BYU ENGINEERING
Civil & Construction Engineering

CAPSTONE

TIMES AND SEASONS BUILDING PLATFORM DESIGN
PROJECT ID: CEEN_CPST_004

by

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A Capstone Project Final Report

Submitted to

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I Dig Nauvoo

Department of Civil and Construction Engineering
Brigham Young University

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Executive Summary

PROJECT TITLE: TIMES AND SEASONS BUILDING PLATFORM DESIGN
PROJECT ID: CEEn_CPST_004
PROJECT SPONSOR: I Dig Nauvoo
TEAM NAME: CSW Engineering

In 2021, the basement and foundation of one of the Times and Seasons Print Shops in Nauvoo was unearthed. As this site has significant historical value, it is a top priority to preserve and display the original foundation. Furthermore, a replica of the print shop is intended to be built over the top of the foundation. Thus, this project required a design for a foundation and platform that would support all the loads from the facsimile building and separate them from the original foundation, while at the same time providing access to and exhibiting the authentic foundation.

After several iterations, the most efficient design scheme was selected for this report. The final design consists of three main parts: foundation, platform, and viewing area. The design was based on the intended building use being public use or light storage. The foundation was designed using six helical piers, placed to avoid disrupting the historic basement. The platform design consists of four mildly reinforced concrete beams, which are supported by the helical piers directly above the walls of the existing foundation. The beams are intended to be cast-in-place directly onto the connection components of the helical piers. The viewing area is composed of terraced seating on the east side of the basement. It will provide a view of the east basement wall as well as the original staircase. This terrace is enclosed on the north and south by concrete retaining walls.

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Introduction

It is common in modern engineering practice to replace the old and crumbling with the new and more efficient. However, in the efforts to preserve and celebrate the old, the Times and Seasons building project is reversing this pattern. With modern engineering and construction technologies and methods, this project is seeking to protect and preserve the archeologically and historically valuable. To accomplish this overarching goal, our team has conducted weeks of research, design, drawing, and revising tasks. From October of 2023 to April of 2024, we have worked under the mentorship of engineers, architects, and archeologists to protect and preserve the historic foundation of the Times and Seasons building. This project began with the development of a rough design for a supporting platform to underly the future Times and Seasons building replica. This design was informed by site surveys, archeological dig surveys, and architectural renderings of the proposed building

With knowledge of the building construction, use, and location on the site, loads from the structure were able to be determined and platform design began. Beams were designed for several weeks balancing the needs of durability and practicality. Mildly reinforced concrete beams and steel beam designs were accomplished providing options for later project decisions by the sponsor. Mildly reinforced concrete beams were selected as the best choice for our team and designed using the reinforced concrete ACI 318 code. Concurrent with beam design, helical piers were selected as the best option for supporting the platform and for anchoring it to the ground. The most convincing factors that decided their use are the piers' ease of installation and relative minimization of ground disturbance. These foundation elements were designed according to Intermountain Helical Pier design documents and recommendations. As a slight addition to the original scope of the project, a viewing terrace was also designed on the East side of the site to provide viewing of the basement. This addition added value to the project by highlighting the central motivation for the platform design -- to preserve and celebrate the original basement. Some assumptions, such as geotechnical soil characteristics, water table depth, and construction material availability had to be made to move forward with the design of most main parts of the structure. Each of the above design steps and their respective assumptions are detailed in this report along with some additional recommendations and considerations which address necessary points of historic authenticity, safety, and public needs. These carefully considered supporting thoughts are included for their importance with regards to the final design.

The last portion of the project brought all previous models and designs together into the useful document of structural drawings which have been selectively included in this report. The expectations of this project included both supporting the Times and Seasons building and also celebrating and enhancing the historic elements of the site. By balancing the archeological, architectural, and engineering requirements, this project report seeks to meet these expectations and support recommendations that will be of great value to IDigNauvoo.

Schedule

The following schedule in **Table 1** lists significant periods of work, meetings, and project milestones for the entire time spent on the project.

Table 1: Project Timeline

Week of	Subject of Work	Meetings	Project Milestones
10/23/2023	Organization	Introductory Dinner	
10/30/2023	Organization	Team Meeting	
11/6/2023	Scope Determination and Building Loads	Team and Mentor Meetings	
11/13/2023	Scope Determination and Building Loads	Team and Mentor Meetings	
11/20/2023	Statement of Work	Team and Mentor Meetings	
11/27/2023	Statement of Work	Team and Mentor Meetings	Statement of Work Completed
12/4/2023	Building Loads	Team and Mentor Meetings	
12/11/2023	Building Loads	Team Meeting	
12/18/2023	Finals		
12/25/2023	Christmas Break		
1/1/2024	Christmas Break		
1/8/2024	Organization and Building loads	Team and Mentor Meetings	Building Loads Completed
1/15/2024	Beam Material and Scope	Team, Mentor, Faculty, and Sponsor Meetings	Scope Determined Solidly
1/22/2024	Beam Design	Team, Mentor, and Faculty Meetings	
1/29/2024	Site Layout, Helical Pier Design, and Beam Design	Team and Mentor Meetings	
2/5/2024	Helical Pier Design	Team and Mentor Meetings	Helical Piers Completed
2/12/2024	Site Layout, Connection Designs, and Beam Design	Team and Mentor Meetings	Plans Fitted to Archeological Survey of Original Basement
2/19/2024	Plan Drawing and Beam Design	Team and Mentor Meetings	

2/26/2024	Plan Drawing and Beam Design		
3/4/2024	Plan Drawings and Viewing Area Design	Team and Mentor Meetings	
3/11/2024	Plan Drawing and Beam Design	Team and Mentor Meetings	
3/18/2024	Plan Drawing and Beam Design	Team and Mentor Meetings	
3/25/2024	Plan Drawing, Beam Design, and Presentation Work	Team and Mentor Meetings	Beam Design Completed
4/1/2024	Finalizing Plan Sets and Presentation Work	Team and Mentor Meetings	Plans Completed
4/8/2024	Presentation Work	Final Team and Mentor Meetings	Final Project Report Complete
4/15/2024		Celebration Dinner and Final Presentation	Final Presentation Complete

Assumptions & Limitations

Many of the assumptions made in this project were regarding the use of the building. First, it was assumed that it would be open to the public and used primarily for public visitations, making it in the risk III category. The assumed loads imposed onto the platform are included in **Table 2**. With these given loads the building use is limited public use or light storage and is not suitable for use as an essential facility.

Table 2: Platform Loading

	Loads (psf)	
	Dead	Live
Exterior Wall	12	N/A
Floor	30	125
Roof	20	20
Snow	N/A	20

Because the foundation-platform system would have considerable self-weight, it was assumed that the uplift forces of the wind would be unable to overcome the deadload. Thus, for the design, the wind load was not considered. This could limit the utility of the design and wind loads should be considered more carefully before it is implemented.

Also, the dimensions of the existing foundation were assumed to be 16.5 x 33.5 ft. However, the true dimensions may be smaller, and these afore-mentioned dimensions were adopted to be conservative for loads and beam spans. They may limit the ability of the design to historically represent the building replica but should remain structurally sound should the true dimensions be smaller.

Furthermore, the beams constituting the platform were assumed to bear the weight of the building concentrically. In actuality, the building walls will be placed on the outer edge of the beams, leading to eccentric loading, which could affect the behavior and performance of the beams.

Finally, no soil data was available for this site. Based on previous data gathered near the site, it was assumed that the soil would be composed of clay and—according to ASCE 7-16—can be assumed to have a bearing capacity of 1500 psf. Additionally, the piers were designed using an assumed factor of safety of 2.0, which limits the ultimate capacity of the pier significantly. This may limit the design because if soil data for the site is obtained, the piers may be designed more efficiently. Ultimately, the manufacturer and installer of the piers will determine the actual sizing and depth to which they will be driven.

Design, Analysis & Results

Platform Loads

To begin the design of the platform, we had to understand the type of loads the building would be exerting on our platform. We began by gathering data about the replica building itself from the architect and using these dimensions to calculate the design loads according to the ASCE 7 code book. This information was input into a spreadsheet to organize the information and quickly calculate loads.

Table 3: Building Dimensions

Space Classification:	Light Storage
Building Width(ft)	16.5
Building Length(ft)	33.5
Building Height(ft)	15.3
Level 1 Wall Height(ft)	7.65
Level 2 Wall Height(ft)	7.65
Roof Height(ft)	5.65
Roof Pitch (Radians)	0.60
Roof Chord(ft)	10.00
Roof Surface Area(ft²)	669.95
Building Area(ft²)	552.75
Building Perimeter(ft)	100

Table 4 : Loads for Calculation of Design Loads

Code Loads	Dead Load	Live Load
Exterior Wall Loads(psf)	12	N/A
Floor 1 Loads(psf)	30	125
Floor 2 Loads(psf)	30	125
Roof Loads(psf)	20	20
Snow Load(psf)	N/A	20

It was provided that the construction method for the building would be balloon framing, this meant that the roof trusses and floor joist would be delivering all their load into the walls. The floor joists and roof trusses will be running from the west wall to the east wall. This means that the east and west wall would be picking up all the roof and floor loads while the north and south would not have any additional loads exerted on them. This information was then used to calculate the tributary area and the loads each wall would be exerting on the platform.

Table 5 : Tributary Area and Distributed Loads

Distributed Loads on Platform	North Side of Platform	South Side of Platform	East Side of Platform	West Side of Platform
Trib Floor(ft)	0	0	8.25	8.25
Trib Roof(ft)	0	0	9.9992	9.9992
Trib Wall(ft)	20.95	20.95	15.3	15.3
Dead Load(lb/ft)	251.4	251.4	878.58	878.58
Live Floor Load(lb/ft)	0	0	2062.5	2062.5
Live Roof Load(lb/ft)	0	0	199.98	199.98
Live Snow Load(lb/ft)	0	0	165	165

Table 6 : Final LRFD Loads for Design

	North & South Distributed Loads		East & West Distributed Loads	
LFRD Equations	**LFRD Loads(lb/ft)**	**LFRD Loads(Kip/ft)**	**LFRD Loads(lb/ft)**	**LFRD Loads(Kip/ft)**
1.4D	351.96	0.35	1230.02	1.23
1.2D + 1.6L + 0.5(Lrr or S or R)	301.68	0.30	4454.29	4.45
1.2D + 1.6(Lrr or S or R) + (L or 0.5W)	301.68	0.30	3436.78	3.44

Platform Design

For completeness it was proposed that the platform—consisting of beams—be designed using steel, mildly reinforced concrete, and prestressed concrete to allow for selection of the most economical and efficient beam. We began the beam design using the previously determined loads from the building. The East and West side beams support most of the load and controlled the platform design. Thus, the design of these more critical beams will be discussed in further detail.

For the steel beam design, we utilized the fourteenth edition of the American Institute of Steel Construction (AISC) Manual. After the initial steel beam design was selected, it was determined that steel would be less efficient than concrete due to concerns with corrosion. Thus, steel beams were eliminated from our final design process.

An initial design for mildly reinforced concrete beams (using American Concrete Institute (ACI) 318-19) was also created and presented to our mentors. After considering the preliminary dimensions, it was determined that a mildly reinforced beam would provide a sufficiently shallow depth. Adding prestressing steel would allow for a shallower beam, but the economic and material cost were not worth the slightly smaller dimensions that could be achieved.

After the initial design was presented, several iterations of beam designs were considered. Finally, the most efficient beam was selected. This was a continuous beam that would span the entire East/West side of the building. It was supported by three helical piers at asymmetrical intervals. With the help of our mentors the reaction forces for the beam were determined. With that information a shear and moment diagram were also produced. These diagrams, included below as **Figure 1** and **Figure 2**, controlled the design and detailing of the beams.

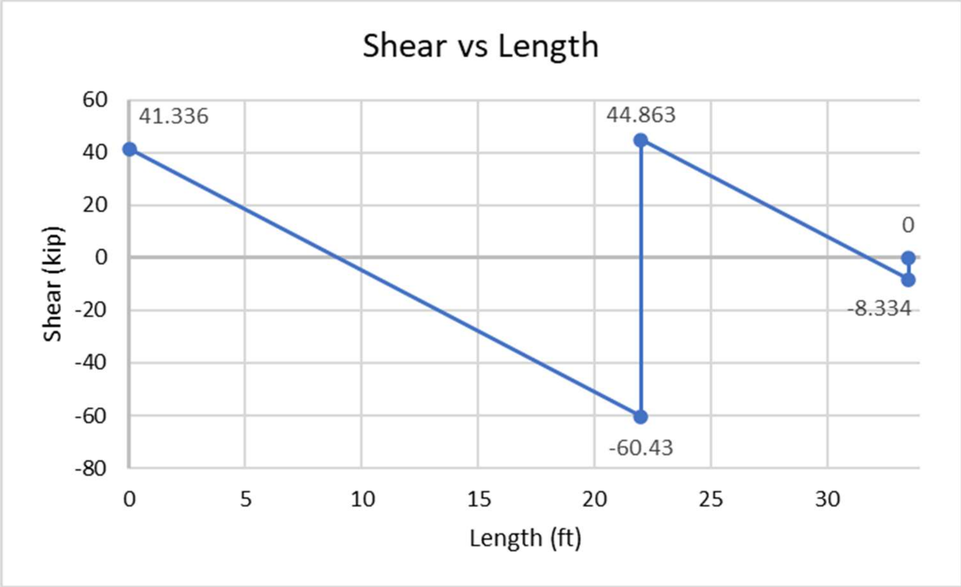

Figure 1: Shear Diagram for East/West Beams

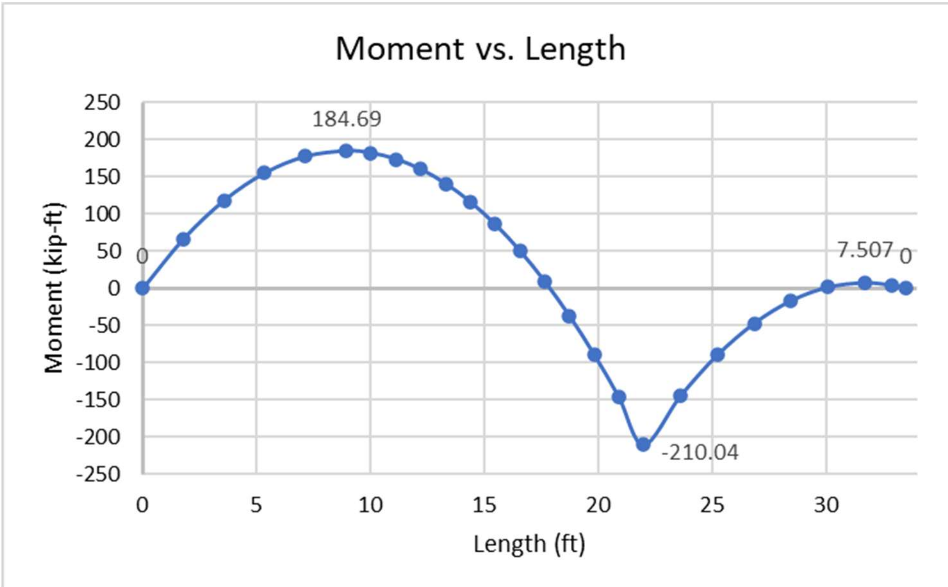

Figure 2: Moment Diagram for East/West Beams

Again, the beam was designed using the standards of ACI 318-19. The axial steel reinforcement required to meet the demands of the moment were considered first, followed by a consideration of the shear reinforcement. The steel reinforcement was selected to be as uniform as possible throughout the beam for ease of construction. The final beam design is as shown below in **Figure 3**.

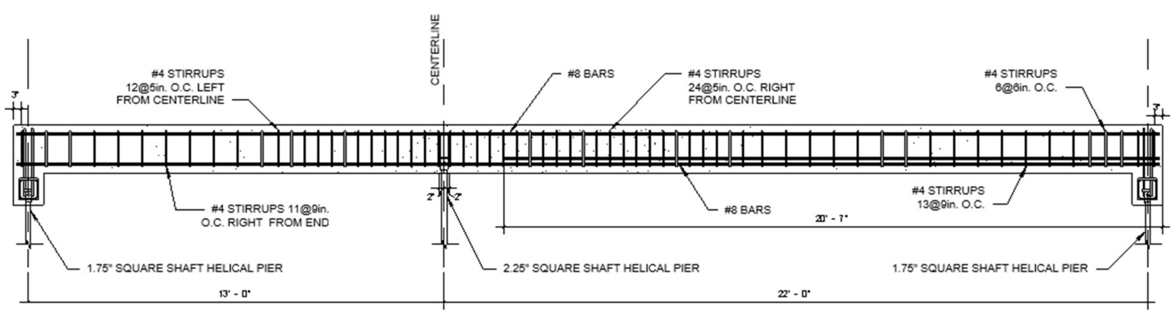

Figure 3: Section of East and West Type Beams

After the large beam design was completed, a design for the North/South side beams was also done. As these were simply supported beams with comparatively small loadings, the design was much quicker. Currently the load capacity far exceeds the demand, but to meet the minimum code specifications in ACI 318-19 the design cannot be further optimized. This beam design is shown in **Figure 4**.

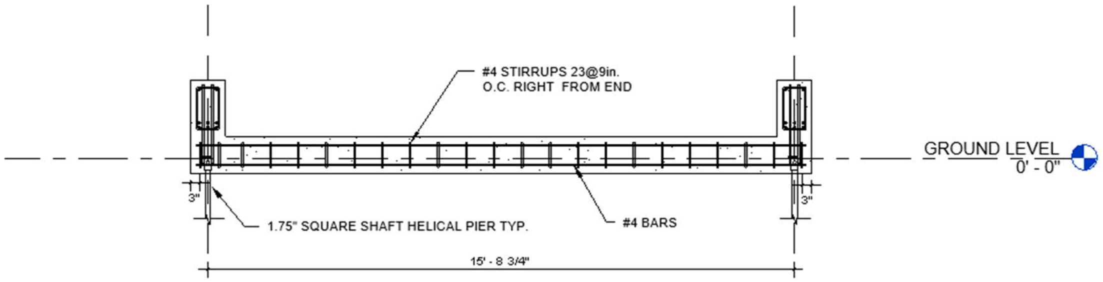

Figure 4: Shear Diagram for East/West Beams

Helical Pier Design

Seeking to transfer the loads of the reconstructed building and platform, different foundation types were considered. Larger-footprint concrete footings were not supportive of the preservation needs of the project due to the need for deeper and more invasive excavations around all sides of the existing basement. Less invasive options were then investigated with the understanding that the lighter loads of the small building would likely permit such foundation elements. Push piers foundation elements were considered briefly, but the idea was discarded due to the possibility of very uneven bedrock conditions that can be common in karst areas. With unpredictable bedrock support push piers are not adequate protection to a structure. Under the direction of mentors and due to the possibility of uplift resistance, helical piers were finally selected as the desired foundation element.

These members come to the construction site as prefabricated segments that screw into the ground to a depth at which sufficient resistance to installation torque is experienced. At this depth, the pier is assumed to have sufficient bearing capacity to support the required loads. The helical piers for this project were selected from the company catalog of Intermountain Helical Pier and sized using the *Intermountain Helical Pier Design Guide* and its supporting capacity charts. The loads carried by each pier were determined by distributing the LRFD combined loads which were determined during beam design across the platform beams. A series of six piles was selected to support the structure in the arrangement shown in **Figure 5** below.

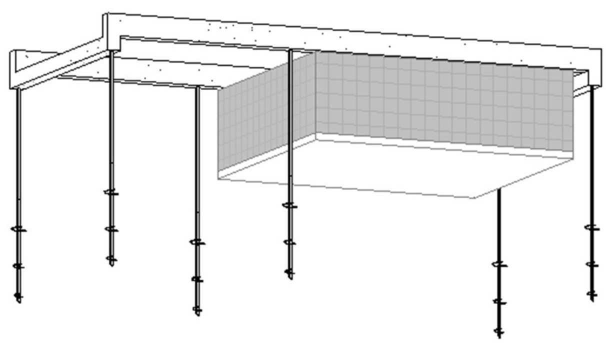

Figure 5: Helical Pier Layout (viewed from below basement level)

The helical piers located on the corners of the platform bear less load than those in the middle.

Table 7 below lists the loads and the design information for corner and middle piers. It is suggested that when installing piers, corners are screwed in first. This will not only allow for the correct alignment of the middle piers, but also inform the installer concerning the ground conditions while placing piers carrying less load. This will inform the decision of how to install the middle pier. Based on geotechnical investigation work accomplished by Dr. Kyle Rollins in Nauvoo, bedrock depth is estimated to be between

20 and 5 feet below grade at the building site. During installation, helical piers may hit the bedrock and not gain installation resistance necessary to ensure bearing capacity by measurement. The tip bearing capacity of the pier is then used to support the building. This is why the installation sequence of the piers if suggested.

Table 7: Helical Pier Selection Information

Pile Location	Required Capacity (lb)	Factor of Safety	Ultimate Capacity (lb)	Pier Selected	Design Capacity (lb)	Installation Torque Coefficient (ft^{-1})	Installation Torque (ft-lb)
Northeast Corner	35839	2	71678	1.75 in solid square shaft or 3 in tubular	110000	10	11000
Northwest Corner	35839	2	71678	1.75 in solid square shaft or 3 in tubular	110000	10	11000
East Middle	82675	2	165350	2.25 in solid square shaft or 4 in tubular	200000	10	20000
West Middle	82675	2	165350	2.25 in solid square shaft or 4 in tubular	200000	10	20000
Southeast Corner	57098	2	114196	2.25 in solid square shaft or 4 in tubular	200000	10	11000
Southwest Corner	57098	2	114196	2.25 in solid square shaft or 4 in tubular	200000	10	11000

Connection Design

In order to join the helical pier to the beams they support, a connection suggested by Intermountain Helical Pier was selected that embeds into the cast in place concrete. Considerable redesign of the beam reinforcement was required to accommodate this connection. **Figure 6** below shows a detail of this connection from the drawings created for this project.

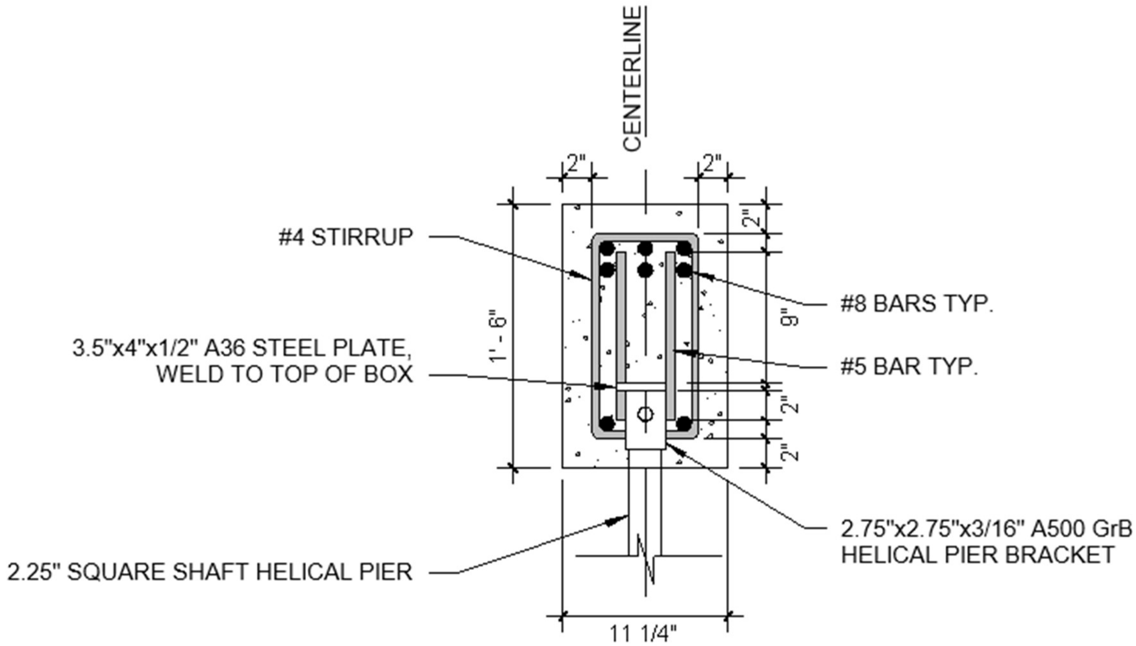

Figure 6: Helical Pier to Beam Connection

Terrace Design

The addition of the terrace area to the original scope of our work was motivated by the desire to show how the platform design will provide viewing of the historic basement, which is the main reason for the platform's existence. The idea for the viewing area originated in architectural ideas about how to best celebrate the original basement foundation. Eventually, it became an extension to the scope of our project and a great learning experience. The total depth of the viewing area is equal to the five-foot depth of the basement. With three levels of seating, it will provide an ideal location to hold lectures on the archeology and history of the building and its connections to the Times and Seasons newspaper.

To design the seating area, a retaining wall design was developed and paired with simple concrete slabs laid on a gravel layer prepared on a cut earthen slope. Due to only basic NRCS soils survey information being present for the site, retaining wall design was accomplished in consultation with BYU faculty and adopting a conservative design for the five-foot depth. The concrete slab thicknesses were determined based on three-inch cover depths and recommended steel reinforcement selection. **Figure 7** and **Figure 8** below shows a general view and a section view from the structural drawings for this terraced area. **Figure 9** below shows a section view of the retaining wall. As shown in the picture, the south wall of the original staircase leading down into the basement has been removed to allow for viewing into the original basement through the original doorway if this is desired. Railing is suggested to be placed around the original steps at top and bottom to limit deterioration of the historic steps from visitors.

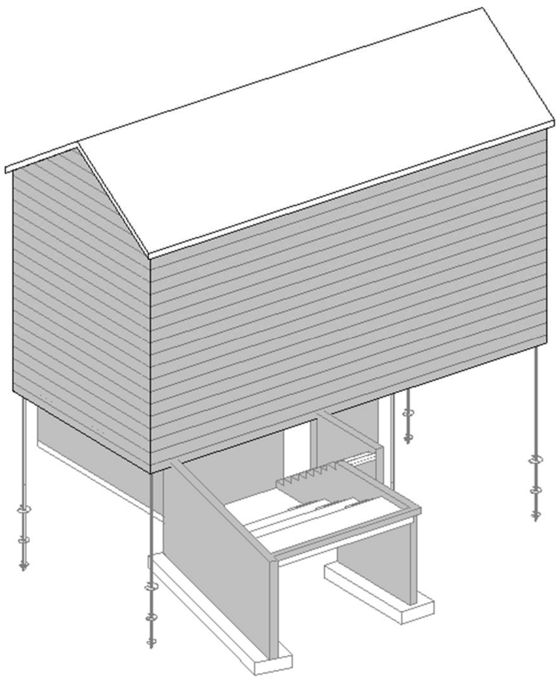

Figure 7: General View of Terraced Seating Area

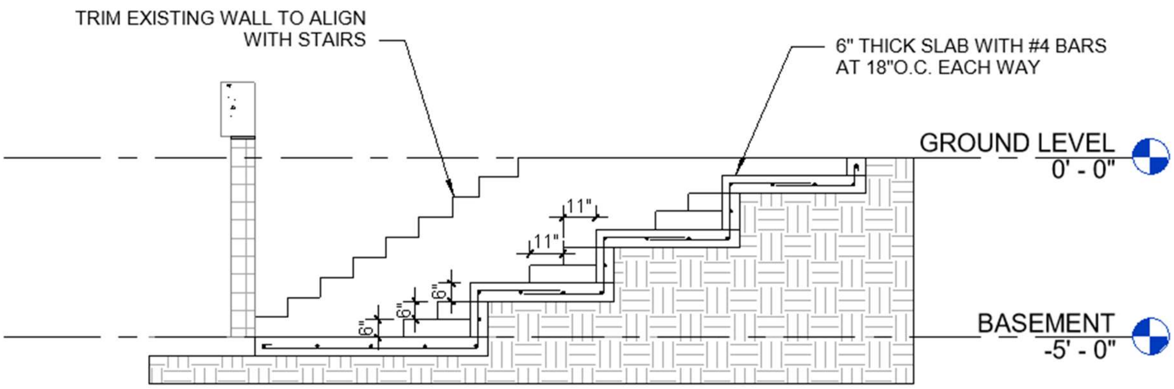

Figure 8: Terraced Seating Area Section View

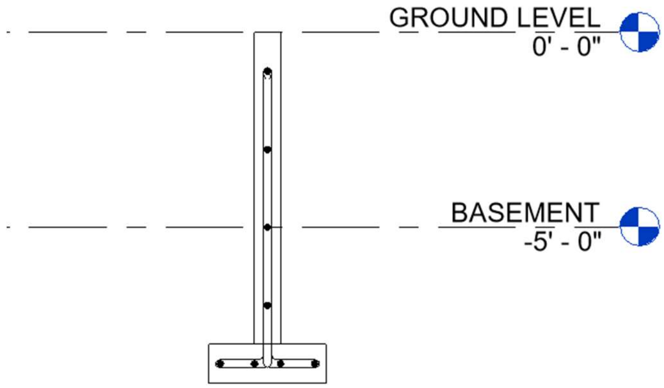

Figure 9: Retaining Wall Section View

Related Issues

The Times and Seasons building project is unique in many ways, and the implications related to public health, safety, cultural, social, environmental, and economic factors are just as unique. Understanding the costs and benefits that come with any construction project are absolutely necessary, and as the Times and Seasons building design work progressed, the public's needs have been continuously considered. Factors that affect public health and safety have been identified and include stairway design, room dimensions, fall risk, wheelchair accessibility, traffic dangers, and construction safety.

Public Health and Safety

Most of these public health concerns were addressed while designing the outdoor viewing area terrace on the East side of the historic building foundation. This sunken seating area was designed using code-compliant stairs and rails. The rails should include a stairway handrail and railing around the top of the terrace walls. This reduces fall risk and increases overall accessibility to the site. Also, in order to determine if basement accessibility should be a main design concern, it was discussed whether or not people would be permitted to enter the historic basement space. In the end, it was determined that because the basement ceiling height was only 5 ft tall, accessibility to that underground area would not be a main concern of the design and that the outdoor viewing area would accomplish the desired celebration of the historic basement without necessarily entering it. Raising the overall building elevation using grading techniques or lowering the basement by deepening it was also considered to increase the ceiling height of the basement. However, due to the competing desire for historical accuracy, the above plan was prioritized.

Wheelchair access to the outdoor terrace will be available at the top-most level even with the original grade. Due to space requirements and slope, a wheelchair ramp would be impractical for this shallow viewing area. Being situated close to the side of Water Street, traffic safety around the outside terrace is also a concern. This road has light traffic at a low speed, a 20-mph speed limit and would likely have a crossing area connecting it to the concrete sidewalk on the opposite side of the street. To ensure greater safety, a bordering fence may be useful on the south side of the property. A split-rail fence could support the historic appearance of the site while also providing needed safety. This would deter children who might be playing in the yard or the open area to the east of the building from getting into the road. Also, guardrails may be considered where the road is closest to the terraced seating area as it would create a serious hazard if a vehicle without control were to go off the road at this location.

Cultural, Social, Economic, and Environmental Factors

The cultural factors that this project would affect are firstly its contribution to the historic value of the old Nauvoo district. This project's preservation of an archeologically significant structure and educational opportunities are benefits that likely outweigh the disturbance to the archeological site necessary in order to construct the project. The historic district of Nauvoo has been widely rebuilt for this purpose. No ill social effects are likely to occur due to this project's construction. The marginal increase in tourism to Nauvoo, if influenced at all by this project, is likely to improve this area both socially and economically. Though tourism could alter the town's economy and culture, the area is already well-adjusted to this form of business and would likely benefit from continued or increased visitation. Though specific project costs are not included in our project's main scope, the general expense should be thought of. As this project is being directed by a non-profit organization, financial returns were not assumed to be the main achievement. Our team strongly suggests that the cultural, social, and local economic returns from the project justify the initial monetary requirements.

Lastly, the environmental effects of construction should be addressed. This project will require excavations and heavy equipment. Stress on the riverside environment may be minimized through the proper implementation of erosion control. Due to paved roads already being in place, construction equipment can be easily supported to and from the site. The use of steel and concrete over more short-term sustainable materials, such as lumber, was selected despite their energy costs. It was considered necessary for this project's completion to use steel and concrete for the platform foundation and terrace area due to the building and soil loads. With time, the durability of these materials will also contribute to the sustainability of their use. To prevent the sunken terrace and basement area from filling up with precipitation runoff, adequate drainage will need to be designed. Drainage from the site after construction will need to be continued to the storm drain system of the historic district of Nauvoo if possible. If it is not, direct drainage to the Mississippi may need to be implemented. In this case, control of pollution or liquid waste entering the drainage system is necessary.

Lessons Learned

One of the major challenges we encountered was finding a time to meet regularly and collaborate with our team members, mentors, and sponsors. We learned to prioritize the meeting for certain people who were most involved and helpful for the project but did not exclude those with less important roles. We finally set a weekly meeting time that worked well for our team and most others in the group, although not everyone was able to attend each week. We learned to work with those who were able to attend

Another challenge we encountered was communicating ideas and solutions in a precise yet understandable manner to people from a variety of backgrounds. We discovered that there is a great disparity in terminology between disciplines and background. In this project we worked with professors, engineers, architects, surveyors, and archeologists. With such varied experience, we initially struggled to convey and understand ideas, and come to agreements on the direction our work would take. Eventually, we discovered that using visuals paired with a description or discussion was the most effective way to come to a common understanding. This tactic enabled us to create a reasonable scope for our project.

We also learned about the design process. In previous classes, we have designed only small portions or segments of a project. This project gave us experience designing from start to finish, even though it was a small scope. It was instructive to discover that one of the most difficult parts of the project was defining the necessary parameters and requirements, in other words the problem statement, before beginning the bulk of the design. It was also educational to see how the project changed and adapted as it progressed. The best way we found to overcome these difficulties was to collaborate with everyone while defining the scope of the project. It was also worth the time to create a tool for designing different aspects of the project that made it simple to iterate on the design and adjust it for changes.

Finally, one of the most difficult parts of the actual design was the detailing of connections. Similarly to the problem addressed previously, in prior classes we were accustomed to designing beams or foundations, but the connection between the two was only addressed briefly. We found that detailing these connections requires knowledge and experience. The project mentors, especially our industry mentors, provided great direction regarding detailing the connections. We suggest that for such areas, experts should be consulted for the design.

Conclusions

From the project's results, we have reached an understanding that every project requires a significant number of iterations. For loads superimposed on the platform by the building we determined that wind loads would not need to be considered. This was due to the fact that the foundation and platform would have significant self weight. We concluded that the uplift forces would be unable to overcome these deadloads, and thus the wind loads could be ignored.

We also concluded that using steel beams for the platform would be ineffective. The platform will be constructed close to grade and the lot is adjacent to the Mississippi River. The combination of these factors will create a moist and highly corrosive environment for steel. While there are strategies to combat such corrosion, these methods require regular inspections. Accessing these beams after installation could be difficult. For these reasons it was decided to eliminate steel beams from the final design.

Prestressed concrete was also eliminated from the final design, but for different reasons. After creating an initial beam design using only mildly reinforced concrete, we determined that we could achieve a sufficiently shallow beam without the addition of prestressing. Although prestressing could be used to lower the building a couple of inches more, we concluded that the economic and material cost was too high to do so.

Similarly, we considered the use of several other foundation methods. We found that any other footing-type foundation would require too much area to be effective in being placed near the existing foundation. They would either create longer than necessary spans for the beams or obstruct the view of the foundation. Most piles would also disturb the foundation as they were driven into the ground. While helical piers do not provide the greatest capacity, we concluded that they would be the most effective in this situation. Not only would they provide the required capacity with only six piers, but also, they would provide minimal disturbance to the foundation and allow for easy viewing of the original basement.

Recommendations

To summarize the above design and multiple considerations the following recommendations are listed:

1. We recommend the use of a beam platform design to support the proposed reconstruction of the Times and Seasons building.
    a. The balloon framing of the original structure places all floor loads into the walls. Therefore, supporting the structure with beams directly beneath the walls saves in material costs and increases the simplicity of the design.
2. We recommend the use of mildly reinforced concrete beams to make up the platform due to the durability they would add to the design.
3. We recommend the use of helical pier foundation elements to support the building and platform because of the benefits they provide in installation, strength, and minimal archeological disturbance.
    a. Because these foundation elements screw into the existing soil, less excavation is required to occur around the historic basement which would likely not support itself if the soil was removed to construct other more traditional foundation designs.
4. We recommend the development of an outside terraced seating area on the East side of the original basement to display and celebrate this historically significant structure which constitutes the motivation for the entire project.
    a. Though this excavation does invade upon one side of the original basement, it would effectively communicate the significance of the reconstruction project making the replica building more than just a small yet interesting building in Nauvoo.
5. Lastly, we recommend that the design documented in the structural drawings provided to IDigNauvoo be implemented in planning and constructing the proposed platform, helical pier foundation, and basement viewing terrace along with its notes and the recommendations recorded in this report.

Appendix A

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EDUCATION

Bachelor of Science in Civil and Construction Engineering *Brigham Young University* *Provo, UT*

- Graduation Date - April 2024, GPA – 3.76
- Member of concrete canoe competition team and ASCE (BYU student chapter)
- Most relevant coursework completed: Soil Mechanics, Foundation Design, Pavement Design, Reinforced Concrete Design, Mechanics of Materials, Geology, Surveying, GPS, ArcGIS, Structural Analysis, Hydrology

TECHNICAL EXPERIENCE

Geotechnical Lab and Field Technician *Applied Geotechnical Engineering Consultants* **Jan 2023-Current**

- Performed a wide array of laboratory soil and construction material tests to provide data to licensed engineers for project decision making
- Testing Experience: visual-manual classification, gradation, proctor, Atterberg, consolidation, CBR, permeability, unconfined strength, triaxial and direct shear, concrete strength, and others
- Worked with contractors in the field to ensure quality construction of rammed aggregate piers

Civil Engineering Intern *LJA Engineering* **Jun 2021-Aug 2021**

- Completed sewer utility field surveys and assessments using GPS, ESRI ArcMap application, and GoPro unit to assist engineering team in producing accurate sewer system models
- Performed construction observation of pipeline installation, roadway paving, and CIPP installation to document and report work as a company representative for the client
- Designed and produced plans of an adaptor unit for pipeline smoke tester using AutoCAD helping LJA to expand its services to sewer line smoke testing
- Wrote Standard Operational Procedure documents to train future fieldwork employees to carry out sewer utility surveys

Construction and Land Surveying Team Member *Clinton Engineering and Surveying* **Jun 2022-Aug 2022**

- Performed surveying layout for geotechnical and other construction projects using GPS, Total Station, Robotic Total Station, and Auto Level
- Collected coordinates and elevations of utilities, grading, drainage, and right of way locations to create topographical surveys for clients
- Performed property line boundary surveys for private landowners
- Learned construction staking practices and observation techniques to develop a valuable understanding of how engineered designs either fit or fail in the real world

Construction Worker *Wilson Brothers Excavation* **May 2014-Aug 2015**

- Laid out, dug, and poured several small foundations over two summers with 3-man construction team learning the true basics of soils and foundation work

SKILLS AND ACCOMPLISHMENTS

- Practical work experience acquired from daily life on a family beef cattle farm and practiced on construction sites
- Russian-speaking church volunteer in Ukraine full-time from 2018 to 2020
- Recipient of the Walter R. Courtenay Eagle Scout Award for designing and leading retaining wall construction project in Fall Creek Falls State Park - Spencer, TN

Drake S. Church

Phone: 770-814-1200 Email: drakeschurch@gmail.com LinkedIn: www.linkedin.com/in/drake-church

ABOUT ME: I enjoy interacting with others and cherish the relationships with my family and friends. I am hardworking, honest, and enjoy living my life and experiencing new things. My hobbies are spending time in the hiking, camping, hunting, playing/watching sports, and wakeboarding.

EDUCATION:

Brigham Young University **Graduation April 2025**

- BS in Civil Engineering
- Current GPA of 3.76
- Relevant course work taken includes Structural Analysis, Soil Mechanics, Hydraulics, Transportation, and Structural Steel Design

WORK EXPERIENCE:

Aptive **Summers of 2021 and 2022**
Salesman NC, KY, and TX

- Generated over 225k in reoccurring revenue for Aptive
- Mastered identifying customers' needs and presenting how the product and service met their needs
- Temporarily lived in multiple states to contact, pitch, and sell pest control services door to door

Brigham Young University **September 2021-Currently**
Architectural Drafter Provo, Utah

- Drafting plans for demolition and remodeling projects on campus
- Using Revit and Bluebeam in order to create, edit, and print plans for markup
- Working and coordinating in teams in order to accomplish project goals

Kimley-Horn **May 2023-August 2023**
Land Development Services Intern Phoenix, Arizona

- Designed utility, storm, and grading plans to be submitted for city and client approval
- Used AutoCAD and Bluebeam to edit and markup plans
- Worked within a group and personally coordinated with 3 clients to complete projects

DAVIS & CHURCH INC. **July 2022-August 2022**
Structural Engineering Intern Alpharetta, Georgia

- Participated in the design and development of several high-rise building projects
- Worked and communicated under two different engineers
- Calculated vertical and lateral loads and designed uplift anchors, wall studs, headers, etc.

ACOMPLISMENTS, LANGUAGES AND OTHER SKILLS:

- Eagle Scout, Phi Eta Sigma member, and Tau Beta Pi member
- Proficient in Spanish
- Proficient in AutoCAD, Revit, and Bluebeam
- Experience with Microsoft Excel, VBA, and Python

VOLUNTEER:

The Church of Jesus Christ of Latter-Day Saints **September 2018-March 2020**
Missionary San Jose, Costa Rica

- Voluntarily served and helped for 18 months various communities throughout Costa Rica
- Taught about Christ, self-sufficient classes, and English classes
- Led and trained groups of 10-25 missionaries to be more effective and efficient in their work
- All tasks were performed in Spanish

Brian Shawcroft

(719) 580-9282 · brianshawcroft1@gmail.com · www.linkedin.com/in/brian-shawcroft/

EDUCATION

Brigham Young University — Apr 2024
Bachelor of Science: Civil Engineering — Provo, UT
- GPA 4.0
- Emphasis in Structural Engineering
- Scholarships: Marigold N. Saunders and Edwin S. Hinckley

RELEVANT EXPERIENCE

Brigham Young University — Aug 2022-Present
Research Assistant — Provo, UT
- Investigated over 20 technical papers to understand isogeometric analysis (IGA)
- Developed 15 software plug-ins to connect multiple parts for IGA
- Performed isogeometric and hybrid finite element/isogeometric analysis for a vehicle collision

Brigham Young University — Aug 2021-Apr 2023
Teaching Assistant — Provo, UT
- Taught a statics concept to co-workers weekly to prepare to guide students
- Provided walk-in support to mentor students
- Created and presented a review of material to 20 students at the end of the semester to increase understanding and final exam performance

Davis Engineering Service, Inc — Jan 2018-May 2018
Intern — Alamosa, CO
- Learned ArcGIS through independent study to become an asset to the firm
- Used ArcGIS to document project locations to provide a map of past projects
- Updated and organized project documents for easy access

OTHER EXPERIENCE

Aptive Environmental, Inc — Apr 2022-Aug 2023
Direct to Home Sales Representative — San Jose and Los Angeles, CA
- Extended services to between 60 and 80 clients daily to earn more business
- Generated $180,000 in revenue

Absmier Landscaping and Construction — May 2021-Aug 2021
Light Equipment Operator — Alamosa, CO
- Used plans and drawing to install storm drain and sewage
- Maintained the job site safe and navigable

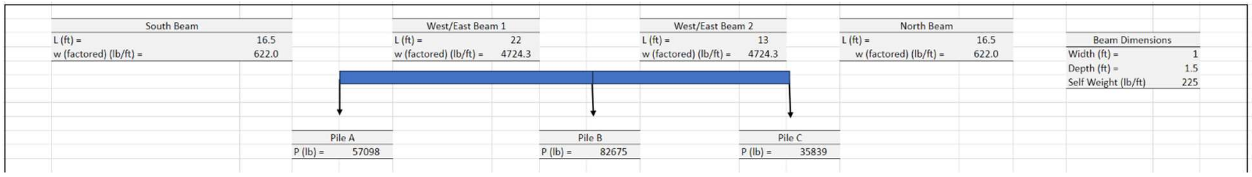
Jesse Shawcroft Construction — May 2012-June 2018
Construction Worker — La Jara, CO
- Remodeled kitchens and bathrooms to owner's expectations
- Built garages, including laying the foundation, framing, roofing, and finishing
- Installed and maintained sprinkler systems in yards and gardens

ACHIEVEMENTS/SKILLS

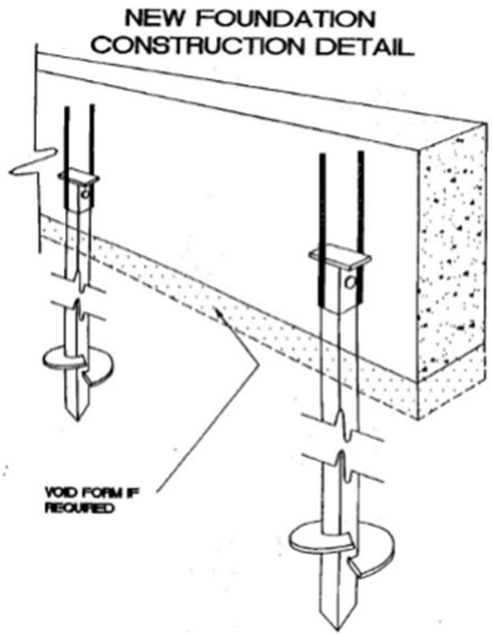
- Published and presented "Establishing Connectivity for Isogeometric and Hybrid FEA/Isogeometric Analyses with Multiple Parts through Beam Element Projection" at i-ETC conference 2023
- Proficient with C# and python coding languages

Appendix B

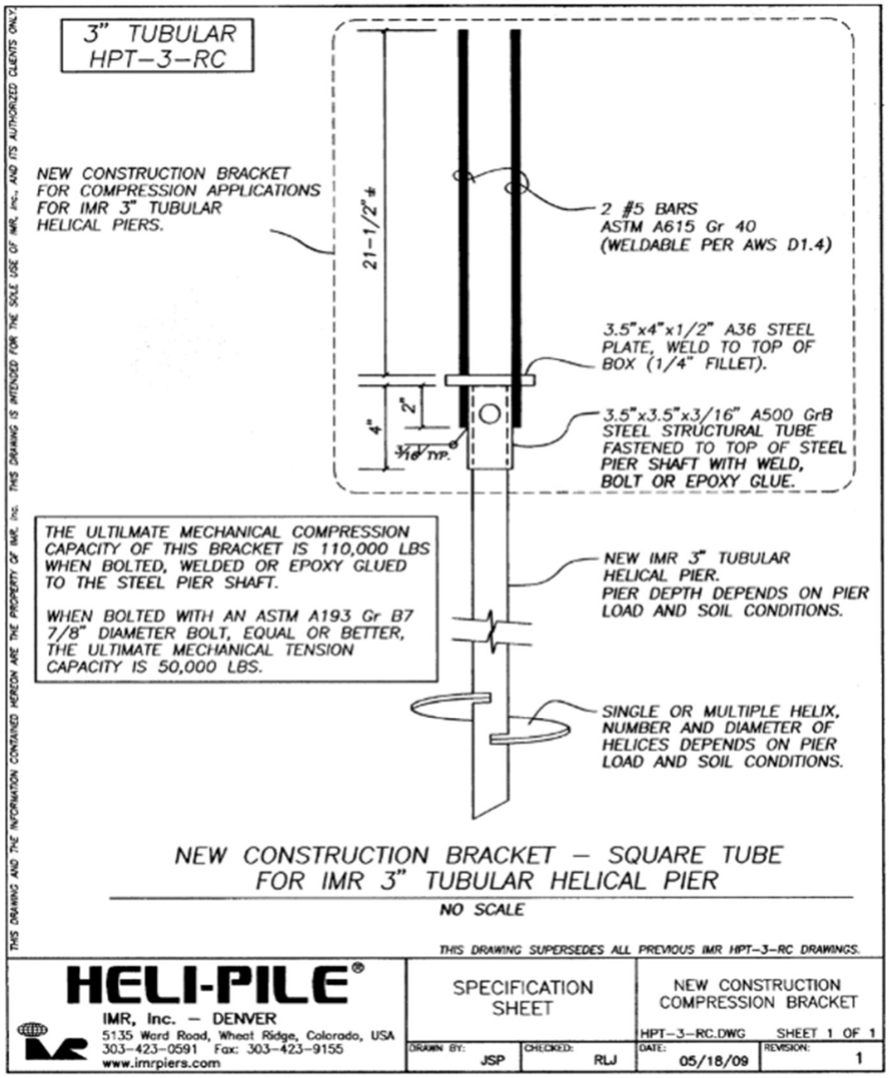
Helical Pier Calculations:



Intermountain Helical Pier Recommended Connection Detail No. 1:



Intermountain Helical Pier Recommended Connection Detail No. 2:



Intermountain Helical Pier Design Table for Pier Sizing:

1 Square Shaft Size and Type (IMR Cat. Number)	2 Shaft and Helix Galvanizing	3 Shaft Steel Minimum Yield Strength, F_y	4 Maximum Shaft Torque	5 New Fdns. Ultimate Capacity, Compr. or Tension[1]	6 Underpin Ultimate Capacity, Bracket Limited	7 Helix Steel Minimum Yield Strength, F_y	8 Ultimate Per Helix Capacity, Compr. or Tension[2]
1.5 inch (38.1 mm) Solid Shaft (HPC15)	ASTM B633	70 ksi (483 Mpa)	5,500 ft-lbs (7.46 kN-m)	55,000 lbs (245 kN)	55,000 lbs (245 kN)	80 ksi (552 Mpa)	70,000 lbs (311 kN)
1.5 inch (38.1 mm) Solid Shaft (HPC15X)	ASTM B633	90 ksi (621 Mpa)	7,000 ft-lbs (9.49 kN-m)	70,000 lbs (311 kN)	70,000 lbs (311 kN)	80 ksi (552 Mpa)	70,000 lbs (311 kN)
1.75 inch (44.5 mm) Solid Shaft (HPC17)	ASTM B633	90 ksi (621 Mpa)	11,000 ft-lbs (14.9 kN-m)	110,000 lbs (489 kN)	110,000 lbs (489 kN)	80 ksi (552 Mpa)	70,000 lbs (311 kN)
2.0 inch (50.8 mm) Solid Shaft (HPC20)	ASTM B633	90 ksi (621 Mpa)	16,000 ft-lbs (21.7 kN-m)	150,000 lbs (667 kN)	Per Application	80 ksi (552 Mpa)	70,000 lbs (311 kN)
2.25 inch (57.2 mm) Solid Shaft (HPC22)	ASTM B633	90 ksi (621 Mpa)	23,000 ft-lbs (31.2 kN-m)	200,000 lbs (890 kN)	Per Application	80 ksi (552 Mpa)	70,000 lbs (311 kN)
1.5 inch (38.1 mm) Modular (HP15X)	ASTM B633	90 ksi (621 Mpa)	7,000 ft-lbs (9.49 kN-m)	70,000 lbs (311 kN)	70,000 lbs (311 kN)	80 ksi (552 Mpa)	70,000 lbs (311 kN)
1.75 inch (44.5 mm) Modular (HP17)	ASTM B633	90 ksi (621 Mpa)	11,000 ft-lbs (14.9 kN-m)	110,000 lbs (489 kN)	110,000 lbs (489 kN)	80 ksi (552 Mpa)	70,000 lbs (311 kN)
2.0 inch (50.8 mm) Tubular (HPFT2)	ASTM B633	50 ksi (345 Mpa)	4,000 ft-lbs (5.42 kN-m)	40,000 lbs (178 kN)	40,000 lbs (178 kN)	80 ksi (552 Mpa)	70,000 lbs (311 kN)
2.5 inch (63.5 mm) Tubular (HPFT25)	ASTM B633	50 ksi (345 Mpa)	7,000 ft-lbs (9.49 kN-m)	70,000 lbs (311 kN)	70,000 lbs (311 kN)	80 ksi (552 Mpa)	70,000 lbs (311 kN)
3.0 inch (76.2 mm) Tubular (HPFT3)	ASTM B633	50 ksi (345 Mpa)	11,000 ft-lbs (14.9 kN-m)	110,000 lbs (489 kN)	110,000 lbs (489 kN)	80 ksi (552 Mpa)	70,000 lbs (311 kN)
4.0 inch (102 mm) Tubular (HPFT4)	ASTM B633	50 ksi (345 Mpa)	20,000 ft-lbs (27.1 kN-m)	200,000 lbs (890 kN)	Per Application	80 ksi (552 Mpa)	70,000 lbs (311 kN)

[1]Recommended default empirical installation torque coefficient (k_t) is 10 ft^{-1} (32.8 m^{-1}) except for the 4.0 inch (102 mm) Tubular. The 4.0 inch (102 mm) Tubular is application specific, testing is recommended. See Eq. 2-1 on p. 2-1 of PART 2.
[2]All HELI-PILE® helices are 0.5 inch (12.7 mm) thick. Helix capacities given are for 12 inch (305 mm) diameter and smaller. Larger helices are rated at 80% of the given value.