Structural Background

Introduction

The Structural Depth analysis will look at many different things regarding the structure of the Hershey Academic Support Center. First, design criteria including some material strengths and code references will be presented as a guide to the work that follows. Next, existing conditions of both the gravity and lateral load will be presented to give a foundation to work from. Lateral systems will be next with more specifics and the actual calculation of partial fixity. After these values are confirmed, the floor system will be examined using the new loads in the Type 2 with Wind analysis. Lastly, conclusions will be made as to the success of the study and insights will be given as to why the data showed specific results.

Design Criteria

The main code used in the design of the Hershey Academic Support Building was the BOCA 1996 code, but for current design purposes and the purpose of computer analysis, ASCE 7-02 was used. The original building also used the 9th Edition of the Allowable Stress Design for structural steel calculations, but AISC Load and Resistance Factor Design, 3rd Edition was used for my calculations.

Another criterion given by the building designers was material strengths Concrete will be stone aggregate concrete with a minimum compressive strength of 4000 psi at 28 days. All Structural steel beams will be Fy = 50,000 psi as given by ASTM A-572 and all columns, angles, channels, and miscellaneous steel will be Fy = 36,000 psi as given by ASTM A-36. Welded connections shall be done with E70XX Electrodes with 3/16" minimum material and bolted connections will use ¾" ø ASTM A325N high strength bolts minimum. Lastly, all metal floor deck shall be 3" VLI – Galvanized 20 Gage composite decking and will be designed to resist a floor shear load of 2000 plf and a roof shear load of 3000 plf as well as uplift loads. All of these specifications were conformed to throughout the analysis.

Gravity loads used on the building are as follows:

Dead Loads

Total Roof Dead Load = 30 psf
Total Penthouse Dead Load = 125 psf
Total Office Dead Load = 70 psf

Live Loads

Roof = 30 psf + snow drifting
High Density File Storage = 200 psf, uniformly distributed
Main Floor = 100 psf (with corridors and partitions)
Mechanical Penthouse = 150 psf
Stairs = 100 psf
Total Snow Load = 21 psf

Lateral loading conditions that were used to check the structure:

~Case #1: 1.4D
~Case #2: 1.2D + 1.6L + 0.5S
~Case #3: 1.2D + 1.6S + 0.8W
~Case #4: 1.2D + 1.6W + 0.5L + 0.5S
~Case #5: 1.2D + 1.0E + 0.5L + 0.2S
~Case #6: 0.9D +1.6W
~Case #7: 0.9D + 1.0E

Existing Conditions

Presented below are some of the more important existing conditions of the Hershey Academic Support Center. Any other relevant conditions can be found in the appropriate Appendix.

Gravity Spot Check

A gravity load spot check was performed on the interior beams, a typical girder and a typical column to ensure stability. The results were:

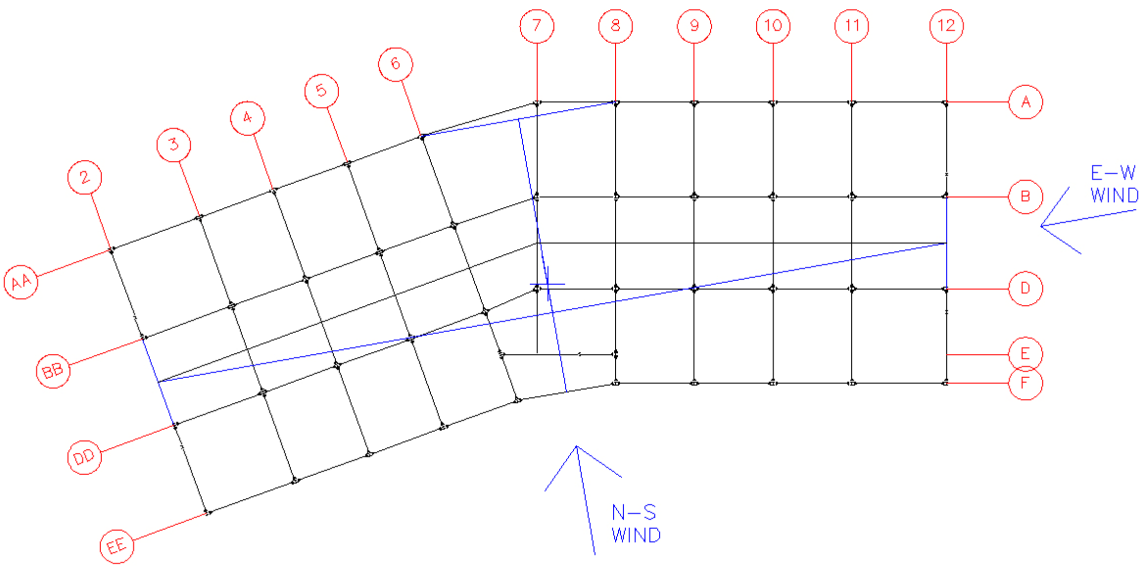
Typical beam – $øM_n$ = 274.78'k --> W18x40 with $ø_bM_p$ = 294'k
The original design was a W16x31 with ¾" of camber, which is why the designed beam is larger.

Typical Girder – $øM_n$ = 313.60'k --> W21x44 with $ø_bM_p$ = 358'k
The original design was a W21x50 and since this is larger than the projected girder from wind moments, it passes shear checks.

Typical Column – P_{EFF} = 842.88k --> W14x90 with $ø_b M_p$ = 969k
The original design was a W14x120 which can be attributed to the extra weight of the Mechanical Penthouse and possibly the wet weight of the composite slab.

Lateral Load Case Check

Using the 7 load cases above, loads were calculated and the controlling case was found to be Load Case #6: 0.9D+1.6W. This also led to the introduction of Type 2 with Wind Analysis that is explained a little later on.

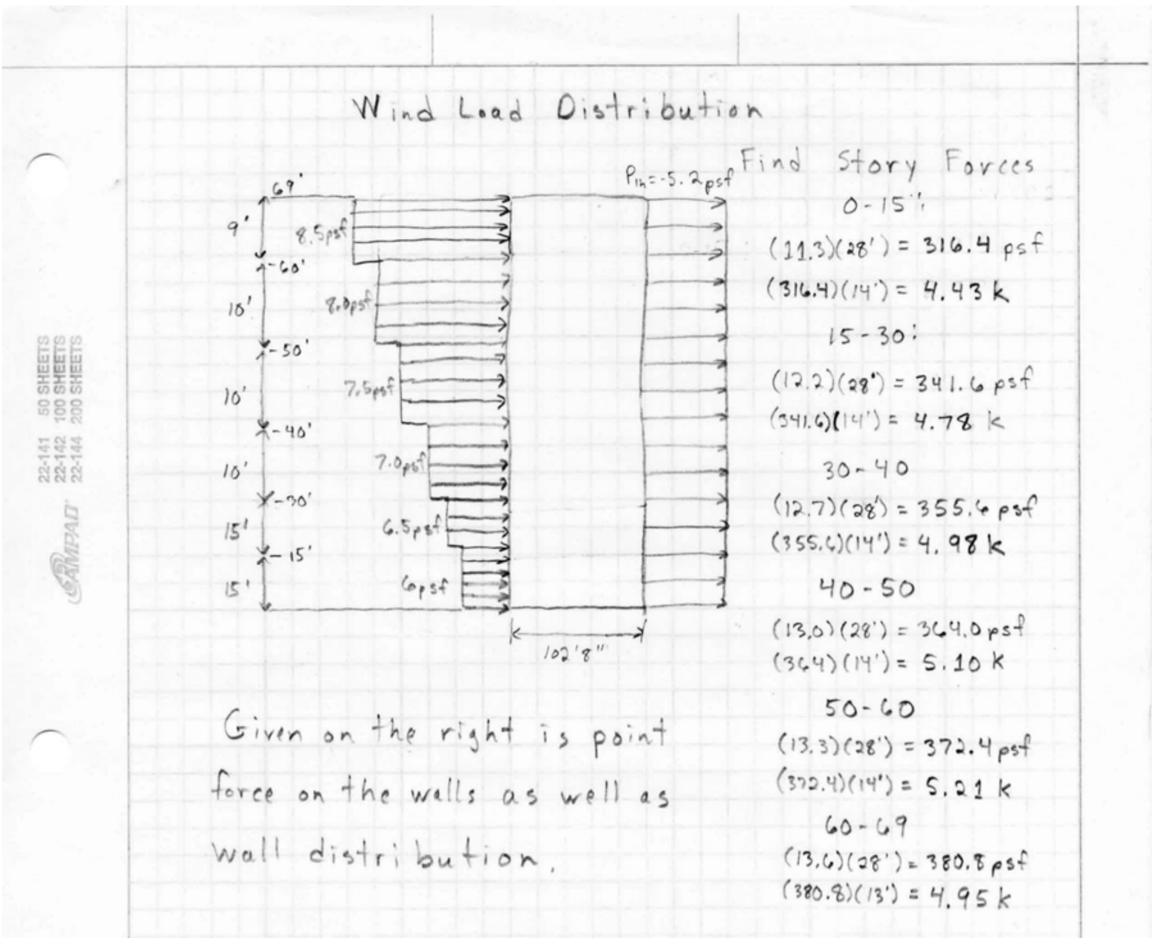


Wind Loads

z (ft)	K_z	q_z	(P_{wz}) N-S	(P_{lh}) N-S	(P_{tot}) N-S	(P_{wz}) E-W	(P_{lh}) E-W	(P_{tot}) E-W
0-15	0.85	9.06304	6.079937	-5.21265	11.29259	6.257873	-3.21912	9.476997
20	0.9	9.59616	6.437581	-5.21265	11.65023	6.625984	-3.21912	9.845107
25	0.94	10.02266	6.723695	-5.21265	11.93635	6.920472	-3.21912	10.1396
30	0.98	10.44915	7.00981	-5.21265	12.22246	7.21496	-3.21912	10.43408
40	1.04	11.0889	7.438982	-5.21265	12.65163	7.656692	-3.21912	10.87582
50	1.09	11.62202	7.796626	-5.21265	13.00928	8.024802	-3.21912	11.24393
60	1.13	12.04851	8.08274	-5.21265	13.29539	8.319291	-3.21912	11.53841
70	1.17	12.47501	8.368855	-5.21265	13.58151	8.613779	-3.21912	11.8329

	N-S	E-W
Story Shear @ 0	21.21098	6.811023
Story Shear @ 1	43.07454	13.87904
Story Shear @ 2	46.18385	15.10357
Story Shear @ 3	48.39108	15.97283
Story Shear @ 4	50.09928	16.64556
Story Shear @ 5	35.30126	10.81774

The charts shown above summarize the results found from my wind calculation analysis. Shown below is the wind loading for a typical building wall as well as story forces. Specific calculations of wind forces are located in the Appendix as well as the calculation of Seismic forces.



Story Deflection Check

Story Deflection for the assumed fully restrained moment connections was calculated by SAP2000 which was used to analyze each moment frame individually in the building. Using a 1k force at the top of the each frame structure, story deflections were found and then converted into stiffness values by the equation Stiffness (K) = 1/deflection (Δ). When combined, these stiffnesses

give the load distribution for the moment frame, the floor, and the total section as well. The values obtained for a typical frame in each section are listed below. Detailed calculations can be found in the appendix.

Deflection Calculation H/400: ((69')*(12in/ft))/400 = 2.07in
East Section Frame #12: Story Drift = 2.02in < 2.07in ALLOW
West Section Frame #2: Story Drift = 1.91in < 2.07in ALLOW
Center Section Frame #D: Story Drift = 1.83in < 2.07in ALLOW

Spot Checks, Overturning, and Strength checks were all also calculated as well and all of them passed (Detailed Calculations in the Appendix).