General physical properties of ceramic materials include:-
1- Density:- there are three types of density:
a) Green density:- represents the mass of a material before firing divided by its total volume it is significant in:
***** Consider a good indicator for material toughness (dry toughness), whereas increments in green density increase dry toughness.
* Consider a good indicator for interrelate process happening between grains after firing by comparison it with density of materials after firing. Green density increases by increasing
1) compaction pressure. 2) decreasing applied compaction rate. 3)decreasing particles hardness. 4)particle size. 5)particle size distribution.

b) Apparent density(bulk density):- it's a ratio between fired mass and exterior volume (total volume)

c) True density:- its also called true specific weight and it's the ratio between fired mass to the volume of solid part only and it's a constant property for each material.

2- Porosity and water Absorption:- Most ceramic products can be classed as pores solids, in which the continuity of the solid matter is interrupted by voids of different kinds.
In general there are two main types of pores: open and sealed or closed pores.
Open pores are voids which are accessible to penetrate by a fluid they exist because of the imperfect packing of the particles of the material and also due to escape of gases during drying and firing processes.
Sealed pores are formed on firing when bubbles of gas are frozen into the glassy matrix, or when open pores are sealed by molten materials, so pores were isolated inside material. Two types of porosity
a) ***Apparent porosity:-*** is the ratio of the open pores volume to the total volume of the object.
b) ***True porosity:-*** is the ratio of the open and closed pores volume to the total volume of the object.
c) ***Water absorption:-***is the ratio of open pore volume to the dry weight of the test piece.

2- ***Specific gravity:-*** is the ratio of material density to the water density at 4°C or it's the ratio between ceramic material weight to the weight of water volume equal to the volume of solid material part.
In calculating these physical properties we depend on the ASTM standard (C-373-88) and each test result is the average of three samples.

Procedure and Calculation:
1- Drying the test specimens to constant mass by heating in an oven at 150°C, followed by cooling in a desiccator. The dry mass (D), was determined to the nearest 0.01 g.

2- Immersing the specimens in a pan of distilled water and boiling them for 5 h, taking care that the specimens are covered with water at all times. Using setter pins or some similar device to separate the specimens from the bottom and sides of the pan and from each other. After 5 h boiling, allowing the specimens to soak for an additional 24 h.

3- After impregnation of the test specimen in water, then the suspended mass (S), was determined to the nearest 0.01 g, while suspended in water.

4- After determination of the suspended mass, each specimen was blotted lightly with a moistened cotton cloth to remove all excess water from the surface. The saturated mass (M), was determine to the nearest 0.01 g after rolling the specimen lightly on the wet cloth.

Excessive blotting of specimen will introduce error by withdrawing water from the pores of the specimen. Make the weighing immediately after blotting, the whole operation being completed as quickly as possible to minimize errors caused by evaporation of water from the specimen.

Calculate the exterior volume, V, in cubic centimeters, as follows:

V = M – S -----------------(1)

Calculate the volumes of open pores VOP and impervious portions VIP in cubic centimeters as follows:

VOP = M - D -----------(2)

VIP = D - S ---------------(3)

The apparent porosity, P, expresses as a percent as:

P = {(M – D)/V} * 100 -------------(4)

The water absorption, A, expresses as a percent as:

A ={(M – D)/D} * 100 -----------(5)

Calculate the true density, T:

T = D/(D – S) -------------(6)

Bulk density:

B = D/V --------(7)

Calculate the specific gravity with respect to water at 4°C, using ASTM standard **(C 329 – 88)** the *Pycnometer method* as follows:

S.G = (W – p)/{(W**1** – p) – (W**2** – W)} (8)

Where:-

p = weight of the stoppered pycnometer .

W = weight of the stoppered pycnometer and specimen.

W1 = weight of the stoppered pycnometer filled with water.

W2 = weight of the stoppered pycnometer, specimen, and water.

Moisture content and loss on ignition:

The moisture content of raw materials is a very important consideration as it varies between wide limits in the same materials owing to such factors as condition of shipping and storage and the chemical and physical nature of the materials. Water may occur in materials in two different ways as water mechanically held (mechanical water), or as water of constitution. Water of constitution is water tied up as an integral part of the molecule, as in ($Al_2O_3.3H_2O$) or as water of crystallization as in borax ($Na_2B_4O_7.10H_2O$). This water of constitution is generally constant for any one particular material. The mechanically held water is the water or moisture on the surface or between the particles of the material. To determine the water mechanically held or, in some cases, some of the water of crystallization, a weighed sample is placed in a dryer at 110◦C until it comes to constant weight. The difference between the weight of the sample when dry and its original weight is the weight of the mechanical water contained in it. The percentage moisture may be based either on the original weight or on the dry weight. The latter is the better practice.

Example

Suppose a 100 g sample of clay, after being dried to constant weight at 110◦C, weights 87 g. what is the percentage moisture based on 1) The wet weight? 2)The dry weight?

100 - 87 =13 g of moisture

Percentage moisture (W. W.)= (Grams of moisture/ Wet weight) X 100

=13/100X100= 13%

Percentage moisture (D. W.)= (Grams of moisture/ Dry weight) X 100

= 13/87)X100= 14.9%

Many ceramic materials contain other volatile constituents, beside water, which are driven off only at higher temperatures. Clay for instance, may contain carbonaceous materials, which decompose, carbon, which oxidizes and carbonates, which decompose along with sulphides, sulphates, and other salts, which break down under oxidation, reduction, or heating. The temperatures at which these changes take place vary in different materials and for different constituents. The determination of these volatile constituents is important in the calculation of melted weights of frits for enamels, glazes etc. The loss on ignition, gives an indication of the carbon content of clays.

The loss on ignition is the percentage loss in weight of strongly heated sample to constant weight at a specified temperature, it is determined by ignition of all of the volatile constituents. In the laboratory such a test is made by heating a weighed sample in a porcelain crucible, the difference between the original weight of the sample and its weight after ignition is

the loss on ignition, and it represent as a percentage based on unignited sample weight or on ignited weight.

Percentage loss on ignition = (loss in weight/ weight of original sample)* 100

On heating a sample of clay, the mechanical water left from drying is first driven off. Near red heat, the water of constitution is driven off, carbonaceous material decompose, and if there is sufficient air present, the carbon burns to carbon dioxide. if the sample is not heated too fast all the carbon burns out, but if it is heated too fast the carbon becomes entrapped by the fusion of the material and is thereby protected from further oxidation. The sulphides begin to decompose and oxidize to the oxides of sulphur, which go off as a gas, at higher temperature the carbonates decompose into the oxides of the metal and carbon dioxide gas, and at still higher temperature, under proper conditions, even the sulphates decompose.