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CAPSTONE

The Seattle Building
Project ID: CEEn_CPST_012

by

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A Capstone Project Technical Report

Submitted to

Dr. John Judd
American Institute of Steel Construction

Department of Civil and Construction Engineering
Brigham Young University

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Executive Summary

PROJECT TITLE: The Seattle Building
PROJECT ID: CEEn_CPST_012
PROJECT SPONSOR: American Institute of Steel Construction
TEAM NAME: JJAS Engineering

Most tall buildings use reinforced concrete walls in the core of the building to resist wind and seismic loads. However, conventional core walls must remain elastic when subjected to wind loads. This can prevent ductile behavior when subjected to seismic loads. This project is part of an ongoing research effort at BYU sponsored by the American Institute of Steel Construction to explore the potential of coupled composite plate shear walls filled with concrete to allow inelastic wind behavior.

The objective of this project is to produce ductile core wall designs for a 46-story building located in Seattle, Washington. One design will be produced for a 110-mph wind. The focus of the project is on the design of the core walls only. The design of the surrounding gravity frame, the foundation design, and connections and detailing outside the core wall area are beyond the scope of the project.

Sequential Tasks	Completion Date	Ongoing Tasks	Completion Date
1. Determine Dead, Live, and Wind loads ("Story Forces") for each story	01/30/2022	Prepare design Documents (deliverables) ● Structural calculations report ● Revit models of the core walls ● Core wall modeling tool	04/11/2022
2. Learn how to and design C-PSW/CF walls	03/31/2022		
3. Design the coupling beams	04/05/2022		

Our deliverables are a structural calculations report, structural drawings of the core walls, and revit models of the core walls.

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Introduction

The objective of this project is to produce ductile core wall designs for a 46-story building located in Seattle, Washington. Dr. Judd has generously made himself available for meeting with us as much as weekly to provide guidance. Most of the work was done individually, but we've met at least once a week to coordinate.

Our deliverables include:

- Structural calculations report
  - A calculations report for the core walls is the most important part of the project and is what AISC is requesting. There are three types of walls depending on their shape. The most basic is the C-Shaped panel, used primarily the outermost core walls. Then the I-shaped walls, and then the straight walls coupled together with beams in the center. Our design begins with the C-Shaped panels in the North-South direction and then will transition to the coupled walls in the East-West direction and end with the design of the coupling beams.
- Structural drawings of the core walls
  - To scale drawings of the core wall designs as a pdf.
- Revit models of the core walls
  - Scaled models in Revit of the structure's core in three different sections of the building

See task break-down and completion dates below:

1. Determine dead, live, and wind loads - 01/30/2022
   a. Determine Dead Loads
      i. List Dead load sources
      ii. Determine Dead loads for various floors
      iii. Prepare summary/report
      iv. Revise as needed
   b. Determine Live Loads
   c. Determine Wind Loads
      i. Determine wind loads for North-South direction
      ii. Determine wind loads for East-West direction
2. Learn how-to and design C-PSW/CF walls - 03/31/2022
   a. Research and understand how to design the C-PSW/CF walls
   b. Design the walls in the North-South direction
   c. Design the walls in the East-West direction along with the coupling beams
3. Design the coupling beams - 04/05/2022
   a. Design the walls with coupling beams in the East-West direction
4. Prepare design documents - 04/11/2022

Schedule

We anticipated the project would be completed by March 31st, 2022, but it was instead completed by April 5th, 2022. We allocated 78 days to determine loads in which time we were able to successfully determine the dead and live loads per story of the building. Then, using ASCE 7-16, we were able to determine the wind loads on the building in both the North-South, and East-West directions at each floor of the building. We then gave ourselves 24 days to design the walls and coupling beams. This we were able to accomplish by using a design example found in Volume 1 of the "Companion to the AISC *STEEL CONSTRUCTION MANUAL,*" for both the North-South, and East-West directions for each third of the building. We were then able to design the coupling beams for each story in the East-West direction. We worked on the design documents along the way, for a total of 102 days. Each task has been added to our Gantt chart, with each sub-task.

See Gantt chart in Appendix A.

Assumptions & Limitations

Even though our building is fictitious, it needed to be realistic. However, due to the nature of our project only lasting a few months, and the amount of time that would be required to fully design this building, there needed to be limits and assumptions in order to design our building in the time given.

- Our assumptions include:
    - The governing force on our structure would be the 110 mph wind; seismic forces were not considered when designing the core walls.
        - This wind speed is assuming the worst case scenario in Seattle, Washington according to ASCE 7-16
    - The foundation design was to be adequate
    - The vertical loads will be distributed among steel beams, girders, and columns which are also adequate
        - The core walls will only be supporting its own weight
    - Welds and other construction connections required to construct the walls will be adequate, and thus won't be detailing out how to manufacture the walls
    - Live load will be 100 psf
    - The composite walls are essentially a composite HSS pipe, but in larger scale
    - Risk Category will be III and Exposure will be C according to ASCE 7-16
    - The building is Flexible or Dynamically Sensitive to calculate the gust force according to ASCE 7-16
- Our limiting factors include:
    - The wall strength must meet within the safety factor that we calculate
    - Our steel plates can be no less than ⅜" thick
    - For the coupling beam walls, the beam length divided by the beam depth must be between 3 and 5
    - For the coupling beam walls, the total height divided by the length of one wall must be greater than 4

Design, Analysis & Results

Our design and analysis process consists of 5 steps. The first step was to familiarize ourselves with ASCE 7-16 and how to use it to determine the dead, live, and wind loads. We then determined the building's dead and live loads. After determining the dead and live loads, we began our analysis of the wind story forces. Once we had determined the live, dead, and wind loads for our building, we were able to begin designing the C-PSW/CF core walls. Our final step was designing the coupling beams.

Dead Loads

The first step in the design process was to determine the dead and live loads that would be acting on the structure. To do so, we used the following building description and floor schematic:

Building description: The building is to be 100-ft wide by 150-ft long with a 3 by 5 bay layout. The shear walls are located in the service core area.

Figure 1: Ground Level Dimensions

Using the above schematic we were able to use the designated material shapes to determine the weight of the materials. This data was then used to calculate the frame dead loads.

Table 1: Dead Loads

Floor Dead Load		
Steel Decking	2.49	psf
Concrete Cover	33	psf
Steel Girders	2.26	psf
Fire proofing	12.2	psf
Wood/steel studs w/ 1/2" gypsum	8	psf
MISC	5	psf
Total	63	psf

Wall Dead Load				
Concrete	145	pcf	8.4E-05	kci
Steel	491	pcf	2.8E-04	kci
Total			3.68E-04	kci

Total Dead Load		
Floor Dead Load	0.06	ksf
Wall Dead Load	3.7E-04	kci

If a live load is to be considered 100 psf will be used.

Wind Load

An exposure category C, risk category III, and a basic wind speed of 110 mph is the basis for the wind design. Using ASCE 7-16 we determined the wind loads for the North-South and East-West direction. Below are some of the relevant numbers in calculating the wind loads. A full summary of the wind parameters and loads has been included in the appendix of this report.

Table 2: Wind Parameters

Wind Parameters		North-South	East-West	Source
Exposure Catagory:		C	C	Given
Risk Catagory:		III	III	Given
Basic Wind Speed	V (mph) =	110	110	Given
Gust-effect factor	Gf =	1.09	1.11	ASCE 7-16: 26.9-10
Windward external pressure coefficient	Cp =	0.8	0.80	ASCE 7-16: Figure 27.3-1
Leeward external pressure coefficient	Cp =	-0.5	-0.40	ASCE 7-16: Figure 27.3-1

The core wall design has been divided into three sections. The top: roof to 31st story, the middle: 30th story to 16th story, and the bottom: 15th story to ground level. The loads on the core walls are worst case as the lower the story is, therefore we designed corewalls according to the loads at the 31st, 16th, and ground level for both the directions.

Table 3: Wind Forces

North-South Loads		
Design wind pressure, p (psf)	Design wind force, f (kips)	Vx (kips)
65.00	126.76	2151
59.80	116.60	3978
0.00	0.00	5478

East-West Loads		
Design wind pressure, p (psf)	Design wind force, f (kips)	Vx (kips)
60.82	39.54	693.54
55.52	36.09	1261.31
0.00	0.00	1720.87

The wind force accumulates as we go down the structure, so a cumulative force (Vx) was used as the story force.

Designing the C-PSW/CF Walls

The East-West walls were idealized, similar to a moment frame, having two piers with a coupling beam connecting them at each story. The piers need to be designed to resist the axial shear and moment caused by the wind load as well as axial load due to the dead load of the structure. The wind load on the frame causes one pier to be in compression and one in tension.

The coupling beams were to be designed such that a plastic hinge will form where the coupling beams connect to the piers before a hinge would form at the base of the frame. To create this relationship we calculated the loads on the piers and then back calculated the loads required for the beams. A full summary of this process is included in the appendix.

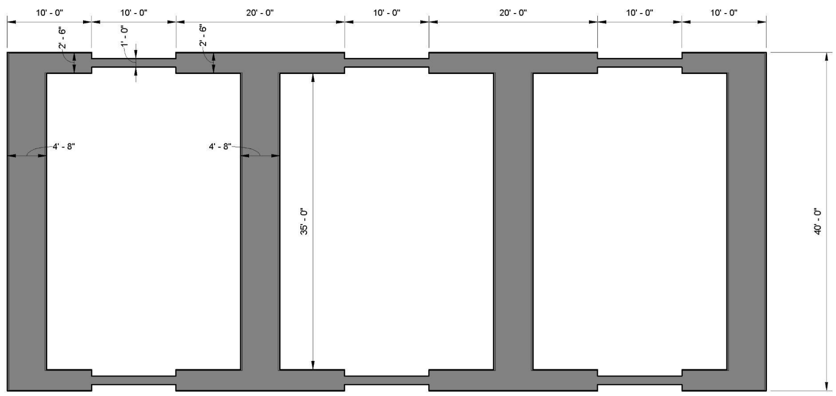


Figure 2: Top View of Floors 1-15

The North-South walls were simpler in design as they are wall sections. We idealized the walls as cantilevered columns and found the loads they are required to resist. A summary of this process is included in the appendix.

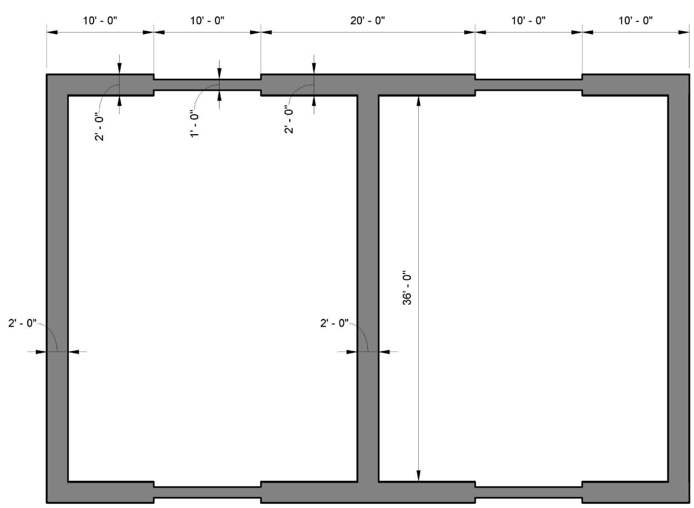


Figure 3: Top View of Floors 16-30

To calculate the composite plate shear wall capacities for flexure and axial strength we plotted an interaction curve based on the shear wall geometry. The plate thickness and the thickness of the wall section were the most relevant variables. An increase in either increases the flexure and axial strength, though note that the thicker the wall the heavier the wall becomes. At the base of the structure the compressive load can become the governing factor of the design, so keeping the walls thinner above aids in keeping the compressive loads small.

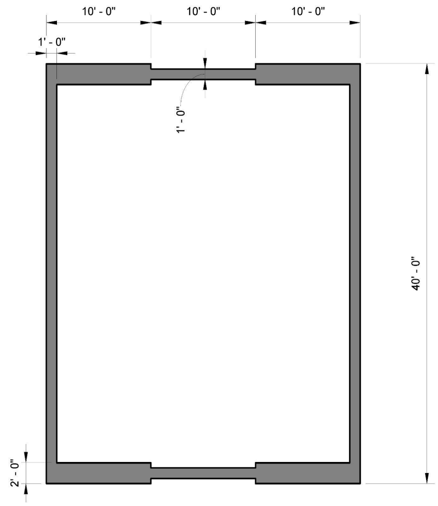


Figure 4: Top View of Floors 31-46

East-West Wall Design

The coupling beam's effect on the pier walls is the coupling ratio and is similar to a ratio of the stiffness of the beams to the pier walls. We designed for a coupling ratio as close to 0.6 as we could get while keeping the beam to depth ratio between 3 and 5. An average coupling ratio for all three designs is closer to 0.7. We could potentially get a smaller coupling ratio by shortening the beams, analyzing fewer stories per design, making the beams thinner, or making the walls thicker. We kept the beams at 10’ in length for convenience, as that would mean we have (2) 10’ piers and (1) 10’ beam. See a summary of the East-West wall design below:

Section		**Top**	
Direction		**East-West**	
Section Type		**Pier**	
Member Width		2	ft
Member Depth		10	ft
Member Length		13	ft
Plate Thickness		1	in
	Applied (k)	Strength (k)	
Shear	347	8992	96%
Axial Compression	2,790	k	
Axial Tension	(1,054)	k	
Moment	20,348	k-ft	

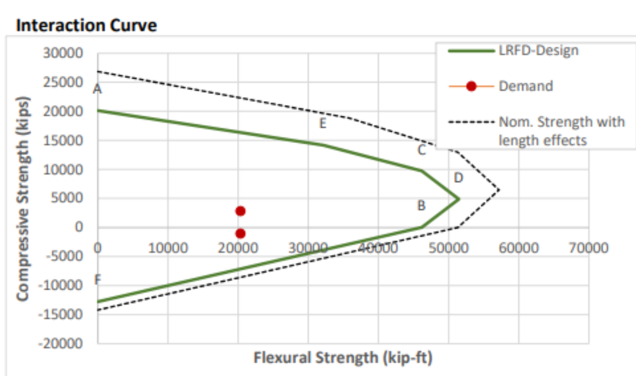
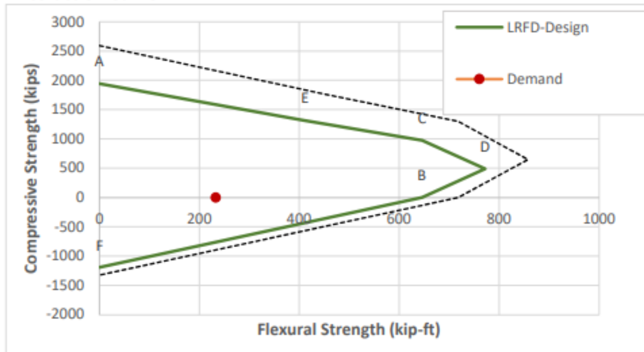


Figure 5: East-West Interaction Curves

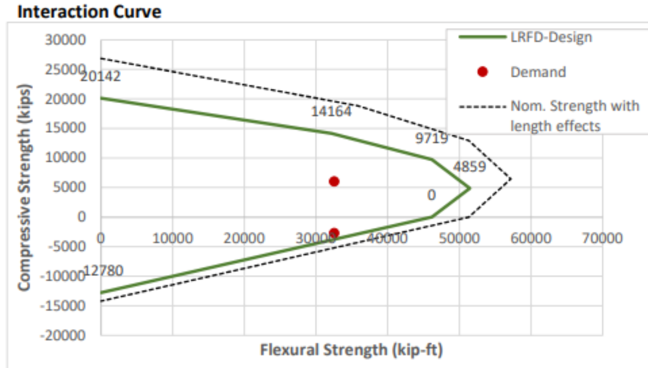
Section		**Top**	
Direction		**East-West**	
Section Type		**Coupling Beam**	
Member Width		1	ft
Member Depth		2	ft
Member Length		10	ft
Plate Thickness		0.375	in
	Applied (k)	Strength (k)	
Shear	47	505	91%
Axial Compression	0	k	
Axial Tension	0	k	
Moment	233	k-ft	
Coupling Ratio		0.73	

Interaction Curve



Section		**Middle**	
Direction		**East-West**	
Section Type		**Pier**	
Member Width		2	ft
Member Depth		10	ft
Member Length		13	ft
Plate Thickness		1	in
	Applied (k)	Strength (k)	
Shear	315	8992	96%
Axial Compression	6,053	k	
Axial Tension	(2,690)	k	
Moment	32,543	k-ft	

Interaction Curve



Section		**Middle**	
Direction		**East-West**	
Section Type		**Coupling Beam**	
Member Width		1	ft
Member Depth		2	ft
Member Length		10	ft
Plate Thickness		0.375	in
	Applied (k)	Strength (k)	
Shear	79	505	84%
Axial Compression	0	k	
Axial Tension	0	k	
Moment	394	k-ft	
Coupling Ratio		0.73	

Interaction Curve

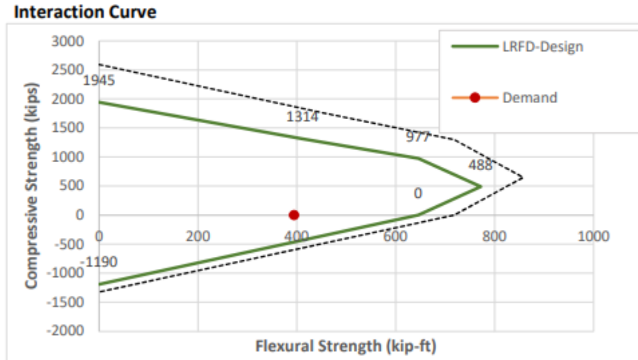
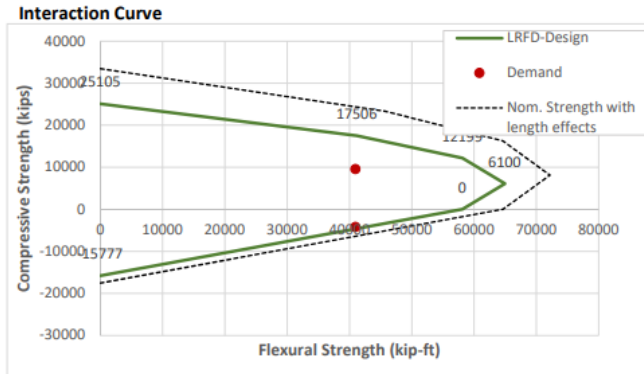


Figure 5: East-West Interaction Curves Continued

Section		**Bottom**	
Direction		**East-West**	
Section Type		**Pier**	
Member Width		2.5	ft
Member Depth		10	ft
Member Length		15	ft
Plate Thickness		1.1875	in
	Applied (k)	Strength (k)	
Shear	287	10754	97%
Axial Compression	9,580	k	
Axial Tension	(4,180)	k	
Moment	40,923	k-ft	



Section		**Bottom**	
Direction		**East-West**	
Section Type		**Coupling Beam**	
Member Width		1	ft
Member Depth		2	ft
Member Length		10	ft
Plate Thickness		0.375	in
	Applied (k)	Strength (k)	
Shear	95	505	81%
Axial Compression	0	k	
Axial Tension	0	k	
Moment	475	k-ft	
Coupling Ratio		0.70	

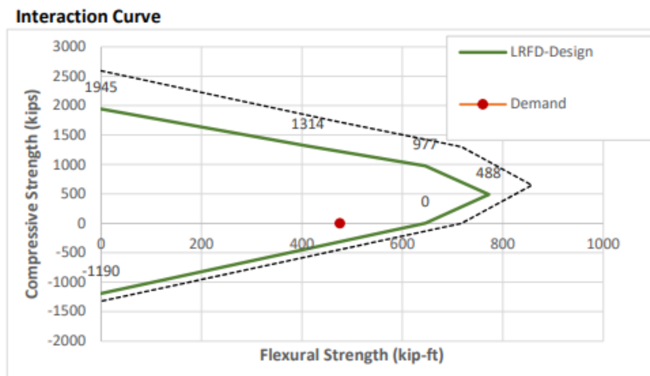


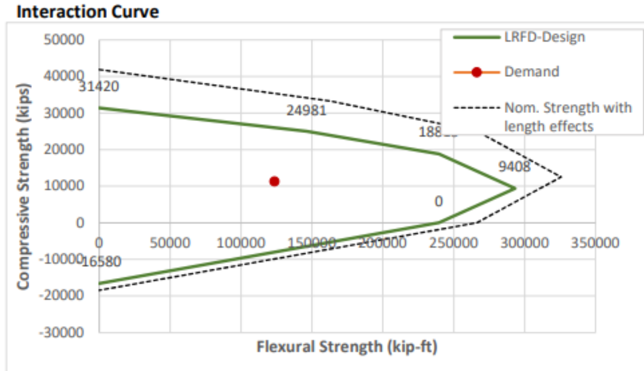
Figure 5: East-West Interaction Curves Continued

North-South Wall Design

The North-South wall design was mainly controlled by axial compression as the dead load of the walls above became quite high near the base of the structure.

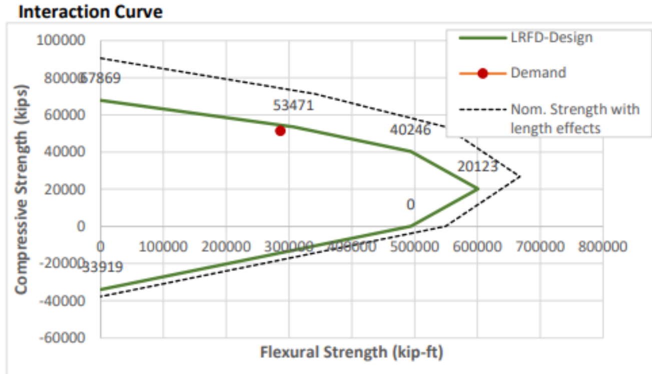
Section		Top	
Direction		North-South	
Section Type		Pier	
Member Width		1	ft
Member Depth		40	ft
Member Length		13	ft
Plate Thickness		0.375	in
	Applied (k)	Strength (k)	
Shear	1,076	14478	93%
Axial Compression	11,339	k	
Axial Tension	0	k	
Moment	123,526	k-ft	

Interaction Curve



Section		Middle	
Direction		North-South	
Section Type		Pier	
Member Width		2	ft
Member Depth		40	ft
Member Length		13	ft
Plate Thickness		0.75	in
	Applied (k)	Strength (k)	
Shear	1,326	28911	95%
Axial Compression	51,359	k	
Axial Tension	0	k	
Moment	286,334	k-ft	

Interaction Curve



Section		Bottom	
Direction		North-South	
Section Type		Pier	
Member Width		4.67	ft
Member Depth		40	ft
Member Length		15	ft
Plate Thickness		2.5	in
	Applied (k)	Strength (k)	
Shear	1,369	89238	98%
Axial Compression	157,553	k	
Axial Tension	0	k	
Moment	436,109	k-ft	

Interaction Curve

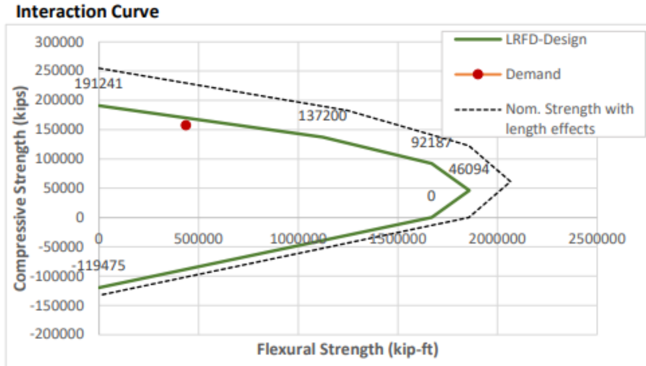


Figure 6: North-South Interaction Curves

Related Issues

There are many issues that impact every project that need to be addressed. They include public health, safety, welfare, global factors, cultural factors, social factors, environmental factors, and economic factors. These are important to consider because every job has or will have issues and it is better to address them before they happen so that they can be prevented or reduce their effects if at all possible.

The first issue is public health. The most likely impact to public health is the pollution created through the production process of the materials that will be used in the building. The main materials are concrete and steel. Cement production releases sulfur dioxide, nitrogen oxide, and carbon monoxide into the atmosphere. When sulfur dioxide mixes with water and air, it becomes sulfuric acid, also known as acid rain. Nitrogen oxide damages vegetation which includes crops that provide people all over the world with food. Carbon monoxide affects greenhouse gasses and global warming, which could eventually lead to extreme weather changes. Steel production releases carbon dioxide, naphthalene, and many more. Carbon dioxide affects the greenhouse gasses like carbon monoxide. Naphthalene is toxic and it is used to kill insects and repel animals. While the concrete and steel will not be produced on site, the health of the people producing it will be affected and the pollution will add to what is already there and eventually affect everyone.

The second issue is public safety. The most obvious concern is that the building is 46 stories so if it were to fail anywhere in the design, that would cause a lot of casualties. Because that has been a problem for tall buildings in the past, there are safety factors built into the calculations for building core walls like the ones we've designed. It is also designed so that the beams will yield before the walls will fail so that there is plenty of warning and so that they can be repaired or replaced before they fail.

Public welfare is the next issue and it is very similar to the last two. Pollution and potential beam or wall failure are always a risk with new structures and that's why there are safety factors built into the calculations.

Global factors also include the pollution that was mentioned with the public health issue. Another factor that involves the rest of the world is where the materials are coming from. While we would not need to buy the steel or concrete from another country because the United States makes their own steel and concrete, we would still need to purchase some of the materials used to produce steel and concrete from other countries. In some cases it is cheaper to buy materials from somewhere else and have them shipped than to make it on-site because of how much the materials cost in different places. So even if we produce our own steel, we will still likely have to import products in order to make our own steel.

Cultural factors will not play as big of a role as other issues on this list. People in Seattle are used to large buildings being built. Some things would change like how there will be more places to live or work. The area that the building will be constructed in was used for something previously and some people that live and work in that area already might want to leave that area the way it was and not add a new building. Public wants need to be considered too.

Social factors are similar to the cultural factors in that the people in the area will be used to large buildings being built around them so that won't be anything new. Going along with that line of thought though, those same people might want the large scale building productions to stop. Take, for example, the people of Provo who want the construction on the highway to be done because it has been a work in progress for years. The people in Seattle might also want to keep the land that is being used for the building as whatever it was already being used for. As was mentioned before in the cultural factors section, whatever was there originally might have been something that the people living around there wanted to keep.

The most impactful environmental factor is, once again, pollution: acid rain, global warming, extreme weather conditions, etc. There is also the issue of finding somewhere to put all the waste from clearing out what was already in the area and also the products of making concrete and steel.

Economic factors include the cost of steel and concrete production and also labor costs. Steel costs about $520 per ton to be produced and concrete costs $8 per square foot to be poured. Our building is around 34000 tons total. Just for the materials, this is a multimillion dollar project. With labor costs and everything else, this project will cost well over $20 million. The economy is also affected by pollution because pollution affects crops which affect the public and the economy.

Lessons Learned

The most frequent challenge we encountered was a lack of communication when team members had things come up in their schedule, and weren't able to meet for team meetings. We saw this as a problem because if a team member didn't show up we didn't know if they were late, or were absent. Moving forward we as a team made a commitment that whenever one of us won't be able to make it that it must be communicated.

Another challenge was that we would have frequent errors when doing our calculations. The only way to overcome this was double checking our values, and finding what went wrong. This allowed us to be patient, and allowed us to be more observant for future calculations.

Conclusions and Recommendations

We have concluded that a C-PSW/CF core building has sufficient strength and ductility that it can be used to adequately resist wind loads. Our design of the core walls and coupling beams for a 46 story building located in Seattle, Washington, are adequate for wind speeds of 110 mph. Further, as was stated in the design requirements, we have found that our designed coupling beams will fail before the shear walls. These conclusions are accurate, and are supported by our analysis, described above.

From our conclusions we believe that the following recommendations should be considered before applying the C-PSW/CF method to future projects:

- Our shear wall design should be modeled to scale and then tested to ensure that the design will work as predicted by our analysis
- A C-PSW/CF design that has been analyzed, tested and found adequate for wind loadings, should be analyzed to see if the same design is adequate for seismic loading

We believe these recommendations will allow the C-PSW/CF method to be refined, and implemented safely in areas with both strong wind and seismic activity.

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Appendix A - Additional Figures and Tables

Table 4: Gantt Chart

Task ID	Task Name	Dur. (d)	Start Date	End Date	Week 1							Week 2							Week 3							Week 4							Week 5						
					M	T	W	Th	F	S	SU	M	T	W	Th	F	S	SU	M	T	W	Th	F	S	SU	M	T	W	Th	F	S	SU	M	T	W	Th	F	S	SU
					11/15	11/16	11/17	11/18	11/19	11/20	11/21	11/22	11/23	11/24	11/25	11/26	11/27	11/28	11/29	11/30	12/1	12/2	12/3	12/4	12/5	12/6	12/7	12/8	12/9	12/10	12/11	12/12	12/13	12/14	12/15	12/16	12/17	12/18	12/19
0.0	**Complete Scope of work**	7	11/15	11/22																																			
0.1	Introduction	1	11/16	11/17																																			
0.2	Proposed Work Plan	1	11/17	11/18																																			
0.3	Schedule	3	11/15	11/18																																			
0.4	Faculties, Tools and Equipment	0	11/19	11/19																																			
0.5	Project Budget	3	11/19	11/22																																			
0.6	Deliverables	0	11/15	11/15																																			
0.7	Performance Standards	0	11/15	11/15																																			
0.8	Statement of Qualification	7	11/15	11/22																																			
1.0	**Determine dead, live, and wind loads**	54	11/22	2/22																																			
1.10	Determine Dead Loads	17	11/22	12/9																																			
1.11	List Dead load sources	0	11/29	11/29																																			
1.12	Determine loads for listed dead loads	0	11/29	11/29																																			
1.13	Determine Dead loads for various types of floors	0	11/29	11/29																																			
1.14	Prepare summary/report	0	11/29	11/29																																			
1.15	Present to Dr. Judd	0	1/7	1/7																																			
1.16	Revise	1	1/8	1/9																																			
1.17	Prepare summary/report	1	1/10	1/11																																			
1.2	Determine Live Loads	0	1/12	1/12																																			
1.3	Determine wind Loads	64	1/7	2/22																																			
2.0	**Learn how to and design C-PSW/CF walls**	19	2/22	3/13																																			
3.0	**Design the coupling beams**	24	3/1	4/5																																			
4.0	**Prepare Design Documents**	11	4/1	4/11																																			

Task ID	Task Name	Dur. (d)	Start Date	End Date	Week 6							Week 7							Week 8							Week 9							Week 10						
					M	T	W	Th	F	S	SU	M	T	W	Th	F	S	SU	M	T	W	Th	F	S	SU	M	T	W	Th	F	S	SU	M	T	W	Th	F	S	SU
					12/20	12/21	12/22	12/23	12/24	12/25	12/26	12/27	12/28	12/29	12/30	12/31	1/1	1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9	1/10	1/11	1/12	1/13	1/14	1/15	1/16	1/17	1/18	1/19	1/20	1/21	1/22	1/23
0.0	**Complete Scope of work**	7	11/15	11/22																																			
0.1	Introduction	1	11/16	11/17																																			
0.2	Proposed Work Plan	1	11/17	11/18																																			
0.3	Schedule	3	11/15	11/18																																			
0.4	Faculties, Tools and Equipment	0	11/19	11/19																																			
0.5	Project Budget	3	11/19	11/22																																			
0.6	Deliverables	0	11/15	11/15																																			
0.7	Performance Standards	0	11/15	11/15																																			
0.8	Statement of Qualification	7	11/15	11/22																																			
1.0	**Determine dead, live, and wind loads**	54	11/22	2/22																																			
1.10	Determine Dead Loads	17	11/22	12/9																																			
1.11	List Dead load sources	0	11/29	11/29																																			
1.12	Determine loads for listed dead loads	0	11/29	11/29																																			
1.13	Determine Dead loads for various types of floors	0	11/29	11/29																																			
1.14	Prepare summary/report	0	11/29	11/29																																			
1.15	Present to Dr. Judd	0	1/7	1/7																																			
1.16	Revise	1	1/8	1/9																																			
1.17	Prepare summary/report	1	1/10	1/11																																			
1.2	Determine Live Loads	0	1/12	1/12																																			
1.3	Determine wind Loads	64	1/7	2/22																																			
2.0	**Learn how to and design C-PSW/CF walls**	19	2/22	3/13																																			
3.0	**Design the coupling beams**	24	3/1	4/5																																			
4.0	**Prepare Design Documents**	11	4/1	4/11																																			

Task ID	Task Name	Dur. (d)	Start Date	End Date	Week 11							Week 12							Week 13							Week 14							Week 15						
					M	T	W	Th	F	S	SU	M	T	W	Th	F	S	SU	M	T	W	Th	F	S	SU	M	T	W	Th	F	S	SU	M	T	W	Th	F	S	SU
					1/24	1/25	1/26	1/27	1/28	1/29	1/30	1/31	2/1	2/2	2/3	2/4	2/5	2/6	2/7	2/8	2/9	2/10	2/11	2/12	2/13	2/14	2/15	2/16	2/17	2/18	2/19	2/20	2/21	2/22	2/23	2/24	2/25	2/26	2/27
0.0	**Complete Scope of work**	7	11/15	11/22																																			
0.1	Introduction	1	11/16	11/17																																			
0.2	Proposed Work Plan	1	11/17	11/18																																			
0.3	Schedule	3	11/15	11/18																																			
0.4	Faculties, Tools and Equipment	0	11/19	11/19																																			
0.5	Project Budget	3	11/19	11/22																																			
0.6	Deliverables	0	11/15	11/15																																			
0.7	Performance Standards	0	11/15	11/15																																			
0.8	Statement of Qualification	7	11/15	11/22																																			
1.0	**Determine dead, live, and wind loads**	54	11/22	2/22																																			
1.10	Determine Dead Loads	17	11/22	12/9																																			
1.11	List Dead load sources	0	11/29	11/29																																			
1.12	Determine loads for listed dead loads	0	11/29	11/29																																			
1.13	Determine Dead loads for various types of floors	0	11/29	11/29																																			
1.14	Prepare summary/report	0	11/29	11/29																																			
1.15	Present to Dr. Judd	0	1/7	1/7																																			
1.16	Revise	1	1/8	1/9																																			
1.17	Prepare summary/report	1	1/10	1/11																																			
1.2	Determine Live Loads	0	1/12	1/12																																			
1.3	Determine wind Loads	64	1/7	2/22																																			
2.0	**Learn how to and design C-PSW/CF walls**	19	2/22	3/13																																			
3.0	**Design the coupling beams**	24	3/1	4/5																																			
4.0	**Prepare Design Documents**	11	4/1	4/11																																			

Table 4: Gantt Chart Continued

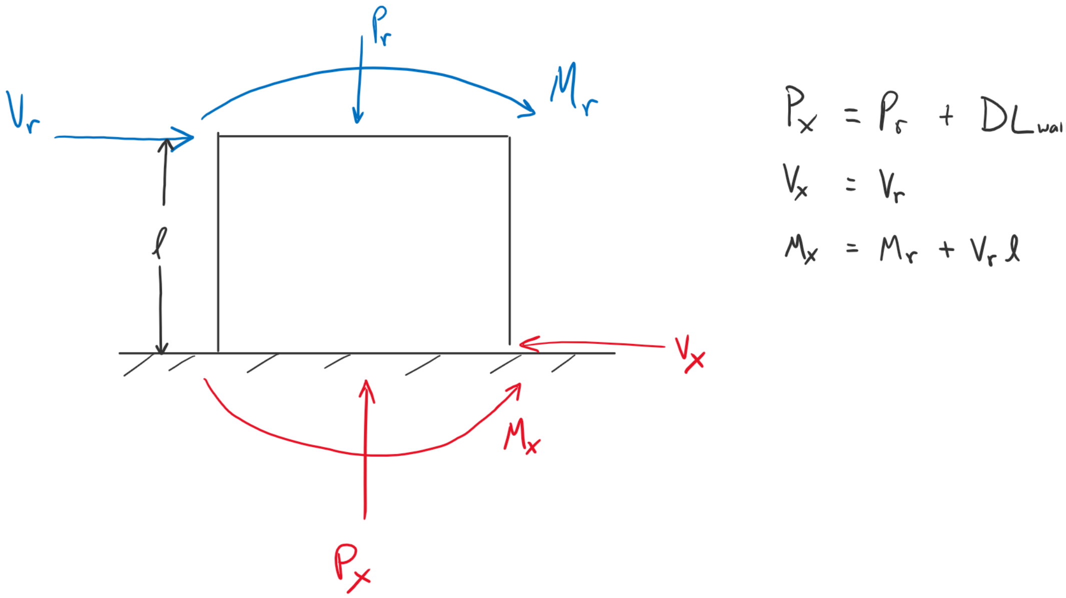
Task ID	Task Name	Dur. (d)	Start Date	End Date	Week 16 M 2/28	Week 16 T 3/1	Week 16 W 3/2	Week 16 Th 3/3	Week 16 F 3/4	Week 16 S 3/5	Week 16 SU 3/6	Week 17 M 3/7	Week 17 T 3/8	Week 17 W 3/9	Week 17 Th 3/10	Week 17 F 3/11	Week 17 S 3/12	Week 17 SU 3/13	Week 18 M 3/14	Week 18 T 3/15	Week 18 W 3/16	Week 18 Th 3/17	Week 18 F 3/18	Week 18 S 3/19	Week 18 SU 3/20	Week 19 M 3/21	Week 19 T 3/22	Week 19 W 3/23	Week 19 Th 3/24	Week 19 F 3/25	Week 19 S 3/26	Week 19 SU 3/27	Week 20 M 3/28	Week 20 T 3/29	Week 20 W 3/30	Week 20 Th 3/31	Week 20 F 4/1	Week 20 S 4/2	Week 20 SU 4/3
0.0	**Complete Scope of work**	**7**	**11/15**	**11/22**																																			
0.1	Introduction	1	11/16	11/17																																			
0.2	Proposed Work Plan	1	11/17	11/18																																			
0.3	Schedule	3	11/15	11/18																																			
0.4	Faculties, Tools and Equipment	0	11/19	11/19																																			
0.5	Project Budget	3	11/19	11/22																																			
0.6	Deliverables	0	11/15	11/15																																			
0.7	Performance Standards	0	11/15	11/15																																			
0.8	Statement of Qualification	7	11/15	11/22																																			
1.0	**Determine dead, live, and wind loads**	**54**	**11/22**	**2/22**																																			
1.10	Determine Dead Loads	17	11/22	12/9																																			
1.11	List Dead load sources	0	11/29	11/29																																			
1.12	Determine loads for listed dead loads	0	11/29	11/29																																			
1.13	Determine Dead loads for various types of floors	0	11/29	11/29																																			
1.14	Prepare summary/report	0	11/29	11/29																																			
1.15	Present to Dr. Judd	0	1/7	1/7																																			
1.16	Revise	1	1/8	1/9																																			
1.17	Prepare summary/report	1	1/10	1/11																																			
1.2	Determine Live Loads	0	1/12	1/12																																			
1.3	Determine wind Loads	64	1/7	2/22																																			
2.0	**Learn how to and design C-PSW/CF walls**	**19**	**2/22**	**3/13**																																			
3.0	**Design the coupling beams**	**24**	**3/1**	**4/5**																																			
4.0	**Prepare Design Documents**	**11**	**4/1**	**4/11**																																			

Task ID	Task Name	Dur. (d)	Start Date	End Date	Week 21 M 4/4	Week 21 T 4/5	Week 21 W 4/6	Week 21 Th 4/7	Week 21 F 4/8	Week 21 S 4/9	Week 21 SU 4/10	Week 22 M 4/11	Week 22 T 4/12	Week 22 W 4/13
0.0	**Complete Scope of work**	**7**	**11/15**	**11/22**										
0.1	Introduction	1	11/16	11/17										
0.2	Proposed Work Plan	1	11/17	11/18										
0.3	Schedule	3	11/15	11/18										
0.4	Faculties, Tools and Equipment	0	11/19	11/19										
0.5	Project Budget	3	11/19	11/22										
0.6	Deliverables	0	11/15	11/15										
0.7	Performance Standards	0	11/15	11/15										
0.8	Statement of Qualification	7	11/15	11/22										
1.0	**Determine dead, live, and wind loads**	**54**	**11/22**	**2/22**										
1.10	Determine Dead Loads	17	11/22	12/9										
1.11	List Dead load sources	0	11/29	11/29										
1.12	Determine loads for listed dead loads	0	11/29	11/29										
1.13	Determine Dead loads for various types of floors	0	11/29	11/29										
1.14	Prepare summary/report	0	11/29	11/29										
1.15	Present to Dr. Judd	0	1/7	1/7										
1.16	Revise	1	1/8	1/9										
1.17	Prepare summary/report	1	1/10	1/11										
1.2	Determine Live Loads	0	1/12	1/12										
1.3	Determine wind Loads	64	1/7	2/22										
2.0	**Learn how to and design C-PSW/CF walls**	**19**	**2/22**	**3/13**										
3.0	**Design the coupling beams**	**24**	**3/1**	**4/5**										
4.0	**Prepare Design Documents**	**11**	**4/1**	**4/11**										

Table 5: Shear Wall Material Properties

Material Properties			
Basis	=	Specified (e.g. Fy)	
Steel			
Specified yield stress	F_y =	50	ksi
Expected yield stress factor	Ry =	1.3	
Yield stress	=	50	ksi
Modulus of elasticity	E_s =	29000	ksi
Shear Modulus of elasticity	G_s =	11200	ksi
Concrete			
Specified compressive stress	f'_c =	6	ksi
Expected yield stress factor	Ry =	1.3	
Compressive stress	=	6	ksi
Unit weight	wc =	145	pcf
Modulus of elasticity	E_c =	4415	ksi

Cantilever Column Idealization



Frame Idealization

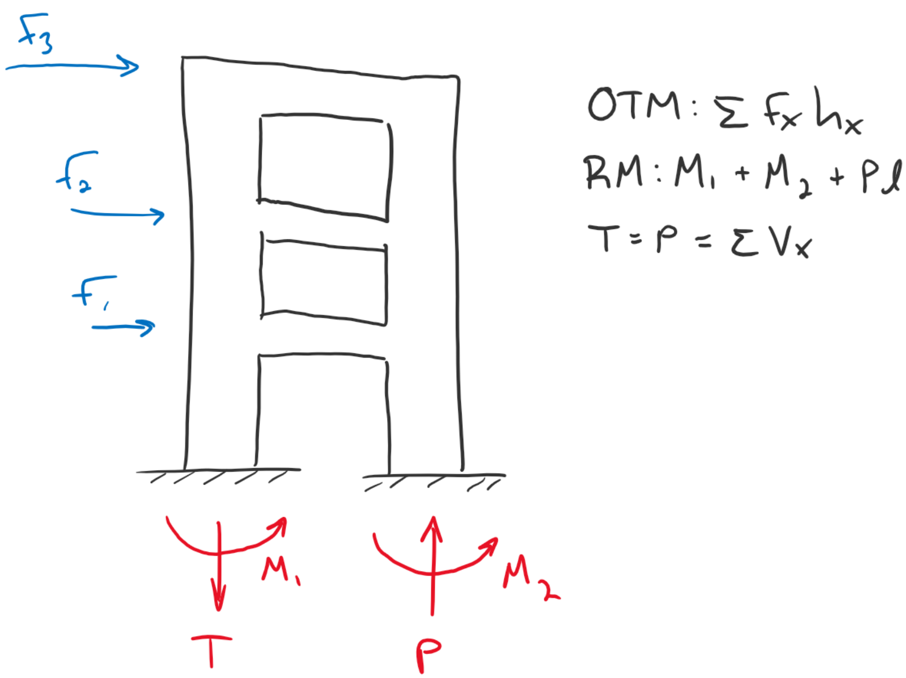


Figure 7: Idealizations

Table 6: Wind Loadings per Story

Story Number	Story Height (ft)	Height from base (ft)	North-South Loads						
			Velocity pressure, qz (lb/ft^2)	Velocity pressure, qh (lb/ft^2)	Design wind pressure, p (psf)	Design wind force, f (kips)	Axial load, Px (Kips)	Vx (kips)	Moment, M (kip-ft)
47	0	600	48.59	48.59	68.62	66.91	0	67	870
46	13	587	48.37	48.59	68.43	133.44	83	200	3474
45	13	574	48.14	48.59	68.23	133.05	250	333	7808
44	13	561	47.91	48.59	68.03	132.66	500	466	13867
43	13	548	47.67	48.59	67.83	132.26	834	598	21645
42	13	535	47.43	48.59	67.62	131.85	1251	730	31137
41	13	522	47.19	48.59	67.40	131.44	1751	862	42338
40	13	509	46.94	48.59	67.19	131.01	2334	993	55242
39	13	496	46.68	48.59	66.96	130.58	3001	1123	69844
38	13	483	46.42	48.59	66.74	130.14	3752	1253	86137
37	13	470	46.16	48.59	66.51	129.69	4586	1383	104116
36	13	457	45.89	48.59	66.27	129.23	5503	1512	123776
35	13	444	45.61	48.59	66.03	128.76	6503	1641	145109
34	13	431	45.32	48.59	65.78	128.28	7587	1769	168110
33	13	418	45.03	48.59	65.53	127.78	8754	1897	192772
32	13	405	44.73	48.59	65.27	127.28	10005	2024	219088
31	13	392	44.43	48.59	65.00	126.76	11339	2151	247052
30	13	379	44.11	48.59	64.73	126.22	12840	2277	276658
29	13	366	43.79	48.59	64.45	125.68	14507	2403	307897
28	13	353	43.46	48.59	64.16	125.11	16341	2528	340762
27	13	340	43.12	48.59	63.86	124.53	18342	2653	375247
26	13	327	42.76	48.59	63.56	123.94	20510	2777	411343
25	13	314	42.40	48.59	63.24	123.32	22845	2900	449041
24	13	301	42.02	48.59	62.92	122.68	25346	3023	488335
23	13	288	41.64	48.59	62.58	122.03	28014	3145	529215
22	13	275	41.23	48.59	62.23	121.34	30849	3266	571673
21	13	262	40.81	48.59	61.86	120.63	33850	3387	615699
20	13	249	40.38	48.59	61.49	119.90	37018	3506	661283
19	13	236	39.93	48.59	61.09	119.13	40353	3626	708416
18	13	223	39.45	48.59	60.68	118.33	43855	3744	757088
17	13	210	38.96	48.59	60.25	117.49	47524	3861	807286
16	13	197	38.44	48.59	59.80	116.60	51359	3978	859001
15	13	184	37.89	48.59	59.32	115.67	55599	4094	912219
14	13	171	37.31	48.59	58.82	114.69	60244	4208	966929
13	13	158	36.69	48.59	58.28	113.65	65295	4322	1023116
12	13	145	36.03	48.59	57.71	112.53	70750	4435	1080765
11	13	132	35.33	48.59	57.10	111.34	76610	4546	1139862
10	13	119	34.57	48.59	56.43	110.05	82876	4656	1200390
9	13	106	33.73	48.59	55.71	108.64	89546	4765	1262330
8	13	93	32.82	48.59	54.91	107.08	96622	4872	1325662
7	13	80	31.79	48.59	54.02	105.35	104102	4977	1390364
6	13	67	30.63	48.59	53.01	103.37	111988	5080	1456409
5	13	54	29.27	48.59	51.83	101.07	120279	5181	1523769
4	13	41	27.62	48.59	50.40	98.27	128974	5280	1592406
3	13	28	25.49	48.59	48.55	94.66	138075	5374	1662273
2	13	15	22.35	48.59	45.82	103.09	147580	5478	1744436
1	15	0	0.00	0.00	0.00	0.00	157553	5478	1744436

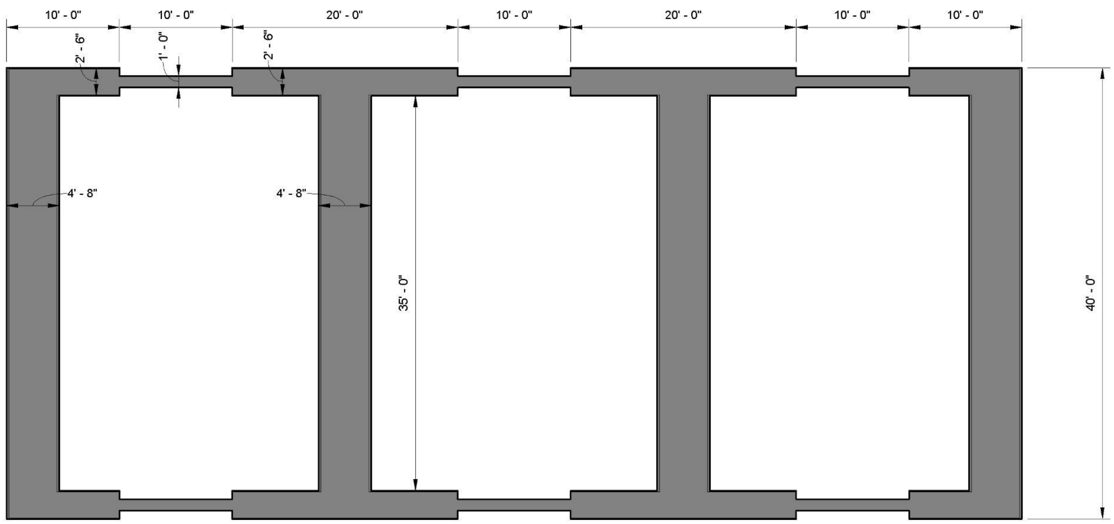
Table 6: Wind Loadings per Story Continued

Story Number	Story Height (ft)	Height from base (ft)	East-West Loads: Design wind pressure, p (psf)	Design wind force, f (kips)	Vx (kips)	Pier: Overturning Moment (k-ft)	Tension (kips)	Compression (kips)	Shear (per pier) kips	Moment (per pier) k-ft	Resisting Moment k-ft
47	0	600	64.51	41.93	41.93	0	0	0	0	0	0
46	13	587	64.31	41.80	83.73	272	14	14	21	136	544
45	13	574	64.11	41.67	125.41	680	48	48	42	204	1359
44	13	561	63.91	41.54	166.95	1222	95	95	63	271	2445
43	13	548	63.70	41.40	208.35	1899	156	156	83	339	3799
42	13	535	63.48	41.26	249.61	2711	231	231	104	406	5421
41	13	522	63.27	41.12	290.74	3656	318	318	125	472	7311
40	13	509	63.05	40.98	331.72	4734	419	419	145	539	9467
39	13	496	62.82	40.83	372.55	5944	534	534	166	605	11889
38	13	483	62.59	40.68	413.24	7287	662	662	186	672	14575
37	13	470	62.36	40.53	453.77	8762	802	802	207	737	17524
36	13	457	62.11	40.37	494.14	10368	957	957	227	803	20736
35	13	444	61.87	40.21	534.36	12105	1124	1124	247	868	24210
34	13	431	61.62	40.05	574.41	13972	1304	1304	267	933	27943
33	13	418	61.36	39.88	614.29	15968	1497	1497	287	998	31936
32	13	405	61.09	39.71	654.00	18094	1703	1703	307	1063	36187
31	13	392	60.82	39.54	693.54	20348	1922	1922	327	1127	40695
30	13	379	60.55	39.35	732.89	20943	2094	2094	347	595	43077
29	13	366	60.26	39.17	772.06	21570	2217	2217	366	627	45586
28	13	353	59.97	38.98	811.04	22229	2345	2345	386	659	48222
27	13	340	59.66	38.78	849.82	22920	2480	2480	406	690	50984
26	13	327	59.35	38.58	888.40	23642	2621	2621	425	722	53871
25	13	314	59.03	38.37	926.77	24395	2769	2769	444	753	56883
24	13	301	58.70	38.15	964.92	25179	2923	2923	463	784	60019
23	13	288	58.35	37.93	1002.85	25993	3082	3082	482	815	63279
22	13	275	58.00	37.70	1040.55	26839	3248	3248	501	845	66660
21	13	262	57.63	37.46	1078.00	27715	3421	3421	520	876	70164
20	13	249	57.24	37.21	1115.21	28621	3599	3599	539	906	73788
19	13	236	56.84	36.95	1152.16	29557	3783	3783	558	936	77533
18	13	223	56.42	36.67	1188.83	30523	3973	3973	576	966	81396
17	13	210	55.98	36.39	1225.22	31518	4169	4169	594	995	85378
16	13	197	55.52	36.09	1261.31	32543	4371	4371	613	1025	89478
15	13	184	55.04	35.77	1297.08	33012	4544	4544	631	703	92288
14	13	171	54.52	35.44	1332.52	33493	4687	4687	649	722	95175
13	13	158	53.98	35.09	1367.61	33987	4833	4833	666	741	98138
12	13	145	53.40	34.71	1402.31	34493	4983	4983	684	760	101177
11	13	132	52.77	34.30	1436.61	35012	5137	5137	701	778	104289
10	13	119	52.10	33.86	1470.48	35543	5294	5294	718	797	107475
9	13	106	51.36	33.38	1503.86	36086	5455	5455	735	815	110734
8	13	93	50.55	32.86	1536.72	36641	5620	5620	752	832	114063
7	13	80	49.64	32.27	1568.99	37207	5788	5788	768	850	117463
6	13	67	48.61	31.60	1600.58	37785	5960	5960	784	867	120931
5	13	54	47.41	30.82	1631.40	38374	6135	6135	800	884	124465
4	13	41	45.95	29.87	1661.26	38974	6313	6313	816	900	128065
3	13	28	44.06	28.64	1689.91	39585	6495	6495	831	915	131726
2	13	15	41.28	30.96	1720.87	40206	6680	6680	845	932	135455
1	15	0	0.00	0.00	1720.87	40923	6880	6880	860	1076	139757

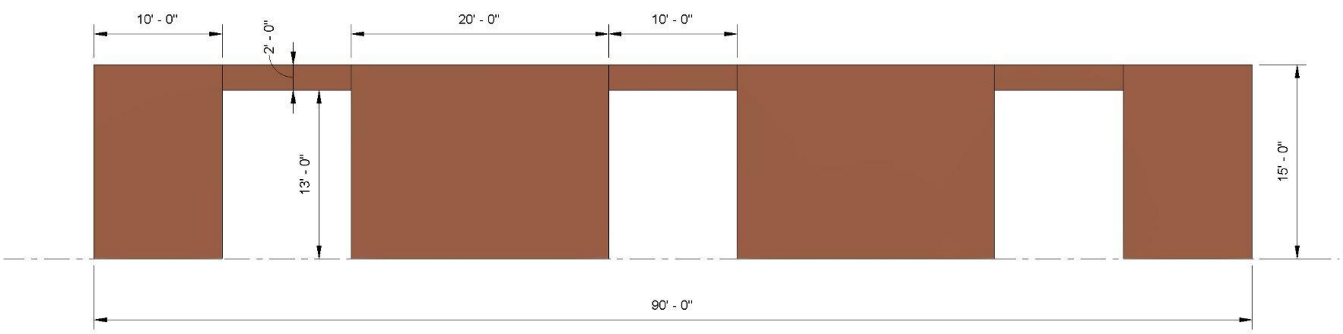
Final Design

Base Floor:

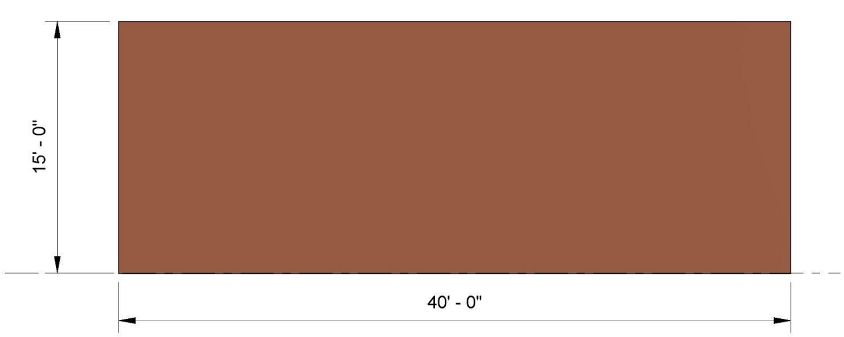
Top Elevation



North-South Elevation

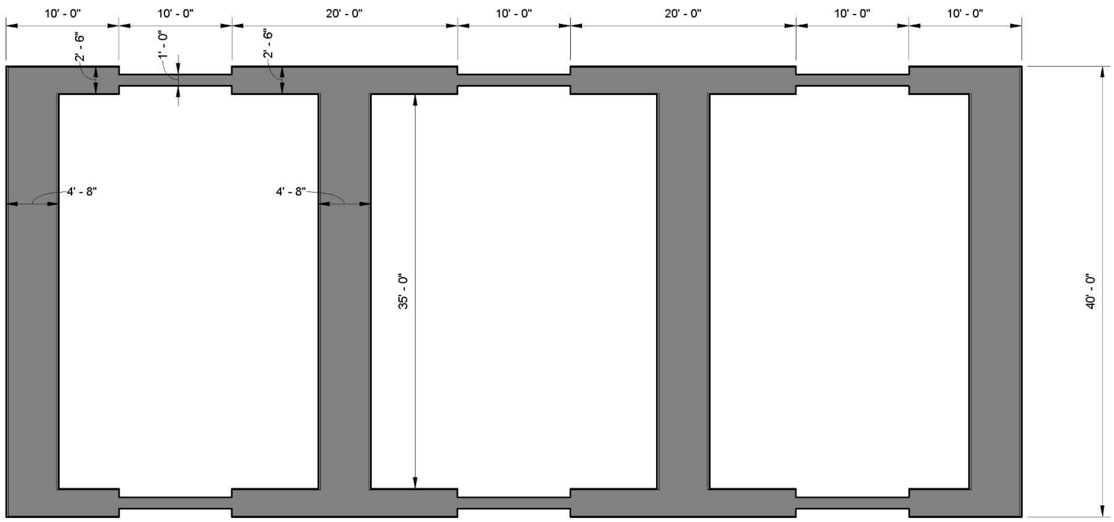


East-West Elevation

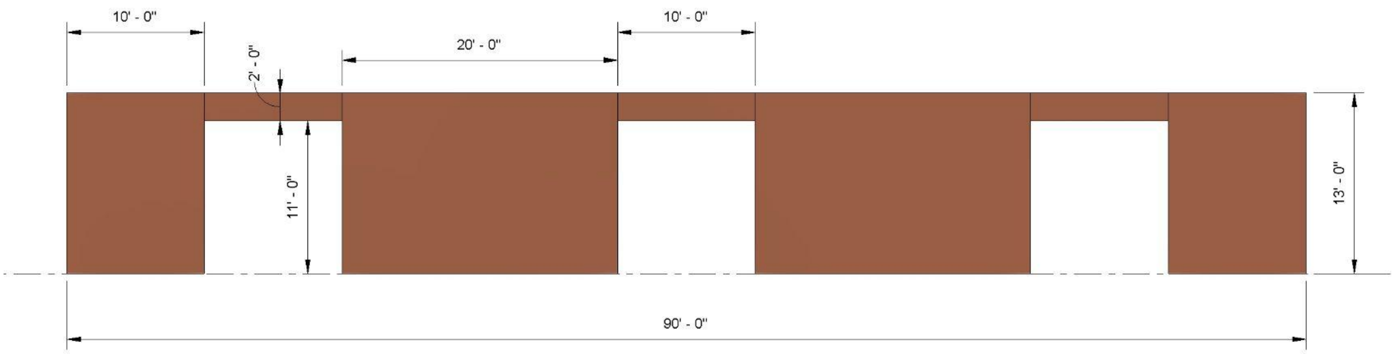


Floors 2-15:

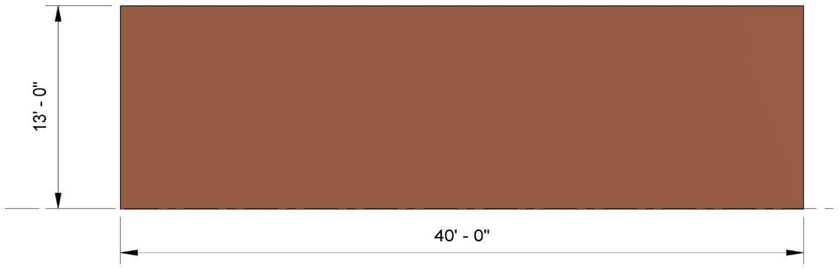
Top Elevation



North-South Elevation

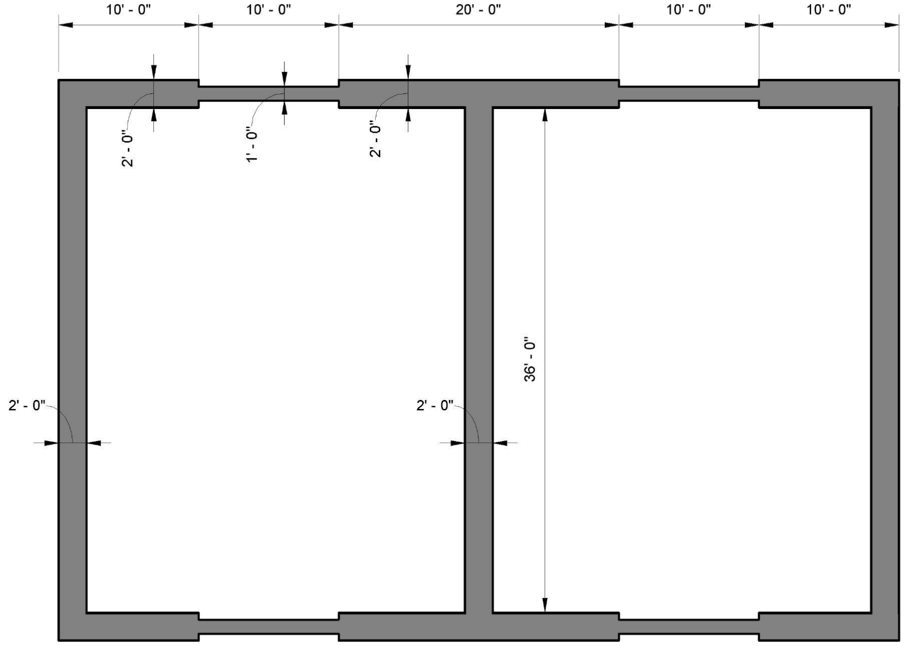


East-West Elevation

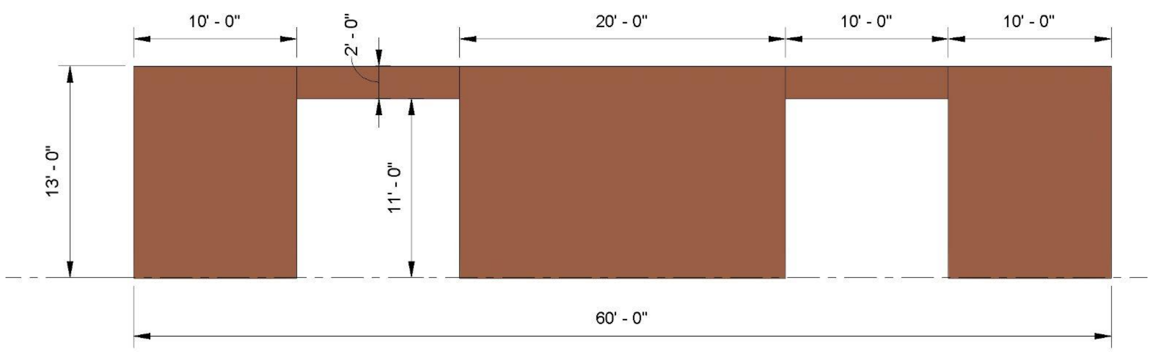


Floors 16-30:

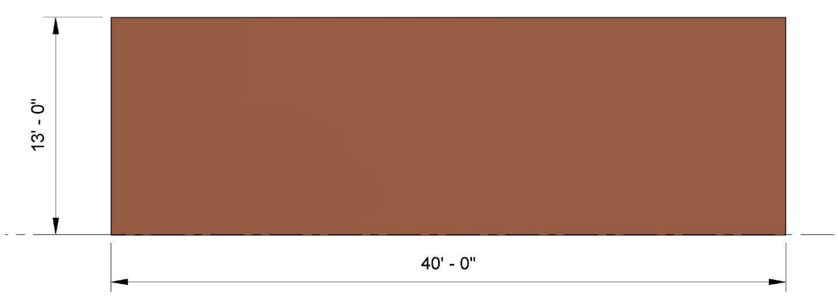
Top Elevation



North-South Elevation

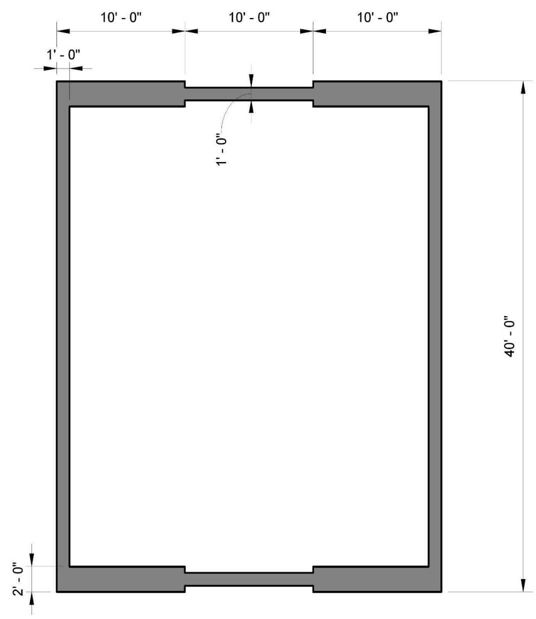


East-West Elevation

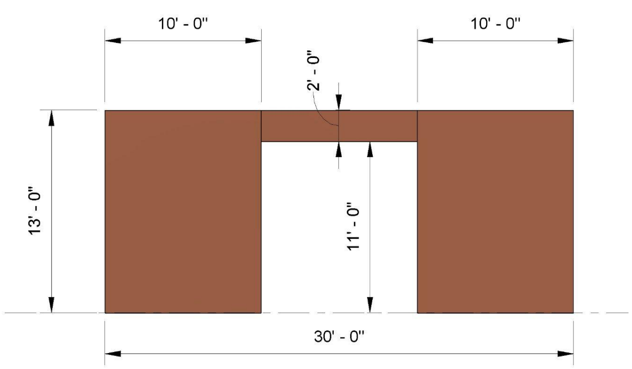


Floors 31-46:

Top Elevation



North-South Elevation



East-West Elevation

Appendix B - Resumes

John M. H. Cassler

Orem, UT 84097
Home Phone: 801-225-2794
Cell Phone: 979-676-5313
jmhcassler@gmail.com

Educational Achievement

- *Brigham Young University* – Undergraduate- Dec 2022 - GPA 3.5
  - ***Civil Engineering Major*** – Jan. 2019-Present
    - Materials and Statics
    - Enrolled in Structural Analysis
    - Engineering Software (see below)
  - ***Construction Management Experience*** – Sep 2018-Dec 2018

Competencies and Skills

- ***Rough Construction***— Sep 2012-Present
  - Designed, built, and remolded several homes as a rough carpenter
- Advanced Architecture Software Experience:
  - ***SolidWorks*** —Apr. 2014
  - ***Revit*** – Sep. 2018-Present
  - ***CAD*** – Sep. 2018-Present
  - ***Arc-GIS Pro*** – Jan. 2019- Present

Work Experience

- Montgomery Kitchen and Bath – Jun 2015- Jun 2019
  - Worked as an Apprentice Carpenter every summer and gained valuable skills with finished carpentry
- Acute Engineering
  - Worked as an intern designing and engineering residential homes

Awards

- ***Skills USA*** – Apr. 2014-Jun. 2015
  - First Place in the State of Texas, Job Skills Demonstration-2014
  - *First Place in the State of Texas, Carpentry-2015*
  - *16th Place in the Nation, Carpentry-2015*
- Eagle Scout, Boy Scouts of America

Extracurricular activities and community service

- Habitat for Humanity – Jun 2014-Present
  - Volunteered to assist with constructing homes for those in need

Adam Dinkins

(801)995-1231
adamdinkins12@gmail.com

Graduation: April 2022
BS in Civil Engineering
GPA: 3.0

Experience

Designed, engineered, and detailed 100's of light-frame structures under the guidance of a PE.

- Laid-out framing.
- Performed calculations of members for both vertical and lateral load.
- Modeled, designed, and detailed shear walls, cantilevered columns, and moment frames.
- Modeled, designed, and detailed steel members and connections.
- Modeled using excel tools, Risa, Enercalc, etc.
- Designed using Autocad, Bluebeam, and Revit.

Mentored 10+ new co-workers to increase learning and efficiency in the workplace.

- Met daily with mentorees increasing their understanding and creating a culture of accountability, hard work, and good friends.
- Effectively communicated via interpersonal communication, emails, and internal communication such as Slack, Microsoft Teams, etc.
- Led group discussions regarding structural calculations, and effective design.

Created 10+ tools through excel, increasing productivity and efficiency.

- Created using VBA and excels built-in commands to perform tedious tasks automatically and accurately.

Became the top performer in a new workplace in under two months.

- Top performer in terms of productivity.

I enjoy hard work and being a part of a team. I learn quickly and always like a new challenge. I know I can add value to your company as I have to others in the past.

Recent Work history

Acute Engineering -- Student Engineer	May 2020 to Present
Solcius -- Commissions Specialist & Proposal Generator	Sept 2018 to June 2020

STEPHANIE BRUNSON

Provo, Utah 913-683-0880
stephaniebrunson61@gmail.com linkedin.com/in/sbrunson61

EDUCATION

CIVIL ENGINEERING, BRIGHAM YOUNG UNIVERSITY, PROVO, UT

EXPECTED GRADUATION APRIL 2022

GPA 3.25

Relevant Coursework:

Statics, Dynamics, Drafting with CAD, Geomatics with ArcGIS, Computational Methods, Multivariable Calculus, Structural Analysis, Hydraulics and Fluid Flow Theory, Elementary Soil Mechanics, Materials (including metals, woods, composites, concrete, masonry, and asphalt), Applications of GIS, Reinforced Concrete Design, Foundation Engineering, and Capstone

Study Abroad:

Summer 2019 travelled abroad to Italy, France, and the Netherlands to study ancient and modern infrastructure

RELEVANT SKILLS

Experience with ArcGIS and Trimble Business Center

WORK EXPERIENCE

SUMMER 2021

INTERN, MONTANA DEPARTMENT OF TRANSPORTATION, MILES CITY, MT

- Worked with the survey crew and in on-site concrete testing
- Measured top soil piles, staked cattle guards and approach pipe, checked grade for the scrapers and rollers
- Staked where the concrete was to be poured using GPS robotics, conducted slump and air content tests on concrete on-site

SUMMER 2018

INTERN, UTAH DEPARTMENT OF TRANSPORTATION, SALT LAKE CITY, UT

- Traffic Operations Center, Fiber Optics
- Shadowed supervisors at various job sites
- Created three different maps and a story map using ArcGIS and ESRI Story Maps
- Gained experience in the business side of the Utah Department of Transportation

SUMMER 2017

INTERN, DEPARTMENT OF PUBLIC WORKS, KANSAS CITY, MO

- Shadowed supervisors at various job sites
- Reported on the future of transportation; how autonomous vehicles affect infrastructure and estimated costs and completion times of the projects
- Gained experience in reading Blueprints and other types of plans

Joshua Blom

(631) 294-9364 · jblom66@icloud.com · linkedin.com/in/joshua-blom

EDUCATION

Brigham Young University — Apr 2023

Bachelor of Science/Civil Engineering, Emphasis in Structural Engineering — Provo, UT

- James M. Passey Scholarship and Brigham Young Grant
- Structural Analysis, and Structural Steel Design
- Reinforced Concrete Design, and Prestressed Concrete Design
- Polish Language
- SAP 2000

EXPERIENCE

CE 304 Metals, Woods, & Composites — Sep 2021-Present

Teacher's Assistant — Provo, UT

Under the direction of the professor I taught two different laboratory sessions and instructed students on how to operate necessary machinery. Further, I graded each student based on their participation and their demonstrated knowledge during the laboratory sessions.

- Taught groups of 3-9 students concepts relating to the course material
- Clarified difficult concepts and laboratory procedures
- Evaluated student's understanding through quizzes, and lab reports.

Baron Estate — Jun 2018-Aug 2020

Caretaker — East Hampton, New York

As caretaker of the Baron estate I was entrusted with the care of the structures, and vehicles. I was also tasked with ensuring any other need of the Baron family was met in a timely manner.

- Consulted in the hiring process of 1 individual
- Organized documents and workspaces
- Contacted and coordinated vendors when outside services were needed
- Maintained structures, vehicles, and artwork within the estate

Bulgin & Associates — Feb 2015-Jun 2018

Laborer — Southampton, New York

My main duties were the upkeep and organization of the job site. This included removing waste, managing the protection of finished products, and assisting the carpenters.

- Handled the acquisition and transportation of materials
- Maintained worksite cleanliness and appearance
- Aided interior designers in the organization, arranging, and placing of expensive items and artwork

VOLUNTEER EXPERIENCE

The Church of Jesus Christ of Latter-Day Saints — Feb 2013-Feb 2015

Trainer/Zone Leader/District Leader — Warsaw, Poland

- Trained 2 new missionaries in the rules and procedures of the Poland, Warsaw mission
- Planned and instructed 26 different trainings for missionaries throughout Poland
- Served in private gardens by doing yard work and repairs

SKILLS/ACHIEVEMENTS

- Microsoft Office
- Eagle Scout
- Dedicated work ethic, working an average of 60 hours per week