Residual Stress and the Compression Properties of Steel

Memorandum

COUPON TESTING

by

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A. TENSION COUPONS

1. DIMENSIONS (see ASTM: A370-55T, (p. 338)

2. ALIGNMENT

Usually a geometrical alignment by eye is satisfactory. For exact alignment reference is made to the procedure for compression tests and may be applied with minor modifications to tension tests.

3. TESTING PROCEDURES (see ASTM: A370-55T)

4. TESTING SPEED

(a) ASTM (A370 - 54T) - Material Acceptance Test

Any convenient speed of testing may be used up to one-half the specified yield point. When this point is reached, the rate of separation of the cross-heads shall not exceed 1/16 in. per minute per inch of gage length maintained through the yield strength. Likewise, such crosshead speed shall not exceed 1/16 in. per minute per inch of gage length. (Cross head speed may be set at free running to above specified values.)

As an alternate, the rate of stressing shall not exceed 100,000 psi per minute. (Ed. note: This corresponds to about 57 microinches/inch/sec.)

(b) Simulated Mill Tests

The object is to simulate the tension tests as done in steel mill laboratories which follow the procedures listed in (a). At the Bethlehem Steel Laboratory in Bethlehem, Pa., it was observed that the tests were made at about 30 to 50 microinches/inch/sec. (see Fig. B)

(c) "Fritz Lab speed"

Any convenient strain rate may be taken in the elastic range as long as it is smaller than the allowable testing speed by ASTM standards. The elastic rate of loading that corresponds to a given elastic strain rate for a coupon of given area may be conveniently obtained from Figures A and B. The following values should be recorded which are needed for a statistical collection of data:
1. The yield point corresponding to the chosen elastic strain rate.

2. Measurement of the plastic strain rate with unchanged valve opening.

3. The "static" value of the yield point. (Head of the testing machine stationary—strain rate equal to zero. On hydraulic machine use dial gage to check that head is stationary.)

Figure C shows a plot of the yield point ratios corresponding to a given plastic strain rate and zero strain rate versus plastic strain rate for which additional data is needed.
B. COMPRESSION COUPONS

1. DIMENSIONS (see CRC Tech. Memo #2 Draft, May 20, 1954)

\[
\begin{align*}
&b > t \quad \text{(1)} \\
&L \leq 4.5t \quad \text{(2)} \\
&L \geq 2b + t \quad \text{(3)} \\
&b < g < 2b \quad \text{(4)}
\end{align*}
\]

Fig. 1 is a plot of $L$ vs. $t$ for eq. (2) as upper limit for $L$. With the same horizontal scale for both $b$ and $t$, in Figs. 1 and 2 the lower limit for $b$ is determined per eq. (1).

In Fig. 2 is a plot of $g$ vs. $b$ with their limits as per eq. (4). Likewise, with $L$ as parameter eq. (3) is shown.

Sample procedure for dimension coupons:

Given: $t = 0.667''$

From Fig. (1) obtain $L_{\text{max}} = 3.0$, a vertical line through this point gives $b_{\text{min}}$.

Proceeding to Fig. (2), $L = 3.0$ defines another upper limit. For the given $t = 0.667$, the hatched area yields any point desired. Usually, a desired $g$ is on hand thus reducing the working "area" to a line ($g = 1.0$ for instance--see sketch)

Thus, $0.667 < b < 1.0$

$2.35 \leq L \leq 3.0$

2. SPEED OF TESTING

For strain rate see under tension coupons.

3. ALIGNMENT

(a) The initial load should be at least 5% of the estimated yield load.

(b) The maximum alignment load should not exceed about $1/3$ of the estimated yield load.

(c) Strains should be measured on at least two opposite sites which are critical in respect to buckling. Insertion of paper-thin foils between specimen and bearing plates gives a good qualitative picture of end bearing. This is especially necessary if strains are measured only at two sides.

(d) At the maximum alignment load no strain should
vary more than ±5% from the average strain of all gages.

(e) Corrections for the out of squareness of the specimen is best made by using a set of leveling discs together with a level.

Reference is also made to CRC Tech. Memo #2 and 220A.9 which give a detailed description of compression coupon testing.
STRAIN RATE COUPON TESTING

\[ E = 30 \times 10^6 \text{ psi} \]

Fig. A
$E = 30 \times 10^6$ psi

$\dot{\varepsilon} =$ Strain Rate

$\circ =$ Measurements

$\odot =$ No Change in Speed in Elastic Range

Fig. B
NOMOGRAPH FOR DIMENSIONS OF COMPRESSION COUPON SPECIMENS

Fig. 1

$L = 4.5t$

$L_{\text{max}} = 3.0$

Given $t$

Thickness $2.0$ (in.)

Gage Length

Available Range

Lower Limit of $L$

Upper Limit of $L$

Determined Range of $L$ & $b$

Fig. 2

$g = b$

$L = 5$

$L = 4$

$L = 3$

$L = 2$

$L = 1$

$g = 1.0$

$g$

Given $g$

$0.667$ Breadth $1.0$

$2.0$ (in.)

$0.667$ Breadth $1.0$

$2.0$ (in.)