CANNONDESIGN

# ECMC Skilled Nursing Facility

462 Grider Street Buffalo, NY 14215


Brian Brunnet
Structural Option
AE 482 – Senior Thesis
Dr. Ali Memari


# Presentation Outline

1. Project Background
2. Scope of Work
3. Structural Depth Study
   i. Foundation System
   ii. Gravity System
   iii. Lateral Force Resisting System
4. Mechanical Breadth
5. Construction Management Breadth
6. Summary of Conclusions
7. Acknowledgments


# Project Background

Building Statistics:

- Location: 462 Grider St. Buffalo, NY 14215
- Occupant: Erie County Medical Center
- Occupancy Type: Medical
- Size: 296,000 SF
- Number of Stories: 6
- Maximum Height: 90’-0”
- Completion Date: July 2012
- Project Cost: $95 Million
- Delivery Method: Design-Bid-Build

ECMC CANNONDESIGN

Project Team:

- Owner: ECMC Corporation
- Architect: Cannon Design
- Construction Manager: LP Ciminelli
- Structural Engineer: Cannon Design
- Civil Engineer: Watts Architecture & Engineering
- MEP Engineer: M/E Engineering

WATTS ARCHITECTURE & ENGINEERING, P.C.
LPCiminelli Integrity and ingenuity at work
M/E ENGINEERING, P.C.

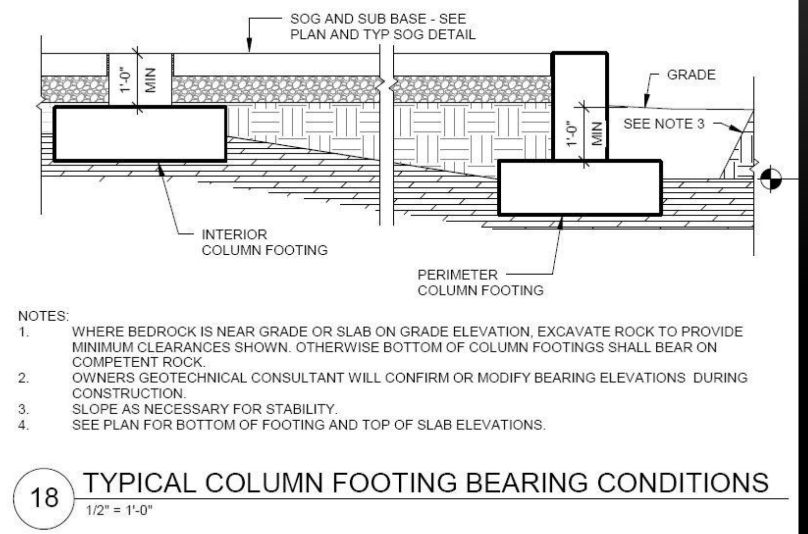
# Project Background

1. Project Background
2. Scope of Work
3. Structural Depth Study
   1. Foundation System
   2. Gravity System
   3. Lateral Force Resisting System
4. Mechanical Breadth
5. Construction Management Breadth
6. Summary of Conclusions
7. Acknowledgments

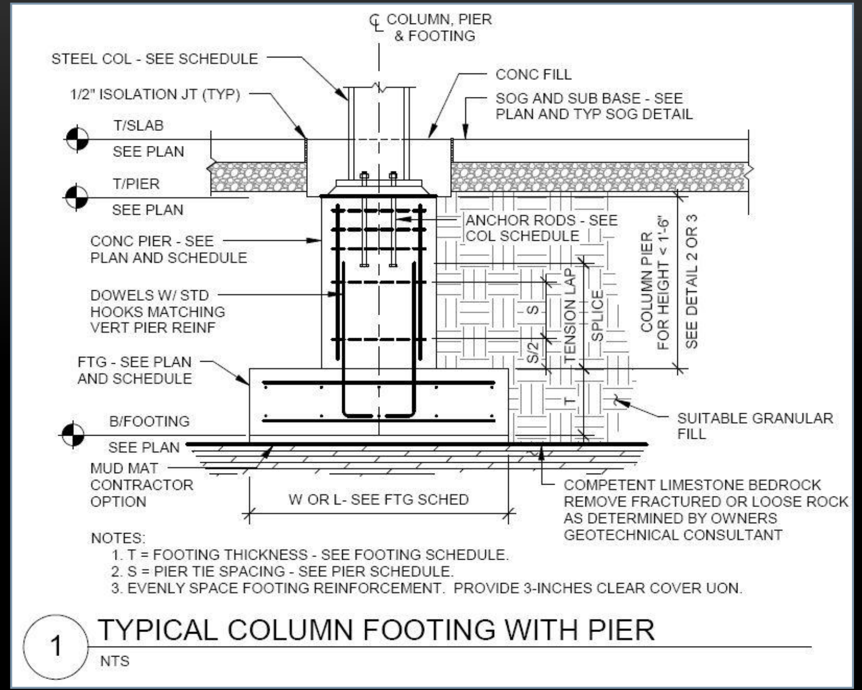
## Existing Structural System

Foundation System:

- 5” Slab on Grade
- 12” Concrete Mat beneath elevator core
- Square Spread Footings
  - Sizes range from 3’-6” to 7’
  - Depths range from 1’-8” to 2’-8”
  - 3000 psi Normal Weight concrete
  - Soil Bearing Capacity of 16,000 psf




18 TYPICAL COLUMN FOOTING BEARING CONDITIONS
1/2" = 1'-0"




1 TYPICAL COLUMN FOOTING WITH PIER
NTS

**FOOTING SCHEDULE**

**ALLOWABLE BEARING PRESSURE : 16000 PSF**

| MARK | WIDTH | LENGTH | DEPTH | REINFORCING (EW BOT UON) | REMARKS |
|---|---|---|---|---|---|
| F3.5 | 3'-6" | 3'-6" | 1'-8" | 5-#5 | |
| F4.5 | 4'-6" | 4'-6" | 1'-10" | 8-#5 | |
| F4.5-6.5 | 4'-6" | 6'-6" | 1'-10" | 8-#5 LW, 10-#7 SW | |
| F5.5 | 5'-6" | 5'-6" | 2'-2" | 6-#7 | |
| F6.5 | 6'-6" | 6'-6" | 2'-6" | 9-#7 | |
| F6.5-8 | 6'-6" | 8'-0" | 2'-6" | 9-#7 LW, 12-#7SW | |
| F7-A3 | 7'-0" | 7'-0" | 2'-8" | 10-#7 B, 12-#7 T | HOOK TOP BARS, SEE DETAILS 15 & 16 |
| F7-A4 | 7'-0" | 7'-0" | 2'-8" | 10-#7 B, 12-#7 T | HOOK TOP BARS, SEE DETAILS 15 & 16 |

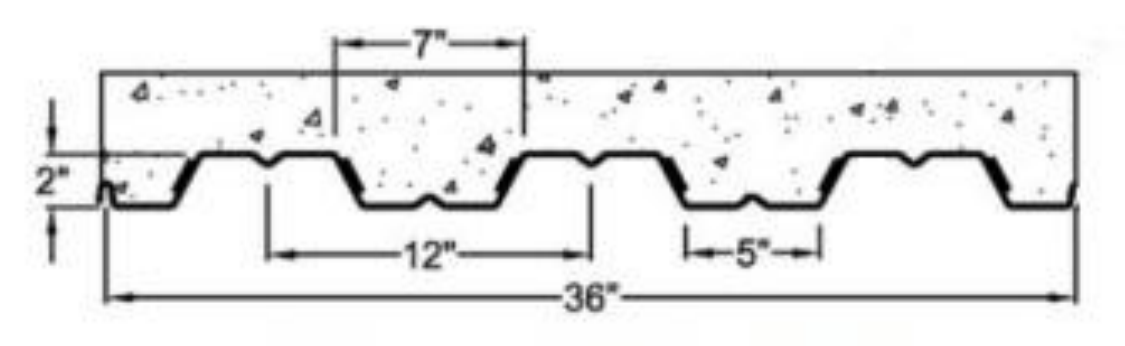
# Project Background

## Existing Structural System

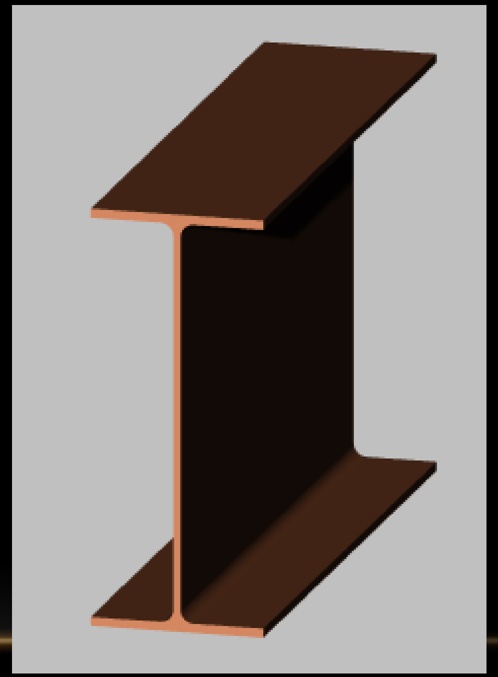
Gravity System:

- Composite Metal Decking
    - 5¼” LWC Floor Slab on 2” 20 Gage Metal Decking
    - Blended Fiber Reinforcement

- Composite Steel Framing
    - Column Sizes of W10
    - Beam Sizes of W12 to W16
    - Girder sizes ranged from W14 to W24
    - Column Splices at 2nd and 4th floors




2" Composite Floor Deck

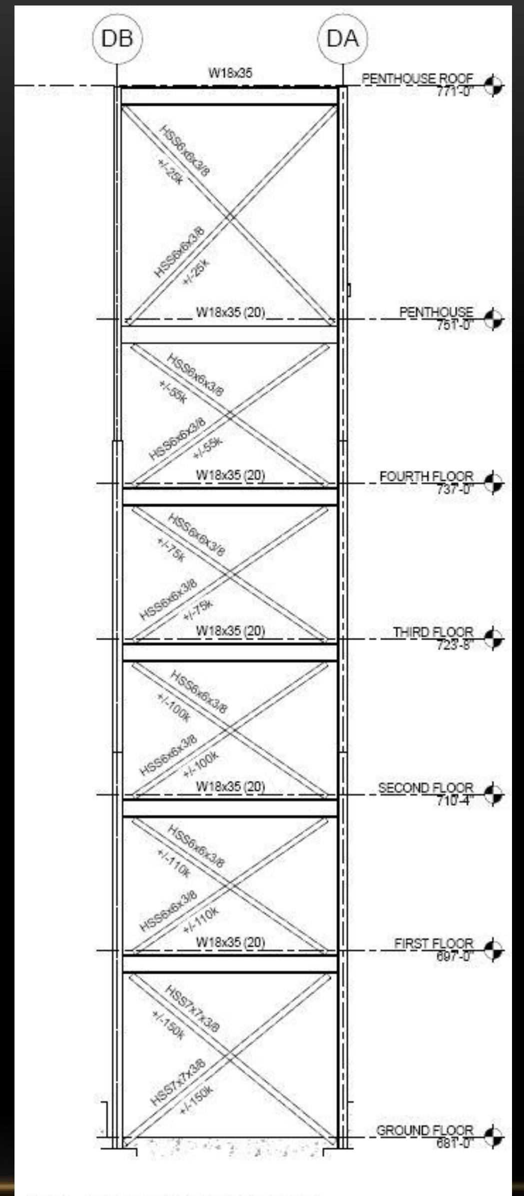


# Project Background

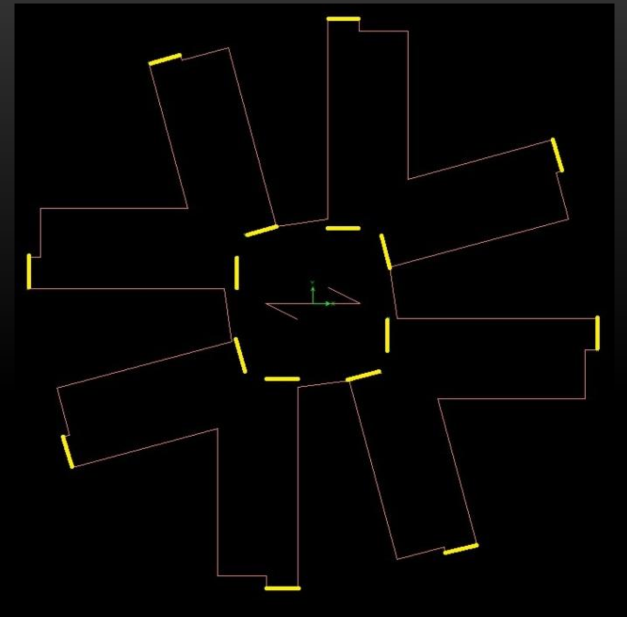
## Existing Structural System

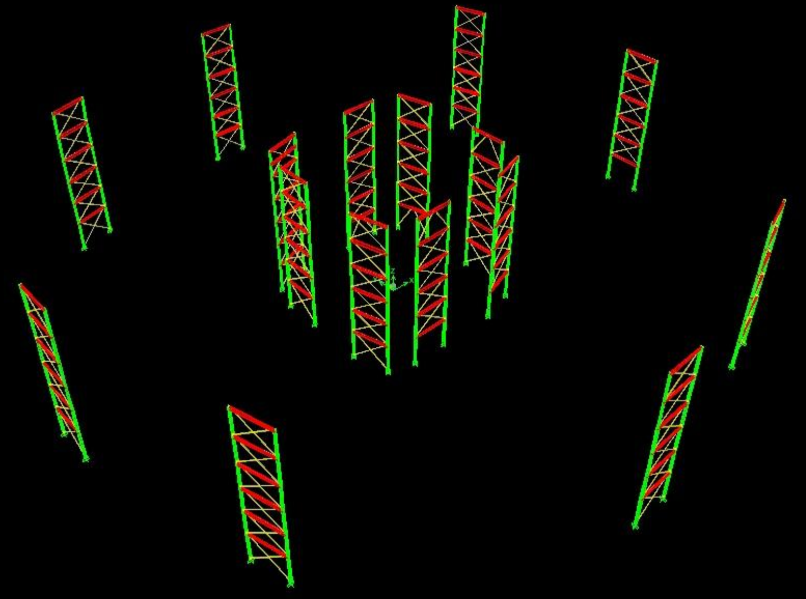
Lateral Force Resisting System:

- Concentrically Braced Frame system
  - HSS Cross Bracing range in size from 6x6x3/8 to 7x7x1/2
  - Lateral system located at the end of each and surrounding the building core
  - Layout consists of a Radial Geometry

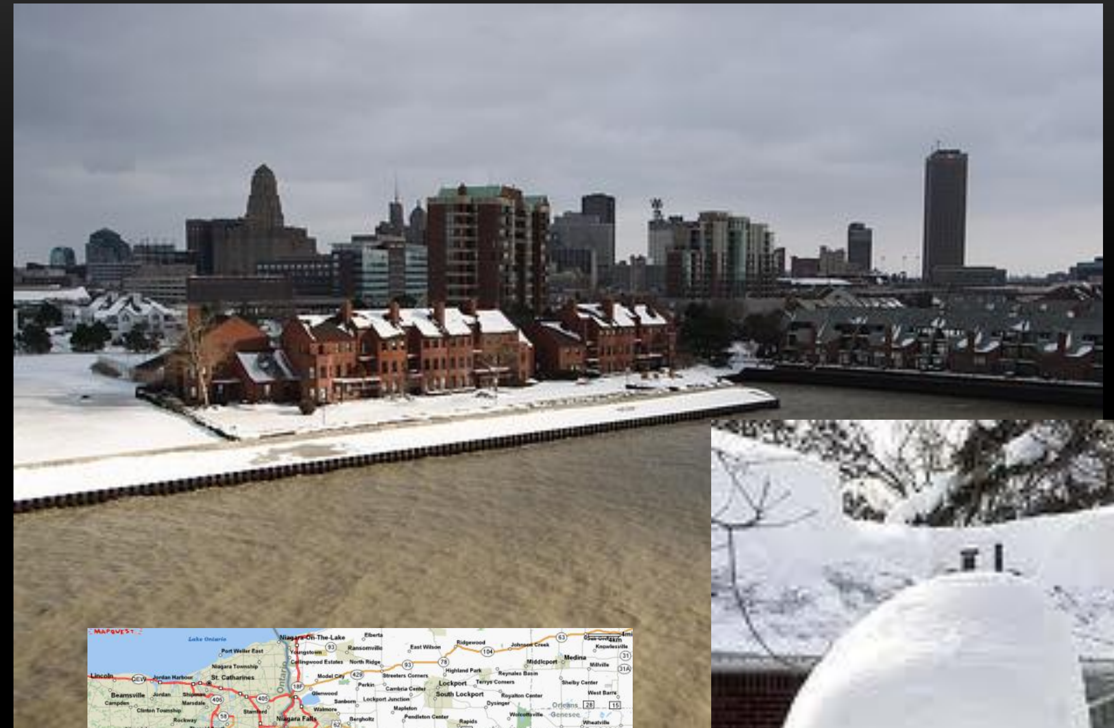


5 ELEVATION GRID D1
NTS





# Scope of Work



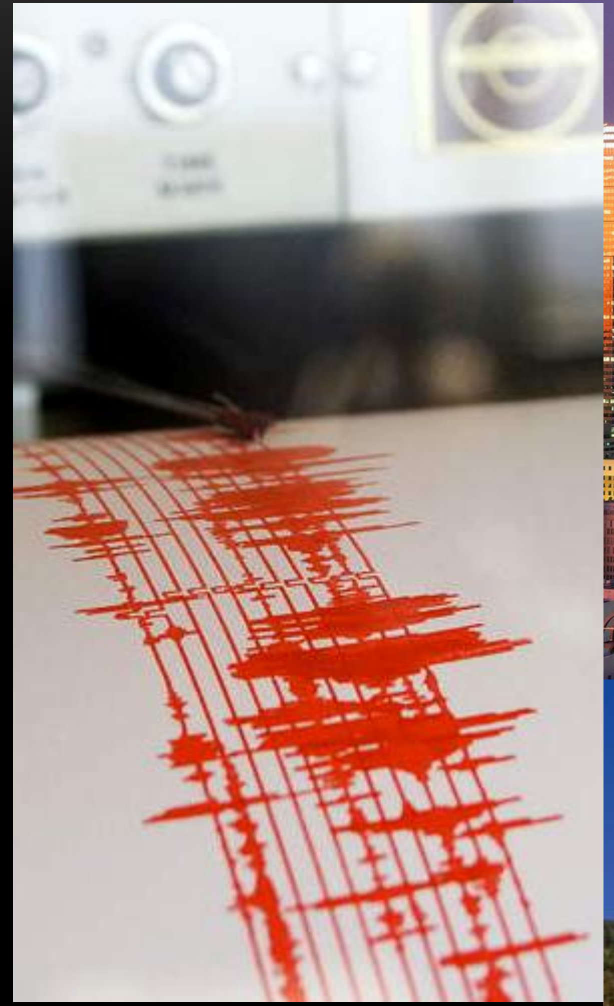
Buffalo, NY

Problem Statement:

- Existing Structural System currently the most efficient and economical
- Design Similar Structural System for Downtown Los Angeles, CA
- High Seismic activity in this new location

Problem Solution:

- Design Adequate Foundations
- Design Lighter Floor System
- Design Sufficient Lateral System:
  - Base Isolation
  - Concentric Braced Frame System




Los Angeles, CA

# Scope of Work

1. Project Background
2. Scope of Work
3. Structural Depth Study
   i. Foundation System
   ii. Gravity System
   iii. Lateral Force Resisting System
4. Mechanical Breadth
5. Construction Management Breadth
6. Summary of Conclusions
7. Acknowledgments

Project Goals:

Structural Depth Study
- Reduce Floor System Weight
- Maintain Architectural Layout
- Design Adequate Foundation and Lateral Systems for new location

Mechanical Breadth Study
- Verify Existing mechanical AHU’s are adequate for new location’s climate

Construction management Breadth Study
- Impact on construction schedule & cost

# Structural Depth Study

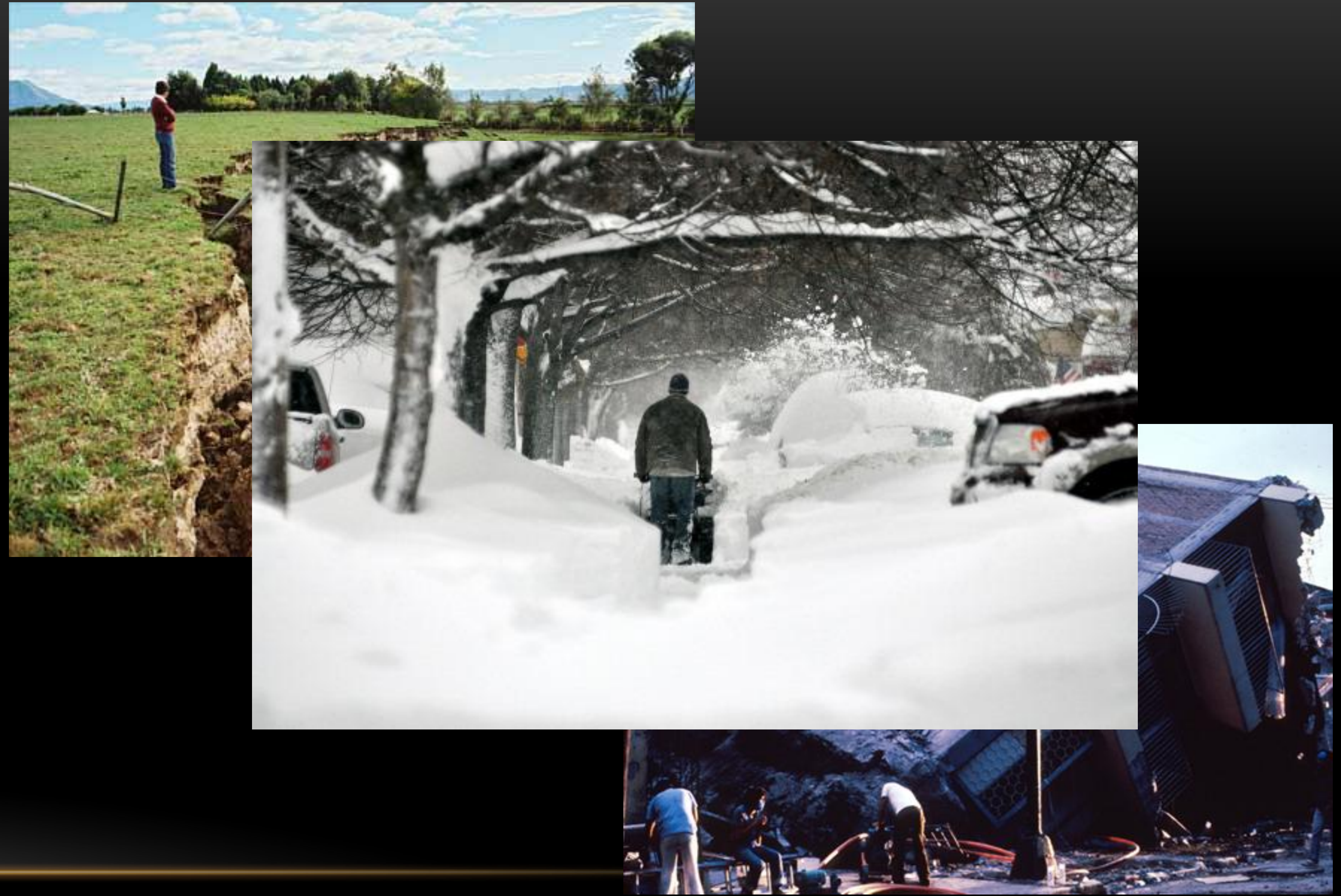
1. Project Background
2. Scope of Work
3. Structural Depth Study
    i. Foundation System
    ii. Gravity System
    iii. Lateral Force Resisting System
4. Mechanical Breadth
5. Construction Management Breadth
6. Summary of Conclusions
7. Acknowledgments

Buffalo, NY:

- Wind Loads primarily dominated Lateral System Design
- Snow Loads contributed to Gravity System

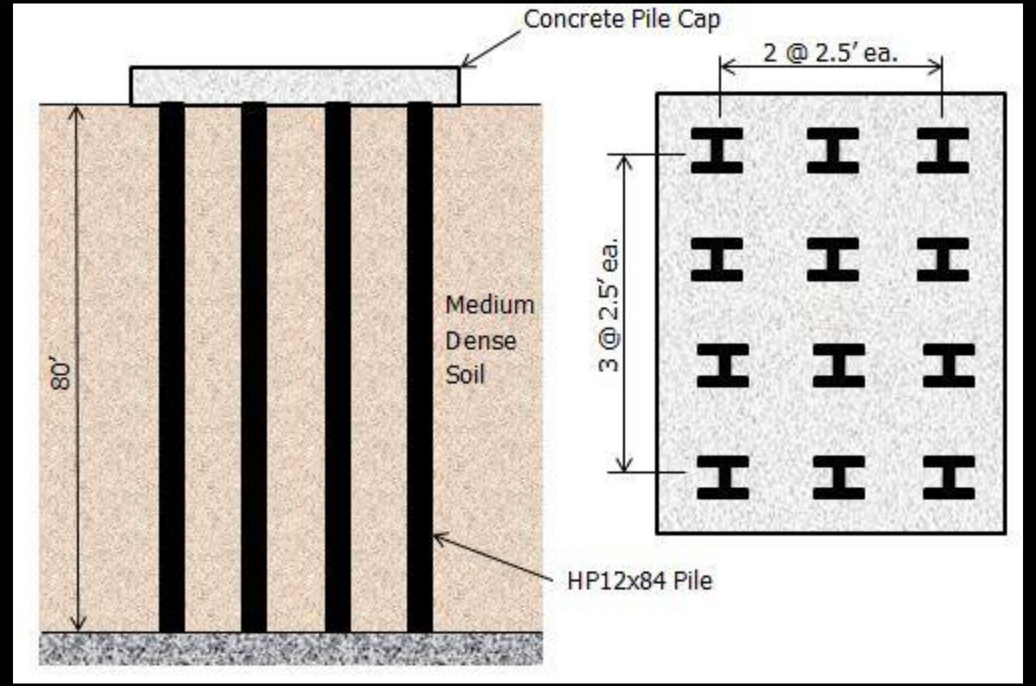
Los Angeles, CA:

- Highly Active Seismic Region
- Frequent Earthquakes
- Possibility of Soil Liquefaction
- Bedrock is located around 80’ depth
- Densely Populated Area

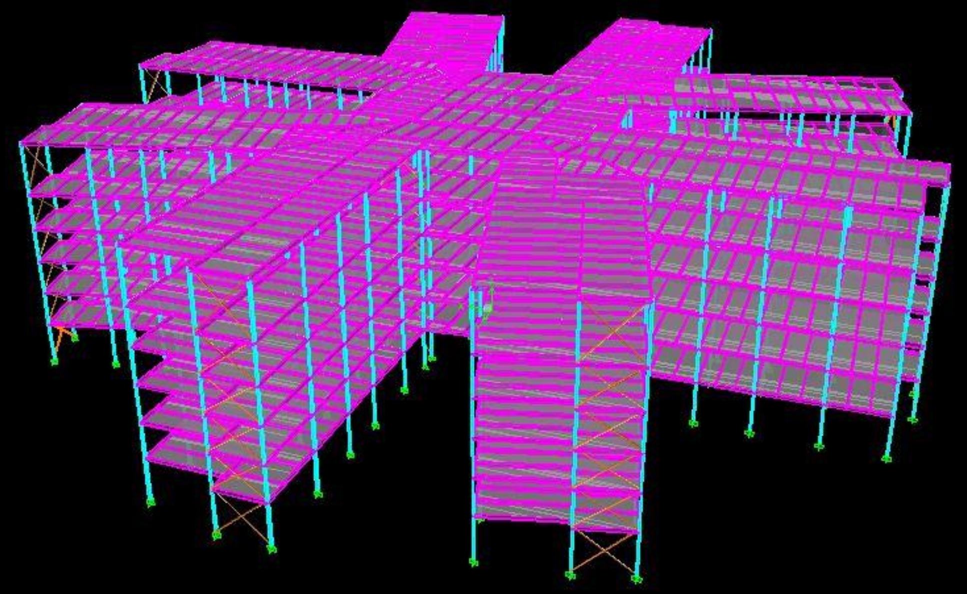


# Structural Depth Study

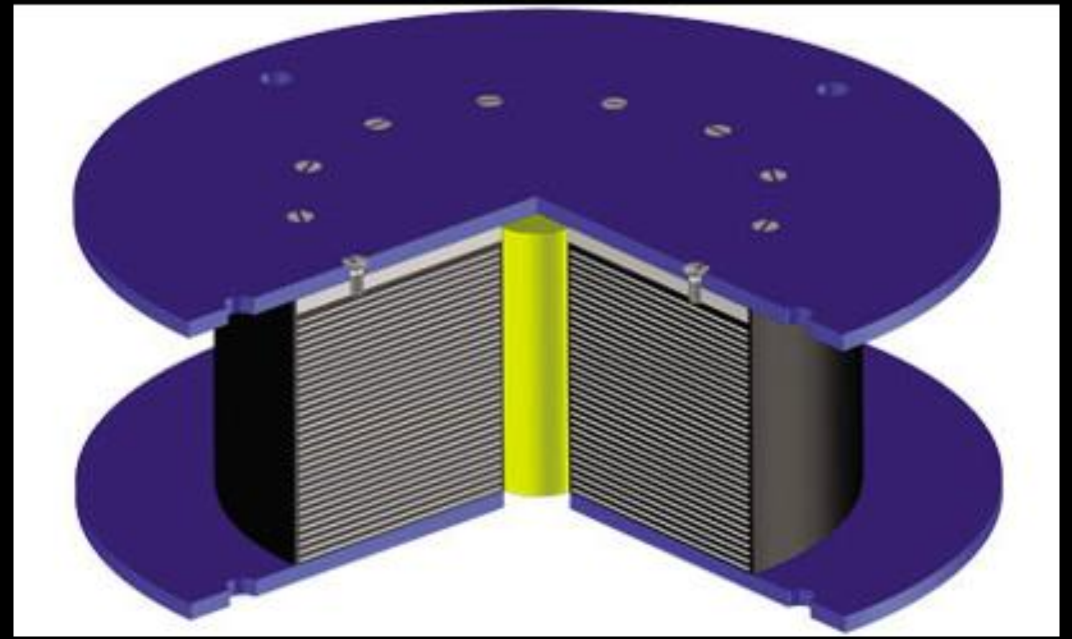
The following systems will be evaluated:




Foundation System



Gravity System



Lateral Force Resisting System

# Foundation System

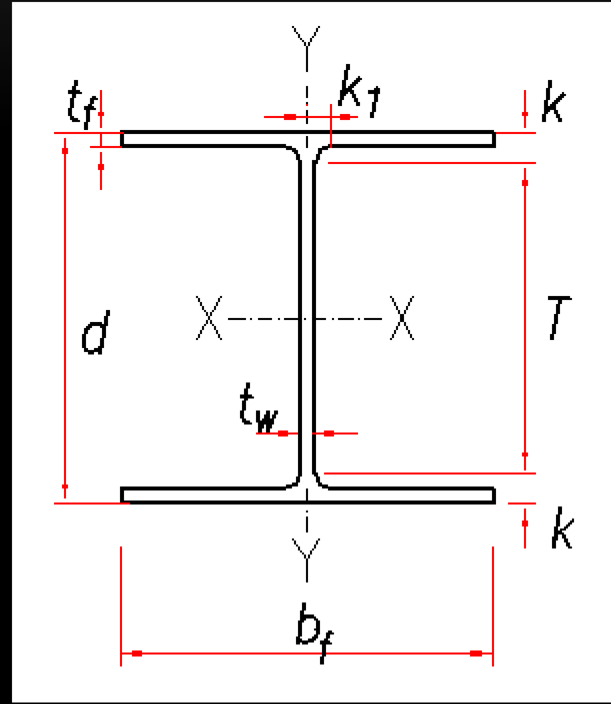
1. Project Background
2. Scope of Work
3. Structural Depth Study
   i. Foundation System
   ii. Gravity System
   iii. Lateral Force Resisting System
4. Mechanical Breadth
5. Construction Management Breadth
6. Summary of Conclusions
7. Acknowledgments

Los Angeles, CA:

- 2,000 to 5,000 psi bearing strength
- Large Vertical/Lateral Loads on foundation
- 80' depth to Limestone Bedrock
- Possibility of Liquefaction

Solution: Deep Foundation

- Driven piles provide adequate bearing strength
- Use of Bodine Resonant Pile Driver
  - Relatively Quiet Vs. Impact Hammer

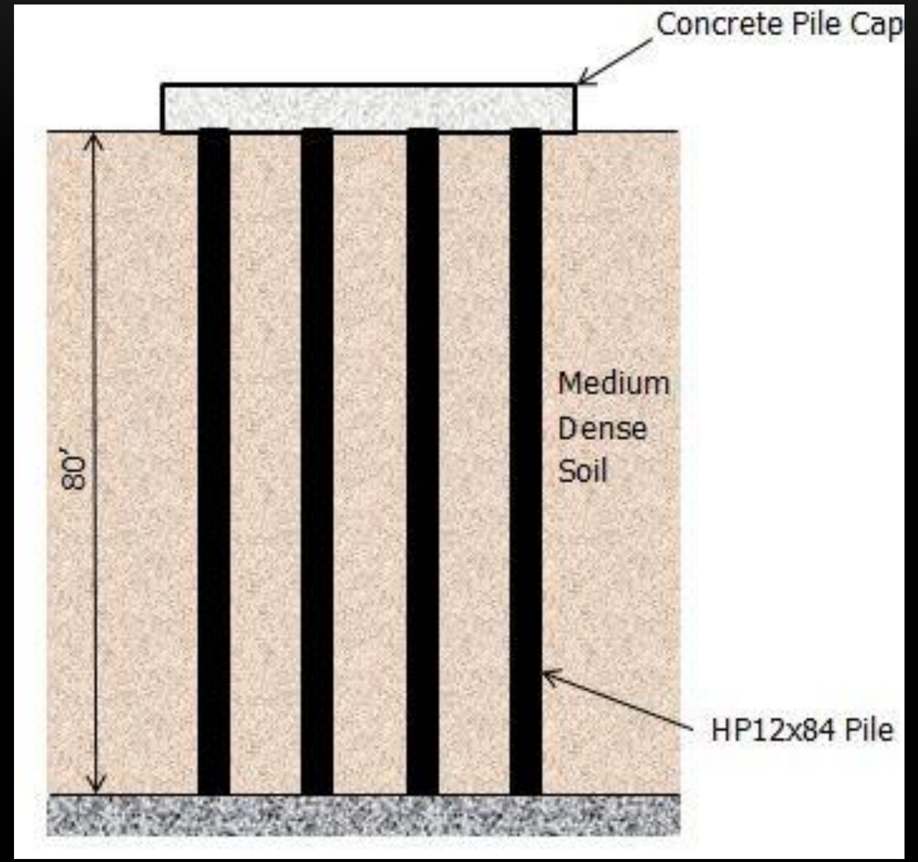


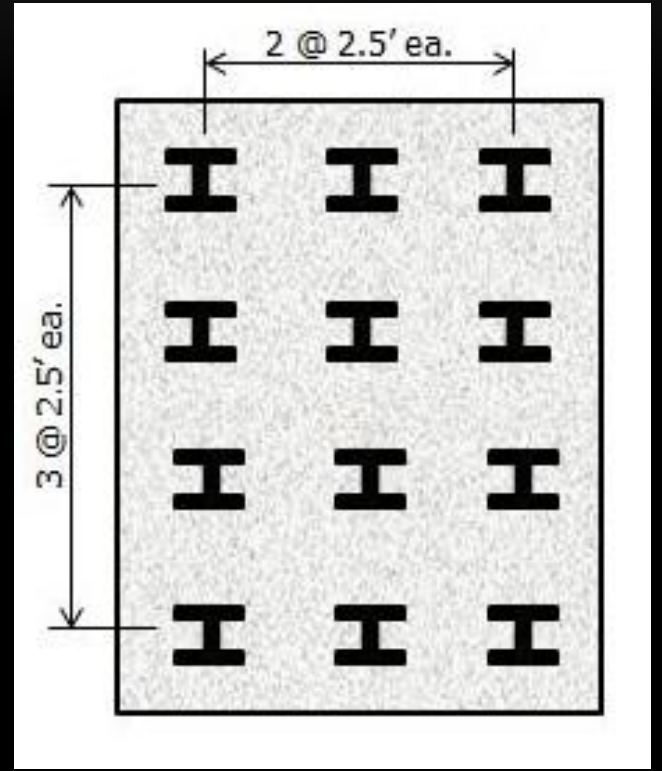

# Foundation System

1. Project Background
2. Scope of Work
3. Structural Depth Study
   i. Foundation System
   ii. Gravity System
   iii. Lateral Force Resisting System
4. Mechanical Breadth
5. Construction Management Breadth
6. Summary of Conclusions
7. Acknowledgments

Deep Foundation Design Results:

- Pile Shape Size: HP12x84
- Pile Capacity: 597 Kips / Pile
- Safety Factor: 3.5
- Pile Length: 80’ (bearing on bedrock)
- Largest Footing: 9’ x 6’ w/ 12 Piles



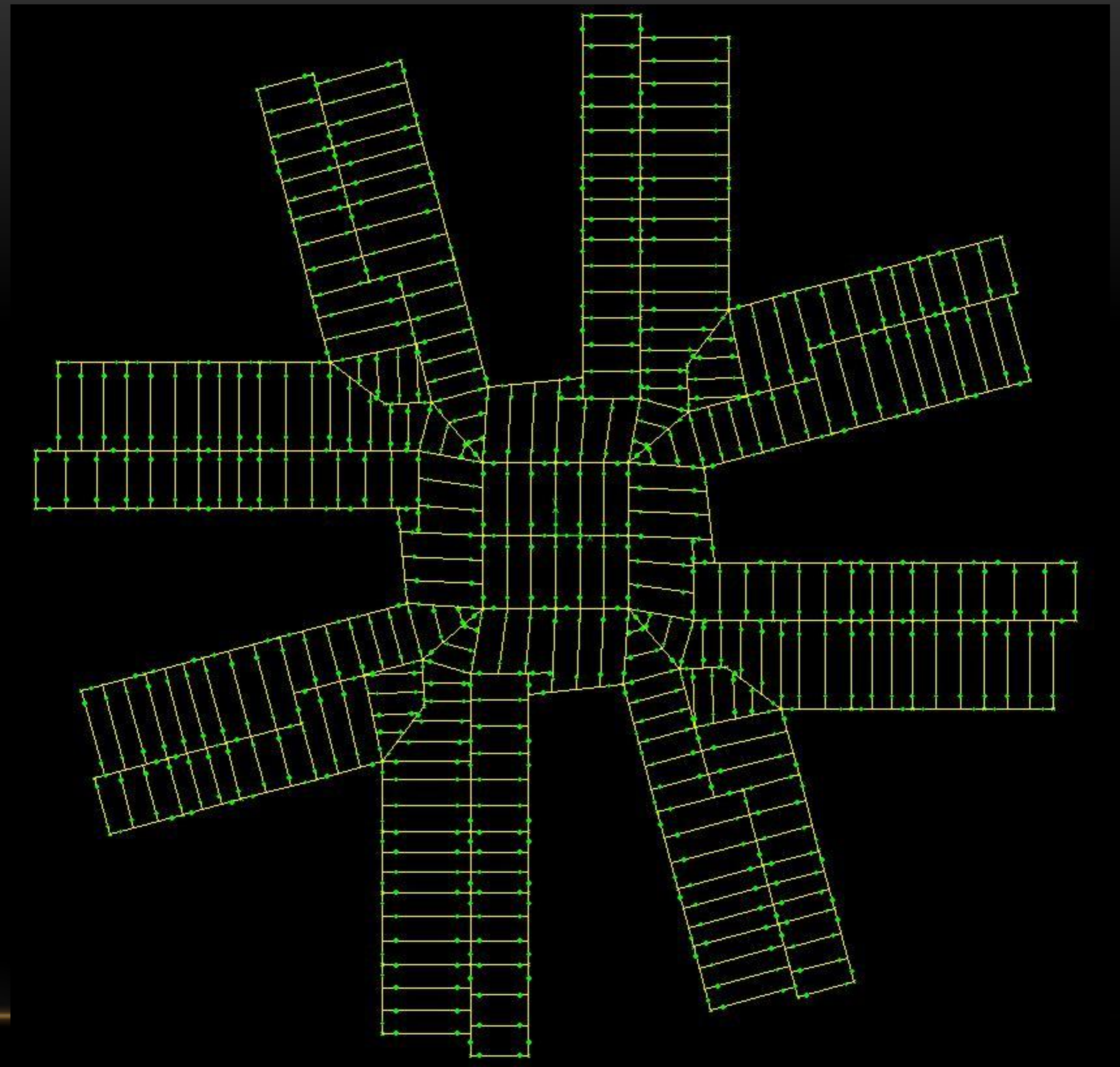



# Gravity System



Framing Plan:

- Bays vary in size / largest = 29'-2" x 26'-0"
- Columns match wall partitions in plan
- Composite Decking spans parallel to wing
- Beams span perpendicular to wing
- Girders span parallel to wing



# Gravity System

1. Project Background
2. Scope of Work
3. Structural Depth Study
   i. Foundation System
   ii. Gravity System
   iii. Lateral Force Resisting System
4. Mechanical Breadth
5. Construction Management Breadth
6. Summary of Conclusions
7. Acknowledgments

Design Loads:

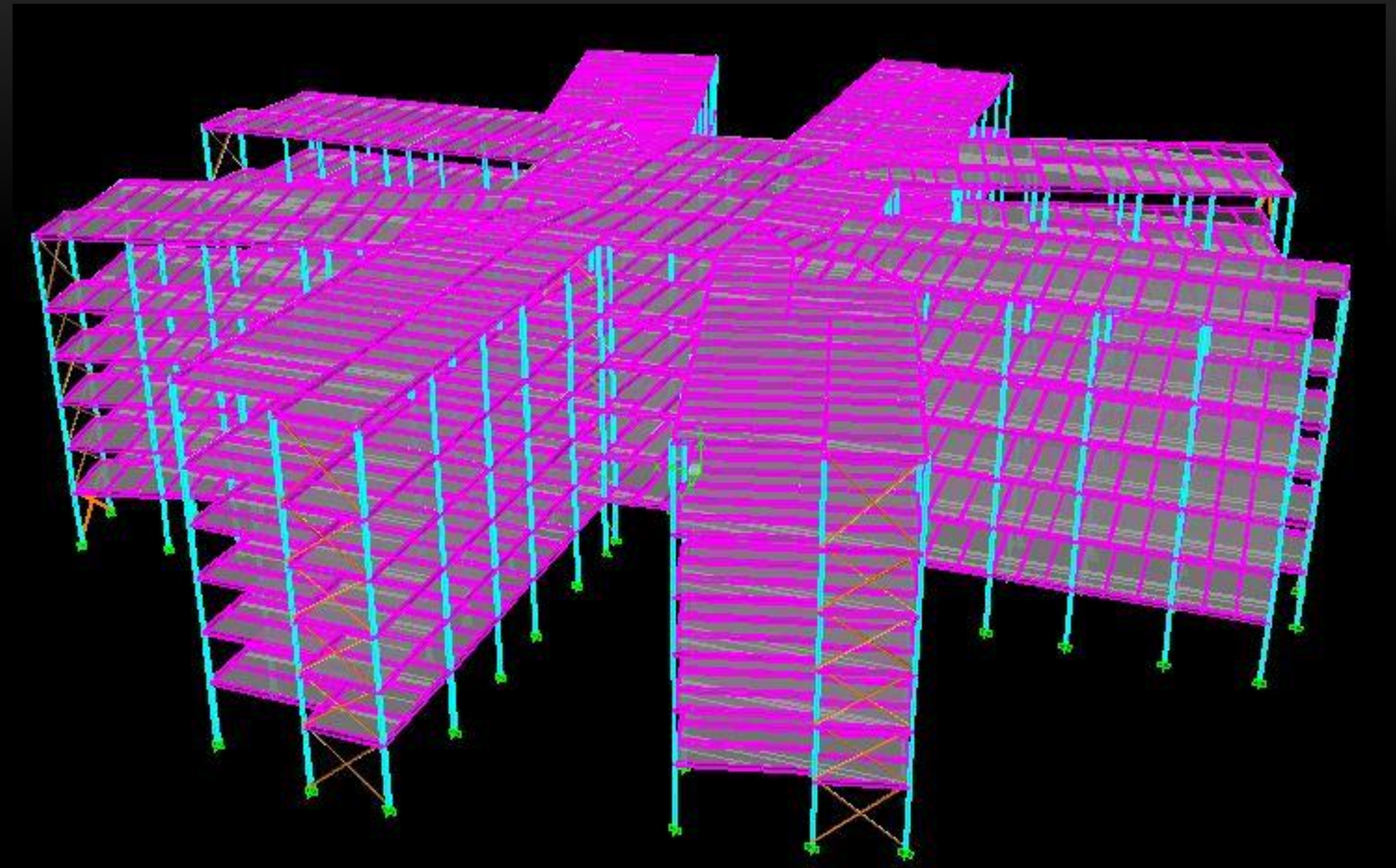
- ASCE 7-10
  - Live loads
  - Superimposed Dead Loads

Serviceability Criteria: Deflection

- Live Load = L/360
- Total Load = L/240

Controlling Load Combination:

- $1.2D + 1.6L + 0.5L_r$



# Gravity System



Gravity System Design Results:

- Composite Steel Slab
  - 3VLI22 steel decking
  - 5” total thickness
  - Reduced floor weight from 42 psf to 35 psf
- Composite W-Flange Steel Beam
  - W14x26 (w/16 shear studs)
  - Redesign lighter than Existing (by 5 lb)
- Composite W-Flange Steel Girder
  - W18x35 (w/ 20 shear studs)
  - Same weight as existing, less studs

- W-Flange Steel Columns
  - W10 shapes used for easy spliced connections
  - Sizes range from W10x33 to W10x60
  - Design relatively similar to Existing

| Seismic Weight Comparison (Los Angeles, CA) | | |
|---|---|---|
| | Existing Building Design | New Building Design |
| Building Weight | 26,045 kips | 21,527 kips |
| Base Shear | 7918 kips | 6550 kips |
| Total Moment | 423,898 ft-k | 350,694 ft-k |

# Lateral Force Resisting System

1. Project Background
2. Scope of Work
3. Structural Depth Study
   i. Foundation System
   ii. Gravity System
   iii. Lateral Force Resisting System
4. Mechanical Breadth
5. Construction Management Breadth
6. Summary of Conclusions
7. Acknowledgments

Lead-Core Rubber Base Isolation:

- Increases building period
- Reduces building lateral drift
- Incorporation of lead core dampens seismic forces and re-aligns building after quake

| Seismic Base Isolation Comparison (Los Angeles, CA) | | |
|---|---|---|
| | No Base Isolation | Base Isolation |
| Building Period | 1.4754 sec | 4.1803 sec |
| Base Shear | 6550 kips | 6550 kips |
| Total Moment | 350,694 ft-k | 350,694 ft-k |
| Displacement (@ 90') | 2.971" | 2.64" |
| Drift (@90') | 0.025" | 0.018" |
| Member Size | W14x370 | W14x283 |


1. Project Background
2. Scope of Work
3. Structural Depth Study
   i. Foundation System
   ii. Gravity System
   iii. Lateral Force Resisting System
4. Mechanical Breadth
5. Construction Management Breadth
6. Summary of Conclusions
7. Acknowledgments

# Lateral Force Resisting System

| Wind Variables | | | ASCE Reference |
|---|---|---|---|
| Basic Wind Speed | $V$ | 115mph | Fig. 26.5-1B |
| Directional Factor | $K_d$ | 0.85 | Tab. 26.6-1 |
| Occupancy Category | | III | Tab. 1.5-1 |
| Exposure Category | | B | Sec. 26.7.3 |
| Exposure Classification | | Enclosed | Sec. 26.2 |
| Building Natural Frequency | $n_1$ | 0.833 (flexible) | Eq. 26.9-4 |
| Topographic Factor | $K_{zt}$ | 1 | Fig. 26.8-1 |
| Velocity Pressure Exposure Coefficient evaluated at Height Z | $K_z$ | varies | Tab. 27.3-1 |
| Velocity Pressure at Height Z | $q_z$ | varies | Eq. 27.3-1 |
| Velocity Pressure at Mean Roof Height | $q_h$ | 23.96 | Eq. 27.3-1 |
| Gust Effect Factor | $G$ | 0.859 | Eq. 26.9.5 |
| Product of Internal Pressure Coefficient and Gust Effect Factor | $GC_{pi}$ | 0.18<br>-0.18 | Tab. 26.11-1 |
| External Pressure Coefficient (Windward) | $C_p$ | 0.8 | Fig. 27.4-1 |
| External Pressure Coefficient (Leeward) | $C_p$ | -0.5 (Symmetric, L/B = 1.0) | Fig. 27.4-1 |

Wind Design Variables

| Seismic Design Variables | | No Base Isolation | | Base Isolated | | ASCE Reference |
|---|---|---|---|---|---|---|
| Site Class | | D | | D | | Sec. 20.3.2 |
| Occupancy Category | | III | | III | | Sec. C1.5.1 |
| Importance Factor | | 1.25 | | 1.25 | | Tab. 1.5-2 |
| Structural System | | Steel Special Concentrically Braced Frames | | Steel Special Concentrically Braced Frames | | Tab. 12.2-1 |
| Spectral Response Acceleration, short | $S_s$ | 2.432 | | 2.432 | | Fig. 22-1 |
| Spectral Response Acceleration, 1 s | $S_1$ | 0.853 | | 0.853 | | Fig. 22-2 |
| Site Coefficient | $F_a$ | 1 | | 1 | | Tab. 11.4-1 |
| Site Coefficient | $F_v$ | 1.5 | | 1.5 | | Tab. 11.4-2 |
| MCE Spectral Response Acceleration, short | $S_{ms}$ | 2.432 | | 2.432 | | Eq. 11.4-1 |
| MCE Spectral Response Acceleration, 1 s | $S_{m1}$ | 1.279 | | 1.279 | | Eq. 11.4-2 |
| Design Spectral Acceleration, Short | $S_{ds}$ | 1.622 | | 1.622 | | Eq. 11.4-3 |
| Design Spectral Acceleration, 1 s | $S_{d1}$ | 0.853 | | 0.853 | | Eq. 11.4-4 |
| Seismic Design Category | $S_{dc}$ | E | | E | | Sec. 11.6 |
| Response Modification Coefficient | $R$ | 6.0 | | 6.0 | | Tab. 12.2-1 |
| Building Height (above grade) (ft) | $h_n$ | 90 | | 90 | | |
| | | North/South | East/West | North/South | East/West | |
| Approximate Period Parameter | $C_t$ | 0.02 | 0.02 | 0.02 | 0.02 | Tab. 12.8-2 |
| Approximate Period Parameter | $x$ | 0.75 | 0.75 | 0.75 | 0.75 | Tab. 12.8-2 |
| Calculated Period Upper Limit Coefficient | $C_u$ | 1.4 | 1.4 | 1.4 | 1.4 | Tab. 12.8-1 |
| Approximate Fundamental Period | $T_a$ | 0.584 | 0.584 | 0.584 | 0.584 | Eq. 12.8-7 |
| Fundamental Period | $T$ | 1.4081 | 1.4754 | 4.1803 | 4.1866 | Sec. 12.8.2 |
| Long Period Transition Period | $T_L$ | 8 | 8 | 8 | 8 | Fig. 22-12 |
| Seismic Response Coefficient | $C_s$ | 0.304 | 0.304 | 0.304 | 0.304 | Eq. 12.8-2 |
| Structural Period Exponent | $k$ | 1.042 | 1.042 | 1.042 | 1.042 | Sec. 12.8.3 |

Seismic Design Variables

# Lateral Force Resisting System



Design Loads:

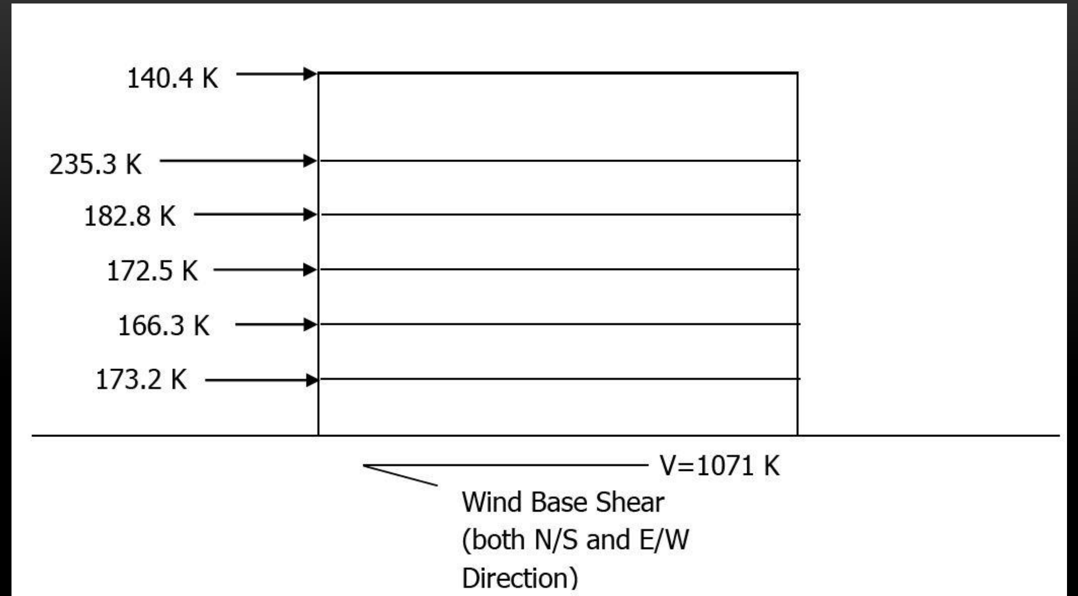
- ASCE 7-10
  - Wind Loads (Directional Method)
  - Seismic Loads (Equiv. Lat. Force Method)

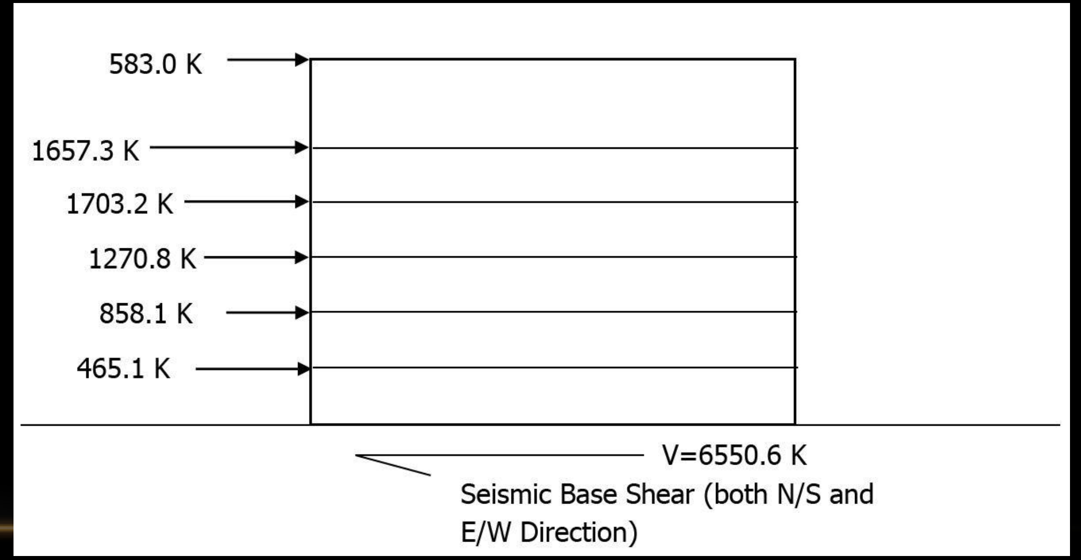
Serviceability Criteria: Drift Criteria

- $\Delta_{Wind}$= H/400
- $\Delta_{Seismic}$ = $0.02H_{sx}$

Controlling Load Combination:

- 1.2D + 1.0E + 1.0L



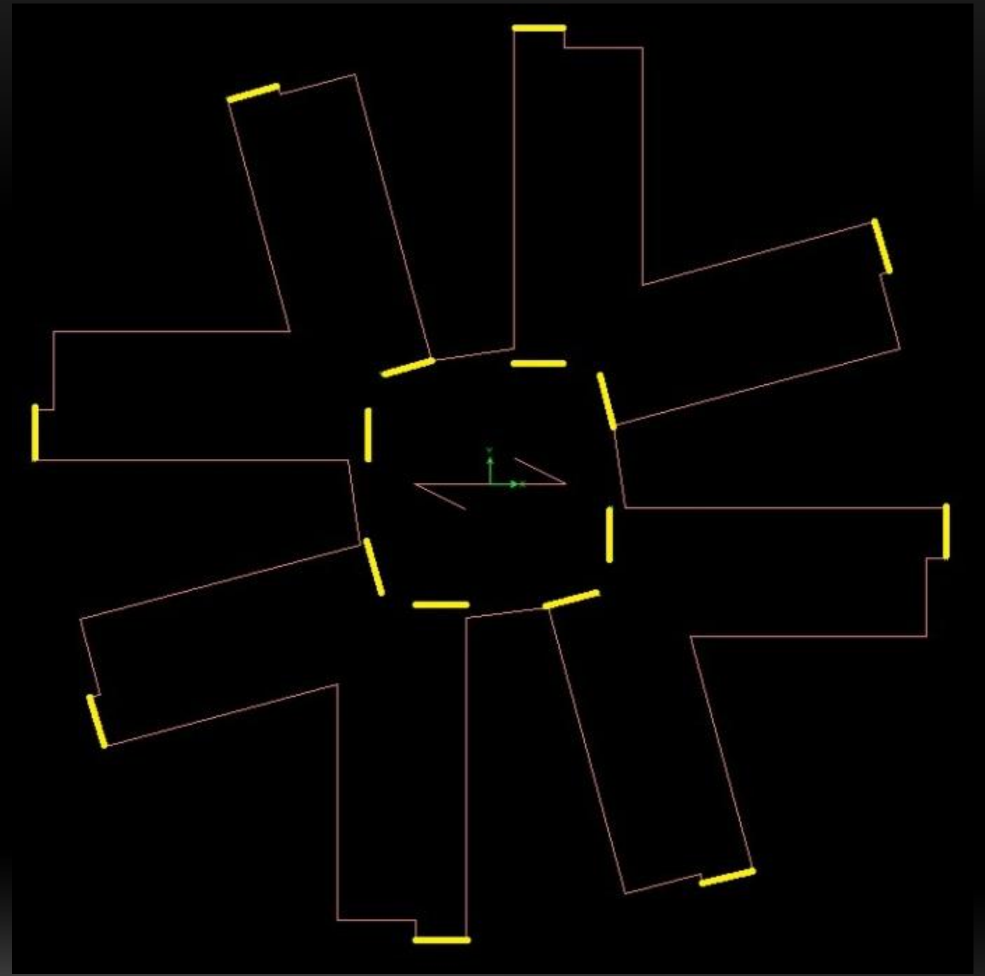



# Lateral Force Resisting System

1. Project Background
2. Scope of Work
3. Structural Depth Study
   i. Foundation System
   ii. Gravity System
   iii. Lateral Force Resisting System
4. Mechanical Breadth
5. Construction Management Breadth
6. Summary of Conclusions
7. Acknowledgments

Frame Stiffness:

- Equally about 12% contribution



## Relative Story Stiffness: X Direction

Relative Story Stiffness Ratio ($R_{ix}$)

P = 1000 kips

| X-Direction Displacement $\Delta_p$ (in) | Frame # | A1 | A8 | B9 | B15 | C1 | C8 | D9 | D15 |
|---|---|---|---|---|---|---|---|---|---|
| | Pent. RF | 4.127 | 4.173 | - | - | - | - | - | - |
| | Pent. FL | 3.147 | 3.130 | 3.104 | 3.117 | 3.100 | 3.117 | 3.144 | 3.130 |
| | 4 | 2.147 | 2.126 | 2.093 | 2.110 | 2.089 | 2.110 | 2.144 | 2.126 |
| | 3 | 1.317 | 1.296 | 1.264 | 1.280 | 1.260 | 1.280 | 1.313 | 1.296 |
| | 2 | 0.665 | 0.652 | 0.632 | 0.642 | 0.629 | 0.642 | 0.663 | 0.652 |
| | 1 | 0.263 | 0.257 | 0.246 | 0.252 | 0.245 | 0.252 | 0.262 | 0.257 |

| Story Stiffness $K_{ix} = P/\Delta_p$ (kip/in) | Frame # | A1 | A8 | B9 | B15 | C1 | C8 | D9 | D15 | $\Sigma K_{ix}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pent. RF | 242.3068 | 239.6358 | - | - | - | - | - | - | 481.9425 |
| | Pent. FL | 317.7848 | 319.4888 | 322.2065 | 320.8316 | 322.5494 | 320.7801 | 318.056 | 319.4786 | 2561.176 |
| | 4 | 465.812 | 470.4775 | 477.7374 | 474.001 | 478.675 | 473.8663 | 466.5267 | 470.3226 | 3777.419 |
| | 3 | 759.5806 | 771.9027 | 791.4523 | 781.3721 | 793.9659 | 781.0059 | 761.4406 | 771.5454 | 6212.266 |
| | 2 | 1504.352 | 1534.684 | 1583.03 | 1558.118 | 1589.572 | 1557.147 | 1508.978 | 1533.742 | 12369.62 |
| | 1 | 3796.522 | 3897.116 | 4060.089 | 3974.563 | 4081.633 | 3972.984 | 3812.429 | 3894.081 | 31489.42 |
| | | | | | | | | | $\Sigma k_{ix,total}$ : | 56891.84 |

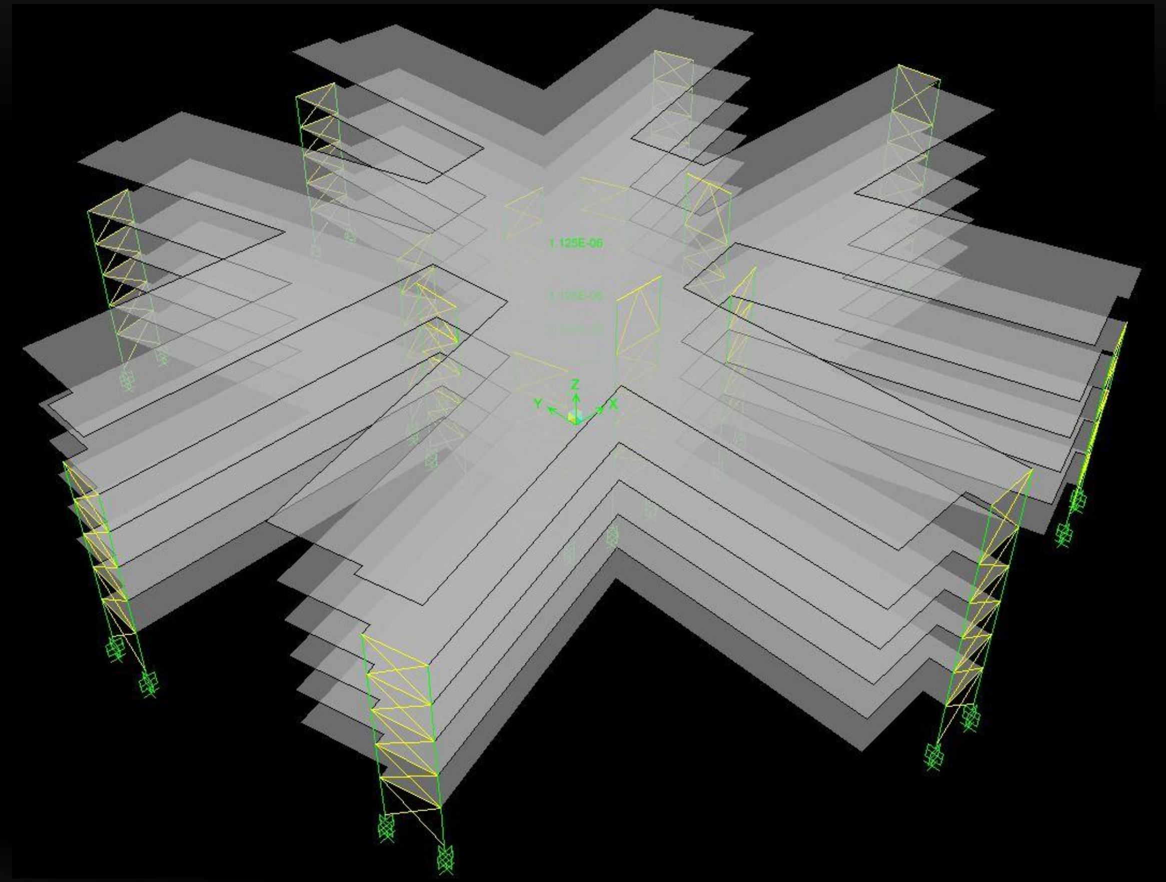
| Relative Story Stiffness Ratio $R_{ix} = K_{ix}/K_{ix,total}$ | Frame # | A1 | A8 | B9 | B15 | C1 | C8 | D9 | D15 |
|---|---|---|---|---|---|---|---|---|---|
| | Pent. RF | 0.502771 | 0.497229 | - | - | - | - | - | - |
| | Pent. FL | 0.124078 | 0.124743 | 0.125804 | 0.125267 | 0.125938 | 0.125247 | 0.124184 | 0.124739 |
| | 4 | 0.123315 | 0.12455 | 0.126472 | 0.125483 | 0.12672 | 0.125447 | 0.123504 | 0.124509 |
| | 3 | 0.122271 | 0.124255 | 0.127402 | 0.125779 | 0.127806 | 0.12572 | 0.122571 | 0.124197 |
| | 2 | 0.121617 | 0.124069 | 0.127977 | 0.125963 | 0.128506 | 0.125885 | 0.121991 | 0.123993 |
| | 1 | 0.120565 | 0.12376 | 0.128935 | 0.126219 | 0.129619 | 0.126169 | 0.12107 | 0.123663 |
| Average | | 0.122369 | 0.124275 | 0.127318 | 0.125742 | 0.127718 | 0.125694 | 0.122664 | 0.12422 |

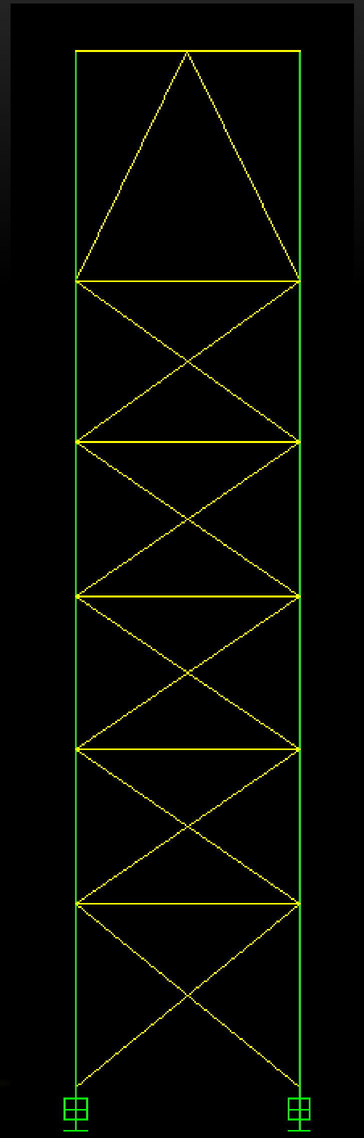
# Lateral Force Resisting System

1. Project Background
2. Scope of Work
3. Structural Depth Study
   i. Foundation System
   ii. Gravity System
   iii. Lateral Force Resisting System
4. Mechanical Breadth
5. Construction Management Breadth
6. Summary of Conclusions
7. Acknowledgments

| Controlling Seismic Drift (x-direction) | | | |
|---|---|---|---|
| Floor | Story Drift (in) | Allowable Story Drift (in) | Is this OK? |
| Roof | 0.0184 | 0.400 | yes |
| PH Floor | 0.0152 | 0.280 | yes |
| 4th Floor | 0.0168 | 0.267 | yes |
| 3rd Floor | 0.0156 | 0.267 | yes |
| 2nd Floor | 0.0123 | 0.267 | yes |
| 1st Floor | 0.0073 | 0.320 | yes |

| Controlling Wind Displacement (x-direction) | | | | |
|---|---|---|---|---|
| Floor | Height above Ground (ft) | Displacement (in) | Allowable Displacement (in) | Is this OK? |
| Roof | 90 | 2.523 | 2.700 | yes |
| PH Floor | 70 | 1.519 | 2.100 | yes |
| 4th Floor | 56 | 1.127 | 1.680 | yes |
| 3rd Floor | 42.667 | 0.751 | 1.280 | yes |
| 2nd Floor | 29.333 | 0.413 | 0.880 | yes |
| 1st Floor | 16 | 0.153 | 0.480 | yes |





# Mechanical Breadth



Mechanical System:

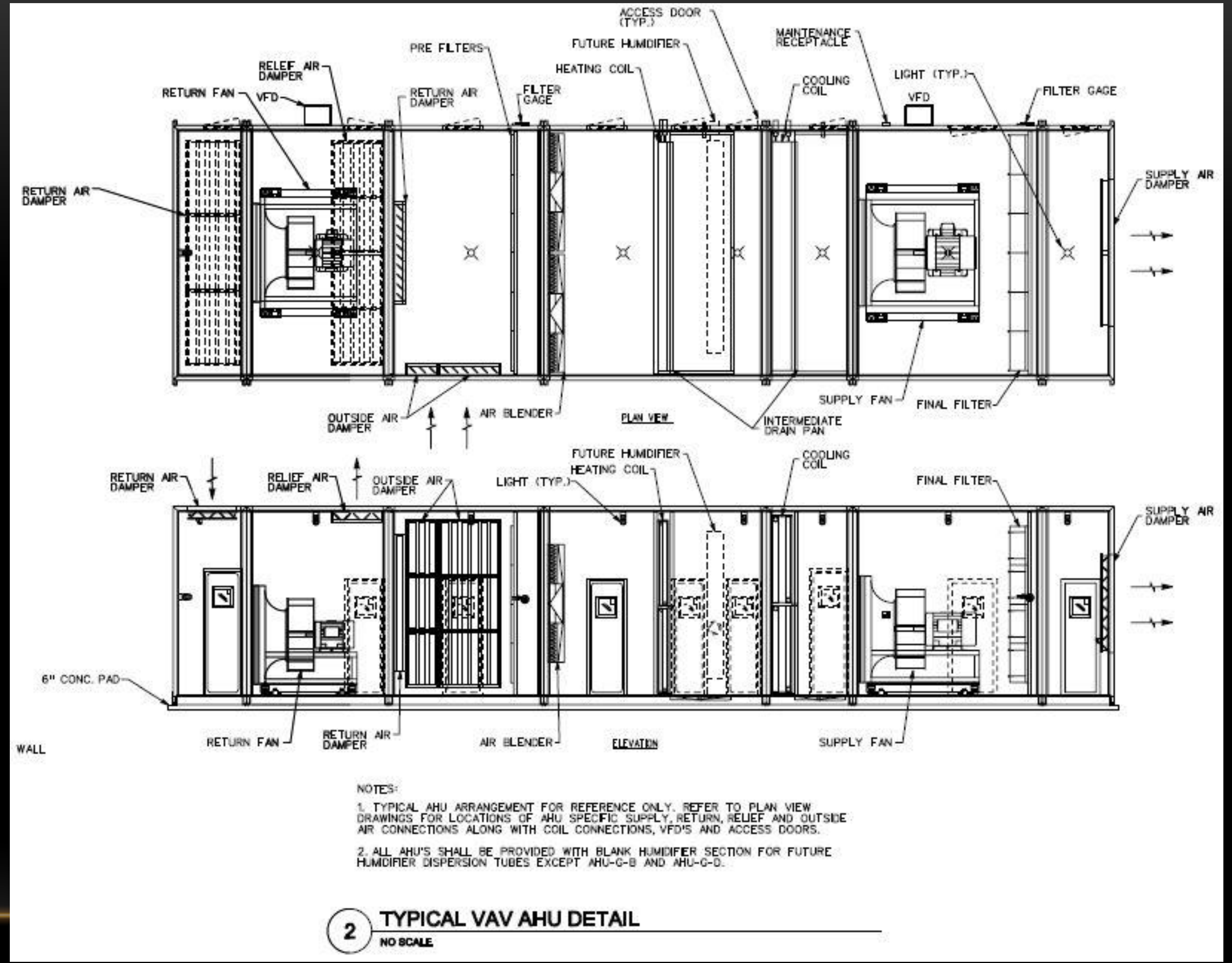
- Variable Air Volume (VAV) system
- 12 separate AHU’s
- Energy Recovery Wheels used for resident rooms

Buffalo, NY:

- Summer: 86ºF
- Winter: 1ºF

Los Angeles, CA:

- Summer: 84ºF
- Winter: 43ºF



# Mechanical Breadth



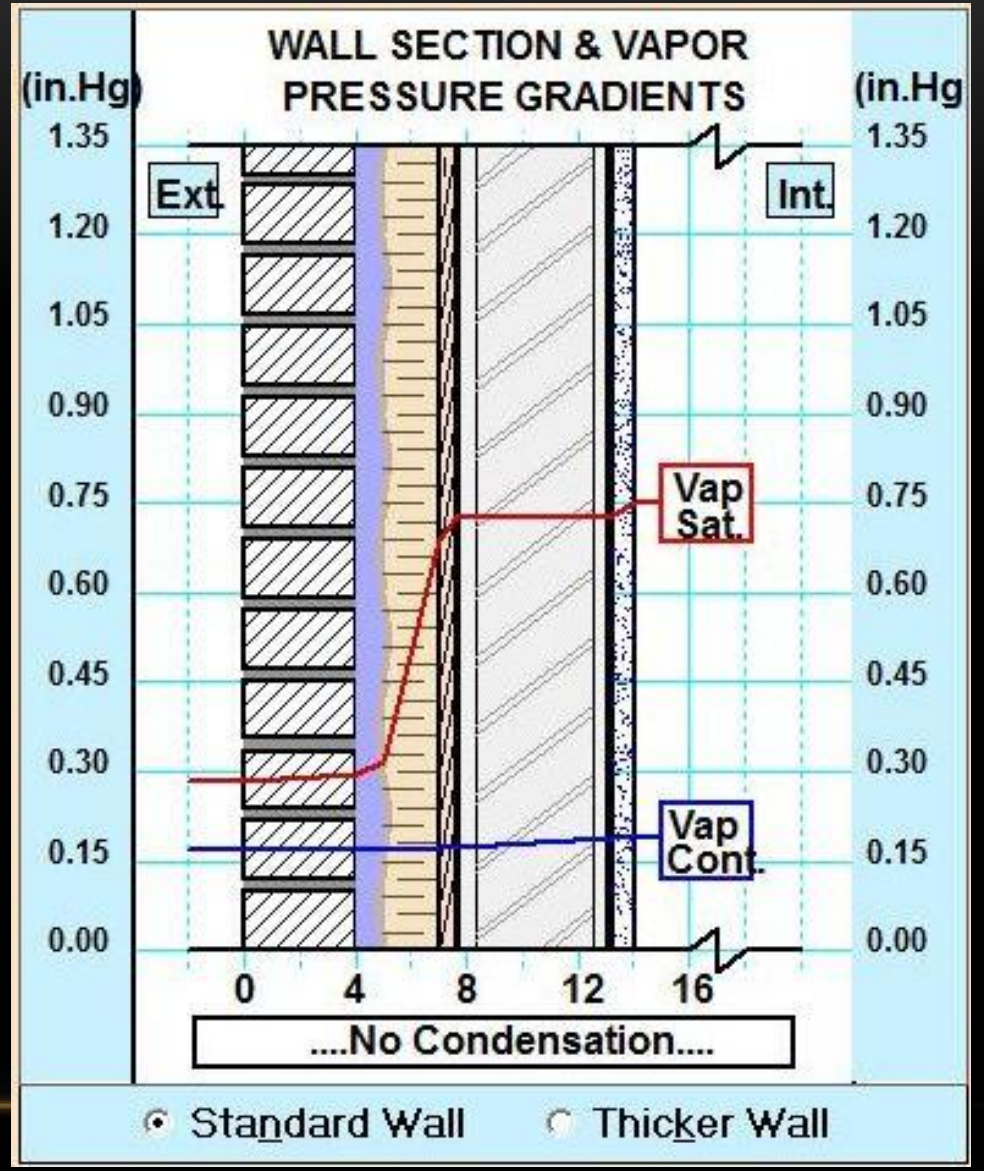
Mechanical System Results:

Buffalo, NY:

- Max Summer $Q_S$: 8,189,038 BTU/hr
- Max Winter $Q_S$: 38,411,170 BTU/hr
- Possible Condensation within Wall Cavity in Summer season

Los Angeles, CA:

- Max Summer $Q_S$: 7,988,607 BTU/hr
- Max Winter $Q_S$: 34,202,119 BTU/hr
- No Condensation



# Construction Management breadth

1. Project Background
2. Scope of Work
3. Structural Depth Study
   i. Foundation System
   ii. Gravity System
   iii. Lateral Force Resisting System
4. Mechanical Breadth
5. Construction Management Breadth
6. Summary of Conclusions
7. Acknowledgments

Cost Analysis:

- Project Cost increased by roughly 6%
- Primarily due to addition of LRB Isolators

| Component | Quantity | Labor | | Material | | TOTALS | |
|---|---|---|---|---|---|---|---|
| | | Unit Cost | Amount | Unit Cost | Amount | Redesigned | Original Design |
| WF Lateral Steel Columns | 138.183 TN | 715.68/TN | 196,784 | 2,074.64/TN | 286,674 | $385,567 | $118,605 |
| HSS Steel Bracing | 30.3 TN | 715.65/TN | 21,684 | 2,074.64/TN | 62,862 | $84,726 | $95,099.00 |
| HP Steel Piles | 30720 VLF | - | - | 44.25/VLF | 1,359,360 | $1,359,360 | - |
| Lead Rubber Base Isolators | 207 | - | - | 20,000/LRB | 4,140,000 | $4,140,000 | - |
| | | | | | TOTALS | $5,969,653 | $213,704 |

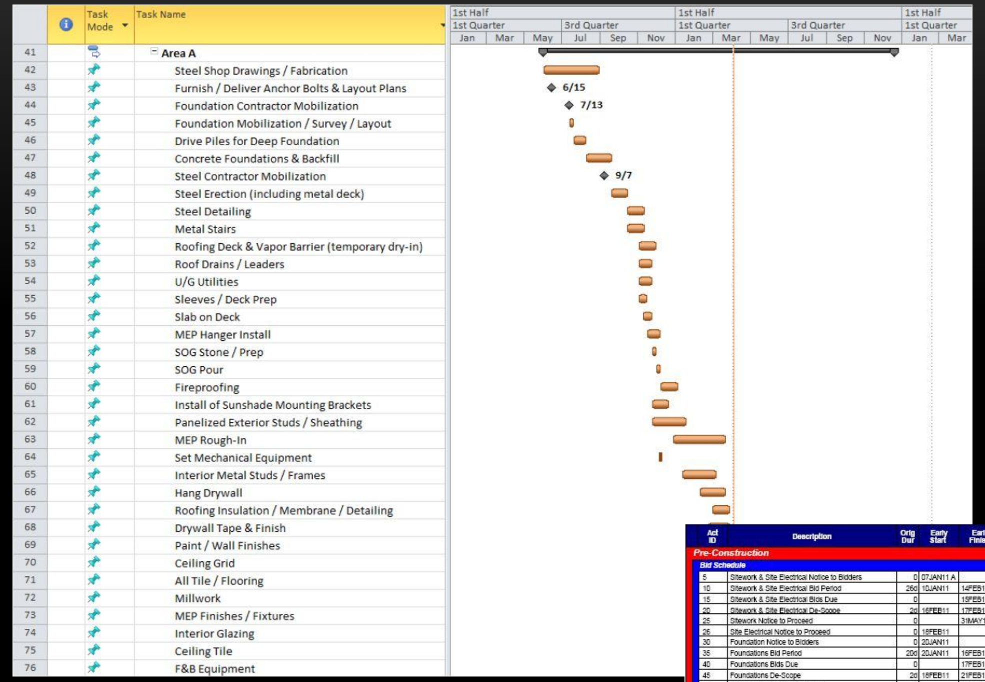
| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 05-00-00 | | METALS | | | | | | | | |
| 05-00-00 | | METALS | | | | | | | | |
| | 85 | MISC METAL ALLOWANCE | 1.00 | LS | - | - | - | - | 53,625 | 53,625.00 /LS | 53,625 |
| | | METALS | | | | | | | 53,625 | 0.20 /GSF | 53,625 |
| | | 275,000.00 GSF | | | | | | | | | |
| | | 0.003 Equipment hours | | | | | | | | | |
| 05-10-00 | | Structural Metal Framing | | | | | | | | | |
| | 05 | WF STEEL COLUMN | 274.960 | TN | 715.682 /TN | 196,784 | 2,074.644 /TN | 570,444 | - | 2,790.33 /TN | 767,228 |
| | 10 | HSS STEEL COLUMN | 34.082 | TN | 715.653 /TN | 24,391 | 2,074.644 /TN | 70,708 | - | 2,790.30 /TN | 95,099 |
| | 40 | STRUCT FLOOR FRAMING | 809.42 | TN | 716.031 /TN | 579,569 | 2,074.66 /TN | 1,679,270 | - | 2,790.69 /TN | 2,258,840 |
| | 40 | STRUCT FLOOR FRAMING - TUBE STEEL AT FINS | 48.07 | TN | 716.04 /TN | 34,419 | 2,074.66 /TN | 99,725 | - | 2,790.70 /TN | 134,143 |
| | 40 | STRUCT FLOOR FRAMING | 57.42 | TN | 716.04 /TN | 41,111 | 2,074.66 /TN | 119,117 | - | 2,790.70 /TN | 160,228 |
| | 45 | STRUCT ROOF FRAMING | 214.50 | TN | 716.041 /TN | 153,589 | 2,074.66 /TN | 445,010 | - | 2,790.70 /TN | 598,599 |
| | 65 | MOMENT CONNECTIONS | 33.00 | EA | 524.034 /EA | 17,293 | 322.04 /EA | 10,627 | - | 846.072 /EA | 27,920 |
| | 70 | MISC. CONNECTIONS AT FLOOR | 121.413 | TN | 947.33 /TN | 115,018 | 2,173.421 /TN | 263,882 | - | 3,120.75 /TN | 378,899 |
| | 70 | MISC. CONNECTIONS AT FLOOR - TUBE STEEL AT FINS | 7.21 | TN | 947.38 /TN | 6,831 | 2,173.422 /TN | 15,670 | - | 3,120.80 /TN | 22,501 |
| | 70 | MISC. CONNECTIONS AT FLOOR | 8.612 | TN | 947.38 /TN | 8,159 | 2,173.423 /TN | 18,718 | - | 3,120.80 /TN | 26,876 |
| | 75 | MISC. CONNECTIONS AT ROOF | 32.97 | TN | 947.38 /TN | 31,235 | 2,173.421 /TN | 71,658 | - | 3,120.80 /TN | 102,893 |
| | 80 | SHEAR CONNECTIONS | 3,893.00 | EA | 1.91 /EA | 7,428 | 1.072 /EA | 4,175 | - | 2.98 /EA | 11,603 |
| | 100 | CLOSURE ANGLE AT FLOOR DECK | 16,737.14 | LF | 6.522 /LF | 109,158 | 12.83 /LF | 214,743 | - | 19.352 /LF | 323,901 |
| | 135 | HUNG LINTELS | 482.00 | LF | 20.38 /LF | 9,823 | 20.183 /LF | 9,728 | - | 40.562 /LF | 19,551 |
| | 135 | LOOSE LINTELS @ MASONRY | 3,440.00 | LF | 12.67 /LF | 43,584 | 12.55 /LF | 43,166 | - | 25.22 /LF | 86,750 |
| | | Structural Metal Framing | | | 5.012/GSF | 1,378,391 | 13.224/GSF | 3,636,641 | | 18.24 /GSF | 5,015,032 |
| | | 275,000.00 GSF | | | | | | | | | |
| | | 20,822.27 Labor hours | | | | | | | | | |
| | | 2,462.331 Equipment hours | | | | | | | | | |

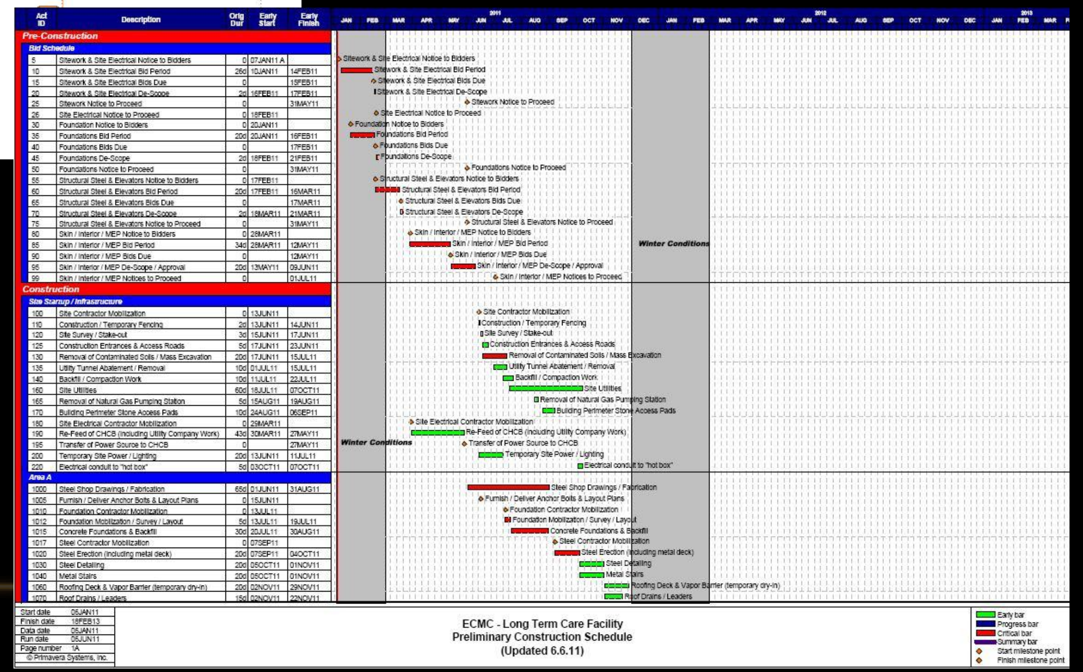
# Construction Management breadth

1. Project Background
2. Scope of Work
3. Structural Depth Study
   i. Foundation System
   ii. Gravity System
   iii. Lateral Force Resisting System
4. Mechanical Breadth
5. Construction Management Breadth
6. Summary of Conclusions
7. Acknowledgments

Schedule Impact:

- Project Schedule increased by 170 days
- Primary Impact:  installation of Pile Foundations
- 2 week setback due to installation of LRB isolators





1. Project Background
2. Scope of Work
3. Structural Depth Study
   i. Foundation System
   ii. Gravity System
   iii. Lateral Force Resisting System
4. Mechanical Breadth
5. Construction Management Breadth
6. Summary of Conclusions
7. Acknowledgments

# Summary of Conclusions

Foundation Redesign:

- HP 12x84 Grouped Steel Pile Deep Foundation
  - Sufficiently designed for strength requirements
  - Increased project cost and schedule

Gravity System Redesign:

- Composite Floor System
  - Sufficiently designed for strength and Deflection requirements
  - Slightly Reduced Floor Weight
  - Maintained architectural floor layout

Lateral System Redesign:

- Concentrically Braced Frames
  - Sufficient Strength
  - Drift reduced due to LRB isolators
  - Limited displacements and drifts due to wind and seismic
  - LRB isolators increased project cost and schedule

Mechanical Breadth:

- VAV mechanical system is adequate for new location

Construction Management Breadth:

- Cost was only increased by roughly 6%
- Project schedule was increased by 170 days

# Acknowledgements




Cannon Design:

- Rachel Chicchi
- Douglas Flynn
- Brenda Onnen

The Pennsylvania State University:

- Prof. M. Kevin Parfitt
- Prof. Robert Holland
- The entire AE faculty and staff

All my friends, family, and classmates for their continuous support and encouragement

1. Project Background
2. Scope of Work
3. Structural Depth Study
   i. Foundation System
   ii. Gravity System
   iii. Lateral Force Resisting System
4. Mechanical Breadth
5. Construction Management Breadth
6. Summary of Conclusions
7. Acknowledgments

# Questions & Comments