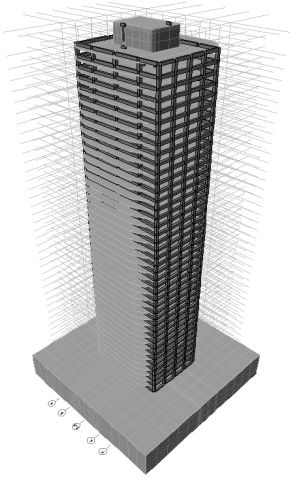
PEER

Building Design and Modeling

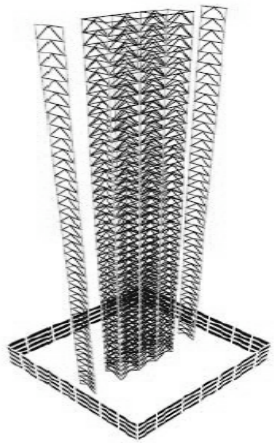
Three Building Systems

42-story reinforced concrete core wall

42-story reinforced concrete dual system



40-story steel special moment-frame



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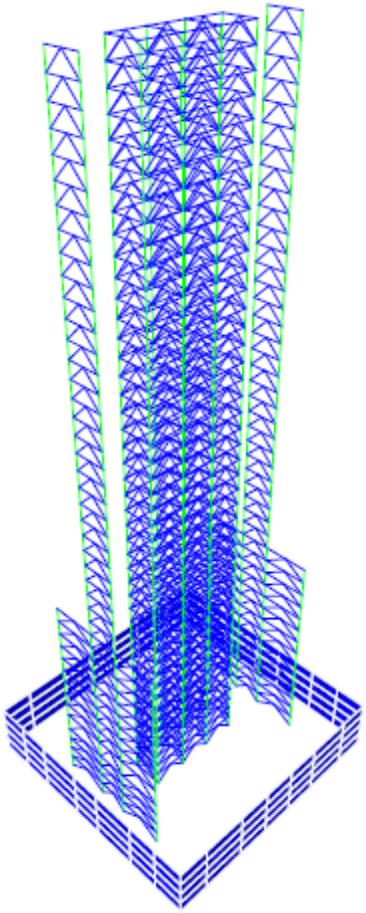
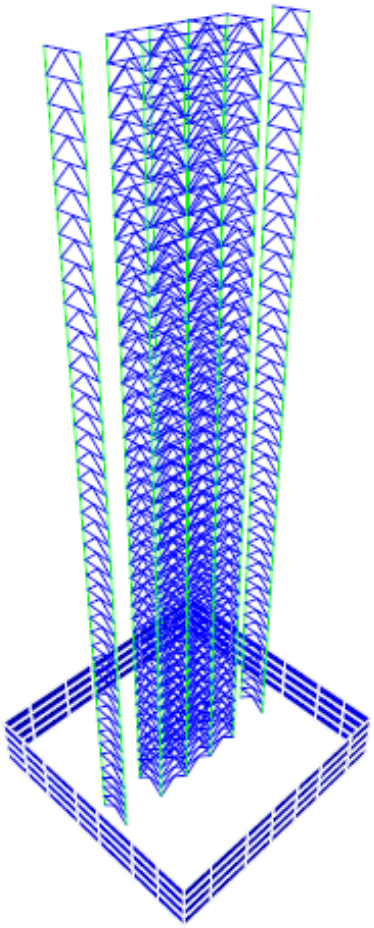
40-Story Buckling Restrained B.F.



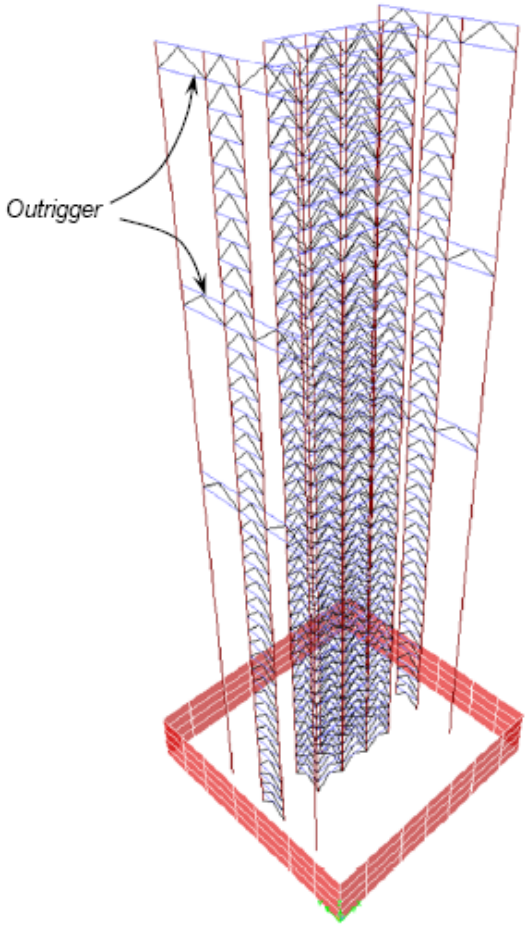
Bldg. 3A

T_{1NS} = 5.3sec



Bldg. 3B

T_{1NS} = 6.5 sec



Bldg. 3C

T_{1NS}= 5.7 sec

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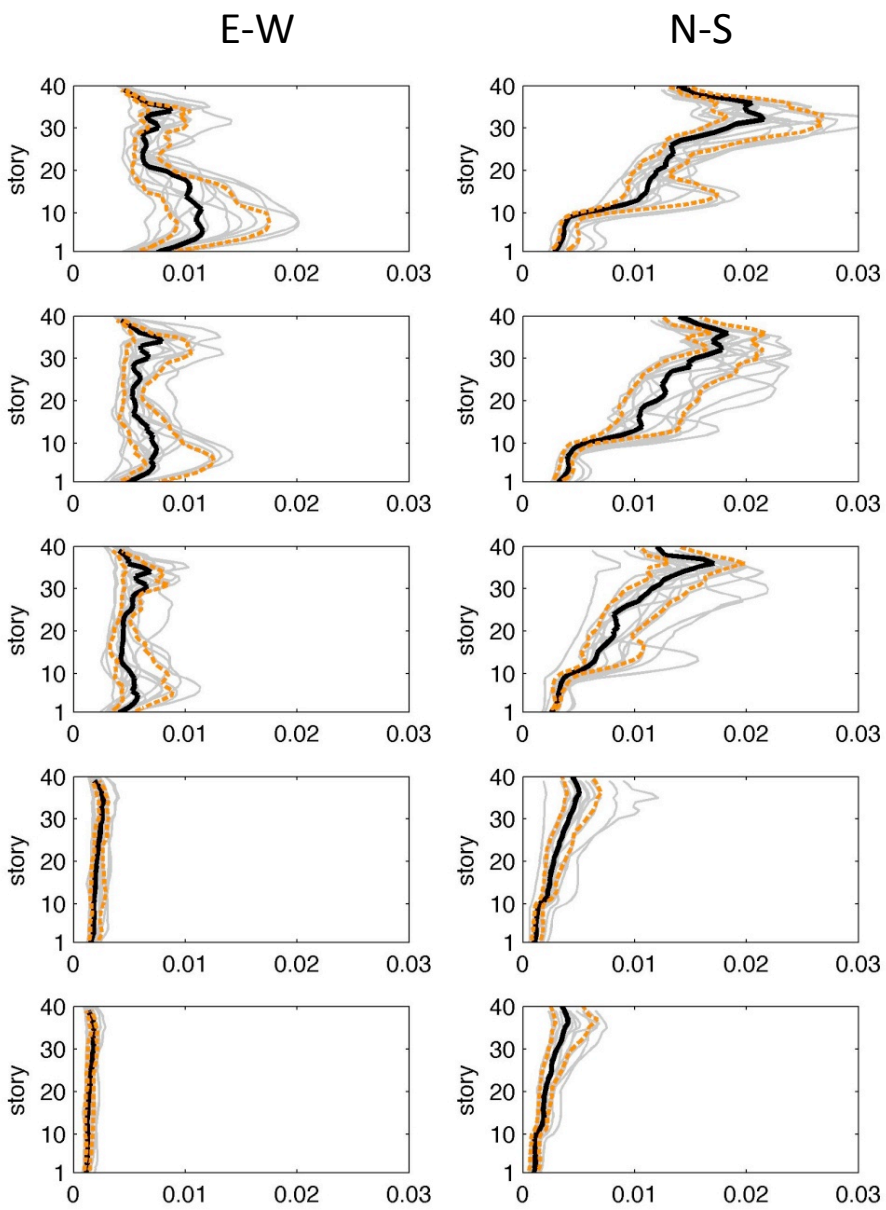
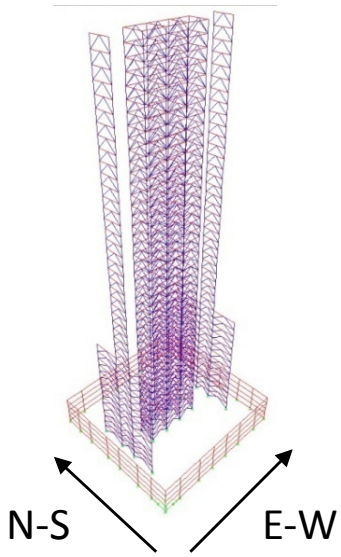
Building 3A

Return Period	GM set
4975 (years)	OVE
2475 (years)	MCE
475 (years)	DBE
43 (years)	SLE43
25 (years)	SLE25



MAXIMUM IDR

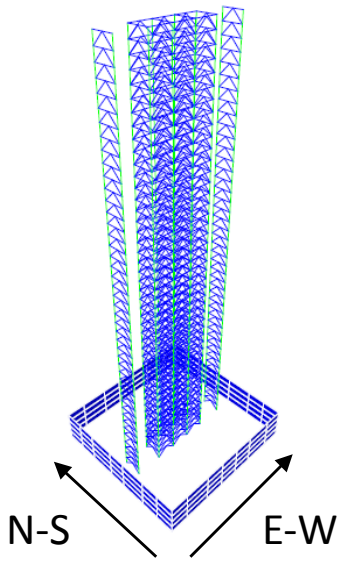


median

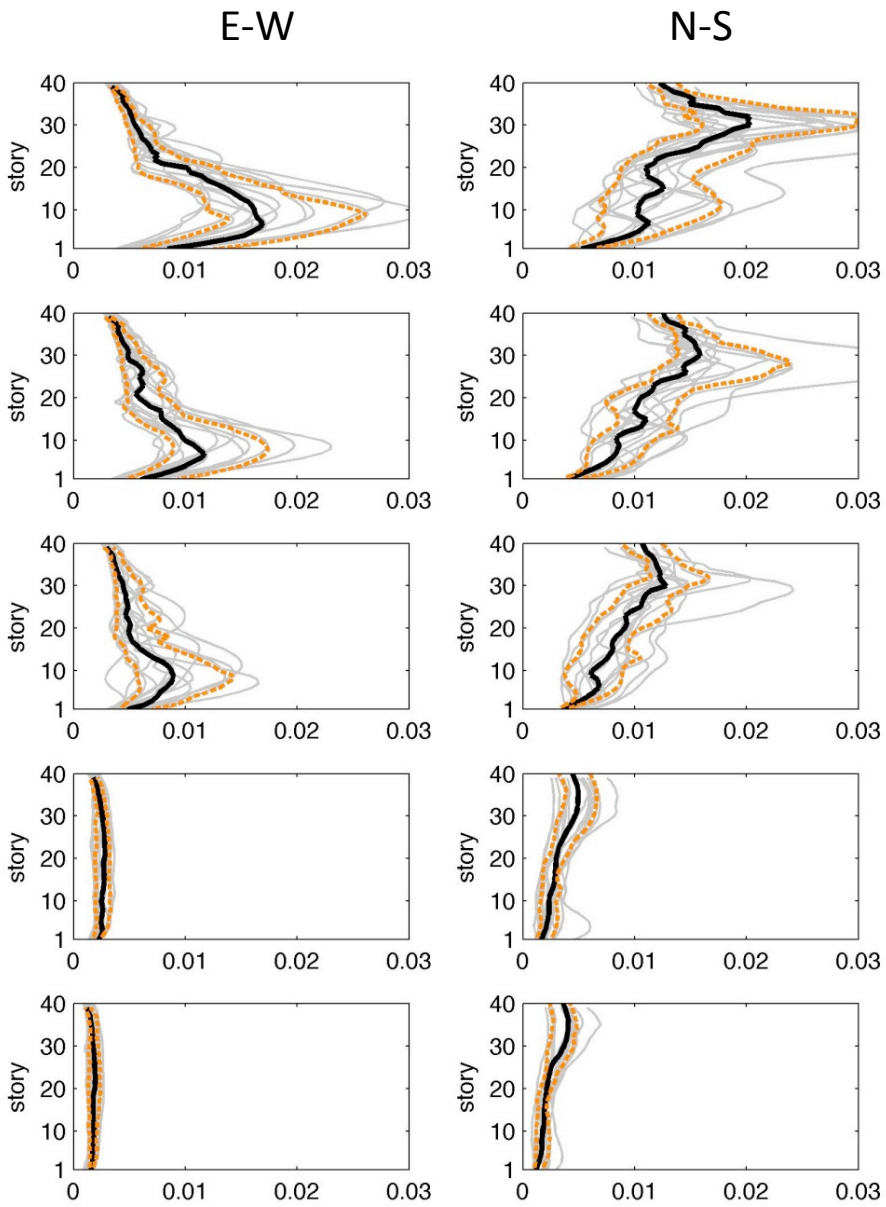
%16th and %84th

Individual earthquake

Building 3B



Return Period	GM set
4975 (years)	OVE
2475 (years)	MCE
475 (years)	DBE
43 (years)	SLE43
25 (years)	SLE25



MAXIMUM IDR

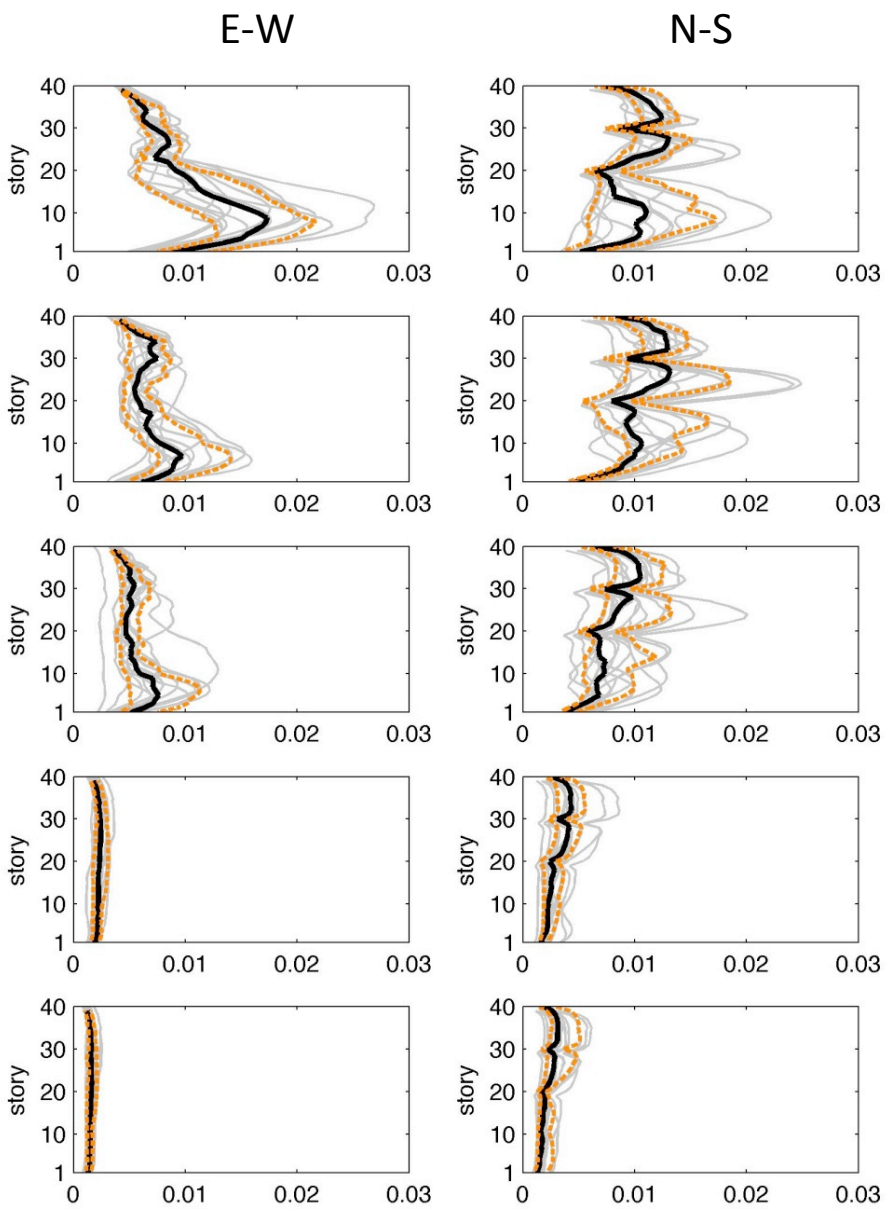
median

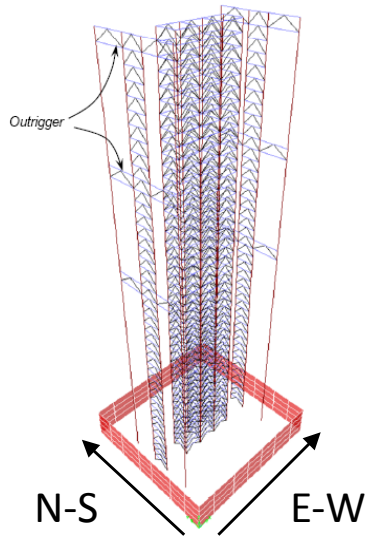
%16th and %84th

Individual earthquake

Building 3C

Return Period	GM set
4975 (years)	OVE
2475 (years)	MCE
475 (years)	DBE
43 (years)	SLE43
25 (years)	SLE25





median

%16th and %84th

Individual earthquake

Cost and Benefit Studies

- Construction Costs
  - Detailed building take-offs
- Loss Calculations
  - Generic approach
    - Conventional loss assessment based on inter-story drift and floor acceleration results
    - Similar components in all buildings.
  - Detailed ATC 58 approach
    - Detailed building inventories
    - Detailed losses based on ATC 58 fragilities and consequence functions

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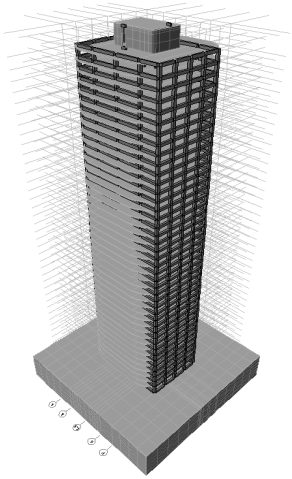
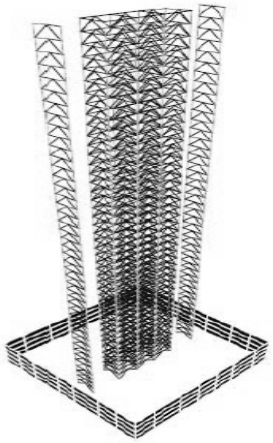
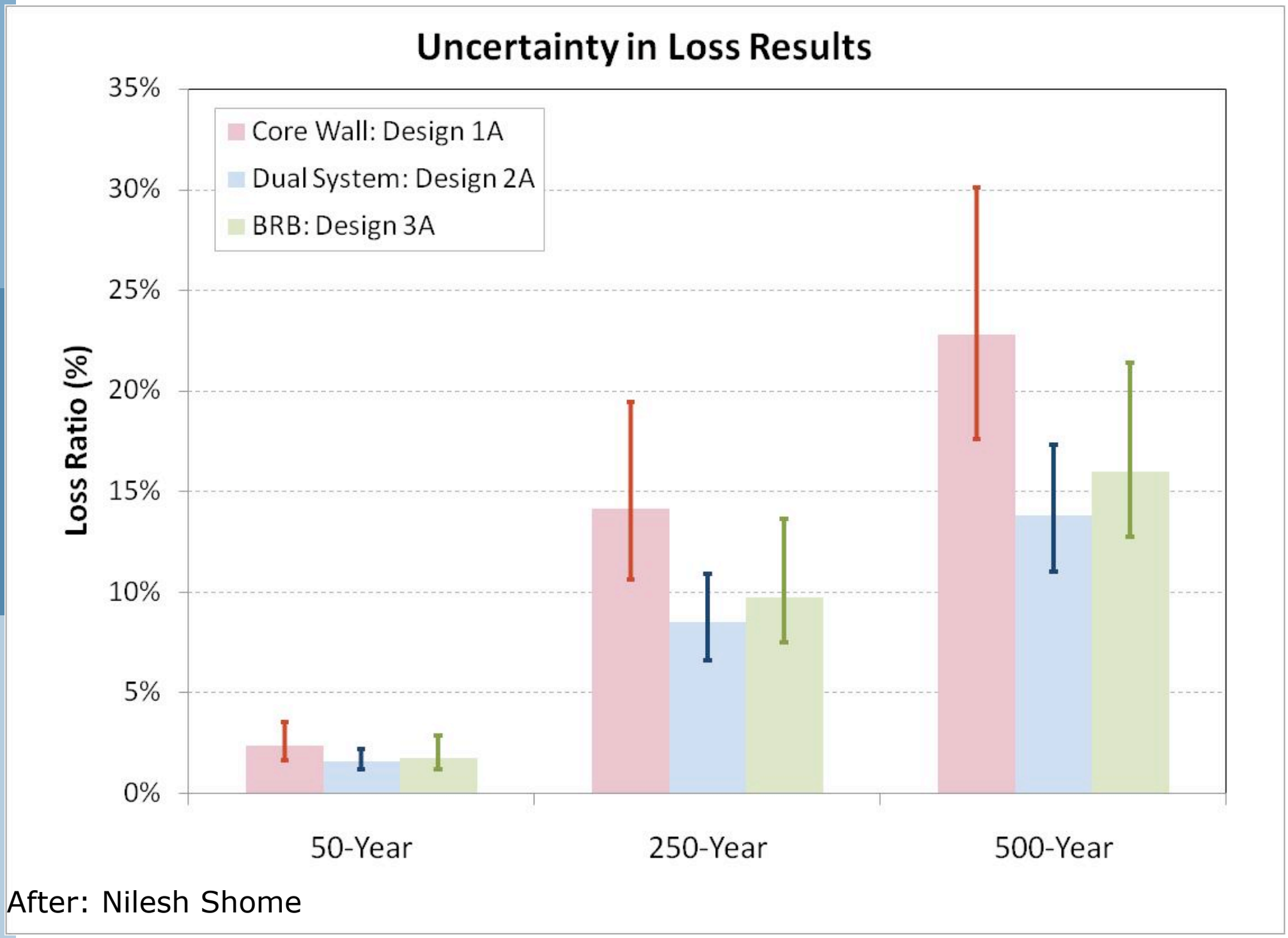
Construction costs (under review)



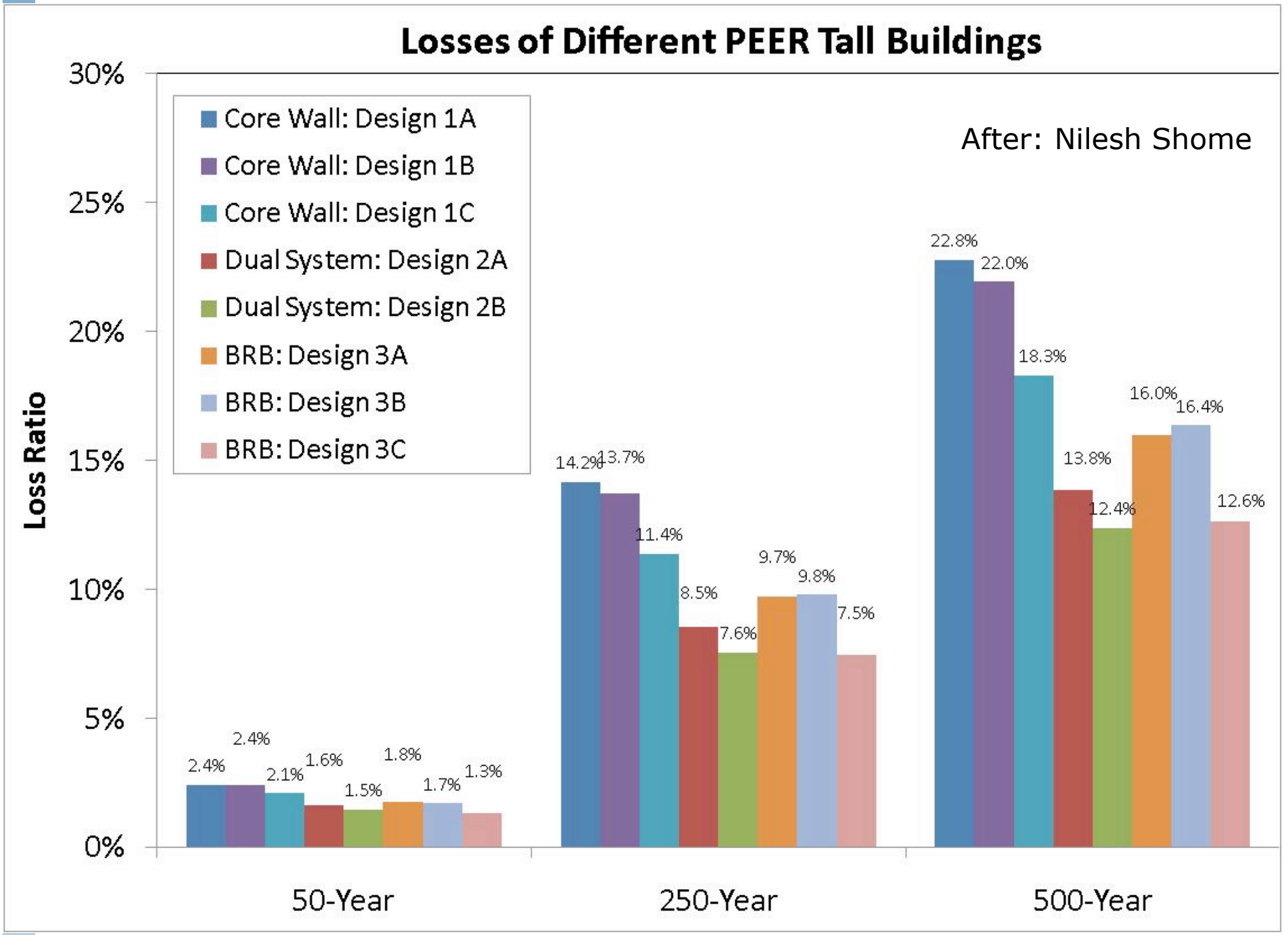


Design	Building 1	Building 2	Building 3
A	$223M	$237M	$355M
B	$222M	$237M	$340M
C	$227M	$237M	$345M

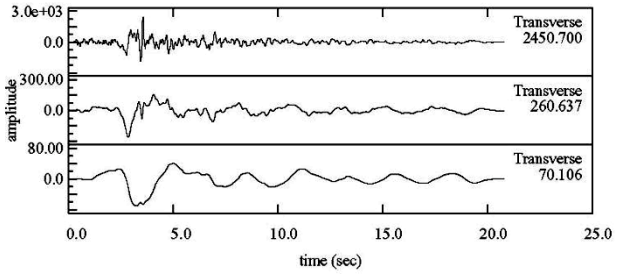
Source: Davis Langdon

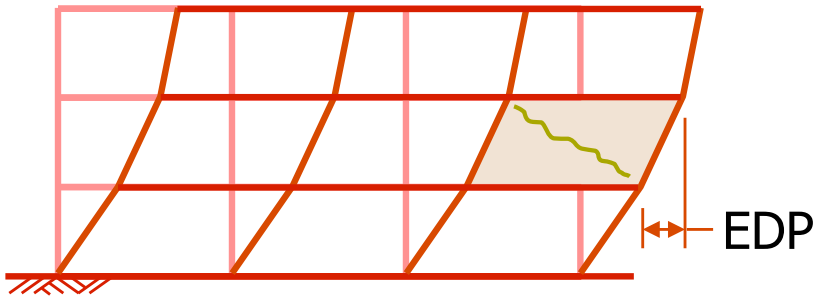


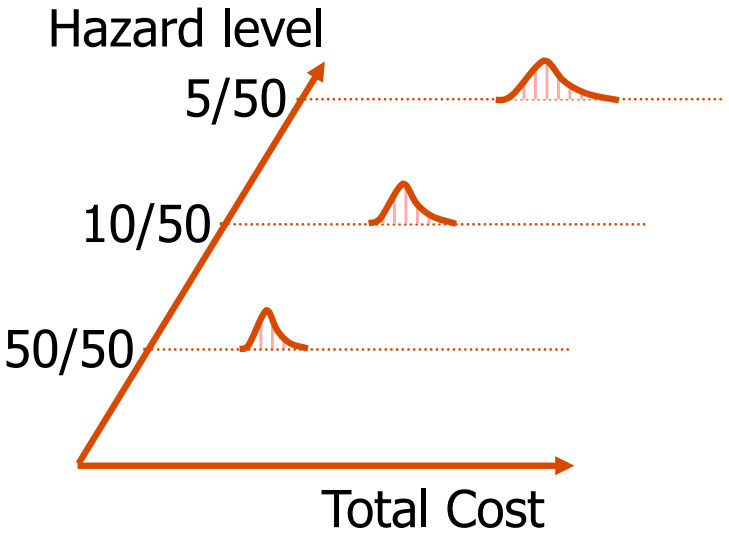
After: Nilesh Shome

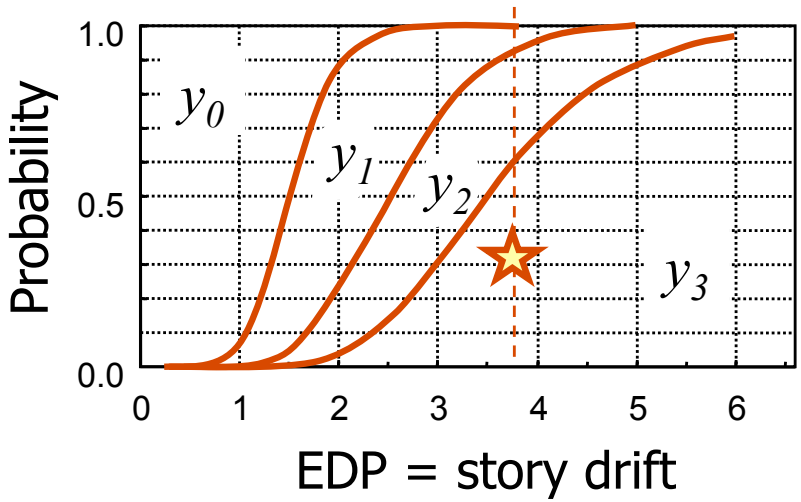

Losses of Different PEER Tall Buildings
After: Nilesh Shome
Loss Ratio
30%
25%
20%
15%
10%
5%
0%
Core Wall: Design 1A
Core Wall: Design 1B
Core Wall: Design 1C
Dual System: Design 2A
Dual System: Design 2B
BRB: Design 3A
BRB: Design 3B
BRB: Design 3C
2.4%
2.4%
2.1%
1.6%
1.5%
1.8%
1.7%
1.3%
14.2%
13.7%
11.4%
8.5%
7.6%
9.7%
9.8%
7.5%
22.8%
22.0%
18.3%
13.8%
12.4%
16.0%
16.4%
12.6%
50-Year
250-Year
500-Year

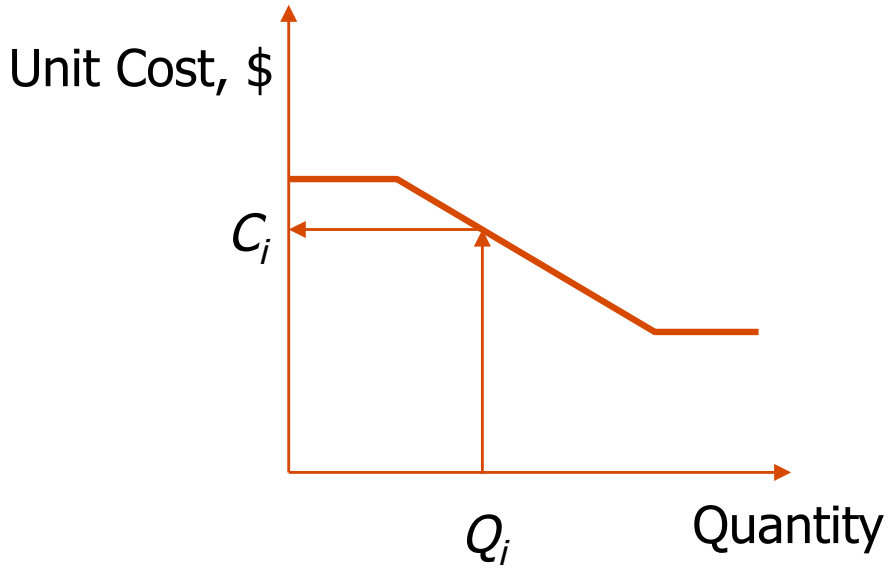
ATC 58 repair costs



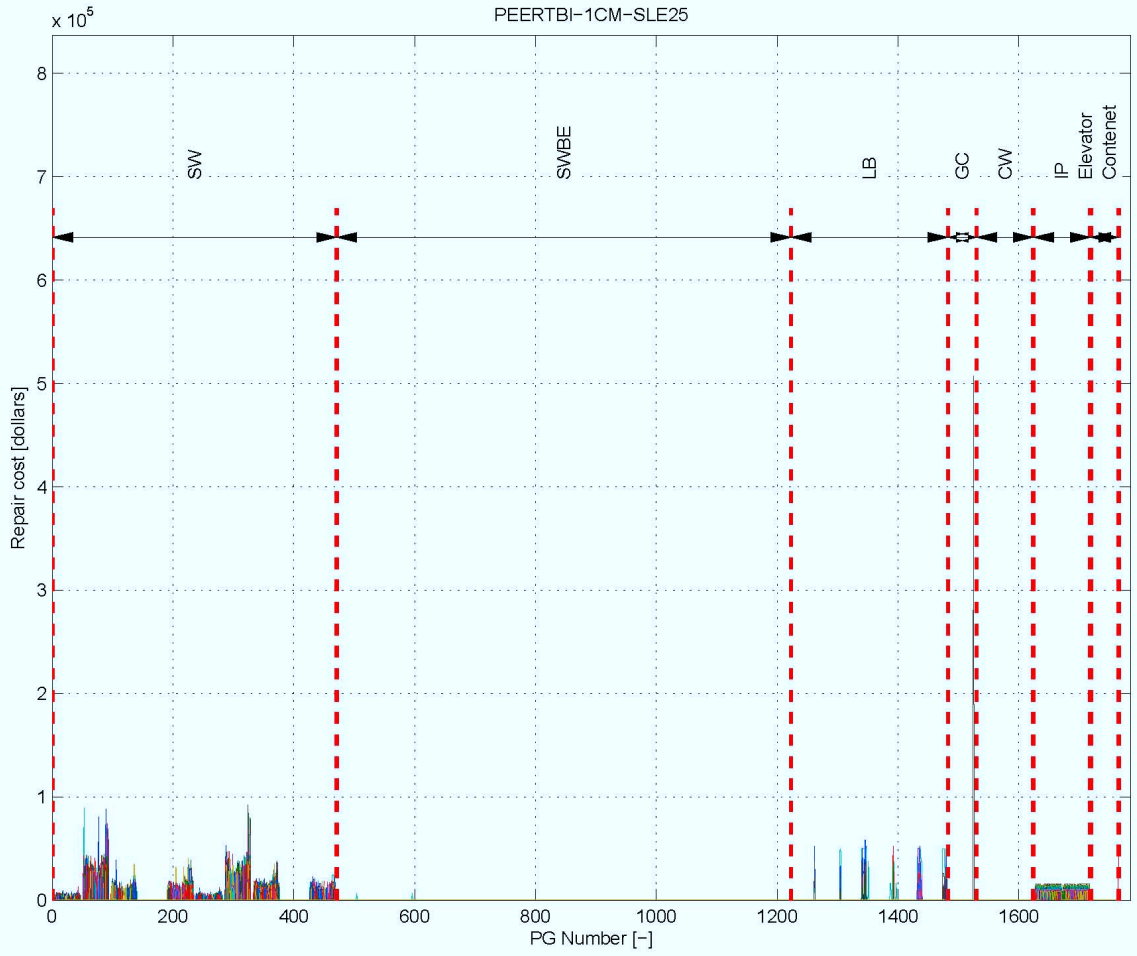








Core Wall – Building 1C – 25yrs



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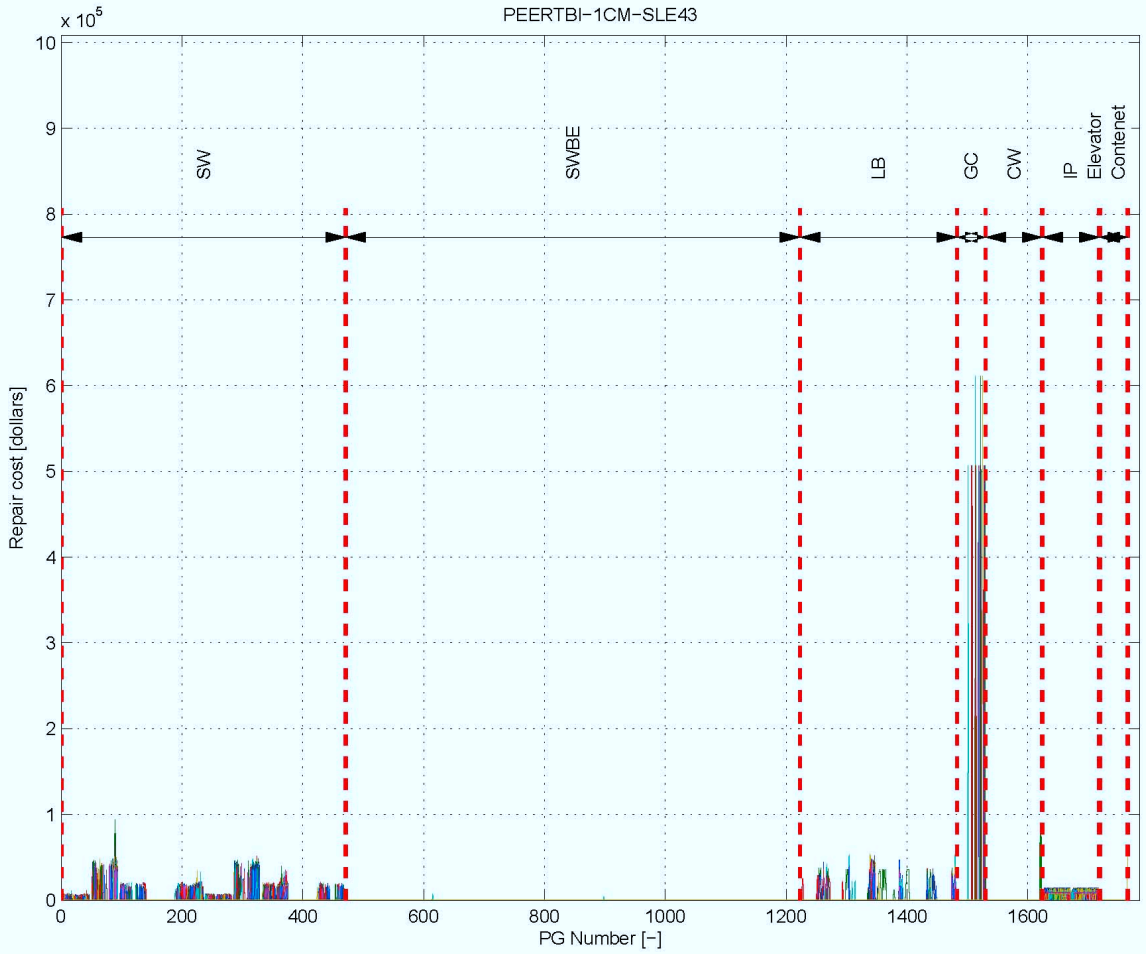
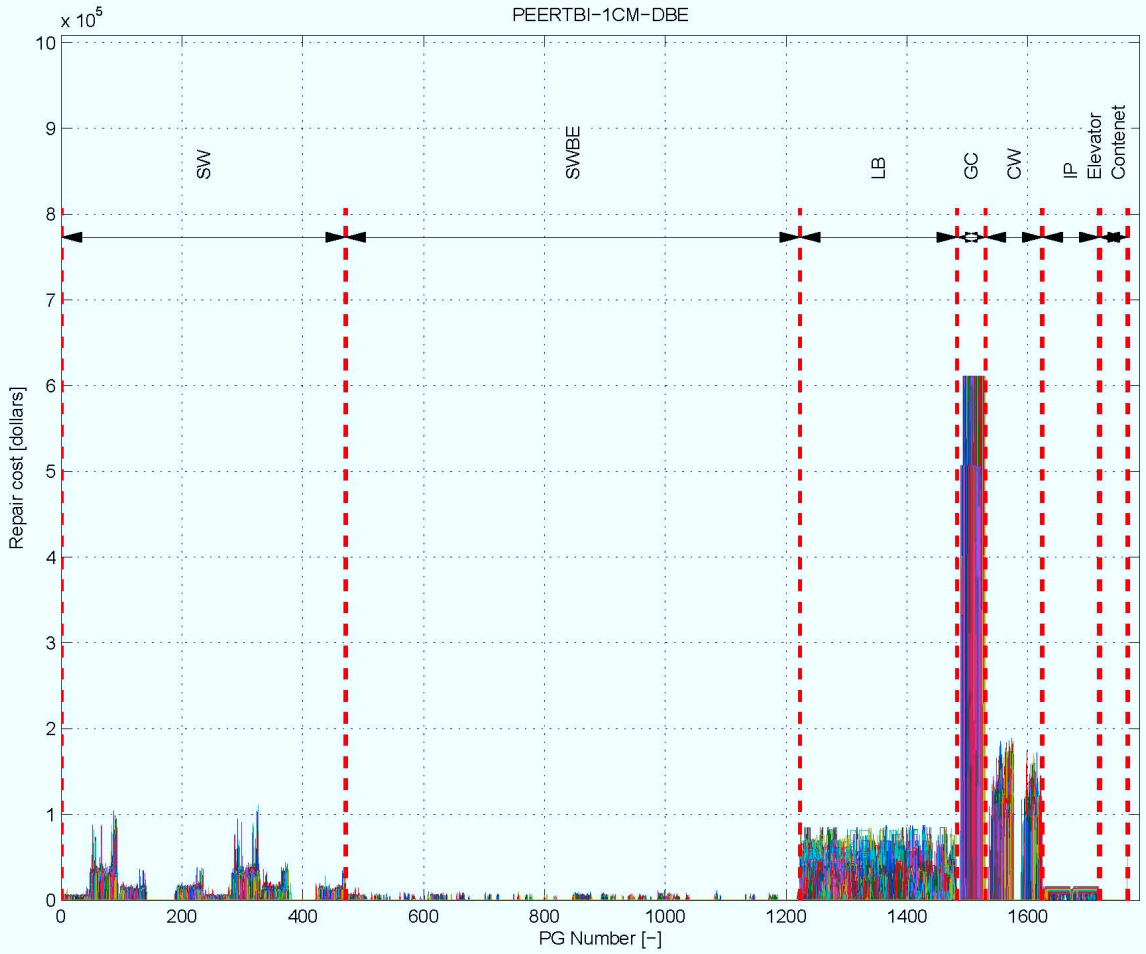
Core Wall – Building 1C – 43yrs



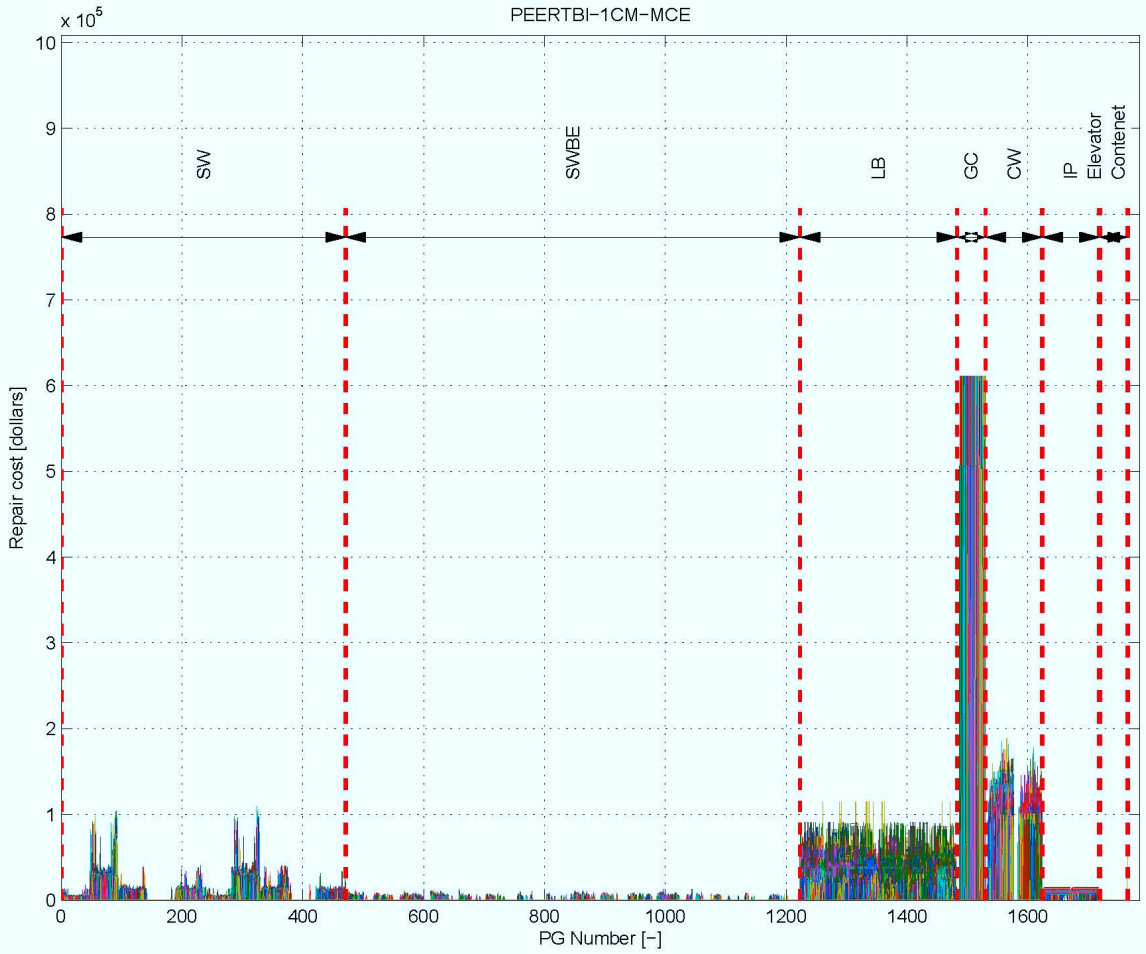
PEER

Core Wall – Building 1C – 475yrs



PEER

Core Wall – Building 1C – 2475yrs



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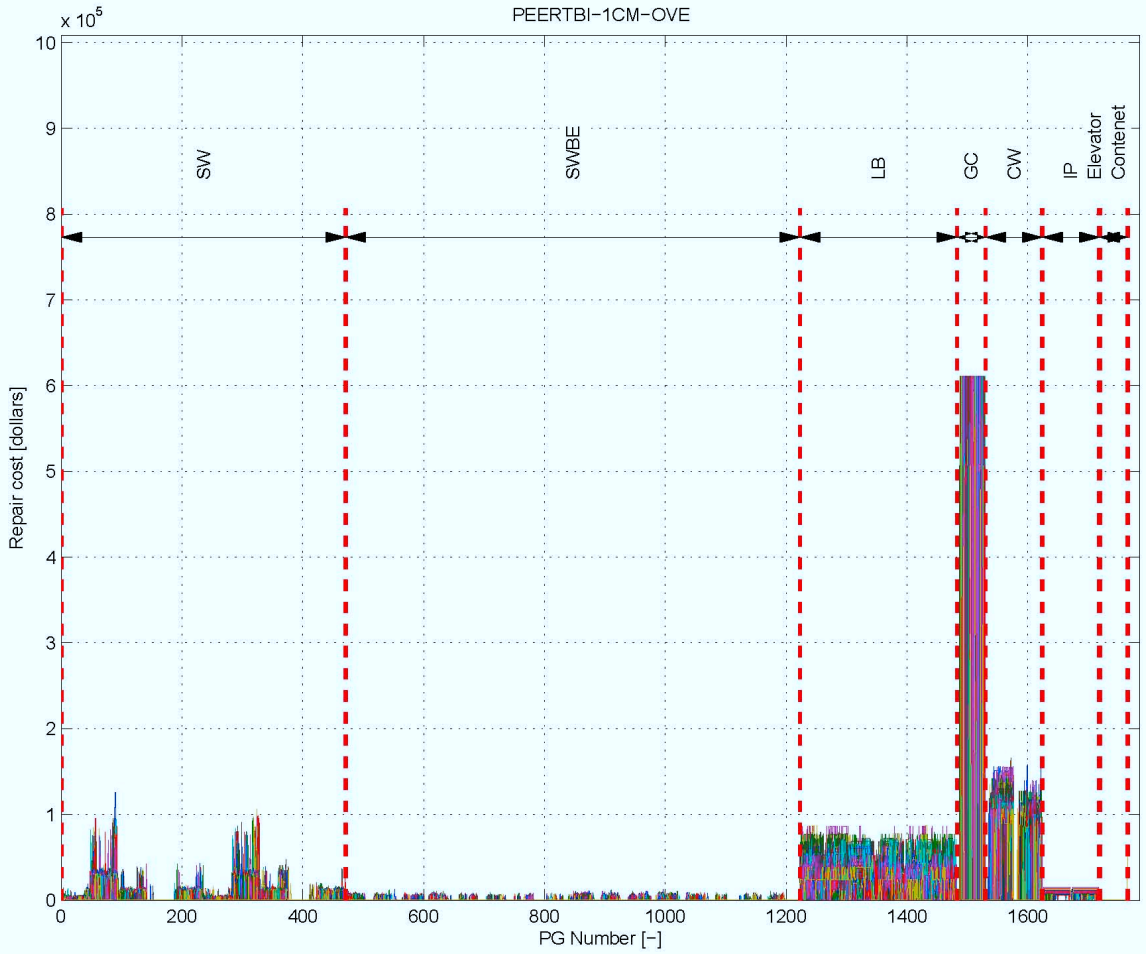
Core Wall – Building 1C – 4975yrs



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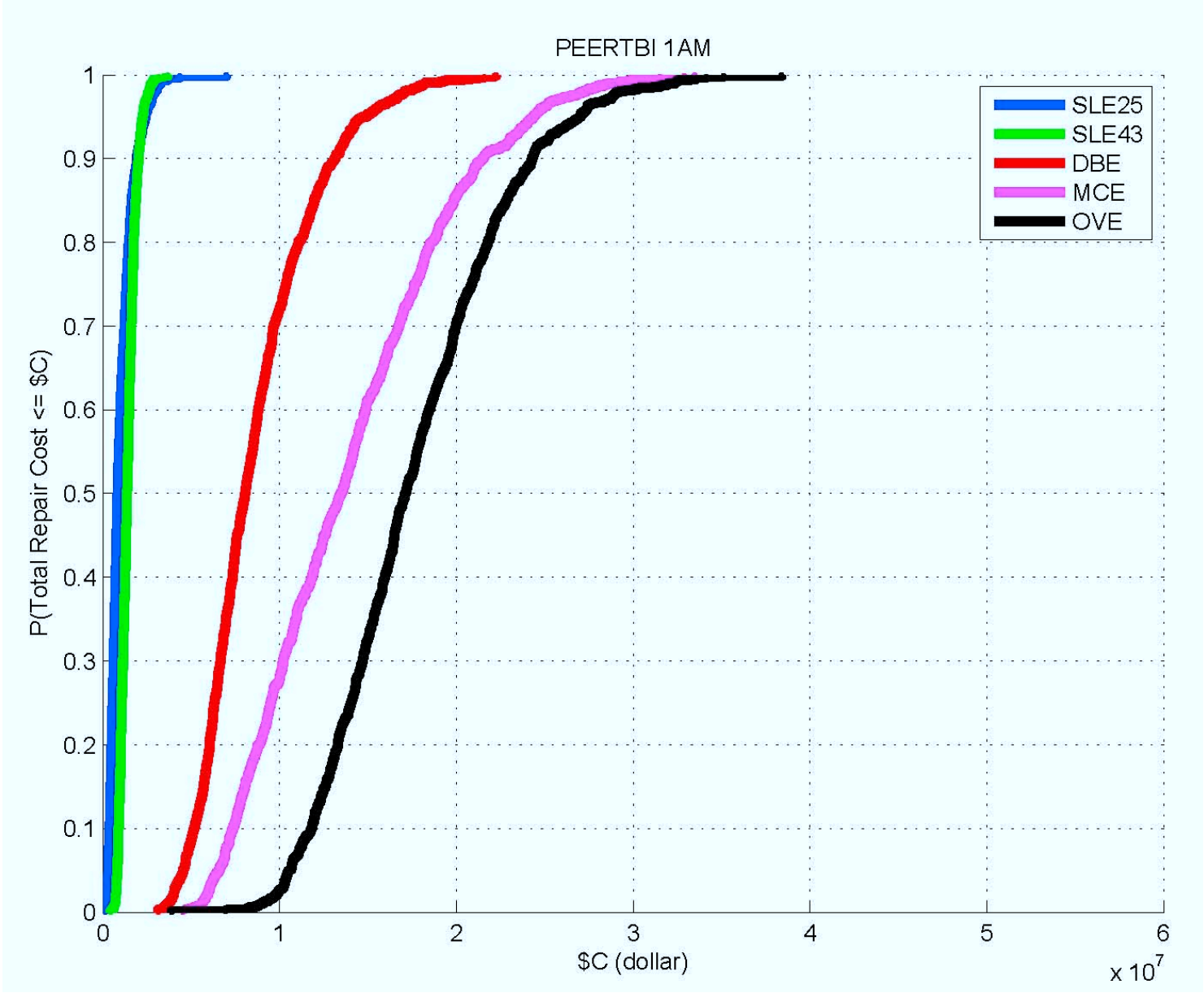
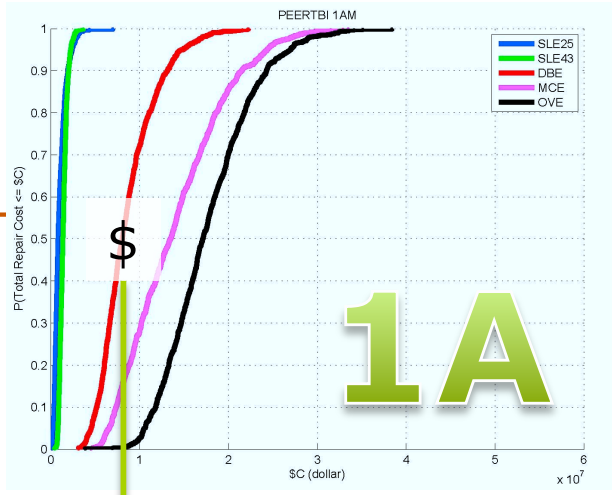
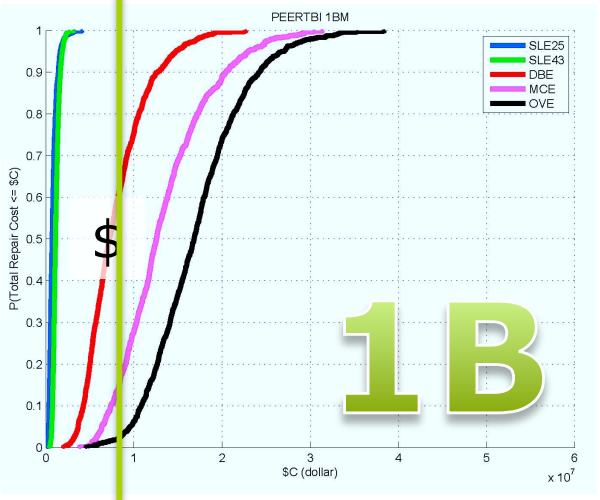
Core Wall – Building 1A

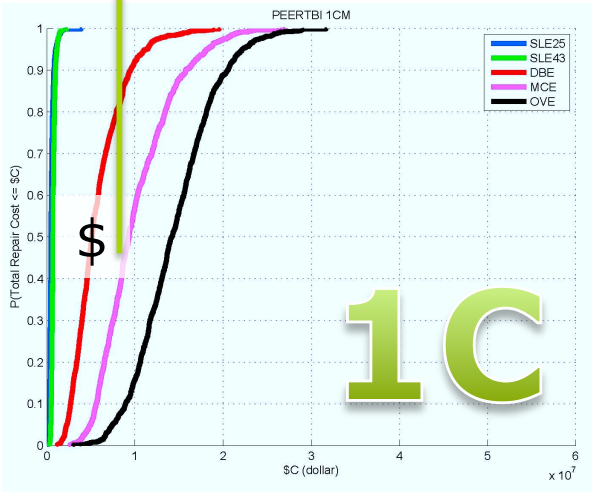


PEER

Core Wall Losses







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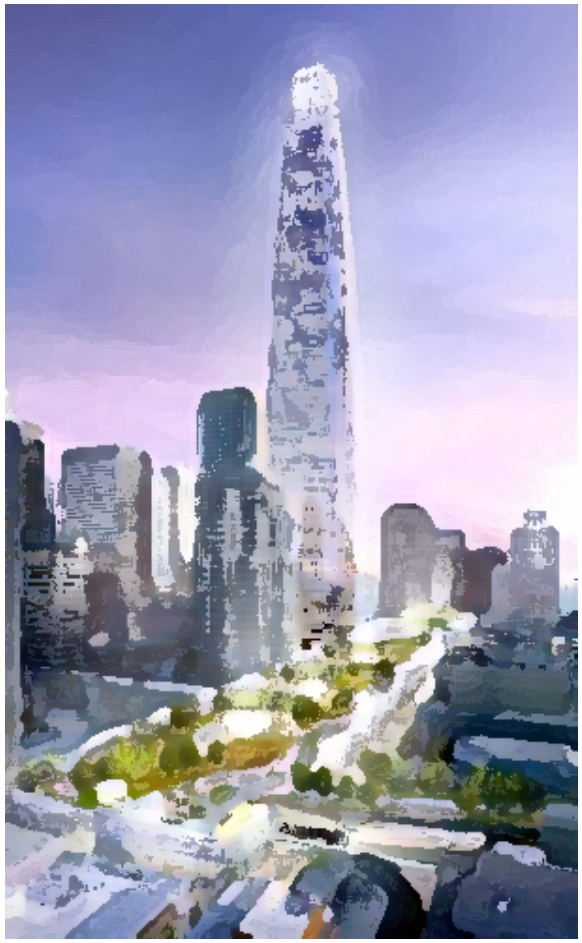

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