CAAP Annual Report

Date of Report: *April 10, 2016*

Contract Number: *DTPH56-14-H-CAP01*

Prepared for: *DOT*

Project Title: *Patch and Full-Encirclement Repairs for Through-Wall Defects*

Prepared by: *The University of Tulsa*

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For quarterly period ending: *April 10, 2016*

Business and Activity Section

(a) Generated Commitments

As was the case for the related project, 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 Purchased	Cost
Piping and fittings	$1,409
Strain gage supplies	$347.85

(b) Status Update of Past Quarter Activities

During this past quarter, we have accomplished the following research activities

1. Continued fatigue testing of small scale samples.
2. Continued strain gage study of repairs.
3. Continued DIC studies of repairs.
4. Submitted conference paper to the Society of Experimental Mechanics.

Student in charge of following research: Stephen Theisen (M.S. – expected summer 2016)

Small Scale Test Program

At the moment, we are testing the final specimens of the small scale testing. We had a pressure sensor sensor failure which halted testing. We are waiting for a replacement sensor to arrive. The results of the fatigue testing to date indicate that the patch specimens do have slightly lower cycles to failure when compared to the full encirclement repairs. This behavior was captured in our earlier FEA studies that predicted the patch specimens would have higher strain levels. A summary of the testing is shown in Figure 1. One specimen set experienced runout and it is evident that each group took a different approach in determining the appropriate repair thickness. We have solicited information from all companies about their design process and are reviewing that information this quarter. At a minimum,

all companies complied with PCC-2 with respect to extent of repair, as was requested. There was some variation in the decisions made for thickness of repair. One set of small scale specimens for group B had a testing issue that will need to be resolved with additional testing. We have discussed this with the company and are working on a reinstall schedule.

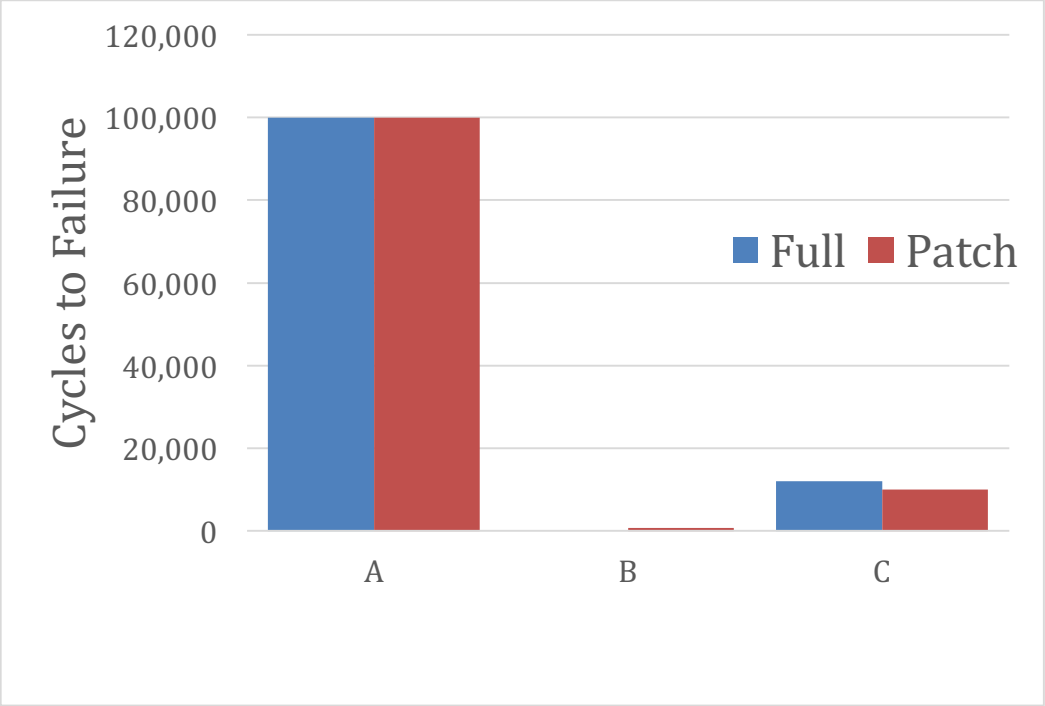

Figure 1: Cycles to failure of the completed specimens.

Strain Gage Testing Results

The strain gage testing is continuing as we finish up the small scale testing results. One of our main tasks is understanding the evolution of the strain levels as the testing progresses and to compare the strain levels between repairs. A representative data set for a patch specimen is shown in Figure 2. The data is this figure is for a strain gage applied over the defect region oriented in the hoop direction. Three sets of data are shown, four loops starting at 2,800 cycles, four loops at 6,000 cycles, and four loops at 12,000 cycles. The final data set is near the failure of this particular specimen. One of the interesting features of this data is that the strain appears to increases as the sample nears failure. This behavior could be consistent with a progression of an interfacial fatigue crack that does not allow the repair to return to the initial deformation state. There has been some debate about whether this repair will allow for any stable crack growth since through-wall defects are essentially in load-control fatigue. We are hoping to compare some of this data to DIC below to attempt to determine if there has been any crack growth.

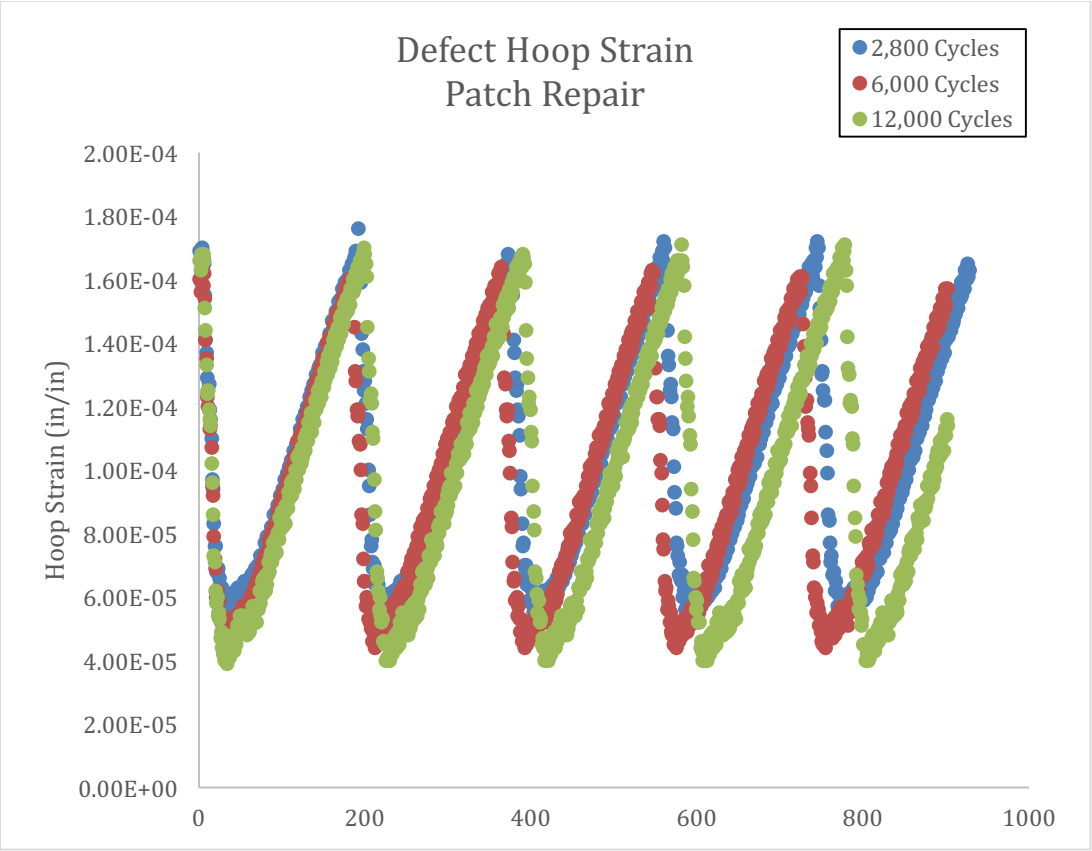

Figure 2: Strain measurements for a strain gauge applied over the defect in the hoop direction for a patch repair. Each peak represents one pressure cycle.

Digital Image Correlation

We have performed DIC testing on all three participants at this point. As expected, specimens that failed with fewer loading cycles tended to show higher strain levels during testing. For the specimen that experienced run-out, the strain levels were so low that they were not discernable above background noise during the testing. Other samples were identifiable and two representative testing images are

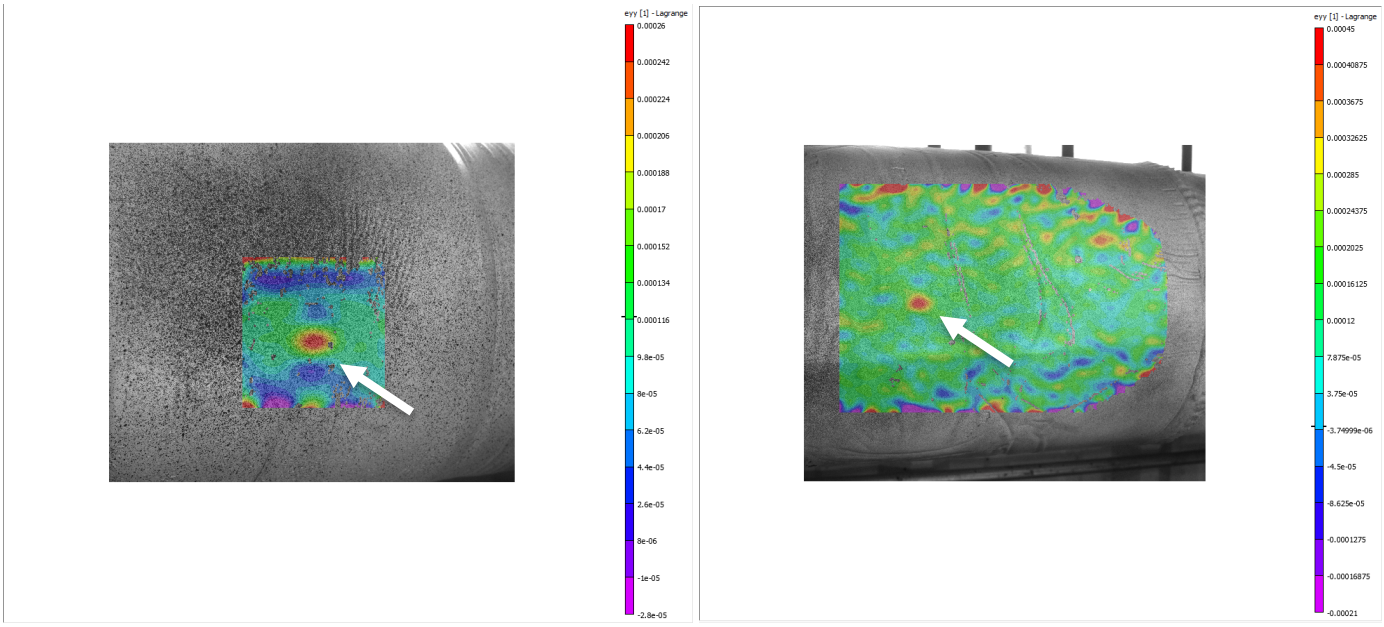

Figure 3: DIC results for two specimens. Through-wall defect is shown as a red spot in the center of the image. Indicated by an arrow in both images.

shown in Figure 2 with arrows indicating the location of the through-wall defect. In both images we are getting noise contamination from wrinkles in the surface of the repair. We are working on refining

the analysis to eliminate this noise. This is one difficulty of using DIC, but the full-field measurements are not achievable using other, traditional, techniques.

Large Scale Specimen
The large scale specimen is currently being welded and should be ready for installs this quarter. Since there are two related projects with large-scale specimens, we are having to juggle installation and testing schedules for both. We expect the non-through wall specimen to have testing completed at the end of may, at which point the through-wall testing on the large scale specimen will begin.

(c) Description of any Problems/Challenges

During this past quarter there was one challenge, the failure of the pressure sensor has delayed the finalization of the strain and DIC testing. A replacement sensor will arrive in a week and we will finalize the DIC and strain gage testing at that point. We are also working on retesting the specimens that had invalid data. Due to the nature of the defect in this study, we will not need to remake the pipe test specimens as we can simply grit-blast the existing repair and re-use the test specimen. As in last quarter, we are working to make sure that the two patch related programs are moving together and are attempting to limit any slow-downs with respect to testing conflicts for these two test programs.

(d) **Planned Activities for the Next Quarter** –
Planned activities for the next quarter include the following

1. Continue fatigue testing of small scale repairs.
2. Complete fabrication of large-scale test vessel.
3. Complete DIC study of repaired pipes.