Upper Campus Housing Project

Nicole Hazy

Structural

Advisor: Dr. Hanagan

Presentation Outline

- Introduction and Project Background
- Problem Statement and Proposed Solution
- Depth Study
  - Two-Way System Design
  - Lateral System Design
- Breadth Study
  - Thermal Gradient
  - Cost and Duration
- Conclusions

Upper Campus Housing Project

Stadium Drive, Pittsburgh, PA

Building Statistics

- Occupancy Type: Residential
- Approximate Size: 161,600 ft^2
- Number of Stories Above Grade: 9
- Dates of Construction: 5/05-7/06
- Approximate Overall Building Cost: $33 million

Project Team

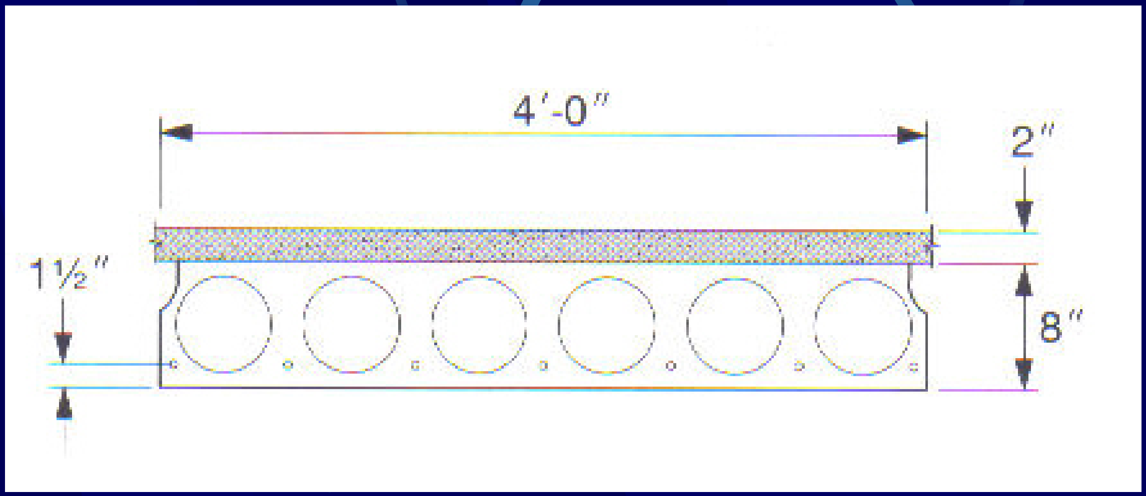
- Owner: The University of Pittsburgh
- Construction Manager: P.J. Dick Inc.
- Architect: Perkins Eastman Architects
- Civil/Site/Landscape Engineer: The Gateway Engineers Inc.
- Structural Engineer: Atlantic Engineering Services
- MEP Engineer: Elwood S. Tower Corporation

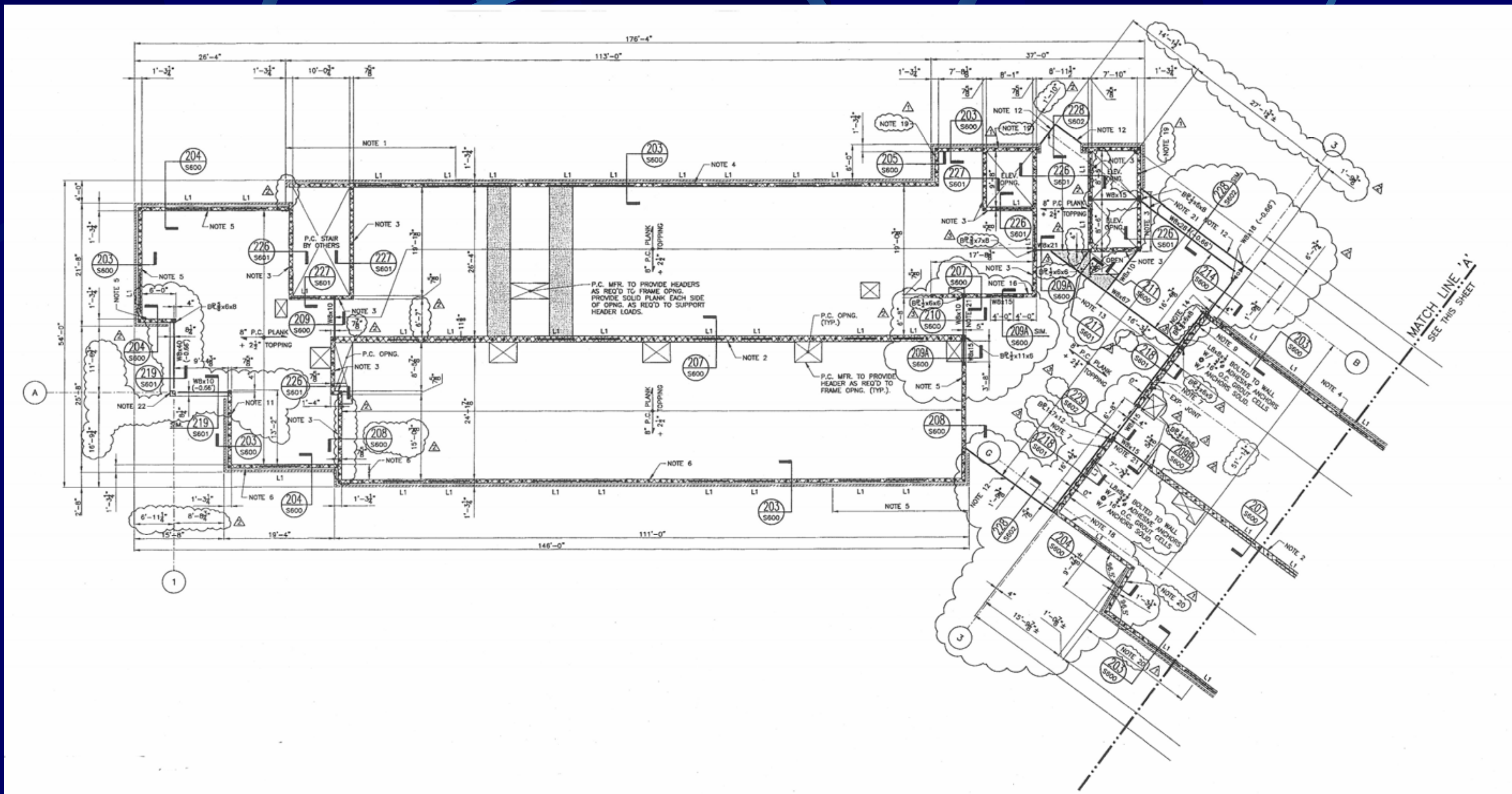
Relevant Building Codes

- International Building Code
- ASTM
- ACI 318
- ACI 530
- AISC
- ASCE7-02

Existing Conditions

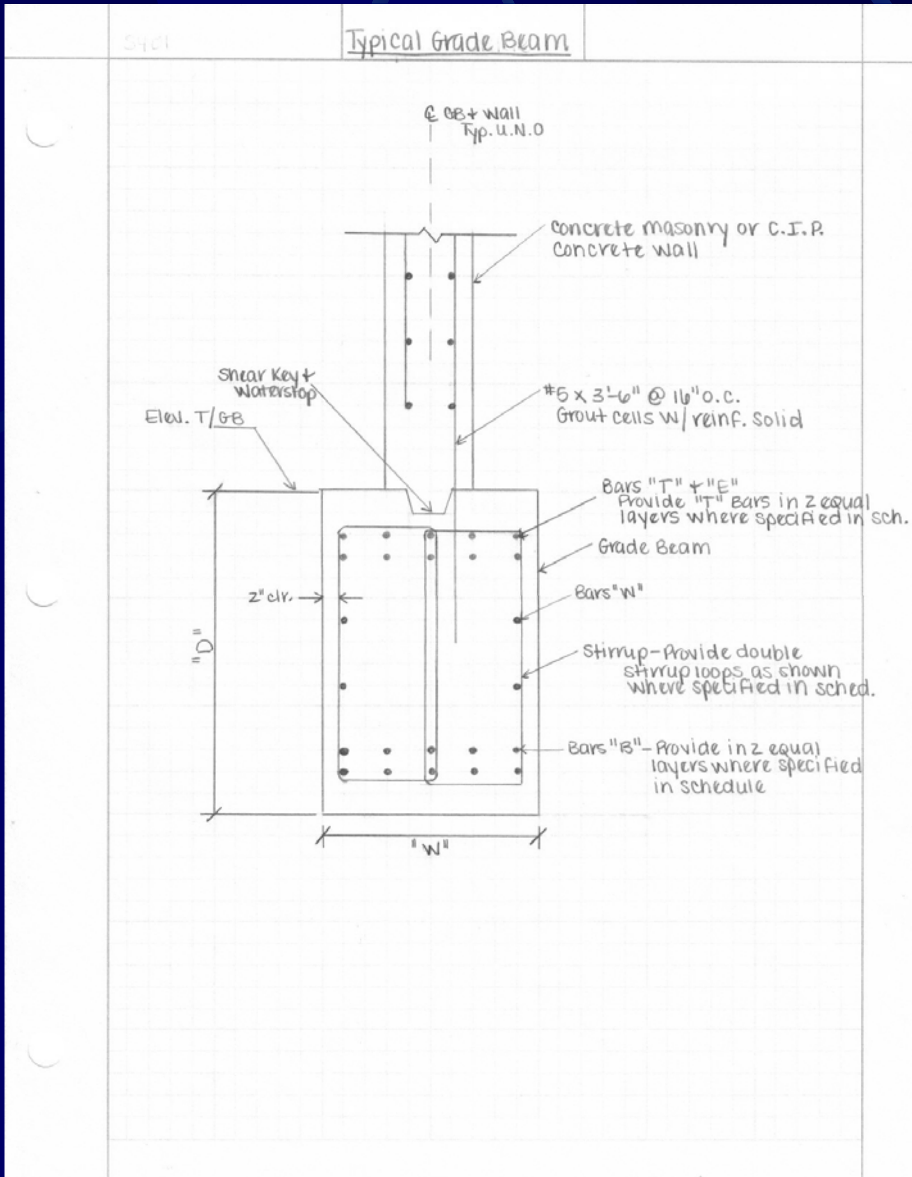
- Structural System
  - Framing

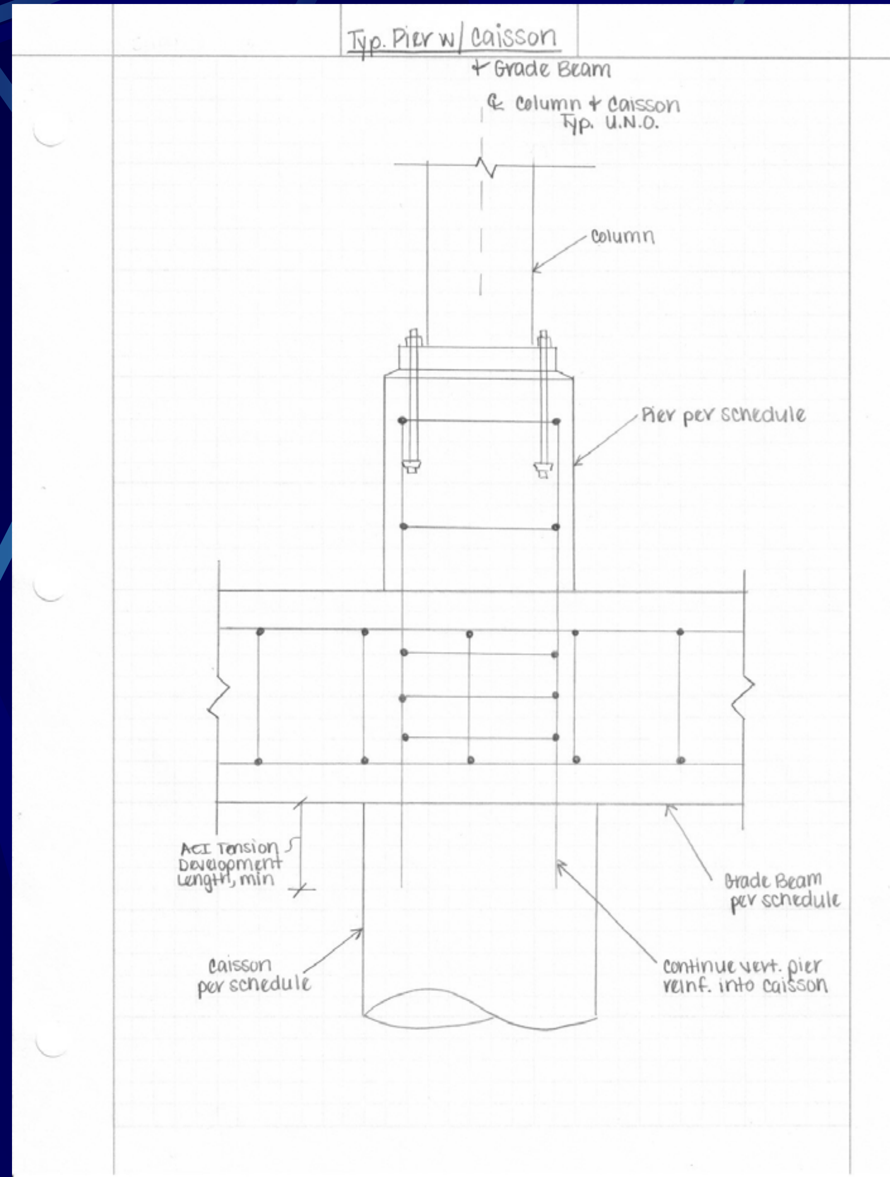



176'-4"
113'-0"
146'-0"
111'-0"
MATCH LINE 'A'
SEE THIS SHEET

Existing Conditions

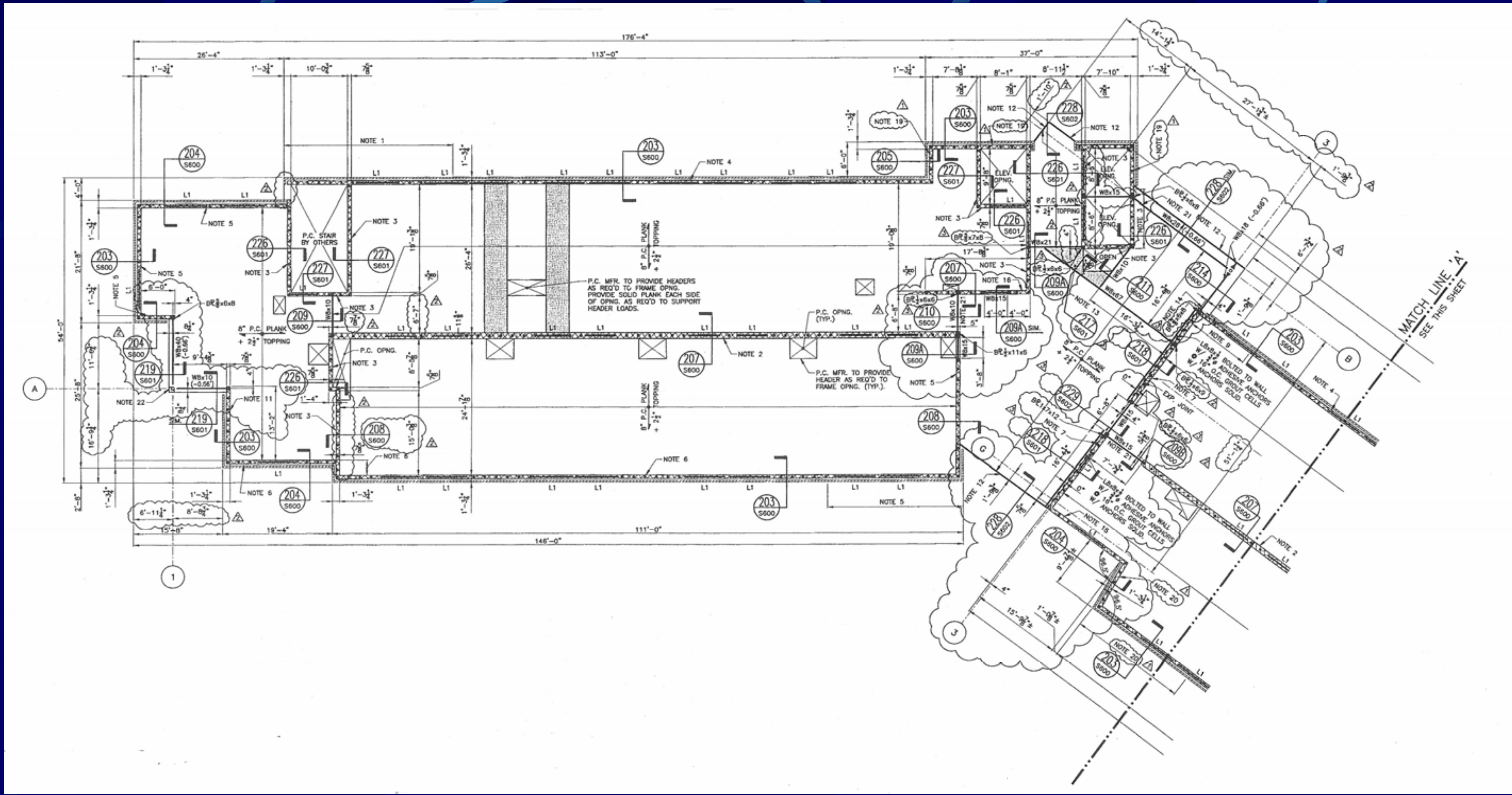
- Structural System
  - Framing
  - Foundations


Typical Grade Beam
℄ GB + Wall
Typ. U.N.O
Concrete masonry or C.I.P. concrete wall
Shear Key + Waterstop
Elev. T/GB
#5 x 3'-6" @ 16" o.c.
Grout cells w/ reinf. solid
Bars "T" + "E"
Provide "T" Bars in 2 equal layers where specified in sch.
Grade Beam
2" clr.
Bars "W"
"D"
Stirrup - Provide double stirrup loops as shown where specified in sched.
Bars "B" - Provide in 2 equal layers where specified in schedule
"W"


Typ. Pier w/ Caisson
+ Grade Beam
℄ Column + Caisson
Typ. U.N.O.
Column
Pier per schedule
ACI Tension Development Length, min
Grade Beam per schedule
Caisson per schedule
Continue vert. pier reinf. into caisson

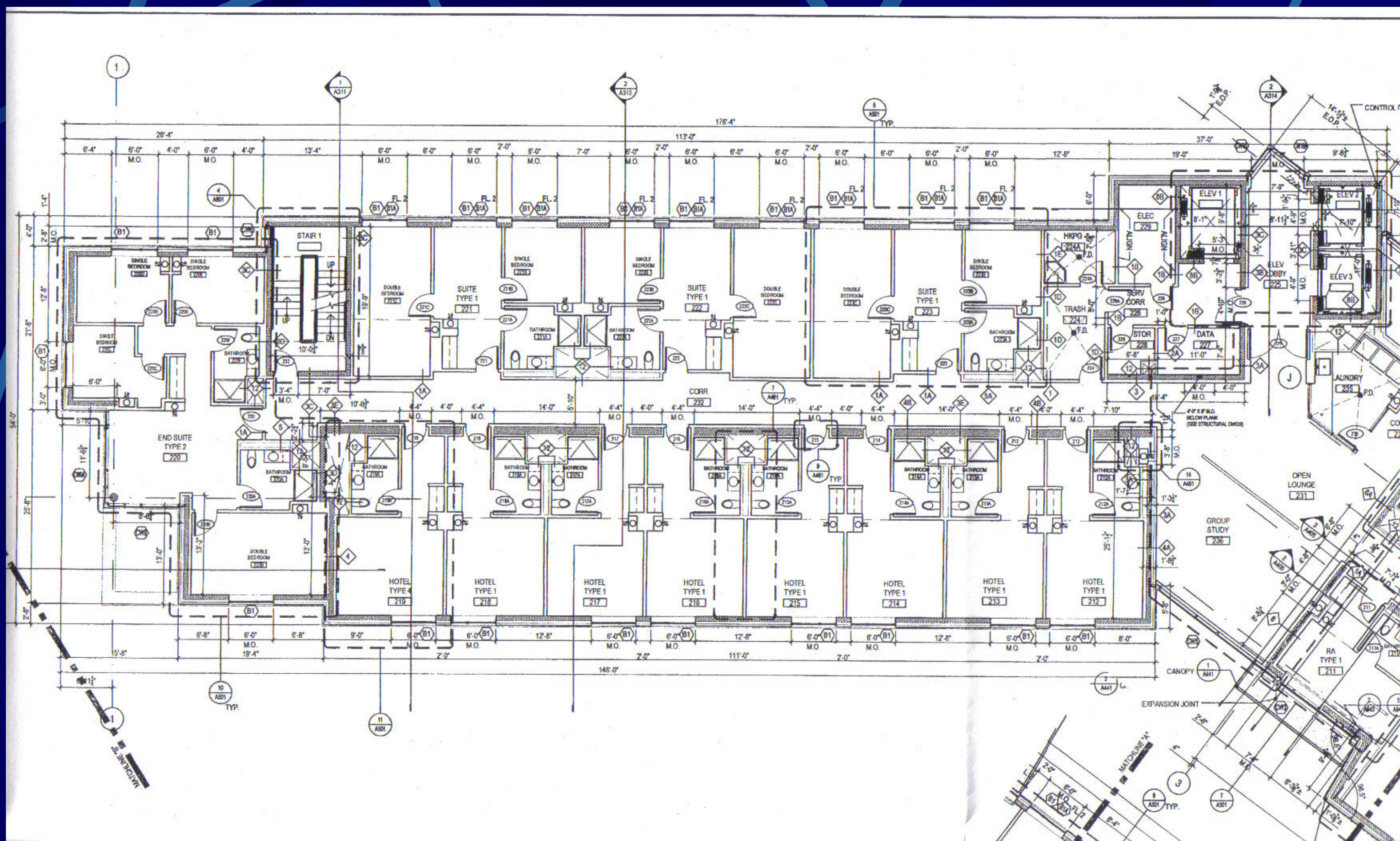
Existing Conditions

- Structural System
  - Framing
  - Foundations
  - Lateral System

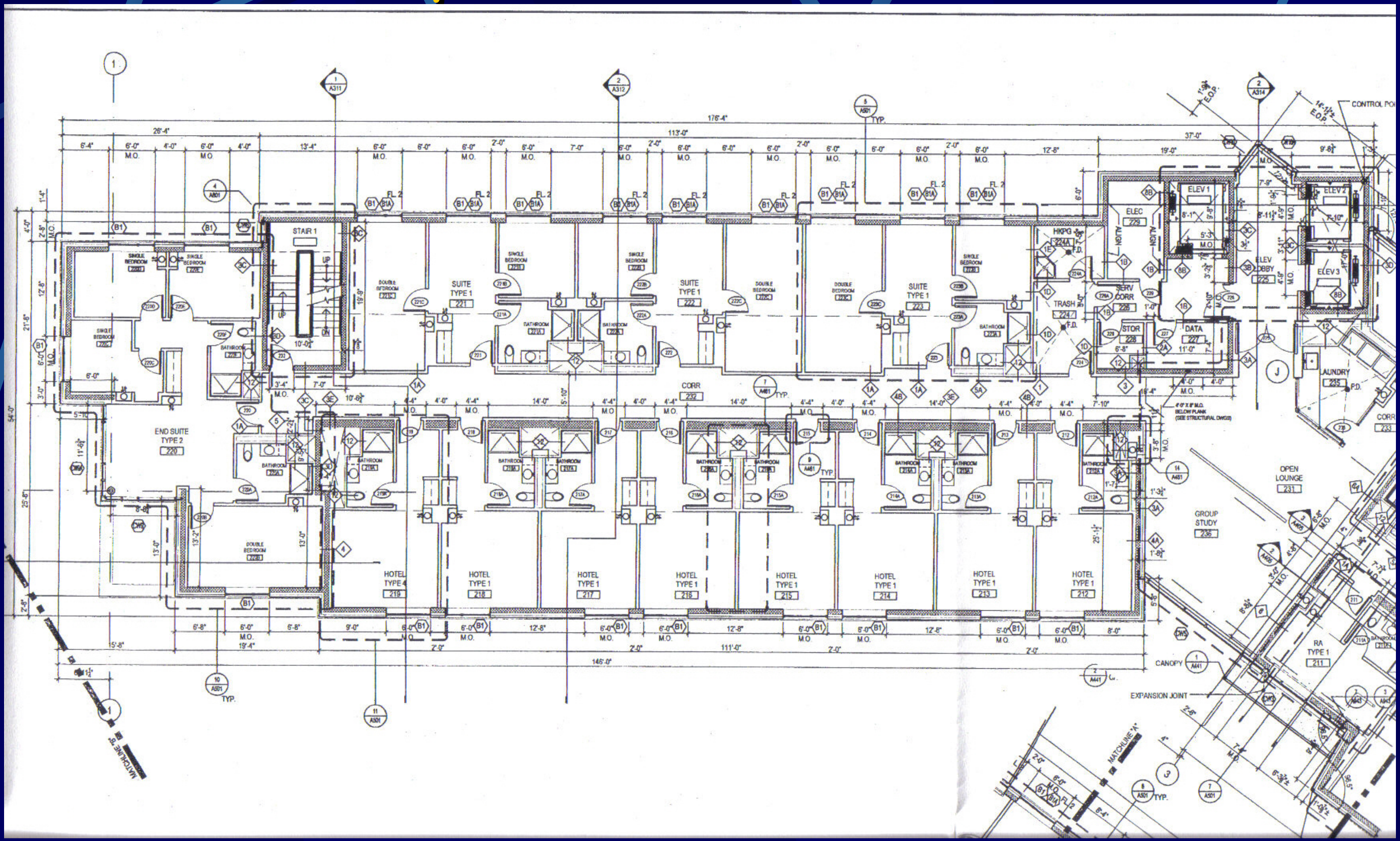


176'-4"
113'-0"
37'-0"
146'-0"
111'-0"
P.C. STAIR BY OTHERS
P.C. MFR. TO PROVIDE HEADERS AS REQ'D TO FRAME OPNG. PROVIDE SOLID PLANK EACH SIDE OF OPNG. AS REQ'D TO SUPPORT HEADER LOADS.
P.C. MFR. TO PROVIDE HEADER AS REQ'D TO FRAME OPNG. (TYP.).
8" P.C. PLANK + 2½" TOPPING
MATCH LINE 'A'
SEE THIS SHEET

Problem Statement



Proposed Solution



Depth Study

- Designed using ADOSS
- Two-way Flat-plate system
- f'c=4000psi
- Fy=60,000psi

Gravity Loads

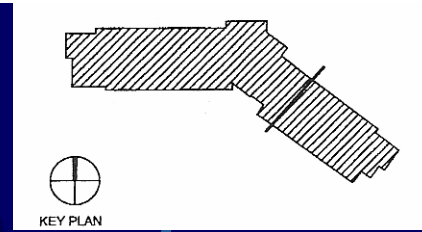
- Dead Load (self-weight): Computed by ADOSS
- Superimposed Dead Load: 25psf
- Live Load: 80psf
- Roof/Snow: 30psf

Slab

- ACI 318 Table 9.5(c)
  - t_{min}=ln/30=(27ft –2ft)(12in/ft)/30=10”
- As_{min}=0.0018Ag=0.216in^2/ft (#5@12”)

Slab Reinforcement

- Distance from reinforcement to tension face = 1.5”
- Minimum Bar Size = #4
- Minimum Clear Bar Spacing = 6”
- 100% Column Fixity
- Long and short bar extensions were completed by ADOSS which complies with ACI Figure 13.3.8.



Slab Reinforcement

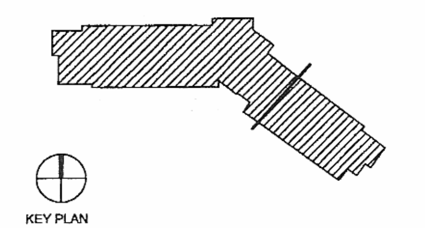
N E G A T I V E   R E I N F O R C E M E N T

COLUMN NUMBER	PATT NO.	LOCATION @COL FACE	TOTAL DESIGN (ft-k)	COLUMN STRIP AREA (sq.in)	COLUMN STRIP WIDTH (ft)	MIDDLE STRIP AREA (sq.in)	MIDDLE STRIP WIDTH (ft)
1	4	|| R	229.4	6.15	13.5	2.92	13.5
2	4	L ||	-485.8	10.22	13.0	3.24	14.0
3	4	L ||	-197.2	5.26	13.0	3.02	14.0

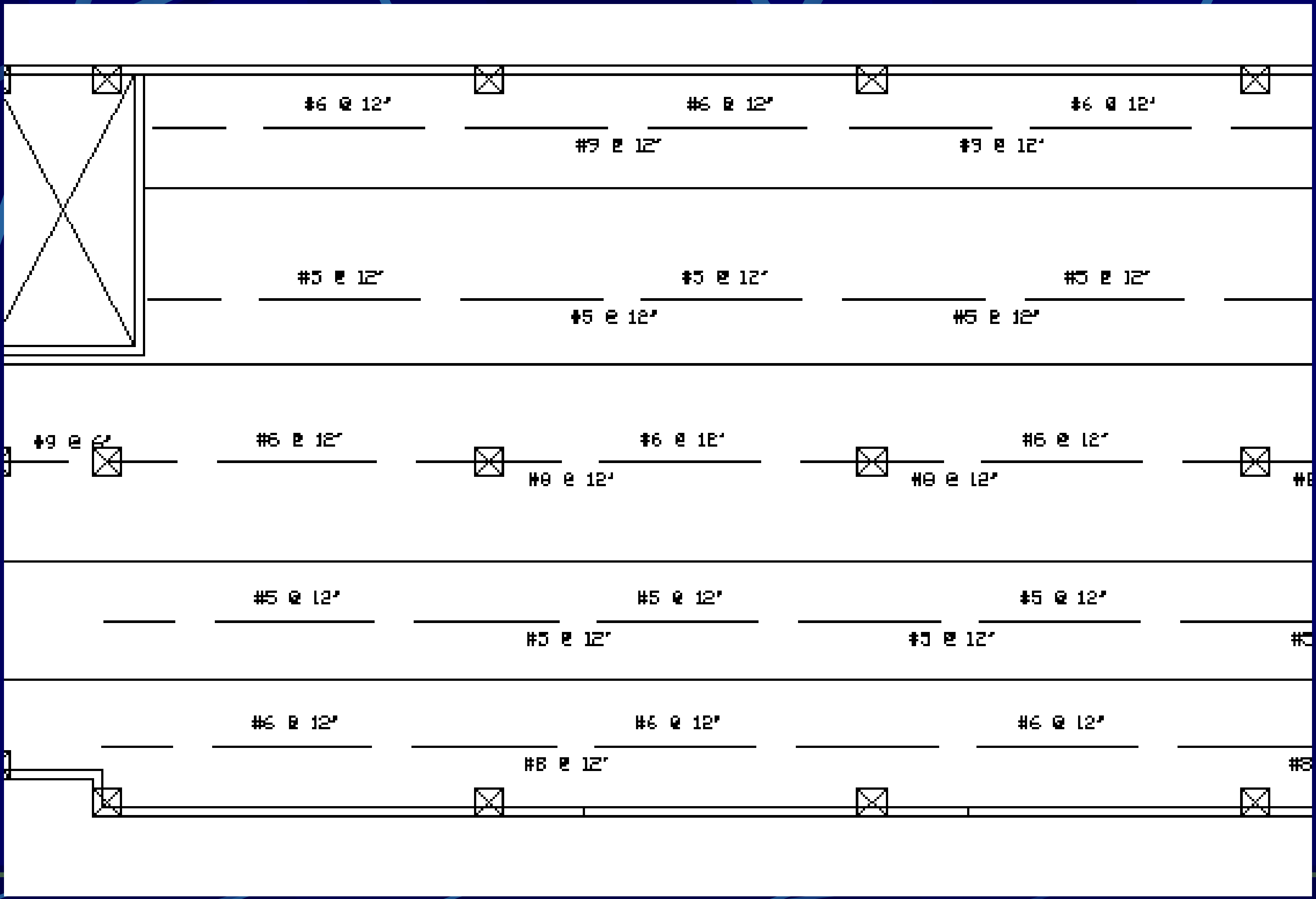
P O S I T I V E   R E I N F O R C E M E N T

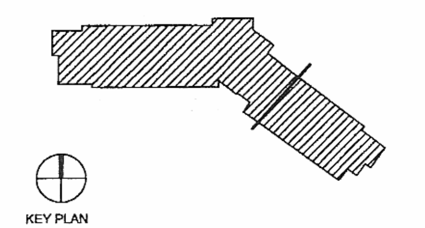
SPAN NUMBER	PATT NO.	LOCATION FROM LEFT (ft)	TOTAL DESIGN (ft-k)	COLUMN STRIP AREA (sq.in)	COLUMN STRIP WIDTH (ft)	MIDDLE STRIP AREA (sq.in)	MIDDLE STRIP WIDTH (ft)
2	4	12.8	333.4	5.42	13.5	3.57	13.5
3	4	14.9	304.4	4.94	13.0	3.25	14.0

$A_s = 6.15 in^2/13.5 ft = 0.456\ in^2/ft$ (#7 at 12")

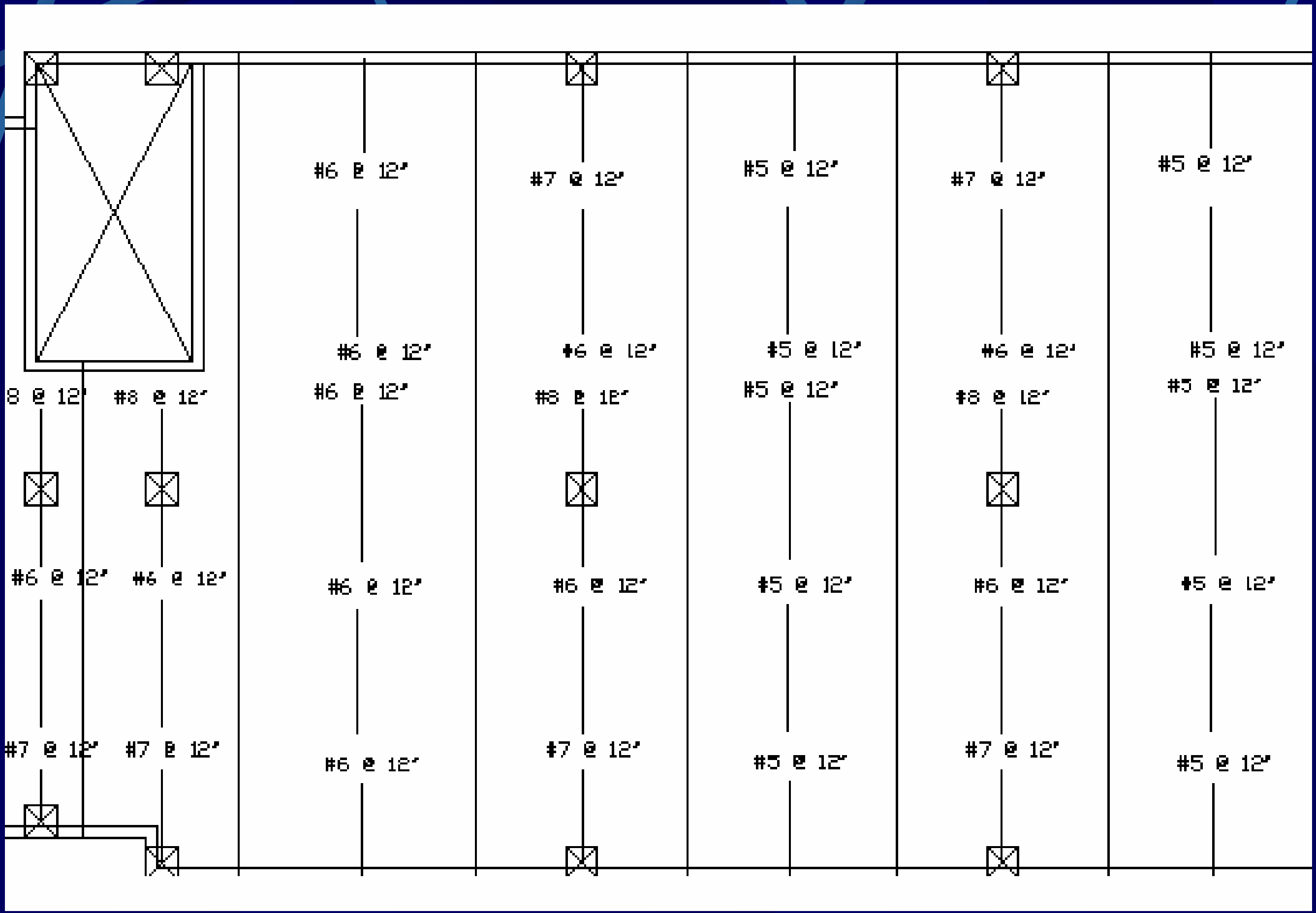


Slab Reinforcement





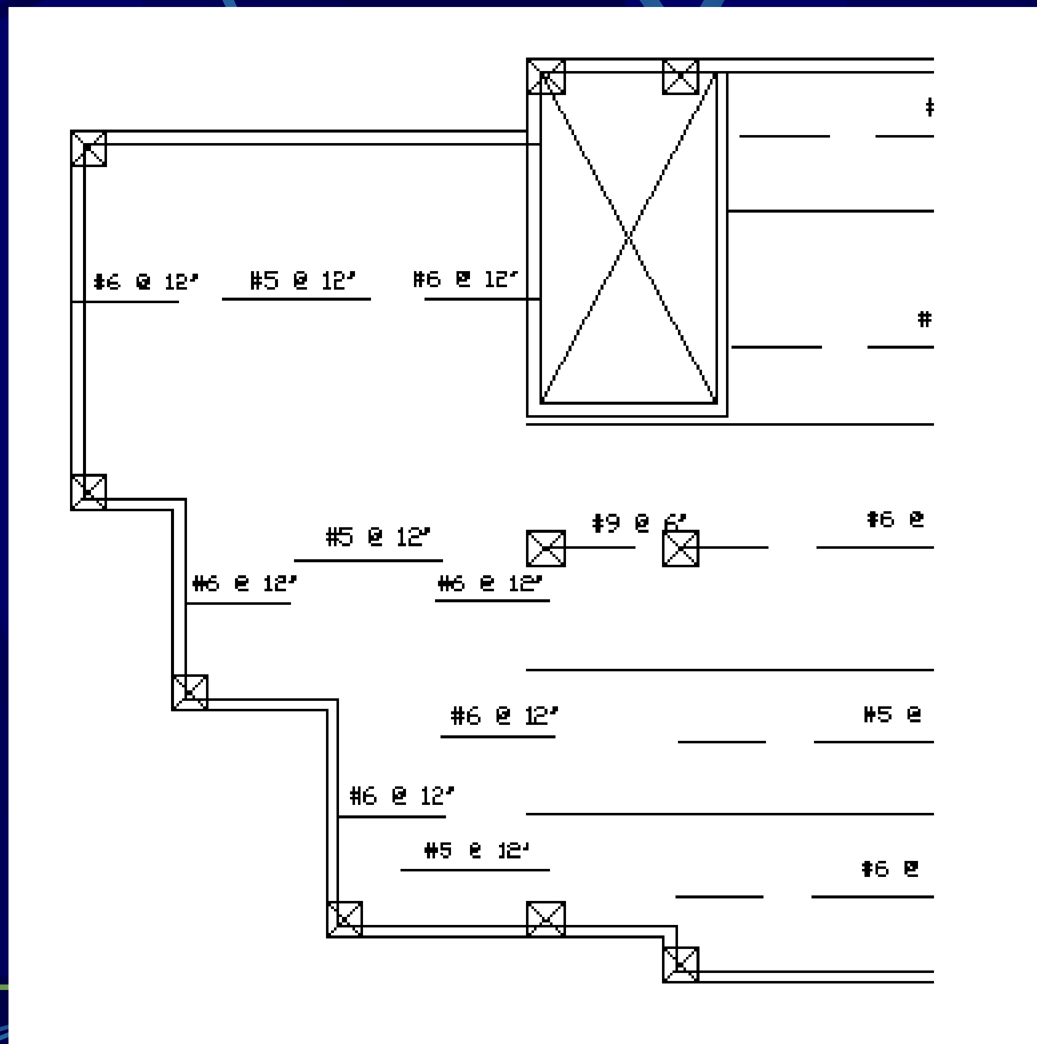
Slab Reinforcement



Slab Reinforcement

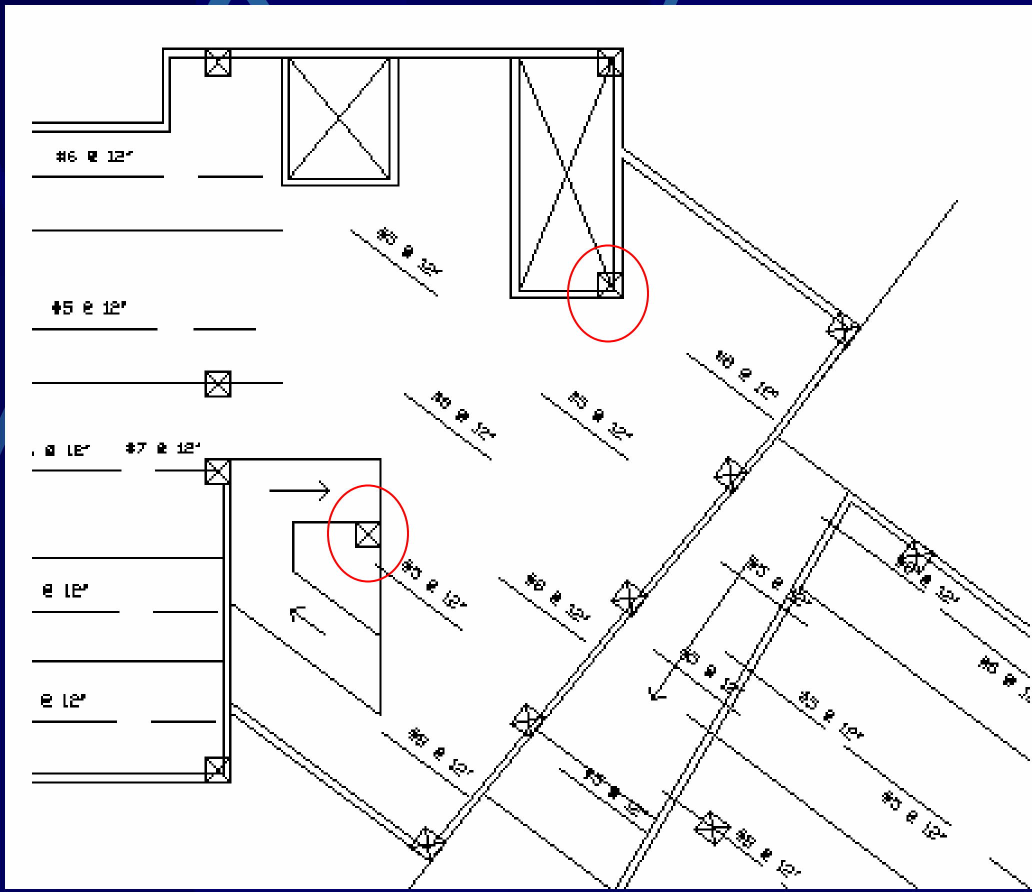
- End spans and center section
- Also designed in ADOSS
- Checked with a max moment of $wL^2/8$

Slab Reinforcement



Slab Reinforcement

- T-Beam Design
  - Depth=10"+6"
  - Width=24"
  - 5-#8's for Flexure
  - #3's for Shear (1 at 2" and 18 at 9")



Columns

- Designed using Interaction Diagrams
- CRSI Design Handbook: 26" minimum column for shear
- Column Capitals 5" x 5" extension
- ACI 10.16.8.6
  - $As_{min}=0.01Ag=6.76in^2$ (12#7)
  - $As_{max}=0.08Ag$

Columns

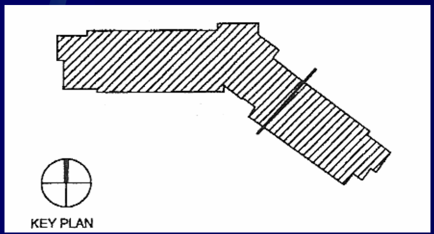
- Interaction Diagram (γ=0.8) from Design of Concrete Structures textbook
- Minimum Concrete Cover = 1.5”
- Strength Reduction Factor = 0.65
- Lateral ties for <#10 bars = #3

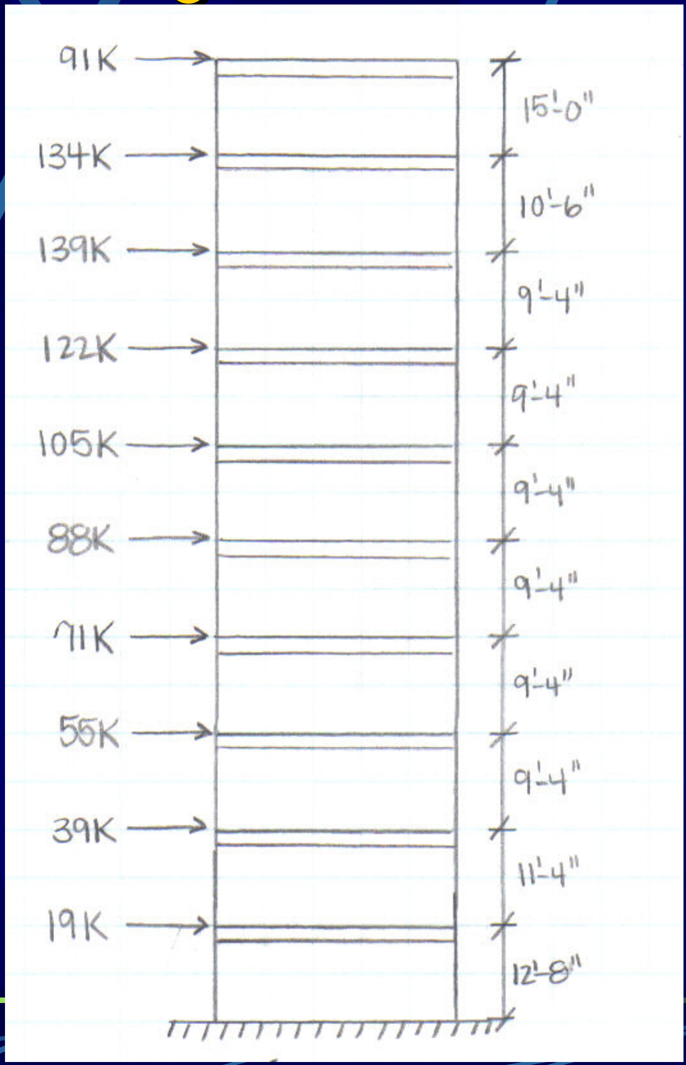
Columns

- Lateral Tie Spacing
  - 16 x dia. Longitudinal bars = 14"
  - 48 x dia. Tie = 48.375"
  - ½ Least dimension of column = 13"

Lateral Design

- 10" Concrete Shear Walls
- Seismic loading based on ASCE7-02





Lateral Design

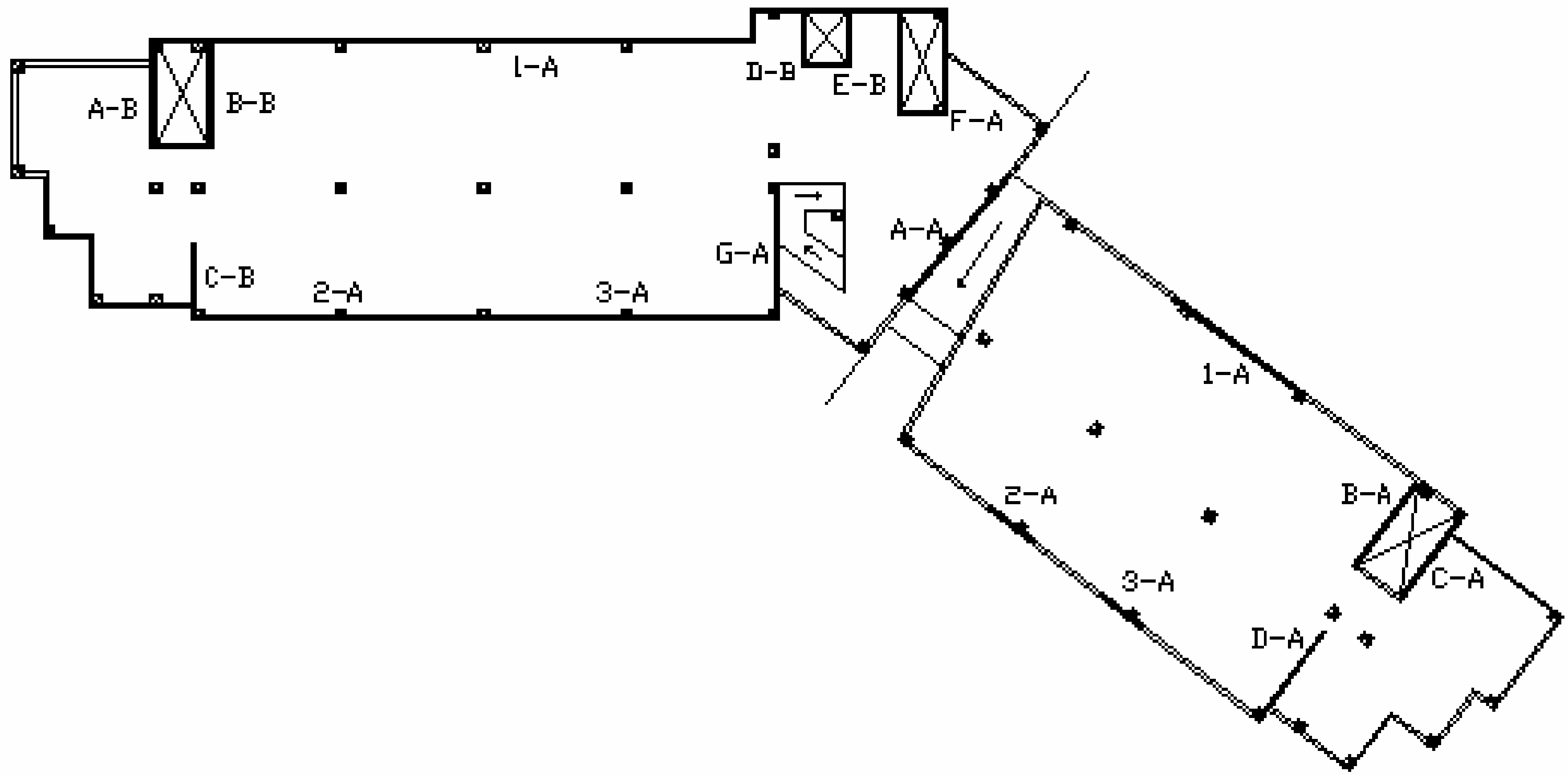
<u>Shear Wall Type A</u>

- Horizontal Steel
  - #10 at 12"
- Vertical Steel
  - First and Last 12"
    - 20-#10's
  - #5 at 12"

<u>Shear Wall Type B</u>

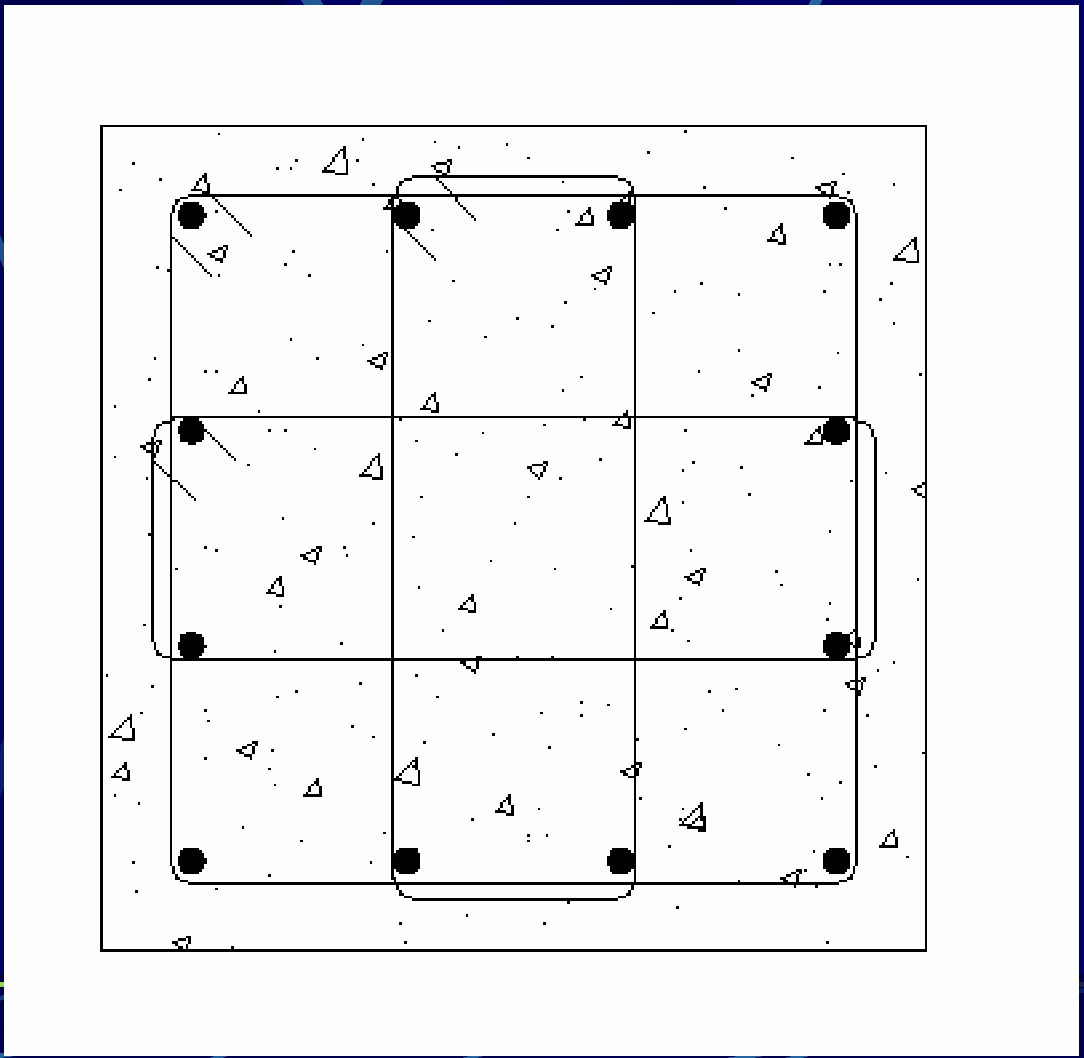
- Horizontal Steel
  - #5 at 12"
- Vertical Steel
  - First and Last 12"
    - 20-#8's
  - #5 at 12"

Lateral Design



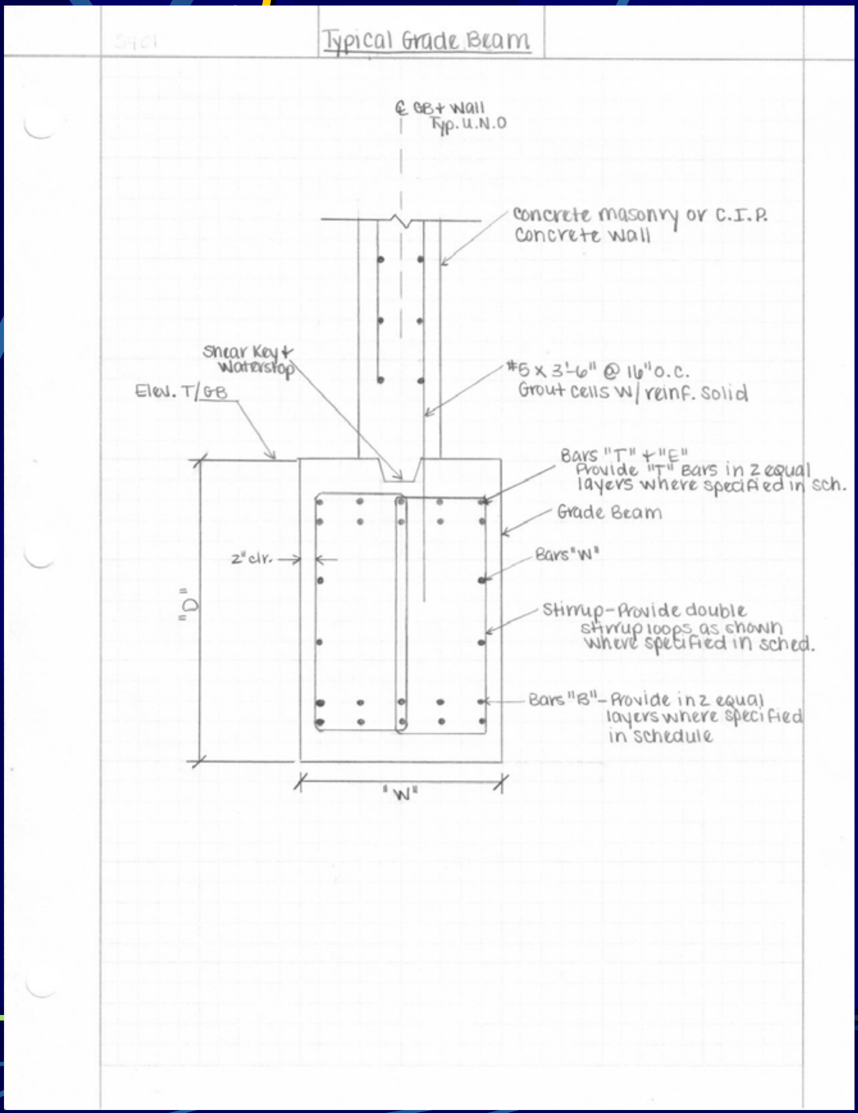
Lateral Design

- Lateral Ties



Lateral Design

- Shear wall to foundation



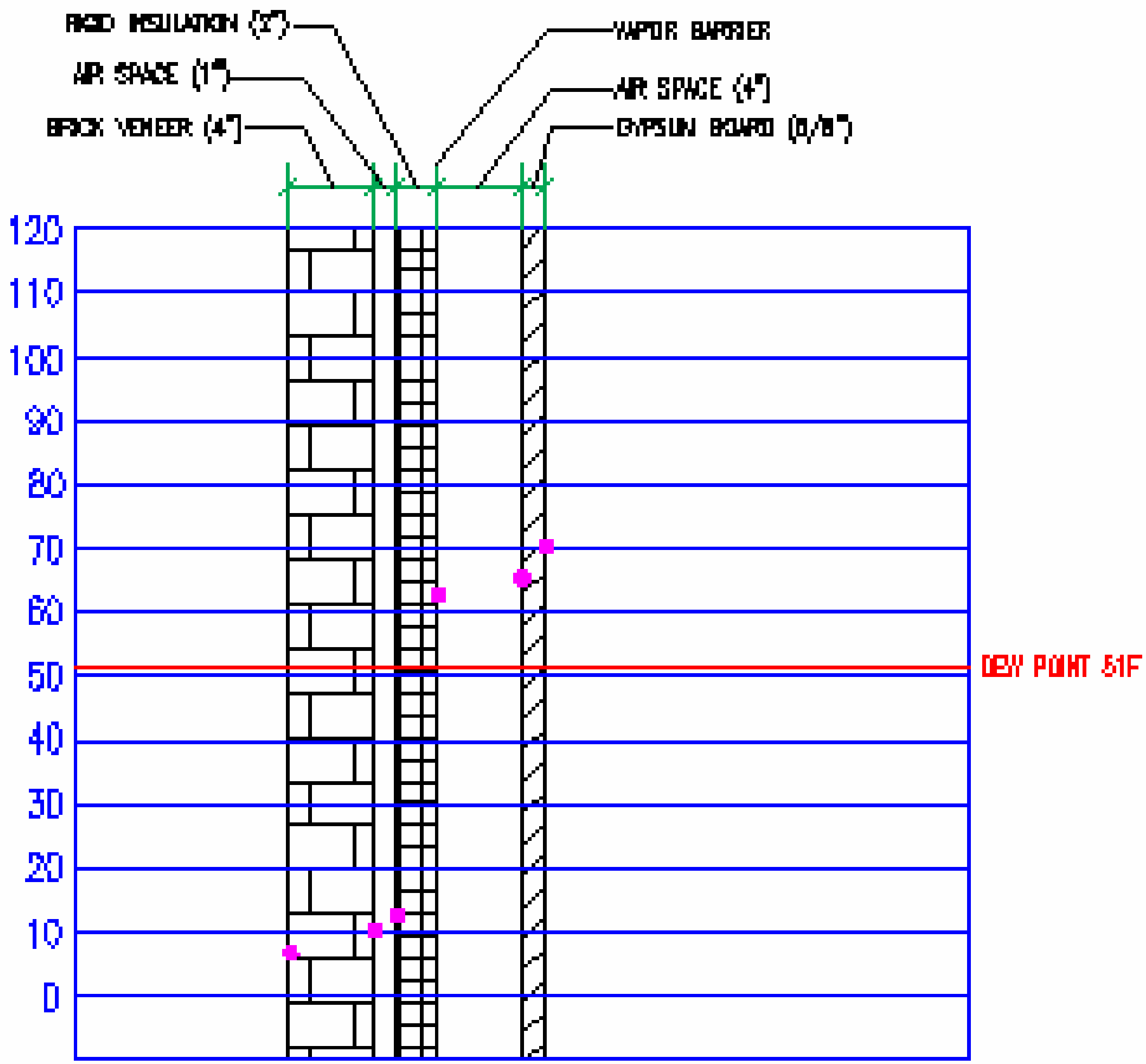
Drift

- $\Delta = (Ph^3/3EI)+(2.78Ph/AE)$
- $E = 33(145pcf)^{1.5}(4000psi)^{0.5}$
  $=3644ksi$
- $\Delta_{allowable} = H/400 = 105.5ft(12in/ft)/400$
  $= 3.165"$

Thermal Gradient

- Dew Point Temperatures
  - Summer = 55F
    - 50% RH, 75F
  - Winter = 51F
    - 50% RH, 71F
- Max Allowable U-Factor = 0.064
  - ASHRAE std. 90.1-2004
- Outdoor Design Conditions
  - ASHRAE Design Handbook of Fundamentals 1993
  - Summer = 86F
  - Winter = 7F

WINTER WALL HEAT TRANSFER DIAGRAM



Cost and Duration Comparison

- Two-Way System
  - Material: $11,967
  - Labor: $7,305
  - Labor Fringes: $2,004
  - Equipment: $837
  - Total: $22,113
  - Man-hours: 353
- One-Way System
  - Material: $8,091
  - Labor: $1,815
  - Labor Fringes: $887
  - Equipment: $265
  - Total: $11,058
  - Man-hours: 92

Conclusions

Acknowledgements

- AE Faculty
- Advisor: Dr. Hanagan
- Fellow AE students
- Atlantic Engineering Services
- The University of Pittsburgh

- Questions???