Wilson

SURVEY/ENGINEERING

STRUCTURAL ENGINEERING STUDY OF RAFT ISLAND BRIDGE, APRIL 2012

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STRUCTURAL ENGINEERING STUDY OF RAFT ISLAND BRIDGE

INDEX

EXECUTIVE SUMMARY

Samples were taken from all pile caps, X-braces, and at least one longitudinal brace between bents 3 and 46. In addition, observations were made of the condition of the condition of the precast/prestressed concrete deck, and compared to earlier engineering surveys [Reference 1].

We conclude that the bridge, after repairs to the substructure (i.e. wooden structure) and other repairs described herein has a 25 year useful life. Inspection costs are $2,800 per year, with total maintenance costs over the 25 year period totaling between $105,000 and $129,000, depending on the scope of remediation.

Note that the costs, in current dollars, are sensitive to inflation and interest rates. For example, if the RIAA is able to get a return on investment in a sinking fund of inflation plus 2.5%, the present value of all costs, including inspection, may be between $130,400 and $148,000. However, forecasting interest and inflation is beyond the scope of Wilson Engineering’s services.

Should the precast deck be replaced throughout with new precast/prestressed concrete units, the bridge has a useful life of 50 years. Costs of annual inspection and maintenance for this option are discussed later in the report.

Note that by obtaining and comparing the estimates of probable construction cost for bridge remediation from reliable contractors, these estimates of future costs can be improved, as explained in the report.

To fully understand these conclusions, it is necessary to read this report carefully, examining the illustrations, tables, and background information presented.

PURPOSE AND SCOPE

The Raft Island Improvement Association (RIAA) contracted with Wilson Engineering to study the potential for long term repair (remediation) of the Raft Island Bridge (RIB). Terms and conditions of service are in the agreement between RIAA and Wilson dated March 27, 2012.

The scope may be concisely stated as follows. Consult the agreement for further detail:

(1) Examine wood X bracing, horizontal bracing, and pilecaps for decay
(2) Refine documentation of condition as sent in Feb 21, 2012 e-mail
(3) Coordinate w/ General Contractors an opinion of probable construction cost for repairs, including pile remediation to preliminary specifications purposely drawn up for this project
(4) Include specifications for an option of an entirely new precast concrete deck
(5) Provide sealed report to RIAA on results, including anticipated annual inspection and maintenance costs

This report should assist in making a decision to remediate or replace the bridge.

SUMMARY OF FIELD WORK

Field work proceeded during times of low tides on April 9, 10, and 11, 2012. These were minus tides that also occurred during daylight hours, allowing safer working conditions, as well as enhancing the ability to make good observations. A 36' ladder was used to allow access to the pilecaps and X- braces.

See Figures 1 and 2 for the definitions of the member designations for the bents and cross braces. (Layperson note: A bent is a collection of piles and its pilecap.) These figures are oriented looking north.

Core samples (1/4") were drilled out of spots on the bents as noted, samples placed in sealable plastic bags, and the cores plugged and sealed. Each sample was labeled by bent number and sample location. Visual inspection was also performed on the cross beams and any other place of interest, such as concrete integrity on bottom of deck. These observations were noted in a field book as they occurred. In addition, more than 200 photos were taken.

Field collected samples were checked again at the Wilson Engineering offices, to confirm conclusions made as to the integrity of the wood. In the great majority of cases, there was no difficulty in judging decayed (wet, dark brown, consistency of pipe tobacco) versus wood in good condition (new in color and often smelling strongly of creosote treatment). When in doubt, members were judged to be unsound.

Results are summarized in Tables 1 and 2. Those members that were sampled were noted with "xx" in the tables. Those members which are judged to be in need of repair are noted as "RIK" for "Replace in Kind." Note that in cases where pilecaps are noted "RIK" pressure injection of epoxy resin is also an acceptable repair method.

REMEDIATION STRATEGY

The strategy is nearly exactly as had been discussed earlier in the February 21 e-mail. It is best summed up by reference to Figures 1 through 6:

1. Replace wood members as noted "RIK" in the Tables.
2. Replace wood members as noted "RIK" in the Tables.
3. Wrap all piles from bents 3 through 46 in fiberglass jackets (made to desired color) and grout them from 2' below mudline to 10.5' elevation, according to the datum established by Aspen Land Survey. The piles would first be cleaned of sea life, reinforcing steel applied around the pile, and the fiberglass jackets zippered into place. Grout would be tremied into the jacket forms. Where bracings intersect piles at a jacket, the bracing would be bolted through the jacket, which would be "tailored" for this purpose.

   Where piles are already wrapped, the existing wrap would be checked for soundness, and if need be, demolished. (None were found to be unsound where informally checked.) Wraps would be spliced to the existing to bring the total length of wrap to the standard noted above.
4. Apply galvanized steel flashing to the tops of guardrail posts, as well as spacers, pilecaps, and cross braces. See Figure 3. Optionally, the W-Section guardrail may also be replaced at this time.
5. Improve the abutments at both ends of the bridge with cast-in-place concrete (or pumpable controlled density fill concrete). See Figure 4.

6. Demolish the existing plate expansion joints, and use traffic quality compressible expansion seals (or bellows type seals) as replacements. This is illustrated in Figure 5.
7. Locally resurface the asphaltic driving surface where water has been seen to pool, allow 3000 sf for preliminary cost exercises.
8. As an option, remove the driving surface and the existing concrete deck units, and replace them with new precast/prestressed concrete units. These would have a preformed crown, so that no asphalt would be required. This is illustrated in Figure 6, and is discussed at further length later in this report.

LIFE OF EXISTING PRESTRESSED CONCRETE DECK UNITS

When evaluating the condition of the prestressed concrete deck units, several aspects have been considered, including experience with similar structures and engineering judgment. Not the least, the history of the RIB is considered.

Design Load and Materials Behavior

The RIB was designed for H15-44 truck loading. Trucks use the bridge, but the mixture of heavy trucks versus automotive traffic is lower than usual for a highway bridge, due to the residential nature of Raft Island. The design of the deck units shows considerable ultimate strength capacity past initial cracking of concrete.

Prestressed concrete behaves differently than reinforced concrete. Prestressing places the concrete in compression, in which it has an inherently high strength. Even after cracking begins due to heavy loads, designs (including the RIB units) allow for an overstrength capacity until the units fail beyond repair. My calculations indicate that the typical spans can carry truck loading without exceeding the initial cracking. The lack of cracking (with very few exceptions, see Ref. 2) seen in the deck units bears this out. Prestressing also works to seal up cracks and reduce microcracking.

Reports of Excessive Chlorides

In considering the description found in Reference 3 of excessive chlorides, the sampling methods, sampling areas, sampling depths, measured chloride levels, or the criteria by which the chlorides were deemed excessive are all of importance but were not stated. These are important distinctions that render the conclusions important, but not at all conclusive. Further, and perhaps most importantly, it is not clear what the nature of the chosen standards were based on, i.e. tests or experience with structures in service.

Concrete is known for exhibiting a wide variability in performance, and generally standards are based on regression lines drawn through data points, with large factors of safety applied. Reference 4 cites maximum allowable chloride levels in concrete ranging from as low as 75 parts per million (ppm) to as high as 3640 ppm – a ratio of 48:1. Clearly, there is a great deal of variability in opinion.

Comparison to Other Structures – Experience on the Oregon Coast

The Ben Jones Bridge, constructed on the Oregon Coast Highway in 1927, is one of the most beautifully sited bridges in the state, on Highway 101 (Ref. 5). It is a major structure, 360' long with a 160' main span, located close to salt spray. It was rehabilitated for corrosion in 2001, according to historical records posted by the State of Oregon – 74 years after construction. Note that it was not prestressed, but ordinary reinforced concrete. Other concrete bridges in southern Oregon, including the Rock Point Bridge (built 1920, rehabilitated 2009, per Ref. 6) have had similar life spans.

Ben Jones Bridge
Photo: Reference 5

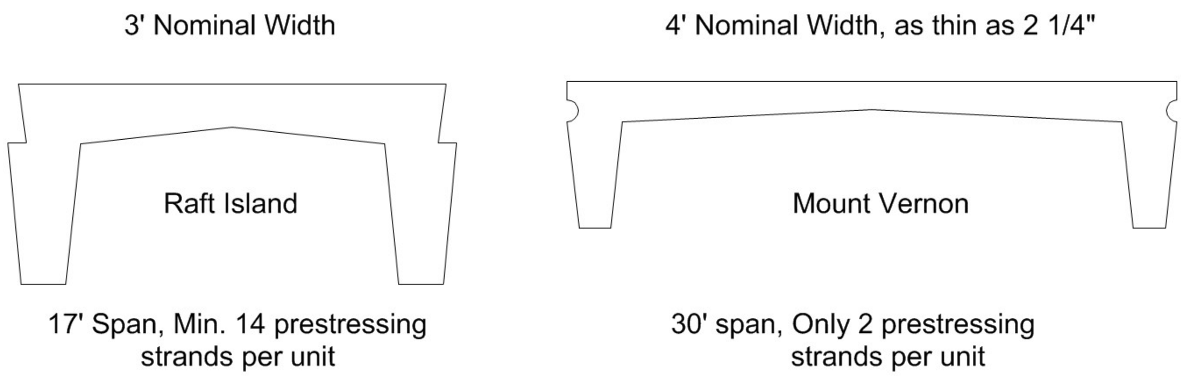
Weathering of Structure in Recent Years

The structure covers approximately 15,500 sf area. With the ribs of the deck units, more than 25,000 sf of surface area of concrete exists on the underside of the RIB. Not even 5 sf of spalls which reached reinforcing had developed since the comprehensive survey six years ago, less than 0.02 percent. This is not indicative of a structure approaching the end of its life. Rust stains are uncommon, and are mainly confined to the low-stressed areas of the diaphragms over the pilecaps.

Comparison to Structure in Mt. Vernon, Washington

The Mt. Vernon structure was built in 1962 out of relatively lightweight prestressed concrete units designed *exclusively* for automotive loads, though heavy trucks access the area without restriction. During flooding of the Skagit River, such trucks are called for to carry sandbags to protect the downtown area. The trucks create very substantial overloads (Ref. 7). I have personal experience with two projects to repair this structure. Fewer than 10 (of more than 350) units were replaced in 1994, while others were repaired in place with epoxy injection, some of which had cracks exceeding 3/8" in width. These units remain in service.

The very fact that this structure is still in use speaks to the fact even grievously damaged precast concrete structures can be repaired in place. Also, it should be noted that the RIB deck units are much stronger than the units used in Mt. Vernon, even though a similar load placed on the 30' span of the Mt. Vernon structure produces three times the bending moment in a RIB unit with a 17' span.



Not only do precast/prestressed concrete have considerable overload capacity, but there are a variety of options for repairs of damaged units.

Conclusion

In summary, the following considerations have been taken into account.

- The units appear to be in good condition at the present time, with virtually no service load cracks.
- "High" (though just how high is not known) chloride levels have been detected. There is not a research consensus, however, as to what levels lead to a damage threshold.
- The units have been repaired, with little deterioration noted in the last six years.
- The units are approximately 55 years old, or about 20 – 30 years younger than concrete bridges exposed to salt spray in Oregon at the time of their remediation.
- The RIB units are much more durable than those in Mt. Vernon, still in service after 50 years.
- If an isolated unit fails, it can be repaired or replaced.

Given the above, a service life of 25 years can reasonably be expected for the concrete deck units.

LIFE & MAINTENANCE OF REMEDIATED BRIDGE: EXISTING DECK PANELS

Discussion of Life Span

The advantages of performing the remediation in one contract is that the work is done pro-actively and takes advantages of economies of scale. The deck is capable of 25 years of life; is the rest of structure?

The piles would last 25 years at the mudline, given the experience of previous wrapping projects and also the repaired pile that is known to have been on the RIB for 14 years and which shows no signs of deterioration at the repair (Ref. 1).

The creosote treatment higher on the piles is still quite visible. Also, the X-bracing serves as a useful reference point in the way in which the wood may deteriorate. The field survey noted that many braces were in generally good condition, hollowed out at their tops, due to wind driven rain, especially from the west. See the photo below, from bent 3 as an illustration.

Note top of X-Brace rotting

The piles are flashed, and are also covered by pile caps that in very few cases are in exceptionally good condition. They are not subject to this type of deterioration, as a result.

The bridge can be serve another 25 years, though there will be repairs required from time to time.

Annual Estimated Costs

These costs are given in *current* dollars below, with the time value of money only briefly discussed.

Inspection costs are $2,800, based on what Wilson Engineering would charge at our fee structure. Maintenance of bracing is based on the replacement of approximately 10% of members in years 4, 8, 12, 16, and 20. Approximate repair costs of $20,000 in each of those five contracts are anticipated. Also, in year 12, allow $5,000 for concrete deck patching / spall repair, and $24,000 for replacement of the existing "W" rail guardrail, which can optionally be done at present. The guardrail costs of $15 per lineal foot are close to those listed in Reference 10.

Note that these are difficult costs to forecast, as they depend on means and methods of contractors and their labor costs as much as material costs. A check on could be made by applying the numbers of bracing members anticipated over the next 25 years to need replacement, or 50%, pro-rata to the opinions of costs that are given by contractors in the coming days.

If the RIAA is able to get a return on investment of 2.5% over inflation, then the present value of all costs comes to $130,387, round to $130,400 to be reasonable. This is including inspection but with the guardrail having been done initially. If the guardrail is left until year 12, then the present value is $148,200. Forecasting inflation of materials and/or labor, as well as the interest rates that the RIAA might get on investments in a sinking fund is beyond the scope of this study, however.

OPTION OF REMEDIATING BRIDGE AND REPLACING ALL DECK PANELS

There are two producers of precast/prestressed concrete in the State of Washington that produce bridge products capable of being used to replace the deck of the RIB. One is Central Premix Prestress, (Spokane) who has supplied projects even in Bellingham. The other producer is Concrete Technology Inc. of Tacoma, who is relatively close to Raft Island and who could barge product to the site. I have had preliminary conversations with technical sales representatives of each company, who have confirmed the statements below.

Central Prestress has a unique Tri-Deck product that may form an economical solution. It can be produced in various depths and in widths from 4' to 7'. Please refer to Figure 6A for an illustration. It could be produced in 5' widths so that one lane could be done at a time with just two widths of deck panels. It comes with a pre-made crown, so no asphaltic pavement is required.

CTC feels that their most economical solution would be to use solid slabs 12" deep, to which they could also add a crown. If desired, two ducts for a moderate post-tensioning could be included so that joints over pilecaps would be precompressed to reduce water intrusion to the substructure.

When asking contractors for pricing opinions on the RIB, the option of a total deck replacement should be explored.

LIFE & MAINTENANCE OF REMEDIATED BRIDGE WITH ALL NEW DECK PANELS

Discussion of Life Span

An entirely replaced deck could be expected to last 75 years. The substructure is discussed below.

After 25 years, the wrapped portions of the piles should still be useful – and if need be, could be jacketed again. However, the piles above the wrap and the bracing members can be expected to be deteriorating at a rate that another large scale remediation would be needed, rather than performing annual or semi-annual repairs. They can also be wrapped, perhaps with FRP or other technologies that are in early adoption stages at this time. If monies were placed into a sinking fund to save for this event, then another round of substructure repairs could be done after 25 years. There would be further inspection and maintenance, to a point at which the bridge is uneconomical, that being when another large repair project is called for.

The life span of a remediated bridge with deck panels all replaced is judged to be 50 years.

Annual Estimated Costs

The costs of the first 25 years are the same as without all new panels, except that the $5,000 for spall patching and the $24,000 for guardrails would not be incurred. Caveats and statements regarding use of costs provided by interested contractor apply in this case as well. However, an additional investment in a sinking fund would be required to cover the anticipated cost of another round of major repairs at 25 years. The further investment at 25 years would be approximately $400,000, based on the preliminary numbers obtained in the recent past from interested contractors, and anticipating that such work would not require as much time spent working on structures submerged by tides. Unfortunately, it is extremely difficult to predict costs of work 25 years into the future.

NOTE ON SEISMIC RISK

The bridge may – or may not – be subject to damage due to soil liquefaction during an earthquake. When loose soils of a certain sand/silt mix are subjected to earthquake motions, the soils may lose their frictional and bearing capacity as loose strata below are densified during shaking, and water comes to the top, creating a “quicksand” condition. In such a condition, piles may temporarily lose their capacity during an earthquake.

Another related risk is lateral spreading, in which soils slump due to lack of bearing capacity during earthquakes. There is virtually no risk from spreading, as the soils in the vicinity of RIB are quite flat.

Some soils are vulnerable to liquefaction, and some are not. It is worth looking at historical records, in the absence of a soils report and analysis.

The University of Washington established a web page (Ref. 8) to collect and disseminate observations following the February 2001 Nisqually Earthquake, which had its epicenter relatively close to Raft Island. Some liquefaction was seen at the Port of Olympia, and “abundant” sand boils at Terminal 30 at the Port of Seattle, were among prominent observations. However, damage to pile supported structures at the Port of Olympia was minor, and in the Nisqually Delta itself, there was “remarkably little evidence of liquefaction or movement.”

A geotechnical engineer that I work with quite a bit suggested that the geotechnical company that is working for you on the potential new bridge will be evaluating liquefaction potential of the foundation soils as part of their process. Therefore, it seems like they could provide useful information regarding liquefaction potential and impacts on the existing piles and bridge performance (Ref. 9).

There are methods of alleviating risk of liquefaction, which might qualify for FEMA monies. A study of how to perform remedial work is not included in the FEMA grant structure. Only after examination of a soils report and analysis might a qualified contractor take on the design/build task of addressing this problem, if it indeed exists.

Based on the observations from the Nisqually earthquake, there is a reasonable chance that the bridge is not vulnerable to liquefaction.

REFERENCES

1 Exeltech Consulting, 2011 Annual Bridge Inspection Report for Raft Island Bridge, July 2011.

2 Exeltech Consulting, 2008 Annual Bridge Inspection Report for Raft Island Bridge, September 2008.

3 Sargent Engineers Inc., Raft Island Bridge Condition Evaluation, Project No. A04208.00, April 2005 Available on RIAA website

4 Federal Highway Administration, FHWA-RD-02-107, Chapter 1, available online.

5 Web page for Oregon State University School of Civil and Construction Engineering

6 Daily Journal of Commerce Oregon, May 26, 2011.

7 Reports on file at Mt. Vernon Public Works, and photos of the parking structure (including at flood stage) are included with the Wikipedia article about Mt. Vernon.

8 http://www.ce.washington.edu/~nisqually/geo/facts_and_figures.html

9 Personal communications with J. Robert Gordon, P.E.

10 www.wsdot.wa.gov/NR/...D409.../CableBarrierssubmittalforTRB.pdf

11 United Facilities Criteria, Maintenanace of Waterfront Facilities, UFC 4-150-07, June 2001.

APPENDIX A: Figures and Tables

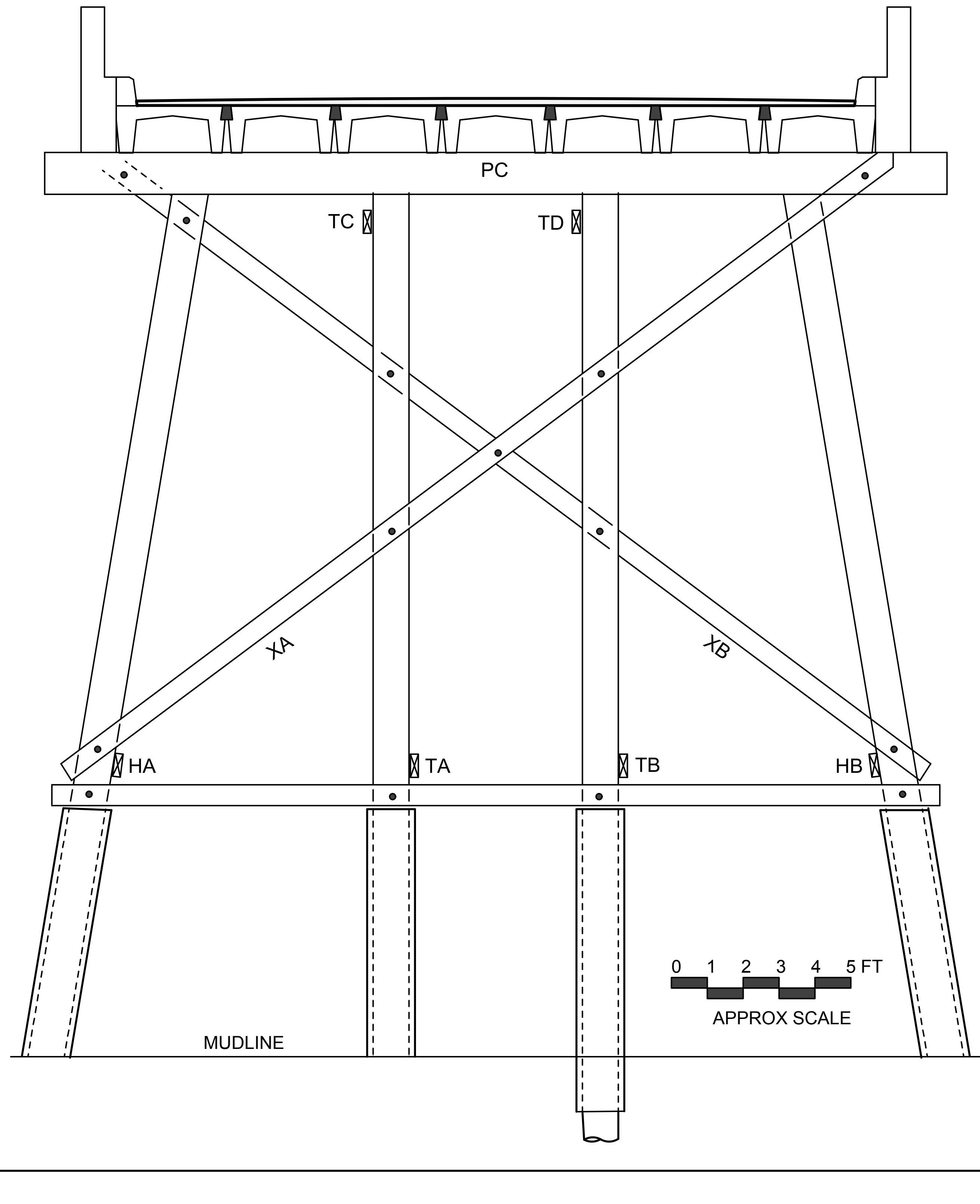
PROJECT RAFT ISLAND BRIDGE STUDY

PROJECT # 2012-046 REFERENCE **FIGURE 1**

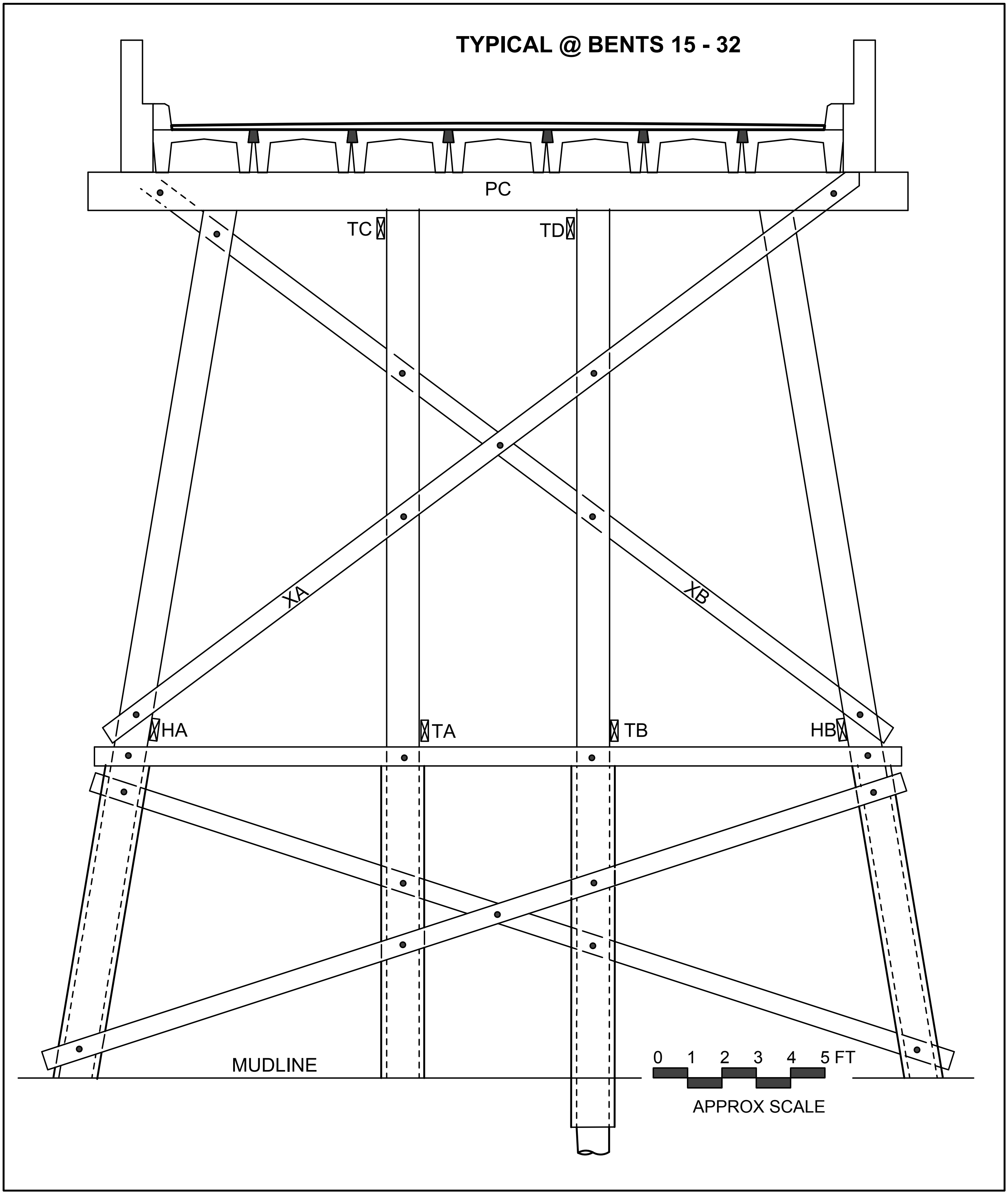
SUBJECT FIELD INVESTIGATION OF APRIL 9 - 11, 2012

RESULTS / KEYED TO RECOMMENDATIONS

TYPICAL @ BENTS 3 - 14 & 33 - 46



PROJECT	RAFT ISLAND BRIDGE STUDY
PROJECT #	2012-046 REFERENCE **FIGURE 2**
SUBJECT	FIELD INVESTIGATION OF APRIL 9 - 11, 2012
	RESULTS / KEYED TO RECOMMENDATIONS



PROJECT	RAFT ISLAND BRIDGE STUDY		
PROJECT #	2012-046	REFERENCE	FIGURE 3
SUBJECT	RECOMMENDATIONS FOR POTENTIAL UPGRADE		

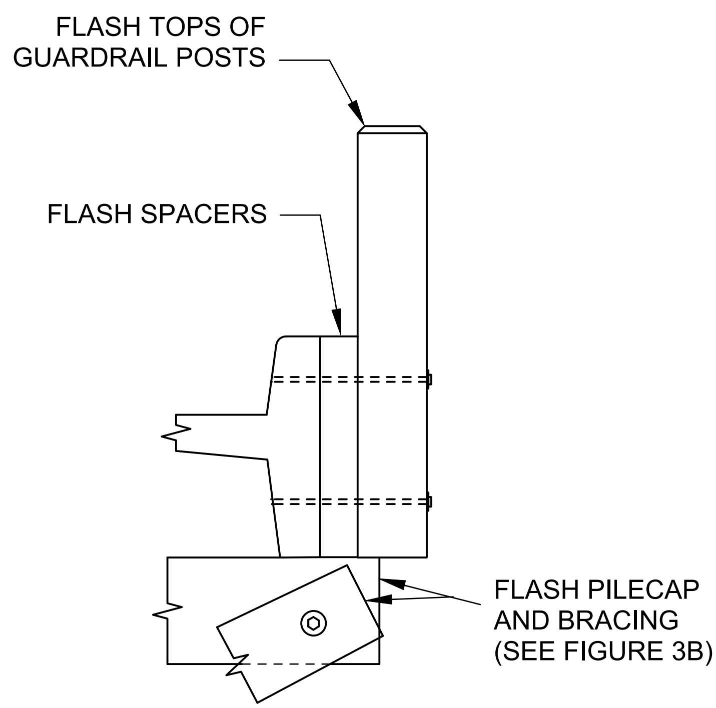


FIGURE 3A - GUARDRAIL POST FLASHING

FIGURE 3B - PILECAP AND BRACE FLASHING

PROJECT	RAFT ISLAND BRIDGE STUDY		
PROJECT #	2012-046	REFERENCE	**FIGURE 4**
SUBJECT	RECOMMENDATIONS FOR POTENTIAL UPGRADE		

SEE FIGURE 4B BELOW

FIGURE 4A - AREA OF APPLICATION AT ISLAND END, MAINLAND END SIMILAR

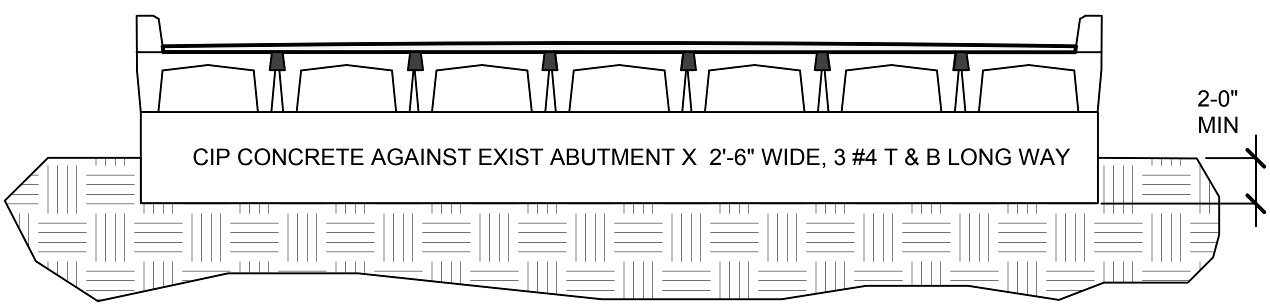
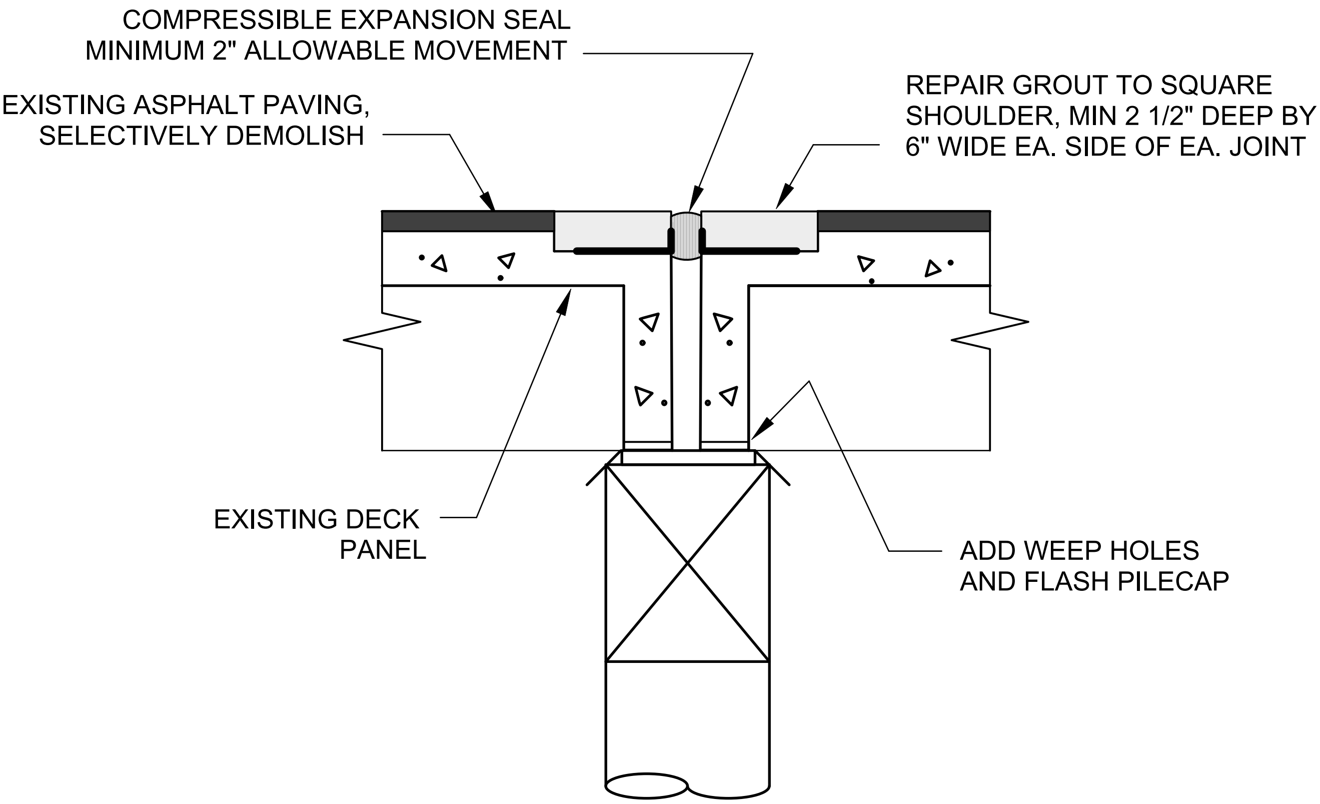


FIGURE 4B - TYPICAL ABUTMENT UPGRADE

PROJECT	RAFT ISLAND BRIDGE STUDY		
PROJECT #	2012-046	REFERENCE	**FIGURE 5**
SUBJECT	RECOMMENDATIONS FOR POTENTIAL UPGRADE		



NOTE: MECHANICALLY ANCHOR EXPANSION JOINT SEAL TO GROUT WITH BOLTS OR FLAT BARS ATTACHED TO DECK BELOW GROUT

FIGURE 5 - CONCEPT FOR REPLACEMENT OF EXPANSION JOINT

PROJECT	RAFT ISLAND BRIDGE STUDY
PROJECT #	2012-046 — REFERENCE **FIGURE 6**
SUBJECT	RECOMMENDATIONS FOR POTENTIAL UPGRADE

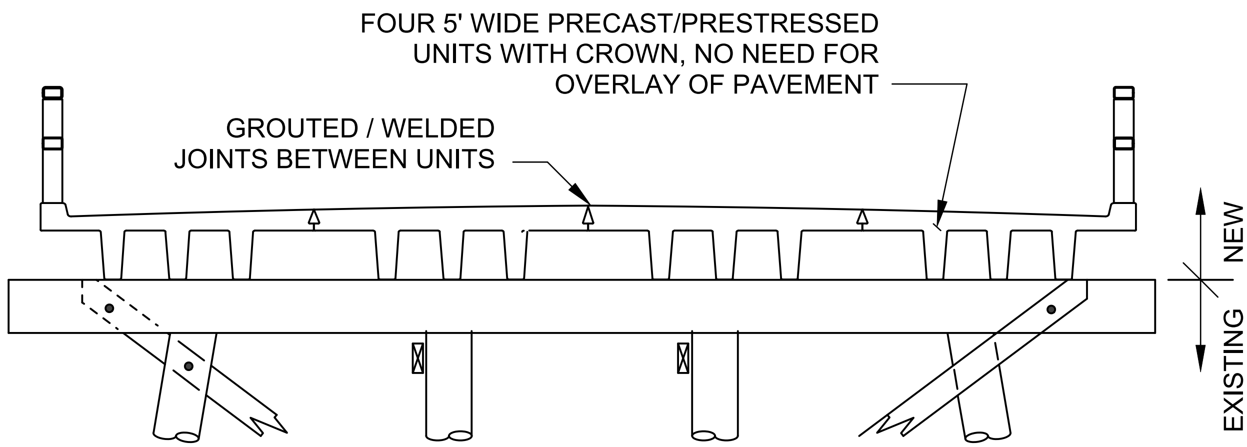


FIGURE 6A - TRI BULB CONCEPT

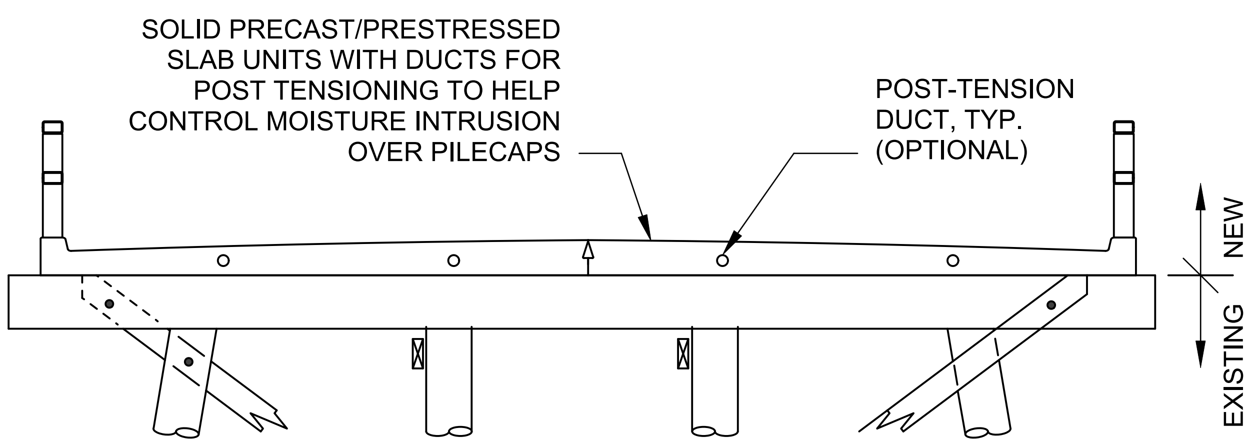


FIGURE 6B - SOLID SLAB CONCEPT

Raft Island Bridge Evaluation, April 2012 **TABLE 1**

CAP #	PC	XA	XB	NOTES
3	xx	xx	xx	OK
4	xx	xx	xx	OK
5	xx	xx	xx	OK
6	xx	xx	xx	OK
7	xx	RIK	RIK	Sand up to X-braces
8	xx	xx	xx	OK
9	xx	RIK	xx	XA spliced
10	xx	xx	xx	OK
11	xx	xx	xx	OK
12	xx	xx	RIK	XB shows rot
13	xx	xx	xx	OK
14	xx	xx	xx	PC checked @ ends
15	xx	xx	xx	OK
16	RIK	xx	xx	PC shows rot at CL
17	xx	xx	xx	OK
18	xx	xx	xx	OK
19	xx	xx	xx	OK
20	xx	xx	xx	OK
21	xx	xx	xx	OK
22	xx	xx	xx	OK
23	RIK	xx	xx	PC shows rot at CL
24	xx	RIK	RIK	XA & XB bad
25	xx	xx	xx	OK
26	xx	RIK	RIK	XA shows rot
27	xx	RIK	RIK	XA & XB bad
28	xx	RIK	RIK	XA & XB bad
29	xx	RIK	RIK	XA & XB bad
30	xx	RIK	RIK	XA & XB bad
31	xx	RIK	RIK	XA & XB bad
32	xx	RIK	xx	XA bad
33	xx	RIK	xx	XA bad
34	xx	RIK	RIK	XA & XB bad
35	xx	RIK	xx	XA & XB bad
36	xx	RIK	RIK	XA & XB bad
37	xx	xx	xx	OK
38	xx	xx	RIK	XB bad
39	xx	xx	RIK	XB bad
40	xx	RIK	RIK	XA & XB bad
41	xx	RIK	xx	XB bad
42	xx	RIK	RIK	XA & XB bad
43	xx	RIK	RIK	XA & XB bad
44	RIK	RIK	RIK	XA & XB bad
45	xx	RIK	RIK	XA & XB bad
46	xx	xx	xx	OK

Raft Island Bridge Evaluation, April 2012 **TABLE 2**

CAP #	TA	TB	TC	TD	HA	HB
3		xx	xx			
5	xx		xx			
7	xx		xx			
9	xx			xx		
11		xx		xx		
13	xx			xx		
15		xx	xx			
17	xx			xx		
19		xx	xx			
21	xx			xx		
23						
25	xx		xx			
27	xx RIK	RIK	RIK	xxRIK	RIK	RIK
29	RIK	xx RIK	xx RIK	RIK	RIK	RIK
31	RIK	xx RIK	x RIK	RIK	RIK	RIK
33	xx RIK	RIK	RIK	xx RIK	RIK	RIK
35		xx	xx			
37	xx		xx			
39		xx	xx			
41		xx		xx		
43		xx		xx		
45		xx				

Note: By this system, all "T" braces, parallel to the span of the bridge, are numbered at the lower-numbered bents. Figures 1 and 2 show them as they are typically oriented (E and W connections to piles) on the odd - numbered bents. By this convention, Figures 1 and 2 views looking north.

Horizontal braces (HA and HB) were checked visually. Tie braces, bent to bent, were checked for the brace at each bent, nearest the mudline, that visually appeared to be the worst of a set. For brevity, only the odd numbered bents are given in the table. So, for example, TD at pilecap 3 was checked as it attached low to pilecap 4 (i.e. the equivalent of TA at PC 4).

APPENDIX B: OPTIONS TO PROVIDE CONTRACTORS FOR OPINIONS OF PRICING

1) Repair of piles and bracing, abutments, expansion joints, as described in Appendix A and the report

2) Same as above, with the addition of new "W" section guardrail for the entire bridge

3) Same as 1), with the addition that all precast decks would also be replaced

In all cases, the contractors shall consider the standards for pile repair contained in Appendix C

APPENDIX C: GUIDE SPECIFICATION

REPAIR OF TIMBER PILES WITH EPOXY RESIN OR CEMENTITIOUS GROUT

CONTENTS

1. GENERAL

This Part covers the repair of piles by encapsulating the timber in cementitious grout. Alternatively, a method using epoxy resin is may be proposed by the contractor for review by the Engineer of Record. It is the responsibility of the contractor proposing this alternate to demonstrate that such a method achieves the same results in terms of strength and design life as a cementitious grout encapsulation.

The Contractor shall inspect all piles at the site, and familiarize himself with the working conditions and the conditions of the piles.

2. MATERIALS

The Contractor shall supply all materials required for the repair of the piles.

The proposed grout / concrete mix shall be limited to 3/8" max. dia. aggregate, with min. 4000 psi compressive strength (28 days), and polyethylene fibers such that a modulus of rupture of 800 psi per ASTM-C78 is achieved. Water for the mix shall be potable.

Jackets shall be of nylon or other durable fibers that have demonstrated in previous service (see Part 4, Warranty) a 20 year life in saltwater applications.

3. METHODOLOGY

The Contractor shall undertake the repair in accordance with a Contractor's Methodology Statement, stating all the steps that will be required to produce durable repairs. At a minimum, this statement should include:

- Method of removing remove marine growth, debris and decomposed timber in a manner consistent with environmental permits
- Method of installing jacket to a minimum of 2' below mudline to 10.5' (baseline per Aspen Land Survey, April 2012)
- Method to accommodate bolting to replaced bracing timbers
- Method of installing jackets where there are already partial-length jacketed piles

The jackets shall be sized to allow an average minimum 4" clear around the diameter of the existing piles, with spacers to maintain this clear cover to no less than 3" at any point.

Grout shall be installed into the jacket by the tremie method, taking care to prevent the intrusion of seawater.

The work shall proceed, in general, as described in Navy and Tri-Services Manual UFC 4-150-07, June 2001 regarding the in-situ repair of piles.

4. WARRANTY

The Contractor shall have experience in repair of piles, in salt water, using the techniques proposed for the Raft Island Bridge. The Contractor shall show that such piles are still in service after 20 years, and provide documentation to the RIAA Project Manager.

The Contractor shall warrant all repair work for a period of 2 years, including but not limited to the loss of strength of the epoxy or grout, erosion of the product under the action of seawater, reduced flexibility and cracking.

5. PAYMENT

Progress payment for pile repair will be made pro-rata based on the number of piles completed in a pay period versus the total number in the contract. Piles shall not be accepted for payment until all repairs are done, including removal of marine growth, jacketing, grouting, and the demolition & replacement of timber bracing.