Best Buy Corporate Building D (4)
Richfield, MN

Technical Assignment I

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Structural Option
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September 29th, 2008

Executive Summary:

This report is an analysis of the existing structural systems in Best Buy Corporate Building D, located in Richfield, MN. Building D is one of 4 buildings connected to a central hub. Completed in February of 2003, the corporate center was a means to consolidate their several offices and 7,500 employees located throughout Minneapolis, MN. The four buildings include a commons area containing the Best Buy University, childcare center, fitness center, transit stop, parking facilities and employee cafeteria. The 42.5-acre campus is surrounded by a one-mile walking/biking path, ponds and natural landscaping. The focus of this report, Building 4 or D, is a six story braced frame, steel system.

The 304,610 square foot building consists of slab on grade construction with wide flange steel columns supported on concrete piers. Lateral loads are supported by a braced frame system and the exterior of the building is provided by an architectural precast curtain wall. Considering the large amounts of integrated technologies, there are no other major dead or live loads other than those listed in the provided drawings. The occupancy of the building, as expected, is primarily for office use. There are a few open spaces on the first level for future tenants, but the bulk of the building has open space for office partitions. The building is as mentioned 6 stories measuring 88' in height. The building façade on the north-west end tappers outward as its height increases. For purposes of analysis with respect to wind loading, the largest dimension was used in order to stay conservative. The maximum total base shear was found to be 1,350 kips in the N-S direction with 1,027 kips due to wind loading. The maximum overturning moment was found to be 73,378 ft-kips again in the N-S direction and again with 52,210 ft-kips being a result of wind loading. While seismic loading was calculated, the results were small in comparison. This is a reasonable result considering the location of the site and its distance from earthquake prone areas.

The code basis for this building is U.B.C. 1997, but to keep the entire set of calculations standard with the current structural technology, ASCE 7-05 was used to calculate Wind and Seismic forces. When performing my spot check analysis, I found that the calculated members were slightly different than the proposed members in the design, however typically close. For the gravity loading, the beams and girders I calculated were slightly different than in the original design which is most likely due to the code difference (ASD to LRFD). Also, the change in design code can be attributed for part of the difference.

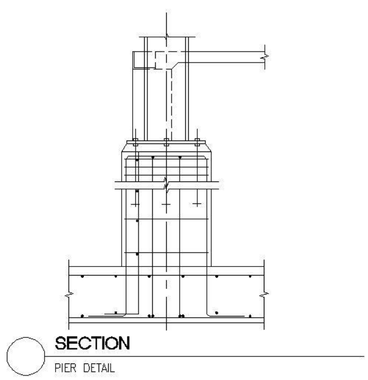
Building Description:

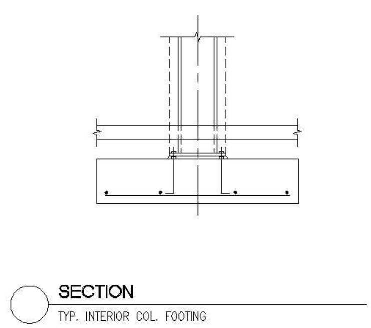
General:

The Best Buy corporate campus consists of four buildings connected by a central hub. This report focuses on building number four, which is a six story braced frame, steel system. The 304,610 square foot building consists of slab on grade construction with wide flange steel columns supported on concrete piers. Lateral loads are supported by a braced frame system. The exterior of the building consists of an architectural precast curtain wall with integrated ribbon windows. Considering the large amounts of integrated technologies, there are no other major dead or live loads other than those listed in the provided drawings. The occupancy of the building, as expected, is primarily for office use. There are a few open spaces on the first level for future tenants, but the bulk of the building has open space for office partitions.

Foundation:

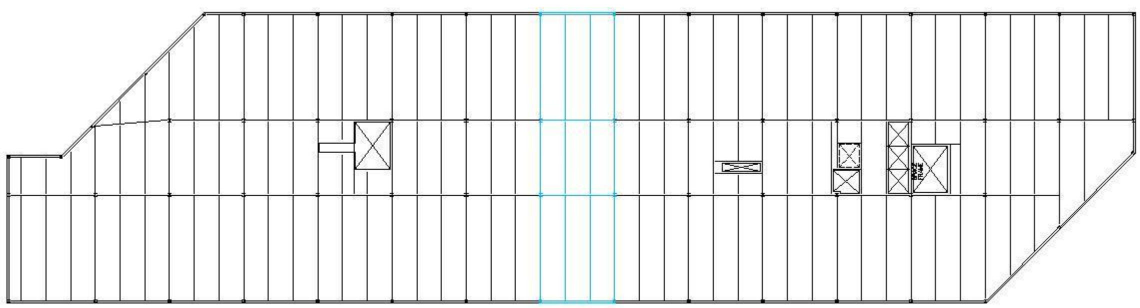
The foundation for this structure uses a combination of spread footings and piers for the interior and strip footings on the exterior. The concrete slab on grade is unreinforced with a 4" minimum depth with the basement slab on grade having a 6" minimum. Footings are placed under the columns and braced from system. Step footings were used where needed for extra support. All exterior footings must extend 4' below the finished grade to protect from frost with open air foundations having a minimum of 5'. Spread and strip footings were designed for a net soil bearing pressure of 10,000 psf.

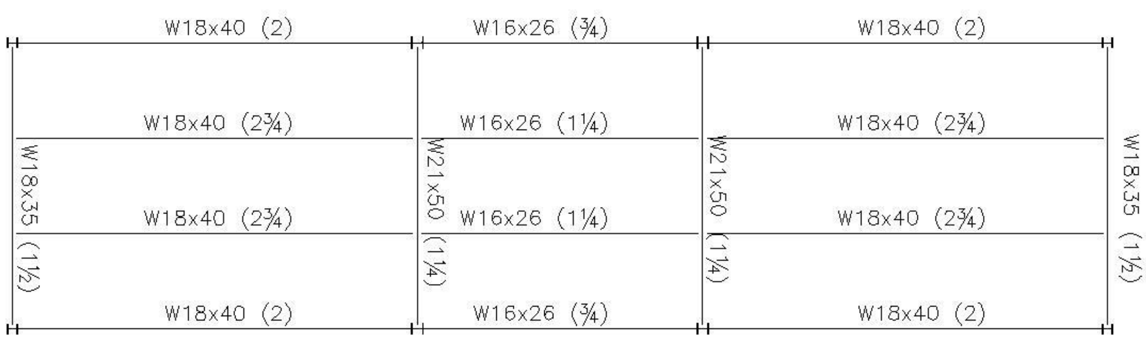




Floor System:

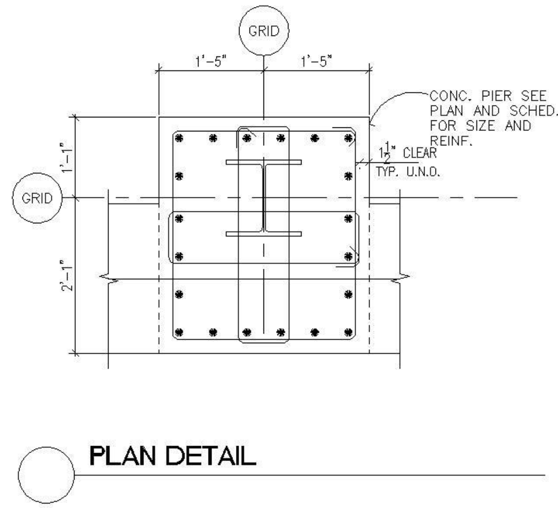
The floor system Building D utilizes a composite beam floor framing system. The overall slab is 6¼" using 3" 20 gauge composite deck and 3¼" lightweight concrete covering. The first floor uses #4 rebar at 18" on center for concrete reinforcing while the remaining floors use 6x6-W2.1xW2.1 welded wire frame. Each internal bay has a typical size of 30'x30' and external bays are typically 30'x42'8". The internal beams are typically W16x26 while the typical external beam is W18x40. Finally, the typical internal girder size is W21x50 and external is W18x35. Material strength is given as 3500 psi for the concrete and A992 50 ksi steel for the beams and girders. Spray on fireproofing was used to meet the fire rating required for the building. The floor framing system along with a typical interior bay is shown below.





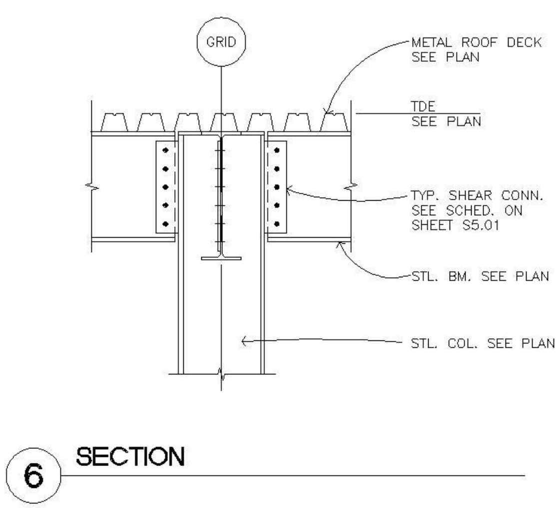
Columns:

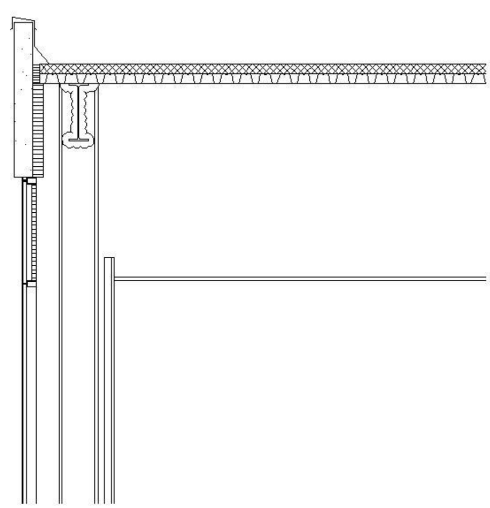
While columns for the building vary in size and weight, the typical column depth is 14”. The columns are spaced according to the bay size mentioned previously. Below is a typical column cross section showing overall column size and reinforcement.



Roof:

As with the floor system, the roof consists of a composite deck using 3” 20 gauge roof decking with 3 ½” lightweight concrete. This system is covered by a rigid insulation and B.U.R. system. Girder size did not need to increase for the interior; however the exterior girders were increased to W24x55. There is a penthouse located on the roof that houses all the major mechanical components for the entire building.





Connections:

Best Buy Building D uses both shear and double plate connections. The schedules are shown below along with a typical connection detail.

BEAM CONNECTION SCHEDULE

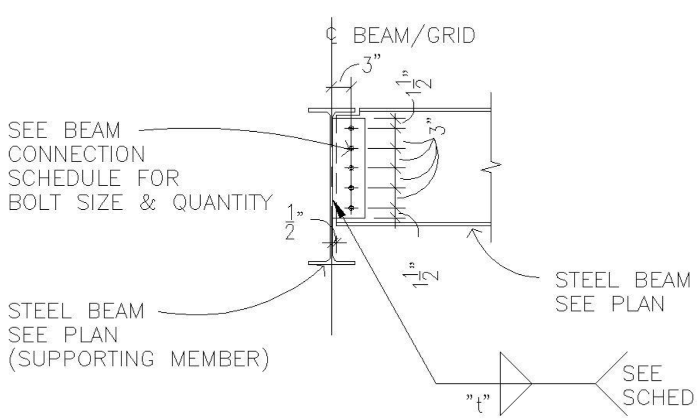
SINGLE SHEAR TAB (FLEXIBLE) CONNECTION
USING SHORT-SLOTTED HOLES TRANSVERSE TO DIRECTION OF LOAD.

BEAM SIZE	CONNECTION CAPACITY (ϕR_u)	SHEAR TAB SIZE	WELD SIZE "t"	NO. OF ¾"ϕ A325-N BOLTS	REMARKS
W8 W10	11 kips	PL ¼x4½x0'-6"	3/16"	2	14 kips w/o COPED FLANGE
W12 W14	28 kips	PL ¼x4½x0'-9"	3/16"	3	
W16	45 kips	PL ¼x4½x1'-0"	3/16"	4	
W18	62 kips	PL ¼x4½x1'-3"	3/16"	5	
W21	79 kips	PL 5/16x4½x1'-6"	¼"	6	
W24	96 kips	PL 5/16x4½x1'-9"	¼"	7	
W27 W30	113 kips	PL ⅜x4½x2'-0"	5/16"	8	
W33	130 kips	PL 7/16x4½x2'-3"	⅜"	9	

BEAM CONNECTION SCHEDULE

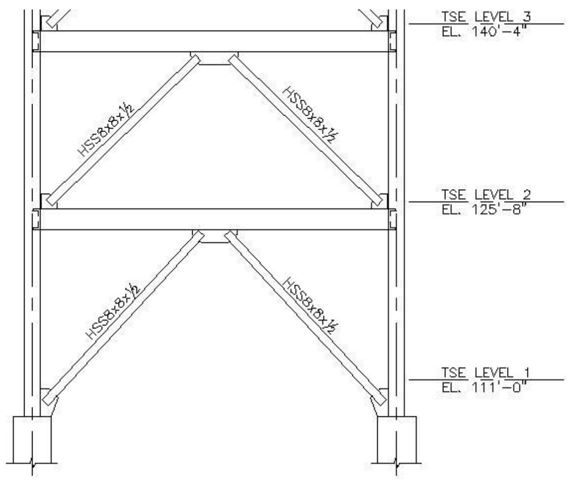
ALL BOLTED DOUBLE ANGLE CONNECTIONS
USING SHORT–SLOTTED HOLES TRANSVERSE TO DIRECTION OF LOAD.

BEAM SIZE	CONNECTION CAPACITY (ϕR_U)	ANGLE SIZE	NO. OF ¾"ø A325–N BOLTS	REMARKS
W8	11 kips	∠ 4x3½x¼x0'–6"	2	24 kips w/o COPED FLANGE
W10	20 kips	∠ 4x3½x¼x0'–6"	2	27 kips w/o COPED FLANGE
W12	33 kips	∠ 4x3½x¼x0'–9"	3	40 kips w/o COPED FLANGE
W14	47 kips	∠ 4x3½x¼x0'–9"	3	
W16	66 kips	∠ 4x3½x¼x1'–0"	4	
W18	96 kips	∠ 4x3½x¼x1'–3"	5	
W21	133 kips	∠ 4x3½x5/16x1'–6"	6	
W24	175 kips	∠ 4x3½x5/16x1'–9"	7	
W27 W30	233 kips	∠ 4x3½x5/16x2'–0"	8	
W33	286 kips	∠ 4x3½x5/16x2'–3"	9	

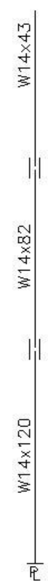


Lateral System:

For the lateral system, this building utilizes a composite floor system and braced framing. The vertical members of the braced frame consist of 3 W14 columns spliced together at the 3rd and 5th floors. The beams between these columns are heavier, W16x57. As shown below, there are 2 diagonal HSS members to provide further support.

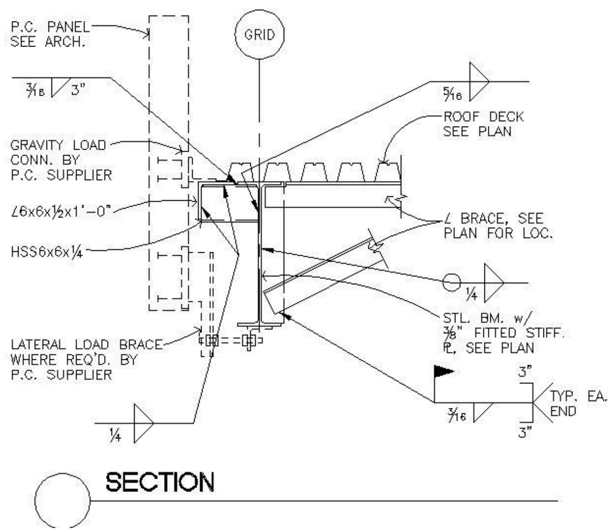


BRACE FRAME ELEVATION



Envelope:

The building has an angled wall on the end furthest from the central hub. The façade is 6" architectural precast concrete separated by ribbon windows on each level. The precast components were cast with gravity load connections and lateral load bracing where required by the precast supplier. A detail of the precast connection to the building frame is shown below. This is at the roof level, however it is typical throughout.



Design Codes:

- Building code: ASCE 7-05
- Cast-In-Place Concrete: "Building Code Requirements for Reinforced Concrete" (ACI 318)
- Masonry: Building Code Requirements for Masonry Structures
- Structural Steel: 13th Edition of "Steel Construction Manual"
- Welding: The American Welding Society Code for Buildings (AWS D1.1)
- Metal Decking: "Specification of the Steel Deck Institute"

Materials:

Cast-In-Place Concrete:

- Footings and foundation walls - 4000 psi at 28 days
- Interior slab on grade - 4000 psi at 28 days
- Exterior slab on grade - 4000 psi at 28 days
- Topping and concrete over metal decking - 3500 psi at 28 days
- Lightweight concrete has minimum dry unit weight of 107 pcf and maximum of 115 pcf

Masonry:

- Hollow masonry unit -1900 psi as provided by ASTM C90
- Grout - 2000 psi at 28 days

Steel:

- Structural wide flange shapes - F_y = 50,000 psi as given by ASTM A992
- Base plate at braced frame - F_y = 50,000 psi as given by A572
- Structural tube - F_y = 46,000 psi as given by ASTM A500, Grade B
- Structural pipe - F_y = 35,000 psi as given by ASTM A53, Grade B
- Welding electrodes - E70XX as given by A233
- Deck welding electrodes - E60XX as given by A233
- High strength bolts - F_y = 74,000 psi as given by A325
- Anchor bolts - F_y = 36,000 psi as given by A36

Metal Deck:

- All metal floor deck shall be 3” deep, minimum 20 gauge, conforming to ASTM A611 or A446
- All metal roof deck shall be minimum 20 gauge, 3” deep type N, wide rib, minimum $I=0.964in^4$, minimum $S_p=0.501in^3$, minimum $S_n=0.552in^3$ per foot of width and yield stress 33,000 psi minimum

Metal Studs:

- Metal studs 16 gauge and thicker - F_y = 50 ksi
- Metal studs 18 gauge and thinner - F_y = 33 ksi

Gravity Loads:

All gravity load calculations found in the existing building used Universal Building Code 1997 as their design standard. For simplicity and current accurate standards, I will use ASCE 7-05 to find, factor, and calculate all gravity loads in the building. If uniform differences in sizes occur, it may be a result of this change.

Live Loads:

Roof:		40 psf + Snow loads
Floor:	Level 1:	100 psf
	Levels 2-6:	80 psf
Stairs, Corridors and Lobbies:		100 psf
Mechanical Rooms:		<u>125 psf</u>
Total:		445 psf + Snow loads

Dead Loads:

Roof:	(Design)	25 psf
Floor:	(Superimposed)	5 psf
	(Finishes @ Level 1)	25 psf
	(Partitions @ Levels 2-6)	<u>20 psf</u>
Total:		75 psf

Snow Loads:

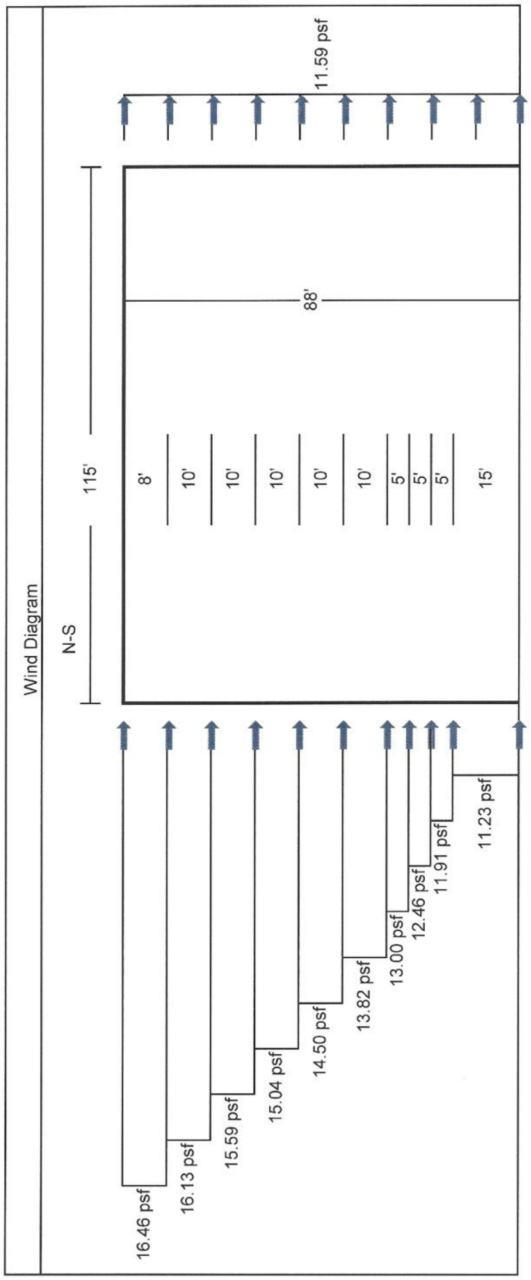
Use the equation	$p_f=0.7*C_e*C_t*I*p_g$
From Table 7-2, Exposure Factor, C_e =	0.9
From Table 7-3, Thermal Factor, C_t =	1.0
From Table 7-4, Importance Factor, I =	1.1
From Figure 7-1, Ground Snow Load, p_g =	50 psf
Total Snow Load =	34.65 psf

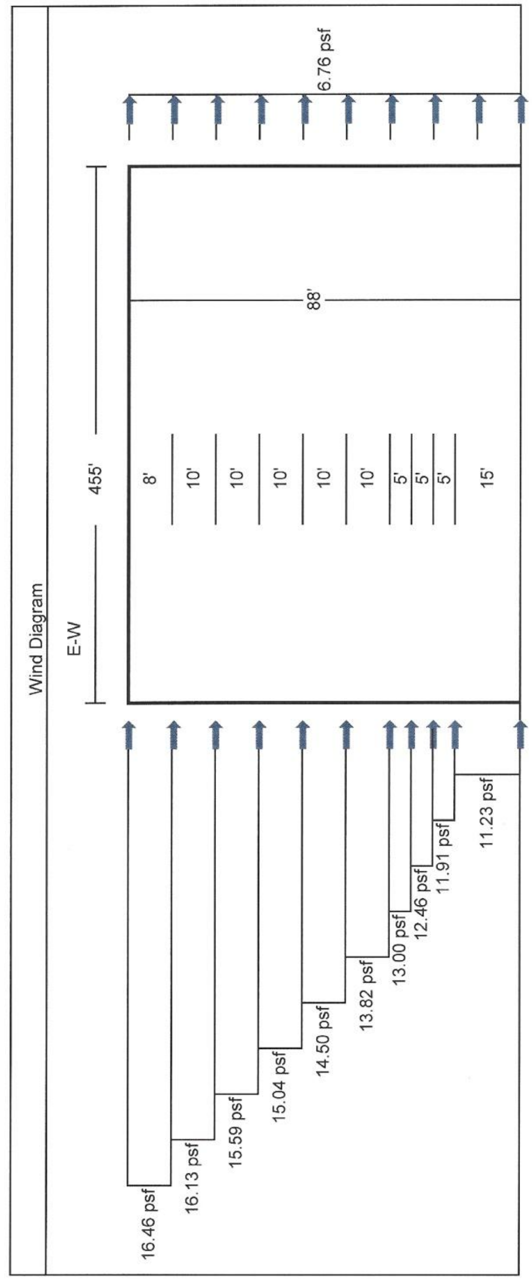
Wind Loads:

The charts below summarize the results found from my wind calculation analysis. Specific calculations of wind forces are located in the Appendix in Excel form. Wind loading diagrams also follow.

	Windward		Leeward		Max (psf) N-S	Max (psf) E-W
Z(ft)	N-S	E-W	N-S	E-W		
0-15	11.23	11.23	-11.59	-6.76	22.82	17.99
20	11.91	11.91	-11.59	-6.76	23.50	18.67
25	12.46	12.46	-11.59	-6.76	24.05	19.22
30	13.00	13.00	-11.59	-6.76	24.59	19.76
40	13.82	13.82	-11.59	-6.76	25.41	20.58
50	14.50	14.50	-11.59	-6.76	26.09	21.26
60	15.04	15.04	-11.59	-6.76	26.63	21.80
70	15.59	15.59	-11.59	-6.76	27.18	22.35
80	16.13	16.13	-11.59	-6.76	27.72	22.89
90	16.54	16.54	-11.59	-6.76	28.13	23.30
88	16.46	16.46	-11.59	-6.76	28.05	23.22

	N-S	E-W
Shear @ 6	185.97	38.87
Shear @ 5	181.91	37.83
Shear @ 4	176.29	36.41
Shear @ 3	170.60	34.97
Shear @ 2	156.75	31.65
Shear @ 1	3.43	0.68
Shear @ Ground	152.35	30.36
Base Shear	1,027.29	210.76
Overturning Moment	52,210.43	10,808.69


Wind Diagram
N-S
115'
88'
11.59 psf
8'
10'
10'
10'
10'
10'
5'
5'
5'
15'
16.46 psf
16.13 psf
15.59 psf
15.04 psf
14.50 psf
13.82 psf
13.00 psf
12.46 psf
11.91 psf
11.23 psf


Wind Diagram
E-W
455'
88'
6.76 psf
8'
10'
10'
10'
10'
10'
5'
5'
5'
15'
16.46 psf
16.13 psf
15.59 psf
15.04 psf
14.50 psf
13.82 psf
13.00 psf
12.46 psf
11.91 psf
11.23 psf

Seismic Loads:

The charts below summarize the results found from my seismic calculation analysis. Specific calculations of seismic forces are located in the Appendix in Excel form.

Summary N-S						
Level	w_x	h_x	$w_x h_x^k$	C_{vx}	F_x (kips)	M_x (ft-kips)
6	1,796.14	88.00	2,376,777.04	0.25556	82.45	7,255.79
5	2,867.05	73.35	2,832,213.68	0.30454	98.25	7,206.76
4	2,867.05	58.68	1,979,465.13	0.21284	68.67	4,029.51
3	2,867.05	44.01	1,247,305.17	0.13412	43.27	1,904.31
2	2,867.05	29.34	650,545.91	0.06995	22.57	662.14
1	2,867.05	14.67	213,800.17	0.02299	7.42	108.81
Σ	16,131.39		9,300,107.09	1.00	322.63	21,167.32

Summary E-W						
Level	w_x	h_x	$w_x h_x^k$	C_{vx}	F_x (kips)	M_x (ft-kips)
6	1,796.14	88.00	2,376,777.04	0.25556	82.45	7,255.79
5	2,867.05	73.35	2,832,213.68	0.30454	98.25	7,206.76
4	2,867.05	58.68	1,979,465.13	0.21284	68.67	4,029.51
3	2,867.05	44.01	1,247,305.17	0.13412	43.27	1,904.31
2	2,867.05	29.34	650,545.91	0.06995	22.57	662.14
1	2,867.05	14.67	213,800.17	0.02299	7.42	108.81
Σ	16,131.39		9,300,107.09	1.00	322.63	21,167.32

Further Considerations:

The following items were not covered in this technical report, but are still important to completely understand all of the building systems:

- Wind uplift on the roof
- Snow drift
- Story drift from lateral forces
- Deflection checks from gravity and lateral forces
- Specific lateral load calculations and values

Appendix

Best Buy Building D Assumptions and Information

Wind Loading Calculations

Wind Load Analysis

Building Properties	
B (ft)	115
L (ft)	455
h (ft)	88.00
K_{zt}	1
K_d	0.85
V (mph)	90
Importance	III
I_w	1.15
Exposure	B
α	7
z_g	1200
z_{min}	30
c	0.3
$\in$	0.333333
l	320
$\bar{\alpha}$	0.250
$\bar{b}$	0.45
$\underline{a}$	0.143
$\underline{b}$	0.84

Period Parameters	
Struct. Type	Steel
C_t	0.02
x	0.75
(check eq) T	0.5746
Natural *f*	1.7402
Rigidity	Rigid

Rigid	
g_Q=g_v	3.4
$\check{z}$	52.8
$I_{\check{z}}$	0.277397
$L_{\check{z}}$	374.2743
Q	0.83668
G	0.85

Windward	
Cp	0.8

Flexible	
g_R	4.32
R_n	0.024
N_1	15.97
η_h	17.28
η_B	0.196
η_L	299.07
R_h	0.056
R_B	0.881
R_L	0.003
$V_{\check{z}}$	40.77
β	0.05
R	0.11
G_f	0.8388

	Leeward	
	Ratio	C_p
N-S	0.253	-0.50
E-W	3.957	-0.20

Pressure Coefficients		
Internal Enc. Type	Enclosed	
Internal (GC_{pi})	0.18	+/-

Pressures			
Windward	N-S	P_z	0.851
	E-W	P_z	0.851
Leeward	N-S	P_h	-0.599
	E-W	P_h	-0.350

Flexiblity	
g_R	4.32
R_n	0.024
N_1	15.97
η_h	17.28
η_B	0.196
η_L	299.07
R_h	0.056
R_B	0.881
R_L	0.003
$V_{\check{z}}$	40.77
β	0.05
R	0.11
G_f	0.8388

K_z and q_z		
Z(ft)	K_z	q_z
0-15	0.57	11.55
20	0.62	12.57
25	0.66	13.38
30	0.70	14.19
40	0.76	15.40
50	0.81	16.42
60	0.85	17.23
70	0.89	18.04
80	0.93	18.85
90	0.96	19.46
88.00	0.95	19.34

	Leeward	
	Ratio	C_p
N-S	0.253	-0.50
E-W	3.957	-0.20

Wind Distribution N-S									
Min	Max	pressure (psf)	Level	h/floor	Z-real	Area	Force	V (k)	M(ft-k)
0	14.67	22.82	Ground	0	0	6674.85	152.35	152.35	0.00
14.67	15	22.82	1	14.67	14.67	150.15	3.43	3.43	50.28
15	20	23.50	2	14.67	29.34	2275.00	53.47	156.75	4599.00
20	25	24.05	2			2275.00	54.71		
25	29.34	24.59	2			1974.70	48.56		
29.34	30	24.59	3	14.67	44.01	300.30	7.39	170.60	7508.00
30	40	25.41	3			4550.00	115.61		
40	44.01	26.09	3			1824.55	47.60		
44.01	50	26.09	4	14.67	58.68	2725.45	71.10	176.29	10344.71
50	58.68	26.63	4			3949.40	105.19		
58.68	60	26.63	5	14.67	73.35	600.60	16.00	181.91	13342.89
60	70	27.18	5			4550.00	123.66		
70	73.35	27.72	5			1524.25	42.25		
73.35	80	27.72	6	14.65	88.00	3025.75	83.88	185.97	16365.56
80	88	28.05	6			3640.00	102.09		
							Sum	1027.29	52210.43

Wind Distribution E-W									
Min	Max	pressure (psf)	Level	h/floor	Z-real	Area	Force	V (k)	M(ft-k)
0	14.67	17.99	Ground	0	0	1687.05	30.36	30.36	0.00
14.67	15	17.99	1	14.67	14.67	37.95	0.68	0.68	10.02
15	20	18.67	2	14.67	29.34	575.00	10.74	31.65	928.64
20	25	19.22	2			575.00	11.05		
25	29.34	19.76	2			499.10	9.86		
29.34	30	19.76	3	14.67	44.01	75.90	1.50	34.97	1538.95
30	40	20.58	3			1150.00	23.66		
40	44.01	21.26	3			461.15	9.80		
44.01	50	21.26	4	14.67	58.68	688.85	14.64	36.41	2136.36
50	58.68	21.80	4			998.20	21.76		
58.68	60	21.80	5	14.67	73.35	151.80	3.31	37.83	2774.58
60	70	22.35	5			1150.00	25.70		
70	73.35	22.89	5			385.25	8.82		
73.35	80	22.89	6	14.65	88.00	764.75	17.51	38.87	3420.14
80	88	23.22	6			920.00	21.36		
							Sum	210.76	10808.69

Pressure Distribution						
			N-S		E-W	
Level	h/floor (ft)	Z (ft)	V (k)	M (ft-k)	V (k)	M (ft-k)
6	14.65	88.00	185.97	16,365.56	38.87	3,420.14
5	14.67	73.35	181.91	13,342.89	37.83	2,774.58
4	14.67	58.68	176.29	10,344.71	36.41	2,136.36
3	14.67	44	170.60	7,508.00	34.97	1,538.95
2	14.67	29.34	156.75	4,599.00	31.65	928.64
1	14.67	14.67	3.43	50.28	0.68	10.02
0	0	0	152.35		30.36	
Σ			1,027.29	52,210.43	210.76	10,808.69

Seismic Loading Calculations

Building Properties	
B (ft)	115
L (ft)	455
h (ft)	88.00
# of Stories	6.00
ave. h/floor (ft)	14.67
Seismic Use group	III
Imp. (e)	1.5
Site Classification	B
S_s (%g)	0.06
S_1 (%g)	0.027
R	3
C_t	0.028
x	0.8
T_L	12
C_u	1.7
F_a	1
F_v	1
S_{MS}	0.06
S_{M1}	0.027
S_{DS}	0.04
S_{D1}	0.018

Response	
T_a	1.01
C_s	0.02

Load Summary (psf)	
Roof Dead	25
Snow	34.65
Floor Dead	50
Ex. Wall Dead	15
avg. wroof (lbs)	1,796.14
avg. wfloors (lbs)	2,867.05
Wtotal (lbs)	16,131.39
V (lbs)	322.63

Distribution	
k	1.60539

Summary N-S						
Level	w_x	h_x	$w_x h_x^k$	C_{vx}	F_x (kips)	M_x (ft-kips)
6	1,796.14	88.00	2,376,777.04	0.25556	82.45	7,255.79
5	2,867.05	73.35	2,832,213.68	0.30454	98.25	7,206.76
4	2,867.05	58.68	1,979,465.13	0.21284	68.67	4,029.51
3	2,867.05	44.01	1,247,305.17	0.13412	43.27	1,904.31
2	2,867.05	29.34	650,545.91	0.06995	22.57	662.14
1	2,867.05	14.67	213,800.17	0.02299	7.42	108.81
Σ	16,131.39		9,300,107.09	1.00	322.63	21,167.32

Summary E-W						
Level	w_x	h_x	$w_x h_x^k$	C_{vx}	F_x (kips)	M_x (ft-kips)
6	1,796.14	88.00	2,376,777.04	0.25556	82.45	7,255.79
5	2,867.05	73.35	2,832,213.68	0.30454	98.25	7,206.76
4	2,867.05	58.68	1,979,465.13	0.21284	68.67	4,029.51
3	2,867.05	44.01	1,247,305.17	0.13412	43.27	1,904.31
2	2,867.05	29.34	650,545.91	0.06995	22.57	662.14
1	2,867.05	14.67	213,800.17	0.02299	7.42	108.81
Σ	16,131.39		9,300,107.09	1.00	322.63	21,167.32

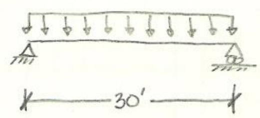
SPOT CHECK

→ TYPICAL OFFICE FLOOR ←

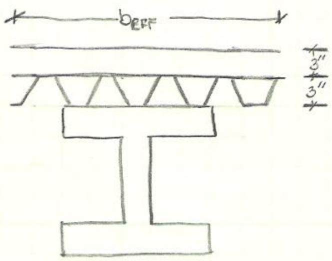
DEAD LOAD = CONC. + DECKING + STEEL + MEP + FINISHING = 70 PSF
LIVE LOAD = 100 PSF (OFFICE)

LOAD FACTORS ⇒ $1.2D + 1.6L = 1.2(70) + 1.6(100) = 244$ PSF

$P_U = 244$ PSF $W_U = (10)(244) = 2.44$ KLF



→ TYPICAL BEAM CALCULATION ←



$f'_c = 4$ KSI $F_y = 50$ KSI

$W_U = 2.44$ KLF

$M_U = \frac{w_U l^2}{8} = \frac{(2.44)(30)^2}{8} = 274.5$ 'K

ASSUME $a = 1"$ $b_{EFF} = \text{MIN}\left[\begin{array}{l} l_n = 120" \\ \frac{30}{4}(12) = \underline{90"} \end{array}\right]$

$Y_2 = 6 - \frac{a}{2} = 5.5"$

USING LRFD TABLE 3-19 USE W18×40 → $\phi M_p = 294$'K

PNA @ 7 (WORST CASE) FOR $Y_2 = 5.5"$ → $\phi M_p = 428$'K & $\Sigma Q_N = 147$ K

$\Sigma Q_N = .85 f'_c b a$ → $a = \frac{\Sigma Q_N}{.85 f'_c b} = \frac{147}{.85(4)(90)} = .480$

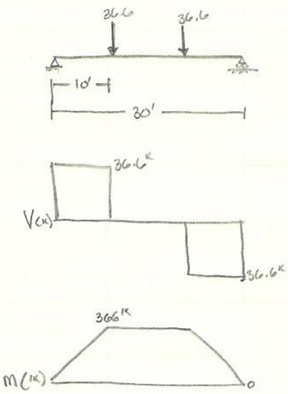
$Y_2 = 6 - \frac{.48}{2} = 5.76"$ → $\phi M_p = 430.6$'K

$\frac{\Sigma Q_N}{\text{SHEAR STUD}} = \frac{147}{9} = 16.33$ → 34 SHEAR STUDS

BEAM DESIGN → W18×40 w/ 34 SHEAR STUDS

THIS BEAM SIZE IS LARGER THAN THE W16×26 USED ON THE INTERIOR BEAMS, HOWEVER DOES MATCH BEAMS USED ON THE OUTER BAYS. THE INNER BAYS MAY HAVE ADDITIONAL SUPPORT ALLOWING THEM TO BE SMALLER.

→ TYPICAL GIRDER CALCULATIONS ←



$P = \frac{w_u l}{2} = \frac{2.44(30)}{2} = 36.6^K$

$M_u = 36.6(10) = 366^{1K}$

ASSUME $a = 1''$ $b_{EFF} = \min \begin{bmatrix} 120'' \\ \underline{90''} \end{bmatrix}$

$Y_2 = 5.5''$

TRY W18x55 ⇒ $\phi M_p = \underline{420}^{1K}$

$\Sigma Q_N = 810^K$

$a = \frac{810}{.85(4)(90)} = 2.65''$ $Y_2 = 6 - \frac{2.65}{2} = 4.675''$

FOR PNA @ 7 + $Y_2 = 4.675$ → $\phi M_P = 580.8^{1K}$

DESIGN USES W21x50 WHICH HAS A $\phi M_P = 413^{1K}$ AND COULD HAVE JUST AS EASILY BEEN USED. LIGHTER WEIGHT MAY BE LESS COSTLY IN THIS SITUATION.

→ TYPICAL COLUMN CALCULATIONS ←

DEAD LOAD = 70 + 5 (SELF WEIGHT) = 75 PSF

LIVE LOAD = 100 PSF

$1.2(75) + 1.6(100) = 250$ PSF $P_U = 250$ PSF

$P_{FLOOR} = 250(4500) = 1125^K$ $\omega_U = 2.44 + .05(1.2) = 2.5$ KLF

$M_U = \frac{2.5(30)^2}{12} = \underline{187.5}^{1K}$

$P_{WALL} = 30(2220) = 66.6^K$ $P_{TOT} = \underline{1191.6}^K$ $P_{EFF} = 1498.35^K$

ASSUMING K = 1 KL = 14.67' W14 USED IN DESIGN SO START THERE

W14 x 132 $1510^K > 1498^K$ ∴ OK

THE COLUMNS USED IN DESIGN RANGE FROM W14x90 TO W14x145. DEPENDING ON OTHER LOADS NOT ACCOUNTED FOR OR OVER COMPENSATED FOR, THIS RESULT IS WITHIN ACCEPTABLE RANGE.