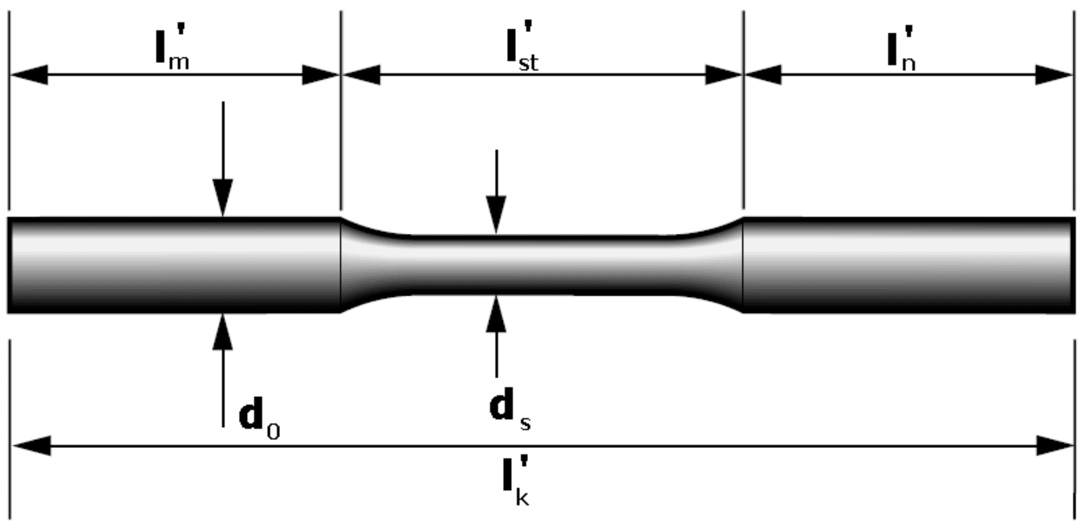
TENSILE TEST

d_0= 16.5mm F_0=213.825mm^2 (Calculations 1) l_0=160mm $\sigma=P/F_0$ $\varepsilon=\Delta l/l_0$

No	σ (N/mm²)	ε 10^{-4}	P (kgf)	P (N)
1	0	0	0	0
2	87.169414	5	1900	18639
3	192.69028	10	4200	41202
4	298.21115	15	6500	63765
5	348.67766	20	7600	74556
6	348.67766	25	7600	74556
7	348.67766	30	7600	74556

E=195311.714 (Modulus of Elasticity) (Calculations 6)
σ_p= 298 N/mm^2 σ_y= 349 N/mm^2 σ_u= 523 N/mm^2 σ_f= 395 N/mm^2
σ_p : Proportional stress, σ_y : Yield Stress,
(Calculations 4)
σ_u : Ultimate Stress, σ_f : Fracture Stress
(Calculations 5)

l'm= 36mm, l'n= 107.9mm, l'k= 200.2mm



ε_{u1}=0.2 ε_{u2}=0.1989 ε_u=0.1995 ε=0.25125 ε_{st}=0.05175
(Calculations 2)

Ψ (Reduction in Cross Section)=28.95% (Calculations 3)

Calculations:
1)

$$F_0 = \frac{\pi d_0^{\ 2}}{4}$$

$$= \frac{\pi (16.5)^2}{4} = 213.825mm^2$$

2)

$$\varepsilon_{u1} = \frac{l'_m - l_m}{l_m} = \frac{36-30}{30} = 0.2$$

$$\varepsilon_{u2} = \frac{l'_n - l_n}{l_n} = \frac{107.9-90}{90} = 0.1989$$

$$\varepsilon_u = \frac{(\varepsilon_{u1} - \varepsilon_{u2})}{2} = \frac{0.2+0.1989}{2} = 0.1995$$

$$\varepsilon = \frac{l'_k - l_k}{l_k} = \frac{200.2-160}{160} = 0.25125$$

$$\varepsilon_{st} = \varepsilon - \varepsilon_u = 0.05175$$

3)

$$\psi = \frac{A_0 - A_f}{A_0}$$

We will find out the final cross section, by the help of volume conservation in area st.

$$A_f * l'_{st} = A_0 * l_{st}$$

$$l'_{st} = 200.2 - (107.9 + 36) = 56.3$$

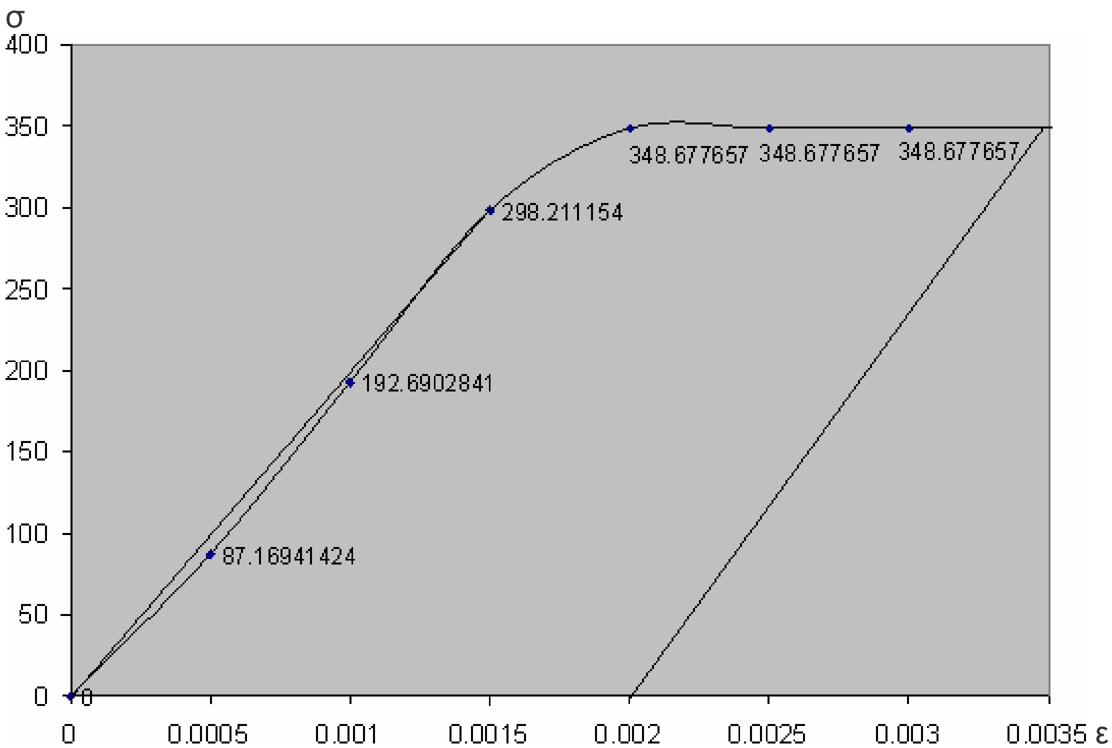
$$l_{st} = 160 - (90 + 30) = 40$$

$$A_f * 56.3 = A_0 * 40$$

$$A_f = \frac{40 A_0}{56.3}$$

$$\psi = 1 - \frac{A_f}{A_0} = 0.2895$$

4)
We will draw the Stress Strain Diagram up to ε=0.0035 to observe Proportional and yielding limit easier.



As we can see here the proportional limit is about 298N/mm^2, and yielding limit is about 349 N/mm^2.

5)
The force of σ_u (Ultimate Stress) is found 11400kg$_f$ in the lab experiment. We will find ultimate stress in N/mm^2.

$$\sigma_u = \frac{11400 \cdot 9.81}{F_0} = \frac{111834}{213.825} = 523.016$$

The force of σ_f (Fracture Stress) is found 8600kg$_f$ in the lab experiment. We will find fracture stress in N/mm^2.

$$\sigma_f = \frac{8600 \cdot 9.81}{F_0} = \frac{84366}{213.825} = 394.556$$

6)
$E = \frac{\sum \sigma_i \varepsilon_i}{\sum \varepsilon_i^2}$ We should use the straight-line portion of the stress strain diagram.

$$\sum \sigma_i \varepsilon_i = (87.169 * 0.0005) + (192.690 * 0.001) + (298.211 * 0.0015) = 0.683591$$

$$\sum \varepsilon_i^2 = (0.0005^2) + (0.001^2) + (0.0015^2) = 0.0000035$$

E=0.683591/0.0000035=195311.714

Procedures:

Specimen Apparatus Preparation:

We prepared 16.5mm in diameter, and 16cm long plain steel. Punched marks on the specimen at 1cm interval long. Also we prepared extensometer, and Hydraulic Tensile Testing machine.

Using Extensometer:

We attached the extensometer onto specimen, after that started the hydraulic testing machine. At the beginning the values of extensometer and hydraulic testing machine should be 0. After starting hydraulic machine the instructor read the values of extensometer at the same time the operator read the values of hydraulic testing machine. At a certain value of stress the hydraulic testing machine started to show same value, so we detached the extensometer.

Necking and Fracture:

We continued to use the hydraulic testing machine. At some time the specimen started necking. After some time of necking the specimen fractured at a point.

Measurements:

After the fracture of the specimen, the operator gave the values of Ultimate (Necking), and Fracture Force. We measured the necking and other parts of the specimen.

Definitions:

Engineering Stress, σ: The load divided by the initial cross-sectional area. Note that stress based on the initial cross-section decreases beyond the ultimate strength.
Elastic Limit, σ_a: Maximum stress for which stress will be directly proportional to strain. The end to the straight-line portion of the stress-strain curve. Equal to proportional limit.
Elastic Modulus (Modulus of Elesticity), E: The ratio of stress to strain for the initial straight-line portion of the stress-strain curve. Determined by:

$$E = \frac{\sum \sigma_i \varepsilon_i}{\sum \varepsilon_i^2}$$

Percent Reduction of Area (Reduction in Cross Section), Ψ: A measurement of the fracture ductility. Defined as:

$$\psi = \frac{A_0 - A_f}{A_0} * 100\%$$

Where:

A_o is the initial cross-sectional area

A_f is the final cross-sectional area at the location of fracture.

Values for Ψ range from near zero for brittle materials to high values (approaching 100%) for ductile materials which can neck severely at failure.
Proportional Limit (Stress), σ_p : Engineering stress at the point where the straight-line portion of the stress-strain curves ends. It is the limiting value for which the stresses and strains are proportional to one another. Some materials do not have a well-defined proportional limit and in many cases the value may vary with the judgment of the engineer and the precision of the scale of the graph. Equal to the elastic limit.
Ultimate Strength (Stress), σ_u: Highest engineering stress reached at any time during the test. Also known as the tensile (or compressive) strength.
Yielding Strength (Stress), σ_y: Engineering stress that causes a specified amount of permanent strain. The specified permanent strain is referred to as the offset or permanent set. The most commonly used offset is 0.002 in/in or 0.2%. The magnitude of the offset should be reported with the value of the yield strength. The method followed is to draw a line parallel to the initial slope of the stress-strain curve, but offset by a specified amount of strain. The point at which this line intersects the stress-strain curve is the yield point at the specified offset. Yield strength is a particularly useful measurement for materials with no definite proportional limit.

Stress - Strain Diagram