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Residual stress measurements on 12b19 shape a572, August 1967

E. S. Marquez

Residual Stress Measurements on 12 B 19 Shape (A572)

by

E. S. Marquez

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Fritz Engineering Laboratory
Department of Civil Engineering
Lehigh University
Bethlehem, Pennsylvania

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ABSTRACT

The primary objective of this report is to determine the residual stress distribution in the 12 B 19 shape (A572 steel). This was done as a part of an investigation to apply plastic design in high strength steels. The data obtained will be used to check beam-column theory. A number of diagrams and curves are presented as results. Tension-coupon tests were also performed as a routine check on the static yield stress.

I. INTRODUCTION

The standard specification for high-strength low-alloy columbium-vanadium steels of structural quality has been adopted by the American Society for Testing and Materials in 1966 [1]. This covers six grades of shapes, plates, and bars intended for riveted, bolted, or welded construction of bridges, buildings, and other structures (42, 45, and 50) and those intended for riveted or bolted construction of bridges, and for riveted, bolted, or welded construction in other applications (grades 55, 60, and 65).

The application of plastic design in high strength steels is being investigated in the Fritz Engineering Laboratory of Lehigh University. Project 343 was designed to verify the plastic theory by a series of tests on steel with a yield stress value of 65 ksi.

Tests to obtain the mechanical properties, stub column tests, and beam tests are underway at the Fritz Laboratory to determine the strain hardening properties, to check local buckling, to observe the average yield stress, and to check lateral brace spacing and shear provisions. Residual stress measurements on some shapes were made also to verify beam-column theory.

One Beam test~~s~~ under moment gradient ~~and uniform moment~~ ~~have~~ has been conducted to check local buckling and lateral bracing criteria. The 12 B 19 shape, the strain-hardening modulus of which was found to be 582 ksi, was specially chosen for these tests because from its listed properties, the values of b/t and d/w are 11.49 and 50.70, respectively. The values are close to the limiting ratios for E_{st} = 600 ksi, b/t and d/w equal to 11.75 and 52.10 respectively.

II. RESIDUAL STRESS MEASUREMENTS

A portion of the 12 B 19 shape unaffected by the beam test (under moment gradient) was selected for the residual stress measurements. The sectioning method (2) was adopted for simplicity. Other methods of determining residual stresses are described elsewhere (3).

Holes were laid out for strain measurements over a 10-in. gage length on both sides of the web and on both sides of the flanges (4). Figure 1 shows the layout of the section selected. A standard 10-inch mild steel bar was used to observe changes in temperature during readings. Following an initial set of readings taken on the gage points, the final strains were obtained after the 11-inch section had been sawed into 1/2"-wide strips. Residual stress measurements at other beam sections to check the variation of stress distribution along the length of the beam was not necessary (4) according to previous investigations.

III. COUPON TESTS

Specimens for the coupon tests were taken from the beam tested in moment gradient. These tests were made to verify the discrepancy of the actual beam test results and the theoretical curve and to check the static yield value. The E value obtained was used in the computation of the residual stresses from the measured strains. ASTM specifications and recommendations (5) for standard rectangular tensile test specimens with 8-in. gage length were followed on all the tests. Figure 2 shows the location of the coupons with respect to the beam cross-section.

IV. DISCUSSION OF RESULTS

The diagram showing the average residual stress distribution in Fig. 3 exhibits a maximum tensile stress of 6.3 ksi at the junction of the flange and the web and a maximum compressive stress of 6.8 ksi at the flange tip. The greatest variation between stresses of the two sides of the flange was 2.2 ksi.

The stress-strain curves for the standard coupons taken from the web and flange are shown in Figs. 4 and 5. The average static yield stress measured was 65.7 ksi with a maximum deviation of 0.7 ksi. The moduli of elasticity were averaged at 29,500 ksi. This value was adopted in the computation of the residual stresses.

The maximum residual stress obtained from actual measurements on the 16 WF 71 shape is 18.8 ksi compression and 20.0 ksi tension. Assume that these values are typical in the A572 steel specimens for the purposes of discussion. The actual moment computed by using the maximum load on the beam test under moment gradient gives a stress value of 30.0 ksi. (See the computations at the end of this report.) Adding this actual stress to the assumed residual stress of 20.0 ksi, the resulting value is less than the limiting stress of proportionality.

V. CONCLUSION

The computation to check yielding by adding the actual stress obtained from the maximum load of the beam test and the assumed residual stress taken from another A572 shape can be considered valid since no yielding or permanent deformation occurred as a result of the beam previously tested under moment gradient.

Figure 3 shows that the stress distribution pattern is similar to that taken from shapes of structural carbon steel (6) but with a lower maximum stress value.

VI. ACKNOWLEDGEMENTS

This study forms a part of an investigation of A572 steel being carried out at the Fritz Engineering Laboratory, Department of Civil Engineering, Lehigh University. Dr. Lynn S. Beedle is the director of the laboratory and the acting chairman of the department as well as the project director for this research.

Special thanks are due to Professor Lynn S. Beedle for his much-needed advice and encouragement.

VII. FIGURES

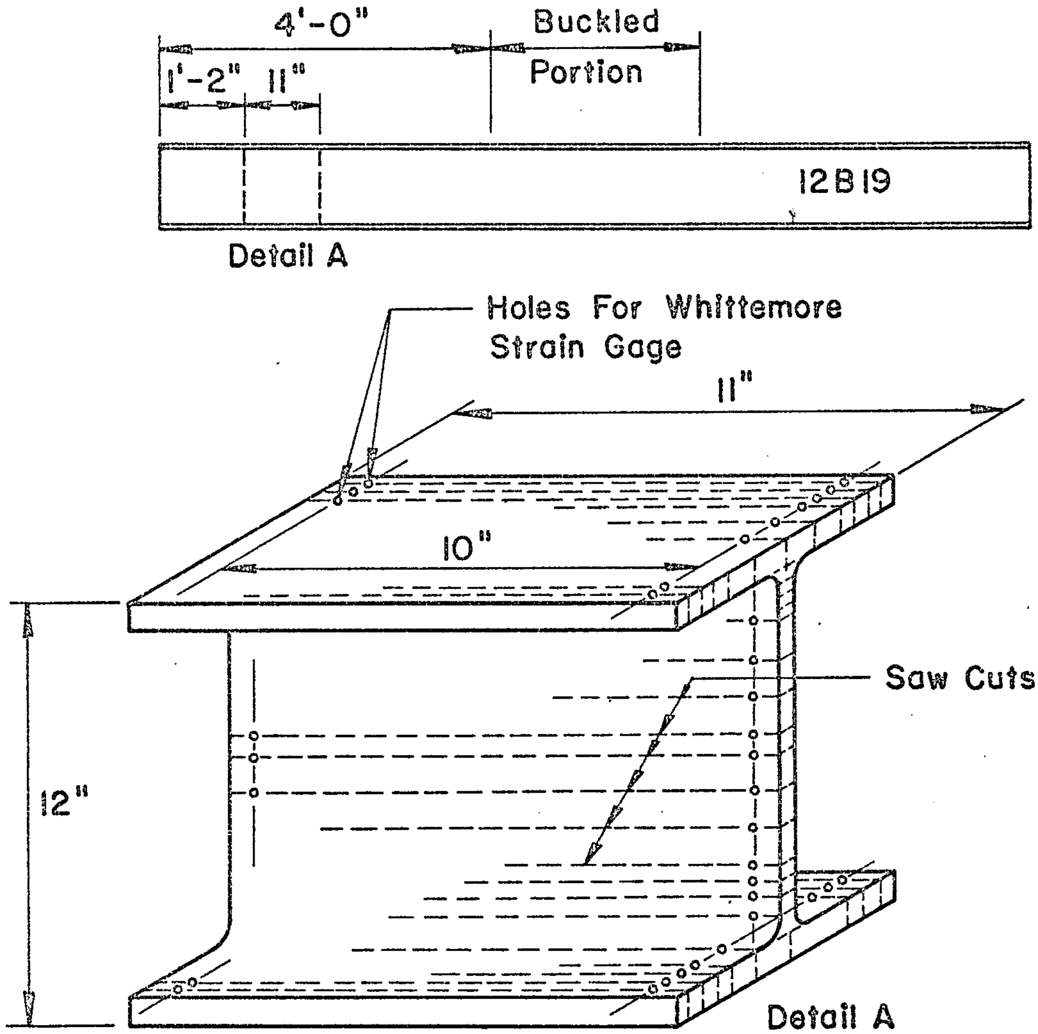

Fig. 1 - Layout for residual stress measurement

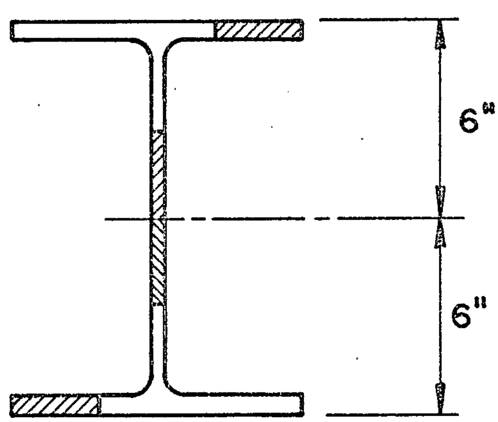

Fig. 2 - Location of tensile coupons

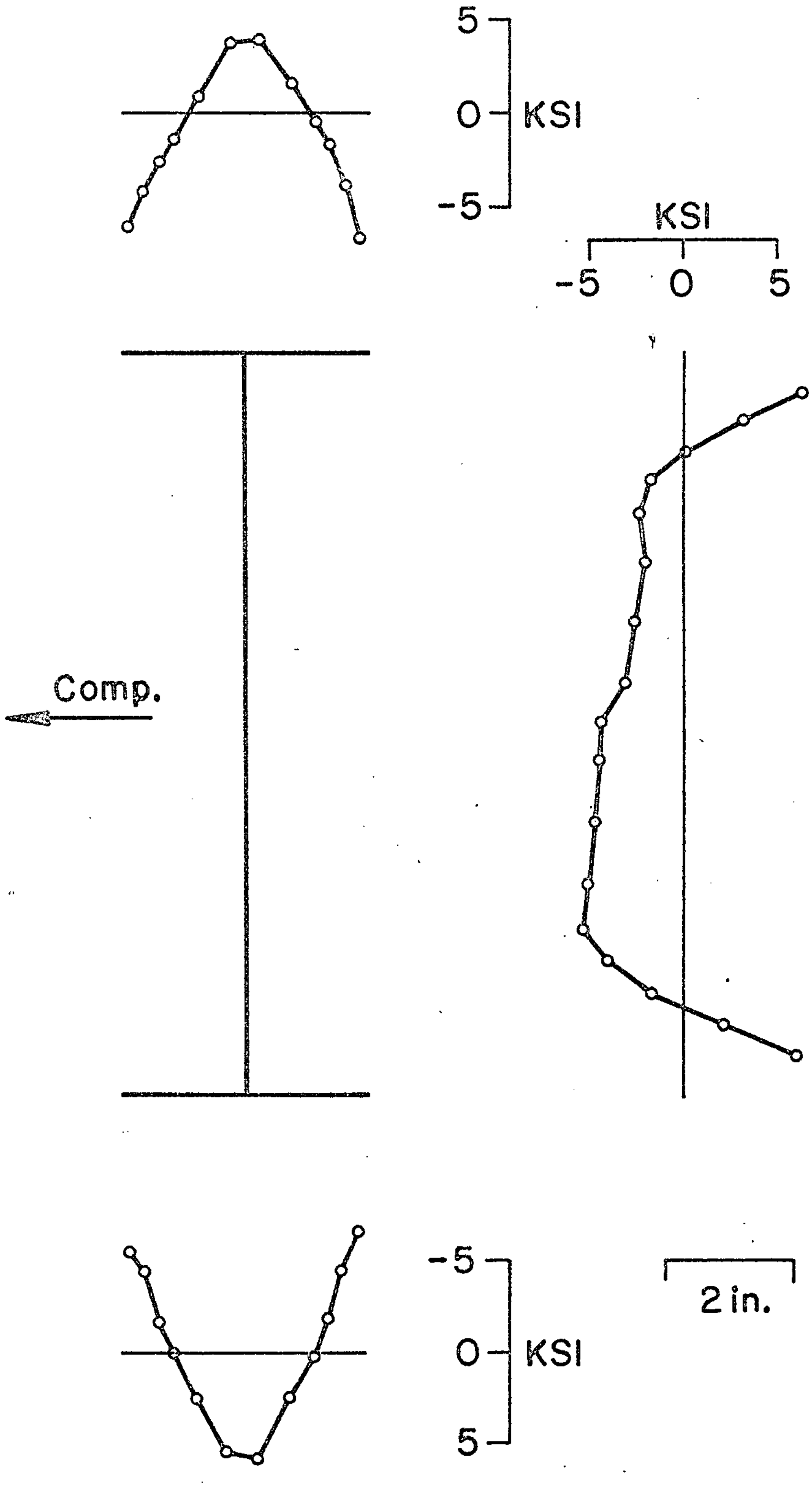

Fig. 3 - Residual stress distribution in 12 B 19 shape

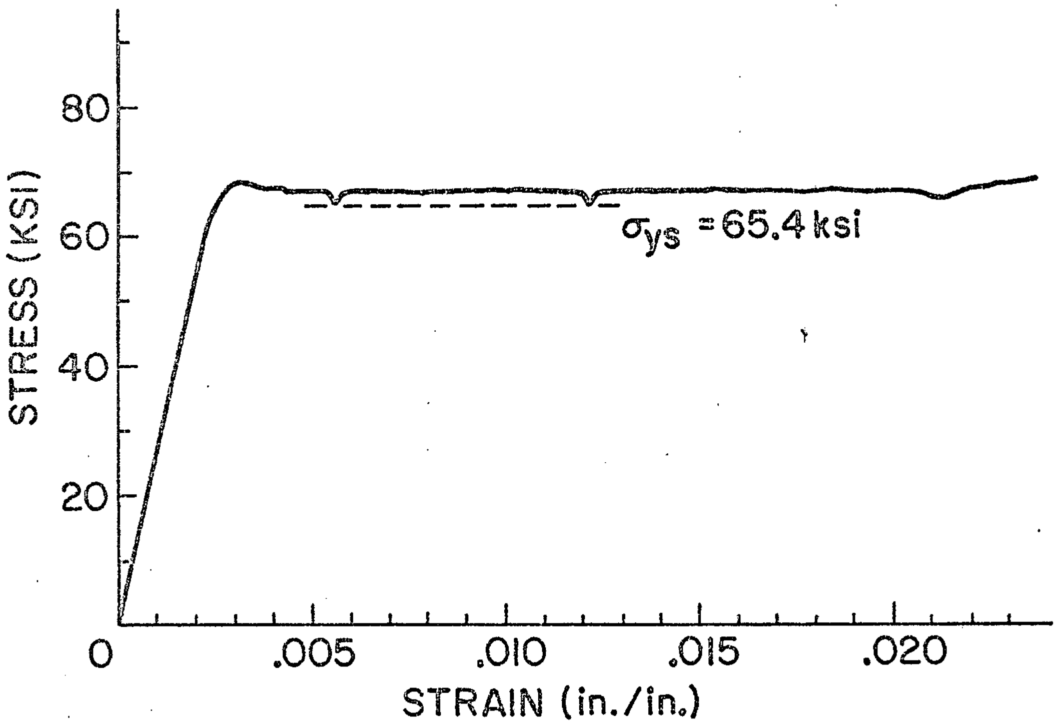

Fig. 4 - Stress-strain curve for coupon taken from the web

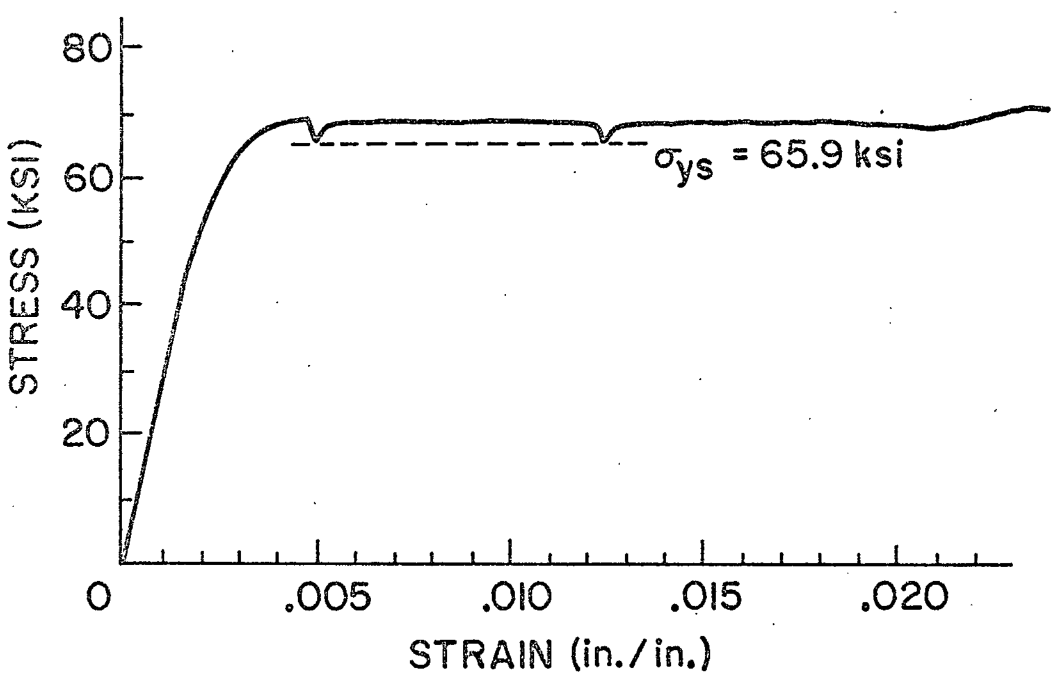

Fig. 5 - Stress-strain curve for coupon taken from the flange

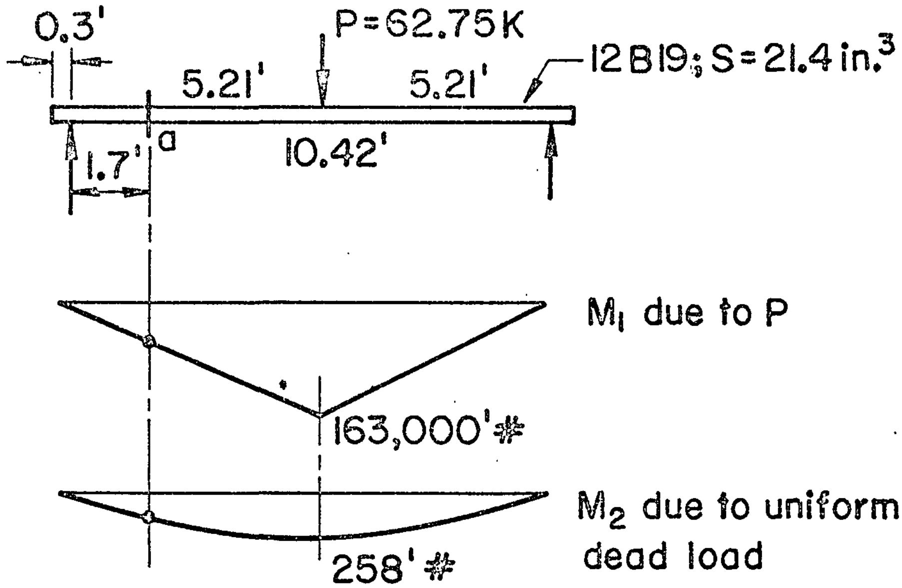

Fig. 6

$$M_{1m} = \frac{PL}{4} = \frac{62,750 \times 10.42}{4} = 163,000 \text{ 'lb}$$

$$M_{2m} = \frac{1}{8} wL^2 = \frac{1}{8} \times 19 \times \overline{10.42}^2 = 258 \text{ 'lb}$$

at section a:

$$M_{a1} = \frac{1.7}{5.21} \times 163,000 = 53,300 \text{ 'lb}$$

$$M_{a2} = 258 - \frac{\overline{3.51}^2}{\overline{5.21}^2} \times 258 = 258\ (1-0.454) = 141 \text{ 'lb}$$

$$M_{aT} = 53,300 + 141 = 53,441 \text{ 'lb}$$

$$fa = \frac{M_a}{S} = \frac{53,441}{21.4} \times 12 = 30,000 \text{ psi}$$

IX. REFERENCES

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