

## **Tensile Test Results of Post Tensioning Cables From the Midbay Bridge**

### **Background**

The Midbay bridge, located on State Road 293 between State Road 20 and U.S. 98 in Niceville, Florida is a concrete segmental box bridge with approximately 140 spans. The bridge uses a total of six external post-tensioning cables as the primary live load resistance system, with three of the six cables on either side of the boxes. Each cable is composed of 19 – 0.6” diameter steel cables that are stressed to 31,000 pounds each at the time of construction. The cables are held in place between steel anchors and surrounded by a protective sleeve. The primary anchorage system consists of end steel blocks with post-tensioning wedges, while the secondary anchorage system relies on a grout that is pumped into the casing surrounding the strands.

An inspection of the post-tensioning system during the year 2000 revealed that a significant number of these cables were exhibiting signs of corrosion and possibly, improper grout. The corrosion has been speculated to have been caused by trapped moisture in voids where grout should have existed. Inspection using a borescope inserted into a hole drilled through the anchorage assembly revealed that several wires in various individual strands have ruptured and others have had some level of corrosion.

### **Objective**

A request was made to the Florida Department of Transportation Structural Research Center to test the strands from one of the corroded cables to determine the tensile capacity remaining for the reinforcement.

### **Test Method**

The AASHTO Standard Method of Test for “Mechanical Testing of Steel Products”, designation T 244-92 (ASTM Designation A 370-92) was followed to determine the tensile properties of the strands. More specifically, section A7 of the procedure “Method of Testing Uncoated Seven-Wire Stress-Relieved Strand For Prestressed Concrete” was referenced directly for the test procedure.

## **Specimens**

Two portions of cables were removed from the bridge and transported to the Structural Research Center in Tallahassee. The first portion was reported to be a damaged cable with significant corrosion on various strands. The cable was cut approximately 15' from the anchorage end and removed from the bridge. The second portion consisted of strands that were reported to be in acceptable condition with no sign of corrosion and chosen to be used as control specimens.

Visual inspection of the anchorage assembly revealed corrosion of the anchor wedges, both inside the grip area and between the anchorage plate and the wedges (See Photos 1 – 3). No sign of slip was apparent in the wedges. The strands that were still connected to the anchorage assembly had enough corrosion to cause pitting of the steel surface for approximately the first 8" of length outside the anchor region (See Photos 4 – 7). The strands were removed from the anchor plate preserving the entire length of the cable that was provided to the Structures Research Center.

Each corroded cable was cleaned using an abrasive pad to determine the extent of the pitting. In all cases the deepest pitting reached a maximum average depth of 0.0015".

## **Test procedure**

The strands were cut to a length of 60" and gripped using a post tensioning anchor with a universal chucking device. Steel sleeves were inserted between the chucks and inserted in the V-Grip assembly of the load frame. This sleeve insures that hydraulic gripping pressure from the load frame is not directly applied to the specimen. The combination of steel sleeve and chucks leaves a 36" gauge length exceeding the minimum requirement of 24" stipulated by AASHTO (See Photos 8 - 12). Several individual wires were instrumented with electrical resistance strain gauges at the center of the gauge length. The steel assembly was placed in the gripping portion of an MTS-550 universal material testing system load frame. This load frame is capable of applying a force of 550 kips in tension or compression and is fully controllable in terms of load rate, whether through displacement or load control to satisfy the requirements of the testing procedure.

Following the AASHTO test procedure, each strand was loaded to approximately 10 percent of the expected minimum breaking strength of the specimen, which was assumed at 5 kips, prior to beginning the test. The load rate was set at 125 $\mu\epsilon$ /second and proceeded until rupture of the specimen. The load, stress and strain were all monitored using a high speed data acquisition system with readings being taken twice every second throughout the duration of the test.

The instrumentation used was as follows:

- 1 – A minimum of two electrical resistance strain gauges with an accuracy of  $\pm 5 \mu\epsilon$  and a maximum elongation of 20,000  $\mu\epsilon$ .

- 2 – The load frame load cell with an accuracy of  $\pm 50$  lbs with the most recent calibration occurring in June 2000.

All instruments used in the test are standard instruments used by the Structural Research Center on a regular basis and have proven to be highly accurate and reliable.

### **Test Results**

The following table summarizes the results observed during the test:

<b>Specimen Number</b>	<b>Initial Condition</b>	<b>Yield Strength <math>f_y</math> (ksi)</b>	<b>Ultimate Strength <math>f_u</math> (ksi)</b>
CONT-1	OK – Control Specimen	246.6	279.4
CONT-2	OK – Control Specimen	244.7	278.8
CORR-1	light pitting, corrosion	245.9	248.0
CORR-2	light pitting, corrosion	Not achieved	240.7
CORR-3	light pitting, corrosion	Not achieved	240.4
CORR-4	mild corrosion	253.1	264.4
CORR-5	light pitting, corrosion	240.1	250.7
CORR-6	light pitting, corrosion	246.1	246.8
CORR-7	light pitting, corrosion	245.0	245.0

**TABLE 1 – Test Result Summary**

$F_y$ , according to the AASHTO test procedure is achieved at a 1% extension of strain or 10,000  $\mu\epsilon$ . For specimens CORR-2 and CORR-3, this extension is not achieved until after rupture of the first wire, which is defined as failure for the specimen.

The average results are as follows:

<b>Specimen Type</b>	<b>Yield Strength <math>f_y</math> (ksi)</b>	<b>Ultimate Strength <math>f_u</math> (ksi)</b>
Control	245.65	279.1
Corroded	246.04*	248.0

**TABLE 2 – Test Result Averages**

\* Note: The value reported in this table of yield strength for the corroded strands does not include specimens CORR-2 and CORR-3 since they did not achieve the requirements of the AASHTO test procedure. Additionally, note should be made that specimen CORR-7 fails at the yield point (See Figure 9).

For the corroded specimens, failure always occurred within the pitted portion of the strand, with the exception of Specimen CORR-4, which failed in a manner similar to that of the control specimens. Photos 13 – 18 show the condition of the strands at failure for all corroded specimens except CORR-4.

Figures 1 – 9 show the stress vs. strain relationship for each of the strands tested. Note that the ultimate strength for the control specimens can not be shown on the plot since it occurs at an elongation far beyond the capacity of the measurement device.



**Photo 1** – End View of Anchor Plate



**Photo 2** – Side View of Anchor Plate



**Photo 3** – Anchor Wedges With Corrosion



**Photo 4** – Close-up Of Pitting Corrosion



**Photo 5** – Pitting Corrosion



**Photo 6** – Strand Ends After Removal From Anchor



**Photo 7** – *Strand After Removal From Wedge*



**Photo 8** – *Insertion of Specimen in Chucks*



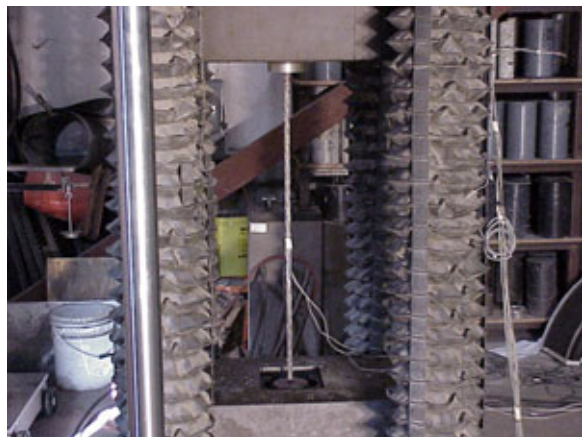
**Photo 9** – *View of Chucked Specimen*



**Photo 10** – *Chucked Specimen With Blocking Sleeve Installed*



**Photo 11** – *Blocking Sleeve Being Placed Into V-Grips*



**Photo 12** – *Specimen in Load Frame*



**Photo 13** – Failure of Corroded Specimen # 1



**Photo 14** – Failure of Corroded Specimen #2



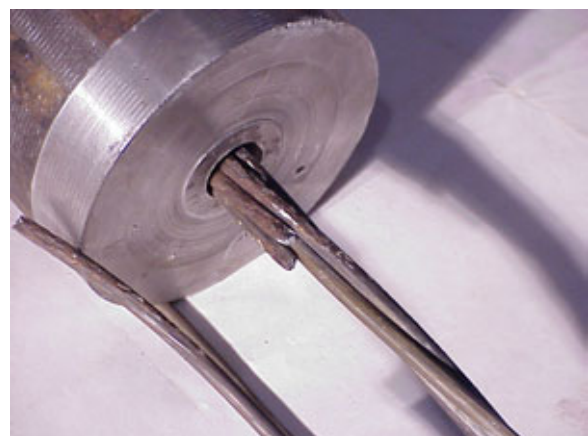
**Photo 15** – Failure of Corroded Specimen #3



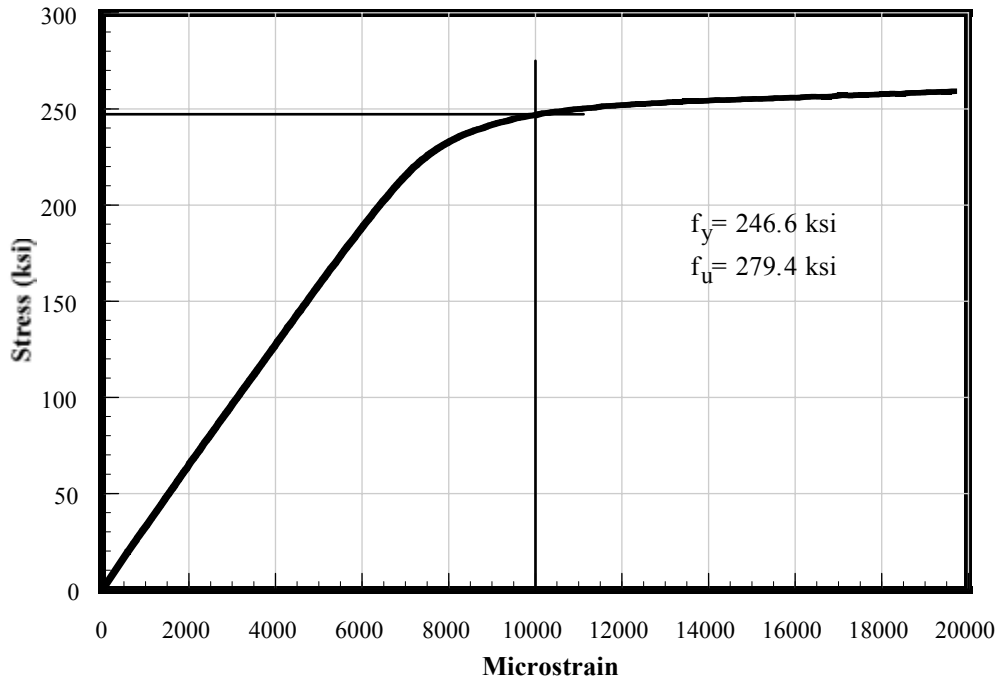
**Photo 16** – Failure of Corroded Specimen #5



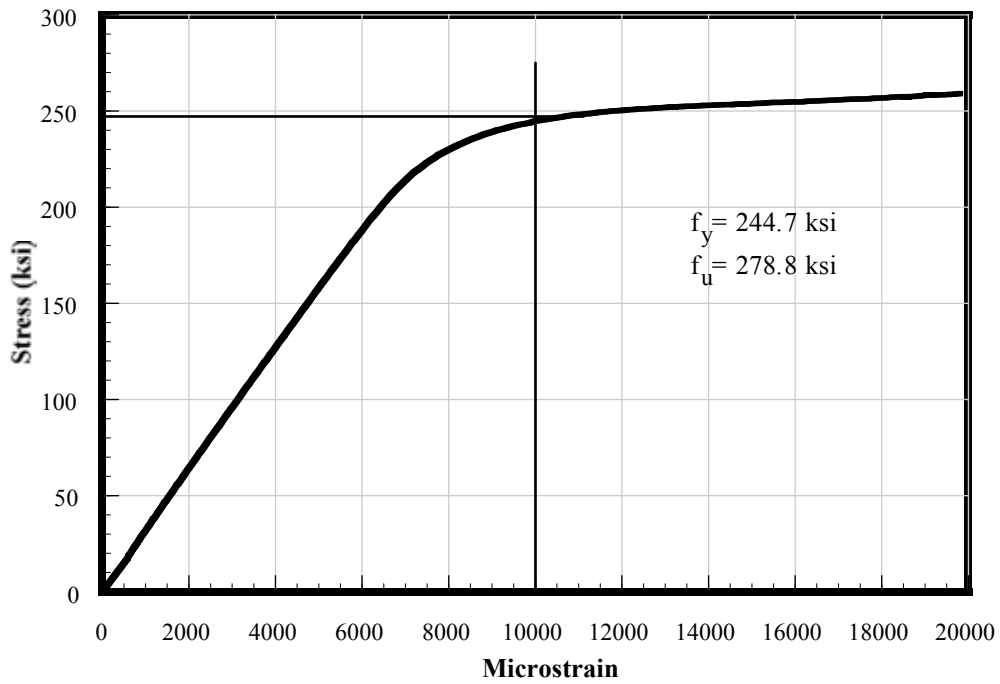
**Photo 17** – Failure of Corroded Specimen #6



**Photo 18** – Failure of Corroded Specimen #7

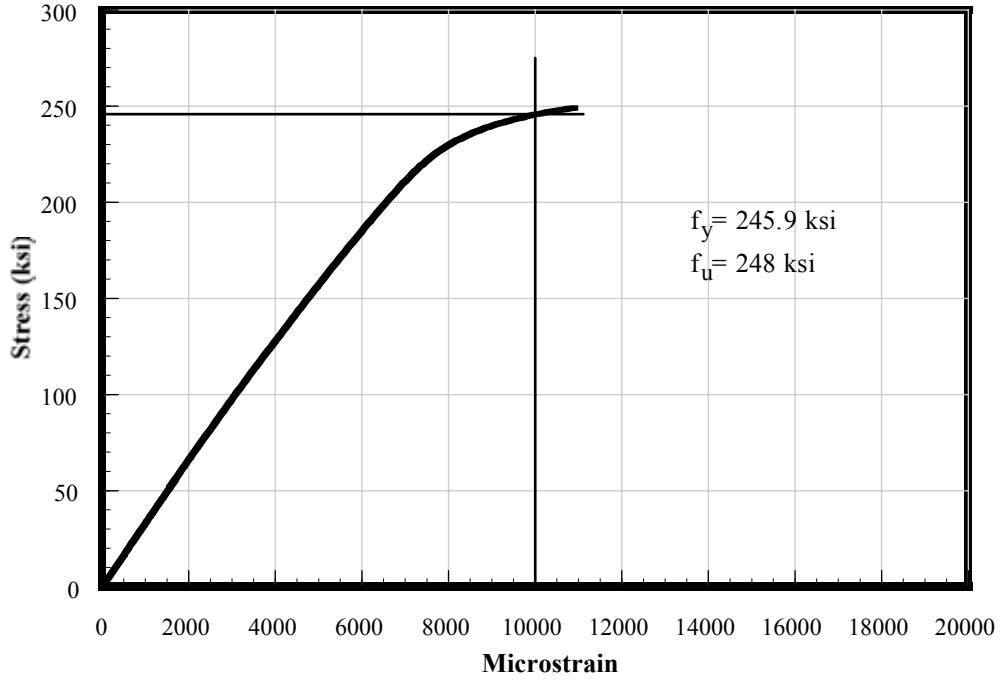


**Figure 1 - Stress vs. Strain  
Specimen CONT-1**

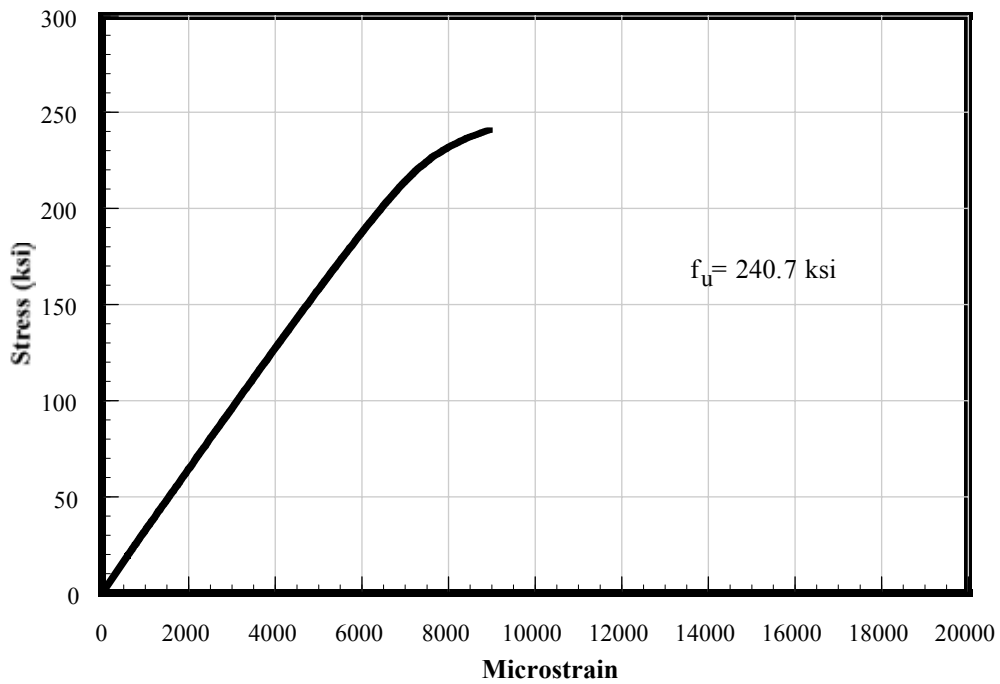


**Figure 2 - Stress vs. Strain  
Specimen CONT-2**

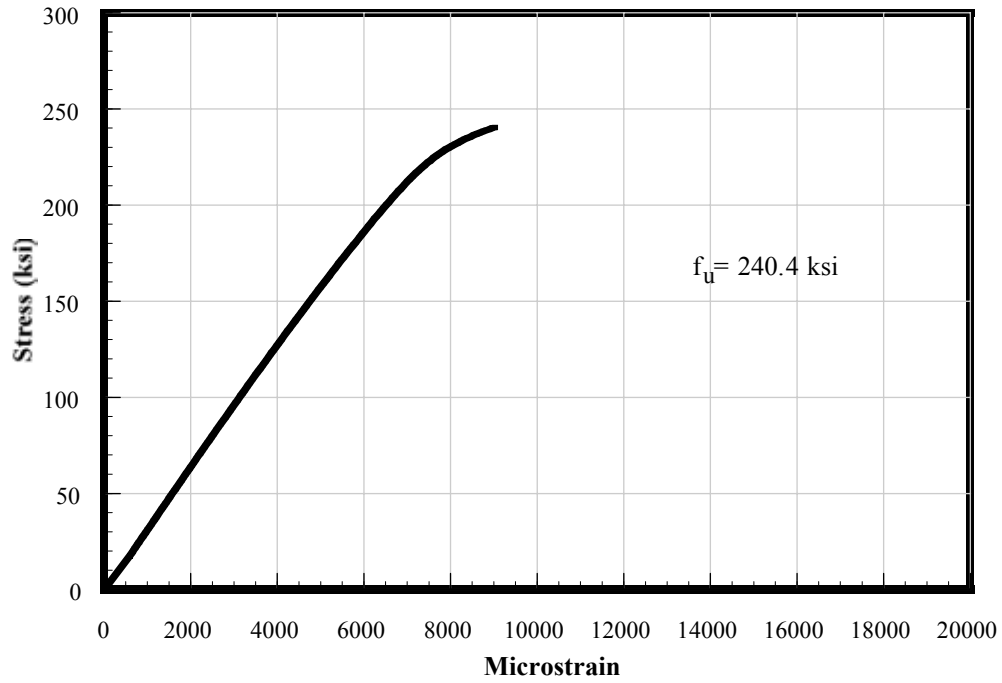




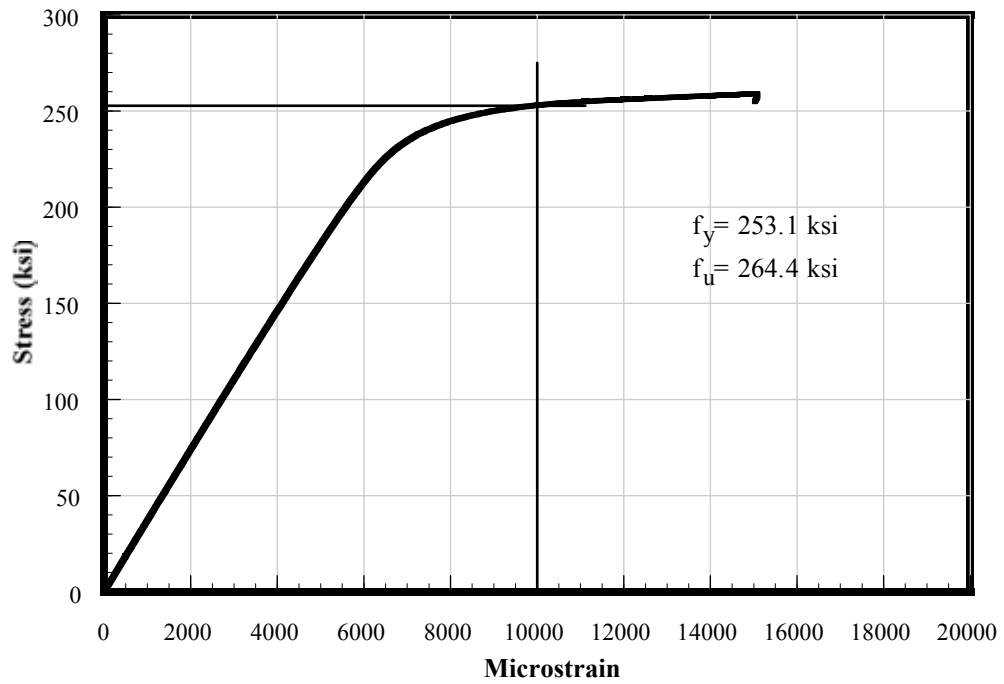
**Figure 3- Stress vs. Strain  
Specimen CORR-1**



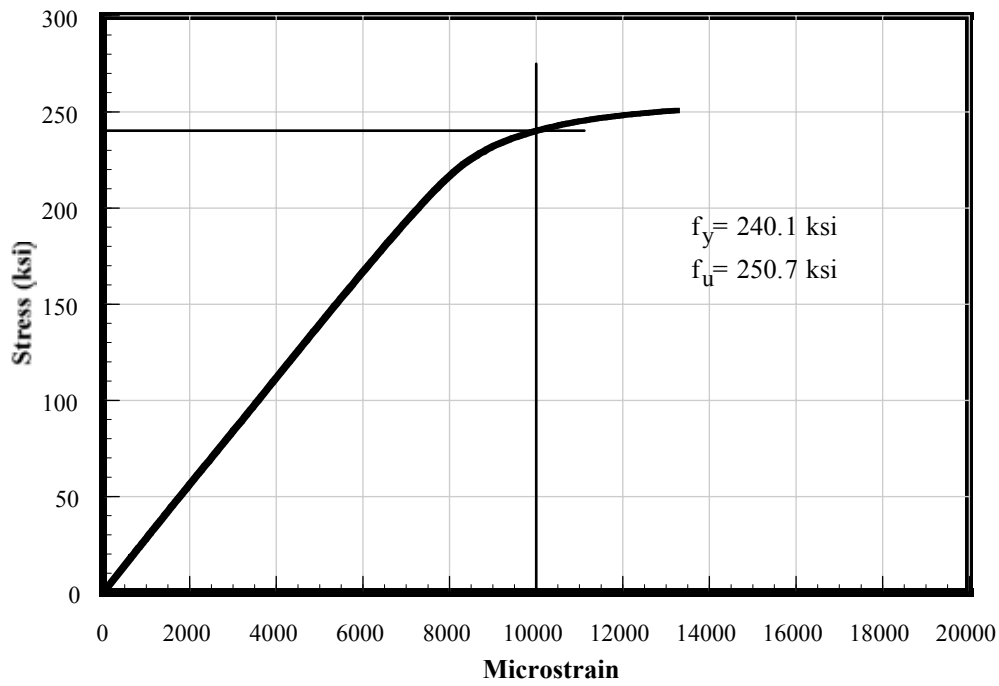
**Figure 4 - Stress vs. Strain  
Specimen CORR-2**



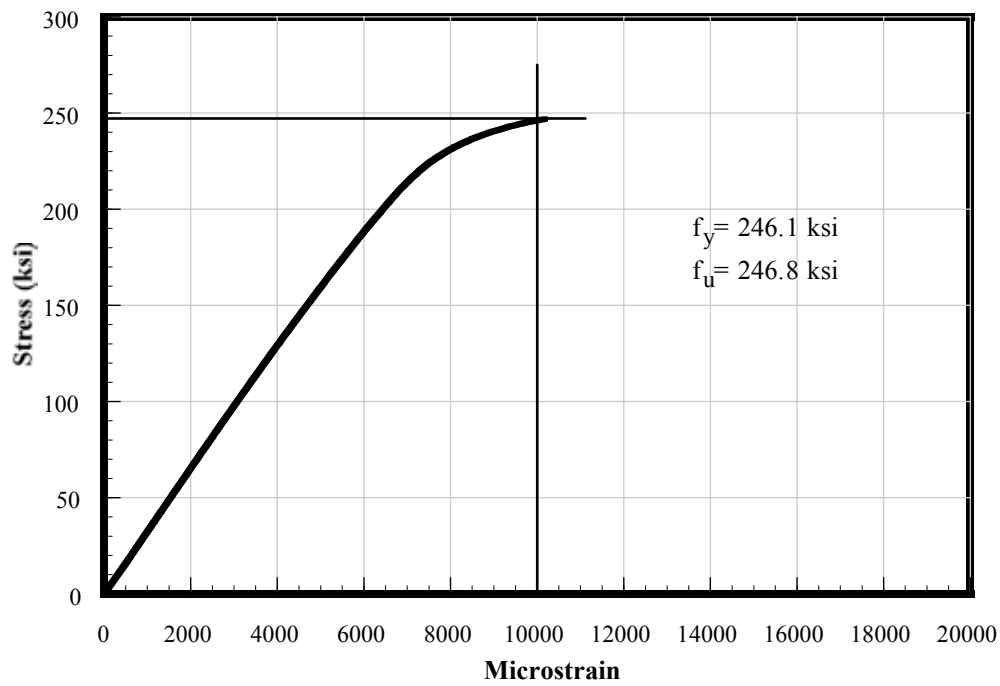
**Figure 5 - Stress vs. Strain  
Specimen CORR-3**



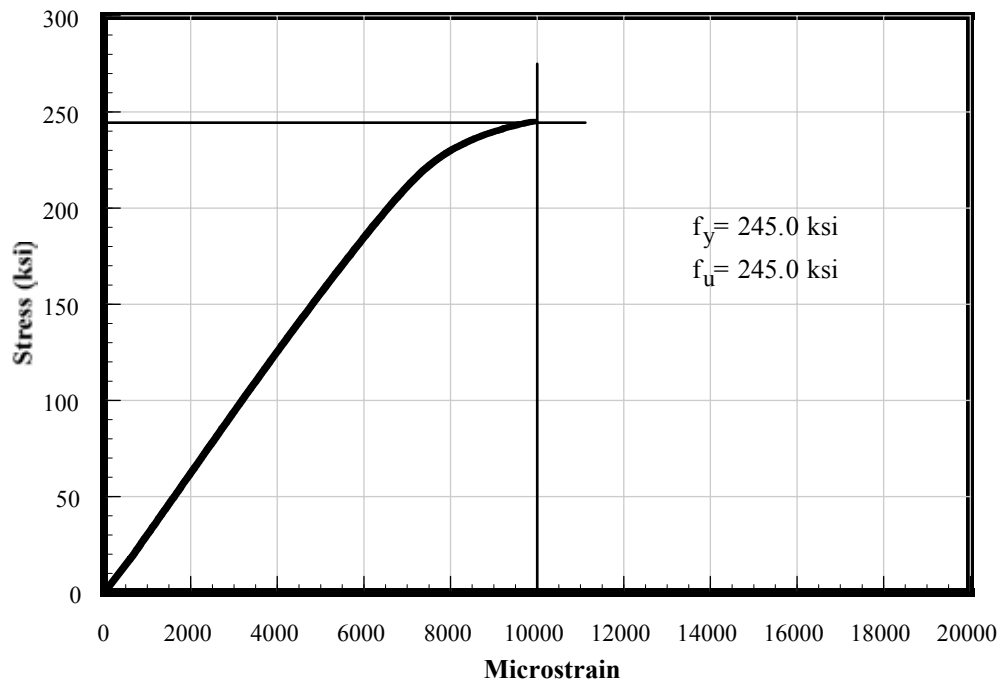
**Figure 6 - Stress vs. Strain  
Specimen CORR-4**



**Figure 7 - Stress vs. Strain  
Specimen CORR-5**



**Figure 8 - Stress vs. Strain  
Specimen CORR-6**



**Figure 9 - Stress vs. Strain  
Specimen CORR-7**