RESIDENTAL OBSERVATION TOWER PROJECT

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IMAGINEERING INC.
You Imagine It, We Engineer It

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EXECUTIVE SUMMARY

Imagineering Inc. developed three design alternatives for an 80-foot residential tower for the client, Paul Taylor. The three design alternatives consisted of two steel truss towers: special concentrically braced frame and an eccentrically braced frame, and one timber shear wall tower on a concrete podium. When considering design options for the client, load combinations of gravity, wind, seismic, snow, and live loads were considered on the structures. These forces were used to determine the uplift and overturning of the structure to help determine an adequate foundation design. Two foundation designs were considered, shallow and pile, for each alternative.

All design elements are preliminary and will require further design. Basic designs were completed to a 10% concept design to help the client determine the feasibility and cost of these design alternatives. This study finds that the timber shear wall design on a concrete podium was determined to not be constructable when considering material strength limitations due to high base shear from wind loads. A more in-depth design and consideration could show that this is design is feasible. The steel truss towers were both feasible with the designs presented, and Imagineering Inc. recommends the client choose Design A, the SCBF, as it’s cost estimate is comparable with that of the EBF tower, and potentially can be much less with future optimization of the steel structure. With this design, a pile foundation is recommended because of the ease of construction and reliability in unknown soil conditions.

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1.0 INTRODUCTION

Paul Taylor has had the dream of living in a tree house ever since he was young. His desire is to live above the tree line to have a complete 360° view. He wants to be closer to the stars on which he loves to gaze. He has asked Imagineering Inc to help him begin this process of designing his dream house - a residential tower in which he can live.

The proposed location of the tower is between Anchor Point and Homer, Alaska, directly off the Sterling Highway as shown in Figure 1. If the residential tower is built, it will become a landmark. It will be seen by every car passing the highway at this location, similar to the “Dr. Seuss House” off the Parks Highway between Talkeetna and Big Lake. The tower and its unique singularity will be present for every person to witness. The client’s request is a unique idea for the Kenai Peninsula, and it is important that the designs presented and considered can withstand the seismic and environmental conditions in Alaska as well as be an appropriate structure for its region.

Figure 1: Map of the Location of the Residential Tower

2.1 PROJECT SPECIFICATIONS

The criteria for the residential tower were unrestricted in most areas of the design process. Currently, there is a hill in the nearby landscape that limits the client's views. The client has requested the tower be built at a height that can see adequately over the hill to allow him a 360-degree view. From drone shots taken of the landscape and surrounding area, it was determined that an 80-foot tower would meet this requirement. For the living space the client has requested a 30-foot by 30-foot (900 ft^2) dimension with a wraparound deck, 360 view windows, and sky lights. All structure materials were allowed to be considered in this feasibility study for the design alternatives.

2.2 SCOPE OF WORK

For the feasibility study, Imagineering Inc. has designed the tower structure from multiple materials and developed recommended foundation designs. There will be no design elements for the interior living space of the tower. An assumed weight of the living space will be used for all calculations. Considerations for facilities and piping were not considered in this feasibility study. The feasibility study focused on the structure calculations to determine governing loads and overturning of the structure.

The following are the elements that were included in this feasibility study:

- Creating Design Alternatives
- Calculating Loads
- Load analysis using RISA 3D Modeling
- Foundation Design
- Cost Estimations

2.3 DESIGN CRITERIA

IBC 2018 and, by extension, ASCE 7-16 were referenced as the basis for design in this project. While the state of Alaska is currently still utilizing IBC 2012, it is assumed that by the date of permitting for this project, Alaska will have adopted IBC 2018 and ASCE 7-16.

The following is the design criteria used:

Table 1: Design Criteria, ASCE 7-16

Load	Criteria
Wind	Risk Category II Exposure C Roughness C Wind Speed: 160 mph
Seismic	Site Class D Risk Category D S_{DS} 1.2, $S_1$0.6,
Live Load	40 psf residential, 60 psf deck
Dead Load	25 psf floor, 25 psf roof
Snow Load	40 psf

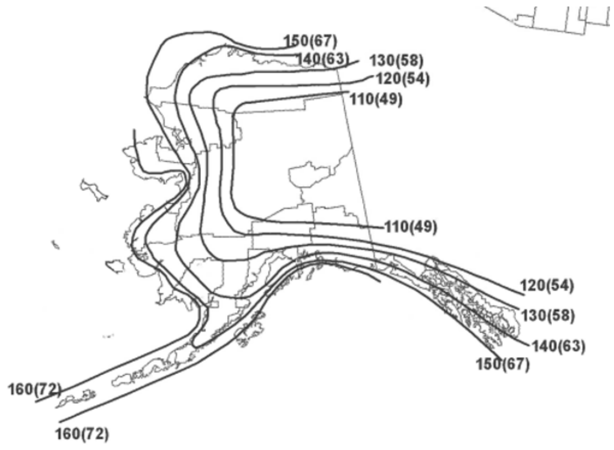


Figure 2: ASCE 7-16 Wind Speeds for Alaska

3.0 DESIGN ALTERNATIVES

Imagineering Inc. considered several design material options and ultimately decided on two steel truss frame designs and one timber shear wall design built on a concrete podium for a third, contrasting design. These materials were chosen for the feasibility study as they are common in Alaska. Steel is a reliable material that is relatively easily built and transported. Timber was another material chosen for its common construction use, and concrete was chosen because it can be formed on site. The designs were limited due to the seismic criteria for the area and the height limitations listed in ASCE 7-16. Special concentrically braced frame code allows for a height of 160 ft. Eccentrically braced frames also allow for a height of 160 ft and was chosen for its higher seismic response modification factor. Timber shear walls are limited to 65 ft in height, but the 80 ft height requirement could be met by adding the concrete podium.

3.1 DESIGN ALTERNATIVE A

Design A was considered because of its simple construction and reliability. It is a special concentrically braced frame. This means it is proportioned to maximize inelastic drift capacity. It is used to resist lateral loads through vertical concentric truss system of the steel frames. Its members align together at the joints of the structure as illustrated in Figure 3. This structure was considered desirable because it could be primarily fabricated off-site . The connections are not too expensive typically, and it is the most standard design of the three design alternatives.

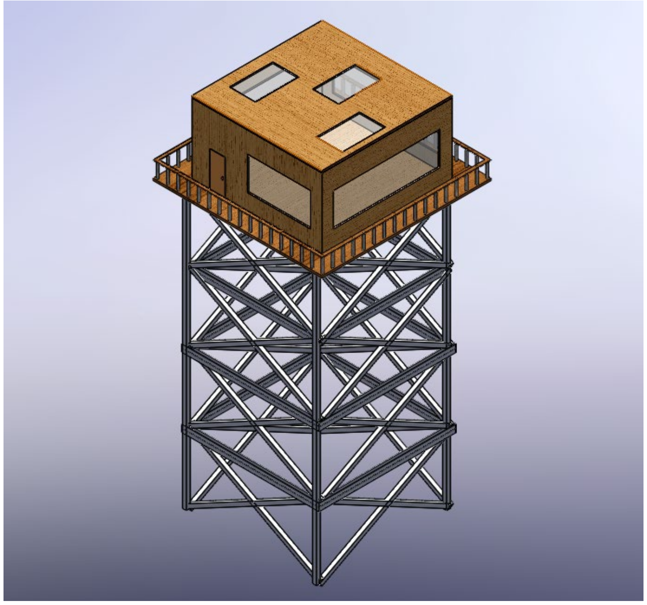
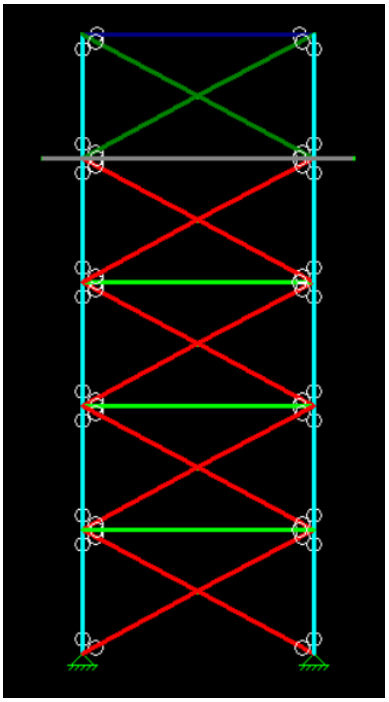


Figure 3: 3D Rendering Design Alternative A

The seismic calculation on Design Alternative A included a response modification factor, R value, from ASCE 7-16 for special concentrically braced frames. This R value can reduce the load of the seismic force on the structure due to the ductility of the tower. Less ductile structures have a lower R value as the seismic load does not dissipate over the structure as in a more flexible structure. The SCBF has a response modification factor value of 6 which is higher (and therefore more ductile) than the ordinary concentric braced frame (with R of 3.25). The calculations of the seismic loads are included in Appendix A.

Wind loads on the tower were calculated using an open structure analysis due to the open design of the SCBF truss. The wind loads are limited by the reduced surface area in the open structure. The living pace wind load was calculated as a closed structure with uplift considered as a canopy design. Uplift was applied to both the roof and the bottom of the living space.

The steel weight of the building consisted of all the truss under the living space and the steel floor framing for the living quarters. The structure was modeled in RISA 3D to determine its deflection and beam sizes based on the combinations of loads applied. Figure 4 below shows the selected member sizes for design alternative A. This design weight of the steel is 92,000 lbs.



	Section Set	Member Size
(cyan)	Legs	HSS 8x8x5/16
(green)	Horizontals	W 12x40
(red)	Braces	HSS 4x4x1/4
(gray)	Deck	W 8x31
(magenta)	Stairs	W 8x31
(blue)	Floor Framing Level	W 21x68
(navy)	Roof Framing Level	W 18x50

Figure 4: Design A Member Details

With these beam sizes, the structure meets the design load demands. The beams with the most force on them are the top beams with the live loads which required a larger sized beam for the girders. In conclusion, this design was considered feasible.

3.2 DESIGN ALTERNATIVE B

Design B uses an eccentrically braced frame as shown in Figure 5. An eccentrically braced frame combines the advantages of a stiff braced frame but allows for the inelastic advantages of a more ductile framing system. This is achieved through the link in the beams were the braces meet. This link flexes during seismic movements, preventing fracture.

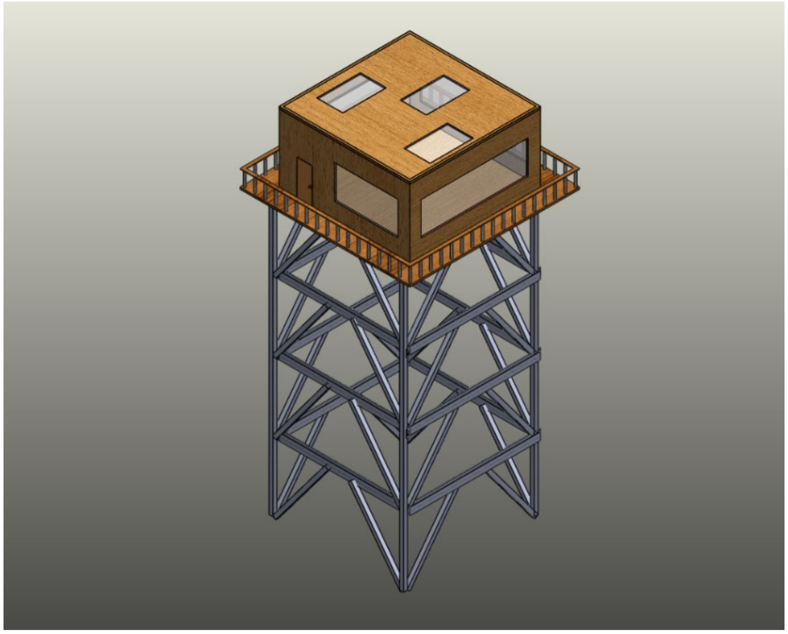
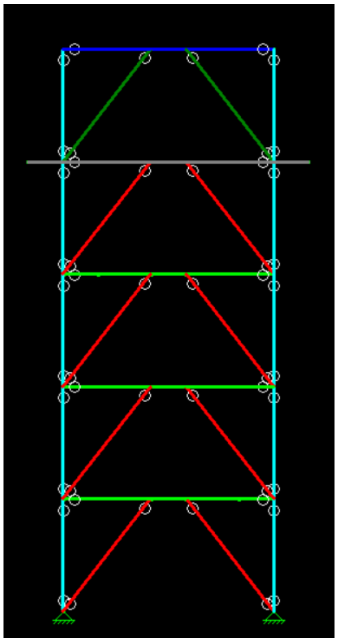


Figure 5: 3D Rendering of Design Alternative B

While the structures are similar in appearance, the difference in the bracing does affect the loads on the structure. An eccentrically braced frame is much more ductile than the special concentrically braced frame. This allows the R value to move from 6 to 8. The effect that this change had on the seismic load was relatively small, and is shown in Appendix B. The wind calculated values for Design Alternative B are the same as Design Alternative A.

The EBF truss tower was chosen as an alternative because of its higher R value, however, wind loads continued to control the forces on the structure. Figure 6 below shows the members that were sized using RISA 3D loads analysis. The total weight of steel in this design is 91,000 lbs.

This weight is likely to increase with the seismic detailing requirements for the connections and member if this design were to be progressed.



	Section Set	Member Size
	Legs	HSS 8x8x5/16
	Horizontals	W 18x71
	Braces	HSS 5x5x1/2
	Deck	W 8x31
	Stairs	W 8x31
	Floor Framing Level	W 10x60
	Roof Framing Level	W 8x48

Figure 6: Design Alternative B Member Details

3.3 DESIGN ALTERNATIVE C

Design Alternative C consists of timber shear walls, which are walls designed to resist lateral forces, such as wind and seismic, atop a concrete podium. The 3D rendering of this design is in Figure 7. The shear walls are designed to reduce sway and damage to the structure. Timber is much cheaper than steel and a good option, but can require more maintenance. The timber portion is on top of a podium because per the ASCE 7-16 code, wood shear wall structures can only be 65 feet tall in areas of Seismic Design Category D. To accommodate these criteria, a 64-foot building was designed on top of a 16-foot-tall podium. The concrete podium was proposed because it can be cheaper than steel and provide a very secure base. Steel could be used as an alternate to the podium design to allow for more off-site construction.

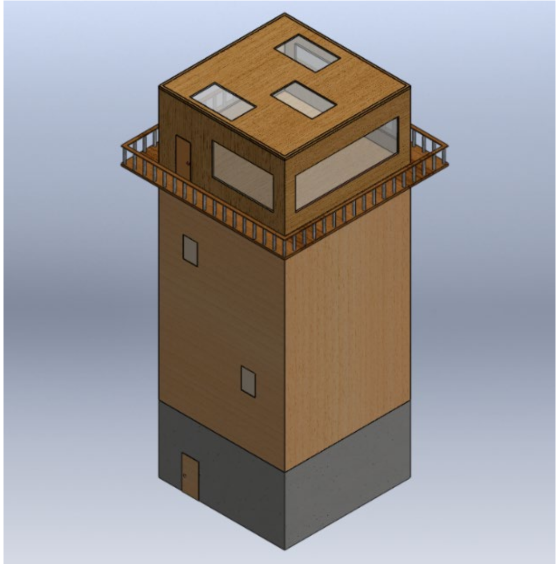


Figure 7:3D Rendering of Design Alternative C

The wind calculations for this structure are drastically different from the previous two designs as this design is fully enclosed. The force of the wind is much higher as it has more surface area to hit. This distribution of the wind is illustrated in Figure 8. Once again, the wind forces governed over seismic in this design. The vertical seismic load, in Appendix C, is smaller than the wind loads. As the design is fully enclosed, wind uplift only must be considered on the roof the living space.

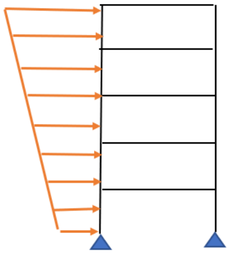


Figure 8: Wind Distribution for a Closed Structure

The concrete design for rebar was out of scope of the feasibility study, but reinforcement will need to be heavier at the corners of the wall and lighter in the center. The wall thickness for the 16-foot podium was considered to make sure the wall could hold up the 64-foot timber structure. To determine the thickness of the concrete wall, the moment and shear at the foundation were considered. Using engineering judgement, a 10-inch-thick concrete wall was used.

After calculating shear and uplift forces on the structure, in Appendix C, timber detailing was determined to be 2x10 studs at 24 inches on center. The timber framed walls would need to be double sheathed in plywood, exterior and interior of the studs. The connection of the timber structure to the concrete podium, would need to counteract a very high uplift force as the wind forces are very high. While the typical connections available are not sufficient for the forces, there are some options in the market that could potentially be adequate. Further design is required to determine the correct connection to secure the tower to the podium.

3.4 FOUNDATION DESIGNS

Foundation design was analyzed using general knowledge of the soil composition in the Homer area as well as an Alaska Department of Transportation bore log that contained samples taken on the client's property during the early to mid-1990's. All assumptions concerning the soil properties were made conservatively and with the strong recommendation that the client, should he choose to pursue construction of any design alternative, should hire a service to perform a complete geotechnical analysis of his property and reassess each foundation alternative. Supplementary soil properties were found using the Naval Facilities Engineering Systems Command (NAVFAC) design manual 7.01.

Two design options were pursued as foundation alternatives. The assumed soil properties are the same for both foundations. Seasonal active layer is assumed to be 5 feet deep; it is assumed that the soil properties beyond the soft top layer of peat remain as stiff hard sandy silt grading to gravely silty sand due to the lack of data beyond that soil layer. See figure 9.

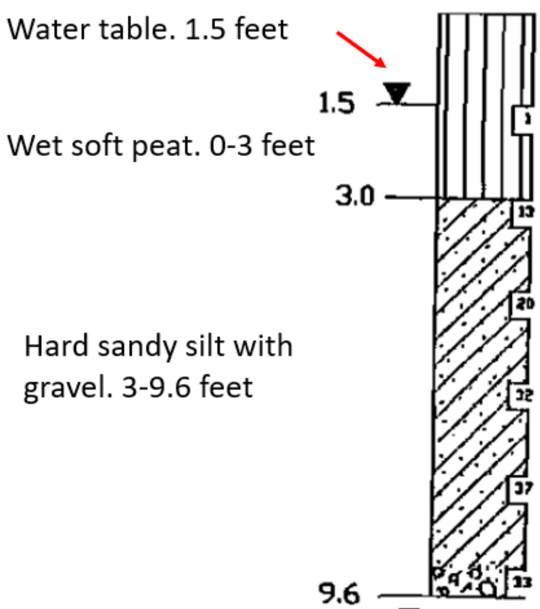


Figure 9: Simplified DOT Soil Core

The first alternative is a large diameter single driven pile in each corner of the tower. The calculations that were performed in the analysis of the pile foundation were bearing and tensile capacity as well as a lateral capacity check. The second alternative is a cold shallow foundation placed below the assumed frost depth. The calculations that were performed in the analysis of the shallow foundation were bearing capacity, uplift capacity, and elastic settlement based on bearing capacity.

The recommended pile foundation based on the previously mentioned assumptions is a 60 foot long, 24-inch diameter piles with 0.7-inch-thick walls. There will be one pile placed at each corner of the structure. See Figure 10 for a visual representation of the pile foundation alternative.

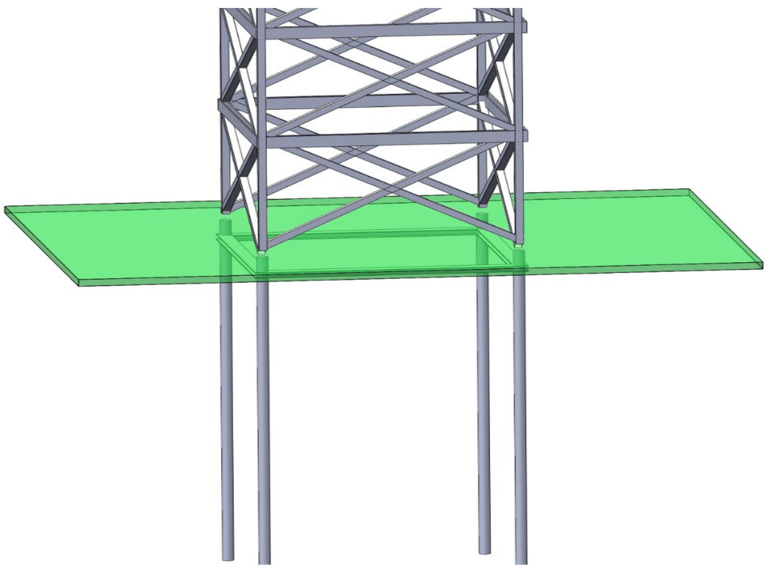


Figure 10: Pile Foundation with grade beam, not to scale

The shallow foundation will require 6 feet of excavation of existing material, in addition to any further excavation as recommended by in depth geotechnical analysis to provide a stable base. Backfill should be suitable Type A material that can be found in the surrounding area. A square foundation with 9 ft sides will be placed at the base of each tower leg. See Figure 11 for a visual representation of the shallow foundation alternative.

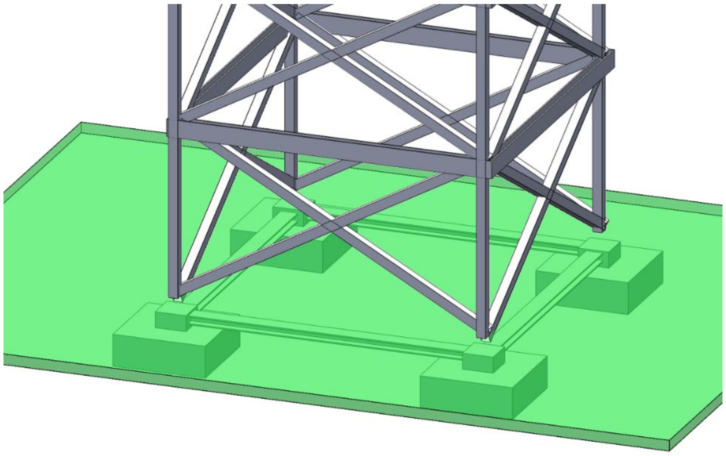


Figure 11: Shallow foundation with grade beam, not to scale

Our recommendation for both foundations is that each side should be connected by a grade beam for additional lateral capacity and overall stability of the structure. In the case of the pile foundation, the grade beam should be a steel section that is placed above ground level to keep it from deteriorating. If a shallow foundation is used, we recommend pouring a concrete grade beam below ground level.

Design alternative C will require further foundation analysis due the loads produced by the structure. It is our recommendation to consider group piles at each corner of design alternative C along with further geotechnical analysis. A basic analysis of group piles using the single pile capacities was performed and called for the use of 2 piles at each corner of the building to resist the increased uplift and shear forces.

4.0 COST ESTIMATES

Cost estimating was completed with the assistance of HMS, Inc. The living space was a static cost across all three designs as the design remains constant. Its cost was determined to be $245,000. Estimates were obtained on all three tower design alternatives. Both foundation designs, pile and shallow, were also considered in the cost estimation. The basic cost estimation listed in tables 2 and 3, do not include any contingencies or escalations.

Table 2: Tower Alternative Cost Estimates

Tower Design Alternative	Basic Cost Estimate
Design A	$455,000
Design B	$450,000
Design C	$185,000

Table 3: Foundation Alternative Cost Estimate

Foundation Alternative	Basic Cost Estimate
Shallow	$50,000
Single Pile at each Leg	$90,000
Group Piles at each Leg	$110,000

The full cost of the structure will vary as this is a preliminary estimate with only a 10% design. Further design of connections and optimization of the designs will potentially drastically change the estimates. It is worth noting as well that the price of steel has significantly increased in recent years, therefore greatly increasing the estimate for tower alternatives A and B. The final recommendation will include a cost as a total of living space, tower design, and selected foundation with all included contingencies and escalations.

5.0 DESIGN COMPARISON

Each tower and foundation design alternative was chosen for evaluation for its specific benefits to the client. Ultimately, the major factors that influenced the selection of a preferred design were structural design, cost, and client requests.

All three tower designs can potentially be structurally sound; however, some elements may be more difficult to design. Design B, ECF, will require more detailed connections than the SCBF. Design C, the timber shear, needs additional design for the connection to the podium base. Design A has a common design which would allow for fewer difficult connection designs.

The current cost estimate shows that Design C is only $185,000 versus $450,000 or more for other two designs. While this cost is considerably less, it is certain that this cost will increase with further design. The initial cost does not include any interior detailing or exterior protection. Each level in the timber shear wall tower will have to have finishes at every 16 feet high, this could potentially multiple the cost of the structure by four, making it not cost effective. Design B, while lighter than A, will also likely be considerably more expensive due to the cost to design the complicated ECF connections. Design A is most likely to have a reduced cost in final design due to the ability to more easily optimize the member sizing at each level.

Each tower design meets the basic requests of the client as the living space is standard across the three. The benefit of Design C, however, is the ability to secure the building from intruders since it is fully enclosed as the client would like to be able to secure his structure. For Designs A and B, additional design work would have to be completed to secure the open tower.

The shallow foundation option, while less expensive than the pile foundation, will require considerably more on-site work as a large amount of soil must be excavated to install the concrete pads. The pile foundation is more expensive, but often more secure in unknown soil conditions.

6.0 RECOMMENDATIONS

After completing the analysis of Designs A, B, and C, Design A has been determined to be the most beneficial design for the client. This design, while more steel weight than design B, is still ultimately more cost effective as the construction of the tower is less intricate on the connection design. Design A meets all the criteria set by the client: 80 feet tall, 900 ft^2 of living space with a wraparound deck, and the ability to add windows around the living area. The aesthetics of Design A and B are almost identical as well.

For the foundation, piles are the recommendation for this structure. Piles require less excavation than the shallow foundation and are a safer choice for the unknown soil conditions.

The final cost estimate of Design Alternative A with a pile foundation is $2 million, which will allow Mr. Taylor to live his dream of owning an adult tree house.

Appendix A:

Alternative A

Design A

Live Load

Living Space Dimensions

$l := 30\ ft$

$w := 30\ ft$

$Living\_Space := l \cdot w = 900\ ft^2$

$LL\_LS := 40\ psf$

Table 4.3-1: Residenital (all other areas except stairs)

Deck Dimensions: 3 ft perimeter

$Area\_Deck := 396\ ft^2$

$LL\_Deck := 1.5\ LL\_LS = 60\ psf$

Table 4.3-1: Balconies and Decks 1.5 times area served

$L := LL\_LS + LL\_Deck = 100\ psf$

Snow Load

$S := 40\ psf$ Table 7.2-1: ASCE 7-16 Homer

Roof Dimensions

$l := 30\ ft$

$w := 30\ ft$

$Area\_Roof := l \cdot w = 900\ ft^2$

Dead Load

$D := 50\ psf$ *Assumed for Design A and B

Seismic Load A

ACT Hazards Data for Homer, AK

$S_{DS} := 1.2$

$\rho := 1.3$ ASCE 7-16 12.3.4.2

$D := 50\ psf$ Assumed*

$R := 6$ Steel Special Concentrically braced frame

Design A

$I_e := 1$

$E_v := 0.2 \cdot S_{DS} \cdot D = 12\ psf$ ASCE 7-16 12.4-4a

$W := D + .2 \cdot S = 58\ psf$ Weight: Dead Load + 20% of Snow Load

$C_s := \dfrac{S_{DS}}{\dfrac{R}{I_e}} = 0.2$

$V := C_s \cdot W = 11.6\ psf$

$E_h := \rho \cdot V = 15.08\ psf$ ASCE 7-16 12.4-4

Qe=V

$E_h t := Living\_Space \cdot E_h = 13.572\ kip$

$\dfrac{E_h t}{4} = 3.393\ kip$

Wind Calcs for Design A and B (Truss Tower)

Wind Calcs on Side of Truss Area

Beam: Wide Flange		Column: HSS		Diagonal: HSS	
Size:		Size:		Size:	
height:	10.2 in	height:	10.2 in	height:	12 in

Height tower	64 ft	
Width Side	30 ft	
Gross Area Side	1920 ft^2	*(height*width)*
Steal Area	482.8 ft^2	
e	0.251458	*(steel area/gross area)*
Cf	2.769321	*(Figure 29.4-3)*

Assupmtions	
Kz	1.21
Kzt	1
Kd	0.85
Ke	1
G	0.85

V	160 mph	*(Figure 26.5-1A)*
qz	67.40378 lb/ft^2	*(26.10-1)*
F	158.6633 lb/ft^2	*(29.4-1)*
F in pounds	76602.64 lb	

Wind Calcs on Roof

qz	67.40378 lb/ft^2	*(26.10-1)*
G	0.85	*assume*

Load Case A			
C_{nw}	1.2	C_{nl}	0.3
Load Case B			
C_{nw}	-1.1	C_{nl}	-0.1

$P_{cw\ case\ A}$	68.75185 lb/ft^2	*(27.3-2)*
$P_{cl\ case\ A}$	17.18796 lb/ft^2	*(27.3-2)*
$P_{cw\ case\ B}$	-63.0225 lb/ft^2	*(27.3-2)*
$P_{cl\ case\ B}$	-5.72932 lb/ft^2	*(27.3-2)*

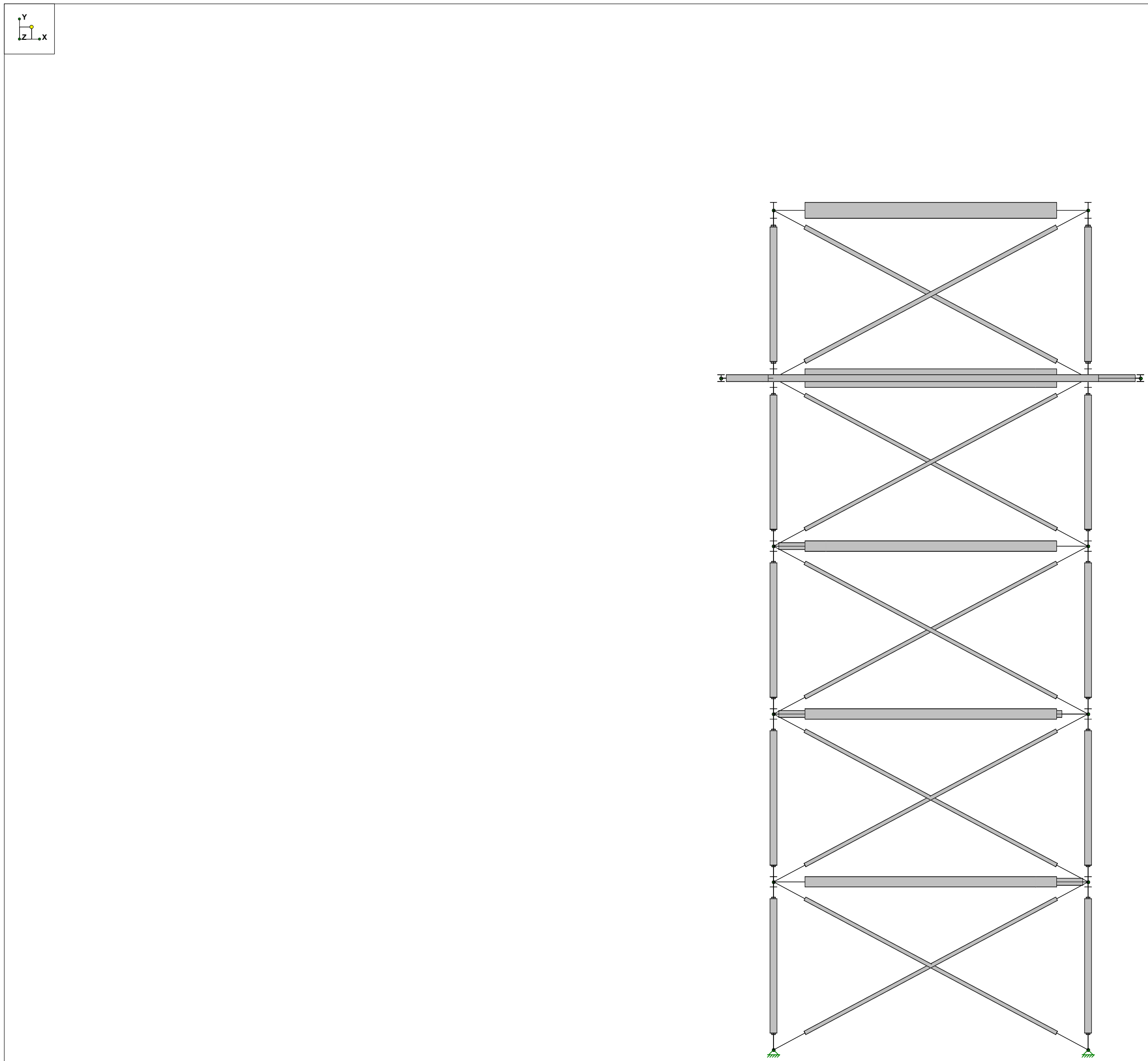
Living Cooridors Side Wind

P	85.3 lb/ft^2	*(Table 27.5-1 at 80 ft- Conservative value)*

Table 27.5-1 *(Continued)*. Main Wind Force Resisting System, Part 2 [$h \leq 160$ ft ($h \leq 48.8$ m)]: Enclosed Simple Diaphragm Bu

Exposure C

h (ft)	Along-wind Net Wall Pressure	V (mi/h) 110 L/B 0.5	110 L/B 1	110 L/B 2	115 L/B 0.5	115 L/B 1	115 L/B 2	120 L/B 0.5	120 L/B 1	120 L/B 2	130 L/B 0.5	130 L/B 1	130 L/B 2	140 L/B 0.5	140 L/B 1	140 L/B 2	160 L/B 0.5	160 L/B 1	160 L/B 2	
160	p_h	49.2	48.7	43.7	54.5	53.8	48.3	60.0	59.3	53.3	72.2	71.1	64.1	85.8	84.3	76.1	117.4	115.0	103.9	1
	p_0	36.1	35.7	30.0	40.0	39.5	33.2	44.1	43.5	36.6	53.0	52.2	44.0	62.9	61.9	52.3	86.2	84.4	71.5	1
150	p_h	48.0	47.5	42.6	53.0	52.4	47.1	58.4	57.7	51.9	70.1	69.2	62.3	83.3	82.0	74.0	113.8	111.7	101.0	1
	p_0	35.5	35.2	29.6	39.3	38.8	32.7	43.3	42.8	36.1	52.0	51.3	43.3	61.7	60.7	51.4	84.3	82.8	70.2	1
140	p_h	46.6	46.2	41.4	51.5	51.0	45.8	56.7	56.1	50.4	68.1	67.2	60.6	80.7	79.6	71.8	110.2	108.3	98.0	1
	p_0	34.9	34.6	29.1	38.6	38.2	32.2	42.4	42.0	35.5	50.9	50.3	42.6	60.4	59.5	50.6	82.4	81.0	68.9	1
130	p_h	45.3	45.0	40.2	50.0	49.6	44.5	55.0	54.5	48.9	65.9	65.2	58.7	78.1	77.1	69.6	106.4	104.7	94.8	1
	p_0	34.3	34.0	28.7	37.8	37.5	31.7	41.6	41.2	34.9	49.9	49.3	41.9	59.1	58.3	49.6	80.5	79.2	67.6	1
120	p_h	43.9	43.6	39.0	48.5	48.1	43.1	53.3	52.8	47.4	63.8	63.1	56.8	75.4	74.6	67.3	102.6	101.1	91.5	1
	p_0	33.6	33.4	28.2	37.1	36.8	31.1	40.7	40.4	34.3	48.8	48.3	41.1	57.7	57.1	48.7	78.5	77.3	66.2	1
110	p_h	42.5	42.3	37.7	46.9	46.6	41.6	51.5	51.1	45.8	61.5	61.0	54.8	72.7	72.0	64.8	98.6	97.3	88.1	1
	p_0	32.9	32.8	27.7	36.3	36.1	30.6	39.9	39.6	33.6	47.7	47.3	40.3	56.3	55.8	47.6	76.4	75.4	64.7	1
100	p_h	41.1	40.9	36.4	45.2	45.0	40.1	49.6	49.3	44.1	59.2	58.8	52.7	69.8	69.3	62.3	94.5	93.5	84.5	1
	p_0	32.3	32.1	27.2	35.5	35.4	30.0	39.0	38.8	33.0	46.5	46.2	39.4	54.9	54.4	46.6	74.2	73.4	63.2	
90	p_h	39.6	39.4	35.0	43.5	43.3	38.5	47.7	47.5	42.3	56.8	56.5	50.6	66.9	66.5	59.7	90.3	89.4	80.8	1
	p_0	31.6	31.5	26.6	34.7	34.6	29.4	38.1	37.9	32.3	45.4	45.1	38.5	53.4	53.1	45.5	72.1	71.4	61.6	
80	p_h	38.0	37.9	33.5	41.8	41.6	36.9	45.8	45.6	40.5	54.4	54.2	48.3	63.9	63.6	56.9	85.9	85.3	76.8	1
	p_0	30.9	30.8	26.1	33.9	33.8	28.7	37.2	37.1	31.5	44.2	44.0	37.6	52.0	51.7	44.3	69.8	69.3	59.8	
70	p_h	36.4	36.3	32.0	39.9	39.9	35.2	43.7	43.6	38.6	51.9	51.7	45.9	60.8	60.6	54.0	81.4	81.0	72.7	1



Imagineering Inc.	Tower	SK - 3
		Apr 19, 2022 at 8:21 PM
		Tower Design 1 (1).r3d

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	Iyy [in4]	Izz [in4]	J [in4]
1	Legs	HSS8x8x10	Column	Tube	A992	Typical	16.4	146	146	244
2	Horizontals	W12x40	Beam	Wide Flange	A992	Typical	11.7	44.1	307	.906
3	Braces	HSS4x4x8	VBrace	Tube	A500 Gr.B R...	Typical	6.02	11.9	11.9	21
4	deck	W8x31	Beam	Wide Flange	A992	Typical	9.13	37.1	110	.536
5	stairs	W8x31	Beam	Wide Flange	A992	Typical	9.13	37.1	110	.536
6	Floor Framin...	W21x68	Beam	Wide Flange	A992	Typical	20	64.7	1480	2.45
7	Roof Framin...	W18x50	Beam	Wide Flange	A992	Typical	14.7	40.1	800	1.24
8	Dummy Bra...	HSS5x5x3	VBrace	Tube	A992	Typical	3.28	12.6	12.6	19.9

Member Distributed Loads (BLC 4 : Live Load Living)

	Member Label	Direction	Start Magnitude[lb/ft,...	End Magnitude[lb/ft,F...	Start Location[ft,%]	End Location[ft,%]
1	M13	Y	-600	-600	0	0
2	M51	Y	-600	-600	0	0

Member Distributed Loads (BLC 5 : Live Load Deck)

	Member Label	Direction	Start Magnitude[lb/ft,...	End Magnitude[lb/ft,F...	Start Location[ft,%]	End Location[ft,%]
1	M105A	Y	-150	-150	0	0
2	M68	Y	-150	-150	0	0
3	M104B	Y	-150	-150	0	0
4	M51	Y	-150	-150	0	0
5	M34	Y	-150	-150	0	0
6	M82A	Y	-150	-150	0	0
7	M13	Y	-150	-150	0	0
8	M83A	Y	-150	-150	0	0

Member Distributed Loads (BLC 6 : Snow Load)

	Member Label	Direction	Start Magnitude[lb/ft,...	End Magnitude[lb/ft,F...	Start Location[ft,%]	End Location[ft,%]
1	M73	Y	-600	-600	0	0
2	M80	Y	-600	-600	0	0

Member Distributed Loads (BLC 8 : Earthquake V)

	Member Label	Direction	Start Magnitude[lb/ft,...	End Magnitude[lb/ft,F...	Start Location[ft,%]	End Location[ft,%]
1	M13	Y	-180	-180	0	0
2	M51	Y	-180	-180	0	0

Member Distributed Loads (BLC 9 : Dead Load)

	Member Label	Direction	Start Magnitude[lb/ft,...	End Magnitude[lb/ft,F...	Start Location[ft,%]	End Location[ft,%]
1	M13	Y	-750	-750	0	0
2	M51	Y	-750	-750	0	0

Joint Loads and Enforced Displacements (BLC 3 : Wind Living Closed)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/f...
1	1.6	L	Z	-10.3
2	1.5	L	Z	-10.3
3	2.6	L	Z	-10.3
4	2.5	L	Z	-10.3

Joint Loads and Enforced Displacements (BLC 11 : Wind Roof)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/f...
1	1.6	L	Y	-10.3
2	2.6	L	Y	-10.3
3	3.6	L	Y	-10.3
4	4.6	L	Y	-10.3

Member Point Loads (BLC 4 : Live Load Living)

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M13	y	0	0
2	M13	y	0	0

Member Point Loads (BLC 7 : Earthquake Hz)

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M13	Z	-3.375	0
2	M102A	Z	-3.375	0
3	M51	Z	-3.375	0
4	M103A	Z	-3.375	0

Member Point Loads (BLC 10 : Earthquake Hx)

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M103A	x	-3.375	0
2	M51	x	-3.375	0
3	M13	x	-3.375	0
4	M102A	x	-3.375	0

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Z Gravity	Joint	Point	Distribut...	Area(M...	Surface...
1	Gravity	DL		-1						
2	Wind Open Tower	WL							2	
3	Wind Living Closed	WL				4				
4	Live Load Living	LL					2	2		
5	Live Load Deck	LL						8		
6	Snow Load	SL						2		
7	Earthquake Hz	ELZ			-.2		4			
8	Earthquake V	ELY						2		
9	Dead Load	DL						2		
10	Earthquake Hx	ELX	-.2				4			
11	Wind Roof	WLY				4				

Load Combination Design

	Description	ASIF	CD	Service	Hot Rolled	Cold For...	Wood	Concrete	Masonry	Aluminum	Stainless	Connection
1	LC1				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	LC2				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	LC3a				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	LC3b				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	LC4				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6	LC5				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Load Combination Design (Continued)

	Description	ASIF	CD	Service	Hot Rolled	Cold For...	Wood	Concrete	Masonry	Aluminum	Stainless	Connection
7	LC6/Ex				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8	LC6/Ez				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9	LC7/Ex				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
10	LC7/Ez				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11	Self Weight				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
12	DL				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
13	SL				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
14	LL				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
15	W1				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
16	W2				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
17	E1				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
18	E2				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Appendix B:

Alternative B

Design B

Live Load

Living Space Dimensions

$l := 30\ ft$

$w := 30\ ft$

$Living\_Space := l \cdot w = 900\ ft^2$

$LL\_LS := 40\ psf$

Table 4.3-1: Residenital (all other areas except stairs)

Deck Dimensions: 3 ft perimeter

$Area\_Deck := 396\ ft^2$

$LL\_Deck := 1.5\ LL\_LS = 60\ psf$

Table 4.3-1: Balconies and Decks 1.5 times area served

$L := LL\_LS + LL\_Deck = 100\ psf$

Snow Load

$S := 40\ psf$ Table 7.2-1: ASCE 7-16 Homer

Roof Dimensions

$l := 30\ ft$

$w := 30\ ft$

$Area\_Roof := l \cdot w = 900\ ft^2$

Dead Load

$D := 50\ psf$ *Assumed for Design A and B

Design B

$E_{vB} := 0.2 \cdot S_{DS} \cdot D = 12\ psf$

$R_B := 8$

$W := D + .2 \cdot S = 58\ psf$

$C_{sB} := \frac{S_{DS}}{\frac{R_B}{I_e}} = 0.15$

$V_B := C_{sB} \cdot W = 8.7\ psf$

$E_{hB} := \rho \cdot V_B = 11.31\ psf$

$E_htB := Living\_Space \cdot E_{hB} = 10.179\ kip$

$\frac{E_htB}{4} = 2.545\ kip$

Wind Calcs for Design A and B (Truss Tower)

Wind Calcs on Side of Truss Area

Beam: Wide Flange		Column: HSS		Diagonal: HSS	
Size:		Size:		Size:	
height:	10.2 in	height:	10.2 in	height:	12 in

Height tower	64 ft	
Width Side	30 ft	
Gross Area Side	1920 ft^2	*(height*width)*
Steal Area	482.8 ft^2	
e	0.251458	*(steel area/gross area)*
Cf	2.769321	*(Figure 29.4-3)*

Assupmtions	
Kz	1.21
Kzt	1
Kd	0.85
Ke	1
G	0.85

V	160 mph	*(Figure 26.5-1A)*
qz	67.40378 lb/ft^2	*(26.10-1)*
F	158.6633 lb/ft^2	*(29.4-1)*
F in pounds	76602.64 lb	

Wind Calcs on Roof

qz	67.40378 lb/ft^2	*(26.10-1)*
G	0.85	*assume*

Load Case A			
C_{nw}	1.2	C_{nl}	0.3
Load Case B			
C_{nw}	-1.1	C_{nl}	-0.1

$P_{cw\ case\ A}$	68.75185 lb/ft^2	*(27.3-2)*
$P_{cl\ case\ A}$	17.18796 lb/ft^2	*(27.3-2)*
$P_{cw\ case\ B}$	-63.0225 lb/ft^2	*(27.3-2)*
$P_{cl\ case\ B}$	-5.72932 lb/ft^2	*(27.3-2)*

Living Cooridors Side Wind

P	85.3 lb/ft^2	*(Table 27.5-1 at 80 ft- Conservative value)*

Table 27.5-1 *(Continued)*. Main Wind Force Resisting System, Part 2 [$h \leq 160$ ft ($h \leq 48.8$ m)]: Enclosed Simple Diaphragm Bu

Exposure C

h (ft)	Along-wind Net Wall Pressure	V (mi/h) 110 L/B 0.5	110 L/B 1	110 L/B 2	115 L/B 0.5	115 L/B 1	115 L/B 2	120 L/B 0.5	120 L/B 1	120 L/B 2	130 L/B 0.5	130 L/B 1	130 L/B 2	140 L/B 0.5	140 L/B 1	140 L/B 2	160 L/B 0.5	160 L/B 1	160 L/B 2	
160	p_h	49.2	48.7	43.7	54.5	53.8	48.3	60.0	59.3	53.3	72.2	71.1	64.1	85.8	84.3	76.1	117.4	115.0	103.9	1
	p_0	36.1	35.7	30.0	40.0	39.5	33.2	44.1	43.5	36.6	53.0	52.2	44.0	62.9	61.9	52.3	86.2	84.4	71.5	1
150	p_h	48.0	47.5	42.6	53.0	52.4	47.1	58.4	57.7	51.9	70.1	69.2	62.3	83.3	82.0	74.0	113.8	111.7	101.0	1
	p_0	35.5	35.2	29.6	39.3	38.8	32.7	43.3	42.8	36.1	52.0	51.3	43.3	61.7	60.7	51.4	84.3	82.8	70.2	1
140	p_h	46.6	46.2	41.4	51.5	51.0	45.8	56.7	56.1	50.4	68.1	67.2	60.6	80.7	79.6	71.8	110.2	108.3	98.0	1
	p_0	34.9	34.6	29.1	38.6	38.2	32.2	42.4	42.0	35.5	50.9	50.3	42.6	60.4	59.5	50.6	82.4	81.0	68.9	1
130	p_h	45.3	45.0	40.2	50.0	49.6	44.5	55.0	54.5	48.9	65.9	65.2	58.7	78.1	77.1	69.6	106.4	104.7	94.8	1
	p_0	34.3	34.0	28.7	37.8	37.5	31.7	41.6	41.2	34.9	49.9	49.3	41.9	59.1	58.3	49.6	80.5	79.2	67.6	1
120	p_h	43.9	43.6	39.0	48.5	48.1	43.1	53.3	52.8	47.4	63.8	63.1	56.8	75.4	74.6	67.3	102.6	101.1	91.5	1
	p_0	33.6	33.4	28.2	37.1	36.8	31.1	40.7	40.4	34.3	48.8	48.3	41.1	57.7	57.1	48.7	78.5	77.3	66.2	1
110	p_h	42.5	42.3	37.7	46.9	46.6	41.6	51.5	51.1	45.8	61.5	61.0	54.8	72.7	72.0	64.8	98.6	97.3	88.1	1
	p_0	32.9	32.8	27.7	36.3	36.1	30.6	39.9	39.6	33.6	47.7	47.3	40.3	56.3	55.8	47.6	76.4	75.4	64.7	1
100	p_h	41.1	40.9	36.4	45.2	45.0	40.1	49.6	49.3	44.1	59.2	58.8	52.7	69.8	69.3	62.3	94.5	93.5	84.5	1
	p_0	32.3	32.1	27.2	35.5	35.4	30.0	39.0	38.8	33.0	46.5	46.2	39.4	54.9	54.4	46.6	74.2	73.4	63.2	
90	p_h	39.6	39.4	35.0	43.5	43.3	38.5	47.7	47.5	42.3	56.8	56.5	50.6	66.9	66.5	59.7	90.3	89.4	80.8	1
	p_0	31.6	31.5	26.6	34.7	34.6	29.4	38.1	37.9	32.3	45.4	45.1	38.5	53.4	53.1	45.5	72.1	71.4	61.6	
80	p_h	38.0	37.9	33.5	41.8	41.6	36.9	45.8	45.6	40.5	54.4	54.2	48.3	63.9	63.6	56.9	85.9	85.3	76.8	1
	p_0	30.9	30.8	26.1	33.9	33.8	28.7	37.2	37.1	31.5	44.2	44.0	37.6	52.0	51.7	44.3	69.8	69.3	59.8	
70	p_h	36.4	36.3	32.0	39.9	39.9	35.2	43.7	43.6	38.6	51.9	51.7	45.9	60.8	60.6	54.0	81.4	81.0	72.7	1

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	Iyy [in4]	Izz [in4]	J [in4]
1	Legs	HSS8x8x10	Column	Tube	A500 Gr.B R...	Typical	16.4	146	146	244
2	Horizontals	W18x71	Beam	Wide Flange	A992	Typical	20.9	60.3	1170	3.49
3	Braces	HSS5x5x8	VBrace	Tube	A500 Gr.B R...	Typical	7.88	26	26	44.6
4	deck	W8x31	Beam	Wide Flange	A992	Typical	9.13	37.1	110	.536
5	stairs	W8x31	Beam	Wide Flange	A992	Typical	9.13	37.1	110	.536
6	Hortizontals ...	W10x60	Beam	Wide Flange	A992	Typical	17.7	116	341	2.48
7	Horizontals ...	W8x48	Beam	Wide Flange	A992	Typical	14.1	60.9	184	1.96
8	Dummy Bra...	HSS4x4x8	VBrace	Double Angle	A500 Gr.B R...	Typical	6.02	11.9	11.9	21

Joint Loads and Enforced Displacements (BLC 3 : Wind Living Closed)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/f...
1	1.6	L	Z	-10.3
2	2.6	L	Z	-10.3
3	1.5	L	Z	-10.3
4	2.5	L	Z	-10.3

Joint Loads and Enforced Displacements (BLC 11 : Wind Roof)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/f...
1	3.6	L	Y	-15
2	1.6	L	Y	-15
3	4.6	L	Y	-15
4	2.6	L	Y	-15

Member Point Loads (BLC 4 : Live Load Living)

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M13	y	0	0
2	M13	y	0	0

Member Point Loads (BLC 7 : Earthquake Hz)

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M13	Z	-3.375	0
2	M102A	Z	-3.375	0
3	M51	Z	-3.375	0
4	M103A	Z	-3.375	0

Member Point Loads (BLC 10 : Earthquake Hx)

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M103A	x	-3.375	0
2	M51	x	-3.375	0
3	M13	x	-3.375	0
4	M102A	x	-3.375	0

Member Distributed Loads (BLC 4 : Live Load Living)

	Member Label	Direction	Start Magnitude[lb/ft,...	End Magnitude[lb/ft,F...	Start Location[ft,%]	End Location[ft,%]
1	M13	Y	-600	-600	0	0
2	M51	Y	-600	-600	0	0

Member Distributed Loads (BLC 5 : Live Load Deck)

	Member Label	Direction	Start Magnitude[lb/ft,...	End Magnitude[lb/ft,F...	Start Location[ft,%]	End Location[ft,%]
1	M105A	Y	-150	-150	0	0
2	M68	Y	-150	-150	0	0
3	M104B	Y	-150	-150	0	0
4	M51	Y	-150	-150	0	0
5	M34	Y	-150	-150	0	0
6	M82A	Y	-150	-150	0	0
7	M13	Y	-150	-150	0	0
8	M83A	Y	-150	-150	0	0

Member Distributed Loads (BLC 6 : Snow Load)

	Member Label	Direction	Start Magnitude[lb/ft,...	End Magnitude[lb/ft,F...	Start Location[ft,%]	End Location[ft,%]
1	M73	Y	-600	-600	0	0
2	M80	Y	-600	-600	0	0

Member Distributed Loads (BLC 8 : Earthquake V)

	Member Label	Direction	Start Magnitude[lb/ft,...	End Magnitude[lb/ft,F...	Start Location[ft,%]	End Location[ft,%]
1	M13	Y	-180	-180	0	0
2	M51	Y	-180	-180	0	0

Member Distributed Loads (BLC 9 : Dead Load)

	Member Label	Direction	Start Magnitude[lb/ft,...	End Magnitude[lb/ft,F...	Start Location[ft,%]	End Location[ft,%]
1	M13	Y	-750	-750	0	0
2	M51	Y	-750	-750	0	0

Member Distributed Loads (BLC 12 : BLC 2 Transient Area Loads)

	Member Label	Direction	Start Magnitude[lb/ft,...	End Magnitude[lb/ft,F...	Start Location[ft,%]	End Location[ft,%]
1	M90	Z	-211.56	-211.56	0	5
2	M93	Z	-211.56	-211.56	0	5
3	M94	Z	-211.56	-211.56	0	25
4	M97	Z	-211.56	-211.56	0	5
5	M98	Z	-211.56	-211.56	0	5
6	M100	Z	-211.56	-211.56	0	25
7	M83A	Z	-211.56	-211.56	5	35
8	M104B	Z	-211.56	-211.56	5	35
9	M14	Z	-211.56	-211.56	0	16
10	M15	Z	-211.56	-211.56	0	16
11	M16	Z	-211.56	-211.56	0	16
12	M17	Z	-211.56	-211.56	0	16
13	M18	Z	-211.56	-211.56	0	16
14	M19	Z	-211.56	-211.56	0	16
15	M20	Z	-211.56	-211.56	0	16
16	M21	Z	-211.56	-211.56	0	16
17	M35	Z	-211.56	-211.56	0	16

Member Distributed Loads (BLC 12 : BLC 2 Transient Area Loads) (Continued)

	Member Label	Direction	Start Magnitude[lb/ft,...	End Magnitude[lb/ft,F...	Start Location[ft,%]	End Location[ft,%]
18	M36	Z	-211.56	-211.56	0	16
19	M37	Z	-211.56	-211.56	0	16
20	M38	Z	-211.56	-211.56	0	16
21	M52	Z	-211.56	-211.56	0	16
22	M53	Z	-211.56	-211.56	0	16
23	M54	Z	-211.56	-211.56	0	16
24	M55	Z	-211.56	-211.56	0	16
25	M4	Z	-489.232	-489.232	0	30
26	M7	Z	-489.232	-489.232	0	30
27	M10	Z	-489.232	-489.232	0	30
28	M13	Z	-224.782	-224.782	0	30
29	M42	Z	-489.232	-489.232	0	30
30	M45	Z	-489.232	-489.232	0	30
31	M51	Z	-224.782	-224.782	0	30
32	M112A	Z	-489.232	-489.232	0	30

Member Area Loads (BLC 2 : Wind Open Tower)

	Joint A	Joint B	Joint C	Joint D	Direction	Distribution	Magnitude[psf]
1	4.5	3.5	3.1	4.1	Z	Open Structure	-158.66
2	1.5	2.5	2.1	1.1	Z	Open Structure	-158.68

Basic Load Cases

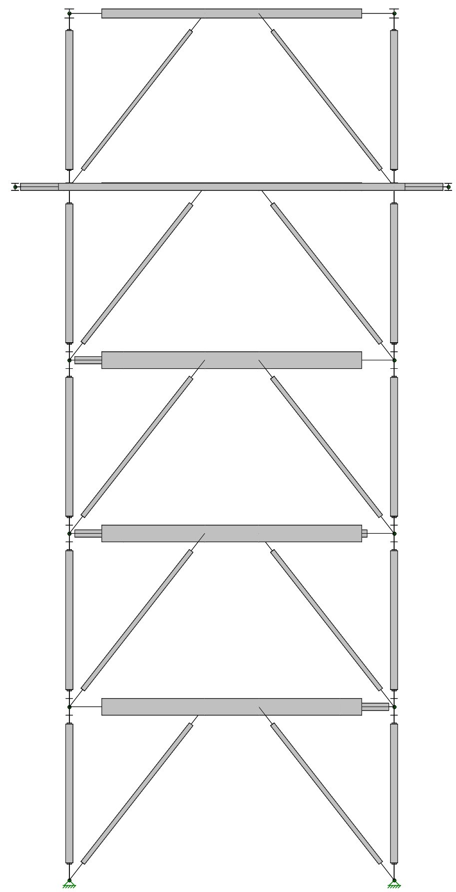
	BLC Description	Category	X Gravity	Y Gravity	Z Gravity	Joint	Point	Distribut...	Area(M...	Surface...
1	Gravity	DL		-1						
2	Wind Open Tower	WL							2	
3	Wind Living Closed	WL				4				
4	Live Load Living	LL					2	2		
5	Live Load Deck	LL						8		
6	Snow Load	SL						2		
7	Earthquake Hz	ELZ			-.2		4			
8	Earthquake V	ELY						2		
9	Dead Load	DL						2		
10	Earthquake Hx	ELX	-.2				4			
11	Wind Roof	WLY				4				
12	BLC 2 Transient A...	None						32		

Load Combination Design

	Description	ASIF	CD	Service	Hot Rolled	Cold For...	Wood	Concrete	Masonry	Aluminum	Stainless	Connection
1	LC1				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	LC2				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	LC3a				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	LC3b				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	LC4				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6	LC5				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7	LC6/Ex				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8	LC6/Ez				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9	LC7/Ex				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Load Combination Design (Continued)

	Description	ASIF	CD	Service	Hot Rolled	Cold For...	Wood	Concrete	Masonry	Aluminum	Stainless	Connection
10	LC7/Ez				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11	Self Weight				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
12	DL				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
13	SL				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
14	WL1				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
15	WL2				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
16	LL				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
17	E1				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
18	E2				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes



Envelope Only Solution

Imagineering Inc.	Tower	SK - 1
		Apr 19, 2022 at 8:33 PM
		Tower Design B2 (2).r3d

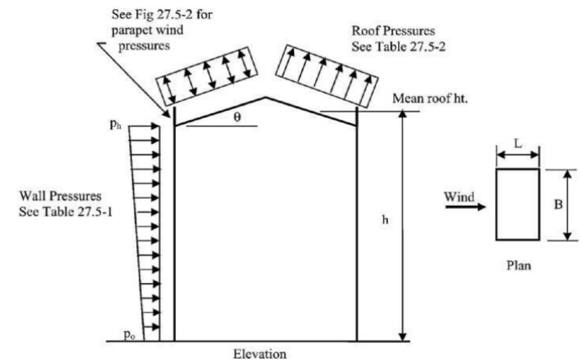
Appendix C:

Alternative C

Wind Calcs for Design C (Fully Enclosed Structure)

Assumptions
Risk Category 2
Building Class 2
Exposure C
Roughness C
Wind Speed: 160 mph
Roof: Flat

Diagram



Note
For Application of Wind Pressures, see Tables 27.5-1 and 27.5-2

FIGURE 27.5-1 Main Wind Force Resisting System, Part 2 [$h \leq 160$ ft ($h \leq 48.8$ m)]: Enclosed Simple Diaphragm Buildings, Wind Pressures, Walls and Roof

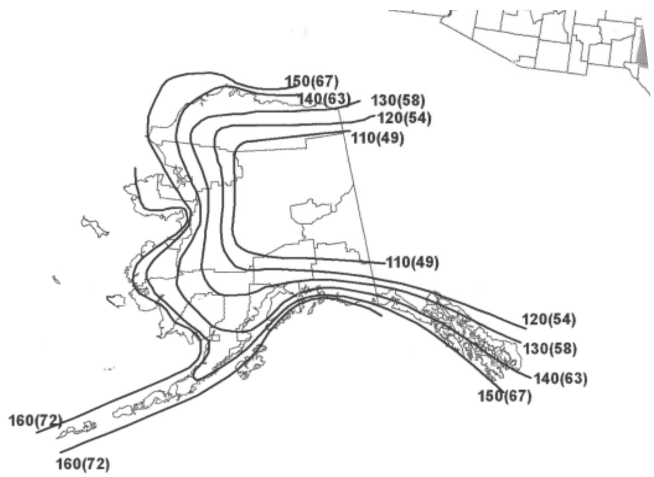


FIGURE 26.5-1A Basic Wind Speeds for Risk Category II Buildings a

: design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m)
erpolation between contours is permitted.
d coastal areas outside the last contour shall use the last wind speed c
ous terrain, gorges, ocean promontories, and special wind regions sh
eds correspond to approximately a 7% probability of exceedance i
0 years).

Table 27.5-1 *(Continued)*. Main Wind Force Resisting System, Part 2 [$h \leq 160$ ft ($h \leq 48.8$ m)]: Enclosed Simple Diaphragm Bu

Exposure C

		***V* (mi/h)**																		
	Along-wind Net Wall Pressure	**110**			**115**			**120**			**130**			**140**			**160**			
		L/B			***L/B***			***L/B***			***L/B***			***L/B***			***L/B***			
***h* (ft)**		**0.5**	**1**	**2**	**0.5**	**1**	**2**	**0.5**	**1**	**2**	**0.5**	**1**	**2**	**0.5**	**1**	**2**	**0.5**	**1**	**2**	
160	p_h	49.2	48.7	43.7	54.5	53.8	48.3	60.0	59.3	53.3	72.2	71.1	64.1	85.8	84.3	76.1	117.4	115.0	103.9	1
	p_0	36.1	35.7	30.0	40.0	39.5	33.2	44.1	43.5	36.6	53.0	52.2	44.0	62.9	61.9	52.3	86.2	84.4	71.5	1
150	p_h	48.0	47.5	42.6	53.0	52.4	47.1	58.4	57.7	51.9	70.1	69.2	62.3	83.3	82.0	74.0	113.8	111.7	101.0	1
	p_0	35.5	35.2	29.6	39.3	38.8	32.7	43.3	42.8	36.1	52.0	51.3	43.3	61.7	60.7	51.4	84.3	82.8	70.2	1
140	p_h	46.6	46.2	41.4	51.5	51.0	45.8	56.7	56.1	50.4	68.1	67.2	60.6	80.7	79.6	71.8	110.2	108.3	98.0	1
	p_0	34.9	34.6	29.1	38.6	38.2	32.2	42.4	42.0	35.5	50.9	50.3	42.6	60.4	59.5	50.6	82.4	81.0	68.9	1
130	p_h	45.3	45.0	40.2	50.0	49.6	44.5	55.0	54.5	48.9	65.9	65.2	58.7	78.1	77.1	69.6	106.4	104.7	94.8	1
	p_0	34.3	34.0	28.7	37.8	37.5	31.7	41.6	41.2	34.9	49.9	49.3	41.9	59.1	58.3	49.6	80.5	79.2	67.6	1
120	p_h	43.9	43.6	39.0	48.5	48.1	43.1	53.3	52.8	47.4	63.8	63.1	56.8	75.4	74.6	67.3	102.6	101.1	91.5	1
	p_0	33.6	33.4	28.2	37.1	36.8	31.1	40.7	40.4	34.3	48.8	48.3	41.1	57.7	57.1	48.7	78.5	77.3	66.2	1
110	p_h	42.5	42.3	37.7	46.9	46.6	41.6	51.5	51.1	45.8	61.5	61.0	54.8	72.7	72.0	64.8	98.6	97.3	88.1	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

	p_0	32.9	32.8	27.7	36.3	36.1	30.6	39.9	39.6	33.6	47.7	47.3	40.3	56.3	55.8	47.6	76.4	75.4	64.7	1
100	p_h	41.1	40.9	36.4	45.2	45.0	40.1	49.6	49.3	44.1	59.2	58.8	52.7	69.8	69.3	62.3	94.5	93.5	84.5	1
	p_0	32.3	32.1	27.2	35.5	35.4	30.0	39.0	38.8	33.0	46.5	46.2	39.4	54.9	54.4	46.6	74.2	73.4	63.2	
90	p_h	39.6	39.4	35.0	43.5	43.3	38.5	47.7	47.5	42.3	56.8	56.5	50.6	66.9	66.5	59.7	90.3	89.4	80.8	1
	p_0	31.6	31.5	26.6	34.7	34.6	29.4	38.1	37.9	32.3	45.4	45.1	38.5	53.4	53.1	45.5	72.1	71.4	61.6	
80	p_h	38.0	37.9	33.5	41.8	41.6	36.9	45.8	45.6	40.5	54.4	54.2	48.3	63.9	63.6	56.9	85.9	85.3	76.8	1
	p_0	30.9	30.8	26.1	33.9	33.8	28.7	37.2	37.1	31.5	44.2	44.0	37.6	52.0	51.7	44.3	69.8	69.3	59.8	
70	p_h	36.4	36.3	32.0	39.9	39.9	35.2	43.7	43.6	38.6	51.9	51.7	45.9	60.8	60.6	54.0	81.4	81.0	72.7	1

Main Wind Force Resisting System – Part 2		h ≤ 160 ft.
Table 27.6-2	Wind Pressures - Roof	Application of Roof Pressures
Enclosed Simple Diaphragm Buildings		

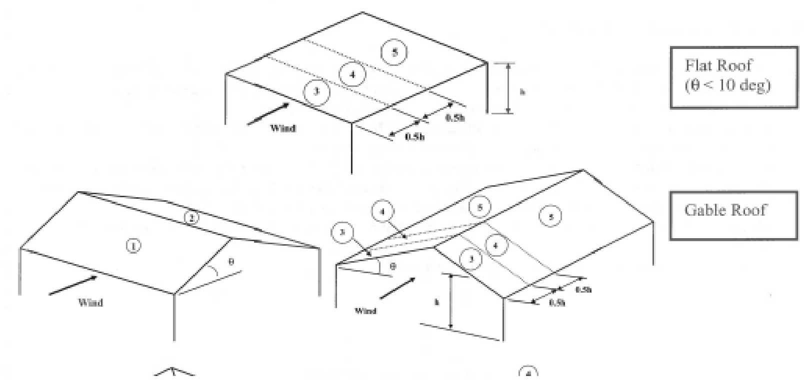
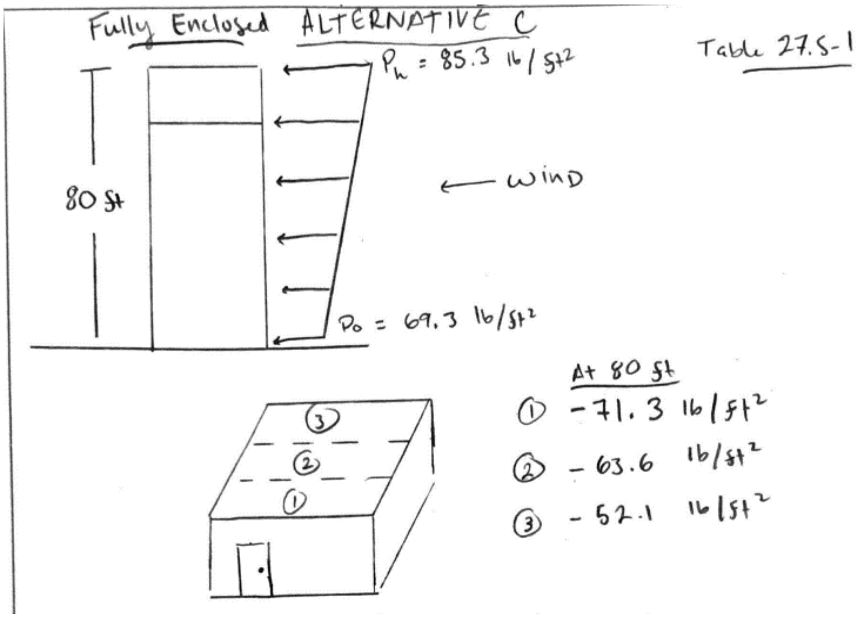


Table 27.5-2

			160				
h	Roof Slope	Load	Zone				
(ft)		Case	1	2	3	4	5
100	Flat < 2:12 (9.46°)	1	NA	NA	−74.7	−66.6	−54.6
		2	NA	NA	0.0	0.0	0.0
	3:12 (14.0°)	1	−73.3	−52.8	−74.7	−66.6	−54.6
		2	10.6	−14.9	0.0	0.0	0.0
	4:12 (18.4°)	1	−60.3	−48.6	−74.7	−66.6	−54.6
		2	20.9	−21.4	0.0	0.0	0.0
	5:12 (22.6°)	1	−48.4	−48.6	−74.7	−66.6	−54.6
		2	27.8	−23.3	0.0	0.0	0.0
	6:12 (26.6°)	1	−38.8	−48.6	−74.7	−66.6	−54.6
		2	30.7	−23.3	0.0	0.0	0.0
	9:12 (36.9°)	1	−22.5	−48.6	−74.7	−66.6	−54.6
		2	36.7	−23.3	0.0	0.0	0.0
	12:12 (45.0°)	1	−12.7	−48.6	−74.7	−66.6	−54.6
		2	36.7	−23.3	0.0	0.0	0.0
90	Flat < 2:12 (9.46°)	1	NA	NA	−73.1	−65.2	−53.4
		2	NA	NA	0.0	0.0	0.0
	3:12 (14.0°)	1	−71.7	−51.6	−73.1	−65.2	−53.4
		2	10.3	−14.5	0.0	0.0	0.0
	4:12 (18.4°)	1	−59.0	−47.6	−73.1	−65.2	−53.4
		2	20.4	−20.9	0.0	0.0	0.0
	5:12 (22.6°)	1	−47.3	−47.6	−73.1	−65.2	−53.4
		2	27.2	−22.8	0.0	0.0	0.0
	6:12 (26.6°)	1	−38.0	−47.6	−73.1	−65.2	−53.4
		2	30.0	−22.8	0.0	0.0	0.0
	9:12 (36.9°)	1	−22.0	−47.6	−73.1	−65.2	−53.4
		2	35.9	−22.8	0.0	0.0	0.0
	12:12 (45.0°)	1	−12.4	−47.6	−73.1	−65.2	−53.4
		2	35.9	−22.8	0.0	0.0	0.0
80	Flat < 2:12 (9.46°)	1	NA	NA	−71.3	−63.6	−52.1
		2	NA	NA	0.0	0.0	0.0
	3:12 (14.0°)	1	−70.0	−50.4	−71.3	−63.6	−52.1

Final Answer:



STANDARD LOAD EACH LEVEL

Level	h	Fx	Fx/2	O.T.	Wall DL R.O.T.	UPLIFT 0.6D+0.7E	SHEAR (0.7E)
	ft	kips	kips	kips	kips	kips	plf
Roof	64	10.8	5.4	2.9	2.9	-0.3	126
Main Floor	48	13.3	6.7	9.3	2.9	-3.1	281
Store 3	32	6.0	3.0	17.3	2.9	-6.9	351
Store 2	16	3.0	1.5	26.2	2.9	**-11.4**	**386**
Store 1	0	0.0	0.0	26.2	0.0		

STORAGE LOAD EXTRA LEVELS

Level	h	Fx	Fx/2	O.T.	Wall DL R.O.T.	UPLIFT 0.6D+0.7E	SHEAR (0.7E)
	ft	kips	kips	kips	kips	kips	plf
Roof	64	11.9	6.0	3.2	2.9	-0.5	139
Main Floor	48	14.8	7.4	10.3	2.9	-3.7	311
Store 3	32	11.2	5.6	20.4	2.9	-9.1	442
Store 2	16	5.6	2.8	32.0	2.9	**-15.5**	**508**
Store 1	0	0.0	0.0	32.0	0.0		

STANDARD (Stage 2)

Level	h	Fx	Fx/2	O.T.	Wall DL R.O.T.	UPLIFT 0.6D+0.7E	Shear (0.7E)
	ft	kips	kips	kips	kips	kips	plf
Roof	80	24.4	12.2	6.5	2.9	-2.8	285
Main Floor	64	32.2	16.1	21.6	2.9	-11.7	660
Store 3	48	16.4	8.2	41.1	2.9	-23.6	851
Store 2	32	10.9	5.5	63.4	2.9	-37.5	978
Store 1	16	50.6	25.3	99.3	2.9	**-60.8**	**1568**

STORAGE (Stage 2)

Level	h	Fx	Fx/2	O.T.	Wall DL R.O.T.	UPLIFT 0.6D+0.7E	Shear (0.7E)
	ft	kips	kips	kips	kips	kips	plf
Roof	80	23.6	11.8	6.3	2.9	-2.7	1843
Main Floor	64	31.1	15.6	20.9	2.9	-11.2	2206
Store 3	48	26.6	13.3	42.6	2.9	-24.6	2517
Store 2	32	17.8	8.9	69.0	2.9	-41.4	2724
Store 1	16	48.8	24.4	108.4	2.9	**-67.3**	**3294**

qz = 60.03412 psf
p = 66.3377 psf
V= 151 mph

WIND LOAD CHECK

Level	h	Fx	Fx/2	O.T.	Wall DL R.(	UPLIFT 0.6D+0.6W	SHEAR (0.6W)
	ft	kips	kips	kips	kips	kips	plf
Roof	80	15.9	8.0	4.2	2.9	-0.8	186
Main Floor	64	31.8	15.9	17.0	2.9	-6.7	557
Store 3	48	31.8	15.9	38.2	2.9	-17.7	929
Store 2	32	31.8	15.9	67.9	2.9	**-33.8**	**1300**
Store 1	16	31.8	15.9	106.1		**-56.8**	**1672**

Site Parameters

Occupancy		II	*Table 1.5-1*		Code Notes:			
Importance Factor	I_e	1.00	*Table 1.5-2*		**Using § 11.4.8 Excpt. 2**			
Site Class		D-	*§ 11.4.3, Chapter 20*					

Use D- if no soil investigation has been performed

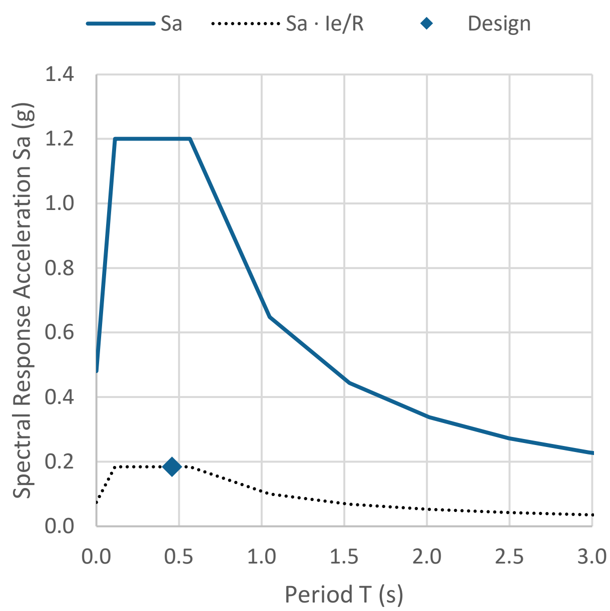
Mapped MCE_R 5% Damped Parameters

0.2s-period Accel.	S_s	1.50	g	*§ 11.4.2,4*	S_{ms}	1.80	g	*Eq. 11.4-1*
1s-period Accel.	S_1	0.60	g	*§ 11.4.2*	S_{m1}	1.02	g	*Eq. 11.4-2*
Long Trans. Period	T_L	16	s	*Fig. 22-14, -15*				
0.2s-period Site Coeff.	F_a	1.20		*Table 11.4-1*	S_{ds}	1.20	g	*Eq. 11.4-3*
1s-period Site Coeff.	F_v	1.70		*Table 11.4-2*	S_{d1}	0.68	g	*Eq. 11.4-4*
Seis. Design Category	SDC	D		*§ 11.6*				

E.L.F Procedure

§ 12.8

Structure Type		All others		
Response Mod. Factor	R	6.5		*Table 12.2-1*
Structural Height	h_n	65	ft	
	C_t	0.02		*Table 12.8-2*
	x	0.75		*Table 12.8-2*
Structure Period	T_a	0.458	s	*Eq. 12.8-7*
	T_0	0.113	s	
	T_s	0.567	s	
Seismic Resp. Coeff.	C_{s2}	0.185		*Eq. 12.8-2*
	C_{s3}	0.228		*Eq. 12.8-3*
	C_{s4}	7.99		*Eq. 12.8-4*
	C_{s5}	0.053		*Eq. 12.8-5*
	C_{s6}	0.046		*Eq. 12.8-6*
Design C_S	C_s	0.185		*§ 12.8.1.1*
				§ 11.4.8
Structural Period Exp.	k	1		*§ 12.8.3*
Seismic Weight	W	236	kip	*§ 12.7.2*
Seismic Base Shear	V	44	kip	*Eq. 12.8-1*



NOTE TO USER
Unused rows may be removed by extending the Excel Table object using the grip in the bottom right.

Design Forces / **Diaphragm Loads**

Level	w_x (kip)	h_x (ft)	$w_x \cdot h_x^k$	C_{vx}	F_x (kip)	V_xLRFD (kip)	V_xASD (kip)	-	ΣF_i (kip)	Σw_i (kip)	F_{px} (kip)
Roof	37	64	2350	0.274	11.92	11.9	8.3		11.9	37	12
Main Floor	61	48	2911	0.339	14.76	26.7	18.7		26.7	97	17
Store 3	69	32	2213	0.258	11.22	37.9	26.5		37.9	167	17
Store 2	69	16	1107	0.129	5.612	43.5	30.5		43.5	236	17
Store 1	0	0	0	0.000	0	43.5	30.5		43.5	236	0
Σ	236		9E+03	1.00	44						

Treehouse
(Storage Load)
Environmental Loads

Calculated By: XX on XX/XX/XXXX
Reviewed By:

Site Parameters

Occupancy		II	*Table 1.5-1*	Code Notes:				
Importance Factor	I_e	1.00	*Table 1.5-2*	**Using § 11.4.8 Excpt. 2**				
Site Class		D-	*§ 11.4.3, Chapter 20*					

Use D- if no soil investigation has been performed

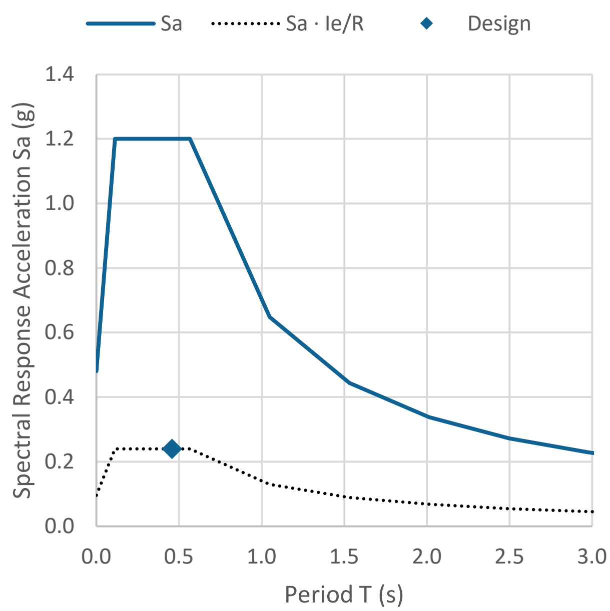
Mapped MCE_R 5% Damped Parameters

0.2s-period Accel.	S_s	1.50	g	*§ 11.4.2,4*	S_{ms}	1.80	g	*Eq. 11.4-1*
1s-period Accel.	S_1	0.60	g	*§ 11.4.2*	S_{m1}	1.02	g	*Eq. 11.4-2*
Long Trans. Period	T_L	16	s	*Fig. 22-14, -15*				
0.2s-period Site Coeff.	F_a	1.20		*Table 11.4-1*	S_{ds}	1.20	g	*Eq. 11.4-3*
1s-period Site Coeff.	F_v	1.70		*Table 11.4-2*	S_{d1}	0.68	g	*Eq. 11.4-4*
Seis. Design Category	SDC	D		*§ 11.6*				

E.L.F Procedure

§ 12.8

Structure Type		All others		
Response Mod. Factor	R	5		*Table 12.2-1*
Structural Height	h_n	65	ft	
	C_t	0.02		*Table 12.8-2*
	x	0.75		*Table 12.8-2*
Structure Period	T_a	0.458	s	*Eq. 12.8-7*
	T_0	0.113	s	
	T_s	0.567	s	
Seismic Resp. Coeff.	C_{s2}	0.240		*Eq. 12.8-2*
	C_{s3}	0.297		*Eq. 12.8-3*
	C_{s4}	10.38		*Eq. 12.8-4*
	C_{s5}	0.053		*Eq. 12.8-5*
	C_{s6}	0.06		*Eq. 12.8-6*
Design C_S	C_s	0.240		*§ 12.8.1.1* *§ 11.4.8*
Structural Period Exp.	k	1		*§ 12.8.3*
Seismic Weight	W	616	kip	*§ 12.7.2*
Seismic Base Shear	V	148	kip	*Eq. 12.8-1*



NOTE TO USER
Unused rows may be removed by extending the Excel Table object using the grip in the bottom right.

Design Forces / **Diaphragm Loads**

Level	kip w_x	ft h_x	$w_x \cdot h_x^k$	C_{vx}	kip F_x	kip V_xLRFD	kip V_xASD	-	kip ΣF_i	kip Σw_i	kip F_{px}
Roof	37	80	2938	0.159	23.56	23.6	16.5		23.6	37	18
Main Floor	61	64	3881	0.210	31.13	54.7	38.3		54.7	97	29
Store 3	69	48	3320	0.180	26.63	81.3	56.9		81.3	167	33
Store 2	69	32	2213	0.120	17.75	99.1	69.3		99.1	236	29
Store 1	381	16	6090	0.330	48.85	147.9	103.5		147.9	616	91
Σ	616		2E+04	1.00	148						

Site Parameters

Occupancy		II	*Table 1.5-1*	Code Notes:
Importance Factor	I_e	1.00	*Table 1.5-2*	**Using § 11.4.8 Excpt. 2**
Site Class		D-	*§ 11.4.3, Chapter 20*	

Use D- if no soil investigation has been performed

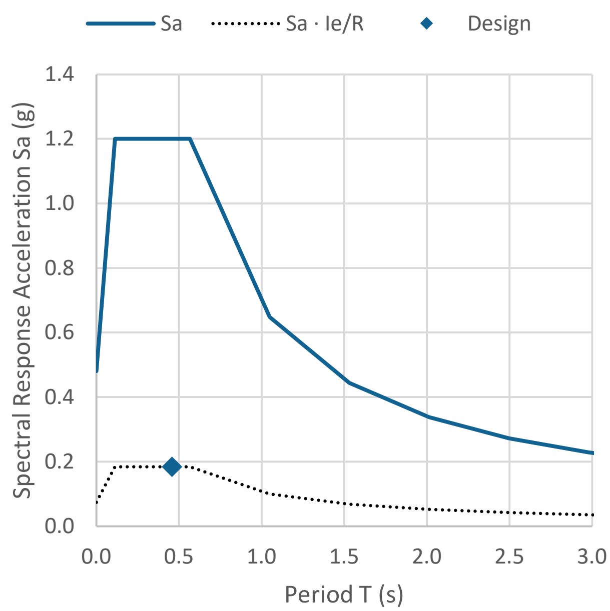
Mapped MCE_R 5% Damped Parameters

0.2s-period Accel.	S_s	1.50	g	*§ 11.4.2,4*	S_{ms}	1.80	g	*Eq. 11.4-1*
1s-period Accel.	S_1	0.60	g	*§ 11.4.2*	S_{m1}	1.02	g	*Eq. 11.4-2*
Long Trans. Period	T_L	16	s	*Fig. 22-14, -15*				
0.2s-period Site Coeff.	F_a	1.20		*Table 11.4-1*	S_{ds}	1.20	g	*Eq. 11.4-3*
1s-period Site Coeff.	F_v	1.70		*Table 11.4-2*	S_{d1}	0.68	g	*Eq. 11.4-4*
Seis. Design Category	SDC	D		*§ 11.6*				

E.L.F Procedure

§ 12.8

Structure Type		All others		
Response Mod. Factor	R	6.5		*Table 12.2-1*
Structural Height	h_n	65	ft	
	C_t	0.02		*Table 12.8-2*
	x	0.75		*Table 12.8-2*
Structure Period	T_a	0.458	s	*Eq. 12.8-7*
	T_0	0.113	s	
	T_s	0.567	s	
Seismic Resp. Coeff.	C_{s2}	0.185		*Eq. 12.8-2*
	C_{s3}	0.228		*Eq. 12.8-3*
	C_{s4}	7.99		*Eq. 12.8-4*
	C_{s5}	0.053		*Eq. 12.8-5*
	C_{s6}	0.046		*Eq. 12.8-6*
Design C_S	C_s	0.185		*§ 12.8.1.1* *§ 11.4.8*
Structural Period Exp.	k	1		*§ 12.8.3*
Seismic Weight	W	179	kip	*§ 12.7.2*
Seismic Base Shear	V	33	kip	*Eq. 12.8-1*



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Design Forces / **Diaphragm Loads**

	kip	ft			kip	kip	kip		kip	kip	kip
Level	w_x	h_x	$w_x \cdot h_x^k$	C_{vx}	F_x	V_xLRFD	V_xASD	-	ΣF_i	Σw_i	F_{px}
Roof	37	64	2350	0.325	10.77	10.8	7.5		10.8	37	11
Main Floor	61	48	2911	0.403	13.34	24.1	16.9		24.1	97	15
Store 3	41	32	1313	0.182	6.017	30.1	21.1		30.1	138	10
Store 2	41	16	656.6	0.091	3.008	33.1	23.2		33.1	179	10
Store 1	0	0	0	0.000	0	33.1	23.2		33.1	179	0
Σ	179		7E+03	1.00	33						

Treehouse
(Standard Load)
Environmental Loads

Calculated By: XX on XX/XX/XXXX
Reviewed By:

Site Parameters

Occupancy		II	*Table 1.5-1*	Code Notes:	
Importance Factor	I_e	1.00	*Table 1.5-2*		**Using § 11.4.8 Excpt. 2**
Site Class		D-	*§ 11.4.3, Chapter 20*		

Use D- if no soil investigation has been performed

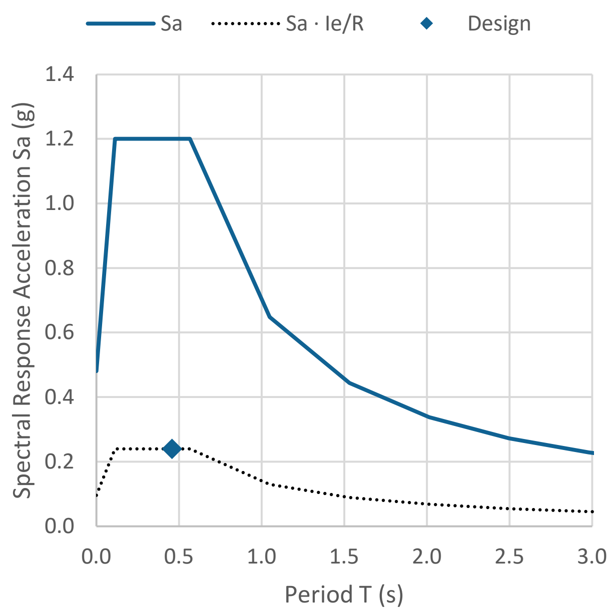
Mapped MCE_R 5% Damped Parameters

0.2s-period Accel.	S_s	1.50	g	*§ 11.4.2,4*	S_{ms}	1.80	g	*Eq. 11.4-1*
1s-period Accel.	S_1	0.60	g	*§ 11.4.2*	S_{m1}	1.02	g	*Eq. 11.4-2*
Long Trans. Period	T_L	16	s	*Fig. 22-14, -15*				
0.2s-period Site Coeff.	F_a	1.20		*Table 11.4-1*	S_{ds}	1.20	g	*Eq. 11.4-3*
1s-period Site Coeff.	F_v	1.70		*Table 11.4-2*	S_{d1}	0.68	g	*Eq. 11.4-4*
Seis. Design Category	SDC	D		*§ 11.6*				

E.L.F Procedure

§ 12.8

Structure Type		All others		
Response Mod. Factor	R	5		*Table 12.2-1*
Structural Height	h_n	65	ft	
	C_t	0.02		*Table 12.8-2*
	x	0.75		*Table 12.8-2*
Structure Period	T_a	0.458	s	*Eq. 12.8-7*
	T_0	0.113	s	
	T_s	0.567	s	
Seismic Resp. Coeff.	C_{s2}	0.240		*Eq. 12.8-2*
	C_{s3}	0.297		*Eq. 12.8-3*
	C_{s4}	10.38		*Eq. 12.8-4*
	C_{s5}	0.053		*Eq. 12.8-5*
	C_{s6}	0.06		*Eq. 12.8-6*
Design C_S	C_s	0.240		*§ 12.8.1.1* *§ 11.4.8*
Structural Period Exp.	k	1		*§ 12.8.3*
Seismic Weight	W	560	kip	*§ 12.7.2*
Seismic Base Shear	V	134	kip	*Eq. 12.8-1*



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Design Forces / **Diaphragm Loads**

Level	kip w_x	ft h_x	$w_x \cdot h_x^k$	C_{vx}	kip F_x	kip V_xLRFD	kip V_xASD	-	kip ΣF_i	kip Σw_i	kip F_{px}
Roof	37	80	2938	0.181	24.39	24.4	17.1		24.4	37	18
Main Floor	61	64	3881	0.240	32.22	56.6	39.6		56.6	97	29
Store 3	41	48	1970	0.122	16.35	73.0	51.1		73.0	138	20
Store 2	41	32	1313	0.081	10.9	83.9	58.7		83.9	179	19
Store 1	381	16	6090	0.376	50.56	134.4	94.1		134.4	560	91
Σ	560		2E+04	1.00	134						

Date Printed: 4/19/2022

C:\Users\m\AppData\Local\Temp\Temp1_Alternate 3.zip\Seismic Design Loads ASCE 7-16 (standard loads - stage 2)

Site Parameters

Occupancy		II	*Table 1.5-1*	Code Notes:				
Importance Factor	I_e	1.00	*Table 1.5-2*	**Using § 11.4.8 Excpt. 2**				
Site Class		D-	*§ 11.4.3, Chapter 20*					

Use D- if no soil investigation has been performed

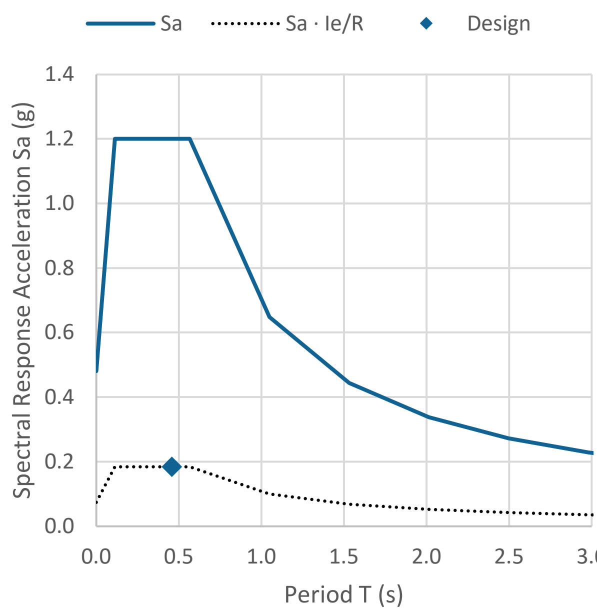
Mapped MCE_R 5% Damped Parameters

0.2s-period Accel.	S_s	1.50	g	*§ 11.4.2,4*	S_{ms}	1.80	g	*Eq. 11.4-1*
1s-period Accel.	S_1	0.60	g	*§ 11.4.2*	S_{m1}	1.02	g	*Eq. 11.4-2*
Long Trans. Period	T_L	16	s	*Fig. 22-14, -15*				
0.2s-period Site Coeff.	F_a	1.20		*Table 11.4-1*	S_{ds}	1.20	g	*Eq. 11.4-3*
1s-period Site Coeff.	F_v	1.70		*Table 11.4-2*	S_{d1}	0.68	g	*Eq. 11.4-4*
Seis. Design Category	SDC	D		*§ 11.6*				

E.L.F Procedure

§ 12.8

Structure Type		All others		
Response Mod. Factor	R	6.5		*Table 12.2-1*
Structural Height	h_n	65	ft	
	C_t	0.02		*Table 12.8-2*
	x	0.75		*Table 12.8-2*
Structure Period	T_a	0.458	s	*Eq. 12.8-7*
	T_0	0.113	s	
	T_s	0.567	s	
Seismic Resp. Coeff.	C_{s2}	0.185		*Eq. 12.8-2*
	C_{s3}	0.228		*Eq. 12.8-3*
	C_{s4}	7.99		*Eq. 12.8-4*
	C_{s5}	0.053		*Eq. 12.8-5*
	C_{s6}	0.046		*Eq. 12.8-6*
Design C_S	C_s	0.185		*§ 12.8.1.1* *§ 11.4.8*
Structural Period Exp.	k	1		*§ 12.8.3*
Seismic Weight	W	179	kip	*§ 12.7.2*
Seismic Base Shear	V	33	kip	*Eq. 12.8-1*



NOTE TO USER
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Design Forces **Diaphragm Loads**

Level	w_x (kip)	h_x (ft)	$w_x \cdot h_x^k$	C_{vx}	F_x (kip)	V_xLRFD (kip)	V_xASD (kip)	-	ΣF_i (kip)	Σw_i (kip)	F_{px} (kip)
Roof	37	64	2350	0.325	10.77	10.8	7.5		10.8	37	11
Main Floor	61	48	2911	0.403	13.34	24.1	16.9		24.1	97	15
Store 3	41	32	1313	0.182	6.017	30.1	21.1		30.1	138	10
Store 2	41	16	656.6	0.091	3.008	33.1	23.2		33.1	179	10
Store 1	0	0	0	0.000	0	33.1	23.2		33.1	179	0
Σ	179		7E+03	1.00	33						

Appendix D:

Foundation Alternatives

PILE FOUNDATION

Compressive and Tensile Capacity

Pile depth, properties, and size. From ASCE Steel Construction Manual

Embedment length below seasonal frost depth L_e, assume seasonal frost depth (L_a)=5 feet

$L_e := 55\ ft$

$L_a := 5\ ft$

Using Pipe 16 Std. from ASCE Steel Construction Manual

$D := 24\ in$ $D_{in} := 23.3\ in$

$$A_t := \pi \cdot \left(\frac{D}{2}\right)^2 - \pi \cdot \left(\frac{D_{in}}{2}\right)^2 = 0.181\ ft^2$$

$W_p := 94.7\ \frac{lb}{ft} \cdot \left(L_e + L_a\right) = \left(5.682 \cdot 10^3\right)\ lb$ assume 12 x-strong pipe, 1/2" wall

Loads from structure

$BL := 341700\ lb$ Highest bearing pressure combination

$DL := 126200\ lb + 20000\ lb$ Building weight

$U_{wind} := 41300\ lb$ Highest uplift combination

Bearing capacity factor, take phi (friction angle of dense sandy silt to sandy gravel) =34 degrees

$N_q := 42$

Earth pressure coefficient

$K_{hc} := 1.3$

Friction angle between pile and soil

$\delta := 20\ °$

Find depth that P_0 maximum occurs, conservative approach

$P_{0max} := 20 \cdot D = 40\ ft$

Find effective stress at a depth of 3.0 feet and 40 feet assuming homogenous soil below 3 foot depth, work in separate excel sheet

γ_1 and γ_2 are assumptions based on NAVFAC 7.01 soil properties

$\gamma_3 := 130\ \frac{lb}{ft^3}$ $\gamma_w := 62.4\ \frac{lb}{ft^3}$ $\gamma_1 := 80\ \frac{lb}{ft^3}$ $\gamma_2 := 95\ \frac{lb}{ft^3}$

$P_{3ft} := 168.9\ \frac{lb}{ft^2}$

$P_{max} := 2670\ \frac{lb}{ft^2}$

$P_{ave} := \frac{\left(P_{max} + P_{3ft}\right)}{2} = 1419\ \frac{lb}{ft^2}$

Find pile surface areas discounting top layer organics

$S := \left(20\ ft - 3\ ft\right) \cdot \pi \cdot D$ $S_1 := \left(L_e - 20\ ft\right) \cdot \pi \cdot D$

Find load capacity in compression

$Q_{ult} := P_{max} \cdot N_q \cdot A_t + \left(K_{hc} \cdot P_{ave} \cdot \tan(\delta) \cdot S + K_{hc} \cdot P_{max} \cdot \tan(\delta) \cdot S_1\right) = 369814\ lb$

Apply safety factor to find ultimate compressive load capacity

$FS := 3$

$Q_{all} := \frac{Q_{ult}}{FS} = 123271\ lb$

Find ultimate load capacity in tension

$K_{ht} := 0.7$

$T_{ult} := K_{ht} \cdot P_{ave} \cdot \tan(\delta) \cdot S + K_{ht} \cdot P_{max} \cdot \tan(\delta) \cdot S_1 = (1.882 \cdot 10^5)\ lb$

$W_p = 5682\ lb$

$FS := 2.5$

$T_{all} := \frac{T_{ult}}{FS} + W_p = 80972\ lb$

Add 1/4 of structure weight to allowable tensile capacity in accordance with industry standards

$$T_{all} := T_{all} + \frac{1}{4} \cdot DL = 117522\ lb$$

Find frost heave force considering 3 feet of peat and 2 feet of silty soils

$P_u := \frac{40\ \frac{lb}{in^2} \cdot 2 + 10\ \frac{lb}{in^2} \cdot 3}{5} = 22\ \frac{lb}{in^2}$

Soil Type	P_u
Silty (most frost-susceptible) soils	40 psi (270 kPa)
Organic soils	10 psi (70 kPa)
Silty granular soils	20 psi (140 kPa)

$L_a = 5\ ft$

Find total uplift

$$U := P_u \cdot D \cdot \pi \cdot L_a + \frac{U_{wind}}{4} = 109851\ lb$$

Calculated ultimate compressive load on pile per pile leg

$$Q_{uc} := \frac{BL}{4} = 85425\ lb$$

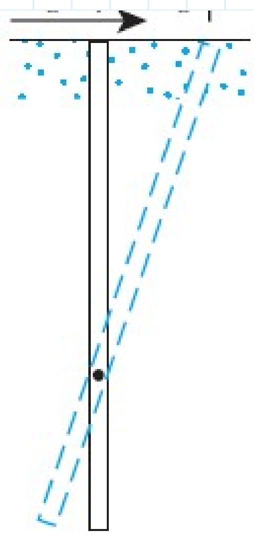
Check compressive capacity versus compressive load and tensile capacity versus total uplift

$Q_{all} > Q_{uc} = 1$ $T_{all} > U = 1$

Lateral Capacity (Pile Deflection)

Using Winklers model:

$$x_z(z) = A_x \frac{Q_g T^3}{E_p I_p} + B_x \frac{M_g T^2}{E_p I_p}$$



There will be no moment transferred from the tower, only lateral load

$M_g := 0$

Steel modulus of elasticity

$E_p := 29000 \ ksi$

Find moment of inertia using Pipe 16 Std. from ASCE Steel Construction Manual

$I_p := 1820 \ in^4 = 0.0878 \ ft^4$

From professional opinion

$n_h := 35 \ \frac{lbf}{in^3}$

Find characteristic length of soil-pile section

$$T := \sqrt[5]{\frac{E_p \cdot I_p}{n_h}} = 68.498\ in$$

Total pile length

$$L := L_e + L_a = 60\ ft$$

L/T is greater than 5, use table 9.15 to find A_x

$$\frac{L}{T} = 10.511$$

Using excel to solve for pile deflection gives a maximum deflection of 0.12 inches at the top of the pile

T (in)	53.46		Ax	x(z) (in)
Qg (kip)	5		2.435	0.121716
Ep (ksi)	29000		2.273	0.113618
Ip (in^4)	527		2.112	0.10557
			1.952	0.097573
			1.796	0.089775

Lateral load (Pile Moment)

Using Winkler's model

$$M_z(z) = A_m Q_g T + B_m M_g$$

There will be no moment transferred from the tower, only lateral load

$$M_g := 0$$

Find pile properties using Pipe 16 Std. from ASCE Steel Construction Manual

$Z := 196\ in^3$ $\qquad$ $F_y := 46000\ \dfrac{lbf}{in^2}$

Using excel to find pile moment gives a maximum moment of 17.2 kip*ft

$M_u := 17.2\ kip \cdot ft$

Find ultimate moment capacity of pile

$\phi := 0.9$

$\phi M_n := \phi \cdot F_y \cdot Z = 676.2\ kip \cdot ft$

Check maximum moment occurring in pile versus ultimate moment capacity of pile

$\phi M_n > M_u = 1$

Pile Settlement

$s_e = s_{e(1)} + s_{e(2)} + s_{e(3)}$

Find s_{e1}, elastic settlement of pile

$$s_{e(1)} = \frac{(Q_{wp} + \xi Q_{ws})L}{A_p E_p}$$

Use ratio of load capacity of tip and skin resistance of pile to find amount of load carried by the tip and the skin resistance

Fraction of load capacity carried by pile tip

$$\frac{P_{max} \cdot N_q \cdot A_t}{Q_{ult}} = 0.055$$

Fraction of load capacity carried by skin resistance

$$\frac{\left(K_{hc} \cdot P_{ave} \cdot \tan(\delta) \cdot S + K_{hc} \cdot P_{max} \cdot \tan(\delta) \cdot S_1\right)}{Q_{ult}} = 0.945$$

$Q_{wp} := \frac{BL}{4} \cdot 0.058 = \left(4.955 \cdot 10^{3}\right)\ lb$ $\qquad Q_{wp} := \left(1.639 \cdot 10^{3}\right)\ lbf$

$Q_{ws} := \frac{BL}{4} \cdot 0.942 = \left(8.047 \cdot 10^{4}\right)\ lb$ $\qquad Q_{ws} := \left(2.661 \cdot 10^{4}\right)\ lbf$

Triangular distribution

$\xi := 0.67$

Area of the tip of the pile

$A_p := A_t$ $\qquad A_t = 0.181\ ft^2$

Elastic settlement of pile

$$s_{e1} := \frac{\left(Q_{wp} + \xi \cdot Q_{ws}\right) \cdot L}{A_t \cdot E_p} = 0.019\ in$$

Find s_{e2} settlement caused by load at pile tip

$$s_{e(2)} = \frac{q_{wp} D}{E_s}\left(1 - \mu_s^2\right) I_{wp}$$

$Q_{wp} := 2.26 \cdot 10^{3}\ lb$ $\qquad Q_{ws} := 2.599 \cdot 10^{4}\ lb$

Point load per unit area at the pile point

$$q_{wp} := \frac{Q_{wp}}{A_p} = \left(1.251 \cdot 10^{4}\right) \frac{lb}{ft^2}$$

Influence factor

$I_{wp} := 0.85$

Steel modulus of elasticity

$$E_s := 500000 \frac{lb}{ft^2}$$

Poisson's ratio for soil

$$\mu_s := 0.30$$

Settlement caused by load at pile tip

$$s_{e2} := \frac{q_{wp} \cdot D}{E_s} \cdot \left(1 - \mu_s\right) \cdot I_{wp} = 0.357 \; in$$

Find s_{e3}, settlement caused by load transmitted along pile shaft

$$s_{e(3)} = \left(\frac{Q_{ws}}{pL}\right) \frac{D}{E_s}(1 - \mu_s^2) I_{ws}$$

Pile perimeter

$$p := 2 \cdot \pi \cdot \left(\frac{D}{2}\right) - 2 \cdot \pi \cdot \left(\frac{D_{in}}{2}\right) = 0.183 \; ft$$

Influence factor

$$I_{ws} := 2 + 0.35 \cdot \sqrt{\frac{L}{D}} = 3.917$$

Settlement caused by load transmitted along pile shaft

$$s_{e3} := \left(\frac{Q_{ws}}{p \cdot L}\right) \cdot \frac{D}{E_s} \cdot \left(1 - {\mu_s}^2\right) \cdot I_{ws} = 0.404 \; in$$

Find total elastic settlement of one pile

$$s_e := s_{e1} + s_{e2} + s_{e3} = 0.78 \; in$$

Pile Foundation Summary

Final Conservative Pile Foundation (assuming future building calculations do not produce any higher uplift or load values): (Single pile capacities)

- Pile Outside Diameter= 24 inches

- Pile Length= 60 feet

- Uplift Capacity= 117500 pounds

- Settlement= 0.78 inches

- Bearing capacity= 123200 pounds

- Moment capacity= 676 kip*feet

SHALLOW FOUNDATION

Bearing Capacity

Shallow foundation calculations modified for high water table Case I

$q_u = 1.3c'N_c + qN_q + 0.4\gamma BN_\gamma$ (for shallow square foundations)

Take angle of internal friction from blow counts and sand density, Meyerhof 1956

$\phi := 34°$

Take bearing capacity factors from Principles of Foundation Engineering, Table 4.2

$N_c := 52.64$ $N_q := 36.50$ $N_\gamma := 38.04$

Assume that cohesion will dissipate over time, disregard

$c' := 0$

Find soil properties, interpolated from blow counts and NAVFAC 7.01

$\gamma := 100 \frac{lb}{ft^3}$ $\gamma_w := 62.4 \frac{lb}{ft^3}$ $\gamma_{sat} := 130 \frac{lb}{ft^3}$

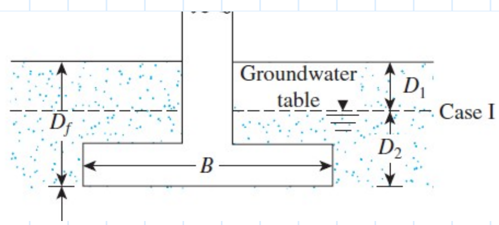
Assumed foundation dimensions

$D_1 := 1.5\ ft$ Taken from core log above

$D_2 := 4.5\ ft$

$D_f := D_2 + D_1 = 6\ ft$

$B := 9\ ft$



Find Ultimate bearing capacity for Case I

Case I. If the water table is located so that $0 \le D_1 \le D_f$, the factor q in the bearing capacity equations takes the form

$$q = \text{effective surcharge} = D_1\gamma + D_2(\gamma_{sat} - \gamma_w) \quad (4.23)$$

Find effective surcharge

$$q := D_1 \cdot \gamma + D_2 \cdot (\gamma_{sat} - \gamma_w) = 454.2 \ \frac{lb}{ft^2}$$

Find bearing capacity

$$q_u := q \cdot N_q + 0.4 \cdot \gamma \cdot B \cdot N_\gamma = (3.027 \cdot 10^4) \ \frac{lb}{ft^2}$$

Apply conservative safety factor of 3 to find ultimate bearing capacity

$$FS := 3$$

$$q_{all} := \frac{q_u}{FS} = 10091 \ \frac{lb}{ft^2}$$

Compare compressive bearing capacity to ultimate bearing pressure on footing

$$BL = 341700 \ lb$$

$$p := \frac{\left(\frac{BL}{4}\right)}{B \cdot B} = 1055 \ \frac{lb}{ft^2}$$

$$q_{all} > p = 1$$

Allowable bearing capacity is greater than bearing pressure from structure, foundation works. Design requires additional 1 foot excavation and backfill with suitable Type A material.

Uplift Capacity

Find uplift capacity of the footing (Qu) by changing bearing capacity

$$A := B \cdot B = 81 \ ft^2$$

$$D_f = 6 \ ft$$

$$F_q = \frac{Q_u}{A \gamma D_f}$$

Soil friction angle

$$\phi' := 34 \ °$$

Interpolate in Table 5.5 to find K_u, m, $\left(\frac{D_f}{B}\right)cr$

$$\frac{D_f}{B}=0.667$$

Table 5.5 Variation of K_u, m, and $(D_f/B)_{cr}$

Soil friction angle, ϕ' (deg)	K_u	m	$(D_f/B)_{cr}$ for square and circular foundations
20	0.856	0.05	2.5
25	0.888	0.10	3
30	0.920	0.15	4
35	0.936	0.25	5
40	0.960	0.35	7
45	0.960	0.50	9

Using engineering judgement, $\frac{D_f}{B}$ will be less than $\left(\frac{D_f}{B}\right)cr$

Interpolate K_u

$$K_u:=0.920+\left(\frac{(34-30)}{35-30}\right)\cdot(0.936-0.920)=0.933$$

Interpolate m

$$m:=0.15+\left(\frac{(34-30)}{35-30}\right)\cdot(0.25-0.15)=0.23$$

Calculate non dimensional breakout factor

$$F_q:=1+2\cdot\left(1+m\cdot\left(\frac{D_f}{B}\right)\right)\cdot\left(\frac{D_f}{B}\right)\cdot K_u\cdot\tan(\phi')=1.968$$

Find γ for soil backfilled over foundation, assumed as type A material that can be found in the local area

$$\gamma:=125\ \frac{lb}{ft^3}$$

Typical Values of Soil Index Properties (from *NAVFAC 7.01*)

Soil Type	γ (lb/ft^3)	γ_{sub} (lb/ft^3)
Sand; clean, uniform, fine or medium	84 - 136	52 - 73
Silt; uniform, inorganic	81 - 136	51 - 73
Silty Sand	88 - 142	54 - 79
Sand; Well-graded	86 - 148	53 - 86
Silty Sand and Gravel	90 - 155	56 - 92
Sandy or Silty Clay	100 - 147	38 - 85
Silty Clay with Gravel; uniform	115 - 151	53 - 89
Well-graded Gravel, Sand, Silt and Clay	125 - 156	62 - 94
Clay	94 - 133	31 - 71
Colloidal Clay	71 - 128	8 - 66
Organic Silt	87 - 131	25 - 69
Organic Clay	81 - 125	18 - 62

Calculate uplift capacity

$$F_q = \frac{Q_u}{A \cdot \gamma \cdot D_f} \xrightarrow{solve, Q_u} \frac{119528.13988818171337 \cdot lb \cdot ft^3}{ft^3} = 119528 \; lb$$

Apply safety factor

$FS := 2$

$$Q_u := \frac{90539 \; lbf}{2} = 45.27 \; kip$$

Compare uplift capacity to uplift from structure

$U_{wind} = 41300 \; lb$ $\qquad$ $U_{1leg} := \frac{41300 \; lbf}{4} = \left(1.033 \cdot 10^4\right) \; lbf$

$$Q_u > U_{1leg} = 1$$

Foundation Settlement

Find footing properties and restate soil properties

$q_{all} = \left(1.009 \cdot 10^4\right) \frac{lb}{ft^2}$ $\qquad$ Bearing capacity as calculated above

$\mu_s := 0.30$

Correlated from blow counts

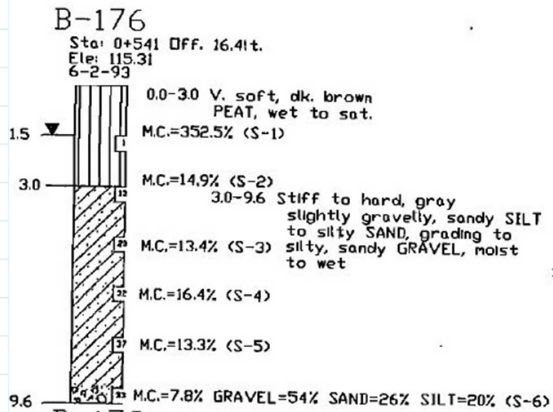
$E_s := 500000 \frac{lb}{ft^2}$

$B' := \frac{B}{2} = 4.5 \; ft$

$\alpha := 4$

Find shape factor Is. Exact soil layer thickness (H) is unknown, use end of soil layer at 9.6 ft as layer thickness

$H := 9.6\ ft$



$m' := \frac{B}{B} \qquad n' := \frac{H}{\left(\frac{B}{2}\right)}$

Find equation factors

$$A_0 := m' \cdot \ln\left(\frac{\left(\left(1+\sqrt{1+m'^2}\right)\cdot\sqrt{m'^2+n'^2}\right)}{m'\cdot\sqrt{1+n'^2+m'^2}}\right) = 0.799$$

$$A_1 := \ln\left(\frac{\left(\left(m'+\sqrt{1+m'^2}\right)\cdot\sqrt{1+n'^2}\right)}{m'+\sqrt{1+n'^2+m'^2}}\right) = 0.469$$

$$A_2 := \frac{m'}{n'\cdot\sqrt{m'^2+n'^2+1}} = 0.183$$

$$F_1 := \frac{1}{\pi}\cdot\left(A_0+A_1\right) = 0.403$$

$$F_2 := \frac{n'}{2\cdot\pi}\cdot\tan\left(A_2\right)^{-1} = 1.833$$

$$I_s := F_1 + \frac{\left(1-2\cdot\mu_s\right)}{1-\mu_s}\cdot F_2 = 1.451$$

$$\frac{D_f}{B}=0.667 \qquad \mu_s=0.3$$

Table 7.4 Variation of I_f with D_f/B, B/L, and μ_s

μ_s	D_f/B	B/L 0.2	0.5	1.0
0.3	0.2	0.95	0.93	0.90
	0.4	0.90	0.86	0.81
	0.6	0.85	0.80	0.74
	1.0	0.78	0.71	0.65

$$I_f:=\frac{(0.74+0.65)}{2}=0.695$$

Calculate allowable bearing capacity of flexible foundation based on 1 inch settlement

$$S_{e\_flx}:=1\ in=0.083\ ft$$

$$S_e=q_o(\alpha B')\frac{1-\mu_s^2}{E_s}I_sI_f$$

$$S_{e\_flx}=q_o\cdot(\alpha\cdot B')\cdot\frac{(1-\mu_s{}^2)}{E_s}\cdot I_s\cdot I_f$$

$$\frac{S_{e\_flx}}{(\alpha\cdot B')\cdot\frac{(1-\mu_s{}^2)}{E_s}\cdot I_s\cdot I_f}=(2.523\cdot 10^3)\ \frac{lb}{ft^2}$$

$$p=(1\cdot 10^3)\ \frac{lb}{ft^2}$$

$$q_o:=2523\ \frac{lb}{ft^2} \qquad q_o>p=1$$

Based on 1 inch settlement, the maximum allowable bearing capacity of the foundation is 2523 psf, which is still greater than the bearing pressure from the structure.

Calculate elastic settlement of rigid foundation

$$S_e:=0.93\cdot S_{e\_flx}=0.93\ in$$

Shallow Foundation Summary

Final Conservative Shallow Foundation (assuming future building calculations do not produce any higher uplift or load values): (Values for one pad)

- Dimensions= 9'x9'

- Depth to bottom of footing= 6 feet

- Uplift capacity= 45270 pounds

- Elastic settlement= 0.93 inches

- Bearing capacity based on settlement= 2523 pounds per square foot

PILE FOUNDATION

Design Alternative C

Detailed analysis should be performed before final design, calculations carried out below consider only the uplift and shear force from the structure and the pile capacities calculated above

$Q_{all} := 123271\ lbf = 123.271\ kip$

$T_{all} := 80972\ lb$

$U_c := 67\ kip$

Approximate shear force on one corner

$Shear := 1568\ \frac{lbf}{ft} \cdot 40\ ft = 62.72\ kip$

In order to ensure minimal pile deflection, use 2 pile groups in each building corner.

Dw	1.5	ft

Pile Foundation
Effective Stress

Depth	Unit Wt	Total Stress	eutral Stre:	Eff Stress
ft	pcf	psf	psf	psf
0	80	0	0	0
1	80	80	0	80
1.5	80	120	0	120
2.5	95	215	62.4	152.6
3	95	262.5	93.6	168.9
4	130	392.5	156	236.5
5	130	522.5	218.4	304.1
6	130	652.5	280.8	371.7
7	130	782.5	343.2	439.3
8	130	912.5	405.6	506.9
9	130	1042.5	468	574.5
10	130	1172.5	530.4	642.1
11	130	1302.5	592.8	709.7
12	130	1432.5	655.2	777.3
13	130	1562.5	717.6	844.9
14	130	1692.5	780	912.5
15	130	1822.5	842.4	980.1
16	130	1952.5	904.8	1047.7
17	130	2082.5	967.2	1115.3
18	130	2212.5	1029.6	1182.9
19	130	2342.5	1092	1250.5
20	130	2472.5	1154.4	1318.1
21	130	2602.5	1216.8	1385.7
22	130	2732.5	1279.2	1453.3
23	130	2862.5	1341.6	1520.9
24	130	2992.5	1404	1588.5
25	130	3122.5	1466.4	1656.1
26	130	3252.5	1528.8	1723.7
27	130	3382.5	1591.2	1791.3
28	130	3512.5	1653.6	1858.9
29	130	3642.5	1716	1926.5

30	130	3772.5	1778.4	1994.1
31	130	3902.5	1840.8	2061.7
32	130	4032.5	1903.2	2129.3
33	130	4162.5	1965.6	2196.9
34	130	4292.5	2028	2264.5
35	130	4422.5	2090.4	2332.1
36	130	4552.5	2152.8	2399.7
37	130	4682.5	2215.2	2467.3
38	130	4812.5	2277.6	2534.9
39	130	4942.5	2340	2602.5
40	130	5072.5	2402.4	2670.1
41	130	5202.5	2464.8	2737.7
42	130	5332.5	2527.2	2805.3
43	130	5462.5	2589.6	2872.9
44	130	5592.5	2652	2940.5
45	130	5722.5	2714.4	3008.1
46	130	5852.5	2776.8	3075.7
47	130	5982.5	2839.2	3143.3
48	130	6112.5	2901.6	3210.9
49	130	6242.5	2964	3278.5
50	131	6373.5	3026.4	3347.1

Pile Foundation
Lateral deflection

T (in)	68.5	Ax	x(z) (in)
Qg (kip)	5	2.435	0.074143
Ep (ksi)	29000	2.273	0.06921
Ip (in^4)	1820	2.112	0.064308
		1.952	0.059436
		1.796	0.054686
		1.644	0.050058
		1.496	0.045552
		1.353	0.041197
		1.216	0.037026
		1.086	0.033068
		0.962	0.029292
		0.738	0.022471
		0.544	0.016564
		0.381	0.011601
		0.247	0.007521
		0.142	0.004324
		-0.075	-0.00228
		-0.05	-0.00152
		-0.009	-0.00027

$$x_z(z) = A_x \frac{Q_g T^3}{E_p I_p} + B_x \frac{M_g T^2}{E_p I_p}$$

Pile Foundation
Moment at depth z

T (ft)	4.455
Qg (kip)	5

$$M_z(z) = A_m Q_g T + B_m M_g$$

Am	M(z) (ft*kip)
0	0
0.1	2.2275
0.198	4.41045
0.291	6.482025
0.379	8.442225
0.459	10.224225
0.532	11.8503
0.595	13.253625
0.649	14.456475
0.693	15.436575
0.727	16.193925
0.767	17.084925
0.772	17.1963
0.746	16.61715
0.696	15.5034
0.628	13.9887
0.225	5.011875
0	0
-0.033	-0.735075

Appendix E:

Cost Estimates

ROM CONCEPT DESIGN SUBMITTAL
CONSTRUCTION COST ESTIMATE

RESIDENTIAL OBSERVATION TOWER
ANCHOR POINT, ALASKA

PREPARED FOR:

UAA Capstone Design Group
Michele Lott, John Scott, Jayci VanDehey
2900 Spirit Drive
Anchorage, Alaska 99508

April 7, 2022

4103 Minnesota Drive • Anchorage, Alaska 99503 p: 907.561.1653 • f: 907.562.0420 • e: mail@hmsalaska.com

NOTES REGARDING THE PREPARATION OF THIS ESTIMATE

DRAWINGS AND DOCUMENTS

Level of Documents:	(4) concept renderings
Date:	April 1, 2022
Provided By:	UAA Capstone Design Group (Michele Lott, John Scott, and Jayci VanDehey) of Anchorage, Alaska

RATES

Pricing is based on current material, equipment and freight costs.

Labor Rates:	A.S. Title 36 working 60 hours per week
Premium Time:	16.70%

BIDDING ASSUMPTIONS

Contract:	Standard construction contract without restrictive bidding clauses
Bidding Situation:	Competitive bids assumed
Bid Date:	January 2023
Start of Construction:	April 2023
Months to Complete:	Within (4) months completion

EXCLUDED COSTS

1. A/E design fees
2. Administrative and management costs
3. Furniture, furnishings and equipment
4. Remediation of contaminated soils or abatement of any hazardous materials, if found during construction
5. Site preparation and improvements (except those specifically included with Substructure scope)
6. Utilities, including electrical, water, waste, and telecommunications
7. Interior finishes
8. Weather protection to tower structure in Design C

NOTES REGARDING THE PREPARATION OF THIS ESTIMATE (Continued)

GENERAL

When included in HMS Inc.'s scope of services, opinions or estimates of probable construction costs are prepared on the basis of HMS Inc.'s experience and qualifications and represent HMS Inc.'s judgment as a professional generally familiar with the industry. However, since HMS Inc. has no control over the cost of labor, materials, equipment or services furnished by others, over contractor's methods of determining prices, or over competitive bidding or market conditions, HMS Inc. cannot and does not guarantee that proposals, bids, or actual construction cost will not vary from HMS Inc.'s opinions or estimates of probable construction cost.

This estimate assumes normal escalation based on the current economic climate. HMS Inc. will continue to monitor this, as well as other international, domestic and local events, and the resulting construction climate, and will adjust costs and contingencies as deemed appropriate.

Due to the rapidly evolving nature of the COVID-19 coronavirus pandemic and its affect on the economy, and more specifically the construction industry, HMS Inc. is incorporating an additional contingency titled '**Unique Market Risk**'. The amount provided for in the estimate will be adjusted as the situation continues to change and the effect on construction pricing becomes more quantifiable.

GROSS FLOOR AREA

OBSERVATION TOWER

Tower Deck	**900**	**SF**

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CONCEPT DESIGN COST SUMMARY

	Total	*Cost per SF*	*Area*
OPTION 1 - SHALLOW FOUNDATION/DESIGN A STRUCTURE	$ 1,968,552	$ 2,187	900 SF
OPTION 2 - PILE FOUNDATION/DESIGN A STRUCTURE	2,069,469	2,299	900 SF
OPTION 3 - SHALLOW FOUNDATION/DESIGN B STRUCTURE	1,958,892	2,177	900 SF
OPTION 4 - PILE FOUNDATION/DESIGN B STRUCTURE	2,059,808	2,289	900 SF
OPTION 5 - SHALLOW FOUNDATION/DESIGN C STRUCTURE	1,460,021	1,622	900 SF
OPTION 6 - PILE FOUNDATION/DESIGN C STRUCTURE	1,560,937	1,734	900 SF

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OPTION 1 - SHALLOW FOUNDATION/ DESIGN A STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL*		*LABOR*		*TOTAL*	*TOTAL*
			RATE $	*TOTAL $*	*RATE $*	*TOTAL $*	*UNIT RATE $*	*MATERIAL/LABOR $*
SUBSTRUCTURE								
Note: Excludes site pad preparation.								
Excavate, backfill and dispose for footings/foundation	201	CY	2.50	503	13.50	2,714	16.00	3,217
Concrete spread footings (4)	42	CY	175.00	7,350	100.00	4,200	275.00	11,550
Concrete pilasters (4)	6	CY	175.00	1,050	95.00	570	270.00	1,620
Concrete tie beams	27	CY	175.00	4,725	120.00	3,240	295.00	7,965
Concrete waste (5%)	4	CY	175.00	700	100.00	400	275.00	1,100
Pump concrete	79	CY	50.00	3,950			50.00	3,950
Bar reinforcement	6,000	LBS	1.15	6,900	0.80	4,800	1.95	11,700
Form footings, tie beams, and bases	1,176	SF	4.00	4,704	5.20	6,115	9.20	10,819
SUPERSTRUCTURE								
Tower Construction								
W-beams	92,000	LBS	2.75	253,000	1.25	115,000	4.00	368,000
Miscellaneous angles, bolts, and connections (15% assumed)	13,800	LBS	2.65	36,570	2.20	30,360	4.85	66,930
Crane and operator	2	WK	5500.00	11,000	3600.00	7,200	9100.00	18,200

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OPTION 1 - SHALLOW FOUNDATION/ DESIGN A STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
SUPERSTRUCTURE (Continued)								
Floor Construction								
14" BCI 90 joists	1,444	LF	4.75	6,859	1.60	2,310	6.35	9,169
Joist blockings	75	LF	2.40	180	1.90	143	4.30	323
R-21 batt insulation	900	SF	0.85	765	0.45	405	1.30	1,170
2"x6" tongue and groove decking	1,444	SF	8.50	12,274	3.65	5,271	12.15	17,545
5/8" plywood soffit sheathing	900	SF	1.95	1,755	1.25	1,125	3.20	2,880
Miscellaneous joist hangers, connection hardware, etc.	1	LOT	450.00	450	700.00	700	1150.00	1,150
Roof Construction								
Glulam beam roof framing	900	SF	45.25	40,725	30.25	27,225	75.50	67,950
5/8" roof sheathing	900	SF	1.95	1,755	0.95	855	2.90	2,610
Brackets, bolts, connection hardware, etc.	1	LOT	800.00	800	1120.00	1,120	1920.00	1,920
Stair Construction								
42" wide grate stair treads	108	EA	250.00	27,000	70.00	7,560	320.00	34,560
Galvanized metal concrete filled landing	96	SF	50.40	4,838	20.00	1,920	70.40	6,758

OPTION 1 - SHALLOW FOUNDATION/ DESIGN A STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
SUPERSTRUCTURE (Continued)								
Stair Construction (Continued)								
42" high painted steel pipe railings and posts	266	LF	99.00	26,334	28.00	7,448	127.00	33,782
EXTERIOR CLOSURE								
Exterior Walls								
2"x6" wood studs, 16" o/c, including plates	2,280	LF	2.65	6,042	1.50	3,420	4.15	9,462
1/2" plywood sheathing	1,920	SF	1.70	3,264	1.30	2,496	3.00	5,760
T1-11 siding, painted	1,920	SF	3.63	6,970	2.46	4,723	6.09	11,693
Vapor retarder	1,920	SF	0.12	230	0.15	288	0.27	518
Air barrier	1,920	SF	0.85	1,632	0.65	1,248	1.50	2,880
6" batt insulation	1,920	SF	0.85	1,632	0.60	1,152	1.45	2,784
5/8" gypboard, inside (tape/texture excluded)	1,920	SF	0.66	1,267	1.55	2,976	2.21	4,243
Exterior Openings								
3'0"x6'8" pre-hung insulated fiberglass door, complete	1	EA	1300.00	1,300	250.00	250	1550.00	1,550
Vinyl windows (4)	240	SF	60.00	14,400	10.50	2,520	70.50	16,920

OPTION 1 - SHALLOW FOUNDATION/ DESIGN A STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
ROOFING SYSTEMS								
Corrugated metal panel roofing system, including insulation and flashings (excludes skylights)	900	SF	6.80	6,120	4.35	3,915	11.15	10,035
MISCELLANEOUS								
Equipment and fuel allowance	2	MOS	112000.00	224,000			112000.00	224,000
SUBTOTAL:				*$ 721,044*		*$ 253,669*		*$ 974,713*
Labor Premium Time	16.70%					42,363		42,363
SUBTOTAL:								*$ 1,017,076*
General Requirements, Overhead, and Profit	37.00%							376,318
Unique Market Risk	5.00%							69,670
Estimator's Contingency	30.00%							438,919
Escalation	3.50%							66,569
TOTAL ESTIMATED COST:								***$ 1,968,552***

OPTION 2 - PILE FOUNDATION/DESIGN A STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
SUBSTRUCTURE								
Note: By subcontractor. Excludes site pad preparation.								
Excavate, backfill and dispose for tie beams	47	CY	2.50	118	13.50	635	16.00	753
16" diameter, 83 lbs./LF steel pile (assumes good soil conditions)	200	VLF	257.30	51,460	37.14	7,428	294.44	58,888
Pile points, 16" diameter, welded to pile	4	EA	380.00	1,520	215.00	860	595.00	2,380
Pile rig mobilization/demobilization costs	1	LOT	2500.00	2,500	4000.00	4,000	6500.00	6,500
Concrete tie beam	27	CY	175.00	4,725	90.00	2,430	265.00	7,155
Concrete waste (5%)	2	CY	175.00	350	90.00	180	265.00	530
Pump concrete	29	CY	50.00	1,450			50.00	1,450
Bar reinforcement	2,160	LBS	1.15	2,484	0.80	1,728	1.95	4,212
Form tie beams	500	SF	4.00	2,000	5.20	2,600	9.20	4,600
SUBTOTAL:				*$ 66,607*		*$ 19,861*		*$ 86,468*
Labor Premium Time	16.70%					3,317		3,317
SUBTOTAL:				*$ 66,607*		*$ 23,178*		*$ 89,785*

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OPTION 2 - PILE FOUNDATION/DESIGN A STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL*		*LABOR*		*TOTAL*	*TOTAL*
			RATE $	*TOTAL $*	*RATE $*	*TOTAL $*	*UNIT RATE $*	*MATERIAL/LABOR $*
Subcontractor's Overhead and Profit on Material and Labor	20.00%			13,321		4,636		17,957
SUBTOTAL SUBSTRUCTURE:				*$ 79,928*		*$ 27,814*		*$ 107,742*
SUPERSTRUCTURE								
Tower Construction								
W-beams	92,000	LBS	2.75	253,000	1.25	115,000	4.00	368,000
Miscellaneous angles, bolts, and connections (15% assumed)	13,800	LBS	2.65	36,570	2.20	30,360	4.85	66,930
Crane and operator	2	WK	5500.00	11,000	3600.00	7,200	9100.00	18,200
Floor Construction								
14" BCI 90 joists	1,444	LF	4.75	6,859	1.60	2,310	6.35	9,169
Joist blockings	75	LF	2.40	180	1.90	143	4.30	323
R-21 batt insulation	900	SF	0.85	765	0.45	405	1.30	1,170
2"x6" tongue and groove decking	1,444	SF	8.50	12,274	3.65	5,271	12.15	17,545
5/8" plywood soffit sheathing	900	SF	1.95	1,755	1.25	1,125	3.20	2,880
Miscellaneous joist hangers, connection hardware, etc.	1	LOT	450.00	450	700.00	700	1150.00	1,150

OPTION 2 - PILE FOUNDATION/DESIGN A STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
EXTERIOR CLOSURE (Continued)								
Roof Construction								
Glulam beam roof framing	900	SF	45.25	40,725	30.25	27,225	75.50	67,950
5/8" roof sheathing	900	SF	1.95	1,755	0.95	855	2.90	2,610
Brackets, bolts, connection hardware, etc.	1	LOT	800.00	800	1120.00	1,120	1920.00	1,920
Stair Construction								
42" wide grate stair treads	108	EA	250.00	27,000	70.00	7,560	320.00	34,560
Galvanized metal concrete filled landing	96	SF	50.40	4,838	20.00	1,920	70.40	6,758
42" high painted steel pipe railings and posts	266	LF	99.00	26,334	28.00	7,448	127.00	33,782
Exterior Walls								
2"x6" wood studs, 16" o/c, including plates	2,280	LF	2.65	6,042	1.50	3,420	4.15	9,462
1/2" plywood sheathing	1,920	SF	1.70	3,264	1.30	2,496	3.00	5,760
T1-11 siding, painted	1,920	SF	3.63	6,970	2.46	4,723	6.09	11,693
Vapor retarder	1,920	SF	0.12	230	0.15	288	0.27	518
Air barrier	1,920	SF	0.85	1,632	0.65	1,248	1.50	2,880

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OPTION 2 - PILE FOUNDATION/DESIGN A STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
<u>EXTERIOR CLOSURE (Continued)</u>								
<u>Exterior Walls (Continued)</u>								
6" batt insulation	1,920	SF	0.85	1,632	0.60	1,152	1.45	2,784
5/8" gypboard, inside (tape/texture excluded)	1,920	SF	0.66	1,267	1.55	2,976	2.21	4,243
<u>Exterior Openings</u>								
3'0"x6'8" pre-hung insulated fiberglass door, complete	1	EA	1300.00	1,300	250.00	250	1550.00	1,550
Vinyl windows (4)	240	SF	60.00	14,400	10.50	2,520	70.50	16,920
<u>ROOFING SYSTEMS</u>								
Corrugated metal panel roofing system, including insulation and flashings (excludes skylights)	900	SF	6.80	6,120	4.35	3,915	11.15	10,035
<u>MISCELLANEOUS</u>								
Equipment and fuel allowance	2	MOS	112000.00	224,000			112000.00	224,000
SUBTOTAL:				*$ 691,162*		*$ 231,630*		*$ 922,792*
Labor Premium Time	16.70%					38,682		38,682
SUBTOTAL SUPERSTRUCTURE/EXTERIOR CLOSURE/ROOFING:				*$ 691,162*		*$ 270,312*		*$ 961,474*
SUBTOTAL OPTION 2:								*$ 1,069,216*

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OPTION 2 - PILE FOUNDATION/DESIGN A STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
General Requirements, Overhead, and Profit	37.00%							395,610
Unique Market Risk	5.00%							73,241
Estimator's Contingency	30.00%							461,420
Escalation	3.50%							69,982
TOTAL ESTIMATED COST:								***$ 2,069,469***

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OPTION 3 - SHALLOW FOUNDATION/ DESIGN B STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
SUBSTRUCTURE								
Note: Excludes site pad preparation.								
Excavate, backfill and dispose for footings/foundation	201	CY	2.50	503	13.50	2,714	16.00	3,217
Concrete spread footings (4)	42	CY	175.00	7,350	100.00	4,200	275.00	11,550
Concrete pilasters (4)	6	CY	175.00	1,050	95.00	570	270.00	1,620
Concrete tie beams	27	CY	175.00	4,725	120.00	3,240	295.00	7,965
Concrete waste (5%)	4	CY	175.00	700	100.00	400	275.00	1,100
Pump concrete	79	CY	50.00	3,950			50.00	3,950
Bar reinforcement	6,000	LBS	1.15	6,900	0.80	4,800	1.95	11,700
Form footings, tie beams, and bases	1,176	SF	4.00	4,704	5.20	6,115	9.20	10,819
SUPERSTRUCTURE								
Tower Construction								
W-beams	91,000	LBS	2.75	250,250	1.25	113,750	4.00	364,000
Miscellaneous angles, bolts, and connections (15% assumed)	13,650	LBS	2.65	36,173	2.20	30,030	4.85	66,203
Crane and operator	2	WK	5500.00	11,000	3600.00	7,200	9100.00	18,200

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OPTION 3 - SHALLOW FOUNDATION/ DESIGN B STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL*		*LABOR*		*TOTAL*	*TOTAL*
			RATE $	*TOTAL $*	*RATE $*	*TOTAL $*	*UNIT RATE $*	*MATERIAL/LABOR $*
SUPERSTRUCTURE (Continued)								
Floor Construction								
14" BCI 90 joists	1,444	LF	4.75	6,859	1.60	2,310	6.35	9,169
Joist blockings	75	LF	2.40	180	1.90	143	4.30	323
R-21 batt insulation	900	SF	0.85	765	0.45	405	1.30	1,170
2"x6" tongue and groove decking	1,444	SF	8.50	12,274	3.65	5,271	12.15	17,545
5/8" plywood soffit sheathing	900	SF	1.95	1,755	1.25	1,125	3.20	2,880
Miscellaneous joist hangers, connection hardware, etc.	1	LOT	450.00	450	700.00	700	1150.00	1,150
Roof Construction								
Glulam beam roof framing	900	SF	45.25	40,725	30.25	27,225	75.50	67,950
5/8" roof sheathing	900	SF	1.95	1,755	0.95	855	2.90	2,610
Brackets, bolts, connection hardware, etc.	1	LOT	800.00	800	1120.00	1,120	1920.00	1,920
Stair Construction								
42" wide grate stair treads	108	EA	250.00	27,000	70.00	7,560	320.00	34,560
Galvanized metal concrete filled landing	96	SF	50.40	4,838	20.00	1,920	70.40	6,758

OPTION 3 - SHALLOW FOUNDATION/ DESIGN B STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL*		*LABOR*		*TOTAL*	*TOTAL*
			RATE $	*TOTAL $*	*RATE $*	*TOTAL $*	*UNIT RATE $*	*MATERIAL/LABOR $*
SUPERSTRUCTURE (Continued)								
Stair Construction (Continued)								
42" high painted steel pipe railings and posts	266	LF	99.00	26,334	28.00	7,448	127.00	33,782
EXTERIOR CLOSURE								
Exterior Walls								
2"x6" wood studs, 16" o/c, including plates	2,280	LF	2.65	6,042	1.50	3,420	4.15	9,462
1/2" plywood sheathing	1,920	SF	1.70	3,264	1.30	2,496	3.00	5,760
T1-11 siding, painted	1,920	SF	3.63	6,970	2.46	4,723	6.09	11,693
Vapor retarder	1,920	SF	0.12	230	0.15	288	0.27	518
Air barrier	1,920	SF	0.85	1,632	0.65	1,248	1.50	2,880
6" batt insulation	1,920	SF	0.85	1,632	0.60	1,152	1.45	2,784
5/8" gypboard, inside (tape/texture excluded)	1,920	SF	0.66	1,267	1.55	2,976	2.21	4,243
Exterior Openings								
3'0"x6'8" pre-hung insulated fiberglass door, complete	1	EA	1300.00	1,300	250.00	250	1550.00	1,550
Vinyl windows (4)	240	SF	60.00	14,400	10.50	2,520	70.50	16,920

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OPTION 3 - SHALLOW FOUNDATION/ DESIGN B STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
ROOFING SYSTEMS								
Corrugated metal panel roofing system, including insulation and flashings (excludes skylights)	900	SF	6.80	6,120	4.35	3,915	11.15	10,035
MISCELLANEOUS								
Equipment and fuel allowance	2	MOS	112000.00	224,000			112000.00	224,000
SUBTOTAL:				*$ 717,897*		*$ 252,089*		*$ 969,986*
Labor Premium Time	16.70%					42,099		42,099
SUBTOTAL:								*$ 1,012,085*
General Requirements, Overhead, and Profit	37.00%							374,471
Unique Market Risk	5.00%							69,328
Estimator's Contingency	30.00%							436,765
Escalation	3.50%							66,243
TOTAL ESTIMATED COST:								***$ 1,958,892***

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OPTION 4 - PILE FOUNDATION/DESIGN B STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
SUBSTRUCTURE								
Note: By subcontractor. Excludes site pad preparation.								
Excavate, backfill and dispose for tie beams	47	CY	2.50	118	13.50	635	16.00	753
16" diameter, 83 lbs./LF steel pile (assumes good soil conditions)	200	VLF	257.30	51,460	37.14	7,428	294.44	58,888
Pile points, 16" diameter, welded to pile	4	EA	380.00	1,520	215.00	860	595.00	2,380
Pile rig mobilization/demobilization costs	1	LOT	2500.00	2,500	4000.00	4,000	6500.00	6,500
Concrete tie beam	27	CY	175.00	4,725	90.00	2,430	265.00	7,155
Concrete waste (5%)	2	CY	175.00	350	90.00	180	265.00	530
Pump concrete	29	CY	50.00	1,450			50.00	1,450
Bar reinforcement	2,160	LBS	1.15	2,484	0.80	1,728	1.95	4,212
Form tie beams	500	SF	4.00	2,000	5.20	2,600	9.20	4,600
SUBTOTAL:				*$ 66,607*		*$ 19,861*		*$ 86,468*
Labor Premium Time	16.70%					3,317		3,317
SUBTOTAL:				*$ 66,607*		*$ 23,178*		*$ 89,785*

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OPTION 4 - PILE FOUNDATION/DESIGN B STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
Subcontractor's Overhead and Profit on Material and Labor	20.00%			13,321		4,636		17,957
SUBTOTAL SUBSTRUCTURE:				*$ 79,928*		*$ 27,814*		*$ 107,742*
SUPERSTRUCTURE								
Tower Construction								
W-beams	91,000	LBS	2.75	250,250	1.25	113,750	4.00	364,000
Miscellaneous angles, bolts, and connections (15% assumed)	13,650	LBS	2.65	36,173	2.20	30,030	4.85	66,203
Crane and operator	2	WK	5500.00	11,000	3600.00	7,200	9100.00	18,200
Floor Construction								
14" BCI 90 joists	1,444	LF	4.75	6,859	1.60	2,310	6.35	9,169
Joist blockings	75	LF	2.40	180	1.90	143	4.30	323
R-21 batt insulation	900	SF	0.85	765	0.45	405	1.30	1,170
2"x6" tongue and groove decking	1,444	SF	8.50	12,274	3.65	5,271	12.15	17,545
5/8" plywood soffit sheathing	900	SF	1.95	1,755	1.25	1,125	3.20	2,880
Miscellaneous joist hangers, connection hardware, etc.	1	LOT	450.00	450	700.00	700	1150.00	1,150

OPTION 4 - PILE FOUNDATION/DESIGN B STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
SUPERSTRUCTURE (Continued)								
Roof Construction								
Glulam beam roof framing	900	SF	45.25	40,725	30.25	27,225	75.50	67,950
5/8" roof sheathing	900	SF	1.95	1,755	0.95	855	2.90	2,610
Brackets, bolts, connection hardware, etc.	1	LOT	800.00	800	1120.00	1,120	1920.00	1,920
Stair Construction								
42" wide grate stair treads	108	EA	250.00	27,000	70.00	7,560	320.00	34,560
Galvanized metal concrete filled landing	96	SF	50.40	4,838	20.00	1,920	70.40	6,758
42" high painted steel pipe railings and posts	266	LF	99.00	26,334	28.00	7,448	127.00	33,782
EXTERIOR CLOSURE								
Exterior Walls								
2"x6" wood studs, 16" o/c, including plates	2,280	LF	2.65	6,042	1.50	3,420	4.15	9,462
1/2" plywood sheathing	1,920	SF	1.70	3,264	1.30	2,496	3.00	5,760
T1-11 siding, painted	1,920	SF	3.63	6,970	2.46	4,723	6.09	11,693
Vapor retarder	1,920	SF	0.12	230	0.15	288	0.27	518

OPTION 4 - PILE FOUNDATION/DESIGN B STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
EXTERIOR CLOSURE (Continued)								
Exterior Walls (Continued)								
Air barrier	1,920	SF	0.85	1,632	0.65	1,248	1.50	2,880
6" batt insulation	1,920	SF	0.85	1,632	0.60	1,152	1.45	2,784
5/8" gypboard, inside (tape/texture excluded)	1,920	SF	0.66	1,267	1.55	2,976	2.21	4,243
Exterior Openings								
3'0"x6'8" pre-hung insulated fiberglass door, complete	1	EA	1300.00	1,300	250.00	250	1550.00	1,550
Vinyl windows (4)	240	SF	60.00	14,400	10.50	2,520	70.50	16,920
ROOFING SYSTEMS								
Corrugated metal panel roofing system, including insulation and flashings (excludes skylights)	900	SF	6.80	6,120	4.35	3,915	11.15	10,035
MISCELLANEOUS								
Equipment and fuel allowance	2	MOS	112000.00	224,000			112000.00	224,000
SUBTOTAL:				*$ 688,015*		*$ 230,050*		*$ 918,065*

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OPTION 4 - PILE FOUNDATION/DESIGN B STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
Labor Premium Time	16.70%					38,418		38,418
SUBTOTAL SUPERSTRUCTURE/EXTERIOR CLOSURE/ROOFING:				*$ 688,015*		*$ 268,468*		*$ 956,483*
SUBTOTAL OPTION 4:								*$ 1,064,225*
General Requirements, Overhead, and Profit	37.00%							393,763
Unique Market Risk	5.00%							72,899
Estimator's Contingency	30.00%							459,266
Escalation	3.50%							69,655
TOTAL ESTIMATED COST:								***$ 2,059,808***

OPTION 5 - SHALLOW FOUNDATION/ DESIGN C STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL*		*LABOR*		*TOTAL UNIT RATE*	*TOTAL MATERIAL/LABOR*
			RATE $	*TOTAL $*	*RATE $*	*TOTAL $*	*$*	*$*
SUBSTRUCTURE								
Note: Excludes site pad preparation.								
Excavate, backfill and dispose for footings/foundation	201	CY	2.50	503	13.50	2,714	16.00	3,217
Concrete spread footings (4)	42	CY	175.00	7,350	100.00	4,200	275.00	11,550
Concrete pilasters (4)	6	CY	175.00	1,050	95.00	570	270.00	1,620
Concrete tie beams	27	CY	175.00	4,725	120.00	3,240	295.00	7,965
Concrete waste (5%)	4	CY	175.00	700	100.00	400	275.00	1,100
Pump concrete	79	CY	50.00	3,950			50.00	3,950
Bar reinforcement	6,000	LBS	1.15	6,900	0.80	4,800	1.95	11,700
Form footings, tie beams, and bases	1,176	SF	4.00	4,704	5.20	6,115	9.20	10,819
SUPERSTRUCTURE								
Tower Construction								
Concrete walls	72	CY	175.00	12,600	100.00	7,200	275.00	19,800
Concrete waste (5%)	4	CY	175.00	700	100.00	400	275.00	1,100
Pump concrete	76	CY	50.00	3,800			50.00	3,800

OPTION 5 - SHALLOW FOUNDATION/ DESIGN C STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL*		*LABOR*		*TOTAL*	*TOTAL*
			RATE $	*TOTAL $*	*RATE $*	*TOTAL $*	*UNIT RATE $*	*MATERIAL/LABOR $*
SUPERSTRUCTURE (Continued)								
Tower Construction (Continued)								
Bar reinforcement	8,640	LBS	1.15	9,936	0.80	6,912	1.95	16,848
Form walls	1,176	SF	7.20	8,467	8.30	9,761	15.50	18,228
Allowance for door frame forming	1	LOT	90.00	90	700.00	700	790.00	790
2"x12" pressure treated plate	120	LF	4.30	516	1.60	192	5.90	708
2"x10" wood studs, 16" o/c, including plates	6,480	LF	3.15	20,412	1.55	10,044	4.70	30,456
1/2" plywood sheathing at walls	11,520	SF	1.70	19,584	1.30	14,976	3.00	34,560
1/2" plywood sheathing at diaphragm (3 each)	2,700	SF	1.70	4,590	1.30	3,510	3.00	8,100
24" Pre-engineered wood floor trusses	1,350	LF	15.00	20,250	5.00	6,750	20.00	27,000
Miscellaneous connection hardware	3	LOT	450.00	1,350	700.00	2,100	1150.00	3,450
Crane and operator	2	WK	5500.00	11,000	3600.00	7,200	9100.00	18,200
Floor Construction (Living Quarters)								
14" BCI 90 joists	1,444	LF	4.75	6,859	1.60	2,310	6.35	9,169
Joist blockings	75	LF	2.40	180	1.90	143	4.30	323
R-21 batt insulation	900	SF	0.85	765	0.45	405	1.30	1,170

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OPTION 5 - SHALLOW FOUNDATION/ DESIGN C STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
SUPERSTRUCTURE (Continued)								
Floor Construction (Living Quarters) (Continued)								
2"x6" tongue and groove decking	1,444	SF	8.50	12,274	3.65	5,271	12.15	17,545
Miscellaneous joist hangers, connection hardware, etc.	1	LOT	450.00	450	700.00	700	1150.00	1,150
Roof Construction (Living Quarters)								
Glulam beam roof framing	900	SF	45.25	40,725	30.25	27,225	75.50	67,950
5/8" roof sheathing	900	SF	1.95	1,755	0.95	855	2.90	2,610
Brackets, bolts, connection hardware, etc.	1	LOT	800.00	800	1120.00	1,120	1920.00	1,920
Staircase Construction (Wood)								
Wooden stairs and landings	456	SF	152.24	69,421	20.90	9,530	173.14	78,951
Handrail and brackets	63	LF	28.00	1,764	12.75	803	40.75	2,567
EXTERIOR CLOSURE								
Exterior Walls								
2"x6" wood studs, 16" o/c, including plates	2,280	LF	2.65	6,042	1.50	3,420	4.15	9,462
1/2" plywood sheathing	1,920	SF	1.70	3,264	1.30	2,496	3.00	5,760

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OPTION 5 - SHALLOW FOUNDATION/ DESIGN C STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
EXTERIOR CLOSURE (Continued)								
Exterior Walls (Continued)								
T1-11 siding, painted	1,920	SF	3.63	6,970	2.46	4,723	6.09	11,693
Vapor retarder	1,920	SF	0.12	230	0.15	288	0.27	518
Air barrier	1,920	SF	0.85	1,632	0.65	1,248	1.50	2,880
6" batt insulation	1,920	SF	0.85	1,632	0.60	1,152	1.45	2,784
5/8" gypboard, inside (tape/texture excluded)	1,920	SF	0.66	1,267	1.55	2,976	2.21	4,243
Exterior Openings								
3'0"x6'8" pre-hung insulated fiberglass door, complete	1	EA	1300.00	1,300	250.00	250	1550.00	1,550
Vinyl windows (4)	240	SF	60.00	14,400	10.50	2,520	70.50	16,920
Exterior Openings in Tower Structure								
3'0"x6'8" pre-hung insulated fiberglass door, complete	1	EA	1300.00	1,300	250.00	250	1550.00	1,550
Vinyl windows (4)	240	SF	60.00	14,400	10.50	2,520	70.50	16,920

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OPTION 5 - SHALLOW FOUNDATION/ DESIGN C STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
ROOFING SYSTEMS								
Corrugated metal panel roofing system, including insulation and flashings (excludes skylights)	900	SF	6.80	6,120	4.35	3,915	11.15	10,035
MISCELLANEOUS								
Equipment and fuel allowance	2	MOS	112000.00	224,000			112000.00	224,000
SUBTOTAL:				*$ 560,727*		*$ 165,904*		*$ 726,631*
Labor Premium Time	16.70%					27,706		27,706
SUBTOTAL:								*$ 754,337*
General Requirements, Overhead, and Profit	37.00%							279,105
Unique Market Risk	5.00%							51,672
Estimator's Contingency	30.00%							325,534
Escalation	3.50%							49,373
TOTAL ESTIMATED COST:								***$ 1,460,021***

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OPTION 6 - PILE FOUNDATION/DESIGN C STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL*		*LABOR*		*TOTAL*	*TOTAL*
			RATE $	*TOTAL $*	*RATE $*	*TOTAL $*	*UNIT RATE $*	*MATERIAL/LABOR $*
<u>SUBSTRUCTURE</u>								
Note: By subcontractor. Excludes site pad preparation.								
Excavate, backfill and dispose for tie beams	47	CY	2.50	118	13.50	635	16.00	753
16" diameter, 83 lbs./LF steel pile (assumes good soil conditions)	200	VLF	257.30	51,460	37.14	7,428	294.44	58,888
Pile points, 16" diameter, welded to pile	4	EA	380.00	1,520	215.00	860	595.00	2,380
Pile rig mobilization/demobilization costs	1	LOT	2500.00	2,500	4000.00	4,000	6500.00	6,500
Concrete tie beam	27	CY	175.00	4,725	90.00	2,430	265.00	7,155
Concrete waste (5%)	2	CY	175.00	350	90.00	180	265.00	530
Pump concrete	29	CY	50.00	1,450			50.00	1,450
Bar reinforcement	2,160	LBS	1.15	2,484	0.80	1,728	1.95	4,212
Form tie beams	500	SF	4.00	2,000	5.20	2,600	9.20	4,600
SUBTOTAL:				*$ 66,607*		*$ 19,861*		*$ 86,468*
Labor Premium Time	16.70%					3,317		3,317
SUBTOTAL:				*$ 66,607*		*$ 23,178*		*$ 89,785*

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OPTION 6 - PILE FOUNDATION/DESIGN C STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
Subcontractor's Overhead and Profit on Material and Labor	20.00%			13,321		4,636		17,957
SUBTOTAL SUBSTRUCTURE:				*$ 79,928*		*$ 27,814*		*$ 107,742*
SUPERSTRUCTURE								
Tower Construction								
Concrete walls	72	CY	175.00	12,600	100.00	7,200	275.00	19,800
Concrete waste (5%)	4	CY	175.00	700	100.00	400	275.00	1,100
Pump concrete	76	CY	50.00	3,800			50.00	3,800
Bar reinforcement	8,640	LBS	1.15	9,936	0.80	6,912	1.95	16,848
Form walls	1,176	SF	7.20	8,467	8.30	9,761	15.50	18,228
Allowance for door frame forming	1	LOT	90.00	90	700.00	700	790.00	790
2"x12" pressure treated plate	120	LF	4.30	516	1.60	192	5.90	708
2"x10" wood studs, 16" o/c, including plates	6,480	LF	3.15	20,412	1.55	10,044	4.70	30,456
1/2" plywood sheathing at walls	11,520	SF	1.70	19,584	1.30	14,976	3.00	34,560
1/2" plywood sheathing at diaphragm (3 each)	2,700	SF	1.70	4,590	1.30	3,510	3.00	8,100
24" Pre-engineered wood floor trusses	1,350	LF	15.00	20,250	5.00	6,750	20.00	27,000

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OPTION 6 - PILE FOUNDATION/DESIGN C STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
SUPERSTRUCTURE (Continued)								
Tower Construction (Continued)								
Miscellaneous connection hardware	3	LOT	450.00	1,350	700.00	2,100	1150.00	3,450
Crane and operator	2	WK	5500.00	11,000	3600.00	7,200	9100.00	18,200
Floor Construction (Living Quarters)								
14" BCI 90 joists	1,444	LF	4.75	6,859	1.60	2,310	6.35	9,169
Joist blockings	75	LF	2.40	180	1.90	143	4.30	323
R-21 batt insulation	900	SF	0.85	765	0.45	405	1.30	1,170
2"x6" tongue and groove decking	1,444	SF	8.50	12,274	3.65	5,271	12.15	17,545
Miscellaneous joist hangers, connection hardware, etc.	1	LOT	450.00	450	700.00	700	1150.00	1,150
Roof Construction (Living Quarters)								
Glulam beam roof framing	900	SF	45.25	40,725	30.25	27,225	75.50	67,950
5/8" roof sheathing	900	SF	1.95	1,755	0.95	855	2.90	2,610
Brackets, bolts, connection hardware, etc.	1	LOT	800.00	800	1120.00	1,120	1920.00	1,920

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OPTION 6 - PILE FOUNDATION/DESIGN C STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
SUPERSTRUCTURE (Continued)								
Staircase Construction (Wood)								
Wooden stairs and landings	456	SF	152.24	69,421	20.90	9,530	173.14	78,951
Handrail and brackets	63	LF	28.00	1,764	12.75	803	40.75	2,567
EXTERIOR CLOSURE								
Exterior Walls								
2"x6" wood studs, 16" o/c, including plates	2,280	LF	2.65	6,042	1.50	3,420	4.15	9,462
1/2" plywood sheathing	1,920	SF	1.70	3,264	1.30	2,496	3.00	5,760
T1-11 siding, painted	1,920	SF	3.63	6,970	2.46	4,723	6.09	11,693
Vapor retarder	1,920	SF	0.12	230	0.15	288	0.27	518
Air barrier	1,920	SF	0.85	1,632	0.65	1,248	1.50	2,880
6" batt insulation	1,920	SF	0.85	1,632	0.60	1,152	1.45	2,784
5/8" gypboard, inside (tape/texture excluded)	1,920	SF	0.66	1,267	1.55	2,976	2.21	4,243
Exterior Openings								
3'0"x6'8" pre-hung insulated fiberglass door, complete	1	EA	1300.00	1,300	250.00	250	1550.00	1,550

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OPTION 6 - PILE FOUNDATION/DESIGN C STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
EXTERIOR CLOSURE (Continued)								
Exterior Openings (Continued)								
Vinyl windows (4)	240	SF	60.00	14,400	10.50	2,520	70.50	16,920
Exterior Openings in Tower Structure								
3'0"x6'8" pre-hung insulated fiberglass door, complete	1	EA	1300.00	1,300	250.00	250	1550.00	1,550
Vinyl windows (4)	240	SF	60.00	14,400	10.50	2,520	70.50	16,920
ROOFING SYSTEMS								
Corrugated metal panel roofing system, including insulation and flashings (excludes skylights)	900	SF	6.80	6,120	4.35	3,915	11.15	10,035
MISCELLANEOUS								
Equipment and fuel allowance	2	MOS	112000.00	224,000			112000.00	224,000
SUBTOTAL:				*$ 530,845*		*$ 143,865*		*$ 674,710*
Labor Premium Time	16.70%					24,025		24,025
SUBTOTAL SUPERSTRUCTURE/EXTERIOR CLOSURE/ROOFING:				*$ 530,845*		*$ 167,890*		*$ 698,735*
SUBTOTAL OPTION 6:								*$ 806,477*

OPTION 6 - PILE FOUNDATION/DESIGN C STRUCTURE	*QUANTITY*	*UNIT*	*MATERIAL RATE $*	*MATERIAL TOTAL $*	*LABOR RATE $*	*LABOR TOTAL $*	*TOTAL UNIT RATE $*	*TOTAL MATERIAL/LABOR $*
General Requirements, Overhead, and Profit	37.00%							298,396
Unique Market Risk	5.00%							55,244
Estimator's Contingency	30.00%							348,035
Escalation	3.50%							52,785

TOTAL ESTIMATED COST: ***$ 1,560,937***