

FINAL DELIVERABLE

Title	Volga Pedestrian Bridge and Trail Engineering & Design	ann <mark>ninna</mark>
Completed By	Ryan McDonough, Nathan Gjersvik, Ryan Kowalsky, Spencer McDermott	
Date Completed	May 2020	
UI Department	Department of Civil & Environmental Engineering	
Course Name	CEE:4850:0001 Project Design & Management	
Instructor	Richard Fosse	
Community Partners	City of Volga	MA

This project was supported by the Iowa Initiative for Sustainable Communities (IISC), a community engagement program at the University of Iowa. IISC partners with rural and urban communities across the state to develop projects that university students and IISC pursues a dual mission of enhancing quality of life in Iowa while transforming teaching and learning at the University of Iowa.

Research conducted by faculty, staff, and students of The University of Iowa exists in the public domain. When referencing, implementing, or otherwise making use of the contents in this report, the following citation style is recommended:

[Student names], led by [Professor's name]. [Year]. [Title of report]. Research report produced through the Iowa Initiative for Sustainable Communities at the University of Iowa.

This publication may be available in alternative formats upon request.

Iowa Initiative for Sustainable Communities The University of Iowa 347 Jessup Hall Iowa City, IA, 52241 Phone: 319.335.0032 Email: iisc@uiowa.edu Website: http://iisc.uiowa.edu/

The University of Iowa prohibits discrimination in employment, educational programs, and activities on the basis of race, creed, color, religion, national origin, age, sex, pregnancy, disability, genetic information, status as a U.S. veteran, service in the U.S. military, sexual orientation, gender identity, associational preferences, or any other classification that deprives the person of consideration as an individual. The University also affirms its commitment to providing equal opportunities and equal access to University facilities. For additional information contact the Office of Equal Opportunity and Diversity, (319) 335-0705.



Pedestrian Bridge and Trail

Volga, IA

KGMM Engineering

May 8, 2020

University of Iowa

TABLE OF CONTENTS

Section Section	on I Executive Summary
1. 2. 3.	Name of Organization3Organization Location and Contact Information3Organization and Design Team Description3
Sectio	on III Design Services
1. 2.	Project Scope
Sectio	on IV Constraints, Challenges, and Impacts 4
1. 2. 3.	Constraints4Challenges4Societal Impact within the Community and/or the State of Iowa5
Section Section	on V Alternative Solutions that were Considered
1. 2. 3. 4. 5. 6. 7. 8.	Bridge Deck6Bridge Truss7Hydrologic Information10Hydraulic Design10Abutment Design12Pier Design14Pedestrian Trail15Riprap Design16
Section Append	on VII Engineer's Cost Estimate
Ap Ap Ap Ap Ap Ap	pendix A – StreamStats Output.19pendix B – Base Flood Elevation Calculations.26pendix C – Substructure Design Calculations.31pendix D – Earthwork Report58pendix E – Riprap Design Calculations59pendix F – Design Drawings.60pendix G – Design Renderings and Models.61
Refer	ences

Section I Executive Summary

The City of Volga, Iowa requested the design of a new pedestrian bridge to connect the east and west ends of town which are separated by the Volga River. The existing bridge that would allow pedestrians to cross the Volga River was partially washed away by a flood and is unserviceable. According to the City, many pedestrians use the existing trail system, however, it is a challenge to travel from the campground to the Reflection Park area because the only available crossing is the county bridge on highway C2W. This vehicular bridge is an unsafe pedestrian crossing, which is a primary driver for the design of a new pedestrian bridge. Another issue the City noted about the remains of the existing bridge is the buildup of debris on the piers when the river is at a high stage. The purpose of this project is to connect the two sides of Volga with a pedestrian bridge along with connecting trails and demolition of the remains of the old bridge. The connection will provide excellent pedestrian mobility within the city, promote safer pedestrian walkways, and furnish better access to city services such as the Volga U Campground and the new Reflection Park.

KGMM Engineering has designed a new pedestrian bridge to cross the Volga River at Volga Street. The new bridge has been designed with a 12-foot width to accommodate pedestrians, cyclists, commercial lawnmowers, and utility terrain vehicles (UTVs). The design width is adequate for multiple simultaneous users and is sufficient to satisfy all AASHTO design standards for pedestrian bridges in the event federal money becomes available for the project. The new bridge will provide pedestrians safe access to key city services and save city staff time when crossing the Volga River. The proposed bridge superstructure is a prefabricated Pratt truss design from Contech Engineered Solutions which is approximately 12-feet wide and 9-feet-10-inches tall, or equal provided by another manufacturer. The truss is made of Corten steel that will achieve a weathered look to provide a natural aesthetic. The bridge superstructure is presented in Section 6.2 of this report. Figure 1.1 represents a 3D rendering of the full project site, including the pedestrian bridge and trail.

Hydraulic and hydrologic design considerations ensure that the bridge and bridge connections can withstand applicable loading scenarios beyond vertical loads due to pedestrians and vehicles, including wind, ice, debris, and water forces. The design freeboard for the proposed bridge is 3.9 feet above the 50-year flood, which is more than the required 3 feet above the 50-year flood and will allow ample space for floating debris to pass under the bridge during a flood event. Also, the backwater 400 feet upstream due to the proposed bridge is 1.32 inches, while the maximum value is 1.5 feet at a location 1.5 times the length of the bridge upstream. See sections 6.3 and 6.4 of this report for the hydrologic and hydraulic designs, respectively.

Reinforced concrete abutments support the bridge on each side of the river. They are situated such that they are out of the 100-year floodplain and will not negatively impact the flow of the river. The bridge spans are attached to the abutments by anchor bolts designed by Contech Engineered Solutions. The total height of each abutment is 11-feet-6-inches, including a 3-foot-10-inch beam seat, a 2-foot stem, and a 1-foot-3-inch approach slab seat. The abutment footing is 10 feet wide by 15 feet long. The abutments are presented in Section 6.5 of this report.



Figure 1.1. 3D rendering of the proposed pedestrian bridge and trail.

The bridge design includes one reinforced concrete pier which is situated out of the main river channel to reduce the amount of debris buildup and loading associated with high flows. The pier is also situated such that any debris that may build up can safely be removed by city staff. A T-shaped pier was chosen for design as it can withstand large hydraulic forces and reduces the column size in the river. The pier is a total of 23-feet tall, including the pier cap, column, and footing. The pier cap width is 15 feet, the column width is 5 feet, and the footing width is 13 feet. The pier footing is founded by deep-seated piles to ensure minimal settlement occurs. The bridge pier is presented in section 6.6 of this report. A protective riprap layer was designed around the pier and both abutments to minimize potential scour and destabilization of the bridge. The proposed riprap design is presented in Section 6.9 of this report.

Connecting to the bridge is a 10-foot wide shared-use path. The path is constructed of a 6-inch thick layer of Portland cement concrete (PCC) with a design cross slope of 1.5% to account for drainage while meeting Americans with Disabilities Act (ADA) regulations. The trail was designed to meet all ADA regulations and followed the IADOT Design Manual standards for pedestrian trail design. The trail will serve pedestrians, cyclists, commercial lawn mowers, and UTVs, and may serve equestrians in the future. The total length of the shared-use trail is approximately 640 feet. The pedestrian trail design is presented in Section 6.8 of this report.

The engineer's project cost estimate has been produced for the pedestrian bridge and trail which includes the cost of materials, labor, equipment, overhead, profit, contingency, possible easements or property acquisition, final design, and administration. The total project cost is estimated to be \$1,494,000. Unit costs for each major bid item were determined from RSMeans Cost Handbooks and the IADOT bid tabulations. The full cost estimate is presented in Section VII of this report.

Section II Organization Qualifications and Experience

1. Name of Organization

KGMM Engineering

2. Organization Location and Contact Information

Ryan McDonough – Project Manager Email: ryan-p-mcdonough@uiowa.edu

3. Organization and Design Team Description

KGMM is a team of senior civil engineering students at the University of Iowa in the capstone design class. The team is comprised of four members: Ryan McDonough, Nathan Gjersvik, Ryan Kowalsky, and Spencer McDermott. Ryan McDonough is specializing in structural design and business management, Nathan Gjersvik is specializing in transportation design with a focus area of civil engineering practice, Ryan Kowalsky is specializing in civil engineering practice, and Spencer McDermott is specializing in structural design and business management. Each individual performed a team role and a substantive task leader role.

Section III Design Services

1. Project Scope

The goal of this project was to reconnect the city of Volga with a pedestrian bridge over the Volga River that divides it, including designing a trail to connect the bridge with the existing network of trails, and estimating the cost for the removal of the existing bridge remains. The designed trail creates a continuous path from the campground on the east side of the river to the kayak/boat launch area of the Reflection Park on the west side. The need for a bridge has been long overdue since the existing bridge partially washed away during a flood in 1999, leaving the bridge unserviceable. KGMM included a cost estimate for the removal of the existing bridge that can be performed along with the construction of the new bridge or divided into a separate phase.

2. Work Plan

Throughout the project, KGMM Engineering followed the Gantt Chart timeline laid out in Figure 3.2.1. KGMM informed the client weekly of goals, completed tasks, and problems that were faced with the project.



Figure 3.2.1. Project Gantt Chart.

Section IV Constraints, Challenges, and Impacts

1. Constraints

In brainstorming and developing the options for constructing a bridge to cross the Volga River, the design team came across various project constraints. The primary constraint is that the bridge cannot, in any way, increase the flood risk for the community. The team considered multiple bridge locations to determine the best site to meet all of the City's requests without causing an increased flood risk. Another major constraint was the available budget. The City of Volga may have to receive grant money to pay for the design and construction of the bridge. Budget limited KGMM's design and kept the design team budget conscious.

2. Challenges

A challenge the team noticed immediately is the amount of debris buildup on the piers of the washed-out bridge. This posed as a hurdle the team, which the resolved by constructing a 150-foot span to keep the center pier out of the normal flow of the river. Another challenge was the unprecedented Coronavirus (COVID-19). The University of Iowa transitioned to online courses mid-semester, which made the flow of the project

much more difficult as each of the team members worked remotely and could not meet face to face for collaboration. COVID-19 also limited our team to only one site visit, so the team had to rely heavily on aerial data and available maps of Volga.

3. Societal Impact within the Community and/or the State of Iowa

The addition of a pedestrian bridge in Volga will bring many positive outcomes to the community. With the town currently having limited access to cross to the other side of town without driving all the way around, it leaves a divided community. This pedestrian bridge, KGMM feels, will tie the community and the walking trail systems back together.

A positive impact this bridge and trail system will have on the community is connecting the campground and the old middle school on the east side of the river to the west side, which is home to the kayak entrance as well as multiple other attractions soon to come in the Reflection Park. This bridge will allow for additional tourism and revenue as campers will have direct access to the gorgeous Volga Reflections Park as well as the kayak boat ramp.

Section V Alternative Solutions that were Considered

The layout and terrain in the city of Volga presented many unique options for designing a bridge to cross the Volga River. KGMM Engineering collaborated with the City to produce three potential locations for bridge crossings that would each satisfy the City's needs. Alternative 1 was a bridge crossing the Volga River between Volga Street and Chase Street. Alternative 2 included the removal and replacement of the existing Cass Street bridge which is partially washed out due to flooding. Alternative 3 included a pedestrian connection to the existing C2W bridge south of town. Figure 5.1 graphically shows the locations of each alternative considered.

The advantages and disadvantages of each alternative were critically analyzed to choose the best project site for the City. Alternative 1 presented many advantages, including proximity to the Reflection Park and existing trails, the highest dike elevation on the west side, the possibility for another senior design group to provide a culvert for street drainage, only one pier in the river, and proximity to the largest population of children in the city. However, Alternative 1 would possibly require a temporary construction easement for private properties located near the dike. Alternative 2 was advantageous because it would remove the old bridge which is considered an "eyesore," it is located in the center of town, it can easily connect to the school and gymnasium on the east side of the river, and it could help another senior design group alleviate some flow at the flood gates. However, Alternative 2 would require the most initial funding, it would have at least two piers in the river, and it is at an elevation that has previously been flooded. The only advantage of Alternative 3 is the possibility of simply connecting to the existing C2W bridge, eliminating the need for a completely new bridge. However, Alternative 3 is located far from the center of town and the trail connection would traverse through an area that is frequently flooded.

Upon seeking input from the City, KGMM Engineering chose Alternative 1 for design. A new bridge across Volga Street would meet all of the City's requirements, including connecting the east and west ends of town, connection to existing trails, fewer piers in the river, and low cost.



Figure 5.1. Volga pedestrian bridge alternative locations considered.

Section VI Final Design Details

The goal of this project was to produce a pedestrian bridge that would suit the needs of the City of Volga for many years to come. The delivered design can accommodate pedestrians, cyclists, UTVs, and commercial lawnmowers, and connects the two seemingly disconnected sides of Volga. The following sections describe each design element and the description includes the methods used to size elements, select materials, and estimate quantities. See Appendices F and G for design drawings and design renderings/models, respectively.

1. Bridge Deck

Our team began designing the bridge deck by reading through the Iowa DOT Design manual for pedestrian bridges to determine the loading scenarios we would need to consider. The next step was to calculate loads to use for the bridge deck following AASHTO LRFD standards. The load combination used was a 90 psf live load on the full deck or one 20,000 lb vehicle load to represent a maintenance vehicle, a 35 psf wind load on the full height of the bridge as if it was enclosed, and a 20 psf upward wind force applied at 3' from the edge of the deck in the transverse direction per AASHTO 3.8.2. From these two resources the team determined that the bridge deck would be a 12' wide, 6'' deep concrete slab that will be doubly reinforced with #6 deformed reinforcing steel (rebar). Figure 6.1.1 shows an image of the cross-section of the bridge. The rebars will be spaced 6'' on-center (OC) in the east-west direction and 1' OC in the north-south direction. The concrete will be poured over a trapezoidal metal deck form designed by the prefab company that will be attached to steel W14x43 floor beams. The bridge deck

will share the camber of the truss and will drain at the supports and laterally due to the pavement crown applied when paving. The hand-rail system will be attached directly to the bridge truss. The hand and toe rub rail will be C4x1x10 GA steel members and the safety rail will be steel HSS 1x1x1/8.



Figure 6.1.1 Bridge cross-section

2. Bridge Truss

The bridge truss KGMM used was a prefabricated steel truss designed by Contech Engineered Solutions from Alexandria, Minnesota. This is one of many prefab companies in the area, and others include Bridge Brothers and Pioneer Bridges. We decided to use a prefab company to design the steel truss because we determined it would be cheaper to design and construct. We recommend receiving bids from each of these companies to find the most economical choice. The bridge design we chose was a two-span bridge with spans of 150 feet and 117 feet. By using these spans, the 267-foot total span can be cleared with one pier outside of the main river channel. This was a concern expressed by our client as they wanted to minimize the obstruction of the river flow and prevent debris buildup. The truss is designed using HSS members ($F_v = 50$ kip). Figure 6.2.1 shows a member schedule for the truss. The individual bridge spans are shown below in Figures 6.2.2 and 6.2.3 as well as the entire bridge in Figure 6.2.4. The loading on the bridge was based on LRFD standards and the Iowa DOT Design Manual. The weathered steel finish we chose was the most economical solution and will have a rustic look and does not require repainting. They also offer a painted finish for an additional cost. Figure 6.2.5 shows examples of different finishes.

SCHEDULE OF MEMBERS					
TOP CHORD	HSS 10 x 10 x 3/8				
BOTTOM CHORD	HSS 10 x 10 x 3/8				
VERTICAL	HSS 8 x 8 x 3/8				
END VERTICAL	HSS 10 x 10 x 3/8				
DIAGONAL	HSS 6 x 4 x 1/4 ①				
BRACE DIAGONAL	HSS 4 x 4 x 1/4				
FLOOR BEAM	W 14 x 43				
END FLOOR BEAM	HSS 10 x 10 x 3/8 (STACKED)				
TOE RAIL	C4 x 1 x 10 GA (R.F.)				
RUB RAIL	C4 x 1 x 10 CA (R.F.)				
SIDE DAM	L 6 x 4 x 5/16				
SAFETY RAIL	HSS 1 x 1 x 1/8				

USE HSS 8 x 6 x 3/8 END TWO BAYS, HSS 6 x 6 x 1/4 3RD & 4TH BAYS. TYP EACH END. DOUBLE MITER ALL DIAGONALS.

USE 2 HSS 10 x 10 x 3/8 STACKED FOR END FLOOR BEAMS TYP EACH END.

Figure 6.2.1. Schedule of members.



Figure 6.2.2. 150' truss



Figure 6.2.3. 117' truss.



Figure 6.2.4. Full bridge span from 3D model.



Figure 6.2.5. Weathered steel vs. painted finish.

3. Hydrologic Information

The Volga River hydrologic information was determined using the online program StreamStats from the United States Geological Survey (USGS). The analysis point selected indicated an upstream drainage area of 262 square miles. The exceedance probability discharges for the 2, 5, 10, 25, 50, 100, 200, and 500-year flood were determined using StreamStats and are as follows:

- Q₂ = 5,150 cfs
- Q₅ = 9,230 cfs
- Q₁₀ = 12,200 cfs
- Q₂₅ = 16,100 cfs
- $Q_{50} = 19,300 \text{ cfs}$
- Q₁₀₀ = 22,300 cfs
- Q₂₀₀ = 25,500 cfs
- Q₅₀₀ = 29,700 cfs

According to the Iowa DOT LRFD Bridge Design Manual Section 3.2.2, the design exceedance probability discharge for a bridge is the 50-year flood, so a river flow rate of 19,300 cfs was used for bridge design. See Appendix A for the full StreamStats output. The base flood elevation (BFE) was determined using ESRI ArcMap and was determined to be 794.5 feet upon linear interpolation of the water surface elevation (WSEL) data provided by the Iowa Department of Natural Resources (IDNR). See Appendix B for the full BFE calculation process.

4. Hydraulic Design

The Hydraulic analysis was completed using the Army Corps of Engineers program, HEC-RAS. The Iowa DNR states that for any bridge or culvert structure there must be a minimum freeboard of 3.0 feet during a 50-year flood event and a maximum backwater of fewer than 1 foot during a 100-year flood event. Upon completion of HEC-RAS analysis it was determined that during a 50-year flood event, the freeboard was roughly 3.9 feet. Figure 6.4.1 depicts the water surface level for the 50-year event. The backwater analysis determined that the backwater created by the construction of the bridge was 1.32" at a distance of roughly 450 feet upstream. Figure 6.4.2 displays the water surface profile before construction, and Figure 6.4.3 displays the water surface profile after construction. Once the bridge at Cass St. is removed, the backwater will drop below the 1.32" and should see a net positive decrease in water level due to the old bridge having two piers in the river.



Figure 6.4.1. Water surface elevation during the 50-year flood event.



Figure 6.4.2. Water surface profile before bridge construction.



Figure 6.4.3. Water surface profile after bridge construction.

5. Abutment Design

The bridge abutments were designed using AASHTO LRFD methods presented in the IADOT Bridge Design Manual (BDM). The bearing capacity calculations were based on the methods presented in *Foundation Analysis and Design* by Joseph E. Bowles. As the designed bridge is intended to be prefabricated, it is not feasible to use integrated abutments for the bridge. Therefore, KGMM chose stub abutments with spread footings as foundations. The abutment width (dimension parallel to the bridge direction) was 10.0 feet and the length (dimension perpendicular to the bridge direction) was 15.0 feet. The abutment stem was designed to be a total of 5.0 feet wide, with a 1-foot-inch beam seat and a 1-foot-3-inch approach slab seat. The steel reinforcement at the abutment bottom was chosen to be 19 #5 rebars at 6-inch OC spacing. The dowel bars are designed to be #8 rebars and connect the abutment footing and stem. The stem reinforcement is made up of #6 rebars. A splice length of 1-foot-6-inches is used for the stem reinforcement and the dowel bars. The height of the stem is 9-feet-10-inches, with a 3-foot-10-inch beam seat and a 6-inch approach slab seat. The total height of the abutment and footing is 11-feet-10-inches. See Figure 6.5.1 for the final abutment design and Appendix C for abutment design calculations. Consult the design drawings for element dimensions and details as well as a reinforcement key.



Figure 6.5.1. (a) Abutment cross section; (b) profile view; (c) plan view.

A three-dimensional (3D) rendering of the abutment was developed by KGMM is shown in Figure 6.5.2 such that the client can easily visualize the finished product.



Figure 6.5.1. 3D rendering of the abutments from two different viewpoints.

One of the major design considerations for this bridge was the elevation at which the low steel would be set at. According to the IDNR, for new bridges and roadway embankments, the freeboard must be 3 feet or more between the BFE and the low superstructure horizontal bridge member unless a licensed engineer provides certification that the bridge is designed to withstand the applicable effects of ice and the horizontal stream loads and uplift forces associated with the 100-year flood. Thus, the bridge was designed with the low steel 3.9 feet above the 50-year flood. The low steel elevation is 795.5 feet (NAD83-11 datum) and is the same elevation as the beam seat elevation and the top of pier elevation. The low steel elevation choice also affected the location of the pier and trail, so careful consideration was taken when determining final elevations.

6. Pier Design

The bridge T-pier was designed based on AASTHO LRFD Section 3.6.5 presented in the IADOT BDM Section 6.6 along with Excel calculation files produced and published by IADOT. Hydraulic loading was computed using AASHTO LRFD 3.7, and the design was checked to ensure the pier has adequate strength to resist wind, ice, and water loading. The pier cap and pier cap overhang were designed using an IADOT Excel file called LRFD_Cap_Design_General.xlsb which is published on the Final Design Software section of the BDM. Using this software, the pier cap was checked for flexural strength and shear strength for the applied loading. Outputs include rebar dimensions and details as well as shrinkage and temperature reinforcement. The pier piles were designed using the IADOT Excel file Pile_Length_LRFD_WEAP.xlsb which determines the number of piles and pile length for the given loading, soil information, and pile type. The pier pile footing was designed using the IADOT Excel file LRFD_Footing_Design_General.xlsb and uses the pile information along with the soil information to determine the dimensions and required reinforcement for pier footings. See Figure 6.6.1 for general schematics of the pier. Upon completion of the design, the pier dimensions are as follows:

- Pier cap height = 3.0 feet
- Pier cap depth = 3.0 feet
- Pier cap overhang = 5.0 feet
- Pier column width = 5.0 feet
- Pier column depth = 3.0 feet
- Pier column height (un-tapered) = 12.5 feet
- Pier footing width = 10.0 feet
- Pier footing length = 13.0 feet
- Pier footing thickness = 4.0 feet
- Pier piles: 12 HP10x42 piles with a contract length of 65.0 feet, spaced at 3.0 feet OC, embedded 1.0 feet, with an edge spacing of 1.0 feet.



Figure 6.6.1. (a) Pier cross section; (b) profile view; (c) plan view; (d) pile cap plan view.

A 3D rendering was also developed for the pier and pile cap, as shown in Figure 6.6.2.



Figure 6.6.2. 3D rendering of the pier and pile cap.

7. Pedestrian Trail

Trail design followed the Iowa DOT Design Manual sections 12A-2 Standards for Accessibility and 12B-2 Shared Use Path Design. The trail was determined to be Type 2 based on the criteria of a path serving as a transportation route to facilities that fulfill a basic life need, provide access to services, or provide a safe route for non-drivers. The recommended shared-use trail was designed as a 10-foot wide by 6-inch Portland Cement Concrete (PCC) shared path trail, with a 2-foot graded earth shoulder on both sides of the trail. The trail should be machine placed and broom finished, or burlap drag surfaced to provide texture. The path was designed with a maximum cross slope of 2.0% with a construction target value of 1.5%. Based on a design speed of 18 mph for bicyclists, the minimum radius for any curve on the path is 60 feet, with grades equal to or less than 5.0% to meet ADA regulations. All portions of the trail were designed to comply with ADA regulations. See Figure 6.7.1 for the trail typical section.

The earthwork and grading for the trail follow the Iowa DOT Design Manual sections 10B-1 Seeding, Fertilizing, and Mulching and 12B-2 Shared Use Path Design. Volumetric analysis was completed in Autodesk Civil3D and the Cut/Fill quantity amounted to 669.19 cubic yards of fill. The target cross slope of 1.5% will be more than adequate to ensure that water drains off of the sidewalk and down into the river valley below. There will be 4 feet on both sides of the trail corridor that will also need to be seeded and fertilized as they will be cleared during construction. The total area needed to be seeded and fertilized is 0.156 acres. See Appendix D for the earthwork report provided by Civil3D.



Figure 6.7.1. Typical trail cross-section.

8. Riprap Design

Scour protection for the bridge pier and abutments is critical for the long-term serviceability of the bridge. To minimize scour potential at the bridge pier and abutments, a protective riprap layer was designed. The riprap layer design was based on recommendations from the IADOT BDM section 3.7.3.5 and section C3.2.2.7, and the FHWA publication *Evaluating Scour at Bridges, Fifth Edition*, commonly known as HEC-18. According to the IADOT BDM 3.7.3.5, slope protection for bridges typically is specified to a minimum of the 50-year flood elevation. Using hydraulic and hydrologic data for the Volga River, the references recommended a 2- to 3-foot thick layer of Class E revetment stone which extends 10 feet upstream and downstream from the abutments and is 10 feet wide in both directions at the pier. A layer of engineering fabric is recommended under the layer of riprap, according to IADOT BDM guidelines and standard drawings. See Appendix E for the riprap design calculations. Figure 6.8.1 depicts the final riprap design configuration and its relation to the substructure elements.



Figure 6.8.1. Riprap design configuration.

Section VII Engineer's Cost Estimate

The primary source used to estimate the cost of the Volga Pedestrian Bridge and Trail was the Iowa Department of Transportation's Bid Tabulation. The costs associated with the steel trusses for the prefabricated bridge were estimated by Contech and the remaining bid item costs were determined by KGMM. Table 7.1 displays the material unit legend to clarify the units used for cost estimation.

U
Unit Description
Cubic Yard
Each
Per Station
Acre
Square Yard
Square Foot
Hour
Linear Feet
Ton (2000 lbs)

Table 7.1. Material unit legend.

Table 7.2 displays the final cost estimate for the Volga Pedestrian Bridge and Trail. KGMM recommends performing the entire project in a single phase which includes the construction of the pedestrian bridge and trail as well as the demolition of the remains of the Cass Street Bridge. Performing the project in a single phase would decrease the overall project cost as equipment would only be transported once and would be in the area for the Cass Street bridge demolition. The crane and crane operator could quickly and easily demolish the Cass Street bridge after installing the bridge superstructure, which would reduce the costs associated with equipment mobilization and rental. However, the client may phase the project in two steps if necessary. KGMM recommends that Phase 1 consist of the construction of the pedestrian trail and the bridge substructures as well as the installation of the prefabricated bridge superstructure. It is recommended that Phase 2 consist of the demolition of the Cass Street bridge. The total project cost estimate including contingency, engineering fees, and administration fees is \$1,494,000.00.

volga i caestilari rian ana sinage							
Bridge (Superstructure and Substructure)							
ltem	Unit	Quantity	ntity \$Price/Unit			Total	
Steel Truss	EA	4	\$	219,000.00	\$	876,000.00	
Deck(267x12x.5)	CY	60	\$	200.00	\$	12,000.00	
Subgrade Stabilization Material	SY	260	\$	3.00	\$	780.00	
Scour Protection	CY	173	\$	40.00	\$	6,925.00	
Cast-In-Place Portland Cement							
Concrete	CY	90.5	\$	243.00	\$	22,000.00	
#4 Reinforcement Bar	TON	0.25	\$	695.00	\$	175.00	
#9 Reinforcement Bar	TON	3.1	\$	800.00	\$	2,500.00	
#11 Reinforcement Bar	TON	0.49	\$	835.00	\$	410.00	
Concrete Pump Rental	HR	20	\$	175.00	\$	3,500.00	
H-Pile installation	LF	780	\$	71.00	\$	55,500.00	

Table 7.2. Final project cost estimate.

Volga Pedestrian Trail and Bridge

Total Bridge Cost

\$ 979,790.00

Trail							
ltem	Unit	Quantity	y \$ Price/Unit Total			Total	
Recreational Trail, PCC 6"	SY	710	\$	34.98	\$	24,900.00	
Special Backfill	CY	562.79	\$	21.13	\$	11,900.00	
Corrugated Metal Culvert (12")	LF	14	\$	21.50	\$	301.00	
Seeding and Fertilizing	ACRE	0.1304	\$	2,027.37	\$	265.00	
Clearing and Grubbing	ACRE	0.3260	\$	1,757.56	\$	575.00	
Granular Subbase	SY	710	\$	8.20	\$	5,825.00	
Special Compaction of Subgrade for Recreational Trail	STA	6.39	\$	365.65	\$	2,350.00	
Erosion Control	EA	2	\$	500.00	\$	1,000.00	
Aluminum, Reflective Trail Signs	EA	5	\$	25.00	\$	125.00	
Wood Posts for Trail Signs (4x4)	EA	5	\$	16.98	\$	90.00	
Total Trail Cost \$ 47,340.00							

Bridge Removal

Bridge Removal (350x68)	SF	23800	\$	7.00	\$	167,000.00
			Total Re	emoval Cost	\$	167,000.00
		Pha	se 1 Const	ruction Cost	\$1	,027,200.00
		Pha	se 2 Const	ruction Cost	\$	167,000.00
		Т	otal Const	ruction Cost	\$1	,194,200.00
				Easements	\$	-
			10% C	ontingencies	\$	120,000.00
		15% Engineeri	ing and Ad	ministration	\$	179,130.00
			Total	Project Cost	\$1	,494,000.00

Appendices

The following appendices contain the outputs, design calculations, assumptions, and standards referenced for each design element.

Appendix A – StreamStats Output

The USGS StreamStats program was implemented to determine design flood flowrates for the Volga River at the bridge location. See below the StreamStats output file.

StreamStats Report Volga IA 31 Mar 2020



Location of proposed Pedestrian Bridge.

Basin Characteristics					
Parameter Code	Parameter Description	Value	Unit		
DRNAREA	Area that drains to a point on a stream	262	square miles		
STREAM_VARG	Streamflow variability index as defined in WRIR 02-4068, computed from regional grid	0.405	dimensionless		
DRNFREQ	Number of first order streams per square mile of drainage area	1.24	1st-order streams per square mile		

Parameter			
Code	Parameter Description	Value	Unit
SSURGOC	Percentage of area of Hydrologic Soil Type C from SSURGO	5.4	percent
PRECIP	Mean Annual Precipitation	35.4	inches
RSD	Relative stream density first defined in SIR 2012_5171	0.31	dimensionless
HYSEP	Median percentage of baseflow to annual streamflow	57.37	percent
SSURGOB	Percentage of area of Hydrologic Soil Type B from SSURGO	92.9	percent
SSURGOD	Percentage of area of Hydrologic Soil Type D from SSURGO	0.31	percent
DESMOIN	Area underlain by Des Moines Lobe	0	percent
BSHAPE	Basin Shape Factor for Area	2.88	dimensionless
SSURGOKSAT	Saturated hydraulic conductivity in micrometers per second from NRCS SSURGO database	19.55	micrometers per second
I24H10Y	Maximum 24-hour precipitation that occurs on average once in 10 years	4.37	inches
SSURGOA	Percentage of area of Hydrologic Soil Type A from SSURGO	1.44	percent

General Flow Statistics Parameters [Low Flow Northeast annual 2012 5171]							
Parameter Code	Parameter Name	Value	Units		Min Limit	Max Limit	
DRNAREA	Drainage Area	262	square mi	les	1.4	6506	
STREAM_VARG	Streamflow Variability Index from Grid	0.405	dimension	lless	0.206	0.61	
DRNFREQ	Drainage Frequency	1.24	1st-order square mi	streams per le	0.295	2.78	
General Flow Statistics Flow Report[Low Flow Northeast annual 2012 5171]							
PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE:							
Standard Error (oth	ier see report)						
Statistic		,	Value	Unit	PII	Plu	

Statistic	Value	Unit	PII	Plu
Harmonic Mean Streamflow	59.1	ft^3/s	22	159

General Flow Statistics Citations

Eash, D.A., and Barnes, K.K.,2012, Methods for estimating selected low-flow frequency statistics and harmonic mean flows for streams in Iowa: U.S. Geological Survey Scientific Investigations Report 2012-5171, 99 p. (http://pubs.usgs.gov/sir/2012/5171/)

Flow-Duration Statistics Parameters[Statewide Flow Duration 2012 5232]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	262	square miles	15.5	7782
SSURGOC	SSURGO Percent Hydrologic Soil Type C	5.4	percent	0.09	83.5
PRECIP	Mean Annual Precipitation	35.4	inches	27.7	38
RSD	Relative Stream Density	0.31	dimensionless	0.22	0.49
HYSEP	Hydrograph separation percent	57.37	percent	20.3	78
STREAM_VARG	Streamflow Variability Index from Grid	0.405	dimensionless	0.21	0.76
SSURGOB	SSURGO Percent Hydrologic Soil Type B	92.9	percent	5.7	99.4
SSURGOD	SSURGO Percent Hydrologic Soil Type D	0.31	percent	0	57

Flow-Duration Statistics Flow Report[Statewide Flow Duration 2012 5232]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SEp
1 Percent Duration	1770	ft^3/s	23.5
5 Percent Duration	638	ft^3/s	23.6
10 Percent Duration	339	ft^3/s	24.2
15 Percent Duration	356	ft^3/s	24.6
20 Percent Duration	279	ft^3/s	22.1
30 Percent Duration	200	ft^3/s	17.1

Statistic	Value	Unit	SEp
40 Percent Duration	144	ft^3/s	14.9
50 Percent Duration	111	ft^3/s	16.4
60 Percent Duration	83.1	ft^3/s	22.1
70 Percent Duration	54.8	ft^3/s	32.4
80 Percent Duration	49.6	ft^3/s	40.1
85 Percent Duration	42.7	ft^3/s	42.5
90 Percent Duration	38.1	ft^3/s	51
95 Percent Duration	26.3	ft^3/s	74.9
99 Percent Duration	18.7	ft^3/s	

Flow-Duration Statistics Citations

Linhart, S.M., Nania, J.F., Sanders, C.L., Jr., and Archfield, S.A.,2012, Computing daily mean streamflow at ungaged locations in Iowa by using the Flow Anywhere and Flow Duration Curve Transfer statistical methods: U.S. Geological Survey Scientific Investigations Report 2012–5232, 50 p. (http://pubs.usgs.gov/sir/2012/5232/)

Peak-Flow Statist	tics Pa	ITAMETERS[46 Percent (121 square miles	s) Peak Region	122013508	6]				
Parameter Co	de	Parameter Name	Value	Units	;	Min Lir	nit	Ma	x Limit
DRNAREA		Drainage Area	262	squa	re miles	0.08		778	33
DESMOIN		Des Moines Lobe	0	perce	ent	0		100)
BSHAPE		Basin Shape Factor	2.88	dime	nsionless	0.806		13.	94
Peak-Flow Statist	tics Pa	ITAMETERS[54 Percent (141 square miles	s) Peak Region	3 2013 508	6]				
Parameter Code	Para	ameter Name		Value	Units		Min Lim	it	Max Limit
Parameter Code DRNAREA	Par a Drai	ameter Name inage Area		Value 262	Units square mil	es	Min Lim	it 5	Max Limit 2809
Parameter Code DRNAREA BSHAPE	Para Drai Bas	ameter Name inage Area in Shape Factor		Value 262 2.88	Units square mil	es	Min Lim 0.08	it 5 39	Max Limit 2809 13.523
Parameter Code DRNAREA BSHAPE SSURGOKSAT	Para Drai Bas SSU Con	ameter Name inage Area in Shape Factor IRGO Saturated Hydraul ductivity	lic	Value 262 2.88 19.55	Units square mili dimension micromete second	es ess rs per	Min Lim 0.08 0.33	it 5 39 33	Max Limit 2809 13.523 33.572

Value Units

Parameter Code Parameter Name

Min Limit Max Limit

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	262	square miles	0.08	7783
Peak-Flow Statistics Pa	rameters[54 Percent (141 square mi	iles) Peak Regior	n 3 DA only 2015 5055]		
Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit

Peak-Flow Statistics Flow Report[46 Percent (121 square miles) Peak Region 2 2013 5086]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp
2 Year Peak Flood	4420	ft^3/s	2130	9190	46.8
5 Year Peak Flood	8180	ft^3/s	5410	12400	25.7
10 Year Peak Flood	11600	ft^3/s	8290	16200	20.8
25 Year Peak Flood	16700	ft^3/s	12200	22800	19.4
50 Year Peak Flood	20000	ft^3/s	14400	27700	20.4
100 Year Peak Flood	23100	ft^3/s	16200	33000	22.3
200 Year Peak Flood	29300	ft^3/s	19700	43600	24.9
500 Year Peak Flood	31500	ft^3/s	20100	49400	28.2

Peak-Flow Statistics Flow Report[54 Percent (141 square miles) Peak Region 3 2013 5086]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp
2 Year Peak Flood	4530	ft^3/s	2270	9060	43.1
5 Year Peak Flood	8970	ft^3/s	5430	14800	30.4
10 Year Peak Flood	11900	ft^3/s	7590	18700	27
25 Year Peak Flood	16400	ft^3/s	10500	25500	26.5
50 Year Peak Flood	19000	ft^3/s	11900	30300	27.8
100 Year Peak Flood	22400	ft^3/s	13800	36400	29.1
200 Year Peak Flood	25900	ft^3/s	15600	43000	30.5
500 Year Peak Flood	30000	ft^3/s	17100	52500	33.7

Peak-Flow Statistics Flow Report [46 Percent (121 square miles) Peak Region 2 DA only 2015 5055]

Ph. Prediction Interval-Lower, Ph. Prediction Interval-Opper, SEP. Standard Error of Prediction, SE. Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp
2 Year Peak Flood	3590	ft^3/s	1720	7530	47.4
5 Year Peak Flood	7000	ft^3/s	4450	11000	28.2
10 Year Peak Flood	9630	ft^3/s	6590	14100	23.6
25 Year Peak Flood	13200	ft^3/s	8990	19300	24
50 Year Peak Flood	15900	ft^3/s	10600	23900	25.4
100 Year Peak Flood	18800	ft^3/s	12200	28900	26.9
200 Year Peak Flood	21700	ft^3/s	13600	34500	29.1
500 Year Peak Flood	25500	ft^3/s	15200	42700	32.6

Peak-Flow Statistics Flow Report [54 Percent (141 square miles) Peak Region 3 DA only 2015 5055]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp
2 Year Peak Flood	5150	ft^3/s	2580	10300	44
5 Year Peak Flood	9230	ft^3/s	5330	16000	34.4
10 Year Peak Flood	12200	ft^3/s	7180	20700	33.2
25 Year Peak Flood	16100	ft^3/s	9440	27600	33.6
50 Year Peak Flood	19300	ft^3/s	10900	34000	35.6
100 Year Peak Flood	22300	ft^3/s	12300	40500	37.6
200 Year Peak Flood	25500	ft^3/s	13700	47800	39.7
500 Year Peak Flood	29700	ft^3/s	15100	58500	43.2

Peak-Flow Statistics Citations

Eash, D.A., Barnes, K.K., and Veilleux, A.G.,2013, Methods for estimating annual exceedance-probability discharges for streams in Iowa, based on data through water year 2010: U.S. Geological Survey Scientific Investigations Report 2013-5086, 63 p. with a (http://pubs.usgs.gov/sir/2013/5086/)

Eash, D.A.,2015, Comparisons of estimates of annual exceedance-probability discharges for small drainage basins in Iowa, based on data through water year 2013: U.S. Geological Survey Scientific Investigations Report 2015–5055, 37 p. (http://dx.doi.org/10.3133/sir20155055.) USGS Data Disclaimer: Unless otherwise stated, all data, metadata and related materials are considered to satisfy the quality standards relative to the purpose for which the data were collected. Although these data and associated metadata have been reviewed for accuracy and completeness and approved for release by the U.S. Geological Survey (USGS), no warranty expressed or implied is made regarding the display or utility of the data for other purposes, nor on all computer systems, nor shall the act of distribution constitute any such warranty.

USGS Software Disclaimer: This software has been approved for release by the U.S. Geological Survey (USGS). Although the software has been subjected to rigorous review, the USGS reserves the right to update the software as needed pursuant to further analysis and review. No warranty, expressed or implied, is made by the USGS or the U.S. Government as to the functionality of the software and related material nor shall the fact of release constitute any such warranty. Furthermore, the software is released on condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from its authorized or unauthorized use.

USGS Product Names Disclaimer: Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Application Version: 4.3.11

Appendix B – Base Flood Elevation Calculations

The base flood elevation (BFE) for the 100-year flood was determined using data obtained from IDNR, a preliminary flood insurance rate map (FIRM) from FEMA, and a rating curve for the Volga river produced using the USGS WaterWatch program.

ESRI ArcMap shapefiles containing water surface elevations (WSELs) of the 100-year flood were provided from IDNR. The WSEL downstream from the bridge is 793.4639 feet and the WSEL upstream from the bridge is 795.4095 feet. See Figure B.1 and Figure B.2 for Civil3D screenshots of the provided section locations and WSELs.

Filter by Layer	▼			A BACK	1
Layers	Volga_X-Sections (1)	5.	A AND		1 1
Hyperlink					Basto
Web Address	None				- 1
Display Text	None		SWA OF AN		and a second
General	·				1/20
Feature Class	Default:Volga_X-Sections				1
Coordinate System	UTM83-15		AAL S		
Feature Properties		STREAM LOU			
Featld					1 and
OBJECTID	98	The I want		W7C	1
XS_LN_ID	07060004VolgaR_044391.58		4	112 34	
WTR_NM	Volga River		18 - 1	CONTRACTOR OF	and at
STREAM_STN	44391.5800		175 14 1		-
START_ID	07060004VolgaR_000000.00		12/6-14	1 Million and 1	
XS_LTR	<null></null>		18 C		
XS_LN_TYP	NOT LETTERED, NOT MAPPED		P BREAK		
WSEL_REG	241.8478				Jul .
STRMBED_EL	236.8940		C THE HAVE		2
LEN_UNIT	METERS				
V_DATUM	NAVD88		1/11-24/	ATT OF ANY AND A	
PROF_XS_TE	<null></null>		1 1	ALL STATES	
MODEL_ID	44391.58		1 1 16		
SOURCE_CIT	STUDY1			State Paral State	
Shape_Leng	1627.4454		1 215		See 2
WSEL_FT	793.4639		1 1 1 1 1 1	A KON LA	6 11
Geometry	· · · ·	-+-	1 LATE		\mathbb{W}
Туре	Linestring			A Mark Street	-
Vertex	1	m Str. Land	AS ARCH	COLLAR COLLAR	in the
Vertex X	619766.3698	mas	11 12 14		12 FC
Vertex Y	4740619.7326		S(1)		- B
A CALLER			loig		as 1
and the second		A Day of the	1 2		THE OWNER

Figure B.1. Provided WSEL downstream from the bridge.

ap Feature(s)		PARALA AV	State State		
ilter by Layer	~	lip			
Layers	Volga_X-Sections (1)	Des Contraction of the second s	St. Charles	AND A DAY AND	
lyperlink	-				
Web Address	None				1.25
Display Text	None			1	11
eneral	-			2020 IND	
Feature Class	Default:Volga_X-Sections				
Coordinate System				N States	1
eature Properties	·••		St and the	A Salie / a	6.6
Featld			- 199 Ja-	Stat	-1-
OBJECTID	99	- St	NY Y M		1 miles
XS_LN_ID	07060004VolgaR_045039.19	the second se	(1) 1 1 1 1	11 0 Star	The second
WTR_NM	Volga River	Q.	KKEREN	8	No.
STREAM_STN	45039.1900	de de la companya de	X G X Same		
START_ID	07060004VolgaR_000000.00	ų į	STR SAFEL	3	
XS_LTR	<null></null>				2
XS_LN_TYP	NOT LETTERED, NOT MAPPED				rila ;
WSEL_REG	242.4408				18.1
STRMBED_EL	237.5560		H STAN		
LEN_UNIT	METERS	Disalst			理問
V_DATUM	NAVD88	a Fille ou			
PROF_XS_TE	<null></null>				
MODEL_ID	45039.19		State - All In	175))	
SOURCE_CIT	STUDY1	The seal of the			1.14
Shape_Leng	1242.8681				
WSEL_FT	795.4095	ton - and	Strank BI		
eometry	· · · · · · · · · · · · · · · · · · ·			A SAL	D
Туре				and	R. U
Vertex	1				
Vertex X			Volga St	The second	1
Vertex Y					de la
13 / 2					TP

Figure B.2. Provided WSEL upstream from the bridge.

To estimate the WSEL at the proposed bridge location, the bridge was estimated to be halfway between the two sections provided. See Figure B.3 which depicts the relative locations of the sections and the bridge. The yellow lines represent the locations of the sections and the red line indicates the location of the proposed bridge.



Figure B.3. Relative locations of the proposed bridge and the provided sections.

The calculation of the WSEL at the bridge is as follows:

WSEL = $0.5 \times (793.4639 \text{ ft} + 795.4095 \text{ ft}) = 794.4367 \text{ ft} \approx 794.5 \text{ ft}$. This is the estimated BFE for the bridge location. To check that the estimated BFE is accurate, the 794.0 feet contour line

from Civil3D was compared to the preliminary FIRM from FEMA. See the comparison in Figure B.4.



Figure B.4. Contour line comparison to the preliminary FEMA FIRM.

As shown in Figure B.4, the 794.0 contour line matches well with the blue 100-year flood elevation provided by FEMA. One last check of the BFE comes from USGS WaterWatch. A rating curve for the Volga River at Littleport, Iowa was created using USGS WaterWatch. Rating curves are used to estimate the WSEL for different discharge values. The discharge for a 100-year flood was determined to be 22,300 cfs, so the gage height at Littleport is estimated to be 21 feet. See the rating curve in Figure B.5. The datum for the gage height at Littleport is 677.0 feet above NGVD29, so a total height of 698.0 feet was determined for the BFE at Littleport. Next, the BFE was be converted to NAD83-11 so that a proper comparison could be made. The conversion from NGVD29 to NAD83-11 is shown in Figure B.6. From the conversion, the BFE for Littleport is 800.17 feet. A 5-foot increase in the BFE from Volga to Littleport is reasonable, therefore the BFE at Volga is reasonably accurate.



Figure B.5. Rating curve for the Volga River at Littleport, Iowa. From USGS WaterWatch.

		O N L	INE VERTICA	L DATU	M T I	RANSF	ORMATION
		Home	About VDatum	Download	Do	ocs & Suppor	rt Contact Us
		_			mation —		
* Region :			Contiguous United States				¥
	_	_		—Horizontal Info	rmation—		
			Sou	irce			Target
Reference Fi	rame:		NAD 1927		•	NAD83(2011)
Coor. Syster	m:		Geographic (Longitude, Latitud	le)	•	Geographic (Longitude, Latitude) 🔹
Unit:			meter (m)			meter (m)	· · · · · · · · · · · · · · · · · · ·
Zone:				AL E - 0101	Ŧ		AL E - 0101 🔻
			Sou	— 🗹 Vertical Info	ormation —		Target
Reference Fi	rame:		NGVD 1929			NAD83(2011)
Unit:			foot (U.S. Survey) (US_ft)		۲	foot (U.S. Su	rvey) (US_ft) •
			Height Soundin	g		Height	e Sounding
			GEOID model: GEOID12B	٣		GEOID mo	odel: GEOID12B 🔻
Point Convers	sion	ASCII	File Conversion				
			Input				Output
Longitude:	-91 2	2 08.0000	0	Conver	rt	Longitude:	-91.3688882524
Latitude:	42 45	5 14.00000)	Reset		Latitude:	42.7538888463
Height:	698			Degree	s	Height:	800.170
	Driv	e to on ma	ap Reset Map				Drive to on map Reset Map
	to	DMS			Vertica	Uncertainty (+/-):	19.64688 cm

Figure B.6. Vertical datum transformation.

Appendix C – Substructure Design Calculations

The substructure designed includes abutments on the east and west ends of the pedestrian bridge as well as one pier to connect the two bridge spans. Below are the abutment design calculations.

		.,			
Material proper	ties:				
Concrete density:	$Wc \coloneqq$	$0.150 \frac{kip}{ft^3}$			
Concrete 28-day compressive stren	gth: $f_c' = 4$.0 <i>ksi</i>			
Reinforcement str	ength: $fy := 6$	0 <i>ksi</i>			
Soil properties:	(assumed)				
Backfill: Unit weight: Active pressure Passive pressur Internal friction In-situ soil: Unit weight: Saturated unit Water unit wei Effective unit w	e coefficient: re coefficient: n angle: weight: ght: veight:	$\gamma b := 120 \ pcf$ Kab := 0.33 Kpb := 3 $\phi' := 29 \ deg$ $\gamma := 120 \ pcf$ $\gamma sat := 135 \ pc$ $\gamma w := 62.4 \ pc$ $\gamma' := \gamma sat - \gamma w$	cf f v=72.6 pcf	ohesion:	<i>c'</i> :=0 <i>psf</i>
Active pressure Internal frictior	e coefficient: n angle:	$Ka \coloneqq 0.4$ $\phi \coloneqq 32 \ deg$			
Active pressure Internal friction Granular Cohesive	e coefficient: h angle: $+\Delta H/H$ 0.0005-0.002 (0) 0.01-0.02	$Ka := 0.4$ $\phi := 32 \ deg$ $-\Delta H/H$ $0.005 - 0.01$ $0.02 - 0.04$	K _o K 0.5 0.1 0.6 0		<u>K_p</u> 3.0 2.4
Active pressure Internal friction Granular Cohesive	e coefficient: h angle: +ΔH/H 0.0005–0.002 0.01–0.02	$Ka := 0.4 \phi := 32 \ deg$ $-\Delta H/H 0.005 - 0.01 0.02 - 0.04 $	Ko K 0.5 0.1 0.6 0	33 4	<u>Kp</u> 3.0 2.4
Active pressure Internal friction Granular Cohesive	e coefficient: n angle: + <u>∆H/H</u> 0.0005-0.002 0.01-0.02	$Ka := 0.4 \phi := 32 \ deg$ $-\Delta H/H 0.005-0.01 0.02-0.04 0.$	Ko K 0.5 0.1 0.6 0.1 (a) (b)	<u>a</u> 33 4	Kp 3.0 2.4
Active pressure Internal friction Granular Cohesive	e coefficient: n angle: +∆H/H 0.0005-0.002 (0 0.01-0.02	Ka := 0.4 $\phi := 32 \ deg$ $-\Delta H/H$ 0.005 - 0.01 0.02 - 0.04	Ko K 0.5 0.1 0.6 0 (a) (a)	transat: b) erea	Kp 3.0 2.4

The abutment free-body diagram for analysis:



Abutment Loading Se	cenario:
Superstructure:	
- Dead load of 47,87	'5 lb (not including slab weight)
- Live load of 40,500) Ib
Bridge reactions:	
- Vertical dead react	ion = 47,875 lb (4 per bridge)
- Vertical live reactio	n = 40,500 lb (4 per bridge)
 Vehicle reaction = 	10,000 lb
- 20 psf wind uplift =	= -15,375 lb windward side and -5,125 lb leeward side
 Vertical wind react 	$ion = \pm 9,895 \text{ lb}$
- Horizontal wind rea	action = 25,815 lb
- Longitudinal therm	al reaction = 7,185 ID (at each of 4 base plates)
- Bridge total weight	= 191,500 lb (not including slab weight)
- Bridge lifting weigh	nt = 81,700 lb (including slab weight)
$BridgeWeight \coloneqq 191.5$	kip
VehicleLoad := 10 kip	
$DL \coloneqq 0.5 \cdot BridgeWeight$	$ht + VehicleLoad = 105.75 \ kip$
$BridgeLiveLoad \coloneqq 4 \cdot 4$	$0.5 \ kip = 162 \ kip$
$LL \coloneqq 0.5 \cdot BridgeLiveL$	$oad = 81 \ kip$
$deg \coloneqq \frac{n}{180}$	
100	
Assumed Footing Dir	nensions:
Footing width: B:	$=10 \ ft$
Footing length: L :	=15 <i>ft</i>
Footing thickness	
	=2 ft
Feating Donthe	
rooting Depths:	
Slab thickness:	$t_{alab} := 6 \ in = 0.5 \ ft$
	-suu o oo jo
Backwall required heigh	ht: $h_{bw} = 39 \ in = 3.25 \ ft$
Footing depth:	
	$D_f := h_{bw} + t_f - t_{slab} + 6 \ ft = 10.75 \ ft$

Popring Conseity Evolution	an using Vasie's Paaring Canasity Equation	
bearing capacity Evaluation	on using vesic's bearing capacity equation	lā
Factor of Safety:	$FS_q := 3$	
Vesic's bearing capacity equal	tion:	
$q_n = c' N_c \left(s_c d_c i_c b_c g_c \right) + q_s N_q \left(s_c d_c i_c b_c g_c \right) + q_s N_s \left(s_c d_c i_c b_c g_c \right) + q_s N_s \left(s_c d_c i_c b_c g_c \right) + q_s N_s \left(s_c d_c i_c b_c g_c \right) + q_s N_s \left(s_c d_c i_c b_c g_c \right) + q_s N_s \left(s_c d_c i_c b_c g_c \right) + q_s N_s \left(s_c d_c i_c b_c g_c \right) + q_s N_s \left(s_c d_c i_c b_c g_c \right) + q_s N_s \left(s_c d_c i_c b_c g_c \right) + q_s N_s \left(s_c d_c i_c b_c g_c \right) + q_s N_s \left(s_c d_c i_c b_c g_c \right) + q_s N_s \left(s_c d_c i_c b_c g_c \right) + q_s N_s \left(s_c d_c i_c b_c g_c \right) + q_s N_s \left(s_c d_c i_c b_c g_c \right) + q_s N_s \left(s_c d_c i_c b_c g_c \right) + q_s \left(s_c d_c i_c b_c g_c \right) + q_s \left(s_c d_c i_c b_c g_c $	$\left(s_{q}d_{q}i_{q}b_{q}g_{q} ight)+rac{1}{2}\left.\gamma BN_{\gamma}\left(s_{\gamma}d_{\gamma}i_{\gamma}b_{\gamma}g_{\gamma} ight)$	
$N_q \coloneqq \exp\left(\pi \cdot an(\phi) ight) \cdot (an(4$	$5 \cdot deg + 0.5 \cdot \phi) \Big)^2 = 23.177$	
$N_c := \frac{N_q - 1}{\tan(\phi)} = 35.49$		
$N_{\gamma} \coloneqq 2 \left(N_q + 1 \right) \tan\left(\phi\right) = 30.2$	215	
Shape factors:	Depth factors:	
$s_c \coloneqq 1 + \left(\frac{B}{L}\right) \left(\frac{N_q}{N_c}\right) = 1.435$	$\frac{D_f}{B} = 1.075 \qquad \therefore \qquad k \coloneqq \operatorname{atan}\left(\frac{D_f}{B}\right) = 0.822$	2 rad
$s_q \coloneqq 1 + \left(\frac{B}{L}\right) \tan(\phi) = 1.417$	$d_c \coloneqq 1 + 0.4 \ k = 1.329$	
$(B) \circ (B)$	$d_q = 1 + 2 k \cdot \tan(\phi) (1 - \sin(\phi))^2 = 1.227$,
$s_{\gamma} = 1 - 0.4 \left(\frac{1}{L}\right) = 0.733$	$d_{\gamma} \coloneqq 1$	
Load inclination factors: Since no Service I limit sta	te required, the horizontal loads are neglected.	
$i_c \coloneqq 1$ $i_q \coloneqq 1$ $i_\gamma \coloneqq 1$		
Base inclination factors: Level base, so all are equa	l to 1.	
$b_c \coloneqq 1$ $b_q \coloneqq 1$ $b_\gamma \coloneqq 1$		
Ground inclination factors: Footing near slope, so nee	d these factors.	
$\beta \coloneqq 15$ (assumed river ba	ink slope, degrees)	
0		

Groundwater effects:	offects	on soil	unit wei	aht	
	Incets	011 3011		jiic.	
Soil surcharge load:					
$q_s \coloneqq D_f \cdot \gamma b = 1290 \ psf$					
Allowable bearing pressure:					
$q_n \coloneqq c' \cdot N_c \cdot \left(s_c \cdot d_c \cdot i_c \cdot b_c \cdot g_c \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot i_q \cdot b_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot i_q \cdot b_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot i_q \cdot b_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot i_q \cdot b_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot i_q \cdot b_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot i_q \cdot b_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot i_q \cdot b_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot i_q \cdot b_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot i_q \cdot b_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot i_q \cdot b_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot d_q \cdot i_q \cdot b_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot d_q \cdot i_q \cdot b_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot d_q \cdot d_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot d_q \cdot d_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot d_q \cdot d_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot d_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot d_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot g_q \right) + q_s \cdot N_q \cdot \left(s_q \cdot d_q \cdot g_q \right) + q_s \cdot \left(s_q \cdot d_q \right) + q_s \cdot \left(s_q \cdot d_$	+0.5•7	$\gamma b \cdot B \cdot N$	$V_{\gamma} \cdot (s_{\gamma} \cdot d)$	$_{\gamma} \cdot i_{\gamma} \cdot b_{\gamma}$	$\cdot g_\gamma angle$
$q_n = 34.971 \ ksf$					
Dead load eccentricity:					
$e_{DL} \coloneqq 19 \ in = 1.583 \ ft$					
Reduction factor due to eccentricity:					
$R_e := 1 - \left(\frac{e_{DL}}{B}\right)^{0.5} = 0.602$					
Reduced allowable bearing pressure:					
$q_n' \coloneqq q_n \cdot (1 - R_e) = 13.915 \ \textit{ksf}$					
Applied Bearing Pressure:					
Total vertical load (dead + live), no load combinations:					
$P_{tot} \coloneqq DL + LL = 186.75 \ kip$					
$A_f \coloneqq B \cdot L = 150 \ ft^2$					
$q_{applied} \coloneqq \frac{P_{tot}}{A_f} = 1.245 \ \textit{ksf}$					
Bearing Capacity Safety Factor Check:					
Check if the allowable bearing pressure is greater than t by a factor of safety	he app	olied pre	essure m	ultiplied	
$FS_q \cdot q_{applied} = 3.735 \ \textit{ksf}$ < $q_n' = 13.915 \ \textit{ksf}$ OK		FS_{true} :=	$=\frac{q_n'}{a}$	=11.17	7
			<i>Happlied</i>		

Active	earth pressure:	
$P_a = 0$	$.5 \cdot \gamma b \cdot Kab \cdot D_f^2 = 2.288 \frac{kip}{ft}$ $h_a := \frac{2 D_f}{3} = 7.167 ft$	
Overt Ac	urning moments: moments about footing heel ive earth pressure	
$M_o \coloneqq$	$P_a \cdot (D_f - h_a) \cdot L = 122.987 \ ft \cdot kip$	
Resis Liv	ing moments: moments about footing heel e load, dead load, concrete weight, and trail slab weight	
$M_L \coloneqq$	$LL \cdot (5 ft - (1 ft + 7 in)) = 276.75 ft \cdot kip$	
$M_D :=$	$DL \cdot (5 \ ft - (1 \ ft + 7 \ in)) = 361.313 \ ft \cdot kip$	
$M_R \coloneqq$	$M_L + M_D = 638.063 \ ft \cdot kip$	
Overt	urning factor of safety:	
$FS_o \coloneqq$	$\frac{M_R}{M_o} = 5.188 > 3 \qquad \text{OK}$	
Slidi	ng Stability Analysis:	
Total	vertical loading:	
$P_{tot} =$	186.75 <i>kip</i>	
Frictio	nal resistance:	
<i>F</i>	$=P_{t-t}\cdot \tan(\phi) + B\cdot L\cdot c' = 116.694$ kip	
- max		
гасцо	F	
FS_v :=	$\frac{r_{max}}{P_a \cdot L} = 3.4$ > 3 OK	



Created with PTC Mathcad Express. See www.mathcad.com for more information.

$\delta_{ERigidCorner} \coloneqq 0.93 \cdot \left(\alpha \cdot I_s \cdot I_f \cdot \left(\frac{q_{net} \cdot \langle q_{net} \rangle }{q_{net} \cdot \langle q_{net} \rangle } \right) \right) = 0.93 \cdot \left(\frac{q_{net} \cdot \langle q_{net} \rangle }{q_{net} \cdot \langle q_{net} \rangle } \right)$	$\frac{(1-\mu^2)}{E} B' = 0.107 \ in$
Since both the corner settlement and foundation are very small, the design inches for footings.	the center settlement values for the abutment is OK. Settling limits are approximately 0.5"
Abutment Structural Analysis Us	ing ACI 318-11:
Abutment details and dimensions:	
Thickness of stem	$t_{stem} \coloneqq 2 \; ft$
Length of toe	$l_{toe} \coloneqq 2.75 \ ft$
Length of heel	l_{heel} :=2.25 ft
Thickness of footing	t_{foot} := 2 ft
Concrete cover	$d_c \coloneqq 3$ in
Stem Steel	#5 @ 12 in
Heel Steel	#5 @ 12 in
Transverse reinforcing	#5 @ 12 in
Yield strength of steel	$f_y = 60 \ ksi$
Resistance Factor for Tension	$\phi_f := 0.90$
Resistance Factor for Shear	ф :=0.00
Resistance ractor for Shear	$\phi_v = 0.90$

Loading and soil data:	
Allowable bearing capacity w/ factor of safety	$q_b \coloneqq \frac{q_n'}{FS_q} = 4638.411 \ psf$
Self pressure	$q_{self} \coloneqq t_{foot} \cdot Wc + \gamma b \cdot \left(D_f - t_{foot} \right) = 1350 \ psf$
Allowable soil pressure	$q_{allow} \coloneqq q_b - q_{self} = 3288.411 \ psf$
Area of footing needed	$A_{needed} \coloneqq \frac{P_{tot}}{q_{allow}} = 56.79 \ ft^2$
Footing weight	$W_{foot} \coloneqq Wc \cdot B \cdot L \cdot t_{foot} = 45000 \ lbf$
Overburden weight	$W_{OB} \coloneqq 0.5 \ \gamma b \cdot B \cdot L \cdot \left(D_f - t_{foot} \right) = 78750 \ lbf$
Soil pressure	$\begin{aligned} q_{soil} &\coloneqq \left(P_{tot} + W_{foot} + W_{OB}\right) \div \left(L \cdot B\right) = 2070 \ psf \\ & \text{OK since } q_{allow} = 3288 \ psf \end{aligned}$
Upward pressure on the footing for us	se in shear and flexural design:
Factored vertical load:	
$P_u \coloneqq \max \left(1.4 \cdot DL, 1.2 \cdot DL + 1.6 \cdot LL \right)$)=256.5 <i>kip</i>
Upward pressure on the footing from	the soil: $q_u \coloneqq \frac{P_u}{A_f} = 1.71 \ ksf$
Steel cover and diameters:	
$d_b \coloneqq 0.625 \ \textit{in} \qquad c_c \coloneqq 3 \ \textit{in} \qquad c_1 \coloneqq c_c + 3 \ \textit{in} \qquad c_1 \equiv c_c + 3 \ \textit{in} \ c_1 \equiv c_1 \equiv c_c + 3 \ \textit{in} \ c_1 \equiv c_1 \equiv c_1 \ c_1 \equiv c_1 = 3 \ \textit{in} \ c_1 \equiv c_1 \equiv c_1 = 3 \ \textit{in} \ c_1 \equiv c_1 \equiv c_1 = 3 \ \textit{in} \ c_1 \equiv c_1 \equiv c_1 \equiv c_1 \equiv c_1 = 3 \ \textit{in} \ c_1 \equiv $	0.5 $d_b = 3.313$ in $c_2 := c_c + d_b + 0.5$ $d_b = 3.938$ in
$c_{avg} \! \coloneqq \! 0.5 \left(c_1 \! + \! c_2 ight) \! = \! 3.625 \; in$	
Effective depth of footing: $d \coloneqq t_{foot}$	$-c_{avg} = 20.375 \ in$
Check for one-way shear at critical se	ction, distance d from face of stem:
$V_{uOneWay} \coloneqq q_u \cdot B \cdot \left(\frac{L - c_1}{2} - d\right) = 96.85$	55 <i>kip</i>
$\lambda = 1$ normal weight concrete	
$\phi V_c \coloneqq 0.75 \cdot 2 \cdot 1 \cdot \sqrt{4000} \cdot 10 \cdot 12 \cdot \frac{20.3}{10}$	$\frac{375}{00} = 231.953$ \therefore $\phi V_c \coloneqq 231.953 \ kip$
Since $V_u < \phi V_c$, the footing thickness	s is adequate for one-way shear.

Check for two-way (punching shear:
$V_{uPunchOut} \coloneqq q_u \cdot (A_f - (c_1 + d) (c_2 + d)) = 249.661 \ kip$
$\beta \coloneqq \frac{c_1}{c_2} = 0.841 \qquad b_o \coloneqq 2 \cdot (c_1 + d) + 2 \cdot (c_2 + d) = 96 \text{ in } \alpha_s \coloneqq 40$
$\phi V_{cPunchOut} \coloneqq 0.75 \cdot min\left(4, \left(2 + \frac{4}{\beta}\right), \left(2 + \alpha_s \cdot \frac{d}{b_o}\right)\right) \cdot 1 \cdot \sqrt{4000} \cdot 96 \cdot 20.375 = 371124.906$
$\phi V_{cPunchOut} = 371.125 \ kip$
Since $V_{uPunchOut} < \phi V_{cPunchOut}$, the footing is adequate for two-way shear.
Flexural reinforcement:
Width of rectangular section: $b := B = 120$ in
Bending moment (cantilever beam: $M_u := q_u \cdot B \cdot \left(\frac{L - c_1}{2}\right) \left(\frac{L - c_2}{4}\right) = 461.76 \ ft \cdot kip$
Preliminary area of steel using rule of thumb: $A_s = M_u/(4 \ d)$
$A_{sPrelim} \coloneqq \frac{461.76}{4 \cdot 20.375} = 5.666 \qquad A_b \coloneqq 0.310 \ in^2 \qquad N_{bars} \coloneqq \frac{5.666}{0.310} = 18.277$
Use 19#5 bars. Minimum steel area based on shrinkage and temperature for slabs:
$ \rho_{min} = 0.0018 $ for $f_y = 60000 \ psi$ $A_s := 19 \cdot A_b = 5.89 \ in^2$
$A_{sMin} \coloneqq ho_{min} \cdot b \cdot t_{foot} = 5.184 \ in^2$ Trial area more than this so OK.
Max bar spacing: $s_{max} \coloneqq min\left(3 \cdot t_{foot}, 18 \ in\right) = 18 \ in$
Bar spacing provided: $s_{prov} \coloneqq \frac{b}{19} = 6.316$ in Less than max so OK.
Check flexural strength of rectangular section using standard procedure:
$\beta_1 \coloneqq \max\left(0.65, 0.85 - 0.05 \cdot \frac{f_c' - 4000 \ psi}{1000 \ psi}\right) = 0.85 \qquad E_s \coloneqq 29000 \ ksi \varepsilon_{ty} \coloneqq \frac{f_y}{E_s} = 0.002$
$A_{sTensionControlled} \coloneqq \frac{0.85 \cdot f_c' \cdot b \cdot \beta_1}{f_y} \cdot \left(\frac{3 \cdot d}{8}\right) = 44.163 \ in^2 \qquad \text{We provide less than this so OK}$
$a \coloneqq \frac{A_s \cdot f_y}{0.85 \cdot f_c' \cdot b} = 0.866 \ in \qquad M_n \coloneqq A_s \cdot f_y \cdot \left(d - \frac{a}{2}\right) = 587.289 \ ft \cdot kip \qquad \phi_F \coloneqq 0.9$
$M_r := \phi_F \cdot M_n = 528.56 \ ft \cdot kip$ $M_u = 461.76 \ ft \cdot kip$





See the separate appendix for design drawings and final abutment details. Below are the design calculations for the pier column, footing, and pile foundation.

Volga Pier Calculation	is Using AASHTO LRFD and Iowa DOT BDM:	
Hydraulic data:		
Average flow velocity	: $V_{avg} = 5.5 \frac{ft}{s}$	
Low flow elevation at	pove top of footing: $H_w \coloneqq 4.0 \; ft$	
Water force (WA) calcul	ations:	
Drag coefficients: Longitudinal C_D Lateral C_L	= 1.40 (assume debris is present) = 0.00 (no skew between pier and stream flow)	
Average hydraulic press	ures:	
Longitudinal pressure	$p_{Davg} := \frac{C_D \cdot 5.5^2}{1000} = 0.042 p_{Davg} := 0.042 ksf$	
Lateral pressure:	$p_{Lavg} := rac{C_L \cdot 5.5^2}{1000} = 0$ $p_{Lavg} := 0 \ ksf$	
Maximum pressures:		
Longitudinal:	$p_{Dmax}:=2 \cdot p_{Davg}=0.084 \ ksf$	
Lateral:	$p_{Lmax} \coloneqq 2 \cdot p_{Lavg} = 0 \ ksf$	
Column depth (width wi	th respect to the stream channel): $D_c = 3.0 \; ft$	
Stream force on column		
Longitudinal:	$P_D \coloneqq p_{Dmax} \cdot D_c = 0.252 \ rac{kip}{ft}$	
Lateral:	$P_L \coloneqq p_{Lmax} \cdot D_c = 0 \; rac{kip}{ft}$	
Total column buoyancy	force: $F_{BC} \coloneqq H_w \cdot 5 \ ft \cdot D_c \cdot 0.0624 \ \frac{kip}{ft^3} = 3.744 \ kip$	up
Column buoyancy force	per foot: $w_{BC} \coloneqq 5 \ ft \cdot D_c \cdot 0.0624 \ \frac{kip}{ft^3} = 0.936 \ \frac{kip}{ft}$	up
Footing buoyancy force:	$F_{BF} = 2 ft \cdot 8 ft \cdot 6 ft \cdot 0.0624 \frac{kip}{r^3} = 5.99 kip$	up



				Critical Points				Fifth Points A	long Taper		
Dist from 0.1. Oshur	a to Daint of Internet N		A	В	С	0	1	2	3	4	5
Dist. from C.L. Colum Dist. from Cap End to	Point of Interest, X1+)	((2+X3-X	6,441	1,000	1.000	5.000	4.000	4.750	2.000	1.000	0.000
Section Height, Hx Estimat'd Dist. from (ap Bot. to C.G. of Bar	Group, ds	7.000 6.583	3.800 3.383	3.800 3.383	7.000 6.583	6.200 5.783	5.400 4.983	4.600 4.183	3.800 3.383	3.000 2.583
Factored Shear, Vu	tue to P1		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Factored Shear, Vu,	tue to P2		130.72	130.72	130.72	130.72	130.72	130.72	130.72	130.72	0.00
Factored Shear, Vu,	due to Diaphragm		0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
Factored Shear, Vu,	due to Pier Cap		19.74	1.91	1.91	14.06	10.35	7.09	4.28	1.91	0.00
Total Pacibled Sileal	, vu		100.46	152.65	152.65	144.70	141.07	197.01	135.00	102.00	0.00
Factored Moment, M	u due to P1		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Factored Moment, M Eactored Moment, M	udue to P2		711.24	0.00	0.00	522.88	392.16	261.44	130.72	0.00	0.00
Factored Moment, M	u due to Pier Cap		54.82	0.92	0.92	30.47	18.30	9.62	3.98	0.92	0.00
Total Factored Mome	nt, Mu		766.09	0.92	0.92	553.36	410.47	271.06	134.70	0.92	0.00
Estimate Flexura	I Reinforcement F	Required									
				Critical Points				Fifth Points A	long Taper		
Daugh Eatlands of t	and the second second		A	В	С	0	1	2	3	4	5
Rough Estimate of A	required at each section	uni	2.170	0.005	0.005	1.064	1.320	1.011	0.598	0.005	0.000
Rough Estimate of M	aximum A _s required		2.17	0 in^2							
Estimate of the numb	er of bars	#7	4			Note: The fle	exural reinfor	cement informat	ion on the left	is an	
required for bar sizes		#8	3			estimat	te of what is i	required for the	overhang. In t	he next	
		#10	2			reinform	cement to be	used in the des	ion checks	actual	
		#11	2			remote	comont to be	about in the des	get structed.		
Enter Flexural a	d Shear Reinf for	r Design (Checks	1							
				_							
Stirrup Bar Size (i.e.	14, #5, etc.)		4	_							
Total Area of Shear	gs (Typ. 4 legs for doub tirrups	ne hoops)	2	in ²	Stimup cost	cina is entere	d later				
Total Area of orlean a	on op 3		0.400		Garrup spe	ung is entere	a dici.				
Bar Size for Flexural	Reinforcement (i.e. #9,	#10, etc.)	9								
Laver	d' (in) by Laver	No. of Ba	rs per Laver	-							
1	3.1875	10.0100	8								
2	7.1875										
3	11.1875										
4	10.1870	-									
Total Bar Area Input,	A _s provided		8.00	0 in²							
Distance from Top of	Cap to C.G. of Bar Gro	oup, d'	3.18	8 in	Total bar a	rea is lumped	at its center	of gravity.			

Enter Plexural Keint, Development Lengths	,									
Available Cap Length for #9 Development Length	75.292	in	Measured f	from critical sa	m and assume	es 2" end clear	rance.			
Straight Bar Development Length (Non-Epoxy Coated I	Reinforcemen)	Aashto Lrfd	15.10.8.2.1a-	c					
Basic Development Length for a # 9 Bar	81.216	in								
Reinforcement Location Factor, Art	1.300	Top bar fact	lor Literat in dai	termination of	a Califo call	D112 bu defe	di unan ann a	-		
One-balf Center to Center Bar Spacing	4 267	in	Used in de	termination of	c. User can (verwrite	uit, user can c	verwrite.		
Reinforcement Confinement Factor. A.	0.400		AL and the	refore k. assu	med to be 0.	Werthing.				
Excess Reinforcement Factor, A	0.271	By default s	et equal to g	6/g118. User	can overwrite.					
Development Length for a # 9 Bar	12.000	in								
Enter Develop Length Used for a # 9 Bar	12.000	in								
is cap cong Enough for Develop cengin?	TES									
Standard Hook Development Length (Non-Epoxy Coate	ed Reinforcem	ent)	Aashto Lrfd	15.10.8.2.4						
Basic Development Length for a # 9 Bar	21.432	in .								
Excess Reinforcement Factor 3	0.800	By default s	et equal to de	6/a118 User	can overwrite					
Development Length for a # 9 Bar	9.024	in		orgino. Osci	can overwrite.					
Enter Develop Length Used for a # 9 Bar	10.000	in								
Is Cap Long Enough for Develop Length?	YES									
Enter Bar End Type for Development		1								
(S = straight, H = hook)	2		1							
Development Length Used for a # 9 Bar	12.000	in	This is use	d to determine	e effective area	a of flexural re	inforcement.			
Check Flexural Reinforcement										
Flexural Capacity Check Aashto Lrfd 5.6.3.2										
	A	Critical Point	ts	0	1	Fifth Points A	long Taper	4	5	-
Bar Area Provided, A.	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	0.000	in ²
Fraction of Bar Area that is Effective	1.000	0.833	0.833	1.000	1.000	1.000	1.000	0.833	0.000	
Effective Bar Area Provided, Ase	8.000	6.667	6.667	8.000	8.000	8.000	8.000	6.667	0.000	in ²
Factored Applied Moment, Muz	766.088	0.919	0.919	553.359	410.466	271.062	134.696	0.919	0.000	k*ft
Depth of Equivalent Stress Block, a Distance from Can Bottom to C.G. of Bar Group, d	3.922	3.268	3.268	3.922	3.922	3.922	3.922	3.268	0.000	in
bistance non oup bolion to 0.0. of bar oroup, a	00.010	1000 000	1000 055	2939 662	2493.062	2147 462	1001 000	42.410	02.010	
Factored Flexural Resistance, Mr. = (Mn.	2838,662	1223.300	1220.000	2000.002			1801.862	1223.355	0.000	k*π
Factored Flexural Resistance, Mr ₂ = dMr ₂ Is Mr ₂ >= Mu, ? Minimum Reinforcement Check Aashto Li Yield to UII: Tensile Strength Ratio, r ₃ Flexural Cracking Variability Factor, r ₁ Modulus of Rupure, f. e 0.37°, r	2838.662 Yes rfd 5.4.2.6 and 0.750 1.600 0.740	Yes 15.6.3.3 Using 0.75 r	Yes Yes Using a co	Yes 67 is conserva	Yes ative for Grade	Yes 60 reinforcen	Yes	2.6 is conserv	Yes	k*ft
Factored Flexural Resistance, Mr ₂ = dMn ₂ Is Mr ₂ > # Mu ₂ ? Minimum Reinforcement Check Aashlo Li Yield to UII. Tensile Strength Ratio, 73 Flexural Cracking Variability Factor, 71 Modulus of Rupture, f, = 0.374 ⁺ ₆ ³⁵	2838.662 Yes rfd 5.4.2.6 and 0.750 1.600 0.740	Yes 5.6.3.3 Using 0.75 r ksi	Yes rather than 0.	Yes 67 is conserva	Yes ative for Grade	Yes 60 reinforcen 0.24 from Aasi	Yes	2.6 is conserv	Ves	k*ft
Factored Flexural Resistance, Mr ₂ = 4Mn ₂ Is Mr ₂ >= Mu ₂ ? Minimum Reinforcement Check Aashto Li Yield to UII. Tensile Strength Ratio, 73 Flexural Cracking Variability Factor, 74 Modulus of Rupture, f ₁ = 0.37*f ₂ ⁴⁵	2838.662 Yes rtd 5.4.2.6 and 0.750 1.600 0.740	Yes 5.6.3.3 Using 0.75 r ksi Critical Point B	Yes Yes Using a co	Yes 67 is conservation of 0.3	Yes ative for Grade	Yes 60 reinforcen 0.24 from Aasi Fifth Points A 2	Yes Yes hent. hto Lrfd C5.4.3	1223.355 Yes 2.6 is conserv 4	0.000 Yes rative.	k*ft
Factored Flexural Resistance, Mrz = 4Mnz Is Mrz >= Muz ? Minimum Reinforcement Check Yield to UII. Tensile Strength Ratio, 73 Flexural Cracking Variability Factor, 7, Modulus of Rupture, fr = 0.37*fc ⁸³ Factored Flexural Resistance, Mrz = 4Mnz	2838.662 Yes rtd 5.4.2.6 and 0.750 0.750 0.740 A 2838.662	Yes Yes 5.6.3.3 Using 0.75 r ksi Critical Point B 1223.355	Yes Yes Using a co ts 1223.355	Yes 67 is conservation 67 is con	Yes ative for Grade	Yes 60 reinforcen 0.24 from Aasl Fifth Points A 2 2147.462	Yes Nent. hto Lrfd C5.4. Nong Taper 3 1801.862	1223.355 Yes 2.6 is conserv 4 1223.355	0.000 Yes vative.	k*ft k*ft
Factored Flexural Resistance, Mrz = 6Mnz Is Mrz > Mu z Minimum Reinforcement Check Aashto Li Yield to Uit: Tensile Strength Ratio, 73 Flexural Cracking Variability Factor, 71 Modulus of Rupture, 1, = 0.371°, ⁶³ Factored Flexural Resistance, Mrz = 6Mnz Section Modulus of Cap, Sz	2838.662 Yes ftd 5.4.2.6 and 0.750 0.750 0.740 A 2838.662 24.500	Yes Yes 5.6.3.3 Using 0.75 r ksi Critical Point B 1223.355 7.220	Yes Yes Using a coll ts C 1223.365 7.220	Yes 67 is conservation 67 is conservation 0 2838.662 24.500	Yes ative for Grade 7 rather than 1 2493.062 19.220	Yes 60 reinforcen 0.24 from Aasi Fifth Points A 2 2147.462 14.580	Yes hent. hto Lrfd C5.4. <u>Jong Taper</u> 3 1801.862 10.580	1223.355 Yes 2.6 is conserv 4 1223.355 7.220	0.000 Yes rative. 5 0.000 4.500	к*п
Factored Flexural Resistance, Mr_= (Mr_ IS Mr_s > Mu_ ? Minimum Reinforcement Check Aashto Li Yield to UII. Tensile Strength Ratio, 73 Flexural Cracking Variability Factor, 71 Modulus of Rupture, f, = 0.37*f_ ²⁵ Factored Flexural Resistance, Mr_= (Mr_ Section Modulus of Cap. Sa Cracking Moment, Mr_s = 73*17*f_*S_ IS Mr_> Mr_7.	2838.662 Yes Ind 5.4.2.6 and 0.750 0.740 A 2838.662 24.500 3132.864 No	Yes 5.6.3.3 Using 0.75 r ksi Critical Point B 1223.355 7.220 923.236 Yes	Yes Yes Using a co ts C 1223.355 7.220 923.236 Yes	Yes 67 is conserva- efficient of 0.3 2838.662 24.500 3132.864 No	Yes Yes ative for Grade 17 rather than 1 2493.062 19.220 2457.700 Yes	Yes 60 reinforcen 0.24 from Aasl Fifth Points A 2 2147.462 14.580 1864.374 Yes	Yes Nent. No Lrfd C5.4.3 Nong Taper 3 1801.862 10.580 1352.886 Yes	1223.355 Yes 2.6 is conserv 4 1223.355 7.220 923.236 Yes	0.000 Yes 7400 5 0.000 4.500 575.424 No	k*ft k*ft ft' k*ft
$\label{eq:result} \begin{split} & \mbox{Factored Flexural Resistance, } Mr_z = \phi Mr_z \\ & \mbox{Iminum Reinforcement Check} & \mbox{Aashlo Li} \\ & \mbox{Iminum Reinforcement Check} & \mbox{Aashlo Li} \\ & \mbox{Yield to UII: Tensile Strength Ratio, } \gamma_1 \\ & \mbox{Fexural Cracking Variability Factor, } \gamma_1 \\ & \mbox{Modulus of Rupture, } r_i = 0.37^* r_z^{5.5} \\ & \mbox{Factored Flexural Resistance, } Mr_z = \phi Mr_z \\ & \mbox{Section Modulus of Cap, } S_z \\ & \mbox{Cracking Moment, } Mcr_z = \gamma_3^* r_z^* r_z^* S_z \\ & \mbox{Image Is } Mr_z = 0.02 \\ & \mbox{Modulus of Cap, } S_z \\ & \mbox{Cracking Moment, } Mcr_z = \gamma_3^* r_z^* r_z^* S_z \\ & \mbox{Image Is } Mr_z = 0.02 \\ & \mbox{Moment, } Mr_z = 0.02 \\ & \m$	2838.662 Yes rdd 5.4.2.6 and 0.750 0.740 A 2838.662 24.500 3132.864 No	Yes 5.6.3.3 Using 0.75 r ksi Crttical Point B 1223.355 7.220 923.236 Yes	Yes Yes Using a co S C 1223.355 7.220 923.236 Yes	Yes 67 is conservation efficient of 0.3 0 2838.662 24.500 3132.864 No	Yes ative for Grade 7 rather than (2493.062 19.220 2457.700 Yes	Yes 60 reinforcen 0.24 from Aasl Fifth Points A 2 2147.462 14.580 1864.374 Yes	Yes hent. hto Lrfd C5.4. long Taper 3 1801.862 10.580 1352.886 Yes	1223.355 Yes 2.6 is conserv 4 1223.355 7.220 923.236 Yes	0.000 Yes vative. 5 0.000 4.500 575.424 No	к*п к*п п ³ к*п
Factored Flexural Resistance, $Mr_{z} = qMn_{z}$ Minimum Reinforcement Check Aashto Li Yield to UI: Tensile Strength Ratio, γ_{1} Flexural Cracking Variability Factor, γ_{1} Modulus of Rupture, $t_{z} = 0.37^{+}r_{z}^{+5}$ Factored Flexural Resistance, $Mr_{z} = qMn_{z}$ Saction Modulus of Cap, S_{2} Cracking Moment, $Mr_{z} = \gamma_{3}\gamma_{1}r_{z}^{+}S_{z}$ Is $Mr_{z} >= Mrc_{z}$ OR	2838.662 Yes rtd 5.4.2.6 and 0.750 0.740 A 2838.662 24.500 3132.864 No	T223.385 Yes 15.6.3.3 Using 0.75 r ksi Critical Point B 1223.385 7.220 923.236 Yes Critical Point	Yes Yes Using a co Using a co I223.355 7.220 923.236 Yes	Yes 67 is conservation efficient of 0.3 0 2838.662 24.500 3132.864 No	Yes Yes ative for Grade 7 rather than i 2493.062 19.220 2457.700 Yes	Yes 60 reinforcen 0.24 from Aasi Fifth Points A 2 2147.462 14.580 1864.374 Yes Fifth Points A	Yes Yes hent. hto Lrfd C5.4. Uong Taper 3 1801.862 10.580 1352.886 Yes Uong Taper	1223.355 Yes 2.6 is conserv 4 1223.355 7.220 923.236 Yes	0.000 Yes vative. 5 0.000 4.500 575.424 No	κ*π κ*π κ*π κ*π
Factored Flexural Resistance, $Mr_z = \phi Mr_z$ Minimum Reinforcement Check Aashto Li Yield to UII. Tensile Strength Ratio, γ_3 Flexural Cracking Variability Factor, γ_1 Modulus of Rupture, $f_z = 0.37^{+} f_z^{+S}$ Factored Flexural Resistance, $Mr_z = \phi Mr_z$ Factored Flexural Resistance, $Mr_z = \phi Mr_z$ Section Modulus of Cap, S_2 Cracking Moment, $Mr_z = \gamma_3 \gamma_1 \gamma_1 \gamma_2$ Image: OR	2338.662 Yes 1d 5.4.2.6 and 0.750 0.740 A 2338.662 24.500 3132.664 No	T223.385 Yes 15.6.3.3 Using 0.75 r ksi Critical Point Yes Yes Yes Critical Point Yes Critical Point B B	C C 1223.355 7 Ves 1223.355 7.220 923.236 Yes 125 125 125	Ves 67 is conservation 67 is conservation 0 2838.662 24.500 3132.864 No	Yes Yes 17 rather than 1 2493.062 19.220 2457.700 Yes	Prime Prime 60 reinforcen 0.24 from Aasi 0.24 from Aasi 2 2147,462 14,580 1864,374 Yes Fifth Points A 2 2 2 1864,374 Yes	Yes Yes hent. hto Lrfd C5.4.3 1801.862 10.580 1352.886 Yes Ves	1223.355 Yes 2.6 is conserv 4 1223.356 7.220 933.236 Yes 4 4	0.000 Yes vative. 5 0.000 4.500 575.424 No	к*п к*п к*п
Factored Flexural Resistance, $Mr_{z} = \phi Mr_{z}$ Minimum Reinforcement Check Aashto Li Yield to Uit. Tensile Strength Ratio, γ_{3} Flexural Cracking Variability Factor, γ_{1} Modulus of Rupture, $f_{z} = 0.37T_{z}^{-85}$ Factored Flexural Resistance, $Mr_{z} = \phi Mr_{z}$ Section Modulus of Cap. S ₂ Cracking Moment, $Mr_{z} = \gamma_{3}\gamma_{1}T_{z}^{*}S_{z}$ (is $Mr_{z} >= Mr_{c}$, ? •••• OR •••• Effective A _{xx} provided	233.662 Yes 110 5 4.2 6 and 0.750 1.600 0.740 A 233.662 234.600 234.500 23132.864 No	T223.385 Yes 15.6.3.3 Using 0.75 r ksi Critical Point B 6.687 1.023	Yes Yes active than 0.1 Using a co 1223.355 7.220 923.236 Yes Is C 6.667 6.067	Ves 57 is conservi efficient of 0.3 0 2838.662 24.500 3132.864 No	Yes Yes Ative for Grade Trainer than 1 2493.062 19.220 2457.700 Yes 1 8.000 Control Co	Ves 60 reinforcen 24 from Aasi Fifth Points A 2 2147,462 14,580 1864,374 Ves Fifth Points A 2 8,000 199 from SA	Non-Se2 Yes hent. hto Lrfd C5.4. Jong Taper 3 10.580 1352.886 Yes Jong Taper 3 8.000 120.580	1223.356 Yes 2.5 is conserv 4 1223.355 7.220 923.236 Yes 4 6.667	0.000 Yes vative. 5 0.000 4.500 575.424 No 5 0.000 0.000	k*ft k*ft k*ft in ²
Factored Flexural Resistance, $Mr_z = \phi Mn_z$ [Is $Mr_z >= Mu_z$? Minimum Reinforcement Check Aashto Li Yield to UII: Tensile Strength Ratio, γ_1 Flexural Cracking Variability Factor, γ_1 Modulus of Rupture, $f_z = 0.377r_z^{15}$ Factored Flexural Resistance, $Mr_z = \phi Mn_z$ Section Modulus of Cap, S ₂ Cracking Moment, $Mcr_z = \gamma_3 \gamma_1 r_1^4 r_2$ Is $Mr_z >= Mr_z$? Effective A ₁₀₀ provided 1.337Mu_z A resulted based on 1.337Mu_z	2338.662 Yes 110 5 4.2.6 and 0.750 1.600 0.740 A 2538.662 24.500 3132.864 No	Yes Yes 15.6.3.3 Using 0.75 r ksi Critical Point B 1223.355 7.220 922.236 Yes Critical Point B 6.667 1.22 0.006	C C 1223.355 7.220 223.355 7.220 922.236 Yes 15 C 6.667 1.22 0.005 0.005	Ves Yes 57 is conserved efficient of 0.3 0 2838.662 24.500 3132.864 No 0 8.000 736.57 2.036	Yes Yes i7 rather than i 1 2493.062 19.220 2457.700 Yes 1 8.000 545.52 1.714	Ves 60 reinforcen 2.24 from Aasi Fifth Points A 2.147,462 14,580 1864,374 Ves Fifth Points A 2.8,000 366,61 1.307	Non.842 Yes Yes	1223.355 Yes 2.5 is conserv 4 1223.355 7.220 923.236 Yes 4 6.667 1.22 0.066	ative.	k*ft k*ft ft ² k*ft in ²
Factored Flexural Resistance, $Mr_z = qMr_z$ Minimum Reinforcement Check Aashto Li Yield to UII. Tensile Strength Ratio, r_{13} Flexural Cracking Variability Factor, r_1 Modulus of Rupture, $f_z = 0.37^z f_z^{-8.5}$ Factored Flexural Resistance, $Mr_z = (Mr_z)$ Section Modulus of Cap, S_2 Cracking Moment, $Mr_z = r_{13}^2 r_1^2 r_2^2$ Is $Mr_z > mr_z$ Effective A_{se} provided 1.337Mu_z A, required based on 1.337Mu_z Is ER. A_{se} provided	2338.562 Yes rtd 5 4.2.6 and 0.750 1.500 0.740 A 2838.662 24.500 3132.844 No A 8.000 1018.90 2.825 Yes	T223.385 Yes 5.6.3.3 Using 0.75 r ksi Critical Point B 1223.355 Yes Critical Point B 6.667 1.22 0.065 Yes	C C 1223.359 Yes arather than 0.1 Using a co Using a co S 7.220 S 923.236 Yes S C 6.667 1.22 0.006 Yes	Ves 67 is conservation 67 is conservation 67 is conservation 67 is conservation 0 2838.662 24.500 3132.864 No 0	Yes Yes ative for Grade 17 rather than i 2493.062 19.220 2457.700 Yes 1 8.000 545.92 1.714 Yes	Fifth Points A 2 24 from Aasi 2.24 from Aasi 2 2.147,462 14.580 1864.374 Yes Fifth Points A 2 5.000 360.51 1.307 Yes	Test 1, 56.2 Yes hent. Mong Taper 3 1801, 562 10, 580 1352, 586 Yes Jong Taper 3 10, 580 1352, 586 Yes Jong Taper 3 8.000 179,15 0,765	1223.355 Yes 2.6 is conserv 1223.356 7.220 923.236 Yes 4 6.667 1.22 0.006 Yes	ative. 5 0.000 4.500 575.424 No 5 0.000 0.000 0.000 0.000 0.000 Ves	k*ft k*ft k*ft k*ft k*ft
$\label{eq:result} \begin{split} & \mbox{Factored Flexural Resistance, } Mr_z = \mbox{M}r_z = \mb$	2338.662 Yes Ifd 5 4.2.6 and 0.780 0.740 A 2838.662 24.600 3132.864 No A 8.000 1018.90 2.828 Yes	T223.386 Yes 5.6.3.3 Using 0.75 r ksi Critical Point B 1223.386 Yes Critical Point B 6.667 1.22 0.006 Yes	Yes Yes Jusing a coll C 1223.365 7.220 923.236 Yes ts C 6.667 1.22 0.006 Yes	Ves Yes 67 is conservation efficient of 0.3 0 2338.652 24.500 3132.864 No 0 0.0 0.00 0.00 0.00 0.00 0.00 2.036 Yes	Yes Yes ative for Grade 17 rather than I 2493.062 19.220 2467.700 Yes 1 8.000 S45.52 1.774 Yes	Ves 60 reinforcent 0.24 from Aasi Fitth Points A 2 2147.462 145.80 1864.374 Yes Fitth Points A 2 8.000 360.81 1.307 Yes	Isol.sez Yes Yes Into Lrid C5.4.3 Mong Taper 3 1801.s62 10.580 105.862 Yes Ves 3 8.000 179.15 0.768 Yes	1223.356 Yes 2.5 is conserv 4 1223.355 7.220 923.236 Yes 4 6.667 Yes	0.000 Yes 740000 55 0.000 575.424 No 55 0.000 0.000 0.000 745	k'ft k'ft k'ft in ²
$\label{eq:result} \begin{split} & \mbox{Factored Flexural Resistance, } M_{R_{2}} = \phi M_{R_{2}} \\ & \mbox{Minimum Reinforcement Check} & \mbox{Aashlo Li} \\ & \mbox{Minimum Reinforcement Check} & \mbox{Aashlo Li} \\ & \mbox{Yield to UII. Tensile Strength Ratio, } \gamma_{1} \\ & \mbox{Fectored Flexural Resistance, } M_{R_{2}} = \phi M_{R_{2}} \\ & \mbox{Factored Flexural Resistance, } M_{R_{2}} = \phi M_{R_{2}} \\ & \mbox{Factored Flexural Resistance, } M_{R_{2}} = \phi M_{R_{2}} \\ & \mbox{Section Modulus of Cap. } S_{R_{2}} \\ & \mbox{Cracking Moment, } M_{R_{2}} = \gamma_{2}\gamma_{1}\gamma_{1}^{4}\gamma_{2} \\ & \mbox{Is Berline Allowed Based on 1.33'Mu_{2} \\ & \mbox{Is Effective } A_{se} \mbox{provid} > = A_{s} \mbox{regiver Based on 1.33'Mu_{2} ? \\ & \mbox{Is Effective } A_{se} \mbox{provid} > = A_{s} \mbox{regiver Based on 1.33'Mu_{2} ? \\ & \mbox{Is Effective } A_{se} \mbox{provid} > = A_{s} \mbox{regiver Based on 1.33'Mu_{2} ? \\ & \mbox{Is Effective } A_{se} \mbox{provid} > = A_{s} \mbox{regiver Based on 1.33'Mu_{2} ? \\ & \mbox{Is Effective } A_{se} \mbox{provid} > = A_{s} \mbox{regiver Based on 1.33'Mu_{2} ? \\ & \mbox{Is Effective } A_{se} \mbox{provid} > = A_{s} \mbox{regiver Based on 1.33'Mu_{2} ? \\ & \mbox{Is Effective } A_{se} \mbox{provid} > \\ & \m$	2338.662 Yes rd 5 4.2.6 and 0.750 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.750 0.740 0.750	Teta Second	Yes Yes ather than 0.1 Using a co Iz23.356 7.220 923.236 Yes Is C 6.667 1.22 0.006 Yes	Ves Yes 67 is conservation efficient of 0.3 0 2838.662 24.500 3132.864 No 0	Yes Yes tive for Grade for ather than i 1 2493.062 19.220 2457.700 Yes 1 8.000 545.52 1.714 Yes	Fifth Points A 2 2147.462 145.80 145.80 1864.374 Yes Fifth Points A 2 1.307 Yes	Isol.sez Yes Yes	1223.356 Yes 2.6 is conserv 4 1223.356 7.220 923.236 Yes 4 6.667 1.22 0.006 Yes	0.000 Yes vative. 5 0.000 4.500 575.424 No 5 0.000 0.000 0.000 0.000 Yes	κ'ft κ'ft π' κ'ft in' κ'ft in'
$\label{eq:result} \begin{aligned} & \texttt{Factored Piexural Resistance, } M_r_z = \texttt{A}M_r_z \\ & \texttt{Minimum Reinforcement Check} \\ & \texttt{Mainimum Reinforcement Check} \\ & \texttt{Aashb Li} \end{aligned}$	233.662 Yes Ifd 5 4.2.6 and 0.750 1.600 0.740 253.662 24.500 3132.864 No 132.864 No 132.864 Xes 24.500 1018.50 2.825 Yes	T2233 Yes 5.6.3.3 Using 0.75 r Ksi Critical Point B 1223.355 Yes	C C 122.355 Yes 20 923.236 Yes Yes	Ves Yes 67 is conserved efficient of 0.3 283.662 24.500 3132.864 No 0 0 0 0 0 0 0 0 0 0 0 0 9 135.87 2.036 Yes	Yes Yes tative for Grade Yes Yes Yes Yes Yes Yes Yes Yes Yes Ye	Yes 60 reinforcen 2.24 from Aasi 2147,462 1484.374 Yes Fifth Points A 2 1864.374 Yes S.000 366.81 1.307 Yes	Isol.se./ Yes wes hent. hto Lrfd C5.4. Jong Taper 3 1301.862 1352.886 Yes Jong Taper 3 8.000 179.15 0.768 Yes	1223.356 Yes 2.5 is conserv 4 1223.355 7.220 923.236 Yes 4 6.667 1.22 0.006 Yes	0.000 Yes 0.000 4.500 575.424 No 5 5 0.000 0.000 0.000 Yes	κ'π κ'π κ'π κ'π κ'π κ'π κ'π
$\label{eq:result} \begin{split} & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Minimum Reinforcement Check} & \mbox{Aashb Li} \\ & \mbox{Minimum Reinforcement Check} & \mbox{Aashb Li} \\ & \mbox{Yield to UIT. Tensile Strength Ratio, } r_3 \\ & \mbox{Flexural Cracking Variability Factor, } r_1 \\ & \mbox{Modulus of Rupture, } t, = 0.37 r_1^{+3} \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Section Modulus of Cap, } S_z \\ & \mbox{Cracking Moment, } Mc_z = r_3^{+1} r_1^{+} S_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Section Modulus of Cap, } S_z \\ & \mbox{Cracking Moment, } Mc_z = r_3^{+1} r_1^{+} S_z \\ & \mbox{Is More Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z = 6 Mr_z \\ & \mbox{Factored Flexural Resistance, } Mr_z \\ & \mbo$	233.662 Yes Id 5.4.2.6 and 0.759 1.600 0.740 A 2838.662 24.800 3132.864 No 2.838 4.600 3132.864 No	Trees Yes 5.6.3.3 Using 0.75 r ksi Critical Point B 1223.356 Yes Critical Point B 6.667 1.22 0.006 Yes	C C 122.356 Yes C 122.356 7.220 923.236 Yes C 6.667 1.22 0.006 Yes	0 0 233.652 24.500 3132.864 No 0 233.652 Yes Yes	Yes Yes ative for Grade i7 rather than i 1 2493.062 19.220 2457.700 Yes 1 1 8.000 545.52 1.774 Yes	Ves 60 reinforcen 24 from Aasi Fifth Points A 2 2147.462 14.580 1864.374 Ves Fifth Points A 2 8.000 360.61 1.307 Yes	Isol.sez Yes Yes Isol.sez hlo Lrfd C5.4.3 Isol.sez 100.sez Isol.sez 10.sez Isol.sez 10.sez Isol.sez 10.sez Isol.sez 10.sez Isol.sez 10.sez Isol.sez 10.sez Isol.sez Ves Yes Ves Yes	1223.356 Yes 2.6 is conserv 4 1223.356 7.220 923.236 Yes 4 6.667 1.22 0.006 Yes	0.000 Yes 74tive. 5 0.000 4.500 575.424 No 5 5 0.000 0.000 0.000 Yes	k*ft k*ft k*ft in ²
Factored Flexural Resistance, Mr_= (Mn_ IS Mr_>= Mu, ? Minimum Reinforcement Check Aashto Li Yield to UII. Tensile Strength Ratio, 71 Flexural Cracking Variability Factor, 71 Modulus of Rupture, f, = 0.37*7, ⁸³ Factored Flexural Resistance, Mr_= (Mn_ Section Modulus of Cap. S2 Cracking Moment, Mr_= 73*1,*1,*S2 IS Mr_> Mrc, ? OR Effective A3e provided 1.33*Mu_ A1, required based on 1.33*Mu_ IS Eff. A3e provid >= A8 regid based on 1.33*Mu_?	233.662 Yes Itd 5.4.2.6 and 0.750 1.600 0.740 2338.662 24.500 3132.864 No 3132.864 No 3132.854 No	1223.386 Yes 5.6.3.3 Using 0.75 r ksi B 1223.386 Yes Critical Point B 6.667 1.22 0.006 Yes	Yes rather than 0. Using a coll S C 1220.365 7.220 923.236 Yes IS C 6.667 1.22 0.006 Yes	0 0 24.500 3132.864 No 0 2.000 8.000 736.392 Yes	Yes Yes Yes Yes It is the for Graded Ves Is 2493.062 Is 2497.700 Yes In 1 8.000 S45.92 I.714 Yes In 1	Ves 60 reinforcen 2 24 from Aasis Fifth Points A 2 147.462 14.580 1864.374 Ves Fifth Points A 2 8.000 3 60.51 1.307 Ves	Isol.sez Yes wes 1 hto Lrfd C5.4.3 Jong Taper 3 1 10.580 1352.886 Yes 1 1 Ves 3 0.768 0.768 0.768 Yes Yes 1 <td>1223.355 Yes 2.6 is conserv 1223.356 7.220 923.236 Yes 4 6.667 1.22 0.006 Yes</td> <td>0.000 Yes ative. 5 0.000 4.500 575.424 No 575.424 No 0.000 0.000 0.000 0.000 Yes</td> <td>k*ft k*ft in² k*ft</td>	1223.355 Yes 2.6 is conserv 1223.356 7.220 923.236 Yes 4 6.667 1.22 0.006 Yes	0.000 Yes ative. 5 0.000 4.500 575.424 No 575.424 No 0.000 0.000 0.000 0.000 Yes	k*ft k*ft in ² k*ft
Factored Flexural Resistance, $M_r = 6Mr_e$ Minimum Reinforcement Check Aashto Li Yield to Uit. Tensile Strength Ratio, γ_3 Flexural Cracking Variability Factor, γ_1 Modulus of Rupture, $f_r = 0.3^{+}r_r^{+S}$ Factored Flexural Resistance, $Mr_e = 6Mr_e$ Section Modulus of Cap. S, Cracking Moment, $Mcr_e = \gamma_3^{+}r_r^{+}r_s^{+}$ Effective A_{se} provided 1.33 ⁺ Mu _e Is Effective Cap. Provided 1.33 ⁺ Mu _e Set Carl Cap. Carl Cap. Carl Cap. Carl Carl Cap. Carl Carl Carl Carl Carl Carl Carl Carl 	233.662 Yes 1d 5.4.2.6 and 0.750 0.740 0.740 233.662 24.500 2132.864 No A 8.000 1018.50 2.825 Yes	I22.3360 Yes 15.6.3.3 Using 0.75 r ksi Critical Point B 1223.356 Yes Critical Point B 0.006 Yes	Yes rather than 0.0 Using a co S C 1223.356 Yes Yes S C 1223.356 Yes Yes S C 6.667 1.22 0.006 Yes	0 0 0 2338.662 243.662 24.600 3132.864 No 0 8.000 0 735.97 2.036 Yes	Yes Yes It we for Grade I rather than i I I I I I I I I I I I I I I I I I I I	Ves Fith Points A 2 147,480 1484,374 14864,374 Yes Fith Points A 2 8,000 360,51 1,307 Yes	Isol.sez Yes nent. hto Lrfd C5.4. Jong Taper 3 1301.862 Yes Jong Taper 3 100.880 Yes Jong Taper 3 8.000 179.15 0.768 Yes	1223.386 Yes 2.6 is conserv 1223.366 7.220 923.236 Yes 4 6.867 1.22 0.006 Yes	0.000 Yes 5 0.000 4.500 575.422 No 575.422 No 0.000 0.000 Yes	k*ft k*ft in ² k*ft
Factored Flexural Resistance, Mrz = 6Mrz Minimum Reinforcement Check Aashto Li Yield to Uit: Tensile Strength Ratio, 73 Flexural Cracking Variability Factor, 71 Modulus of Rupture, f, = 0.371% ³⁵ Factored Flexural Resistance, Mrz = 6Mrz Section Modulus of Cap, S2 Cracking Moment, Mrz = 7371% ¹⁵ S Effective A ₁₀₀ provided 1.331Muz A, required based on 1.331Muz Is Eff. A ₁₀₀ provided 1.331Muz	233.662 Yes td 5.4.2.6 and 0.759 1.600 0.740 A 2833.662 24.500 3132.84 No 2.838 4.500 3132.84 No	T223.380 Yes 5.6.3.3 Using 0.76 r ksi Critical Point B 1223.385 Critical Point B 5.657 1.22 0.006 Yes	C C 1223.336 7.220 923.236 Yes 15 C C 6.667 1.22 0.006 Yes Yes	0 0 233.652 24.500 3132.864 No 0 233.653 Yes Yes	Yes Yes ative for Grade i7 rather than i 1 2493.052 19.220 2457.700 Yes 1 1 8.000 545.92 1.774 Yes	Ves 160 reinforcen 224 from Aasi Fifth Points A 2 2147.462 1864.374 Ves Fifth Points A 2 8.000 360.81 1.307 Yes	Isol.es/ Yes nent. hto Lrfd C5 4: Jong Taper 3 1801.862 10.580 1352.886 Vong Taper 3 8.000 179.15 0.768 Yes	1223.356 Yes 2.6 is conserv 4 1223.356 7.220 923.236 Yes 4 6.667 1.22 0.006 Yes	0.000 Yes ative. 5 0.000 575.424 No 5 5.424 No 0.000 0.000 Yes	κ'π π' κ'π κ'π κ'π η'
Factored Flexural Resistance, Mr_= (Mn_ E Mr_2 > Mu, ? Minimum Reinforcement Check Aasho Li Yield to UII. Tensile Strength Ratio, rja Flexural Cracking Variability Factor, r, Modulus of Rupture, f_= 0.37 rf_s ³⁰ Factored Flexural Resistance, Mr_= (Mn_ Section Modulus of Cap, Sa Cracking Moment, Mcr, = rja*r,*f,*S_ Is Mr_> = Mre, ? Effective A ₁₄ , provided 1.33*Mu ₂ Is Eff. A ₁₄ , provid >= A ₁ regid based on 1.33*Mu ₂ ?	233.662 Yes Id 5.4.2.6 and 0.750 1.600 0.740 233.662 24.500 3132.864 No 8.000 1018.90 2.825 Yes	T223380 Yes 156.3.3 Using 0.75 f Ksl Critical Point B 7.220 923.236 Yes Critical Point B 6.667 1.000 Yes	Yes arather than 0.0 Using a co- ts C 1223.355 7.220 923.236 Yes ts C 6.667 1.22 0.006 Yes	0 0 233.662 24.600 3132.864 No 0 5.000 735.87 2.035 200 Yes	Yes Yes ative for Grade 17 rather than i 2493.062 19.20 2457.700 Yes 1 1.000 545.52 1.714 Yes	Ves 60 reinforcen 0.24 from Aasi Fifth Points A 2 2147.462 145.80 1564.374 Yes Fifth Points A 2 8.000 36.61 1.307 Yes	Isol.sez Yes hent.	1223.356 Yes 2.6 is conserv 4 4 1223.356 7.220 923.236 Yes 4 4 6.667 1.22 0.006 Ves	0.000 Yes 5 0.000 4.500 75.424 No 5 5.00 0.00 0.00 0.00 9 Yes	κ'π π' κ'π κ'π κ'π μ'
Factored Flexural Resistance, $M_r = 6Mr_2$ Minimum Reinforcement Check Aashto Li Yield to Uit. Tensile Strength Ratio, γ_3 Flexural Cracking Variability Factor, γ_1 Modulus of Rupture, $f_r = 0.3^r f_r^{-8}$ Factored Flexural Resistance, $Mr_z = (Mr_z)$ Factored Flexural Resistance, $Mr_z = (Mr_z)$ Cracking Moment, $Mcr_z = \gamma_3^* \gamma_r f_r^* S_z$ Factored Flexural Resistance, $Mr_z = (Mr_z)$ Gracking Moment, $Mcr_z = \gamma_3^* \gamma_r f_r^* S_z$ Factored Flexural Resistance, $Mr_z = (Mr_z)$ Gracking Moment, $Mcr_z = \gamma_3^* \gamma_r f_r^* S_z$ Factored Flexural Resistance, $Mr_z = (Mr_z)^* \gamma_r f_r^* S_z$ Gracking Moment, $Mcr_z = \gamma_3^* \gamma_r f_r^* S_z$ Is $Mr_z >= Mre_z$ Gracking Moment, $Mcr_z = \gamma_3^* \gamma_r f_r^* S_z$ Is $Mr_z >= Mre_z$ Gracking Moment, $Mcr_z = \gamma_3^* \gamma_z f_r^* S_z$ Is ST_{A_z} required based on 1.33* Mu_z State $Mr_z = Mr_z = M$	233.662 Yes 1d 5.4.2.6 and 0.750 0.740 0.740 233.662 24.500 3132.864 No 1018.50 2.825 Yes	I22.3360 Yes Using 0.75 r ksi Critical Point B 1223.356 Yes Critical Point B 0.006 Yes	Yes arather than 0.0 Using a co S C 1223.356 Yes Yes S C 1223.356 Yes S C 6.667 1.22 0.006 Yes	0 0 0 0 0 0 0 0 0 0 0 0 0 0	Yes Yes It we for Grade I rather than i I I I I I I I I I I I I I I I I I I I	Ves Fith Points A 2 147,460 2 147,460 2 147,460 2 147,460 1864,374 Yes Fith Points A 2 8,000 360,51 1,307 Yes	Isol.es/ Yes http://www.second.es/ http://www.second.es/ 100.800 1352.886 Yes 3 5.000 175.15 0.768 Yes	1223.356 Yes 2.6 is conserv 1223.356 7.220 923.236 Yes 4. 6.867 1.22 0.006 Yes	0.000 Yes 50.000 875.424 No 5 0.000 0.000 Yes	k*ft k*ft in² k*ft
Factored Flexural Resistance, Mr_= (Mr_ E Mr_> = Mu, 7 Minimum Reinforcement Check Aashto Li Yield to Uit: Tensile Strength Ratio, 73 Flexural Cracking Variability Factor, 71 Modulus of Rupture, f, = 0.371°, ⁴⁵ Factored Flexural Resistance, Mr_= (Mr_s Section Modulus of Cap, S2 Cracking Moment, Mc7_= 73,71°, ⁴⁵ Cracking Moment, Mc7_= 74,71°, ⁴⁵ Is Mr_s >= Mr_s, 70°, 71°, ⁴⁵ Is Mr_s = A_s req ⁴ based on 1.33°, ⁴⁰ Mu, 7 Section 1.33°, ⁴⁰ M	233.662 Yes td 5.4.2.6 and 0.759 1.600 0.740 A 2838.662 24.500 3132.864 No 2.825 Yes	1223380 Yes 15.6.3.3 Using 0.76 f ksi Critical Point B 1223.356 Yes Critical Point B Critical Point C Critical Point B Critical Point C Critical Point C C C Critical Point C C Critical Point C C C Critical Point C C C C C C C C C C C C C C C C C C C	C C 1223.356 7.220 923.236 Yes Is C C 6.667 1.22 0.006 Yes Yes	0 0 233.652 24.500 3132.864 No 0 23.63 Yes Yes	Yes Yes alive for Grade i7 rather than i 1 2493.062 19.220 2457.700 Yes 1 1 8.000 545.92 1.714 Yes	Ves 160 reinforcen 224 from Aasl Fifth Points A 22147.450 1864.374 Ves Fifth Points A 2 8.000 360.81 1.307 Yes	Isol.es/ Yes hent. total total 10,580 1352,886 Yes Jong Taper 3 10,580 1352,886 Yes Jong Taper 3 8,000 179,15 0,768 Yes	1223.356 Yes 2.6 is conserv 4 1223.356 7.220 923.236 Yes 4 6.667 1.22 0.006 Yes	0.000 Yes 5 0.000 575.424 No 2 5 5 0.000 0.000 0.000 Yes	K*TR K*TR Tr ³ K*TR in ²
Factored Flexural Resistance, Mr_= (Mr_ E Mr_s > Mu, ? Minimum Reinforcement Check Aashto Li Yield to Uit. Tensile Strength Ratio, rjs Flexural Cracking Variability Factor, r, Modulus of Rupture, f_= 0.37 T_s ³⁰ Factored Flexural Resistance, Mr_= (Mr_ Section Modulus of Cap, Sc Cracking Moment, Mcr, = rjs ⁻ rjt ⁻ t ⁻ S_ Is Mr_s >= Mre, ? Effective A ₁₂ provided 1.33 [*] Mu ₂ Is Eit. A ₁₂ provid >= A ₁ regid based on 1.33 [*] Mu ₂ ?	233.662 Yes td 5.4.2.6 and 0.750 0.740 0.740 2538.662 24.800 3132.584 No 8.000 1018.30 2.826 Yes	1223.380 Yes 15.6.3.3 Using 0.75 f ksl Critical Point B 323.236 Yes Critical Point B 6.667 1.22 0.006 Yes	Yes arather than 0.0 Using a co- ts C Yes 1223.355 7.220 923.236 Yes ts C 6.667 1.22 0.005 Yes	0 0 233.662 24.600 3132.864 No 0 8.000 735.87 2.035 200 8.900	Yes Yes ative for Grade 17 rather than i 2493.062 19.20 2457.700 Yes 1 8.000 545.52 1.774 Yes	Ves 60 reinforcen 0.24 from Aasi Fifth Points A 2 147,462 14.880 1864.074 Yes Fifth Points A 2 2.47,462 8.000 360.61 1.307 Yes	Isol.es/ Yes hent. to Lrfd C5.4.1 Jong Taper 3 1801.862 Yes Ves Ves Jong Taper 3 8.000 179.15 0.768 Yes	1223.356 Yes 2.6 is conserv 4 4 1223.356 7.220 923.236 Yes 4 6.667 1.22 0.006 Yes	0.000 Yes 5 0.000 875.424 No 5 5 0.000 0.000 0.000 Yes	K"ft K"ft K"ft K"ft in ²
Factored Flexural Resistance, Mr_= (Mr_ EMr_s=Mu, ? Minimum Reinforcement Check Aashto Li Yield to Uit. Tensile Strength Ratio, rjs Flexural Cracking Variability Factor, rj Modulus of Rupture, f, = 0.37*f,* ⁸ Factored Flexural Resistance, Mr_= (Mr_ Section Modulus of Cap, S, Cracking Moment, Mcr_= rjs*r,*f,*S_ Is Mr_s>= Mrc_,? —— OR Effective A _{se} provided 1.33*Mu_ Is Eff. A _{we} provided 1.33*Mu_ Is Eff. A _{we} provided 1.33*Mu_ Is Eff. A _{we} provided 1.33*Mu_ Section 1.33*Mu_	233.662 Yes 1d 5 4 2 6 and 0.750 0.740 0.740 233.662 24.500 3132.864 NO 1018.50 2.825 Yes	I22.3360 Yes Using 0.75 f ksi Critical Point B 1223.356 Yes Critical Point B 6.967 1.22 0.006 Yes	Yes rather than 0.0 Using a co S C 1223.356 Yes Yes S C 1223.356 Yes S C 6.667 1.22 0.006 Yes	0 0 0 2338.662 243.662 24.600 3132.864 No 0 0 0 20.036 735.97 2.036 Yes Yes	Yes Yes It ves I	Ves Fith Points A 2 147,462 2 147,462 14864,374 Yes Fith Points A 2 8,000 360,51 1,307 Yes	Isol.es/ Yes nent. hto Lrfd C5.4. Jong Taper 3 1301.862 105.880 1352.886 Yes Jong Taper 3 8.000 179.15 0.768 Yes	1223.356 Yes 2.6 is conserv 1223.356 7.220 923.236 Yes 4. 6.867 1.22 0.006 Yes	0.000 Yes 5 5 0.000 875.424 No 5 5 0.000 0.00 0.000 Yes	k*ft k*ft k*ft in* k*ft
Factored Flexural Resistance, Mrg = 6Mrg Is Mrg >= Mug ? Minimum Reinforcement Check Aashto Li Yield to Uit. Tensile Strength Ratio, 73 Flexural Cracking Variability Factor, 71 Modulus of Rupture, f, = 0.371% ¹⁵ Factored Flexural Resistance, Mrg = 6Mrg Section Modulus of Cap, Sg Cracking Moment, Mcg = 7371% ¹⁵ — OR Effective A ₁₀₀ provided 1.337Mug A, required based on 1.337Mug Is Eff. A ₁₀₀ provided Is Mr, a ₁₀₀ provided Is Mr, a ₁₀₀ provided Is Mrg A, required based on 1.337Mug	233.662 Yes td 5.4.2.6 and 0.759 1.600 0.740 A 2833.662 24.500 3132.84 No 2.838.62 2.4.500 3132.84 No	I22.3380 Yes Is 6.3.3 Using 0.76 r Is 6.3.3 Using 0.76 r B 122.336 7.220 932.236 Yes Critical Point B 6.667 1.22 0.006 Yes	C C 1223.356 7.220 923.236 Yes Is C C 6.667 1.22 0.006 Yes Yes	0 0 233.652 24.500 3132.864 No 0 233.652 Yes Yes	Yes Yes it ves if cather than i 1 2483.052 19.220 2457.700 Yes 1 1 8.000 545.92 1.714 Yes	Ves 160 reinforcen 224 from Aasl Fifth Points A 22147.450 1864.374 Ves Fifth Points A 2 8.000 360.81 1.307 Yes	Isol.es/ Yes hent. total total 1801.862 1801.862 1801.862 1801.863 1801.863 1801.863 1801.863 1801.863 1801.863 1801.865 Ves Jong Taper 3 8.000 179.15 0.768 Yes	1223.356 Yes 2.6 is conserv 4 1223.356 7.220 923.236 Yes 4 6.667 1.22 0.006 Yes	0.000 Yes 5. 0.000 4.500 876.424 No 0.000 0.000 Ves	k*ft k*ft in ² in ²
Factored Flexural Resistance, Mr_= (Mr_ EMT_>= Mu, ? Minimum Reinforcement Check Aashto Li Yield to Uit. Tensile Strength Ratio, rjs Flexural Cracking Variability Factor, rj Modulus of Rupture, f_= 0.37°T_s ³⁵ Factored Flexural Resistance, Mr_= (Mr_s Section Modulus of Cap, S, Cracking Moment, Mcr_= rjs*r,*f,*S_ Is Mr_>= Mre, ? Effective A _{re} provided 1.33*Mu ₂ A, required based on 1.33*Mu ₂ Is Eff. A _{re} provided 1.33*Mu ₂	233.662 Yes td 5.4.2.6 and 0.750 0.740 0.740 233.662 24.500 3132.844 No 8.000 1018.90 2.825 Yes	1223.380 Yes 15.6.3.3 Using 0.75 f ksi Critical Point B 923.236 Yes Critical Point B 6.667 Yes	Izz.300 Yes rather than 0.1 Using a co- Izz.355 7.220 923.236 Yes Izz.355 7.220 923.236 Yes Izz.355 7.220 Yes Yes Ves Yes	0 0 0 233.662 24.600 3132.864 No 0 0 0 0 233.692 24.600 3132.854 No 132.854 Ves	Yes Yes ative for Grade 17 rather than i 2493.062 19.20 2457.700 2457.700 Yes 1 8.000 545.92 1.774 Yes	Yes Yes 60 reinforcen 0.24 from Aasi Fifth Points A 2 2147.462 14.580 1864.374 Yes 8.000 360.51 1.307 Yes	Isol.es/ Yes hent. tot Lrfd C5.4. Jong Taper 3 1801.862 105.860 1352.886 38.000 179.15 0.768 Yes	1223.356 Yes 2.6 is conserv 1223.356 7.220 923.236 Yes 4 6.667 1.22 0.006 Yes	0.000 Yes 3.000 5.000 0.000 0.00 0.00 0.00 0.00 Ves	k'ft k'ft k'ft k'ft in ²
Factored Flexural Resistance, Mr_= (Mr_ EMr_>= Mu, ? Minimum Reinforcement Check Aashto Li Yield to UII: Tensile Strength Ratio, 73 Flexural Cracking Variability Factor, 71 Modulus of Rupture, f_ = 0.37*f_* ⁸ Factored Flexural Resistance, Mr_= (Mr_ Section Modulus of Cap, Sa Cracking Moment, Mr_= *13*7*f_*Sa Cracking Moment, Mr_= *13*7*f_*Sa (IS Mr_=>= Mr_= *13*7*f_*Sa Cracking Moment, Mr_= *13*7*f_*Sa (IS Mr_=>= Mr_= *13*7*f_*Sa Cracking Moment, Mr_= *13*7*f_*Sa (IS Mr_=>= Mr_= *13*7*f_*Sa Cracking Moment, Mr_= *13*7*f_*Sa Cracking Moment, Mr_= *13*7*f_*Sa Cracking Moment, Mr_= *13*7*f_*Sa (IS Mr_=>=	233.662 Yes Id 5.4.2.6 and 0.759 1.600 0.740 233.662 24.500 3132.64 No 1018.90 2.825 Yes	I22.3360 Yes 15.6.3.3 Using 0.76 f Ksl Critical Point B 122.356 Yes Critical Point B 6.667 1.22 0.006 Yes	Izz.300 Yes rather than 0.0 Using a co Izz.355 C 122.355 7.220 923.236 Yes Is C C. 6.667 1.22 0.006 Yes Yes	0 0 0 233.654 0 233.654 0 3132.854 No 0 0 3.036 736.97 2.036 Yes 9	Yes Yes It ves I	Ves Fith Points A 2 147.480 1864.374 Yes Fith Points A 2 147.462 3 000 3 000 3 000 1 .307 Yes	Isol.es/ Yes hent. to Lrfd C5 4. Jong Taper 3 1301.862 10.580 Yes Jong Taper 3 8.000 179.15 0.768 Yes	1223.356 Yes 2.6 is conserv 4 1223.356 7.220 923.236 Yes 4 6.667 Yes Yes 4 0.006 Yes	0.000 Yes 5 0.000 4.500 4.500 57.8.42 NO 0.000 0.000 Yes	K*TR K*TR TC ² K*TR In ² In ² In ² K*TR In ² In ² K*TR In ² K*TR In ² K*TR In ² K*TR K*TR K*TR K*TR K*TR K*TR K*TR K*TR K*TR K*T
Factored Flexural Resistance, Mrg = 6Mrg Iminimum Reinforcement Check Aashto Li Yield to Uit. Tensile Strength Ratio, 73 Flexural Cracking Variability Factor, 71 Modulus of Rupture, f, = 0.371% ¹⁵ Factored Flexural Resistance, Mrg = 6Mrg Factored Flexural Resistance, Mrg = 6Mrg Cracking Moment, Mcg = 73,71% ¹⁵ Factored Flexural Resistance, Mrg = 6Mrg Cracking Moment, Mcg = 73,71% ¹⁵ Factored Flexural Resistance, Mrg = 6Mrg Cracking Moment, Mcg = 73,71% ¹⁵ Factored Flexural Resistance, Mrg = 6Mrg Cracking Moment, Mcg = 73,71% ¹⁵ Factored Flexural Resistance, Mrg = 6Mrg Cracking Moment, Mcg = 73,71% ¹⁵ Cracking Moment, Mcg = 74,71% ¹⁵ Cracking Moment, Mcg = 74,71% ¹⁵ Is Br. A _{tex} provided 1.33 ¹⁵ Mug Is Eff. A _{tex} provided 1.33 ¹⁵ Mug Is Br. A _{tex} provided 1.33 ¹⁵ Mug Is Br. A _{tex} provided I.33 ¹⁶ Mug Is Br. A _{tex} provided I.33 ¹⁶ Mug Is Br. A _{tex} provided I.33 ¹⁶ Mug Is	233.662 Yes Id 5.4.2.6 and 0.759 1.600 0.740 A 2838.662 24.500 3132.864 No 2.838 4.500 3132.864 No	1223380 Yes 156.3.3 Using 0.75 / Ksl Critical Point B 923.236 Yes Critical Point B 6.667 1.22 0.006 Yes	Yes rather than 0.1 Using a co- ts C 1223.356 Yes Sc C	0 0 233.662 24.800 3132.864 No 0 8.000 736.87 20.000 Yes 9.000	Yes Yes It ves I	Fifth Points A 2147:462 2147:462 2147:462 14:80 1864.374 Yes Fifth Points A 2000 8:000 366.81 1.307 Yes	Isol.sez Yes http://www.second.se	1223.356 Yes 2.6 is conserv 4 1223.356 7.220 923.236 Yes 4 6.667 1.22 0.006 Yes	0.000 Yes 5. 0.000 4.500 877.424 No 0.000 0.000 0.000 Yes	K"ft ft*
Factored Flexural Resistance, Mr_= (Mr_ Is Mr_>= Mu, ? Minimum Reinforcement Check Aashto Li Yield to Uit. Tensile Strength Ratio, rja Flexural Cracking Variability Factor, rj Modulus of Rupture, f, = 0.37°T, ⁸ Factored Flexural Resistance, Mr_= (Mr_ Section Modulus of Cap, S, Cracking Moment, Mcr_= rja*r, 'f, 'S_ Is Mr_>= Mre, ? Is OR Effective A _{se} provided 1.33°Mu ₂ Is Eff. A _{tu} provided 1.33°Mu ₂ Is Eff. A _{tu} provided 1.33°Mu ₂	233.662 Yes 1d 5 4 2 6 and 0.750 0.740 233.662 24.500 213246 No A 8.000 1018.90 2.826 Yes	I223.380 Yes Using 0.75 r Ksl Critical Point B 1223.356 Yes Critical Point B 0.006 Yes	Izz.300 Yes rather than 0.0 Using a color Using a color Izz.3356 Izz.356 Yes	0 0 0 0 0 2338.662 24.600 3132.864 No 0 0 8.000 735.97 2.036 Yes	Yes Yes It ves I	Yes 60 reinforcen 224 from Aasi 2147.462 2147.462 1864.374 Yes 200 360.51 1.307 Yes	Isol.es/ Yes htp://docs.es/ Jong Taper 3 1801.662 100.580 1352.886 8.000 178.15 0.768 Yes	1223.356 Yes 2.6 is conserv 1223.356 7.220 923.236 Yes 4 6.867 7.220 923.236 Yes	0.000 Yes S S 0.000 S S S 0.000 S S S S S S S S S	K*ft K*ft in ² K*ft
Factored Flexural Resistance, Mr_= (Mr_ Is Mr_>= Mu, 7 Minimum Reinforcement Check Aashto Li Yield to UII: Tensile Strength Ratio, 73 Flexural Cracking Variability Factor, 71 Modulus of Rupture, 1, = 0.371°, ⁸⁵ Factored Flexural Resistance, Mr_= (Mr_s Section Modulus of Cap, Sa Cracking Moment, Mc_s = 7371°, ¹ 75 Is Mr_s >= Mrc, 7 OR Effective A _{se} provided 1.337Ma _s Is ER, A _{se} provided 1.337Mu _s Is ER, A _{se} provided 1.337Mu _s Is ER, A _{se} provided 1.337Mu _s	233.662 Yes Id 5.4.2.6 and 0.759 1.600 0.740 24.500 3132.844 No 24.500 3132.844 No 2.838.662 24.500 3132.844 No	T22.3360 Yes 15.6.3.3 Using 0.76 f ksi Critical Point B 122.356 7.220 923.236 Yes Critical Point B 6.667 1.22 0.006 Yes	C C 1223.356 7.220 923.236 Yes 1223.356 Yes 1223.356 Yes 1223.356 Yes 123.356 Yes 123.356 Yes Yes Yes	0 0 233.652 24.500 3132.864 No 0 233.657 2.036 Yes	Yes Yes It is a second	Ves 60 reinforcen 2.24 from Aasl Fifth Points A 2 2147.462 1864.374 Yes Fifth Points A 2 8.000 360.61 1.307 Yes	Isol.esc Yes hent. to Lrfd C5 4: Jong Taper 3 1302.826 Yes Jong Taper 3 8.000 179.15 0.768 Yes	1223.356 Yes 2.6 is conserv 4 1223.356 7.220 923.236 Yes 4 6.667 1.22 0.006 Yes 1.22 0.006 Yes	0.000 Yes 5 0.000 4.500 578.424 NO 0.000 0.000 Yes	к'п к'п к'п к'п к'п к'п
Factored Flexural Resistance, Mr_= (Mr_ Is Mr_>= Mu, ? Minimum Reinforcement Check Aashto Li Yield to UII: Tensile Strength Ratio, rjs Flexural Cracking Variability Factor, r, Modulus of Rupture, f_= 0.37 T_s ³⁰ Factored Flexural Resistance, Mr_= (Mr_ Secton Modulus of Cap, S, Cracking Moment, Mcr, = rjs ⁻ ri, "t,"S_ Is Mr_>= Mre, ? Effective A ₁₂ provided 1.33 'Mu ₂ Is EII: A ₁₂ provid >= A ₁ regid based on 1.33 'Mu ₂ ?	233.662 Yes td 5.4.2.6 and 0.750 0.740 0.740 233.662 24.800 3132.544 No 1018.30 2.826 Yes	T223.380 Yes 15.6.3.3 Using 0.75 f Ksi Critical Point B 1223.326 Yes Critical Point B 6.667 1.22 0.006 Yes	Yes arather than 0.0 Using a co- S C C Yes Yes S C C S C S C S.667 1.22 S C S.667 Yes Yes	0 0 233.662 24.600 3132.864 No 0 8.000 735.87 2.035 Yes 9.000	Yes Yes ative for Grade 1 2493.062 19.20 2457.700 Yes 1 1 2457.700 Yes 1 Yes 1 1 2457.700 Yes Yes 1 Yes 1 1 1	Ves Ves Concernent of the second seco	Isol.es/ Yes hent. to Lrfd C5.4.1 Jong Taper 3 1801.862 Yes Ves	1223.356 Yes 2.6 is conserv 1223.356 7.220 923.236 Yes 4 6.667 Yes 4 1.22 0.006 Yes 1.22 0.006 Yes 1.22 1.2	0.000 Ves	K'II K'II II II II K'II II II II II II II II II II II II II

section is in Transition, then the user may adjust the	Flexural Phi Fa	actor, ¢, in cel	G54. If the s	section is com	pression-conti	rolled then do	not use this sl	heet.		
f rebar does not yield ($f_s < f_y$) then do not use this shee	t	Critical Point	6			Fifth Points A	long Taper			1
	A	B	С	0	1	2	3	4	5	1
ocation of Neutral Axis, c	4.614	3.845	3.845	4.614	4.614	4.614	4.614	3.845	0.000	in
rension Controlled? $z_t \ge z_{tr} = 0.005$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	n/a	in/in
Compression Controlled? Et <= Ect = 0.002	No	No	No	No	No	No	No	No	n/a	
ransition? $\varepsilon_{tl} > \varepsilon_t > \varepsilon_{cl}$	No	No	No	No	No	No	No	No	n/a	
lexure Phi Factor, ¢, for Design	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.750]
/d_	0.057	0.091	0.091	0.057	0.065	0.075	0.089	0.091	0.000	1
$1.003/(0.003 + \epsilon_{cl})$ where $\epsilon_{cl} = 0.002$	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	
$s c/d_s \le 0.003/(0.003 + \epsilon_{cl})$ such that $f_s = f_y$?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	1
		Critical Daint				Fifth Deinte A	long Tapor			1
	A	B	C	0	1	2	3	4	5	1
s Flexural Reinf. Adequate?	YES	YES	YES	YES	YES	YES	YES	YES	YES]
Check Shear Reinforcement Simplified Shear Design Aashto Lrfd 5.7 and	To increase Maximum s specifically 5.7	size of shear tirrup spacing $3.4.1, \beta = 2.0$	r reinforceme is 12" based 0 and $\theta = 45$	nt bars go to o I on the Bridge degrees	cell G106. e Design Manu	ial (BDM 6.6.4	.1.1.1).			
		Critical Point	5			Fifth Points A	long Taper			1
fotal Factored Shear Vu	A 150 463	B	C 132 632	0	141 074	2	3	4	5	k
ffective Shear Depth, dv	78.852	40.779	40.779	78.852	69.252	59.652	50.052	40.779	32.813	in
hax. Permissible Factored Shear Resistance, Vr_{max}	2554.796	1321.224	1321.224	2554.796	2243.756	1932.716	1621.676	1321.224	1063.125	ĸ
actored Concrete Shear Resistance, Vc	322.926	167.003	167.003	322.926	283.611	244.295	204.980	167.003	134.379	k
Stirrup Spacing, s, Aashto Lrfd Eq. 5.7.3.3-4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	in
Stirrup Spacing, s, Aashto Lrfd Eq. 5.7.2.5-1	10.549	10.549	10.549	10.549	10.549	10.549	10.549	10.549	10.549	in
Stirrup Spacing, s, Aashto Lrfd Eq. 5.7.2.6-1 & 2	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	in
	A	Critical Point B	cap are not co s C	onsidered.	1	Fifth Points A	long Taper 3	4	5	
otal Factored Shear, Vu	A 150,463	Critical Point B 132.633	cap are not or s C 132.633	0 144.788	1 141.074	Fifth Points A	Jong Taper 3 134.996	4	5	k
otal Factored Shear, Vu otal Factored Moment, Mu	A 150.463 766.088	Critical Point B 132.633 0.919	C 132.633 0.919	0 144.788 553.359	1 141.074 410.466	Fifth Points A 2 137.810 271.062	long Taper 3 134.996 134.696	4 132.633 0.919	5 0.000 0.000	k k*ft
otal Factored Shear, Vu Iotal Factored Moment, Mu Effective Shear Depth, dv Max Permissible Factored Shear Resistance. Vr	A 150.463 766.088 78.852 2554.796	Critical Point B 132.633 0.919 40.779 1321.224	C 132.633 0.919 40.779 1321.224	0 144.788 553.359 78.852 2554.796	1 141.074 410.466 69.252 2243.756	Fifth Points A 2 137.810 271.062 59.652 1932.716	long Taper 3 134.996 134.696 50.052 1621.676	4 132.633 0.919 40.779 1321.224	5 0.000 0.000 32.813 1063.125	k k*ft in k
otal Factored Shear, Vu otal Factored Moment, Mu Iffective Shear Depth, dv Max. Permissible Factored Shear Resistance, Vr _{max} Jezural Reint, Strain, _{sp} , Aashto Lrfd Eq. 5.7.3.4.2-4	A 150.463 766.088 78.852 2554.796 0.00130	Critical Point B 132.633 0.919 40.779 1321.224 0.00137	cap are not or s C 132.633 0.919 40.779 1321.224 0.00137	0 144.788 553.359 78.852 2554.796 0.00125	1 141.074 410.466 69.252 2243.756 0.00122	Fifth Points A 2 137.810 271.062 59.652 1932.716 0.00119	Uong Taper 3 134.996 134.696 50.052 1621.676 0.00116	4 132.633 0.919 40.779 1321.224 0.00137	5 0.000 0.000 32.813 1063.125 0.00000	k k*ft in k in/in
Iotal Factored Shear, Vu Iotal Factored Moment, Mu Iffective Shear Depth, dv Max. Permissible Factored Shear Resistance, Vr _{max} Pexural Reinf. Strain, t _p , Aasho Lrfd Eq. 5.7.3.4.2-4 = 4.8(1(+ 750°s_1), Aashto Lrfd Eq. 5.7.3.4.2-1	A 150.463 766.088 78.852 2554.796 0.00130 2.433	Critical Point B 132.633 0.919 40.779 1321.224 0.00137 2.366	cap are not or s C 132.633 0.919 40.779 1321.224 0.00137 2.366	0 144.788 553.359 78.852 2554.796 0.00125 2.479	1 141.074 410.466 69.252 2243.756 0.00122 2.510	Fifth Points A 2 137.810 271.062 59.652 1932.716 0.00119 2.538	llong Taper 3 134.996 134.696 50.052 1621.676 0.00116 2.563	4 132.633 0.919 40.779 1321.224 0.00137 2.366	5 0.000 0.000 32.813 1063.125 0.00000 4.800	k k*ft in k in/in
otal Factored Shear, Vu otal Factored Moment, Mu Effective Shear Depth, dv Max, Permissible Factored Shear Resistance, Vr _{max} Nexural Reint, Strain, s., Aashto Lrid Eq. 5.7.3.4.2-4 = 29 + 3500°s ₄ , Aashto Lrid Eq. 5.7.3.4.2-3	A 150.463 766.088 78.852 2554.796 0.00130 2.433 33.540	Critical Point B 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802	c s C 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802	0 144.788 553.359 78.852 2554.796 0.00125 2.479 33.369	1 141.074 410.466 69.252 2243.756 0.00122 2.510 33.257	Fifth Points A 2 137.810 271.062 59.652 1932.716 0.00119 2.538 33.158	Uong Taper 3 134.996 134.696 50.052 1621.676 0.00116 2.563 33.073	4 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802	5 0.000 32.813 1063.125 0.00000 4.800 29.000	k k*ft in k in/in deg
fotal Factored Shear, Vu fotal Factored Moment, Mu Effective Shear Depth, dv Max. Permissible Factored Shear Resistance, Vr _{inac} Revunal Reint, Strain, ₁₆ , Aashto Lrif Eq. 5.7.3.4.2-4 = 4.8(il + 750°+ ₁₆), Aashto Lrif Eq. 5.7.3.4.2-1 = 29 + 530°+ ₁₆ , Aashto Lrif Eq. 5.7.3.4.2-3 'actored Concrete Shear Resistance, V/c terqu ⁶ Factored Shear Resistance, N/c	A 150.463 766.088 78.852 2554.796 0.00130 2.433 33.540 392.850 0.000	Critical Point B 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000	s C 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000	0 144.788 553.359 78.852 2554.796 0.00125 2.479 33.369 400.296 0.000	1 141.074 410.466 69.252 2243.756 0.00122 2.510 33.257 355.975 0.000	Fifth Points A 2 137.810 271.062 59.652 1932.716 0.00119 2.538 33.158 310.050 0.000	long Taper 3 134.996 134.696 50.052 1621.676 0.00116 2.563 33.073 262.679 0.000	4 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000	5 0.000 0.000 32.813 1063.125 0.00000 4.800 29.000 322.510 0.000	k k*ft in k in/in deg k k
otal Factored Shear, Vu total Factored Moment, Mu iffective Shear Depth, dv Max. Permissible Factored Shear Resistance, Vr _{max} Neural Reint. Strain, _{sp} . Aastho Lrfd Eq. 5.7.3.4.2-4 i = 4.8(H + 750° s ₁). Aastho Lrfd Eq. 5.7.3.4.2-1 i = 29 + 350° s ₁ . Aastho Lrfd Eq. 5.7.3.4.2-3 iactored Concrete Shear Resistance, 4Vc ledgt Factored Shear Reinforcement Resistance, 4Vc Mirup Spacing, S. Aastho Lrfd Eq. 5.7.3.4	A 150.463 766.088 78.852 2554.796 0.00130 2.433 33.540 392.850 0.000 N/A	Critical Point B 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A	cap are not or s C 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A	0 144.788 553.359 78.852 2554.796 0.00125 2.479 33.369 400.296 0.000 N/A	1 141.074 410.466 69.252 2243.756 0.00122 2.510 33.257 355.975 0.000 N/A	Fifth Points A 2 137.810 271.062 59.652 1932.716 0.00119 2.538 33.158 310.050 0.000 N/A	Jong Taper 3 134.996 134.696 50.052 1621.676 0.00116 2.563 33.073 262.679 0.000 N/A	4 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A	5 0.000 32.813 1063.125 0.00000 4.800 29.000 322.510 0.000 N/A	k k*ft in k in/in deg k k k in
otal Factored Shear, Vu otal Factored Shear, Vu Effective Shear Depth, dv Hax, Permissible Factored Shear Resistance, Vr _{max} hexural Reint, Strain, e., Aashto Lrif Eq. 5.7.3.4.2.4 = 4.8(1+750-4), Aashto Lrif Eq. 5.7.3.4.2.3 actored Concrete Shear Resistance, av/c level Factored Shear Reinforcement Resistance, dv/s simup Spacing, S. Aashto Lrif Eq. 5.7.3.4.2.5 itimp Spacing, S. Aashto Lrif Eq. 5.7.3.5.1 Shear Resistance, Shear Resistance, dv/s Simup Spacing, S. Aashto Lrif Eq. 5.7.3.5.1 Shear Resistance, Shear Resistance, dv/s Simup Spacing, S. Aashto Lrif Eq. 5.7.3.5.1 Shear Resistance, Shear Resistance, Shear Resistance, dv/s Shear Res	A 150.463 766.088 78.852 2554.796 0.00130 2.433 33.540 392.850 0.000 N/A 10.549 24.000	Critical Point B 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10.549 24.000	cap are not or s C 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10.549 24.000	0 144.788 553.359 78.852 2554.796 0.00125 2.479 33.369 400.296 0.000 N/A 10.549 24.000	1 141.074 410.466 69.252 2243.756 0.00122 2.510 33.257 355.975 0.000 N/A 10.549 24.000	Fifth Points A 2 137.810 271.062 59.652 1932.716 0.00119 2.538 33.158 310.050 0.000 N/A 10.549 24.000	Uong Taper 3 134.996 134.696 50.052 1621.676 0.00116 2.563 33.073 262.679 0.000 N/A 10.549 24.000	4 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10.549 24.000	5 0.000 32.813 1063.125 0.00000 4.800 29.000 322.510 0.000 N/A 10.549 24.000	k k*ft in k in/in deg k k in in
otal Factored Shear, Vu otal Factored Moment, Mu Effective Shear Depth, dv Max, Permissible Factored Shear Resistance, Vr _{mar} Jexural Reint, Strain, s _a , Aashto Lrid Eq. 5.7.3.4.2-1 = 2.9.350°, Aashto Lrid Eq. 5.7.3.4.2-3 actored Concrete Shear Resistance, 4VC teq0 Factored Shear Resistance, 4VC stirrup Spacing, S. Aashto Lrid Eq. 5.7.2.5-1 Stirrup Spacing, Stirrup Spacing,	A 150.463 766.088 78.852 2554.796 0.00130 2.433 33.540 392.850 0.000 N/A 10.549 N/A 10.549 10.500	Critical Point B 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10.549 24.000 10.500	cap are not or s C 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10.549 24.000 10.500	0 144.788 553.359 78.852 2554.796 0.00125 2.479 33.369 400.296 0.000 N/A 10.549 24.000 10.500	1 141.074 410.466 69.252 2243.756 0.00122 2.510 33.257 355.975 0.000 N/A 10.549 24.000 10.500	Fifth Points A 2 137.810 271.062 59.652 1932.716 0.00119 2.538 33.158 310.050 N/A 10.549 24.000 10.500	Uong Taper 3 134.996 134.696 50.052 1621.676 0.00116 2.563 33.073 262.679 0.000 N/A 10.549 24.000 10.500	4 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10.549 24.000 10.500	5 0.000 0.000 32.813 1063.125 0.00000 4.800 29.000 322.510 0.000 N/A 10.549 24.000 10.500	k k*ft in k in/in deg k k in in in in
otal Factored Shear, Vu total Factored Moment, Mu tiffective Shear Depth, dv Max. Permissible Factored Shear Resistance, Vr _{max} Revural Reint, Strain, ₁₆ , Aashto Lrfd Eq. 5.7.3.4.2.4 = 4.8(H + 750° ₁₆), Aashto Lrfd Eq. 5.7.3.4.2.3 ractored Concrete Shear Resistance, 4Vc tedgr Factored Shear Resistance, kvc stimup Spacing, 5, Aashto Lrfd Eq. 5.7.2.4.2.1 silmup Spacing, 5, Aashto Lrfd Eq. 5.7.2.4.2.1 silmup Spacing, 5, Aashto Lrfd Eq. 5.7.2.6.1.8.2 imal Stirrup Spacing, 5	A 150.463 766.088 78.852 2554.796 0.00130 2.433 33.540 392.850 0.000 N/A 10.549 24.000 10.500	Critical Point B 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10.549 24.000 10.500	cap are not or s C 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10.549 24.000 10.500	0 144,788 553,369 78,852 2554,796 0.00125 2,479 33,369 400,296 0.000 N/A 10,549 24,000 10,500	1 141.074 410.466 69.252 2243.756 0.00122 2.510 33.257 355.975 0.000 N/A 10.549 24.000 10.500	Fifth Points A 2 137.810 271.062 59.652 1932.716 0.00119 2.538 33.158 310.050 0.000 N/A 10.549 24.000 10.500	Jong Taper 3 134.996 134.696 134.696 50.052 1621.676 0.00116 2.563 33.073 262.679 0.000 N/A 10.549 24.000 10.500	4 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10.549 24.000 10.500	5 0.000 0.000 32.813 1063.125 0.00000 4.800 25.000 322.510 0.000 N/A 10.549 24.000 10.500	k k*ft in k in/in deg k k k in in in
otal Factored Shear, Vu otal Factored Moment, Mu Effective Shear Depth, dv Max. Pemissiles Factored Shear Resistance, Vr _{max} Pexural Reint, Strain, _u , Aashto Lrift Eq. 5.7.3, 4.2-4 = 4.8(1+75°), Aashto Lrift Eq. 5.7.3, 4.2-4 = 29 + 3500° _u , Aashto Lrift Eq. 5.7.3, 4.2-4 lardored Concrete Shear Resintance, «Vic Simup Spacing, S. Aashto Lrift Eq. 5.7.3, 2.5-1 Simup Spacing, S. Aashto Lrift Eq. 5.7.2.5-1 & 2 inal Stirrup Spacing, s	A 150.463 766.088 78.852 2554.796 0.00130 2.433 33.540 392.850 0.000 N/A 10.549 24.000 10.500	Critical Point B 132.633 0.819 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10.549 24.000 10.500	C 132.633 0.819 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10.549 24.000 10.500	0 144.788 553.582 2554.796 0.00125 2.479 33.389 400.295 0.000 N/A 10.549 24.000 10.500	1 141.074 410.466 69.252 2243.756 0.00122 2.510 33.257 355.975 0.000 N/A 10.549 24.000 10.500	Fifth Points A 2 137.810 271.062 59.652 1932.716 0.00119 2.538 33.158 310.050 0.000 N/A 10.549 24.000 10.500	Jong Taper 3 134.996 134.696 50.052 1621.676 0.00116 2.563 33.073 262.679 0.000 N/A 10.549 24.000 10.500	4 132.633 0.919 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10.549 24.000 10.500	5 0.000 0.000 32.813 1063.125 0.00000 4.800 29.000 322.510 0.000 N/A 10.549 24.000 10.500	k k*ft in/in k in/in in in in
otal Factored Shear, Vu otal Factored Shear, Vu Effective Shear Depth, dv Max, Permissible Factored Shear Resistance, Vr _{max} lexural Reint, Strain, s., Aashto Lrid Eq. 5.7.3.4.2-4 = 29 + 3500°s, Aashto Lrid Eq. 5.7.3.4.2-3 actored Concrete Shear Resistance, 4Vc tedy Factored Shear Resistance, 4Vc simup Spacing, S. Aashto Lrid Eq. 5.7.2-6 timup Spacing, S. Aashto Lrid Eq. 5.7.2-5-1 timup Spacing, S.	A 150,463 766,088 78,852 2554,796 0,00130 2,433 33,540 392,850 0,000 N/A 10,549 24,000 10,500	Critical Point B 132:633 0.519 40.779 1321:224 0.00137 2.366 3.3.802 137:535 0.000 N/A 10.549 10.500	s C 132.633 0.819 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10.549 24.000 10.500	0 144.788 553.359 78.882 2554.796 0.00125 2.479 33.369 400.295 0.000 N/A 10.200 N/A 10.500	1 141.074 410.465 69.252 2243.756 0.0012 2.510 33.257 355.975 0.000 N.IA 10.540 10.500	Fifth Points A 2 137.810 271.062 59.652 1932.716 0.0017 2.538 33.158 310.050 N/A 10.549 24.000 10.500	Jong Taper 3 134,896 50.052 1621,676 0.00116 2.563 33.073 262,679 0.000 N/A 10.549 24,000 10.500	4 132.633 0.819 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10.500	5 0.000 0.000 32.813 1063.125 0.00000 4.800 322.510 0.000 322.510 0.000 322.510 0.000 10.549 24.000	k k*ft in/in deg k k k in in in
otal Factored Shear, Vu otal Factored Moment, Mu Effective Shear Depth, dv Max, Permissible Factored Shear Resistance, Vr _{nar} lexural Reint, Strain, s _e , Aashto Lrfd Eq, 5.7.3.4.2-1 = 2.9 s300°, ashto Lrfd Eq, 5.7.3.4.2-3 actored Concrete Shear Resistance, 4Vc teq0 ⁴ Factored Shear Resistance, 4Vc stimup Spacing, s, Aashto Lrfd Eq, 5.7.2.5-1 stimup Spacing, s	A 150.463 766.088 78.852 2554.796 0.00130 2.433 33.540 392.850 0.00130 2.433 33.540 30.649 24.000 10.500	Certical Point B 132,633 40,779 1321,524 0.00137 2.366 33,802 197,535 0.000 N/A 10,549 24,000 10,500	s c 132.633 0.819 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10.500	0 144.788 553.359 78.852 2554.796 0.00125 2.479 33.359 400.296 0.000 N/A 10.549 24.000 10.500	1 141.074 410.456 69.252 2243.756 0.00122 2.510 33.257 355.975 0.000 N/A 10.549 24.000 10.500	Fifth Points A 2 137.810 271.062 59.652 1932.716 0.00119 2.538 33.158 30.050 0.000 N/A N/A 10.549 24.000	Ung Taper 3 134,895 50,052 1621,676 0,00116 2,563 33,073 262,679 0,000 N/A 10,549 24,000 10,500	4 132.633 0.819 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10.540 24.000 10.500	5 0.000 32.813 1063.125 0.0000 25.000 322.510 0.000 N/A 10.540 10.500	k k*ft in k in/in deg k k k in in in
otal Factored Shear, Vu otal Factored Moment, Mu Effective Shear Depth, dv Max. Permissible Factored Shear Resistance, Vr _{max} Pexural Reint, Strain, _u , Aashto Lrift Eq. 5.7.3, 4.2-4 = 4.8(1+75%), Aashto Lrift Eq. 5.7.3, 4.2-4 = 29 + 3500° u, Aashto Lrift Eq. 5.7.3, 4.2-3 actored Concrete Shear Resintance, v/vc Simup Spacing, S. Aashto Lrift Eq. 5.7.3, 2.5-1 Simup Spacing, S. Aashto Lrift Eq. 5.7.3.5-1 Stimup Spacing, S. Aashto Lrift Eq. 5.7.3.5-1 Stimup Spacing, S. Aashto Lrift Eq. 5.7.2.5-1 Stimup Spacing, S. Sashto Lrift Eq. 5.7.2.5-1 Stimup Spacing, Stimup Spacing, Stimup Stim	A 150.453 766.085 78.852 2554.796 0.00130 2.433 33.540 392.850 0.000 N/Å 10.549 10.500	Certical Point B 132.633 0.919 40.779 1321.224 0.00137 2.366 197.535 0.000 N/A 10.549 24.000 10.500	C C 132.633 0.819 40.779 1321.224 0.00137 2.966 33.802 197.535 0.000 N/A 10.549 24.000 10.500	0 144.789 553.369 78.852 2554.796 0.00125 2.479 33.369 400.295 0.000 NiA 10.549 24.000 10.500	1 141.074 410.456 69.252 2243.756 0.0012 2.510 33.257 0.000 N/A 10.549 24.000 10.500	Fifth Points A 2 137.810 271.062 59.652 1932.716 0.0019 2.538 33.158 33.158 310.050 0.000 N/A 10.549 24.000 10.500	Ung Taper 3 134,696 50,052 1621,676 0,00116 2,563 33,073 262,679 0,000 N/A 10,549 24,000 10,500	4 132.633 0.819 40.779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10.549 24.000 10.500	5 0.000 32.813 1063.125 0.0000 25.000 322.510 0.0000 N/A 10.549 24.000 10.500	k k*tt in k in/in deg k k in in in in
otal Factored Shear, Vu otal Factored Moment, Mu Effective Shear Depth, dv Max, Permissible Factored Shear Resistance, Vr _{max} Nexural Reint, Strain, s., Aashto Lrid Eq. 5.7.3.4.2-4 = 29 + 3500°s, Aashto Lrid Eq. 5.7.3.4.2-3 actored Concrete Shear Resistance, 4Vc EqG' Factored Shear Reinstorem Resistance, 4Vc Simup Spacing, S. Aashto Lrid Eq. 5.7.2.6-1 simup Spacing, S. Aashto Lrid Eq. 5.7.2.6-1 simup Spacing, S. Aashto Lrid Eq. 5.7.2.6-1 Straing Spacing, S. Straing Straing, Straing Straing, Straing Spacing, S. Straing Straing, Straing Spacing, Straing Straing, Straing Spacing, Straing Straing, Straing Spacing, Straing Straing, Straing Spacing, Straing Spacing, Straing Straing, Straing Spacing, Straing Straing, Straing Spacing, Straing Straing, Straing Spacing, Straing Spacing, Straing Spacing, Straing Spacing, Straing, Straing Spacing, Straing Spacing, Straing Spacing, Straing, Straing Spacing, Straing Spacing, Straing Spacing, Straing Spacing, Straing Spacing, Straing Straing, Straing Spacing, Straing Straing Spacing, Str	A 150.463 766.088 78.852 2554.796 0.00130 32.554 33.540 32.850 0.000 N/A 10.500	Certical Point B 132,633 0,919 40,779 1321,224 0,00137 2,266 3,802 197,835 0,000 N/A 10,500	C C 132.633 44 0.00137 2.266 3.3802 132.632 3.3802 137.535 0.000 N/A 10.500 10.500	0 144.788 553.359 78.852 2554.796 0.00125 2.479 33.359 400.296 0.000 N/A 10.540 10.500	1 141.074 410.466 69.222 2243.766 0.00122 2.510 33.257 0.000 N/A 10.549 24.000 10.500	Fifth Points A 2 137.802 271.862 59.852 1932.716 0.00119 2.538 30.050 0.000 N/A 10.590 10.500	Ung Taper 3 96 194.896 194.896 50.052 1621.876 0.00116 2.563 33.073 262.679 0.000 N/A 10.580	4 132.633 0.819 40,779 1321.224 0.00137 2.366 33.802 197.535 0.000 N/A 10,530 24.000 10.500	5 0.000 32.813 1063.125 0.0000 4.800 29.000 322.610 0.000 N/A 10.549 24.000 10.500	k k*tt in k in/in deg k k in in in in
otal Factored Shear, Vu otal Factored Moment, Mu Effective Shear Depth, dv Max, Pemissible Factored Shear Resistance, Vr _{mar} Texural Reint, Strain, s _a , Aashto Lrfd Eq, 5.7.3.4.2-1 = 2.9.350°, Aashto Lrfd Eq, 5.7.3.4.2-3 ractored Concrete Shear Resistance, 4Vc teq0 Factored Shear Resistance, 4Vc Stirrup Spacing, s, Aashto Lrfd Eq, 5.7.2.5-1 Stirrup Spacing, s	Aug. 2010 Aug. 2	Context Protects of the Context of the Context Protects of the Context of the Con	C 122.632 40.719 40.719 1321.224 40.00137 2.366 33.802 197.535 0.000 N/A 10.549 24.000 10.500	0 144.788 553.359 78.852 2554.796 0.00125 2.479 33.359 400.295 0.000 N/A 10.549 24.000 10.500	1 141.074 410.468 69.252 2243.756 0.00122 2.510 33.287 358.975 0.000 N/A 10.549 24.000 10.500	Fifth Points A 2 137,810 271,082 59,582 1932,716 0.00119 2,538 331,050 0.000 N/A 10,549 24,000 10,500	Ung Taper 3 134,696 50,052 1124,696 60,00116 2,663 33,073 262,679 0,000 N/A 10,549 24,000 10,500	4 132.633 0.519 40.779 1321.224 0.00137 2.366 0.000 137.535 0.000 N/A 10.549 24.000 10.500	5 0.000 32.813 1063.125 0.0000 4.800 4.800 322.610 0.000 N/A 10.549 24.000 10.500	k k*ft in/in k in/in in in
otal Factored Shear, Vu otal Factored Moment, Mu Effective Shear Depth, dv Max. Pemissible Factored Shear Resistance, Vr _{max} hexural Reint, Strain, _{sc} , Aashto Lrift Eq. 5.7.3.4.2.4 = 4.8(1+75%), Aashto Lrift Eq. 5.7.3.4.2.3 actored Concrete Shear Resintance, w/c Birrup Spacing, S. Aashto Lrift Eq. 5.7.3.4.2.3 itimup Spacing, S. Aashto Lrift Eq. 5.7.3.2.5.1 itimup Spacing, S. Aashto Lrift Eq. 5.7.3.2.5.1 itimup Spacing, S. Aashto Lrift Eq. 5.7.3.2.6.1 & 2 itinup Spacing, S. Aashto Lrift Eq. 5.7.2.6.1 & 2 itinup Spacing, S. Sashto Lrift Eq. 5.7.2.6	A 150.453 766.085 788.622 2554.796 0.00130 2.433 335.840 392.850 0.000 N/A 10.549 24.000 10.500	Contexal Points B 132,633 0,919 13221,224 0,00137 2,366 33,802 197,535 0,000 N/A 10,549 24,000 10,500	C C 132.633 0.0137 0.0137 0.0137 0.0137 0.0137 0.0137 0.0137 0.0137 0.0000 0.0000 0.000 0.000 0.000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0	0 0 144.788 553.359 78.852 2554.796 0.00125 2.479 0.000 N/A 10.549 10.500	1 141.074 410.468 69.224.7.56 0.00122 2.510 33.257 33.257 335.975 0.000 NIA 10.500	Fifth Points A 2 137.810 59.652 1932.716 0.00119 2.538 30.050 0.000 N/A 10.560 10.500	Ung Taper 3 134.696 50.052 1621.676 0.00116 2.563 33.073 262.679 0.000 N/A 10.549 10.560	4 122.633 40.779 1321.224 0.00137 2.266 33.802 197.835 0.000 N/A 10.500	5 0.000 0.000 32.813 1063.125 0.00000 4.800 322.510 0.000 322.510 0.000 322.510 0.000 10.500	k k*ft in/in deg k k in in in
otal Factored Shear, Vu otal Factored Moment, Mu Effective Shear Depth, dv Max, Permissible Factored Shear Resistance, Vr _{max} lexural Reint, Strain, s., Aashto Lrfd Eq. 5.7.3.4.2-4 = 29 + 3500°s, Aashto Lrfd Eq. 5.7.3.4.2-3 actored Concrete Shear Resistance, 4Vc limup Spacing, S. Aashto Lrfd Eq. 5.7.3-4 itimup Spacing, S. Aashto Lrfd Eq. 5.7.2-6-1 itimup Spacing, S. Aashto Lrfd Eq. 5.7.2-6-1 itimup Spacing, S. Aashto Lrfd Eq. 5.7.2-6-1 limup Spacing, S. Aashto Lrfd Eq. 5.7.2-6-1 Activity Spacing, Stativity Spacing, S	A A 150.463 766.088 78.852 2554.796 0.00130 33.540 32.850 0.000 N/A 10.549 24.000 10.549 24.000	Contexa Pointe B 132,633 0,919 40,779 1321,224 0,0019 1321,224 0,0019 1321,224 0,0019 1321,224 0,000 197,535 0,000 10,549 24,000 10,549	C C 132.633 0.815 0.000 0.137 0.200 0.000 0.137 0.200 0.000 0.137 0.200 0.000 0.137 0.200 0.0000 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.00	0 0 144,788 553,359 78.852 2554,796 0.00125 2.479 0.00125 2.479 0.001 2.479 0.000 NiA 10.549 24.000 10.500	1 141.074 410.468 65.252 2243.756 0.00122 2.510 33.257 33.257 355.975 0.000 NiA 10.549 24.000 10.500	Fifth Points A 2 137.810 271.062 59.652 1932.716 0.00119 2.538 3.3188 33.158 33.158 33.10.850 0.000 NiA 10.549 24.000 10.500	Jong Taper 3 134.995 134.895 50.052 1621.676 0.00116 2.863 33.073 252.679 0.000 NiA 10.549 24.000 10.540 10.500	4 132.633 0.319 40.779 1321.224 0.00137 2.266 33.802 137.535 0.000 N/A 10.549 24.000 10.500	5 0.000 0.2813 1063.125 0.00000 29.000 29.000 322.610 0.000 N/A 10.500	k k*tt in k in/in deg k k in in in in
otal Factored Shear, Vu otal Factored Moment, Mu Effective Shear Depth, dv Max, Pemissible Factored Shear Resistance, Vr _{me} , Pecural Reint, Strain, s., Aashto Lrid Eq. 5.7.3.4.2-1 = 4.8/(1+750°c,), Aashto Lrid Eq. 5.7.3.4.2-3 ractored Concrete Shear Resistance, 4Vc leteqT Factored Shear Resistance, 4Vc Hirrup Spacing, S., Aashto Lrid Eq. 5.7.2.5-1 Sitrup Spacing, S., Aashto Lrid Eq. 5.7.2.5-1 stimup Spacing, Stimup S	A 150.463 766.082 78.852 2554.796 0.00130 2.433 33.540 352.850 0.025 24.000 10.500	Contexal Point B 132,633 0,919 40,779 1321,224 0,00137 2,366 33,802 137,535 0,000 117,535 0,000 10,500	C C 132.643 0.0157 0.0157 0.0157 0.0157 0.0157 0.0157 0.0157 0.0157 0.0157 0.0157 0.000 0.0157 0.0545 0.0000 0.0000 0.0545 0.00000 0.0000 0.0000 0.00000 0.0000 0.0000 0.0000 0.000000	0 144.788 553.359 78.852 2554.796 0.00125 2.479 0.00125 2.479 0.00125 2.479 0.00125 2.479 0.00125 2.479 0.000125 2.479 0.000125 2.479 0.000125 2.479 0.000125 0.0000000 0.0000000000000	1 141.074 410.465 69.252 2243.756 0.0012 33.257 0.000 N/A 24.060 10.500	Fifth Points A 2 2 137.810 271.062 59.562 59.562 59.562 59.562 50.050 0.000 N/A N/A 10.549 24.000 10.500	Ung Taper 3 14.996 14.895 50.052 1621.676 0.00116 2.663 33.073 262.679 0.000 N/A N/A 10.549 24.000 10.500	4 132.633 0.319 40.779 1321.224 0.00137 2.366 33.802 187.535 0.000 N/A 10.649 24.000 10.690	5 0.000 02.813 1063.125 0.00000 4.800 322.810 0.000 N/A 10.500 10.500	k k*tt in k in/in deg k k in in in
otal Factored Shear, Vu otal Factored Moment, Mu tifective Shear Depth, dv Max. Pemissible Factored Shear Resistance, Vr _{max} hexural Reint, Strain, _u , Aashto Lrift Eq. 5.7.3.4.2.4 = 4.8(1+75%), Aashto Lrift Eq. 5.7.3.4.2.3 actored Concrete Shear Resintance, w/c tergd Factored Shear Reinforcement Resistance, dvs timup Spacing, S. Aashto Lrift Eq. 5.7.3.2.5.1 timup Spacing, S. Aashto Lrift Eq. 5.7.3.2.5.1 timup Spacing, S. Aashto Lrift Eq. 5.7.3.2.5.1 timup Spacing, S. Aashto Lrift Eq. 5.7.2.5.1 & 2 timup Spacing, S. Aashto Lrift Eq. 5.7.2.6.1 & 2 timup Spacing, S. Aashto Lri	A 150.463 766.085 78.852 2554.796 0.00130 2.433 33.580 0.00 0.00 0.00 0.00130 2.433 33.580 0.001 0.003 0.	Contexa Point B 132,633 0,919 40,779 1321,224 0,00137 1321,224 0,00137 2,266 33,802 137,535 0,000 N/A 10,549 10,500	C C 13.800 C C C C C C C C C C C C C C C C C C	0 0 144.788 553.359 78.852 2554.796 0.00125 2.479 33.359 0.0000 N/A 400.295 0.0000 N/A 10.549 24.000 10.500	1 141.074 410.465 65.252 2243.756 0.00122 2.510 33.257 355.975 0.000 N/A 10.545 24.000 10.500	Fifth Points A 2 137.810 59.652 1932.716 0.00119 2.538 33.158 33.158 33.158 33.0.050 0.000 N/A 10.549 24.000 10.500	Ung Taper 3 134,995 50,052 152,1876 0,00115 2,563 33,073 282,679 0,000 N/A 10,545 24,060 10,500	4 132,633 0,919 40,779 1321,224 0,00137 2,366 33,802 197,635 0,000 N/A 10,549 24,000 10,500	5 0.000 32.813 1063.125 0.00000 32.510 25.000 322.510 0.000 N/A 10.549 10.549	k k*tti in k k k k in in in in
otal Factored Shear, Vu otal Factored Moment, Mu Effective Shear Depth, dv Max, Permissible Factored Shear Resistance, Vr _{max} lexural Reint, Strain, s., Aashto Lrfd Eq. 5.7.3.4.2-4 = 29 + 3500°s, Aashto Lrfd Eq. 5.7.3.4.2-3 actored Concrete Shear Resistance, 4Vc stimup Spacing, S. Aashto Lrfd Eq. 5.7.2.6-1 stimup Spacing, S. Sashto Lrfd Eq. 5.7.2.6-1 stimup Spacing, Sashto Lrfd Eq. 5.7.2.6-1 stimup Spacing, Sashto Lrfd Eq. 5.7.2.6-1 stimup Spacing, Sashto Sa	A 160.463 764.083 78.852 254.788 0.00130 2.433 33.540 0.000 N/A 10.560	Context Providence of the second seco	C C 132.642 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.0001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.00	0 0 144.78 53.399 78.852 254.796 0.00125 2.479 33.389 400.295 0.000 N/A 10.500	1 141.074 410.466 69.252 2243.756 0.00122 2.5510 33.257 0.000 N/A 10.500 10.500	Fitth Points A 2 137.810 271.062 59.852 1932.716 0.00119 2.538 31.050 0.090 N/A 10.540 10.500	Non Non 1000 134.995 134.995 50.052 50.052 1621.876 0.00116 2.563 33.073 282.679 0.000 N.04 10.500 10.500	4 132,633 0,919 40,779 1321,224 0,00137 2,360 133,802 197,535 0,000 N/A 10,500	5 0.000 0.000 32.813 1063.125 0.00000 4.800 322.610 0.0000 N/A 10.549 24.000 10.500	k k*tti in k in/in in in in
otal Factored Shear, Vu otal Factored Moment, Mu Effective Shear Depth, dv Max. Pemissible Factored Shear Resistance, Vr. Pecural Reint, Strain, s., Aashto Lrid Eq. 5.7.3.4.2-1 = 4.8/(1 + 750°s.), Aashto Lrid Eq. 5.7.3.4.2-3 actored Concrete Shear Resistance, 4Vc Hergel Factored Shear Resistance, 4Vc Hirrup Spacing, S., Aashto Lrid Eq. 5.7.2.5-1 Sitrup Spacing, S., Sashto Lrid Eq. 5.7.2.5-1 Sitrup Spacing, Sitter Sitrup Spacing, Sitter	A 150.463 766.082 78.852 78.852 2554.796 0.00130 2.433 33.540 0.0133 2.433 33.540 N/A 10.500 10.500	Contexal Point B 132,633 0,919 40,779 1321,224 0,00137 2,366 133,802 187,535 0,000 N/A 10,545 10,500	C C C C C C C C C C C C C C C C C C C	0 0 144.78 553.359 78.852 2554.796 0.00125 2.475 3.359 0.002 0.002 2.400 10.550 10.500	1 141.074 410.465 69.252 2243.756 0.0012 33.257 N/A 10.540 10.500	Fitth Points A 2 137.810 271.062 59.652 1932.716 0.00119 33.158 33.0000 N/A 10.540 10.500	Vong Taper 3 134,996 50.052 1621.676 0.0011 265.679 0.000 N/A 24.000 10.500	4 132,633 0,919 1321,224 0,00137 1321,224 0,000 133,802 197,535 0,000 N/A 10,545 10,500	5 0.000 32.813 1063.125 0.00000 4.800 25.000 322.610 0.000 N/A 10.549 24.000 10.500	k k*ft in k k k in in in in
otal Factored Shear, Vu otal Factored Moment, Mu tifective Shear Depth, dv Max. Pemissible Factored Shear Resistance, Vr _{max} Pexural Reint, Strain, _{sc} , Aashto Lrife Eq. 5.7.3.4.2.4 = 4.8(1+75%), Aashto Lrife Eq. 5.7.3.4.2.3 actored Concrete Shear Resistance, ₄ Vc tergd Factored Shear Reinforcement Resistance, ₄ Vc simup Spacing, S. Aashto Lrife Eq. 5.7.3.2.5.1 simup Spacing, S. Aashto Lrife Eq. 5.7.3.2.6.1 & 2 inal Stirrup Spacing, s. Aashto Lrife Eq. 5.7.2.6.1 & 2 inal Stirrup Spacing, s.	A 150.463 764.088 78.852 254.796 0.00130 2.433 33.540 0.000 N/A 10.549 24.000 10.500	Contexa Point B 132,633 0,919 40,775 1321,224 0,00137 2,266 33,802 197,535 0,000 N/A 10,549 10,500	C C 13266 PM C C C C C C C C C C C C C C C C C C	0 0 144.788 553.359 78.852 2554.796 0.00125 2.473 33.359 0.0000 N/A 400.295 0.0000 N/A 10.545 24.000 10.500	1 141.074 410.465 65.252 2243.756 0.00122 2.510 33.257 355.975 0.000 N/A 10.545 24.000 10.500	Fifth Points A 2 137.810 251.062 59.652 1932.716 0.00119 2.538 33.158 33.158 33.158 33.0.050 0.000 N/A 10.549 24.000 10.500	Ung Taper 3 134,995 50,052 152,1876 0,0018 2,563 33,073 282,679 0,000 N/A 10,545 24,060 10,500	4 132,633 0,919 140,779 1321,224 0,00137 2,366 33,802 197,635 0,000 N/A 10,549 24,000 10,500	5 0.000 0.000 32.813 1063.125 0.0000 25.000 322.610 0.0000 N/A 10.549 24.000 10.500	k k*ft in k k in/in in in
otal Factored Shear, Vu otal Factored Moment, Mu :ffective Shear Depth, dv Max, Pemissible Factored Shear Resistance, Vr _{max} Pecural Reint, Strain, s., Aashto Lrid Eq. 5.7.3.4.2.4 = 28 + 3500°s _e , Aashto Lrid Eq. 5.7.3.4.2.3 actored Concrete Shear Resistance, 4Vc stimp Spacing, S. Aashto Lrid Eq. 5.7.3.4. stimp Spacing, S. Aashto Lrid Eq. 5.7.2.6.1 stimp Spacing, S. Sashto Lrid Eq. 5.7.2.6.1 stimp Spacing, Stimp Stimp Spacing, Stimp Spacing, Stimp Stimp Spacing, Stimp Stimp Spacing, Stimp Stimp Spacing, Stimp Stimp Stimp Spacing, Stimp S	A 160.463 764.083 78.852 254.788 0.00130 2.433 33.540 0.000 N/A 10.560	Context Prove B 132,633 0,811 132,1224 0,00137 2,266 3,3802 137,535 0,000 N/A 10,545 24,000 10,500	C C C C C C C C C C C C C C C C C C C	0 0 144.78 53.399 78.852 256.4796 0.00125 2.479 33.389 400.295 0.000 N/A 10.500	1 141.074 410.466 69.252 2243.756 0.0012 2.5510 33.257 0.000 N/A 10.500 10.500	Fitth Points A 2 137.810 271.062 59.852 1932.716 0.00119 2.538 31.050 0.000 N/A 10.540 10.500	Non Non 104.995 154.995 154.995 50.052 50.052 1621.876 0.00116 2.563 33.073 250.679 0.000 N/A 10.500 10.500	4 132,633 0,919 40,779 1321,224 0,00137 2,266 33,802 187,635 0,000 N/A 10,500	5 0.000 0.000 32.813 0.0000 4.800 25.000 32.2.810 0.000 10.549 10.549	k k*tt in/in deg k k in in in
otal Factored Shear, Vu otal Factored Moment, Mu Effective Shear Depth, dv Max. Pemissible Factored Shear Resistance, Vr _{max} . Pecural Reint, Strain, s., Aashto Lrid Eq. 5.7.3.4.2-1 = 2.9. s500°-s, Aashto Lrid Eq. 5.7.3.4.2-3 actored Concrete Shear Resistance, 4Vc Hergel Factored Shear Resistance, 4Vc Sitrup Spacing, S., Aashto Lrid Eq. 5.7.2.5-1 Sitrup Spacing, S., Sashto Lrid Eq. 5.7.2.5-1 Sitrup Spacing, Sashto Lrid Eq. 5.7.2.5-1 Sitrup Spacing, Sashto Lrid Eq. 5.7.2.5-1 Sitrup Spacing, Sashto Lrid Spacing, Sashto Lrid Sp	A 160.463 766.463 768.852 2554.736 0.00130 2.433 33.540 0.0133 2.433 33.540 N/A 10.500 10.500	Contexal Point B 132,633 0,819 40,779 1321,224 0,00137 2,366 133,802 187,535 0,000 N/A 10,545 10,500	C C C C C C C C C C C C C C C C C C C	0 0 144.78 553.359 78.852 2554.796 0.00125 2.475 0.002 0.002 0.002 2.475 0.002 0	1 141.074 410.465 69.252 2243.756 0.0012 33.257 N/A 33.257 N/A 24.000 10.500	Fitth Points A 2 137.810 271.062 59.652 1932.716 0.00119 33.158 33.0000 N/A 10.540 10.500	Vong Taper 3 134,996 50.052 1621.676 0.0011 265.679 0.000 N/A 24.000 10.500	4 132,633 0,919 102,1224 0,00137 102,1224 0,000 107,535 0,000 N/A 10,500 10,500	5 0.000 0.000 0.0000 4.800 9.25.00 9.25.00 9.25.00 9.22.50 9.000 9.22.50 9.000 9.22.50 9.0000 9.00000 9.00000 9.00000 9.00000 9.00000 9.00000 9.00000000	k krtt in/in deg k k in in in in
otal Factored Shear, Vu otal Factored Moment, Mu Iffective Shear Depth, dv Max. Pemissible Factored Shear Resistance, Vr _{max} Pexural Reint, Strain, ₁₄ , Aashto Lrift Eq. 5.7.3.4.2.4 = 4.8(1+75%), Aashto Lrift Eq. 5.7.3.4.2.3 actored Concrete Shear Resistance, 4Vc Birrup Spacing, S. Aashto Lrift Eq. 5.7.3.4.2.3 itiming Spacing, S. Aashto Lrift Eq. 5.7.3.4.2.3 itiming Spacing, S. Aashto Lrift Eq. 5.7.3.6.1 Stirrup Spacing, S. Aashto Lrift Eq. 5.7.3.6.1 itiming Spacing, S. Aashto Lrift Eq. 5.7.2.6-1 & 2 itining Spacing, S	A 160.463 764.088 78.852 254.796 0.00130 2.433 33.540 0.000 N/A 10.549 24.000 10.500	Context Point B B 10,6037 1321,224 0,00137 1321,224 0,00137 1321,224 0,000 10,538 24,000 10,500	C C 13266	0 0 144.788 553.359 78.852 2554.796 0.00125 0.00125 0.0000 N/A 10.545 24.000 10.500	1 141.074 410.465 65.252 2243.756 0.0012 2.510 33.257 355.975 0.000 N/A 10.545 24.000 10.500	Fifth Points A 2 137.810 271.062 59.652 1932.716 0.00119 2.538 33.158 33.158 33.158 33.10.860 0.000 N/A 10.549 24.000 10.500	Ung Taper 3 134,995 50,052 1621,876 0,001 12,863 2,863 33,073 262,679 0,000 N/A 10,545 24,060 10,500	4 132,633 0,919 140,779 1321,224 0,00137 2,366 33,802 197,535 0,000 N/A 10,549 24,000 10,500	5 0.000 0.000 4.800 23.003 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 0.0000 4.800 23.000 0.00000 0.000000	k ktrtt in/in deg k k in in in
otal Factored Shear, Vu otal Factored Moment, Mu :Ifective Shear Depth, dv Max. Pemissible Factored Shear Resistance, Vr _{max} Perural Reint, Strain, s., Aashto Lrfd Eq. 5.7.3.4.2.4 = 29 + 3500°s, Aashto Lrfd Eq. 5.7.3.4.2.3 actored Concrete Shear Resistance, 4Vc stimup Spacing, S. Aashto Lrfd Eq. 5.7.3.4. stimup Spacing, S. Aashto Lrfd Eq. 5.7.2.6-1 stimup Spacing, S. Aashto Lrfd Eq. 5.7.2.6-1 attraction of the stimup Spacing, S. Aashto Lrfd Eq. 5.7.2.6-1 stimup Spacing, S. Stimup Spacing, S	A 160.463 764.083 78.852 254.785 0.00130 2.433 33.540 0.000 N/A 10.560	Context Prove B 132,633 40,779 1321,224 40,779 1321,224 40,779 1321,224 137,835 6,000 N/A 10,545 24,000 10,500	C C C C C C C C C C C C C C C C C C C	0 0 144.78 53.399 78.852 2554.796 0.00125 2.475 33.389 400.295 0.000 N/A 10.500	1 141.074 410.465 69.252 2243.756 0.000 33.257 0.000 N/A 10.500 10.500	Fitth Points A 2 137.810 271.062 59.852 1932.716 0.00119 2.538 31.050 0.000 0.060 0.000 0.000 0.000 0.000 0.000 10.500	Non 134.995 134.995 50.052 50.052 1621.676 0.00116 2.563 33.073 25.679 0.000 10.500 10.500 10.500	4 132,633 0,919 40,779 1321,224 0,00137 2,266 0,000 133,802 187,835 0,000 10,500 10,500	5 0.000 0.000 0.0000 4.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000	k ktrtt in k k k k in in in
otal Factored Shear, Vu otal Factored Moment, Mu Iffective Shear Depth, dv Max. Pemissile Factored Shear Resistance, Vr _{max} Perural ReInt, Strain, _u , Aashto Lrift Eq. 5.7.3.4.24 = 2.9.4300°-u, Aashto Lrift Eq. 5.7.3.4.2-3 actored Concrete Shear Resintance, v/c terg/ Factored Shear Reinforcement Resistance, v/s Simup Spacing, S. Aashto Lrift Eq. 5.7.3.2-5.1 Simup Spacing, S. Aashto Lrift Eq. 5.7.2.5-1 & 2 inal Stirrup Spacing, s. Aashto Lrift Eq. 5.7.2.6-1 & 2 inal Stirrup Spacing, s.	A 160.463 766.463 768.482 78.822 2554.786 0.00130 2.433 33.540 0.0133 2.4000 N/A 10.500 10.500	Contexal Point B 132,633 0,919 40,779 1321,224 0,00137 2,366 133,802 187,535 0,000 N/A 10,545 10,500	C C 132.633 C C 132.633 0.919 40.779 132.1.324 0.00137 2.366 3.3.802 197.635 0.000 10.4500 10.500	0 0 144.78 553.359 78.852 2554.796 0.00125 2.475 3.359 0.002 0.002 2.4000 10.500 10.500	1 141.074 410.465 69.252 2243.756 0.0012 33.257 N/A 10.540 10.540 10.500	Fitth Points A 2 137.810 271.062 59.652 1932.716 0.00119 33.158 33.0000 N/A 10.540 10.500	Vong Taper 3 134,996 50.052 1621.676 0.0011 265.679 0.000 N/A 24.000 10.500	4 132,633 0,919 1321,224 0,00137 1321,224 0,000 197,535 0,000 N/A 10,545 10,500	5 0.000 0.000 0.0000 4.800 0.0000 0.000 0.000 0.000 0.000 0.000 10.500	k křítt in kin in/in deg k in in in in
otal Factored Shear, Vu otal Factored Moment, Mu Iffective Shear Depth, dv Max. Pemissible Factored Shear Resistance, Vr _{max} Pexural Reint, Strain, ₁₄ , Aashto Lrid Eq. 5.7.3.4.2.4 = 4.8(1+75°), Aashto Lrid Eq. 5.7.3.4.2.3 actored Concrete Shear Resistance, 4/vc Simup Spacing, 5. Aashto Lrid Eq. 5.7.3.2.5.1 Simup Spacing, 5. Aashto Lrid Eq. 5.7.2.5.1 Simup Spacing, 5. Aashto Lrid Eq. 5.7.2.5.1 Simup Spacing, 5. Aashto Lrid Eq. 5.7.2.6.1 & 2 Simup Spacing, 5. Aashto Lrid Eq. 5.7.2.6.1 & 2 Simup Spacing, 5. Aashto Lrid Eq. 5.7.2.6.1 & 2 Simup Spacing, 5. Sashto L	A 160.463 764.088 78.852 258.78.852 258.78.852 24.33 33.540 0.001 0.322.850 0.000 N/Å 10.540 10.500	Context Point B 32,635 132,635 132,635 132,122 132,122 132,122 132,122 132,122 137,535 0.000 N/A 10,590 10,590	C C C C C C C C C C C C C C C C C C C	0 0 144.788 553.359 78.852 2554.796 0.00125 0.00125 0.0000 NIA 10.545 24.000 10.500	1 141.074 410.465 65.252 2243.756 0.001 33.257 355.975 0.000 N/A 10.549 24.000 10.500	Fifth Points A 2 137.810 271.062 59.652 1932.716 0.00119 2.538 33.158 33.158 33.158 33.10.860 0.000 N/A 10.549 24.000 10.500	Ung Taper 3 134,995 50.052 152,1876 0.001 12,563 2,563 33.073 262,679 0.000 N/A 10,545 24,060 10,500	4 132,633 0,919 140,779 1321,224 0,00137 2,366 33,802 197,535 0,000 N/A 10,549 24,000 10,500	5 0.000 0.000 2.813 1063.125 23.000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.0000 4.800 23.000 0.00000 0.0000 0.000000	k ktrtt in k in/in deg k k in in in
otal Factored Shear, Vu otal Factored Moment, Mu :Ifective Shear Depth, dv Max. Pemissible Factored Shear Resistance, Vrax. Perural Reint, Strain, s., Aashto Lrift Eq. 5.7.3.4.2.4 = 28 + 3500°s, Aashto Lrift Eq. 5.7.3.4.2.3 actored Concrete Shear Resistance, 4Vc immp Spacing, S. Aashto Lrift Eq. 5.7.2.6-1 immp Spacing, S. Aashto Lrift Eq. 5.7.2.6-1 & 2 immi Stirrup Spacing, S. Aashto Lrift Eq. 5.7.2.6-1 is the stirrup Spacing, S. Aashto Lrift Eq. 5.7.2.6-1 Aashto Lrift Eq. 5.7.	A 160.463 764.083 78.852 254.785 0.00130 2.433 33.540 0.000 N/A 10.560 10.500	Context Prove B 132,633 40,779 1321,224 40,779 1321,224 0,00137 2,360 137,835 0,000 N/A 10,545 24,000 10,500	C C C C C C C C C C C C C C C C C C C	0 0 144.78 53.399 78.852 2554.796 0.00125 2.475 33.389 400.296 0.000 N/A 10.500 10.500	1 141.074 410.465 69.252 224.3.756 0.000 N/A 10.500 10.500	Fitth Points A 2 137.810 271.062 59.652 1932.716 0.00119 2.538 310.550 0.000 0.000 0.000 0.000 0.000 0.000 0.000 10.500	Non Non 3 3 134.995 50.052 50.052 1621.676 0.00116 2.563 33.073 25.679 0.000 10.540 10.500 10.500	4 132,633 0,919 40,779 1321,224 0,00137 2,256 0,000 133,802 197,835 0,000 10,500 10,500	5 0.000 0.000 0.0000 4.000 0.0000 0.0000 0.000 0.000 0.000000	k ktriti in k in/in deg k k in in in in
otal Factored Shear, Vu otal Factored Moment, Mu Iffective Shear Depth, dv Max. Pemissile Factored Shear Resistance, Vr _{max} Perural ReInt, Strain, _u , Aashto Lrift Eq. 5.7.3.4.2-4 i = 4.8(1+76°), Aashto Lrift Eq. 5.7.3.4.2-3 ratored Concrete Shear Resintance, v/c terg/ Factored Shear Reinforcement Resistance, (v/s Simup Spacing, S. Aashto Lrift Eq. 5.7.3.2-5.1 Simup Spacing, S. Aashto Lrift Eq. 5.7.3.2-5.1 Simup Spacing, S. Aashto Lrift Eq. 5.7.2.5-1 & 2 inal Stirrup Spacing, s. Ashto Lrift Eq. 5.7.3.2-1 inal Stirrup Spacing, s. Stirrup Spacing, S. Aashto Lrift Eq. 5.7.2.5-1 Stirrup Spacing, S. Aashto Lrift Eq. 5.7.2.5-1 Stirrup Spacing, S. Aashto Lrift Eq. 5.7.2.5-1 Stirrup Spacing, S. Stirrup Spacing, S. Stirrup Spacing, Starter Stirrup Starte	A A 160.463 766.463 768.482 2554.786 0.00130 2.433 33.540 N/A 10.500 10.500	Octos in Piere B 132,633 0,919 40,779 1321,224 0,00137 2,266 33,802 187,535 0,000 N/A 10,500	C C 132.633 C C 132.633 0.919 132.633 0.919 132.1.224 0.00137 2.366 3.3.802 197.635 0.000 10.45 24.000 10.500 10.500	0 144.78 153.359 78.852 2554.796 0.00125 2.475 3.359 0.000 10.500 10.500 10.500	1 141.074 410.465 69.252 2243.756 0.0012 33.257 N/A 10.540 10.540 10.500	Fitth Points A 2 137.810 271.062 59.652 1932.716 0.00119 33.158 33.0000 N/A 10.540 10.500	Vong Taper 3 134,996 50.052 1621.876 0.0011 282.679 0.000 N/A 10.540 10.500	4 132,633 0,919 10,719 1321,224 0,0013 197,535 0,000 N/A 10,545 10,500	5 0.000 0.000 0.0000 4.800 0.0000 0.0000 0.0000 0.000 0.000 0.000000	k krtt in kindin deg k k in in in
otal Factored Shear, Vu otal Factored Moment, Mu Iffective Shear Depth, dv Max. Pemissible Factored Shear Resistance, Vr _{max} Pexural Reint, Strain, _{sc} , Aashto Lrife Eq. 5.7.3.4.2.4 = 4.8(1+75°), Aashto Lrife Eq. 5.7.3.4.2.3 actored Concrete Shear Resistance, ₄ Vc tergd Factored Shear Reinforcement Resistance, ₄ Vc simup Spacing, S. Aashto Lrife Eq. 5.7.3.2.5 isomorphic Shear Resistance, <u>1</u> isomorphic Shear Resistance, <u>1</u> timp Spacing, S. Aashto Lrife Eq. 5.7.3.2.5 isomorphic Shear Resistance, <u>1</u> isomorphic Shear Resistance,	A 160.463 764.088 78.852 258.78.852 258.78.852 24.33 33.540 0.001 0.322.850 0.000 N/Å 10.560 10.500	Context Point B 132,633 0,001779 1321,224 0,001377 2,366 1372,336 0,000 N/A 10,580 10,500	C C C C C C C C C C C C C C C C C C C	0 0 144.788 553.359 78.852 2554.796 0.00125 0.00125 0.0000 NiA 10.549 24.000 10.549	1 141.074 410.465 65.252 2243.756 0.001 33.257 355.975 0.000 N/A 10.549 24.000 10.500	Fifth Points A 2 137.810 271.062 59.652 1932.716 0.0011 2.538 3.3.158 3.3.158 3.3.158 3.3.0.060 0.000 N/A 10.549 24.000 10.500	Ung Taper 3 134,996 50.052 1621.876 0.0011 2.563 33.073 262.679 0.000 N/A 10.549 24.000 10.500	4 132,633 0,919 140,779 1321,224 0,00137 137,535 0,000 N/A 10,549 24,000 10,500	5 0.000 0.000 22.813 1063.125 23.000 23.000 23.000 23.000 0.0000 10.0000 10.000 10.000	k trtt in k in/in deg k k k in in in
otal Factored Shear, Vu total Factored Moment, Mu Iffective Shear Depth, dv Max. Pemissible Factored Shear Resistance, Vr _{max} lexural Reint, Strain, s., Aashto Lrift Eq. 5.7.3.4.2.4 i = 29: 43(01 + 75)-3, Aashto Lrift Eq. 5.7.3.4.2.3 lactored Concrete Shear Resistance, 4V/c limiting Spacing, S. Aashto Lrift Eq. 5.7.2.6-1 limiting Spacing, S. Aashto Lrift Eq. 3.7.2.6-1 limiting Spacing, S. Aashto Lrift Eq. 3.7.2.6-1	A 160.463 764.083 78.852 254.785 254.785 0.00130 2.433 33.540 0.000 N/A 10.500 10.500	Context Point B 132,633 40,779 1321,224 40,779 1321,224 0.00137 2,360 137,835 0.000 N/A 10,545 24,000 10,500	C C C C C C C C C C C C C C C C C C C	0 0 144.78 53.399 78.852 2554.796 0.00125 2.475 33.389 400.295 0.000 N/A 10.500 10.500	1 141.074 410.465 69.252 224.0.756 0.000 N/A 10.500 10.500 10.500	Fitth Points A 2 137.810 271.062 59.652 1932.716 0.00119 2.538 310.550 0.000 0.000 0.000 0.000 0.000 0.000 0.000 10.500	Non Na 0.000 10.500 100.000 10.24.000 100.000 10.24.000 10.500 10.500	4 132,633 0,919 40,779 1321,224 0,00137 2,260 0,000 197,835 0,000 10,540 10,540 10,500	5 0.000 0.000 0.0000 4.000 0.0000 0.000 0.000000	k krtt in k in/in deg k k k in in in

Additional Longitudinal Reinforcement Ashto Lrtd 5.7.3.5 See Ashto Lrtd 5.7.3.5 and RDM 6.6.4.1.1 for additional information reparding the applicability of this provision.			
	Additional Longitudinal Reinforcement	Aashto Lrfd 5.7.3.5 nai information regarding the applicability of this provision	

Base 6 off of Shear Method 1 or 2 1 Method 1 = Simplified Shear 2 = General Shear Design

		method 1 - c	simplified on	cur, z - Gener	iai Shear Desi	ign				
The user has the opportunity to enter a stirrup spacing.		Critical Points	5			Fifth Points A	long Taper			1
The stirrup size and number of legs remain the same.	A	В	С	0	1	2	3	4	5	1
Stirrup Spacing Used	10.500	10.500	10.500	10.500	10.500	10.500	10.500	10.500	10.500	in
θ based on Shear Method 1	45.000	45.000	45.000	45.000	45.000	45.000	45.000	45.000	45.000	deg
Mu/(dv*(y)	129.541	0.301	0.301	93.570	79.029	60.588	35.882	0.301	0.000	K.
Vu	150.463	132.633	132.633	144.788	141.074	137.810	134.996	132.633	0.000	ĸ
Vu/o _v	167.181	147.369	147.369	160.875	156.749	153,122	149.996	147.369	0.000	ĸ
0.5*Vs	83.591	46.604	46.604	80.438	78.374	68.173	57.202	46.604	0.000	ĸ
$As^*fy = Mu/(dv^*\phi_f) + (Vu/\phi_v - 0.5^*Vs)^*cot\theta$	213.131	101.066	101.066	174.007	157.403	145.537	128.676	101.066	0.000	ĸ
Total As Needed	3.552	1.684	1.684	2.900	2.623	2.426	2.145	1.684	0.000	in ²
Additional Longitudinal Reinf. Needed, Alx	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	in ²

Crack Control and S&T Reinforcement

 Crack Control: Flexure Reinforcement
 Aashto Lrfd 5.6.7. Spacing should also comply with Aashto Lrfd 5.10.3.1 and 5.10.3.2.

 See cell G56 to change the Exposure Factor, y_e, which is typically set to 1.00 (Class 1) for pier caps.
 See cell G56 to change the Exposure Factor, y_e which is typically set to 1.00 (Class 1) for pier caps.

Concrete Cover Thickness to Reinf. Center, d., 1.88 3.180 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.0000 0.000 0.0000 <	3.188 1.139 0.000 0.000 0.000 0.000 0.000 0.000 1 0.00677 0.264 0.000 0 n/a 5 No 0.000 0.469 0.000 0.469 0.195 12.000	in k*ftt k*ftt k*ftt k*ftt k*ftt in in in in in in
55 1.056 1.107 1.064 1.044 1.071 1.084 1.071 1.084 1.071 1.084 1.071 1.084 1.071 1.081 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 <th>1.139 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.024 0.0067 0.224 0.000 0.020 0.025 No 0.000 5.465 0.195 12.000</th> <th>k*ft k*ft k*ft k*ft k*ft in in in in in in</th>	1.139 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.024 0.0067 0.224 0.000 0.020 0.025 No 0.000 5.465 0.195 12.000	k*ft k*ft k*ft k*ft k*ft in in in in in in
Service Moment, Ms due to P1 0.0000 0.000 0.000 <t< th=""><th>0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000</th><th>k*ft k*ft k*ft k*ft k*ft k*ft k*ft k*ft</th></t<>	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	k*ft k*ft k*ft k*ft k*ft k*ft k*ft k*ft
Service Moment, Ms oue ib p2 440.849 0.000 0.001 0.81.850 78.750 88.775 0.000 0.0011 0.011 0.011	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	k*ft k*ft k*ft k*ft k*ft k*ft in in in in in in
Service Moment, Ms due to Diaphragm 0.021 0.001	0.000 0.000 0.0007 0.0067 0.264 0.264 0.000 0.126 0.000 0.000 5.469 0.195 12.000	k*ft k*ft k*ft in in in in in in in in in
Service Moment, Ms due to Pier Cap 43.857 0.735 0.735 14.40 7.895 0.736 Orabl Service Moment, Ms 524.726 0.736 0.726 377.889 278.773 14.40 7.895 0.185 0.736 Orabl Service Moment, Ms 524.726 0.736 0.726 377.889 278.773 14.40 7.895 0.736 0.736 Factor for Distance to Neutral Axis, k 0.178 0.3237 0.2327 0.0217 0.00524 0.00276 0.0051 0.00427 0.0268 Reinforcement Stress at Service Level, fs. 10.354 0.028 0.028 0.227 7.486 6.288 4.813 2.846 0.028 Max. Spa. of Top Layer of Neg. Flexural Reinf, s 57.6 22376.0 22.5 96.3 129.1 219.8 22978.0 62.5 96.3 103.1 0.327 Grack Control: Skin Reinforcement Ashto Lfd 5.6.7. Spacing should also comply with Ashto Lfd 5.10.3.1 and 5.10.3.2 Yes Yes Yes Yes Yes Yes Yes Yes	0.000 0.000 0.000 0.264 0.000 0.264 0.000 0.724 0.000 0.744 0.000 0.000 0.000 0.469 0.195 12.000	k*ft k*ft ksi in in in in in in in
Total Service Moment, Ms 524,726 0.736 0.738 277.88 279.773 184.460 91.557 0.736 Reinforcement Ratio, p 0.00276 0.00524 0.00524 0.00527 0.00512 0.00521 0.00521 0.00521 0.00521 0.00527 0.00527 0.00521 0.00521 0.00521 0.00521 0.00527 0.00521 0.00521 0.00527 0.00521 0.0201 0.216 0.227 0.217 0.178 0.188 0.201 0.216 0.227 Reinforcement Stress at Service Level, f _s 10.354 0.028 0.028 7.456 6.288 4.813 2.846 0.028 Max. Spa. of Top Layer of Neg. Flexural Reinf., s 57.6 22378.0 22378.0 98.3 129.1 219.8 22378.4 Crack Control: Skin Reinf.required rement Aashto Lrfd 5.6.7. Spacing should also comply with Aashto Lrfd 5.10.3.1 and 5.10.3.2 4 5 0 1 2 4 6 0 1 2 4 5 7 8 7 8 7 8 </td <td>0.000 0.0067 0.264 0.000 0 n/a 5 No 0.000 5.459 0.195 12.000</td> <td>k*tt 7 ksi in in in in in in</td>	0.000 0.0067 0.264 0.000 0 n/a 5 No 0.000 5.459 0.195 12.000	k*tt 7 ksi in in in in in in
Reinforcement Railo, p 0.00276 0.00824 0.00275 0.00275 0.00276 0.00276 0.00312 0.00312 0.00312 0.00312 0.00312 0.00321 0.00312<	4 0.00671 0.264 0.000 0 n/a 5 No 0.000 5.469 0.195 12.000	7 ksi in in in in in in in
Critical Points 0.178 0.237 0.237 0.178 0.188 0.201 0.216 0.237 Reinforcement Stress at Service Level, f _{ss} 10.354 0.028 0.428 7.456 6.288 4.813 2.446 0.028 Max. Spa. of Top Layer of Neg. Flexural Reinf., s 57.6 22378.0 82.5 98.3 129.1 219.8 22378.0 Grack Control: Skin Reinforcement Aashto Lrld 5.6.7. Spacing should also comply with Aashto Lrld 5.10.3.1 and 5.10.3.2. Critical Points 6.149 0.610 0.495 0.275 Yes 9.34 0.149 0.405 0.375 0.244 0.149 0.410 0.495 0.375 0.264 0.144 Max Spacing of Skin Reinf. Required 12.000 7.069 7.069 12.000 11.869 10.3.2. Area of Skin Reinf. Required per Face. A _h 0.213 0.218 0.211 0.209 12.000 11.869 10.269 5.669 7.069 Shrinkag	0.264 0.000 5 n/a 5 No 0.000 5.469 0.195 12.000	ksi in in'/f in in'/f
Critical Control: Skin Reinforcement 10.354 0.028 0.028 7.456 6.288 4.813 2.846 0.028 Max. Spa. of Top Layer of Neg. Flexural Reinf., s 57.6 22378.0 22378.0 82.5 98.3 129.1 219.8 22378.0 22378.0 82.5 98.3 129.1 219.8 22378.0 22378.0 82.5 98.3 129.1 219.8 22378.0 22378.0 82.5 98.3 129.1 219.8 22378.0 22378.0 82.5 98.3 129.1 219.8 22378.0 2378.0 82.5 98.3 129.1 219.8 22378.0 2378.0 2378.0 23 4 3 </td <td>0.000 0 n/a 5 No 0.000 5.469 0.195 12.000</td> <td>ksi in in in in in</td>	0.000 0 n/a 5 No 0.000 5.469 0.195 12.000	ksi in in in in in
Max. Spa. of Top Layer of Neg. Flexural Reinf., s 57.6 22378.0 22378.0 82.5 98.3 129.1 219.8 22378.0 Crack Control: Skin Reinforcement Aashlo Lifd 5.6.7. Spacing should also comply with Aashlo Lifd 5.10.3.1 and 5.10.3.2. Critical Points Critical Points Sint Reinf. Required 7. (Is d _{wettows bac} >3.007) Critical Points Fifth Points Along Taper A B C 0 1 2 3 4 is Skin Reinf. Required 7. (Is d _{wettows bac} >3.007) Yes	0 n/a 5 No 0.000 5.469 0.195 12.000	in '/f
Crack Control: Skin Reinforcement Aashlo Lifd 5.6.7. Spacing should also comply with Aashlo Lifd 5.10.3.1 and 5.10.3.2 Critical Points Critical Points Fifth Points Along Taper A B C 0.1 2 3 4 is Skin Reinf. Required 7 (Is d _{verturn bar} >3.00°?) Yes Yes Yes Yes Yes Yes Yes 0.254 0.149 Area of Skin Reinf. Required 12.000 7.069 7.069 12.000 11.869 10.269 8.669 7.069 Shrinkage and Temp. Reinforcement Aashlo Lifd 5.10.6. Spacing should also comply with Aashlo Lifd 5.10.3.1 and 5.10.3.2 Area of Skin Reinf. Required per Face, A, 0.213 0.218 0.273 0.263 0.251 0.236 0.218 Max Spacing of Skin Reinf. Required 12.000	5 No 0.000 5.469 0.195 12.000	in'// in in'// in
Critical Points Fifth Points Along Taper A B C 0 1 2 3 4 is Skin Reinf. Required ? (Is d _{unt term kar} > 5.00?) Yes Yes <td>5 No 0.000 5.469 0.195 12.000</td> <td>in⁻/f in in⁻/f</td>	5 No 0.000 5.469 0.195 12.000	in ⁻ /f in in ⁻ /f
A B C 0 1 2 3 4 s Skin Reinf. Required ? (is d _{extens bar} > 3.00?) Yes Yes <t< td=""><td>5 No 0.000 5.469 0.195 12.000</td><td>in²/f in in²/f</td></t<>	5 No 0.000 5.469 0.195 12.000	in ² /f in in ² /f
Skin Reint. Required per Face, A _{th} 0.610 0.149 0.149 0.610 0.045 0.279 0.264 0.149 Max Spacing of Skin Reint. Required 12.000 7.069 7.069 12.000 11.869 10.269 8.669 7.069 Shrinkage and Temp. Reinforcement Aashto Lrld 5.10.6. Spacing should also comply with Aashto Lrld 5.10.3.1 and 5.10.3.2. Area of Skin Reint. Required 0.273 0.218 0.213 0.263 0.251 0.236 0.218 Max Spacing of Skin Reint. Required 12.000	0.000 5.469 0.195 12.000	in ² /f
Area of Skin Reinf. Required per Face, A _{sk} 0.610 0.149 0.610 0.495 0.279 0.284 0.148 Max Spacing of Skin Reinf. Required 12.000 7.069 7.069 12.000 11.665 10.269 8.669 7.065 Shrinkage and Temp. Reinforcement Aashto Lifd S 10.6. Spacing should also comply with Aashto Lifd S 10.3.1 and S 10.3.2. Area of Skin Reinf. Required per Face, A, 0.273 0.218 0.273 0.263 0.251 0.236 0.218 Max Spacing of Skin Reinf. Required 12.000	0.000 5.469 0.195 12.000	in*/f in in*/f in
Max spacing of skin Reint. Required 12.000 7.069 12.000 11.669 10.269 8.669 7.065 Shrinkage and Temp. Reinforcement Aashto Lifd 5.10.6. Spacing should also comply with Aashto Lifd 5.10.3.1 and 5.10.3.2. Area of Skin Reinf. Required per Face, A, 0.273 0.218 0.273 0.265 0.251 0.236 0.218 Max Spacing of Skin Reinf. Required 12.000	0.195 12.000	in ⁻ /f
Shrinkage and Temp, Reinforcement Aashto Lrfd 5.10.5. Spacing should also comply with Aashto Lrfd 5.10.3.1 and 5.10.3.2 Area of Skin Reinf. Required per Face, A, 0.273 0.218 0.273 0.263 0.251 0.236 0.218 Max Spacing of Skin Reinf. Required 12.000 <t< th=""><th>0.195</th><th>in*//</th></t<>	0.195	in*//
Area of Skin Reinf. Required per Face, A, 0.273 0.218 0.218 0.273 0.263 0.251 0.236 0.218 Max Spacing of Skin Reinf. Required 12.000 12.000 12.000 12.000 12.000 12.000 12.000 12.000 12.000	0.195	in*/f
Max Spacing of Skin Reinf. Required 12.000 12.000 12.000 12.000 12.000 12.000 12.000 12.000 12.000 12.000	12.000	in

DISCRETE FLEXURE	AND SHEAR	DESIGN		Aashto Lrf	5.6 and 5.7 Cap Depth (Z)					
Pier Cap Design at One Di	screte Location									
Cap Height (Y)			3.000	ft	6000 B					
Concrete Strength fc			4.000	n ksi	ashto Lrfd 5 4 2 1 Height					
Flexural Reinforcement Yield Strength, fy 60.000					ashto Lrfd 5.4.3.1 (Y) 0000					
Shear Reinforcement Yield	Strength, fy		60.000	ksi	ashto Lrfd 5.4.3.1					
Reinforcement Modulus of	Elasticity, Es		29000.000	ksi	ashto Lrfd 5.4.3.2					
Flexure Resistance Phi Fac	ctor, or		0.900	Begin by as	uming a tension-controlled section, φ _f = 0.9 Aashto Lrfd 5.5.4.2.					
Shear Resistance Phi Fact	or, q _v		0.900	$\phi_{v} = 0.9 - 1$	Isnto Lind 5.5.4.2.					
Concrete Onit Weight, 76			0.150	KCT						
Intermediate Calculations					ashto Lrfd 3.5.1 and 5.4.2.4, typically 0.150 kcf					
Whitney Stress Block Factor	οε, α1		0.850	Aashto Lrfd	5.6.2.2					
Whitney Stress Block Factor	or, β ₁		0.850	Aashto Lrfd	5.6.2.2					
Compression-controlled Str	rain Limit, e _{el}		0.002	Aashto Lrfd 5.6.2.1						
Tension-controlled Strain L	imit, e _t		0.005	Aashto Lrfd	5.6.2.1					
Concrete Modulus of Elasti Modular Patio	city, Ec		4266.223	KSI	ashto Lrtd 5.4.2.4, aggregate correction factor is set to 1.0					
modular (Valio, N			7,000	Additio Life						
Design Bottom Cap Reinfo	rcement				Design Top Cap Reinforcement					
Factored Applied Positive 1	Moment, Mu _z		766.090	k*ft	Factored Applied Negative Moment, Muz 766.090 k*ft					
					none. Use positive value for negative moments.					
Rough Estimate of As requi	red		5.373	in^2	Rough Estimate of A _s required 5.373 in ⁴ 2					
required for bar sizes:	ours.	#8	7		required for har sizes: #8 7					
required for par sizes.		#9	6		19 6					
		#10	5		#10 5					
		#11	4	l	#11 4					
Bar Size for Flexural Reinfo	prcement		9	1	Bar Size for Flexural Reinforcement 9					
	d' (in) by Laver.	No. of			d' (in) by Laver, No. of					
Reinforcement	Measured from	Bars per	d _s (in) by		Reinforcement Measured from Bars per d _s (in) by					
Layer	Bottom of Cap	Layer	Layer		Layer Top of Cap Layer Layer					
1	3.1875	8	32.8125		1 3.1875 8 32.8125					
2	7.1875		28.8125		2 7.1875 28.8125					
4	11.1875		24.8125		3 11.1875 24.8125 4 15.1875 20.8125					
,			20.0120		20.0120					
Total Bar Area Input, As pro	ovided		8.000	in^2	Total Bar Area Input, A _s provided 8.000 in ⁴ 2					
Distance from Top of Cap t	o C.G. of Bar Gro	up, d _s	32.813	in	Distance from Bottom of Cap to C.G. of Bar Group, ds 32.813 in					
Note: Total bar area is lump	ped at its center of	f gravity.			Note: Total bar area is lumped at its center of gravity.					
Flexural Capacity Check	Aashto Lrf	d 5.6.3.2								
Contract of the local state	- AGAING LIT				Protocol America I I and a second					
Factored Applied Moment,	Mu _z		766.090	k*ft	Factored Applied Moment, Muz 766.090 k*ft					
Eactored Eleveral Registers	ce Mr = Mr		3.922	in Late	Eactored Eleveral Resistance, Mr. = 4Mn 4440.652 1/18					
Is Mu. <= Mr. ?	cc, wiz - owing		Yes	6 IL	Is Mu, <= Mr. ?					
			143		143					
Minimum Reinforcement	Check	Aashto Lrfd	5.4.2.6 and 5.6.3	.3						
For modulus of rupture. usi	ing a coefficient of	0.37 rather th	an 0.24 from Aa	shto Lrfd C5	.2.6 is conservative.					
Modulus of Rupture, fr = 0.3	37*f ₀ 05		0.740	ksi	Modulus of Rupture, $f_r = 0.37$ f $_c^{0.5}$ 0.740 ksi					
Section Modulus of Can S		1	4.500	ft^3	Section Modulus of Cap. S. 4 500 843					
Yield to Ult. Tensile Strengt	th Ratio, 7, (0.67 o	or 0.75)	0.750		Yield to Ult. Tensile Strength Ration, y ₄ (0.67 or 0.75) 0.750					
and a second officing	v Factor, y. (1.6)		1,600		Flexural Cracking Variability Factor, Y (1.6) 1.600					
Flexural Cracking Variability			575,424	k*ft	Cracking Moment, Mcr, = y ₃ *y ₁ *f,*S, 575.424 k*ft					
Flexural Cracking Variability Cracking Moment, Mcr. = 9	3"Y1"f,"S2				Is Mcrz <= Mrz ? Yes					
Flexural Cracking Variabilit Cracking Moment, Mcr _z = Is Mcr _z <= Mr _z ?	3*71*fr*Sz		Yes	1						
Flexural Cracking Variabilit Cracking Moment, Mcr _z = y Is Mcr _z <= Mr _z ?	OR		Yes		OR					
Flexural Cracking Variabilit Cracking Moment, $Mcr_z = \gamma$ Is $Mcr_z \le Mr_z$?	OR		Yes	in/2	A required based on 133Mu 7 998 w/s					
Flexural Cracking Variabilit Cracking Moment, Mcr _z = Is Mcr _z <= Mr _z ? A _s required based on 1.33" Is A. provid b= A. pendid ba	OR Muz ased on 1.33"Mu	-	Yes 7.298 Yes	in^2	OR A ₂ required based on 1.33 ¹ Mu ₂ 7.298 in ¹ 2 Is A. provid >= A. regid based on 1.33 ¹ Mu ₂ ? Yes					
Flexural Cracking Variabilit Cracking Moment, Mcr _z = γ is Mcr _z <= Mr _z ? A _x required based on 1.33" is A _x prov'd >= A _x req'd ba	OR Mu _z ased on 1.33°Mu,		Yes 7.298 Yes	in ⁴ 2	OR A ₂ required based on 1.33*Mu ₂ 7.298 in*2 Is A ₂ prov'd >= A ₂ req'd based on 1.33*Mu ₂ ? Yes					
Flexural Cracking Variabilit Cracking Moment, Mcr _z = γ Is Mcr _z <= Mr _z ? A _x required based on 1.33° Is A _x prov'd >= A _x req'd ba	OR Mu _z ased on 1.33"Mu,		Yes 7.298 Yes	in^2	OR A, required based on 1.33'Mu, 7.298 in ⁴ 2 Is A, prov'd >= A, req'd based on 1.33'Mu,? Yes					
Flexural Cracking Variabilit Cracking Moment, Mcr _z = 7 Is Mcr _z <= Mr _z ? A _z required based on 1.33" Is A _z prov'd >= A _z req'd bi	OR Mu <u>z</u> ased on 1.33"Mu,	.?	Yes 7.298 Yes	in^2	OR A, required based on 1.33 ⁺ Mu ₂ 7.298 in ⁴ 2 Is A, prov'd >= A, req'd based on 1.33 ⁺ Mu ₂ ? Yes					
Flexural Cracking Variabilit Cracking Moment, Mcr. = 7 Is Mcr. <= Mr. ? A, required based on 1.33* Is A, prov'd >= A, req'd bi	OR Mu <u>z</u> ased on 1.33°Mu,	 ?	Yes 7.298 Yes	in^2	OR [A ₄ required based on 1.33 [*] Mu ₂ 7.298 in ⁴ 2 Is A ₅ prov'd >= A ₅ req'd based on 1.33 [*] Mu ₂ ? Yes					
Flexural Cracking Variabilit Cracking Moment, Mcr ₂ = 7 Is Mcr ₂ <= Mr ₂ ? A ₂ required based on 1.33 th Is A ₂ prov'd >= A ₂ req'd bi	OR Mu <u>z</u> ased on 1.33"Mu,	.?	Yes 7.298 Yes	in^2	OR A, required based on 1.33 ¹ Mu, 7.298 in ⁴ 2 Is A, prov'd >= A, req'd based on 1.33 ¹ Mu,? Yes					
Flexural Cracking Variability Cracking Moment, Mc, = γ Is Mcr, ⊂ Mr, ? A, required based on 1.33* Is A, prov'd >= A, req'd bo	OR Mu <u>z</u> ased on 1.33 ⁻ Mu	.?	Yes 7.298 Yes	in^2	OR A, required based on 1.33*Mu, 7.298 in*2 Is A, prov'd >= A, req'd based on 1.33*Mu,? Yes					
Flexural Gracking Variabilit Cracking Moment, Mcr. = ; Is Mcr., ⊂ Mrr. ? A, required based on 1.33* Is A, prov'd >= A, reg'd bi	5"/11"S2 OR Mu2 ased on 1.33"Mu,	?	Yes 7.298 Yes	in^2	OR A, required based on 1.33 [*] Mu, 7.298 in ⁴ 2 Is A, prov'd >= A, req'd based on 1.33 [*] Mu,? Yes					
Flexural Cracking Warehilts Cracking Moment, Mcr, = : Is Mcr, <= Mr, ? A, required based on 1.33* (s A, prov'd >= A, req'd bi	OR Mu_ ased on 1.33"Mu,	.?	Yes 7.298 Yes	in^2	OR A_required based on 1.33*Mu, 7.298 in*2 Is A_ prov'd >= A_req'd based on 1.33*Mu,? Yes					
Flexural Cracking Variability Cracking Moment, Mc, = ; is Mcr,	OR Mu <u>z</u> ased on 1.33 ⁻ Mu,	?	Yes 7.298 Yes	in*2	OR A, required based on 1.33'Mu, 7.298 in*2 Is A, prov'd >= A, req'd based on 1.33'Mu,? Yes					
Flexural Cracking Variabilit Cracking Moment, Mcr. = ; Is Mcr. < = Mrr. ? A, required based on 1.33* Is A, prov'd >= A, req'd bi	OR Mu ₂ ased on 1.33"Mu,	?	Yes 7.298 Yes	in*2	OR A, required based on 1.33 ¹ Mu, 7.298 in ¹ /2 Is A, prov'd >= A, req'd based on 1.33 ¹ Mu,? Yes					
Flexural Cracking Varability Cracking Moment, Mcr, = γ Is Mcr, ⊂ Mr, ? A, required based on 1.33° Is A, prov'd >= A, req'd bi	OR Mu <u>z</u> ased on 1.33"Mu,	.?	Yes 7.298 Yes	in*2	OR A, required based on 1.33*Mu, 7.298 in*2 Is A, prov'd >= A, req'd based on 1.33*Mu,? Yes					
Flexural Cracking Variabilit Cracking Moment, Mcr. = : is Mcr., ⊂ Mrr., ? A, required based on 1.33° Is A, prov'd >= A, req'd bi	OR Mu, ased on 1.33'Mu,		Yes 7.298 Yes	in*2	OR A _x required based on 1.33 [*] Mu _x 7.298 in ⁴ 2 Is A _x prov'd >= A _x req'd based on 1.33 [*] Mu _x ? Yes					

Location of Teentral Axis, c Ver Tensile Strain in the Extreme Tension Steel, s ₁ Tension Controlled? $\mathbf{e}_s > \mathbf{e}_s = 0.005$ Compression Controlled? $\mathbf{e}_s > \mathbf{e}_s = 0.005$ Transition? $\mathbf{e}_s > \mathbf{e}_s > \mathbf{e}_s$ Fiexure Phi Factor, \mathbf{e}_s for Design Jdd, J003(0.003 + $\mathbf{e}_s)$ where $\mathbf{e}_s = 0.002$ is cid _k <= 0.003(0.003 + $\mathbf{e}_s)$ such that $\mathbf{f}_s = \mathbf{f}_s$? Is Fiex. Reint. Adequate? YES, Fiexural Reinf New Disference of Case	4.614 m 0.018 in/in Yes No 0.900 0.141 0.600 Yes is Adequate.	Not Treating Treatin	4.014 m 0.018 infn Yes No 0.900 0.141 0.600 Yes
Tension Controlled? $r_{a} > r_{a} = 0.005$ compression Controlled? $r_{a} > r_{a} = 0.005$ compression Controlled? $r_{a} < r_{a} = 0.002$ Tensure Phi Factor, r_{b} , for Design Did. $003(0.003 + r_{a})$ where $r_{a} = 0.002$ s clds < $< 0.003(0.003 + r_{a})$ such that $f_{a} = f_{a}$? S Flex. Reinf. Adequate? YES, Flexural Reinf	0.000 mm No 0.000 0.141 0.600 Yes is Adequate.	Tarresion Controlled 7 $e_4 > e_{ad} = 0.005$ Compression Controlled 7 $e_4 > e_{ad} = 0.002$ Transition 7 $e_{ad} = 0.002$ Transition 7 $e_{ad} = 0.002$ Transition 7 $e_{ad} = 0.002$ Fiexure Phi Factor, ϕ_{b} for Design Cid, $0.003(0.003 + e_{ad})$ where $e_{ad} = 0.002$ Is cid, $< 0.003(0.003 + e_{ad})$ such that $f_a = f_7$?	Ves No No 0.900 0.141 0.600 Yes Yes
Compression Controlled $T_{e_1} <= e_{e_1} = 0.002$ Transition $T_{e_2} > x_2 > x_{e_1}$ Resure Phi Factor, e_1 , for Design Jd_0 0.0034 r_{e_2}) where $r_{e_1} = 0.002$ s cld_s <= 0.0034 (0.003 + r_{e_2}) such that $f_s = f_s T$ s Flex. Reinf. Adequate? YES, Flexural Reinf	No No 0.900 0.141 0.600 Yes	Compression Controlled? $e_t <= e_{cd} = 0.002$ Transition? $e_0 = 0.005 > e_t > e_{cd} = 0.002$ Flexure Phi Factor, ϕ_t for Design cld_s 0.003(0.003 + $e_{cd})$ where $e_d = 0.002$ Is cld_s <= 0.003(0.003 + $e_{cd})$ such that $f_s = f_T$?	No No 0.900 0.141 0.600 Yes
fransition? $e_0 > e_0 > e_{cd}$ lexure Phi Factor, e_0 , for Design id_0 $10030(0.003 + e_0)$ where $e_{cd} = 0.002$ s cid_0 <= 0.0003(0.003 + e_0) such that $f_0 = f_0$? s Flex. Reinf. Adequate? YES, Flexural Reinf	No 0.900 0.141 0.600 Yes	$\label{eq:result} \begin{split} & Transition? e_{e} = 0.005 > e_{e} > e_{ed} = 0.002 \\ & Flexure Phi Factor, \phi_{e}, for Design \\ & cid_{a} \\ & 0.003(0.003 + e_{ed}) \text{ where } e_{ed} = 0.002 \\ & Is cid_{a} < = 0.003(0.003 + e_{ed}) \text{ such that } f_{a} = f_{\gamma}? \end{split}$	No 0.900 0.141 0.600 Yes
Flexure Phi Factor, (v, for Design cld_ 0.003(0.003 + r_g) where r_g = 0.002 s cld_s <= 0.003(0.003 + r_g) such that f_s = f_y?	0.900 0.141 0.600 Yes . is Adequate.	Flexure Phi Factor, ϕ_{1} for Design (c/d, 0.003i(0.003 + ϵ_{aj}) where $\epsilon_{aj} = 0.002$ Is cid ₃ <= 0.003i(0.003 + ϵ_{aj}) such that $f_{a} = f_{y}$?	0.900 0.141 0.600 Yes
id _a 10030 (003 + ε _a) where ε _a = 0.002 s cid _a <= 0.0030(0.003 + ε _a) such that f _a = f _y ? s Flex. Reinf. Adequate? YES, Flexural Reinf	0.141 0.600 Yes . is Adequate.	cld_{s} $0.003(0.003 + \epsilon_{d})$ where $\epsilon_{d} = 0.002$ $ls cld_{s} <= 0.003(0.003 + \epsilon_{d})$ such that $f_{s} = f_{y}?$	0.141 0.600 Yes
d_{a} $003(0.003 + \epsilon_{a})$ where $\epsilon_{a} = 0.002$ c $c d_{a} <= 0.003[(0.003 + \epsilon_{a})$ such that $f_{a} = f_{f}$? 5 Flex. Reinf. Adequate? YES, Flexural Reinf	0.141 0.600 Yes	c/d_s $0.003/(0.003 + \epsilon_{cl})$ where $\epsilon_{cl} = 0.002$ $ s c/d_s <= 0.003/(0.003 + \epsilon_{cl})$ such that $f_s = f_y$?	0.141 0.600 Yes
003(0.003 + r ₀) where e ₁ = 0.002 a cld ₂ <= 0.003(0.003 + e ₀) such that f ₂ = f ₂ ? 5 Flex. Reinf. Adequate? YES, Flexural Reinf	0.600 Yes . is Adequate.	$\begin{array}{l} 0.003'(0.003 + \epsilon_{d}) \text{ where } \epsilon_{d} = & 0.002 \\ \hline \text{Is c/d}_{s} <= 0.003'(0.003 + \epsilon_{d}) \text{ such that } f_{s} = f_{y}? \end{array}$	0.600 Yes
s c/d _s <= 0.003(0.003 + t _{ell}) such that f _s = f _y ?	Yes	Is $c/d_s \le 0.003/(0.003 + \epsilon_{cl})$ such that $f_s = f_y$?	Yes
s Flex. Reinf. Adequate? YES, Flexural Reinf	is Adequate.		
ibeer Deinfersement Check Archite Lofd		Is Flex. Reinf. Adequate? YES, Flexural Reint	f. is Adequate.
Shear Keinforcement Check Aashio Lhu :	5.7 and specifically 5.7	4.1 and 2	
Simplified Shear Design Aashto Lrfd 5.7 and spe	cifically 5.7.3.4.1, $\beta = 3$	and θ = 45 degrees	
Factored Applied Shear, Vu	150.460 k	Factored Applied Shear, Vu	150.460 k
Stirrup Bar Size (i.e. #4, #5, etc.)	4	Stirrup Bar Size (i.e. #4, #5, etc.)	4
Number of Stirrup Legs (Typ. 4 legs for double hoops)	2	Number of Stirrup Legs (Typ. 4 legs for double hoops)	2
Total Area of Shear Stirrups	0.400 in ²	Total Area of Shear Stirrups	0.400 in ²
Stirrup Spacing at Location of Interest (i.e. at Mu)	10.500 in	Stirrup Spacing at Location of Interest (i.e. at Mu)	10.500 in
Beta, 8	2.0001	(Beta, 0	2.000
Theta, 0	45.000 deg	Theta, 0	45.000 deg
Effective Shear Depth, dv	30.852 in	Effective Shear Depth, dv	30.852 in
Concrete Shear Resistance V	140 388	Concrete Shear Resistance V	140 388 4
Stirrup Shear Resistance V.	70.518 k	Stirrup Shear Resistance, V	70.518 k
$V_{0} = V_{c} + V_{c}$	210 906 k	Vn. = Vc + Ve	210.906 k
/n = 0.25*fc*bv*dv	1110.662 k	Vn = 0.25*fc*bv*dv	1110.662 k
Vn = minimum of Vn _{cs} and Vn _{max}	210.906 k	Vn = minimum of Vn _{cs} and Vn _{max}	210.906 k
TIME			
l _v *Vn	189.815 k	¢ v *Vn	189.815 k
Factored Applied Shear, Vu	150.460 k	Factored Applied Shear, Vu	150.460 k
s Shear Design Adequate2 + 11/o >= 1/u	Vee	Is Shear Design Adequate2 + *\/o >= \/u	Voe
a onear beargh Adequater ov Att >= An	Tes	le Stielet Design Moeduate r 64 Au >- 40	res
General Shear Design Aashto Lrfd 5.7 and spe	cifically 5.7.3.4.2, varia	e β and θ	
Use positive value for shears and moments.			
Factored Applied Shear, Vu	150.460 k	Factored Applied Shear, Vu	150.460 k
ractored Applied Positive Moment, Muz	766.090 k*ft	Factored Applied Negative Moment, Muz	766.090 k*ft
Stirrup Bar Size (i.e. #4, #5, etc.)	4	Stirrup Bar Size (i.e. #4 #5. etc.)	4
Number of Stirrup Legs (Typ. 4 legs for double hoops)	2	Number of Stirrup Legs (Tvp. 4 legs for double hoops)	2
Total Area of Shear Stirrups	0.400 in ²	Total Area of Shear Stirrups	0.400 in*
Stirrup Spacing at Location of Interest (i.e. at Mu)	6.000 in	Stirrup Spacing at Location of Interest (i.e. at Mu)	6.000 in
Effective Shear Depth, dv	30.852 in	Effective Shear Depth, dv	30.852 in
Flexural Reinf Strain + Aashto I rfd Ed 573424	0.00193 inte	Flexural Reinf Strain a Aashto I rfd Ec 573424	0.00193 info
3 = 4 8/(1 + 750*s.) Asshto Lifd Eq. 5.7.3.4.2-4	1 959	8 = 4.8/(1 + 750*s.) Apphilo Life Eq. 5.7.3.4.2-4	1 959
a = 29 + 3500*z. Aashto I fd Eq. 5.7.3.4.2.3	35 765	$B = 29 + 3500^{\circ}r_{e}$ Aashto L fd Eq. 5.7.3.4.2.1	35 765
Concrete Shear Resistance V	137 540 1	Concrete Shear Resistance V.	137 540 k
Stimus Shear Resistance V.	171 327 k	Stimus Shear Resistance V.	171 327 k
Vn = Vr + Vs	309.967	Vn. = Vc + Vs	308.867 L
/n = 0.25*fc*hu*du	1110 662 L	Vn = 0.25*fc*hv*dv	1110.662 k
Vn = minimum of Vn and Vn	308.867	Vn = minimum of Vn and Vn	308.867 k
The second s	300.001 K	The manufactor of the grant the state	300.00r K
	277.981 k	φ _ν *Vn	277.981 k
l√*Vn		Factored Applied Shear, Vu	150.460 k
NrVn Factored Applied Shear, Vu	150.460 k		
N*Vn Factored Applied Shear, Vu	150.460 k	In Obsers Design Adaptation Bit and the	Mar
Vn = minimum of Vn _{cs} and Vn _{max}	277.981 k	VNexx -0.25 fc DV dV Vn = minimum of Vnex and Vnexx	277.981 k 150.460 k

The user has the opportunity to enter a stirrup spacing. Stirrup Spacing Used	The stirrup size and number of le	egs remain the same.	10.500 in
Sundp Spacing Used	10.300 11	Carrup Spacing Osed	10.000 11
Values based on shear method chosen.	0.400 in ²	Values based on shear method chosen.	0.400 in ²
B	45.000 deg	θ	45.000 deg
Effective Shear Depth, dv	30.852 in	Effective Shear Depth, dv	30.852 in
Vu	150.460 k	Vu	150.460 k
Mu	766.090 k	Mu	766.090 K
Mu/(dv*₀r)	331.085 k	Mu/(dv*or)	331.085 k
/u/ov	167.178 k	Vu/o _v	167.178 k
0.5*Vs	35.259 k	0.5*Vs	35.259 k
$As^*fy = Mu/(dv^*\phi_f) + (Vu/\phi_v - 0.5^*Vs)^*\cot\theta$	463.003 k	$As^*fy = Mu/(dv^*\phi_f) + (Vu/\phi_v - 0.5^*Vs)^*cot\theta$	463.003 k
Total As Needed	7.717 in*	Total As Needed	7.717 in*
f value for additional longitudinal reinforcement is zero	or negative it means that this pro	ovision of the code is satisfied.	0.000 #1
Crack Control: Flexure Reinf. Aashto Lr f fss >= 0.60°fy = 36 ksi, then the user needs to redesig	fd 5.6.7. Spacing should also co in the section.	mply with Aashto Lrfd 5.10.3.1 and 5.10.3.2.	
Exposure Factor, ye (Typically 1.00) Class 1 and 2 exposure factors are 1.00 and 0.75 respe	1.000 ctively.	Exposure Factor, ye (Typically 1.00) Class 1 and 2 exposure factors are 1.00 and 0.75 res	1.000 pectively.
Concrete Cover Thickness to Reinf. Center, d _e อิร	3.188 in 1.139	Concrete Cover Thickness to Reinf. Center, de	3.188 in 1.139
User Value for Positive Service Mz	766.090 k*ft	User Value for Negative Service M _z	766.090 k*ft
See Aashto Lrfd 5.4.2.4 and 5.7.1 for Ec and n			
Reinforcment Ratio, p	0.00677	Reinforcment Ratio, p	0.00677
Concrete Modulus of Elasticity, E _e	4266.223 ksi	Concrete Modulus of Elasticity, E _c	4266.223 ksi
Factor for Distance to Neutral Axis, k	0.264	Factor for Distance to Neutral Axis, k	0.264
Reinforcement Stress at Service Level	38.402 ksi	Reinforcement Stress at Service Level	38.402 ksi
Max Spa of Bot aver of Pos Elevural Point	9.632 in	Max Spa of Bot Laver of Pos Eleveral Point	9.632 in
Crack Control: Skin Reinf. Aashto Lr	fd 5.6.7. Spacing should also co	mply with Aashto Lrfd 5.10.3.1 and 5.10.3.2.	
s Skin Reinf. Required ? (Is d _{ext tens bar} > 3.00'?)	No	Is Skin Reinf, Required ? (Is dayther by > 3.00'?)	No
		Concerns one of the second sec	
Area of Skin Reinf. Required per Face, Ask	0.000 in^2 per ft	Area of Skin Reinf. Required per Face, Ask	0.000 in*2 per ft
Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required	0.000 in^2 per ft 5.469 in	Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required	0.000 in^2 per ft 5.469 in
Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Bautimet par Eace. A	0.000 in^2 per ft 5.469 in fd 5.10.6. Spacing should also c	Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2 (Area of Skin Bainf Damited new Face A	0.000 in*2 per ft
Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in fd 5.10.6. Spacing should also c 0.195 in*2 per ft 12.000 in	Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrid 5:10.3.1 and 5:10.3.2. Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in fd 5.10.6. Spacing should also c 0.195 in*2 per ft 12.000 in	Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2. Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Area of Skin Reinf, Required per Face, A _{sk} Max Spacing of Skin Reinf, Required Shrinkage and Temp, Reinf, Aashto Lr Area of Skin Reinf, Required per Face, A _{sk} Max Spacing of Skin Reinf, Required	0.000 im ² per R 5.469 in fd 5.10.6. Spacing should also c 0.195 im ² per R 12.000 in	Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2. Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Area of Skin Reinf, Required per Face, A _{as} Max Spacing of Skin Reinf, Required Shrinkage and Temp, Reinf, Aashto Lr Area of Skin Reinf, Required per Face, A _{as} Max Spacing of Skin Reinf, Required	0.000 im ² per ft 5.469 in 1d 5.10.6. Spacing should also c 0.195 im ² per ft 12.000 in	Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required omply with Aashto Lrid 5.10.3.1 and 5.10.3.2. Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required	0.000 im ² per ft 5.469 in Id 5.10.6. Spacing should also c 0.195 im ² per ft 12.000 in	Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2. Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required	0.000 im ² per R 5.469 in 1d 5 10.6. Spacing should also c 0.195 im ² per R 12.000 in	Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required omply with Aaahto Lrfd 5:10.3.1 and 5:10.3.2 Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.195 in*2 per ft 0.195 in*2 per ft 0.195 in*2 per ft 12.000 in
Area of Skin Reinf. Required per Face, A _{as} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _{as} Max Spacing of Skin Reinf. Required	0.000 im*2 per R 5.469 in d 5.10.6. Spacing should also c 0.195 im*2 per R 12.000 in	Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrid 5.10.3.1 and 5.10.3.2 [Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required	0.000 im ² per ft 5.469 in Id 5.10.6. Spacing should also c 0.195 im ² per ft 12.000 in	Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrid 5.10.3.1 and 5.10.3.2. Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required	0.000 in*2 per R 5.469 in d 5.10.6. Spacing should also c 0.195 in*2 per R 12.000 in	Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2. Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.195 in*2 per ft 0.195 in*2 per ft 0.195 in*2 per ft 12.000 in
Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required	0.000 im*2 per R 5.469 in d 5.10.6. Spacing should also c 0.195 im*2 per R 12.000 in	Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2 Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Vrea of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Vrea of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in Id 5.10.6. Spacing should also c 0.195 in*2 per ft 12.000 in	Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required omply with Aashto Lrid 5.10.3.1 and 5.10.3.2. Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _{sk} Max Spacing of Skin Reinf. Required	0.000 in*2 per R 5.469 in 1d 5.10.6. Spacing should also c 0.195 in*2 per R 12.000 in	Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2. Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.195 in*2 per ft 0.195 in*2 per ft 12.000 in
Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Varea of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required	0.000 im*2 per R 5.469 in d 5.10.6. Spacing should also c 0.195 im*2 per R 12.000 in	Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2 Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Vrea of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Vrea of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required	0.000 in*2 per 1 5.469 in 15.506. Spacing should also c 0.195 in*2 per 1 12.000 in	Area of Skin Reinf. Required per Face, A _a . Max Spacing of Skin Reinf. Required omply with Aashto Lrid 5.10.3.1 and 5.10.3.2. Area of Skin Reinf. Required per Face, A _a . Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Vrea of Skin Reinf. Required par Face, A _{ak} Max Spacing of Skin Reinf. Required ihrinkage and Temp. Reinf. Aashto Lr Vrea of Skin Reinf. Required par Face, A _{ak} Max Spacing of Skin Reinf. Required	0.000 in*2 per R 5.469 in d 5.10.6. Spacing should also c 0.195 in*2 per R 12.000 in	Area of Skin Reinf. Required per Face, A _A Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5:10.3.1 and 5:10.3.2. Area of Skin Reinf. Required per Face, A _A Max Spacing of Skin Reinf. Required	0.195 in*2 per ft 0.195 in*2 per ft 0.195 in*2 per ft 12.000 in
krea of Skin Reinf, Required per Face, A _a Max Spacing of Skin Reinf, Required Shrinkage and Temp, Reinf, Aashto Lr Area of Skin Reinf, Required per Face, A _a Max Spacing of Skin Reinf, Required	0.000 im*2 per R 5.469 in d 5.10.6. Spacing should also c 0.195 im*2 per R 12.000 in	Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2 Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 1d 5.10.6. Spacing should also c 0.135 in*2 per ft 12.000 in	Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2 Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Vrea of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per R 5.469 in d 5.10.6. Spacing should also c 0.195 in*2 per R 12.000 in	Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5:10.3.1 and 5:10.3.2. Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.000 im*2 per R 5.469 in d 5.10.6. Spacing should also c 0.195 im*2 per R 12.000 in	Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2 Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in d 5.10.6. Spacing should also c 0.155 in*2 per ft 12.000 in	Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2 Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Ivrea of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per R 5.469 in d 5 10.6. Spacing should also c 0.195 in*2 per R 12.000 in	Area of Skin Reinf. Required per Face. A _{a.} Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5:10.3.1 and 5:10.3.2. Area of Skin Reinf. Required per Face. A _{a.} Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in
Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required	0.000 in*2 per 1 5.469 in 15.506. Spacing should also c 0.195 in*2 per 1 12.000 in	Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2 Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Aashto L	0.000 in*2 per R 5.469 in 15.506. Spacing should also c 0.195 in*2 per R 12.000 in	Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2. Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required	0.195 in*2 per ft 0.195 in*2 per ft 12.000 in
Vea of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Aea of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per R 5.469 in d 5 10.6. Spacing should also c 0.195 in*2 per R 12.000 in	Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5:10.3.1 and 5:10.3.2. Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required in a spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 15.106. Spacing should also c 0.195 in*2 per ft 12.000 in	Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2 Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Area of Skin Reinf. Required per Face, A _a . Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _a . Max Spacing of Skin Reinf. Required	0.000 in*2 per R 5.469 in 15.506. Spacing should also c 0.195 in*2 per R 12.000 in	Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5:10.3.1 and 5:10.3.2. Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in
Area of Skin Reinf. Required per Face, A _{at} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Required Area of Skin Reinf. Required per Face, A _{at} Max Spacing of Skin Reinf. Required	0.000 in*2 per 1 5.469 in 15.106. Spacing should also c 0.195 in*2 per 1 12.000 in	Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5:10.3.1 and 5:10.3.2 Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required a spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 15.10.6. Spacing should also c 0.155 in*2 per ft 12.000 in	Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2. Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in
Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Required Aashto Lr Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per R 5.469 in d 5.10.6. Spacing should also c 0.195 in*2 per R 12.000 in	Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5:10.3.1 and 5:10.3.2. Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in
Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per 1 5.469 in 15.10.6. Spacing should also c 0.195 in*2 per 1 12.000 in 12.000 in	Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2 Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.195 in*2 per ft 0.195 in*2 p
Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 14 5.10.6. Spacing should also c 0.195 in*2 per ft 12.000 in 12.000 in	Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2. Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in 12.000 in
Area of Skin Reinf. Required per Face, A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per 1 5.469 in 15.106. Spacing should also c 0.195 in*2 per 1 12.000 in 12.000 in	Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2 Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required	0.195 in*2 per ft 0.195 in*2 p
Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required Shrinkage and Temp. Reinf. Aashto Lr Area of Skin Reinf. Required per Face, A _{ak} Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 15.10.6. Spacing should also c 0.155 in*2 per ft 12.000 in 12.000 in 12.000 in	Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required omply with Aashto Lrfd 5.10.3.1 and 5.10.3.2 Area of Skin Reinf. Required per Face. A _a Max Spacing of Skin Reinf. Required	0.000 in*2 per ft 5.469 in 0.195 in*2 per ft 12.000 in 0.195 in*2 per ft 12.000 in 0.195 in*2 per ft 12.000 in 0.195 in*2 per ft 0.195 in*







Created with PTC Mathcad Express. See www.mathcad.com for more information.





Pier dimensions, reinforcement, and	situation:
Pier cap:	
Cap height:	3.0 ft
Cap depth:	3.0 ft
Top cap reinforcement:	6#9 @ 6" c/c and 3#9 @12" c/c
Bottom cap reinforcement:	6#9 @ 6" c/c and 3#9 @12" c/c
Shear reinforcement:	Single hoop #4 stirrups @ 10.5" c/c
Skin reinforcement:	Not required
S&T reinforcement:	1#4 @ 12" c/c
Pier cap overhang:	
Cap overhang flexural	4#9 @ 10" c/c
reinforcement:	
Cap overhang shear reinforcement:	Single hoop #4 stirrups @ 10.5" c/c
Skin reinforcement:	4#4, two on each side @ 10.5"c/c
S&T reinforcement:	2#4 @ 10.5" c/c
Pier column:	
Column width:	3.0 ft
Column height (untapered):	12'-6"
Reinforcement:	8#9, square symmetric spacing
Pier footing:	
Footing width:	10'-0"
Footing length:	13'-0"
Footing depth:	4'-0"
Short dimension reinforcement:	18#8 symmetrically placed
Long dimesion reinforcement:	22#8 symmetrically placed
Skin reinforcement:	Not required.
S&T reinforcement:	#4 @ 6" c/c
Pier piles:	
Shape:	HP10x42
Number:	12
Edge spacing:	1'-2"
Spacing:	3'-0"
Embedment:	1'-0"
Contract length:	65 ft
Axial load capacity:	P := 179 kin (BDM Table 6.2.6.1-1)

Appendix D – Earthwork Report

See Figure D.1 for the earthwork report provided by Civil3D.

Cut/Fill Report						
Generated:	2020-04-27 13:47:03					
By user:	kowalsky					
Drawing:	\\iowa.uiowa.edu\shared\Engineering\Home\kowalsky\windowsdata\Desktop\Final Trail Drawings\\\iowa.uiowa.edu\shared\Engineering\Home\kowalsky\windowsdata\Desktop\Final Trail Drawings\Volga_4_15.dwg					

Volume Summary								
Name	Туре	Cut Factor	Fill Factor	2d Area (Sq. Ft.)	Cut (Cu. Yd.)	Fill (Cu. Yd.)	Net (Cu. Yd.)	
Cut- FillBeforeBridge1	full	1.000	1.000	2804.25	1.21	274.17	272.95 <fill></fill>	
CutFillAfterBridge1	full	1.000	1.000	10135.33	3.56	293.40	289.84 <fill></fill>	

Totals				
	2d Area (Sq. Ft.)	Cut (Cu. Yd.)	Fill (Cu. Yd.)	Net (Cu. Yd.)
Total	12939.58	4.78	567.57	562.79 <fill></fill>

* Value adjusted by cut or fill factor other than 1.0

Figure D.1. Cut/Fill earthwork report from Civil3D.

Appendix E – Riprap Design Calculations

Below are the equations and methods used to design the riprap layer around the pier and abutments.

Riprap at abutments: IADOT BDM C3.2.2.7 Scour.

- $V_{avg} = Q/A = 2.33$ ft/s (from HEC-RAS output)
- If $V_{avg} < 8$ ft/s, use Class E revetment stone
- If $V_{avg} \ge 8$ ft/s, use Class B revetment stone \therefore USE CLASS E
- Riprap upstream and downstream from the abutment, about 10'
- Riprap 2' deep into existing soil to prevent floodway constriction

Final design: 2-foot deep riprap layer which extends 10 feet upstream and downstream from the abutment with engineering fabric underlain.

Riprap at piers: HEC-18 section 7.5.1 and IADOT Standard Bridge Sheet 1006C - MACADAM STONE SLOPE PROTECTION - STUB ABUTMENT.

- $D_{50} = \frac{(KV)^2}{153.6} = \frac{(1.7*2.33*1.3)^2}{153.6} = 0.17 \text{ ft.}$
- D_{50} = median stone diameter, ft
- K = coefficient of pier shape, 1.5 for round nose and 1.7 for square nose
- V = velocity approaching pier = (Q/A)*C, C = 0.9 for near bank/ straight, 1.7 for middle/ curved. ∴ Use 1.3 for between middle and edge of channel and straight bank.
- Use Class E since $D_{50} < 1$ ft (Class E $D_{50} = 1.0$ ft)
- Width of riprap should be 2 x pier column width minimum. IADOT usually uses 25' for county bridges, but no need for this pedestrian bridge.
- Thickness = $3 \times D_{50} = 3 \times 1.0$ ft = 3.0 ft
- Width = $2 \times 5.0^{\circ} = 10.0^{\circ}$ (column width = 5.0 ft)

Final design: 3-foot deep riprap layer which extends 10 feet in all directions from the pier with engineering fabric underlain.

Appendix F – Design Drawings

The design drawings are available in a file titled "Volga Pedestrian Bridge.pdf" located in the project submittals folder.

Appendix G – Design Renderings and Models

This section is a collection of images from the 3D model created using Autodesk Infraworks.



Figure G.1. 3D rendering of the entire project, looking north.



Figure G.2. 3D rendering of the pedestrian bridge, looking north.



Figure G.3. 3D rendering view looking west.



Figure G.4. 3D rendering of the bridge approach, looking west.



Figure G.5. 3D rendering view looking south from the Reflection Park.



Figure G.6. 3D rendering pedestrian view looking west, showing the expansion joint.

References

- (2008). AASHTO LRFD bridge design specifications. Washington, D.C.: American Association of State Highway and Transportation Officials.
- (2020, January). LRFD bridge design manual. Ames: Iowa Department of Transportation.
- Arneson, L. A., Zevenbergen, L. W., Lagasse, P. F., & Clopper, P. E. (2012). *Evaluating scour at bridges* (5th ed.). Washington, D.C.: Federal Highway Administration.
- Bowles, J. E. (1996). Foundation analysis and design (5th ed.). New York: McGraw-Hill.
- FEMA Flood Map Service Center. (n.d.). Retrieved April 16, 2020, from https://msc.fema.gov/portal/home
- Iowa DOT Bridges and Structures Final Bridge Design Software. (n.d.). Retrieved April 16, 2020, from https://iowadot.gov/bridge/Automation-Tools/Final-Design-Software
- Iowa DOT Design Manual. (n.d.). Retrieved April 16, 2020, from https://iowadot.gov/design/Design-manual
- Iowa DNR Storm Water Manual. (2009, October 28). Retrieved April 26th, 2020, from https://www.iowadnr.gov/Environmental-Protection/Water-Quality/NPDES-Storm-Water/Storm-Water-Manual
- US Department of Commerce, National Oceanic and Atmospheric Administration, & National Ocean Service. (2019, October 24). NOAA/NOS Web Vertical Datums Transformation. Retrieved April 16, 2020, from https://vdatum.noaa.gov/vdatumweb/
- U.S. Geological Survey, 2016, The StreamStats program, online at http://streamstats.usgs.gov, accessed on March 31, 2020.
- WaterWatch. (2020, April 16). Retrieved April 16, 2020, from https://waterwatch.usgs.gov/?id=mkrc