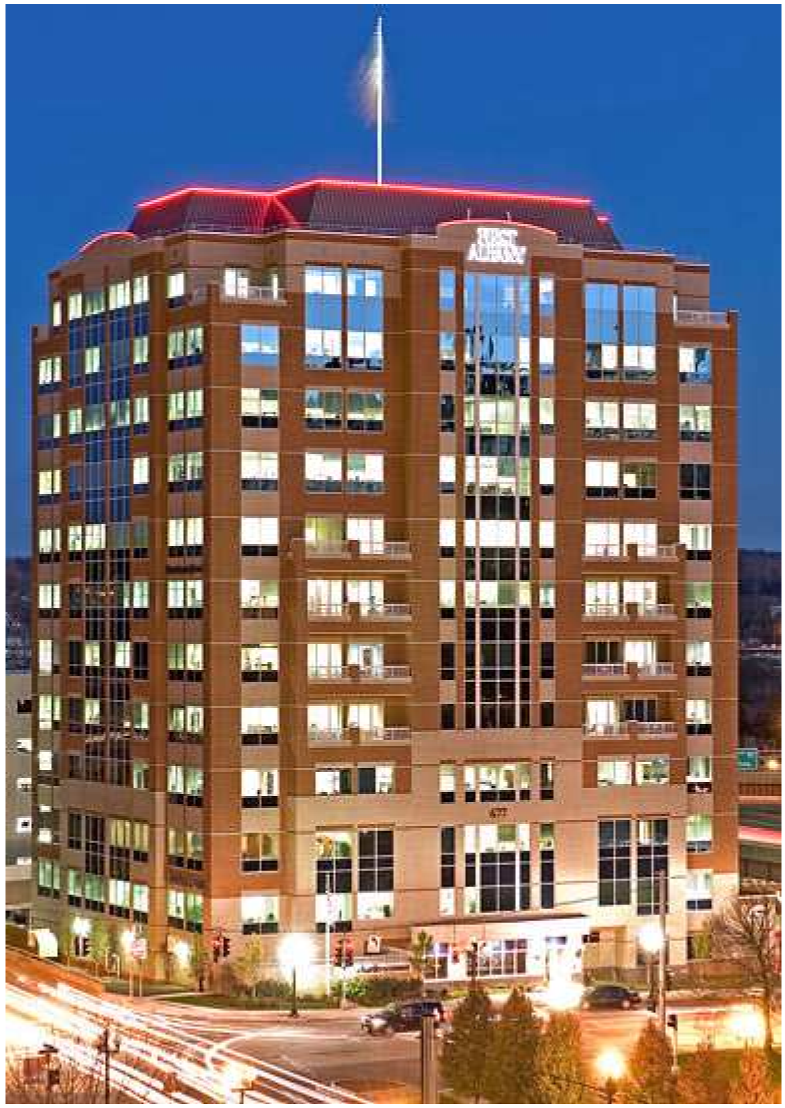
The First Albany Building

677 Broadway
Albany, NY



Gerald Craig

Architectural Engineering

Structural option

Consultant:
Dr. Boothby

October 6, 2009

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EXECUTIVE SUMMARY

The First Albany Building is a 12 story, 180,000 square feet structure designed to house mixed-use office space and condominiums. Dimensions of the building are roughly 115' x 135' and the overall height is about 172' to the mechanical penthouse roof. The first floor is at grade and the building has no basement. The exterior of the building is mostly brick veneer.

The foundation system consists of a mixture of H piles, pile caps, and grade beams to support the structure. The first floor is supported by a 6" concrete slab on grade with the remaining 11 stories (and roof) comprised of a semi-regular grid of simply supported beams and girders. Floor slabs are 4.5" thick on a composite steel deck. Composite steel and concrete design was utilized in the floor members (partial composite action). Lateral forces are resisted by sets of concentrically braced steel frames around the core of the building. Bracing patterns include "K", inverted "K", and standard diagonal. The braced frames each act like a vertical, cantilevered truss. There are 2 wide frames in the east-west direction and 3 narrower frames in the north-south direction.

Live loads used by the engineer were found to be 70 psf for the lower floors and 115 psf for the upper floors. Live loads required by ASCE 7-05 Chapter 4 were found to be roughly the same. Spot checks of existing structural elements' performance and serviceability confirmed that the loads calculated were close to those used by the design engineer.

ASCE 7-05 was used to determine all wind and seismic loads. For wind loads Method 2 (Analytical procedure) of ASCE 7-05 Chapter 6 was used. Design wind velocity was found to be 90 mph. Seismic design loads were established using the equivalent lateral force procedure outlined in ASCE 7-05 Chapter 12. The First Albany Building was found to be in a Seismic Design Category "B".

INTRODUCTION

Building Description

The First Albany Building is a 12 story, 180,000 square feet structure designed to house mixed-use office space and condominiums. Dimensions of the building are roughly 115' x 135' and the overall height is about 172' to the mechanical penthouse roof. The first floor is at grade and the building has no basement. The exterior of the building is mostly brick veneer.

The foundation system consists of a mixture of H piles, pile caps, and grade beams to support the structure. The first floor is supported by a 6" concrete slab on grade with the remaining 11 stories (and roof) comprised of a semi-regular grid of simply supported beams and girders. H-piles had to be driven to practical refusal to fully support the building. Six test piles were driven and their capacities tested to verify calculated load capacities of all the piles. Design capacity of each pile was 120 tons.

Gravity loads are resisted by a 4.5" reinforced concrete slab utilizing composite deck design. The floor slab is supported by a semi-regular grid of simply supported beams and girders. Composite beam and composite deck design (partial composite action) was incorporated in to the floor system design and bays are typically about 25'x25' with some variations. Sizes of floor members range between W12 and W18 shapes with varying numbers of shear stud connectors on each member. Column lines transfer loads directly to the ground through pile caps and to the piles themselves. The piles are laid out symmetrically under each cap because there are no eccentricities associated with column loads.

Lateral forces are resisted by sets of concentrically braced steel frames around the core of the building. Bracing patterns include "K", inverted "K", and standard diagonal. The braced frames each act like a vertical, cantilevered truss. There are 2 wide frames in the east-west direction and 3 narrower frames in the north-south direction.

Material specifications

<u>Structural Steel</u> –

Miscellaneous shapes, plates, bars	–	ASTM A36, Fy = 36 ksi
Structural Shapes, W8 and larger	–	ASTM A572, Grade 50, Fy = 50 ksi
Hollow Structural Shapes (HSS)	–	A500, Grade B, Fy = 46 ksi (square and rect.)
	–	ASTM A53, Type E or S, Fy = 35 ksi (round shapes)
Anchor Bolts	–	ASTM A307
	–	ASTM A449 (at braced bays)

<u>Cast-in-place Concrete</u> –

Slab on Grade	–	3500 psi (28 day compressive strength)
Supported Floor Slabs	–	4000 psi, lightweight (115 pcf)
Grade Beams, Pile Caps, Walls	–	4000 psi
Foundation Piers	–	6000 psi
Reinforcing bars	–	ASTM A615, Grade 60, deformed
Welded Reinforcing bars	–	ASTM A706, Grade 60
Welded Wire Fabric	–	ASTM A185 (Sheet type only)

<u>Steel Deck</u> –

Roof Deck	–	1 ½" x 22 Gage Type B Rib Deck
Floor Deck	–	2" x 22 Gage Composite Floor Deck

APPLICABLE BUILDING CODES

New York State Building Code 2002
New York State Energy Conservation Code
"Manual of Steel Construction" AISC ASD 9th Ed.
"Building Code Requirements for Structural Concrete" ACI 318-02

Gravity Live Loads

	Loading Used by Engineer	ASCE 7-05 Required Loading		
Office Space (2-8)	50 psf +20 psf Partition Allowance	50 +15	psf	(ASCE 7-05, Table 4.1) (Partition Allowance)
Office Space (9-12) +Computer Use	100 psf +15 psf Access Flooring	100	psf	(ASCE 7-05 Table 4.1)
Office Space File Storage	125 psf	125	psf	(ASCE 7-05 Table 4.1)
Stairways	100 psf	100	psf	(ASCE 7-05 Table 4.1)
Roof Snow Load	65 psf	65	psf	(NYS Bldg Code)
Balconies	100 psf	100	psf	(ASCE 7-05 Table 4.1)
Roof	20 psf	20	psf	(ASCE 7-05 Table 4.1)
Restaurants	100 psf	100	psf	(ASCE 7-05 Table 4.1)

Dead Loads

	Loading	
MEP	15	psf
Structural Steel	15	psf
Concrete Slab	43	psf
Deck	2	psf
Finishes	5	psf
Misc	10	psf
Total	90	psf

Live Load Reductions

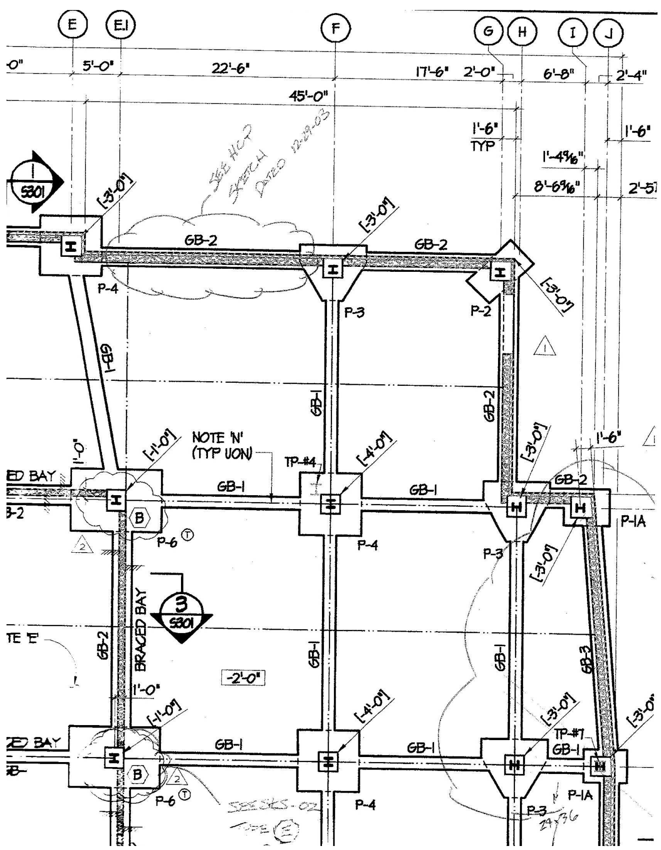
Reduction Factor (RF) = $0.25+15/\sqrt{(K_{LL}*A_T)}$
For structural members supporting 1 floor; RF ≥ 0.5
For structural members supporting 2 or more floors; RF ≥ 0.4

STRUCTURAL SYSTEM DISCUSSION

The foundation system is a network of reinforced concrete grade-beams and pile caps. With Site Class D and the layout of the lateral force resisting system, 134 H-piles (HP14x89) had to be driven to practical refusal to fully support the building. Six test piles were driven and their capacities tested to verify calculated load capacities of all the piles. The design load capacity of each pile is 120 tons. Grade beams range in size and design as follows:

Cast-in-place Concrete Grade Beam Schedule												
Mark	'W'	'D'	'A' Bars		'B' Bars		'C' Bars		'D' Bars		Stirrups	
			No.	Size	No.	Size	No.	Size	No.	Size	Size	Spacing
GB-1	18	18	-	-	3	#6	-	-	3	#6	#3	24" O.C.
GB-2	20	20	-	-	4	#9	2	#9	2	#9	#3	8" O.C.
GB-3	20	20	-	-	5	#9	2	#9	2	#9	#3	8" O.C.
GB-4	20	30	-	-	5	#9	3	#9	3	#9	#3	12" O.C.
GB-5	32	30	-	-	5	#9	3	#9	3	#9	#3	12" O.C.
GB-6	28	20	-	-	5	#9	3	#9	3	#9	#3	12" O.C.

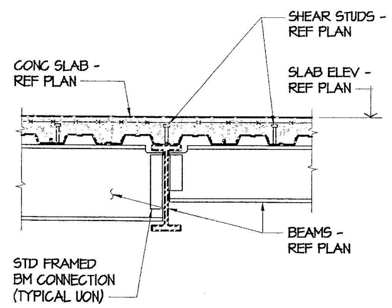
The grade beams bind the pile caps together into a semi-rigid matrix so they act as together. Columns transfer loads directly to the ground through pile caps and to the piles themselves. The piles are laid out symmetrically under each cap because there are no eccentricities associated with column loads.



Partial Foundation Plan
(See Appendix B for a larger/clearer plan)

Gravity loads are resisted by a 4.5" reinforced concrete slab supported by a semi-regular grid of simply supported beams and girders. Composite beam and composite deck design was incorporated in to the structure and bays are typically about 25'x25' with some variations. Sizes of floor members range between W12 and W18 shapes with appropriate numbers of shear stud connectors on each member. A braced frame approach to the structure provided a relatively simple structural analysis and design as well as simplified constructability. With this design the majority of the connections could be designed as a simple shear tab types. Load paths travel straight down column lines. A few members around the perimeter act as transfer girders to get the loads to the column lines. These can be identified on the plan when the end of a girder (supporting beams) frames into another girder and not a column (usually close to a column line). Steel decking spans at least 3 bays per piece, allowing the slab to be designed as continuous over supports. Welded wire mesh was used as reinforcing for negative moments. Columns in this structure see no bending moments and their capacities are governed by their buckling limit. Beams and girders are designed as "simple beams" (pinned ends) eliminating negative moments making them excellent candidates for composite beam design.

TYPICAL FRAMING PLAN

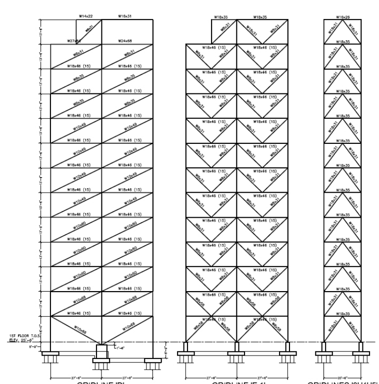


TYPICAL INTERIOR BEAM CONNECTION DETAIL

NTS

(See Appendix B for a larger/clearer plan)

Lateral forces, wind and seismic, are resisted by sets of braced frames around the core of the building. Bracing patterns include "K", inverted "K", and standard diagonal. The braced frames each act like a vertical, cantilevered truss. This is the only area in the structure where combined loading of structural members occurs. Horizontal members act as beam-columns (bending moments plus axial force). They carry gravity loads as well as axial loads from lateral forces. Vertical and diagonal members only resist axial loads.



BRACED BAY ELEVATIONS

(See Appendix B for a larger/clearer section)

WIND LOADS as per ASCE 7-05

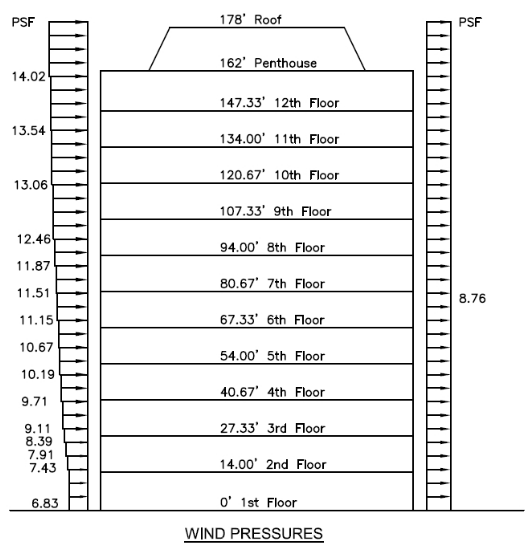
Wind loads were analyzed using section 6 of ASCE 7-05. Appendix A contains a detailed analysis of wind loads using the equations and factors set forth in ASCE. These factors are dependent on building location and characteristics as well as experimental data.

Design Criteria

Height	h			172’
Dimensions				115’x135’
Wind directionality factor	Kd	6.5.4		0.85
Importance Factor	I	6.5.5		1.0
Wind Exposure Category		6.5.6		B
Basic Wind Speed	V			90 MPH
Topographic Factor	Kzt	6.5.7		1.0
Gust Factor	Gf	6.5.8		0.85
External Pressure Coeff.	Cpf	6.5.11.2	Windward	0.8
			Leeward	-0.5
			Sides	-0.7

$q_z = 0.00256(K_z*K_{zt}*K_d*V^2*I)$

h	Kz	Kzt	Kd	V	I	qz	Gf	Cp	Pressure (psf)
									Windward
0-15	0.57	1.00	0.85	90.00	1.00	10.05	0.85	0.80	6.83
20	0.62	1.00	0.85	90.00	1.00	10.93	0.85	0.80	7.43
25	0.66	1.00	0.85	90.00	1.00	11.63	0.85	0.80	7.91
30	0.70	1.00	0.85	90.00	1.00	12.34	0.85	0.80	8.39
40	0.76	1.00	0.85	90.00	1.00	13.40	0.85	0.80	9.11
50	0.81	1.00	0.85	90.00	1.00	14.28	0.85	0.80	9.71
60	0.85	1.00	0.85	90.00	1.00	14.98	0.85	0.80	10.19
70	0.89	1.00	0.85	90.00	1.00	15.69	0.85	0.80	10.67
80	0.93	1.00	0.85	90.00	1.00	16.39	0.85	0.80	11.15
90	0.96	1.00	0.85	90.00	1.00	16.92	0.85	0.80	11.51
100	0.99	1.00	0.85	90.00	1.00	17.45	0.85	0.80	11.87
120	1.04	1.00	0.85	90.00	1.00	18.33	0.85	0.80	12.46
140	1.09	1.00	0.85	90.00	1.00	19.21	0.85	0.80	13.06
160	1.13	1.00	0.85	90.00	1.00	19.92	0.85	0.80	13.54
180	1.17	1.00	0.85	90.00	1.00	20.62	0.85	0.80	14.02
									Leeward
180	1.17	1.00	0.85	90.00	1.00	20.62	0.85	-0.50	-8.76
									Sides
180	1.17	1.00	0.85	90.00	1.00	20.62	0.85	-0.70	-12.27



(See Appendix B for a larger/clearer view)

Through a generalized analysis of the buildings fundamental period set forth in ASCE 7-05 the building was found to behave as a flexible structure. (*See the seismic loads section for the building period calculation*)

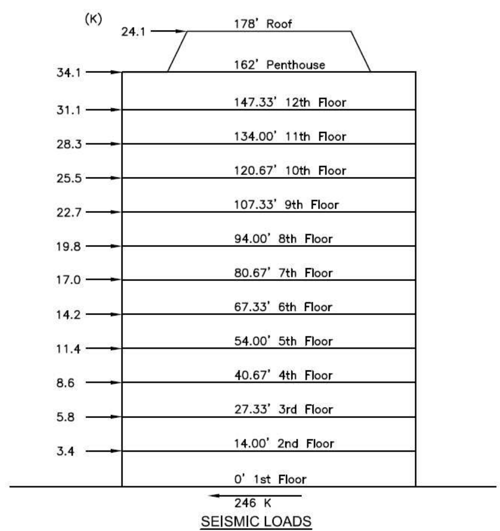
SEISMIC LOADS as per ASCE 7-05

Seismic loads were found using the applicable sections of ASCE 7-05; Equivalent Lateral Force procedure (12.8). All factors and accelerations were found using the tables and equations contained in ASCE. All dead loads used are based on ASCE 7-05 and are listed in the gravity loads section of this report.

Site Class	D	
Occupancy Category	II	
Importance Factor	1.0	
Seismic Design Category	B	
Response Modification Factor (R)	5	
Period (Ta)	1.46	
Ss	0.229	*
S1	0.069	*
SDS	0.28	
SD1	0.12	
T_L	6	Figure 22-15
Cs	0.016	
Base Shear (V)	246 (K)	

*From USGS website - earthquake.usgs.gov/research/hazmaps/design

Level	w_x (k)	h_f (ft)	h_x (ft)	$w_x(h_x)$^k	F_x (K)	V_x (K)	M_x (FT-K)
Pent	750	16.00	178.00	133500.0	24.1	0.0	4286.5
12	1170	14.67	162.00	189540.0	34.2	24.1	5538.8
11	1170	13.33	147.33	172380.0	31.1	58.3	4581.3
10	1170	13.33	134.00	156780.0	28.3	89.4	3789.6
9	1170	13.33	120.67	141180.0	25.5	117.6	3073.0
8	1170	13.33	107.33	125580.0	22.7	143.1	2431.4
7	1170	13.33	94.00	109980.0	19.8	165.8	1864.9
6	1170	13.33	80.67	94380.0	17.0	185.6	1373.3
5	1170	13.33	67.33	78780.0	14.2	202.6	956.9
4	1170	13.33	54.00	63180.0	11.4	216.8	615.4
3	1170	13.33	40.67	47580.0	8.6	228.2	349.0
2	1170	13.33	27.33	31980.0	5.8	236.8	157.7
1	1350	14.00	14.00	18900.0	3.4	242.6	47.7
Total	14970			1363740.0	246.0	246.0	29065.7



(See Appendix B for a larger/clearer view)

CONCLUSIONS

In the first technical report the existing structural conditions were introduced through a detailed description of the foundation, gravity load resisting and lateral load resisting systems. Structural concepts were investigated including determining loads on the lateral force resisting system. Spot checks of gravity loads were done on typical beams, girders, and columns under design loads. W shapes as noted in the calculations were found adequate to resist moments, shears, and/or axial forces resulting from typical uniform dead and live loads. A more in depth analysis containing the analysis of the gravity and lateral loads in the structural frame as well as addressing serviceability requirements will be contained in a later report. The results of the gravity load spot checks have been presented in Appendix D.

ASCE 7-05 was used to determine all wind and seismic loads. For wind loads Method 2 (Analytical procedure) of ASCE 7-05 section 6 was used. Seismic design loads were established using the equivalent lateral force procedure set forth in ASCE 7-05. Seismic load calculations have been presented in Appendix C.

APPENDIX A – PROJECT TEAM MEMBERS

Owner & Developer

Columbia Development Companies
302 Washington Ave. Ext., Albany, NY 12203
http://www.columbiadev.com/

Architect

HCP Architects
302 Washington Ave. Ext., Albany, NY 12203
http://www.hcpdesign.com/

Construction Manager & General Contractor

BBL Construction Services
302 Washington Ave. Ext., Albany, NY 12203
http://www.bblconstructionservices.com/

Structural Engineers

Stroud, Pence, & Associates LTD
204-A Grayson Road, Virginia Beach, VA 23462
http://www.stroudpence.com/

Site Engineers & Surveyor

Hershberg & Hershberg
18 Locust Street, Albany, NY 12203
http://www.hhershberg.com/

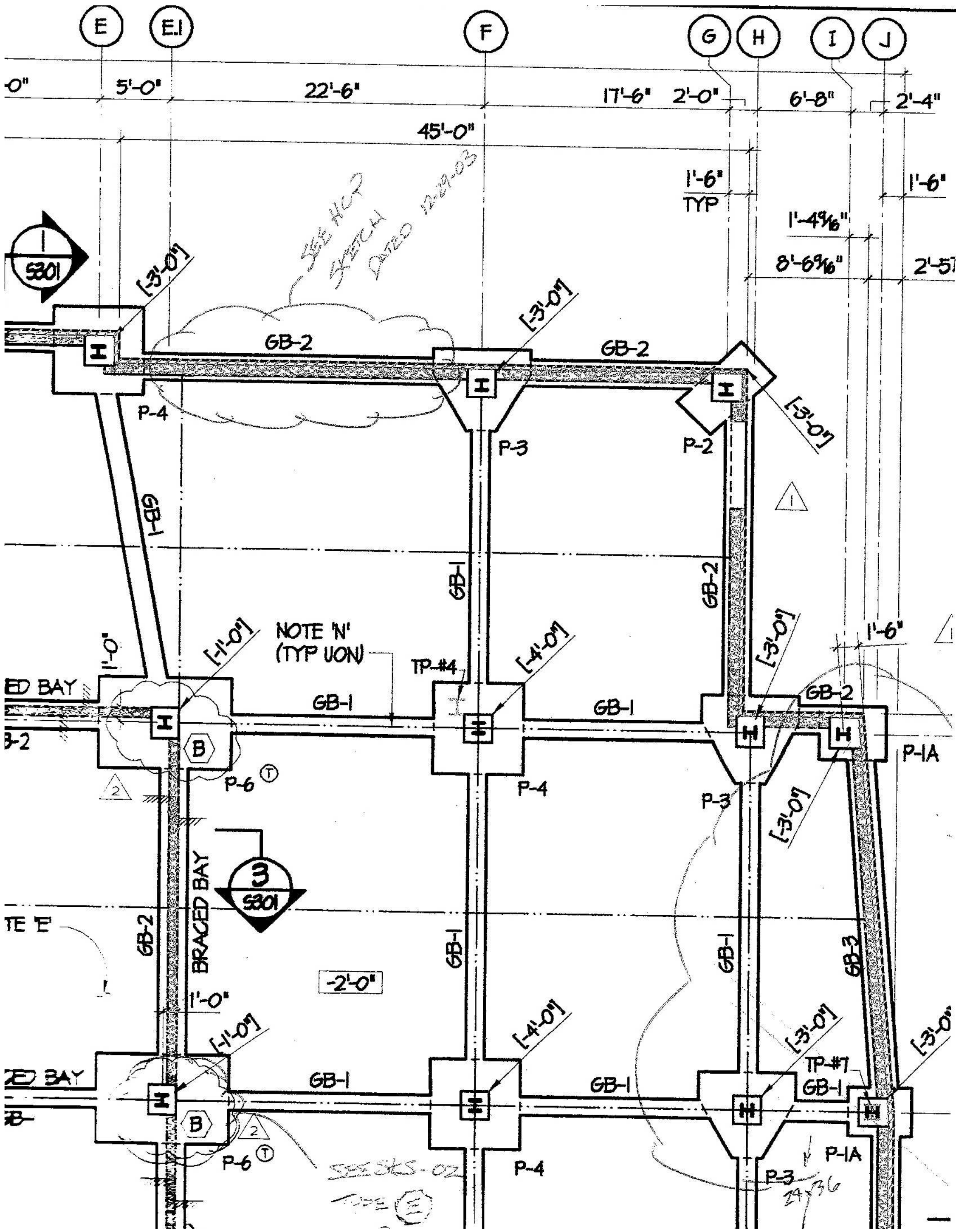
Geotechnical Engineers

Dente Engineering, P.C.
594 Broadway, Watervliet, NY 12189
http://www.dente-engineering.com/

Interior Designer / Architect

Woodward, Connor, Gillies, & Seleman
20 Corporate Woods Blvd, Albany, NY 12211
http://www.wcgsarchitects.com/

APPENDIX B – FIGURES

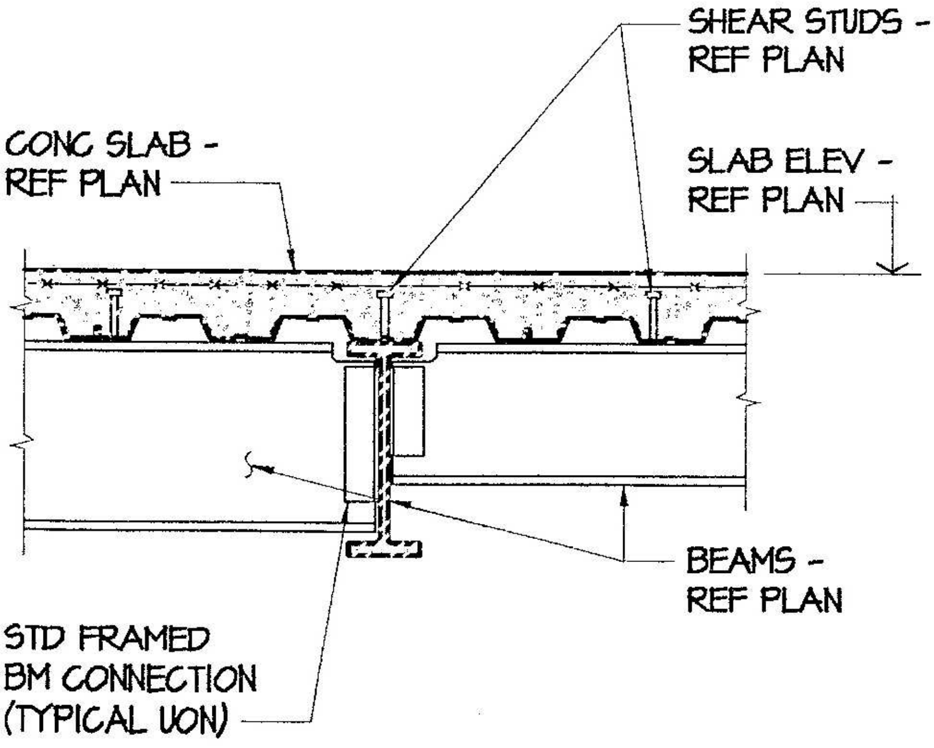


PARTIAL FOUNDATION LAYOUT

APPENDIX B – FIGURES

TYPICAL FRAMING PLAN

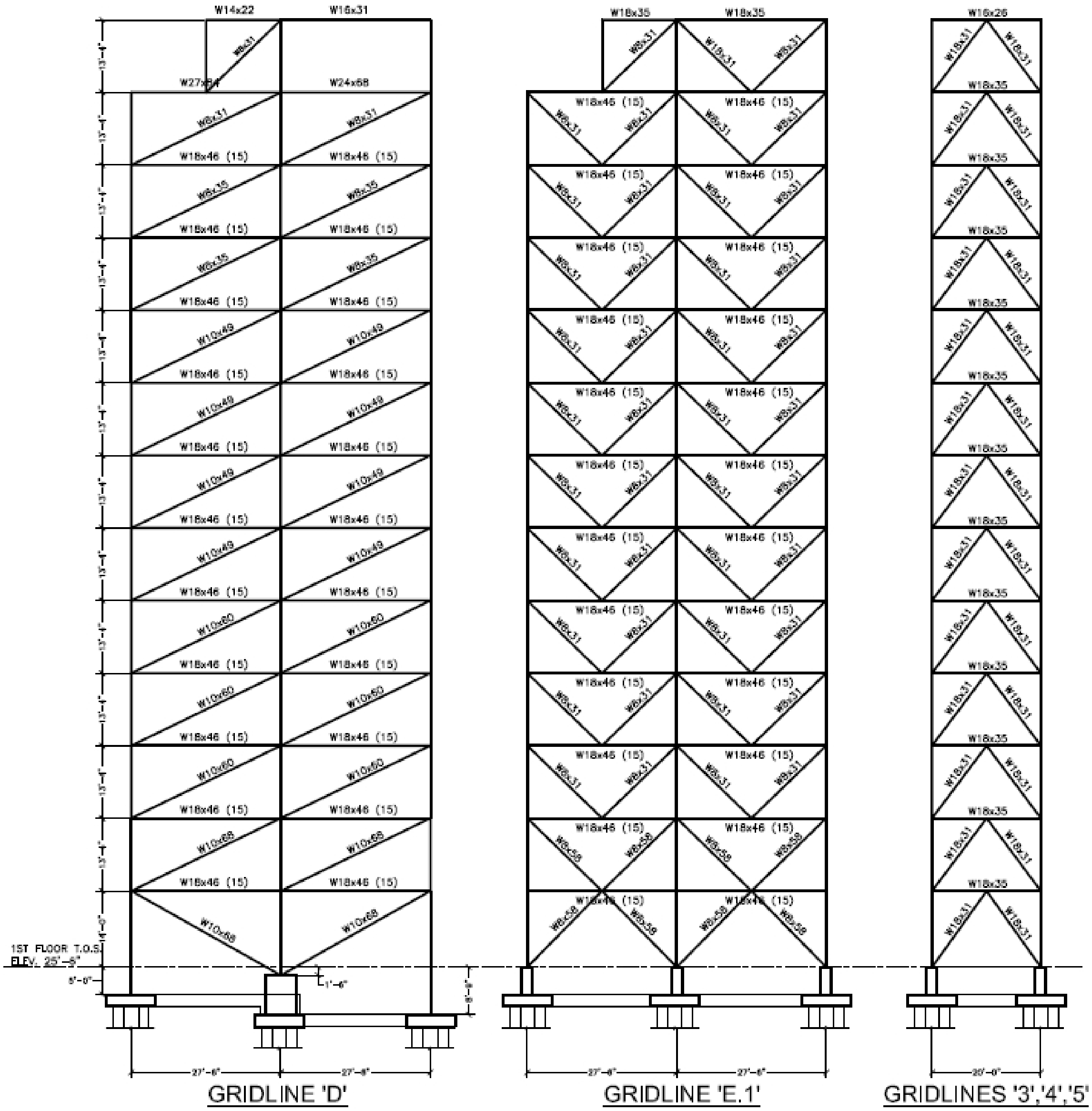
APPENDIX B – FIGURES



TYPICAL INTERIOR BEAM CONNECTION DETAIL

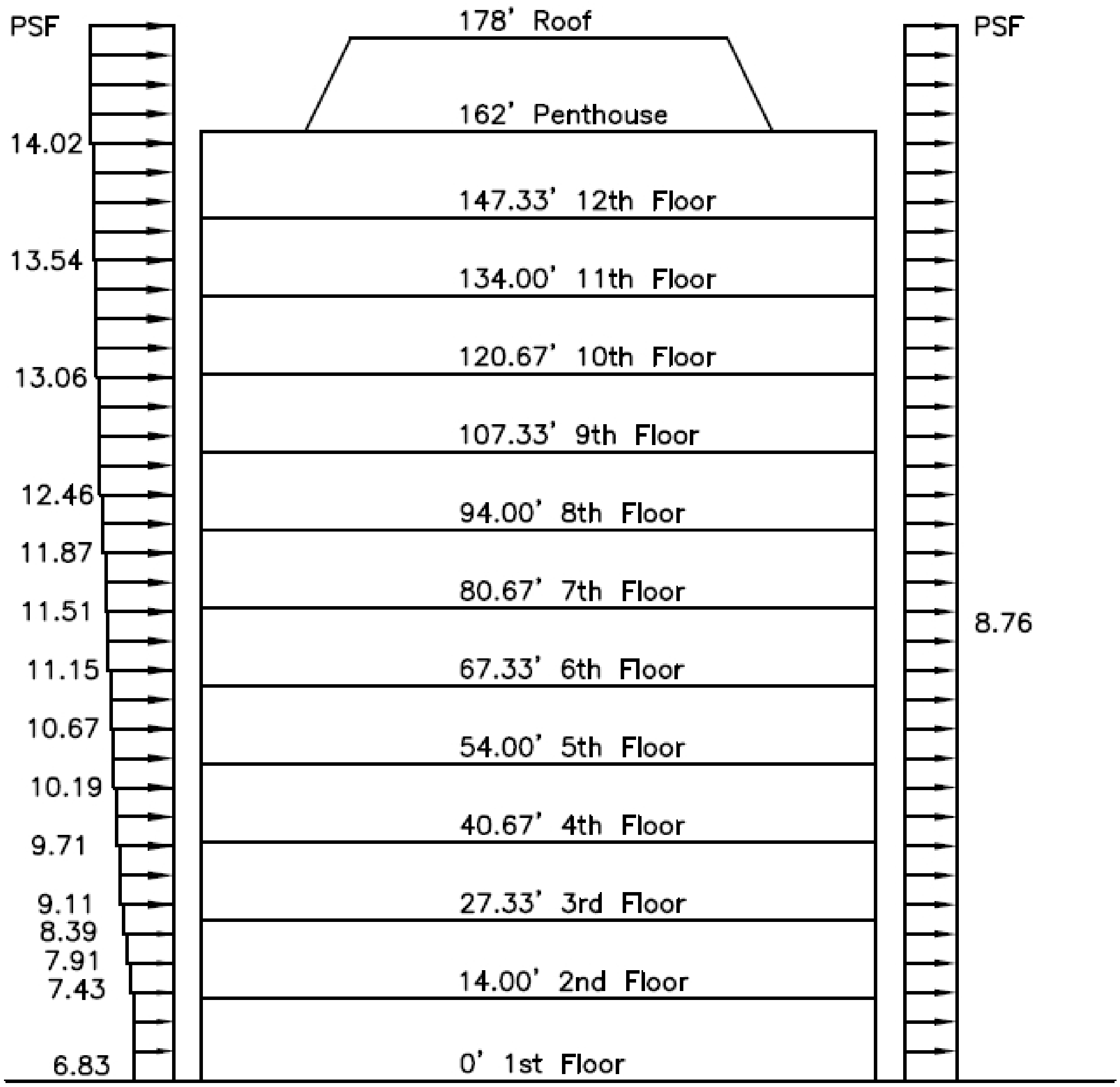
NTS

APPENDIX B – FIGURES



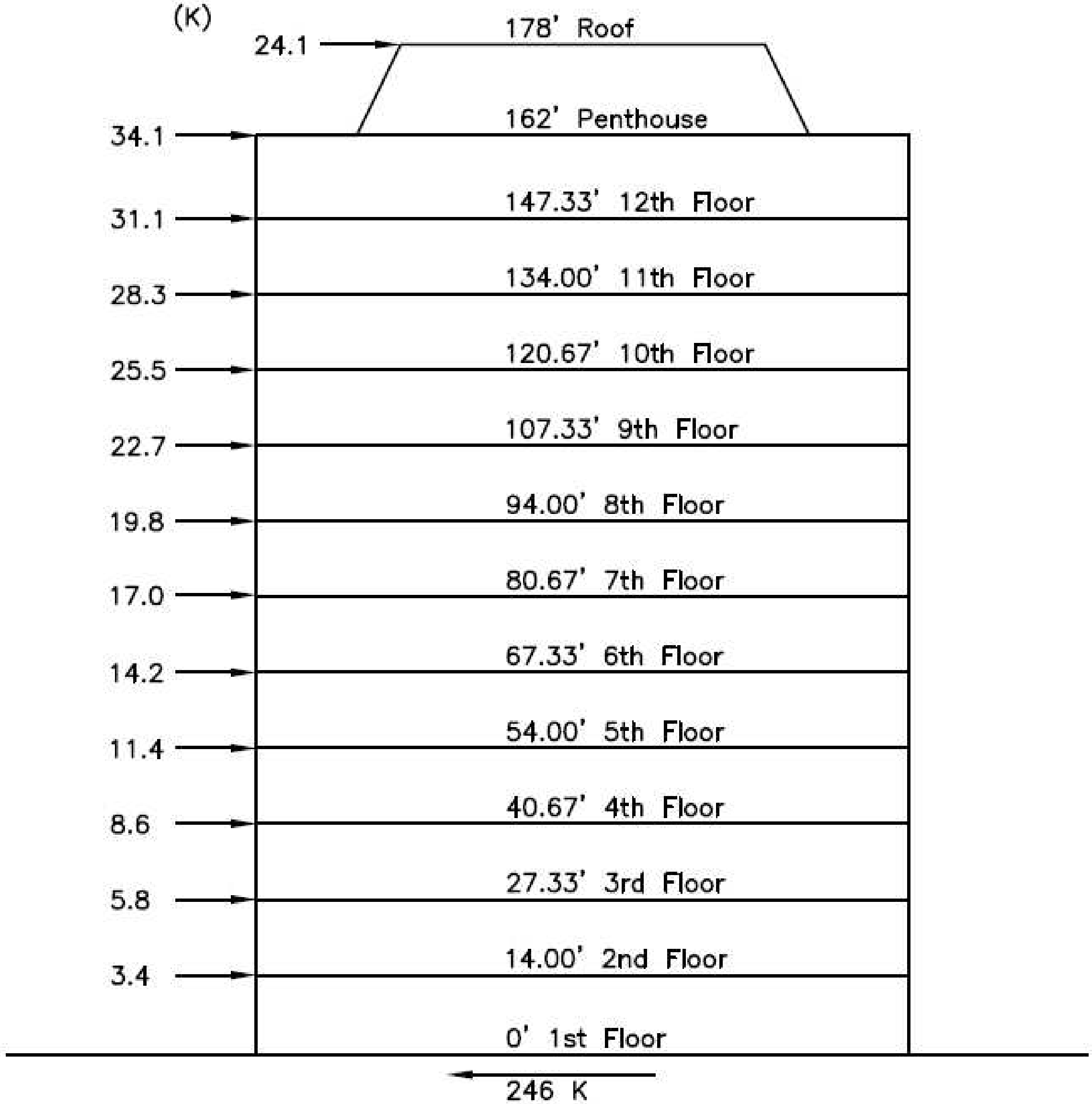
BRACED BAY ELEVATIONS

APPENDIX B – FIGURES



WIND PRESSURES

APPENDIX B – FIGURES



SEISMIC LOADS

APPENDIX C – SEISMIC LOAD CALCULATIONS

SEISMIC CALCS

SITE CLASS "D" (FIRM SOILS)

$v_s = 600 - 1200$ ft/s $\bar{N} = 15 - 50$ $\bar{S}_u = 1000 - 2000$ PSF

SDS = 0.28 $S_1 = 0.069$ FROM USGS WEBSITE
SD1 = 0.12 $S_S = 0.229$

OCCUPANCY CATEGORY – II
IMPORTANCE CATEGORY – 1.0
SEISMIC DESIGN CAT. – B
RESPONSE MOD. FACTOR – R = 5

$T_L = 6$ (FIG. 22-15)

$T_a = C_t h_n^x = 0.03(178)^{0.75} = 1.46$
$C_t = 0.03$
$x = 0.75$
$h = 178'$

$$C_s = \frac{SD1}{T(R/I)} \leq \frac{SDS}{R/I}$$

$$= \frac{0.12}{1.46(5/1)} \leq \frac{0.28}{5/1}$$

$$= 0.016 \leq 0.056$$

W: $A_{TOTAL} = 140{,}000$ SF

DL = 90 PSF = 12,600 k
PARTITIONS = 10 PSF = 1400 k
20% SNOW LOAD = 13 PSF = 150 k
ROOF MECHANICAL = 500 k
14650 K

BASE SHEAR:

$V = C_s W = 0.016(14970) = 246$ K

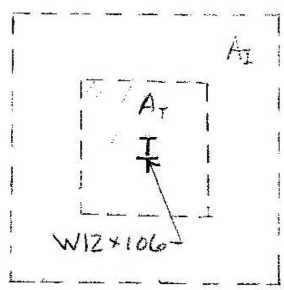
$k = 1$ (12.8.3)

$$F_x = \frac{w_x h_x^k}{\sum w_i h_i^k} V$$

APPENDIX D – SPOT CHECK CALCULATIONS

COLUMN CHECK @ F-4 LEVEL 1

LL = 70 PSF (2 - 8)
LL = 115 PSF (9 - 12)
SL = 65 PSF (ROOF)
DL = 90 PSF



TRIBUTARY AREA PER FLOOR $A_T = (27.5/2 + 27.5/2)(22.5/2 + 17.5/2)$

$A_T = 550$ SF

INFLUENCE AREA PER FLOOR $A_I = (27.5 + 27.5)(22.5 + 17.5)$

$A_I = 2200$ SF

DL PER FLOOR = 49.5 K
DL TOTAL = 618.8 K

LL TOTAL $= (70 \cdot 550)7 + (115 \cdot 550)4$
= 522.5 K

SL TOTAL $= 65 \cdot 550$
= 35.8 K

LOAD COMBINATIONS:
1.4 DL
1.2 DL + 1.6 LL + 0.5 SL
1.2 DL + 1.6 SL + LL

$1.4(618.8\text{ k}) = 866.3\text{ K}$

$1.2(618.8) + 1.6(0.4)(522.5) + 0.5(35.8) = 1094.9\text{ K} \Leftarrow P_u$

$1.2(618.8) + 1.6(35.8) + 522.5(0.4) = 1008.8\text{ K}$

LIVE LOAD REDUCTION

$RF = 0.25 + 15/\sqrt{A_I} = 0.25 + 15/\sqrt{(2200 \cdot 12)} = 0.34$

LOWER LIMIT = 0.4

AISC MANUAL OF STEEL CONST.

$KL = 14'$ W12×106 $\phi P_n = 1130\text{ K}$ $\underline{P_u \geq \phi P_n}$

$P_u = 1094.9\text{ K}$

APPENDIX C – SEISMIC LOAD CALCULATIONS

BEAM CHECK @ C-4 : D4 (LEVELS 9-12)

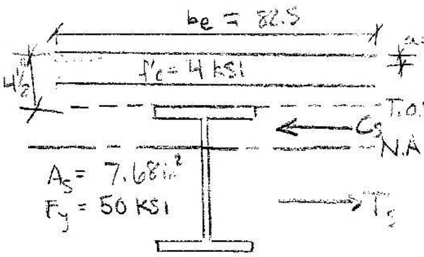
W16x26 (10 STUDS)

TRIBUTARY WIDTH = 6.875'
LL = 115 PSF
DL = 90 PSF

I——————I
← 27'-6" →

STUD STRENGTH ASSUMED – 9.9 K (3/4" ϕ 3½ LONG)

$\Sigma Q_n = 9.9k(10) = 99K$



$\leftarrow C_c = 99k$

$b_e = S = 82.5"$
$= L/4 = 82.5"$

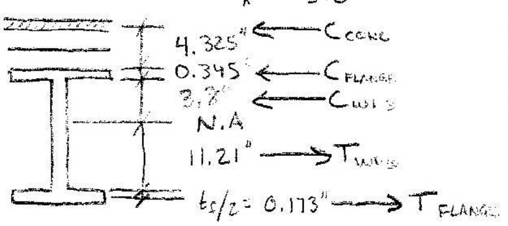
$C_c = 0.85 f'_c (b_e) a$
$99 = 0.85(4)(82.5) a$
$a = 0.35"$

$C = C_s + C_c = 241.5 k$
$T_s = 241.5 k$

$A_s F_y = 384k$ $C_s = 142.5 k$

$b_f = 5.5"$ $A_f = 1.9"$ $A_f F_y = 95 K$ $142.5 - 95 = 47.5 K$
$t_f = 0.345"$

$t_w = 0.25"$ $(F_y) t_w (x) = 47.5$
$x = 3.8"$



$M_n = 99k(3.8 + 0.345 + 4.325)$ — 838.5
$+ (50)(5.5 \times 0.34)(3.8 + 0.345/2)$ — 376.9
$+ (50)(0.25 \times 3.8)(3.8/2)$ — 90.3
$+ (50)(0.25 \times 11.21)(11.21/2)$ — 785.4
$+ (50)(5.5 \times 0.345)(11.21 + 0.173)$ — 1080.0

$= 3171.1$ FT·K

$\phi M_n = 0.9 M_n$

$\phi M_n = 2854$ FT·K

LOAD COMBO. LL = 790.6 PLF
DL = 618.8 PLF

1.2DL + 1.6LL

LL REDUCTION:
$A_T = 27.5 \times 13.75 = 378.13 FT^2$

$0.25 + 15/\sqrt{378.13} = 1.02 \leftarrow N.A.$

$W_u = 1.2(618.8) + 1.6(790.6) = 2 K/FT$

$M_u = \frac{w_u l^2}{8} = \frac{2(27.5)^2}{8} = 189.1$ ft·k

*BEAM DESIGN CONTROLLED BY DEFLECTION

APPENDIX E – PICTURES

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