



BRIDGE DECK PRESERVATION PROCEDURES FOR THE ARIZONA DEPARTMENT OF TRANSPORTATION

Final Report 520

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16. Abstract The primary objective of this project is to identify several common bridge deck maintenance activities that are performed by contract, review the current Arizona Department of Transportation (ADOT) specifications for those maintenance activities, modify the specifications where appropriate to reflect current accepted practice, and to serve as a model to guide future efforts at updating specifications. To complete the project, all of ADOT's bridge deck maintenance specifications were reviewed. The following repairs were identified for further evaluation: • Temporary repair of expansion joints. • Minor collision damage repair of concrete I-beam girders. • Hole in deck repair (with and without asphalt overlay). • Bridge railing repair (concrete and aluminum). Bridge preservation specifications from other agencies were then collected and reviewed. This led to the selection of two treatments to develop new draft specifications: • Bridge Deck Repair: Full-Depth Patch. • Prestressed Concrete I-Beam: Minor Repair by Patching and Epoxy Resin Base Adhesive Injection. Draft specifications were developed and submitted to ADOT for review and possible implementation, thereby completing the project.					
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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS					APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol	Symbol	When You Know	Multiply By	To Find	Symbol
<u>LENGTH</u>					<u>LENGTH</u>				
in	inches	25.4	millimeters	mm	mm	millimeters	0.039	inches	in
ft	feet	0.305	meters	m	m	meters	3.28	feet	ft
yd	yards	0.914	meters	m	m	meters	1.09	yards	yd
mi	miles	1.61	kilometers	km	km	kilometers	0.621	miles	mi
<u>AREA</u>					<u>AREA</u>				
in ²	square inches	645.2	square millimeters	mm ²	mm ²	square millimeters	0.0016	square inches	in ²
ft ²	square feet	0.093	square meters	m ²	m ²	square meters	10.764	square feet	ft ²
yd ²	square yards	0.836	square meters	m ²	m ²	square meters	1.195	square yards	yd ²
ac	acres	0.405	hectares	ha	ha	hectares	2.47	acres	ac
mi ²	square miles	2.59	square kilometers	km ²	km ²	square kilometers	0.386	square miles	mi ²
<u>VOLUME</u>					<u>VOLUME</u>				
fl oz	fluid ounces	29.57	milliliters	mL	mL	milliliters	0.034	fluid ounces	fl oz
gal	gallons	3.785	liters	L	L	liters	0.264	gallons	gal
ft ³	cubic feet	0.028	cubic meters	m ³	m ³	cubic meters	35.315	cubic feet	ft ³
yd ³	cubic yards	0.765	cubic meters	m ³	m ³	cubic meters	1.308	cubic yards	yd ³
NOTE: Volumes greater than 1000L shall be shown in m ³ .									
<u>MASS</u>					<u>MASS</u>				
oz	ounces	28.35	grams	g	g	grams	0.035	ounces	oz
lb	pounds	0.454	kilograms	kg	kg	kilograms	2.205	pounds	lb
T	short tons (2000lb)	0.907	megagrams (or "metric ton")	mg (or "t")	mg (or "t")	megagrams (or "metric ton")	1.102	short tons (2000lb)	T
<u>TEMPERATURE (exact)</u>					<u>TEMPERATURE (exact)</u>				
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C	°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F
<u>ILLUMINATION</u>					<u>ILLUMINATION</u>				
fc	foot candles	10.76	lux	lx	lx	lux	0.0929	foot-candles	fc
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²	cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
<u>FORCE AND PRESSURE OR STRESS</u>					<u>FORCE AND PRESSURE OR STRESS</u>				
lbf	poundforce	4.45	newtons	N	N	newtons	0.225	poundforce	lbf
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa	kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²

SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380

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INTRODUCTION

A significant number of Arizona Department of Transportation's (ADOT's) bridges are 20 years and older. As these bridges age, they are deteriorating from a wide range of forces including load-related damage and damage due to environmental effects such as freeze thaw action, sulfate attack, ASR reactivity, and so on. And as they deteriorate, the need for repairs to ADOT's structures is becoming increasingly common. While historically ADOT's maintenance crews have performed many bridge repairs, bridge maintenance activities are becoming increasingly complex, and some require the use of specialized materials or equipment that are not available to ADOT. As such, this work ends up being performed under on-call contracts.

ADOT is interested in ensuring that all bridge maintenance work is performed to the highest possible standards. This can be accomplished by verifying that the specifications that apply to bridge maintenance are comprehensive, up-to-date, and reflect the current state of the practice.

PROJECT OBJECTIVES

The primary objective of this project is to identify several common bridge deck maintenance activities that are performed by on-call contract, review the current ADOT specifications for those maintenance activities, and recommend modifications to the specifications where appropriate to reflect current accepted practice. This project is intended to serve as a demonstration of the feasibility of developing such specifications for Arizona and not as a process which results in the development of a comprehensive set of new bridge maintenance guidelines. As such, the goal is to develop one or two specifications to serve as a model for future efforts.

PROJECT APPROACH

The approach taken to accomplish the project objectives consists of the following tasks:

- Review ADOT specifications.
- Collect and review bridge preservation specifications from other agencies.
- Develop draft specifications.

The work accomplished in each of these tasks is described in greater detail in the remainder of this summary.

Review ADOT Specifications

ADOT provided a list of bridge preservation activities which might be performed under on-call contract. These preservation activities include the following:

- Temporary repair of expansion joints.
- Minor collision damage repair of concrete I-beam girders.
- Hole in deck repair (with and without asphalt overlay).
- Bridge railing repair (concrete and aluminum).

To begin this project, the existing ADOT Standard Specifications and Supplemental (or Special) Specifications were reviewed to determine the applicable sections for the preservation items. Although the focus of subsequent efforts was to consolidate existing information and obtain relevant additional information for only one to two of the preservation items, material was collected on all of the preservation activities to compare available specifications.

Collect and Review Bridge Preservation Specifications from Other Agencies

A survey of state highway agency (SHA) bridge maintenance practices was conducted as part of this project. Maintenance engineers in SHAs around the country were asked to summarize the type of bridge maintenance work that is done both by contract and by agency forces. The results of this survey are summarized in Appendix A (Summary of State Highway Agencies' Bridge Deck Maintenance Practices). One product of this survey is the identification of SHAs that have developed bridge preservation procedures that are of interest to this project.

The Federal Highway Administration's website was also searched for documents on bridge preservation activities. This site primarily was useful in identifying which SHAs might have relevant documents of value to this project, particularly supplemental specifications. The result is that documents were obtained from a number of SHAs, including California, Connecticut, Alabama, North Carolina, Ohio, Illinois, Rhode Island, Oregon, Pennsylvania, and Michigan. Materials collected included standard specifications and supplemental specifications relating to bridge preservation activities. The collected materials were then reviewed to determine the state-of-the-practice for the provided bridge preservation activities.

Develop Draft Specifications

The applicable portions of the ADOT Standard Specifications and Supplemental Specifications were used as the basis for developing the proposed draft specifications. In addition to ADOT's own specifications, the results of the SHA specifications review were used to supplement the draft specifications.

The result was the development of two specifications from the initial four preservation activities, as identified below:

- Bridge Deck Repair: Full-Depth Patch

This specification covers deck slab repairs requiring removal and replacement to the full depth of the deck (hole in deck). It includes (but is not necessarily limited to) the following activities: bituminous surface removal and replacement; removal and disposal of deteriorated concrete; constructing false work to support forms; constructing forms; cleaning and repair of the existing reinforcement steel, where required; cleaning and preparing of the bonding surface; and placing new concrete.

- Prestressed Concrete I-Beam: Minor Repair by Patching and Epoxy Resin Base Adhesive Injection

This specification addresses the repair of minor spalling and cracking in prestressed concrete I-beams. This specification includes (but is not necessarily limited to) the following activities: removal and disposal of damaged or deteriorated concrete; cleaning and preparing of the bonding surface; cleaning of the existing reinforcement steel; furnishing and injecting epoxy-resin base adhesives; constructing falsework to support forms, where required; constructing forms; and placing new concrete.

These two draft specifications were submitted to ADOT in January 2005, effectively completing the project. These are included as Appendix B (Proposed Specification for Prestressed Concrete I-Beam: Minor Repair by Patching and Epoxy-Resin Base Adhesive Injection) and Appendix D (Proposed Specification for Bridge Deck Repair: Full-Depth Patch). For the prestressed concrete I-beam specification, a draft checklist that could be used by inspectors or foremen overseeing this type of activity was also developed and submitted to provide an example of additional documentation that can be included in a bridge maintenance manual to assist with ensuring the work is completed properly. That checklist is included as Appendix C (Proposed Checklist for Prestressed Concrete I-Beam: Minor Repair by Patching and Epoxy-Resin Base Adhesive Injection).

RECOMMENDATIONS

The documents prepared in this project constitute draft specifications. Ultimately, there are several steps that need to be taken to turn draft specifications into revised and adopted agency specifications.

1. Carry out an internal review of the proposed specification, including representatives from Bridge and Maintenance Groups. If applicable, develop a revised specification based on the feedback.

2. Carry out several trial repairs based on the draft specifications. Collect feedback from those doing the repairs.
3. Identify lessons learned from the trial repairs, and develop modified specifications if applicable.
4. When the draft specification is finalized, develop a checklist to accompany the bridge maintenance activity.
5. Prepare a brief (1 to 2-hour) workshop that can be used to train Maintenance personnel on the new specification.
6. Repeat this process for other repairs that can be made by Maintenance personnel.

APPENDIX A

SUMMARY OF STATE HIGHWAY AGENCIES' BRIDGE DECK MAINTENANCE PRACTICES

**APPENDIX A - SUMMARY OF STATE HIGHWAY AGENCIES' BRIDGE DECK
MAINTENANCE PRACTICES**

State	Contact Name	Phone Number	Maintenance work performed by State or Contractor?	Comments
Arkansas	Jim Barnett	501-569-2231	State	State crews perform deck patching, crack sealing, and joint repairs. Maintenance work is performed primarily based upon experience of crews. Contractors used for rehabilitation work.
California	Larry Orcutt	916-654-5849	Both	State crews have capabilities of doing work and will work on small projects. Contractors work on projects with large quantities of repair work. The state has written specifications to cover repair work.
Connecticut	Franco Liberatore	860-594-2626	Both	State crews perform deck patching, crack sealing, and joint repair work. The State has a 2-year "as needed" contract to allow a contractor to perform work when State crews cannot get work completed, but they usually don't require contractor work. They have a maintenance manual for repair work.
Florida	Sharon Holmes	850-488-8814	State	Maintenance is performed by area maintenance yards in each District. <i>Bridge Maintenance and Repair Manual</i> covers maintenance work performed by crews.
Illinois	Dave Johnson	217-782-7231	Contractor	Routine maintenance work is performed by contractors. Maintenance work includes deck patching, crack sealing, and joint repairs. State crews perform temporary or emergency work. Specifications cover work items.

**APPENDIX A - SUMMARY OF STATE HIGHWAY AGENCIES' BRIDGE DECK
MAINTENANCE PRACTICES (Continued)**

State	Contact Name	Phone Number	Maintenance work performed by State or Contractor?	Comments
Indiana	Mike Bowman	317-232-5508	Both	Minor patching and crack sealing are performed by District crews. Extensive patching and joint repairs are conducted by contractors. Maintenance work is covered by general specifications, but they do not have a specific manual for maintenance work.
Kentucky	Don Herd	502-564-4556	State	State crews perform deck patching and joint repairs, but do not typically crack seal. Work is performed based upon crew experience; specifications exist for materials and anticipated resource requirements.
Louisiana	Karl Finch	225-379-1572	Both	District and State crews perform deck patching, crack sealing, and joint repairs. Contractors perform railing and barrier repairs. General maintenance manual includes bridge maintenance items. Currently revising manual to a performance based specification.
Maine	Brian Pickard	207-287-2661	State	State crews perform deck patching, cleaning, and joint repairs. They do not specifically perform crack sealing, but some sealing is performed on bridge decks in conjunction with road work. Repair work is conducted based on field crew experience; the agency is currently in the process of creating a manual.

**APPENDIX A - SUMMARY OF STATE HIGHWAY AGENCIES' BRIDGE DECK
MAINTENANCE PRACTICES (Continued)**

State	Contact Name	Phone Number	Maintenance work performed by State or Contractor?	Comments
Michigan	Larry Galehouse	517-322-5774	Contractor	Contractor performs cleaning, sealing, deck patching, joint repairs, and other bridge repairs on bridge maintenance contracts falling under "Scheduled" or "Preventive" maintenance categories. State crews perform emergency repairs, such as high load hits. There are specifications for the repair work and at least some of the work is under warranty.
Mississippi	John Vance	601-359-7111	State	State crews perform deck patching and crack sealing. General specifications cover materials and methods, but they have no specific maintenance manual.
Missouri	Don Hillis	573-751-2785	State	State crews perform deck patching, crack sealing, cleaning, and smaller rehabilitation projects. They have a maintenance manual that covers repair work.
Nevada	Frank Taylor	775-888-7050	State	State crews perform deck patching, crack sealing, and cleaning work. They have a "Maintenance Management Series" that covers repair work materials and methods.

**APPENDIX A - SUMMARY OF STATE HIGHWAY AGENCIES' BRIDGE DECK
MAINTENANCE PRACTICES (Continued)**

State	Contact Name	Phone Number	Maintenance work performed by State or Contractor?	Comments
New Jersey	Rod Roberson	609-530-2590	Both	State crews typically perform maintenance work. Contracts will occasionally be put out for bid for large quantities of repair work. Maintenance work includes crack sealing, joint repairs, deck patching, and cleaning. They have a set of operational bulletins that directs how repair work is to be performed.
New Mexico	Earl Franks		Both	Reactive maintenance, such as blown joints, is performed by State crews. Deck patching and surface sealing are performed by a contractor under a general services agreement. They do not have a manual, but they do have specifications that cover contracted items.
North Carolina	Steve Varnedoe	919-715-5662	State	Field crews from the Field Bridge Maintenance operations perform any work, including small bridge replacement.
Ohio	Brad Fagrell	614-466-3893	State	Deck patching, crack sealing, and cleaning are performed by District crews, but usually as reactive maintenance. They have a maintenance manual that covers repair work. They are in the process of allocating more funds for preventive maintenance and may increase contract work.

**APPENDIX A - SUMMARY OF STATE HIGHWAY AGENCIES' BRIDGE DECK
MAINTENANCE PRACTICES (Continued)**

State	Contact Name	Phone Number	Maintenance work performed by State or Contractor?	Comments
Oklahoma	John Fuller	405-521-4675	State	Deck patching, crack sealing, and railing repairs are conducted by State crews. Work is usually based upon the experience of the crew, but they do have general specifications.
Oregon	Doug Tindall	503-986-3005	Both	Repairs, such as cleaning, deck patching, crack sealing, and joint repairs, are conducted by State crews. Large quantities of repair work may be performed by contractors or by State crews with no specific reasoning for one way or the other. State crew repairs generally performed based on experience and general specifications cover contract work.
South Carolina	Leaf Woods	803-737-1290	Both	Majority of maintenance work is performed by State crews, including deck patching, crack sealing, joint repair, and some HMA overlay work. Large quantities of deck patching or joint repairs may be performed by contractors. Most repair work is based on crew experience.
Tennessee	Gerald Gregory	615-741-2027	State	County and District crews perform cleaning activities. State crews perform deck patching and joint repairs. Repair work is performed based upon experience; specifications cover materials but not methods.

**APPENDIX A - SUMMARY OF STATE HIGHWAY AGENCIES' BRIDGE DECK
MAINTENANCE PRACTICES (Continued)**

State	Contact Name	Phone Number	Maintenance work performed by State or Contractor?	Comments
Washington	Ken Kirkland	360-705-7851	State	State crews perform joint repairs, deck patching, and crack sealing. Maintenance work is covered under the construction and design manual.
Wisconsin	Finn Hubbard	608-266-8489	State	County crews perform deck patching, cleaning, crack sealing, and deck sealing. Specifications provide approved materials but repair work is based upon crew experience.

APPENDIX B

PROPOSED SPECIFICATION FOR PRESTRESSED CONCRETE I-BEAM: MINOR REPAIR BY PATCHING AND EPOXY-RESIN BASE ADHESIVE INJECTION

APPENDIX B

PROPOSED SPECIFICATION FOR PRESTRESSED CONCRETE I-BEAM: MINOR REPAIR BY PATCHING AND EPOXY-RESIN BASE ADHESIVE INJECTION

X02.01 DESCRIPTION. This work consists of repairing minor spalling and cracking in prestressed concrete I-beams. The work under this item shall include all material, equipment, and labor for repairing spalls and cracks in prestressed concrete I-beams. This work includes, but is not necessarily limited to, removal and disposal of damaged or deteriorated concrete; cleaning and preparing of the bonding surface; cleaning of the existing reinforcement steel; furnishing and injecting epoxy-resin base adhesives; constructing falsework to support forms, where required; constructing forms; and placing new concrete. Spall and crack repair work shall be performed at locations indicated on the Plans or as directed by the Engineer and shall conform to the requirements of the Standard Specifications and these Special Provisions.

The purposes of this work are to restore continuity to the I-beam, protect the steel reinforcement, and restore the shape of the I-beam. This work does not include repair or replacement of damaged prestressing tendons. If damaged prestressing steel is encountered during repair work, work shall be suspended and the Engineer notified.

X02.02 MATERIALS. All products indicated below must be listed in the ADOT Approved Products List.

X02.02.1 Patching Material. Patching material shall be a polymer-modified portland cement concrete with a minimum ultimate strength, $f'_c = 5,500$ psi at 28 days and shall attain a minimum strength of 3,500 psi within 6 to 8 hours before forming can be stripped. The material specification shall meet or exceed the requirements delineated in the Standard Specifications.

X02.02.2 Epoxy Injection Material. Injection material shall be a low viscosity, two-part epoxy-resin system conforming to the requirements of ASTM C-881, Type IV, and shall meet or exceed the requirements delineated in the Standard Specifications. The material shall also be the required grade and class to satisfactorily perform its function.

a. Injection Equipment. The equipment used to meter and mix the two injection adhesive components and inject the mixed adhesive shall be portable, positive displacement type pumps with interlock to provide positive ratio control of exact proportions of the two components at the nozzle.

The injection equipment shall have the automatic pressure control capable of discharging the mixed adhesive at any preset pressure up to 160 ± 5 psi.

The equipment shall have the capability of maintaining the volume ratio for the injection of the adhesive prescribed by the manufacturer of the adhesive within the tolerance of +5 percent by volume at any discharge pressure up to 160 psi.

The injection equipment shall be equipped with sensors on both the component A and component B reservoirs that will automatically stop the machine when only one component is being pumped to the mixer head.

d. Surface Seal. A surface seal material as recommended by the adhesive manufacturer shall be used to confine the injection adhesive in the crack during injection and curing. It shall have adequate strength to hold injection fittings or ports and prevent vent leakage during injection.

X02.03 CONSTRUCTION METHODS. The Contractor shall inspect the structure in order to become acquainted with the nature and extent of the work. Construction methods shall conform with the Standard Specifications. Where this specification deviates from the Standard Specification, the intent of this text shall govern.

X02.03.1 Spall Repair.

a. Surface Preparation. All deteriorated, disintegrated, soft, fractured, or otherwise defective concrete shall be removed from the areas to be repaired to a depth sufficient to expose a bonding surface of sound material as determined by the Engineer. Impact tools may be used only with the approval of the Engineer. At the direction of the Engineer, the perimeter of the area to be repaired will be saw cut to a depth of 0.5 inches. Thin or feathered edges will not be permitted.

Once all deteriorated concrete has been removed, the existing sound concrete shall be maintained in a clean, rough, and surface-saturated moist condition until the concrete repair has been completed. When an epoxy-resin agent is specified, the prepared sound concrete surface shall be thoroughly dried prior to application of the epoxy-resin. Care shall be taken during the removal of the designated portions of the structure to avoid damaging the portions that are to remain in place. Any damage caused by the Contractor to the existing structure that is designated to remain in place shall be repaired or replaced by the Contractor at the Contractor's expense to the satisfaction of the Engineer.

b. Reinforcing Steel. Care shall be exercised during concrete removal and sawcutting to prevent damage to the reinforcing steel and prestressed tendons. All corroded reinforcing bars shall be thoroughly cleaned to remove all rust. The condition of the reinforcing steel and prestressing tendons will be inspected by the Engineer before application of the concrete repair. Repair work shall be suspended if damage to the prestressing tendons is encountered. Such damage may affect the structural stability of an entire span and thus the measures needed to correct the defect are numerous and varied, requiring structural or other technical advice, and are beyond the scope of this work. Any damage to the

existing reinforcing steel caused by the Contractor shall be repaired or replaced at the discretion of the Engineer at no additional cost to the Department.

c. Forms. Forms shall be used for repairs whenever necessary to confine the concrete and shape it to the required lines. Such forms may partially require progressive installation as the concrete is placed as a result of confinements for placing concrete due to the location of the particular repair or restoration required. The forms shall have sufficient strength to withstand the pressure resulting from placing operations, shall be maintained rigidly in position, and shall be sufficiently tight to prevent loss of mortar from the concrete. The use of form oils is expressly forbidden; the Contractor shall use an alternate method or material for facilitating form release that will not cause discoloration or staining of the concrete. All such methods or materials are subject to the approval of the Engineer.

d. Application.

1) Bonding Agent. Epoxy bonding agent shall be an all-purpose high-strength, moisture-insensitive, two-part rigid epoxy adhesive conforming to the requirements of ASTM C-881, Type V, and it shall meet the approval of the Engineer, including contact time, fluidity, and application temperature. The bonding agent shall also be one of those listed on the ADOT Approved Products List.

The Contractor shall follow the manufacturer's recommendations for curing the epoxy bonding agent prior to placing the patching mortar. The patching mortar shall not be placed if the epoxy bonding agent has exceeded the manufacturer's recommended contact time. If the epoxy bonding agent has exceeded its contact time, the Contractor shall follow the manufacturer's recommendations for re-application. An epoxy bonding agent with an extended contact time should be used if required by the timing of concrete placement and/or weather conditions.

2) Placing and Consolidation. Polymer-modified portland cement concrete shall be placed, consolidated, and finished on a previously prepared surface as described in this Specification, and to which an epoxy bonding agent has been applied.

Patching materials shall not be applied when the ambient temperature is below 40 degrees F or is not in accordance with the manufacturer's recommendations.

3) Finish. All exposed surfaces shall be finished straight and true, approximating the original contour as close as practicable. The final finished surfaces shall match the texture, color, and aggregate exposure of

the existing concrete surfaces adjoining or proximate to the area where new concrete has been placed.

4) Curing. Curing procedures and methods shall comply with the polymer-modified portland cement concrete manufacturer's recommendations and as set forth in the Standard Specifications, or as otherwise directed by the Engineer. Use of curing compounds is not permitted unless specifically required by the manufacturer.

X02.03.2 Epoxy Injection

a. Component Ratio Calibration Test. Before work is begun, the equipment shall be ratio and pressure checked. These checks may be done in the field or in the Contractor's office before the equipment is brought to the field. If equipment is tested in the Contractor's office, a letter documenting the test results shall be supplied to the Engineer.

b. Surface Preparation. All deteriorated concrete adjacent to the cracks and areas of application shall be removed prior to proceeding with crack repairs. Surfaces adjacent to cracks or other areas of application shall be cleaned of dirt, dust, grease, oil, efflorescence, or other foreign material matter detrimental to the bond of the epoxy injection/surface seal system. Use of acids or other corrosives will not be permitted. Cleaning methods shall not introduce foreign materials into the crack repair area in such a manner that the penetration of the epoxy adhesive is hindered.

Entry ports shall be provided along the crack at intervals recommended by the manufacturer.

Surface seal material shall be applied to the face of the crack between and around the entry ports. For through-cracks, the surface seal shall be applied to both faces. The surface seal material shall have sufficient strength to withstand injection pressures of 250 psi. The surface seal material shall have sufficient time to reach adequate strength before the Contractor proceeds with the injection.

c. Epoxy Injection. Epoxy injection shall be performed in accordance with the manufacturer's recommended methods. If a recommended application procedure is not available, the Contractor shall use the following epoxy injection technique:

- 1)** Injection of epoxy adhesive shall begin at a lower entry port and continue at sufficient pressure and for adequate duration to fill completely all voids in excess of 0.002 inches to a depth of 12 inches.
- 2)** Before epoxy injection is transferred to the next adjacent port where epoxy adhesive has appeared, the resin exiting an adjacent port shall be clear and free from impurities.

3) This epoxy adhesive injection procedure shall continue until all cracks within the crack network between the designated port interval are completely filled.

4) If port-to-port travel of the epoxy adhesive is not indicated, the work shall immediately be stopped and the Engineer notified.

5) Minimum ambient temperature at time of injection shall be 40 degrees F, or as recommended by the manufacturer.

6) The applicator engaged in the epoxy injection process shall be familiar with the specific epoxy injection method indicated, as well as the operation, maintenance, and trouble-shooting of equipment.

d. Finishing. When cracks are completely filled, epoxy shall be cured for sufficient time in accordance with the manufacturer's recommendations. Surface seal material and injection adhesive runs or spills shall be removed from concrete surfaces in a manner recommended by the manufacturer and approved by the Engineer. The face of the crack shall be finished flush to the adjacent surface and show no indentations or protrusions caused by the placement of entry ports.

X02.03.3 Cleanup. The Contractor shall clean the worksite sufficiently prior to opening the roadway to traffic. Cleanup shall include, but is not limited to, removing all dirt and debris from the roadway and cleaning the repaired surface of loose concrete or foreign matter.

X02.04 METHOD OF MEASUREMENT.

X02.04.1 "Spall Repair" will be measured by the square foot of spall area actually repaired in accordance with the Plans and/or directed by the Engineer. For a spall at the edge of the beam, the measurement will be made from one side only (side or bottom) of the spall repair, whichever produces the larger area.

X02.04.2 "Epoxy Injection Crack Repair" will be measured by the lineal foot along the centerline of the crack actually repaired in accordance with the Plans and/or as directed by the Engineer. Through-cracks will be measured on one side of the beam only.

X02.05 BASIS OF PAYMENT. The accepted quantity of "Spall Repair" shall be paid for at the contract unit price per square foot as listed in the Contract; "Epoxy Injection Crack Repair" will be paid for at the contract unit price per lineal foot as listed in the Contract. The price so-stated shall be full compensation for the work, complete in place, as described and specified herein, and accepted by the Engineer, including, but not limited to, all labor, tools, materials, equipment (including scaffolds), and all other incidentals required to finish the work.

APPENDIX C

PROPOSED CHECKLIST FOR PRESTRESSED CONCRETE I-BEAM: MINOR REPAIR BY PATCHING AND EPOXY-RESIN BASE ADHESIVE INJECTION

APPENDIX C
PROPOSED CHECKLIST FOR PRESTRESSED
CONCRETE I-BEAM: MINOR REPAIR BY PATCHING
AND EPOXY-RESIN BASE ADHESIVE INJECTION

PRE-CONSTRUCTION

Review Plans, Specifications, and Special Provisions for special information, completeness, and accuracy

Prepare yourself and your staff for night work, if necessary

Kick-off meeting with designer (Pre-Job Meeting)

- Clarify location of beams to be repaired
- Clarify plans and specifications
- Discuss lessons learned from past experiences

Material testing

- Review Standard Specifications
- Review Special Provisions
- Prepare to sample and test cylinders
- Ensure that testing staff is certified to perform the required testing
- Review contractor's quality control plan, if specified
- Mix Design
- Epoxy injection equipment calibration test

Create list of Submittals

Review Contingency Plans

- What to do when things go wrong
- Plant or equipment breakdown
- Modulus of rupture does not meet requirements for opening to traffic

DETERMINE EXACT LIMITS OF CONCRETE REMOVAL

Review locations to be removed to ensure that all unsound material is removed

Prepare a beam repair log

- Show location and dimension of spall and crack repairs
- Before pre-sawing begins, match the quantities of spall and crack repairs on the plans with the estimate from the field review

CONCRETE REMOVAL AND CRACK PREPARATION

Concrete removal should be performed without damage to concrete that is to remain in place

Any damage to portions of the structure that are to remain in place should be repaired to a condition satisfactory to the engineer

Repair perimeters can be pre-sawed prior to the removal and replacement

Inspect for sound bonding surface and require additional removal if unsound material is still present

Inspect reinforcement for damage; damaged prestressing tendons may require more extensive repair work

Inspect concrete adjacent to cracks to identify any deteriorated concrete

Crack surfaces clean of debris, oils, and so on

CONCRETE PLACEMENT

Ensure that repair preparation has been inspected and the contractor is permitted to place concrete

Verify that the bonding agent is applied to the entire bonding surface and has not dried

Check that epoxy injection ports are spaced as recommended by the manufacturer

CONCRETE ARRIVES ON-SITE

Check temperature

Watch for consistency of concrete

- How long is the material workable?
- How much slump does it have?
- Other properties

CONCRETE TESTING

Concrete testing requirements are contract-specific

Make arrangements with testing personnel to get the test results to the Inspector, who will reopen the bridge

EPOXY INJECTION

Epoxy exiting adjacent port is free of impurities

CLEAN-UP AND OPENING TO TRAFFIC

Recommend a street sweeper

Concrete quantity should be agreed upon between the State and the contractor

Quantity is based on actual measurements, not quantity on concrete tickets

APPLICABLE STANDARDS AND STANDARD SPECIFICATIONS

Division I: General Provisions

Section 601: Concrete Structures

Section 602: Prestressing Concrete
Section 1006: Portland Cement Concrete
Section 1015: Epoxy Materials

APPENDIX D

PROPOSED SPECIFICATION FOR BRIDGE DECK REPAIR: FULL-DEPTH PATCH

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PROPOSED SPECIFICATION FOR BRIDGE DECK REPAIR: FULL-DEPTH PATCH

X03.01 DESCRIPTION. This work consists of deck slab repairs requiring removal and replacement to the full depth of the deck. The work under this item shall include all material, equipment, and labor for full-depth patching of the bridge deck. This work includes, but is not necessarily limited to, bituminous surface removal and replacement, if required; removal and disposal of deteriorated concrete; constructing falsework to support forms; constructing forms; cleaning and repairing of the existing reinforcement steel, where required; cleaning and preparing of the bonding surface; and placing new concrete. Full-depth deck repairs shall be performed at locations indicated on the Plans or as directed by the Engineer, and shall conform to the requirements of the Standard Specifications and these Special Provisions.

X03.02 MATERIALS. All products indicated below must be listed in the ADOT Approved Products List.

Patch materials shall attain compressive strength of 2,000 psi within 6 hours. The patch material shall attain the required compressive strength of 4,000 psi prior to opening to traffic.

X03.02.1 Accelerated Strength Portland Cement Concrete Patch Material. Accelerated strength patching material shall be a mixture consisting of Type III portland cement and calcium chloride or other accelerators meeting AASHTO M 144 and shall attain a compressive strength of at least 2,000 psi in 6 hours. The material specification shall conform to the requirements of the Standard Specifications Section 1006 for Class S concrete.

X03.02.2 Rapid Setting Patch Material. Rapid setting patch material shall be approved by the Engineer and shall be listed in the ADOT Approved Products List.

X03.02.3 Reinforcement Steel. Materials furnished for reinforcement steel shall conform to the requirements of the Standard Specifications Section 1003.

X03.03 EQUIPMENT. The equipment used shall be subject to the approval of the Engineer and shall meet the following requirements:

X03.03.1 Surface Preparation Equipment. Surface preparation and concrete removal equipment shall be according to the applicable portions of Sections 202 and 601 of the Standard Specifications and the following:

a. Sawing Equipment. Sawing equipment shall be a concrete saw capable of sawing concrete and embedded reinforcing steel to the specified depth.

b. Blast Cleaning Equipment. The blast cleaning may be performed by wet sandblasting, high-pressure waterblasting, shotblasting, or abrasive blasting. Blast cleaning equipment shall be capable of removing rust and old concrete from exposed reinforcement bars, and shall have oil traps.

c. Power-Driven Hand Tools. Power-driven hand tools will be permitted, including light-weight jackhammers. Chipping hammers heavier than a nominal 15-lb class shall not be used for final removal at the boundary of full-depth repairs. Jackhammers or chipping hammers shall not be operated at an angle in excess of 45 degrees measured from the surface of the deck.

d. Hydro-Scarification Equipment. The hydro-scarification equipment shall consist of filtering and pumping units operating with a remote-controlled robotic device. The equipment may use river, stream, or lake water. Operation of the equipment shall be performed and supervised by qualified personnel certified by the equipment manufacturer. Evidence of certification shall be presented to the Engineer. The equipment shall be capable of removing concrete to the specified depth and removing rust and concrete particles from exposed reinforcing bars. Hydroscarification equipment shall be calibrated before being used and shall operate at a minimum of 18,000 psi.

X03.03.2 Concrete Mixing Equipment. Equipment for proportioning and mixing the concrete shall be according to the Standard Specifications Section 1006.

X03.03.3 Finishing Equipment. Finishing equipment shall be according to the Standard Specifications Section 601. Adequate hand tools will be permitted for placing and consolidating concrete in the patch areas and for finishing small patches.

X03.04 CONSTRUCTION REQUIREMENTS. Sidewalks, curbs, drains, and reinforcement and/or existing transverse and longitudinal joints, which are to remain in place, shall be protected from damage during removal and cleaning operations. All damage caused by the Contractor shall be corrected, at the Contractor's expense, to the satisfaction of the Engineer.

The Contractor shall control the runoff water generated by the various construction activities in such a manner as to reduce, to the maximum extent practicable, the discharge of construction debris into adjacent waters, and shall properly dispose of the solids generated according to the Standard Specifications. Runoff water will not be allowed to constitute a hazard on adjacent or underlying roadways, waterways, drainage areas, or railroads, nor be allowed to erode existing slopes.

X03.04.1 Bituminous Surface Removal. In special cases where bituminous concrete overlays are part of the existing deck surface, the bituminous concrete surface course and all waterproofing membrane shall be removed and disposed of according to applicable portions of the Standard Specifications Section 202, except milling equipment

will not be allowed if the deck is to receive a waterproofing membrane system. Removal of the bituminous surface by the use of radiant or direct heat will not be permitted.

The Contractor shall insure that the process of removal of the bituminous overlay and the waterproofing membrane will not cause any damage to the underlying concrete deck and/or bridge joints to remain. The Contractor shall also insure that the proposed removal method will completely remove the existing waterproofing membrane to allow for the proposed deck patching repairs and new waterproofing system installation, if required. The Contractor will note that the thickness of the existing pavement may vary. The specifications, including gross weight(s) of the proposed equipment and/or machinery to be used for the removal operation, shall be submitted to the Engineer for approval prior to the start of work. The proposed equipment and/or machinery loads shall not exceed 40,000 pounds or the posted load limit for the bridge, whichever is less. Damage caused to the deck and/or bridge joints as a result of the Contractor's operation shall be repaired to the satisfaction of the Engineer at no additional cost to the State.

The bituminous overlay and waterproofing removal shall be performed in accordance with the sequence of construction and traffic controls indicated on the Plans. Where required, the Contractor will saw cut the pavement to prevent over-breakage into the vehicular travel areas. In the event that this type of over-breakage does occur, the Contractor shall immediately patch the damaged bituminous areas using a bituminous patching material which conforms with the Standard Specifications, at no additional cost to the State.

The removal operation shall not endanger the general public or interfere with the established traffic maintenance plan. All materials removed must be transported from the site and legally disposed of by the Contractor.

X03.04.2 Surface Preparation. All loose, disintegrated, and unsound concrete shall be removed from portions of the deck slab shown on the plans or as designated by the Engineer. The Engineer will determine the limits of removal as the work progresses.

The Contractor shall take care not to damage reinforcement bars or expansion joints which are to remain in place. Any damage to reinforcement bars or expansion joints shall be corrected at the Contractor's expense. All loose reinforcement bars, as determined by the Engineer, shall be retied at the Contractor's expense.

Full-depth removal shall be performed according to the Standard Specifications Section 202. Saw cuts shall be made on the top of the deck, except those boundaries along the face of curbs, parapets, and joints or where hydro-scarification provided sharp vertical edges. The top saw cut may be omitted if replacement of an existing bituminous overlay is required.

Forms and any required falsework for full-depth repair shall be in accordance with the Standard Specifications.

All form work shall be removed after the curing sequence is complete and prior to opening to traffic.

X03.04.3 Reinforcement. Care shall be exercised during concrete removal to protect the in-place reinforcement bars and structural steel from damage. Any damage to the reinforcement bars or structural steel to remain in place shall be repaired or replaced to the satisfaction of the Engineer at the Contractor's expense. No payment will be allowed for removal and replacement of reinforcement bars damaged by the Contractor in the performance of their work or for any increases in repair dimensions needed to provide splices for these replacement bars or repair to structural steel.

All existing reinforcement bars shall remain in place except as herein provided for corroded bars. Tying of loose bars will be required. Reinforcing bars which have been cut or have lost 25 percent or more of their original cross sectional area shall be supplemented by new in kind reinforcement bars. New bars shall be lapped a minimum of 32 bar diameters to existing bars. An approved "squeeze type" mechanical bar splice capable of developing in tension at least 125 percent of the yield strength of the existing bar shall be used when it is not feasible to provide the minimum bar lap. No welding of bars will be permitted.

X03.04.4 Cleaning. Immediately after completion of the concrete removal and reinforcement repairs, the repair areas shall be cleaned of dust and debris. Once the initial cleaning is completed, the repair areas shall be thoroughly blast cleaned to a roughened appearance free from all foreign matter. Particular attention shall be given to removal of concrete fines. Any method of cleaning which does not consistently produce satisfactory results shall be discontinued and replaced by an acceptable method. All debris, including water, resulting from the blast cleaning shall be confined and shall be immediately and thoroughly removed from all areas of accumulation. If concrete placement does not follow immediately after the final cleaning, the area shall be carefully protected with well-anchored polyethylene sheeting.

Exposed reinforcement bars shall be free of dirt, detrimental scale, paint, oil, or other foreign substances which may reduce bond with the concrete. A tight, non-scaling coating of rust is not considered objectionable. Loose, scaling rust shall be removed by rubbing with burlap, wire brushing, blast cleaning, or other methods approved by the Engineer.

X03.04.5 Placement and Finishing of Concrete.

a. Grout. After the repair areas have been cleaned and immediately prior to concrete placement, a bonding grout shall be applied to the prepared surface in accordance with the manufacturer of the patch material and shall be approved by the Engineer.

b. Concrete Placement. The concrete shall be placed, consolidated, and finished in accordance with Section 601 of the Standard Specifications and as

herein specified. The concrete repair shall be finished to the cross section of the bridge deck. The patch surface shall be struck off flush with the original deck surface.

When an overlay system is not specified, the patches shall be finished in accordance with Section 601 of the Standard Specifications, followed by a light brooming.

c. Curing and Protection. Concrete patches shall be cured according to the Standard Specifications Section 1006, and the curing period shall be 72 hours. A 72-hour minimum drying period shall be required before placing waterproofing or bituminous surfacing, if required.

X03.04.6 Bituminous Surface Repair. If required, replacing waterproofing membrane and bituminous surfacing shall be performed in accordance with appropriate portions of Sections 407 or 411 of the Standard Specifications depending upon the material of the existing bituminous surface. The Engineer will determine the required replacement material.

X03.04.7 Opening to Traffic. The Contractor shall clean the worksite sufficiently prior to opening the roadway to traffic. Cleanup shall include, but is not limited to, removing all dirt and debris from the roadway and cleaning the repaired surface of loose concrete or foreign matter.

No traffic will be permitted on a patch until after the specified cure period, and the concrete has obtained a minimum compressive strength of 4,000 psi.

Construction equipment will be permitted on a patch during the cure period if the concrete has obtained the minimum required strength.

X03.05 METHOD OF MEASUREMENT.

X03.05.1 “Deck Slab Repair – Full Depth” will be measured by the square yard of deck area actually removed and repaired in accordance with the Plans and/or directed by the Engineer.

X03.05.2 When specified, “Bituminous Surface Removal” will be measured by the square yard of surface area actually removed in accordance with the Plans and/or directed by the Engineer.

X03.05.3 When specified, “Bituminous Surface Repair” will be measured by the ton for the mixture actually used in accordance with the Plans and/or directed by the Engineer.

X03.06 BASIS OF PAYMENT. The accepted quantity of "Deck Slab Repair – Full Depth" shall be paid for at the contract unit price per square yard as listed in the Contract; if required, “Bituminous Surface Removal” will be paid for at the contract unit price per

square yard and “Bituminous Surface Repair” will be paid for at the contract unit price per ton as listed in the Contract. The price so-stated shall be full compensation for the work, complete in place, as described and specified herein, and accepted by the Engineer, including, but not limited to, all labor, tools, materials, equipment (including false work), and all other incidentals required to finish the work.

When corroded reinforcement bars are encountered in the performance of this work and replacement is required, the Contractor will be paid according to the Standard Specifications Section 109.

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