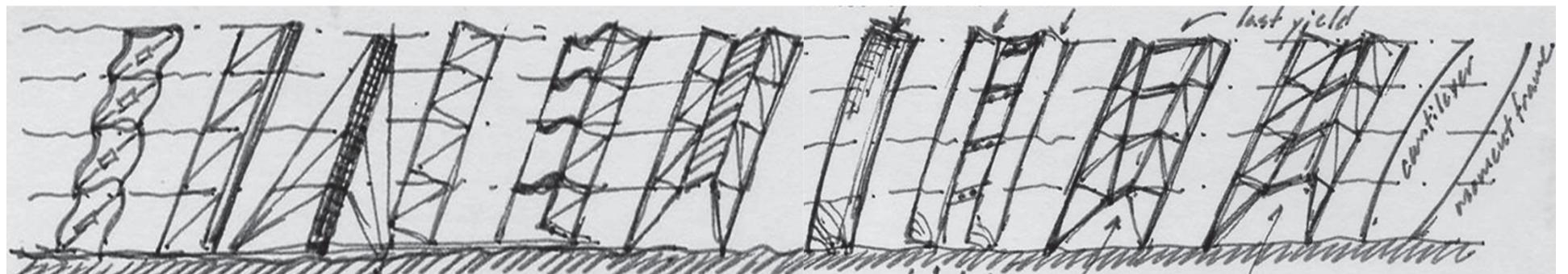


## B a l a n c e   a n d   H a r m o n y



## P r o p o r t i o n i n g   R u l e s   f o r   D e s i g n



## Assessment of First Generation Performance-Based Seismic Design Methods for New Steel Buildings

New SMFs, SCBFs and EBFs designed in accordance with ASCE 7 ...

*have difficulty achieving the ASCE 41 Basic Safety Objective.*

Table 3-32. BSO Performance Summary of Archetype Buildings

Archetype	Design	LSP	LDP	NSP	NDP (based on mean response of record set)
4-Story	ELF RSA	Pass Pass	Pass Pass	Fail Fail	Fail Fail
					Fail Fail Fail Fail Fail Fail

Table 3-29. BSO Performance Summary of Archetype Buildings

Archetype	Design	LSP	LDP	NSP	NDP (based on mean response of record set)
4-Story	ELF RSA	Pass Pass	Pass Pass	Fail Fail	Fail Fail Fail Fail Fail Fail
					Fail Fail Fail Fail Fail Fail

Table 3-32. BSO Performance Summary of Archetype Buildings

Archetype	Design	LSP	LDP	NSP	NDP (based on mean response of record set)
4-Story	ELF	Fail	Pass	Pass	Pass
	RSA	Fail	Fail	Fail	Fail
8-Story	ELF	Fail	Fail	Fail	Fail
	RSA	Fail	Fail	Fail	Fail
16-Story	ELF	Fail	Pass	Pass	Pass
	RSA	Fail	Fail	Fail	Fail



*concentric  
braced  
frames*

*moment frames*

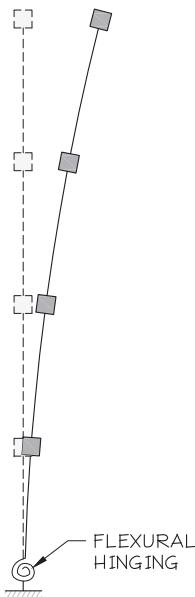
*eccentric  
braced  
frames*

## **S y s t e m   T y p e s   n o t   A r c h i t y p e s**

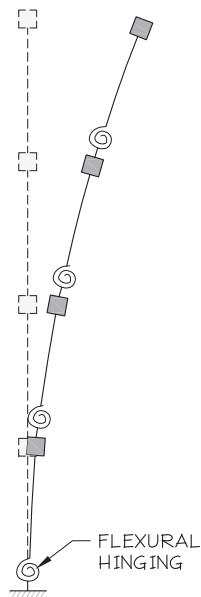
*Each system is proportioned to induce a desired (explicit) mechanism.*



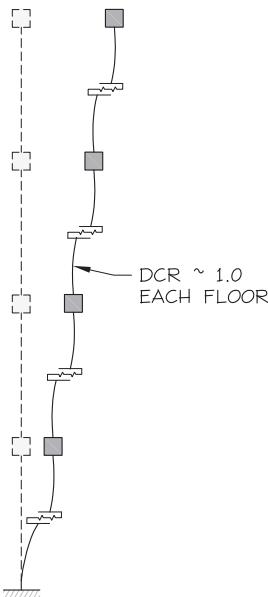
# Building Mechanisms



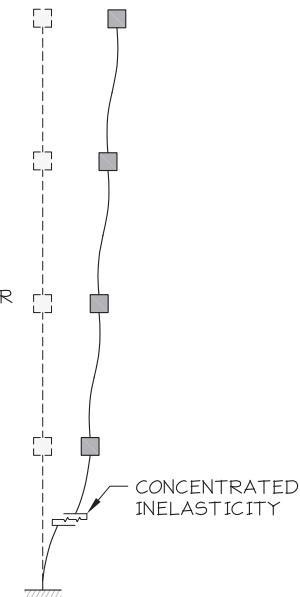
1. FLEXURE - BASE MECHANISM



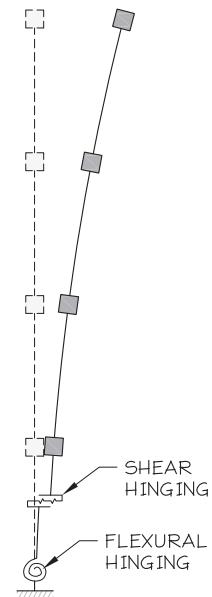
2. FLEXURE - DISTRIBUTED (MULTI-HINGE) MECHANISM



3. SHEAR - BALANCED MECHANISM



4. SHEAR - STORY MECHANISM



5. FLEXURE - SHEAR MECHANISM

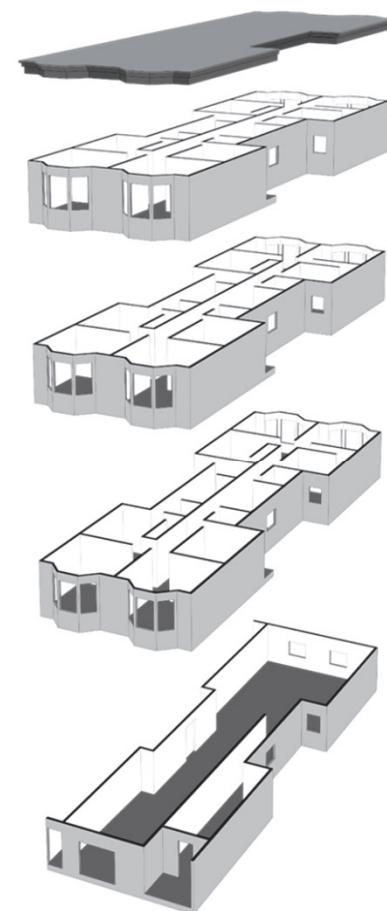
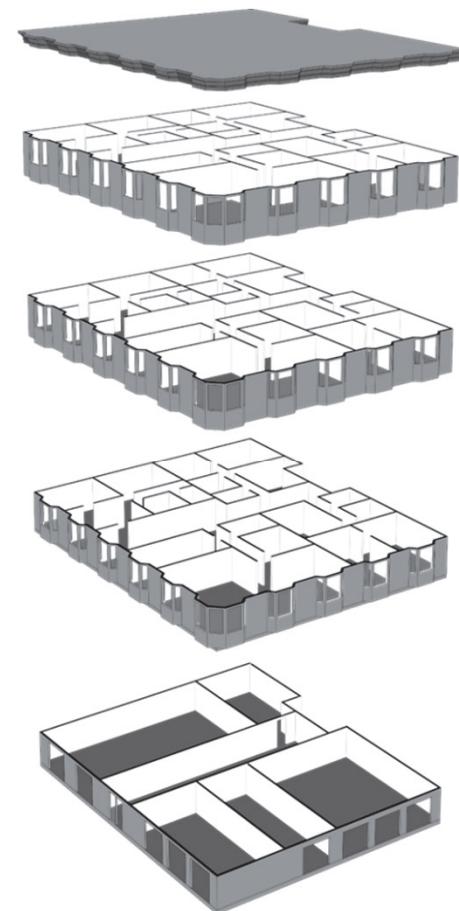
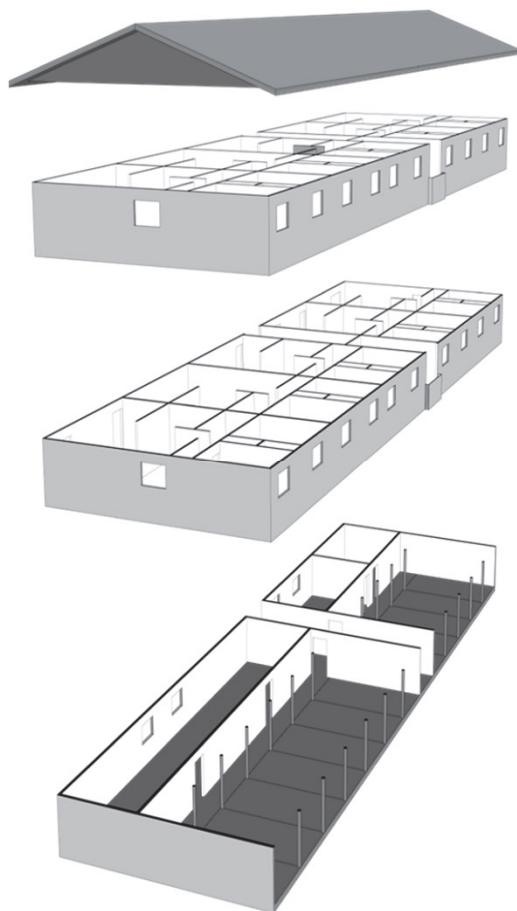




F E M A P 8 0 7

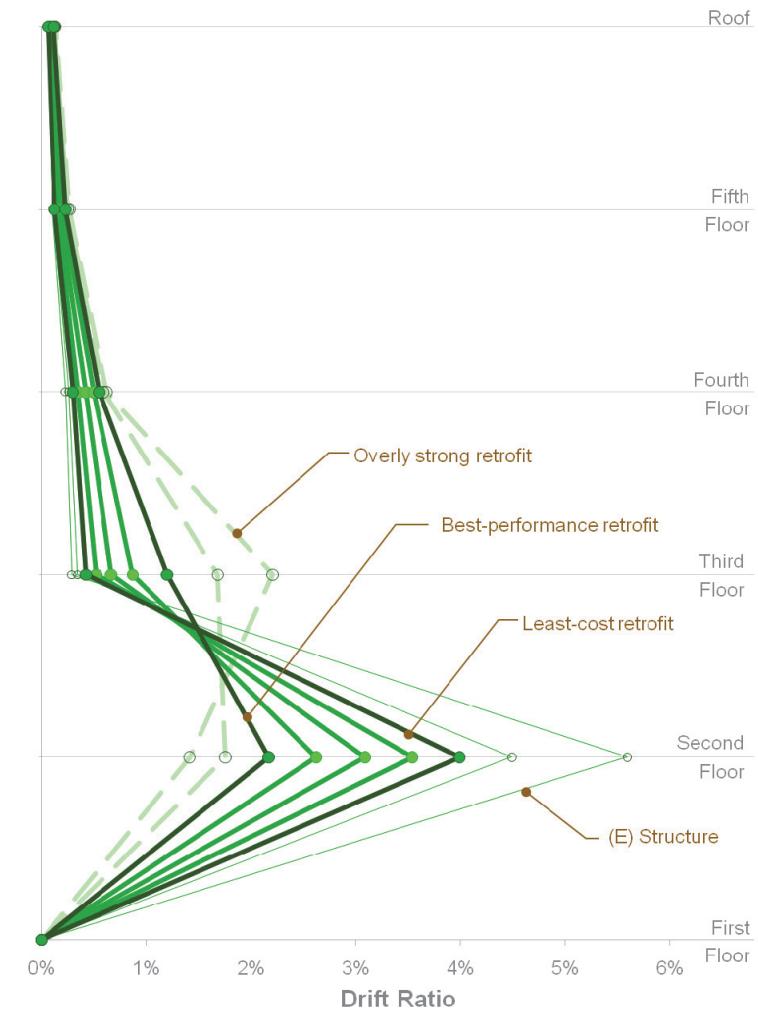
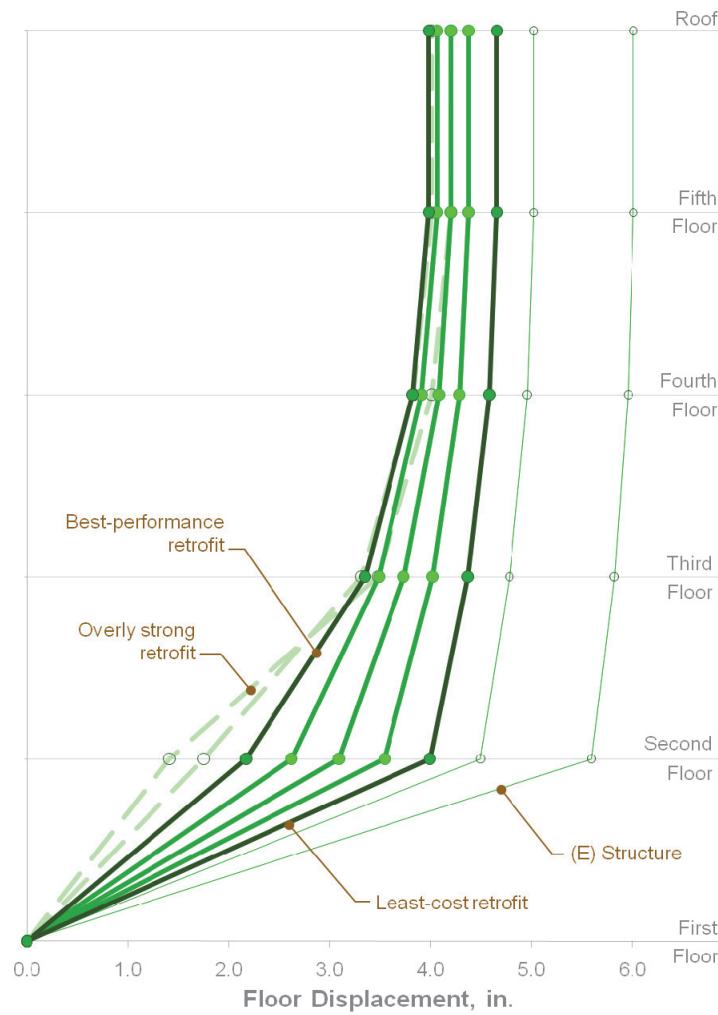
Seismic Evaluation and Retrofit of Multi-Unit Wood-Frame Buildings  
With Weak First Stories



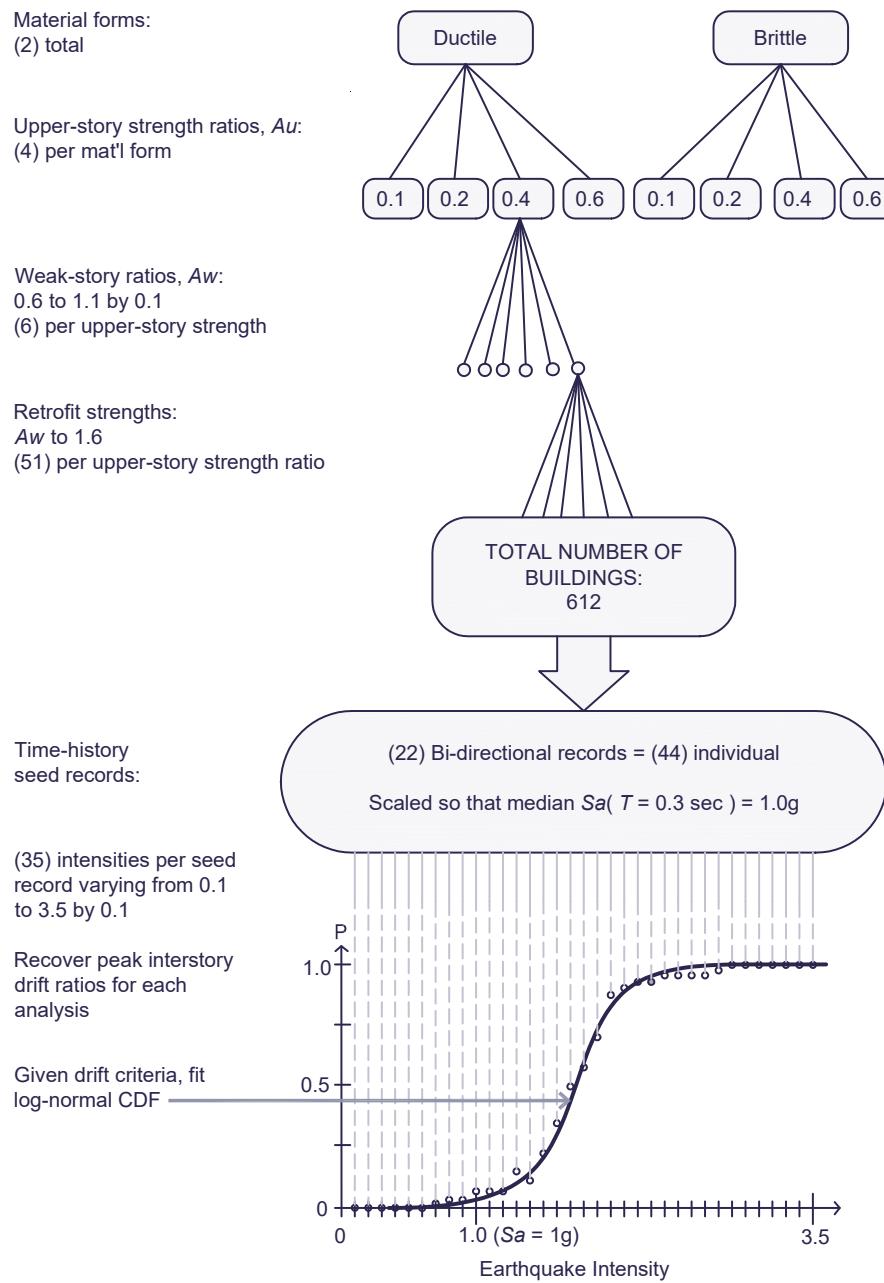


M

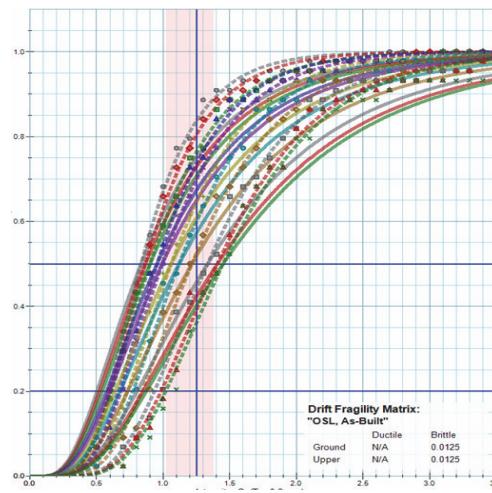
## The Relative Strength Method

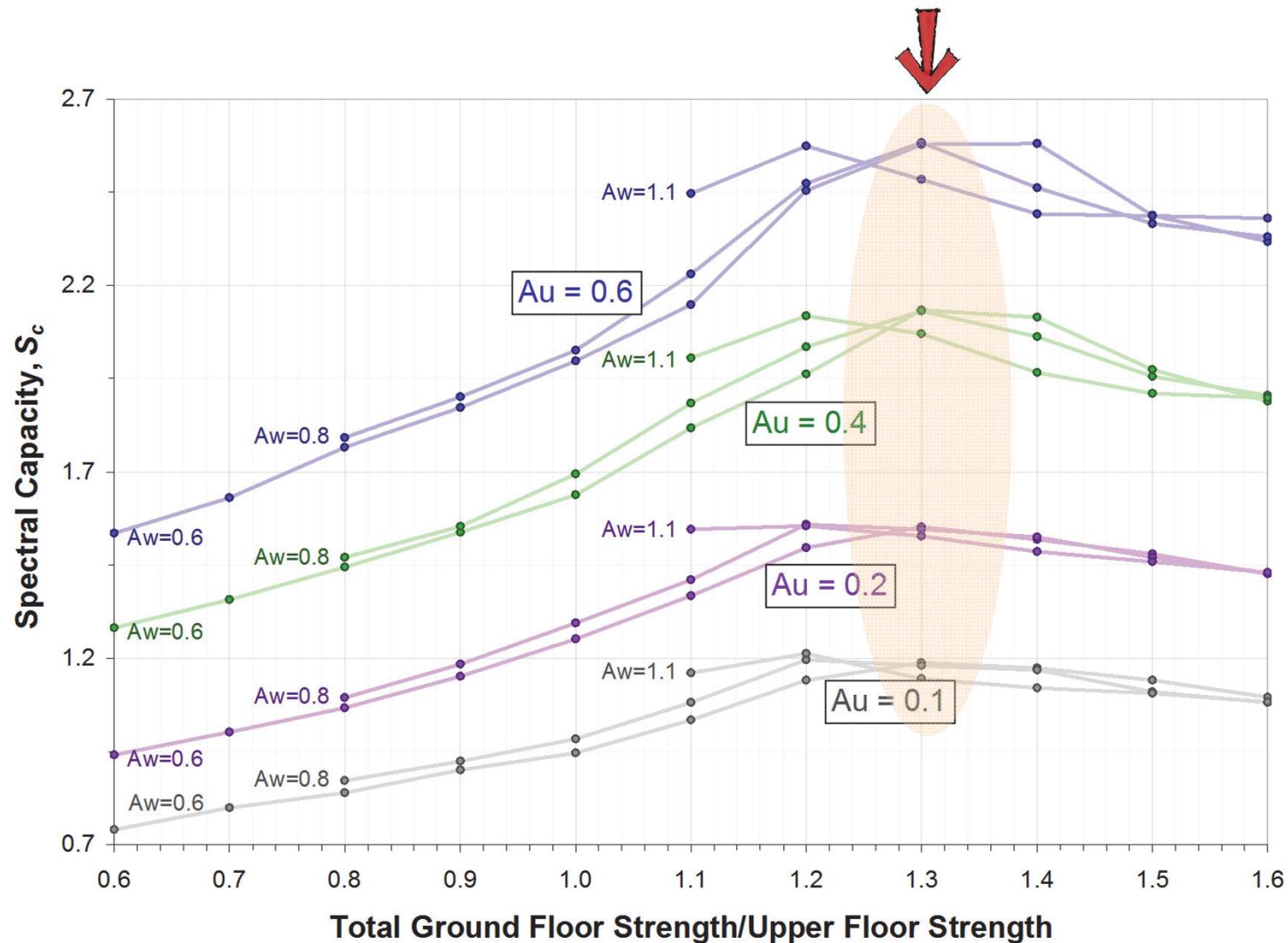


# Surrogate Structures



*The component demands of each mechanism are determined probabilistically (via IDA).*



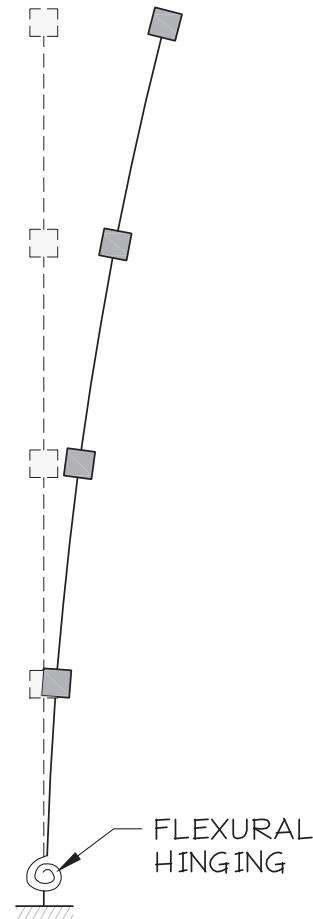




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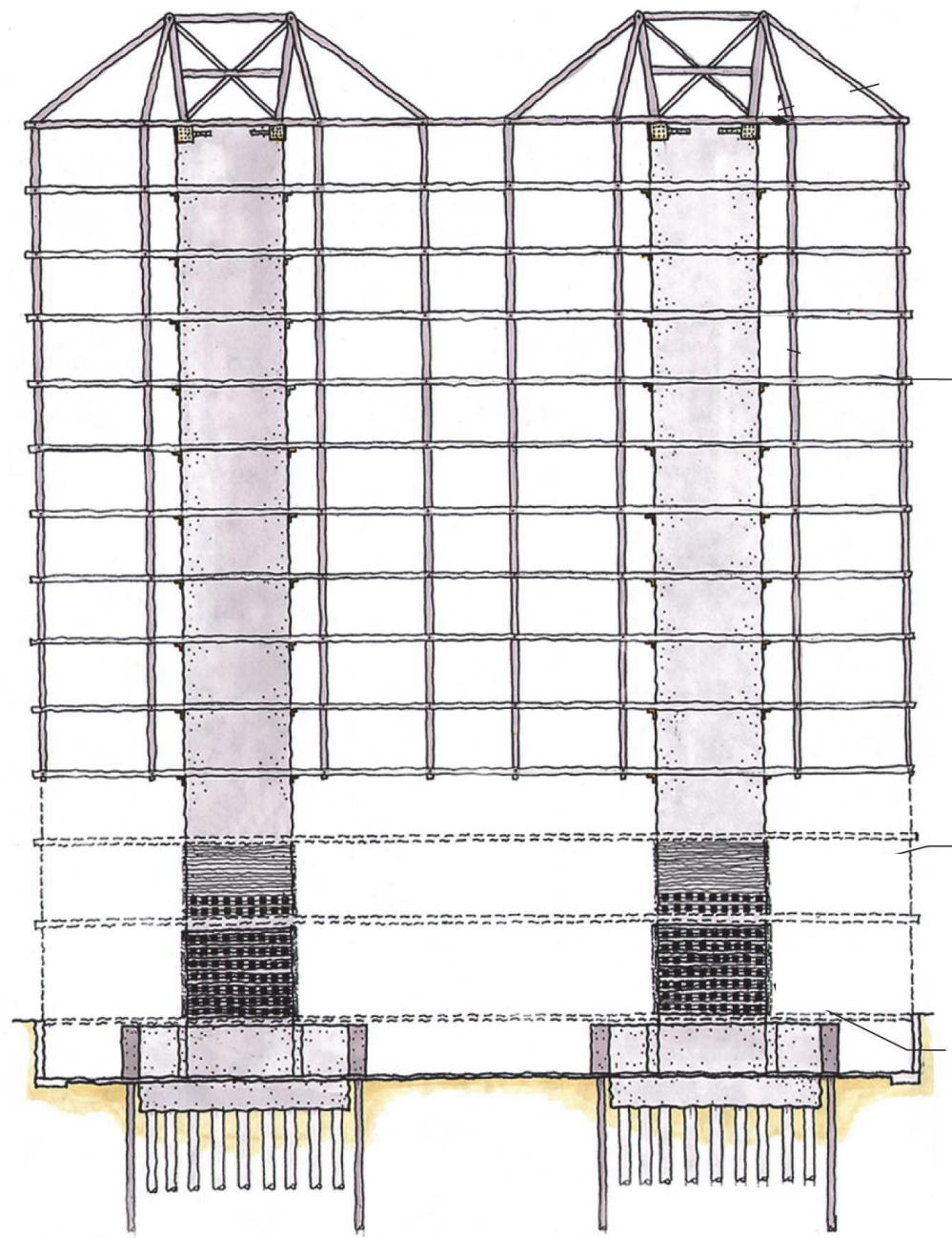
*create*

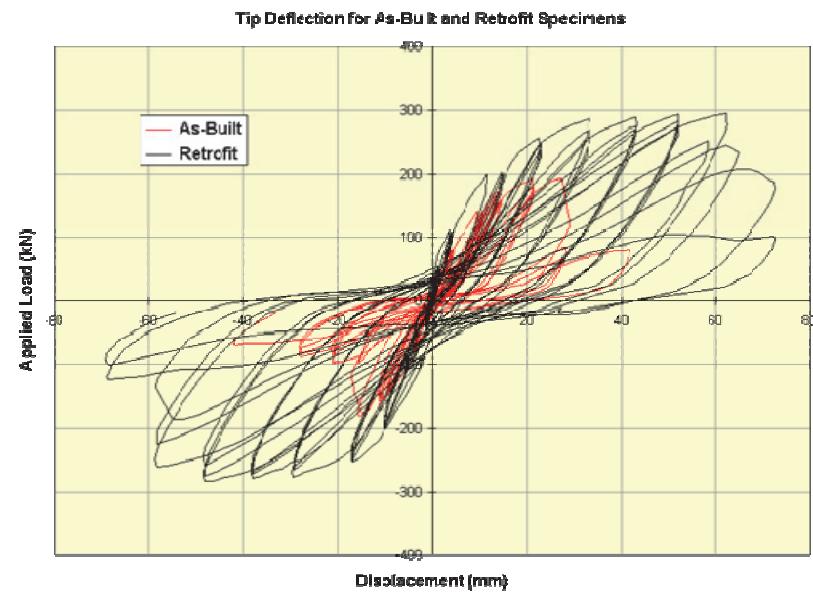
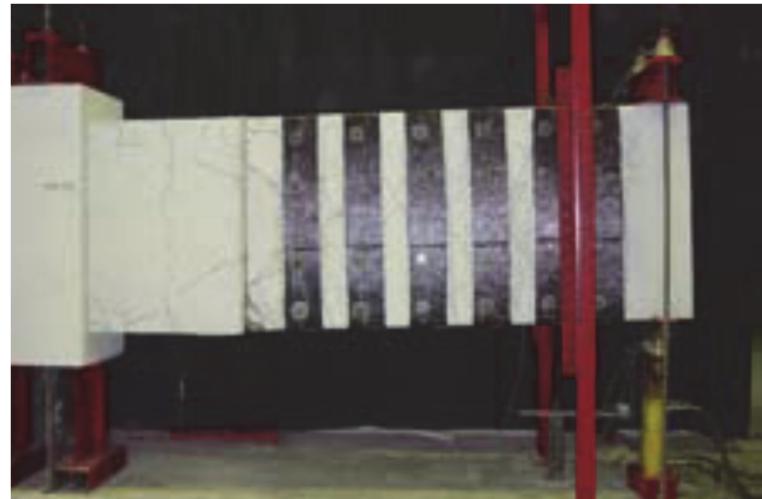
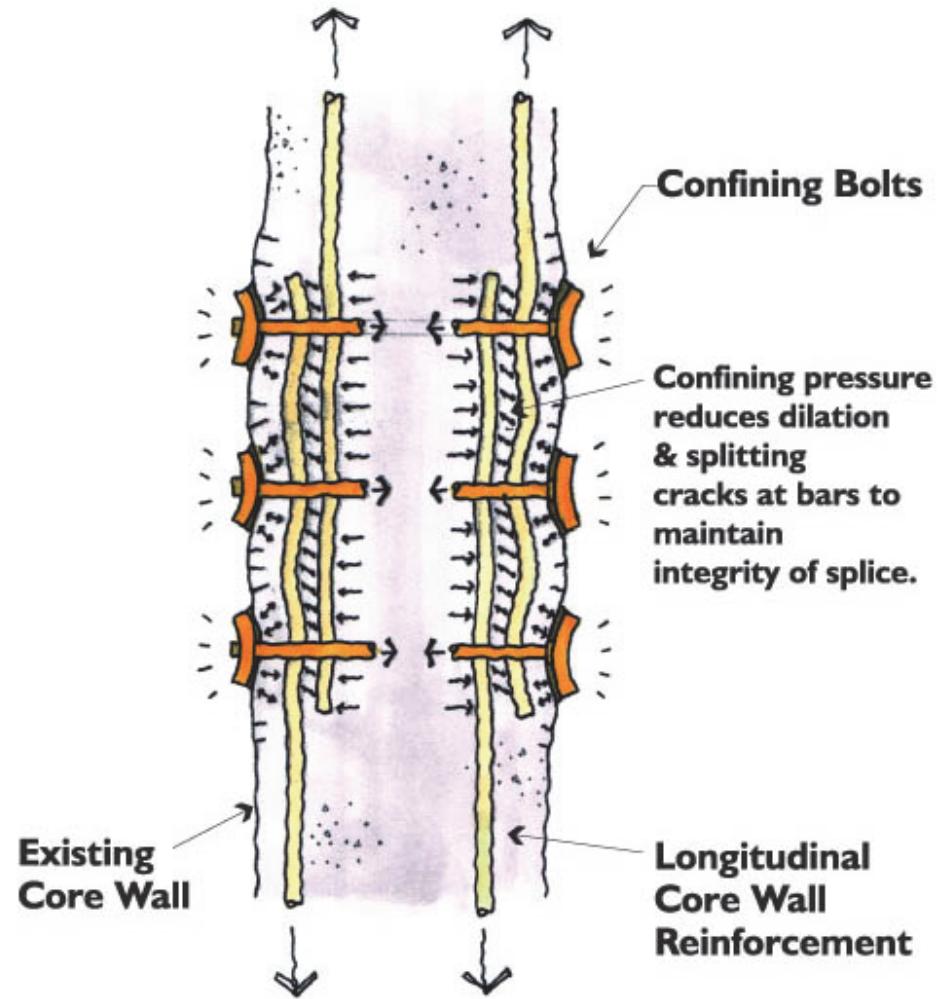
# Proportioning Rules for Cantilever Walls

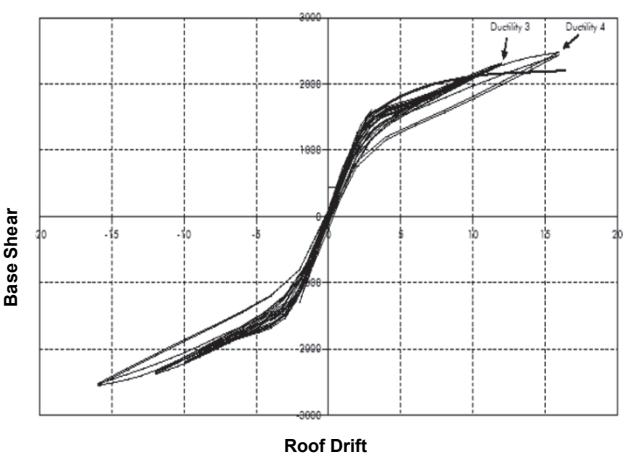
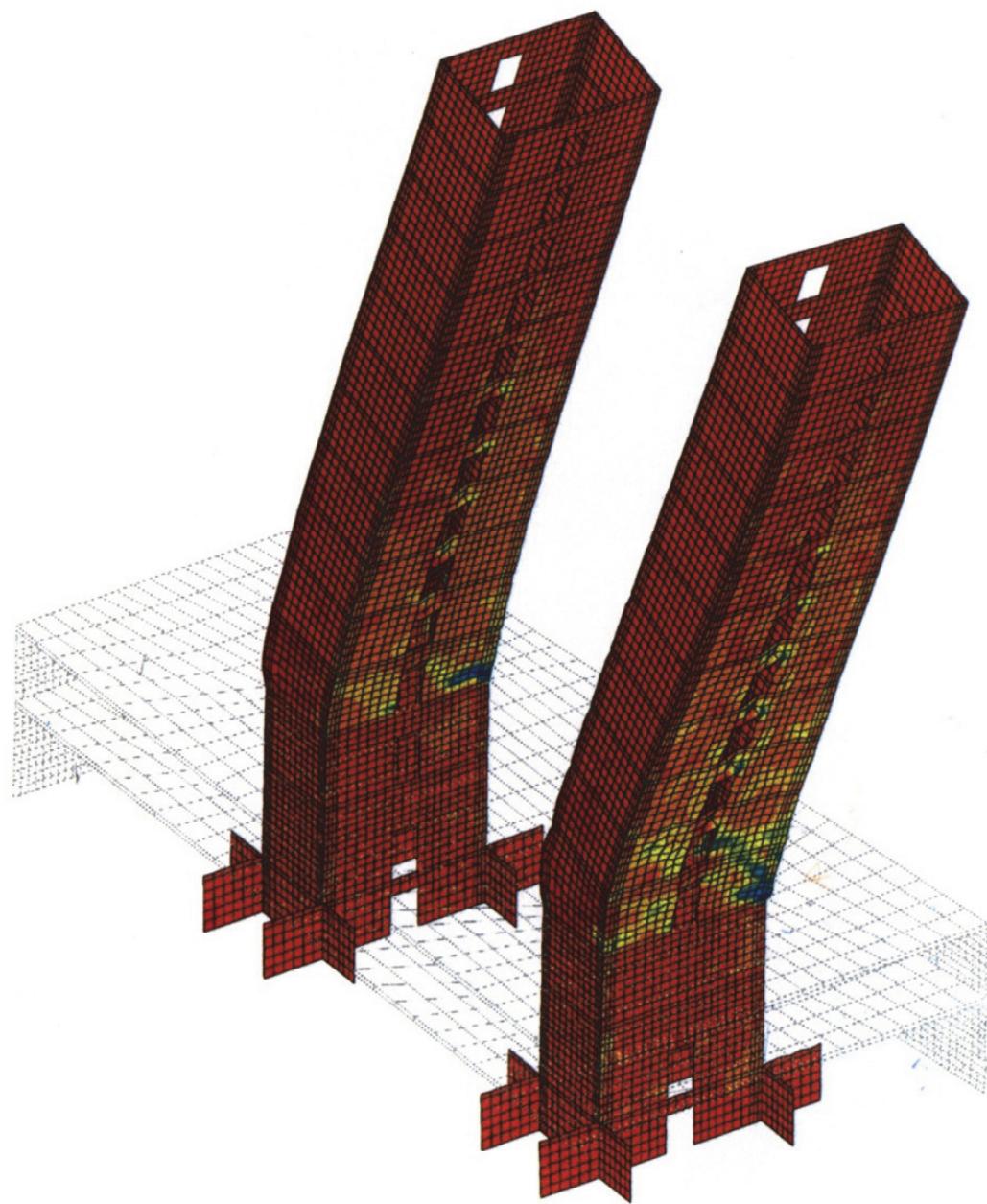


*cantilever wall system with primary flexural mechanism*

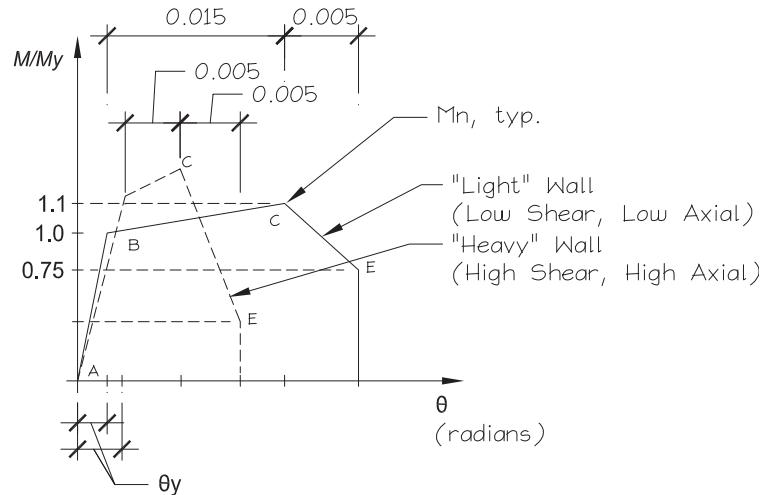






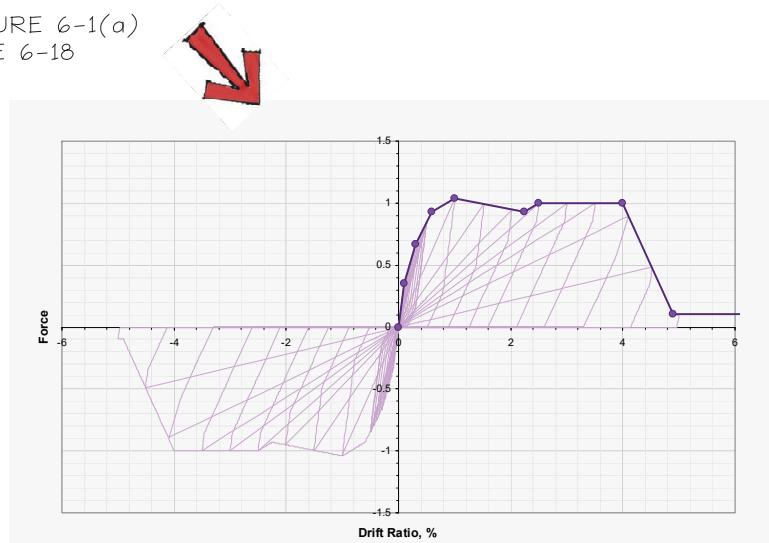
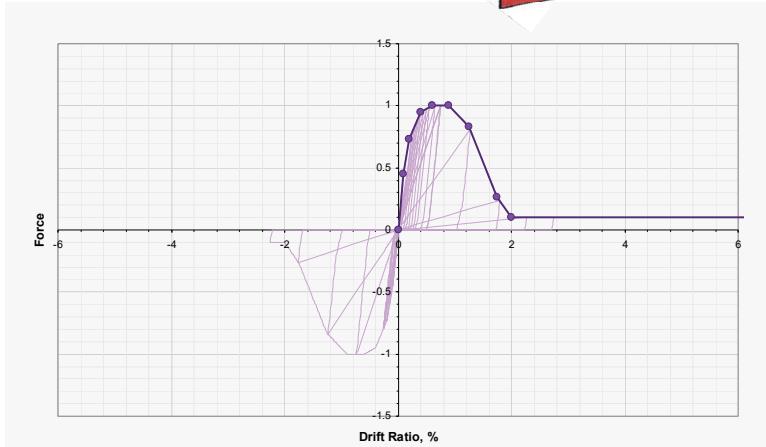


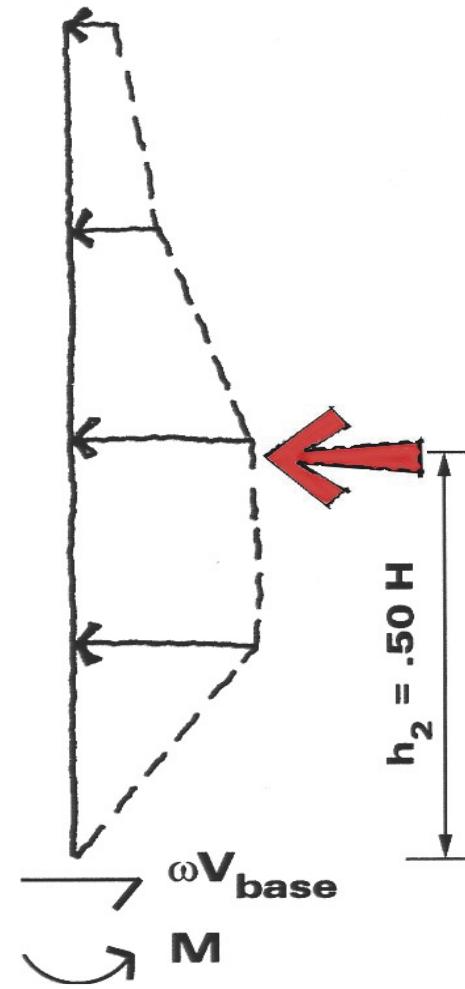
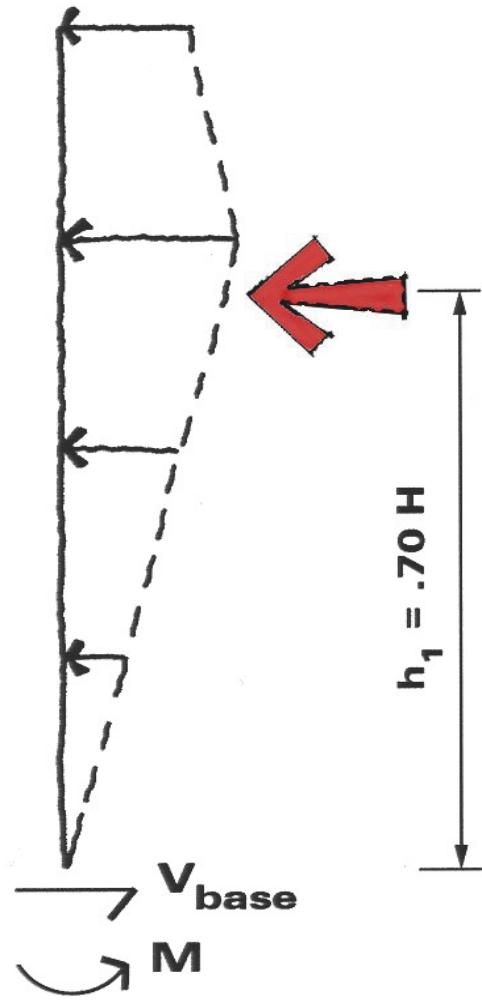
*given various hinge types*



### CONC FLEXURAL WALL

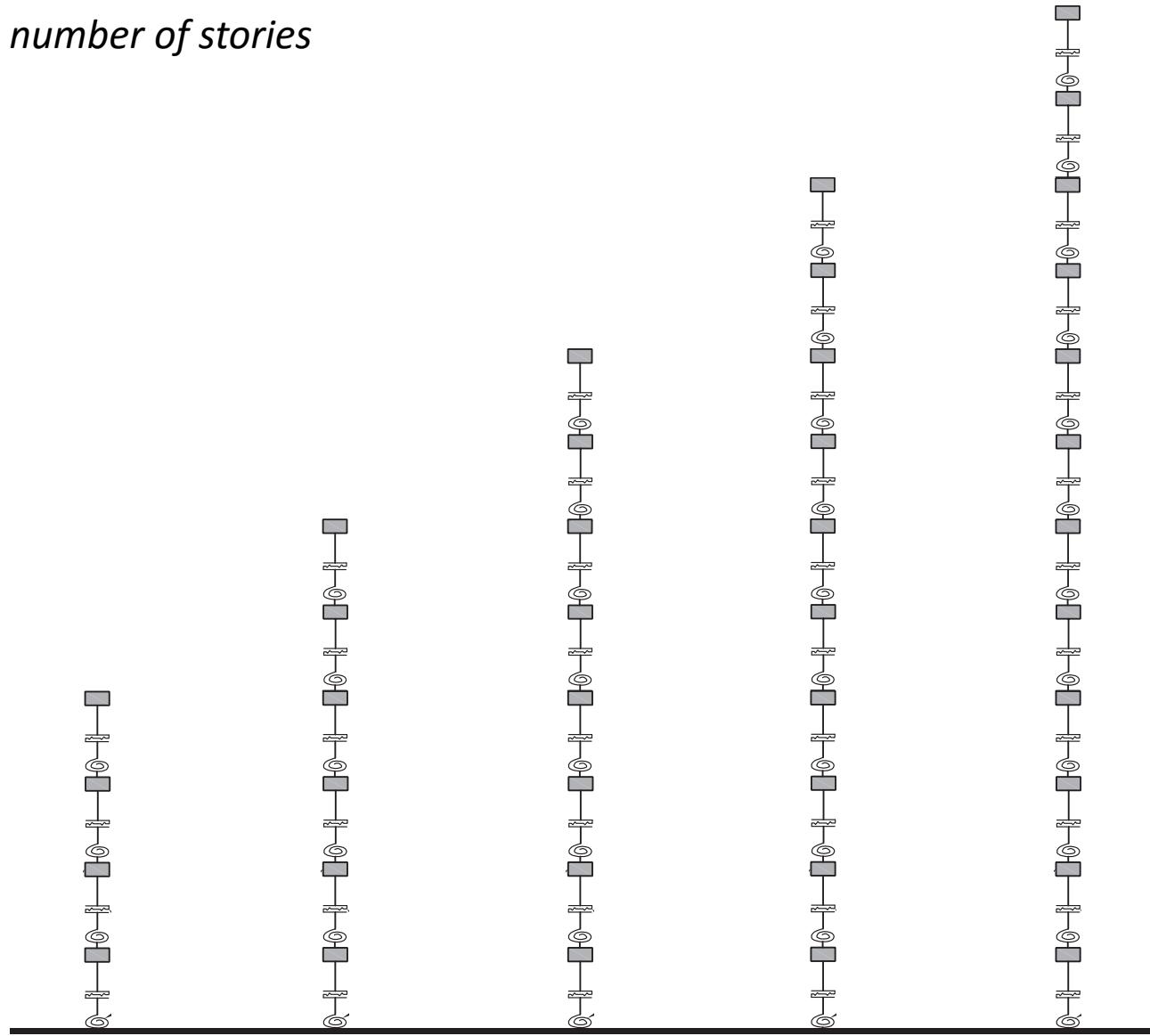
REF. ASCE 41-06 FIGURE 6-1(a)  
§ TABLE 6-18





**M**

*various number of stories*



# Proportioning Rules for Cantilever Walls

Set performance criteria - *max. hinge rotation or max. story drift*

Create various surrogate combinations based on ...

Strength

Flexural hinge types

- Light plastic hinge
- Heavy plastic hinge
- Rocking hinge (PT or foundation)

Story heights (2, 4, 8, 12, 16 ...)

From the surrogate performances we will learn to ...

Determine minimum strengths (multiple Rs)

Determine **corresponding** shear demands

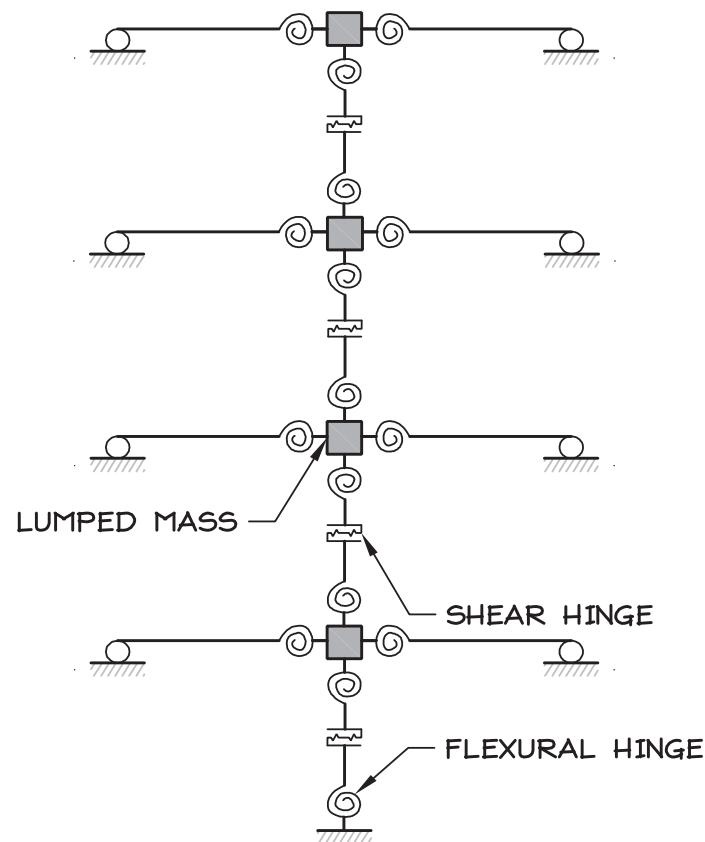
Determine **corresponding** collector demands

Determine strength vs. drift relationships



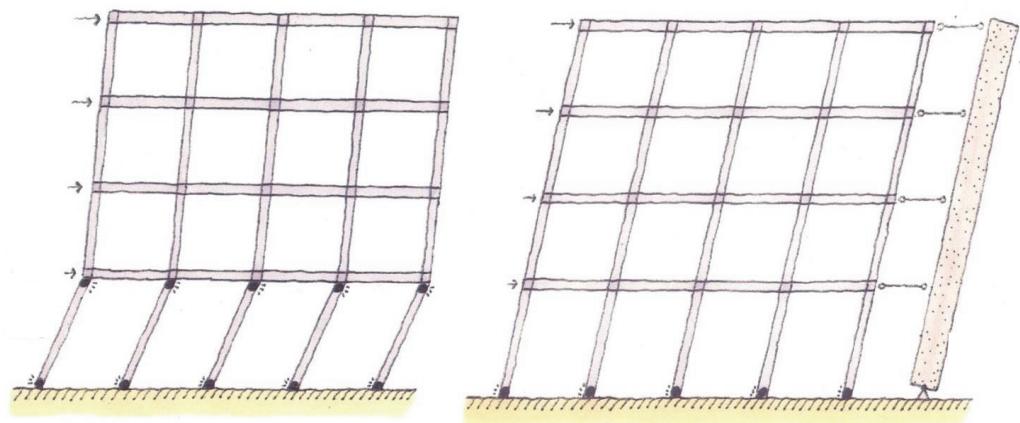
*create*

# Proportioning Rules for Moment Frames

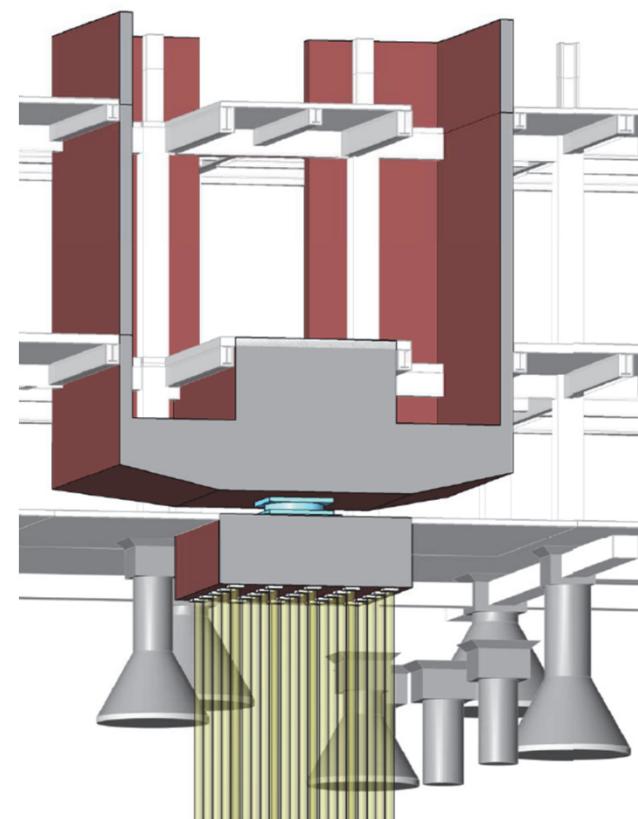
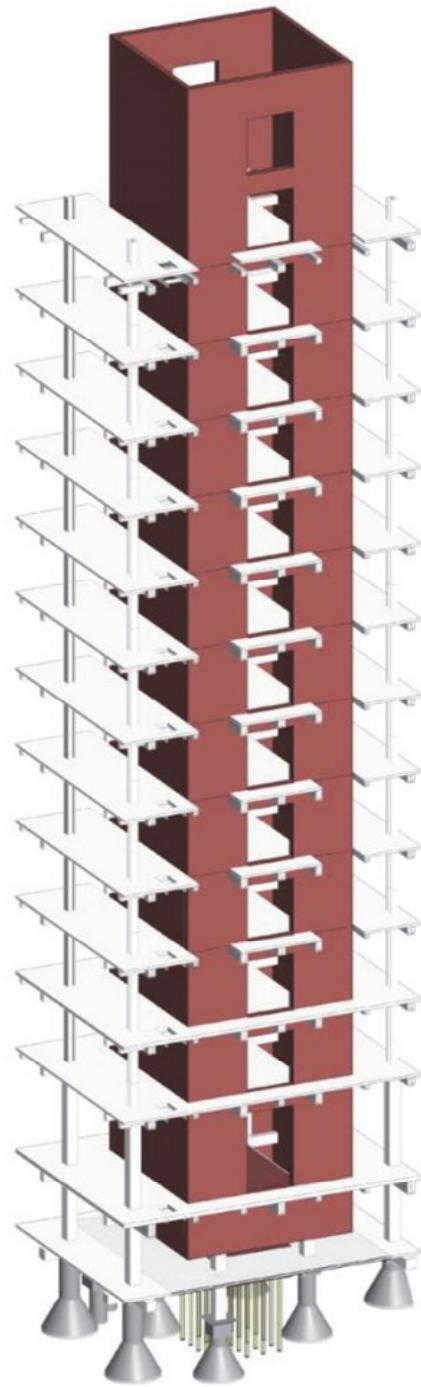


*moment frame system with beam hinges and a tilting mechanism*



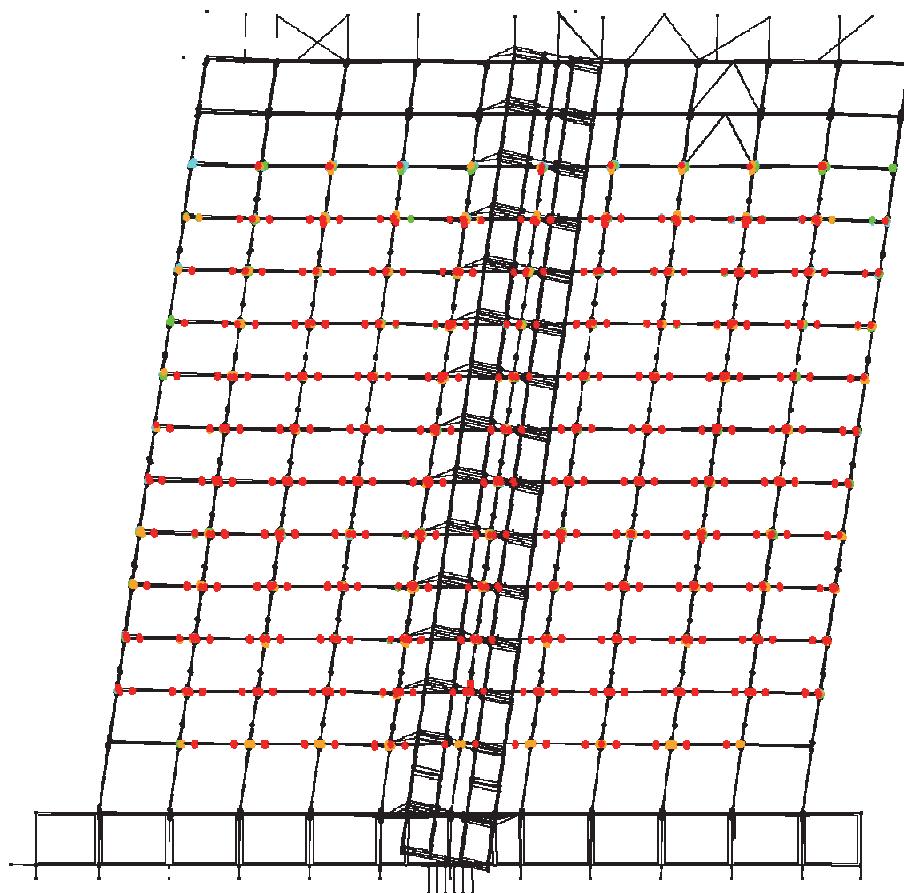
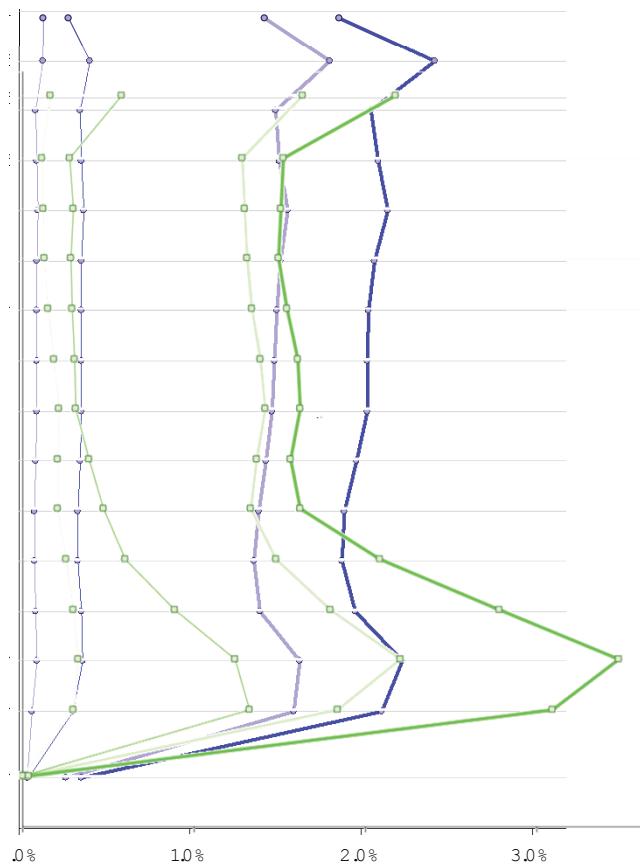


M

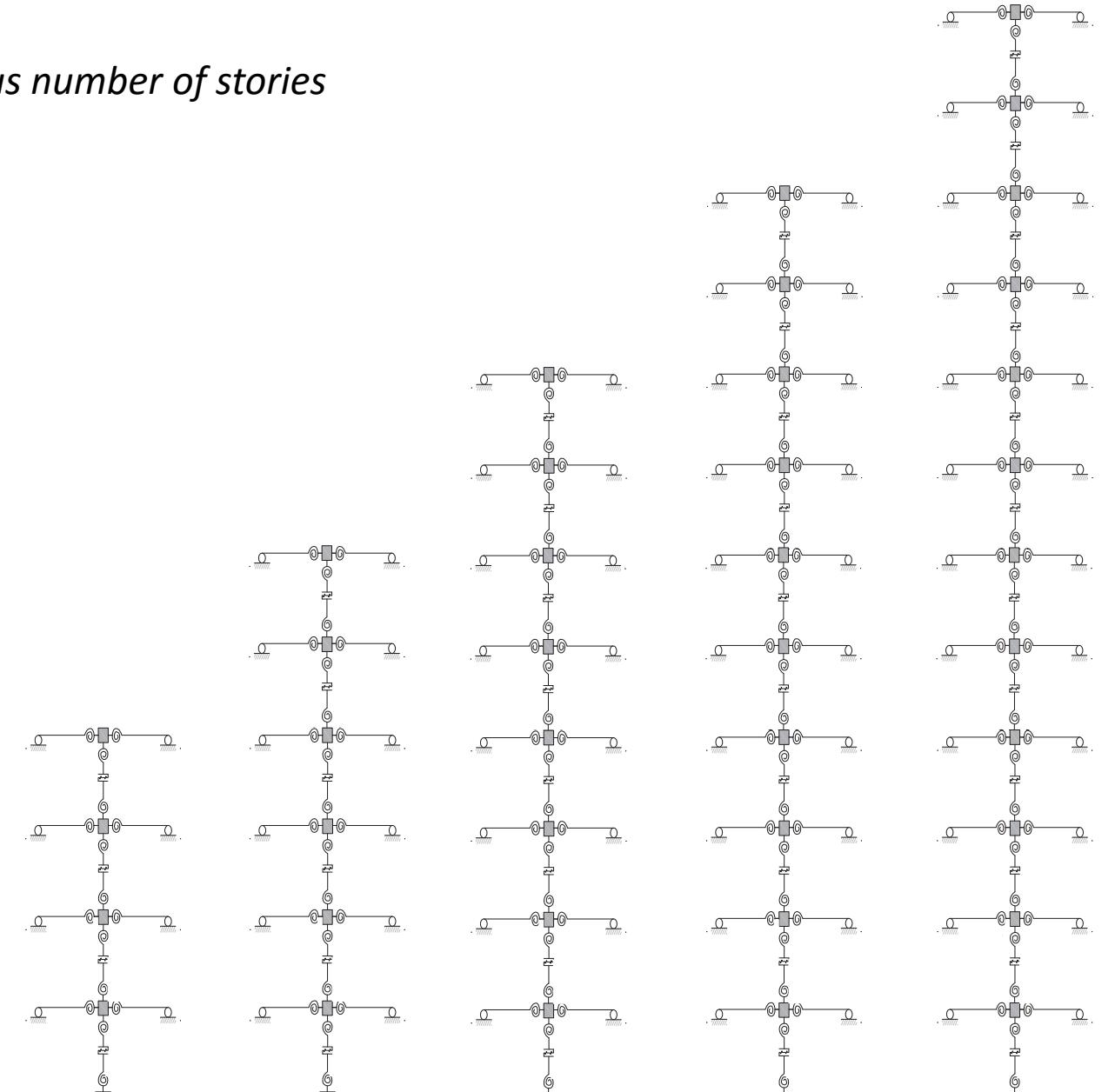


M

## Residual      Transient



*various number of stories*



# Proportioning Rules for Moment Frames

Set performance criteria – *max. hinge rotation or max. story drift*

Create various surrogate combinations based on ...

Strength

Strong column weak beam ratios

Flexural hinge types

Story heights (2, 4, 8, 12, 16 ...)

Supplemental spines (or gravity columns)

From the surrogate performance, we will learn to ...

Determine minimum strengths (multiple Rs)

Determine **corresponding** strong column weak beam ratios

Determine **corresponding** collector demands

Determine strength vs. drift relationships

Determine spine (or gravity column) requirements to  
augment tilting mechanisms



*more ...*

# System Approach to Performance Based Design

Explore more nuanced optimization strategies based on **life-cycle costs**  
... a holistic view of performance

Is more cost effective to add strength?

Or is it more cost effective to add displacement capacity?

For which systems?

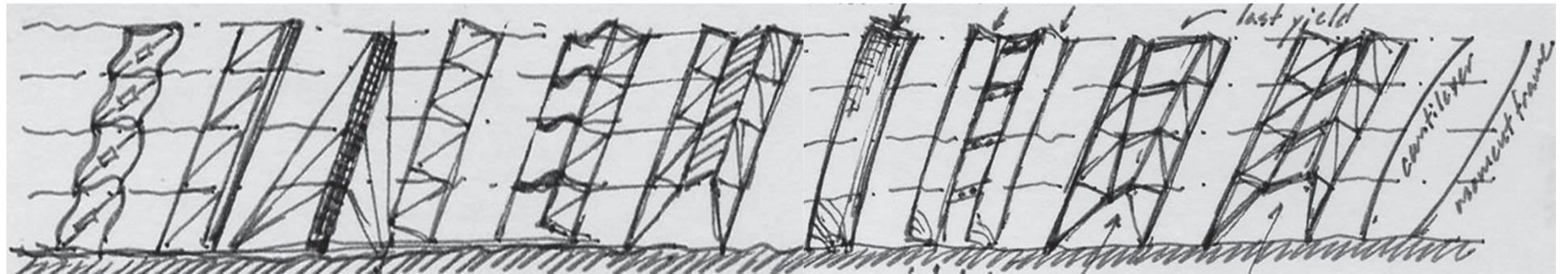
And when?



versus



# B a l a n c e   a n d   H a r m o n y



M