

# CAAP Quarterly Report

Date of Report: *March 9, 2014*

Contract Number: *DTPH56-13-H-CAAP02*

Prepared for: *DOT*

Project Title: *Scaling and Self-Sensing in Composite Repairs of Corrosion Defects*

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For quarterly period ending: *February 28, 2014*

## **Business and Activity Section**

### **(a) Generated Commitments**

There has been no change in project participants or other contracts.

| <b>Supplies Purchased</b>                               | <b>Cost</b> |
|---|-------------|
| Supplies (pipe fittings, adhesives, hydraulic fittings) | \$8.14      |

### **(b) Status Update of Past Quarter Activities**

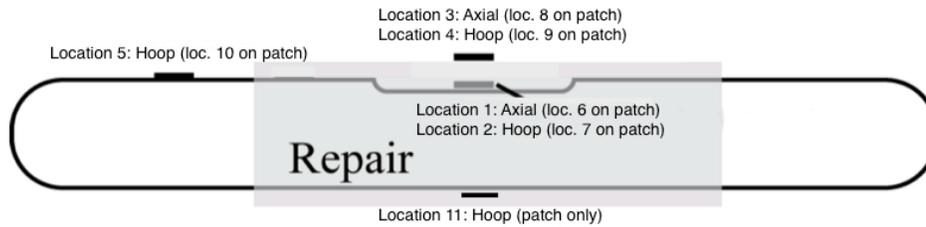
During the last quarterly period we have

1. Completed small-scale sample preparation
2. Contacted participant companies to schedule testing
3. Completed initial shakedown testing with preliminary samples
4. Completed test run of large flaw rolling
5. Two conference papers are in preparation for the Society of Experimental Mechanics

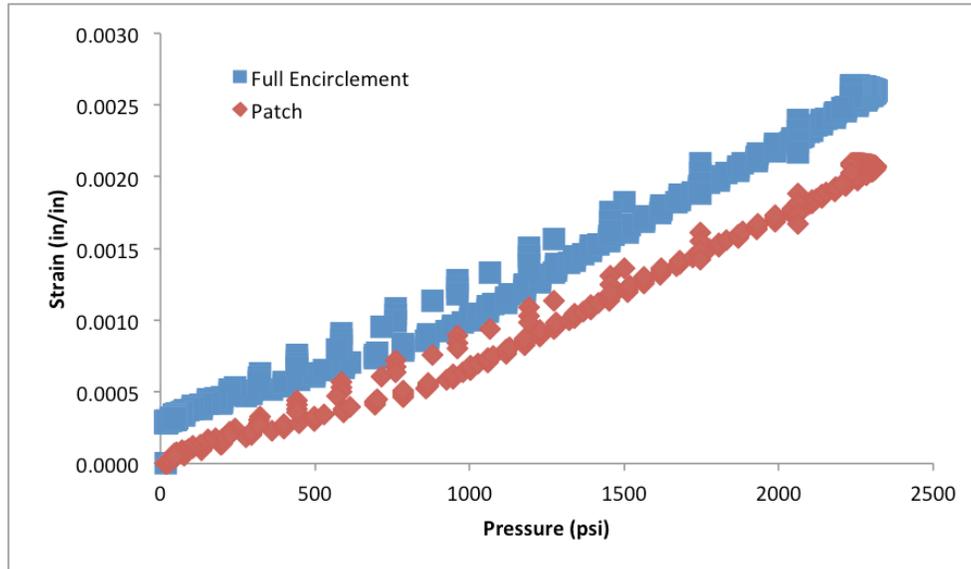
#### Small-Scale Sample Testing and Fabrication

Completed small-scale samples were delivered on 2/28 and we have contacted the participant companies to schedule dates for the application of small-scale repairs. We expect that these installs should be completed by the end of April.

While we are waiting for the installs to be completed, we have been performing some exploratory and shakedown testing using some of the incorrectly fabricated specimens that were delivered in November. We are using these specimens to validate our FEA model and work out issues with fatigue testing. Figure 1 shows the locations of applied strain gages for our preliminary testing of the composite repaired pipes. Results from one pressure cycle are shown in Figure 2, which is the strain response from the damaged section of the underlying pipe (locations 2 and 7 on the gage schematic). As we can see load up and load down are relatively linear, with the variation coming from pressurization rate changes during this test. A comparison of our FEA predictions and the measured strain response is given in Table 1.



**Figure 1: Schematic of strain gage locations.**



**Figure 2: Strain gage data from damaged region of substrate under repair for patch and**

As we can see in the table below, FEA is broadly over-predicting strains for nearly all locations that were measured. This is likely due to a combination of variation in material properties and differences in the thickness of the simulated repair and the as-installed repair. We are currently investigating this issue in order to determine the root cause of the differences.

**Table 1: Comparison of FEA data with gathered experimental data.**

| Strain comparison @ pressure - 2140.75 psi |                |              |           |             |                    |
|--|----------------|--------------|-----------|-------------|--------------------|
|  |                | Experimental | FEA       | Orientation | Percent Difference |
| <b>Full Encirclement Repair</b>            | Strain Gage 1  | 0.0002650    | 0.0003552 | Axial       | 29%                |
|  | Strain Gage 2  | 0.0023690    | 0.0017212 | Hoop        | -32%               |
|  | Strain Gage 3  | 0.0003110    | 0.0005425 | Axial       | 54%                |
|  | Strain Gage 4  | 0.0015880    | 0.0016082 | Hoop        | 1%                 |
|  | Strain Gage 5  | 0.0005750    | 0.0006147 | Hoop        | 7%                 |
| <b>Patch Repair</b>                        | Strain Gage 6  | 0.0003660    | 0.0004497 | Axial       | 21%                |
|  | Strain Gage 7  | 0.0018550    | 0.0017002 | Hoop        | -9%                |
|  | Strain Gage 8  | 0.0004670    | 0.0005415 | Axial       | 15%                |
|  | Strain Gage 9  | 0.0014050    | 0.0016166 | Hoop        | 14%                |
|  | Strain Gage 10 | 0.0005500    | 0.0006203 | Hoop        | 12%                |
|  | Strain Gage 11 | 0.0004530    | 0.0005767 | Hoop        | 24%                |

## Large Vessel Flaw Fabrication

Last report we had fabricated a flaw on a test strip of steel to do an initial test roll and determine if our flaw fabrication strategy would be successful. A picture of the initial flaw as machined is shown in Figure 3. The 4-foot strip of A36 steel was then put through rolls in order to give the specimen a 42-

inch outside diameter, similar to the final diameter of the proposed large test vessel. As shown in Figure 4, we were able to machine the flaw on a flat sheet and then roll into the appropriate diameter. There is some flattening of the flaw, but this is due to the ratio of the flaw to the strip width. We will move to a wider plate that should limit the amount of flattening when the full-scale specimens are rolled into complete circles.



Figure 3: Prototype flaw for rolling tests. Note incomplete machining in corners, this is due to an intentional reduction in machining finish passes.

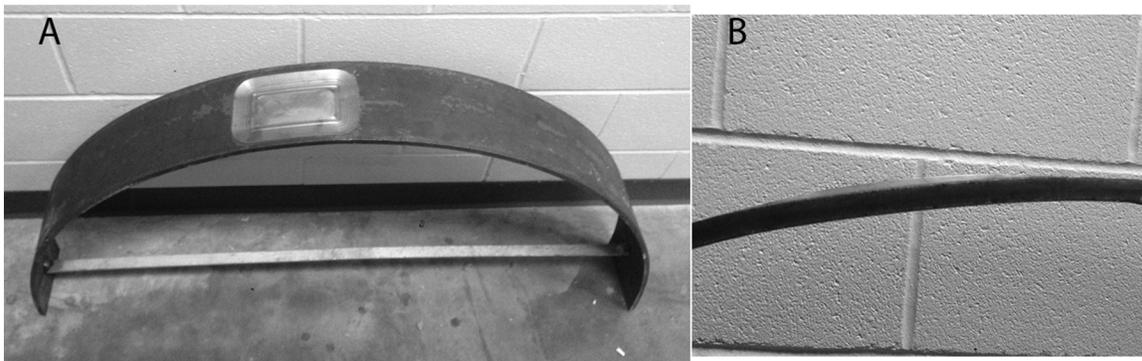


Figure 4: Images of the machined section after rolling. Image A shows the complete specimen and image B shows a close up indicating little deformation. Note: plate will be wider in final design.

### (c) Description of any Problems/Challenges

As described in the previous quarterly report, we are facing is the schedule delays for testing the small-scale pressure vessels. As described above, the small scale-pressure vessels have finally been delivered as of 2/28/15. We are behind schedule for these test, but are have been moving forward on the large scale testing design and initial production testing. Two have the industry collaborators have already requested April install dates for their repairs, which could push us farther behind schedule.

### (d) Planned Activities for the Next Quarter –

Because of the fabrication delay described above, our planned activities for the next quarter are similar to those of last quarter (ending Sept 1.)

1. Complete installation of small-scale test vessel repairs.
2. Initiate and complete a significant portion of the small scale fatigue testing.
3. Begin fabrication of large-scale test vessel and pressure system.