بسم الله الرحمن الرحيم

Benha University
Shoubra Faculty of Engineering

Mechanical Department
1st year Mech.

03.03.2019 – Week 4

Compression test

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Dr. Mahmoud Khedr

Outline

- Factors affecting the tensile testing results - Rolling direction, cold work, C-content.
- Compression test
- Difficulties of The Compression test.
- Behavior of Metals under Static Compressive Stresses
- The cast iron under tension & compression

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Factors affecting the tensile testing results

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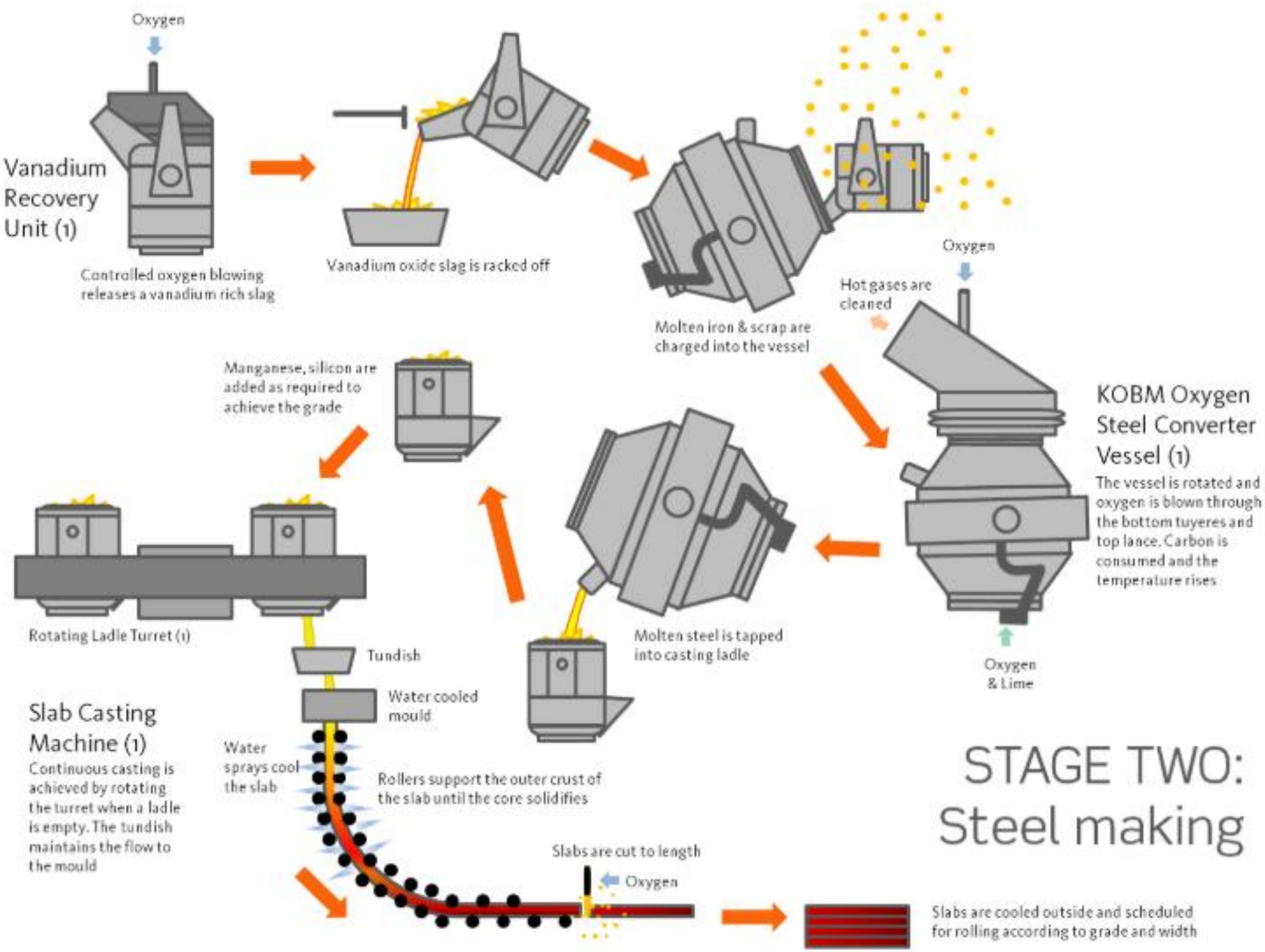
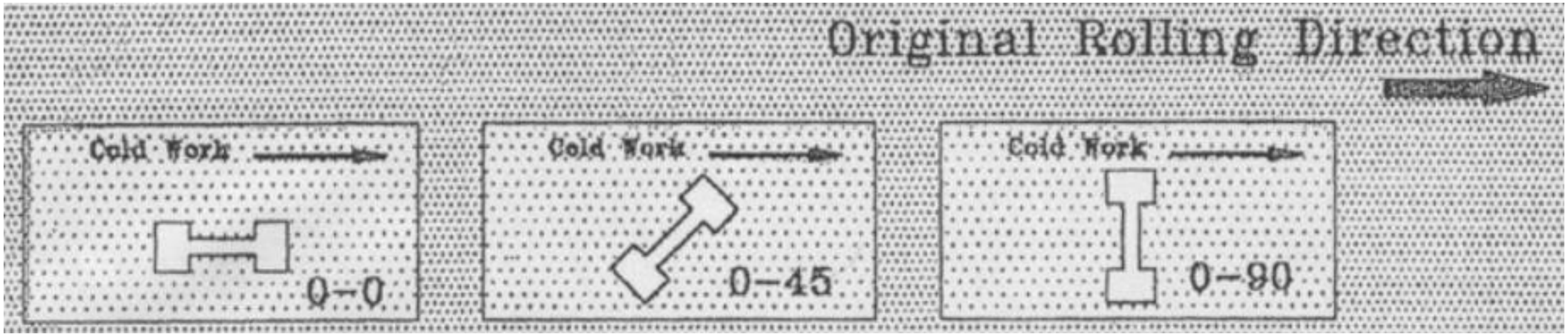
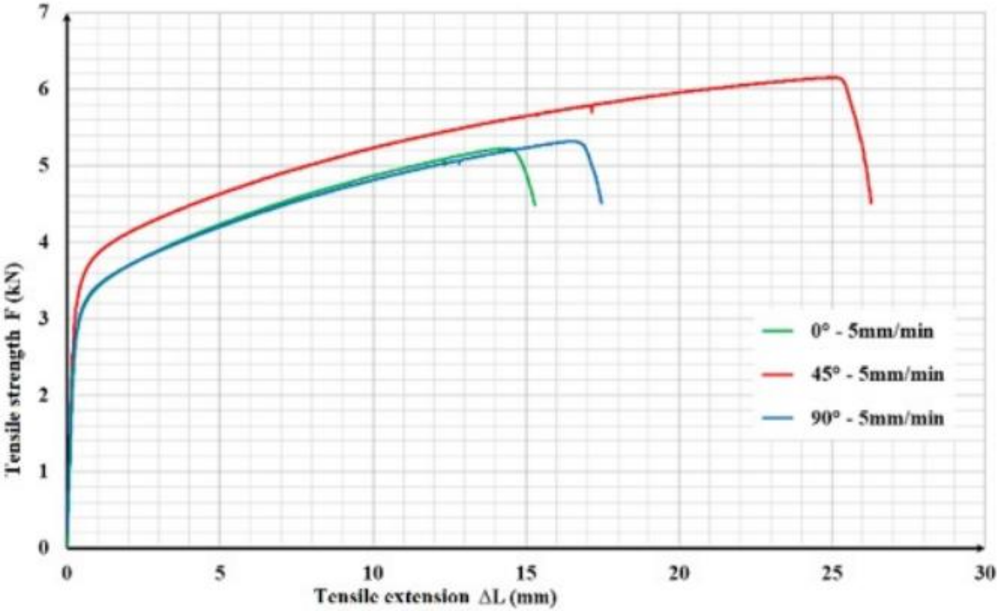
Steel making



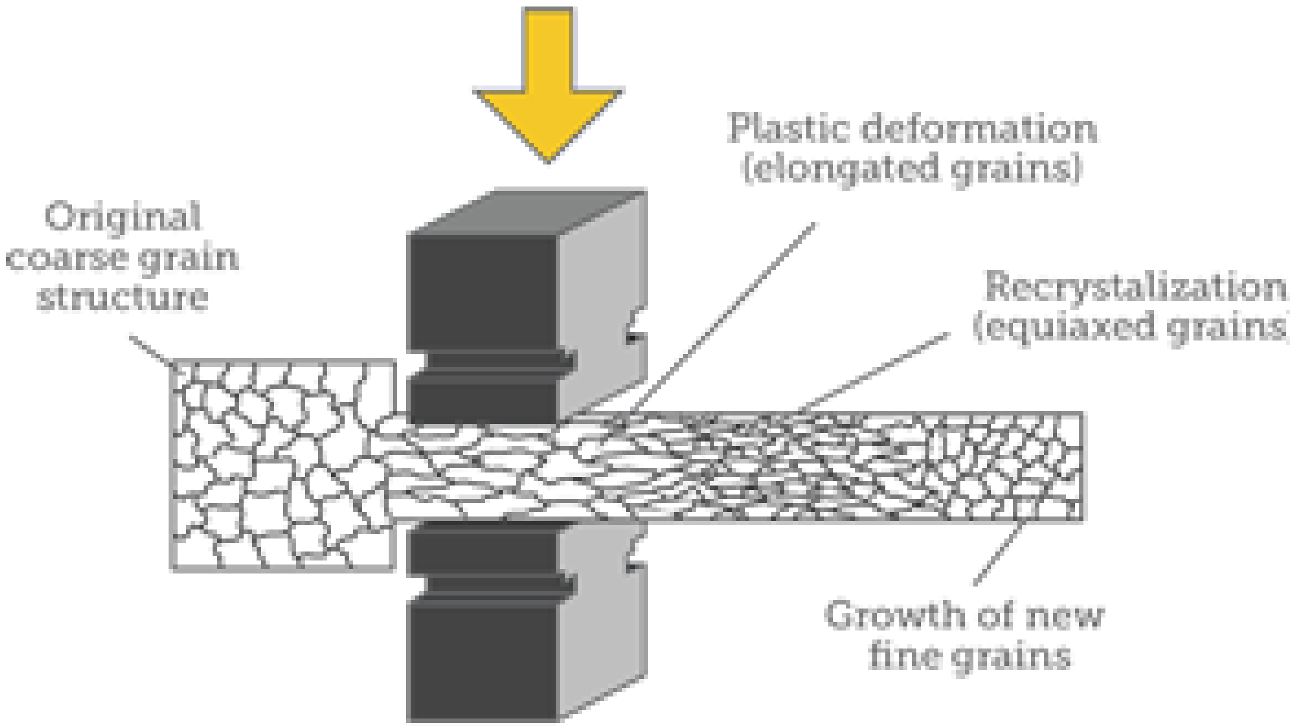
Steel making

Effect of rolling direction on tensile testing results of austenitic stainless steel (AISI304)





Cold working

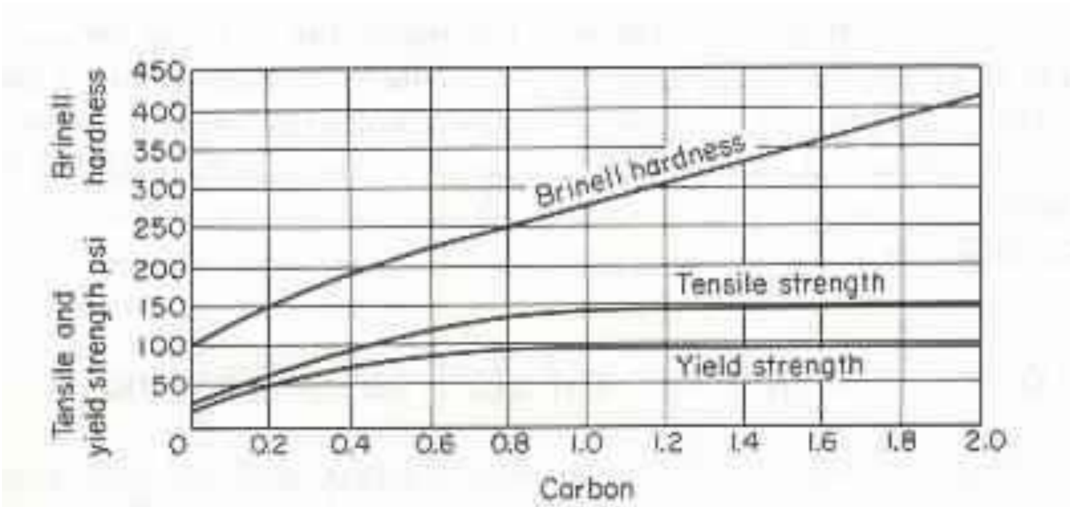


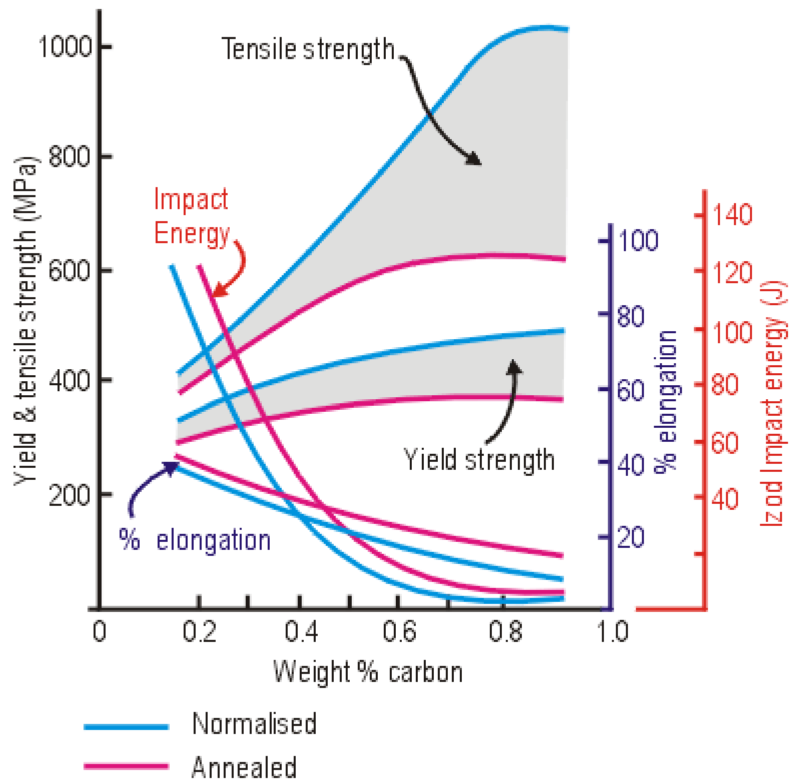
How the open die forging process affects the crystal structure.

Effect of cold work on tensile testing results

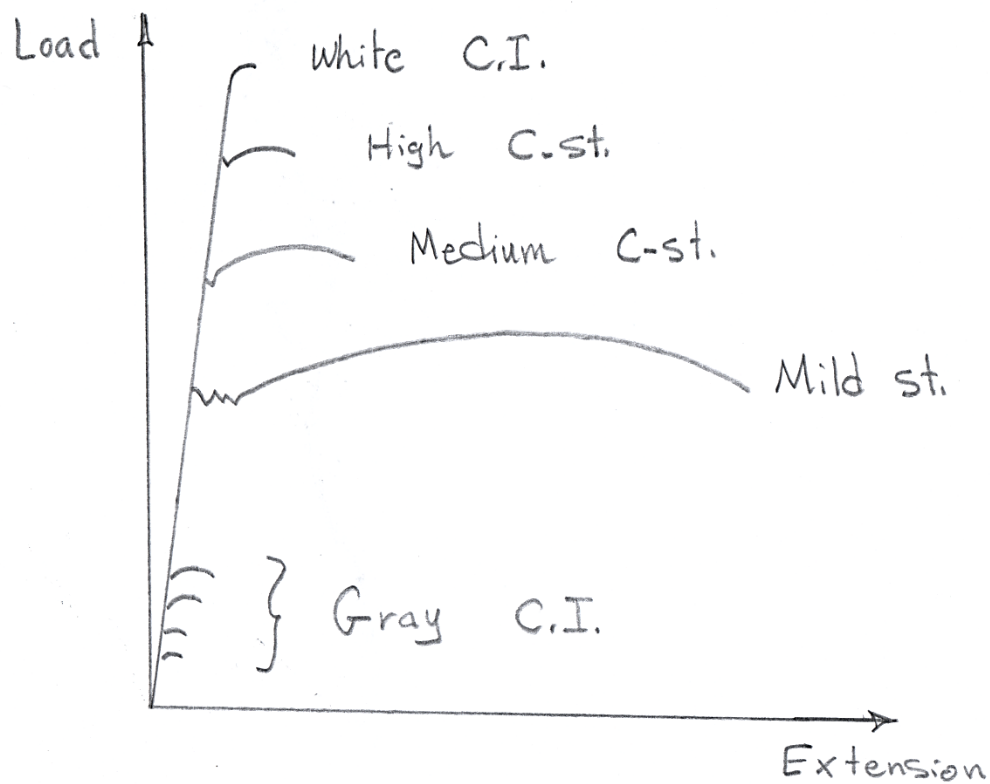
Reduction of area by drawing, %	Yield strength, psi	Tensile strength, psi	Elongation, in 2 in., %	Reduction of area, %
0	40,000	66,000	34	70
10	72,000	75,000	20	65
20	82,000	84,000	17	63
40	86,000	95,000	16	60
60	88,000	102,000	14	54
80	96,000	115,000	7	26

the effect of Carbon content on the tensile behavior of plain C-steel



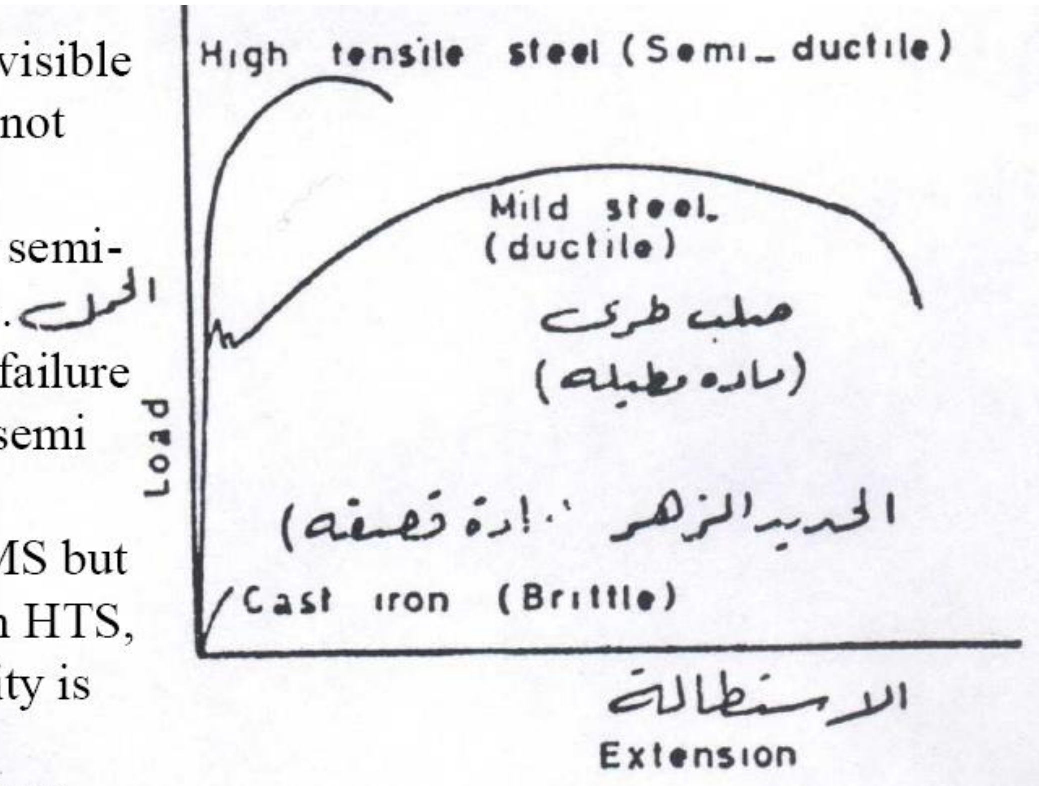


the effect of Carbon content on the tensile behavior



Comparison between P-δ curves in Tension Test

1. Elastic proportional line is visible for mild steel and HTS but not Cast Iron.
2. No yielding takes place for semi-ductile and brittle materials.
3. Necking and cup and cone failure takes place for ductile and semi ductile metals.
4. Ductility is maximum for MS but lesser ductile is exhibited in HTS, while extremely low ductility is measured for CI.
5. HTS exhibit much higher UTS than MS while CI exhibits low UTS



Load-deformation curves for MS, HTS and Cast Iron

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Behavior of Metals under Static Compressive Stresses

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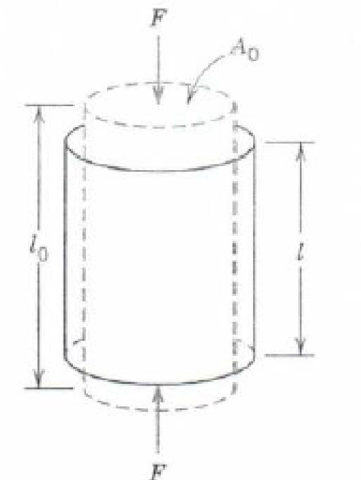
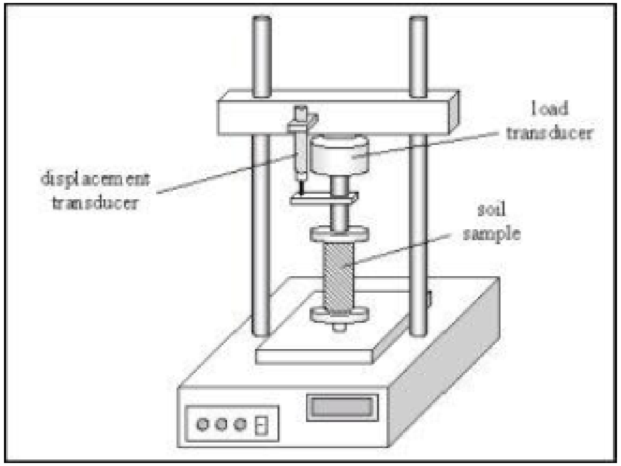
Introduction

•A compression test is conducted in a manner similar to the tensile test, except that the force is compressive and the specimen contracts along the direction of the stress.

• ***Tensile tests are more common*** because they are easier to perform; also, for most materials used in structural applications, very little additional information is obtained from compressive tests.



Schematic illustration of how a compressive load produces contraction and a negative linear strain.



Introduction

The compression test is usually carried out on “non-metal” materials such as concrete, timber, tiles, natural stones to determine compressive strength only.

Rarely it is carried out on metals since most of the important mechanical properties are easily and accurately determined from Tension Test.

Compression test ***may*** be carried out on metals to determine yield stress, Young’s modulus, etc.

Compressive tests are used when a material's behavior under large and permanent loading and strains is desired, or material is brittle in tension.

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Watching a compression testing practice

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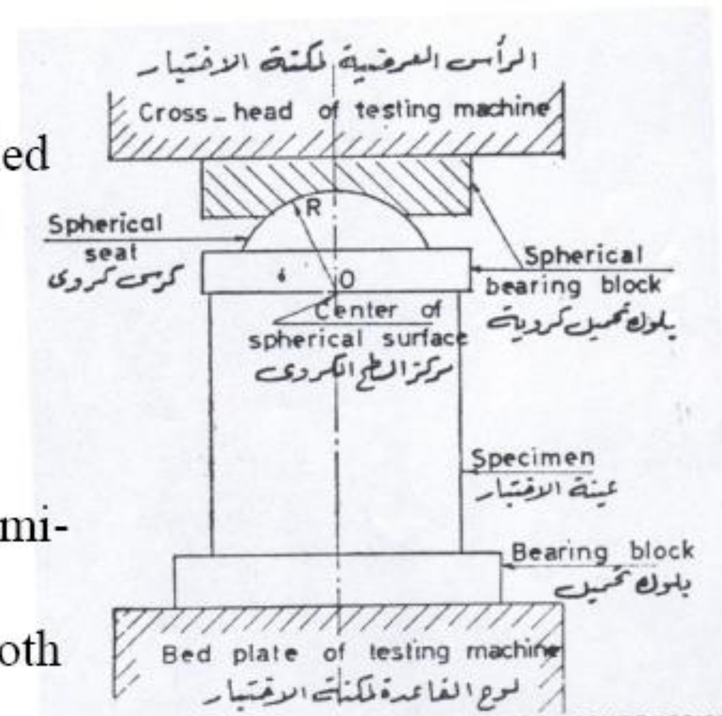
Difficulties of The Compression test

The application of perfectly axial load.

If the load on a specimen is applied through the center of gravity of its cross section, it is called an axial load.

A load at any other point in the cross section is known as an eccentric load.

The testing machine should be equipped with hemi-spherical end to prevent load concentration and apply stresses that are always perpendicular to both ends of the specimen.

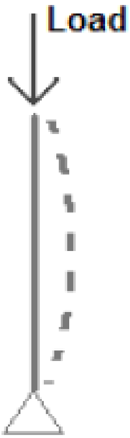


SPHERICAL BEARING BLOCK FOR COMPRESSION TEST

Difficulties of The Compression test

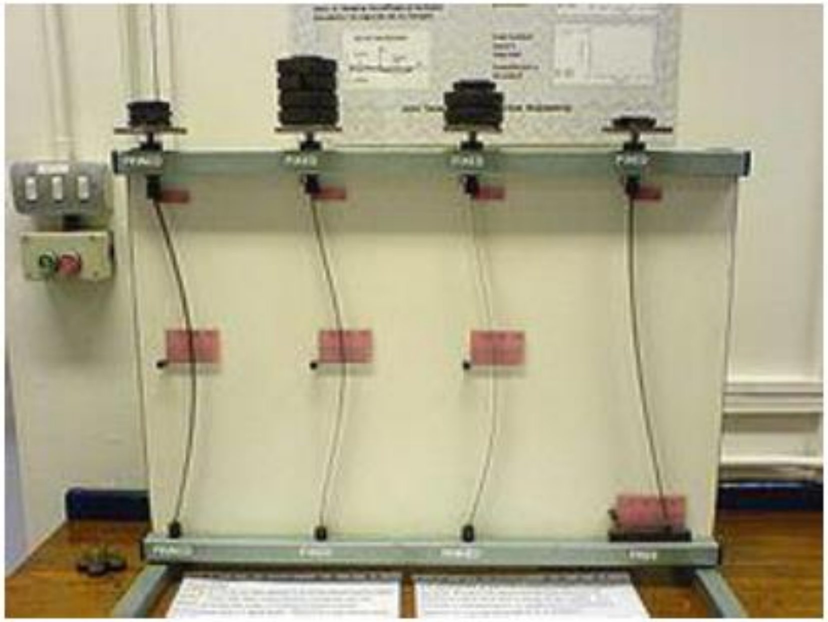
The instability "buckling" of the specimen under compressive stresses

Buckling is characterized by a sudden failure of a structural member subjected to high compressive stress, where the actual compressive stress at the point of failure is less than the ultimate compressive stresses that the material is capable of withstanding. This mode of failure is also described as failure due to elastic instability.



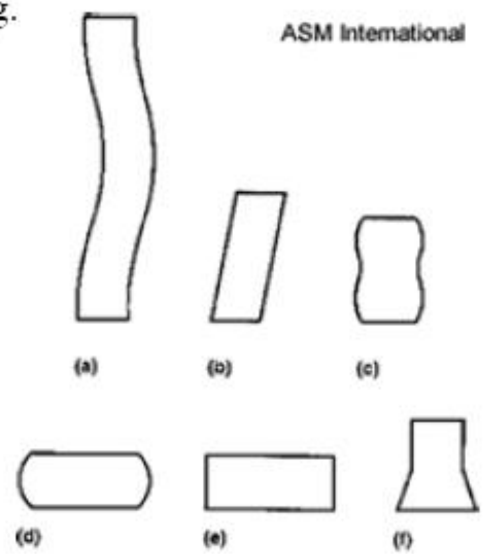
Mathematical analysis of buckling makes use of an axial load eccentricity that introduces a moment, which does not form part of the primary forces to which the member is subjected. When load is constantly being applied on a member, such as specimen, it will ultimately become large enough to cause the member to become unstable. Further load will cause significant and somewhat unpredictable deformations, possibly leading to complete loss of load-carrying capacity. The member is said to have buckled, to have deformed.

Difficulties of The Compression test



A demonstration model illustrating the different "Euler" buckling modes. The model shows how the boundary conditions affect the critical load of a slender column. Notice that each of the columns are identical, apart from the boundary conditions.

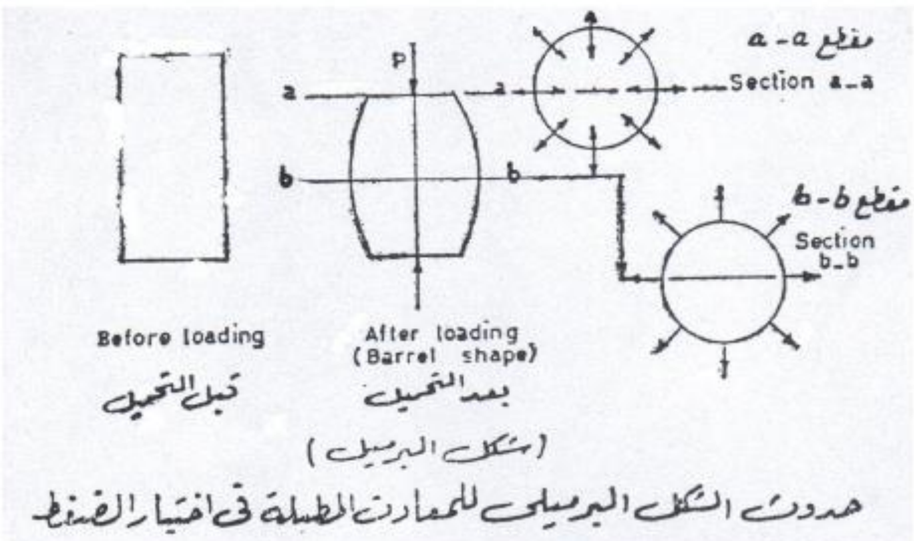
A short specimen under the action of an axial load will fail by direct compression before it buckles, but a long column loaded in the same manner will fail by buckling (bending), the buckling effect being so large that the effect of the direct load may be neglected. The intermediate-length column will fail by a combination of direct compressive stress and bending.

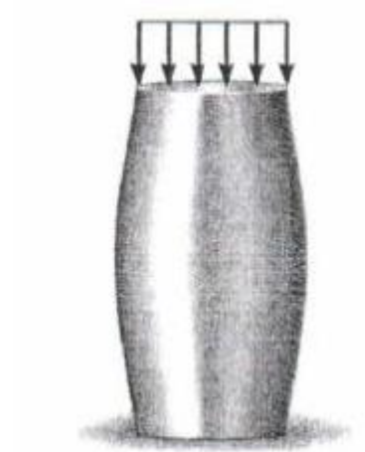


Difficulties of The Compression test

The friction forces near specimen ends

As the load applied on the specimen increases the specimen will generally bulge out or become barrel shaped as the strains become larger due to existence of friction force at both ends that prevents the specimen from freely expand near both ends while the specimen expands freely near the mid-height. Thus the specimen takes the barrel shapes.





Compression causes material to bulge out

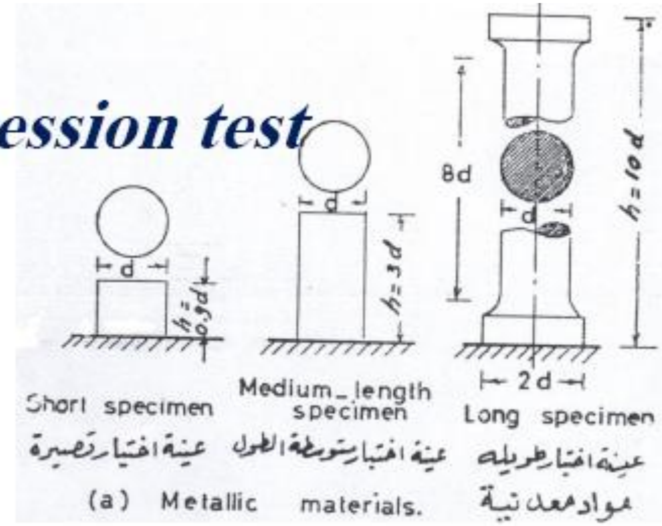
Difficulties of The Compression test

<u>The size of the specimen</u>

One way to prevent buckling is to increase the cross sectional area of the specimen. Due to the high compressive strength, the required applied load will be high and requires testing machines with higher capacity.

Specimen dimensions

Standard Specimens in Compression test

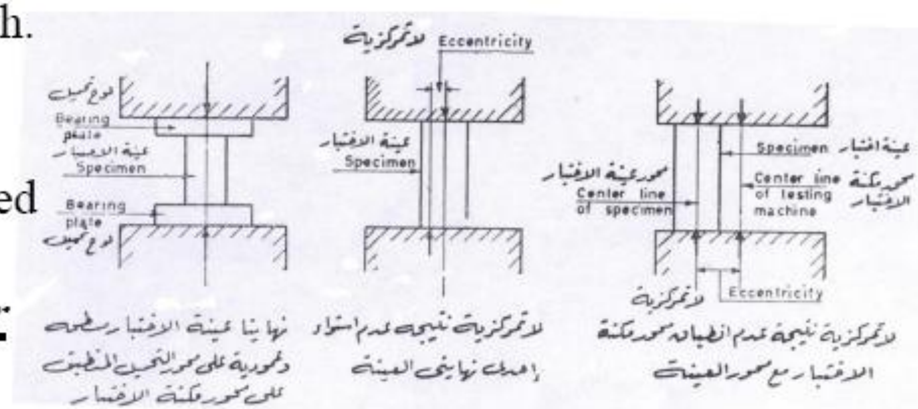


Standard Specimens:

Long Specimens: h = (8-10) d
Used to draw load-deformation curve.
Medium Length Specimens h= (3-5) d
Used for determining the compressive strength.
Short Specimens: h = (0.9-1) d
Used for determining the effect of friction force of compressive strength.

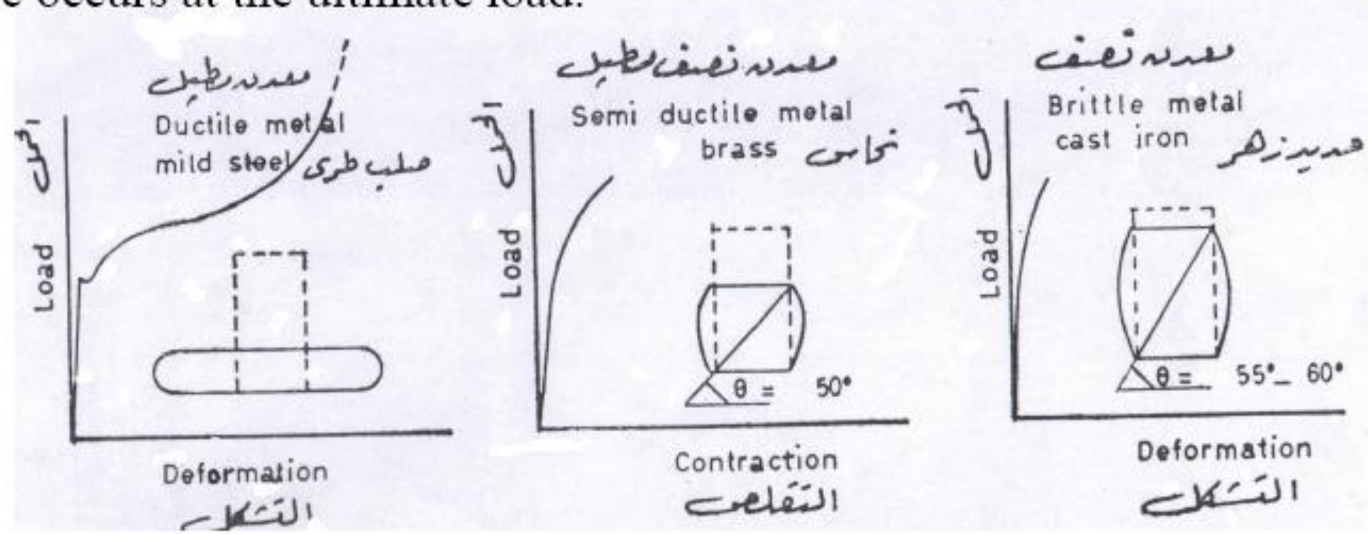
General Requirements:

Eccentric loading should be prevented by ensuring both ends should be ***smooth***, ***flat***, ***parallel to each other*** and ***perpendicular*** to the specimen axis.



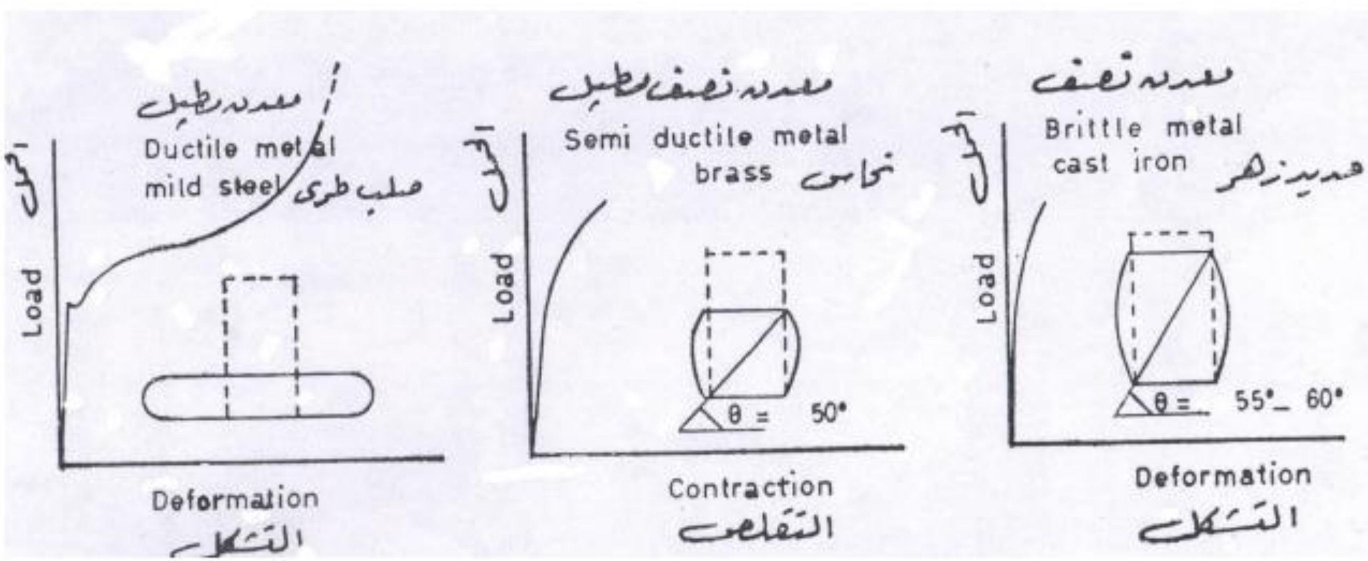
Behavior of metals under compressive loading

Standard specimens with circular cross section subjected to axial compressive will suffer from excessive contraction “deformation” under the loading.
All metals will have a proportional line at the beginning.
Only ductile metals will exhibit yielding.
Brittle (cast iron) and Semi-ductile (brass) metals will take the barrel shape and fails due to shear stresses on a plane inclined by 45+ϕ/2, where ϕ:is the angle of internal friction.
Failure occurs at the ultimate load.



Behavior of metals under compressive loading

Brittle (cast iron) metals will fail due to shear stresses on a plane inclined by (55-60) deg.
Semi-ductile (brass) metals will fail due to shear stresses on a plane inclined 50 deg.
Ductile metals will take the barrel shape ***But*** will not fail and the specimen keeps on flattening under compressive stresses. At rare cases ductile metals will fail in vertical cracks due to existence of impurities in the ductile metal.

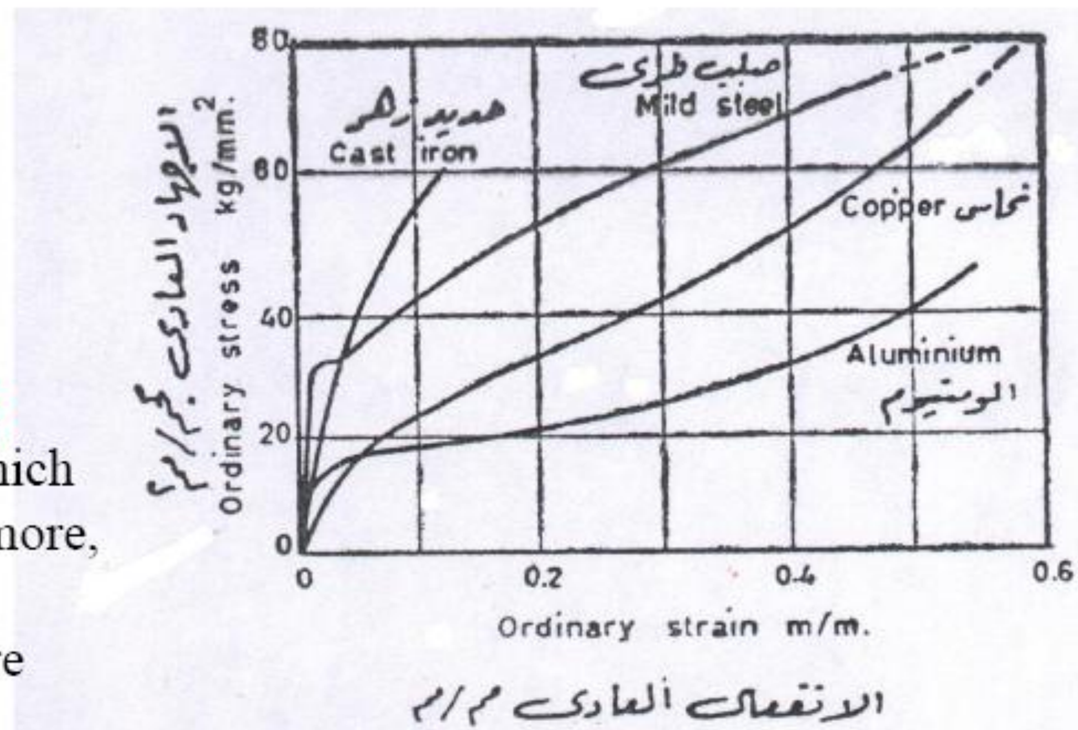


Behavior of metals under compressive loading

•Compressive stress and strain, are calculated similar to tensile counterparts respectively.

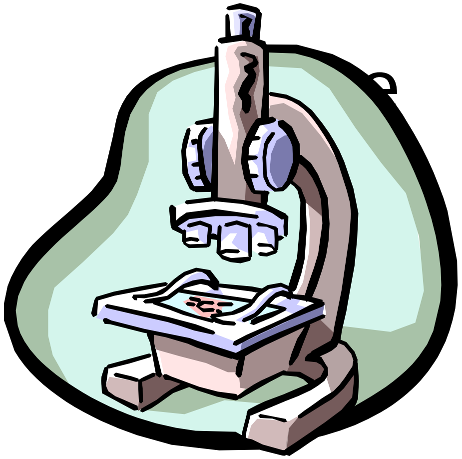
$$\sigma = \frac{P}{A_0} \qquad \varepsilon = \frac{\Delta L}{L_0}$$

• By convention, a ***compressive force*** is taken to be ***negative***, which yields a negative stress. Furthermore, since L_o is greater than L_i, compressive strains computed are necessarily negative.



Observations in Compression Tests

- **Observations:** change in dimensions, critical loads, type of failure,…
- **Brittle** materials: rupture either along a diagonal plane, or with a cone (for cylindrical specimens) or a pyramidal (for square specimens) shaped fracture.
- **Ductile** materials: bulge laterally, e a barrel shape.



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The cast iron under tension & compression

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Effect of load direction on the mechanical properties of C.I.