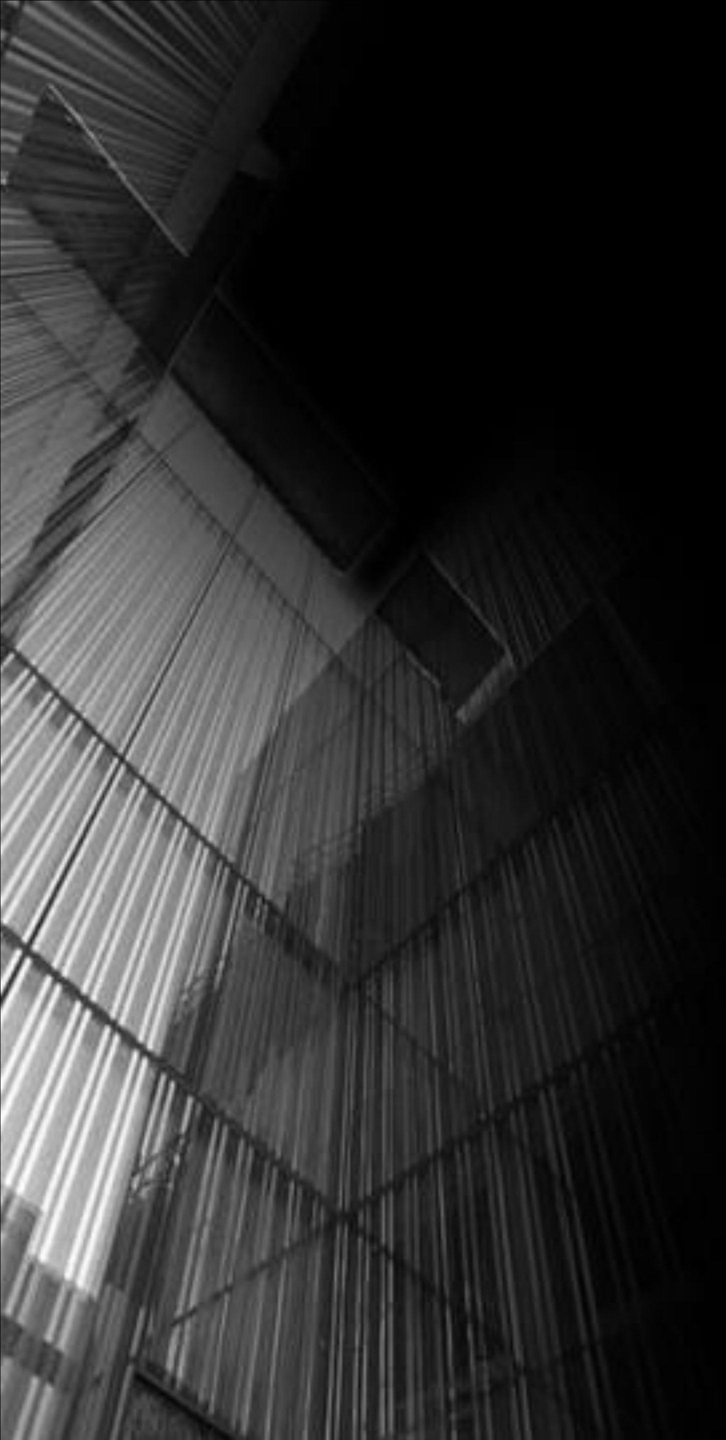

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Trends in Demands for Concrete Performance-Based Seismic Design Towers

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DESIGNING THINGS

REDESIGNING THINGS

Outline

- Introduction
- Motivation
- Database
- Results
- Case Study
- Conclusions
- Questions

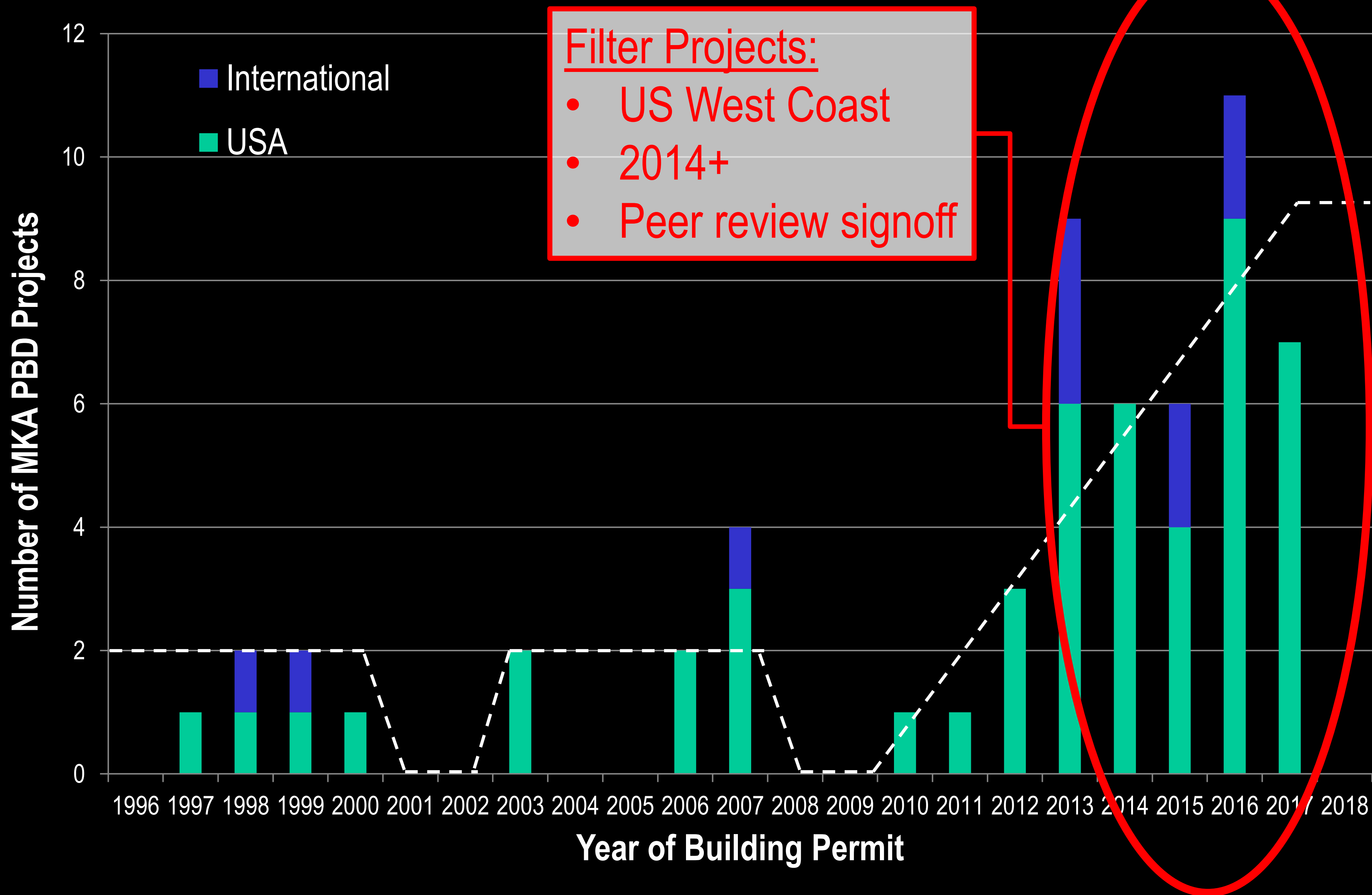
Introduction

- Performance-based Seismic Design
  - 20-year history
  - Popularity
  - Major benefits
- Drawback: uncertainty

Motivation

- Design for DE/SLE alone is inadequate
  - What else can we do early in project?
- Improve estimation of MCE response using DE/SLE demands
  - Best way to reduce uncertainty
  - Eliminate design by “trial and error”
  - Make MCE truly a “verification” stage
- Large project database

PBSD Project History



Database

- Number of buildings: 14
- Height: 295’ to 605’ (average 450’)
- Locations: Seattle, San Francisco, Los Angeles
- Building use: Residential, Office, Hotel
- Site class: C or D
- Ground motions: split between CMS/not CMS, 7 vs. 11, and spectrally matched or amplitude scaled

Database

- For each building, calculate MCE/DE and MCE/SLE results (base shear and moment)
- Example: Building 1, Base Shear
  - MCE_x = 20,400 kips MCE_y = 13,850 kips
  - SLE_x = 4,450 kips SLE_y = 3,400 kips
  - MCE_x/SLE_x = 20,400/4,450 = 4.58
  - MCE_y/SLE_y = 13,850/3,400 = 4.07
  - MCE/SLE = ½ (4.58 + 4.07) = 4.33

Database

Seismic Base Shear Results

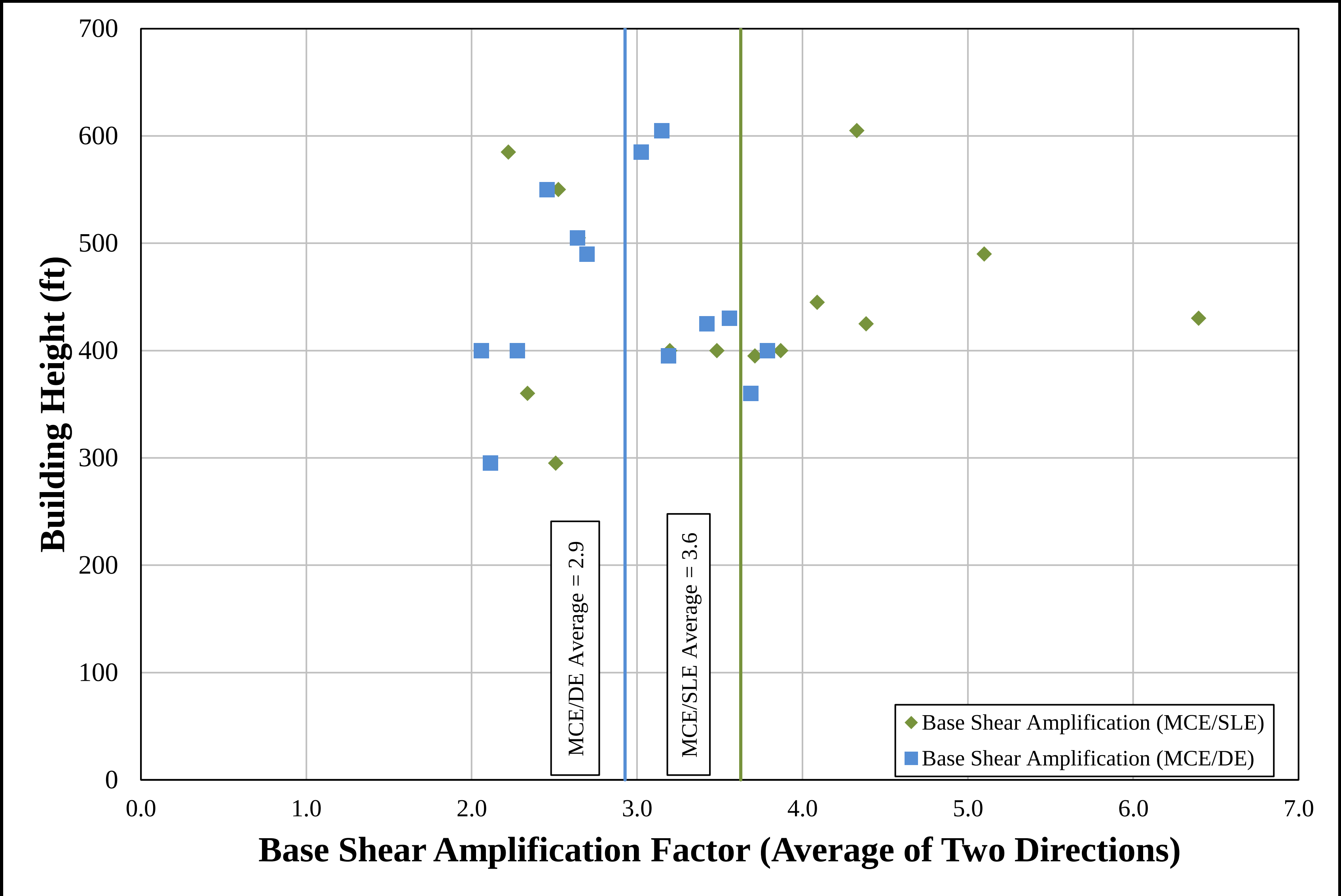
Bldg No.	Approx. Bldg Ht (ft)	Primary Use	Base Shear (k)					
			SLE (x)	SLE (y)	DE (x)	DE (y)	MCE (x)	MCE (y)
1	605	Office	4,450	3,400	5,650	5,150	20,400	13,850
2	395	Residential	3,750	3,050	3,950	3,950	13,700	11,500
3	400	Residential	2,100	2,100	3,950	3,950	7,400	8,850
4	445	Residential	4,400	5,950	--	--	20,750	20,600
5	400	Residential	2,850	3,200	4,250	4,250	9,050	10,300
6	490	Hotel	4,950	3,300	7,600	7,600	22,050	18,950
7	360	Residential	5,850	4,900	3,450	3,450	15,650	9,800
8	400	Residential	2,900	3,500	2,950	2,950	9,800	12,550
9	295	Office	2,950	2,950	3,500	3,500	6,600	8,200
10	505	Residential	5,800	5,250	5,650	5,400	14,650	14,500
11	425	Residential	2,950	2,100	3,200	3,200	12,100	9,800
12	585	Office	12,850	9,500	8,200	8,150	28,000	21,500
13	550	Residential	6,050	5,700	6,050	6,050	15,950	13,750
14	430	Residential	900	1,100	3,000	3,000	17,000	15,800

Database

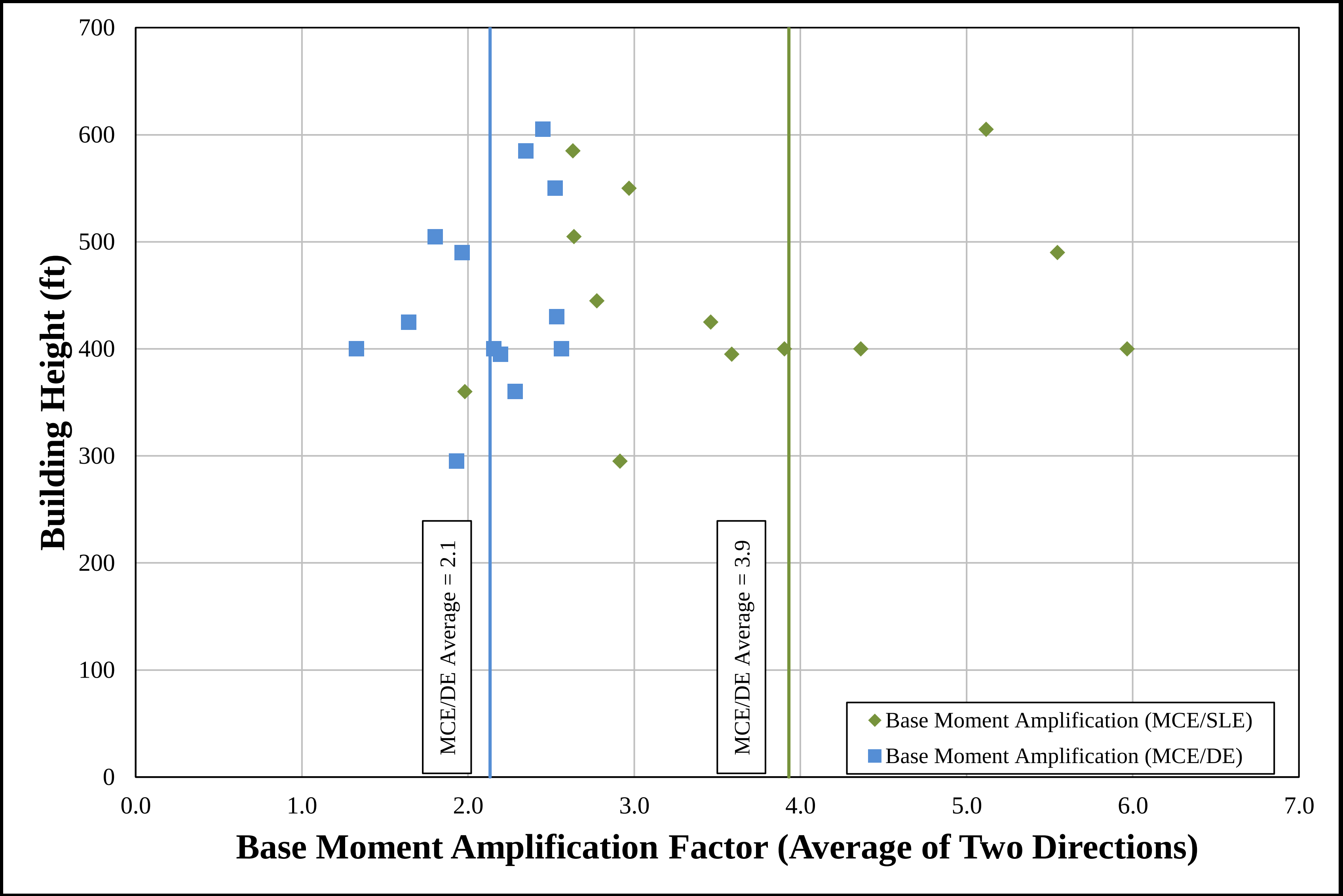
Seismic Base Shear Results

Bldg No.	Approx. Bldg Ht (ft)	Primary Use	Overturning Moment (10^3 k-ft)					
			SLE (x)	SLE (y)	DE (x)	DE (y)	MCE (x)	MCE (y)
1	605	Office	345	701	815	1,244	2,139	2,831
2	395	Residential	282	324	489	489	1,208	936
3	400	Residential	190	137	657	705	683	1,141
4	445	Residential	846	746	--	--	2,571	1,870
5	400	Residential	387	477	870	900	1,416	2,414
6	490	Hotel	621	286	1,377	1,090	3,361	1,622
7	360	Residential	963	531	686	606	2,000	1,000
8	400	Residential	236	265	385	380	900	1,059
9	295	Office	240	333	355	515	750	900
10	505	Residential	778	880	1,231	1,164	2,414	1,911
11	425	Residential	185	290	475	525	610	1,050
12	585	Office	1,212	1,210	1,285	1,436	3,166	3,203
13	550	Residential	753	738	846	902	1,985	2,436
14	430	Residential	120	110	400	320	1,200	1,200

Results – Base Shear



Results – Base Moment

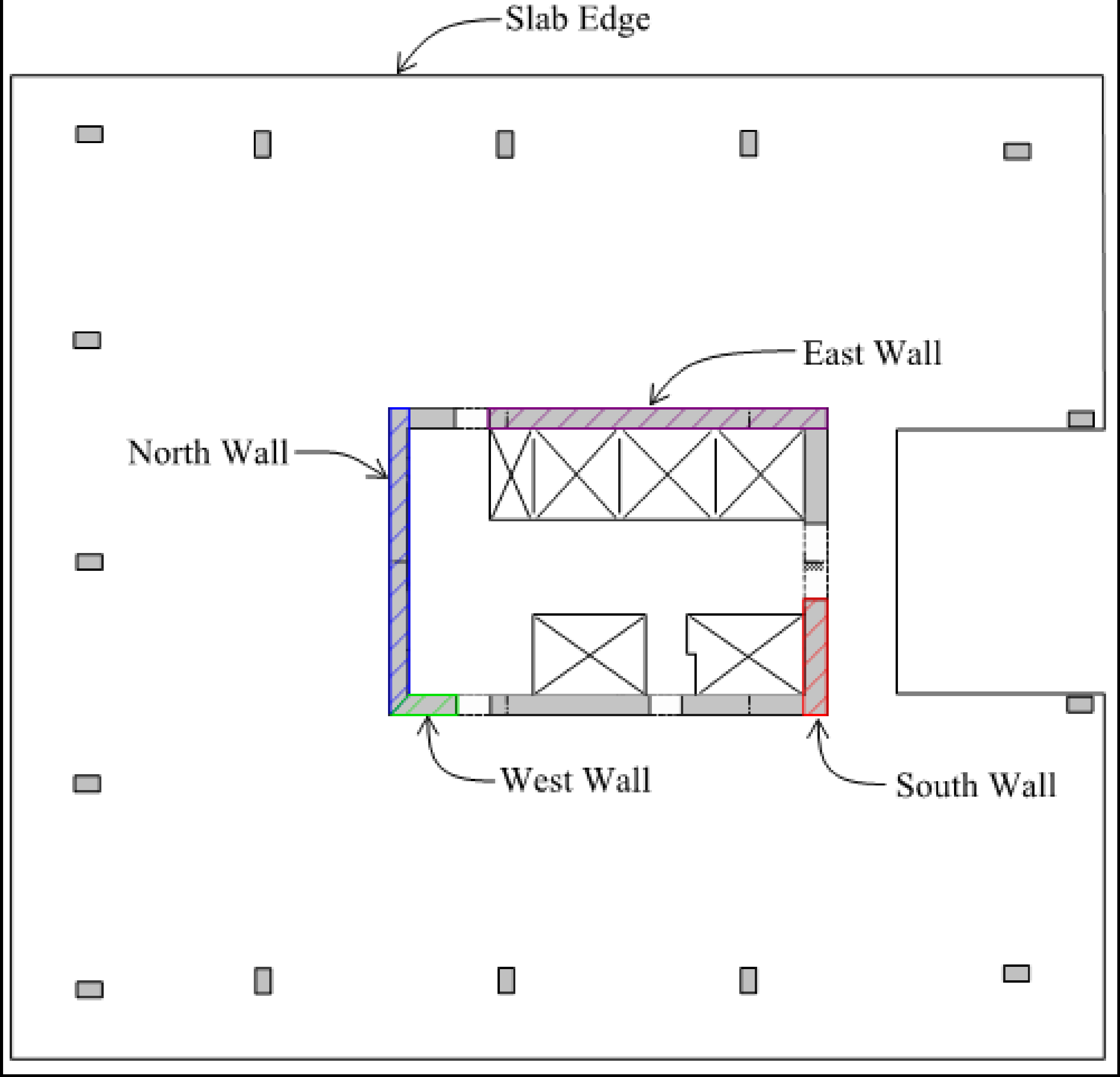


Case Study

- Does the amplification factor at the building's base apply for the full height of the building?
- Variation due to:
  - Localized yielding
  - Relative stiffness
  - Higher mode effects
  - Spectral shape
  - Boundary conditions
  - Damping

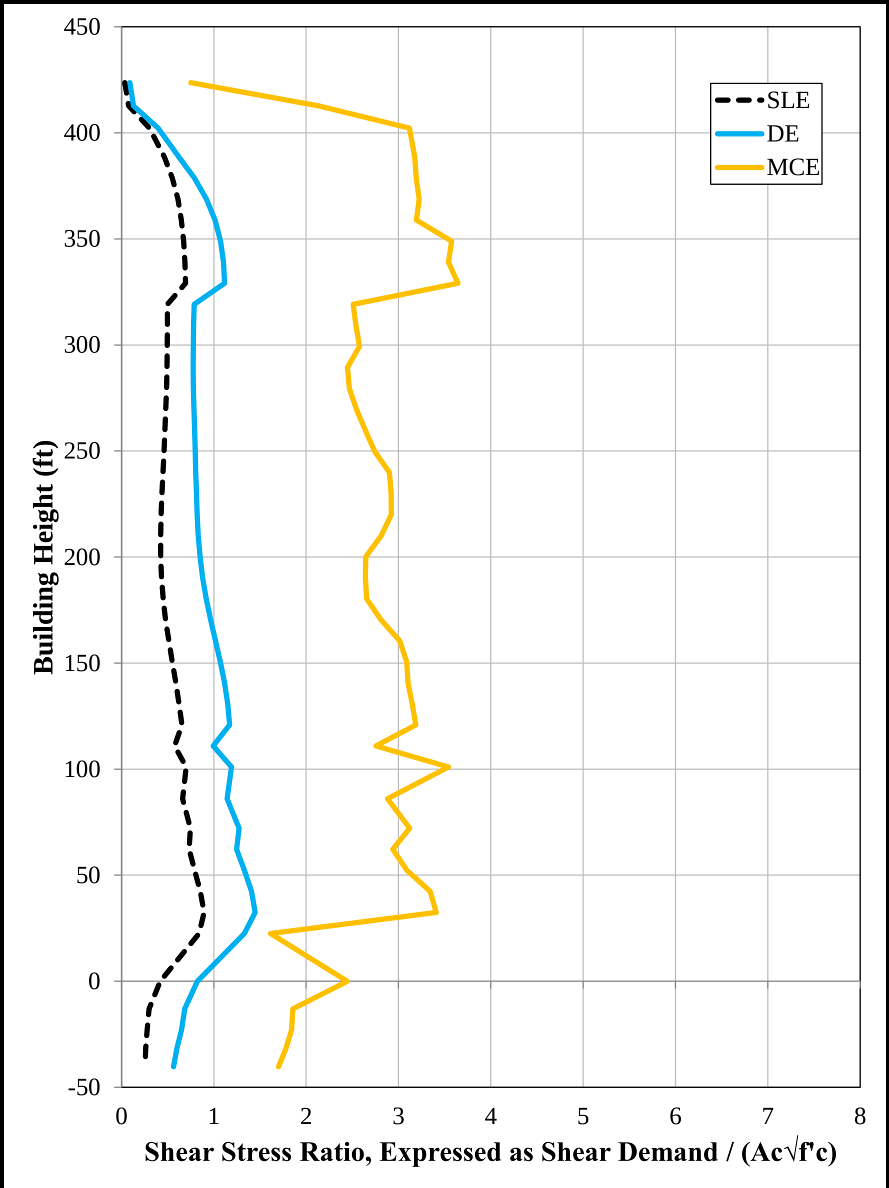
Case Study

- **Sample building:**
  - 40-story residential building
  - US west coast
  - Central concrete core wall
  - 5-level basement

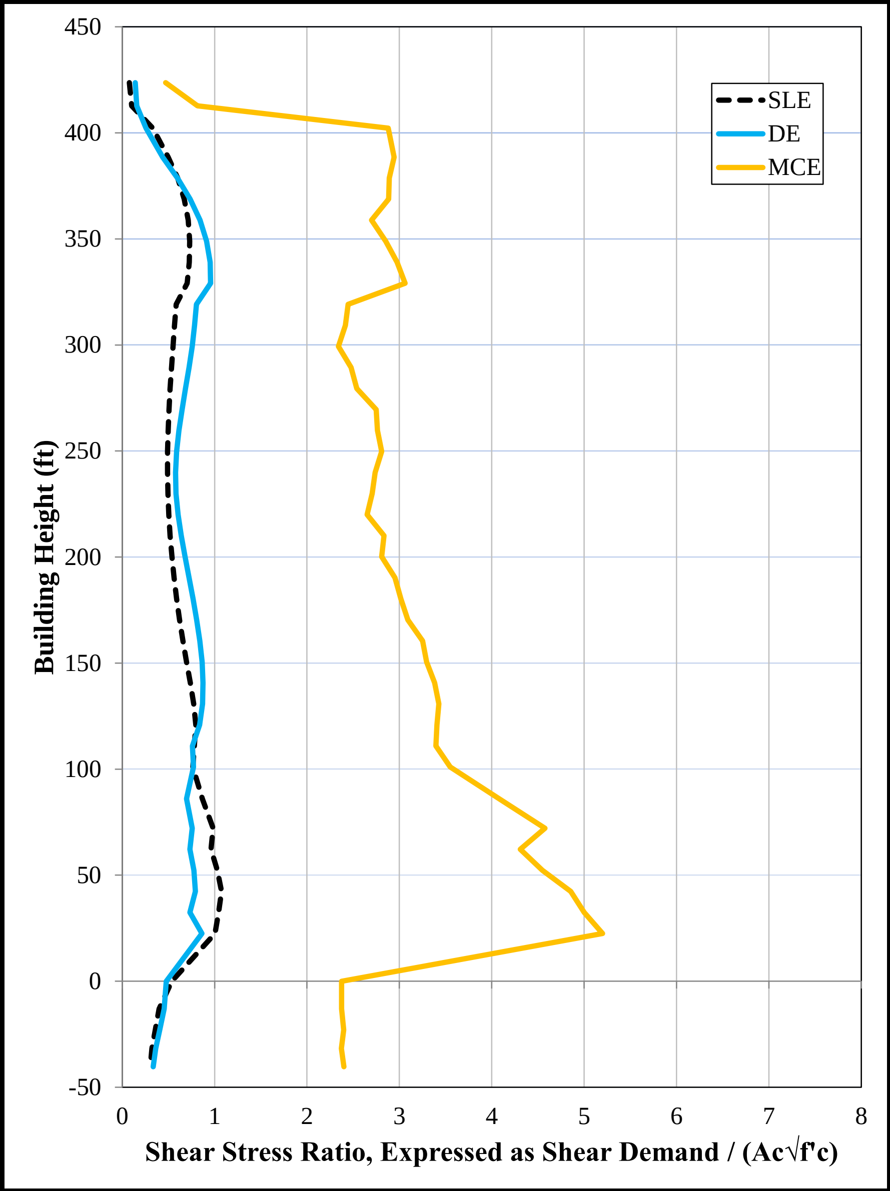


Slab Edge
East Wall
North Wall
West Wall
South Wall

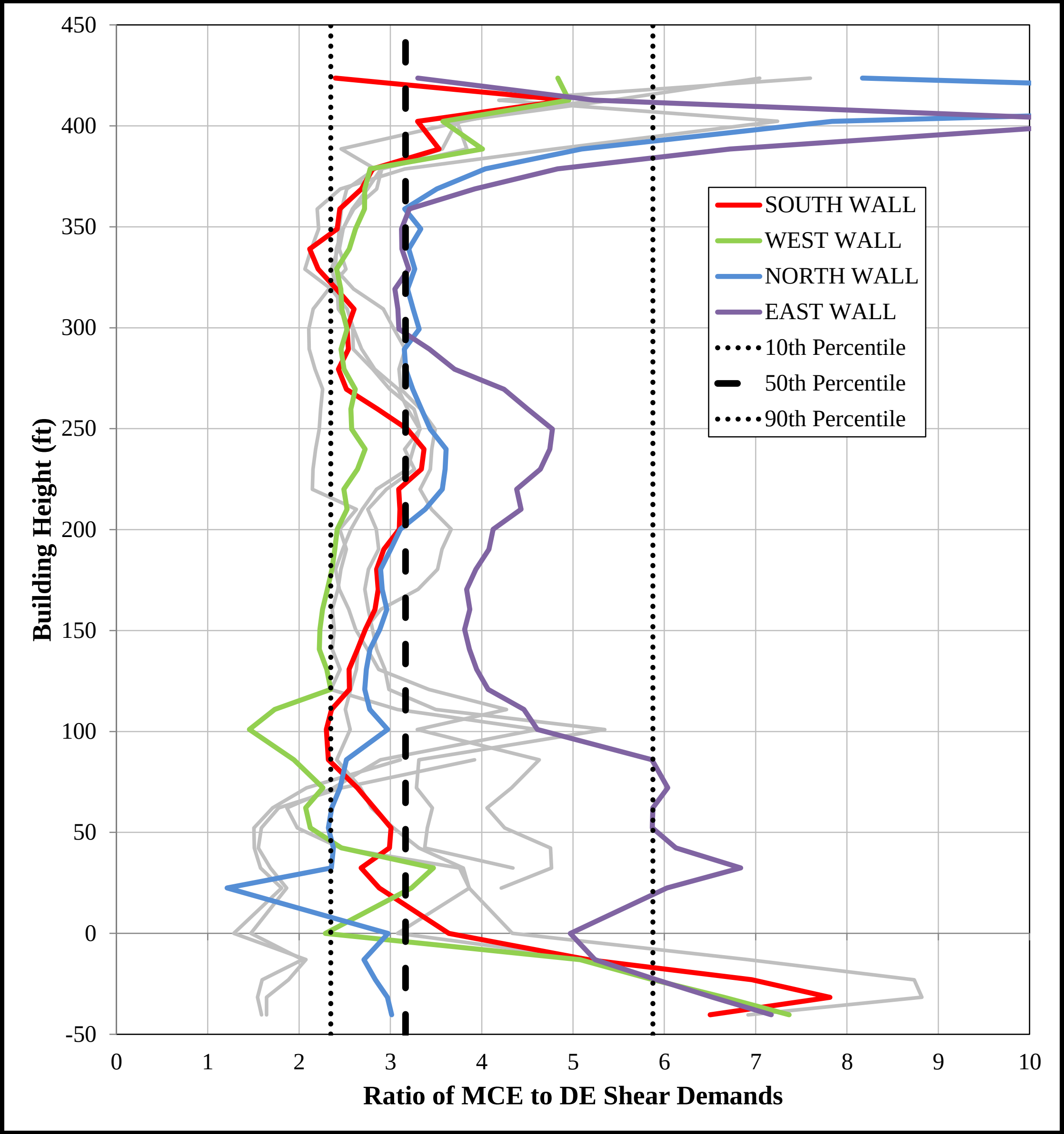
North Wall



East Wall

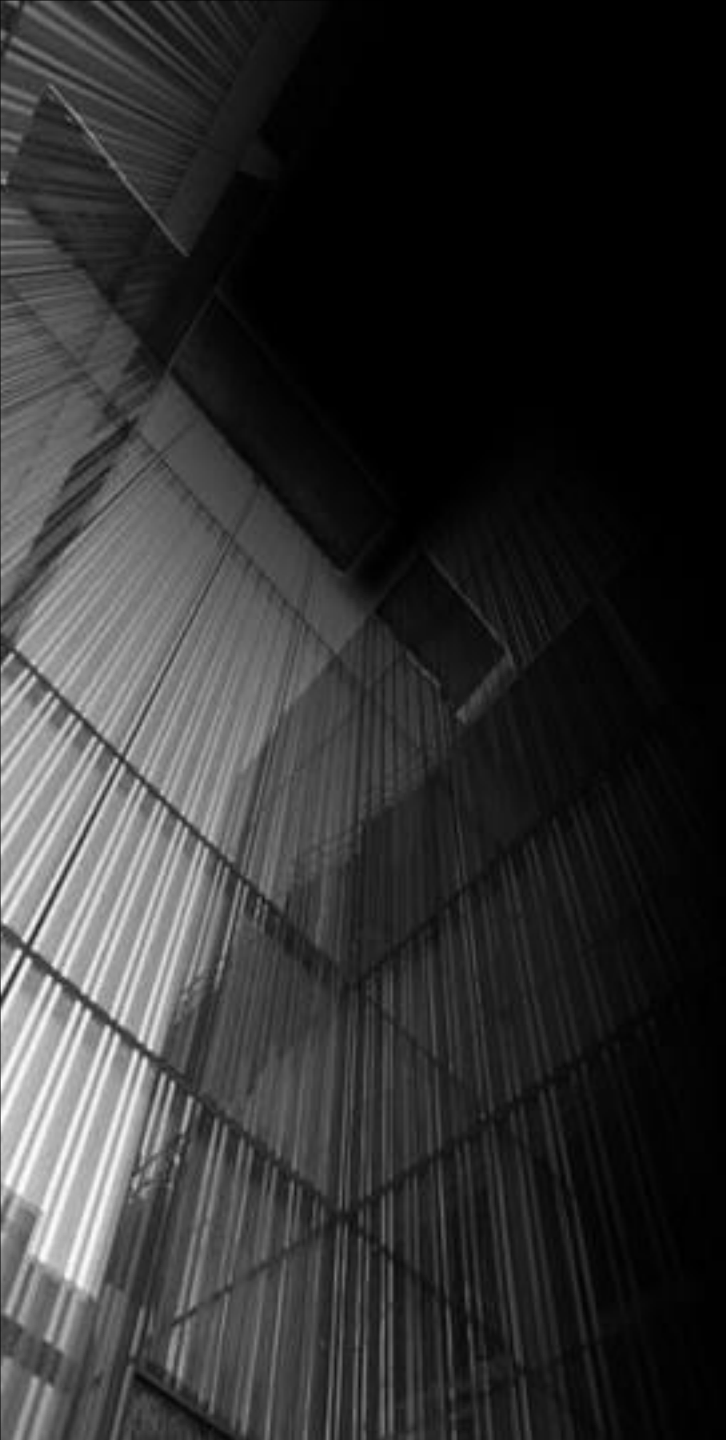


MCE/DE Shear Amplification



Conclusions

- For preliminary proportioning, recommend:
  - 2.5 to 3.5 for MCE/DE wall shears
  - 2.5 to 4.5 for MCE/SLE wall shears
  - 1.8 to 2.5 for MCE/DE overturning moment
  - 2.8 to 5.0 for MCE/SLE overturning moment
- Where possible, use DE for proportioning
  - Less uncertainty
- Keep the variation in mind!
  - Build in “buffer thickness” if possible at certain locations (e.g. base of wall)



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