Steel Tensile Test: Reference Document: ASTM E8

1. Introduction:

The most common material in construction besides concrete is steel. Concrete, though it has a high compressive strength, its tensile strength is usually much lower and mounts up to 8 – 12 % of its compressive strength. Steel, therefore, is used in concrete structural elements to bare tensile loads and bending moments.

Figure 1: Plain Bars

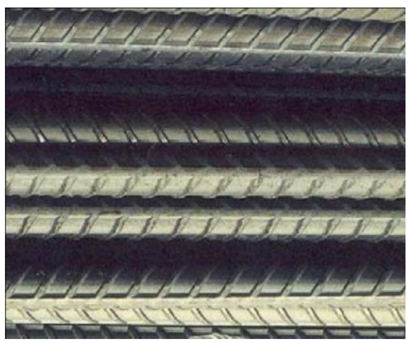


Figure 2: Deformed Bars

Figure 3:Plain & Deformed wires

The major components of steel are Iron and carbon which ranges between 0.01 and 1 percent. Sulfur, phosphorus, manganese, silicon and as much as 20 other alloys are present in steel and are added in various quantities to steel during its manufacturing process depending on the desired hardness, toughness and tensile strength of steel.

Reinforcing steel bars are usually manufactured in 3 different forms:

- Plain bars
- Deformed bars
- Plain & deformed wires

The deformation in deformed steel bars is intended to increase the bonding between steel and concrete and to prevent slippage of the steel reinforcement bars.

Steel reinforcement bars are produced mainly with four different yield strengths, shown in the table below. The grade of steel indicates its yield strength in Ksi.

Table 1: Reinforcement Steel Strength

Type	σ_{yield} (psi)	σ_{yield} (MPa)	Grade
Type1	40,000	300	40
Type 2	50,000	350	50
Type 3	60,000	400	60
Type 4	75,000	500	75

2. Objectives

The objective of this lab experiments is to incrementally load a steel bar till failure, while recording the value of the load and the change in length of the steel bar at each stage. Then based on the collected data, determine:

- Modulus of Elasticity of Steel, E_{steel} & Compare it to the theoretical value.
- Yield strength of Steel, σ_{yield}
- Ultimate strength of steel, $\sigma_{Ultimate}$
- Plot Stress Vs Strain Curve for steel

3. Definitions

- Yield Point: The Point at which an increase in strain occurs without an increase in the stress is defined as the yield point. Stress at this point is defined as the steel yield stress.[1]

4. Equipment

- Universal Testing Machine
- Dial Gauge / Extensometer

Figure 4: Univerisal Testing Machine

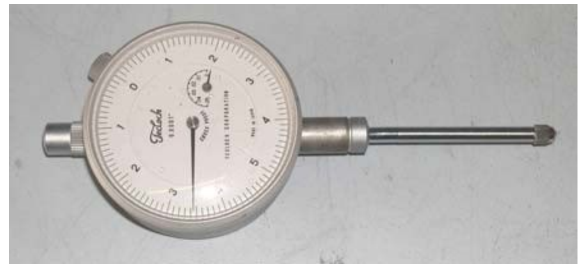


Figure 5: Dial Gauge

5. Procedure (should be written according to our machine)

1. Load a Steel bar into the machine, with a 6” length of steel between the testing machine clamps.
2. Mount the dial gauge and reset to Zero
3. Apply load with in stages, starting with 250 lb and with increments of 250 lb
4. At each load stage record the applied load and the Change in bar length (read from gauge).
5. Keep incrementing the load till failure.

P.s.: At failure notice the tip & cone failure mode of the steel bar.

6. Equations:

$$\sigma = \frac{P}{A} \qquad \varepsilon = \frac{\delta}{L} \qquad E = \frac{\sigma}{\varepsilon} = \frac{\Delta\sigma}{\Delta\varepsilon} \qquad A = \frac{\pi d^2}{4} \qquad L = 6''$$

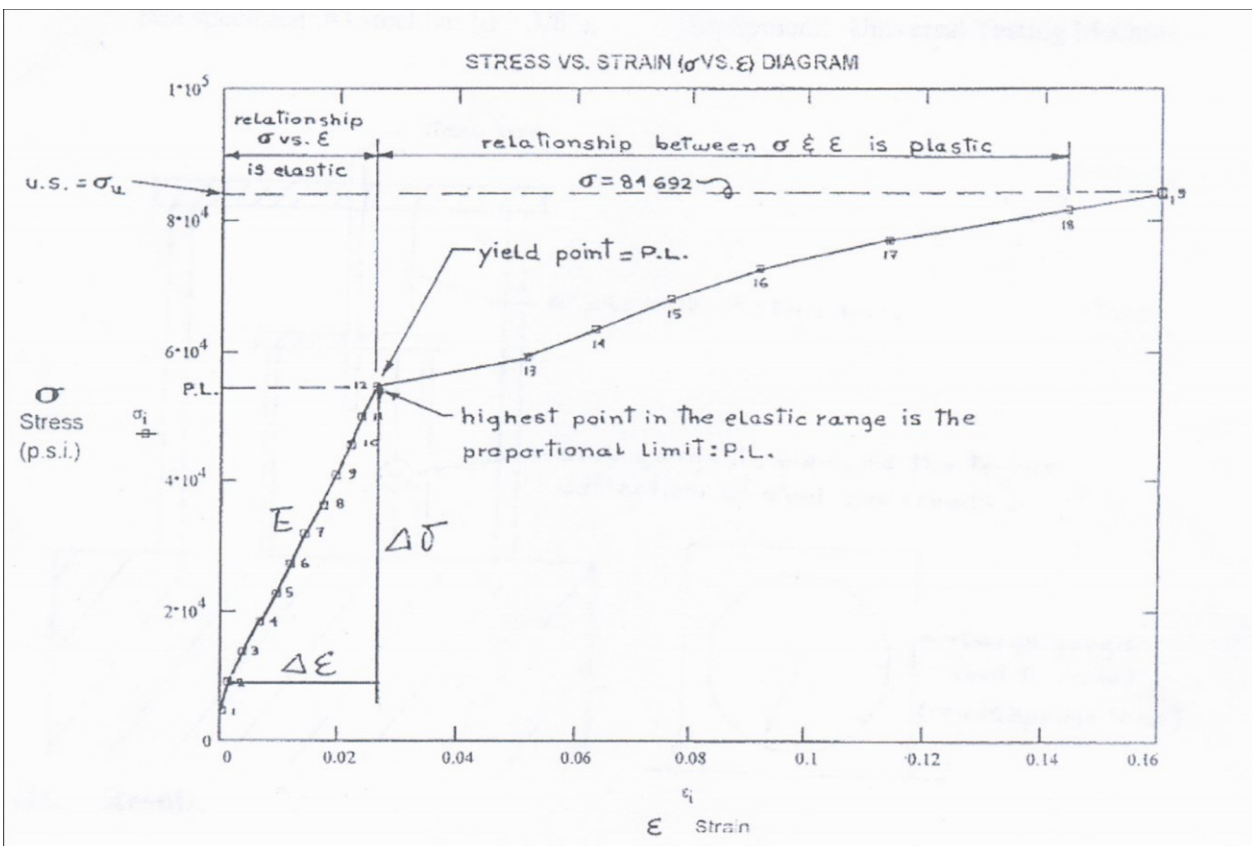
$$E_{Experimental} = \frac{\Delta\sigma}{\Delta\varepsilon}(Slope) \qquad or \qquad E_{Experimental} = E_{ave}$$

$$E_{ave} = \frac{E_1 + E_2 + E_3 + \ldots\ldots\ldots + E_m}{m}$$

$$E_{Theoretical,Steel} = 29\,x10^6\ psi$$

$$\%\ Error = \frac{\left|E_{Experimental} - E_{Theoretical}\right|}{E_{Theoretical}}\ x100\%$$

7. Typical Stress – Strain Curve



8. Calculation Sheet

P (lb)	δ (in)	σ (psi)	ε	E (psi)
250	δ_1	σ_1	ε_1	E_1
500	δ_2	σ_2	ε_2	E_2
750	δ_3	σ_3	ε_3	E_3
….	….	….	….	….
….	….	….	….	….
….	….	….	….	….
….	….	….	….	….
P_m	δ_m	(PL) σ_m	ε_m	E_m
….	….	….	….	N/A
….	….	….	….	N/A
….	….	….	….	N/A
P_{n-1}	δ_{n-1}	σ_{n-1}	ε_{n-1}	N/A
P_n (P_{max})	N/A	σ_n (σ_{max})	N/A	N/A

9. Discussion

Possible source of error: Slipping of the steel at the testing machine grips

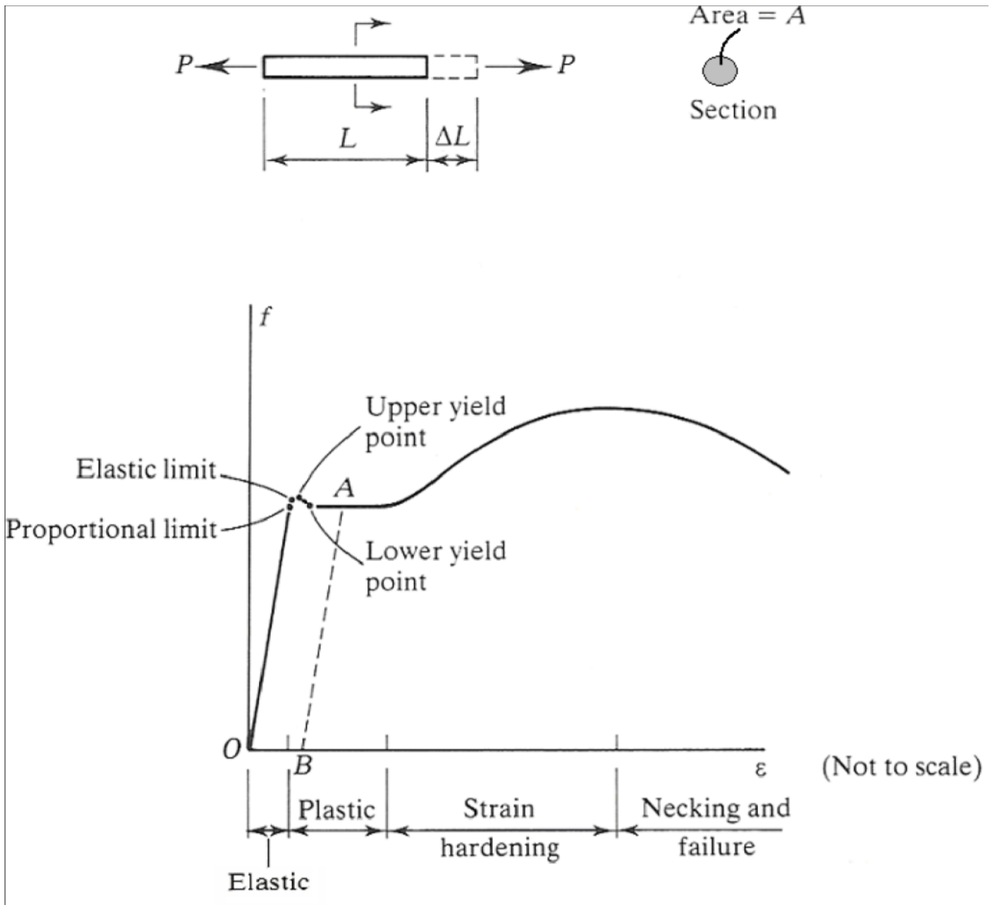


Fig.7. Theoretical Stress-Strain diagram for typical ductile metal.

Necking of the rebar before fracture