Technical Report 4

Lateral System Analysis

Image courtesy of Cannon Design

University of Virginia's College at Wise
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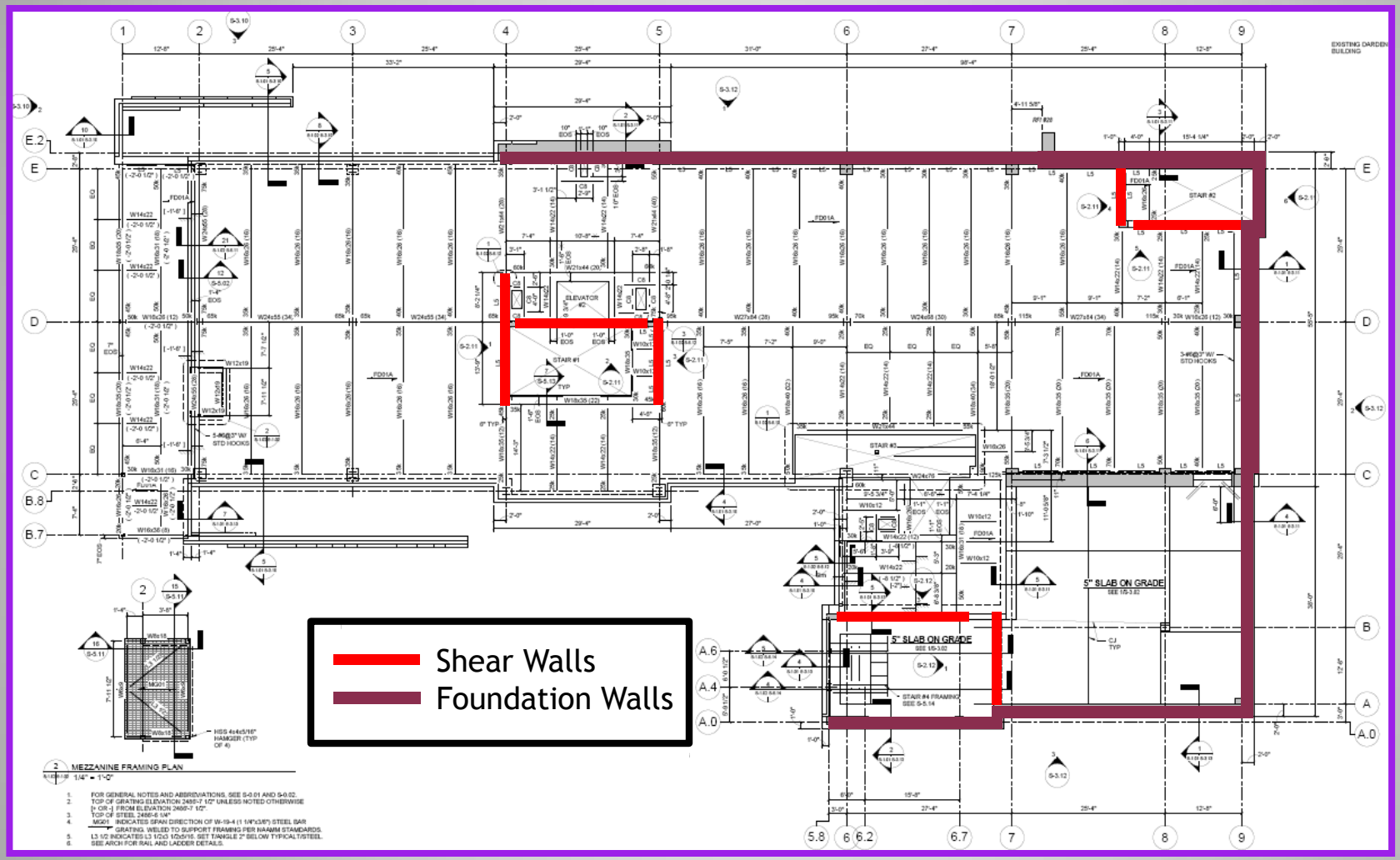
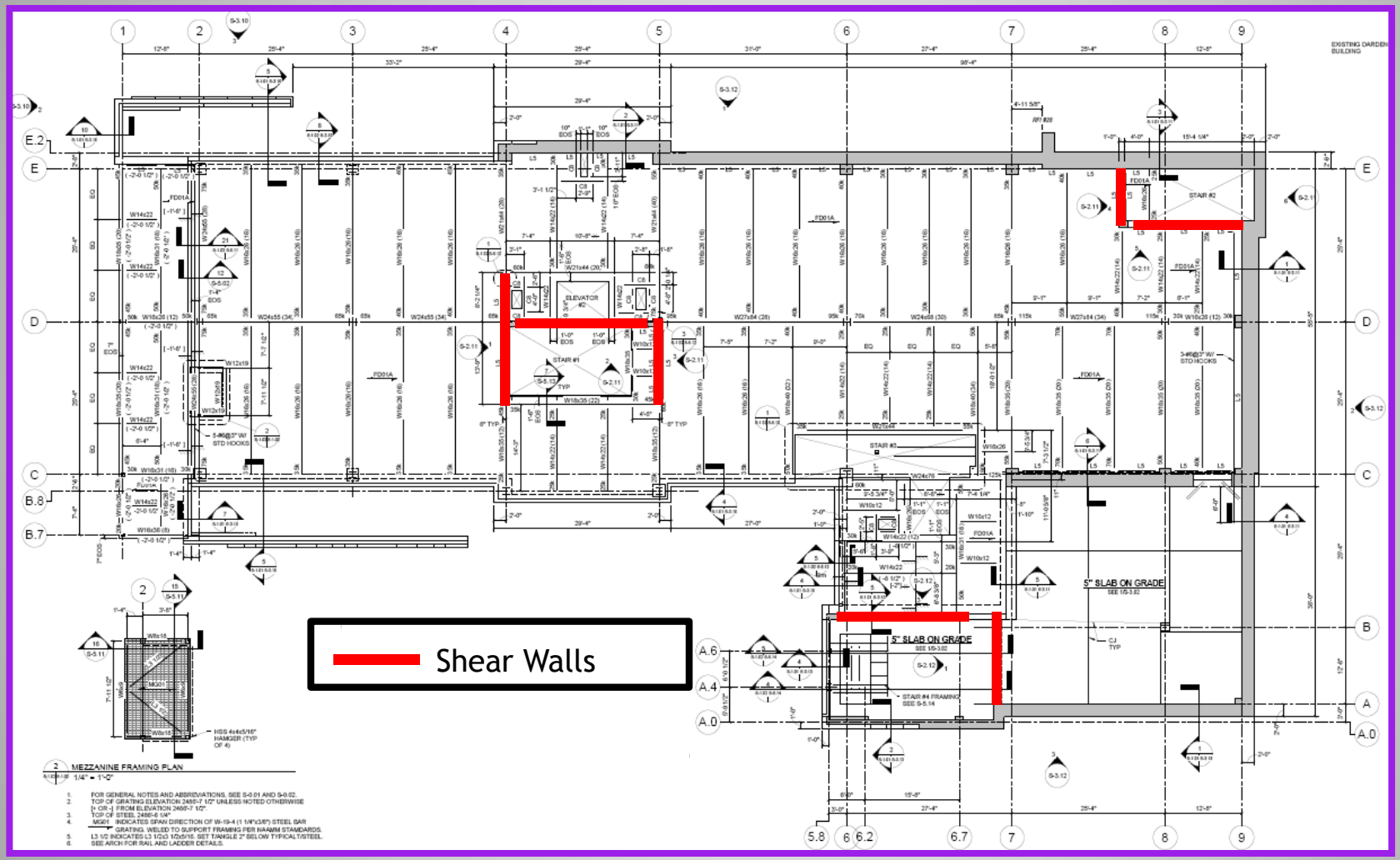
Structural Option
Advisor: Heather Sustersic

Elements Modeled

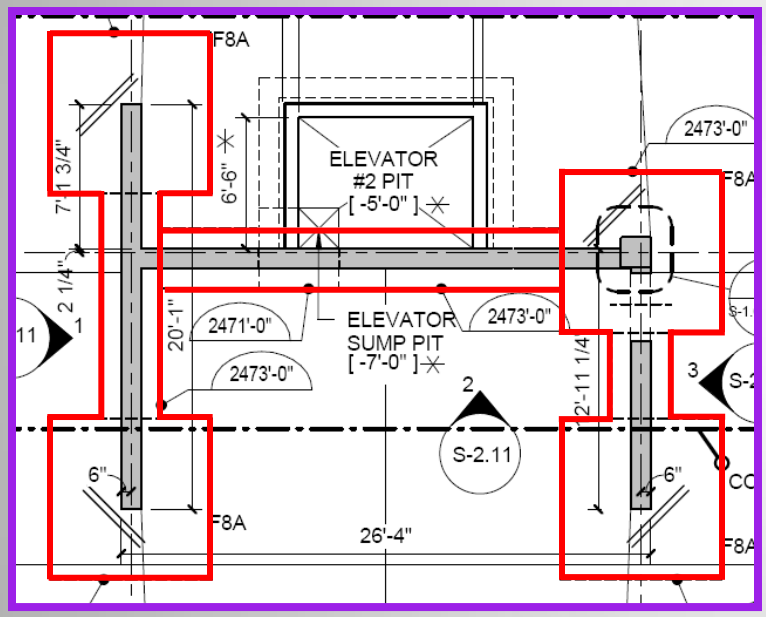


Elements Modeled

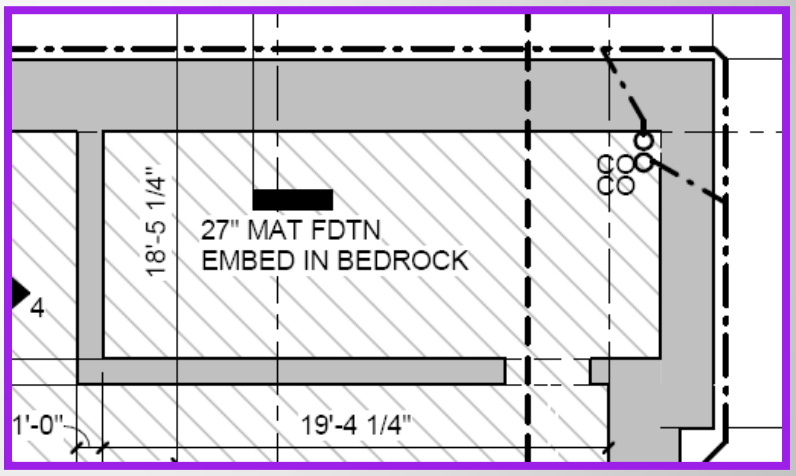


Base Conditions

- Pin Conditions



- Fixed Conditions

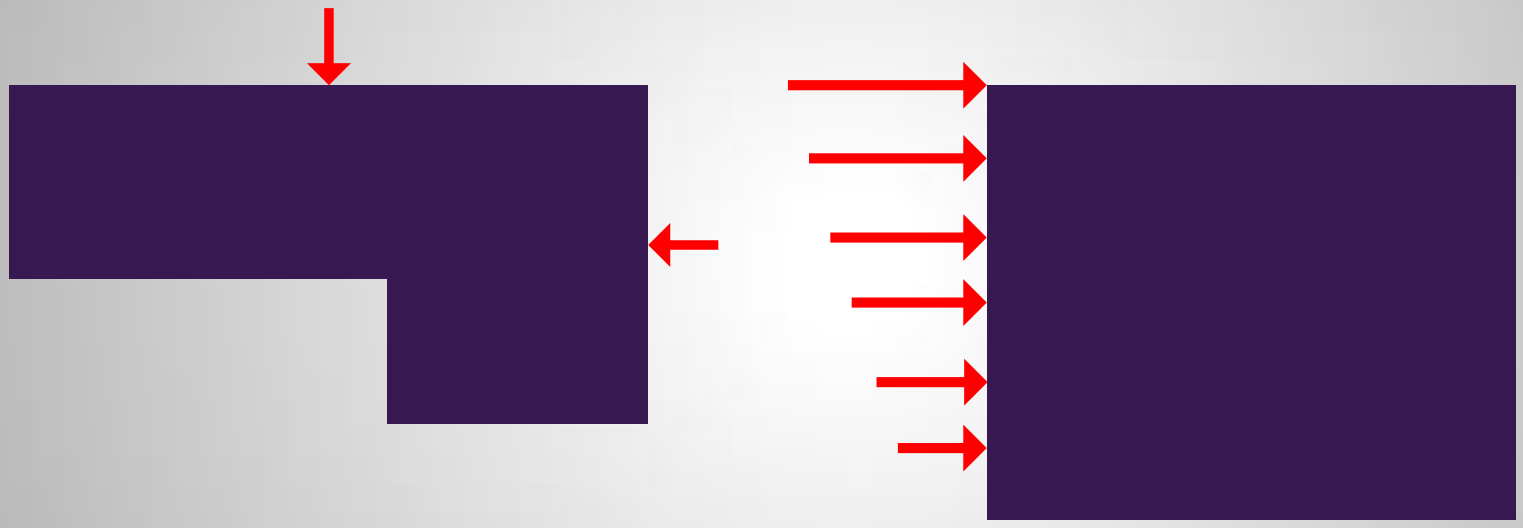


Diaphragm Type

- Rigid
  - Composite steel floor system with composite metal deck
  - Ensures the shear forces are transmitted to the shear walls and not resisted by the diaphragm

Distribution of Forces: Wind

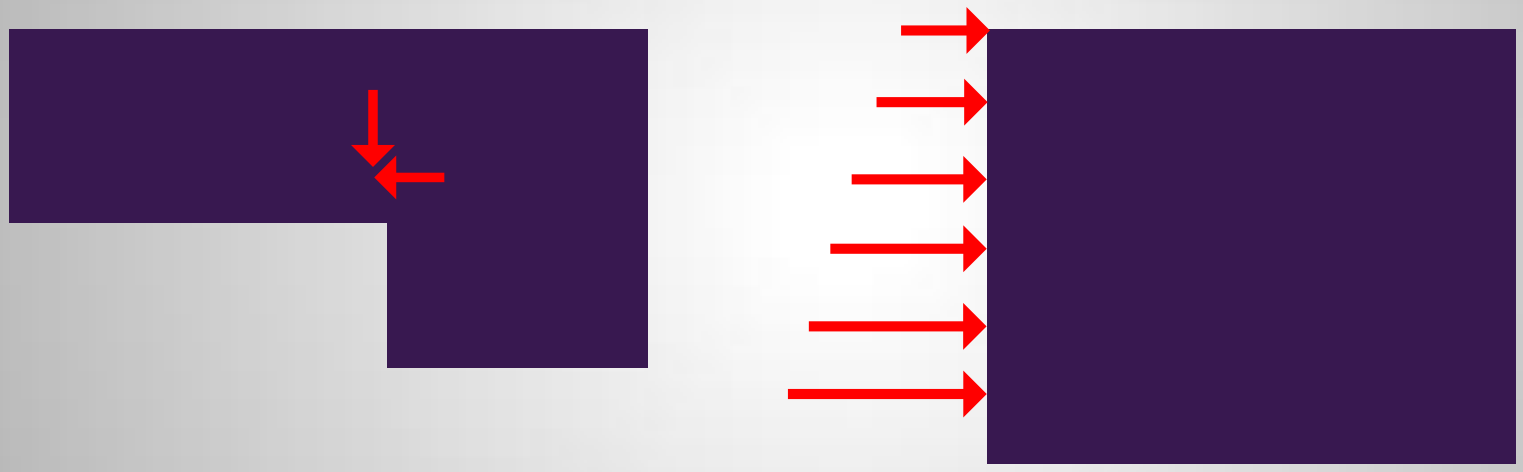
- Horizontal
  - Applied at center of pressure
- Vertical
  - Applied at each story level



ASCE7-05 requires four different wind loading conditions be applied in order to account for quartering winds and torsion. Pressures were calculated for these four cases and applied as forces each story level using tributary area in order to transfer the load through the diaphragm to lateral elements.

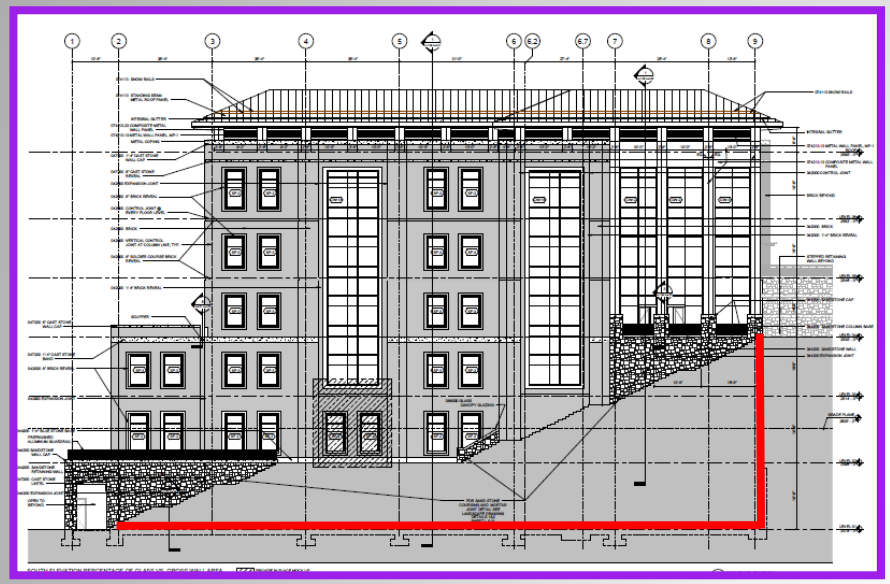
Distribution of Forces: Seismic

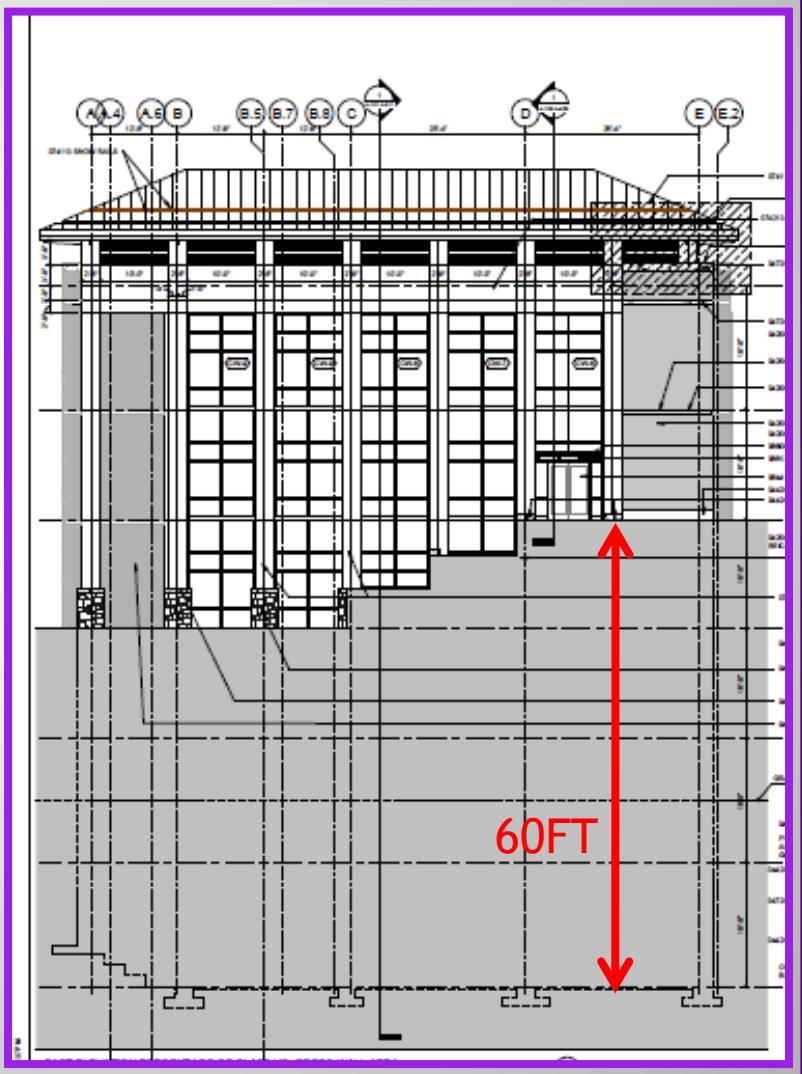
- Horizontal
  - Applied at center of mass
- Vertical
  - Applied at each story level



ASCE7-05 requires that accidental torsion be considered for both orthogonal directions, and orthogonal interaction effects are permitted to be neglected base on the seismic category B. Forces along with moments due to torsion were applied at each story level in order to transfer the load through the diaphragm to lateral elements.

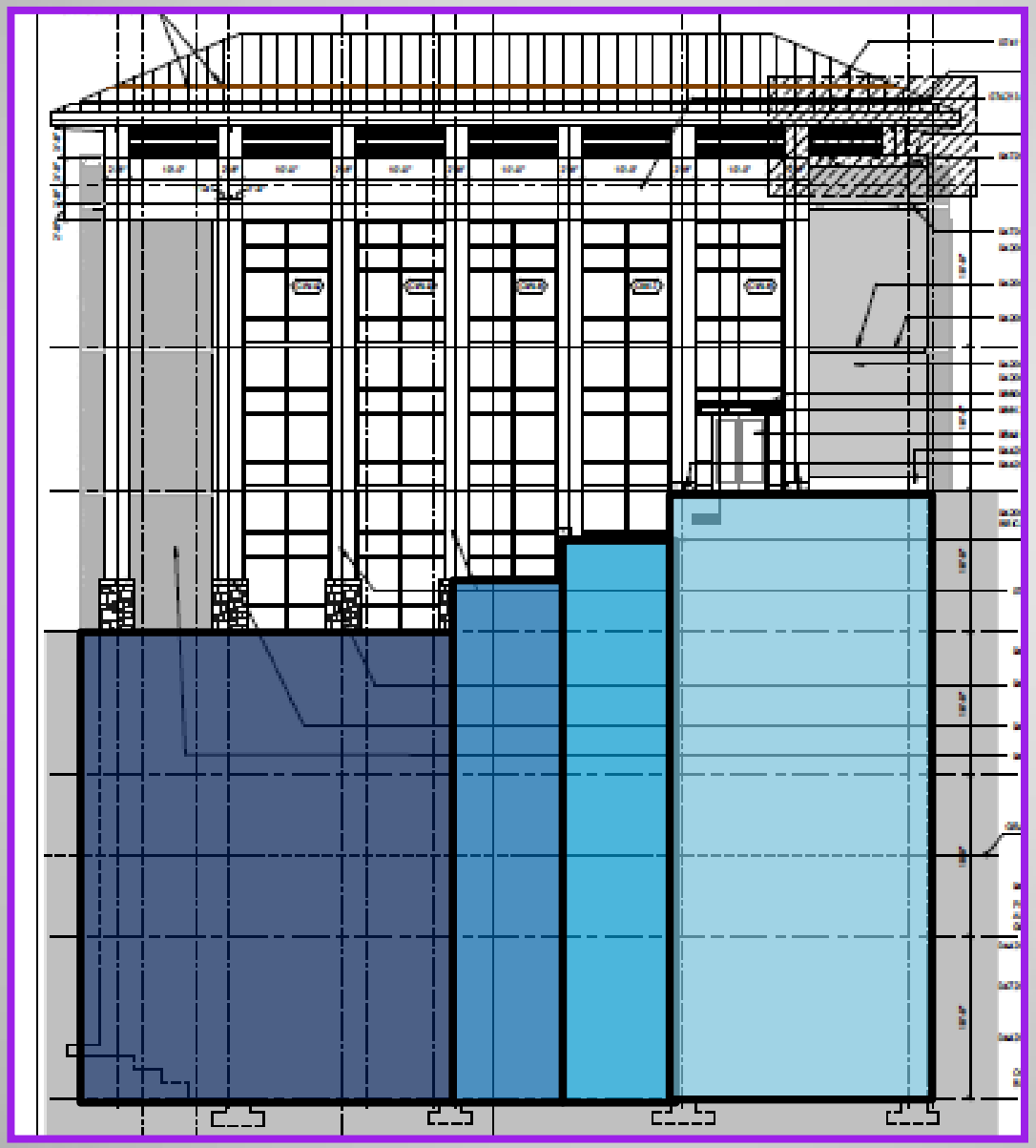
Distribution of Forces: Soil





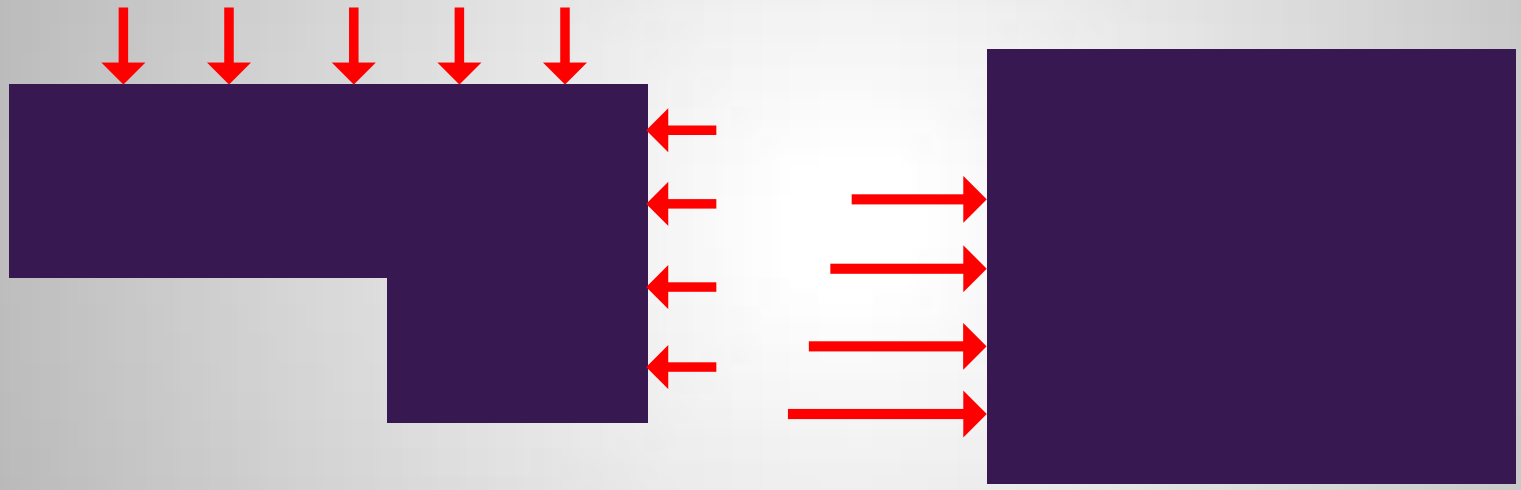
- Max Soil Depth: 60 FT
- Equivalent Lateral Fluid Pressure:
  47 PCF

Distribution of Forces: Soil



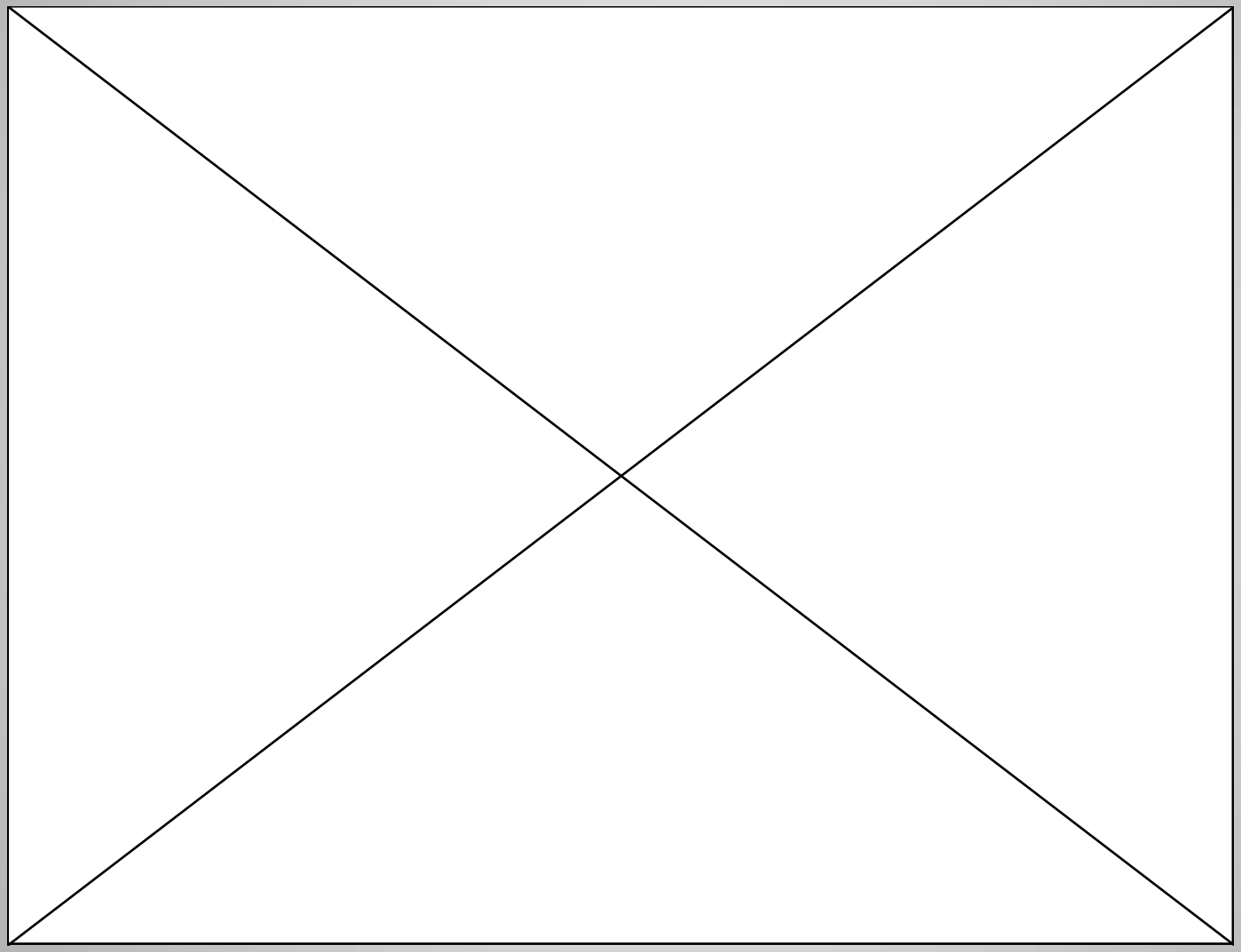
Distribution of Forces: Soil

- Horizontal
  - Applied at center of each wall section
- Vertical
  - Applied at each story level below grade

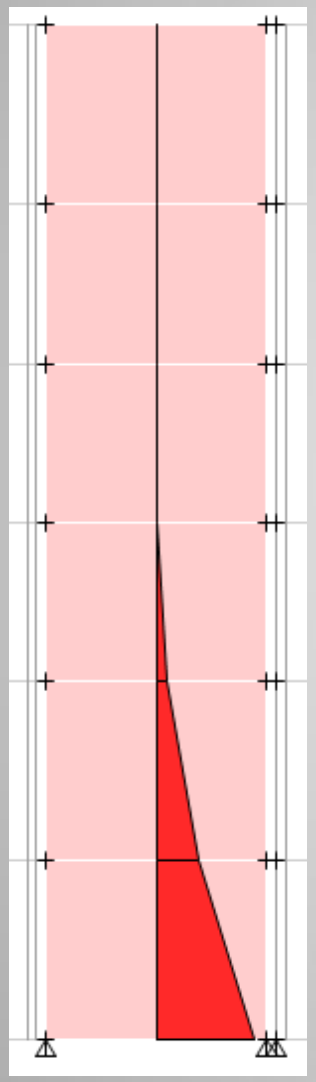


The equivalent lateral fluid pressure was converted into multiple point loads at each level based on tributary area and soil depth. Forces were applied at each story level in order to transfer the load through the diaphragm to lateral elements.

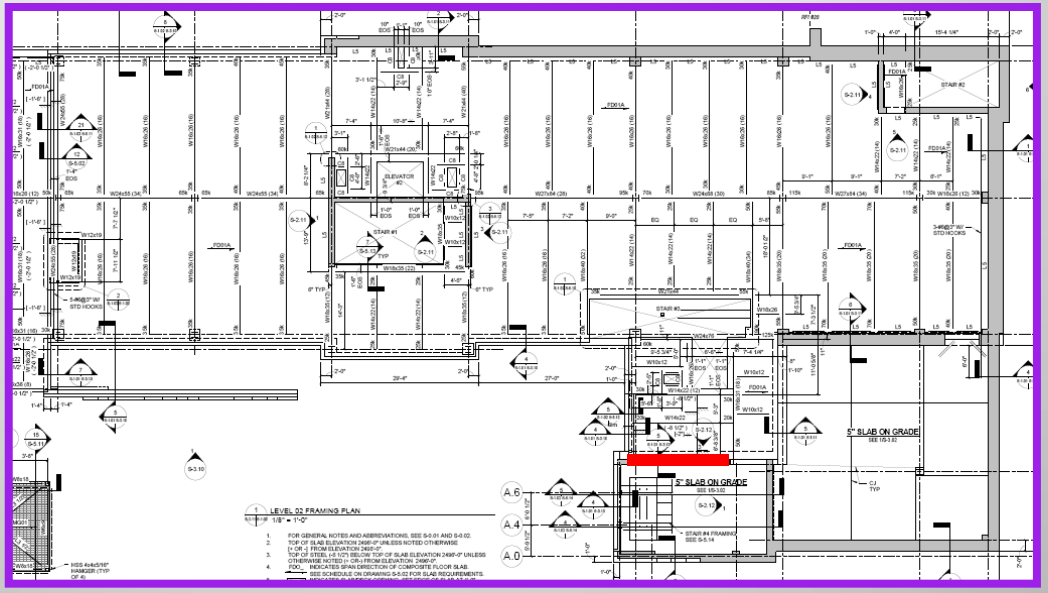
Animation: Seismic X-Direction (+Moment)



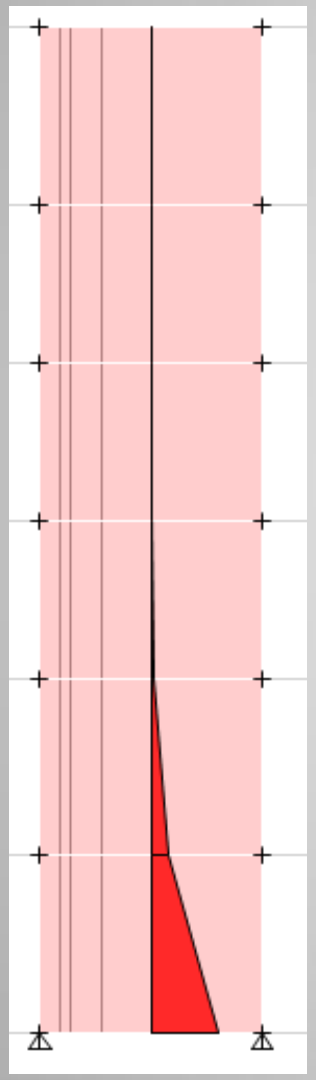
Moment Diagram – Critical Members



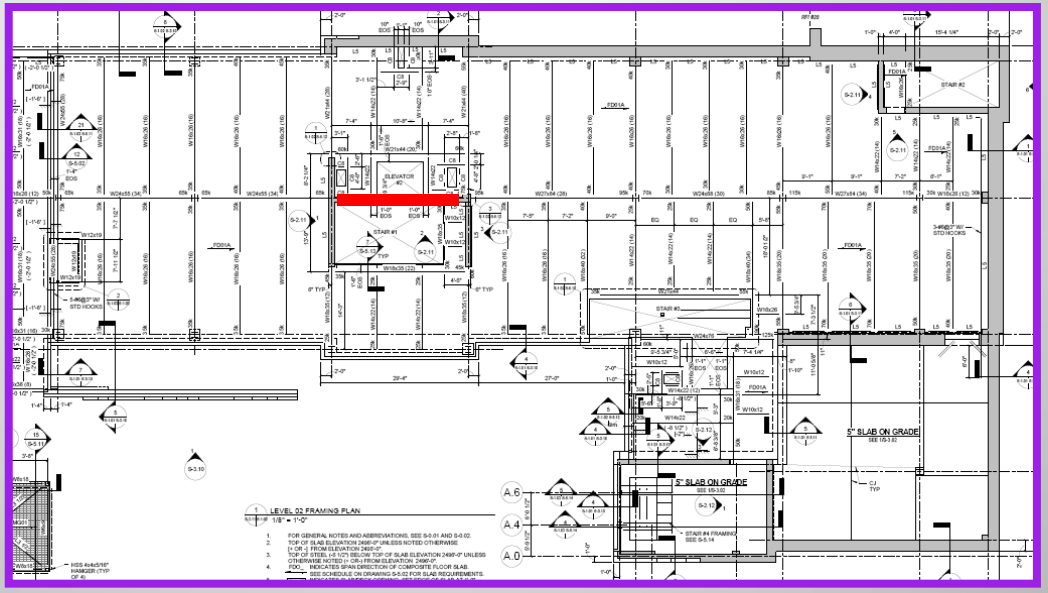
- Shear Wall 2
  - Wall thickness at base: 33”
  - Loading Condition: Soil Loads in the x-direction
  - Maximum Moment: 65,214 K-FT



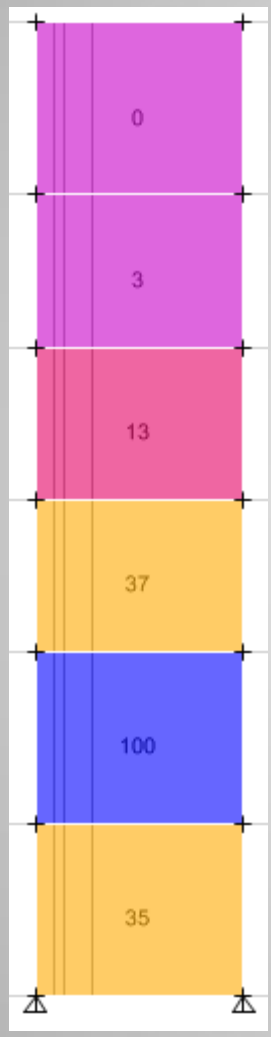
Moment Diagram – Critical Members



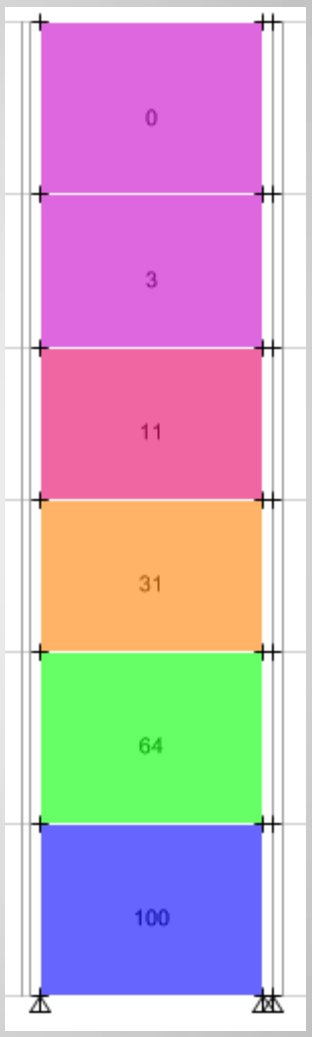
- Shear Wall 6
  - Wall thickness at base: 12”
  - Loading Condition: Soil Loads in the x-direction
  - Maximum Moment: 51,194 K-FT



Member Utilization Ratios



- Shear Wall 2
  - Wall thickness at base: 33”
  - All other wall thicknesses: 12”



- Shear Wall 6
  - Wall thickness at base: 12”
  - All other wall thicknesses: 12”

Is the Lateral System Acceptable?

- Criteria for Acceptability
  - Strength
  - Drift – Wind
  - Drift – Seismic
  - Overturning Moment

Is the Lateral System Acceptable?

- Strength

  Controlling Load Combination:

  0.9D + 1.0E +1.6H

  - Shear Wall 2
    - ϕV_n = 14,140k > 4,585 k → **PASSED**
  - Shear Wall 6
    - ϕV_n = 4,752k > 2,726k → **PASSED**

Is the Lateral System Acceptable?

- Drift – Wind

Drift criteria: H/400

Wind Load Cases			
Load Case	Maximum Drift (in)	Allowable Drift (in)	Pass/Fail
Wind Case 1 X-Direction	0.588931	3.06	PASS
Wind Case 1 Y-Direction	2.618755	3.06	PASS
Wind Case 2 X-Direction (+M)	0.680642	3.06	PASS
Wind Case 2 X-Direction (-M)	0.544755	3.06	PASS
Wind Case 2 Y-Direction (+M)	2.843785	3.06	PASS
Wind Case 2 Y-Direction (-M)	1.511819	3.06	PASS
Wind Case 3	2.142169	3.06	PASS
Wind Case 4 (+Moments in Same Direction)	3.006926	3.06	PASS
Wind Case 4 (-Moments in Same Direction)	1.472554	3.06	PASS
Wind Case 4 (+Moments in Opposite Direction)	2.286839	3.06	PASS
Wind Case 4 (-Moments in Opposite Direction)	1.594228	3.06	PASS

Is the Lateral System Acceptable?

- Drift – Seismic

Drift criteria:

TABLE 12.12-1 ALLOWABLE STORY DRIFT, Δ_a [a,b]

Structure	Occupancy Category		
	I or II	III	IV
Structures, other than masonry shear wall structures, 4 stories or less with interior walls, partitions, ceilings and exterior wall systems that have been designed to accommodate the story drifts.	$0.025h_{sx}$ [c]	$0.020h_{sx}$	$0.015h_{sx}$
Masonry cantilever shear wall structures [d]	$0.010h_{sx}$	$0.010h_{sx}$	$0.010h_{sx}$
Other masonry shear wall structures	$0.007h_{sx}$	$0.007h_{sx}$	$0.007h_{sx}$
All other structures	$0.020h_{sx}$	$0.015h_{sx}$	$0.010h_{sx}$

[a] h_{sx} is the story height below Level x.

Loading Conditions Checked

- Seismic x-direction + eccentricity
- Seismic x-direction – eccentricity
- Seismic y-direction + eccentricity
- Seismic y-direction - eccentricity

→ PASSED

Is the Lateral System Acceptable?

- Overturning Moment

  Controlling Load Combination:

  0.9D + 1.0E +1.6H

  - Overturning moment in the x-direction
    - M_{resist} = 461,528 k-ft > $M_{overturn}$ = 73,764 k-ft → **PASSED**
  - Overturning moment in the y-direction
    - M_{resist} = 1,496,161 k-ft > $M_{overturn}$ = 154,774 k-ft → **PASSED**

Is the Lateral System Acceptable?

- Conclusion
  - Lateral system acceptable according to industry standard serviceability and strength considerations.

Thank You! Any Questions?