CAAP Annual Report

Date of Report: *July 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: *June 31, 2016*

Business and Activity Section

(a) Generated Commitments

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

Supplies Purchased	Cost
Pressure Transducers	$332.00
Pipe and Fittings	$379.56

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. Completed 4-layer straight pipe testing.
2. Continued elbow testing.
3. Continued FEA modeling of the elbow specimens.
4. Developed new approach for elbow defect analysis.

Straight Pipe Testing

We have completed the straight pipe testing for repairs that consisted of four layers of the composite. The results of this burst testing are shown Table 1.

Table 1: Hydrostatic burst test results for four layer repairs on a straight pipe with drilled and eroded flaws.

	1	2	3	4	Average	STD
Drilled	945	1084	650	1083	940.5	177
Eroded	1024	935	964	1827	1187.5	370

Based on these results, we can conclude that the drilled and eroded flaws on straight pipes are essentially the same. This implies that the deflection of the substrate is not impacting the interfacial fracture energy in a measureable manner and that the existing guidance in PCC-2 is likely conservative for all flaws. Additionally, we have filled in further two-layer tests and it does appear that there is an

increase in through-repair failures for the two layer repairs. We are working on determining the root cause of these failures.

Elbow Testing and Flaw Characterization

In the last quarter we have been working to complete testing of elbows with drilled and eroded flaws. Based on our current results, eroded flaws do appear to have lower failure pressures when compared to drilled flaws. The current results of our pressure testing are shown in Table 2. We are working with FEA and additional testing to understand the causes of this performance difference.

Table 2: Hydrostatic burst test results for four layer repairs on a repaired elbow with drilled and eroded flaws.

	1	2	3	4	Average	STD
Drilled	2299	3405	4000	4000	3426	694
Eroded	1245	1157	1464	2140	1501	385

One potential area of concern is the exact size of the produced flaw in the elbow specimens. The approach of creating an epoxy mold has worked well with the straight flaws, but this approach has not been successful with the elbows due to the large size. We are experimenting with creating clay molds of the inside surface of the pipe. We then analyze these molds using DIC. Some initial results are shown in Figures 1 and 2 below. These initial experiments are very promising and we are working with this technique to improve our shape resolution. We plan on using these measurements to create an FEA model that more accurately captures the stresses at the interface and in the repair.

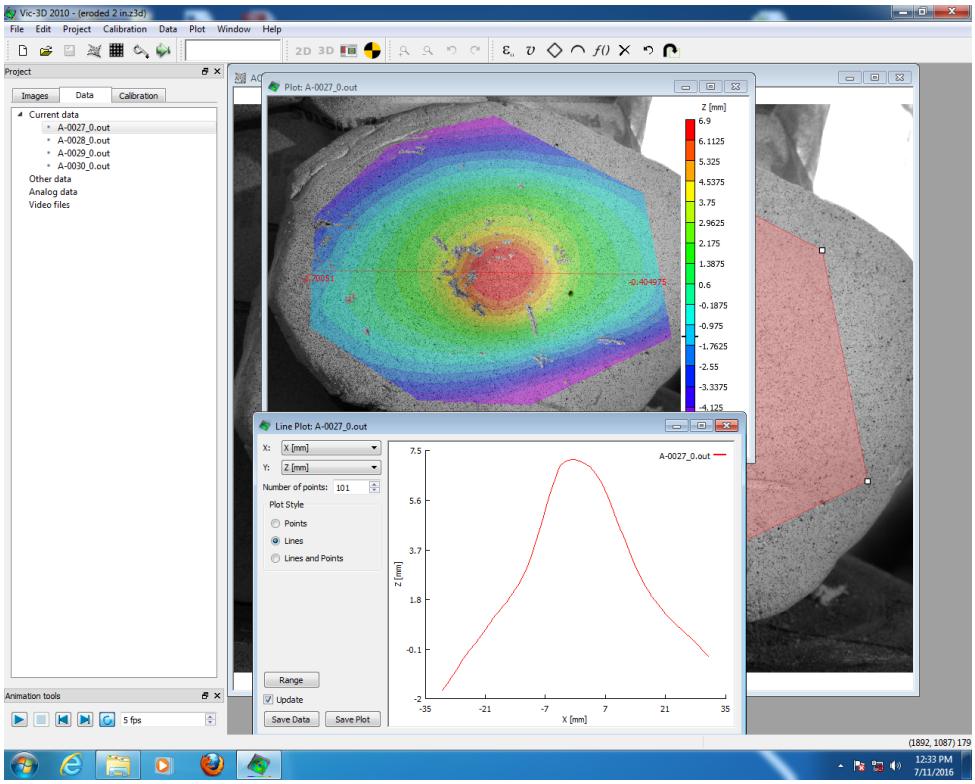

Figure 1: DIC result for the shape measurement of the clay mold for an eroded elbow. . Inset line graph is the shape along an axial centerline.

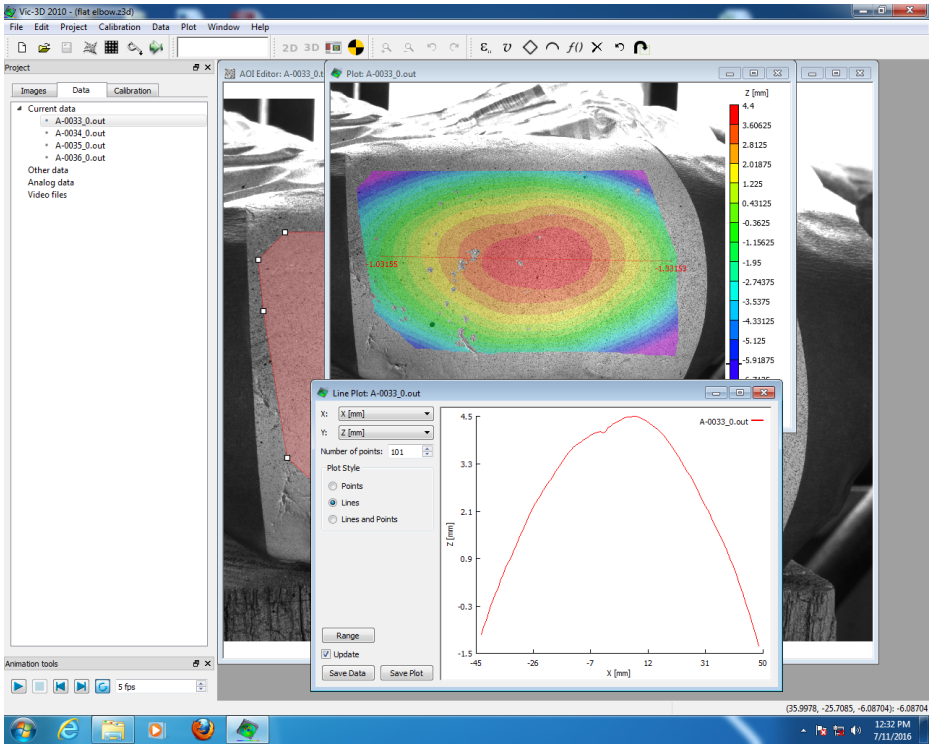

Figure 2: DIC shape measurement for a clay mold of an un-eroded elbow. Inset line graph is the shape along an axial centerline.

Finite Element Studies

We have continued finite element modeling of the elbow repairs during the past quarter. WE are still working to validate the FEA model with our current 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 or challenges occurred 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 FEA modeling of the repair.
3. Continue elbow testing.
4. Continue flaw characterizations