CAAP Annual Report

Date of Report: *Jan. 12, 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: *Jan 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	$375.00
Testing supplies	$17.36
Pipe and fittings	$384.00
Welding services	$80.00

(b) Status Update of Past Quarter Activities

During the past quarter we have completed the following research activities

1. Continued straight pipe testing.
2. Begun eroding elbows for pressure testing.
3. Performed additional DIC on straight pipe specimens.
4. Begun FEA modeling of the elbow specimens.

Straight Pipe Testing

We are continuing to perform straight pipe testing on eroded and drilled specimens. We encountered some issues with the DIC testing that took longer than expected to resolve. The additional work on the DIC slowed testing of the straight pipe. We have resolved those issues and are now resuming testing. Our goal is to have approximately six valid tests for the erosion specimens and the drilled specimens to perform comparisons.

Elbow Erosion

We have begun working on producing appropriate and repeatable erosion damage on elbows in order to investigate the impact of a diffuse flaw on repair performance. Figure 1 shows an image of a test elbow with erosion damage. Determining the total extent of the eroded region is not straight-forward, but we are working with our collaborator, Dr. McLaury, to develop simple approaches for characterizing the total eroded region. We expect to begin installing repairs on these specimens this quarter.

Figure 1: Images of initial test erosion of 4 inch long radius elbow. Marks on the interior of the left image indicate approximate extent of the eroded region

Digital Image Correlation Studies

Strain gages are an important tool in this study, but suffer from the fact that they are effectively point measurements of strain. For this damage scenario having full-field information is critical to understanding the difference between the drilled test specimens and the eroded specimens. In the previous quarter we had performed some initial DIC studies, but had unexpected results. We have determined that spurious specimen motion and suboptimal lighting was the primary cause of these results.

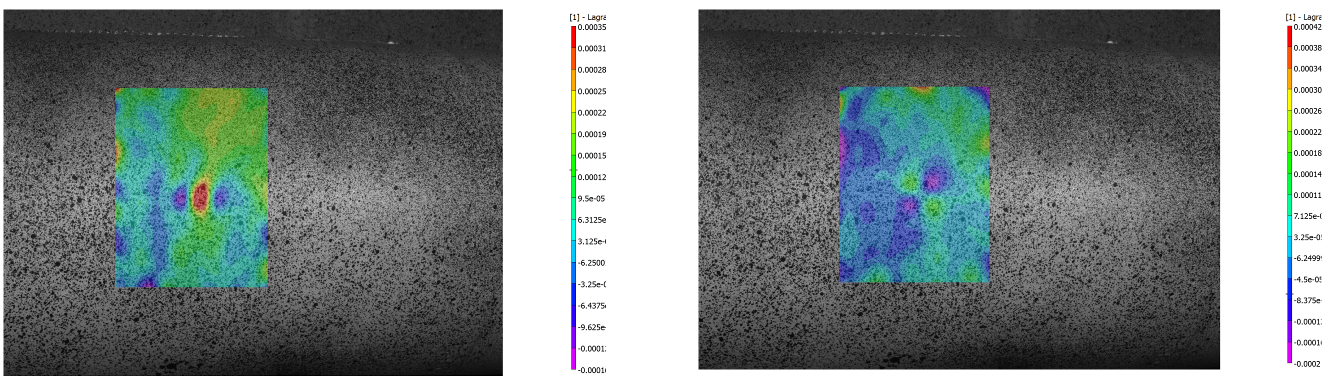

Figure 2: Strain fields for an eroded specimen with x (axial) strain on left and shear strain on the left.

Figure 2 shows the axial and shear strain fields for the eroded specimens with an internal pressure of approximately 1000 psi. The strain in the repair is clearly visible and we can see the local region of compression surrounding the tensile strain in the left image of figure 2. The right image also clearly shows the expected “cloverleaf” pattern of shear strain for a membrane-type deformation. There is still some noise in the measurements in figure 2 and we are working to reduce this and improve measurement fidelity. DIC has been shown to be nearly as accurate as strain gages when lighting and speckle pattern are good. We are still having some issues with lighting.

Aside from the full-field measurements, DIC also allows us to extract profiles in displacement and strain. This is especially useful when comparing to FEA predictions. For example, extracting the out-of-plane displacement values along the centerline of the specimen allows us to make direct comparison with prediction from FEA or analytical models. For example, Figure 3 shows a preliminary comparison of the DIC-determined profile (points) with the predicted deformation profile from an analytical prediction of displacement (solid line). The prediction and the measurement match quite closely with respect to the total displacement. However, this is a very preliminary comparison and more testing is needed to determine if the analytical model that underpins the leaking pipe design calculations actually capture the maximum deflections this accurately.

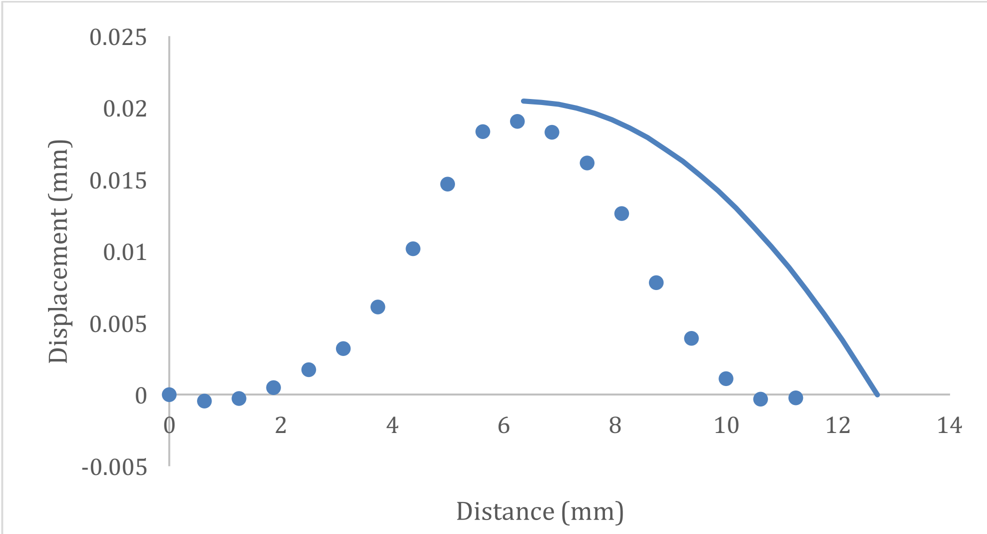

Figure 3: Preliminary comparison of analytically predicted deformation profile with profile measured from DIC.

We are continuing to work with DIC, FEA, and analytical tools to help understand how the presence of diffuse damage impacts the strain state in the repair.

(c) Description of any Problems/Challenges

We had some delays due to issues with DIC testing last quarter that slowed the straight pipe testing. We are proceeding and expect to complete the straight pipe testing during the next 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 straight-pipe testing.
3. Continue FEA modeling of the repair.
4. Begin elbow testing.