Retrofit of SPC-1 Hospital Buildings to SPC-2
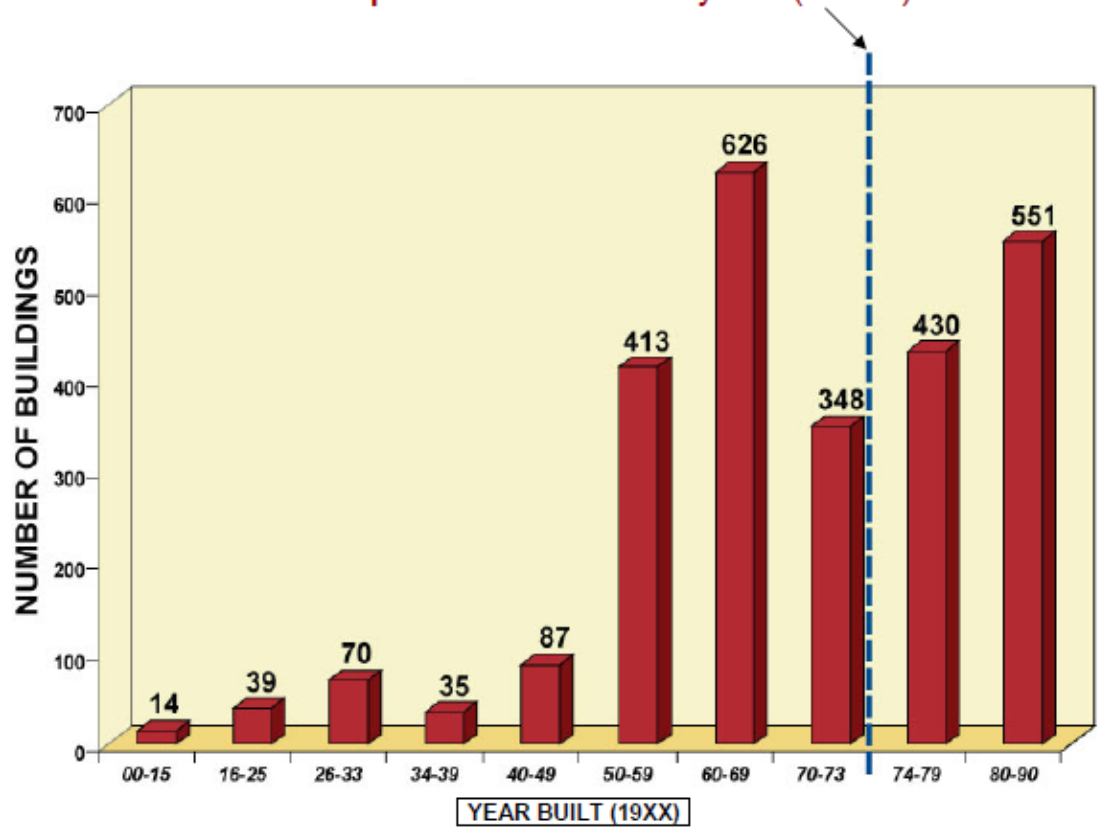
Roy Lobo, Principal Structural Engineer
OSHPD

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

Earthquake Damage to Concrete Hospital Buildings (1971 Sylmar)

Most of California's hospital buildings were constructed prior to the 1973 Hospital Seismic Safety Act (HSSA).

OLIVE VIEW HOSPITAL

Chart: NUMBER OF BUILDINGS vs YEAR BUILT (19XX)

Year Built	Number of Buildings
00-15	14
16-25	39
26-33	70
34-39	35
40-49	87
50-59	413
60-69	626
70-73	348
74-79	430
80-90	551

HSSA 1983

"129675. This chapter shall be known and may be cited as the Alfred E. Alquist Hospital Facilities Seismic Safety Act of 1983. 129680.

(a) It is the intent of the Legislature that hospital buildings that house patients who have less than the capacity of normally healthy persons to protect themselves, and that must be reasonably capable of providing services to the public after a disaster, shall be designed and constructed to resist, insofar as practical, the forces generated by earthquakes, gravity, and winds. In order to accomplish this purpose, the office shall propose proper building standards for earthquake resistance based upon current knowledge, and provide an independent review of the design and construction of hospital buildings. "

Common Deficiencies in Non-Ductile Concrete Buildings

Soft story
Weak Story
Vertical Discontinuities
Torsion
Redundancy
Defection Incompatibility
Shear failure
Strong Column/Weak Beam
Coupling Beams
Overturning

# Case Study: SPC-1 Hospital Building

Hospital

Building Description

- Constructed in 1960's
- Five stories plus basement
- Gravity System
  - Reinforced concrete pan joist system
  - Interior reinforced concrete columns
  - Perimeter reinforced concrete bearing/shear walls
  - Isolated and continuous spread reinforced concrete foundations
- Lateral System
  - 8" thick perforated reinforced concrete bearing/shear walls
  - Continuous spread reinforced concrete foundations
- Unique Issues
  - "Weakened plane joints" = 1.75" reveals with $^2/_3$ of horizontal rebar cut
  - Wall piers do not have hooks on horizontal bars
  - Non-conforming SPC-1

Conventional Retrofit Design
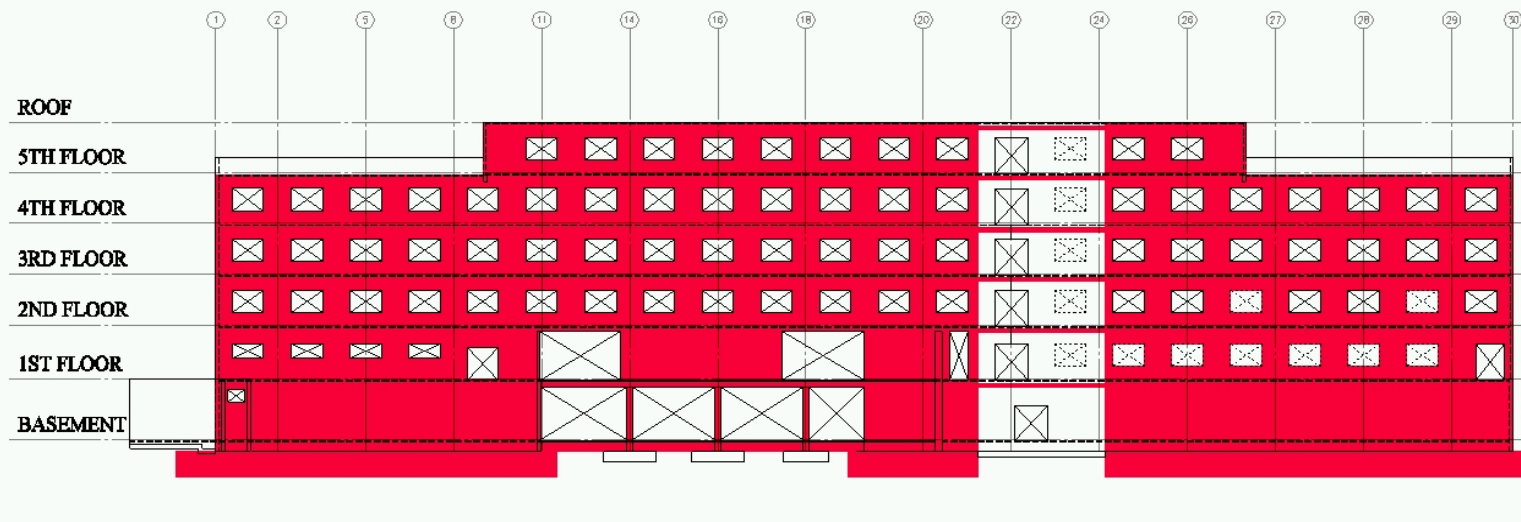
Conventional Retrofit Design

Wall Elevation

Wall Elevation

Indicates 24" of reinforced concrete wall thickening
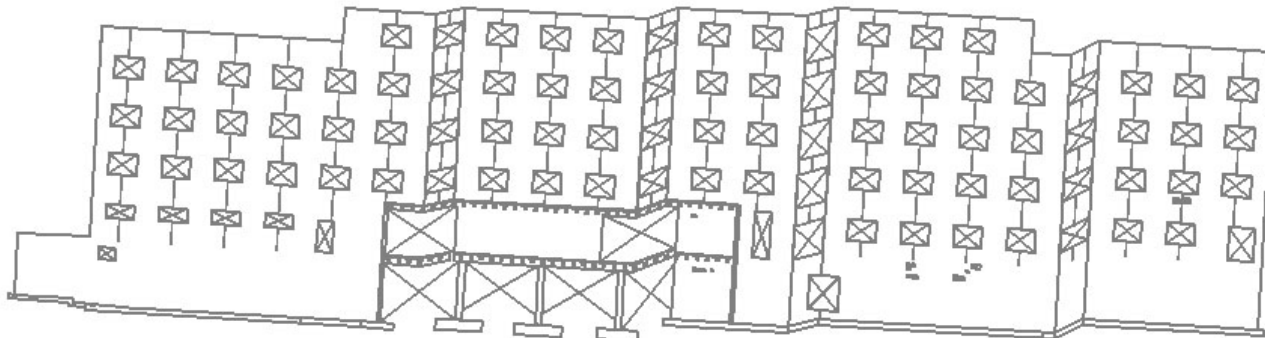
Conventional Retrofit Design
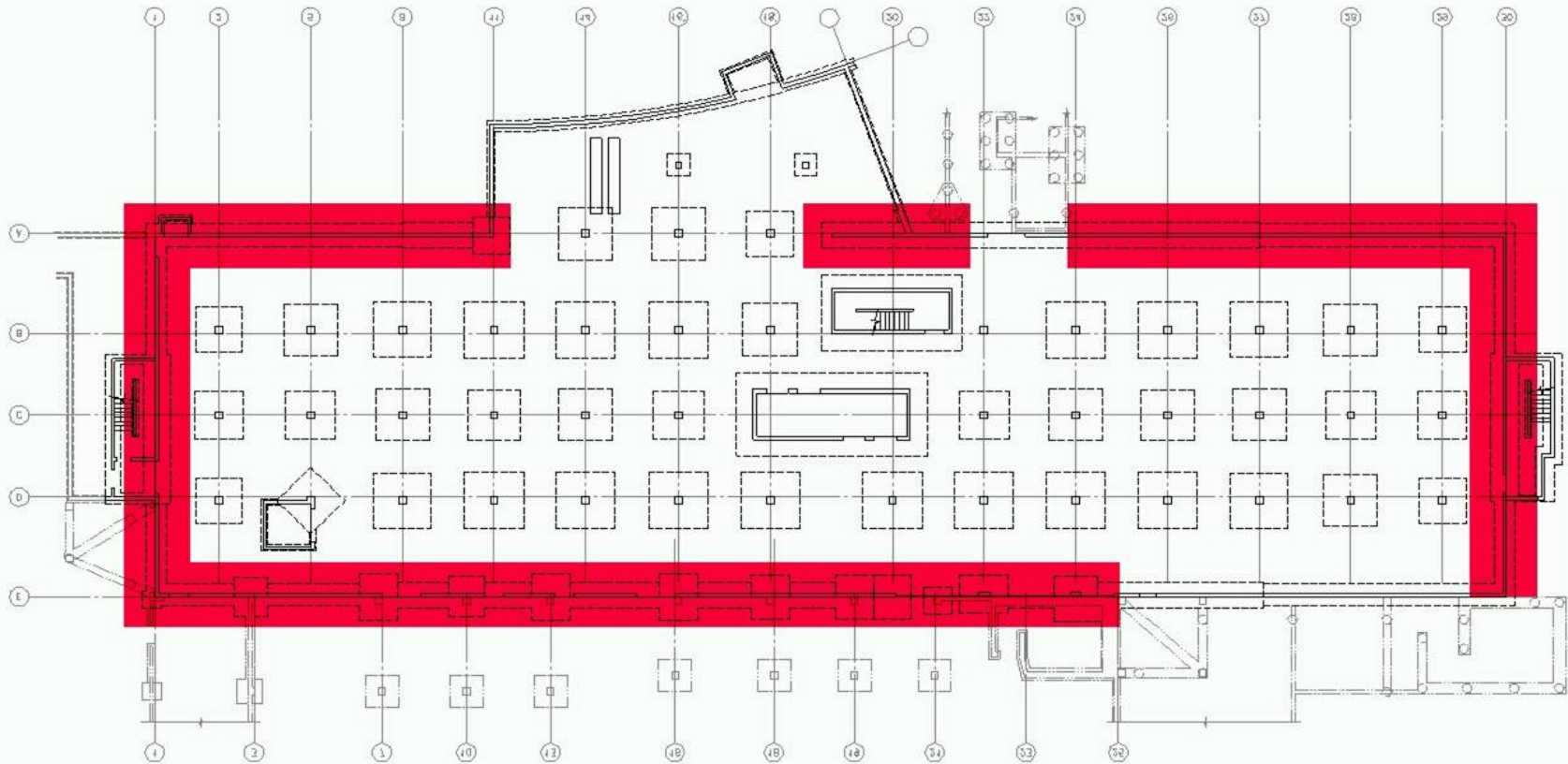
Foundation Plan

Indicates new 14 ft wide by 6 ft deep reinforced concrete foundations
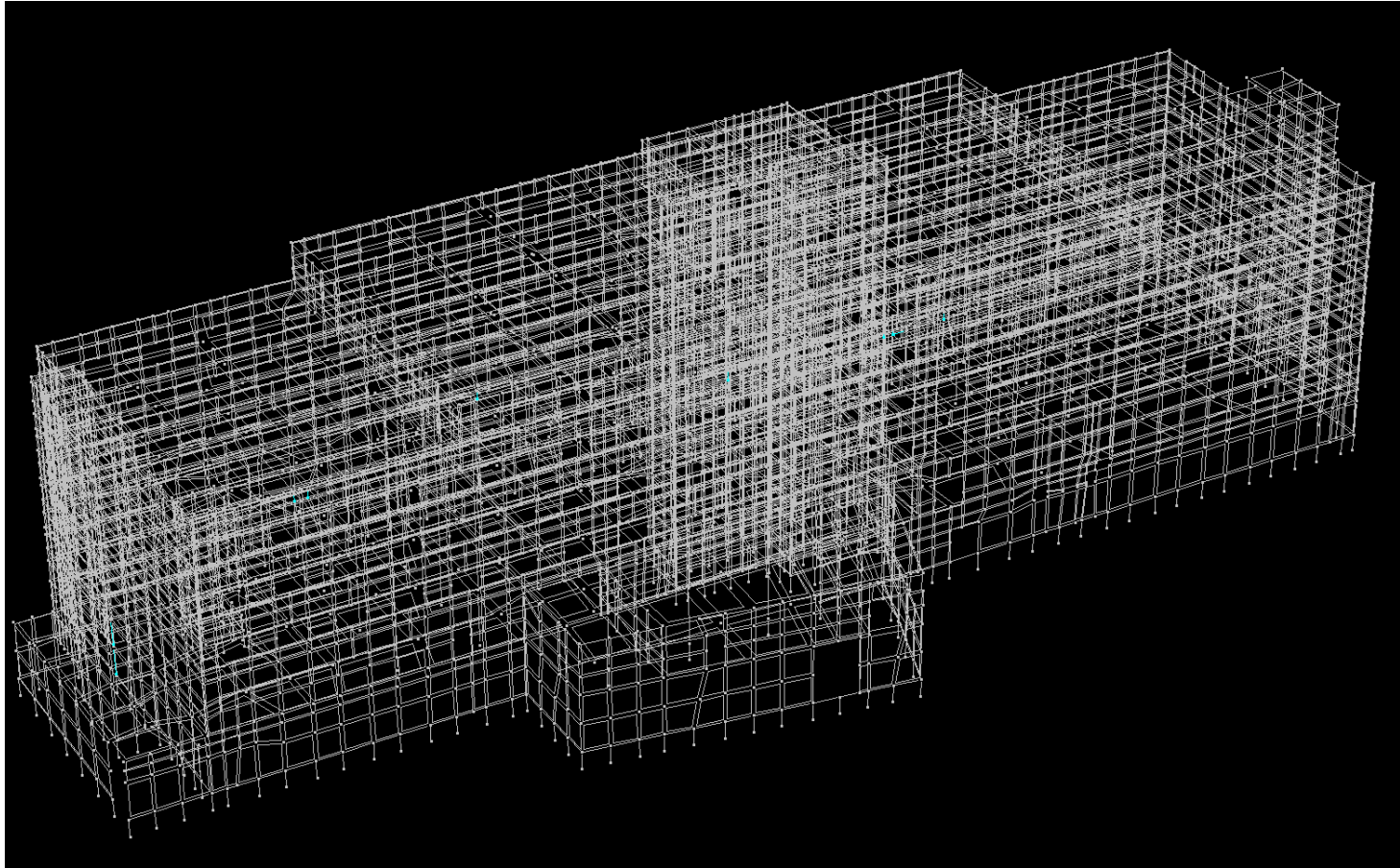
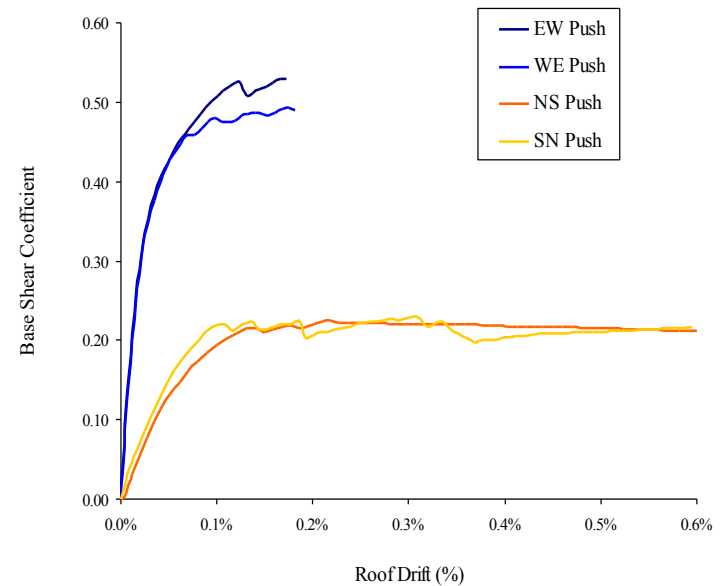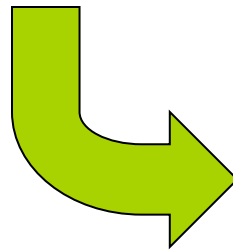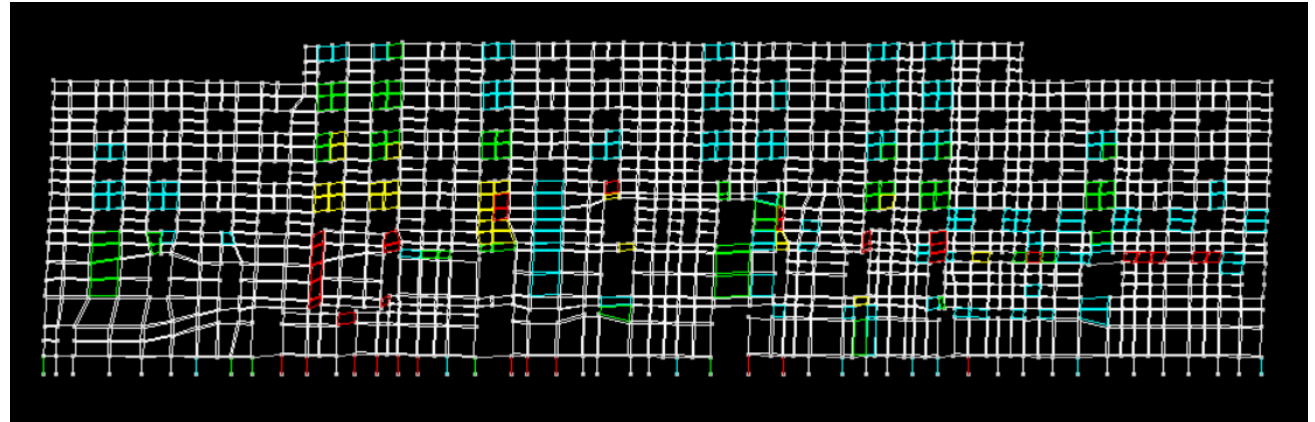# Studying Potential Mechanisms
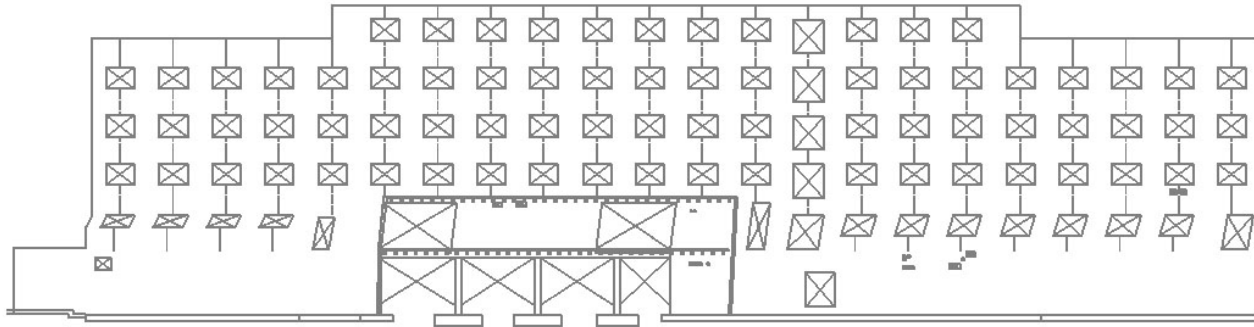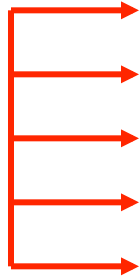

Soft Story Mechanism
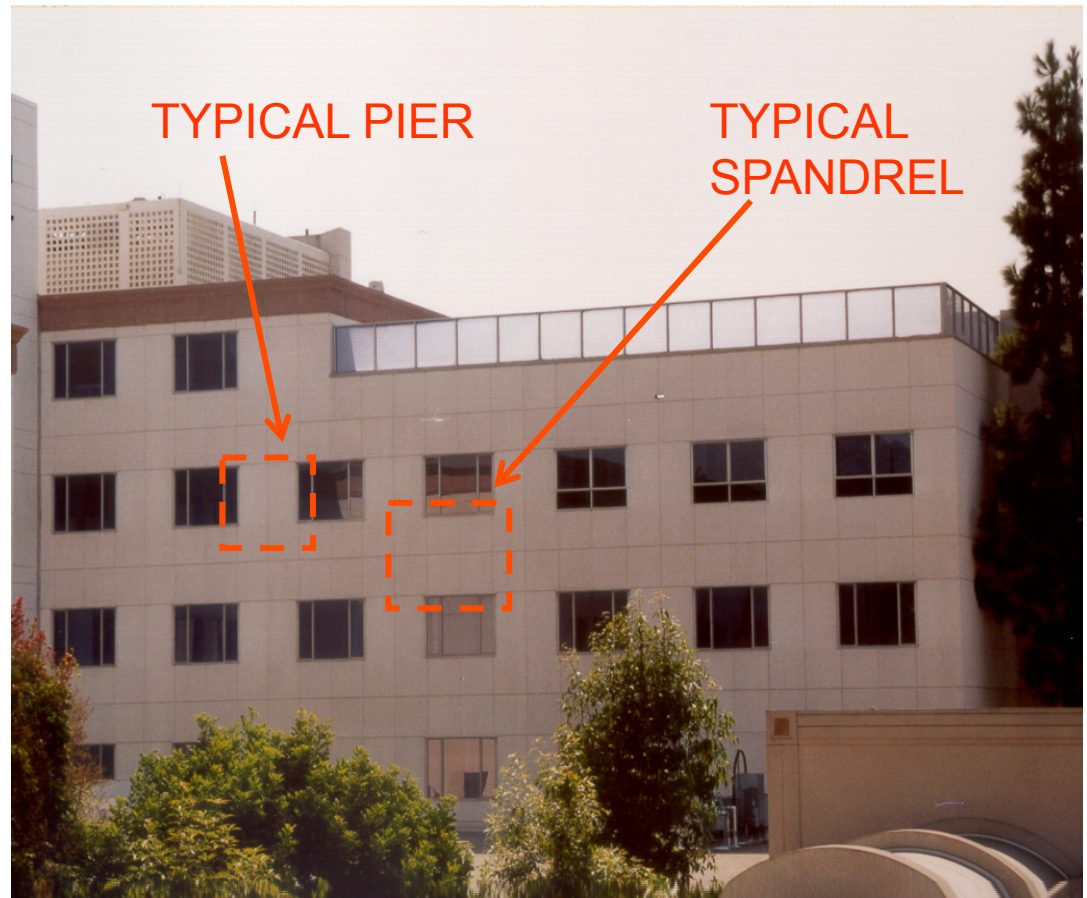

Rocking Mechanism

Perform Model

Non-linear Pushover Analysis

PUSH

Component Testing Program

- Consists of representative shear wall spandrels and piers
- Purpose is to provide more representative backbone curves than provided by FEMA-356
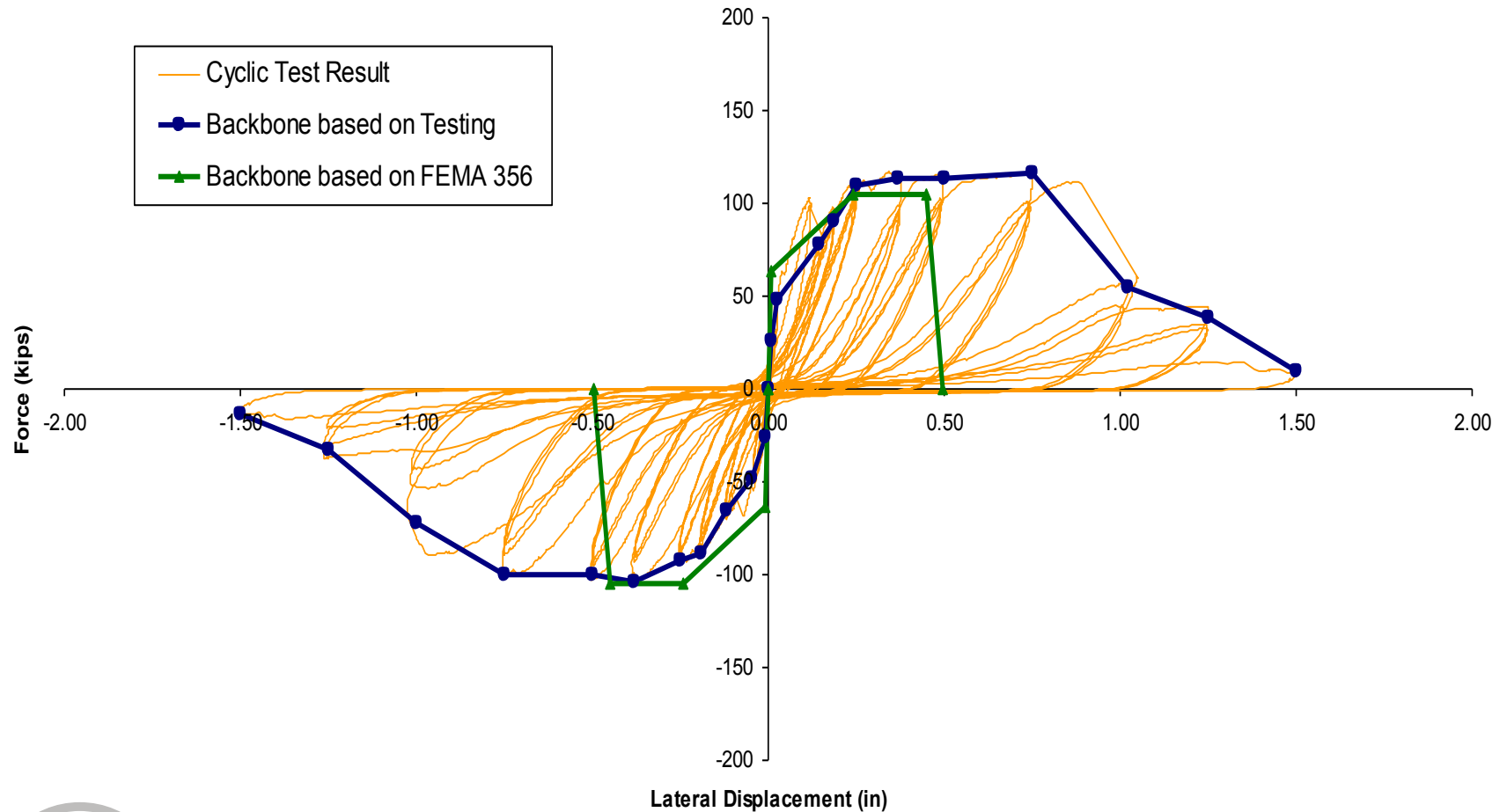- Involve OSHPD in testing through approved testing criteria and observation of tests

TYPICAL PIER

TYPICAL SPANDREL
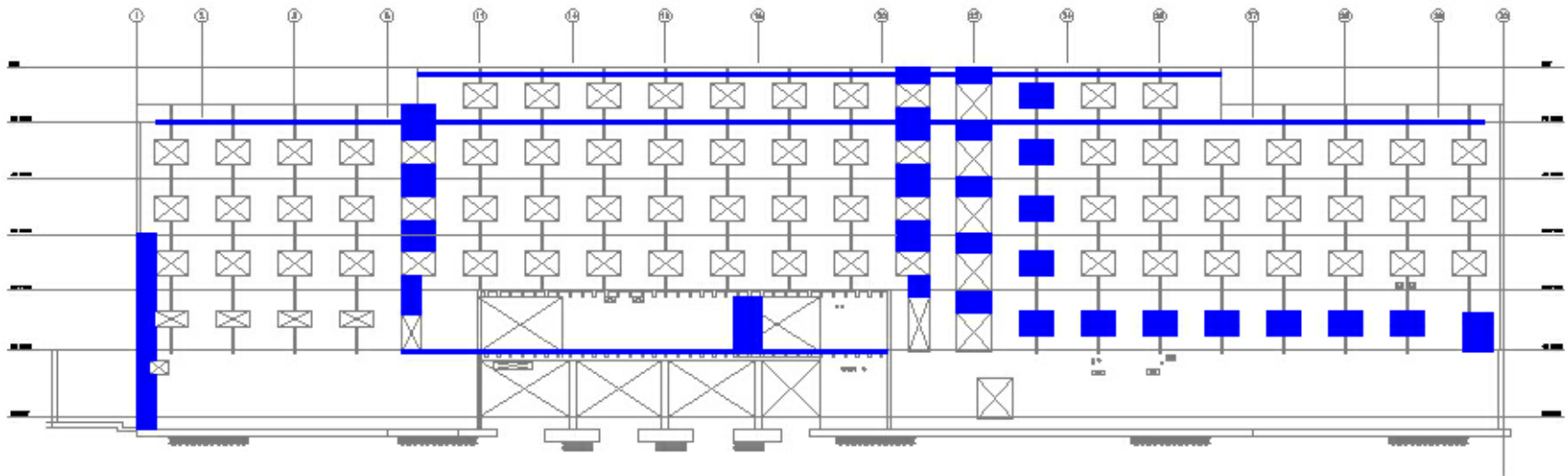
UCLA Lab Testing Setup
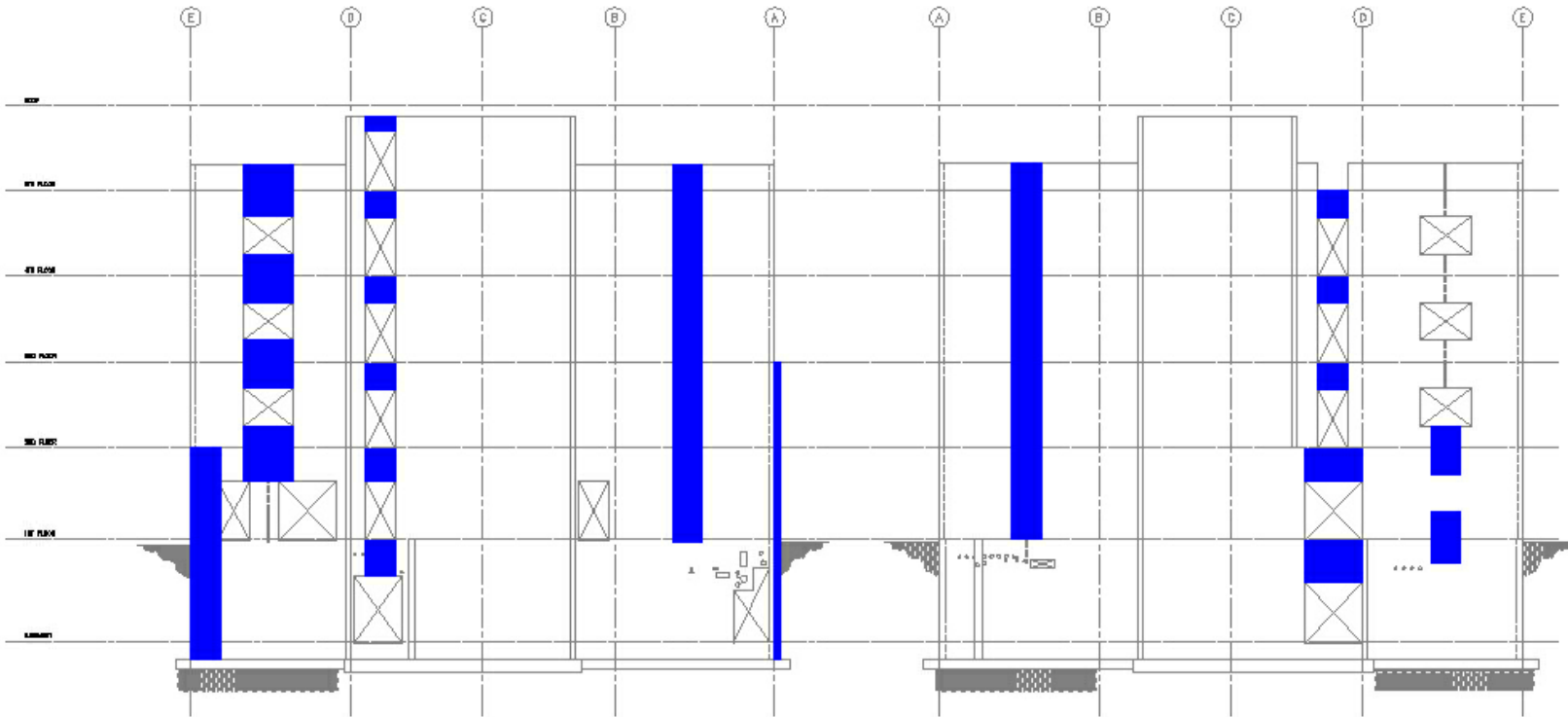
Spandrel Test Results

Tested vs. Assumed Backbone Curves (Spandrels)

Retrofit using non-linear analysis

Retrofit using Nonlinear Analysis
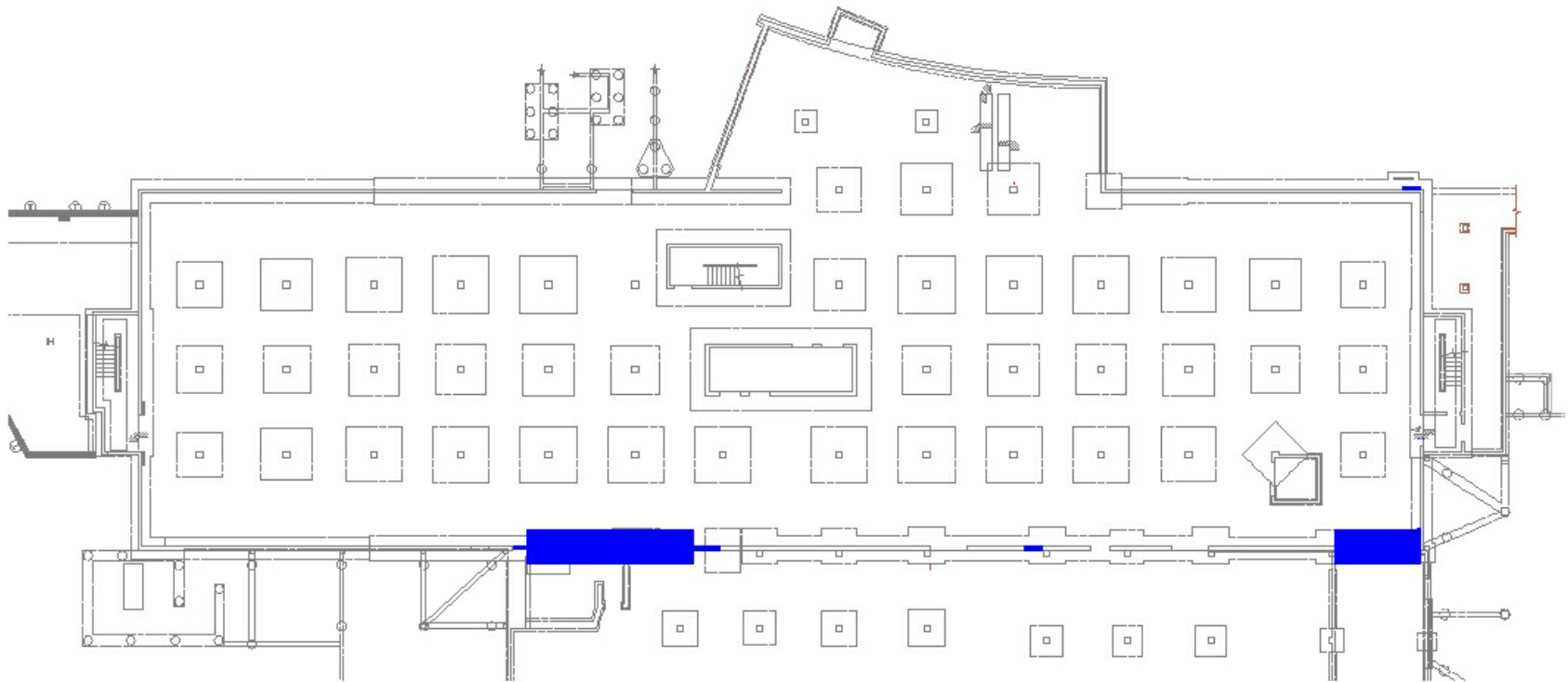

Wall Elevation   Wall Elevation

Indicates 8" of concrete thickening or concrete "catch" mechanisms above building exits
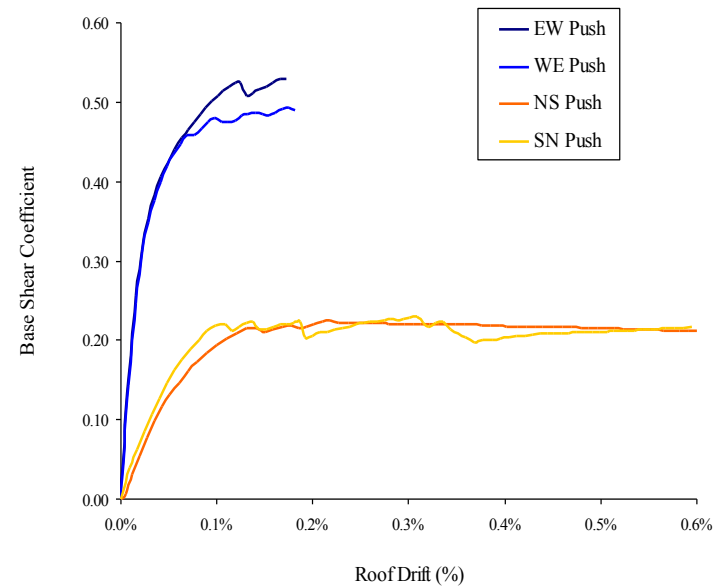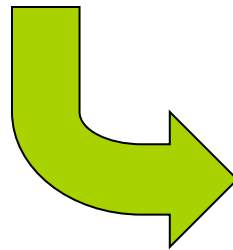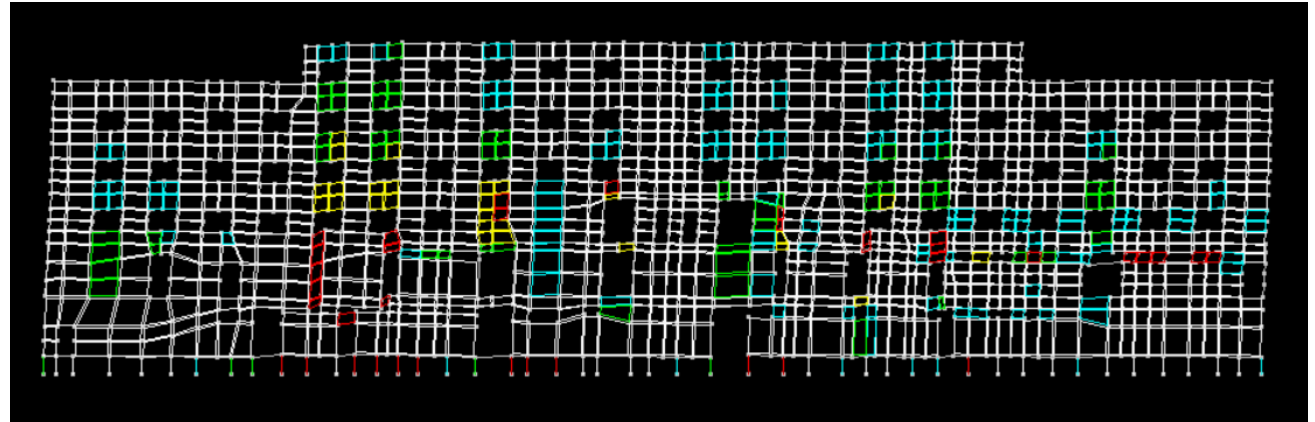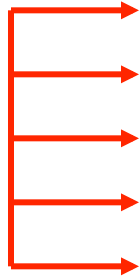
Retrofit using Nonlinear Analysis

Foundation Plan

 Indicates approximately 18" of concrete footing thickening

Non-linear Pushover Analysis

PUSH

Risk Targeted Retrofit to SPC-2

- Where the Office has performed a collapse probability assessment, and the Probability of Collapse is less than or equal to 1.20% (HAZUS)

- Could required mitigation of some significant structural deficiencies.

Significant Structural Deficiencies pertinent to Concrete Buildings

- Short Captive Column
- Weak Story
- Soft Story
- Torsion
- Deflection Incompatibility
- Vertical Discontinuity
- Weak Columns
- Load Path

NORTHRIDGE 20
SYMPOSIUM

Case Study – Collapse Probability

Building Height = 65'-8"

Building Type = C1M,

Concrete Moment Frame

Code Year = 1964

Deficiencies = Weak Column Concrete,

Deflection Incompatibility

Fault Distance = 10.7 km

Fault Magnitude = 7.0

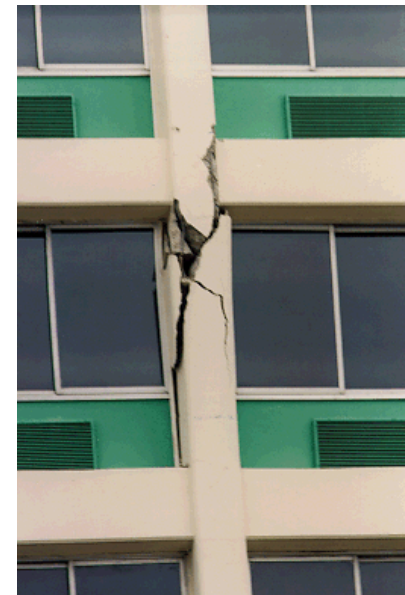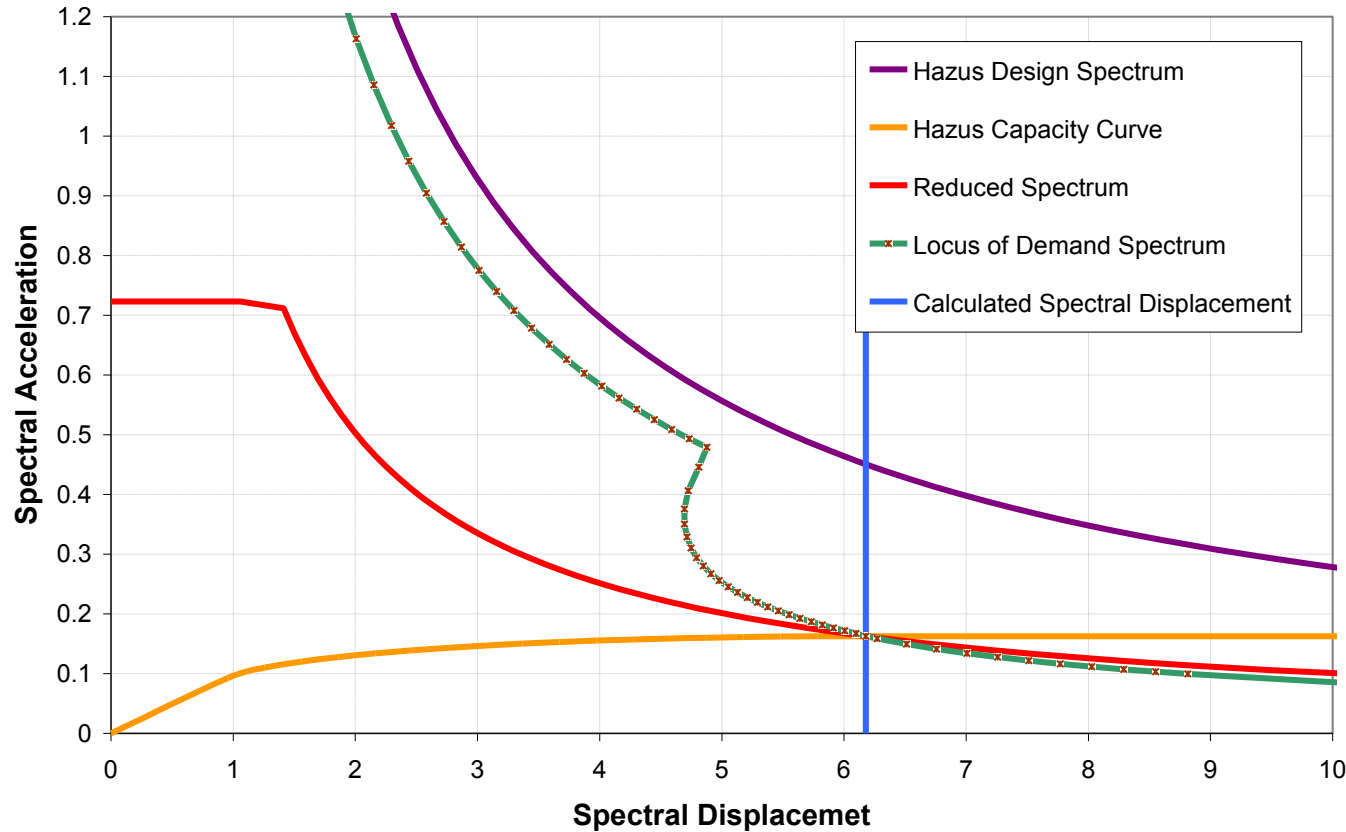Zone = 4

Sa03 = 1.498 g

Sa10 = 0.533 g

Building Input Parameters

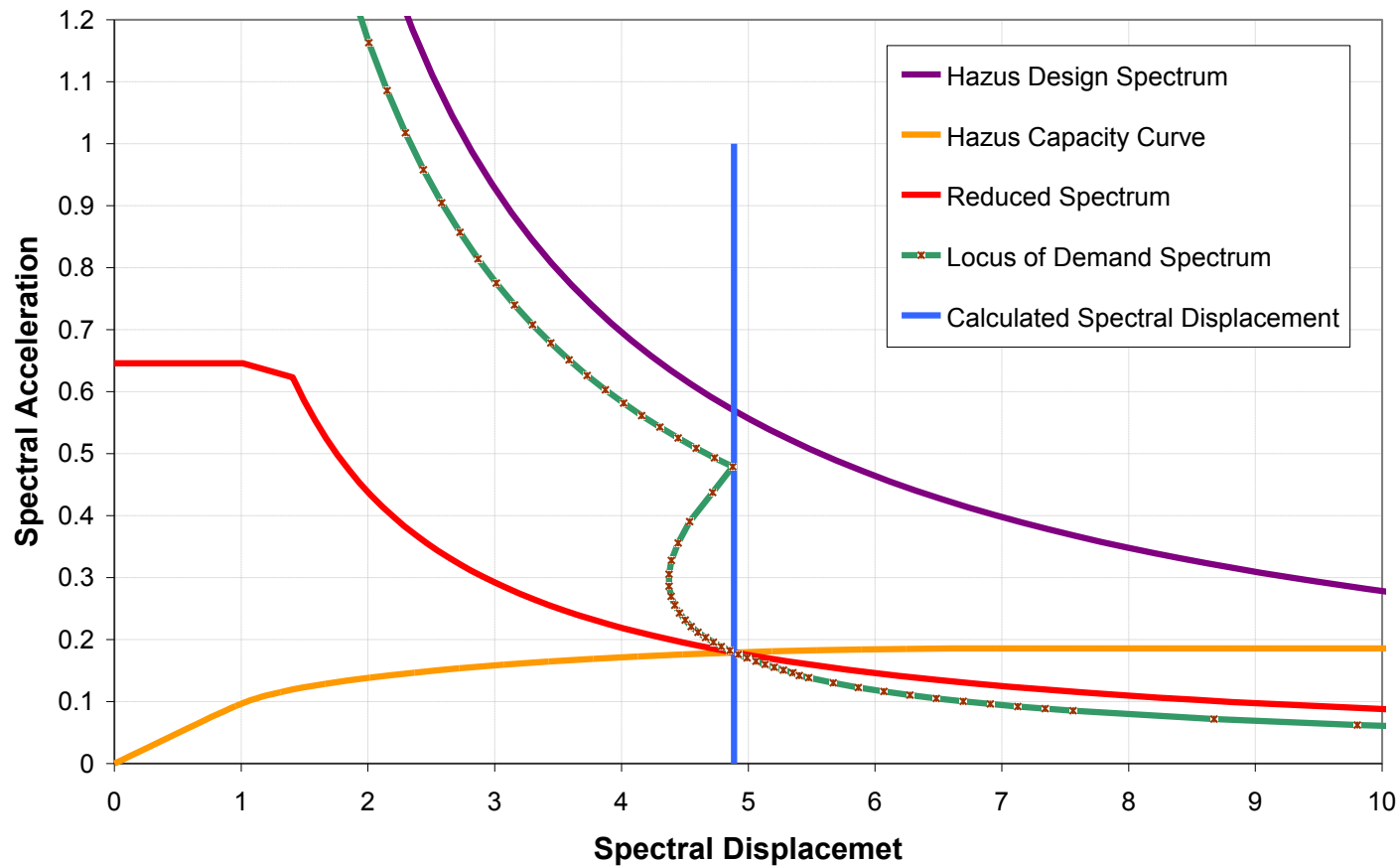| Response Parameter	Case a (No Deficiencies)	Case b (With Deficiencies)
Building Capacity		
$A_y =$	0.09	0.09
$D_y =$	0.96	0.96
$A_u =$	0.19	0.16
$D_u =$	6.95	6.08
Building Response		
$\kappa =$	0.6	0.4
Building Fragility		
$S_{DC} =$	19.29	16.08
$\beta =$	0.81	0.91
Collapse Rate Factor		
$P[COL|STR_5] =$	0.13	0.25

Collapse Probability, with Deficiencies

Sd = 6.18 inches, P|Col = 3.67%

Collapse Probability, No Deficiencies

Sd = 4.89 inches, P|Col = 0.59%

Common Retrofit Techniques

- FRP
- New Shear Walls
- Concrete jacketing
- Dampers
- Alternate methods for shear enhancement

Questions ?