**CROSS-SECTION TEST**

by

A. W. Huber

1. **OBJECT**
   
   a. To find the compressive strength of the section.
   
   b. To get data for plotting column curves.

   Important Limitation: symmetry of residual stresses.

2. **PREPARATIONS**
   
   a. **Selection**
      
      Choose section at least a distance equal to the depth away from end of flame-cut sections. Piece must be clear from cold-bending yield lines.

   b. **Required Length L**
      
      Minimum: 2d + 10" or 3d
      
      where: d depth of section
      
      Maximum: 20ry or 5d
      
      where: ry radius of gyration at y-y axis

   c. **Mill Ends of Cross-Section Flat**
   
   d. **Measurement of Area**

   In accordance with 205 Manual:
   
   1. measure of thickness of flanges and webs, also obtain one good print of the section.
   
   2. obtain area from weight of cross-section.
   
   e. **Type of Gages and Their Placing**

      Principally gages which are to measure the average strains in the cross-section should be placed at locations where the material is under residual tension. Thus for most WF section the flange centers will be appropriate for gage locations.

      Types: SR-4 gages A-9 (6" gage length)

      \[
      \frac{1}{10,000} \text{ dial gages with proper fixtures}
      \]

      convenient gage length 10".
All gages should be placed at the center of the section. At least two gages should be placed at different locations (for instance, at the two flange centers). For greater dependability of the data it is advisable to have both an SR-4 and a mechanical gage at the same location. Sketched below are a few typical gage arrangements.

For alignment place SR-4 gages at the four corners. Whitewash specimen before the test.

f. Set-up in Testing Machine

The ends of the cross-section specimen should rest against flat bearing plates. The top plate or plates should be thick enough to ensure a nearly uniform stress distribution. Between the head of the testing machine and top bearing plate a special bevelled bearing plate should be used. By rotating one of the bevelled faces against the other, alignment is achieved.

A less satisfactory alternate is to use a spherical bearing of sufficient size. After alignment rotation should be prevented by inserting wedges. Fig. 1 shows a typical test set-up.
3. TESTING PROCEDURES

a. Alignment Test

Good alignment is essential. It should be made up to 1/3 of the predicted yield load \( P_Y = \frac{A}{\sigma_Y} \) or 1/2 of estimated first yield load \( P_p = (\sigma_Y - \sigma_R)A \). The variation of individual strains at the four corners should be less than 5% from their average at the maximum alignment load.

Important: Alignment at very low loads only is unsatisfactory. Proper working of all gages should also be checked.

b. Actual Test

Choice of load increments: 1/10 of predicted first yield load up to that load then successive reduction in load increments, best obtained from a graph plotted during the test. It is very important to have sufficient points (at least five) in the "knee" of the stress-strain diagram.

Initial yield will be evident by the development of yield lines (made clearly visible by the whitewash) and beginning deviation of the stress-strain curve from linear behavior. Record the corresponding load. The first yield lines (apart from lines that develop at the ends due to certain non-uniformity of stresses) should be consistent with residual stress pattern.

The procedure of obtaining the readings after yielding has started will depend on the type of testing machine used. Load and strain must both stabilize. A suggested criterion is a change in load of less than 1% and a change in strains of less than 5% in the time period required to take the readings.
After the maximum load has been reached readings can be taken at larger strain intervals and should be continued until the carrying capacity is reduced due to local buckling.

Note: A reduction not exceeding 5% of maximum load may be observed at larger strains before local buckling.
Straining should be continued to about 3/4 of maximum load unless damage to equipment or undesirable deformation pattern is produced.

4. EVALUATION OF DATA

The data must be evaluated before column curves can be drawn. A convenient procedure is the following:
   a. Plot all load-strain data to a large scale.
   b. Determine the slopes from this curve by the "mirror technique" (i.e. normals to the curve can be determined fairly accurately by the image of the curve in a mirror strip being lined up with the exterior of the curve).
   c. Using the measured area $\sigma$, $E$, and $E_t$ can be determined.
   d. Plot a stress-tangent modulus graph for all gages. This graph will be an indication of the reliability of the data. If the difference between the individual curves is small, use one average curve, otherwise also include the maximum and minimum curve.
e. Calculations as outlined in the Final Report of the Pilot Program (220A.9) may now proceed.* Warning: Formulas in that report apply only for one definite sequence of yielding (flange-edges and flange first, web last). For other sequences similar formulas can be quickly obtained and applied if the residual stresses can be assumed to be symmetrical.