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UNIVERSITY OF CENTRAL FLORIDA'S ACADEMIC VILLAGES
ORLANDO, FL

Executive Summary
Structural Technical Report 3
Lateral System Analysis and Confirmation Design
November 21, 2005

This technical assignment includes an in depth analysis of the University of Central Florida's Academic Villages lateral system. The Academic Villages located in Orlando, Florida. It is a complex of ten separate dormitories built to accommodate 500 new freshman students. The buildings are various sizes ranging from 14,000 square feet to 22,000 square feet. Each building is 4 stories tall and 44'-8" above the ground. Each floor has between eleven and fifteen 24 ft x 28 ft apartment units. The existing lateral system in the Academic Villages is composed entirely of interior and exterior masonry shear walls in both N-S and E-W directions at each level.

Located in Florida, wind was the critical case for this structure. The building deflection was calculated based on the overall stiffness of the shear walls at every level and was found to be well under then allowable limit of H/400. The results from STAAD.pro 2002 did not confirm this, however, I believe this could be a result of my technical difficulties with the software. The overturning moment due to wind was well under the resisting moment due to the dead load. It was not expected to be a factor since the building is only 4 stories tall.

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Introduction:

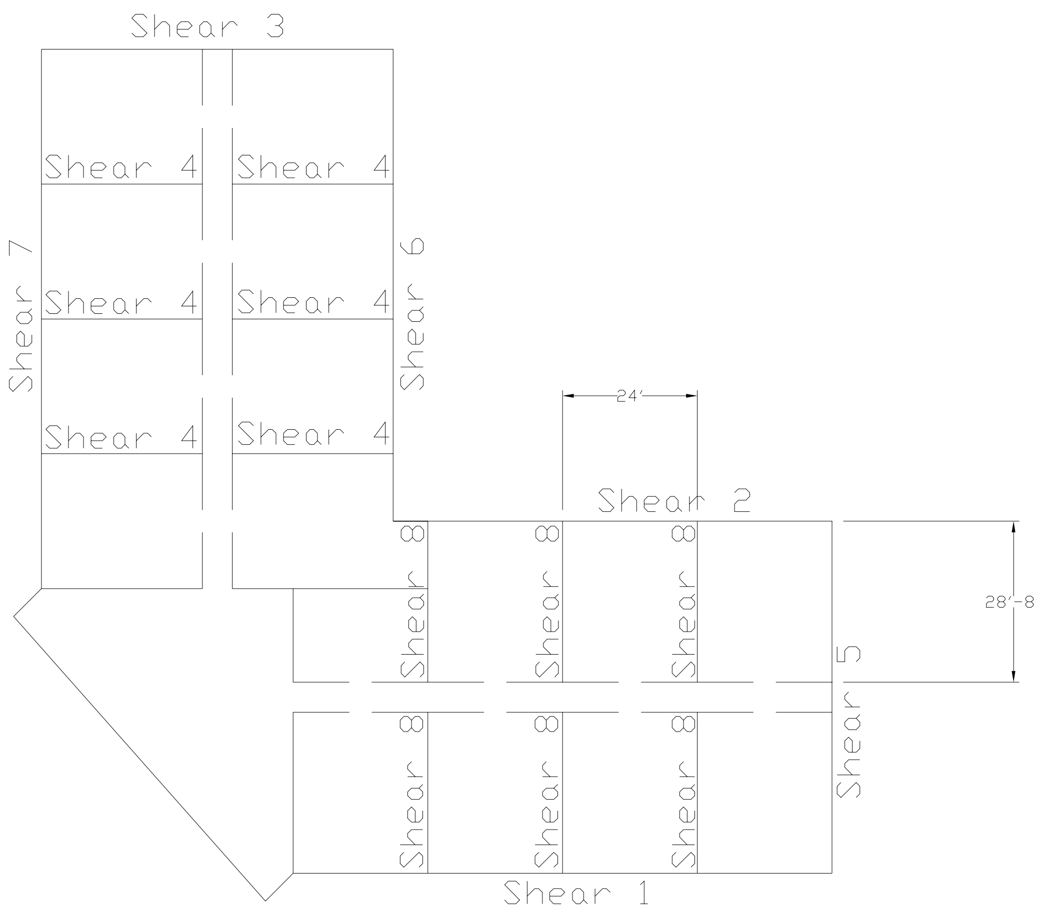
The University of Central Florida's Academic Villages located in Orlando, Florida. It is a complex of ten separate dormitories built to accommodate 500 new freshman students. The buildings are various sizes ranging from 14,000 square feet to 22,000 square feet. Each building is 4 stories tall and 44'-8" above the ground. Each floor has between eleven and fifteen 24 ft x 28 ft apartment units.

Existing Structure:

The existing lateral system in the Academic Villages is composed almost entirely of interior and exterior masonry shear walls in both directions at every level. All walls are typically 8" cmu units with #5 @ 24" reinforcement. The location of each shear walls is shown on the diagram on the following page. The actual forces at each floor and their sums at each level, which were taken from the drawings is in indicated in the table below.

Shear Wall Force Schedule (kips)

	Shear 1		Shear 2		Shear 3		Shear 4	
	Each Floor	Total	Each Floor	Total	Each Floor	Total	Each Floor	Total
4th Floor	7.21	7.21	6.01	6.01	2.56	2.56	1.07	1.07
3rd Floor	13.52	20.73	11.27	17.28	4.79	7.35	1.97	3.04
2nd Floor	13.48	34.21	11.23	28.51	4.77	12.12	1.98	5.02
	Shear 5		**Shear 6**		**Shear 7**		**Shear 8**	
	Each Floor	**Total**	**Each Floor**	**Total**	**Each Floor**	**Total**	**Each Floor**	**Total**
4th Floor	2.1	2.1	6.04	6.04	5.18	5.18	1.07	1.07
3rd Floor	3.94	6.04	11.32	17.36	9.7	14.88	1.97	3.04
2nd Floor	3.93	9.97	11.28	28.64	9.67	24.55	1.98	5.02



Wind Loads:

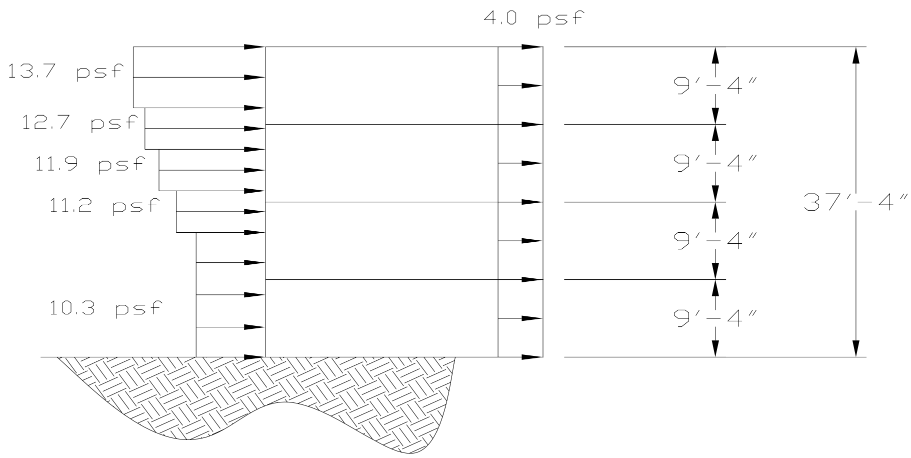
The wind load was calculated using the same procedure from Technical Assignment 1 using ASCE 7-02. Please refer to Technical Assignment 1 for extensive wind load calculations. Due to its symmetrical appearance, the wind load pressures in the North-South and East-West directions were the same.

Wind load has been calculated based on:

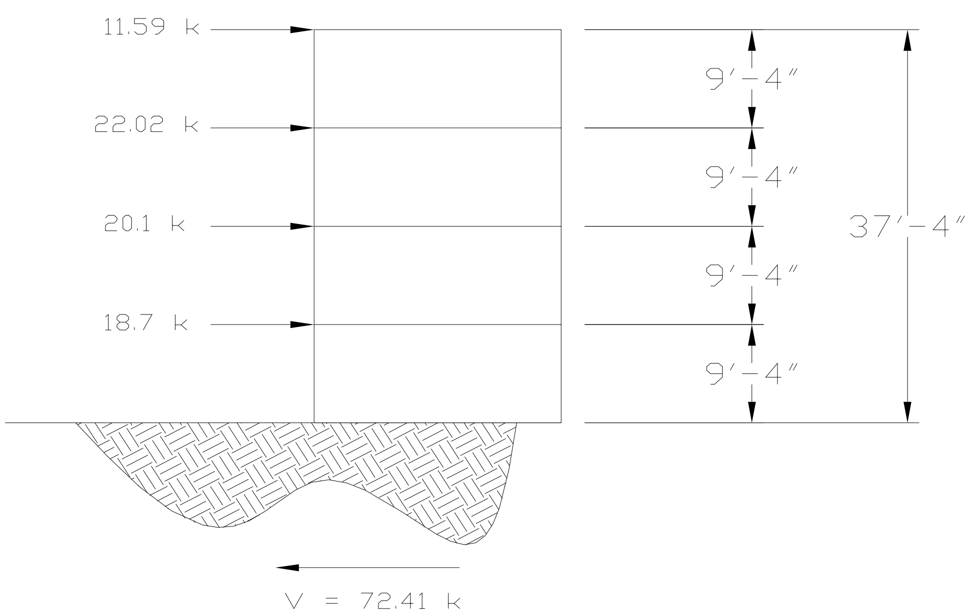
- Wind speed = 100 mph (from drawings)
- Importance factor: 1.15
- Exposure Category B
- Maximum windward pressure = 13.7 psf
- Maximum leeward pressure = 4.0 psf
- Base Shear = 72.41 kips

(See diagrams on the following page.)

Wind Pressure Distribution						
			Windward		Leeward	
Height (ft)	K_z	q_z (psf)	C_p	Pressure (psf)	C_p	Pressure (psf)
0-15	0.57	14.26	0.85	10.3	-0.25	4.04
15-20	0.62	15.51	0.85	11.21	-0.25	4.04
20-25	0.66	16.52	0.85	11.94	-0.25	4.04
25-30	0.7	17.52	0.85	12.66	-0.25	4.04
30-40	0.76	19.02	0.85	13.74	-0.25	4.04



Windward and Leeward Pressure



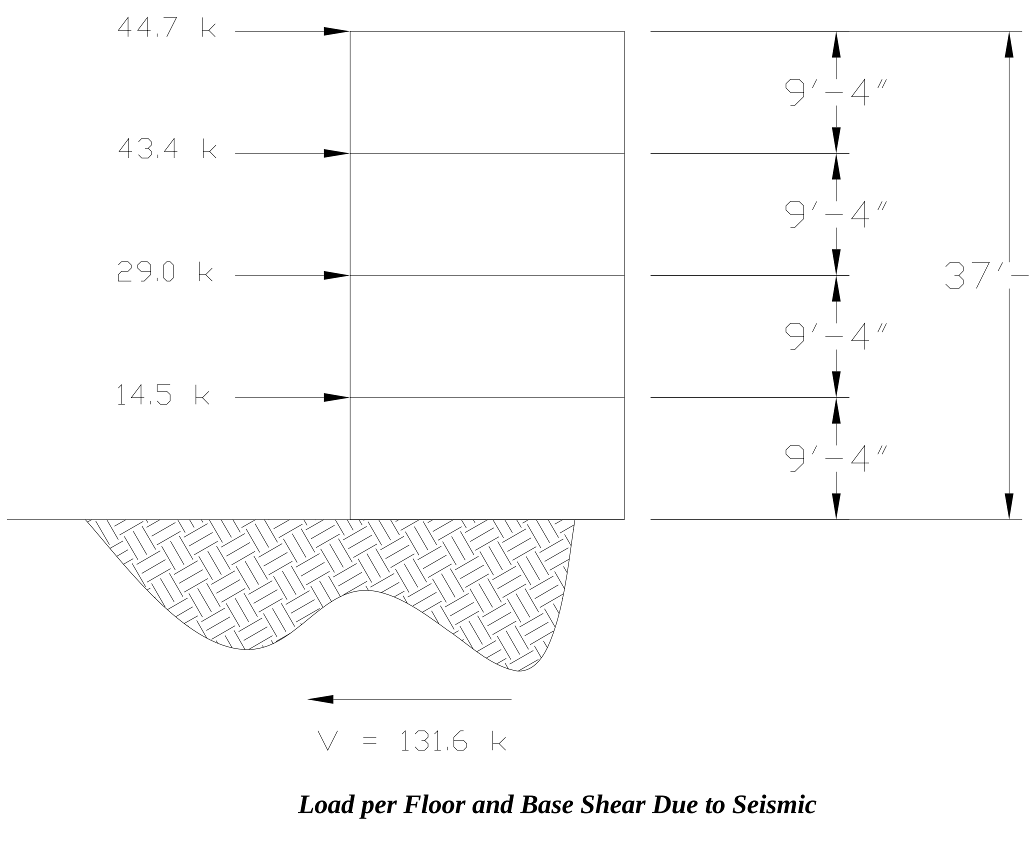
Load per Floor and Base Shear Due to Wind

Seismic Loads:

The seismic loads were calculated using ASCE 7-02, the same procedure used in Technical Assignment 1. Please refer to Technical Assignment 1 for extensive seismic load calculations.

Seismic load has been calculated based on:

- Seismic Use Group II
- Importance Factor: 1.0
- Site Class D (allowable soil pressure is 2000 psi)
- R = 3 (ordinary reinforced masonry shear walls)
- Roof Dead Load = 50 psf
- Floor Dead Load = 60 psf
- Wall Dead Load = 42 psf
- Site-Adjusted Spectral Response Acceleration for 0.2 second period (S_{MS}) = 0.12g
- Site-Adjusted Spectral Response Acceleration for 1.0 second period (S_{M1}) = 0.07g



Load per Floor and Base Shear Due to Seismic

Lateral Load Path:

The wind provides a non-uniform distributed load on exterior walls of the structure. This non-uniform load is distributed to the horizontal diaphragms (floors). From the horizontal diaphragms, the load is distributed from floor to floor via the masonry shear walls down to the second floor. From the second floor, the load is distributed between reinforced concrete columns and exterior shear/bearing walls. Loads in the interior concrete columns go to stepped footings and loads in the exterior shear/bearing walls go to spread footings, which have a minimum bearing capacity of 2000 psf.

Exterior Walls → Floor → Shear Walls → Load Bearing Walls / Concrete Columns
→ Stepped / Spread Footings → Ground

Load Combinations:

The following load combinations were checked from ASCE 7-02:

1. 1.2D + 1.6L
2. 1.2D + 1.6L + 0.5(L_r or S)
3. 1.2D + 1.6(L_r or S) + (L or 0.8W)
4. 1.2D + 1.6W + L + 0.5(L_r or S)
5. 1.2D + 1.0E + L + 0.2S

Overturning Moment:

Since this building is only 4 stories tall and is not a slender building, the overturning moment will not be much of a concern. The overturning moment due to wind was 3,560 foot*kips, which clearly controlled over the seismic overturning moment of 1,600 foot*kips. The resisting moment due to the buildings dead load was more than sufficient at 52,000 foot-kips. See appendix for calculations.

Lateral Load Distribution:

There was no evidence in the drawings to indicate that anything other than the shear walls were taking the lateral loads. Therefore, in order to keep this analysis as simple as possible, it is to be assumed that all lateral loads are accounted for by the shear walls using the direct stiffness method. The stiffness for each shear wall was calculated in the spreadsheet below. The shear values calculated from the wall stiffness account for both direct shear and shear due to torsion since the building is L-shaped.

Wall Stiffness Calculations

	# of walls	Length (ft)	Width (ft)	Area (ft^2)	f'c (psi)	E (psi)	Height (ft)	H/L
Shear 1	1	96	0.67	64.32	4000	3800000	9.3	0.096875
Shear 2	1	78	0.67	52.26	4000	3800000	9.3	0.119231
Shear 3	1	52	0.67	34.84	4000	3800000	9.3	0.178846
Shear 4	6	24	0.67	16.08	4000	3800000	9.3	0.3875
Shear 5	1	0.67	52	34.84	4000	3800000	9.3	13.8806
Shear 6	1	0.67	78	52.26	4000	3800000	9.3	13.8806
Shear 7	1	0.67	96	64.32	4000	3800000	9.3	13.8806
Shear 8	6	0.67	24	16.08	4000	3800000	9.3	13.8806

	I (in4)	EI	K	K (%)
Shear 1	73728.00	2.8017E+11	85860	17.29%
Shear 2	39546.00	1.5027E+11	125560	25.28%
Shear 3	11717.33	4.4526E+10	174720	35.18%
Shear 4	6912.00	2.6266E+10	105860	21.31%
Shear 5	0.03	95241.6167	123	0.02%
Shear 6	0.03	95241.6167	123	0.02%
Shear 7	0.03	95241.6167	123	0.02%
Shear 8	0.15	571449.7	98	0.02%
		∑	496670	

Deflection:

The deflection of each level was calculated by dividing the load due to wind at each level by the calculated story stiffness. A maximum allowable drift of H/400 was found to be 0.0933 ft or 1.12 inches. The calculated deflections at each level were less than then allowable value, which was expected because the building is only 4 stories high. Using STAAD.pro 2002, the largest deflection was found to be 0.1587 ft or 1.9 inches, which is greater than the allowable H/400 limit. This could be due to technical difficulties with the software. (Please see appendix for deflection tables.)

Deflections

Floor	K(total)	F (lbs)	Δ (ft)
1	496670	14500	0.03
2	496670	29000	0.06
3	496670	43400	0.09
4	496670	44700	0.09

Conclusion:

Through building analysis and checks, it was found that the building was very rigid and designed acceptably for the critical lateral loading case of wind.

Appendix

2^{nd} Floor

	L (ft)	W (ft)	H (ft)	A (ft^2)	F(k)	f'c (psi)	E (psi)	$\Delta_{FLEXURE}$	Δ_{SHEAR}	Δ_{TOTAL}
Wall 1	96	1	9.3	96	13.38	4000	3800000	0.00787	0.0263	0.03417
Wall 2	78	1	9.3	78	11.23	4000	3800000	0.00582	0.0546	0.06042
Wall 3	52	1	9.3	52	4.77	4000	3800000	0.00265	0.0456	0.04825
Wall 4	24	1	9.3	24	1.98	4000	3800000	0.00456	0.0216	0.02616
Wall 5	52	1	9.3	52	3.93	4000	3800000	0.00336	0.0489	0.05226
Wall 6	78	1	9.3	78	11.28	4000	3800000	0.00886	0.0984	0.10726
Wall 7	96	1	9.3	96	9.67	4000	3800000	0.00456	0.0745	0.07906
Wall 8	24	1	9.3	24	1.98	4000	3800000	0.00664	0.0458	0.05244

3^{rd} Floor

	L (ft)	W (ft)	H (ft)	A (ft^2)	F(k)	f'c (psi)	E (psi)	$\Delta_{FLEXURE}$	Δ_{SHEAR}	Δ_{TOTAL}
Wall 1	96	1	9.3	96	13.52	4000	3800000	0.00985	0.0246	0.03445
Wall 2	78	1	9.3	78	11.27	4000	3800000	0.00546	0.0489	0.05436
Wall 3	52	1	9.3	52	4.79	4000	3800000	0.00556	0.0233	0.02886
Wall 4	24	1	9.3	24	1.97	4000	3800000	0.00668	0.0546	0.06128
Wall 5	52	1	9.3	52	3.94	4000	3800000	0.00123	0.0934	0.09463
Wall 6	78	1	9.3	78	11.32	4000	3800000	0.00882	0.0579	0.06672
Wall 7	96	1	9.3	96	9.7	4000	3800000	0.00156	0.0699	0.07146
Wall 8	24	1	9.3	24	1.97	4000	3800000	0.00213	0.0393	0.04143

4th Floor

	L (ft)	W (ft)	H (ft)	A (ft^2)	F(k)	f'c (psi)	E (psi)	$\Delta_{FLEXURE}$	Δ_{SHEAR}	Δ_{TOTAL}
Wall 1	96	1	9.3	96	7.21	4000	3800000	0.0846	0.0465	0.1311
Wall 2	78	1	9.3	78	6.01	4000	3800000	0.0464	0.0246	0.071
Wall 3	52	1	9.3	52	2.56	4000	3800000	0.0564	0.0266	0.083
Wall 4	24	1	9.3	24	1.07	4000	3800000	0.0549	0.0462	0.1011
Wall 5	52	1	9.3	52	2.1	4000	3800000	0.0594	0.0261	0.0855
Wall 6	78	1	9.3	78	6.04	4000	3800000	0.0798	0.0261	0.1059
Wall 7	**96**	**1**	**9.3**	**96**	**5.18**	**4000**	**3800000**	**0.0633**	**0.0954**	**0.1587**
Wall 8	24	1	9.3	24	1.07	4000	3800000	0.0642	0.0613	0.1255

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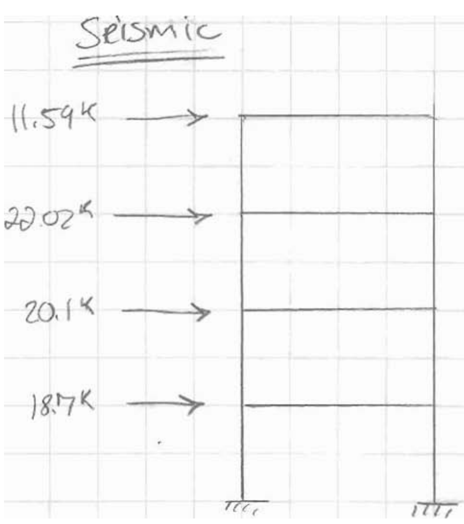
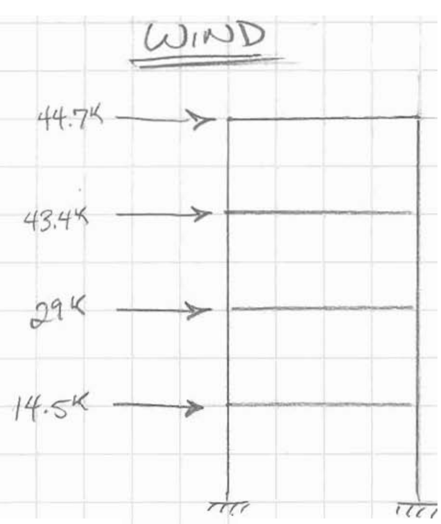
Design Calculations

Project	Prepared by	Date
Subject/Title: Overturning Moments	Reviewed by	Date
	Calculation Number	Sheet of





$M_o = 18.7(9.33') + 20.1(18.67') + 22.02(28') + 11.59(37.3') = 1598\ ^{'K}$

$M_o = 14.5(9.33') + 29(18.67') + 43.4(28') + 44.7(37.33') = 3560\ ^{'K}$ controls

Resisting Moment due to dead load

$DL_{roof} = 50$ psf

$DL_{Floors} = (150 \text{ pcf})(4''/12) + 15 \text{ psf} = 65$ psf

WALLS = 65 psf

From seismic calculations

$W_{building} = 2785$ K

$\Rightarrow M_R = 2785 \times 18.67 = 52000\ ^{'K} > 3560\ ^{'K}$ due to WIND

ok

Form No. 9-324B