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Building: The Duncan Center
Location: Dover, DE
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TECHNICAL ASSIGNMENT 3

EXECUTIVE SUMMARY

This report is an in depth analysis of the Lateral Load Resisting System for the Duncan Center in Dover, DE. Wind and seismic lateral loads are resisted by this six story building's moment frames. The moment frames were analyzed to determine the systems performance due to lateral loads, drift, overturning, and torsion. These analyses were carried out through a RAM Structural System model and checked by hand calculation through spot checks of the models strength analyses.

It was found that the system performed satisfactorily, especially considering a code change of an increase in wind speeds by 20 mph since its original design. In terms of strength the building only had approximately 25% of the lateral beams in the North-South direction overstressed, probably due to the previously mentioned increase in wind speeds. The East-West direction lateral beams and lateral columns were found capable of carrying this increased load.

Drift analysis of the building revealed that the building on average is experiencing a total drift of 50% over the allowed H/600, again probably due to the increase in wind speeds. The story drift values were comparable and could resist the increased loads most likely due to the sizable columns, which were initially designed for a seventh floor that was removed later on in the design process.

Failure of the building by overturning is not a matter of concern due to the approximate 10 times available resistance to overturning of the building by weight. Similarly, torsion is not a substantial factor due to the building's symmetry. Inclusion of 5% accidental torsion in design more than aptly accounts for any torsion created by building irregularities.

Finally, the spot checks performed to confirm the model's accuracy were successful and validated the use of results for other analyses besides strength analysis.

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I. Introduction

The Duncan Center is a premium office building located in Dover, DE. There are a total of six floors with the building reaching an overall height of 93'-0". Open flex office space is located on the first four floors, a reception and banquet hall on the fifth floor, and a penthouse holding the building management offices on the sixth floor. Small electrical and mechanical rooms are also located on the sixth floor with the larger electrical and mechanical room located in the basement along with storage space. Balconies augment the fourth and fifth floors and the overall structure is crowned with an arched penthouse.

The purpose of this report is to provide an in depth study and analysis of the lateral system of the Duncan Center. Analysis will performed with the aid of a RAM Structural System model which will be backed up with hand calculations to verify results. All model lateral loading from wind and seismic forces will be determined by hand calculation based upon ASCE 7-05. Applicable LRFD load combinations to be considered will also be from ASCE 7-05 in order to determine the existing structure's lateral stability based upon strength, drift, overturning, and torsion. Additional calculations in support of the material presented in this report are available upon request.

II. Structural Systems

Foundation System

A deep foundation system comprised of auger cast concrete piles is utilized, as per the recommendation of the geotechnical engineer, John D. Hynes & Associates, Inc. The structural engineer was presented with the choice of several different diameters and depths of piles and a 16" diameter, 40' long pile reinforced with a rebar cage in the top 10' of the pile of 6-#6 bars and #3 ties at 12" o.c. was selected. This pile system affords a bearing capacity of 85 tons.

On top of these piles rest the pile caps of various cross section with a depth of 3'-1" each. Above the pile caps rest the 24"x24" concrete piers with 8-#8 vertical bars and #3 ties at 12" o.c. The piers are connected by 1' wide by 2' deep grade beams reinforced with 4-#6 bars top and bottom and #3 ties at 12" o.c. Columns rest on top of the piers connected by 18"x18" steel baseplates ranging in thickness from 1" to 2-1/4" with 4-1" diameter A325N bolts.

The basement slab on-grade is a 4" cast-in place concrete slab reinforced with 6x6 W2.9xW2.9 welded wire fabric on 4" of porous fill.

Floor Systems

Typical on all floors is a 5" composite slab including a 2" 20 gage composite metal deck reinforced with 6x6 W2.0xW2.0 welded wire fabric. The deck is spot welded to the composite structural steel members beneath and accompanied by 23-3/4" x 4" long shear studs for girders and 14-3/4" x 4" long shear studs for beams. This provides the overall floor system with a fire rating of 2 hours, including spray-on fire proofing for both the deck and structural members, and forms a rigid diaphragm.

A typical floor bay is 27'-8"x24'-5" with the beams running in the long direction, W16x31 interior and W18x35 between columns. The interior beams rest upon W24x55 girders which transfer the load to the columns; see Figure 1: Second Floor Framing Plan in Sketches.

Lateral Load Resisting System

Lateral loads are resisted by the Duncan Center's is moment connected frames, six-three span frames in the North-South direction and four-five span frames in the East-West direction; see Figure 1: Second Floor Framing Plan in Sketches for clarification. Each girder and beam between columns is moment connected by shear tabs with full penetration welds to the columns; see Figure 2: Typical Column Flange Moment Connection and Figure 3: Typical Column Web Moment Connection in Sketches. Columns range from W12x45 to W12x136 and are spliced at the third and the fifth floor.

III. Sketches

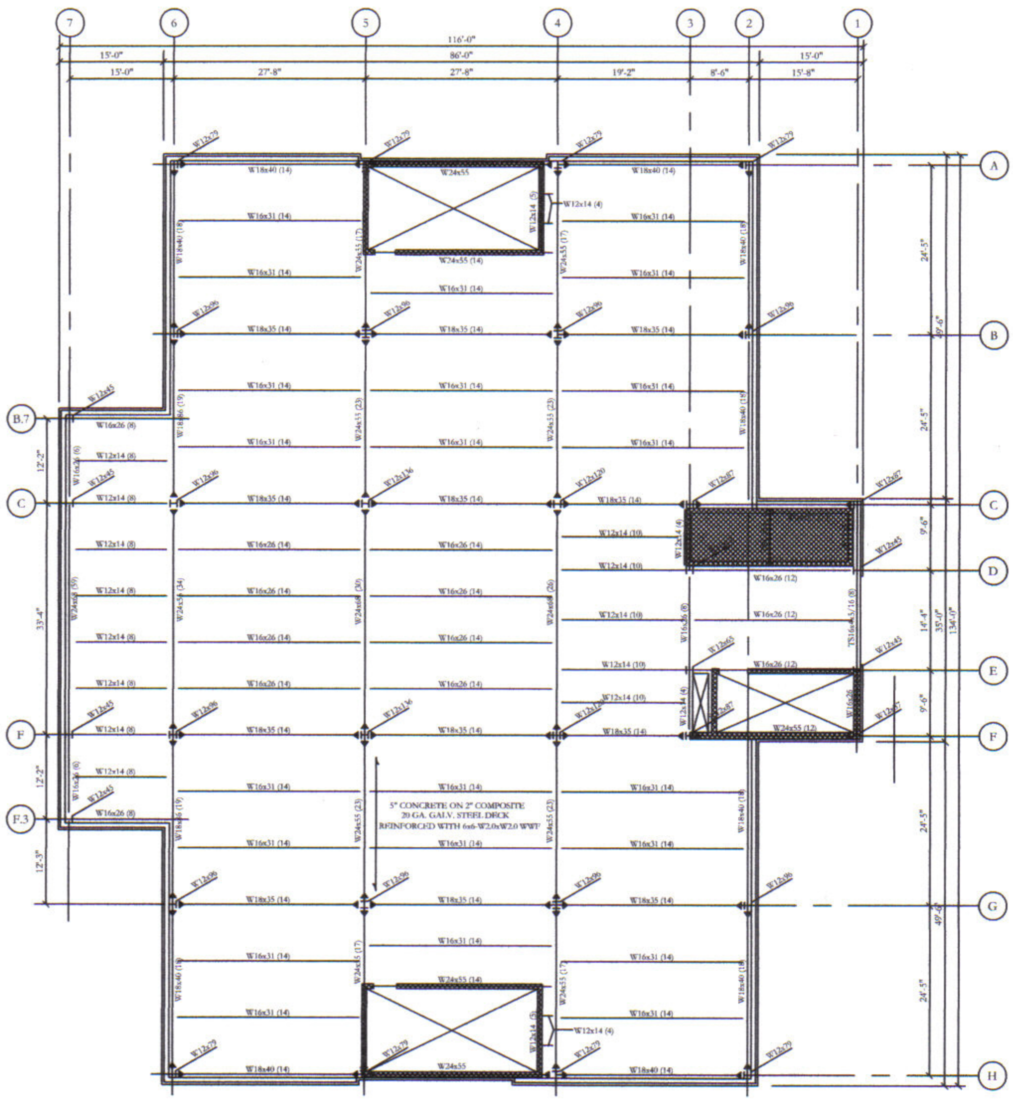

Figure 1: Second Floor Framing Plan

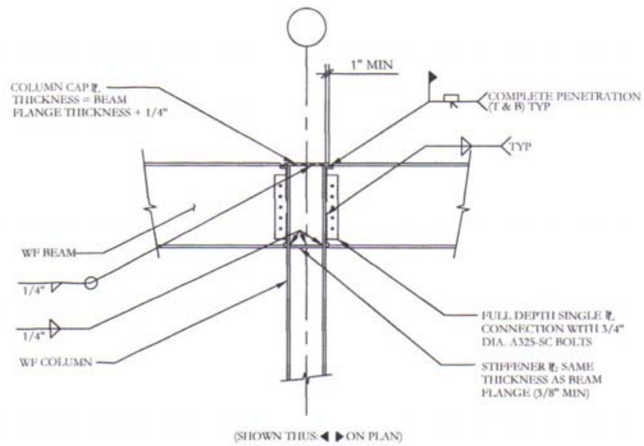

Figure 2: Typical Column Flange Moment Connection Detail

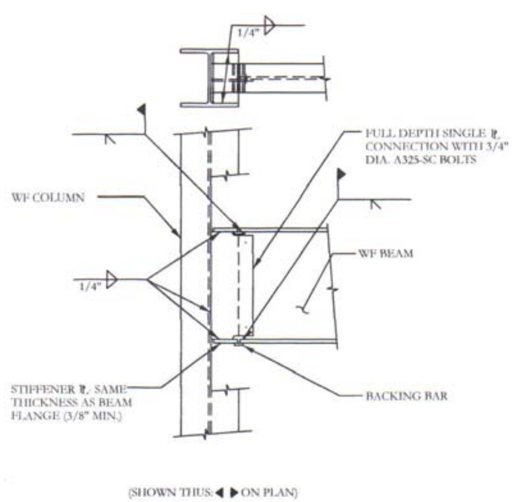

Figure 3: Typical Column Web Moment Connection Detail

IV. Codes and Reference Standards

Design Codes and Reference Standards-As Built

National Building Code: Building Officials and Code Administrators (BOCA) 1999
"National Building Code"
Design Loads: American Society of Civil Engineers (ASCE) 7-98
"Minimum Design Loads for Buildings and Other Structures"
Steel Reference Standard: American Institute of Steel Construction (AISC) ASD 9th Edition
"Allowable Stress Design and Plastic Design Specification for Structural Steel Buildings"
Concrete Reference Standard: American Concrete Institute (ACI) 318-99
"Building Code Requirements for Structural Concrete"

Note: Many of the versions here have been assumed based on the dates of design and construction as the specifications reads "the latest edition" for all reference standards.

Analysis Codes and Reference Standards-As Checked for this Report

Hand Calculation

National Building Code: International Code Council (ICC) 2006
"International Building Code (IBC)"
Design Loads: American Society of Civil Engineers (ASCE) 7-05
"Minimum Design Loads for Buildings and Other Structures"

RAM Structural System

National Building Code: International Code Council (ICC) 2003 (customized to for 2006)
"International Building Code (IBC)"
Design Loads: American Society of Civil Engineers (ASCE) 7-02 (customized for 7-05)
"Minimum Design Loads for Buildings and Other Structures"

Steel Reference Standard: American Institute of Steel Construction (AISC) LRFD 3rd Edition
"Specification for Structural Steel Buildings"
Concrete Reference Standard: American Concrete Institute (ACI) 318-02
"Building Code Requirements for Structural Concrete"

V. Building Loads

Dead Loads

Roof	22	PSF
Balcony	78	PSF
Floor	70	PSF
Exterior Wall	55	PSF
Partition Wall	20	PSF

See Appendix pg.17 for further breakdown per loading condition.

Note: Building dead loads do not include supporting structural member self-weights.

Live Loads

Space	Load	
Roof	20	PSF
Balcony	100	PSF
Stairs and Exits	100	PSF
Corridor-First Floor	100	PSF
Corridor-Other Floors	80	PSF
Lobby	100	PSF
Dance Halls and Ballrooms	100	PSF
Office Space	50	PSF

Wind Loads

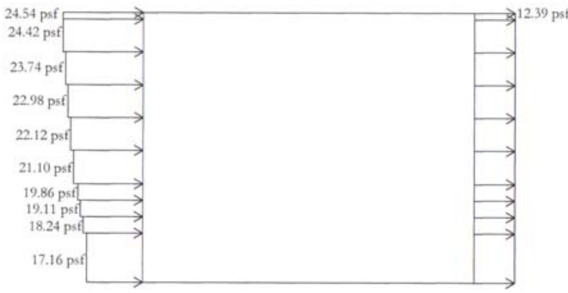

Figure 4: North-South Direction Wind Load

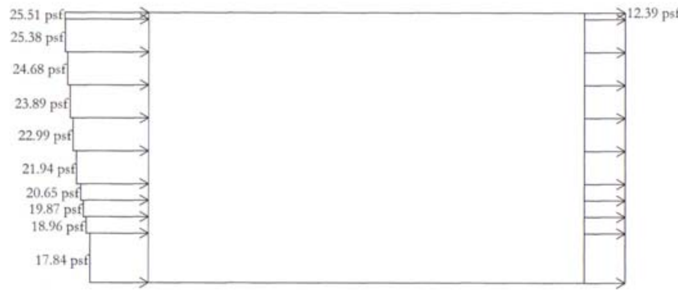

Figure 5: East-West Direction Wind Load

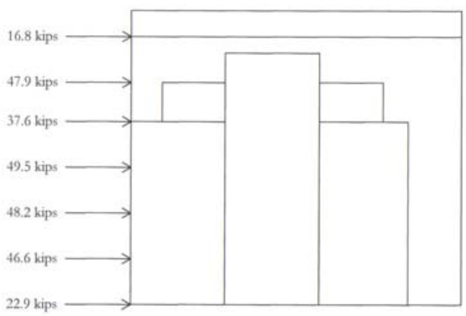

Figure 6: North-South Direction Story Shear

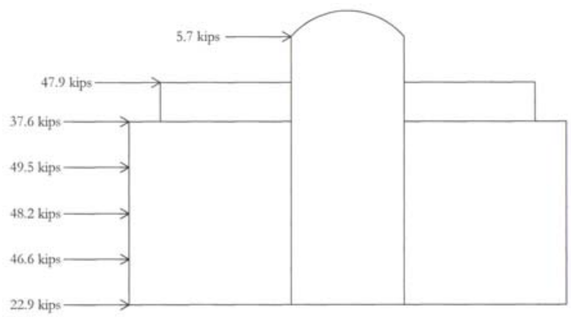

Figure 7: East-West Direction Story Shear

See Appendix pg.18 for calculations.

Seismic Loads

Equivalent Lateral Force

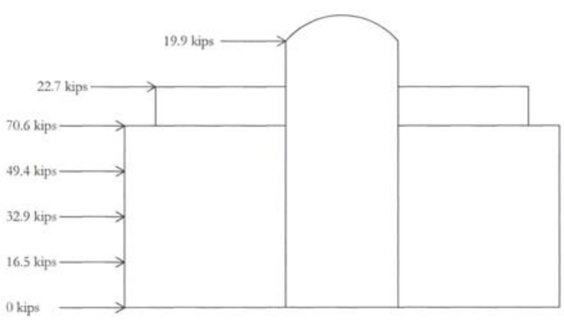

Figure 8: Story Shear

See Appendix pg.22 for calculations.

Load Combinations

LRFD

1. $1.4D$
2. $1.2D+1.6L+0.5L_r$
3. $1.2D+1.6L_r+L$
4. $1.2D+1.6L_r+0.8W$
5. $1.2D+1.6L_r-0.8W$
6. $1.2D+1.6W+L+0.5L_r$
7. $1.2D-1.6W+L+0.5L_r$
8. $1.2D+1.0E+L+0.5L_r$
9. $1.2D-1.0E+L+0.5L_r$
10. $0.9D+1.6W$
11. $0.9D-1.6W$
12. $0.9D+1.0E$
13. $0.9D-1.6W$

VI. Lateral Analysis

Lateral Distribution

Lateral loads are distributed through the structural system of the Duncan Center by the following load path:

1. Exterior brick wall
2. Metal cold-formed steel back-up studs
3. Perimeter moment frame steel beams
4. Interior moment frame steel beams
5. Columns
6. Piers
7. Grade Beams
8. Auger-cast piles

The distribution after the load is transferred from the metal studs is performed through relative stiffness. In order to perform this analysis the most accurately and expediently, a RAM Structural System model was utilized to distribute the lateral loads to the steel moment frames. The model was spot checked in order to confirm the model's validity.

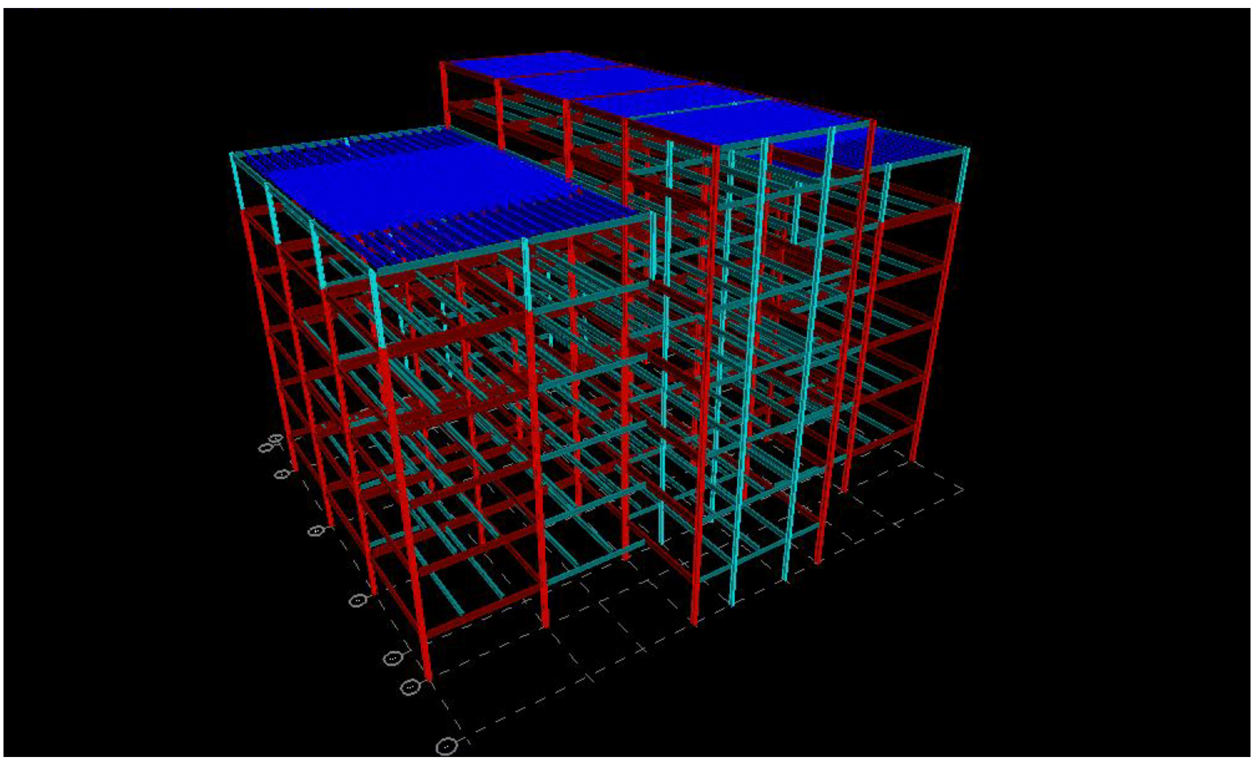

Figure 9: RAM Structural System 3D Model

Strength

By performing a member code check in RAM Structural System, it was found that the lateral system performed adequately in the East-West direction and for all the columns. However, as demonstrated in the chart below, there were a quantifiable number of beams in the North-South direction which did not meet the necessary requirements. It is probable that the beams failed due to an increase in the wind loading per ASCE 7-05 from ASCE 7-98 in that the original building was designed to withstand 80 mph winds versus 100 mph winds per the new code. Other members, particularly the columns, were not influenced by this increased wind speed as the columns were designed for a seventh story to be added, which was later eliminated.

	North-South Direction
Story	% Passing
Roof	100.0
6	100.0
5	100.0
4	80.0
3	40.0
2	40.0
1	100.0
Total	75.9

See Appendix pg.25 for calculations.

Drift

Analysis of the drift seen by the lateral system of the Duncan Center showed that the system obtained satisfactory results, as shown in the below table, for story shear. In terms of total drift, though, the structure system fell short. This can be attributed to the increased wind speed as described in the above strength comparison discussion.

X-Axis		Y-Axis	
Location	% Over drift	Location	% Over drift
Point A6		Point A6	
Story Drift-2nd	67.2	Story Drift-2nd	66.1
Story Drift-3rd	62.0	Story Drift-3rd	68.3
Story Drift-4th	65.4	Story Drift-4th	74.1
Story Drift-5th	75.2	Story Drift-5th	82.6
Total Drift	219.3	Total Drift	153.9
Point C6		Point C6	
Story Drift-6th	94.2	Story Drift-6th	94.4
Story Drift-Roof	90.7	Story Drift-Roof	96.7
Total Drift	177.5	Total Drift	116.4

See Appendix pg.26 for calculations.

Overturning

In order to determine the overturning moment of the structure, the story shears and resulting moments due to their height were calculated and compared due to wind and seismic loading. The resisting moment from the weight of the building counteracted the overturning moments by approximately 10 times, hence ensuring an improbability of this failure from occurring.

Overturning Moment (kip*ft)	Resisting Moment (kip*ft)
22874.33	251079.58

See Appendix pg.35 for calculations.

Torsion

From the table below it is seen that the difference between the center of mass and the center of geometry for each floor is less than 5%. Thus, any torsion that may occur in the building can be taken into account for by the included accidental torsion in the RAM Structural System model of 5%.

	X-Axis	Y-Axis
Story	% Error	% Error
Roof	4.64	0.00
6	2.18	0.11
5	1.17	0.00
4	0.29	0.00
3	0.26	0.00
2	0.13	0.00
1	0.73	0.00

See Appendix pg.36 for calculations.

VII. Spot Check

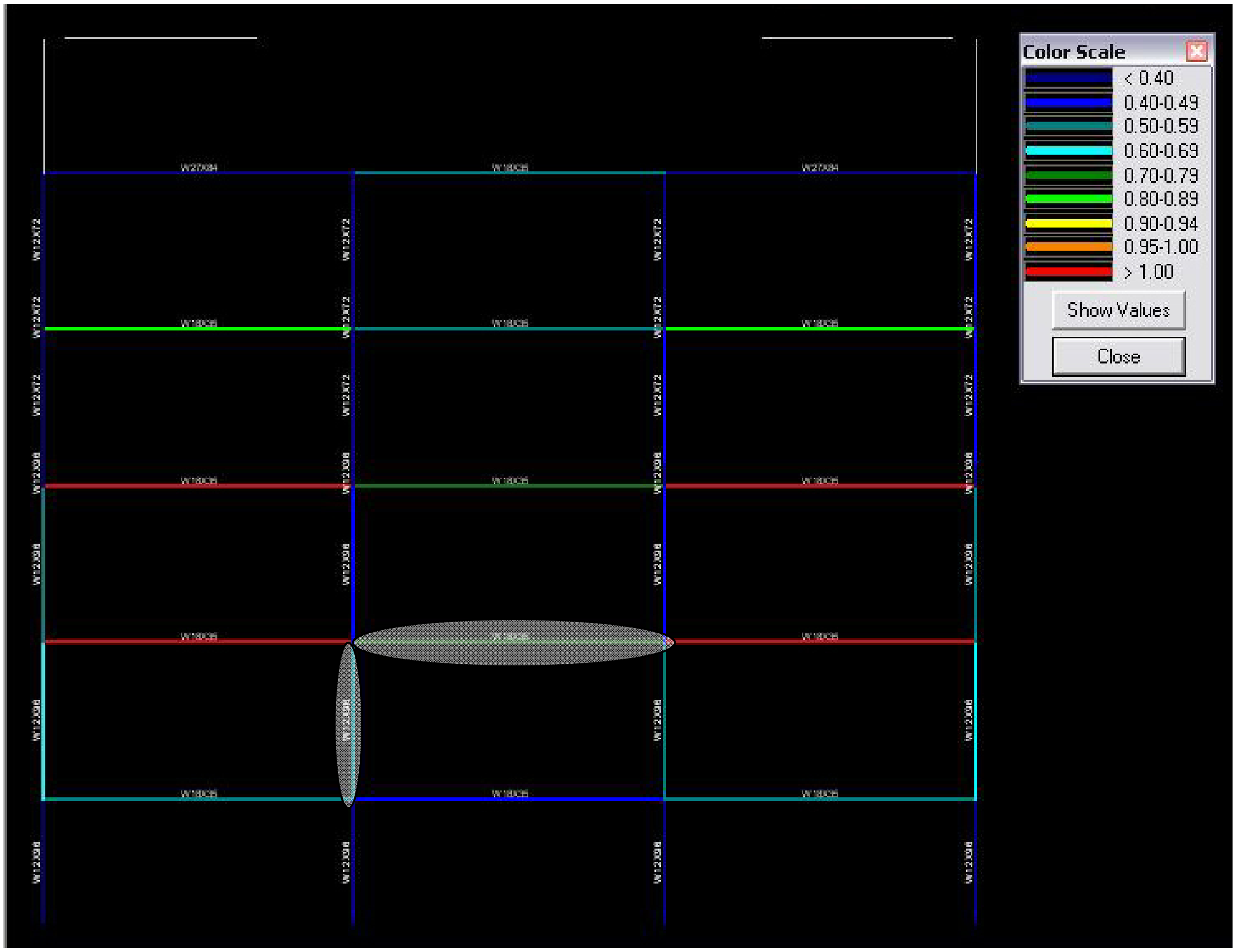

Figure 10: RAM Structural System Spot Check Frame

Second Floor Interior Frame Beam

W18x35	
Strong Axis Moment (kip*ft)	Strong Axis Shear (kips)
80.4160	8.0580

Comparison of the results due to the lateral loading of the W18x35 in the spot check of the percentage of capacity consumed per the given loading in the table above, found the results to be matching. The percent of capacity utilized per the model is 78% and 77% per hand calculation. Hence, it can be concluded that the program is accurately performing strength analysis. One not of concern is that the unbraced length is given to be the full span of the member and not braced by the deck, which will require further investigation into the assumptions of RAM Structural System.

See Appendix pg.37 for calculations.

Second Floor Interior Frame Column

W12x96		
Axial (kips)	Strong Axis Moment (kip*ft)	Weak Axis Moment (kip*ft)
204.7680	186.5780	62.8200
Strong Axis Shear (kips)	Weak Axis Shear (kips)	
34.4140	11.1040	

A similar spot check was done similar to the above beam spot check and found that the results for percent of capacity used were not as close as with the beam, but comparable. From the model 52% was utilized, where as it was calculated by hand to have 65% utilized. This is due to the hand calculation analysis of the worst case for each load type and not per the overall worst load combination, for a conservative and more simplistic analysis.

See Appendix pg.41 for calculations.

VIII. Conclusion

It has been determined through the analyses included in this report that the lateral system of the Duncan Center performs satisfactorily. The only points of concern are the overstress of some lateral beams and an elevated level of drift due to the increased wind speed from 80 mph per the original design to 100 mph per the current code requirements. Spot checks were also performed and confirmed the accurate analysis of the structure, with the exception of the bracing of the top flange of beams, which may also be a contributing factor to the failure in strength of the approximate 25% of lateral beams in the North-South direction.

VI. Appendix

Dead Loads

Roof			Balcony		
Metal Roof Sheathing	1	PSF	Concrete Pavers	12	PSF
4" Rigid Insulation	6	PSF	4" Rigid Insulation	6	PSF
Steel Deck	2	PSF	Concrete	48	PSF
Light-gage Steel Trusses	3	PSF	Deck	2	PSF
HVAC	3	PSF	HVAC	3	PSF
Acoustical Ceiling Tile	2	PSF	Acoustical Ceiling Tile	2	PSF
Miscellaneous	5	PSF	Miscellaneous	5	PSF
Total	22	PSF	Total	78	PSF
Floor			Exterior Wall		
Quarry Tile Flooring	10	PSF	4" Brick Façade	40	PSF
Concrete	48	PSF	5/8" Gypsum Board	3	PSF
Steel Deck	2	PSF	6" Batt Insulation	6	PSF
HVAC	3	PSF	5/8" Gypsum Board	3	PSF
Acoustical Ceiling Tile	2	PSF	Miscellaneous	3	PSF
Miscellaneous	5	PSF			
Total	70	PSF	Total	55	PSF
Partition Wall					
5/8" Gypsum Board	3	PSF			
6" Batt Insulation	6	PSF			
5/8" Gypsum Board	3	PSF			
Miscellaneous	8	PSF			
Total	20	PSF			

Wind Loads

Main Wind Force Resisting System
$V=100$ mph
$K_d=0.85$
Occupancy Category III
$I=1.15$
Exposure Category C
15 ft$<z=82$ ft$< z_g=900$ ft
$\alpha=9.5$
$K_z=2.01(z/z_g)^{2/\alpha}$ (see table below)
$K_{zt}=1.0$
$C_t=0.028$
$h_n=82$ ft
$x=0.8$
$T_a=C_t h_n^x$
$=(0.028)(82 \text{ ft})^{0.8}$
$=0.951$ s
$T\leq C_u T_a=(1.7)(0.951 \text{ s})=1.62$ s
$f=1/T$
$=1/1.57$ s
$=0.637 H_z<1.0 H_z$ Flexible Building
North-South Direction
$c=0.20$
$z=0.6h$
$=0.6(82 \text{ ft})$
$=49.2 \text{ ft}>z_{min}=15$ ft OK
$I_z=c(33/z)^{1/6}$
$=(0.20)(33/49.2 \text{ ft})^{1/6}$
$=0.187$
$g_Q=3.4$
$B=132.67$ ft
$h=82$ ft
$\ell=500$
$\varepsilon=1/5.0$
$L_z=\ell(33/z)^{\varepsilon}$
$=500(33/49.2 \text{ ft})^{(1/5.0)}$
$=462$ ft
$Q=(1/(1+0.63((B+h)/L_z)^{0.63})^{1/2}$
$=(1/1+0.63((132.67 \text{ ft}+82 \text{ ft})/462)^{0.63})^{1/2}$
$=0.849$
$n_1=f$
$=0.637 H_z$
$g_R=(2\ln(3600n_1)^{1/2}+(0.577/(2\ln(3600n_1)^{1/2})$
$=(2\ln(3600(0.637))^{1/2}+(0.577/(2\ln(3600(0.637))^{1/2})$
$=3.94$

Assuming β=0.02
b=0.65
α=1/6.5
$V_z=b(z/33)^{\alpha}V(88/60)$
$=(0.65)(49.2\text{ ft}/33)^{(1/6.5)}(100\text{ mph})(88/60)$
=101 mph
$N_1=n_1V_z/L_z$
$=(0.637)(101\text{ mph})/462\text{ ft}$
=0.139

$R_n=7.47N_1/(1+10.3N_1)^{5/3}$
$=7.47(0.139)/(1+10.3(0.139))^{5/3}=$
=0.236
$R_h=(1/(4.6n_1h/V_z))-((1/2(4.6n_1h/V_z)^2)(1-e^{-2(4.6n1h/Vz)}))$
$= (1/(4.6(0.637)(82\text{ ft})/101\text{ mph}))$
$-((1/2(4.6(0.637)(82\text{ ft})/101\text{ mph}))^2)(1-e^{-2(4.6(0.637)(82\text{ ft})/(101\text{ mph}))}))$
=0.333
$R_B=(1/(4.6n_1B/V_z))-((1/2(4.6n_1B/V_z)^2)(1-e^{-2(4.6n1B/Vz)}))$
$= (1/(4.6(0.637)(132.67\text{ ft})/101\text{ mph}))$
$-((1/2(4.6(0.637)(132.67\text{ ft})/101\text{ mph})^2)(1-e^{-2(4.6(0.637)(132.67\text{ ft})/101\text{ mph})}))$
=0.226
L=101.25 ft
$R_L=(1/(15.4n_1L/V_z))-((1/2(15.4n_1L/V_z)^2)(1-e^{-2(15.4n1L/Vz)}))$
$= (1/(15.4(0.637)(101.25\text{ ft})/101\text{ mph}))$
$-((1/2(15.4(0.637)(101.25\text{ ft})/101\text{ mph})^2)(1-e^{-2(15.4(0.637)(101.25\text{ ft})/101\text{ mph})}))$
=0.097
$R=((1/\beta)R_nR_hR_B(0.53+0.47R_L))^{1/2}$
$=((1/0.02)(0.236)(0.333)(0.226)(0.53+0.47(0.097))^{1/2}$
=0.715
g_V =3.4
$G=0.925((1+1.7I_z(g_Q{}^2Q^2+g_R{}^2R^2)^{1/2})/(1+1.7g_VI_z))$
$=0.925((1+1.7(0.187)((3.4)^2(0.849)^2+(3.94)^2(0.715)^2)^{1/2})/(1+1.7\ (3.4)(0.187)))$
=1.01
East-West Direction (see North-South Direction for other values)
B=101.25 ft
$Q=(1/(1+0.63((B+h)/\ L_z)^{0.63})^{1/2}$
$=(1/1+0.63((101.25\text{ ft}+82\text{ ft})/462)^{0.63})^{1/2}$
=0.860
$R_B=(1/(4.6n_1B/V_z))-((1/2(4.6n_1B/V_z)^2)(1-e^{-2(4.6n1B/Vz)}))$
$= (1/(4.6(0.637)(101.25\text{ ft})/101\text{ mph}))$
$-((1/2(4.6(0.637)(101.25\text{ ft})/101\text{ mph})^2)(1-e^{-2(4.6(0.637)(101.25\text{ ft})/101\text{ mph})}))$
=0.283
L=132.67 ft
$R_L=(1/(15.4n_1L/V_z))-((1/2(15.4n_1L/V_z)^2)(1-e^{-2(15.4n1L/Vz)}))$
$= (1/(15.4(0.637)(132.67\text{ ft})/101\text{ mph}))$
$-((1/2(15.4(0.637)(132.67\text{ ft})/101\text{ mph})^2)(1-e^{-2(15.4(0.637)(132.67\text{ ft})/101\text{ mph})}))$
=0.075

$R=((1/\beta)R_nR_hR_B(0.53+0.47R_L))^{1/2}$
$=((1/0.02)(0.236)(0.333)(0.283)(0.53+0.47(0.075))^{1/2}$
$=0.793$
$G=0.925((1+1.7I_z(g_Q{}^2Q^2+g_R{}^2R^2)^{1/2})/(1+1.7g_VI_z))$
$=0.925((1+1.7(0.187)((3.4)^2(0.849)^2+(3.94)^2(0.793)^2)^{1/2})/(1+1.7\ (3.4)(0.187)))$
$=1.05$
Windward
Cp=0.8
Leeward, North-South Direction
L=101.25 ft
B=132.67 ft
L/B=101.25 ft/132.67 ft
=0.763
$C_p=-0.5$
Leeward, East-West Direction
L=132.67 ft
B=101.25 ft
L/B=132.67 ft/101.25 ft
=1.310
$C_p=-0.438$
$q_z=0.00256\ K_z\ K_{zt}\ K_dV^2I$ (see table below)
$q=q_z$ windward
$=q_h$ leeward
$q_i=q_h$
$P=qG\ C_p$ (see table below)

			P (psf)			
			North-South Direction		East-West Direction	
z (ft)	Kz	qz (psf)	Windward	Leeward	Windward	Leeward
82	1.21	30.4	24.54	-12.39	25.51	-11.29
80	1.21	30.2	24.42	-12.39	25.38	-11.29
70	1.17	29.4	23.74	-12.39	24.68	-11.29
60	1.14	28.4	22.98	-12.39	23.89	-11.29
50	1.09	27.4	22.12	-12.39	22.99	-11.29
40	1.04	26.1	21.10	-12.39	21.94	-11.29
30	0.98	24.6	19.86	-12.39	20.65	-11.29
25	0.95	23.7	19.11	-12.39	19.87	-11.29
20	0.90	22.6	18.24	-12.39	18.96	-11.29
15	0.85	21.2	17.16	-12.39	17.84	-11.29
0	0.00	0.0	0.00	-12.39	0.00	-11.29

Story	Height (ft)	Tributary Height Above (ft)	Tributary Height Below (ft)	Tributary Height (ft)
Roof	82	2	2.5	4.5
6	73	4.5	8.5	13.0
5	56	8.5	7.0	15.5
4	42	7.0	7.0	14.0
3	28	7.0	7.0	14.0
2	14	7.0	7.0	14.0
1	0	7.0	NA	7.0

Story Width		Story Shear (kips)	
North-South Direction	East-West Direction	North-South Direction	East-West Direction
101.25	34.67	16.8	5.7
101.25	34.67	47.9	16.3
67.75	114.00	37.6	62.9
101.25	132.67	49.5	64.5
101.25	132.67	48.2	62.7
101.25	132.67	46.6	60.5
101.25	132.67	22.9	29.7

Cumulative Shear (kips)	
North-South Direction	East-West Direction
16.8	5.7
64.7	22.1
102.3	85.0
151.8	149.5
200.0	212.2
246.6	272.7
269.4	302.3

Seismic Loads

Latitude: 39.17° N
Longitude: -75.54 ° W
From USGS Java Ground Motion Parameter Calculator
S_s=0.172
S_1=0.079
Assuming Site Class D (Not reported in Geotechnical Engineer's Report)
F_a=1.6
F_v=2.4
$S_{MS}=F_aS_s$
=(1.6)(0.172)
=0.275
$S_{M1}=F_vS_1$
=(2.4)(0.079)
=0.190
S_{DS}=2/3 S_{MS}
=(2/3)(0.275)
=0.183
S_{D1}=2/3 S_{M1}
=(2/3)(0.190)
=0.127
T_L=6 s
C_u=1.65
C_t=0.028
h_n=82 ft
x=0.8
$T_a=C_th_n^x$
$=(0.028)(82\text{ ft})^{0.8}$
=0.951 s
$T \leq C_u T_a$
=(1.65)(0.951 s)
=1.57 s
Occupancy Category III
I=1.25
Seismic Design Category B
Ordinary Steel Moment Frames
R=3.5
C_s equals the smallest of:
$C_s= S_{DS}/(R/I)$
=(0.183)/(3.5/1.25)
=0.065
$T=1.62\text{ s}<T_L=6\text{ s}$
$C_s= S_{D1}/(T(R/I))$
=(0.127)/(1.62(3.5/1.25))
=0.028
S_1=0.079>0.6

$C_s = S_1/(R/I)$
$=(0.079)/(3.5/1.25)$
$=0.028$
$C_s=0.028>0.01$ OK
$V= C_sW$
$=(0.028)(7557 \text{ kips})$
$=212 \text{ kips}$
$k=1.56$
$C_{vx}=w_xh_x^k/\Sigma w_ih_i^k$
$F_x=C_{vx}V$

Story	Floor Area (sf)	Floor Dead Load (psf)	Floor Self-Weight (psf)
Roof	8138	22	5
6	2179	70	10
Balcony	4772	78	10
5	8138	70	10
4	12910	70	10
3	12910	70	10
2	12910	70	10
1	12910	70	10
Story	Tributary Wall Height (ft)	Wall Perimeter (ft)	Wall Dead Load (psf)
Roof	4.5	271.84	55
6	13.0	271.84	55
Balcony	5.0	467.84	48
5	15.5	363.50	55
4	14.0	467.84	55
3	14.0	467.84	55
2	14.0	467.84	55
1	7.0	467.84	55

Building Weight	
Story	Total Floor Weight (kips)
Roof	287
6	369
Balcony	532
5	961
4	1393
3	1393
2	1393
1	1213
Total	7541

Story Shear							
Story	wx (kips)	hx (ft)	k	wxhx^k	Cvx	V (kips)	Fx (kips)
Roof	287	82	1.56	36714	0.09373	212	19.9
6	369	73	1.56	41986	0.10719	212	22.7
5	1493	56	1.56	130441	0.33303	212	70.6
4	1393	42	1.56	91272	0.23302	212	49.4
3	1393	28	1.56	60848	0.15535	212	32.9
2	1393	14	1.56	30424	0.07767	212	16.5
1	1213	0	1.56	0	0.00000	212	0.0
Total	7541	NA	NA	391684	1	NA	212.0

Wind Base Shear=1.6(269 kips)=430 kips>Seismic Base Shear=212 kips; Wind Controls

Strength

	North-South Direction		
Story	Failed	Total	% Passing
Roof	0	8	100.0
6	0	8	100.0
5	0	20	100.0
4	4	20	80.0
3	12	20	40.0
2	12	20	40.0
1	0	20	100.0
Total	28	116	75.9

Drift

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CRITERIA:

Rigid End Zones:	Ignore Effects		
Member Force Output:	At Face of Joint		
P-Delta:	Yes	Scale Factor:	1.00
Diaphragm:	Rigid		
Ground Level:	First Floor		

LOAD CASE DEFINITIONS:

D	DeadLoad	RAMUSER
Ln	NegLiveLoad	RAMUSER
W1	WindLoadX	W_User
W2	WindLoadY	W_User
E1	SeismicLoadX	EQ_User
E2	SeismicLoadY	EQ_User

RESULTS:

Location (ft): (15.000, 131.000)

Story	LdC	Displacement		Story Drift		Drift Ratio	
		X	Y	X	Y	X	Y
		in	in	in	in		
High Roof	D	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Ln	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	W1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	W2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	E1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	E2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sixth Floor	D	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Ln	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	W1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	W2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	E1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	E2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Low Roof	D	0.0082	0.0534	0.0220	0.0528	0.0002	0.0004
	Ln	0.0215	-0.0501	0.0122	-0.0472	0.0001	0.0003
	W1	2.6021	-0.0078	0.3747	-0.0081	0.0026	0.0001
	W2	-0.8056	1.9453	-0.2487	0.1696	0.0017	0.0012
	E1	2.4760	-0.0061	0.2863	-0.0061	0.0020	0.0000
	E2	-0.9329	2.0813	-0.4597	0.3283	0.0032	0.0023

Drift

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Story	LdC	Displacement		Story Drift		Drift Ratio	
Fifth Floor	D	-0.0138	0.0007	-0.0067	0.0008	0.0000	0.0000
	Ln	0.0093	-0.0029	0.0051	-0.0005	0.0000	0.0000
	W1	2.2273	0.0003	0.4138	0.0000	0.0025	0.0000
	W2	-0.5568	1.7757	-0.1183	0.2214	0.0007	0.0013
	E1	2.1897	0.0000	0.4298	-0.0000	0.0026	0.0000
	E2	-0.4733	1.7530	-0.1201	0.3036	0.0007	0.0018
Splice Level 2	D	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Ln	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	W1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	W2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	E1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	E2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fourth Floor	D	-0.0071	-0.0002	-0.0035	-0.0001	0.0000	0.0000
	Ln	0.0042	-0.0024	0.0036	-0.0002	0.0000	0.0000
	W1	1.8136	0.0003	0.5773	-0.0001	0.0034	0.0000
	W2	-0.4385	1.5543	-0.1588	0.4078	0.0009	0.0024
	E1	1.7599	0.0001	0.6027	-0.0002	0.0036	0.0000
	E2	-0.3532	1.4494	-0.1384	0.4522	0.0008	0.0027
Splice Level 1	D	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Ln	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	W1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	W2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	E1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	E2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Third Floor	D	-0.0036	-0.0001	-0.0027	-0.0001	0.0000	0.0000
	Ln	0.0005	-0.0022	0.0015	-0.0019	0.0000	0.0000
	W1	1.2362	0.0004	0.6638	0.0005	0.0040	0.0000
	W2	-0.2796	1.1465	-0.1662	0.5542	0.0010	0.0033
	E1	1.1572	0.0002	0.6449	0.0004	0.0038	0.0000
	E2	-0.2148	0.9971	-0.1318	0.5185	0.0008	0.0031
Second Floor	D	-0.0009	0.0000	-0.0009	0.0000	0.0000	0.0000
	Ln	-0.0010	-0.0003	-0.0010	-0.0003	0.0000	0.0000
	W1	0.5724	-0.0001	0.5724	-0.0001	0.0034	0.0000
	W2	-0.1134	0.5923	-0.1134	0.5923	0.0007	0.0035
	E1	0.5123	-0.0001	0.5123	-0.0001	0.0030	0.0000
	E2	-0.0830	0.4787	-0.0830	0.4787	0.0005	0.0028
First Floor	D	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Ln	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	W1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Drift

Story	LdC	Displacement		Story Drift		Drift Ratio	
	W2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	E1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	E2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Location (ft): (15.000, 82.170)

Story	LdC	Displacement		Story Drift		Drift Ratio	
		X	Y	X	Y	X	Y
		in	in	in	in		
High Roof	D	-0.0255	0.0113	-0.0017	0.0024	0.0000	0.0000
	Ln	0.0439	-0.0063	0.0140	-0.0003	0.0001	0.0000
	W1	2.8300	-0.0184	0.0972	-0.0072	0.0009	0.0001
	W2	-0.2411	2.0028	-0.0174	0.0107	0.0002	0.0001
	E1	2.6569	-0.0141	0.0839	-0.0054	0.0008	0.0001
	E2	-0.3150	2.2113	-0.0417	0.0356	0.0004	0.0003
Sixth Floor	D	-0.0238	0.0089	-0.0017	-0.0445	0.0000	0.0007
	Ln	0.0298	-0.0060	0.0083	0.0441	0.0001	0.0007
	W1	2.7327	-0.0112	0.1183	-0.0035	0.0020	0.0001
	W2	-0.2237	1.9921	-0.0205	0.0468	0.0003	0.0008
	E1	2.5731	-0.0087	0.0875	-0.0026	0.0015	0.0000
	E2	-0.2732	2.1756	-0.0399	0.0943	0.0007	0.0016
Low Roof	D	-0.0221	0.0534	-0.0081	0.0528	0.0001	0.0004
	Ln	0.0216	-0.0501	0.0110	-0.0472	0.0001	0.0003
	W1	2.6144	-0.0078	0.3874	-0.0081	0.0027	0.0001
	W2	-0.2033	1.9453	-0.0615	0.1696	0.0004	0.0012
	E1	2.4856	-0.0061	0.2959	-0.0061	0.0021	0.0000
	E2	-0.2333	2.0813	-0.1129	0.3283	0.0008	0.0023
Fifth Floor	D	-0.0140	0.0007	-0.0071	0.0008	0.0000	0.0000
	Ln	0.0106	-0.0029	0.0052	-0.0005	0.0000	0.0000
	W1	2.2270	0.0003	0.4139	0.0000	0.0025	0.0000
	W2	-0.1417	1.7757	-0.0301	0.2214	0.0002	0.0013
	E1	2.1897	0.0000	0.4300	-0.0000	0.0026	0.0000
	E2	-0.1204	1.7530	-0.0304	0.3036	0.0002	0.0018
Splice Level 2	D	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Ln	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	W1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	W2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	E1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	E2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fourth Floor	D	-0.0069	-0.0002	-0.0034	-0.0001	0.0000	0.0000

Drift

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Story	LdC	Displacement		Story Drift		Drift Ratio	
	Ln	0.0053	-0.0024	0.0038	-0.0002	0.0000	0.0000
	W1	1.8131	0.0003	0.5774	-0.0001	0.0034	0.0000
	W2	-0.1117	1.5543	-0.0404	0.4078	0.0002	0.0024
	E1	1.7597	0.0001	0.6028	-0.0002	0.0036	0.0000
	E2	-0.0900	1.4494	-0.0352	0.4522	0.0002	0.0027
Splice Level 1	D	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Ln	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	W1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	W2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	E1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	E2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Third Floor	D	-0.0035	-0.0001	-0.0026	-0.0001	0.0000	0.0000
	Ln	0.0016	-0.0022	0.0024	-0.0019	0.0000	0.0000
	W1	1.2357	0.0004	0.6633	0.0005	0.0039	0.0000
	W2	-0.0712	1.1465	-0.0424	0.5542	0.0003	0.0033
	E1	1.1569	0.0002	0.6445	0.0004	0.0038	0.0000
	E2	-0.0547	0.9971	-0.0336	0.5185	0.0002	0.0031
Second Floor	D	-0.0009	0.0000	-0.0009	0.0000	0.0000	0.0000
	Ln	-0.0008	-0.0003	-0.0008	-0.0003	0.0000	0.0000
	W1	0.5724	-0.0001	0.5724	-0.0001	0.0034	0.0000
	W2	-0.0289	0.5923	-0.0289	0.5923	0.0002	0.0035
	E1	0.5124	-0.0001	0.5124	-0.0001	0.0031	0.0000
	E2	-0.0211	0.4787	-0.0211	0.4787	0.0001	0.0028
First Floor	D	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Ln	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	W1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	W2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	E1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	E2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Story	Height (ft)	H/600 or 0.2h
Roof	9	1.80
6	17	3.40
5	14	2.80
4	14	2.80
3	14	2.80
2	14	2.80
Total to 5	56	1.12
Total to Roof	82	1.64

X-Axis				
	Point A6			
	Story Drift-2nd	Story Drift-3rd	Story Drift-4th	Story Drift-5th
Load Cases				
1.4D	-0.0013	-0.0038	-0.0049	-0.0094
1.2D+1.6L	-0.0027	-0.0008	0.0016	0.0001
1.2D+0.8W1	0.4568	0.5278	0.4576	0.3230
1.2D-0.8W1	-0.4590	-0.5343	-0.4660	-0.3391
1.2D+0.8W2	-0.0918	-0.1362	-0.1312	-0.1027
1.2D-0.8W2	0.0896	0.1297	0.1228	0.0866
1.2D+L+1.6W1	0.9138	1.0603	0.9231	0.6591
1.2D+L-1.6W1	-0.9179	-1.0638	-0.9243	-0.6650
1.2D+L+1.6W2	-0.1835	-0.2677	-0.2547	-0.1922
1.2D+L-1.6W2	0.1794	0.2642	0.2535	0.1863
1.2D+L+1.0E1	0.8176	1.0301	0.9637	0.6847
1.2D+L-1.0E1	-0.8218	-1.0336	-0.9649	-0.6906
1.2D+L+1.0E2	-0.1349	-0.2126	-0.2220	-0.1951
1.2D+L-1.0E2	0.1307	0.2091	0.2208	0.1892
0.9D+1.6W1	0.9150	1.0597	0.9205	0.6561
0.9D-1.6W1	-0.9167	-1.0645	-0.9268	-0.6681
0.9D+1.6W2	-0.1823	-0.2684	-0.2572	-0.1953
0.9D-1.6W2	0.1806	0.2635	0.2509	0.1833
0.9D+1.0E1	0.8189	1.0294	0.9612	0.6817
0.9D-1.0E1	-0.8205	-1.0343	-0.9675	-0.6937
0.9D+1.0E2	-0.1336	-0.2133	-0.2246	-0.1982
0.9D-1.0E2	0.1320	0.2085	0.2183	0.1861

X-Axis				
	Point A6			
	Story Drift-2nd	Story Drift-3rd	Story Drift-4th	Story Drift-5th
Worst Case				
Positive Maximum	0.9150	1.0603	0.9637	0.6847
Negative Maximum	0.9179	1.0645	0.9675	0.6937
Load Cases	1.2D+L-1.6W1	0.9D-1.6W1	0.9D-1.0E1	0.9D-1.0E1
Maximum	0.9179	1.0645	0.9675	0.6937
H/600 or 0.2h	2.80	2.80	2.80	2.80
% Over drift	67.2	62.0	65.4	75.2
	Point A6	Point C6		
	Total Drift	Story Drift-6th	Story Drift-Roof	Total Drift
Load Cases				
1.4D	-0.0193	-0.0024	-0.0024	-0.0357
1.2D+1.6L	-0.0017	0.0112	0.0204	0.0396
1.2D+0.8W1	1.7653	0.0926	0.0757	2.2334
1.2D-0.8W1	-1.7984	-0.0967	-0.0798	-2.2946
1.2D+0.8W2	-0.4620	-0.0184	-0.0160	-0.2235
1.2D-0.8W2	0.4289	0.0144	0.0119	0.1623
1.2D+L+1.6W1	3.5564	0.1955	0.1675	4.5413
1.2D+L-1.6W1	-3.5709	-0.1830	-0.1436	-4.5147
1.2D+L+1.6W2	-0.8981	-0.0265	-0.0159	-0.3725
1.2D+L-1.6W2	0.8836	0.0391	0.0398	0.3991
1.2D+L+1.0E1	3.4963	0.1463	0.1462	4.2643
1.2D+L-1.0E1	-3.5108	-0.1337	-0.1223	-4.2377
1.2D+L+1.0E2	-0.7645	-0.0576	-0.0548	-0.4907
1.2D+L-1.0E2	0.7500	0.0701	0.0787	0.5173
0.9D+1.6W1	3.5513	0.1878	0.1540	4.5051
0.9D-1.6W1	-3.5761	-0.1908	-0.1571	-4.5510
0.9D+1.6W2	-0.9033	-0.0343	-0.0294	-0.4087
0.9D-1.6W2	0.8785	0.0313	0.0263	0.3628
0.9D+1.0E1	3.4911	0.1385	0.1327	4.2281
0.9D-1.0E1	-3.5159	-0.1415	-0.1358	-4.2740
0.9D+1.0E2	-0.7697	-0.0654	-0.0683	-0.5270
0.9D-1.0E2	0.7449	0.0623	0.0652	0.4811

X-Axis				
	Point A6	Point C6		
	Total Drift	Story Drift-6th	Story Drift-Roof	Total Drift
Worst Case				
Positive Maximum	3.5564	0.1955	0.1675	4.5413
Negative Maximum	3.5761	0.1908	0.1571	4.5510
Load Cases	0.9D-1.6W1	1.2D+L+1.6W1	1.2D+L+1.6W1	0.9D-1.6W1
Maximum	3.5761	0.1955	0.1675	4.5510
H/600 or 0.2h	1.12	3.40	1.80	1.64
% Over drift	219.3	94.2	90.7	177.5

Y-Axis				
	Point A6			
	Story Drift-2nd	Story Drift-3rd	Story Drift-4th	Story Drift-5th
Load Cases				
1.4D	0.0000	-0.0001	-0.0001	0.0011
1.2D+1.6L	-0.0005	-0.0032	-0.0004	0.0002
1.2D+0.8W1	-0.0001	0.0003	-0.0002	0.0010
1.2D-0.8W1	0.0001	-0.0005	0.0000	0.0010
1.2D+0.8W2	0.4738	0.4432	0.3261	0.1781
1.2D-0.8W2	-0.4738	-0.4435	-0.3264	-0.1762
1.2D+L+1.6W1	-0.0005	-0.0012	-0.0005	0.0005
1.2D+L-1.6W1	-0.0001	-0.0028	-0.0002	0.0005
1.2D+L+1.6W2	0.9474	0.8847	0.6522	0.3547
1.2D+L-1.6W2	-0.9480	-0.8887	-0.6528	-0.3538
1.2D+L+1.0E1	-0.0005	-0.0014	-0.0006	0.0005
1.2D+L-1.0E1	-0.0001	-0.0027	0.0000	0.0005
1.2D+L+1.0E2	0.7656	0.8276	0.7232	0.4862
1.2D+L-1.0E2	-0.7662	-0.8316	-0.7238	-0.4853
0.9D+1.6W1	-0.0002	0.0007	-0.0003	0.0007
0.9D-1.6W1	0.0002	-0.0009	0.0001	0.0007
0.9D+1.6W2	0.9477	0.8866	0.6524	0.3550
0.9D-1.6W2	-0.9477	-0.8868	-0.6526	-0.3535
0.9D+1.0E1	-0.0002	0.0006	-0.0004	0.0007
0.9D-1.0E1	0.0002	-0.0007	0.0002	0.0007
0.9D+1.0E2	0.7659	0.8295	0.7234	0.4865
0.9D-1.0E2	-0.7659	-0.8297	-0.7236	-0.4850

Y-Axis				
	Point A6			
	Story Drift-2nd	Story Drift-3rd	Story Drift-4th	Story Drift-5th
Worst Case				
Positive Maximum	0.9477	0.8866	0.7234	0.4865
Negative Maximum	0.9480	0.8887	0.7238	0.4853
Load Cases	1.2D+L-1.6W2	1.2D+L-1.6W2	1.2D+L-1.0E2	0.9D+1.0E2
Maximum	0.9480	0.8887	0.7238	0.4865
H/600 or 0.2h	2.80	2.80	2.80	2.80
% Over drift	66.1	68.3	74.1	82.6
	Point A6	Point C6		
	Total Drift	Story Drift-6th	Story Drift-Roof	Total Drift
Load Cases				
1.4D	0.0010	-0.0623	0.0034	0.0158
1.2D+1.6L	-0.0038	0.0172	0.0024	0.0035
1.2D+0.8W1	0.0011	-0.0562	-0.0029	-0.0012
1.2D-0.8W1	0.0006	-0.0506	0.0086	0.0283
1.2D+0.8W2	1.4214	-0.0160	0.0114	1.6158
1.2D-0.8W2	-1.4197	-0.0908	-0.0057	-1.5887
1.2D+L+1.6W1	-0.0016	-0.0149	-0.0089	-0.0222
1.2D+L-1.6W1	-0.0025	-0.0037	0.0141	0.0367
1.2D+L+1.6W2	2.8391	0.0656	0.0197	3.2117
1.2D+L-1.6W2	-2.8432	-0.0842	-0.0145	-3.1972
1.2D+L+1.0E1	-0.0021	-0.0135	-0.0061	-0.0153
1.2D+L-1.0E1	-0.0021	-0.0051	0.0112	0.0298
1.2D+L+1.0E2	2.7984	0.1416	0.0595	3.5453
1.2D+L-1.0E2	-2.8025	-0.1602	-0.0544	-3.5308
0.9D+1.6W1	0.0011	-0.0457	-0.0094	-0.0193
0.9D-1.6W1	0.0002	-0.0345	0.0137	0.0396
0.9D+1.6W2	2.8418	0.0348	0.0193	3.2147
0.9D-1.6W2	-2.8405	-0.1149	-0.0150	-3.1943
0.9D+1.0E1	0.0006	-0.0442	-0.0065	-0.0124
0.9D-1.0E1	0.0006	-0.0359	0.0108	0.0327
0.9D+1.0E2	2.8011	0.1108	0.0591	3.5483
0.9D-1.0E2	-2.7999	-0.1909	-0.0548	-3.5279

Y-Axis				
	Point A6	Point C6		
	Total Drift	Story Drift-6th	Story Drift-Roof	Total Drift
Worst Case				
Positive Maximum	2.8418	0.1416	0.0595	3.5483
Negative Maximum	2.8432	0.1909	0.0548	3.5308
Load Cases	1.2D+L-1.6W2	0.9D-1.0E2	1.2D+L+1.0E2	0.9D+1.0E2
Maximum	2.8432	0.1909	0.0595	3.5483
H/600 or 0.2h	1.12	3.40	1.80	1.64
% Over drift	153.9	94.4	96.7	116.4

Overturning

	Overturning Moment (kip*ft)		
Story	Wind North-South Direction	Wind East-West Direction	Seismic
Roof	1377.38	469.88	1629.46
6	4720.60	1609.68	1658.92
5	5726.03	4758.54	3953.68
4	6374.81	6278.07	2074.84
3	5599.42	5940.66	922.15
2	3452.11	3817.49	230.54
1	0.00	0.00	0.00
Total	27250.35	22874.33	10469.60
	Resisting Moment (kip*ft)		
Story	Height (ft)	Total Floor Weight (kips)	Resisting Moment (kip*ft)
Roof	82	287	23534.52
6	73	369	26914.05
5	56	1493	83615.92
4	42	1393	58507.55
3	28	1393	39005.03
2	14	1393	19502.52
1	0	1213	0.00
Total	NA	7541	251079.58

Torsion

	X-Axis				
Story	Average Left	Average Right	Center of Geometry	Center of Mass	% Error
Roof	15.00	113.67	64.34	61.35	4.64
6	15.00	113.67	64.34	62.93	2.18
5	15.00	101.99	58.49	59.18	1.17
4	8.40	101.99	55.19	55.35	0.29
3	8.40	101.99	55.19	55.05	0.26
2	8.40	101.99	55.19	55.12	0.13
1	8.40	101.99	55.19	54.79	0.73
	Y-Axis				
Story	Average Top	Average Bottom	Center of Geometry	Center of Mass	% Error
Roof	82.17	48.83	65.50	65.50	0.00
6	82.17	48.83	65.50	65.57	0.11
5	131.00	0.00	65.50	65.50	0.00
4	131.00	0.00	65.50	65.50	0.00
3	131.00	0.00	65.50	65.50	0.00
2	131.00	0.00	65.50	65.50	0.00
1	131.00	0.00	65.50	65.50	0.00

Member Forces

RAM Frame v11.0
DataBase: Technical Assignment 3 12/02/07 22:57:45
Building Code: IBC

STEEL BEAM INFORMATION:

Beam Number: 5	**Frame Number: 0**	
Level: Second Floor	I-End (42.67,24.42)	J-End (70.34,24.42)
Fy (ksi) = 50.00	Beam Size = W18X35	
Length (ft) = 27.67		

INPUT PARAMETERS:

		I-End	J-End
Fixity	Major Axis:	Fix	Fix
	Minor Axis:	Fix	Fix
	Torsion:	Fix	Fix
Rigid End Zone (in):		0.00	0.00 (Ignore)
Member Force Output:		At Face of Joint	

P-Delta: Yes Scale Factor: 1.00
Diaphragm: Rigid
Ground Level: First Floor

LOAD CASES:

D	DeadLoad	RAMUSER
Ln	NegLiveLoad	RAMUSER
W1	WindLoadX	W_User
W2	WindLoadY	W_User
E1	SeismicLoadX	EQ_User
E2	SeismicLoadY	EQ_User

MEMBER FORCES:

LdC	@	P kips	Mmajor kip-ft	Mminor kip-ft	Vmajor kips	Vminor kips	Tors kip-ft
D	i	-0.00	-13.64	-0.00	2.85	0.00	0.00
	j	-0.00	-13.28	0.00	-2.82	0.00	0.00
Ln	i	0.00	31.92	0.00	-6.79	-0.00	0.00
	j	0.00	31.58	-0.00	6.77	-0.00	0.00
W1	i	0.00	40.54	0.00	-2.93	-0.00	0.00
	j	0.00	-40.54	-0.00	-2.93	-0.00	0.00
W2	i	0.00	5.76	-0.00	-0.42	-0.00	-0.00
	j	0.00	-5.75	-0.00	-0.42	-0.00	-0.00
E1	i	-0.00	37.86	0.00	-2.74	-0.00	0.00
	j	-0.00	-37.86	-0.00	-2.74	-0.00	0.00
E2	i	0.00	4.42	0.00	-0.32	-0.00	-0.00
	j	0.00	-4.42	-0.00	-0.32	-0.00	-0.00

	Strong Axis Moment (kip*ft)	Strong Axis Shear (kips)
Load Cases		
1.4D	-19.0960	3.9900
1.2D+1.6L	34.7040	-7.4440
1.2D+0.8W1	16.0640	1.0760
1.2D-0.8W1	-48.8000	5.7640
1.2D+0.8W2	-11.7600	3.0840
1.2D-0.8W2	-20.9760	3.7560
1.2D+L+1.6W1	80.4160	-8.0580
1.2D+L-1.6W1	-49.3120	1.3180
1.2D+L+1.6W2	24.7680	-4.0420
1.2D+L-1.6W2	6.3360	-2.6980
1.2D+L+1.0E1	76.1280	-7.7540
1.2D+L-1.0E1	-45.0240	1.0140
1.2D+L+1.0E2	22.6240	-3.8820
1.2D+L-1.0E2	8.4800	-2.8580
0.9D+1.6W1	52.5880	-2.1230
0.9D-1.6W1	-77.1400	7.2530
0.9D+1.6W2	-3.0600	1.8930
0.9D-1.6W2	-21.4920	3.2370
0.9D+1.0E1	48.3000	-1.8190
0.9D-1.0E1	-72.8520	6.9490
0.9D+1.0E2	-5.2040	2.0530
0.9D-1.0E2	-19.3480	3.0770
Worst Case		
Positive Maximum	80.4160	7.2530
Negative Maximum	77.1400	8.0580
Load Cases	1.2D+L+1.6W1	1.2D+L+1.6W2
Maximum	80.4160	8.0580

Member Code Check

RAM Frame v11.0
DataBase: Technical Assignment 3 — 12/02/07 20:30:22
Building Code: IBC — Steel Code: AISC LRFD

BEAM INFORMATION:

Story Level = Second Floor   Frame Number = 0   Beam Number = 5
Fy (ksi) = 50.00
Beam Size = W18X35

INPUT DESIGN PARAMETERS:

	X-Axis	Y-Axis
Lu for Axial (ft)	27.67	27.67
Lu for Bending (ft)	27.67	27.67
K	1.00	1.00
Braced Against Joint Translation	No	No
Top Flange Continuously Braced	No	
Bottom Flange Continuously Braced	No	

CONTROLLING BEAM SEGMENT FORCES - SHEAR

Segment distance (ft) i - end	0.00
j - end	27.67

Load Combination: 1.200 D - 1.600 W1

SHEAR CHECK:

Vux (kips) =	8.11	0.90*Vnx (kips) =	143.37	Vux/0.90*Vnx =	0.057
Vuy (kips) =	0.00	0.90*Vny (kips) =	137.70	Vuy/0.90*Vny =	0.000

CONTROLLING BEAM SEGMENT FORCES - FLEXURE

Segment distance (ft) i - end	0.00
j - end	27.67

Load Combination: 1.200 D - 1.600 W1

CALCULATED PARAMETERS:

Pu (kips) =	-0.00	0.90*Pn (kips) =	31.35
Mux (kip-ft) =	-81.23	0.90*Mnx (kip-ft) =	104.17
Muy (kip-ft) =	-0.00	0.90*Mny (kip-ft) =	28.80
Cbx =	2.37		

INTERACTION EQUATION:

Pu/ϕPn = 0.000
Eq H1-1b: 0.000 + 0.780 + 0.000 = 0.780

SECOND FLOOR INTERIOR FRAME BEAM SPOT CHECK

W18X35

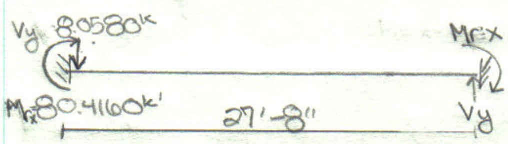
GRIDLINE G 415

78% CAPACITY

SPAN: 27'-8"

LOADS: $M_{Ex} = 80.4160^{k'}$

$V_y = 8.0580^{k}$



COMPACT SECTION:

$\lambda p = 0.38\sqrt{\frac{E}{F_y}} = 0.38\sqrt{\frac{29000\ KSI}{50\ KSI}} = 8.67 > \lambda = \frac{b}{2t_f} = 7.06$ COMPACT FLANGE

$\lambda p = 3.76\sqrt{\frac{E}{F_y}} = 3.76\sqrt{\frac{29000\ KSI}{50\ KSI}} = 90.6 > \lambda = \frac{h}{t_w} = 53.5$ COMPACT WEB

BENDING:

$L_b = 27.67' > L_r = 12.4'$

$F_{cr} = \frac{C_b \pi^2 E}{\left(\frac{L_b}{r_{ts}}\right)^2}\sqrt{1 + 0.078\frac{Jc}{S_x h_o}\left(\frac{L_b}{r_{ts}}\right)^2}$

$= \frac{(2.37)\pi^2(29000\ KSI)}{\left(\frac{(27.67')(12)}{1.52}\right)^2}\sqrt{1 + 0.078\frac{(0.506)}{(57.6\ IN^3)(17.3)}\left(\frac{(27.67')(12)}{1.52}\right)^2}$

$= 24.2\ KSI$

$\phi M_{cx} = \phi F_{cr} S_x = (0.90)(24.2\ KSI)(57.6\ IN^3)(1/12) = 105^{k'}$

$\leq \phi M_p = \phi f_y Z_x = (0.90)(50\ KSI)(66.5\ IN^3)(1/12) = 249^{k'}$

$= 249^{k'} > M_{Ex} = 80.4^{k'}$ √OK

SHEAR:

$\frac{h}{t_w} = 53.5 < 2.24\sqrt{\frac{E}{F_y}} = 2.24\sqrt{\frac{29000\ KSI}{50\ KSI}} = 53.9$

$\phi V_n = \phi 0.6 f_y A_w C_v = (0.9)(0.6)(50\ KSI)(0.300")(17.7")(1.0) = 159^{k} > V_{uy} = 8.06^{k}$ √OK

% CAPACITY

$\left(\frac{M_{rx}}{\phi M_{cx}}\right)100\% = \left(\frac{80.4^{k'}}{105^{k'}}\right)100\% = 77\% \approx 78\%$

1/1

Member Forces

RAM Frame v11.0
DataBase: Technical Assignment 3 12/02/07 22:57:45
Building Code: IBC

STEEL COLUMN INFORMATION:

Column Number: 7 **Frame Number: 0**
Level Top: Second Floor Column Line (42.67,24.42)
Bot: First Floor
Fy (ksi) = 50.00 Column Size = W12X96
Orientation (deg) = 90.00 Length (ft) = 14.00

INPUT PARAMETERS:

		Top	Bottom
Fixity	Major Axis:	Fix	Fix
	Minor Axis:	Fix	Fix
	Torsion:	Fix	Fix
Joint Face Dist (in):			
	Major:	11.80	11.80
	Minor:	8.85	8.85
Rigid End Zone (in):			
	Major:	0.00	0.00 (Ignore)
	Minor:	0.00	0.00 (Ignore)

Member Force Output: At Face of Joint
P-Delta: Yes Scale Factor: 1.00
Diaphragm: Rigid
Ground Level: First Floor

LOAD CASES:

D	DeadLoad	RAMUSER
Ln	NegLiveLoad	RAMUSER
W1	WindLoadX	W_User
W2	WindLoadY	W_User
E1	SeismicLoadX	EQ_User
E2	SeismicLoadY	EQ_User

MEMBER FORCES:

LdC	@	P kips	Mmajor kip-ft	Mminor kip-ft	Vmajor kips	Vminor kips	Tors kip-ft
D	T	88.60	-2.54	1.00	0.42	-0.16	-0.00
	B	88.60	2.46	-0.94	0.42	-0.16	-0.00
Ln	T	-194.43	-0.33	-1.66	-0.01	0.28	0.00
	B	-194.43	-0.43	1.87	-0.01	0.28	0.00
W1	T	5.98	0.09	38.70	-0.01	-6.85	0.00
	B	5.98	-0.06	-47.08	-0.01	-6.85	0.00
W2	T	8.07	-114.50	4.31	21.20	-0.79	0.01
	B	8.07	140.58	-5.63	21.20	-0.79	0.01
E1	T	6.03	0.09	33.69	-0.01	-6.03	0.00
	B	6.03	-0.06	-41.78	-0.01	-6.03	0.00
E2	T	7.66	-87.85	3.03	16.57	-0.57	0.00
	B	7.66	111.52	-4.07	16.57	-0.57	0.00

	Axial (kips)	Strong Axis Moment (kip*ft)	Weak Axis Moment (kip*ft)
Load Cases			
1.4D	124.0400	-3.5560	1.4000
1.2D+1.6L	-204.7680	-3.5760	-1.4560
1.2D+0.8W1	111.1040	-2.9760	32.1600
1.2D-0.8W1	101.5360	-3.1200	-29.7600
1.2D+0.8W2	112.7760	-94.6480	4.6480
1.2D-0.8W2	99.8640	88.5520	-2.2480
1.2D+L+1.6W1	-78.5420	-3.2340	61.4600
1.2D+L-1.6W1	-97.6780	-3.5220	-62.3800
1.2D+L+1.6W2	-75.1980	-186.5780	6.4360
1.2D+L-1.6W2	-101.0220	179.8220	-7.3560
1.2D+L+1.0E1	-78.4620	-3.2340	53.4440
1.2D+L-1.0E1	-97.7580	-3.5220	-54.3640
1.2D+L+1.0E2	-75.8540	-143.9380	4.3880
1.2D+L-1.0E2	-100.3660	137.1820	-5.3080
0.9D+1.6W1	89.3080	-2.1420	62.8200
0.9D-1.6W1	70.1720	-2.4300	-61.0200
0.9D+1.6W2	92.6520	-185.4860	7.7960
0.9D-1.6W2	66.8280	180.9140	-5.9960
0.9D+1.0E1	89.3880	-2.1420	54.8040
0.9D-1.0E1	70.0920	-2.4300	-53.0040
0.9D+1.0E2	91.9960	-142.8460	5.7480
0.9D-1.0E2	67.4840	138.2740	-3.9480
Worst Case			
Positive Maximum	124.0400	180.9140	62.8200
Negative Maximum	204.7680	186.5780	62.3800
Load Cases	1.2D+1.6L	1.2D+L+1.6W2	0.9D+1.6W1
Maximum	204.7680	186.5780	62.8200

	Strong Axis Shear (kips)	Weak Axis Shear (kips)
Load Cases		
1.4D	0.5880	-0.2240
1.2D+1.6L	0.4880	0.2560
1.2D+0.8W1	0.4960	-5.6720
1.2D-0.8W1	0.5120	5.2880
1.2D+0.8W2	17.4640	-0.8240
1.2D-0.8W2	-16.4560	0.4400
1.2D+L+1.6W1	0.4780	-10.8720
1.2D+L-1.6W1	0.5100	11.0480
1.2D+L+1.6W2	34.4140	-1.1760
1.2D+L-1.6W2	-33.4260	1.3520
1.2D+L+1.0E1	0.4780	-9.5600
1.2D+L-1.0E1	0.5100	9.7360
1.2D+L+1.0E2	27.0060	-0.8240
1.2D+L-1.0E2	-26.0180	1.0000
0.9D+1.6W1	0.3620	-11.1040
0.9D-1.6W1	0.3940	10.8160
0.9D+1.6W2	34.2980	-1.4080
0.9D-1.6W2	-33.5420	1.1200
0.9D+1.0E1	0.3620	-9.7920
0.9D-1.0E1	0.3940	9.5040
0.9D+1.0E2	26.8900	-1.0560
0.9D-1.0E2	-26.1340	0.7680
Worst Case		
Positive Maximum	34.4140	11.0480
Negative Maximum	33.5420	11.1040
Load Cases	1.2D+L+1.6W2	0.9D+1.6W1
Maximum	34.4140	11.1040

Member Code Check

RAM Frame v11.0
DataBase: Technical Assignment 3 — 12/02/07 20:30:22
Building Code: IBC — Steel Code: AISC LRFD

COLUMN INFORMATION:

Story Level = Second Floor   Frame Number = 0   Column Number = 7
Fy (ksi) = 50.00
Column Size = W12X96

INPUT DESIGN PARAMETERS:

	X-Axis	Y-Axis
Lu (ft)	14.00	14.00
K	1.38	1.00
Braced Against Joint Translation	No	No

CONTROLLING COLUMN FORCES - SHEAR

Load Combination: 1.200 D + 1.600 W2

Shear	Top	Vux (kips)	34.42
		Vuy (kips)	1.46
Shear	Bot.	Vux (kips)	34.42
		Vuy (kips)	1.46

SHEAR CHECK:

Vux (kips) =	34.42	0.90*Vnx (kips) =	188.60	Vux/0.90*Vnx =	0.182
Vuy (kips) =	-1.46	0.90*Vny (kips) =	592.92	Vuy/0.90*Vny =	0.002

CONTROLLING COLUMN FORCES - FLEXURE

Load Combination: 1.200 D + 1.600 W2

Axial		Load (kips)	119.23
Moment	Top	Mux (kip-ft)	-186.25
		Muy (kip-ft)	8.10
Moment	Bot.	Mux (kip-ft)	227.88
		Muy (kip-ft)	-10.14

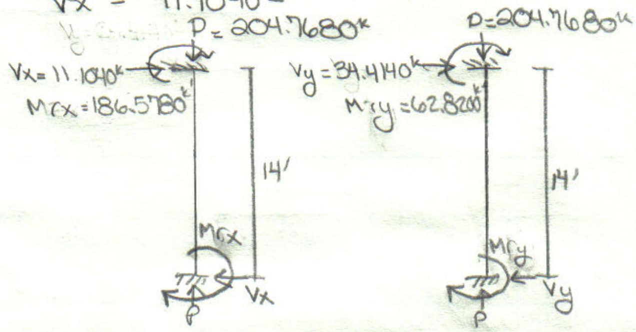
CALCULATED PARAMETERS:

Pu (kips) =	119.23	0.85*Pn (kips) =	966.12
Mux (kip-ft) =	227.88	0.90*Mnx (kip-ft) =	551.25
Muy (kip-ft) =	-10.14	0.90*Mny (kip-ft) =	249.75
Cbx =	2.24		

INTERACTION EQUATION:

$Pu/\phi Pn$ = 0.123
Eq H1-1b: 0.062 + 0.413 + 0.041 = 0.516

SECOND FLOOR INTERIOR FRAME COLUMN SPOT CHECK
W12x96
GRIDLINE G 1/2
52% CAPACITY
HEIGHT: 14'-0"
LOADS: $P_r = 204.7680^k$
$M_{rx} = 186.5780^{k'}$
$M_{ry} = 62.8200^{k'}$
$V_y = 34.4140^k$
$V_x = 11.1040^k$



STRONG AXIS   WEAK AXIS

COMPACT SECTION:

$\lambda_p = 0.38\sqrt{\frac{E}{F_y}} = 0.38\sqrt{\frac{29000\text{ ksi}}{50\text{ ksi}}} = 8.67 > \lambda = \frac{b_f}{2t_f} = 6.76$ COMPACT FLANGE

$\lambda_p = 3.76\sqrt{\frac{E}{F_y}} = 3.76\sqrt{\frac{29000\text{ ksi}}{50\text{ ksi}}} = 90.6 > \lambda = \frac{h}{t_w} = 17.7$ COMPACT WEB

COMPRESSION:

$G_{Ax} = G_{Bx} = \dfrac{\frac{2(270\text{ in}^4)}{(14')(12)}}{\frac{2(510\text{ in}^4)}{(27.67')(12)}} = 1.05$ $K = 1.38$ $G_{Ay} = G_{By} = \dfrac{\frac{2(833\text{ in}^4)}{(14')(12)}}{\frac{2(1350\text{ in}^4)}{(27.67')(12)}} = 1.18$ $K = 1.00$

$K = 1.38$

$\frac{Kl}{r_x} = \frac{(1.38)(14')(12)}{5.47''} = 42.4$

$\frac{Kl}{r_y} = \frac{(1.00)(14')(12)}{3.11''} = 54.0 \leftarrow$ CONTROLS

$\frac{Kl}{r_y} = 55.4 < 4.71\sqrt{\frac{E}{F_y}} = 4.71\sqrt{\frac{29000\text{ ksi}}{50\text{ ksi}}} = 113.4$

$F_e = \frac{\pi^2 E}{\left(\frac{Kl}{r_y}\right)^2} = \frac{\pi^2(29000\text{ ksi})}{(55.4)^2} = 93.3\text{ ksi}$

$F_{cr} = \left(0.658^{F_y/F_e}\right)F_y = \left(0.658^{(50\text{ ksi})/(93.3\text{ ksi})}\right)(50\text{ ksi}) = 40.0\text{ KSI}$

$\phi P_c = \phi F_{cr} A_g = (0.90)(40.0\text{ ksi})(28.2\text{ in}^2) = 1015^k > P_r = 205^k$ ✓OK

1/2

FLEXURE - STRONG AXIS:

$L_p = 10.6' < L_b = 14' < L_r = 46.6'$

$M_p = f_y Z_x = (50\ ksi)(147\ in^3)(1/12) = 613^{k'}$

$\phi M_{cx} = \phi C_b \left[M_p - (M_p - 0.7 f_y S_x)\left(\frac{L_b - L_p}{L_r - L_p}\right) \right] \leq M_p$

$= (0.90)(1.0)\left[613^{k'} - (613^{k'} - 0.7(50\ ksi)(131\ in^3)(1/12))\left(\frac{14' - 10.6'}{46.6' - 10.6'}\right) \right] \leq 613^{k'}$

$= 532^{k'} > M_{rx} = 187^{k'}$ ✓OK

FLEXURE - WEAK AXIS:

$\phi M_n = \phi M_p = \phi f_y Z_y = (0.90)(50 ksi)(67.5\ in^3)(1/12) = 253^{k'}$

$\leq \phi 1.6 f_y S_y = (0.90)1.6(50 ksi)(44.4\ in^3)(1/12) = 266^{k'}$

$= 266^{k'} \geq M_{ry} = 62.8^{k'}$ ✓OK

SHEAR - STRONG AXIS:

$\frac{h}{t_w} = 17.7 \leq 2.24\sqrt{\frac{E}{F_y}} = 2.24\sqrt{\frac{29000\ ksi}{50 ksi}} = 53.9$ ✓OK

$\phi V_n = \phi 0.6 F_y A_w C_v = (0.90)0.6(50\ ksi)(0.550'')(12.7'')(1.0) = 189^k > V_{ux} = 11.1^k$ ✓OK

SHEAR - WEAK AXIS:

$\frac{h}{t_w} = 17.7 < 1.10\sqrt{\frac{k_v E}{F_y}} = 1.10\sqrt{\frac{(1.2)(29000\ ksi)}{50 ksi}} = 29.0$

$\phi V_n = \phi 0.6 F_y A_w C_v = (0.90)0.6(50\ ksi)(12.2'')(0.9'')(1.0) = 296^k > V_{uy} = 34.4^k$ ✓OK

COMBINED COMPRESSION AND FLEXURE:

$\frac{P_r}{P_c} + \frac{8}{9}\left(\frac{M_{rx}}{M_{cx}} + \frac{M_{ry}}{M_{cy}}\right) \leq 1.0$

$\frac{205^k}{1128^k} + \frac{8}{9}\left(\frac{187^{k'}}{591^{k'}} + \frac{62.8^{k'}}{296^{k'}}\right) = 0.65 \leq 1.0 \ne 0.52$

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