

Residential Observation Tower



IMAGINEERING INC.
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Project Overview





Project Overview

Importance: Supporting community member's lifelong dream of living in a tree house

- Semester Goal: Alternatives Analysis to 10% Completion
 - Evaluate multiple structures and foundations



Introduction

Project Overview





Agenda

Introduction

- Project Overview
- Location

Background

- Tower Requirements
- Scope of Work
- Design Criteria

Design Options

- Design Alternative A
- Design Alternative B
- Design Alternative C
- Foundation Design
- Design Comparison

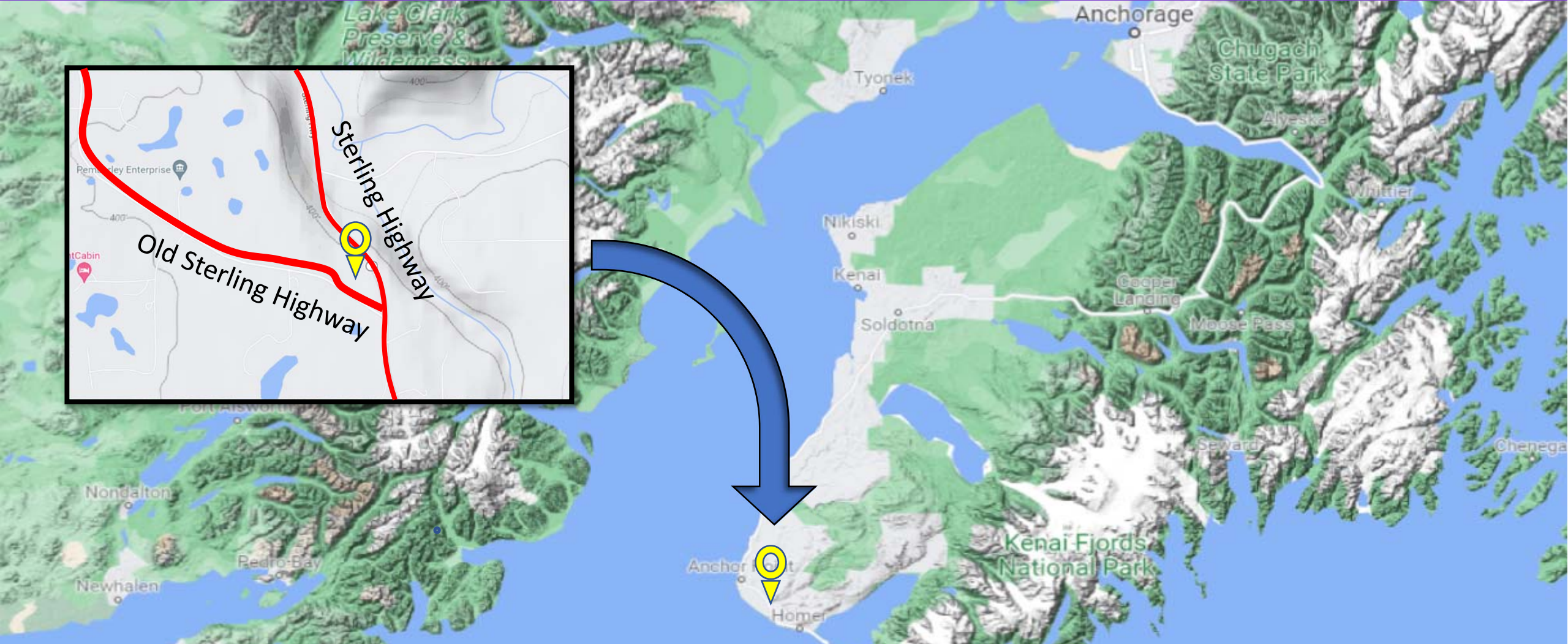
Summary

- Cost Estimate
- Recommendation



Introduction

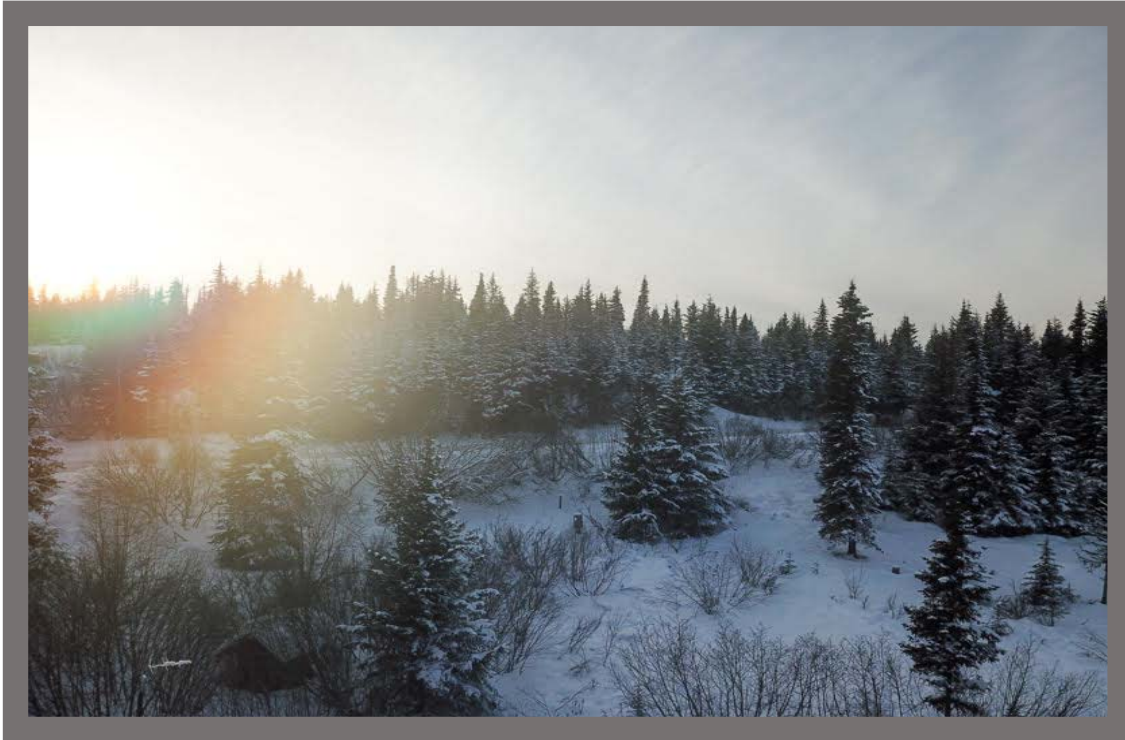
Location





Introduction

Location: Drone Photo



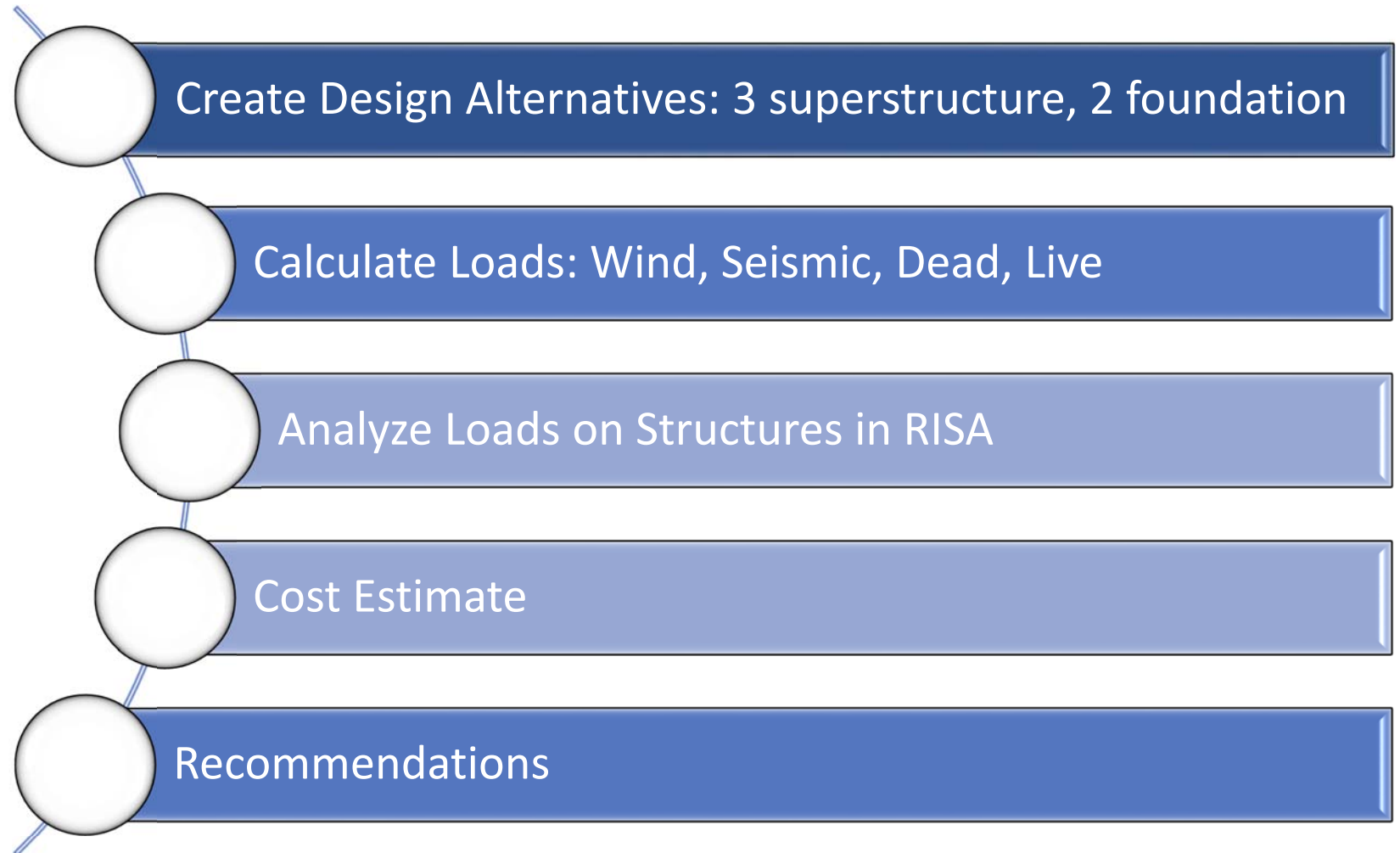
View from 30 ft



View from 60 ft

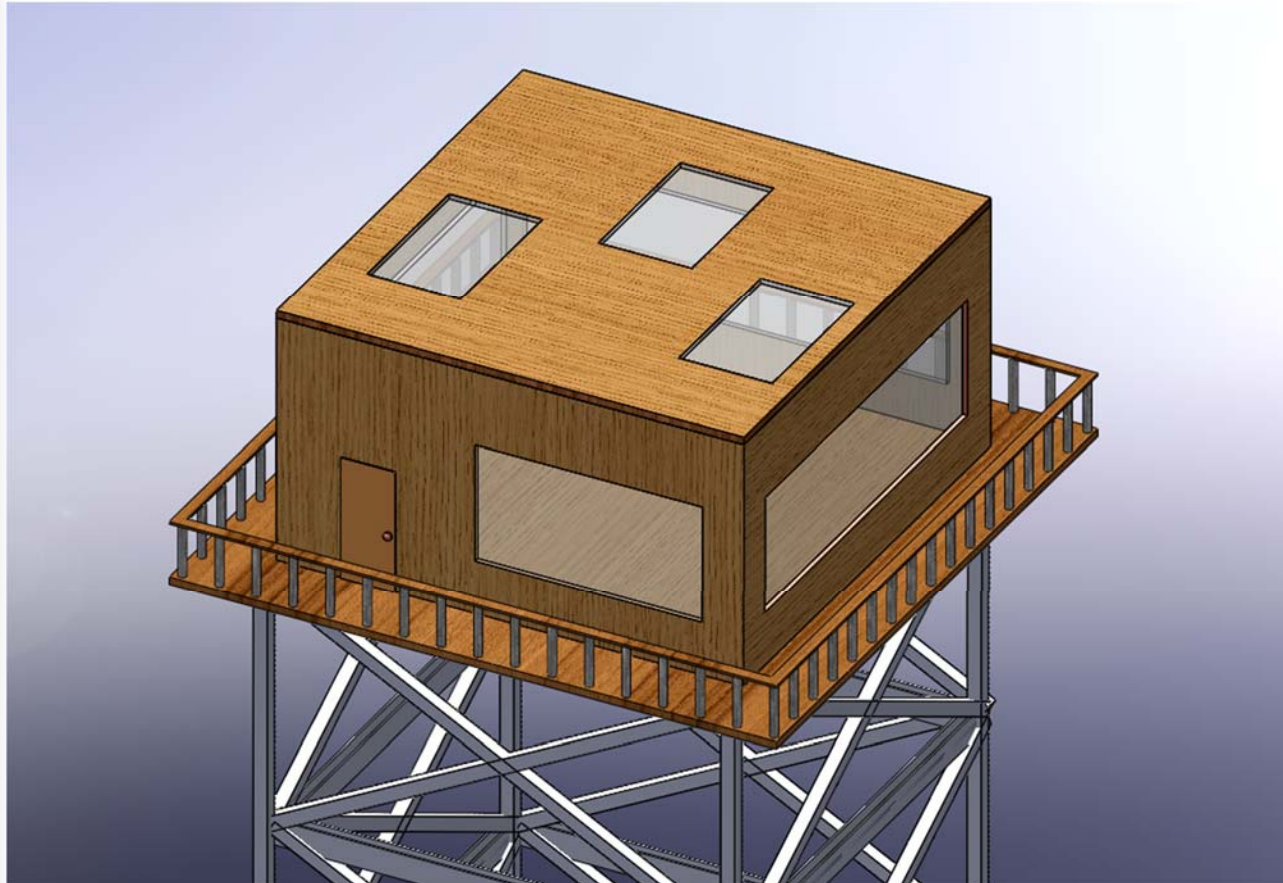


Scope of Work





Tower Specifications



Requirements

- 80 ft max roof height
- 900 ft² living space
 - 1 bedroom and 1 bathroom
- sky lights
- 360° view
- Wrap-around deck

Alternatives

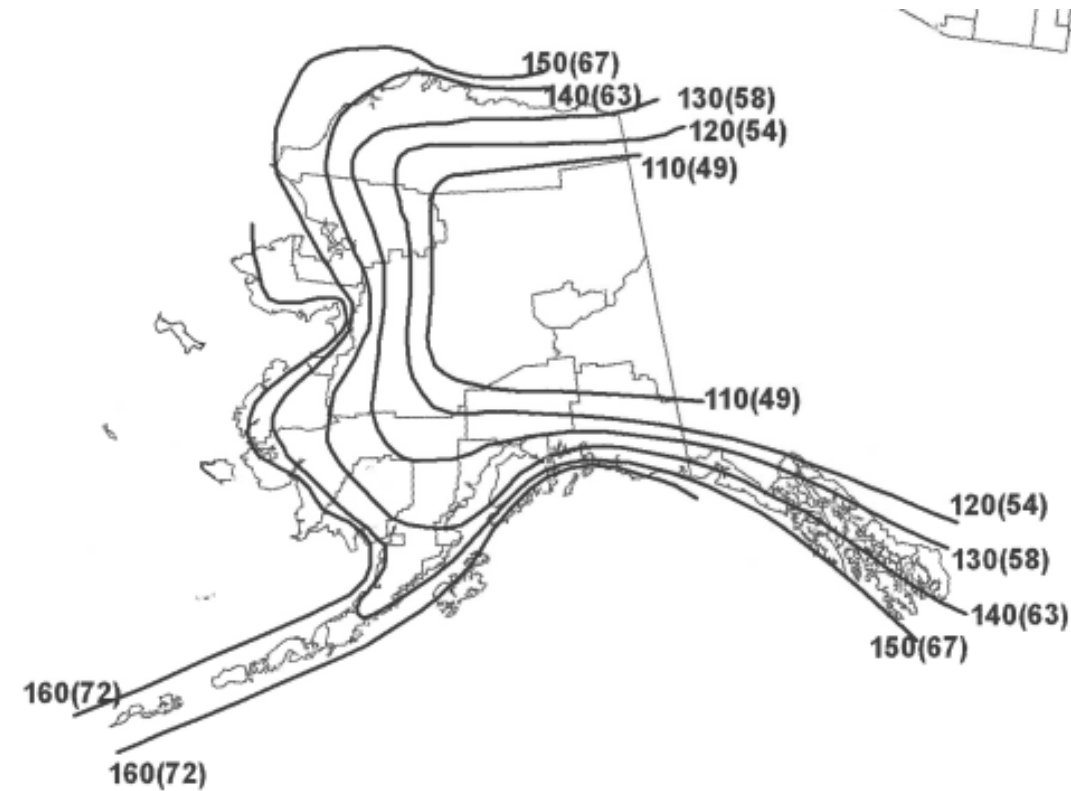
- Any materials can be considered



Criteria from 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

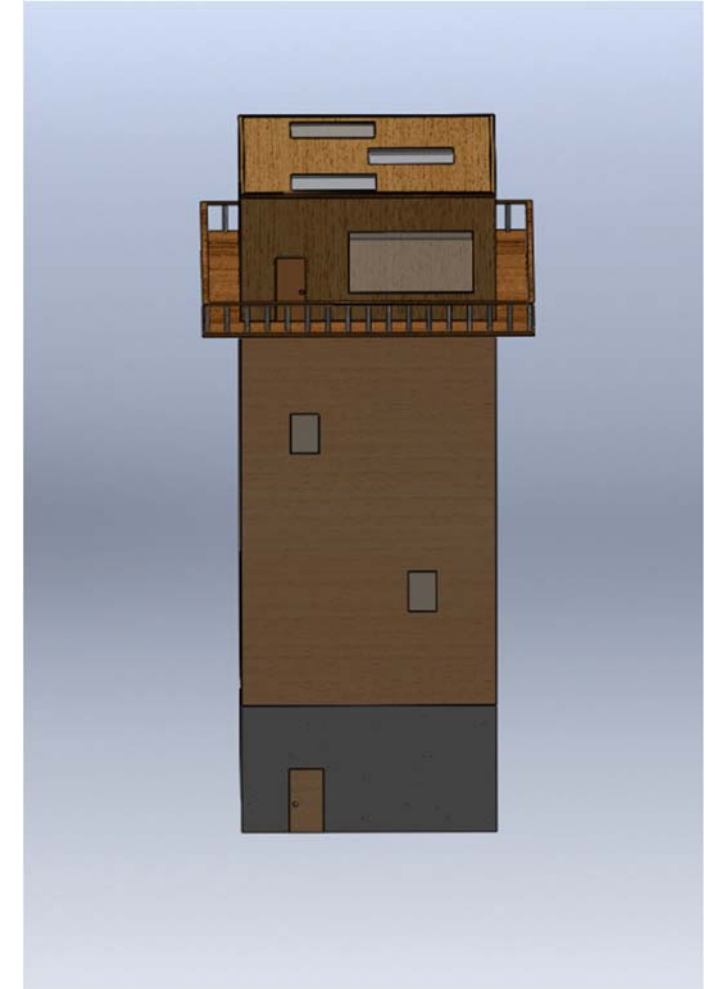
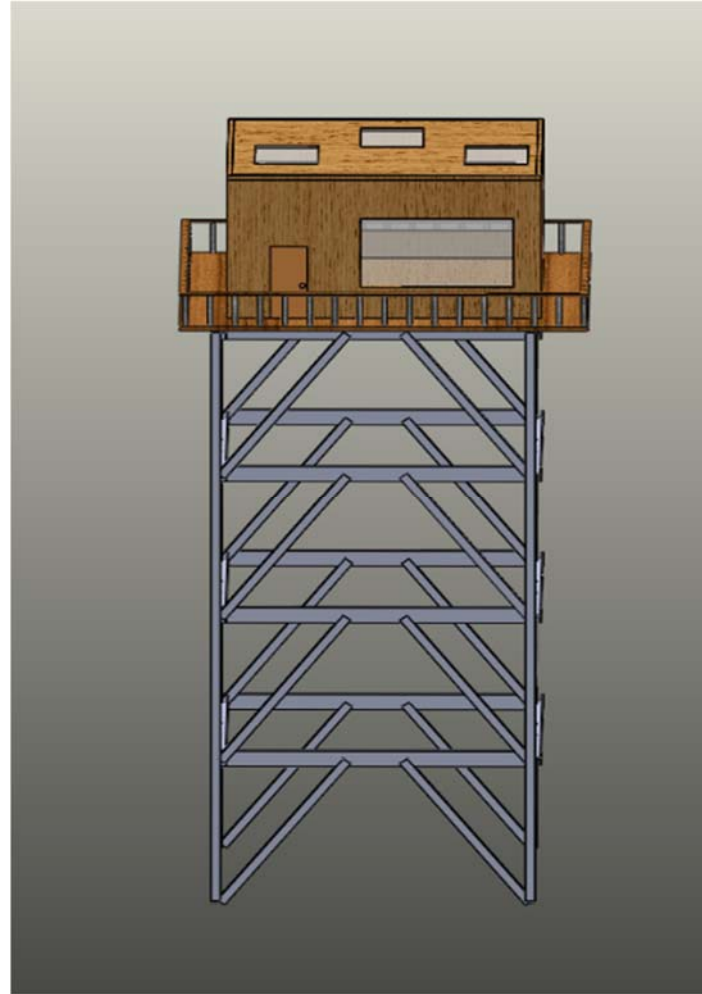
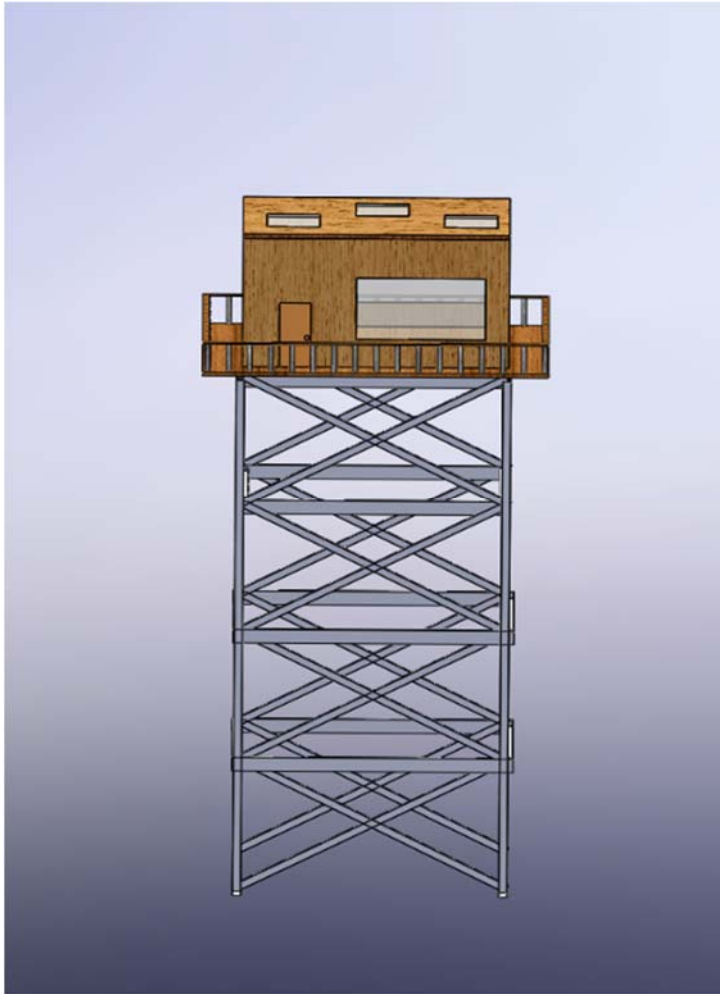
* Snow Drift- not considered





Design Options

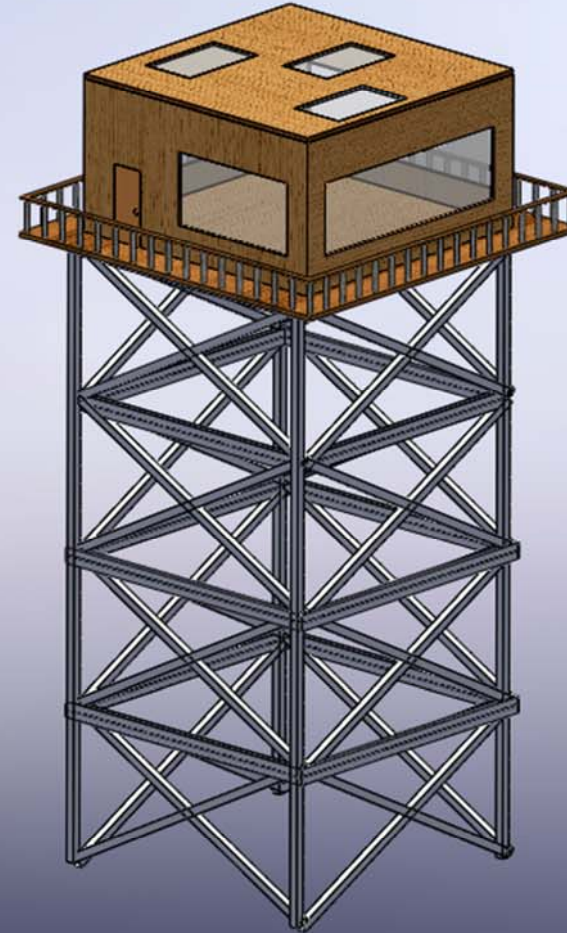
Design Comparison





Specifications

- Special Concentrically Braced Frame
- Members
 - Columns: HSS
 - Braces: HSS
 - Beams: W Flange





Special Concentrically Braced Frames

PROS:

- Less on-site construction
- Connections are less expensive to design
- Most standardized design

CONS:

- Need to consider uplift on top and bottom of living space: Canopy
- Lower Response Modification Factor Value= 6



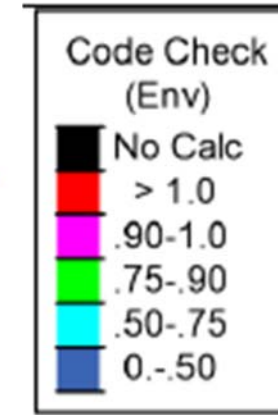
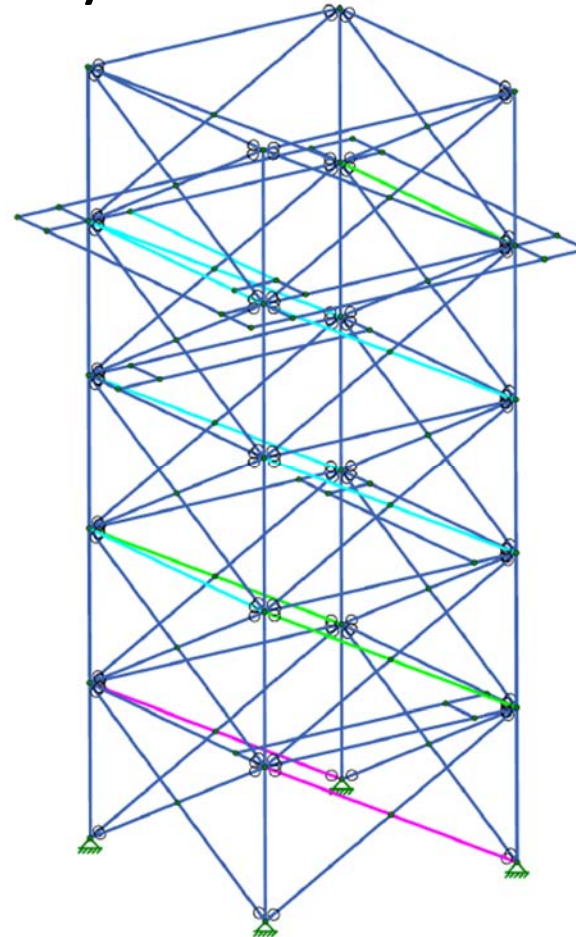
Special Concentrically Braced Frames

Evaluation Process

1. Calculate loads
2. Put forces on RISA Model

Notes:

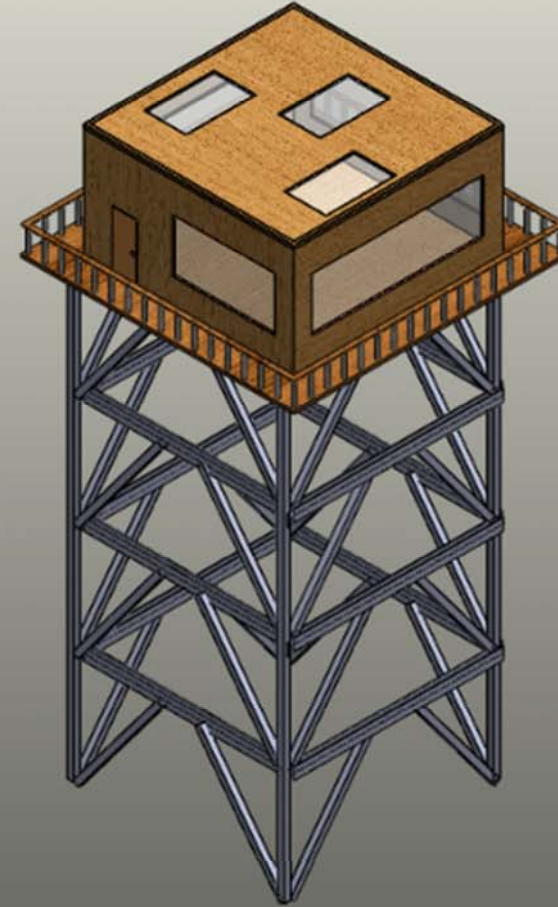
1. Did not calculate loads on connections
2. Wind governs loads, Seismic governs detailing
3. Steel Weight: 92,000 lbs



Design	Base Shear (kip)
A	100

Specifications

- Eccentrically Braced Frame
- Members
 - Columns: HSS
 - Braces: HSS
 - Beams: W Flange





Eccentrically Braced Frames

PROS:

- Higher Response Modification factor value for Earthquake = 8
- Potentially less steel, more cost effective
- Less on-site construction

CONS:

- Need to consider uplift on top and bottom of living space
- Eccentric Connections can be costly to design
- Increased tower sway



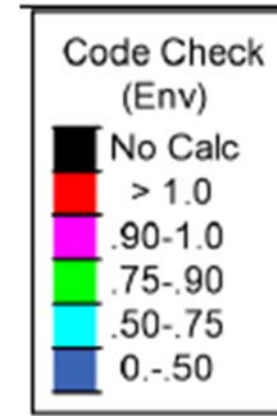
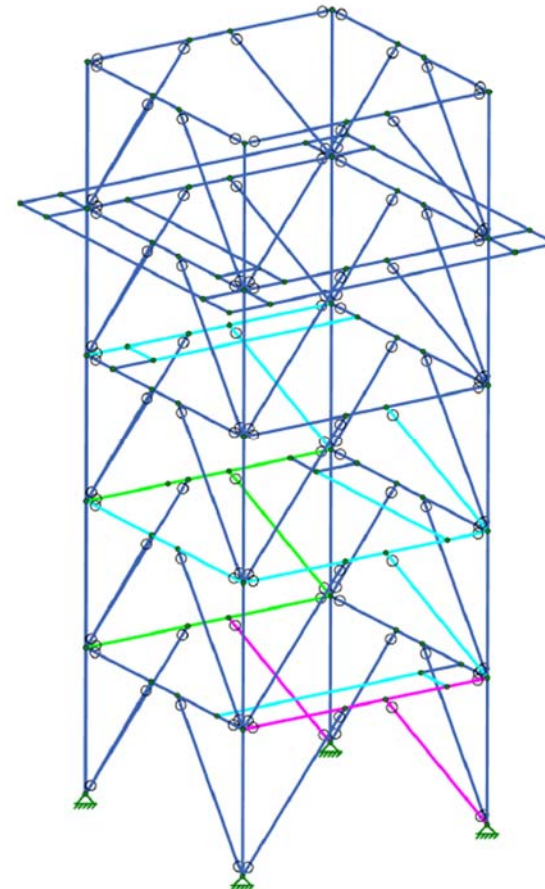
Eccentrically Braced Frames

Evaluation Process

1. Calculate loads
2. Put forces on RISA Model

Notes:

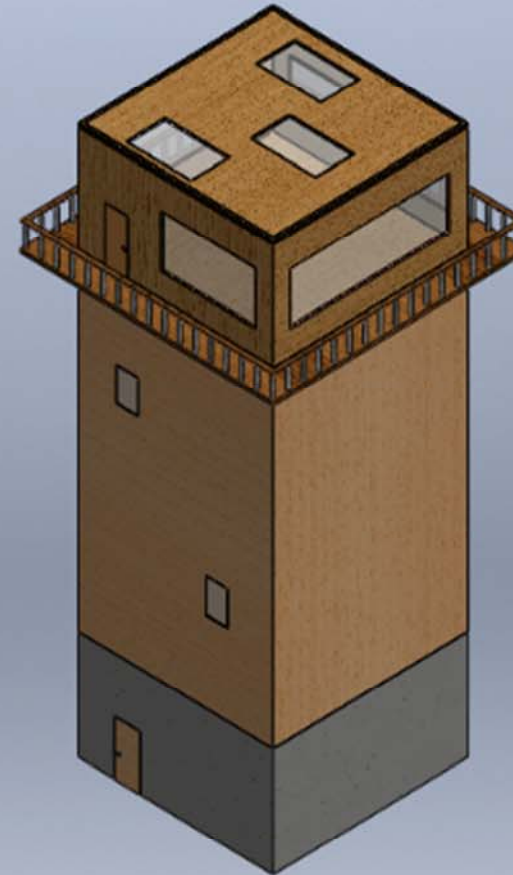
1. Did not calculate loads on connections
2. Wind governs loads, Seismic governs detailing
3. Steel Weight: 91,000 lbs



Design	Base Shear (kip)
A	100
B	116

Specifications

- Concrete at podium
- Timber shear walls
- Fully enclosed





Shear Walls with Timber and Concrete/Steel Podium

PROS:

- Easier to lock and secure building
- Opportunity for convenient storage space
- Less steel, timber is much cheaper

CONS:

- Calculated side wind loads are much higher than truss
- Seismic limitation on timber shear walls is 65 ft
- Potentially more maintenance for timber
- Potential for high heat cost
- More on-site construction



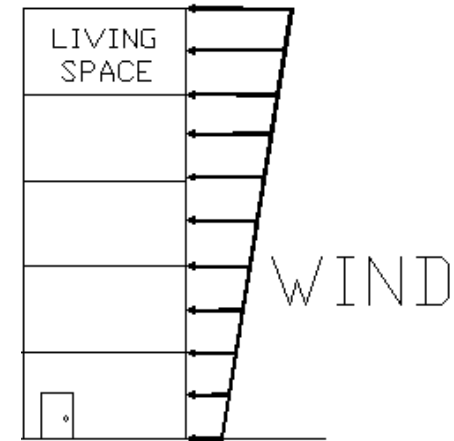
Shear Walls with Timber and Concrete/Steel Podium

Evaluation Process

1. Calculate shear wall loads
2. Evaluate concrete podium
3. Evaluate connection between shear wall and podium

Notes:

1. Uplift at connection between shear wall and podium was large
2. Governing Load: Wind



Design	Base Shear (kip)
A	100
B	116
C	160



Design A & B: Wind was governing force, so R value for earthquakes did not benefit the structure. If earthquake loads governed, Design B would have had a different steel weight than Design A.

Design C: Has very large vertical seismic loads at connection between timber structure and concrete podium. Connection design for timber will require additional review.



Foundation Overview

Shallow Foundation Overview

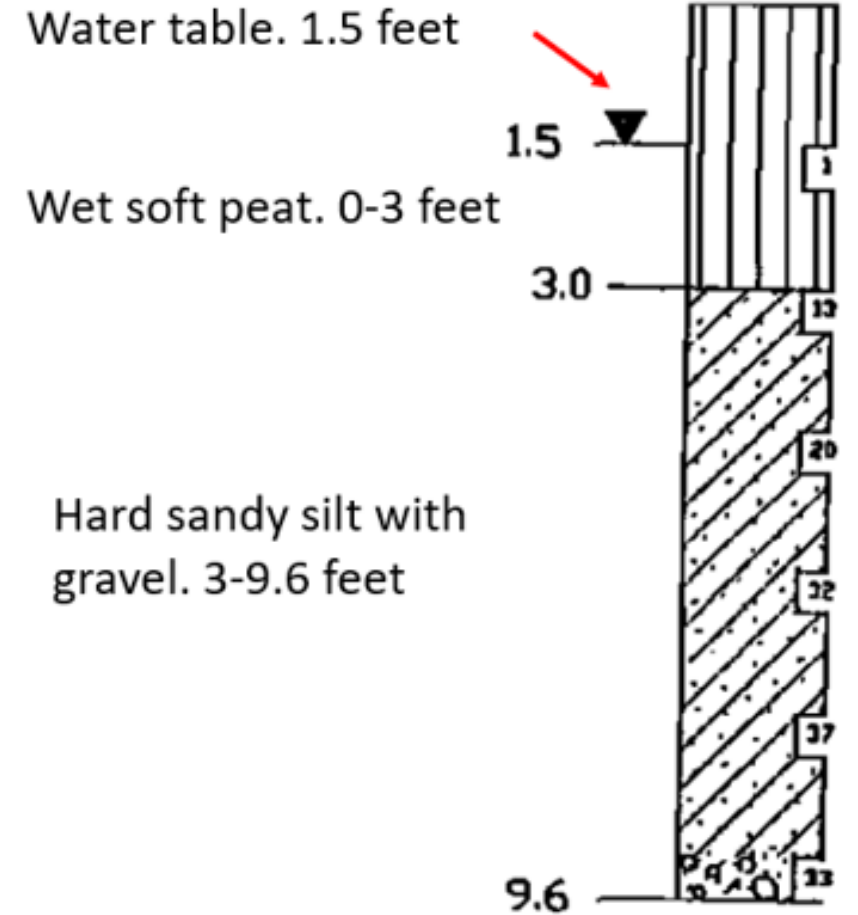
- Potentially more cost effective
- Complex on site construction
- Designed using conservative assumptions about soil properties

Pile Foundation Overview

- Higher expense due to cost of steel
- Relatively simple construction
- Designed using conservative assumptions about soil properties



- Soil Properties are based on DOT cores taken 1995
- Further geotechnical analysis is needed to find accurate soil properties, frost depth, and current water table
- Design C: 2 Piles at each corner, based on single pile construction strength



Courtesy of Alaska DOT

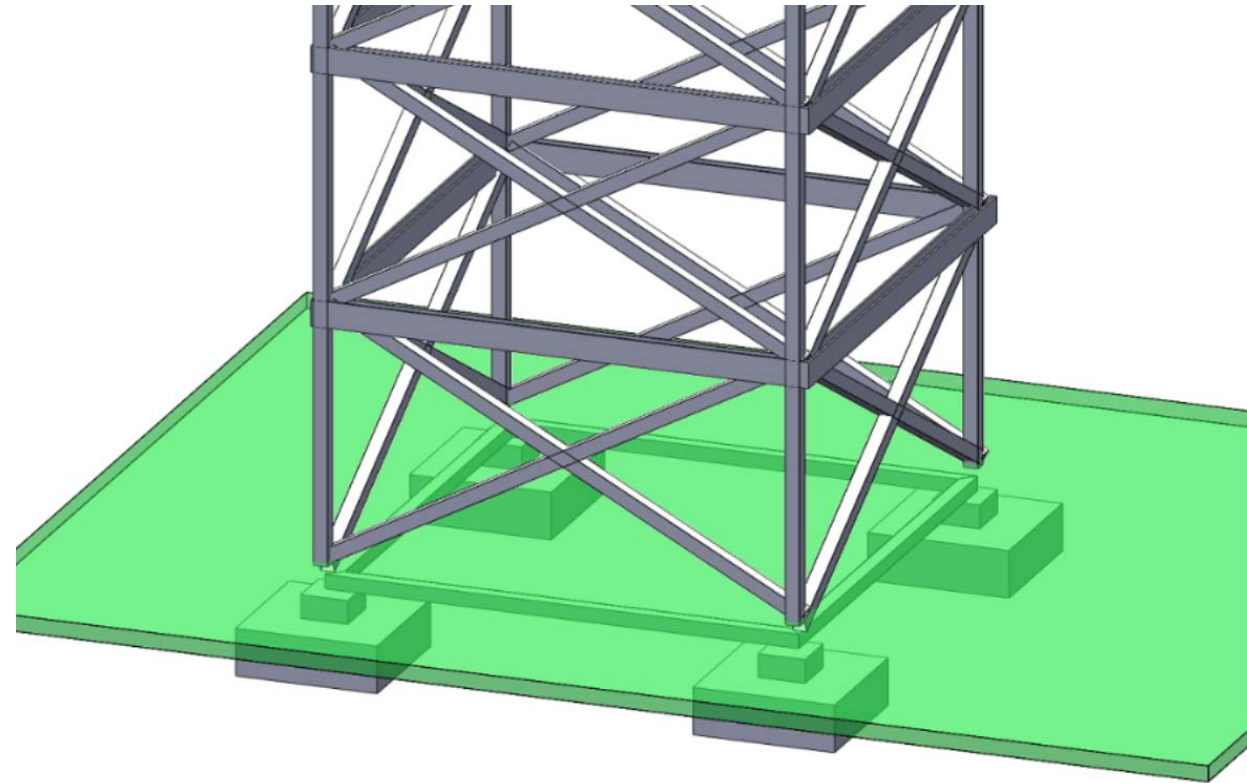


Shallow Foundation

Load Type	Building Load (kip)	Footing Capacity (kip)
Bearing	342	817
Uplift from wind	42	181

Settlement (in)	0.9
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- Soil properties were found using DOT core information and NAVFAC DM 7.01



Images not to scale

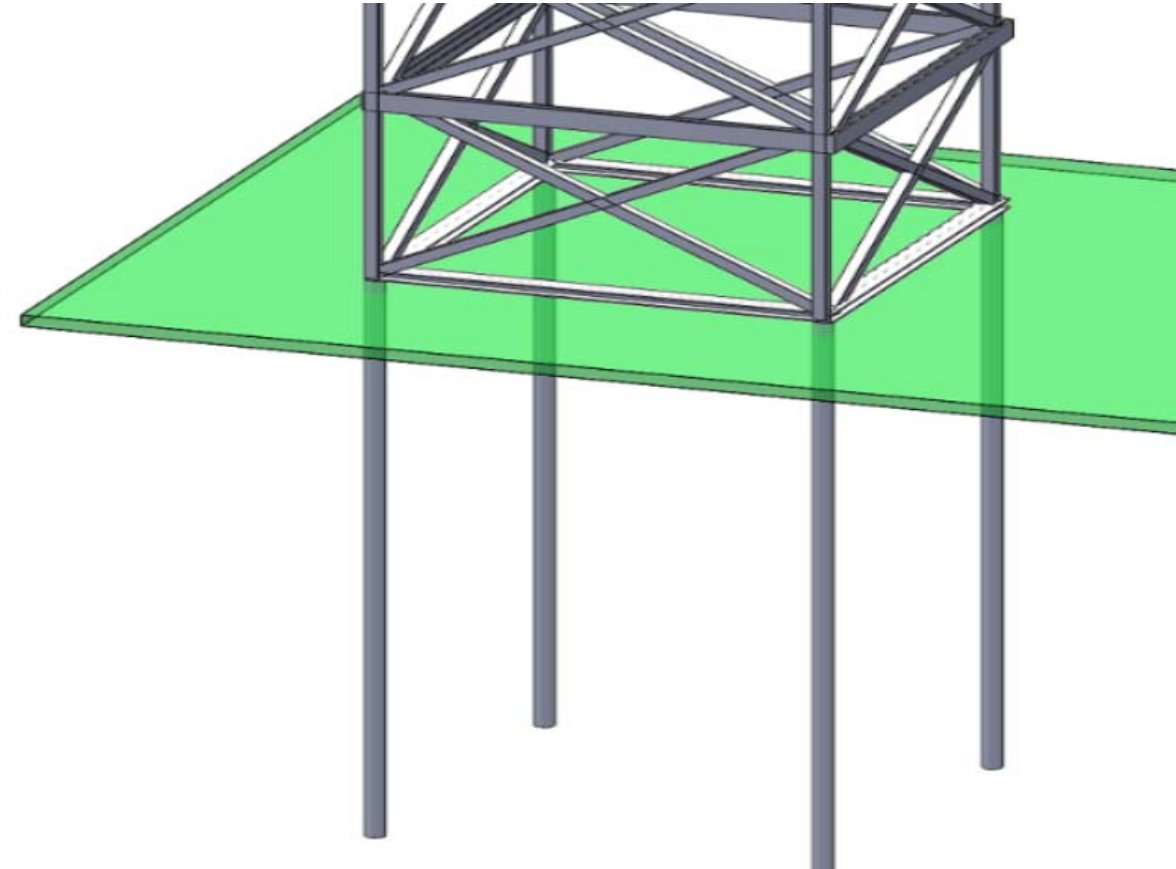


Pile Foundation

Load Type	Building Load (kip)	Pile Capacity (kip)
Bearing	342	493
Uplift from wind and frost heave	440	470

Settlement (in)	0.8
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- Soil properties were found using DOT core information and NAVFAC DM 7.01

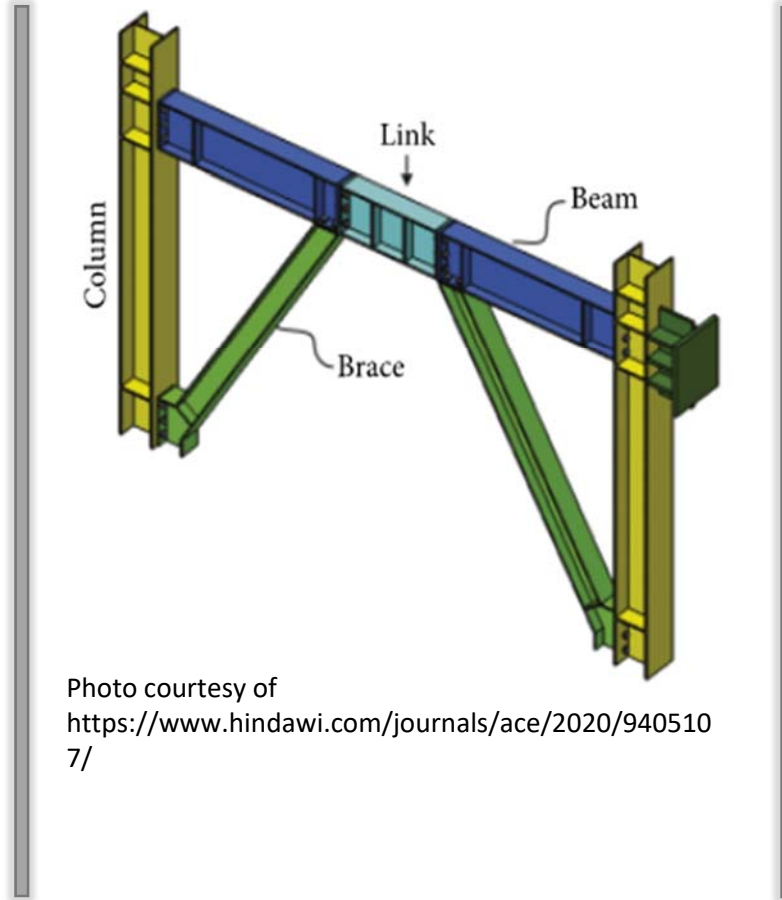


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Design Alternative	Cost Estimate
Design A	\$800,000
Design B	\$790,000
Design C	\$350,000

Living space is standard for all designs: \$430,000



Other Considerations:

- Design A- can optimize steel by levels to decrease cost
- Design B- links (Expensive)
- Design C- special connections to withstand high forces

*Estimate courtesy of Josh Bablonka at HMS, Inc.



Cost Estimate

Foundation Alternative Designs A and B	Basic Cost Estimate
Shallow	\$98,000
Pile	\$193,000

Foundation Alternative Designs C	Basic Cost Estimate
Group Piles	\$298,000

Living space is standard for all designs: \$430,000

Other Considerations:

- Both prices subject to change
- Shallow: Will require complex on-site construction
- Pile: Expensive material cost, simple construction methods

*Estimate courtesy of Josh Bablonka at HMS, Inc.



Tower Design

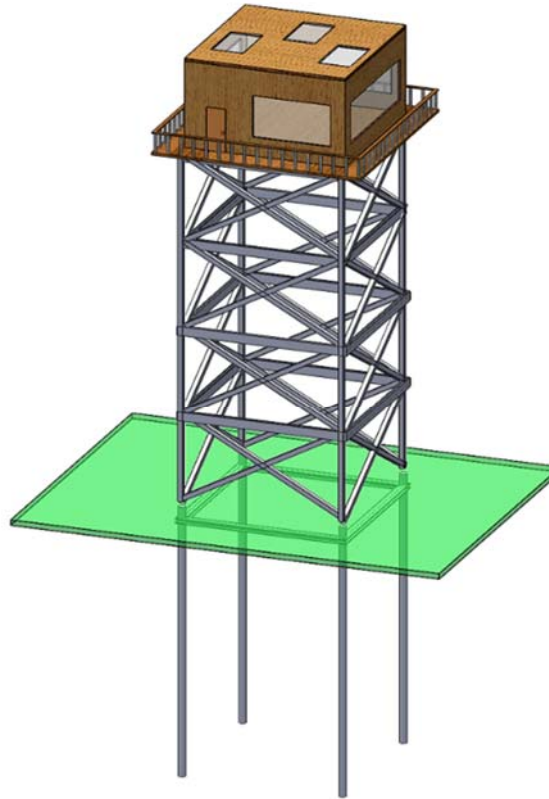
Design Alternative A

- Special concentrically braced frame

Foundation Design

Pile Foundation

- 24 inch diameter
- 60 feet long
- 4 piles total



Final Cost: \$2 Million

Reasoning

- Meets all the criteria by client
- Most reliable superstructure design
- Safe foundation option



Budget

- Total Billed to Date: \$48,400
- Budget at this stage: \$60,000
- Percent of Budget: 79%

This invoice includes:
Completed Design study on Designs A, B, and C
2 foundations, cost estimate



Acknowledgments

- Scott Hamel, PE, SE, PhD
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- Paul Taylor

Questions?

