CAAP Quarterly Report

Date of Report: *December 1, 2014*

Contract Number: *DTPH56-13-H-CAAP02*

Prepared for: *DOT*

Project Title: *Scaling and Self-Sensing in Composite Repairs of Corrosion Defects*

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For quarterly period ending: *November 30, 2014*

Business and Activity Section

(a) Generated Commitments

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

Supplies Purchased	Cost
Supplies (pipe fittings, adhesives, hydraulic fittings)	$1,768.26
Welding	$924.00
Machining Inserts	97.99

(b) Status Update of Past Quarter Activities

During the last quarterly period we have

1. Performed FEA analysis on large and small-scale samples.
2. Investigated impact of flaw orientation on substrate stress and strain state.
3. Delivered small-scale specimens for fabrication.
4. Fabricated prototype defect for large-scale test specimen.
5. Begun initial testing for self-sensing repair approach.
6. Investigated the impact of Poisson ratio of dimensional restoration putty on repair strains.

Because of limitations of our in-house machining capability, we are investigating the effect of orientation on the flaw for the large-scale sample. We have run initial FEA simulations on the flaw in both orientations. Internal pressure was set at 100 psi as we had determined that this would be below the critical pressure value required to yield the flaw. As you can see in Table 1, there is approximately 30% difference between the two orientations, with the axial orientation being the more severe.

Table 1: Summary of FEA results on axial and hoop orientation of the flaws.

Defect Orientation	Substrate Strain (in/in)	Max Stress (psi)
Hoop	6.878E-04	22430
Axial	9.474E-04	30500

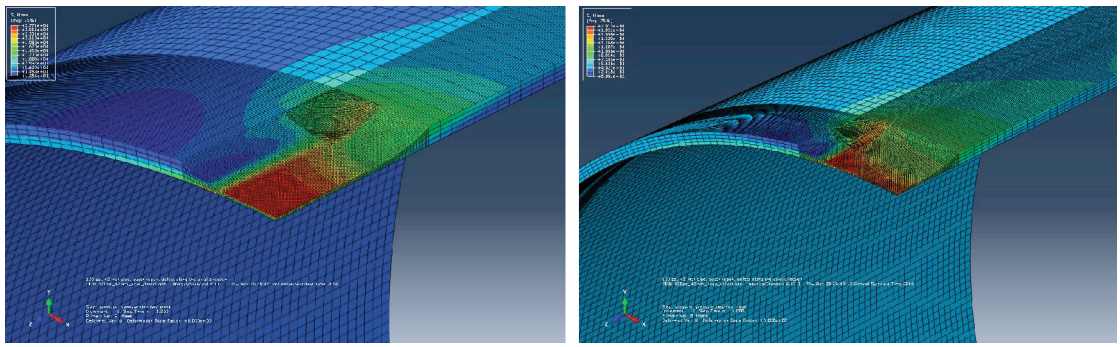


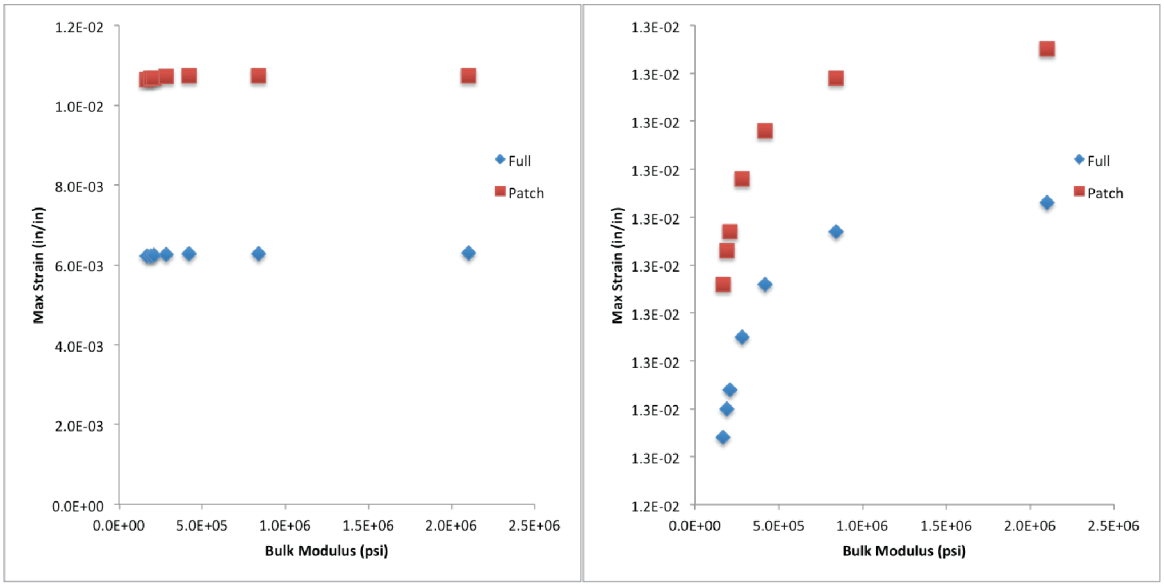
Figure 1: Comparison of axial (left image) and hoop (right image) orientation for the proposed flaw.

We are working o see if we can modify the flaw dimensions to more approach the axial orientation, which is the orientation on the small-scale repair samples.

In addition to the simulation, we are currently working through the prototyping phase for fabrication of the large vessel. Because direct fabrication of the flaw onto a section of 42-inch pipe will likely be difficult to accomplish with machining that is locally available, we are working on a rolling procedure to produce the flaws on the 42 inch vessel. We are planning on milling the flaws into a flat plate, the same wall thickness as the base pipe and then rolling the resulting defect into a 42 inch diameter cylinder. These defect hoops will then be welded into place to form the test vessel. We have fabricated a prototype defect, shown in Figure 2, and will be test rolling this thin plate to determine the effect of rolling on the defect. Assuming that no significant challenges are encountered, we will move forward on this procedure for sample fabrication. It is important to note that the prototype flaw in Figure 2, did not have finish passes to remove the significant ridges that are present. The final machined flaws will have these finish passes to eliminate ridges.

Figure 2: Prototype flaw for rolling tests. Note incomplete machining in corners, this is due to an intentional reduction in machining finish passes.

At the ASME PCC-2 meeting, there was considerable discussion on the importance of the dimensional restoration putty for repairs like the ones studied in this project. As part of the discussion, we were interested in the impact of putty Poisson ration (and therefore bulk modulus) on the performance of repairs. To investigate this we have performed a series of FEA simulations investigating this behavior. For the simulation results in Figure 3, we have two views of the same simulations. Substrate strain represents the strain in the repair region underneath the repair and the repair strain represents the maximum strain in the composite repair. Increasing bulk modulus is based solely on a Poisson ratio that approached 0.5.



Substrate Strain Repair Strain

Figure 3: FEA predictions for the strain in the substrate and the repair

All of these results represent a 75% wall loss specimen and loading at full MAOP. Not unexpectedly, the repair strain has little response to the Poisson ratio as the substrate for both the patch and full encirclement repairs is yielding. The repair strain has a strong response to dimensional restoration putty bulk modulus, with repair strain increasing and then plateauing with as the Poisson ratio approaches 0.5. At least for yielding repairs, it appears that a lower Poisson ratio may, in fact, be more appropriate for improved repair performance.

(c) Description of any Problems/Challenges

In the last report, we had indicated that we had identified a source for a new large-scale vessel from a local company, Superior Pipeline. They offered a 36 in vessel and, potentially, a 42 in vessel for use in this project. Since that report, we have investigated the available vessels and have determined that they will not be suitable for this research. All vessels had wall thicknesses that were approximately one inch or greater, or had a large number of wall penetrations for flanges. We have decided to move forward on purchasing a section of 42 inch diameter, standard wall pipe to serve as the large scale vessels. We have also sourced heads for this pipe and will be moving toward purchase in the near future.

The second challenge we are facing is the scheduling for welding fabrication of the small-scale test pipes. At the ASME PCC-2 meeting in September, the flaw design was finalized. Within a week of this meeting we had completed machining of all test pipes and were working with a welder to finish fabrication. Six samples were welded shortly after the delivery of the raw material, but a miscommunication caused a coupling to be welded too close to the machined flaw. We have corrected this communication issue, but we are now still waiting (as of 12/1/14) for the remaining samples to be welded so that we can begin testing. We are currently searching for a welder that can perform the required fabrication on a shorter time scale. We were planning to have had repairs installed and testing to have begun by the end of this quarter. We are now behind schedule due to fabrication delays. As soon as the pipes are fabricated, we will begin repair installs and testing.

***(d)* Planned Activities for the Next Quarter** –
Because of the fabrication delay described above, our planned activities for the next quarter are similar to those of last quarter (ending Sept 1.)

1. Complete sample manufacture and repair installs
2. Complete a significant portion of the small-scale fatigue testing.
3. Begin fabrication and preparation for large scale testing.