Trade of Metal Fabrication

Module 3:	Plate Fabrication
Unit 10:	Conical Fabrication
	Phase 2

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Document Release History

Date	Version	Comments
22/12/06	First draft	
13/12/13	SOLAS transfer	

Module 3 – Plate Fabrication

Unit 10 – Conical Fabrication

Duration – 17 Hours

Learning Outcome:

By the end of this unit each apprentice will be able to:

- Draw a conical development using radial line development
- Mark out conical development using trammel bar
- Fabricate cone using a press brake
- Define proper and improper fractions and mixed numbers
- Calculate using arithmetic fractions
- Describe strength of material (elasticity and elastic limit)

Key Learning Points:

D	Read, interpret and draw radial line pattern developments. *(Instructor explains this in classroom).*
Sk	Plate marking and plate forming.
Rk Sk	Development - half patterns, full patterns. *(Instructor explains this in classroom).*
M	Calculate using: arithmetic fractions. *(Instructor explains this in classroom).*
M	Calculate using p times the difference from the developed diameter and the finished diameter for the cut out required to form a cone. *(Instructor explains this in classroom).*
H	Hot metals. Machine safety.
P	Ability, presentation and standard of work.
H Rk	Methods of storage and handling sheets and plates and precautions to be observed. *(Also see "Handling of Material" section in Module 3 Unit 1).*
Sc	Strength of materials.

Training Resources:

- Drawing equipment
- Apprentice tool kit
- Fabrication workshop facilities
- Oxy/fuel cutting equipment
- Trammel bar
- Press brake
- M.M.A. plant and consumables
- 5mm mild steel plate
- Safety equipment
- Protective equipment

Key Learning Points Code:

M = Maths D= Drawing RK = Related Knowledge Sc = Science

P = Personal Skills Sk = Skill H = Hazards

Hot Metals

Furnace Temperatures

An important auxiliary to a furnace is some method of measuring its temperature, because the successful heat treatment of steel depends on close adherence to the correct temperature. There are many methods used for this, a simple one being to put in the furnace some substance which melts at the temperature it is desired to verify. The substances used for this are moulded in the form of cones from mixtures of Kaolin, lime, feldspar, magnesia, quartz and boric acid, with their melting temperatures arranged in steps from 600°C to 2000 °C. When a furnace temperature is required, several of these cones, covering a range of melting temperatures within which the temperature of the furnace is judged to lie, are put in and observed. The temperature is then judged from which cones collapse, and which remain unaffected by the heat of the furnace. For example, to verify a temperature judged to be 810°-820°C, cones having melting points of 790, 815 and 835°C might be put in, the temperature then being estimated from their condition after sufficient time had elapsed for them to be affected. These cones are called *Seger Cones* or Sentinels and Figure 1 shows how they appear after a test.

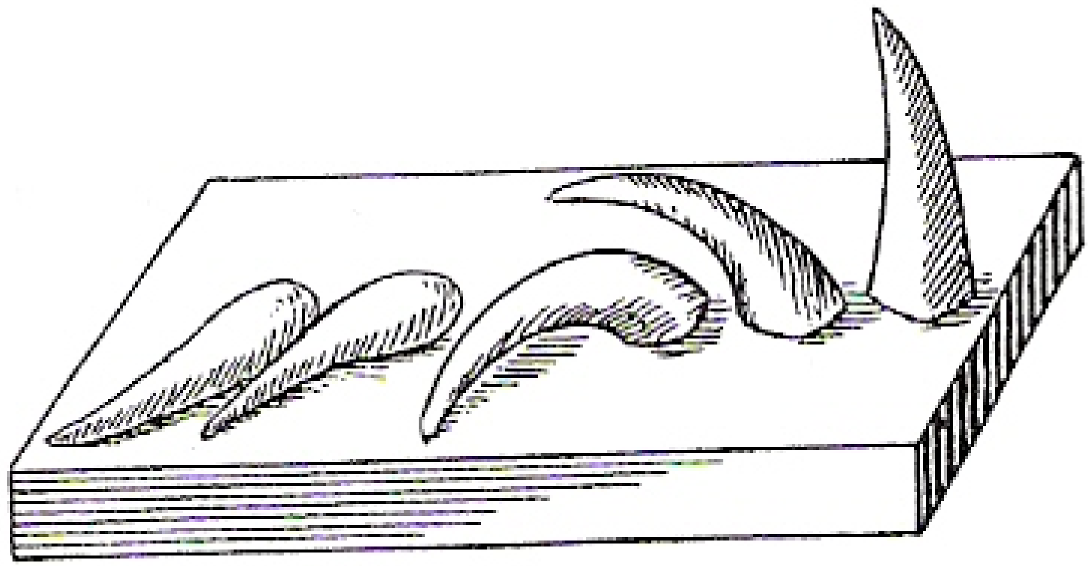


Figure 1 - Seger Cones after being in Furnace

Strength of Materials

Mechanical Testing

Designers and engineers need to know how metals are going to perform when they are used. Special tests have been developed to test for mechanical properties, such as:

- Strength
- Ductility
- Hardness
- Toughness
- Fatigue

These tests are used for both standardisation and checking of quality.

Tensile Testing

A metal which can be drawn out into a thin wire is said to be ductile. Ductility of a metal can be found by using an extensometer. Many types of extensometer exist. Any extensometer has two basic parts:

(a) some method of applying a pull to the test piece (specimen) and showing how much of a load is applied

(b) a method of measuring the amount the specimen stretches or extends during the test.

Specimen pieces of metal are made to suit the machine being used because machines have different ways of holding the pieces.

These specimen pieces may be rectangular or circular, but must have a standard cross-sectional area, and also have marks 50mm apart.

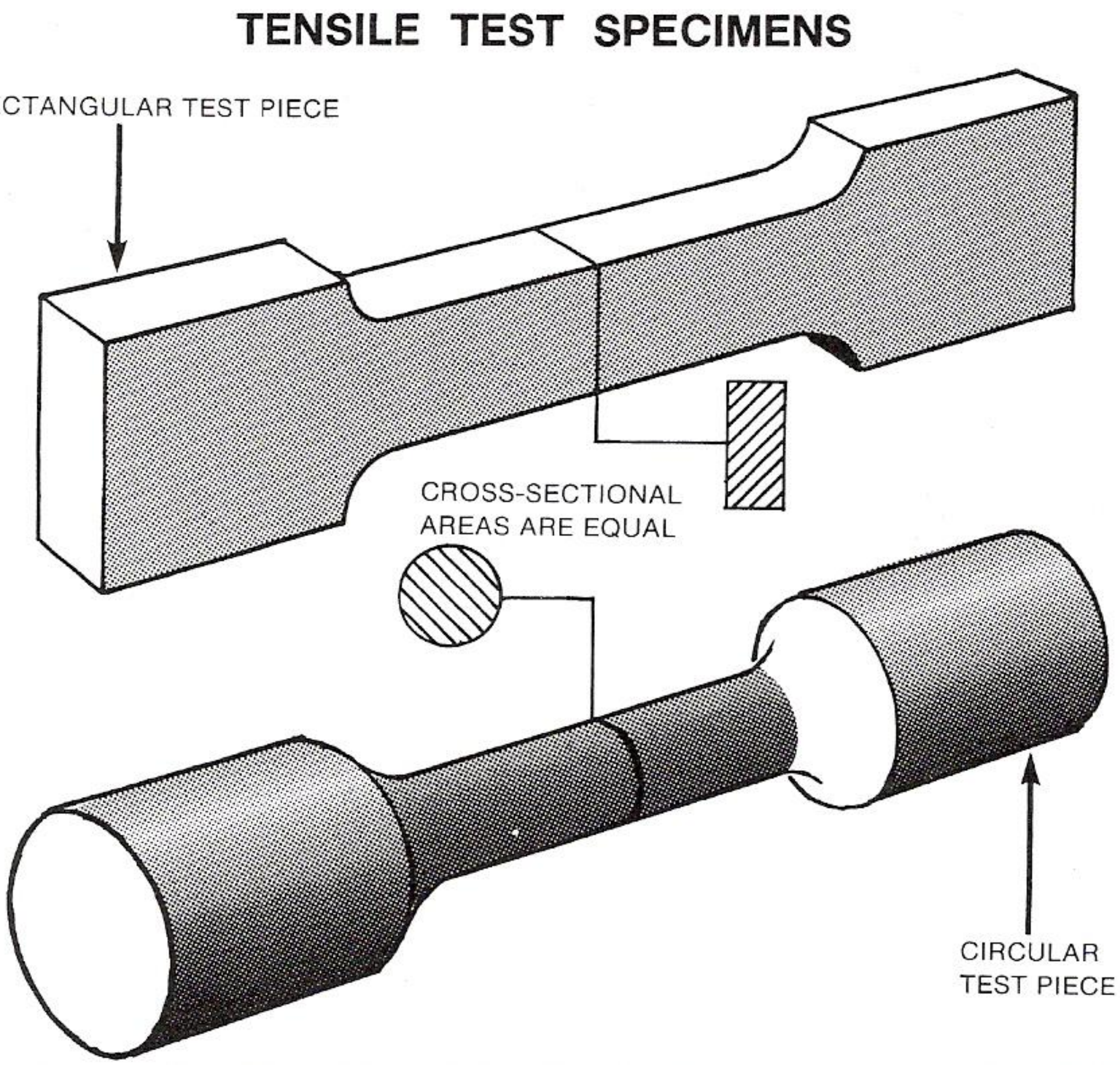


Figure 2 - Tensile Strength Specimens

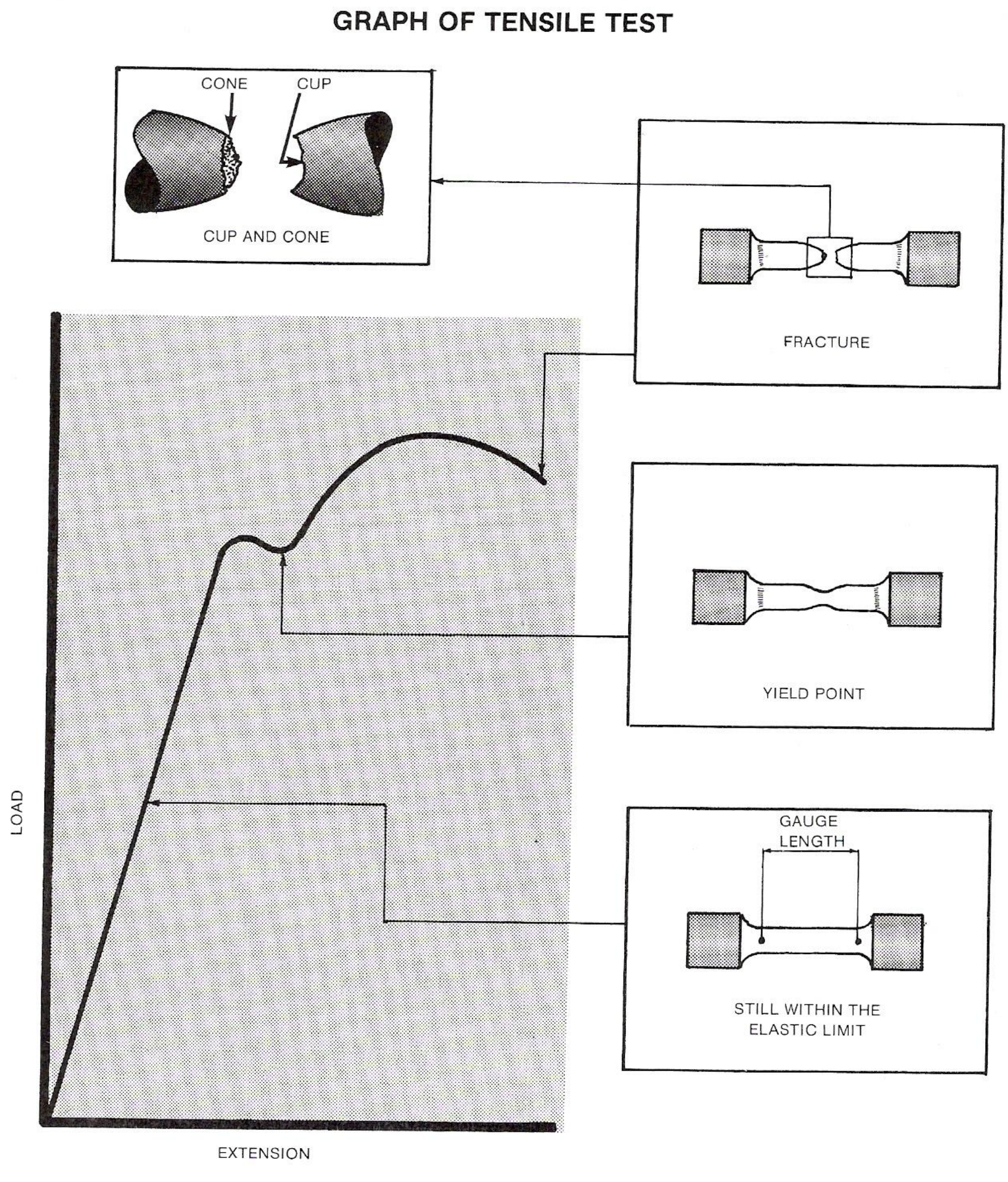


Figure 3 - Graph of Tensile Test

Strain

$$\text{Strain} = \frac{\text{Extension}}{\text{Original Length}}$$

E.G. A steel bar which was 4 metres long is stretched by 6mm. Find the strain.

Extension = Change in Length = 0.006m

Original Length = 4m

Strain $= \frac{0.006}{4} = 0.0015$ or 1.5×10^{-3}

Stress

When a load or force is applied to a piece of metal, the load is carried by the whole area of cross section. In other words, each unit of area carries an equal amount of load.

It is the amount of load or force carried by a unit area that is called stress.

$$\text{Stress} = \frac{\text{Load}}{\text{Cross-Sectional Area}}$$

E.G. If a steel bar of diameter 8mm has got a pull of 402N, find the stress in the bar.

Cross-Sectional Area $= 0.785 \times D^2$

$= 0.785 \times 64\ mm^2$

$= 50.24\ mm^2$

Load = 402 N

So Stress $= \frac{402}{50.24} = 8\ N/mm^2$

Modulus of Elasticity

In the elastic range of a material, stress is directly proportional to strain, which is another way of stating Hooke's Law.

So, $\frac{\text{Stress}}{\text{Strain}}$ will be constant for each material.

The constant is called Young's Modulus of Elasticity, where

$$\text{Young's Modulus of Elasticity (E)} = \frac{\text{Stress}}{\text{Strain}}$$

E.G. In a tensile test on a non-ferrous alloy, the test piece had a gauge length of 50mm, and a diameter of 10mm. If, in the middle of its elastic range, a load of 20 kN produced an extension of 0.1mm, find Young's Modulus of Elasticity.

$$\textbf{Strain} = \frac{\textbf{Extension}}{\textbf{Original Length}}$$

$$= \frac{0.1}{50} = 0.02$$

$$\text{Stress} = \frac{\text{Load}}{\text{Cross-Sectional Area}}$$

Cross-sectional area = 0.785 x D^2 = 78.5mm²

$$\text{Stress} = \frac{20}{78.5} = 0.255\text{kN/mm}^2$$

So, Young's Modulus of Elasticity $= \frac{0.255}{0.002}$

= 127.5 kN/mm²

(1 kN = 1000N and 1m² = 1,000,000 mm²)

So, 127.5 kN/mm² = 127.5 x 10^9 N/m²

This is the way E is usually expressed. Young's Modulus gives an indication of the stiffness of the material. The value of E can be the same in compression as in tension for some materials, but this is not always so.

Tensile Strength

Tensile strength is the maximum force or load applied to the specimen before it fractures, divided by the original cross-sectional area.

$$\text{Tensile Strength} = \frac{\text{Maximum Load (N)}}{\text{Cross-Sectional Area (mm}^2\text{)}}$$

Tensile strength is sometimes called Ultimate Tensile Strength.

Ductility

An indication of the ductility of the metal used in the test is given by percentage elongation.

$$\text{Percentage Elongation} = \frac{\text{Extension}}{\text{Original Length}} \times 100$$

Sometimes the reduction in area is used for ductility.

$$\text{Percentage Reduction in Area} = \frac{\text{Reduction in Area}}{\text{Original Area}} \times 100$$

Many materials such as hardened steel or non ferrous metals have no well defined yield point, so the proof stress is used. The yield point is more important than the tensile strength and a stress which gives a certain amount of extension is specified. This specified stress is known as proof stress. Figure 4 shows how the figure is arrived at.

Shear Strength

A shear force tends to shear the material into two parts. Shear force is used in cutting with scissors, tinsnips, guillotine and in 'punching' or piercing with a press. Figure 5 shows a bar of metal being sheared.

$$\text{Shear Strength} = \frac{\text{Maximum Load}}{\text{Area in Shear}}$$

E.G. If the bar in Figure 4 has a cross-sectional area of 60mm² and the metal it is made from has a shear strength of 210 N/mm², what force is necessary to shear the bar?

Cross-sectional area of bar	= 60mm²
Shear strength of metal	= 210N/mm²
Force required	= 60 x 210N
	= 12600N
	or 12.6kN

PROOF STRESS IS USED FOR MATERIALS WHICH DO NOT HAVE WELL DEFINED ELASTIC LIMITS, E.G. DUCTILE METALS AND NEARLY ALL PLASTICS. IT IS THE STRESS WHICH WILL CAUSE A PERCENTAGE INCREASE IN THE GAUGE LENGTH — USUALLY 0·1%.

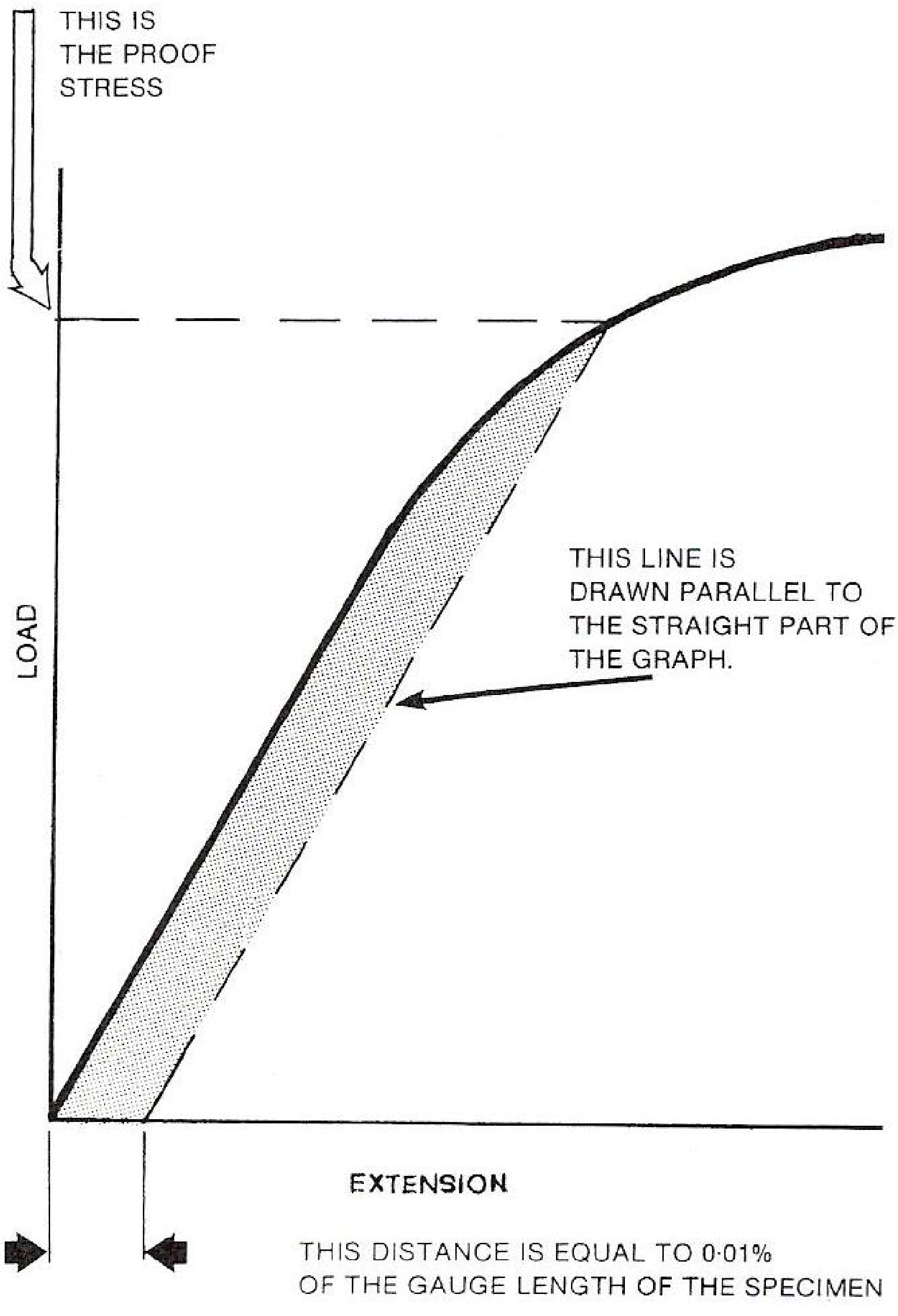


Figure 4 - Proof Stress

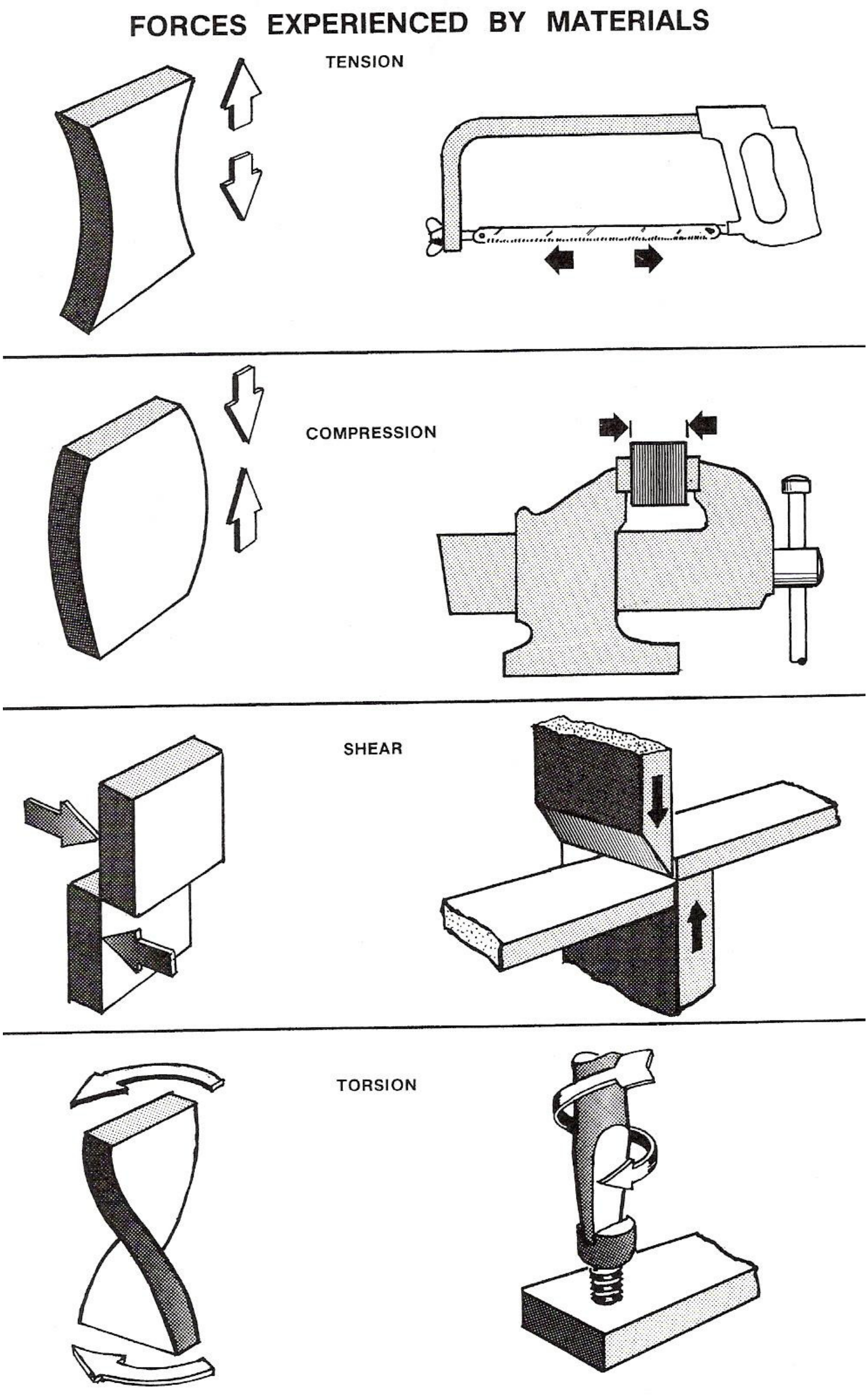


Figure 5 - Forces Experienced by Materials

Compressive Strength

This is the strength of the material in compression and is calculated from:

$$\text{Compression Strength} = \frac{\text{Load}}{\text{Area in Compression}}$$

Factor of Safety

When an engineer designs a component, the stress which the component will be subjected to is taken into account. The dimensions necessary to withstand the stress are calculated. If these exact figures were used, failure of the component could occur due to either an increase in load or a deterioration of the material. This is why it is the practice to make the components capable of withstanding much greater loads than their safe working loads.

E.G. Supposing a component is to withstand a load of 50kN, but it is designed so that it can withstand 200kN.

Here, the factor of safety, as it is called, is equal to 4 as shown below:

Safe working load	= 50kN
Maximum load	= 200kN
Factor of safety	= 200/50 = 4

Self Assessment

Questions on Background Notes – Module 3.Unit 10

1. Briefly explain the mechanical testing of Steel.

2. In relation to steels what do the terms Stress and Strain mean?

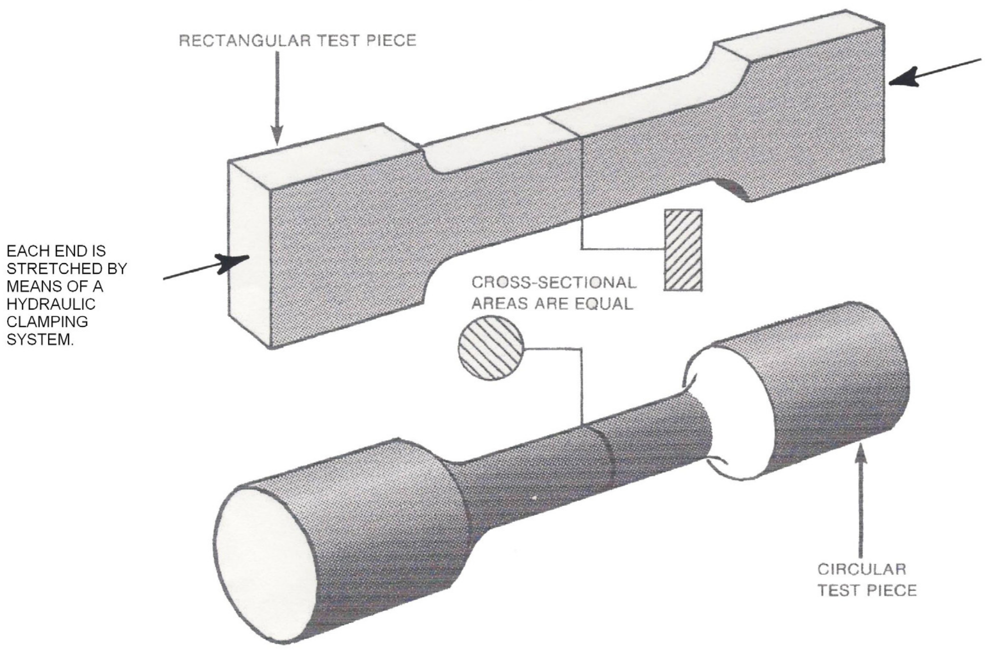
3. What does Compressive and Shear strength mean?

Answers to Questions 1-3. Module3.Unit 10

1.

Testing of Steel by Mechanical means:

Figure 3.



2.

Stress:

When a load or force is applied to a piece of metal, the load is carried by the whole area of cross section.. Each unit of area carries an equal amount of the load. It is the amount of load or force carried by a unit area that is called stress.

$$\textbf{Stress} = \frac{\textbf{Load}}{\textbf{Cross Section Area}}$$

E.g. If a steel bar of diameter 8mm has got a pull of 402N, the stress in the bar is as follows:

$$\begin{aligned}\text{Cross Section Area} &= 0.785 \times D^2 \\ &= 0.785 \times 64\text{mm}^2 \\ &= 50.24\text{mm}^2\end{aligned}$$

$$\text{Load} = 402 \text{ N}$$

$$\text{So Stress} = \frac{402}{50.24} = 8 \text{ N/mm}^2$$

Strain:

$$\textbf{Strain} = \frac{\textbf{Extension}}{\textbf{Original Length}}$$

E.g. A steel bar which was 4 meters long is stretched by 6mm.

Extension = Change in Length = 0.006m
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$$\text{Strain} = \frac{0.006}{4} = 0.0015 \text{ or } 1.5 \times 10^3$$

3.

a. Compressive Strength:

This is the strength of the material in compression and is calculated from:

$$\textbf{Compression Strength} = \frac{\textbf{Load}}{\textbf{Area in Compression}}$$

↓ ↓

Compression

↑ ↑

b. Shear Strength:

A shear force tends to shear the material into two parts. Shear force is used in cutting with scissors, tinsnips, guillotine and in punching or piercing with a press.

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