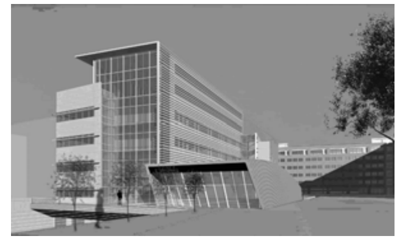
Timothy Mueller
Structural Option
Walter Schneider



FDA CDRH Laboratory

Silver Spring, Maryland

Technical Assignment #3—Lateral System Analysis and Confirmation Design

Executive Summary:

The FDA CDRH Laboratory is an office and laboratory space located on the Food and Drug Administration's White Oak Consolidation Campus. It is a four story building with a full below grade ground floor and fifth floor penthouse suite. With a high bay laboratory located on its west side. It has a total square footage of 139,805 and a height of 86' above grade.

The building is made mainly out of cast-in-place concrete. Which allows for its frame, made of pan-joist and columns to act as both a gravity and lateral system. Due to the monolithic nature of the building's concrete structural system, all the members are fixed and allow loads to travel through them. They also allow the transfer of moments caused by lateral forces.

Through this assignment I was able to continue my analysis of the building's lateral system that was touched upon in Technical Assignment #1. I looked at many different factors relating to lateral forces, from story drift and the overturning moment of the entire building, to the shear caused by torsion and the strength found in single lateral resistive members.

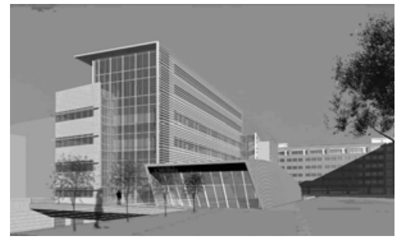
I used both computer analysis and hand calculations throughout this assignment and found that computers make for very quick work of intricate details of a building that could take hours and even days to solve out by hand. However, without any hand calculations, an error in computer calculations can easily be lost in the many outputs of a computer. Quick hand calculations, do not take a great deal of time and can reinforce what a computer has already stated, allow the engineer to be more confident in the computer output and understanding of the building system, as well as possibly show a better outlook of what members can handle rather then what they will endure.

By looking at my system with both a computer program, and by hand, I proved that the original engineer of the CDRH Laboratory designed a structural system that can withstand all the lateral conditions that I tested. The slight differences in exact numbers between the original system and the design requirements that I looked at could be caused by many circumstances, including but not limited to, new code requirements in the codes and design criteria that I used as compared to the original design codes, as well as rounding when converting dimensions from metric to English units.

I found that seismic lateral loads control as was estimated in Technical Assignment #1, and the controlling equation was 1.2D + 1.0E + 0.5L + 0.2 S. I also found that the overall deflection of the building was satisfactory to the criteria of H/400 , however, torsion did need to be taken into account when looking at the shear on members. Lastly I found exactly how much loading a single member can handle when both gravitational and lateral forces are applied. This analysis proved that the CDRH Laboratory's columns are designed to resist any load that they are predicted to encounter.

The overall outcome from this project was that a building that is very heavy such as the CDRH Laboratory, and that is made of primarily concrete, will not be affected by wind, however, seismic can cause for some problems. However, a short, "squat" building, also like the CDRH Laboratory, will resist seismic loads very well. When these two conditions are combined, the building itself can resist many lateral forces, and will not need additional lateral resisting systems, such as shear walls, or additional foundation elements to prevent overturn. However, when designing a building, one must also look at all conditions to be sure that no assumption is broad and that there is a good base of knowledge of what information is being provided either by a computer program or by hand calculations.

Timothy Mueller
Structural Option
Walter Schneider



FDA CDRH Laboratory

Silver Spring, Maryland

Introduction:

The FDA CDRH Laboratory , located on the FDA consolidation campus in Silver Spring, Maryland is a four story building topped with a 5th floor penthouse suite totaling 133,833 square feet of space. Its main purpose is to serve the FDA's Research Devices and Radiological Health Center, with both office and laboratory suites. The signature section of this building is a 5,972 square foot, one story, high-bay laboratory space found on the west side of the main laboratory and office space. The building, with only the exception of the penthouse and high-bay laboratory, is made of cast-in-place concrete.

The roof and structure of the penthouse, as well as that of the high-bay laboratory, are made of W-shape steel. The typical column in the penthouse is either a W12 or W10 shape with typical steel beams in the roofing systems ranging from W8's to W14's. The high-bay laboratory is composed of W18 steel beams framing into W24 girders. The steel lateral resistive force in roofing system is moment frames. Also assisting in the resistance of lateral forces is the composite floor system made of 2" ribbed metal deck and a total of 6" of concrete. The typical floor system, throughout main portions of the building, are made of 4.5" thick one way slabs, spanning in the north-south direction.

There are two typical joist layouts, both of which are pan-joist systems due to the monolithic pour of the slab and joist. The first typical plan has10" wide, and 16" deep joists, spaced 5'-3" on center. These joists span either 18' or 15'–5" and are designed with the same requirements as beams due to their large size and spacing. They are reinforced with #3 rebar on top, #6 rebar on the bottom, and the shear force is resisted with #3 rebar.

The second typical bay is also a pan-joist system with the joist dimension of 16"X16". These joists are spaced 3' on center and span a distance of 30'-9". The top and shear reinforcement is #3 rebar, with #8 bottom reinforcement. These bays feed into a system of beams, also poured monolithically. The typical beam is 19.7" wide by 20.5" deep and spans 21'. The reinforcement at the midspan is comprised of 3 - #9 rebar with endspan reinforcement of 6 - #9 rebar. The shear forces are resisted with #3 rebar at 5.9" and then R rebar at 9". All concrete used in the pan-joist system, as well as the beams have a strength of 4000psi. The beams then feed into the typical 24"X18" concrete columns, which have a strength of 5000psi and are reinforced with 6-#8 rebar.

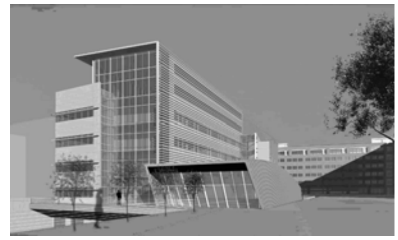
Due to the monolithic nature of cast-in-place concrete, along with the "long-stout" shape of the building, no additional lateral resistance, beyond the fixed connections, is needed in the building frame. There are also non-standard progressive collapse beams that are to hold above loads, at least for a short period of time, when lower supports are removed. The entire building rests on a typical foundation system of spread-footings below all columns and a step footing around the perimeter of the building.

In this report I will continue the research of the lateral system that is found in Technical Report #1 by comparing more detailed hand calculations with data that was found using the RAM structural modeling system. The findings of this report will be demonstrated in the following divisions:

Loading Conditions
Distribution of Loads
Building Lateral System—Controlling load condition
Analysis—Drift, Torsion, Overturning, Member Strength
Conclusion

Timothy Mueller
Structural Option
Walter Schneider

FDA CDRH Laboratory
Silver Spring, Maryland



Loading Conditions:

Dead loads:

All dead load values derived from ASCE 7-02, Section 3

Concrete: 150pcf

Superimposed: 25psf (assumed)

Ceiling:	Acoustical Fiber board	1psf
Floor:	VCT	1psf
Mechanical/Electrical:		10psf
Partitions:		13psf
Total:		25psf

Live Loads:

All live load values come from ASCE 7-02, Section 4

Light Manufacturing (Most Laboratory Spaces): 125psf

Light Storage (Supplementary Laboratory Spaces): 125psf

Although there are many different criteria for loading conditions, the controlling loading of 125psf can cover all loading in the CDRH Laboratory. This is primarily due to the storage spaces available in the secondary laboratories found on the typical office area and the light manufacturing and large amount of equipment found in the laboratory spaces.

Snow Loads:

Loading was found using ASCE 7-02, Section 7

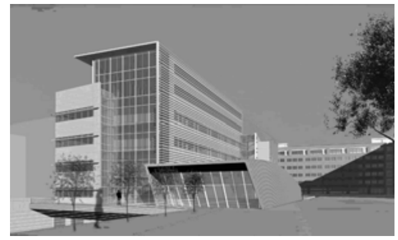
The snow load was found to be 20psf

This load is not used in determining seismic because is it below 30psf. However, it is used in finding the controlling lateral loading

Example of snow loading calculation see appendix A

Loading Combinations: (From LRFD/ASCE 7)

1.4D
1.2D + 1.6L +0.5S
1.2D + 1.6S + (0.5L or 0.8W)
1.2D + 1.6W + 0.5L + 0.5S
1.2D + 1.0E + 0.5L + 0.2S
0.9D + (1.6W or 1.0E)



Wind Loads:

Loading was found using ASCE 7-02, Section 6

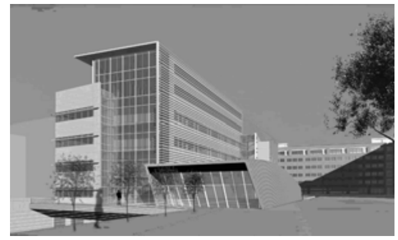
A spreadsheet utilizing the factors and formulas given in the ASCE manual was used to calculate the distributed wind loads. The wind was calculated in both the north-south direction and the east-west direction for both the main building and the laboratory space. The two spaces could be analyzed separately for this report because they are not connected above grade. The buildings do work together to resist the lateral forces, however, they are only working together underground. Due to the wind only effecting above grade elements, this connection can be ignored when finding the effects. Some important assumptions made about the wind loading are that the buildings were approximated as a "box". The main building was analyzed with the dimensions of the north and south walls being 64.2' long, the east and west walls being 304.5' long with a height of 86.0236' above the ground level. The laboratory "box" was analyzed with the dimensions of the north-south walls being 47.4081', the east-west walls having a length of 84', and a 18.4416' above ground height.

The following are the main factors used in referencing the site and building conditions. All values were found using either the ASCE-7 02 manual, or were documented in the building specifications.

Building Information		
Basic Wind Speed (mph)	V	90
Wind Importance Factor	I_w	1.0
Exposure Category	-	B
Enclosure Classification	-	Enclosed
Building Category	-	II
Importance Factor	I	1.00
Internal Pressure Coefficient	GC_{pi}	0.18

The above conditions lead to the four resulting force charts on the following page.

See Appendix B the complete spreadsheet documents used to find the resulting wind forces.

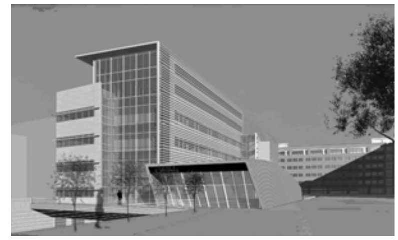


RESULTS N/S Main Building							
z(ft)	k_z(T6-3)	q_z	$P_{sidewall}$(psf)	$P_{leeward}$(psf)	$P_{windward}$(psf)	$P_{internal}$(psf)	P_{total}(psf)
0-15	0.70	12.338	-7.341	-2.876	8.390	3.046	11.266
20	0.70	12.338	-7.341	-2.876	8.390	3.046	11.266
25	0.70	12.338	-7.341	-2.876	8.390	3.046	11.266
30	0.70	12.338	-7.341	-2.876	8.390	3.046	11.266
40	0.76	13.395	-7.970	-2.876	9.109	3.046	11.985
50	0.81	14.277	-8.495	-2.876	9.708	3.046	12.585
60	0.85	14.982	-8.914	-2.876	10.188	3.046	13.064
70	0.89	15.687	-9.334	-2.876	10.667	3.046	13.544
80	0.93	16.392	-9.753	-2.876	11.146	3.046	14.023
90	0.96	16.921	-10.068	-2.876	11.506	3.046	14.382

RESULTS N/S Laboratory							
z(ft)	k_z(T6-3)	q_z	$P_{sidewall}$(psf)	$P_{leeward}$(psf)	$P_{windward}$(psf)	$P_{internal}$(psf)	P_{total}(psf)
0-15	0.70	12.338	-7.341	-5.244	8.390	2.221	13.633
20	0.70	12.338	-7.341	-5.244	8.390	2.221	13.633

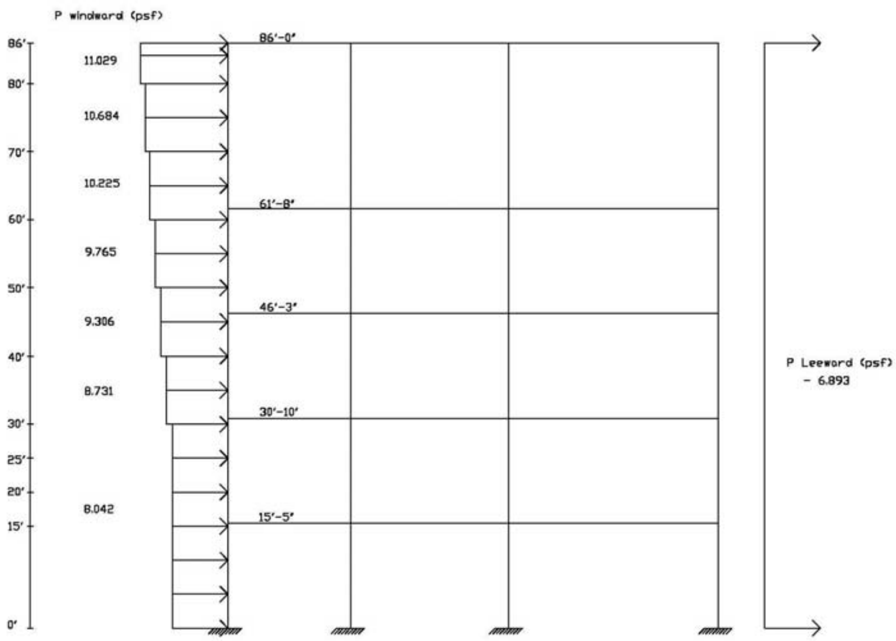
RESULTS E/W Main Building							
z(ft)	k_z(T6-3)	q_z	$P_{sidewall}$(psf)	$P_{leeward}$(psf)	$P_{windward}$(psf)	$P_{internal}$(psf)	P_{total}(psf)
0-15	0.70	12.338	-7.037	-6.893	8.042	3.046	14.935
20	0.70	12.338	-7.037	-6.893	8.042	3.046	14.935
25	0.70	12.338	-7.037	-6.893	8.042	3.046	14.935
30	0.70	12.338	-7.037	-6.893	8.042	3.046	14.935
40	0.76	13.395	-7.640	-6.893	8.731	3.046	15.624
50	0.81	14.277	-8.142	-6.893	9.306	3.046	16.199
60	0.85	14.982	-8.545	-6.893	9.765	3.046	16.658
70	0.89	15.687	-8.947	-6.893	10.225	3.046	17.118
80	0.93	16.392	-9.349	-6.893	10.684	3.046	17.577
90	0.96	16.921	-9.650	-6.893	11.029	3.046	17.922

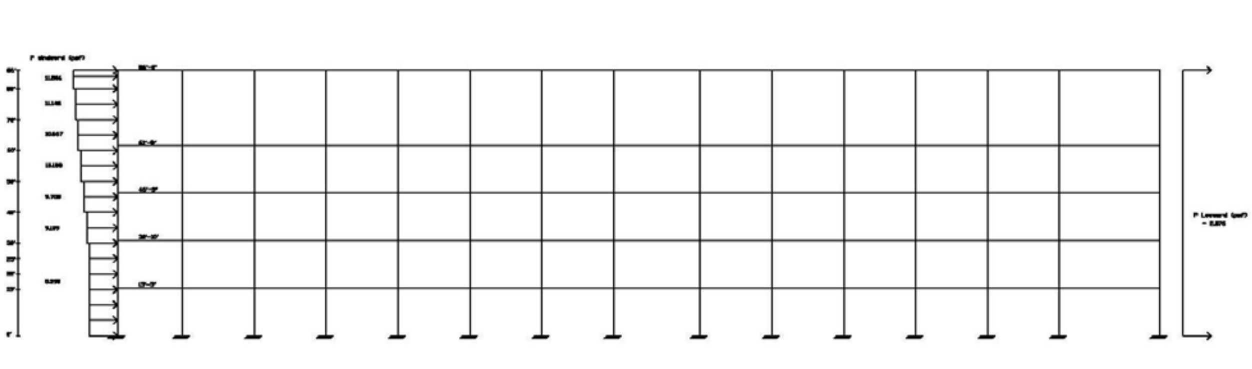
RESULTS E/W Laboratory							
z(ft)	k_z(T6-3)	q_z	$P_{sidewall}$(psf)	$P_{leeward}$(psf)	$P_{windward}$(psf)	$P_{internal}$(psf)	P_{total}(psf)
0-15	0.70	12.338	-7.421	-2.832	8.481	2.221	11.313
20	0.70	12.338	-7.421	-2.832	8.481	2.221	11.313



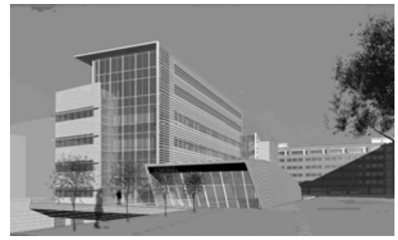
The results are then displayed on a frame.

The Following two results are for the main building:



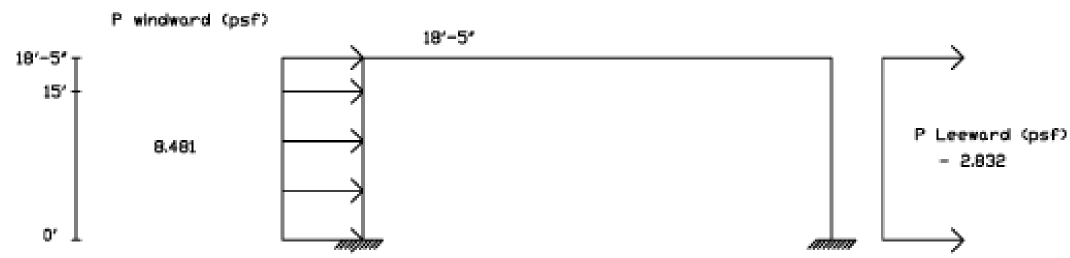


Timothy Mueller
Structural Option
Walter Schneider



FDA CDRH Laboratory
Silver Spring, Maryland

The results for the laboratory frame wind calculations:



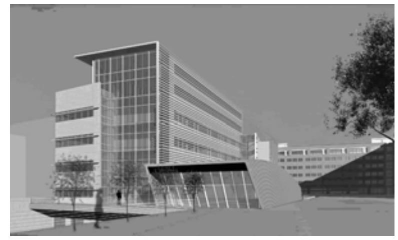
As can be seen from the distributed wind loading on the frames, the short frame takes similar loading to the larger on the first floor.

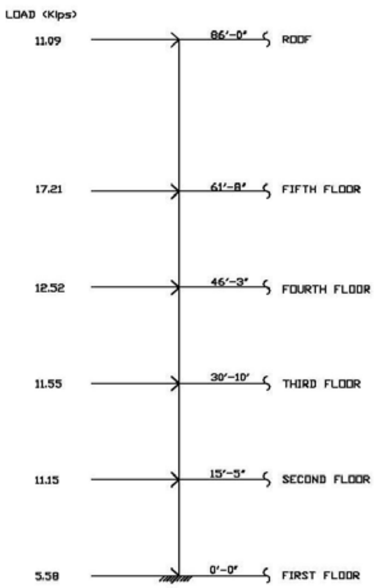
These results are then factored into point loads by multiplying the distributed forces on the wall by the tributary width of the floor that the distributed load is affecting, and the width of the affected wall.

The results can then be displayed on the frame (which can be seen on the following page)

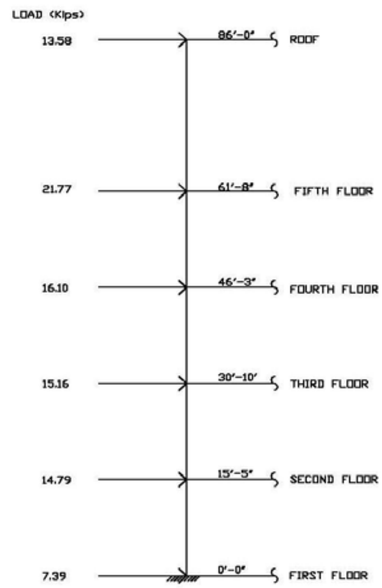
Timothy Mueller
Structural Option
Walter Schneider

FDA CDRH Laboratory
Silver Spring, Maryland

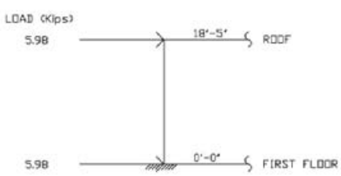




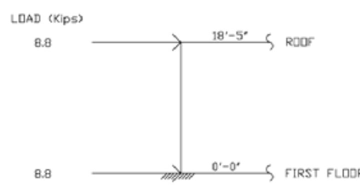
N/S CONCENTRATED WIND LOADS



E/W CONCENTRATED WIND LOADS

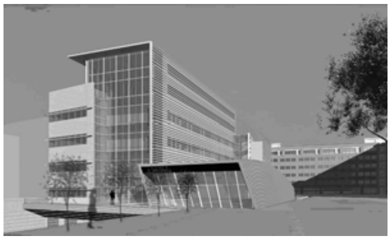


N/S CONCENTRATED WIND LOADS
LABORATORY



E/W CONCENTRATED WIND LOADS
LABORATORY

Example of N/S main building wind load spreadsheet calculation see appendix B-1
Example of E/W main building wind load spreadsheet calculation see appendix B-2
Example of main building floor wind point loads see appendix B-1-6 and B-2-6
Example of N/S laboratory wind load spreadsheet calculation see appendix B-3
Example of E/W laboratory wind load spreadsheet calculation see appendix B-4
Example of laboratory floor wind point loads see appendix B-3-6 and B-4-6



Seismic Loads:

Loading was found using ASCE 7-02, Section 9

As with wind loading, seismic loading was calculated using a spreadsheet. The important assumptions used when finding seismic loading was that all floors have the same loading conditions. This assumption could be made because all of the floors have the same layout of interior laboratory space surrounded by private offices. Other assumptions included that the building was again a "box", neglecting the area of the high-bay laboratory, and that the structure was not specifically detailed for seismic loading. Also, due to a continuous lateral resistive system of rigid concrete frames throughout the entire building in both directions, the seismic loading would be the same on each floor in each direction. Because of this continuity found in the lateral system, a north/south loading was not taken separately from an east/west loading. The wall masses as well as the roof and bay loadings were found using the ASCE 7-02 manual.

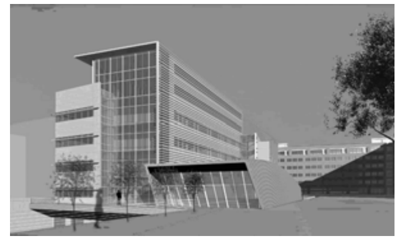
Some important factors about the site and building were found using the ASCE-7 manual, or were documented in the building specifications. These values can be seen in the table below:

Building Information		
Site Class Definition	-	C
Seismic Use Group	-	I
Seismic Design Category	-	B
Occupancy Importance Factor	I	1
Response Modification Factor	R	3
Spectral Response Accel Short	S_s	19%
Spectral Response Accel 1 sec	S_1	7%
Site Coefficient	F_a	1.200
Site Coefficient	F_v	1.700

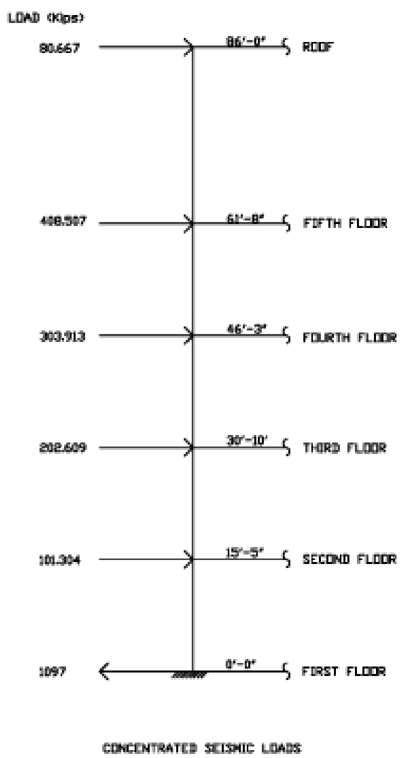
When using these factors along with equations, both of which are found in the ASCE-7 manual, the following results were found:

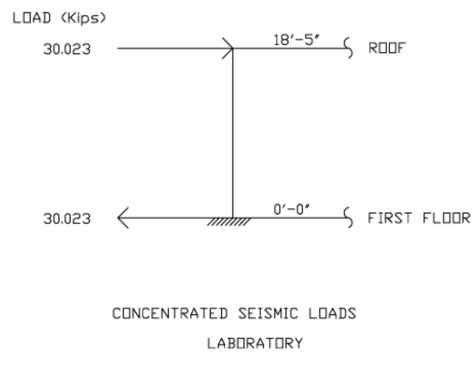
RESULTS					
Floor #	$(W_x)(h_x)$^k (Foot-Pounds)	C_{vx}	F_x (Pounds)	F_x (Kips)	V_x (Kips)
Roof	51753158.27	0.074	80666.640	80.667	
Penthouse	262085292.33	0.372	408507.242	408.507	80.667
Fourth	194981030.96	0.277	303913.136	303.913	489.174
Third	129987353.97	0.185	202608.757	202.609	793.087
Second	64993676.99	0.092	101304.379	101.304	995.696
Sum	703800512.51	1.000	1097000.154	1097.000	
Base Shear	1097000.15			1097.000	1097.000

RESULTS					
Floor #	$(W_x)(h_x)$^k (Foot-Pounds)	C_{vx}	F_x (Pounds)	F_x (Kips)	V_x (Kips)
Roof	18274570.18	1.000	30023.267	30.023	
Sum	18274570.18	1.000	30023.267	30.023	
Base Shear	30023.27			30.023	30.023



When displayed on the building frame the loading is represented as follows:

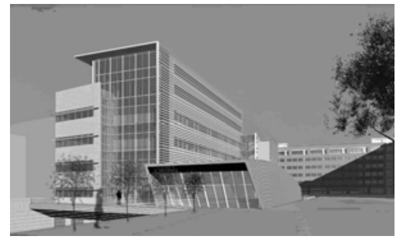




These results were found as floor point loads. They were also found to be the controlling lateral load type; with the worse case load being the 408.507 kips on the fifth floor of the main laboratory space. This load was then laterally distributed using moment distribution.

Example of main buildings seismic loading calculations see appendix C-1-1
Example of main building seismic load spreadsheet calculation see appendix C-1-3
Example of laboratory seismic loading calculations see appendix C-2-1
Example of laboratory seismic load spreadsheet calculation see appendix C-2-2

Timothy Mueller
Structural Option
Walter Schneider

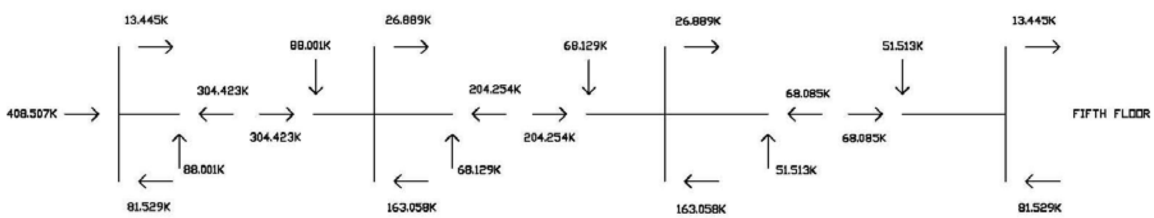


FDA CDRH Laboratory
Silver Spring, Maryland

Distribution of Loads on the Lateral Resistive System:

The CDRH laboratory utilizes its concrete construction to resist lateral loads. Because this is a rather stout building (the height is less then 1/3 the length) the lateral forces are very minimal as compared to the large amount of rigid frames that make up the building. Because the building was cast monolithically, all the joints are fixed and therefore resist moment. The load distribution through the building is very simple: the load travels from the point of contact through the façade to the beams that support it, the beams then send it through the frame at each intersection with columns and beams loads being distributed to the following beams and columns so that no single member is carrying a majority of the load. The load will then travel from the columns down through the building until it reaches the foundations which will distribute the load into the ground.

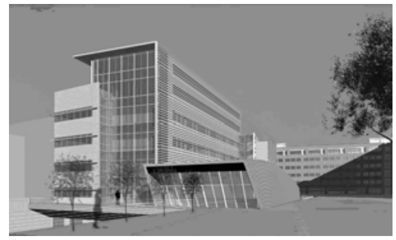
One can see how the lateral forces go from point loads on the side of the building to horizontal and vertical forces within the frame by viewing the portal method that was used in the critical seismic loading.



WORST CASE INTERNAL LATERAL FORCES (SEISMIC)

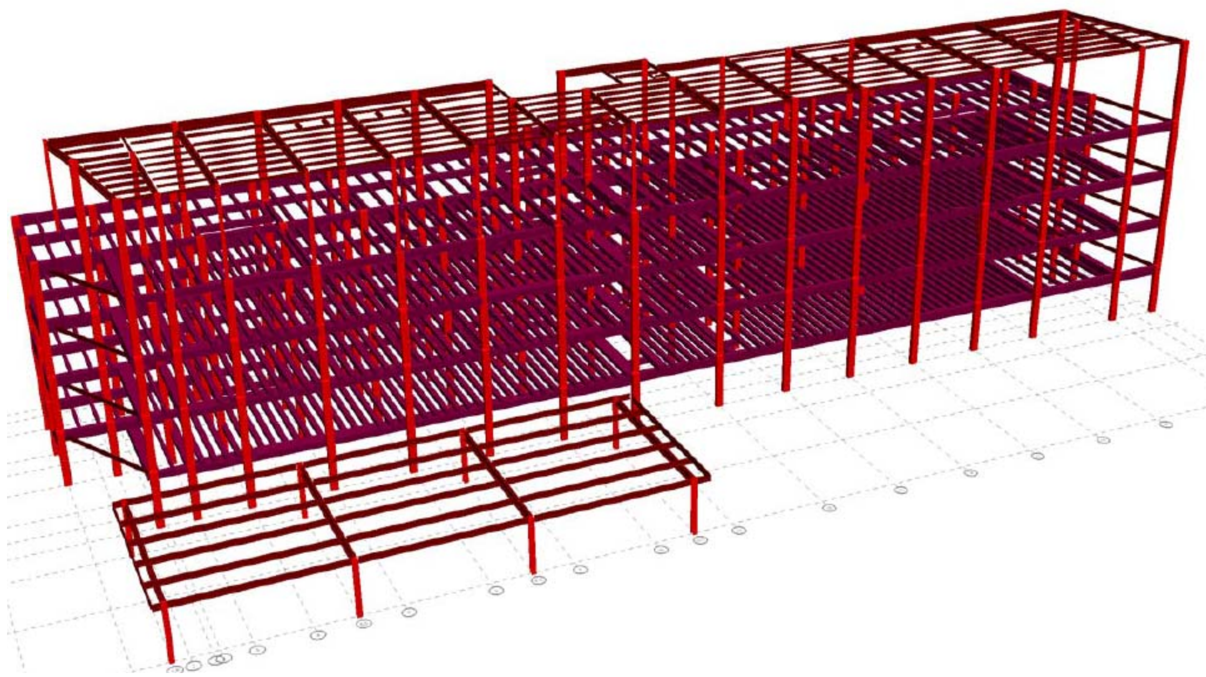
From this diagram, one can see that each bay takes part of the loading with the final bay taking interior vertical loads of 51.531 kips and horizontal loads of 13.445 kips and 81.529 kips. The load is dissipated over the entire building. I chose to look at the smaller span because all the loads would be larger because of the lower area to distribute it over. Even when looking at the smaller bay, with the highest lateral force, the load in the most affected area (the horizontal floor at the point load) has over a 100 kip reduction to the exterior force due to the distribution of the load over the entire lateral system.

For an example of a portal frame to find the distribution of lateral loading see appendix D



Building Lateral System:

Each loading condition was added into the structural system of RAM 2003. All building members were first put into RAM and each member size was pre-designated. Because the actual structural system was used, the actual loading conditions could then be used on the model.



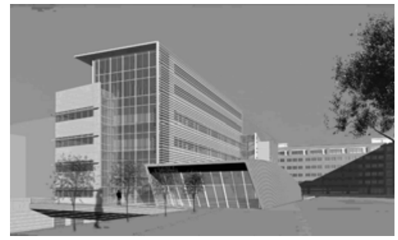
From the loading conditions that I derived by hand, I was able to find the controlling loading condition by using RAM. Because there were over 10 different wind conditions and 4 different seismic conditions alone, when put into combinations, there were over 41 possible loading combinations. RAM allowed me to easily find the controlling combination to be:

1.2D + 1.0E + 0.5L + 0.2 S

When E is equal to the seismic force in the y-direction with negative eccentricity force.

This condition is consistent with my finding, earlier in this report, in which I determined that the seismic would be the controlling lateral force over wind.

I was also able to use RAM to calculate the story drifts and compare them to the H/400 criteria. Again, using the hand calculated values of live, dead, wind, and seismic forces, I was able to view how each of these forces effected the building as a whole. The results can be found on the next page.



Analysis:

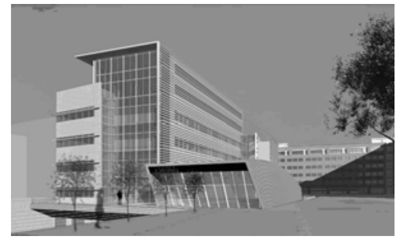
Story Drifts:

The story drifts were found using RAM 2003. A 3-D structural model was constructed and all of the real loading conditions were placed on the model. The controlling load condition for the north and south walls was the seismic loads in the y-direction with a positive eccentricity placed in the y-direction (the east-west direction). The controlling load condition for the east and west walls was also seismic, however it was in the x-direction with a negative eccentricity placed in the x-direction (the north-south direction).

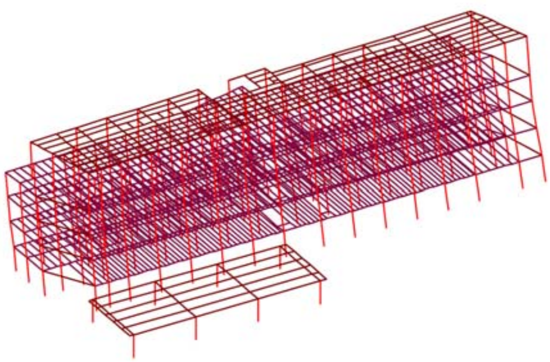
The resultant drifts on each floor are as follows:

	Y-direction	H/400	X-direction	H/400
Roof	2.23"	2.59"	2.09"	2.59"
Per Floor	0.35"	0.73"	0.46"	0.73"
Penthouse	1.88"	1.85"	1.63"	1.85"
Per Floor	0.33"	0.46"	0.29"	0.46"
Fourth Floor	1.55"	1.39"	1.33"	1.39"
Per Floor	0.50"	0.46"	0.43"	0.46"
Third Floor	1.05"	0.93"	0.90"	0.93"
Per Floor	0.61"	0.46"	0.51"	0.46"
Second Floor	0.44"	0.46"	0.39"	0.46"
Per Floor	0.44"	0.46"	0.39"	0.46"

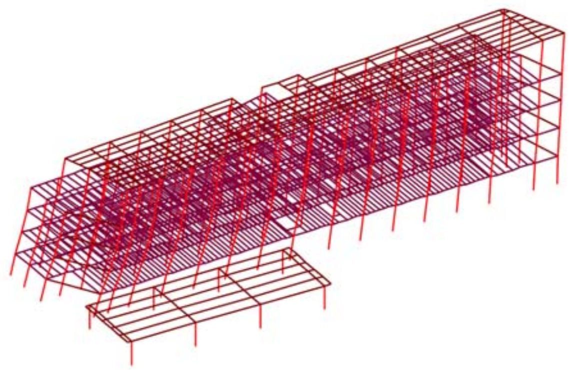
As one can see from the comparison of the story drifts in both the x and y directions, the overall drift of the building is kept below the required h/400 criteria in both the x and the y. However, as one looks at the drift of each floor, and the total drifts of the building as you go up floor by floor, some of the interior floors do not pass the criteria. The failing of these is to the hundredths of an inch and could be caused by many circumstances including multiple conversions between metric and english units of measurement, the center of mass could be slightly off due to additional weights that were not taken into account, along with many other small errors. Exaggerated images of the resultant shape due to seismic loading in the x and y can be seen on the following page.



Seismic Loaded in the y with positive eccentricity



Seismic Loaded in the x with negative eccentricity



For more details of the story drifts caused by seismic loading see appendix E

Torsion:

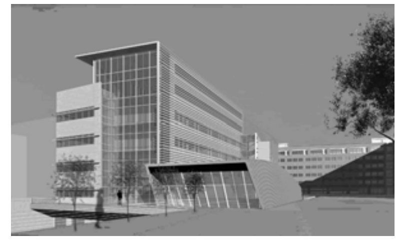
Due to the symmetry in all directions of the building, there is no eccentricity when finding the resistance of the CRDH Laboratory to lateral loads. However, the eccentricity is taken to be the 5% of the building total length in both the north-south and east-west directions, as required by code. The center of moment is also found to be in the center of the main laboratory building, due to the negligible weight of the mainly steel constructed laboratory that is only connected on the underground level; as compared to the cast-in-place main building with an area over 22 times the square footage of the laboratory. The following are the resultant shear forces caused by torsion at each level of the CDRH Laboratory.

Torsional Shear Forces	
x-direction	y-direction
F2= 2.62608	F2= 2.62608
F3= 4.05218	F3= 4.05218
F4= 6.07826	F4= 6.07826
Fpent= 8.17014	Fpent= 8.17014
Froof= 1.61334	Froof= 1.61334

The torsional shear on the building was found in both the x and y directions (north-south and east-west directions respectively), to be large enough to be considered when finding total shear forces on the building. This is especially the case at the penthouse level, where the shear torsion is found to be nearly 10% of the shear value found in the controlling seismic lateral loading case.

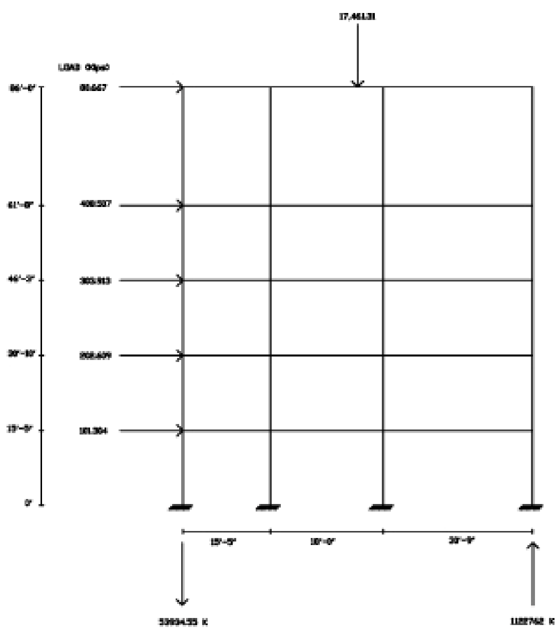
The average torsional values are similar to those given in the output of RAM, however, only through using hand calculations can one easily understand how the moment of the building as a whole can effect each member as a shear force.

Example of torsional shear calculations see appendix F

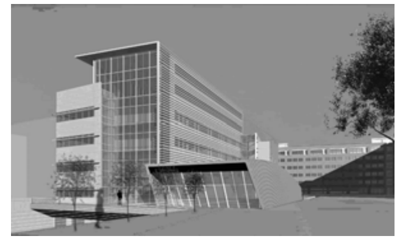


Overturning Moment:

The controlling frame for the overturning moment is in the short direction, due to the smaller length of the building causing for a smaller resistive moment from the dead load on the building. A diagram of the loading on the section of the building can be seen below. Even when the controlling side of the building is looked at, the overturning moment is much smaller then the resistive moment due to extremely large dead load caused by the concrete construction of the CRDH building. It is found that the overturning moment is only 53,934 kips while the resistive moment is 1,122,762 kips, therefore overturning moment does not cause the need for additional foundation connections. Uplift can be considered negligible due to this extremely large resistive moment.



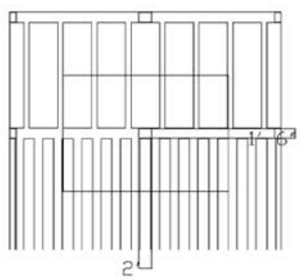
For an example of the overturning moment and the resistive moment see appendix G



Member Strength:

Typical Column Gravity Load:

To find if the columns could withstand the lateral loading we first needed to find the axial loading which was done by examining the gravity loads that each column was typically subject to (the dead weight plus the member weight of a typical column). The column below is a 5000psi, 24"X18" column, with 6-#8 rebar, which is typical for most of the columns found in the FDA-CDRH Laboratory.



Typical Column

The column was found to support up to 1836 kips which well exceeded the 231.5 kips found on the column between the third and fourth floor, and was also large enough to support the loading of 866 kips in the column (of the same size) found between the ground and first floor.

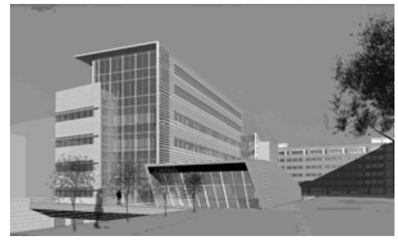
Example of the typical column axial analysis see appendix H-1

Column Lateral Moment:

After the column passed the axial loading, the lateral loading could be added to the column, due to the fact that all lateral loads are withstood using only the fixity of the frame. The forces used were the same forces found using the portal method on the seismic loading, thus assuring that the column could withstand the worst loading case. The interior column spanning the fifth floor to the roof, has a strength of 1836 kips, and proved to be more than enough capacity to support the gravity load from the roof as well as the estimated moment of 84 ft-kips per frame caused by the lateral force. This value was checked using figure 18.18.5.6, and was found to be in the "safe range".

Example of the column analysis with lateral loading see appendix H-2

Example of figure 18.18.5.6 see appendix H-3



Conclusion:

By taking a more in-depth look at the lateral system of the CDRH Laboratory, one can see that a concrete structure, although not subject to high deflection due to wind, is very susceptible to seismic loadings due to its increased weight. The CDRH Laboratory, however, also had its profile to work against both major lateral loading cases (seismic and wind), and because of its "squat" shape the building did not need additional resistive systems for the lateral loads, beyond its own fixed connections, caused by the monolithic nature of cast-in-place concrete.

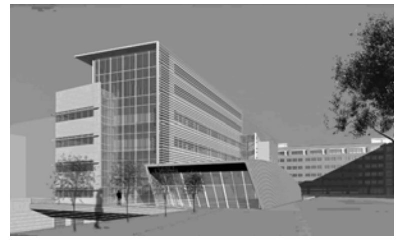
In this technical assignment I was able to utilize both my own traditional engineering knowledge in doing hand calculations, as well as my technical knowledge and computer skills to analyze the lateral forces and reactions on the CDRH Laboratory. I was able to find that you must get a basic understanding of your subject by using hand calculations, such as knowing which case will most likely control (seismic) and then using the computer to your advantage so that one does not need to go though 41 different loading cases to find which is the critical loading condition. In this case the hand calculation and the computer program both proved that seismic did control over wind with the equation of 1.2D + 1.0E + 0.5L + 0.2 S. In continuing the analysis of the lateral system, one finds other useful ways to use the computer program to assist in shortening some very grueling equations such as finding the total drift of the building, however, the stiffness was found by using hand calculations to be sure that your drifts were not too outrageous as compared to the strength of the building. In this condition it was found that the "squat" building was able to resist the seismic loading to a desired deflection under the H/400 criteria.

The stiffness was then used to derive torsion and to find if the shear forces caused by torsion would need to be considered in the members. The torsion did turn out to be large enough to need to be considered and this was confirmed by looking at the RAM report for torsion and finding similar values for the overall torsion of the building.

Again the heavy characteristic of traditional concrete construction proved to resist the overturning moment, due to the very large force caused by the mass of the building to resist all lateral forces. This also shows that additional concerns did not need to be taken into consideration for the foundation system of the CDRH Laboratory.

Finally the member strength was able to be compared using RAM and then solved by hand to prove that the a particular member was more than able to hold any critical load placed on it. By doing the hand calculation and then using another tool available to engineers, design charts and tables, the columns were found to not only be more than able to resist all vertical forces, but also resist the lateral forces, with a great deal of additional strength available to resist unexpected loads.

As one can see, computers allow for great ease in understanding many different conditions in a much more reasonable time than that of hand calculations, however, hand calculations can give you a better understanding of what is causing all the reactions that are occurring in a building. Hand calculations can also allow you to see how large, or little, of a total load a member can handle, not just the type of load that that member has on it, and allows for a great way to solve a future changes that my occur to a structure.



Appendix A
Snow Loads

Snow Load (ASCE 7-02)

$P_f = 0.7 C_e C_t I P_g$

$C_e = 0.9$		Table 7-2
$C_t = 1.0$		Table 7-3
$I = 1.0$		Table 7-4
$P_g = 25$ psf		Figure 7-1

$P_f = 0.7(0.9)(1.0)(1.0)(25\ \text{psf}) = 15.75$ psf

do not use in Seismic because

it is below 30 psf

Because $P_g > 20$ psf

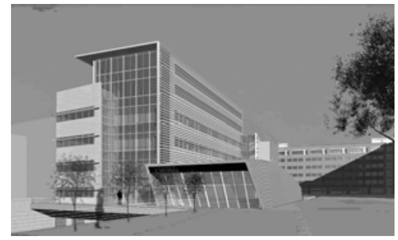
$P_f = 20 I$

$P_f = 20(1.0) = 20$ psf > 15.75 psf

$\therefore$

$P_f = 20$ psf

still below 30 psf $\therefore$ do not use in Seismic



Appendix B
Wind Loads

Section 1– North/South
Main Building

Main Wind Force Resisting System per ASCE7-02
Assumptions:
Assume for preliminary calculations that laboratory does not effect main building
***FOR ALL "h"

***Calculating Wind in Direction:	**N/S**

Building Name	FDA-CDRH Laboratory
Building Location	Silver Spring, Maryland

Building Information		
Basic Wind Speed (mph)	V	90
Wind Importance Factor	I_w	1.0
Exposure Category	-	B
Enclosure Classification	-	Enclosed
Building Category	-	II
Importance Factor	I	1.00
Internal Pressure Coefficient	GC_{pi}	0.18
Wind Design Pressure (psf)	$P_{windward}$	11.506
Wind Design Pressure (psf)	$P_{leeward}$	-2.876

RESULTS							
z(ft)	K_z(T6-3)	q_z	$P_{sidewall}$(psf)	$P_{leeward}$(psf)	$P_{windward}$(psf)	$P_{internal}$(psf)	P_{total}(psf)
0-15	0.70	12.338	-7.341	-2.876	8.390	3.046	11.266
20	0.70	12.338	-7.341	-2.876	8.390	3.046	11.266
25	0.70	12.338	-7.341	-2.876	8.390	3.046	11.266
30	0.70	12.338	-7.341	-2.876	8.390	3.046	11.266
40	0.76	13.395	-7.970	-2.876	9.109	3.046	11.985
50	0.81	14.277	-8.495	-2.876	9.708	3.046	12.585
60	0.85	14.982	-8.914	-2.876	10.188	3.046	13.064
70	0.89	15.687	-9.334	-2.876	10.667	3.046	13.544
80	0.93	16.392	-9.753	-2.876	11.146	3.046	14.023
90	0.96	16.921	-10.068	-2.876	11.506	3.046	14.382

Main Wind Force Resisting System per ASCE7-02

Assumptions:
Assume for preliminary calculations that laboratory does not effect main building
"""FOR ALL "h"

"""Calculating Wind in Direction:	N/S

"""References ir
ASCE

Building Name	Fairmont State Eng/Tech Annex			
Building Location	Fairmont, WV			
Location Data	**Variable**	**Reference**	**Chart/Fig.**	**Value**
Occupancy Type	-	1.5.1	T1-1	II
Importance Factor	I	6.5.5	T6-1	1.00
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	104.0682
Height Above Ground	z	6.300	Spec	86.0236
Horiz. Length ll to Wind Dir.	L	6.300	Spec	304.5
Horiz. Length Perp. to Wind	B	6.300	Spec	64.2
Horizontal Dimension Ratio	L/B	F6-6	Spec	4.74
Mean Roof Height	h	6.200	"	104.0682
"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	62.44092
Mean Hourly Wind Speed	V_z	6.5.8.2	Eq 6-14	69.67
Height atm Boundary	z_g	6.300	T6-2	1200
Velocity Pressure Exp."	k_z	6.5.6.6	T6-3""	0.96

Velocity Pressure Exp.*	k_h	6.5.6.6	T6-3**	0.96
*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	394.95
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	$T_a=C_t(h_n^x)$	0.65
Natural Frequency	n_1	6.5.8.2	$n_1=1/T_a$	1.53
Rigid or Flexible	-	6.5.8.2	$n_1>1$?	Rigid

E

Resonance	Variable	Reference	Chart/Fig.	Value	η
R_l Coefficient	R_h	6.5.8.2	Eq 6-13	0.090	10.545
R_l Coefficient	R_B	6.5.8.2	Eq 6-13	0.142	6.505
R_l Coefficient	R_l	6.5.8.2	Eq 6-13	0.010	103.291
Reduced Frequency	N_1	6.5.8.2	Eq 6-13	8.700	
Resonance Coefficient	R_n	6.5.8.2	Eq 6-13	0.036	
Damping Ratio	β	6.300	Section 9	0.050	
Resonant Response Factor	R	6.5.8.2	Eq 6-10	0.070	

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	0.85
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	16.921
Velocity Pressure @ h	qh	6.5.12.2	T6-3*	16.921
*$q_h=0.00256k_hk_{zt}k_d(V^2)I$				

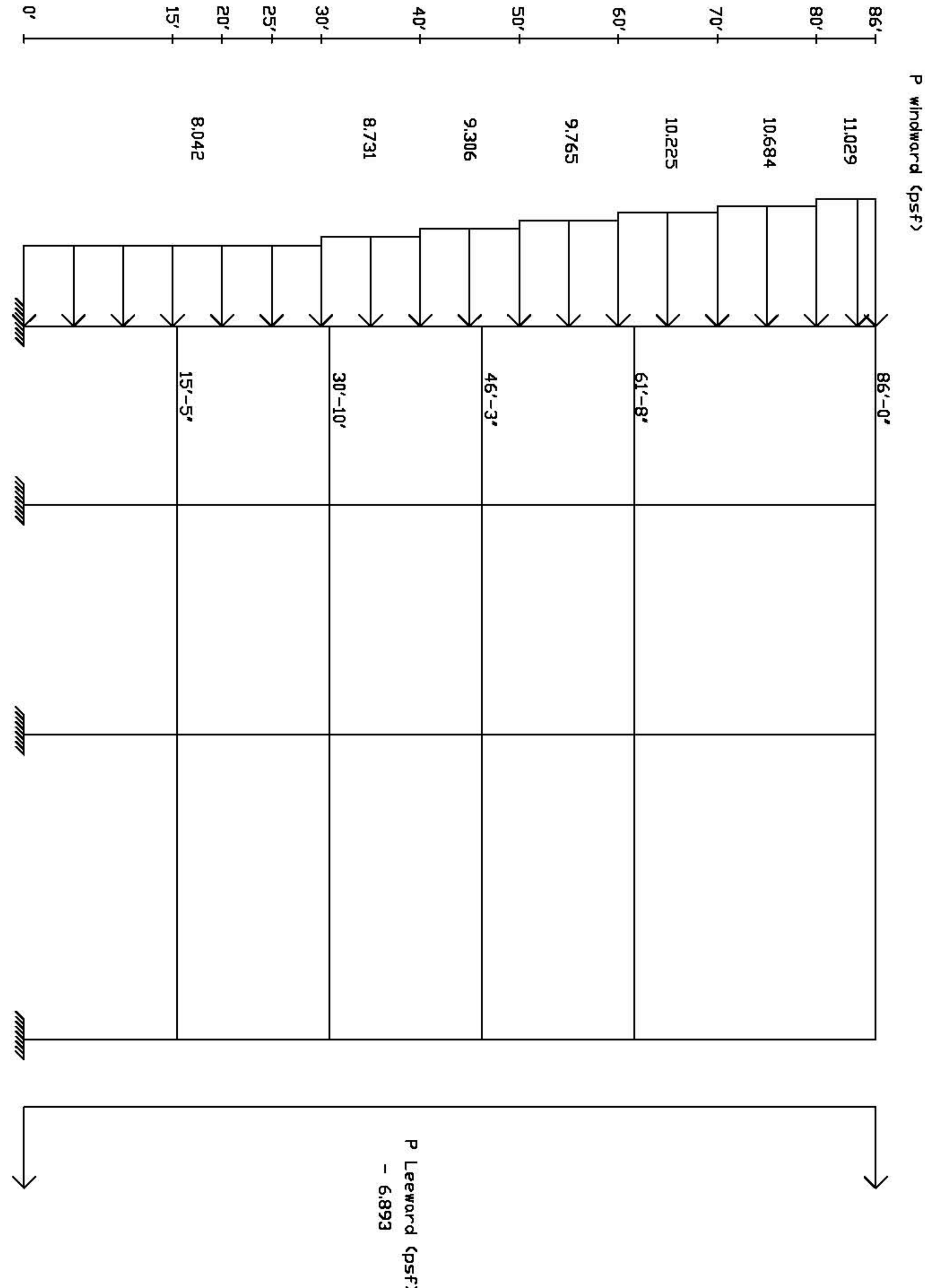
Ext. Pressure Coefficient	Variable	Reference	Chart/Fig.	Value
Windward Side	C_p	6.5.11.2	F6-6*	0.8
Leeward Side	C_p	6.5.11.2	F6-6*	-0.2
Sidewall	C_p	6.5.11.2	F6-6*	-0.7
*Formulas must be checked with any new code changes				

Leeward Pressure (psf)	P_l	6.5.12.2	$P_l=q_hG_fC_p$	-2.876

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	0.70	12.338	-7.341	-2.876	8.390	11.266
20	0.70	12.338	-7.341	-2.876	8.390	11.266
25	0.70	12.338	-7.341	-2.876	8.390	11.266
30	0.70	12.338	-7.341	-2.876	8.390	11.266
40	0.76	13.395	-7.970	-2.876	9.109	11.985
50	0.81	14.277	-8.495	-2.876	9.708	12.585
60	0.85	14.982	-8.914	-2.876	10.188	13.064
70	0.89	15.687	-9.334	-2.876	10.667	13.544
80	0.93	16.392	-9.753	-2.876	11.146	14.023
90	0.96	16.921	-10.068	-2.876	11.506	14.382
**k_z and k_h: Use "Kz" Sheet to copy and paste values						

Internal Wind Pressure	Variable	Reference	Chart/Fig.	Value
Enclosure Classification	GC_{pi}	Table 6-5	T6-7"	0.180
Velocity Pressure @ h	qh	6.5.12.2	T6-3"	16.921
Internal Wind Pressure (psf)	$(qh)(GC_{pi})$			3.046
*$q_h=0.00256k_hk_{zt}k_d(V^2)I$				


P windward (psf)
0'
15'
20'
25'
30'
40'
50'
60'
70'
80'
86'
11.029
10.684
10.225
9.765
9.306
8.731
8.042
86'-0"
61'-8"
46'-3"
30'-10'
15'-5"
P Leeward (psf)
- 6.893

Wind Load → Point Load Calculations (N/S)

Floor #1 (height)(force)(width) height = ½ floor above + ½ floor below

$$\left(\frac{15.42}{2}\right)(11.266)(64.2) = 5576.47\text{lbs} = 5.58^k$$

Level #2

$$(15.42)(11.266)(64.2) = 11152.93\text{lbs} = 11.15^k$$

Level #3

$$((6.87)(11.266) + (8.55)(11.985))(64.2) = 11547.60\text{lbs} = 11.55^k$$

Level #4

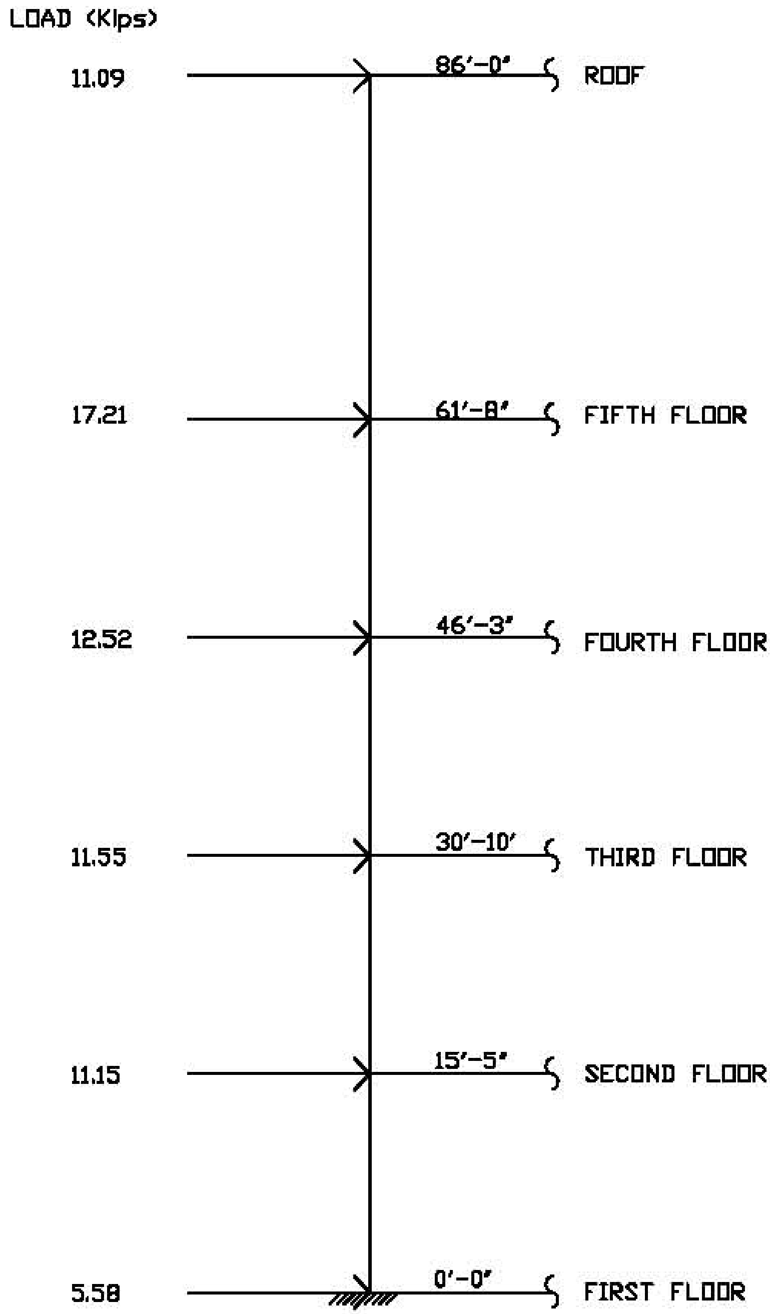
$$((1.45)(11.985) + (10)(12.585) + (3.97)(13.064))(64.2) = 12524.93\text{lbs} = 12.52^k$$

Level #5

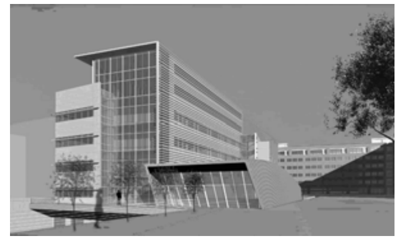
$$((6.03)(13.064) + (10)(13.544) + (3.84)(14.023))(64.2) = 17209.72\text{lbs} = 17.21^k$$

Roof

$$((6.16)(14.023) + (6)(14.382))(64.2) = 11085.65\text{lbs} = 11.09\text{k}$$



N/S CONCENTRATED WIND LOADS



Appendix B
Wind Loads

Section 2– North/South Laboratory

Main Wind Force Resisting System per ASCE7-02
Assumptions:
Assume for preliminary calculations that laboratory acts separately from main bu
***FOR ALL "h"

***Calculating Wind in Direction:	**N/S**

Building Name	FDA-CDRH Laboratory
Building Location	Silver Spring, Maryland

Building Information		
Basic Wind Speed (mph)	V	90
Wind Importance Factor	I_w	1.0
Exposure Category	-	B
Enclosure Classification	-	Enclosed
Building Category	-	II
Importance Factor	I	1.00
Internal Pressure Coefficient	GC_{pi}	0.18
Wind Design Pressure (psf)	$P_{windward}$	8.390
Wind Design Pressure (psf)	$P_{leeward}$	-5.244

RESULTS							
z(ft)	K_z(T6-3)	q_z	$P_{sidewall}$(psf)	$P_{leeward}$(psf)	$P_{windward}$(psf)	$P_{internal}$(psf)	P_{total}(psf)
0-15	0.70	12.338	-7.341	-5.244	8.390	2.221	13.633
20	0.70	12.338	-7.341	-5.244	8.390	2.221	13.633

Main Wind Force Resisting System per ASCE7-02
Assumptions:
Assume for preliminary calculations that laboratory acts separately from main building
***FOR ALL "h"

***Calculating Wind in Direction:	N/S

***References in ASCE

Building Name	Fairmont State Eng/Tech Annex			
Building Location	Fairmont, WV			
Location Data	Variable	Reference	Chart/Fig.	Value
Occupancy Type	-	1.5.1	T1-1	II
Importance Factor	I	6.5.5	T6-1	1.00
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	36.4862
Height Above Ground	z	6.300	Spec	18.4416
Horiz. Length II to Wind Dir.	L	6.300	Spec	47.4081
Horiz. Length Perp. to Wind	B	6.300	Spec	125.9843
Horizontal Dimension Ratio	L/B	F6-6	Spec	0.38
Mean Roof Height	h	6.200	*	31.6946
*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	30
Mean Hourly Wind Speed	V_z	6.5.8.2	Eq 6-14	58.00
Height atm Boundary	z_g	6.300	T6-2	1200
Velocity Pressure Exp.*	k_z	6.5.6.6	T6-3**	0.70

Velocity Pressure Exp.*	k_h	6.5.6.6	T6-3**	0.70
*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	310.09
Turbulence Intensity Factor	c	6.300	T6-2	0.30
Intensity of Turbulence	I_z	6.5.8.1	Eq 6-5	0.30

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	$T_a = C_t(h_n^x)$	0.30
Natural Frequency	n_1	6.5.8.2	$n_1 = 1/T_a$	3.37
Rigid or Flexible	-	6.5.8.2	$n_1 > 1$?	Rigid

Resonance	Variable	Reference	Chart/Fig.	Value	η
R_l Coefficient	R_h	6.5.8.2	Eq 6-13	0.111	8.466
R_l Coefficient	R_B	6.5.8.2	Eq 6-13	0.029	33.652
R_l Coefficient	R_l	6.5.8.2	Eq 6-13	0.023	42.394
Reduced Frequency	N_1	6.5.8.2	Eq 6-13	18.006	
Resonance Coefficient	R_n	6.5.8.2	Eq 6-13	0.022	
Damping Ratio	β	6.300	Section 9	0.050	
Resonant Response Factor	R	6.5.8.2	Eq 6-10	0.026	

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	4.47
Background Response	Q	6.5.8.1	Eq 6-6	0.84
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	12.338
Velocity Pressure @ h	qh	6.5.12.2	T6-3*	12.338
*$q_h = 0.00256 k_h k_{zt} k_d (V^2) I$				

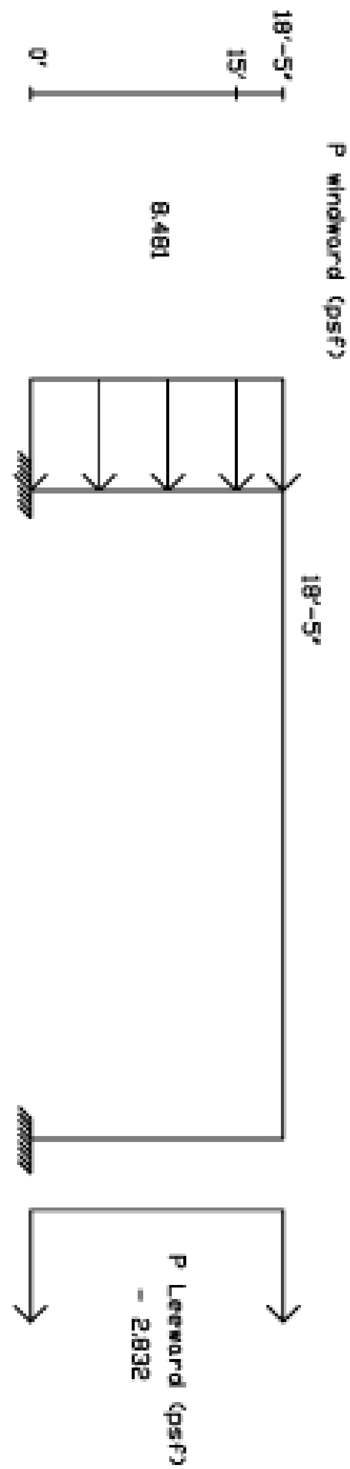
Ext. Pressure Coefficient	Variable	Reference	Chart/Fig.	Value
Windward Side	C_p	6.5.11.2	F6-6*	0.8
Leeward Side	C_p	6.5.11.2	F6-6*	-0.5
Sidewall	C_p	6.5.11.2	F6-6*	-0.7
*Formulas must be checked with any new code changes				

Leeward Pressure (psf)	P_l	6.5.12.2	$P_l = q_h G_f C_p$	-5.244

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	0.70	12.338	-7.341	-5.244	8.390	13.633
20	0.70	12.338	-7.341	-5.244	8.390	13.633
**k_z and k_h: Use "Kz" Sheet to copy and paste values						

Internal Wind Pressure	Variable	Reference	Chart/Fig.	Value
Enclosure Classification	GC_{pi}	Table 6-5	T6-7"	0.180
Velocity Pressure @ h	qh	6.5.12.2	T6-3"	12.338
Internal Wind Pressure (psf)	$(qh)(GC_{pi})$			2.221
*$q_h = 0.00256 k_h k_{zt} k_d (V^2) I$				


18'-5'
15'
0'
P windword (psf)
8.481
18'-5'
P Leeword (psf)
- 2.832

Wind Load → Point load Calculations

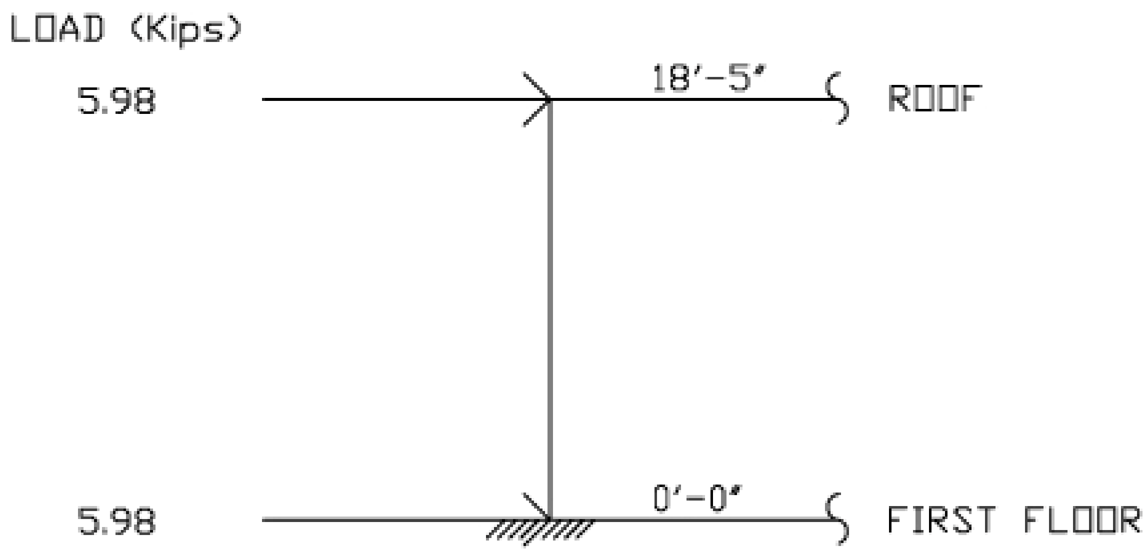
Laboratory

N-S

(height)(force)(width)   height = $\frac{1}{2}$ floor above + $\frac{1}{2}$ floor below

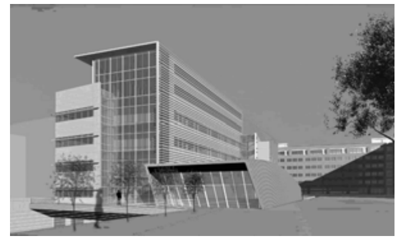
Floor #1: $\left(\frac{18.5}{2}\right)(13.634)(47.4') = 5977.8\text{ lbs}$
$= 5.98\text{ K}$

Roof: $\left(\frac{18.5}{2}\right)(13.634)(47.4') = 5977.8\text{ lbs}$
5.98 K



N/S CONCENTRATED WIND LOADS

LABORATORY



Appendix B
Wind Loads

Section 3– East/West
Main Building

Main Wind Force Resisting System per ASCE7-02

Assumptions:
Assume for preliminary calculations that laboratory does not effect main building
***FOR ALL "h"

***Calculating Wind in Direction:	**E/W**

Building Name	FDA-CDRH Laboratory
Building Location	Silver Spring, MD

Building Information		
Basic Wind Speed (mph)	V	90
Wind Importance Factor	I_w	1.0
Exposure Category	-	B
Enclosure Classification	-	Enclosed
Building Category	-	II
Importance Factor	I	1.00
Internal Pressure Coefficient	GC_{pi}	0.18
Wind Design Pressure (psf)	$P_{windward}$	11.029
Wind Design Pressure (psf)	$P_{leeward}$	-6.893

RESULTS							
z(ft)	K_z(T6-3)	q_z	$P_{sidewall}$(psf)	$P_{leeward}$(psf)	$P_{windward}$(psf)	$P_{internal}$(psf)	P_{total}(psf)
0-15	0.70	12.338	-7.037	-6.893	8.042	3.046	14.935
20	0.70	12.338	-7.037	-6.893	8.042	3.046	14.935
25	0.70	12.338	-7.037	-6.893	8.042	3.046	14.935
30	0.70	12.338	-7.037	-6.893	8.042	3.046	14.935
40	0.76	13.395	-7.640	-6.893	8.731	3.046	15.624
50	0.81	14.277	-8.142	-6.893	9.306	3.046	16.199
60	0.85	14.982	-8.545	-6.893	9.765	3.046	16.658
70	0.89	15.687	-8.947	-6.893	10.225	3.046	17.118
80	0.93	16.392	-9.349	-6.893	10.684	3.046	17.577
90	0.96	16.921	-9.650	-6.893	11.029	3.046	17.922

Main Wind Force Resisting System per ASCE7-02

Assumptions:
Assume for preliminary calculations that laboratory does not effect main building
***FOR ALL "h"

***Calculating Wind in Direction:	E/W

Building Name	FDA-CDRH Laboratory			
Building Location	Silver Spring, MD			
Location Data	Variable	Reference	Chart/Fig.	Value
Occupancy Type	-	1.5.1	T1-1	II
Importance Factor	I	6.5.5	T6-1	1.00
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	104.0682
Height Above Ground	z	6.300	Spec	86.0236
Horiz. Length II to Wind Dir.	L	6.300	Spec	64.2
Horiz. Length Perp. to Wind	B	6.300	Spec	304.5
Horizontal Dimension Ratio	L/B	F6-6	Spec	0.21
Mean Roof Height	h	6.200	*	104.0682
*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	62.44092
Mean Hourly Wind Speed	V_z	6.5.8.2	Eq 6-14	69.67
Height atm Boundary	z_g	6.300	T6-2	1200
Velocity Pressure Exp.*	k_z	6.5.6.6	T6-3**	0.96
Velocity Pressure Exp.*	k_h	6.5.6.6	T6-3**	0.96
*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	$\bar{\epsilon}$	6.5.8.1	T6-2	0.33
Integral Length Scale, Turb.	L_z	6.5.8.1	Eq 6-7	394.95
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	0.035
Period Exponent	x	9.5.3.2	T9.5.5.3.2	0.9
Approx. Fund. Period	T_a	9.5.3.2	$T_a=C_t(h_n^x)$	2.29
Natural Frequency	n_1	6.5.8.2	$n_1=1/T_a$	0.44
Rigid or Flexible?	-	6.5.8.2	$n_1>1$?	Flexible

Resonance	Variable	Reference	Chart/Fig.	Value	η
R_l Coefficient	R_h	6.5.8.2	Eq 6-13	0.278	3.002
R_l Coefficient	R_B	6.5.8.2	Eq 6-13	0.107	8.783
R_l Coefficient	R_L	6.5.8.2	Eq 6-13	0.148	6.200
Reduced Frequency	N_1	6.5.8.2	Eq 6-13	2.477	
Resonance Coefficient	R_n	6.5.8.2	Eq 6-13	0.078	
Damping Ratio	β	6.300	Section 9	0.050	
Resonant Response Factor	R	6.5.8.2	Eq 6-10	0.168	

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	3.99
Background Response	Q	6.5.8.1	Eq 6-6	0.78
Gust Factor	G_f	6.5.8.2	Eq 6-8	0.81

Wind Pressure	Variable	Reference	Chart/Fig.	Value
Velocity Pressure	qz	6.5.10	Eq 6-15	16.921
Velocity Pressure @ h	qh	6.5.12.2	T6-3*	16.921

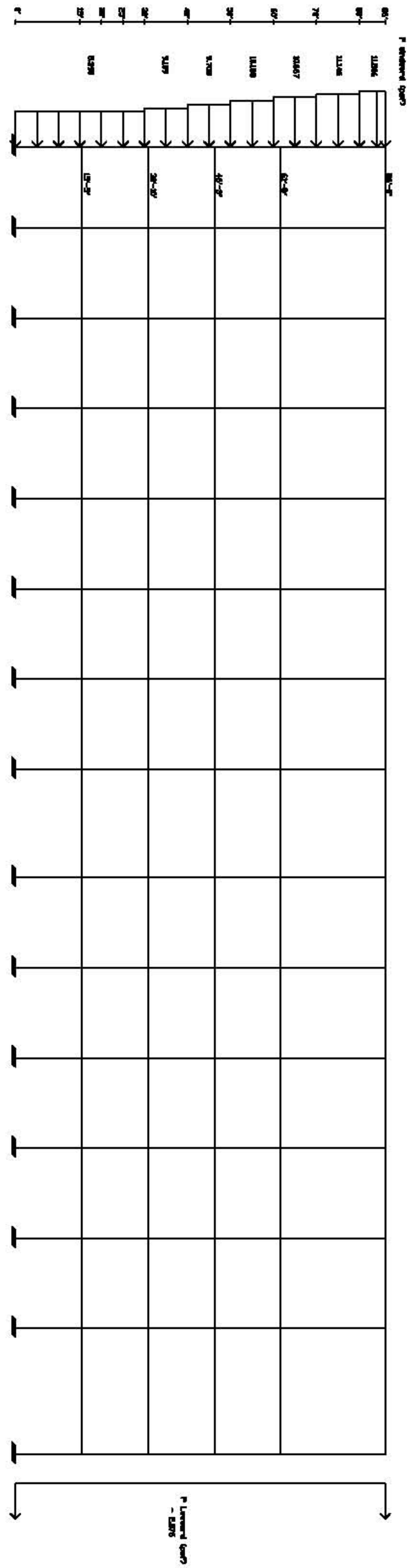
*$q_h=0.00256k_hk_{zt}k_d(V^2)I$

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"	-0.500
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	$P_1=q_hG_fC_p$	-6.893
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)
0-15	0.70	12.338	-7.037	-6.893	8.042
20	0.70	12.338	-7.037	-6.893	8.042
25	0.70	12.338	-7.037	-6.893	8.042
30	0.70	12.338	-7.037	-6.893	8.042
40	0.76	13.395	-7.640	-6.893	8.731
50	0.81	14.277	-8.142	-6.893	9.306
60	0.85	14.982	-8.545	-6.893	9.765
70	0.89	15.687	-8.947	-6.893	10.225
80	0.93	16.392	-9.349	-6.893	10.684
90	0.96	16.921	-9.650	-6.893	11.029
**k_z and k_h: Use "Kz" Sheet to copy and paste values					

Internal Wind Pressure	Variable	Reference	Chart/Fig.	Value
Enclosure Classification	GC_{pi}	Table 6-5	T6-7"	0.180
Velocity Pressure @ h	qh	6.5.12.2	T6-3"	16.921
Internal Wind Pressure (psf)	(qh)(GC_{pi})			3.046
*$q_h=0.00256k_hk_{zt}k_d(V^2)I$				



Wind Load → Point Load Calculations (E/W)

Floor #1 (height)(force)(width)

$$\left(\frac{15.42}{2}\right)(14.935)(64.2) = 7392.56 \text{ lbs} = 7.39^{k}$$

Level #2

$$(15.42)(14.935)(64.2) = 14785.11 \text{ lbs} = 14.79^{k}$$

Level #3

$$((6.87)(14.935) + (8.55)(15.624))(64.2) = 15163.31 \text{ lbs} = 15.16^{k}$$

Level #4

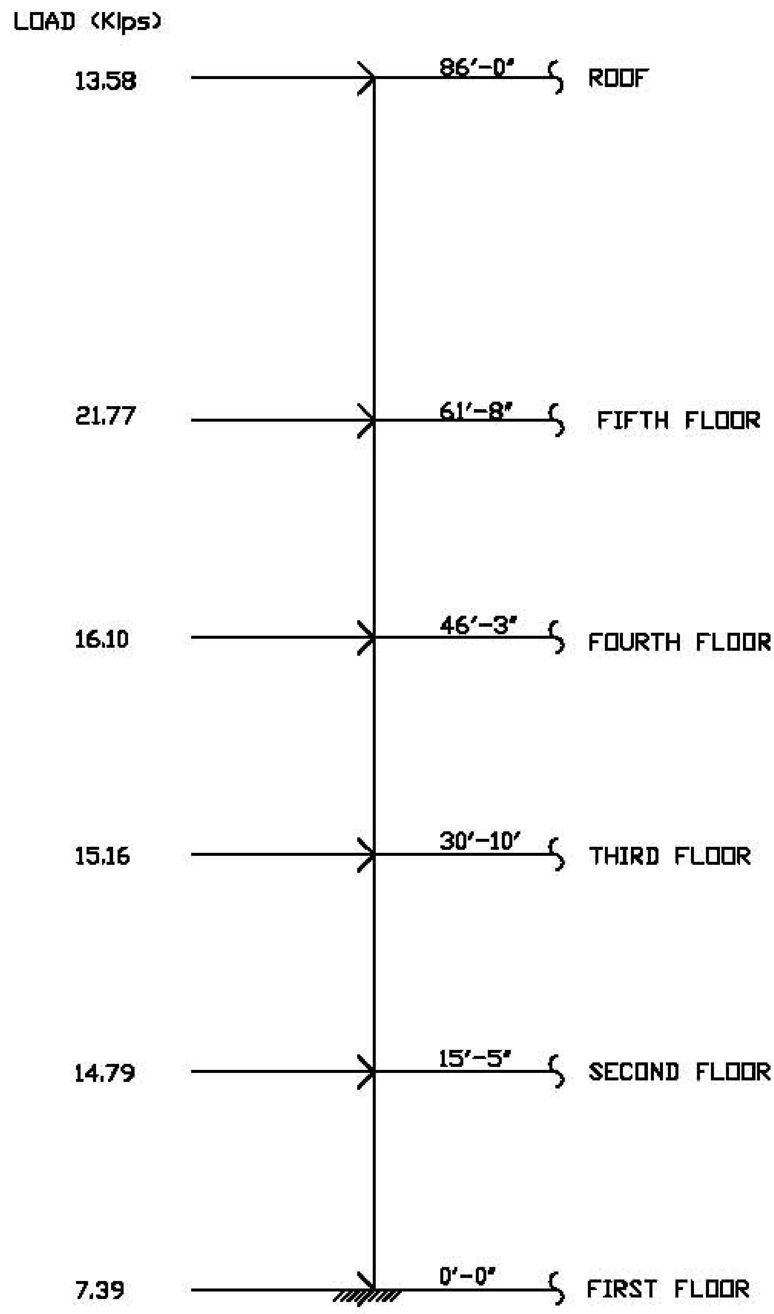
$$((1.45)(15.642) + (10)(16.199) + (3.97)(16.658))(64.2) = 16101.56 \text{ lbs} = 16.10^{k}$$

Level #5

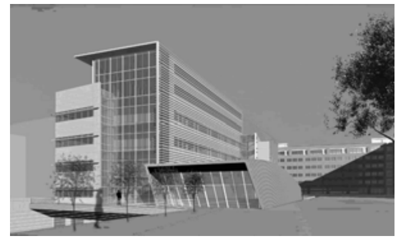
$$((6.03)(16.658) + (10)(17.118) + (3.84)(17.577))(64.2) = 21771.72 \text{ lbs} = 21.77^{k}$$

Roof

$$((6.16)(17.577) + (6)(17.922))(64.2) = 13854.77 \text{ lbs} = 13.85^{k}$$



E/W CONCENTRATED WIND LOADS



Appendix B
Wind Loads

Section 4– East/West Laboratory

Main Wind Force Resisting System per ASCE7-02
Assumptions:
Assume for preliminary calculations that laboratory acts separately from main bu
***FOR ALL "h"

***Calculating Wind in Direction:	**E/W**

Building Name	FDA-CDRH Laboratory
Building Location	Silver Spring, MD

Building Information		
Basic Wind Speed (mph)	V	90
Wind Importance Factor	I_w	1.0
Exposure Category	-	B
Enclosure Classification	-	Enclosed
Building Category	-	II
Importance Factor	I	1.00
Internal Pressure Coefficient	GC_{pi}	0.18
Wind Design Pressure (psf)	$P_{windward}$	8.481
Wind Design Pressure (psf)	$P_{leeward}$	-2.832

RESULTS

z(ft)	K_z(T6-3)	q_z	$P_{sidewall}$(psf)	$P_{leeward}$(psf)	$P_{windward}$(psf)	$P_{internal}$(psf)	P_{total}(psf)
0-15	0.70	12.338	-7.421	-2.832	8.481	2.221	11.313
20	0.70	12.338	-7.421	-2.832	8.481	2.221	11.313

Main Wind Force Resisting System per ASCE7-02

Assumptions:
Assume for preliminary calculations that laboratory acts separately from main building
***FOR ALL "h"

***Calculating Wind in Direction:	E/W

Building Name	FDA-CDRH Laboratory			
Building Location	Silver Spring, MD			
Location Data	Variable	Reference	Chart/Fig.	Value
Occupancy Type	-	1.5.1	T1-1	II
Importance Factor	I	6.5.5	T6-1	1.00
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	36.4862
Height Above Ground	z	6.300	Spec	18.4416
Horiz. Length ll to Wind Dir.	L	6.300	Spec	125.9843
Horiz. Length Perp. to Wind	B	6.300	Spec	47.4081
Horizontal Dimension Ratio	L/B	F6-6	Spec	2.66
Mean Roof Height	h	6.200	*	31.6946
*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	30
Mean Hourly Wind Speed	V_z	6.5.8.2	Eq 6-14	58.00
Height atm Boundary	z_g	6.300	T6-2	1200
Velocity Pressure Exp.*	k_z	6.5.6.6	T6-3**	0.70
Velocity Pressure Exp.*	k_h	6.5.6.6	T6-3**	0.70
*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	$\bar{\epsilon}$	6.5.8.1	T6-2	0.33
Integral Length Scale, Turb.	L_z	6.5.8.1	Eq 6-7	310.09
Turbulence Intensity Factor	c	6.300	T6-2	0.30
Intensity of Turbulence	I_z	6.5.8.1	Eq 6-5	0.30

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	$T_a = C_t(h_n^x)$	0.30
Natural Frequency	n_1	6.5.8.2	$n_1 = 1/T_a$	3.37
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	0.111	8.466
R_1 Coefficient	R_B	6.5.8.2	Eq 6-13	0.076	12.663
R_1 Coefficient	R_L	6.5.8.2	Eq 6-13	0.009	112.661
Reduced Frequency	N_1	6.5.8.2	Eq 6-13	18.006	
Resonance Coefficient	R_n	6.5.8.2	Eq 6-13	0.022	
Damping Ratio	β	6.300	Section 9	0.050	
Resonant Response Factor	R	6.5.8.2	Eq 6-10	0.045	

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	4.47
Background Response	Q	6.5.8.1	Eq 6-6	0.89
Gust Factor	G_f	6.5.8.2	Eq 6-8	0.86

Wind Pressure	Variable	Reference	Chart/Fig.	Value
Velocity Pressure	qz	6.5.10	Eq 6-15	12.338
Velocity Pressure @ h	qh	6.5.12.2	T6-3*	12.338

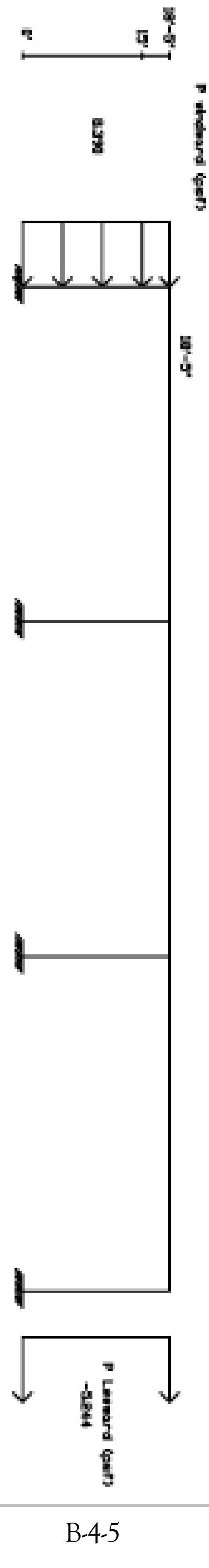
*$q_h = 0.00256 k_h k_{zt} k_d (V^2) I$

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"	-0.267
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	$P_1 = q_h G_f C_p$	-2.832
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)
0-15	0.70	12.338	-7.421	-2.832	8.481
20	0.70	12.338	-7.421	-2.832	8.481
**k_z and k_h: Use "Kz" Sheet to copy and paste values					

Internal Wind Pressure	Variable	Reference	Chart/Fig.	Value
Enclosure Classification	GC_{pi}	Table 6-5	T6-7"	0.180
Velocity Pressure @ h	qh	6.5.12.2	T6-3"	12.338
Internal Wind Pressure (psf)	$(qh)(GC_{pi})$			2.221
*$q_h = 0.00256 k_h k_{zt} k_d (V^2) I$				


P windward (psf)
P Leeward (psf)

Wind Load → Point load Calculations

Laboratory

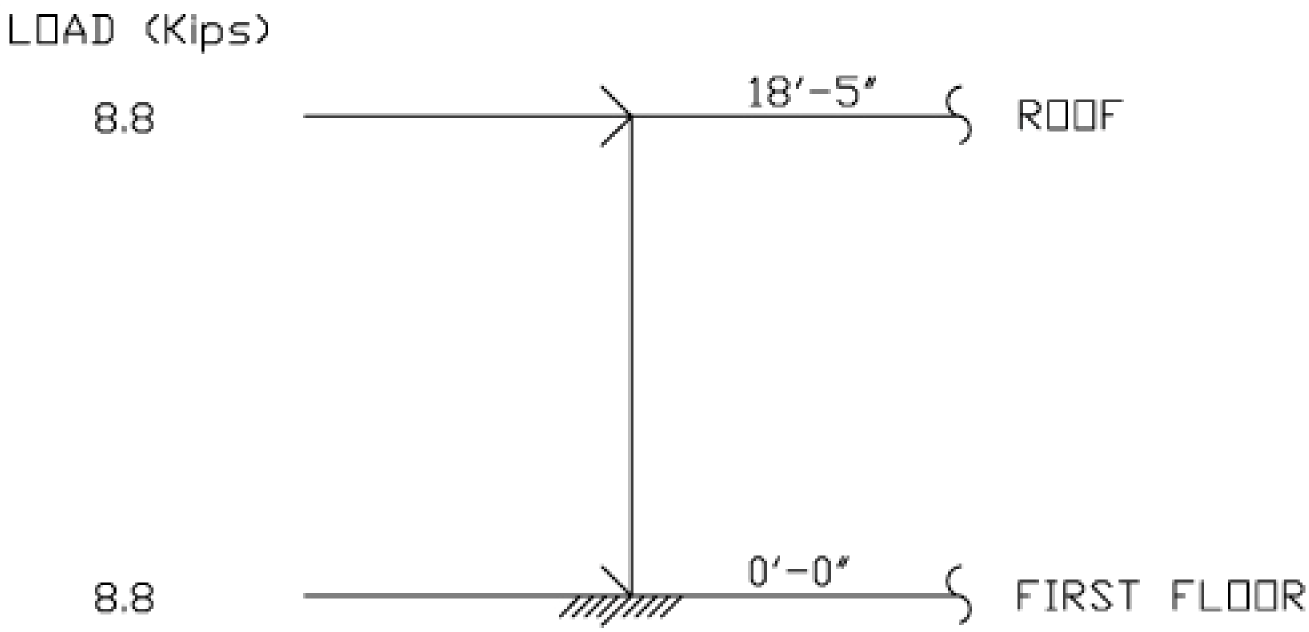
E-W

Floor #1 : $\left(\frac{18.5}{2}\right)(11.313)(84') = 8790.2$ lbs

8.8k

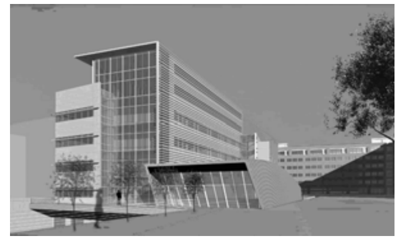
Roof : $\left(\frac{18.5}{5}\right)(11.313)(84') = 8790.2$ lbs

8.8k



E/W CONCENTRATED WIND LOADS

LABORATORY



Appendix C
Seismic Loads

Section 1– Loading
Main Building

Wall loads (for seismic calculations)

Averaged perimeter size:

19574mm = 64.2 ft

x

92800mm = 304.5 ft

total area

2(64.2) + 2(304.5) = 737.4 ft

Wall masses

from ASCE 7-02

40% windows : 8psf

60% 2x6 @ 16in 5/8 in gypsum, insulated, 3/8 in, siding : 12psf

Total mass for walls

0.4(8psf) + 0.6(12psf) = 10.4 psf (737.4 ft) = 7668.96 plf

Mass in linear feet (must add height)

Roof massing

from ASCE 7.02

Cement tile : 16psf

MEP : 10psf

10psf + 16psf = 26 psf

Roof load

(64.2 ft)(304.5 ft)(26 psf) = 508277.4 lbs

= 508.27k

Loads: (for Seismic Calculations)

Estimate of total load on building

2 typical bays

Typ (1) has 2 sizes 21' × 18' & 21' × 15'-5"

21' × 18' Typ 1 total load

51,546.57 lbs = 9,450 + 33,262.5 + 8834.07 =

21' × 15' 5" Typ 2 total load

$$\frac{21 \times 15.4167}{21 \times 18} = \frac{X}{51,546.57\text{ lbs}}$$

X = 44148.78 lbs

Typ (11) has 1 size 21' × 30' 9"

total load

118,701.22 lbs = 16,143.75 + 93,723.4 + 8834.07

Typical floor has

13 typ 11 bay

15 typ 1 (21' × 18') bay

15 typ 1 (21' × 15.5') bay

Total load per floor =

13 (118,701.22 lbs) + 15 (51,546.57 lbs + 118,701.22 lbs)

$$= \frac{4096832.71\text{ lbs}}{(304.5 \times 64.2)} = 209.56\text{ psf}$$

Seismic Calc per ASCE7 FDA-CDRH Laboratory

Building Name	FDA-CDRH Laboratory
Building Location	Silver Spring, Maryland

Building Information		
Site Class Definition	-	C
Seismic Use Group	-	I
Seismic Design Category	-	B
Occupancy Importance Factor	I	1
Response Modification Factor	R	3
Spectral Response Accel Short	S_s	19%
Spectral Response Accel 1 sec	S_1	7%
Site Coefficient	F_a	1.200
Site Coefficient	F_v	1.700

RESULTS					
Floor #	$(W_x)(h_x)$^k (Foot-Pounds)	C_{vx}	F_x (Pounds)	F_x (Kips)	V_x (Kips)
Roof	51753158.27	0.074	80666.640	80.667	
Penthouse	262085292.33	0.372	408507.242	408.507	80.667
Fourth	194981030.96	0.277	303913.136	303.913	489.174
Third	129987353.97	0.185	202608.757	202.609	793.087
Second	64993676.99	0.092	101304.379	101.304	995.696
Sum	703800512.51	1.000	1097000.154	1097.000	
Base Shear	1097000.15			1097.000	1097.000

Building Name:	FDA-CDRH Laboratory
Building Location:	Silver Spring, Maryland

Location Data:			
Response Modification Factor	R	3	9.5.2.2
Occupancy Importance Factor	I	1	
Seismic Use Group		I	9.5.2.5
Seismic Design Category		B	Table 9.5.2.5.1
Site Class Definition		C	9.4.1.2.3.

Loading Data:			
Roof Dead Load		26	ASCE 7-02 Table C3-1
Floor Dead Load		209.56	
Snow Load		0	0 if less than 30 psf
Exterior Wall Load		10.4	ASCE 7-02 Table C3-1
Total Square Footage		97744.5	
Square Footage Per Floor		19548.9	
Perimeter		737.4	
Floor Heights	Pethouse	24.3438	
	Fourth	15.4199	
	Third	15.4199	
	Second	15.4199	
	First	15.4199	

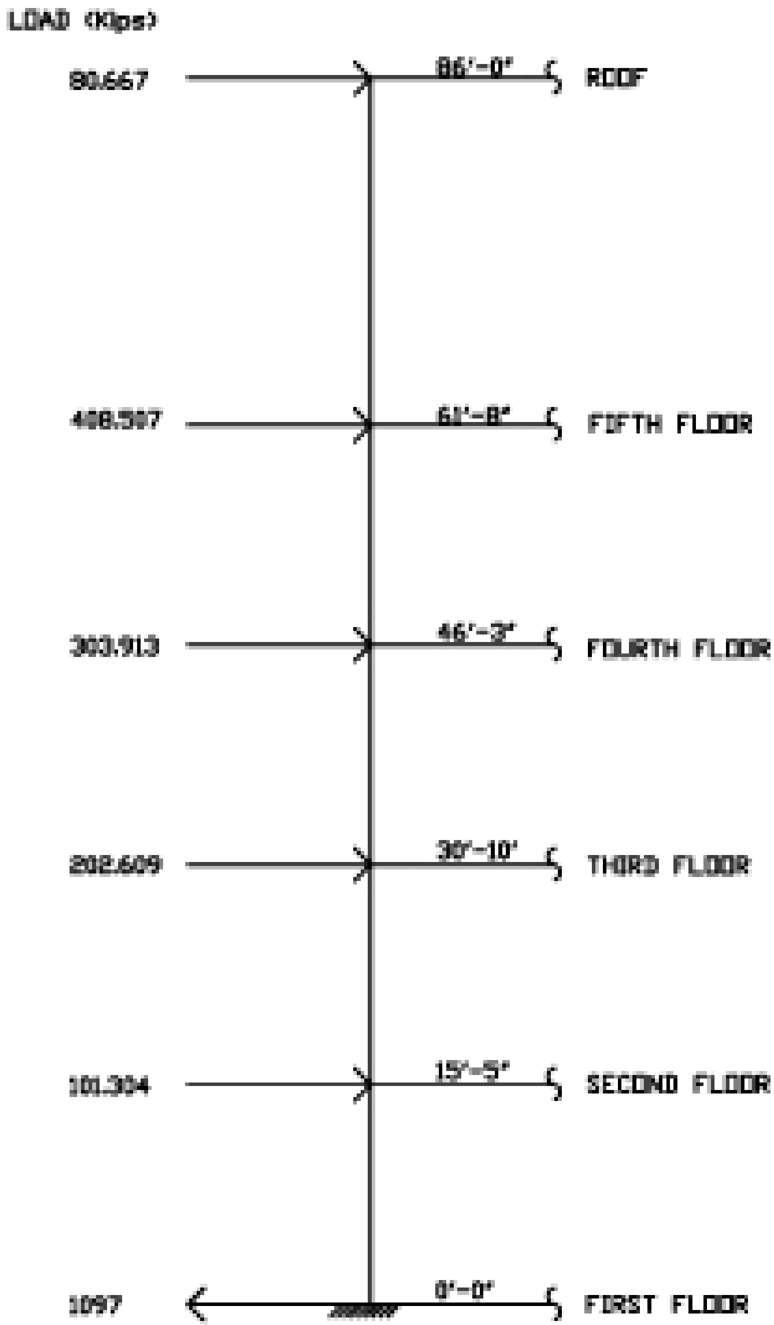
Seismic Data			
	Ss	0.19	Figure 9.4.1.1.a
	Sl	0.07	Figure 9.4.1.1.b
Site Class		C	9.4.1.2.3.
	Fa	1.2	Table 9.4.1.2.4.a
	Sms	0.228	Sms=(Fa)(Ss)
Sds Multiplier		0.66666667	9.4.1.2.5
	Sds	0.152	Sds=(2/3)(Sms)
	Fv	1.7	Table 9.4.1.2.4.b
	Sml	0.119	Sml=(Fv)(Sl)
Sdl Multiplier		0.66666667	(2/3)

	Sdl	0.07933333	Sdl=(2/3)(Sml)	
Importance Factor	I	1		
Seismic Use Group		I	9.5.2.5	
Seismic Design Category		B	Table 9.5.2.5.1	

Use Equivalent Lateral Force Analysis 9.5.5

Analysis - 9.5.5				
Roof Load	Wrf	601617.214	Wrf=(Rsqft)(Rload)+(Perl)(1/2Rheight)(WallLoad)	
Floor Loads	Wp	4249140.6	Wrf=(Psqft)(Pload)+(Perl)(.5*P+.5*4)(WallLoad)	
	W4	4214922.08	Wrf=(4sqft)(4load)+(Perl)(.5*4+.5*3)(WallLoad)	
	W3	4214922.08	Wrf=(3sqft)(3load)+(Perl)(.5*3+.5*2)(WallLoad)	
	W2	4214922.08	Wrf=(2sqft)(2load)+(Perl)(.5*2+.5*1)(WallLoad)	
	W1	4155794.78	Wrf=(1sqft)(1load)+(Perl)(.5*1)(WallLoad)	
Total Load	Wt	21651318.8	Wt=Wrf+Wp+W4+W3+W2+W1	
	Cu	1.7	Table 9.5.5.3.1	
	Ct	0.02	Table 9.5.5.3.2	
	x	0.75	Table 9.5.5.3.2	
Total Height	hn	104.0682	Structural	
Number of Stories	N	5	Structural	
Approx Period	Ta	0.65165619	Ta=(Ct)(hn)^x	
Approx Period (all conc N<12)	Ta	0.5	Ta=0.1N	**Used this value
Seismic Response	Csmax	0.05288889	Cs=Sdl/(T(R/I))	
Seismic Response	Csmin	0.006688	Cs=0.044SdsI	
Seismic Response	Cs	0.05066667	Cs=Sds/(R/I)	
Seismic Base Shear	V	1097000.15	V=CsW	
	K	1	k=1 for T <= 0.5s	
(wx)(hx)^k	r	51753158.3	(wx)(hx)^k	
	p	262085292		
	f4	194981031		
	f3	129987354		
	f2	64993677		
	total	703800513		
Cvx	Cr	0.07353385	Cvx=(Wx*hx^k)/(SUM(Wi*hi^k))	
	Cp	0.37238577		
	C4	0.27704019		
	C3	0.18469346		
	C2	0.09234673		
Check Cvx=1	1=	1		

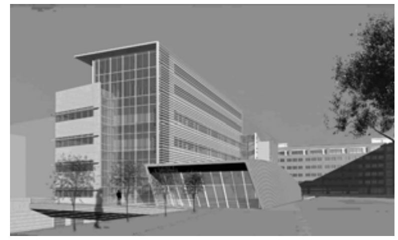
Fx	Fr	80666.64	Fx=Cvx*V
	Fp	408507.242	
	F4	303913.136	
	F3	202608.757	
	F2	101304.379	



CONCENTRATED SEISMIC LOADS

Timothy Mueller
Structural Option
Walter Schneider

FDA CDRH Laboratory
Silver Spring, Maryland



Appendix C
Seismic Loads

Section 2– Loading
Laboratory

Loads: (For Seismic Calculations) Laboratory

Estimate of total load on building

Beam Weight

2(HSS 20 × 4 × 1/2) = 2 (79.4 lb/ft)(47.4') = 7527.12 lbs
4(W24 × 146) = 4 (146 lb/ft)(47.4') = 27681.6 lbs
18(W18 × 50) = 18 (50 lb/ft)(42') = 37800.0 lbs
8(W12 × 74) = 8 (74 lb/ft)(42') = 24864 lbs

97872.12 lbs

97.87^k

Slab weight

2" lok-floor w/ 6" concrete 60 psf

60 psf (132.9' × 47.4') = 377967.6 lbs

377.97^k

Total weight of roof = 377.97^k + 97.87^k

= 475.8^k

$\frac{475.8^k}{(132.9' \times 47.4')} = 75 \text{ lb/ft}^2$

Wall loads

Average perimeter size

132.9' × 47.4'   2(132.9') + 2(47.4') = 360.6'

(ASCE 7.02) Wall masses 30% windows 8psf (two short ends)

70% 2×6@16", 5/8" gypsum, insulated

; 5/8" siding 12psf

Total mass for walls

0.3(8psf) + 0.7(12psf) = 10.8psf

Mass in linear feet (must add height) 10.8psf (360.6') = 3894.48 plf

Seismic Calc per ASCE7 FDA-CDRH Laboratory	

Building Name	FDA-CDRH Laboratory
Building Location	Silver Spring, Maryland

Building Information		
Site Class Definition	-	C
Seismic Use Group	-	I
Seismic Design Category	-	B
Occupancy Importance Factor	I	1
Response Modification Factor	R	3
Spectral Response Accel Short	S_S	19%
Spectral Response Accel 1 sec	S_1	7%
Site Coefficient	F_a	1.200
Site Coefficient	F_v	1.700

RESULTS					
Floor #	$(W_x)(h_x)$^k (Foot-Pounds)	C_{vx}	F_x (Pounds)	F_x (Kips)	V_x (Kips)
Roof	18274570.18	1.000	30023.267	30.023	
Sum	18274570.18	1.000	30023.267	30.023	
Base Shear	30023.27			30.023	30.023

Building Name:	FDA-CDRH Laboratory
Building Location:	Silver Spring, Maryland

Location Data:			
Response Modification Factor	R	3	9.5.2.2
Occupancy Importance Factor	I	1	
Seismic Use Group		I	9.5.2.5
Seismic Design Category		B	Table 9.5.2.5.1
Site Class Definition		C	9.4.1.2.3.

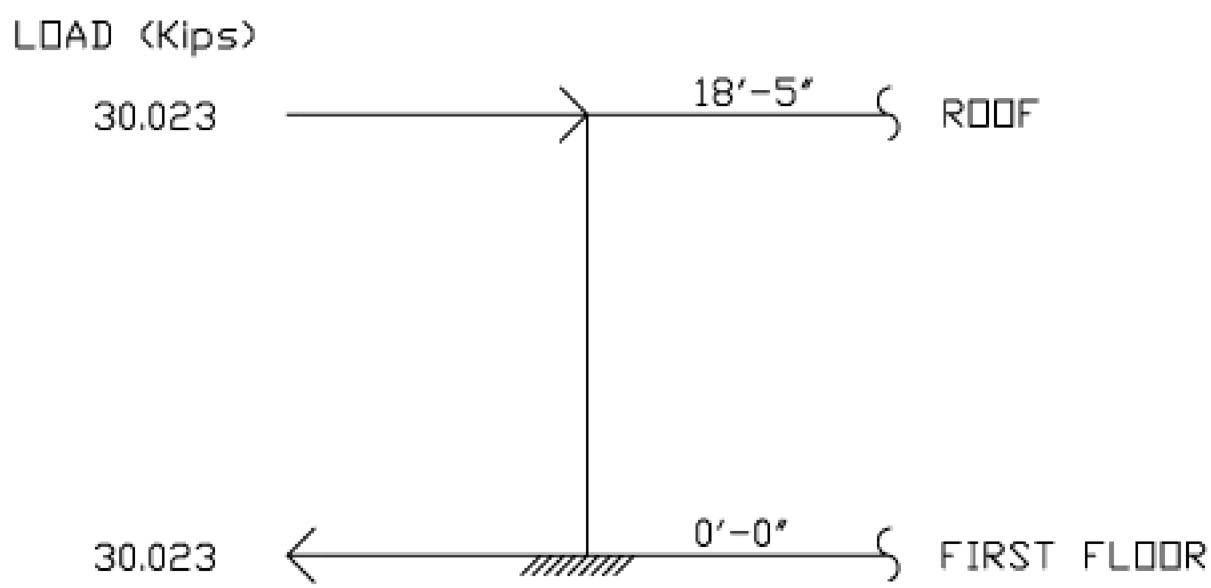
Loading Data:			
Roof Dead Load		75	ASCE 7-02 Table C3-1
Floor Dead Load		0	
Snow Load		0	0 if less than 30 psf
Exterior Wall Load		10.8	ASCE 7-02 Table C3-1
Total Square Footage		6299.46	
Square Footage Per Floor		6299.46	
Perimeter		360.6	
Floor Heights	Second	15.4199	
	First	15.4199	

Seismic Data			
	Ss	0.19	Figure 9.4.1.1.a
	Si	0.07	Figure 9.4.1.1.b
Site Class		C	9.4.1.2.3.
	Fa	1.2	Table 9.4.1.2.4.a
	Sms	0.228	Sms=(Fa)(Ss)
Sds Multiplier		0.66666667	9.4.1.2.5
	Sds	0.152	Sds=(2/3)(Sms)
	Fv	1.7	Table 9.4.1.2.4.b
	Smi	0.119	Smi=(Fv)(Si)
Sdi Multiplier		0.66666667	(2/3)
	Sdi	0.07933333	Sdi=(2/3)(Smi)
Importance Factor	I	1	

Seismic Use Group		I	9.5.2.5
Seismic Design Category		B	Table 9.5.2.5.1

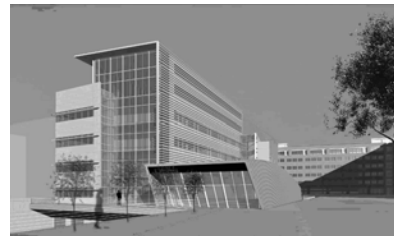
Use Equivalent Lateral Force Analysis 9.5.5

Analysis - 9.5.5			
Roof Load	Wrf	592564.484	Wrf=(Rsqft)(Rload)+(Peri)(1/2Rheight)(WallLoad)
Total Load	Wt	592564.484	Wt=Wrf+Wp+W4+W3+W2+W1
	Cu	1.7	Table 9.5.5.3.1
	Ct	0.02	Table 9.5.5.3.2
	x	0.75	Table 9.5.5.3.2
Total Height	hn	104.0682	Structural
Number of Stories	N	5	Structural
Approx Period	Ta	0.65165619	Ta=(Ct)(hn)^x
Approx Period (all conc N<12)	Ta	0.5	Ta=0.1N **Used this value
Seismic Response	Csmax	0.05288889	Cs=Sdi/(T(R/I))
Seismic Response	Csmin	0.006688	Cs=0.044SdsI
Seismic Response	Cs	0.05066667	Cs=Sds/(R/I)
Seismic Base Shear	V	30023.2672	V=CsW
	K	1	k=1 for T <= 0.5s
(wx)(hx)^k	r	18274570.2	(wx)(hx)^k
	total	18274570.2	
Cvx	Cr	1	Cvx=(Wx*hx^k)/(SUM(Wi*hi^k))
Check Cvx=1	1=	1	
Fx	Fr	30023.2672	Fx=Cvx*V



CONCENTRATED SEISMIC LOADS

LABORATORY



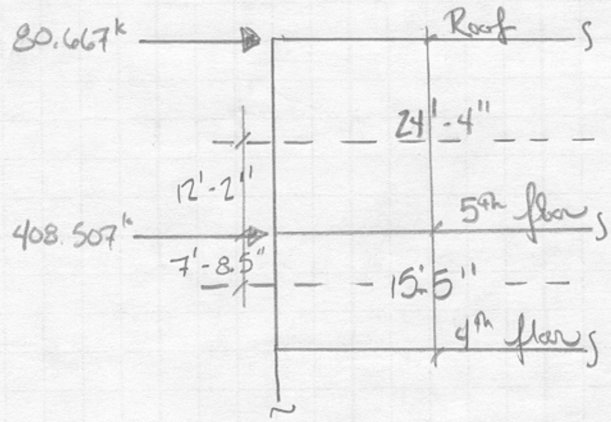
Appendix D
Load Distribution

Portal Analysis

Lateral Loading across building

Portal Method:

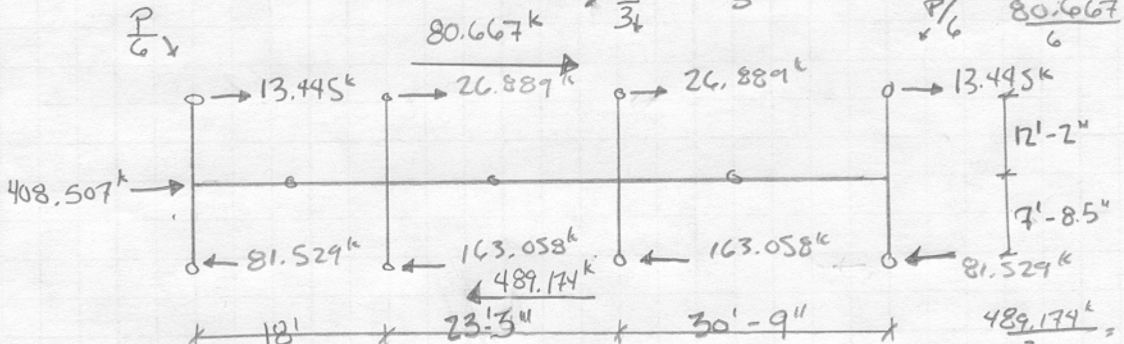
Seismic Controls → 5th Floor is worse case



Due to same lateral reaction structure (concrete has fixed joints ∴ it is a moment frame) in the N-S direction and the E-W direction we can just look at either frame. I will look at the South end of the building (E-W direction)

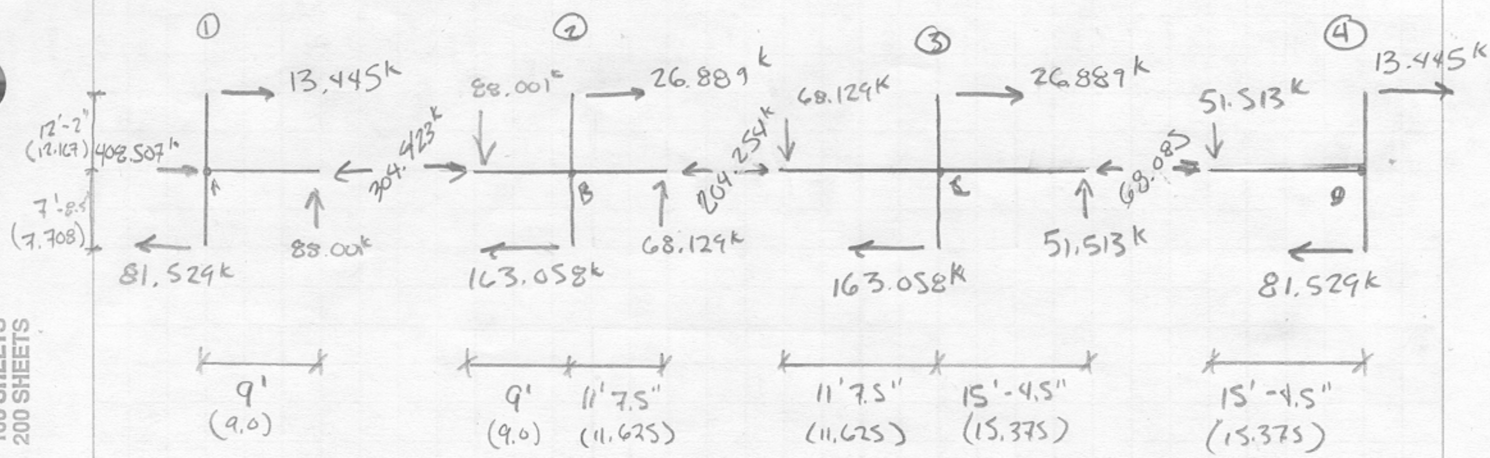
$P/3 = \frac{80.667^k}{3} = 26.889^k$

$P/6 \quad \frac{80.667^k}{6} = 13.445^k$



$\frac{489.174^k}{3} = 163.058^k$

$\frac{489.174^k}{6} = 81.529^k$



$\circlearrowright + \Sigma M_A = 0 = 12.167'(13.445^k) - x(9.0) + 7.708'(81.529^k)$

$x = 88.00^k$

$\circlearrowright + \Sigma M_B = 0 = -88.001^k(9') + 26.889^k(12.167') - x(11.625') + (163.058^k)(7.708')$

$x = 68.129^k$

$\circlearrowright + \Sigma M_C = 0 = -68.129^k(11.625') + 26.889^k(12.167') - x(15.375') + 163.058^k(7.708')$

$x = 51.513^k$

Check w M_D

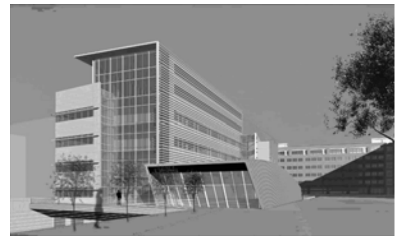
$\circlearrowright + \Sigma M_D = 0 = 13.445^k(12.167') + 81.529^k(7.708^k) - x(15.375')$

$x = 51.513^k$

$51.513^k = 51.513^k$ ✓

Timothy Mueller
Structural Option
Walter Schneider

FDA CDRH Laboratory
Silver Spring, Maryland



Appendix E
Story Drift

Story Displacements

RAM Frame v8.1
DataBase: FDA-CDRH Laboratory Lateral — 11/20/05 12:48:21
Building Code: IBC

CRITERIA:

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

LOAD CASE DEFINITIONS:

D	DeadLoad	RAMUSER
Lp	PosLiveLoad	RAMUSER
Rfp	PosRoofLiveLoad	RAMUSER
W1	Wind	Wind_IBC00_1_X
W2	Wind	Wind_IBC00_1_Y
W3	Wind	Wind_IBC00_2_X+E
W4	Wind	Wind_IBC00_2_X-E
W5	Wind	Wind_IBC00_2_Y+E
W6	Wind	Wind_IBC00_2_Y-E
W7	Wind	Wind_IBC00_3_X+Y
W8	Wind	Wind_IBC00_3_X-Y
W9	Wind	Wind_IBC00_4_CW
W10	Wind	Wind_IBC00_4_CCW
E1	Seismic	EQ_ASCE7-95_X_+E_F
E2	Seismic	EQ_ASCE7-95_X_-E_F
E3	Seismic	EQ_ASCE7-95_Y_+E_F
E4	Seismic	EQ_ASCE7-95_Y_-E_F

Level: Roof

Center of Mass (m): (48.80, 9.80)

LdC	Disp X mm	Disp Y mm	Theta Z rad
D	0.01796	18.41193	0.00021
Lp	0.45436	20.83486	0.00012
Rfp	-0.07247	-0.09844	0.00003
W1	2.72481	0.04597	0.00000
W2	1.46124	21.16731	0.00007
W3	2.33818	0.03355	0.00000
W4	2.43024	0.04690	0.00001
W5	2.37310	18.69349	0.00012
W6	0.18406	18.34930	0.00000
W7	3.13953	15.90996	0.00006
W8	0.94768	-15.84100	-0.00005
W9	1.90443	13.78877	0.00000
W10	3.58976	14.05367	0.00009
E1	51.16417	2.87873	0.00090
E2	53.02264	3.14941	0.00100
E3	7.65162	56.58970	0.00039

E4	-1.60282	55.24182	-0.00011

Level: Penthouse

Center of Mass (m): (48.80, 9.80)

LdC	Disp X mm	Disp Y mm	Theta Z rad
D	-0.56884	6.46797	0.00001
Lp	-0.68692	5.38448	0.00002
Rfp	-0.02755	-0.16349	-0.00000
W1	1.83148	0.02688	0.00000
W2	0.87392	16.04400	0.00004
W3	1.56433	0.01877	-0.00000
W4	1.64076	0.02827	0.00000
W5	1.57735	14.14058	0.00008
W6	-0.04799	13.93642	-0.00001
W7	2.02905	12.05316	0.00003
W8	0.71817	-12.01283	-0.00003
W9	1.14944	10.46789	-0.00001
W10	2.40139	10.62514	0.00006
E1	39.75628	2.07517	0.00075
E2	41.29951	2.26915	0.00083
E3	6.01288	47.79571	0.00031
E4	-1.67178	46.82976	-0.00011

Level: Floor 4

Center of Mass (m): (48.80, 9.80)

LdC	Disp X mm	Disp Y mm	Theta Z rad
D	-0.44103	5.35616	0.00000
Lp	-0.55842	4.43332	0.00000
Rfp	-0.00734	-0.04486	-0.00000
W1	1.52024	0.01887	0.00000
W2	0.67884	13.26874	0.00003
W3	1.29752	0.01256	-0.00000
W4	1.36291	0.02045	0.00000
W5	1.26617	11.69198	0.00006
W6	-0.07821	11.52831	-0.00001
W7	1.64931	9.96570	0.00002
W8	0.63106	-9.93740	-0.00002
W9	0.92502	8.65692	-0.00001
W10	1.96127	8.78306	0.00005
E1	32.57147	1.64203	0.00061
E2	33.84349	1.79768	0.00068
E3	4.88563	39.37679	0.00025
E4	-1.44850	38.60173	-0.00009

Story Displacements

RAM Frame v8.1
DataBase: FDA-CDRH Laboratory Lateral
Building Code: IBC

11/20/05 12:48:21

Level: Floor 3

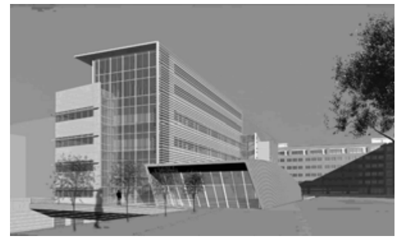
Center of Mass (m): (48.80, 9.80)

LdC	Disp X mm	Disp Y mm	Theta Z rad
D	-0.16944	3.75667	0.00000
Lp	-0.20035	3.48209	0.00000
Rfp	-0.00247	-0.01695	-0.00000
W1	1.07027	0.01088	0.00000
W2	0.44774	9.26224	0.00002
W3	0.91268	0.00678	-0.00000
W4	0.96030	0.01226	0.00000
W5	0.86945	8.15994	0.00004
W6	-0.08589	8.04898	-0.00001
W7	1.13851	6.95484	0.00002
W8	0.46690	-6.93852	-0.00002
W9	0.62779	6.04271	-0.00001
W10	1.36461	6.12827	0.00003
E1	22.03605	1.06328	0.00042
E2	22.90709	1.16565	0.00047
E3	3.28383	26.56413	0.00017
E4	-1.05363	26.05437	-0.00006

Level: Floor 2

Center of Mass (m): (48.80, 9.80)

LdC	Disp X mm	Disp Y mm	Theta Z rad
D	-0.03682	1.26716	0.00000
Lp	-0.03882	1.19457	0.00000
Rfp	-0.00064	-0.00417	-0.00000
W1	0.48241	0.00342	0.00000
W2	0.18052	4.12247	0.00001
W3	0.41077	0.00184	-0.00000
W4	0.43344	0.00415	0.00000
W5	0.38112	3.63011	0.00002
W6	-0.06522	3.58422	-0.00000
W7	0.49719	3.09442	0.00001
W8	0.22642	-3.08929	-0.00001
W9	0.26284	2.68992	-0.00000
W10	0.60725	2.72532	0.00002
E1	9.44359	0.40813	0.00019
E2	9.82715	0.44845	0.00021
E3	1.38346	11.18040	0.00007
E4	-0.52648	10.97965	-0.00003



Appendix F
Torsional Loads

Torsional Shear Forces	
x-direction	y-direction
F2= 2.62608	F2= 2.62608
F3= 4.05218	F3= 4.05218
F4= 6.07826	F4= 6.07826
Fpent= 8.17014	Fpent= 8.17014
Froof= 1.61334	Froof= 1.61334

Stiffness= k=p/Δ

x-direction	y-direction	
p= 1097	p= 1097	from seismic loading
Δ= 0.174166667	Δ= 0.185833333	
k= 6298.564593	k= 5903.139013	

Using a 5% eccentricity due to the entire building acting in the lateral system

x-direction	y-direction
length (ft)	
l= 320.2	l= 64.3
eccentricity (0.05l) ft.	
ecc= 16.01	ecc= 3.215

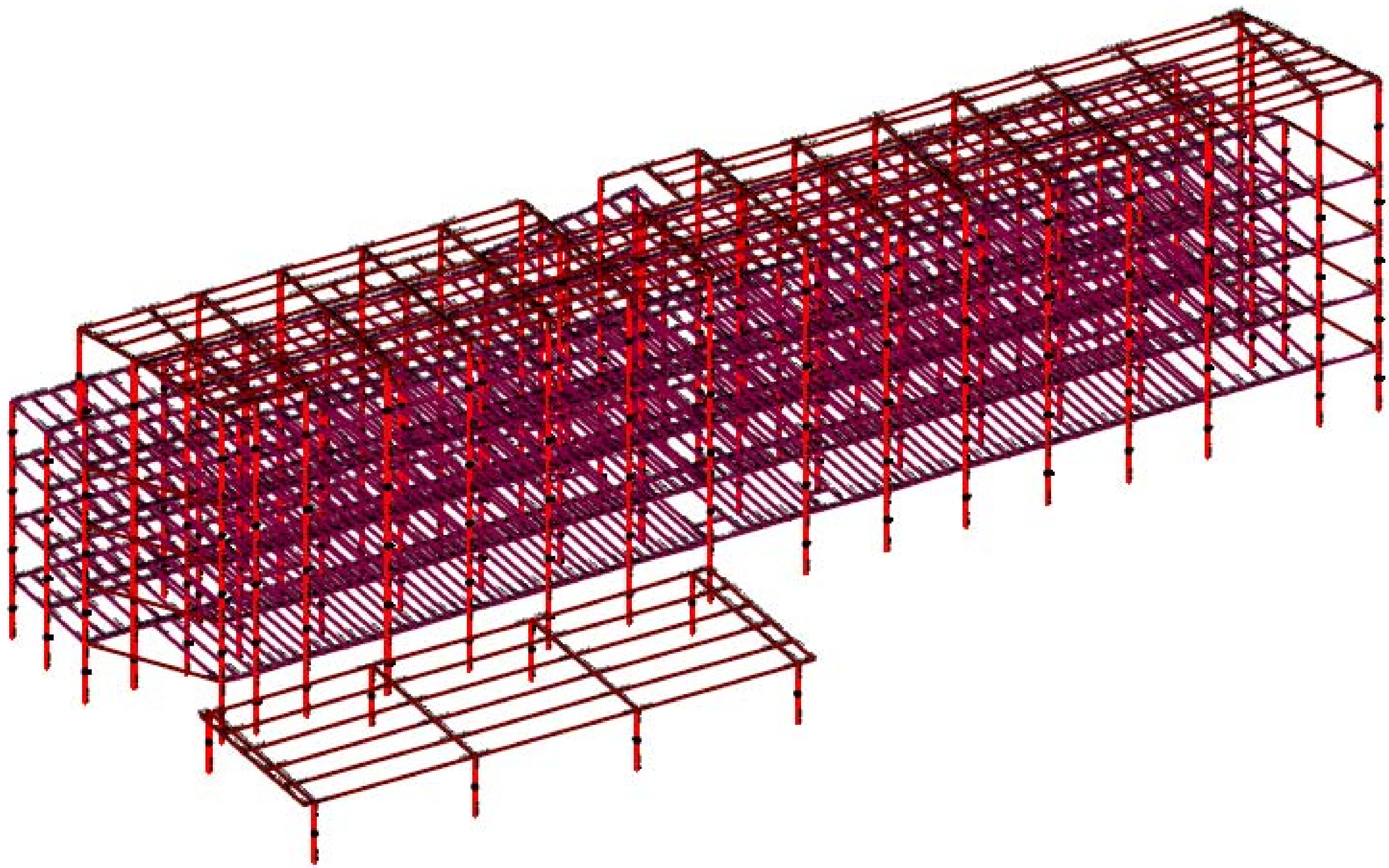
Moment on each floor

Moment = force(eccentricity) ft-kips

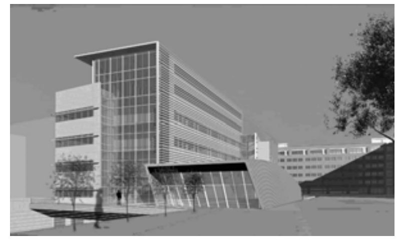
x-direction	y-direction	
F2= 131.304	F2= 131.304	handcalculated seismic loading was used to solve for the moment forces
M2= 2102.17704	M2= 422.14236	
F3= 202.609	F3= 202.609	
M3= 3243.77009	M3= 651.387935	
F4 303.913	F4 303.913	
M4= 4865.64713	M4= 977.080295	
Fpent= 408.507	Fpent= 408.507	
Mpent= 6540.19707	Mpent= 1313.350005	
Froof= 80.667	Froof= 80.667	
Mroof= 1291.47867	Mroof= 259.344405	

(Kidi)/(∑Kidi^2)	
x-direction	y-direction
Ki= 6298.564593	Ki= 5903.139013
di= 160.1	di= 32.15
Kidi= 1008400.191	Kidi= 189785.9193
Kidi^2= 161444870.6	Kidi^2= 6101617.305
(Kidi)/(∑Kidi^2)	(Kidi)/(∑Kidi^2)
0.001249219	0.00622084

Fi torsion = M(Kidi)/(∑Kidi^2) kips



The above image represents the torsional values given by RAM, and are displayed on the members themselves. This images shows the great amount of output a computer program can provide, however, it also demonstrates the level of understanding one must have to be able to interpret the data.



Appendix G
Overturning Moment

Overturning Moment

Forces of the controlling condition (seismic) - kips

Froof=	80.667
Fpent=	408.507
F4=	303.913
F3=	202.609
F2=	101.304

Distance from the ground to the force - ft

Droof=	85.9
Dpent=	61.6
D4=	46.2
D3=	30.8
D2=	15.4

Moment on building (overturning moment) - ft-kips

M=	53934.55

Weight of all floors - kips

Wroof=	601.6172
Wpent=	4214.922
W4=	4214.922
W3=	4214.922
W2=	4214.922
Wtotal=	17461.31

Legth of building in critical direction (short wall) - ft

L=	64.3

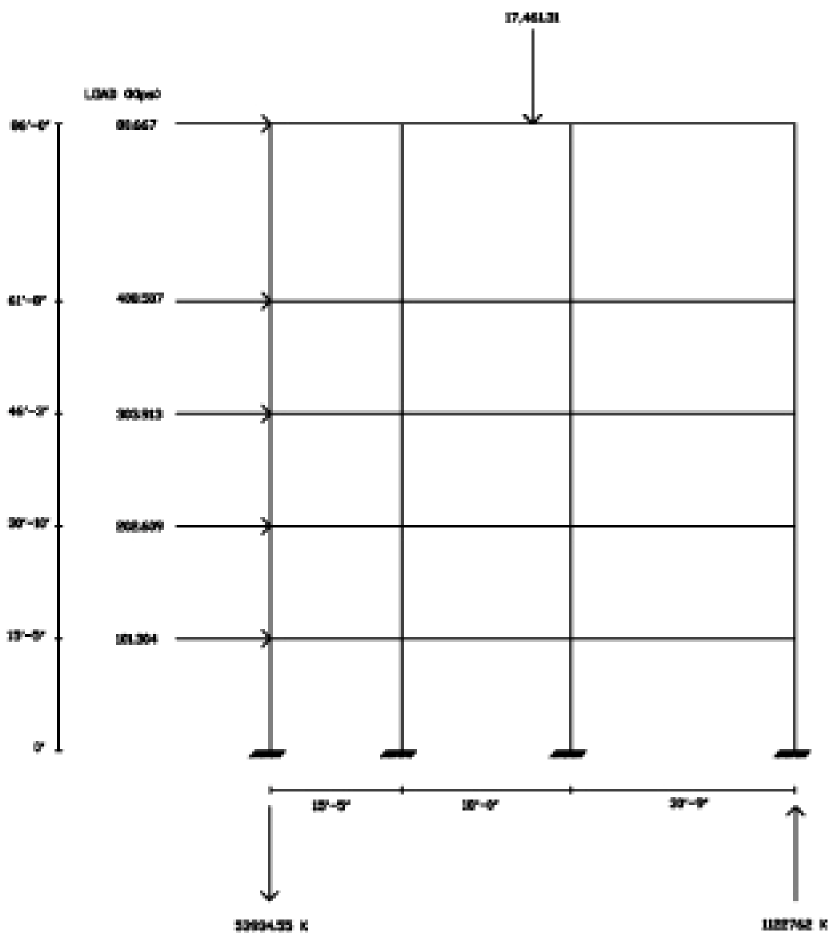
Moment due to mass of building (resistive moment) - ft-kips

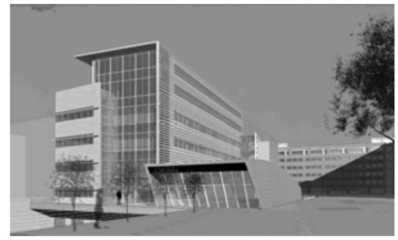
M=	1122762

Uplift is negligible compared to the large forces caused by siesmic

Resistive moment is much greater then overturning moment

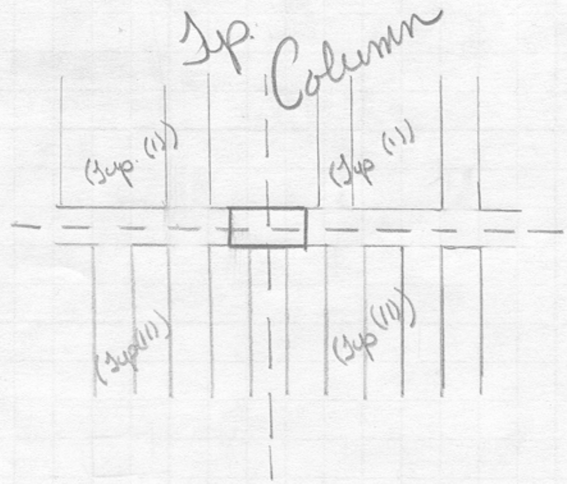
1122762	>>>	53934.55


0'



Appendix H
Member Strength

Section 1– Axial Column



Loads on column:

Typ I ... Typ II

(1/4 (live + slab + joist + beam + supimp)) 2 + (1/4 (live + slab + joist + beam + supimp)) 2 + Roof + column

Live Load = 125psf

Typ I → 125 psf (21' × 18') = 47,250 lbs

Typ II → 125psf (21' × 30.75') = 80,718.75 lbs

Super Imposed DL

Typ I → 25 psf (21' × 18') = 9,450 lbs

Typ II → 25 psf (21' × 30.75') = 16,143.75 lbs

Slab & Joist

Typ I - 33,262.5 lbs } from Typ. Bay analysis

Typ II - 93,723.4 lbs

beam

Typ I - 420.67 plf (21') = 8834.07 lbs

Typ II - 420.67 plf (21') = 8834.07 lbs

Total Load (for floors)

1.6 live + 1.2 dead

Typ I - 1.6 (47,250) + 1.2 (9,450 + 33,262.5 + 8834.07)

= 137,455.884 lbs = 137.46^k

Typ II - 1.6 (80,718.75) + 1.2 (16,143.75 + 93,723.4 + 8834.07)

= 271,591.464 lbs = 271.59^k

Roof loading

26 psf

for area of bay

26 psf (2 (¼ (21 ft × 18 ft)) + (2 (¼ (21' × 30.75'))))

= 13308.75 lbs = 13.31^k

Snow load

15.75 psf

for area of bay

15.75 psf (2 (¼ (21 ft × 18 ft)) + (2 (¼ (21' × 30.75'))))

= 8062.03 lbs = 8.06^k

Total load for Roof just in section being viewed

1.6 live + 1.2 dead + 0.5 snow

1.6 (0) + 1.2 (13308.75) + 0.5 (8062.03)

= 20001.515 lbs = 20^k

Total Load on Column for 3rd floor → 4th floor

(this is in section of the building not effected by 5th floor penthouse)

Column weight from above 150pcf (2'×1.5'×15.5') = 6975 = 6.975^k

$P_{act} = \frac{1}{4}(137.46)(2) + \frac{1}{4}(271.59)(2) + 20 + 6.975$

$P_{act} = 231.5^k$

Total load column can support

assume column dimension: 24"×18" @ 5000psi concrete

$P_{all} = f'_c A_c$

(5000psi)(24"×18") = 2,160,000 lbs

= 2160^k

$\phi P_{all} > P_{act}$

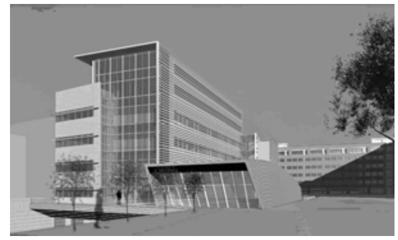
$0.85(2160^k) > 231.5^k$

$1836^k > 231.5^k$ ✓ ok

Column designed handles required loading.

Timothy Mueller
Structural Option
Walter Schneider

FDA CDRH Laboratory
Silver, Spring Maryland

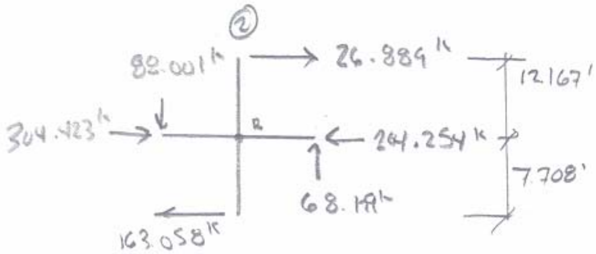


Appendix H
Member Strength

Section 2– Column Moment

Lateral Loading on columns

Look at column on interior span (2)



M_B @ 163.058k

= 163.058k (7.708')

= 1256.85 1-k over whole length ∴ per row estimate $\frac{1256.85^{1k}}{13}$ = 83.79 1k per frame

column must support this moment.

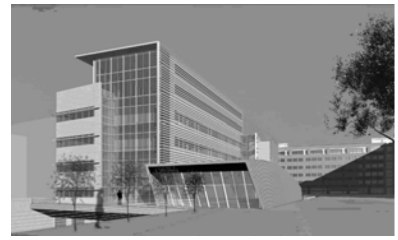
Look value up in chart 16.16.5.6

Column is 24" × 18" with 6 # 8 bars @ 5000psi

checking the largest column on chart (18" × 18") for 5000 psi and 6#8 bar which passes ∴ a larger column will pass and my column passes ✓

Timothy Mueller
Structural Option
Walter Schneider

FDA CDRH Laboratory
Silver, Spring Maryland

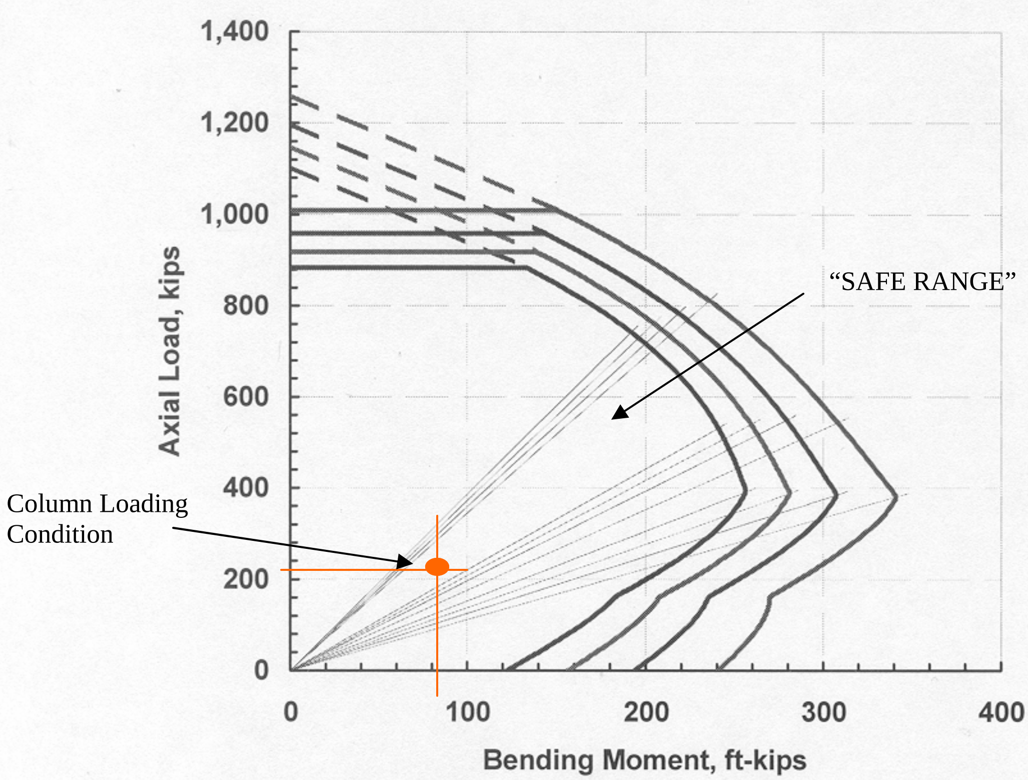


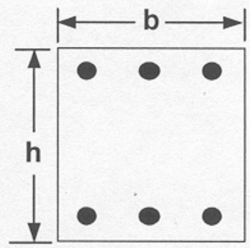
Appendix H
Member Strength

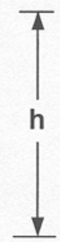
Section 3– Moment Chart

STRUNET
CONCRETE DESIGN AIDS

Concrete Colum Strength Interaction Diagram: 18.18.5.6







Conncrete Strength, f'_c	5	ksi
Steel Yield Strength, f_y	60	ksi
Clear Cover to Ties	1.5	in
Column Dimensions		
b	18	in
h	18	in

Ties	#3		#3		#3		#3	
Bars	6#7		6#8		6#9		6#10	
P. No.	φP	φM	φP	φM	φP	φM	φP	φM
1	1104	0	1149	0	1198	0	1261	0
2	884	0	919	0	958	0	1009	0
3	884	134	919	139	958	144	1009	150
4	742	192	762	204	784	218	812	235
5	532	241	540	259	550	279	544	308
6	392	256	389	281	386	308	381	341
7	0	122	0	157	0	194	0	241