Lecture No. one: Atomic structure and types of bonding **Time : 2 Hours**

Atomic structure

Atoms are recognized as the basic continents of materials joining together in a collagenous manner to form crystalline or amorphous structure.

This assemblage of atoms may be in the form of gasses, liquid or solid. Specific difference between atoms and the way they behave mechanically, physically and chemically are due principally to their individual atomic or electronic structure.

Structurally, the core of an atom "it's nucleus" is composed of positively charged particles known as Proton and uncharged particles called Neutrons. The number of Proton is also known as the atomic number (Z). The sum of Protons and Neutrons in the nucleus determines the atomic weight.

The nucleus is surrounded by the Electrons with mass equal to 1/1836 of mass of Proton. The charge is equal in magnitude, but opposite in sign to the charge of Proton.. Also the number of electrons in an atom equals the number of Proton.

The energy of Electron becomes progressively greater as their distance from the nucleus increase. Thus it is convenient to separate the Electrons into shells containing different energy characteristics. However the Electron in specific shell posses approximately the same energy.

The distribution of Electrons in each of the shells of a given atom is governed by these rules:

- The maximum number of Electrons in each level is given as ($2n^2$) where n is the number of shell.
- A- An outermost or highest energy level can contain no more than eight Electrons.
- B- A next to outermost energy level can contain no more than eighteen Electrons

Types of bonding

A significant feature of the structure of atom is the number of Electrons in the outermost shell. These are called valence electrons. They are important in determine the ability of an atom to bond with other atoms.

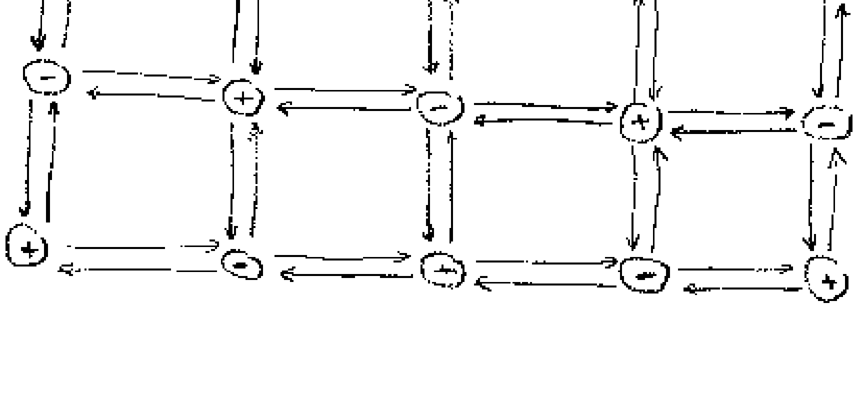
1. **Covalent Bonding:**

Some times, an atom will share valence Electrons with a neighboring atom in order to satisfy such a stable configuration. This sharing of Electrons produces very strong attractive forces between the atoms and is termed **Covalent bonding.**

The best known example of this type of bonding is the hydrogen molecule (H_2). Try to describe this bond?

2. **Ionic Bonding:**

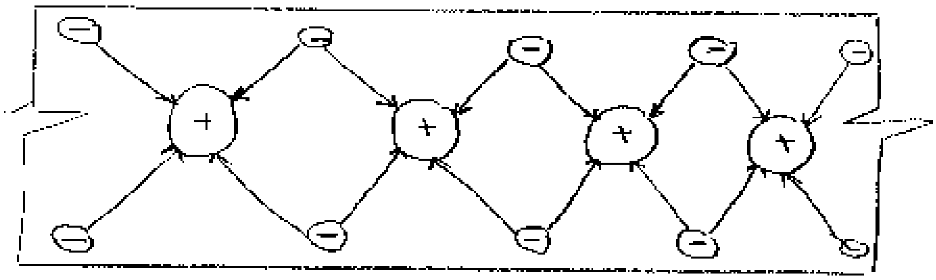
This type of atomic bonding results from mutual attraction of positive (+) and negative (-) charges. It depends on the ability of the atoms to gain or lose electrons.
If an electron is removed from the outer shell, the atom becomes positively charge (electropositive). When an electron is added to outer shell, the atom becomes negatively charge (electronegative). An atom which has lost or gained an electron is called ion and the atoms are said to ionized. Electropositive and electronegative ions attract each other and ionic bond is established between them. The negative charged ion is now attracted to a positive ion, thus, forming the basic for ionic bonding. Both types of ions have achieved a more stable electron configuration by the transfer of valence electrons, and in so doing, they have been mutually attracted. Compound that format ionic bonds include NaCl , $CaCl_2$, Al_2O_3 and MgO. The ionic bond for typical compound is show in Fig. below:



3. Metallic bond:

The covalent or ionic bonds are almost exclusively found in non metallic materials.

Unlike the covalent or ionic bonds, the metallic bond can not exist simply between a few atoms, it is found only where there are a large number of atoms in close approximately. In a piece of metal, the valence electrons of all. The atoms are shared mutually in complex system. The metallic bond in crystals is shown in Fig. below:



The combination of positively charged cores and the surrounding electron cloud or gas produces the attractive forces of the metallic bond. The detached valence electrons or electron cloud are responsible for such metallic characteristics as:

1. High thermal conductivity
2. High electrical conductivity
3. Opaqueness to light

4. Van der Waal's Forces:

Van der Waal's inter atomic attraction is relatively week, and therefore is not considered extremely important with respect to engineering materials. However, sometimes, Van der Waal's forces are the only that operate between atoms.

H.W.

1. Describe the ionic bonding between magnesium (Atomic No. is 12) and chlorine (Atomic No. is 17)

2. Describe the covalent bonding for (H_2O)

3. Describe the covalent bonding for (SiO_2)

Lecture No. Two: Mechanical Properties of materials   Time : 2 Hours

An important consideration in the choice of a material is the way it behave when subjected to force. The mechanical properties of a material are a measure of the resistance it show to the application of the basic type of force:

1. Tensile force
2. Compressive force
3. Shear Force

Stress

Normal stress :

The application of an external force to a body cause internal resisting force within the body, whose resultant is equal in magnitude but opposite in direction to the applied force.

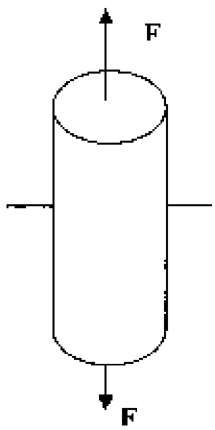
If the a bar subjected to a longitudinal axial force causing internal resisting force distributed continuously over the cross section of the bar as shown in the free diagram. If the applied force passes through the centered of the cross section of the bar, the resisting force will be distributed uniformly over the cross section for resisting loads of geometrically similar members. The uniform distribution of internal resisting can be express in the form of force per unit area as:

Stress (σ) = F/A

Where F The applied force

A- cross sectional area

And if the cross sectional area is normal to the direction of the load, the stress called " Normal stress



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Bearing stress:

Bearing stress occurs when there is contact between two bodies. The external applied force is known as bearing and the pressure between the two bodies is known as a bearing stress. Bearing stress occurs between the post and plate, the plate and footing and between the footing and soil.

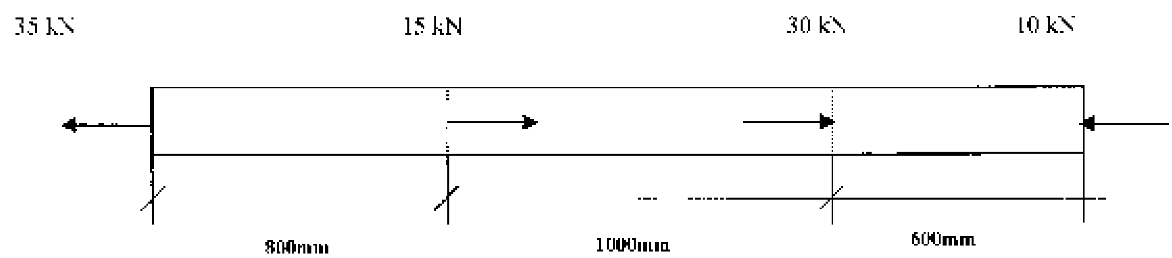
Shearing stress:

Shearing stresses occur when the force being resisted act in the plane of the reacting area.

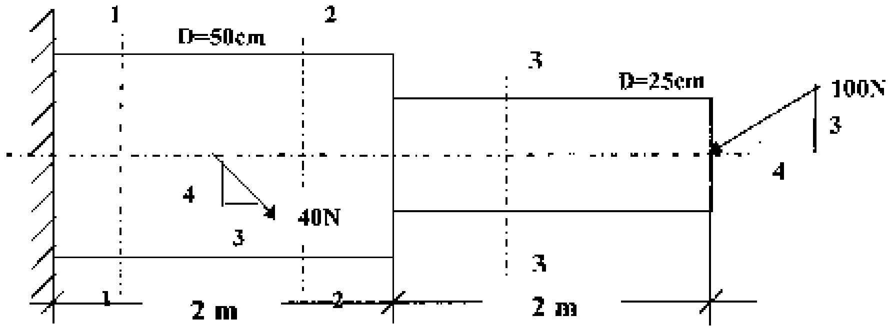
τ = Shearing force/ Area being sheared

H.W.:

1.An aluminum bar having a cross sectional area of 160 mm2 carries the axial loads at the positions shown in Fig. below., compute the stress at each parts of aluminum



2. Determine the stress in each section shown in Fig below



Lecture No. Three: Mechanical Properties of materials (Cont'd) **Time : 2 Hours**

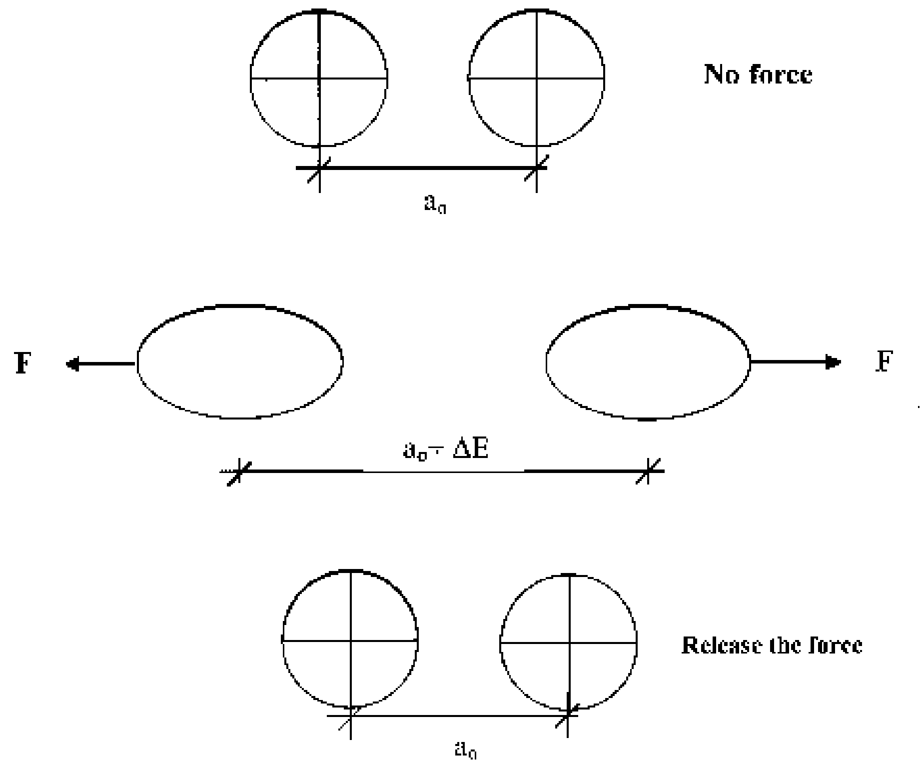
Deformation

When an engineering material is subjected to forces, their atoms may be change their equilibrium positions. The total change in a dimension due to an applied force is known as deformation (Δ).

1. Elastic deformation :

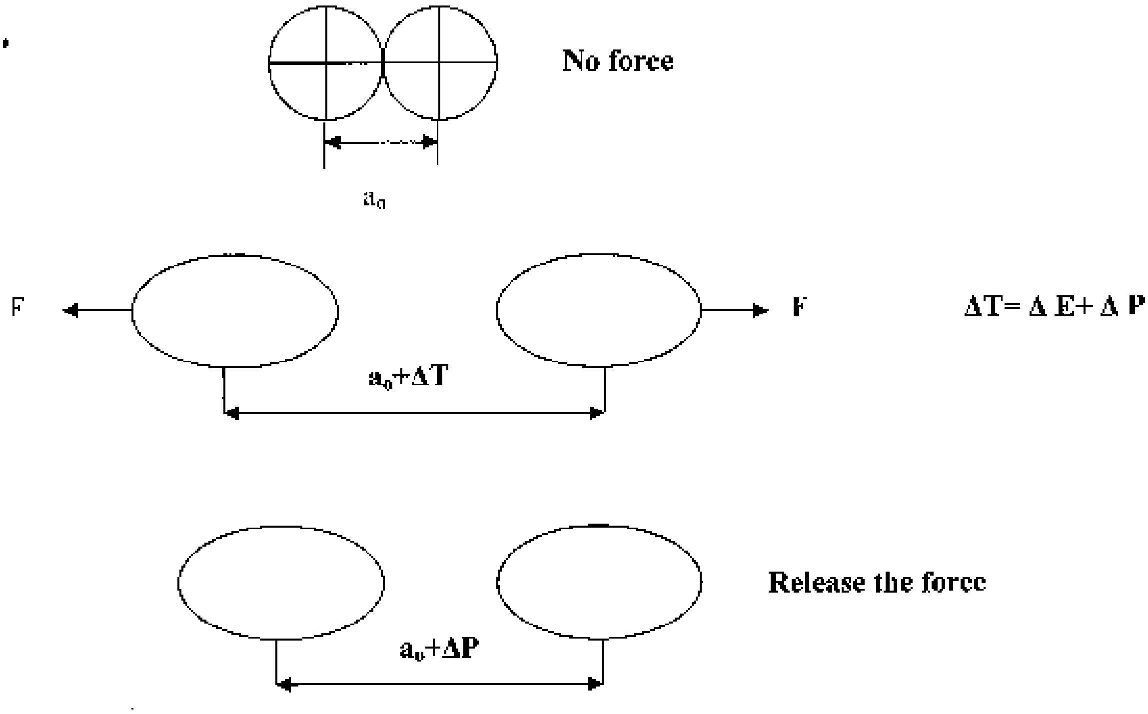
If the atom can resume their equilibrium positions when the imposed force are released, the deformation is termed elastic. Elastic deformation that is recoverable and indicates the relative resistance of a material.

Elasticity: is the property of a material to return to its initial form and dimension after the deforming force is removed.



2. Plastic deformation:

If an engineering undergoes deformation which exceed the elastic capacity (elastic deformation), the deformation is permanent and termed plastic. Plastic deformation is non recoverable and leaves the atoms permanently displaced from their original positions when the forces are released. The process of plastic deformation is shown below:



Strain

Engineering strain:

When a member is subjected to a tensile or compressive stress, it undergoes a deformation (Δ). Tensile force causes an elongation of the body, while compressive causes a shortening of the dimension of the body in the direction of the force. The elongation (or shortening) per unit length is called strain (ϵ).

Average strain (ϵ) = Δ / Lo , mm/mm dimensionless

Where Lo – is the original length

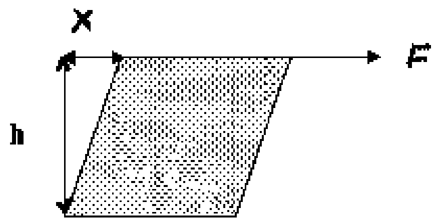
The strain at any position is more correctly named as true strain, i.e. the ratio of the change in dimensions to the instantaneous dimensions. .

$\epsilon_{true} = \ln(\epsilon + 1)$

Shear strain :

It is defined as the ratio of displacement (X) to the distance between the planes (h).

Shear strain = X/h = tan Θ



H.W.

1. Differentiate between elastic deformation and plastic deformation