



**SPR Quarterly Progress Report**  
July 1, 2009 through September 30, 2009

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Date        October 6, 2009

**TO:**        Technical Advisory Committee Members:

James Garrard, ODOT  
Ray Bottenberg, ODOT  
Steven Soltesz, ODOT  
Tim Rogers, FHWA  
Bernie Covino, NETL

**FROM:**    Steve Soltesz, Research Engineer, phone: (503) 986-2851

**1.        Project**

Replacing Thermal Sprayed Zinc Anodes  
SPR # 682

**2.        Key Dates**

Start Date for ODOT:        July 2008  
Completion Date for ODOT:    September 2010

**3.        Principal Investigator**

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**4.        Progress**

- Task 1: Survey of the current practice (100% complete)

The research team has conducted a comprehensive literature review to gather existing information relevant to this project, including CP basics, concrete surface preparation, anode material options, methods of testing anode performance and

predicting anode service life, methods of anode application/installation and replacement, methods of monitoring performance of CP systems, and other advancements in the CP technologies. A detailed Internet-based search was conducted, using online databases; and a draft literature review report has been prepared. On the basis of the literature review, the research team also designed and widely distributed two online surveys aimed to identify key contacts and to capture the CP field experience of ODOT and other identified agencies, with particular emphasis on their successes or failures with the use of thermally sprayed zinc to protect bridge substructures and methods for old anode removal and surface preparation before the new anode application. CP experience of other industries such as those protecting naval facilities and parking structures were sought, through the survey of consulting firms (such as Corrpro and Vector) and targeted practitioners and researchers. The two surveys were delivered to the TAC for review and comments and then the revised surveys were distributed to the identified contacts and professional forums. We obtained the survey responses and completed the literature review report draft. In the last quarter, we further improved and finalized the report by integrating the ODOT panel review comments and additional peer review comments.

- Task 2: Investigation methods of zinc anode removal and concrete surface preparation (35% complete)

The research team coordinated with ODOT and NETL to identify the samples from previous research projects related to this topic and obtained the concrete samples. Experiments were designed to conduct the preliminary laboratory investigation, on the basis of the information gathered from the comprehensive literature review and the surveys. We also identified ways of renting several critical equipment needed for the laboratory experiments. Some trials were conducted to explore the reasonable ranges of influential factors. In May 2009, an amendment to the work plan and its revised version were submitted to ODOT, to follow up on the May 15, 2009 teleconference between the project P.I. and the technical advisory committee (TAC). The amendment to the work plan for the experimental effort deals with best practices for removal and re-application of arc spray zinc corrosion protection. The work is separated into three main tasks including: 1) Determination of the physical and electrochemical condition of the NETL samples; 2) Determination of the bond strength of the zinc arc spray coating, electrical resistance and gas permeability as a function of residual reaction layer thickness; and 3) if determined necessary from the 2<sup>nd</sup> task, investigating the development and application of a cement “skin primer” mix design for resurfacing the concrete before re-applying arc spray zinc. This cement skin will need to be tested to verify that it does not reduce the overall performance of the corrosion protection system. In the last quarter we made significant progress on these tasks and some details are provided below.

The work completed this quarter focused on the response of the NETL concrete samples with respect to electrical resistance and gas permeability as a function of

the reaction layer thickness. Electrical resistance of the concrete samples was measured using Electrochemical Impedance Spectroscopy (EIS) and the DC method (multi-meter). The permeability of the concrete samples was measured using a test method in which vaporized methanol is passed through a thin concrete disc as a function of time.

The laboratory work started by selecting 6 samples from the NETL inventory that was shipped to MSU earlier in the year. The samples were chosen based on equivalent electrochemical age and chloride content. The six samples selected have equivalent ages ranging from 5 to 45 years and all of the samples had 5 percent chloride added at mixing. Once the source samples were selected, small cubes (25mm) and thin discs (15mm thick x 92mm) were cut from them. Before the electrical resistance testing started, the cubes were analyzed using SEM/EDX to determine the approximate thickness of the reaction layer. After the imaging work was completed, the cube samples were placed in a humidity-controlled chamber for 48 hours before starting the EIS and DC resistivity measurements. The moisture content of the cube samples ranged between 5 to 6 percent during testing. The thin discs, used to measure the gas permeability measurements, were oven dried for 18 hours prior to starting each test. The results of these tests generally show that once 100 percent of the reaction layer is removed, the DC resistivity, equivalent capacitance and the gas permeability increase. For many of the samples the EIS and gas permeability data show that as the reaction layer is removed the sample becomes more porous, has possibly larger pores and more pore connectivity. Figure 1 shows the gas and electrical data for one of the 6 samples.

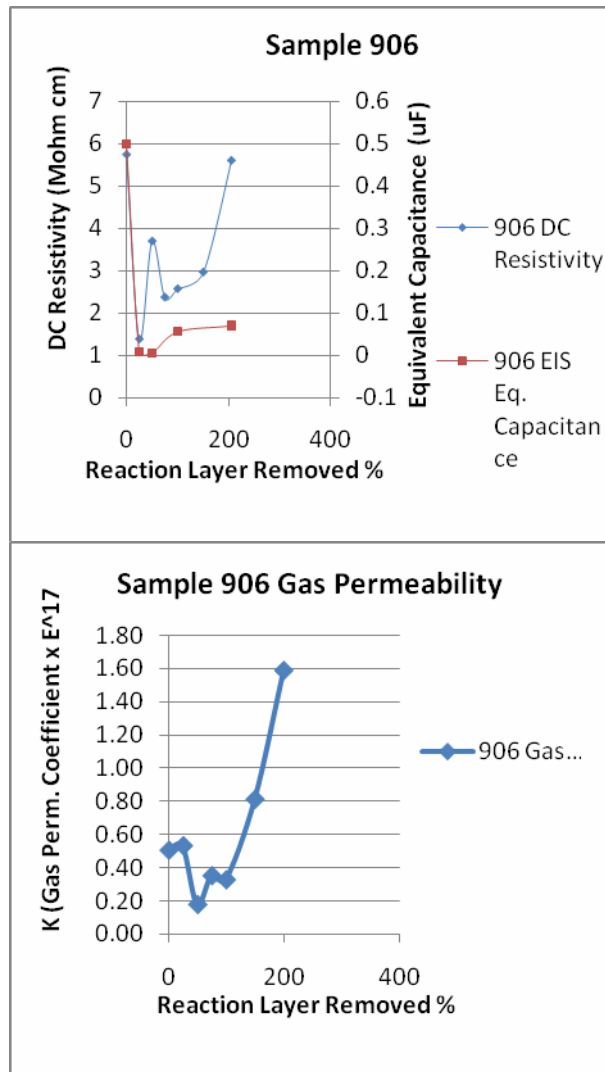


Figure 1 DC Resistivity, Equivalent Capacitance and Gas Permeability

In addition to the laboratory effort, progress was made arranging to have the NETL samples sprayed by a metalizing contractor in the state of Oregon. The remaining sections from the source samples (from which the laboratory samples were cut for the abovementioned investigation), will be re-metalized so that the bond strength can be measured as a function of the reaction layer thickness. To accomplish this, the remaining samples will cut into a minimum of two pieces, large enough to check bond strength at least 3 sites on the surface of each metalized concrete sample. The reaction layer surface of the two pieces will be prepared by removing half of the reaction layer (0.5mm) from one piece and then profiling the resulting surface by sand blasting. Both pieces will be profiled in the same manner but only one sample will have a fraction of the reaction layer removed first. Once the surface preparation is complete, the samples will be re-metalized by Great Western Corp in North Bend Oregon. This work is underway now and will continue throughout this quarter. Results from the bond strength tests coupled with the gas permeability and electrical resistance data will offer a more complete picture of what

is happening at the zinc/concrete interface and thus guide the experimental plan for next steps.

- Task 3: Final report and presentation (0% complete)

**5. Problems**

- None encountered so far. It should be noted, however, that the actual research contract was not signed until August 7, 2008, which caused some delay in the project schedule. The research team at WTI-MSU got the thermal spray equipment from ODOT but it was not the appropriate type; as such, we will use the combined option of renting equipment vs. subcontracting some thermal spray work. Some changes have occurred to the original work plan in an effort to make the research reliable and usable in the end, which on the other hand does pose some risk for project delay and cost overrun.

**6. Work Planned for Next Quarter**

- We will focus our efforts on the bond strength testing on metalized concrete samples. Once the data are obtained, we will seek a decision from the ODOT panel in terms of next steps to be taken in the WTI Corrosion and Sustainable Infrastructure Laboratory. Ideally, *knowing how much reaction layer to remove and whether or not to treat the prepared concrete surface (after removal of old zinc and part or all of the reaction layer) with a cementitious primer before spraying the new zinc*, we would be able to accelerate the progress on Task 2.

**7. Finances**

VENDOR	FY'09	FY'10	FY11	FY'12	TOTALS
ORIGINAL BUDGET	\$ -	\$ -			\$ -
<b>REVISED BUDGET</b>	<b>\$ 87,041</b>	\$ 102,959	\$ -		\$ 190,000
EXPENDITURES - VENDOR	\$ 87,041	\$ 20,503	\$ -	\$ -	\$ 107,544
<b>BALANCE</b>	\$ -	\$ 82,456	\$ -	\$ -	\$ 82,456
ODOT	FY'09	FY'10	FY11	FY'12	TOTALS
ORIGINAL BUDGET	\$61,250	\$122,500	\$61,250		\$ 245,000
<b>REVISED BUDGET</b>	<b>\$8,994</b>	\$5,000	\$0		\$ 13,994
EXPENDITURES - ODOT	\$ 8,994	\$ 1,816	\$ -	\$ -	\$ 10,810
<b>BALANCE</b>	\$ -	\$ 3,184	\$ -	\$ -	\$ 3,184
PROJECT	FY'09	FY'10	FY11	FY'12	TOTALS
ORIGINAL BUDGET	\$ 61,250	\$ 122,500	\$ 61,250	\$ -	\$ 245,000
<b>REVISED BUDGET</b>	<b>\$ 96,035</b>	\$ 107,959	\$ -	\$ -	\$ 203,994
EXPENDITURES - PROJECT	\$ 96,035	\$ 22,319	\$ -		\$ 118,354
<b>BALANCE</b>	\$ -	\$ 85,640	\$ -	\$ -	\$ 85,640

Account Description	Budget	Spent	Outstanding	Remaining
<b>Expense</b>				
61111 Vacation	0.00	1,693.33	0.00	(1,693.33)
<b>Total Acct Type:</b>	<b>0.00</b>	<b>1,693.33</b>	<b>0.00</b>	<b>(1,693.33)</b>
61124 Professionals	78,585.00	38,557.86	5,275.83	34,751.31
61125 Classified	0.00	718.36	81.61	(799.97)
61127 Grad Research Assist	0.00	125.56	0.00	(125.56)
<b>Total Acct Type: FAC/PROF/CLASSI/GRAD</b>	<b>78,585.00</b>	<b>39,401.78</b>	<b>5,357.44</b>	<b>33,825.78</b>
61202 Hourly Overtime	0.00	22.11	0.00	(22.11)
61224 TEMP HRLY	0.00	5,811.38	0.00	(5,811.38)
61225 STUDENT LABOR	0.00	464.78	1,228.17	(1,692.95)
<b>Total Acct Type: Temp Hrly/Stud/W-S</b>	<b>0.00</b>	<b>6,298.27</b>	<b>1,228.17</b>	<b>(7,526.44)</b>
<b>Total Salary</b>	<b>78,585.00</b>	<b>47,393.38</b>	<b>6,585.61</b>	<b>24,606.01</b>
61499 Benefits-General	25,934.00	16,929.93	0.00	9,004.07
<b>Total Acct Type:</b>	<b>25,934.00</b>	<b>16,929.93</b>	<b>0.00</b>	<b>9,004.07</b>
<b>Total Benefits</b>	<b>25,934.00</b>	<b>16,929.93</b>	<b>0.00</b>	<b>9,004.07</b>
<b>Total Personnel Services</b>	<b>104,519.00</b>	<b>64,323.31</b>	<b>6,585.61</b>	<b>33,610.08</b>
62102 Consultant/Professio	0.00	321.06	0.00	(321.06)
62198 Campus Services	0.00	4,980.00	0.00	(4,980.00)
62199 General Contracted S	10,365.00	0.00	0.00	10,365.00
<b>Total Acct Type: Contracted Services</b>	<b>10,365.00</b>	<b>5,301.06</b>	<b>0.00</b>	<b>5,063.94</b>
62208 Laboratory Supplies	0.00	1,060.40	168.66	(1,229.06)
62210 Minor Tools/Inst/Equ	0.00	4,430.42	31.78	(4,462.20)
62244 Chemicals	0.00	49.63	0.00	(49.63)
62299 General Sup/Materi	13,000.00	0.00	0.00	13,000.00
62827M Admin Cost - IDC	55,724.00	32,074.63	0.00	23,649.37
<b>Total Acct Type: Supplies</b>	<b>68,724.00</b>	<b>37,615.08</b>	<b>200.44</b>	<b>30,908.48</b>
62304 Postage/Mailing	0.00	71.18	65.02	(136.20)
62399 General Communicatio	200.00	0.00	0.00	200.00
<b>Total Acct Type: Communications</b>	<b>200.00</b>	<b>71.18</b>	<b>65.02</b>	<b>63.80</b>
62405 In-State Travel	0.00	126.96	0.00	(126.96)
62499 General Travel	6,192.00	0.00	0.00	6,192.00
<b>Total Acct Type: Travel</b>	<b>6,192.00</b>	<b>126.96</b>	<b>0.00</b>	<b>6,065.04</b>
62704 Equipmt Repair/Maint	0.00	106.69	0.00	(106.69)
<b>Total Acct Type: Repair/Maintenance</b>	<b>0.00</b>	<b>106.69</b>	<b>0.00</b>	<b>(106.69)</b>
<b>Total Operations</b>	<b>85,481.00</b>	<b>43,220.97</b>	<b>265.46</b>	<b>41,994.57</b>
<b>TOTAL EXPENSE</b>	<b>190,000.00</b>	<b>107,544.28</b>	<b>6,851.07</b>	<b>75,604.65</b>

## WTI Expenditures

Account Description	Budget	Spent	Outstanding	Remaining
<b>Expense</b>				
61499 Benefits-General	4,516.00	5,866.62	0.00	(1,350.62)
<b>Total Acct Type:</b>	<b>4,516.00</b>	<b>5,866.62</b>	<b>0.00</b>	<b>(1,350.62)</b>
<b>Total Benefits</b>	<b>4,516.00</b>	<b>5,866.62</b>	<b>0.00</b>	<b>(1,350.62)</b>
61124 Professionals	13,685.00	14,803.77	98.09	(1,216.86)
61125 Classified	0.00	112.72	0.00	(112.72)
<b>Total Acct Type: FAC/PROF/CLASSI/GRAD</b>	<b>13,685.00</b>	<b>14,916.49</b>	<b>98.09</b>	<b>(1,329.58)</b>
<b>Total Salary</b>	<b>13,685.00</b>	<b>14,916.49</b>	<b>98.09</b>	<b>(1,329.58)</b>
<b>Total Personnel Services</b>	<b>18,201.00</b>	<b>20,783.11</b>	<b>98.09</b>	<b>(2,680.20)</b>
62208 Laboratory Supplies	0.00	0.00	4.28	(4.28)
62299 General Sup/Materi	3,000.00	0.00	0.00	3,000.00
62827M Admin Cost - IDC	8,799.00	8,624.99	0.00	174.01
<b>Total Acct Type: Supplies</b>	<b>11,799.00</b>	<b>8,624.99</b>	<b>4.28</b>	<b>3,169.73</b>
<b>Total Operations</b>	<b>11,799.00</b>	<b>8,624.99</b>	<b>4.28</b>	<b>3,169.73</b>
<b>TOTAL EXPENSE</b>	<b>30,000.00</b>	<b>29,408.10</b>	<b>102.37</b>	<b>489.53</b>