The University of Toledo
Department of Civil Engineering
Senior Design Project
Fall 2012

FINAL REPORT for the

David Root Bridge Replacement

Submitted to:	Doug Collins, Director of Facilities Maintenance The University of Toledo
	Dan Klett, University Architect The University of Toledo
	Patrick Lawrence, Ph.D, Chair of Geography and Planning The University of Toledo
Submitted by:	Blair Newman Danielle Sheppa Kathryn Gillette Todd Cereghin Nicholas Steyer
Advisors:	Douglas K. Nims, Ph.D, P.E. Cyndee L. Gruden, Ph.D, P.E. David T. Charville, P.E.

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Table of Contents

Table of Figures

Table of Tables

Department of Civil Engineering Senior Design Executive Summary Report

David Root Bridge Replacement

Fall Semester 2012

Team Members:

Blair Newman
Danielle Sheppa
Kathryn Gillette
Nicholas Steyer
Todd Cereghin

Project Clients:

Doug Collins
Director of Facilities Maintenance
The University of Toledo
419-530-1018
Douglas.Collins@rockets.utoledo.edu

Dan Klett
Facilities Planning
The University of Toledo
419-530-1453
Daniel.Klett@utoledo.edu

Dr. Patrick Lawrence
Professor and Department Chair
The University of Toledo
419-530-4128
Patrick.Lawrence@utoledo.edu

Faculty Mentor:

Dr. Douglas Nims
Associate Professor
The University of Toledo
419-530-8122
douglas.nims@utoledo.edu

Consulting Mentor:

David T. Charville, P.E.
Project Manager
Tetra Tech
419-418-0512
dave.charville@tetratech.com

Problem Statement

The David Leigh Root Bridge, crossing the Ottawa River at the intersection of Stadium Drive and North Towerview Boulevard, was constructed in 1961. The bridge has sustained significant damage over the past fifty years, including spalling, efflorescence and cracking. The lack of ample walkway width has hindered pedestrian traffic and safety and made it difficult for people with disabilities.

Objective

The evident deterioration, the current absence of aesthetic appeal, and the lack of pedestrian serviceability have led the University of Toledo to investigate bridge replacement options. In order to secure future funding for a replacement, suggested options must account for aesthetics, project schedule, and overall project cost.

This project will evaluate and provide bridge replacement alternatives including conceptual drawings, calculations, and cost and scheduling estimations.

Constraints

- Construction Cost
- Construction Timeline
- Client Aesthetic Preference
- Americans with Disabilities Act (ADA)
- Utilization of Existing Substructure
- Existing Utilities Attached to Substructure

Solution Approach

The design was completed using the Load and Resistance Factor Design (LRFD) in accordance with the Ohio Department of Transportation (ODOT), American Association of State Highway and Transportation Officials (AASHTO), and Americans with Disabilities act (ADA) requirements.

For copies of this report contact:

University of Toledo
Department of Civil Engineering
2801W. Bancroft Street
Toledo, Ohio 43606
Mail Stop #307
419.530.8120

Alternatives

Three options were prepared for the final report. A point based rubric was scored in order to provide a recommendation of final product. Each bridge was judged on cost, bridge longevity, repair and maintenance, construction schedule, aesthetic appeal, vehicle and pedestrian considerations, and ADA compliance.

1. **Repair of Current Bridge**
   The condition of the current bridge was analyzed and recommendations were formed. They include patching unsound (faulty) concrete, installing drainage at the base of the abutments, repairing the damaged hand railing, epoxy injection of cracks, epoxy sealing, and widening the sidewalks to allow pedestrians more room.

2. **New Steel Bridge**
   The steel bridge was designed to correct issues with pedestrian safety, ADA requirements, aesthetics, and will better accommodate any future site expansion. The final design utilizes five W21x83 steel beams to support an 8 inch reinforced concrete deck with 8 foot wide sidewalks on both sides. It also features a custom designed parapet wall with lights to illuminate the sidewalks at night. The utilities are located in the 9 foot bay between the steel beams. Lastly, this new bridge has a life expectancy of at least 75 years.

3. **New Pre-stressed Concrete Bridge**
   A new concrete bridge will correct issues with pedestrian safety, ADA requirements, aesthetics, and will better accommodate any future site expansion. The final design contains nine-48"x21" and one-36"x21" box beams placed side by side that support a 6 inch concrete slab and a 3.5 inch asphalt wearing surface. It also features a custom designed parapet wall with lighting to illuminate the sidewalks at night. Additionally, it has precast concrete arches to add to appeal of the bridge.

Alternative	Cost	Timeline	Lifespan
Repair	$58,342	29 Days	20 Years
Steel	$554,616	82 Days	75+ Years
Concrete	$581,792	72 Days	35+ Years

Recommendation

Based on the cost, lifespan, aesthetics, and accessibility for the disabled, repair and maintenance, and vehicle and pedestrian considerations, the steel I-beam bridge was determined to be the best option.

Problem Statement

The David Leigh Root Bridge, crossing the Ottawa River at the intersection of Stadium Drive and North Towerview Boulevard, was constructed in 1961. The bridge has sustained significant damage over the past fifty years, including spalling, efflorescence and cracking. The lack of ample walkway width has hindered pedestrian traffic and safety and made it unusable for people with disabilities. The evident deterioration, the current absence of aesthetic appeal and the lack of pedestrian serviceability has led the University of Toledo to investigate different bridge replacement options. In order to secure future funding for a replacement, suggested options must account for aesthetics, project schedule and overall project cost.

This project will contain the investigation of bridge replacement alternatives complete with conceptual drawings, calculations and cost and scheduling estimations.

History of the Bridge

In 1961, plans were drawn for a new traffic and pedestrian bridge over the Ottawa River connecting the north and south areas of campus. This bridge is located on the eastern side of campus between Savage Arena and Health and Human Services Building (formerly the College of Engineering). A well-known billboard company owned by David Root had numerous billboards displayed throughout the city, one of which was on the corner of The University of Toledo's campus. As a result of a negotiation, the unsightly billboard on campus was removed and the new bridge was named after the owner of the billboard company[1]. Figure 1 shows the current condition of the bridge.

Figure 1. Current Condition of the David Root Bridge[2]

[1] Meeting – Dr. Patrick Lawrence

[2] DGL "University of Toledo 2011 Bridge Inspection Report" p. 48

Current Bridge Physical Characteristics

The current bridge characteristics were acquired from DGL's 2011 Bridge Inspection Report. This inspection was completed in November of 2011. The characteristics described below are broken down into superstructure, substructure and the approach slab portions of the bridge. Figure 2 displays the components of each category. Superstructure will include the deck, sidewalks, and end joints. The piers, pier caps and abutments construct the substructure of a bridge. The approach slab will address the sidewalk approach and roadway to bridge transition.

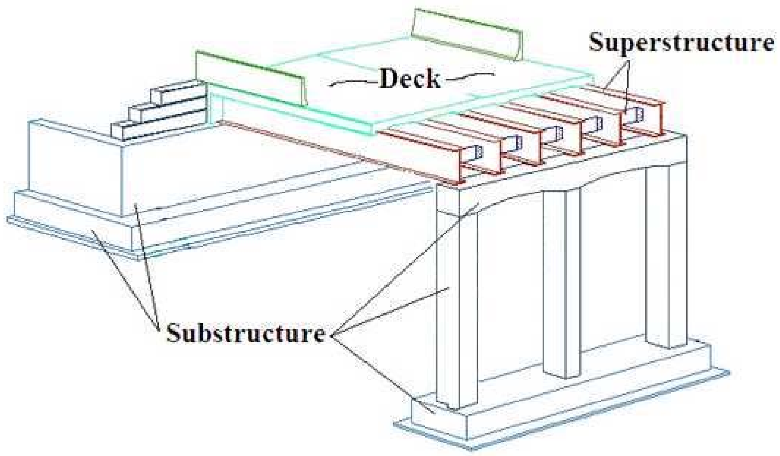

Figure 2. Bridge Component Detail[3]

Superstructure

The constructed bridge is a three-span bridge extending 109'8". The three spans measure 32, 43, and 32 feet respectively from north to south. It is a continuous slab concrete deck with concrete abutments and piers. The roadway consists of two 12 foot lanes with two 4 foot sidewalks and two 1 foot railings. This combined totals a deck width of 34 feet. Figure 3 below shows a few typical bridge elements.

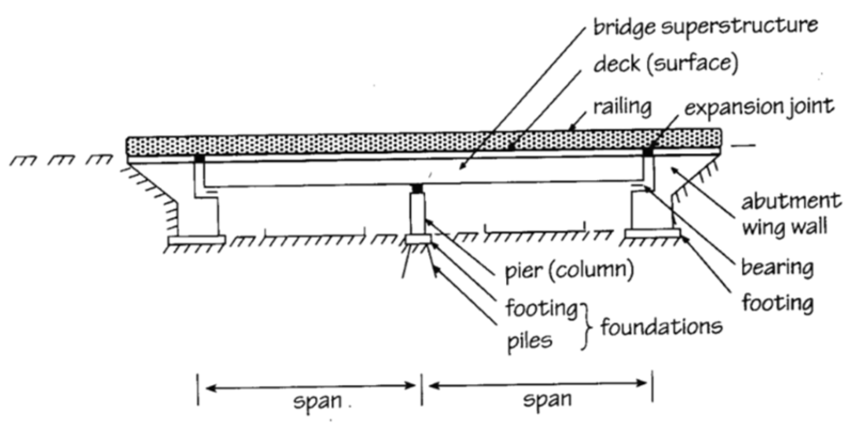

Figure 3. Typical Bridge Elements[4]

The driving surface of the bridge is in good condition except for some minor cracks along the east and west sides of the wheel lanes. Cracks have also been noted on the sidewalks and end joints in various locations. Figure 4 shows transverse cracking along the sidewalk on the northwest corner of the bridge.

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[3] "Bridge Structural Elements Diagram" MDOT Department of Transportation

[4] "Calgary Bridges: Teacher Resource and Field Trip Guide" pp 84

Figure 4. Transverse Cracking[5]

As a result of these cracks, there is heavy efflorescence staining, spalling, and exposed rebar on the west side of the bridge. Efflorescence occurs when moisture is able to flow within the concrete; typically due to cracking. Calcium carbonate is a byproduct of the concrete and water mixture which can develop recrystalized carbon and chloride compounds. These chemicals form white surface deposits that slowly deteriorate the strength of the concrete[5,6]. When the concrete is weakened to the point of failure, it will fall off the structure exposing the rebar. This occurrence is known as spalling. Figure 5 displays efflorescence staining and concrete spalling along the western side of the bridge.

Figure 5. Efflorescent Staining and Spalling[7]

During the inspection by DGL in 2011, two areas on the deck near the south abutment were evaluated to be unsound. A sounding test involves tapping the concrete deck with a steel rod to listen for hollow areas. When a hollow area is exposed, it is said to be unsound. That is, the concrete is not secure to the steel rebar and could chip away or fall off the structure.

[5] DGL "University of Toledo 2011 Bridge Inspection Report" pp 51
[6] Rossow, Mark "Bridge Materials Inspection: Concrete"
[7] DGL "University of Toledo 2011 Bridge Inspection Report" pp 53

Substructure

The existing structure supports multiple campus utility loops, including a steam line, chilled water line, and electrical conduits. The utilities consist of metal pipes ranging from 4 to 21 inches in diameter and PVC pipes with 4 inch diameter. Even though two of the connections have been abandoned on the south side, the utility lines were determined to be in good condition. [8]

Figure 6. Abandoned Utility Pipe[9]

According to DGL, the substructure has been rated as being in poor condition. The south abutment is in more severe condition than its northern counterpart. The south side is experiencing major cracks, heavy efflorescent staining, and spalling along the face of the abutment. Although the north abutment shows signs of water leakage through the entire abutment, the sound test along its face proved it to be in fair condition. Two of the worst areas cited were the southwest and northwest corners of the bridge which have experienced significant spalling. The first layer of reinforcing steel has been exposed at these areas due to the loss of concrete. Although the majority of the substructure is in a poor state, the concrete piers are in good condition.[10]

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[8] DGL "University of Toledo 2011 Bridge Inspection Report" pp 47
[9] DGL "University of Toledo 2011 Bridge Inspection Report" pp 54
[10] DGL "University of Toledo 2011 Bridge Inspection Report" pp 47

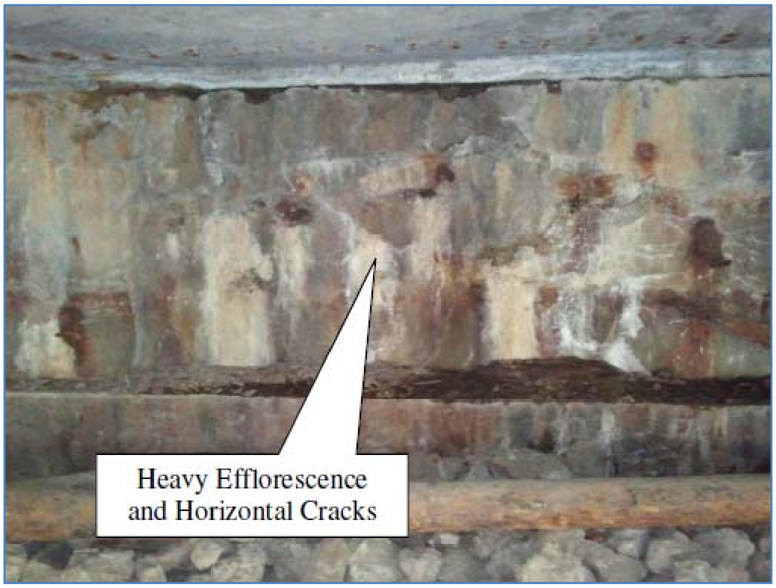


Figure 7. South Abutment[11]

The approach slabs were inspected and deemed to be in good condition. However, a few minor cracks were noted in the northeast sidewalk approach. A continuing evaluation of these cracks will be performed by the group to monitor any settling that may occur. A minimum of a one foot gap exists between the existing guardrail and any of the four corners of the bridge. In addition, the guardrail on the northwest side of the bridge is skewed towards the road.[12]

[11] DGL "University of Toledo 2011 Bridge Inspection Report" pp 54
[12] DGL "University of Toledo 2011 Bridge Inspection Report" pp 47

Constraints

Through extensive research and many meetings with clients, a list of constraints was created. These constraints will be applied to assure that the project meets the needs of the clients and is compliant with all suitable regulations. Six constraints have been developed and are discussed below.

Utilities

There are currently several electrical conduits running along the east corner of the bridge. The electrical and communication lines that run through the conduit connect to various buildings across campus. In addition to the conduit, a large steam and chilled water line that originates from Savage Arena is hung from the underside of the bridge and is connected to various buildings on campus. From Figure 8 and Figure 9 below, the locations and the destinations of the electric conduit and steam and chilled water lines can be seen. The main challenge from this constraint will be to determine how to incorporate the utilities into the alternatives. Another challenge for our team will be to decide how to temporarily maintain the utilities either by temporarily shoring them up in place or by temporarily relocating them, during bridge construction.

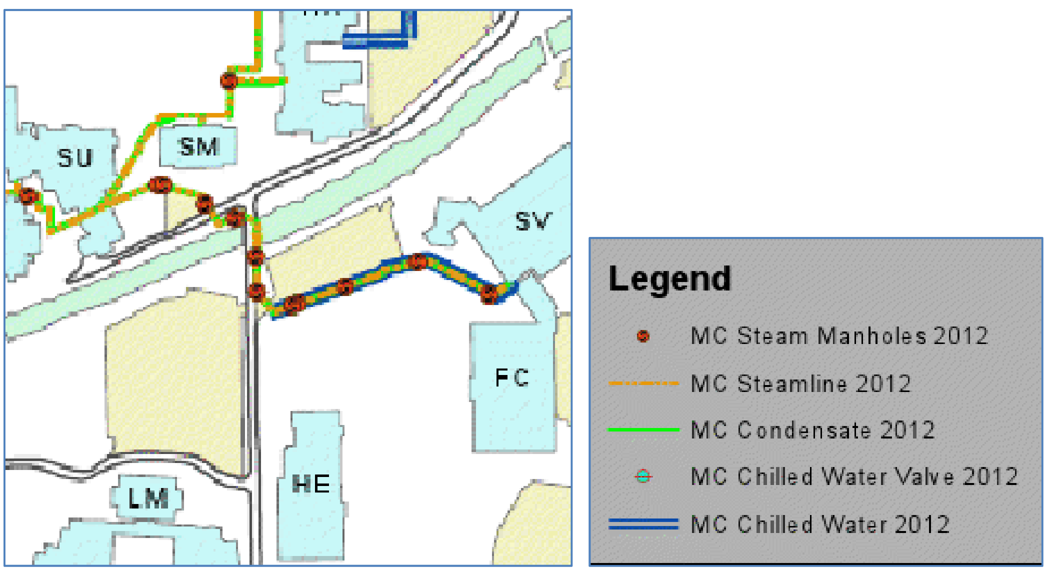
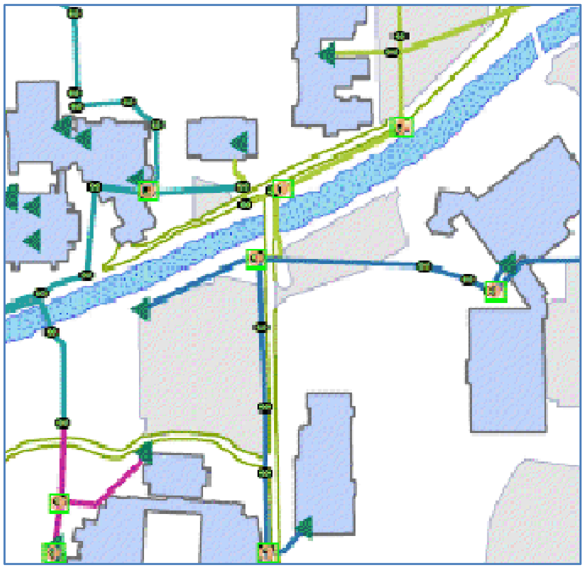


Figure 8. Steam and Chilled Waterlines[13]

[13] Facilities Information Systems- Steam & Chilled Water



Legend	
[*]	MC Electrical Switch 2012
	MC_Transformer
	MC_Electric_Manholes
MC_ELECTRICAL_NETWORK	
	<all other values>
	Feeder Breaker "A"
	Feeder Breaker "A/B"
	Feeder Breaker "B/A"
	Feeder Breaker "C"
	Feeder Breaker "D"
	Feeder Breaker "D/C"
	Feeder Breaker "E"
	Feeder Breaker "F"
	Feeder Breaker "G"
	Feeder Breaker "H"

Figure 9. Electrical Utilities[14]

Budget

The clients have not specified a budget because funds have not yet been allocated to build this project. However, the clients have all said that the project should try to stay to a minimum price and still be a desirable product. The overall cost of the project will vary due to the different materials used and the amount of labor required to build each alternative. The challenge will be to come up with a design that meets the clients' needs while keeping costs as low as possible.

Construction Timeline

The amount of time it takes to construct the bridge and the time of the year that the bridge will be built are very important to the clients. The bridge must be able to be built during the summer semester while there is the least amount of pedestrian and vehicular traffic on campus. This limits the majority of the construction to occur between mid-May and mid-August. Smaller non-roadway items, such as seeding, could be done during the beginning of the fall semester if they were not able to be completed before the end of the summer semester. When designing the bridge, the group will have to ensure that the bridge will be able to be constructed within these times. This will affect the design of the bridge and the practicality of the chosen designs being completed within the time constraint.

Client Aesthetic Preferences

Since there are many clients on this project, it may be difficult to accommodate all views on aesthetics. All clients believe that the bridge should retain the gothic look and stone pieces like the majority of main campus buildings. While retaining this gothic look, some more modern images may be cast into the sides such as a rocket or the university logo. It may be difficult to retain the gothic look while bringing in a more modern feel using the casts. Additionally, we will

[14] Facilities Information Systems- Main Campus Electrical Utilities

also have to look into the cost of a basic stone form liner and the added cost that would come with having logos added to the liner. Another consideration is whether the various options presented should contain the same aesthetic features or be completely different designs.

Americans with Disabilities Act

The Americans with Disabilities Act (ADA) regulates many aspects of a pedestrian walkway. ADA has guidelines and requirements that must be met so that walkways are accessible not only to an average pedestrian, but also to those in wheelchairs and with other disabilities. The two most important guidelines we will address will be the width of the side walk and the steepness (grade) of the walkway. By abiding by these guidelines, the sidewalk will be accessible for most any person.

Utilization of Existing Substructure

In order to keep the cost down, the clients have asked that the piers of the existing bridge be reused if possible. The current piers have been evaluated by DGL Engineering and were found to be adequate for their current loading and are estimated to last another 50 years with some minor repair. However, in order to meet other constraints, the bridge deck will have to be widened, therefore increasing its weight. Our challenge will be to determine the capacity of the piers and whether they will be able to support the additional loading. Also, with a wider bridge being designed, the pier caps would need to be replaced and widened.

Path Forward

The design approach for this project will focus on the deterioration of the bridge, and will also consider additional project constraints and client preferences. A thorough assessment of future site changes are being investigated so that the final product will accommodate current problems, some problems outside the scope of this project, and possible long term plans of the university. This assessment included meetings with all clients, faculty mentor Dr. Douglas Nims, consulting mentor David T. Charville P.E., consulting transportation engineer Dr. Eddie Chou, and consulting transportation engineer Dr. Nicholas Kissoff. See Appendix B for further information on each of these meetings.

Considerations Beyond Scope of Project

Throughout the design and planning process, several different ideas were considered towards improving this area of campus. Even though these ideas were discussed and researched, the group found that several ideas were beyond the scope of the project. A few of these ideas are discussed below.

Re-designing the Intersection North of the Bridge

As the group looked into ideas of how to make the bridge easier to travel across for pedestrians and vehicles, ideas came up which involved improving the intersection north of the bridge. Currently, this is a T-intersection with a three-way stop for all vehicles as shown in Figure 10 on the next page. There are two bus stops at this intersection and can also be seen in the figure. One option for altering this intersection was to make a continuous right turn for the traffic traveling south to north on the bridge. A few of the issues with this idea are the relocation of the current bus stop on the bridge and how to address the pedestrian traffic on the eastern side of the bridge. After looking at these situations, the group decided to just focus on the bridge itself, otherwise these problems would have stretched beyond the focus of the bridge.

Designs of the Bridge

The group also looked at different ideas regarding the actual design of the bridge. The clients wanted the bridge to be wide enough for pedestrians to comfortably pass each other on the sidewalks, and they also wanted to give pedestrians the chance to enjoy the scenic views of the river. They had suggested incorporating some kind of lookout area with benches for people to relax and look at the wildlife and nature. While exploring options of how to accommodate a lookout area, different ideas were discussed about the layout of the bridge. One option was to make the bridge more of a plaza with lookout areas and benches, while having traffic flow through the middle[15]. This idea was ruled out because of the practicality of it being on the campus, as well as the cost of designing something of that extent. It would also affect the east side of the bridge with the pedestrian crossing and the current bus stop.

Another option that was considered was creating two separate bridges; having one accommodating the traffic and the other accommodating pedestrians. This idea would also be very expensive and would pose the question of where to place the pedestrian bridge with respect to the parking lots and buildings. This idea also interfered with the bus stop because if there were not any sidewalks on the traffic bridge, the pedestrians would have no place to go or be dropped off.

The final idea was to eliminate all traffic on the bridge and make it a pedestrian only bridge. It would eliminate the poorly designed T-intersection, and increase pedestrian comfort, accessibility, and safety from vehicle collisions. This was quickly turned down because it would hinder the flow of traffic on campus and make it very difficult for buses to travel around campus.

[15] Meeting- Dr. Nicholas Kissoff

Design Considerations

Those items uncovered during investigation include the need to investigate solutions to the T-intersection of Stadium Drive and North Towerview Boulevard, pedestrian crossings both south and north of the bridge, and the UT bus route stops near the bridge[16,17]. See Figure 10 for the current site layout.

Figure 10. Current Site Layout[17]

Proposed Solutions

In order to accomplish the goals and needs of all stakeholders, the design team will be assessing three options: a bridge repair, a steel bridge replacement, and a concrete bridge replacement. Each of the two new alternatives will be designed using the Load and Resistance Factor Design (LRFD) in accordance with the Ohio Department of Transportation (ODOT), American Association of State Highway and Transportation Officials (AASHTO), and ADA requirements.

Bridge Repair

Repairing the bridge will entail the repair of the deck, parapet, bridge guardrail, sidewalks, curbs, abutments, abutment beam seats, deck expansion joints, approach guardrail, and rail transitions[19,20]. A sounding test performed by group members indicates the areas of the bridge in need of concrete replacement. The area of railing on the southeast area of the bridge that was damaged will be replaced with the existing 5 inch railing. The sidewalks will be repaired in the areas noted in the DGL report, and they will also be widened by one foot on both the east and west sides of the bridge. This will be done by shortening the width of both traffic lanes from 12' to 11' to enable more comfortable travel for pedestrians along the sidewalk. By narrowing the lanes, it will also slow the traffic through this intersection and over the bridge which will improve the safety for pedestrians. In addition to adjusting the sidewalks, underdrains will be installed on the north and south ends of the bridge to help divert water away from the deteriorated abutments and will prevent future deterioration. The abandoned pipe that is located on the south side of the bridge will be removed as well. Patching will also be done on the abutments in areas where the rebar is exposed and where the sounding tests failed. In addition to these repairs, the bridge will be stained for aesthetic purposes. A schedule that is found in Appendix F is re-created below that shows some detail for the work. These repairs will allow the bridge to be in use for an additional twenty years without having to replace the structure.

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[16] Meeting – Dr. Eddie Chou
[17] Meeting - Dr. Nicholas Kissoff
[18] Google Maps
[19] DGL "University of Toledo 2011 Bridge Inspection Report" pp. 46-82
[20] Loy "Structural and Safety Inspection of Vehicular and Pedestrian Bridges" pp. 16-23

Table 1. Replacement Schedule

Act ID	Activity Name	Orig Dur	Rem Dur	Total Float	Start	Finish
	David Root Bridge Replace...	20	20	39	02-Jun-14	30-Jun-14
A1960	Abutment Drainage	3	3	39	02-Jun-14	04-Jun-14
A1980	Repair Railing	1	1	41	02-Jun-14	02-Jun-14
A1990	Epoxy Seal and Inject	1	1	58	02-Jun-14	02-Jun-14
A1950	Concrete Patching	7	7	39	05-Jun-14	13-Jun-14
A1970	Widen Sidewalk	9	9	39	16-Jun-14	26-Jun-14
A1940	Seeding and Mulching	1	1	39	27-Jun-14	27-Jun-14
A1920	Project Complete	0	0	39	30-Jun-14	30-Jun-14

Steel Alternative

The steel alternative involves a full replacement of the superstructure and abutments. As shown below in Figure 11, the deck is comprised of five W21x83 steel girders spaced at 9 feet, with 3 foot overhangs. The 8 inch, cast in place slab is cast with the steel girders and a 2 inch haunch, in order to create a composite section, which allows both materials to act together in the resisting of loadings. The new 42 foot deck allows for two one foot concrete parapets, two 8 foot concrete sidewalks and two 12 foot traffic lanes. To account for the increase in bridge width, the existing 34 foot pier cap must be removed and replaced with a new 42 foot design. The span of the bridge remains the same at 107 feet long. The new beam sizes designed to AASHTO standards, using a girder line analysis, which determined factored, ultimate loadings for strength and service limit states. Details for this analysis are represented in Appendix D.

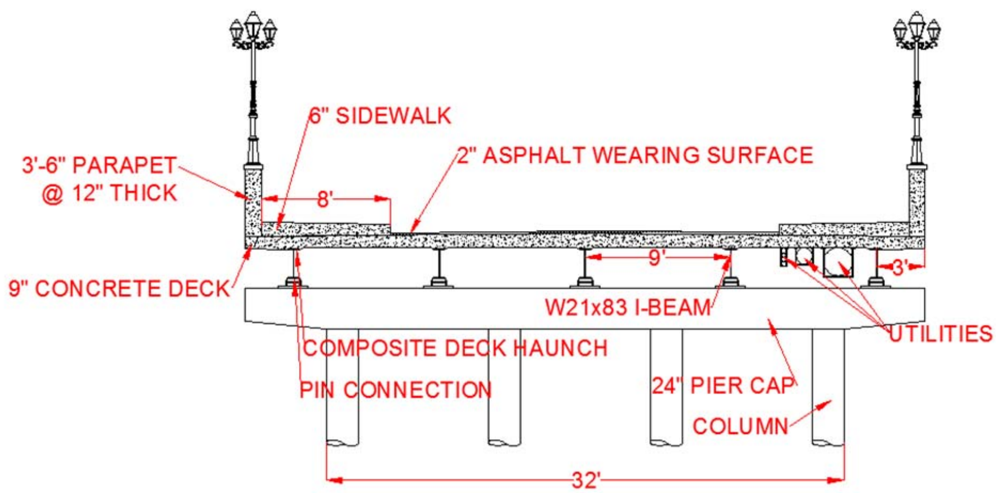

Figure 11. Steel Bridge Cross-Section

The new proposed abutments are designed to the Army Corps of Engineers specifications and to be integral with the steel girders. This means that the ends of each girder are embedded 2 feet and the abutments are poured around them. A non-integral design would create two joints; one between the girder and abutment and one between the abutment and approach pavement. The integral design allows for a jointless connection between the girder and abutment, limiting the possibilities of future abutment issues. With the addition of a new 6 inch corrugated pipe underdrain, future drainage and moisture issues will be greatly reduced.

Within the calculations of the steel design, it was essential to calculate the moments and shears for live loads, truck loads, and tandem loads across the bridge. These were the calculation constraints that helped determine the beam size and beam spacing. Table 2 below shows the unfactored, undistributed live loads used in the steel calculations. The crossed-out value in the interior M104 represents the corrected distribution factor for the W21x83 beams.

Table 2. Unfactored, Undistributed Live Loads

	Truck Moments (k-ft)			Truck Shears (k)		
	M104	M200	M205	V100	V110	V200
Truck	257.04	-216.36	296.84	48.11	-54.06	57.13
Tandem	291.23	-185.69	311.49	53.17	-55.056	58.36
LL	63.24	-92.81	82.2	10.24	-10.6	13.76
Interior	0.751 ~~0.834~~	Exterior	0.826			
Interior	0.906	Exterior	0.8	0.629		

The moments and shears for the critical section were calculated using a girder line analysis and were analyzed using SAP 2000. The results of the analysis are shown in Table 3 below. The values highlight in yellow show the greatest values for moment and shear that are used in design calculations. More detailed calculations for the steel design can be found in Appendix D.

Table 3. Moments and Shears for Critical Section

Moments and Shears at Critical Section							
		Moments (k-ft)			Shears (k)		
Load Type	Value	M104	M200	M205	V100	V110	V200
Uniform	1	64.40	-145.01	86.11	11.47	-20.53	21.5
D1I	1.075	69.23	-155.89	92.57	12.33	-22.07	23.11
D2I	0.6	38.64	-87.01	51.67	6.88	-12.32	12.90
DWI	0.225	14.49	-32.63	19.37	2.58	-4.62	4.84
D1E	1.019	65.62	-147.77	87.75	11.69	-20.92	21.91
D2E	0.6	38.64	-87.01	51.67	6.88	-12.32	12.90
DWE	0.225	14.49	-32.63	19.37	2.58	-4.62	4.84
LL+IM	TDM+LL	383.18	-296.81	424.40	74.31	-76.94	84.08
Strength I (Interior)		827.14	-871.96	952.05	157.93	-184.56	199.42
Strength I (Exterior)		822.63	-861.81	946.02	157.12	-183.12	197.91
Service II (Interior)		620.49	-661.37	715.32	118.39	-139.03	150.16
Service II (Exterior)		616.89	-653.25	710.50	117.75	-137.88	148.95
Fatigue (Interior)		409.74	-498.12	481.91	77.52	-96.71	103.91
Fatigue (Exterior)		406.14	-490.00	477.08	76.88	-95.56	102.71
Construction (Interior)		134.84	-303.61	180.29	24.02	-42.98	45.02
Construction (Exterior)		130.33	-293.46	174.27	23.21	-41.55	43.51

This option addresses the utilities constraint by neatly tucking the steam and chilled water lines, as well as, the electrical conduit in one of the 9 foot bays between two of the girders. This allows the new bridge option to maintain its aesthetic appeal, while remaining fully functional as a utility transportation mode. With the completion of the steam and chilled water loops prior to the start of this project, the current lines are able to be backfed through the university. A temporary electric feed will need to be run across the river, as the current lines on the bridge will not be able to be taken offline.

The aesthetics of this bridge, shown in Figure 12, are meant to incorporate the classic look of main campus, while providing the longevity of a new bridge. The use of lannon stone form liners allows the parapet walls to acquire the look of the existing stone used on University Hall and other structures on campus, while lowering material cost. After the parapets are cast and cured, the individual stone sections are stained different colors to attain the beautiful, natural look of lannon stone. Spaced approximately every 7’-4” are 2’-4” by 7” decorative windows formed into the parapet walls. For contrast, the borders will be stained black. Protective wire strands are spaced at 4 inches to meet safety regulations. The parapet wall angles outward 5 feet at each end of the bridge and finishes with 6 foot high turrets. These cast-in-place structures are designed to replicate elements found in the architecture of University Hall. For additional contrast, the steel girders will be painted black to match the windows. Light fixtures will also be added to the parapets and will be spaced every 36’ on both sides of the bridge. These fixtures are shown in Figure 11 above.

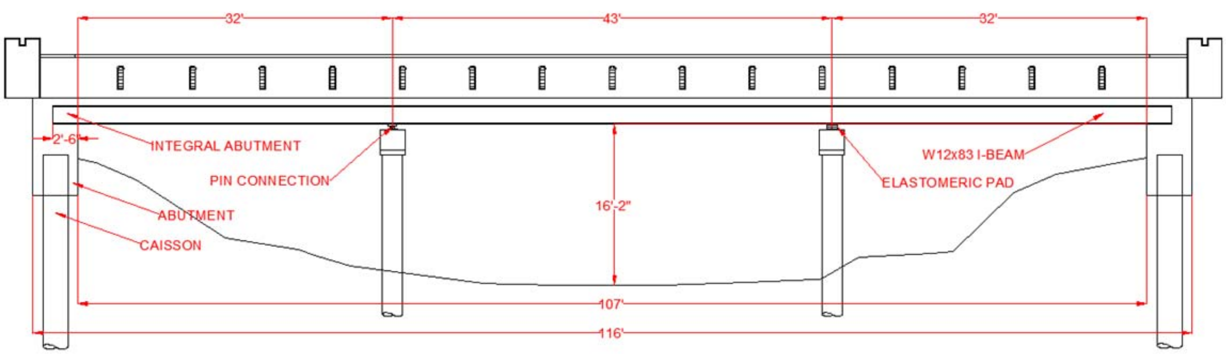

Figure 12. Steel Bridge Aesthetics

With the new steel option, the life span of the deck is estimated at 75 years. Based on the DGL bridge inspection, with the light repair to the piers, their life span is lengthened 50 more years. Thus, the piers will need to be addressed before the deck life is complete. This proposed option definitely corrects pedestrian safety issues, as well as, ADA accessibility and aesthetics. The bridge also accounts for possible, nearby site changes that the university may want to make in the future. The project has an estimated cost of approximately $555,000 and has an estimated project duration of 82 days. These figures fit well into the initial project constraints of low cost and a summer semester construction period. Overall, the steel design seems to be a very viable option for the university to entertain.

Pre-stressed Concrete Alternative

The pre-stressed concrete alternative of this project will require replacing the abutments, repair of the capped piers, and replacement of the superstructure. Two options for the concrete alternative were explored; a continuous concrete slab and a box beam design. The continuous concrete slab deck would include replacing the abutments, repairing the capped piers, and pouring a new pier cap. After completing calculations and cost estimates on the slab option, the group decided the box beam design would be more appropriate. One factor that disqualified the slab design was the failure to complete the project within the specified three month construction timeline. This was mainly due to the lengthy process of tying steel reinforcement prior to the slab being poured.

A box beam is a prestressed concrete box with tensile bars in the top and bottom of the beam along with reinforcing strands in the bottom. Due to being prefabricated, the construction timeline can be more easily accomplished than the concrete slab option. Calculations were completed to determine the maximum shear and bending moments in each span due to four main weights; beam, diaphragm, barrier, and wearing surface weight. Using this information, the design of the box beams could be completed after determining the amount of reinforcing steel needed to counteract the maximum moment. Full details of the calculations can be found in Appendix C and the tables summarizing these calculations can be seen below in Table 4 and Table 5.

Table 4. Moment Factors used in Maximum Moment Calculations- Spans 1 & 3

Spans 1 & 3 = 32'-0"

Distance	Section	Beam Weight		Diaphragm Weight		Barrier Weight		Wearing Surface		Max. Shear Force
x	x/L	Shear	Moment	Shear	Moment	Shear	Moment	Shear	Moment	V_x
(ft)	(ft)	(kips)	(ft*kips)	(kips)	(ft*kips)	(kips)	(ft*kips)	(kips)	(ft*kips)	(kip/lane)
0.000	0.000	9.344	0.0000	6.5555	0.0000	0.8728	0.0000	4.9920	0.0000	10.2400
1.216	0.038	8.6339	13.4947	6.0573	7.6686	0.8065	1.0210	4.6126	5.8396	9.4765
3.200	0.100	7.4752	33.2237	5.2444	18.8799	0.6982	2.5137	3.9936	14.3770	8.2944
6.400	0.200	5.6064	59.0643	3.9333	33.5643	0.5237	4.4687	2.9952	25.5590	6.5536
9.600	0.300	3.7376	77.5219	2.6222	44.0531	0.3491	5.8652	1.9968	33.5462	5.0176
12.80	0.400	1.8688	88.5965	1.3111	50.3464	0.1746	6.7031	0.9984	38.3386	3.6864
16.00	0.500	0.000	92.2880	0.0000	52.4442	0.0000	6.9824	0.0000	39.9360	2.5600

Table 5. Moment Factors used in Maximum Moment Calculations- Span 2

Span 2 = 43'-0"

Distance	Section	Beam Weight		Diaphragm Weight		Barrier Weight		Wearing Surface		Max. Shear Force
x	x/L	Shear	Moment	Shear	Moment	Shear	Moment	Shear	Moment	V_x
(ft)	(ft)	(kips)	(ft*kips)	(kips)	(ft*kips)	(kips)	(ft*kips)	(kips)	(ft*kips)	(kip/lane)
0.0000	0.0000	15.5015	0.0000	8.8090	0.0000	1.1728	0.0000	6.7080	0.0000	13.7600
1.8240	0.0380	14.1864	27.0754	8.0617	15.3860	1.0733	2.0485	6.1389	11.7164	12.6174
4.8000	0.1000	12.0407	66.1013	6.8423	37.5631	0.9110	5.0011	5.2104	28.6042	10.8595
9.6000	0.2000	8.5799	115.5907	4.8757	65.6863	0.6491	8.7455	3.7128	50.0198	8.3018
14.4000	0.3000	5.1191	148.4683	2.9090	84.3695	0.3873	11.2329	2.2152	64.2470	6.0871
19.2000	0.4000	1.6583	164.7341	0.9424	93.6128	0.1255	12.4636	0.7176	71.2858	4.2154
24.0000	0.5000	-1.8025	164.3880	-1.0243	93.4162	-0.1364	12.4374	-0.7800	71.1360	2.6865

In order to account for a maximum moment of 1106 ft*kip calculated in Strength I load combination, the design will include nine-48”x21” (AASHTO Type B21-48) and one-36”x21” (AASHTO Type B21-36). There will be 20 strands spaced at 2 inch along the bottom of the B21-48 box beam with two-No. 5 full-length tensile bars above them spaced at 27 inches. In addition, there will be four-No. 5 full-length tensile bars spaced at 10 inches across the top of the 48”x21” beam. For Type B21-36 box beams, 20 strands will be spaced 2 inches apart along the bottom of the beam with two-No. 5 full-length tensile bars spaced at 18 inches above the strands. The 20 strands will be divided into two rows of 10 strands. Four No. 5 full-length tensile bars will be spaced at 7 inches across the top of the Type B21-36 box beam. The box beam dimensions for our design are found below in Figure 13.

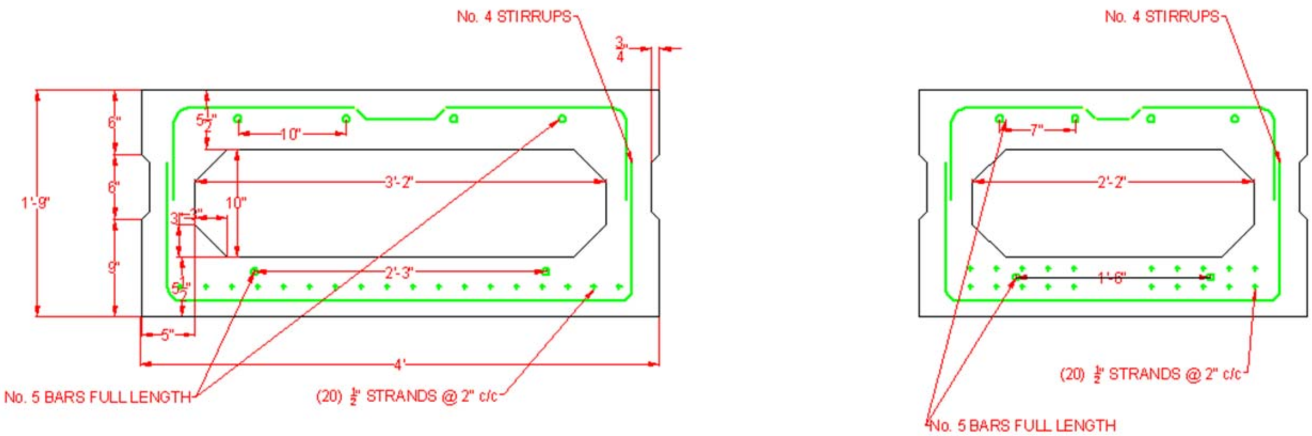

Figure 13. Prestressed Concrete Box Beam Dimensions

The first constraint addressed in the concrete alternative was the existing utilities that are run across the bridge. With the information gathered from a meeting with Mr. Michael Green, the current structure is holding three electrical conduits, one 21 inch diameter steam line, and one 12 inch diameter chilled water line. By the time of the bridge construction, a utility loop around campus will be completed and the ability to backfeed steam and chilled water will be plausible[21]. Temporary conduits will have to be installed for the duration of construction for the electrical utilities.

For the new design, the utilities were concealed in between two box beams. The nine- 48”x21” will be side-by-side spanning 36 feet. A 3 foot wide pocket will be left for the utility lines to run through followed by single 36”x21” box beam to equal the full width of the structure of 42 feet. The 36” box beam will be on the outside of the utilities and will carry the weight of the parapet walls and sidewalk. Figure 14 shows a drawing detailing the utility void.

[21] Meeting – Mr. Michael Green

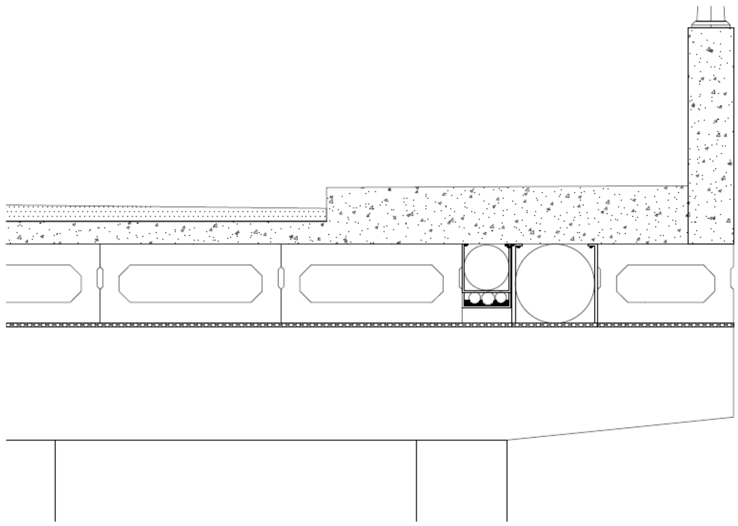

Figure 14. Utility Void in Prestressed Concrete Bridge Design

The concrete box beam option ranked the most expensive at $582,000. However, the bridge demolition and construction can be completed in 72 days which complies with our timeline constraint of the three summer months. In addition, the life span of a box beam bridge is 35+ years.

The inspiration for the bridge aesthetics came from the lannon stone used on the University buildings as well as the gothic theme on campus. Form liners will be used to create the image of lannon stone arches which will continue into the parapet wall. The parapet wall will have sections of railing dividing the solid wall to allow a more scenic view of the Ottawa River. New lighting fixtures will be installed that better represent a gothic look on campus. Figure 15 shows a profile of the concrete bridge aesthetics. As shown, the fixtures will be placed in the center of each solid parapet section on both sides.

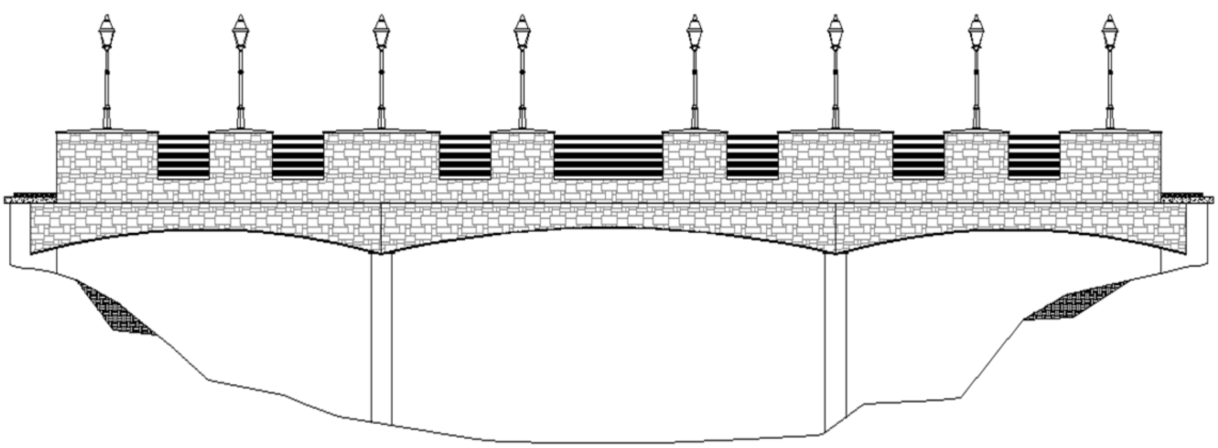

Figure 15. Profile Drawing of Proposed Concrete Box Beam Alternative

The concrete option, like the steel, was designed to have a total width of 42 feet. This incorporates two 12 foot driving lanes, two 8 foot sidewalks, and two one foot parapet walls. Therefore, the bridge will meet ADA regulations. This will make it easier for the disabled to reach all areas on campus as well as the handicap parking lot directly across the bridge. The 8 foot sidewalks will also allow for the University motorized snow plows to clean the sidewalks in a single pass. The parapets will be one foot wide and will hold the light fixtures. These light fixtures will enhance pedestrian and vehicle safety on the bridge by providing adequate lighting to improve visibility.

Based on all of the requirements, constraints, and calculations, a cross-section of the bridge was designed as shown in Figure 16 below. The plan view of the bridge with just the elevations and abutment placements can be seen in Figure 17.

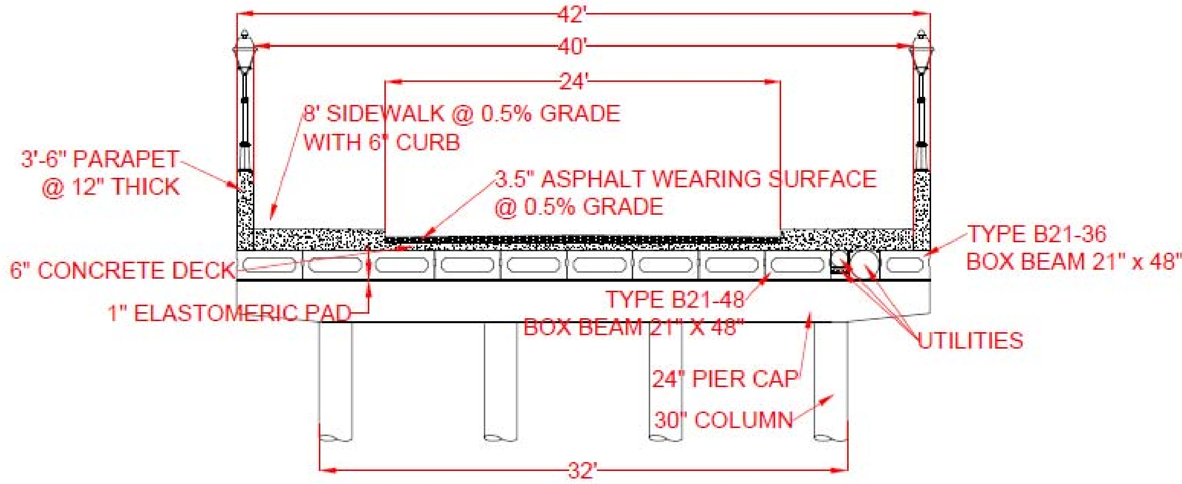

Figure 16. Prestressed Concrete Bridge Design Cross-Section

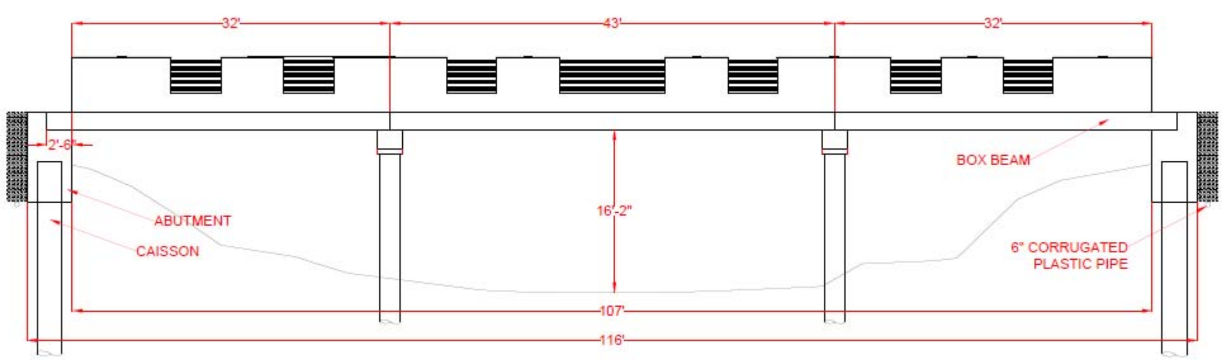

Figure 17. Plan View of Prestressed Concrete Bridge Design

Finally, the concrete alternative complies with the utilization of the existing structure constraint. The new box beam superstructure will be supported by the existing piers. According to the DGL report done in 2011, the piers have a lifespan of 20+ years without any repair[22]. However while conducting the demolition and construction, the piers will be patched with a concrete compound to increase the life of the structure 50+ years. The north and south abutments will be replaced and new pier caps will be poured to accommodate the wider structure.

Permits

Before performing work on the bridge, permits will have to be completed and approved. The permit that is pertinent to this bridge is the U.S. Army Corps of Engineers 404 Permit. The 404 Permit relates to the Clean Water Act[23] and is required to be completed for any construction work over a body of water. The 404 Permit requires several different aspects and details of the proposed project[24]. A general location map must be provided that shows the waterway shoreline, the wetland edge, the direction of water flow, the exact location of the project, the nearest street or road, nearest intersection, and the nearest town. A plan view map and cross-section map are also required. In addition to the maps, the applicant must provide a description of the proposed work as well as the reason for the work and the construction schedule. Optional information includes photographs, an alternative analysis, sizes and types of equipment being used on the project, and secondary environmental impacts that might occur as a result of the construction. An IDEM Section 401 Water Quality Certification also needs to be obtained and like the 404 Permit, this certification complements the Clean Water Act. This certification has many similar requirements and it also has a Stream Impact section where information about the river would need to be included. Once the permit and certification are both received, the construction of the bridge may begin.

Utilities

The utilities involved in this project require different approaches and depend on the type of work being completed. After meeting with Mr. Michael Green, the group gained a better understanding of the current utilities along the bridge[25]. From that meeting, decisions were made for how to address the utilities with the different design options. One project that would be completed before the university addresses the David Root Bridge is the steamed and chilled water line utilities loop on main campus. This would allow one portion of the campus to be shut off while the other portion maintains full utility use. The work for the utility loop will begin July 2013. This finished project will aid in addressing the utilities on the construction of the bridge.

For the bridge repair, the utilities would remain in place. The work would be completed with caution as to not damage any of the pipes hanging from the bridge. By not removing the utilities, it would keep the cost of the repair option down, and it eliminates the risk of a utility malfunction that could affect the university.

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[22] DGL "University of Toledo 2011 Bridge Inspection Report" pp 47
[23] Ohio EPA "401 Water Quality Certification and Isolated Wetland Permitting Section"
[24] "Department of the Army Permit Requirements"
[25] Meeting- Mr. Michael Green

For the steel and concrete options, different approaches will be taken on the different utilities. The chilled and steamed water lines will be shut off and removed during the construction of the bridge. They will be removed with the purpose of salvaging the pipes and re-using them on the final bridge. Additional pipe will be needed to accommodate the wider structure, but the cost of the small portions would be less expensive than replacing the entire pipe along the bridge. The electrical utility line will be a temporary line until the construction is complete. If a temporary line isn't put in place for the electricity, there is a chance that the electric loop will malfunction. This would result in a loss of power throughout the entire campus. The utilities will be attached to the newly designed bridges in locations not visually noticeable unlike the current bridge and the repair option. This will help enhance the aesthetics by reducing the visibility of the pipes along the bridge.

Best Option Determination

In order to determine a recommendation of the three options, a best option determination table was created in order to assess each option via point scale and is shown in Table 6 below. The different factors of importance were determined based on constraints and items discussed during meetings with the clients. Factors considered will include cost, bridge longevity, repair and maintenance, construction schedule, aesthetic appeal, vehicle and pedestrian considerations, and ADA compliance. Each of the three clients received a list of the factors and were asked to rate them out of a total of 100 cumulative points based on their personal opinion of importance. Each of their scores were averaged and counted as 75% of the average weight. Every group member also contributed with their own ratings. The group members' scores were averaged and counted as a total of 25% of the average weights.

There are some pros and cons to each option that were identified prior to receiving the weighted ratings. Because the cost of the bridge is important and the clients want it to be kept at a reasonable cost, the repair option would be the least expensive choice. Although it would allow the bridge to last an additional twenty years, this option would prevent major aesthetic changes that the new bridge options would offer. With the longevity of the bridge as a factor, the new bridges would provide for more years of service than the current bridge. The new options also allow for designs that would widen the sidewalks and make pedestrian travel easier along the bridge.

The group examined the final design of each alternative (repair, steel, and concrete) and rated their factors with a value from 1% to 100% based on how well they felt the option addressed the factor. For example, the bridge repair did very little to address the aesthetics of the bridge so the group rated it with a 28%, where as the steel alternative has a lot of methods to address the aesthetics so it received an 82.25%. The ratings are the numbers in parentheses in Table 6. Next the rating for each factor was multiplied by its corresponding average weight to come up with a partial total. The partial totals are the numbers above the percentage in Table 6. Lastly, all of the partial totals for each alternative were added together to come up with their corresponding total.

Table 6. Best Option Determination Table

	Best Option Determination Table							
	Aesthetics	Bridge Life	Cost	Disabled Accessibility	Repair & Maintenance	Vehicle & Pedestrian Considerations	Schedule	**Total**
AVG WEIGHT	14.57	12.29	16.86	17.36	11.14	14.14	13.64	**100.0**
Bridge Repair	4.08 (28%)	4.52 (36.75%)	15.43 (91.5%)	5.99 (34.5%)	4.23 (38%)	4.91 (34.75%)	12.89 (94.5%)	**52.0**
Steel Alternative	11.98 (82.25%)	11.77 (95.75%)	11.46 (68%)	15.80 (91%)	9.39 (84.25%)	10.43 (73.75%)	9.41 (69%)	**80.2**
Concrete Alternative	12.38 (85%)	6.88 (56%)	9.02 (53.5%)	15.80 (91%)	8.41 (75.5%)	10.29 (72.75%)	10.26 (75.25%)	**73.0**

The average weights of each option give the group ideas of what to look for when determining the final recommendation. Disabled Accessibility is the highest concern and is clearly addressed in the concrete and steel alternatives with wider sidewalks for pedestrians. Widening the sidewalks was put in the repair option, but their width was limited to the existing structure. Cost was the next most important aspect of the designs, and solely based on this option, the bridge repair would be the best choice. Although the repair option has several aspects to it, the new steel and concrete designs would require costs such as demolition that the repair option wouldn't need. Aesthetics as well as Vehicle and Pedestrian Considerations were closely rated, and after looking at the three options, the bridge repair would be the least aesthetically pleasing and wouldn't address the safety of the pedestrians and drivers as well as the steel and concrete bridges. Both of these new bridges would tie in the gothic theme of the campus through their parapet designs, and would also address pedestrian safety by having wider sidewalks to allow for students to be farther away from the vehicles when walking across the bridge. The schedule was the next most important item in the table, and this was what helped the group determine the type of concrete bridge to design. The box beam pre-fabricated features and the steel design I-beams wouldn't require a great amount of time to put together on the bridge during the construction. Since the scheduling was an initial constraint, the group made an effort to continuously make sure that the designs for the bridge would be able to be completed in the short time frame. Finally, the construction life and repair and maintenance were the least important aspects of the design for the clients and the group members. This allows the group to really consider the repair option over the new designs because it would be less expensive and would require some maintenance. It also wouldn't last as long as the new bridges. Although these three aspects bring focus on the repair option, based on the other criteria, it wouldn't be the best recommendation.

Conclusion

Based on the Best Option Determination Table, the group determined that the steel bridge replacement would be the optimal solution. The results of the weighted scores directly relate to the earlier predictions that the group had made with the immediate pros and cons of the design options. Although the repair option was the least expensive and had the most efficient construction schedule, its ratings in all the other categories were lower than the steel and concrete alternatives. This eliminated the repair from being a final recommendation. Between the steel and concrete bridge designs, the categories that reduced the scores of the concrete bridge were its longevity, its cost, and its repair and maintenance. The $30,000 difference between the concrete and steel designs proves that the concrete option is not the best investment for the university. Both of the new design options have aesthetic appeal, vehicle and pedestrian considerations, and address the ADA accessibility. Since the steel bridge will be able to last over 75 years, the investment to design this option would benefit the university, while having a lower level of repair and maintenance throughout its life. The steel bridge also has the lower cost of the two new bridge designs and this was a constraint that the clients emphasized to keep at a reasonable price. Overall, the steel design provides pedestrians with adequate sidewalk widths, ADA accessibility, and more room to avoid the traffic on the bridge. Its parapet design provides a gothic aesthetic quality that matches the university's buildings and the design's overall cost was less than the concrete option. Its schedule ensures that it will be complete by the time classes start in August, and it will have very minimal maintenance required. Because of these aspects of the different bridge options, the group's final recommendation for the university is to pursue the steel bridge design.

Schedule

October 4th, 2012	Deliver Scope Report to Clients
November 8th, 2012	Mid-Design Meeting with Clients
December 3rd, 2012	Deliver Final Report to Clients
December 4th, 2012	Presentation of Final Report to Clients
December 7th, 2012	Presentation of Final Report at Senior Design Expo

Persons Contacted

Dr. Douglas Nims
Associate Professor
The University of Toledo
419-530-8122
DOUGLAS.NIMS@utoledo.edu

Dr. Cyndee Gruden
Associate Professor
The University of Toledo
419-530-8128
Cyndee.Gruden@utoledo.edu

Doug Collins
Director of Facilities Maintenance
The University of Toledo
419-530-1018
Douglas.Collins@rockets.utoledo.edu

Dan Klett
Facilities Planning
The University of Toledo
419-530-1453
Daniel.Klett@utoledo.edu

Dr. Patrick Lawrence
Professor and Department Chair
The University of Toledo
419-530-4128
Patrick.Lawrence@utoledo.edu

Dr. Eddie Chou
Professor
The University of Toledo
419-530-8123
Yein.Chou@utoledo.edu

Dr. Nicholas Kissoff
Associate Professor/Director
The University of Toledo
419-530-3165
Nicholas.Kissoff@utoledo.edu

Ahmmed Hammada
Graduate Assistant
The University of Toledo
Ahmmed.Hammada@rockets.utoledo.edu

Ahmed Hamid
Principle/Project Manager
DGL Consulting Engineers, LLC

David T. Charville, P.E.
Project Manager
Tetra Tech
419-418-0512
dave.charville@tetratech.com

Michael Green
Director of Energy Management
The University of Toledo
419-530-1036
Michael.Green@utoledo.edu

James Graff
Director of Facilities Operations
The University of Toledo
419-530-1053
James.Graff@utoledo.edu

Xiaozhong Zhang
Program Database Analyst
The University of Toledo
419-530-1458
Xiaozhong.Zhang@rockets.utoledo.ed

Mike Ahten
Project Manager/Estimator
Mosser Construction
419-334-3801
mahten@mossergrp.com

Jorge Baez
Project Manager/Estimator
Mosser Construction
419-334-3801
jbaez@mossergrp.com

Sandy Heschel
Project Manager/Estimator
Mosser Construction
419-334-3801
sheschel@mossergrp.com

Nickee Linder
Project Support Assistant
Mosser Construction
419-334-3801
nlinder@mossergrp.com

Rusty Parker
Chief Estimator
Mosser Construction
419-334-3801
aparker@mossergrp.com

Doug Shealy
Vice President
Mosser Construction
419-334-3801
dshealy@mossergrp.com

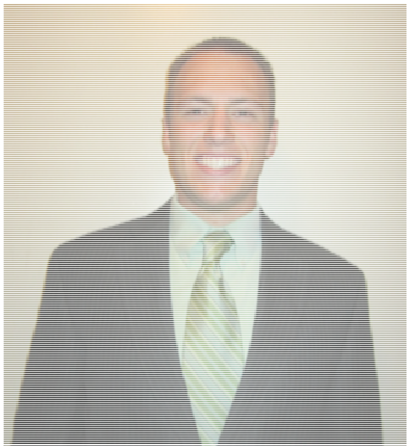
Statement of Qualifications

Blair Newman is a senior at the University of Toledo in the Bachelor of Science in Civil Engineering program. He has completed a total of four co-ops with two different companies. His first was with AquaBlok, Ltd in Toledo, OH, where he gained experience in the testing, manufacturing and sale of product used for sediment remediation and other environmental engineering applications. His next three terms where with the Toledo Zoo Facilities Construction Department, where he gained valuable small construction project design and management experience. Three of his designs were ultimately issued as field instructions for the $16 million Tembo Trail exhibit. Throughout his co-ops, Blair has gained valuable communication skills, by dealing with contractors, zoo staff and the public. Upon graduation in December of 2012, Blair will begin employment as a Facilities Construction Coordinator for the Toledo Zoo.

Danielle Sheppa is currently a senior at The University of Toledo and will receive her Bachelor of Science degree in Civil Engineering. She has completed three co-ops with the Ohio Department of Transportation throughout her education, all of which were in different departments. Her first semester consisted of working on construction sites and aiding in inspections and calculations. The following co-op semester, she was in the Office of Highway Management and worked under an engineer who focused on culverts and drainage systems throughout the district. Danielle's last semester was in the Office of Planning and Engineering where she gained experience with various computer programs and updating project plans. She hopes to apply her knowledge from co-oping and coursework towards the fields of construction and transportation.

Kathryn Gillette is senior at the University of Toledo completing her Bachelor of Science degree in Civil Engineering. She has fulfilled three co-op terms with the City of Toledo. Spending most of her time at the Division of Streets, Bridges, and Harbor, Kathryn was involved in bridge inspection and surface treatment. She also worked with ArcGIS at the Division of Engineering Services. A fourth co-op was completed at Danis Building Construction Company in Dayton, OH. Kathryn experienced many project engineer responsibilities such as writing requests for information, updating permit plans and master plans, and performing quality control inspections. Upon graduation, Kathryn Gillette hopes to pursue a position as a project engineer and work in the construction industry.

Todd Cereghin is a senior at the University of Toledo and will be earning a Bachelor of Science in Civil Engineering in December of 2012 and a minor in renewable energy at a later date. He draws knowledge from his co-ops and previous employment in construction as a laborer. He has completed three co-ops with two different employers and maintained part time work with each of them throughout his school career. His first co-op was with the City Engineers Office of Defiance, OH. There he was placed on a rotation to be introduced to work in every department. For his final two co-ops, Todd worked in the Facilities Construction Department at the Toledo Zoo, Toledo, OH. At the zoo, Todd learned all portions of the department, eventually culminating in the creation and management of a project from start to finish. After graduation, Todd hopes to work for a design-build firm and enroll in graduate school.



Nicholas Steyer is a senior at the University of Toledo working on his last semester in the Civil Engineering Program. During his college career, Nicholas participated in three co-ops with the Ohio Department of Transportation (ODOT), two of which were in construction and the third was in highway management, and he participated in a co-op with Mosser Construction in the heavy highway division. He is currently working part-time for Mosser Construction in order to further his knowledge of bridge construction. During his work experiences, he has been exposed to the construction of multiple traffic bridges and has learned the thought process that goes along with constructing a bridge. Upon his graduation in December, Nicholas plans to find a full time position in the construction industry.

BLAIR ANTHONY NEWMAN

1420 Lawnview Avenue
Toledo, OH 43607
740-506-2765
blair.newman@rockets.utoledo.edu

EDUCATION — August 2008-Present

The University of Toledo, Toledo, Ohio
Bachelor of Science, *Civil Engineering*
- Anticipated Graduation Date: December 2012
- Grade Point Average: 3.639

EXPERIENCE

January 2011-Present

The Toledo Zoological Society, Toledo, OH
Facilities Construction Co-op
- Assisted the Facilities & Planning Department employees in day-to-day tasks involving facilities construction, maintenance and horticulture
- Acted as Project Manager/Superintendent on various small projects
- Created and maintained energy monitoring databases, including work with solar renewable energy
- Carried out in-house design work that was implemented in multi-million dollar construction projects
- Encountered and solved unique engineering problems related to animal captivity

May 2010-January 2011

AquaBlok, Ltd., Toledo, OH
Intern
- Facilitated the production of various products used in sediment remediation and other geotechnical and environmental applications
- Helped in the procurement of equipment and materials
- Put together sample and literature packages for prospective clients
- Carried out fluid dynamics experiments on newly designed products

COMMUNITY ACTIVITIES

Relay for Life, Children's Miracle Network, American Red Cross

HONORS & AWARDS

Rocket Gold Scholarship
Dean's List – Fall 2008, Fall 2010, Summer 2011, Spring 2012

COLLEGIATE ACTIVITIES

The International Fraternity of Phi Gamma Delta, Upsilon Tau Chapter – Member, Recruitment Chairman, Scholarship Chairman, Judicial Board Justice
Order of Omega Greek Leadership Society – Member
University of Toledo Engineers' Council – Member, Signage Committee
American Society of Civil Engineers – Student Member, Secretary, Concrete Canoe Team Member
First Year Rocket Engineers – Past Member

REFERENCES

Available upon request

DANIELLE SHEPPA
216-702-4396
Danielle.Sheppa2@rockets.utoledo.edu

1752 North Westwood Ave, Apt J
Toledo, Ohio 43607

29216 Buchanan Drive
Bay Village, Ohio 44140

OBJECTIVE

To secure a full-time position in the Civil Engineering field that will complement my academic endeavors.

EDUCATION
August 2008-
Present

The University of Toledo, Toledo, Ohio
Bachelor of Science, Civil Engineering
Minor: Business Administration

- Anticipated Graduation Date: December 2012
- Grade Point Average: 3.321

COMPUTER SKILLS

Microsoft Office Suite
Microsoft Windows 98/NT
AutoCAD 2009
MicroStation/Geopak

EXPERIENCE
August 2011-
December 2011

Ohio Department of Transportation- District 12 Garfield Heights, Ohio
Co-op Student- Office of Planning and Engineering

- Conducted speed studies
- Created and analyzed crash queries
- Reviewed and updated project plans
- Designed a bridge sealing project

January 2011 -
May 2011

Ohio Department of Transportation- District 12 Garfield Heights, Ohio
Co-op Student- Office of Highway Management

- Performed culvert inspections
- Created and updated culvert inventory system
- Updated culvert plans

June 2010 -
August 2010

Ohio Department of Transportation- District 12 Garfield Heights, Ohio
Co-op Student- Construction

- Performed project inspections
- Calculated and confirmed payment items
- Assisted in concrete testing

HONORS/AWARDS

The University of Toledo Honors Program
The University of Toledo Rocket Gold Scholarship
American Society of Highway Engineers Scholarship
Dean’s List: Spring 2009, Spring 2012, Summer 2012
Girl Scout Gold Award

COLLEGIATE ACTIVITIES

Alpha Chi Omega Sorority
American Society of Civil Engineers (ASCE)
Women in Science and Engineering (WISE)
CIVE Mentor Group

COMMUNITY ACTIVITIES

The University of Toledo Halloween Walk
Visit Second Chance Center (Prostitute & Human Trafficking Victim Center)
Wrap Up Toledo (Blanket Collection for the homeless)

REFERENCES

Available upon request

KATHRYN A. GILLETTE

Kathryn.Gillette@rockets.utoledo.edu
(330) 321-3181

Local Address
1752 N. Westwood Ave., Apt. J
Toledo, OH 43607

Permanent Address
739 Falling Oaks Drive
Medina, OH 44256

OBJECTIVE

To secure a full time position in the Civil Engineering field that will apply my academic endeavors with hands-on experience.

EDUCATION
August 2008-Present

The University of Toledo, Toledo, Ohio
Bachelor of Science, Civil Engineering
Minor, Mathematics

- Anticipated Graduation Date: December 2012
- Grade Point Average: 2.963

COMPUTER SKILLS

- AutoCAD
- Microsoft Office Suite
- BMS Bridge Rating System
- ArcGIS

EXPERIENCE
May 2012-
August 2012

Danis Building Construction Company (Dayton, OH)
Engineering Co-op Student

- Write Requests for Information
- Perform quality control checklists and punchlists
- Supervise and monitor subcontractors
- Maintain infectious control between occupied hospital and areas under construction

May 2010-
December 2011

City of Toledo Div. of Streets, Bridges, and Harbor (Toledo, OH)
Engineering Co-op Student

- Assist P.E. in inspecting city bridges
- Conduct testing during surface treatment
- Supervise weed control program
- Conducted fleet analysis and composed a report for City Council

COLLEGIATE ACTIVITIES

First Year Rocket Engineer (FYRE) member
American Society for Civil Engineers (ASCE) member
Build concrete canoe for ASCE Competition 2009

COMMUNITY SERVICE

Musical Quartet Performances

- Handicap for Society
- Art Exhibitions
- Weddings

ASCE

- Clean the Streams
- Clean Central Avenue, Toledo, OH

REFERENCES

Available Upon Request

TODD M. CEREGHIN

712 Alton Ave.
Defiance, OH 43512
419-980-8481
todd.cereghin@rockets.utoledo.edu

OBJECTIVE	To secure a position in the field of civil engineering and construction management in which I will be given the opportunity to take on work of increasing difficulty.
EDUCATION August 2007- Present	**The University of Toledo,** Toledo, Ohio *Bachelor of Science, Civil Engineering* *Minor in Renewable Energy (2013)* • Anticipated Graduation Date: December 2012
EXPERIENCE August 2010 – Present	**The Toledo Zoo,** Toledo, Ohio *Cooperative Education Intern* • Designed and managed small project • Assisted Director of Facilities & Planning
May 2009-August 2009	**The City of Defiance,** Defiance, Ohio *Cooperative Education Intern* • Maintained Defiance City GIS • Designed small project
August 2008-May 2010	**The University of Toledo, Chemistry Department** *Peer Leader* • Provide supplemental teaching and assistance to my group of students • Tailor and create an effective workshop weekly
March 2007 - August 2010	**Kiessling Construction,** Defiance, Ohio *Construction Worker* • Performed general construction labor • Operated light vehicles and power tools
COMPUTER SKILLS	**Microsoft Office Suite, AutoCAD, Alibre, AccuGlobe, ArcView, On Screen Take Off , Google SketchUp, Adobe, BlueBeam**
HONORS & AWARDS	**Presidents List, Deans List, Congressional Award,** **ASCE Student Scholarship, F.O.E. Scholarship Award,** **UT Genesis Scholarship, AmeriCorps Education Award,**
COLLEGIATE ACTIVITIES	**Chi Epsilon Honors Society** *President Aug 11 – Dec 12* **American Society of Civil Engineers** *Volunteer Coordinator Jan 10 - Aug 12* **Engineers Without Boarders** *Member Aug 08 – Aug 11*
REFERENCES	Available upon request

NICHOLAS STEYER

3284 South US 23
Alvada, OH 44802
567-207-7353
nicholas.steyer@rockets.utoledo.edu

OBJECTIVE

To obtain a position in the Civil Engineering field that will allow me to use my knowledge and skills to help a company in reaching its goals and to find long-term employment.

EDUCATION

The University of Toledo, Toledo, Ohio
Bachelor of Science, Civil Engineering
- Anticipated Graduation Date: December 2012
- Grade Point Average: 3.68

HONORS & AWARDS

University of Toledo Blue Tower Scholarship
Dean's List

COMPUTER SKILLS

Microsoft Office Suite
AutoCAD

EXPERIENCE

May 2012-Present

Mosser Construction, Fremont, Ohio
Co-op Student
- Assisted in preparing bids
- Managed job quantities
- Took part in pre-bid inspections

August 2011-December 2011

Ohio Department of Transportation District 2, Bowling Green, Ohio
Co-op Student
- Inspected work done by the contractor
- Used GPS to layout points in Microstation
- Calculated costs of extra work

January 2011-May 2011

Ohio Department of Transportation District 2, Bowling Green, Ohio
Co-op Student
- Assisted in Step 2 Dispute Presentation
- Calculated quantities from plans
- Participated in progress meetings

May 2010-August 2010

Ohio Department of Transportation District 2 Bowling Green, Ohio
Co-op Student
- Designed route marker signs for Tiffin
- Produced cost estimates
- Conducted quality control

COLLEGIATE ACTIVITIES

American Society of Civil Engineers (ASCE) member

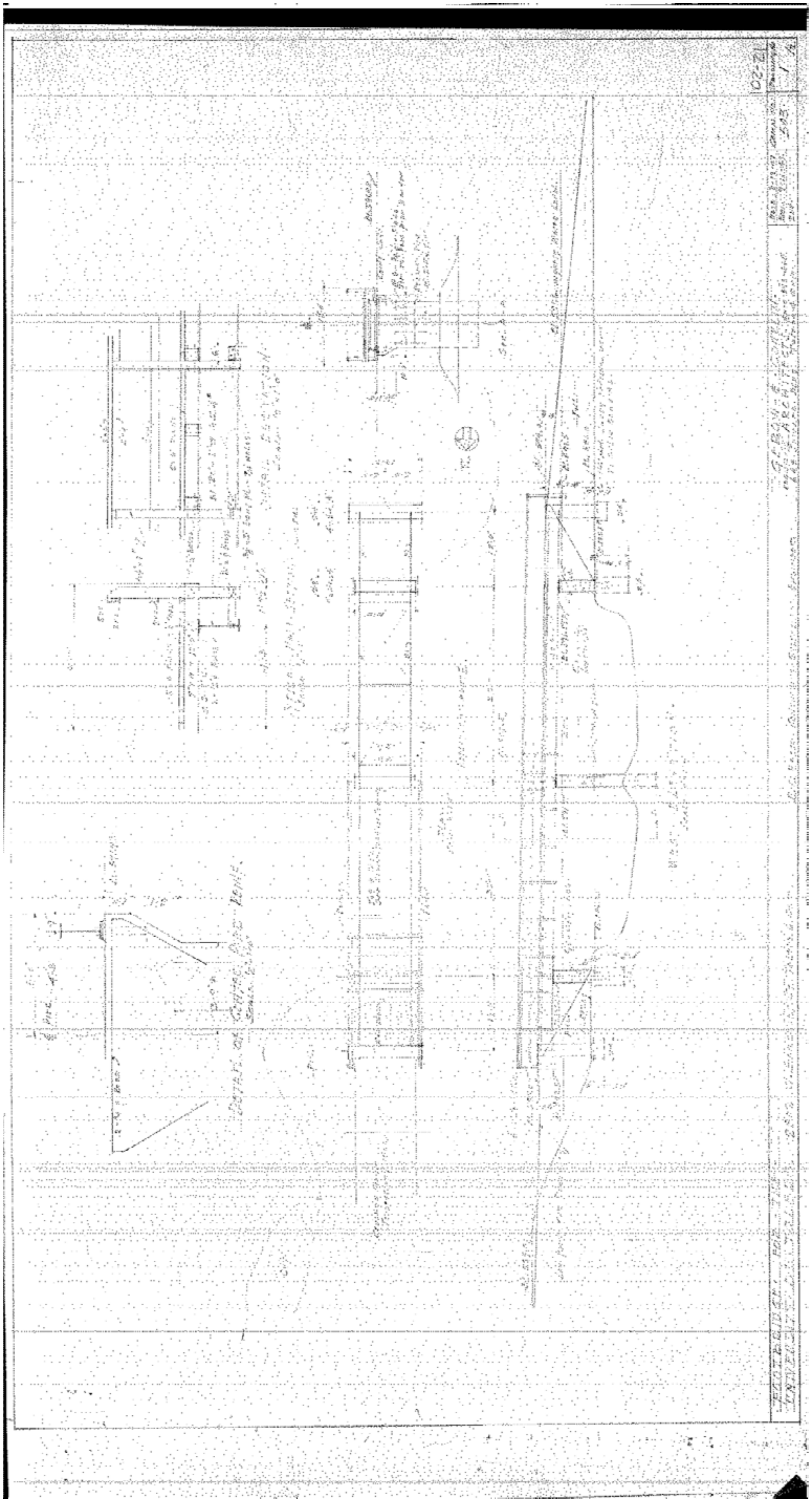
COMMUNITY ACTIVITIES

Volunteer Fire Fighter at NBS Joint Fire District
Vice-President of New Riegel Volunteer Fireman Incorporate
Regularly give blood at the American Red Cross

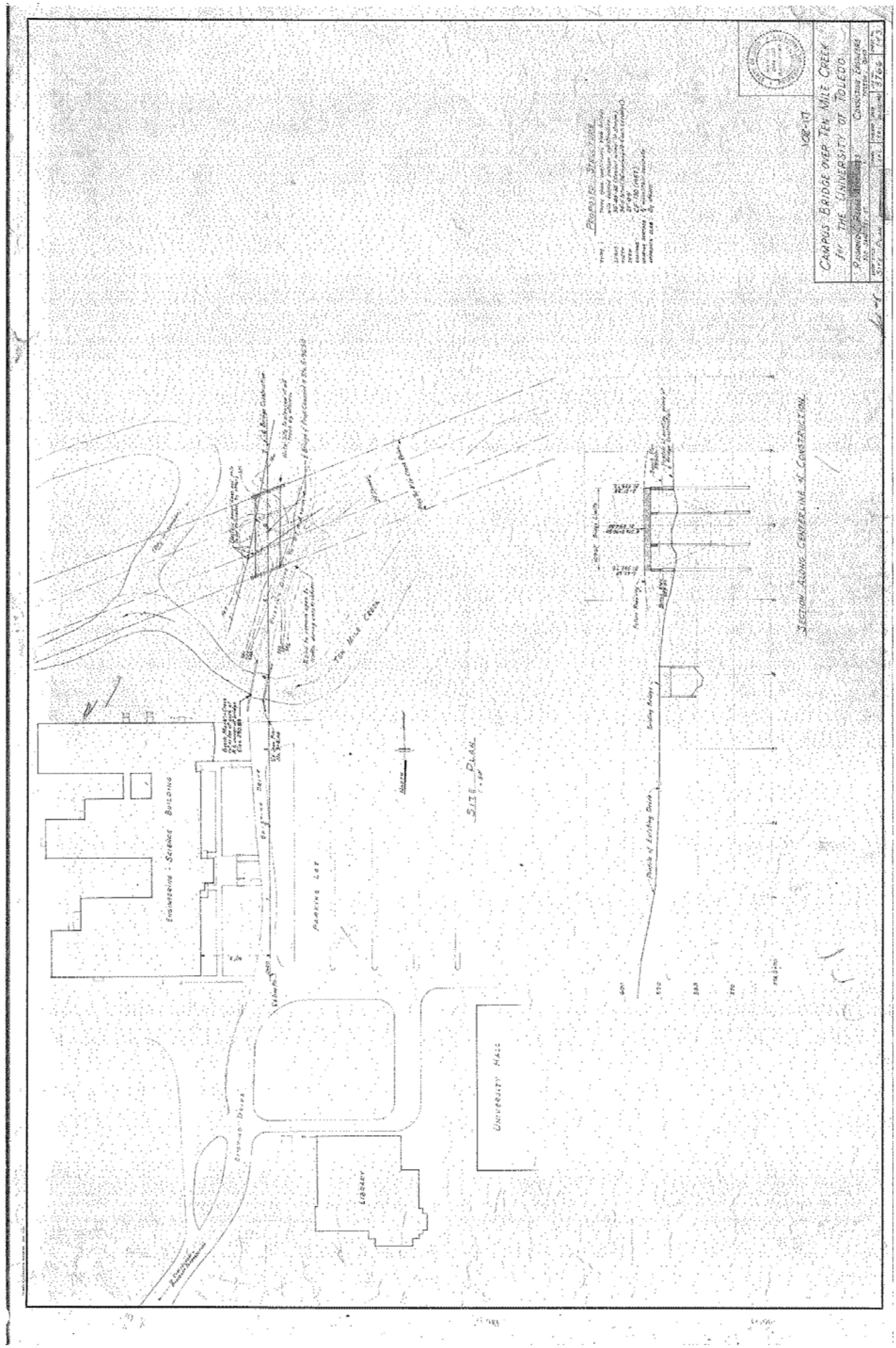
REFERENCES

Available upon request

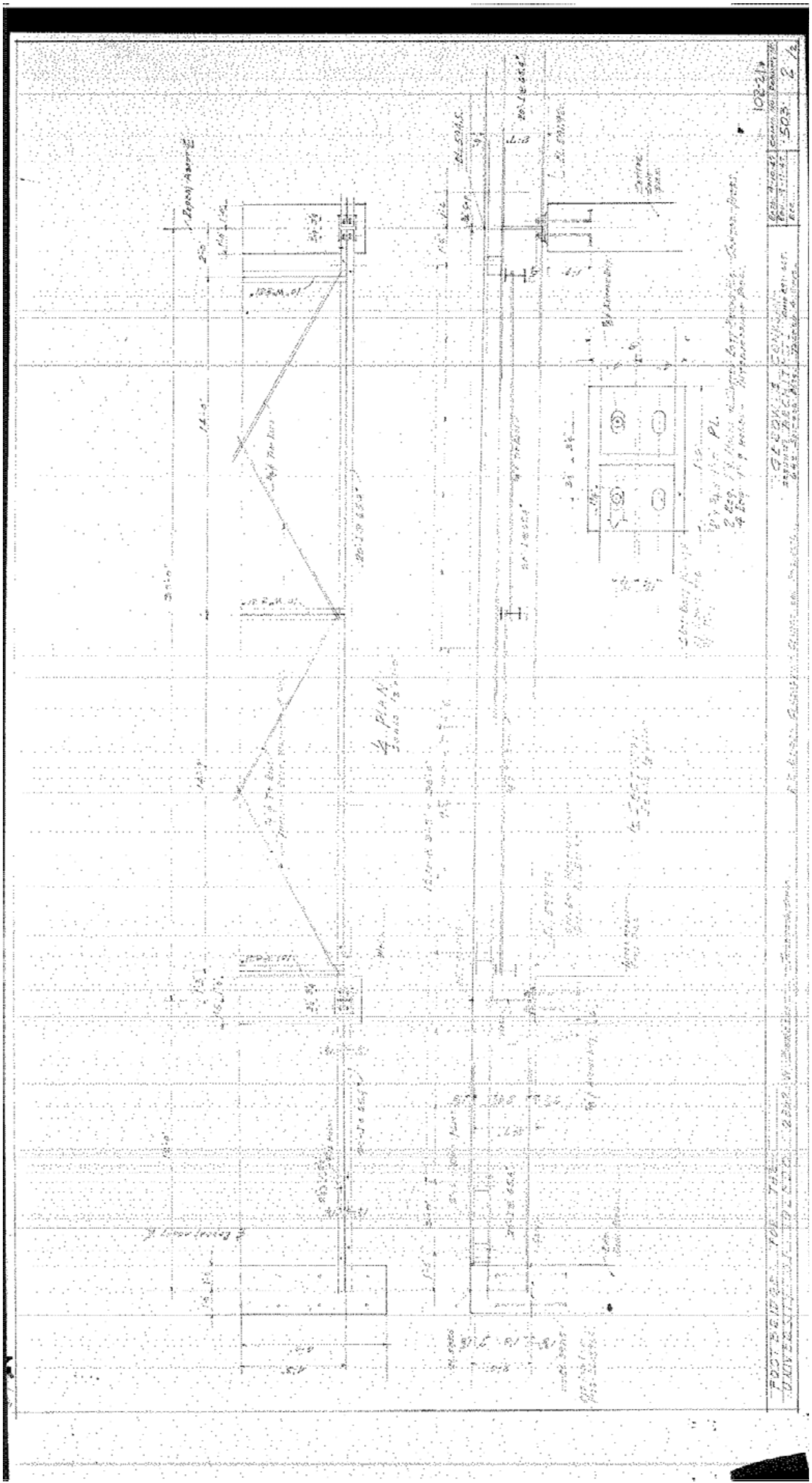
Appendix A - Historical Drawings



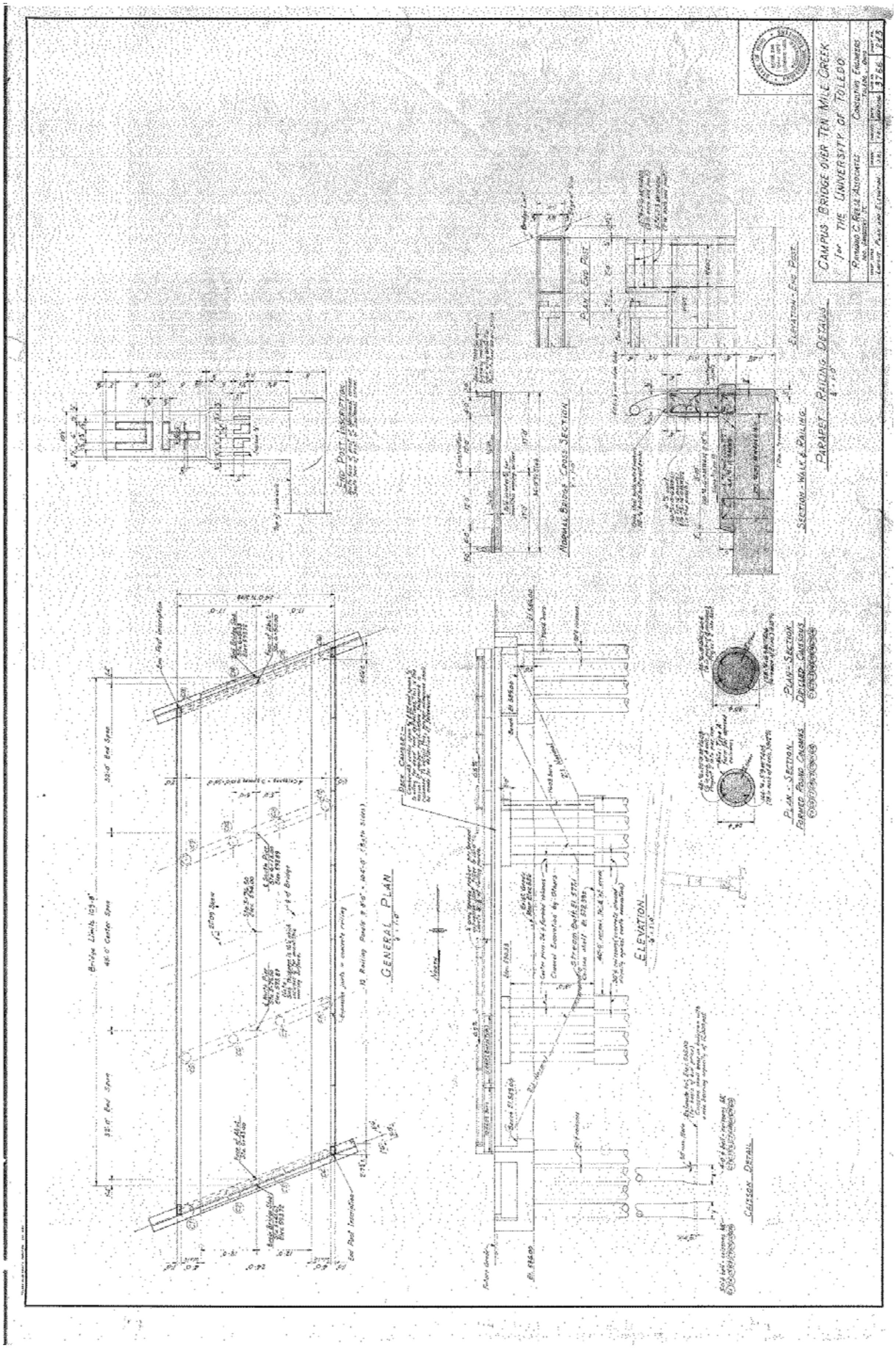
Appendix A - Historical Drawings



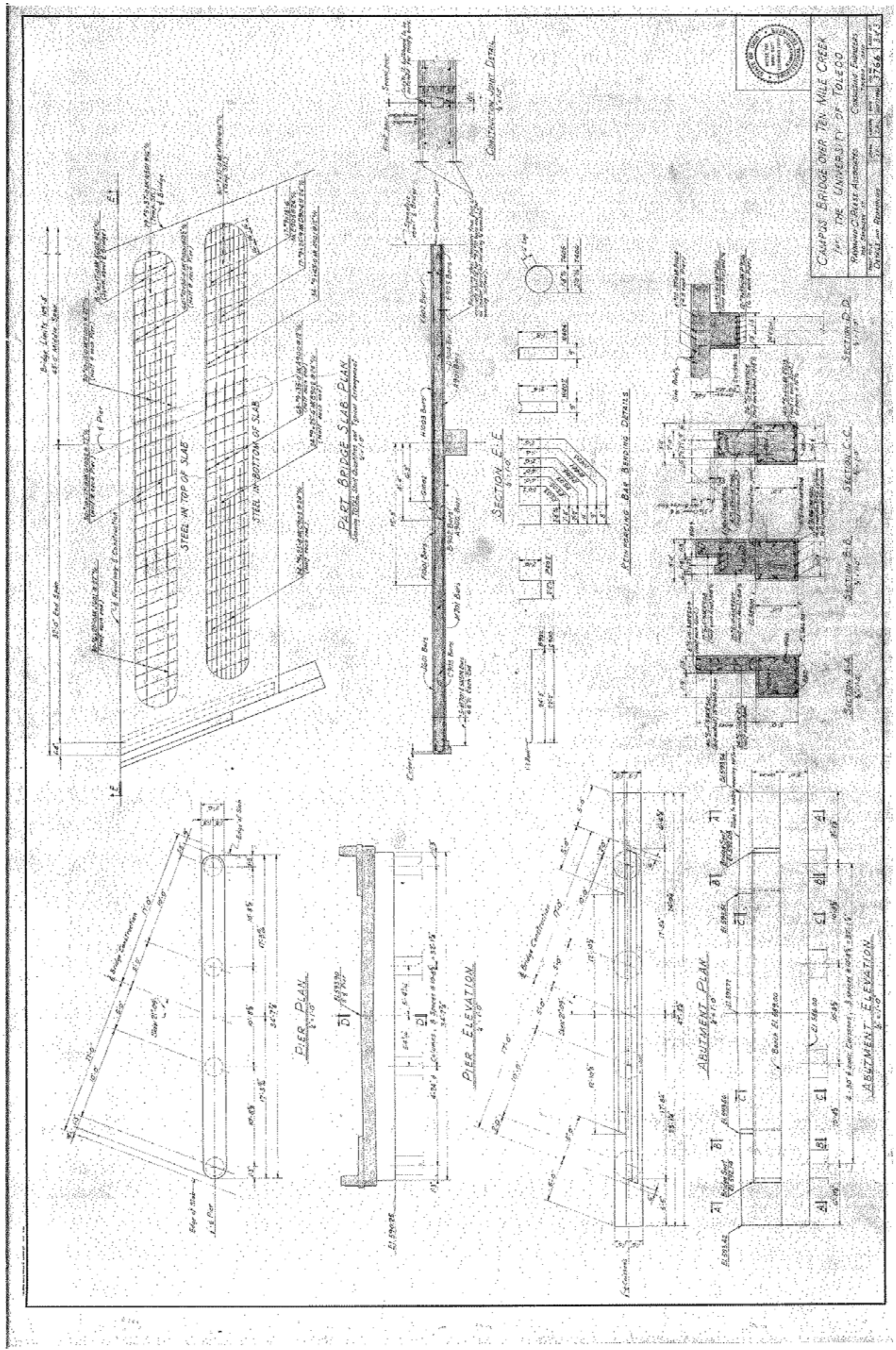
Appendix A - Historical Drawings



Appendix A - Historical Drawings



Appendix A - Historical Drawings



Appendix B- Meeting Minutes

DRB Meeting Minutes
Sunday, August 26, 2012
NI 3rd Floor Tables
2:00-2:45 p.m.

This meeting addressed the overall senior design project of the re-design of the David Root Bridge and discussed the preparation for meeting with the stakeholders.

Those in attendance: Dr. Douglas Nims, Blair Newman, Kathryn Gillette, Todd Cereghin, and Danielle Sheppa

Reports:

- Dr. Nims:
    - Look into bridge codes
    - See old projects online (bring a flash-drive to Dr. Nims for him to upload project details)
    - Make sure we deliver what we promise when meeting with stakeholders
    - Send Dr. Nims a text message with our name in it for contact purposes
        - 419-297-7158
    - Look up old inspection reports on David Root Bridge

New Business:

- Meet with stakeholders on site and obtain the following information:
    - Site information (old plans, survey information, etc.)
    - Traffic information
    - Environmental information
        - Talk with Patrick Lawrence
    - Aesthetic requirements
        - Do they want anything special out of this bridge?
    - Utilities information (lighting, gas lines, etc.)
    - What is their budget?
    - Safety issues (traffic/pedestrian accidents)
    - Landscaping possibilities
    - What is the state of the project/is this project in the works?
    - Standard load: HS20, should the new bridge be designed to handle heavier loads and what are the foundations designed for?
- Items to look over:
    - "Design of Highway Bridges" (Puckett & Barker)
    - Look at AASHTO
    - National Steel Bridge Alliance
    - PCI Publications
- Kathryn will meet with Dr. Nims to call Kris Cousino from the City of Toledo- Division of Streets, Bridges, and Harbors to ask about being the group's industrial mentor throughout this project

Appendix B- Meeting Minutes

David Root Bridge Meeting Minutes
Thursday, August 30, 2012
SM 3066
3:30-4:30

This meeting began on-site and allowed the group to talk with one of the clients and the mentor about the scope of the project. A walk-through of the bridge was done, pictures were taken, and a meeting followed with further information.

Those in attendance: Dr. Douglas Nims, Dan Klett (one of the clients), David Charville (mentor), Blair Newman, Kathryn Gillette, Todd Cereghin, Nick Steyer, and Danielle Sheppa

Reports:

- Dan Klett gave the following information:
  - The steam utilities links Savage Hall with the rest of the campus and their future plan is to link it to the university's central system
  - Complications include how to maintain the utilities during construction
    - Look at the overall utility loop and see if the utilities under the bridge can be shut off for construction
  - Put thought into the aesthetics of the bridge
    - Use of masonry, stone, similar light fixtures as those seen around campus
    - Design a bridge that enhances the university's atmosphere
    - Collegiate and gothic materials to give it a historical look
  - Think about how to accommodate pedestrians on and around the bridge
    - Crossings on both sides/ one side of the bridge
    - Accommodate bikers with a bike lane?
    - Maybe talk to the mixed-use pathways group to exchange ideas
  - Changing loads from HS-20 to HS-25 isn't essential
  - Restoring the bridge instead of re-designing may be an option to look at
  - There is no set budget for this project
  - Look into the bridge alignment
  - The project should consist of a rehab alternative, concrete re-design, and steel re-design
  - Contact Michael Green (Director of Energy Management), Jim Graff (Director of Facilities), and Jeff Newton (UT Police) for additional information
- David Charville:
  - What to look for when checking the current condition of the bridge:
    - Look at the overall condition, capacity, and costs
    - Calculate the shear reinforcement of the pier caps
  - Rehabbing the existing deck doesn't make sense and it won't buy much time on the bridge

New Business:

- Meet with Doug Collins, Michael Green, Patrick Lawrence, and other contacts to obtain more information before starting calculations and further planning
- Look over the materials given by Dan Klett (CD, bridge inspection report, site information, etc.)
- Get in contact with David Charville to plan next meeting

Appendix B- Meeting Minutes

David Root Bridge Meeting Minutes
Thursday, September 6, 2012
SM 3066
3:30-4:30

This meeting was for the group to talk to the remaining clients and receive final input towards their vision of the David Root Bridge.

Those in attendance: Dr. Patrick Lawrence, Mr. Doug Collins, Blair Newman, Nick Steyer, Kathryn Gillette, Todd Cereghin, and Danielle Sheppa

Reports:

- Patrick Lawrence:
    - The David Root Bridge History: The University of Toledo wanted a large billboard removed that was property of a company owned by a man named David Root. The university made a deal with David to name the bridge after him if they removed the billboard.
    - ADA accessibility is a key concern for the new design of the bridge
    - Sample core of levee material will be mailed to Blair
    - Ottawa River information:
        - In-stream habitat restoration is in progress
        - Installing in August 2013
        - No in-stream habitats are proposed near the bridge because the new flow can affect the piers, pilings, etc.
        - Army Corps has design and construction specs
        - USGS gauging station for water levels
        - Surveying work: Tom Gary (topographic and cross-sections)
    - Current bridge clearance is ok
    - Consider sitting benches/ outlook area for pedestrians
    - Look at the T-intersection and possible alterations

- Doug Collins:
    - The facilities website has a lot of information about typical design standards on the university's property
        - Sidewalks = 8'
    - Mr. Zang might have steamline information
    - Ahmmed might also have information on the steamline
    - Follow up with DGL on traffic counts (he will e-mail Blair about findings)
    - Look at installing cameras/ conduit for cameras on bridge for safety purposes
    - The current lighting is ok; accent lighting is an option for aesthetics
    - Keep the budget reasonable

New Business:

- Follow up on getting all the information mentioned (steamline information, traffic counts, Army Corps, etc.)

Appendix B- Meeting Minutes

DRB Meeting Minutes
Thursday, September 13, 2012
Civil Conference Room
3:45-4:15 p.m.

This meeting focused on the vehicle and pedestrian traffic on the bridge.

Those in attendance: Dr. Chou, Blair Newman, Nick Steyer, Kathryn Gillette, and Danielle Sheppa

Reports:

- Dr. Chou:
    - A continuous right-turn is a good option to consider for the north side of the bridge at the current t-intersection (make pedestrians only able to walk on the west side of the bridge)
    - If the group changes the pedestrian flow of traffic, consider relocating the bus stops
        - Is there enough room for a bus stop near the bridge?
    - Look at forced pedestrian crossing closer to Savage Arena
    - Do pedestrian and traffic counts
        - Peak time is somewhere between 8:30-10:30 a.m.
        - Focus on NB and SB traffic and pedestrians

New Business:

- Update the group's blog
- Work on the first rough draft of the scope and get most of it completed by Tuesday, September 18, 2012
- The different sections of the scope were assigned to the following group members:
    - Blair: Problem Statement
    - Danielle & Kathryn: Background
    - Nick: Constraints
    - Todd: Path Forward
- Michael will be in charge of looking over the DGL bridge report and deciding which information is important for the project
- Plan to meet on Wednesday, September 19, 2012 to update the whole group

Appendix B- Meeting Minutes

DRB Meeting Minutes
Tuesday, September 18, 2012
NI 1052
11:10-11:50 a.m.

The purpose of this meeting was to meet with Dr. Kissoff and discuss possibilities for addressing the pedestrian and vehicular traffic along the bridge.

Those in attendance: Dr. Kissoff, Kathryn Gillette, Todd Cereghin, and Danielle Sheppa

Reports:

- Dr. Kissoff:
  - Will send the group information on Larry Loy's Master's Thesis that discusses the bridge inspection
  - AASHTO should have information on adequate bridge separations between pedestrians and vehicles
  - One suggestion is to build a utility/pedestrian bridge to be used to hold the utilities and carry pedestrians, and have a separate traffic-only bridge
  - Look into just making the sidewalks very wide (>10')
  - Another suggestion: design a plaza with a road going through it
    - Look into designing a speed table/paver/rumble strips to slow down traffic along the bridge
    - Address the bus stop issue

Appendix B- Meeting Minutes

DRB Meeting Minutes
Thursday, October 4, 2012
SM 3066
3:30-4:45 p.m.

The purpose of this meeting was to present the group's scope to the clients.

Those in attendance: Dr. Patrick Lawrence, Doug Collins, Dan Klett, Blair Newman, Kathryn Gillette, Nick Steyer, Todd Cereghin, and Danielle Sheppa

Client Comments:

- Doug Collins:
    - Look into the costs of removing the abandoned utility line on the south side of the bridge
    - Make sure to see how wide the bridge can be made without needing to add extra piers
    - For the bridge repair option, check ADA standards and see if it would be possible remove the parapet walls and have a cantilever railing to make the sidewalks and extra foot wide
    - Consider all permits that would be required for the construction of the bridge and be sure to include them in the final report
- Dan Klett:
    - Talk to Michael Green about the use of the utilities during the summer
        - If the full utility loop is finished by the time the bridge construction starts, consider breaking the utility loop
        - Ask Michael if it would be possible to do this and keep feeding the appropriate buildings
    - Dave Dysard is the public face of the City of Toledo's Planning Department
        - Consider talking to him about the current work being done on the Westwood Ave bridge
        - Donald Connor is another person to consider contacting
    - Aesthetics are personal; try not to please everyone who is involved but maintain a good view and sight line
    - One idea: remove all traffic on the bridge except for the shuttle service and big events such as football games and concerts
    - Look at the weights of the options (cost, ADA, longevity, aesthetics, etc.) for the possible bridge designs
    - Contact Wendy Wiitala (ADA compliance officer) for specific information on ADA guidelines
- Patrick Lawrence:
    - Make sure that construction doesn't occur during the spring season because of the fish spawning
    - Check that all of the appropriate permits are being used for both around-the-water and in-the-water operations

New Business:

- Blair: Contact Dr. Nims about a meeting time on Sunday, October 7, 2012
- Michael: create a construction schedule that fits the constraints
- Kathryn: contact Michael Green about utility information
- Danielle: contact Wendy Wiitala, look up ADA information, and compute pier calculations

Appendix B- Meeting Minutes

DRB Meeting Minutes
Friday, October 12, 2012
Plant Operations Room 1070
9:00-10:00 a.m.

This meeting focused on the utilities on and around the bridge as well as the utility loop completion date.

Those in attendance: Michael Green, Danielle Sheppa, and Kathryn Gillette

Reports:

- Michael Green:
  - Utility loop to be completed by July 1, 2013
    - Bridge construction should wait to occur after loop completion
  - Brand new lines; University loses money
    - New utility manhole would have to be ripped out and redone if bridge is widened
  - Backfeed of utilities possible for steam and chilled after loop done
    - Steam could be sacrificed for a bit, but have to be mindful of people's comfort
  - Will need temporary lines for electrical lines
    - 15 kVa supply on west side of DRB and only other supply located on traffic bridge by CPA
    - If no temp installed and CPA electrical line has problem, whole north campus will be without power
  - Possible temporary for tele/data lines
    - Mr. Zhang will have list of all utilities on DRB
    - Mike Firsdon and "Mark Magrow" contacts for tele/data lines
      - Unable to find contact information on Mark Magrow

Appendix B- Meeting Minutes

DRB Meeting Minutes
Thursday, November 8, 2012
Plant Operations
3:30-4:45 p.m.

This meeting was to present the clients with the current progress on the bridge design options.

Those in attendance: Doug Collins, Dan Klett, Blair Newman, Nick Steyer, Todd Cereghin, and Danielle Sheppa

Reports:

- Dan Klett:
  - Look into parapet options- steel railings instead of a concrete parapet
  - For the repair option, replace the bent railing at existing
  - For the steel design option, check the safety of spacing in the parapet details
  - Look into rolling a curvature into the I-beams for elevation purposes

- Doug Collins:
  - Make sure that the utilities are able to be sustained during the construction process
  - As far as the elevation goes, use the bridge by the CPA as a reference
  - Like the partial railing and partial stone wall idea for the concrete options parapet idea

Appendix C- Box Beam Design Calculations

Box Beam Design: non-composite, LRFD Specifications

MATERIALS:

Precast Beams: AASHTO Box Beams

Concrete Strength at Transfer $f_{primeCI} := 5.0 ksi$

Concrete Strength at 28 Days $f_{primeC} := 7.0 ksi$

Concrete Unit Weight $\gamma_c := 0.150 \frac{kip}{ft^3}$

Overall beam length $L_{overall} := 109 ft - 8 in$

Span Lengths $L_1 := 32 ft - 0 in$

$L_2 := 43 ft - 0 in$

$L_3 := 32 ft - 0 in$

Prestressing Strands: LRFD Specifications

Seven Wire, Low-Relaxation Strands Diameter $D_s := 0.5 in$

Strand Area $A_s := 0.167 in^2$ per strand

Ultimate Strength $f_{pu} := 270.0 ksi$

Yield Strength $\phi := 0.9$ $f_{py} := \phi \cdot f_{pu} = 243 ksi$

Modulus of Elasticity $E_p := 28500 ksi$

Stress Limits for Strands

Before Transfer $f_{pi} := 0.75 f_{pu} = 202.5 ksi$

After All Losses $f_{pe} := 0.8 \cdot f_{py} = 194.4 ksi$

Reinforcing Bars

Yield Strength $f_y := 60.0 ksi$

Modulus of Elasticity $E_s := 29000 ksi$

New Jersey Type Barrier $\gamma_b := \frac{0.300 kip}{ft}$ per side

Wearing Surface: compacted asphalt pavement unit weight

$$\gamma_{ws} := \left[\left(\frac{110 lbf}{yd^2 \cdot in}\right)\frac{(1 kip)}{(1000 lbf)}\left(\frac{1 yd^2}{9 ft^2}\right)\left(\frac{12 in}{ft}\right)\right] = 0.147 \cdot \frac{kip}{ft^3}$$

Asphalt overlay = 3.5 inches thick (avg)

$Overlay := 3.5 in = 0.292 ft$

Appendix C- Box Beam Design Calculations

CROSS-SECTION PROPERTIES FOR A TYPICAL INTERIOR BEAM: Type B21-48

Widtl $W_{beam2} := 48in$ Heigh $H_{beam2} := 21in$ Are $A_{beam2} := 632.1in^2$

Distance from Centroid to Extreme Bottom Fiber of Precast Beam

$$y_{bottom2} := 10.40in$$

Distance from Centroid to Extreme Top Fiber of Precast Beam

$$y_{top2} := H_{beam2} - y_{bottom2} = 0.883ft \qquad y_{top2} = 10.6 \cdot in$$

Moment of Inertia about Centroid of the Beam $I_2 := 37044in^4$

estimated large by using bh^3/12

Section Modulus for Extreme Bottom Fiber of Precast Beam

$$S_{b2} := \frac{I_2}{y_{bottom2}} = 15.42gal \qquad S_{b2} = 3.562 \times 10^3 \cdot in^3$$

Section Modulus for Extreme Top Fiber of Precast Beam

$$S_{t2} := \frac{I_2}{y_{top2}} = 15.129gal \qquad S_{t2} = 3.495 \times 10^3 \cdot in^3$$

$$Weight_2 := \frac{0.721kip}{ft}$$

Modulus of Elasticity of Concrete

At Transfer $E_{c1} := 33000(\gamma_c)^{1.5} \cdot \sqrt{f_{primeCI}}$ $E_{ci} := 3834.47in^3$

At Service Loads $E_{c2} := 33000(\gamma_c)^{1.5} \cdot \sqrt{f_{primeC}}$ $E_c := 4286.83in^3$

SHEAR FORCES AND BENDING MOMENTS:

Beam Self-Weight:

$$W_{b2} := \frac{0.721kip}{ft}$$

Diaphragm Weight:

$$W_{d2} := \left(\frac{8}{12}\right)\left[\left[\frac{(48-10)}{12}\right]\left[\frac{(27-11)}{12}\right] - 4\left(\frac{1}{2}\right)\left(\frac{3}{12}\right)\left(\frac{3}{12}\right)\right](\gamma_c) = 0.41\frac{1}{ft^2}\cdot\frac{kip}{ft}$$

Barrier Weight: Width of 42' needs 9- 48" box beams and 1- 36" box beams

$$W_{barrier2} := \frac{2 \cdot \gamma_b}{10} = 0.06 \cdot \frac{kip}{ft}$$

Dead Load of Wearing Surface: Wearing Surface = 42'

$$DL_{ws2} := \left(\frac{3}{12}\right)\left[\frac{\left[42 \cdot (\gamma_{ws} + \gamma_c)\right]}{10}\right] = 0.312\frac{1}{ft^2}\cdot\frac{kip}{ft}$$

Appendix C- Box Beam Design Calculations

CROSS-SECTION PROPERTIES FOR A TYPICAL INTERIOR BEAM: Type B21-36

Width $W_{beam} := 36in$ Height $H_{beam} := 21in$ Area $A_{beam} := 496in^2$

Distance from Centroid to Extreme Bottom Fiber of Precast Beam

$$y_{bottom} := 10.37in$$

Distance from Centroid to Extreme Top Fiber of Precast Beam

$$y_{top} := H_{beam} - y_{bottom} = 0.886ft \qquad y_{top} = 10.63 \cdot in$$

Moment of Inertia about Centroid of the Beam $I := 27783in^4$

Section Modulus for Extreme Bottom Fiber of Precast Beam

$$S_b := \frac{I}{y_{bottom}} = 11.598gal \qquad S_b = 2.679 \times 10^3 \cdot in^3$$

Section Modulus for Extreme Top Fiber of Precast Beam

$$S_t := \frac{I}{y_{top}} = 11.314gal \qquad S_t = 2.614 \times 10^3 \cdot in^3$$

$$Weight := \frac{0.584kip}{ft}$$

Modulus of Elasticity of Concrete

At Transfer $E_{c1a} := 33000(\gamma_c)^{1.5} \cdot \sqrt{f_{primeCI}}$ $E_{cia} := 3834.47in^3$

At Service Loads $E_{c2a} := 33000(\gamma_c)^{1.5} \cdot \sqrt{f_{primeC}}$ $E_{ca} := 4286.83in^3$

SHEAR FORCES AND BENDING MOMENTS:

Beam Self-Weight:

$$W_b := \frac{0.584kip}{ft}$$

Diaphragm Weight:

$$W_d := \left(\frac{8}{12}\right)\left[\left[\frac{(36-10)}{12}\right]\left[\frac{(27-11)}{12}\right] - 4\left(\frac{1}{2}\right)\left(\frac{3}{12}\right)\left(\frac{3}{12}\right)\right](\gamma_c) = 0.276\frac{1}{ft^2} \cdot \frac{kip}{ft}$$

Barrier Weight: Width of 42' needs 14- 36" box beams

$$W_{barrier} := \frac{2 \cdot \gamma_b}{14} = 0.043 \cdot \frac{kip}{ft}$$

Dead Load of Wearing Surface:

$$DL_{ws} := \left(\frac{3}{12}\right)\left[\frac{\left[3 \cdot (\gamma_{ws} + \gamma_c)\right]}{1}\right] = 0.222\frac{1}{ft^2} \cdot \frac{kip}{ft}$$

Appendix C- Box Beam Design Calculations

Shear Forces and Bending Moments Due to Live Loads

Number of Design Lanes: where w = clear roadway width in ft $w := 24$

$No_{lanes} := \frac{w}{12} = 2$ lanes

$b := 48$ inches $L_{s1} := 32$ ft $N_b := 10$ beams

$L_{s2} := 43$ ft

$k := 2.5\left(N_b\right)^{-0.2} = 1.577$

$L_{s3} := 32$ ft

$$A_o := (b \cdot in - 5in) \cdot \left(H_{beam2} - 5.5in\right) = 666.5 \cdot in^2$$

$$J_1 := \left[\frac{4 \cdot A_o^{\ 2}}{2\left(\frac{b \cdot in - 5in}{5.5in}\right) + 2\left(\frac{H_{beam2} - 5.5in}{5in}\right)}\right] = 8.137 \times 10^4 \cdot in^4$$

Distribution factor for moment for interior girder: DFM

$$DFM_{S1L2} := k \cdot \left(\frac{b}{305}\right)^{0.6} \left(\frac{b}{12.0 \cdot L_{s1}}\right)^{0.2} \left(\frac{\frac{I_2}{in^4}}{\frac{J_1}{in^4}}\right)^{0.06} = 0.327 \qquad \frac{lanes}{beam}$$

$$DFM_{S2L2} := k \cdot \left(\frac{b}{305}\right)^{0.6} \left(\frac{b}{12.0 \cdot L_{s2}}\right)^{0.2} \left(\frac{\frac{I_2}{in^4}}{\frac{J_1}{in^4}}\right)^{0.06} = 0.309 \qquad \frac{lanes}{beam}$$

$$DFM_{S3L2} := k \cdot \left(\frac{b}{305}\right)^{0.6} \left(\frac{b}{12.0 \cdot L_{s1}}\right)^{0.2} \left(\frac{\frac{I_2}{in^4}}{\frac{J_1}{in^4}}\right)^{0.06} = 0.327 \qquad \frac{lanes}{beam}$$

I.2 and J.1 are divided by in^4 for the empirical formula to compute calculation correctly.

DFM.S1L2, DFM.S2L2, and DFM.S3L2 show the distribution factor for 2 or more lanes loaded.

Appendix C- Box Beam Design Calculations

$$DFM_{S1L1} := k \cdot \left(\frac{b}{33.3 \cdot L_{s1}}\right)^{0.5} \cdot \left(\frac{\frac{I_2}{in^4}}{\frac{J_1}{in^4}}\right)^{0.25} = 0.275 \qquad \frac{lanes}{beam}$$

$$DFM_{S2L1} := k \cdot \left(\frac{b}{33.3 \cdot L_{s2}}\right)^{0.5} \cdot \left(\frac{\frac{I_2}{in^4}}{\frac{J_1}{in^4}}\right)^{0.25} = 0.237 \qquad \frac{lanes}{beam}$$

$$DFM_{S3L1} := k \cdot \left(\frac{b}{33.3 \cdot L_{s1}}\right)^{0.5} \cdot \left(\frac{\frac{I_2}{in^4}}{\frac{J_1}{in^4}}\right)^{0.25} = 0.275 \qquad \frac{lanes}{beam}$$

DFM.S1L1, DFM.S2L1, and DFM.S3L1 show the distribution factor for 1 lane loaded.

DFM.L2 Control $\quad DFM_{CL2} := DFM_{S1L2} = 0.327 \frac{lanes}{beam}$

For Fatigue Limit State, single design truck should be used. Therefore, use DFM for one loaded lane and the multiple presence factor, m, for one design lane loaded which is 1.2.

DFM.L1 Control $\quad DFM_{CL1} := DFM_{S1L1} = 0.275 \frac{lanes}{beam} \qquad m_{L1} := 1.2$

Distribution factor for fatigue limit state:

$$DFM_{fls} := \frac{DFM_{CL1}}{m_{L1}} = 0.229 \qquad \frac{lanes}{beam}$$

Distribution factor for shear for interior beam: DFV

$$DFV_{S1L2} := \left(\frac{b}{156}\right)^{0.4} \left(\frac{b}{12.0 \cdot L_{s1}}\right)^{0.1} \left(\frac{\frac{I_2}{in^4}}{\frac{J_1}{in^4}}\right)^{0.05} = 0.487 \qquad \frac{lanes}{beam}$$

Appendix C- Box Beam Design Calculations

$$DFV_{S2L2} := \left(\frac{b}{156}\right)^{0.4}\left(\frac{b}{12.0 \cdot L_{s2}}\right)^{0.1}\left(\frac{\frac{I_2}{in^4}}{\frac{J_1}{in^4}}\right)^{0.05} = 0.473 \qquad \frac{lanes}{beam}$$

$$DFV_{S3L2} := \left(\frac{b}{156}\right)^{0.4}\left(\frac{b}{12.0 \cdot L_{s1}}\right)^{0.1}\left(\frac{\frac{I_2}{in^4}}{\frac{J_1}{in^4}}\right)^{0.05} = 0.487 \qquad \frac{lanes}{beam}$$

DFV.S1L2, DFV.S2L2, and DFV.S3L2 show the distribution factor for 2 or more lanes loaded.

$$DFV_{S1L1} := \left(\frac{b}{130 \cdot L_{s1}}\right)^{0.15} \cdot \left(\frac{\frac{I_2}{in^4}}{\frac{J_1}{in^4}}\right)^{0.05} = 0.492 \qquad \frac{lanes}{beam}$$

$$DFV_{S2L1} := \left(\frac{b}{130 \cdot L_{s2}}\right)^{0.15} \cdot \left(\frac{\frac{I_2}{in^4}}{\frac{J_1}{in^4}}\right)^{0.05} = 0.471 \qquad \frac{lanes}{beam}$$

$$DFV_{S3L1} := \left(\frac{b}{130 \cdot L_{s3}}\right)^{0.15} \cdot \left(\frac{\frac{I_2}{in^4}}{\frac{J_1}{in^4}}\right)^{0.05} = 0.492 \qquad \frac{lanes}{beam}$$

DFV.S1L1, DFV.S2L1, and DFV.S3L1 show the distribution factor for 1 lane loaded.

DFV.L2 Control $\qquad DFV_{CL2} := DFV_{S1L2} = 0.487 \frac{lanes}{beam}$

DFV.L1 Control $\qquad DFV_{CL1} := DFV_{S1L1} = 0.492 \frac{lanes}{beam}$

Appendix C- Box Beam Design Calculations

Dyanmic Allowance

For Fatigue Limit: $IM_{fl} := 0.15$ (15%)

For All Other Limits: $IM_{ol} := 0.33$ (33%)

Truck load shear forces and bending moments per beam for all limits except Fatigue Limit State:

$V_{LT} := \left[DFV_{CL2} \cdot \left(1 + IM_{ol}\right)\right] = 0.648$ kips*shear force per lane

$M_{LT} := \left[DFM_{CL2} \cdot \left(1 + IM_{ol}\right)\right] = 0.435$ ft-kips*bending moment per lane

Bending moment of fatigue truck load:

$M_f := \left[DFM_{fls} \cdot \left(1 + IM_{fl}\right)\right] = 0.264$ ft-kips*bending moment per lane

Lane load shear forces and bending moments per beam for all limits except Fatigue Limit State:

$V_{LL} := DFV_{CL2} = 0.487$ kips*lane load shear force

$M_{LL} := DFM_{CL2} = 0.327$ ft-kips*lane load bending moment

These calculations are implemented in the Excel Spreadsheet tables shown below.

Spans 1 & 3 = 32'-0"		
Beam Weight =	0.721	(kip/ft)
Diaphragm Weight =	0.40972	(kip/dia)
Barrier Weight =	0.05455	(kip/ft)
Wearing Surface =	0.312	(kip/ft)
Span 1 & 3 Length =	32	(ft)

Span 2 = 43'-0"		
Beam Weight =	0.721	(kip/ft)
Diaphragm Weight =	0.40972	(kip/dia)
Barrier Weight =	0.05455	(kip/ft)
Wearing Surface =	0.312	(kip/ft)
Span 2 Length =	43	(ft)

Spans 1 & 3 = 32'-0"

Distance	Section	Beam Weight		Diaphragm Weight		Barrier Weight		Wearing Surface		Max. Shear Force
x	x/L	Shear	Moment	Shear	Moment	Shear	Moment	Shear	Moment	V_x
(ft)	(ft)	(kips)	(ft*kips)	(kips)	(ft*kips)	(kips)	(ft*kips)	(kips)	(ft*kips)	(kip/lane)
0.0000	0.0000	9.3440	0.0000	6.5555	0.0000	0.8728	0.0000	4.9920	0.0000	10.2400
1.2160	0.0380	8.6339	13.4947	6.0573	7.6686	0.8065	1.0210	4.6126	5.8396	9.4765
3.2000	0.1000	7.4752	33.2237	5.2444	18.8799	0.6982	2.5137	3.9936	14.3770	8.2944
6.4000	0.2000	5.6064	59.0643	3.9333	33.5643	0.5237	4.4687	2.9952	25.5590	6.5536
9.6000	0.3000	3.7376	77.5219	2.6222	44.0531	0.3491	5.8652	1.9968	33.5462	5.0176
12.8000	0.4000	1.8688	88.5965	1.3111	50.3464	0.1746	6.7031	0.9984	38.3386	3.6864
16.0000	0.5000	0.0000	92.2880	0.0000	52.4442	0.0000	6.9824	0.0000	39.9360	2.5600

Appendix C- Box Beam Design Calculations

Span 2 = 43'-0"

Distance	Section	Beam Weight		Diaphragm Weight		Barrier Weight		Wearing Surface		Max. Shear Force
x	x/L	Shear	Moment	Shear	Moment	Shear	Moment	Shear	Moment	V_x
(ft)	(ft)	(kips)	(ft*kips)	(kips)	(ft*kips)	(kips)	(ft*kips)	(kips)	(ft*kips)	(kip/lane)
0.0000	0.0000	15.5015	0.0000	8.8090	0.0000	1.1728	0.0000	6.7080	0.0000	13.7600
1.8240	0.0380	14.1864	27.0754	8.0617	15.3860	1.0733	2.0485	6.1389	11.7164	12.6174
4.8000	0.1000	12.0407	66.1013	6.8423	37.5631	0.9110	5.0011	5.2104	28.6042	10.8595
9.6000	0.2000	8.5799	115.5907	4.8757	65.6863	0.6491	8.7455	3.7128	50.0198	8.3018
14.4000	0.3000	5.1191	148.4683	2.9090	84.3695	0.3873	11.2329	2.2152	64.2470	6.0871
19.2000	0.4000	1.6583	164.7341	0.9424	93.6128	0.1255	12.4636	0.7176	71.2858	4.2154
24.0000	0.5000	-1.8025	164.3880	-1.0243	93.4162	-0.1364	12.4374	-0.7800	71.1360	2.6865

Spans 1 & 3 = 32'-0"

Distance	Section	Dynamic Allowance		Design Lane Load		Fatigue w/ Dyn.Allow.
x	x/L	V_{LT}	M_{LT}	V_{LL}	M_{LL}	M_f
(ft)	(ft)	(kips)	(ft*kips)	(kips)	(ft*kips)	(ft*kips)
0.0000	0.0000	33.1039	0.0000	34.9937	0.0000	0.0000
1.2160	0.0380	31.3282	25.1228	33.6585	18.9008	8.9375
3.2000	0.1000	28.4311	59.9988	31.4801	45.1392	19.8058
6.4000	0.2000	23.7583	100.2753	27.9665	75.4407	27.6307
9.6000	0.3000	19.0855	120.8295	24.4529	90.9045	30.5219
12.8000	0.4000	14.4127	131.1666	20.9393	98.6814	26.4410
16.0000	0.5000	9.7399	126.6366	17.4257	95.2734	10.3792

Span 2 = 43'-0"

Distance	Section	Dynamic Allowance		Design Lane Load		Fatigue w/ Dyn.Allow.
x	x/L	V_{LT}	M_{LT}	V_{LL}	M_{LL}	M_f
(ft)	(ft)	(kips)	(ft*kips)	(kips)	(ft*kips)	(ft*kips)
0.0000	0.0000	36.5891	0.0000	27.5123	0.0000	0.0000
1.8240	0.0380	34.6070	41.6282	26.0219	31.3184	18.2288
4.8000	0.1000	31.3730	99.3107	23.5901	74.7150	41.7517
9.6000	0.2000	26.1568	165.5980	19.6680	124.5854	63.4425
14.4000	0.3000	20.9407	198.8621	15.7458	149.6112	76.3250
19.2000	0.4000	15.7245	215.2871	11.8237	161.9683	71.3515
24.0000	0.5000	10.5084	198.5347	7.9015	149.3649	46.3172

Appendix C- Box Beam Design Calculations

Load Combinations

$M_{g1} := 92.2880 \cdot ft \cdot kip$

$M_{D1} := 52.4442 \cdot ft \cdot kip$

$M_{b1} := 6.9824 \cdot ft \cdot kip$

$M_{ws1} := 39.9360 \cdot ft \cdot kip$

$M_{LT1} := 131.1666 \cdot ft \cdot kip$

$M_{LL1} := 98.6814 \cdot ft \cdot kip$

$DC_1 := M_{g1} + M_{D1} + M_{b1} = 151.715 \cdot ft \cdot kip$

$DW_1 := M_{ws1} = 39.936 \cdot ft \cdot kip$

$LL_1 := M_{LT1} = 131.167 \cdot ft \cdot kip$

$IM_1 := M_{LL1} = 98.681 \cdot ft \cdot kip$

$M_{g2} := 164.7341 \cdot ft \cdot kip$

$M_{D2} := 93.6128 \cdot ft \cdot kip$

$M_{b2} := 12.4636 \cdot ft \cdot kip$

$M_{ws2} := 71.2858 \cdot ft \cdot kip$

$M_{LT2} := 215.2871 \cdot ft \cdot kip$

$M_{LL2} := 161.9683 \cdot ft \cdot kip$

$DC_2 := M_{g2} + M_{D2} + M_{b2} = 270.81 \cdot ft \cdot kip$

$DW_2 := M_{ws2} = 71.286 \cdot ft \cdot kip$

$LL_2 := M_{LT2} = 215.287 \cdot ft \cdot kip$

$IM_2 := M_{LL2} = 161.968 \cdot ft \cdot kip$

Appendix C- Box Beam Design Calculations

Service I: check compressive stress in prestressed concrete components. This is the general load combination for service limit state stress but is not applied to Service III.

$$Q_{S1.1} := 1.00\cdot\left(DC_1 + DW_1\right) + 1.00\cdot\left(LL_1 + IM_1\right) = 421.499\,ft\cdot kip$$

$$Q_{S1.2} := 1.00\cdot\left(DC_2 + DW_2\right) + 1.00\cdot\left(LL_2 + IM_2\right) = 719.352\,ft\cdot kip$$

Service III: check tensile stress in prestressed concrete components. This is a special load combination for service limit state stress to control cracking due to tension.

$$Q_{S3.1} := 1.00\cdot\left(DC_1 + DW_1\right) + 0.80\cdot\left(LL_1 + IM_1\right) = 375.529\,ft\cdot kip$$

$$Q_{S3.2} := 1.00\cdot\left(DC_2 + DW_2\right) + 0.80\cdot\left(LL_2 + IM_2\right) = 643.901\,ft\cdot kip$$

Strength I: check ultimate strength. This is the general load combination for strength limit state design.

$$Q_{max1} := 1.25\cdot\left(DC_1\right) + 1.50\cdot\left(DW_1\right) + 1.75\cdot\left(LL_1 + IM_1\right) = 651.781\,ft\cdot kip$$

$$Q_{max2} := 1.25\cdot\left(DC_2\right) + 1.50\cdot\left(DW_2\right) + 1.75\cdot\left(LL_2 + IM_2\right) = 1.106\times 10^3\cdot ft\cdot kip$$

$$Q_{min1} := 0.90\left(DC_1\right) + 0.65\cdot\left(DW_1\right) + 1.75\cdot\left(LL_1 + IM_1\right) = 564.736\,ft\cdot kip$$

$$Q_{min2} := 0.90\left(DC_2\right) + 0.65\cdot\left(DW_2\right) + 1.75\cdot\left(LL_2 + IM_2\right) = 950.262\,ft\cdot kip$$

Fatigue: check stress range in strands. This is a special load combination to check tensile range in strands due to live load and dynamic allowance.

$$Q_{t1} := 0.75\cdot\left(LL_1 + IM_1\right) = 172.386\,ft\cdot kip$$

$$Q_{t2} := 0.75\cdot\left(LL_2 + IM_2\right) = 282.942\,ft\cdot kip$$

Stress Load Stresses at Midspan

Bottom tensile stresses:

$$f_{b1} := \left[\frac{\left[M_{g1} + M_{D1} + M_{b1} + M_{ws1} + (0.8)\cdot\left(M_{LT1} + M_{LL1}\right)\right]}{S_b}\right] = 1.682\cdot ksi$$

$$f_{b2} := \left[\frac{\left[M_{g2} + M_{D2} + M_{b2} + M_{ws2} + (0.8)\cdot\left(M_{LT2} + M_{LL2}\right)\right]}{S_{b2}}\right] = 2.169\cdot ksi$$

Tensile stress limit at service limit state:

$$T_{sls} := 0.19\cdot\sqrt{f_{primeC}} \qquad T_{sl} := 0.503\cdot ksi$$

$$f_{pb1} := f_{b1} - T_{sl} = 1.179\,ksi \qquad f_{pb2} := f_{b2} - T_{sl} = 1.666\,ksi$$

Appendix C- Box Beam Design Calculations

Assume the distance between the center of gravity of strands and the bottom fiber of the beam equals 4.5 inches at midspan.

Strand eccentricity at midspan:

$$e_{c1} := 8.42 \cdot in$$

Total Prestress Force After All Losses:

$$P_{pe1} := \frac{f_{pb1}}{\left(\frac{1}{A_{beam}}\right) + \left(\frac{e_{c1}}{S_b}\right)} = 228.536 kip$$

Assume final losses = 20% of f.pi, then final prestresses = P.f

$$P_f := A_s \cdot f_{pi} \cdot (1 - 0.20) = 27.054 kip$$

Number of Strands Required:

$$N_{s1} := \frac{P_{pe1}}{P_f} = 8.447$$

From ODOT Prestressed Concrete Non-Composite Adjacent Box Beams with Straight Strands, use 14-16 strands.

Take (20) 1/2-in-diameter, 270 ksi strands

$$y_{bs} := \frac{[(20 \cdot 2in) + (2 \cdot 27in) + (4 \cdot 10 \cdot in)]}{26} = 5.154 \cdot in$$

$$e_{cs1} := y_{bottom} - y_{bs} = 5.216 \cdot in \qquad M_{u1} := Q_{max1} = 651.781 \cdot ft \cdot kip$$

$$e_{cs2} := y_{bottom2} - y_{bs} = 5.246 \cdot in \qquad M_{u2} := Q_{max2} = 1.106 \times 10^3 \cdot ft \cdot kip$$

$$h_f := 5.5 \cdot in$$

$$k_{as} := 2\left[1.04 - \left(\frac{f_{py}}{f_{pu}}\right)\right] = 0.28 \qquad b_w := 2 \cdot 5in = 10 \cdot in$$

$$A_{ps} := 26 \cdot A_s = 4.342 \cdot in^2$$

For the bottom 20 strands, the strand location from the bottom of the box is 2 inches.

$$d_p := 21in - y_{bs} = 15.846 \cdot in$$

$$A_{smild} := 0in^2 \qquad A_{cprime} := 0in^2$$

$$\beta_1 := 0.85 - 0.05\left(\frac{f_{primeC}}{ksi} - 4.0\right) = 0.7$$

$$b_{cf} := 48 \cdot in$$

Appendix C- Box Beam Design Calculations

$$c_{cf} := \frac{\left[\left(A_{ps} \cdot f_{pu}\right) + \left(A_{smild} \cdot f_y\right) - \left(A_{cprime} \cdot f_y\right)\right]}{0.85 \cdot f_{primeC} \cdot \beta_1 \cdot b_{cf} + k_{as} \cdot A_{ps} \cdot \left(\frac{f_{pu}}{d_p}\right)} = 5.313 \cdot in$$

$$a := \beta_1 \cdot c_{cf} = 3.719 \cdot in$$

$$f_{ps} := f_{pu} \cdot \left[1 - k_{as} \cdot \left(\frac{c_{cf}}{d_p}\right)\right] = 244.65 ksi$$

$$M_n := A_{ps} \cdot f_{ps} \cdot \left[d_p - \left(\frac{a}{2}\right)\right] + 0.85 \cdot f_{primeC} \cdot \left(b_{cf} - b_w\right) \cdot \beta_1 \cdot h_f \cdot \left(\frac{a}{2} - \frac{h_f}{2}\right) = 1.174 \times 10^3 \cdot ft \cdot kip$$

$$\phi_2 := 1.00$$

$$M_r := \phi_2 \cdot M_n = 1.174 \times 10^3 \cdot ft \cdot kip$$

M.r is greater than M.u max which is 1.045 x 10^3 ft*kip. Therefore, design moment is 1.065 x 10^3 ft*kip.

Appendix D- Steel Design Calculations

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Concrete Deck Design

Girder Spacing: $S = 9$

Number of Girders $N = 5$

Deck top Cover $Cover_t = 2.5in$

Deck Bottom Cover $Cover_b = 1in$

Concrete Density $W_c = 0.150kcf$

Concrete 28-day Compressive Strength $f'_c = 4.0ksi$

Reinforcement Strength $f_y = 60ksi$

Future Wearing Surface $W_{FWS} = 0.140\ kcf$

Parapet Weight per Foot $W_{par} = 0.262\ k/ft$

Width at Base $W_{base} = 1.0ft$

Parapet Height $H_{par} = 3.5'$

Minimum Slab Thickness

$$t_{min} = \frac{S+10}{30} = \frac{9+10}{30}(12) = 7.6in$$

To account for sacrificial wearing

$$t_s = 8in$$

Overhang thickness

$$t_o = 9in$$

Dead Loads

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Interior Beam

DW₁:

Slab - $(0.150\ kcf)\left(\frac{8\ ft}{12}\right)(9\ ft) = 0.90\ k/ft$

Girder - $(0.150\ k/ft)$

Haunch - $\frac{(2")(12")(0.150\ kcf)}{144} = 0.025\ k/ft$

$1.075\ k/ft$

D2:

Barrier $= \frac{2(4.3705\ ft^2)(0.150\ kcf)}{5} = 0.262\ k/ft$

Sidewalk $= \frac{2(5.6429\ ft^2)(0.150\ kcf)}{5} = 0.339\ k/ft$

$0.60\ k/ft$

DWS

Wearing Surface

$(0.150)\left(\frac{2}{12}\right)(9) = 0.225\ k/ft$

Exterior Beam

D_1 = Slab - $(0.150)\left(\frac{9}{12}\right)(3+4.5) = 0.844\ k/ft$

Girder - $0.150\ k/ft$

Haunch - $0.025\ k/ft$

$1.019\ k/ft$

$D_2 = 0.60\ k/ft$

DW_S = Wearing Surface $= (0.150)\left(\frac{2}{12}\right)(9) = 0.225\ k/ft$

Distribution Factors - Moment

Distribution Factors
For Moment

Interior $L = 32^{ft}$ positive flexure

One lane

$$mg_M^{SI} = 0.06 + \left(\frac{S}{14}\right)^{0.4}\left(\frac{S}{L}\right)^{0.3}\left(\frac{K_g}{12Lt_s^3}\right)^{0.1}$$

$$= 0.06 + \left(\frac{9}{14}\right)^{0.4}\left(\frac{9}{32}\right)^{0.3}(1.0)^{0.1} = 0.633$$

Two Lane

$$mg_M^{MI} = 0.75 + \left(\frac{S}{9.5}\right)^{0.6}\left(\frac{S}{L}\right)^{0.2}(1.0)^{0.1}$$

$$= 0.075 + \left(\frac{9}{9.5}\right)^{0.6}\left(\frac{9.5}{32}\right)^{0.2}(1.0)^{0.1} = \underline{0.834}$$

Interior $L_{ave} = 37.5$ negative Flexure

One Lane

$$mg_M^{SI} = 0.06 + \left(\frac{9}{14}\right)^{0.4}\left(\frac{9}{37.5}\right)^{0.3}(1.0)^{0.1} = 0.606$$

Two Lane

$$mg_M^{MI} = 0.075 + \left(\frac{9}{9.5}\right)^{0.6}\left(\frac{9}{37.5}\right)^{0.2}(1.0)^{0.1} = 0.803$$

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Distribution Factors - Moment

Interior

$L = 43$ ft

$$mg_M^{SI} = 0.06 + \left(\frac{9}{14}\right)^{0.4}\left(\frac{9}{43}\right)^{0.3}(1.0)^{0.1} = 0.58$$

$$Mg_M^{MI} = 0.075 + \left(\frac{9}{9.5}\right)^{0.6}\left(\frac{9}{43}\right)^{0.2}(1.0)^{0.1} = 0.783$$

Exterior

One lane Loaded

$$R = 0.5P\left(\frac{9+3}{9}\right) = 0.667P$$

$$mg_M^{SE} = 1.2(0.667) = 0.8$$

Two Lane Loaded

$$Mg_m^{ME} = e \cdot mg_M^{MI}$$

$$e = 0.77 + \frac{d_e}{9.1} = 0.77 + \frac{2}{9.1} = 0.99$$

$$(0.99)(0.834) = \underline{0.826}$$

Distribution Factors for Shear

Interior Beam - One Design Lane Loaded (L= 32')

$$mg_v^{SI} = 0.36 + \frac{S}{25} = 0.36 + \frac{9}{25} = 0.720$$

Interior Beam - Two or more Design Lane Loaded (L=32')

$$mg_v^{MI} = 0.2 + \frac{S}{12} - \left(\frac{S}{L}\right)^{2.0} = 0.2 + \frac{9}{12} - \left(\frac{9}{32}\right)^{2.0} = \underline{0.871}$$

Interior Beam - One Design Lane Loaded (L= 43')

$$mg_v^{SI} = 0.720$$

Interior Beam - Two or more Design Lane Loaded (L= 43')

$$mg_v^{MI} = 0.2 + \frac{9}{12} - \left(\frac{9}{43}\right)^{2.0} = \underline{0.906} \text{ governs}$$

Interior Beam - One Design Lane Loaded (L = 37.5')

$$mg_v^{SI} = 0.720$$

Interior Beam - Two or more Design Lane Loaded (L= 37.5')

$$mg_v^{MI} = 0.2 + \frac{9}{12} - \left(\frac{9}{37.5}\right)^{2.0} = 0.892$$

Distribution Factors - Shear

Exterior Beam - One Design Lane Loaded

Lever Rule: $mg_v^{SE} = 0.8$ governs

Exterior Beam - Two or More Design Lane Loaded

$$mg_v^{ME} = e \cdot mg_v^{MI} = (0.80)(0.906) = 0.725$$

$$e = 0.6 + \frac{d_e}{10} = 0.6 + \frac{2}{10} = 0.80$$

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Live Loads

W21X83

Truck Placement for M_{max} at 205

$M_{205} = 296.84$ k-ft

Tandem Placement for M_{max} at 205

$M_{205} = 311.49$ k-ft governs

142.94

Lane load Placement for M_{max} at 205

$M^{+}_{205} = 82.20$ k-ft $M^{-}_{110/200} = -92.81$ k-ft

Truck Placement for M_{min} at 110/200

$M_{110,200} = -142.94$ k-ft (Rear facing 1.0L)

-216.36 k-ft (Truck at 205)

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W21x83

Effective Flange Width (Interior)

1. $\frac{1}{4}(37.5') = 112.5$
2. $12(7.6) + \frac{8.36}{2} = 95.38''$
3. $108''$

95.38" governs

Effective Flange Width (Exterior)

1. $\frac{1}{8}(32') = 48''$
2. $6(7.6) + \frac{8.36}{4} = 47.69''$
3. $36''$

36" governs

$b_e = \frac{b_i}{2} + 36 = \frac{95.3}{2} + 36 = 83.65''$

Modular Ratio for $f_c' = 4\,ksi$ $n = 8$

Trial Section Properties

W21 x 83

$I_x = 1830\,in^4$ $b_f = 8.36$

$I_y = 81.4\,in^4$ $t_f = 0.835$

$A = 24.3\,in^2$ $t_w = 0.515$

$Z_x = 196\,in^3$ $d = 21.4$

$S_x = 171\,in^3$

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W21X83

Short term concrete Section Properties

	A	y	Ay	$\lvert y-\bar{y}\rvert$	$A(y-\bar{y})^2$	I_o
Concrete	$7.6(95.38)/8 = 90.61$	$2+\frac{7.6}{2}+21.4 = 27.2$	2465	3.5	1110	436
Steel	24.3	10.7	260	13.0	4107	1830
	114.91		2725		5217	2266

$$\bar{y} = \frac{\Sigma Ay}{\Sigma A} = \frac{2465}{114.91} = 23.7\ in$$

$$y_t = 21.4+2+7.6-23.7 = 7.3\ in$$

$$I_x = 5217+2266 = 7483\ in^4$$

$$S_t = \frac{7483}{7.3} = 1025\ in^3$$

$$S_b = \frac{7483}{23.7} = 315\ in^3$$

Long term concrete Section Properties

	A	y	Ay	$\lvert y-\bar{y}\rvert$	$A(y-\bar{y})^2$	I_o
Concrete	30.2	27.2	821	7.37	1640	145
steel	24.3	10.7	260	9.13	2026	1830
	54.5		1081		3666	1975

$$\bar{y} = \frac{\Sigma Ay}{\Sigma A} = \frac{1081}{54.5} = 19.83\ in$$

$$y_t = 21.4+2+7.6-19.83 = 11.17\ in$$

$$I_x = 3666+1975 = 5641\ in^4$$

$$S_t = \frac{5641}{11.17} = 505\ in^3$$

$$S_b = \frac{5641}{19.83} = 284\ in^3$$

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W21X83

Member Proportions

$$\frac{D}{t_w} \leq 150$$

$$\frac{21.4 - 2(0.835)}{0.515} = 19.73 \leq 150 \quad \underline{OK}$$

$$\frac{b_f}{2t_f} \leq 12$$

$$\frac{8.36}{2(0.835)} = 5.0 < 12 \quad \underline{OK}$$

$$b_f \geq \frac{D}{6}$$

$$8.36 \geq \frac{21.4}{6}$$

$$8.36 \geq 3.57 \quad \underline{OK}$$

$$t_f \geq 1.1 t_w$$

$$0.835 \geq 1.1(0.515)$$

$$0.835 \geq 0.5665 \quad \underline{OK}$$

$$0.1 \leq \frac{I_{compression\ flange}}{I_{tension\ flange}} \leq 1$$

$$0.1 \leq 1 \leq 1 \quad \underline{OK}$$

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Construction Shear

$$V_u \le \phi V_{cr} = \phi C V_p = \phi C (0.58) F_y D t_w$$

$$= 1.0(0.58)(50)(21.4)(0.515) = 319.6^{kips}$$

$$45.02 < 319.6^{kips} \quad OK$$

Service Limit State

a) Live Load Deflection:

$$\frac{43(12)}{800} = 0.645 in$$

$$mg_{deflection} = m\left(\frac{No. Lanes}{No. beams}\right) = 0.85\left(\frac{2}{5}\right) = 0.34$$

$$P_1 = P_2 = 0.34(32)\left(1+\frac{IM}{100}\right) = (0.34)(32)(1.33) = 14.47^{kips}$$

$$P_3 = (0.34)(8)(1.33) = 3.62\ kips$$

$$\Delta_{LL\,Truck} = 0.601\ in \quad (SAP)$$

$$\Delta_{25\%\,LL\,Truck} = 0.25(0.601) + 0.36 = 0.51 < 0.645 \quad OK!$$

b) Minimum Depth $= \frac{(12)(43)}{30} = 17.2 < 21$

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2) $f_f + \frac{f_l}{2} \le 0.95 R_h F_{yf} = 0.95(1.0)(50) = 47.5\ ksi$

Load	M_{D1}	M_{D2}	M_{D3}	$1.3 M_{LL+IM}$	S_b Steel	S_b composite	Stress
D_1	192.57				171		6.5
D_2		51.67				284	2.2
D_3			19.37			284	0.82
LL+IM				551.72		315	27.02
Total							36.54

$Max\ f_f = 36.54 < 47.5\ ksi$ OK

Strength II Limit State

- The specified minimum yield strength of the flange does not exceed 70ksi
- The web satisfies the proportion Limits
- $\frac{2D_{cp}}{t_w} \le 3.76\sqrt{\frac{E}{F_y}}$ PNA is in deck

$A_{steel} = 24.3 in^2 \quad F_y = 50 ksi$

$(24.3)(50) = 1215\ kips$

$C = 0.85(4)(95.38)(7.6) = 2465\ kips \ge 1215$

$C = 0.85(f_c')b_e a = 0.85(4)(95.38)a = 1215$

$a = 3.75$

$Lever = (21.4 + 2 + 7.6) - \frac{21.4}{2} - \frac{3.75}{2} = 18.43\ in$

$$\phi_m M_n = \frac{1.0(1215)(18.43)}{12} = 1866 \text{ k-ft}$$

$M_u \leq \phi_m M_n$

$M_u = 952.05 \text{ k-ft} \leq 1866 \text{ k-ft}$ OK

The ductility requirement

$3.75 \leq 0.42(31) =$

$3.75 \leq 13.02$

Shear Design

$V_u \leq \phi V_{cr} = \phi C V_p = 319.6$ kips

$199.42^{\text{kips}} < 319.6$ kips OK

Shear Connectors

Use $\frac{3}{4}$-in diameter studs, 4 in.

$\frac{4}{0.75} = 5.33 > 4$ OK

Transverse spacing: 3in

Cover and Penetration: 2in into the Deck

2.5in Clear Cover

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Dimension and Detail Requirements

Material Thickness

$t_w = 0.515 > 0.25$ OK

Diaphragms and Cross Frames

C15x33.98

$A_s = 9.96 in^2$ $r_y = 0.904 in$ $L_B = \frac{32}{4} = 8 ft = 96 in$ $\frac{43}{4} = 10.75 = 129 in$

$W_{Bot} = \frac{\gamma P_D d}{2} = \frac{1.4(21.4/12)(0.050)}{2} = 0.0624 \, k/ft$

span 1+3

$P_{wBot} = W_{Bot} L_b = (0.0624)(8)(1/2) = 0.250 \, kips$

Span 2

$P_{wBot} = W_{Bot} L_B = (0.0624)(10.75)(1/2) = 0.335 \, kips$

Span 1+3

$P_{wtop} = \left[1.4(0.050)(21.4+9+52)\left(\frac{1}{12}\right)\right]\left[\frac{(32-8)/2}{5 \text{ girders}}\right] = 1.151 \, kips$

Span 2

$P_{wtop} = \left[1.4(0.050)(21.4+9+52)\left(\frac{1}{12}\right)\right]\left[\frac{\overset{3.225}{(43-10.75)/2}}{5 \text{ girders}}\right] = 1.55 \, kips$

Span 1+3

$F_{uD} = P_{wBot} + P_{wTop} = 0.250 + 1.15 = 1.4 \, kips$

Span 2

$F_{uD} = P_{wBot} + P_{wTop} = 0.335 + 1.55 = 1.885 \, kips$

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axial resistance

$$\frac{KL}{r_y} = \frac{1.0(108)}{0.904} = 119.5 < 140$$

$$\lambda = \left(\frac{KL}{r_s \pi}\right)^2 \frac{F_y}{E} = \left(\frac{1.0(108)}{0.904\pi}\right)^2 \frac{50}{29000} = 2.50 > 2.25$$

$$P_n = \frac{0.88 F_y A_s}{\lambda} = \frac{0.88(50)(9.96)}{2.5} = 175.30 \text{ kips}$$

$$P_r = \phi_c P_n = 0.9(175.30) = 157.77 >> P_{wBot} = 0.335 \quad \text{OK}$$

End diaphragms

$$P_r = 157.77 >> 1.885 \text{ kips} \quad \text{OK}$$

C15 X33.9 M270 Grade 50 for all diaphragms

Lateral bracing provided at quarter points of each span

Dead Load Camber

Span	1 + 3	Interior	$\Delta_{CL} = 0.287$ in
Span	2	Interior	$\Delta_{CL} = 0.678$ in
Span	1 + 3	Exterior	$\Delta_{CL} = 0.278$ in
Span	2	Exterior	$\Delta_{CL} = 0.658$ in

Camber 0.678 in

Skew Correction – Moment & Shear

Moment Distribution

The Bending Moment may be reduced in bridges with a skew of $30 \le \theta \le 60$

$\theta = 20°$

<u>No skew correction</u>

Shear Distribution

The shear forces shall be adjusted with skew

$0° \le \theta \le 60°$

support shear of Exterior Beam

$$mg_V^{SE\,\prime} = \left(1.0 + 0.20\left(\frac{12Lt_s^3}{K_g}\right)^{0.3} \tan\theta\right) mg_V^{SE}$$

$$= \left(1.0 + 0.20\left(\frac{12(43)(8)^3}{68{,}836\,in^4}\right) \tan(20°)\right) 0.8 = \underline{0.629}$$

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W36x150 -

Pg 71

Adjusted Distribution Factors for W21x83

Interior:

$$K_g = n(I + Ae_g^2) =$$

$$n = \frac{E_{Beam}}{E_{conc}} = \frac{29,000}{1820\sqrt{4}} = 7.98$$

$I = 1830 \text{ in}^4$

$A = 24.3 \text{ in}^2$

$$e_g = \frac{21.4}{2} + 2 + 4 = 16.7 \text{ in}$$

$$K_g = (8)(1830 + (24.3)(16.7)^2) = 68,856 \text{ in}^4$$

$$mg_m^{MI} = 0.075 + \left(\frac{S}{9.5}\right)^{0.6}\left(\frac{S}{L}\right)^{0.2}\left(\frac{K_g}{12Lt_s}\right)^{0.1}$$

$$= 0.075 + \left(\frac{9}{9.5}\right)^{0.6}\left(\frac{9}{32}\right)^{0.2}\left(\frac{68,856}{(12)(32)(8)^3}\right)^{0.1} = \underline{\underline{0.751}}$$

Appendix E- Option Costs

<u>Bridge Rehab</u> Start: June 2, 2014 End: June 30, 2014

1. Concrete Patching
    a. 278 SF
    b. $18,934
2. Abutment Drainage
    a. Both Abutments = $11,411
3. Widen Sidewalk
    a. 260 FT
    b. $3,721
4. Repair Hand Railing
    a. 1 section
    b. $644
5. Epoxy Injection
    a. 40 FT
    b. $3,923
6. Epoxy Sealing
    a. 300 SF
    b. $2,360

Repair Cost: $40,993

Demo Bridge Deck

a. $61,850

Demo Abutments

a. Both Abutments = $6,816

<u>Steel Bridge</u> Start: June 2, 2014 End: August 22, 2014 (Includes Demo Time)

1. Abutments
    a. Both Abutments = $29,383
2. Superstructure (Beams, deck, sidewalk, parapet, etc.)
    a. $317,770
3. Pier Caps
    a. Both Caps = $16,290

Steel Bridge Cost: $363,443

<u>Box Beam Bridge</u> Start: June 2, 2014 End: August 12, 2014 (Includes Demo Time)

1. Abutments
    a. Both Abutments = $33,682

2. Superstructure
    a. $336,201
3. Pier Caps
    a. Both Caps = $20,736

Box Beam Bridge Cost: $459,285

<u>**General Conditions**</u>

1. For Steel Beam and Box Beam Bridges
    a. $122,507
2. For Rehab
    a. $17,349

Total Repair Cost: $58,342

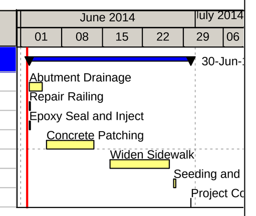
Total Steel Bridge Cost: $554,616

Total Box Beam Bridge Cost: $581,792

Appendix F- Option Schedules

David Root Bridge
Replacement Rehab

Act ID	Activity Name	Orig Dur	Rem Dur	Total Float	Start	Finish
	David Root Bridge Replace...	20	20	39	02-Jun-14	30-Jun-14
A1960	Abutment Drainage	3	3	39	02-Jun-14	04-Jun-14
A1980	Repair Railing	1	1	41	02-Jun-14	02-Jun-14
A1990	Epoxy Seal and Inject	1	1	58	02-Jun-14	02-Jun-14
A1950	Concrete Patching	7	7	39	05-Jun-14	13-Jun-14
A1970	Widen Sidewalk	9	9	39	16-Jun-14	26-Jun-14
A1940	Seeding and Mulching	1	1	39	27-Jun-14	27-Jun-14
A1920	Project Complete	0	0	39	30-Jun-14	30-Jun-14



Actual Work
Remaining Work
Critical Remaining Work

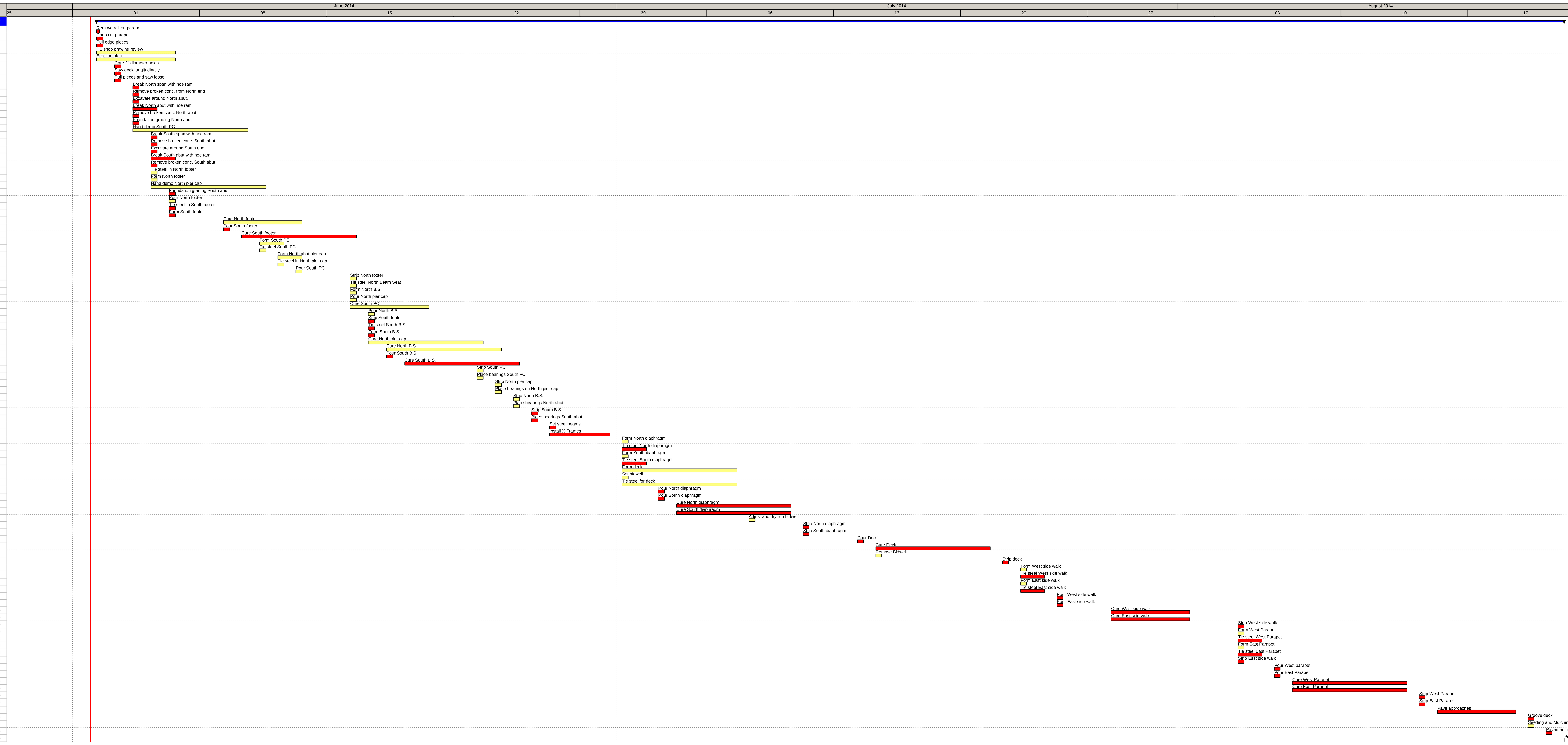
Mosser Construction, Inc.

122 S. Wilson Ave.

Fremont, OH 43420

David Root Bridge Replacement Steel

Act ID	Activity Name	Orig Dur	Rem Dur	Total Float	Start	Finish
David Root Bridge Replace...		59	59	0	02-Jun-14	22-Aug-14
A1000	Remove rail on parapet	1	1	0	02-Jun-14	02-Jun-14
A1010	Chop cut parapet	1	1	0	02-Jun-14	02-Jun-14
A1020	Pull edge pieces	1	1	0	02-Jun-14	02-Jun-14
A1510	PE shop drawing review	5	5	14	02-Jun-14	06-Jun-14
A1520	Erection plan	5	5	14	02-Jun-14	06-Jun-14
A1030	Core 2" diameter holes	1	1	0	03-Jun-14	03-Jun-14
A1040	Saw deck longitudinally	1	1	0	03-Jun-14	03-Jun-14
A1050	Pull pieces and saw loose	1	1	0	03-Jun-14	03-Jun-14
A1060	Break North span with hoe ram	1	1	0	04-Jun-14	04-Jun-14
A1070	Remove broken conc. from North...	1	1	0	04-Jun-14	04-Jun-14
A1100	Excavate around North abut.	1	1	0	04-Jun-14	04-Jun-14
A1110	Break North abut with hoe ram	2	2	0	04-Jun-14	05-Jun-14
A1120	Remove broken conc. North abut.	1	1	0	04-Jun-14	04-Jun-14
A1130	Foundation grading North abut.	1	1	0	04-Jun-14	04-Jun-14
A1445	Hand demo South PC	5	5	3	04-Jun-14	10-Jun-14
A1080	Break South span with hoe ram	1	1	0	05-Jun-14	05-Jun-14
A1090	Remove broken conc. South abut.	1	1	0	05-Jun-14	05-Jun-14
A1140	Excavate around South end	1	1	0	05-Jun-14	05-Jun-14
A1150	Break South abut with hoe ram	2	2	0	05-Jun-14	06-Jun-14
A1160	Remove broken conc. South abut	1	1	0	05-Jun-14	05-Jun-14
A1180	Tie steel in North footer	1	1	1	05-Jun-14	05-Jun-14
A1190	Form North footer	1	1	1	05-Jun-14	05-Jun-14
A1385	Hand demo North pier cap	5	5	3	05-Jun-14	11-Jun-14
A1170	Foundation grading South abut	1	1	0	06-Jun-14	06-Jun-14
A1200	Pour North footer	1	1	1	06-Jun-14	06-Jun-14
A1220	Tie steel in South footer	1	1	0	06-Jun-14	06-Jun-14
A1230	Form South footer	1	1	0	06-Jun-14	06-Jun-14
A1210	Cure North footer	5	5	1	09-Jun-14	13-Jun-14
A1240	Pour South footer	1	1	0	09-Jun-14	09-Jun-14
A1250	Cure South footer	5	5	0	10-Jun-14	16-Jun-14
A1450	Form South PC	2	2	3	11-Jun-14	12-Jun-14
A1460	Tie steel South PC	1	1	4	11-Jun-14	11-Jun-14
A1390	Form North abut pier cap	2	2	3	12-Jun-14	13-Jun-14
A1400	Tie steel in North pier cap	1	1	4	12-Jun-14	12-Jun-14
A1470	Pour South PC	1	1	3	13-Jun-14	13-Jun-14
A1260	Strip North footer	1	1	1	16-Jun-14	16-Jun-14
A1270	Tie steel North Beam Seat	1	1	1	16-Jun-14	16-Jun-14
A1280	Form North B.S.	1	1	1	16-Jun-14	16-Jun-14
A1410	Pour North pier cap	1	1	3	16-Jun-14	16-Jun-14
A1480	Cure South PC	5	5	3	16-Jun-14	20-Jun-14
A1290	Pour North B.S.	1	1	1	17-Jun-14	17-Jun-14
A1310	Strip South footer	1	1	0	17-Jun-14	17-Jun-14
A1320	Tie steel South B.S.	1	1	0	17-Jun-14	17-Jun-14
A1330	Form South B.S.	1	1	0	17-Jun-14	17-Jun-14
A1420	Cure North pier cap	5	5	3	17-Jun-14	23-Jun-14
A1300	Cure North B.S.	5	5	1	18-Jun-14	24-Jun-14
A1340	Pour South B.S.	1	1	0	18-Jun-14	18-Jun-14
A1345	Cure South B.S.	5	5	0	19-Jun-14	25-Jun-14
A1490	Strip South PC	1	1	3	23-Jun-14	23-Jun-14
A1500	Place bearings South PC	1	1	3	23-Jun-14	23-Jun-14
A1430	Strip North pier cap	1	1	3	24-Jun-14	24-Jun-14
A1440	Place bearings on North pier cap	1	1	3	24-Jun-14	24-Jun-14
A1350	Strip North B.S.	1	1	1	25-Jun-14	25-Jun-14
A1360	Place bearings North abut.	1	1	1	25-Jun-14	25-Jun-14
A1370	Strip South B.S.	1	1	0	26-Jun-14	26-Jun-14
A1380	Place bearings South abut.	1	1	0	26-Jun-14	26-Jun-14
A1530	Set steel beams	1	1	0	27-Jun-14	27-Jun-14
A1540	Install X-Frames	2	2	0	27-Jun-14	30-Jun-14
A1550	Form North diaphragm	1	1	1	01-Jul-14	01-Jul-14
A1560	Tie steel North diaphragm	2	2	0	01-Jul-14	02-Jul-14
A1600	Form South diaphragm	1	1	1	01-Jul-14	01-Jul-14
A1610	Tie steel South diaphragm	2	2	0	01-Jul-14	02-Jul-14
A1650	Form deck	5	5	3	01-Jul-14	07-Jul-14
A1660	Set bidwell	1	1	7	01-Jul-14	01-Jul-14
A1655	Tie steel for deck	5	5	3	01-Jul-14	07-Jul-14
A1570	Pour North diaphragm	1	1	0	03-Jul-14	03-Jul-14
A1620	Pour South diaphragm	1	1	0	03-Jul-14	03-Jul-14
A1580	Cure North diaphragm	5	5	0	04-Jul-14	10-Jul-14
A1630	Cure South diaphragm	5	5	0	04-Jul-14	10-Jul-14
A1670	Adjust and dry run bidwell	1	1	3	08-Jul-14	08-Jul-14
A1590	Strip North diaphragm	1	1	0	11-Jul-14	11-Jul-14
A1640	Strip South diaphragm	1	1	0	11-Jul-14	11-Jul-14
A1680	Pour Deck	1	1	0	14-Jul-14	14-Jul-14
A1690	Cure Deck	5	5	0	15-Jul-14	21-Jul-14
A1695	Remove Bidwell	1	1	5	15-Jul-14	15-Jul-14
A1700	Strip deck	1	1	0	22-Jul-14	22-Jul-14
A1720	Form West side walk	1	1	1	23-Jul-14	23-Jul-14
A1730	Tie steel West side walk	2	2	0	23-Jul-14	24-Jul-14
A1770	Form East side walk	1	1	1	23-Jul-14	23-Jul-14
A1780	Tie steel East side walk	2	2	0	23-Jul-14	24-Jul-14
A1740	Pour West side walk	1	1	0	25-Jul-14	25-Jul-14
A1790	Pour East side walk	1	1	0	25-Jul-14	25-Jul-14
A1750	Cure West side walk	5	5	0	28-Jul-14	01-Aug-14
A1800	Cure East side walk	5	5	0	28-Jul-14	01-Aug-14
A1760	Strip West side walk	1	1	0	04-Aug-14	04-Aug-14
A1810	Form West Parapet	1	1	1	04-Aug-14	04-Aug-14
A1820	Tie steel West Parapet	2	2	0	04-Aug-14	05-Aug-14
A1860	Form East Parapet	1	1	1	04-Aug-14	04-Aug-14
A1870	Tie steel East Parapet	2	2	0	04-Aug-14	05-Aug-14
A1805	Strip East side walk	1	1	0	04-Aug-14	04-Aug-14
A1830	Pour West parapet	1	1	0	06-Aug-14	06-Aug-14
A1880	Pour East Parapet	1	1	0	06-Aug-14	06-Aug-14
A1840	Cure West Parapet	5	5	0	07-Aug-14	13-Aug-14
A1890	Cure East Parapet	5	5	0	07-Aug-14	13-Aug-14
A1850	Strip West Parapet	1	1	0	14-Aug-14	14-Aug-14
A1900	Strip East Parapet	1	1	0	14-Aug-14	14-Aug-14
A1910	Pave approaches	3	3	0	15-Aug-14	19-Aug-14
A1710	Groove deck	1	1	0	20-Aug-14	20-Aug-14
A1940	Seeding and Mulching	1	1	1	20-Aug-14	20-Aug-14
A1930	Pavement markings	1	1	0	21-Aug-14	21-Aug-14
A1920	Project Complete	0	0	0	22-Aug-14	22-Aug-14



Actual Work
Remaining Work
Critical Remaining Work
Milestone
Summary

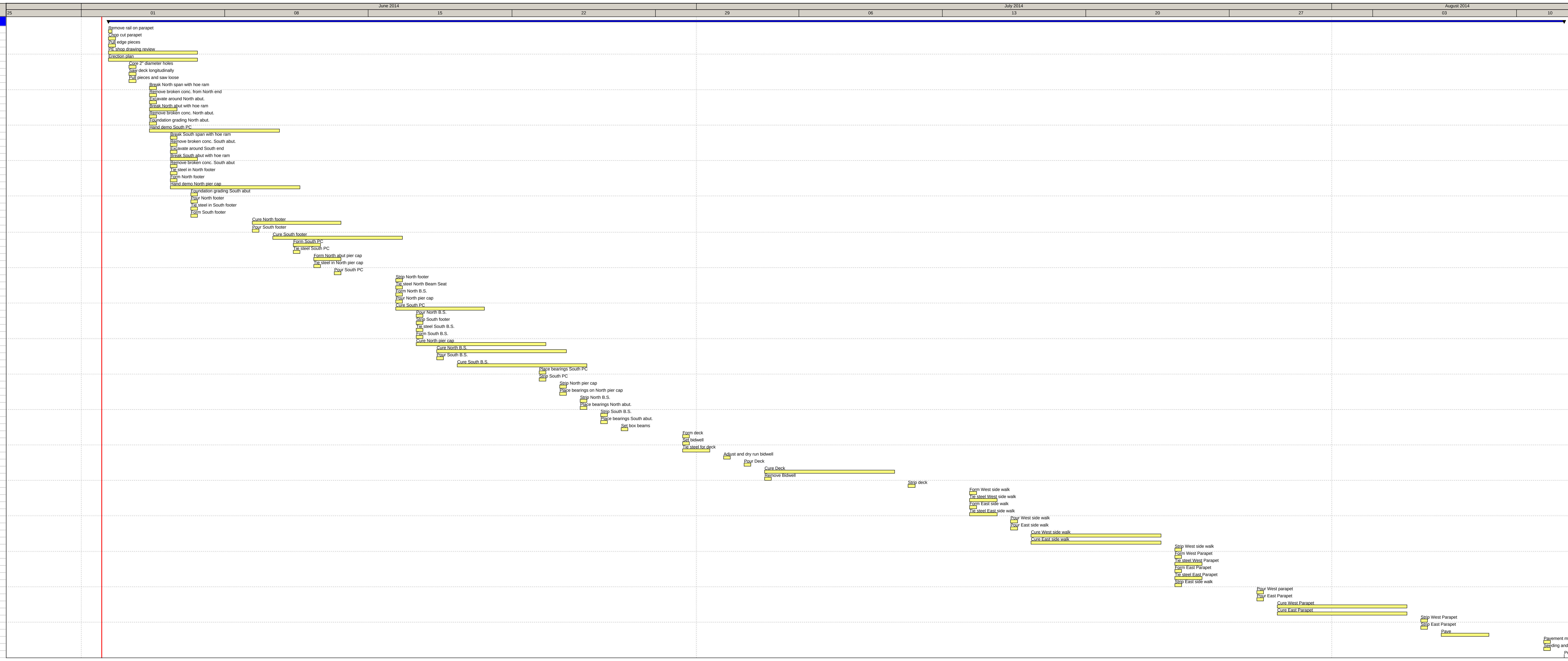
Mosser Construction, Inc.

122 S. Wilson Ave.

Fremont, OH 43420

David Root Bridge Replacement Box Beams

Act ID	Activity Name	Orig Dur	Rem Dur	Total Float	Start	Finish
David Root Bridge Replace...		51	51	8	02-Jun-14	12-Aug-14
A1000	Remove rail on parapet	1	1	8	02-Jun-14	02-Jun-14
A1010	Chop cut parapet	1	1	8	02-Jun-14	02-Jun-14
A1020	Pull edge pieces	1	1	8	02-Jun-14	02-Jun-14
A1510	PE shop drawing review	5	5	22	02-Jun-14	06-Jun-14
A1520	Erection plan	5	5	22	02-Jun-14	06-Jun-14
A1030	Core 2" diameter holes	1	1	8	03-Jun-14	03-Jun-14
A1040	Saw deck longitudinally	1	1	8	03-Jun-14	03-Jun-14
A1050	Pull pieces and saw loose	1	1	8	03-Jun-14	03-Jun-14
A1060	Break North span with hoe ram	1	1	8	04-Jun-14	04-Jun-14
A1070	Remove broken conc. from North...	1	1	8	04-Jun-14	04-Jun-14
A1100	Excavate around North abut.	1	1	8	04-Jun-14	04-Jun-14
A1110	Break North abut with hoe ram	2	2	8	04-Jun-14	05-Jun-14
A1120	Remove broken conc. North abut.	1	1	8	04-Jun-14	04-Jun-14
A1130	Foundation grading North abut.	1	1	8	04-Jun-14	04-Jun-14
A1445	Hand demo South PC	5	5	11	04-Jun-14	10-Jun-14
A1080	Break South span with hoe ram	1	1	8	05-Jun-14	05-Jun-14
A1090	Remove broken conc. South abut.	1	1	8	05-Jun-14	05-Jun-14
A1140	Excavate around South end	1	1	8	05-Jun-14	05-Jun-14
A1150	Break South abut with hoe ram	2	2	8	05-Jun-14	06-Jun-14
A1160	Remove broken conc. South abut	1	1	8	05-Jun-14	05-Jun-14
A1180	Tie steel in North footer	1	1	9	05-Jun-14	05-Jun-14
A1190	Form North footer	1	1	9	05-Jun-14	05-Jun-14
A1385	Hand demo North pier cap	5	5	11	05-Jun-14	11-Jun-14
A1170	Foundation grading South abut	1	1	8	06-Jun-14	06-Jun-14
A1200	Pour North footer	1	1	9	06-Jun-14	06-Jun-14
A1220	Tie steel in South footer	1	1	8	06-Jun-14	06-Jun-14
A1230	Form South footer	1	1	8	06-Jun-14	06-Jun-14
A1210	Cure North footer	5	5	9	09-Jun-14*	13-Jun-14
A1240	Pour South footer	1	1	8	09-Jun-14	09-Jun-14
A1250	Cure South footer	5	5	8	10-Jun-14	16-Jun-14
A1450	Form South PC	2	2	11	11-Jun-14	12-Jun-14
A1460	Tie steel South PC	1	1	12	11-Jun-14	11-Jun-14
A1390	Form North abut pier cap	2	2	11	12-Jun-14	13-Jun-14
A1400	Tie steel in North pier cap	1	1	12	12-Jun-14	12-Jun-14
A1470	Pour South PC	1	1	11	13-Jun-14	13-Jun-14
A1260	Strip North footer	1	1	9	16-Jun-14	16-Jun-14
A1270	Tie steel North Beam Seat	1	1	9	16-Jun-14	16-Jun-14
A1280	Form North B.S.	1	1	9	16-Jun-14	16-Jun-14
A1410	Pour North pier cap	1	1	11	16-Jun-14	16-Jun-14
A1480	Cure South PC	5	5	11	16-Jun-14	20-Jun-14
A1290	Pour North B.S.	1	1	9	17-Jun-14	17-Jun-14
A1310	Strip South footer	1	1	8	17-Jun-14	17-Jun-14
A1320	Tie steel South B.S.	1	1	8	17-Jun-14	17-Jun-14
A1330	Form South B.S.	1	1	8	17-Jun-14	17-Jun-14
A1420	Cure North pier cap	5	5	11	17-Jun-14	23-Jun-14
A1300	Cure North B.S.	5	5	9	18-Jun-14	24-Jun-14
A1340	Pour South B.S.	1	1	8	18-Jun-14	18-Jun-14
A1345	Cure South B.S.	5	5	8	19-Jun-14	25-Jun-14
A1500	Place bearings South PC	1	1	11	23-Jun-14	23-Jun-14
A1490	Strip South PC	1	1	11	23-Jun-14	23-Jun-14
A1430	Strip North pier cap	1	1	11	24-Jun-14	24-Jun-14
A1440	Place bearings on North pier cap	1	1	11	24-Jun-14	24-Jun-14
A1350	Strip North B.S.	1	1	9	25-Jun-14	25-Jun-14
A1360	Place bearings North abut.	1	1	9	25-Jun-14	25-Jun-14
A1370	Strip South B.S.	1	1	8	26-Jun-14	26-Jun-14
A1380	Place bearings South abut.	1	1	8	26-Jun-14	26-Jun-14
A1530	Set box beams	1	1	8	27-Jun-14	27-Jun-14
A1650	Form deck	1	1	8	30-Jun-14	30-Jun-14
A1660	Set bidwell	1	1	9	30-Jun-14	30-Jun-14
A1655	Tie steel for deck	2	2	8	30-Jun-14	01-Jul-14
A1670	Adjust and dry run bidwell	1	1	8	02-Jul-14	02-Jul-14
A1680	Pour Deck	1	1	8	03-Jul-14	03-Jul-14
A1690	Cure Deck	5	5	8	04-Jul-14	10-Jul-14
A1695	Remove Bidwell	1	1	13	04-Jul-14	04-Jul-14
A1700	Strip deck	1	1	8	11-Jul-14	11-Jul-14
A1720	Form West side walk	1	1	9	14-Jul-14	14-Jul-14
A1730	Tie steel West side walk	2	2	8	14-Jul-14	15-Jul-14
A1770	Form East side walk	1	1	9	14-Jul-14	14-Jul-14
A1780	Tie steel East side walk	2	2	8	14-Jul-14	15-Jul-14
A1740	Pour West side walk	1	1	8	16-Jul-14	16-Jul-14
A1790	Pour East side walk	1	1	8	16-Jul-14	16-Jul-14
A1750	Cure West side walk	5	5	8	17-Jul-14	23-Jul-14
A1800	Cure East side walk	5	5	8	17-Jul-14	23-Jul-14
A1760	Strip West side walk	1	1	8	24-Jul-14	24-Jul-14
A1810	Form West Parapet	1	1	9	24-Jul-14	24-Jul-14
A1820	Tie steel West Parapet	2	2	8	24-Jul-14	25-Jul-14
A1860	Form East Parapet	1	1	9	24-Jul-14	24-Jul-14
A1870	Tie steel East Parapet	2	2	8	24-Jul-14	25-Jul-14
A1805	Strip East side walk	1	1	8	24-Jul-14	24-Jul-14
A1830	Pour West parapet	1	1	8	28-Jul-14	28-Jul-14
A1880	Pour East Parapet	1	1	8	28-Jul-14	28-Jul-14
A1840	Cure West Parapet	5	5	8	29-Jul-14	04-Aug-14
A1890	Cure East Parapet	5	5	8	29-Jul-14	04-Aug-14
A1850	Strip West Parapet	1	1	8	05-Aug-14	05-Aug-14
A1900	Strip East Parapet	1	1	8	05-Aug-14	05-Aug-14
A1910	Pave	3	3	8	06-Aug-14	08-Aug-14
A1930	Pavement markings	1	1	8	11-Aug-14	11-Aug-14
A1940	Seeding and Mulching	1	1	8	11-Aug-14	11-Aug-14
A1920	Project Complete	0	0	8	12-Aug-14	12-Aug-14



Actual Work
Remaining Work
Critical Remaining Work
Milestone
Summary

Mosser Construction, Inc.
122 S. Wilson Ave.
Fremont, OH 43420

Appendix G- Plan Drawings

DAVID ROOT BRIDGE REPLACEMENT PROJECT

THE UNIVERSITY OF TOLEDO
DEPARTMENT OF CIVIL ENGINEERING SENIOR DESIGN
FALL 2012

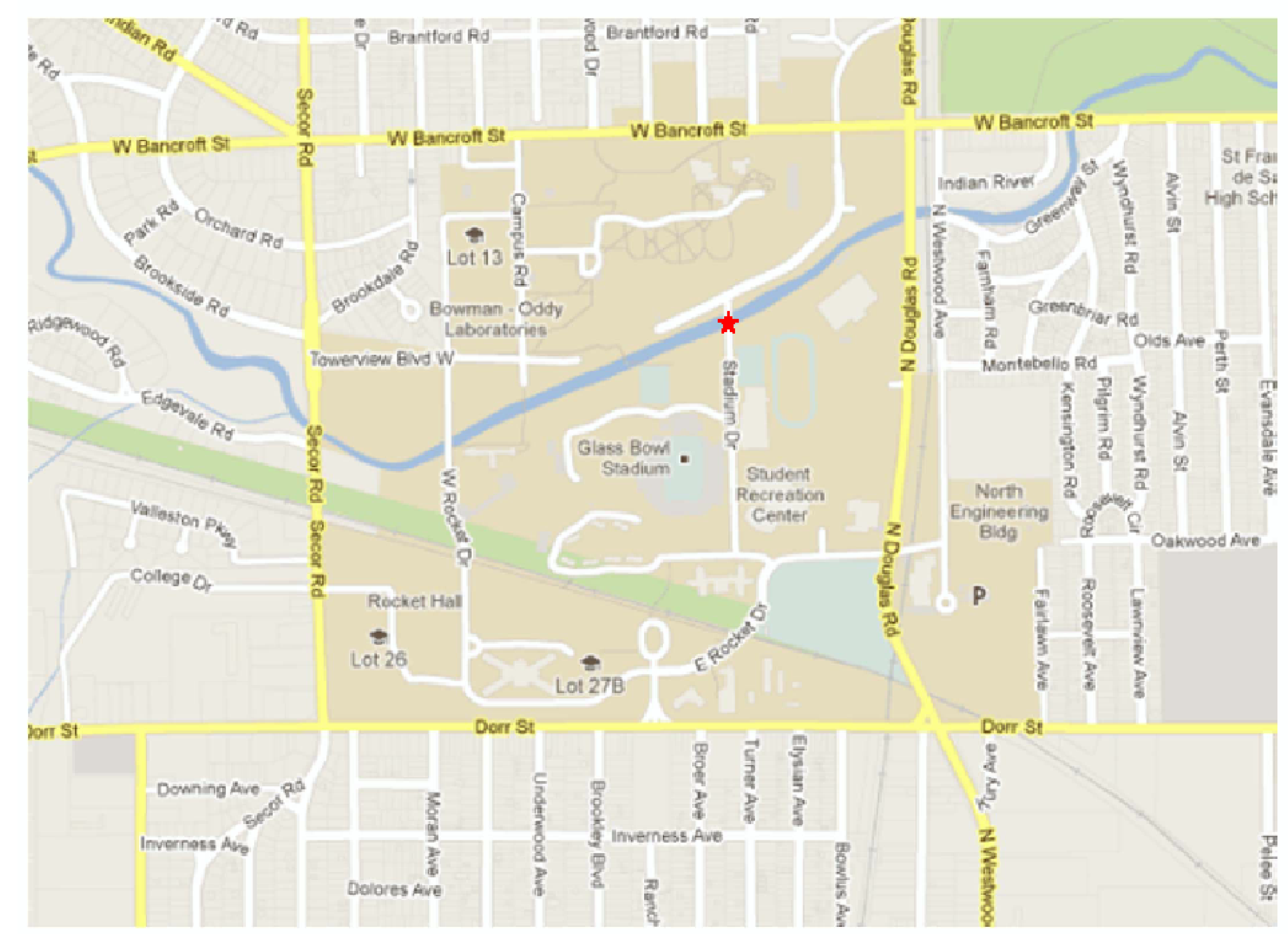
DRAWING INDEX

BRIDGE SITE PLAN
SCALE = NTS

DISCLAIMER:

THE FOLLOWING DRAWINGS ARE STUDENT WORK. THE CONTENTS OF THESE DRAWINGS REFLECT THE VIEWS OF THE STUDENTS WHO ARE RESPONSIBLE FOR THE FACTS AND THE ACCURACY OF THE DATA PRESENTED HEREIN. THE CONTENTS DO NOT NECESSARILY REFLECT THE VIEWS OF THE UNIVERSITY OF TOLEDO. THE SPECIFICATIONS IN THESE DRAWINGS SHOULD NOT BE USED WITHOUT CONSULTING A PROFESSIONAL ENGINEER.

DAVID ROOT BRIDGE
SCALE = NTS

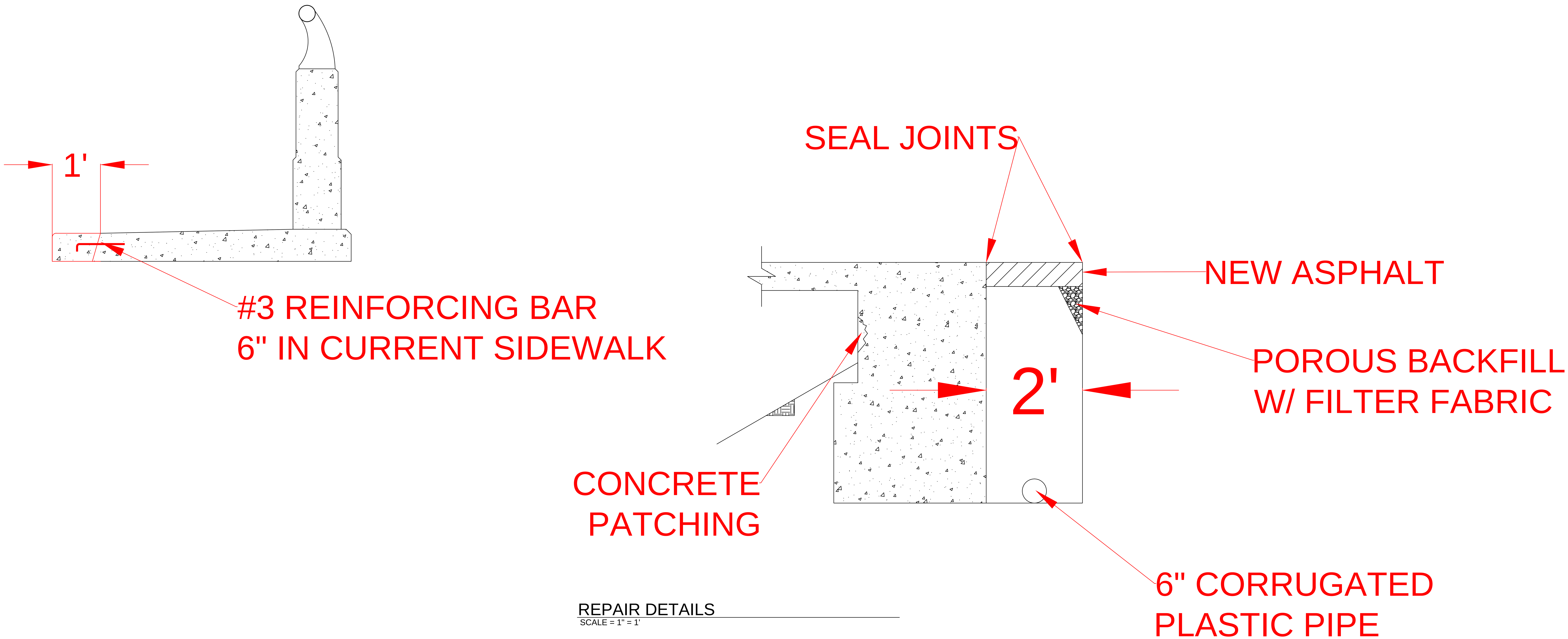


UNIVERSITY OF TOLEDO
SCALE = NTS

DAVID ROOT BRIDGE
REPLACEMENT PROJECT

TITLE SHEET

SHEET NO.
1



REPAIR DETAILS
SCALE = 1" = 1'

DAVID ROOT BRIDGE
REPLACEMENT PROJECT

BRIDGE REPAIR DETAIL

SHEET NO.
2

DAVID ROOT BRIDGE
REPLACEMENT PROJECT

STEEL BRIDGE SITE PLAN

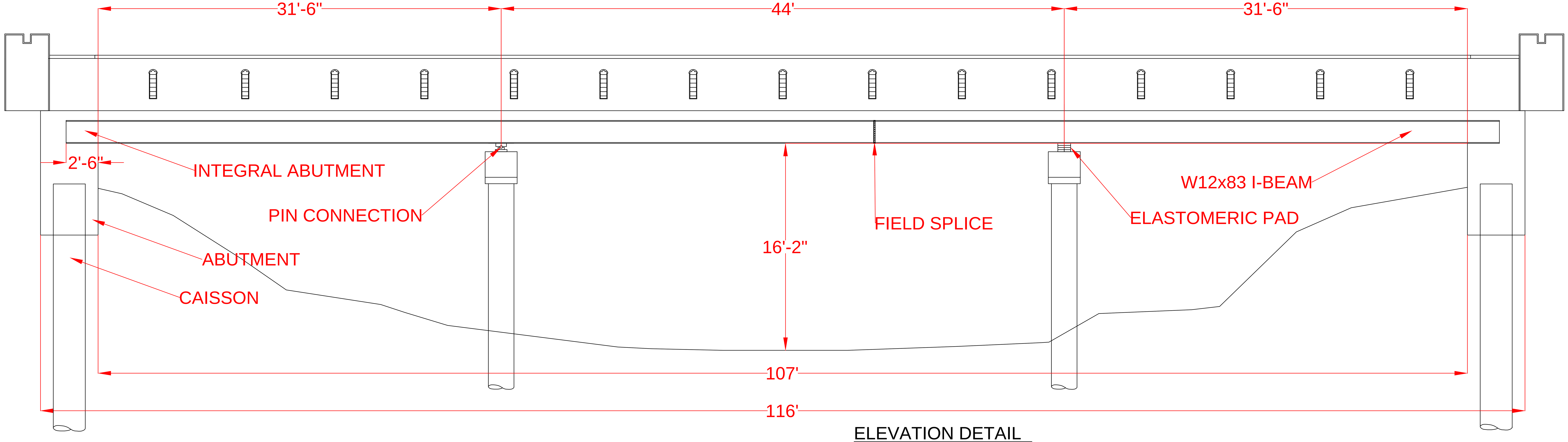
SHEET NO.
3

CONCEPTUALIZED BRIDGE ELEVATION
SCALE = 1/4" = 1'

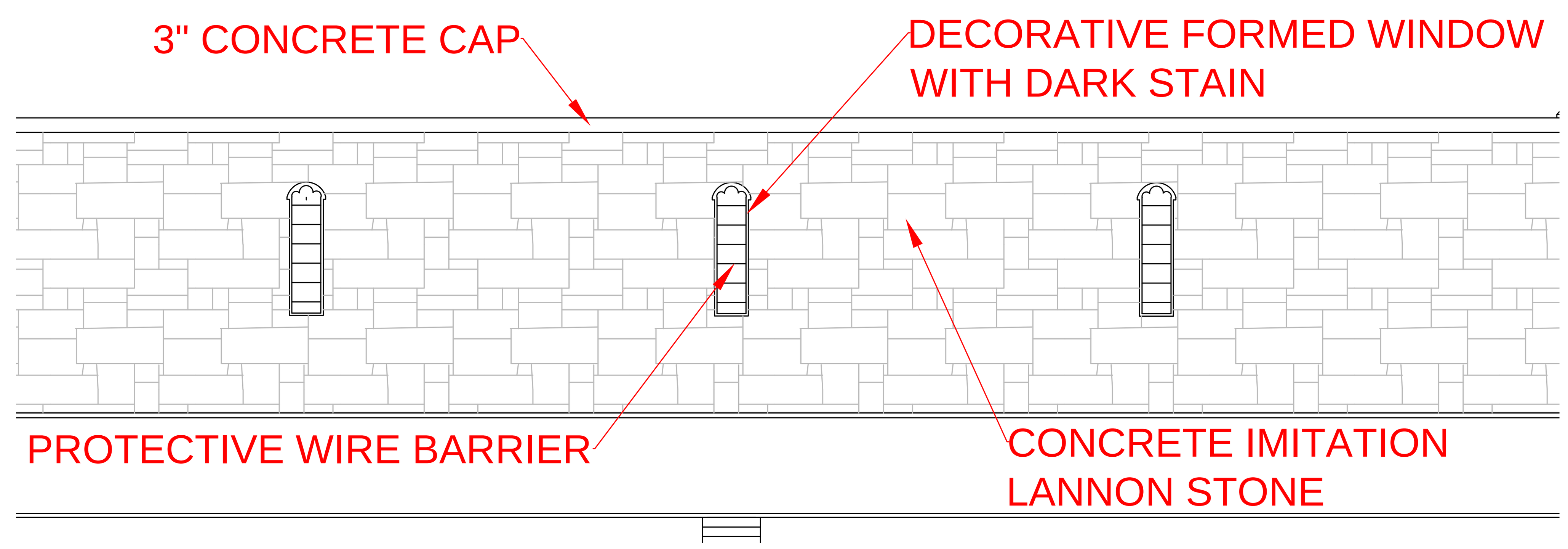
DAVID ROOT BRIDGE
REPLACEMENT PROJECT

FINISHED STEEL BRIDGE

SHEET NO.
4



ELEVATION DETAIL
SCALE = 1/4" = 1'



AESTHECTIC FINISH
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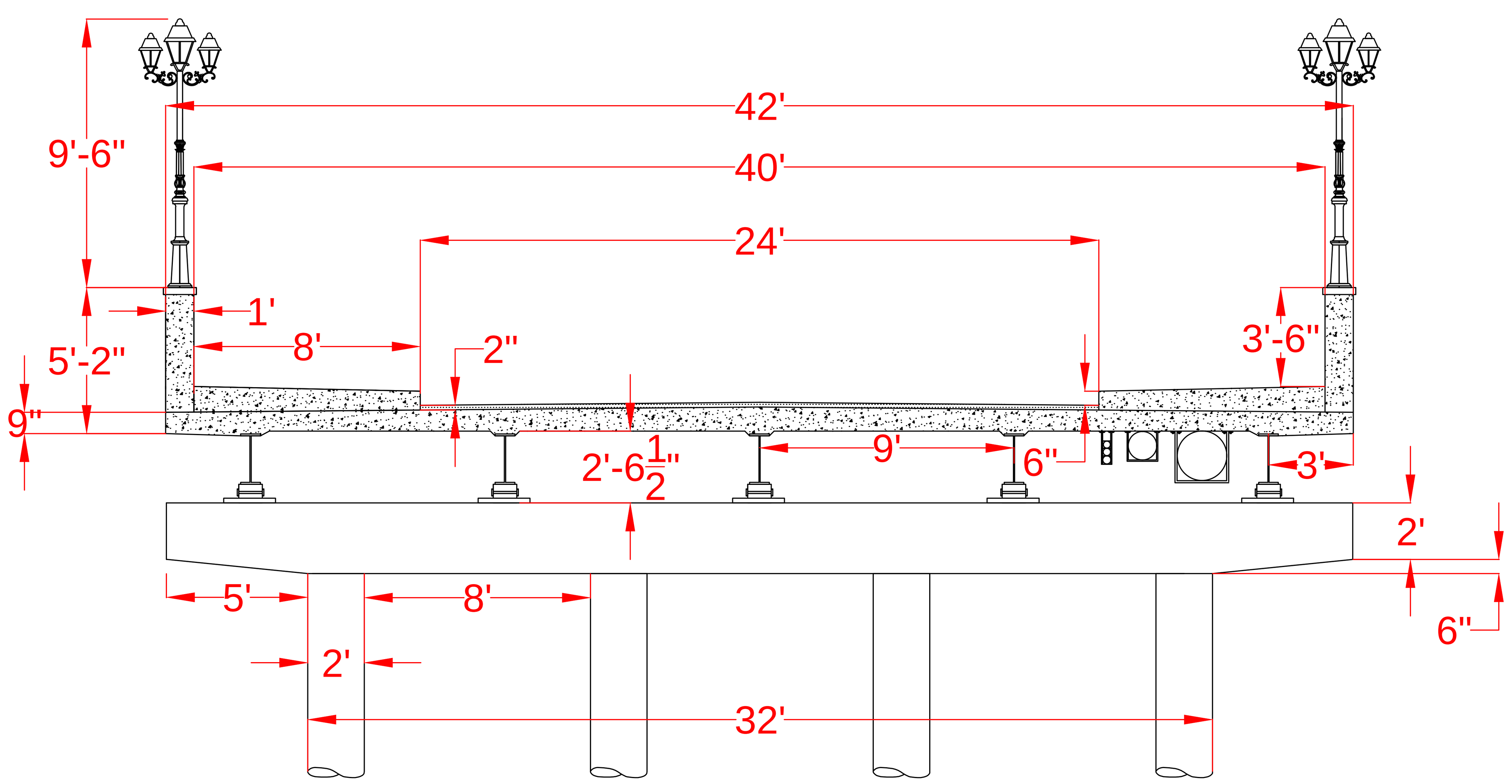

CROSS SECTION DIMENSIONS
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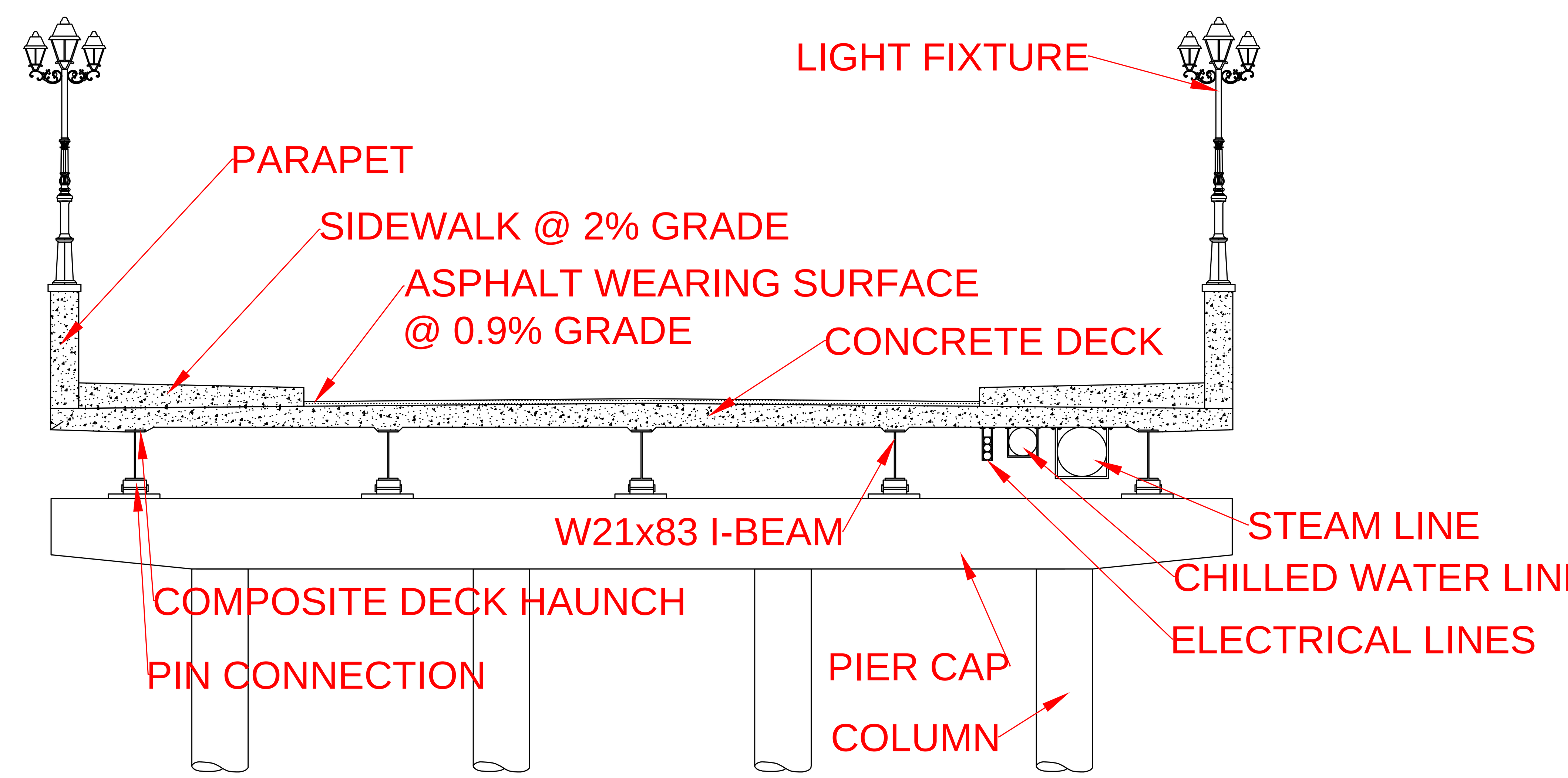


CROSS SECTION LABELS
SCALE = 1/4" = 1'

DAVID ROOT BRIDGE REPLACEMENT PROJECT

STEEL BRIDGE DETAIL

SHEET NO.
5

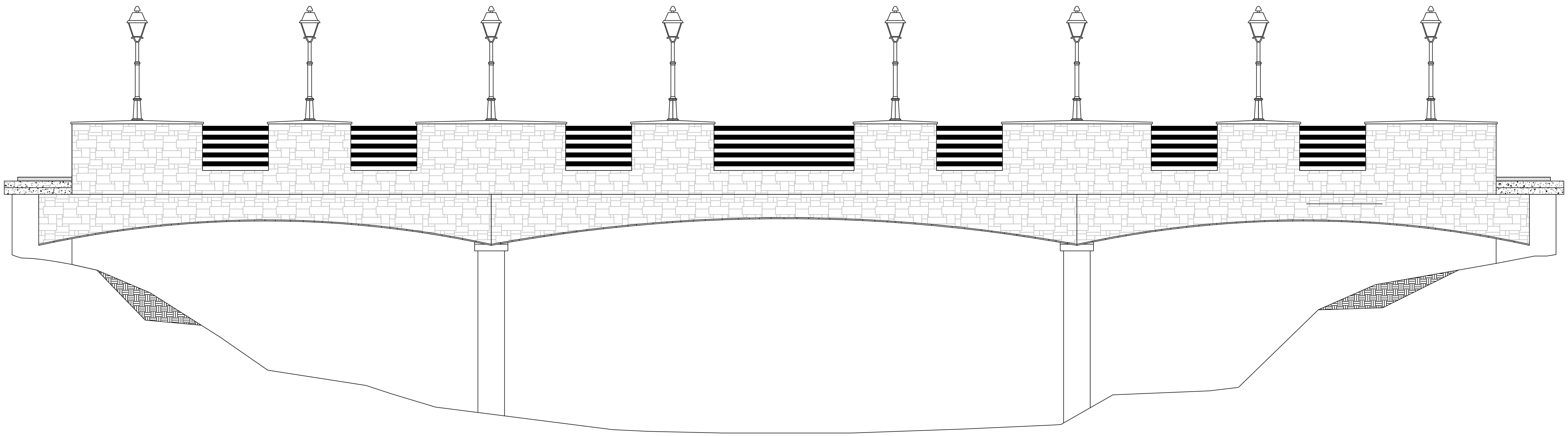
CONCRETE BRIDGE SITE PLAN

SCALE = 1/8" = 1'

DAVID ROOT BRIDGE REPLACEMENT PROJECT

CONCRETE BRIDGE SITE PLAN

SHEET NO.
6



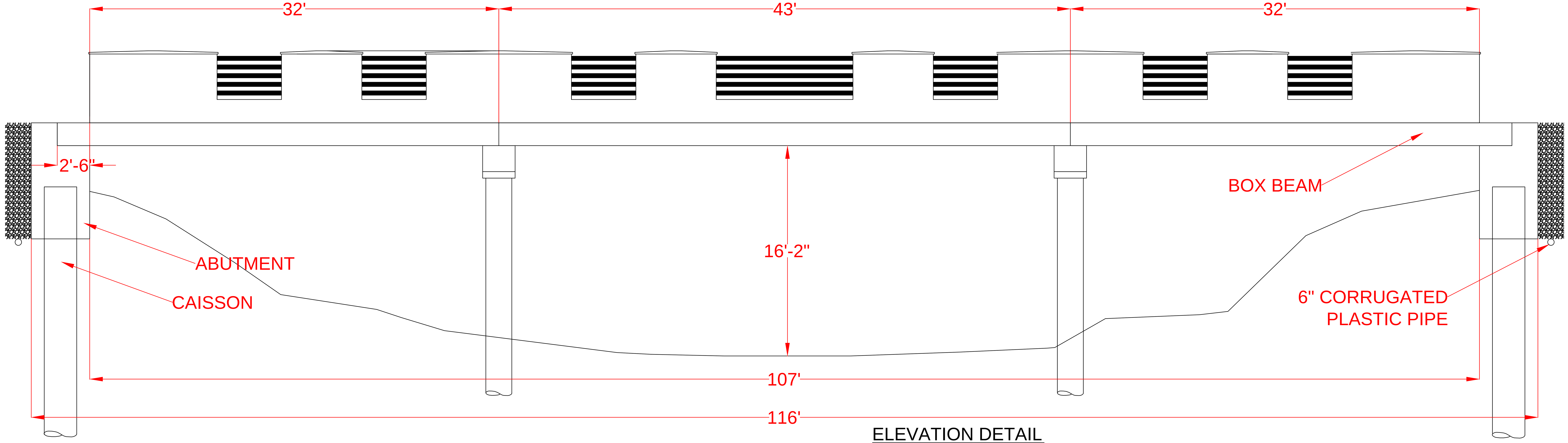
CONCEPTUALIZED BRIDGE ELEVATION

SCALE = 1/4" = 1'

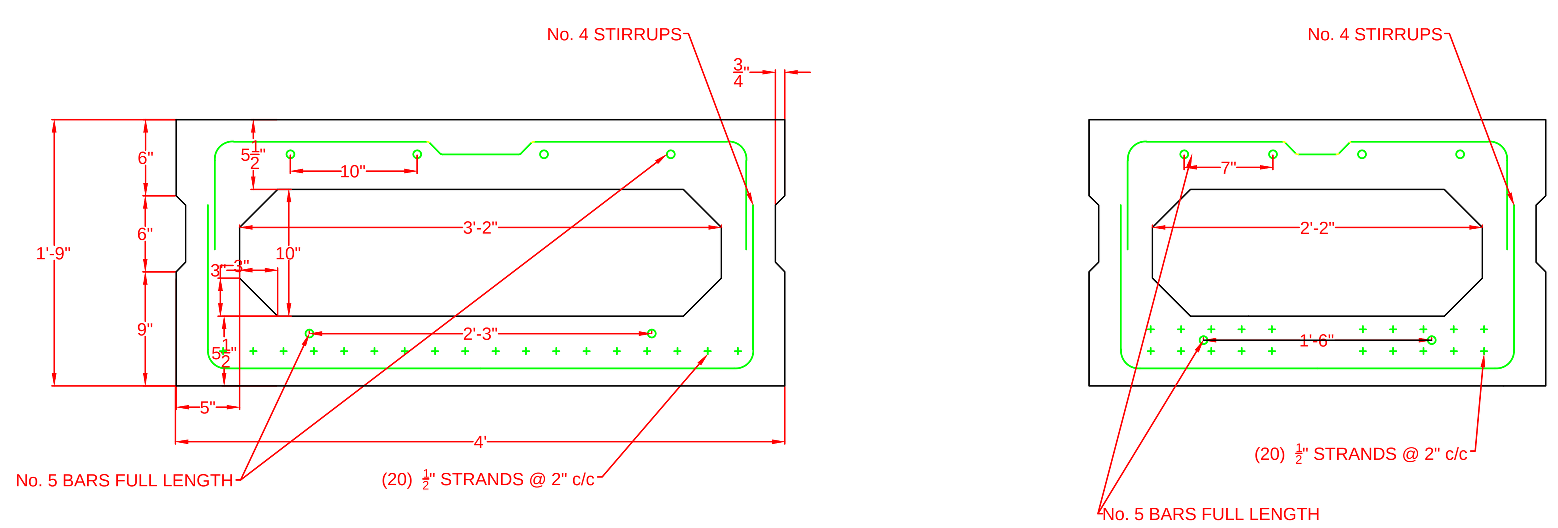
DAVID ROOT BRIDGE
REPLACEMENT PROJECT

FINISHED CONCRETE BRIDGE

SHEET NO.
7



ELEVATION DETAIL
SCALE = 1/4" = 1'



BOX BEAM DETAILS
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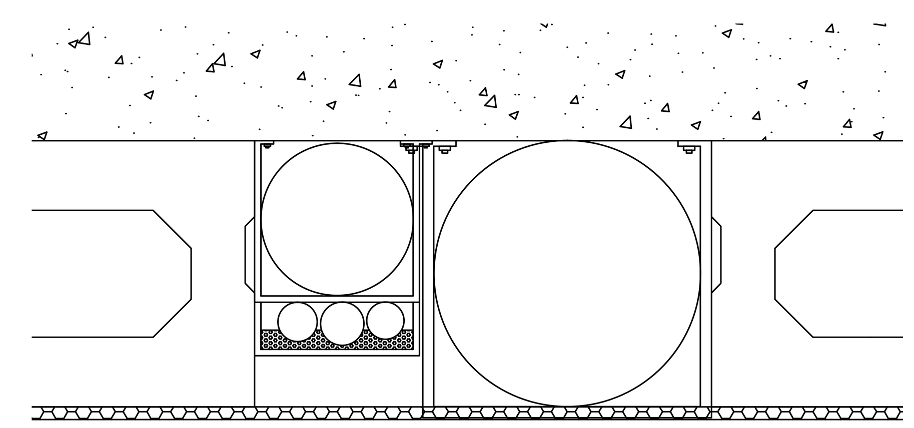

UTILITIES POCKET
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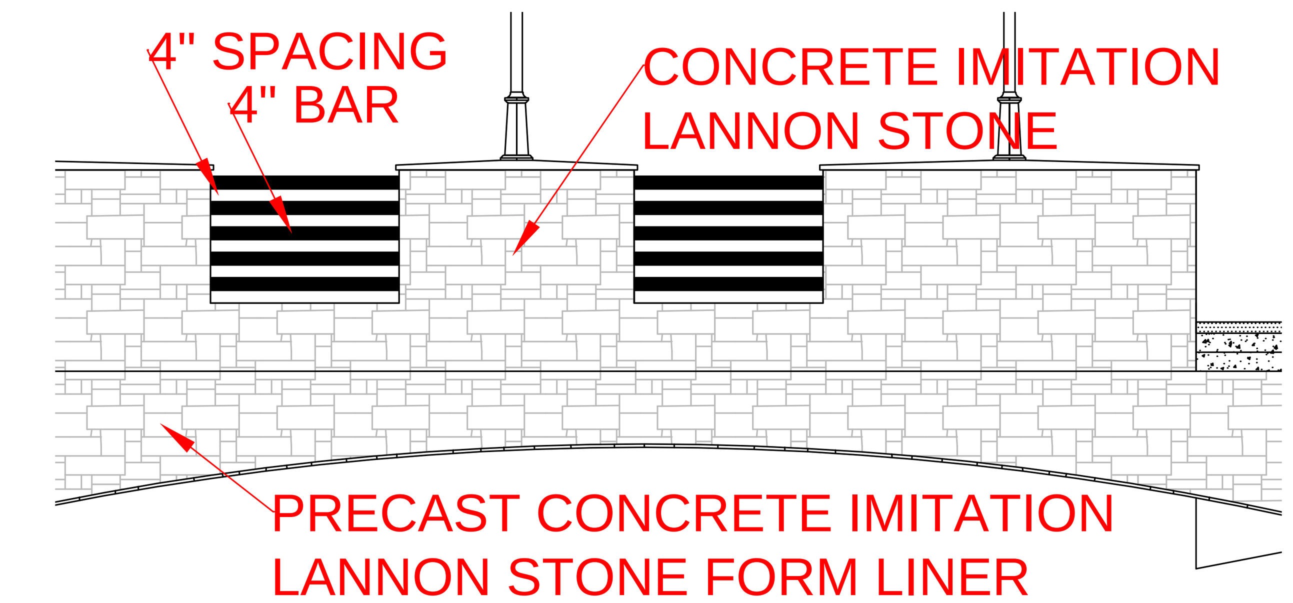

AESTHECTIC FINISH
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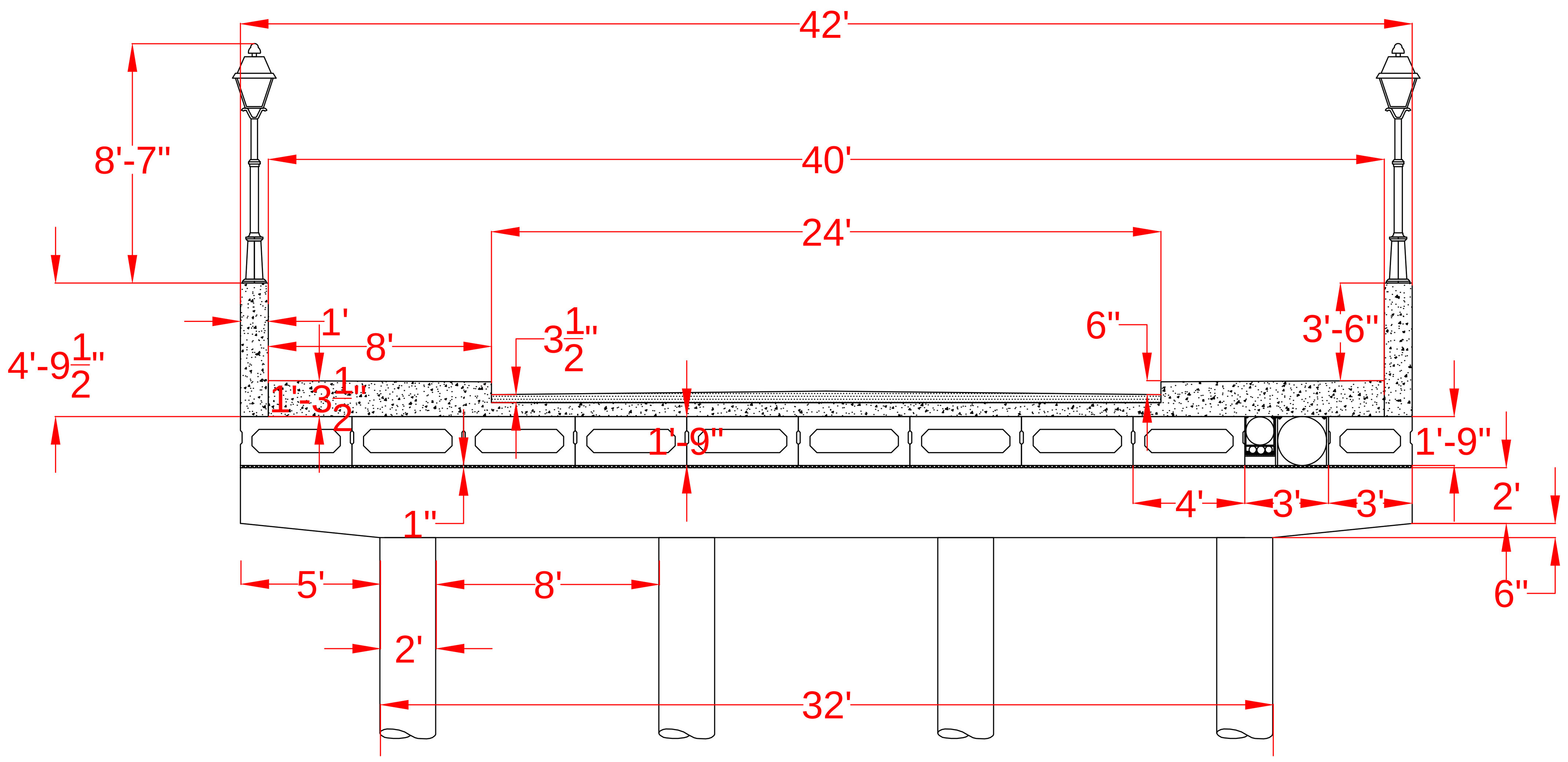
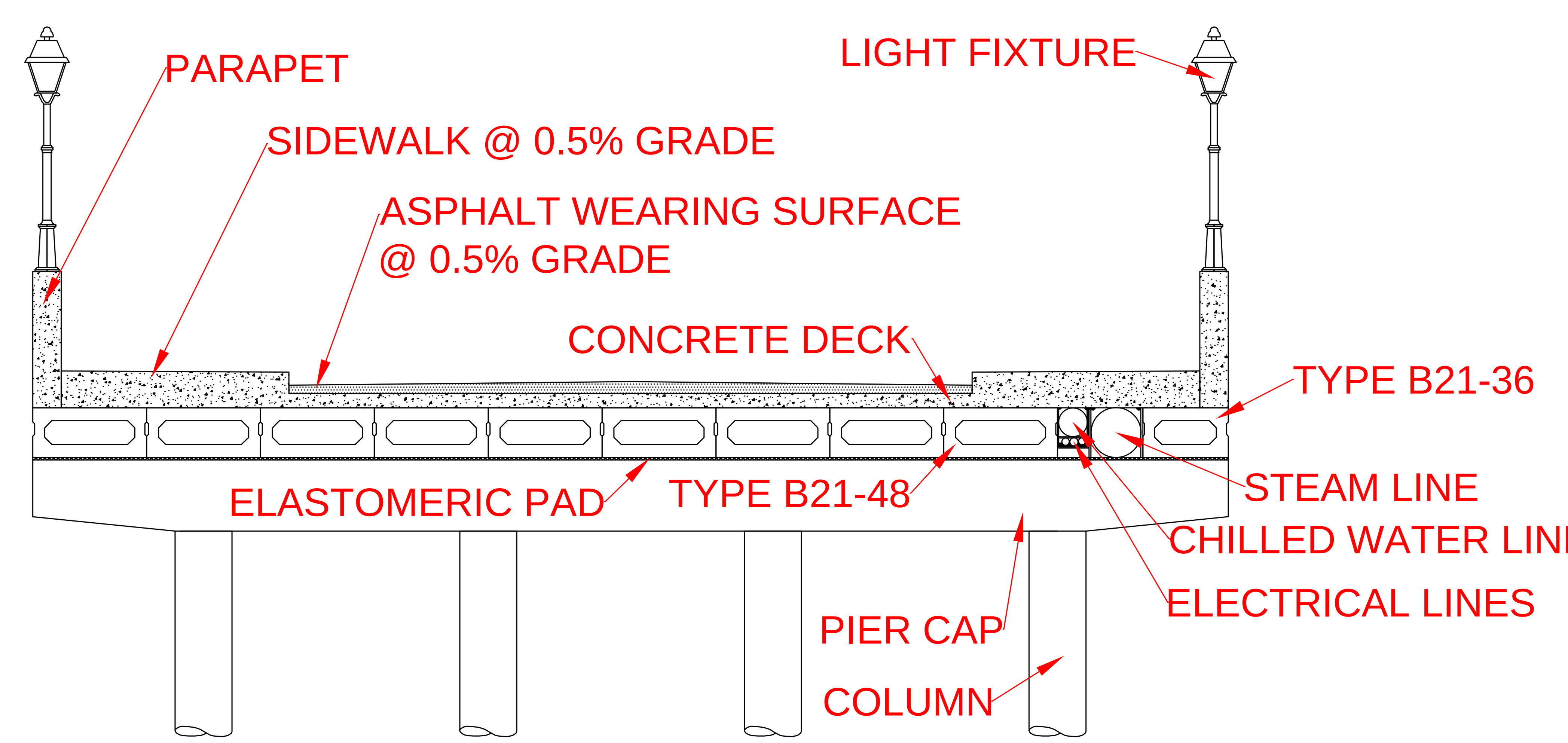


CROSS SECTION DIMENSIONS
SCALE = 1/4" = 1'



CROSS SECTION LABELS
SCALE = 1/4" = 1'

DAVID ROOT BRIDGE
REPLACEMENT PROJECT

CONCRETE BRIDGE DETAILS

SHEET NO.
8

Appendix H- References

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