CAAP Annual Report

Date of Report: *April 11, 2016*

Contract Number: *DTPH56-14-H-CAP02*

Prepared for: *DOT/PHMSA*

Project Title: *Wall Break-through in Composite Repaired 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

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

Supplies Purchased	Cost
Welding Services	$552.60
Testing supplies	$13.02

Student in charge of following research: Omar Ramirez (M.S. – expected fall 2016 / spring 2017)

(b) Status Update of Past Quarter Activities

During the past quarter we have completed the following research activities

1. Complete 2-layer straight pipe testing.
2. Begun testing of elbow specimens.
3. Continued FEA modeling of the elbow specimens.
4. Submitted conference paper on this work to the Society for Experimental Mechanics.

Straight Pipe Testing

We have completed the straight pipe testing for repairs that consisted of two layers of composite material. The results of this burst testing are shown in Figure 1. From these results we can conclude that the current design methodology would be appropriate for flaws that have been produced from an erosion or corrosion type process. This can be determined by observing that the valid tests (n=4) for the eroded specimens had nearly identical failure pressures when compared to the drilled holes of the same diameter. However, there is one additional concern. We found that this testing tending to have a significant number of through-wrap failures, which can significantly lower the average failure pressure (triangles in Figure 1). While this failure mode can occur during drilled testing, it appears to occur more frequently in the eroded system. To investigate this failure mode more, we are preparing to run an additional set of tests using four layer repairs. Increased repair thickness has helped to reduce through-repair failures in previous drilled-hole testing.

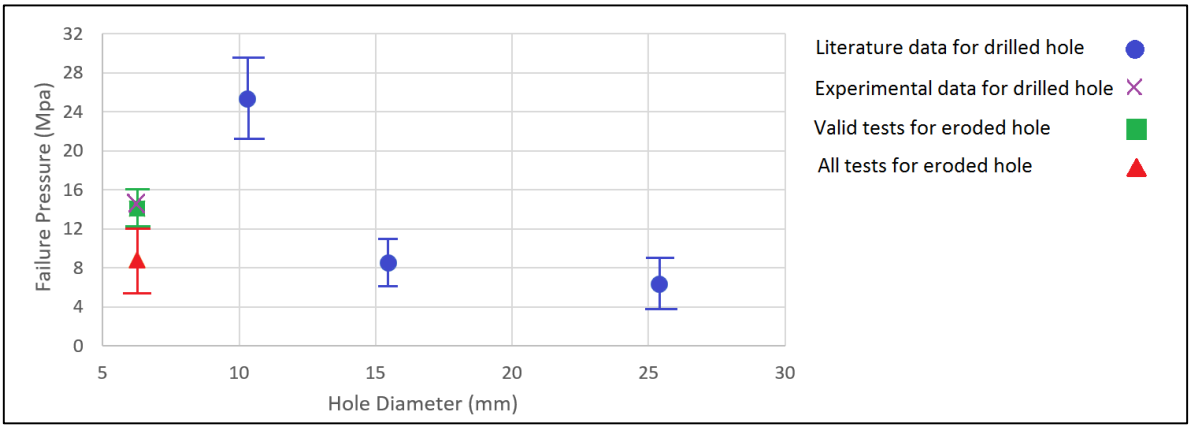

Figure 1: Comparison of failure pressures for current results (square, triangle, and x) and previous testing on the same repair system.

Elbow Testing

Last quarter we had begun producing elbow specimens for testing using a dry erosion process similar to one we used to produce flaws on the straight specimens. During the past quarter, we were able to complete enough specimens to begin testing. We have run three elbow tests and two drilled elbow control tests at this point. Average failure pressures for the eroded elbow are 1290 psi (n=3). For the drilled specimens we have had one failure at 2299 psi and a second specimen that sustained 3500 psi without bursting. We are testing additional drilled specimens at the moment. Based on this initial test data it does appear that erosion damage in elbows does have an effect on failure pressure. This may be due to the fact that elbows tend to fail through-repair rather than at the interface. We had already observed a tendency for eroded repairs to fail through the repair thickness rather than at the interface. Testing and DIC analysis are continuing in the current quarter.

Digital Image Correlation Studies

We have continued to run DIC on tests that we are conduction for both elbows and straight pipes. Last quarter we presented some results for a comparison of theoretical predictions of the deformed profile of the repair over the defect and the DIC-measured profile. Since that result, we have improved our testing process and have determined that the reference line for the experimental results was incorrect. Figure 2 shows new data for a 2-layer straight pipe specimen with the theoretical prediction and the experimentally determined profile. From the results in Figure 2, we can see that the predicted deformation profile has a maximum deflection that is significantly larger than that measured by DIC.

The over-prediction by the theoretical approach will tend to increase the crack-driving force at any given pressure and produce a more conservative prediction for failure pressure. Additional conservatism in the design could help to address the tendency for repairs installed over diffuse flaws to fail through the repair rather than at the interface. We are continuing DIC studies, which should help us to better characterize the performance of the repairs compared to the design models.

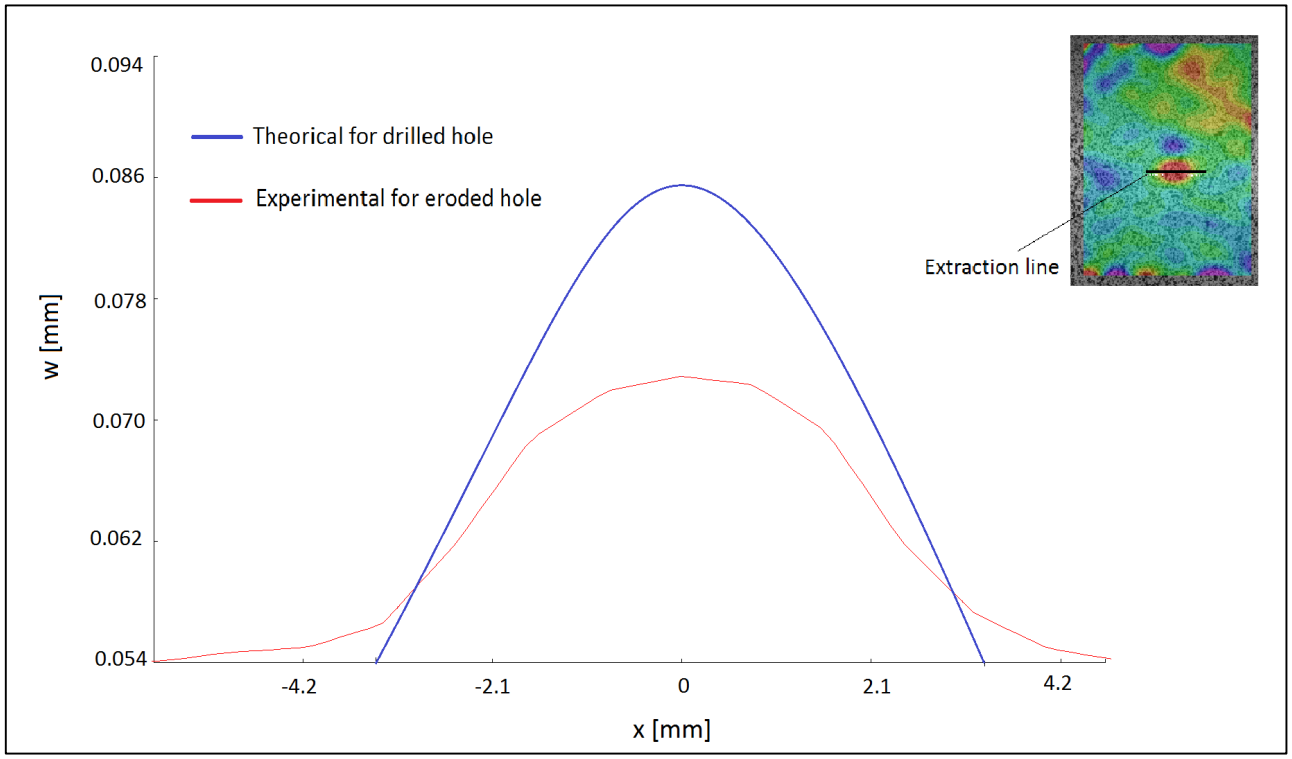

Figure 2: Comparison of theoretical and measured deformation profiles of an eroded-straight pipe flaw.

Finite Element Studies

We have begun finite element modeling of the elbow repairs during the past quarter. At the moment, we are observing some spurious behavior of the eroded flaws. We are working to determine if the deformation profile predicted by FEA is real or a simulation artifact. FEA is critical to the elbow work as there are few interface failures in elbow testing and the combination of DIC and FEA will be needed to understand the impact of the eroded-type flaws.

(c) Description of any Problems/Challenges

No serious delays except for the FEA issues we have encountered. We are working though those and expect to have additional results by the end of this quarter.

(d) Planned Activities for the Next Quarter –

Planned activities for the next quarter include the following

1. Continue testing and strain analysis using eroded specimens and digital image correlation.
2. Continue 4 layer repairs using straight-pipe samples.
3. Continue FEA modeling of the repair.
4. Continue elbow testing.