Alternative Analysis

Potter Marsh - Old Boardwalk Rebuild Project

CED 2020.04

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Table of Contents

1. Project Introduction

1.1 Location

The project is in Anchorage, Alaska, located 10 miles south of downtown. It is accessible from the New Seward Highway, with the entrance located just pass the Rabbit Creek exit and across from the Rabbit Creek Rifle Range entrance. It has 0.5 miles of boardwalk, accessible bathrooms and designated parking at the main entrance.

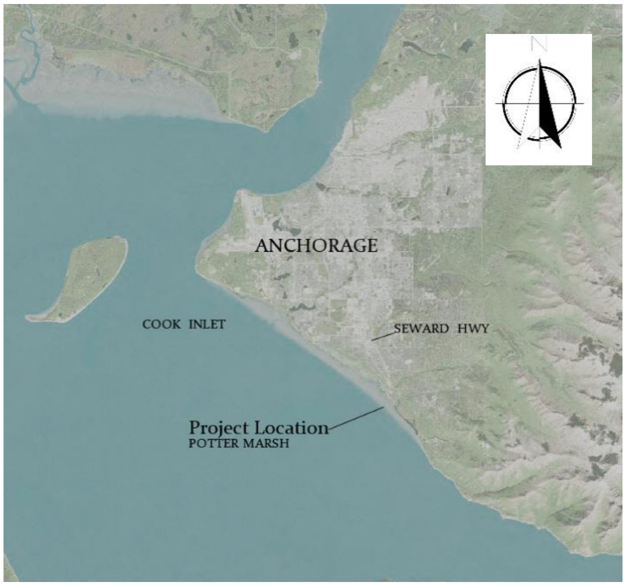

Figure 1: Location of Potter Marsh Boardwalk

1.2 Introduction

Potter Marsh is located at the south end of the Anchorage Coastal Wildlife Refuge and is a well-known birding area. The marsh came about when the Alaska Railroad embankment was built in 1917. The embankment blocked saltwater flow while also containing the freshwater from Rabbit Creek, Little Rabbit Creek, and Little Survival Creek. Now many migratory birds along with other wildlife, from moose to salmon, frequent the 564-acre area. In 1985, a 1,500-foot-long boardwalk was built along the Seward Highway so people could view and enjoy the variety of animals while conserving the natural habitat.

The Alaska Department of Fish and Game (ADF&G) maintains the Potter Marsh Wildlife Viewing Boardwalk area and has recognized the need to improve the outdated structural components, fix shifting foundations, and redesign the overall 1985 boardwalk section. The team at Extron pursued a goal to analyze four design alternatives based on ADF&G requests and provide 35% design documents for the selected alternative including boardwalk structures, environmental and hydraulic analyses, and cost estimations.

1.3 Existing Conditions

Many of the problems with the boardwalk are visible such as loose railings, shifted joists, rot, and frostjacked piles. The boardwalk has exceeded its intended lifespan, does not meet all current codes and lacks certain design features that improve visitor experience. Some examples of this are a lack of a distinct destination at the end of the boardwalk, as well as a lack of emphasized viewing areas that encourage visitors to linger in notable locations.

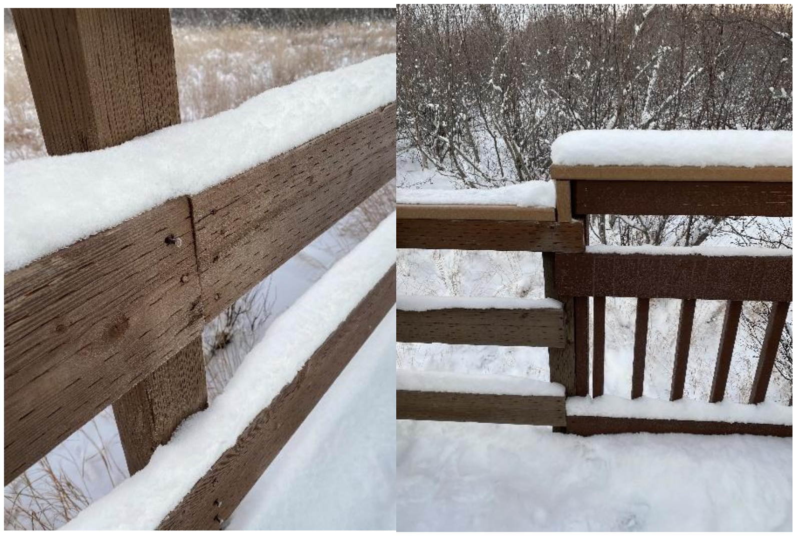

FIGURE 2: EXISTING CONDITIONS

Since the land is a bog, there are several environment conditions to take note of. The area is a flood zone AE meaning it is at high risk of flooding, and the risk is amplified by the ground conditions and the topography. According to the Natural Resources Conservation Service, referenced in Appendix B, the soil falls under hydrologic class D which has a low infiltration rate. Additionally, the marsh is very flat, which reduces runoff. However, this terrain characteristic adds to the experience of visiting Potter Marsh so one can see its entirety.

1.4 Design Criteria

The design criteria chosen are conceived with the following outcomes in mind.

1. Experience: A new boardwalk design should engage the visitor and be able to accommodate the many people who tour Potter Marsh since its Anchorage's most popular wildlife viewing site.
   a. Features: Design should consider off-shoot viewing boardwalks and platforms, and an elevated wildlife viewing tower to add to the visitor's experience.
   b. Safety: The boardwalk should be built according to the current codes and standards that emphasize safety. This will consider handicap accessibility and boardwalk stability.
   c. Noise Reduction: The new design alternatives should consider rerouting to get visitors further from the existing highway and railroad and deeper into the marsh's environment.
2. Environmental & Water Impact: Any design should preserve the core area of the marsh's wildlife habitat.
3. Possible Complications: Each alternative will pose its own possible complications that will need to be addressed if selected.
4. Cost: The new design will provide the best visitor experience for a given level of investment.

5. Time of Construction: The construction of the alternatives must be able to be scheduled in such a way as to minimize its effect on the environment and the visitor's experience.

Four alternatives were researched in order to find the most effective design for the Potter Marsh Boardwalk. Layouts and details are described in the following sections.

1.5 Environmental Impact

There are several factors that must be taken into consideration when constructing in a marsh, especially a wildlife sanctuary. The greatest of these are avoiding disruptions to local flora and fauna. Fortunately, the construction season taking place during the winter does help mitigate some of these concerns. The vast majority of animal activity in this particular marsh happens during the warmer months. The remaining concerns from flora and fauna can be dealt with, in this case, by routing the new boardwalk in such way that it doesn't interfere with nesting or feeding areas.

Another consideration is moving construction equipment in and around the marsh. The vast majority of construction equipment could not be used in a marsh due to the lack of solid ground. Waiting for winter for the ground to freeze mostly solves this, but deep snow can still be an obstruction. The best way around this is the creation of temporary ice roads, which, if done correctly, have no lasting environmental effects once the roads melt away.

An additional consideration for this project, in particular, is noise pollution. Due to the nature of construction in a marsh, all of the foundations must be pile foundations. Because of the close proximity to the Turnagain Arm, the subterranean noise generated by driving piles could disrupt local wildlife, such as beluga whales, who have a sensitivity to sound.

As with all projects, there are several permits that have to be applied for and gained before construction. The needed permits depend on a variety of factors, including the area in which the construction is happening, the presence of endangered or protected wildlife, and the source of funding. One permit that this project will require for certain is the US Army Corp of Engineers Fill Permit, due to the construction happening in a wetland. Additional permits that would be required are a Floodplain Development Permit, Fish Habitat Permit, and perhaps an Eagle Take Permit if there is an occupied nest close enough to the project area.

1.6 Hydrological Impact

Several hydrologic calculations were performed on the area of interest: floodplain level, outgoing velocity, rainfall intensity, and peak-runoff. All calculations mentioned can be found in Appendix B. Equations were obtained from the third edition of *Water-Resources Engineering* by David A. Chin.

First explored was the floodplain level. The base flood elevation for zone AE, which the boardwalk is located in, is 16 ft above sea level for 100-year storm according to Federal Emergency Management Agency (FEMA). Volumes of the floodplain, boardwalk, and piles were found from the Alternative 4 Design. This design was used in calculations as it would increase the floodplain the most. The volume of the proposed boardwalk was added to the volume of Zone AE to find if the added structure increased the floodplain height. The results show that there is negligible impact.

Second, the outflow velocity was found using the steady-state continuity equation. Inflow maximum values (Estes, 1987) were used as the culverts should still preform at peak flow. The result was 0.25 ft/s for velocity heading out of the marsh via the three culverts under the Seward Highway.

Third, rainfall intensity, was found for the Anchorage area. "Many drainage districts require that the performance of drainage systems be analyzed for a standard 24-h storm with a specified return period, typically on the order of 25 years" (Chin, 2013, p. 422). Therefore, 25 years was used for the annual series and 24 hours was used for the rainfall duration. This resulted in a rainfall intensity of 0.9 inches per hour.

Lastly, peak-runoff was found using the rational method and the Natural Resources Conservation Service Technical Report 55 (NRCS-TR55) Method. Using the rational method, runoff was about 73 cubic feet per second. By the NRCS-TR55 method, peak runoff was 66 cubic feet per second. Both calculations can be viewed in Appendix B. The results are consistent with the geotechnical report which indicates a high runoff potential for the site since the hydrologic soil group D has a low infiltration rate.

1.7 Structural Analysis

Preliminary models for the various super structural components were designed using RISA 3D software. The main boardwalk and platform concepts were designed to merge aesthetically and structurally with the existing 2008 boardwalk. The boardwalk sections are 8ft wide, allowing ease of passage for visitors walking in opposite directions, with space for wheelchair accessibility. Ramped sections of the boardwalk were designed with a maximum slope of 1:12 as required by the 2010 ADA Standards for Accessible Design. The 25ft elevated viewing tower was designed with wrap-around stairs and two small deck viewing opportunities at 9.25 ft and 14.5ft above the boardwalk with a larger platform at 18 ft above the boardwalk (25 ft above ground level). For the Rabbit Creek crossing point and salmon viewing area, a 40-ft long donut-shaped bridge was designed to span the length of the creek bed, allowing visitors to peer both into the center gap and over the outside edges of the structure for wildlife viewing. Modules for the structural designs are explored in Section 3 of this document.

Live loads on any likely places of assembly, including the viewing tower, platforms, and salmon viewing bridges, were considered 100psf on flat surfaces as required in ASCE 7-16, or the equivalent of a densely packed group of people. Live loads on both the staircases and the boardwalk sections unlikely to be used at assembly areas were considered to be 60psf (ASCE 7-16).

Calculations for snow, wind and seismic loads can be found in Appendix C following guidelines given by ASCE 7-16. Snow load calculations yielded a 33.6psf load throughout all flat superstructure surfaces. Wind loads were calculated using a 50-year gust of 155 mph (librarystage.municode.com/ak/anchorage), and yielded horizontal loads of approximately

115psf for the tower, and 85psf for all other structural segments. Wind loads are greatly impacted by the railing design and size of joists and beams.

Seismic loads yielded differing values for each structural component, as the weight of the structure is critical. Seismic loads were applied horizontally to the deck area in the RISA 3D software. The boardwalk received a load of approximately 85plf, the donut bridge approximately 110plf, and the platform approximately 85plf. The viewing tower was loaded with a 2.9kip seismic load.

Key member calculations for shear, moment, deflection and buckling capacities can be found in Appendix C. All structures use A992 steel and Douglas fir timber with composite railing finishes. Additionally, all handrails and deck were designed to be aesthetically uniform to the existing 2008 boardwalk which meets current building codes.

2. Alternatives

2.1 Alternative 1

2.1.1 Description and Experience

Alternative 1 provides no changes and keeps the current boardwalk. The experience offered by the current boardwalk lacks in several areas. Its proximity to the highway and railroad leads to loud noises that can disrupt visitors experience. The linear nature of the boardwalk and lack of dedicated viewing platforms limits the ability of visitors to interact with the marsh. While not unsafe, the current guard rails do not meet modern building codes. In addition to this there are loose nails and gaps between boards that could pose a tripping hazard as the boardwalk continues to deteriorate.

2.1.2 Environmental Impact

This alternative will have no additional environmental impacts as there is no construction. However, there may be some impacts due to maintenance depending on the extent of the maintenance needed.

2.1.3 Hydrological Impact

There will be no hydrology impact for this alternative as there will be no changes to the site.

2.1.4 Foundation Design

Due to the frost heaved foundations and general wear, the current boardwalk decks are dilapidated, and the handrails are loose. As more frost heave occurs, the boardwalk will interfere with handicap accessibility and could become unsafe for visitors due to damaged handrails or boardwalk planks.

2.1.5 Cost

While there are no costs due to construction there are maintenance cost associated with the use of the old boardwalk which are expected to increase as the boardwalk keeps aging.

2.1.6 Time of Construction

There is no time of construction associated with this alternative.

2.2 Alternative 2

2.2.1 Description and Experience

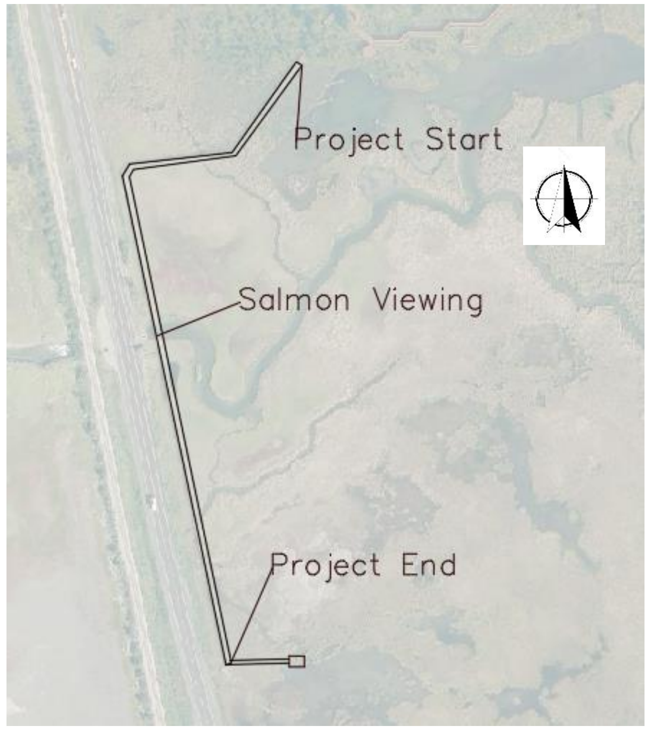

FIGURE 3: ALTERNATIVE 2 ALIGNMENT

Alternative 2 proposes that a new boardwalk deck be designed and constructed utilizing the existing foundation. The experience offered by this alternative is very similar to that of Alternative 1, except for safety. The new decking and railings would all meet current building codes and would be in much better condition. This combined with the leveling of the deck, caused by trimming the frost heaved piles, would result in an improved visitor experience.

2.2.2 Environmental Impact

This alternative will have minimal environmental impact due to reuse of the existing pile foundations and the proximity to the highway reducing construction traffic through the marsh itself. Though minimal, construction for Alternative 2 will impact wildlife and vegetation, including sedge species, waterfowl, moose, fish, and land birds, some of which frequent the marsh during all seasons. We would expect the wildlife and vegetation to make a fast and full recovery, especially with a winter season, non-invasive construction plan.

2.2.3 Hydrological Impact

Since the location of piles will be reused along with the same area of the walk, no calculations or estimations for the hydrology is needed for this alternative. This is assuming the build design of the old walk is adequate for the hydrology of the area.

2.2.4 Foundation Design

This alternative will likely face complications when reusing the existing piles from the old boardwalk because of frost heave and settling of the soils within the marsh. The boardwalk may deteriorate faster with the use of the already-heaving piles.

2.2.5 Cost

Cost for this option would be the lowest of the three alternatives that involve construction. While initial construction costs would be low the potential for additional maintenance after construction would add to the cost thus rendering this option potentially almost as expensive as a new boardwalk.

Cost: $1,488,000

2.2.6 Time of Construction

This alternative has the shortest construction time, not counting Alternative 1. This is because no new additional foundations need to be installed and no new features need to be constructed. This alternative in particular benefits from a close proximity to the highway in terms of construction. That is because a crane could be used to place the new deck sections directly from the highway, limiting the necessity of moving equipment on the marsh itself which would require the creation of temporary ice roads.

2.3 Alternative 3

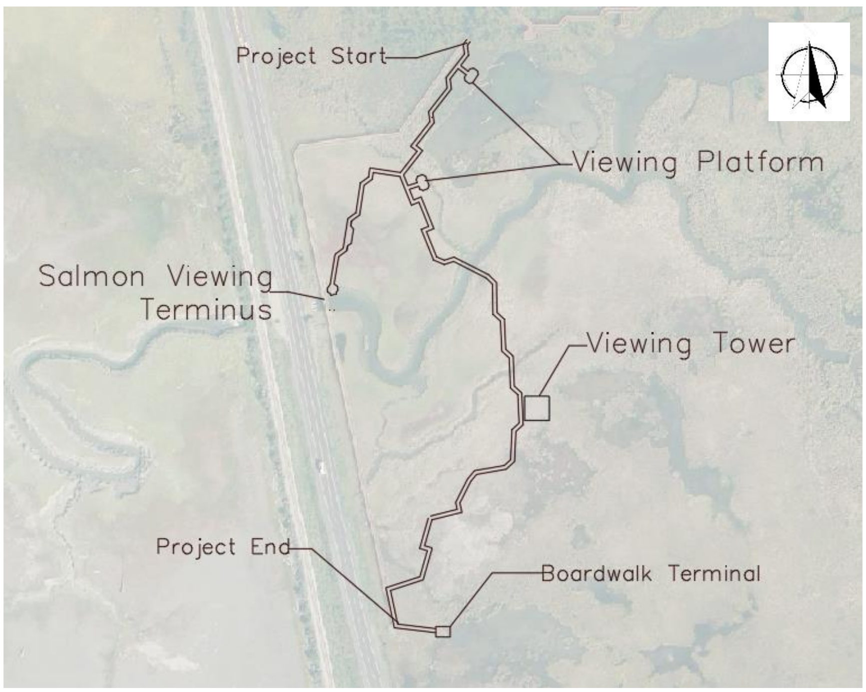

FIGURE 4: ALTERNATIVE 3 ALIGNMENT

2.3.1 Description and Experience

Alternative 3 proposes an entirely new boardwalk, including foundations, whose alignment is shifted further into the marsh compared to the current design. In addition, the nonlinear design of this alternative encourages visitor interaction both with each other and their environment. The primary new features of this alternative design include an off shoot ending in a doughnut shaped viewing platform at a popular salmon viewing area and a viewing tower. These modules can be viewed in Section 3.1. The new features and distance from the highway/railroad will improve visitor experience while the new construction will meet all current building codes.

2.3.2 Environmental Impact

The primary environmental concerns in this alternative come from two sources. The first is the construction of temporary ice roads in Potter Marsh, and the second is the effects of driving new piles. Because the vast majority of the wildlife activity takes place during the summer and the construction season for this project is in the winter, the construction should minimally interfere with the wildlife. The impacts concerning the feeding and nesting areas would be addressed while planning the route of the ice roads and equipment.

2.3.3 Hydrological Impact

The addition of new piles would increase the base of the floodplain, some of which would be offset by the removal of the piles from the original foundation. However, the increase would be considerably small, much less than the thousandth of a foot as in Alternative 4.

2.3.4 Foundation Design

The marsh's ice must be thick enough to support construction machinery and personnel for the foundations. The reliance on thick ice can be reduced by using drilled piles, which require less equipment. Parts of the tower or viewing platforms may be preassembled and airlifted into the marsh, as field welding and/or crane construction (if necessary) may not be feasible.

2.3.5 Cost

This alternative has the second highest initial construction cost. The new alignment would have to be constructed from the ground up. In addition, the entire structure including foundation from the old boardwalk would need to be removed. The demolition of the old boardwalk adds considerable cost to the project as with Alternative 2. However, the proposed viewing tower and salmon platform in this alternative increase cost as well.

Cost: $2,860,000

2.3.6 Time of Construction

Time of construction is the second highest regarding this alternative because it includes demolition and new construction. Removal of the old boardwalk may pose challenges unforeseen in the initial plans due to its age. Additionally, the new boardwalk, viewing tower and salmon platform will be constructed from the ground up which takes manpower and time, while also necessitating the creation of temporary ice roads on the marsh. The new boardwalk and structures will be erected over the course of one winter, weather permitting. This construction timeline will minimize visitor impact as winter is the least active period for community members and wildlife alike. The 2008 boardwalk section will remain open to visitors and be unaffected by construction of the new boardwalk.

2.4 Alternative 4

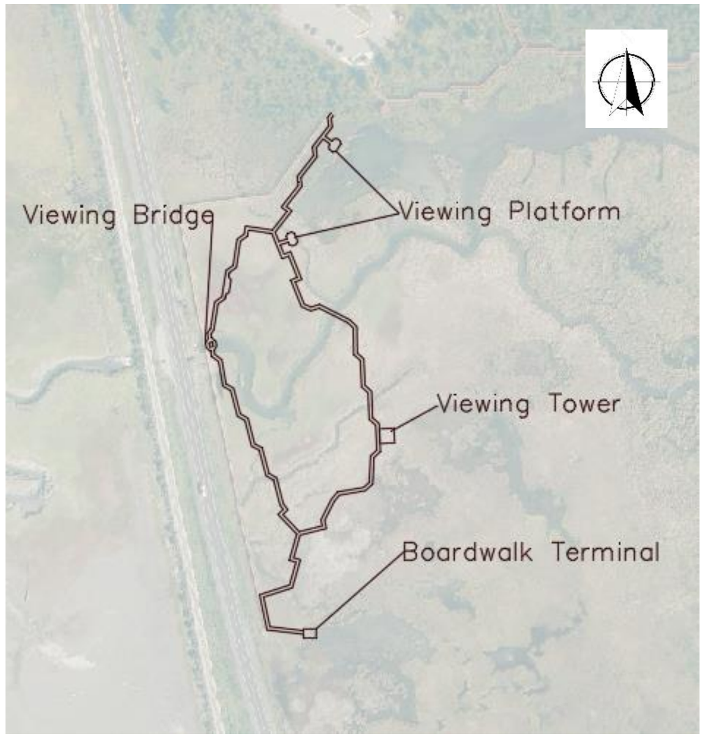

FIGURE 5: ALTERNATIVE 4 ALIGNMENT

2.4.1 Description and Experience

This alternative is similar to Alternative 3, with two major additions. First, changing the salmon viewing platform to a doughnut shaped bridge. Second, an additional length of boardwalk connecting the salmon viewing area the main boardwalk after the viewing tower. The latter difference would give visitors two different experiences coming to and from the parking area.

2.4.2 Environmental Impact

The primary environmental concerns in this alternative are identical to those found in Alternative 3, with the addition of the nesting and feeding area concerns from the additional length of boardwalk.

2.4.3 Hydrological Impact

The hydrological impact from this alternative is almost identical to that of Alternative 3, only to a greater degree due to extra piles and the extension of the boardwalk. Though the increase to the floodplain is still of no significant amount. The original floodplain without a new build is 16ft while with the boardwalk in this alternative, the floodplain increases to 16.001ft.

2.4.4 Foundation Design

As with Alternative 3, the marsh’s ice must be thick enough to support construction machinery and personnel for the foundations. This alternative would use drilled piles, which require less equipment. Parts of the tower or viewing platforms may be preassembled and airlifted into the marsh, as field welding and/or crane construction (if necessary) may not be feasible.

2.4.5 Cost

The final alternative is the most expensive option as it is the most complicated design also. This alternative and the latter share the same cost considerations. However, Alternative 4 adds 500 linear feet of boardwalk closing the loop and exchanging the salmon platform into a viewing bridge. The additional structure being the viewing tower remain the same.

Cost: $3,536,000

2.4.6 Time of Construction

Time needed for this alternative is nearly the same as alternative 3. Demolition of the old boardwalk and construction of the new facility is largely the same. Adding more linear feet of boardwalk in this alternative increases the time of construction proportionally to the added amount of new boardwalk.

Alternative 4 offers more flexibility with construction phasing due to the boardwalk loop and other features. If a single winter is not sufficient for construction, access to and erection of the viewing tower and salmon viewing bridge will be the first priority. The completion of the boardwalk loop may be extended into the following winter if necessary or desired.

3. Conclusion and Recommendation

Considering the design criteria discussed in this document, Alternative 4 is the recommended alternative. The purpose of the Potter Marsh Boardwalk Rebuild Project is to increase the usability and popularity of the facility, which a completely new boardwalk with additional structures, as proposed in Alternative 4, will achieve. This alternative allows visitors to experience a boardwalk loop, viewing tower, platforms, and improved salmon viewing area to enhance visitor experience.

Alternative 4 is, however, the most expensive alternative. Though Alternative 3 includes a viewing tower and platforms for a slightly lower cost and construction time, the boardwalk loop adds an experiential aspect that is well worth the cost. Alternative 4 will provide the Anchorage community with a desirable destination for decades to come.

3.1 Design Modules

3.1.1 Boardwalk

The boardwalk design represents a typical 10-foot section of boardwalk decking, including associated railing and piles, as seen above. Modular design for this boardwalk gives the client freedom to align the boardwalk to specific paths along the marsh as it guides visitors to critical areas where wildlife is more prominent. The boardwalk was also designed to have a maximum slope of 8% following the disability act. This allows the boardwalk to change in elevation to portray more dramatic experience as people walk along the path. The lower height of the boardwalk is designed as a deterrent for large animals like moose from wandering into the highway. Handrails were designed in accordance to the international building code in such a way that it is aesthetically pleasing, safe, and follows the guidelines. The boardwalk is designed to withstand the maximum live load, snow load, wind load and seismic load.

FIGURE 6: BOARDWALK MODEL

The cost of the boardwalk per square footage is $200. The cost of labor is incorporated as twice the cost of the square footage. The material calculation and more can be found in Appendix A Table A.2.1.

3.1.2 Viewing platform

This represents the viewing decks that visitors would find at the end of the off shoots that can be found along the boardwalk route, including associated railings and piles as seen in Figure 7. The viewing platforms will have interpretive panels and scopes. It provides an area for visitors to stop, gaze at the wildlife and read information about them. This hexagon shape is chosen for aesthetic purposes. It mimics the 2018 boardwalk and creates a unified look.

The cost of the platforms is calculated using the material cost and adding twice the material cost to account for the labor which comes out to be $51,600 per platform. The material take off can be found in Appendix A Table A.2.4.

FIGURE 7: VIEWING PLATFORM MODEL

3.1.3 Viewing bridge

The viewing bridge, otherwise called the doughnut bridge, is designed to be a cantilever bridge with a cavity in the center. Its purpose is to increase the capacity of salmon viewers and provide alternative paths for passerby. The opening is also to allow for sunlight to reach the fish and vegetation underneath. The handrail mimics that of the boardwalk and the shape is consistent with the viewing platforms to provide a unified design.

The cost of the viewing bridge is calculated using the material cost and adding twice the material cost to account for the labor. The cost comes out to be $65,000. The material take off can be found in Appendix A Table A.2.2.

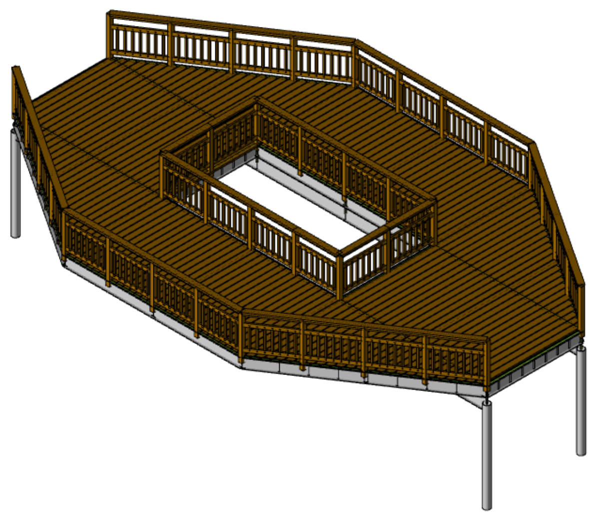

FIGURE 8: VIEWING BRIDGE MODEL

3.1.4 Viewing tower

The purpose of the tower is to provide an elevated view of the marsh for the visitors. It has a height of 25ft provides for an interesting destination that incorporates interpretive panels and scopes. The bridge is designed to be connected directly in the boardwalk alignment and has three levels of the view accessible by stairs.

The viewing tower cost $136,000 including the cost of the material and cost of labor. The material take off is found in Appendix A Table A.2.3.

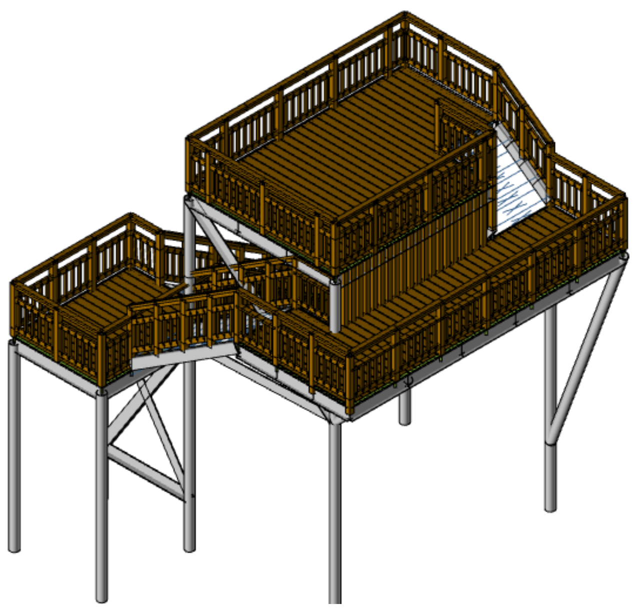

FIGURE 9: TOWER MODEL

3.2 Phasing

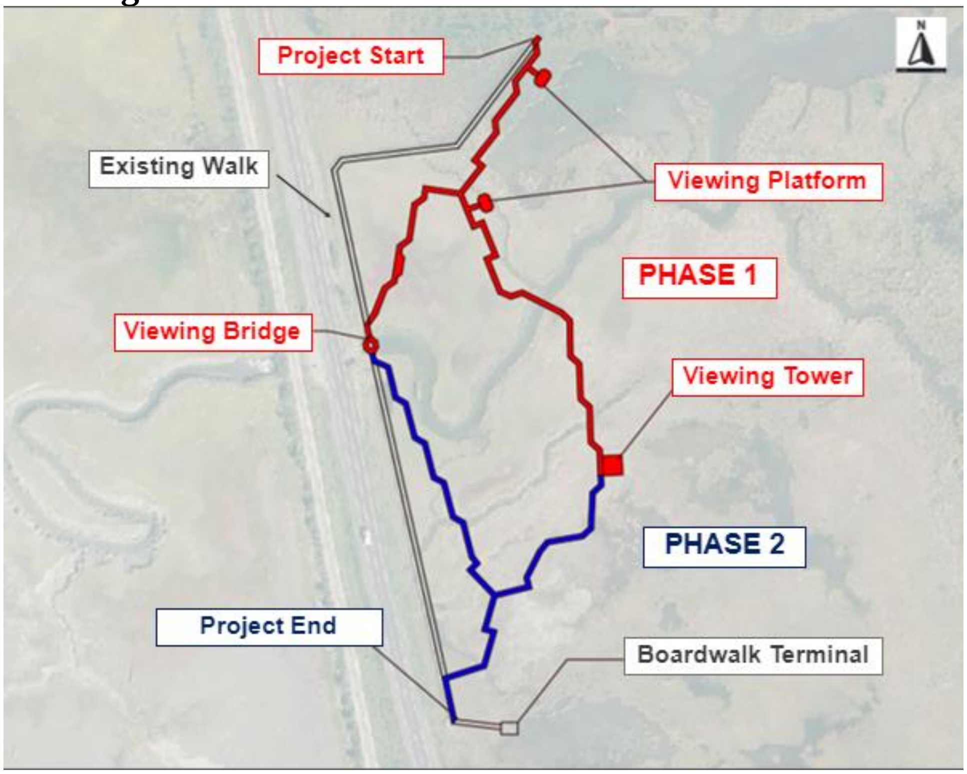

FIGURE 10: SELECTED DESIGN ALTERNATIVE AND PHASING

3.2.1 Phase 1

Phase 1 incorporates the following modules: viewing decks, viewing bridge and viewing tower. The alignment meanders through the marsh, taking advantage of different locations like the salmon viewing area and Canada goose flats. However, the route in this phase will not provide the option to continue past the salmon viewing terminus toward the boardwalk terminal.

The foundations required for this design are screw piles, identical to the additional alternatives. The project total includes all the cost associated with all the features and phases calculates to $4 million. For more details, see Appendix A.

3.2.2 Phase 2

Shown in Figure 10 in blue is the alignment for the final phase to complete the selected alternative. It incorporates the loop and the following modules: viewing decks, viewing bridge and viewing tower.

This design option exhibits all of the features requested by the client which ultimately increases the experience that the boardwalk can provide for its visitors. In order to provide a great experience, different types of visitors were considered. Toward the beginning of the walk, a viewing platform is included for those who would like to experience the walk but do not have the time to complete it. Large viewing decks are to accommodate for large groups and the loop gives the visitors an all-encompassing path.

Taking the west boardwalk will cut through the Canada goose area which comprise of 40-60 nesting pairs. This path then leads to the salmon viewing bridge which has the capacity to hold a classroom of students for educational purposes. Continuing this route will lead to a choice between the boardwalk terminal or looping around to get to the viewing tower.

The foundation incorporated in this alternative is a screw pile design which is best suited for the conditions of the project location. The design calls for the boardwalk to be raised off the ground at least 8’ and up as needed. The advantage to using a screw pile design is the ease of installation. The equipment required to install screw piles are a fraction of the size compared to traditional pile driving equipment. Challenges regarding the foundation include the problem with heaving due to frost action in the area. To mitigate the probability of frost heaving the piles will be driven deep below the frost line. The expense saved using screw piles allows for deep installation below the frost line.

The cost for this phase is $3.13 million which leads the project total cost to be $7.13. For more details, see Appendix A.

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Appendix

Appendix A. Cost Calculation

A.1 Cost of Alternatives

Project No.: 2020.04
Project Name: Potter Marsh Boardwalk Rebuild
Location: Anchorage, AK

Item No.	Item	Unit	Unit Price	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
				Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
	Removal of Structures and Obstructions	L.S.	$ 10,000.00				$ 10,000.00		$ 10,000.00		$ 10,000.00
	Erosion, Sediment, and Polution Control Admin	L.S.	$ 10,000.00				$ 10,000.00		$ 10,000.00		$ 10,000.00
	Temporary Erosion, Sediment, and Polution Control	L.S.	$ 15,000.00				$ 15,000.00		$ 15,000.00		$ 15,000.00
	Construction Surveying	L.S.	$ 15,001.00				$ 20,000.00		$ 35,000.00		$ 50,000.00
	Design/Permitting	L.S.	$ 49,699.60				$ 103,130.00		$ 198,226.04		$ 245,072.00
	Construction Administration	L.S.	$ 15,003.00				$ 10,313.00		$ 19,822.60		$ 24,507.20
	Traffic Maintenance	C.S.	$ 1,500.00				$ 1,500.00		$ 1,500.00		$ 1,500.00
	Mobilization and Demobilization	L.S.	$ 51,000.00				$ 74,800.00		$ 144,130.40		$ 177,720.00
	Drive Structural Steel Pile	Ea.	$ 370.00				$ -	199	$ 73,630.00	250	$ 92,500.00
	Furnish Structural Steel Helical Pile	L.F.	$ 50.00				$ -	3980	$ 199,000.00	5000	$ 250,000.00
	Viewing Tower	L.S.	$ 244,000.00				$ -		$ 244,000.00		$ 244,000.00
	Creek Viewing Platform	L.S.	$ 100,000.00				$ -				$ 100,000.00
	Viewing Deck	L.S.	$ 50,000.00				$ -		$ 50,000.00		
	Boardwalk	S.F.	$ 75.00			12000	$ 900,000.00	16000	$ 1,200,000.00	20000	$ 1,500,000.00
Contingency	30%						$ 343,422.90		$ 660,092.71		$ 816,089.76
Total					$0.00		$ 1,488,165.90		$ 2,860,401.76		$ 3,536,388.96

Figure A.1: Cost of Alternatives 1, 2, 3 and 4

A.2 Cost of Modules

Boardwalk				
Description	**Unit**	**Unit Price**	**Quatity**	**Amount**
HSS 6.625x0.375	EA	$ 250.00	8	$ 2,000.00
W10x45	EA	$ 556.80	2	$ 1,100.00
2x10	EA	$ 19.34	26	$ 500.00
2x2	EA	$ 3.89	36	$ 100.00
2x4	EA	$ 8.98	96	$ 900.00
2x6	EA	$ 13.67	20	$ 300.00
4x4	EA	$ 18.77	31	$ 600.00
Total Raw Materials	LF	$ 5,473.83	1	$ 5,500.00
Construction Cost	LS	2.00	1	$ 10,900.00
Total				$ 16,400.00
Area	SF	80		$ 200.00

Figure A.2.1: Cost of Boardwalk

Bridge				
Description	Unit	Unit Price	Quatity	Amount
HSS 6.625x0.375	EA	$250.00	10	$2,500
W10x17	EA	$500.00	24	$12,000
W12x19	EA	$235.10	8	$1,900
2x10	EA	$19.34	28	$500
2x2	EA	$3.89	252	$1,000
2x4	EA	$8.98	108	$1,000
2x6	EA	$13.67	123	$1,700
4x4	EA	$18.77	38	$700
Raw Materials	EA	$ 32,080.31	1	$32,100
Construction Cost	LS	2.00	1	$64,200
Total				$96,300

Fig A.2.2: Cost of Bridge

Tower				
Description	Unit	Unit Price	Quatity	Amount
HSS6.625x0.375	EA	$ 250.00	15	$ 3,800.00
HSS8x4x8	EA	$ 214.20	12	$ 2,600.00
L7x4x10	EA	$ 200.00	9	$ 1,800.00
W10x17	EA	$ 500.00	34	$ 17,000.00
W8x13	EA	$ 175.50	25	$ 4,400.00
2x2	EA	$ 3.89	266	$ 1,000.00
2x4	EA	$ 8.98	760	$ 6,800.00
2x6	EA	$ 13.67	82	$ 1,100.00
4x4	EA	$ 18.77	192	$ 3,600.00
1 in	EA	$ 18.90	55	$ 1,000.00
Raw Materials	EA	$ 43,460.50	1	$ 43,500.00
Construction Cost	LS	2.00	1	$ 86,900.00
Total				$ 130,400.00

Figure A.2.3: Cost of Tower

Platform				
Description	Unit	Unit Price	Quatity	Amount
HSS6.6255x0.375	EA	$ 250.00	48	$ 12,000.00
W6x12	EA	$ 148.50	7	$ 1,039.50
24F-1.8E DF 2x4	EA	$ 10.00	22	$ 220.00
2x10	EA	$ 19.34	31	$ 599.54
DF 2X2	EA	$ 4.00	93	$ 372.00
DF 2X4	EA	$ 8.98	35	$ 314.30
DF 2X5	EA	$ 15.00	130	$ 1,950.00
DF 2X6	EA	$ 15.00	25	$ 375.00
DF 4X4	EA	$ 20.00	16	$ 320.00
Raw Materials	SF	$ 17,190.34	1	$ 17,190.34
Construction Cost	LS	2.00	1	$ 34,380.68
Total				$51,600.00

Figure A.2.4 Cost of Platform

A.3 Cost of Options

Project Name: Potter Marsh Boardwalk Rebuild
Location: Anchorage, AK

Item No.	Item	Unit	Unit Price	Phase 1		Phase 2	
				Quantity	Amount	Quantity	Amount
	Removal of Structures and Obstructions	L.S.	$ 10,000.00	1	$ 10,000.00	1	$ 5,000.00
	Erosion, Sediment, and Polution Control Admin	L.S.	$ 10,000.00	1	$ 10,000.00	1	$ 10,000.00
	Temporary Erosion, Sediment, and Polution Contro	L.S.	$ 10,000.00	1	$ 10,000.00	1	$ 10,000.00
	Construction Surveying	L.S.	$ 3,000.00	1	$ 3,000.00	1	$ 3,000.00
	Traffic Maintenance	C.S.	$ 1,500.00	1	$ 1,500.00	1	$ 1,500.00
	Mobilization and Demobilization	L.S.	$ 40,000.00	1	$ 40,000.00	1	$ 30,000.00
	Drive Structural Steel Pile - 3.5"	Ea.	$ 765.00	324	$ 247,860.00	220	$ 168,300.00
	Structural Steel Pile Installation	LF	$ 75.00	6480	$ 486,000.00	4400	$ 330,000.00
	Viewing Tower	L.S.	$ 136,000.00		$ -	1	$ 136,000.00
	Creek Viewing Bridge	L.S.	$ 65,000.00	1	$ 65,000.00		$ -
	Platform	L.S.	$ 24,000.00	2	$ 48,000.00		$ -
	Boardwalk	S.F.	$ 205.27	11000	$ 2,257,954.88	8810	$ 1,808,416.59
	Total Basic Bid				**$ 3,179,314.88**		**$ 2,502,216.59**
	Contingency (10% of Basic Bid)		10.00%		$ 317,931.49		$ 250,221.66
	Design Service (5% of Basic Bid)		5.00%		$ 158,965.74		$ 125,110.83
	Construction Administration (10% of Basic Bid)		10.00%		$ 317,931.49		$ 250,221.66
	Interp and education (4 panels, $7.5k/Panel)	per Panel	$ 7,500.00	3	$ 22,500.00		$ -
	Project Total				**$ 3,996,643.59**		**$ 3,127,770.73**

	area	footing
Phase 1	11000	324
Phase 2	8810	220

Figure A.3: Cost of Phase 1 and 2

Appendix B. Hydrologic Analysis

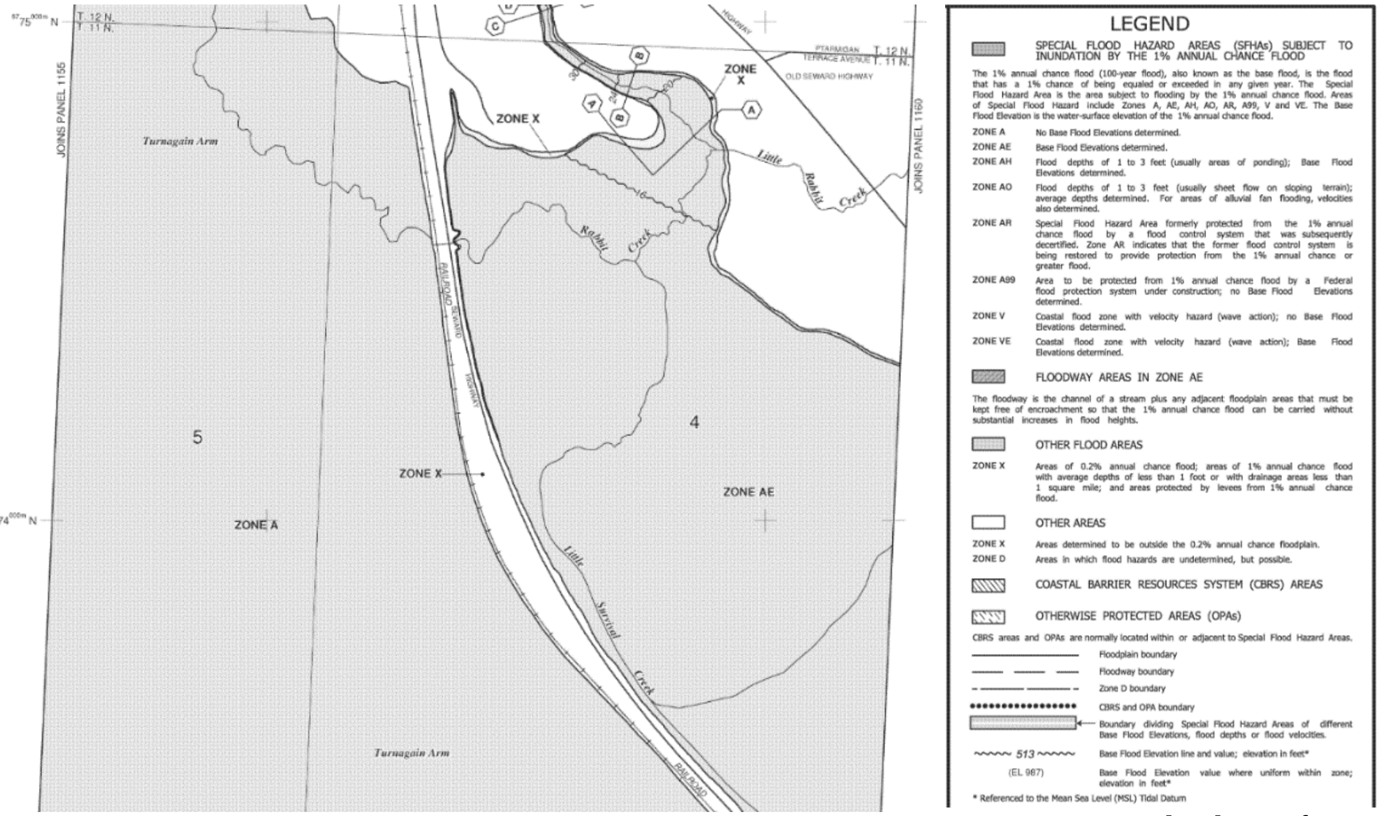


Figure B.1: Flood Map for Potter Marsh from FEMA

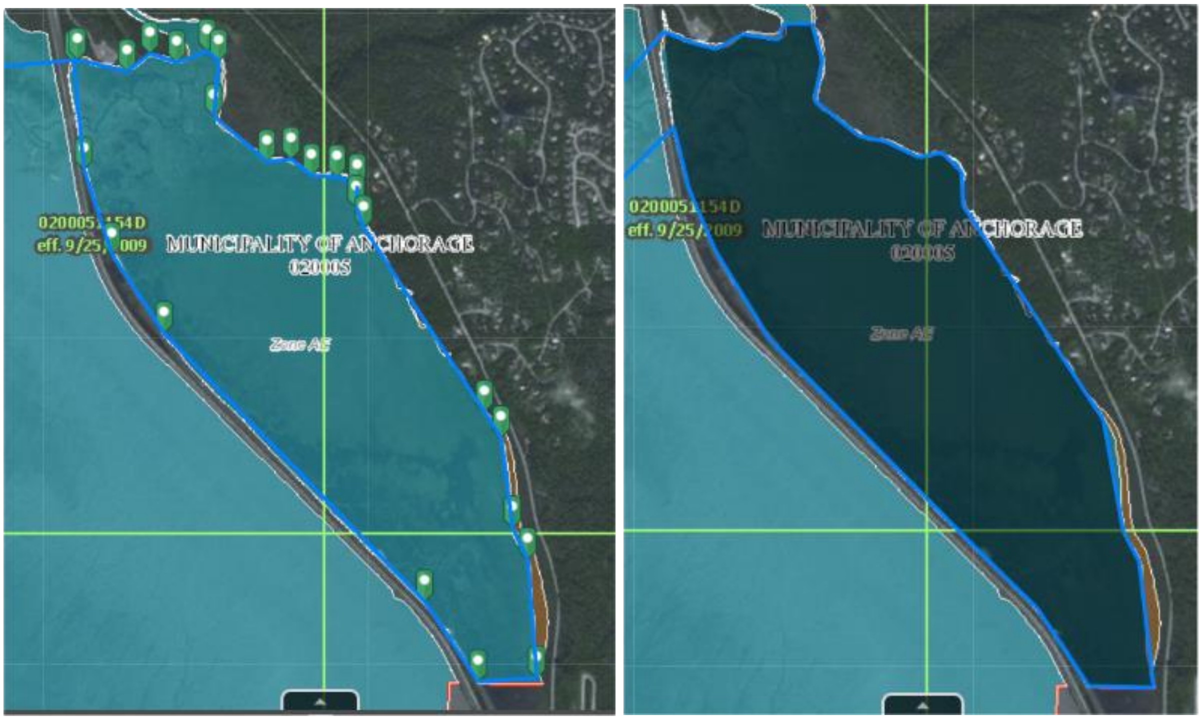


Figure B.2: Zone AE Perimeter and Area from FEMA

Floodplain Level

Variables:

P is wetted perimeter of zone AE

A_AE is area of zone AE

R is hydraulic radius

H is height of floodplain

d is diameter of the piles

h is height of the piles

n is number of piles

Figure B.1 $H := 16\ ft$

Figure B.2 $P := 20855\ ft$ $A := 17030804\ ft^2$

$d := 3.5\ in$ $h := 8\ ft$ $n := 542$

$$R := \frac{A}{P} = 816.629\ ft$$

$$V_{floodplain} := A \cdot H = \left(2.725 \cdot 10^{8}\right)\ ft^3$$

$$V_{walk} := 22348.7933\ ft^2 \cdot 1\ ft = \left(2.235 \cdot 10^{4}\right)\ ft^3$$

$$V_{piles} := \pi \cdot \left(\frac{d}{2}\right)^2 \cdot h \cdot n = 88.301\ m \cdot ft^2$$

$$V_{total} := V_{floodplain} + V_{walk} + V_{piles} = \left(2.725 \cdot 10^{8}\right)\ ft^3$$

$$\frac{V_{total}}{A} = 16.001\ ft$$

Figure B.3: Floodplain Level Calculations

	Flow (cfs)					
Month	Little Susitna River	Willow Creek	Rabbit Creek	Little Rabbit Creek	Little Survival Creek	Terror River
Jan	29.4	80.6	10.7	2.6	0.7	60.0
Feb	23.3	67.2	7.8	2.0	0.7	60.0
Mar	19.2	57.7	7.1	1.8	0.7	60.0
Apr	22.0	67.1	9.7	2.6	0.7	100.0
May	207.6	338.8	16.2	5.4	1.2	150.0
Jun	212.0	338.8	19.8	5.4	1.2	150.0
Jul	240.4	700.0	19.8	5.4	1.2	150.0
Aug	212.0	550.0	19.8	5.4	1.2	150.0
Sep	212.0	338.8	19.8	5.4	1.2	150.0
Oct	130.3	263.5	19.8	5.4	1.2	150.0
Nov 1-15	60.4	141.5	18.3	5.3	1.2	100.0
Nov 16-30	60.4	141.5	18.3	5.3	1.2	60.0
Dec	38.0	97.7	13.3	3.2	1.2	60.0

Figure B.4: Instream Flow from Alaska Department of Fish and Game

Figure B.5: Measurement of the Culverts

Steady-State Continuity Equation:

Variables:

A_1 is area of rivers

V_1 velocity of the rivers

A_2 is the area of the culverts

V_2 is velocity of the culverts

$$Q = A \cdot V$$

$$A_1 \cdot V_1 = A_2 \cdot V_2$$

Figure B.4

$$Q_{LRC} := 5.4 \ \frac{ft^3}{s} \qquad Q_{LSC} := 1.2 \ \frac{ft^3}{s} \qquad Q_{RC} := 19.8 \ \frac{ft^3}{s}$$

$$Q_1 := Q_{LRC} + Q_{RC} + Q_{LSC} = 26.4 \ \frac{ft^3}{s}$$

Figure B.5

$$d := \frac{(20.06 \ ft)}{3} = 6.687 \ ft$$

$$A_2 := 3 \cdot \left(\pi \cdot \left(\frac{d}{2} \right)^2 \right) = 105.349 \ ft^2 \qquad V_2 := \frac{Q_1}{A_2} = 0.251 \ \frac{ft}{s}$$

Figure B.6: Outflow Velocity Calculations using Steady-State Continuity Equation

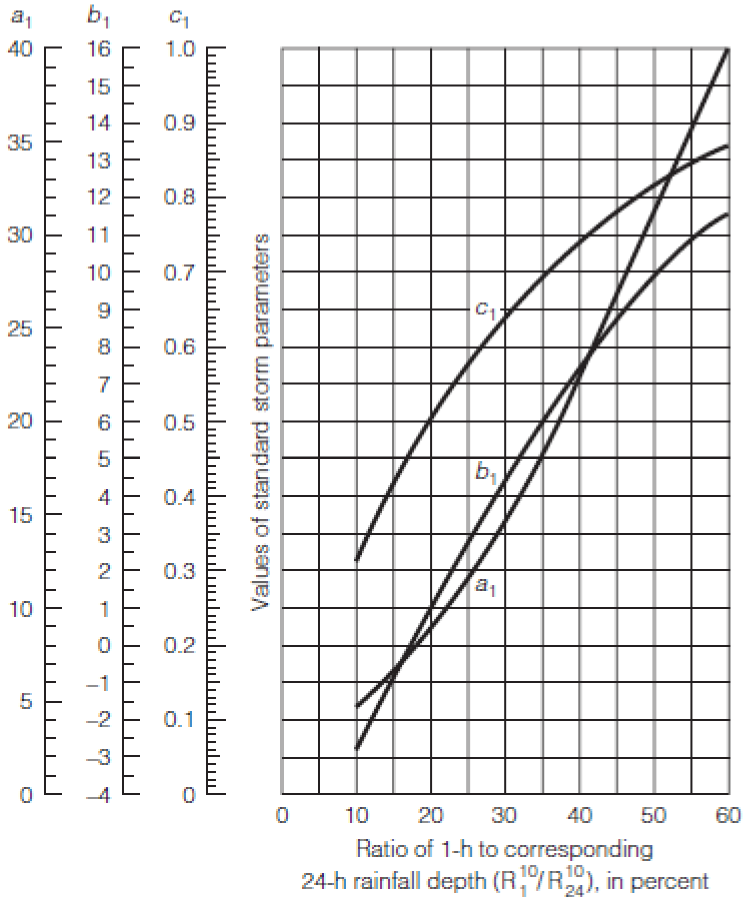


Figure B.7: Constants in Chen IDF Curve

Rainfall Intensity:

Variables:				
	T_a	Annual series	R_{1_10}	10-year 1-hour rainfall
	T_p	Partial-duration series	R_{24_10}	10-year 24-hour rainfall
	t	Rainfall Duration	R_{1_100}	100-year 1-hour rainfall

$R_{1\_10} := 0.45$

$R_{24\_10} := 2.5$

$R_{1\_100} := 0.61$

Values retrieved from Consortium Library, Department of Commerce, Technical Paper No. 47 Probable Maximum Precipitaion and Rainfall-Frequency Data for Alaska

$T_a := 25$ years $\qquad t := 24$ hours

Eq. 9.2 $\qquad T_p := \dfrac{-1}{\ln\left(1 - T_a^{-1}\right)} = 24.497$ years

Eq. 9.5 $\qquad x := \dfrac{R_{1\_100}}{R_{1\_10}} = 1.356$

Figure B.7 $\qquad \dfrac{R_{1\_10}}{R_{24\_10}} = 0.18$ = 18% $\qquad a_1 := 7.5 \quad b_1 := -0.25 \quad c_1 := 0.45$

Eq. 9.4 $\qquad a := a_1 \cdot R_{1\_10} \cdot \left((x-1)\log\left(\dfrac{T_p}{10}\right) + 1\right) = 3.842$

Eq. 9.3 $\qquad i = \dfrac{a}{\left(t + b_1\right)^{c_1}} \qquad i := \dfrac{3.842}{(t - 0.25)^{0.45}} = 0.924$ in./h

Figure B.8: Rainfall Intensity Calculations

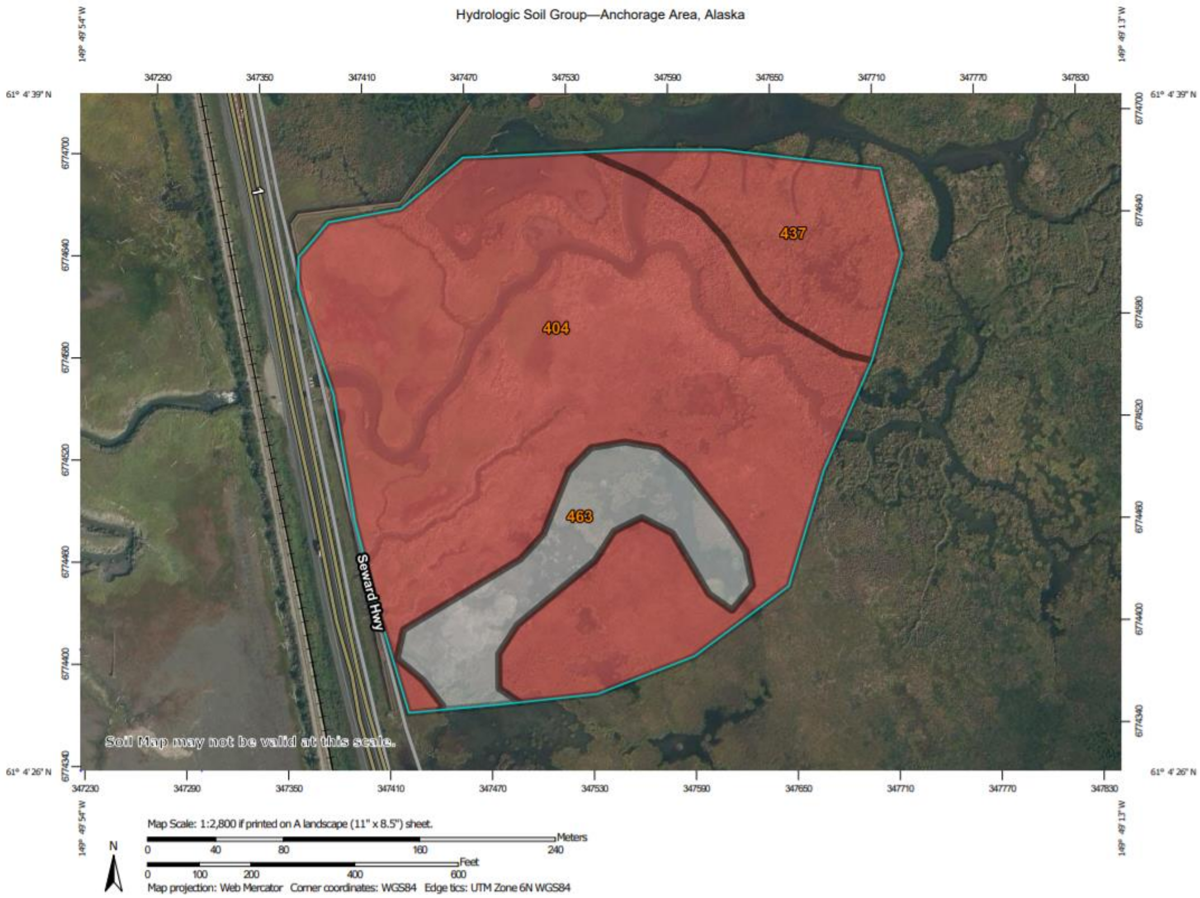
TABLE 10.7: Typical Runoff Coefficients for Return Periods of 2–10 years

Description of area	Runoff coefficient
Business:	
Downtown areas	0.70–0.95
Neighborhood areas	0.50–0.70
Residential:	
Single-family areas	0.30–0.50
Multiunits, detached	0.40–0.75
Multiunits, attached	0.60–0.75
Residential, suburban	0.25–0.40
Apartment dwelling areas	0.50–0.70
Industrial:	
Light areas	0.50–0.80
Heavy areas	0.60–0.90
Parks, cemeteries	0.10–0.25
Playgrounds	0.20–0.35
Railroad yard areas	0.20–0.35
Unimproved areas	0.10–0.30
Pavement:	
Asphalt or concrete	0.70–0.95
Brick	0.70–0.85
Semipermeable blocks	0.60–0.70
Roofs	0.75–0.95
Lawns, sandy soil:	
Flat, 2%	0.05–0.10
Average, 2%–7%	0.10–0.15
Steep, ≥7%	0.15–0.20
Lawns, heavy soil:	
Flat, 2%	0.13–0.17
Average, 2%–7%	0.18–0.22
Steep, ≥7%	0.25–0.35

Sources: ASCE (2006a); Hvitved-Jacobsen (2010).

Figure B.9: Typical Runoff Coefficients

Hydrologic Soil Group—Anchorage Area, Alaska



USDA **Natural Resources Conservation Service** | Web Soil Survey National Cooperative Soil Survey | 2/10/2020 Page 1 of 4

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:25,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Anchorage Area, Alaska
Survey Area Data: Version 15, Oct 22, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 26, 2011—Aug 29, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Figure B.10: Hydrologic Soil Group for Potter Marsh from the Natural Resource Conservation Service, USDA

TABLE 9.14: Curve Numbers for Various Urban Land Uses

Cover type and hydrologic condition		Curve numbers for hydrologic soil group A	B	C	D
Lawns, open spaces, parks, golf courses:					
Good condition: grass cover on 75% or more of the area		39	61	74	80
Fair condition: grass cover on 50%–75% of the area		49	69	79	84
Poor condition: grass cover on 50% or less of the area		68	79	86	89
Paved parking lots, roofs, driveways, etc.		98	98	98	98
Streets and roads:					
Paved with curbs and storm sewers		98	98	98	98
Gravel		76	85	89	91
Dirt		72	82	87	89
Paved with open ditches		83	89	92	93
Commercial and business areas	(85% impervious*)	89	92	94	95
Industrial districts	(72% impervious*)	81	88	91	93
Row houses, town houses, and residential with lot sizes ≤ 0.05 ha (1/8 ac)	(65% impervious*)	77	85	90	92
Residential average lot size:					
0.10 ha (1/4 ac)	(38% impervious*)	61	75	83	87
0.14 ha (1/3 ac)	(30% impervious*)	57	72	81	86
0.20 ha (1/2 ac)	(25% impervious*)	54	70	80	85
0.40 ha (1 ac)	(20% impervious*)	51	68	79	84
0.80 ha (2 ac)	(12% impervious*)	46	65	77	82
Developing urban areas (no vegetation established)					
Newly graded area		77	86	91	94
Western desert urban areas:					
Natural desert landscaping (pervious area only)		63	77	85	88
Artificial desert landscaping		96	96	96	96
Cultivated agricultural land					
Fallow					
Straight row or bare soil		77	86	91	94
Conservation tillage (Poor)		76	85	90	93
Conservation tillage (Good)		74	83	88	90

Note: *The impervious area is assumed to be directly connected to the drainage system, with the impervious area having a CN of 98, and the pervious area taken as equivalent to open space in good hydrologic condition.

Figure B.11: Curve Number

TABLE 10.8: Pond and Swamp Adjustment Factor, F_p

Percentage of pond and swamp areas	F_p
0	1.00
0.2	0.97
1.0	0.87
3.0	0.75
5.0*	0.72

Note: *If the percentage of pond and swamp areas exceeds 5%, then consideration should be given to routing the runoff through these areas.

Figure B.12: Table for Pond and Swamp Adjustment Factor

Figure B-2 Approximate geographic boundaries for NRCS (SCS) rainfall distributions

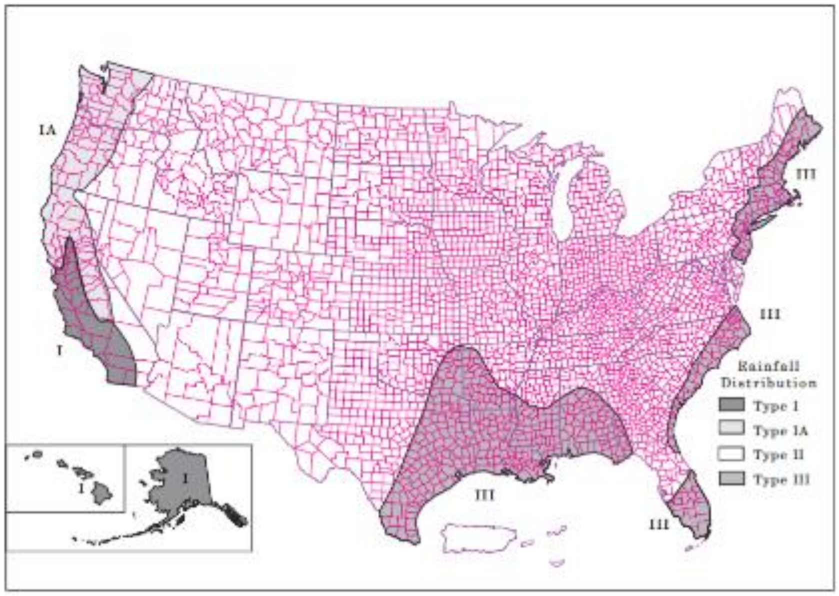


Figure B.13: Rainfall Type Distribution for the United States

TABLE 10.9: Parameters Used to Estimate Unit Peak Discharge, q_u

Rainfall type	I_a/P	C_o	C_1	C_2
I	0.10	2.30550	−0.51429	−0.11750
	0.20	2.23537	−0.50387	−0.08929
	0.25	2.18219	−0.48488	−0.06589
	0.30	2.10624	−0.45695	−0.02835
	0.35	2.00303	−0.40769	0.01983
	0.40	1.87733	−0.32274	0.05754
	0.45	1.76312	−0.15644	0.00453
	0.50	1.67889	−0.06930	0.0
IA	0.10	2.03250	−0.31583	−0.13748
	0.20	1.91978	−0.28215	−0.07020
	0.25	1.83842	−0.25543	−0.02597
	0.30	1.72657	−0.19826	0.02633
	0.50	1.63417	−0.09100	0.0
II	0.10	2.55323	−0.61512	−0.16403
	0.30	2.46532	−0.62257	−0.11657
	0.35	2.41896	−0.61594	−0.08820
	0.40	2.36409	−0.59857	−0.05621
	0.45	2.29238	−0.57005	−0.02281
	0.50	2.20282	−0.51599	−0.01259
III	0.10	2.47317	−0.51848	−0.17083
	0.30	2.39628	−0.51202	−0.13245
	0.35	2.35477	−0.49735	−0.11985
	0.40	2.30726	−0.46541	−0.11094
	0.45	2.24876	−0.41314	−0.11508
	0.50	2.17772	−0.36803	−0.09525

Figure B.14: Parameters Used in Estimating Peak Discharge

Figure B.15: Length of the Flow

Peak-Runoff Models:

The Rational Method

Variables:

C	Runoff Coefficient (dimensionless)		
A	Area of the catchment (L^2)	$A = 1582213.465\ m^2$	
i	Rainfall intensity (LT^-1)	$i := 0.924\ \frac{in}{hr}$	
Q_p	Peak-runoff rate (L^3T^-1)		

Figure B.9 $C := 0.2$ Unimproved area

Eq. 10.35 $Q_{p\_RM} := C \cdot i \cdot A = 72.854\ \frac{ft^3}{s}$

NRCS-TR55 Method

Variables: CN Curve Number

Figure B.10 Hydrologic Soil Group D

Figure B.11 $CN := 80$ Open Sapce, Good Condition: grass cover on more than 75% of area

Eq. 9.81 $S := \frac{1}{0.0394} \cdot \left(\frac{1000}{CN} - 10\right) = 63.452$ Note: equation is rearranged and S is in mm

$i := 0.924\ \frac{in}{hr}$ $t := 24\ hr$

$P := i \cdot t = 56.327\ cm$

Eq. 9.80 $P = 563.27\ mm$ > $S \cdot 0.2\ mm = 12.69\ mm$

$$Q := \frac{(P - 0.2\ mm\ S)^2}{P + 0.8\ mm\ S} = 493.685\ mm$$

Figure B.12 $F_p := 0.72$ Percentage of pond area exceed 5%

Eq. 10.47 $I_a := 0.2\ mm \cdot S = 12.69\ mm$

Figure B.13 Type I Rainfall

Figure B.14 $\frac{I_a}{P} = 0.023$ If Ia/P < 0.1, values of C0, C1, and C2 corresponding to Ia/P = 0.1

$C_0 := 2.30550$ $C_1 := -0.51429$ $C_2 := -0.11750$

$i := 0.924$ $C = 0.2$

Eq. 10.36 $i_e := C \cdot i = 0.185$

Figure B.15 $L := 2670$ ft

Can't use the Kerby equation because L > 365 m

Can't use the Izzard equation because i_e* L > 3.9 m^2/h

$S_0 := 0.0025$ Slope of marsh is very small thus using 0.25% slope

Kirpich Equation $t_c := 0.019 \cdot \frac{L^{0.77}}{S_0^{\ 0.385}} = 82.978$ t_c has to be in hrs

Eq. 10.46 $q_u := 10^{\left(C_0 + C_1 \cdot \log(t_c) + C_2 \cdot (\log(t_c))^2 - 2.366\right)} = 0.033$

$q_u := 0.033 \frac{\left(\frac{m^3}{s}\right)}{cm \cdot km^2}$

Eq. 10.45 $q_p := q_u \cdot A \cdot Q \cdot F_p = 1.856 \frac{m^3}{s}$ $q_p = 65.542 \frac{ft^3}{s}$

Figure B.16: Peak Runoff Calculations

Appendix C. Structural Analysis

Seismic Loads- Tower

Assume site class D, risk category II

$I_e := 1.0$ (Table 1.5-2)

$S_s := 1.5$ (Figure 22-3)

$S_1 := 0.682$ https://hazards.atcouncil.org/

$F_a := 1.0$ (Table 11.4-1)

$F_v := 1.7$ (Table 11.4-2)

$S_{MS} := F_a \cdot S_s = 1.5$

$S_{M1} := F_v \cdot S_1 = 1.159$

$S_{DS} := \frac{2}{3} \cdot S_{MS} = 1$ 11.4-3

$S_{D1} := \frac{2}{3} \cdot S_{M1} = 0.773$ 11.4-4

$R := 4.5$ Table 15.4-1 steel intermediate moment frame

Period Approximation

$T_L := 16\ s$ 22-15 figure

$C_t := 0.02$ 12.8-2 table (all other systems)

$x := 0.75$

$h_n := 25\ ft$

$T_a := C_t \cdot \left(\frac{h_n}{ft}\right)^x \cdot sec = 0.224\ s$ 12.8-7 (approximation)

$T_a := 0.127\ s$ (Actual period RISA)

$T_a < T_L = 1$

Find response coeff

$$C_{s1} := \frac{S_{DS}}{\left(\frac{R}{I_e}\right)} = 0.222$$ 12.8-2

$$C_{smax} := \frac{S_{D1}}{\frac{T_a}{s} \cdot \left(\frac{R}{I_e}\right)} = 1.352$$ 12.8-3

$$C_{smin} := \frac{\left(0.8\ S_1\right)}{\left(\frac{R}{I_e}\right)} = 0.121$$ 15.4-2

$$C_s := C_{s1} = 0.222$$

Seismic Weight

$grate := 6.21\ plf$ Plates (grating)

$W_{grate} := 78\ ft \cdot grate = 0.484\ kip$

$W_{steel} := 12.8\ kip$

$W_{wood} := 2.9\ kip$

$W_{tower} := W_{steel} + W_{wood} + W_{grate} = 16.184\ kip$

$$V_{tower} := C_s \cdot W_{tower} = 3.597\ kip$$

Seismic Loads- boardwalk

Assume site class D, risk category I

$I_e := 1.0$ (Table 1.5-2)

$S_s := 1.5$ (Figure 22-3)

$S_1 := 0.75$ (Figure 22-4)

$F_a := 1.0$ (Table 11.4-1)

$F_v := 1.7$ (Table 11.4-2)

$S_{MS} := F_a \cdot S_s = 1.5$

$S_{M1} := F_v \cdot S_1 = 1.275$

$S_{DS} := \frac{2}{3} \cdot S_{MS} = 1$ 11.4-3

$S_{D1} := \frac{2}{3} \cdot S_{M1} = 0.85$ 11.4-4

$R := 2$ Table 15.4-2 amusement structures and momuments

Period Approximation

$T_L := 16\ s$ 22-15 figure

$C_t := 0.2$ 12.8-2 table (all other systems)

$x := 0.75$

$h_n := 12\ ft$

$$T_a := C_t \cdot \left(\frac{h_n}{ft}\right)^x \cdot sec = 1.289\ s$$

$T_a < T_L = 1$

Find response coeff

$$C_{s1} := \frac{S_{DS}}{\left(\frac{R}{I_e}\right)} = 0.5$$ 12.8-2

$$C_{s2} := \frac{S_{D1}}{\frac{T_a}{s} \cdot \left(\frac{R}{I_e}\right)} = 0.33$$ 12.8-3

$$C_{smin} := \frac{\left(0.8\ S_1\right)}{\left(\frac{R}{I_e}\right)} = 0.3$$

$C_s := C_{s2} = 0.33$

Line load boardwalk

$W_{steel} := 1.6\ kip$ $W_{wood} := 0.9\ kip$ $L_{boardwalk} := 10\ ft$

$W_b := W_{steel} + W_{wood} = 2.5\ kip$

$V_{boardwalk} := C_s \cdot W_b = 0.824\ kip$

$\frac{V_{boardwalk}}{L_{boardwalk}} = 82.397\ plf$

Line Load donut bridge

$W_{steel} := 7.1\ kip$ $W_{wood} := 6\ kip$ $L_{donut} := 40\ ft$

$W_d := W_{steel} + W_{wood} = 13.1\ kip$

$V_{donut} := C_s \cdot W_d = 4.318\ kip$

$\frac{V_{donut}}{L_{donut}} = 107.94\ plf$

Line Load platform

$W_{steel} := 2.4\ kip$ $W_{wood} := 2.6\ kip$ $L_{platform} := 240\ in$

$W_p := W_{steel} + W_{wood} = 5\ kip$

$V_{platform} := C_s \cdot W_p = 1.648\ kip$

$\frac{V_{platform}}{L_{platform}} = 82.397\ plf$

Drift

Allowable Story Drift

$h_{sx} := 292\ in$ height of Risa model tower

$\Delta_a := 0.025\ h_{sx} = 7.3\ in$ Table 12.12-1 Risk Category II

Flat Roof Snow Load

$C_e := 0.8$ (Table 7.3-1 ASCE 7, Assuming roughness D)

$C_t := 1.2$ (Table 7.3-2 ASCE 7)

$I_s := 1.0$ (Table 1.5-2: risk category II for snow

$p_g := 50\ psf$ because not as many ppl in winter)

$100\ psf = 0.1\ ksf$

$p_f := 0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g = 33.6\ psf$

Live Load

Platform and tower top level: 100psf (P14 ASCE 7)
Walkways and elevated platforms: 60psf
Terraces- pedestrian: 100psf

IDK what boardwalk would be considered- hamel said pedestrian bridge

*Negate holes in decking for applying live load, because live load is already conservative as is

Wind Load- tower

(Zone III https://librarystage.municode.com/ak/anchorage)

$V := 155$ mph

(or basic wind speed -26.5-1B Risk Category II)

(Use exposure D section 26.7.3)

$K_z := 1.08$ (Table 26.10-1 assume median 20ft above ground)

$K_{zt} := 1.0$ (unsure how to consider hills/escarpments in area- section 26.8)

$K_d := 0.85$ (Wind directionality factor Table 26.6-1)

$K_e := 1.0$ (26.9)

$q_z := 0.00256\ \textbf{psf}\ K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 56.461\ \textbf{psf}$

$G := 0.85$ (26.11.1)

Solving for Cf

$A_{rail} := 9284\ \textbf{in}^2$ $A_{col} := 6500\ \textbf{in}^2$

$A_{brace} := 5901\ \textbf{in}^2$ $A_{frame} := 4104\ \textbf{in}^2$

$A_{stairs} := \left(1344\ \textbf{in}^2 + 2084\ \textbf{in}^2\right) = \left(3.428 \cdot 10^3\right)\ \textbf{in}^2$

$A_{solid} := A_{rail} + A_{brace} + A_{stairs} + A_{col} + A_{frame} = \left(2.922 \cdot 10^4\right)\ \textbf{in}^2$ (Total solid area for Tower face in YZ direction)

$A_{gross} := 80726\ \textbf{in}^2$

$\varepsilon := \dfrac{A_{solid}}{A_{gross}} = 0.362$

$C_f := 4.0\ \varepsilon^2 - 5.9\ \varepsilon + 4.0 = 2.389$ (Figure 29.4-3)

$A_f := A_{solid} = (2.922 \cdot 10^4)\ in^2$

$F := q_z \cdot G \cdot C_f \cdot A_f = 23.258\ kip$ (equation 29.4-1)

$q_{tower} := \frac{F}{A_f} = 0.115\ ksf$ (area load for tower)

$b_{col} := 6.5\ in$ $b_{frame} := 6\ in$ $b_{rail2} := 1.5\ in$

$b_{brace} := 7\ in$ $b_{stairs} := 7\ in$ $b_{rail4} := 3.5\ in$

$b_{rail5} := 4.5\ in$

$w_{brace} := q_{tower} \cdot b_{brace} = 66.869\ plf$

$w_{col} := q_{tower} \cdot b_{col} = 62.092\ plf$

$w_{frame} := q_{tower} \cdot b_{frame} = 57.316\ plf$

$w_{stairs} := q_{tower} \cdot 0.3 = 34.39\ psf$

$w_{rail2} := q_{tower} \cdot b_{rail2} = 14.329\ plf$

$w_{rail4} := q_{tower} \cdot b_{rail4} = 33.434\ plf$

$w_{rail5} := q_{tower} \cdot b_{rail5} = 42.987\ plf$

Wind Load - boardwalk

$V := 155$ mph (Zone III https://librarystage.municode.com/ak/anchorage

(Use exposure D section 26.7.3)

$K_z := 1.03$ (Table 26.10-1 assume median 0-15ft above ground)

$K_{zt} := 1.0$ (unsure how to consider hills/escarpments in area-section 26.8)

$K_d := 0.85$ (Wind directionality factor Table 26.6-1)

$K_e := 1.0$ (26.9)

$q_z := 0.00256\ psf\ K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 53.847\ psf$

$G := 0.85$ (26.11.1)

$\varepsilon := \frac{5123}{17880} = 0.287$ (ratio of solid area to gross area of one solid face)

$C_f := 1.8$ (Figure 29.2-4 for flat sided members assuming E between 0.1 and 0.29)

$F := q_z \cdot G \cdot C_f \cdot A_f = 16.716\ kip$ (equation 29.4-1)

$q_{board} := \frac{F}{A_f} = 0.082\ ksf$ (area load for boardwalk)

$b_{col} := 6\ in$ $b_{joist} := 12\ in$ $b_{rail2} := 1.5\ in$

$b_{rail4} := 3.5\ in$

$b_{rail5} := 4.5\ in$

$w_{col} := q_{board} \cdot b_{col} = 41.193\ plf$

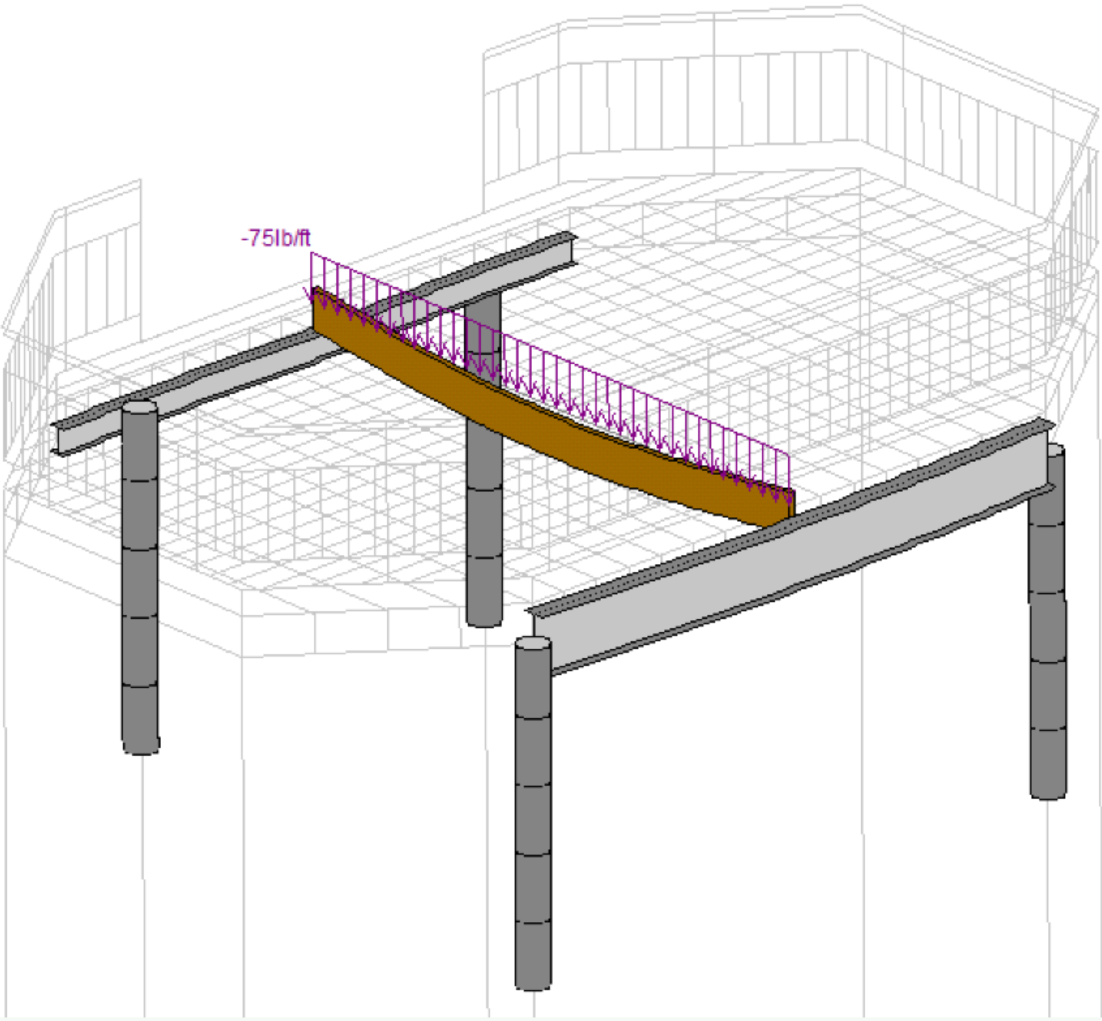
$w_{joist} := q_{board} \cdot b_{joist} = 82.386\ plf$

$w_{rail2} := q_{board} \cdot b_{rail2} = 10.298\ plf$

$w_{rail4} := q_{board} \cdot b_{rail4} = 24.029\ plf$

$w_{rail5} := q_{board} \cdot b_{rail5} = 30.895\ plf$

Member Calculation



NDS 2018

$C_t := 1.0$
$C_M := 1.0$
$C_L := 1.0$
$C_F := 1.1$
$C_{fu} := 1.0$
$C_i := 0.8$
$C_{i\_E} := 0.95$
$C_r := 1.15$
$\lambda := 0.8$
$\phi_b := 0.85$ $\quad K_{F\_b} := 2.54$
$\phi_v := 0.8$ $\quad K_{F\_b} := 2.70$

NDS - supp

$b := 1.5\ \mathbf{in}$
$d := 9.25\ \mathbf{in}$

$S_{xx} := 21.39\ \mathbf{in}^3$
$A := 13.88\ \mathbf{in}^2$
$I_{xx} := 98.93\ \mathbf{in}^4$

Assumption:

moisture content 19%
Incieced
$L := 12\ \mathbf{ft}$

Size Category: Dimension Lumber
DF-L No.2
Reference Design Values:

$F_b := 900\ \mathbf{psi}$
$F_v := 180\ \mathbf{psi}$
$E := 1600000\ \mathbf{psi}$

Adjusted LRFD values:

$$F'_{bn} := F_b \cdot C_M \cdot C_t \cdot C_L \cdot C_F \cdot C_{fu} \cdot C_i \cdot C_r \cdot K_{F\_b} \cdot \phi_b \cdot \lambda$$

$$F'_{bn} = 240.801\ \boldsymbol{ksf}$$

$$F'_{vn} := F_v \cdot C_M \cdot C_t \cdot C_i \cdot K_{F\_b} \cdot \phi_b \cdot \lambda$$

$$F'_{vn} = 0.264\ \boldsymbol{ksi}$$

Adjusted moment and shear resistances:

$$M'_n := F'_{bn} \cdot S_{xx} = 2.981\ \boldsymbol{kip \cdot ft}$$

$$V'_n := \frac{2}{3}\ F'_{vn} \cdot A = 2.446\ \boldsymbol{kip}$$

Factored LRFD moment and shear from risa model

$LL := 75\ \boldsymbol{plf}$

$SL := 18.9\ \boldsymbol{plf}$

$DL := 2.4\ \boldsymbol{plf}$

$$w_u := 1.2 \cdot DL + 1.6 \cdot LL + 0.5 \cdot SL$$

$$M_u := \frac{w_u \cdot L^2}{8} = 2.382\ \boldsymbol{kip \cdot ft}$$

$$V_u := \frac{w_u \cdot L}{2} = 0.794\ \boldsymbol{kip}$$

$$\Delta_{Total} := \frac{5 \cdot (LL + DL) \cdot L^4}{384 \cdot E \cdot I_{xx}} = 0.228\ \boldsymbol{in}$$

$$\Delta_{Live} := \frac{5 \cdot (LL) \cdot L^4}{384 \cdot E \cdot I_{xx}} = 0.221\ \boldsymbol{in}$$

CHECK!

$\Delta_{Total} = 0.228\ \boldsymbol{in}$ < $\Delta_S := \frac{L}{360} = 0.4\ \boldsymbol{in}$

$\Delta_{Live} = 0.221\ \boldsymbol{in}$ < $\Delta_{DS} := \frac{L}{240} = 0.6\ \boldsymbol{in}$

GOOD!!!

$M_u = 2.382\ \boldsymbol{kip \cdot ft}$ < $M'_n = 2.981\ \boldsymbol{kip \cdot ft}$

$V_u = 0.794\ \boldsymbol{kip}$ < $V'_n = 2.446\ \boldsymbol{kip}$

GOOD!!!

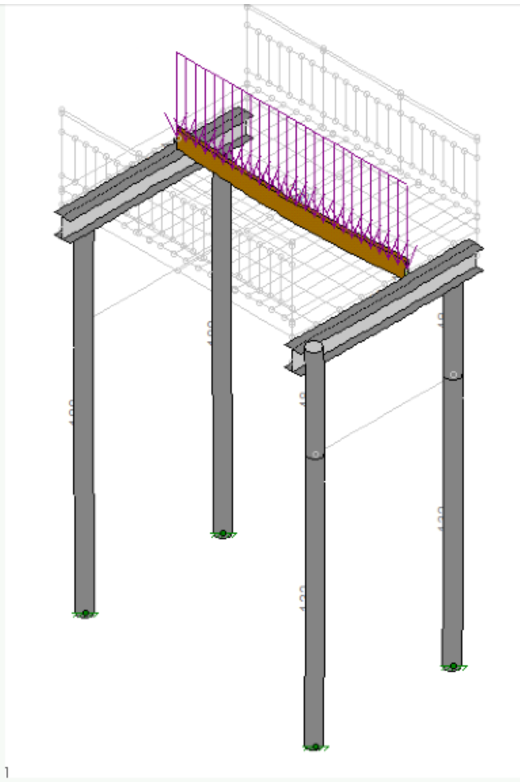
NDS 2018

$C_t := 1.0$
$C_M := 1.0$
$C_L := 1.0$
$C_F := 1.1$
$C_{fu} := 1.0$
$C_i := 0.8$
$C_{i\_E} := 0.95$
$C_r := 1.15$
$\lambda := 0.8$
$\phi_b := 0.85$ $K_{F\_b} := 2.54$
$\phi_v := 0.8$ $K_{F\_b} := 2.70$

NDS - supp

$b := 1.5\ in$
$d := 9.25\ in$

$S_{xx} := 21.39\ in^3$
$A := 13.88\ in^2$
$I_{xx} := 98.93\ in^4$



Assumption:
moisture content 19%
Incieced
$L := 10\ ft$

Size Category: Dimension Lumber
DF-L No.2
Reference Design Values:

$F_b := 900\ psi$
$F_v := 180\ psi$
$E := 1600000\ psi$

Adjusted LRFD values:

$F'_{bn} := F_b \cdot C_M \cdot C_t \cdot C_L \cdot C_F \cdot C_{fu} \cdot C_i \cdot C_r \cdot K_{F\_b} \cdot \phi_b \cdot \lambda$

$F'_{bn} = 240.801\ ksf$

$F'_{vn} := F_v \cdot C_M \cdot C_t \cdot C_i \cdot K_{F\_b} \cdot \phi_b \cdot \lambda$

$F'_{vn} = 0.264\ ksi$

Adjusted moment and shear resistances:

$M'_n := F'_{bn} \cdot S_{xx} = 2.981\ kip \cdot ft$

$V'_n := \frac{2}{3} F'_{vn} \cdot A = 2.446\ kip$

Factored LRFD moment and shear from risa model

$LL := 100\ plf$
$SL := 25.2\ plf$
$DL := 2.4\ plf$

$w_u := 1.2 \cdot DL + 1.6 \cdot LL + 0.5 \cdot SL$

$$M_u := \frac{w_u \cdot L^2}{8} = 2.194\ kip \cdot ft$$

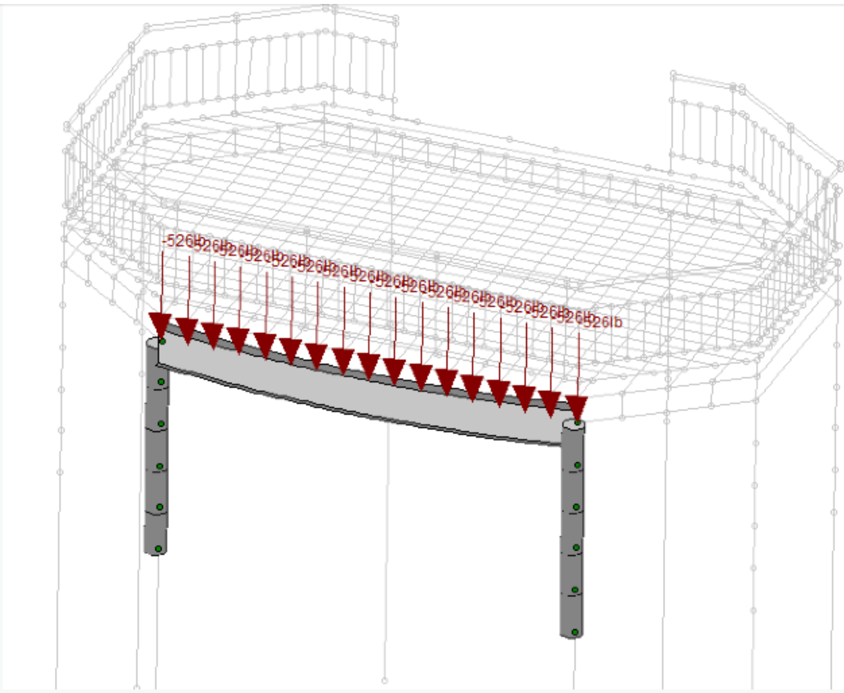
$$V_u := \frac{w_u \cdot L}{2} = 0.877\ kip$$

$$\Delta_{Total} := \frac{5 \cdot (LL + DL) \cdot L^4}{384 \cdot E \cdot I_{xx}} = 0.146\ in$$

$$\Delta_{Live} := \frac{5 \cdot (LL) \cdot L^4}{384 \cdot E \cdot I_{xx}} = 0.142\ in$$

CHECK!

$\Delta_{Total} = 0.146\ in$	<	$\Delta_S := \frac{L}{360} = 0.333\ in$	
$\Delta_{Live} = 0.142\ in$	<	$\Delta_{DS} := \frac{L}{240} = 0.5\ in$	GOOD!!!
$M_u = 2.194\ kip \cdot ft$	<	$M'_n = 2.981\ kip \cdot ft$	
$V_u = 0.877\ kip$	<	$V'_n = 2.446\ kip$	GOOD!!!



$F_y := 50\ \boldsymbol{ksi}$

$E := 29000\ \boldsymbol{ksi}$

$\phi := 0.9$

$L := 12\ \boldsymbol{ft}$

$c := 1.0$

AISC 15th, W14X22

$Z_x := 33.2\ \boldsymbol{in}^3$ $S_x := 29\ \boldsymbol{in}^3$ $I_x := 199\ \boldsymbol{in}^4$ $r_y := 1.04\ \boldsymbol{in}$ $t_w := 0.23\ \boldsymbol{in}$

$r_{ts} := 1.27\ \boldsymbol{in}$ $h_o := 13.4\ \boldsymbol{in}$ $J := 0.208\ \boldsymbol{in}^4$ $d := 13.7\ \boldsymbol{in}$ $b\_2t_f := 7.46$

$h\_t_w := 53.3$ $h_c := 11.625\ \boldsymbol{in}$

$LL := 600\ \boldsymbol{plf}$
$SL := 151.2\ \boldsymbol{plf}$
$DL := 22\ \boldsymbol{plf} + 2.4\ \boldsymbol{plf}$

$w_u := 1.2 \cdot DL + 1.6 \cdot LL + 0.5 \cdot SL$

$M_u := \frac{w_u \cdot L^2}{8} = 19.168\ \boldsymbol{kip \cdot ft}$

$\Delta_{total} := \frac{5 \cdot (LL + DL) \cdot L^4}{384 \cdot E \cdot I_x} = 0.05\ \boldsymbol{in}$

$V_u := \frac{w_u \cdot L}{2}$

$\Delta_{Live} := \frac{5 \cdot (LL) \cdot L^4}{384 \cdot E \cdot I_x} = 0.049\ \boldsymbol{in}$

Flanges (Case 10)

$\lambda_f := b\_2t_f = 7.46$ < $\lambda_{pf} := 0.38 \cdot \sqrt{\frac{E}{F_y}} = 9.152$ Compact

Web (Case 15)

$\lambda := h\_t_w = 53.3$ < $\lambda_p := 3.76 \cdot \sqrt{\frac{E}{F_y}} = 90.553$ Compact

Check Yield and LTB (Table F1.1)

Yielding

$M_p := F_y \cdot Z_x = 138.333\ \boldsymbol{kip \cdot ft}$ AISC 15th, F2-1

Lateral-Torsional Buckling

$L_b := L = 12\ \boldsymbol{ft}$

$$L_p := 1.76 \cdot r_y \cdot \sqrt{\frac{E}{F_y}}$$ AISC 15th, F2-5

$$L_r := 1.95 \cdot r_{ts} \cdot \left(\frac{E}{0.7 \cdot F_y}\right) \cdot \sqrt{\left(\frac{J \cdot c}{S_x \cdot h_o}\right) + \sqrt{\left(\frac{J \cdot c}{S_x \cdot h_o}\right)^2 + 6.76 \cdot \left(\frac{(0.7\ F_y)}{E}\right)^2}}$$ AISC 15th, F2-6

$L_p = 44.082\ \boldsymbol{in}$ < $L_b = 144\ \boldsymbol{in}$ > $L_r = 125.127\ \boldsymbol{in}$ AISC 15th, use F2-3

$C_b := 1.14$ AISC 15th, tabe 3-1

$$F_{cr} := \frac{C_b \cdot \pi^2 \cdot E}{\left(\frac{L_b}{r_{ts}}\right)^2} \left(\sqrt{1 + \left(0.078 \cdot \left(\frac{J \cdot c}{S_x \cdot h_o}\right) \cdot \left(\frac{L_b}{r_{ts}}\right)^2\right)}\right) = 31.462\ \boldsymbol{ksi}$$

$M_n := F_{cr} \cdot S_x = 76.033\ \boldsymbol{kip \cdot ft}$ AISC 15th, F2-3

$M_n := min\left(M_n, M_p\right) = 76.033\ \boldsymbol{kip \cdot ft}$ LTB Governs

$\phi M_n := M_n \cdot \phi = 68.43\ \boldsymbol{kip \cdot ft}$ > $M_u = 19.168\ \boldsymbol{kip \cdot ft}$ moment is good

Check Shear

Webs

$h\_t_w = 53.3$ < $2.24 \cdot \sqrt{\frac{E}{F_y}} = 53.946$

AISC 15th, Use G2.2

$\phi_v := 1.0$ $C_{v1} := 1.0$

$A_w := d \cdot t_w = 3.151\ in^2$

$V_n := 0.6 \cdot F_y \cdot A_w \cdot C_{v1} = 94.53\ kip$ AISC 15th, G2.1

$\phi V_n := V_n \cdot \phi = 85.077\ kip$ > $V_u = 6.389\ kip$ Shear is good

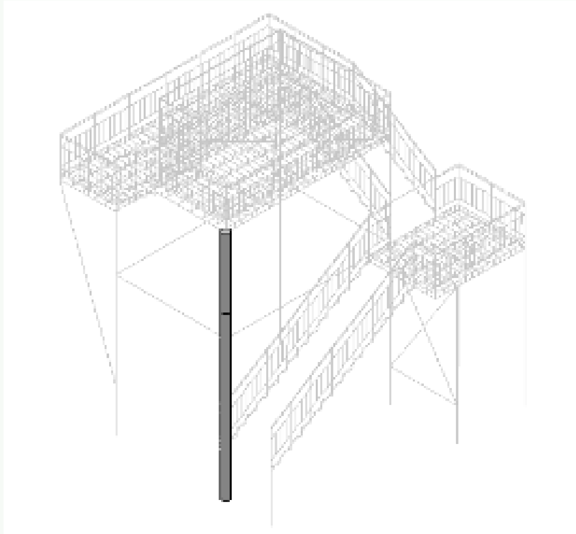
Check Deflection With LL Limit Equal to L/360 and TL Limit Equal to L/240
Using AISC Beam Tables For Deflection (Case 7 & 9)

$\Delta_{total} = 0.05\ in$ < $\frac{L}{240} = 0.6\ in$

$\Delta_{Live} = 0.049\ in$ < $\frac{L}{360} = 0.4\ in$

Deflection is good

Column Buckling Calcs



$E := 29000\ ksi$

$F_y := 46\ ksi$ A500 Gr. C

$\phi_c := 0.9$

$L_{top} := 99\ in$
$L_{bot} := 50\ in$
$L_{mid} := 100.5\ in$ $I_{xbm} := 32.4\ in^4$
$A_g := 6.88\ in^2$ $I_{xst} := 71.8\ in^4$
$I_{col} := 34\ in^4$
$r := 2.22\ in$

Effective Length
mid section

$$G_{bot} := \left(\frac{I_{col}}{L_{bot}} + \frac{I_{col}}{L_{mid}}\right) \cdot \left(\frac{1}{\frac{I_{xst}}{182\ in}}\right) = 2.581$$ (C-A-7-3)

$$G_{top} := \left(\frac{I_{col}}{L_{top}} + \frac{I_{col}}{L_{mid}}\right) \cdot \left(\frac{1}{\frac{I_{xbm}}{177.5\ in}}\right) = 3.735$$ (C-A-7-3)

$K_{mid} := 1.85$ (Fig C-A-7-2) sidesway uninhibited top section

$G_{top} := 10$ (hinge)

$$G_{bot} := \left(\frac{I_{col}}{L_{top}} + \frac{I_{col}}{L_{mid}}\right) \cdot \left(\frac{1}{\frac{I_{xbm}}{177.5\ in}}\right) = 3.735$$ (C-A-7-3)

$K_{top} := 2.41$ (Fig C-A-7-2) sidesway uninhibited

Find Slenderness

$$L\_r_{top} := K_{top} \cdot \frac{L_{top}}{r} = 107.473$$ governs

$$L\_r_{mid} := K_{mid} \cdot \frac{L_{mid}}{r} = 83.75$$

$$test := 4.71 \cdot \sqrt{\frac{E}{F_y}} = 118.261$$

$L\_r_{top} < test = 1$ not globally slender

Find column capacity

$$F_e := \frac{(\pi^2 \cdot E)}{(L\_r_{top})^2} = 24.78\ ksi$$ (E3-4)

$$F_{cr} := 0.658^{\left(\frac{F_y}{F_e}\right)} \cdot F_y = 21.151\ ksi$$ (E3-2)

$$\phi_c P_n := \phi_c \cdot F_{cr} \cdot A_g = 130.964\ kip$$ (E3-1)

$\phi_c P_n = 130.964\ kip$

Local Buckling

$D\_t := 19.0$

$$\lambda_r := 0.11 \cdot \frac{E}{F_y} = 69.348$$ no slender elements

Load on column
(conservatively)

$L_1 := 108\ in$

$L_2 := 76\ in$
$DL := 4\ kip$ (Conservative estimation)
$LL := 100\ psf$
$SL := 34\ psf$

$$L_{total} := (L_1 \cdot L_2) \cdot (1.6\ LL + 0.5\ SL) + 1.2\ DL = 14.889\ kip$$

$\phi_c P_n = 130.964\ kip$ > $L_{total} = 14.889\ kip$ Buckling Capacity good.