KEY NUMBER. 13455

US-12 Memorial Bridge Feasibility Study

FINAL REPORT

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1. EXECUTIVE SUMMARY

The US-12 Memorial Bridge crossing the Clearwater River between Lewiston and North Lewiston, Idaho does not meet current standards for state highway bridges. Built in 1949, this bridge has been rated as scour critical by two scour assessment studies. To provide a bridge crossing that meets standards, the Idaho Transportation Department (ITD) Bridge Division and District 2 are investigating the feasibility of retrofitting and widening the bridge and mitigating the identified scour risks. This feasibility study evaluates bridge modifications required to bring the bridge deck into compliance with roadway and pedestrian standards. The study also refines the scour assessment for the bridge and provides a scour mitigation concept. A construction phasing plan and estimate describe the methods, duration of construction, and provide a baseline funding level required to perform the work.

Widening Analysis: The widened deck configuration incorporates ideal roadway elements, while also integrating with the US-12 & 21st Street Intersection project that is under final design and will connect to the south end of the bridge. Incorporating two-12' wide lanes with 6' wide outside shoulders in each direction, an open median, and 6' wide walkways separated from the roadway by a traffic barrier led to the development of a 78'-0" wide bridge deck. This is increased from the existing 62'-0" deck section. To support this widened deck, new girders are required to replace the existing variable depth girders. While maintaining the existing roadway profile, vertical clearance, and three-span continuous configuration, the existing 6-girder superstructure will be replaced with an 8-girder configuration supported on a new reinforced concrete bent cap made integral with the existing columns. The capacity of the existing columns was found to be structurally adequate to support this widened configuration, requiring no additional retrofit. The bearing analysis of the pier footings indicates that 10 ksf bearing capacity is required to support the additional weight and loading of the proposed widening.

Future Bearing Capacity Confirmation: The as-built plans seem to indicate that the streambed is capable of producing 10 ksf bearing capacity. To confirm the footing bearing capacities and that the pier foundations can adequately support the proposed widening without the risk of settlement, a geotechnical investigation will need to be performed in the next phase of this project. This assessment, including a subsurface investigation, will determine if the bridge widening can be performed with or without footing retrofit work. The footings can be fortified with micro-piles if the recommended bearing capacity is less than 10 ksf.

Scour Analysis and Countermeasures: An updated HEC-RAS hydraulic model provided a significant scour depth reduction and a reduction of over 50% for the 500-year flood flow. These results, coupled with the underwater inspections of the current condition of the footings, are the basis of the recommendation to use rip rap as a scour countermeasure to protect the footings while continually monitoring the streambed to determine if a more robust countermeasure is required.

Construction Phasing: A two phase construction technique can be implemented to remove and replace half of the bridge superstructure at a time while maintaining a minimum of one lane of traffic in each direction across the bridge and limiting the duration of traffic impacts to one construction season. The construction phasing and assumptions incorporated into the cost estimate align with the established project goal of mitigating impacts to the travelling public. The estimated 130 days of traffic impacts was achieved through the proposed use of accelerated bridge construction techniques. This limits work in the waterway to July and August and limits overall construction to a single construction season.

Cost Estimate: A preliminary project cost estimate, including bridge demolition and construction for the bridge retrofit, widening, and scour countermeasures was performed. The cost for construction mobilization, traffic control, demolition and removal of bridge components, installation of new bridge elements, a ¾" Polyester Polymer Concrete (PPC) bridge deck overlay, and scour countermeasure installation is estimated at $15.7M in 2018 construction costs. This cost, which does not include contingencies, is within the $20M budget that ITD has allocated for this bridge retrofit. ITD will use internal processes to escalate construction costs for future construction. We recommend accounting for project unknowns with a 10% contingency and an additional 10% for items not estimated resulting in an additional amount of $3.1M.

Conclusion: The calculated scour risk is considerably less than previously assessed and ongoing monitoring or minimal countermeasures may be appropriate. The bearing capacity of the streambed is a significant unknown and is recommended for further study at the onset of the design phase. While the foundations can be fortified with micro-piles, the work in the waterway may have corresponding environmental impacts that increase the overall project duration and increase costs. Ultimately, the results of this feasibility study indicate that the desired bridge widening is structurally feasible, can be constructed within given mobility and schedule constraints, will tie in to the existing US-12 & 21st Street Intersection project without complication, and is estimated to cost $15.7M in 2018 construction costs.

2. BRIDGE DESCRIPTION AND BACKGROUND

Constructed in 1949, the US-12 Memorial Bridge spans the Clearwater River, connecting the city of Lewiston, ID on the south to North Lewiston. The bridge is posted with a speed limit of 35 miles per hour (mph) and in 2015 had an average daily traffic (ADT) of 30,000, with a truck ADT of 7%. At the south end of the bridge, the bridge spans over an active railroad before US-12 curves to the west and runs along the Clearwater River, eventually crossing the Snake River into Clarkston, WA. The ongoing US-12 & 21st Street Intersection project in Lewiston, which extends along US-12 up to the limits of the bridge, will improve the south end connections of the bridge by creating a signalized intersection between US-12, Main Street, and 21st Street.

Travelling north of the bridge into North Lewiston, the highway features an intersection of US-12, which follows the Clearwater River to the east; US-95, which continues north up to Moscow, ID; and Idaho State Highway 128, which continues west along the Clearwater River.

Figure 1: Vicinity map of North Lewiston, Lewiston and Clarkston (Source: Google Maps)

This 12-span, 1,352' long bridge was designed under 1944 code requirements and does not meet many of the current standards for a state highway bridge. The bridge roadway, which includes four 11'-0" wide lanes, does not have a shoulder in either direction, and the 5' wide walkways are not sufficient to support the bicycle and pedestrian access needs on each side of the river. Additionally, the bridge is one of 112 bridges that are classified as "Commerce Restricting Bridges" on the State Highway System, which restricts over legal annual permit trucks travelling on the bridge.

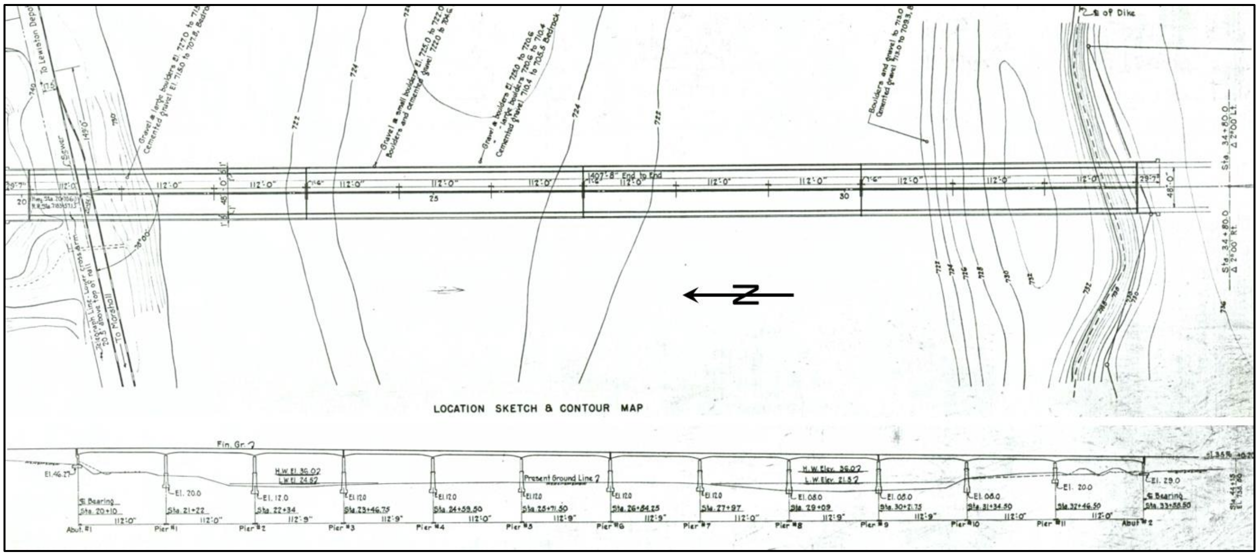


Figure 2: US-12 Memorial Bridge As-Built Plan and Elevation

These issues keep the bridge from adequately serving the changing needs of Lewiston and the region, therefore the ITD Bridge Division and District 2 are seeking to expand the width of the US-12 Memorial Bridge to accommodate an increased level of pedestrian and bike access and to provide a shoulder for the roadway. To support this deck width expansion and to accommodate the current code requirement of HL-93 truck loading, a replacement bridge superstructure is required along with associated modifications to the bridge substructure.

ITD's FY23 preliminary budget for this bridge rehabilitation work is $20M, and the aim of this feasibility study is to develop the bridge widening and rehabilitation concept and to determine if this concept can be constructed within the allocated budget.

2.1. Existing Superstructure and Deck Configuration

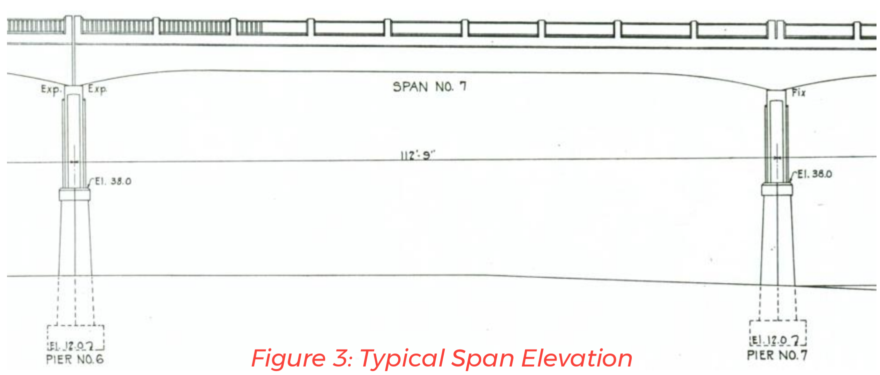


Figure 3: Typical Span Elevation

The existing 62'-0" wide deck section of the US-12 Memorial Bridge includes (2) - 11'-0" wide traffic lanes in each direction separated by a 1'-6" wide median barrier. 1'-3" wide shoulders flank the outside lanes in each direction, and a 1'-0" wide barrier separates the shoulder from the 5'-0" wide walkways on each overhang. Six variable depth steel girders, ranging from 4' deep at mid-span to 6.5' deep at the bearings, support the bridge deck. The typical girder spacing is 11'-0", with the exception being the 8'-6" spacing between the two interior girders. Each girder sits directly above one of the six columns that comprise the substructure at each pier. See Figure 4 for the as-built superstructure configuration.

Since the as-built drawings do not identify the material properties of the steel girders, the *AASHTO Bridge Evaluation Manual* was utilized to define the strength of the girders. For structural steel used in construction between 1936 to 1963, AASHTO defines a yield strength, F_y, of 33 ksi, and a tensile strength, F_t, of 66 ksi.

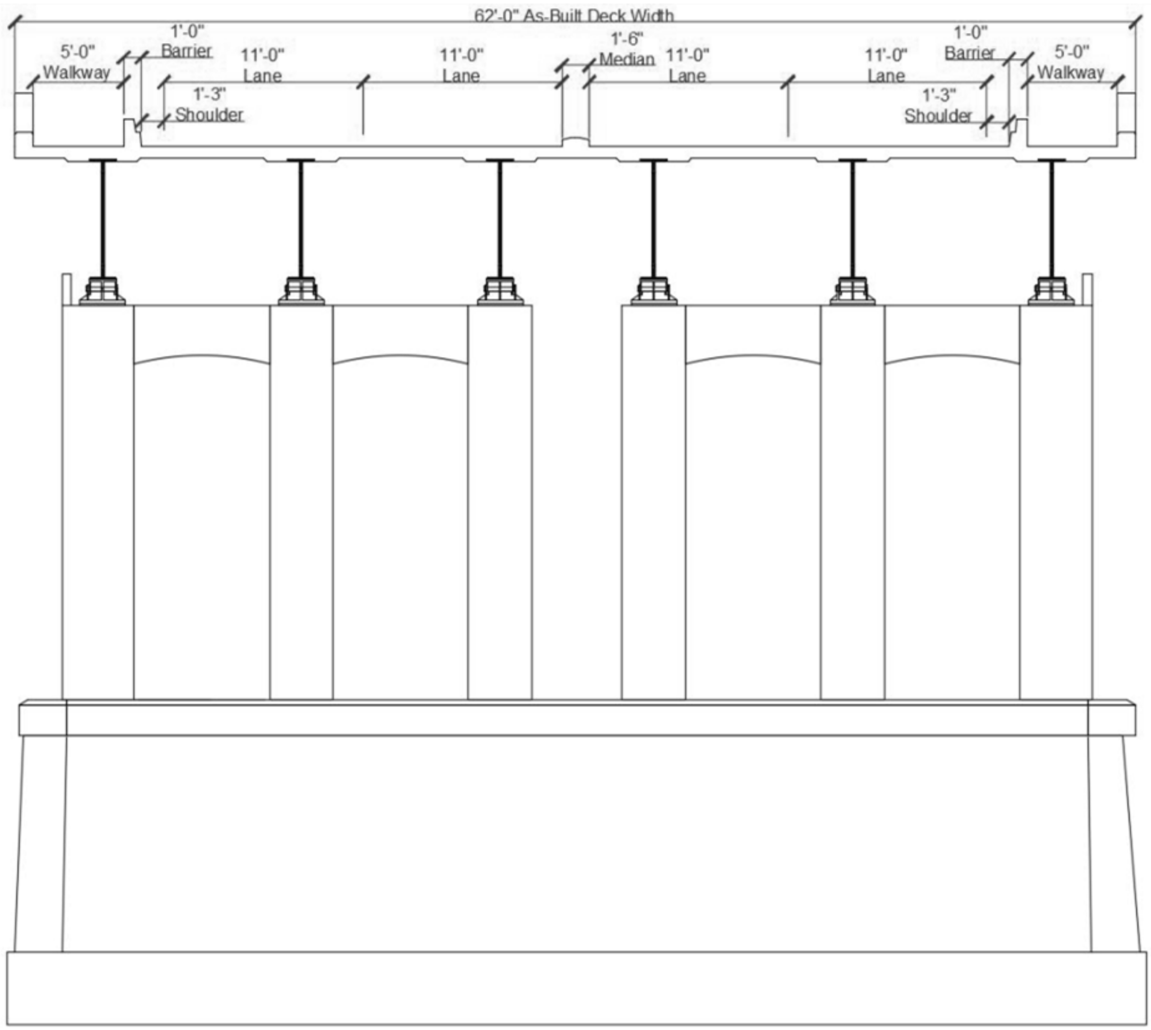


Figure 4: Existing Bridge Deck Cross-Section and As-built Typical Bent Substructure Configuration

2.2. Existing Substructure Properties and Condition

The two bridge abutments are supported on pile foundations while the 11 intermediate piers are on spread footings. Each pier consists of six reinforced concrete columns on a pedestal supported by a spread footing. The footings for piers 1 and 11 are founded in the river embankment, while piers 2 through 10 are within the limits of the river and are all embedded in the riverbed. The Design Notes on the as-built drawings identify the footing bearing capacity as 10 ksf.

The four interior columns are 3.5’ x 3.5’ square columns, while the exterior columns are 4’ x 3.5’. Each pair of three columns that support half of the bridge deck are connected at the top of the columns with a thin transverse diaphragm. See Figure 4 for the as-built substructure configuration.

The as-built drawings identify the concrete compressive strength as f'_c = 3 ksi, while there is no mention of the reinforcement material properties. The *AASTHO Bridge Evaluation Manual* was utilized to define the yield strength of the rebar, which is identified as f_y = 33ksi for construction performed pre-1954.

2.3. Summary of Bridge Inspections and Investigations

ITD’s maintenance plan for this bridge includes a series of inspections and evaluations to regularly monitor the bridge condition. Included in this inspection plan are routine bridge inspections performed biennially, scour evaluations when deemed necessary, and underwater inspections performed every 60 months. The most recent results of these inspections and evaluations are discussed in the sections below.

2.3.1. Routine Inspections

The most recent biennial bridge inspection was conducted by ITD inspectors in February 2017, with the prior inspection performed in April 2015. This inspection includes the bridge superstructure elements; non-structural elements such as the bridge railing, curbs, utilities, and expansion joints; and substructure elements above the water level. The maintenance recommendations include monitoring the bearing units and replacing these units when necessary; repainting the bridge rail; and cleaning and painting the steel girders and cross bracing.

The inspection provided the following bridge element condition ratings:

- Overall structure condition: 6 (Satisfactory, meets minimum criteria)
- Deck condition: 6 (Satisfactory)
- Superstructure condition: 6 (Satisfactory)
- Substructure condition: 6 (Satisfactory)
- Channel condition: 8 (Protected)
- Deck geometry: 2 (Intolerable – Replace)
- Deck load capacity: 2 (Intolerable)
- Bridge Rail: 0 (Substandard)
- Footings: Scour Critical - Unstable

The intolerable ratings for deck geometry and deck load capacity result in a recommendation for a deck replacement.

2.3.2. Scour Evaluations

Based on the results of scour evaluations conducted in 1997 and 2008, the US-12 Memorial Bridge has been assessed a National Bridge Inspection Standards (NBIS) item 113 rating of 3, indicating the bridge is scour critical. A 2008 report by Ayres Associates included a review and assessment of hydrographic survey data from the Walla Walla district of the United States Army Corps of Engineers (USACE) performed between 1985 and 2006. These surveys of the channel floor grade, shown in Figure 5, indicate that the grade has changed significantly since the initial construction of the bridge; however, it has seen negligible change in the seven surveys conducted since 1985. The major grade changes since construction have led to the development of local scour and footing exposure at piers 4 through 8, which is further corroborated by the September 2017 underwater investigation discussed below.

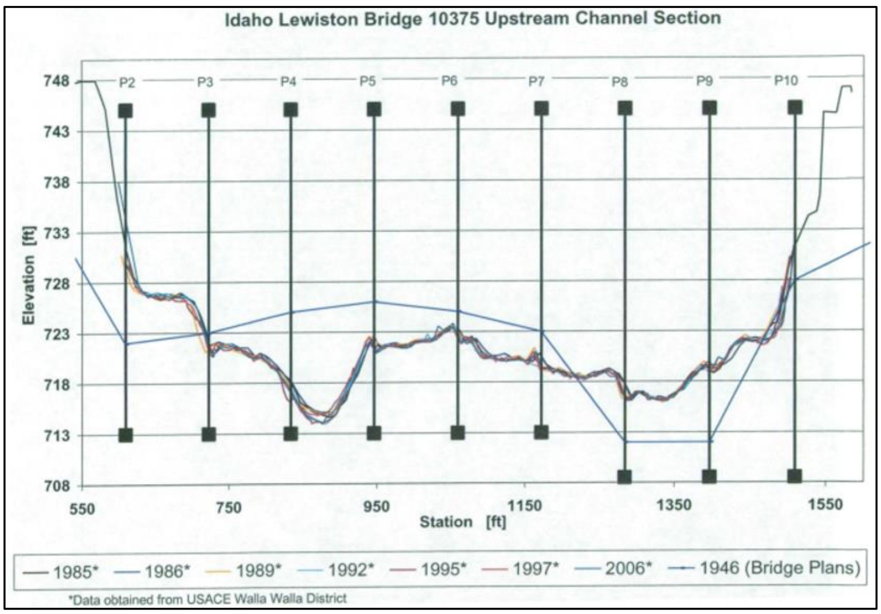


Figure 5: Historical survey data of the Clearwater River channel floor elevations along the US-12 Memorial Bridge (Reference: 2008 Scour Evaluation by Ayres Associates)

It is likely that the most significant change in the stream bed profile occurred when the Lewiston Dam was removed and the Lower Granite Dam was constructed in the 1970's. Levees were also built along with the Lower Granite Dam construction, and those conditions likely contributed to a change in the channel bed between the original construction of the US-12 Memorial Bridge and the stream bed surveys that began in 1985. An additional consideration is the possibility that the original stream bed mapping provided in the initial survey is a mirrored profile of the actual stream and that the following surveys followed suit, displaying a much larger stream bed variation than has actually occurred. It is important to note, however, that none of the streambed surveys indicate that the footing at any pier has been exposed.

The 1997 scour evaluation by HDR calculated a scour depth of 18.9' below the thalweg elevation which is 17.7' below the bottom of the footings. Piers 1 and 11 are outside the limits of the river channel and are not affected by the calculated scour. Piers 8 through 10 were assessed to be adequately founded on solid rock and not susceptible to scouring. The remaining piers 2 through 7 were identified as the critical footings susceptible to scour.

The 2008 scour evaluation by Ayers Associates confirmed many of the findings of the previous evaluation with some exceptions. Piers 3 through 7 were again found to be scour critical with calculated scour depths up to 27.8' for a 100-year event. Pier 2 was no longer listed as deficient since the change in channel floor elevation at this pier has provided additional embedment depth beyond the as-built condition. This report cites the 1997 report conclusion that piers 8 through 10 do not need countermeasures as they are founded on bedrock, and not susceptible to scour.

Based on the scour depth results, Ayers Associates concluded that scour countermeasures were required for piers 3 through 7. The Ayers report proposed countermeasures for these piers consisting of A-jacks at the base of the footings at an estimated cost of $618,000.

2.3.3. Underwater Inspections

The underwater inspection frequency for this bridge is 60 months, with the most recent underwater inspection of the bridge substructure performed by Collins Engineering in September 2017. The inspection included the spread footings for piers 2 through 10. This report indicates that the substructure and channel conditions are adequate with NBI ratings of 6 (Satisfactory) and 8 (Good) respectively; but with a rating of 3 (Serious Condition) for scour. This rating indicates that this bridge is scour critical in corroboration with the scour evaluations discussed above and the previous underwater inspection performed in September, 2012. Minor footing exposure of up to 8" for pier 4 and 1' for pier 8 were identified.

The inspectors identified an accumulation of timber debris at the upstream noses of piers 4, 6, and 9. The report also identified hairline cracks and abrasions in the footings and pier walls and spalls in the pier walls ranging from hairline up to 2' wide by 1' high and 8" deep. The spalling is minor and does not require immediate action, but it is recommended that the final design team evaluates the merits of fixing the spalls. The only maintenance recommendation provided in the report was the low priority task of removing the timber debris at piers 4, 6, and 9.

2.4. Utilities and Right of Way

The US-12 & 21st Street Intersection project was used as a reference to identify the existing utilities that are running along the length of the bridge. The utility drawings from this project, shown in Figure 6, identify fiber optic lines owned by CableOne, Port of Whitman/Port of Lewiston, and Century Link running along the length of the bridge.

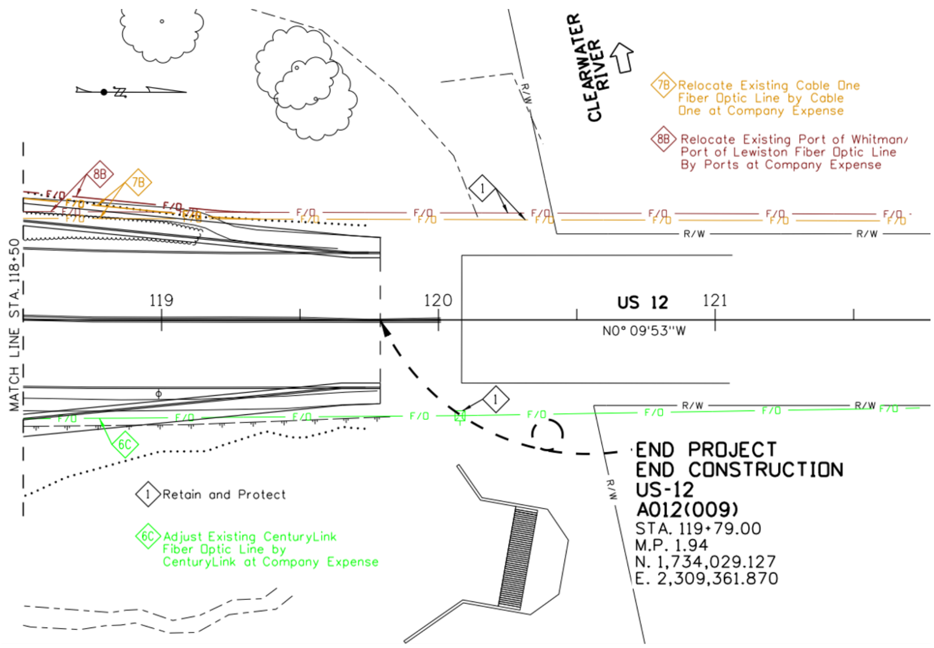


Figure 6: Utilities at the southern Memorial Bridge abutment per the Utility Plans from the US-12 & 21st Street Intersection Project

Figure 7: Utility hangers of the (a) west and (b) east sides of Abutment No. 2 on the north end of the bridge

Per the 2017 biennial bridge inspection report, the CenturyLink fiber optic on the east side of the bridge and the CableOne line on the west side of the bridge are 4" conduits, while the Port of Whitman/Port of Lewiston line is a 2" conduit running along the west side of the bridge. These conduits are attached to the underside of the deck overhangs, as shown in Figure 7 and Figure 8. Additional ITD-owned electrical conduit runs along the outside face of each overhang, connecting to the light poles that are attached to the overhang and spaced along the length of bridge. There are four poles along each side of the bridge for a total of eight poles. No sewer or water utilities have been identified along the bridge length or at the bridge abutments. During the bridge widening final design, the utilities that have been identified will need to be verified and confirmation that there are no additional utilities present in the construction zone will need to be provided. This will ensure that the proper utility protection and relocation plan can be provided throughout the construction process. Additionally, it appears that the widening can be completed within the existing right of way, but an aerial easement or agreement is likely needed with both the railroad and the owner of the Clearwater River, which is presumed to be Idaho State Lands.

Figure 8: View from the north abutment of the utility attachments to the east side of the bridge

2.5. Environmental

The Clearwater River has been designated a Section 10 waterway by the Coast Guard. This designation tightly regulates any work done over this waterway. ITD's environmental manager has indicated that the construction work associated with this project may qualify for an Environmental Assessment (EA) if work performed under the water surface is required.

The majority of the required construction work associated with the bridge widening has a minimal impact on the river. The bridge abutments are not within the limits of the waterway; therefore, the abutment removal and replacement work will not affect the waterway. The superstructure replacement work, while being supported on barges within the waterway, will not require any work to be performed underwater. Finally, the columns and pedestal foundation at each pier do not require any structural retrofit work to be performed. The only work that would be performed underwater is the scour remediation effort and the foundation strengthening, if required. As final design efforts progress, a determination will need to be made if an EA will be required to perform the scour remediation work.

3. BRIDGE WIDENING EVALUATION

This feasibility study aims to determine the maximum allowable deck width that can be accommodated by the existing bridge substructure and what retrofit, if any, is needed to support the preferred bridge cross-section. The roadway constraints considered while developing this upper bound cross-section include the following:

- **Overhang and Walkway details:** *Appendix A2.6 – Structure Width* from ITD LRFD Bridge Design Manual (BDM), provides overhang and walkway details for bridges with speed limits below and above 45 mph.
    - **Selection Option:** Although the Memorial Bridge is a bridge with speeds less than 45 mph, ITD has indicated that their preference is to use a traffic barrier to separate the walkway from the roadway. This option also reduces the potential structural demand on the deck overhang due to barrier weight, the weight of the thickened sidewalk, and vehicle collisions on the barrier. Therefore, the overhang detail shown in Figure 9(b) was selected for the new bridge configuration, utilizing a 6'-0" wide walkway to meet the current city standard for sidewalk widths and to adequately tie into the US-12 & 21st Street Intersection project south of the bridge.

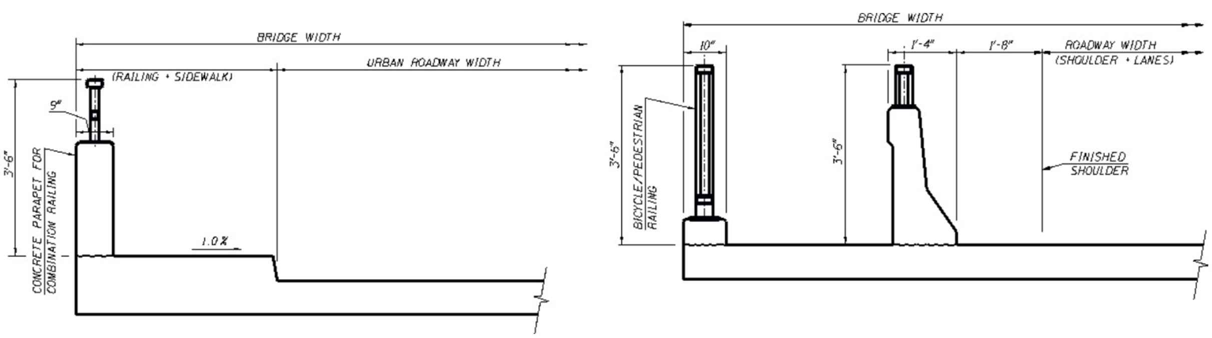


Figure 9: Details from ITD Bridge Design Manual, Appendix A2.6 for (a) Raised Sidewalk for Bridges with Speeds 45mph and Lower and (b) At-Grade Sidewalk for Speeds over 45mph

- **Median Width and Type of Delineation:** ITD BDM has no provisions on this. The key constraints were to tie into the roadway connections at either end of the bridge, both in terms of the width of the median and the method of delineation, whether utilizing a full height barrier, a curb similar to the as-built condition, or using only a striped median.
    - **Selected Option:** ITD expressed reservations about the utilization of a curb for safety purposes, and also indicated that a full height barrier is used for access control, which is not a requirement for this bridge. Also, the barrier does not allow flexibility for maintenance purposes nor emergency vehicle access and it may increase the difficulty in oversized load permitting. Based on the safety concerns and future flexibility, a 4'-0" wide open striped median was selected, which is the minimum recommended by *AASHTO Geometric Design of Highways and Streets* and is

identical to median configurations used for other comparable ITD facilities, such as Bryden Canyon Road in Lewiston. This option can also easily taper to meet the 3'-0" wide open striped median at the south end of the bridge which will be built as part of the US-12 & 21st Street Intersection project (refer to Figure 10).

- **Maintain Grade, Clearance, and Alignment of Existing Bridge**: To match the elevation and grade of the connecting roadways to the north and south of the bridge, the proposed alternative maintains the existing bridge profile. The existing superstructure vertical clearances are acceptable for the waterway and the railroad. The proposed superstructure concept maintains existing vertical clearances.

- **Number and Width of Lanes**: The widened bridge section maintains the existing two lanes of traffic in each direction for a total of four lanes. Due to the heavy truck volumes, *AASHTO* recommends a 12' lane width. These 12' lanes are easily tapered to meet the varying lane widths ranging from 11'-0" to 12'-0" at the south end of the bridge as part of the US-12 & 21st Street Intersection project (refer to Figure 10).

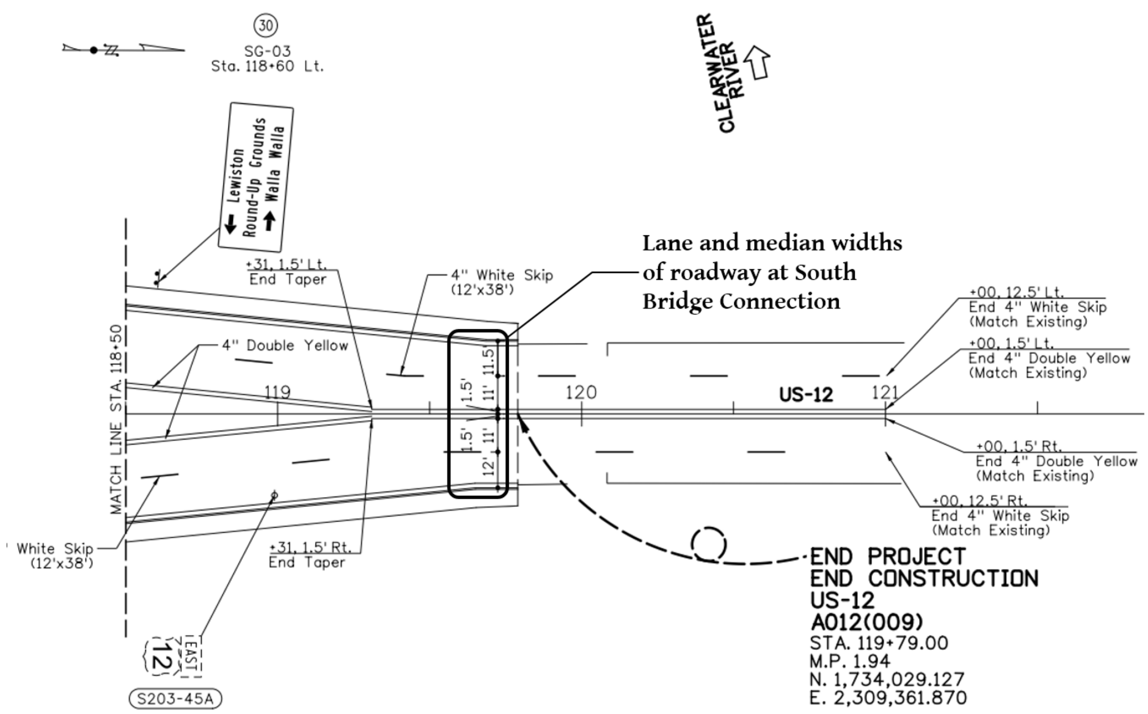


Figure 10: US-12 roadway configuration at the southern Memorial Bridge connection per the current level of design for the on-going US-12 & 21st Street Intersection Project

- **Roadway Shoulder Widths:** Utilizing a 6'-0" wide shoulder on the outside of both travelling directions is preferable to ITD in order to provide flexibility as a future bicycle lane which is in line with the recommendations within *AASHTO Bicycle Facilities Guide*, while also providing an adequate shoulder to allow for maintenance activities, deck rehabilitation projects, and emergencies.

- **Support current live load criteria:** The widened deck section must support the current live load criteria of an HL-93 loading to allow the bridge to perform without load restrictions.

These constraints were utilized to create an upper bound deck cross section of 78'-0" in width, which is shown in Figure 11. The sections below describe the structural analysis that was performed to determine the adequacy of the proposed replacement girders and the existing substructure, and to develop required retrofit actions that must be taken to support the widened bridge deck.

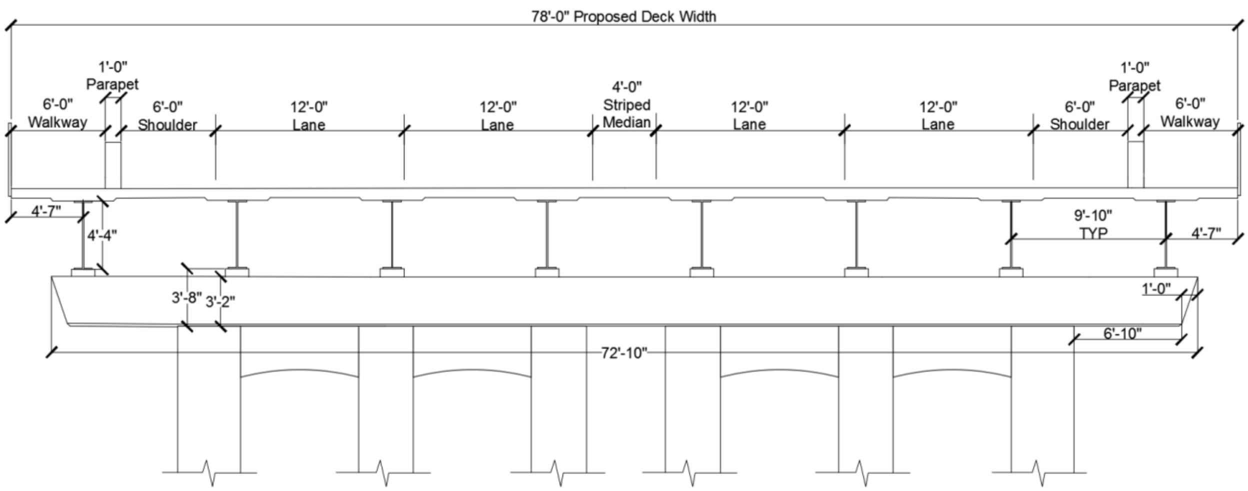


Figure 11: Preferred Widened Deck Cross-Section

3.1. Structural Approach, Methodology, and Assumptions

To develop the overall widening concept and to determine its structural and financial feasibility, a structural analysis of the bridge with the new 78'-0" wide deck shown in Figure 11 was performed. This analysis required a capacity check of the major new structural elements and existing elements to be maintained.

3.1.1. Superstructure

Utilizing the increased structural steel strength of current construction over the materials available during the original construction of this bridge (f_y = 50 ksi vs f_y = 33 ksi) allowed for reduced girder depths to support the widened deck. The shallower girders also allow for the placement of a bent cap to support the girders on lower profile elastomeric bearings, which also structurally connects all of the columns. See Figure 12 for the comparison between as-built and retrofitted conditions. Note that the bridge deck (assumed to be 8" thick), bearings, and barriers were not analyzed at this conceptual level.

3.1.2. Substructure

The existing columns will support the new bent cap and superstructure since their capacities can adequately support the widened configuration. The analysis results indicate that the as-built column capacities are sufficient for these increased demands, so column retrofit and strengthening actions to increase the column capacities are not necessary.

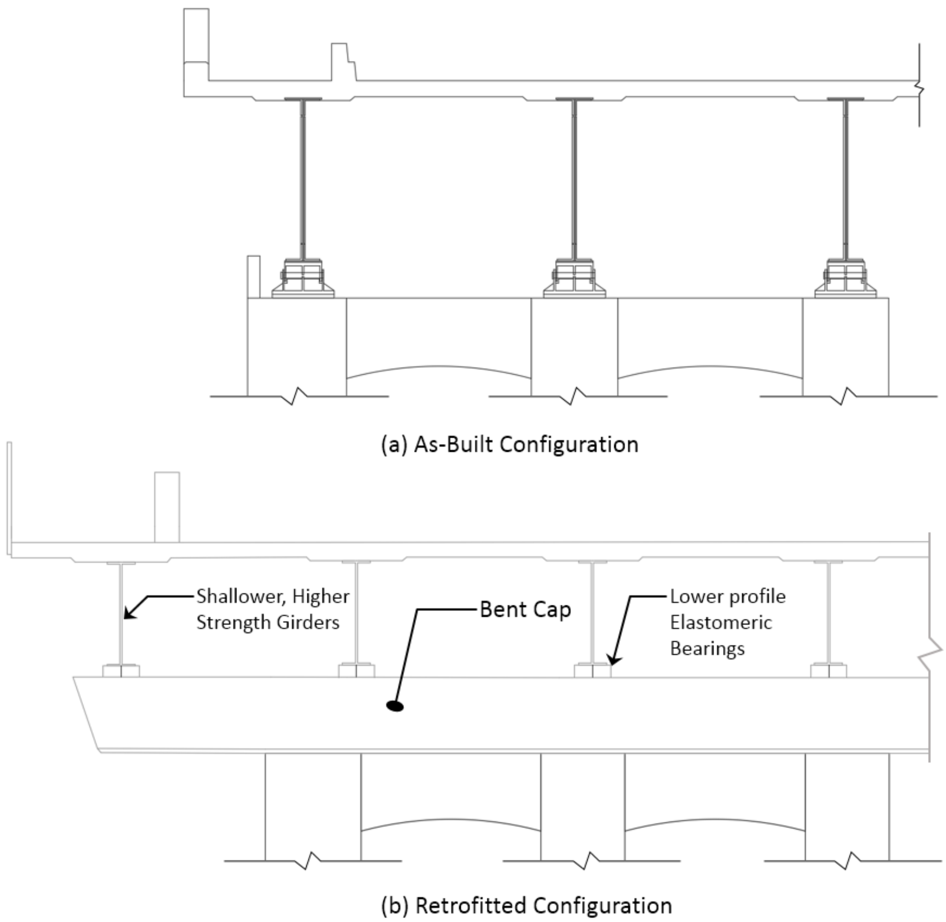


Figure 12: Configuration comparisons of (a) As-built superstructure with (b) Retrofitted superstructure

To accommodate the bridge widening at the abutment locations, ITD has indicated their intention to fully replace the existing abutments.

3.2. Structural Analysis

The replacement girders were analyzed under the loading from the 78'-0" wide bridge deck. The 4'-4" deep girders spaced at 9'-10" are acceptable for the demands from the widened deck with HL-93 live loading in both the negative and positive moment regions.

The remaining gap below the bottom of the replacement girders and the top of the existing columns allows for a bent cap height of 3'-2".

To match the existing expansion joint layout along the length of the bridge, the widening concept proposes placing a joint after every three spans, for a total of five expansion joint locations. These joints allowed the proposed girders to be analyzed as a three-span continuous superstructure.

Since the abutments will have a total replacement, no structural analysis was performed for the existing abutments nor for a replacement abutment. This analysis will be performed once this concept moves into design.

An in-depth description of the analysis assumptions and results are provided in *Appendix C: Deck Widening Structural Analysis.*

3.2.1. Superstructure Analysis Description, Assumptions, and Results

The replacement girders were analyzed under the factored loading from the 78'-0" wide bridge deck. The load combinations from *AASHTO LRFD Bridge Design Specifications* were applied to the structure. The load cases that were included in these combinations and applied to the girder analysis include the following:

- HL-93 truck loading (including a 33% impact loading per AASHTO) with the applicable LRFD live load distribution factors for interior and exterior girders, applied as moving loads along the span length to create a force and moment envelope.
- Pedestrian live load of 75 psf applied over the widths of the walkways, which was assumed to be supported by the exterior girders only.
- Weight of the deck structural components, including barriers, deck, girder haunches, girders, and cross-bracing, along with the weight of non-structural future wearing surface overlay.

The 4'-4" deep girders spaced at 9'-10" are acceptable to support the load demand from the widened deck with HL-93 live loading in both the negative and positive moment regions.

3.2.2. Substructure Analysis Description, Assumptions, and Results

An analysis model was developed using CSi Bridge to analyze the retrofitted substructure, which consists of the as-built columns supporting the new bent cap beam (see Figure 13). Applying the superstructure forces described in *Section 3.2.1 Superstructure Analysis Description, Assumptions, and Results,* along with wind, seismic, and truck braking forces, the demands on these substructure elements were determined.

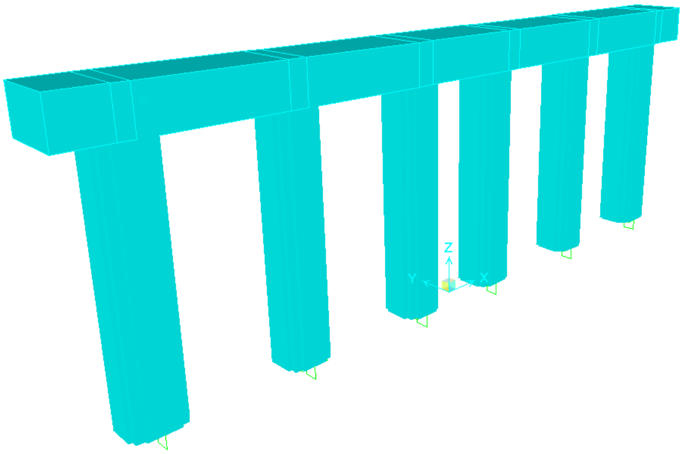


Figure 13: Substructure Analysis Model

The demands on the bent cap (see Figure 14) were used to provide a design for the element, while the demands on the columns (Figure 15) were compared with their as-built capacities. As seen in Figure 15, the 4' wide x 3.5' deep exterior columns experience the largest flexural demands, as the widened bridge deck supported on a large bent cap overhang generates a considerable amount of bending on these columns, while the 3.5' square interior columns experience a much lower level of bending. The increased size and capacity of the exterior columns provides adequate capacity to support the demand identified from the analysis.

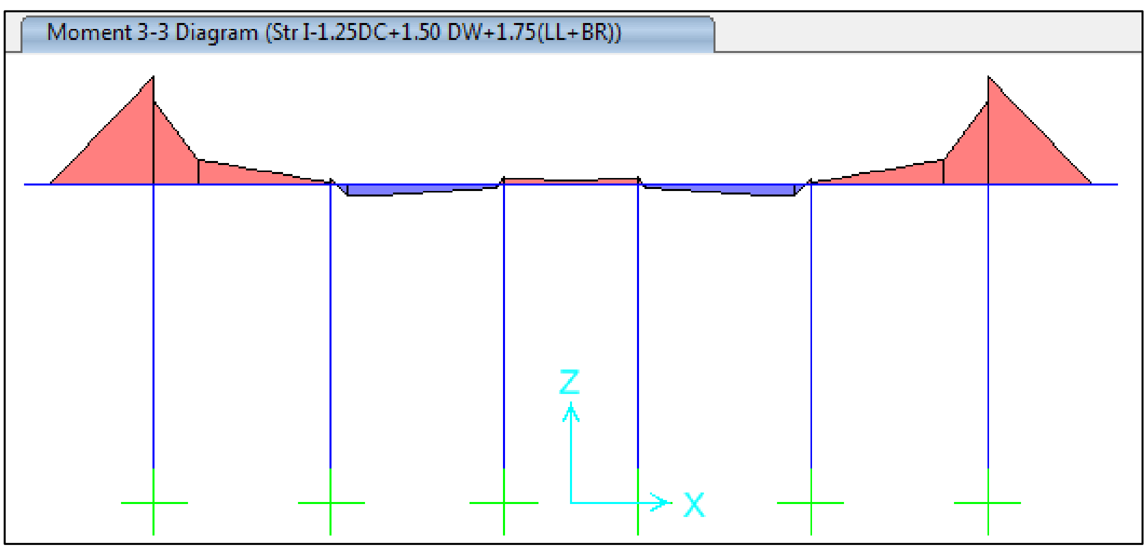


Figure 14: Analysis Model Results - Flexural demands on bent cap beam under widening configuration

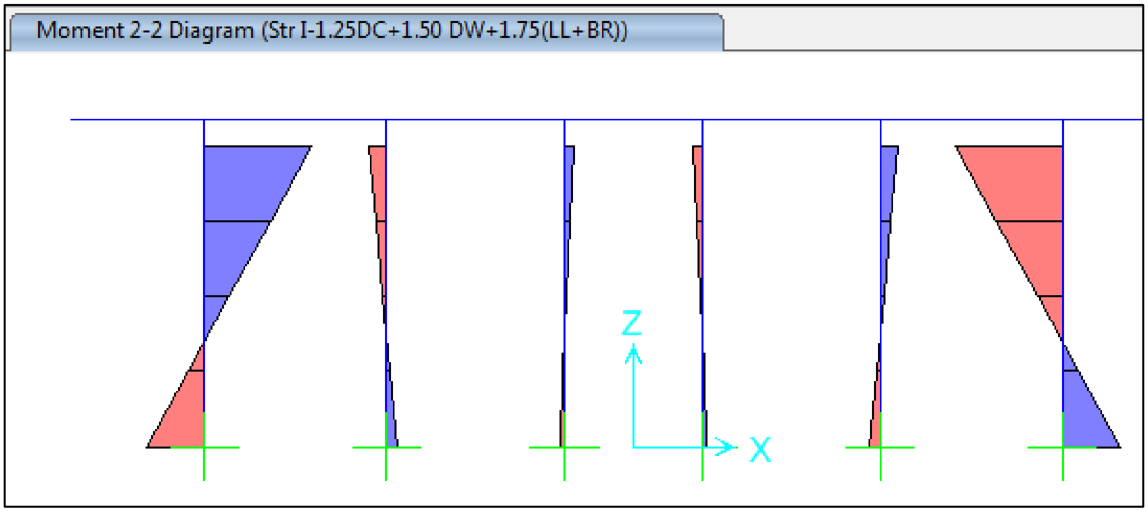


Figure 15: Analysis Model Results - Flexural demands on as-built columns under widening configuration

Since the column capacities were found to be adequate, no retrofit or strengthening actions are required for the columns to support the preferred widened bridge deck alternative.

3.2.3. Foundation Bearing Capacity Results

In order to validate the existing pier footings without implementing any retrofit measures, the footing bearing capacities were checked against the bearing demands for the preferred deck widening concept. The footing bearing capacity, identified as 10 ksf per the as-built plans, was first checked against the bearing demands under the existing configuration as a baseline of the capacity to demand (C/D) ratios of the footings in their current condition. The weights from the existing superstructure, columns, pedestal, and footing along with the original design live load were applied to determine the as-built bearing C/D ratios for each pier. The controlling C/D ratio for the existing service condition is 1.54 at pier 8, as shown in Table 1.

Table 1: Footing Bearing Capacity Results

Pier	As- Built Condition		Widened Deck Condition	
	Bearing Stress psf	C/D	Bearing Stress psf	C/D
1	6127	1.63	9474	1.06
2	6079	1.65	9007	1.11
3	5609	1.78	8299	1.20
4	6024	1.66	8952	1.12
5	5996	1.67	8925	1.12
6	5527	1.81	8217	1.22
7	5942	1.68	8870	1.13
8	6514	1.54	9443	1.06
9	6045	1.65	8734	1.14
10	6459	1.55	9388	1.07
11	5772	1.73	9119	1.10

The widened deck condition increases dead and live load, and also includes additional bearing demands generated from braking and wind forces. These increased demands result in a controlling C/D ratio of 1.06 at piers 1 and 8, indicating that the as-built bearing capacity provided by the existing footings is adequate to support the preferred deck widening concept.

To ensure that adequate bearing of the footing on the underlying soils can be maintained and that the bearing capacity identified in the as-built plans can be achieved to accommodate the future widening, countermeasures must be taken at some of the pier locations to prevent future scour from occurring on this scour critical bridge. These countermeasures are discussed and outlined in *Section 4: Scour Assessment and Countermeasure Recommendations.*

The 10ksf bearing capacity identified on the as-built drawings is a relatively high bearing capacity that may not currently be provided by the streambed in the current condition. It is recommended that a geotechnical engineer confirm the bearing capacity values for the footings to ensure that the increased bridge widening loads can be sufficiently supported. An additional subsurface investigation and boring log analysis is needed to provide an adequate geotechnical recommendation for bearing capacity.

If the geotechnical analysis indicates that the bearing capacity is less than 10 ksf, settlement is a concern, necessitating footing retrofit work to be performed to adequately support the widening. Preliminary discussions with micropile experts indicates that the footings are good candidates for strengthening with micropiles. The concrete footings would first be cored and then a micropile would be installed through the footing for a depth of 20' to 30'. Each micropile can resist between 100 kips and 150 kips with a maximum cost of about $10,000 per pile, including the cost to access, core, furnish, and install the micropile. Clearly, additional soil information is needed to adequately estimate the cost of underpinning the foundations, but a conservative estimate might be as many as 20 micropiles per foundation, or an additional $200,000 per pier. This has significant cost implications to the project, but the feasibility of the project is still valid. Utilizing a foundation retrofit technique such as micropiles may remove the scour critical rating for the bridge, eliminating the need to perform the footing scour countermeasures, which could balance out the overall project cost. A detailed cost estimate would need to be provided for the proposed foundation retrofit to go along with the bridge widening cost to determine if the project could be funded under the ITD's current rehabilitation budget for this bridge.

4. SCOUR ASSESSMENT AND COUNTERMEASURE RECOMMENDATIONS

The US-12 Memorial Bridge across the Clearwater River is supported on vertical abutments and solid-wall (below the water surface) concrete piers with spread footings. Bridge 10375 as-built plans establish the existing bathymetry of the Clearwater River as ranging from gravel to boulder material sitting on good bedrock. Piers 1 through 7 and 11 are situated on the gravel to boulder material, while piers 8, 9, and 10 are on bedrock.

The bridge is located at a bend in the Clearwater River approximately 1.5 miles from the confluence with the Snake River. This reach falls within the reservoir of the Lower Granite Dam. Levees were placed at both banks to contain flood flows within the channel. The configuration of the piers and location of the levees essentially eliminate the possibility of flow contraction of the channel at the bridge.

ITD commissioned two scour evaluation studies to be completed for the bridge in March 1997 and July of 2008, both of which were discussed in *Section 2.3.2* within this report. As outlined in that section, both of these studies found the bridge to be scour critical based on the Federal Highway Administration (FHWA) guidance for Evaluating Scour at Bridges (HEC 18) and the NBIS.

The March 1997 report calculated velocity of water from a HEC-RAS model to be 11.9 feet per second (fps), which is a value high enough to be considered impactful. This water velocity with an angle of attack at 5-degrees at each pier resulted in a calculated maximum total scour depth of 18.9', which is at a depth below the bottom of the footing.

The July 2008 report reviewed the results from the previous study to verify the scour calculations and assessments. As discussed in the scour report summary, the historical channel cross section survey indicates that the streambed elevation and geometry shifted from the as-built condition but has remained relatively constant for the past 20 years. The 2008 report included the creation of a new HEC-RAS model which implemented the USACE hydrographic survey, and the local scour was re-evaluated for more frequent floods event intervals. The results were that the bridge was predicted to be scour critical in the 2-year flood event.

From the assessment of these two reports, the calculations and input parameters into the analyses from the previous studies and the actual conditions surveyed at the US-12 Memorial Bridge do not coincide. As a result, this study was undertaken to review the scour evaluations and identify the scour related action items.

4.1. Current Foundation Condition

This latest study of the scour condition of the bridge included the creation of a new HEC-RAS model using information provided from:

- USGS Scientific Investigations Report 2012-5089 Bathymetric and Underwater Video Survey of Lower Granite Reservoir and Vicinity, Washington and Idaho, 2009-10
- USGS FEMA effective model, 1982
- US 12 Over the Clearwater River in Lewiston, Idaho Inspection Plan and Notes September 2017

This new HEC- RAS model reach length extends to approximately 2.5 miles of the Clearwater River. The methodology for extending the reach modeled was to allow for water surface elevation (WSE) and velocities in the channel to normalize within the boundary conditions defined from the previous studies.

The bathymetric data from the USGS report was provided, and a review of the data confirms that the downstream gradient is consistent and generally between 0.0002 ft/ft and 0.0008 ft/ft. The video survey provides visual evidence to support generally low water velocity at the bottom of the channel.

The Underwater Inspection Plan and Notes provided from the recent bridge inspections identified locations where debris buildup, footing exposure, and scour depression was observed. The top of footings located at pier 4 and 8 were documented as exposed in the report.

Results of the HEC-RAS model are provided in *Appendix D: HEC-RAS Model Analysis Results*.

4.2. Scour Mitigation Strategy

The results of the new HEC-RAS model indicate a significant reduction of the water velocity in the Clearwater River as compared with the initial studies, a reduction of over 50% for the 500-year flood flow of 140,000 cfs which was used in the March 1997 study. The results appear to be consistent with the observed type and consistency of flow of the Clearwater River. See the following table for the Scour Results from the new model for pier 4, which is the location that will experience the largest scour:

Table 2: HEC-RAS Model Scour Results for Pier 4

Return Interval (Yr)	Velocity (ft/s)	Scour Depth (ft)*	Remaining Embedment (ft)**
2	3.94	5.90	-4.60
5	4.74	6.44	-5.14
10	5.06	6.65	-5.35
20	5.43	6.89	-5.59
50	5.77	7.10	-5.80
100	5.97	7.22	-5.92
200	6.16	7.34	-6.04
500	6.63	7.63	-6.33

* Vertical distance measured from the 1997 channel floor elevation of 713.3 at pier 4.
** Vertical distance measured from the bottom of existing footing elevation (ELE = 712.0) to the scour depth ELE. Negative values indicate undermining of the footing.

The resulting recommendation for scour mitigation at the bridge piers is that placement of typical rip rap to protect the spread footings is likely a sufficient scour countermeasure for this structure. No rip rap is recommended where the spread footings are located on bedrock, until evidence of scour is observed.

A-jacks, the scour countermeasure recommended for this bridge by the past scour assessments, require considerable stream bed work to prepare for placement, and the footprint of the observed localized scour on this bridge does not appear to be significant enough to warrant placement of A-jacks at this time. Continued monitoring of the streambed is recommended to determine when and if more obtrusive scour countermeasures are required. The expected lifespan for the piers of the bridge could impact the selection of the material. If the foundations are fortified with micropiles to provide adequate bearing capacity, scour countermeasures may not be required at all.

Rip rap is recommended to protect the footings of the Memorial Bridge as a cost-effective solution as compared to the use of A-jacks. The D50 of the rip rap used to conduct the scour calculations was selected to be 152 mm (approximately 6”) and is a reasonable size of revetment typically more readily available. The material is easily placed at the location for protection, and does not require a significant stream bed preparation. Additionally, the material more closely resembles the natural material on the channel bottom.

4.3. Cost Estimate of Scour Countermeasures

The scope of the selected scour mitigation method needs to be further vetted in the next phase of the project; however, for cost estimation purposes, the cost of rip rap installation is included in the final cost estimation. The rip rap installation cost is $189,000 in 2018 dollars. As a cost comparison, installing A-jacks instead of the rip rap would cost $810,000. The A-jack installation provided within ITD’s 2013 US-95 Clearwater Bridge Scour Mitigation Project (Project No. A012(333)) was utilized as a basis for determining this A-jacks installation cost.

5. CONSTRUCTION EVALUATION

A full critical path method (CPM) schedule has been performed for the concept phase (Refer to *Appendix B: Project Construction Schedule and Cost Estimate* for the schedule). The schedule does not account for the time associated with shop drawing development and review, nor the lead time required for any pre-cast elements since these items will be considered by the design team when they select an advertisement date. The schedule and phasing provide a construction approach that limits impacts to the traveling public to a single construction season.

5.1. Proposed Construction Methods and Phasing

The initial scour mitigation work (if needed after additional geotechnical investigations are performed) will likely be performed prior to any structure modifications. Ideally, this work would occur within the overall construction schedule and within the environmental work windows.

After the scour countermeasures have been placed, the widening effort can commence. The construction methods proposed to complete the bridge widening are to be completed in two phases. Sketches of the bridge cross-section at various steps of these phases are provided in *Appendix A: Conceptual Construction Phasing Sketches.*

Phase I: The first phase shifts traffic to one side of the bridge in order to demolish and remove the other side of the bridge superstructure. The remaining half of the existing bridge carries one lane of traffic in each direction. Safety measures such as the installation of a concrete barrier at the median, sheet piling at the abutment, and other safety devices are installed prior to the start of the Phase I activities.

This traffic shift requires the use of the entire remaining deck for vehicular use and will remove pedestrian access from the bridge. Understanding ITD's concern for environmental justice and the negative impacts of restricting pedestrian mobility, a free temporary shuttle service for the duration of Phase I is recommended to provide access to the affected communities across the bridge.

During this phase, the bridge will be demolished in half width sections and removed in segments by saw cutting the bridge deck and cutting the steel girders where necessary and rigging sections to be removed with barge supported cranes. After demolition of the first half has been completed, the pre-cast bent cap for that half of the bridge can be installed. As the bent caps are being installed, the new steel girders can be fabricated in three-span sections prior to being transported by barge up the river to be lifted into place. In sequence behind the girder erection, the concrete crews will install the stay in place forms and pour the concrete deck, parapets, abutments, and approach panels. Once all the cure times and specified concrete strengths have been reached, the contractor can prepare for the traffic switch from the remaining half of the existing bridge deck to the new half of the widened bridge deck and Phase II can begin.

Phase II: The second phase includes the demolition and replacement of the second half of the existing superstructure. Once the Phase I work has been completed and the traffic has been switched over to the completed half of the widened deck, pedestrian traffic may be allowed on the new bridge. The remaining half of the existing superstructure will then be demolished and removed in segments as described in Phase I. After the Phase II demolition has been completed, the installation of the pre-cast bent cap, girders, stay-in-place forms, and concrete work for the second half of the widened deck can be completed. The final step in Phase II after concrete cure times and specified strengths have been reached consists of the placement of the PPC overlay.

After the PPC overlay has been placed, the bridge widening work will be substantially completed, allowing for the opening of two lanes of traffic and pedestrian access in each direction.

5.2. Deck Construction

One accelerated bridge technique that was considered to reduce traffic impacts was the use of full-depth precast deck panels in place of a cast-in-place (CIP) concrete deck. By utilizing precast panels that can be shipped on site for installation, the volume of concrete poured on site is greatly reduced, which reduces the labor time connected with rebar installation and concrete placement, while also nearly eliminating the amount of concrete curing time.

There is a significant cost increase for using precast panels, which requires a large time savings to justify utilizing them for the project. Under the proposed phasing, the CIP deck is expected to take 18 days. Utilizing the precast panels results in a savings of approximately 10 days in Phase I of construction, while also generating a total cost increase of approximately $750,000. Since the proposed schedule using a CIP deck fits within the required schedule restraints, the use of full-depth precast panels is not recommended.

5.3. Construction Phasing Costs and Assumptions

The structural components associated with the bridge widening make up a considerable portion of the project costs. These structural elements and the assumptions behind the phasing of the installation of these elements is provided below:

- Abutments – new wider abutments are required to accommodate the wider superstructure. The construction of the abutments is to be completed in halves and will need to protect the existing road by installing sheet piles.
- Precast Bent Caps - these precast elements reduce the construction duration, and can be placed quickly. The construction will be done in halves with a closure pour if necessary.
- Steel Girders – these will be assembled off-site in sections to be transported by barge and lifted and set in place with marine based cranes.
- Bridge Deck – will be constructed with stay-in-place forms and will follow closely behind the girder erection. The deck components include casting the bridge deck in place with a closure pour to tie the two phases together, CIP parapets, pedestrian railing, marine equipment, and the PPC overlay.

In addition to the quantities and costs associated with the structural components outlined above, there are costs associated with the construction phasing activities. Included in these phasing costs are the following:

- Mobilization – includes all of the direct costs to mobilize equipment, including marine equipment, and operation of support vessels. This cost includes all of the project indirect costs, both duration based (6 months of full operation) and fixed costs related to supervision, surveying, permitting, field office personnel, insurance, bonds, and other costs associated with managing the project.
- Traffic Control – includes temporary concrete safety barrier, devices, and maintenance during the two phases of construction, and shuttle services for pedestrians for 6 months.
- Demolition of Superstructure – includes the cost to remove and replace utility lines, dump fees, marine equipment, and performing off-site demolition of the bridge sections. The cost estimate for this line item assumes that the contractor is able to cut out the deck in segments, removing the sections with cranes and lowering them down to barges to be removed offsite.

The costs for the structural elements and phasing have an additional markup of 8% applied to them to account for the contractor's estimated profit and overhead. A full cost breakdown of the costs associated with structural elements and construction phasing are provided in *Appendix B: Project Construction Schedule and Cost Estimate*.

A 10% contingency is placed on the subtotal of the items above, along with a 10% additional cost for items not estimated.

6. CONSTRUCTION COST ESTIMATE AND CONCLUSION

The table below provides the estimated costs for each of the construction elements of the bridge widening and scour mitigation project, resulting in a construction cost estimate of $15.7M in 2018 dollars. This value does not include a 10% contingency nor an additional 10% for items not estimated as described in *Section 5.3*. The scour mitigation cost provided is for rip rap installation. If A-jacks are required upon further investigation, the scour mitigation cost will increase as described in *Section 4.3 Cost Estimate of Scour Countermeasures*. This estimate does not include costs to add bearing capacity to the foundations elements. Our preliminary investigation indicates that installing micropiles may cost as much as $200,000 for each that cannot provide 10 ksf bearing. In a worst-case scenario, installing micropiles may add over $2M to the project.

A more in depth cost break down for each of these line items is provided in *Appendix B: Project Construction Schedule and Cost Estimate*.

Table 3: Project Cost Estimate Summary

Item Description	Quantity	Units	Unit Price	Total Price
Mobilization	1	LS	$ 1,678,111.41	$ 1,678,000
Traffic Control	1	LS	$ 296,620.65	$ 297,000
Demo Light Poles	6	EA	$ 2,160.00	$ 13,000
Demo Bridge Superstructure (Parapets, Deck, Bents)	83,700	SF	$ 10.99	$ 920,000
Remove and Replace Abutments	2	EA	$ 101,298.73	$ 203,000
Install Precast Bent Caps (500 CY)	11	EA	$ 97,023.53	$ 1,067,000
Install Elastomeric Bearing Pads	104	EA	$ 2,836.41	$ 295,000
Install Steel Girders (2,366,618 lbs)	96	EA	$ 63,236.31	$ 6,071,000
Install Bridge Deck (2,434 CY)	105,300	SF	$ 45.88	$ 4,831,000
Install Light Poles	6	EA	$ 21,600.00	$ 130,000
Scour Mitigation	5	EA	$ 40,000.00	$ 189,000
			Total Construction Costs in 2018 Dollars:	$ 15,694,000
			10% Contingency and 10% for items not estimated (20% Total):	*$ 3,139,000*

The deck installation cost is provided on a square foot basis in the table above because this cost includes the installation of parapets, pedestrian rail, PPC overlay, and the use of the marine equipment (platform barges, tug boats, cranes, and transport barges) required to perform this work. On a cost per cubic yard (CY) of concrete, the deck placement cost is $1,048/CY for the 2,434 CY of concrete ($2,552,000 total). Similarly, the costs for bent caps are provided on a per unit basis. Broken down on a cost per CY of concrete, the bent cap cost translates to $2,134/CY to place 500 CY.

Engineering and Construction Engineering costs have not been provided as ITD does not include these costs in their construction estimates. Additionally, costs have been provided in 2018 dollars since ITD has an internal process of escalating costs for future construction. To help indicate possible costs in 2023, the table below provides a cost escalation schedule based on various levels of annual inflation. The 2023 escalated costs shown below do not include contingencies.

Table 4: 2023 Cost Escalation Schedule for Various Levels of Inflation

Annual Inflation	2023 Escalated Cost
2%	$ 17,327,000
4%	$ 19,094,000
6%	$ 21,002,000
8%	$ 23,060,000

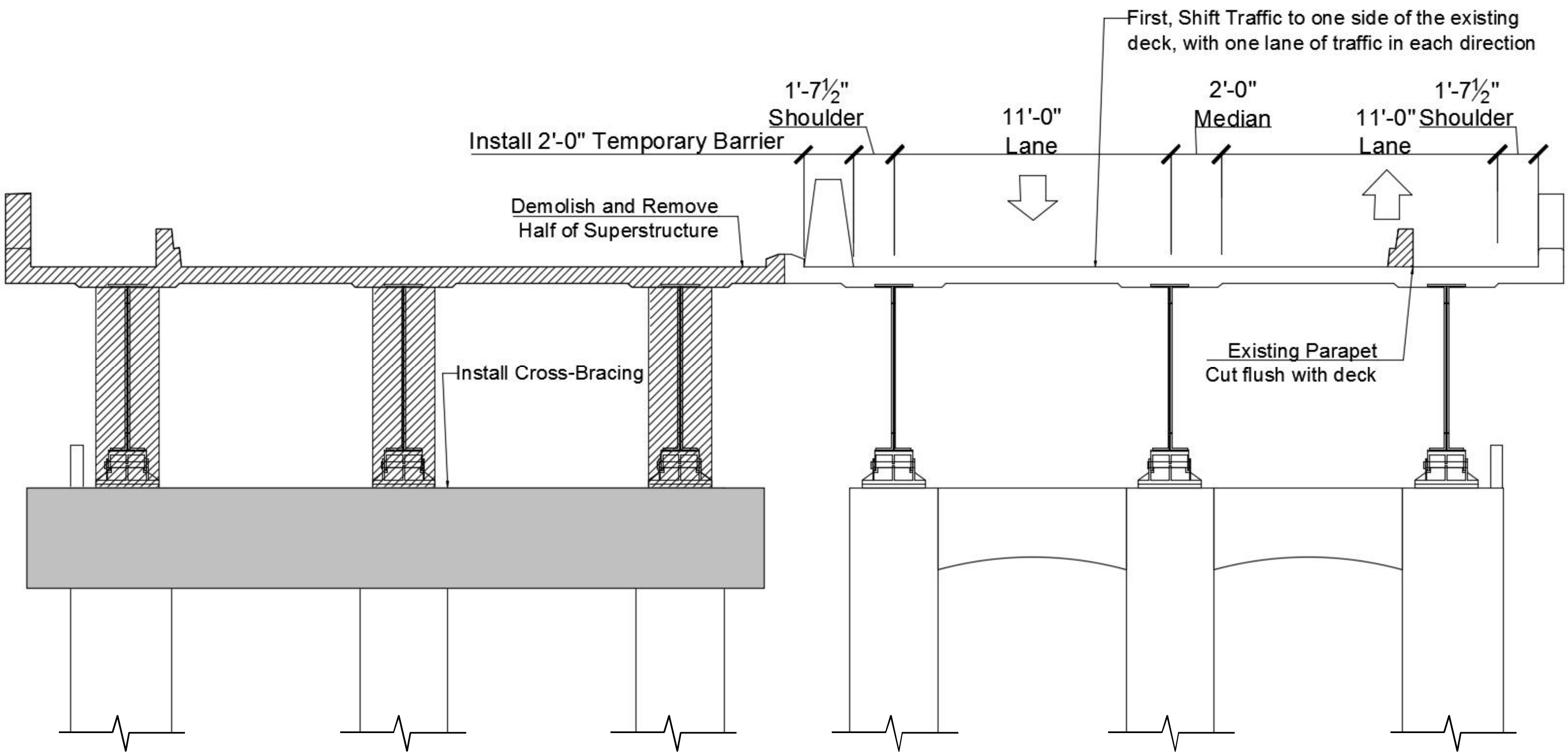
Conclusion: The results of this feasibility study indicate that the desired bridge widening is structurally feasible, can be constructed within given mobility and schedule constraints, will tie in to the existing US-12 & 21st Street Intersection project without complication, and is estimated to cost $15.7M in 2018 dollars.

APPENDICES

Appendix A: Conceptual Construction Phasing Sketches

Project: *ITD US-12 Memorial Bridge Feasibility Study*

Subject: *Construction Phasing Sections | Phase I*

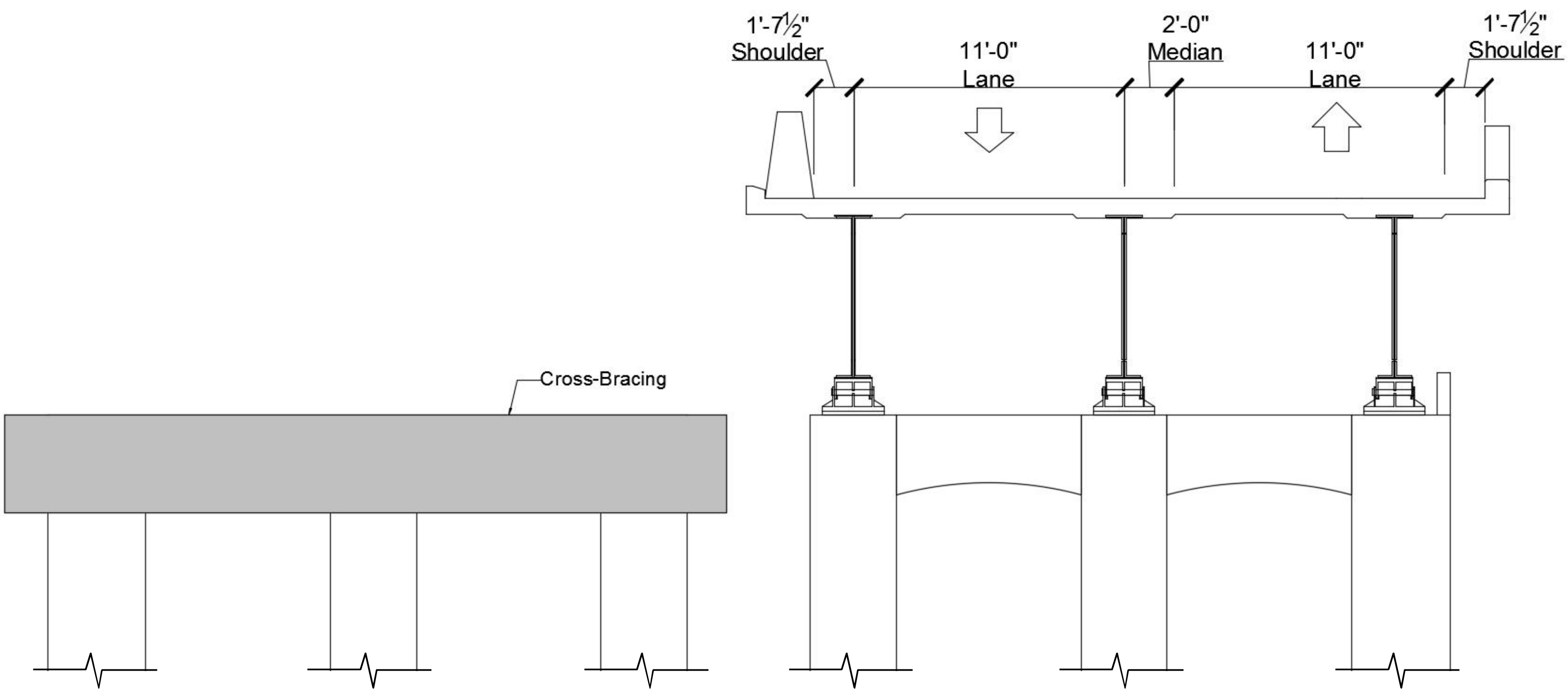


Phase I

1. Install a traffic barrier inside of the median curb and demolish the existing parapet between the roadway and the walkway on the half of bridge deck that is to remain in place during Phase I
2. Shift Traffic to that side of existing bridge deck with one lane of traffic in each direction.
3. Install cross-bracing at the top of the column to support potential crane work and construction phasing activities.
4. Demolish and remove the opposite half of the superstructure.

Project: *ITD US-12 Memorial Bridge Feasibility Study*

Subject: *Construction Phasing Sections | Phase I*



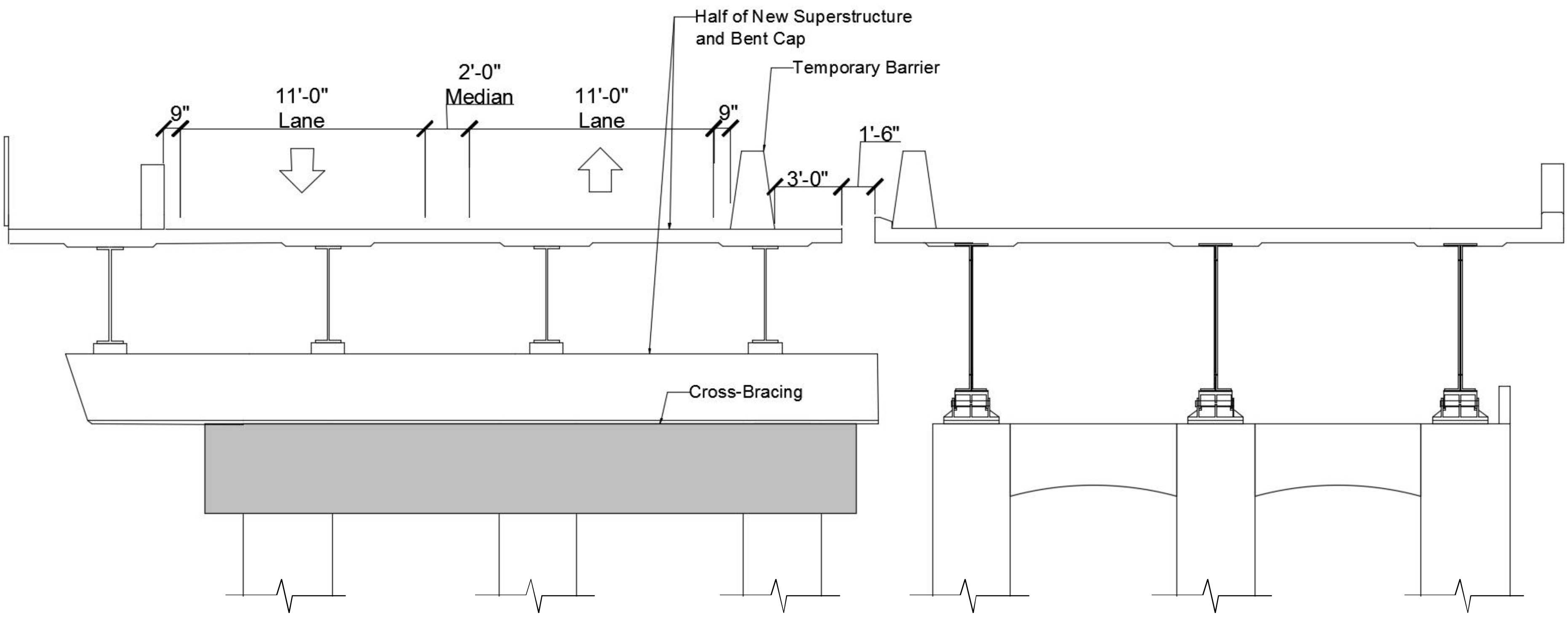
Phase I

1. Install a traffic barrier inside of the median curb and demolish the existing parapet between the roadway and the walkway on the half of bridge deck that is to remain in place during Phase I
2. Shift Traffic to that side of existing bridge deck with one lane of traffic in each direction.
3. Install cross-bracing at the top of the column to support potential crane work and construction phasing activities.
4. Demolish and remove the opposite half of the superstructure.
5. Mobilize for new superstructure construction once first half of superstructure is removed.

Key №: 13455 Page:

Project: *ITD US-12 Memorial Bridge Feasibility Study*

Subject: *Construction Phasing Sections | Phase I*

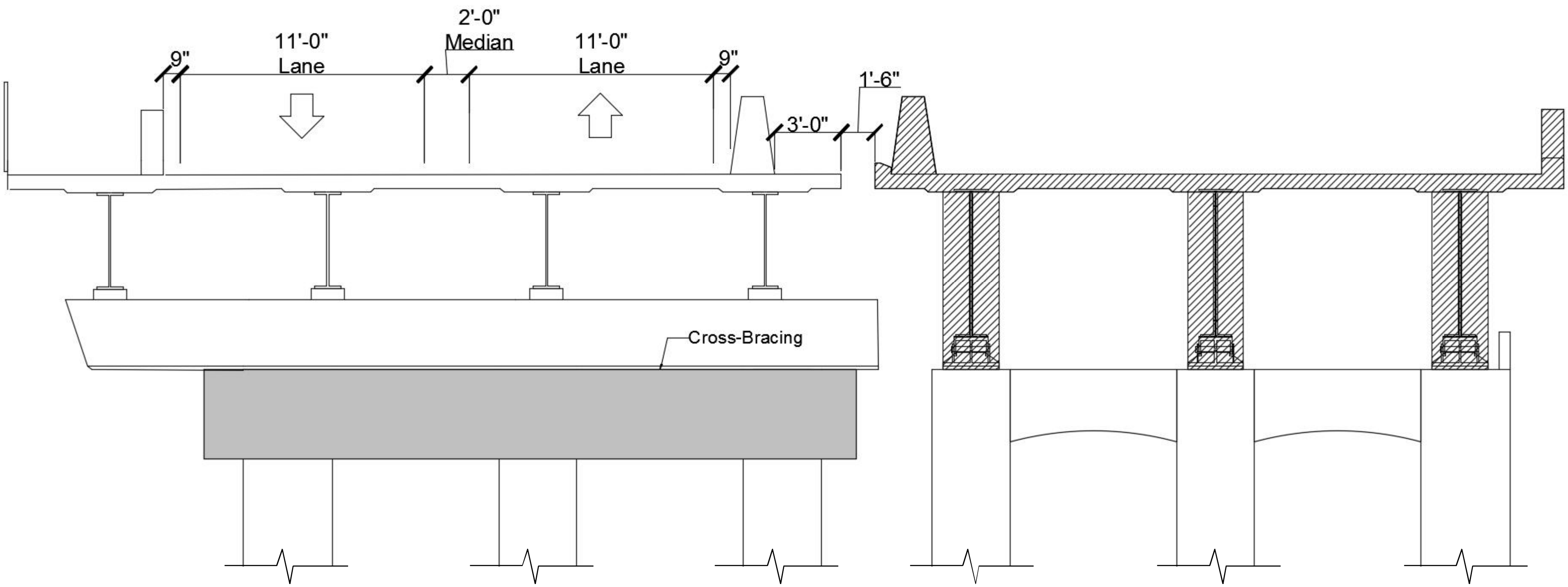


Phase I

1. Install a traffic barrier inside of the median curb and demolish the existing parapet between the roadway and the walkway on the half of bridge deck that is to remain in place during Phase I
2. Shift Traffic to that side of existing bridge deck with one lane of traffic in each direction.
3. Install cross-bracing at the top of the column to support potential crane work and construction phasing activities.
4. Demolish and remove the opposite half of the superstructure.
5. Mobilize for new superstructure construction once first half of superstructure is removed.
6. Install half of the new superstructure and bent cap in place of the demolished half of the bridge.
7. Shift traffic to the new half of the bridge deck, with a lane in each direction. Pedestrian traffic can resume on this half of the bridge.

Project: *ITD US-12 Memorial Bridge Feasibility Study*

Subject: *Construction Phasing Sections | Phase II*

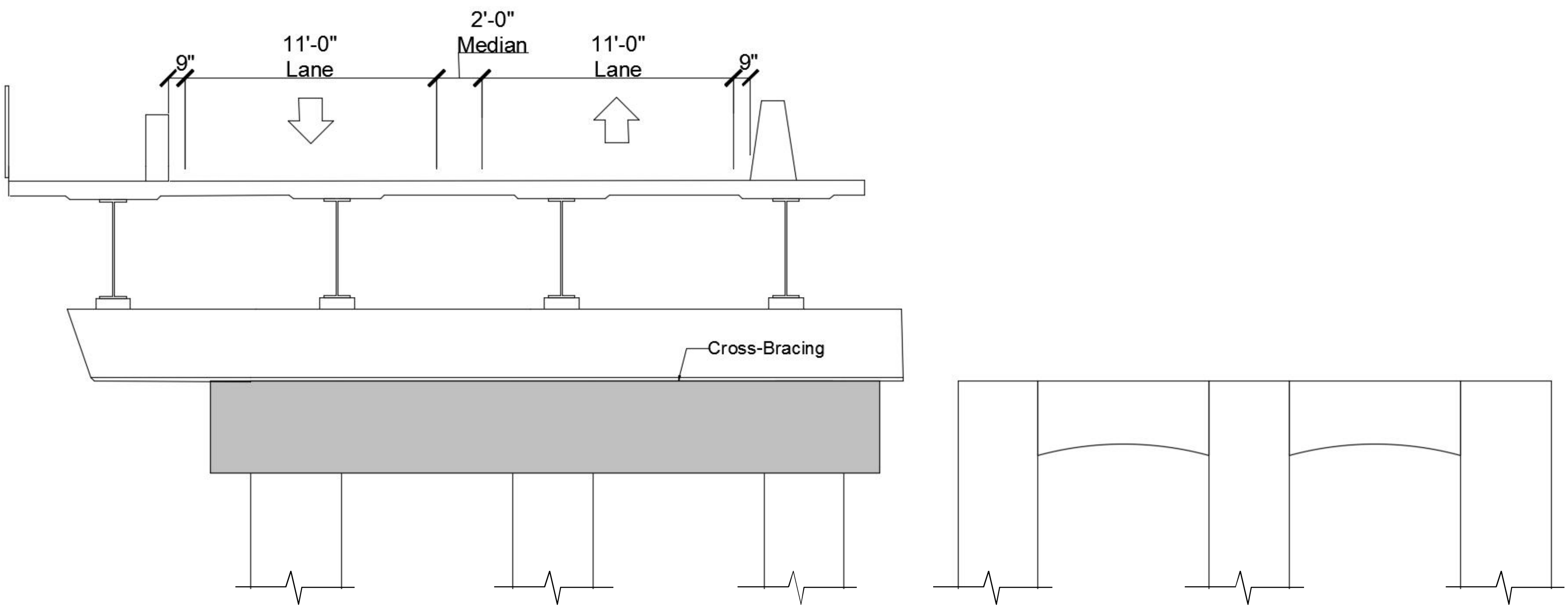


Phase II

1. Demolish and remove the second half of the old superstructure.

Project: *ITD US-12 Memorial Bridge Feasibility Study*

Subject: *Construction Phasing Sections | Phase II*

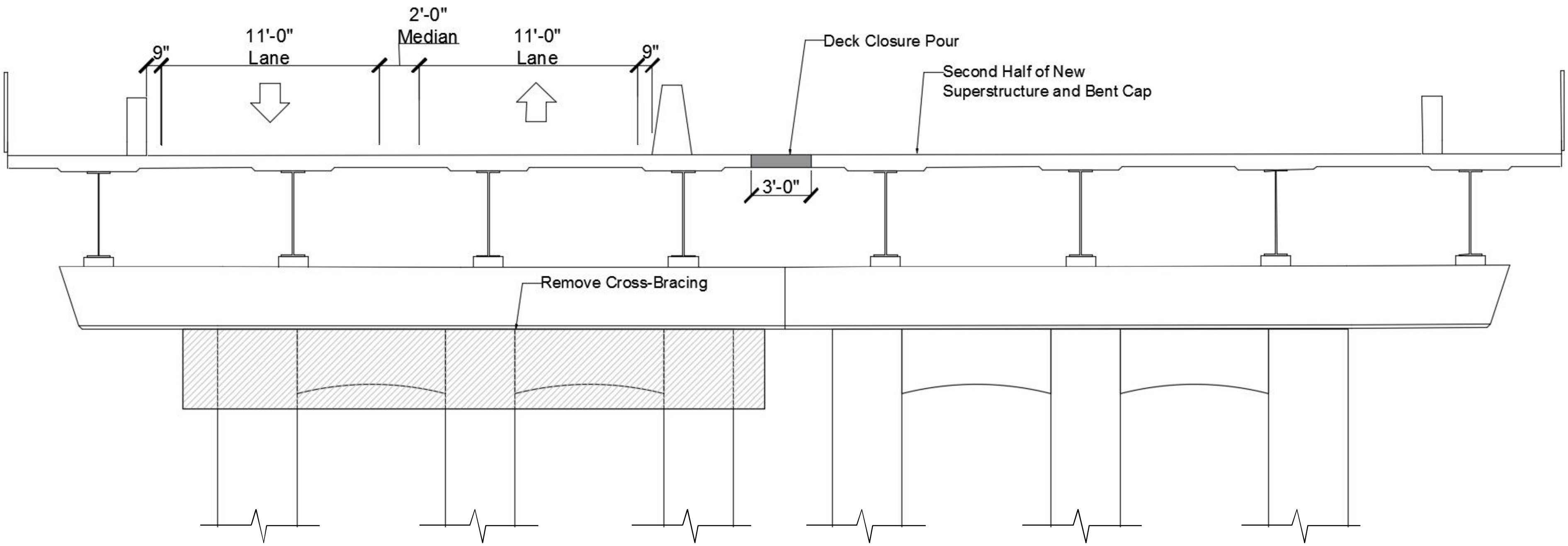


Phase II

1. Demolish and remove the second half of the old superstructure. Mobilize for new superstructure construction once second half of old superstructures has been fully removed.

Project: *ITD US-12 Memorial Bridge Feasibility Study*

Subject: *Construction Phasing Sections | Phase II*

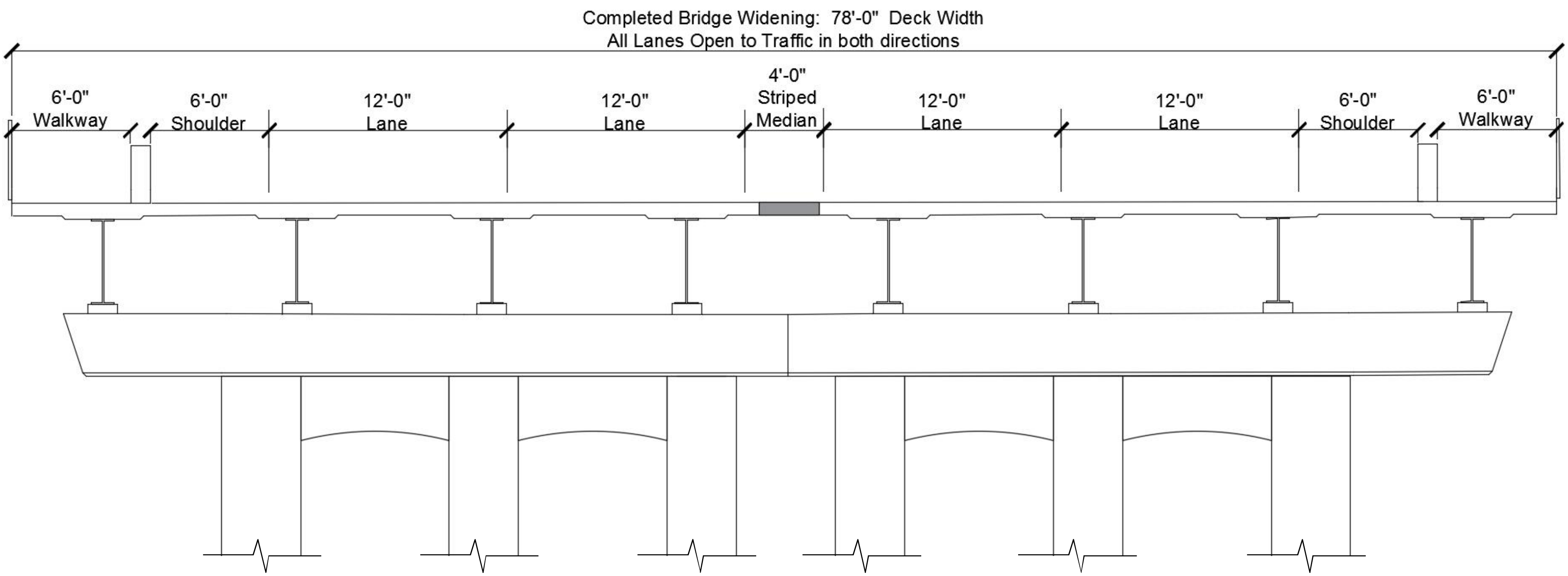


Phase II

1. Demolish and remove the second half of the old superstructure. Mobilize for new superstructure construction once second half of old superstructures has been fully removed.
2. Install the second half of the new superstructure and bent cap.
3. Place the deck closure pour strip between the two bridge halves.

Project: *ITD US-12 Memorial Bridge Feasibility Study*

Subject: *Construction Phasing Sections | Phase II*



Phase II

Construction is complete. Open up two lanes of traffic in each direction.

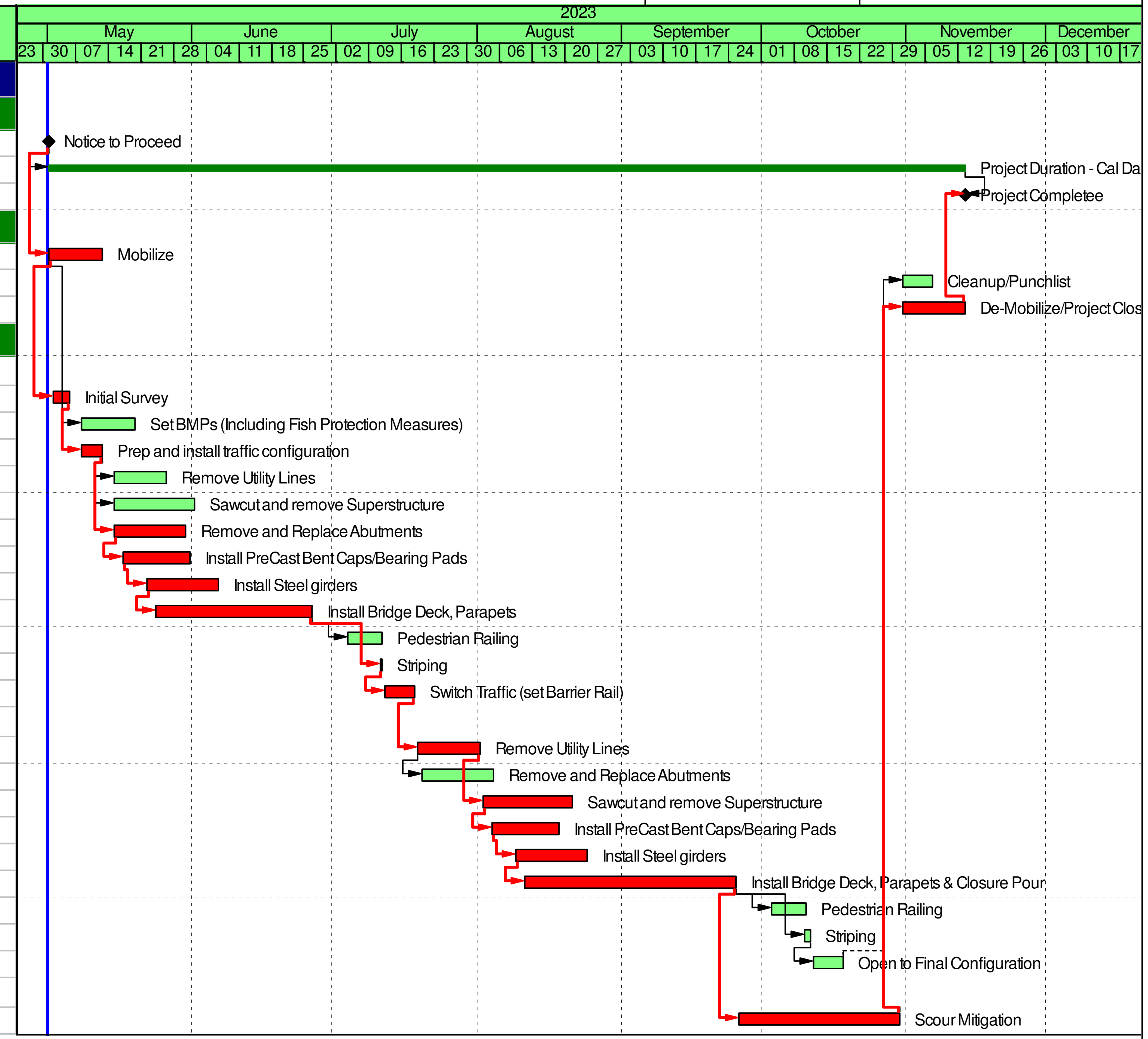
Appendix B: Project Cost Estimates

ITD US-12 Memorial Bridge Concept Schedule

Concept Schedule

20-Nov-17
Page 1 of 1

Activity ID	Activity Name	Est Dur	Start	Finish	Comments
	ITD US-12 Memorial Bridge Concept Schedule	141	01-May-23	13-Nov-23	
	Project	197	01-May-23	13-Nov-23	
A100	Notice to Proceed	0	01-May-23		
A110	Project Duration - Cal Days	197	01-May-23	13-Nov-23	
A120	Project Completee	0		13-Nov-23	
	Mobe & Demobe	141	01-May-23	13-Nov-23	
B100	Mobilize	10	01-May-23	12-May-23	
B110	Cleanup/Punchlist	5	31-Oct-23	06-Nov-23	
B120	De-Mobilize/Project Closeout	10	31-Oct-23	13-Nov-23	
	Construction	130	02-May-23	30-Oct-23	
	Phase 1 Traffic Configuration	56	02-May-23	18-Jul-23	
C100	Initial Survey	4	02-May-23	05-May-23	
C110	Set BMPs (Including Fish Protection Measures)	10	08-May-23	19-May-23	
C120	Prep and install traffic configuration	5	08-May-23	12-May-23	
C130	Remove Utility Lines	10	15-May-23	26-May-23	
C140	Sawcut and remove Superstructure	14	15-May-23	01-Jun-23	
C150	Remove and Replace Abutments	12	15-May-23	30-May-23	Concurrent construction on North/South
C160	Install PreCast Bent Caps/Bearing Pads	11	17-May-23	31-May-23	
C170	Install Steel girders	12	22-May-23	06-Jun-23	
C180	Install Bridge Deck, Parapets	24	24-May-23	26-Jun-23	
C200	Pedestrian Railing	6	04-Jul-23	11-Jul-23	
C190	Striping	1	11-Jul-23	11-Jul-23	
C220	Switch Traffic (set Barrier Rail)	5	12-Jul-23	18-Jul-23	
	Phase 2 Traffic Configuration	66	19-Jul-23	18-Oct-23	
C500	Remove Utility Lines	10	19-Jul-23	01-Aug-23	
C520	Remove and Replace Abutments	12	20-Jul-23	04-Aug-23	Concurrent construction on North/South
C510	Sawcut and remove Superstructure	14	02-Aug-23	21-Aug-23	
C530	Install PreCast Bent Caps/Bearing Pads	11	04-Aug-23	18-Aug-23	
C540	Install Steel girders	12	09-Aug-23	24-Aug-23	
C550	Install Bridge Deck, Parapets & Closure Pour	32	11-Aug-23	25-Sep-23	
C570	Pedestrian Railing	6	03-Oct-23	10-Oct-23	
C560	Striping	2	10-Oct-23	11-Oct-23	
C580	Open to Final Configuration	5	12-Oct-23	18-Oct-23	Nightwork
	Scour Mitigation	25	26-Sep-23	30-Oct-23	
D100	Scour Mitigation	25	26-Sep-23	30-Oct-23	



Remaining Level of Effort
Remaining Work
Critical Remaining Work
Milestone

Idaho Department of Transportation
US-12 Memorial Bridge
Concept Schedule

Date	Revision	Checked	Approved
20-Nov-17	Rev 1.00 - Concept Schedule		

IDAHO TRANSPORTATION DEPARTMENT

US-12 MEMORIAL BRIDGE 2018 COSTS

Biditem	Description	Quantity	Units	Unit Price	Bid Total
10	Mobilization	1.000	LS	1,678,111.41	1,678,111.41
20	Traffic Control	1.000	LS	296,620.65	296,620.65
30	Demo Light Poles	6.000	EA	2,160.00	12,960.00
40	Demo Bridge SuperStructure (Parapets, Deck, Bents)	83,700.000	SF	10.99	919,863.00
100	Remove and Replace Abutments	2.000	EA	101,298.73	202,597.46
110	Install Precast Bent Caps	11.000	EA	97,023.53	1,067,258.83
120	Install Elastomeric Bearing Pads	104.000	EA	2,836.41	294,986.64
130	Install Steel Girders	96.000	EA	63,236.31	6,070,685.76
140	Install Bridge Deck	105,300.000	SF	45.88	4,831,164.00
160	Install Light Poles	6.000	EA	21,600.00	129,600.00
170	Scour Mitigation	5.000	EA	37,800.00	189,000.00
	Bid Total				**$15,692,847.75**

Biditem 10 — Mobilization

Takeoff Qty: 1.000 LS

Bid Qty: 1.000 LS

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	426,449.20	490,924.38	917,373.58	232,933.28	283,500.00	0.00	120,000.00	1,553,806.86
Total	426,449.20	490,924.38	917,373.58	232,933.28	283,500.00	0.00	120,000.00	1,553,806.86

Manhours	Unit/MH	MH/Unit	$/MH	Base Labor/MH	Total Labor/MH	Unit/CH
6,360.0000	0.0002	6,360.0000	244.3093	67.0518	144.2411	0.0006

Activity: 910001 Mobilize Equipment Quantity: 1 Unit: LS

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	4,090.80	3,171.78	7,262.58	18,088.80	0.00	0.00	0.00	25,351.38
Total	4,090.80	3,171.78	7,262.58	18,088.80	0.00	0.00	0.00	25,351.38

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
25,351.3800	120.0000	0.0083	211.2615	15.0000	0.0667	15.0000	1,690.0920

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
120.0000	0.0083	120.0000	60.5215	4,090.8000

Calendar: 58 5- 8's Hrs/Shift: 8 WC: CIVIL Heavy Civil

Crew: TRNSPT Transport Prod: 0 Eff: 100.00 Crew Hrs: 120.00 Labor Pcs: 1.00 Equipment Pcs: 1.00

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
8TRNSPRT	TruckTractor & Lowboy	1.00	120.00	HR	150.74	100.00	150.74	18,088.80
OPERATOR 1	EXC,GRADE, PAVE	1.00	120.00	MH	34.09	100.00	60.52	7,262.58

Activity: 919001 Job Cleanup Quantity: 1 Unit: LS

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	4,707.20	4,675.10	9,382.30	19,792.48	0.00	0.00	0.00	29,174.78
Total	4,707.20	4,675.10	9,382.30	19,792.48	0.00	0.00	0.00	29,174.78

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
29,174.7800	80.0000	0.0125	364.6848	10.0000	0.1000	10.0000	2,917.4780

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
160.0000	0.0063	160.0000	58.6394	4,707.2000

Calendar: 58 5- 8's Hrs/Shift: 8 WC: IRON Structural Steel

Crew: HOUSE House Keeping/Cleanup Prod: 0 Eff: 100.00 Crew Hrs: 80.00 Labor Pcs: 2.00 Equipment Pcs: 3.00

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
8BHRB	Rubber Tired Backhoe	1.00	80.00	HR	125.77	100.00	125.77	10,061.28
8PU150	1/2 ton Pickup	1.00	80.00	HR	14.05	100.00	14.05	1,124.00
8TRKDMP17	Truck 17 Ton Dump	1.00	80.00	HR	107.59	100.00	107.59	8,607.20
LABOR GEN	GENERAL LABORER	1.00	80.00	MH	25.00	100.00	49.65	3,972.00
OPERATOR 2	LOADER, ROLLER, DOZER	1.00	80.00	MH	33.84	100.00	67.63	5,410.30

Activity: 92001 Project Supervision Quantity: 6 Unit: MO

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	64,275.20	72,139.58	136,414.78	12,364.00	0.00	0.00	0.00	148,778.78
Total	385,651.20	432,837.50	818,488.70	74,184.00	0.00	0.00	0.00	892,672.70

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
148,778.7833	176.0000	0.0057	845.3340	105.6000	0.0568	17.6000	8,453.3400

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
5,280.0000	0.0011	880.0000	155.0168	64,275.2000

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Crew: SUPER Supervision Prod: HU 176 Eff: 100.00 Crew Hrs: 1056.00 Labor Pcs: 5.00 Equipment Pcs: 5.00

Notes: Grading superintendent - 6 Months
Additional Bridge superintendent - 3 Months
Project Engineer - 33 Months
Additional CM time - 6 Months
Additional PM Time - 6 Months
Additional Office support - 3 Months

Not carrying full support through the winter to complete minor items in the spring

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
8PU150	1/2 ton Pickup	5.00	5,280.00	HR	14.05	100.00	14.05	74,184.00
XCM	CONSTRUCTION MANAGER	1.00	1,056.00	MH	92.00	110.00	200.20	211,415.42
XFE	FIELD ENGINEER	1.00	1,056.00	MH	35.00	110.00	99.05	104,591.52
XPE	PROJECT ENGINEER	1.00	1,056.00	MH	45.00	110.00	115.92	122,406.24
XPM	PROJECT MANAGER	1.00	1,056.00	MH	100.00	110.00	213.70	225,667.20
XSUPER	PROJECT SUPERINTENDENT	1.00	1,056.00	MH	60.00	110.00	146.22	154,408.32

Activity: 930000 Small Tools Quantity: 1 Unit: LS

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2MISC	Misc Materials	1.00	25,000.00	MH	3.00	108.00	3.24	81,000.00

Activity: 99990 Project Cranes Quantity: 1 Unit: LS

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Notes: Included in the items.

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
8CR050C	Crane, 50 T , Crawler	1.00	0.00	HR	150.00	100.00	0.00	0.00
8CR155	Manitowoc 4000 W 155 Ton	1.00	0.00	HR	288.00	100.00	0.00	0.00
8CR200	Manitowoc 4100 W 200 Ton	1.00	0.00	HR	455.00	100.00	0.00	0.00
OP1	Operator - Crane, Exc	1.00	0.00	MH	0.00	110.00	0.00	0.00

Activity: 99991 Permitting Quantity: 1 Unit: LS

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2PERMITS	Misc Permits	1.00	1.00	LS	15,000.00	108.00	16,200.00	16,200.00

Activity: 99993 Project Office Quantity: 6 Unit: MO

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2PROJOFFICE	Project Office	1.00	6.00	MO	3,500.00	108.00	3,780.00	22,680.00

Activity: 99994 Survey Quantity: 1 Unit: LS

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	32,000.00	50,240.00	82,240.00	20,868.00	0.00	0.00	0.00	103,108.00
Total	32,000.00	50,240.00	82,240.00	20,868.00	0.00	0.00	0.00	103,108.00

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
103,108.0000	400.0000	0.0025	257.7700	50.0000	0.0200	50.0000	2,062.1600

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
800.0000	0.0013	800.0000	102.8000	32,000.0000

Calendar: 58 5- 8's Hrs/Shift: 8 WC: IRON Structural Steel

Crew: SURVEY Survey Crew Prod: 0 Eff: 100.00 Crew Hrs: 400.00 Labor Pcs: 2.00 Equipment Pcs: 2.00

Notes: Survey for bridge construction and preconstruction survey/vibration monitoring

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
8PU250	3/4 ton Pickup	1.00	400.00	HR	17.17	100.00	17.17	6,868.00
8SURV	Survey Equipment	1.00	400.00	HR	35.00	100.00	35.00	14,000.00
XFE	FIELD ENGINEER	1.00	400.00	MH	35.00	100.00	94.95	37,980.00
XPE	PROJECT ENGINEER	1.00	400.00	MH	45.00	100.00	110.65	44,260.00

Activity: 99995 River Equipment Quantity: 5 Unit: MO

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	0.00	0.00	0.00	20,000.00	324.00	0.00	14,000.00	34,324.00
Total	0.00	0.00	0.00	100,000.00	1,620.00	0.00	70,000.00	171,620.00

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2NAVLIGHTS	Navigation lights	1.00	5.00	MO	300.00	108.00	324.00	1,620.00
4TRANSPORT	Transport sub	1.00	1.00	LS	70,000.00	100.00	70,000.00	70,000.00
8CRANEBARGE	Crane Barge	1.00	0.00	MO	35,000.00	100.00	0.00	0.00
8JONBOAT	Jon Boats	1.00	10.00	MO	2,500.00	100.00	2,500.00	25,000.00
8MATBARGE	Material Barge	1.00	0.00	MO	2,110.00	100.00	0.00	0.00
8PORTABARGE	Portabarge	1.00	0.00	MO	3,520.00	100.00	0.00	0.00
8TUGBOAT	Tubboat	1.00	5.00	MO	15,000.00	100.00	15,000.00	75,000.00

Activity: 99996 Insurance Quantity: 1 Unit: LS

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2INSURANCE	Project Insurance	1.00	6.00	MO	15,000.00	108.00	16,200.00	97,200.00

Activity: 99997 Engineering Quantity: 1 Unit: LS

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
4ENG	Engineering Sub	1.00	1.00	LS	50,000.00	100.00	50,000.00	50,000.00

Activity: 99999 Project Bonds Quantity: 1 Unit: LS

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2BOND	Bonds	1.00	20,000,000.00	$	0.00	108.00	0.00	64,800.00

Biditem 20

Traffic Control

Takeoff Qty: 1.000 LS

Bid Qty: 1.000 LS

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	29,716.72	34,399.39	64,116.11	17,212.64	193,320.00	0.00	0.00	274,648.75
Total	29,716.72	34,399.39	64,116.11	17,212.64	193,320.00	0.00	0.00	274,648.75

Manhours	Unit/MH	MH/Unit	$/MH	Base Labor/MH	Total Labor/MH	Unit/CH
820.0000	0.0012	820.0000	334.9375	36.2399	78.1904	0.0016

Activity: A TEMP BARRIER Quantity: 2000 Unit: LF

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	2.59	1.86	4.45	4.07	59.40	0.00	0.00	67.92
Total	5,177.92	3,719.55	8,897.47	8,146.88	118,800.00	0.00	0.00	135,844.35

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
8.5222	0.0400	25.0000	213.0544	8.0000	250.0000	0.0040	16,980.5438

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
160.0000	12.5000	0.0800	55.6092	2.5890

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: CIVIL Heavy Civil

Crew: H&A Material Handling Prod: UH 25 Eff: 100.00 Crew Hrs: 80.00 Labor Pcs: 2.00 Equipment Pcs: 1.00

Notes: Initial Move 3 nights
Switch 3 nights
Remove 2 nights

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2ATTENUATOR	Temo Attenuator	1.00	2.00	EA	15,000.00	108.00	16,200.00	32,400.00
2TEMPBARRIER	CONC BARRIER	1.00	2,000.00	LF/M	40.00	108.00	43.20	86,400.00
8FORK	10,000 LB Forklift	1.00	80.00	HR	101.84	100.00	101.84	8,146.88
LABOR GEN	GENERAL LABORER	1.00	80.00	MH	25.00	110.00	47.08	3,766.00
OPERATOR 2	LOADER, ROLLER, DOZER	1.00	80.00	MH	33.84	110.00	64.14	5,131.47

Activity: B TC SUPERVISOR Quantity: 6 Unit: MO

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	4,089.80	5,113.31	9,203.11	1,510.96	0.00	0.00	0.00	10,714.07
Total	24,538.80	30,679.84	55,218.64	9,065.76	0.00	0.00	0.00	64,284.40

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
10,714.0667	88.0000	0.0114	121.7508	52.8000	0.1136	8.8000	1,217.5076

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
660.0000	0.0091	110.0000	83.6646	4,089.8000

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: CIVIL Heavy Civil

Crew: TC TC SUPERVISION Prod: HU 88 Eff: 100.00 Crew Hrs: 528.00 Labor Pcs: 1.25 Equipment Pcs: 1.00

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
8PU250	3/4 ton Pickup	1.00	528.00	HR	17.17	100.00	17.17	9,065.76
FORMAN	FORMAN	1.00	528.00	MH	36.00	110.00	92.81	49,004.74
LABOR GEN	GENERAL LABORER	0.25	132.00	MH	25.00	110.00	47.08	6,213.90

Activity: C DEVICES Quantity: 6 Unit: MO

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: CIVIL Heavy Civil

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2DEVICES	TC DEVICES	1.00	6.00	MO	1,500.00	108.00	1,620.00	9,720.00

Activity: D CROSSOVER Quantity: 1 Unit: LS

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: CIVIL Heavy Civil

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2MISC	Misc Materials	1.00	4.00	EA	15,000.00	108.00	16,200.00	64,800.00

Biditem 30

Demo Light Poles

Takeoff Qty: 6.000 EA

Bid Qty: 6.000 EA

Activity: A Demo Light Poles Quantity: 6 Unit: EA

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
4ELEC	Electric - Sub	1.00	6.00	EA	2,000.00	100.00	2,000.00	12,000.00

Biditem 40

Demo Bridge SuperStructure (Parapets, Deck, Bents)

Takeoff Qty: 83,700.000 SF

Bid Qty: 83,700.000 SF

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	1.57	1.54	3.11	2.56	2.34	0.00	2.15	10.17
Total	131,607.42	129,037.12	260,644.54	214,655.17	196,128.00	0.00	180,000.00	851,427.71

Manhours	Unit/MH	MH/Unit	$/MH	Base Labor/MH	Total Labor/MH	Unit/CH
4,120.6600	20.3123	0.0492	206.6241	31.9384	63.2531	78.8631

Activity: A Sawcut Quantity: 2500 Unit: LF

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	2.27	2.44	4.71	3.33	0.00	0.00	0.00	8.04
Total	5,679.44	6,094.70	11,774.14	8,324.42	0.00	0.00	0.00	20,098.56

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
8.0394	0.0333	30.0000	241.1828	8.3333	300.0001	0.0033	2,411.8282

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
166.6600	15.0006	0.0667	70.6477	2.2718

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: CIVIL Heavy Civil

Crew: SAW SAWCUTTING Prod: UH 30 Eff: 100.00 Crew Hrs: 83.33 Labor Pcs: 2.00 Equipment Pcs: 2.00

Notes: Includes cut and grind of curb wall on phase 1

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
8CIPSAW	Concrete Saw	1.00	83.33	HR	12.11	100.00	12.11	1,009.13
8PUMECH	Mechanics Truck	1.00	83.33	HR	87.79	100.00	87.79	7,315.29
FORMAN	FORMAN	1.00	83.33	MH	36.00	110.00	92.81	7,734.03
LABOR SKILL	SKILLED LABORER	1.00	83.33	MH	25.96	110.00	48.48	4,040.11

Activity: B Remove Deck/Parapets spans Quantity: 24 Unit: EA

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	2,249.06	2,006.17	4,255.23	2,377.87	2,250.00	0.00	0.00	8,883.10
Total	53,977.44	48,148.04	102,125.48	57,068.88	54,000.00	0.00	0.00	213,194.36

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
6,633.0983	10.0000	0.1000	663.3098	24.0000	1.0000	1.0000	8,883.0983

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
1,680.0000	0.0143	70.0000	60.7890	2,249.0600

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: CIVIL Heavy Civil

Crew: DEMOSP Demo Special Prod: HU 10 Eff: 100.00 Crew Hrs: 240.00 Labor Pcs: 7.00 Equipment Pcs: 2.00

Notes: 12 spans in each phase. Misc steel is for rigging and removing whole spans.

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2MISCSTEEL	Misc Steel	1.00	1.00	LS	50,000.00	108.00	54,000.00	54,000.00
8CR050C	Crane, 50 T , Crawler	1.00	240.00	HR	150.00	100.00	150.00	36,000.00
8PUMECH	Mechanics Truck	1.00	240.00	HR	87.79	100.00	87.79	21,068.88
FORMAN	FORMAN	1.00	240.00	MH	36.00	110.00	92.81	22,274.88
IRON	IRON WORKER	2.00	480.00	MH	28.12	110.00	61.19	29,372.18
LABOR SKILL	SKILLED LABORER	3.00	720.00	MH	25.96	110.00	48.48	34,907.99
OPER CRANE	CRANE HEAVY - PILE, DRIVE	1.00	240.00	MH	34.34	110.00	64.88	15,570.43

Activity:	D	Install safety/environmental nets	Quantity:	24	Unit:	EA

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: CIVIL Heavy Civil

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2FALLPROTECT	Fall protection (Debris)	1.00	24.00	EA	5,000.00	108.00	5,400.00	129,600.00

Activity:	E	Haul off & dumpfees	Quantity:	2320	Unit:	CY

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	5.39	4.46	9.85	20.87	5.40	0.00	0.00	36.12
Total	12,513.60	10,344.49	22,858.09	48,415.50	12,528.00	0.00	0.00	83,801.59

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
30.7214	0.1940	5.1556	158.3858	45.0000	51.5556	0.0194	1,862.2576

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
450.0000	5.1556	0.1940	50.7958	5.3938

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: CIVIL Heavy Civil

Crew: HAUL17 HAUL 17 TON END DUMPS Prod: UH 5.1556 Eff: 100.00 Crew Hrs: 450.00 Labor Pcs: 1.00 Equipment Pcs: 1.00

Notes: 2067 CY of Deck and 250 CY of walls/guardrail, etc.
Any Salvage will be counted as a wash from hauling expenses, etc. This is an opportunity for the contractor to provide lower bid

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2DUMPFEES	Dumpfees	1.00	2,320.00	CY	5.00	108.00	5.40	12,528.00
8TRKDMP17	Truck 17 Ton Dump	1.00	450.00	HR	107.59	100.00	107.59	48,415.50
TEAMSTER	TEAMSTER	1.00	450.00	MH	25.28	110.00	50.80	22,858.09

Activity:	F	Remove Utility lines and hang	Quantity:	12	Unit:	EA

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	1,799.25	1,964.78	3,764.03	1,902.30	0.00	0.00	0.00	5,666.33
Total	21,590.97	23,577.41	45,168.38	22,827.55	0.00	0.00	0.00	67,995.93

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
5,666.3275	8.0000	0.1250	708.2909	9.6000	1.2500	0.8000	7,082.9094

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
672.0000	0.0179	56.0000	67.2149	1,799.2475

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Crew: DEMOSP Demo Special Prod: HU 8 Eff: 100.00 Crew Hrs: 96.00 Labor Pcs: 7.00 Equipment Pcs: 2.00

Notes: 12 spans

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
8CR050C	Crane, 50 T , Crawler	1.00	96.00	HR	150.00	100.00	150.00	14,400.00
8PUMECH	Mechanics Truck	1.00	96.00	HR	87.79	100.00	87.79	8,427.55
FORMAN	FORMAN	1.00	96.00	MH	36.00	110.00	100.73	9,670.27
IRON	IRON WORKER	2.00	192.00	MH	28.12	110.00	67.38	12,936.66
LABOR SKILL	SKILLED LABORER	3.00	288.00	MH	25.96	110.00	54.19	15,608.02
OPER CRANE	CRANE HEAVY - PILE, DRIVE	1.00	96.00	MH	34.34	110.00	72.43	6,953.43

Activity:	G	Re-Install Utility Lines	Quantity:	12	Unit:	EA

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	1,799.25	1,964.78	3,764.03	1,902.30	0.00	0.00	0.00	5,666.33
Total	21,590.97	23,577.41	45,168.38	22,827.55	0.00	0.00	0.00	67,995.93

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
5,666.3275	8.0000	0.1250	708.2909	9.6000	1.2500	0.8000	7,082.9094

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
672.0000	0.0179	56.0000	67.2149	1,799.2475

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Crew: DEMOSP Demo Special Prod: HU 8 Eff: 100.00 Crew Hrs: 96.00 Labor Pcs: 7.00 Equipment Pcs: 2.00

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
8CR050C	Crane, 50 T , Crawler	1.00	96.00	HR	150.00	100.00	150.00	14,400.00
8PUMECH	Mechanics Truck	1.00	96.00	HR	87.79	100.00	87.79	8,427.55
FORMAN	FORMAN	1.00	96.00	MH	36.00	110.00	100.73	9,670.27
IRON	IRON WORKER	2.00	192.00	MH	28.12	110.00	67.38	12,936.66
LABOR SKILL	SKILLED LABORER	3.00	288.00	MH	25.96	110.00	54.19	15,608.02
OPER CRANE	CRANE HEAVY - PILE, DRIVE	1.00	96.00	MH	34.34	110.00	72.43	6,953.43

Activity: H Marine Equipment Rental Quantity: 30 Unit: DAYS

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	0.00	0.00	0.00	0.00	0.00	0.00	6,000.00	6,000.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	180,000.00	180,000.00

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Activity: I Demo spans off-site Quantity: 24 Unit: EA

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	677.29	720.63	1,397.92	2,299.64	0.00	0.00	0.00	3,697.56
Total	16,255.00	17,295.07	33,550.07	55,191.27	0.00	0.00	0.00	88,741.34

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
3,697.5558	4.0000	0.2500	924.3890	9.6000	2.5000	0.4000	9,243.8896

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
480.0000	0.0500	20.0000	69.8960	677.2917

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Crew: DEMOBR BRIDGE DEMO CREW Prod: HU 4 Eff: 100.00 Crew Hrs: 96.00 Labor Pcs: 5.00 Equipment Pcs: 4.00

Notes: 330 is used to manuever material, 320 has a hoeram attachment, Loader loads trucks for hauloff. Mechanic truck for misc welding cuts.

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
8BHLG	Trackhoe Large Cat 330 (or S	1.00	96.00	HR	215.83	100.00	215.83	20,719.49
8BHMED	Trackhoe Medium Cat 320 (or	1.00	96.00	HR	145.43	100.00	145.43	13,961.09
8LOADLG	Loader Large 950H Articulate	1.00	96.00	HR	125.87	100.00	125.87	12,083.14
8PUMECH	Mechanics Truck	1.00	96.00	HR	87.79	100.00	87.79	8,427.55
FORMAN	FORMAN	1.00	96.00	MH	36.00	110.00	100.73	9,670.27
LABOR GEN	GENERAL LABORER	2.00	192.00	MH	25.00	110.00	52.58	10,094.40
OPERATOR 1	EXC,GRADE, PAVE	1.00	96.00	MH	34.09	110.00	72.01	6,912.94
OPERATOR 2	LOADER, ROLLER, DOZER	1.00	96.00	MH	33.84	110.00	71.59	6,872.46

Biditem 100

Remove and Replace Abutments

Takeoff Qty: 2.000 EA

Bid Qty: 2.000 EA

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	1,354.58	1,441.26	2,795.84	4,599.28	0.00	0.00	86,400.00	93,795.12
Total	2,709.16	2,882.52	5,591.68	9,198.55	0.00	0.00	172,800.00	187,590.23

Manhours	Unit/MH	MH/Unit	$/MH	Base Labor/MH	Total Labor/MH	Unit/CH
80.0000	0.0250	40.0000	2,344.8779	33.8645	69.8960	0.1250

Activity: A Install Sheet Piles Quantity: 2 Unit: EA

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Notes: INCLUDES SHEET PILING ALONG RR 480 SF

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
4SHEETPILES	SheetPiles	1.00	1,080.00	SF	60.00	100.00	60.00	64,800.00

Activity: B Demo Existing Abutment Quantity: 4 Unit: EA

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	677.29	720.63	1,397.92	2,299.64	0.00	0.00	0.00	3,697.56
Total	2,709.16	2,882.52	5,591.68	9,198.55	0.00	0.00	0.00	14,790.23

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
3,697.5575	4.0000	0.2500	924.3894	1.6000	2.5000	0.4000	9,243.8938

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
80.0000	0.0500	20.0000	69.8960	677.2900

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Crew: DEMOBR BRIDGE DEMO CREW Prod: HU 4 Eff: 100.00 Crew Hrs: 16.00 Labor Pcs: 5.00 Equipment Pcs: 4.00

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
8BHLG	Trackhoe Large Cat 330 (or S	1.00	16.00	HR	215.83	100.00	215.83	3,453.25
8BHMED	Trackhoe Medium Cat 320 (or	1.00	16.00	HR	145.43	100.00	145.43	2,326.85
8LOADLG	Loader Large 950H Articulate	1.00	16.00	HR	125.87	100.00	125.87	2,013.86
8PUMECH	Mechanics Truck	1.00	16.00	HR	87.79	100.00	87.79	1,404.59
FORMAN	FORMAN	1.00	16.00	MH	36.00	110.00	100.73	1,611.71
LABOR GEN	GENERAL LABORER	2.00	32.00	MH	25.00	110.00	52.58	1,682.40
OPERATOR 1	EXC,GRADE, PAVE	1.00	16.00	MH	34.09	110.00	72.01	1,152.16
OPERATOR 2	LOADER, ROLLER, DOZER	1.00	16.00	MH	33.84	110.00	71.59	1,145.41

Activity: C Install Piles Quantity: 4 Unit: EA

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
4PILEDRIVER	PILE DRIVER	1.00	4.00	EA	10,000.00	100.00	10,000.00	40,000.00

Activity: D FPS Abutments Quantity: 4 Unit: EA

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
4CONC	Concrete - Sub	1.00	4.00	EA	12,000.00	100.00	12,000.00	48,000.00

Activity: E FPS Approach Panels Quantity: 4 Unit: EA

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
4CONC	Concrete - Sub	1.00	4.00	EA	5,000.00	100.00	5,000.00	20,000.00

Biditem 110

Install Precast Bent Caps

Takeoff Qty: 11.000 EA

Bid Qty: 11.000 EA

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	6,964.55	7,296.70	14,261.25	7,238.08	16,519.09	0.00	51,818.18	89,836.60
Total	76,610.07	80,263.72	156,873.79	79,618.85	181,710.00	0.00	570,000.00	988,202.64

Manhours	Unit/MH	MH/Unit	$/MH	Base Labor/MH	Total Labor/MH	Unit/CH
2,404.0000	0.0046	218.5455	411.0660	31.8677	65.2553	0.0302

Activity: A Install Precast Bent Caps Quantity: 22 Unit: EA

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total

U. Cost	2,249.06	2,455.98	4,705.04	2,377.87	8,075.45	0.00	0.00	15,158.36
Total	49,479.32	54,031.56	103,510.88	52,313.14	177,660.00	0.00	0.00	333,484.02

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
7,082.9100	10.0000	0.1000	708.2910	22.0000	1.0000	1.0000	15,158.3645

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
1,540.0000	0.0143	70.0000	67.2149	2,249.0600

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Crew: DEMOSP Demo Special Prod: HU 10 Eff: 100.00 Crew Hrs: 220.00 Labor Pcs: 7.00 Equipment Pcs: 2.00

Notes: Half width Bents with Closure Pours

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2PRECASTBENT	Precast Bent Cap	1.00	470.00	CY	350.00	108.00	378.00	177,660.00
8CR050C	Crane, 50 T , Crawler	1.00	220.00	HR	150.00	100.00	150.00	33,000.00
8PUMECH	Mechanics Truck	1.00	220.00	HR	87.79	100.00	87.79	19,313.14
FORMAN	FORMAN	1.00	220.00	MH	36.00	110.00	100.73	22,161.04
IRON	IRON WORKER	2.00	440.00	MH	28.12	110.00	67.38	29,646.51
LABOR SKILL	SKILLED LABORER	3.00	660.00	MH	25.96	110.00	54.19	35,768.38
OPER CRANE	CRANE HEAVY - PILE, DRIVE	1.00	220.00	MH	34.34	110.00	72.43	15,934.95

Activity: B Marine Equipment Rental Quantity: 0.5 Unit: MO

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	0.00	0.00	0.00	0.00	0.00	0.00	1,140,000.00	1,140,000.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	570,000.00	570,000.00

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
4BRIDGETRK	Bridge access Truck	1.00	1.00	MO	30,000.00	100.00	30,000.00	30,000.00
4MARINE	Barges, Crane, tugs	1.00	30.00	DAY	18,000.00	100.00	18,000.00	540,000.00

Activity: F Closure Pours FPS Quantity: 12 Unit: EA

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	2,260.90	2,186.01	4,446.91	2,275.48	337.50	0.00	0.00	7,059.89
Total	27,130.75	26,232.16	53,362.91	27,305.71	4,050.00	0.00	0.00	84,718.62

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
6,722.3850	12.0000	0.0833	560.1988	14.4000	0.8333	1.2000	5,883.2375

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
864.0000	0.0139	72.0000	61.7626	2,260.8958

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: STRUCT Structures

Crew: FPSSM Concrete Form, Pour, Strip Prod: HU 12 Eff: 100.00 Crew Hrs: 144.00 Labor Pcs: 6.00 Equipment Pcs: 2.00

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2CONC	concrete	1.00	30.00	CY	125.00	108.00	135.00	4,050.00
8FORK	10,000 LB Forklift	1.00	144.00	HR	101.84	100.00	101.84	14,664.38
8PUMECH	Mechanics Truck	1.00	144.00	HR	87.79	100.00	87.79	12,641.33
CARPENTER	CARPENTER	2.00	288.00	MH	28.70	110.00	60.46	17,413.32
FORMAN	FORMAN	1.00	144.00	MH	36.00	110.00	96.41	13,883.33
LABOR SKILL	SKILLED LABORER	3.00	432.00	MH	25.96	110.00	51.08	22,066.26

Biditem 120

Install Elastomeric Bearing Pads

Takeoff Qty: 104.000 EA

Bid Qty: 104.000 EA

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total

U. Cost	220.44	258.19	478.63	203.67	1,944.00	0.00	0.00	2,626.31
Total	22,925.76	26,852.26	49,778.02	21,181.99	202,176.00	0.00	0.00	273,136.01

Manhours	Unit/MH	MH/Unit	$/MH	Base Labor/MH	Total Labor/MH	Unit/CH
728.0000	0.1429	7.0000	375.1868	31.4914	68.3764	1.0000

Activity: A Install Elastomeric Bearing Pads Quantity: 104 Unit: EA

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	220.44	258.19	478.63	203.67	1,944.00	0.00	0.00	2,626.31
Total	22,925.76	26,852.26	49,778.02	21,181.99	202,176.00	0.00	0.00	273,136.01

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
682.3078	1.0000	1.0000	682.3078	10.4000	10.0000	0.1000	26,263.0779

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
728.0000	0.1429	7.0000	68.3764	220.4400

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Crew: IRON Steel Erection Prod: HU 1 Eff: 100.00 Crew Hrs: 104.00 Labor Pcs: 7.00 Equipment Pcs: 3.00

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2BEARING PAD	Elastomeric Bearing Pads	1.00	104.00	EA	1,800.00	108.00	1,944.00	202,176.00
8FORK	10,000 LB Forklift	1.00	104.00	HR	101.84	100.00	101.84	10,590.94
8PU150	1/2 ton Pickup	1.00	104.00	HR	14.05	100.00	14.05	1,461.20
8PUMECH	Mechanics Truck	1.00	104.00	HR	87.79	100.00	87.79	9,129.85
FORMAN	FORMAN	1.00	104.00	MH	36.00	110.00	100.73	10,476.13
IRON	IRON WORKER	4.00	416.00	MH	28.12	110.00	67.38	28,029.43
LABOR SKILL	SKILLED LABORER	2.00	208.00	MH	25.96	110.00	54.19	11,272.46

Biditem 130

Install Steel Girders

Takeoff Qty: 96.000 EA

Bid Qty: 96.000 EA

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	604.19	650.51	1,254.69	645.39	51,917.68	0.00	4,734.38	58,552.14
Total	58,001.76	62,448.86	120,450.62	61,957.01	4,984,097.51	0.00	454,500.00	5,621,005.14

Manhours	Unit/MH	MH/Unit	$/MH	Base Labor/MH	Total Labor/MH	Unit/CH
1,824.0000	0.0526	19.0000	3,081.6914	31.7992	66.0365	0.3333

Activity: A PURCHASE MATERIALS Quantity: 2300000 Unit: LBS

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	0.00	0.00	0.00	0.00	2.17	0.00	0.00	2.17
Total	0.00	0.00	0.00	0.00	4,984,097.51	0.00	0.00	4,984,097.51

Calendar: 58 5- 8's Hrs/Shift: 8 WC: STRUCT Structures

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2MISC	Misc Materials	1.00	2,366,618.00	LBS	0.25	108.00	0.27	638,986.86
2STUCTSTEEL	STRUCTURAL STEEL	1.00	2,366,618.00	LBS	1.70	108.00	1.84	4,345,110.65

Activity: B HANDLE MATERIALS Quantity: 24 Unit: LOAD

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	167.68	146.06	313.74	203.67	0.00	0.00	0.00	517.41
Total	4,024.32	3,505.34	7,529.66	4,888.13	0.00	0.00	0.00	12,417.79

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
517.4079	2.0000	0.5000	258.7040	6.0000	4.0000	0.2500	2,069.6317

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
144.0000	0.1667	6.0000	52.2893	167.6800

Calendar: 58 5- 8's Hrs/Shift: 8 WC: STRUCT Structures

Crew: H&A Material Handling Prod: HU 2 Eff: 100.00 Crew Hrs: 48.00 Labor Pcs: 3.00 Equipment Pcs: 1.00

Notes: NO ROOM FOR STAGING, WILL PLACE DIRECTLY FROM TRUCK

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
8FORK	10,000 LB Forklift	1.00	48.00	HR	101.84	100.00	101.84	4,888.13
LABOR GEN	GENERAL LABORER	2.00	96.00	MH	25.00	100.00	46.65	4,478.40
OPERATOR 2	LOADER, ROLLER, DOZER	1.00	48.00	MH	33.84	100.00	63.57	3,051.26

Activity: C INSTALL SPANS Quantity: 24 Unit: EA

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	2,249.06	2,455.98	4,705.04	2,377.87	0.00	0.00	0.00	7,082.91
Total	53,977.44	58,943.52	112,920.96	57,068.88	0.00	0.00	0.00	169,989.84

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
7,082.9100	10.0000	0.1000	708.2910	24.0000	1.0000	1.0000	7,082.9100

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
1,680.0000	0.0143	70.0000	67.2149	2,249.0600

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Crew: DEMOSP Demo Special Prod: HU 10 Eff: 100.00 Crew Hrs: 240.00 Labor Pcs: 7.00 Equipment Pcs: 2.00

Notes: THIS WORK CAN BE DONE AT NIGHT WITH THE ROAD CLOSED FROM THE OPEN LANES

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
8CR050C	Crane, 50 T , Crawler	1.00	240.00	HR	150.00	100.00	150.00	36,000.00
8PUMECH	Mechanics Truck	1.00	240.00	HR	87.79	100.00	87.79	21,068.88
FORMAN	FORMAN	1.00	240.00	MH	36.00	110.00	100.73	24,175.68
IRON	IRON WORKER	2.00	480.00	MH	28.12	110.00	67.38	32,341.65
LABOR SKILL	SKILLED LABORER	3.00	720.00	MH	25.96	110.00	54.19	39,020.05
OPER CRANE	CRANE HEAVY - PILE, DRIVE	1.00	240.00	MH	34.34	110.00	72.43	17,383.58

Activity: D MARINE EQUIPMENT Quantity: 88 Unit: EA

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	0.00	0.00	0.00	0.00	0.00	0.00	5,164.77	5,164.77
Total	0.00	0.00	0.00	0.00	0.00	0.00	454,500.00	454,500.00

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
4BRIDGETRK	Bridge access Truck	1.00	0.75	MO	30,000.00	100.00	30,000.00	22,500.00
4MARINE	Barges, Crane, tugs	1.00	24.00	DAY	18,000.00	100.00	18,000.00	432,000.00

Biditem 140

Install Bridge Deck

Takeoff Qty: 105,300.000 SF

Bid Qty: 105,300.000 SF

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	1.11	1.09	2.20	1.09	10.91	0.00	28.28	42.49
Total	116,374.90	114,995.83	231,370.73	115,279.43	1,149,262.56	0.00	2,977,800.00	4,473,712.72

Manhours	Unit/MH	MH/Unit	$/MH	Base Labor/MH	Total Labor/MH	Unit/CH
3,776.0000	27.8867	0.0359	1,184.7756	30.8196	61.2740	197.9323

Activity: 31001 Form/Strip Deck ph 1 Quantity: 50000 Unit: SF

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	0.44	0.44	0.88	0.46	0.00	0.00	0.00	1.33
Total	22,186.56	21,803.21	43,989.77	22,754.76	0.00	0.00	0.00	66,744.53

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
1.3349	0.0024	416.6667	556.2044	12.0000	4,166.6667	0.0002	5,562.0442

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
720.0000	69.4444	0.0144	61.0969	0.4437

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: STRUCT Structures

Crew: FPSSM Concrete Form, Pour, Strip Prod: UH 416.6667 Eff: 100.00 Crew Hrs: 120.00 Labor Pcs: 6.00 Equipment Pcs: 2.00

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
8FORK	10,000 LB Forklift	1.00	120.00	HR	101.84	100.00	101.84	12,220.32
8PUMECH	Mechanics Truck	1.00	120.00	HR	87.79	100.00	87.79	10,534.44
FORMAN	FORMAN	1.00	120.00	MH	36.00	110.00	96.41	11,569.44
LABOR SKILL	SKILLED LABORER	3.00	360.00	MH	25.96	110.00	51.08	18,388.56
MASON	Concrete Mason/Finisher	2.00	240.00	MH	27.10	110.00	58.47	14,031.77

Activity: 31002 Temp Deck Shoring Quantity: 105300 Unit: SF

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: STRUCT Structures

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
4BLDG	Building - Sub	1.00	105,300.00	SF	10.00	100.00	10.00	1,053,000.00

Activity: 31003 Form/Strip Deck ph 2 Quantity: 50000 Unit: SF

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	0.44	0.48	0.93	0.46	0.00	0.00	0.00	1.38
Total	22,186.56	24,223.56	46,410.12	22,754.76	0.00	0.00	0.00	69,164.88

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
1.3833	0.0024	416.6667	576.3740	12.0000	4,166.6667	0.0002	5,763.7400

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
720.0000	69.4444	0.0144	64.4585	0.4437

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Crew: FPSSM Concrete Form, Pour, Strip Prod: UH 416.6667 Eff: 100.00 Crew Hrs: 120.00 Labor Pcs: 6.00 Equipment Pcs: 2.00

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
8FORK	10,000 LB Forklift	1.00	120.00	HR	101.84	100.00	101.84	12,220.32
8PUMECH	Mechanics Truck	1.00	120.00	HR	87.79	100.00	87.79	10,534.44
FORMAN	FORMAN	1.00	120.00	MH	36.00	110.00	100.73	12,087.84
LABOR SKILL	SKILLED LABORER	3.00	360.00	MH	25.96	110.00	54.19	19,510.03
MASON	Concrete Mason/Finisher	2.00	240.00	MH	27.10	110.00	61.72	14,812.25

Activity: 31004 Pour Deck Quantity: 2435 Unit: CY

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	12.05	11.78	23.83	15.26	0.00	0.00	0.00	39.09
Total	29,340.96	28,680.58	58,021.54	37,154.76	0.00	0.00	0.00	95,176.30

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
39.0868	0.0493	20.2917	793.1358	12.0000	202.9167	0.0049	7,931.3583

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
960.0000	2.5365	0.3943	60.4391	12.0497

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: STRUCT Structures

Crew: FPSSM Concrete Form, Pour, Strip Prod: UH 20.2917 Eff: 100.00 Crew Hrs: 120.00 Labor Pcs: 8.00 Equipment Pcs: 3.00

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
8COP50	Concrete Pump - 50 cy/hr	1.00	120.00	HR	120.00	100.00	120.00	14,400.00
8FORK	10,000 LB Forklift	1.00	120.00	HR	101.84	100.00	101.84	12,220.32
8PUMECH	Mechanics Truck	1.00	120.00	HR	87.79	100.00	87.79	10,534.44

FORMAN	FORMAN	1.00	120.00	MH	36.00	110.00	96.41	11,569.44
LABOR SKILL	SKILLED LABORER	3.00	360.00	MH	25.96	110.00	51.08	18,388.56
MASON	Concrete Mason/Finisher	4.00	480.00	MH	27.10	110.00	58.47	28,063.54

Activity: 31005 Closure Pour Quantity: 1350 Unit: LF

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	11.02	11.85	22.87	8.43	0.00	0.00	0.00	31.30
Total	14,881.68	15,992.20	30,873.88	11,377.38	0.00	0.00	0.00	42,251.26

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
31.2972	0.0444	22.5000	704.1877	6.0000	225.0000	0.0044	7,041.8767

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
480.0000	2.8125	0.3556	64.3206	11.0235

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Crew: FPSSM Concrete Form, Pour, Strip Prod: UH 22.5 Eff: 100.00 Crew Hrs: 60.00 Labor Pcs: 8.00 Equipment Pcs: 2.00

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
8FORK	10,000 LB Forklift	1.00	60.00	HR	101.84	100.00	101.84	6,110.16
8PUMECH	Mechanics Truck	1.00	60.00	HR	87.79	100.00	87.79	5,267.22
CARPENTER	CARPENTER	2.00	120.00	MH	28.70	110.00	63.91	7,668.83
FORMAN	FORMAN	1.00	60.00	MH	36.00	110.00	100.73	6,043.92
LABOR SKILL	SKILLED LABORER	3.00	180.00	MH	25.96	110.00	54.19	9,755.01
MASON	Concrete Mason/Finisher	2.00	120.00	MH	27.10	110.00	61.72	7,406.12

Activity: 32500 Materials Quantity: 1 Unit: CY

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	0.00	0.00	0.00	0.00	1,033,972.56	0.00	0.00	1,033,972.56
Total	0.00	0.00	0.00	0.00	1,033,972.56	0.00	0.00	1,033,972.56

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: CIVIL Heavy Civil

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2C0004	4000 PSI Concrete	1.07	2,434.25	CY	144.00	108.00	155.52	378,574.56
2MISCMAT	MISC MATERIAL	1.00	2,434.00	CY	25.00	108.00	27.00	65,718.00
2REINFSTEEL	REINFORCING STEEL	1.00	455,000.00	LB	1.20	108.00	1.30	589,680.00

Activity: B FPS PARAPET Quantity: 350 Unit: CY

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	79.37	69.42	148.79	60.68	329.40	0.00	0.00	538.87
Total	27,779.14	24,296.28	52,075.42	21,237.77	115,290.00	0.00	0.00	188,603.19

Crew $/Unit	Crew Hrs/Unit	Units/Crew Hr	$/Crew Hour	Shifts	Units/Shift	Shifts/Unit	$/Shift
209.4663	0.3200	3.1250	654.5821	11.2000	31.2500	0.0320	16,839.5705

Manhours	Unit/MH	MH/Unit	Total Labor/MH	Base Labor/Unit
896.0000	0.3906	2.5600	58.1199	79.3690

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: CIVIL Heavy Civil

Crew: FPSSM Concrete Form, Pour, Strip Prod: UH 3.125 Eff: 100.00 Crew Hrs: 112.00 Labor Pcs: 8.00 Equipment Pcs: 2.00

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
2CONC	concrete	1.00	350.00	CY	125.00	108.00	135.00	47,250.00
2REINFSTEEL	REINFORCING STEEL	1.00	52,500.00	LB	1.20	108.00	1.30	68,040.00
8FORK	10,000 LB Forklift	1.00	112.00	HR	101.84	100.00	101.84	11,405.63
8PUMECH	Mechanics Truck	1.00	112.00	HR	87.79	100.00	87.79	9,832.14
CARPENTER	CARPENTER	2.00	224.00	MH	28.70	110.00	57.59	12,900.81
FORMAN	FORMAN	1.00	112.00	MH	36.00	110.00	92.81	10,394.94
LABOR SKILL	SKILLED LABORER	3.00	336.00	MH	25.96	110.00	48.48	16,290.40
MASON	Concrete Mason/Finisher	2.00	224.00	MH	27.10	110.00	55.76	12,489.27

Activity:	C	MARINE EQUIPMENT	Quantity:	1	Unit:	MO

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	0.00	0.00	0.00	0.00	0.00	0.00	685,500.00	685,500.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	685,500.00	685,500.00

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
4BRIDGETRK	Bridge access Truck	1.00	1.25	MO	30,000.00	100.00	30,000.00	37,500.00
4MARINE	Barges, Crane, tugs	1.00	36.00	DAY	18,000.00	100.00	18,000.00	648,000.00

Activity:	D	Install Pedestrian Railing	Quantity:	2700	Unit:	LF

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
4RAIL	Ped Railing	1.00	2,700.00	LF	75.00	100.00	75.00	202,500.00

Activity:	Z	PPC Deck	Quantity:	105300	Unit:	SF

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
4CONC	Concrete - Sub	1.00	86,400.00	SF	12.00	100.00	12.00	1,036,800.00

Biditem 160

Install Light Poles

Takeoff Qty: 6.000 EA

Bid Qty: 6.000 EA

Activity:	A	Install Light Poles	Quantity:	6	Unit:	EA

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
4ELEC	Electric - Sub	1.00	6.00	EA	20,000.00	100.00	20,000.00	120,000.00

Biditem 170

Scour Mitigation

Takeoff Qty: 5.000 EA

Bid Qty: 5.000 EA

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
U. Cost	0.00	0.00	0.00	0.00	0.00	0.00	35,000.00	35,000.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	175,000.00	175,000.00

Activity:	A	Scour Mitigation	Quantity:	5	Unit:	EA

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Notes:
```
Assume 500 SY/Pier

Taken from Tahoe Unit price $1080/SY
           Winona Unit Price $943/SY

Similar Project on the 2013 US-95 Clearwater Scour Mitigation
Standard Ajacks per pier = 2079 Ea Unit price = $60.3 ea = $/Pier = $125,363

Use $150,000 per each Pier for 2018 Construction Season
```

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
4SCOUR	Scour Protection (AJACKS)	1.00	0.00	EA	150,000.00	100.00	0.00	0.00

Activity:	B	Marine Equipment	Quantity:	1	Unit:	MO

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Notes: Included in price of Ajacks

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
4MARINE	Barges, Crane, tugs	1.00	0.00	DAY	18,000.00	100.00	0.00	0.00

Activity: C Scour Mitigation RIPRAP Quantity: 5 Unit: EA

Calendar: 510 5-10 HR WORKWEEK Hrs/Shift: 10 WC: IRON Structural Steel

Resource	Description	Pcs/Wste	Quantity	Unit	Unit Cost	Tax/OT %	Actual UC	Total
4SCOURRIPRAP	RipRap	1.00	5.00	EA	35,000.00	100.00	35,000.00	175,000.00

Report Summary

	Base Labor	Burden	Total Labor	Equipment	Perm Matls	Const Matls	Sub	Total
Total	864,395	941,804	1,806,199	752,037	7,190,194	0	4,782,100	14,530,530

Job Notes

Estimate created on: 11/12/2017 by User#: 0 -
Source estimate used: C:\HEAVYBID\EST\ESTMAST

Calendars Used In Estimate

58	5- 8's
510	5-10 HR WORKWEEK

Appendix C: Deck Widening Structural Analysis

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1. Description

This feasibility study aims to determine the allowable deck width that can be accommodated on the existing pier substructure, which consists of six (6) reinforced concrete columns supported on tall pier footing. The replacement superstructure consists of an 8" deep deck supported on new steel girders, with a new pier cap placed on top of the columns to tie them together and to provide a support for the new girders along the deck width.

This analysis will check the bearing capacity of the pier footings, and the structural capacity of the proposed pier cap, the proposed girders, and the unretrofitted as-built columns.

2. Criteria and references

[1] AASHTO LRFD, 7th Edition

[2] Memorial Bridge As-Built Drawings

[3] AASHTO Manual for Bridge Evaluation, 2011

3. Methods of analysis

- Excel spreadsheets and Mathcad worksheets
- CSi Bridge Analysis Software for structural analysis

4. Assumptions

4.1 Material Properties

- As-built Concrete – f’c = 3ksi per As-Built Drawings; Concrete for retrofit, f’c = 4ksi
- As-Built Rebar – no defined on As-Built Drawings; per AASHTO Manual for Bridge Evaluation, fy = 33ksi for construction pre-1954.
- Structural Steel Girders – Grade 50 steel, fy=50ksi

4.2 Superstructure Forces

The following loads were applied to the superstructure:

4.2.1 Vehicle Live Loading

The modified structure is designed under HL93 design loading, which takes the largest effect from (1) the combination of the HS20 truck loading with a 0.64psf lane load and (2) the combination of the AASHTO design tandem loading with a 0.64psf lane load.

Live load distribution to each girder is applied per LRFD Art. 4.6.2.2.2.

4.2.2 Pedestrian (Live) Loading

Pedestrian loads were applied to the width of the proposed walkway per LRFD 3.6.1.6

5. Analysis Steps

- *Step 1*: Define proposed retrofitted superstructure section including preliminary design of new steel girders (non-composite checks in Mathcad analysis).
- *Step 2*: Calculate superstructure forces to apply to exterior, interior, and center girders (Mathcad).
- *Step 3*: Apply calculated forces to girders to determine design shear and moments in girder for composite section design (GoBeam spreadsheet). Unfactored girder reactions also determined to apply to the 3D analysis model for the substructure analysis.
- *Step 4*: Calculate substructure forces to apply to 3D analysis model (Mathcad).
- *Step 5*: Within CSi Bridge analysis software, apply substructure forces and girder reaction forces to the substructure model. Apply load combinations to determine the controlling shear force and moment demands for the retrofitted bent cap and the as-built columns.
- *Step 6*: Post process the CSi Bridge model output, summarizing the design demands from the model.
- *Step 7*: Check the as-built column capacities against the demands generated from the 3D model (P-M interaction provided by both spreadsheet analysis and CSi Bridge Section Modeler as verification).
- *Step 8*: Check the new bent cap capacity against the demands generated from the 3D model (P-M interaction provided by both spreadsheet analysis).
- *Step 9*: Check the pier footing bearing capacities for (1) the as-built condition and (2) the retrofitted case with the new superstructure and pier cap.
- *Step 10*: Perform design of the replacement girders for the (1) Negative Moment Region and (2) Positive Moment Region.

6. Analysis Step 1: Deck Sections for As-Built and Proposed Retrofit

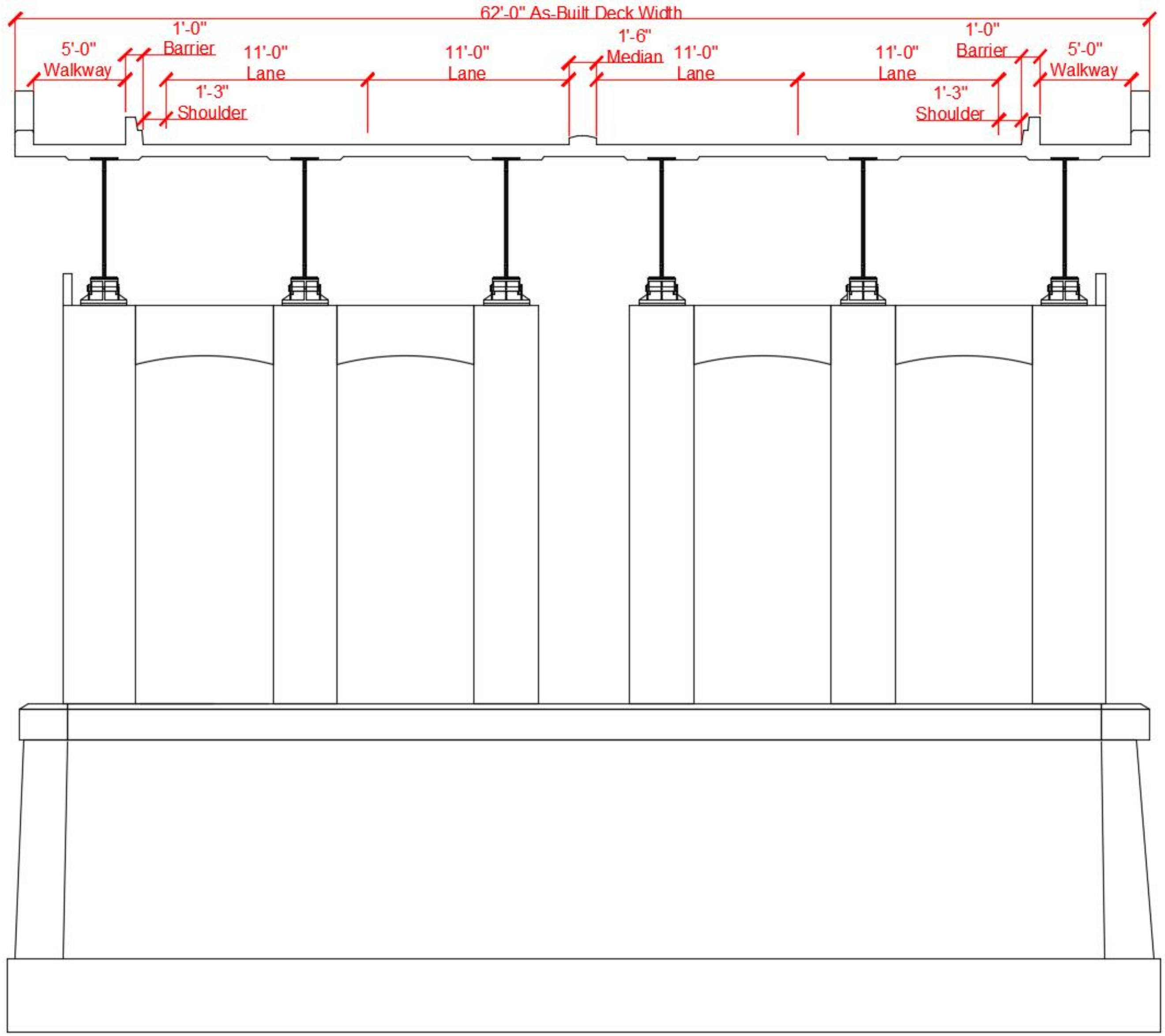
Computation Sheet	Key №:	13455	Page:	1 of 4
Project: ITD US-12 Memorial Bridge Feasibility Study	Made by:	JWC	Date:	9/27/17
Subject: Draft Deck Sections | As-Built 62'-0" Deck Width	Checked by:		Date:	

Deck Section Properties:

Deck Width: 62'-0"

- 4 – 11' wide lanes
- 1'-3" shoulders, 5'-0" walkways, no shoulder to median

Number of Girders: 6 @ 11' typ (8'-6" for center girders) with 4'-10" overhangs



Computation Sheet	Key №: 13455	Page: 2 of 4
Project: *ITD US-12 Memorial Bridge Feasibility Study*	Made by: JWC	Date: 10/24/17
Subject: *Draft Deck Sections | Proposed 78'-0" Deck Width*	Checked by:	Date:

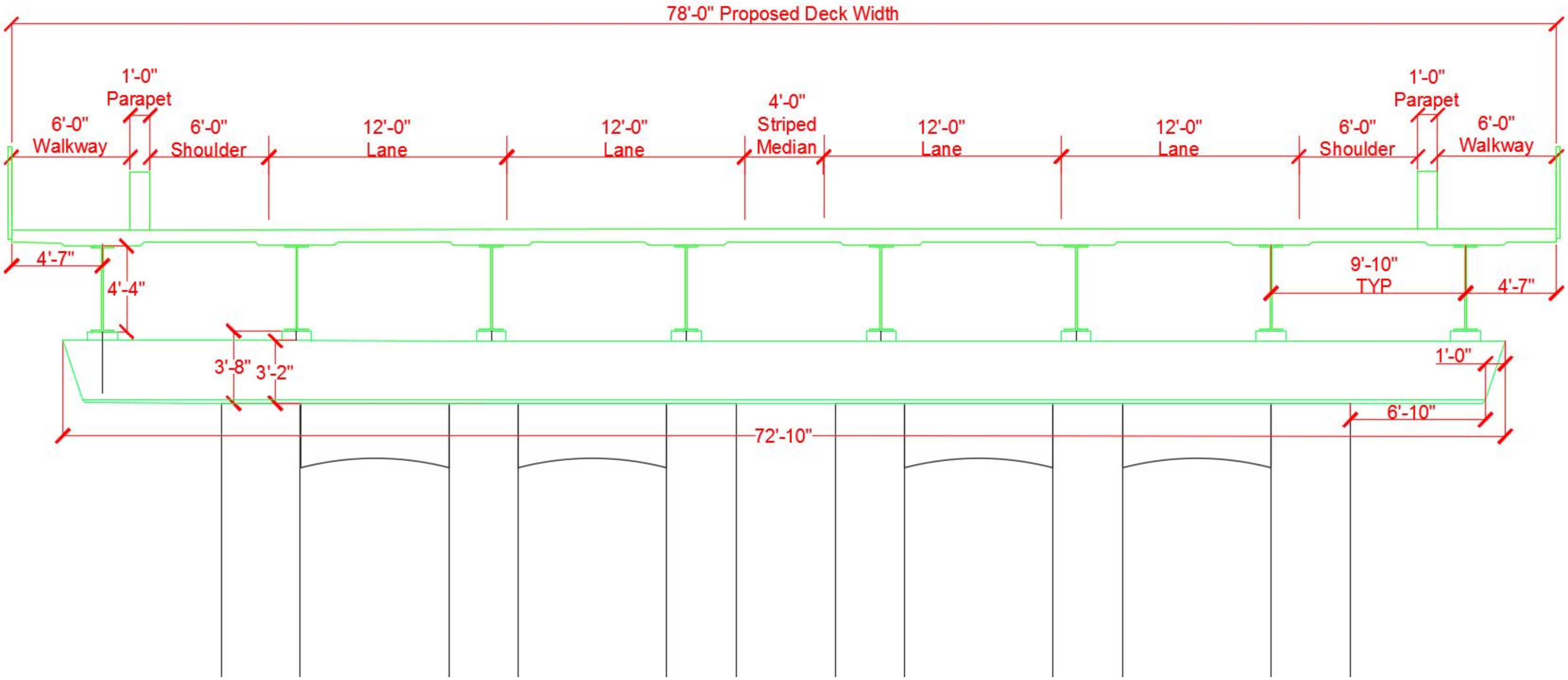
Deck Section Properties:

Deck Width: 78'-0"

- 4 – 12' wide lanes
- 6'-0" shoulders, 6'-0" walkways, 4'-0" striped median

Number of Girders: 8 @ 9'-10" with 4'-7" overhangs

Bent Cap: 3'-2" high x 5' wide



7. Analysis Step 2: Superstructure Force Calculations

Preliminary Single-Span Steel Girder Design:

Input Bridge Properties

Bridge Deck Dimensions

Lane Number & Width: $N_{lane} := 4$ $W_{lane} := 12ft$

Shoulder Number & Width: $N_{shoulder} := 2$ $W_{shoulder} := 6ft$

Barrier Number & Width: $N_{median} := 0$ $W_{median} := 2ft$ $N_{med\_should} := 1$ $W_{med\_should} := 4ft$

$N_{barrier} := 2$ $W_{barrier} := 1ft + 0in$ $h_{barrier} := 2ft + 8in$

Assumed Barrier Weight: $w_{median} := 408plf$ per ITD Bridge Rail Properties for "Median Parapet"

$w_{barrier} := 265plf$ per ITD Bridge Rail Properties for "Combo Ped Rail & Parapet"

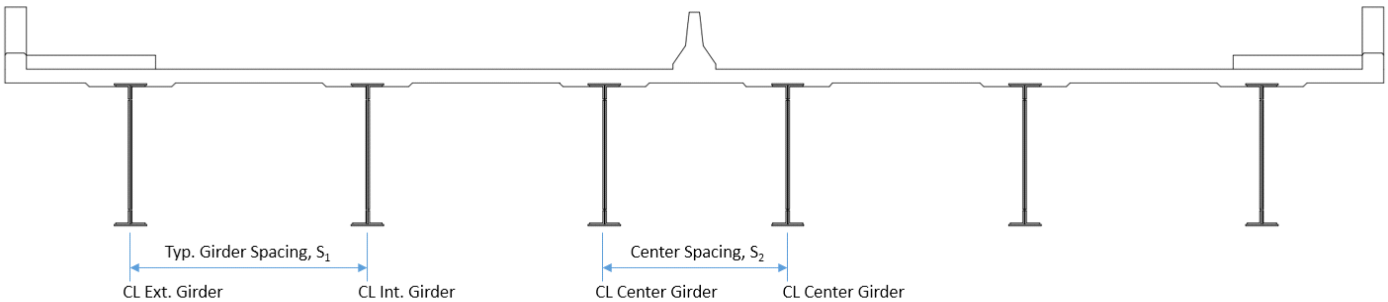
Walkway Number & Width: $N_{walk} := 2$ $W_{walk} := 6ft$ Height (above deck): $h_{walk} := 8in$

Span Length: $L_{span} := 112ft$

Number of Continuous Spans: $N_{span} := 3$

Girder Spacing: $S_1 := 9ft + 10in$ typical, UNO $S_2 := 9ft + 10in$ between center girders

Overhang Length (from Ext Girder CL): $W_{overhang} := 4ft + 7in$ Number of Girders: $N_{girder} := 8$



Superstructure Cross-Section

	Exterior Girder	Interior Girder	Center Girder
Girder Tributary Widths	$w_{trib\_ext} := \frac{S_1}{2} + W_{overhang}$	$w_{trib\_int} := S_1$	$w_{trib\_cent} := \frac{S_1 + S_2}{2}$
	$w_{trib\_ext} = 9.50\,ft$	$w_{trib\_int} = 9.83\,ft$	$w_{trib\_cent} = 9.83\,ft$

Girder Dimensions

Top Flange Thickness: $t_{f\_top} := \begin{pmatrix} 1 \\ 2 \end{pmatrix} in$ $\begin{pmatrix} \text{Positive} \\ \text{Negative} \end{pmatrix}$

Top Flange Width: $b_{f\_top} := \begin{pmatrix} 16 \\ 16 \end{pmatrix} in$ $\begin{pmatrix} \text{Positive} \\ \text{Negative} \end{pmatrix}$

Bottom Flange Thickness: $t_{f\_bot} := \begin{pmatrix} 1 \\ 2 \end{pmatrix} in$ $\begin{pmatrix} \text{Positive} \\ \text{Negative} \end{pmatrix}$

Bottom Flange Width: $b_{f\_bot} := \begin{pmatrix} 16 \\ 16 \end{pmatrix} in$ $\begin{pmatrix} \text{Positive} \\ \text{Negative} \end{pmatrix}$

Web Thickness: $t_w := \begin{pmatrix} 0.5 \\ 0.5 \end{pmatrix} in$ $\begin{pmatrix} \text{Positive} \\ \text{Negative} \end{pmatrix}$

Web Height: $h_w := \begin{pmatrix} 50 \\ 50 \end{pmatrix} in$ $\begin{pmatrix} \text{Positive} \\ \text{Negative} \end{pmatrix}$

Concrete Deck & Haunch Dimensions

Deck Thickness: $t_{deck} := 8in$

Haunch Thickness: $t_{haunch} := 3in$

Haunch Width: $b_{haunch} := b_{f\_bot_1} + 8in = 24 \cdot in$

Haunch Area (for weight calcs)

$A_{haunch} := t_{haunch} \cdot (b_{haunch}) = 72 \cdot in^2$

NOTE:
Positive Region: For max (+) Moment (near mid-span)
Negative Region: For max (-) Moment (@ Inter. support)

Length of Positive Region Girder: $L_{pos} := 82ft$

Length of Negative Region Girder: $L_{neg} := L_{span} - L_{pos} = 30\,ft$

Material Properties

Structural Steel Yield Stress: $f_y := 50ksi$

Steel Unit Weight: $\gamma_s := 490pcf$

Modulus of Elasticity: $E_s := 29000ksi$

Concrete Compressive Stress: $f'_c := 4ksi$

Reinforced Concrete Unit Weight: $\gamma_c := 155pcf$

Input Bridge Properties

Girder Preliminary Dimension Checks

Girder Spacing

$$W_{deck} := N_{lane} \cdot W_{lane} + N_{shoulder} \cdot W_{shoulder} + N_{walk} \cdot W_{walk} \ldots + N_{barrier} \cdot W_{barrier} + N_{median} \cdot W_{median} + N_{med\_should} \cdot W_{med\_should}$$

$$W_{deck} = 78 \cdot ft$$

Girder Cross-Sectional Properties - Top Value is for the Positive Region, Bottom Value for the Negative Region

Girder Depth

$$D := t_{f\_bot} + h_w + t_{f\_top} \qquad D = \begin{pmatrix} 52 \\ 54 \end{pmatrix} \cdot in$$

Cross-Sectional Area

$$A_{girder} := \begin{pmatrix} b_{f\_top_1} \cdot t_{f\_top_1} + b_{f\_bot_1} \cdot t_{f\_bot_1} + h_{w_1} \cdot t_{w_1} \\ b_{f\_top_2} \cdot t_{f\_top_2} + b_{f\_bot_2} \cdot t_{f\_bot_2} + h_{w_2} \cdot t_{w_2} \end{pmatrix} \qquad A_{girder} = \begin{pmatrix} 57 \\ 89 \end{pmatrix} \cdot in^2$$

Neutral Axis Depth

$$y_{NA} := \frac{b_{f\_top} \cdot t_{f\_top} \cdot \left(h_w + t_{f\_bot} + \frac{t_{f\_top}}{2} \right) + h_w \cdot t_w \cdot \left(t_{f\_bot} + \frac{h_w}{2} \right) + b_{f\_bot} \cdot t_{f\_bot} \cdot \left(\frac{t_{f\_bot}}{2} \right)}{b_{f\_top} \cdot t_{f\_top} + h_w \cdot t_w + b_{f\_bot} \cdot t_{f\_bot}} \qquad y_{NA} = \begin{pmatrix} 26 \\ 27 \end{pmatrix} \cdot in$$

Moment of Inertia

$$Ixx_{f\_top} := \begin{bmatrix} \frac{b_{f\_top_1} \cdot \left(t_{f\_top_1}\right)^3}{12} \\ \frac{b_{f\_top_2} \cdot \left(t_{f\_top_2}\right)^3}{12} \end{bmatrix} = \begin{pmatrix} 1.3 \\ 10.7 \end{pmatrix} \cdot in^4 \qquad Ixx_{f\_bot} := \begin{bmatrix} \frac{b_{f\_bot_1} \cdot \left(t_{f\_bot_1}\right)^3}{12} \\ \frac{b_{f\_bot_2} \cdot \left(t_{f\_bot_2}\right)^3}{12} \end{bmatrix} = \begin{pmatrix} 1.3 \\ 10.7 \end{pmatrix} \cdot in^4 \qquad Ixx_{web} := \begin{bmatrix} \frac{t_{w_1} \cdot \left(h_{w_1}\right)^3}{12} \\ \frac{t_{w_2} \cdot \left(h_{w_2}\right)^3}{12} \end{bmatrix} = \begin{pmatrix} 5208 \\ 5208 \end{pmatrix} \cdot in^4$$

$$I_{xx_1} := \left[Ixx_{web_1} + t_{w_1} \cdot h_{w_1} \cdot \left(t_{f\_bot_1} + \frac{h_{w_1}}{2} - y_{NA_1} \right)^2 \right] \ldots + \left[Ixx_{f\_top_1} + t_{f\_top_1} \cdot b_{f\_top_1} \cdot \left(h_{w_1} + t_{f\_bot_1} + \frac{t_{f\_top_1}}{2} - y_{NA_1} \right)^2 \right] \ldots + \left[Ixx_{f\_bot_1} + t_{f\_bot_1} \cdot b_{f\_bot_1} \cdot \left(y_{NA_1} - \frac{t_{f\_bot_1}}{2} \right)^2 \right]$$

$$I_{xx_2} := \left[Ixx_{web_2} + t_{w_2} \cdot h_{w_2} \cdot \left(t_{f\_bot_2} + \frac{h_{w_2}}{2} - y_{NA_2}\right)^2\right] \dots$$
$$+ \left[Ixx_{f\_top_2} + t_{f\_top_2} \cdot b_{f\_top_2} \cdot \left(h_{w_2} + t_{f\_bot_2} + \frac{t_{f\_top_2}}{2} - y_{NA_2}\right)^2\right] \dots$$
$$+ \left[Ixx_{f\_bot_2} + t_{f\_bot_2} \cdot b_{f\_bot_2} \cdot \left(y_{NA_2} - \frac{t_{f\_bot_2}}{2}\right)^2\right]$$

$$I_{xx} = \begin{pmatrix} 26019 \\ 48493.67 \end{pmatrix} \cdot in^4$$

$$Iyy_{f\_top} := \begin{bmatrix} \frac{t_{f\_top_1} \cdot \left(b_{f\_top_1}\right)^3}{12} \\ \frac{t_{f\_top_2} \cdot \left(b_{f\_top_2}\right)^3}{12} \end{bmatrix} = \begin{pmatrix} 341 \\ 683 \end{pmatrix} \cdot in^4 \qquad Iyy_{f\_bot} := \begin{bmatrix} \frac{t_{f\_bot_1} \cdot \left(b_{f\_bot_1}\right)^3}{12} \\ \frac{t_{f\_bot_2} \cdot \left(b_{f\_bot_2}\right)^3}{12} \end{bmatrix} = \begin{pmatrix} 341 \\ 683 \end{pmatrix} \cdot in^4 \qquad Iyy_{web} := \begin{bmatrix} \frac{h_{w_1} \cdot \left(t_{w_1}\right)^3}{12} \\ \frac{h_{w_2} \cdot \left(t_{w_2}\right)^3}{12} \end{bmatrix} = \begin{pmatrix} 0.5 \\ 0.5 \end{pmatrix} \cdot in^4$$

$$I_{yy} := Iyy_{web} + Iyy_{f\_top} + Iyy_{f\_bot} \qquad I_{yy} = \begin{pmatrix} 683.19 \\ 1365.85 \end{pmatrix} \cdot in^4$$

Depth to Tension Fiber

$$c_x := \frac{h_w}{2} + t_{f\_bot} \qquad c_x = \begin{pmatrix} 26 \\ 27 \end{pmatrix} \cdot in$$

$$y_b := c_x$$

$$y_t := c_x$$

$$c_y := \begin{pmatrix} \frac{\min\left(b_{f\_top_1}, b_{f\_bot_1}\right)}{2} \\ \frac{\min\left(b_{f\_top_2}, b_{f\_bot_2}\right)}{2} \end{pmatrix} \qquad c_y = \begin{pmatrix} 8 \\ 8 \end{pmatrix} \cdot in$$

Elastic Section Modulus

$$S_x := \frac{I_{xx}}{c_x} \qquad S_x = \begin{pmatrix} 1000.7 \\ 1796.1 \end{pmatrix} \cdot in^3$$

$$S_y := \frac{I_{yy}}{c_y} \qquad S_y = \begin{pmatrix} 85.4 \\ 170.7 \end{pmatrix} \cdot in^3$$

Plastic Section Modulus

$$Z_x := \begin{bmatrix} \frac{t_{w_1}\cdot\left(h_{w_1}\right)^2}{4} + t_{f\_top_1}\cdot b_{f\_top_1}\cdot\left(\frac{h_{w_1}}{2}+\frac{t_{f\_top_1}}{2}\right) + t_{f\_bot_1}\cdot b_{f\_bot_1}\cdot\left(\frac{h_{w_1}}{2}+\frac{t_{f\_bot_1}}{2}\right) \\ \frac{t_{w_2}\cdot\left(h_{w_2}\right)^2}{4} + t_{f\_top_2}\cdot b_{f\_top_2}\cdot\left(\frac{h_{w_2}}{2}+\frac{t_{f\_top_2}}{2}\right) + t_{f\_bot_2}\cdot b_{f\_bot_2}\cdot\left(\frac{h_{w_2}}{2}+\frac{t_{f\_bot_2}}{2}\right) \end{bmatrix} \qquad Z_x = \begin{pmatrix} 1128.5 \\ 1976.5 \end{pmatrix}\cdot in^3$$

$$Z_y := \begin{bmatrix} \frac{h_{w_1}\cdot\left(t_{w_1}\right)^2}{4} + \frac{t_{f\_top_1}\cdot\left(b_{f\_top_1}\right)^2}{4} + \frac{t_{f\_bot_1}\cdot\left(b_{f\_bot_1}\right)^2}{4} \\ \frac{h_{w_2}\cdot\left(t_{w_2}\right)^2}{4} + \frac{t_{f\_top_2}\cdot\left(b_{f\_top_2}\right)^2}{4} + \frac{t_{f\_bot_2}\cdot\left(b_{f\_bot_2}\right)^2}{4} \end{bmatrix} \qquad Z_y = \begin{pmatrix} 131.1 \\ 259.1 \end{pmatrix}\cdot in^3$$

Elastic Bending Capacity

$$M_{yx} := S_x\cdot f_y \qquad M_{yx} = \begin{pmatrix} 4169.7 \\ 7483.6 \end{pmatrix}\cdot kip\cdot ft$$

$$M_{yy} := S_y\cdot f_y \qquad M_{yy} = \begin{pmatrix} 355.8 \\ 711.4 \end{pmatrix}\cdot kip\cdot ft$$

Plastic Bending Capacity

$$M_{px} := Z_x\cdot f_y \qquad M_{px} = \begin{pmatrix} 4702.1 \\ 8235.4 \end{pmatrix}\cdot kip\cdot ft$$

$$M_{py} := Z_y\cdot f_y \qquad M_{py} = \begin{pmatrix} 546.4 \\ 1079.7 \end{pmatrix}\cdot kip\cdot ft$$

Preliminary Girder Checks

Article, Table, Figure and Equation references are for AASHTO LRFD Bridge Specifications unless otherwise noted

Minimum Depth (Table 2.5.2.6.3-1)

$$D_{min} := 0.032\cdot L_{span} \qquad \boxed{D_{min} = 43\cdot in}$$

$$CHECK_1 := \begin{vmatrix} \text{"Minimum Depth - OK"} & \text{if} & \min(D) \geq D_{min} \\ \text{"Minimum Depth - NG"} & \text{if} & \min(D) < D_{min} \end{vmatrix} = \text{"Minimum Depth - OK"}$$

$$\boxed{\frac{D_1}{D_{min}} = 1.21} \qquad \boxed{\frac{D_2}{D_{min}} = 1.26}$$

Minimum Web Thickness (Eq. 6.10.2.1-2)

$$CHECK_2 := \begin{cases} \text{"Web Thickness - OK"} & \text{if } \dfrac{D_1}{t_{w_1}} \le 150 \;\wedge\; \dfrac{D_1}{t_{w_1}} \le 150 \\ \text{"Web Thickness - NG"} & \text{otherwise} \end{cases} = \text{"Web Thickness - OK"}$$

$$\frac{D}{t_w} = \begin{pmatrix} 104 \\ 108 \end{pmatrix} \qquad \frac{150}{\left(\frac{D}{t_w}\right)} = \begin{pmatrix} 1.4 \\ 1.4 \end{pmatrix}$$

$$CHECK_3 := \begin{cases} \text{"Minimum Web Thickness - OK"} & \text{if } t_{w_1} \ge 0.5in \;\wedge\; t_{w_2} \ge 0.5in \\ \text{"Minimum Web Thickness - NG"} & \text{otherwise} \end{cases} = \text{"Minimum Web Thickness - OK"}$$

$$\frac{t_{w_1}}{0.5in} = 1.00$$

Minimum Flange Width (Eq. 6.10.2.2-2)

$$b_f := \begin{pmatrix} \min\left(b_{f\_top_1}, b_{f\_bot_1}\right) \\ \min\left(b_{f\_top_2}, b_{f\_bot_2}\right) \end{pmatrix} = \begin{pmatrix} 16 \\ 16 \end{pmatrix} \cdot in$$

$$CHECK_4 := \begin{cases} \text{"Flange Width - OK"} & \text{if } b_{f_1} \ge \dfrac{D_1}{6} \;\wedge\; b_{f_2} \ge \dfrac{D_2}{6} \\ \text{"Flange Width - NG"} & \text{otherwise} \end{cases} = \text{"Flange Width - OK"}$$

$$\frac{D}{6} = \begin{pmatrix} 8.7 \\ 9 \end{pmatrix} \cdot in \qquad \frac{b_f}{\left(\frac{D}{6}\right)} = \begin{pmatrix} 1.8 \\ 1.8 \end{pmatrix}$$

Minimum Flange Thickness (Eq. 6.10.2.2-3)

$$t_f := \begin{pmatrix} \min\left(t_{f\_top_1}, t_{f\_bot_1}\right) \\ \min\left(t_{f\_top_2}, t_{f\_bot_2}\right) \end{pmatrix} = \begin{pmatrix} 1.0 \\ 2.0 \end{pmatrix} \cdot in$$

$$\max\left(0.75in, 1.1 \cdot t_w\right) = 0.75 \cdot in \qquad \frac{t_f}{\left(\left(\max\left(0.75in, 1.1 \cdot t_w\right)\right)\right)} = \begin{pmatrix} 1.3 \\ 2.7 \end{pmatrix}$$

$$CHECK_5 := \begin{cases} \text{"Minimum Flange Thickness - OK"} & \text{if } t_{f_1} \ge \max\left(0.75in, 1.1 \cdot t_{w_1}\right) \;\wedge\; t_{f_2} \ge \max\left(0.75in, 1.1 \cdot t_{w_2}\right) \\ \text{"Minimum Flange Thickness - NG"} & \text{otherwise} \end{cases} = \text{"Minimum Flange Thickness - OK"}$$

Top Flange Width (Eq. C6.10.3.4-1)

$$CHECK_6 := \begin{cases} \text{"Min Top Flange Width - OK"} & \text{if } \begin{cases} b_{f\_top_1} \geq \dfrac{L_{span}}{85} \\ b_{f\_top_1} \geq \dfrac{L_{span}}{85} \end{cases} \\ \text{"Min Top Flange Width - NG"} & \text{otherwise} \end{cases}$$

$$\frac{L_{span}}{85} = 15.8 \cdot in$$

$$\frac{b_{f\_top}}{\left(\dfrac{L_{span}}{85}\right)} = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$$

$$CHECK_6 = \text{"Min Top Flange Width - OK"}$$

Flange Width to Thickness Ratio (Eq. 6.10.2.2-1)

$$CHECK_7 := \begin{cases} \text{"Flange Width to Thickness Ratio - OK"} & \text{if } \begin{cases} \dfrac{b_{f_1}}{2 \cdot t_{f_1}} \leq 12.0 \\ \dfrac{b_{f_2}}{2 \cdot t_{f_2}} \end{cases} \\ \text{"Flange Width to Thickness Ratio - NG"} & \text{otherwise} \end{cases} = \text{"Flange Width to Thickness Ratio - OK"}$$

$$\frac{b_f}{2 \cdot t_f} = \begin{pmatrix} 8 \\ 4 \end{pmatrix} \qquad \frac{12.0}{\left(\dfrac{b_f}{2 \cdot t_f}\right)} = \begin{pmatrix} 1.5 \\ 3 \end{pmatrix}$$

Check Summary

$$CHECK = \begin{pmatrix} \text{"Minimum Depth - OK"} \\ \text{"Web Thickness - OK"} \\ \text{"Minimum Web Thickness - OK"} \\ \text{"Flange Width - OK"} \\ \text{"Minimum Flange Thickness - OK"} \\ \text{"Min Top Flange Width - OK"} \\ \text{"Flange Width to Thickness Ratio - OK"} \end{pmatrix}$$

Girder Preliminary Dimension Checks

Superstructure Forces

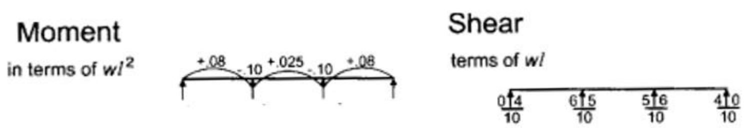
Girder Forces Along Span - Values in yellow applied to GoBeam spreadsheet to determine moment envelopes along span

Girder Uniform Weight Along Span

Average Girder Area Along Span: $A_{gird\_ave} := \dfrac{A_{girder_1} \cdot L_{pos} + A_{girder_2} \cdot L_{neg}}{L_{span}}$ $A_{gird\_ave} = 65.6 \cdot in^2$

Girder Uniform Weight along Span: $w_{girder} := A_{gird\_ave} \cdot \gamma_s$ $w_{girder} = 0.22 \cdot \dfrac{kip}{ft}$

Maximum (+) and (-) Moments along Continuous Section: *For 3-span Continuous Section*



Max (+) Moment: $M_{pos\_girder} := 0.08 w_{girder} \cdot L_{span}^2$ $M_{pos\_girder} = 223.9 \cdot kip \cdot ft$

Max (-) Moment: $M_{neg\_girder} := -0.10 w_{girder} \cdot L_{span}^2$ $M_{neg\_girder} = -279.9 \cdot kip \cdot ft$

Shear @ End Supports: $V_{girder1} := \dfrac{4}{10} w_{girder} \cdot L_{span}$ $V_{girder1} = 10 \cdot kip$

Shear @ Int. Support: $V_{girder2} := \dfrac{6}{10} w_{girder} \cdot L_{span}$ $V_{girder2} = 15 \cdot kip$

Additional DC Distributed Forces along Girders
(Barriers, Median, and Sidewalk forces distributed equally to all girders per AASHTO C4.6.1.2.4b)

Diaphragm and Cross-Bracing Uniform Weight along Span: $w_{diaph} := \begin{pmatrix} 0.03 \\ 0.03 \\ 0.03 \end{pmatrix} \dfrac{kip}{ft}$ $\begin{pmatrix} \text{Exterior Girder} \\ \text{Interior Girder} \\ \text{Center Girder} \end{pmatrix}$ *30 plf assumed per girder*

Concrete Deck and Haunches: $w_{deck} := \gamma_c \cdot t_{deck} \cdot \begin{pmatrix} w_{trib\_ext} \\ w_{trib\_int} \\ w_{trib\_cent} \end{pmatrix} + A_{haunch} \cdot \gamma_c$ $w_{deck} = \begin{pmatrix} 1.06 \\ 1.09 \\ 1.09 \end{pmatrix} \cdot \dfrac{kip}{ft}$

Barrier and Median Force per girder: $w_{bar\_med} := \dfrac{N_{barrier} \cdot w_{barrier} + N_{median} \cdot w_{median}}{N_{girder}}$ $w_{bar\_med} = 0.07 \cdot \dfrac{kip}{ft}$

Walkway: $w_{walk} := \dfrac{\gamma_c \cdot h_{walk} \cdot W_{walk} \cdot N_{walk}}{N_{girder}} = 0.2 \cdot \dfrac{kip}{ft}$ $w_{walk} = 0.16 \cdot \dfrac{kip}{ft}$

DW Forces: Future Overlay $W_{overlay} := 25psf$

Distributed Force along Girders: $w_{overlay} := W_{overlay} \cdot \begin{pmatrix} w_{trib\_ext} \\ w_{trib\_int} \\ w_{trib\_cent} \end{pmatrix}$ $w_{overlay} = \begin{pmatrix} 0.24 \\ 0.25 \\ 0.25 \end{pmatrix} \cdot \dfrac{kip}{ft}$

Superstructure Forces

Composite Deck Calculations for Modular Ratio of n - POSITIVE MOMENT REGION

Beam Dimensions

Cast-In-Place Slab Concrete - Modulus of Elasticity (LRFD 5.4.2.4-1)

$$E_{c\_slab} := \left[33000 \cdot \left(\frac{\gamma_c - 5pcf}{\frac{kip}{ft^3}}\right)^{1.5} \cdot \sqrt{\frac{f'_c}{ksi}}\right] \cdot ksi \qquad E_{c\_slab} = 3834 \cdot ksi$$

Effective Deck Width of Composite Section (LRFD 4.6.2.6.1)

$$S_{eff} := \min\left[\frac{L_{span}}{4}, \left(12 \cdot t_{deck} + \max\left(t_{w_1}, \frac{b_{f_1}}{2}\right)\right), S_1, S_2\right] \qquad S_{eff} = 104 \cdot in$$

Composite Transformation

Modular Ratio Between Slab and Beam Materials (LRFD 5.7.1)

$$n := \frac{E_s}{E_{c\_slab}} \qquad n = 7.5634$$

Transformed Flange Width

$$b_{f\_tr} := \frac{S_{eff}}{n} \qquad b_{f\_tr} = 13.75 \cdot in$$

Transformed Deck Area

$$A_{flange\_trans} := \frac{S_{eff} \cdot t_{deck}}{N} \qquad A_{flange\_trans} = 115\, ft^{-1} \cdot lb^{-1} \cdot s^2 \cdot in^2$$

Haunch Dimensions

Transformed Width of Haunch

$$b_{haunch\_tr} := \frac{b_{haunch}}{n} \qquad b_{haunch\_tr} = 3.2 \cdot in$$

Transformed Area of Haunch

$$t_{haunch} = 3 \cdot in$$

$$A_{haunch\_tr} := b_{haunch\_tr} \cdot t_{haunch} \qquad A_{haunch\_tr} = 9.5 \cdot in^2$$

Deck Moment of Inertia

$$I_{haunch\_tr} := \frac{b_{haunch\_tr} \cdot t_{haunch}^3}{12} \qquad I_{haunch\_tr} = 7.14 \cdot in^4$$

Deck Dimensions

Cross-Sectional Deck Area

$A_{deck\_tr} := b_{f\_tr} \cdot t_{deck} = 0.8\, ft^2$ $\qquad A_{deck\_tr} = 110 \cdot in^2$

Deck Moment of Inertia

$$I_{deck\_tr} := \frac{b_{f\_tr} \cdot t_{deck}^{\,3}}{12} \qquad I_{deck\_tr} = 586.7 \cdot in^4$$

Composite Sectional Properties

Number of Individual Sections

$i := 1 .. 3$

Cross-Sectional Area of Composite Section

$A_c := A_{girder_1} + A_{haunch\_tr} + A_{deck\_tr}$ $\qquad A_c = 177 \cdot in^2$

Overall Depth of Composite Section

$h_c := D_1 + t_{deck} + t_{haunch}$ $\qquad h_c = 63 \cdot in$

Distance From Bottom of Composite Section To Centroid Individual Section

$$y_{b\_tr} := \begin{pmatrix} y_{b_1} \\ D_1 + \frac{t_{haunch}}{2} \\ D_1 + t_{haunch} + \frac{t_{deck}}{2} \end{pmatrix} = \begin{pmatrix} 26 \\ 53.5 \\ 59 \end{pmatrix} \cdot in \quad \begin{pmatrix} \text{"Girder"} \\ \text{"Haunch"} \\ \text{"Deck"} \end{pmatrix}$$

Respective Transformed Areas * Distances From Bottom of Composite Section To Centroid Individual Section

$$A := \begin{pmatrix} A_{girder_1} \\ A_{haunch\_tr} \\ A_{deck\_tr} \end{pmatrix} = \begin{pmatrix} 57 \\ 9.5 \\ 110 \end{pmatrix} \cdot in^2 \qquad \begin{pmatrix} \text{"Girder"} \\ \text{"Haunch"} \\ \text{"Deck"} \end{pmatrix}$$

$$A_{y\_b_i} := A_i \cdot y_{b\_tr_i} \qquad A_{y\_b} = \begin{pmatrix} 1482 \\ 509.29 \\ 6490.2 \end{pmatrix} \cdot in^3$$

Distance From Bottom Fiber of Beam to Centroid of Composite Section

$$y_{bc} := \frac{A_1 \cdot y_{b\_tr_1} + A_2 \cdot y_{b\_tr_2} + A_3 \cdot y_{b\_tr_3}}{A_1 + A_2 + A_3} \qquad y_{bc} = 48 \cdot in$$

Distance From Centroid of Composite Section to Top of Beam

$y_{tg} := D_1 - y_{bc}$ $\qquad y_{tg} = 4 \cdot in$

Distance From Centroid of Composite Section to Top of Deck

$y_{tc} := h_c - y_{bc}$ $\qquad y_{tc} = 15 \cdot in$

Areas * Distances Between Centroid of Composite Section and Individual Sections Squared

$Ad2_i := A_i \cdot \left(y_{bc} - y_{b\_tr_i}\right)^2$ $\qquad Ad2 = \begin{pmatrix} 27707 \\ 283 \\ 13196 \end{pmatrix} \cdot in^4$

Composite Moment of Inertia (Parallel Axis Theorem: $I = I_i + A_i{*}d_i^2$)

$I_{c\_beam} := I_{xx_1} + Ad2_1$ $\qquad I_{c\_beam} = 53726 \cdot in^4$

$I_{c\_haunch} := I_{haunch\_tr} + Ad2_2$ $\qquad I_{c\_haunch} = 290 \cdot in^4$

$I_{c\_deck} := I_{deck\_tr} + Ad2_3$ $\qquad I_{c\_deck} = 13782 \cdot in^4$

$I_{c\_pos} := I_{c\_beam} + I_{c\_haunch} + I_{c\_deck}$ $\qquad I_{c\_pos} = 67799 \cdot in^4$

Composite Section Modulus For Composite Beam Bottom

$S_{bc\_pos} := \dfrac{I_{c\_pos}}{y_{bc}}$ $\qquad S_{bc\_pos} = 1411 \cdot in^3$

Composite Section Modulus For Extreme Top Fiber of Girder

$S_{tg\_pos} := \dfrac{I_{c\_pos}}{y_{tg}}$ $\qquad S_{tg\_pos} = 17154 \cdot in^3$

Composite Section Modulus For Extreme Top Fiber of Deck Slab

$S_{tc\_pos} := \left(\dfrac{1}{n}\right) \cdot \left(\dfrac{I_{c\_pos}}{y_{tc}}\right)$ $\qquad S_{tc\_pos} = 600 \cdot in^3$

Composite Deck Calculations for Modular Ratio of n - POSITIVE MOMENT REGION

Live Load Distribution Factors

The Live Load distribution factors calculated here are inserted into the spreadsheet summarizing the shears and moments for the unfactored single lane of HL93 live load (plus impact) along the girder length. This generates the LL distributed to each girder.

Distance Between CoG of Girder and Deck
LRFD 4.6.2.2.1

$$e_g := \frac{h_w}{2} + t_{f\_bot} + t_{haunch} + \frac{t_{deck}}{2} = \begin{pmatrix} 33 \\ 34 \end{pmatrix} \cdot in \qquad \begin{pmatrix} \text{Positive Region} \\ \text{Negative Region} \end{pmatrix}$$

Longitudinal Stiffness Parameter
LRFD Eq. 4.6.2.2.1-1

$$K_g := n \cdot \left[I_{xx} + \begin{bmatrix} A_{girder_1} \cdot \left(e_{g_1}\right)^2 \\ A_{girder_2} \cdot \left(e_{g_2}\right)^2 \end{bmatrix} \right] = \begin{pmatrix} 6.7 \times 10^5 \\ 1.1 \times 10^6 \end{pmatrix} \cdot in^4 \qquad \begin{pmatrix} \text{Positive Region} \\ \text{Negative Region} \end{pmatrix}$$

$$LL\_CHECK_1 := \begin{cases} \text{"Table 4.6.2.2.2b-1 Applicable - OK"} & \text{if } \begin{cases} 3.5ft \le S_1 \le 16ft \\ 3.5ft \le S_2 \le 16ft \\ 4.5in \le t_{deck} \le 12in \\ 20ft \le L_{span} \le 240ft \\ 4 \le N_{girder} \\ 10000in^4 \le K_{g_1} \le 7000000in^4 \\ 10000in^4 \le K_{g_2} \le 7000000in^4 \end{cases} \\ \text{"Table 4.6.2.2.2b-1 NOT Applicable - NG"} & \text{otherwise} \end{cases}$$

$S_1 = 9.8\,ft$ $\quad S_2 = 9.8\,ft$

$t_{deck} = 8 \cdot in$

$L_{span} = 112\,ft$

$N_{girder} = 8$

$$K_g = \begin{pmatrix} 6.7 \times 10^5 \\ 1.1 \times 10^6 \end{pmatrix} \cdot in^4$$

$LL\_CHECK_1 = \text{"Table 4.6.2.2.2b-1 Applicable - OK"}$

Live Load Distribution Factors - input for HL93 Load Moment and Shear Diagram spreadsheet

Table 4.6.2.2.1-2: L for use in LL Distribution Factor Equations:

- For Positive Moment and Shear, $L = L_{span}$
- For Negative Moment, $L = average(L_{span1}, L_{span2}) = L_{span}$

Moment in Interior Beams: LRFD Table 4.6.2.2.2b-1

One Lane Loaded:

Positive Moment
$$g_{int\_posmom\_1} := 0.06 + \left(\frac{S_1}{14ft}\right)^{0.4} \cdot \left(\frac{S_1}{L_{span}}\right)^{0.3} \cdot \left[\frac{K_{g_1}}{L_{span} \cdot \left(t_{deck}^{\ 3}\right)}\right]^{0.1} = 0.48$$

Negative Moment
$$g_{int\_negmom\_1} := 0.06 + \left(\frac{S_1}{14ft}\right)^{0.4} \cdot \left(\frac{S_1}{L_{span}}\right)^{0.3} \cdot \left[\frac{K_{g_2}}{\left(L_{span}\right) \cdot \left(t_{deck}^{\ 3}\right)}\right]^{0.1} = 0.50$$

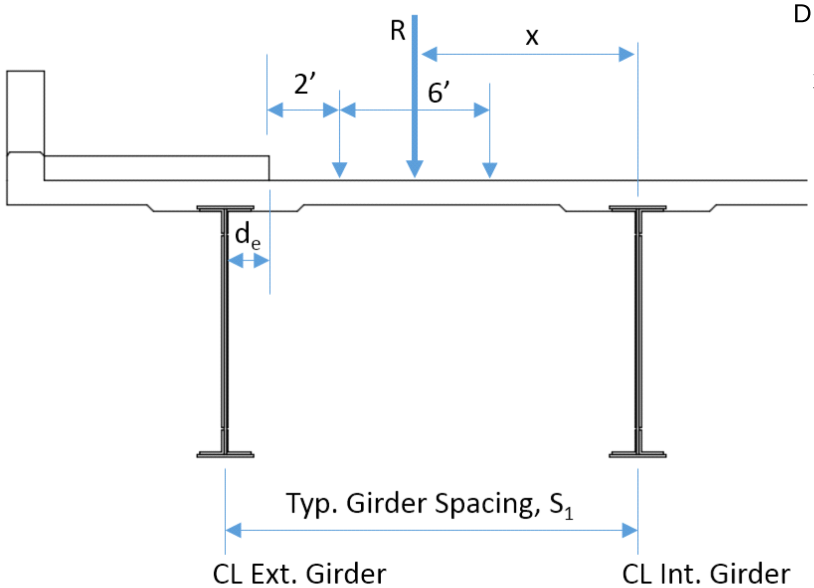
Two or More Lanes Loaded:

Positive Moment $g_{int\_posmom\_2} := 0.075 + \left(\frac{S_1}{9.5ft}\right)^{0.6} \cdot \left(\frac{S_1}{L_{span}}\right)^{0.2} \cdot \left[\frac{K_{g_1}}{L_{span} \cdot \left(t_{deck}^{\ 3}\right)}\right]^{0.1} = 0.70$

Negative Moment $g_{int\_negmom\_2} := 0.075 + \left(\frac{S_1}{9.5ft}\right)^{0.6} \cdot \left(\frac{S_1}{L_{span}}\right)^{0.2} \cdot \left[\frac{K_{g_2}}{\left(L_{span}\right) \cdot \left(t_{deck}^{\ 3}\right)}\right]^{0.1} = 0.74$

Moment in Exterior Beams: LRFD Table 4.6.2.2.2d-1

One Lane Loaded - Use Lever Rule



Distance from Int Girder to Axle Resultant Force

$x := S_1 + W_{overhang} \ldots$
$+ -\left(2ft + 3ft + W_{walk} + W_{barrier}\right)$ $= 2.4\ ft$

Lever Rule Dist Factor to Ext Girder

$Lever := \frac{x}{S_1} = 0.25$

Multiple Presence Factor
Table 3.6.1.1.2-1 $\boxed{m := 1.20}$

LL Distribution Factor

$g_{ext\_posmom1} := m \cdot Lever = 0.29$

$g_{ext\_negmom1} := g_{ext\_posmom1} = 0.29$

Two or More Lanes Loaded - Apply factor "e" to Interior girder factors

Distance from CL of Ext Girder to edge of sidewalk (+ is toward overhang, - is toward center of span)

$d_e := W_{overhang} - W_{barrier} - W_{walk} = -2.4\ ft$

For 2 or more - apply factor e to the internal factor $\boxed{e_{ext} := 0.77 + \frac{d_e}{9.1ft} = 0.5}$

LL Distribution Factor

$g_{ext\_posmom\_2} := e_{ext} \cdot g_{int\_posmom\_2} = 0.35$ $g_{ext\_negmom\_2} := e_{ext} \cdot g_{int\_negmom\_2} = 0.37$

Shear in Interior Beams: LRFD Table 4.6.2.2.3a-1

One Lane Loaded: $g_{int\_shear\_1} := 0.36 + \left(\frac{S_1}{25ft}\right) = 0.75$

Two or More Lanes Loaded: $g_{int\_shear\_2} := 0.20 + \left(\frac{S_1}{12ft}\right) - \left(\frac{S_1}{35ft}\right)^{2.0} = 0.94$

Shear in Exterior Beams: LRFD Table 4.6.2.2.3b-1

One Lane Loaded:
Lever Rule $g_{ext\_shear\_1} := g_{ext\_posmom1} = 0.29$

Two or More Lanes Loaded: Apply factor "e" to Interior girder factors

For 2 or more - apply factor e to the internal factor $\boxed{e_{shear} := 0.60 + \frac{d_e}{10.0ft} = 0.36}$

LL Distribution Factor $g_{ext\_shear\_2} := e_{shear} \cdot g_{int\_shear\_2} = 0.34$

Live Load Distribution Factors for Deflection - Reference: LRFD 2.5.2.6.2
For composite design, the stiffness of the cross-section used for deflection should include the entire roadway width; therefore, the distribution factor is essentially the number of lanes loaded divided by the number of girders. Additionally, the multiple presence factor from Article 3.6.1.1.2 applies.

For $N_{lane} = 4$ Multiple presence factor per LRFD Table 3.6.1.1.2-1: $\boxed{m_{defl} := 0.65}$

LL Distribution Factor $g_{defl} := m_{defl} \cdot \left(\frac{N_{lane}}{N_{girder}}\right) = 0.33$

Live Load Distribution Factors

8. Analysis Step 3: Span analysis for superstructure demands and girder reactions

Computation Sheet

Project	ITD US-12 Memorial Bridge Feasibility Study - 78'-0" Deck Width, 8 girders
Subject	Girder Shear and Moment Diagrams under LL, DC, and DW Loading

made by JWC Date 10/11/17
checked by Date

HL93 Live Load Moment and Shear Diagrams

Live Load Distribution Factors, g (See attached calculations)

	Exterior		Interior	
	1 Lane	2+ Lanes	1 Lane	2+ Lanes
(+) Moment	0.29	0.35	0.48	0.7
(-) Moment	0.29	0.37	0.5	0.74
Shear	0.29	0.34	0.75	0.94

Notes on LL Values:
HL93 (+IM) values are direct output from the GoBeam Analysis; these values include a 33% impact factor. The distribution factors for each girder and lane loading combination are applied to these values to provide the LL design moments for each case.

	Maximum (+) Moment Envelope, kip-ft					Maximum (+) Shear Envelope, kip					Maximum (-) Moment Envelope, kip-ft					Maximum (-) Shear Envelope, kip				
Length Along Cont. Spans, X (ft)	HL93 (+IM) - unfactored	Exterior, 1 Lane g = 0.29	Exterior, 2+ Lanes g = 0.35	Interior, 1 Lane g = 0.48	Interior, 2+ Lanes g = 0.70	HL93 (+IM) - unfactored	Exterior, 1 Lane g = 0.29	Exterior, 2+ Lanes g = 0.34	Interior, 1 Lane g = 0.75	Interior, 2+ Lanes g = 0.94	HL93 (+IM) - unfactored	Exterior, 1 Lane g = 0.29	Exterior, 2+ Lanes g = 0.37	Interior, 1 Lane g = 0.50	Interior, 2+ Lanes g = 0.74	HL93 (+IM) - unfactored	Exterior, 1 Lane g = 0.29	Exterior, 2+ Lanes g = 0.34	Interior, 1 Lane g = 0.75	Interior, 2+ Lanes g = 0.94
0	0.00	0.00	0.00	0.00	0.00	105.07	30.47	35.72	78.80	98.76	0.00	0.00	0.00	0.00	0.00	-10.92	-3.17	-3.71	-8.19	-10.26
9.333	980.57	284.37	343.20	470.68	686.40	89.67	26.00	30.49	67.25	84.29	-101.89	-29.55	-37.70	-50.95	-75.40	-11.27	-3.27	-3.83	-8.45	-10.59
18.666	1722.89	499.64	603.01	826.99	1206.02	75.23	21.82	25.58	56.42	70.72	-203.78	-59.10	-75.40	-101.89	-150.80	-17.43	-5.05	-5.93	-13.07	-16.38
27.999	2234.40	647.98	782.04	1072.51	1564.08	61.84	17.93	21.03	46.38	58.13	-305.67	-88.64	-113.10	-152.84	-226.20	-26.71	-7.75	-9.08	-20.03	-25.11
37.332	2545.62	738.23	890.97	1221.90	1781.94	49.56	14.37	16.85	37.17	46.58	-407.56	-118.19	-150.80	-203.78	-301.60	-38.89	-11.28	-13.22	-29.17	-36.55
46.665	2662.47	772.12	931.86	1277.99	1863.73	38.44	11.15	13.07	28.83	36.13	-509.45	-147.74	-188.50	-254.73	-377.00	-51.44	-14.92	-17.49	-38.58	-48.35
55.998	2611.20	757.25	913.92	1253.38	1827.84	28.54	8.28	9.70	21.41	26.83	-611.34	-177.29	-226.20	-305.67	-452.39	-64.23	-18.63	-21.84	-48.17	-60.38
65.331	2398.05	695.43	839.32	1151.06	1678.63	19.91	5.77	6.77	14.93	18.71	-713.23	-206.84	-263.90	-356.62	-527.79	-77.14	-22.37	-26.23	-57.85	-72.51
74.664	2014.31	584.15	705.01	966.87	1410.01	12.57	3.65	4.28	9.43	11.82	-815.12	-236.39	-301.60	-407.56	-603.19	-90.01	-26.10	-30.60	-67.51	-84.61
83.997	1483.55	430.23	519.24	712.10	1038.49	7.57	2.20	2.57	5.68	7.12	-917.02	-265.93	-339.30	-458.51	-678.59	-102.71	-29.79	-34.92	-77.03	-96.55
93.33	859.75	249.33	300.91	412.68	601.82	3.70	1.07	1.26	2.77	3.48	-1045.97	-303.33	-387.01	-522.99	-774.02	-115.08	-33.37	-39.13	-86.31	-108.18
102.663	401.29	116.38	140.45	192.62	280.91	3.56	1.03	1.21	2.67	3.35	-1657.69	-480.73	-613.34	-828.84	-1226.69	-126.97	-36.82	-43.17	-95.23	-119.36
112	398.66	115.61	139.53	191.36	279.06	3.56	1.03	1.21	2.67	3.35	-2533.82	-734.81	-937.51	-1266.91	-1875.03	-126.97	-36.82	-43.17	-95.23	-119.36
112	398.66	115.61	139.53	191.36	279.06	121.07	35.11	41.16	90.80	113.81	-2533.82	-734.81	-937.51	-1266.91	-1875.03	-17.80	-5.16	-6.05	-13.35	-16.73
121.333	400.77	116.22	140.27	192.37	280.54	107.48	31.17	36.54	80.61	101.03	-1704.68	-494.36	-630.73	-852.34	-1261.46	-18.00	-5.22	-6.12	-13.50	-16.92
130.666	852.51	247.23	298.38	409.20	596.75	93.66	27.16	31.84	70.24	88.04	-1270.61	-368.48	-470.13	-635.30	-940.25	-18.63	-5.40	-6.34	-13.98	-17.52
139.999	1397.20	405.19	489.02	670.66	978.04	79.91	23.18	27.17	59.94	75.12	-1129.54	-327.57	-417.93	-564.77	-835.86	-21.45	-6.22	-7.29	-16.08	-20.16
149.332	1818.98	527.50	636.64	873.11	1273.28	66.52	19.29	22.62	49.89	62.53	-1018.80	-295.45	-376.96	-509.40	-753.91	-31.00	-8.99	-10.54	-23.25	-29.14
158.665	2069.82	600.25	724.44	993.52	1448.88	53.75	15.59	18.28	40.31	50.53	-908.06	-263.34	-335.98	-454.03	-671.96	-41.83	-12.13	-14.22	-31.37	-39.32
167.998	2140.43	620.73	749.15	1027.41	1498.30	41.84	12.13	14.22	31.38	39.33	-797.32	-231.22	-295.01	-398.66	-590.02	-53.74	-15.59	-18.27	-40.31	-50.52
177.331	2069.89	600.27	724.46	993.55	1448.93	31.00	8.99	10.54	23.25	29.14	-908.01	-263.32	-335.96	-454.01	-671.93	-66.52	-19.29	-22.62	-49.89	-62.53
186.664	1819.12	527.55	636.69	873.18	1273.39	21.45	6.22	7.29	16.09	20.16	-1018.75	-295.44	-376.94	-509.37	-753.87	-79.91	-23.17	-27.17	-59.93	-75.11
195.997	1397.42	405.25	489.10	670.76	978.19	18.63	5.40	6.34	13.98	17.52	-1129.49	-327.55	-417.91	-564.74	-835.82	-93.65	-27.16	-31.84	-70.24	-88.03
205.33	852.74	247.29	298.46	409.31	596.92	18.00	5.22	6.12	13.50	16.92	-1270.51	-368.45	-470.09	-635.26	-940.18	-107.47	-31.17	-36.54	-80.60	-101.02
214.663	400.92	116.27	140.32	192.44	280.64	17.80	5.16	6.05	13.35	16.73	-1704.38	-494.27	-630.62	-852.19	-1261.24	-121.07	-35.11	-41.16	-90.80	-113.80
224	398.66	115.61	139.53	191.36	279.06	17.80	5.16	6.05	13.35	16.73	-2533.82	-734.81	-937.51	-1266.91	-1875.03	-121.07	-35.11	-41.16	-90.80	-113.80
224	398.66	115.61	139.53	191.36	279.06	126.98	36.82	43.17	95.23	119.36	-2533.82	-734.81	-937.51	-1266.91	-1875.03	-3.56	-1.03	-1.21	-2.67	-3.35
233.333	401.13	116.33	140.40	192.54	280.79	115.09	33.38	39.13	86.32	108.18	-1658.01	-480.82	-613.46	-829.00	-1226.93	-3.70	-1.07	-1.26	-2.77	-3.48
242.666	859.49	249.25	300.82	412.55	601.64	102.72	29.79	34.92	77.04	96.55	-1046.05	-303.36	-387.04	-523.03	-774.08	-7.57	-2.19	-2.57	-5.68	-7.11
251.999	1483.30	430.16	519.15	711.98	1038.31	90.02	26.10	30.61	67.51	84.62	-917.05	-265.95	-339.31	-458.53	-678.62	-12.57	-3.65	-4.27	-9.43	-11.82
261.332	2014.11	584.09	704.94	966.77	1409.88	77.14	22.37	26.23	57.86	72.51	-815.16	-236.40	-301.61	-407.58	-603.22	-19.90	-5.77	-6.77	-14.93	-18.71
270.665	2397.92	695.40	839.27	1151.00	1678.54	64.24	18.63	21.84	48.18	60.38	-713.27	-206.85	-263.91	-356.64	-527.82	-28.54	-8.28	-9.70	-21.40	-26.83
279.998	2611.15	757.23	913.90	1253.35	1827.81	51.44	14.92	17.49	38.58	48.36	-611.38	-177.30	-226.21	-305.69	-452.42	-38.43	-11.15	-13.07	-28.83	-36.13
289.331	2662.48	772.12	931.87	1277.99	1863.73	38.89	11.28	13.22	29.17	36.56	-509.49	-147.75	-188.51	-254.75	-377.03	-49.55	-14.37	-16.85	-37.16	-46.58
298.664	2545.72	738.26	891.00	1221.94	1782.00	26.71	7.75	9.08	20.03	25.11	-407.60	-118.21	-150.81	-203.80	-301.63	-61.83	-17.93	-21.02	-46.38	-58.12
307.997	2234.57	648.03	782.10	1072.59	1564.20	17.43	5.06	5.93	13.07	16.39	-305.71	-88.66	-113.11	-152.86	-226.23	-75.23	-21.82	-25.58	-56.42	-70.71
317.33	1723.16	499.72	603.11	827.12	1206.21	11.27	3.27	3.83	8.45	10.59	-203.82	-59.11	-75.41	-101.91	-150.83	-89.66	-26.00	-30.48	-67.24	-84.28
326.663	980.94	284.47	343.33	470.85	686.66	10.92	3.17	3.71	8.19	10.26	-101.93	-29.56	-37.72	-50.97	-75.43	-105.06	-30.47	-35.72	-78.79	-98.76
336	0.00	0.00	0.00	0.00	0.00	10.92	3.17	3.71	8.19	10.26	0.00	0.00	0.00	0.00	0.00	-105.06	-30.47	-35.72	-78.79	-98.76

wsp

Computation Sheet

Project	ITD US-12 Memorial Bridge Feasibility Study - 78'-0" Deck Width, 8 girders	made by JWC	Date	10/11/17
Subject	Girder Shear and Moment Diagrams under LL, DC, and DW Loading	checked by	Date	

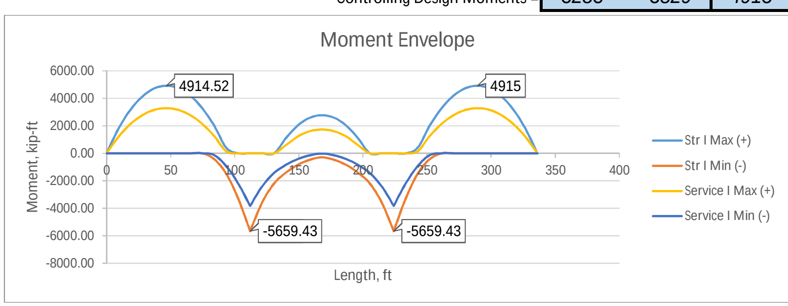
Exterior Girder Force Diagram - 2+ Live Load Lanes

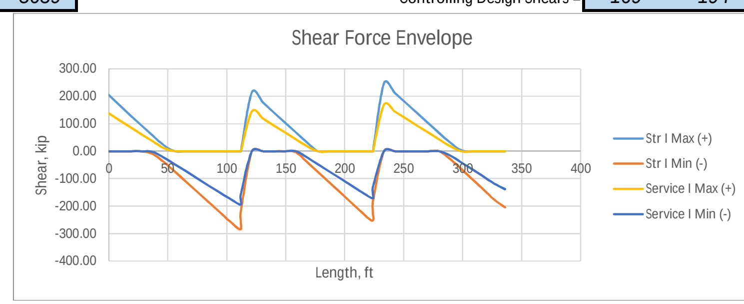
Moment Envelope, kip-ft

Length, X (ft)	LL (HL-93) 2+ Lanes LF = 1.75	LL (HL-93) 2+ Lanes LF = 1.75	LL (Ped) max LF = 1.75	LL (Ped) min LF = 1.75	DC - Ext LF = 1.25	DW - Ext LF = 1.50	Service I Max (+)	Service I Min (-)	Str I Max (+)	Str I Min (-)
0	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00
9.333	343.20	-37.70	192.08	-23.52	576.85	89.90	1202.03	0.00	1792.65	0.00
18.666	603.01	-75.40	344.96	-47.04	1019.55	158.89	2126.41	0.00	3171.72	0.00
27.999	782.04	-113.10	458.64	-70.56	1328.10	206.98	2775.75	0.00	4141.77	0.00
37.332	890.97	-150.80	533.12	-94.08	1502.49	234.15	3160.73	0.00	4721.50	0.00
46.665	**931.86**	-188.50	568.40	-117.6	1542.74	240.43	3283.43	0.00	4914.52	0.00
55.998	913.92	-226.20	564.48	-141.12	1448.83	225.79	3153.03	0.00	4736.93	0.00
65.331	839.32	-263.90	521.36	-164.64	1220.78	190.25	2771.70	0.00	4192.53	0.00
74.664	705.01	-301.60	439.04	-188.16	858.57	133.80	2136.42	0.00	3275.99	0.00
83.997	519.24	-339.30	317.52	-211.68	362.21	56.45	1255.42	-132.32	2001.77	-426.78
93.33	300.91	-387.01	156.80	-235.2	-268.30	-41.81	147.60	-932.32	402.90	-1486.96
102.663	140.45	-613.34	-43.12	-388.08	-1032.96	-160.98	0.00	-2195.37	0.00	-3285.17
112	139.53	**-937.51**	**-188.16**	-658.56	**-1931.8**	-301.06	0.00	***-3829***	0.00	***-5659***
112	139.53	-937.51	-188.16	-658.56	-1931.78	-301.06	0.00	-3828.91	0.00	-5659.43
121.333	140.27	-630.73	-11.76	-403.76	-1193.94	-186.07	0.00	-2414.50	0.00	-3581.89
130.666	298.38	-470.13	125.44	-282.24	-590.26	-91.99	0.00	-1434.62	0.00	-2192.45
139.999	489.02	-417.93	246.96	-282.24	-120.74	-18.82	596.43	-839.72	1108.82	-1404.44
149.332	636.64	-376.96	344.96	-282.24	214.64	33.45	1229.69	-411.10	2036.28	-835.11
158.665	724.44	-335.98	403.76	-282.24	415.87	64.81	1608.88	-137.54	2591.40	-464.84
167.998	749.15	-295.01	423.36	-282.24	482.94	75.26	1730.72	-19.04	2768.47	-293.61
177.331	724.46	-335.96	403.76	-282.24	415.87	64.81	1608.90	-137.52	2591.44	-464.80
186.664	636.69	-376.94	344.96	-282.24	214.64	33.45	1229.75	-411.08	2036.37	-835.08
195.997	489.10	-417.91	246.96	-282.24	-120.74	-18.82	596.50	-839.70	1108.95	-1404.41
205.33	298.46	-470.09	125.44	-282.24	-590.26	-91.99	0.00	-1434.58	0.00	-2192.39
214.663	140.32	-630.62	-11.76	-403.76	-1193.94	-186.07	0.00	-2414.39	0.00	-3581.70
224	139.53	**-937.51**	-188.16	-658.56	-1931.78	-301.06	0.00	-3828.91	0.00	-5659.43
224	139.53	-937.51	-188.16	-658.56	-1931.78	**-301.06**	0.00	-3828.91	0.00	-5659.43
233.333	140.40	-613.46	-43.12	-388.08	-1032.96	-160.98	0.00	-2195.49	0.00	-3285.38
242.666	300.82	-387.04	156.80	-235.2	-268.30	-41.81	147.51	-932.35	402.74	-1487.02
251.999	519.15	-339.31	317.52	-211.68	362.21	56.45	1255.33	-132.33	2001.61	-426.80
261.332	704.94	-301.61	439.04	-188.16	858.57	133.80	2136.35	0.00	3275.87	0.00
270.665	839.27	-263.91	521.36	-164.64	1220.78	190.25	2771.66	0.00	4192.45	0.00
279.998	913.90	-226.21	564.48	-141.12	1448.83	225.79	3153.01	0.00	4736.90	0.00
289.331	**931.87**	-188.51	**568.40**	-117.6	**1542.74**	**240.43**	***3283***	0.00	***4915***	0.00
298.664	891.00	-150.81	533.12	-94.08	1502.49	234.15	3160.77	0.00	4721.56	0.00
307.997	782.10	-113.11	458.64	-70.56	1328.10	206.98	2775.81	0.00	4141.88	0.00
317.33	603.11	-75.41	344.96	-47.04	1019.55	158.89	2126.51	0.00	3171.89	0.00
326.663	343.33	-37.72	192.08	-23.52	576.85	89.90	1202.16	0.00	1792.88	0.00
336	0.00	0.00	0.00	-2.5E-06	0.00	0.00	0.00	0.00	0.00	0.00
						Controlling Design Moments =	*3283*	*-3829*	*4915*	*-5659*

Shear Envelope, kip

Length, X (ft)	LL (HL-93) 2+ Lanes LF = 1.75	LL (HL-93) 2+ Lanes LF = 1.75	LL (Ped) max LF = 1.75	LL (Ped) min LF = 1.75	DC - Ext LF = 1.25	DW - Ext LF = 1.50	Service I Max (+)	Service I Min (-)	Str I Max (+)	Str I Min (-)
0	35.72	-3.71	22.7	-2.52	69.0	10.8	138.15	0.00	204.57	0.00
9.333	30.49	-3.83	18.5	-2.52	54.6	8.5	112.10	0.00	166.73	0.00
18.666	25.58	-5.93	14.3	-2.52	40.2	6.3	86.38	0.00	129.47	0.00
27.999	21.03	-9.08	10.1	-2.52	25.9	4.0	61.01	0.00	92.82	0.00
37.332	16.85	-13.22	5.9	-2.52	11.5	1.8	36.02	-2.45	56.84	-10.49
46.665	13.07	-17.49	1.7	-2.52	-2.9	-0.4	11.43	-23.33	21.55	-39.28
55.998	9.70	-21.84	-1.7	-5.88	-17.2	-2.7	0.00	-47.65	0.00	-74.10
65.331	6.77	-26.23	-1.7	-10.08	-31.6	-4.9	0.00	-72.86	0.00	-110.45
74.664	4.28	-30.60	-1.7	-14.28	-46.0	-7.2	0.00	-98.05	0.00	-146.79
83.997	2.57	-34.92	-1.7	-18.48	-60.4	-9.4	0.00	-123.18	0.00	-183.03
93.33	1.26	-39.13	-1.7	-22.68	-74.7	-11.6	0.00	-148.20	0.00	-219.06
102.663	1.21	-43.17	-1.7	-26.88	-89.1	-13.9	0.00	-173.05	0.00	-254.81
112	1.21	**-43.17**	**-1.68**	-31.08	**-103.49**	**-16.13**	0.00	***-194***	0.00	***-283.5***
112	41.16	-6.05	-1.7	-31.08	-103.5	-16.1	0.00	-156.75	0.00	-218.53
121.333	36.54	-6.12	25.2	0	71.9	11.2	144.81	0.00	214.68	0.00
130.666	31.84	-6.34	21.0	0	57.5	9.0	119.30	0.00	177.78	0.00
139.999	27.17	-7.29	16.8	0	43.1	6.7	93.81	0.00	140.93	0.00
149.332	22.62	-10.54	12.6	0	28.7	4.5	68.44	0.00	104.28	0.00
158.665	18.28	-14.22	8.4	-1.5E-08	14.4	2.2	43.29	0.00	68.01	-3.56
167.998	14.22	-18.27	4.2	-4.2	0.0	0.0	18.42	-22.47	32.24	-39.33
177.331	10.54	-22.62	0.0	-8.4	-14.4	-2.2	0.00	-47.63	0.00	-75.60
186.664	7.29	-27.17	0.0	-12.6	-28.7	-4.5	0.00	-73.00	0.00	-112.25
195.997	6.34	-31.84	0.0	-16.8	-43.1	-6.7	0.00	-98.48	0.00	-149.10
205.33	6.12	-36.54	0.0	-21	-57.5	-9.0	0.00	-123.99	0.00	-186.00
214.663	6.05	-41.16	0.0	-25.2	-71.9	-11.2	0.00	-149.43	0.00	-222.77
224	6.05	-41.16	0.0	-29.4	-86.2	-13.4	0.00	-170.24	0.00	-251.45
224	**43.17**	-1.21	**0.00**	-29.4	**-86.24**	**-13.44**	0.00	-130.29	***0.00***	-181.53
233.333	39.13	-1.26	26.9	1.68	89.1	13.9	169.01	0.00	247.74	0.00
242.666	34.92	-2.57	22.7	1.68	74.7	11.6	143.99	0.00	211.71	0.00
251.999	30.61	-4.27	18.5	1.68	60.4	9.4	118.86	0.00	175.47	0.00
261.332	26.23	-6.77	14.3	1.68	46.0	7.2	93.67	0.00	139.13	0.00
270.665	21.84	-9.70	10.1	1.68	31.6	4.9	68.47	0.00	102.78	0.00
279.998	17.49	-13.07	5.9	1.68	17.2	2.7	43.31	0.00	66.49	0.00
289.331	13.22	-16.85	2.5	-1.68	2.9	0.4	***19***	-15.20	31.82	-28.16
298.664	9.08	-21.02	2.5	-5.88	-11.5	-1.8	0.00	-40.19	3.24	-64.14
307.997	5.93	-25.58	2.5	-10.08	-25.9	-4.0	0.00	-65.56	0.00	-100.79
317.33	3.83	-30.48	2.5	-14.28	-40.2	-6.3	0.00	-91.28	0.00	-138.05
326.663	3.71	-35.72	2.5	-18.48	-54.6	-8.5	0.00	-117.33	0.00	-175.89
336	3.71	-35.72	2.5	-22.68	-69.0	-10.8	0.00	-138.14	0.00	-204.57
						Controlling Design Shears =	*169*	*-194*	*248*	*-283*



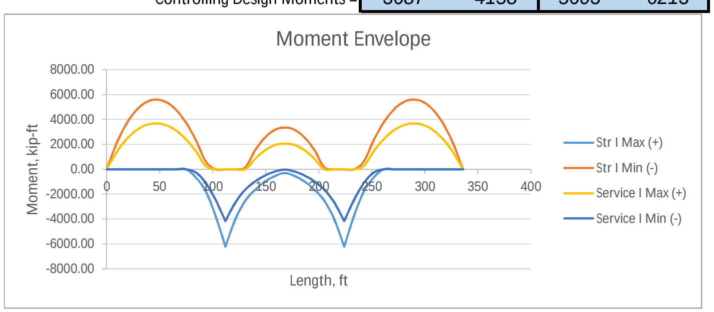


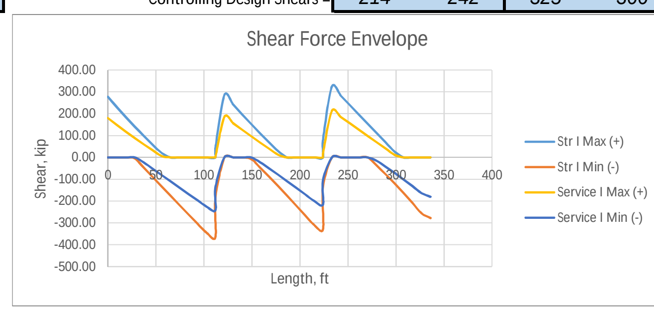
Computation Sheet

Project	ITD US-12 Memorial Bridge Feasibility Study - 78'-0" Deck Width, 8 girders	made by	JWC	Date	10/11/17
Subject	Girder Shear and Moment Diagrams under LL, DC, and DW Loading	checked by		Date	

Interior Girder Force Diagram - 2+ Live Load Lanes

	Moment Envelope, kip-ft								Shear Envelope, kip							
	LL (HL-93) 2+ Lanes	LL (HL-93) 2+ Lanes	DC - Int	DW - Int	Service I Max (+)	Service I Min (-)	Max (+)	Min (-)	LL (HL-93) 2+ Lanes	LL (HL-93) 2+ Lanes	DC - Int	DW - Int	Service I Max (+)	Service I Min (-)	Max (+)	Min (-)
Length, X (ft)	LF = 1.75	LF = 1.75	LF = 1.25	LF = 1.50			Str. I	Str. I	LF = 1.75	LF = 1.75	LF = 1.25	LF = 1.50			Str. I	Str. I
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	98.76	-10.26	70.3	11.2	180.30	0.00	277.55	0.00
9.333	686.40	-75.40	588.09	93.64	1368.13	0.00	2076.78	0.00	84.29	-10.59	55.7	8.9	148.84	0.00	230.40	0.00
18.666	1206.02	-150.80	1039.41	165.51	2410.95	0.00	3658.07	0.00	70.72	-16.38	41.0	6.5	118.28	0.00	184.84	0.00
27.999	1564.08	-226.20	1353.97	215.60	3133.65	0.00	4753.00	0.00	58.13	-25.11	26.4	4.2	88.71	0.00	141.00	-4.66
37.332	1781.94	-301.60	1531.76	243.91	3557.61	0.00	5398.96	0.00	46.58	-36.55	11.7	1.9	60.17	-22.97	98.97	-46.52
46.665	**1863.73**	-377.00	1572.79	250.44	3686.96	0.00	5603.18	0.00	36.13	-48.35	-2.9	-0.5	32.74	-51.75	58.87	-88.98
55.998	1827.84	-452.39	1477.06	235.20	3540.10	0.00	5397.84	0.00	26.83	-60.38	-17.6	-2.8	6.44	-80.76	20.77	-131.84
65.331	1678.63	-527.79	1244.56	198.18	3121.37	0.00	4790.57	0.00	18.71	-72.51	-32.2	-5.1	0.00	-109.88	0.00	-174.89
74.664	1410.01	-603.19	875.29	139.38	2424.68	0.00	3770.71	0.00	11.82	-84.61	-46.9	-7.5	0.00	-138.97	0.00	-217.88
83.997	1038.49	-678.59	369.26	58.80	1466.55	-250.53	2367.13	-637.75	7.12	-96.55	-61.5	-9.8	0.00	-167.89	0.00	-260.59
93.33	601.82	-774.02	-273.53	-43.56	284.74	-1091.10	645.95	-1761.78	3.48	-108.18	-76.2	-12.1	0.00	-196.51	0.00	-302.76
102.663	280.91	-1226.69	-1053.09	-167.69	0.00	-2447.46	0.00	-3714.59	3.35	-119.36	-90.9	-14.5	0.00	-224.67	0.00	-344.14
112	279.06	**-1875.03**	-1969.41	-313.60	0.00	***-4158***	0.00	-6213.46	3.35	**-119.36**	**-105.50**	**-16.80**	0.00	***-241.66***	0.00	***-365.95***
112	279.06	-1875.03	-1969.41	-313.60	0.00	-4158.04	0.00	-6213.46	113.81	-16.73	-105.5	-16.8	0.00	-139.03	42.09	-186.36
121.333	280.54	-1261.46	-1217.20	-193.82	0.00	-2672.49	0.00	-4019.79	101.03	-16.92	73.3	11.7	185.96	0.00	285.89	0.00
130.666	596.75	-940.25	-601.76	-95.82	0.00	-1637.84	148.38	-2541.38	88.04	-17.52	58.6	9.3	155.99	0.00	241.34	0.00
139.999	978.04	-835.86	-123.09	-19.60	835.35	-978.55	1528.31	-1646.01	75.12	-20.16	44.0	7.0	126.08	0.00	196.91	0.00
149.332	1273.28	-753.91	218.82	34.84	1526.95	-500.24	2554.04	-993.55	62.53	-29.14	29.3	4.7	96.51	0.00	153.06	-7.36
158.665	1448.88	-671.96	423.97	67.51	1940.36	-180.48	3166.76	-544.71	50.53	-39.32	14.7	2.3	67.51	-22.33	110.24	-46.99
167.998	1498.30	-590.02	492.35	78.40	2069.06	-19.26	3355.07	-299.49	39.33	-50.52	0.0	0.0	39.33	-50.52	68.82	-88.41
177.331	1448.93	-671.93	423.97	67.51	1940.41	-180.45	3166.85	-544.64	29.14	-62.53	-14.7	-2.3	12.15	-79.51	29.18	-131.24
186.664	1273.39	-753.87	218.82	34.84	1527.05	-500.21	2554.22	-993.48	20.16	-75.11	-29.3	-4.7	0.00	-109.09	0.00	-175.08
195.997	978.19	-835.82	-123.09	-19.60	835.50	-978.51	1528.58	-1645.95	17.52	-88.03	-44.0	-7.0	0.00	-138.99	0.00	-219.51
205.33	596.92	-940.18	-601.76	-95.82	0.00	-1637.77	148.67	-2541.25	16.92	-101.02	-58.6	-9.3	0.00	-168.97	0.00	-264.06
214.663	280.64	-1261.24	-1217.20	-193.82	0.00	-2672.26	0.00	-4019.40	16.73	-113.80	-73.3	-11.7	0.00	-198.74	0.00	-308.24
224	279.06	**-1875.03**	-1969.41	-313.60	0.00	-4158.04	0.00	-6213.46	16.73	-113.80	-87.9	-14.0	0.00	-215.72	0.00	-330.06
224	279.06	-1875.03	**-1969.4**	**-313.60**	0.00	***-4158***	0.00	***-6213***	**119.36**	-3.35	**-87.92**	**-14.00**	17.44	-105.27	***77.98***	-136.76
233.333	280.79	-1226.93	-1053.09	-167.69	0.00	-2447.70	0.00	-3715.01	108.18	-3.48	90.9	14.5	213.50	0.00	324.59	0.00
242.666	601.64	-774.08	-273.53	-43.56	284.56	-1091.16	645.63	-1761.88	96.55	-7.11	76.2	12.1	184.88	0.00	282.42	0.00
251.999	1038.31	-678.62	369.26	58.80	1466.37	-250.56	2366.82	-637.80	84.62	-11.82	61.5	9.8	155.96	0.00	239.71	0.00
261.332	1409.88	-603.22	875.29	139.38	2424.55	0.00	3770.46	0.00	72.51	-18.71	46.9	7.5	126.87	0.00	196.71	0.00
270.665	1678.54	-527.82	1244.56	198.18	3121.28	0.00	4790.41	0.00	60.38	-26.83	32.2	5.1	97.75	0.00	153.67	0.00
279.998	1827.81	-452.42	1477.06	235.20	3540.06	0.00	5397.78	0.00	48.36	-36.13	17.6	2.8	68.74	-15.74	110.80	-37.04
289.331	**1863.73**	-377.03	**1572.79**	**250.44**	***3687***	0.00	***5603***	0.00	36.56	-46.58	2.9	0.5	***39.96***	-43.18	68.34	-77.15
298.664	1782.00	-301.63	1531.76	243.91	3557.67	0.00	5399.07	0.00	25.11	-58.12	-11.7	-1.9	11.52	-71.71	26.49	-119.17
307.997	1564.20	-226.23	1353.97	215.60	3133.77	0.00	4753.21	0.00	16.39	-70.71	-26.4	-4.2	0.00	-101.29	0.00	-163.02
317.33	1206.21	-150.83	1039.41	165.51	2411.13	0.00	3658.40	0.00	10.59	-84.28	-41.0	-6.5	0.00	-131.84	0.00	-208.58
326.663	686.66	-75.43	588.09	93.64	1368.39	0.00	2077.23	0.00	10.26	-98.76	-55.7	-8.9	0.00	-163.31	0.00	-255.73
336	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.26	-98.76	-70.3	-11.2	0.00	-180.29	0.00	-277.54
				Controlling Design Moments =	*3687*	*-4158*	*5603*	*-6213*				Controlling Design Shears =	*214*	*-242*	*325*	*-366*





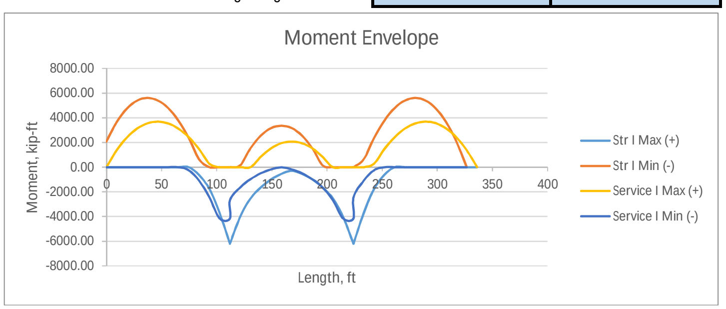
Computation Sheet

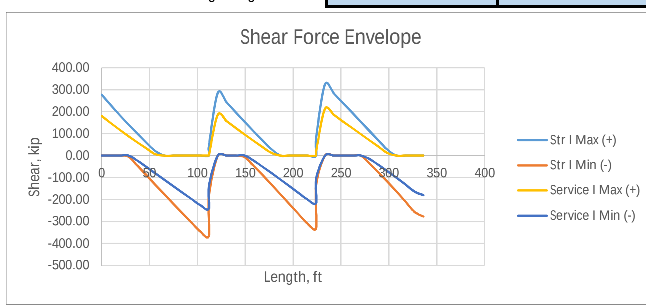
Project: ITD US-12 Memorial Bridge Feasibility Study - 78'-0" Deck Width, 8 girders — made by JWC — Date 10/11/17

Subject: Girder Shear and Moment Diagrams under LL, DC, and DW Loading — checked by — Date

Center Girder Force Diagram - 2+ Live Load Lanes

	Moment Envelope, kip-ft								Shear Envelope, kip							
Length, X (ft)	LL (HL-93) 2+ Lanes LF = 1.75	LL (HL-93) 2+ Lanes LF = 1.75	DC - Cent LF = 1.25	DW - Cent LF = 1.50	Service I Max (+)	Service I Min (-)	Max (+) Str. I	Min (-) Str. I	LL (HL-93) 2+ Lanes LF = 1.75	LL (HL-93) 2+ Lanes LF = 1.75	DC - Cent LF = 1.25	DW - Cent LF = 1.50	Service I Max (+)	Service I Min (-)	Max (+) Str. I	Min (-) Str. I
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	98.76	-10.26	70.3	11.2	180.30	0.00	277.55	0.00
9.333	686.40	-75.40	588.09	93.64	1368.13	0.00	2076.78	0.00	84.29	-10.59	55.7	8.9	148.84	0.00	230.40	0.00
18.666	1206.02	-150.80	1039.41	165.51	2410.95	0.00	3658.07	0.00	70.72	-16.38	41.0	6.5	118.28	0.00	184.84	0.00
27.999	1564.08	-226.20	1353.97	215.60	3133.65	0.00	4753.00	0.00	58.13	-25.11	26.4	4.2	88.71	0.00	141.00	-4.66
37.332	1781.94	-301.60	1531.76	243.91	3557.61	0.00	5398.96	0.00	46.58	-36.55	11.7	1.9	60.17	-22.97	98.97	-46.52
46.665	**1863.73**	-377.00	1572.79	250.44	3686.96	0.00	5603.18	0.00	36.13	-48.35	-2.9	-0.5	32.74	-51.75	58.87	-88.98
55.998	1827.84	-452.39	1477.06	235.20	3540.10	0.00	5397.84	0.00	26.83	-60.38	-17.6	-2.8	6.44	-80.76	20.77	-131.84
65.331	1678.63	-527.79	1244.56	198.18	3121.37	0.00	4790.57	0.00	18.71	-72.51	-32.2	-5.1	0.00	-109.88	0.00	-174.89
74.664	1410.01	-603.19	875.29	139.38	2424.68	0.00	3770.71	0.00	11.82	-84.61	-46.9	-7.5	0.00	-138.97	0.00	-217.88
83.997	1038.49	-678.59	369.26	58.80	1466.55	-250.53	2367.13	-637.75	7.12	-96.55	-61.5	-9.8	0.00	-167.89	0.00	-260.59
93.33	601.82	-774.02	-273.53	-43.56	284.74	-1091.10	645.95	-1761.78	3.48	-108.18	-76.2	-12.1	0.00	-196.51	0.00	-302.76
102.663	280.91	-1226.69	-1053.09	-167.69	0.00	-2447.46	0.00	-3714.59	3.35	-119.36	-90.9	-14.5	0.00	-224.67	0.00	-344.14
112	279.06	**-1875.03**	**-1969.41**	**-313.60**	0.00	***-4158***	0.00	***-6213***	3.35	**-119.36**	**-105.50**	**-16.80**	0.00	***-241.66***	0.00	***-365.95***
112	279.06	-1875.03	-1969.41	-313.60	0.00	-4158.04	0.00	-6213.46	113.81	-16.73	-105.5	-16.8	0.00	-139.03	42.09	-186.36
121.333	280.54	-1261.46	-1217.20	-193.82	0.00	-2672.49	0.00	-4019.79	101.03	-16.92	73.3	11.7	185.96	0.00	285.89	0.00
130.666	596.75	-940.25	-601.76	-95.82	0.00	-1637.84	148.38	-2541.38	88.04	-17.52	58.6	9.3	155.99	0.00	241.34	0.00
139.999	978.04	-835.86	-123.09	-19.60	835.35	-978.55	1528.31	-1646.01	75.12	-20.16	44.0	7.0	126.08	0.00	196.91	0.00
149.332	1273.28	-753.91	218.82	34.84	1526.95	-500.24	2554.04	-993.55	62.53	-29.14	29.3	4.7	96.51	0.00	153.06	-7.36
158.665	1448.88	-671.96	423.97	67.51	1940.36	-180.48	3166.76	-544.71	50.53	-39.32	14.7	2.3	67.51	-22.33	110.24	-46.99
167.998	1498.30	-590.02	492.35	78.40	2069.06	-19.26	3355.07	-299.49	39.33	-50.52	0.0	0.0	39.33	-50.52	68.82	-88.41
177.331	1448.93	-671.93	423.97	67.51	1940.41	-180.45	3166.85	-544.64	29.14	-62.53	-14.7	-2.3	12.15	-79.51	29.18	-131.24
186.664	1273.39	-753.87	218.82	34.84	1527.05	-500.21	2554.22	-993.48	20.16	-75.11	-29.3	-4.7	0.00	-109.09	0.00	-175.08
195.997	978.19	-835.82	-123.09	-19.60	835.50	-978.51	1528.58	-1645.95	17.52	-88.03	-44.0	-7.0	0.00	-138.99	0.00	-219.51
205.33	596.92	-940.18	-601.76	-95.82	0.00	-1637.77	148.67	-2541.25	16.92	-101.02	-58.6	-9.3	0.00	-168.97	0.00	-264.06
214.663	280.64	-1261.24	-1217.20	-193.82	0.00	-2672.26	0.00	-4019.40	16.73	-113.80	-73.3	-11.7	0.00	-198.74	0.00	-308.24
224	279.06	**-1875.03**	-1969.41	-313.60	0.00	-4158.04	0.00	-6213.46	16.73	-113.80	-87.9	-14.0	0.00	-215.72	0.00	-330.06
224	279.06	-1875.03	-1969.41	-313.60	0.00	-4158.04	0.00	-6213.46	**119.36**	-3.35	**-87.92**	**-14.00**	17.44	-105.27	***77.98***	-136.76
233.333	280.79	-1226.93	-1053.09	-167.69	0.00	-2447.70	0.00	-3715.01	108.18	-3.48	90.9	14.5	213.50	0.00	324.59	0.00
242.666	601.64	-774.08	-273.53	-43.56	284.56	-1091.16	645.63	-1761.88	96.55	-7.11	76.2	12.1	184.88	0.00	282.42	0.00
251.999	1038.31	-678.62	369.26	58.80	1466.37	-250.56	2366.82	-637.80	84.62	-11.82	61.5	9.8	155.96	0.00	239.71	0.00
261.332	1409.88	-603.22	875.29	139.38	2424.55	0.00	3770.46	0.00	72.51	-18.71	46.9	7.5	126.87	0.00	196.71	0.00
270.665	1678.54	-527.82	1244.56	198.18	3121.28	0.00	4790.41	0.00	60.38	-26.83	32.2	5.1	97.75	0.00	153.67	0.00
279.998	1827.81	-452.42	1477.06	235.20	3540.06	0.00	5397.78	0.00	48.36	-36.13	17.6	2.8	68.74	-15.74	110.80	-37.04
289.331	**1863.73**	-377.03	**1572.79**	**250.44**	***3687***	0.00	***5603***	0.00	36.56	-46.58	2.9	0.5	***39.96***	-43.18	68.34	-77.15
298.664	1782.00	-301.63	1531.76	243.91	3557.67	0.00	5399.07	0.00	25.11	-58.12	-11.7	-1.9	11.52	-71.71	26.49	-119.17
307.997	1564.20	-226.23	1353.97	215.60	3133.77	0.00	4753.21	0.00	16.39	-70.71	-26.4	-4.2	0.00	-101.29	0.00	-163.02
317.33	1206.21	-150.83	1039.41	165.51	2411.13	0.00	3658.40	0.00	10.59	-84.28	-41.0	-6.5	0.00	-131.84	0.00	-208.58
326.663	686.66	-75.43	588.09	93.64	1368.39	0.00	2077.23	0.00	10.26	-98.76	-55.7	-8.9	0.00	-163.31	0.00	-255.73
336	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.26	-98.76	-70.3	-11.2	0.00	-180.29	0.00	-277.54
				Controlling Design Moments =	*3687*	*-4158*	*5603*	*-6213*				Controlling Design Shears =	*214*	*-242*	*325*	*-366*





Computation Sheet

Project	ITD US-12 Memorial Bridge Feasibility Study - 78'-0" Deck Width, 8 girders	made by	JWC	Date	10/11/17
Subject	Girder Bearing Reactions and Mid-Span Deflections under LL, DC, and DW Loading	checked by		Date	

Pier Reactions from Superstructure forces

Live Load Distribution Factors, g (See attached calculations)

	Exterior		Interior	
	1 Lane	2+ Lanes	1 Lane	2+ Lanes
Shear	0.29	0.34	0.75	0.94
Deflection	---	0.33	---	0.33

Notes on LL Values:
HL93 (+IM) values are direct output from the GoBeam Analysis; these values include a 33% impact factor. The distribution factors for each girder and lane loading combination are applied to these values to provide the LL reactions for each case.

	Reaction Force, kip				
Bent	HL93 (+IM) - unfactored	Exterior, 1 Lane g = 0.29	Exterior, 2+ Lanes g = 0.34	Interior, 1 Lane g = 0.75	Interior, 2+ Lanes g = 0.94
Abut. 1	118.00	34.22	40.12	88.50	110.92
Pier 1	216.70	62.84	73.68	162.53	203.70
Pier 2	216.70	62.84	73.68	162.53	203.70
Pier 3	118.00	34.22	40.12	88.50	110.92

	Exterior Girder Reactions						Interior Girder Reactions					Center Girder Reactions				
Bent	LL (HL-93) 2+ Lane LF = 1.75	LL (Ped) LF = 1.75	DC - Ext LF = 1.25	DW - Ext LF = 1.50	Service I	Str. I	LL (HL-93) 2+ Lane LF = 1.75	DC - Int LF = 1.25	DW - Int LF = 1.50	Service I	Str. I	LL (HL-93) 2+ Lane LF = 1.75	DC - Cent LF = 1.25	DW - Cent LF = 1.50	Service I	Str. I
Abut. 1	40.12	22.70	69.00	10.80	142.62	212.39	110.92	70.30	11.20	192.42	298.79	110.92	70.30	11.20	192.42	298.79
Pier 1	**73.68**	**60.50**	**189.70**	**29.60**	353.48	516.34	**203.70**	**193.40**	**30.80**	427.90	644.42	**203.70**	**193.40**	**30.80**	427.90	644.42
Pier 2	73.68	60.50	189.70	29.60	353.48	516.34	203.70	193.40	30.80	427.90	644.42	203.70	193.40	30.80	427.90	644.42
Pier 3	40.12	22.70	69.00	10.80	142.62	212.39	110.92	70.30	11.20	192.42	298.79	110.92	70.30	11.20	192.42	298.79

NOTE: Girder reactions for Pier 1 are applied to the Csi Bridge model for the substructure.

Mid-Span Deflections

	Transient Loading - Modular Ratio of n						Long Term Permanent Loading - Modular Ratio of 3n		
Girder	HL93 (+IM) - unfactored	HL93 (+IM) factored	LL (Ped)	DC - Ext	DW - Ext	Service I	DC - Ext	DW - Ext	Service I
Exterior	2.57	0.85	0.65	1.54	0.24	3.28	1.92	0.30	2.22
Interior	2.57	0.85	0.00	1.57	0.25	2.67	1.61	0.31	1.92
Center	2.57	0.85	0.00	1.57	0.25	2.67	1.88	0.31	2.19

WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 21-Sep-17
GoBeam **Version 2016.06**	Subject: HL93 LL - Single Lane Loaded	Checker: Date:

Modulus of elasticity, E

Beam:	29000	ksi
Columns:	3600	ksi

Beam end restraints

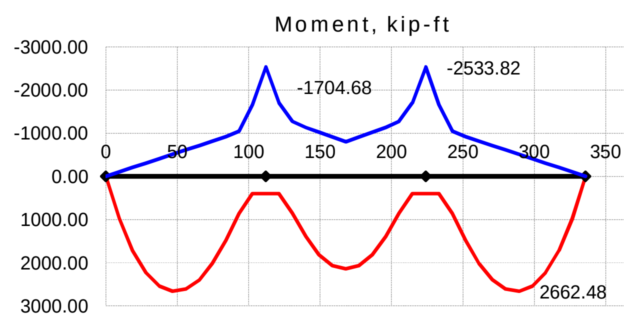
Left End	Right End
Support	Support

Sway frame: ☐

Span №	1	2	3
Length, ft	112	112	112
Moment of Inertia, ft^4	3.2	3.2	3.2

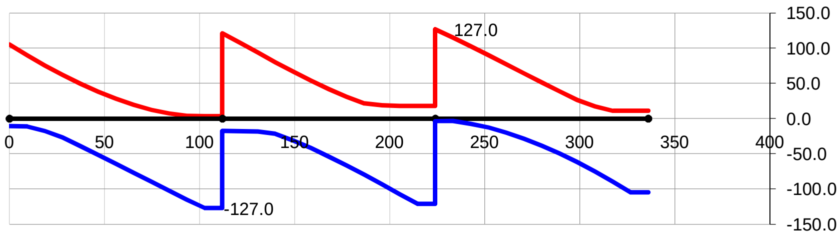
Support №	1	2	3	4
Support coordinate, ft	0	112	224	336
Vertical spring constant, kip/ft				
Support type or hinge	Roller	Roller	Roller	Roller
Column under Length, ft				
Moment of Inertia, ft^4				
Column above Length, ft				
Moment of Inertia, ft^4				
Induced support displacements, ft				

Positive loads: ↑ ↺	Load case:	Moving loads: HL93 Truck+Lane, HL93 Two Trucks+Lane (0.9), HL93 Tandem+Lane, HL93 Two Tandems+Lane (0.9)			
Comment	Load Type	WA kip or kip/ft	WB kip/ft	LA ft	LB ft

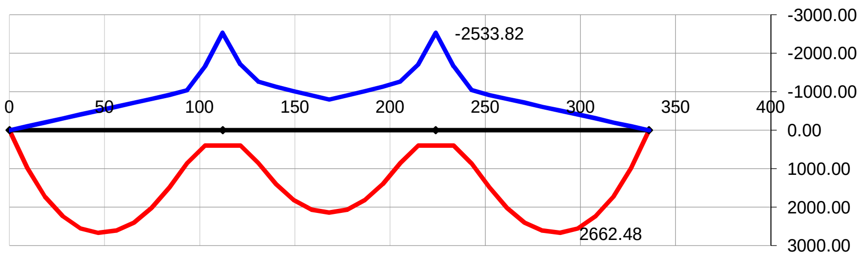


WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 21-Sep
GoBeam **Version 2016.06**	Subject: HL93 LL - Single Lane Loaded	Checker: Date:

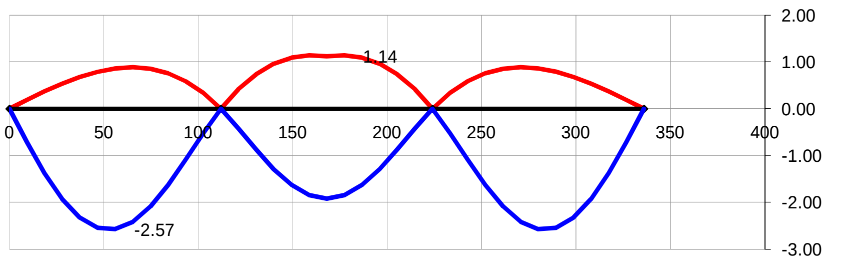
Moving loads: HL93 Truck+Lane, HL93 Two Trucks+Lane (0.9), HL93 Tandem+Lane, HL93 Two Tandems+Lane (0.9) ()



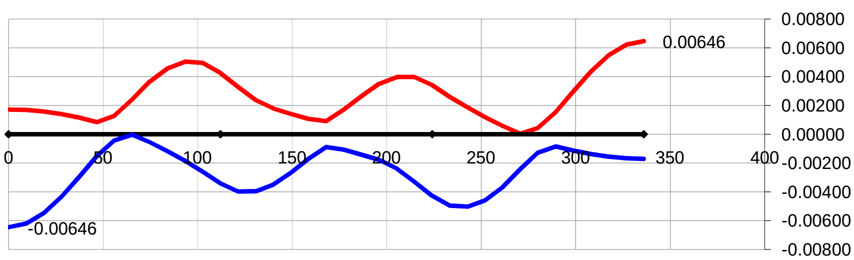
Shear, kip	
Max =	127.0
Min =	-127.0



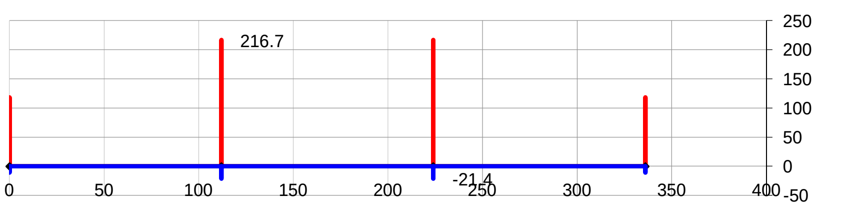
Moment, kip*ft	
Max =	2662.48
Min =	-2533.82



Deflections, in	
Max =	1.14
Min =	-2.57



Rotations, rad	
Max =	0.00646
Min =	-0.00646



Reactions, kip	
Max =	216.7
Min =	-21.4

WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 21-Sep-17
GoBeam **Version 2016.06**	Subject: HL93 LL - Single Lane Loaded	Checker: Date:

Moving loads: HL93 Truck+Lane, HL93 Two Trucks+Lane (0.9), HL93 Tandem+Lane, HL93 Two Tandems+Lane (0.9)
Load multiplier = 1, Truck Impact = 1.33 ,Lane Impact = 1

X, ft	**MAXIMUM FORCE ENVELOPE** Shear, kip	Moment, kip-ft	Deflections, in	Rotations, rad
0	105.1	0.00	0.00	0.00171
9.333	89.7	980.57	0.19	0.00167
18.666	75.2	1722.89	0.37	0.00157
27.999	61.8	2234.40	0.54	0.00139
37.332	49.6	2545.62	0.68	0.00114
46.665	38.4	2662.47	0.79	0.00084
55.998	28.5	2611.20	0.86	0.00128
65.331	19.9	2398.05	0.88	0.00242
74.664	12.6	2014.31	0.85	0.00366
83.997	7.6	1483.55	0.75	0.00458
93.33	3.7	859.75	0.58	0.00504
102.663	3.6	401.29	0.34	0.00496
112	3.6	398.66	0.00	0.00427
112	121.1	398.66	0.00	0.00427
121.333	107.5	400.77	0.42	0.00329
130.666	93.7	852.51	0.74	0.00238
139.999	79.9	1397.20	0.96	0.00179
149.332	66.5	1818.98	1.09	0.00142
158.665	53.8	2069.82	1.14	0.00107
167.998	41.8	2140.43	1.12	0.00090
177.331	31.0	2069.89	1.14	0.00170
186.664	21.4	1819.12	1.09	0.00267
195.997	18.6	1397.42	0.96	0.00350
205.33	18.0	852.74	0.74	0.00397
214.663	17.8	400.92	0.42	0.00398
224	17.8	398.66	0.00	0.00342
224	127.0	398.66	0.00	0.00342
233.333	115.1	401.13	0.34	0.00260
242.666	102.7	859.49	0.58	0.00185
251.999	90.0	1483.30	0.75	0.00117
261.332	77.1	2014.11	0.85	0.00057
270.665	64.2	2397.92	0.88	0.00004
279.998	51.4	2611.15	0.86	0.00043
289.331	38.9	2662.48	0.79	0.00152
298.664	26.7	2545.72	0.68	0.00296
307.997	17.4	2234.57	0.54	0.00435
317.33	11.3	1723.16	0.37	0.00548
326.663	10.9	980.94	0.19	0.00621
336	10.9	0.00	0.00	0.00646

X, ft	**MINIMUM FORCE ENVELOPE** Shear, kip	Moment, kip-ft	Deflections, in	Rotations, rad
0	-10.9	0.00	0.00	-0.00646
9.333	-11.3	-101.89	-0.71	-0.00621
18.666	-17.4	-203.78	-1.37	-0.00548
27.999	-26.7	-305.67	-1.93	-0.00435
37.332	-38.9	-407.56	-2.32	-0.00296
46.665	-51.4	-509.45	-2.54	-0.00152
55.998	-64.2	-611.34	-2.57	-0.00043
65.331	-77.1	-713.23	-2.42	-0.00004
74.664	-90.0	-815.12	-2.09	-0.00057
83.997	-102.7	-917.02	-1.63	-0.00117
93.33	-115.1	-1045.97	-1.09	-0.00185
102.663	-127.0	-1657.69	-0.52	-0.00260
112	-127.0	-2533.82	0.00	-0.00342
112	-17.8	-2533.82	0.00	-0.00342
121.333	-18.0	-1704.68	-0.42	-0.00398
130.666	-18.6	-1270.61	-0.87	-0.00397
139.999	-21.4	-1129.54	-1.29	-0.00350
149.332	-31.0	-1018.80	-1.63	-0.00267
158.665	-41.8	-908.06	-1.84	-0.00170
167.998	-53.7	-797.32	-1.92	-0.00090
177.331	-66.5	-908.01	-1.84	-0.00107
186.664	-79.9	-1018.75	-1.63	-0.00142
195.997	-93.7	-1129.49	-1.29	-0.00179
205.33	-107.5	-1270.51	-0.87	-0.00238
214.663	-121.1	-1704.38	-0.42	-0.00329
224	-121.1	-2533.82	0.00	-0.00427
224	-3.6	-2533.82	0.00	-0.00427
233.333	-3.7	-1658.01	-0.52	-0.00496
242.666	-7.6	-1046.05	-1.09	-0.00504
251.999	-12.6	-917.05	-1.63	-0.00458
261.332	-19.9	-815.16	-2.09	-0.00367
270.665	-28.5	-713.27	-2.42	-0.00243
279.998	-38.4	-611.38	-2.57	-0.00128
289.331	-49.6	-509.49	-2.54	-0.00084
298.664	-61.8	-407.60	-2.32	-0.00114
307.997	-75.2	-305.71	-1.93	-0.00139
317.33	-89.7	-203.82	-1.37	-0.00157
326.663	-105.1	-101.93	-0.71	-0.00167
336	-105.1	0.00	0.00	-0.00171

WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

Modulus of elasticity, E
Beam: 29000 ksi
Columns: 3600 ksi

Beam end restraints
Left End: Support
Right End: Support

Sway frame: ☐

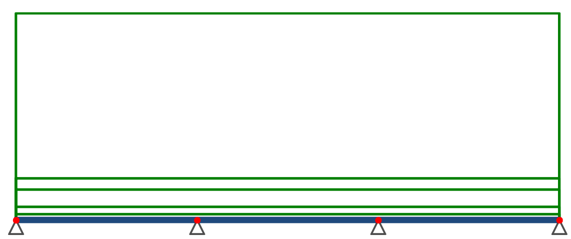
Span №	1	2	3
Length, ft	112	112	112
Moment of Inertia, ft^4	3.1	3.1	3.1

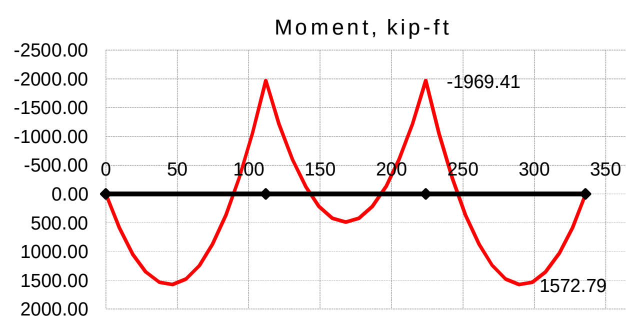
Support №	1	2	3	4
Support coordinate, ft	0	112	224	336
Vertical spring constant, kip/ft				
Support type or hinge	Roller	Roller	Roller	Roller
Column under Length, ft				
Moment of Inertia, ft^4				
Column above Length, ft				
Moment of Inertia, ft^4				
Induced support displacements, ft				

Positive loads: ↑ ↺

Load case: DC - Interior Beam

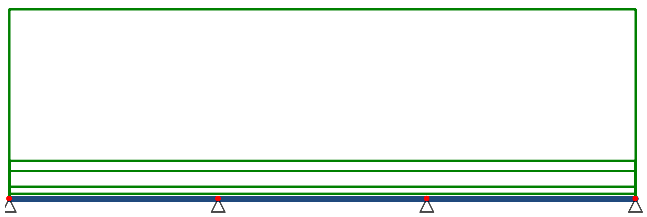
Comment	Load Type	WA kip or kip/ft	WB kip/ft	LA ft	LB ft
Girder	Linear	-0.22	-0.22	0	336
Deck - Interior	Linear	-1.09	-1.09	0	336
Diaph + Xbracing	Linear	-0.03	-0.03	0	336
Barrier + Median	Linear	-0.07	-0.07	0	336
Walkway Wt.	Linear	-0.16	-0.16	0	336

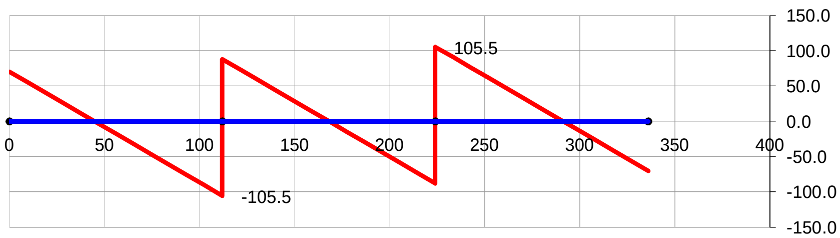




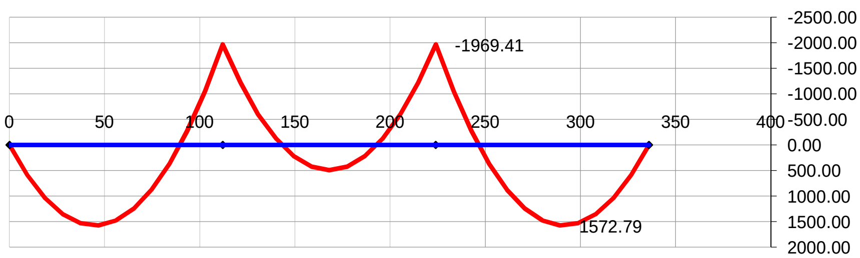
WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

FORCE / DISPLACEMENTS DIAGRAMS DUE TO STATIC LOAD CASE: DC - Interior Beam

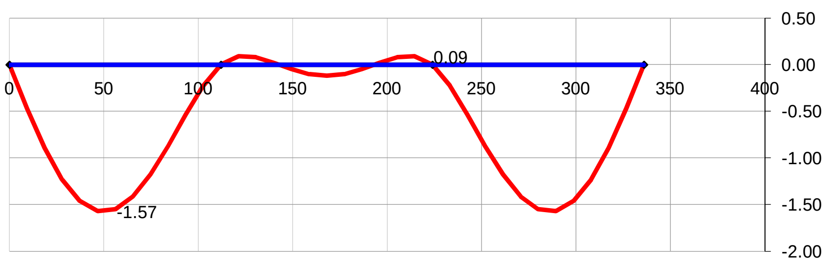




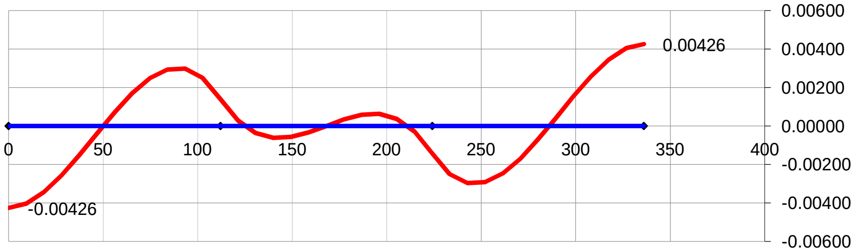
Shear, kip	
Max =	105.5
Min =	-105.5



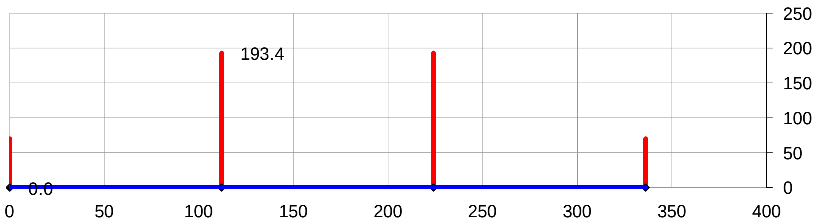
*Moment, kip*ft*	
Max =	1572.79
Min =	-1969.41



Deflections, in	
Max =	0.09
Min =	-1.57



Rotations, rad	
Max =	0.00426
Min =	-0.00426



Reactions, kip	
Max =	193.4
Min =	0.0
ΣR =	527.52

C:\Users\clarkju\Documents\PB Work, Scheduling, etc\Projects\ITD - Memorial Bridge in Lewiston\2 - Superstructure\78ft wide deck, 8 girders\Superstructure Loads_GoBeam_9.83ft spacing

WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

LOAD CASE: DC - Interior Beam

ANALYSIS RESULTS				
X, ft	Shear, kip	Moment, kip-ft	Deflections, in	Rotations, rad
0	70.3	0.00	0.00	-0.00426
1E-06	70.3	0.00	0.00	-0.00426
9.3333	55.7	588.09	-0.47	-0.00404
18.667	41.0	1039.41	-0.89	-0.00344
28	26.4	1353.97	-1.23	-0.00257
37.333	11.7	1531.76	-1.46	-0.00153
46.667	-2.9	1572.79	-1.57	-0.00040
56	-17.6	1477.06	-1.55	0.00071
65.333	-32.2	1244.56	-1.41	0.00170
74.667	-46.9	875.29	-1.18	0.00247
84	-61.5	369.26	-0.87	0.00293
93.333	-76.2	-273.53	-0.54	0.00297
102.67	-90.9	-1053.09	-0.23	0.00250
112	-105.5	-1969.41	0.00	0.00142
112	-105.5	-1969.41	0.00	0.00142
112	87.9	-1969.41	0.00	0.00142
121.33	73.3	-1217.20	0.09	0.00028
130.67	58.6	-601.76	0.08	-0.00037
140	44.0	-123.09	0.02	-0.00062
149.33	29.3	218.82	-0.05	-0.00058
158.67	14.7	423.97	-0.10	-0.00034
168	0.0	492.35	-0.12	0.00000
177.33	-14.7	423.97	-0.10	0.00034
186.67	-29.3	218.82	-0.05	0.00058
196	-44.0	-123.09	0.02	0.00062
205.33	-58.6	-601.76	0.08	0.00037
214.67	-73.3	-1217.20	0.09	-0.00028
224	-87.9	-1969.41	0.00	-0.00142
224	-87.9	-1969.41	0.00	-0.00142
224	105.5	-1969.41	0.00	-0.00142
233.33	90.9	-1053.09	-0.23	-0.00250
242.67	76.2	-273.53	-0.54	-0.00297
252	61.5	369.26	-0.87	-0.00293
261.33	46.9	875.29	-1.18	-0.00247
270.67	32.2	1244.56	-1.41	-0.00170
280	17.6	1477.06	-1.55	-0.00071
289.33	2.9	1572.79	-1.57	0.00040
298.67	-11.7	1531.76	-1.46	0.00153
308	-26.4	1353.97	-1.23	0.00257
317.33	-41.0	1039.41	-0.89	0.00344
326.67	-55.7	588.09	-0.47	0.00404
336	-70.3	0.00	0.00	0.00426
336	-70.3	0.00	0.00	0.00426

Horizontal sway displacements = 0 in

	Max	Min	Area	Area(+)	Area(-)
Shear	105.5	-105.5	0.0	7582.2	-7582.2
Moment	1572.79	-1969.41	106457.45	202033.08	-95575.63
Deflections	0.09	-1.57	-212.98	3.47	-216.45
Rotations	0.00426	-0.00426	0.00000	0.28545	-0.28545
Reactions	193.4	70.3			

Coordinate	Reaction	Displ.
X, ft	**R, kip**	**Δ, in**
0	70.3	0.00
112	193.4	0.00
224	193.4	0.00
336	70.3	0.00

ΣR = 527.52 kip

WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

Modulus of elasticity, E

Beam: 29000 ksi

Columns: 3600 ksi

Beam end restraints

Left End: Support

Right End: Support

Sway frame: ☐

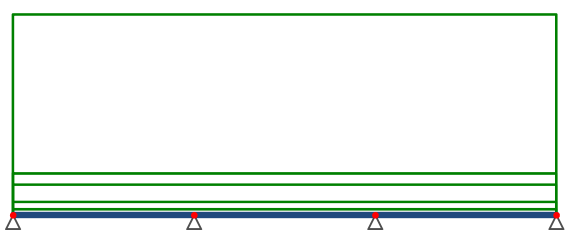
Span №	1	2	3
Length, ft	112	112	112
Moment of Inertia, ft^4	3.1	3.1	3.1

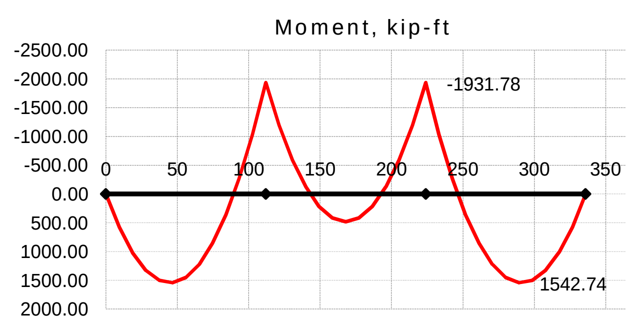
Support №	1	2	3	4
Support coordinate, ft	0	112	224	336
Vertical spring constant, kip/ft				
Support type or hinge	Roller	Roller	Roller	Roller
Column under Length, ft				
Moment of Inertia, ft^4				
Column above Length, ft				
Moment of Inertia, ft^4				
Induced support displacements, ft				

Positive loads: ↑ ↺

Load case: DC - Exterior Beam

Comment	Load Type	WA kip or kip/ft	WB kip/ft	LA ft	LB ft
Girder	Linear	-0.22	-0.22	0	336
Deck - Exterior	Linear	-1.06	-1.06	0	336
Diaph + Xbracing	Linear	-0.03	-0.03	0	336
Barrier + Median	Linear	-0.07	-0.07	0	336
Walkway Wt.	Linear	-0.16	-0.16	0	336

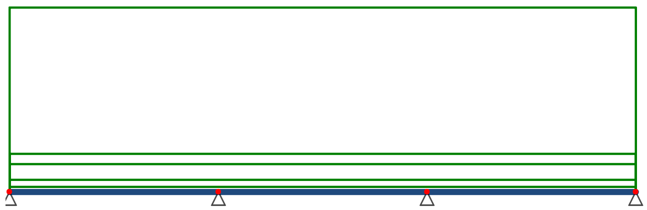




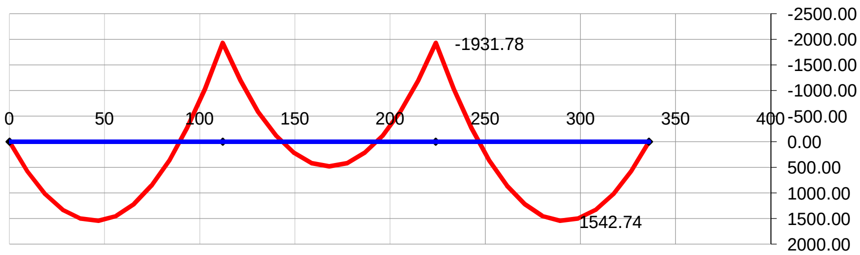
C:\Users\clarkju\Documents\PB Work, Scheduling, etc\Projects\ITD - Memorial Bridge in Lewiston\2 - Superstructure\78ft wide deck, 8 girders\Superstructure Loads_GoBeam_9.83ft spacing

WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

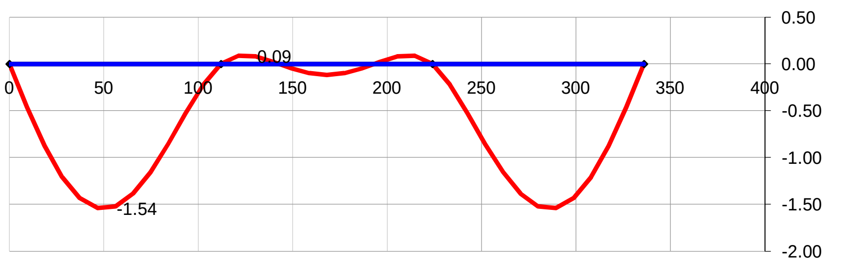
FORCE / DISPLACEMENTS DIAGRAMS DUE TO STATIC LOAD CASE: DC - Exterior Beam



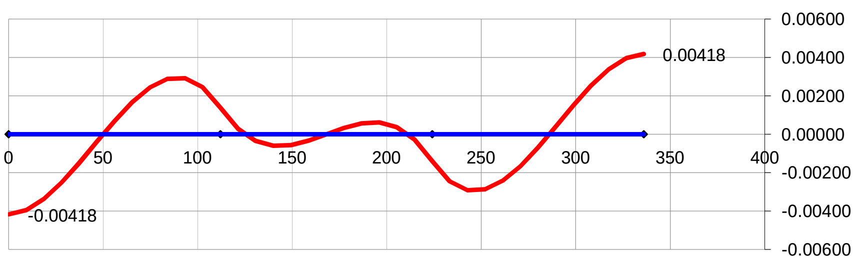
Shear, kip	
Max =	103.5
Min =	-103.5



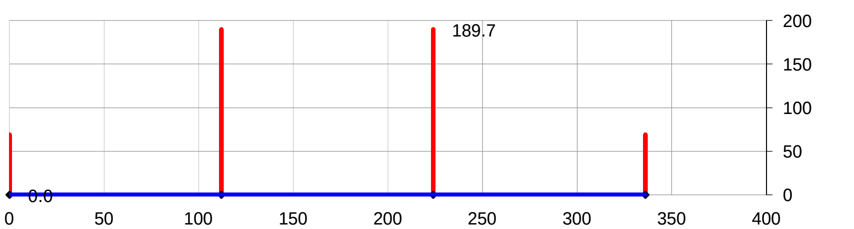
Moment, kip*ft	
Max =	1542.74
Min =	-1931.78



Deflections, in	
Max =	0.09
Min =	-1.54



Rotations, rad	
Max =	0.00418
Min =	-0.00418



Reactions, kip	
Max =	189.7
Min =	0.0
ΣR =	517.44

WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

LOAD CASE: DC - Exterior Beam

ANALYSIS RESULTS				
X, ft	Shear, kip	Moment, kip-ft	Deflections, in	Rotations, rad
0	69.0	0.00	0.00	-0.00418
1E-06	69.0	0.00	0.00	-0.00418
9.3333	54.6	576.85	-0.46	-0.00396
18.667	40.2	1019.55	-0.87	-0.00338
28	25.9	1328.10	-1.21	-0.00252
37.333	11.5	1502.49	-1.43	-0.00150
46.667	-2.9	1542.74	-1.54	-0.00039
56	-17.2	1448.83	-1.52	0.00070
65.333	-31.6	1220.78	-1.39	0.00167
74.667	-46.0	858.57	-1.16	0.00242
84	-60.4	362.21	-0.86	0.00287
93.333	-74.7	-268.30	-0.53	0.00291
102.67	-89.1	-1032.96	-0.22	0.00245
112	-103.5	-1931.78	0.00	0.00139
112	-103.5	-1931.78	0.00	0.00139
112	86.2	-1931.78	0.00	0.00139
121.33	71.9	-1193.94	0.09	0.00027
130.67	57.5	-590.26	0.08	-0.00036
140	43.1	-120.74	0.02	-0.00061
149.33	28.7	214.64	-0.05	-0.00057
158.67	14.4	415.87	-0.10	-0.00033
168	0.0	482.94	-0.12	0.00000
177.33	-14.4	415.87	-0.10	0.00033
186.67	-28.7	214.64	-0.05	0.00057
196	-43.1	-120.74	0.02	0.00061
205.33	-57.5	-590.26	0.08	0.00036
214.67	-71.9	-1193.94	0.09	-0.00027
224	-86.2	-1931.78	0.00	-0.00139
224	-86.2	-1931.78	0.00	-0.00139
224	103.5	-1931.78	0.00	-0.00139
233.33	89.1	-1032.96	-0.22	-0.00245
242.67	74.7	-268.30	-0.53	-0.00291
252	60.4	362.21	-0.86	-0.00287
261.33	46.0	858.57	-1.16	-0.00242
270.67	31.6	1220.78	-1.39	-0.00167
280	17.2	1448.83	-1.52	-0.00070
289.33	2.9	1542.74	-1.54	0.00039
298.67	-11.5	1502.49	-1.43	0.00150
308	-25.9	1328.10	-1.21	0.00252
317.33	-40.2	1019.55	-0.87	0.00338
326.67	-54.6	576.85	-0.46	0.00396
336	-69.0	0.00	0.00	0.00418
336	-69.0	0.00	0.00	0.00418

Horizontal sway displacements = 0 in

	Max	Min	Area	Area(+)	Area(-)
Shear	103.5	-103.5	0.0	7437.3	-7437.3
Moment	1542.74	-1931.78	104423.23	198172.57	-93749.34
Deflections	0.09	-1.54	-208.91	3.40	-212.32
Rotations	0.00418	-0.00418	0.00000	0.27999	-0.27999
Reactions	189.7	69.0			

Coordinate	Reaction	Displ.
X, ft	**R, kip**	**Δ, in**
0	69.0	0.00
112	189.7	0.00
224	189.7	0.00
336	69.0	0.00

ΣR = 517.44 kip

WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

Modulus of elasticity, E
Beam: 29000 ksi
Columns: 3600 ksi

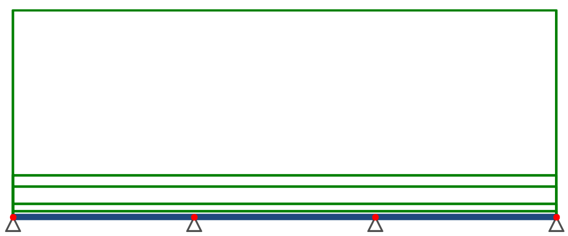
Beam end restraints
Left End: Support
Right End: Support

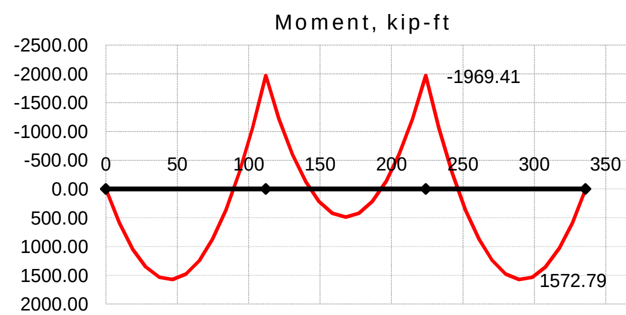
Sway frame: ☐

Span №	1	2	3
Length, ft	112	112	112
Moment of Inertia, ft^4	3.1	3.1	3.1

Support №	1	2	3	4
Support coordinate, ft	0	112	224	336
Vertical spring constant, kip/ft				
Support type or hinge	Roller	Roller	Roller	Roller
Column under Length, ft				
Moment of Inertia, ft^4				
Column above Length, ft				
Moment of Inertia, ft^4				
Induced support displacements, ft				

Positive loads: ↑ ↺	Load case:	DC - Center Beam			
Comment	Load Type	WA kip or kip/ft	WB kip/ft	LA ft	LB ft
Girder	Linear	-0.22	-0.22	0	336
Deck - Interior	Linear	-1.09	-1.09	0	336
Diaph + Xbracing	Linear	-0.03	-0.03	0	336
Barrier + Median	Linear	-0.07	-0.07	0	336
Walkway Wt.	Linear	-0.16	-0.16	0	336

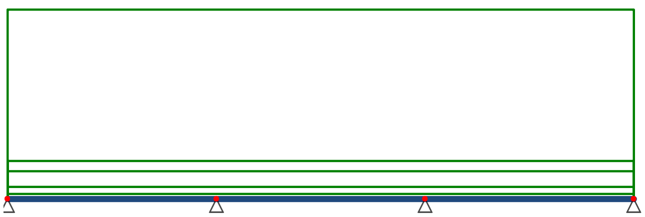


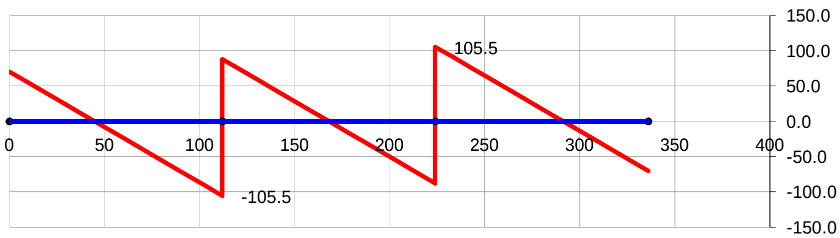


C:\Users\clarkju\Documents\PB Work, Scheduling, etc\Projects\ITD - Memorial Bridge in Lewiston\2 - Superstructure\78ft wide deck, 8 girders\Superstructure Loads_GoBeam_9.83ft spacing

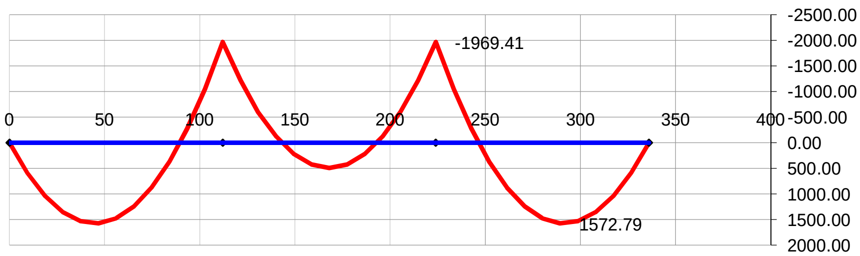
WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

FORCE / DISPLACEMENTS DIAGRAMS DUE TO STATIC LOAD CASE: DC - Center Beam

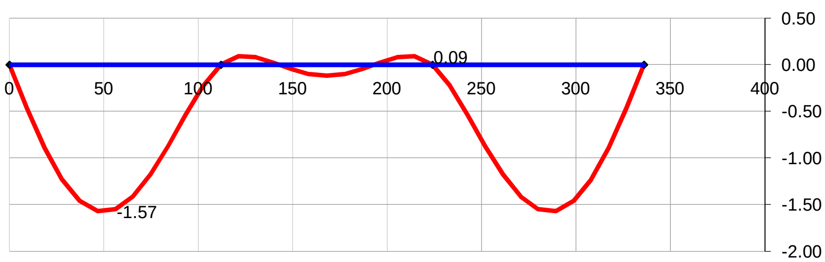




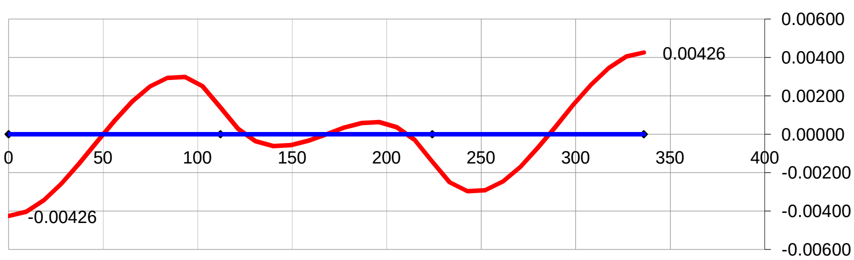
Shear, kip	
Max =	105.5
Min =	-105.5



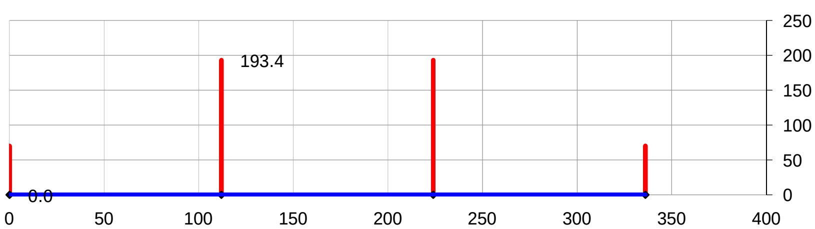
Moment, kip*ft	
Max =	1572.79
Min =	-1969.41



Deflections, in	
Max =	0.09
Min =	-1.57



Rotations, rad	
Max =	0.00426
Min =	-0.00426



Reactions, kip	
Max =	193.4
Min =	0.0
ΣR =	527.52

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WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

LOAD CASE: DC - Center Beam

ANALYSIS RESULTS				
X, ft	Shear, kip	Moment, kip-ft	Deflections, in	Rotations, rad
0	70.3	0.00	0.00	-0.00426
1E-06	70.3	0.00	0.00	-0.00426
9.3333	55.7	588.09	-0.47	-0.00404
18.667	41.0	1039.41	-0.89	-0.00344
28	26.4	1353.97	-1.23	-0.00257
37.333	11.7	1531.76	-1.46	-0.00153
46.667	-2.9	1572.79	-1.57	-0.00040
56	-17.6	1477.06	-1.55	0.00071
65.333	-32.2	1244.56	-1.41	0.00170
74.667	-46.9	875.29	-1.18	0.00247
84	-61.5	369.26	-0.87	0.00293
93.333	-76.2	-273.53	-0.54	0.00297
102.67	-90.9	-1053.09	-0.23	0.00250
112	-105.5	-1969.41	0.00	0.00142
112	-105.5	-1969.41	0.00	0.00142
112	87.9	-1969.41	0.00	0.00142
121.33	73.3	-1217.20	0.09	0.00028
130.67	58.6	-601.76	0.08	-0.00037
140	44.0	-123.09	0.02	-0.00062
149.33	29.3	218.82	-0.05	-0.00058
158.67	14.7	423.97	-0.10	-0.00034
168	0.0	492.35	-0.12	0.00000
177.33	-14.7	423.97	-0.10	0.00034
186.67	-29.3	218.82	-0.05	0.00058
196	-44.0	-123.09	0.02	0.00062
205.33	-58.6	-601.76	0.08	0.00037
214.67	-73.3	-1217.20	0.09	-0.00028
224	-87.9	-1969.41	0.00	-0.00142
224	-87.9	-1969.41	0.00	-0.00142
224	105.5	-1969.41	0.00	-0.00142
233.33	90.9	-1053.09	-0.23	-0.00250
242.67	76.2	-273.53	-0.54	-0.00297
252	61.5	369.26	-0.87	-0.00293
261.33	46.9	875.29	-1.18	-0.00247
270.67	32.2	1244.56	-1.41	-0.00170
280	17.6	1477.06	-1.55	-0.00071
289.33	2.9	1572.79	-1.57	0.00040
298.67	-11.7	1531.76	-1.46	0.00153
308	-26.4	1353.97	-1.23	0.00257
317.33	-41.0	1039.41	-0.89	0.00344
326.67	-55.7	588.09	-0.47	0.00404
336	-70.3	0.00	0.00	0.00426
336	-70.3	0.00	0.00	0.00426

Horizontal sway displacements = 0 in

	Max	Min	Area	Area(+)	Area(-)
Shear	105.5	-105.5	0.0	7582.2	-7582.2
Moment	1572.79	-1969.41	106457.45	202033.08	-95575.63
Deflections	0.09	-1.57	-212.98	3.47	-216.45
Rotations	0.00426	-0.00426	0.00000	0.28545	-0.28545
Reactions	193.4	70.3			

Coordinate	Reaction	Displ.
X, ft	**R, kip**	**Δ, in**
0	70.3	0.00
112	193.4	0.00
224	193.4	0.00
336	70.3	0.00

ΣR = 527.52 kip

WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

Modulus of elasticity, E

Beam:	29000	ksi
Columns:	3600	ksi

Beam end restraints

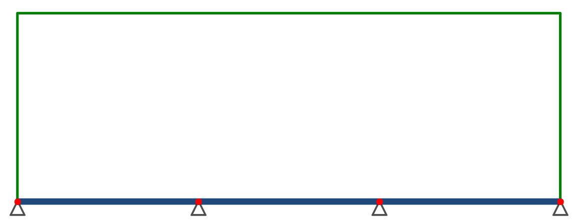
Left End	Right End
Support	Support

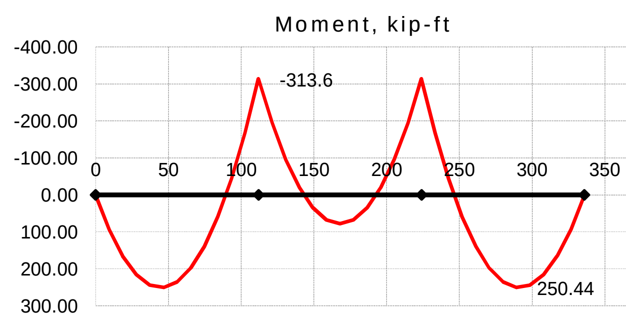
Sway frame: ☐

Span №	1	2	3
Length, ft	112	112	112
Moment of Inertia, ft^4	3.1	3.1	3.1

Support №	1	2	3	4
Support coordinate, ft	0	112	224	336
Vertical spring constant, kip/ft				
Support type or hinge	Roller	Roller	Roller	Roller
Column under Length, ft				
Moment of Inertia, ft^4				
Column above Length, ft				
Moment of Inertia, ft^4				
Induced support displacements, ft				

Positive loads: ↑ ↺	Load case:	DW - Interior Beam			
Comment	Load Type	WA kip or kip/ft	WB kip/ft	LA ft	LB ft
Overlay	Linear	-0.25	-0.25	0	336

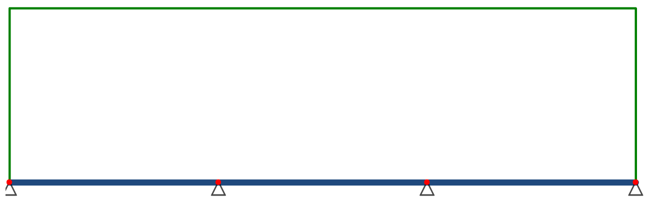


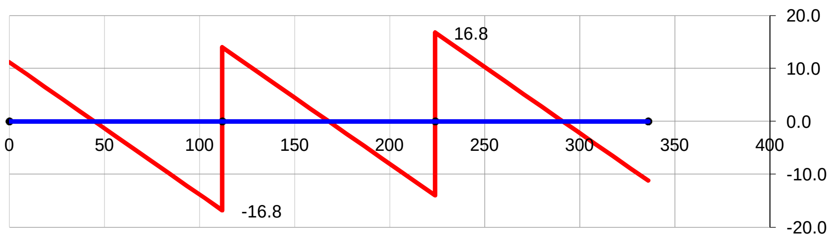


C:\Users\clarkju\Documents\PB Work, Scheduling, etc\Projects\ITD - Memorial Bridge in Lewiston\2 - Superstructure\78ft wide deck, 8 girders\Superstructure Loads_GoBeam_9.83ft spacing

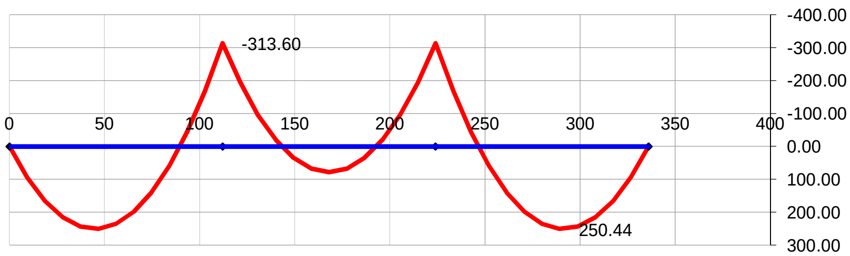
WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC	Date: 11-Oct
GoBeam Version 2016.06	Subject: Superstructure Loading on Girders	Checker:	Date:

FORCE / DISPLACEMENTS DIAGRAMS DUE TO STATIC LOAD CASE: DW - Interior Beam

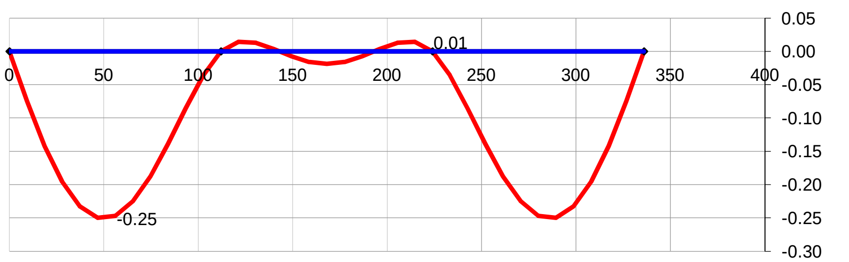




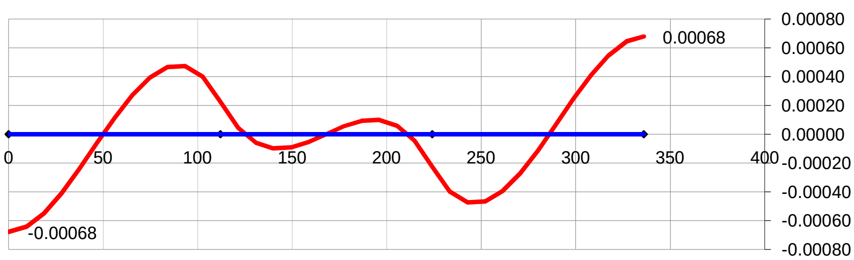
Shear, kip	
Max =	16.8
Min =	-16.8



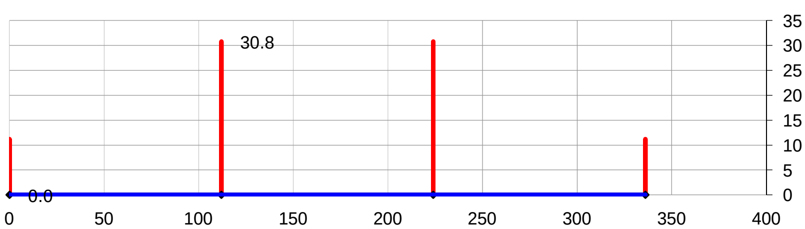
Moment, kip*ft	
Max =	250.44
Min =	-313.60



Deflections, in	
Max =	0.01
Min =	-0.25



Rotations, rad	
Max =	0.00068
Min =	-0.00068



Reactions, kip	
Max =	30.8
Min =	0.0
ΣR =	84

WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

LOAD CASE: DW - Interior Beam

ANALYSIS RESULTS				
X, ft	Shear, kip	Moment, kip-ft	Deflections, in	Rotations, rad
0	11.2	0.00	0.00	-0.00068
1E-06	11.2	0.00	0.00	-0.00068
9.3333	8.9	93.64	-0.07	-0.00064
18.667	6.5	165.51	-0.14	-0.00055
28	4.2	215.60	-0.20	-0.00041
37.333	1.9	243.91	-0.23	-0.00024
46.667	-0.5	250.44	-0.25	-0.00006
56	-2.8	235.20	-0.25	0.00011
65.333	-5.1	198.18	-0.23	0.00027
74.667	-7.5	139.38	-0.19	0.00039
84	-9.8	58.80	-0.14	0.00047
93.333	-12.1	-43.56	-0.09	0.00047
102.67	-14.5	-167.69	-0.04	0.00040
112	-16.8	-313.60	0.00	0.00023
112	-16.8	-313.60	0.00	0.00023
112	14.0	-313.60	0.00	0.00023
121.33	11.7	-193.82	0.01	0.00004
130.67	9.3	-95.82	0.01	-0.00006
140	7.0	-19.60	0.00	-0.00010
149.33	4.7	34.84	-0.01	-0.00009
158.67	2.3	67.51	-0.02	-0.00005
168	0.0	78.40	-0.02	0.00000
177.33	-2.3	67.51	-0.02	0.00005
186.67	-4.7	34.84	-0.01	0.00009
196	-7.0	-19.60	0.00	0.00010
205.33	-9.3	-95.82	0.01	0.00006
214.67	-11.7	-193.82	0.01	-0.00004
224	-14.0	-313.60	0.00	-0.00023
224	-14.0	-313.60	0.00	-0.00023
224	16.8	-313.60	0.00	-0.00023
233.33	14.5	-167.69	-0.04	-0.00040
242.67	12.1	-43.56	-0.09	-0.00047
252	9.8	58.80	-0.14	-0.00047
261.33	7.5	139.38	-0.19	-0.00039
270.67	5.1	198.18	-0.23	-0.00027
280	2.8	235.20	-0.25	-0.00011
289.33	0.5	250.44	-0.25	0.00006
298.67	-1.9	243.91	-0.23	0.00024
308	-4.2	215.60	-0.20	0.00041
317.33	-6.5	165.51	-0.14	0.00055
326.67	-8.9	93.64	-0.07	0.00064
336	-11.2	0.00	0.00	0.00068
336	-11.2	0.00	0.00	0.00068

Horizontal sway displacements = 0 in

	Max	Min	Area	Area(+)	Area(-)
Shear	16.8	-16.8	0.0	1207.4	-1207.4
Moment	250.44	-313.60	16951.82	32170.87	-15219.05
Deflections	0.01	-0.25	-33.91	0.55	-34.47
Rotations	0.00068	-0.00068	0.00000	0.04545	-0.04545
Reactions	30.8	11.2			

Coordinate	Reaction	Displ.
X, ft	**R, kip**	**Δ, in**
0	11.2	0.00
112	30.8	0.00
224	30.8	0.00
336	11.2	0.00

ΣR = 84 kip

WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

Modulus of elasticity, E

Beam: 29000 ksi

Columns: 3600 ksi

Beam end restraints

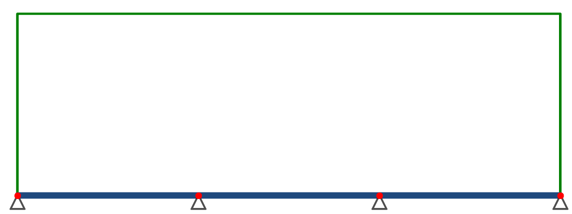
Left End: Support — Right End: Support

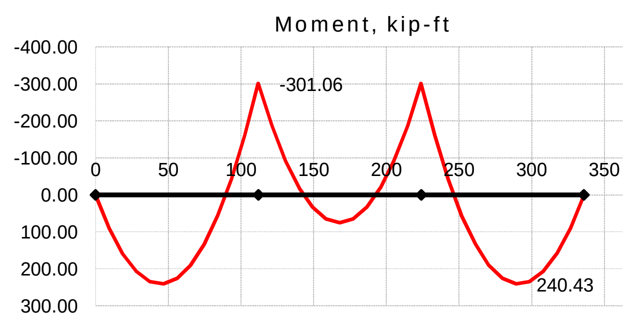
Sway frame: ☐

Span №	1	2	3
Length, ft	112	112	112
Moment of Inertia, ft^4	3.1	3.1	3.1

Support №	1	2	3	4
Support coordinate, ft	0	112	224	336
Vertical spring constant, kip/ft				
Support type or hinge	Roller	Roller	Roller	Roller
Column under Length, ft				
Moment of Inertia, ft^4				
Column above Length, ft				
Moment of Inertia, ft^4				
Induced support displacements, ft				

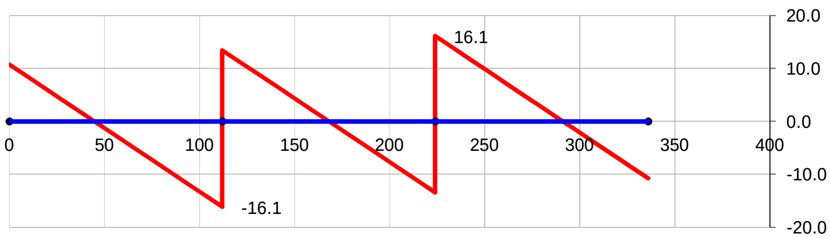
Positive loads: ↑ ↺	Load case:	DW - Exterior Beam			
Comment	Load Type	WA kip or kip/ft	WB kip/ft	LA ft	LB ft
Overlay	Linear	-0.24	-0.24	0	336



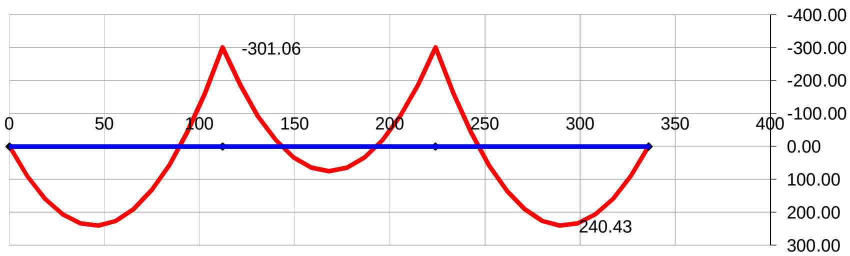


WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

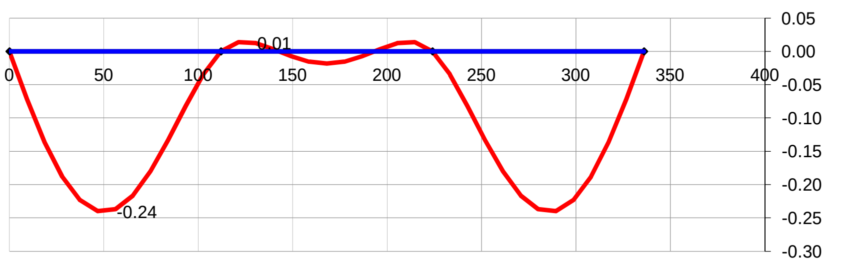
FORCE / DISPLACEMENTS DIAGRAMS DUE TO STATIC LOAD CASE: DW - Exterior Beam



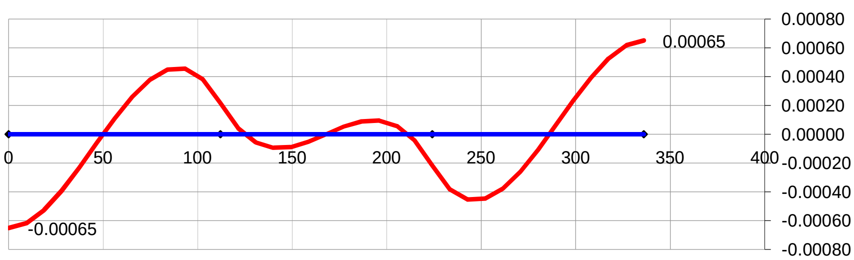
Shear, kip	
Max =	16.1
Min =	-16.1



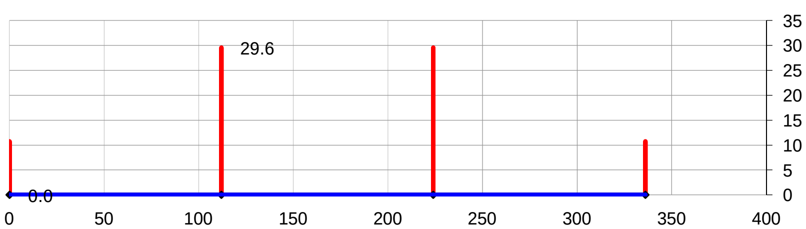
Moment, kip*ft	
Max =	240.43
Min =	-301.06



Deflections, in	
Max =	0.01
Min =	-0.24



Rotations, rad	
Max =	0.00065
Min =	-0.00065



Reactions, kip	
Max =	29.6
Min =	0.0
ΣR =	80.64

C:\Users\clarkju\Documents\PB Work, Scheduling, etc\Projects\ITD - Memorial Bridge in Lewiston\2 - Superstructure\78ft wide deck, 8 girders\Superstructure Loads_GoBeam_9.83ft spacing

WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

LOAD CASE: DW - Exterior Beam

ANALYSIS RESULTS				
X, ft	Shear, kip	Moment, kip-ft	Deflections, in	Rotations, rad
0	10.8	0.00	0.00	-0.00065
1E-06	10.8	0.00	0.00	-0.00065
9.3333	8.5	89.90	-0.07	-0.00062
18.667	6.3	158.89	-0.14	-0.00053
28	4.0	206.98	-0.19	-0.00039
37.333	1.8	234.15	-0.22	-0.00023
46.667	-0.4	240.43	-0.24	-0.00006
56	-2.7	225.79	-0.24	0.00011
65.333	-4.9	190.25	-0.22	0.00026
74.667	-7.2	133.80	-0.18	0.00038
84	-9.4	56.45	-0.13	0.00045
93.333	-11.6	-41.81	-0.08	0.00045
102.67	-13.9	-160.98	-0.03	0.00038
112	-16.1	-301.06	0.00	0.00022
112	-16.1	-301.06	0.00	0.00022
112	13.4	-301.06	0.00	0.00022
121.33	11.2	-186.07	0.01	0.00004
130.67	9.0	-91.99	0.01	-0.00006
140	6.7	-18.82	0.00	-0.00009
149.33	4.5	33.45	-0.01	-0.00009
158.67	2.2	64.81	-0.02	-0.00005
168	0.0	75.26	-0.02	0.00000
177.33	-2.2	64.81	-0.02	0.00005
186.67	-4.5	33.45	-0.01	0.00009
196	-6.7	-18.82	0.00	0.00009
205.33	-9.0	-91.99	0.01	0.00006
214.67	-11.2	-186.07	0.01	-0.00004
224	-13.4	-301.06	0.00	-0.00022
224	-13.4	-301.06	0.00	-0.00022
224	16.1	-301.06	0.00	-0.00022
233.33	13.9	-160.98	-0.03	-0.00038
242.67	11.6	-41.81	-0.08	-0.00045
252	9.4	56.45	-0.13	-0.00045
261.33	7.2	133.80	-0.18	-0.00038
270.67	4.9	190.25	-0.22	-0.00026
280	2.7	225.79	-0.24	-0.00011
289.33	0.4	240.43	-0.24	0.00006
298.67	-1.8	234.15	-0.22	0.00023
308	-4.0	206.98	-0.19	0.00039
317.33	-6.3	158.89	-0.14	0.00053
326.67	-8.5	89.90	-0.07	0.00062
336	-10.8	0.00	0.00	0.00065
336	-10.8	0.00	0.00	0.00065

Horizontal sway displacements = 0 in

	Max	Min	Area	Area(+)	Area(-)
Shear	16.1	-16.1	0.0	1159.1	-1159.1
Moment	240.43	-301.06	16273.75	30884.04	-14610.29
Deflections	0.01	-0.24	-32.56	0.53	-33.09
Rotations	0.00065	-0.00065	0.00000	0.04364	-0.04364
Reactions	29.6	10.8			

Coordinate	Reaction	Displ.
X, ft	**R, kip**	**Δ, in**
0	10.8	0.00
112	29.6	0.00
224	29.6	0.00
336	10.8	0.00

ΣR = 80.64 kip

WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

Modulus of elasticity, E

Beam: 29000 ksi

Columns: 3600 ksi

Beam end restraints

Left End: Support

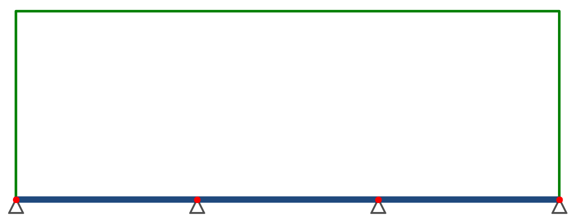
Right End: Support

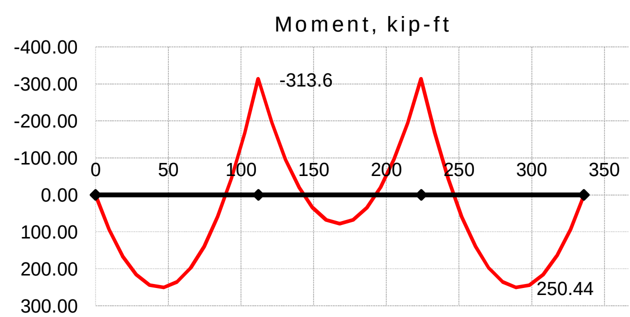
Sway frame: ☐

Span №	1	2	3
Length, ft	112	112	112
Moment of Inertia, ft^4	3.1	3.1	3.1

Support №	1	2	3	4
Support coordinate, ft	0	112	224	336
Vertical spring constant, kip/ft				
Support type or hinge	Roller	Roller	Roller	Roller
Column under Length, ft				
Moment of Inertia, ft^4				
Column above Length, ft				
Moment of Inertia, ft^4				
Induced support displacements, ft				

Positive loads: ↑ ↺	Load case:	DW - Center Beam			
Comment	Load Type	WA kip or kip/ft	WB kip/ft	LA ft	LB ft
Overlay	Linear	-0.25	-0.25	0	336

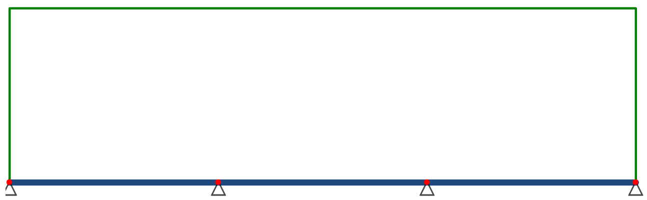


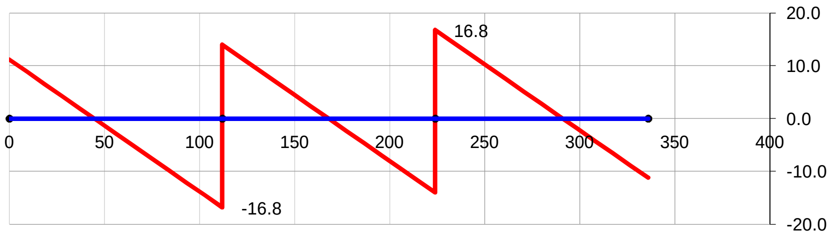


C:\Users\clarkju\Documents\PB Work, Scheduling, etc\Projects\ITD - Memorial Bridge in Lewiston\2 - Superstructure\78ft wide deck, 8 girders\Superstructure Loads_GoBeam_9.83ft spacing

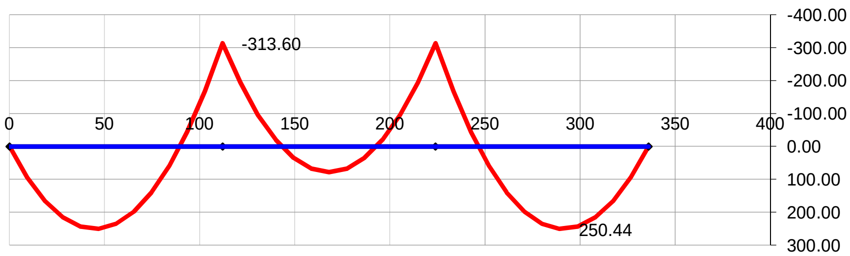
WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

FORCE / DISPLACEMENTS DIAGRAMS DUE TO STATIC LOAD CASE: DW - Center Beam

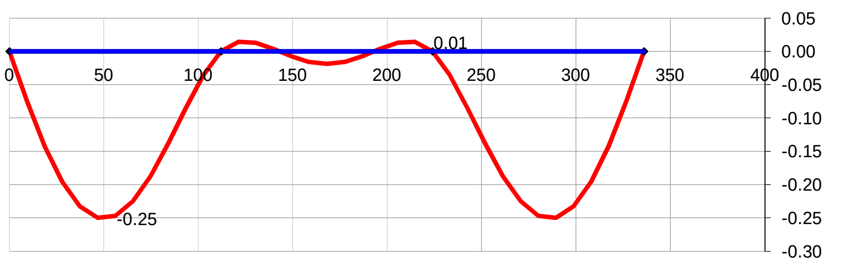




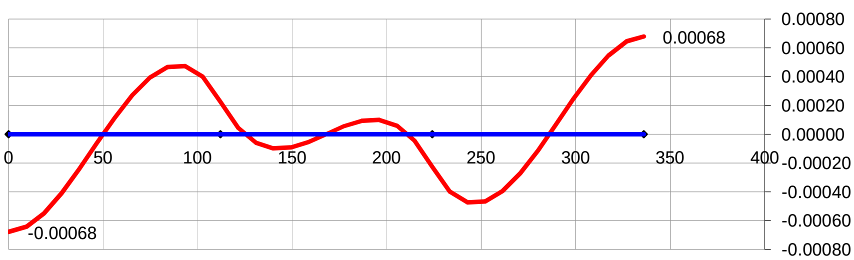
Shear, kip	
Max =	16.8
Min =	-16.8



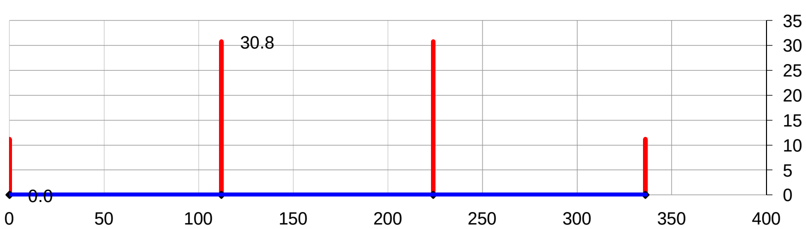
Moment, kip*ft	
Max =	250.44
Min =	-313.60



Deflections, in	
Max =	0.01
Min =	-0.25



Rotations, rad	
Max =	0.00068
Min =	-0.00068



Reactions, kip	
Max =	30.8
Min =	0.0
ΣR =	84

WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

LOAD CASE: DW - Center Beam

ANALYSIS RESULTS				
X, ft	Shear, kip	Moment, kip-ft	Deflections, in	Rotations, rad
0	11.2	0.00	0.00	-0.00068
1E-06	11.2	0.00	0.00	-0.00068
9.3333	8.9	93.64	-0.07	-0.00064
18.667	6.5	165.51	-0.14	-0.00055
28	4.2	215.60	-0.20	-0.00041
37.333	1.9	243.91	-0.23	-0.00024
46.667	-0.5	250.44	-0.25	-0.00006
56	-2.8	235.20	-0.25	0.00011
65.333	-5.1	198.18	-0.23	0.00027
74.667	-7.5	139.38	-0.19	0.00039
84	-9.8	58.80	-0.14	0.00047
93.333	-12.1	-43.56	-0.09	0.00047
102.67	-14.5	-167.69	-0.04	0.00040
112	-16.8	-313.60	0.00	0.00023
112	-16.8	-313.60	0.00	0.00023
112	14.0	-313.60	0.00	0.00023
121.33	11.7	-193.82	0.01	0.00004
130.67	9.3	-95.82	0.01	-0.00006
140	7.0	-19.60	0.00	-0.00010
149.33	4.7	34.84	-0.01	-0.00009
158.67	2.3	67.51	-0.02	-0.00005
168	0.0	78.40	-0.02	0.00000
177.33	-2.3	67.51	-0.02	0.00005
186.67	-4.7	34.84	-0.01	0.00009
196	-7.0	-19.60	0.00	0.00010
205.33	-9.3	-95.82	0.01	0.00006
214.67	-11.7	-193.82	0.01	-0.00004
224	-14.0	-313.60	0.00	-0.00023
224	-14.0	-313.60	0.00	-0.00023
224	16.8	-313.60	0.00	-0.00023
233.33	14.5	-167.69	-0.04	-0.00040
242.67	12.1	-43.56	-0.09	-0.00047
252	9.8	58.80	-0.14	-0.00047
261.33	7.5	139.38	-0.19	-0.00039
270.67	5.1	198.18	-0.23	-0.00027
280	2.8	235.20	-0.25	-0.00011
289.33	0.5	250.44	-0.25	0.00006
298.67	-1.9	243.91	-0.23	0.00024
308	-4.2	215.60	-0.20	0.00041
317.33	-6.5	165.51	-0.14	0.00055
326.67	-8.9	93.64	-0.07	0.00064
336	-11.2	0.00	0.00	0.00068
336	-11.2	0.00	0.00	0.00068

Horizontal sway displacements = 0 in

	Max	Min	Area	Area(+)	Area(-)
Shear	16.8	-16.8	0.0	1207.4	-1207.4
Moment	250.44	-313.60	16951.82	32170.87	-15219.05
Deflections	0.01	-0.25	-33.91	0.55	-34.47
Rotations	0.00068	-0.00068	0.00000	0.04545	-0.04545
Reactions	30.8	11.2			

Coordinate	Reaction	Displ.
X, ft	**R, kip**	**Δ, in**
0	11.2	0.00
112	30.8	0.00
224	30.8	0.00
336	11.2	0.00

ΣR = 84 kip

WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 06-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

Modulus of elasticity, E

Beam: 29000 ksi

Columns: 3600 ksi

Beam end restraints

Left End: Support

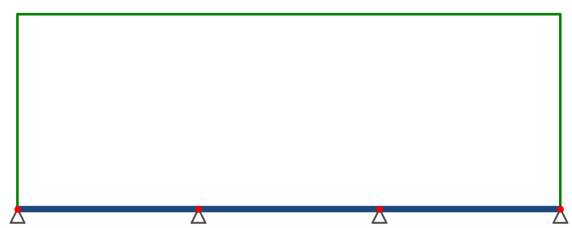
Right End: Support

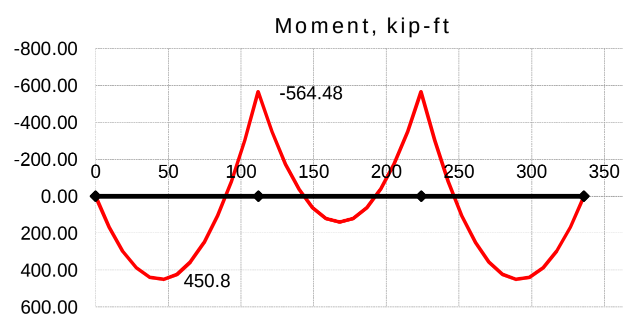
Sway frame: ☐

Span №	1	2	3
Length, ft	112	112	112
Moment of Inertia, ft^4	3.1	3.1	3.1

	Support №	1	2	3	4
	Support coordinate, ft	0	112	224	336
	Vertical spring constant, kip/ft				
	Support type or hinge	Roller	Roller	Roller	Roller
Column under	Length, ft				
	Moment of Inertia, ft^4				
Column above	Length, ft				
	Moment of Inertia, ft^4				
	Induced support displacements, ft				

Positive loads: ↑ ↺	Load case:	Ped LL - Ext (1)			
Comment	Load Type	WA kip or kip/ft	WB kip/ft	LA ft	LB ft
Ped LL (0.075ksf)	Linear	-0.45	-0.45	0	336





WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 06-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

Modulus of elasticity, E
Beam: 29000 ksi
Columns: 3600 ksi

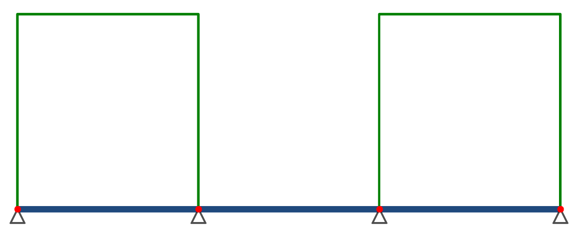
Beam end restraints
Left End: Support
Right End: Support

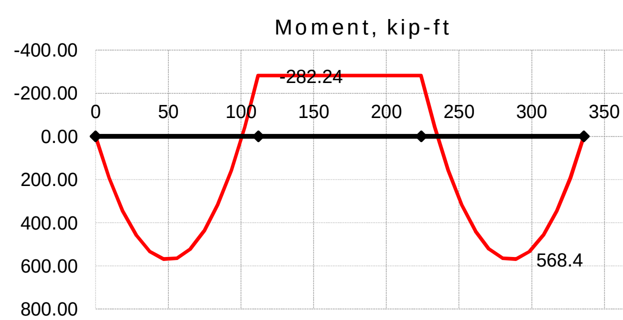
Sway frame: ☐

Span №	1	2	3
Length, ft	112	112	112
Moment of Inertia, ft^4	3.1	3.1	3.1

Support №	1	2	3	4
Support coordinate, ft	0	112	224	336
Vertical spring constant, kip/ft				
Support type or hinge	Roller	Roller	Roller	Roller
Column under Length, ft				
Moment of Inertia, ft^4				
Column above Length, ft				
Moment of Inertia, ft^4				
Induced support displacements, ft				

Positive loads: ↑ ↺	Load case:	Ped LL - Ext (2)			
Comment	Load Type	WA kip or kip/ft	WB kip/ft	LA ft	LB ft
Ped LL (0.075ksf)	Linear	-0.45	-0.45	0	112
Ped LL (0.075ksf)	Linear	-0.45	-0.45	224	336





WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 06-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

Modulus of elasticity, E

Beam:	29000	ksi
Columns:	3600	ksi

Beam end restraints

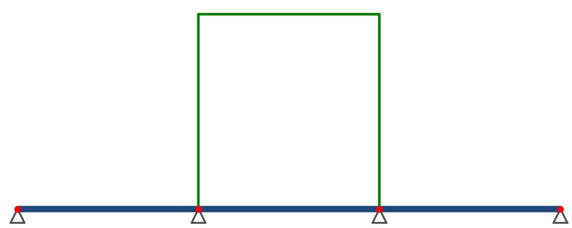
Left End	Right End
Support	Support

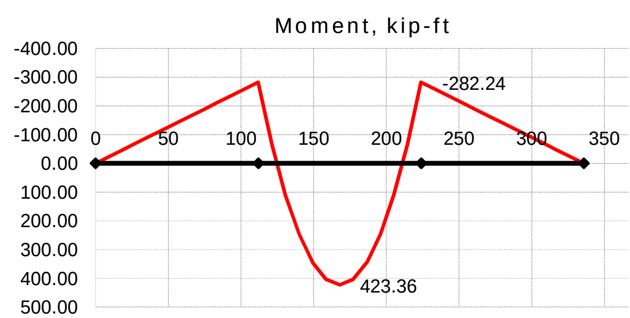
Sway frame: ☐

Span №	1	2	3
Length, ft	112	112	112
Moment of Inertia, ft^4	3.1	3.1	3.1

Support №	1	2	3	4
Support coordinate, ft	0	112	224	336
Vertical spring constant, kip/ft				
Support type or hinge	Roller	Roller	Roller	Roller
Column under Length, ft				
Moment of Inertia, ft^4				
Column above Length, ft				
Moment of Inertia, ft^4				
Induced support displacements, ft				

Positive loads: ↑ ↺	Load case:	Ped LL - Ext (3)			
Comment	Load Type	WA kip or kip/ft	WB kip/ft	LA ft	LB ft
Ped LL (0.075ksf)	Linear	-0.45	-0.45	112	224





WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: **JWC** Date: 06-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

Modulus of elasticity, E
Beam: 29000 ksi
Columns: 3600 ksi

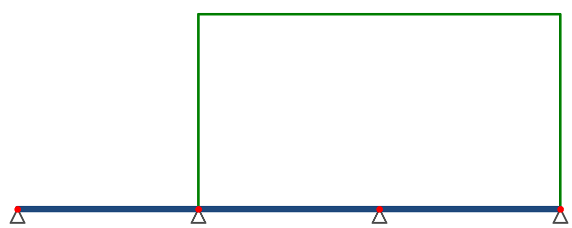
Beam end restraints
Left End: Support
Right End: Support

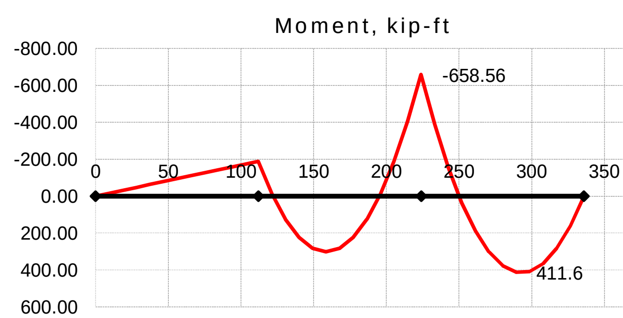
Sway frame: ☐

Span №	1	2	3
Length, ft	112	112	112
Moment of Inertia, ft^4	3.1	3.1	3.1

Support №	1	2	3	4
Support coordinate, ft	0	112	224	336
Vertical spring constant, kip/ft				
Support type or hinge	Roller	Roller	Roller	Roller
Column under Length, ft				
Moment of Inertia, ft^4				
Column above Length, ft				
Moment of Inertia, ft^4				
Induced support displacements, ft				

Positive loads: ↑ ↺	Load case:	Ped LL - Ext (4)			
Comment	Load Type	WA kip or kip/ft	WB kip/ft	LA ft	LB ft
Ped LL (0.075ksf)	Linear	-0.45	-0.45	112	336





C:\Users\clarkju\Documents\PB Work, Scheduling, etc\Projects\ITD - Memorial Bridge in Lewiston\2 - Superstructure\75.50ft wide deck, 8 girders\Superstructure Loads_GoBeam_9.5ft spacing

WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 06-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

Modulus of elasticity, E

Beam: 29000 ksi

Columns: 3600 ksi

Beam end restraints

Left End: Support

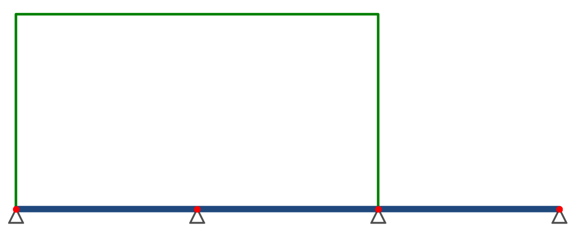
Right End: Support

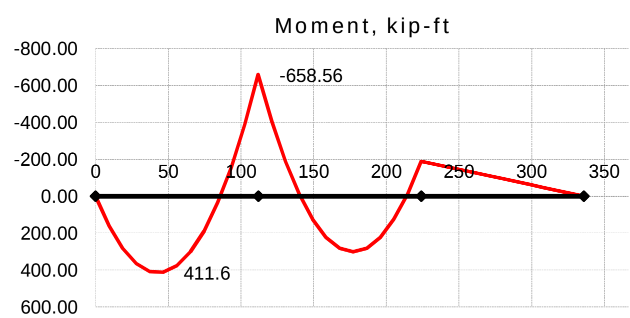
Sway frame: ☐

Span №	1	2	3
Length, ft	112	112	112
Moment of Inertia, ft^4	3.1	3.1	3.1

Support №	1	2	3	4
Support coordinate, ft	0	112	224	336
Vertical spring constant, kip/ft				
Support type or hinge	Roller	Roller	Roller	Roller
Column under Length, ft				
Moment of Inertia, ft^4				
Column above Length, ft				
Moment of Inertia, ft^4				
Induced support displacements, ft				

Positive loads: ↑ ↺	Load case:	Ped LL - Ext (5)			
Comment	Load Type	WA kip or kip/ft	WB kip/ft	LA ft	LB ft
Ped LL (0.075ksf)	Linear	-0.45	-0.45	0	224





WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 06-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

Modulus of elasticity, E

Beam:	29000	ksi
Columns:	3600	ksi

Beam end restraints

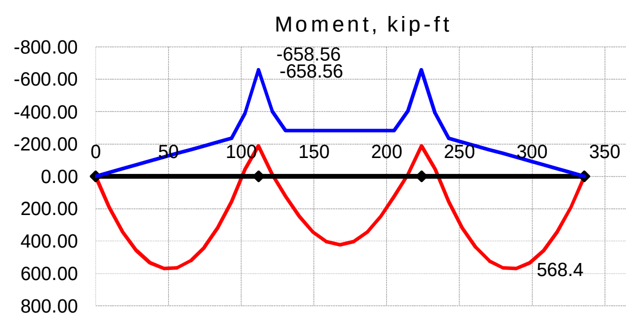
Left End	Right End
Support	Support

Sway frame: ☐

Span №	1	2	3
Length, ft	112	112	112
Moment of Inertia, ft^4	3.1	3.1	3.1

Support №	1	2	3	4
Support coordinate, ft	0	112	224	336
Vertical spring constant, kip/ft				
Support type or hinge	Roller	Roller	Roller	Roller
Column under Length, ft				
Moment of Inertia, ft^4				
Column above Length, ft				
Moment of Inertia, ft^4				
Induced support displacements, ft				

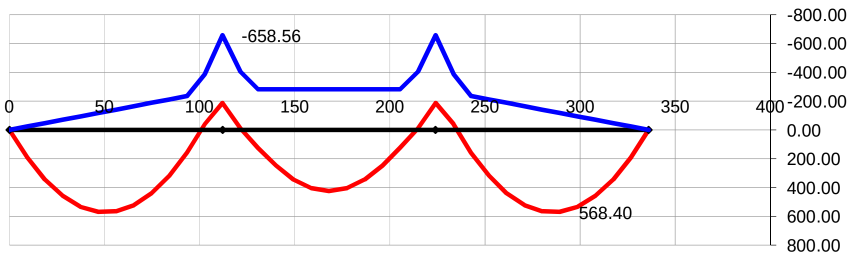
Positive loads: ↑ ↺	Load case:	Envelopes of Ped1, Ped2, Ped3, Ped4, Ped5			
Comment	Load Type	WA kip or kip/ft	WB kip/ft	LA ft	LB ft



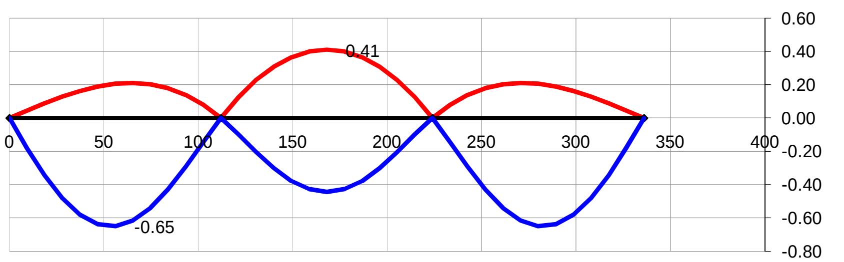
WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 6-Oct
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker: Date:

FORCE / DISPLACEMENTS DIAGRAMS DUE TO STATIC LOAD CASE: Envelopes of Ped1, Ped2, Ped3, Ped4, Ped5 ()

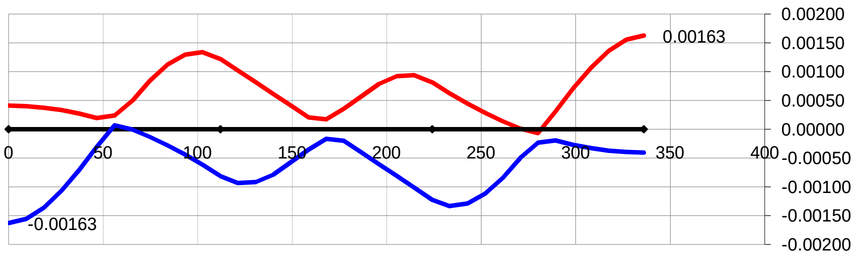
Shear, kip	
Max =	31.1
Min =	-31.1



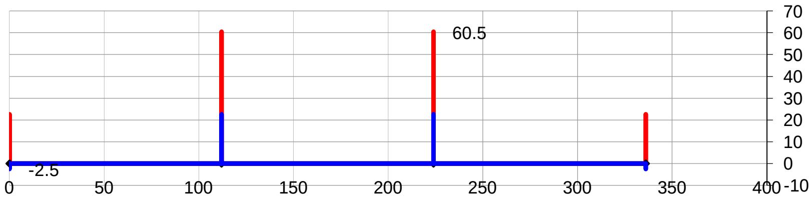
*Moment, kip*ft*	
Max =	568.40
Min =	-658.56



Deflections, in	
Max =	0.41
Min =	-0.65



Rotations, rad	
Max =	0.00163
Min =	-0.00163



Reactions, kip	
Max =	60.5
Min =	-2.5

WSP	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC
		Date: 06-Oct-17
GoBeam **Version 2016.06**	Subject: Superstructure Loading on Girders	Checker:
		Date:

Envelopes of Ped1, Ped2, Ped3, Ped4, Ped5

X, ft	MAXIMUM ENVELOPES Shear, kip	Moment, kip-ft	Deflections, in	Rotations, rad	X, ft	MINIMUM ENVELOPES Shear, kip	Moment, kip-ft	Deflections, in	Rotations, rad
0	22.7	0.00	0.00	0.00041	0	-2.5	0.00	0.00	-0.00163
1E-06	22.7	0.00	0.00	0.00041	1E-06	-2.5	0.00	0.00	-0.00163
9.33333	18.5	192.08	0.05	0.00040	9.33333	-2.5	-23.52	-0.18	-0.00156
18.6667	14.3	344.96	0.09	0.00037	18.6667	-2.5	-47.04	-0.34	-0.00136
28	10.1	458.64	0.13	0.00033	28	-2.5	-70.56	-0.48	-0.00107
37.3333	5.9	533.12	0.16	0.00027	37.3333	-2.5	-94.08	-0.58	-0.00071
46.6667	1.7	568.40	0.19	0.00020	46.6667	-2.5	-117.60	-0.64	-0.00031
56	-1.7	564.48	0.21	0.00024	56	-5.9	-141.12	-0.65	0.00007
65.3333	-1.7	521.36	0.21	0.00050	65.3333	-10.1	-164.64	-0.62	-0.00001
74.6667	-1.7	439.04	0.20	0.00084	74.6667	-14.3	-188.16	-0.54	-0.00014
84	-1.7	317.52	0.18	0.00112	84	-18.5	-211.68	-0.43	-0.00028
93.3333	-1.7	156.80	0.14	0.00129	93.3333	-22.7	-235.20	-0.29	-0.00044
102.667	-1.7	-43.12	0.08	0.00134	102.667	-26.9	-388.08	-0.14	-0.00062
112	-1.7	-188.16	0.00	0.00122	112	-31.1	-658.56	0.00	-0.00081
112	-1.7	-188.16	0.00	0.00122	112	-31.1	-658.56	0.00	-0.00081
112	29.4	-188.16	0.00	0.00122	112	0.0	-658.56	0.00	-0.00081
121.333	25.2	-11.76	0.13	0.00102	121.333	0.0	-403.76	-0.10	-0.00094
130.667	21.0	125.44	0.23	0.00081	130.667	0.0	-282.24	-0.20	-0.00092
140	16.8	246.96	0.31	0.00061	140	0.0	-282.24	-0.30	-0.00079
149.333	12.6	344.96	0.36	0.00041	149.333	0.0	-282.24	-0.38	-0.00057
158.667	8.4	403.76	0.40	0.00020	158.667	0.0	-282.24	-0.43	-0.00035
168	4.2	423.36	0.41	0.00017	168	-4.2	-282.24	-0.44	-0.00017
177.333	0.0	403.76	0.40	0.00035	177.333	-8.4	-282.24	-0.43	-0.00020
186.667	0.0	344.96	0.36	0.00057	186.667	-12.6	-282.24	-0.38	-0.00041
196	0.0	246.96	0.31	0.00079	196	-16.8	-282.24	-0.30	-0.00061
205.333	0.0	125.44	0.23	0.00092	205.333	-21.0	-282.24	-0.20	-0.00081
214.667	0.0	-11.76	0.13	0.00094	214.667	-25.2	-403.76	-0.10	-0.00102
224	0.0	-188.16	0.00	0.00081	224	-29.4	-658.56	0.00	-0.00122
224	0.0	-188.16	0.00	0.00081	224	-29.4	-658.56	0.00	-0.00122
224	31.1	-188.16	0.00	0.00081	224	1.7	-658.56	0.00	-0.00122
233.333	26.9	-43.12	0.08	0.00062	233.333	1.7	-388.08	-0.14	-0.00134
242.667	22.7	156.80	0.14	0.00044	242.667	1.7	-235.20	-0.29	-0.00129
252	18.5	317.52	0.18	0.00028	252	1.7	-211.68	-0.43	-0.00112
261.333	14.3	439.04	0.20	0.00014	261.333	1.7	-188.16	-0.54	-0.00084
270.667	10.1	521.36	0.21	0.00001	270.667	1.7	-164.64	-0.62	-0.00050
280	5.9	564.48	0.21	-0.00007	280	1.7	-141.12	-0.65	-0.00024
289.333	2.5	568.40	0.19	0.00031	289.333	-1.7	-117.60	-0.64	-0.00020
298.667	2.5	533.12	0.16	0.00071	298.667	-5.9	-94.08	-0.58	-0.00027
308	2.5	458.64	0.13	0.00107	308	-10.1	-70.56	-0.48	-0.00033
317.333	2.5	344.96	0.09	0.00136	317.333	-14.3	-47.04	-0.34	-0.00037
326.667	2.5	192.08	0.05	0.00156	326.667	-18.5	-23.52	-0.18	-0.00040
336	2.5	0.00	0.00	0.00163	336	-22.7	0.00	0.00	-0.00041
336	2.5	0.00	0.00	0.00163	336	-22.7	0.00	0.00	-0.00041

9. Analysis Step 4: Substructure Forces for 3D Analysis Input

Calculations of Forces applied to the CSi Bridge Substructure Model

Braking and Wind Forces

Braking Force, **BR** *:* (**AASHTO 3.6.4**)

Axle Weight of Design Truck $wt_{truck} := 8kip + 32kip + 32kip = 72 \cdot kip$

Axle Weight of Design Tandem $wt_{tandem} := 25kip + 25kip = 50 \cdot kip$

Design Lane Load - applied over 10 ft width (AASHTO 3.6.1.2.4) $w_{lane} := 0.64klf$

Continuous Span Length: $Cont\_Length := N_{span} \cdot L_{span} = 336\,ft$

Multiple Presence Factor for $\frac{N_{lane}}{2} = 2$

NOTE: For number of lanes in same direction

$$m_{BR} := \begin{cases} 1.2 & \text{if } 0.5 \cdot N_{lane} = 1 \\ 1.0 & \text{if } 0.5 \cdot N_{lane} = 2 \\ 0.85 & \text{if } 0.5 \cdot N_{lane} = 3 \\ 0.65 & \text{if } 0.5 \cdot N_{lane} > 3 \end{cases} = 1.00$$

Braking Force (per lane)

$$BR_{per\_lane} := \begin{bmatrix} 0.25 \cdot wt_{truck} \\ 0.25 \cdot wt_{tandem} \\ 0.05 \cdot (wt_{truck} + w_{lane} \cdot Cont\_Length) \\ 0.05 \cdot (wt_{tandem} + w_{lane} \cdot Cont\_Length) \end{bmatrix} = \begin{pmatrix} 18 \\ 12.5 \\ 14.4 \\ 13.3 \end{pmatrix} \cdot kip$$

Total Braking Force in Superstructure Level

$$BR_{tot} := \max(BR_{per\_lane}) \cdot \frac{N_{lane}}{2} \cdot m_{BR}$$

$$\boxed{BR_{tot} = 36 \cdot kip}$$

Height at which BR Force Acts: (Load applied parallel to lane CL) $h_{BR} := 6ft$

Braking Force is distributed longitudinally along the entire continuous section, which is 3 spans for this case. As such, the force is assumed to be distributed equally to each of the sets of bearing pads. The stiffness factor below is used to determine the portion of the braking force applied to the intermediate bents through at the bearing level.

Number of Intermediate Piers $N_{int\_piers} := 2$

Number of Pads in End/Expansion Piers $N_{end\_piers} := 1 + 1 = 2$

Portion of BR force applied to each Intermediate/Continuous Pier

$$k_{BR} := \frac{1}{N_{int\_piers} + N_{end\_piers}} = 0.25$$

BR force applied to each girder bearing

$$BR_{per.gird} := \frac{k_{BR} \cdot BR_{tot}}{0.5 \cdot N_{girder}} = 2.25 \cdot kip$$

*Wind Load on Structure, **WS**:* (**AASHTO 3.8**)

Heights and Elevations of Structural Elements

High Water ELE $ELE_{high\_water} := 36.0ft$

Low Water ELE $ELE_{low\_water} := 24.50ft$

Ave Water ELE $ELE_{water\_ave} := \dfrac{ELE_{high\_water} + ELE_{low\_water}}{2} = 30.3\,ft$

Superstructure ELE $ELE_{super} := 59.76ft + (8ft + 10in) = 68.6\,ft$

Proposed Bent Cap Height $h_{bent} := 3ft + 2in$

Bent Cap CoG ELE $ELE_{bent} := 59.76ft + h_{bent} = 62.9\,ft$

As-Built Column Height (Pier 1) $h_{col} := 59.76ft - 38ft = 21.8\,ft$

Column CoG ELE $ELE_{col} := 38ft + \dfrac{h_{col}}{2} = 48.9\,ft$

Height of Superstructure $Z_{super} := ELE_{super} - ELE_{water\_ave} = 38.3\,ft$

Height of Bent Cap $Z_{bent} := ELE_{bent} - ELE_{water\_ave} = 32.7\,ft$

Height of Column $Z_{col} := ELE_{col} - ELE_{water\_ave} = 18.6\,ft$

Specify Upstream Surface Condition

(Insert '*Open_Country*', '*Suburban*', or '*City*' - See **AASHTO C3.8.1.1** for condition descriptions)

Upstream_Surface_Condition := Open_Country

AASHTO Table 3.8.1.1-1

Friction Velocity :

$$V_0 := \begin{cases} 8.20mph & \text{if Upstream\_Surface\_Condition = Open\_Country} \\ 10.90mph & \text{if Upstream\_Surface\_Condition = Suburban} \\ 12.00mph & \text{if Upstream\_Surface\_Condition = City} \end{cases} \qquad V_0 = 8.2 \cdot mph$$

Friction Length of Upstream Fetch :

$$Z_0 := \begin{cases} 0.23ft & \text{if Upstream\_Surface\_Condition = Open\_Country} \\ 3.28ft & \text{if Upstream\_Surface\_Condition = Suburban} \\ 8.20ft & \text{if Upstream\_Surface\_Condition = City} \end{cases} \qquad Z_0 = 0.23 \cdot ft$$

$V_{30} := 100mph$ Wind Velocity @ 30 ft above low ground or design water level

$V_B := 100mph$ Base Wind Velocity @ 30 ft above low ground or design water level (**AASTHO 3.8.1.2** and **3.8.2**)

Design Wind Velocity at Design Elevation, Z

$$V_{DZ} := \begin{cases} (0\text{mph}) & \text{if } Z_{super} < 30\text{ft} \\ \left[2.5 \cdot V_0 \cdot \left(\frac{V_{30}}{V_B}\right) \cdot \ln\left(\frac{Z_{super}}{Z_0}\right)\right] & \text{if } Z_{super} \geq 30\text{ft} \end{cases}$$

$V_{DZ} = 104.9 \cdot \text{mph}$ **(AASHTO 3.8.1.1-1)**

Base Wind Pressure (**AASHTO Table 3.8.1.2-1**):

Superstructure Component	Windward Load	Leeward Load
Trusses, Columns, and Arches	$P_{B1} := 0.05\text{ksf}$	$P_{B1\_Leeward} := 0.025\text{ksf}$
Beams	$P_{B2} := 0.05\text{ksf}$	$P_{B2\_Leeward} := 0\text{ksf}$
Large Flat Surfaces	$P_{B3} := 0.04\text{ksf}$	$P_{B3\_Leeward} := 0\text{ksf}$

Wind Pressures on Structural Elements:

Transverse Design Wind Pressure for Beams: $P_{D2} := P_{B2} \cdot \left(\frac{V_{DZ}}{V_B}\right)^2$ $\boxed{P_{D2} = 0.06 \cdot \text{ksf}}$

Exposed superstructure tributary area at Pier $A_{super\_WS} := L_{span} \cdot \left(D_2 + t_{deck} + h_{barrier}\right) = 877.3\,\text{ft}^2$

Transverse WL on Superstructure $WS_{super} := P_{D2} \cdot A_{super\_WS} = 48.3 \cdot \text{kip}$

Transverse WL per Girder (at bearing ELE) $WS_{sup.per.girder} := \frac{WS_{super}}{N_{girder}} = 6.03 \cdot \text{kip}$

Longitudinal Base Wind Pressure for Wind Force at 60 degree Skew (Critical Case, per LRFD Table 3.8.1.2.2-1) $\boxed{P_{B\_long} := 0.019\text{ksf}}$

Longitudinal Design Wind Pressure $P_{D\_long} := P_{B\_long} \cdot \left(\frac{V_{DZ}}{V_B}\right)^2 = 0.02 \cdot \text{ksf}$

Longitudinal WL per Girder (at bearing ELE) $WS_{sup.long.per.girder} := \frac{P_{D\_long} \cdot A_{super\_WS}}{N_{girder}} = 2.29 \cdot \text{kip}$

Wind Forces Applied Directly to the Substructure (**AASHTO 3.8.1.2.3**) $\boxed{WS_{sub} := 0.040\text{ksf}}$
Applied Transversely and Longitudinally simultaneously

Proposed Bent Cap Length and Width $\boxed{L_{bent} := 69\text{ft} + 6\text{in}}$ $\boxed{w_{bent} := 5\text{ft} + 0\text{in}}$

Exposed superstructure tributary area at Pier $A_{bent\_tr} := w_{bent} \cdot h_{bent} = 15.8\,\text{ft}^2$

Transverse WL on Bent Cap $WS_{bent\_tr} := WS_{sub} \cdot A_{bent\_tr} = 0.63 \cdot \text{kip}$

Longitudinal Distributed WL along Bent Cap Length

$WS_{bent\_long} := WS_{sub} \cdot h_{bent} = 0.13 \cdot \frac{kip}{ft}$

As-Built Column Dimensions
b - along trans direction
w - along long direction

$b_{col\_A} := 4ft + 0in$ $b_{col\_BC} := 3ft + 6in$ $w_{col} := 3ft + 6in$

Longitudinal Distributed WL along Column Height

$WS_{col\_longA} := WS_{sub} \cdot b_{col\_A} = 0.16 \cdot \frac{kip}{ft}$

$WS_{col\_longBC} := WS_{sub} \cdot b_{col\_BC} = 0.14 \cdot \frac{kip}{ft}$

Transverse Distributed WL along Column Height

$WS_{col\_tr} := WS_{sub} \cdot w_{col} = 0.14 \cdot \frac{kip}{ft}$

Wind Forces on Live Load, **WL** (**AASHTO 3.8.1.3**)

Transverse Wind Load on Vehicles: $WL_{veh\_trans} := 0.10klf$

Longitudinal Wind Load on Vehicles: $WL_{veh\_long} := 0.04klf$

Height of WL (above roadway): $h_{WL} := 6ft$

Transverse WL on Superstructure (over tributary length of pier)

$WL_{tr} := WL_{veh\_trans} \cdot L_{span} = 11.2 \cdot kip$

Longitudinal WL on Superstructure (over width of super)

$WL_{long} := WL_{veh\_long} \cdot W_{deck} = 3.1 \cdot kip$

WL per Girder (at bearing ELE)

$WL_{tr.per.girder} := \frac{WL_{tr}}{N_{girder}} = 1.40 \cdot kip$ $WL_{long.per.girder} := \frac{WL_{long}}{N_{girder}} = 0.39 \cdot kip$

Vertical Wind Pressure, **WS** (**AASHTO 3.8.2**) - Limit States: Strength III and Service IV

Vertical Wind Pressure Bridge Deck: $WS_{vert} := 0.020ksf$

Longitudinal Vertical Wind Line Load on Bridge Deck:

$w_{WS\_vert} := WS_{vert} \cdot (W_{deck}) = 1.6 \cdot klf$

Vertical Load per Girder

$P_{WS\_vert} := \frac{w_{WS\_vert} \cdot L_{span}}{N_{girder}}$ $\boxed{P_{WS\_vert} = 21.8 \cdot kip}$

Moments from BR, WS, and WL Loads on Bent Cap: Since the CoG of these loads are above the CoG of the bent cap, which is where these loads will be applied within the CSi Bridge Model, the moment effect from these loads must be applied to the bent cap CoG.

Distance from CoG of Bent Cap to CoG of BR Load $d_{BR} := \frac{h_{bent}}{2} + \left(D_2 + t_{deck} + h_{barrier}\right) + h_{BR} = 15.4\,ft$

Distance from CoG of Bent Cap to CoG of WS Load (CoG of superstructure) $d_{WS} := \frac{h_{bent}}{2} + \frac{\left(D_2 + t_{deck} + h_{barrier}\right)}{2} = 5.5\,ft$

Distance from CoG of Bent Cap to CoG of WL Load $d_{WL} := \frac{h_{bent}}{2} + \left(D_2 + t_{deck} + h_{barrier}\right) + h_{WL} = 15.4\,ft$

Moments Applied at the Girder Locations at the CoG of the Bent Cap

Braking Force, BR $M_{BR\_gird} := BR_{per.gird} \cdot d_{BR} = 34.7 \cdot kip \cdot ft$

Wind on Structure, WS $M_{WS\_tr} := WS_{sup.per.girder} \cdot d_{WS} = 33.2 \cdot kip \cdot ft$ $M_{WS\_long} := WS_{sup.long.per.girder} \cdot d_{WS} = 12.6 \cdot kip \cdot ft$

Wind on LL, WL $M_{WL\_tr} := WL_{tr.per.girder} \cdot d_{WL} = 21.6 \cdot kip \cdot ft$ $M_{WL\_long} := WL_{long.per.girder} \cdot d_{WL} = 6 \cdot kip \cdot ft$

Summary of BR, WS, and WL Forces to apply to Substructure Analysis Model

Forces and Moments Applied to Girder Bearing Locations

Load Case	Transverse	Longitudinal	Vertical
Braking Force, BR	---	$BR_{per.gird} = 2.25 \cdot kip$ $M_{BR\_gird} = 34.7 \cdot kip \cdot ft$	---
Wind on Structure, WS	$WS_{sup.per.girder} = 6.03 \cdot kip$ $M_{WS\_tr} = 33.2 \cdot kip \cdot ft$	$WS_{sup.long.per.girder} = 2.3 \cdot kip$ $M_{WS\_long} = 12.6 \cdot kip \cdot ft$	$P_{WS\_vert} = 21.84 \cdot kip$ *Only for Str III
Wind on LL, WL	$WL_{tr.per.girder} = 1.4 \cdot kip$ $M_{WL\_tr} = 21.6 \cdot kip \cdot ft$	$WL_{long.per.girder} = 0.39 \cdot kip$ $M_{WL\_long} = 6 \cdot kip \cdot ft$	---

Forces Applied to Bent Cap

Load Case	Transverse (point load)	Longitudinal (distrib. force)
Wind on Structure, WS	$WS_{bent\_tr} = 0.63 \cdot kip$	$WS_{bent\_long} = 0.13 \cdot \frac{kip}{ft}$

Distributed Forces Applied along Column Height

Load Case	Transverse (distrib. load)	Longitudinal (distrib. force)
Wind on Structure, WS	$WS_{col\_tr} = 0.14 \cdot \frac{kip}{ft}$	$WS_{col\_longA} = 0.16 \cdot \frac{kip}{ft}$ $WS_{col\_longBC} = 0.14 \cdot \frac{kip}{ft}$

Braking and Wind Forces

Seismic Forces to Apply to Substructure Model

Seismic Girder Loads - Applied at Bearing Height
For Substructure Analysis within CSi Bridge Model

PGA (per USGS, units of g) $PGA := 0.0765$ Site Factor (LRFD 3.10.3.2) $F_{pga} := 1.0$

Seismic Acceleration Coefficient (per LRFD Eq. 3.10.4.2-2) $A_s := F_{pga} \cdot PGA = 0.0765$

Short Period Spectral Accel Coeff. (per USGS) $S_S := 0.1689$ Site Factor (LRFD 3.10.3.2) $F_a := 1.0$

Short Period Acceleration Coefficient (per LRFD Eq. 3.10.4.2-3) $S_{DS} := F_a \cdot S_S = 0.1689$

Long Period Spectral Accel Coeff. (per USGS) $S_{1\_long} := 0.0561$ Site Factor (LRFD 3.10.3.2) $F_v := 1.0$

Long Period Acceleration Coefficient (per LRFD Eq. 3.10.4.2-3) $S_{D1} := F_v \cdot S_{1\_long} = 0.0561$

Design Response Spectral Acceleration Coefficient (per Seismic LRFD Eq. 3.4.1-7) $S_a := S_{DS} = 0.1689$

Period at End of Constant Design Spectral Acceleration Plateau (LRFD 3.10.4.2) $T_S := \left(\frac{S_{D1}}{S_{DS}}\right) \cdot sec = 0.33\,s$

Period at Beginning of Constant Design Spectral Acceleration Plateau (LRFD 3.10.4.2) $T_0 := 0.2 \cdot T_S = 0.07\,s$

DL and SIDL per girder supported at bearings $W_{DL\_SIDL} := \left(w_{girder} + w_{deck_3} + w_{median} + w_{overlay_3}\right) \cdot L_{span} = 220.7 \cdot kip$

Superstructure Seismic Force Assumptions

The seismic force distributed from the girders to the substructure through the bearings is a function of the period of movement of the bearings. The bearing calculations below are used to determine the seismic force coefficient of the superstructure.

Bearing Parameters

Dimension of Bearing perpendicular to axis of rotation (Along Span Length) $L_{brg} := 14in$

Dimension of Bearing parallel to axis of rotation (Transverse to Span Length) $W_{brg} := \min(b_{f\_top}) - 2in = 14 \cdot in$

Bearing Area: $A_{brg} := L_{brg} \cdot W_{brg}$ $A_{brg} = 196 \cdot in^2$

Number of Bearings per girder $n_{bear} := 1$

Thickness of Internal Elastomeric Layer $h_{ri} := 0.5in$ Number of Internal Elastomeric Layers $n_{int} := 4$

Thickness of External Elastomeric Layer $h_{re} := 0.25in$ Number of External Elastomeric Layers $n_{ext} := 2$

Total Thickness of Bearing $h_{rt} := n_{int} \cdot h_{ri} + n_{ext} \cdot h_{re}$ $\boxed{h_{rt} = 2.5 \cdot in}$

Bearing Section Modulus: $S_{bear} := \dfrac{W_{brg} \cdot h_{ri}^{2}}{6}$ $\boxed{S_{bear} = 0.6 \cdot in^{3}}$

Shear Modulus $\boxed{G_{brg} := 0.160 ksi}$

Shape Factor $S_i := \dfrac{L_{brg} \cdot W_{brg}}{2 \cdot h_{ri} \cdot (L_{brg} + W_{brg})}$ $S_i = 7$ **LRFD 14.7.5.1-1**

Bearing Transverse Stiffness $K_{brg} := \dfrac{G_{brg} \cdot A_{brg}}{h_{rt}} = 150.5 \cdot \dfrac{kip}{ft}$

Unfactored Bearing Loads (from GoBeam Spreadsheet Analysis)

	Maximum Bearing Force	Minimum Bearing Force*
DC + DW Girder Reactions	$P_{DL\_max} := (189.70 + 29.60)kip = 219.3 \cdot kip$	$P_{DL\_min} := 2 \cdot (67.6 + 10.3)kip = 155.8 \cdot kip$
LL Girder Reactions	$P_{LL\_max} := 199.36kip$	$P_{LL\_min} := 0kip$
Service Normal Force on Bearing	$P_{serv\_max} := P_{DL\_max} + P_{DL\_max} = 438.6 \cdot kip$	$P_{serv\_min} := P_{DL\_min} + P_{LL\_min} = 155.8 \cdot kip$
Period of Bearing	$T_{brg\_max} := 2 \cdot \pi \cdot \sqrt{\dfrac{P_{serv\_max}}{g \cdot K_{brg}}} = 1.9\,s$	$T_{brg\_min} := 2 \cdot \pi \cdot \sqrt{\dfrac{P_{serv\_min}}{g \cdot K_{brg}}} = 1.1\,s$

Elastic Seismic Coefficient - LRFD Eqs. 3.10.4.2-1, 4, and 5

$$C_{sm\_max} := \begin{cases} \left[A_s + (S_{DS} - A_s) \cdot \left(\dfrac{T_{brg\_max}}{T_0}\right)\right] & \text{if } T_{brg\_max} \le T_0 \\ S_{DS} & \text{if } T_0 < T_{brg\_max} \le T_S \\ \dfrac{S_{D1}}{\left(\dfrac{T_{brg\_max}}{sec}\right)} & \text{if } T_S < T_{brg\_max} \end{cases}$$

$$C_{sm\_min} := \begin{cases} A_s + (S_{DS} - A_s) \cdot \left(\dfrac{T_{brg\_min}}{T_0}\right) & \text{if } T_{brg\_min} \le T_0 \\ S_{DS} & \text{if } T_0 < T_{brg\_min} \le T_S \\ \dfrac{S_{D1}}{\left(\dfrac{T_{brg\_min}}{sec}\right)} & \text{if } T_S < T_{brg\_min} \end{cases}$$

$C_{sm\_max} = 0.030$ $C_{sm\_min} = 0.050$

Superstructure Seismic Force Transferred Through the Bearing at each Girder $V_{EQ\_bear} := \max(C_{sm\_max} \cdot W_{DL\_SIDL}, C_{sm\_min} \cdot W_{DL\_SIDL})$ $\boxed{V_{EQ\_bear} = 11 \cdot kip}$

Maximum Horizontal Displacement of Bridge Superstructure - LRFD 14.7.5.3.2

$$\Delta_{brg\_max} := \frac{P_{serv\_max} \cdot C_{sm\_max}}{K_{brg}} = 1.04 \cdot in \qquad \Delta_{brg\_min} := \frac{P_{serv\_min} \cdot C_{sm\_min}}{K_{brg}} = 0.6 \cdot in$$

Maximum Allowable Displacement $\Delta_{brg\_allow} := \frac{h_{rt}}{2} = 1.3 \cdot in$

$$CHECK_{13} := \begin{vmatrix} \text{"Bearing Shear Deformation - OK"} & \text{if } 0.5 \cdot h_{rt} \geq \max(\Delta_{brg\_min}, \Delta_{brg\_max}) \\ \text{"Bearing Shear Deformation - NG"} & \text{if } 0.5 \cdot h_{rt} < \max(\Delta_{brg\_min}, \Delta_{brg\_max}) \end{vmatrix}$$

$$\boxed{\frac{\Delta_{brg\_allow}}{\max(\Delta_{brg\_min}, \Delta_{brg\_max})} = 1.2}$$

$$\boxed{CHECK_{13} = \text{"Bearing Shear Deformation - OK"}}$$

Seismic Substructure Loads - use S_a (conservatively)

Distributed Load Applied Along Length of Pier Cap $w_{EQ\_cap} := (h_{bent} \cdot w_{bent} \cdot \gamma_c) \cdot S_a = 0.41 \cdot \frac{kip}{ft}$

Cross-Section Area of Columns (from CSi Bridge Modeler) $A_{col\_A} := 1824in^2$ $A_{col\_BC} := 1584in^2$

Distributed Load Applied Along Height of Columns

Col A $w_{EQ\_colA} := (A_{col\_A} \cdot \gamma_c) \cdot S_a = 0.33 \cdot \frac{kip}{ft}$ Cols B/C $w_{EQ\_colBC} := (A_{col\_BC} \cdot \gamma_c) \cdot S_a = 0.29 \cdot \frac{kip}{ft}$

Seismic Forces to Apply to Substructure Model

10. Analysis Step 5: Substructure Analysis within CSi Bridge Model

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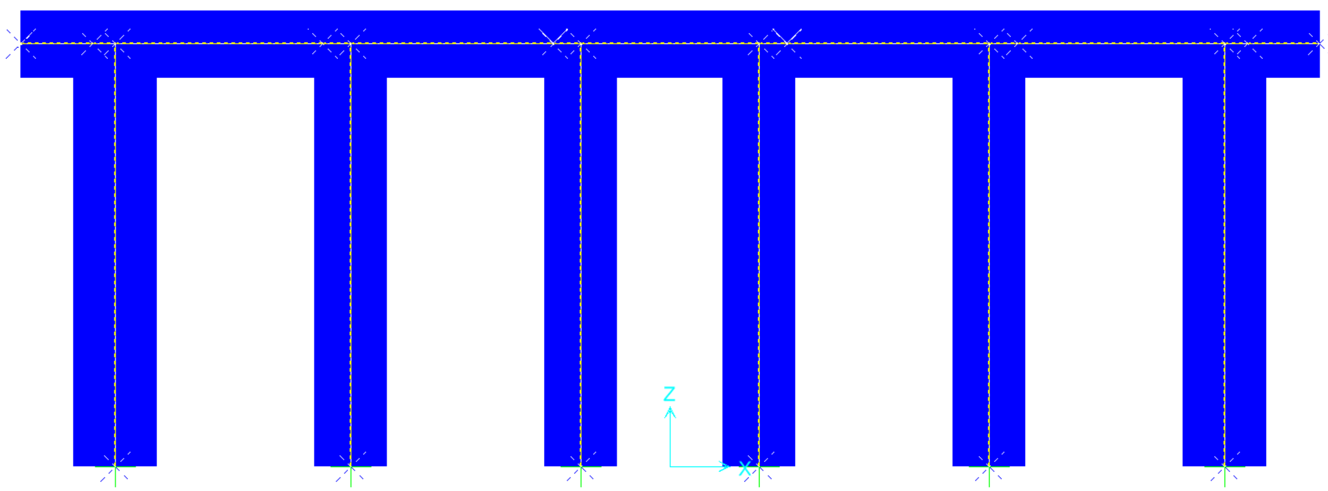
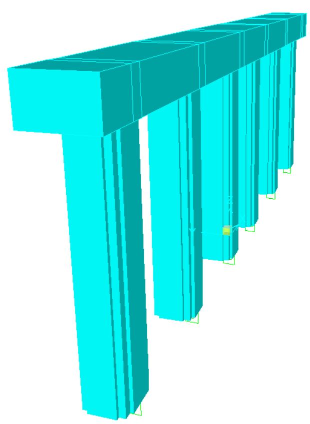
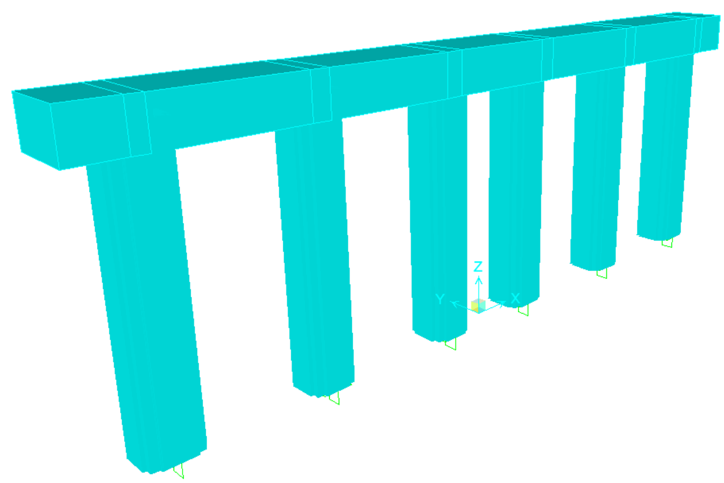
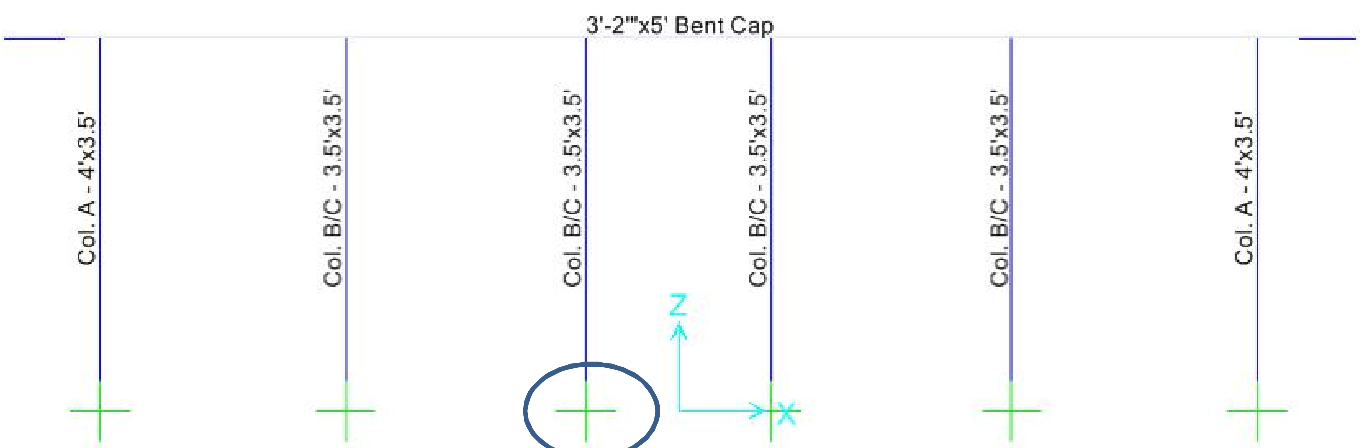
CSi Bridge Model of Pier 1 Substrucure







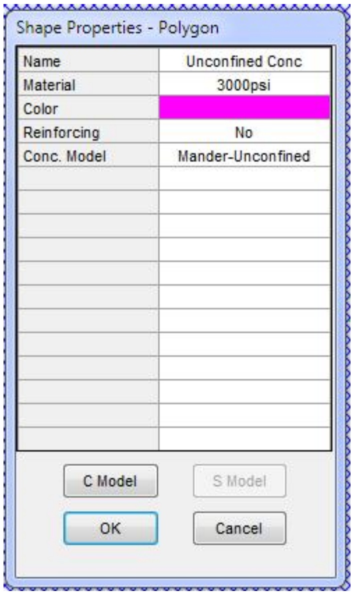
Frame Section Properties

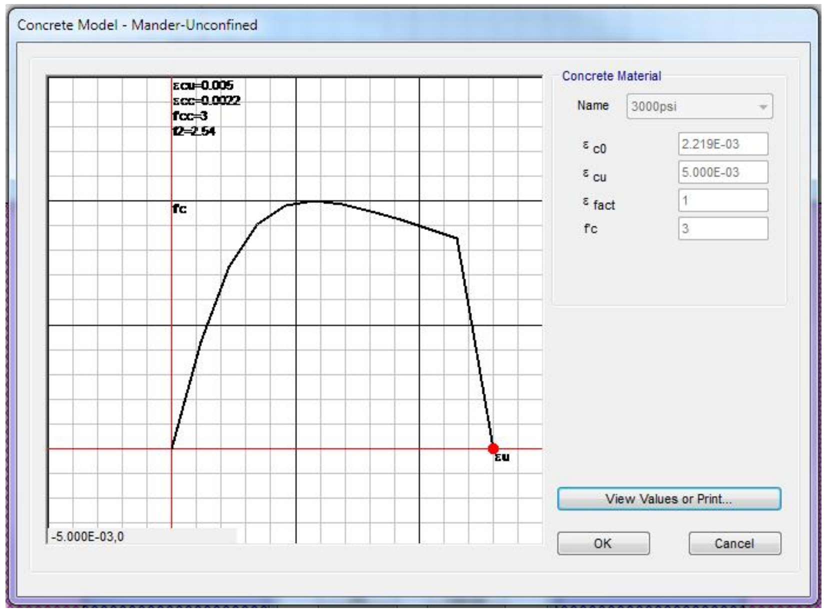


Modeled as fully fixed at interface between column base and top of footing

Material Properties

Unconfined Concrete Model



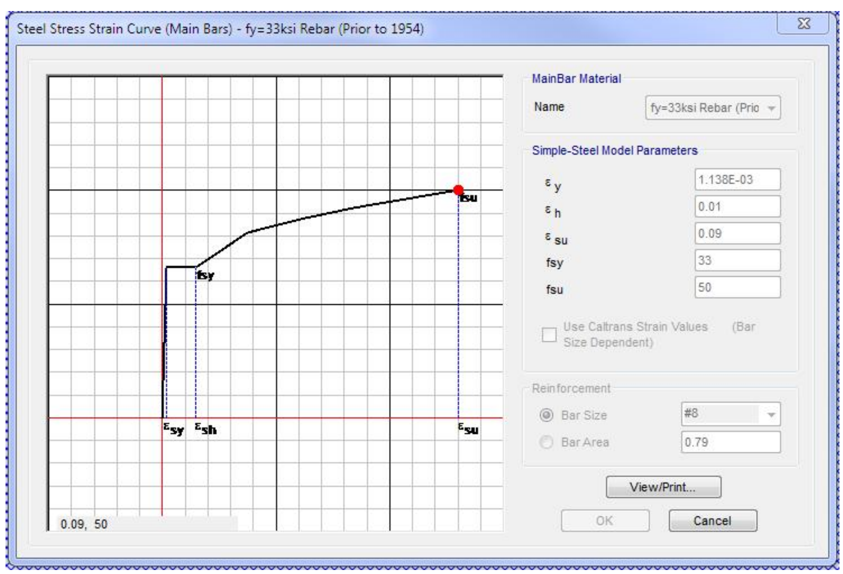


Steel Reinforcement Stress-Strain Properties – f_y=33 ksi

Per AASHTO Bridge Evaluation Manual 2011

Table 6A.5.2.2-1—Yield Strength of Reinforcing Steel

Type of Reinforcing Steel	Yield Strength, f_y, ksi
Unknown steel constructed prior to 1954	33.0
Structural grade	36.0
Billet or intermediate grade, Grade 40, and unknown steel constructed during or after 1954	40.0
Rail or hard grade, Grade 50	50.0
Grade 60	60.0



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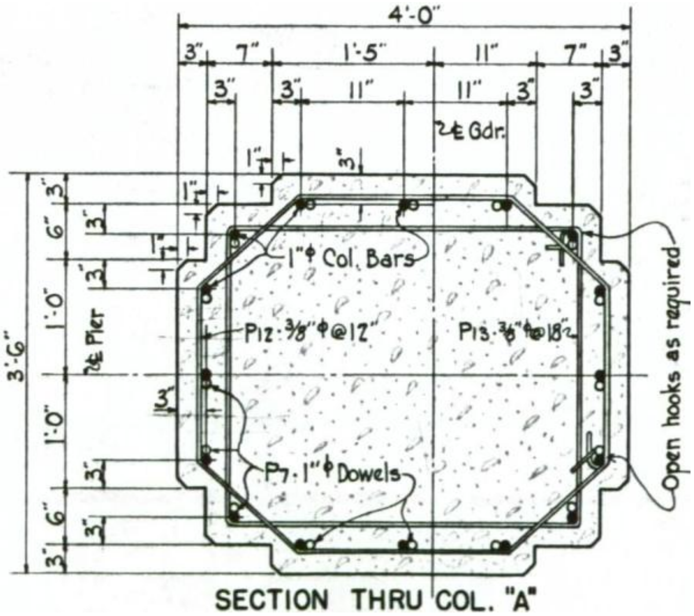
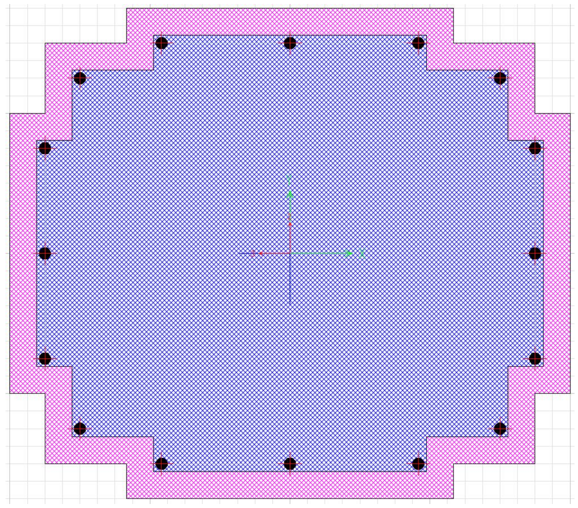
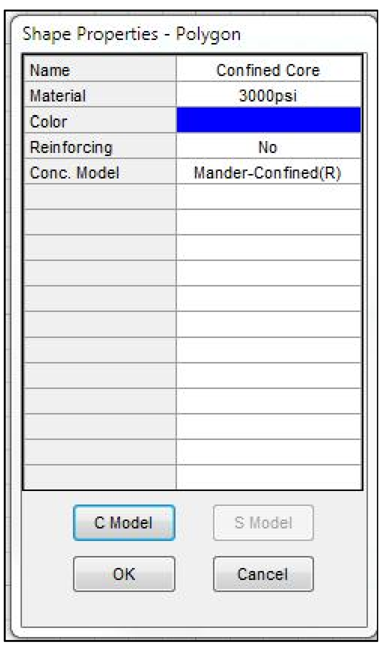
Frame Member Section Properties

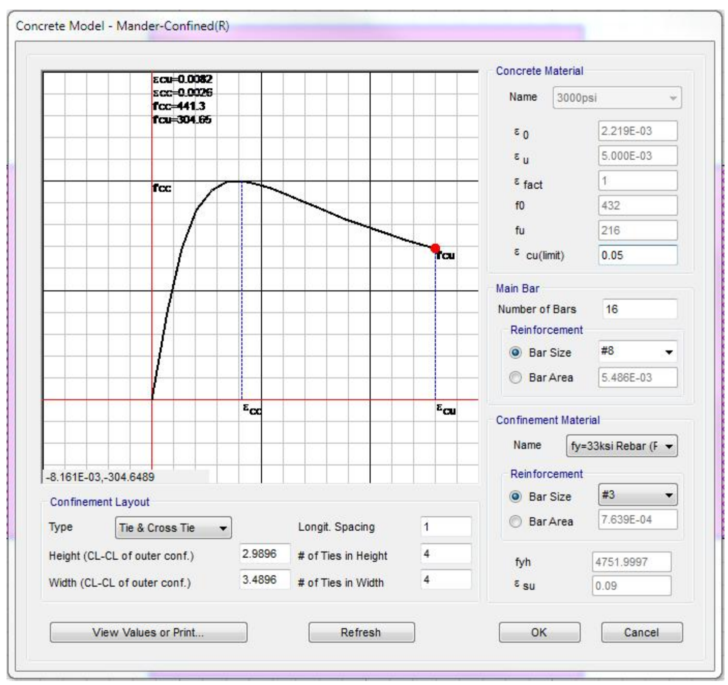
Col. A – 4’x3.5’ – Local Axes 3 = Transverse Direction, Axes 2 = Longitudinal Direction





Concrete Model for Confined Concrete
#3 ties at 12” (units in kips and in)





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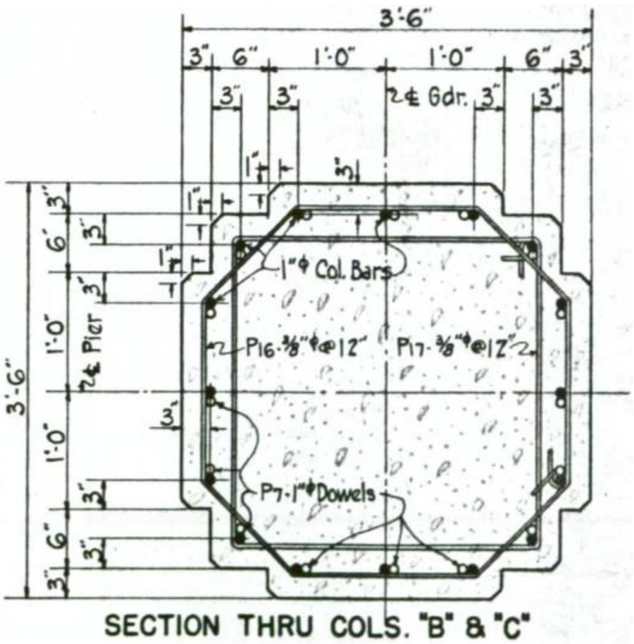
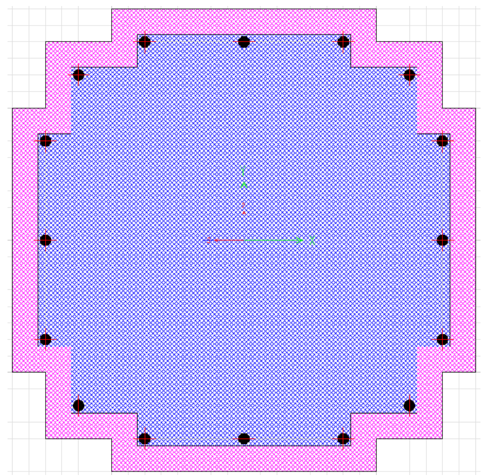
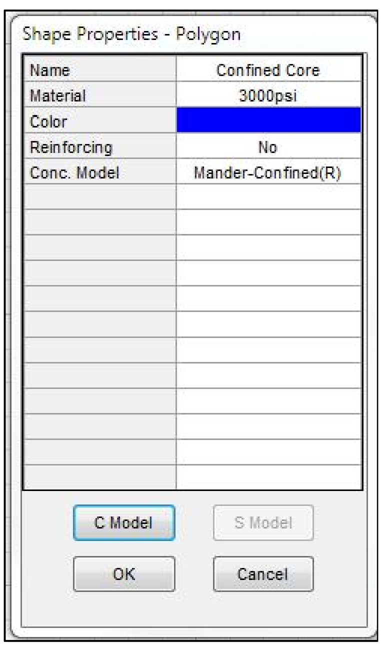
Frame Member Section Properties

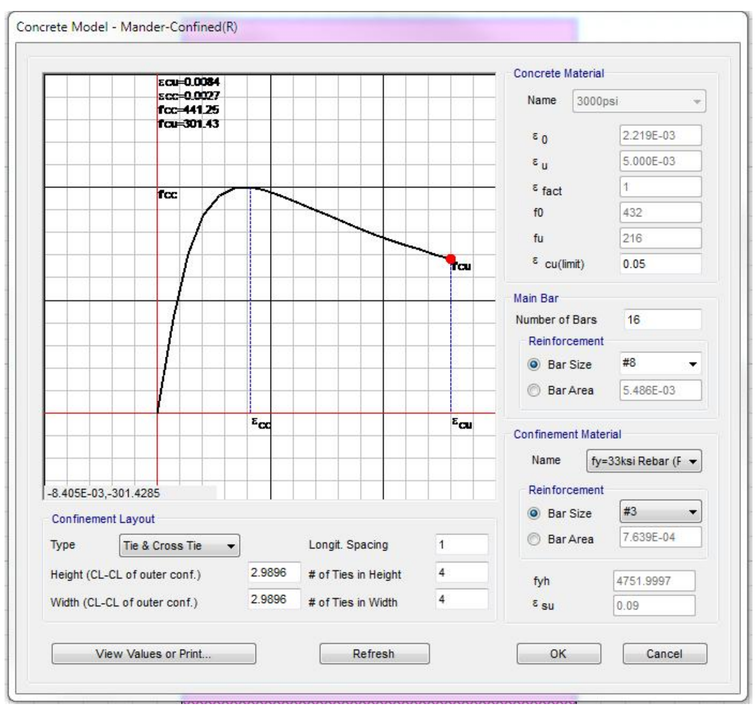
Col. B/C – 3.5’ x 3.5’ – Local Axes 3 = Transverse Direction, Axes 2 = Longitudinal Direction





Concrete Model for Confined Concrete
#3 ties at 12” (units in kips and in)





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Frame Member Section Properties

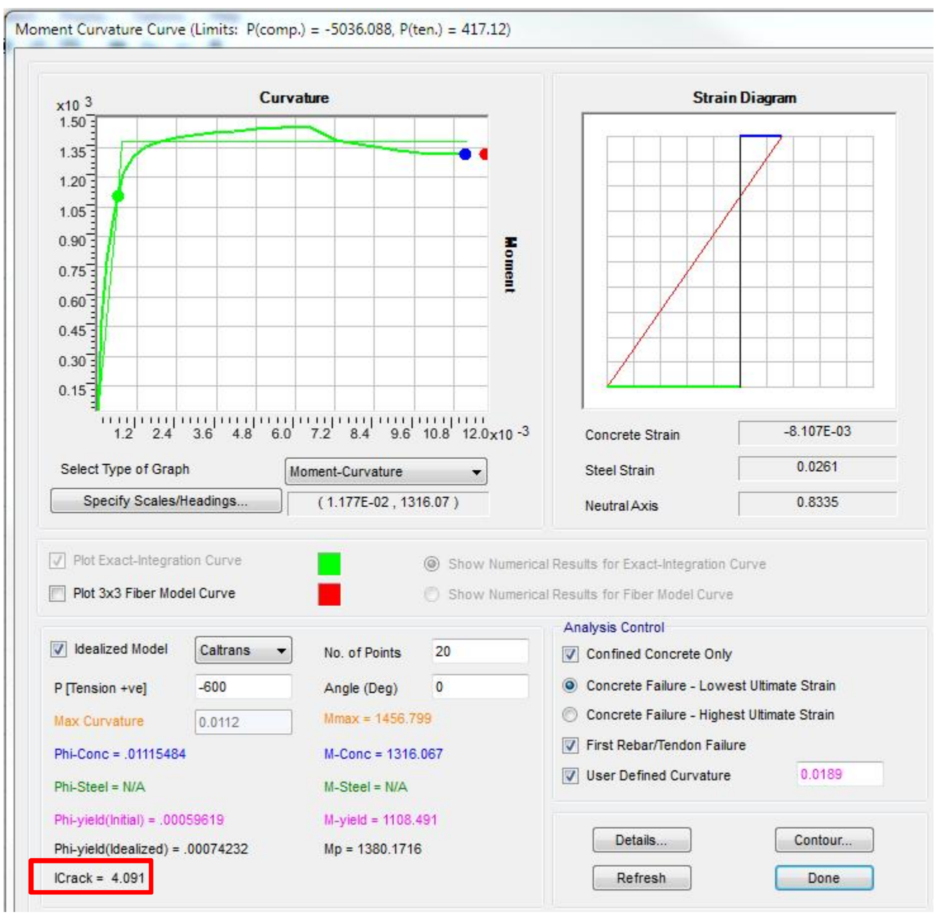
Column Stiffness modification factors

To account for how the cracked section properties of the column will affect the stiffness of the members, a modification factor was applied to the moments of inertia of the columns as a ratio of the cracked to gross moments of inertia. For non-seismic load cases, the factor was assumed to be 0.8. For seismic cases, the factor was determined as a ratio of Icr/Ig (see below).

Column	I_{cr} (ft^4)	I_g (ft^4)	Modification Factor = Icr/Ig
A – trans	5.471	14.77	0.37
A – long	4.091	11.30	0.37
B/C – both directions	3.191	9.73	0.33

Example for I_{crack} determination for Col A – longitudinal direction using Section Modeler

NOTE: For Ext. Event Load case, the axial force at maximum moment is approximately 600 kips for Col A and 300 kips for Col B/C. These values were used, respectively, to determine the I_{crack} for the columns



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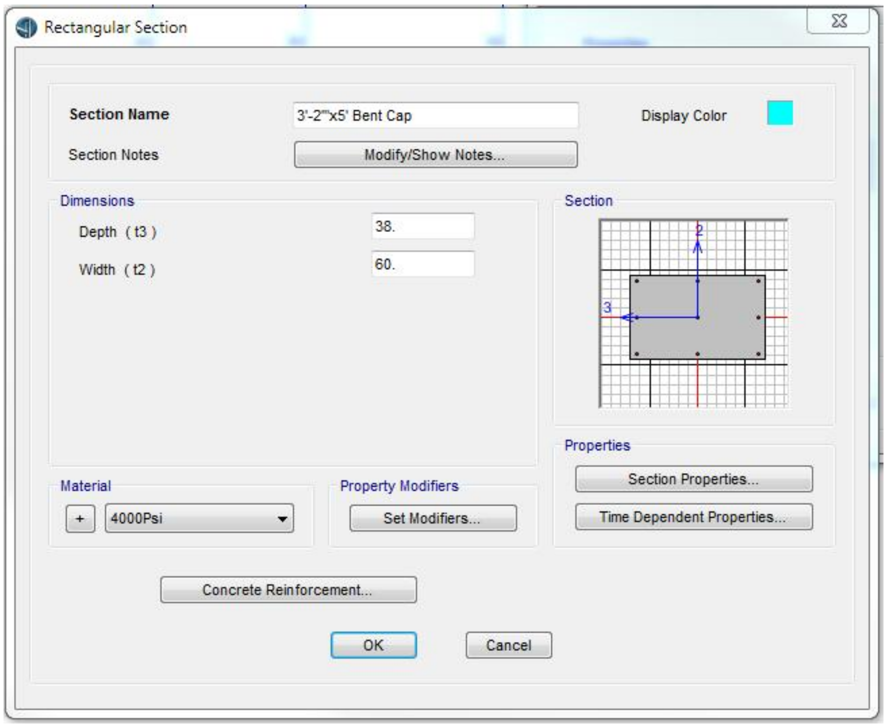
Frame Member Section Properties

Bent Cap – 3’-2” x 5’ Bent Cap – Local Axes 2 = Vertical Direction, Axes 3 = Longitudinal Direction



Bent Cap Stiffness modification factors

To account for how the cracked section properties of the bent cap will affect the stiffness of the members, a modification factor was applied to the moments of inertia of the columns as a ratio of the cracked to gross moments of inertia. This value was assumed to be 0.5 for the bent cap.

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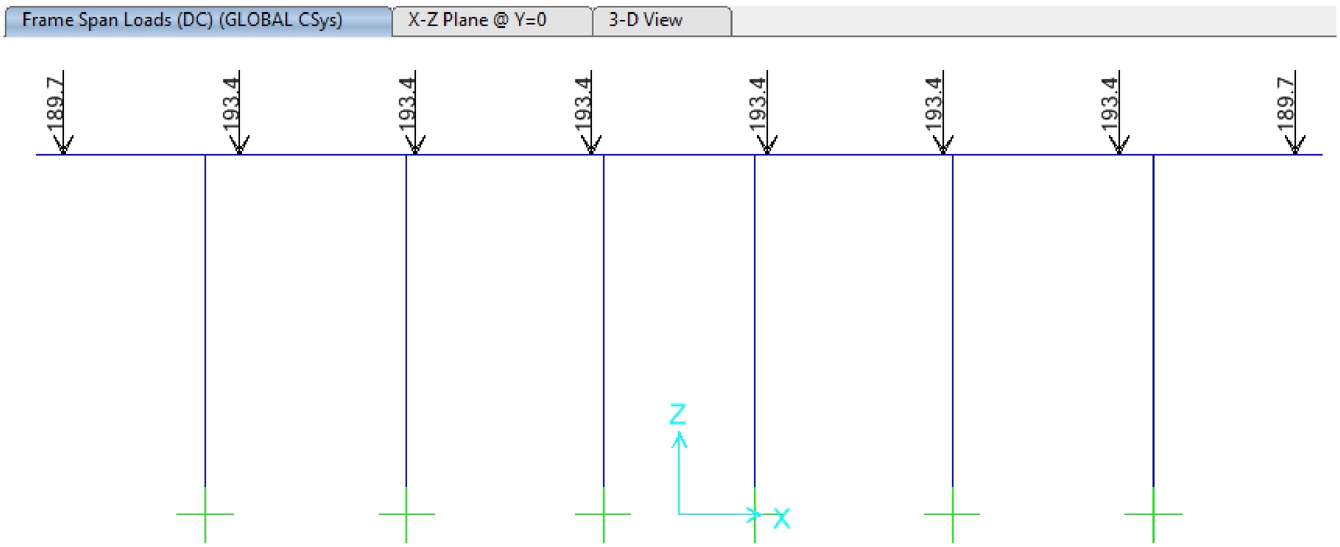
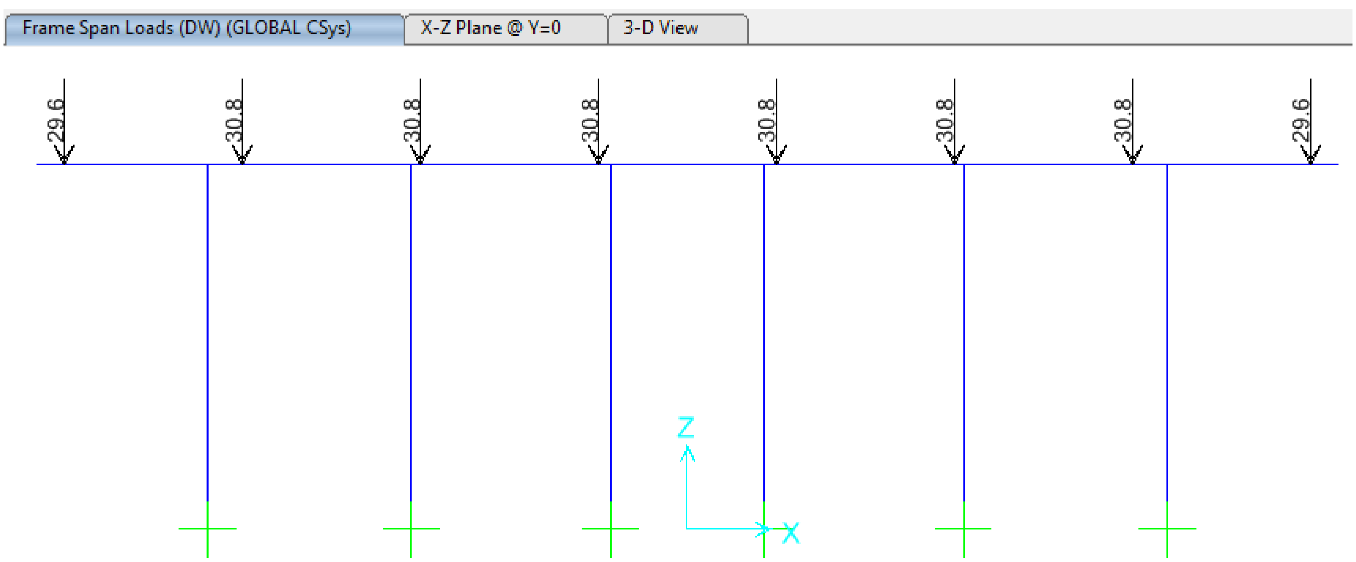
Girder Reaction Forces – see GoBeam results for summary of girder forces (units: kip, ft)

Load Case: DEAD – includes the structure self-weight (substructure only)

Load Case: DC



Load Case: DW



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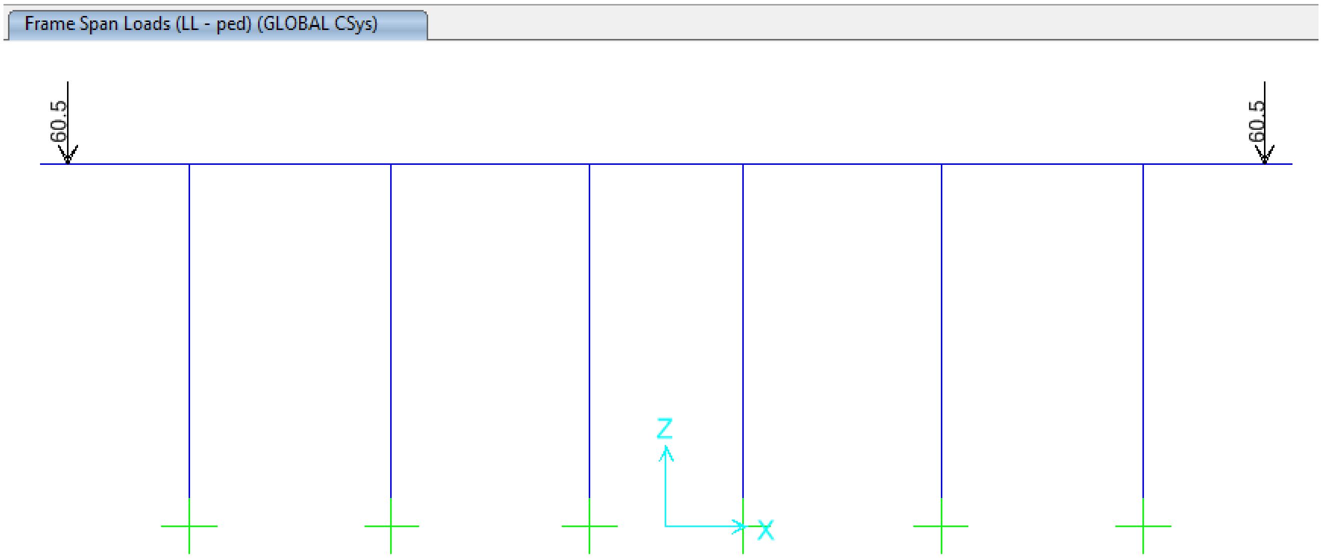
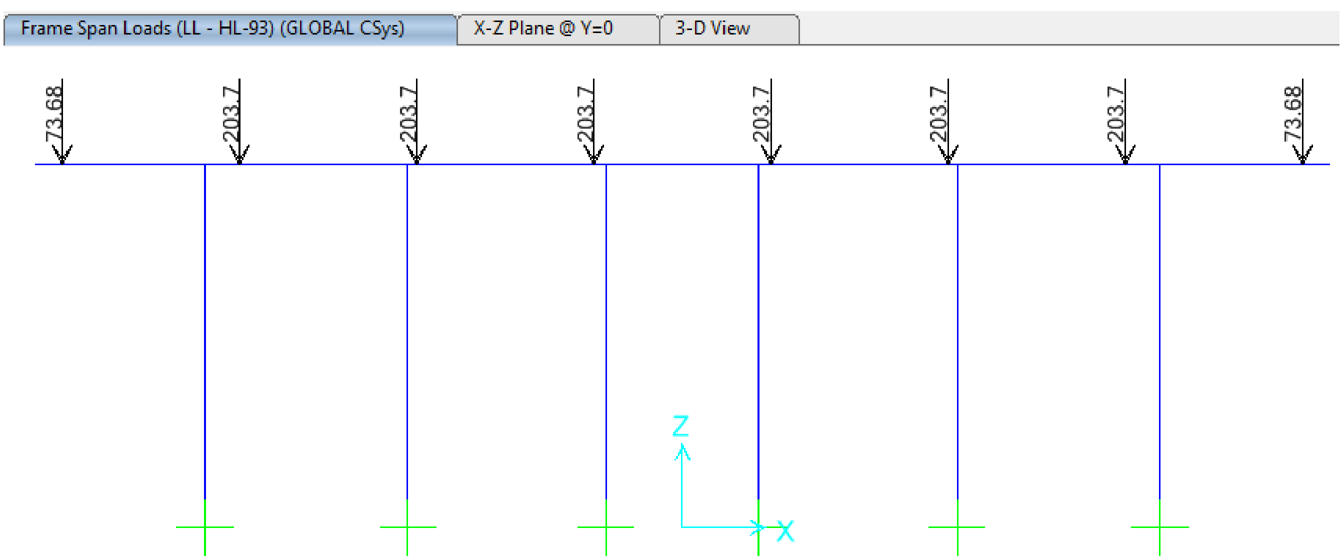
Girder Reaction Forces - continued

Load Case: LL-ped



Load Case: LL-HL-93



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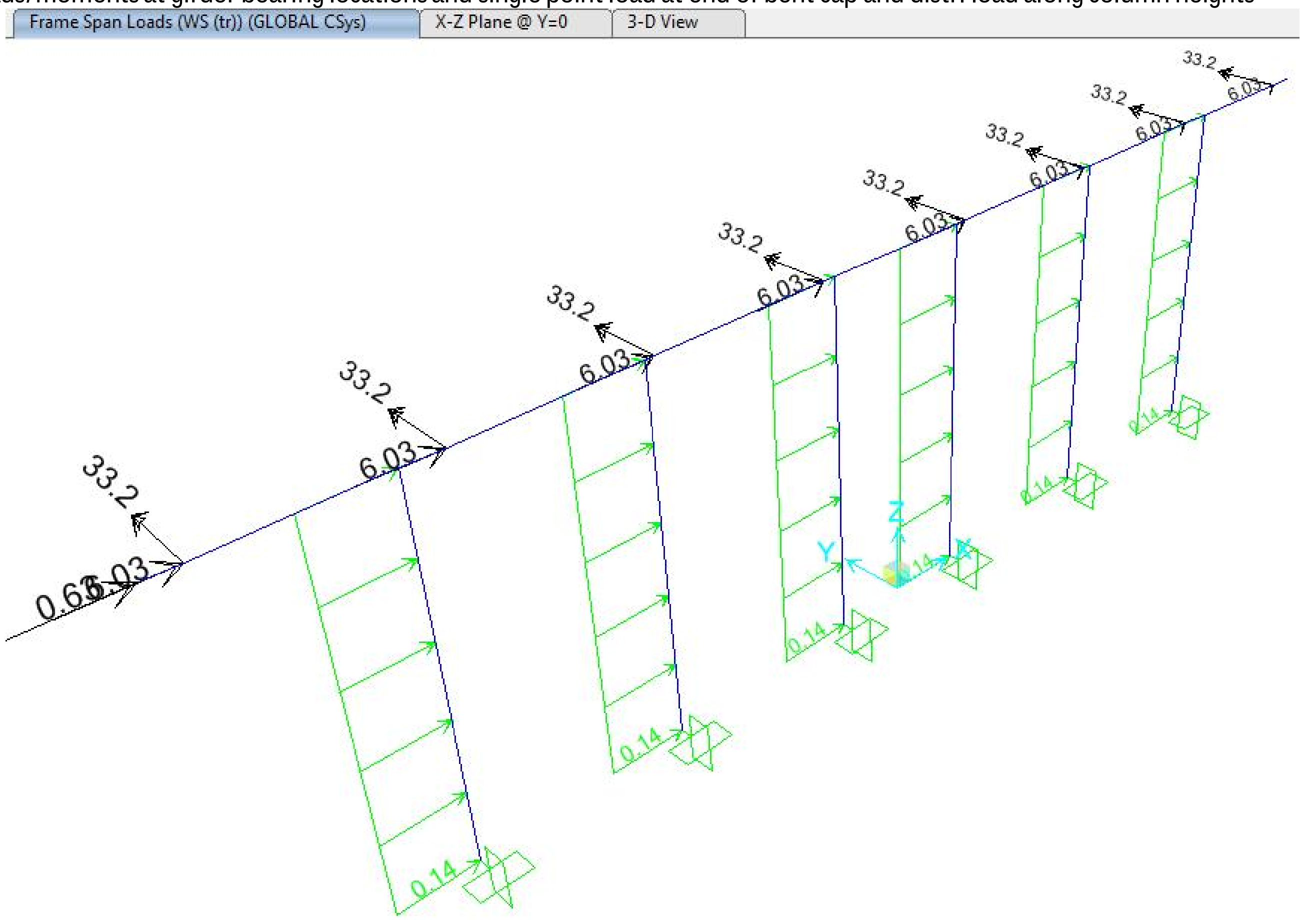
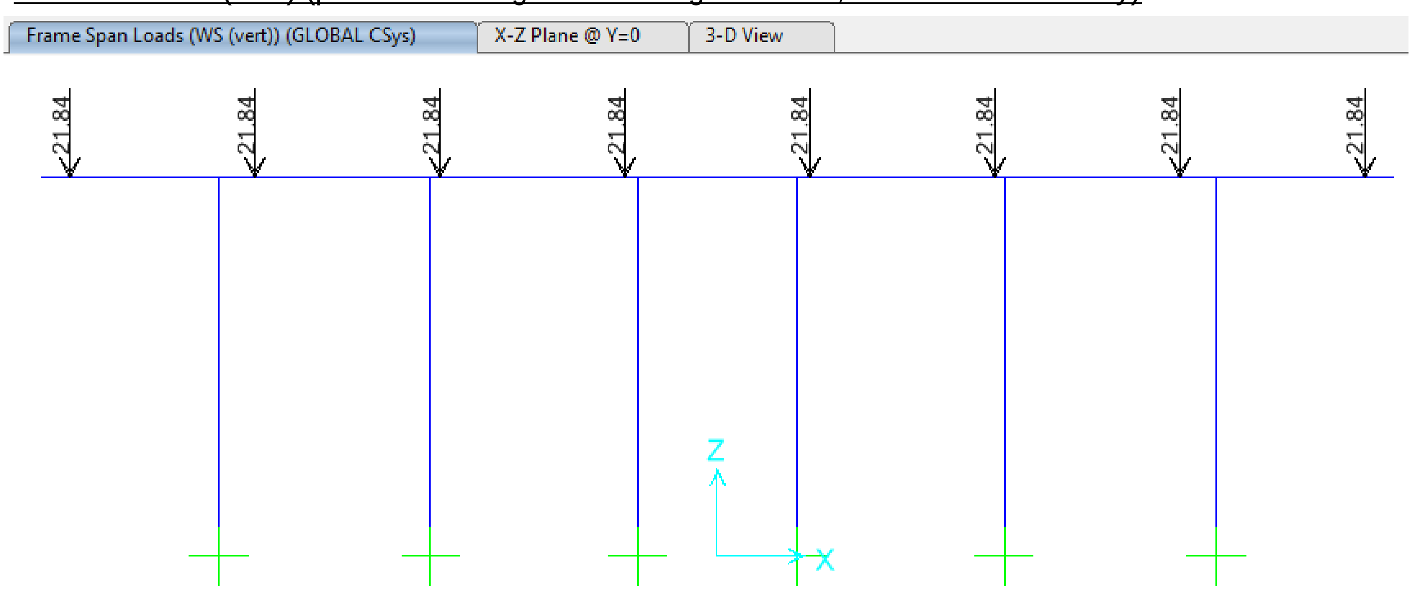
Forces Applied to Substructure

Load Case: WS (tr)

Point loads/moments at girder bearing locations and single point load at end of bent cap and distr. load along column heights



Load Case: WS(vert) (point loads at girder bearing locations, Str. III load case only)



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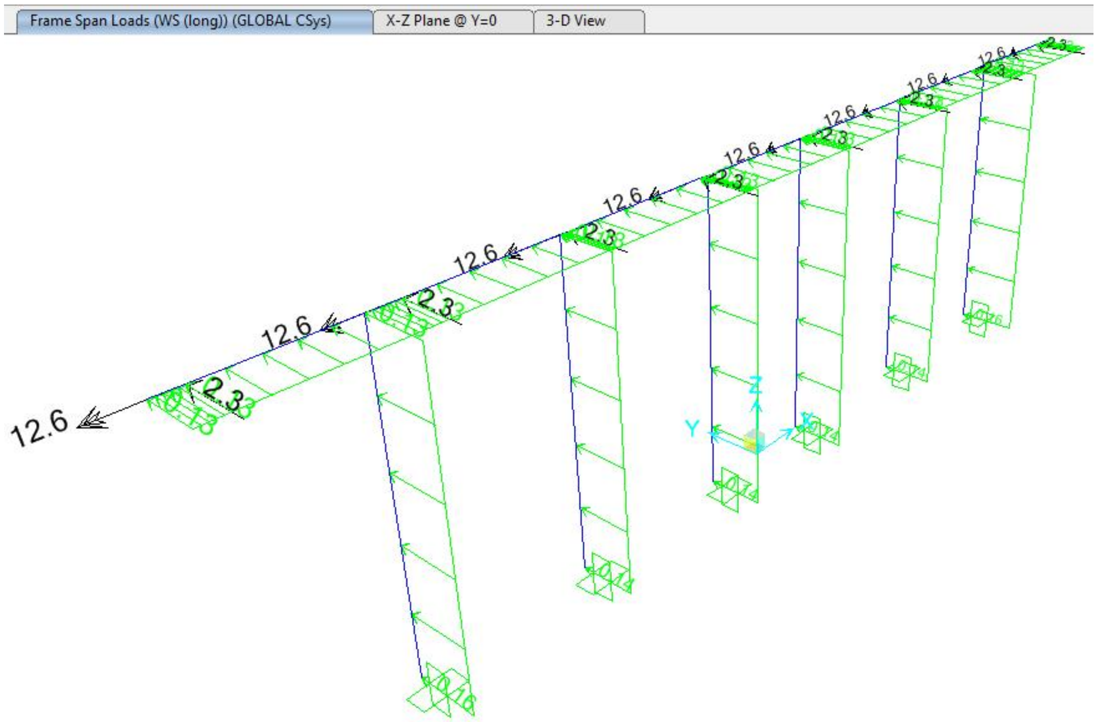
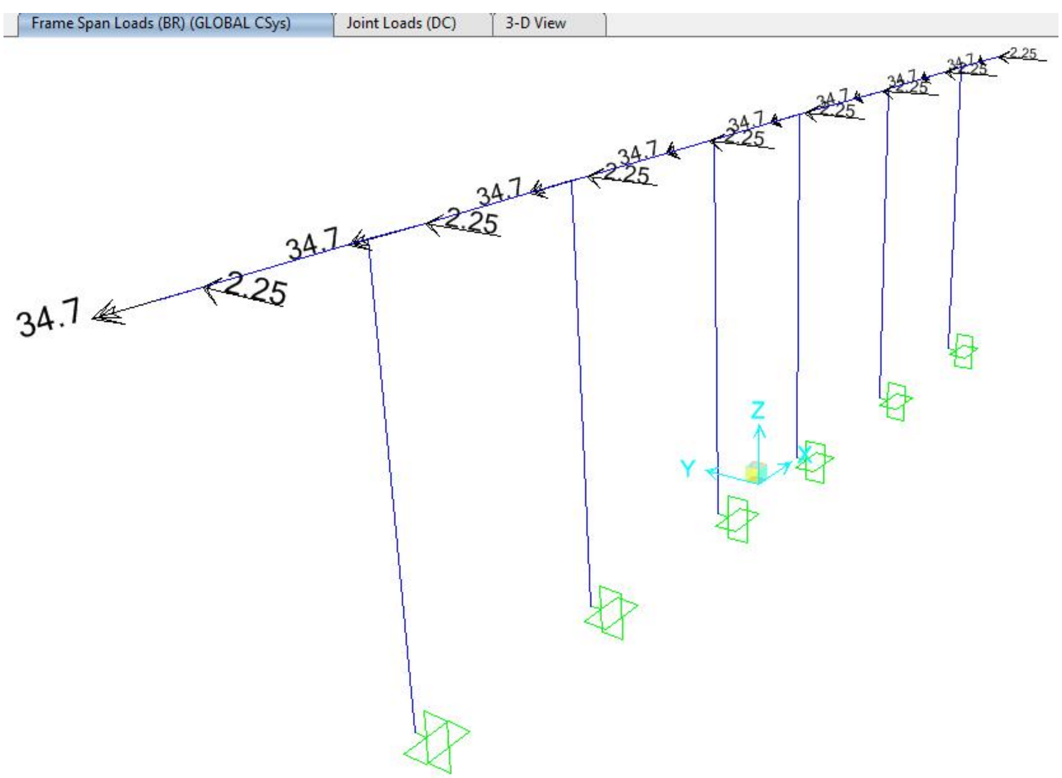
Forces Applied to Substructure - continued

Load Case: WS (long) (distributed loads on bents and columns; point force/moment @ girder)



Load Case: BR (point loads/moments at girder bearing locations)



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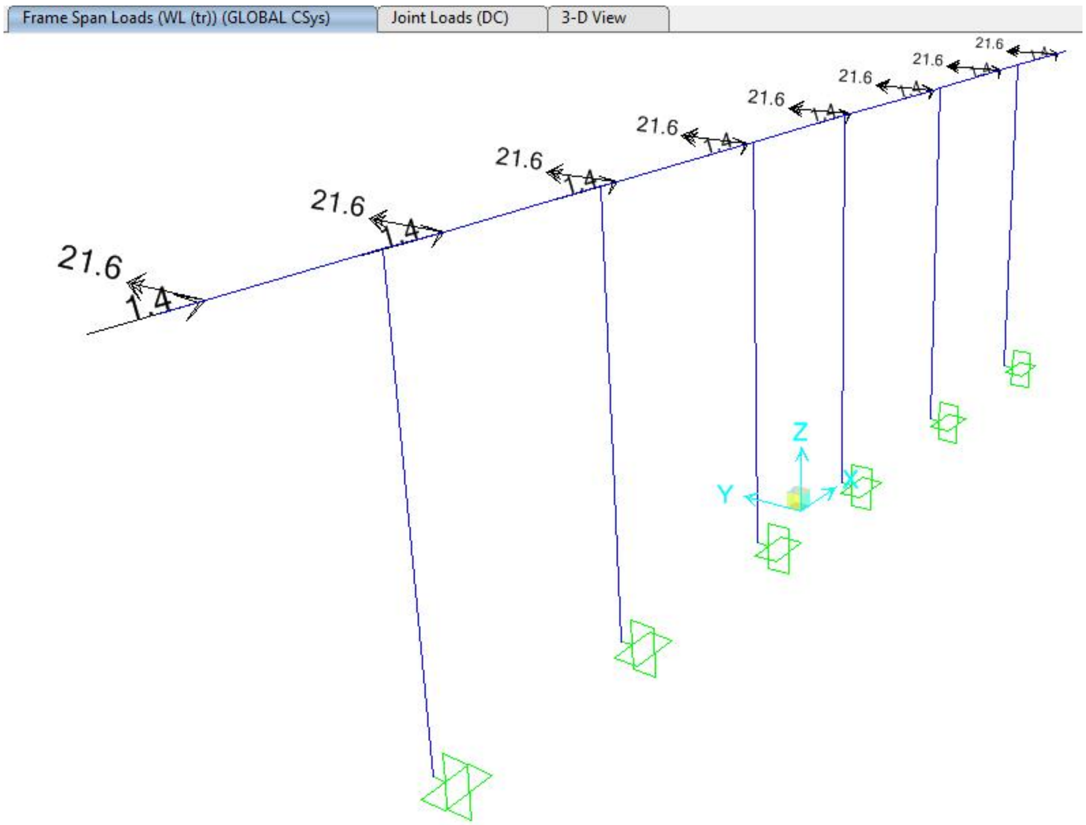
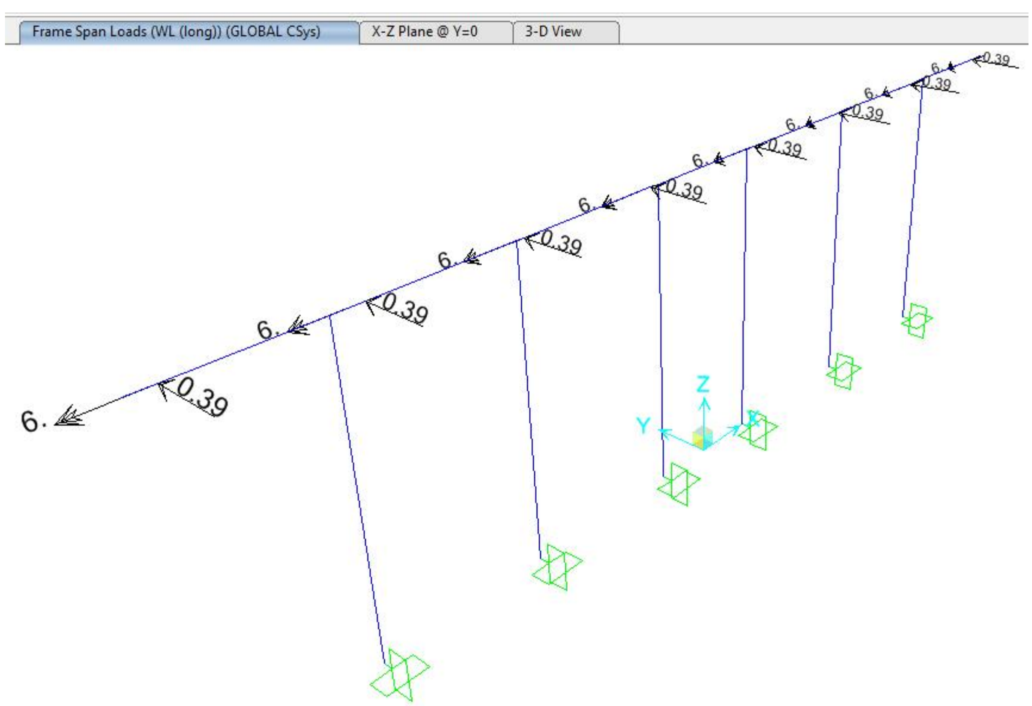
Forces Applied to Substructure

Load Case: WL (tr) (point loads/moments at girder bearing locations)



Load Case: WL (long) (point loads/moments at girder bearing locations)



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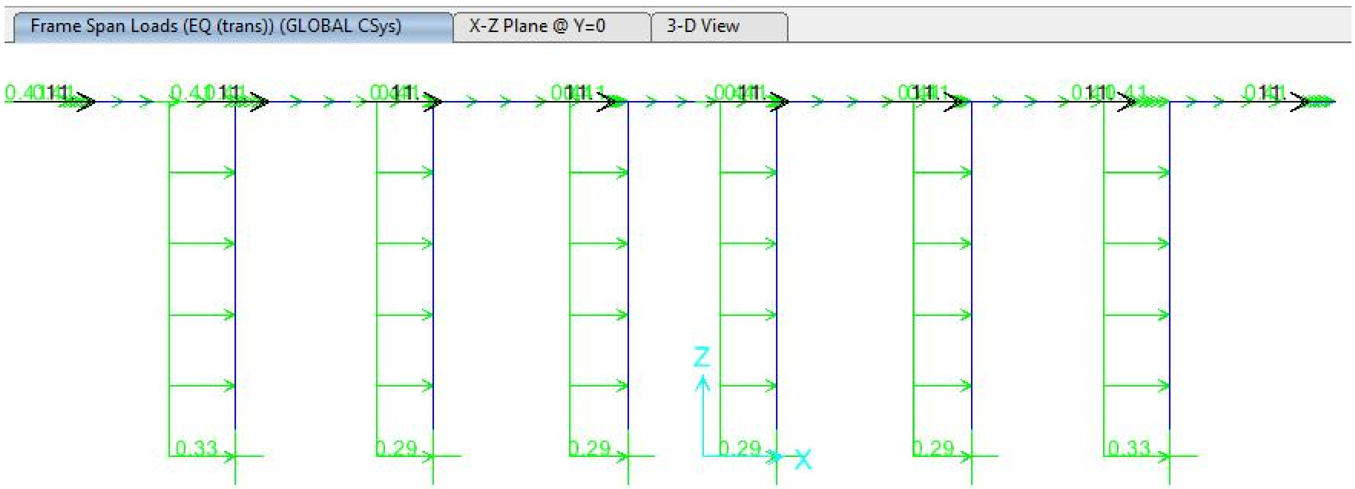
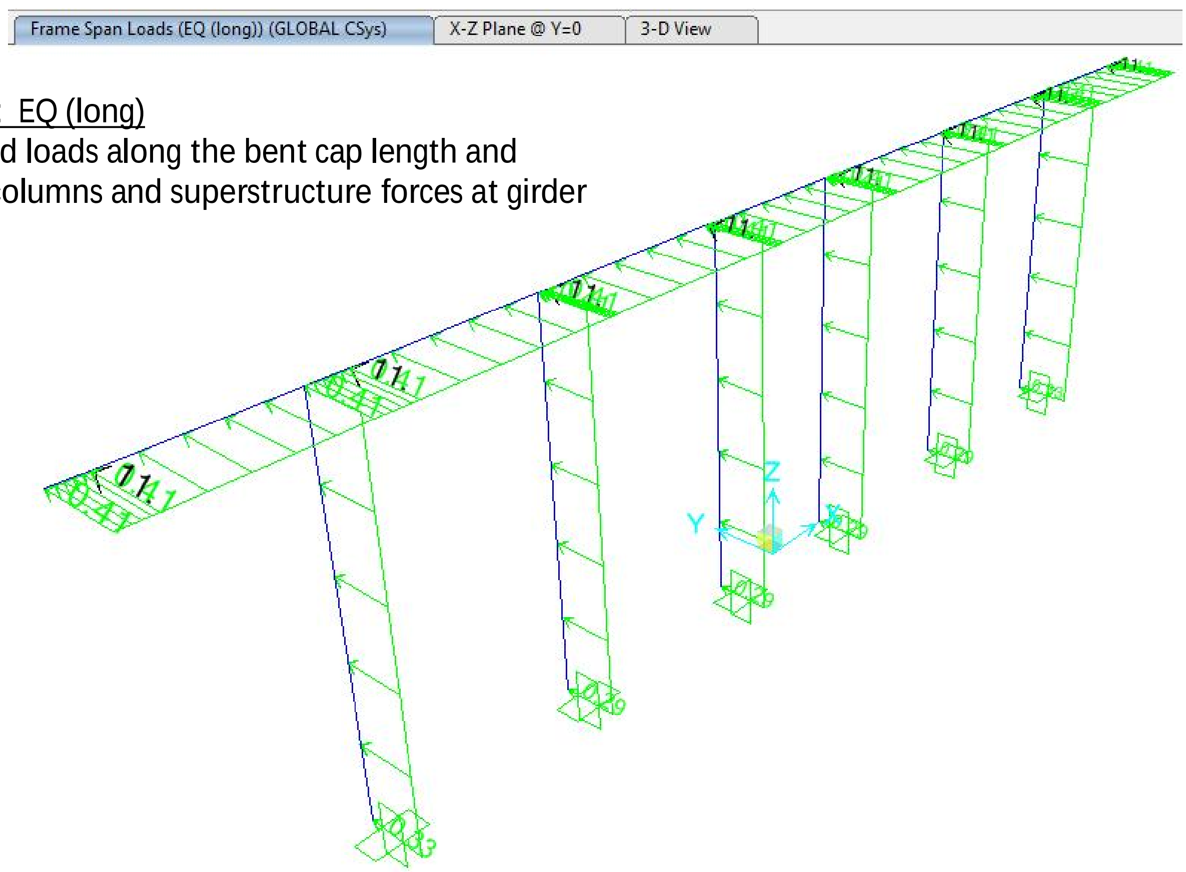
Forces Applied to Substructure - continued

Load Case: EQ (trans) (distributed loads along the bent cap length and height of columns and superstructure force at girder locations)



Load Case: EQ (long)
(distributed loads along the bent cap length and height of columns and superstructure forces at girder locations)



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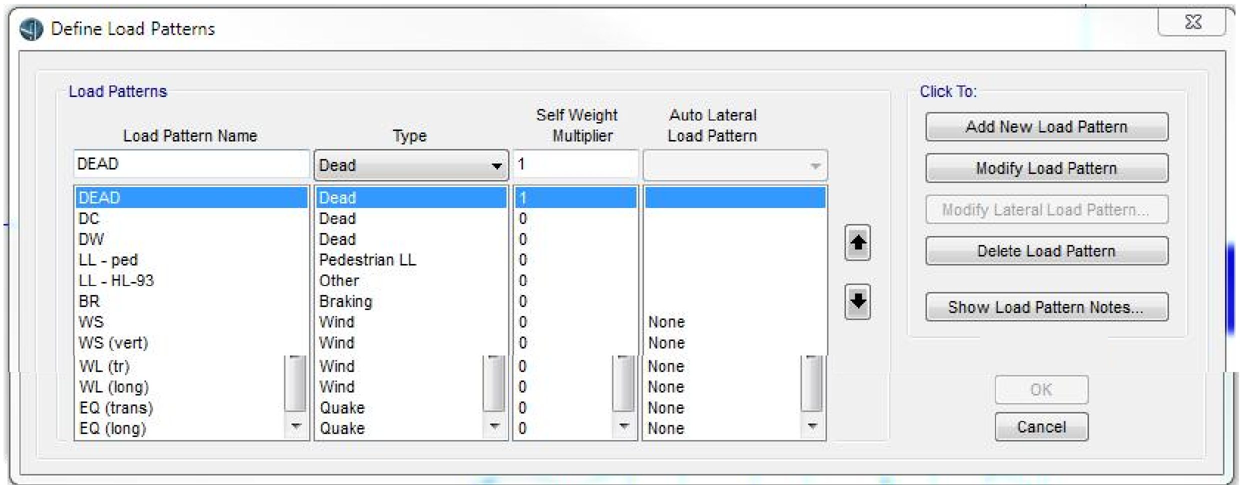
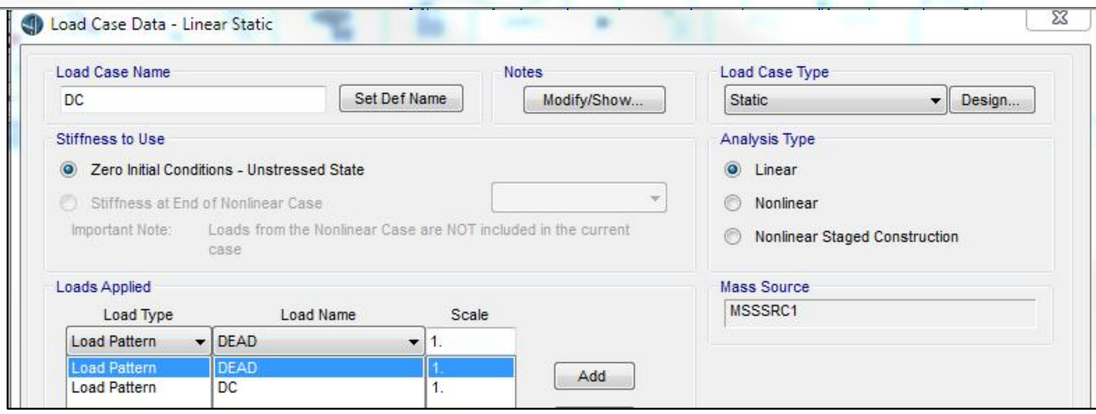
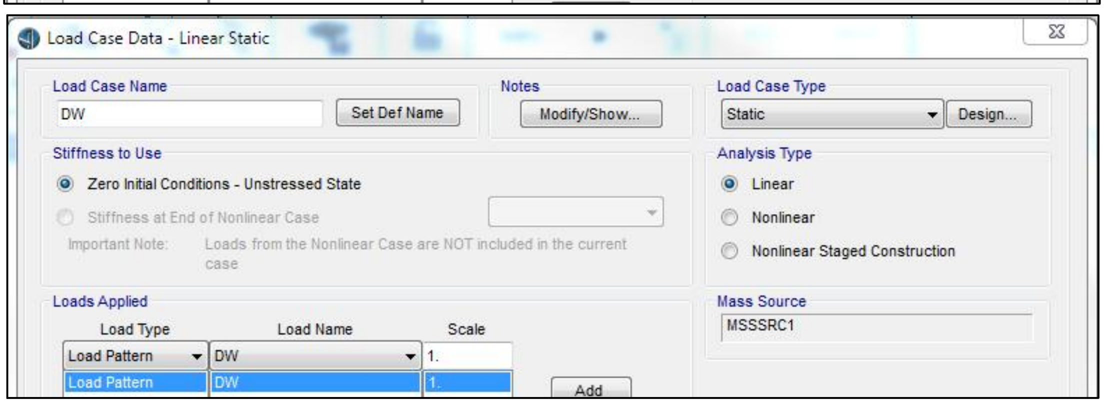
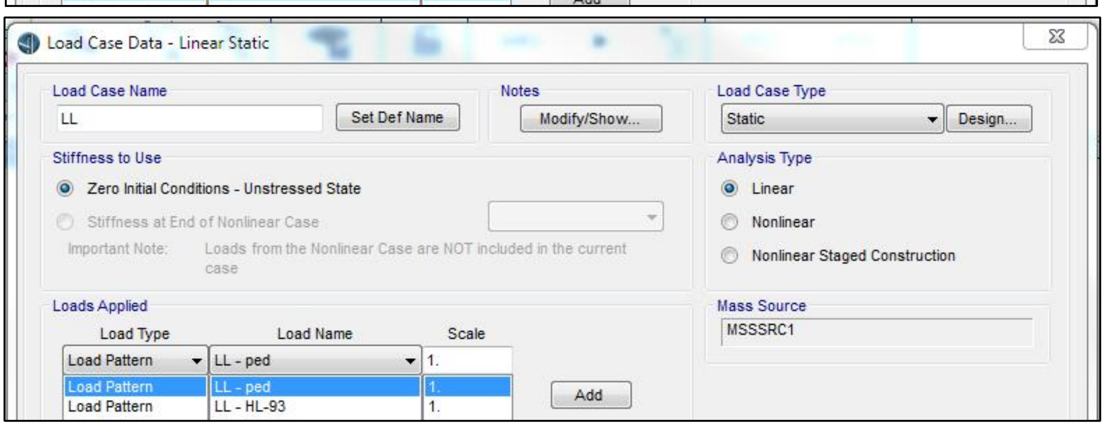
Load Pattern Definitions





Load Case Definitions





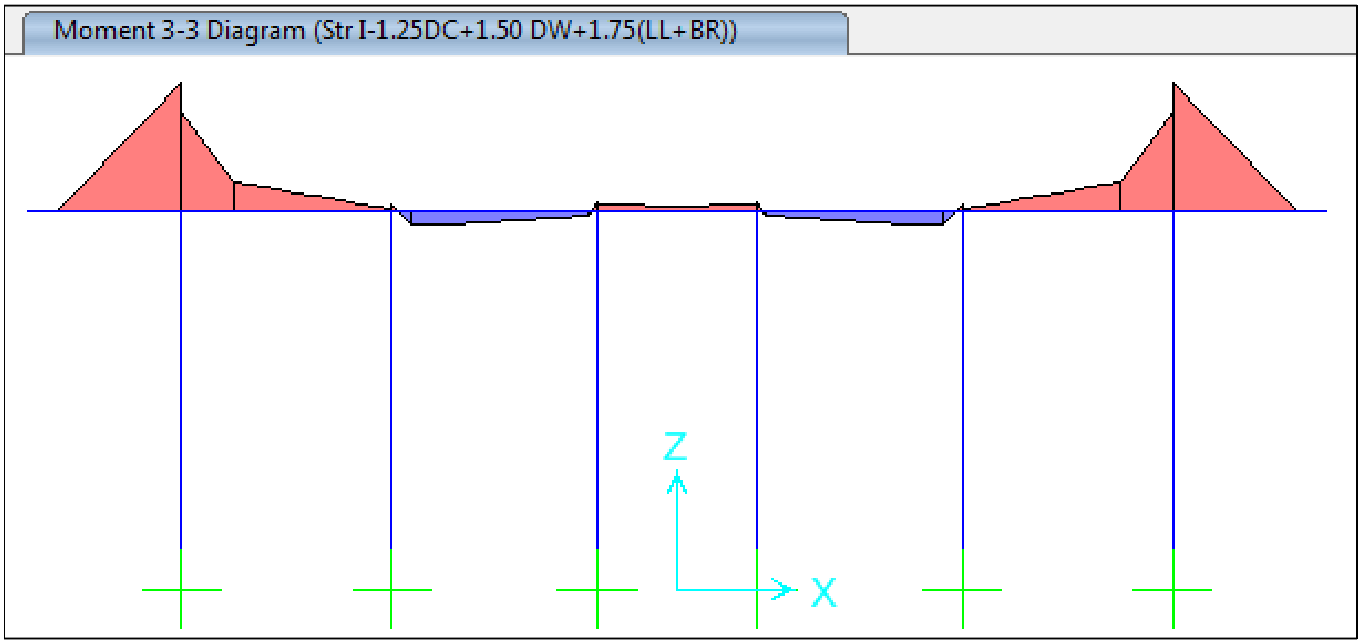
ComboName	ComboType	CaseName	ScaleFactor
Str I-1.25DC+1.50 DW+1.75(LL+BR)	Linear Add	DC	1.25
Str I-1.25DC+1.50 DW+1.75(LL+BR)		DW	1.5
Str I-1.25DC+1.50 DW+1.75(LL+BR)		LL	1.75
Str I-1.25DC+1.50 DW+1.75(LL+BR)		BR	1.75
Str III(1)-1.25DC+1.50DW+1.4WS(tr)	Linear Add	DC	1.25
Str III(1)-1.25DC+1.50DW+1.4WS(tr)		DW	1.5
Str III(1)-1.25DC+1.50DW+1.4WS(tr)		WS (tr)	1.4
Str III(1)-1.25DC+1.50DW+1.4WS(tr)		WS (vert)	1.4
Str III(2)-1.25DC+1.50DW+1.4WS(long)	Linear Add	DC	1.25
Str III(2)-1.25DC+1.50DW+1.4WS(long)		DW	1.5
Str III(2)-1.25DC+1.50DW+1.4WS(long)		WS (long)	1.4
Str III(2)-1.25DC+1.50DW+1.4WS(long)		WS (vert)	1.4
Str III(3)-1.25DC+1.50DW+1.4WS(tr+long)	Linear Add	DC	1.25
Str III(3)-1.25DC+1.50DW+1.4WS(tr+long)		DW	1.5
Str III(3)-1.25DC+1.50DW+1.4WS(tr+long)		WS (long)	1.4
Str III(3)-1.25DC+1.50DW+1.4WS(tr+long)		WS (vert)	1.4
Str III(3)-1.25DC+1.50DW+1.4WS(tr+long)		WS (tr)	1.4
Str V(1)-1.25DC+1.50DW+1.35(LL+BR)+0.4WS(tr)+1.0WL	Linear Add	DC	1.25
Str V(1)-1.25DC+1.50DW+1.35(LL+BR)+0.4WS(tr)+1.0WL		DW	1.5
Str V(1)-1.25DC+1.50DW+1.35(LL+BR)+0.4WS(tr)+1.0WL		LL	1.35
Str V(1)-1.25DC+1.50DW+1.35(LL+BR)+0.4WS(tr)+1.0WL		WS (tr)	0.4
Str V(1)-1.25DC+1.50DW+1.35(LL+BR)+0.4WS(tr)+1.0WL		WL (tr)	1.
Str V(2)-1.25DC+1.50DW+1.35(LL+BR)+0.4WS(long)+1.0WL	Linear Add	DC	1.25
Str V(2)-1.25DC+1.50DW+1.35(LL+BR)+0.4WS(long)+1.0WL		DW	1.5
Str V(2)-1.25DC+1.50DW+1.35(LL+BR)+0.4WS(long)+1.0WL		LL	1.35
Str V(2)-1.25DC+1.50DW+1.35(LL+BR)+0.4WS(long)+1.0WL		WS (long)	0.4
Str V(2)-1.25DC+1.50DW+1.35(LL+BR)+0.4WS(long)+1.0WL		WL (long)	1.
Str V(3)-1.25DC+1.50DW+1.35(LL+BR)+0.4WS(tr+long)+1.0WL	Linear Add	DC	1.25
Str V(3)-1.25DC+1.50DW+1.35(LL+BR)+0.4WS(tr+long)+1.0WL		DW	1.5
Str V(3)-1.25DC+1.50DW+1.35(LL+BR)+0.4WS(tr+long)+1.0WL		LL	1.35
Str V(3)-1.25DC+1.50DW+1.35(LL+BR)+0.4WS(tr+long)+1.0WL		WS (long)	0.4
Str V(3)-1.25DC+1.50DW+1.35(LL+BR)+0.4WS(tr+long)+1.0WL		WL (tr)	1.
Str V(3)-1.25DC+1.50DW+1.35(LL+BR)+0.4WS(tr+long)+1.0WL		WL (long)	1.
Str V(3)-1.25DC+1.50DW+1.35(LL+BR)+0.4WS(tr+long)+1.0WL		WS (tr)	0.4
Ext Ia (1.00tr+0.3long)-1.25DC+1.5DW+1.0EQ(tr)+0.3EQ(long)	Linear Add	DC	1.25
Ext Ia (1.00tr+0.3long)-1.25DC+1.5DW+1.0EQ(tr)+0.3EQ(long)		DW	1.5
Ext Ia (1.00tr+0.3long)-1.25DC+1.5DW+1.0EQ(tr)+0.3EQ(long)		EQ (trans)	1.
Ext Ia (1.00tr+0.3long)-1.25DC+1.5DW+1.0EQ(tr)+0.3EQ(long)		EQ (long)	0.3
Ext Ib (0.3tr+1.0long)-1.25DC+1.5DW+0.3EQ(tr)+1.0EQ(long)	Linear Add	DC	1.25
Ext Ib (0.3tr+1.0long)-1.25DC+1.5DW+0.3EQ(tr)+1.0EQ(long)		DW	1.5
Ext Ib (1.00tr+0.3long)-1.25DC+1.5DW+0.3EQ(tr)+1.0EQ(long)		EQ (trans)	0.3
Ext Ib (0.3tr+1.0long)-1.25DC+1.5DW+0.3EQ(tr)+1.0EQ(long)		EQ (long)	1.
ServI(1)-1.0(DC+DW+LL+BR+WL)+0.3WS(tr)	Linear Add	DC	1.
ServI(1)-1.0(DC+DW+LL+BR+WL)+0.3WS(tr)		DW	1.
ServI(1)-1.0(DC+DW+LL+BR+WL)+0.3WS(tr)		LL	1.
ServI(1)-1.0(DC+DW+LL+BR+WL)+0.3WS(tr)		BR	1.
ServI(1)-1.0(DC+DW+LL+BR+WL)+0.3WS(tr)		WL (tr)	1.
ServI(1)-1.0(DC+DW+LL+BR+WL)+0.3WS(tr)		WS (tr)	0.3
ServI(2)-1.0(DC+DW+LL+BR+WL)+0.3WS(long)	Linear Add	DC	1.
ServI(2)-1.0(DC+DW+LL+BR+WL)+0.3WS(long)		DW	1.
ServI(2)-1.0(DC+DW+LL+BR+WL)+0.3WS(long)		LL	1.
ServI(2)-1.0(DC+DW+LL+BR+WL)+0.3WS(long)		BR	1.
ServI(2)-1.0(DC+DW+LL+BR+WL)+0.3WS(long)		WL (long)	1.
ServI(2)-1.0(DC+DW+LL+BR+WL)+0.3WS(long)		WS (long)	0.3
ServI(3)-1.0(DC+DW+LL+BR+WL)+0.3WS(tr+long)	Linear Add	DC	1.
ServI(3)-1.0(DC+DW+LL+BR+WL)+0.3WS(tr+long)		DW	1.
ServI(3)-1.0(DC+DW+LL+BR+WL)+0.3WS(tr+long)		LL	1.
ServI(3)-1.0(DC+DW+LL+BR+WL)+0.3WS(tr+long)		BR	1.
ServI(3)-1.0(DC+DW+LL+BR+WL)+0.3WS(tr+long)		WL (long)	1.
ServI(3)-1.0(DC+DW+LL+BR+WL)+0.3WS(tr+long)		WL (tr)	1.
ServI(3)-1.0(DC+DW+LL+BR+WL)+0.3WS(tr+long)		WS (long)	0.3
ServI(3)-1.0(DC+DW+LL+BR+WL)+0.3WS(tr+long)		WS (tr)	0.3

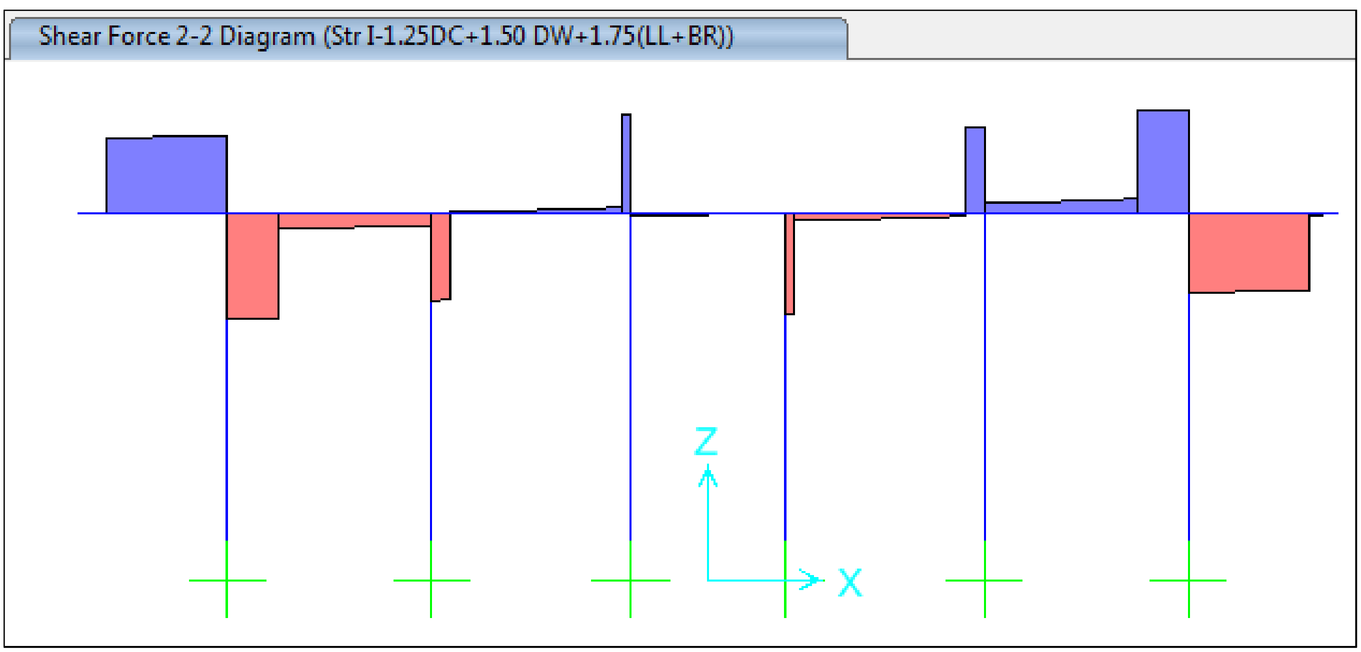
11. Analysis Step 6: CSi Bridge Model Output – Shear and Moment Demands for Bent Cap and Columns

	Computation Sheet	Job №: 201612642	Page: of
Project:	ITD US-12 Memorial Bridge Feasibility Study	Made by: JWC	Date: 9/27/17
Subject:	Substructure Retrofit Model Analysis	Checked by:	Date:

<u>Model Output – Bent Cap Moment M3 and Shear V2 (vertical) Diagrams</u> (only one load case shown, see summary table for summary of output forces)

Str I: 1.25DC+1.50DW+1.75(LL+BR)

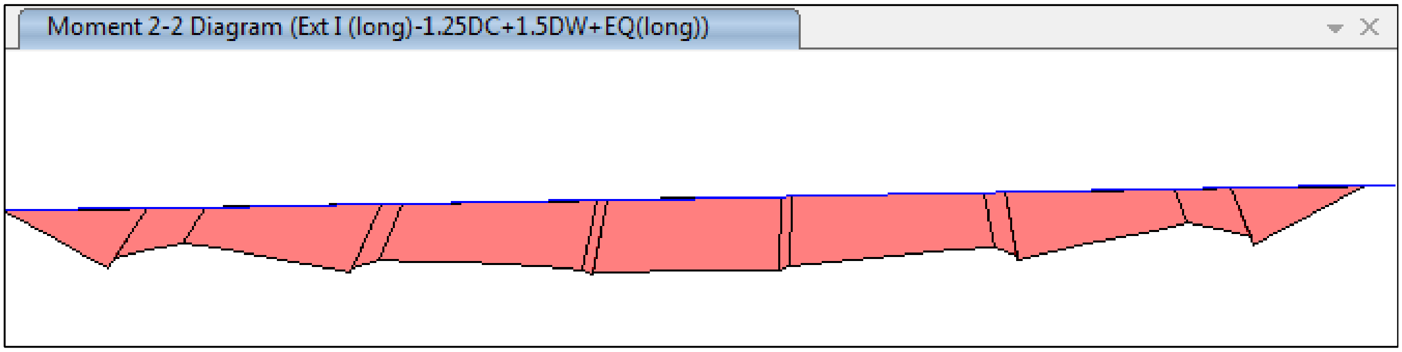


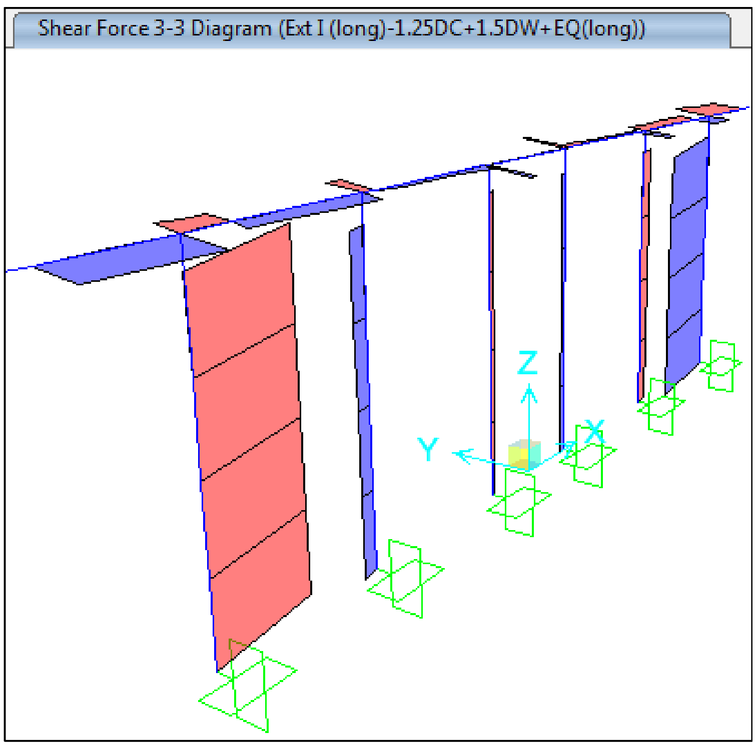


Computation Sheet	Job №: 201612642	Page:	of
Project: ITD US-12 Memorial Bridge Feasibility Study	Made by: JWC	Date: 9/27/17	
Subject: Substructure Retrofit Model Analysis	Checked by:	Date:	

<u>Model Output – Bent Cap Moment M2 and Shear V3 (Longitudinal) Diagrams</u> (only one load case shown, see summary table for summary of output forces)

Ext I (long)

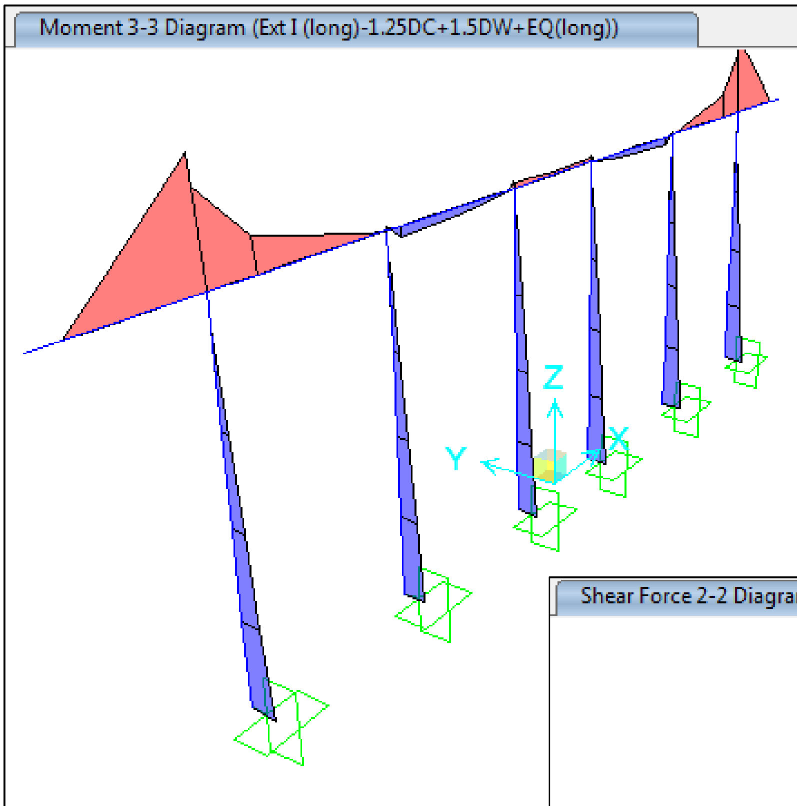


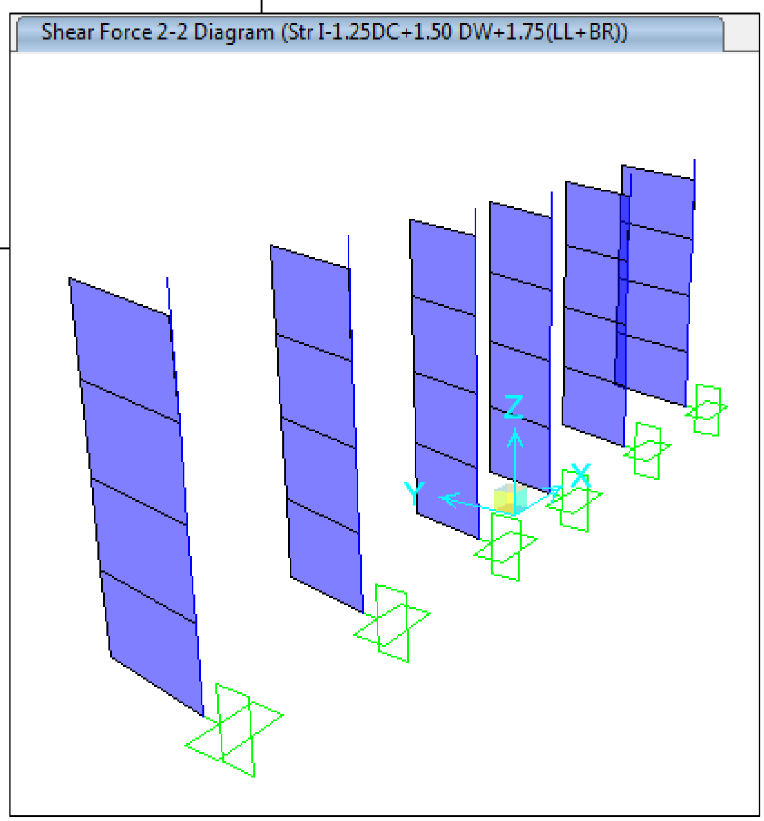


	Computation Sheet	Job №:	201612642	Page:	of
Project:	*ITD US-12 Memorial Bridge Feasibility Study*	Made by:	JWC	Date:	9/27/17
Subject:	*Substructure Retrofit Model Analysis*	Checked by:		Date:	

<u>Model Output – Column Moments and Shears in Longitudinal Direction</u> (only one load case shown, see summary table for summary of output forces)

Ext I (long) 1.25DC+1.50DW+1.0EQ (long)

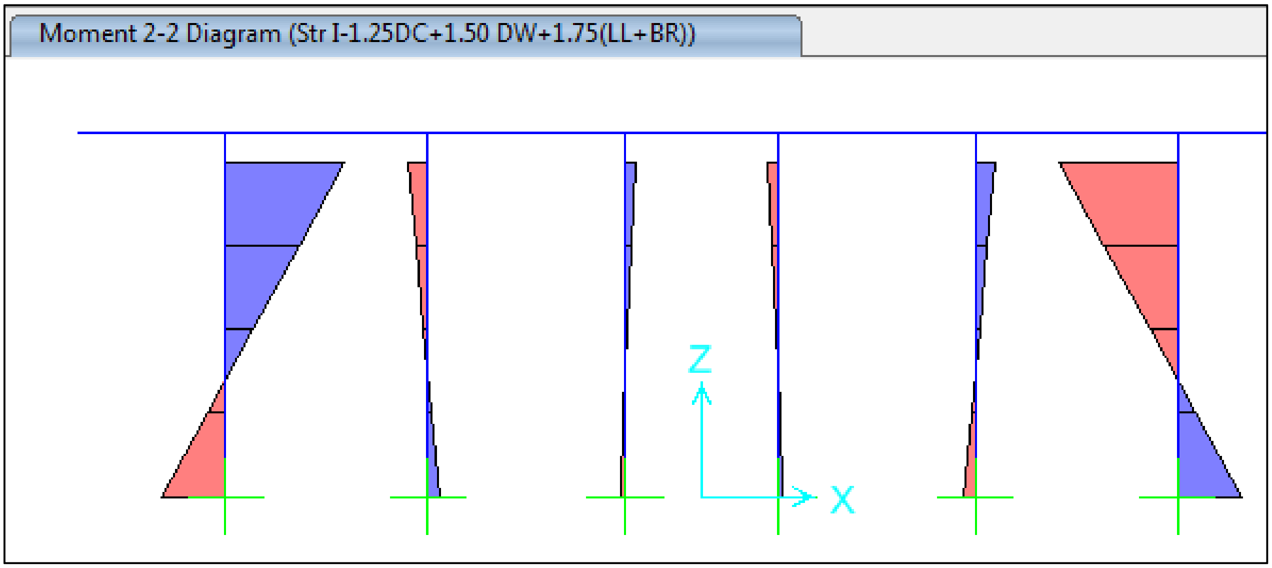


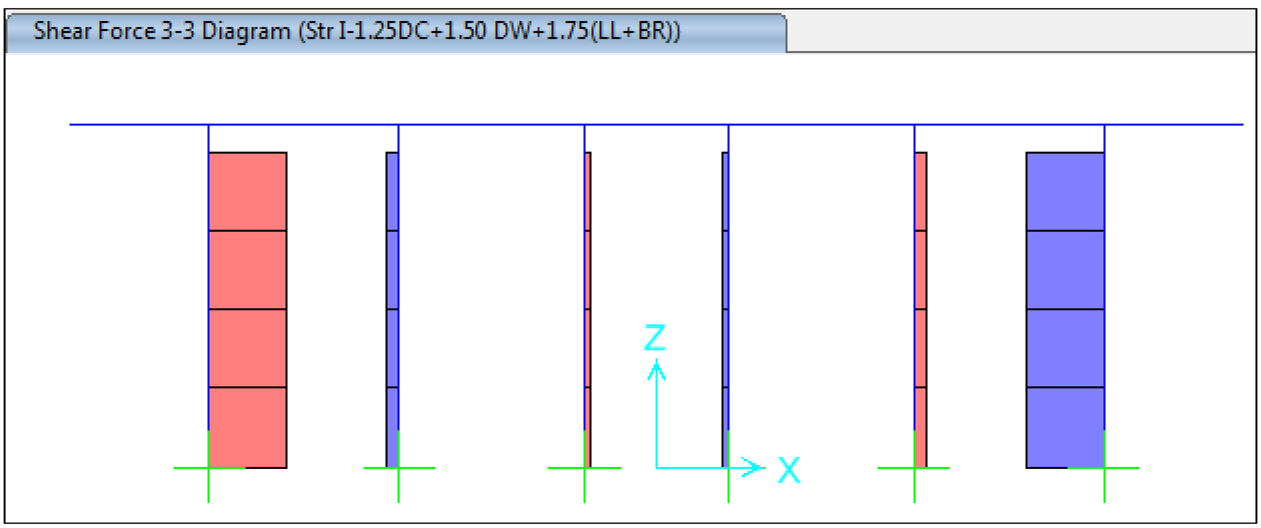


	Computation Sheet	Job №: 201612642	Page: of
Project:	ITD US-12 Memorial Bridge Feasibility Study	Made by: JWC	Date: 9/27/17
Subject:	Substructure Retrofit Model Analysis	Checked by:	Date:

Model Output – Column Moment M2 and Shear V3 (Transverse) Diagrams (only one load case shown, see summary table for summary of output forces)

Str I: 1.25DC+1.50DW+1.75(LL+BR)





Computation Sheet

Project	ITD US-12 Memorial Bridge Feasibility Study - 78'-0" Deck Width, 8 girders	made by	JWC	Date 10/11/17
Subject	Csi Bridge Model Output - Bent Cap and Model Design Forces	checked by		Date

Principal Direction (Vertical for Bent Cap, Transverse for Columns) - Moments and Shear Forces from CSi Bridge Model

M3/V2 for Bents, M2/V3 for Columns

Results at Maximum (+) and (-) Moments, M_{max}, in each element (Absolute max. moment for Columns)

	Strength I			Strength III			Strength V			Extreme Event I			Service I		
Element	M_{max} kip	$V@M_{max}$, kip-ft	Axial Load kip	M_{max} kip	$V@M_{max}$, kip-ft	Axial Load kip	M_{max} kip	$V@M_{max}$, kip-ft	Axial Load kip	M_{max} kip	$V@M_{max}$, kip-ft	Axial Load kip	M_{max} kip	$V@M_{max}$, kip-ft	Axial Load kip
Bent Cap, (+) M	149.9	0.6	-138.1	139.0	2.6	-92.6	155.3	3.0	-126.7	196.2	102.4	-73.8	122.0	2.0	-97.3
Bent Cap, (-) M	-4219.6	544.3	0.0	-2649.0	340.1	-8.4	-3829.5	490.6	-3.8	-2360.4	309.5	14.9	-2935.4	375.9	-3.2
Col. A	1908.8	155.5	1283.0	1292.0	110.2	710.0	1745.3	144.7	1129.0	1001.8	89.4	671.3	1336.9	111.0	861.2
Col. B/C	205.9	17.4	611.0	246.6	23.4	292.0	239.9	21.7	529.0	275.8	26.2	216.0	187.7	17.1	402.0

Results at Maximum Shear Force, V_{max}, in each element

	Strength I			Strength III			Strength V			Extreme Event I			Service I		
Element	V_{max} kip	$M@V_{max}$, kip-ft	Axial Load kip	V_{max} kip	$M@V_{max}$, kip-ft	Axial Load kip	V_{max} kip	$M@V_{max}$, kip-ft	Axial Load kip	V_{max} kip	$M@V_{max}$, kip-ft	Axial Load kip	V_{max} kip	$M@V_{max}$, kip-ft	Axial Load kip
Bent Cap	734.6	2064.3	-155.5	415.3	1341.0	-98.8	661.0	1904.2	-140.7	423.8	1695.6	-58.2	505.2	1460.5	-107.9
Col. A	155.5	1908.8	1283.0	113.8	790.5	754.4	145.7	954.0	1173.0	95.5	716.5	715.0	111.8	734.7	896.6
Col. B/C	17.4	205.9	611.0	27.0	221.8	330.0	22.7	172.4	568.0	31.6	261.0	255.0	17.8	136.8	433.0

Longitudinal (along roadway) Direction - Moments M2 and Shear Forces V3 from CSi Bridge Model

M2/V3 for Bents, M3/V2 for Columns

Results at Absolute Maximum Moments, M_{max}, in each element

	Strength I			Strength III			Strength V			Extreme Event I			Service I		
Element	M_{max} kip	$V@M_{max}$, kip-ft	Axial Load kip	M_{max} kip	$V@M_{max}$, kip-ft	Axial Load kip	M_{max} kip	$V@M_{max}$, kip-ft	Axial Load kip	M_{max} kip	$V@M_{max}$, kip-ft	Axial Load kip	M_{max} kip	$V@M_{max}$, kip-ft	Axial Load kip
Bent Cap	31.2	3.9	0.0	33.6	4.9	0.0	12.7	1.8	0.0	105.3	14.9	4.5	28.1	3.7	0.0
Col. A	227.7	7.1	1327.0	238.3	13.4	778.9	90.6	4.5	1186.0	579.6	33.9	758.2	203.7	7.7	908.0
Col. B/C	170.7	4.4	649.0	179.4	9.5	338.0	68.1	3.2	572.0	403.9	22.4	266.0	152.9	5.0	437.0

Results at Maximum Shear Force, V_{max}, in each element

	Strength I			Strength III			Strength V			Extreme Event I			Service I		
Element	V_{max} kip	$M@V_{max}$, kip-ft	Axial Load kip	V_{max} kip	$M@V_{max}$, kip-ft	Axial Load kip	V_{max} kip	$M@V_{max}$, kip-ft	Axial Load kip	V_{max} kip	$M@V_{max}$, kip-ft	Axial Load kip	V_{max} kip	$M@V_{max}$, kip-ft	Axial Load kip
Bent Cap	3.9	31.2	0.0	4.9	33.6	0.0	1.8	12.7	0.0	14.9	105.3	4.5	3.7	28.1	0.0
Col. A	7.1	227.7	1327.0	13.4	238.3	778.9	4.5	90.6	1186.0	33.9	579.6	758.2	7.7	203.7	908.0
Col. B/C	4.4	170.7	649.0	9.5	179.4	338.0	3.2	68.1	572.0	22.4	403.9	266.0	5.0	152.9	437.0

12. Analysis Step 7: As-Built Column Structural Capacity Check

Computation Sheet

Project	ITD US-12 Memorial Bridge Feasibility Study - 78'-0" Deck Width, 8 girders	made by JWC	Date 10/11/17
Subject	Column Flexural Capacity Check	checked by	Date

Material Properties for Columns (As-Built Conditions) Concrete Strength, f'_c = 3ksi Rebar Yield Strength, f_y = 33 ksi Resistance factors: ϕ_b=0.9, ϕ_c=0.75

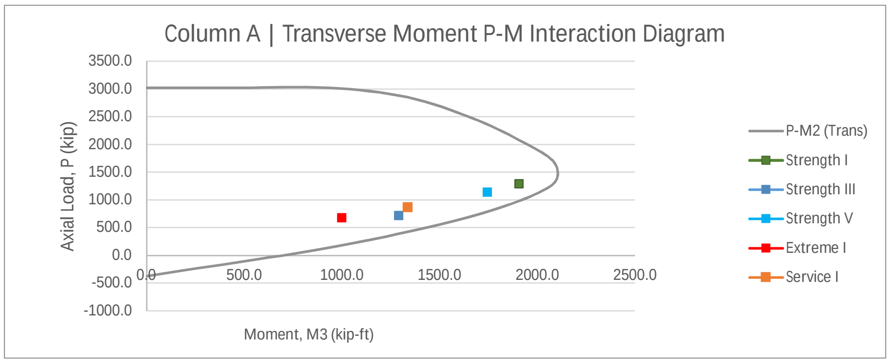
Column Moment Interaction Diagrams - CSi Bridge Section Modeler

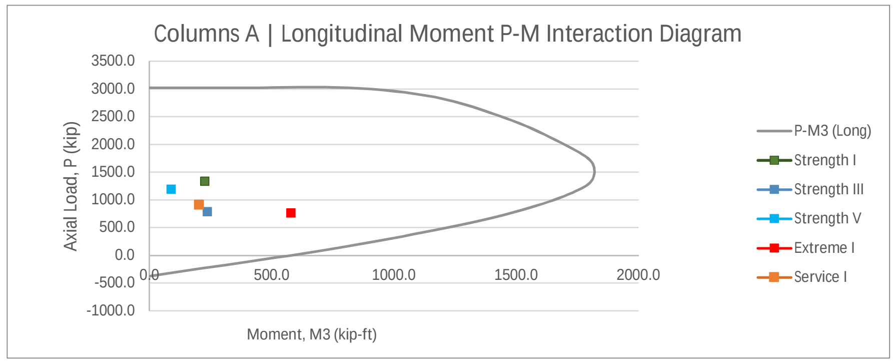
Column A			Columns B & C		
P kip	M2 (trans) kip-ft	*M3 (long)* kip-ft	P kip	M2 (trans) kip-ft	*M3 (long)* kip-ft
3022.0	0.0	0.0	2654.0	0.0	0.0
3022.0	476.6	406.8	2654.0	359.5	359.5
3022.0	932.0	815.1	2654.0	714.1	714.1
2853.0	1334.2	1168.0	2506.0	1025.7	1025.7
2478.0	1664.1	1454.0	2173.0	1282.7	1282.7
2079.0	1906.3	1660.4	1815.0	1472.5	1472.5
1669.0	2087.6	1809.7	1448.0	1608.8	1608.8
1253.0	2069.3	1784.6	1077.0	1588.6	1588.6
728.2	1686.9	1447.4	609.6	1291.1	1291.1
166.2	977.8	813.6	113.8	733.4	733.4
-375.4	0.0	0.0	-375.4	0.0	0.0

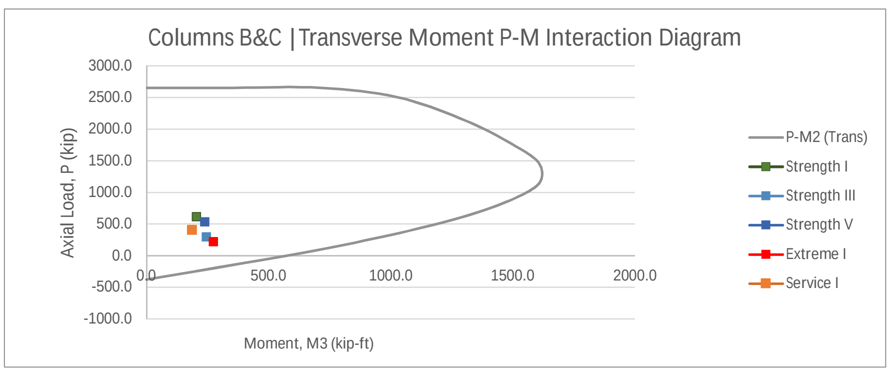
Column Demands from CSi Bridge Model

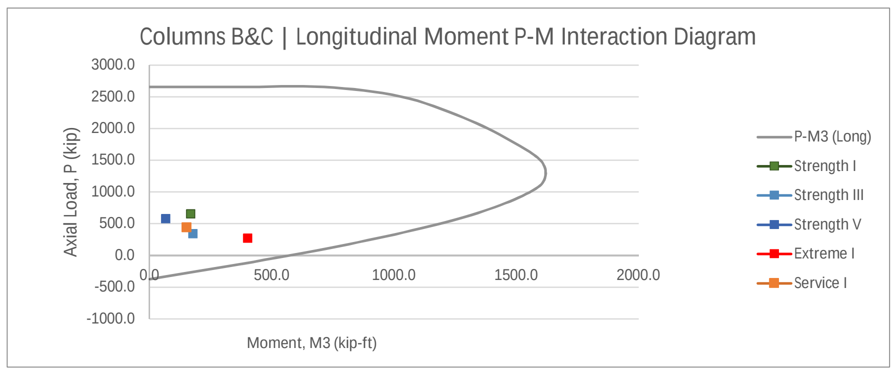
Column A Demands	Transverse			Longitudinal			
Load Combination	P_u kip	M_u kip-ft	ϕM_n kip-ft	P_u kip	M_u kip-ft	ϕM_n kip-ft	C/D
Strength I	1283	*1908.8*	2070.6	1327	*227.7*	1789.1	1.08
Strength III	710	*1292*	1663.9	778.9	*238.3*	1479.9	1.29
Strength V	1129	*1745.3*	1978.9	1186	*90.63*	1741.6	1.13
Extreme I	671.3	*1001.8*	1615.1	758.2	*579.6*	1466.6	1.61
Service I	861.2	*1336.9*	1783.8	908	*203.72*	1562.9	1.33

Column B/C Demands	Transverse			Longitudinal			
Load Combination	P_u kip	M_u kip-ft	ϕM_n kip-ft	P_u kip	M_u kip-ft	ϕM_n kip-ft	C/D
Strength I	611	*205.9*	1292.0	649	*170.74*	1316.2	6.27
Strength III	292	*246.6*	933.8	338	*179.35*	985.6	3.79
Strength V	529	*239.9*	1200.4	572	*68.13*	1248.8	5.00
Extreme I	216	*275.798*	848.4	266	*403.89*	904.6	2.24
Service I	402	*187.7*	1057.6	437	*152.89*	1096.9	5.63









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WSP PARSONS BRINCKERHOFF	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 27-Sep-17	Project #
ShortCol Copyright © 2007	Subject: Column A Flexural Analysis Longitudinal Direction	Checker: Date:	Page:

Last modified: 30-Dec-11

Reinforced concrete column capacity

Materials:

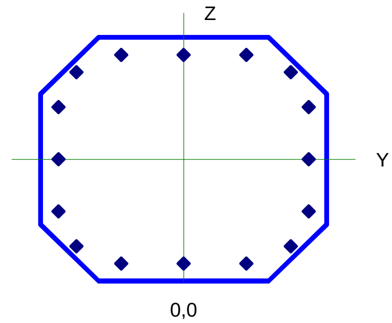
Concrete f'_c = 3 ksi γ_c = 150 lb/ft³
Steel f_y = 33 ksi E_c = 3,321 ksi
Max. conc. strain ε_c = -0.003 E_s = 29,000 ksi

Design Code: AASHTO LRFD-static

Resistance Factors ϕ_b = 0.9 ϕ_c = 0.75

Section Properties:

Height = 42 in   Width = 48 in
Chamfer = 9.75 in
A_C = 1825.875 in² A_T = 1924 in²
I_C = 235446.6 in⁴ I_T = 254801.34 in⁴
Y_{bC} = 21 in Y_{bT} = 21.00 in



Longitudinal Reinforcement:

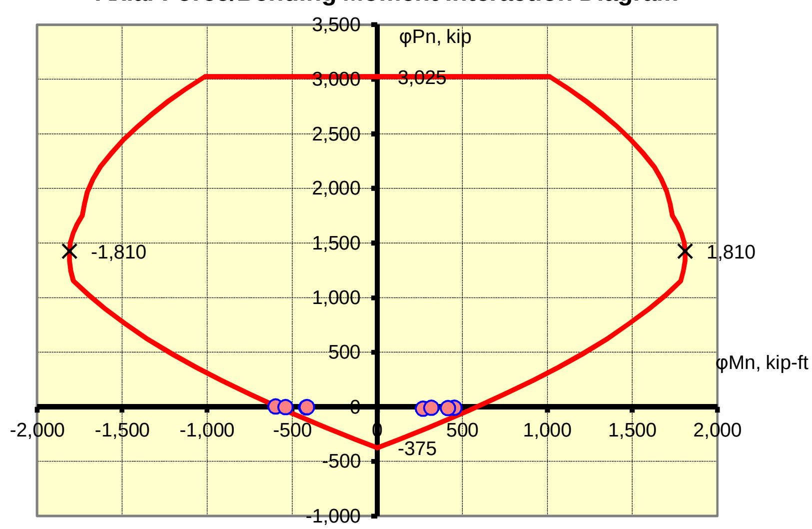
Bar Area = 0.79 in²
No.bars = 16 (< 200)
Σ(As) = 12.64 in²
As/Ac = 0.69%

Confinement: (•) Ties/Stirrups ( ) Spiral   4#6

f_{yt} = 33 ksi   Stirrup/Tie bar area : 0 in²
Number of stirrup legs in prime direction : 0
in secondary direction : 0
Tie/stirrup spacing, s : 6 in
Concrete cover to tie bar, c : 1.5 in

Reinforcing Bar No.	Area A_s in²	Coordinates, in Y (from ctr.)	Z (from bot.)
1	0.79	-18.00	6.00
2	0.79	-10.50	3.00
3	0.79	0.00	3.00
4	0.79	10.50	3.00
5	0.79	18.00	6.00
6	0.79	-21.00	12.00
7	0.79	21.00	12.00
8	0.79	-21.00	21.00
9	0.79	21.00	21.00
10	0.79	-21.00	30.00
11	0.79	21.00	30.00
12	0.79	-18.00	36.00
13	0.79	-10.50	39.00
14	0.79	0.00	39.00
15	0.79	10.50	39.00
16	0.79	18.00	36.00

Axial Force/Bending Moment Interaction Diagram



Positive moment creates tension at the bottom fibers

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WSP PARSONS BRINCKERHOFF	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 27-Sep-17	Project #
ShortCol Copyright © 2007	Subject: Column A Flexural Analysis Transverse Direction	Checker: Date:	Page:

Last modified: 30-Dec-11

Reinforced concrete column capacity

Materials:

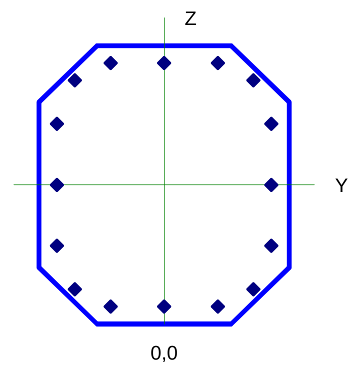
Concrete f'_c = 3 ksi γ_c = 150 lb/ft³
Steel f_y = 33 ksi E_c = 3,321 ksi
Max. conc. strain ε_c = -0.003 E_s = 29,000 ksi

Design Code: AASHTO LRFD-static

Resistance Factors ϕ_b = 0.9 ϕ_c = 0.75

Section Properties:

Height = 48 in Width = 42 in
Chamfer = 9.75 in
A_C = 1825.875 in² A_T = 1924 in²
I_C = 304207.2 in⁴ I_T = 330984.87 in⁴
Y_{bC} = 24 in Y_{bT} = 24.00 in



Longitudinal Reinforcement:

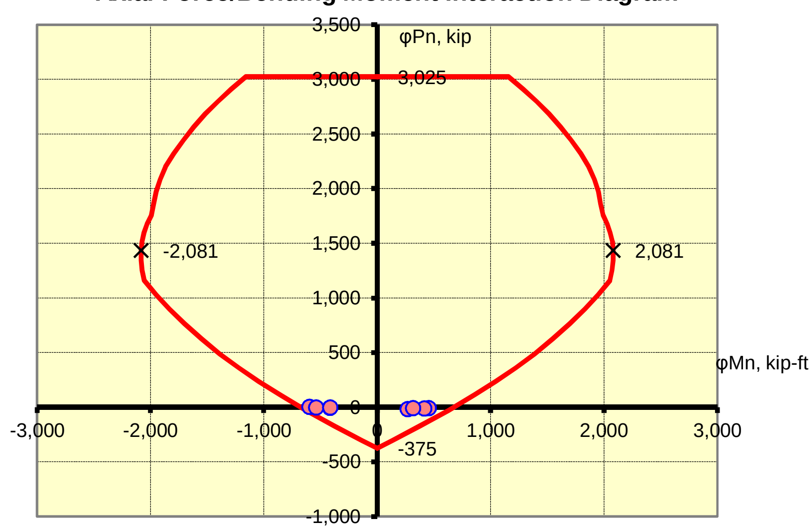
Bar Area = 0.79 in²
No.bars = 16 (< 200)
Σ(As) = 12.64 in²
As/Ac = 0.69%

Confinement: (●) Ties/Stirrups ( ) Spiral 4#6

f_{yt} = 33 ksi Stirrup/Tie bar area : 0 in²
Number of stirrup legs in prime direction : 0
in secondary direction : 0
Tie/stirrup spacing, s : 6 in
Concrete cover to tie bar, c : 1.5 in

Reinforcing Bar No.	Area A_s in²	Coordinates, in Y (from ctr.)	Coordinates, in Z (from bot.)
1	0.79	-15.00	42.00
2	0.79	-18.00	34.50
3	0.79	-18.00	24.00
4	0.79	-18.00	13.50
5	0.79	-15.00	6.00
6	0.79	-9.00	45.00
7	0.79	-9.00	3.00
8	0.79	0.00	45.00
9	0.79	0.00	3.00
10	0.79	9.00	45.00
11	0.79	9.00	3.00
12	0.79	15.00	42.00
13	0.79	18.00	34.50
14	0.79	18.00	24.00
15	0.79	18.00	13.50
16	0.79	15.00	6.00

Axial Force/Bending Moment Interaction Diagram



Positive moment creates tension at the bottom fibers

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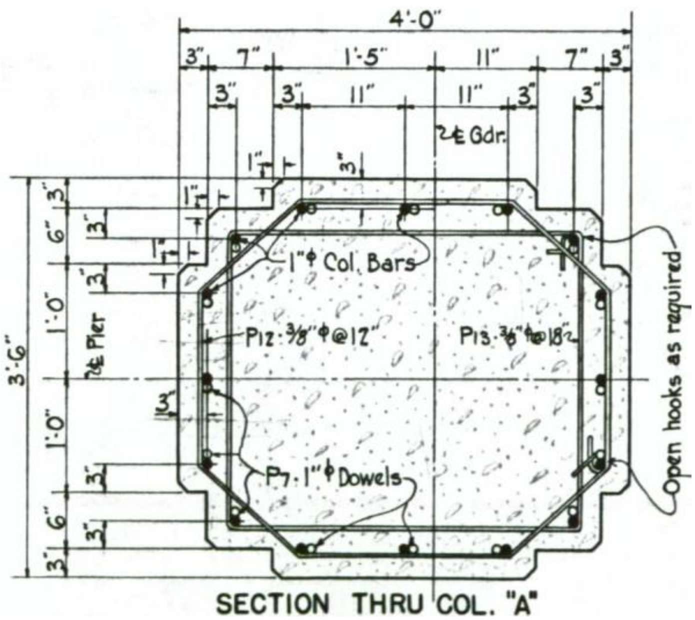
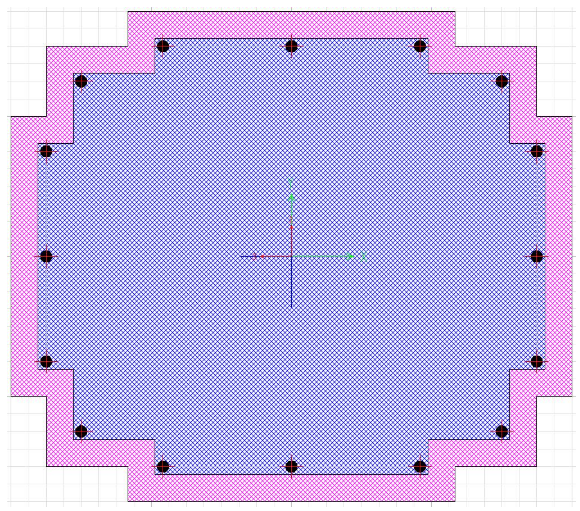
Subject:	*Substructure Retrofit Model Analysis*	Checked by:	Date:

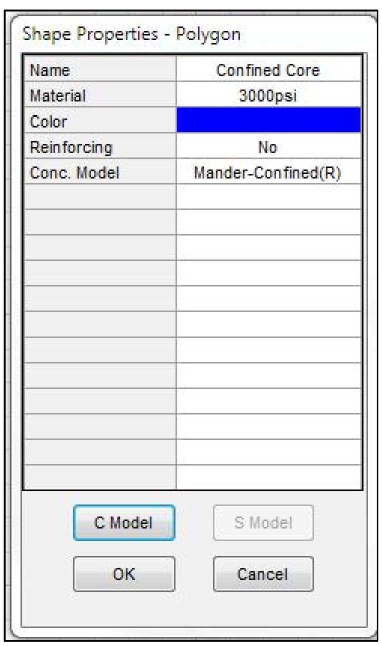
<u>Frame Member Section Properties</u>

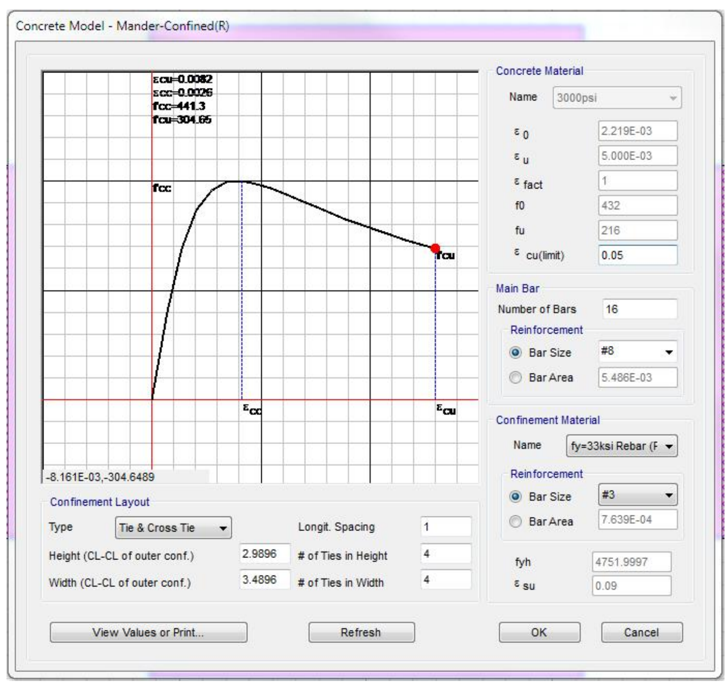
<u>Col. A – 4'x3.5' – Local Axes 3 = Transverse Direction, Axes 2 = Longitudinal Direction</u>





Concrete Model for Confined Concrete
#3 ties at 12" (units in kips and in)



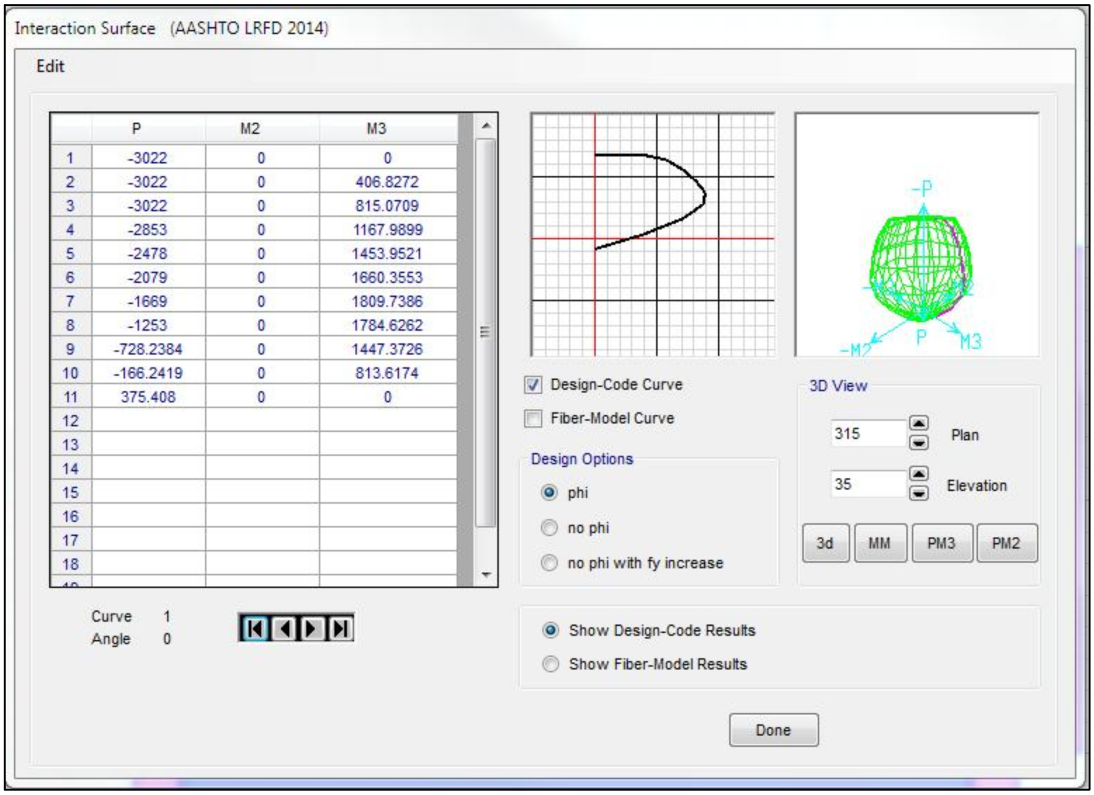


wsp	*Computation Sheet*	Job №: 201612642	Page:	of
Project:	*ITD Memorial Bridge Feasibility Study*	Made by: JWC	Date:	9/27/17
Subject:	*Substructure Retrofit Model Analysis*	Checked by:	Date:	

<u>Column A CSI Bridge P-M Diagram – checked against "Shortcol" spreadsheet values</u>

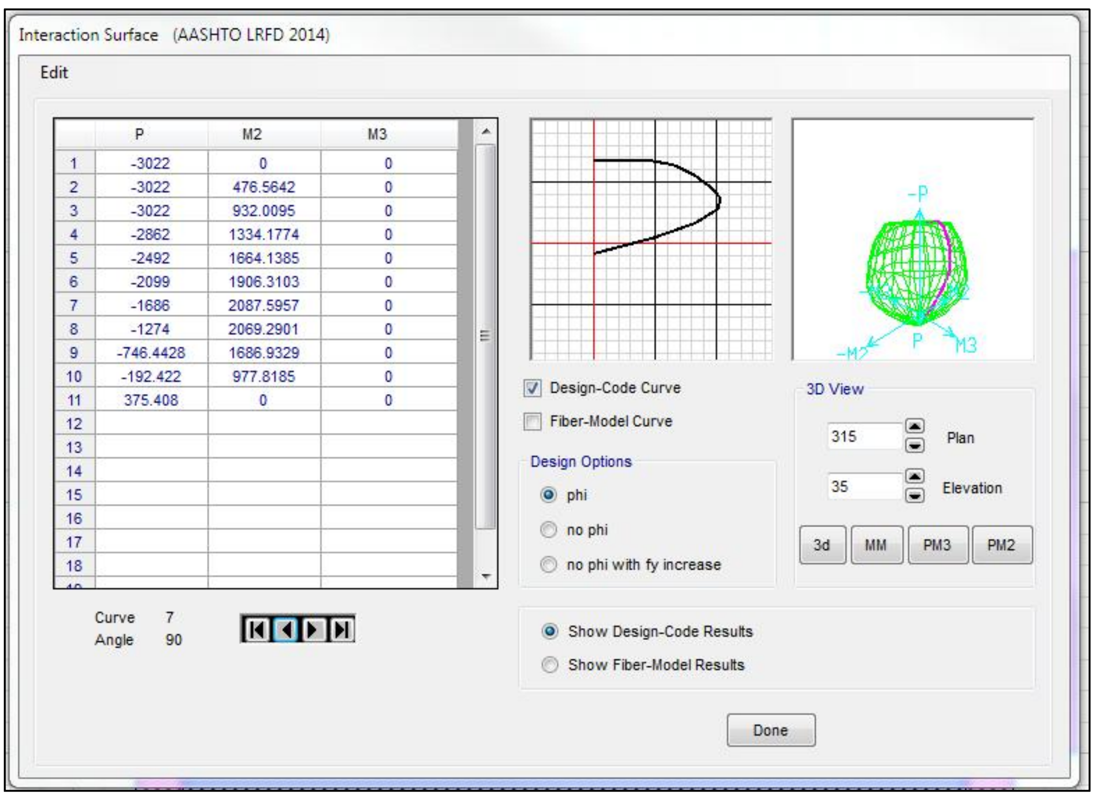
Resistance Factors per AASHTO LRFD 5.5.4.2 – ϕ_b=0.9, ϕ_c = 0.75

M3 - Longitudinal Direction



	P	M2	M3
1	-3022	0	0
2	-3022	0	406.8272
3	-3022	0	815.0709
4	-2853	0	1167.9899
5	-2478	0	1453.9521
6	-2079	0	1660.3553
7	-1669	0	1809.7386
8	-1253	0	1784.6262
9	-728.2384	0	1447.3726
10	-166.2419	0	813.6174
11	375.408	0	0
12			
13			
14			
15			
16			
17			
18			

M2 - Transverse Direction



	P	M2	M3
1	-3022	0	0
2	-3022	476.5642	0
3	-3022	932.0095	0
4	-2862	1334.1774	0
5	-2492	1664.1385	0
6	-2099	1906.3103	0
7	-1686	2087.5957	0
8	-1274	2069.2901	0
9	-746.4428	1686.9329	0
10	-192.422	977.8185	0
11	375.408	0	0
12			
13			
14			
15			
16			
17			
18			

Computation Sheet	Job №: 201612642	Page:	of
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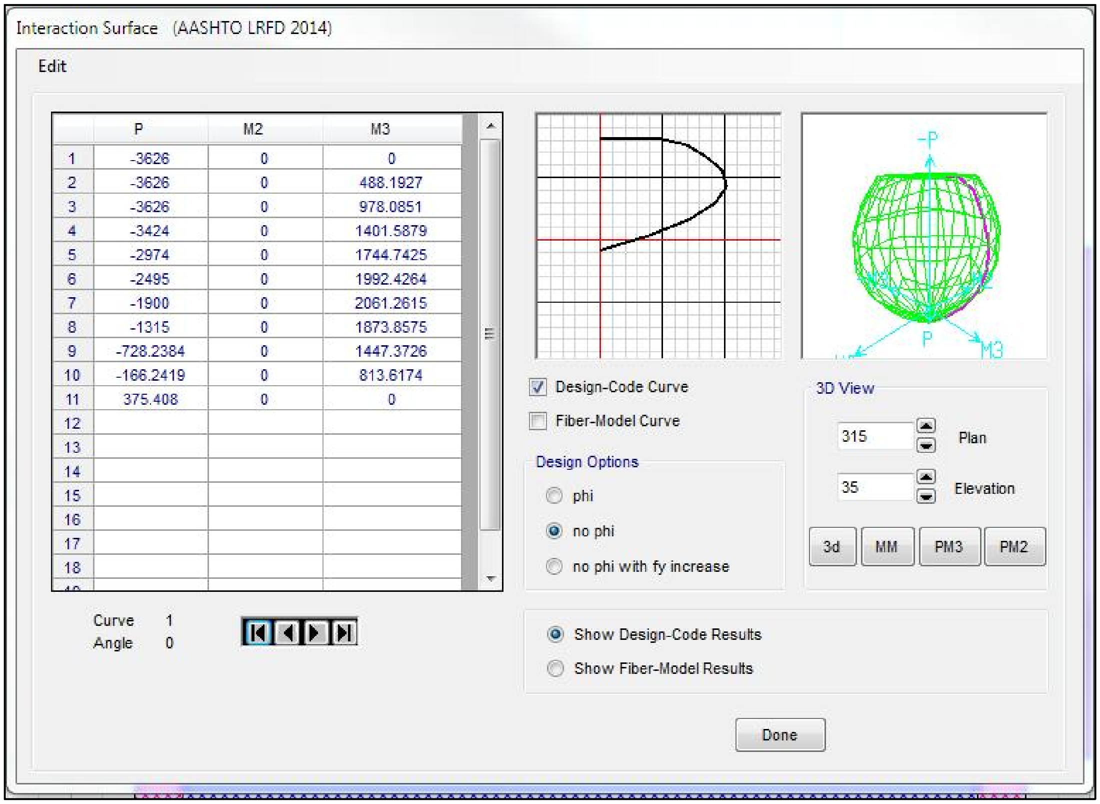
Subject: *Substructure Retrofit Model Analysis*	Checked by:	Date:	

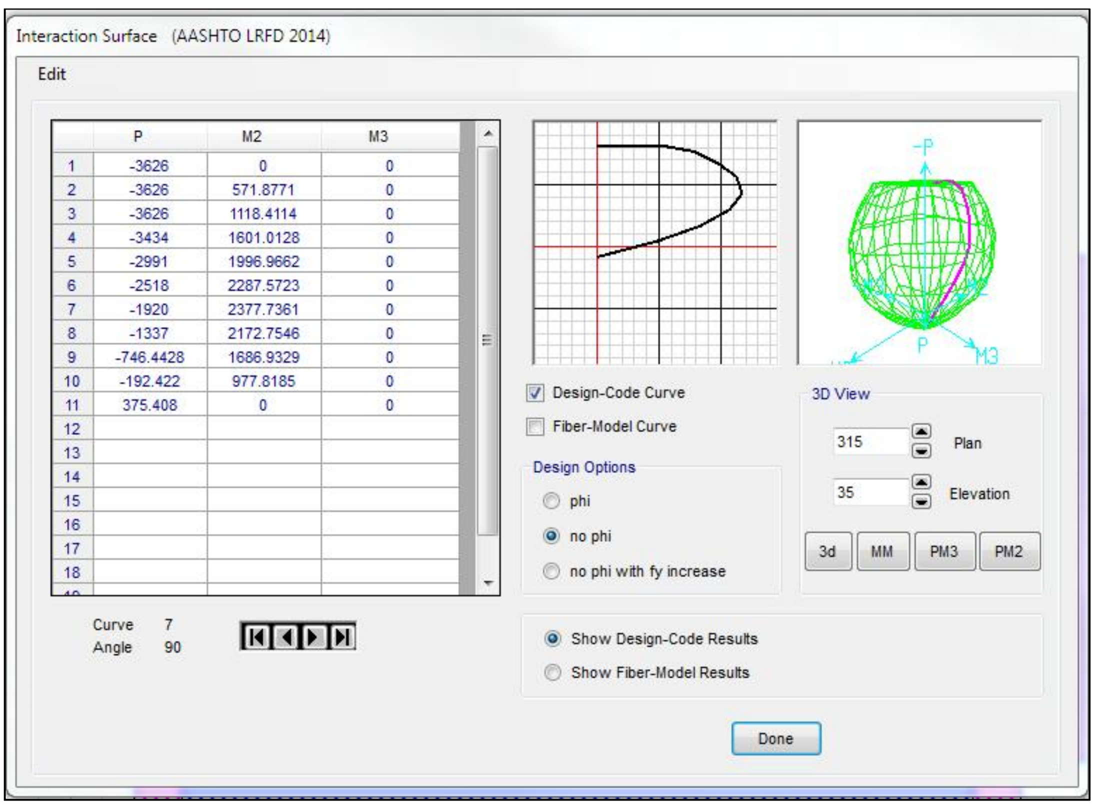
Column A CSI Bridge P-M Diagram for Extreme Event I – ϕ_b=1.0, ϕ_c = 1.0

M3 - Longitudinal Direction



	P	M2	M3
1	-3626	0	0
2	-3626	0	488.1927
3	-3626	0	978.0851
4	-3424	0	1401.5879
5	-2974	0	1744.7425
6	-2495	0	1992.4264
7	-1900	0	2061.2615
8	-1315	0	1873.8575
9	-728.2384	0	1447.3726
10	-166.2419	0	813.6174
11	375.408	0	0
12			
13			
14			
15			
16			
17			
18			

M2 - Transverse Direction



	P	M2	M3
1	-3626	0	0
2	-3626	571.8771	0
3	-3626	1118.4114	0
4	-3434	1601.0128	0
5	-2991	1996.9662	0
6	-2518	2287.5723	0
7	-1920	2377.7361	0
8	-1337	2172.7546	0
9	-746.4428	1686.9329	0
10	-192.422	977.8185	0
11	375.408	0	0
12			
13			
14			
15			
16			
17			
18			

WSP PARSONS BRINCKERHOFF	Project: ITD Memorial Bridge Feasibility Study	Engineer: JWC Date: 27-Sep-17	Project #
ShortCol Copyright © 2007	Subject: Column A Flexural Analysis Long&Trans Directions	Checker: Date:	Page:

Last modified: 30-Dec-11

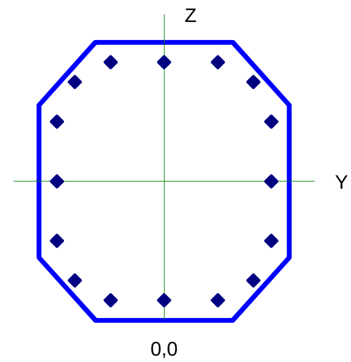
Reinforced concrete column capacity

Materials:

Concrete f'_c = 3 ksi γ_c = 150 lb/ft³
Steel f_y = 33 ksi E_c = 3,321 ksi
Max. conc. strain ε_c = -0.003 E_s = 29,000 ksi

Design Code: AASHTO LRFD-static

Resistance Factors ϕ_b = 0.9 ϕ_c = 0.75



Section Properties:

Height = 42 in   Width = 42 in
Chamfer = 9.5 in
A_C = 1583.5 in² A_T = 1681 in²
I_C = 200999 in⁴ I_T = 220353.67 in⁴
Y_{bC} = 21 in Y_{bT} = 21.00 in

Longitudinal Reinforcement:

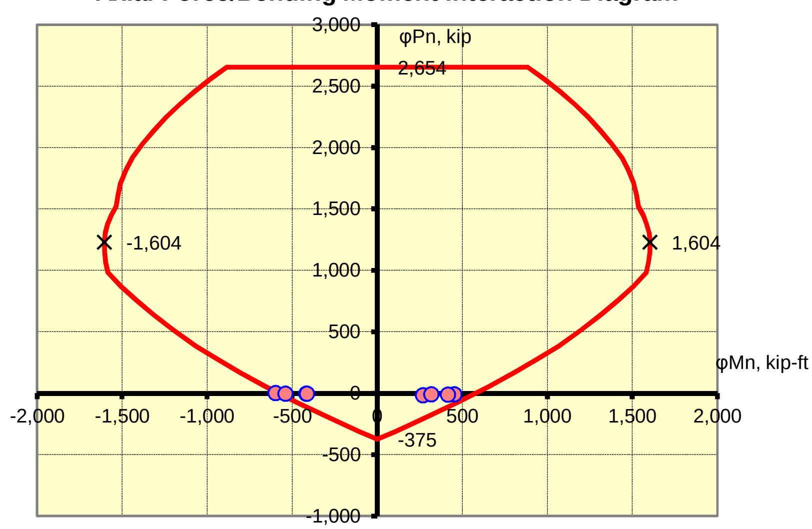
Bar Area = 0.79 in²
No.bars = 16 (< 200)
Σ(As) = 12.64 in²
As/Ac = 0.80%

Confinement: ◉ Ties/Stirrups ○ Spiral   4#6

f_{yt} = 33 ksi   Stirrup/Tie bar area : 0 in²
Number of stirrup legs in prime direction : 0
in secondary direction : 0
Tie/stirrup spacing, s : 6 in
Concrete cover to tie bar, c : 1.5 in

Reinforcing Bar No.	Area A_s in²	Coordinates, in Y (from ctr.)	Z (from bot.)
1	0.79	15.00	36.00
2	0.79	9.00	39.00
3	0.79	0.00	39.00
4	0.79	-9.00	39.00
5	0.79	-15.00	36.00
6	0.79	18.00	30.00
7	0.79	-18.00	30.00
8	0.79	18.00	21.00
9	0.79	-18.00	21.00
10	0.79	18.00	12.00
11	0.79	-18.00	12.00
12	0.79	15.00	6.00
13	0.79	9.00	3.00
14	0.79	0.00	3.00
15	0.79	-9.00	3.00
16	0.79	-15.00	6.00

Axial Force/Bending Moment Interaction Diagram



Positive moment creates tension at the bottom fibers

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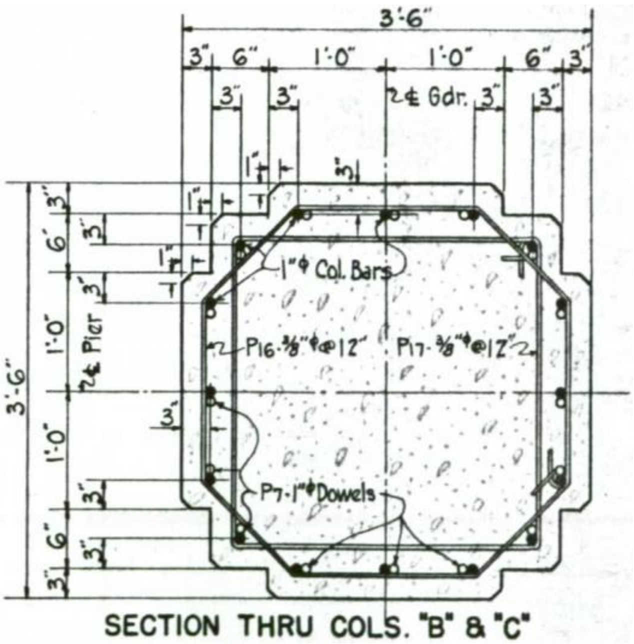
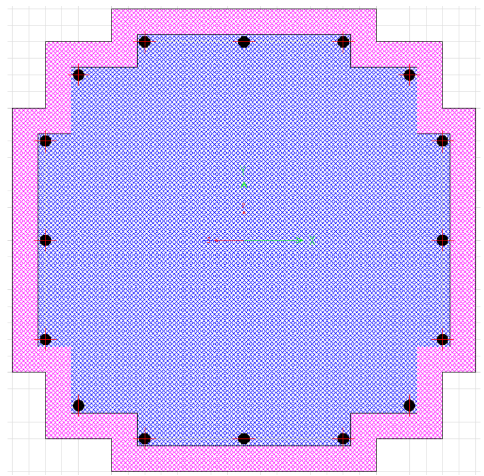
Subject:	Substructure Retrofit Model Analysis	Checked by:	Date:

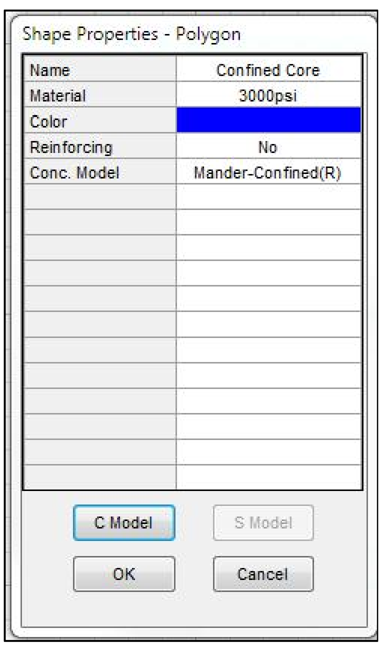
Frame Member Section Properties

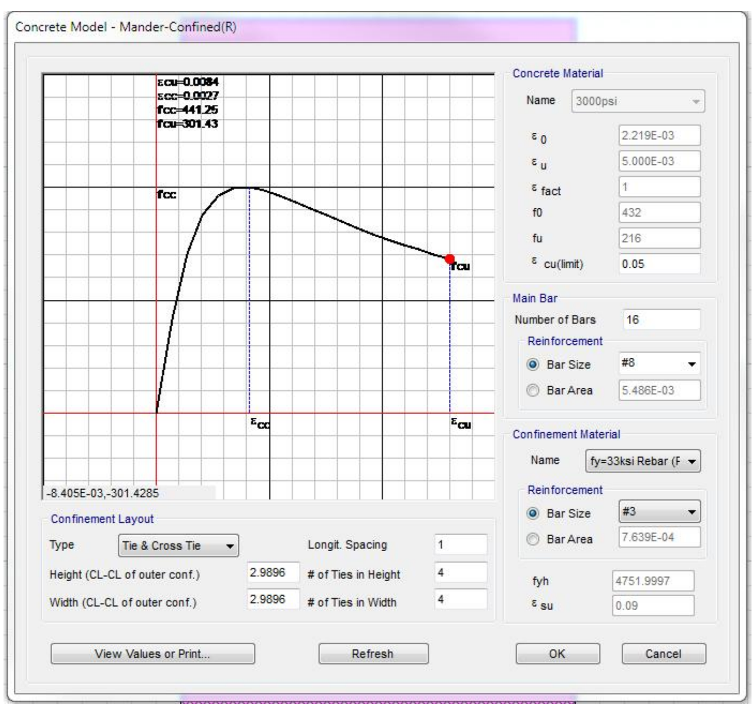
Col. B/C – 3.5' x 3.5' – Local Axes 3 = Transverse Direction, Axes 2 = Longitudinal Direction





Concrete Model for Confined Concrete
#3 ties at 12" (units in kips and in)

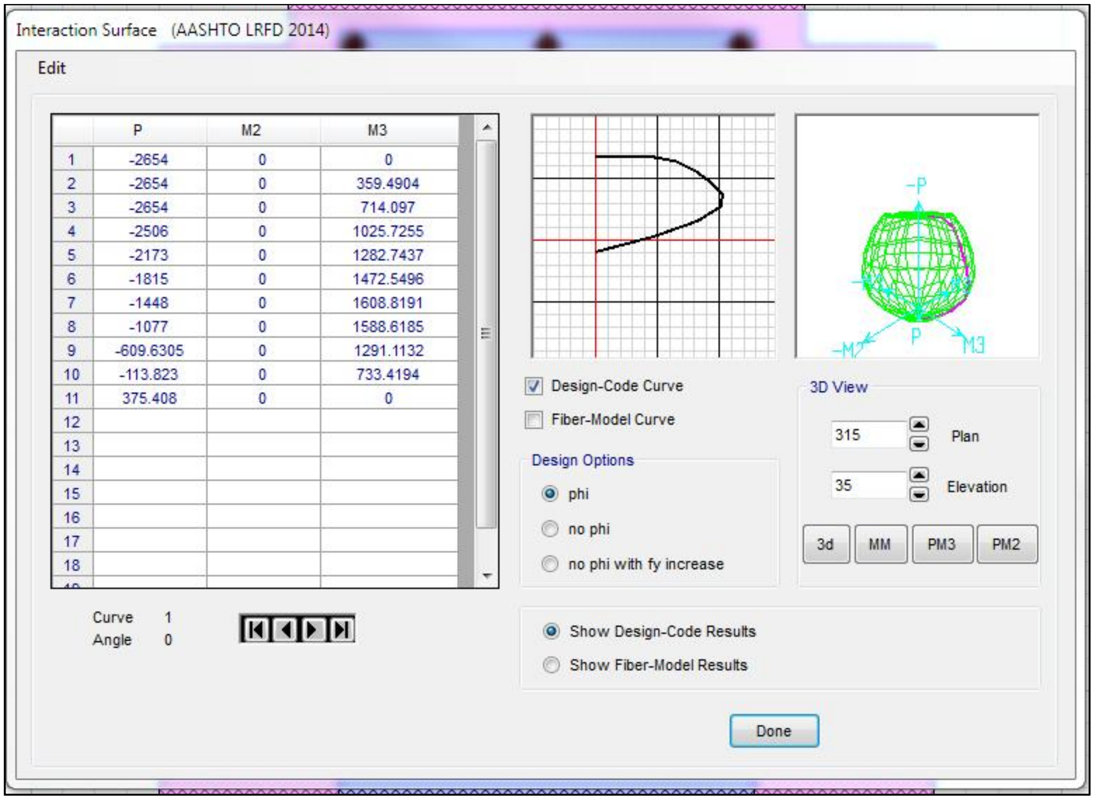




Column B/C CSI Bridge P-M Diagram – checked against "Shortcol" spreadsheet values

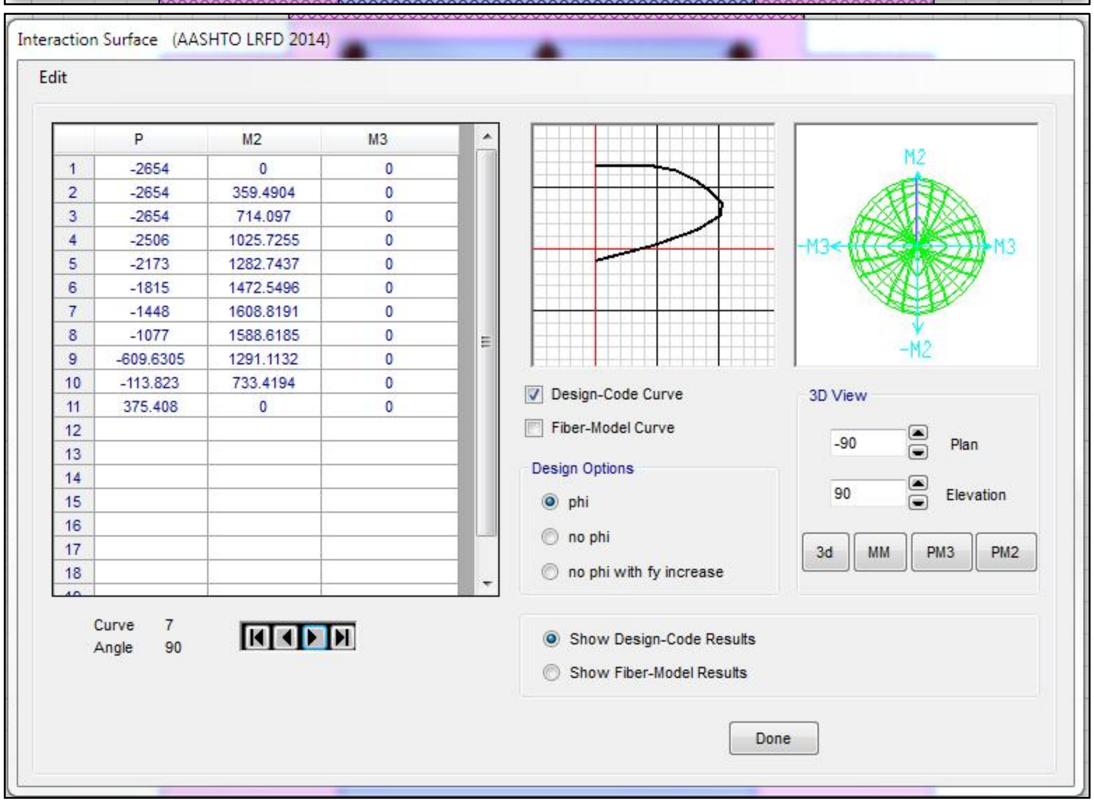
Resistance Factors per AASHTO LRFD 5.5.4.2 – ϕ_b=0.9, ϕ_c = 0.75

M3 - Longitudinal Direction



	P	M2	M3
1	-2654	0	0
2	-2654	0	359.4904
3	-2654	0	714.097
4	-2506	0	1025.7255
5	-2173	0	1282.7437
6	-1815	0	1472.5496
7	-1448	0	1608.8191
8	-1077	0	1588.6185
9	-609.6305	0	1291.1132
10	-113.823	0	733.4194
11	375.408	0	0
12			
13			
14			
15			
16			
17			
18			

M2 - Transverse Direction

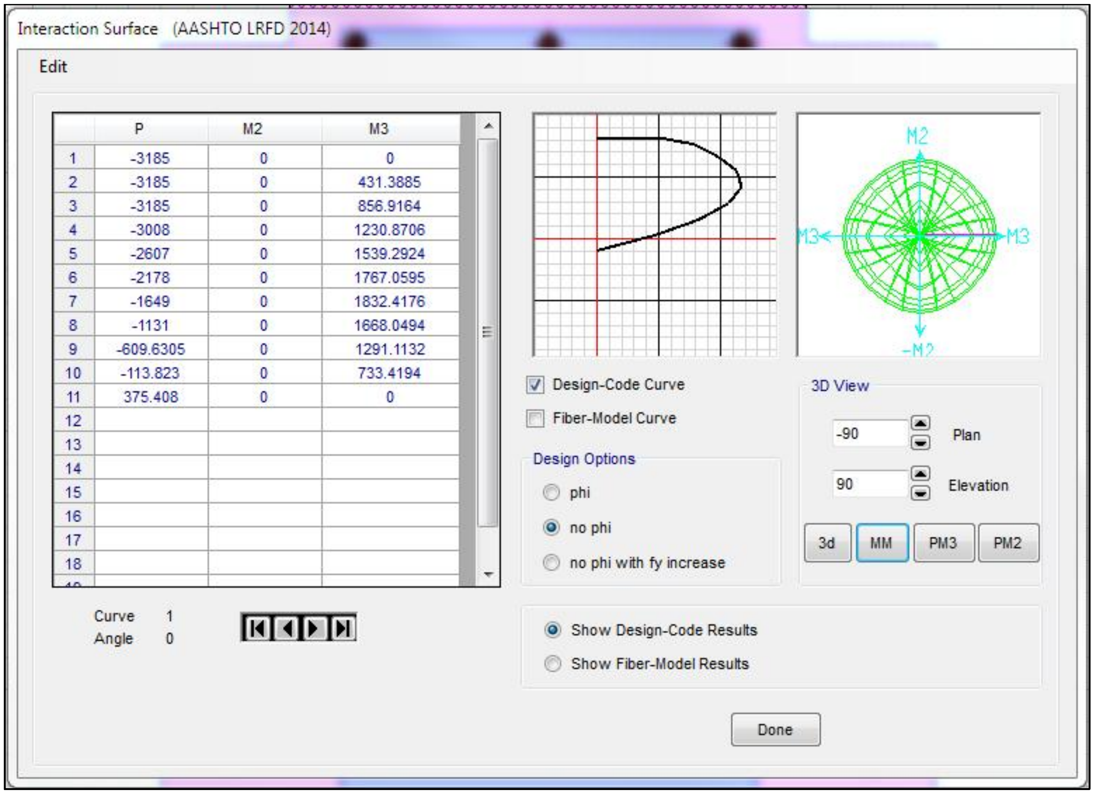


	P	M2	M3
1	-2654	0	0
2	-2654	359.4904	0
3	-2654	714.097	0
4	-2506	1025.7255	0
5	-2173	1282.7437	0
6	-1815	1472.5496	0
7	-1448	1608.8191	0
8	-1077	1588.6185	0
9	-609.6305	1291.1132	0
10	-113.823	733.4194	0
11	375.408	0	0
12			
13			
14			
15			
16			
17			
18			

wsp	Computation Sheet	Job №: 201612642	Page:	of
Project:	*ITD Memorial Bridge Feasibility Study*	Made by: JWC	Date:	9/27/17
Subject:	*Substructure Retrofit Model Analysis*	Checked by:	Date:	

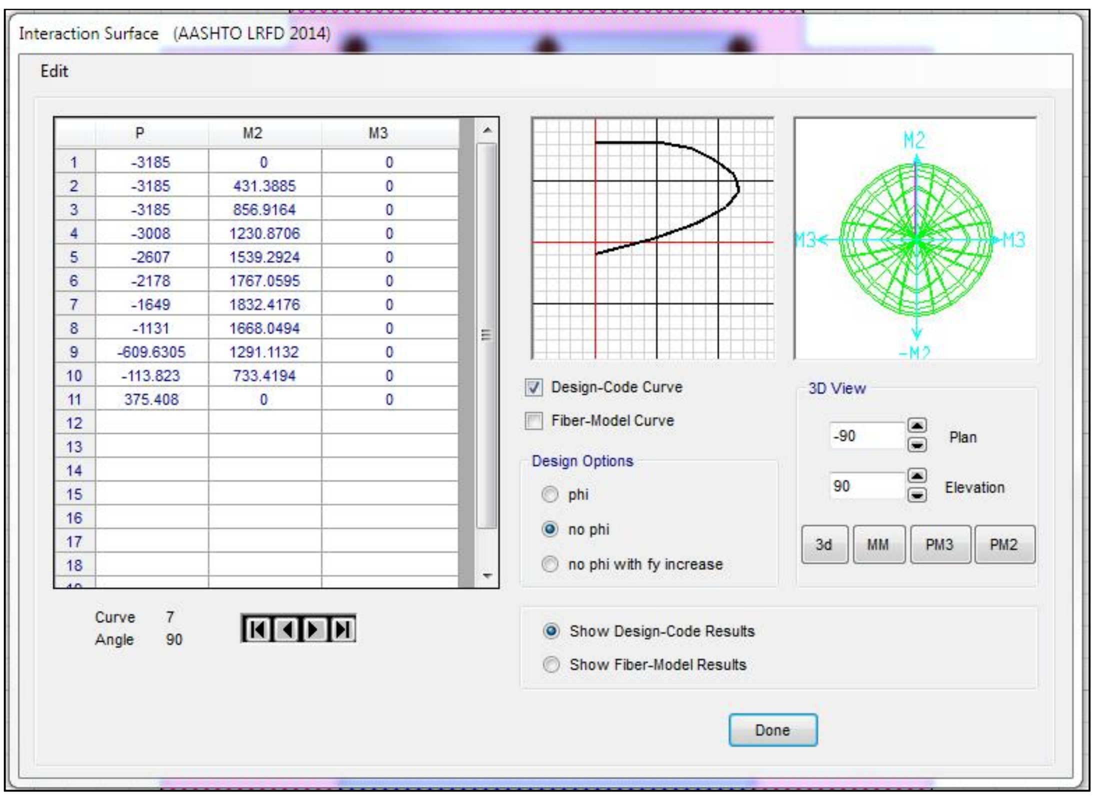
Column B/C CSI Bridge P-M Diagram for Extreme Event I – ϕ_b=1.0, ϕ_c = 1.0

M3 - Longitudinal Direction



	P	M2	M3
1	-3185	0	0
2	-3185	0	431.3885
3	-3185	0	856.9164
4	-3008	0	1230.8706
5	-2607	0	1539.2924
6	-2178	0	1767.0595
7	-1649	0	1832.4176
8	-1131	0	1668.0494
9	-609.6305	0	1291.1132
10	-113.823	0	733.4194
11	375.408	0	0
12			
13			
14			
15			
16			
17			
18			

M2 - Transverse Direction



	P	M2	M3
1	-3185	0	0
2	-3185	431.3885	0
3	-3185	856.9164	0
4	-3008	1230.8706	0
5	-2607	1539.2924	0
6	-2178	1767.0595	0
7	-1649	1832.4176	0
8	-1131	1668.0494	0
9	-609.6305	1291.1132	0
10	-113.823	733.4194	0
11	375.408	0	0
12			
13			
14			
15			
16			
17			
18			

13. Analysis Step 8: Retrofit Bent Cap Structural Capacity Check

WSP PARSONS BRINCKERHOFF	Project: ITD US-12 Memorial Bridge Feasibility Study	Engineer: JWC Date: 11-Oct-17	Project #
ShortCol Copyright © 2007	Subject: Pier Cap Flexural Analysis - Vertical Direction Top: 10-#14; Bot: 10-#10, Side: 5-#8 EF	Checker: Date:	Page:

Last modified: 30-Dec-11

Reinforced concrete column capacity

Materials:

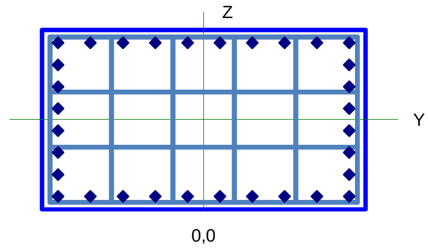
Concrete f'_c = 4 ksi γ_c = 145 lb/ft³
Steel f_y = 60 ksi E_c = 3,644 ksi
Max. conc. strain ε_c = -0.003 E_s = 29,000 ksi

Design Code: AASHTO LRFD-static

Resistance Factors ϕ_b = 0.9 ϕ_c = 0.75

Section Properties:

Height = 38 in Width = 60 in
Chamfer = 0 in
A_C = 2280 in² A_T = 2591 in²
I_C = 274360 in⁴ I_T = 342707.54 in⁴
Y_{bC} = 19 in Y_{bT} = 19.43 in



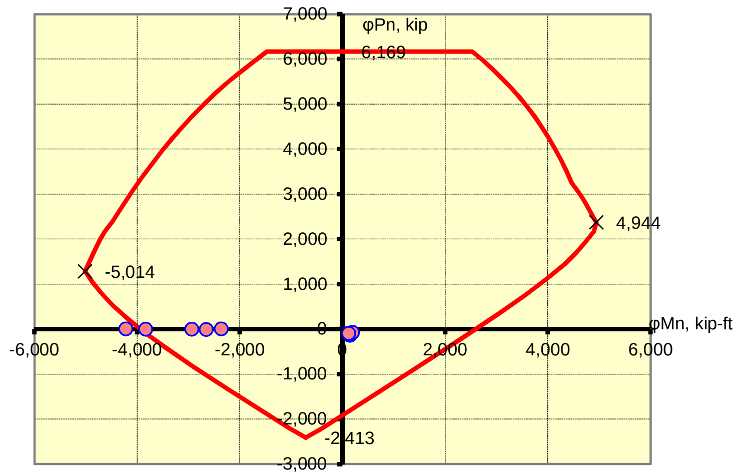
Longitudinal Reinforcement:

No.bars = 32 (< 200)
Σ(As) = 44.68 in²
As/Ac = 1.96%

Confinement: (●) Ties/Stirrups ( ) Spiral 4#6
f_{yt} = 60 ksi Stirrup/Tie bar area : 0.44 in²
Number of stirrup legs in prime direction : 6
in secondary direction : 4
Tie/stirrup spacing, s : 6 in
Concrete cover to tie bar, c : 1.5 in

Reinforcing Bar No.	Area A_s in²	Coordinates, in Y (from ctr.)	Z (from bot.)
1	1.27	-27.00	2.75
2	1.27	-21.00	2.75
3	1.27	-15.00	2.75
4	1.27	-9.00	2.75
5	1.27	-3.00	2.75
6	1.27	3.00	2.75
7	1.27	9.00	2.75
8	1.27	15.00	2.75
9	1.27	21.00	2.75
10	1.27	27.00	2.75
11	0.79	-27.00	7.39
12	0.79	27.00	7.39
13	0.79	-27.00	12.04
14	0.79	27.00	12.04
15	0.79	-27.00	16.68
16	0.79	27.00	16.68
17	0.79	-27.00	21.32
18	0.79	27.00	21.32
19	0.79	-27.00	25.96
20	0.79	27.00	25.96
21	0.79	-27.00	30.61
22	0.79	27.00	30.61
23	2.25	-27.00	35.25
24	2.25	-21.00	35.25
25	2.25	-15.00	35.25
26	2.25	-9.00	35.25
27	2.25	-3.00	35.25
28	2.25	3.00	35.25
29	2.25	9.00	35.25
30	2.25	15.00	35.25
31	2.25	21.00	35.25
32	2.25	27.00	35.25

Axial Force/Bending Moment Interaction Diagram



Positive moment creates tension at the bottom fibers

Factored Loads Description			Pu kip	Mu kip-ft	Capacity φMn kip-ft	Demand/ Capacity Ratio
Str I	Min	Moment	0	-4219.6	-3930	107%
Str I	Max	Moment	-138	150	2417	6%
Str III	Min	Moment	-8.4	-2,649	-3921	68%
Str III	Max	Moment	-92.6	139	2476	6%
Str V	Min	Moment	-3.8	-3,830	-3926	98%
Str V	Max	Moment	-126.7	155	2432	6%
Ext I	Min	Moment	0	-2,360	-3930	60%
Ext I	Max	Moment	-74	196	2501	8%
Serv I	Min	Moment	-3.2	-2,935	-3926	75%
Serv I	Max	Moment	-97.3	122	2470	5%

Critical Section is at the CL of Column A; Cross-beam section can be increase at this location to account for the required increase in moment capacity.

14. Analysis Step 9: Pier Footing Bearing Capacity Checks for (1) As-Built Condition and (2) Retrofitted Superstructure and Bent Cap

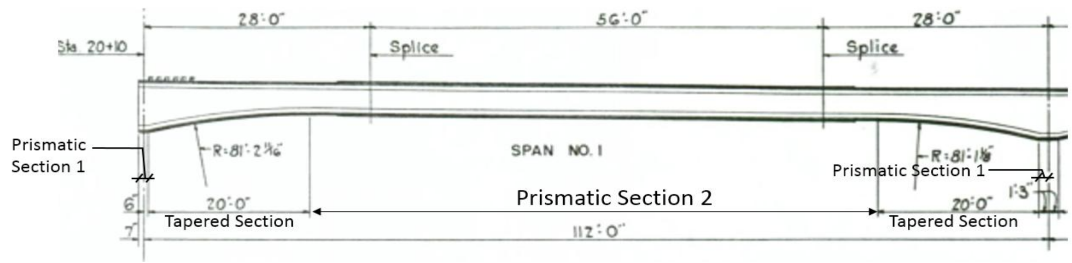
As-Built Condition

Superstructure

Superstructure elements include (1) Steel Plate Girders, (2) Cross Bracing, (3) Expansion Joint Plates, and (4) Concrete Elements and Walkway Railing

Girder Properties

Span Length =	112.00	ft
Web Height at Ends, H_{web1} =	6.50	ft; per Dwg. No. 5226
Web Height at MS, H_{web2} =	4.00	ft; per Dwg. No. 5226
Web Thickness =	0.56	in, per Dwg. No. 5226
Chord height, h =	2.50	ft
Typ. Girder Spacing, S =	11.00	ft
Overhang Length =	4.75	ft
Number of Girders =	6.00	
Number of Spaces =	5.00	



(1) Steel Plate Girder

Steel Volumes and Weights per Girder

Prismatic Section 1

Element	Height in	Thickness in	Area in^2	Length ft	# per Span	Vol ft^3
Web Plate	6.50	0.56	3.66	1.25	2	0.06
Top Cover PLs	0.63	18.00	11.25	1.25	2	0.20
T&B Ls - 8"x8"x3/4"	---	---	7.75	1.25	8	0.54
Bot Cover PLs	0.63	18.00	11.25	1.25	2	0.20
Vert Stiff Ls - 4"x7"x1/2"	---	---	5.25	6.50	4	0.95
Vert Fills - 8"x3/4"	8.00	0.75	6.00	5.17	4	0.86
					Total =	2.80

Tapered Section

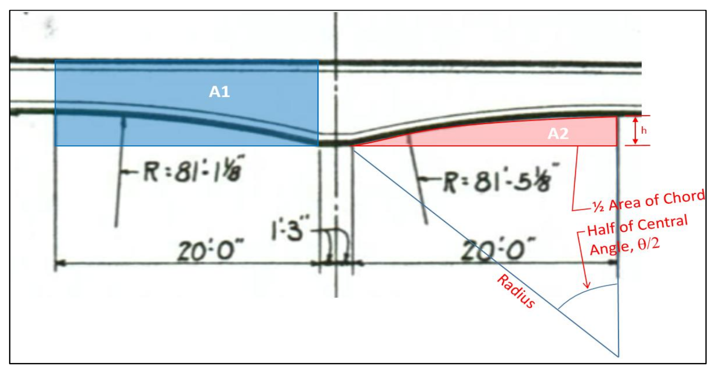
Web:

Length =	20.00	ft
Area A1 = H_{web1} x L =	130.00	ft^2
Radius =	81.42	ft
Central Angle, θ =	28.47	deg
A2 = 1/2 Area of Chord =	33.47	ft^2
Area = A1 - A2 =	96.53	ft^2
Web thickness =	0.56	in
Number per Span =	2	
Volume per Span =	9.05	ft^3

Arc Equations:

$$\theta = 2\arccos\left(1 - \frac{h}{R}\right)$$

$$A = \frac{R^2}{2}\left(\frac{\alpha\pi}{180^\circ} - \sin\alpha\right)$$



Additional Plates:

Element	Height in	Thickness in	Area in^2	Length ft	# per Span	Vol ft^3	Notes:
Top Cover PLs	0.63	18.00	11.25	20.00	2	3.13	
T&B Ls - 8"x8"x3/4"	---	---	7.75	20.00	8	8.61	
Bot Cover PLs	0.63	18.00	11.25	20.00	2	3.13	
Vert Stiff Ls - 4"x6"x3/8"	---	---	3.61	5.25	10	1.32	Per Dwg. No. 5226 - 5 per tapered section, average length used
Shear Device - 5-3/4x5 T's	---	---	16.50	0.54	40	2.47	Used Section Props for WT5x56 (depth = 5.68");length is average of lengths as shown on Dwg. 5227; spaced at 1' along span
					Total =	18.64	

Prismatic Section 2

Element	Height in	Thickness in	Area in^2	Length ft	# per Span	Vol ft^3	Notes:
Web Plate	48.00	0.56	27.00	72.00	1.00	13.50	
Top Cover PLs	0.63	18.00	11.25	64.00	2.00	10.00	Ave. Length = average(72' total section length, 56' double plate length)
T&B Ls - 8"x8"x3/4"	---	---	7.75	72.00	4.00	15.50	
Bot Cover PLs	0.63	18.00	11.25	64.00	2.00	10.00	Ave. Length = average(72' total section length, 56' double plate length)
Shear Device - 5-3/4x5 T's	---	---	16.50	0.54	72	4.44	Used Section Props for WT5x56 (depth = 5.68");length is average of lengths as shown on Dwg. 5227; spaced at 1' along span
Splice Plates							
T&B Ls - 7.25"x7.25"x7/8"	7.25	0.88	11.92	6.00	8	3.97	4 per section, 2 splices per span
Web Splice PLs - 26"x1/2"	32.00	0.50	16.00	2.17	4	0.96	2 per section, 2 splices per span
					Total =	58.38	

Total Plate Girder Weight

Vol. of Steel per girder per span =	88.87	ft^3
Wt. of Steel per Girder =	43.55	kip
Reaction @ Bearing per Girder =	21.77	kip

(2) Cross Bracing - Calculated for each Girder Unit, which is a set of one Girder A, B, and C (2 units per total deck cross-section) - See Dwg. Nos. 5227 and 5228

	Element	Area in^2	Length ft	#	Vol ft^3	Notes:
@ Exp Joint	Top 18"x50 WF beam	14.70	4.58	4	1.87	
@ Exp Joint	Bot MC18"x42.7	12.60	4.58	4	1.60	
@ Exp Joint	Overhang 30"x108 WF beam	17.83	4.25	2	1.05	31.7in^2 at the girder interface, tapers down to 3.75" at cantilever - average area taken over 4.25' length, applied to Ext. Girder only
Intermediate	Single MC18"x42.7	12.60	4.58	10	4.01	
Cont. Bents	T&B MC18"x42.7 @ bearing	12.60	4.58	2	0.80	Located @ Continuous Bents (Pier 1, 2, 4, 5, 7, 8, 10, 11); 1/2 of weight included for each span
				Total =	9.33	

Girder A (Exterior) Total per span =	3.12	ft^3,	Wt =	1.53	kip	Overhang + 1/4 cross bracing
Girder B (Center) Total per span =	4.14	ft^3,	Wt =	2.03	kip	1/2 cross bracing
Girder C (Interior) Total per span =	2.07	ft^3,	Wt =	1.01	kip	1/4 cross bracing
Check =	9.33					

(3) Expansion Joint Assembly - Abutments 1 & 2 and Piers 3, 6, and 9 - Outlined on Dwg. No. 5230

Abutment 1 Assembly (Abutment 2 similar)

Element:	Height in	Thickness in	Area in^2	Length ft	# per Joint	Vol ft^3
EP1 + EP5: East Roadway	11.50	1.00	11.50	23.29	1.00	1.86
EP2 + EP6: West Roadway	11.50	1.00	11.50	23.29	1.00	1.86
6x6x1/2L supporting EP5/EP6	---	---	5.77	23.29	2.00	1.87
8x6x1/2L supporting EP5/EP6	---	---	6.75	23.29	2.00	2.18
4x6x1/2L supporting EP1/EP2	---	---	4.75	23.29	2.00	1.54
EP13, EP14: Sidewalk	11.50	0.50	5.75	5.04	2.00	0.40
EP 17, EP18: Sidewalk	2.00	0.50	1.00	5.04	2.00	0.07
4x6x1/2L supporting EP13,14,17,18	---	---	4.75	5.04	4.00	0.67
EP25: Dividing Strip	12.83 *	0.25	3.21	0.96	2.00	0.04
EP30: Outer Curb	7.00 *	0.25	1.75	0.96	4.00	0.05
EP35: Roadway Barrier	46.11 *	0.25	11.53	0.96	2.00	0.15
					Total =	10.69
					Wt =	5.24 kip
				Reaction per Girder =		0.87 kip

Pier 3 Assembly (Piers 6 and 9)

Element:	Height in	Thickness in	Area in^2	Length ft	# per Joint	Vol ft^3
EP9 + EP11: Roadway	16.50	1.00	16.50	23.29	1.00	2.67
EP10 + EP12: Roadway	16.50	1.00	16.50	23.29	1.00	2.67
6x6x1/2L supporting EP9/EP10, E11/E12	---	---	5.77	23.29	4.00	3.73
8x6x1/2L supporting EP9/EP10, EP11/EP12	---	---	6.75	23.29	4.00	4.37
EP21, EP22: Sidewalk	16.00	0.50	8.00	5.04	2.00	0.56
EP 23, EP24: Sidewalk	2.00	0.50	1.00	5.04	2.00	0.07
8x4x1/2L supporting EP21-EP24	---	---	5.75	5.04	4.00	0.81
EP28, EP29: Dividing Strip	12.83 *	0.25	3.21	1.33	2.00	0.06
EP33: Outer Curb	7.00 *	0.25	1.75	1.33	4.00	0.06
EP38, EP39: Roadway Barrier	46.11 *	0.25	11.53	1.33	2.00	0.21
					Total =	15.21
					Wt =	7.45 kip
				Reaction per Girder =		1.24 kip

*Height = Total Length along plate surface

(4) Concrete Deck Weights per Span

Deck Section View on Dwg. No. 5224

Element	Girder A Width in	Depth in	Area in^2	Length ft	# per Span	Vol ft^3	Girder B Width in	Depth in	Area in^2	Length ft	# per Span	Vol ft^3	Girder C Width in	Depth in	Area in^2	Length ft	# per Span	Vol ft^3
Deck	123.00	7.75	953.25	112.00	1	741.42	132.00	7.75	1023.00	112.00	1	795.67	117.00	7.75	906.75	112.00	1	705.25
Curb	12.00	0.67	8.00	112.00	1	6.22	---	---	0.00	112.00	0	0.00	---	---	0.00	112.00	0	0.00
Barrier	---	---	171.00	112.00	1	133.00	---	---	0.00	112.00	0	0.00	---	---	0.00	112.00	0	0.00
Haunch	10.00	2.00	20.00	112.00	1	15.56	10.00	3.09	30.94	112.00	1	24.06	10.00	4.47	44.69	112.00	1	34.76
Strip	---	---	0.00	---	0	0.00	---	---	0.00	---	0	0.00	---	---	48.00	112.00	1	37.33
Post	12.00	31.50	378.00	15.00	8	315.00	---	---	0.00	---	0	0.00	---	---	0.00	---	0	0.00
Post	12.00	34.50	414.00	16.00	2	92.00	---	---	0.00	---	0	0.00	---	---	0.00	---	0	0.00
					Total =	1303.19					*Total =*	819.73					*Total =*	777.34
				Wt. per Span =		195.48 kip				*Wt. per Span =*		122.96 kip				*Wt. per Span =*		116.60 kip
				Reaction per Girder =		97.74 kip				*Reaction per Girder =*		61.48 kip				*Reaction per Girder =*		58.30 kip

Walkway Railing - Steel Framing Elements Supported by Girder A (Exterior) Only

Element	Properties per Panel Area in^2	Length ft	# per panel	# of panels per span	Vol ft^3
Vert L2x2x1/4	0.94	1.92	13		1.46
End Vert C5x9	2.64	1.92	2	9	0.63
T&B C5x9	2.64	11.00	2		3.63
				Total =	5.72
				Wt. per Span =	2.80 kip
				Reaction per Girder =	1.40 kip

"Future" Wearing Surface - per "Design Notes" on Dwg. No. 5216

Weight of Wearing Surface = 25.0 psf per "Design Notes" on Dwg. No. 5216

	Girder A	Girder B	Girder C
Trib. Area (ft^2)	1148	1232	1092
Weight per Span (kip)	28.7	30.8	27.3
Reaction per Girder (kip)	14.35	15.4	13.65

Superstructure Reaction Forces at each Pier

Pier	Reaction Distribution Factor	Girder A: Girder	Cross Bracing	Exp. Jt	Conc. + Railing	*Total * Factor*	Girder B: Girder	Cross Bracing	Exp. Jt	Concrete	*Total * Factor*	Girder C: Girder	Cross Bracing	Exp. Jt	Concrete	*Total * Factor*	Total Superstructure DL	Total Superstructure LL per Girder Reactions on Dwg. 5244
Abut 1	0.9	21.77	0.765	0.87	113.49	*123.21*	21.77	1.014	0.87	76.88	*90.49*	21.77	0.507	0.87	71.95	*85.59*	*598.59*	*282.83*
1	1.1	43.55	1.530	0.00	226.98	*299.27*	43.55	2.028	0.00	153.76	*219.27*	43.55	1.014	0.00	143.90	*207.31*	*1451.69*	*460.60*
2	1.1	43.55	1.530	0.00	226.98	*299.27*	43.55	2.028	0.00	153.76	*219.27*	43.55	1.014	0.00	143.90	*207.31*	*1451.69*	*460.60*
3	0.9	43.55	1.530	1.24	226.98	*245.97*	43.55	2.028	1.24	153.76	*180.52*	43.55	1.014	1.24	143.90	*170.73*	*1194.45*	*460.60*
4	1.1	43.55	1.530	0.00	226.98	*299.27*	43.55	2.028	0.00	153.76	*219.27*	43.55	1.014	0.00	143.90	*207.31*	*1451.69*	*460.60*
5	1.1	43.55	1.530	0.00	226.98	*299.27*	43.55	2.028	0.00	153.76	*219.27*	43.55	1.014	0.00	143.90	*207.31*	*1451.69*	*460.60*
6	0.9	43.55	1.530	1.24	226.98	*245.97*	43.55	2.028	1.24	153.76	*180.52*	43.55	1.014	1.24	143.90	*170.73*	*1194.45*	*460.60*
7	1.1	43.55	1.530	0.00	226.98	*299.27*	43.55	2.028	0.00	153.76	*219.27*	43.55	1.014	0.00	143.90	*207.31*	*1451.69*	*460.60*
8	1.1	43.55	1.530	0.00	226.98	*299.27*	43.55	2.028	0.00	153.76	*219.27*	43.55	1.014	0.00	143.90	*207.31*	*1451.69*	*460.60*
9	0.9	43.55	1.530	1.24	226.98	*245.97*	43.55	2.028	1.24	153.76	*180.52*	43.55	1.014	1.24	143.90	*170.73*	*1194.45*	*460.60*
10	1.1	43.55	1.530	0.00	226.98	*299.27*	43.55	2.028	0.00	153.76	*219.27*	43.55	1.014	0.00	143.90	*207.31*	*1451.69*	*460.60*
11	1.1	43.55	1.530	0.00	226.98	*299.27*	43.55	2.028	0.00	153.76	*219.27*	43.55	1.014	0.00	143.90	*207.31*	*1451.69*	*460.60*
Abut 2	0.9	21.77	0.765	0.87	113.49	*123.21*	21.77	1.014	0.87	76.88	*90.49*	21.77	0.507	0.87	71.95	*85.59*	*598.59*	*282.83*

^--- Reaction Distribution Factor: 0.9 for end piers of continuous span, 1.1 for interior piers

Substructure

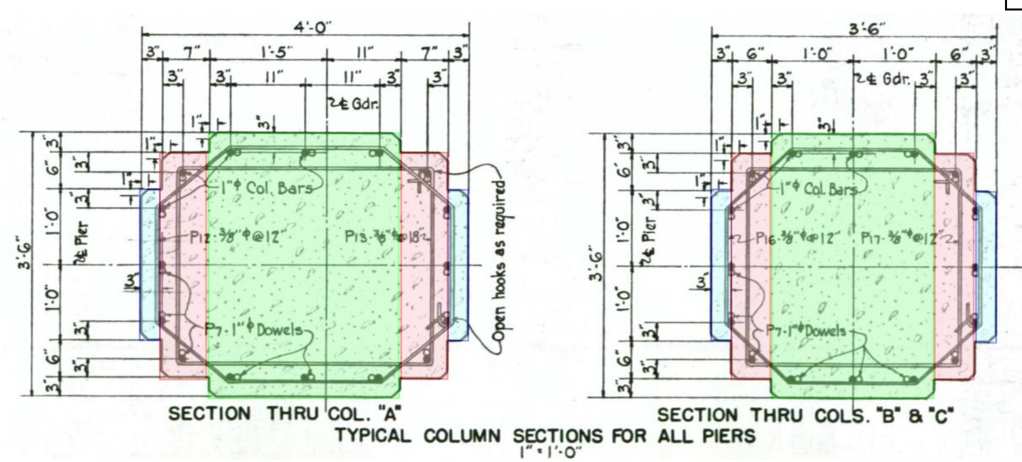
Max Allowable footing bearing = 10,000 psf, per Design Notes on As-Built Dwg. No. 5216

Reinforced Concrete unit weight, γ_c = 0.15 kcf, per LRFD C3.5.1 (including 0.005 kcf for reinforcement and 0.145 kcf for normal plain concrete)

	Pier 1		Piers 2-10		Pier 11	
Top of Pedestal =	38	ft; per Half Elev on Dwg. No. 5237	38	ft; per Half Elev on Dwg. No. 5238	38	ft; per Half Elev on Dwg. No. 5237
Pedestal Cap Height =	2	ft; per Section A-A on Dwg. No. 5237	2	ft; per Section A-A on Dwg. No. 5237	2	ft; per Section A-A on Dwg. No. 5237
Top of Pedestal Stem Wall =	36	ft	36	ft	36	ft
Pedestal Stem Wall Height =	12	ft; per Section A-A on Dwg. No. 5237	20	ft; per Section A-A on Dwg. No. 5237	12	ft; per Section A-A on Dwg. No. 5237
Base of Pedestal Stem Wall =	24	ft	16	ft	24	ft
Footing Height =	4.33	ft; 4' per Section A-A on Dwg. No. 5237, increased per Dwg. No. 5216	4	ft; per Section A-A on Dwg. No. 5238	4	ft; per Section A-A on Dwg. No. 5237
Base of Lower Footing =	19.67	ft; per Dwg. No. 5216	12.00	ft; per Dwg. No. 5238	20	ft; per Dwg. No. 5216
Leveling Course Height =	0	ft, for Piers 8, 9, & 10 Only	4	ft, for Piers 8, 9, & 10 Only	0	ft, for Piers 8, 9, & 10 Only
Base of Leveling Course ELE =	19.67	ft	8.00	ft; per Dwg. No. 5238	20	ft

Column Area Calculations - properties per Sections on Dwg. No. 5237 (cross-section the same for all piers)

		Area 1 (blue)			Area 2 (red)			Area 3 (green)							
	# of Cols	Width	Height	Area	Width	Height	Area	Width	Height	Area	Total Area per Pier		Longitudinal	Area	Reinforcement
	Unit	in	in	in^2	in	in	in^2	in	in	in^2	in^2	ft^2	Rebar	in^2	Ratio
Column "A"	2	6	24	144	14	36	504	28	42	1176	3648	25.33	16-#8 bars	12.64	0.69%
Columns "B&C"	4	6	24	144	12	36	432	24	42	1008	6336	44.00	16-#8 bars	12.64	0.80%
											Total =	69.33			



Column Weight per Pier

Pier	Dwg No.	Pier Cap Top ELE ft	Col Height ft	Col Volume ft^3	Weight kip
1	5237	59.76	21.76	1508.69	226.30
2	5240	58.65	20.65	1431.73	214.76
3	5240	57.38	19.38	1343.68	201.55
4	5240	55.61	17.61	1220.96	183.14
5	5241	54.09	16.09	1115.57	167.34
6	5241	52.82	14.82	1027.52	154.13
7	5241	51.05	13.05	904.80	135.72
8	5242	49.54	11.54	800.11	120.02
9	5242	48.27	10.27	712.05	106.81
10	5242	46.49	8.49	588.64	88.30
11	5242	44.98	6.98	483.95	72.59

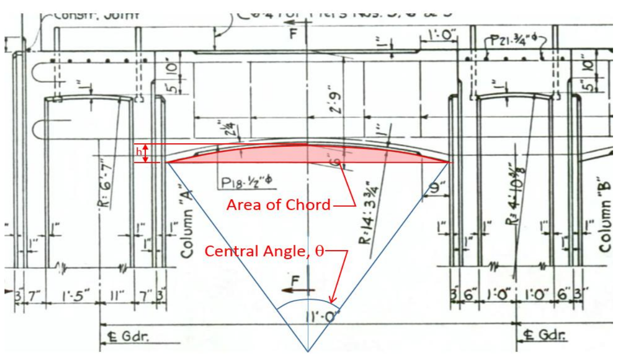
Footing Weight per Pier

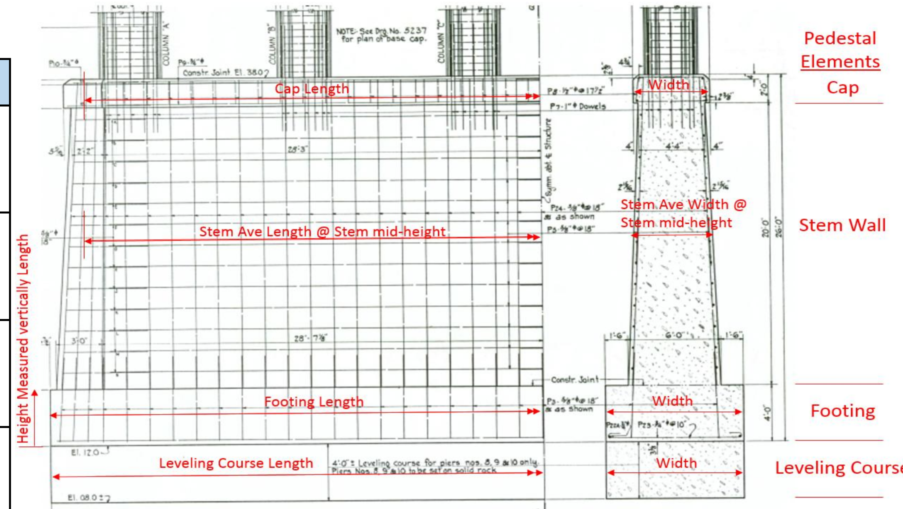
Pier	Element	Dwg No.	Length ft	Width ft	Height ft	Bearing Area, ft^2	Volume ft^3	Weight kip
	Cap		59.14	5	2		591.41	
	Stem		59.13	4.83	12		3429.25	
1	Footing	5237	63	8	4.33	504	2182.32	930.45
	Leveling Course		0	0	0		0.00	
	Cap		59.14	5	2		591.41	
	Stem		59.43	5.17	20		6140.80	
2-7	Footing	5238	64	9	4	576	2304.00	1355.43
	Leveling Course		0	0	0		0.00	
	Cap		59.14	5.00	2		591.41	
	Stem		59.43	5.17	20		6140.80	
8-10	Footing	5238	64	9	4	576	2304.00	1701.03
	Leveling Course		64	9	4		2304.00	
	Cap		59.14	5.00	2		591.41	
	Stem		59.13	4.83	12		3429.25	
11	Footing	5237	63	8	4	504	2016.00	905.50
	Leveling Course		0	0	0		0.00	

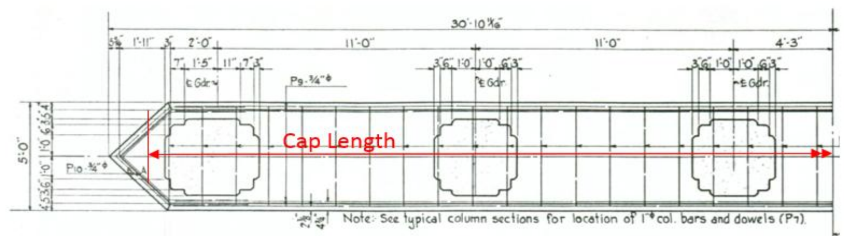
Pier Cap Diaphragm Weight per Pier

	# per Pier	Central Angle, θ (deg)	Area of Chord ft^2	Length ft	Height ft	A = L*H - A_{chord}, ft^2	Width ft	Col Volume ft^3	Weight per Pier kip
Diaphragm	4	30.03	2.42	7.50	3.25	21.95	1.375	30.18	18.11
Girder Stop	2	---	---	0.50	1.71	0.85	3.00	2.56	0.77
								Total Wt =	18.88

Arc Equations: $\theta = 2\arccos\left(1-\frac{h}{R}\right)$ $\quad A=\frac{R^2}{2}\left(\frac{\alpha\pi}{180^\circ}-\sin\alpha\right)$







HALF PLAN OF BASE CAP FOR ALL PIERS

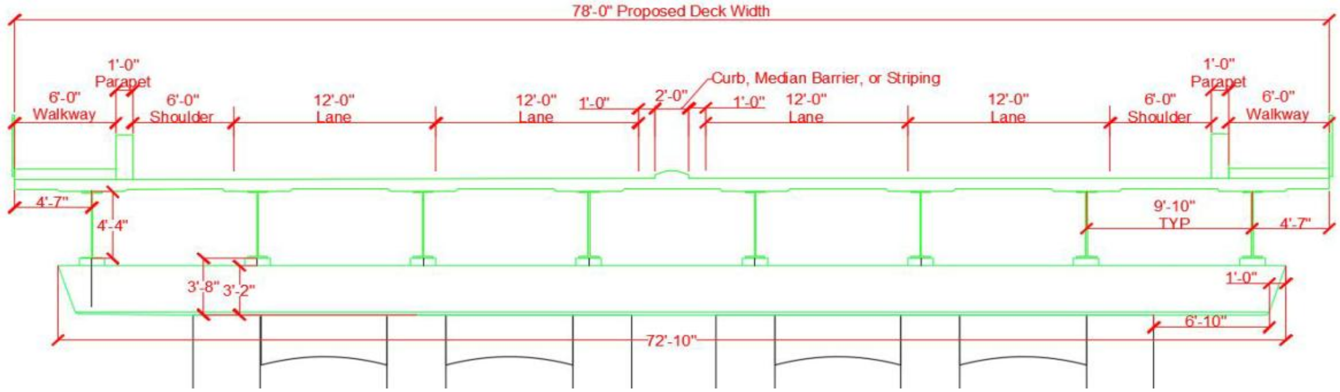
*NOTE on Lengths of Cap and Stem: Ends of these elements are wedge/triangular shaped. The lengths of the elements for area calculation purposes was taken from the mid-point of the wedge on one end of the element to the mid-point of the wedge on the other end.

Summary of Bearing DL on Footing

Pier	Weight (kip) Column	Footing	Diaph + G. Stop	Superstructure (DL + LL)	Total	Bearing Stress psf	Bearing C/D
1	226.3	930.45	18.88	1912.29	3087.92	6126.82	1.63
2	214.8	1355.43	18.88	1912.29	3501.36	6078.74	1.65
3	201.6	1355.43	18.88	1655.05	3230.91	5609.22	1.78
4	183.1	1355.43	18.88	1912.29	3469.74	6023.86	1.66
5	167.3	1355.43	18.88	1912.29	3453.93	5996.41	1.67
6	154.1	1355.43	18.88	1655.05	3183.49	5526.89	1.81
7	135.7	1355.43	18.88	1912.29	3422.32	5941.52	1.68
8	120.0	1701.03	18.88	1912.29	3752.21	6514.26	1.54
9	106.8	1701.03	18.88	1655.05	3481.77	6044.74	1.65
10	88.3	1701.03	18.88	1912.29	3720.49	6459.19	1.55
11	72.6	905.50	18.88	1912.29	2909.26	5772.33	1.73

wsp	Computation Sheet	page		of	
Project	ITD US-12 Memorial Bridge Feasibility Study	made by	JWC	Date	10/11/17
Subject	Pier Footing Bearing Capacity Check	checked by		Date	

Bearing Capacity Check for Deck Widening Condition with Superstructure Replacement



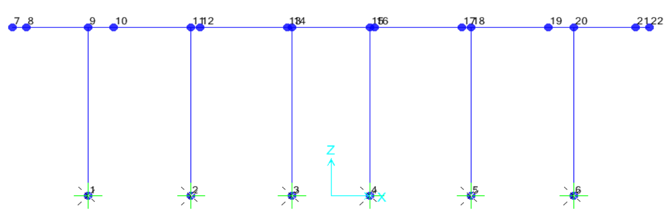
Cap Beam Retrofit

Height	*3.17*	*ft*
Length	*71.83*	*ft*
Width	*5.00*	*ft*
Vol	*1137.36*	*ft^3*
Wt	*170.60*	*kip*

Deck Widening Configuration - 78'-0" Wide Deck: Summary of Bearing DL + LL on Footing

Pier	Column	Footing	Reactions from Trans and Long Forces	Diaph + G. Stop	DL + LL (from Pier Reactions)	Weight Total with Cap	Bearing Stress psf	Bearing C/D
	Weight (kip)							
1	226.3	930.45	154.15	18.88	3274.34	4774.73	9473.67	1.06
2	214.8	1355.43	154.15	18.88	3274.34	5188.17	9007.24	1.11
3	201.6	1355.43	154.15	18.88	2879.52	4780.14	8298.85	1.20
4	183.1	1355.43	154.15	18.88	3274.34	5156.56	8952.35	1.12
5	167.3	1355.43	154.15	18.88	3274.34	5140.75	8924.91	1.12
6	154.1	1355.43	154.15	18.88	2879.52	4732.72	8216.52	1.22
7	135.7	1355.43	154.15	18.88	3274.34	5109.13	8870.02	1.13
8	120.0	1701.03	154.15	18.88	3274.34	5439.03	9442.76	1.06
9	106.8	1701.03	154.15	18.88	2879.52	5031.00	8734.37	1.14
10	88.3	1701.03	154.15	18.88	3274.34	5407.31	9387.69	1.07
11	72.6	905.50	154.15	18.88	3274.34	4596.07	9119.19	1.10

^--- From Csi Bridge Model Output below



Output from CSI Bridge Model

TABLE: Joint Reactions at Base of Columns (includes weight of columns and superstructure forces)

Joint	OutputCase	F1 Vert Kip	F2 Trans Kip	F3 Long Kip	M1 Torsion Kip-ft	M2 In Long Kip-ft	M3 In Trans Kip-ft
1	ServI(1)-1.0(DC+DW+LL+BR+WL)+0.3WS(tr)	896.558	-111.805	-4.072	2.3141	130.1113	-734.706
2		440.92	6.03	-2.535	1.0504	97.5675	24.9198
3		480.92	-13.366	-2.393	0.319	92.7111	-103.0914
4		483.835	2.239	-2.393	-0.319	92.711	-4.2627
5		433.155	-17.843	-2.535	-1.0504	97.5675	-136.7989
6		919.414	103.799	-4.072	-2.3142	130.1116	627.91

Total with weight of columns and all superstructure forces =	*3654.802*	*kip*
Column Wt. =	*226.3*	*kip*
Superstructure Vertical DL + LL =	*3274.34*	*kip*
Vertical Reaction Force from Transverse/Longitudinal Forces =	*154.154*	*kip, input for Bearing Capacity Checks above*

15. Analysis Step 10: Replacement Girder Design

Section 1: Negative Moment Region

Section 2: Positive Moment Region

INPUT DATA

Memorial Bridge (-)M @ Pier

MATERIALS

Steel modulus elasticity, E = 29000 ksi

Specified minimum steel	Yield Strength		Tensile Strength	
Top flange, Fytop =	50	ksi	Fu = 65	ksi
Bottom flange, Fybot =	50	ksi	Fu = 65	ksi
Web, Fyw =	50	ksi	Fu = 65	ksi
Stiffener, Fys =	50	ksi	Fu = 65	ksi
Reinforcing bar steel, fy =	60	ksi		
Deck concrete compressive strength, f'c =	4	ksi		
Classification strength of weld metal, Fexx =	50	ksi		
Short-term modulus of elasticity, Ec =	3834	ksi	(based on 150 pcf concrete unit weight)	
Long-term modulus of elasticity Ect = Ec/3 =	1278	ksi		

RESISTANCE FACTORS

Flexure, ϕ_f =	1.00
Shear, ϕ_V =	1.00
Tension fracture, ϕ_U =	0.80
Tension yielding, ϕ_Y =	0.95
Compression, ϕ_C =	0.90
Shear in thoat of weld metal, ϕ_{e2} =	0.8

Demand/Capacity Ratio		
NONCOMPOSITE =	0.41	OK
POSITIVE =	N/A	N.G.
NEGATIVE =	0.92	OK
SHEAR =	0.62	OK

GIRDER PLATES (in)

	Width, bf	Thick, tf
Top flange	16	2
Bottom flange	16	2
	Depth, D	Thick, tw
Web	50	0.5

Flange to web fillet weld size: 0.3125 in

CONCRETE DECK (in)

	Width, bs	Thick, ts
Effective slab	104	8
Reinforcing Bars	Ar (in^2)	Cr (in)
top	5.72	2.875
bottom	4.03	5.1875

TRANSVERSE STIFFENERS

Exist?	YES	
Spacing, do =	78	in
Number of stiffeners, Ns =	1	
Width, bt =	7	in
Thickness, tp =	0.625	in
Interior web panel(YES/NO) =	YES	

LONGITUDINAL STIFFENERS

Exist?	NO	
ds =	24	in
Width, bl =	8	in
Thickness, ts =	0.5	in
Unbraced Length, Lb =	300	in; diaphragms placed at 25' max

LOADS

Analysis Type
- Positive Moment
- Negative Moment (selected)

2

Factored noncompoosite construction Load

Axial, kip	Shear kip	Moment kip-in	Bottom Flange Moment
0	106	-29,535	0
		50,000	

Load Component	Nominal Forces				Service -II					Web Fatigue		Fatigue			
	Axial, (Assoc. with M) kip	Shear kip	Moment kip-in	Bottom Flange Moment	Load Factor	Axial, kip	Shear kip	Moment kip-in	Bottom Flange Moment	Load Factor	Shear	Load Factor	Axial, (Assoc. with M) kip	Shear kip	Moment kip-in
Noncomposite DL	0	-106	-23,628	0	1	0	-106	-23,628	0	1	-106				
Composite DL	0	-17	-3,763	0	1	0	-17	-3,763	0	1	-17				
HL-93 (Max)	0	119	22,365	0	1.3	0	155	29,074	0	0	0				
HL-93 (Min)	0	-119	-22,500	0	1.3	0	-155	-29,250	0	0	0				
TU+CR+SH+SE(M+)	0	0	0	0	1	0	0	0	0	0	0				
TU+CR+SH+SE(M-)	0	0	0	0	1	0	0	0	0	0	0				
Earthquake (EQ)	0	0	0	0	0	0	0	0	0	0	0				
Wind on Girders, WS	0	0	0	0	0	0	0	0	0	0	0				
Wind on cars, WL	0	0	0	0	0	0	0	0	0	0	0				
Fatigue Truck (Max)	0	0	0	0	0	0	0	0	0	1.5	0	0.75	0	0	0
Fatigue Truck (Min)	0	0	0	0	0	0	0	0	0	1.5	0	0.75	0	0	0
Total						0	277	-56,641	0		-122				

Active load combination:		Strength_I			
Load Component	Load Factor	Axial	Shear	Moment	Bottom Flange Moment
Noncomposite DL	1.25	0	-132	-29,535	0
Composite DL	1.354	0	-23	-5,095	0
HL-93 (Max)	1.75	0	209	39,138	0
HL-93 (Min)	1.75	0	-209	-39,375	0
TU+CR+SH+SE(M+)	1	0	0	0	0
TU+CR+SH+SE(M-)	1	0	0	0	0
Earthquake (EQ)	0	0	0	0	0
Wind on Girders, WS	0	0	0	0	0
Wind on cars, WL	0	0	0	0	0
Total:		0	364	-74,005	0

Load Component	Strength-I				
	Load Factor	Axial	Shear	Moment	Bottom Flange Moment
Noncomposite DL	1.25	0	-132	-29,535	0
Composite DL	1.354	0	-23	-5,095	0
HL-93 (Max)	1.75	0	209	39,138	0
HL-93 (Min)	1.75	0	-209	-39,375	0
TU+CR+SH+SE(M+)	1	0	0	0	0
TU+CR+SH+SE(M-)	1	0	0	0	0
Earthquake (EQ)	0	0	0	0	0
Wind on Girders, WS	0	0	0	0	0
Wind on cars, WL	0	0	0	0	0
Total:		**0**	**364**	**-74,005**	**0**

Load Component	Strength-III				
	Load Factor	Axial	Shear	Moment	Bottom Flange Moment
Noncomposite DL	1.25	0	-132	-29,535	0
Composite DL	1.354	0	-23	-5,095	0
HL-93 (Max)	0	0	0	0	0
HL-93 (Min)	0	0	0	0	0
TU+CR+SH+SE(M+)	1	0	0	0	0
TU+CR+SH+SE(M-)	1	0	0	0	0
Earthquake (EQ)	0	0	0	0	0
Wind on Girders, WS	1.4	0	0	0	0
Wind on cars, WL	0	0	0	0	0
Total:		**0**	**155**	**-34,630**	**0**

Load Component	Strength-V				
	Load Factor	Axial	Shear	Moment	Bottom Flange Moment
Noncomposite DL	1.25	0	-132	-29,535	0
Composite DL	1.354	0	-23	-5,095	0
HL-93 (Max)	1.35	0	161	30,192	0
HL-93 (Min)	1.35	0	-161	-30,375	0
TU+CR+SH+SE(M+)	1	0	0	0	0
TU+CR+SH+SE(M-)	1	0	0	0	0
Earthquake (EQ)	0	0	0	0	0
Wind on Girders, WS	0.4	0	0	0	0
Wind on cars, WL	1	0	0	0	0
Total:		**0**	**316**	**-65,005**	**0**

SECTION PROPERTIES

Modular ratio, n =E/Ec = 7.56 (Short-term)
Modular ratio, nt =E/Ect = 22.69 (Long-term)

Element	Horiz. dim	Vert. dim.	Area	Centroid from bot.
	b	d	A=bd	yb
Slab	104	8	832	58.000
Top Flange	16	2	32	53.000
Web	0.5	50	25	27.000
Bottom Flange	16	2	32	1.000
Slab reinforcing			9.75	58.169

PROPERTIES ABOUT CENTROID OF SECTION

	Property	Steel Section	Composite Section		
			short-term n=E/Ec	long-term nt=E/Ect	reinf. Only (neg. flex.)
Total height	Sum(d)	54.000	62.000	62.000	
Total area	A	89.00	207.46	134.99	98.75
Centroid from bottom	ybot	27.000	44.708	37.572	30.077
Centroid from top	ytop	27.000	9.292	16.428	23.923
Moment inertia	Ix	48,494	97,955	77,891	57,031
	Iy	1,366			
Section Modulus	Sb	1,796	2,191	2,073	1,896
	St	1,796	10,542	4,742	2,384
Dist bet CL flanges	h	52			
Dist. to reference line	e	0	17.708	10.572	3.077
Static Moment	B=Ae	0	3,674	1,427	304

PROPERTIES ABOUT REFERENCE POINT (STEEL CENTROID)

	Steel Section	Slab Reinf.	Slab Concrete	n = 7.56 Transf'd	n = 22.69 Transf'd	reinf. Only Transf'd
y (down +)	0	-31.169	-31.000			
A, in^2	89	9.75	832	207.5	135.0	98.75
B, in^3	0	-304	-25,792	-3,674	-1,427	-304
I, in^4	48,494	9,472	803,989	163,007	92,980	57,966
AI-B^2	4,315,936			20,321,526	10,514,193	5,631,783

Non-Composite Steel Section

MATERIALS

Compression flange, Fyc =	50	ksi
Tension Flange, Fyt =	50	ksi
Web, Fyw =	50	ksi

LOADS

Factored Moment, Mu =	-29,535	kip-in
Factored Axial Force, Pu =	0	kip
Lower moment at the end of unbraced length, Ml =	-29,535	kip-in
Higher moment at the end of unbraced length, Mh =	-29,535	kip-in

STEEL SECTION PROPERTIES

Compression flange plate (bottom) width, bf =	16	in	
thickness, tf =	2	in	
Tension flange plate (top) width, bt =	16	in	
thickness, tt =	2	in	
Web Plate height, D =	50	in	
thickness, tw =	0.5	in	
Section centroid from compression face , yc =	27.00	in	
Section centroid from tension face, yt =	27.00	in	
St. Venant torsional Inertia, J =	80.7	in^4	(A6.3.3-9)
Moment Inertia of compr. flange about vert. axis, Iyc =	682.7	in^4	
Moment Inertia of tension flange about vert. axis, Iyt =	682.7	in^4	
Effective radius of gyration for LTB, rt =	4.45	in	(C6.10.8.2.3-1)
Depth of web in compression in the elastic range Dc =	25.00	in	
Depth of web in compression at plastic moment Dcp =	25.00	in	
Unbraced length of compression flange Lb =	300	in	
Section modulus about compression flange Sxc =	1796	in^3	
Section modulus about tension flange Sxt =	1796	in^3	

SUMMARY OF NONCOMPOSITE SECTION ANALYSIS. (Satisfied)

	General section proportions are satisfied =		TRUE	D/C	
Compression flange	fbu+fl <= ϕ_fRhFyc	16.4 ≤ 50.00	TRUE	0.33	(6.10.3.2.1-1)
	fbu+fl/3 <= ϕ_fFnc	16.4 ≤ 40.19	TRUE	0.41	(6.10.3.2.1-2)
	fbu <= ϕ_fFcrw	16.4 ≤ 50.00	TRUE	0.33	(6.10.3.2.1-3)
Tension flange	fbu+fl <= ϕ_fRhFyt	16.4 ≤ 50.00	TRUE	0.33	(6.10.3.2.2-1)
Shear	Vu <= ϕ_vVcr	105.5 ≤ 465.14	TRUE	0.23	(6.10.3.3-1)
			Final statement =	**0.409**	**OK**

Flexural resistance, Mr = ϕ_f*Mn = 72,187 kip-in

CROSS-SECTION PROPORTION LIMITS (6.10.2) (Satisfied)

6.10.2.1 Web Proportions D/tw <= 150 100.0 <= 150 TRUE (6.10.2.1.1-1) and (6.10.2.1.2-1)

6.10.2.2 Flange Proportions

Parameter	Compress. Flange	Tension Flange	Limit			
bf/2tf =	4.0	4.0	≤ 12	12.0	TRUE	(6.10.2.2-1)
bf =	16.0	16.0	≥ D/6 =	8.3	TRUE	(6.10.2.2-2)
tf =	2	2	≥ 1.1tw =	0.550	TRUE	(6.10.2.2-3)
Iyc/Iyt = 1.00			0.1 ≤ Iyc/Iyt ≤ 10		TRUE	(6.10.2.2-4)

Conclusion: Section general proportions meet requirements = **TRUE**

FLEXURE 6.10.8

COMPRESSION-FLANGE FLEXURAL RESISTANCE 6.10.8.2

Fnc = RbRhFyc =	50.00	ksi	(6.10.8.2.2-1)
Fyr = Max(0.5Fyc,Min(0.7Fyc,Fyw) =	35	ksi	(6.10.8.2.2 Page 6-147)

6.10.8.2.2 Local Buckling Resistance (FLB)

Flange slenderness, λf =bfc/2tfc =	4.0		(6.10.8.2.2-3)
Compact,limit λpf =0.38√(E/Fyc) =	9.2		(6.10.8.2.2-4)
Noncompact limit λrf =0.56√(E/Fyr) =	16.1		(6.10.8.2.2-5)
Reduction factor to Fnc due to FLB =	1.000		(6.10.8.2.2-1,2)
Fnc(FLB) =	50.00	ksi	

6.10.8.2.3 Lateral Torsional Resistance (LTB)

Effective radius of gyration for LTB, rt =	4.45	in	(C6.10.8.2.3-1)
Unbraced length, Lb =	300	in	
Compact limit Lp =rt*√(E/Fyc) =	107.1	in	(6.10.8.2.3-4)
Noncompact limit Lr =π*Lp =	402.1	in	(6.10.8.2.3-5)
Cb =	1		
Elastic LTB stress, Fcr =	62.88	ksi	(6.10.8.2.3-8)
Reduction factor to Fnc due to LTB =	0.804		(6.10.8.2.3-2,3)
Fnc(LTB) =	40.19	ksi	

Flexural resistance Fnc = Min(FLB, LTB) = 40.19 ksi

TENSION-FLANGE FLEXURAL RESISTANCE 6.10.8.3

Fnt = Rh*Fyt = 50.00 ksi (6.10.8.3-1)

STRESSES UNDER FACTORED LOADS

P	M	A	I	B	fo	γ	fbu(top)	fbu(bot)
0	-29,535	89.0	48,494	0	0.000	-0.6090	16.444	-16.444

fc/Fnc =	0.409		
ft/Fnt =	0.329		
f/F =	**0.409**		
Mn =	72,187	kip-in	
Flexural capacity according to Appendix A Mn =	11,983	kip-in	Applicable

LATERAL BENDING IN BOTTOM FLANGE

Ml =	0	kip-in
Compression Flange fl =	0.000	ksi
Tension Flange fl =	0.000	ksi

WEB BEND-BUCKLING RESISTANCE 6.10.1.9

Fcrw = min[0.9Ek/(D/tw)^2, RhFyc, Fyw/0.7] = **50.0** ksi (6.10.1.9.1-1)

Bend-Buckling Coefficient, k

For webs without long. Stiffeners, k = 9/(Dc/D)^2 = 36.0 (Applicable) (6.10.1.9.1-2)

For webs with longitudinal stiffeners

k=if(ds/Dc≥0.4,max(5.17/(ds/D)²,9/(Dc/D)²),11.64/((Dc-ds)/D)²) = N/ A (6.10.1.9.2-1,2)

k = 36.0

HYBRID FACTOR, Rh 6.10.1.10.1

	Compress.	Tension	Total
y = y(c.g)-tf =	25.00	25.00	50
f =My*y/Inc =	-46.30	-46.30	
hw = y*(1-Fyw/f)=	0.00	0.00	
a = y-hw/3 =	0.00	0.00	
P = (f-Fyw)tw*hw/2 =	0.00	0	0.00
aP =	0	0	0
Myr = My-aP=	-89,803		

Rh = Myr/My = 1.000 (6.10.4.3.1c-2)

WEB LOAD-SHEDDING FACTOR, Rb 6.10.1.10.2

$\lambda rw = 5.7\sqrt{(E/Fyc)}$ =	137.3		(6.10.1.10.2-4)
awc=2Dc*tw/(bf*tf) =	0.78	in	(6.10.1.10.2-5)
2Dc/tw =	100.0		
λrw =	137.3		
2Dc/tw ≤ λrw , Rb =	1.000		(Rb = 1)

MOMENT GRADIENT CORRECTION FACTOR Cb A6.3.3.3

Assume girder properties are identical at the both brace points, then Pl/Ph = Ml/Mh = 1

Cb = 1.75-1.05(Pl/Ph)+0.3(Pl/Ph)^2 = 1.00 (6.10.8.2.3-7)

Cb <= 1.75 if Ml and Mh are from moment envelope
Cb <= 2.30 if Ml is concurrent with Mh
Cb = 1.0 for unbraced cantilever
Cb = 1.0 if moment between brace points larger than Mh

Overwrite Cb = 1.00

Final Cb = 1.00

Composite Section in Negative Moment

(Applicable)

LOADS

Factored Moment, Mu =	-74,005	kip-in	
Lower moment at the end of unbraced length, Ml =	-74,005	kip-in	
Higher moment at the end of unbraced length, Mh =	-74,005	kip-in	

STEEL SECTION PROPERTIES

Centroid of slab reinf. Bars from composite centroid, yr =	29.048	in	
Effective radius of gyration for LTB, rt =	4.43	in	(C6.10.8.2.3-1)
Depth of web in compression in the elastic range Dc =	26.99	in	
Depth of web in compression at plastic moment Dcp =	36.70	in	
Unbraced length of compression flange Lb =	300	in	
Section modulus about compression flange Sxc =	1,896	in^3	
Section modulus about tension flange Sxt =	2,384	in^3	

SUMMARY OF COMPOSITE SECTION ANALYSIS. (Satisfied)

Flexural resistance, Mr = ϕ_fMn =		80,788	kip-in	(Calculated by Appendix A6 procedures)
Demand/capacity ratio Mu/Mr =		0.916	OK	
Service limit state stress ratio =		0.644	OK	
Factored stresses in flanges f(top)=	35.10	0.702	OK	
f(bot)+fl/3=	-39.90	0.994	OK	
Final statement =		**0.916**	**OK**	

FLEXURE 6.10.8

COMPRESSION-FLANGE FLEXURAL RESISTANCE 6.10.8.2

Fnc = RbRhFyc =	50.00	ksi	(6.10.8.2.2-1)
Fyr = Max(0.5Fyc,Min(0.7Fyc,Fyw) =	35	ksi	(6.10.8.2.2 Page 6-144)

6.10.8.2.2 Local Buckling Resistance (FLB)

Flange slenderness, λf =bf/2tf =	4.0		(6.10.8.2.2-3)
Compact limit, λpf =0.38√(E/Fyc) =	9.2		(6.10.8.2.2-4)
Non-compact limit, λrf =0.56√(E/Fyr) =	16.1		(6.10.8.2.2-5)
Resistance reduction due to FLB =	1.000		(6.10.8.2.2-1,2)
Fnc(FLB) =	50.00	ksi	

6.10.8.2.3 Lateral Torsional Resistance (LTB)

Effective radius of gyration for LTB, rt =	4.43	in	(C6.10.8.2.3-1)
Unbraced length, Lb =	300	in	
Compact limit Lp =rt*√(E/Fyc) =	106.6	in	(6.10.8.2.3-4)
Noncompact limit Lr =π*Lp =	400.4	in	(6.10.8.2.3-5)
Cb =	1.00		
Elastic LTB stress, Fcr =	62.35	ksi	(6.10.8.2.3-8)
Resistance reduction due to LTB =	0.803		(6.10.8.2.3-2,3)
Fnc(LTB) =	40.13	ksi	

Compression flange flexural resistance:

Fnc = Min(FLB, LTB) = 40.13 ksi

TENSION-FLANGE FLEXURAL RESISTANCE 6.10.8.3

Fnt = Rh*Fyt = 50.00 ksi (6.10.8.3-1)

STRESSES UNDER FACTORED LOADS

Loads	P	M	A	I	B	fo	γ	ft(top)	fc(bot)
D1	0	-29,535	89.0	48,494	0	0.000	-0.609	16.444	-16.444
D2	0	-5,095	98.8	57,966	-304	-0.275	-0.089	2.137	-2.687
L	0	-39,375	98.8	57,966	-304	-2.125	-0.690	16.517	-20.766
Total:	0	-74,005				-2.400	-1.39	35.098	-39.898

fc/Fnc = 0.994
ft/Fnt = 0.702
f/F = 0.994 Bottom flange controls
Flexural capacity based on flange stress, Mn = 74,440 kip-in
Flexural capacity according to Appendix A Mn = 80,788 kip-in **Applicable**
Final Flexural Capacity Mn = **80,788** kip-in

LATERAL BENDING IN BOTTOM FLANGE

Ml = 0 kip-in
fl = 6Ml/(tbot*bbot^2) = 0.000 ksi

SERVICE LIMIT STATE OF PERMANENT DEFLECTION 6.10.4.2 **(Satisfied)**

Stress in flanges

Load	P	M	A	I	B	fo	γ	ft(top)	fc(bot)
D1	0	-23,628	89.0	48,494	0	0.000	-0.4872	13.155	-13.155
D2	0	-3,763	98.8	57,966	-304	-0.203	-0.0660	1.579	-1.985
L	0	-29,250	98.8	57,966	-304	-1.578	-0.5129	12.269	-15.426
Total:	0	-56,641				-1.781	-1.07	27.003	-30.566

fl = 0.00 ksi

Bottom:	fc <= Fcrw	30.6 <= 50.0	TRUE	(6.10.4.2.2-4)
bottom:	fc +fl/2 <= 0.95RhFyf	30.6 <= 47.5	TRUE	(6.10.4.2.2-2)
top:	ft <= 0.95RhFyf	27.0 <= 47.5	TRUE	(6.10.4.2.2-1)

Conclusion: section meets service limit state requierements = **TRUE**
Stress Ratio = 0.644

Check if maximum concrete tensile stress exceeds 2fr= 0.48√f'c (using uncracked section properties)

Load	P	M	A	I	B	fo	γ	fc(top)
D2	0	-3,763	135.0	92,980	-1,427	-0.511	-0.0483	1.180
L	0	-29,250	207.5	163,007	-3,674	-5.288	-0.2986	5.164
							Total:	6.344

Stress in concrete fc ≤ (2fr= 0.48√f'c) 6.3 ≤ 0.960 FALSE
Use steel+slab reinforcing member properties

WEB BEND-BUCKLING RESISTANCE 6.10.1.9

Fcrw = min[0.9Ek/(D/tw)², RhFyc, Fyw/0.7] = **50.0** ksi (6.10.1.9.1-1)
Bend-Buckling Coefficient, k
For webs without long. Stiffeners, k = 9/(Dc/D)² = 30.9 (Applicable) (6.10.1.9.1-2)
For webs with longitudinal stiffeners
k=IF(ds/Dc≥0.4,MAX(5.17/(ds/D)²,9/(Dc/D)²),11.64/((Dc-ds)/D)²) N/ A (6.10.1.9.2-1,2)
k = 30.9

HYBRID FACTOR, Rh 6.10.1.10.1

	Compress.	Tension	Total
y = y(c.g)-tf =	26.99	23.01	50
f =My*y/Inc =	-49.98	-42.61	
hw = y*(1-Fyw/f)=	0.00	0.00	
a = y-hw/3 =	0.00	0.00	
P = (f-Fyw)tw*hw/2 =	0.00	0	0.00
aP =	0	0	0
Myr = My-aP=	-89,803		

Rh = Myr/My = **1.000** (6.10.4.3.1c-2)

WEB LOAD-SHEDDING FACTOR, Rb 6.10.1.10.2

λrw = 5.7√(E/Fyc) = 137.3 (6.10.1.10.2-4)
awc=2Dc*tw/(bf*tf) = 0.84 in (6.10.1.10.2-5)
Rb = 1.000 (6.10.1.10.2.-3)

MOMENT GRADIENT CORRECTION FACTOR Cb 6.10.4.2.5A

Assume girder properties are identical at the both brace points, then Pl/Ph = Ml/Mh = 1.000
Cb = 1.75-1.05(Pl/Ph)+0.3(Pl/Ph)^2 = 1.00 (6.10.4.2.5a-4)
Cb <= 1.75 if Ml and Mh are from moment envelope
Cb <= 2.30 if Ml is concurrent with Mh
Cb = 1.0 for unbraced cantilever
Cb = 1.0 if moment between brace points larger than Mh
Overwrite Cb = 1.00
Final Cb = 1.00

SHEAR RESISTANCE 6.10.9

Maximum Transverse stiffeners spacing **(Satisfied)**

Maximum Stress Ratio =	0.619		OK
Transverse stiffeners spacing, do =	78	in	
For web interior panel 3.0D =	150.0 >=	78	TRUE
For web end panel 1.5D =	75.0 >=	78	N/A
For webs with longitudinal stiffenrs 1.5D =	75.0 >=	78	N/A
Conclusiont: Transv. stiffeners spacing satisfies code requirements =			**TRUE**
Girder web is considered STIFFENED =			TRUE

Calculations of C (ratio of the shear buckling stress to the shear yield strength)

Shear buckling coefficient, k = 5+5/(do/D)² =	7.05		(6.10.9.3.2-7)
D/tw =	100.0		Use formula (6.10.9.3.2-6) for C
1.12√(Ek/Fyw) =	71.6		
1.40*√(Ek/Fyw) =	89.6		
C =	0.642		(6.10.9.3.2-6)

Plastic Shear Force	Vp = 0.58FywD*tw =	725	kip	(6.10.9.2-2) and (6.10.9.3.2-3)
Shear capacity of unstiffened webs	N/A Vn = CVp =	465	kip	(6.10.9.2-1)
Shear capacity of interior web panels	**(Applicable)**	6.10.9.3.2		
	2Dtw/(bfc*tfc+bft*tft) =	0.8 ≤ 2.5		TRUE
	Vn = Vp[C+0.87(1-C)/(√(1+(do/D)²))] =	587	kip	(6.10.9.3.2-2)
Shear capacity of end web panels	(Not Applicable)	6.10.9.3.3		
	Vn = Vcr = CVp =	465	kip	(6.10.9.3.3-1)
Final Shear Resistance	**Vn =**	**587**	kip	
	Vu =	364	kip	
	Stress Ratio $Vu/\phi_v Vn$ =	**0.619**		

INPUT DATA

Memorial Bridge (+)M @ Midspan

MATERIALS

Steel modulus elasticity, E = 29000 ksi

Specified minimum steel	Yield Strength		Tensile Strength	
Top flange, Fytop =	50	ksi	Fu = 65	ksi
Bottom flange, Fybot =	50	ksi	Fu = 65	ksi
Web, Fyw =	50	ksi	Fu = 65	ksi
Stiffener, Fys =	50	ksi	Fu = 65	ksi
Reinforcing bar steel, fy =	60	ksi		
Deck concrete compressive strength, f'c =	4	ksi		
Classification strength of weld metal, Fexx =	50	ksi		
Short-term modulus of elasticity, Ec =	3834	ksi	(based on 150 pcf concrete unit weight)	
Long-term modulus of elasticity Ect = Ec/3 =	1278	ksi		

RESISTANCE FACTORS

Flexure, ϕ_f =	1.00
Shear, ϕ_V =	1.00
Tension fracture, ϕ_U =	0.80
Tension yielding, ϕ_Y =	0.95
Compression, ϕ_C =	0.90
Shear in thoat of weld metal, ϕ_{e2} =	0.8

Demand/Capacity Ratio		
NONCOMPOSITE =	0.60	OK
POSITIVE =	0.91	OK
NEGATIVE =	N/A	N/A
SHEAR =	0.62	OK

GIRDER PLATES (in)

	Width, bf	Thick, tf
Top flange	16	1
Bottom flange	16	1
	Depth, D	Thick, tw
Web	50	0.5
Flange to web fillet weld size:		0.3125 in

CONCRETE DECK (in)

	Width, bs	Thick, ts
Effective slab	104	8
Reinforcing Bars	Ar (in^2)	Cr (in)
top	5.72	2.875
bottom	4.03	5.1875

TRANSVERSE STIFFENERS

Exist?	YES	
Spacing, do =	78	in
Number of stiffeners, Ns =	1	
Width, bt =	7	in
Thickness, tp =	0.625	in
Interior web panel(YES/NO) =	YES	

LONGITUDINAL STIFFENERS

Exist?	NO	
ds =	24	in
Width, bl =	8	in
Thickness, ts =	0.5	in

Unbraced Length, Lb = 300 in; diaphragms placed at 25' max

LOADS

Analysis Type
- (●) Positive Moment
- ( ) Negative Moment

1

Factored noncompoosite construction Load

Axial, kip	Shear kip	Moment kip-in	Bottom Flange Moment
0	106	23,580	0
		50,000	

Load Component	Nominal Forces				Service -II					Web Fatigue		Fatigue			
	Axial, (Assoc. with M) kip	Shear kip	Moment kip-in	Bottom Flange Moment	Load Factor	Axial, kip	Shear kip	Moment kip-in	Bottom Flange Moment	Load Factor	Shear	Load Factor	Axial, (Assoc. with M) kip	Shear kip	Moment kip-in
Noncomposite DL	0	-106	18,864	0	1	0	-106	18,864	0	1	-106				
Composite DL	0	-17	3,005	0	1	0	-17	3,005	0	1	-17				
HL-93 (Max)	0	119	22,365	0	1.3	0	155	29,074	0	0	0				
HL-93 (Min)	0	-119	-22,500	0	1.3	0	-155	-29,250	0	0	0				
TU+CR+SH+SE(M+)	0	0	0	0	1	0	0	0	0	0	0				
TU+CR+SH+SE(M-)	0	0	0	0	1	0	0	0	0	0	0				
Earthquake (EQ)	0	0	0	0	0	0	0	0	0	0	0				
Wind on Girders, WS	0	0	0	0	0	0	0	0	0	0	0				
Wind on cars, WL	0	0	0	0	0	0	0	0	0	0	0				
Fatigue Truck (Max)	0	0	0	0	0	0	0	0	0	1.5	0	0.75	0	0	0
Fatigue Truck (Min)	0	0	0	0	0	0	0	0	0	1.5	0	0.75	0	0	0
Total						0	277	50,943	0		-122				

Active load combination:			Strength_I		
Load Component	Load Factor	Axial	Shear	Moment	Bottom Flange Moment
Noncomposite DL	1.25	0	-132	23,580	0
Composite DL	1.354	0	-23	4,069	0
HL-93 (Max)	1.75	0	209	39,138	0
HL-93 (Min)	1.75	0	-209	-39,375	0
TU+CR+SH+SE(M+)	1	0	0	0	0
TU+CR+SH+SE(M-)	1	0	0	0	0
Earthquake (EQ)	0	0	0	0	0
Wind on Girders, WS	0	0	0	0	0
Wind on cars, WL	0	0	0	0	0
Total:		0	364	66,787	0

Load Component	Strength-I				
	Load Factor	Axial	Shear	Moment	Bottom Flange Moment
Noncomposite DL	1.25	0	-132	23,580	0
Composite DL	1.354	0	-23	4,069	0
HL-93 (Max)	1.75	0	209	39,138	0
HL-93 (Min)	1.75	0	-209	-39,375	0
TU+CR+SH+SE(M+)	1	0	0	0	0
TU+CR+SH+SE(M-)	1	0	0	0	0
Earthquake (EQ)	0	0	0	0	0
Wind on Girders, WS	0	0	0	0	0
Wind on cars, WL	0	0	0	0	0
Total:		**0**	**364**	**66,787**	**0**

Load Component	Strength-III				
	Load Factor	Axial	Shear	Moment	Bottom Flange Moment
Noncomposite DL	1.25	0	-132	23,580	0
Composite DL	1.354	0	-23	4,069	0
HL-93 (Max)	0	0	0	0	0
HL-93 (Min)	0	0	0	0	0
TU+CR+SH+SE(M+)	1	0	0	0	0
TU+CR+SH+SE(M-)	1	0	0	0	0
Earthquake (EQ)	0	0	0	0	0
Wind on Girders, WS	1.4	0	0	0	0
Wind on cars, WL	0	0	0	0	0
Total:		**0**	**155**	**27,649**	**0**

Load Component	Strength-V				
	Load Factor	Axial	Shear	Moment	Bottom Flange Moment
Noncomposite DL	1.25	0	-132	23,580	0
Composite DL	1.354	0	-23	4,069	0
HL-93 (Max)	1.35	0	161	30,192	0
HL-93 (Min)	1.35	0	-161	-30,375	0
TU+CR+SH+SE(M+)	1	0	0	0	0
TU+CR+SH+SE(M-)	1	0	0	0	0
Earthquake (EQ)	0	0	0	0	0
Wind on Girders, WS	0.4	0	0	0	0
Wind on cars, WL	1	0	0	0	0
Total:		**0**	**316**	**57,842**	**0**

SECTION PROPERTIES

Modular ratio, n =E/Ec = 7.56 (Short-term)
Modular ratio, nt =E/Ect = 22.69 (Long-term)

Element	Horiz. dim	Vert. dim.	Area	Centroid from bot.
	b	d	A=bd	yb
Slab	104	8	832	56.000
Top Flange	16	1	16	51.500
Web	0.5	50	25	26.000
Bottom Flange	16	1	16	0.500
Slab reinforcing			9.75	56.169

PROPERTIES ABOUT CENTROID OF SECTION

	Property	Steel Section	Composite Section		
			short-term n=E/Ec	long-term nt=E/Ect	reinf. Only (neg. flex.)
Total height	Sum(d)	52.000	60.000	60.000	
Total area	A	57.00	175.46	102.99	66.75
Centroid from bottom	ybot	26.000	46.262	39.411	30.407
Centroid from top	ytop	26.000	5.738	12.589	21.593
Moment inertia	Ix	26,019	61,268	49,174	33,597
	Iy	683			
Section Modulus	Sb	1,001	1,324	1,248	1,105
	St	1,001	10,678	3,906	1,556
Dist bet CL flanges	h	51			
Dist. to reference line	e	0	20.262	13.411	4.407
Static Moment	B=Ae	0	3,555	1,381	294

PROPERTIES ABOUT REFERENCE POINT (STEEL CENTROID)

	Steel Section	Slab Reinf.	Slab Concrete	n = 7.56 Transf'd	n = 22.69 Transf'd	reinf. Only Transf'd
y (down +)	0	-30.169	-30.000			
A, in^2	57	9.75	832	175.5	103.0	66.75
B, in^3	0	-294	-24,960	-3,555	-1,381	-294
I, in^4	26,019	8,874	753,237	133,303	67,697	34,893
AI-B^2	1,483,083			10,749,936	5,064,208	2,242,600

Non-Composite Steel Section

MATERIALS

Compression flange, Fyc =	50	ksi
Tension Flange, Fyt =	50	ksi
Web, Fyw =	50	ksi

LOADS

Factored Moment, Mu =	23,580	kip-in
Factored Axial Force, Pu =	0	kip
Lower moment at the end of unbraced length, Ml =	23,580	kip-in
Higher moment at the end of unbraced length, Mh =	23,580	kip-in

STEEL SECTION PROPERTIES

Compression flange plate (top) width, bf =	16	in	
thickness, tf =	1	in	
Tension flange plate (bottom) width, bt =	16	in	
thickness, tt =	1	in	
Web Plate height, D =	50	in	
thickness, tw =	0.5	in	
Section centroid from compression face , yc =	26.00	in	
Section centroid from tension face, yt =	26.00	in	
St. Venant torsional Inertia, J =	12.3	in^4	(A6.3.3-9)
Moment Inertia of compr. flange about vert. axis, Iyc =	341.3	in^4	
Moment Inertia of tension flange about vert. axis, Iyt =	341.3	in^4	
Effective radius of gyration for LTB, rt =	4.17	in	(C6.10.8.2.3-1)
Depth of web in compression in the elastic range Dc =	25.00	in	
Depth of web in compression at plastic moment Dcp =	25.00	in	
Unbraced length of compression flange Lb =	300	in	
Section modulus about compression flange Sxc =	1001	in^3	
Section modulus about tension flange Sxt =	1001	in^3	

SUMMARY OF NONCOMPOSITE SECTION ANALYSIS. **(Satisfied)**

	General section proportions are satisfied =		TRUE	D/C	
Compression flange	fbu+fl <= ϕ_fRhFyc	23.6 ≤ 50.00	TRUE	0.47	(6.10.3.2.1-1)
	fbu+fl/3 <= ϕ_fFnc	23.6 ≤ 39.18	TRUE	0.60	(6.10.3.2.1-2)
	fbu <= ϕ_fFcrw	23.6 ≤ 50.00	TRUE	0.47	(6.10.3.2.1-3)
Tension flange	fbu+fl <= ϕ_fRhFyt	23.6 ≤ 50.00	TRUE	0.47	(6.10.3.2.2-1)
Shear	Vu <= ϕ_vVcr	105.5 ≤ 465.14	TRUE	0.23	(6.10.3.3-1)
			Final statement =	**0.601**	**OK**

Flexural resistance, Mr = ϕ_f*Mn = 40,791 kip-in

CROSS-SECTION PROPORTION LIMITS (6.10.2) **(Satisfied)**

6.10.2.1 Web Proportions D/tw <= 150 100.0 <= 150 TRUE (6.10.2.1.1-1) and (6.10.2.1.2-1)

6.10.2.2 Flange Proportions

Parameter	Compress. Flange	Tension Flange	Limit			
bf/2tf =	8.0	8.0	≤ 12	12.0	TRUE	(6.10.2.2-1)
bf =	16.0	16.0	≥ D/6 =	8.3	TRUE	(6.10.2.2-2)
tf =	1	1	≥ 1.1tw =	0.550	TRUE	(6.10.2.2-3)

Iyc/Iyt = 1.00 0.1 ≤ Iyc/Iyt ≤ 10 TRUE (6.10.2.2-4)

Conclusion: Section general proportions meet requirements = **TRUE**

FLEXURE 6.10.8

COMPRESSION-FLANGE FLEXURAL RESISTANCE 6.10.8.2

Fnc = RbRhFyc =	50.00	ksi	(6.10.8.2.2-1)
Fyr = Max(0.5Fyc,Min(0.7Fyc,Fyw) =	35	ksi	(6.10.8.2.2 Page 6-147)

6.10.8.2.2 Local Buckling Resistance (FLB)

Flange slenderness, λf =bfc/2tfc =	8.0		(6.10.8.2.2-3)
Compact,limit λpf =0.38√(E/Fyc) =	9.2		(6.10.8.2.2-4)
Noncompact limit λrf =0.56√(E/Fyr) =	16.1		(6.10.8.2.2-5)
Reduction factor to Fnc due to FLB =	1.000		(6.10.8.2.2-1,2)
Fnc(FLB) =	50.00	ksi	

6.10.8.2.3 Lateral Torsional Resistance (LTB)

Effective radius of gyration for LTB, rt =	4.17	in	(C6.10.8.2.3-1)
Unbraced length, Lb =	300	in	
Compact limit Lp =rt*√(E/Fyc) =	100.5	in	(6.10.8.2.3-4)
Noncompact limit Lr =π*Lp =	377.2	in	(6.10.8.2.3-5)
Cb =	1		
Elastic LTB stress, Fcr =	55.33	ksi	(6.10.8.2.3-8)
Reduction factor to Fnc due to LTB =	0.784		(6.10.8.2.3-2,3)
Fnc(LTB) =	39.18	ksi	
Flexural resistance Fnc = Min(FLB, LTB) =	39.18	ksi	

TENSION-FLANGE FLEXURAL RESISTANCE 6.10.8.3

Fnt = Rh*Fyt =	50.00	ksi	(6.10.8.3-1)

STRESSES UNDER FACTORED LOADS

P	M	A	I	B	fo	γ	fbu(top)	fbu(bot)
0	23,580	57.0	26,019	0	0.000	0.9063	-23.563	23.563

fc/Fnc =	0.601		
ft/Fnt =	0.471		
f/F =	**0.601**		
Mn =	39,212	kip-in	
Flexural capacity according to Appendix A Mn =	40,791	kip-in	Applicable

LATERAL BENDING IN BOTTOM FLANGE

Ml =	0	kip-in
Compression Flange fl =	0.000	ksi
Tension Flange fl =	0.000	ksi

WEB BEND-BUCKLING RESISTANCE 6.10.1.9

Fcrw = min[0.9Ek/(D/tw)^2, RhFyc, Fyw/0.7] = **50.0** ksi (6.10.1.9.1-1)

Bend-Buckling Coefficient, k

For webs without long. Stiffeners, k = 9/(Dc/D)^2 = 36.0 (Applicable) (6.10.1.9.1-2)

For webs with longitudinal stiffeners

k=if(ds/Dc≥0.4,max(5.17/(ds/D)²,9/(Dc/D)²),11.64/((Dc-ds)/D)²) = N/ A (6.10.1.9.2-1,2)

k = 36.0

HYBRID FACTOR, Rh 6.10.1.10.1

	Compress.	Tension	Total
y = y(c.g)-tf =	25.00	25.00	50
f =My*y/Inc =	48.08	48.08	
hw = y*(1-Fyw/f)=	0.00	0.00	
a = y-hw/3 =	0.00	0.00	
P = (f-Fyw)tw*hw/2 =	0.00	0	0.00
aP =	0	0	0
Myr = My-aP=	50,037		

Rh = Myr/My = 1.000 (6.10.4.3.1c-2)

WEB LOAD-SHEDDING FACTOR, Rb 6.10.1.10.2

$\lambda rw = 5.7\sqrt{(E/Fyc)}$ =	137.3		(6.10.1.10.2-4)
awc=2Dc*tw/(bf*tf) =	1.56	in	(6.10.1.10.2-5)
2Dc/tw =	100.0		
λrw =	137.3		
2Dc/tw ≤ λrw , Rb =	1.000		(Rb = 1)

MOMENT GRADIENT CORRECTION FACTOR Cb A6.3.3.3

Assume girder properties are identical at the both brace points, then Pl/Ph = Ml/Mh = 1

Cb = 1.75-1.05(Pl/Ph)+0.3(Pl/Ph)^2 = 1.00 (6.10.8.2.3-7)

Cb <= 1.75 if Ml and Mh are from moment envelope
Cb <= 2.30 if Ml is concurrent with Mh
Cb = 1.0 for unbraced cantilever
Cb = 1.0 if moment between brace points larger than Mh

Overwrite Cb = 1.00

Final Cb = 1.00

Composite Section in Positive Moment

(Applicable)

SUMMARY OF COMPOSITE SECTION ANALYSIS. **(Satisfied)**

Service limit state stress ratio =		**0.91**	OK
For compact section **Applicable**			
Flexural resistance, ϕ_f*Mn =		75,845	kip-in
Mu + 1/3*fl*Sxt =		66,787	kip-in
Demand/capacity ratio =		**0.88**	OK
For noncompact section **N/A**			
Flexural resistance, ϕ_f*Mn =		58,343	kip-in
Factored stresses in flanges f(top)=	-28.27	**N/A**	OK
f(bot)+fl/3 =	56.38	**N/A**	OK
Final Statement		**0.91**	**OK**

COMPACT SECTION REQUIREMENTS 6.10.6.2.2

Fyf ≤ 70 ksi	50.0 ≤ 70	TRUE	
2Dc/tw ≤ 150	100.0 ≤ 150	TRUE	(6.10.2.1.1-1,2)
2Dcp/tw ≤ 3.76√(E/Fyc)	0.0 ≤ 90.6	TRUE	(6.10.6.2.2-1)
Conclusion: Section is compact =		**TRUE**	

COMPACT SECTIONS FLEXURAL RESISTANCE 6.10.7.1 **Applicable**

Mp =	87,405	kip-in	(Appendix D6.1)
Dp =	6.41	in	
Dt =	60	in	
Dp/Dt =	0.107	> 0.1 , k = 1.07-0.7Dp/Dt = 0.995	
Mn = Mp*k =	86,991	kip-in	(6.10.7.1.2-2)
Mn ≤ 1.3RhMy =	75,845	kip-in	(6.10.7.1.2-3)
(minimum of above) Mn =	75,845	kip-in	

NONCOMPACT SECTIONS FLEXURAL RESISTANCE 6.10.7.2 **N/A**

Compression flange, Fnc = RbRhFyc =	50.00	ksi	(6.10.7.2.-1)
Tension flange, Fnt = RhFyt =	50.00	ksi	(6.10.7.2.-2)

Stresses due to factored loads

Short-term (L) load scale factor = 0.784

	P	M	A	I	B	fo	γ	ftop	fbot
D1	0	23,580	57.0	26,019	0	0.000	0.906	-23.563	23.563
D2	0	4,069	103.0	67,697	-1,381	1.110	0.083	-1.042	3.261
L	0	39,138	175.5	133,303	-3,555	12.944	0.639	-3.665	29.552
Lmax	0	30,693						-2.874	23.176
D1+D2+Lm	0	58,343						**-27.48**	**50.00**
	Pn	Mn							

LATERAL BENDING IN BOTTOM FLANGE

Ml =	0	kip-in
fl = 6Ml/(tbot*bbot²) =	0.000	ksi
Sxt = Myt/Fyt =	1,167	in^3
1/3*fl*Sxt =	0	kip-in

SERVICE LIMIT STATE OF PERMANENT DEFLECTION 6.10.4.2 **(Satisfied)**

Stress in flanges

Load	P	M	A	I	B	fo	γ	fc(top)	ft(bot)
D1	0	18,864	57.0	26,019	0	0.000	0.725	-18.850	18.850
D2	0	3,005	103.0	67,697	-1,381	0.820	0.061	-0.769	2.409
L	0	29,074	175.5	133,303	-3,555	9.615	0.475	-2.723	21.953
Total:	0	50,943				10.435	1.26	-22.342	43.212

Lateral flange bending stress, fl = 0.00 ksi

Top:	fc ≤ 0.95RhFyf	22.3 ≤ 47.5	TRUE	(6.10.4.2.2-1)
Bottom:	ft + fl/2 ≤ 0.95RhFyf	43.2 ≤ 47.5	TRUE	(6.10.4.2.2-2)

Demand/Capacity stress ratio = 0.910

Check maximum concrete stress in the deck for compact sections **Applicable**

Load	P	M	A	I	B	fo	γ	fc(top)
D2+L	0	32,079	175.5	133,303	-3,555	10.609	0.524	-7.193
						n = 7.56	fcc=fc/n =	-0.951

Stress in concrete fcc ≤ 0.6f'c 1.0 ≤ 2.400 TRUE

Demand/Capacity stress ratio = 0.396

Conclusion: section meets service limit state requierements = **TRUE**

DUCTILITY REQUIREMENTS Dp ≤ 0.42Dt 6.4 ≤ 25.2 TRUE (6.10.7.3-1)

HYBRID FACTOR, Rh 6.10.1.10.1

ρ = Fyw/fn =	1.000		
β = 2Dntw/Afn =	2.035		
Dn =	32.56	in	
fn =	48.51	ksi	
Rh =	**1.000**		(6.10.1.10.1-1)

WEB LOAD-SHEDDING FACTOR, Rb 6.10.1.10.2

λrw = 5.7√(E/Fyc) =	137.3		(6.10.1.10.2-4)
awc=2Dc*tw/(bf*tf) =	1.09	in	(6.10.1.10.2-5)
Rb =	**1.000**		(6.10.1.10.2.-3)

WEB BEND-BUCKLING RESISTANCE 6.10.1.9

Fcrw = min[0.9Ek/(D/tw)², RhFyc, Fyw/0.7] = **50.0** ksi (6.10.1.9.1-1)

Bend-Buckling Coefficient, k

For webs without long. Stiffeners, k = 9/(Dc/D)² = 74.0 (Applicable) (6.10.1.9.1-2)

For webs with longitudinal stiffeners

k=IF(ds/Dc≥0.4,MAX(5.17/(ds/D)²,9/(Dc/D)²),11.64/((Dc-ds)/D)²) N/ A (6.10.1.9.2-1,2)

k = 74.0

SHEAR RESISTANCE 6.10.9

Maximum Transverse stiffeners spacing	**(Satisfied)**			
	Maximum Stress Ratio =	0.619		OK
	Transverse stiffeners spacing, do =	78 in		
	For web interior panel 3.0D =	150.0 >= 78		TRUE
	For web end panel 1.5D =	75.0 >= 78		N/A
	For webs with longitudinal stiffenrs 1.5D =	75.0 >= 78		N/A
	Conclusiont: Transv. stiffeners spacing satisfies code requirements =			**TRUE**
	Girder web is considered STIFFENED =			TRUE
Calculations of C	(ratio of the shear buckling stress to the shear yield strength)			
	Shear buckling coefficient, $k = 5+5/(do/D)^2$ =	7.05	(6.10.9.3.2-7)	
	D/tw =	100.0	Use formula (6.10.9.3.2-6) for C	
	$1.12\sqrt{Ek/Fyw}$ =	71.6		
	$1.40*\sqrt{Ek/Fyw}$ =	89.6		
	C =	0.642	(6.10.9.3.2-6)	
Plastic Shear Force	Vp = 0.58FywD*tw =	725 kip	(6.10.9.2-2) and (6.10.9.3.2-3)	
Shear capacity of unstiffened webs	N/A Vn = CVp =	465 kip	(6.10.9.2-1)	
Shear capacity of interior web panels	**(Applicable)**	6.10.9.3.2		
	2Dtw/(bfc*tfc+bft*tft) =	1.6 ≤ 2.5		TRUE
	$Vn = Vp[C+0.87(1-C)/(\sqrt{1+(do/D)^2})]$ =	587 kip	(6.10.9.3.2-2)	
Shear capacity of end web panels	(Not Applicable)	6.10.9.3.3		
	Vn = Vcr = CVp =	465 kip	(6.10.9.3.3-1)	
Final Shear Resistance	**Vn =**	**587** kip		
	Vu =	364 kip		
	Stress Ratio $Vu/\phi_v Vn$ =	**0.619**		

16. Design References

- For special permits, use a one-lane loaded condition only. Where a one-lane loaded condition is assumed, the LRFD multiple presence factor need not be applied (the built-in multiple presence factor in the LRFD one-lane distribution factor should be divided out).
- For routine permits, a multi-lane loaded condition shall be assumed. Permit trucks of equal weights shall be assumed to be present in each lane in determining the governing distribution factor.

6A.4.5.7—Continuous Spans

Closely spaced heavy axles can cause uplift in end spans of continuous bridges. During permit reviews, uplift in continuous span bridges and its effect upon bearings should be considered.

C6A.4.5.7

When the upward *LL* reaction reduces the total reaction to less than ten percent of normal downward *DL* reaction, uplift may be considered to occur. Unless the uplift is counteracted (by weights or tie-downs), the vehicle should not be permitted on the bridge.

6A.5—CONCRETE STRUCTURES

6A.5.1—Scope

The provisions of Article 6A.5 apply to the evaluation of concrete bridge components reinforced with steel bars and/or prestressing strands or bars. The provisions of Article 6A.5 combine and unify the requirements for reinforced and prestressed concrete.

Provisions for the rating of segmental concrete bridges using the LRFR methodology are given in Article 6A.5.11.

6A.5.2—Materials

6A.5.2.1—Concrete

When the compressive strength of concrete, f'_c, is unknown and the concrete is in satisfactory condition, f'_c for reinforced concrete superstructure components may be taken as given in Table 6A.5.2.1-1 by considering the date of construction.

Table 6A.5.2.1-1—Minimum Compressive Strength of Concrete by Year of Construction

Year of Construction	Compressive Strength, f'_c, ksi
Prior to 1959	2.5
1959 and Later	3.0

For prestressed concrete components, the compressive strengths shown above may be increased by 25 percent.

Where the quality of the concrete is uncertain, cores should be taken for mechanical property testing. Where mechanical properties have been established by testing, the nominal value for strength is typically taken as the mean of the test values minus 1.65 standard deviations to provide a 95 percent confidence limit. Average test values should not be used for evaluation. Guidance on material sampling for bridge evaluation is provided in Article 5.3.

C6A.5.2.1

Cores may also be taken where the initial load capacity based on design concrete strength is considered inadequate. Concrete strength may have little effect on the capacity of flexural members. However, in the case of compression members, the axial capacity increase may be as large as the concrete strength increase.

6A.5.2.2—Reinforcing Steel

Yield strengths for reinforcing steels are specified in Table 6A.5.2.2-1. Yield strengths of unknown reinforcing steel may be estimated by considering the date of construction. Where practical, specimens of unknown steel should be obtained for testing to ascertain more accurate mechanical properties.

Table 6A.5.2.2-1—Yield Strength of Reinforcing Steel

Type of Reinforcing Steel	Yield Strength, f_y, ksi
Unknown steel constructed prior to 1954	33.0
Structural grade	36.0
Billet or intermediate grade, Grade 40, and unknown steel constructed during or after 1954	40.0
Rail or hard grade, Grade 50	50.0
Grade 60	60.0

6A.5.2.3—Prestressing Steel

Where the tensile strength of the prestressing strand is unknown, the values specified in Table 6A.5.2.3-1 based on the date of construction may be used.

Table 6A.5.2.3-1—Tensile Strength of Prestressing Strand

Year of Construction	Tensile Strength, f_{pu}, ksi
Prior to 1963	232.0
1963 and Later	250.0

C6A.5.2.3

Stress-relieved strands should be assumed when the strand type is unknown.

6A.5.3—Resistance Factors

Resistance factors, φ, for concrete members, for the strength limit state, shall be taken as specified in LRFD Design Article 5.5.4.2.

C6A.5.3

For service limit states, φ = 1.0.

6A.5.4—Limit States

The applicable limit states and their load combinations for the evaluation of concrete members are specified for the various rating procedures. The load combinations, and the load factors which comprise them, are specified in Table 6A.4.2.2-1 and in these Articles.

6A.6—STEEL STRUCTURES

6A.6.1—Scope

The provisions of Article 6A.6 shall apply to the evaluation of steel and wrought-iron components of bridges. The provisions of Article 6A.6 apply to components of straight or horizontally curved I-girder bridges and straight or horizontally curved single or multiple closed-box or tub girder bridges.

C6A.6.1

LRFD Design Article 6.10 provides a unified approach for consideration of combined major-axis bending and flange lateral bending from any source in I-sections. In load rating, flange lateral bending effects from wind and deck placement need not be considered.

Bridges containing both straight and curved segments are to be treated as horizontally curved bridges.

6A.6.2—Materials

6A.6.2.1—Structural Steels

The minimum mechanical properties of structural steel given in Table 6A.6.2.1-1 may be assumed based on the year of construction of the bridge when the specification and grade of steel are unknown.

Table 6A.6.2.1-1—Minimum Mechanical Properties of Structural Steel by Year of Construction

Year of Construction	Minimum Yield Point or Minimum Yield Strength, F_y, ksi	Minimum Tensile Strength, F_u, ksi
Prior to 1905	26	52
1905 to 1936	30	60
1936 to 1963	33	66
After 1963	36	66

Where it is possible to identify the designation (AASHTO or ASTM) and grade of the steel from available records, it is possible to determine the minimum yield and tensile strengths to be used for evaluation by reviewing the designation specification.

In cases where the initial evaluation suggests load capacity inadequacies, or there is doubt about the nature and quality of a particular material, the mechanical properties can be verified by testing. Mechanical properties of the material should be determined based on coupon tests. The nominal values for yield and tensile strength are typically taken as the mean test value minus 1.65 standard deviation to provide a 95 percent confidence limit. Average test values should not be used for evaluation. Guidance on material sampling for bridge evaluation is provided in Article 5.3 of this Manual.

Actual values of yield and ultimate tensile stresses reported on mill certificates should not be used for evaluation. Instead, the strength used should be the guaranteed minimum value as specified for the grade of steel shown. The resistance factors account for the fact that the mean strength of the material supplied usually exceeds the minimum specified strength.

C6A.6.2.1

Mechanical properties of eyebars, high-strength eyebars, forged eyebars, and cables vary depending on manufacturer and year of construction. When information from records is not available, microstructural and chemical analyses and hardness testing are helpful in classifying the material. In the absence of material tests, the Engineer should carefully investigate the material properties using manufacturer's data and compilation of older steel properties before establishing the yield point and tensile strength to be used in load rating the bridge.

6A.6.2.2—Pins

If the material designation for pins is unknown, the yield strength may be selected from Table 6A.6.2.2-1, based on the year of construction.

Table 6A.6.2.2-1—Minimum Yield Point of Pins by Year of Construction

Year of Construction	Minimum Yield Point, F_y, ksi
Prior to 1905	25.5
1905 through 1935	30
1936 through 1963	33
After 1963	36

6A.6.2.3—Wrought Iron

When the material designation is unknown for wrought iron, the minimum tensile strength, F_u, should be taken as 48 ksi and the minimum yield point, F_y, should be taken as 26 ksi.

Where practical, coupon tests should be performed to confirm the minimum mechanical properties used in the evaluation.

6A.6.3—Resistance Factors

Resistance factors, φ, for steel members, for the strength limit state, shall be taken as specified in LRFD Design Article 6.5.4.2.

C6A.6.3

For service limit states, φ = 1.0.

6A.6.4—Limit States

The applicable limit states and their load combinations for the evaluation of structural steel and wrought iron members are specified for the various rating procedures. The load combinations, and the load factors which comprise them, are specified in Table 6A.4.2.2-1 and in these Articles.

6A.6.4.1—Design-Load Rating

Strength I and Service II load combinations shall be checked for the design loading. Live load factors shall be taken as tabulated in Table 6A.4.2.2-1.

In situations where fatigue-prone details are present (category C or lower) a rating factor for infinite fatigue life should be computed. Members that do not satisfy the infinite fatigue life check may be evaluated for remaining fatigue life using procedures given in Section 7. This is an optional requirement.

C6A.6.4.1

Rating factors for applicable strength, service, and fatigue limit states computed during the design load rating will aid in identifying vulnerable limit states for further evaluation and future inspections.

U.S. Geological Survey - Earthquake Hazards Program

Unified Hazard Tool

Please do not use this tool to obtain ground motion parameter values for the design code reference documents covered by the U.S. Seismic Design Maps web tools (e.g., the International Building Code and the ASCE 7 or 41 Standard). The values returned by the two applications are not identical.

Input

Edition

Conterminous U.S. 2014 (v4.0.x)

Spectral Period

Peak ground acceleration

Latitude

Decimal degrees

46.5

Time Horizon

Return period in years

975

Longitude

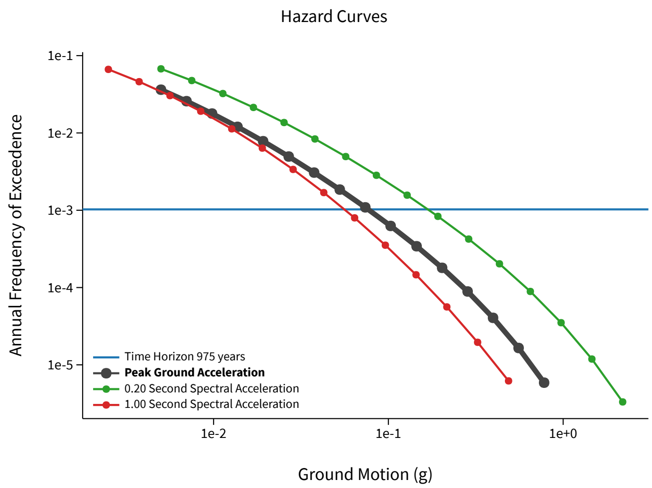
Decimal degrees, negative values for western longitudes

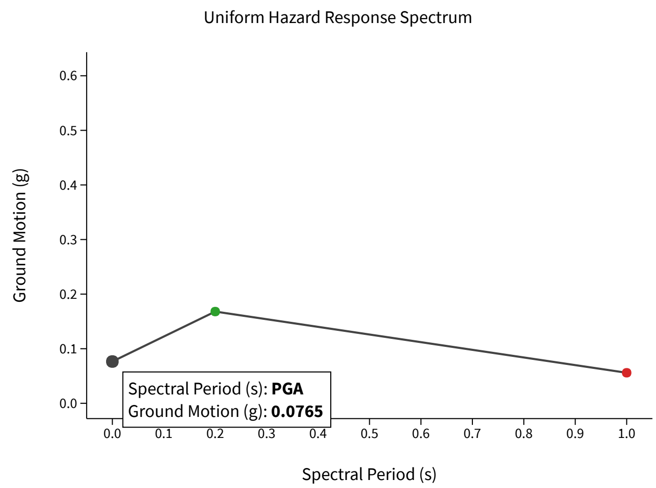
-117

Site Class

760 m/s (B/C boundary)

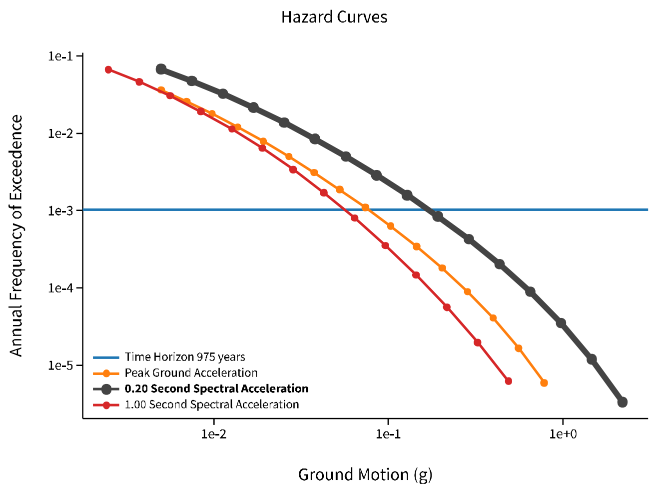
Hazard Curve

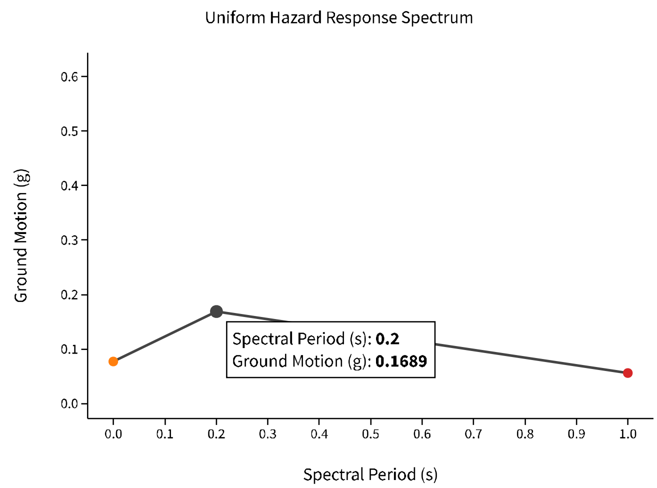




[View Raw Data](#)

Hazard Curve





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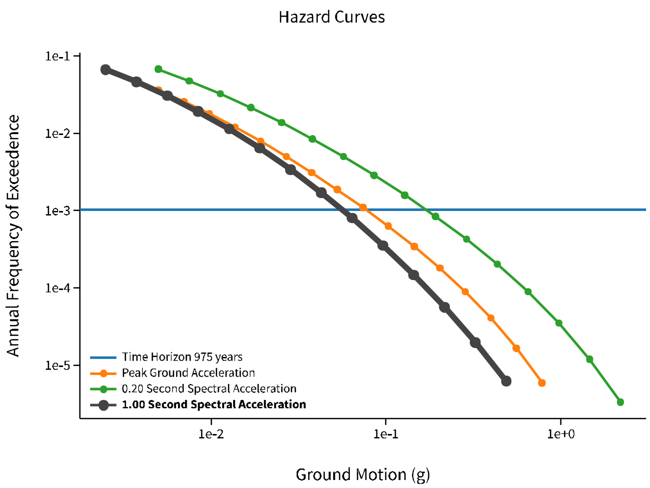
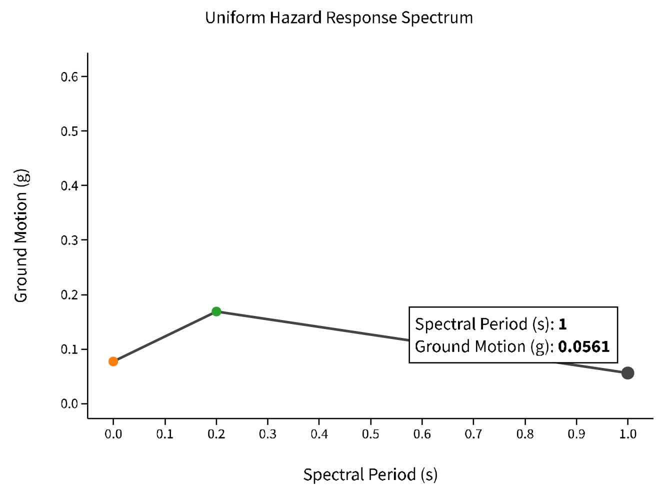
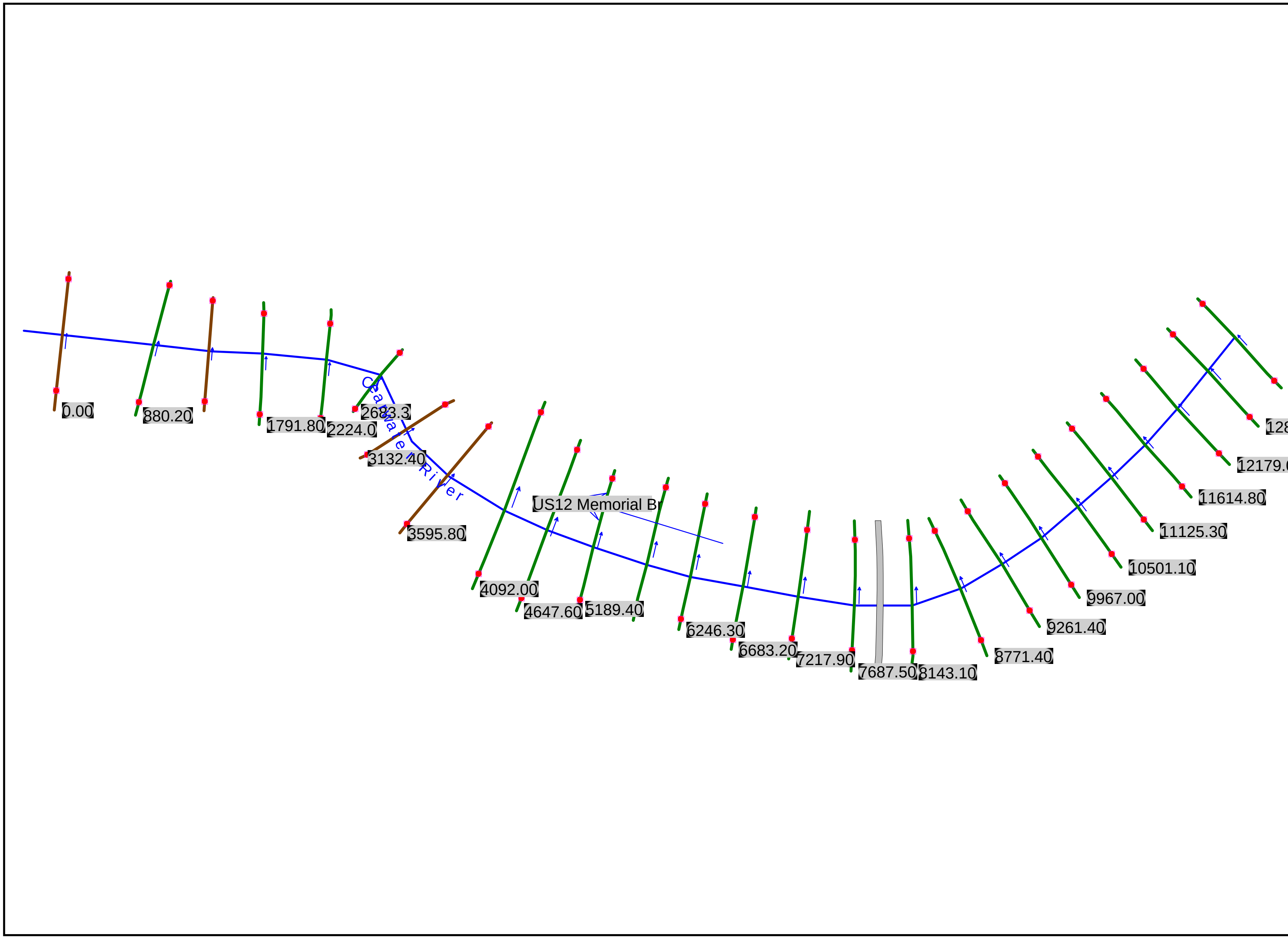
Hazard Curve





View Raw Data

Appendix D: HEC-RAS Model Analysis Results



0.00
380.20
1791.80
2224.0
2683.3
3132.40
3595.80
4092.00
4647.60
5189.40
US12 Memorial Br
6246.30
6683.20
7217.90
7687.50
8143.10
8771.40
9261.40
9967.00
10501.10
11125.30
11614.80
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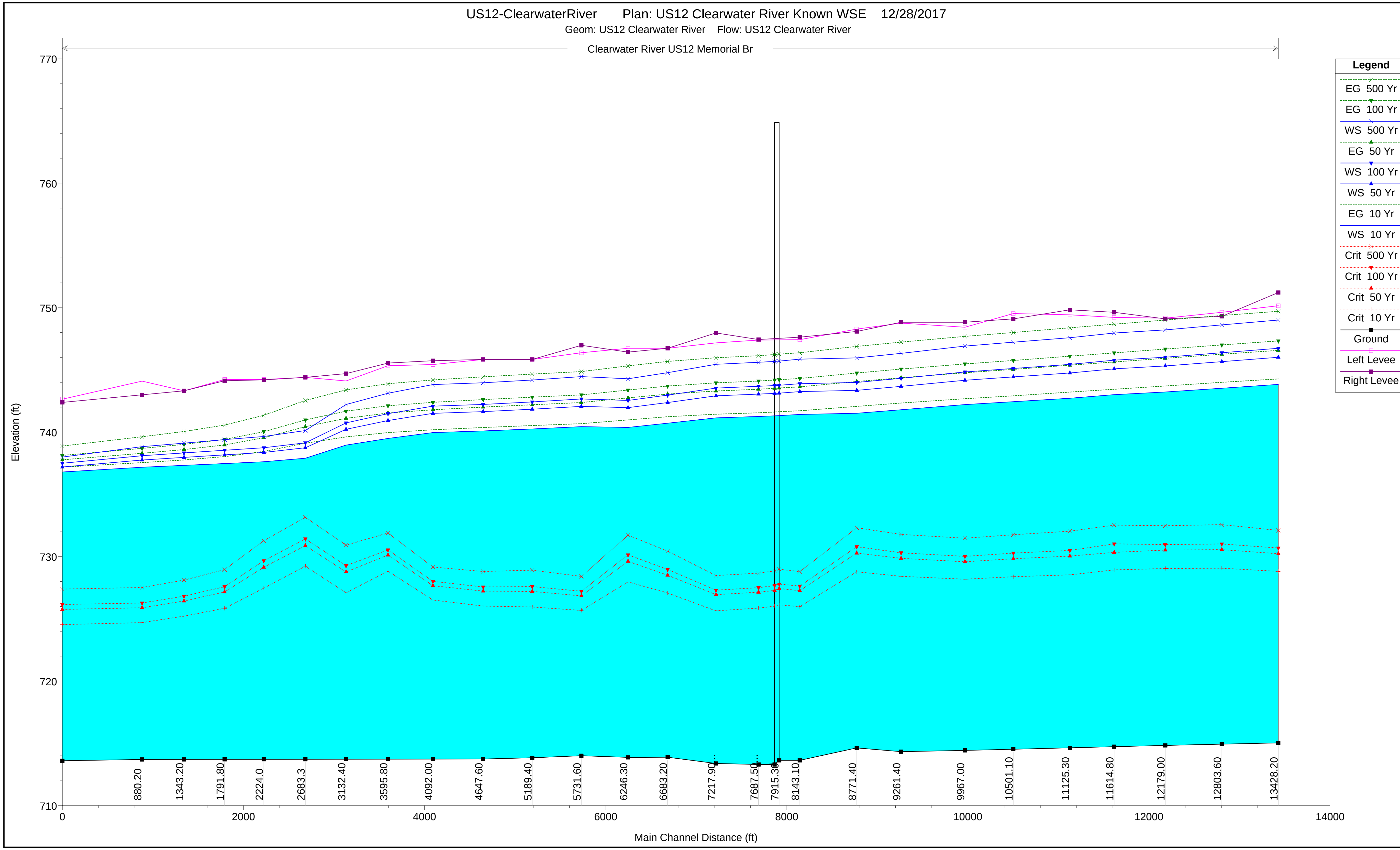
12803.60
13428.20



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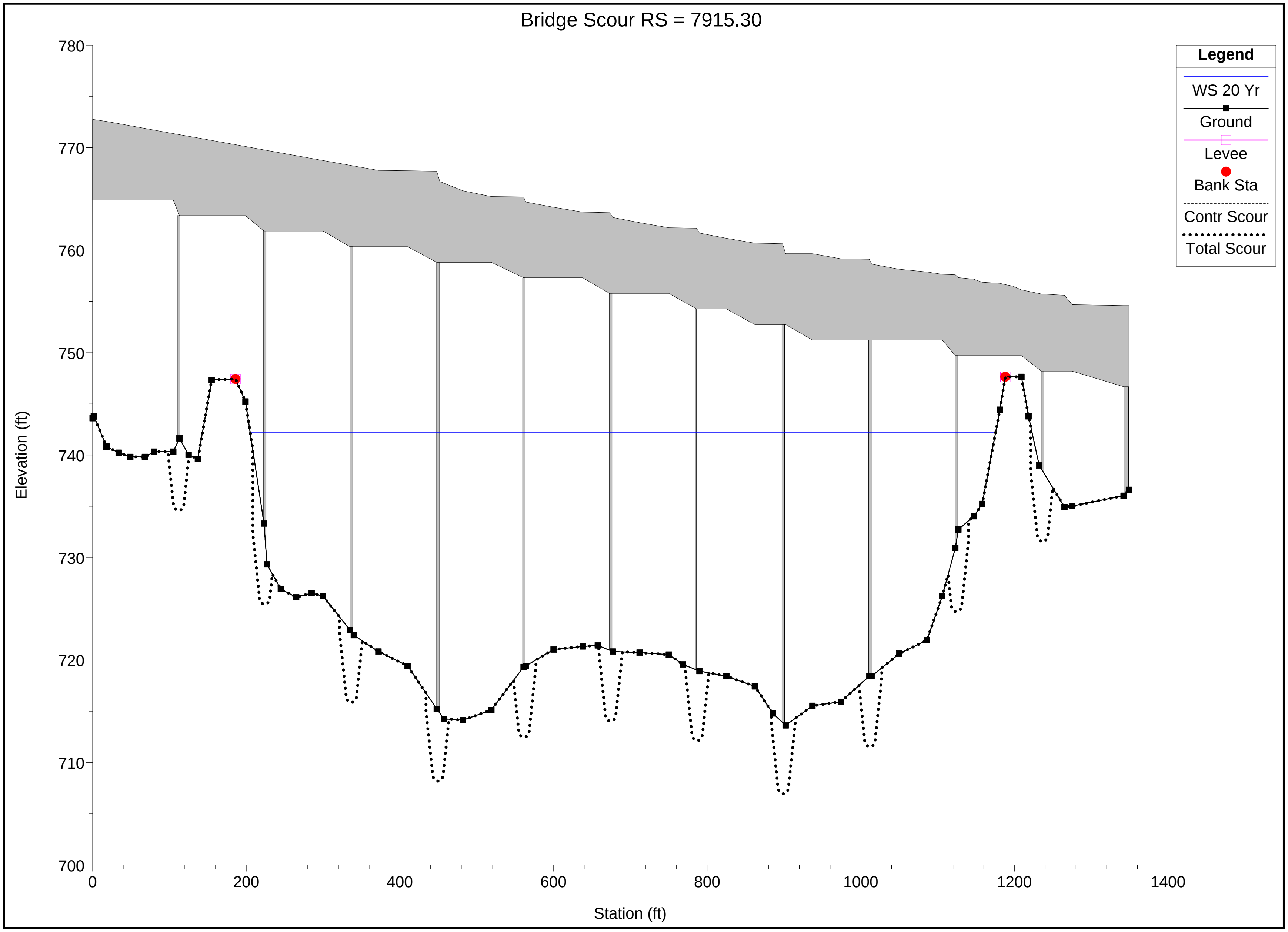
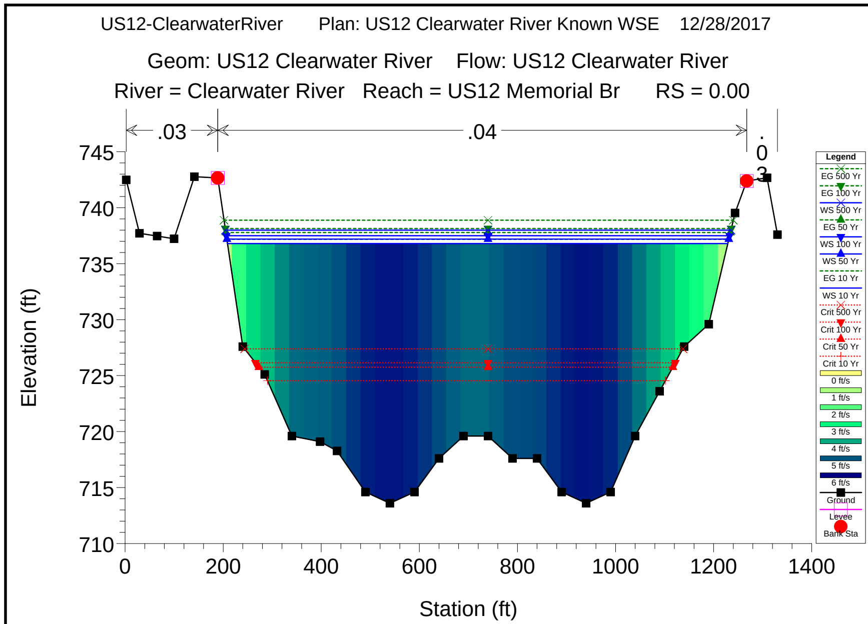
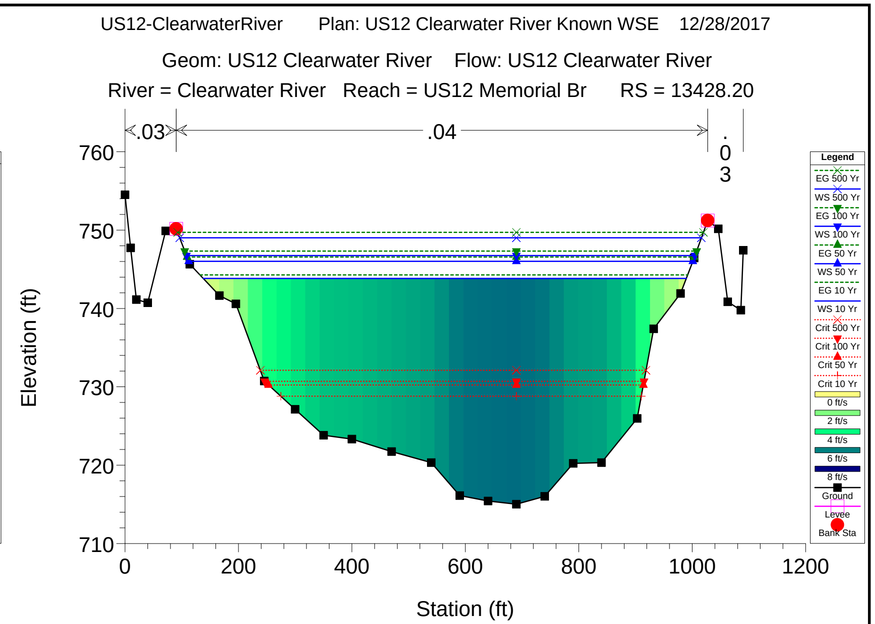
Geom: US12 Clearwater River Flow: US12 Clearwater River
Clearwater River US12 Memorial Br
Legend
EG 500 Yr
EG 100 Yr
WS 500 Yr
EG 50 Yr
WS 100 Yr
WS 50 Yr
EG 10 Yr
WS 10 Yr
Crit 500 Yr
Crit 100 Yr
Crit 50 Yr
Crit 10 Yr
Ground
Left Levee
Right Levee
Elevation (ft)
Main Channel Distance (ft)
770
760
750
740
730
720
710
0
2000
4000
6000
8000
10000
12000
14000
880.20
1343.20
1791.80
2224.0
2683.3
3132.40
3595.80
4092.00
4647.60
5189.40
5731.60
6246.30
6683.20
7217.90
7687.50
7915.30
8143.10
8771.40
9261.40
9967.00
10501.10
11125.30
11614.80
12179.00
12803.60
13428.20



Bridge Scour RS = 7915.30
Legend
WS 20 Yr
Ground
Levee
Bank Sta
Contr Scour
Total Scour
Elevation (ft)
Station (ft)
780
770
760
750
740
730
720
710
700
0
200
400
600
800
1000
1200
1400


US12-ClearwaterRiver Plan: US12 Clearwater River Known WSE 12/28/2017
Geom: US12 Clearwater River Flow: US12 Clearwater River
River = Clearwater River Reach = US12 Memorial Br RS = 0.00
.03
.04
.03
Elevation (ft)
Station (ft)
Legend
EG 500 Yr
EG 100 Yr
WS 500 Yr
EG 50 Yr
WS 100 Yr
WS 50 Yr
EG 10 Yr
WS 10 Yr
Crit 500 Yr
Crit 100 Yr
Crit 50 Yr
Crit 10 Yr
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Bank Sta

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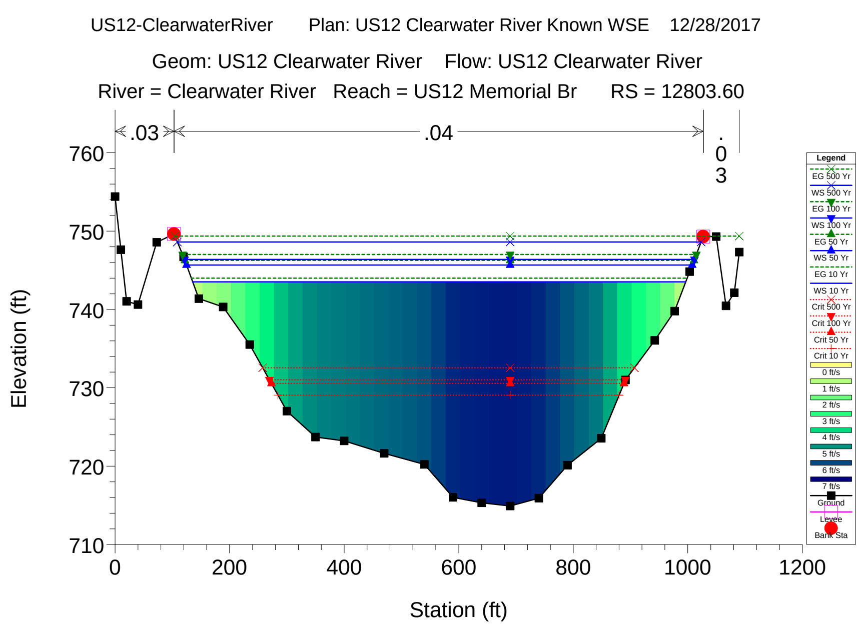
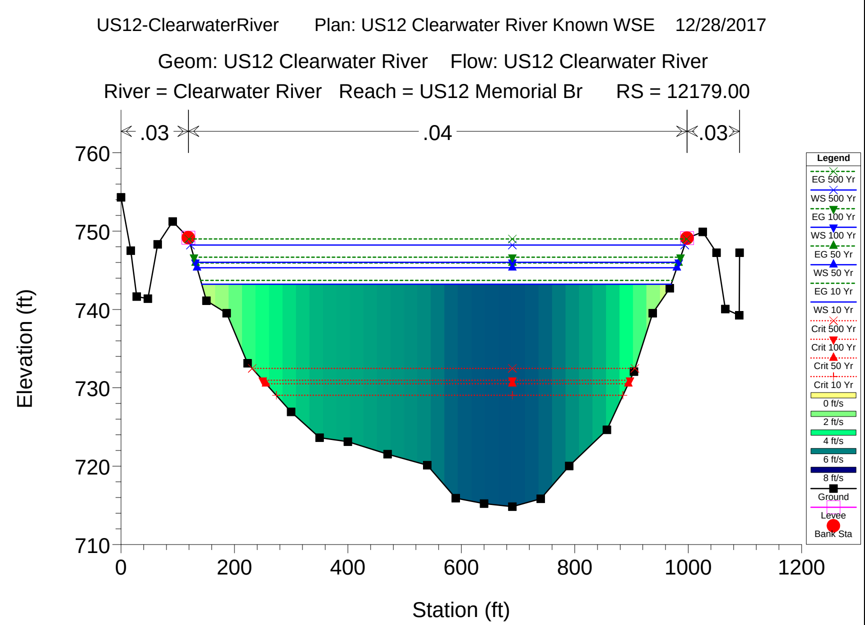
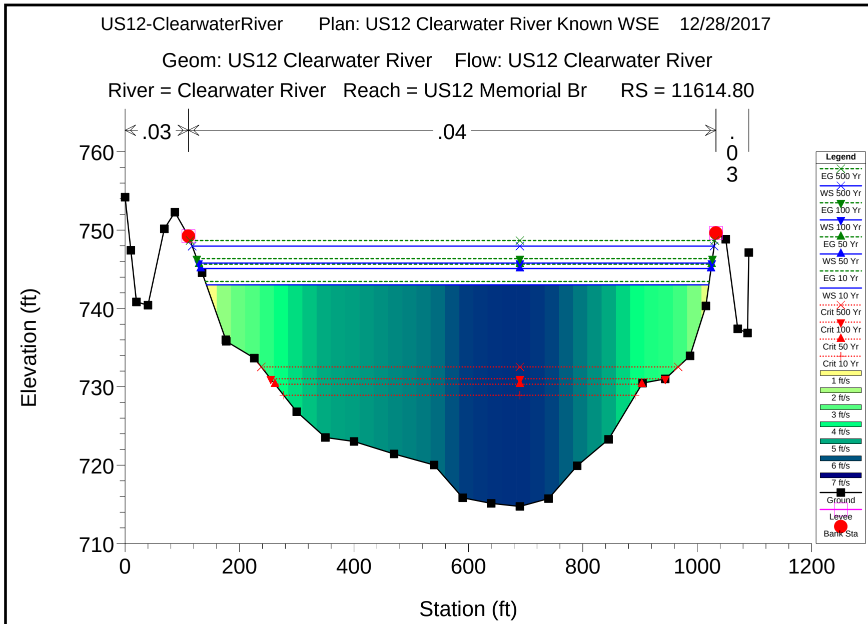
Geom: US12 Clearwater River Flow: US12 Clearwater River
River = Clearwater River Reach = US12 Memorial Br RS = 13428.20
.03
.04
.03
Elevation (ft)
Station (ft)
Legend
EG 500 Yr
WS 500 Yr
EG 100 Yr
WS 100 Yr
EG 50 Yr
WS 50 Yr
EG 10 Yr
WS 10 Yr
Crit 500 Yr
Crit 100 Yr
Crit 50 Yr
Crit 10 Yr
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Levee
Bank Sta

US12-ClearwaterRiver Plan: US12 Clearwater River Known WSE 12/28/2017
Geom: US12 Clearwater River Flow: US12 Clearwater River
River = Clearwater River Reach = US12 Memorial Br RS = 12803.60
.03
.04
.03
Elevation (ft)
Station (ft)
Legend
EG 500 Yr
WS 500 Yr
EG 100 Yr
WS 100 Yr
EG 50 Yr
WS 50 Yr
EG 10 Yr
WS 10 Yr
Crit 500 Yr
Crit 100 Yr
Crit 50 Yr
Crit 10 Yr
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Levee
Bank Sta

US12-ClearwaterRiver Plan: US12 Clearwater River Known WSE 12/28/2017
Geom: US12 Clearwater River Flow: US12 Clearwater River
River = Clearwater River Reach = US12 Memorial Br RS = 12179.00
.03
.04
.03
Elevation (ft)
Station (ft)
Legend
EG 500 Yr
WS 500 Yr
EG 100 Yr
WS 100 Yr
EG 50 Yr
WS 50 Yr
EG 10 Yr
WS 10 Yr
Crit 500 Yr
Crit 100 Yr
Crit 50 Yr
Crit 10 Yr
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Levee
Bank Sta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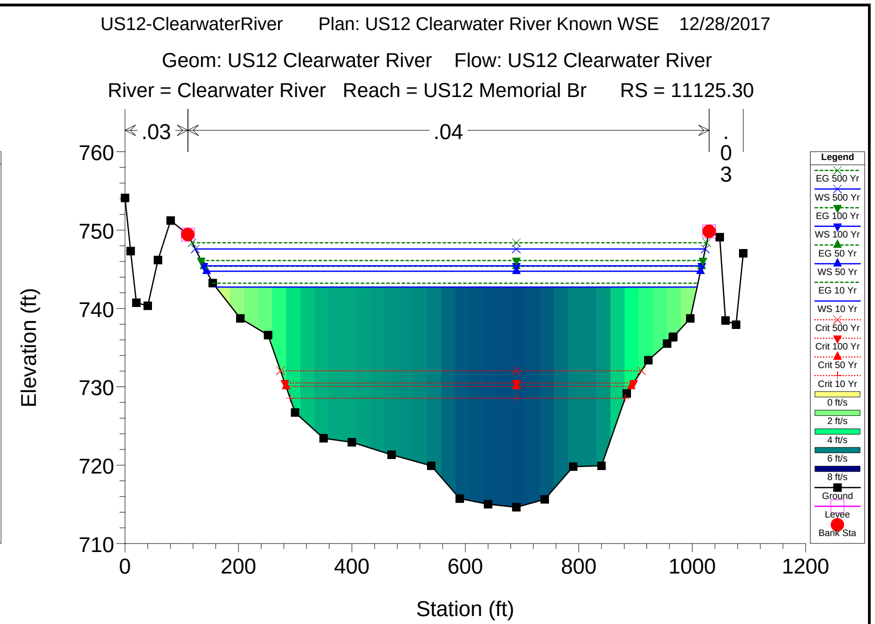
Geom: US12 Clearwater River Flow: US12 Clearwater River
River = Clearwater River Reach = US12 Memorial Br RS = 11614.80
Elevation (ft)
Station (ft)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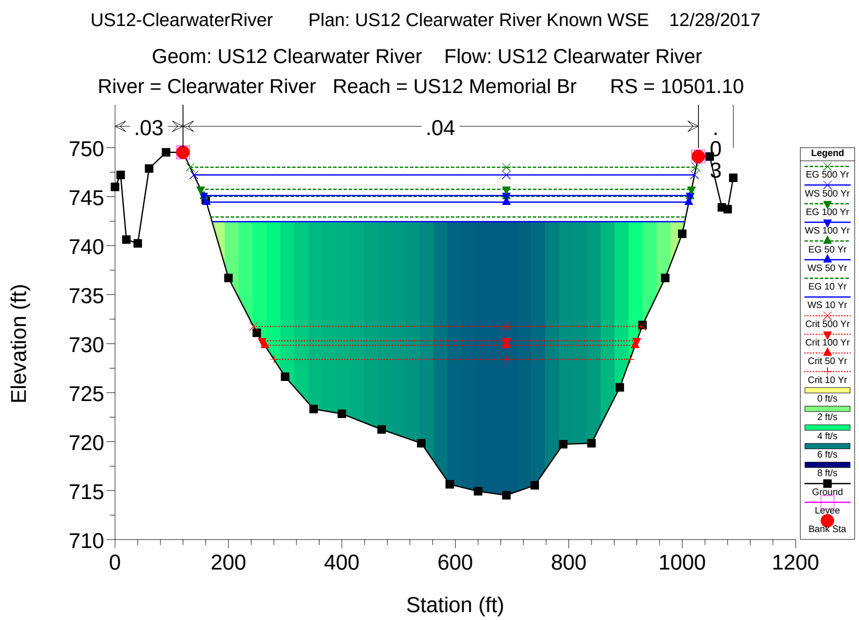
River = Clearwater River Reach = US12 Memorial Br RS = 11125.30
Elevation (ft)
Station (ft)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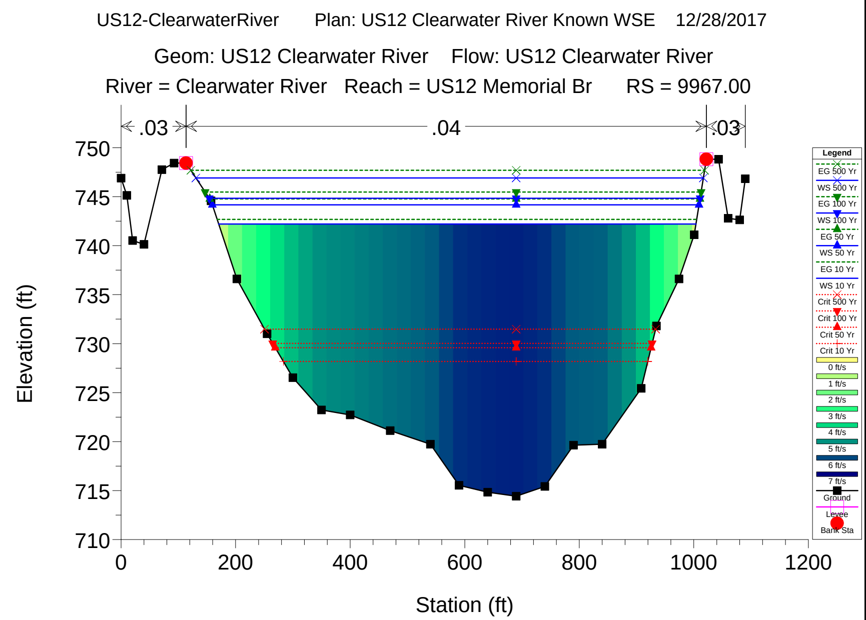
River = Clearwater River Reach = US12 Memorial Br RS = 10501.10
Elevation (ft)
Station (ft)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Geom: US12 Clearwater River Flow: US12 Clearwater River
River = Clearwater River Reach = US12 Memorial Br RS = 9967.00
Elevation (ft)
Station (ft)

HEC-RAS Plan: Knwn WSE River: Clearwater River Reach: US12 Memorial Br

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
US12 Memorial Br	13428.20	2 Yr	58680.00	715.03	740.72	726.73	741.01	0.000294	4.30	13652.50	775.29	0.18
US12 Memorial Br	13428.20	5 Yr	77400.00	715.03	742.84	728.17	743.23	0.000380	5.04	15363.21	833.52	0.21
US12 Memorial Br	13428.20	10 Yr	86400.00	715.03	743.84	728.81	744.28	0.000408	5.33	16207.39	851.85	0.22
US12 Memorial Br	13428.20	20 Yr	97200.00	715.03	744.95	729.55	745.45	0.000440	5.66	17166.38	872.20	0.23
US12 Memorial Br	13428.20	50 Yr	108000.00	715.03	746.02	730.23	746.57	0.000467	5.96	18108.85	888.82	0.23
US12 Memorial Br	13428.20	100 Yr	115200.00	715.03	746.74	730.69	747.33	0.000478	6.14	18753.64	896.36	0.24
US12 Memorial Br	13428.20	200 Yr	122400.00	715.03	747.45	731.10	748.07	0.000488	6.31	19388.48	903.63	0.24
US12 Memorial Br	13428.20	500 Yr	140000.00	715.03	749.01	732.11	749.71	0.000516	6.73	20813.19	919.72	0.25
US12 Memorial Br	12803.60	2 Yr	58680.00	714.93	740.49	726.94	740.81	0.000354	4.49	13062.02	798.70	0.20
US12 Memorial Br	12803.60	5 Yr	77400.00	714.93	742.54	728.42	742.97	0.000445	5.24	14772.53	850.94	0.22
US12 Memorial Br	12803.60	10 Yr	86400.00	714.93	743.53	729.07	744.00	0.000468	5.53	15614.29	861.00	0.23
US12 Memorial Br	12803.60	20 Yr	97200.00	714.93	744.62	729.84	745.15	0.000495	5.87	16559.25	872.15	0.24
US12 Memorial Br	12803.60	50 Yr	108000.00	714.93	745.67	730.56	746.26	0.000519	6.18	17480.67	882.97	0.24
US12 Memorial Br	12803.60	100 Yr	115200.00	714.93	746.38	731.02	747.01	0.000531	6.36	18113.18	890.33	0.25
US12 Memorial Br	12803.60	200 Yr	122400.00	714.93	747.08	731.47	747.74	0.000541	6.53	18736.31	897.78	0.25
US12 Memorial Br	12803.60	500 Yr	140000.00	714.93	748.62	732.57	749.37	0.000572	6.95	20131.08	914.70	0.26
US12 Memorial Br	12179.00	2 Yr	58680.00	714.83	740.27	726.87	740.59	0.000342	4.50	13039.55	775.11	0.19
US12 Memorial Br	12179.00	5 Yr	77400.00	714.83	742.26	728.36	742.69	0.000435	5.29	14629.84	817.37	0.22
US12 Memorial Br	12179.00	10 Yr	86400.00	714.83	743.22	729.05	743.71	0.000463	5.60	15423.25	827.89	0.23
US12 Memorial Br	12179.00	20 Yr	97200.00	714.83	744.29	729.80	744.84	0.000494	5.96	16311.52	837.17	0.24
US12 Memorial Br	12179.00	50 Yr	108000.00	714.83	745.32	730.53	745.93	0.000520	6.29	17177.56	846.11	0.25
US12 Memorial Br	12179.00	100 Yr	115200.00	714.83	746.02	730.97	746.67	0.000534	6.48	17773.90	852.22	0.25
US12 Memorial Br	12179.00	200 Yr	122400.00	714.83	746.71	731.45	747.40	0.000546	6.67	18360.91	858.18	0.25
US12 Memorial Br	12179.00	500 Yr	140000.00	714.83	748.22	732.48	749.01	0.000580	7.12	19666.31	871.31	0.26
US12 Memorial Br	11614.80	2 Yr	58680.00	714.73	740.11	726.76	740.39	0.000326	4.26	13778.19	858.11	0.19
US12 Memorial Br	11614.80	5 Yr	77400.00	714.73	742.06	728.26	742.45	0.000394	5.00	15465.31	871.67	0.21
US12 Memorial Br	11614.80	10 Yr	86400.00	714.73	743.01	728.93	743.45	0.000417	5.30	16299.48	878.05	0.22
US12 Memorial Br	11614.80	20 Yr	97200.00	714.73	744.07	729.69	744.56	0.000443	5.64	17229.75	885.10	0.23
US12 Memorial Br	11614.80	50 Yr	108000.00	714.73	745.09	730.34	745.64	0.000466	5.96	18135.27	892.06	0.23
US12 Memorial Br	11614.80	100 Yr	115200.00	714.73	745.78	731.02	746.37	0.000477	6.14	18759.52	896.93	0.24
US12 Memorial Br	11614.80	200 Yr	122400.00	714.73	746.47	731.47	747.09	0.000488	6.32	19373.41	901.70	0.24
US12 Memorial Br	11614.80	500 Yr	140000.00	714.73	747.96	732.53	748.67	0.000517	6.75	20731.68	912.14	0.25
US12 Memorial Br	11125.30	2 Yr	58680.00	714.63	739.89	726.44	740.22	0.000374	4.54	12916.03	809.60	0.20
US12 Memorial Br	11125.30	5 Yr	77400.00	714.63	741.79	727.90	742.23	0.000465	5.35	14473.89	835.72	0.23
US12 Memorial Br	11125.30	10 Yr	86400.00	714.63	742.72	728.54	743.22	0.000496	5.66	15260.23	848.60	0.24
US12 Memorial Br	11125.30	20 Yr	97200.00	714.63	743.75	729.28	744.32	0.000531	6.02	16143.14	860.91	0.25
US12 Memorial Br	11125.30	50 Yr	108000.00	714.63	744.75	730.04	745.38	0.000559	6.35	17008.46	870.93	0.25
US12 Memorial Br	11125.30	100 Yr	115200.00	714.63	745.44	730.50	746.11	0.000573	6.54	17609.97	877.82	0.26

HEC-RAS Plan: Knwn WSE   River: Clearwater River   Reach: US12 Memorial Br (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
US12 Memorial Br	11125.30	200 Yr	122400.00	714.63	746.12	730.95	746.82	0.000585	6.72	18203.43	884.58	0.26
US12 Memorial Br	11125.30	500 Yr	140000.00	714.63	747.59	732.04	748.39	0.000621	7.17	19516.65	899.34	0.27
US12 Memorial Br	10501.10	2 Yr	58680.00	714.53	739.69	726.27	739.99	0.000326	4.37	13431.55	804.90	0.19
US12 Memorial Br	10501.10	5 Yr	77400.00	714.53	741.53	727.73	741.95	0.000412	5.18	14932.36	825.40	0.21
US12 Memorial Br	10501.10	10 Yr	86400.00	714.53	742.45	728.39	742.92	0.000441	5.51	15691.41	833.31	0.22
US12 Memorial Br	10501.10	20 Yr	97200.00	714.53	743.46	729.13	744.00	0.000475	5.88	16537.83	842.05	0.23
US12 Memorial Br	10501.10	50 Yr	108000.00	714.53	744.44	729.83	745.04	0.000505	6.22	17367.53	850.52	0.24
US12 Memorial Br	10501.10	100 Yr	115200.00	714.53	745.12	730.29	745.76	0.000521	6.42	17946.48	857.82	0.25
US12 Memorial Br	10501.10	200 Yr	122400.00	714.53	745.78	730.72	746.46	0.000536	6.61	18518.69	865.69	0.25
US12 Memorial Br	10501.10	500 Yr	140000.00	714.53	747.23	731.76	748.01	0.000578	7.08	19783.19	882.84	0.26
US12 Memorial Br	9967.00	2 Yr	58680.00	714.43	739.52	726.14	739.82	0.000321	4.35	13497.19	805.81	0.19
US12 Memorial Br	9967.00	5 Yr	77400.00	714.43	741.32	727.55	741.73	0.000410	5.17	14960.12	825.77	0.21
US12 Memorial Br	9967.00	10 Yr	86400.00	714.43	742.21	728.18	742.69	0.000440	5.50	15705.92	833.32	0.22
US12 Memorial Br	9967.00	20 Yr	97200.00	714.43	743.21	728.91	743.74	0.000475	5.88	16535.78	841.63	0.23
US12 Memorial Br	9967.00	50 Yr	108000.00	714.43	744.17	729.58	744.77	0.000506	6.22	17350.01	849.71	0.24
US12 Memorial Br	9967.00	100 Yr	115200.00	714.43	744.84	730.02	745.48	0.000523	6.43	17920.08	856.83	0.25
US12 Memorial Br	9967.00	200 Yr	122400.00	714.43	745.49	730.47	746.17	0.000540	6.62	18483.97	866.02	0.25
US12 Memorial Br	9967.00	500 Yr	140000.00	714.43	746.91	731.48	747.69	0.000586	7.10	19728.62	885.98	0.27
US12 Memorial Br	9261.40	2 Yr	58680.00	714.33	739.24	726.33	739.57	0.000369	4.64	12641.06	759.78	0.20
US12 Memorial Br	9261.40	5 Yr	77400.00	714.33	740.93	727.78	741.41	0.000487	5.55	13958.02	790.49	0.23
US12 Memorial Br	9261.40	10 Yr	86400.00	714.33	741.80	728.42	742.34	0.000523	5.90	14645.79	797.45	0.24
US12 Memorial Br	9261.40	20 Yr	97200.00	714.33	742.75	729.14	743.37	0.000565	6.31	15407.57	803.30	0.25
US12 Memorial Br	9261.40	50 Yr	108000.00	714.33	743.68	729.86	744.37	0.000602	6.69	16154.97	808.99	0.26
US12 Memorial Br	9261.40	100 Yr	115200.00	714.33	744.33	730.31	745.07	0.000619	6.91	16681.29	812.98	0.27
US12 Memorial Br	9261.40	200 Yr	122400.00	714.33	744.96	730.76	745.75	0.000636	7.12	17198.97	816.88	0.27
US12 Memorial Br	9261.40	500 Yr	140000.00	714.33	746.33	731.78	747.24	0.000683	7.64	18320.94	825.27	0.29
US12 Memorial Br	8771.40	2 Yr	58680.00	714.63	739.03	726.59	739.38	0.000411	4.71	12461.37	795.20	0.21
US12 Memorial Br	8771.40	5 Yr	77400.00	714.63	740.67	728.12	741.16	0.000525	5.62	13776.53	809.43	0.24
US12 Memorial Br	8771.40	10 Yr	86400.00	714.63	741.52	728.78	742.07	0.000562	5.97	14464.91	815.71	0.25
US12 Memorial Br	8771.40	20 Yr	97200.00	714.63	742.45	729.56	743.08	0.000606	6.38	15226.17	822.61	0.26
US12 Memorial Br	8771.40	50 Yr	108000.00	714.63	743.36	730.28	744.07	0.000645	6.76	15975.97	829.34	0.27
US12 Memorial Br	8771.40	100 Yr	115200.00	714.63	744.00	730.80	744.75	0.000663	6.98	16508.50	834.26	0.28
US12 Memorial Br	8771.40	200 Yr	122400.00	714.63	744.62	731.23	745.43	0.000680	7.19	17033.50	839.38	0.28
US12 Memorial Br	8771.40	500 Yr	140000.00	714.63	745.97	732.32	746.89	0.000731	7.71	18167.62	850.37	0.29
US12 Memorial Br	8143.10	2 Yr	58680.00	713.63	738.96	724.26	739.13	0.000170	3.35	17507.79	955.68	0.14
US12 Memorial Br	8143.10	5 Yr	77400.00	713.63	740.58	725.44	740.84	0.000225	4.06	19063.68	963.01	0.16
US12 Memorial Br	8143.10	10 Yr	86400.00	713.63	741.43	725.98	741.72	0.000246	4.35	19877.53	966.82	0.17

HEC-RAS Plan: Knwn WSE River: Clearwater River Reach: US12 Memorial Br (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
US12 Memorial Br	8143.10	20 Yr	97200.00	713.63	742.35	726.72	742.69	0.000270	4.68	20773.75	970.99	0.18
US12 Memorial Br	8143.10	50 Yr	108000.00	713.63	743.26	727.27	743.64	0.000292	4.99	21654.14	975.08	0.19
US12 Memorial Br	8143.10	100 Yr	115200.00	713.63	743.90	727.63	744.31	0.000304	5.17	22279.07	977.97	0.19
US12 Memorial Br	8143.10	200 Yr	122400.00	713.63	744.52	727.98	744.97	0.000314	5.35	22893.58	980.78	0.20
US12 Memorial Br	8143.10	500 Yr	140000.00	713.63	745.86	728.80	746.38	0.000345	5.78	24212.46	988.87	0.21
US12 Memorial Br	7915.30		Bridge									
US12 Memorial Br	7687.50	2 Yr	58680.00	713.30	738.85	724.15	739.03	0.000169	3.35	17512.73	952.70	0.14
US12 Memorial Br	7687.50	5 Yr	77400.00	713.30	740.44	725.33	740.69	0.000226	4.07	19024.79	958.54	0.16
US12 Memorial Br	7687.50	10 Yr	86400.00	713.30	741.26	725.87	741.56	0.000247	4.36	19819.49	961.60	0.17
US12 Memorial Br	7687.50	20 Yr	97200.00	713.30	742.17	726.59	742.51	0.000272	4.70	20691.86	964.91	0.18
US12 Memorial Br	7687.50	50 Yr	108000.00	713.30	743.06	727.14	743.45	0.000294	5.01	21548.78	968.12	0.19
US12 Memorial Br	7687.50	100 Yr	115200.00	713.30	743.68	727.51	744.10	0.000306	5.20	22159.36	970.40	0.19
US12 Memorial Br	7687.50	200 Yr	122400.00	713.30	744.30	727.86	744.75	0.000317	5.38	22759.21	972.64	0.20
US12 Memorial Br	7687.50	500 Yr	140000.00	713.30	745.62	728.67	746.14	0.000349	5.82	24039.98	979.41	0.21
US12 Memorial Br	7217.90	2 Yr	58680.00	713.38	738.78	723.94	738.95	0.000166	3.33	17627.47	952.33	0.14
US12 Memorial Br	7217.90	5 Yr	77400.00	713.38	740.33	725.12	740.59	0.000222	4.05	19113.57	957.86	0.16
US12 Memorial Br	7217.90	10 Yr	86400.00	713.38	741.15	725.64	741.44	0.000243	4.34	19898.21	960.76	0.17
US12 Memorial Br	7217.90	20 Yr	97200.00	713.38	742.04	726.39	742.38	0.000269	4.68	20758.13	963.94	0.18
US12 Memorial Br	7217.90	50 Yr	108000.00	713.38	742.92	726.95	743.31	0.000292	5.00	21603.69	967.24	0.19
US12 Memorial Br	7217.90	100 Yr	115200.00	713.38	743.54	727.30	743.96	0.000304	5.19	22208.21	969.70	0.19
US12 Memorial Br	7217.90	200 Yr	122400.00	713.38	744.16	727.66	744.60	0.000315	5.37	22802.47	972.12	0.20
US12 Memorial Br	7217.90	500 Yr	140000.00	713.38	745.45	728.48	745.98	0.000348	5.82	24067.57	979.13	0.21
US12 Memorial Br	6683.20	2 Yr	58680.00	713.88	738.50	724.98	738.81	0.000340	4.46	13153.15	789.50	0.19
US12 Memorial Br	6683.20	5 Yr	77400.00	713.88	739.95	726.44	740.40	0.000466	5.41	14312.08	813.80	0.23
US12 Memorial Br	6683.20	10 Yr	86400.00	713.88	740.72	727.08	741.24	0.000509	5.78	14944.05	821.81	0.24
US12 Memorial Br	6683.20	20 Yr	97200.00	713.88	741.56	727.81	742.16	0.000562	6.22	15636.38	830.50	0.25
US12 Memorial Br	6683.20	50 Yr	108000.00	713.88	742.38	728.50	743.06	0.000610	6.62	16323.80	840.04	0.26
US12 Memorial Br	6683.20	100 Yr	115200.00	713.88	742.97	728.97	743.70	0.000635	6.85	16825.69	847.04	0.27
US12 Memorial Br	6683.20	200 Yr	122400.00	713.88	743.56	729.39	744.33	0.000658	7.07	17322.40	853.81	0.28
US12 Memorial Br	6683.20	500 Yr	140000.00	713.88	744.78	730.44	745.68	0.000716	7.62	18369.63	861.72	0.29
US12 Memorial Br	6246.30	2 Yr	58680.00	713.87	738.28	725.70	738.64	0.000427	4.79	12237.77	781.95	0.21
US12 Memorial Br	6246.30	5 Yr	77400.00	713.87	739.64	727.25	740.17	0.000575	5.82	13309.83	795.49	0.25
US12 Memorial Br	6246.30	10 Yr	86400.00	713.87	740.38	727.97	740.98	0.000632	6.21	13903.16	806.94	0.26
US12 Memorial Br	6246.30	20 Yr	97200.00	713.87	741.18	728.83	741.87	0.000701	6.68	14552.35	819.29	0.28
US12 Memorial Br	6246.30	50 Yr	108000.00	713.87	741.97	729.63	742.75	0.000763	7.10	15201.65	831.29	0.29
US12 Memorial Br	6246.30	100 Yr	115200.00	713.87	742.55	730.14	743.38	0.000787	7.35	15682.99	835.15	0.30
US12 Memorial Br	6246.30	200 Yr	122400.00	713.87	743.11	730.60	744.01	0.000810	7.58	16158.23	838.96	0.30

HEC-RAS Plan: Knwn WSE River: Clearwater River Reach: US12 Memorial Br (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
US12 Memorial Br	6246.30	500 Yr	140000.00	713.87	744.29	731.72	745.32	0.000880	8.16	17147.45	846.85	0.32
US12 Memorial Br	5731.60	2 Yr	58680.00	714.00	738.30	723.89	738.44	0.000168	3.02	19443.65	1239.54	0.13
US12 Memorial Br	5731.60	5 Yr	77400.00	714.00	739.69	725.12	739.90	0.000225	3.65	21177.18	1261.13	0.16
US12 Memorial Br	5731.60	10 Yr	86400.00	714.00	740.45	725.68	740.68	0.000245	3.90	22135.06	1272.19	0.16
US12 Memorial Br	5731.60	20 Yr	97200.00	714.00	741.26	726.28	741.54	0.000270	4.19	23181.08	1284.16	0.17
US12 Memorial Br	5731.60	50 Yr	108000.00	714.00	742.07	726.85	742.38	0.000291	4.46	24223.40	1295.83	0.18
US12 Memorial Br	5731.60	100 Yr	115200.00	714.00	742.66	727.22	743.00	0.000301	4.61	24994.44	1304.29	0.19
US12 Memorial Br	5731.60	200 Yr	122400.00	714.00	743.25	727.58	743.60	0.000310	4.75	25757.97	1313.61	0.19
US12 Memorial Br	5731.60	500 Yr	140000.00	714.00	744.46	728.41	744.87	0.000338	5.12	27364.24	1333.73	0.20
US12 Memorial Br	5189.40	2 Yr	58680.00	713.84	738.18	724.18	738.34	0.000202	3.26	18013.88	1175.78	0.15
US12 Memorial Br	5189.40	5 Yr	77400.00	713.84	739.52	725.44	739.76	0.000272	3.95	19603.62	1195.76	0.17
US12 Memorial Br	5189.40	10 Yr	86400.00	713.84	740.26	725.95	740.53	0.000295	4.22	20490.26	1202.58	0.18
US12 Memorial Br	5189.40	20 Yr	97200.00	713.84	741.05	726.61	741.37	0.000323	4.53	21451.94	1209.94	0.19
US12 Memorial Br	5189.40	50 Yr	108000.00	713.84	741.84	727.21	742.20	0.000347	4.82	22409.02	1217.23	0.20
US12 Memorial Br	5189.40	100 Yr	115200.00	713.84	742.43	727.60	742.81	0.000358	4.98	23120.83	1222.54	0.20
US12 Memorial Br	5189.40	200 Yr	122400.00	713.84	743.00	727.95	743.41	0.000368	5.14	23824.22	1227.61	0.21
US12 Memorial Br	5189.40	500 Yr	140000.00	713.84	744.19	728.91	744.66	0.000399	5.54	25286.42	1238.09	0.22
US12 Memorial Br	4647.60	2 Yr	58680.00	713.74	738.07	724.30	738.23	0.000204	3.26	18020.01	1185.21	0.15
US12 Memorial Br	4647.60	5 Yr	77400.00	713.74	739.37	725.49	739.61	0.000278	3.95	19579.41	1213.45	0.17
US12 Memorial Br	4647.60	10 Yr	86400.00	713.74	740.09	726.03	740.37	0.000302	4.22	20464.85	1221.52	0.18
US12 Memorial Br	4647.60	20 Yr	97200.00	713.74	740.88	726.65	741.20	0.000330	4.54	21422.06	1227.21	0.19
US12 Memorial Br	4647.60	50 Yr	108000.00	713.74	741.65	727.23	742.01	0.000355	4.83	22375.44	1232.86	0.20
US12 Memorial Br	4647.60	100 Yr	115200.00	713.74	742.23	727.56	742.62	0.000365	4.99	23089.10	1237.06	0.20
US12 Memorial Br	4647.60	200 Yr	122400.00	713.74	742.80	727.95	743.21	0.000375	5.14	23794.06	1241.21	0.21
US12 Memorial Br	4647.60	500 Yr	140000.00	713.74	743.97	728.81	744.44	0.000406	5.54	25249.62	1249.71	0.22
US12 Memorial Br	4092.00	2 Yr	58680.00	713.73	737.97	724.82	738.11	0.000201	2.98	19669.15	1455.19	0.14
US12 Memorial Br	4092.00	5 Yr	77400.00	713.73	739.25	725.98	739.45	0.000264	3.59	21535.67	1476.55	0.17
US12 Memorial Br	4092.00	10 Yr	86400.00	713.73	739.97	726.51	740.19	0.000283	3.82	22603.73	1488.64	0.17
US12 Memorial Br	4092.00	20 Yr	97200.00	713.73	740.74	727.09	741.00	0.000306	4.09	23761.43	1502.15	0.18
US12 Memorial Br	4092.00	50 Yr	108000.00	713.73	741.51	727.66	741.80	0.000327	4.33	24924.14	1519.00	0.19
US12 Memorial Br	4092.00	100 Yr	115200.00	713.73	742.09	728.02	742.40	0.000336	4.46	25805.13	1531.65	0.19
US12 Memorial Br	4092.00	200 Yr	122400.00	713.73	742.66	728.36	742.98	0.000345	4.59	26681.68	1551.01	0.19
US12 Memorial Br	4092.00	500 Yr	140000.00	713.73	743.82	729.17	744.20	0.000375	4.91	28511.83	1593.75	0.20
US12 Memorial Br	3595.80	2 Yr	58680.00	713.73	737.67	726.89	737.95	0.000449	4.28	13698.72	1077.25	0.21
US12 Memorial Br	3595.80	5 Yr	77400.00	713.73	738.82	728.23	739.24	0.000607	5.17	14958.20	1110.46	0.25
US12 Memorial Br	3595.80	10 Yr	86400.00	713.73	739.50	728.83	739.97	0.000657	5.50	15715.21	1129.55	0.26
US12 Memorial Br	3595.80	20 Yr	97200.00	713.73	740.21	729.49	740.75	0.000716	5.88	16533.52	1147.13	0.27

HEC-RAS Plan: Knwn WSE River: Clearwater River Reach: US12 Memorial Br (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
US12 Memorial Br	3595.80	50 Yr	108000.00	713.73	740.93	730.13	741.53	0.000766	6.22	17364.17	1164.03	0.28
US12 Memorial Br	3595.80	100 Yr	115200.00	713.73	741.49	730.54	742.12	0.000779	6.40	18011.59	1172.62	0.29
US12 Memorial Br	3595.80	200 Yr	122400.00	713.73	742.03	730.96	742.70	0.000790	6.56	18653.95	1181.03	0.29
US12 Memorial Br	3595.80	500 Yr	140000.00	713.73	743.13	731.90	743.89	0.000841	7.02	19953.02	1197.86	0.30
US12 Memorial Br	3132.40	2 Yr	58680.00	713.72	737.36	724.63	737.73	0.000460	4.89	11990.56	785.49	0.22
US12 Memorial Br	3132.40	5 Yr	77400.00	713.72	738.35	726.35	738.92	0.000676	6.06	12781.79	811.89	0.27
US12 Memorial Br	3132.40	10 Yr	86400.00	713.72	738.96	727.10	739.62	0.000763	6.51	13280.26	830.04	0.29
US12 Memorial Br	3132.40	20 Yr	97200.00	713.72	739.59	727.93	740.36	0.000872	7.04	13810.70	847.37	0.31
US12 Memorial Br	3132.40	50 Yr	108000.00	713.72	740.23	728.77	741.11	0.000960	7.52	14353.86	856.78	0.32
US12 Memorial Br	3132.40	100 Yr	115200.00	713.72	740.74	729.27	741.69	0.000995	7.79	14794.90	861.58	0.33
US12 Memorial Br	3132.40	200 Yr	122400.00	713.72	741.25	729.79	742.25	0.001026	8.04	15231.97	865.40	0.34
US12 Memorial Br	3132.40	500 Yr	140000.00	713.72	742.22	730.92	743.40	0.001135	8.71	16075.04	872.72	0.36
US12 Memorial Br	2683.3	2 Yr	58680.00	713.72	736.80	726.77	737.44	0.000812	6.42	9139.51	609.16	0.29
US12 Memorial Br	2683.3	5 Yr	77400.00	713.72	737.45	728.50	738.48	0.001240	8.11	9540.85	614.90	0.36
US12 Memorial Br	2683.3	10 Yr	86400.00	713.72	737.91	729.23	739.11	0.001416	8.80	9819.21	618.85	0.39
US12 Memorial Br	2683.3	20 Yr	97200.00	713.72	738.32	730.08	739.77	0.001656	9.64	10079.24	622.51	0.42
US12 Memorial Br	2683.3	50 Yr	108000.00	713.72	738.75	730.88	740.44	0.001891	10.44	10342.71	626.21	0.45
US12 Memorial Br	2683.3	100 Yr	115200.00	713.72	739.14	731.42	740.98	0.002002	10.88	10591.72	629.68	0.47
US12 Memorial Br	2683.3	200 Yr	122400.00	713.72	739.53	731.94	741.52	0.002108	11.29	10838.78	633.10	0.48
US12 Memorial Br	2683.3	500 Yr	140000.00	713.72	740.13	733.16	742.55	0.002489	12.48	11215.28	638.17	0.52
US12 Memorial Br	2224.0	2 Yr	58680.00	713.72	736.63	725.08	737.07	0.000562	5.31	11057.22	745.17	0.24
US12 Memorial Br	2224.0	5 Yr	77400.00	713.72	737.20	726.70	737.91	0.000877	6.74	11483.20	754.62	0.30
US12 Memorial Br	2224.0	10 Yr	86400.00	713.72	737.62	727.47	738.45	0.001010	7.32	11800.53	761.59	0.33
US12 Memorial Br	2224.0	20 Yr	97200.00	713.72	737.99	728.35	739.00	0.001194	8.04	12084.76	767.78	0.36
US12 Memorial Br	2224.0	50 Yr	108000.00	713.72	738.37	729.15	739.55	0.001376	8.73	12375.27	774.05	0.38
US12 Memorial Br	2224.0	100 Yr	115200.00	713.72	738.75	729.67	740.03	0.001463	9.09	12671.95	780.41	0.40
US12 Memorial Br	2224.0	200 Yr	122400.00	713.72	739.13	730.14	740.51	0.001545	9.44	12968.85	786.72	0.41
US12 Memorial Br	2224.0	500 Yr	140000.00	713.72	739.65	731.27	741.35	0.001848	10.46	13382.73	795.43	0.45
US12 Memorial Br	1791.80	2 Yr	58680.00	713.72	736.56	723.93	736.84	0.000328	4.30	13649.13	842.63	0.19
US12 Memorial Br	1791.80	5 Yr	77400.00	713.72	737.08	725.25	737.55	0.000524	5.49	14093.24	855.86	0.24
US12 Memorial Br	1791.80	10 Yr	86400.00	713.72	737.48	725.85	738.03	0.000612	5.98	14437.25	865.97	0.26
US12 Memorial Br	1791.80	20 Yr	97200.00	713.72	737.82	726.52	738.50	0.000733	6.60	14737.44	874.69	0.28
US12 Memorial Br	1791.80	50 Yr	108000.00	713.72	738.17	727.17	738.97	0.000853	7.18	15045.77	880.79	0.31
US12 Memorial Br	1791.80	100 Yr	115200.00	713.72	738.55	727.59	739.42	0.000910	7.49	15374.38	885.57	0.32
US12 Memorial Br	1791.80	200 Yr	122400.00	713.72	738.92	728.01	739.86	0.000964	7.79	15702.91	890.33	0.33
US12 Memorial Br	1791.80	500 Yr	140000.00	713.72	739.40	728.96	740.57	0.001163	8.68	16133.00	896.52	0.36
US12 Memorial Br	1343.20	2 Yr	58680.00	713.71	736.48	723.47	736.70	0.000239	3.76	15589.04	924.79	0.16

HEC-RAS Plan: Knwn WSE River: Clearwater River Reach: US12 Memorial Br (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
US12 Memorial Br	1343.20	5 Yr	77400.00	713.71	736.95	724.67	737.32	0.000380	4.83	16030.27	927.17	0.20
US12 Memorial Br	1343.20	10 Yr	86400.00	713.71	737.33	725.22	737.77	0.000442	5.27	16382.28	929.07	0.22
US12 Memorial Br	1343.20	20 Yr	97200.00	713.71	737.65	725.83	738.18	0.000529	5.83	16676.09	930.65	0.24
US12 Memorial Br	1343.20	50 Yr	108000.00	713.71	737.97	726.43	738.60	0.000617	6.36	16975.92	932.26	0.26
US12 Memorial Br	1343.20	100 Yr	115200.00	713.71	738.33	726.82	739.02	0.000659	6.65	17310.82	934.05	0.27
US12 Memorial Br	1343.20	200 Yr	122400.00	713.71	738.69	727.21	739.44	0.000700	6.94	17645.04	935.84	0.28
US12 Memorial Br	1343.20	500 Yr	140000.00	713.71	739.12	728.11	740.05	0.000852	7.76	18048.66	937.99	0.31
US12 Memorial Br	880.20	2 Yr	58680.00	713.70	736.39	722.96	736.58	0.000218	3.47	16906.47	1058.36	0.15
US12 Memorial Br	880.20	5 Yr	77400.00	713.70	736.82	724.16	737.13	0.000349	4.46	17360.21	1064.18	0.19
US12 Memorial Br	880.20	10 Yr	86400.00	713.70	737.18	724.70	737.55	0.000407	4.87	17743.14	1069.06	0.21
US12 Memorial Br	880.20	20 Yr	97200.00	713.70	737.47	725.31	737.92	0.000489	5.39	18049.85	1072.96	0.23
US12 Memorial Br	880.20	50 Yr	108000.00	713.70	737.76	725.89	738.30	0.000573	5.88	18363.79	1076.93	0.25
US12 Memorial Br	880.20	100 Yr	115200.00	713.70	738.11	726.28	738.69	0.000613	6.15	18737.63	1081.64	0.26
US12 Memorial Br	880.20	200 Yr	122400.00	713.70	738.45	726.65	739.09	0.000652	6.40	19112.43	1086.34	0.27
US12 Memorial Br	880.20	500 Yr	140000.00	713.70	738.83	727.52	739.63	0.000799	7.17	19525.63	1091.50	0.30
US12 Memorial Br	0.00	2 Yr	58680.00	713.60	736.20	722.80	736.39	0.000214	3.51	16713.27	1014.82	0.15
US12 Memorial Br	0.00	5 Yr	77400.00	713.60	736.50	724.01	736.82	0.000352	4.55	17018.10	1017.45	0.20
US12 Memorial Br	0.00	10 Yr	86400.00	713.60	736.80	724.54	737.19	0.000415	4.99	17323.72	1020.09	0.21
US12 Memorial Br	0.00	20 Yr	97200.00	713.60	737.00	725.16	737.48	0.000506	5.55	17527.92	1021.85	0.24
US12 Memorial Br	0.00	50 Yr	108000.00	713.60	737.20	725.76	737.78	0.000602	6.09	17732.48	1023.61	0.26
US12 Memorial Br	0.00	100 Yr	115200.00	713.60	737.50	726.15	738.13	0.000649	6.39	18039.95	1026.25	0.27
US12 Memorial Br	0.00	200 Yr	122400.00	713.60	737.80	726.52	738.49	0.000695	6.67	18348.21	1028.89	0.28
US12 Memorial Br	0.00	500 Yr	140000.00	713.60	738.00	727.39	738.88	0.000879	7.55	18554.17	1030.64	0.31