CAAP Quarterly Report

Date of Report: *July 10, 2015*

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

Prepared for: *DOT*

Project Title: *Wall Break-through in Composite Repaired Defects*

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For quarterly period ending: *July 10, 2015*

Business and Activity Section

(a) Generated Commitments

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

Supplies Purchased	Cost
Welding	$300.00
Pipe Specimens and Fittings	$1099.08
Erosion Setup Supplies	$1270.77

(b) Status Update of Past Quarter Activities

In the past quarter (starting April 11, 2015), we have completed the following research activities

1. Completed fabrication of three straight pipe test specimens for initial testing
2. Completed characterization of flaws for initial testing.
3. Performed FEA comparison of drilled holes and eroded holes.

Straight Pipe Flaw Production and Characterization

In the last quarter, we began studying the size and shape of erosion flaws that we could produce on straight pipe sections. We are focusing on straight sections at this time to simplify the comparison between drilled defects and the more realistic eroded flaws. This should help us clarify behavior when we investigate the elbow geometry at the end of the project.

Using a custom-designed blast nozzle, we have been able to produce reasonably repeatable erosion defects that mimic the more sloped shape of real flaws. During this quarter we have focused on developing appropriate approaches for the characterization and analysis of the flaws are producing. Our original approach of using handheld UT mapping proved to have insufficient resolution to extract the profile data were desired. Instead, we are now making epoxy molds of the flaw and then characterizing these molds using optical profilometry. Examples of the molds representing the erosion flaws are shown in Figure 1. These were taken from a 6 in nominal pipe that had been eroded using ground glass as the medium. While ground glass is not a typical material that would be present in a flow, it allows for the production of

reasonable flaws in several hours. Flaws produced using sand, or other similar materials, would take days of eroding to reach a similar state.

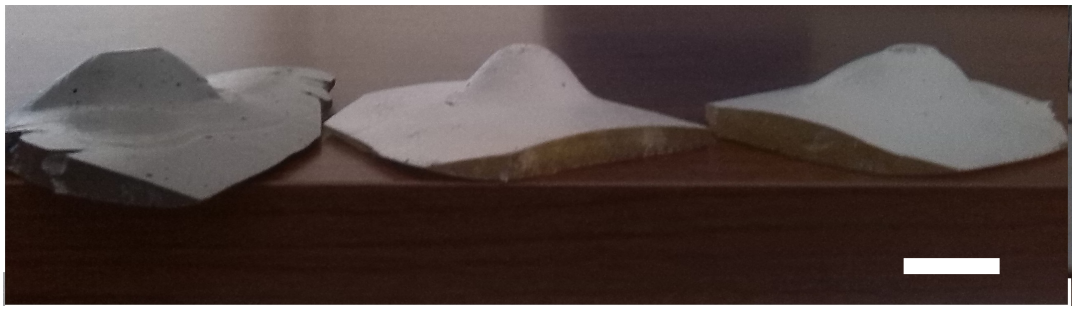

Figure 1: Epoxy molds of eroded flaws from three separate specimens. Scale bar represents approximately 1 inch.

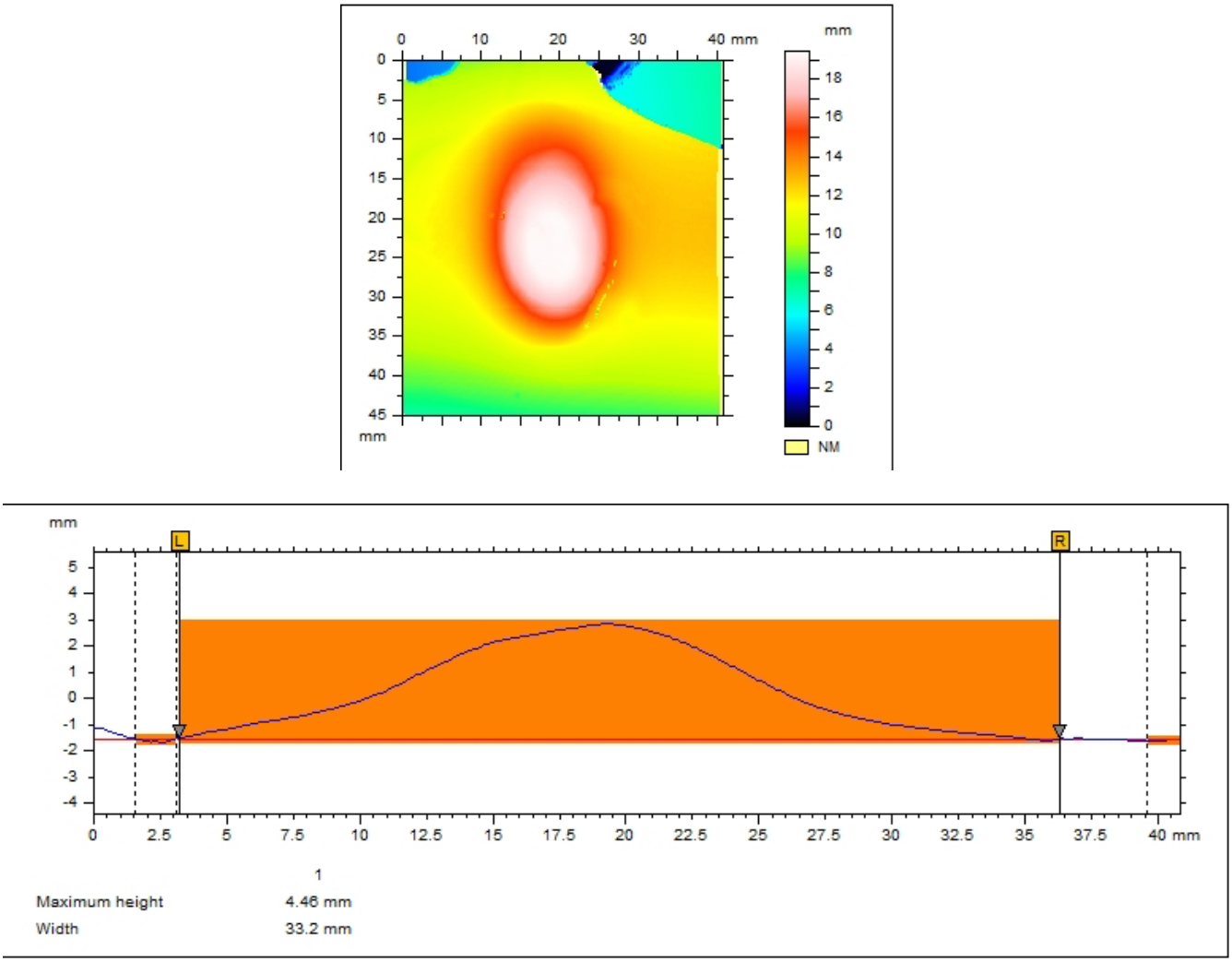

Figure 2: Surface scan and profile of a representative erosion defect in a straight pipe section.

Figure 2and Figure 3 above show surface profilometry and line scan profiles of one of the eroded specimen molds that were shown in Figure 1. For an approximately 0.25 inch break through we have a 1.3 inch flaw extent. We are working to achieve a larger ratio, but this may not be possible with the straight pipe specimens. We will move to elbows later this year and will see if that gives us a larger flaw extent. Regardless we can achieve a ratio of approximately 5 with respect to the breakthrough and the maximum flaw extent. Based on the testing results described below we will likely investigate an approach where we erode to nearly break through and then drill the remaining ligament so that our eroded and drilled specimens are directly comparable.

Finite Element Analysis

During the quarter we have also begun finite element modeling of the repair with the initial goals of comparing the behavior of the drilled flaws with a simulated eroded flaw. Our initial approach is to simulate the erosion using a semicircular undercut around a 0.25 in hole. The flaw size was chosen to approximate the real flaws that we are able to produce and that were characterized as described above. Figure 3 shows screen shots of simulation results for drilled holes (left side) and our simulated erosion flaw (right side). In general the strain levels across the whole model in the erosion flaw are higher that the drilled flaw. But this is not the case at the critical interface between the repair and the substrate.

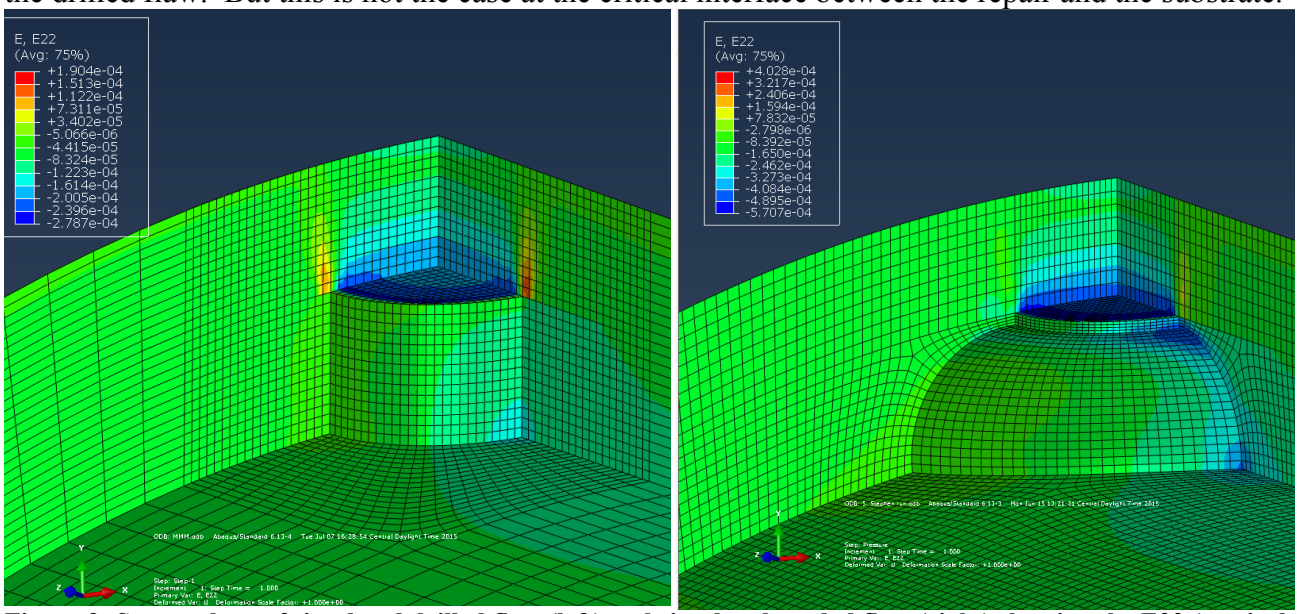

Figure 3: Screen shots of simulated drilled flaw (left) and simulated eroded flaw (right) showing the E22 (vertical up) strains in the repair and substrate.

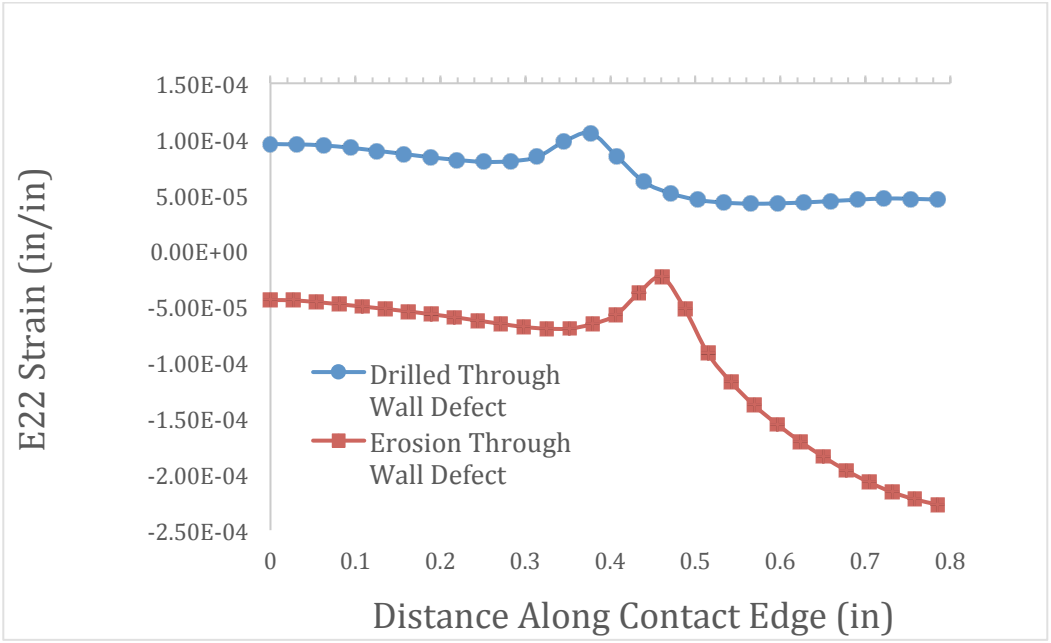

Figure 4: Strain traces along the interface of the steel/composite. Strain is in the tensile (opening direction) for the composite material.

Figure 4 shows a trace of the E22 (opening) strain along the interface between the composite and the substrate. Based on the trace of the strains at this interface, we see that the eroded system is actually compressive at this interface. This result may seem counterintuitive, but is directly related to the thinness of the remaining ligament and the compression due to the internal pressure. These two features of the eroded repair geometry combine to produce the FEA-predicted compressive strains at this location.

At the moment, we expect that the added deformation of the eroded material will generally drive failure pressures up with respect to the drilled specimens. As described in the next section, we will have experimental confirmation of this behavior by the end of next quarter.

Small-Scale Testing

Last quarter we decided to do initial testing using straight pipe specimens to simplify the comparison of drilled and simulated break through flaws. We have fabricated 3 straight specimnes with the erosion flaws described above. These will be wrapped with two layers of repair and then hydrostatically tested until failure. This testing should take place on the week of 7/12. Our industrial partner will supervise and assist the installation of these repairs.

(c) Description of any Problems/Challenges

We have had some issues working out scheduling with our industrial partner, but we are on schedule to wrap and test the eroded flaws the week of July 12th. This has been the only major challenge with the project at the moment. As such one of our planned activities for the next quarter is the same as last quarter.

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

1. Installation of composite on eroded straight line pipes
2. Compare baseline results to repairs performed on drilled through-wall defects.
3. Continue FEA modeling of the repair.