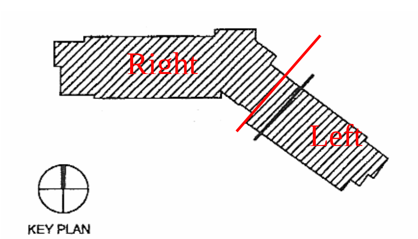
Executive Summary

The University of Pittsburgh is currently constructing a dormitory facility on its upper campus. This building is approximately 161,600sf and 9 stories above grade plus one ground level. The Upper Campus Housing Project will house approximately 500 students. It is located on Stadium Drive, not far from The Peterson Events Center. The building can be broken down into two separate buildings for analysis along the expansion joint located at Column Line 3 (displayed with a red line). For the purposes of this assignment right and left sides of the expansion joint have been designated as shown in the diagram. The main entrance to the building is on the South side. Here, a large staircase leads into the Lobby/Café area. The building façade consists of brick curtain wall containing windows of tempered insulated spandrel and vision glass. The brick façade consists of different shades of light brown, complimenting surrounding structures.

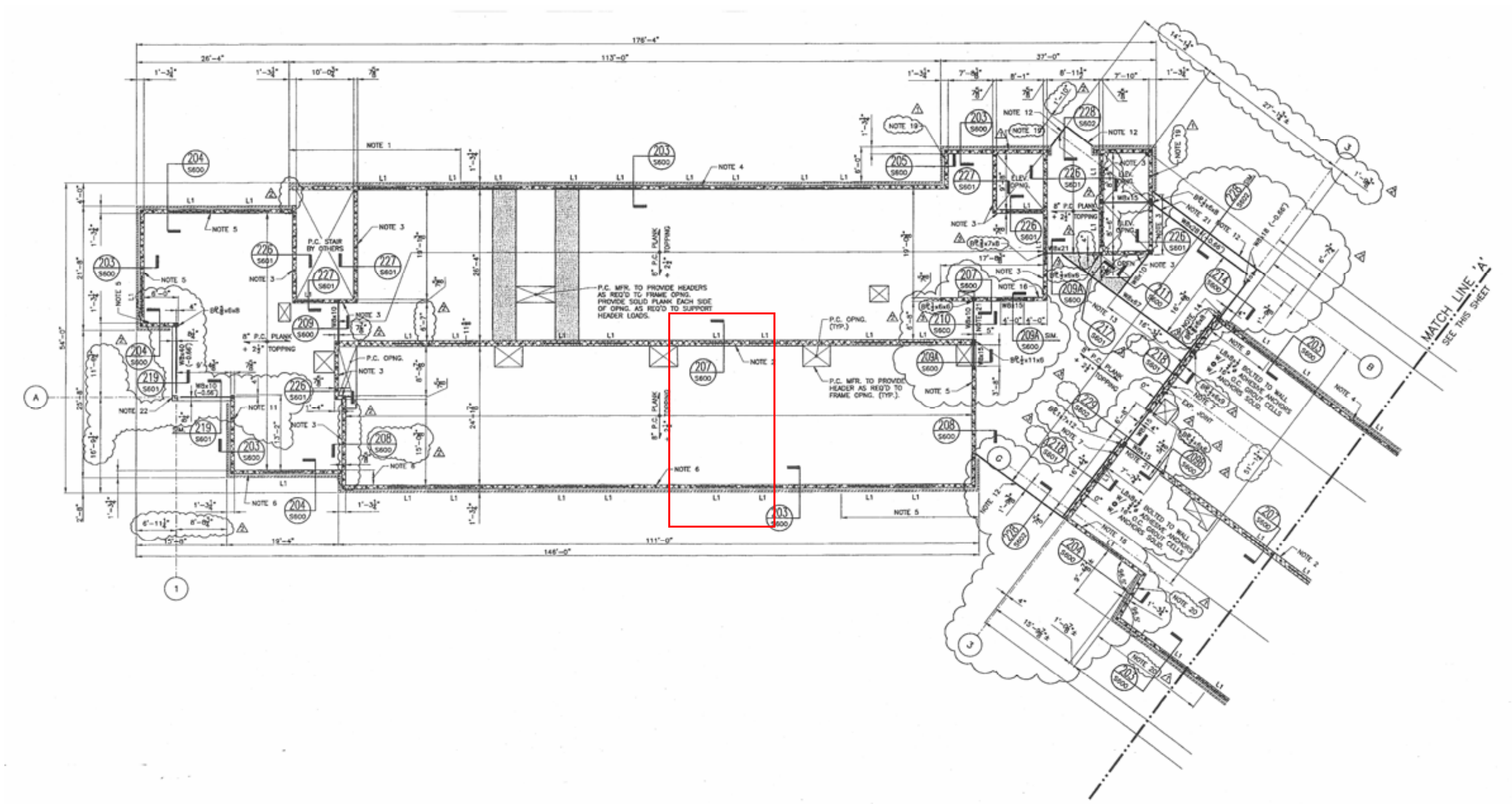


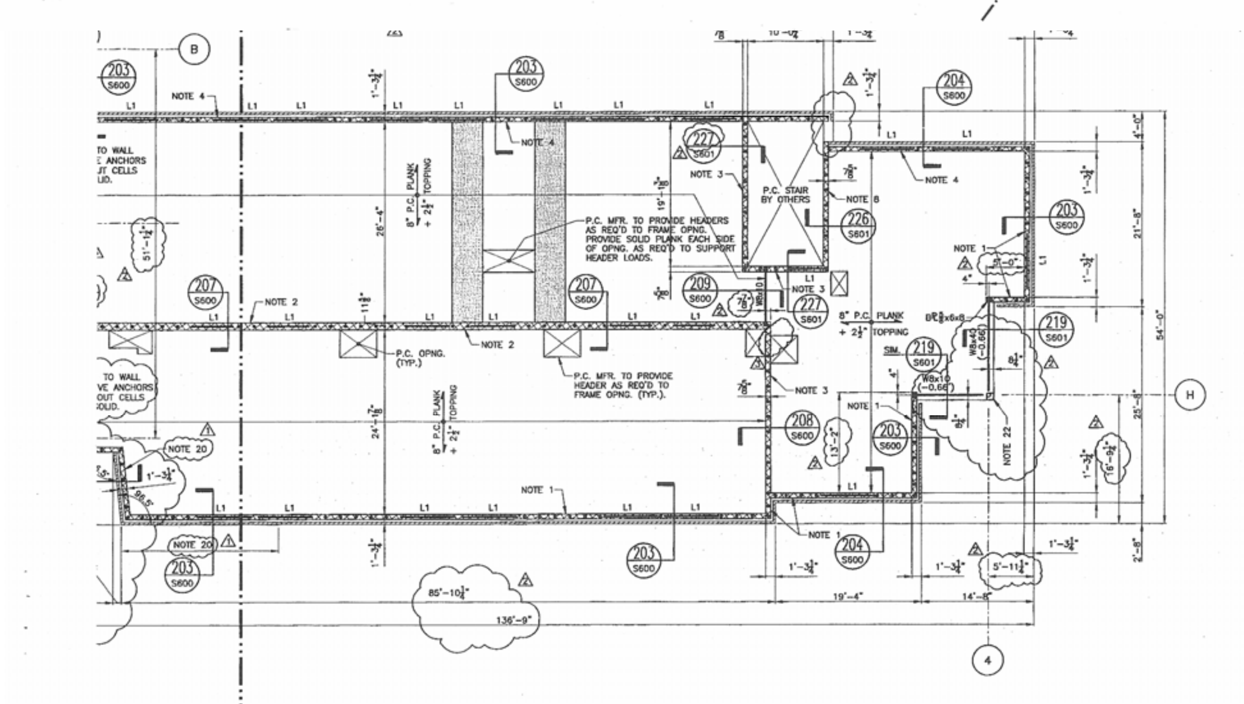
Construction on the Upper Campus Housing Project began in May of 2005 and is expected to end in July of 2006. The overall cost of the dormitory building is approximately 33 million dollars.

This report explores the structural concepts of the building as well as the existing conditions. In addition to a description of the building systems (floor, lateral, and foundation), an analysis of the floor loads and lateral loads was completed. Using the PCI Design Handbook this report demonstrates that for a typical bay the 8" plank with 2 ½" topping is sufficient to carry dormitory floor loads. Also, an analysis of the lateral system and a spot check of a shear wall conclude that it is sufficient to carry the wind loads applied to the structure.

The model building code used to design and analyze this building was IBC 2003.

As stated in the executive summary, the following report will examine the structural concepts and existing conditions of the Upper Campus Housing Project on the University of Pittsburgh's campus. The building consists of 8" precast hollow-core concrete plank with a 2 ½" topping. The plank will be solid were needed, which is to be decided by the manufacturer. The lateral system for the Upper Campus Housing project consists of reinforced masonry bearing and shear walls. Shown below is the typical framing layout used for this building.





Overall Structural System

Framing Information		
Floor	**Typical Framing**	**Typical Span**
First	8" P.C. Plank + 2 1/2" Topping	24'-1 7/8" --> 29'-4"
Second-Eighth	8" P.C. Plank + 2 1/2" Topping	24'-1 7/8" --> 29'-4"
Ninth	8" P.C. Plank + 2 1/2" Topping	24'-1 7/8" --> 29'-4"
Roof	8"-12" P.C. Plank w/o Topping	24'-1 7/8" --> 29'-4"
	HSS6x6x3/8 Galv. Vert. Tube	Roof column
	HSS6x6x1/4	10'
	Galv. 3 1/2" Dia. Std. Pipe	Roof column
	Galv. W10x22	5' --> 8'-7"

Reinforced masonry walls of varying thicknesses and reinforcement designs support the plank system.

There are also five steel columns in this building (1A, 2F, 2J, 3B, 4H). They are all HSS6.625x0.500. Two of these columns (2F and 2J) only span from the ground floor to the first floor (L=12'-6"). Two other columns (1A and 4H) span all the way to the ninth floor. Also, the last of the five columns (3B) spans the entire height of the building. Column 1A sits on a W8x31 transfer girder, which transfers the load from the column into the foundation. Columns 3B and 4H sit on concrete piers at the second floor level.

Also in this building there are four 20" dia. Concrete Piers located at column lines 3C, 3D, 3E, 3G. Each of these concrete piers spans from SOG to the second floor level.

Minimum Design Compression Strength (f'c) at 28 days for Reinforced Concrete:

Foundations	3000psi
Walls	5000psi
Slabs on Grade	4000psi
Interior Slabs	4000psi
Exterior Slabs	4000psi
Structural Slab and Elevated Slab (Ext.)	5000psi
Structural Slab and Elevated Slab (Int.)	4000psi

The location of the lateral resisting elements is displayed on page 9 with the shear wall spot check.

Codes

The following codes were used for the design and analysis of the Upper Campus Housing Project:

- ✓ International Building Code 2003
- ✓ ASTM
- ✓ ACI 318 (Building Code Requirements for Structural Concrete)
- ✓ ACI 530 (Building Code Requirements for Masonry Structures)
- ✓ AISC (Specifications for Structural Steel Buildings)
- ✓ Loading and Lateral Code: International Building Code 2003/ASCE7-02

Loading

DESIGN LOADS	Dead Loads	Partitions	20psf
	Live Loads	Roof	30psf
		LowRoof	70psf
		Lobbies	100psf
		First Floor Corridors	100psf
		Dormitory Living Spaces	40psf
		Mechanical Roof	100psf
		Stairs	100psf
	Wind	Basic Wind Speed (3s Gust)	90mph
		Wind Importance Factor (I_w)	1.15
		Exposure Category	B
		Enclosure Classification	Enclosed
		Building Category	III
		Internal Pressure Ceofficient (GCPI)	0.18
		Wind Design Pressure +P(Windward)	26psf
		Wind Design Pressure -P(leeward)	24psf
		Components and Cladding Pressures	see table
	Seismic	Seismic Design Category	B
		Seismic Use Group	1
		S_{DS}	0.137
		S_{D1}	0.092
		Site Class	D
		Basic Seismic Force Resisting System	Reinf. Masonry Shear Walls
		Design Base Shear	N/A
		Analysis Procedure	IBC 1616.6.1
	Snow	Base Ground SnowLoad P_G	30psf
		Flat Roof SnowLoad P_F	23psf
		Flat LowRoof SnowLoad	70psf
		SnowExposure Factor C_F	1.0
		SnowLoad Importance Factor I_S	1.1
		Thermal Factor C_T	1.0

Dead Load

DL= 20psf (partitions) + 25psf (SDL) + (8" + 2.5")(1ft/12in)(150pcf) = 177psf

Wind Loading

This building uses reinforced masonry shear walls as its main wind resisting system. Wind calculations were done in both the North/South and East/West directions. The following charts display the results in each direction. The calculations are shown in Appendix 1.1.

Lateral Note:

Occupancy Type III

"Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities"

(ASCE7-02 Table 1-1)

Assumptions:

1. Part of the building Ground floor is under the soil height. Other parts of the building are entirely above ground. Therefore, to determine the worst case wind effects I used the height above ground = total height of building.
2. Because there is an expansion joint located along Column Line 3, assume each side of the building will act as its own lateral system.

Worst Case Wind

z(ft)	**k_z(T6-3)	q_z	$P_{sidewall}$(psf)	$P_{leeward}$(psf)	$P_{windward}$(psf)	P_{total}(psf)
0-15	0.57	11.554	-6.874	-8.959	7.856	16.816
20	0.62	12.567	-7.477	-8.959	8.546	17.505
25	0.66	13.378	-7.960	-8.959	9.097	18.056
30	0.70	14.189	-8.442	-8.959	9.648	18.607
40	0.76	15.405	-9.166	-8.959	10.475	19.434
50	0.81	16.418	-9.769	-8.959	11.164	20.124
60	0.85	17.229	-10.251	-8.959	11.716	20.675
70	0.89	18.040	-10.734	-8.959	12.267	21.226
80	0.93	18.851	-11.216	-8.959	12.818	21.777
90	0.96	19.459	-11.578	-8.959	13.232	22.191
100	0.99	20.067	-11.940	-8.959	13.645	22.604
120	1.04	21.080	-12.543	-8.959	14.335	23.294

Snow Loading

The following information comes from ASCE7-02 for a fully exposed structure:

- ✓ Terrain Category B (6.5.6.2)
- ✓ Ce = 0.9 (Table 7-2)
- ✓ Ct = 1.0 (Table 7-3)
- ✓ I = 1.1 (Table 7-4)
- ✓ Pg = 30psf (Figure 7-1)

Flat Roof Snow Load (p_f) = $0.7C_eC_tIPg$ = 20.8psf

Seismic Loading

Calculation of total dead load of structure:

Masonry wall = 120plf(1250ft) = 150K
8" plank = 56psf + 31psf + 10psf (misc) = 97psf
12" plank = 1ft(150pcf) + 10psf = 160psf
Ground Floor = [16322sf(4"/12)(150pcf)]/1000 + 150K = 966.1K
First = [15986sf(97plf)]/1000 + 150K = 1701K
Second → Eighth = [16340sf(97plf)/1000] + 150K = 1735K
Ninth = [13892sf(97plf)/1000] + 150K = 1498K
Roof = [6946sf(97plf) + 6946sf(160plf)]/1000 + 150K = 1935K
Penthouse = [1020sf(160plf)]/1000 = 313.2K

Seismic calculations were done in both North/South and East/West directions. However, for this building both directions are the same. The following chart shows the resultant force per floor level caused by the seismic base shear (V=1219.5K).

Level	w_x	h_x	$w_x h_x^{1.07}$	C_{vx}	F_x
Penth.	313.2	114.84	50132.7	0.0311	26
Roof	1935	109.17	293394	0.1822	152.16
9	1498	98.67	203840	0.1266	105.72
8	1735	89.34	212285	0.1318	110.1
7	1735	80	188628	0.1171	97.826
6	1735	70.67	165189	0.1026	85.67
5	1735	61.34	141966	0.0882	73.627
4	1735	52	118966	0.0739	61.698
3	1735	42.67	96278.8	0.0598	49.932
2	1735	33.34	73938.8	0.0459	38.346
1	1701	24	50995.3	0.0317	26.447
Ground	966.1	12.67	14621.5	0.0091	7.583
SUMs			1610236	1	835.1

V= 835.1

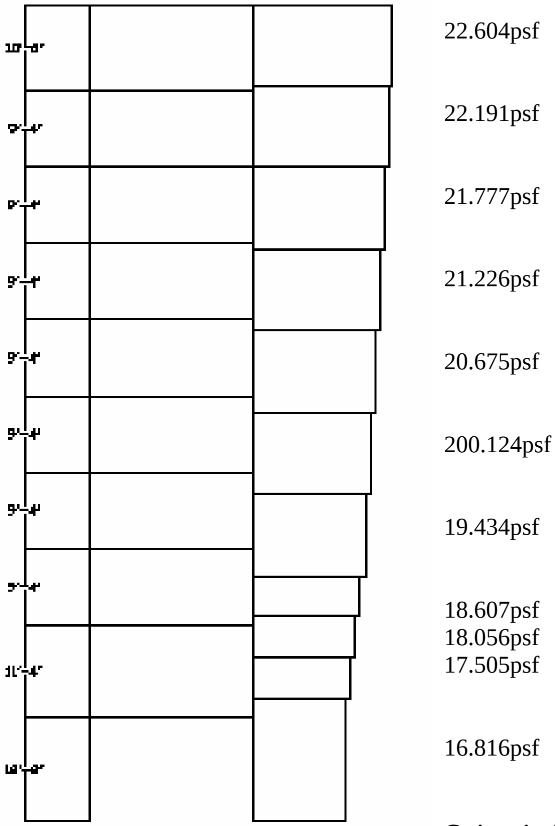
Seismic calculations are shown in Appendix 2.1.

The resulting overturning moment Mo is calculated with the following equation:

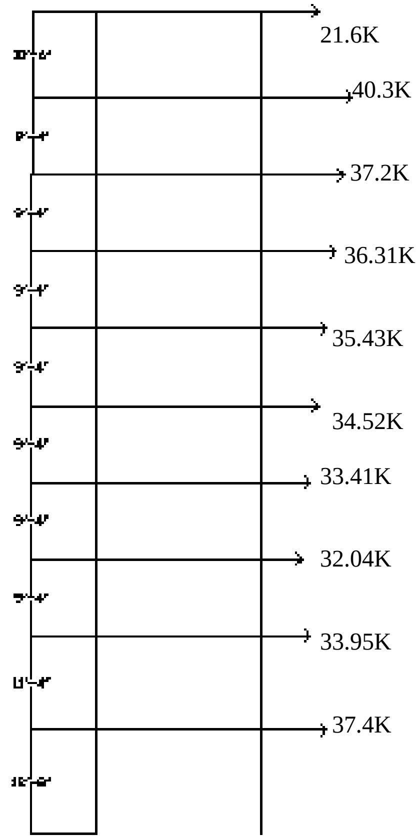
Mo=26K(114.84') + 152.2K(109.17') + 105.72K(98.67') + 110.1K(89.34')
+ 97.826K(80') + 85.67K(70.67') + 73.63K(61.34') + 61.69K(52')
+ 49.93K(42.67') + 38.45K(33.34') + 26.45K(24') + 7.58K(12.67')
= 65622.5 ft-K

The results for all lateral loading are displayed on the next page.

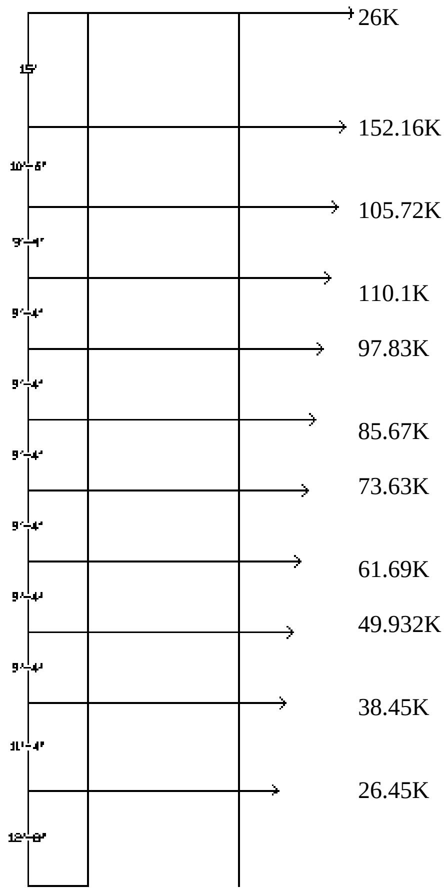
Wind Load Distribution



Wind Load on Each Floor



Seismic Loads



Spot Checks

Plank Check

Typical bay is designated with a red box on the framing layout.

Live Load Reduction:

A_T = Span x 1.5Span = (24'-1 78")(1.5)(24'-1 7/8") = 875.3ft^2 (4.8.5)

K_{LL} = 1.0 (Table 4-2)

L = L_0[0.25 + (15/($K_{LL}A_T$)^0.5)] = 0.76L_0

= 0.76(40psf) = 30.4psf

Dead Load:

Weight of 8" Hollow-core slab without topping = 56psf (PCI)

DL = 25psf + 20psf + 56psf + 2.5"(1ft/12in)(150pcf) = 133psf

Service Load = 30.4psf + 133psf = 163.4psf

PCI Handbook:

Page 2-26

Span = 25ft

8" plank + 2 ½" topping OK

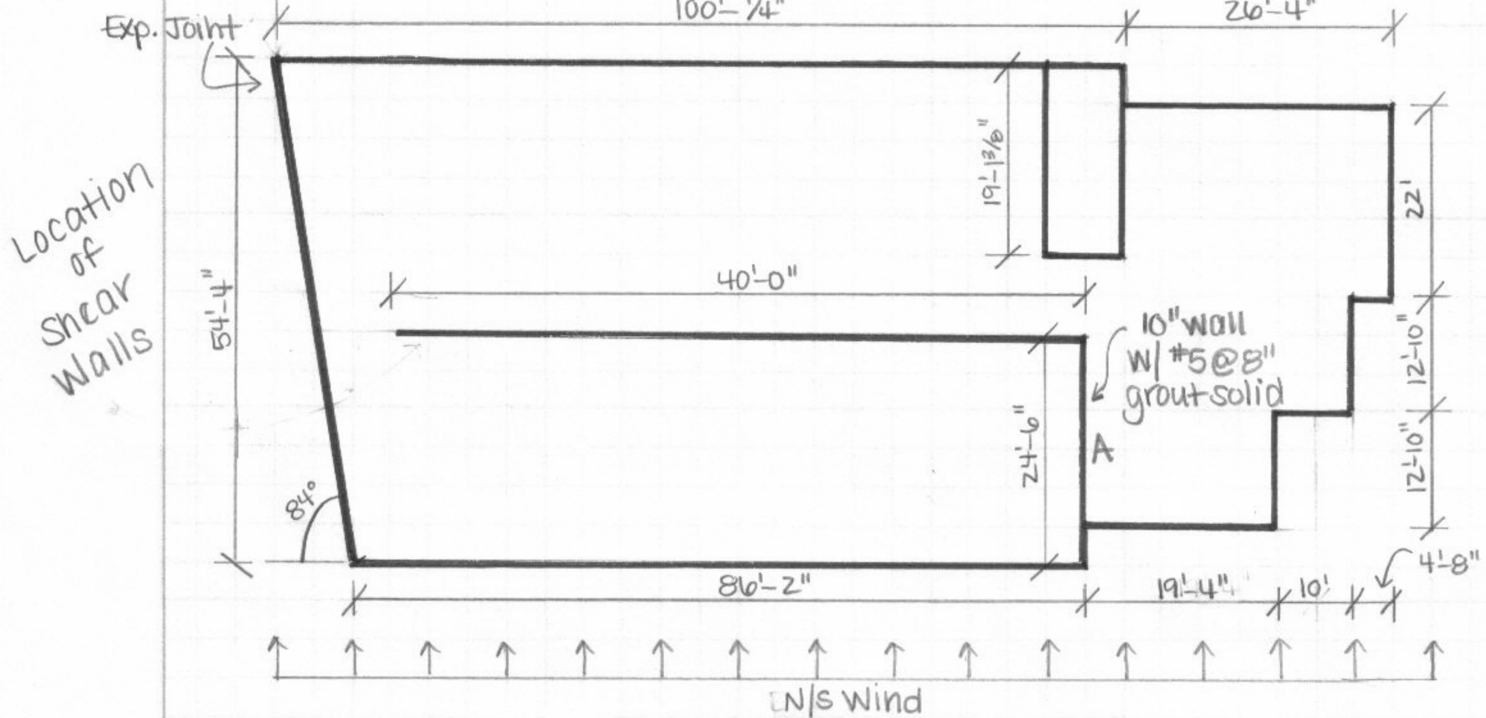
***Reinforcement of plank to be designed by manufacturer

Shear Wall Check

The shear wall check is displayed on the next page.

Masonry Bearing/shear Wall Check

*Neglecting "small" shear walls to be conservative...



Distribute Load using stiffness concept (wall length as a generality)

total length of shear members = 54'-4" + 24'-6" + 2(19'-1 3/8") + 54'-4"
= 171.56'

length of wall "A" = 24'-6"

% of load to wall "A" = $24\,lb/ft^2\,(24.5'/171.56') = 3.43\,lb/ft^2$

Wall Design

$f'_m = 1500\,psi$, GR 60

$A_t = 52.8'(24.5')$
$= 1292.7\,ft^2$

97psf(1292.7)(1.2) + 1.6(40psf) = 150K

150K(9') = 1354.2K

70psf(1292.7)(1.6)
= 144.8K

$S = \frac{1}{6}(9.625)(294")^2 = 138657.8\,in^3$

$A = 9.625"(294") = 2829.8\,in^2$

$f_t = M/S - P/A = [[(5.35K)(12.5')(12) + (4.85K)(23.83')(12) + (4.58)(33.16')(12) + (4.78K)(42.5')(12) + (4.94)(51.8')(12) + (5.07)(61.1)(12) + (5.2)(70.4)(12) + (5.3)(79.7)(12) + (5.8)(89)(12) + (3.1)(100)(12)] / 138657.8 - (1498.9K/2829.8)]$
$= -294.5\,psi$

$R = 0.986$

$F_a = 0.25 f'_m R = 0.25(1500)(0.986) = 369.8\,psi$

Wall OK

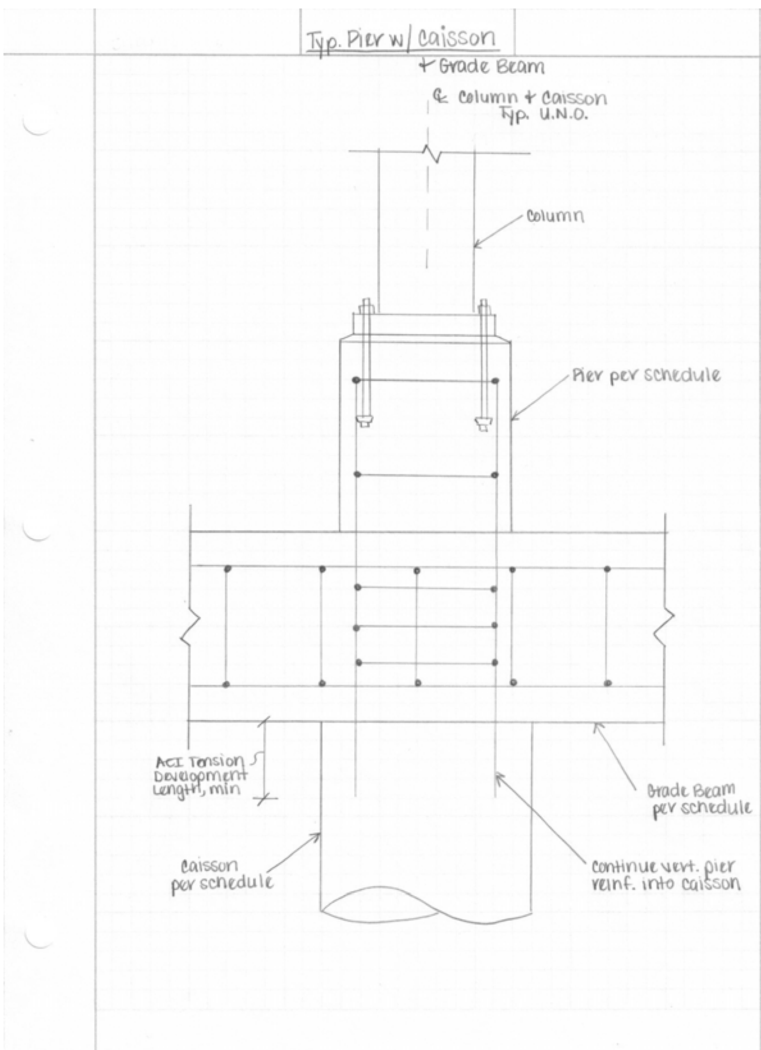
Foundation System

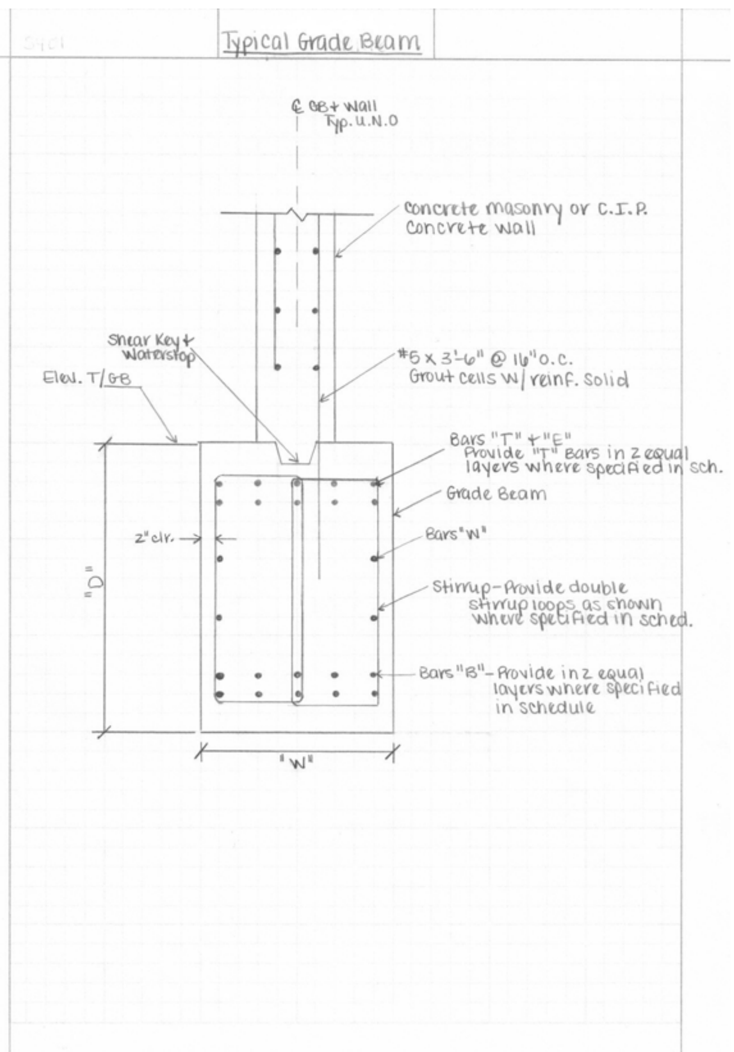
The foundation system of this building begins with 71 drilled concrete caissons. As stated above, each concrete caisson has a concrete strength (f'c) = 3000psi. The diameters of these caissons range from 36"-66". All caissons are designed to bear on either limestone/sandstone bedrock or shale/sandstone bedrock per geotechnical report dated December of 2004.

The foundation system also includes 78 concrete grade beams, which sit on the concrete caissons. The concrete strength of this concrete is also specified at 3000psi. All grade beams have a width = 24", except for GB 67 which has a width = 30". The depths of the grade beams range from 36"-60".

The concrete masonry walls then sit directly on the grade beams. At each connection between a concrete masonry wall and a grade beam there is a key and waterstop. The key is provided to prevent sliding between members. Reinforcement is also used to connect members and transfer load between.

Below are typical foundation details.





Conclusion

The structure of the Upper Campus Housing Project consists of a precast concrete plank floor system with reinforced concrete masonry bearing and shear walls. This report includes a basic analysis of the loads applied to this building. However, there are many more factors that must be considered when analyzing this structure. In a future assignment I will look more in depth into the lateral system. Because of the size of the building and the complexity of the shear wall layout an analysis program such as ETABS will be used to complete the lateral system analysis. Some other factors that must be considered in future analysis are: snow drift, foundation design, and displacement.

Some spot checking was done during the analysis for this report. The plank floor system was analyzed for floor dead and live load. Using the PCI Design Handbook, an 8” hollow-core plank with a 2 ½” topping is sufficient to carry the loads in a typical dorm room area of the building. The reinforcement for the plank will be designed by the plank manufacturer. The manufacturer will also designate where the plank needs to be solid. In the existing plans this occurs on the roof area where the plank is 12”. Also, an analysis on a wall on the first floor was done for dead, live, and wind loading. This analysis concluded that the wall is sufficient to carry the loads applied to it. As stated above a much more in depth analysis will be complete in Tech 3. A description of the foundation system was also complete with two typical foundation details. For future assignments, where the design of the structure will be changed, the foundation system will most likely be effected and possible completely different. For example, if a two-way system is used, spread footings will be used under columns.

Appendix

Nicole Hazy
Faculty Consultant: Dr. Hanagan
Structural
Tech Report 1

Appendix 1.1

Project Name: PITT
Project #: Tech 1
Calculated By: NLH
Date: 5-Oct-05

Main Wind Force Resisting System per ASCE7-02

Assumptions:

***FOR ALL "h"

***Calculating Wind in Direction: **E/W** Left Half of Building

Building Name	Upper Campus Housing Project			
Building Location	Pittsburgh, PA			
Location Data	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Occupancy Type	-	1.5.1	T1-1	III
Importance Factor	I	6.5.5	T6-1	1.15
Surface Roughness	-	6.5.6.2	-	-
Exposure Factor	-	6.5.6.3	-	B
Enclosure Classification**	-	-		Open
				Partially
			X	Enclosed
Internal Pressure Coefficient	GC_{pi}	-	-	0.18
Topographic	K_{zt}	6.5.7.2	F6-4*	1.00
$*K_{zt}=(1+k_1k_2k_3)^2$				
**Place an "X" in the box indicating Enclosure Classification				

Building Dimensions (ft)	**Variable**	**Reference**	**Source**	**Value**
Height Above Base	h_n	9.5.5.3	Spec	102.15
Height Above Ground	z	6.300	Spec	102.15
Horiz. Length ll to Wind Dir.	L	6.300	Spec	184.33
Horiz. Length Perp. to Wind	B	6.300	Spec	54.33
Horizontal Dimension Ratio	L/B	F6-6	Spec	3.39
Mean Roof Height	h	6.200	*	100.99
*Average of roof eave height and height of highest point of roof				

Wind Velocity (mph)	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Basic Wind Speed	V	6.5.4	F6.1	90
Wind Directionality	k_d	6.5.4.4	T6-4	0.85
3-sec Gust Power Law	α	6.300	T6-2	7.0
Mean Wind Speed Factor: α hat	a	6.5.8.2	T6-2	0.25
Wind Coefficient: b hat	b	6.5.8.2	T6-2	0.45
Min Height	z_{min}	6.5.8.2	T6-2	30
Equivalent Height: z hat	z	6.5.8.2	T6-2	60.594
Mean Hourly Wind Speed	V_z	6.5.8.2	Eq 6-14	69.15
Height atm Boundary	z_g	6.300	T6-2	1200
Velocity Pressure Exp.*	k_z	6.5.6.6	T6-3**	1.04

Velocity Pressure Exp.*	k_h	6.5.6.6	T6-3**	1.04
*Calculated for (15'<z<z_g), or use Table 6-3				
**k_z and k_h: Use "Kz" Sheet to find value coordinating to largest "z"				

Integral Length Scale	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Integral Length Scale Factor	ℓ	6.5.8.1	T6-2	320
Integral Length Scale Exp	ε	6.5.8.1	T6-2	0.33
Integral Length Scale, Turb.	L_z	6.5.8.1	Eq 6-7	391.06
Turbulence Intensity Factor	c	6.300	T6-2	0.30
Intensity of Turbulence	I_z	6.5.8.1	Eq 6-5	0.27

Fundamental Period	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Period Coefficient	C_t	9.5.3.2	T9.5.5.3.2	0.02
Period Exponent	x	9.5.3.2	T9.5.5.3.2	0.75
Approx. Fund. Period	T_a	9.5.3.2	$T_a=C_t(h_n^x)$	0.64
Natural Frequency	n_1	6.5.8.2	$n_1=1/T_a$	1.56
Rigid or Flexible	-	6.5.8.2	$n_1>1$?	Rigid

Resonance	**Variable**	**Reference**	**Chart/Fig.**	**Value**	**η**
R_1 Coefficient	R_h	6.5.8.2	Eq 6-13	0.091	10.455
R_1 Coefficient	R_b	6.5.8.2	Eq 6-13	0.162	5.624
R_1 Coefficient	R_l	6.5.8.2	Eq 6-13	0.016	63.884
Reduced Frequency	N_1	6.5.8.2	Eq 6-13	8.801	
Resonance Coefficient	R_n	6.5.8.2	Eq 6-13	0.035	
Damping Ratio	β	6.300	Section 9	0.050	
Resonant Response Factor	R	6.5.8.2	Eq 6-10	0.075	

Gust Effect Factor	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Gust Coefficient	g_q	6.5.8.2	Eq 6-8	3.4
Gust Coefficient	g_v	6.5.8.2	Eq 6-8	3.4
Gust Coefficient	g_r	6.5.8.2	Eq 6-9	4.29
Background Response	Q	6.5.8.1	Eq 6-6	0.86
Gust Factor	G_f	6.5.8.2	Eq 6-8	0.85

Wind Pressure	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Velocity Pressure	qz	6.5.10	Eq 6-15	21.080
Velocity Pressure @ h	qh	6.5.12.2	T6-3*	21.080
*$q_h=0.00256k_hk_{zt}k_d(V^2)I$				

Ext. Pressure Coefficient	Variable	Reference	Chart/Fig.	Value
Windward Side	C_p	6.5.11.2	F6-6*	0.8
Leeward Side	C_p	6.5.11.2	F6-6*	-0.2303608
Sidewall	C_p	6.5.11.2	F6-6*	-0.7
*Formulas must be checked with any new code changes				

Leeward Pressure (psf)	P_1	6.5.12.2	$P_1=q_hG_fC_p$	-4.128

Final Pressure (psf)	$P=q_zG_fC_p-q_hG_fC_p$

z(ft)	**k_z(T6-3)	q_z	$P_{sidewall}$(psf)	$P_{leeward}$(psf)	$P_{windward}$(psf)	P_{total}(psf)
0-15	0.57	11.554	-6.874	-4.128	7.856	11.984
20	0.62	12.567	-7.477	-4.128	8.546	12.673
25	0.66	13.378	-7.960	-4.128	9.097	13.225
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40	0.76	15.405	-9.166	-4.128	10.475	14.603
50	0.81	16.418	-9.769	-4.128	11.164	15.292
60	0.85	17.229	-10.251	-4.128	11.716	15.843
70	0.89	18.040	-10.734	-4.128	12.267	16.395
80	0.93	18.851	-11.216	-4.128	12.818	16.946
90	0.96	19.459	-11.578	-4.128	13.232	17.360
100	0.99	20.067	-11.940	-4.128	13.645	17.773
120	1.04	21.080	-12.543	-4.128	14.335	18.462
140	-	-	-	-	-	-
160	-	-	-	-	-	-
180	-	-	-	-	-	-
200	-	-	-	-	-	-
225	-	-	-	-	-	-
300	-	-	-	-	-	-
350	-	-	-	-	-	-
400	-	-	-	-	-	-
450	-	-	-	-	-	-
500	-	-	-	-	-	-

**k_z and k_h: Use "Kz" Sheet to copy and paste values

Nicole Hazy
Faculty Consultant: Dr. Hanagan
Structural
Tech Report 1

Project Name: PITT
Project #: Tech 1
Calculated By: NLH
Date: 5-Oct-05

Main Wind Force Resisting System per ASCE7-02

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Importance Factor	I	6.5.5	T6-1	1.15
Surface Roughness	-	6.5.6.2	-	-
Exposure Factor	-	6.5.6.3	-	B
Enclosure Classification**	-	-		Open
				Partially
			X	Enclosed
Internal Pressure Coefficient	GC_{pi}	-	-	0.18
Topographic	K_{zt}	6.5.7.2	F6-4*	1.00
$*K_{zt}=(1+k_1k_2k_3)^2$				
**Place an "X" in the box indicating Enclosure Classification				

Building Dimensions (ft)	Variable	Reference	Source	Value
Height Above Base	h_n	9.5.5.3	Spec	102.15
Height Above Ground	z	6.300	Spec	102.15
Horiz. Length ll to Wind Dir.	L	6.300	Spec	136.5
Horiz. Length Perp. to Wind	B	6.300	Spec	54.33
Horizontal Dimension Ratio	L/B	F6-6	Spec	2.51
Mean Roof Height	h	6.200	*	100.99
*Average of roof eave height and height of highest point of roof				

Wind Velocity (mph)	Variable	Reference	Chart/Fig.	Value
Basic Wind Speed	V	6.5.4	F6.1	90
Wind Directionality	k_d	6.5.4.4	T6-4	0.85
3-sec Gust Power Law	α	6.300	T6-2	7.0
Mean Wind Speed Factor: α hat	a	6.5.8.2	T6-2	0.25
Wind Coefficient: b hat	b	6.5.8.2	T6-2	0.45
Min Height	z_{min}	6.5.8.2	T6-2	30
Equivalent Height: z hat	z	6.5.8.2	T6-2	60.594
Mean Hourly Wind Speed	V_z	6.5.8.2	Eq 6-14	69.15
Height atm Boundary	z_g	6.300	T6-2	1200
Velocity Pressure Exp.*	k_z	6.5.6.6	T6-3**	1.04

Velocity Pressure Exp.*	k_h	6.5.6.6	T6-3**	1.04
*Calculated for (15'<z<z_g), or use Table 6-3				
**k_z and k_h: Use "Kz" Sheet to find value coordinating to largest "z"				

Integral Length Scale	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Integral Length Scale Factor	ℓ	6.5.8.1	T6-2	320
Integral Length Scale Exp	ε	6.5.8.1	T6-2	0.33
Integral Length Scale, Turb.	L_z	6.5.8.1	Eq 6-7	391.06
Turbulence Intensity Factor	c	6.300	T6-2	0.30
Intensity of Turbulence	I_z	6.5.8.1	Eq 6-5	0.27

Fundamental Period	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Period Coefficient	C_t	9.5.3.2	T9.5.5.3.2	0.02
Period Exponent	x	9.5.3.2	T9.5.5.3.2	0.75
Approx. Fund. Period	T_a	9.5.3.2	$T_a=C_t(h_n^x)$	0.64
Natural Frequency	n_1	6.5.8.2	$n_1=1/T_a$	1.56
Rigid or Flexible	-	6.5.8.2	n_1>1?	Rigid

Resonance	**Variable**	**Reference**	**Chart/Fig.**	**Value**	**η**
R_1 Coefficient	R_h	6.5.8.2	Eq 6-13	0.091	10.455
R_1 Coefficient	R_b	6.5.8.2	Eq 6-13	0.162	5.624
R_1 Coefficient	R_l	6.5.8.2	Eq 6-13	0.021	47.307
Reduced Frequency	N_1	6.5.8.2	Eq 6-13	8.801	
Resonance Coefficient	R_n	6.5.8.2	Eq 6-13	0.035	
Damping Ratio	β	6.300	Section 9	0.050	
Resonant Response Factor	R	6.5.8.2	Eq 6-10	0.075	

Gust Effect Factor	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Gust Coefficient	g_q	6.5.8.2	Eq 6-8	3.4
Gust Coefficient	g_v	6.5.8.2	Eq 6-8	3.4
Gust Coefficient	g_r	6.5.8.2	Eq 6-9	4.29
Background Response	Q	6.5.8.1	Eq 6-6	0.86
Gust Factor	G_f	6.5.8.2	Eq 6-8	0.85

Wind Pressure	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Velocity Pressure	qz	6.5.10	Eq 6-15	21.080
Velocity Pressure @ h	qh	6.5.12.2	T6-3*	21.080
*q_h=0.00256$k_h k_{zt} k_d(V^2)$I				

Ext. Pressure Coefficient	Variable	Reference	Chart/Fig.	Value
Windward Side	C_p	6.5.11.2	F6-6*	0.8
Leeward Side	C_p	6.5.11.2	F6-6*	-0.2743788
Sidewall	C_p	6.5.11.2	F6-6*	-0.7
*Formulas must be checked with any new code changes				

Leeward Pressure (psf)	P_1	6.5.12.2	$P_1=q_h G_f C_p$	-4.916

Final Pressure (psf)	$P = q_z G_f C_p - q_h G_f C_p$

z(ft)	**k_z(T6-3)	q_z	$P_{sidewall}$(psf)	$P_{leeward}$(psf)	$P_{windward}$(psf)	P_{total}(psf)
0-15	0.57	11.554	-6.874	-4.916	7.856	12.773
20	0.62	12.567	-7.477	-4.916	8.546	13.462
25	0.66	13.378	-7.960	-4.916	9.097	14.013
30	0.70	14.189	-8.442	-4.916	9.648	14.565
40	0.76	15.405	-9.166	-4.916	10.475	15.392
50	0.81	16.418	-9.769	-4.916	11.164	16.081
60	0.85	17.229	-10.251	-4.916	11.716	16.632
70	0.89	18.040	-10.734	-4.916	12.267	17.183
80	0.93	18.851	-11.216	-4.916	12.818	17.735
90	0.96	19.459	-11.578	-4.916	13.232	18.148
100	0.99	20.067	-11.940	-4.916	13.645	18.562
120	1.04	21.080	-12.543	-4.916	14.335	19.251
140	-	-	-	-	-	-
160	-	-	-	-	-	-
180	-	-	-	-	-	-
200	-	-	-	-	-	-
225	-	-	-	-	-	-
300	-	-	-	-	-	-
350	-	-	-	-	-	-
400	-	-	-	-	-	-
450	-	-	-	-	-	-
500	-	-	-	-	-	-

**k_z and k_h: Use "Kz" Sheet to copy and paste values

Nicole Hazy
Faculty Consultant: Dr. Hanagan
Structural
Tech Report 1

Project Name: PITT
Project #: Tech 1
Calculated By: NLH
Date: 5-Oct-05

Main Wind Force Resisting System per ASCE7-02

Assumptions:
***FOR ALL "h"

***Calculating Wind in Direction:	**N/S**	Left Half of Building

Building Name	Upper Campus Housing Project			
Building Location	Pittsburgh, PA			
Location Data	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Occupancy Type	-	1.5.1	T1-1	III
Importance Factor	I	6.5.5	T6-1	1.15
Surface Roughness	-	6.5.6.2	-	-
Exposure Factor	-	6.5.6.3	-	B
Enclosure Classification**	-	-		Open
				Partially
			X	Enclosed
Internal Pressure Coefficient	GC_{pi}	-	-	0.18
Topographic	K_{zt}	6.5.7.2	F6-4*	1.00
$*K_{zt}=(1+k_1k_2k_3)^2$				
**Place an "X" in the box indicating Enclosure Classification				

Building Dimensions (ft)	**Variable**	**Reference**	**Source**	**Value**
Height Above Base	h_n	9.5.5.3	Spec	102.15
Height Above Ground	z	6.300	Spec	102.15
Horiz. Length ll to Wind Dir.	L	6.300	Spec	54.33
Horiz. Length Perp. to Wind	B	6.300	Spec	184.33
Horizontal Dimension Ratio	L/B	F6-6	Spec	0.29
Mean Roof Height	h	6.200	*	100.99
*Average of roof eave height and height of highest point of roof				

Wind Velocity (mph)	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Basic Wind Speed	V	6.5.4	F6.1	90
Wind Directionality	k_d	6.5.4.4	T6-4	0.85
3-sec Gust Power Law	α	6.300	T6-2	7.0
Mean Wind Speed Factor: α hat	a	6.5.8.2	T6-2	0.25
Wind Coefficient: b hat	b	6.5.8.2	T6-2	0.45
Min Height	z_{min}	6.5.8.2	T6-2	30
Equivalent Height: z hat	z	6.5.8.2	T6-2	60.594
Mean Hourly Wind Speed	V_z	6.5.8.2	Eq 6-14	69.15
Height atm Boundary	z_g	6.300	T6-2	1200
Velocity Pressure Exp.*	k_z	6.5.6.6	T6-3**	1.04

Velocity Pressure Exp.*	k_h	6.5.6.6	T6-3**	1.04
*Calculated for (15'<z<z_g), or use Table 6-3				
**k_z and k_h: Use "Kz" Sheet to find value coordinating to largest "z"				

Integral Length Scale	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Integral Length Scale Factor	ℓ	6.5.8.1	T6-2	320
Integral Length Scale Exp	ε	6.5.8.1	T6-2	0.33
Integral Length Scale, Turb.	L_z	6.5.8.1	Eq 6-7	391.06
Turbulence Intensity Factor	c	6.300	T6-2	0.30
Intensity of Turbulence	I_z	6.5.8.1	Eq 6-5	0.27

Fundamental Period	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Period Coefficient	C_t	9.5.3.2	T9.5.5.3.2	0.02
Period Exponent	x	9.5.3.2	T9.5.5.3.2	0.75
Approx. Fund. Period	T_a	9.5.3.2	$T_a=C_t(h_n^x)$	0.64
Natural Frequency	n_1	6.5.8.2	$n_1=1/T_a$	1.56
Rigid or Flexible	-	6.5.8.2	$n_1>1$?	Rigid

Resonance	**Variable**	**Reference**	**Chart/Fig.**	**Value**	**η**
R_1 Coefficient	R_h	6.5.8.2	Eq 6-13	0.091	10.455
R_1 Coefficient	R_b	6.5.8.2	Eq 6-13	0.051	19.082
R_1 Coefficient	R_l	6.5.8.2	Eq 6-13	0.052	18.829
Reduced Frequency	N_1	6.5.8.2	Eq 6-13	8.801	
Resonance Coefficient	R_n	6.5.8.2	Eq 6-13	0.035	
Damping Ratio	β	6.300	Section 9	0.050	
Resonant Response Factor	R	6.5.8.2	Eq 6-10	0.043	

Gust Effect Factor	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Gust Coefficient	g_q	6.5.8.2	Eq 6-8	3.4
Gust Coefficient	g_v	6.5.8.2	Eq 6-8	3.4
Gust Coefficient	g_r	6.5.8.2	Eq 6-9	4.29
Background Response	Q	6.5.8.1	Eq 6-6	0.81
Gust Factor	G_f	6.5.8.2	Eq 6-8	0.85

Wind Pressure	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Velocity Pressure	qz	6.5.10	Eq 6-15	21.080
Velocity Pressure @ h	qh	6.5.12.2	T6-3*	21.080
*$q_h=0.00256k_hk_{z}k_d(V^2)I$				

Ext. Pressure Coefficient	Variable	Reference	Chart/Fig.	Value
Windward Side	C_p	6.5.11.2	F6-6*	0.8
Leeward Side	C_p	6.5.11.2	F6-6*	-0.5
Sidewall	C_p	6.5.11.2	F6-6*	-0.7
*Formulas must be checked with any new code changes				

Leeward Pressure (psf)	P_1	6.5.12.2	$P_1=q_hG_fC_p$	-8.959

Final Pressure (psf)	$P = q_z G_f C_p - q_h G_f C_p$

z(ft)	**k_z(T6-3)	q_z	$P_{sidewall}$(psf)	$P_{leeward}$(psf)	$P_{windward}$(psf)	P_{total}(psf)
0-15	0.57	11.554	-6.874	-8.959	7.856	16.816
20	0.62	12.567	-7.477	-8.959	8.546	17.505
25	0.66	13.378	-7.960	-8.959	9.097	18.056
30	0.70	14.189	-8.442	-8.959	9.648	18.607
40	0.76	15.405	-9.166	-8.959	10.475	19.434
50	0.81	16.418	-9.769	-8.959	11.164	20.124
60	0.85	17.229	-10.251	-8.959	11.716	20.675
70	0.89	18.040	-10.734	-8.959	12.267	21.226
80	0.93	18.851	-11.216	-8.959	12.818	21.777
90	0.96	19.459	-11.578	-8.959	13.232	22.191
100	0.99	20.067	-11.940	-8.959	13.645	22.604
120	1.04	21.080	-12.543	-8.959	14.335	23.294
140	-	-	-	-	-	-
160	-	-	-	-	-	-
180	-	-	-	-	-	-
200	-	-	-	-	-	-
225	-	-	-	-	-	-
300	-	-	-	-	-	-
350	-	-	-	-	-	-
400	-	-	-	-	-	-
450	-	-	-	-	-	-
500	-	-	-	-	-	-
**k_z and k_h: Use "Kz" Sheet to copy and paste values						

Nicole Hazy
Faculty Consultant: Dr. Hanagan
Structural
Tech Report 1

Project Name: PITT
Project #: Tech 1
Calculated By: NLH
Date: 5-Oct-05

Main Wind Force Resisting System per ASCE7-02

Assumptions:
***FOR ALL "h"

***Calculating Wind in Direction:	N/S	Right Half of Building

Building Name	Upper Campus Housing Project			
Building Location	Pittsburgh, PA			
Location Data	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Occupancy Type	-	1.5.1	T1-1	III
Importance Factor	I	6.5.5	T6-1	1.15
Surface Roughness	-	6.5.6.2	-	-
Exposure Factor	-	6.5.6.3	-	B
Enclosure Classification**	-	-		Open
				Partially
			X	Enclosed
Internal Pressure Coefficient	GC_{pi}	-	-	0.18
Topographic	K_{zt}	6.5.7.2	F6-4*	1.00
$*K_{zt}=(1+k_1k_2k_3)^2$				
**Place an "X" in the box indicating Enclosure Classification				

Building Dimensions (ft)	**Variable**	**Reference**	**Source**	**Value**
Height Above Base	h_n	9.5.5.3	Spec	102.15
Height Above Ground	z	6.300	Spec	102.15
Horiz. Length ll to Wind Dir.	L	6.300	Spec	54.33
Horiz. Length Perp. to Wind	B	6.300	Spec	136.5
Horizontal Dimension Ratio	L/B	F6-6	Spec	0.40
Mean Roof Height	h	6.200	*	100.99
*Average of roof eave height and height of highest point of roof				

Wind Velocity (mph)	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Basic Wind Speed	V	6.5.4	F6.1	90
Wind Directionality	k_d	6.5.4.4	T6-4	0.85
3-sec Gust Power Law	α	6.300	T6-2	7.0
Mean Wind Speed Factor: α hat	a	6.5.8.2	T6-2	0.25
Wind Coefficient: b hat	b	6.5.8.2	T6-2	0.45
Min Height	z_{min}	6.5.8.2	T6-2	30
Equivalent Height: z hat	z	6.5.8.2	T6-2	60.594
Mean Hourly Wind Speed	V_z	6.5.8.2	Eq 6-14	69.15
Height atm Boundary	z_g	6.300	T6-2	1200
Velocity Pressure Exp.*	k_z	6.5.6.6	T6-3**	1.04

Velocity Pressure Exp.*	k_h	6.5.6.6	T6-3**	1.04
*Calculated for ($15' < z < z_g$), or use Table 6-3				
**k_z and k_h: Use "Kz" Sheet to find value coordinating to largest "z"				

Integral Length Scale	Variable	Reference	Chart/Fig.	Value
Integral Length Scale Factor	ℓ	6.5.8.1	T6-2	320
Integral Length Scale Exp	ε	6.5.8.1	T6-2	0.33
Integral Length Scale, Turb.	L_z	6.5.8.1	Eq 6-7	391.06
Turbulence Intensity Factor	c	6.300	T6-2	0.30
Intensity of Turbulence	I_z	6.5.8.1	Eq 6-5	0.27

Fundamental Period	Variable	Reference	Chart/Fig.	Value
Period Coefficient	C_t	9.5.3.2	T9.5.5.3.2	0.02
Period Exponent	x	9.5.3.2	T9.5.5.3.2	0.75
Approx. Fund. Period	T_a	9.5.3.2	$T_a=C_t(h_n^x)$	0.64
Natural Frequency	n_1	6.5.8.2	$n_1=1/T_a$	1.56
Rigid or Flexible	-	6.5.8.2	$n_1>1$?	Rigid

Resonance	Variable	Reference	Chart/Fig.	Value	η
R_1 Coefficient	R_h	6.5.8.2	Eq 6-13	0.091	10.455
R_1 Coefficient	R_b	6.5.8.2	Eq 6-13	0.068	14.131
R_1 Coefficient	R_l	6.5.8.2	Eq 6-13	0.052	18.829
Reduced Frequency	N_1	6.5.8.2	Eq 6-13	8.801	
Resonance Coefficient	R_n	6.5.8.2	Eq 6-13	0.035	
Damping Ratio	β	6.300	Section 9	0.050	
Resonant Response Factor	R	6.5.8.2	Eq 6-10	0.049	

Gust Effect Factor	Variable	Reference	Chart/Fig.	Value
Gust Coefficient	g_q	6.5.8.2	Eq 6-8	3.4
Gust Coefficient	g_v	6.5.8.2	Eq 6-8	3.4
Gust Coefficient	g_r	6.5.8.2	Eq 6-9	4.29
Background Response	Q	6.5.8.1	Eq 6-6	0.83
Gust Factor	G_f	6.5.8.2	Eq 6-8	0.85

Wind Pressure	Variable	Reference	Chart/Fig.	Value
Velocity Pressure	qz	6.5.10	Eq 6-15	21.080
Velocity Pressure @ h	qh	6.5.12.2	T6-3*	21.080
$*q_h=0.00256k_hk_zk_d(V^2)I$				

Ext. Pressure Coefficient	Variable	Reference	Chart/Fig.	Value
Windward Side	C_p	6.5.11.2	F6-6*	0.8
Leeward Side	C_p	6.5.11.2	F6-6*	-0.5
Sidewall	C_p	6.5.11.2	F6-6*	-0.7
*Formulas must be checked with any new code changes				

Leeward Pressure (psf)	P_1	6.5.12.2	$P_1=q_hG_fC_p$	-8.959

Final Pressure (psf)	$P = q_z G_f C_p - q_h G_f C_p$

z(ft)	**k_z(T6-3)	q_z	$P_{sidewall}$(psf)	$P_{leeward}$(psf)	$P_{windward}$(psf)	P_{total}(psf)
0-15	0.57	11.554	-6.874	-8.959	7.856	16.816
20	0.62	12.567	-7.477	-8.959	8.546	17.505
25	0.66	13.378	-7.960	-8.959	9.097	18.056
30	0.70	14.189	-8.442	-8.959	9.648	18.607
40	0.76	15.405	-9.166	-8.959	10.475	19.434
50	0.81	16.418	-9.769	-8.959	11.164	20.124
60	0.85	17.229	-10.251	-8.959	11.716	20.675
70	0.89	18.040	-10.734	-8.959	12.267	21.226
80	0.93	18.851	-11.216	-8.959	12.818	21.777
90	0.96	19.459	-11.578	-8.959	13.232	22.191
100	0.99	20.067	-11.940	-8.959	13.645	22.604
120	1.04	21.080	-12.543	-8.959	14.335	23.294
140	-	-	-	-	-	-
160	-	-	-	-	-	-
180	-	-	-	-	-	-
200	-	-	-	-	-	-
225	-	-	-	-	-	-
300	-	-	-	-	-	-
350	-	-	-	-	-	-
400	-	-	-	-	-	-
450	-	-	-	-	-	-
500	-	-	-	-	-	-
**k_z and k_h: Use "Kz" Sheet to copy and paste values						

Seismic Calcs

per ASCE7-02

Seismic Use Group I	Table 9.1.3
Site Classification D	9.4.1.2.1
$S_s = 0.127$	Fig. 9.4.1.1a
$S_1 = 0.054$	Fig 9.4.1.1b
$F_a = 1.6$	Tbl 9.4.1.2a
$F_v = 2.4$	Tbl 9.4.1.2b

$S_{ms} = F_a S_s = 1.6(0.127) = 0.203$
$S_{m1} = F_v S_1 = 2.4(0.054) = 0.129$

$S_{DS} = (2/3) S_{ms} = (2/3) 0.203 = 0.135$
$S_{D1} = (2/3) S_{D1} = (2/3) 0.129 = 0.086$

Seismic Design Category → A

W_{roof} = Penthouse + Low Roof = 313.2K + 1935K = 2248.2K

W_{floor} = Ground + First + 7(Typ Floor) + Ninth

= 966.1K + 1701K + 7(1735K) + 1498K = 16310.1K

W = 2248.2 + 16310.1 = 18558.3K

R = 3	Tbl 9.5.2.2
I = 1.0	Tbl 9.1.4

$T = C_t h_n^x = 0.02(100ft)^{0.75} = 0.632$ Tbl 9.5.5.3.2

$C_s = \frac{S_{DS}}{R/I} = \frac{0.135}{3/1} = 0.045$

$C_{s max} = \frac{S_{D1}}{T(R/I)} = \frac{0.086}{0.632(3/1)} = 0.045$

$C_{s min} = 0.044 I S_{DS} = 0.044(1.0)(0.135) = 0.006$

$V = C_s W = 0.045(18558K) =$ **1835.1K**

$K = 1 + \frac{0.632 - 0.5}{2} = 1.07$