



## LECTURE TWO

### Materials and examination tools

## Properties of Materials

- **What is the meaning of Properties of Materials?**

The Properties of Materials are those characteristics that different materials distinguish from one another and appear as special characteristics of the material, whether by simple sensation or by using precise devices and machines to measure them.

- **What is the meaning of Building Materials?**

The Building Materials are any material used in construction works such as (roads, bridges, airports, buildings, dams, irrigation canals, etc.)

- **What is the importance of studying the properties of construction materials?**

The importance of studying the properties of construction materials that the engineer must be aware of the properties of the materials he uses in the building and also be familiar with their advantages and disadvantages so that he can use them in an optimal manner in order to achieve the lowest cost and the best performance and safer for the project.

\* Different construction sites require building materials with different specifications, and accordingly, to obtain a strong and highly durable structure, we need to study the building materials and their properties well.



For a material to be considered as building material, it should have required engineering properties suitable for construction works. These properties of building materials are responsible for its quality and capacity and helps to decide applications of these material. Such properties of building materials are categorized as follows.

- Physical properties
- Mechanical properties
- Chemical properties
- Electrical properties
- Magnetic properties
- Thermal properties

\* The engineer must be familiar with the properties of construction materials in order for him to be able to examine these materials and determine whether they are suitable for use in construction or not. Therefore, these properties can be divided into the following types:

### **1- Physical Properties of Building Materials:**

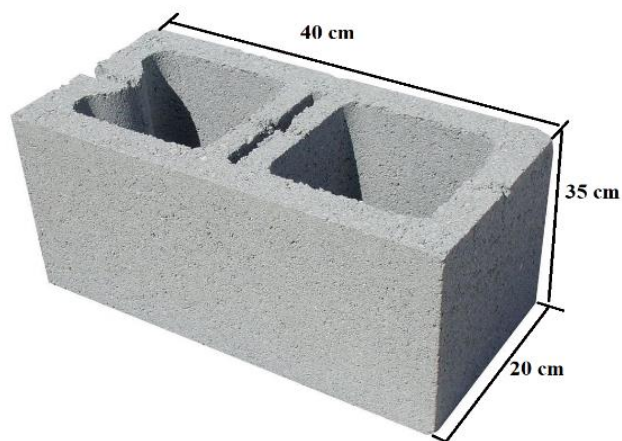
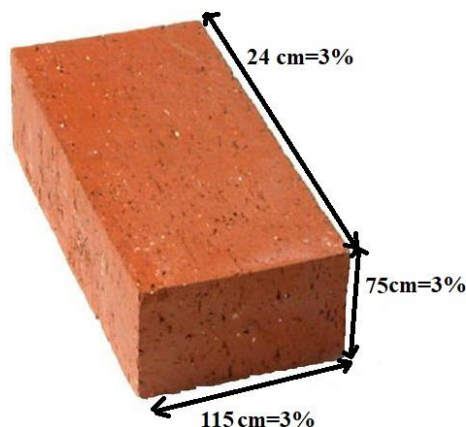
These are the properties required to estimate the quality and condition of the material without any external force. The physical properties of engineering materials are as follows.

- Bulk density
- Porosity
- Durability
- Density

- Density index
- Specific gravity
- Fire resistance
- Frost resistance
- Weathering resistance
- Spalling resistance
- Water absorption
- Water permeability
- Hygroscopicity
- Coefficient of softening
- Refractoriness
- Dimensions.

### A: Dimensions:

Where specifications specify certain dimensions of most building materials, so that if they exceed them by more than the permissible limits, these materials are considered unfit for use, for example (Clay Bricks, Concrete Blocks, Concrete Tiles...etc.)





## B- Density of Building Materials: الكثافة

**Density** is the unit of mass of a volume and it is measured by mass unit divided on volume unit ( $\text{kg/m}^3$ ). **Density** is the ratio of mass of the material to its volume in homogeneous state. Almost all the physical properties of materials are influenced by its density values. Density values of some building materials are given below.

Material	Density ( $\text{kg/m}^3$ )
Steel	7800 – 7900
Brick	2500 -2800
Granite	2600 – 2900

<i>Density</i>	
Common symbols	$\rho, D$
SI unit	$\text{kg/m}^3$
Derivations from other quantities	$\rho = \frac{m}{V}$
Dimension	$\text{L}^{-3}\text{M}$

## C- Porosity of Building Materials (%): نسبة المسامات

**Porosity** is the ratio of the volume of pores in the substance to the volume of its mass. The pores are small units in the material that are filled with water or air, and the pores can be open (continuous) or closed offline. Pores are important in giving the thermal insulation property of the material, but at the same time, the large ratio of pores affects the resistance of this material to the loads. **Porosity** gives the volume of the material occupied by pores. It is the ratio of volume of pores to the volume of material. Porosity influences many properties like thermal conductivity, strength, bulk density, durability etc.



## d- Bulk Density of Building Materials: الكثافة الظاهرية

It is the unit of mass of a material volume at its natural state (Includes voids and pores) and it is measured by mass unit divided on volume unit ( $\text{kg/m}^3$ ).

$$\text{B.D.} = m_1/v_1 \quad (\text{kg/m}^3)$$

Bulk density is not an intrinsic property of a material; it can change depending on how the material is handled. For example, a powder poured into a cylinder will have a particular bulk density; if the cylinder is disturbed, the powder particles will move and usually settle closer together, resulting in a higher bulk density. For this reason, the bulk density of powders is usually reported both as "freely settled" (or "poured" density) and "tapped" density (where the tapped density refers to the bulk density of the powder after a specified compaction process, usually involving vibration of the container. Or we can define **Bulk density** is the ratio of mass to the volume of the material in its natural state that is including voids and pores. It is expressed in  $\text{kg/m}^3$ . Bulk density influences the mechanical properties of materials like strength, heat and conductivity etc. bulk density values of some of the engineering materials are given below.

Building material	Bulk density ( $\text{kg/m}^3$ )
Brick	1600 – 1800
Sand	1450 – 1650
Steel	7850
Heavy concrete	1800 – 2500
Light concrete	500 – 1800
Granite	2500 – 2700

### e- Void Content: محتوى الفراغات

The voids are the empty spaces between the granules of the material (sand, crushed stones) or openings in some building materials (hollow blocks, hollow concrete blocks).

### f- Water Absorption: امتصاص الماء

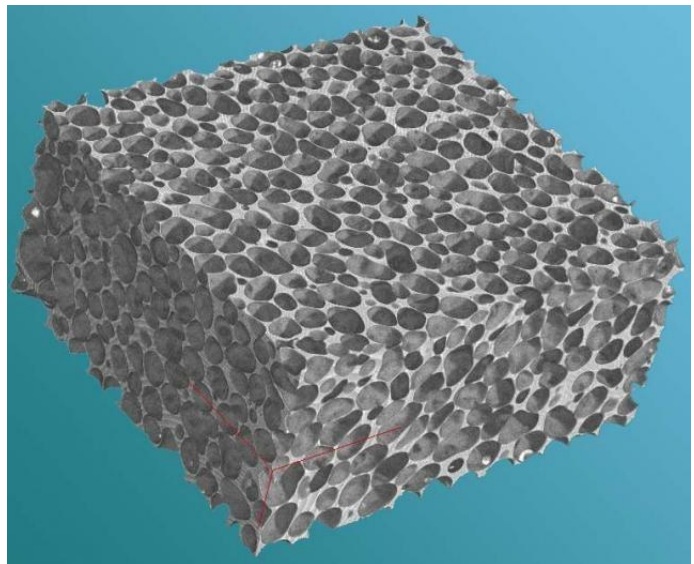
It is the ability of the material to absorb and retain water. It is calculated from the following equation:

$$W = ((M_2 - M_1) / M_1) * 100\%$$

Where:  $M_2$ : Wet weight

$M_1$ : dry weight

W: absorb ratio



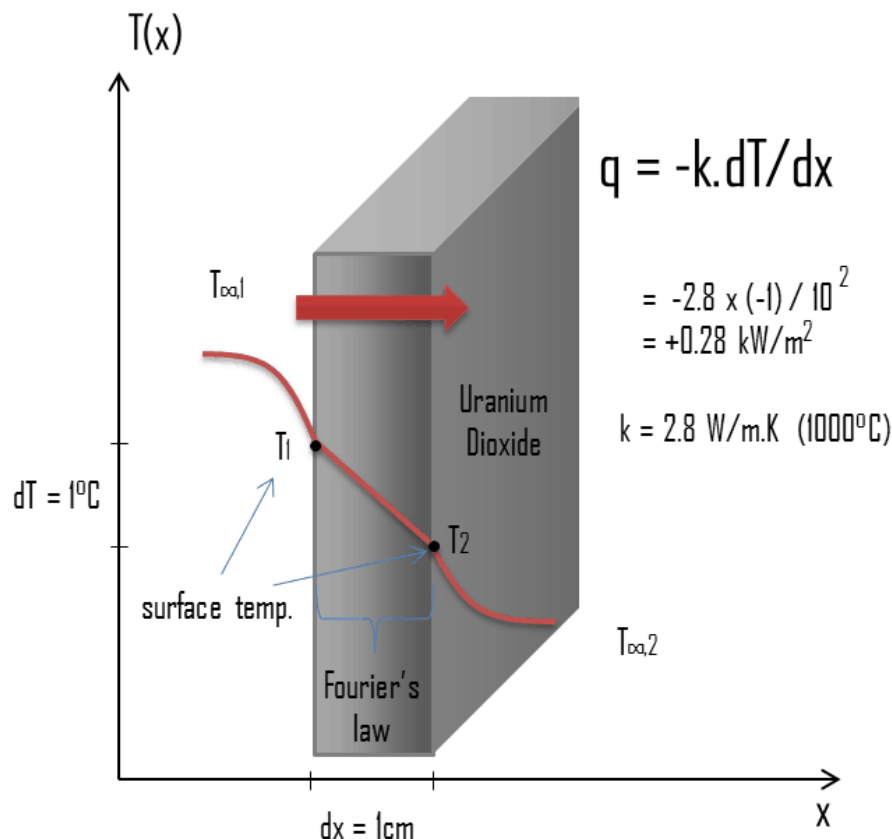
### g- Water Permeability: نفاذية الماء

(It is the ability of a substance to allow liquids (water) to penetrate through it). Permeability in fluid mechanics and the Earth sciences commonly symbolized as (k) is a measure of the ability of a porous material (often, a rock or an unconsolidated material) to allow fluids to pass through it. The ability of a material to permit water through it is called water permeability. Dense materials like glass metals etc. are called impervious materials which cannot allow water through it



## h- Thermal Conductivity: التوصيل الحراري

It is expressed by the coefficient of thermal conductivity coefficient, which equals the amount of heat passing through a sample of 1 m<sup>2</sup> and a thickness of 1 m within one hour when the difference between the temperatures on both ends of the model is 1 C<sup>0</sup>.



## K- Durability: الديمومة

**Durability** is the ability of the material to resist the combined effect of weather and other factors (dissolved salts in water, the effect of freezing and thawing ...) and maintaining design characteristics for the longest possible period. also we can define **Durability** is the ability of a physical product to remain functional, without requiring excessive maintenance or repair, when faced with the challenges of normal operation over its design lifetime. The property of a material to withstand against all atmospheric



actions without losing its strength and shape. Weathering effects the durability of material. For example corrosion occurs in iron due to weathering. To resist this paint layer is provided

### **J- Specific Gravity of Building Materials:الوزن النوعي**

**Specific gravity** is the ratio of mass of given substance to the mass of water at 4°C for the equal volumes. Specific gravity of some materials is listed below.

Material	Specific gravity
Steel	7.82
Cast iron	7.20
Aluminum	2.72

### **L- Fire Resistance of Building Materials:مقاومة الحرق**

The ability to withstand against fire without changing its shape and other properties. Fire resistance of a material is tested by the combined actions of water and fire. Fireproof materials should provide more safety in case of fire.

### **M- Frost Resistance of Building Materials:مقاومة الأنجماد**

The ability of a material to resist freezing or thawing is called frost resistance. It is depends upon the density and bulk density of material. Denser materials will have more frost resistance. Moist material has low frost resistance and they lose their strength in freezing and become brittle.





### N- Water Absorption: امتصاص الماء

The capacity of a material to absorb and retain water in it is known as water absorption. It is expressed in % of weight of dry material. It depends up on the size, shape and number of pores of material.

### O- Hygroscopicity: التميّه (امتصاص الماء من الهواء)

Hygroscopicity is the property of a material to absorb water vapor from the air. It depends on the relative humidity, porosity, air temperature etc.

## QUESTIONS OF LECTURE TWO

- 1- What is the meaning of Properties of Materials?
- 2- What is the meaning of Building Materials?
- 3-What is the importance of studying the properties of construction materials?
- 4- Why should The engineer be familiar with the properties of construction material?
- 5- Define the following (Density, Porosity, Bulk Density, Void Content, Water Absorption, Water Permeability, Thermal Conductivity, Durability, Specific Gravity, Fire Resistance, Frost Resistance Water Absorption, Hygroscopicity).