## APPENDIX A
## Summaries of Questionnaires and Interview Results

| RESPONDANT | COMMENT<br><br>Questions 58 of the Public Questionnaire and Question 37 of the Private Questionnaire |
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| Wyoming | WYDOT has never used cathodic protection for bridge decks or any other concrete bridge components. This technology has always seemed expensive, labor intensive, and of questionable effectiveness. It is possible that our Department might consider the use of this technology in the future if the above concerns could be adequately addressed. |
| Virginia | Cathodic Protection (impressed and galvanic) is a proven technology and is capable of providing considerable service life extension for reinforced concrete structures IF applied and maintained appropriately.<br><br>The market for CP in the transportation arena remains anemic, though great potential exists. The primary obstacle is education of the designers, constructors and maintainers (owners) about the capabilities, limitations, and requirements for an effective installation. Agencies wishing to effectively employ this technology need to develop procedures and retain staff or consulting expertise to ensure the systems are designed and installed properly. It is also imperative, particularly for impressed current systems, that monitoring and maintenance are consistently provided, and repairs or adjustments made in a timely manner.<br><br>Finally, in order to foster adoption of the technology by transportation agencies on a broad scale, the overall cost effectiveness of the systems must be proven. Documentation of actual service life enhancement is the first step. Life cycle cost assessments must be conducted, accounting not only for initial installation costs, but also for inspection and maintenance that is required for each type of system. Finally, true savings, accounting for reduced structure maintenance as well as reduced user costs, must be clearly documented. |
| Tennessee | TDOT has no knowledge about the cathodic protection market. |
| Ontario | The first generation impressed current CP system we used on decks was the conductive coke breeze system. Its performance was not good with depletion of coke around the pancake anodes within 10 years and corrosion of cable connections would increase system resistance and thus demands for current. Furthermore, since the system precludes the use of waterproofing membrane, the concrete surface continues to suffer freeze thaw and salt scaling, with increasing ingress of chloride. When the CP stops functioning, there is so much chloride that the deck would have to be replaced. We do not use this anymore.<br><br>In the early 1990's, we started using the titanium mesh impressed current system. This system performs much better than the coke breeze system and is still recommended for decks today when there is extensive chloride contamination but relatively small corrosion damage. Since the system is used in conjunction with a normal concrete overlay and waterproofing, the concrete surface is also protected and the projected service life is 25 to 30 years. However, the voltage and current output requires on-going monitoring and adjustment and the rectifier may need repair periodically. In the |

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| | current trend of government downsizing and outsourcing of maintenance staff, this technology is not very favorable.<br><br>On the other hand, the galvanic CP system does not depend on external power supply and therefore requires much less maintenance and monitoring. We have increased the use of galvanic CP substantially in the last 5 years; the monitoring data so far shows good performance and effective corrosion control, cost is also very competitive compared with other conventional method. Arc Sprayed Zinc (pure Zinc or Al-Zinc-Indium) has been used on piers, girders and caps. |
| Oklahoma | We like to use the zinc anodes (hockey pucks). Several years ago, we did an experimental bridge with impressed current which failed. |
| North Dakota | I believe the cathodic protection market in North Dakota is nonexistent. I believe there is no market because of the cost of the technologic, lack of understanding the technology, questionably benefits, and lack of bridge preventative maintenance funds. |
| New Mexico | In New Mexico, it is believed that ASR is a bigger problem than corrosion. New Mexico has a very active program to fight ASR. Corrosion is not presently considered the major reason why bridges deteriorate in New Mexico, although there have been some bridges where this is what has been identified as key deterioration mode. |
| Missouri | In Missouri cathodic protection for bridge decks will continue to be used over the next 20 years to protect decks on reinforced concrete superstructure bridges in high traffic areas. It has proven in the last 30 years that it is a reliable way to prolong the life of the bridge deck for 20+ years on structures MoDOT doesn't have the money to replace. Cathodic protection/cathodic prevention may still have a more widespread use on bridge substructures and superstructures.<br><br>Additional needs of the state DOT's are:<br><br>1. For impressed current CP systems on bridge decks a new Guide Specification is needed. DOT's can save money by having simpler specifications, simpler rectifiers and utilize better materials now available. If not a new specification provided by FHWA or AASHTO, they should decide to ratify the use of NACE specifications.<br><br>2. New galvanic anodes and processes need investigated in order to lower prices and improve quality and performance of these systems. |
| Illinois | Our need for CP is dwindling because of our extensive use of epoxy coated reinforcement bars and the continued retirement of structures with black bars. What concerns us now is the use of salt brine solutions on bridge decks usually applied twice per week between October and March. The concentration of salt getting into our decks appears to be much higher, if our epoxy coating breaks down what long term effect will this have on our decks? And can CP address this? |
| Hawaii | In concept, cathodic protection is an excellent means for corrosion protection. Limiting factors are cost, maintenance and monitoring of systems, level of expertise within the DOT, etc. If a new bridge is designed with cathodic protection system included as a means of corrosion protection it would be great, however, doing this for existing bridges are faced with the limiting factors noted. We have used the "hockey |

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| | pucks" for some repairs. We have discussed with Oregon DOT on zinc sprayed protection system but have not implemented yet.<br><br>I feel the market will always be there because there are specific applications where cathodic protection is the most cost-effective solution. However, it is not necessarily the answer for all corrosion protection. |
| Florida | Agencies are reluctant to accept technology because there have been too many over-zealous sales representatives with no in-house expertise to evaluate the proposed systems. |
| California | The CP market is relatively small and very specialized.<br><br>The use of cathodic protection as a rehabilitation methodology has decreased over time because our Department prefers up-front design strategies or mitigation measures as a means of dealing with the corrosion protection of reinforced concrete.<br><br>Department structure designers and specification writers reference Bridge Design Specifications, Article 8.22 which specifies the use of increased clear concrete cover over the reinforcing steel, corrosion resistant concrete mix designs, and epoxy coated reinforcing steel for corrosion protection of reinforced concrete exposed to chloride environments. In addition, the Department uses Structure Reference Specification S8-C04 (90CORR), included with the Contract Special Provisions, which provides specification language for corrosion resistant concrete mix designs as specified in BDS, Article 8.22. Structure Reference Specification S8-C04 (90CORR) specifies the use of mineral admixtures (fly ash, silica fume, metakaolin, etc.), reduced water content, and increased cementitious material content resulting in low permeable, durable concrete. These strategies, in addition to the use of polyester concrete overlays as a wear surface that can be replaced overnight to minimize traffic delays and worker exposure, have been relatively successful and reduce the need for CP.<br><br>However with that said, currently our Department's Office of Structures Maintenance Design still considers CP in limited situations for older existing structures based on factors that include: the type of structure, the structures location (over water or not) and how this effects the ability to be able to construct falsework; if the structure is located in high chain areas; the amount of chloride exposure; the amount of delamination, etc., CP may be a viable rehabilitation method. But these conditions are not typically met and as described above are currently becoming less so with time. |
| Nova Scotia | The main reason why CP is not used in NS is the cost. It is difficult to justify spending X dollars on a system that will not be turned on for 5-10 years after the structure is built. Also maintenance of the system, or lack thereof, will always be an issue. |
| Pennsylvania | -Market will probably be growing. -PennDOT is trying a spray-on zinc system in the next year or so. -For bridge decks that will receive latex overlays, we typically do not install the "hockey pucks" in the patch repair areas with exposed rebar. The latex concrete provides adequate protection by inhibiting the influx of deicing chemicals. |
| Texas | General thought is that the cost is high and monitoring is problematic with own workforce (lack of training, knowledge, and time). Maintenance of system likely will not happen. The benefits are difficult to determine and realize without any sound case |

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| | studies to reference. All we really know is what the sales people tell us. |
| South Dakota | We used impressed current CP systems on three bridge decks about 20-25 years ago. One of the bridge decks was planned to use a Raychem anode system but it failed right away. A titanium mesh system was used to replace it. The systems appeared to work as planned once they were completed. The systems have either been shut down or the structure or overlay system replaced. We also used the chloride extraction system on some bridge columns on a structure about 15-20 years ago that also worked. The lack of use of these types of cathodic protection systems since then appears to be the cost and lack of need for them. We have been using the zinc anodes on some of our rehabilitation projects in our past, current and planned future projects. |
| Prince Edward Island | CP is a growing market, with many jurisdictions looking at extending the serviceability life of their structure. Speaking only for our jurisdiction, factors which hold us back are costs. We are small; therefore, any items which can be removed, or not considered, in order to save money for other projects, it will be. |
| Maryland | Theory of systems is good but our experience indicates the systems require experienced staff and very frequent maintenance. Our opinion is that there is no cost benefit associated with these systems. |
| Utah | Utah DOT has used cathodic protection on seven bridges. Six of these bridges were retrofitted in approximately 1989 with either a conductive polymer or titanium mesh anode cathodic protection system. They are located in the same freeway junction and have since been replaced along with all bridges on the I-15 Reconstruction Project (1997-2001). The systems were not working at the time. The system on the seventh bridge has not functioned for many years and has been turned off. It did have a remote monitoring system. Those involved with these bridge projects are no longer with the Department, therefore, we have little information to share about them, other than that the systems failed and were not able to be maintained. Actual system types are not known. |
| North Carolina | Cathodic Protection market for bridge related application in North Carolina is nonexistent. Too costly. Do not work properly, especially in severe environments. We installed d different systems on 5 different bents of a bridge. All had totally failed within 1 year. Too time consuming to monitor. Systems are not tough enough for severe bridge environments. |
| Contractor 1 | CP market has potential for growth. However, due to lack of education, it is not being utilized enough on reinforced concrete bridges. As an industry we need more awareness of the use of impressed current CP systems. Properly installed and maintained these systems are proven to work. Sacrificial zinc anodes just can't get the job done in most cases (unless in a wet environment), and have hurt the perception of CP in general. |
| Contractor 2 | Although I am presently involved in the Manufacturing of Cathodic Protection Rectifiers, I have been involved in the corrosion industry for approximately 30 years. From my past experience with the protection of bridge deck components a number of problems were encountered, product reliability and longevity was an issue as well as proper installation practices. The result was a number of system failures resulting in |

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| | the end users have a bad taste in their mouths regarding these types of CP applications.<br><br>Technologies and designs have improved over the past few years and the implementation of CP protection should once again be considered as a viable solution to the prevention of corrosion in these applications. |
| Contractor 3 | The CP market for bridges is shrinking.<br><br>Problems derive from all sides of the contract<br><br>Owners:<br><br>1. Inadequate inspection during installation, or making the inspectors less than independent subs to the contractors<br><br>2. Won't accept maintenance responsibility - either in house or by consultants<br><br>Designers:<br><br>1. Designers often break zones by easy geometry - they don't look at variations in concrete resistivity so current distribution is often very bad within a single zone and as much as 90% of the current goes to less than 10% of the surface area.<br><br>2. Allow materials or other commercial considerations to push design<br><br>Materials Providers:<br><br>1. Pushed many materials out of the door with inadequate testing<br><br>Installers:<br><br>1. Don't follow the specifications (only look at the drawings, but that is not unique to bridge CP systems)<br><br>2. Don't become familiar with the process, materials, etc. before starting installation |
| Contractor 4 | In my opinion, there are two primary and equal reasons why CP is not used more extensively throughout the country; lack of understanding of the technology and its associated costs. With respect to the later, I believe too much focus is placed on initial costs rather than life cycle costs. |
| Contractor 5 | Market is changing from decks to substructures. Certain states have special need for CP (MO, MD). Constant current rectifiers were a huge mistake due to failure of electronics. If constant voltage rectifiers were used 25 years ago, there would be a lot less failures. Current swing is minimal. |

CATHODIC PROTECTION OF EXISTING REINFORCED CONCRETE BRIDGE ELEMENTS
Public Agency Survey Results

| | Q4 | Q5 | | | | Q6 | | | | Q7 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Marine % | Deicing % | Both % | Neither % | Marine % | Deicing % | Both % | Neither % | |
| Alberta, Canada | moderate | 0 | 90 | 0 | 10 | 0 | 90 | 0 | 10 | 11 to 15 |
| Arkansas | moderate | 0 | 25 | 0 | 75 | 0 | 15 | 0 | 85 | 0 to 5 |
| Arizona | minor | 20 | 30 | 10 | 40 | 20 | 30 | 10 | 40 | 6 to 10 |
| California | moderate | 10 | 10 | 0 | 80 | 10 | 0 | 0 | 90 | 6 to 10 |
| Colorado | moderate | 0 | 100 | 0 | 0 | 0 | 100 | 0 | 0 | 0 to 5 |
| Florida | moderate | 50 | 0 | 0 | 50 | 50 | 0 | 0 | 50 | |
| Hawaii | moderate | 100 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | none |
| Iowa | moderate | 0 | 100 | 0 | 0 | 0 | 20 | 0 | 80 | |
| Illinois | moderate | 0 | 100 | 0 | 0 | 0 | 100 | 0 | 0 | 11 to 15 |
| Indiana | minor | 0 | 100 | 0 | 0 | 0 | 100 | 0 | 0 | 6 to 10 |
| Maryland | moderate | 5 | 95 | 0 | 0 | 20 | 80 | 0 | 0 | 0 to 5 |
| Missouri | moderate | 0 | 100 | 0 | 0 | 0 | 35 | 0 | 65 | 0 to 5 |
| Mississippi | none | 1 | 2 | 0 | 97 | 1 | 2 | 0 | 97 | 0 to 5 |
| Montana | moderate | 0 | 100 | 0 | 0 | 0 | 10 | 0 | 90 | |
| New Brunswick, Canada | moderate | 15 | 60 | 15 | 10 | 15 | 40 | 5 | 40 | 6 to 10 |
| North Carolina | moderate | 20 | 60 | 0 | 20 | 20 | 60 | 0 | 20 | 11 to 15 |
| North Dakota | moderate | 0 | 100 | 0 | 0 | 0 | 100 | 0 | 0 | 11 to 15 |
| New Jersey | minor | 20 | 80 | 0 | 0 | 20 | 80 | 0 | 0 | 0 to 5 |
| New Mexico | moderate | 0 | 40 | 0 | 60 | 0 | 40 | 0 | 60 | 0 to 5 |
| Nova Scotia, Canada | moderate | 50 | 50 | 0 | 0 | 50 | 50 | 0 | 0 | 16 to 20 |
| New York | major | 5 | 95 | 0 | 0 | 5 | 95 | 0 | 0 | > 20 |
| Oklahoma | major | 0 | 100 | 0 | 0 | 0 | 50 | 0 | 50 | 0 to 5 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Ontario, Canada | moderate | 0 | 100 | 0 | 0 | 0 | 100 | 0 | 0 | 16 to 20 |
| Oregon | major | 10 | 0 | 0 | 90 | 10 | 0 | 0 | 90 | 0 to 5 |
| Pennsylvania | major | 0 | 100 | 0 | 0 | 0 | 100 | 0 | 0 | > 20 |
| Prince Edward Island, Canada | moderate | 0 | 0 | 100 | 0 | 0 | 0 | 100 | 0 | |
| South Carolina | moderate | 5 | 70 | 0 | 25 | 10 | 50 | 0 | 40 | 0 to 5 |
| South Dakota | moderate | 0 | 100 | 0 | 0 | 0 | 25 | 0 | 75 | 0 to 5 |
| Tennessee | moderate | 0 | 50 | 0 | 50 | 0 | 30 | 0 | 70 | 0 to 5 |
| Texas | moderate | 5 | 30 | 0 | 65 | 5 | 30 | 0 | 65 | 6 to 10 |
| Utah | major | 1 | 70 | 0 | 29 | 1 | 45 | 0 | 54 | 11 to 15 |
| Virginia | major | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 to 10 |
| Vermont | major | 0 | 100 | 0 | 0 | 0 | 40 | 0 | 60 | 11 to 15 |
| Washington | moderate | 0 | 99 | 1 | 0 | 1 | 5 | 0 | 94 | 6 to 10 |
| Wyoming | minor | 0 | 90 | 0 | 0 | 0 | 30 | 0 | 0 | 0 to 5 |

**NCHRP SYNTHESIS TOPIC 39-03**

*CATHODIC PROTECTION FOR LIFE EXTENSION OF EXISTING REINFORCED CONCRETE BRIDGE ELEMENTS*

**QUESTIONNAIRE**

# Questionnaire Instructions

## Introduction

Cathodic protection (CP) was first used on bridge decks in the 1970's and on bridge substructures in the 1980's. Since then, it has been employed by a number of State Departments of Transportations (DOTs) on bridges that had experienced reinforcing steel corrosion due to exposure to deicing salts or the marine environment (or both). While the earlier applications of cathodic protection installations were of the impressed current type, significant advances have been made in the past decade in adapting galvanic systems, particularly on substructure elements. The Galvanic systems are simpler and more easily maintained. The use of cathodic protection systems for mitigation of corrosion on reinforced concrete bridge structures is somewhat mixed, with a few States employing cathodic protection extensively and others only on a limited basis or not at all.

Thus, the intent of this synthesis is to determine why States do or do not use cathodic protection technology to mitigate corrosion of reinforced concrete bridge elements. Another goal is to determine what factors may expand the appropriate use of this technology.

The purpose of this questionnaire is to obtain information on the process of selection of corrosion mitigation systems, inclusion of cathodic protection in the selection process, implementation of cathodic protection technology, problems encountered in implementation and monitoring and maintenance, performance of cathodic protection technology, and areas of improvement.

## Instructions for Responding to the Questionnaire

1. The questionnaire is in an Abode Acrobat Format and can be filled out using Adobe Acrobat Reader. If you do not have Adobe Acrobat Reader you can download it from the following site for free. If your Adobe Reader is older than version 7.0, please download the newer version from.

   http://www.adobe.com/products/acrobat/readstep2.html

2. If you only have an Adobe Reader you will not be able to save this file, you will have to fill out the entire form in one session. If you have Adobe Acrobat Standard or Professional you can work in parts and save as you go along. You can complete the questionnaire and print it out for your record. Once you have completed the questionnaire, please click on the "Submit by Email" button on the top of the page. When you click this button, an Email will open up addressed to ali@concorr.com. Please copy the Email to aliakbar.soh@gmail.com. An XML File with the responses will be attached to the Email.

   If you do not have Adobe Acrobat and are using the Adobe Reader, it might be best that you print the questionnaire and mark your responses on it. Once you have answers to all questions, then open the questionnaire in the Abode Reader and fill it out.

3. There is a "Print Form" Button on the top of the questionnaire which you can use to print the questionnaire and keep for your records.

4. In the questionnaire, when only one response is desired, the drop-down list or the pack of buttons will only allow one selection. In questions where selection of more than one option is desirable, the buttons will allow it.

5. When no options are listed and you are required to provide an input, a text box is provided for that purpose.
6. At the end of the questionnaire a large text box is provided. Any thoughts or information pertaining to the application of cathodic protection you would like to share the project team are welcome.
7. If you would like to be considered for interview on the subject matter, please provide your contact information at the end of the questionnaire.

## Definitions

Corrosion Control System: Any technology or system that can be used to slow down, stop, or prevent corrosion of reinforcement in concrete.

Corrosion Condition Evaluation: A condition evaluation specifically conducted to ascertain the cause of corrosion, the stage of the corrosion process, and/or the magnitude of the problem caused by corrosion.

Galvanic Cathodic Protection: Zinc or other active metal is used to control or stop corrosion on reinforcing steel.

Impressed Current Cathodic Protection: An external application of electricity through an anode material installed on the reinforced concrete member is used to control or stop corrosion of reinforcing steel.

Marine Environment: Structure is located within 2 miles of a saline body of water.

# NCHRP SYNTHESIS TOPIC 39-03

*CATHODIC PROTECTION FOR LIFE EXTENSION OF EXISTING REINFORCED CONCRETE BRIDGE ELEMENTS*

## QUESTIONNAIRE

1. Respondent Organization Type? _____ 2. State Alabama

3. Please select all impressed current cathodic protection systems that your organization presently deals with:

- ☐ Titanium Mesh Anode
- ☐ Titanium Mesh Ribbon Anode
- ☐ Conductive Paint
- ☐ Conductive Coke Asphalt
- ☐ Arc Sprayed Titanium
- ☐ Conductive Polymer Coating
- ☐ Other _____
- ☐ Titanium Ribbon Anode
- ☐ Ceramic Anode (Ebonex)
- ☐ Conductive Polymer Anode
- ☐ Arc Sprayed Zinc
- ☐ Arc Sprayed Zinc Alloy (Corrpro)
- ☐ Other _____
- ☐ Other _____

4. Please select all galvanic current cathodic protection systems that your organization presently deals with:

- ☐ Arc Sprayed Zinc
- ☐ Galvashield Anode (All Types)
- ☐ Arc Sprayed Zinc Alloy (Corrpro)
- ☐ 3M Zinc Hydrogel Anode
- ☐ Other _____
- ☐ Atltrista LifeJacket
- ☐ Galvanode Jacket
- ☐ Zinc Bulk Anode
- ☐ Other _____
- ☐ Other _____

5. Please list the types of cathodic protection systems your organization has discontinued the use of and briefly describe why?

Anode _____ Discontinued Because _____

Anode _____ Discontinued Because _____

Anode _____ Discontinued Because _____

Anode _____ Discontinued Because _____

6. What percentage of cathodic protection systems are design-built based on your experience? _____

7. Does your organization design or design-build cathodic protection systems?
- ○ Yes
- ○ No

8. If you do, then who in your organization performs design of cathodic protection systems?

- ☐ NACE Certified Cathodic Protection Specialist
- ☐ P. E. with experience in designing cathodic protection systems
- ☐ Electrical Engineer with experience in designing cathodic protection systems
- ☐ Salesperson

# NCHRP SYNTHESIS TOPIC 39-03

*CATHODIC PROTECTION FOR LIFE EXTENSION OF EXISTING REINFORCED CONCRETE BRIDGE ELEMENTS*

## QUESTIONNAIRE

9. How many NACE Certified Cathodic Protection Specialist(s) does your organization have?
- ☐ 1
- ☐ 0 to 5
- ☐ More than 5

10. Which of the following guidelines does your organization use in the design of cathodic protection systems?
- ☐ NACE
- ☐ AASHTO-ARTBA
- ☐ None

11. In your experience, which of the following is most likely to determine which repair and corrosion control system is selected?
- ☐ Quantity of concrete damage
- ☐ Level of chloride ion contamination
- ☐ Cost of other alternatives
- ☐ Prevention of future damage
- ☐ Agency research and development recommendation
- ☐ Funding available from other sources (FHWA, Congress)
- ☐ Location of structure
- ☐ Structure type
- ☐ Severity of exposure
- ☐ Extension of service life provided by cathodic protection
- ☐ Life cycle cost analysis
- ☐ Consultant recommendaion
- ☐ FHWA recommendation
- ☐ Experience with cathodic protection
- ☐ Other

12. Are cathodic protection systems normally installed by a qualified and/or experienced Contractor?
- ◯ Yes
- ◯ No

13. When non-qualified or inexperienced Contractors install a cathodic protection system, who provides assistance with installation?
- ☐ Your Organization
- ☐ Owner
- ☐ No One
- ☐ Independent NACE Certified or Qualified Cathodic Protection Inspector
- ☐ Engineering Firm that designed the cathodic protection system

14. Usually, quality control during installation of cathodic protection systems is provided by:
- ☐ Contractor, Manufacturer, or Installer
- ☐ Owner
- ☐ Independent NACE Certified or Qualified Cathodic Protection Inspector

15. All or most CP Systems on bridge structures your organization has been involved with are monitored and maintained on a regular basis?
- ◯ Yes
- ◯ No

16. Cathodic protection system monitoring and maintenance is usually performed by:
- ☐ Owner Personnel
- ☐ Contractor
- ☐ Independent NACE Certified or Qualified Cathodic Protection Inspector
- ☐ Cathodic protection system supplier/manufacturer
- ☐ No One

17. Does your organization have any personnel trained to monitor and maintain cathodic protection systems?
- ◯ Yes
- ◯ No

18. Are remote monitoring systems used to monitor cathodic protection systems?
- ◯ Yes
- ◯ No

19. If remote monitoring is used on bridge structures that your organization has been involved with, how often are the systems monitored, i.e. someone actually makes a remote connection to check the status of the system or the system reports back?
- ◯ Once a week
- ◯ Once a month
- ◯ Twice a year
- ◯ Once a year

20. How often is a site visit made to evaluate the condition and the operation of the CP systems your organization has been involved with, whether or not a remote monitoring system is installed?
- ◯ Once every 3 months
- ◯ Once every 6 months
- ◯ Once a year
- ◯ Once every 2 years
- ◯ Once every 5 years

# NCHRP SYNTHESIS TOPIC 39-03

*CATHODIC PROTECTION FOR LIFE EXTENSION OF EXISTING REINFORCED CONCRETE BRIDGE ELEMENTS*

## QUESTIONNAIRE

21. Is the current status of operation of all or some of the cathodic protection systems your organization has been involved with available?
- ◯ Yes
- ◯ No

22. What percentage of cathodic protection systems your organization has been involved with are still operational? ____

23. While they were operational, did they stop corrosion?
- ◯ Yes
- ◯ No

24. Select all of the reasons listed below which were found to be reasons for failure of the cathodic protection systems.

- ☐ Failure of cathodic protection components resulted in the system being not operational for more than 20% of the time.
- ☐ Cathodic protection system not putting out sufficient current due to improper design.
- ☐ Cathodic protection system not putting out sufficient current due to improper settings.
- ☐ Cathodic protection system not operational due to failure of one or more components.
- ☐ Cathodic protection system did not operate due to deficient design.
- ☐ Cathodic protection system not installed as designed.
- ☐ Anode not appropriate for the application.
- ☐ Vandalism damaged system components.
- ☐ Not identified.

25. Which of the following components of the cathodic protection system required the **most** repair and maintenance?
- ◯ Rectifier
- ◯ Remote Monitoring Unit
- ◯ Anode
- ◯ Cable, wiring, conduit
- ◯ Reference cells
- ◯ Current probes
- ◯ Concrete overlay or backfill mat.

26. What is/was the frequency of repair or maintenance required on the cathodic protection system?
- ◯ Once a week
- ◯ Once a month
- ◯ Once a quater
- ◯ Once every 6 months
- ◯ Once a year
- ◯ Once every 2 years
- ◯ Once every 5 years

27. If anode failure for an impressed current cathodic protection has been experienced, please select the range of ages at which failure of each type of anode that has been used by your Agency and the mode of failure if determined.

| | 0 to 5 years | 6 to 10 years | 11 to 15 years | 16 to 20 years | 21 to 25 years | > 25 years | Describe Mode of Failure |
|---|---|---|---|---|---|---|---|
| Titanium Mesh Anode | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Titanium Ribbon | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Ceramic Anodes | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Conductive Paints | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Conductive Polymer Anodes | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Raychem Ferex Anode | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Conductive Coke Asphalt | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Arc Sprayed Zinc Alloy | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Arc Sprayed Zinc | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Arc Sprayed Titanium | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |

# NCHRP SYNTHESIS TOPIC 39-03

*CATHODIC PROTECTION FOR LIFE EXTENSION OF EXISTING REINFORCED CONCRETE BRIDGE ELEMENTS*

## QUESTIONNAIRE

28. If anode failure for a galvanic current cathodic protection has been experienced, please select the range of ages at which failure of each type of anode that has been used by your Agency and the mode of failure if determined.

| | 0 to 5 years | 6 to 10 years | 11 to 15 years | 16 to 20 years | 21 to 25 years | > 25 years | Describe Mode of Failure |
|---|---|---|---|---|---|---|---|
| Arc Sprayed Zinc | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| LifeJacket | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| 3M Zinc Foil | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Arc Sprayed Zinc Alloy | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Bulk Zinc Anode | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Hockey Puck Zinc Anode | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |

29. If rectifier failure has been experienced, which of the following cause(s) for failure were noted?

- ☐ Rectifying element failure.
- ☐ Control card failure.
- ☐ Lighting strikes.
- ☐ Remote monitoring unit failure.
- ☐ Other

30. For how many bridges did your organization provide materials for, installed a cathodic protection system on, or provide consulting services for during the following time periods:

| | | | | | |
|---|---|---|---|---|---|
| 1980 to 1990 | | 1996 to 2000 | | 2006 to Present | |
| 1991 to 1995 | | 2001 to 2005 | | | |

31. What is your organizations's projections for the next 5 years in terms of how many bridges your organization estimates it will provide materials for, install, or provide consulting and engineering services for the installation of cathodic protection systems?

Number Of Bridges

32. Which of the following bridge components does your organization provide materials, installation, and/or consulting services for for and what percentage of your business is in each category.

| | | | | | |
|---|---|---|---|---|---|
| Bridge Decks | | Caps | | Piles | |
| Beams, Girders, Diaphrams | | Columns | | Struts | |
| Footers | | | | | |

# NCHRP SYNTHESIS TOPIC 39-03

*CATHODIC PROTECTION FOR LIFE EXTENSION OF EXISTING REINFORCED CONCRETE BRIDGE ELEMENTS*

## QUESTIONNAIRE

33. Considering your overall experience with the cathodic protection industry, how do you categorize the use of cathodic protection on bridge components when the corrosion condition, severity of exposure, and the service life requirements justify the application of cathodic protection?

- ☐ Rarely considered an option
- ☐ Always considered an option
- ☐ Considered on select projects with special requirements
- ☐ Considered when Consultant or Owner has experience with CP
- ☐ Considered when the Owner is provided assistance and information on the benefits CP can bring to their project

34. If you believe that cathodic protection on bridge components is not used as often as it should be, which of the following factors do you believe is holding back the use of this technology.

- ☐ Lack of understanding of the technology by the bridge owners.
- ☐ Lack of understanding of the technology by engineers entrusted to design repairs and rehabilitation of bridges.
- ☐ The initial cost of cathodic protection systems is prohibitive.
- ☐ The requirement to monitor and maintain the cathodic protection system is quite burdensome.
- ☐ Complexity of technology.
- ☐ Inadequate performance or failure of cathodic protection system.
- ☐ Lack of Consultants who can provide the requisite services to design, assist with installation, and monitor and maintain systems.
- ☐ Lack of standards for selection, design, installation, and operation of the systems.
- ☐ Local preferences for certain technologies.
- ☐ Insufficient marketing by the industry.
- ☐ The Owner does not have the resources to monitor and maintain the cathodic protection systems.
- ☐ Applicators and Contractors that do business with the Owner do not have any experience with the technology.
- ☐ Experience of some State and Local Agencies suggest CP is too complicated, does not work, is to expensive, and requires significant monitoring and maintenance.
- ☐ Other

35. Which of the following factor(s) will encourage the application of cathodic protection:

- ☐ Better understanding of technology by Agency Staff
- ☐ Education of Consultants
- ☐ Trained Applicators and Contractors
- ☐ Reduction in cost of cathodic protection systems
- ☐ Availability of Consultants to monitor and maintain cathodic protection systems
- ☐ Improved technology to monitor and maintain systems
- ☐ Improved quality of system components, which would reduce frequency of repair and maintenance
- ☐ Improved design
- ☐ Technical assistance in selection of appropriate cathodic protection systems for each application
- ☐ All of the above

# NCHRP SYNTHESIS TOPIC 39-03

*CATHODIC PROTECTION FOR LIFE EXTENSION OF EXISTING REINFORCED CONCRETE BRIDGE ELEMENTS*

## QUESTIONNAIRE

36. If your agency has, or is aware of, reports documenting the installation and experience of cathodic protection systems on bridge structures, please list below the name of the reports so that the research team can obtain and review them. The primary goal is to obtain case studies to exemplify good and bad practice for selecting, designing, installing, and operating a cathodic protection system.

# NCHRP SYNTHESIS TOPIC 39-03

*CATHODIC PROTECTION FOR LIFE EXTENSION OF EXISTING REINFORCED CONCRETE BRIDGE ELEMENTS*

## QUESTIONNAIRE

37. Please list and explain what you think about the cathodic protection market. Is it growing, shrinking, nonexistent, or robust? Also provide your thoughts on what factors are holding back the application of cathodic protection on bridge components and what factors would help encourage the application of cathodic protection. You can also provide any thoughts you have on cathodic protection application that have not been or not completely addressed in the questionnaire that you would like to share with the research team.

38. Please provide your contact information if you choose to be interviewed for further clarification or information on this subject topic.

Name

Department

State Alabama

Phone Number

email

**NCHRP SYNTHESIS TOPIC 39-03**

*CATHODIC PROTECTION FOR LIFE EXTENSION OF EXISTING REINFORCED CONCRETE BRIDGE ELEMENTS*

**QUESTIONNAIRE**

# Questionnaire Instructions

## Introduction

Cathodic protection (CP) was first used on bridge decks in the 1970's and on bridge substructures in the 1980's. Since then, it has been employed by a number of State Departments of Transportations (DOTs) on bridges that had experienced reinforcing steel corrosion due to exposure to deicing salts or the marine environment (or both). While the earlier applications of cathodic protection installations were of the impressed current type, significant advances have been made in the past decade in adapting galvanic systems, particularly on substructure elements. The Galvanic systems are simpler and more easily maintained. The use of cathodic protection systems for mitigation of corrosion on reinforced concrete bridge structures is somewhat mixed, with a few States employing cathodic protection extensively and others only on a limited basis or not at all.

Thus, the intent of this synthesis is to determine why States do or do not use cathodic protection technology to mitigate corrosion of reinforced concrete bridge elements. Another goal is to determine what factors may expand the appropriate use of this technology.

The purpose of this questionnaire is to obtain information on the process of selection of corrosion mitigation systems, inclusion of cathodic protection in the selection process, implementation of cathodic protection technology, problems encountered in implementation and monitoring and maintenance, performance of cathodic protection technology, and areas of improvement.

## Instructions for Responding to the Questionnaire

1. This questionnaire should be completed by personnel or department dealing with the repair and rehabilitation of reinforced concrete bridge members and preferably by personnel experienced with cathodic protection or with input from such personnel. The Questionnaire is expected to be completed and received by TRB on or before March 3, 2008.

2. Please respond to Questions 1 to 19 and Questions 52 to 59 even if your Agency has never used cathodic protection.

3. The questionnaire is in an Abode Acrobat Format and can be filled out using Adobe Acrobat Reader. If you do not have Adobe Acrobat Reader you can download it from the following site for free. If your Adobe Reader is older then version 7.0. Please download the newer version.

   http://www.adobe.com/products/acrobat/readstep2.html

4. If you only have an Adobe Reader you will not be able to save this file, you will have to fill out the entire form in one session. If you have Adobe Acrobat Standard or Professional you can work in parts and save as you go along. You can complete the questionnaire and print it out for your record. Once you have completed the questionnaire, please click on the "Submit by Email" button on the top of the page. When you click this button, an Email will open up addressed to ali@concorr.com. Please copy the Email to aliakbar.soh@gmail.com. An XML File with the responses will be attached to the Email.

   If you do not have Adobe Acrobat and are using the Adobe Reader, it might be best that you print the questionnaire and mark your responses on it. Once you have answers to all questions, then open the questionnaire in the Abode Reader and fill it out.

5. There is a "Print Form" Button on the top of the questionnaire which you can use to print the questionnaire and keep for your records.

6. In the questionnaire, when only one response is desired the drop-down list or the pack of buttons will only allow one selection. In questions where selection of more than one option is desirable, the buttons will allow it.

7. When no options are listed and you are required to provide an input, a text box is provided for that purpose.

8. At the end of the questionnaire, a large text box is provided, and any thoughts or information pertaining to the application of cathodic protection you would like to share with the project team are welcome.

9. If you would like to be considered for interview on the subject matter, please provide your contact information at the end of the questionnaire.

## Definitions

Corrosion Control System: Any technology or system that can be used to slow down, stop, or prevent corrosion of reinforcement in concrete.

Corrosion Condition Evaluation: A condition evaluation specifically conducted to ascertain the cause of corrosion, the stage of the corrosion process, and/or the magnitude of the problem caused by corrosion.

Galvanic Cathodic Protection: Zinc or other active metal is used to control or stop corrosion on reinforcing steel.

Impressed Current Cathodic Protection: An external application of electricity through an anode material installed on the reinforced concrete member is used to control or stop corrosion of reinforcing steel.

Marine Environment: Structure is located within 2 miles of a saline body of water.

# NCHRP SYNTHESIS TOPIC 39-03

*CATHODIC PROTECTION FOR LIFE EXTENSION OF EXISTING REINFORCED CONCRETE BRIDGE ELEMENTS*

## QUESTIONNAIRE

1. Respondent Organization Type? State Department of Transportation

2. State Alabama

3. If a Local DOT, then provide name of Locality

4. Please select which best describes the magnitude of corrosion of reinforced concrete on bridge structures owned and maintained by your Agency. a moderate problem

IF CORROSION OF REINFORCING STEEL IS NOT A PROBLEM FOR BRIDGE STRUCTURES OWNED AND/OR MAINTAINED BY YOUR AGENCY, PLEASE STOP, YOU DO NOT NEED TO ANSWER ANY MORE QUESTIONS.

| | |
|---|---|
| 5. Please provide information on types of environmental exposure bridge decks are exposed to in your jurisdiction and the percentage of them exposed to each environment type. (*the total should be 100%*) | Marine Environment<br>Deicing Salt Exposure<br>Both<br>Neither |
| 6. Please provide information on types of environmental exposure bridge substructure elements such as caps, columns, piles, struts, and footers are exposed to in your jurisdiction and the percentage of them exposed to each environment type. (*the total should be 100%*) | Marine Environment<br>Deicing Salt Exposure<br>Both<br>Neither |

7. If chloride based deicing salts are used, please pick the appropriate range of usage in your entire jurisdiction. It is understood that the range of salt usage may significantly vary from one area to another in your jurisdiction.

8. Select all test methods listed below which are used during Routine Bridge Inspection for detection of corrosion.

- ☐ Visual Survey
- ☐ Crack Survey
- ☐ Half-cell Potential Survey
- ☐ Carbonation Testing
- ☐ Electrical Continuity Testing
- ☐ Delamination and Spall Survey
- ☐ Chloride Ion Content Analysis
- ☐ Corrosion Rate Measurement
- ☐ Concrete Resistivity Testing
- ☐ None of the above
- ☐ Other

9. If corrosion of reinforcement is noted during a Routine Bridge Inspection and a corrosion condition evaluation is performed, please select all test methods listed below which are used during corrosion condition evaluation.

- ☐ Visual Survey
- ☐ Crack Survey
- ☐ Half-cell Potential Survey
- ☐ Carbonation Testing
- ☐ Electrical Continuity Testing
- ☐ Delamination and Spall Survey
- ☐ Chloride Ion Content Analysis
- ☐ Corrosion Rate Measurement
- ☐ Concrete Resistivity Testing
- ☐ None of the above
- ☐ Other

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*CATHODIC PROTECTION FOR LIFE EXTENSION OF EXISTING REINFORCED CONCRETE BRIDGE ELEMENTS*

## QUESTIONNAIRE

10. Are there Agency wide standard procedures, protocols, or methodologies for conducting corrosion condition evaluations of reinforced concrete bridge elements?
- ◯ Yes
- ◯ No

11. Does your Agency have procedures, protocols, or methodologies to analyze the data collected during condition evaluation?
- ◯ Yes
- ◯ No

12. Does your Agency have procedures protocols, or methodologies to select repair and corrosion control alternatives based on data collected from condition evaluations?
- ◯ Yes
- ◯ No

13. Which one of the following is **most likely** to determine which repair and corrosion control system is selected.

Quantity of damage

14. If your Agency has procedures, protocols, and/or methodologies to select repair and corrosion control alternatives, does it include Cathodic Protection as one of the alternatives?

- ◯ Yes
- ◯ No

15. If you answered No to Question 14, then please select the reason(s) why your Agency does not consider Cathodic Protection technology as one of the viable alternatives for corrosion control.

- ☐ Exposure environment is not sufficiently corrosive to warrant the use of cathodic protection.
- ☐ Cathodic Protection technology is relatively more expense than other options available.
- ☐ Engineers and contractors that serve the Agency do not have any experience with the technology.
- ☐ Cathodic Protection is too complicated and the Agency does not have sufficient understanding to use it.
- ☐ Past experience with Cathodic Protection has been disappointing.

16. Does your Agency use any of the listed technologies on new structures and existing structures (which have not suffered corrosion of the reinforcement) to extend their service life or to prevent or delay corrosion from starting?

- ☐ Waterproofing membranes
- ☐ Waterproofing with asphalt overlay
- ☐ Sealers
- ☐ Concrete overlays
- ☐ Admixed corrosion inhibitors
- ☐ Surface applied corrosion inhibitors
- ☐ Impressed current cathodic protection
- ☐ Galvanic cathodic protection
- ☐ Other

17. Which of the following corrosion control systems have or are being used by your Agency for corrosion control after repairs are performed?

- ☐ Waterproofing membranes
- ☐ Sealers
- ☐ Concrete overlays
- ☐ Specialty concrete
- ☐ Rebar coatings in repair areas
- ☐ Admixed corrosion inhibitors
- ☐ Surface applied corrosion inhibitors
- ☐ Localized zinc anodes (hockey pucks)
- ☐ Impressed current cathodic protection
- ☐ Galvanic cathodic protection
- ☐ Electrochemical chloride extraction
- ☐ Other

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## QUESTIONNAIRE

18. For which of the following reasons, would or has, your Agency considered using Cathodic Protection?

- ☐ Quantity of concrete damage
- ☐ Level of chloride ion contamination
- ☐ Cost of other alternatives
- ☐ Prevention of future damage
- ☐ Agency research and development recommendation
- ☐ Funding available from other sources (FHWA, Congress)
- ☐ Location of structure
- ☐ Structure type
- ☐ Severity of exposure
- ☐ Extension of service life provided by cathodic protection
- ☐ Life cycle cost analysis
- ☐ Consultant recommendaion
- ☐ FHWA recommendation
- ☐ Experience with cathodic protection
- ☐ Other

19.If your Agency has never or has not used CP in the last 5 years, would your Agency consider using CP in the future when it is applicable?

- ◯ Yes
- ◯ No

ANSWER QUESTIONS 20 TO 52 IF YOUR AGENCY HAS USED CATHODIC PROTECTION OF ANY KIND IN THE PAST

20. Please provide the number of bridge structures on which cathodic protection has been used by your Agency.

21. Provide the number of bridges on which cathodic protection systems has been installed on the following reinforced concrete elements.

| | | | |
|---|---|---|---|
| Bridge Decks | | Columns | |
| Superstructure Elements (beams, girders, diaphragms) | | Piles | |
| Caps | | Footers | |

22. Select the types of cathodic protection systems used on various elements by your Agency.

| | Impressed Current Cathodic Protection | | | | | | | | | | Galvanic Cathodic Protection | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Arc Sprayed Zinc | Arc Sprayed Titanium | Arc Sprayed Zinc Alloys | Conductive Paint | Ceramic Anode | Raychem Ferex | Conductive Polymer | Titanium Mesh Anode | Titanium Ribbon | Other | Arc Sprayed Zinc | Arc Sprayed Zinc Alloys | Hockey Puck Zinc Anode | Zinc Foil Anode | LifeJacket | Zinc Bulk Anode | Other |
| Bridge Decks | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Beams, Girders, & Diaphragms | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Caps | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Columns | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Piles | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Struts | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Footers | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

# NCHRP SYNTHESIS TOPIC 39-03

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## QUESTIONNAIRE

23. Does your Agency have any Standards for design and/or Construction Specifications governing the use of cathodic protection on reinforced concrete bridge elements.

- ◯ Yes
- ◯ No

24. Design of cathodic protection systems are normally performed by:

- ☐ Agency Staff
- ☐ Consultant - Engineering Firm with access to NACE Certified Cathodic Protection Specialist
- ☐ Consultant - Engineering Firm with assistance from manufacturer and/or installer
- ☐ Consultant - Engineering Firm based on Agency Standards and Construction Specifications
- ☐ Contractor or Installer
- ☐ Agency Staff in conjunction with Consultant

25. Are or were installations of cathodic protection systems bid out as Design-Build Projects, and if so, how often?

- ◯ Yes _____ %
- ◯ No

26. Cathodic Protection Design-Build Projects are generally awarded to:

- ☐ Cathodic protection materials provider and/or installer.
- ☐ General Contractor with cathodic protection materials provider and/or installer as Subcontractor
- ☐ General Contractor with an independent cathodic protection consultant.
- ☐ Other _____

27. Quality control during the installation of cathodic protection systems is or was generally provided by:

- ☐ Agency Staff
- ☐ Consultant - Engineering Firm with access to NACE Certified Cathodic Protection Specialist
- ☐ Consultant - Engineering Firm
- ☐ Contractor, manufacturer, installer
- ☐ Independent NACE Certified or Qualified cathodic protection inspector
- ☐ No one

28. Cathodic protection is used by the Agency as one of the several corrosion control systems because:

- ☐ Cathodic protection is the only approved alternative for the exposure environment.
- ☐ Cathodic protection is the only alternative that provides the service life extension desired for many of the high use structures.
- ☐ The Agency Staff has significant experience and has had significant success with the use of cathodic protection.

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## QUESTIONNAIRE

29. For which of the following reason(s) is cathodic protection selected for use:

- ☐ Marine environment where exposure is very corrosive and no other corrosion control system provides service life extension of more than 5 years.
- ☐ Deicing salt exposure which has resulted in high uniform chloride ion contamination and no other corrosion control system is expected to provide service life extension of more than 5 years.
- ☐ Life cycle cost of cathodic protection system is or was lower than any other corrosion control system.
- ☐ Cathodic protection system was expected to provide service life extension in excess of 20 years.
- ☐ Location of the structure required use of an aggressive corrosion protection system.
- ☐ Type of structure.
- ☐ Other

30. Are there new cathodic protection systems planned to be installed in the next 5 years? If yes, how many?

- ◯ Yes # of Bridges: 0
- ◯ No

31. If your Agency has used cathodic protection in the past and is not inclined to use it in the future, then please select the reason(s) which is/are responsible for the decision.

- ☐ Cathodic protection system did not work at all.
- ☐ Cathodic protection did not stop corrosion and concrete repairs were required after cathodic protection installation within 5 years.
- ☐ Cathodic protection component failed and could not be maintained.
- ☐ Monitoring and maintenance was a significant burden.
- ☐ The Agency did not have the resources to monitor and maintain the system.
- ☐ The technology is not well understood by the Agency.
- ☐ The Consultants are not well versed in the technology to recommend it to the Agency.
- ☐ Applicators and contractors that do business with the Agency do not have any experience with the technology.
- ☐ Experience of other Agencies suggest cathodic protection is too complicated, does not work, is too expensive, and requires significant monitoring and maintenance.
- ☐ Agency Staff with experience in cathodic protection retired or have been promoted and new staff have not experience with CP.
- ☐ Cost of cathodic protection was relatively higher than other options.
- ☐ Other

32. Are all cathodic protection systems on Agency structures monitored and maintained on a regular basis?

- ◯ Yes # of Bridges: 0
- ◯ No

33. Cathodic protection system monitoring and maintenance is performed by:

- ☐ Agency Personnel
- ☐ Contractor
- ☐ Both

# NCHRP SYNTHESIS TOPIC 39-03

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## QUESTIONNAIRE

34. Does your Agency have personnel trained to monitor and maintain cathodic protection systems?
- ◯ Yes
- ◯ No

35. Does your Agency have sufficient personnel to monitor and maintain all cathodic protection systems under your jurisdiction?
- ◯ Yes
- ◯ No

36. Does your Agency use Consultants on a regular basis to monitor and maintain cathodic protection systems?
- ◯ Yes
- ◯ No

37. Does your Agency have a program in place to monitor and maintain cathodic protection systems?
- ◯ Yes
- ◯ No

38. Are Remote Monitoring Systems used to monitor some or all of the cathodic protection systems?
- ◯ Yes
- ◯ No

39. If Remote Monitoring Systems are used, how often are the systems remotely monitored, i.e. someone actually makes a connection to check the status of the system?
- ◯ Once a week
- ◯ Once a month
- ◯ Once a year
- ◯ Twice a year

40. How often is a site visit made to evaluate the condition and the operation of the cathodic protection systems, whether or not a remote monitoring system is installed?
- ◯ Once every 3 month
- ◯ Once every 6 months
- ◯ Once a year
- ◯ Once every 2 years
- ◯ Once every 5 years

41. Is the current status of operation of all or some of the cathodic protection systems available to the Agency?
- ◯ Yes
- ◯ No

42. What percentage of cathodic protection systems installed on your Agency Structures are still operational? _____

43. Please select, the average length of time cathodic protection systems have been in operation for, in your jurisdiction?
- ◯ Less then 1 year
- ◯ 1 to 5years
- ◯ 5 to 15 years
- ◯ greater then 15 years

44. While they were operational, did CP systems stop corrosion and extend the remaining service life?
- ◯ Yes
- ◯ No

45. If not, has the cause being determined?
- ◯ Yes
- ◯ No

46. Who determined the cause of failure?

- ☐ Agency Staff
- ☐ Consultant
- ☐ Manufacturer
- ☐ Installer

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## QUESTIONNAIRE

47. Select all of the reasons listed below which were found to be reasons for failure of the cathodic protection systems.

- ☐ Failure of cathodic protection components resulted in the system being not operational for more than 20% of the time.
- ☐ Cathodic protection system not putting out sufficient current due to improper design.
- ☐ Cathodic protection system not putting out sufficient due to improper settings.
- ☐ Cathodic protection system not operational due to failure of one or more components.
- ☐ Cathodic protection system did not operate due to deficient design.
- ☐ Cathodic protection system not installed as designed.
- ☐ Anode not appropriate for the application.
- ☐ Vandalism damaged system components.
- ☐ Not identified.

48. Which of the following components of the cathodic protection system required the **most** repair and maintenance?

- ◯ Rectifier
- ◯ Remote Monitoring Unit
- ◯ Anode
- ◯ Cable, wiring, conduit
- ◯ Reference cells
- ◯ Current probes
- ◯ Concrete overlay or backfill mat.

49. Frequency of repair or maintenance required on the cathodic protection system?

- ◯ Once a week
- ◯ Once a month
- ◯ Once a quater
- ◯ Once every 6 months
- ◯ Once a year
- ◯ Once every 2 years
- ◯ Once every 5 years

50. If anode failure for an impressed current cathodic protection has been experienced, please select the range of ages at which failure of each type of anode that has been used by your Agency and the mode of failure if determined.

| | 0 to 5 years | 6 to 10 years | 11 to 15 years | 16 to 20 years | 21 to 25 years | > 25 years | Describe Mode of Failure |
|---|---|---|---|---|---|---|---|
| Titanium Mesh Anode | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Titanium Ribbon | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Ceramic Anodes | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Conductive Paints | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Conductive Polymer Anodes | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Raychem Ferex Anode | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Conductive Coke Asphalt | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Arc Sprayed Zinc Alloy | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Arc Sprayed Zinc | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Arc Sprayed Titanium | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |

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*CATHODIC PROTECTION FOR LIFE EXTENSION OF EXISTING REINFORCED CONCRETE BRIDGE ELEMENTS*

## QUESTIONNAIRE

51. If anode failure for a galvanic current cathodic protection has been experienced, please select the range of ages at which failure of each type of anode that has been used by your Agency and the mode of failure if determined.

| | 0 to 5 years | 6 to 10 years | 11 to 15 years | 16 to 20 years | 21 to 25 years | > 25 years | Describe Mode of Failure |
|---|---|---|---|---|---|---|---|
| Arc Sprayed Zinc | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| LifeJacket | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| 3M Zinc Foil | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Arc Sprayed Zinc Alloy | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Bulk Zinc Anode | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |
| Hockey Puck Zinc Anode | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |

52. If rectifier failure has been experienced, which of the following cause(s) for failure were noted?

- ☐ Rectifying element failure.
- ☐ Control card failure.
- ☐ Lighting strikes.
- ☐ Remote monitoring unit failure.
- ☐ Other

53. Which of the following factor(s) will encourage the application of cathodic protection:

- ☐ Better understanding of technology by Agency Staff
- ☐ Education of Consultants
- ☐ Trained Applicators and Contractors
- ☐ Reduction in cost of cathodic protection systems
- ☐ Availability of consultants to monitor and maintain cathodic protection systems
- ☐ Improved technology to monitor and maintain systems
- ☐ Improved quality of system components, which would reduce frequency of repair and maintenance
- ☐ Improved design
- ☐ Technical assistance in selection of appropriate cathodic protection systems for each application
- ☐ All of the above

54. Has your Agency performed any research and developmental work on any type of cathodic protection system?

- ◯ Yes
- ◯ No

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## QUESTIONNAIRE

55. If it has performed research and developmental work in the area of cathodic protection, which of the following areas have been included in these efforts?

- ☐ Development of anode materials
- ☐ Performance and applicability of anode materials in the field
- ☐ Performance of one or more types of cathodic protection systems installed on bridge elements
- ☐ Laboratory evaluation of cathodic protection systems(s)
- ☐ Evaluation of rectifiers in the field or in the laboratory
- ☐ Development or evaluation of reference electrodes
- ☐ Development or evaluation of other monitoring instruments
- ☐ Development or evaluation of monitoring protocols
- ☐ Development or evaluation of criteria for for operation of cathodic protection system
- ☐ Development or evaluation of remote monitoring equipment

56. Are reports from these research and development or trial efforts available? If available please provide contact information.

- ○ Yes
- ○ No

Contact Information for obtaining a copy of the reports

57. If your agency has, or is aware of, reports documenting the installation and experience of cathodic protection systems on bridge structures, please list below the name of the reports so that the research team can obtain and review them. The primary goal is to obtain case studies to exemplify good and bad practice for selecting, designing, installing, and operating a cathodic protection system.

# NCHRP SYNTHESIS TOPIC 39-03

*CATHODIC PROTECTION FOR LIFE EXTENSION OF EXISTING REINFORCED CONCRETE BRIDGE ELEMENTS*

## QUESTIONNAIRE

58. Please list and explain what you think about the cathodic protection market. Is it growing, shrinking, nonexistent, or robust? Also provide your thoughts on what factors are holding back the application of cathodic protection on bridge components and what factors would help encourage the application of cathodic protection. You can also provide any thoughts you have on cathodic protection application that have not been or not completely addressed in the questionnaire that you would like to share with the research team

59. Please provide your contact information if you choose to be interviewed for further clarification or information on this subject topic.

Name

Department

State Alabama

Phone Number

email