Repair Recommendations

The repairs needed for the Bonner Bridge were determined during the various stages of the NBIS inspection and the in-depth assessment. During the NBIS inspection deteriorated elements that, in the opinion of the inspector, needed prompt attention to keep the bridge functioning properly and to keep the general public safe, were reported to NCDOT in "Prompt Action" notifications. For details of these notifications, please refer to the NBIS Bridge Inspection Report.

Part of the scope of this assessment was to develop repair recommendations necessary to provide adequate structural capacity for the elements that were determined to be insufficient to carry the current HS20-44 design loading and other loadings described in the structural analysis section. These structurally deficient elements include the deteriorated piles identified during the in-depth assessment and the concrete caps in spans 196, 197, and 198 that had insufficient shear capacity.

Significant deterioration is occurring to the structural elements of the bridge. If the deterioration is not addressed, the structural capacity will continue to degrade over time. Therefore, the majority of repairs are recommended for the purpose of either stopping or slowing down the rate of corrosion of structural elements so that they may continue to provide adequate structural capacity for another ten years or until the year 2016. As described in the discussion of corrosion related deterioration, water, oxygen, and chloride ions are necessary for the corrosion of reinforcing steel. The main source of water that is contributing to the deterioration of the end diaphragms, ends of girder, bearings, bent caps, and tops of columns comes from leakage through the deck expansion joints. Therefore, to stop this continual recharge of water, the consultant team recommends the replacement of all of the expansion joints on the bridge.

In order to stop or slow the corrosion process, delaminated concrete needs to be removed, the reinforcing steel cleaned, and the concrete cover replaced with a cementitious or epoxy repair mortar. Large and deep areas of concrete repair are recommended to be accomplished with shotcrete. Shotcrete is the most economical solution for large and deep repair areas. However, shotcrete repairs require an experienced and well qualified nozzle operator to control the shotcrete process. The consultant team highly recommends the prequalification of shotcrete contractors that have successfully performed high quality repairs under similar working conditions.

Often, due to the chlorides remaining in the existing concrete, delamination and spalling begin to occur adjacent to repaired areas. Therefore, to extend the life of the repair and to keep the adjacent concrete from spalling, the consultant team recommends the use of passive cathodic protection by the installation of sacrificial zinc anodes embedded into the repair at regular intervals. Repairs with passive cathodic protection can be expected to protect the reinforcing steel adjacent to the repairs for approximately 10-15 years.

In addition to the spall/delamination repairs, cracks should be filled to prevent the migration of water, oxygen, and chlorides to the reinforcing steel. Filling or sealing cracks can be accomplished with either epoxy or chemical grouts or gels. Epoxy injection is typically used for structural repairs whereas chemical grouts react with water to fill and seal off cracks. Cracks that are 1/32" or greater in width are recommended to be injected with a hydrophilic or hydrophobic chemical grout to seal off water intrusion through existing cracks.

After the above repairs are completed, the consultant team recommends cleaning and coating the existing and repaired concrete surfaces with a silane or siloxane sealer. The sealer would act as a waterproofing barrier to minimize the migration of water, oxygen, and chlorides through concrete surfaces to the reinforcing steel. As shown in the chlorides vs. depth of penetration graph *(Fig. 29)*, the existing concrete has significant chloride levels 2”-3” or deeper into the concrete surface. The silane sealer will significantly reduce the charging of water to the existing surfaces and minimize the transport of chloride ions to the reinforcing steel that causes the corrosion process.

The steel spans require repair or replacement of corroded members including end diaphragms, lateral bracing, and bearings. In addition, the steel should be repainted to protect the steel from further corrosion. As a minimum, the steel girders should be spot cleaned and painted.

The cored slab spans (123-128B) and associated bents are new and in relatively good condition. Therefore, no repairs are recommended for these spans.

Alternative Repair Methods

Alternative repair methods evaluated included fiber mesh wrapping (FRP composites), wire wrap, and steel strengthening, chloride ion extraction, and comprehensive cathodic protection systems. Fiber mesh wrap, wire wrap methods, and steel strengthening require the concrete substrate to be in sound condition. According to the FHWA FRP paper titled *“FRP Composites Technology Brings Advantages to the American Bridge Building Industry,”* the concrete surface requires some preparation to ensure the substrate is sound and of good structural integrity. The article states “Deteriorated concrete or delaminations must be removed. Spalled surfaces must be built up to provide a level and flat surface for bonding the aligned fabric sheets or laminate. Sharp edges and corners must be rounded to prevent a knife edge action on the fabric… Moisture problem must be corrected before using composites bonded repairs because ambient-cured organic material adhesives are problematic in wet environments”.

For any of the alternative repair methods, spalls and delaminations would need to be repaired prior to adding any wrap or other strengthening systems. Since strengthening is not required and the repairs are only required to provide ten years of service life, it is the opinion of the consultant team that these alternative repair methods are an unnecessary expense and they were not investigated further. Conventional repair methods will result in a ten-year service life; therefore, chloride extraction and comprehensive cathodic protection systems also would only be considered if the required service life was well beyond ten years.

Substructure

Narrative and Sketches of Proposed Repairs

The purpose of the proposed repairs is to limit further deterioration, not to increase structural capacity. The dead load has transferred to the reduced section, so unless the dead load can be temporarily supported during the repair, it will continue to act on the reduced section. The live load could act on the full rehabilitated section if repairs were constructed without live load, an unlikely scenario.

The damaged areas can be broken down into three categories: spall/delamination (dry), spall/delamination (near/below the water surface), and cracking. The difference between the two types of spall/delamination is critical since a wet concrete surface requires a different repair method. Regardless of the repair method used, the section should be repaired to the section's original dimensions. Figure 35 below describes a typical spall/delamination repair.

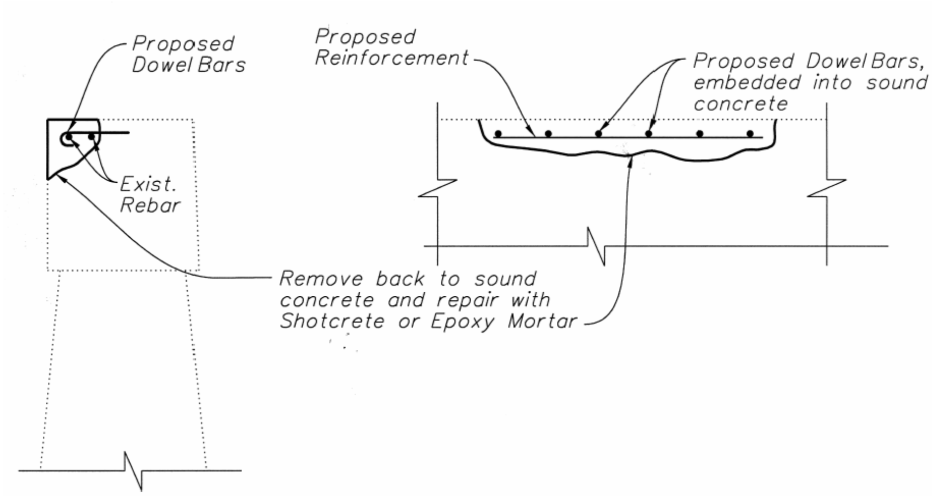

Figure 35. Typical spall/delamination repair.

Spall/Delamination Repairs

The bent caps, columns, and struts exhibit two primary types of damage: spall/delamination and cracking. The repair procedures will be the same for each component. The spall/delamination repair will be performed by shotcrete patching or a trowel applied patch. However, it is essential that all delamination be removed and the surface be properly prepared before the repair installation proceeds. If the delamination is not completely removed, further deterioration and spalling is likely to occur soon after the repair is complete.

It is recommended that the patch repairs be made immediately after removal of the delaminated sections to ensure a good bond. Also, since large sections of the high level span bents will require removal of delamination, the consultant team recommends limiting the amount of the removal between repairs. The purpose of this limitation is to prevent potential instability of the bent due to inadequate confinement of the reinforcing steel. This limitation is especially important for the bent columns, where no reinforcement ties are present to confine the longitudinal reinforcement.

The recommended repair procedure for spalled and delaminated sections is as follows:

1. Remove all spalled/delaminated material (with limitation described above).
2. Clean and roughen surface via high pressure wash.
3. Install anchor bars, wire mesh, etc.
4. Place concrete patch (shotcrete, trowel applied cementitious material, or epoxy mortar)
5. Roller apply silane sealer (once patch is cured)

The repair of the spall/delamination damage on the pile cap (i.e. near or below the water surface), will be accomplished through epoxy mortar patching. As with the shotcrete patching, all deteriorated concrete must be removed and the surface prepared before installing the epoxy mortar.

Crack Repair

The suggested repair for the cracking is epoxy resin or chemical grout injection. Cracks larger than 1/32” are recommended to be repaired. Cracks less than 1/32” are difficult to properly inject. Surface sealing of cracks less than 1/32” is recommended.

For the epoxy resin or chemical grout injection, the procedure involves two major steps. First, the crack is cleaned utilizing a high pressure wash. The next step will depend on which injection material is used. For the epoxy resin injection, the crack must be dry before injecting the resin. For the chemical grout injection, a wet surface is desirable as the chemical grout reacts with water, expands and fills the void of the crack while adhering to the concrete.

Pile Repairs/Pile Jackets

Seven piles were identified in the Underwater Report as significantly deteriorated and pile jackets are recommended. These piles were located at Bent 129 – Pile 5, Bent 144 – Piles 2 and 9, Bent 146 – Piles 6, 12, and 16, and Bent 159 – Pile 7. The structural pile jackets are to be installed over the length of deterioration for the seven identified piles.

Penetrant Sealer

Another key component of the repair process is a penetrant sealer. The purpose of the sealer is to limit the infiltration of water and chlorides into the concrete. The sealer should be roller applied to all concrete surfaces of the bents, whether or not repaired. The sealer manufacturer requires the surface to be dry; therefore, applying sealer to the sides and bottom of the pile cap was not included in the engineer’s opinion of cost. Application to the sides may or may not be possible.

If all the repairs described above are not implemented, the members will continue to deteriorate and will likely incur stresses beyond what they are capable of resisting. This could lead to future posted load limits and even the eventual closing of the bridge.

Concrete Girder Spans

Narrative and Sketch of Proposed Repairs

The intention of the proposed repairs is to limit further deterioration and, in the case of the slab, to increase structural capacity. The damaged areas of the slab, girders, and diaphragms were broken down into two categories: spall/delamination and cracking. For the spall/delamination repairs, it is recommended to repair the section to its original dimensions.

Concrete Slab

The spall/delamination damage is recommended to be repaired by shotcrete patching of the slab. Shotcrete should be applied in accordance with the manufacturer’s recommendations, including recommendations regarding live load on the slab. Figure 36 below describes a typical slab repair.

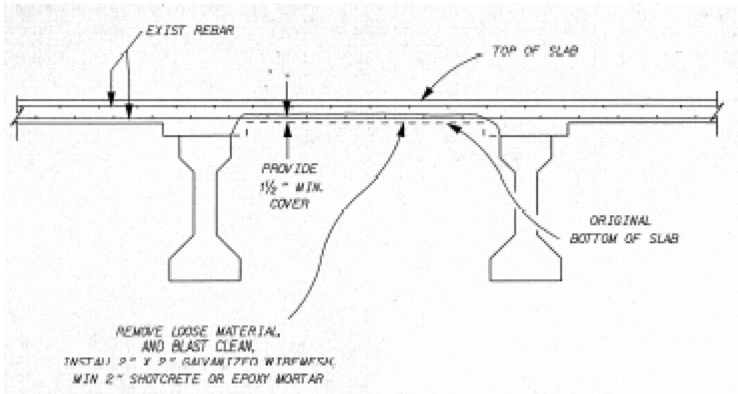

Figure 36. Typical slab repair

45" AASHTO Girders
For the girders, it is recommended that the spall/delamination damage be repaired by epoxy mortar patching, either trowel applied or pumped into a form. Figure 37 below describes a typical girder repair.

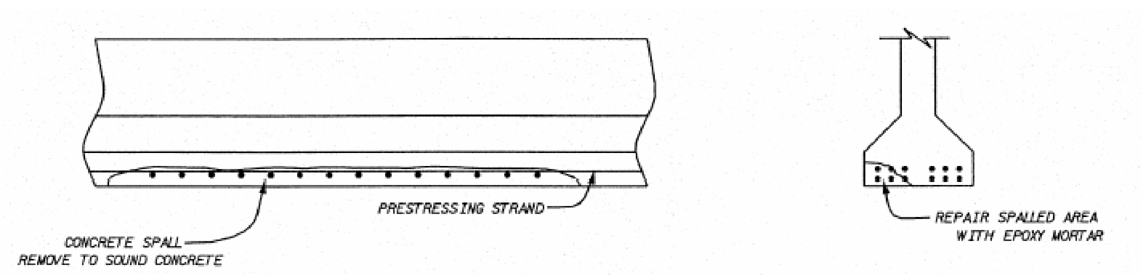

Figure 37. Typical girder repair

It is essential that all delaminated concrete be removed and the surface properly prepared before installation of the epoxy mortar proceeds. If the delamination is not removed, further deterioration and spalling is likely. The suggested repair for the cracking damage is epoxy resin or chemical grout injection. Cracks larger than 1/32" will require injection.

Steel Girder Spans

Narrative and Sketch of Proposed Repairs

Concrete Slab
The intention of the proposed repairs is to limit further deterioration and, in the case of the slab, to increase structural capacity. The types of damage to the concrete slab are the same as those described in the concrete superstructure discussion—spall/delamination and cracking. Repairs are also similar. Figure 38 below describes a typical slab repair.

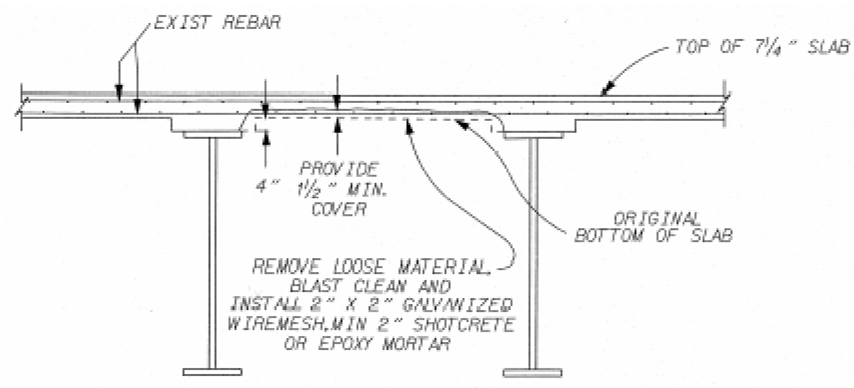

Figure 38. Typical slab repair.

Welded Steel Plate Girders

For the steel girder spans, the repairs involve three major components: the bearings, end diaphragms/lateral bracing, and girders.

Bearings

The bearings appear "frozen" (i.e. allowing no movement) due to corroded steel build up on the formerly moveable components of the bearings. The recommended repair is to replace the entire bearing assembly. Failure to replace the corroded bearings with properly functioning bearings could result in stresses on the bridge components for which they were not designed and could hasten further deterioration of the bridge.

End Diaphragms and Lateral Bracing

At the end diaphragms and lateral bracing, the deteriorated expansion joints above the steel have allowed water to wash over the steel resulting in loss of section due to corrosion. Complete replacement is recommended for the end diaphragms. For the lateral bracing, only those members in the 2 bays adjacent to the end diaphragms at Bents 143 and 146 need to be replaced.

Girders

While the girders showed extensive oxidation and the paint was in poor condition, no major section loss was observed. Therefore, the girders, as well as all other steel components (end diaphragms, lateral bracing, etc.), require painting. If the girders are not painted, then the oxidation will increase, the paint condition will continue to deteriorate, and section loss (with its accompanying strength reduction) will begin. The loss of section reduces the area of steel available to resist loads, thus increasing the stress in the steel. As section loss increases, the incremental loss has an exponential effect on increasing stress in the steel. The loss of the second 10% of the section, for example, would have a much greater impact on the girder stress than the loss of the first 10%.

Recommendations

The repair procedure for spalled/delaminated sections and epoxy resin/chemical grout injection is the same as that described in the concrete superstructure discussion. The bearings can be replaced with the same bearing type as is currently in service. An option worth exploring would be to use elastomeric bearings. However, if elastomeric bearings are used, it is likely that a concrete or structural steel buildup on the bent caps will be required to accommodate the height difference. This can be further evaluated during the design of the repairs. The typical replacement diaphragm would likely be a K-frame with a steel channel as the main member and steel angles as the secondary members. The end diaphragms should be replaced one bay at a time. The lateral bracing will be replaced with a member of the same size as currently in use on the bridge. The girders, end diaphragms, and lateral bracing are recommended to be painted using a 3 coat system: inorganic zinc primer, epoxy intermediate coat and urethane top coat. Before painting, all surfaces should be thoroughly cleaned by blasting.

For Bents 196 to 198, it is recommend that an additional concrete subcap be placed beside the existing exterior subcaps at the location of the exterior girder. While this repair is not needed immediately, it is recommended that it be done with the NBIS repairs at these three bents. Refer to Figure 39 for the proposed supplemental cap repair.

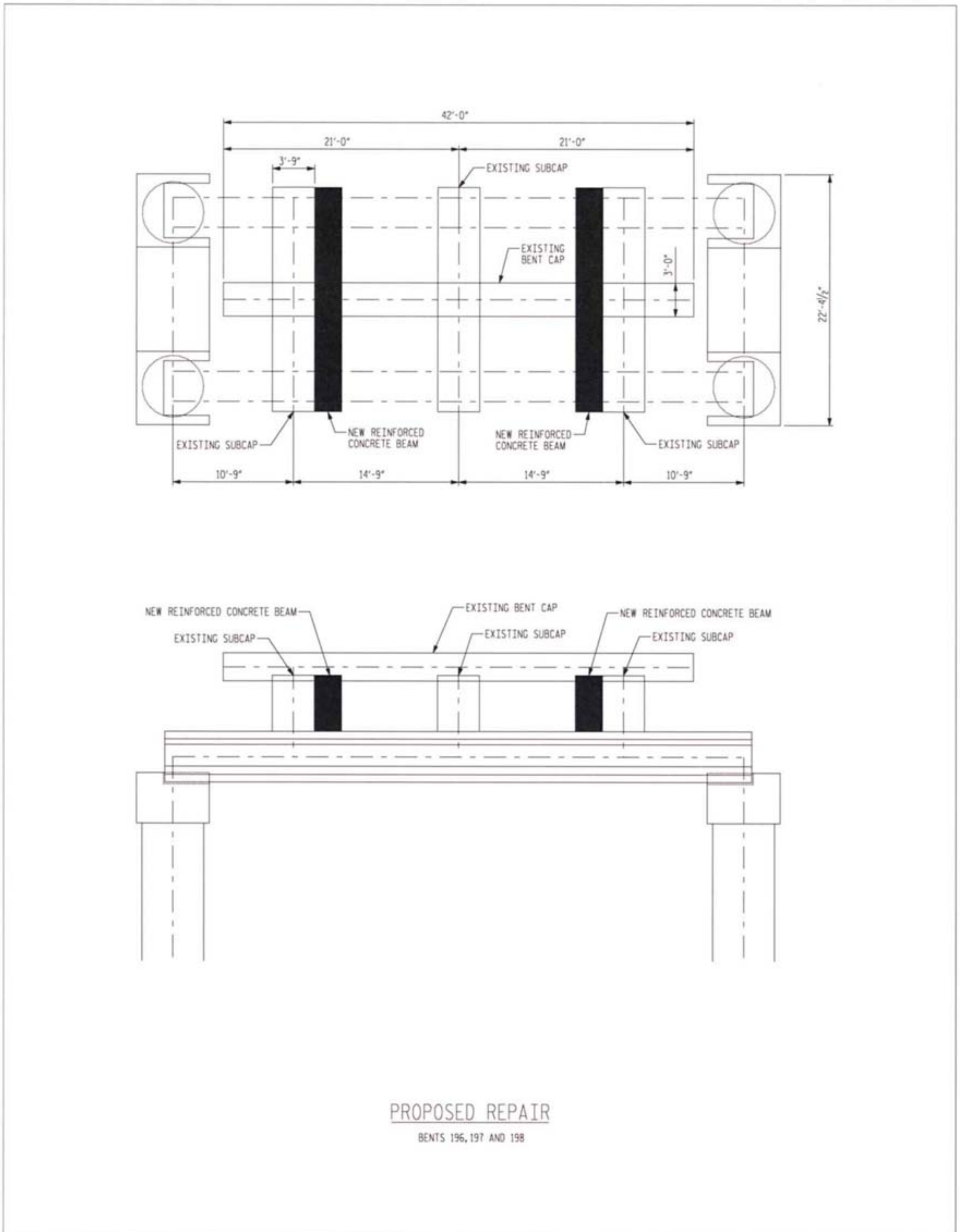

Figure 39. Approach bent cap supplemental support.

Summary of Opinions of Construction Costs

The opinions of probable construction costs presented throughout this assessment were developed from the quantity of cracks, spalls, delaminations, and other deterioration and defects identified during the field investigation. The deterioration and defects are shown graphically in appendix B.1 through B1.10 and quantified in Appendix C. The cost estimates are based on the assumption that all of the repairs are made. Many of the delaminations are small in size and do not merit as high a degree of concern as large delaminated areas. The decision of which specific defects to repair should be made during the development of repair plans. However, if these repairs are delayed, repair costs will likely increase and defective areas left untreated will continue to degrade over time.

Discussion of Repair Costs

The Oregon Inlet presents an extremely difficult, harsh, and challenging construction environment for accomplishing repairs to the Bonner Bridge. Contractors that have worked on the Bonner Bridge over the years attest to the harsh work environment and have noted many challenges that affect efficient and timely construction activities and limit production rates. These challenges can cause a significant increase in bid prices associated with making repairs to this structure. Some noteworthy factors to be considered in estimating probable construction costs in the outer banks coastal environment in Dare County which may not be typical of bridge repairs within other parts of the State include:

- ever- changing weather patterns
- strong tidal flow and swift currents
- specialized under-bridge access equipment
- difficult boat and barge operations for staging workers materials, scaffolding and equipment while maintaining ship navigation
- structural configuration of the bridge that limits equipment access and creates difficulties with traffic control
- operations during tourist season that limit construction activities to nighttime operations

Wind is a daily factor that needs to be considered when performing repairs. Typical wind speeds on the bridge can often exceed 30 mph. High winds can shut down construction operations particularly in the Spring and the Fall. High winds also cause challenges with proper curing of cementitious repair materials, resulting in excessive shrinkage and cracking in the surface of the repair. This can allow chlorides an avenue to the reinforcing steel and result in reduced concrete strength and diminished life expectancy of the repair.

The tidal currents experienced in the area of the bridge are strong and swift and there is a minimal period of slack tide (2-3 hours per day) during which underwater repair operations can be performed. Maneuvering and mooring construction boats and barges in and around the bridge piers during windy conditions with sizable swells can be a challenge for boat captains. When construction activities are located within or near the main channel, coordination with the US Coast Guard is required. Navigation through the main span during less than desirable boating conditions can be difficult as is evidenced by the damage to the fender system.

High mobilization costs are typical for repair work on this bridge due to the high cost of under-bridge access equipment, boats and barges, foul weather and high insurance costs. Under-bridge access equipment is usually limited by a lower reach of 25-30 feet. Since the high level span bents are up to 65 feet high, barges will be necessary for working platforms to repair the lower sections of the high level bents. When under-bridge access equipment is positioned on the deck of the bridge, traffic control is required to allow for safe travel of the public. Traffic control is further complicated by the limited sight distance at the horizontal and vertical curves on the bridge.

The tourist season adds to the difficulty of working on the Bonner Bridge. Before Memorial Day and through the summer months until after Labor Day construction is generally limited to nighttime work with no work permitted during weekends. Nighttime operations can create significant additional costs in construction due to lighting operations and higher wages. The summer months are typically the most productive construction months due to the extended daylight and, therefore, contractors may charge a premium for having crews working nighttime hours in lieu of the productive daylight hours.

Unit Construction Cost Estimates

Unit cost estimates for the various repair items recommended in this report were researched by the team members and discussed at length. Recent unit costs for relevant construction items were obtained from the NCDOT estimates office, Florida DOT (FDOT) database, manufacturers, suppliers, contractors, and NCDOT Bridge Maintenance specifically for recent repairs to the Bonner Bridge. Unit costs and mobilization costs experienced through the bidding process will be affected by how the NCDOT groups the repairs, determines the number of contracts, and the times of the proposed construction contracts. The unit costs will also be affected by the availability of manpower, equipment, materials, and weather patterns at the time of each contract. There are many factors that can affect contractor's bid prices that are known only to the contractors themselves. These include items such as their backlog, their knowledge of the work, past experience, knowledge of the area, the number of contractors available to bid the specific types of work, and each contractor's proposed means and methods for completing the work. The following list contains unit costs for the various repair items that have been identified within this report.

Integral Pile Jacket = $2,000 per linear foot

The pile jacketing will be an underwater application and will require divers, boats, and barges to stage the work, overcoming difficult visibility, and a two to three hour slack tide per day in which to perform repairs. Due to the conditions and the relatively low number of piles, the unit cost is estimated to be significantly higher than the FDOT's integral pile jacket (Item No. 457-70). FDOT's unit cost for 20" (closest size with cost data available) is ~$1,100.

Expansion Joint Seal = $ 50 per linear foot

Expansion joint seal replacement will require the removal of the existing compression joint seal, repair of any deteriorated concrete adjacent to the joint, installation of a backer rod, and placement of the silicon expansion joint seal. To maintain traffic on the bridge, the joint will need to be installed in two phases. The unit cost is based on FDOT's expansion joint seal (Item No. 460-7). The unit cost is $50 LF. Since this type of joint is common, and quantities are substantial, no modification was made to the unit cost of $50 per LF

Traffic Control = $4,000 per week

Traffic control including four flaggers, signs, cones, and other miscellaneous traffic control items is based on A&O's actual expense during the NBIS inspection for the Bonner Bridge. The $4,000 per week allowed for traffic control over the crest of the bridge and indicates the approximate costs per week incurred on this project.

Shotcrete Repair = $900 per cubic foot for deck and approach bents and $1,125 for high level bents.

The anticipated depth for the shotcrete repairs to the substructure is 5 to 6 inches. This depth of repair will require the installation of additional reinforcing dowels and reinforcing mat or wire mesh. In addition, cathodic anodes will be placed around the perimeter of the patch to reduce deterioration of adjacent concrete. A significant amount of repair preparation will be required with restrictions on the amount of delamination removal at one time for high level span bents. These bents will require multi-staging, barge mooring, scaffolding and other staging elements to perform the repair work. Piano wire or similar marker devices will be needed to create uniform surfaces on caps and columns. The surface of the shotcrete will need to have a trowel finish to provide a dense impervious surface. The completed shotcrete will also need to be properly cured to prevent surface cracking.

Epoxy Mortar/ Cementitious Mortar Repair = $1,500 per cubic foot

The anticipated depth for epoxy mortar/cementitious mortar repairs to the superstructure is 2 to 3 inches. With the 2" to 3" superstructure depth of repair, most epoxy mortar or cementitious mortar repairs will require installing formwork for the repair. Typical preparation for the repair requires the removal of concrete a minimum of ½" behind the reinforcing steel. A repair contractor consulted (Carolina Restoration and Waterproofing) noted that the existing concrete is very hard and difficult to remove behind existing reinforcing steel.

Chemical Grout Crack Injection = $100 per linear foot

Crack Injection will require the surface sealing of the cracks, installing injection ports, flushing the cracks with fresh water, injecting the cracks with a chemical grout, removing injection ports, and cleaning and patching the surface after the repair is complete.

Penetrant Sealer = $2 per square foot

Penetrant Sealer will require the surface to be cleaned prior to sealing. It is also recommended that the sealer is applied by rolling rather than spraying to achieve a superior application. The unit cost was based on FDOT's penetrant seal, which involves two items: Penetrant Sealer – Item No. 400-149 (GA) and Cleaning and Sealing Concrete Surfaces – Item No. 400-154 (SF). The unit cost for each is ~$35 GA and ~$1.50 SF. Based in the minimum coverage for sealer, 200 SF/GA, the combined unit cost is $1.50 + $35/200 = $1.68 per SF. To account for over-coverage and roller application, the unit cost was rounded to $2 per LF.

Bearing Replacement = $6,000 each

Steel bearing replacements will require the jacking of the bridge, removal of the existing bearings, cleaning the adjacent steel, replacement of the bearing with a new bearing, and the painting of repaired areas. Since the existing bearings are not commonly used in current designs, cost information was not readily available. The unit cost of the material (~$5 per LB) was based on data from the Kentucky

Transportation Cabinet (KYTC) and Utah fabricators. The installation cost (~$1 per LB) was based on previous FDOT bearing replacements with the cost of the material removed since the bearing type was dissimilar. The cost of installation includes jacking the bridge. The total unit cost per pound is estimated at $6 per pound. Since bearing replacements are most often paid for per bearing, the per pound cost was multiplied by the approximate average bearing weight (1,000 lbs) for a final unit cost of $6,000 EA.

End Diaphragm/Lateral Bracing Replacement = $6 per LB

End Diaphragm/Lateral Bracing Replacement will require temporary bracing during removal of the existing corroded steel members, removal of the existing components, cleaning the adjacent steel, replacement of the removed members and fasteners, and the painting of the repaired areas. Similar to the bearing replacement, the replacement of the end diaphragms will be more complex than new construction (~$2 per LB) and a unit cost is estimated to be $6 per LB.

Paint All Structural Steel (includes containment/disposal of existing paint) = $1000 per TN

Painting All Structural Steel will require cleaning and painting the steel. The unit cost of painting structural steel for FDOT is ~$980 TN. Since the painting can be accomplished by using under-bridge access equipment rather than barges/scaffolding, the unit price was rounded and increased only slightly to $1000/TN.

Replace Timber Wales = $7,000 per MB (MB is thousand board-foot measure)

The unit cost is based on FDOT's structural treated timber (Item No. 470-1). The unit cost is ~$7,000 MB. Since this is a common material, no modification was made to the unit cost of $7,000 per MB.

Replace Steel Wales = $2 LB

Replace Steel Wales requires the coordination with US Coast Guard, maintaining navigational channel, removal of timber wales, removal of damaged steel wale, the replacement of the steel wale, attachment to the remaining steel, and the replacement or reattachment of the timber wales. The unit cost is based on FDOT's structural steel cost of ~$2 per LB.

Replace Wire Wraps = $500 EA

Replacing wire wraps requires the removal of the existing wire wrap and the installation of new wire wrap. The unit cost is based on FDOT's cluster pile wrap (Item No. 455-76). The unit cost is ~$475 EA. While the number of wraps replaced is relatively low, the installation process and material is fairly simple so the unit cost is only increased to $500 EA.

Repair Grouping

Each of the recommended repairs included in the assessment report was classified into one of four groups. **Group A repairs** are recommended to be completed within the next six to twelve months and include:

- jacketing the seven deficient piles identified in the Underwater Assessment
- replacement of the deck expansion joints (continued leaking of water through the joints is causing accelerated deterioration to diaphragms, ends of girders, bearings, caps and the top area of columns)

Group B repairs are to the substructure of the bridge: the substructure cap, column, or pile cap. The substructure components are non-redundant and key elements to the service life of this bridge; therefore, it is recommended that the substructure repairs be completed within the next two years. These repairs include:

- repairing 6,689 CF of spalled and delaminated areas and 1,561 LF of cracking of high level bent members
- repairing 3,669 CF of spalled and delaminated areas and 772 LF of cracking of approach bent members
- applying a penetrant sealer to the member surfaces
- constructing four supplemental caps to provide additional support of the superstructure at Spans 196, 197, and 198

Group C repairs are to the superstructure girders of the bridge. The superstructure components are key elements to the service life of this bridge and therefore it is recommended that the superstructure girder repairs be completed within the next two years. Group C repairs include:

- repairing 3,691 CF of spalled and delaminated areas and 497 LF of cracking on the AASHTO girders
- replacing 16 bearings for the steel spans
- replacement of end diaphragms and lateral bracing in the steel spans

Group D repairs are to the concrete deck and paint on the structural steel of the bridge. It is recommended that these repairs be completed within the next four years. Even though the concrete deck repairs are recommended to be completed within the next four years, if a hole develops in the deck, it could be hazardous to the traveling public; therefore, the deck should be monitored and maintenance repairs performed on an ongoing basis. Group D repairs include:

- repairing the reinforced concrete bridge deck of both the AASHTO girder spans and the steel girder spans
- complete repainting of the structural steel elements

Repair Summary Tables in Order of Grouping

Group A - Pile Jacketing and Expansion Joints

PRELIMINARY ENGINEER'S OPINION OF CONSTRUCTION COST SUMMARY			
DESCRIPTION	QUANTITY	UNIT COST	TOTAL COST
Mobilization (20%)	Lump Sum	Lump Sum	$ 160,000
Pile Jacketing	120 LF	$2,000/LF	$ 240,000
Expansion Joint Replacement	6,600 LF	$50/LF	$ 330,000
Traffic Control	12 WKS	$4,000/WK	$ 48,000
TOTAL CONSTRUCTION COSTS			$ 778,000
Engineering and Construction Engineering and Inspection (25%)			$ 194,500
Contingency (15%)			$ 116,500
TOTAL			$ 1,089,000

Group B - High Level Bent Repairs

PRELIMINARY ENGINEER'S OPINION OF CONSTRUCTION COST SUMMARY			
DESCRIPTION	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	Lump Sum	Lump Sum	$ 1,000,000
Shotcrete Repairs	3,996 CF	$1,125/CF	$ 4,495,500
Epoxy Mortar Repairs	2,893 CF	$1,500/CF	$ 4,339,500
Epoxy Resin / Chemical Grout Injection	1,561 LF	$100/LF	$ 156,100
Penetrant Sealer	90,046 SF	$2/SF	$ 180,100
Traffic Control	30 WKS	$4,000/WK	$ 120,000
TOTAL CONSTRUCTION COSTS			$ 10,291,200
Engineering and Construction Engineering and Inspection (25%)			$ 2,572,800
Contingency (15%)			$ 1,543,000
TOTAL			$ 14,407,000

Group B - Supplemental Caps For Bents 196, 197, & 198

PRELIMINARY ENGINEER'S OPINION OF CONSTRUCTION COST SUMMARY			
DESCRIPTION	QUANTITY	UNIT COST	TOTAL COST
Mobilization (20%)	Lump Sum	Lump Sum	$ 23,000
Concrete Caps and Reinforcing Steel	54 CY	$1,500/CY	$ 81,000
Traffic Control	3 WKS	$4,000/WK	$ 12,000
TOTAL CONSTRUCTION COSTS			$ 116,000
Engineering and Construction Engineering and Inspection (25%)			$ 29,000
Contingency (15%)			$ 16,000
TOTAL			$ 161,000

Group B - Approach Bent Repairs

PRELIMINARY ENGINEER'S OPINION OF CONSTRUCTION COST SUMMARY			
DESCRIPTION	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	Lump Sum	Lump Sum	$ 470,000
Shotcrete Repairs	2,731 CF	$900/CF	$ 2,457,900
Epoxy Mortar Repairs	938 CF	$1,500/CF	$ 1,407,000
Epoxy Resin / Chemical Grout Injection	772 LF	$100/LF	$ 77,200
Penetrant Sealer	107,424 SF	$2/SF	$ 215,000
Traffic Control	20 WKS	$4,000/WK	$ 80,000
TOTAL CONSTRUCTION COSTS			$ 4,707,100
Engineering and Construction Engineering and Inspection (25%)			$ 1,176,775
Contingency (15%)			$ 706,125
TOTAL			$ 6,590,000

Group C - Superstructure Repairs – AASHTO Girder Spans

PRELIMINARY ENGINEER'S OPINION OF CONSTRUCTION COST SUMMARY			
DESCRIPTION	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	Lump Sum	Lump Sum	$ 660,000
AASHTO Girder Epoxy Mortar Repairs	3,691 CF	$1,500/CF	$ 5,536,500
Epoxy Resin / Chemical Grout Injection	497 LF	$100/LF	$ 49,700
Traffic Control	50 WKS	$4,000/WK	$ 200,000
TOTAL CONSTRUCTION COSTS			$ 6,446,200
Engineering and Construction Engineering and Inspection (25%)			$ 1,611,550
Contingency (15%)			$ 967,250
TOTAL			$ 9,025,000

Group C - Superstructure Repairs - Steel Spans

PRELIMINARY ENGINEER'S OPINION OF CONSTRUCTION COST SUMMARY			
DESCRIPTION	QUANTITY	UNIT COST	TOTAL COST
Mobilization (20%)	Lump Sum	Lump Sum	$ 45,000
Bearing Replacement	16 EA	$6,000/EA	$ 96,000
End Diaphragm/Lateral Bracing replacement	8,000 LB	$6/LB	$ 48,000
Traffic Control	8 WKS	$4,000/WK	$ 32,000
TOTAL CONSTRUCTION COSTS			$ 221,000
Engineering and Construction Engineering and Inspection (25%)			$ 55,000
Contingency (15%)			$ 33,000
TOTAL			$ 309,000

Group D - Superstructure Repairs – Deck and Painting Steel Girders

PRELIMINARY ENGINEER'S OPINION OF CONSTRUCTION COST SUMMARY			
DESCRIPTION	QUANTITY	UNIT COST	TOTAL COST
Mobilization (10%)	Lump Sum	Lump Sum	$ 850,500
Deck Shotcrete Repairs	7,843 CF	$900/CF	$ 7,058,700
Paint All Structural Steel	395 TN	$1,000/TN	$ 395,000
Traffic Control	50 WKS	$4,000/WK	$ 200,000
TOTAL CONSTRUCTION COSTS			$ 8,504,200
Engineering and Construction Engineering and Inspection (25%)			$ 2,126,050
Contingency (15%)			$ 1,274,750
TOTAL			$ 11,905,000

TOTAL ENGINEER'S OPINION OF CONSTRUCTION COSTS	**$ 43,486,000**

Conclusion

The Herbert C. Bonner Bridge is in advanced stages of deterioration and is nearing the end of its lifespan. The bridge is anticipated to be replaced within the next ten years. The findings of the NBIS inspection and in-depth assessment are summarized as follows:

1. The bridge, in its current state, is safe for use by the traveling public and does not require any weight limit posting. However, due to the advanced stages of deterioration, replacement of the Bonner Bridge within the next ten years remains a necessity.
2. Delamination, spalling, and cracking are widespread and the bridge had an overall NBIS rating of “POOR”.
3. Testing indicates that the concrete is generally of good quality and strength. However, chloride ions above the corrosion threshold exist to a depth of 4.5” in the columns and pile caps; therefore, active corrosion is occurring and will continue to accelerate.
4. Structural capacities of the bridge components are adequate except for Bent Caps 196, 197, and 198. These caps are overstressed in shear, and it is recommended that additional concrete subcaps be placed to help in carrying the shear load to the crutch bents.
5. Pile loads in several locations were in excess of the 50 ton design capacity, nevertheless the piles have been performing satisfactorily over the past decade provided that the supporting soil substrate is above the critical scour elevation. Pile jackets are recommended for specific deficiencies in seven piles.
6. Re-evaluation of the critical scour elevations is recommended to determine if these elevations need to be revised for a computed 70 ton capacity.
7. Repairs of deteriorated concrete are necessary to minimize the advancement of deterioration and maintain the structural capacity of the bridge and allow continued use over the next ten years. The repairs have been grouped into four main groups – A, B, C, and D.
8. Group A repairs should be made within the next six to twelve months.
9. Group B and C repairs should be made within the next two years
10. Group D repairs should be made within the next four years.

It is anticipated that if these repairs are made properly by an experienced contractor, the Bonner Bridge will be capable of remaining in service and functioning under current design loads for the next ten years.