CAAP Quarterly Report

Date of Report: *Mar. 2, 2015*

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

Prepared for: *DOT*

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

Prepared by: *The University of Tulsa*

Contact Information: *Michael W. Keller, mwkeller@utulsa.edu, 918-631-3198*

For quarterly period ending: *Feb. 29, 2016*

Business and Activity Section

(a) Generated Commitments

One of the project participants, Pipewrap, was acquired by a third party after they committed to this project. As a result, they have been unable to schedule a time to install repairs on their small-scale specimens. At this point, we are planning on dropping them from the study. We are discussing the possibility of them sending us repair materials that we will install for the large scale test.

Supplies	Cost
Testing System Electronics	379.09
Strain Gage Bridge completion units	536.03
Testing system supplies	213.12
Digital signal hardware	284.03
Pressure transducers (2)	1001.49

(b) Status Update of Past Quarter Activities

During the last quarterly period we have

1. Commissioned a new pressure fatigue system.
2. Completed most of the small-scale fatigue tests.
3. Continued the digital image correlation study of the repairs
4. Contacted participants to schedule large scale repair installs.
5. Presented results at PCC-2 meeting in South Carolina

Small-Scale Sample Testing

Small scale testing continued during this quarter and we have nearly completed the small scale testing for this project. The current results for the patch and full-encirclement repairs are given below in Figure 1. These results were conceptually surprising based on the initial discussion and general intuition when they were presented at a recent PCC-2 meeting. However, based on our initial FEA study, these results could be expected.

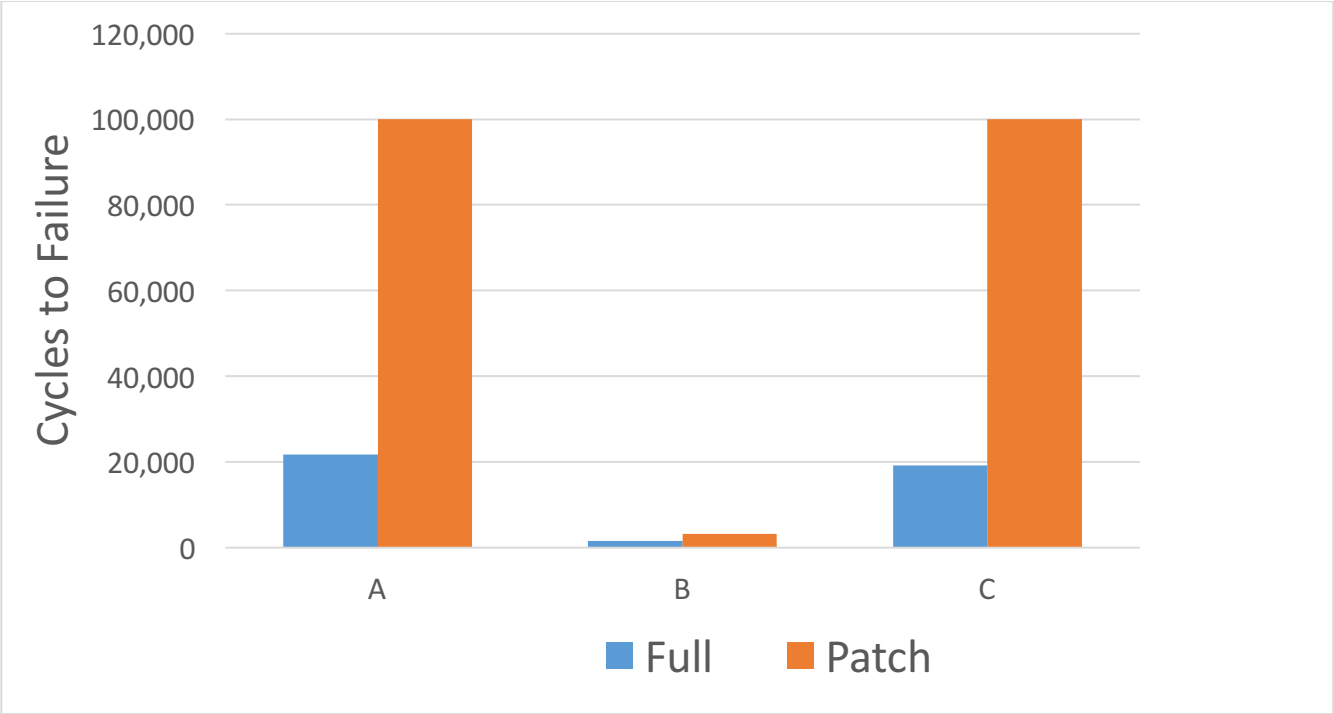

Figure 1: Fatigue cycles to failure for patch and full encirclement repairs. Each bar represents the average of two specimens. Runout was 100,000 cycles.

As can be seen from Figure 2, FEA predictions indicated that for the flaw studied in this project, 75% wall loss, the strains for full-encirclement repairs were actually higher. These same simulations indicated that the repair strains will be approximately the same for both patch and full encirclement repairs. Failure analysis on the fatigue specimens showed that pin-hole leaks formed in the damage area, which lead to the pin-hole repair failures. There were no catastrophic repair failures in this test. It appears that carbon repair systems perform better in this testing program, but the only non-carbon system does not include a primer, which may have impacted performance. We are currently running instrumented tests that should provide additional insight into the actual repair performance.

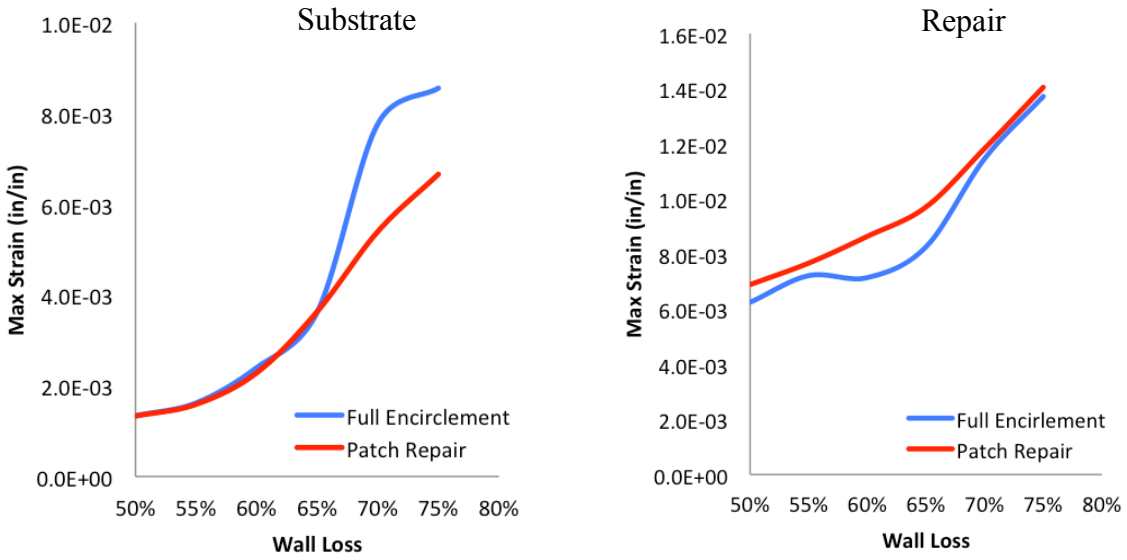

Figure 2: Max strains in the substrate and repair as predicted by FEA.

DIC Study

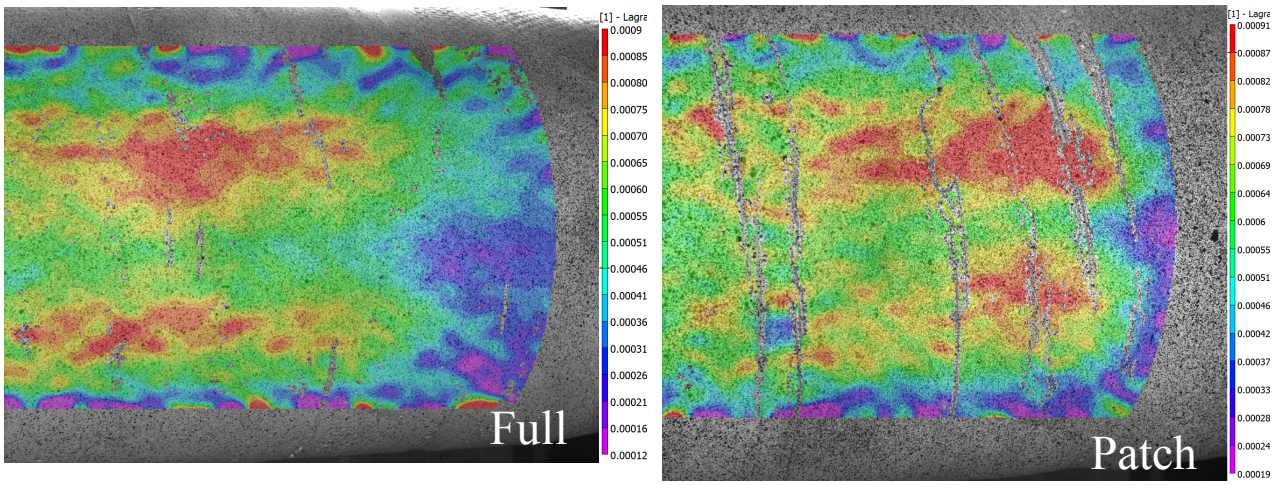

Figure 3: Hoop strain fields for patch and full repairs at MAOP. Red color indicates a maximum strain of 0.09% in both images.

We have completed an initial study of the full encirclement and patch repairs using digital image correlation. This was a challenging study since the repair surfaces were not particularly smooth. The impact of surface ridges can be seen in Figure 2 as uncorrelated stripes in the results. Regardless, the maximum strains measured in this analysis are approximately equivalent, which is in line with the FEA predictions in Figure 2. It is important to note that the FEA above was for a different repair thickness than the repair for which the results are presented. So while the strain trends are the same, the numerical values of the strains are different. Additionally, we see that the maximum strains are also located at the transition regions of the flaw, which would also be expected from a membrane deformation analogy. WE are currently working with this data and the strain gage data that is being collected to understand the actual behavior of the repairs during fatigue.

Self-Sensing

Based on our successful coupon tests, we have fabricated a full-scale specimen to do some initial testing on the monitoring of repair status. This repair was applied over a through-wall defect, as we expect this to have the strongest response to our monitoring approach. As soon as one of the pressure fatigue systems is available, we will run our initial test on this system.

(c) Description of any Problems/Challenges

We are now on schedule to complete this study in late may. Repairs for the large scale system should take place in march with testing beginging the first week of april.

(d) Planned Activities for the Next Quarter –

Since we are in the testing phase, our planned activities for the next quarter are similar to those of last quarter (ending February 29).

1. Complete small scale fatigue testing.
2. Perform an initial on-specimen self-sensing test during the fatigue testing.
3. Install large-scale specimen repairs.
4. Begin large scale testing.