Memo of Work Task Completion

Date: 21 November 2020

To: David Stevens, Research & Innovation Division, Utah DOT

From: Prof. Kyle Rollins, Civil & Environmental Engineering Dept., BYU

Re: Completion of Work Task 9 Evaluation of Tensile Forces (original Task 9 scope, Memo 1)

With this memo I am confirming that we have completed Work Task 9 regarding the prediction of reinforcement tensile forces based on the results from the fixed-head tests, the 24 inch diameter tests, and the pile group test conducted in connection with FHWA Pooled Fund Study TPF-5(381) Evaluation of Lateral Pile Resistance Near MSE Walls at a Dedicated Wall Site-Phase 2. Reference to Phase 1 testing in this memo refers to the previous Pooled Fund Study TPF-5(272). Detailed information regarding the Phase 2 measurement of the tensile forces is provided in three draft final reports for these tests that have previously been submitted to Utah DOT. Therefore, this memo will only provide a summary of the procedure used and the results obtained.

During each lateral load test involving the fixed-head piles, 24-inch diameter pipe piles, and group piles, reinforcements (welded-wire or ribbed strip) were instrumented with strain gauges at seven locations behind the MSE wall. Reinforcements were typically instrumented at four depths and at two distances transverse to the direction of loading for each pile test. Based on Phase 1 testing, a multi-linear regression equation was developed to predict the maximum tensile force in the reinforcements as a function of pile head load, vertical stress, transverse distance from the pile and distance between the pile and the MSE wall. This equation was based entirely on lateral load tests on individual 12-inch diameter (width) piles with a “free-head” boundary condition. During Phase 2 testing we evaluated the ability of the multi-linear regression equation developed in Phase 1 to predict the maximum tensile force for the fixed-head pile test, 24 inch pipe piles test and pile group tests measured in Phase 2 testing.

Figure 1 provides a comparison of the measured and predicted maximum tensile force for reinforcements attached to the MSE wall during the pile group load test with three 12.75-inch diameter piles. About 62% of the measured maximum tensile force values fall within ± one standard deviation of the predicted maximum while 85% of the measured maximum tensile force values fall within ± two standard deviations of the predicted value. Therefore, the distribution of error for the group test is essentially the same as the distribution of error for the Phase 1 testing. This good agreement is likely due to the fact that the group test involved free-head testing of the same pile diameter as in Phase 1.

Figure 2 provides a comparison of the measured and predicted maximum tensile force for reinforcements attached to the MSE wall during lateral load tests with the 24-inch diameter piles. Because the lateral loads for the 24-inch piles were much higher than those for the 12.75-inch piles, the equation did not accurately predict the measured tensile force. To produce better agreement, it was necessary to divide the load by the diameter of the pile. With this correction, the measured and computed maximum reinforcement tensile force values were in reasonable agreement as shown in Figure 2. In addition, the error was similar to that for the original equation. Nevertheless, this simple adjustment to the equation was not statistically derived and may not be appropriate for other situations.

Figure 3 provides a comparison of the measured and predicted maximum tensile force for reinforcements attached to the MSE wall during lateral load tests with the “fixed-head” test piles. The fixed-head boundary condition and the denser compaction of the backfill around test piles allowed the applied lateral force to be 150 to 300% higher than for the free-head test piles at the same spacing behind the MSE wall. As a result, the predicted maximum tensile force was in poor agreement with the measured values, as shown in Figure 3. The results from these three test sequences indicates that the prediction equation for tensile force must be significantly revised. Ideally, we would like to develop one equation that will accurately predict the maximum tensile force for the all of the loading conditions for which we have test data.

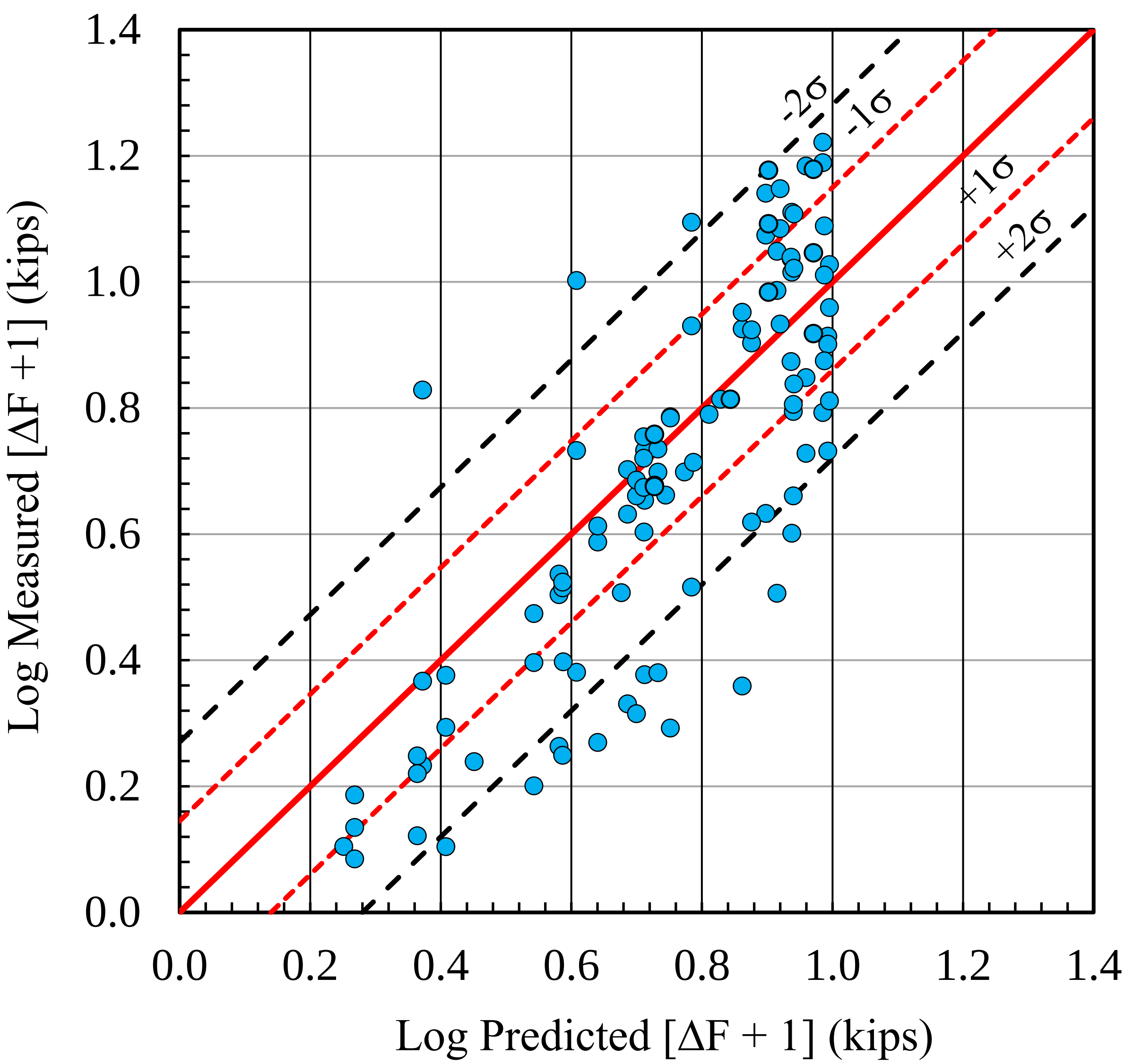

Figure 1. Comparison of measured and computed maximum induced reinforcement tensile force (ΔF) for load tests with pile group consisting of three 12.75-inch diameter pipe piles.

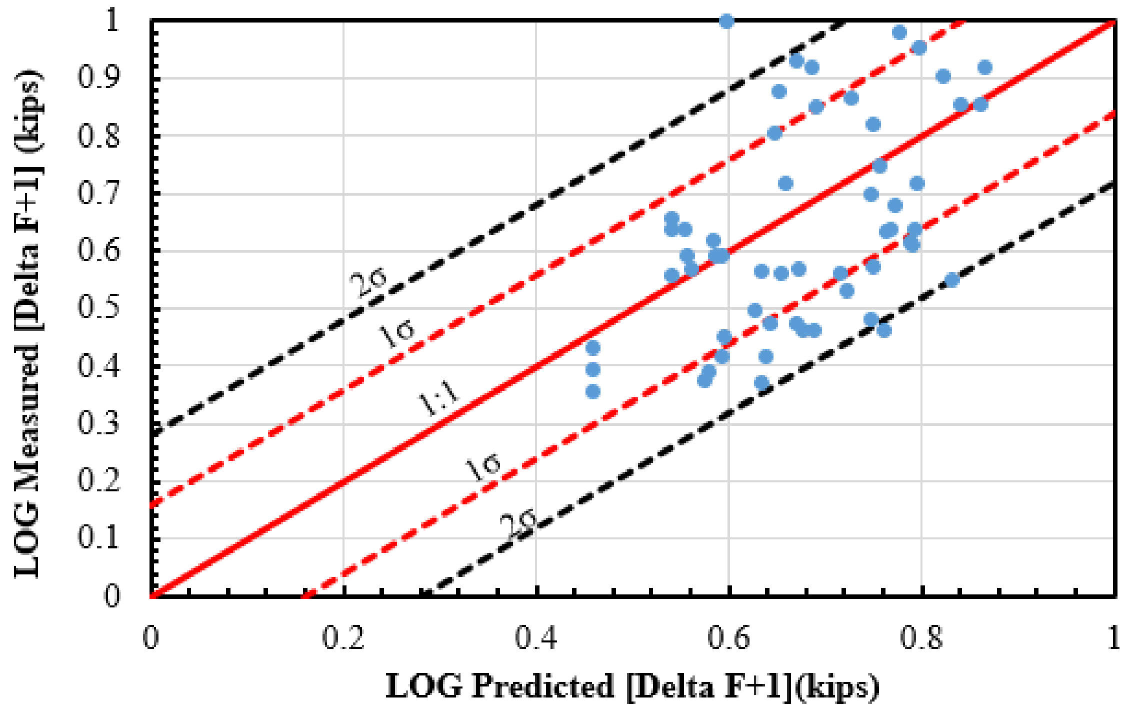

Figure 2. Comparison of measured and computed maximum induced reinforcement tensile force (ΔF) for 24-inch diameter free-head pipe piles.

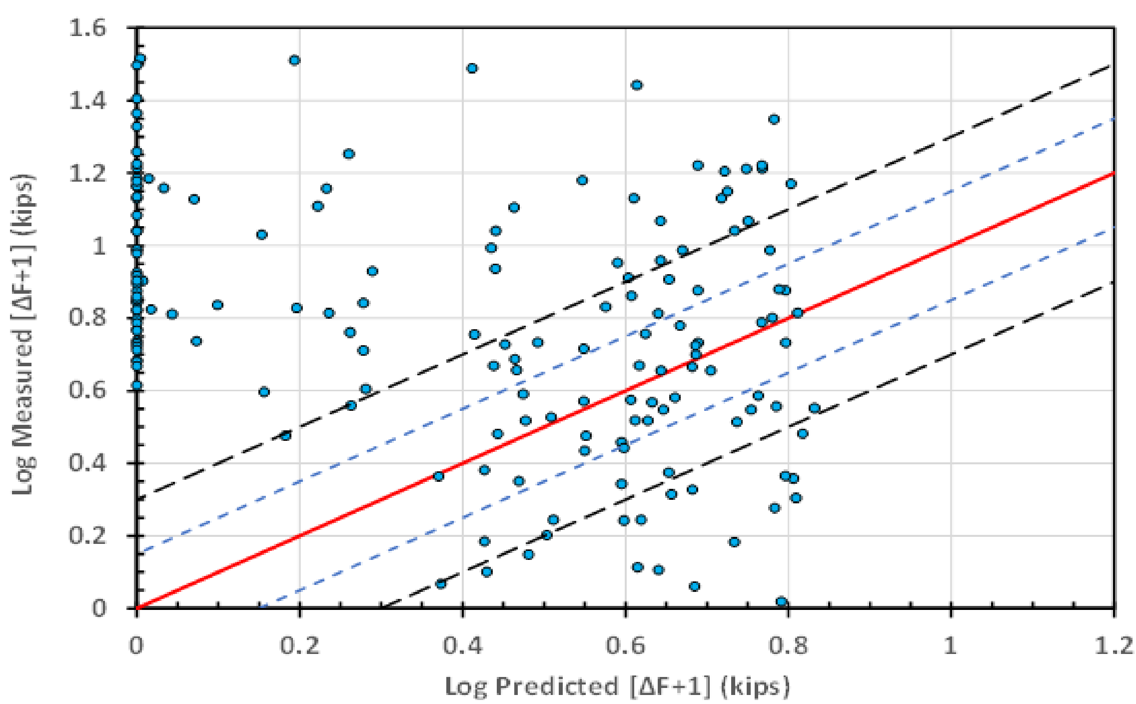

Figure 3. Comparison of measured and computed maximum induced reinforcement tensile force (ΔF) for "fixed-head" test piles.