11.2 Tension Test of Steel Reinforcing Bar

11.2.1 Scope

The tension test relates to the mechanical testing of steel products subjects a machined or full-section specimen of the material under examination to a measured load sufficient to cause rupture. These test methods cover the tension testing of metallic materials in any form at room temperature, specifically, the methods of determination of yield strength, yield point elongation and tensile strength.

*Note.* Room temperature shall be considered to be 10 °C to 38 °C unless otherwise specified.

11.2.2 Apparatus

a) Testing machine: Universal compression / tension machine motorised. Capacity minimum 100-kN for compression and 500 kN for tension, 220-240V, 50 Hz, 1 phase. Suitable for tension testing of reinforcing base up to 25 mm diameter. All accessories for tension testing including universal grip holders to be included during procurement of the machine.

b) Gripping devices

*General:* Various types of gripping devices may be used to transmit the measured load applied by the testing machine to the test specimens. To ensure axial tensile stress within the gauge length, the axis of the test specimen should coincide with the centre line of the heads of the testing machine.

*Loading:* It is the function of the gripping or holding device of the testing machine to transmit the load from the heads of the machine to the specimen under test. The essential requirement is that the load shall be transmitted axially. This implies that the centres of the action of the grips shall be in alignment, in so far as practicable, with the axis of the specimen at the beginning and during the test, and that bending or twisting be held to a minimum. Gripping of the specimen shall be restricted to the section outside the gauge length.

*Wedge Grips:* Testing machines usually are equipped with wedge grips. These wedge grips generally furnish a satisfactory means of gripping long specimens of ductile metal. For proper gripping, it is desirable that the entire length of the serrated face of each wedge be in contact with the specimen.

c) Other Apparatus

i) *Double Pointed Centre Punch or Scribe Marks:* For marking of round specimen.

ii) *Special Scale:* For direct reading of % elongation (for particular gauge length) special pointed scale may be used. Minimum division of 0.5% is sufficient for this purpose.

iii) *Extensometer:* Extensometer with gauge length equal to or shorter than the nominal gauge length of the specimen is used to determine the yield phenomenon.

iv) *Slide calipers.*
11.2.3 Speed of testing

1) Rate of straining: The allowable limits for rate of straining shall be specified in meters per meter per second. Some testing machines are equipped with pacing or indicating devices for the measurement and control of rate of straining, but in the absence of such a device the average rate of straining can be determined with a timing device by observing the time required to effect a known increment of strain.

2) Rate of stressing: The allowable limits for rate of stressing shall be specified in MPa per second. Many testing machines are equipped with pacing or indicating devices for the measurement and control of the rate of stressing, but in the absence of such a device the average rate of stressing shall be determined with a timing device by observing the time required to apply a known increment of stress.

Note. Speed of testing can affect test values because of the rate sensitivity of materials and the temperature-time effects.

3) Elapsed time: The allowable limits for the elapsed time from the beginning of force application (or from some specified stress) to the instant of fracture, to the maximum force, or to some other stated stress, shall be specified in minutes or seconds. The elapsed time can be determined with timing device.

4) When determining yield properties: Unless otherwise specified, any convenient speed of testing may be used up to one half the specified yield strength or yield point, or up to one quarter the specified tensile or ultimate strength, whichever is smaller. The speed above this point shall be within the limits specified. If different speed limitations are required for use in determining yield strength, yield point, tensile strength, elongation, and reduction of cross-sectional area they should be stated in the product specifications. In the absence of any specified limitations on speed of testing the following general rules apply.

   a) The speed of testing shall be such that the loads and strains used in obtaining the test results are accurately indicated.
   b) During the conduct of the test to determine yield strength or yield point, the rate of stress application shall not exceed 12 MPa/sec.

5) When determining tensile strength: After the yield strength point has been determined, the speed may be increased to correspond to a maximum strain rate of 0.01 m/m/s. The extensometer and strain rate indicator may be used to set the strain rate prior to its removal. If the extensometer and strain rate indicator are not used to set this strain rate, the speed should be set not to exceed 0.01 m/m of the length of the reduced section (or distance between the grips for specimens not having reduced sections) per second.

11.2.4 Gauge length, marking.

The gauge should be five times the diameter (unless otherwise specified). Round specimens are gauge marked with a double pointed centre punch or scribe marks. The gauge points shall be approximately equidistant from the centre of the length of section.
11.2.5 Test procedure

a) Measure the diameter of the specimen by the weight method described in section 11.1.3 or by slide calipers.
b) Record extensometer constant and gage length.
c) Fix the specimen at the centre of the properly placed grip of the machine.
d) Fix the extensometer with the specimen.
e) After completion of all arrangements as per requirement (described earlier) and setting the speed of machine, etc. switch the machine on. Load is increased gradually until the specimen fails by tensile force.

Note. If any test specimen fails because of mechanical reasons such as failure of testing equipment or improper specimen preparation, it may be discarded and another specimen taken.

f) Then determine the yield and ultimate strength and elongation etc. Methods of determination of these tensile properties are described in section 11.2.6.

11.2.6 Determination of tensile properties

11.2.6.1 Yield Point: Yield point is the first stress in a material, less than the maximum obtainable stress, at which an increase in strain occurs without an increase in stress as shown in Figure 11.2.2. Yield point is intended for application only for materials that may exhibit the unique characteristic of showing an increase in strain without an increase in stress. For this type of material, the stress-strain diagram is characterised by a sharp knee or discontinuity. Yield point can be determined as described below.

a) ‘Drop of the Beam’ or ‘Halt of the Pointer Method (method commonly used):’

In this method apply an increasing load to the specimen at a uniform rate. When a lever and poise machine is used, keep the beam in balance by running out the poise at approximately steady rate. When the yield point of the material is reached, the increase of the load will stop. However, run the poise a trifle beyond the balance position, and the beam of the machine will drop for a brief but at appreciable interval of time. When a machine equipped with a load-indicating dial
is used, there is a halt or hesitation of the load-indicating pointer corresponding to the drop of the beam. Note the load at the “drop of the beam” or the “half of the pointer” and record the corresponding stress as the yield point.

b) Autographic Diagram Method (alternative to 11.2.6.1(a) if such device is available):

When a sharp-kneed stress-strain diagram is obtained by an autographic recording device, take the stress corresponding to the top of the knee, or the stress at which the curve drops as the yield point.

11.2.6.2 Yield Strength: Yield strength is the stress at which a material exhibits a specified limiting deviation from the proportionality of stress to strain. This is shown in Figure 11.2.2. In a simplified way the stress corresponding to the yield-point may be taken as the ‘Yield-Strength’. In the ‘Halt of the Pointer’ method or when the stress-stress diagram is not available, the ‘Yield-Strength’ is calculated by dividing the load at yield-point by the original cross-sectional area.

11.2.6.3 Tensile/Ultimate Strength: The stress corresponding to the maximum point of the stress-strain diagram is the ‘Tensile Strength’ or ‘Ultimate Strength’. This is shown in Figure 11.2.2. When the stress-strain diagram is not available; calculate the ‘Tensile Strength’ or ‘Ultimate Strength’ by dividing the maximum load the specimen sustains during a tension test by the original cross-sectional area of the specimen.

11.2.6.4 Elongation

a) Fit the ends of the fractured specimen carefully and measure the distance between the gauge marks to nearest 0.25 mm (0.01 in.) for gauge lengths of 50 mm and under, and to the nearest 0.5 percent of the gage length for lengths over 50 mm. A percentage scale reading to 0.5 percent of the gauge length may be used. The elongation is the increase in length of the gauge length, expressed as a percentage of the original gage length. In reporting elongation values, give both the percentage increase and the original gauge length.

b) If any part of the fracture takes place outside of the middle half of the gage length, the elongation value obtained may not be representative of the material. If
the elongation so measured meets the minimum requirements specified, no further testing is indicated, but if the elongation is less than the minimum requirements, discard the test and retest.

11.2.7 **Rounding of test data**

In the absence of a specified procedure for rounding the test data, it is recommended to use the Table 11.2.1 for rounding the test result.

**Table 11.2.1 Recommended Values for Rounding Test Data**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Rounded Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield/Ultimate Strength</td>
<td>0 to &lt;500 MPa</td>
<td>1 MPa</td>
</tr>
<tr>
<td></td>
<td>500 to &lt;1000 MPa</td>
<td>5 MPa</td>
</tr>
<tr>
<td></td>
<td>≥ 1000 MPa</td>
<td>10 MPa</td>
</tr>
<tr>
<td>Elongation</td>
<td>0 to &lt;10%</td>
<td>0.5 %</td>
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<tr>
<td></td>
<td>≥ 10%</td>
<td>1%</td>
</tr>
</tbody>
</table>

**Note.** Round test data to the nearest integral multiple of the values in this table. If the data value is exactly midway between two rounded values, round to the higher value.

11.2.8 **Replacement of specimens**

A test specimen may be discarded and a replacement specimen selected from the same lot of material in the following cases:

a) the original specimen had a poor surface  
b) the original specimen had the wrong dimensions  
c) the test procedure was incorrect  
d) the fracture was outside the gage length  
e) for elongation determinations, the fracture was outside the middle half of the gage length, or  
f) there was a malfunction of the testing equipment

An example data sheet is given as Form 11.2.1.

11.2.9 **Report**

Test information to be reported shall include the following when applicable:

1) Material and sample identification  
2) Yield strength  
3) Yield point  
4) Tensile strength  
5) Elongation (report both the original gage length and the percentage increase).
<table>
<thead>
<tr>
<th>Test of Plain / Deformed M.S. Rod / Ribbed Cold Twisted Bars</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Nominal Diameter</th>
<th>Actual Diameter</th>
<th>Nominal Area Under Test</th>
<th>Unit Weight</th>
<th>Average Unit Weight</th>
<th>Yield or Proof Load</th>
<th>Yield or Proof Strength*</th>
<th>Average Yield or Proof Strength*</th>
<th>Ultimate Load</th>
<th>Ultimate Strength*</th>
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<th>Elongation %</th>
<th>Average Elongation %</th>
<th>Samples were sealed / unsealed</th>
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<th>Actual Diameter</th>
<th>Nominal Area Under Test</th>
<th>Unit Weight</th>
<th>Average Unit Weight</th>
<th>Yield or Proof Load</th>
<th>Yield or Proof Strength*</th>
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Countersigned by:  

Please see overleaf.