Progress Report Project 9-1526

Investigation of the Fatigue Life of Steel Base Plate to Pole Connections for Traffic Structures

by

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Introduction

The second phase of the experimental study is nearing completion. We have tested 20 mast arm specimens and 4 high mast specimens. All of the specimens are providing very good fatigue performance. A summary sheet for each of the specimens has been sent with this report. The summary sheets give the details and photos of the specimens. This report summarizes the results.

We are at a crucial stage in project. If we want to include additional specimens we must make this decision very soon. The current budget does not provide the additional funds required to undertake additional testing. TxDOT has indicated they will fund the project into next year for $50,000. This funding will be used to support the analytical study of other connection geometries. We expect to finish the remaining mast arm tests by end of May and complete all the testing of the high mast specimens in June.

The butt welded mast arms and high mast specimens provide excellent fatigue performance. The only drawback to this detail has been failures at the tack weld used to hold the back up bar in place and corrosion in the space between the back up bar and the shaft. If ceramic back up material were used, the tack weld and the un-galvanized space would be eliminated. The impact of using ceramic backup upon fatigue performance is a topic that could be studied by additional fatigue tests.

In addition to studying the effect of ceramic back up material, the size effect on the high mast results need to be studied. All the specimens to date are the same diameter, 24 inch. The effect of larger diameter specimens upon the fatigue performance needs to be examined. The mast arm tests indicate specimens with an external collar are not very sensitive to changes in pole diameter. This may mean very thick base plates may not be needed with larger diameter poles if collars are used. This needs to be verified experimentally. The estimated cost to continue the project testing 16 additional specimens is $182,000. This cost includes the specimen cost as well as the cost to complete the analytical work. A project meeting will be called shortly to discuss these options.

Effect of Weld Detail Upon Mast Arm Fatigue Strength

The figure below shows the results of the two sets of 10 inch mast arm specimens tested in this project. The increase in fatigue strength of fillet welded socketed connections with increasing end plate thickness is quite evident. The fatigue strength with the 3 inch end plate approaches category D while the specimens with thinner base plates produce results less than category E'. Similar increase in fatigue strength with end plate thickness is evident with the specimen with external collars. The fatigue strength of specimens with external collars and 2 in. end plates exceed category C. The fatigue life of the specimens with the full penetration Wyoming weld detail produced fatigue also in excess of category C with a 2 inch end plate and category B with a 3 inch end plate. Note the specimens with the 3 inch end plates and the Wyoming weld detail were tested at stress range of 24 ksi in order to produce a failure.

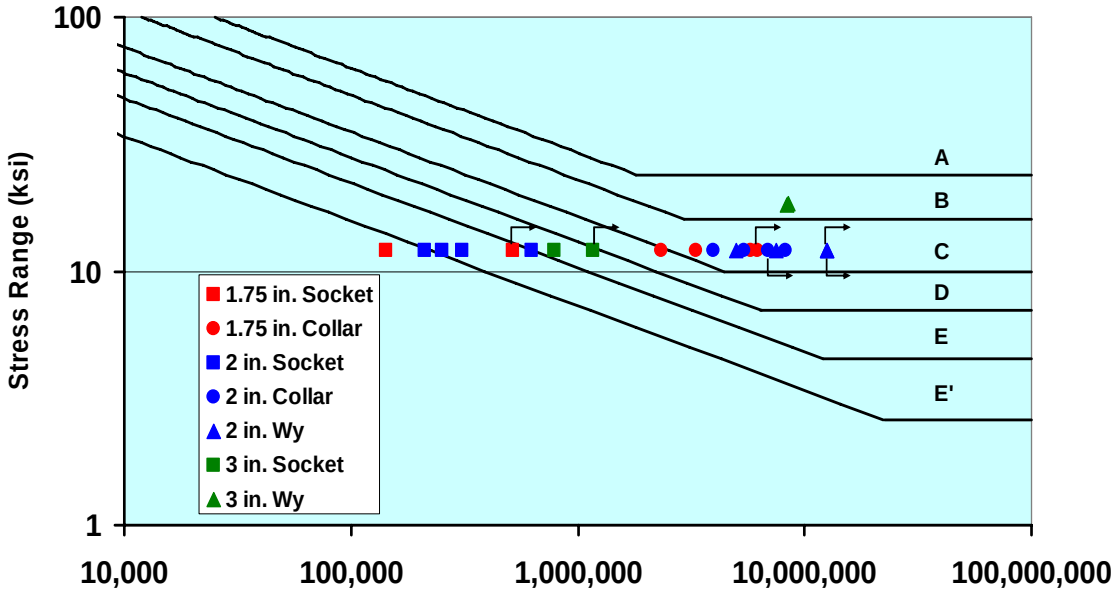

Figure 1
10 inch Mast Arm Results

The influence of mast arm diameter upon fatigue performance is shown in figure 2 below. Eight inch and 12 inch diameter specimens were tested with either an external collar or the Wyoming full penetration weld detail. A 2 inch end plate was used on all these specimens. The specimens were tested at a higher stress range to produce a fatigue failure rather than a runout. The specimens provided very good fatigue performance. The 8 in. specimens with the Wyoming weld detail produced almost category B fatigue performance. The 12 inch specimens with the Wyoming detail provided slightly less fatigue performance, about category C. This was as expected since the relative stiffness of base plate to the mast arm is reduced in these larger mast arms. Both 8 and 12 inch diameter specimens with an external collar provided fatigue performance comparable to the 10 inch specimens. The collar connection appears to be less sensitive to the thickness of the base plate then the either the socket or Wyoming weld detail. The stiffening effect of the collar and the remoteness of the typical failure location from the end plate are likely responsible for this lower sensitivity to thickness/stiffness of the end plate.

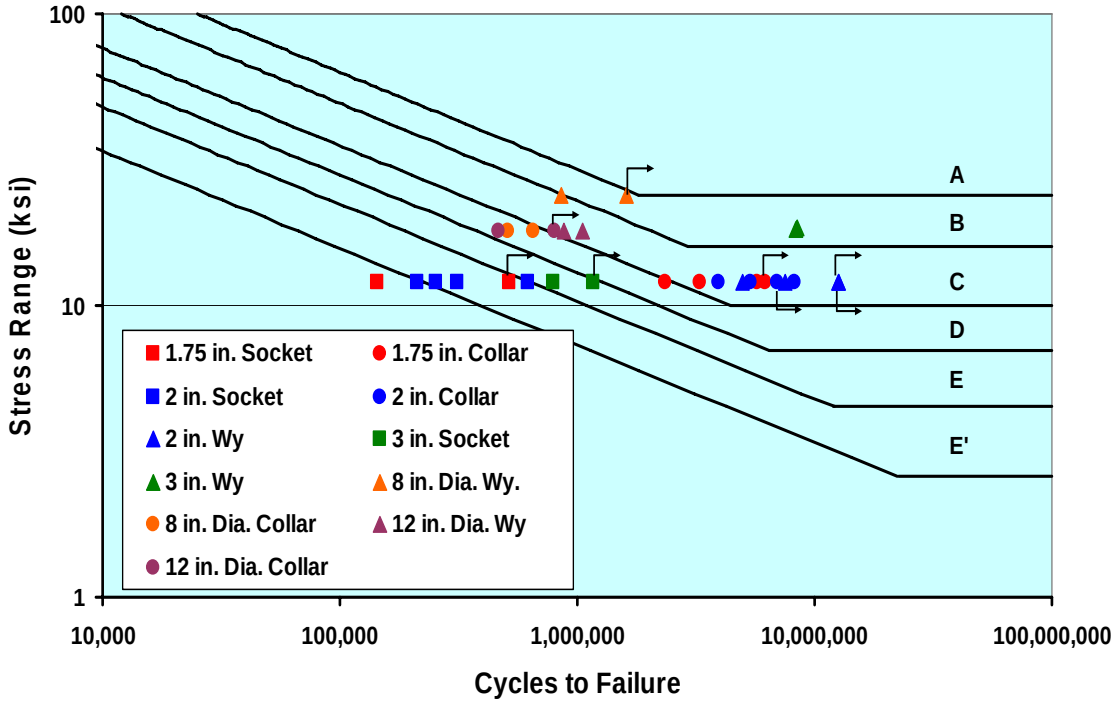

Figure 2
8 and 12 inch Diameter Mast Arms

All of the specimens shown in the previous figures were fabricated by Valmont Industries. Tests of specimens from other suppliers were undertaken to evaluate the effect of the supplier upon the fatigue performance. The fatigue performance of the specimens from additional fabricators is shown in figure 3. All of the specimens shown in figure 3 had the Wyoming weld detail. Specimens were provided by Pelco Structural, Union Metal, and Ameron. The specimens from Union Metal and Ameron had a 10 inch diameter with 3 inch end plates, the Wyoming full penetration weld detail, round sections, and galvanized. The Pelco sections were a nominal 10 inch diameter polygon sections with 2 inch end plates and were not galvanized. The Ameron specimen had a very short fatigue life relative to the other specimens. The cause of the short life of this specimen is being investigated. The replicate specimens from Ameron and Union Metal could not be tested. The length of the specimens exceeded the tolerance and they could not be fit into the test setup.

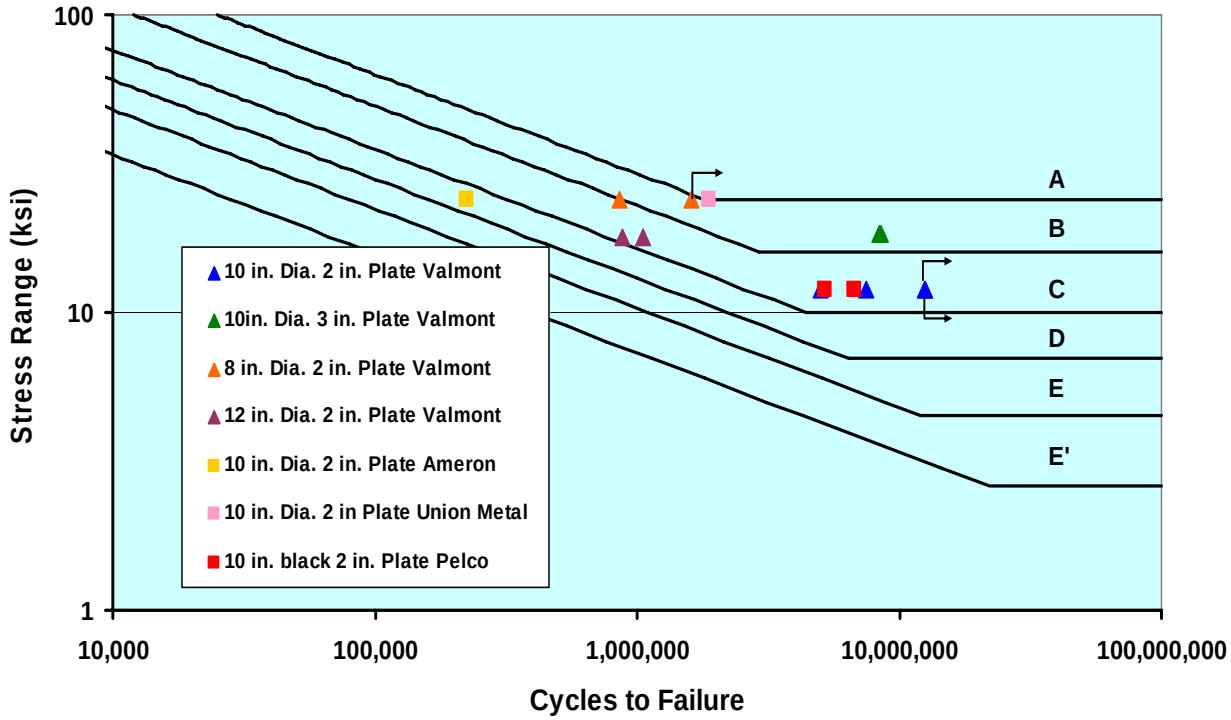

Figure 3 Comparisons of Suppliers

High Mast Tests Results

The high mast tests are behind schedule due to problems with fatigue failures in the test

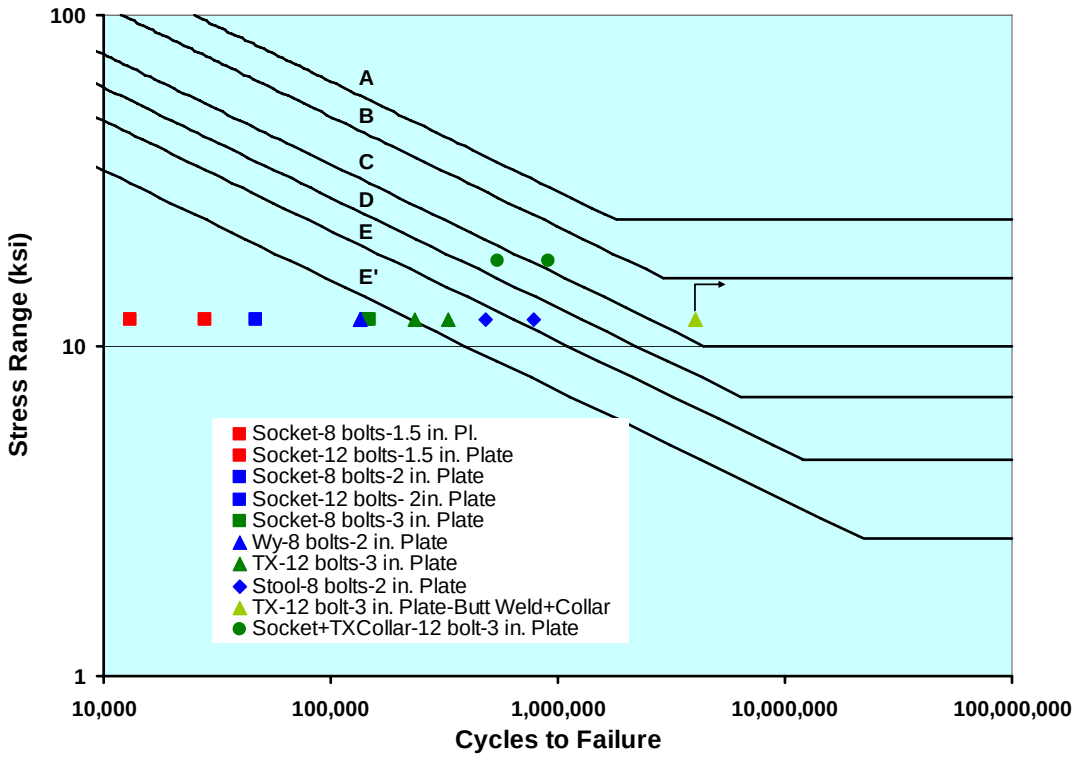

Figure 4 High Mast Test Results

setup and problems with specimen geometry. We increased the size of the rod eyes at the end supports. The large eyes also failed in fatigue. We modified the eyes by machining a 12 mm radius at the critical section and used a roto peening system from 3M to peen the critical region. The testing using these retrofitted eyes is just underway. The number of cycles that we have applied to the high mast specimen in this second series of tests is 3 times all the cycles applied to the first series. The fatigue performance of the second series of high mast arms specimens is much better than the first series. We have completed testing of two sets of specimens and have the test of a third set underway. Figure 4 shows the results of the high mast specimens. The 3 inch thick base plate with either a butt weld or socket connection in conjunction with a collar or ground sleeve provides fatigue performance comparable to category C or D. This is a tremendous improvement in fatigue performance. The earlier tests with thinner base plates failed far below category E'.