Craig Memorial Bascule Bridge

Over the Maumee River

2023 Rehabilitation Alternatives Analysis Report

ODOT Bridge No. LUC-65-05.35

NBI Bridge No. 4805917

Pre-Final Report

Toledo, OH

April 3, 2024

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1.0 Executive Summary

This report presents a comparison of three levels of repair and rehabilitation for the Craig Memorial Bascule Bridge for consideration by the Ohio Department of Transportation (ODOT) and to plan for future construction needs at the structure for the goal of continued safe operation and use by marine, vehicular, and non-motorized traffic.

The alternatives considered for this analysis include:

1) Base Recommended Repairs outlined in the 2023 In-Depth Structural, Mechanical, and Electrical Inspection Report, which are the primary repair needs for the bridge based on the findings of the inspection;
2) Full Mechanical and Electrical Systems Replacement, including removal of the existing equipment for bridge operation and replacement of both systems with modern components;
3) Structural Rehabilitation to Improve Inventory Load Ratings to 1.0 or greater, focusing on strengthening repairs at specific bridge members with low load ratings.

This report includes the details of each alternative, a comparative analysis of one alternative to another in a progressive fashion based on the progressive scope of work for each alternative, considerations for implementation of each alternative, and a life cycle cost analysis.

The analysis included reviewing the detailed scope of each alternative, comparing the aspects of structure benefit related to level of effort and cost for the repairs within each alternative, the overall improvement to the structure and its lifecycle, and other considerations such as constructability and impact to structure use. By discussing advantages and disadvantages of what is included in each alternative, and describing the process of the detailed analysis of the impacts each alternative would make to the structure, several recommendations were developed that should present the beginning of a plan for making the repairs necessary to maintain the structure in the short term and throughout an extended service life.

The analysis of the three alternatives resulted in the recommendation to plan for the largest scope of repairs presented in Alternative 3. This alternative is the most costly approach, however, it is the most comprehensive and beneficial in terms of capital investment that will address immediate deficiencies as well as critical long-term improvements to operation and overall reliability.

It is clear that the bridge needs more than the base recommended repairs in Alternative 1 to continue to function with any confidence in both operation and general use. It is also clear that strengthening repairs should be delayed and follow more detailed structural analysis. Additionally, the structural repairs noted in the bascule span can be deferred to coincide with the strengthening repairs if needed. The benefit versus cost of the strengthening repairs should be revisited following a load rating analysis update, to determine the overall need of these repairs.

Moving forward with Alternative 3 provides ODOT with the best course of action that is easily editable as further details and specifics of operational system replacement is developed. It provides a path for short-term smaller scale repairs to be made as a prelude to the main items of the major repairs. It also leaves the window open for further analysis into the structural capacity of the bridge, through revised and updated load ratings, smaller scale structural repairs, and further evaluation into other strengthening options that may be beyond the scope of this analysis.

Alternative 3 will provide the most benefit to the long-term safe and reliable use of the bridge, maintaining its operational and structural capacity, for the level of effort and resources necessary for a project of this scale and scope. Though the project scope overall contains numerous complicated details, planning at this early stage will aid in determining the most efficient, most effective, and least disruptive means of performing the repairs while fully designing and detailing their installation.

It is further recommended that a combination of the base repair recommendations, the mechanical and electrical system full replacements, and the structural steel strengthening repairs be made to the structure over the next 10 years. The extended duration is for a matter of practicality and budgeting within the bridge's asset management plan, due to the large scale of the repairs and their associated costs. Implementing this repair package should extend the service life of the bridge as a whole for 70 years or more, considering routine and scheduled maintenance and repair activities during that time period.

The cost estimate for the recommended repairs presented in this report assumes a construction year of 2028 to allow for adequate planning, design, and contracting necessary for a project of this scope and complexity. The recommended high-level estimate is based on the conditions observed during the 2023 in-depth inspection, with quantities for deteriorated conditions determined based on these observations. Estimates for Alternative 2 repairs are based on historical costs for similar repair items at other projects. Estimates for Alternative 3 repairs are based on unit cost of installed steel. This estimate is not construction-level detail or comprehensive but is to serve as guideline for planning and budgeting. A detailed engineer's cost estimate will be established during the Plans, Specifications, and Estimate (PS&E) phase.

Alternative	Initial Cost	Service Life Extension	Life-Cycle Cost Present Worth Value (70-yrs, 2028 $$)
1. Base Repairs	$ 6,508,000	15-20 years	$ 24,949,100
2. M&E Operational Replacement	$ 20,016,000	35-50 years*	$ 24,187,600
3. M&E Operational plus Structural Strengthening	$ 20,260,000	35-50 years*	$ 24,431,700

Costs do not include contingency, mobilization, or other percentage based additional costs

** assumes replacement of some operational equipment within analysis period due to equipment and component service life less than analysis period*

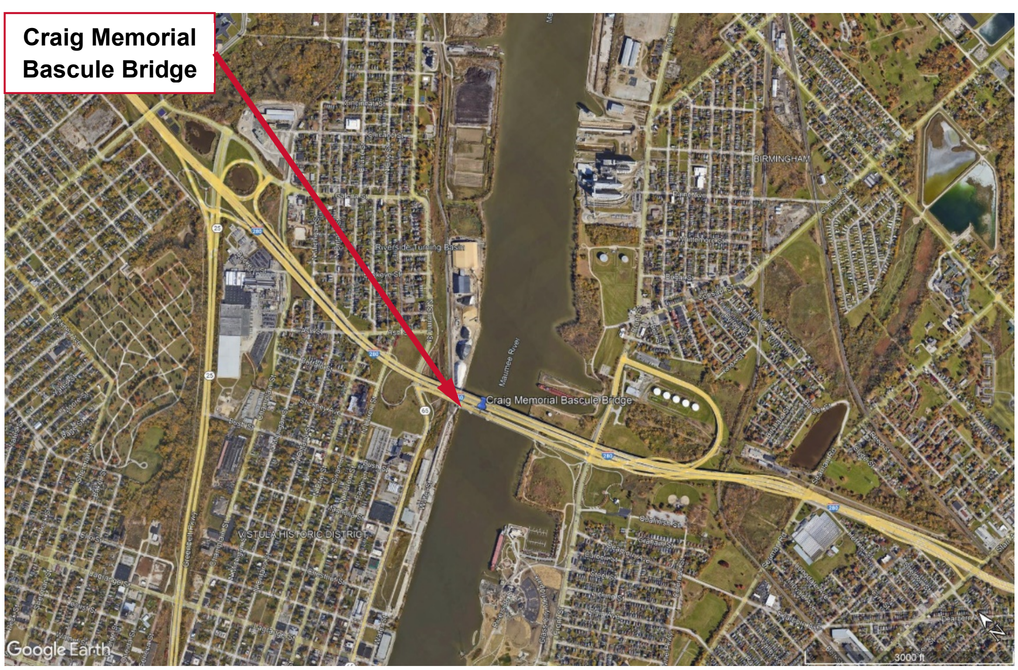
2.0 Introduction

2.1 Location & Description

The Robert Craig Memorial Bascule Bridge is a 10-span, 1600 ft long structure carrying state route 65 over the Maumee River in Toledo, OH. Construction started in 1951 and the bridge opened in January 1957 as part of Ohio's Toledo Expressway System, which later became interstate route IR-280. The bridge carried the interstate until the Veterans' Glass City Skyway Bridge was built in 2007 immediately east of the Craig Bridge, and I-280 was re-routed. The Craig Bridge was re-configured to carry SR-65. The bridge currently carries four lanes of vehicular traffic and a multi-use trail as an expanded sidewalk.

The main lift span is an approximately 245 ft long double leaf bascule, with each leaf consisting of four built-up riveted steel bascule girders, seven transverse floorbeams, 29 stringers, diagonal lateral bracing elements, and sidewalk framing elements. The span provides 200-ft of horizontal clearance for the shipping channel. The roadway deck is an open steel grid welded directly to the stringer top flanges at the grid main bars. The bascule span leaves are supported on two cellular trunnion piers located in the river. Foundations located below the channel flowline are steel pile driven to bedrock and capped with reinforced concrete.

The bascule span is flanked by four approach spans to the south and five to the north. Each approach span is composed of riveted built-up steel girders with floorbeams, stringers and reinforced concrete deck. The approach spans vary in size and configuration, including lanes, sidewalks and the mixed-use trail. The west sidewalk runs the full length of the bridge. The east sidewalk ends in Span 7 where it joins the mixed-use trail. The approach spans are supported on concrete wall type piers in the river and cap and column type piers on land. The pier foundations are concrete capped steel pile driven to bedrock. The North abutment is a cantilevered wall supported on capped pile foundations. The South abutment is cellular with a reinforced concrete deck supported on reinforced concrete walls on pile and with capped pile internal piers. The bascule span control room is located in the North trunnion pier. The previous ramps at the north end of the bridge were removed when the bridge was re-configured for local traffic. The bridge also crosses the Ann Arbor Railroad spur to the Toledo Harbor Warehousing.



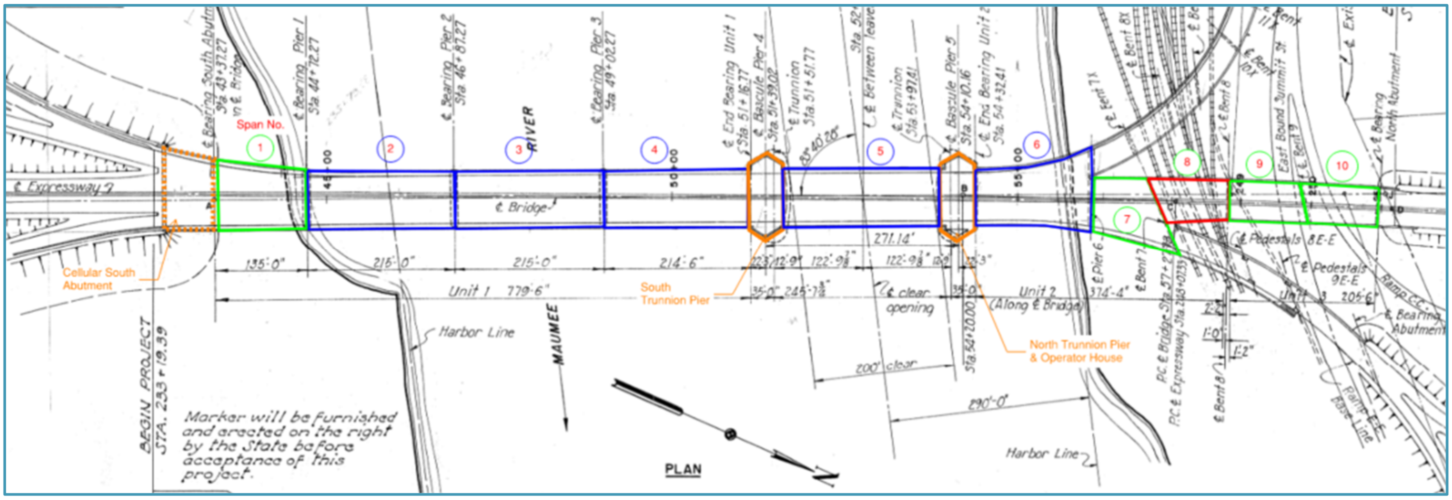


Figure 1: General Plan of Bridge, inspection plan color-coded for span type and access

2.2 Work History

1951-1957:	Designed by consulting engineers Howard, Needles, Tammen & Bergendoff, Kansas City, MO and New York, NY
	Contractor – Mc Dowell Co. Inc., Cleveland OH
	Fabricator – Fort Pitt Bridge Works, Pittsburg, PA
1958:	Bascule pier roofs over the machinery rooms were changed from concrete to steel roofs
1970:	Median curbs were changed to barriers
1980:	Bascule span steel grid deck was replaced, structural steel painted
1996-1997:	Bridge deck replacement, including barriers, railings, joints, drainage; structural steel repairs, painting
2001:	Rebuild of center locks, gear reducers and replacement of gate actuators
2003:	Replacement of brake thrusters
2004:	Replaced auxiliary backup gas engines with diesel engines
2007-2008:	Bridge approaches, sidewalks, barriers and railings were modified for rerouting to SR-65, removal of approach structures at north side of bridge
2011:	Replaced Tender house and Trunnion machine room roofs
2014:	Painting of Structural steel and structural steel repairs

2.3 Scope of Rehabilitation Options and Analysis

This report supplements and references the In-Depth Inspection Condition Findings Report, submitted following completion of the 2023 In-Depth Structural, Mechanical, and Electrical Inspection. From the summary of deterioration observed at the bridge during this current in-depth inspection, recommendations for repair will be outlined for each discipline. Using these recommended repairs, three alternatives for overall bridge rehabilitation will be analyzed with construction cost estimates.

The three alternatives being considered are:

Alternative 1: Recommended Base Repairs – The scope of the Recommended Base Repairs is the set of repairs recommended in the 2023 In-Depth Inspection Report. These represent the repairs needed to maintain the bridge for safe operations for both vehicular and marine traffic.

Alternative 2: Recommended Base Repairs plus Full Operational System Replacement (M&E) – The scope of this alternative includes the basic necessary structural repairs outlined in Alternative 1, plus the full operational system replacement to modern design standards for the mechanical and electrical systems that control the operation of the bascule span.

Alternative 3: Recommended Base Repairs, Full Operational System Replacement & Structural Capacity Rehabilitation – This alternative includes the base repairs recommended in Alternative 1, the full systems replacement added in Alternative 2, and adds repairs needed to increase structural capacity to improve the inventory load ratings to above 1.0 for the members currently rating lower than 1.0 for all vehicles and checks analyzed in the current load rating report provided by ODOT (2019).

Each of the alternatives will be compared and contrasted to highlight the pros and cons of each scope of work, estimated service life extension, initial construction and long-term life-cycle costs, constructability and considerations during construction such as mobility, future maintenance and additional structure improvements needed. Quantities will be included where appropriate for specific repair line items based on the current findings. Cost estimates will be projected to a construction year of 2028 and life cycle costs will project for a 75-year period for planning and asset management purposes. These will be in reference to a baseline “do nothing” option where any maintenance or construction activity on the bridge is limited to maintaining basic service allowing the bridge to operate for marine traffic only during the primary shipping season.

The cost estimate for repairs will utilize a set of standardized repair types with corresponding costs to provide an order of magnitude cost estimate to use for comparison between the alternatives, where applicable to a single or group of repairs. The level of detail of the cost estimate and any related quantities will be to an order of magnitude level of detail to provide comparison between the alternatives and for ODOT to use for decision making. Costs shown are for comparison purposes only for the scope of this report (order of magnitude) and do not represent actual or future costs at the time of construction. A full cost analysis and Engineer’s Estimate should be performed for the desired scope of work for any future construction project to complement detailed design, quantity and contract specifications.

Mechanical analysis of Alternative #2 included a review of the existing mechanical systems from the 2023 Inspection to determine the condition of the existing mechanical components and expected continued service life. The general design of each system was compared against AAHSTO Movable Bridge design guidelines to determine conformance with modern standards. Also considered in the analysis was the frequency of operation of the mechanical systems, the operating environment, and the availability of support for replacement components.

Electrical analysis of Alternative #2 included a review of the existing electrical and control systems from the 2023 Inspection to determine the existing equipment condition and expected continued service life. The information was then compared to current National Electrical Code requirements, typical equipment service life, availability of replacement parts, and AASHTO requirements.

3.0 Scope of Alternatives

3.1 Alternative 1: Recommended Base Repairs

The scope of the Recommended Base Repairs is the set of repairs recommended in the 2023 In-Depth Inspection Report. These represent the repairs needed to maintain the bridge for safe operations for both vehicular and marine traffic. It includes structural, mechanical, and electrical repairs, and recommended minor upgrades to mechanical and electrical systems, deemed necessary to address deficiencies and defects observed during the inspection. The inspection served to reset a baseline of current conditions for this rehabilitation alternatives analysis.

Cost estimates provided for each recommended repair item were preliminary, and based on recent historical costs for similar types and scopes of repairs for similar types of bridges and deficient conditions. For the purposes of this report and comparing this set of base repairs to the more extensive repair packages in Alternatives #2 and #3, the total cost of performing all recommended repairs are used, because base repairs are either included or superseded by the scope of repairs detailed in those alternatives.

This set of repair recommendations is categorized as the most conservative level of investment needed for the bridge and represents the planned short- and medium-term repair activities to keep the structure in safe working condition. While there may be variance in actual design and construction quantities, unit costs, and total costs from this baseline estimate, this is a reasonable estimate for the purpose of analysis and comparison for this report.

3.1.1 Structural

The bridge roadway, superstructure and substructure are in overall fair condition, exhibiting scattered minor to localized moderate deterioration to several bridge elements, and most prevalent in the bascule span. The approach spans on either side of the bascule span exhibit minor painted over section loss to superstructure components located below previous drainage features or otherwise exposed to roadway runoff or the elements, including the expansion joints and previous curb drains. The approach and main piers have previous concrete patch and crack sealing repairs throughout that are in generally good condition, however, also exhibit minor deterioration to repaired and adjacent areas. The bascule span exhibits scattered to widespread painted over section loss to girders, floorbeams, secondary members and connections, to varying degrees relative to percentage loss. There are other corrosion-related deficiencies, such as packing corrosion, holes, and cracking, to both the primary and secondary members in the span. The grid deck and supporting stringers in the bascule span exhibit localized areas of corrosion holes and cracked or broken welds at the grid deck to stringer top flange connections. The roadway deck and topside bridge elements are in generally good to fair condition, exhibiting minor cracking and service deterioration.

The structural repairs included in this alternative will address the main deficiencies as identified during the 2023 inspection and provide improvement to specific bridge components to extend the service life of the bridge as a whole. Primary investments (most extensive and most expensive) are those that will protect the bridge elements including epoxy overlay across the bridge deck surface, cleaning areas of corrosion and repainting, and concrete surface coating at the substructures. These activities are significant in quantity and cost due to the size of the bridge, not to the type of repair. These repair recommendations focus on deterring water infiltration, the primary cause of deterioration to steel and concrete. Additional significant cost repair recommendations include drainage and roadway safety items, such as joints, drain troughs, and bridge barriers. These will serve to limit exposure from water to structural elements below deck, provide a safe travel way for traffic, and assist in maintaining bascule span operation. Structural repairs, to main or secondary load-carrying elements, are minimal as recent structural rehabilitation has made many repairs that remain in good condition. Most structural repair recommendations are focused in the bascule span and consist of additional locations of similar repairs previously performed.

3.1.2 Mechanical

The mechanical components and operations for the bridge are generally in fair condition. The rack gear segment mounting bolts show substantial section loss, up to 100%, as well as corrosion. The open gearing displays excessive backlash, severe scoring and moderate corrosion build up. While it is acceptable for now, the teeth's scoring will exacerbate and expedite operational wear. In addition, the manual brake release levers on both the North and South side required between 120-150 pounds of force to release. These proved difficult for many of the local personnel to operate. As the leaves are descending, the bridge seats abruptly, starting and stopping multiple times before finally becoming fully closed. There were no signs of brake or trunnion rubbing noises, however, the bascule leaves occasionally made “clunking” noises while operating. Furthermore, both the North and South leaves made loud screeching noises during the opening sequence, though the origin of these sounds was not discovered. Where absent, lubrication ports should be inserted in the motor couplings and span lock couplings as indicated. The machinery components generally displayed moderate corrosion, the gear reducers exhibited some oil purging, the gear teeth had scoring on their surfaces, and fasteners were generally corroded. Lastly, the barrier gates would not properly function in the event a vehicle did not stop while the bridge was operating. The bridge is otherwise mechanically sound. The machinery’s service life will be extended with regular maintenance and the repair and/or replacement of the parts as mentioned further in this report.

The mechanical repairs outlined in Alternative 1 will address the primary deficiencies noted in the 2023 Inspection Report in order to maintain operational reliability of the bridge in the short term. The repairs provide service to the existing mechanical systems but do not provide substantial upgrades to modern design standards. The majority of repairs address isolated failures on the machinery which are specific to individual components and not widespread throughout the machinery. Widespread deficiencies are more economically addressed through major rehabilitation of machinery replacement. The repairs are expected to maintain the life of the machinery over a minimum of 15 to 20 years. It is expected that the mechanical systems will still need full replacement within the next 25 years if the Alternative 1 repairs are completed.

3.1.3 Electrical

The electrical distribution and control systems for the bridge and its auxiliaries are generally in poor condition, primarily due to age. The existing electrical and control systems are over 50 years old and are past their useful life expectancy. Due to the age of the existing equipment, operational inconsistencies are frequent and continual emergency repairs are expected. Some of the existing control components do not have readily available spare parts, and/or the ability for in-kind replacement due to physical space constraints and orientations. In addition, the overcurrent protection devices, such as circuit breakers, may not operate as intended and should be evaluated and tested by a certified electrical testing contractor in accordance with he recommended National Electrical Testing Association (NETA) requirements.

The electrical repairs included in this alternative will address the primary safety and operational deficiencies as identified during the 2023 inspection and provide improvement to specific bridge components to extend the service life of the electrical and control systems. These repairs are primarily focused on immediate safety issues and operational improvements within the existing electrical and control systems and do not provide significant changes to reliability or operation.

3.1.4 Recommended Repair List

The following pages outline the specific repair recommendations across the bridge, from the 2023 In-Depth Inspection Report. organized by discipline (structural, mechanical, electrical) then by priority categories as defined below.

The recommended repairs are organized by discipline and categorized based on immediacy of the repair need and type of bridge component. The prioritization categories are defined as follows:

1. **Priority Repairs** – Required work within a one-year period to address deficiencies that require emergency operations that may affect the load capacity of the structure, bascule span operation, or public safety.

2. **Contract Work** – Extensive work within a 2- to 5-year period that if deficiencies become worse, they may cause further damage, prevent span operations, affect traffic or public safety. These may also include engineering analysis, planning, and/or details and drawings.

3. **Capital Maintenance** – Recommended maintenance or repair activities within a 5-year period to be address deficiencies that may affect span operation for non-emergency operations, regulatory compliance, access deficiencies and aesthetics. This is work that may be performed by the Department's maintenance personnel or small-scale repair contracts.

4. **Monitoring** – Field observations where actual repair is not required but will require action if deficiency substantially worsens. There is no cost estimated for these recommendations; they should be implemented into the structure's inspection procedures and this effort should be included with the cost of future structure inspections.

<u>Structural:</u>

Priority Repairs

- Repair the locations of corrosion holes to the bascule span grid deck main bars.
- Replace the connection bolts (missing and in-place) at the vertical plates of the steel barriers in the bascule span.
- Repair locations of disconnected, broken, and missing piping at the drainage components below deck and at the piers.

Contract Work

- Replace the HPR joint material at the South approach.
- Install an epoxy overlay to the concrete deck surface across the bridge.
- Apply silane treatment to the faces of the concrete barriers in the fixed spans.
- Clean and paint the steel barriers in the bascule span.
- Repair the misalignment of the bascule span expansion joint finger plates by removing the plates, cleaning pack rust, painting, and adjusting as necessary during re-installation.
- Repair the bascule span rear longitudinal breaks at the girders by cleaning the pack rust causing the warping at the bases of the plates and straightening the warping.

- Replace the elastomeric troughs below the finger joints at the South Abutment, Piers 4, 5, 8 and the North Abutment.
- Repair the broken concrete header at the South Abutment joint at the West sidewalk.
- Repair the deteriorated areas of FB11S lower web and bottom flange at the North Abutment.
- Repair the locations of holes in the bascule span girder and floorbeam bottom flanges, webs, and bases of vertical stiffeners.
- Repair the locations of holes in the bascule span stringer webs.
- Repair the locations of holes in bascule span bracing members and connection plates.
- Repair the bascule span upper diagonal connections with holes, cracks or fully broken angles.
- Repair the locations of holes in the bascule span sidewalk support beam and post webs.
- Repair the locations of holes in the bascule span catwalk channels.
- Repair the locations of deteriorated bascule span catwalk supports at the diagonal bracing.
- Clean and paint areas of corrosion and localized paint failure at superstructure components in the fixed and bascule spans, localized at areas below expansion joints in the fixed spans and throughout the bascule span.
- Repair cracks greater than 0.0625” wide with injection-seal type repair in the abutment walls and in the solid pier walls.
- Perform concrete patch repairs to areas of delaminated and spalled concrete at the abutment walls, solid pier walls, and column-cap beam piers.
- Apply a concrete surface coating over the vertical and horizontal surfaces of the abutments, wingwalls and piers to seal previous repairs, minor cracking, and prevent water infiltration.
- Repair the corrosion holes at the Span 6 sign gantry east support at the fascia.
- Repair the deteriorated conduit connections, supports and junction boxes throughout the bridge.
- Repair cracks greater than 0.0625” wide with injection-seal type repair in the bascule pier interior walls and other locations within the pier interiors.
- Perform concrete patch repairs to areas of delaminated and spalled concrete at the bascule pier interior walls, counterweight span underside, and other locations within the pier interiors.
- Perform spot cleaning and painting at the tower bases and locations of active corrosion.
- Install reinforcement repairs at the tower bases and other locations of section loss and corrosion holes, and provide drainage protection for the tower interiors.
- Clean and paint the areas of corrosion at the tops of the counterweight and determine if patching repairs are necessary to the counterweight concrete block.
- Repair or replace broken, missing or otherwise deteriorated access stairs, hand railings or related items throughout both pier interiors.
- Install fire and life safety items within both pier interiors.

Capital Maintenance

- Remove the vegetation growth from the northwest quadrant sidewalk and repair the settlement of the sidewalk at the railing transition.
- Repair damaged metal meshing at the overhead sign gantry in Span 4 at the SE access ladder.
- Repair the uplift at the bascule span rear break sidewalk joint cover plates by removing the plates, cleaning pack rust, painting, and adjusting as necessary during re-installation.
- Clear debris from horizontal surfaces in the fixed spans superstructure and pier tops (bird nesting, etc.).

- Clear debris from bascule span horizontal surfaces of girders, floorbeams, secondary members, and other superstructure components.
- Replace missing caps at the tops of light poles.
- Repair or replace missing or out of place hand hole covers at the light poles.
- Repair or replace non-functioning navigational lights at Span 5 and the bascule piers.
- Replace fire extinguishers.

Monitoring

- Monitor the bascule span grid deck for additional cracking at the main bar to stringer connections.
- Monitor the concrete deck underside to track changes in the existing minor cracking and note future in-service deterioration.
- Monitor fixed span girder locations of packing corrosion for growth and additional warping.
- Monitor fixed span girder areas of painted over section loss for paint failure and re-initiating corrosion.
- Monitor fixed span floorbeam areas of painted over section loss and corrosion holes for paint failure and re-initiating corrosion.
- Monitor fixed span sidewalk framing areas of painted over section loss and corrosion holes for paint failure and re-initiating corrosion.
- Monitor bascule span girder areas of painted over section loss for paint failure and re-initiating corrosion.
- Monitor bascule span floorbeam areas of painted over section loss for paint failure and re-initiating corrosion.
- Monitor bascule span bracing member areas of painted over section loss for paint failure and re-initiating corrosion.
- Monitor bascule span sidewalk framing areas of painted over section loss for paint failure and re-initiating corrosion.
- Monitor bearing positions during summer and weather months to confirm normal operation.
- Monitor the tilted bearings at Pier 5 north.
- Monitor corrosion conditions at light pole bases and remove / replace poles as needed in a similar fashion to those removed following this inspection.

Mechanical:

Priority Repairs

- Replace the railings in the machinery rooms around the staircases and open gearing for the safety of maintenance team.
- Adjust/repair manual release hand brakes across all machinery.
- Adjust brakes to factory settings for torque, clearance, and thruster reserve stroke.
- Remove corrosion from brake wheels and ensure brake pads are in contact when set and release fully when energized.
- Replace auxiliary engine batteries.
- Remove stacks of counterweight blocks from machinery room floors to prevent injury and move to storage room or counterweight pit.
- Tighten or replace all loose fasteners across motors, brakes, actuators, housings and supports.
- Fix bottom driven limit switch that slightly contacts target on NE outboard span lock.
- Replace selsyn motor on south side cam assembly and tighten chains on span drive machinery.

- Tighten loose guy wires on traffic gates.

Contract Work

- Evaluate the rack mounting system and bolts, which should be rated by a mechanical or structural engineer based on various loading conditions.
- Clean and repaint areas of corrosion across all machinery.
- Rehabilitate raised buffer cylinders as well as the strike plates and their fasteners.
- Re-align seated buffer cylinders and rehabilitate corroded hardware.
- Rehabilitate supports for open gearing bearings where section loss is present, and pack rust is forming.
- Rehabilitate gear covers and gaskets for G2 gears.
- Replace open gearing.

Capital Maintenance

- Install new lubrication and purge fittings on the motor couplings and add the couplings to the bridge lubrication schedule.
- Clean open gearing of all lubrication, corrosion, and debris. Re-lubricate with fresh grease.
- Monitor gear condition and consider open gearing replacement.
- Lubricate span lock motor couplings regularly. Pull purge plugs when lubricating.
- Replace bulging O-Ring being used on SE motor coupling.
- Install drainage system below roadway breaks to prevent wear and corrosion on open gearing caused by the elements.
- Re-align crank arms and shafts in NE and SW traffic gate housings. Replace arms if they are deformed.
- Clean auxiliary engines of excess grease and oil. Address fluid leaks.
- Clean span lock gearing and racks of all contamination and debris then re-lubricate.
- Adjust bumper for NE vertical traffic gate to ensure it contacts roadway upon lowering.
- Replace all non-functional and missing lighting on traffic gates.
- Replace all locks and handles on traffic gate machinery housings.
- Rehabilitate access doors for swing gate machinery.
- Clean machinery of all excess debris to prevent further wear.
- Monitor condition of wooden counterweight bumpers and contacting plates in counterweight pit along with their fasteners.

Electrical:

Priority Repairs

- Tighten loose guy wires on traffic gates.
- Re-align crank arms and shafts in NE and SW traffic gate housings. Replace arms if they are deformed.
- Test all 3-phase circuit breakers and replace any defective breaker
- Replace missing light at southeast gate
- Install wire numbers for each conductor in termination cabinets and control console
- Investigate the cause for stoppage of the leaves during bridge closing
- Replace missing seals at outdoor enclosures
- Replace missing bulbs and fixtures throughout

- Install emergency lighting
- Install GFCI receptacles in wet locations

Contract Work

- Remove abandoned equipment in the south and north piers, at the utility-owned transformers in the piers, at the monitoring PLC and associated I/O rack, and near the main gear reducers
- Replace original panel boards
- Install a second main drive motor starter cabinet (dedicated to the main drive motors) or replace the existing cabinet
- Replace the remaining starters and relays
- Rehabilitate or replace the existing main drive motors with low insulation ratings and abnormal brush wear
- Replace the existing brake junction boxes with termination cabinets
- Replace the conduit located near the traffic gate actuators that are severely corroded
- Replace the junction/pull/termination boxes / enclosures for the traffic signals
- Clean and properly maintain the overspeed switch
- Replace the existing RGS conduit system
- Replace the original 1950s conductors throughout

Capital Maintenance

- Relocate the utility-owned medium voltage transformers to the roadway deck off of the span
- Relocate the service entrance disconnect to the roadway deck level of the control house
- Replace the remaining conductors in the motor starter cabinet
- Test the 1950s conductors and contactor arc chutes for asbestos
- Replace the existing original 1950s brakes
- Replace the horizontal swing type gates to match the other gates that have more readily available parts
- Replace the original control console switches, pushbuttons, lights and meters equipment with modern parts
- Replace the selsyn transmitters with modern transmitters

Cost Summary by Type and Discipline (2028 $)

Repair Type	Structural	Mechanical	Electrical	Sub-Totals:
Priority Repairs	$ 59,000	$51,000	$93,500	$203,500
Contract Work	$ 3,054,388	$1,374,000	$1,096,000	$5,524,388
Capital Maintenance	$ 21,650	$58,000	$700,000	$779,650
Sub-Totals:	$ 3,135,038	$1,483,000	$1,889,500	
			Overall Total:	**$ 6,507,538**

3.2 Alternative 2: Recommended Base Repairs plus Full Mechanical and Electrical Operational System Replacement

This alternative includes the base repairs recommended in Alternative 1 and adds the full operational systems replacement of the mechanical and electrical (M&E) systems. The M&E systems replacement may supersede repairs recommended identified as part of Alternative 1 as several of those repair recommendations would be accounted for with an M&E system replacement.

The recommendations for M&E replacement are preliminary in nature and do not represent a design. They represent a starting point from which a design can proceed. Additionally, the recommendations presented in this alternative do not include every constructability consideration required for design, cost estimating, and construction. There are numerous ancillary considerations that need to be included in the design phase of the repairs explored herein, however the current analysis considers the major factors contributing to the design effort and overall estimated costs.

3.2.1 Mechanical Systems

3.2.1.1 Span Drive Machinery Replacement

Alternative 2 includes complete replacement of the span drive machinery to achieve a 70-year service life and upgrade the machinery to meet current AASHTO design standards. **Figure 3.2.1.1a** depicts a sample layout for the new span drive machinery.

The system will include two fully redundant electric motors which can operate the leaf independently or together. The current bridge is equipped with a diesel engine for auxiliary operation of the span. While the main motors provide redundancy in the case of a single motor failure, an additional, smaller auxiliary motor may be added which can be powered from the backup generator if main power service were to fail. Note the auxiliary motor is not currently depicted in **Figure 3.2.1.1a** but would be coupled to an additional input shaft on the primary gear reducer.

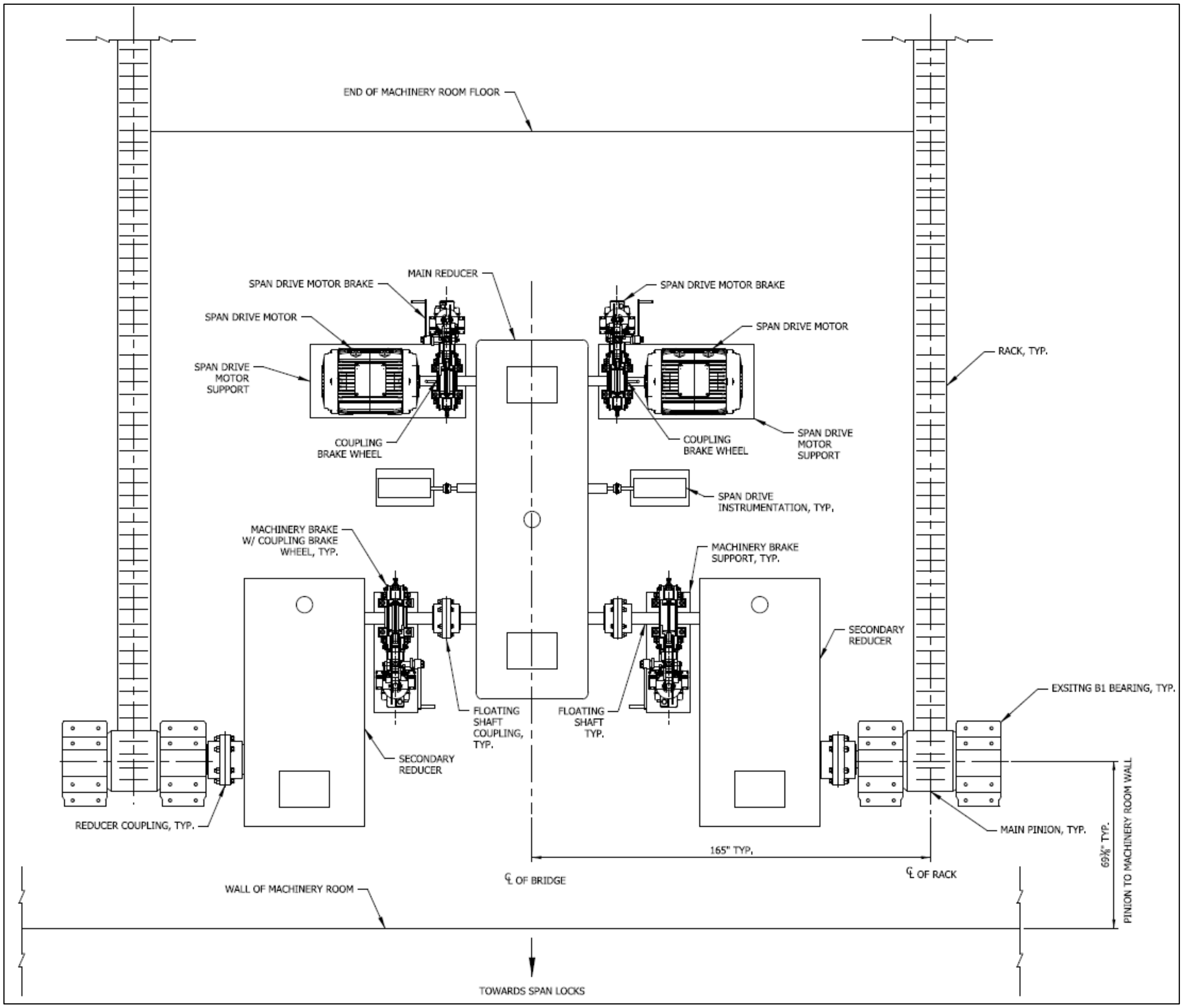


Figure 3.2.1.1a: South Span Drive Machinery Layout (North Similar)

While the bridge is operating, the motors and drives will serve as the primary source of braking. Two motor brakes and two machinery brakes will be provided for each leaf to meet the AASHTO deceleration and holding load requirements. The existing brakes are in poor condition due to frequent exposure to moisture and debris, partially due to their location below the joints between the roadway and bascule girders. The new motor brakes will be located on the input shafts of the primary reducer to allow the motors to be removed for service without losing brake capacity and to avoid the area below the roadway joints. The machinery brakes will be located on the input shafts of the secondary gearboxes to apply braking load as close to the movable span as reasonably possible while utilizing industry standard sized brakes. The brakes will be upgraded to the industry standard electro-hydraulic thruster operated drum brakes which include externally adjustable torque springs, torque scales, adjustable time delay settings, latching manual hand releases, and limit switches for the set, released, and hand released positions. Removable stainless steel brake covers will be provided for each new brake to protect the brakes from the harsh conditions below the bridge.

The existing open gearing, other than the racks and pinions which are a key aspect of the bascule design, will be replaced with enclosed gearboxes. A central primary gear reducer will include a differential to evenly split torque between the two secondary gearboxes that couple directly to the main pinion shafts. The existing open gearing and plain bearings are not shielded from the harsh environment below the bridge and require frequent manual lubrication which is time consuming and leads to a buildup of grease on the machinery floor. Enclosed gearing typically lasts longer than open gearing as it provides automatic lubrication of the gearing and a tight seal around the machinery to prevent contamination. The span drive machinery instrumentation will be coupled to one of the intermediate shafts on the gear reducers for ease of access. The main pinions will be replaced in similar kind with integral main pinion shafts coupled directly to the secondary gear reducers. The main pinion bearings and supports will be replaced to address the corrosion and section loss present at the base of the existing supports. Due to tooth wear, section loss on the casting stiffeners, and widespread bolt failure, the segmental rack segments are expected to be replaced, unless further investigation provides evidence to support a 70-year service life without a major rehabilitation effort.

3.2.1.2 Span Lock System Replacement

The existing span lock machinery is original to the bridge and has several elements in poor condition. Alternative 2 includes complete replacement of the existing span lock system to achieve a 70-year service life and upgrade the machinery to meet current AASHTO design standards. **Figure 3.2.1.1b** depicts a sample layout for the new span drive machinery.

The new span lock system may use utilize individual electric linear actuators to drive lock bars in place of the existing link assemblies. The link assemblies utilize an excessive number of moving parts which require frequent maintenance and introduce multiple points of failure and wear. The new actuators utilize compact enclosed gear reduction and acme screws which require minimal maintenance and are protected against debris and moisture which accelerate wear. Each actuator will be equipped with limit switches for position indication and a hand wheel for manual operation. The actuators will be sized to operate on a backup generator to prevent the need for manual operation in the case of a power failure. Based on additional load and deflection analysis, the four center locks may be reduced to three lock bars to reduce the overall number of moving parts and weight on the span.

New receivers and guides will be added to the span to constrain the lock bars and transfer shear loads between the spans. The receivers and guides will include easily adjustable bronze wear shoes to initially align the lock bars and account for wear over time. Lubrication lines will be added between the grease locations and a centrally located grease manifold to minimize maintenance time and ensure difficult to reach areas receive proper lubrication.

The new system may require access holes to be added through the floor beams near the end of the span and bascule girders to allow room for the longer span lock assemblies. More spacious walkway will be added to access all parts of the new system.

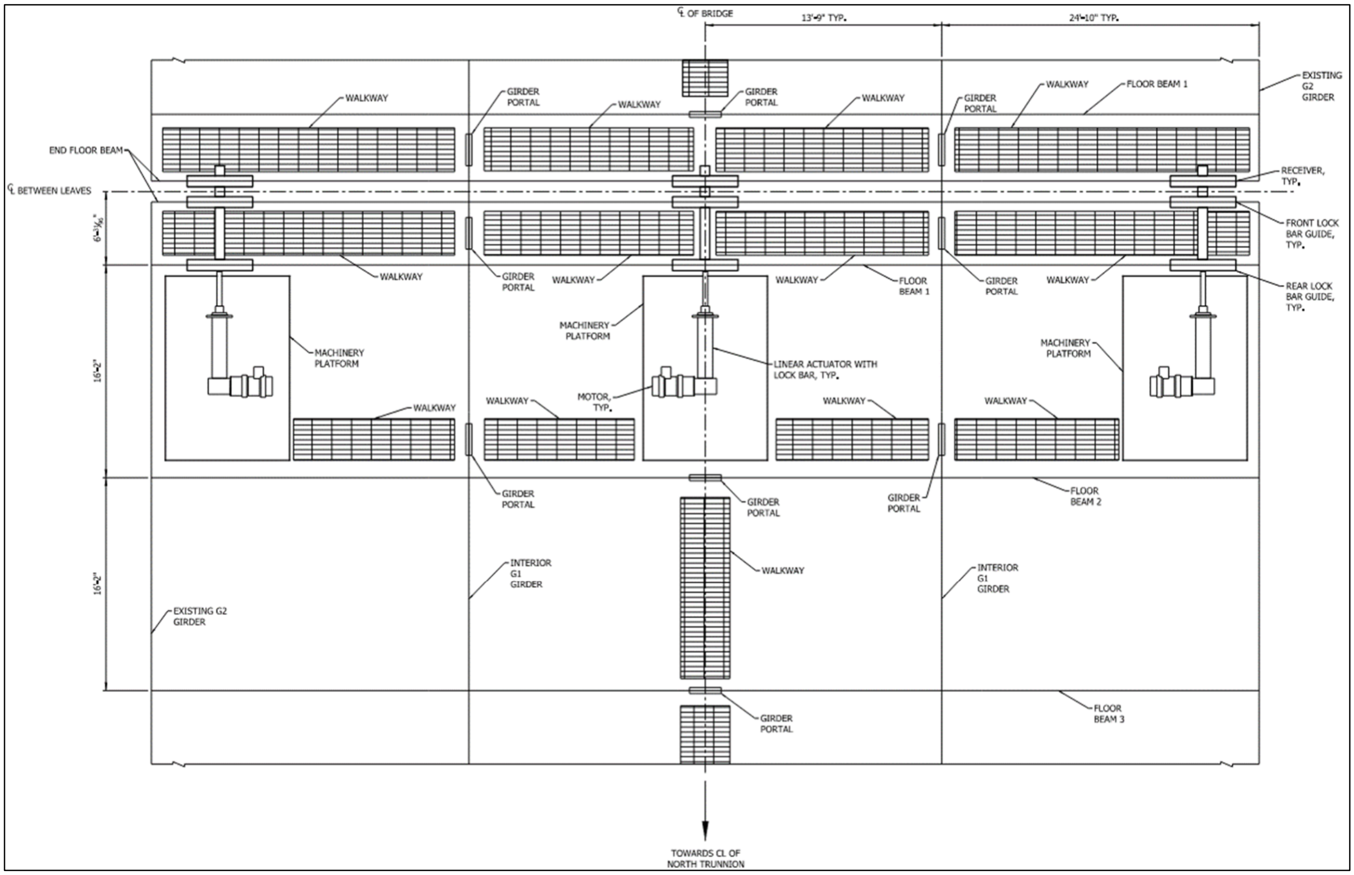


Figure 3.2.1.1b: Sample Span Lock Machinery Layout

3.2.1.3 Trunnion Bearings

The trunnion bearings are in fair condition and require minimal rehabilitation effort. All fasteners and hardware which exhibit section loss and corrosion will be replaced in kind. All areas of corrosion on the bearings and trunnions will be cleaned to bare steel and repainted. A sample of trunnion bearing caps will be removed to check the trunnion journal surfaces for deficiencies. This should be done before construction because it is a long-lead item that will require jacking and shoring schemes if issues are discovered.

3.2.1.4 Live Load Bearings

The live load bearings will be rehabilitated as part of Alternative 2. The existing design provides adjustability on the fixed structure using a threaded bearing that can be raised and lowered and adjustability on the bascule girder using shim-able steel shoes. The threaded bearing design is not equipped with a positive lock to prevent the bearing from moving over time. The design is also prone to corrosion which can cause seizing and prevent future adjustment. The rehabilitation will permanently lock the bearing in place to prevent adjustment, and the shoes on the bascule girders will be adjusted to provide the necessary level of contact between the shoes and bearings. Future adjustment will always be possible using shims below the shoes, so adjustment of the bearing will no longer be required.

3.2.1.5 Span Air Buffers

The existing air buffers used to seat the span will be removed from service. The air buffers provide little benefit when the bridge is driven by electric motors with variable frequency drives as the drives are capable of accurately controlling the speed and torque of the motors during seating. The existing diesel engine will no longer be used to seat the bridge and a new electric auxiliary motor used to seat the bridge on a backup generator would be sized to operate the bridge slower than when using the main span drive motors.

3.2.1.6 Overtravel Air Buffers

The overtravel air buffers will be removed and replaced with thick pads of elastomeric material. The existing buffers are rarely used and often nonfunctional. New elastomeric pads installed on the superstructure and substructure in place of the existing buffers and timber bumpers will be capable of absorbing the kinetic energy of the span during overtravel and prevent damage to the bridge. The pads are economical and maintenance free.

3.2.1.7 Traffic and Barrier Gate Machinery

The existing barrier gates are in poor condition and the cantilevered swing design is not sufficient to prevent roadway traffic from driving through the gate and damaging the bridge or protecting the traveling public. The gates do not extend across the full length of the roadway so cars may drive around the gates. The corroded gate arms are likely subject to complete failure if struck by a vehicle, and the ends of the gates are not supported when in the closed position. The barrier gates will be replaced with a different design which is more robust and supports the end of the gate arm to prevent failure allowing vehicular traffic to pass through or by the gate arm. The new gates will extend the entire width of the roadway to prevent cars from driving around the gates.

The traffic gates will be replaced in kind. Gate replacement is not immediately necessary, but the gates exhibit signs of wear and areas of potential isolated failures. In-kind gate replacement is a minimal additional effort when compared against the larger group of machinery replacements and will provide gates with a service life expected to exceed 30 years.

3.2.1.8 Bridge Balance

As most of the bridge machinery is located on the bridge substructure, minimal balancing effort is expected. The span lock machinery replacement will mostly contribute to the change in bridge balance. The weight expected to be added to offset the new machinery is estimated not to exceed the capacity of the existing bridge and counterweight pockets. More accurate calculations will be performed to determine the change in span balance during construction and strain gauge balance testing will be performed at several points during construction to confirm the balance.

3.2.2 Electrical Systems

As identified in the 2023 inspection the electrical distribution and control systems for the bridge and its auxiliaries are generally in poor condition and need full replacement. Very little of the existing electrical and control system could be salvaged during an electrical and control system replacement. The equipment that could be re-used in most instances would not be prudent or cost effective due to construction staging and/or location of some of the new equipment and for this reason, a complete replacement of all electrical and control system components is considered for this alternative.

3.2.2.1 Power Distribution Equipment

The new power distribution equipment includes the service entrance disconnect, 480V distribution panelboards, lighting panelboards and lighting transformers. As identified in Alternative 1, the existing utility owned equipment will be removed from the bridge and located in more readily accessible location. The relocation of the utility owned equipment will also allow for the relocation of the main service disconnect switch to a better location.

An emergency backup generator with an automatic transfer switch (ATS) will be utilized for backup electrical power.

A new 480V panelboard will be located on both piers to distribute power for the bridge operational loads (motors/brakes) and the HVAC equipment loads. Lighting transformers and panelboards will be utilized to further distribute 120/240V power for smaller loads such as building lighting and receptacles.

3.2.2.2 Main Drive Motors Brakes

In conjunction with the mechanical improvements for the span drive machinery, new main drive motors for span operation will be replaced with invertor-duty/vector type motors. The new motors are designed to be utilized with modern motor control equipment that will allow for significantly increased speed and torque control. The motors would be equipped with encoders to provide speed feedback, condensation heaters and internal thermostats.

The existing motor and machinery brakes will be replaced with new modern brakes with more readily available spare parts and are easier to adjust. The new brakes will be thrustor-style brakes. Similar to the existing brakes, they will include limit switches that provide brake position for the set, release, and hand released indications. Each brake will be enclosed within a stainless-steel enclosure and be equipped with a heater.

As with the existing main drive motors and brakes, NEC required disconnects will be located within sight of each motor and brake.

3.2.2.3 Span Locks

In conjunction with the mechanical improvements for the span lock machinery, the span locks will be driven from a new electric motor. The new motor will be equipped with condensation heaters and a safety disconnect switch that will be located within sight of the motor.

3.2.2.4 Motor and Brake Control

The main drive motors will be controlled by variable frequency drives (VFDs). VFDs have the ability to accurately control the speed of the motors and provide torque limiting, both of which the existing main drive motor controls severely lacked. Each main drive motor will have its own VFD. While it would be a viable option to have all the VFDs located on the near rest pier, for the purposes of this alternative it is assumed that the VFDs controlling the near span drive motors will be located on the near rest pier and the VFDs controlling the far span drive motors will be located on the far rest pier, similar to the existing setup.

There are several different main drive motor control arrangements available and for the purposes of this alternative a similar arrangement to the existing main drive motor control arrangement is anticipated. Under normal conditions it is assumed that both span drive motors will be utilized to operate each leaf. In the event of a VFD and/or motor failure it is anticipated that a single motor would be utilized to operate its corresponding leaf.

Each VFD will also be enclosed within its own enclosure. By installing each VFD within its own enclosure each VFD could be turned on/off and maintained individually.

The motors for the brakes, span locks, and the traffic gates will be controlled using standard NEMA motor starters similar to how they are currently controlled. There are several different ways to install the motor starters and for the purposes of this alternative it is assumed that the motor starters will be installed within a motor control center (MCC). An MCC offers the benefit for each motor starter and subsequent motor to be turned off individually and provides added safety features that will limit the maintenance staff exposure to energized terminal blocks and conductors during maintenance activities.

3.2.2.5 Auxiliary Motor

The existing bridge utilizes diesel engines and manual cutout couplings to operate the bridge during electrical power failures or main drive motor failures. While a diesel engine could be re-installed, it would be prudent to install an electric motor with an electric clutch to operate the bridge, especially if the bridge is equipped with an emergency backup generator as included as part of this alternative. An electric motor and clutch would reduce maintenance costs and allow the bridge tender to operate the bridge during emergencies without having to require maintenance personnel to be dispatched to the bridge immediately if the main drive system malfunction.

3.2.2.6 Traffic Gates

All the existing traffic gates will be replaced, especially the swing out style gates. Each swing out style traffic gate will be replaced as included with Alternative 1, the on-coming swing out, horizontal traffic gates will be replaced to match the off-going traffic gates, which are significantly more common on movable bridges. By replacing the swing out style traffic gates with traditional gates several components, such as the actuator and VFD, will no longer be required further reducing maintenance needs and control system complexity.

3.2.2.7 Control System

As with any movable bridge there are several different control arrangements that can be utilized. The existing relay-based control system, with a programmable logic controller (PLC) monitoring system is no longer typical or considered "good" practice. For the purposes of this alternative, it is assumed that the control system will utilize a PLC system for normal bridge operations and a limited relay-based control system for emergency or auxiliary controls. The main drive motors will only be utilized when operating with the PLC and the auxiliary motor will only be utilized when operating with the relay based controls. This proposed arrangement will provide the opportunity to utilize the automation and troubleshooting features a PLC can provide while still maintaining a limited option of utilizing a simple relay based operation system. This proposed arrangement is the typical setup provided for many modern movable bridge control systems.

While a PLC based control system has the ability to provide "one push button" type of control operations it is generally not practical for highway and pedestrian bridges due to the variability of the traveling public when attempting to lower the traffic gates. All other operations would be automatic. PLC systems can be modified more easily than relay-based control systems. The PLC will provide warnings, alarms and diagnostic information to a human machine interface (HMI) touch screen than can significantly reduce troubleshooting activities in the event of failures.

A relay-based control system will be utilized to operate the span in the event of an emergency or failure of the PLC, main drive motors/VFDs and power outage. The use of a relay-based control system is intentionally limited to help ensure that the normal operating system is fully functional.

A new control console will be installed within the control house to accommodate the new control system and HMI.

3.2.2.8 Instrumentation

Similar to the existing, this alternative includes the installation of several different types of equipment to provide position feedback. Lever arm or proximity type limit switches will be utilized to provide end of travel information such as span lock fully driven, span lock fully pulled and bridge fully seated.

A rotary cam limit switch will be utilized to provide discrete span position locations, such as nearly closed, nearly open, and fully open.

An absolute position encoder (resolver) will be utilized to provide span position indication throughout the travel.

3.2.2.9 Conduit and Conductors

As observed during the 2023 inspection the existing conduit system is in poor condition. While some of the conductors have been replaced, it is not prudent to attempt to re-use the existing conductors based on the condition of the conductors. Since the conduits need to be replaced, new conductors should be installed with all new conduits.

3.2.2.10 Submarine Cable and Cabinets

Primarily due to age of the existing submarine cables, it is prudent to include the installation of new submarine cables and cabinets as part of this alternative. The existing cables are operating well beyond their recommended useful life. In addition, the existing cables will likely not contain the number, type and size of conductors that will be needed, especially in regard to communications. Likewise, the existing cabinets are difficult to maintain and open, which further limits access to the cable terminations. The new submarine cables will include the conductors required for the various power, control, and communication circuits. Ethernet or fiber optic cable will be required for communications to the VFDs and to provide connectivity for the CCTV equipment. The new termination cabinets will be provided with doors that will allow for significantly easier access.

3.2.2.11 Navigation Lighting

New center channel navigation lights and pier lights will be replaced in kind.

3.2.2.12 CCTV

CCTV equipment and cameras will be installed to help assist the bridge tender in ensuring that vehicles and pedestrians are behind the traffic gates, especially on the far approach spans where it can be difficult to determine exact vehicle and pedestrian location. In addition to enhancing the bridge tender's visibility cameras can help provide added security.

3.2.3 Summary of Repair Recommendations

The following pages outline the specific repair recommendations for an M&E Replacement. The recommended repairs are organized by discipline, and it should be noted that M&E equipment routinely effects the other discipline. The recommendations included in this alternative supersede the recommendations that were included in the base repairs Alternative 1as a complete system replacement will address all items identified in Alternative 1.

Mechanical:

- Replace existing traffic gates.
- Replace the span drive machinery systems.
- Replace the span lock systems.
- Rehabilitate the trunnion bearings and inspect the trunnion journals.
- Rehabilitate the live load bearings.
- Remove the air buffers.
- Replace the overtravel buffers and timber bumpers with elastomeric bumpers.
- Rebalance bridge to account for change in balance caused by the machinery replacements.

Electrical:

- Remove the existing electrical and control equipment in its entirety.
- Relocate the utility-owned medium voltage transformers to the roadway deck off of the span.
- Relocate the service entrance disconnect to the roadway deck level of the control house.
- Install generator and ATS.
- Install new 480V distribution panelboards on the near and far rest piers.
- Install new 120/240V lighting panelboards and associated lighting transformers on the near and far rest piers.
- Install new invertor duty main span drive motors.
- Install new motor and machinery brakes.
- Install new span lock motor.
- Install new disconnects for all motors and brakes.
- Install VFDs for main span drive motor control.
- Install a new auxiliary motor and electric clutch.
- Install new traffic gates.
- Install new PLC based control system, with an HMI display. A relay-based control system will also be installed for auxiliary controls.
- Install new control console.
- Install new limit switches and span position instrumentation.
- Install all new conduit and conductors throughout the bridge.
- Install new submarine cable.
- Install new navigation and pier lights.
- Install new CCTV system.

Alternative 2 Cost Summary:

Full Operational System Replacement, 2028 $	
Mechanical	$ 14,050,000
Electrical	$ 2,893,000
Alt 1 Items (str)	$ 3,073,000
Total	**$ 20,016,000**

Costs do not include contingency, mobilization, or other percentage based additional costs

3.3 Alternative 3: Recommended Base Repairs, Full Operational System Replacement & Structural Capacity Rehabilitation

This alternative includes the base repairs recommended in Alternative 1, the full systems replacement added in Alternative 2, and adds repairs needed to increase structural capacity to improve existing inventory load rating factors to above 1.0 for specific members. The repairs recommended do not supersede repairs recommended as part of Alternative 1.

The recommendations for structural capacity improvement repairs are preliminary in nature and do not represent a design. They represent a starting point from which a design can proceed, under the assumption that a load rating analysis is performed prior to initiating specific components of rehabilitation design. Additionally, the recommendations presented in this alternative do not include every constructability consideration required for design, cost estimating, and construction. There are numerous ancillary considerations that need to be included in the design phase of the repairs explored herein.

Structural analysis of Alternative #3 included a review of the existing load rating to determine what and where the controlling member(s) are for the bridge. Using this information, potential repairs based on member location and amount of necessary strengthening (without using detailed capacity and load analysis) were estimated. Updating of the load rating was not included in this scope.

A review of the bridge's general appraisal and sufficiency ratings was performed to determine the components contributing to the rating and if improvements can be made to increase the sufficiency rating to above 80.0 (for eligibility for the Federal Highway Bridge Replacement and Rehabilitation Program funds) and increase the overall appraisal rating. These ratings are calculated based on several bridge inventory items by the FHWA and are not directly editable within a bridge's inventory, but can change based on several items, including overall condition ratings for superstructure and substructure, and the inventory load rating.

- The appraisal rating evaluates a bridge relative to the level of service it provides in comparison to a new structure built to current design standards.
- The sufficiency rating is an indicator of the structure's overall adequacy and is on a 0-100 percentage scale, where 100 represents a completely sufficient structure (designed ideally for its use) and 0 represents a completely insufficient structure (design does not provide any use). The rating formula uses four factors to obtain a numeric value for the percentage.

Both ratings include attributes of the bridge that are generally permanent to the structure, such as geometric features, alignments, clearances, detours and roadway classifications, in addition to attributes that can change, such as condition and load ratings and traffic volumes. It is not guaranteed that a scope of repairs can be performed to improve the sufficiency or appraisal ratings due to the basis on which these ratings are determined. The Craig Memorial Bascule bridge currently has a **sufficiency rating of 32.7**, per the 2022 routine inspection report.

Details on the federal guidelines for these ratings can be found in the 1995 FHWA Coding Guide for the Nation's Bridges (Recording and Coding Guide (dot.gov)) and the ODOT state manual (Ohio Bridge Inventory Guide). Both manuals contain detailed descriptions of the appraisal ratings entered for each bridge by FHWA (calculation based from other inventory data) and for the calculation of the sufficiency rating. A sufficiency rating calculation exercise was performed as part of this alternative's evaluation to determine what components of the rating could be changed to impact the sufficiency rating for the better.

The most recent load rating update was a load factor rating (LFR) analysis performed in 2019 by DGL Consulting Engineers. HDR reviewed both the report and the model file in AASHTOWare BrR (bridge load rating software (version 6.8.3)) to identify, locate, and review the material properties of the members and their evaluation, for load ratings less than 1.0 for the various design and Ohio load rating vehicles. HDR used version 6.8.4, based on backwards-compatibility issues with the current version of the load rating software achieving the same results as the previous analysis.

Reviewing the model input, analysis, and results yielded a total of five (5) controlling members with load ratings less than 1.0, each for the inventory or operating level HS-20 design vehicle. These members were each representative of several similar members within a structural unit. Their locations and details are presented in the following sections.

3.3.1: Span 1 Girder 1 (or 4) at Pier 1

Located in Spans 1-4 of the bridge, the southern 4-span continuous unit, Girder 1 is the exterior girder and representative of Girders 1 and 4 in these spans (**see Figures S1 and S2**). The specific locations along this continuous girder where load ratings are less than 1.0 are:

a. at Pier 1 for "Section 6" in the analysis model, with an Inventory HS-20 (Lane Loading) rating of **0.310 (a.)**. The rating increases in the adjacent "Section 7" at 11 ft north of the pier into Span 2, to 0.697. Both ratings are for the non-composite web bend buckling failure check (AASHTO Equation 10-173). Though this is a constructability check for design, BrR includes this as the overload serviceability check and it is one of the permit load checks for ODOT.
b. at Pier 1 for "Section 6" in the analysis model, with an Operating HS-20 (Lane Loading) rating of **0.519 (b.)** for web bend buckling. This occurs only for Section 6 across the pier as described above.
c. at Pier 1 for "Section 6" in the analysis model, with an Inventory HS-20 (Truck Loading) rating of **0.722 (c.)** for web bend buckling. This occurs only for Section 6 across the pier as described above.

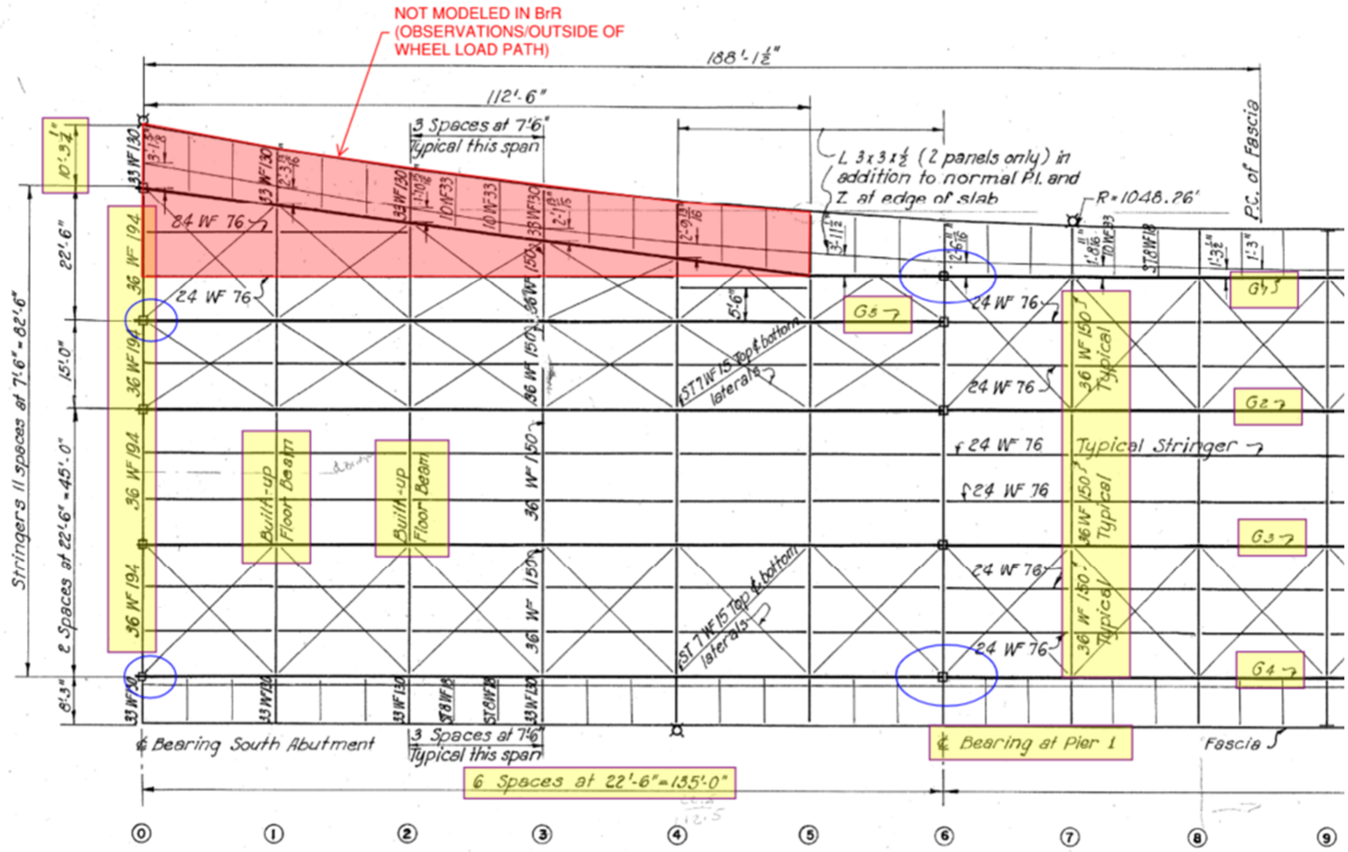


Figure S1: Unit 1 Framing Plan showing locations of controlling load ratings at Girder 1, Pier 1 at right, South Abutment at left

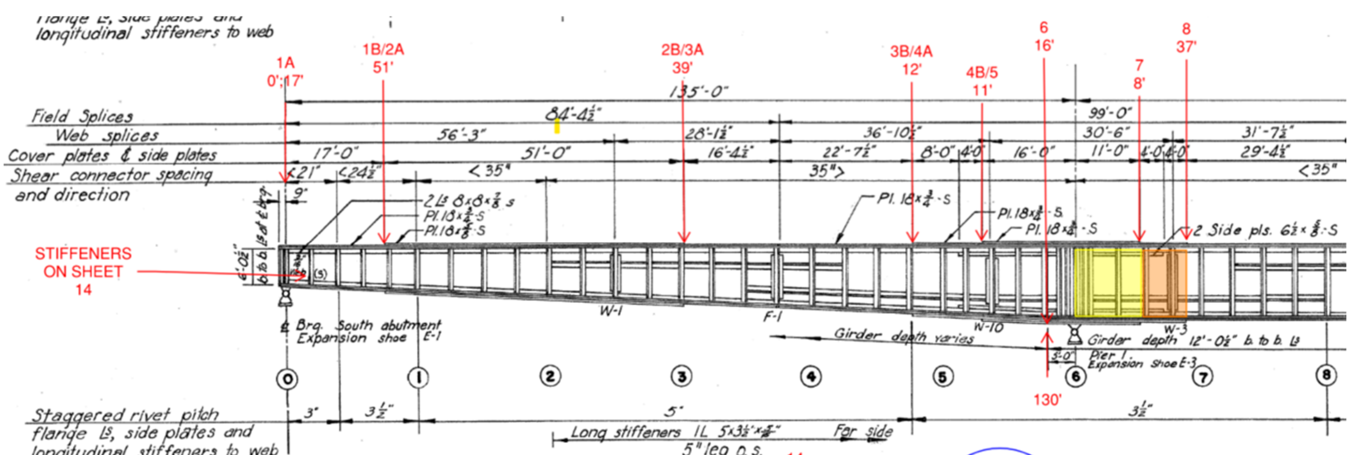


Figure S2: Exterior Girder (1 or 4) from South Abutment into Span 2; Section 6 is yellow highlight, Section 7 is orange highlight

The controlling low rating (HS-20 Inventory Lane) of **0.310 (a.)** is at a constructability check for web bend buckling for the flexure negative moment at the pier, a non-composite dead load limit state in Load Factor Design and Load Factor Rating. The girder cross section in the BrR model at this location only considered the girder web plate. It did not include the additional web plates for the bearing and jacking stiffeners that are present at this location (**see Figure S3**) at either side of the web. A new cross section was added to the model that included the additional web plates, 0.5" thick each for full height of the web (based on flange angle size slightly different than shown in detail). Due to their size – 82" long across the bearing area – they contribute to the overall girder strength and resistance to both shear and web bend buckling at this location (thicker webs are less susceptible to buckling as they are more braced than thinner webs). In AASHTO Equation 10-173, this is represented in the D/t_w term in the denominator of the stress limit, thus increasing the allowable stress of the section. This cross section was selected, and the model was re-analyzed. This change in the girder cross section to model the girder section closer to the actual section proved effective as the BrR rating improved to over 1.0 for web bend buckling, with the new rating at this location of 3.179 in negative bending for HS-20 Inventory (as would be expected for this location).

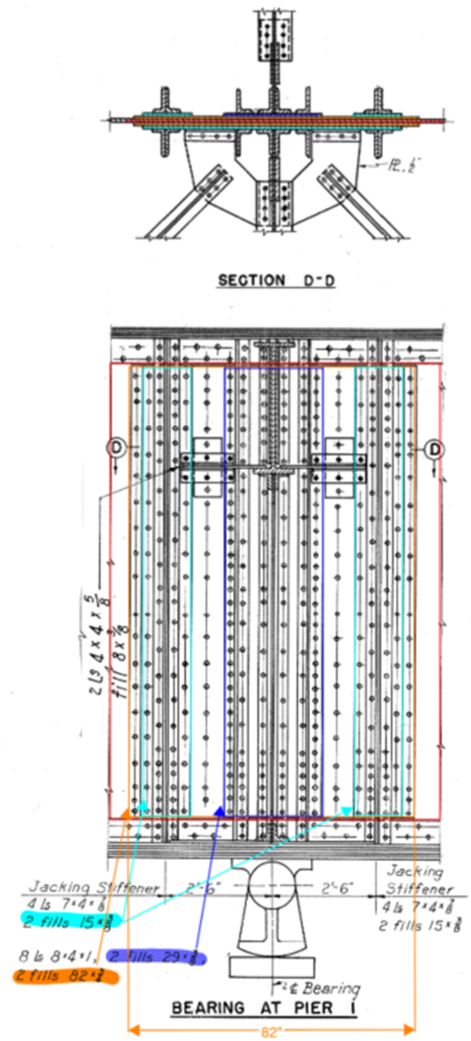


Figure S3: G1 Detail at Pier 1 showing additional plates at web over bearing

The revision to the cross section also changed the location of the new controlling rating (**0.310 (a.)**), now to 3.42 ft into Span 2, where the additional web plates end and only the main web plate remains. The rating is now 0.519 for web bend buckling for HS-20 Inventory Lane.

The HS-20 Operating Lane load rating of **0.518 (b.)** shifts location and increases up to 0.867, similar to the inventory lane rating.

The BrR model should be formally updated to model the girder more accurately at this analysis point, and other likely similar locations. This may involve a substantial change to the modeling and rating of the structure and may yield different results than the load rating performed in 2019. The upper and lower web side plates (6.2" x 0.625") at the girder beyond the bearing and jacking fill plates and stiffener angles are not included in the model. Adding these to the cross section of the girder is not possible in the BrR model, so they remain omitted. BrR also models the additional plates as part of the non-composite section and therefore effective in resisting dead and live load stresses. Since the repair plates are installed after the deck is cast, they will only be effective in resisting live load stresses until a future deck replacement. A supplemental analysis to BrR will be required to account for this in determining final rating factors.

The potential repair to the girder to add capacity for the negative moment would be to add reinforcing plates to the webs within the analyzed Section 6. This would involve fitting reinforcement plates between the upper and lower side plates from the end of the 82" bearing fill plate out to the end of "Section 6", approximately 11 ft from the bearing centerline. Accommodations would be made to fit plates around, or under, the longitudinal and vertical stiffeners. The approximate plate size would be 0.5" thick x 91" long x 115" high (**see Figure S4**). The load rating would need to be re-evaluated to determine if additional plates would need to extend into "Section 7", and how far they would extend into Span 2.

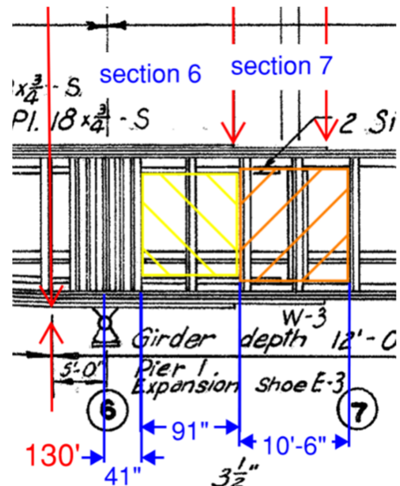


Figure S4: G1 Detail at Pier 1 showing potential additional web plates

The previous HS-20 Inventory Truck controlling rating of **0.722 (c.)** for web bend buckling rises above 1.0 at Pier 1 / Section 6 with the update to the girder cross section. This then changes the controlling HS-20 Inventory Truck rating, which is located at the South Abutment for shear in the web, to 0.901.

<u>3.3.2: Span 1 Girder 1 (or 4) at South Abutment</u>

The fourth rating below 1.0 in Unit 1 was HS-20 Inventory Lane rating of **0.938** for shear in the web at the South Abutment for Girders 1 or 4. The girder is the smallest at this location, so its cross section has the lowest capacity (Section 1A in the analysis model). Reviewing the model in BrR, the girder cross section did not include the web fill plates for the floorbeam and knee brace connections. Due to their size and location providing both continuity for the connection and bracing the web between the flange angles, they can be included. When adding these to the model cross section, the load rating increases above 1.0. However, the plates do not extend into the span, so this only updates the evaluation at 0.0 ft. Controlling shear remains an issue once extending into 0.67 ft into the span where the plates end.

The potential repair to the girder to add capacity for shear away from the bearing centerline would be to add reinforcing plates to the webs within the first few feet of the girder. The existing web is transversely stiffened and adding additional stiffeners would not result in an increased capacity. For materials simplicity, 0.5" thick plates could be used, and they would be sized to fit between the bearing / floorbeam connection angles and fill plates at the end, and the first vertical stiffener, notched around the diagonal bracing connection. The approximate plate size would be 68" long x 56" high. This repair could also be performed at the interior girders, due to the widespread arrested (painted over) section loss throughout the girder ends, floorbeams, and connections. The load rating should be updated to account for the "as-inspected" conditions, considering the section loss, to determine if repairs are necessary.

3.3.3: Bascule Span Floorbeams 7, 8, and 9:

Located in the bascule Span 5 of the bridge, Floorbeams 7, 8, and 9 are the floorbeams at Points 3, 2, and 1 (respectively) on each leaf and are built-up members (**see Figure S5**). Each floorbeam is only representative of the floorbeam that point 3 on each leaf.

- Structural Unit 2, Floorbeam 7. HS-20 Inventory (Truck Loading), with a rating of 0.943.
- Structural Unit 2, Floorbeam 8. HS-20 Inventory (Truck Loading), with a rating of 0.776.
- Structural Unit 2, Floorbeam 9. HS-20 Inventory (Lane Loading), with a rating of 0.862. The HS-20 Inventory Truck has a rating of 0.875 at the same location.

The inventory ratings below 1.0 are for negative moment at the floorbeam connections to the interior girders. The floorbeams are modeled as continuous across the girder connections, however, the floorbeams are connected to girders via angles only in a web to web configuration, see **Photo S1** below. These load ratings are invalid as controlling members, since the floorbeam connection to the girder was not modeled correctly. There are no moment connections for the floorbeam flanges over or through the girder. These should be modeled as simple span connections between the girders.

The re-analysis of the floorbeams should yield load ratings above 1.0 across the bascule span, for moment and shear.

Photo S1: Built-up floorbeam connection to girder via angles, web to web only; no flange connection (inset view)

3.3.4: Bascule Span Girder 2 (Interior Girders 2 & 3):

Located in the bascule Span 5 of the bridge, Girder 2 is the interior girder and representative of Girders 2 and 3 in this span, at either the south or north leaf (**see Figures S5 and S6**). The specific location along the girder where load ratings are less than 1.0 are at "Point 2" of the girder, next to the connection to the floorbeam, with an HS-20 Inventory (Truck Loading) rating of **0.735**, and a HS-20 Inventory (Lane Loading) rating of **0.805**. Both ratings are for shear.

The location of the low rating is at the transition / web splice where the web plate thickness changes from 5/8" to 7/16" (trunnion side towards center break side), from the floorbeam connection at the splice, into the thinner web section, for a length of 14". The low rating at this small length is based on the girder cross section changing just before the loading on the girder changes.

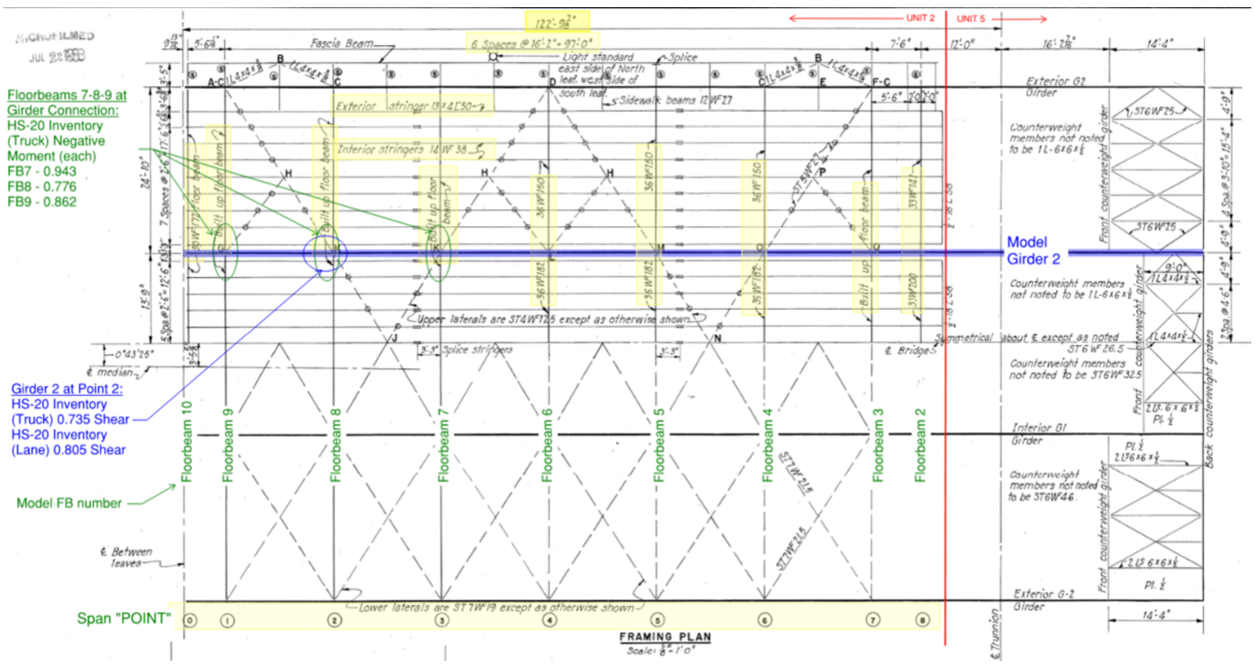


Figure S5: Bascule Span framing plan highlighting controlling members and designations

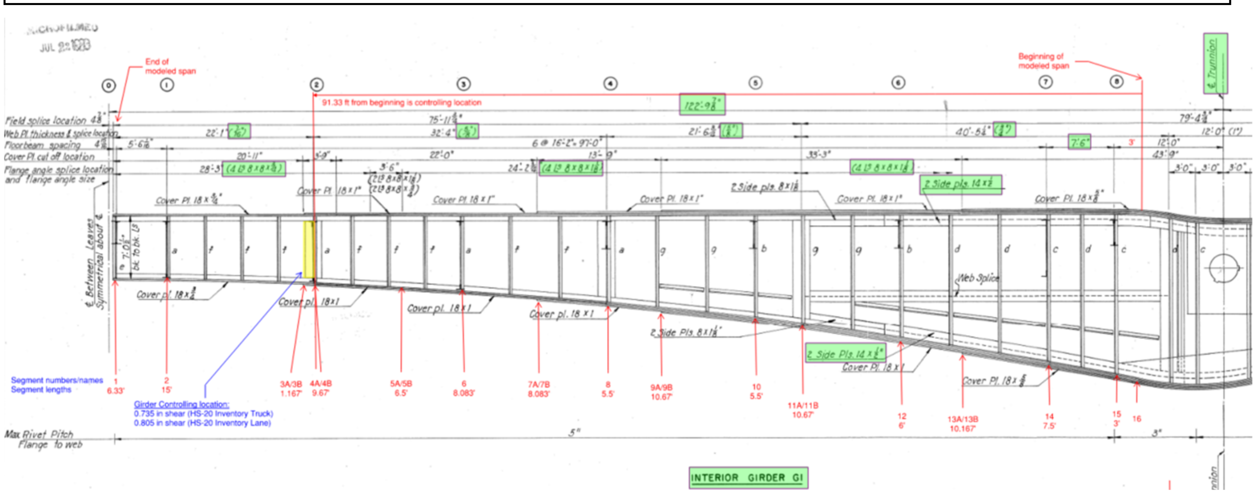


Figure S6: Bascule Girder elevation view highlighting controlling rating location

The low inventory ratings (HS-20 Truck and Lane) are for shear where the web plate transitions in thickness from 5/8” to 7/16”, between the FB2 and FB1 connections (inspection nomenclature). The low rating location is approximately 14 in long between the end of the 5/8” plate into the 7/16” plate, and after the web splice plates as Section 4A to 3B in the model. This is where loading changes on the girder, according to the model, as well as where the girder cross section changes. The analysis section is short due to the web splice, web thickness change, and floorbeam connection proximity.

Initial review of the girder cross section and loading at this location shows the load rating is above 1.0 where the web is 5/8” thick at the floorbeam connection and beyond, and the load rating is above 1.0 near the first vertical stiffener in the 7/16” thick web section. The specific location where the rating increases above 1.0 is at the ends of the flange cover plates at location 3A/3B on the girder. This location is 14 inches from location 4A/4B, which is larger than the web splice on this side of the floorbeam connection.

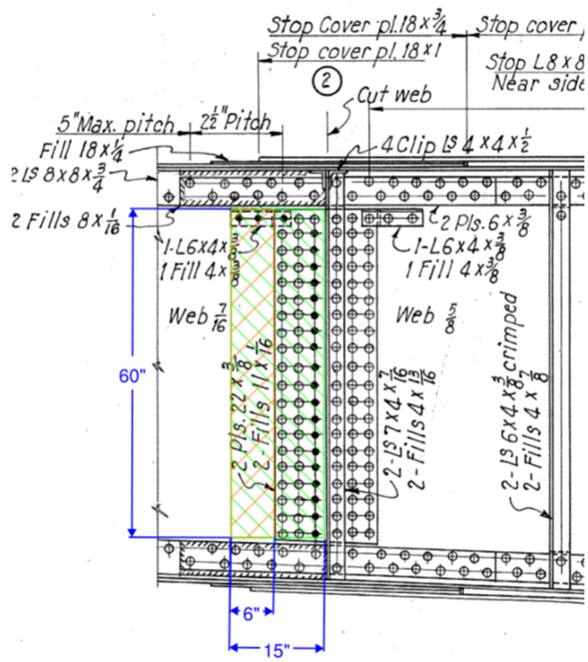


Figure S7: G2 Detail at Point 2 web splice showing potential additional web plate

To increase capacity in the web through this transition section, the potential repair will include additional plates to the girder web. This may need to engage the existing splice plate, and then extend over the 7/16” web for a total length of 15” or more. If the existing splice plate does not need to be engaged, then a narrower plate could be used, with a minimum thickness over 1/4”. Due to the minor capacity improvement needed, the plating could be at one side of the web only. The existing splice on the 7/16” web side includes the main 22” L x 3/8” thick plate, and an 11” L x 1/16” thick fill plate. The reinforcement plate would be approximately 60” H x 6” (or 15”) W and 1/4” thick, at a minimum, as shown in **Figure S7**.

With any additional weight installed in the bascule span, a rebalance check will be needed. If implementing this repair with the Mechanical and Electrical systems full replacement, the rebalance should include the full scope of removal, replacement, and installations in the span.

3.3.5: Summary of Repair Recommendations

Following review of the 2019 Load Rating Report and BrR file, it is recommended the load rating for the bridge be updated to model the members more closely to their actual composition and interactions, as well as to include “as-inspected” conditions to account for section loss. It was found that several load rating values below the 1.0 threshold could be improved by editing the model of the member section or connection to better reflect the as-built condition without introducing unconservative assumptions. The review on the model performed for this project was cursory and focused on the specific members and locations where load ratings were less than 1.0. Additional changes may be necessary when updating the model characteristics, as well as running the analysis in the most recent version of the BrR software. This recommendation will directly impact structural repairs.

It is recommended to follow a complete update of the load rating with design of structural repairs for the three locations identified in this report, allowing for updates based on the results of the updated load rating. The repairs will be strengthening necessary for member capacity improvement to increase the inventory load rating for the member above the 1.0 threshold. While this is recommended and estimated for eight bridge beams at three locations on the bridge for the purposes of this report, the actual repairs and details thereof will be dependent on the updated load rating and design of the repairs.

Steel strengthening repairs at Unit 1:

A. Steel plate installation at Girders 1 +4 webs in Span 2 up to 19 ft from the bearing centerline at Pier 1. Estimated plates to include both sides of web from bearing fill plate edge to 2nd (7 ft 10 in L) or up to 4th (18 ft 4 in L) vertical stiffener north of pier, full height of web and 0.5” thick. Details to be determined.

B. Steel plate installation at Girders 1 + 4 in Span 1 at the South Abutment. Estimated plates to include both sides of web from edge of bearing fill plate to 1st vertical stiffener (5 ft 8 in L), full height of web and 0.5” thick. Details to be determined.

Steel strengthening repairs at Unit 2:

C. Steel plate installation at Girders 2 + 3 in the bascule span at both leaves next to the floorbeam connection at Point 2 (Floorbeam 2). Estimated plate to include one side of web, full height by either 15 in long if engaging splice plate or 6 in long if not (minimum lengths based on 3” bolt spacing, 2 columns of bolts in web outside of splice), and a minimum of 0.25” thick.

3.3.6: Bridge Appraisal and Sufficiency Ratings

A review of the bridge's general appraisal and sufficiency ratings was performed to determine the components contributing to the rating and if improvements can be made to increase this rating. Both the appraisal and sufficiency ratings are calculated by the FHWA based on other bridge inventory items and are not directly editable within a bridge's inventory. However, they can change based on several items, primarily the inventory load rating.

- The appraisal rating evaluates a bridge relative to the level of service it provides in comparison to a new structure built to current design standards. There are five items included in the appraisal ratings and each is coded on a 0 to 9 scale. They are:
  - Structural Evaluation (#67) (Inventory load rating value and ADT)
  - Deck Geometry (#68) (bridge width, number of lanes, vertical clearance over)
  - Bridge Under Clearances (#69) (vertical and horizontal for roadways below)
  - Waterway Adequacy (#71) (waterway opening relative to flow, overtopping during a flood)
  - Approach Roadway Alignment (#72) (roadway curves and widths relative to bridge location)
- The sufficiency rating is an indicator of the structure's overall adequacy and is on a 0-100 percentage scale, where 100 represents a completely sufficient structure (designed ideally for its use) and 0 represents a completely insufficient structure (design does not provide any use). It is used to determine eligibility for federal bridge funds. The rating formula uses four factors to obtain a numeric value for the percentage. Each factor is determined from several inventory item categorizations as well as calculations based on the actual inventory data.

Both ratings include attributes of the bridge that are generally permanent to the structure, such as geometric features, alignments, clearances, detours, and roadway classifications, in addition to attributes that can change, such as condition and load ratings and traffic volumes. It is not guaranteed that a scope of repairs can be performed to improve the sufficiency rating due to the basis on which the rating is determined.

The specifics of the calculation of the bridge's sufficiency rating (SR) were reviewed and checked (via calculation) in detail, following the FHWA guidelines and formulas for computing the various items that determine the rating. This exercise found that the items contributing to the sufficiency rating that are based on the bridge's structural and safety conditions and that can change based on structural rehabilitation or structural deterioration, are primarily controlled by the bridge's controlling inventory load rating. This number has the most significant effect on the overall sufficiency rating of the bridge as the inventory rating in metric tons is directly used in calculating a percentage for bridge load capacity as part of the largest component of the sufficiency rating, the Structural Adequacy and Safety (S1 = 55% of the total, maximum). The complete calculation walk-through is available in the appendix of the FHWA Recording guide (Recording and Coding Guide (dot.gov)).

Following the example calculation step-by-step, the following items were determined for the sufficiency rating. Their variability is noted in how it can positively affect the sufficiency rating, i.e. increase the rating. There are four components to the sufficiency rating, and it is calculated as SR = S1 + S2 + S3 – S4. Each component is determined as follows:

S1: Structural Adequacy & Safety (S1 = 55 – (A + B)) (55% max)

Item A: The lowest component rating for superstructure (#59), substructure (#60), or culvert (#62) determines the coding for this item. The superstructure is the lowest, rated at ‘5’ so A = 10% based on the coding criteria. This item is very difficult to improve and would require the bascule span superstructure to have enough improvements made to rate a 6. This would require strengthening at locations of section loss in girders, floorbeams, stringers to return these members to their design capacity.

Item B: Reduction for Load Capacity. The calculation for B uses the controlling inventory rating in metric tons (IR) directly to determine the reduction percentage: B = (32.4 – IR)^1.5 x 0.3254. The original controlling IR is at Unit 1, Girder 1 and is 0.310 with a metric ton equivalent of 10.12. Improvement of the load rating will have a direct and significant improvement to this factor as part of the sufficiency rating. Any increase in the load rating will lower reduction item B and lower the reduction of S1.

For this bridge, with the current load rating of 0.310 (10.12 metric tons), S1 is 10.79%.

S2: Serviceability and Functional Obsolescence (S2 = 30 – [J + (G+H) + I]) (30% max)

Item J: This is a summation of the appraisal ratings and deck condition rating, each categorized based on fair to poor conditions contributing to reductions from 1% to 5% and has a maximum reduction of 13%.

- Deck condition (Item #58) can change, however any rating of 6 or higher is 0%. The deck condition is currently rated 6.
- Structural Evaluation (Item #67) can change primarily due to the inventory load rating and ADT however it is calculated by FHWA and would require their input. The load rating would need to improve to a point where this coding would change from ‘3’ to ‘6’ and reduce the reduction from 4% to 0%.
- Deck Geometry (#68) will not change without changes to bridge roadway width, ADT, or number of lanes.
- Under Clearances (#69) will not change without changes to vertical and horizontal clearances of roadways below the bridge. It could be argued that the current coding of this item as ‘5’ could be changed to ‘N’ due to a local driveway to a business and a railroad spur are not ‘highways’ (below the north end of the bridge) and the trail below Span 1 is not a highway. This would change the reduction from 2% to 0%.
- Waterway Adequacy (#71) will not change as this is based on the waterway opening relative to the flow of the channel or river, and if overtopping would occur in a flood event. The bridge has more than sufficient waterway opening over the Maumee River, and the approach roadways are below the bridge roadway. Ratings over 6 are coded 0% and this bridge is rated 8.

- Approach Roadway Alignment (#72) will not change as it is based on the roadway alignment on either side of the bridge, and necessary speed reductions. Bridge and approach widths are the same and the bridge is on a vertical curve, so this is rated 5. It could be argued that it could be rated 6 due to signalized intersections on both sides of the bridge controlling traffic so despite the shallow vertical curve, there is no speed reduction needed due to roadway alignment.

Items G & H: These are the width of roadway insufficiency items and are calculated based on the ADT per Lane and the Width per Lane, using Items #28 (No. of Lanes), #29 (ADT), #32 (Appr width), and #51 (Bridge width). They are calculated based on equations and scenarios for number of lanes on the bridge in combination. These items will not change, have a maximum of 15% total, and for this bridge are both 0%.

Item I: The vertical clearance insufficiency is based on the STRAHNET Highway Designation (#100) and the vertical clearance over the bridge deck (#53). This item would only change if the signs had low clearance, which they don't. For this bridge, on a non-STRAHNET route with clearance over 4.87 meters (overhead sign clearance is over 16 ft), this item is 0%.

For this bridge, with the items coded as outlined above, S2 is 22%.

<u>S3: Essentiality for Public Use (S3 = 15 – (C + D) (15% max)</u>

This component uses formulas and category ratings based on the values of S1, S2 and Items #29 (ADT), #19 (Detour Length), and #100 (STRAHNET) to determine C and D. For this bridge, C is 1.17% and D is 0% so S3 is 13.83%.

<u>S4: Special Reductions only used when S1+S2+S3>= 50 (13% max)</u>

For this bridge, S1+S2+S3 = 46.62%, so this additional reduction is not needed, however, our example calculation differed from the sufficiency rating shown on the bridge inventory form of 32.6%, so this additional reduction was included (unable to verify FHWA provided information).

One calculation and two categorization codes determine the value of S4. The calculation can include a reduction due to detour length up to 5%. The structure type code varies from 0% to 5% based on Item #43, and for this bridge is 5% due to it being a complex bascule bridge. The traffic safety Items #36 are coded here based on their values greater than zero, and for this bridge this was 0%. The total for S4 was 5%.

When including in the overall SR calculation for this bridge, SR = 41.62%.

From this review, a few conclusions can be made:

- Improvement to the load rating will directly improve the structural evaluation appraisal rating and the overall sufficiency rating for the bridge.
- It is not likely or cost effective that structural improvements to the bascule span can be made to raise the bridge's overall superstructure condition from 5 to 6.
- ODOT should have discussion with FHWA concerning the appraisal ratings for Items #69 and #72 to determine if changes can be made to reduce their impact on the serviceability reductions to the sufficiency rating.
- A more detailed recalculation of the sufficiency rating may be necessary to find agreement with the inventory number and the process outlined by the FHWA.

Improving structural load capacity is the most effective way to significantly improve the bridge's sufficiency rating. By performing the structural repairs presented in this alternative (performing a full design of the repairs is necessary), it is possible to improve the load rating, and increase it so that all bridge members rate above the 1.0 threshold. A full update to the bridge load rating analysis should be performed prior to design, to fully outline the extent and locations of the proposed repairs, and to assist in the design. It may not be possible to increase the sufficiency rating above the 80% threshold.

There are no additional repair recommendations to be made following the review of the sufficiency rating that are not addressed with the load rating update/review and steel strengthening repairs.

3.3.7: Alternative 3 Cost Estimate Summary

An order of magnitude estimate of the costs for the recommended steel strengthening repairs has been prepared for comparison purposes and inclusion in the Life Cycle Cost Analysis for this report. These are in addition to the costs presented in Alternatives 1 and 2, summarized below.

The cost estimate for steel strengthening repairs for this alternative used an "installed" unit cost for steel of $18.00 per pound. The weight of the repair plates were estimated based on gross volume and preliminary plate sizes as discussed. Other ancillary items were included as percentages based on repair weight and sub-total of repair costs, such as bolts, cleaning, caulking, painting, design, drawings, mobilization, means and methods, etc.

Alternative 3 Component	Cost (2028 $)
Steel Strengthening Repairs only	$ 244,000
Alternative 2 Costs (with adjusted Alt. 1 cost)	$ 20,016,000
Total cost for Alternative 3 (including mobilization and contingency)	$ 20,260,000

Costs do not include contingency, mobilization, or other percentage based additional costs

4.0 Analysis of Alternatives

The intent of this section is to provide more detail into the components of each alternative and the benefits of each to the bridge. Items considered for this analysis include: extension of service life, operational improvement, reliability, construction and life cycle costs, mobility impacts and constructability. These aspects are weighted according to a general level of importance in the overall scheme of bridge repair, specific for this structure due to its location, design, and use. The analysis references previous project examples to consider where scope and type of repairs were similar, though not necessarily in the same combination or context for this report.

It is important to note that the comparisons and contrasts of the alternatives is not a traditional apples to apples approach, as the alternatives are progressive in scale and scope of repairs, each building from the previous and providing more structural and operational improvements. From this perspective, the analysis will focus on the details of each alternative's scope and what the long-term structural health goal is for each alternative. This is based on three concepts: maintaining structure use, improving structure use, and improving structure use and capacity. Though the goals are general in nature, the specifics of the repairs included in each alternative provide a clear path to reaching each goal.

4.1 Service Life

Alternative 1: The extension of the service life of the "Base Repairs" is minimal. These repairs are recommended to address current deterioration or deficiencies and at best, to extend the service life of the affected components by five years, or until the next detailed inspection. They are not of a substantial nature to contribute to the long-term life of the structure. They will maintain current conditions, both operational and structural, but do not make any significant improvements to the bridge or its systems overall.

These repairs are substantial enough to be acted upon as they will maintain the overall fair condition of the bridge, safe use by the traveling public, and safe operation for opening for marine traffic. The items in the set of structural repairs are focused on keeping water out of the deck, superstructure and substructures below, and correcting water-induced deterioration. In addition, there are repairs to address vehicular and non-motorized traffic safety at the roadway and the supports directly below the deck and sidewalks in the bascule span, other capital maintenance improvements, and continued monitoring of conditions during inspections and maintenance activities. While the structural repairs are providing short-term benefits and protection to the structure, they are not contributors in our evaluation of long-term service life from a structural perspective. At best, these repairs can project 5-10 years before other future structural repairs should be anticipated.

The mechanical repairs are focused on maintaining operational component function and use, and safely performing necessary maintenance on the components to keep them in good working condition. Several recommendations include partial component replacement and rehabilitative repairs, some of which would be superseded by full component replacements, and others where design is needed for mixes of older original and newer modern components to work together.

The electrical repairs place a priority on removal and replacement of several components within the electrical operational system to maintain current operations. The findings of the electrical system inspection indicated that though functioning, the reliability of the system's components was low due to several factors including age, overall use, and availability of replacements.

Since the majority of the system remains original to the bridge construction, the components are far outdated based on current design standards. Many of the replacement repairs recommended will address both function and safety of the electrical components, and maintenance thereof.

The mechanical and electrical operational system repair recommendations are addressing immediate and very short-term deterioration and component deficiencies. While they provide significant improvements, they are not contributing to the long-term service life of the bridge or its operational system. These repairs are geared towards maintaining use of the bascule span for marine traffic and for vehicular and non-motorized traffic safety. The set of repairs are recommended to maintain bridge operation until at least the next detailed inspection.

<u>Alternative 2:</u> The extension of service life of Alternative 2 is to extend the service life for 70 or more years. Smaller control system replacements maybe be required over the length of the extended service life to address component obsolescence, especially for electronic equipment such as VFDs and PLCs.

The mechanical repairs are intended to include all major efforts to upgrade and replace the machinery with new systems that require minimal maintenance and additional repair effort over the next 70 years. After implementation of the mechanical recommendations, future work on the machinery will be strictly limited to component maintenance such as cleaning, lubrication, and adjustment for wear.

The electrical recommended repairs are intended to provide an electrical system that meets the requirements of the NEC, allows for easy maintenance, and reduces operational inconsistencies. The control system recommendations place a priority increasing safety and operational reliability.

<u>Alternative 3:</u> The extension of service life will be compared for only the addition of structural repairs to improve the bridge load rating values, as the contributions of repairs previously described in Alternatives 1 & 2 are also included.

Increasing structural capacity through reinforcing repairs to primary load-carrying structural members will provide a significant increase in the service life of the bridge. Generally, an increase in capacity under the same loading conditions will lower the stress in the members. The main load carrying members in the fixed and movable spans of the bridge are the girders and floorbeams, and these are also the members controlling the load rating values for the various vehicles analyzed. Where the members are low in the load ratings are where these members transition in size corresponding to a change in design loading, indicating that the design of the members was efficient, despite being low for a few service checks. Fortunately, for the low rating at Girders 1/4 in the fixed spans, the design check was for the non-composite condition during construction and was seen to improve dramatically when including the additional steel present at the specific location of the low rating.

It is difficult to estimate with certainty how many years of additional service life can be attributed to structural capacity improvements. The bridge was originally designed for the interstate freeway traffic on the route where it was located. The recent re-alignment of the freeway to the newer adjacent bridge next to (and above) the Craig bridge has changed the use and loading on the structure. The bridge has been reconfigured at the deck to provide a mixed use trail in one previous lane, the current roadway lanes re-aligned, and the exit / entrance ramps at the north end have been removed. Vehicle speed has been reduced due to signalized intersections at both ends of the bridge (in addition to bridge opening traffic signals and gates). The types of vehicles have also changed, with a reduction in the heavier truck traffic (from a through-traffic count).

The change in structure use and loading may have a greater impact on the long-term service life as the bridge is now loaded much lighter and less frequently than original design, despite changes in vehicle sizes, configurations, and weights.

For the purpose of this analysis, we will assume an extension of service life due to capacity improvements to be a minimum of 30 years. This is based on overall reduction of stress in the main members and capacity repairs being performed in conjunction with deterioration repairs, even where these repairs occur at separate locations across the structure. Additionally, this service life extension can be justified by the preventative maintenance repairs typical service life extension on simple freeway bridges. Protection from water's detrimental effects on steel and concrete will protect any repairs directly below in the path water may take from deck to river.

The bridge deck is a replacement deck installed during the 1996 rehabilitation and remains in good overall condition. At 27 years old it is approximately halfway into its design service life. Another deck replacement will likely be needed in the next 25-30 years. This should be considered when aligning the general service life extension on the bridge with the specific service life of the proposed repairs. The estimated $30M cost of a deck replacement was not included in the life cycle costs since it will be common across each alternative.

4.2 Operational Improvement

Alternative 1: The recommended structural condition and traffic safety improvements will not serve to directly affect operational improvement of the bridge. However, repair to items such as bridge drainage, joints, barriers, lighting, superstructure paint and minor repairs, will contribute to overall better function of these and related bridge components. Properly functioning bearings and joints will allow for normal structure movement and prevent adverse stress to surrounding elements and reduce the load on the mechanical and electrical systems to operate the bascule span. Properly functioning drainage systems will move water from roadways and sidewalks to areas away from super and substructure elements, aiding in both safe travel along the roadways and protection to elements below deck. Cleaning and painting corrosion, removing debris, and making minor repairs, will provide general improvement of these elements, which may contribute to better support and function of items they support. Maintenance by ODOT staff will be reduced to clean drains, joints, etc.

Alternative 2: The recommended mechanical repairs will serve to improve operation of all systems. The span drive machinery will provide smoother bridge operation and tighter control by utilizing low backlash enclosed gearing, drive controlled electric motors, and brakes with adjustable torque and setting times. The span lock machinery will use fewer moving parts and minimize system friction to increase mechanical efficiency. The actuators will include hand wheels for easy and accessible manual operation in the case of a power failure. Removal of the air buffers will simplify the overall bridge operations. The new traffic and barrier gates will include enclosed machinery for tight control and the new barrier gates will be designed to stop traffic whereas the existing swing gates are not.

The recommended electrical and control system repairs will provide more consistent bridge operations by eliminating the existing random bridge stops and limiting the amount of control provided to the bridge tender. The control system repairs will reduce the ability for the bridge tender to make mistakes during span operations by having a fully interlocked system and motor controls that have a significantly tighter speed control.

Alternative 3: Structural capacity repairs will not add any measurable operational improvements. In combination with the Alternative 1 repair, however, improvement of bridge drainage, joints, and bearings will contribute to overall operational improvement. These common "pinch points" are often the first to deteriorate, wear out, require replacement based on their function and exposure, and often lead to deterioration to other nearby components. Operational improvement may be seen in less stress to primary members under permit and other truck loading conditions, as well increased capacity to allow other permit loads previously restricted from the crossing. While not necessarily operational to the bridge, they are operational improvements to the roadway and route the bridge carries.

4.3 Reliability

Alternative 1: Repairs made to address observed deterioration and improperly functioning components will have a direct impact on the reliability of those components. Replacement of items such as bridge joint seals can be thought of as resetting the service life of that component. While this may not contribute to the bridge's overall service life, new replacement items are more reliable than older in-service items as they do not have the wear, tear, exposure, etc. and start in good condition. Though not directly measurable, repairs to deterioration will contribute to overall structure reliability in terms of properly functioning bridge components (joints, bearings, drains, load path elements). When these elements are functioning as intended, the bridge behaves as intended and can be thought of as more reliable when the behavior is as expected.

This will also contribute to the operational reliability of the bridge, for the mechanical and electrical components that depend on or are supported by the structural components.

Alternative 2: The span drive machinery will be provided with redundancy using a smaller electric motor that can be operated from a generator, removing the need for the diesel engines which require frequent maintenance and several staff members to operate. New enclosed gearing will be protected from environmental factors which are a risk to the existing open gearing during operation. The reliability of the existing brakes is questionable due to unknown torque settings and high friction on the corroded pins and linkages. New brakes will be low maintenance, low friction, and include adjustable torque settings with torque scales. The span lock motors will include individual hand wheels for redundant operation in the case of a power failure, although the motors will be sized to operate from an external generator. Removal of the air buffers and operation of the span using variable frequency drives limits risks from operator errors and air buffer failure

Repairs made to address the current electrical and control systems will have a significant impact on the overall reliability of the bridge. There have been several reported emergency outages with the last few years that are directly related to the current state of the electrical and control systems. For example, simply replacing the existing vintage circuit breakers significantly reduces the chances of an electrical fire, similar to one that had occurred recently.

Alternative 3: Repairs made to address structural capacity will have an indirect effect on bridge and component reliability. Increasing the strength of a bridge beam can be thought of as making it more reliable in supporting regular and heavy loads, or load combinations. The bridge beam itself may be more than capable without the repair, but the repair provides the extra capacity needed under special situations, and thus it becomes more reliable under normal circumstances. Again, not a measurable difference, but at least a difference in the positive direction when considering this repair.

4.4 Construction and Life Cycle Costs

The initial construction costs are estimated for the recommended repairs for each alternative. They represent a high-level cost estimate for guidance and comparison purposes for this analysis and would require much more detail and revisions should any alternative be developed and moved to design and construction. Similarly, life cycle costs are estimated as regularly spaced interval future maintenance and repair costs following the initial construction effort. These are kept as similar as possible between the alternatives to provide the best comparison, however some costs may vary based on specific activities included, and the interval spacing of the costs. Life cycle costs are brought back to "Year 1" and added to initial construction costs to provide the order of magnitude total cost and comparison.

Alternative 1: This set of repairs is the minimum scope, and thus has the lowest construction costs, since there is the least amount of structure improvement involved. It also is the most basic in amount and complexity of repairs needed for the structure. It has the lowest risk based on very few unknowns in design, components of repair, materials, access, and construction means and methods.

When considering the life cycle costs of this alternative, it is assumed that these repairs are short term and that additional, more involved, and complex repairs and replacements (as in Alts #2, & 3) will still be needed later. Since this repair is deferring large scale repairs to later, the life cycle costs will still include the base cost of those repairs later. This will increase the overall 70-year life span analyzed in this report when bringing back repairs to year one for a similar cost comparison.

Alternative 2: This set of repairs is limited to a mechanical and electrical replacement. While this alternative has more risk than Alternative 1, the amount of risk is not significantly more.

When considering life cycle costs of this alternative, it is assumed that regular maintenance is performed, particularly with the mechanical equipment. A preventative maintenance plan and schedule will significantly extend the life of the equipment.

Full replacement of the machinery will include a significant one-time cost which will benefit the bridge for the next 50+ years. Some of the replacement machinery like the gearboxes, bearings, and steel support structures have been witnessed to last for greater than 70 years. Other than continual maintenance, which will be reduced from the effort required for the existing machinery, limited additional costs are expected until the next scheduled full replacement cycle. The upfront cost for replacement will reduce future costs which would otherwise be necessary for smaller rehabilitation projects, emergency repairs, and bridge outages due to mechanical failure.

As with any modern electronic equipment continual advancements of technology will render current technologies obsolete within a few years and the same holds true for PLCs, HMIs and VFDs. This equipment will continually be improved and will eventually be considered obsolete. In general, most PLCs, HMIs and VFDs will no longer be available from the manufacturer within 10-15 years with most replacement parts and manufacturer support ceasing in 15-20 years depending on when on the manufacturer life cycle the equipment was procured.

Alternative 3: The full scope of repairs will have the largest construction cost simply based on scale and scope of the repairs and this alternative being all-inclusive of the base recommendations, full operational system replacement, and structural strengthening. This alternative also has the most risk associated with it, due to the complexity of the combination of repairs and several other factors. The number of unknown factors should reduce once planning, design, and details are worked out should this alternative be selected.

While the initial construction costs for this alternative are the highest, it is anticipated that they can be spread out over the initial five years of a 70-year analysis period, slightly reducing the initial impact. Due to the scale of the repairs, anticipated service life of the repairs, and the extension of service life to the structure overall, there are the least amount of additional costs added over the analysis period. This alternative remains the most expensive for both initial and life cycle costs, but this is due to it having the largest scale of repair activities. If this alternative is not selected, the repairs could be made during a future deck replacement, where there is an added benefit that the repairs would be immediately effective in resisting dead load. Mobilization and other project costs could be mitigated within the larger project.

4.5 Mobility Impacts & Constructability

For each alternative, USCG and environmental permits are anticipated, to a varying level of complexity based on changes to bascule span operation for marine traffic and impact to the waterway. These will need to be further evaluated once the specifics for the selected alternative in terms of scope and design, are determined.

Similarly, utility conflicts will need to be evaluated in more detail during design phase and mitigated as necessary. This will be more involved for Alternatives 2 and 3, where the scope of repairs is larger, and utilities are directly affected by the construction.

<u>Alternative 1:</u> The base set of repairs will have a moderate impact to both vehicular and marine traffic on the bridge. Most of these repairs can be performed with limited restriction of traffic using lane closures and lane shifts, and planned openings. The structural repairs should be able to be conducted during the summer season, working around marine traffic schedules to minimize impact during the shipping season at the river and port. Repairs focused on the bascule span and piers can be deferred to the shipping off-season and work around a normal winter partial shutdown of some activities. Due to the low volume of local traffic, long term single lane closures and diversion of non-motorized traffic to one sidewalk at a time will have a minimal impact on the roadway use, and can assist in facilitating construction activities, shortening duration of lane closures by combining activities where practical.

Repairs to the operational system should be deferred to the shipping off-season where the bridge will not need to be opened for marine traffic. Some activities may occur at other times, however, repairs that halt use of the span opening would be grouped and performed off-season. These repairs should have minimal impact to roadway traffic and repairs involving roadway or traffic features can be combined with structural repairs and lane closures to reduce impact.

The repairs in this alternative are common in terms of constructability and complexity. The bridge itself provides assets that a contractor can utilize as part of their means and methods (such as staging, storage, material handling, etc.) based on the geometry and layout of the site surrounding the bridge. Large access hatches in the piers with semi-integral hoisting equipment and ease of access throughout the piers will be useful for any interior repairs. Existing catwalks and at-grade open space will assist in providing access to primary areas for repair where staging, scaffolding, and other equipment can be temporarily installed for construction.

Localized containment will be necessary for blast cleaning and repainting in the bascule span at areas of corrosion and steel repairs, and the span will require analysis for attached containment and access materials. This will include analysis for when span remains closed and repairs are in progress, as well as if scaffolding and containment remain installed for bridge opening operations, depending on construction schedule.

Railroad coordination will be required for any work in Span 8 below deck. The Ann Arbor Railroad is a short line and the tracks running below the span are a spur line and lightly used, so impacts on the railroad and construction will be minor. The access road next to the tracks and Pier 7 will require additional coordination based on the daily truck traffic, and access through the construction area will need to be maintained.

<u>Alternative 2:</u> These repairs have the potential to have significant impact to vehicular traffic on the bridge. While most of these repairs can be deferred to the shipping off-season where the bridge will not need to be opened for marine traffic it is not guaranteed based sequencing and some material lead times. It is anticipated that the bridge will need to be placed in the fully open position to accommodate the installation of the mechanical equipment and during between times when the existing electrical system is being removed and the new installed. Temporary operating systems and construction staging could reduce outages, but an increased cost.

The repairs in this alternative are common in terms of constructability and complexity. The bridge itself provides assets that a contractor can utilize as part of their means and methods (such as staging, storage, material handling, etc.).

<u>Alternative 3:</u> Access and material handling for structural repairs should be coordinated and combined with other underside repairs where locations overlap or are adjacent. This will assist in easing the constructability of the strengthening repairs. This will be most important for repairs made in the bascule span as coordination between cleaning, painting, and other minor repairs will be necessary for access, materials, and labor. The access methods for construction may include temporary scaffolding between girders and selective removal of deck grating during lane closures. Localized containment will be necessary for blast cleaning. Following repairs in the bascule span, in addition to mechanical and electrical systems, a full span balance will need to be done. This is a fairly simple process, however, correctly balancing with counterweight placement can be an involved process.

The repairs should be designed so the reinforcement materials are of a size that can be handled, positioned, and installed correctly, given the access constraints for the primary locations of reinforcement repairs. The proposed repair plates at the main girders at Pier 1 are large and will need to account for their installation in how they are designed, so they are installed according to the desired effect they will have. Being located at Pier 1 should provide some ease of access at least being directly adjacent to land and being able to construct a platform for repair work to take place. Hoisting materials may require more involved temporary works, based on plate size and location.

Mobility and other constructability impacts / considerations are similar to Alternatives 1 and 2, as these repairs do not significantly change how the other repairs are performed or how the overall construction will impact traffic.

4.6 Weighted Priorities of Components of Alternatives

The overall goal for any rehab project at this bridge will be for long-term, reliable, and safe operation and use. With that, a goal of minimizing future repairs through major improvements now, that is tied to minimizing future dollars spent at this bridge, ranks a close second. The overall thought process behind large-scale repairs and replacements to components and systems that require this level of effort, is that any expenditures of money, resources, and time now will save from more money, resources, and time in the future.

To accomplish the overarching goals at this bridge, several key goals were identified as milestones in to achieve the overall goal for the bridge. Each of these goals are tied to specific improvements to the bridge that can be performed in a variety of combinations. For the purposes of this report, weights of relative importance to the overall goal are assigned in order to compare, contrast, and analyze each alternative and the benefit to performing a specific repair item (or group of related repairs) to the cost of the specific repair and the overall alternative cost. The main milestone goals tied to specific repairs are listed below, with their relative weight based on overall priority of importance, on a scale of 0-100.

- Traffic Safety 30
- Bridge Operation 25
- Bridge Reliability 15
- Bridge Maintenance 10
- Structural Capacity 10
- Repair Longevity 5
- Future Repair Needs 5

Traffic Safety includes vehicular, non-motorized, and marine traffic's safe use of the bridge. This is tied to traffic control components of the bridge such as signals, gates, railings, bridge roadway, and overall structure soundness.

Bridge Operation includes the mechanical and electrical systems that control the bridge opening and closing. This is tied to both these systems and all their components, such as bearings, gears, motors, controls, and the related items.

Bridge Reliability includes the overall condition of the bridge, its ability to function as designed, and the longevity of its various components, structural, mechanical, and electrical. This is tied to the types of repairs made, their expected service life, their durability, and ability to perform in the exposure of the various locations of the bridge.

Bridge Maintenance includes the items that require general maintenance to function, as well as the ability of bridge maintenance personnel to conduct those activities. This is tied to the ease of maintenance of newly installed components, routine maintenance, and cleaning of items such as drainage and joints, and related operational items that require regular service. It also includes the level of effort, and if a replacement item is easier to maintain, or requires maintenance activities at less frequent intervals.

Structural Capacity includes the bridge's ability to carry the traffic and operational loading it was designed for, as well as modern loading it may not have been designed for. Though load rating numbers were low at a few locations, the bridge members were designed according to the design code of the time, and show they perform well in carrying the service loads previously and currently placed on the bridge. This is tied to repairs to structural deterioration and traffic safety at the bridge roadway and related elements, as well as the super and substructures below. This includes repairs as part of Alternative 1 and the strengthening repairs as part of Alternative 3.

Repair Longevity includes the relative service life of the recommended repairs, compared against a "do nothing" option. Replacement of component X versus leaving it as is can be thought of as a unit of time added to the bridge's service life. Quality and type of repair are also considered when comparing similar repairs between alternatives, such as replace a light bulb versus replacing the entire light fixture, they have a different "repair life".

Future Repair Needs incorporates some aspects of a repair's longevity, and if that expected service life falls short of the analysis 70-year period. It accounts for the need to conduct the same or similar repair or replacement to a specific item or group of components at a determined frequency. This could include something simple like changing a light bulb every ten years or replacing the paint on the superstructure every 30 years. This does not apply to all repair types and provides a future emphasis on items typically under more wear and tear due to location, function, and exposure.

Weighted Component Priority Scoring

Component	Score = Rank x Weight, Rank is 3-2-1		
	Alternative 1	Alternative 2	Alternative 3
Traffic Safety	30 (1x30)	60 (2x30)	60 (2x30)
Bridge Operation	25 (1x25)	50 (2x25)	50 (2x25)
Bridge Reliability	15 (1x15)	30 (2x15)	30 (2x15)
Bridge Maintenance	10 (1x10)	20 (2x10)	20 (2x10)
Structural Capacity	10 (1x10)	20 (2x10)	30 (3x10)
Repair Longevity	5 (1x5)	10 (2x5)	10 (2x5)
Future Repair Needs	5 (1x5)	10 (2x5)	10 (2x5)
Total Score:	**100**	**200**	**210**

Component scores are the same where component rank is the same between alternatives

5.0 Summary of Analysis

After reviewing the details of the repairs, overall scope of each alternative, and considering the progressive differences between each alternative, it is evident that providing a more comprehensive and extensive package of repairs will provide the most benefit to the structure's overall use and operation. Comparison to the cost of each alternative over a 70-year life cycle period, where future repairs, additional repairs, can be accounted for to make the comparison closer to an "apples to apples", shows that the larger initial investment in the larger scope of repairs, will have a lower overall cost. The larger scale and scope of repairs initially will provide a greater deferral of future repairs, and those future repairs will be smaller in size and cost. Deferring the major repairs by performing the minimum repairs needed initially, will cause those major repairs to cost more in the future.

The scale and scope of the repairs in Alternatives 2 and 3 for the full replacement of the mechanical and operational systems will address the main issues facing the bridge – safe and reliable operation of the bascule span. These components are critical as they are what control the span opening for marine traffic – without them this is just a fixed bridge. These components are mostly original to the structure and show their age as they have surpassed their expected service life. Besides age, there is wear and tear, which has caused problems with span openings in the recent past. The lack of replacement parts adds to the unreliability of the systems, as they have become so outdated that in order to fix an item in one location, a part has been salvaged and repurposed for another location.

It is also clear that the base repair recommendations of Alternative 1 will not provide any long-term solutions or increase in reliability of bridge operation and service. While the recommendations are geared toward repairs that will at least maintain the components until the next detailed inspection, that is not guaranteed, as while one item is fixed, another aging item may fail or become non-compatible with a mix of fixes, old, original, refurbished, and new. The only was to provide confidence in long-term operations is for a wholesale component replacement. It is also practical to repair some components that are more resilient to age, wear, tear, and deterioration, such as bearings and gearing. The feasibility of removal and replacement of some items like these is very low, and the cost would be very high due to what these items are, where they are, how they function, and the complexities involved.

Analyzing the load rating proved to be a good exercise in taking a deep dive into what directly affects structural capacity, what specific design checks correspond to actual service loading, and how the differences between a structure and the model of a structure predict the behavior differently. The review of the load rating was able to identify and locate specific locations of low load ratings for a variety of loading scenarios and provide details on the section analyzed. The review also identified items requiring re-analysis and changes to the load rating model structure that will better mimic the actual structure, so the rating model predicts the behavior and load rating more accurately. Beyond these items, areas where other design assumptions can be updated and areas where relatively minor repairs can be made were identified. Other updates to a load rating analysis can be made that may supersede the recommended repairs in this report. These may be less conservative, or more accurate, depending on the capabilities of the rating software, relative to the actual behavior observed at the bridge, which is under far less stress than the design vehicle loading now that it no longer carries freeway traffic. A re-analysis of the bridge and its load rating can be a very cost-effective way to "sharpen the pencil" when determining where structural capacity repairs are necessary.

5.1 Alternative Attribute Comparison

The key attributes for improvements to bridge safety, operation and capacity can be treated similarly to the milestone goals in terms of comparing the effect each alternative will have on the goals. These components are compared across the alternatives, with main differences summarized in the following table.

Alternative Attribute Comparison

Attribute by Priority	Alternative 1	Alternative 2	Alternative 3
Traffic Safety	Provides basic improvements and restoration of roadway items	Similar to Alt 1; also provides modern operational signals and gates to improve traffic safety	Nothing additional to Alt 2
Bridge Operation	Provides basic maintenance of operational service with necessary repairs	Provides full upgrade of operational service with new systems	Nothing additional to Alt 2
Bridge Reliability	Minimal improvement through repairs	Major improvement with new systems and components	Nothing additional to Alt 2
Bridge Maintenance	No reduction in level of effort; continual maintenance required for span operation	Will reduce demand on frequent maintenance needs; will be designed to minimize interim repairs and to make other regular maintenance easily accessible	Nothing additional to Alt 2
Structural Capacity	Provides minimal basic improvement to deficient conditions/locations	No improvement; new systems may be lighter which would decrease demand on structure	Increases capacity at the few locations where load rating shows capacity is lacking
Repair Longevity	Short term; less than 15 years expected service life	Long term for operational systems by resetting design life; 50-70 year expected service life of repairs	In combination with Alt 1 + Alt 2 repairs, comprehensive repairs and structural improvements should extend structure service life by 50-70 years
Future Repair Needs	Substantial at 10-20 years or less; will likely require similar to Alt 2 within 10 years and then functions similar to Alt 2	Moderate, will require typical interval repairs to items that wear out, assume 15-20 year cycles on items such as joints, lighting, paint, patching, bridge deck for capital scheduled and preventative maintenance repairs	Nothing additional to Alt 2

5.2 Other Considerations

For any major bridge construction or rehabilitation analysis, a “do nothing” option is typically utilized to contrast a level of effort of zero, with the discussed major level of effort for the construction. For this bridge, a “do nothing” option is not valid, as that would lead to the bridge becoming non-operational for marine traffic. This would likely lead to locking the span in the open position to maintain marine traffic and diverting the roadway traffic south to the Dr. Martin Luther King, Jr. Memorial Bridge. Since this option is not favorable, it was not considered. Full use and operation of the bridge was a mandatory requirement when approaching each repair item and scenario of groups of repairs.

Some considerations for marine traffic have been alluded to in terms of a shipping season and off-season. The most marine traffic operates from September thru January following harvest and primarily consists of foodstuff exports, with 4-5 vessels per week. The remainder of the year is much lighter traffic, typically 1-2 vessels per month. Repairs requiring the bridge to be non-operable for opening should be planned around the September to January shipping season.

Roadway traffic volumes are low at this structure (relative for location and size of structure), with another crossing of the river connecting the same local roads approximately a quarter mile to the south. Through traffic is carried on the I-280 freeway bridge above. It is reasonable to consider a full closure of the bridge roadway for a short duration to accommodate certain repairs where that level of access would be more beneficial to a project’s cost and schedule than the negative impacts from the disruption to traffic for a full closure and detour. This would be most applicable for roadway deck and related component repairs, including lighting, signs, joints, and drainage.

5.3 Recommendation

Based on the evaluation of the repairs contained in each alternative, and the overall effect each alternative would have on the bridge according to achieving the long-term goal via the milestone measurement goals, it is HDR’s recommendation to proceed with Alternative 3, base recommended repairs and full mechanical and electrical operational system replacement, with structural strengthening repairs. Based on the structure’s long term needs of traffic safety, bridge operation and reliability, minimizing maintenance, providing additional structural capacity, providing durable and long-lasting repairs, all to limit future repair needs, Alternative 3 provides the best plan / path to achieving the overall goal for the bridge’s rehabilitation plan. This alternative provides the most comprehensive repair and improvement to the structure in the aspects of its construction, structural, mechanical, and electrical, and meets both the immediate continued safe use needs, and the long-term safe and reliable operation and use.

It is clear that the bridge needs more than the base recommended repairs in Alternative 1 to continue to function with any confidence in both operation and general use. It is also clear that strengthening repairs should be delayed and follow more detailed structural analysis. Additionally, the structural repairs noted in the bascule span can be deferred to coincide with the strengthening repairs if needed. The benefit versus cost of the strengthening repairs should be revisited following a load rating analysis update, to determine the overall need of these repairs.

Moving forward with Alternative 3 provides ODOT with the best course of action that is easily editable as further details and specifics of operational system replacement is developed. It provides a path for short-term smaller scale repairs to be made as a prelude to the main items of the major repairs. It also leaves the window open for further analysis into the structural capacity of the bridge, through revised and updated load ratings, smaller scale structural repairs, and further evaluation into other strengthening options that may be beyond the scope of this analysis.

Alternative 3 will provide the most benefit to the long-term safe and reliable use of the bridge, maintaining its operational and structural capacity, for the level of effort and resources necessary for a project of this scale and scope. Though the project scope overall contains numerous complicated details, planning at this early stage will aid in determining the most efficient, most effective, and least disruptive means of performing the repairs while fully designing and detailing their installation.

It is further recommended that a combination of the base repair recommendations, the mechanical and electrical system full replacements, and the structural steel strengthening repairs be made to the structure over the next 10 years. The extended duration is for a matter of practicality and budgeting within the bridge’s asset management plan, due to the large scale of the repairs and their associated costs. Implementing this repair package should extend the service life of the bridge as a whole for 70 years or more, considering routine and scheduled maintenance and repair activities during that time period.

With construction and life cycle costs so different for each alternative due to the varied and progressive scope of each, true comparisons must be accompanied by clarification to the use of relative comparison only. Based on scope of each alternative, the overall cost for Alternative 3 will always be more than the other alternatives.

<u>Alternative 3:</u>

Base Cost	$ 25,629,000
70-year life cycle cost (year 1 value)	$ 30,676,700
Estimated Construction Duration	24 months
Estimated service life extension	35-50 years
Estimated roadway traffic delay	15 minutes daily
Estimated marine traffic delay	20 minutes daily during shipping season
	None during off-season

Appendix 1:

Cost Estimate & Analysis Worksheets (Construction, Life Cycle Cost Analysis)

2023

BRIDGE COST ESTIMATE WORKSHEET
- CPM, REHAB, REPLACE -

REV. 01/30/2023

OWNER: ODOT
REGION: Lucas County
Toledo

FISCAL YEAR: 2028

DATE: 4/3/2024
ENGINEER: J. Fogg, PE

STRUCTURE ID: LUC-65-05.35
BRIDGE NAME: Craig Bascule

LOCATION: SR-65 over Maumee Rive
PRIMARY WORK ACTIVITY Alternate 1 - Base Recommended Repair
OTHER WORK: Alternative Comparisor

70-year Analysis Perio

				Year 0 - 2028 [list main improvements]		Year 17 - 2045 [list main improvements]		Year 34 - 2062 [list main improvements]		Year 51 - 2079 [list main improvements]		Year 70 - 2098 [list main improvements]	
WORK ACTIVITY	QUANTITY	UNIT	UNIT COST	QUANTITY	TOTAL	QUANTITY	TOTAL	QUANTITY	TOTAL	QUANTITY	TOTAL	QUANTITY	TOTAL
STR Repairs													
Repair the locations of corrosion holes to the bascule span grid deck main bars (3 groups of locatior	3.0	EA	$8,000.00 /EA	3.0	$24,000	6.0	$48,000	10.0	$80,000	15.0	$120,000	20.0	$160,000
Replace the connection bolts (missing and in-place) at the vertical plates of the steel barriers in the bascule spa	1.0	LS	$10,000.00 /LS	1.0	$10,000								
Repair locations of disconnected, broken, and missing piping at the drainage components below deck and at the pie	1.0	LS	$25,000.00 /LS	1.0	$25,000	0.5	$12,500	1.0	$25,000	0.5	$12,500	1.0	$25,000
Replace the HPR joint material at the South approacl	66.0	LF	$28.00 /FT	66.0	$1,848	66.0	$1,848	66.0	$1,848	66.0	$1,848	66.0	$1,848
Install an epoxy overlay to the concrete deck surface across the bridge, include south approach structure deck surfa	21,600.0	SYD	$48.00 /SYD	21,600.0	$1,036,800			21,600.0	$1,036,800			21,600.0	$1,036,800
Apply silane treatment to the faces of the concrete barriers in the fixed spar	23,328.0	SF	$7.00 /SFT	23,328.0	$163,296			23,328.0	$163,296			23,328.0	$163,296
Clean and paint the steel barriers in the bascule spai	3,552.0	SF	$17.00 /SFT	3,552.0	$60,384					3,552.0	$60,384		
Repair the misalignment of the bascule span expansion joint finger plates by removing the plates, cleaning pack rust, pa	85.0	LF	$110.00 /FT	85.0	$9,350								
Repair the bascule span rear longitudinal breaks at the girders by cleaning the pack rust causing the warping at the base	400.0	LF	$125.00 /FT	400.0	$50,000			400.0	$50,000			400.0	$50,000
Replace the elastomeric troughs below the finger joints at the South Abutment, Piers 4, 5, 8 and the North Abutme	5.0	EA	$15,000.00 /EA	5.0	$75,000	5.0	$75,000	5.0	$75,000	5.0	$75,000	5.0	$75,000
Repair the broken concrete header at the South Abutment joint at the West sidewal	1.0	EA	$6,000.00 /EA	1.0	$6,000								
Repair the lower web and bottom flange of FB11S at the North Abutment, areas of active corrosion and section loss (rei	1.0	EA	$10,000.00 /EA	1.0	$10,000								
Repair the locations of holes in the bascule span girder and floorbeam bottom flanges, webs, and bases of vertical stiffe	3.0	EA	$8,000.00 /EA	3.0	$24,000								
Repair the locations of holes in the bascule span stringer web	20.0	EA	$2,500.00 /EA	20.0	$50,000	5.0	$12,500	30.0	$75,000	5.0	$12,500	40.0	$100,000
Repair the locations of holes in bascule span bracing members and connection plate	7.0	EA	$2,000.00 /EA	7.0	$14,000								
Repair the bascule span upper diagonal connections with holes, cracks or fully broken angl	11.0	EA	$6,000.00 /EA	11.0	$66,000								
Repair the locations of holes in the bascule span sidewalk support beam and post wel	11.0	EA	$3,500.00 /EA	11.0	$38,500								
Repair the locations of holes in the bascule span catwalk channel	1.0	LS	$10,000.00 /SYD	1.0	$10,000								
Repair the locations of deteriorated bascule span catwalk supports at the diagonal bracir	2.0	EA	$5,000.00 /EA	2.0	$10,000								
Clean and paint areas of corrosion and localized paint failure at superstructure components in the fixed and bascule spa	8,500.0	SF	$75.00 /SFT	8,500.0	$637,500	8,000.0	$600,000	8,000.0	$600,000	8,000.0	$600,000	8,000.0	$600,000
Repair cracks greater than 0.0625" wide with injection-seal type repair in the abutment walls and in the solid pier wa	274.0	LF	$70.00 /FT	274.0	$19,180	25.0	$1,750	25.0	$1,750	25.0	$1,750	25.0	$1,750
Perform concrete patch repairs to areas of delaminated and spalled concrete at the abutment walls, solid pier walls, and	123.5	CF	$360.00 /CF	123.5	$44,460	100.0	$36,000	100.0	$36,000	100.0	$36,000	100.0	$36,000
Apply a concrete surface coating over the vertical and horizontal surfaces of the abutments, wingwalls and piers to seal	8,800.0	SYD	$47.00 /SYD	8,800.0	$413,600			8,800.0	$413,600			8,800.0	$413,600
Repair the corrosion holes at the Span 6 sign gantry east support at the fasc	1.0	LS	$4,000.00 /LS	1.0	$4,000								
Repair the deteriorated conduit connections, supports and junction boxes throughout the brid	1.0	LS	$75,000.00 /LS	1.0	$75,000								
Repair cracks greater than 0.0625" wide with injection-seal type repair in the bascule pier interior walls and other locatio	331.0	LF	$70.00 /FT	331.0	$23,170	20.0	$1,400	20.0	$1,400	20.0	$1,400	20.0	$1,400
Perform concrete patch repairs to areas of delaminated and spalled concrete at the bascule pier interior walls, counterw	42.5	CF	$360.00 /FT	42.5	$15,300	25.0	$9,000	25.0	$9,000	25.0	$9,000	25.0	$9,000
Perform spot cleaning and painting at the tower bases and locations of active corrosic	400.0	SF	$35.00 /SFT	400.0	$14,000	50.0	$1,750	50.0	$1,750	50.0	$1,750	50.0	$1,750
Install reinforcement repairs at the tower bases and other locations of section loss and corrosion holes, and provide drai	1.0	LS	$30,000.00 /LS	1.0	$30,000								
Clean and paint the areas of corrosion at the tops of the counterweight and determine if patching repairs are necessary	400.0	SF	$70.00 /SFT	400.0	$28,000	50.0	$3,500	50.0	$3,500	50.0	$3,500	50.0	$3,500
Repair or replace broken, missing or otherwise deteriorated access stairs, hand railings or related items throughout both	1.0	LS	$75,000.00 /LS	1.0	$75,000								
Install fire and life safety items within both pier interiors	1.0	LS	$50,000.00 /LS	1.0	$50,000								
Repair the uplift at the bascule span rear break sidewalk joint cover plates by removing the plates, cleaning pack rust, pa	2.0	EA	$4,000.00 /EA	2.0	$8,000								
Replace missing caps at the tops of light poles	22.0	EA	$25.00 /EA	22.0	$550								
Repair or replace missing or out of place hand hole covers at the light pole	1.0	LS	$1,500.00 /LS	1.0	$1,500								
Repair or replace non-functioning navigational lights at Span 5 and the bascule pie	1.0	LS	$10,000.00 /LS	1.0	$10,000								
Replace fire extinguishers - 1 per level at each pier in main access roon	8.0	EA	$200.00 /EA	8.0	$1,600								
MEC Repairs													
Replace the railings in the machinery rooms around the staircases and open gearing for the safety of maintenance te	1.0	LS	$20,000.00 /LS	1.0	$20,000								
Adjust/repair manual release hand levers for brakes across all machinei	1.0	LS	$10,000.00 /LS	1.0	$10,000								
Adjust brakes to factory settings for torque, clearance, and thruster reserve strok	1.0	LS	$4,000.00 /LS	1.0	$4,000								
Remove corrosion from brake wheels and ensure brake pads are in contact when set and release fully when energi:	1.0	LS	$4,000.00 /LS	1.0	$4,000								
Replace auxiliary engine batteries	2.0	EA	$500.00 /EA	2.0	$1,000								
Remove stacks of counterweight blocks from machinery room floors to prevent injury and move to storage room or coun	1.0	LS	$4,000.00 /LS	1.0	$4,000								
Tighten or replace all loose fasteners across motors, brakes, actuators, housings and suppor	1.0	LS	$2,000.00 /LS	1.0	$2,000								
Fix bottom driven limit switch that slightly contacts target on NE outboard span loc	1.0	LS	$1,000.00 /LS	1.0	$1,000								
Replace selsyn motor on south side cam assembly and tighten chains on span drive machine	1.0	LS	$4,000.00 /LS	1.0	$4,000								
Tighten loose guy wires on traffic gates	1.0	LS	$1,000.00 /LS	1.0	$1,000								
Evaluate the rack mounting system and bolts, which should be rated by a mechanical or structural engineer based on va	1.0	LS	$10,000.00 /LS	1.0	$10,000								
Install new lighting in South machinery roon	1.0	LS	$50,000.00 /LS	1.0	$50,000								
Replace swing gates with a sturdier design that includes a locking mechanism to restore intended function of swing gat	1.0	LS	$400,000.00 /LS	1.0	$400,000								
Clean and repaint areas of corrosion across all machiner	1.0	LS	$60,000.00 /LS	1.0	$60,000								
Rehabilitate raised buffer cylinders as well as the strike plates and their fastenei	8.0	EA	$2,000.00 /EA	8.0	$16,000								
Re-align seated buffer cylinders and rehabilitate corroded hardwar	4.0	EA	$2,000.00 /EA	4.0	$8,000								
Rehabilitate supports for open gearing bearings where section loss occurs, and pack rust is formir	1.0	LS	$60,000.00 /LS	1.0	$60,000								
Replace gear covers and gaskets for G2 gears	4.0	EA	$5,000.00 /EA	4.0	$20,000								
Replace open gearing	1.0	LS	$750,000.00 /LS	1.0	$750,000								
Install new lubrication and purge fittings on the motor couplings and add the couplings to the bridge lubrication schedu	1.0	LS	$2,000.00 /LS	1.0	$2,000								
Clean open gearing of all lubrication, corrosion, and debris. Re-lubricate with fresh greas	1.0	LS	$5,000.00 /LS	1.0	$5,000								
Monitor gear condition and consider open gearing rehabilitatic	1.0	LS	$0.00 /LS	1.0	$0								
Lubricate span lock motor couplings regularly. Pull purge plugs when lubricatin	1.0	LS	$2,000.00 /LS	1.0	$2,000								
Replace bulging O-Ring being used on SE motor couplinc	1.0	LS	$1,000.00 /LS	1.0	$1,000								
Install drainage system below roadway breaks to prevent wear and corrosion on open gearing caused by the eleme	1.0	LS	$20,000.00 /LS	1.0	$20,000								
Re-align crank arms and shafts in NE and SW traffic gate housings. Replace arms if they are deforme	1.0	LS	$5,000.00 /LS	1.0	$5,000								
Clean auxiliary engines of excess grease and oil. Address fluid leak	1.0	LS	$1,000.00 /LS	1.0	$1,000								
Clean span lock gearing and racks of all contamination and debris then re-lubrica	1.0	LS	$4,000.00 /LS	1.0	$4,000								
Adjust bumper for NE vertical traffic gate to ensure it contacts roadway upon lowerir	1.0	LS	$1,000.00 /LS	1.0	$1,000								
Replace all non-functional and missing lighting on traffic gate:	1.0	LS	$2,000.00 /LS	1.0	$2,000								
Replace all locks and handles on traffic gate machinery housing	1.0	LS	$5,000.00 /LS	1.0	$5,000								
Rehabilitate access doors for swing gate machinery	1.0	LS	$5,000.00 /LS	1.0	$5,000								
Clean machinery of all excess debris to prevent further wea	1.0	LS	$5,000.00 /LS	1.0	$5,000								
Replace the Span Drive Machiner	1.0	LS	$8,500,000.00 /LS	-		1.0	$14,049,205	-					
Span Drive Machinery Rehabilitatio	1.0	LS	$500,000.00 /LS	-		-		1.0	$1,365,953			1.0	$3,958,911
Replace the Span Lock Machiner	1.0	LS	$3,300,000.00 /LS	-		1.0	$5,454,397	-					
Span Lock Machinery Rehabilitatio	1.0	LS	$200,000.00 /LS	-		-		1.0	$546,381			1.0	$1,583,564
Rehabilitate the Trunnion Bearing	1.0	LS	$60,000.00 /LS	-		1.0	$99,171	-					
Rehabilitate the Live Load Shoe	1.0	LS	$40,000.00 /LS	-		1.0	$66,114	-					
Remove the Air Buffers	1.0	LS	$50,000.00 /EA	-		2.0	$165,285	-					
Replace the Overtravel Buffer:	1.0	LS	$100,000.00 /LS	-		1.0	$165,285	-					
Replace the Traffic Gates	1.0	LS	$600,000.00 /LS	-		1.0	$991,709						
Traffic Gate Rehabilitatior	1.0	LS	$60,000.00 /LS	-		-		1.0	$163,914			1.0	$475,069
Replace the Barrier Gate:	1.0	LS	$1,200,000.00 /LS	-		1.0	$1,983,417	-					
Barrier Gate Rehabilitatioi	1.0	LS	$100,000.00 /LS	-		-		1.0	$273,191			1.0	$791,782
Rebalance the Bridge	1.0	LS	$150,000.00 /LS	-		1.0	$247,927	-					
future costs increased by compounded 3%													
highlighted items are M&E System Full Replacement, deferre													
ELE Repairs													
Test circuit breaker in motor starter cabinets and replace breakers as necessa	1.0	LS	$40,000.00 /LS	1.0	$40,000								
Replace missing light at southeast gat	1.0	LS	$500.00 /LS	1.0	$500								
Install wire numbers at termination cabinets near span lock actuato	1.0	LS	$5,000.00 /LS	1.0	$5,000								
Further investigate the random stopping of the bridge while lowerii	1.0	LS	$8,000.00 /LS	1.0	$8,000								
Install wire numbers at control desl	1.0	LS	$10,000.00 /LS	1.0	$10,000								
Install seals for outdoor cabinet:	1.0	LS	$5,000.00 /LS	1.0	$5,000								
Replace bulbs and/or fixtures	1.0	LS	$5,000.00 /LS	1.0	$5,000								
Install emergency lighting	1.0	LS	$15,000.00 /LS	1.0	$15,000	1.0	$24,793	1.0	$40,979	1.0	$67,731	1.0	$118,767
Install GFCI receptacles for all receptacles located in wet locatior	1.0	LS	$5,000.00 /LS	1.0	$5,000								
Remove abandoned utilty equipment in the south pi	1.0	LS	$25,000.00 /LS	1.0	$25,000								
Remove abandoned low voltage distribution equipment in the north and south pi	1.0	LS	$5,000.00 /LS	1.0	$5,000								
Replace all original panelboard	1.0	LS	$30,000.00 /LS	1.0	$30,000								
Install a second motor starter cabinet dedicated to the main drive motors or replaced the existing cabi	1.0	LS	$300,000.00 /LS	1.0	$300,000								
Replace the remaining original condcutors in the motor startet cabine	1.0	LS	$100,000.00 /LS	1.0	$100,000								
Replace the remaining original motor starters and relays in the motor startet cabin	1.0	LS	$75,000.00 /LS	1.0	$75,000			2.0	$409,786			2.0	$1,187,673
Rehabilitate or replace the existing main drive moto	4.0	EA	$60,000.00 /EA	4.0	$240,000								
Replace the existing brake junction boxes with termination cabinet	8.0	EA	$3,000.00 /EA	8.0	$24,000								
Replace the corroded conduit near the gate actuato	1.0	LS	$3,000.00 /LS	1.0	$3,000								
Replace the corroded enclosures near the traffic signal	1.0	LS	$3,000.00 /LS	1.0	$3,000								
Remove the PLC and associated I/O Rack	1.0	LS	$5,000.00 /LS	1.0	$5,000								
Replace control console pilot devices and meter	1.0	LS	$25,000.00 /LS	1.0	$25,000								
Replace the existing selsyn transmitters with new equipme	1.0	LS	$10,000.00 /LS	1.0	$10,000								
Clean and properly maintain the overspeed switc	1.0	LS	$1,000.00 /LS	1.0	$1,000								
Replace the existing conduit systen	1.0	LS	$250,000.00 /LS	1.0	$250,000								
Relocate the utility owned medium voltage transformers to the roadway deck of off of the sp	1.0	LS	$200,000.00 /LS	1.0	$200,000								
Relocate service entrance disconnect switch to the roadway deck level of the control hou	1.0	LS	$60,000.00 /LS	1.0	$60,000								
Replace the orginal remaining conductor	1.0	LS	$50,000.00 /LS	1.0	$50,000								
Test the orignial conductors and arc chute:	1.0	LS	$5,000.00 /LS	1.0	$5,000								
Replace the existing brake:	8.0	EA	$25,000.00 /EA	8.0	$200,000								
Replace the horizontal swing type gates to match the other gates that have more readily available p	2.0	EA	$75,000.00 /EA	2.0	$150,000								
Replace control console pilot devices and meter	1.0	LS	$25,000.00 /LS	1.0	$25,000								
Replace the existing selsyn transmitters with new equipme	1.0	LS	$10,000.00 /LS	1.0	$10,000								
Replace Remaining panelboard	1.0	LS	$40,000 /LS			1.0	$66,114						
Install Generator and ATS	1.0	LS	$350,000 /LS			1.0	$578,497					1.0	$2,771,238
Replace Lighitng Transformers	1.0	LS	$20,000.00 /LS			1.0	$33,057						
Install Invertor Duty Motor:	4.0	EA	$30,000.00 /EA			4.0	$198,342	2.0	$163,914	2.0	$270,925	4.0	$950,139
Install new motor and brake disconnect	12.0	EA	$7,000.00 /EA			12.0	$138,839					12.0	$665,097
Install Aux Motor and Clutcl	2.0	EA	$80,000.00 /EA			1.0	$132,228			1.0	$361,234		
Replace Remaining Traffic Gate:	2.0	EA	$75,000.00 /EA			2.0	$247,927					4.0	$2,375,347
Install PLC Control Systen	1.0	LS	$300,000.00 /LS			1.0	$495,854	0.5	$409,786	0.8	$1,083,702	1.0	$2,375,347
Install VFD	4.0	EA	$50,000.00 /EA			4.0	$330,570	4.0	$546,381	4.0	$903,085	4.0	$1,583,564
Install new Control Console	1.0	LS	$60,000.00 /LS			1.0	$99,171					1.0	$475,069
Install new limit switches and instrumentatio	1.0	LS	$35,000.00 /LS			1.0	$57,850	1.0	$95,617	1.0	$158,040	1.0	$277,124
Replace Remaining Condui	1.0	LS	$100,000.00 /LS			1.0	$165,285					1.0	$791,782
Replace Remaining Conductor:	1.0	LS	$160,000.00 /LS			1.0	$264,456					1.0	$1,266,852
Install new Submarine Cable	1.0	LS	$250,000.00 /LS			1.0	$413,212					1.0	$1,979,455
Replace Navigation Lighting	1.0	LS	$75,000.00 /LS			1.0	$123,964			1.0	$338,657	1.0	$593,837
Insall new CCTV Systen	1.0	LS	$75,000.00 /LS			1.0	$123,964	0.8	$153,670	1.0	$338,657	1.0	$593,837
Remove Equipment for Repair:	1.0	LS	$75,000.00 /LS			1.0	$123,964	1.0	$204,893	0.3	$84,664	1.0	$593,837
future costs increased by compounded 3%													
highlighted items are M&E System Full Replacement, deferre													
ROAD WORK													
Approach Pavement, 12" RC (incl. removal; add curb, gutter, guardrail) 20' ea. er		SYD	$230.00 /SYD										
Approach Curb & Gutter (incl. removal) 20' ea. quadrar		FT	$57.00 /FT										
Guardrail Anchorage to Bridge (each quadrant)		EA	$2,540.00 /EA										
Guardrail (incl. removal) < 200ft beyond reference lin		FT	$41.00 /FT										
Guardrail Termina (each quadrant)		EA	$3,900.00 /EA										
Roadway Approach Work (beyond approach pavement		LSUM	LSUM										
Utilities		LSUM	LSUM										
TRAFFIC CONTROL *Unit Cost to be determined by Region or TSC Traffic & Safet*													
Part Width Construction		LSUM	LSUM										
Crossovers		EA	/EA										
Temporary Traffic Signals		set	/set										
RR Flagging		LSUM	LSUM										
Detour		LSUM	LSUM										
CONTINGENCY (10% - 20%) (use higher contingency for small projects		%		0%	$0	0%	$0	0%	$0	0%	$0	0%	$0
MOBILIZATION (estimate at 10%		%		0%	$0	0%	$0	0%	$0	0%	$0	0%	$0
CONSTRUCTION TOTAL (DOES NOT INCLUDE PE & CE)					**$6,508,000**		**$27,644,000**		**$6,948,000**		**$4,542,000**		**$28,087,000**

2023

BRIDGE COST ESTIMATE WORKSHEET
- CPM, REHAB, REPLACE -

REV. 01/30/2023

OWNER: ODOT
REGION: Lucas County
Toledo

FISCAL YEAR: 2028

DATE: 4/3/2024
ENGINEER: J. Fogg, PE

STRUCTURE ID: LUC-65-05.35
BRIDGE NAME: Craig Bascule

LOCATION: SR-65 over Maumee River
PRIMARY WORK ACTIVITY: Alternate 2 - Operational System
OTHER WORK: Alternative Comparison

Revisions to Costs in Alternate 1 as shown

70-year Analysis Period

WORK ACTIVITY	QUANTITY	UNIT	UNIT COST	Year 0 - 2028 [list main improvements] QUANTITY	Year 0 - 2028 TOTAL	Year 17 - 2045 [list main improvements] QUANTITY	Year 17 - 2045 TOTAL	Year 34 - 2062 [list main improvements] QUANTITY	Year 34 - 2062 TOTAL	Year 51 - 2079 [list main improvements] QUANTITY	Year 51 - 2079 TOTAL	Year 70 - 2098 [list main improvements] QUANTITY	Year 70 - 2098 TOTAL
STR Repairs													
Repair the locations of corrosion holes to the bascule span grid deck main bars (3 groups of locations	3.0	EA	$8,000.00 /EA	3.0	$24,000	6.0	$48,000	10.0	$80,000	15.0	$120,000	20.0	$160,000
Replace the connection bolts (missing and in-place) at the vertical plates of the steel barriers in the bascule span.	1.0	LS	$10,000.00 /LS	1.0	$10,000								
Repair locations of disconnected, broken, and missing piping at the drainage components below deck and at the pier	1.0	LS	$25,000.00 /LS	1.0	$25,000	0.5	$12,500	1.0	$25,000	0.5	$12,500	1.0	$25,000
Replace the HPR joint material at the South approach.	66.0	LF	$28.00 /FT	66.0	$1,848	66.0	$1,848	66.0	$1,848	66.0	$1,848	66.0	$1,848
Install an epoxy overlay to the concrete deck surface across the bridge, include south approach structure deck surfac	21,600.0	SYD	$48.00 /SYD	21,600.0	$1,036,800			21,600.0	$1,036,800			21,600.0	$1,036,800
Apply silane treatment to the faces of the concrete barriers in the fixed spans	23,328.0	SF	$7.00 /SFT	23,328.0	$163,296			23,328.0	$163,296			23,328.0	$163,296
Clean and paint the steel barriers in the bascule span	3,552.0	SF	$17.00 /SFT	3,552.0	$60,384					3,552.0	$60,384		
Repair the misalignment of the bascule span expansion joint finger plates by removing the plates, cleaning pack rust	85.0	LF	$110.00 /FT	85.0	$9,350								
Repair the bascule span rear longitudinal breaks at the girders by cleaning the pack rust causing the warping at the b	400.0	LF	$125.00 /FT	400.0	$50,000			400.0	$50,000			400.0	$50,000
Replace the elastomeric troughs below the finger joints at the South Abutment, Piers 4, 5, 8 and the North Abutment	5.0	EA	$15,000.00 /EA	5.0	$75,000	5.0	$75,000	5.0	$75,000	5.0	$75,000	5.0	$75,000
Repair the broken concrete header at the South Abutment joint at the West sidewalk.	1.0	EA	$6,000.00 /EA	1.0	$6,000								
Repair the lower web and bottom flange of FB11S at the North Abutment, areas of active corrosion and section loss	1.0	EA	$10,000.00 /EA	1.0	$10,000								
Repair the locations of holes in the bascule span girder and floorbeam bottom flanges, webs, and bases of vertical st	3.0	EA	$8,000.00 /EA	3.0	$24,000								
Repair the locations of holes in the bascule span stringer webs.	20.0	EA	$2,500.00 /EA	20.0	$50,000	5.0	$12,500	30.0	$75,000	5.0	$12,500	40.0	$100,000
Repair the locations of holes in bascule span bracing members and connection plates.	7.0	EA	$2,000.00 /EA	7.0	$14,000								
Repair the bascule span upper diagonal connections with holes, cracks or fully broken angles	11.0	EA	$6,000.00 /EA	11.0	$66,000								
Repair the locations of holes in the bascule span sidewalk support beam and post webs.	11.0	EA	$3,500.00 /EA	11.0	$38,500								
Repair the locations of holes in the bascule span catwalk channels	1.0	LS	$10,000.00 /SYD	1.0	$10,000								
Repair the locations of deteriorated bascule span catwalk supports at the diagonal bracing	2.0	EA	$5,000.00 /EA	2.0	$10,000								
Clean and paint areas of corrosion and localized paint failure at superstructure components in the fixed and bascule	8,500.0	SF	$75.00 /SFT	8,500.0	$637,500	8,000.0	$600,000	8,000.0	$600,000	8,000.0	$600,000	8,000.0	$600,000
Repair cracks greater than 0.0625" wide with injection-seal type repair in the abutment walls and in the solid pier wal	274.0	LF	$70.00 /FT	274.0	$19,180	25.0	$1,750	25.0	$1,750	25.0	$1,750	25.0	$1,750
Perform concrete patch repairs to areas of delaminated and spalled concrete at the abutment walls, solid pier walls, a	123.5	CF	$360.00 /CF	123.5	$44,460	100.0	$36,000	100.0	$36,000	100.0	$36,000	100.0	$36,000
Apply a concrete surface coating over the vertical and horizontal surfaces of the abutments, wingwalls and piers to s	8,800.0	SYD	$47.00 /SYD	8,800.0	$413,600			8,800.0	$413,600			8,800.0	$413,600
Repair the corrosion holes at the Span 6 sign gantry east support at the fascia	1.0	LS	$4,000.00 /LS	1.0	$4,000								
Repair the deteriorated conduit connections, supports and junction boxes throughout the bridge	1.0	LS	$75,000.00 /LS	1.0	$75,000								
Repair cracks greater than 0.0625" wide with injection-seal type repair in the bascule pier interior walls and other loca	331.0	LF	$70.00 /FT	331.0	$23,170	20.0	$1,400	20.0	$1,400	20.0	$1,400	20.0	$1,400
Perform concrete patch repairs to areas of delaminated and spalled concrete at the bascule pier interior walls, counte	42.5	CF	$360.00 /FT	42.5	$15,300	25.0	$9,000	25.0	$9,000	25.0	$9,000	25.0	$9,000
Perform spot cleaning and painting at the tower bases and locations of active corrosion	400.0	SF	$35.00 /SFT	400.0	$14,000	50.0	$1,750	50.0	$1,750	50.0	$1,750	50.0	$1,750
Install reinforcement repairs at the tower bases and other locations of section loss and corrosion holes, and provide c	1.0	LS	$30,000.00 /LS	1.0	$30,000								
Clean and paint the areas of corrosion at the tops of the counterweight and determine if patching repairs are necessa	400.0	SF	$70.00 /SFT	400.0	$28,000	50.0	$3,500	50.0	$3,500	50.0	$3,500	50.0	$3,500
Repair or replace broken, missing or otherwise deteriorated access stairs, hand railings or related items throughout b	1.0	LS	$75,000.00 /LS	1.0	$75,000								
Install fire and life safety items within both pier interiors.	1.0	LS	$50,000.00 /LS	-									
Repair the uplift at the bascule span rear break sidewalk joint cover plates by removing the plates, cleaning pack rus	2.0	EA	$4,000.00 /EA	2.0	$8,000								
Replace missing caps at the tops of light poles.	22.0	EA	$25.00 /EA	-									
Repair or replace missing or out of place hand hole covers at the light poles.	1.0	LS	$1,500.00 /LS	-									
Repair or replace non-functioning navigational lights at Span 5 and the bascule piers	1.0	LS	$10,000.00 /LS	-									
Replace fire extinguishers - 1 per level at each pier in main access rooms	8.0	EA	$200.00 /EA	8.0	$1,600								
MEC Repairs													
Replace the Span Drive Machinery	1.0	LS	$8,500,000.00 /LS	1.0	$8,500,000								
Span Drive Machinery Rehabilitation	1.0	LS	$500,000.00 /LS					1.0	$1,365,953				
Replace the Span Lock Machinery	1.0	LS	$3,300,000.00 /LS	1.0	$3,300,000								
Span Lock Machinery Rehabilitation	1.0	LS	$200,000.00 /LS					1.0	$546,381				
Rehabilitate the Trunnion Bearings	1.0	LS	$60,000.00 /LS	1.0	$60,000								
Rehabilitate the Live Load Shoes	1.0	LS	$40,000.00 /LS	1.0	$40,000								
Remove the Air Buffers	1.0	LS	$50,000.00 /EA	2.0	$100,000								
Replace the Overtravel Buffers	1.0	LS	$100,000.00 /LS	1.0	$100,000								
Replace the Traffic Gates	1.0	LS	$600,000.00 /LS	1.0	$600,000								
Traffic Gate Rehabilitation	1.0	LS	$60,000.00 /LS					1.0	$163,914				
Replace the Barrier Gates	1.0	LS	$1,200,000.00 /LS	1.0	$1,200,000								
Barrier Gate Rehabilitation	1.0	LS	$100,000.00 /LS					1.0	$273,191				
Rebalance the Bridge	1.0	LS	$150,000.00 /LS	1.0	$150,000								
future costs increased by compounded 3%													
ELE Repairs													
Remove existing electrical and controls from the bridge	1.0	LS	$100,000.00 /LS	1.0	$100,000								
Relocate the utility owned medium voltage transformers to the roadway deck of off of the spar	1.0	LS	$200,000.00 /LS	1.0	$200,000								
Relocate service entrance disconnect switch to the roadway deck level of the control house	1.0	LS	$60,000.00 /LS	1.0	$60,000								
Install Generator and ATS	1.0	LS	$350,000.00 /LS	1.0	$350,000					1.0	$1,580,398		
Install new 480V Distirbution Panelboards	1.0	LS	$30,000.00 /LS	1.0	$30,000					1.0	$135,463		
Install new 120/240V Lighting Panelboards and Transformers	1.0	LS	$35,000.00 /LS	1.0	$35,000					1.0	$158,040		
Install new invertor duty motors	4.0	EA	$30,000.00 /EA	4.0	$120,000					4.0	$541,851		
Install new motor and machinery brakes	8.0	EA	$25,000.00 /EA	8.0	$200,000					8.0	$903,085		
Install new disconnects for all motors and brakes	14.0	EA	$7,000.00 /EA	14.0	$98,000					14.0	$442,511		
Install VFD's	4.0	EA	$30,000.00 /EA	4.0	$120,000					4.0	$541,851		
Install Aux Motor and Clutch	2.0	EA	$80,000.00 /EA	2.0	$160,000					2.0	$722,468		
Install emergency lighting	1.0	LS	$15,000.00 /LS	1.0	$15,000	1.0	$24,793	1.0	$40,979	1.0	$67,731	1.0	$118,767
Install traffic gates	4.0	EA	$75,000.00 /EA	4.0	$300,000					4.0	$1,354,627		
Install PLC Control System	1.0	LS	$300,000.00 /LS	1.0	$300,000	0.5	$247,927	0.8	$655,657	1.0	$1,354,627	0.5	$1,187,673
Install new Control console	1.0	LS	$60,000.00 /LS	1.0	$60,000	0.1	$9,917	0.1	$16,391	1.0	$270,925	0.1	$47,507
Install limit switches and instrumentation	1.0	LS	$35,000.00 /LS	1.0	$35,000	1.0	$57,850	1.0	$95,617	1.0	$158,040	1.0	$277,124
Install new conduit	1.0	LS	$150,000.00 /LS	1.0	$150,000							1.0	$1,187,673
Install new conductors	1.0	LS	$160,000.00 /LS	1.0	$160,000							1.0	$1,266,852
Install new Submarine Cable	1.0	LS	$250,000.00 /LS	1.0	$250,000							1.0	$1,979,455
Install new navigation and pier lights	1.0	LS	$75,000.00 /LS	1.0	$75,000			1.0	$204,893			1.0	$593,837
Install new CCTV System	1.0	LS	$75,000.00 /LS	1.0	$75,000	0.8	$99,171	1.0	$204,893	0.8	$270,925	1.0	$593,837
future costs increased by compounded 3%													
ROAD WORK													
Approach Pavement, 12" RC (incl. removal; add curb, gutter, guardrail) 20' ea. end		SYD	$230.00 /SYD										
Approach Curb & Gutter (incl. removal) 20' ea. quadrant		FT	$57.00 /FT										
Guardrail Anchorage to Bridge (each quadrant)		EA	$2,540.00 /EA										
Guardrail (incl. removal) < 200ft beyond reference line		FT	$41.00 /FT										
Guardrail Terminal (each quadrant)		EA	$3,900.00 /EA										
Roadway Approach Work (beyond approach pavement)		LSUM	LSUM										
Utilities		LSUM	LSUM										
TRAFFIC CONTROL *Unit Cost to be determined by Region or TSC Traffic & Safety*													
Part Width Construction		LSUM	LSUM										
Crossovers		EA	/EA										
Temporary Traffic Signals		set	/set										
RR Flagging		LSUM	LSUM										
Detour		LSUM	LSUM										
CONTINGENCY (10% - 20%) (use higher contingency for small projects)		%		0%	$0	0%	$0	0%	$0	0%	$0	0%	$0
MOBILIZATION (estimate at 10%)		%		0%	$0	0%	$0	0%	$0	0%	$0	0%	$0
CONSTRUCTION TOTAL (DOES NOT INCLUDE PE & CE)					**$20,016,000**		**$1,243,000**		**$6,142,000**		**$9,438,000**		**$9,932,000**

2023

BRIDGE COST ESTIMATE WORKSHEET

- CPM, REHAB, REPLACE -

REV. 01/30/2023

OWNER: ODOT
REGION: Lucas County
Toledo

FISCAL YEAR: 2028

DATE: 4/3/2024
ENGINEER: J. Fogg, PE
STRUCTURE ID: LUC-65-05.35
BRIDGE NAME: Craig Bascule

70-year Analysis Period

Bridge Deck	
L	1431
W	70
Area	100170

LOCATION: SR-65 over Maumee River
PRIMARY WORK ACTIVITY: Alternate 3 - Add' Structural Strengthening
OTHER WORK: Alternative Comparison

WORK ACTIVITY	QUANTITY	UNIT	UNIT COST	Year 0 - 2028 [list main improvements] QUANTITY	Year 0 - 2028 TOTAL	Year 17 - 2045 [list main improvements] QUANTITY	Year 17 - 2045 TOTAL	Year 34 - 2062 [list main improvements] QUANTITY	Year 34 - 2062 TOTAL	Year 51 - 2079 [list main improvements] QUANTITY	Year 51 - 2079 TOTAL	Year 70 - 2098 [list main improvements] QUANTITY	Year 70 - 2098 TOTAL
STR Repairs													
Repair the locations of corrosion holes to the bascule span grid deck main bars (3 groups of locations	3.0	EA	$8,000.00 /EA	3.0	$24,000	6.0	$48,000	10.0	$80,000	15.0	$120,000	20.0	$160,000
Replace the connection bolts (missing and in-place) at the vertical plates of the steel barriers in the bascule span.	1.0	LS	$10,000.00 /LS	1.0	$10,000								
Repair locations of disconnected, broken, and missing piping at the drainage components below deck and at the pier	1.0	LS	$25,000.00 /LS	1.0	$25,000	0.5	$12,500	1.0	$25,000	0.5	$12,500	1.0	$25,000
Replace the HPR joint material at the South approach.	66.0	LF	$28.00 /FT	66.0	$1,848	66.0	$1,848	66.0	$1,848	66.0	$1,848	66.0	$1,848
Install an epoxy overlay to the concrete deck surface across the bridge, include south approach structure deck surfac	21,600.0	SYD	$48.00 /SYD	21,600.0	$1,036,800			21,600.0	$1,036,800			21,600.0	$1,036,800
Apply silane treatment to the faces of the concrete barriers in the fixed spans	23,328.0	SF	$7.00 /SFT	23,328.0	$163,296			23,328.0	$163,296			23,328.0	$163,296
Clean and paint the steel barriers in the bascule span.	3,552.0	SF	$17.00 /SFT	3,552.0	$60,384					3,552.0	$60,384		
Repair the misalignment of the bascule span expansion joint finger plates by removing the plates, cleaning pack rust	85.0	LF	$110.00 /FT	85.0	$9,350								
Repair the bascule span rear longitudinal breaks at the girders by cleaning the pack rust causing the warping at the b	400.0	LF	$125.00 /FT	400.0	$50,000			400.0	$50,000			400.0	$50,000
Replace the elastomeric troughs below the finger joints at the South Abutment, Piers 4, 5, 8 and the North Abutment	5.0	EA	$15,000.00 /EA	5.0	$75,000	5.0	$75,000	5.0	$75,000	5.0	$75,000	5.0	$75,000
Repair the broken concrete header at the South Abutment joint at the West sidewalk.	1.0	EA	$6,000.00 /EA	1.0	$6,000								
Repair the lower web and bottom flange of FB11S at the North Abutment, areas of active corrosion and section loss	1.0	EA	$10,000.00 /EA	1.0	$10,000								
Repair the locations of holes in the bascule span girder and floorbeam bottom flanges, webs, and bases of vertical st	3.0	EA	$8,000.00 /EA	3.0	$24,000								
Repair the locations of holes in the bascule span stringer webs.	20.0	EA	$2,500.00 /EA	20.0	$50,000	5.0	$12,500	30.0	$75,000	5.0	$12,500	40.0	$100,000
Repair the locations of holes in bascule span bracing members and connection plates.	7.0	EA	$2,000.00 /EA	7.0	$14,000								
Repair the bascule span upper diagonal connections with holes, cracks or fully broken angles	11.0	EA	$6,000.00 /EA	11.0	$66,000								
Repair the locations of holes in the bascule span sidewalk support beam and post webs.	11.0	EA	$3,500.00 /EA	11.0	$38,500								
Repair the locations of holes in the bascule span catwalk channels	1.0	LS	$10,000.00 /SYD	1.0	$10,000								
Repair the locations of deteriorated bascule span catwalk supports at the diagonal bracing	2.0	EA	$5,000.00 /EA	2.0	$10,000								
Clean and paint areas of corrosion and localized paint failure at superstructure components in the fixed and bascule	8,500.0	SF	$75.00 /SFT	8,500.0	$637,500	8,000.0	$600,000	8,000.0	$600,000	8,000.0	$600,000	8,000.0	$600,000
Repair cracks greater than 0.0625” wide with injection-seal type repair in the abutment walls and in the solid pier wal	274.0	LF	$70.00 /FT	274.0	$19,180	25.0	$1,750	25.0	$1,750	25.0	$1,750	25.0	$1,750
Perform concrete patch repairs to areas of delaminated and spalled concrete at the abutment walls, solid pier walls, a	123.5	CF	$360.00 /CF	123.5	$44,460	100.0	$36,000	100.0	$36,000	100.0	$36,000	100.0	$36,000
Apply a concrete surface coating over the vertical and horizontal surfaces of the abutments, wingwalls and piers to se	8,800.0	SYD	$47.00 /SYD	8,800.0	$413,600			8,800.0	$413,600			8,800.0	$413,600
Repair the corrosion holes at the Span 6 sign gantry east support at the fascia	1.0	LS	$4,000.00 /LS	1.0	$4,000								
Repair the deteriorated conduit connections, supports and junction boxes throughout the bridge	1.0	LS	$75,000.00 /LS	1.0	$75,000								
Repair cracks greater than 0.0625” wide with injection-seal type repair in the bascule pier interior walls and other loca	331.0	LF	$70.00 /FT	331.0	$23,170	20.0	$1,400	20.0	$1,400	20.0	$1,400	20.0	$1,400
Perform concrete patch repairs to areas of delaminated and spalled concrete at the bascule pier interior walls, counte	42.5	CF	$360.00 /FT	42.5	$15,300	25.0	$9,000	25.0	$9,000	25.0	$9,000	25.0	$9,000
Perform spot cleaning and painting at the tower bases and locations of active corrosion	400.0	SF	$35.00 /SFT	400.0	$14,000	50.0	$1,750	50.0	$1,750	50.0	$1,750	50.0	$1,750
Install reinforcement repairs at the tower bases and other locations of section loss and corrosion holes, and provide c	1.0	LS	$30,000.00 /LS	1.0	$30,000								
Clean and paint the areas of corrosion at the tops of the counterweight and determine if patching repairs are necessa	400.0	SF	$70.00 /SFT	400.0	$28,000	50.0	$3,500	50.0	$3,500	50.0	$3,500	50.0	$3,500
Repair or replace broken, missing or otherwise deteriorated access stairs, hand railings or related items throughout b	1.0	LS	$75,000.00 /LS	1.0	$75,000								
Install fire and life safety items within both pier interiors.	1.0	LS	$50,000.00 /LS	-									
Repair the uplift at the bascule span rear break sidewalk joint cover plates by removing the plates, cleaning pack rus	2.0	EA	$4,000.00 /EA	2.0	$8,000								
Replace missing caps at the tops of light poles.	22.0	EA	$25.00 /EA	-									
Repair or replace missing or out of place hand hole covers at the light poles.	1.0	LS	$1,500.00 /LS	-									
Repair or replace non-functioning navigational lights at Span 5 and the bascule piers.	1.0	LS	$10,000.00 /LS	-									
Replace fire extinguishers - 1 per level at each pier in main access rooms	8.0	EA	$200.00 /EA	8.0	$1,600								
Review and Update the Bridge Load Rating	1.0	LS	$30,000.00 /LS	-									
Review and Update the Bridge Sufficiency and Appraisal Rating	1.0	LS	$10,000.00 /LS	-									
Steel Strengthening Repairs at Units 1 & 2 Girders	1.0	LS	$244,000.00 /LS	1.0	$244,000								
bridge deck replacement	100,200.0	SF	$300.00 /SFT										
MEC Repairs													
Replace the Span Drive Machinery	1.0	LS	$8,500,000.00 /LS	1.0	$8,500,000								
Span Drive Machinery Rehabilitation	1.0	LS	$500,000.00 /LS					1.0	$1,365,953				
Replace the Span Lock Machinery	1.0	LS	$3,300,000.00 /LS	1.0	$3,300,000								
Span Lock Machinery Rehabilitation	1.0	LS	$200,000.00 /LS					1.0	$546,381				
Rehabilitate the Trunnion Bearings	1.0	LS	$60,000.00 /LS	1.0	$60,000								
Rehabilitate the Live Load Shoes	1.0	LS	$40,000.00 /LS	1.0	$40,000								
Remove the Air Buffers	1.0	LS	$50,000.00 /EA	2.0	$100,000								
Replace the Overtravel Buffers	1.0	LS	$100,000.00 /LS	1.0	$100,000								
Replace the Traffic Gates	1.0	LS	$600,000.00 /LS	1.0	$600,000								
Traffic Gate Rehabilitation	1.0	LS	$60,000.00 /LS					1.0	$163,914				
Replace the Barrier Gates	1.0	LS	$1,200,000.00 /LS	1.0	$1,200,000								
Barrier Gate Rehabilitation	1.0	LS	$100,000.00 /LS					1.0	$273,191				
Rebalance the Bridge	1.0	LS	$150,000.00 /LS	1.0	$150,000								
future costs increased by compounded 3%													
ELE Repairs													
Remove existing electrical and controls from the bridge	1.0	LS	$100,000.00 /LS	1.0	$100,000								
Relocate the utility owned medium voltage transformers to the roadway deck of off of the spar	1.0	LS	$200,000.00 /LS	1.0	$200,000								
Relocate service entrance disconnect switch to the roadway deck level of the control house	1.0	LS	$60,000.00 /LS	1.0	$60,000								
Install Generator and ATS	1.0	LS	$350,000.00 /LS	1.0	$350,000					1.0	$1,580,398		
Install new 480V Distirbution Panelboards	1.0	LS	$30,000.00 /LS	1.0	$30,000					1.0	$135,463		
Install new 120/240V Lighting Panelboards and Transformers	1.0	LS	$35,000.00 /LS	1.0	$35,000					1.0	$158,040		
Install new invertor duty motors	4.0	EA	$30,000.00 /EA	4.0	$120,000					4.0	$541,851		
Install new motor and machinery brakes	8.0	EA	$25,000.00 /EA	8.0	$200,000					8.0	$903,085		
Install new disconnects for all motors and brakes	14.0	EA	$7,000.00 /EA	14.0	$98,000					14.0	$442,511		
Install VFD's	4.0	EA	$30,000.00 /EA	4.0	$120,000					4.0	$541,851		
Install Aux Motor and Clutch	2.0	EA	$80,000.00 /EA	2.0	$160,000					2.0	$722,468		
Install emergency lighting	1.0	LS	$15,000.00 /LS	1.0	$15,000	1.0	$24,793	1.0	$40,979	1.0	$67,731	1.0	$118,767
Install traffic gates	4.0	EA	$75,000.00 /EA	4.0	$300,000					4.0	$1,354,627		
Install PLC Control System	1.0	LS	$300,000.00 /LS	1.0	$300,000	0.5	$247,927	0.8	$655,657	1.0	$1,354,627	0.5	$1,187,673
Install new Control console	1.0	LS	$60,000.00 /LS	1.0	$60,000	0.1	$9,917	0.1	$16,391	1.0	$270,925	0.1	$47,507
Install limit switches and instrumentation	1.0	LS	$35,000.00 /LS	1.0	$35,000	1.0	$57,850	1.0	$95,617	1.0	$158,040	1.0	$277,124
Install new conduit	1.0	LS	$150,000.00 /LS	1.0	$150,000							1.0	$1,187,673
Install new conductors	1.0	LS	$160,000.00 /LS	1.0	$160,000							1.0	$1,266,852
Install new Submarine Cable	1.0	LS	$250,000.00 /LS	1.0	$250,000							1.0	$1,979,455
Install new navigation and pier lights	1.0	LS	$75,000.00 /LS	1.0	$75,000			1.0	$204,893			1.0	$593,837
Install new CCTV System	1.0	LS	$75,000.00 /LS	1.0	$75,000	0.8	$99,171	1.0	$204,893	0.8	$270,925	1.0	$593,837
future costs increased by compounded 3%													
ROAD WORK													
Approach Pavement, 12" RC (incl. removal; add curb, gutter, guardrail) 20' ea. end		SYD	$230.00 /SYD										
Approach Curb & Gutter (incl. removal) 20' ea. quadrant		FT	$57.00 /FT										
Guardrail Anchorage to Bridge (each quadrant)		EA	$2,540.00 /EA										
Guardrail (incl. removal) < 200ft beyond reference line		FT	$41.00 /FT										
Guardrail Terminal (each quadrant)		EA	$3,900.00 /EA										
Roadway Approach Work (beyond approach pavement)		LSUM	LSUM										
Utilities		LSUM	LSUM										
TRAFFIC CONTROL *Unit Cost to be determined by Region or TSC Traffic & Safety*													
Part Width Construction		LSUM	LSUM										
Crossovers		EA	/EA										
Temporary Traffic Signals		set	/set										
RR Flagging		LSUM	LSUM										
Detour		LSUM	LSUM										
CONTINGENCY (10% - 20%) (use higher contingency for small projects)		%		0%	$0	0%	$0	0%	$0	0%	$0	0%	$0
MOBILIZATION (estimate at 10%)		%		0%	$0	0%	$0	0%	$0	0%	$0	0%	$0
CONSTRUCTION TOTAL (DOES NOT INCLUDE PE & CE)					**$20,260,000**		**$1,243,000**		**$6,142,000**		**$9,438,000**		**$9,932,000**

REV. 02/10/2022

PRESENTATION SHEET FOR
LIFE CYCLE COST ANALYSIS

Structure Number: LUC-65-05.35 Bridge ID: Craig Bascule
Location: SR-65 over Maumee River
Repair Option: Alternate 1 - Base Recommended Repairs

Total 70 Year Life Estimate (at year 0): **$24,949,115.52**

Date	Year	Repair Work	Est. Cost	PWF	Present Value (PWF * Cost)
2028	0		$6,508,000.00	1.0000	$6,508,000.00
20xx	5			0.8219	$0.00
20xx	10			0.6756	$0.00
2045	17		$27,644,000.00	0.5134	$14,191,690.01
20xx	20			0.4564	$0.00
20xx	25			0.3751	$0.00
20xx	30			0.3083	$0.00
2062	34		$6,948,000.00	0.2636	$1,831,159.92
20xx	40			0.2083	$0.00
20xx	45			0.1712	$0.00
2079	51		$4,542,000.00	0.1353	$614,535.29
20xx	55			0.1157	$0.00
20xx	60			0.0951	$0.00
20xx	65			0.0781	$0.00
2098	70		$28,087,000.00	0.0642	$1,803,730.31

Assumptions: Discount Rate = 4%

Calculation of Present Worth Factor (PWF):
Present Value = Future Value x 1 / (1+r)^n
r = real discount rate r = 4%
n = number of year in the future when the cost is incurred (number in "Year" column)

REV. 02/10/2022

PRESENTATION SHEET FOR

LIFE CYCLE COST ANALYSIS

Structure Number: LUC-65-05.35 Bridge ID: Craig Bascule
Location: SR-65 over Maumee River
Repair Option: Alternate 2 - Operational System Replacement

Total 70 Year Life Estimate (at year 0): **$24,187,653.95**

Date	Year	Repair Work	Est. Cost	PWF	Present Value (PWF * Cost)
2028	0		$20,016,000.00	1.0000	$20,016,000.00
20xx	5			0.8219	$0.00
20xx	10			0.6756	$0.00
2045	17		$1,243,000.00	0.5134	$638,122.94
20xx	20			0.4564	$0.00
20xx	25			0.3751	$0.00
20xx	30			0.3083	$0.00
2062	34		$6,142,000.00	0.2636	$1,618,736.93
20xx	40			0.2083	$0.00
20xx	45			0.1712	$0.00
2079	51		$9,438,000.00	0.1353	$1,276,966.98
20xx	55			0.1157	$0.00
20xx	60			0.0951	$0.00
20xx	65			0.0781	$0.00
2098	70		$9,932,000.00	0.0642	$637,827.09

Assumptions: Discount Rate = 4%

Calculation of Present Worth Factor (PWF):
Present Value = Future Value x 1 / (1+r)^n
r = real discount rate r = 4%
n = number of year in the future when the cost is incurred (number in "Year" column)

REV. 02/10/2022

PRESENTATION SHEET FOR

LIFE CYCLE COST ANALYSIS

Structure Number: LUC-65-05.35   Bridge ID: Craig Bascule
Location: SR-65 over Maumee River
Repair Option: Alternate 3 - Add' Structural Strengthening

Total 70 Year Life Estimate (at year 0): **$24,431,653.95**

Date	Year	Repair Work	Est. Cost	PWF	Present Value (PWF * Cost)
2028	0		$20,260,000.00	1.0000	$20,260,000.00
20xx	5			0.8219	$0.00
20xx	10			0.6756	$0.00
2045	17		$1,243,000.00	0.5134	$638,122.94
20xx	20			0.4564	$0.00
20xx	25			0.3751	$0.00
20xx	30			0.3083	$0.00
2062	34		$6,142,000.00	0.2636	$1,618,736.93
20xx	40			0.2083	$0.00
20xx	45			0.1712	$0.00
2079	51		$9,438,000.00	0.1353	$1,276,966.98
20xx	55			0.1157	$0.00
20xx	60			0.0951	$0.00
20xx	65			0.0781	$0.00
2098	70		$9,932,000.00	0.0642	$637,827.09

Assumptions: Discount Rate = 4%

Calculation of Present Worth Factor (PWF):
Present Value = Future Value x 1 / (1+r)^n
r = real discount rate   r = 4%
n = number of year in the future when the cost is incurred (number in "Year" column)

Alternative 3: Steel Strengthening Repairs Estimate

Repair	Steel Plate	qty	steel weight 490 lbs/CF		Bolts 10% wt	total weight lbs	Unit Cost Installed	Sub-Total Cost	caulking, clean & coat 3% cost	Total Cost
Unit 1 at Pier 1										
Girder 1	91 L x 115 H x 0.5 th	2	2967.51	PCF	296.75	3264.26	$ 18.50	$ 60,388.74	$ 1,811.66	$ 62,200.41
Girder 4	91 L x 115 H x 0.5 th	2	2967.51	PCF	296.75	3264.26	$ 18.50	$ 60,388.74	$ 1,811.66	$ 62,200.41
Unit 1 at South Abutment										
Girder 1	68 L x 55 H x 0.5 th	2	1060.53	PCF	106.05	1166.59	$ 18.50	$ 21,581.83	$ 647.46	$ 22,229.29
Girder 4	68 L x 55 H x 0.5 th	2	1060.53	PCF	106.05	1166.59	$ 18.50	$ 21,581.83	$ 647.46	$ 22,229.29
Unit 2 at Bascule Girders - A										
Girders 2 & 3	6 L x 60 H x 0.25 th	4	102.08	PCF	10.21	112.29	$ 18.50	$ 2,077.40	$ 62.32	$ 2,139.72
Unit 2 at Bascule Girders - B										
Girders 2 & 3	15 L x 60 H x 0.25 th	4	255.21	PCF	25.52	280.73	$ 18.50	$ 5,193.49	$ 155.80	$ 5,349.29
									A total	$ 170,999.11
									B total	$ 174,208.68
Add Design, Shop Drawings (15%)								$ 26,131.30		
Add Mobilization (15%)								$ 26,131.30		
Add Access, Means, Methods, Traffic Control (10%)								$ 17,420.87		
									Total	$ 243,892.16
						Per location		$ 21,776.09		

Appendix 2:

Load Rating Analysis Screenshots and Related Reference Materials

From the DGL 2019 Load Rating Report & Bridge Plans:

Controlling member and rating summary: Unit 1

SFN: 4805917
BRIDGE NO.: LUC-00065-0535
Date: 10/30/2019

DGL CONSULTING ENGINEERS

Load Rating Summary

		Vehicle	Rating	Member	Vehicle	Rating	Member	Vehicle	Rating	Member			
Stringers	Unit #1	Inventory	1.146	Unit #1 - Stringer 1 -6	Inventory	1.222	Unit #7 - Stringer 1-6	Inventory	1.262	Unit #36 - Stringer 1-6			
		Operating	1.914	Unit #1 - Stringer 1 -6	Operating	2.041	Unit #7 - Stringer 1-6	Operating	2.108	Unit #36 - Stringer 1-6			
		EV2	1.828	Unit #1 - Stringer 1 -6	EV2	1.949	Unit #7 - Stringer 1-6	EV2	2.014	Unit #36 - Stringer 1-6			
		EV3	1.420	Unit #1 - Stringer 1 -6	EV3	1.529	Unit #7 - Stringer 1-6	EV3	1.588	Unit #36 - Stringer 1-6			
		SU4	1.850	Unit #1 - Stringer 1 -6	SU4	1.997	Unit #7 - Stringer 1-6	SU4	2.077	Unit #36 - Stringer 1-6			
		SU5	1.729	Unit #1 - Stringer 1 -6	SU5	1.880	Unit #7 - Stringer 1-6	SU5	1.962	Unit #36 - Stringer 1-6			
		SU6	1.623	Unit #1 - Stringer 1 -6	SU6	1.775	Unit #7 - Stringer 1-6	SU6	1.859	Unit #36 - Stringer 1-6			
		SU7	1.623	Unit #1 - Stringer 1 -6	SU7	1.775	Unit #7 - Stringer 1-6	SU7	1.859	Unit #36 - Stringer 1-6			
		2F1	2.849	Unit #1 - Stringer 1 -6	2F1	3.081	Unit #7 - Stringer 1-6	2F1	3.208	Unit #36 - Stringer 1-6			
		3F1	2.091	Unit #1 - Stringer 1 -6	3F1	2.291	Unit #7 - Stringer 1-6	3F1	2.401	Unit #36 - Stringer 1-6			
		4F1	1.911	Unit #1 - Stringer 1 -6	4F1	2.068	Unit #7 - Stringer 1-6	4F1	2.153	Unit #36 - Stringer 1-6			
		5C1	2.091	Unit #1 - Stringer 1 -6	5C1	2.291	Unit #7 - Stringer 1-6	5C1	2.401	Unit #36 - Stringer 1-6			
Floor Beams		Vehicle	Rating	Member	Vehicle	Rating	Member	Vehicle	Rating	Member	Vehicle	Rating	Member
	Unit #1	Inventory	2.964	Floorbeam1	Inventory	6.706	Floorbeam2	Inventory	2.147	Floorbeam4	Inventory	2.515	Floorbeam37
		Operating	4.951	Floorbeam1	Operating	11.200	Floorbeam2	Operating	3.586	Floorbeam4	Operating	4.200	Floorbeam37
		EV2	5.259	Floorbeam1	EV2	12.714	Floorbeam2	EV2	4.071	Floorbeam4	EV2	4.441	Floorbeam37
		EV3	4.283	Floorbeam1	EV3	9.669	Floorbeam2	EV3	3.096	Floorbeam4	EV3	3.628	Floorbeam37
		SU4	5.664	Floorbeam1	SU4	12.536	Floorbeam2	SU4	4.014	Floorbeam4	SU4	4.788	Floorbeam37
		SU5	5.439	Floorbeam1	SU5	11.696	Floorbeam2	SU5	3.745	Floorbeam4	SU5	4.578	Floorbeam37
		SU6	5.440	Floorbeam1	SU6	10.517	Floorbeam2	SU6	3.368	Floorbeam4	SU6	4.578	Floorbeam37
		SU7	5.440	Floorbeam1	SU7	9.789	Floorbeam2	SU7	3.135	Floorbeam4	SU7	4.578	Floorbeam37
		2F1	8.541	Floorbeam1	2F1	20.646	Floorbeam2	2F1	6.611	Floorbeam4	2F1	7.101	Floorbeam37
		3F1	6.146	Floorbeam1	3F1	14.016	Floorbeam2	3F1	4.488	Floorbeam4	3F1	5.155	Floorbeam37
		4F1	5.910	Floorbeam1	4F1	12.697	Floorbeam2	4F1	4.066	Floorbeam4	4F1	5.018	Floorbeam37
		5C1	6.146	Floorbeam1	5C1	14.016	Floorbeam2	5C1	4.488	Floorbeam4	5C1	5.155	Floorbeam37
Girders		Vehicle	Rating	Member	Vehicle	Rating	Member						
	Unit #1	Inventory	0.310	Girder 1	Inventory	1.166	Girder 2						
		Operating	0.518	Girder 1	Operating	1.947	Girder 2						
		EV2	1.501	Girder 1	EV2	2.362	Girder 2						
		EV3	1.186	Girder 1	EV3	1.875	Girder 2						
		SU4	1.591	Girder 1	SU4	2.520	Girder 2						
		SU5	1.395	Girder 1	SU5	2.230	Girder 2						
		SU6	1.247	Girder 1	SU6	2.047	Girder 2						
		SU7	1.121	Girder 1	SU7	1.888	Girder 2						
		2F1	2.847	Girder 1	2F1	4.387	Girder 2						
		3F1	1.862	Girder 1	3F1	2.916	Girder 2						
		4F1	1.592	Girder 1	4F1	2.538	Girder 2						
		5C1	1.170	Girder 1	5C1	2.078	Girder 2						

Member Summary

	Vehicle	Rating	Member
Stringers	Inventory	1.146	Unit #1 - Stringer 1 -6
	Operating	1.914	Unit #1 - Stringer 1 -6
	EV2	1.828	Unit #1 - Stringer 1 -6
	EV3	1.420	Unit #1 - Stringer 1 -6
	SU4	1.850	Unit #1 - Stringer 1 -6
	SU5	1.729	Unit #1 - Stringer 1 -6
	SU6	1.623	Unit #1 - Stringer 1 -6
	SU7	1.623	Unit #1 - Stringer 1 -6
	2F1	2.849	Unit #1 - Stringer 1 -6
	3F1	2.091	Unit #1 - Stringer 1 -6
	4F1	1.911	Unit #1 - Stringer 1 -6
	5C1	2.091	Unit #1 - Stringer 1 -6
Floor Beams	Vehicle	Rating	Member
	Inventory	2.147	Floorbeam4
	Operating	3.586	Floorbeam4
	EV2	4.071	Floorbeam4
	EV3	3.096	Floorbeam4
	SU4	4.014	Floorbeam4
	SU5	3.745	Floorbeam4
	SU6	3.368	Floorbeam4
	SU7	3.135	Floorbeam4
	2F1	6.611	Floorbeam4
	3F1	4.488	Floorbeam4
	4F1	4.066	Floorbeam4
	5C1	4.488	Floorbeam4
Girders	Vehicle	Rating	Member
	Inventory	0.310	Girder 1
	Operating	0.518	Girder 1
	EV2	1.501	Girder 1
	EV3	1.186	Girder 1
	SU4	1.591	Girder 1
	SU5	1.395	Girder 1
	SU6	1.247	Girder 1
	SU7	1.121	Girder 1
	2F1	2.847	Girder 1
	3F1	1.862	Girder 1
	4F1	1.592	Girder 1
	5C1	1.170	Girder 1

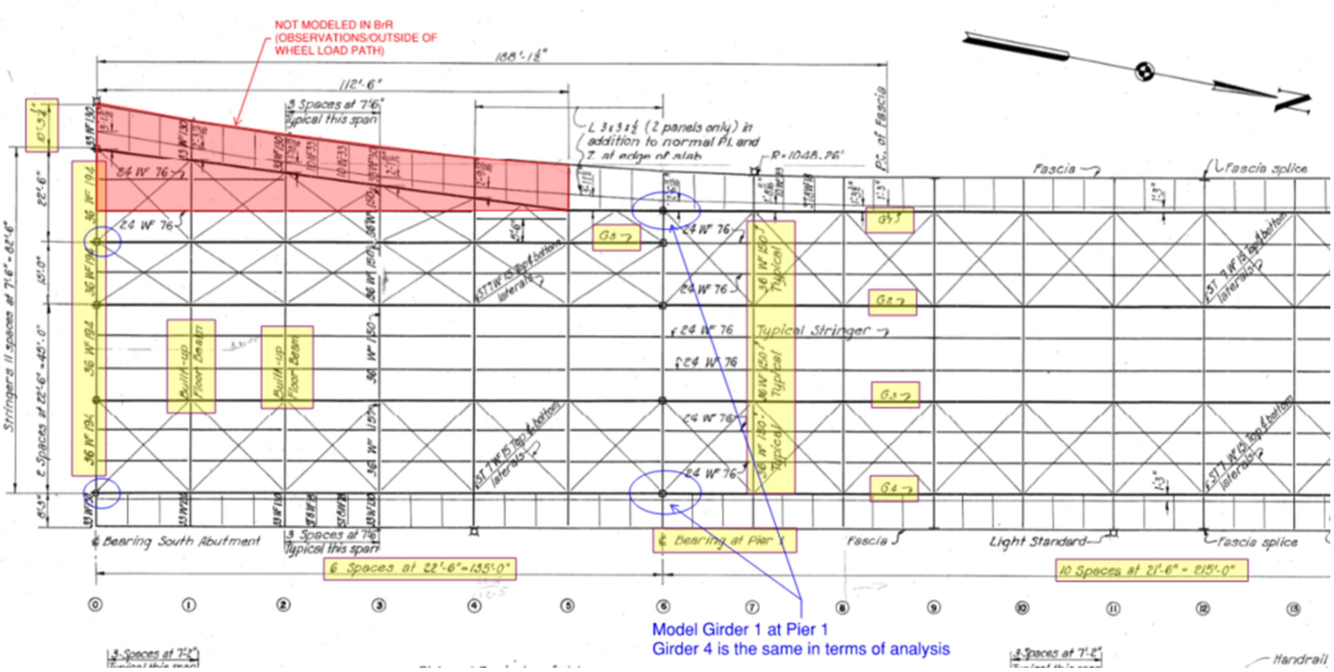
Spans 1-4, Exterior Girders:
0.310 Inventory HS-20 Lane at Pier 1, Sections 6 to 7;

0.518 Operating HS-20 Lane at XXX;

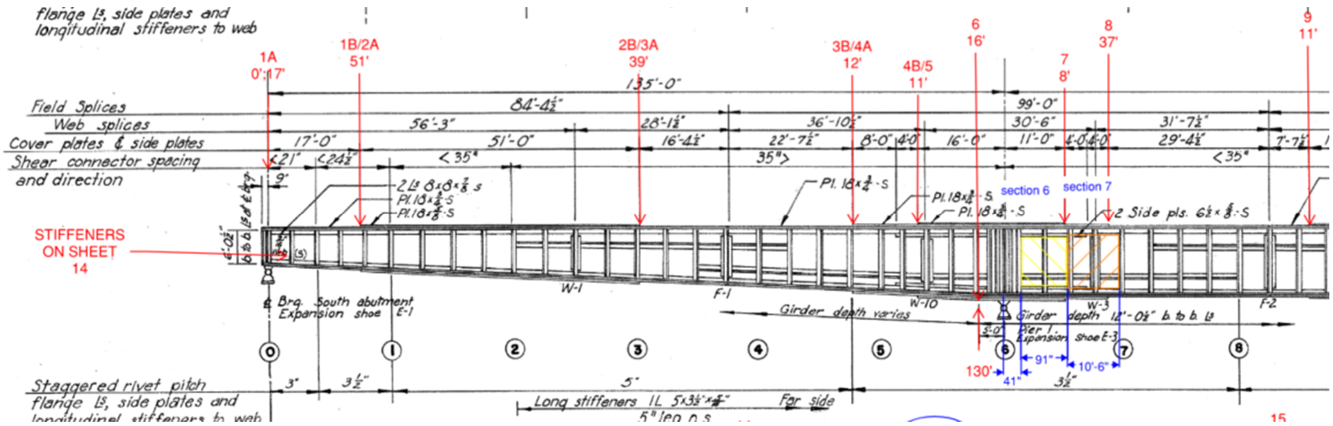
0.722 Inventory HS-20 Truck at XXX;

0.938 Inventory HS-20 (?) at XXX

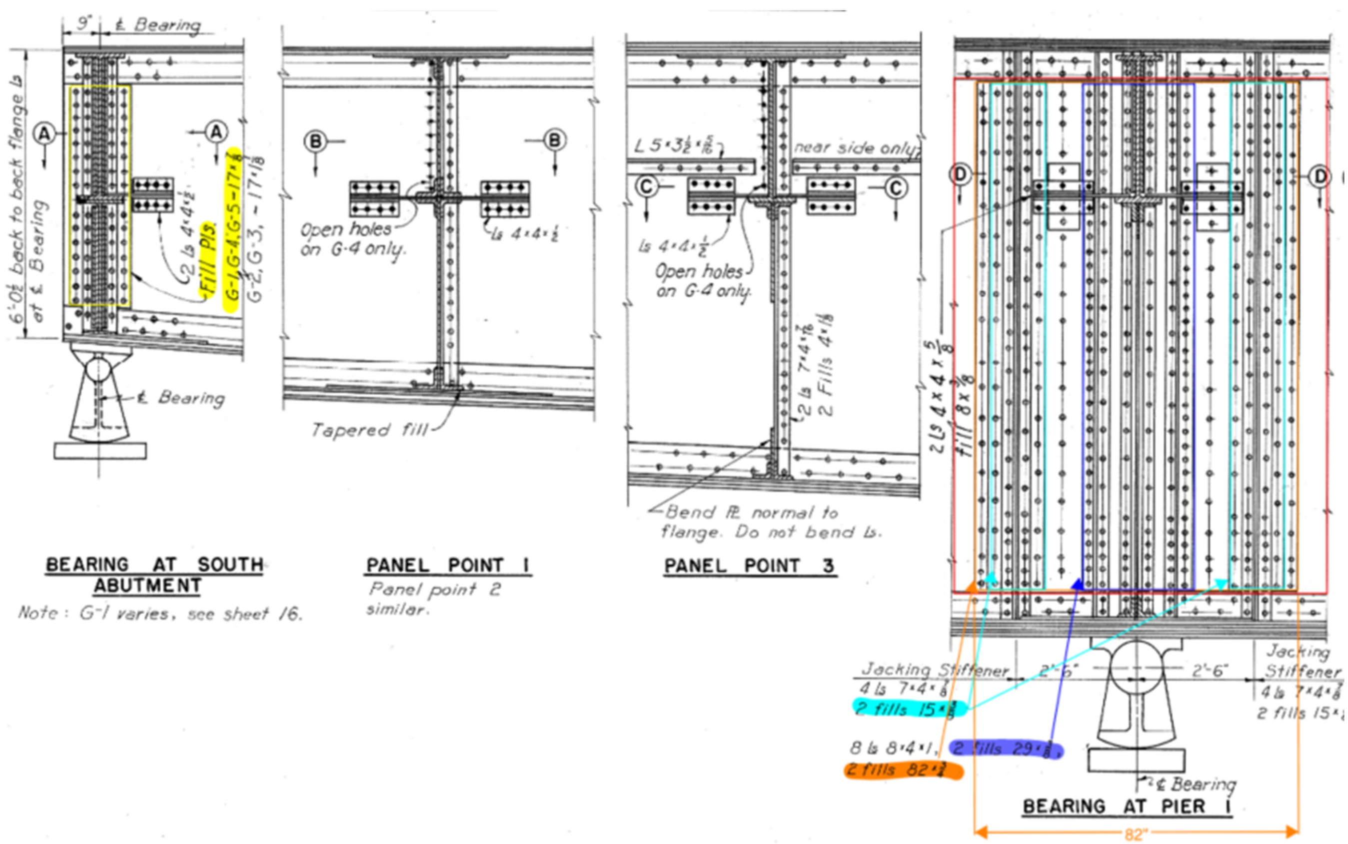
Girder 1 in Unit 1 Controlling location is at Pier 1:



Girder 1 Elevation S. Abut into Span 2:



Girder details elevations at bearings at S. Abut and Pier 1:



Unit 1 information from BrR (screenshots):

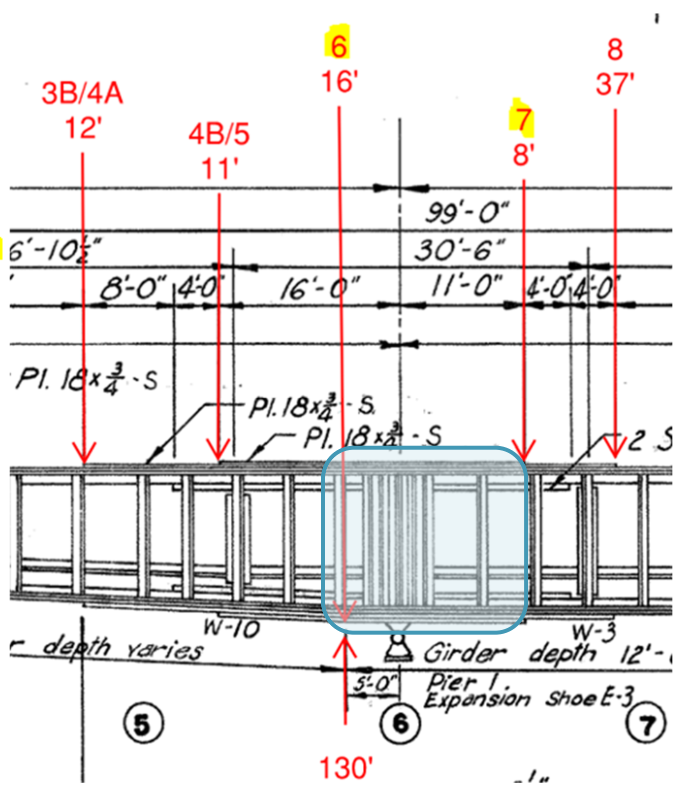
Report Type: Rating Results Summary
Lane/Impact Loading Type: (•) As Requested ( ) Detailed
Display Format: Single rating level per row

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Location (ft)	Location Span-(%)	Limit State	Impact	Lane
HS 20-44	Lane	LFD	Inventory	11.16	0.310	135.00	1 - (100.0)	Service - Steel	As Requested	As Requested
HS 20-44	Lane	LFD	Operating	18.63	0.518	135.00	1 - (100.0)	Service - Steel	As Requested	As Requested
HS 20-44	Axle Load	LFD	Inventory	25.99	0.722	135.00	1 - (100.0)	Service - Steel	As Requested	As Requested
HS 20-44	Axle Load	LFD	Operating	43.41	1.206	135.00	1 - (100.0)	Service - Steel	As Requested	As Requested

Girder Section at the Controlling Location:

Cross Sections | Shear Connectors

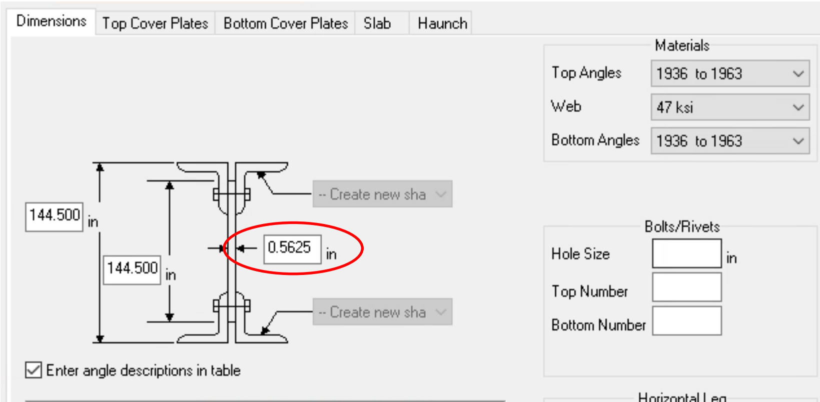
Start Section	End Section	Web Variation	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)
Section 1A	Section 1B	Linear	1	0.00	17.00	17.00
Section 1B	Section 2A	Linear	1	17.00	51.00	68.00
Section 3A	Section 3B	Linear	1	68.00	39.00	107.00
Section 4A	Section 4B	Linear	1	107.00	12.00	119.00
Section 5	Section 6	Linear	1	119.00	11.00	130.00
Section 6	Section 6	None	1	130.00	16.00	146.00
Section 7	Section 7	None	2	11.00	8.00	19.00
Section 8	Section 8	None	2	19.00	37.00	56.00
Section 9	Section 9	None	2	56.00	11.00	67.00
Section 10	Section 10	None	2	67.00	78.00	145.00
Section 9	Section 9	None	2	145.00	10.00	155.00
Section 8	Section 8	None	2	155.00	11.63	166.63
Section 11	Section 11	None	2	166.63	22.38	189.00
Section 12	Section 12	None	2	189.00	9.00	198.00
Section 13	Section 13	None	2	198.00	35.00	233.00
Section 12	Section 12	None	3	18.00	10.00	28.00
Section 11	Section 11	None	3	28.00	41.00	69.00
Section 14	Section 14	None	3	69.00	75.00	144.00
Section 11	Section 11	None	3	144.00	22.63	166.63
Section 15	Section 15	None	3	166.63	13.38	180.00
Section 16	Section 16	None	3	180.00	21.00	201.00
Section 17	Section 17	None	3	201.00	27.00	228.00
Section 16	Section 16	None	4	13.00	17.00	30.00
Section 15	Section 15	None	4	30.00	28.00	58.00
Section 16	Section 16	None	4	58.00	19.00	77.00
Section 17	Section 17	None	4	77.00	96.00	173.00
Section 18A	Section 18B	Linear	4	173.00	13.00	186.00
Section 19A	Section 19B	Linear	4	186.00	25.50	211.50



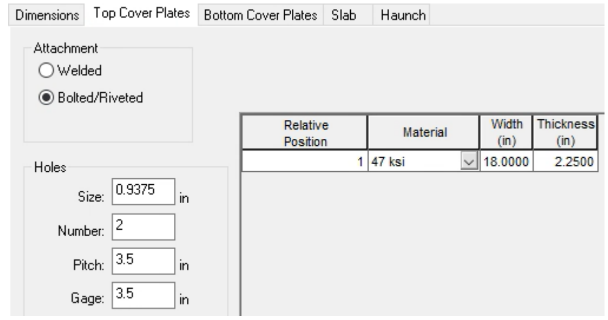
Based on preliminary analysis, if accounting web for the thickness of the additional web plates over Pier 1 the controlling location of the rating shifts. Section 6 (highlighted in blue) with the thickened web rates without issue. Two 1/2” thick web plates are assumed for this section based on the detail pictured below (modified for the exterior girder based on fill plates and web thicknesses), resulting in 1” of additional web thickness. Section 6 with the 9/16” thick web controls 3.42’ into Span 2.

If the web bend buckling issue is resolved, shear at Abutment 1 controls the rating (currently 0.938 inventory). Remaining locations have inventory rating factors above 1.0.

Controlling Girder Definition (Section 6):



	Horz. Leg (in)	Vert. Leg (in)	Horz. Thick (in)	Vert. Thick (in)
Top Angles	8.0000	8.0000	0.8750	0.8750
Bottom Angles	8.0000	8.0000	0.8750	0.8750

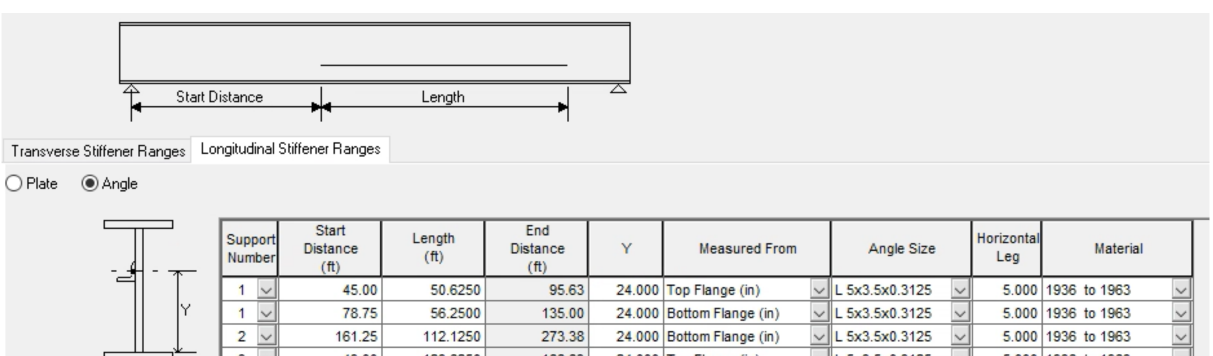


Relative Position	Material	Width (in)	Thickness (in)
1	47 ksi	18.0000	2.2500

Relative Position	Material	Width (in)	Thickness (in)
1	47 ks	18.0000	2.2500

Girder Stiffeners (Along Entire Length):

Name	Support Number	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
Intermediates (L7x4x7/16) (Pair)	1	4.50	4	54.0000	18.00	22.50
Intermediates (L7x4x7/16) (Pair)	1	22.50	16	67.5000	90.00	112.50
Intermediates (L7x4x7/16) (Pair)	1	112.50	6	45.0000	22.50	135.00
Intermediates (L7x4x7/16) (Pair)	2	5.38	38	64.5000	204.25	209.63
Intermediates (L7x4x7/16) (Pair)	3	5.38	38	64.5000	204.25	209.63
Intermediates (L7x4x7/16) (Pair)	4	4.30	3	51.6000	12.90	17.20
Intermediates (L7x4x7/16) (Pair)	4	21.50	35	64.5000	188.13	209.63



Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Y	Measured From	Angle Size	Horizontal Leg	Material
1	45.00	50.6250	95.63	24.000	Top Flange (in)	L 5x3.5x0.3125	5.000	1936 to 1963
1	78.75	56.2500	135.00	24.000	Bottom Flange (in)	L 5x3.5x0.3125	5.000	1936 to 1963
2	161.25	112.1250	273.38	24.000	Bottom Flange (in)	L 5x3.5x0.3125	5.000	1936 to 1963
3	43.00	123.6250	166.63	24.000	Top Flange (in)	L 5x3.5x0.3125	5.000	1936 to 1963
3	150.50	118.2500	268.75	24.000	Bottom Flange (in)	L 5x3.5x0.3125	5.000	1936 to 1963
4	37.63	176.8750	214.50	24.000	Top Flange (in)	L 5x3.5x0.3125	5.000	1936 to 1963

Primary Controlling Rating Calculations at 135.00 ft into Span 1 (Over Pier 1):

```
Steel Builtup Shape - At Location = 135.0000 (ft) - Right     Stage 3

Section at Brace Point


FLEXURE OVERLOAD/SERVICE RATING FACTOR CALCULATIONS

     C - A1*(fDL1+fDL2)
RF = ------------------      (6B.4.1-1)
        A2*fLL(1+I)

where,

   C    = Capacity flange stress
        = .95*Fyf for composite sections
        = .80*Fyf for noncomposite sections
   fDL1 = Stage 1 dead load flange stress
   fDL2 = Stage 2 dead load flange stress
   fLL  = Stage 3 live load flange stress
   I    = Impact Factor
   A1   = Dead Load Factor
   A2   = Live Load Factor


INPUT:

Section Type = Noncomposite
Ignore Overload Operating Rating = No
Stage 1 Unfactored Moment = -11887.6  (kip-ft)
Stage 2 Unfactored Moment =     0.0  (kip-ft)


All Stages:

Component         C          S         Fy
                 (in)      (in^3)     (ksi)
--------------------------------------------
Top Flange    72.250   -11581.19   33.00
Bot Flange    -72.250  11581.19    33.00


Section Type:  Noncomposite
Longitudinal Stiffeners: Yes


Note: If the capacity has been overridden, the Resistance is computed as override phi*override capacity.
      Otherwise the Resistance is computed as per the Specification.
```

Component: Bot Flange

Rating Level	Vehicle	A1	A2	Type	LL (kip-ft)	A3	Adj. LL (kip-ft)	fDC (ksi)	fDW (ksi)	Adj. fLL (ksi)	fLL (ksi)	fR (ksi)	Override Phi	Override fR (ksi)	RF	Capacity (Ton)	Note
Inventory	1	1.00	1.67	Pos	597.5	---	---	-12.32	0.00	---	0.62	26.40	---	---	37.449	1348.15	
Inventory	1	1.00	1.67	Neg	-4009.3	---	---	-12.32	0.00	---	-4.15	-26.40	---	---	2.030	73.07	
Inventory	1	1.00	1.67	Neg	-4009.3	---	---	-12.17	0.00	---	-4.10	-14.29	---	---	0.310	11.16	***
Operating	1	1.00	1.00	Pos	597.5	---	---	-12.32	0.00	---	0.62	26.40	---	---	62.539	2251.41	
Operating	1	1.00	1.00	Neg	-4009.3	---	---	-12.32	0.00	---	-4.15	-26.40	---	---	3.390	122.03	
Operating	1	1.00	1.00	Neg	-4009.3	---	---	-12.17	0.00	---	-4.10	-14.29	---	---	0.518	18.63	***
Inventory	2	1.00	1.67	Pos	415.1	---	---	-12.32	0.00	---	0.43	26.40	---	---	53.901	1940.45	
Inventory	2	1.00	1.67	Neg	-1721.2	---	---	-12.32	0.00	---	-1.78	-26.40	---	---	4.728	170.22	
Inventory	2	1.00	1.67	Neg	-1721.2	---	---	-12.17	0.00	---	-1.76	-14.29	---	---	0.722	25.99	***
Operating	2	1.00	1.00	Pos	415.1	---	---	-12.32	0.00	---	0.43	26.40	---	---	90.015	3240.55	
Operating	2	1.00	1.00	Neg	-1721.2	---	---	-12.32	0.00	---	-1.78	-26.40	---	---	7.896	284.26	
Operating	2	1.00	1.00	Neg	-1721.2	---	---	-12.17	0.00	---	-1.76	-14.29	---	---	1.206	43.41	***

Load Combination Legend:

Code	Vehicle
1	HS 20-44 - Lane
2	HS 20-44 - Truck

*** The web controlled based on eq 10-173.

0.310 Inventory HS-20 Lane

0.722 Inventory HS-20 Truck

Secondary Controlling Rating Calculations at 11.00 ft into Span 2:

Component: Bot Flange

Rating Level	Vehicle	A1	A2	Type	LL (kip-ft)	A3	Adj. LL (kip-ft)	fDC (ksi)	fDW (ksi)	Adj. fLL (ksi)	fLL (ksi)	fR (ksi)	Override Phi	Override fR (ksi)	RF	Capacity (Ton)	Note
Inventory	1	1.00	1.67	Pos	533.2	---	---	-10.21	0.00	---	0.67	26.40	---	---	32.647	1175.30	
Inventory	1	1.00	1.67	Neg	-2902.4	---	---	-10.21	0.00	---	-3.66	-26.40	---	---	2.651	95.45	
Inventory	1	1.00	1.67	Neg	-2902.4	---	---	-10.09	0.00	---	-3.61	-14.29	---	---	0.697	25.09	***
Operating	1	1.00	1.00	Pos	533.2	---	---	-10.21	0.00	---	0.67	26.40	---	---	54.521	1962.75	
Operating	1	1.00	1.00	Neg	-2902.4	---	---	-10.21	0.00	---	-3.66	-26.40	---	---	4.428	159.40	
Operating	1	1.00	1.00	Neg	-2902.4	---	---	-10.09	0.00	---	-3.61	-14.29	---	---	1.164	41.89	***
Inventory	2	1.00	1.67	Pos	294.0	---	---	-10.21	0.00	---	0.37	26.40	---	---	59.207	2131.43	
Inventory	2	1.00	1.67	Neg	-1609.6	---	---	-10.21	0.00	---	-2.03	-26.40	---	---	4.781	172.12	
Inventory	2	1.00	1.67	Neg	-1609.6	---	---	-10.09	0.00	---	-2.00	-14.29	---	---	1.257	45.24	***
Operating	2	1.00	1.00	Pos	294.0	---	---	-10.21	0.00	---	0.37	26.40	---	---	98.875	3559.50	
Operating	2	1.00	1.00	Neg	-1609.6	---	---	-10.21	0.00	---	-2.03	-26.40	---	---	7.984	287.44	
Operating	2	1.00	1.00	Neg	-1609.6	---	---	-10.09	0.00	---	-2.00	-14.29	---	---	2.098	75.54	***

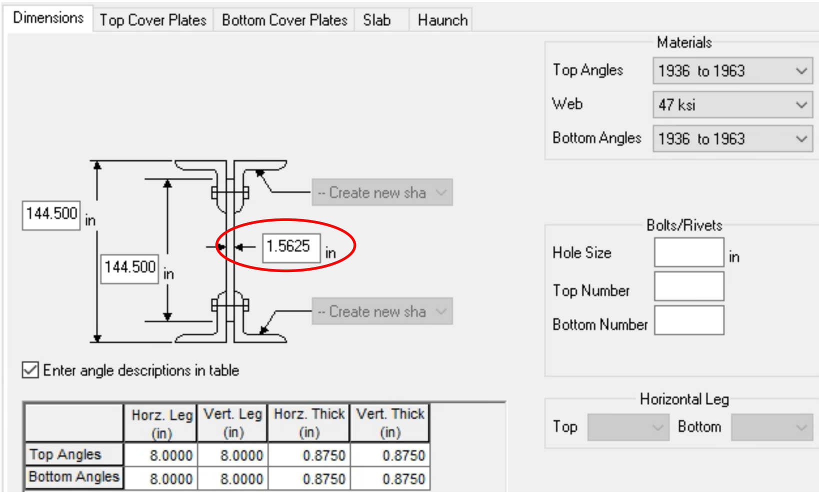
Load Combination Legend:

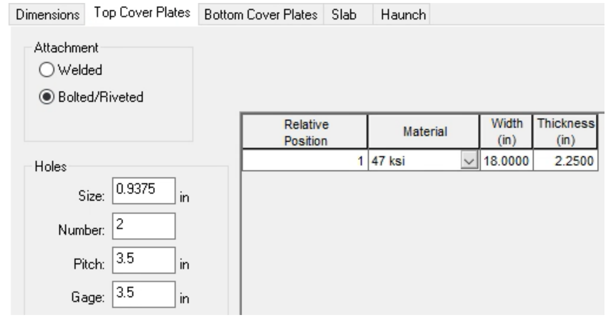
Code	Vehicle
1	HS 20-44 - Lane
2	HS 20-44 - Truck

*** The web controlled based on eq 10-173.

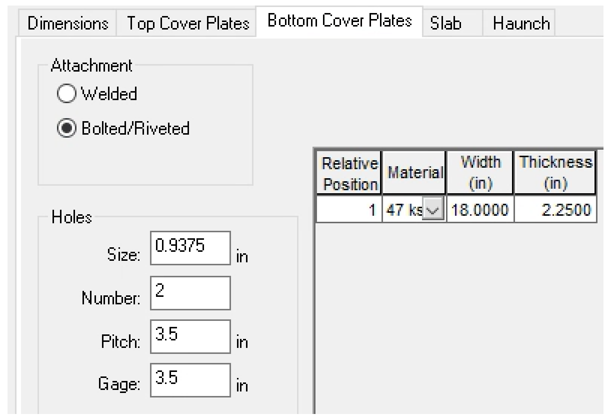
0.697 Inventory HS-20 Lane

Thickened Web Girder Definition (Section 6):

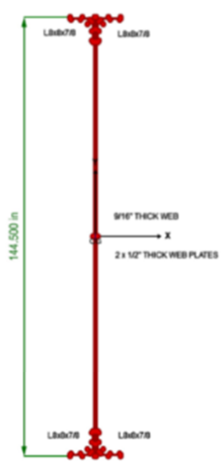




The thickened web girder was analyzed in the model to see what effect that would have on the analysis



Confirming section properties (shape builder program):



Geometric Properties

Area	262.385	in^2
Ix	576293.449	in^4
Ixy	0.000	in^4
Iy	712.670	in^4
Sx+	7976.380	in^3
Sx-	7976.380	in^3
Sy+	86.058	in^3
Sy-	86.058	in^3
Xc	0.000	in
Yc	0.000	in
rx	46.865	in
ry	1.648	in

Principal Properties

I1	576293.449	in^4
I2	712.670	in^4
S1+	7976.380	in^3
S1-	7976.380	in^3
S2+	86.058	in^3
S2-	86.058	in^3
r1	46.865	in
r2	1.648	in
α	0.000	deg

Torsion Properties

Cw	3492692.856	in^6
H	1.000	
J	244.980	in^4
Xsc	0.000	in
Ysc	0.000	in
ro	46.894	in
B1	0.000	in

Overall Properties

Depth	144.500	in
Perimeter	353.973	in
Weight	0.894	K/ft
Width	16.563	in

Polar Properties

Ip	577006.118	in^4
rp	46.894	in

Plastic Properties

Xpna	0.000	in
Ypna	0.000	in
Zx	10746.502	in^3
Zy	216.872	in^3

Capacity nearly doubles by adding the existing fill plates over the bearing to the model section for rating at the pier, and moves controlling location away from pier to end of existing fill plates, and eliminates the second lower rating at 11 ft into Span 2. The new controlling ratings are shown below

Primary Controlling Rating Calculations at 3.42 ft into Span 2 for thickened section:

```
FLEXURE OVERLOAD/SERVICE RATING FACTOR CALCULATIONS

     C - A1*(fDL1+fDL2)
RF = ------------------      (6B.4.1-1)
        A2*fLL(1+I)

where,

   C    = Capacity flange stress
        = .95*Fyf for composite sections
        = .80*Fyf for noncomposite sections
   fDL1 = Stage 1 dead load flange stress
   fDL2 = Stage 2 dead load flange stress
   fLL  = Stage 3 live load flange stress
   I    = Impact Factor
   A1   = Dead Load Factor
   A2   = Live Load Factor


INPUT:

Section Type = Noncomposite
Ignore Overload Operating Rating = No
Stage 1 Unfactored Moment = -10772.9  (kip-ft)
Stage 2 Unfactored Moment =      0.0  (kip-ft)


All Stages:

Component         C          S         Fy
                 (in)      (in^3)     (ksi)
------------------------------------------
Top Flange    72.250   -11581.19    33.00
Bot Flange   -72.250    11581.19    33.00


Section Type:  Noncomposite
Longitudinal Stiffeners: Yes


Note: If the capacity has been overridden, the Resistance is computed as override phi*override capacity.
      Otherwise the Resistance is computed as per the Specification.
```

Component: Bot Flange

Rating Level	Vehicle	A1	A2	Type	LL (kip-ft)	A3	Adj. LL (kip-ft)	fDC (ksi)	fDW (ksi)	Adj. fLL (ksi)	fLL (ksi)	fR (ksi)	Override Phi	Override fR (ksi)	RF	Capacity (Ton)	Note
Inventory	1	1.00	1.67	Pos	538.1	---	---	-11.16	0.00	---	0.56	26.40	---	---	40.339	1452.21	
Inventory	1	1.00	1.67	Neg	-3677.6	---	---	-11.16	0.00	---	-3.81	-26.40	---	---	2.394	86.20	
Inventory	1	1.00	1.67	Neg	-3677.6	---	---	-11.03	0.00	---	-3.76	-14.29	---	---	0.519	18.70	***
Operating	1	1.00	1.00	Pos	538.1	---	---	-11.16	0.00	---	0.56	26.40	---	---	67.366	2425.19	
Operating	1	1.00	1.00	Neg	-3677.6	---	---	-11.16	0.00	---	-3.81	-26.40	---	---	3.999	143.95	
Operating	1	1.00	1.00	Neg	-3677.6	---	---	-11.03	0.00	---	-3.76	-14.29	---	---	0.867	31.23	***
Inventory	2	1.00	1.67	Pos	370.2	---	---	-11.16	0.00	---	0.38	26.40	---	---	58.643	2111.14	
Inventory	2	1.00	1.67	Neg	-1701.7	---	---	-11.16	0.00	---	-1.76	-26.40	---	---	5.175	186.29	
Inventory	2	1.00	1.67	Neg	-1701.7	---	---	-11.03	0.00	---	-1.74	-14.29	---	---	1.123	40.41	***
Operating	2	1.00	1.00	Pos	370.2	---	---	-11.16	0.00	---	0.38	26.40	---	---	97.933	3525.61	
Operating	2	1.00	1.00	Neg	-1701.7	---	---	-11.16	0.00	---	-1.76	-26.40	---	---	8.642	311.11	
Operating	2	1.00	1.00	Neg	-1701.7	---	---	-11.03	0.00	---	-1.74	-14.29	---	---	1.875	67.49	***

Load Combination Legend:

Code	Vehicle
1	HS 20-44 - Lane
2	HS 20-44 - Truck

*** The web controlled based on eq 10-173.

0.519 Inventory HS-20 Lane (0.867 Operating HS-20 Lane)

1.123 Inventory HS-20 Truck

Revised Rating Calculations at 135.00 ft into Span 1 (Over Pier 1):

```
FLEXURE OVERLOAD/SERVICE RATING FACTOR CALCULATIONS

     C - A1*(fDL1+fDL2)
RF = ------------------      (6B.4.1-1)
        A2*fLL(1+I)

where,

   C    = Capacity flange stress
        = .95*Fyf for composite sections
        = .80*Fyf for noncomposite sections
   fDL1 = Stage 1 dead load flange stress
   fDL2 = Stage 2 dead load flange stress
   fLL  = Stage 3 live load flange stress
   I    = Impact Factor
   A1   = Dead Load Factor
   A2   = Live Load Factor


INPUT:

Section Type = Noncomposite
Ignore Overload Operating Rating = No
Stage 1 Unfactored Moment = -11879.8  (kip-ft)
Stage 2 Unfactored Moment =     0.0  (kip-ft)


All Stages:

Component        C         S         Fy
               (in)      (in^3)     (ksi)
------------------------------------------
Top Flange    72.250   -15061.23   33.00
Bot Flange    -72.250  15061.23    33.00


Section Type:  Noncomposite
Longitudinal Stiffeners: Yes


Note: If the capacity has been overridden, the Resistance is computed as override phi*override capacity.
      Otherwise the Resistance is computed as per the Specification.
```

Component: Bot Flange

Rating Level	Vehicle	A1	A2	Type	LL (kip-ft)	A3	Adj. LL (kip-ft)	fDC (ksi)	fDW (ksi)	Adj. fLL (ksi)	fLL (ksi)	fR (ksi)	Override Phi	Override fR (ksi)	RF	Capacity (Ton)	Note
Inventory	1	1.00	1.67	Pos	595.9	---	---	-9.47	0.00	---	0.47	26.40	---	---	45.233	1628.39	
Inventory	1	1.00	1.67	Neg	-4003.9	---	---	-9.47	0.00	---	-3.19	-26.40	---	---	3.179	114.44	
Operating	1	1.00	1.00	Pos	595.9	---	---	-9.47	0.00	---	0.47	26.40	---	---	75.539	2719.42	
Operating	1	1.00	1.00	Neg	-4003.9	---	---	-9.47	0.00	---	-3.19	-26.40	---	---	5.309	191.11	
Inventory	2	1.00	1.67	Pos	414.0	---	---	-9.47	0.00	---	0.33	26.40	---	---	65.106	2343.82	
Inventory	2	1.00	1.67	Neg	-1727.3	---	---	-9.47	0.00	---	-1.38	-26.40	---	---	7.368	265.26	
Operating	2	1.00	1.00	Pos	414.0	---	---	-9.47	0.00	---	0.33	26.40	---	---	99.000	3564.00	
Operating	2	1.00	1.00	Neg	-1727.3	---	---	-9.47	0.00	---	-1.38	-26.40	---	---	12.305	442.99	

Load Combination Legend:

Code	Vehicle
1	HS 20-44 - Lane
2	HS 20-44 - Truck

Girder 1 at Pier 1 now rates 3.179 for Inventory HS-20 Lane

Controlling Rating shifts to Girder 1 in Shear at South Abutment for HS-20 Lane

No screen shots taken for ratings at Unit 1, Girder 1 at South Abutment

From the DGL 2019 Load Rating Report & Bridge Plans:

Controlling member and rating summary: Unit 2

SFN: 4805917
BRIDGE NO.: LUC-00065-0535
Date: 10/30/2019

DGL CONSULTING ENGINEERS

Load Rating Summary

		Vehicle	Rating	Member	Vehicle	Rating	Member
Stringers	Unit #2	Inventory	2.495	Unit #1 - Stringer 1	Inventory	1.388	Unit #1 - Stringer 2
		Operating	4.167	Unit #1 - Stringer 1	Operating	2.318	Unit #1 - Stringer 2
		EV2	4.160	Unit #1 - Stringer 1	EV2	2.359	Unit #1 - Stringer 2
		EV3	3.812	Unit #1 - Stringer 1	EV3	2.663	Unit #1 - Stringer 2
		SU4	5.600	Unit #1 - Stringer 1	SU4	4.110	Unit #1 - Stringer 2
		SU5	5.438	Unit #1 - Stringer 1	SU5	4.110	Unit #1 - Stringer 2
		SU6	5.089	Unit #1 - Stringer 1	SU6	4.343	Unit #1 - Stringer 2
		SU7	5.179	Unit #1 - Stringer 1	SU7	4.887	Unit #1 - Stringer 2
		2F1	7.334	Unit #1 - Stringer 1	2F1	4.550	Unit #1 - Stringer 2
		3F1	5.983	Unit #1 - Stringer 1	3F1	4.110	Unit #1 - Stringer 2
		4F1	5.715	Unit #1 - Stringer 1	4F1	4.990	Unit #1 - Stringer 2
		5C1	5.594	Unit #1 - Stringer 1	5C1	4.007	Unit #1 - Stringer 2

		Vehicle	Rating	Member	Vehicle	Rating	Member	Vehicle	Rating	Member	Vehicle	Rating	Member	Vehicle	Rating	Member	Vehicle	Rating	Member	Vehicle	Rating	Member
Floor Beams	Unit #2	Inventory	1.992	Floorbeam1	Inventory	2.265	Floorbeam3	Inventory	1.908	Floorbeam4	Inventory	0.943	Floorbeam7	Inventory	0.780	Floorbeam8	Inventory	0.872	Floorbeam9	Inventory	2.584	Floorbeam10
		Operating	3.330	Floorbeam1	Operating	3.794	Floorbeam3	Operating	3.186	Floorbeam4	Operating	1.581	Floorbeam7	Operating	1.307	Floorbeam8	Operating	1.461	Floorbeam9	Operating	4.315	Floorbeam10
		EV2	3.610	Floorbeam1	EV2	3.961	Floorbeam3	EV2	3.623	Floorbeam4	EV2	1.770	Floorbeam7	EV2	1.488	Floorbeam8	EV2	1.502	Floorbeam9	EV2	4.450	Floorbeam10
		EV3	2.850	Floorbeam1	EV3	2.667	Floorbeam3	EV3	2.680	Floorbeam4	EV3	1.332	Floorbeam7	EV3	1.099	Floorbeam8	EV3	1.007	Floorbeam9	EV3	4.339	Floorbeam10
		SU4	4.403	Floorbeam1	SU4	3.556	Floorbeam3	SU4	3.370	Floorbeam4	SU4	1.664	Floorbeam7	SU4	1.384	Floorbeam8	SU4	1.339	Floorbeam9	SU4	6.695	Floorbeam10
		SU5	4.403	Floorbeam1	SU5	3.365	Floorbeam3	SU5	3.138	Floorbeam4	SU5	1.560	Floorbeam7	SU5	1.288	Floorbeam8	SU5	1.268	Floorbeam9	SU5	6.695	Floorbeam10
		SU6	4.440	Floorbeam1	SU6	3.089	Floorbeam3	SU6	2.825	Floorbeam4	SU6	1.410	Floorbeam7	SU6	1.159	Floorbeam8	SU6	1.168	Floorbeam9	SU6	7.075	Floorbeam10
		SU7	5.077	Floorbeam1	SU7	3.004	Floorbeam3	SU7	2.659	Floorbeam4	SU7	1.331	Floorbeam7	SU7	1.090	Floorbeam8	SU7	1.146	Floorbeam9	SU7	7.961	Floorbeam10
		2F1	6.051	Floorbeam1	2F1	5.659	Floorbeam3	2F1	5.382	Floorbeam4	2F1	2.671	Floorbeam7	2F1	2.220	Floorbeam8	2F1	2.130	Floorbeam9	2F1	7.455	Floorbeam10
		3F1	4.403	Floorbeam1	3F1	3.950	Floorbeam3	3F1	3.673	Floorbeam4	3F1	1.816	Floorbeam7	3F1	1.510	Floorbeam8	3F1	1.477	Floorbeam9	3F1	6.695	Floorbeam10
		4F1	5.198	Floorbeam1	4F1	3.627	Floorbeam3	4F1	3.346	Floorbeam4	4F1	1.650	Floorbeam7	4F1	1.374	Floorbeam8	4F1	1.362	Floorbeam9	4F1	8.130	Floorbeam10
		5C1	4.153	Floorbeam1	5C1	3.950	Floorbeam3	5C1	3.576	Floorbeam4	5C1	1.766	Floorbeam7	5C1	1.469	Floorbeam8	5C1	1.477	Floorbeam9	5C1	6.527	Floorbeam10

		Vehicle	Rating	Member	Vehicle	Rating	Member
Girders	Unit #2	Inventory	4.069	Girder 1	Inventory	0.735	Girder 2
		Operating	6.796	Girder 1	Operating	1.228	Girder 2
		EV2	6.493	Girder 1	EV2	1.415	Girder 2
		EV3	4.146	Girder 1	EV3	1.079	Girder 2
		SU4	6.398	Girder 1	SU4	1.577	Girder 2
		SU5	6.398	Girder 1	SU5	1.473	Girder 2
		SU6	6.398	Girder 1	SU6	1.387	Girder 2
		SU7	6.398	Girder 1	SU7	1.360	Girder 2
		2F1	10.876	Girder 1	2F1	1.849	Girder 2
		3F1	6.398	Girder 1	3F1	1.381	Girder 2
		4F1	7.769	Girder 1	4F1	1.382	Girder 2
		5C1	6.398	Girder 1	5C1	1.443	Girder 2

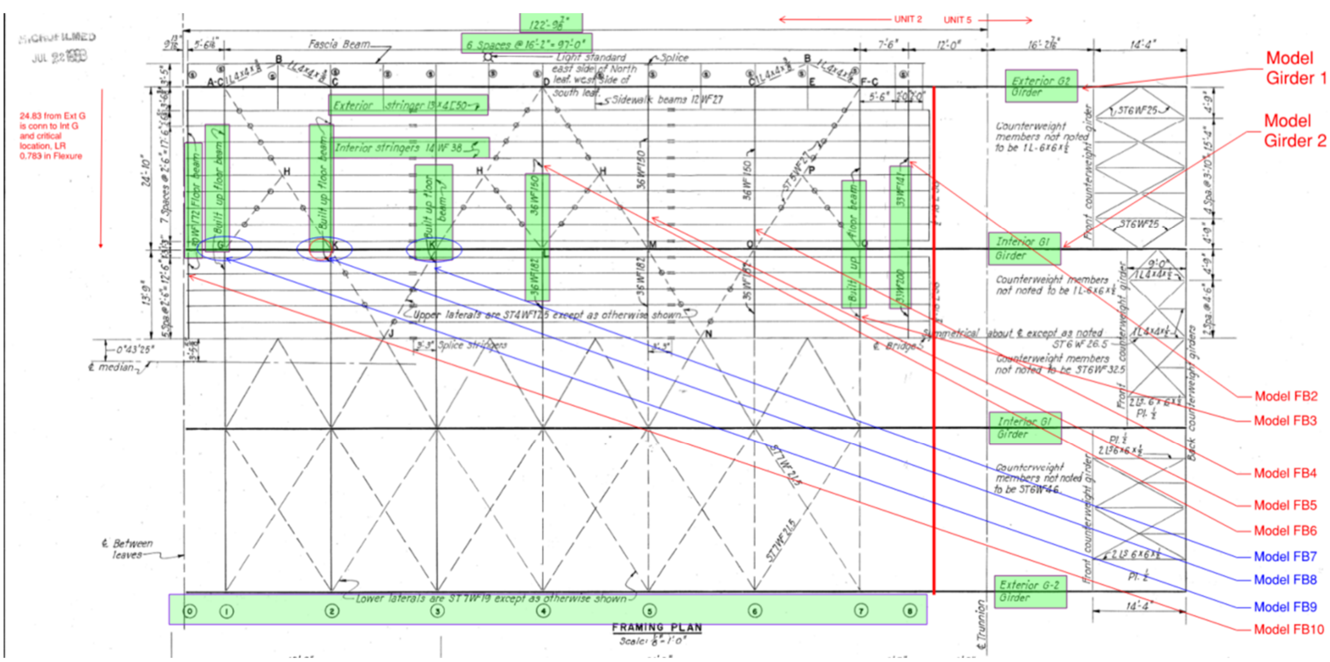
Member Summary

	Vehicle	Rating	Member
Stringers	Inventory	1.388	Unit #1 - Stringer 2
	Operating	2.318	Unit #1 - Stringer 2
	EV2	2.359	Unit #1 - Stringer 2
	EV3	2.663	Unit #1 - Stringer 2
	SU4	4.110	Unit #1 - Stringer 2
	SU5	4.110	Unit #1 - Stringer 2
	SU6	4.343	Unit #1 - Stringer 2
	SU7	4.887	Unit #1 - Stringer 2
	2F1	4.550	Unit #1 - Stringer 2
	3F1	4.110	Unit #1 - Stringer 2
	4F1	4.990	Unit #1 - Stringer 2
	5C1	4.007	Unit #1 - Stringer 2
	Vehicle	**Rating**	**Member**
Floor Beams	Inventory	0.780	Floorbeam8
	Operating	1.307	Floorbeam8
	EV2	1.488	Floorbeam8
	EV3	1.007	Floorbeam9
	SU4	1.339	Floorbeam9
	SU5	1.268	Floorbeam9
	SU6	1.159	Floorbeam8
	SU7	1.090	Floorbeam8
	2F1	2.130	Floorbeam9
	3F1	1.477	Floorbeam9
	4F1	1.362	Floorbeam9
	5C1	1.469	Floorbeam8
	Vehicle	**Rating**	**Member**
Girders	Inventory	0.735	Girder 2
	Operating	1.228	Girder 2
	EV2	1.415	Girder 2
	EV3	1.079	Girder 2
	SU4	1.577	Girder 2
	SU5	1.473	Girder 2
	SU6	1.387	Girder 2
	SU7	1.360	Girder 2
	2F1	1.849	Girder 2
	3F1	1.381	Girder 2
	4F1	1.382	Girder 2
	5C1	1.443	Girder 2

Bascule Span interior or exterior Girders?

where do these floorbeams correspond to in plans?

Girder 2 in Unit 2 is the interior girder, and Floorbeams 7-8-9 are at points 3-2-1 (resp.)



Girder 2 BrR Model information / screen shots:

Report Type: Rating Results Summary
Lane/Impact Loading Type: (●) As Requested ( ) Detailed
Display Format: Single rating level per row

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Location (ft)	Location Span-(%)	Limit State	Impact	Lane
HS 20-44	Lane	LFD	Inventory	28.96	0.805	91.33	1 - (80.2)	Design Shear - Steel	As Requested	As Requested
HS 20-44	Lane	LFD	Operating	48.37	1.344	91.33	1 - (80.2)	Design Shear - Steel	As Requested	As Requested
HS 20-44	Axle Load	LFD	Inventory	26.48	0.735	91.33	1 - (80.2)	Design Shear - Steel	As Requested	As Requested
HS 20-44	Axle Load	LFD	Operating	44.22	1.228	91.33	1 - (80.2)	Design Shear - Steel	As Requested	As Requested

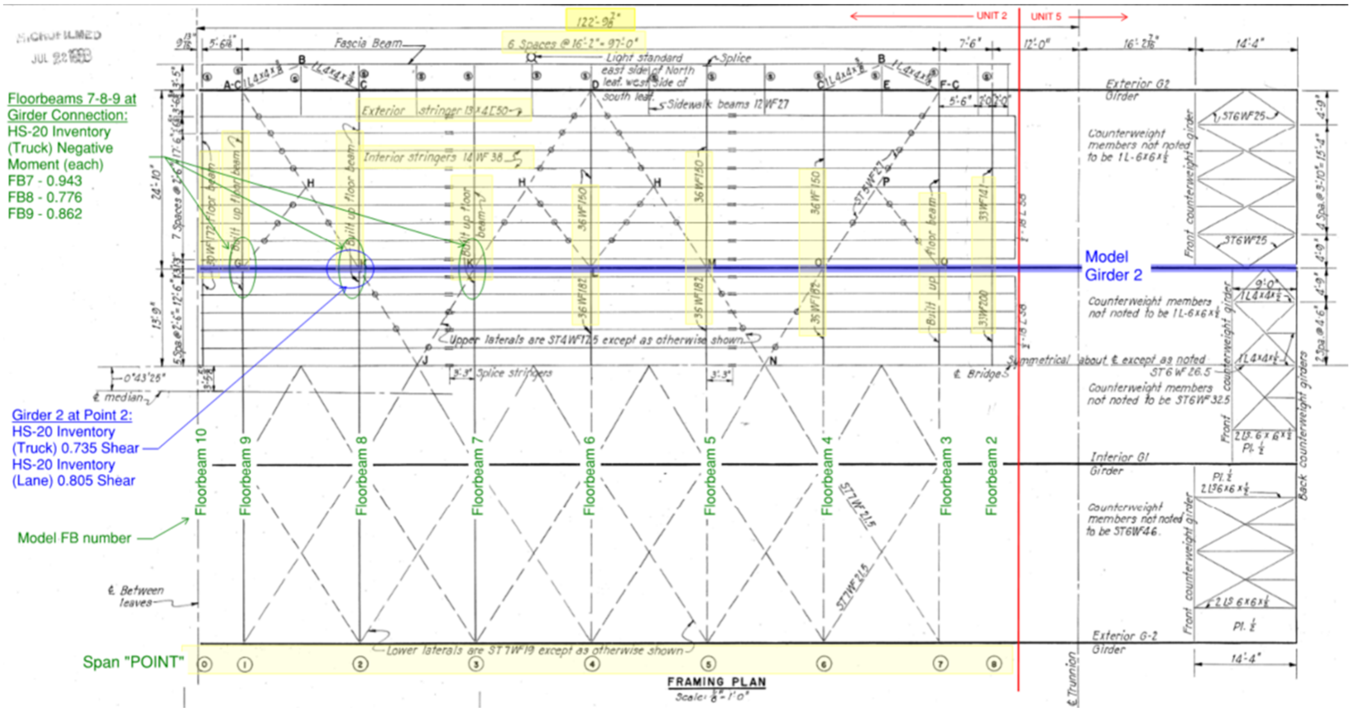
Girder Section at the Controlling Location:

Start Section	End Section	Web Variation	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)
Section 16	Section 15	Linear	1	0.00	3.00	3.00
Section 15	Section 14	Linear	1	3.00	7.50	10.50
Section 14	Section 13B	Linear	1	10.50	10.17	20.67
Section 13A	Section 12	Linear	1	20.67	6.00	26.67
Section 12	Section 11B	Linear	1	26.67	10.67	37.33
Section 11A	Section 10	Linear	1	37.33	5.50	42.83
Section 10	Section 9B	Linear	1	42.83	10.67	53.50
Section 9A	Section 8	Linear	1	53.50	5.50	59.00
Section 8	Section 7B	Linear	1	59.00	8.08	67.08
Section 7A	Section 6	Linear	1	67.08	8.08	75.17
Section 6	Section 5B	Linear	1	75.17	6.50	81.67
Section 5A	Section 4B	Linear	1	81.67	9.67	91.33
Section 4A	Section 3B	Linear	1	91.33	1.17	92.50
Section 3A	Section 2	Linear	1	92.50	15.00	107.50
Section 2	Section 1	Linear	1	107.50	6.33	113.83

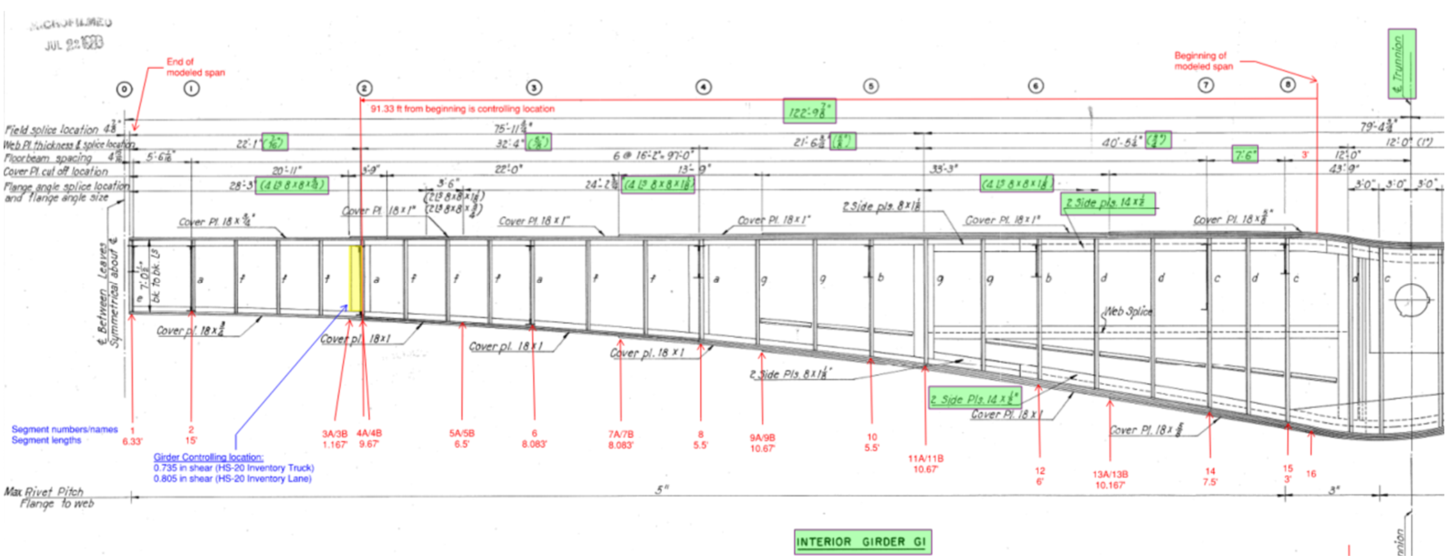
Based on preliminary analysis, the inventory rating factor can be raised above 1.0 by increasing the Section 4A web to 0.625 in thick for a distance of 1’-2” (from 91.33’ to 92.50’).

From Plans:

Girder Location in Bascule Span – one of two leaves shown

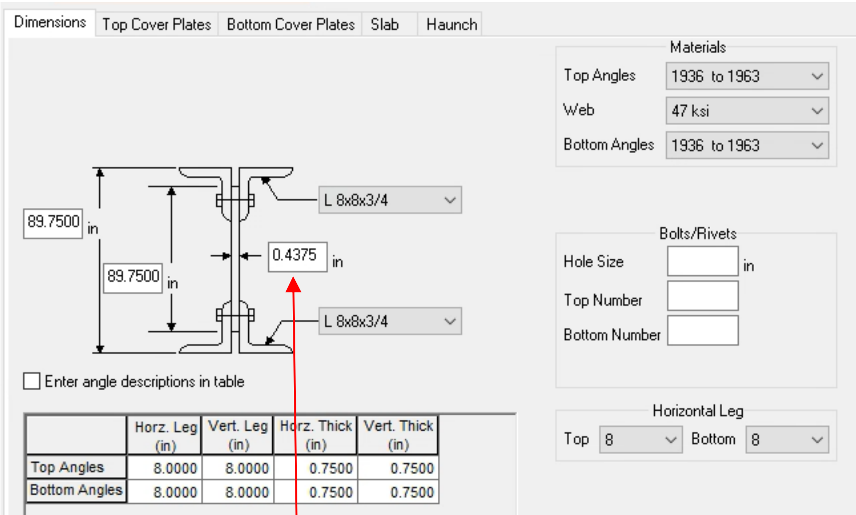


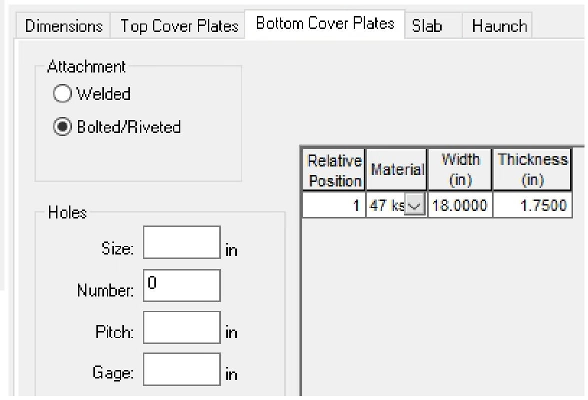
Girder Elevation – low load rating location highlighted, distance from "beginning" of girder next to trunnion pin



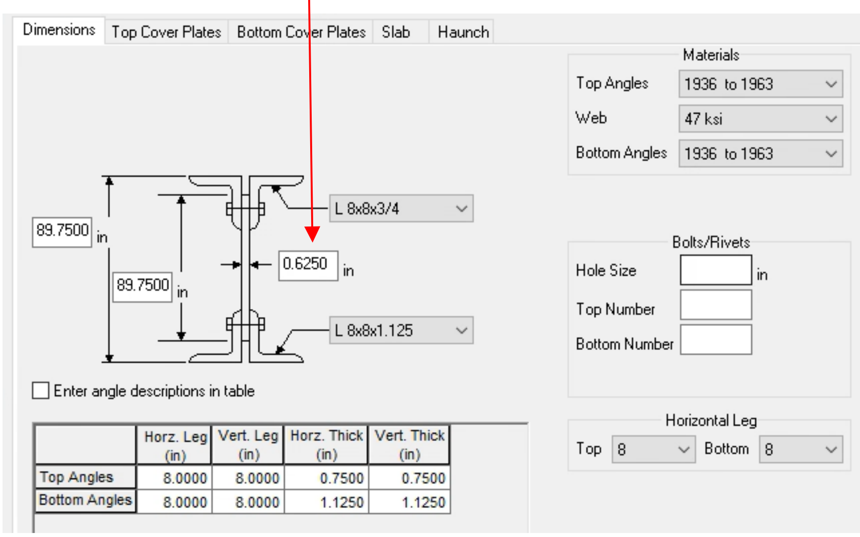
<u>From BrR – Girder Definitions</u>

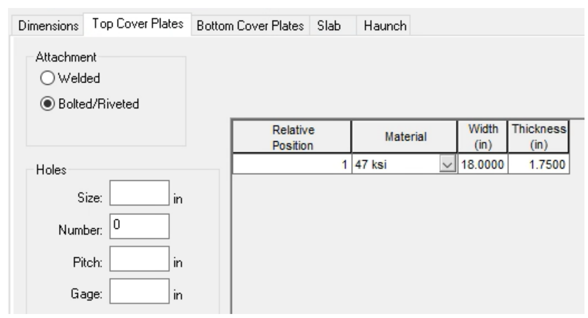
Controlling Girder Definition (Section 4A):

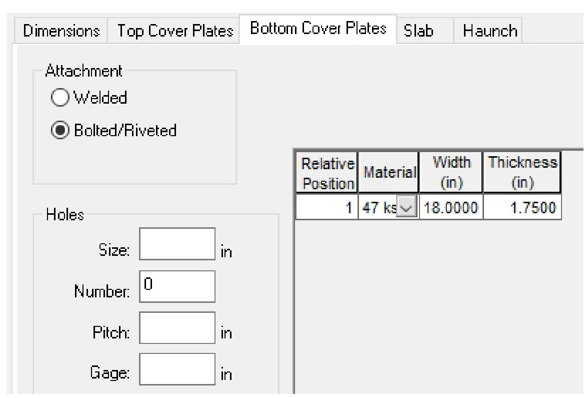




Adjacent Girder Definition (Section 4B):







Primary Controlling Rating Calculations at 91.33 ft into Span 1:

Rating Level	Vehicle	LL (kip)	Adj. LL (kip)	Load Factors A1	Load Factors A2	Vu (kip)	Override Phi (kip)	Override Vu (kip)	RF	Capacity (Ton)
Inventory	1	-275.69	---	1.30	2.17	-929.28	--	--	1.724	62.05
Inventory	1	473.44	---	1.30	2.17	929.28	--	--	0.805	28.96
Operating	1	-275.69	---	1.30	1.30	-929.28	--	--	2.878	103.62
Operating	1	473.44	---	1.30	1.30	929.28	--	--	1.344	48.37
Inventory	2	-417.98	---	1.30	2.17	-929.28	--	--	1.137	40.93
Inventory	2	517.90	---	1.30	2.17	929.28	--	--	0.735	26.48
Operating	2	-417.98	---	1.30	1.30	-929.28	--	--	1.899	68.35
Operating	2	517.90	---	1.30	1.30	929.28	--	--	1.228	44.22

Load Combination Legend:

Code	Vehicle
1	HS 20-44 - Lane
2	HS 20-44 - Truck

Controlling Rating Calculations at 92.50 ft into Span 1:

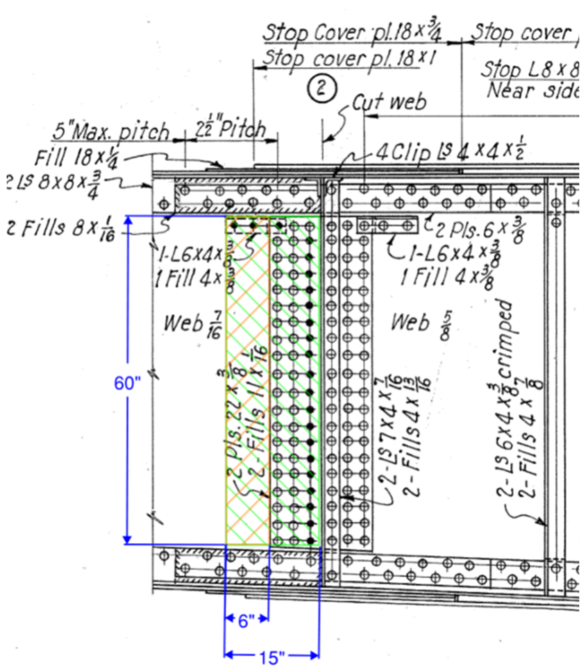
Rating Level	Vehicle	LL (kip)	Adj. LL (kip)	Load Factors A1	Load Factors A2	Vu (kip)	Override Phi (kip)	Override Vu (kip)	RF	Capacity (Ton)
Inventory	1	-0.74	---	1.30	2.17	-925.46	--	--	99.000	3564.00
Inventory	1	92.29	---	1.30	2.17	925.46	--	--	4.115	148.12
Operating	1	-0.74	---	1.30	1.30	-925.46	--	--	99.000	3564.00
Operating	1	92.29	---	1.30	1.30	925.46	--	--	6.871	247.37
Inventory	2	-1.52	---	1.30	2.17	-925.46	--	--	99.000	3564.00
Inventory	2	148.17	---	1.30	2.17	925.46	--	--	2.563	92.27
Operating	2	-1.52	---	1.30	1.30	-925.46	--	--	99.000	3564.00
Operating	2	148.17	---	1.30	1.30	925.46	--	--	4.280	154.09

Load Combination Legend:

Code	Vehicle
1	HS 20-44 - Lane
2	HS 20-44 - Truck

From Plans:

Detail Elevation view of girder at splice / FB connection location; potential reinforcement plates highlighted in yellow and green



Floorbeams 7 – 8 – 9 BrR Model information / screen shots

Floorbeam 7:

Report Type: Rating Results Summary | Lane/Impact Loading Type: (●) As Requested ( ) Detailed | Display Format: Single rating level per row

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Location (ft)	Location Span-(%)	Limit State	Impact	Lane
HS 20-44	Axle Load	LFD	Inventory	33.95	0.943	24.83	1 - (100.0)	Design Flexure - Steel	As Requested	As Requested
HS 20-44	Axle Load	LFD	Operating	55.07	1.530	24.83	1 - (100.0)	Design Flexure - Steel	As Requested	As Requested
HS 20-44	Lane	LFD	Inventory	38.00	1.056	24.83	1 - (100.0)	Design Flexure - Steel	As Requested	As Requested
HS 20-44	Lane	LFD	Operating	61.57	1.710	24.83	1 - (100.0)	Design Flexure - Steel	As Requested	As Requested

Floorbeam 8:

Report Type: Rating Results Summary | Lane/Impact Loading Type: (●) As Requested ( ) Detailed | Display Format: Single rating level per row

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Location (ft)	Location Span-(%)	Limit State	Impact	Lane
HS 20-44	Axle Load	LFD	Inventory	27.92	0.776	24.83	1 - (100.0)	Design Flexure - Steel	As Requested	As Requested
HS 20-44	Axle Load	LFD	Operating	45.19	1.255	24.83	1 - (100.0)	Design Flexure - Steel	As Requested	As Requested
HS 20-44	Lane	LFD	Inventory	31.35	0.871	24.83	1 - (100.0)	Design Flexure - Steel	As Requested	As Requested
HS 20-44	Lane	LFD	Operating	50.67	1.407	24.83	1 - (100.0)	Design Flexure - Steel	As Requested	As Requested

Floorbeam 9:

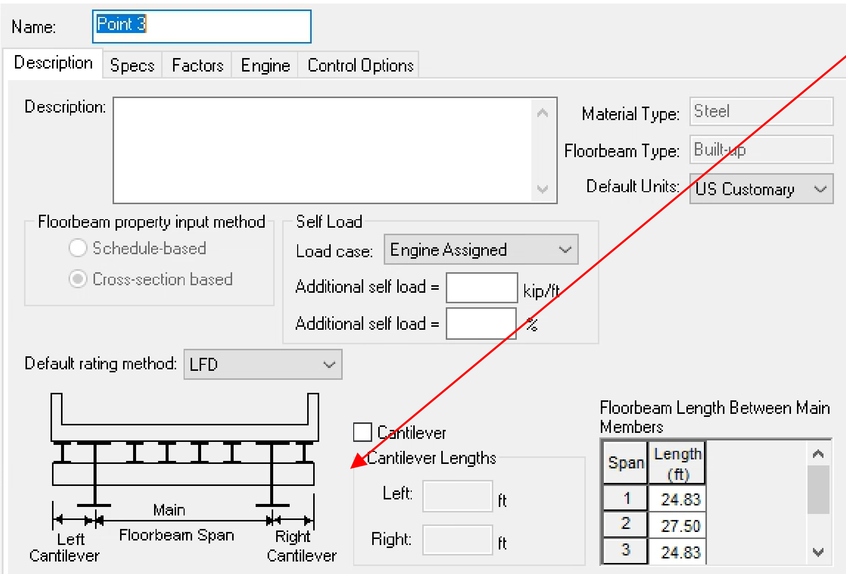
Report Type: Rating Results Summary | Lane/Impact Loading Type: (●) As Requested ( ) Detailed | Display Format: Single rating level per row

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Location (ft)	Location Span-(%)	Limit State	Impact	Lane
HS 20-44	Axle Load	LFD	Inventory	31.49	0.875	24.83	1 - (100.0)	Design Flexure - Steel	As Requested	As Requested
HS 20-44	Axle Load	LFD	Operating	51.11	1.420	24.83	1 - (100.0)	Design Flexure - Steel	As Requested	As Requested
HS 20-44	Lane	LFD	Inventory	31.02	0.862	24.83	1 - (100.0)	Design Flexure - Steel	As Requested	As Requested
HS 20-44	Lane	LFD	Operating	50.36	1.399	24.83	1 - (100.0)	Design Flexure - Steel	As Requested	As Requested

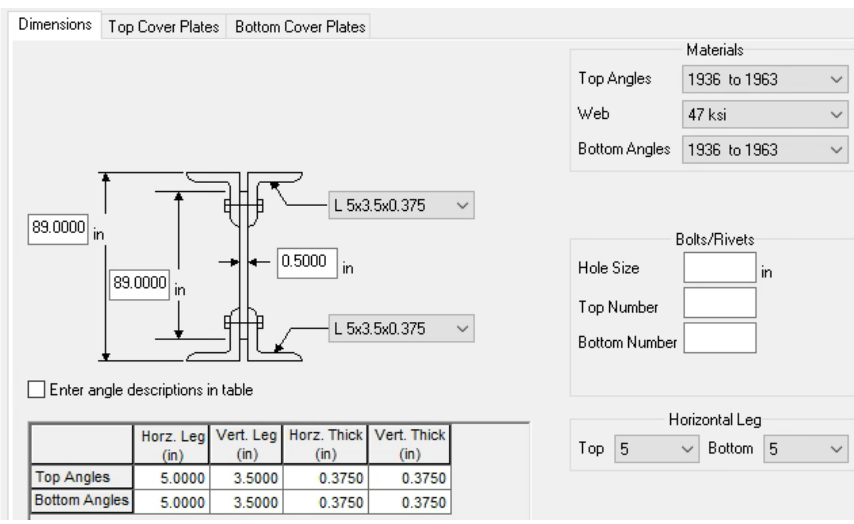
Floorbeam Definitions:

- Floorbeam7
  - FSR Floorbeam Stringer Reactions
  - FLOORBEAM MEMBER ALTERNATIVES
    - Point 3 (E) (C)
- Floorbeam8
  - FSR Floorbeam Stringer Reactions
  - FLOORBEAM MEMBER ALTERNATIVES
    - Point 2 (E) (C)
- Floorbeam9
  - FSR Floorbeam Stringer Reactions
  - FLOORBEAM MEMBER ALTERNATIVES
    - Point 1 (E) (C)

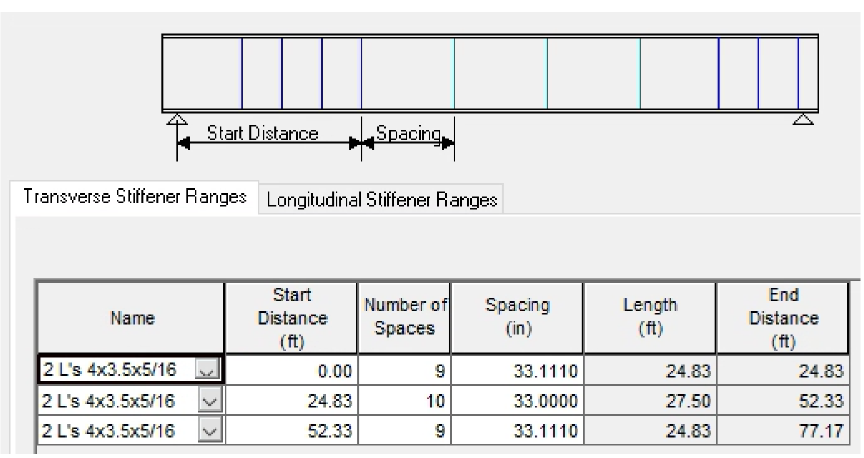
Floorbeam 7 Definition (Point 3):



Span	Length (ft)
1	24.83
2	27.50
3	24.83



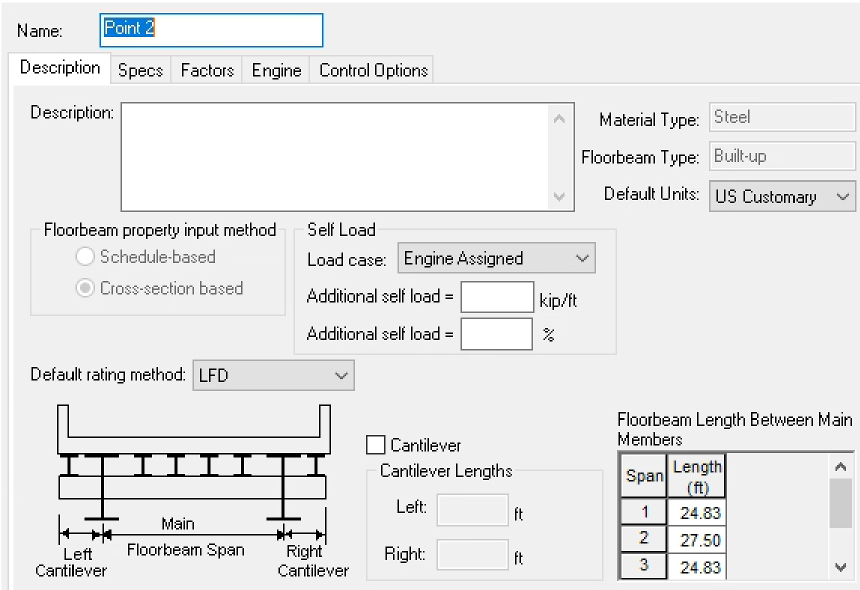
	Horz. Leg (in)	Vert. Leg (in)	Horz. Thick (in)	Vert. Thick (in)
Top Angles	5.0000	3.5000	0.3750	0.3750
Bottom Angles	5.0000	3.5000	0.3750	0.3750

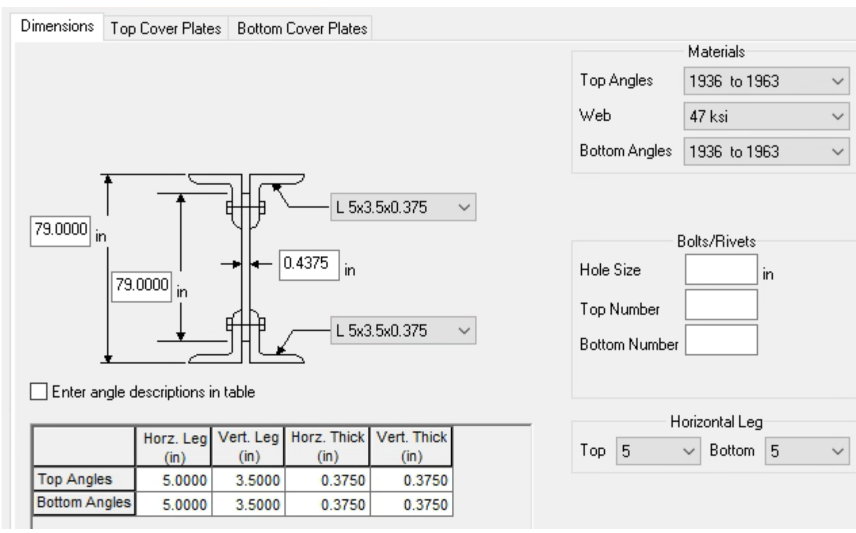


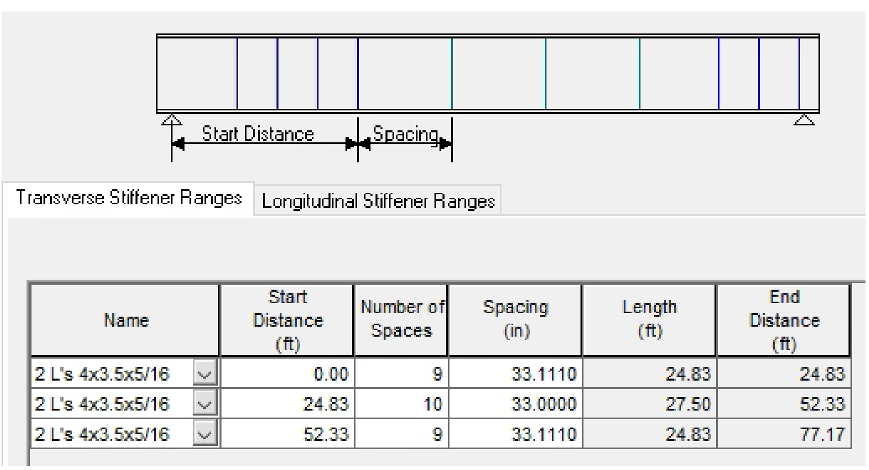
Name	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
2 L's 4x3.5x5/16	0.00	9	33.1110	24.83	24.83
2 L's 4x3.5x5/16	24.83	10	33.0000	27.50	52.33
2 L's 4x3.5x5/16	52.33	9	33.1110	24.83	77.17

The floorbeams are modeled as continuous across the girders as supports – implying a moment connection FB to G; this is not the case, the floorbeam to girder connection is a web to web connection with angles (typical for FB7 – FB8 – FB9)

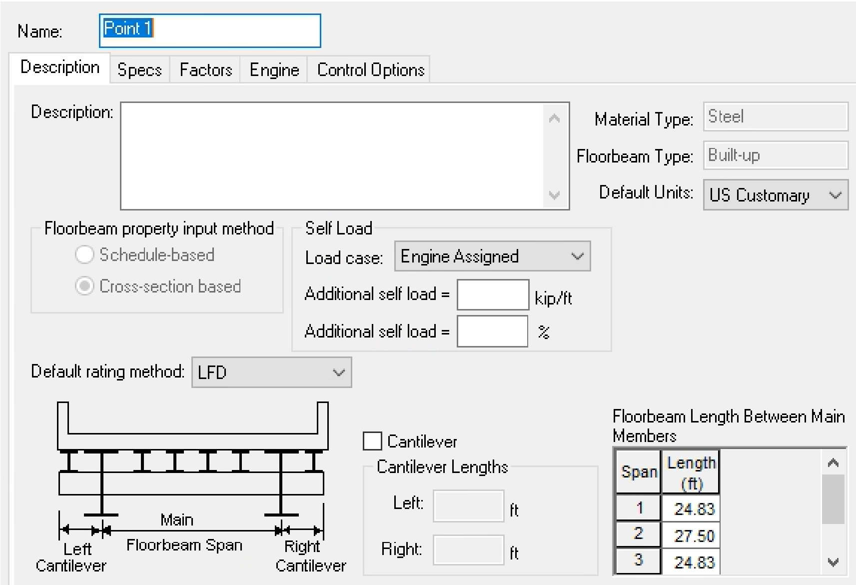
Floorbeam 8 Definition (Point 2):



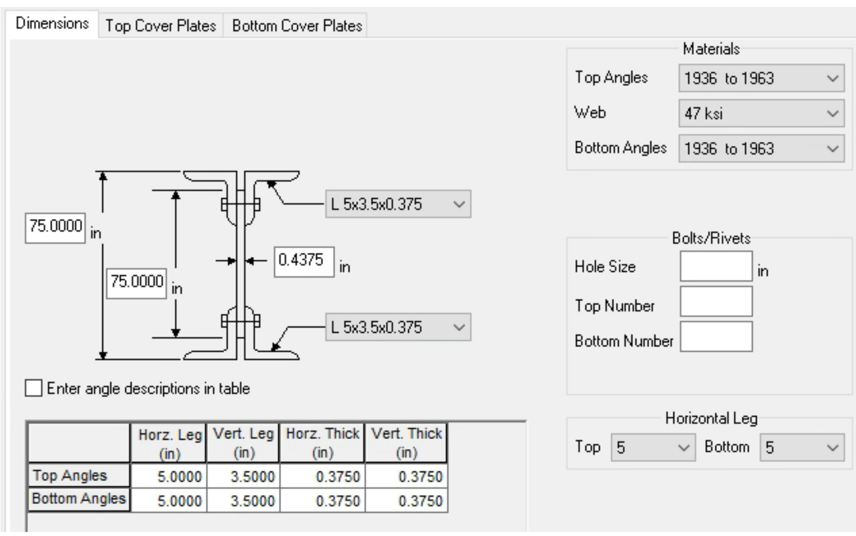




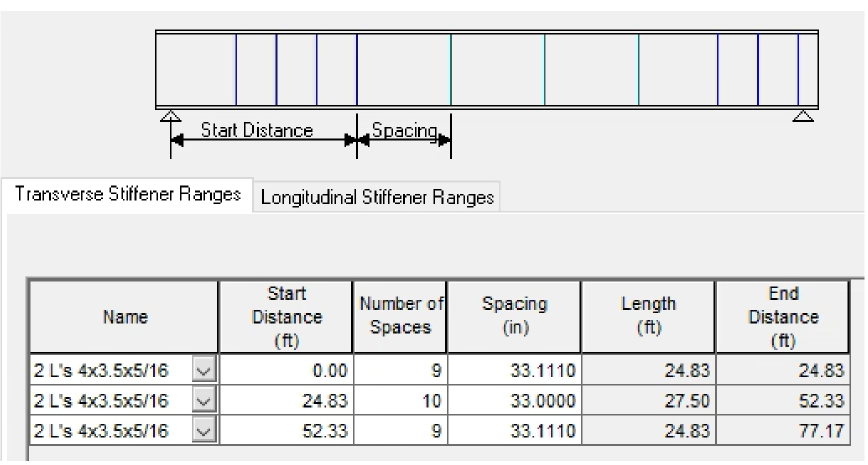
Floorbeam 9 Definition (Point 1):



Span	Length (ft)
1	24.83
2	27.50
3	24.83



	Horz. Leg (in)	Vert. Leg (in)	Horz. Thick (in)	Vert. Thick (in)
Top Angles	5.0000	3.5000	0.3750	0.3750
Bottom Angles	5.0000	3.5000	0.3750	0.3750



Name	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
2 L's 4x3.5x5/16	0.00	9	33.1110	24.83	24.83
2 L's 4x3.5x5/16	24.83	10	33.0000	27.50	52.33
2 L's 4x3.5x5/16	52.33	9	33.1110	24.83	77.17

Primary Floorbeam 7 Controlling Rating Calculations at 24.83 ft into Span 1:

```
Steel Builtup Shape - At Location = 24.8330 (ft) - Right     Stage 3

Section at Brace Point


FLEXURE RATING FACTOR CALCULATIONS

     C - A1*DL
RF = ----------       (6B.4.1-1)
     A2*LL(1+I)

where,

   A1 = Dead Load Factor
   A2 = Live Load Factor
   DL = Dead Load Moment = -150.21 (kip-ft)
   LL = Live Load Moment
   I  = Impact Factor


Note: If the capacity has been overridden, the Resistance is computed as override phi*override capacity.
      Otherwise the Resistance is computed as per the Specification.
```

Rating Level	Vehicle	LL (kip-ft)	Adj. LL (kip-ft)	Load Factors A1	Load Factors A2	Mu (kip-ft)	Override Phi	Override Mu (kip-ft)	RF	Capacity (Ton)
Inventory	2	0.00	---	1.300	2.171	-704.64			99.000	3564.00
Inventory	2	-255.59	---	1.300	2.171	-781.03			1.056	38.00
Operating	2	0.00	---	1.300	1.300	-704.64			99.000	3564.00
Operating	2	-255.59	---	1.300	1.300	-763.52			1.710	61.57
Inventory	1	0.00	---	1.300	2.171	-704.64			99.000	3564.00
Inventory	1	-287.88	---	1.300	2.171	-784.68			0.943	33.95
Operating	1	0.00	---	1.300	1.300	-704.64			99.000	3564.00
Operating	1	-287.88	---	1.300	1.300	-767.79			1.530	55.07

Load Combination Legend:

Code	Vehicle
2	HS 20-44 - Lane
1	HS 20-44 - Truck

Primary Floorbeam 8 Controlling Rating Calculations at 24.83 ft into Span 1:

```
Steel Builtup Shape - At Location = 24.8330 (ft) - Right     Stage 3

Section at Brace Point


FLEXURE RATING FACTOR CALCULATIONS

     C - A1*DL
RF = ----------       (6B.4.1-1)
     A2*LL(1+I)

where,

   A1 = Dead Load Factor
   A2 = Live Load Factor
   DL = Dead Load Moment = -153.64 (kip-ft)
   LL = Live Load Moment
   I  = Impact Factor


Note: If the capacity has been overridden, the Resistance is computed as override phi*override capacity.
      Otherwise the Resistance is computed as per the Specification.
```

Rating Level	Vehicle	LL (kip-ft)	Adj. LL (kip-ft)	--- Load Factors --- A1	A2	Mu (kip-ft)	----- Override ----- Phi	Mu (kip-ft)	RF	Capacity (Ton)
Inventory	2	0.00	---	1.300	2.171	-614.36			99.000	3564.00
Inventory	2	-254.05	---	1.300	2.171	-680.03			0.871	31.35
Operating	2	0.00	---	1.300	1.300	-614.36			99.000	3564.00
Operating	2	-254.05	---	1.300	1.300	-664.59			1.407	50.67
Inventory	1	0.00	---	1.300	2.171	-614.36			99.000	3564.00
Inventory	1	-287.24	---	1.300	2.171	-683.36			0.776	27.92
Operating	1	0.00	---	1.300	1.300	-614.36			99.000	3564.00
Operating	1	-287.24	---	1.300	1.300	-668.46			1.255	45.19

Load Combination Legend:

Code	Vehicle
2	HS 20-44 - Lane
1	HS 20-44 - Truck

Primary Floorbeam 9 Controlling Rating Calculations at 24.83 ft into Span 1:

```
Steel Builtup Shape - At Location = 24.8330 (ft) - Right     Stage 3

Section at Brace Point


FLEXURE RATING FACTOR CALCULATIONS

     C - A1*DL
RF = ----------       (6B.4.1-1)
     A2*LL(1+I)

where,

   A1 = Dead Load Factor
   A2 = Live Load Factor
   DL = Dead Load Moment = -125.56 (kip-ft)
   LL = Live Load Moment
   I  = Impact Factor


Note: If the capacity has been overridden, the Resistance is computed as override phi*override capacity.
      Otherwise the Resistance is computed as per the Specification.
```

Rating Level	Vehicle	LL (kip-ft)	Adj. LL (kip-ft)	--- Load Factors --- A1	A2	Mu (kip-ft)	----- Override ----- Phi	Mu (kip-ft)	RF	Capacity (Ton)
Inventory	2	0.00	---	1.300	2.171	-583.25			99.000	3564.00
Inventory	2	-260.98	---	1.300	2.171	-651.45			0.862	31.02
Operating	2	0.00	---	1.300	1.300	-583.25			99.000	3564.00
Operating	2	-260.98	---	1.300	1.300	-637.85			1.399	50.36
Inventory	1	0.00	---	1.300	2.171	-583.25			99.000	3564.00
Inventory	1	-256.93	---	1.300	2.171	-651.08			0.875	31.49
Operating	1	0.00	---	1.300	1.300	-583.25			99.000	3564.00
Operating	1	-256.93	---	1.300	1.300	-637.40			1.420	51.11

Load Combination Legend:

Code	Vehicle
2	HS 20-44 - Lane
1	HS 20-44 - Truck