

APPENDIX D

GUIDELINES FOR TENSION TESTING OF ROLLED SHAPES USED IN SAC TESTING PROGRAM

Introduction

The purpose of performing the tensile tests of the sections used in the SAC Phase 2 testing program is to provide consistent material strength data which will allow the structural performance of the sections relative to their steel strength to be determined. A mill test report should be obtained for each section used in the test program. A copy of the mill test report and the tension tests done as outlined in this guide should be sent to Karl H. Frank and James O. Malley for distribution to the other investigators.

The purpose of this document is to supplement and modify the requirements of ASTM Specifications A6 and A370. It is assumed that the reader has read and has available a copy of these specifications.

Test Machine and Instrumentation

The test machine should have been calibrated within one year of the test date. A complete or near complete stress strain curve shall be plotted for each specimen. This can be done using the instrumentation on the test machine, i.e. autographic recorder, or from data gathered using an electronic system. If an autographic recorder is used, the resulting plot should be scanned or otherwise converted into a digital format so the stress-strain data can be analyzed by others. The paper used in the extensometer should be selected to insure that the plot of the test results can be successfully scanned. Ordinary graph paper will produce too many grid lines in the scanned data. Normally the range of the extensometer is not large enough to measure the strain at fracture, particularly for the 8 in. gage length plate specimens. An extensometer capable of measuring to at least the initial portion of the strain hardening curve should be used.

The test machine should preferably be a screw type or closed loop machine operated under displacement control in order to obtain the static yield strength of the steel. The static yield strength is the yield strength under the condition of zero strain rate. A closed loop machine under load control cannot be used. An open loop hydraulic machine can be used if the valves and seals are in good condition.

Specimen Types

The preferred specimen type is the 8 in. gage length plate-type 1-1/2 in. wide specimen shown in Fig. 3 of ASTM A370. The sheet and sub-size specimen shown in the figure should not be used. The 1/2 in. round standard specimen shown in Fig. 4 of ASTM A370 should be used if the plate-type specimen strength exceeds the capacity of the testing machine or the material thickness exceeds 4 in. The type of specimen employed should be noted with the test results.

Specimen Location and Orientation

Two test specimens shall be taken from both the web and flange of the shape. The specimens are to be longitudinal specimens with the lengthwise axis of the specimen parallel to the direction of greatest extension of the steel during rolling. The edge of web specimens shall be at least 2 in. from the "k" line of the section. The flange specimens shall be taken from the flat portion of the flange away from the web to flange fillet. If the 1/2 in. round specimen is employed, its longitudinal axis should be located as near as possible to 1/4 of the thickness of the material from the surface.

Specimen Preparation

1. Measure the width and thickness or diameter at three locations along the reduced section of the specimen and record.
2. Lay out two points either 8 or 2 in. apart along the axis of the specimen centered on the reduced section. Using a center punch, punch two small indentations on the specimen. Measure the distance between the two punch marks to the nearest 0.01 in. and record. After completion of the test, the fractured specimen shall be fitted together and the length between the marks measured. The difference between the two measurements divided by the original length is the percent elongation of the specimen.

Insertion of Specimen Into Test Machine

1. The specimen should be inserted into the top cross head and the wedge grips tightened lightly. The specimen should then be checked to insure it is aligned in the machine using a level on the machined edge of the specimen.
2. The machine load-measuring system should be zeroed at this time before the other end of the specimen is gripped.
3. The lower grips should be tightened after the machine is zeroed on the proper scale.

Testing Speed

The maximum stress and strain rate limits given in ASTM A370 paragraphs 11.4.1-11.4.3 do not correlate with one another. In order to provide a test method which can be defined for both a screw type, a closed loop displacement controlled, and a hydraulic machine, a stress rate was selected to define the loading rate of the specimen. The stress or strain rate influences the value of the material strength. A faster strain rate will yield larger strength values, and conversely, slower rates of testing will produce lower values. The actual strain rate used in the coupon tests should be the same strain rate employed in the component test. However to provide a consistent testing method for all investigators and to eliminate the need for measurement of cross head displacement, an elastic loading rate of 50 ksi per minute is to be used until after strain hardening. The rate shall be measured and any adjustments made during the initial elastic loading of the specimen.

The strain or loading rates employed in the test should match the values used in the component test. This would allow the component results to be normalized by the strength values corresponding to the component loading rates. This is a difficult task unless static values are obtained in the component tests. Since the loading rate will vary for each component test and also vary during the test of a component, the measured yield strength at the 50 ksi per minute stress rate shall be used to normalize the results. The dynamic yield stress found using the 0.002 offset method, not the yield point, recorded at this stress rate shall be used to calculate the value of M_p or M_y reported in the component tests. The measured yield strength of the web and flange should be used to calculate the plastic force in the web and flange, respectively, when calculating M_p .

The lowest strength value which is relatively independent of test machine is the static strength. The static strength is measured by stopping the straining of the specimen and holding the strain for approximately 3 minutes. The test method is described in Ref. 3 and depicted in Fig. D-1. If the hold times used for the loading stages of the component are less than 3 minutes, the load at the component hold time as well as the 3 minute value should be recorded. Hydraulic testing machines may not be capable of holding the strain or cross head displacement at a fixed level. Leakage at the seals of loading cylinder will cause the load to reduce and produce an apparent

static value less than the actual. The strain during the hold period should be monitored to ensure that the strain is not changing due to elastic unloading of the specimen. The static yield strength shall be measured three times as shown schematically in Fig. D-2.

The loading rate is normally sped up after the onset of strain hardening. The maximum rate of 1/2 inch per minute per inch of reduced section given in ASTM A370 sect. 11.4.1 should not be exceeded. For the 8 in. gage length plate specimen, this maximum is 4.5 inches per minute. The tensile strength of the steel is also a function of the strain rate. A static value should be measured if the tensile strength of the material is an important parameter in the determination of the connection strength. Bolted connections are an example of a connection where the tensile strength is important. The material's tensile strength determines the net section capacity of the section as well as the bearing strength of the material.

Strain Hardening Modulus and Strain at Strain Hardening

The strain at strain hardening and the strain hardening modulus should be determined as shown in the attached figure which is from Ref. 4. Three methods to measure and define the strain hardening properties of the steel are presented in the reference. The method selected for this investigation is method 2. The strain hardening modulus, E_{st} , is calculated as the arc tangent of the line passing through the points 0.003 and 0.010 strain beyond the center of the dip at the onset of strain hardening. The value of ϵ_{st} is the intersection of this line with the yield plateau.

Test Values To Be Reported

The following values are to be reported for each coupon test.

1. The upper yield point if any.
2. The dynamic yield stress at 0.002 offset.
3. The static yield stress values (3).
4. The strain at strain hardening.
5. Strain hardening modulus.
6. The tensile strength both static and dynamic.
7. The percent elongation.
8. The loading rate used in the test.
9. The type and location of the specimen with respect to steel section.
10. Type and manufacture of test machine.
11. Mill test report.

References

1. ASTM Specification A6 "General Requirements for Rolled Steel Plates, Shapes, Sheet Piling, and Bars for Structural Use".
2. ASTM Specification A370 "Standard Test Methods and Definitions for Mechanical Testing of Steel Products".
3. "Guide to Stability Design Criteria for Metal Structures, 4th Edition", John Wiley & Sons, page 744, B.7 SSRC Technical Memorandum No. 7: Tension Testing.
4. ASCE Manual No. 41 "Commentary on Plastic Design in Steel".

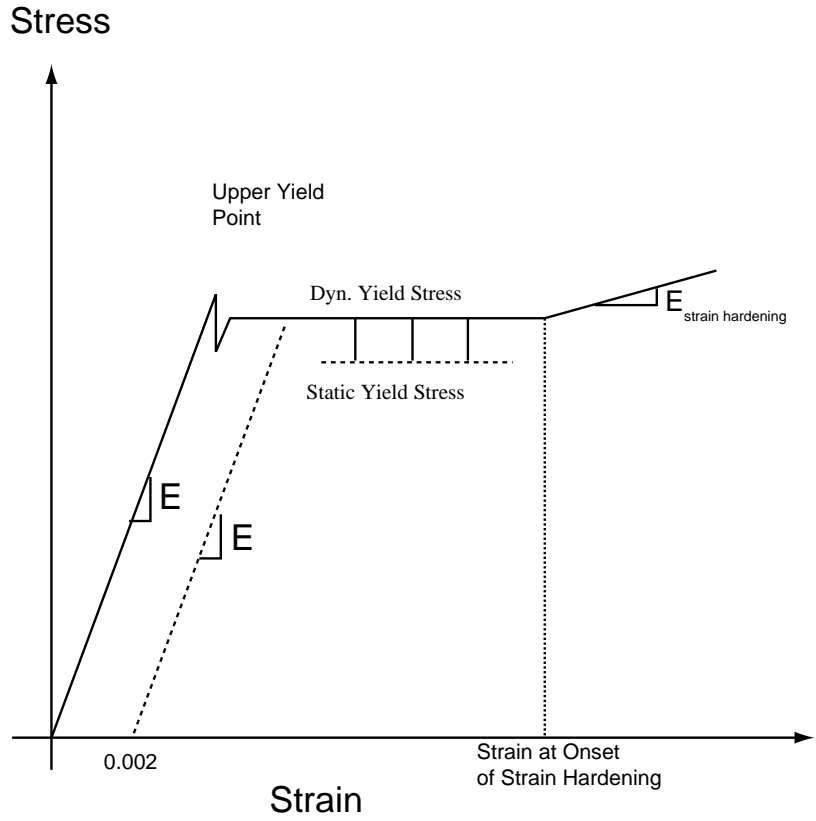


Figure D-1. Definition of Terms

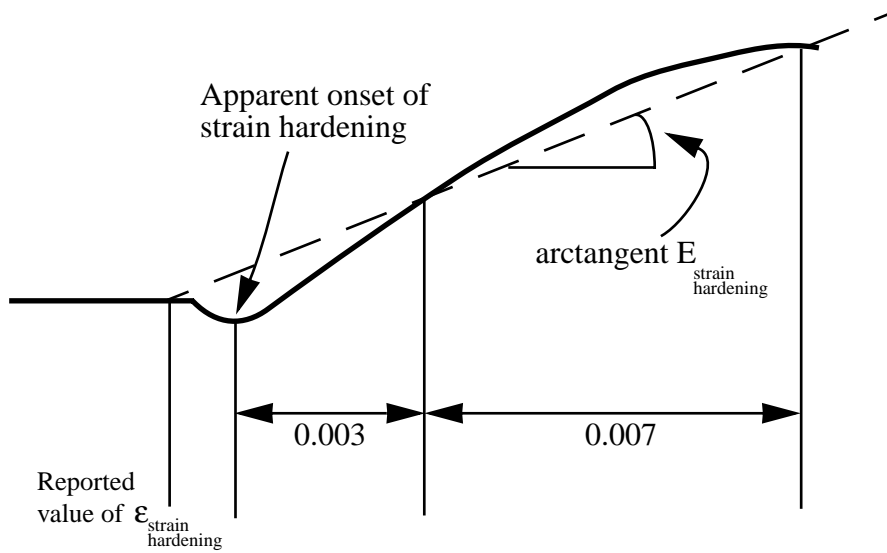


Figure D-2. Strain Hardening Modulus Determination