Clay and Its Classifications

Clay is the most important raw material used for making bricks. It is an earthen mineral mass or fragmentary rock capable of mixing with water and forming a plastic viscous mass which has a property of retaining its shape when molded and dried. When such masses are heated to redness, they acquire hardness and strength. This is a result of micro-structural changes in clay and as such is a chemical property. Purest clays consist mainly of kaolinite ($2SiO_2.Al_2O_3.2H_2O$) with small quantities of minerals such as quartz, mica, feldspar, calcite, magnesite, etc. By their origin, clays are subdivided as residual and transported clays. Residual clays, known as Kaolin or China clay, are formed from the decay of underlying rocks and are used for making pottery the transported or sedimentary clays result from the action of weathering agencies. These are more disperse, contain impurities, and free from large particles of mother rocks.

On the basis of resistance to high temperatures (more than 1580°C), clays are classified as refractory, high melting and low melting clays. The refractory clays are highly disperse and very plastic. These have high content of alumina and low content of impurities, such as Fe2O3, tending to lower the refractoriness. High melting clays have high refractoriness (1350–1580°C) and contain small amount of impurities such as quartz, feldspar, mica, calcium carbonate and magnesium carbonate. These are used for manufacturing facing bricks, floor tiles, sewer pipes, etc. Low melting clays have refractoriness less than 1350°C and have varying compositions.

These are used to manufacture bricks, blocks, tiles, etc. Admixtures are added to clay to improve its properties, if desired. Highly plastic clays which require mixing water up to 28 percent give high drying and burning shrinkage, call for addition of lean admixtures or non-plastic substances such as quartz sand, calotte, ash, etc. Items of lower bulk density and high porosity are obtained by addition of admixture that burn out. The examples of burning out admixtures are sawdust, coal fines, and pulverized coal. etc.

Acid resistance items and facing tiles are manufactured from clay by addition of water-glass or alkalis. Burning temperature of clay items can be reduced by blending clay with fluxes such as feldspar, iron bearing ores, etc. Plasticity of molding mass may be increased by adding surfactants such as sulphite-sodium vinasse (0.1–0.3%).

Physical Properties of Clays

Plasticity, tensile strength, texture, shrinkage, porosity, fusibility and color after burning are the physical properties which are the most important in determining the value of clay. Knowledge of these properties is of more benefit in judging the quality of the raw material than a chemical analysis. By plasticity is meant the property which wetted clay has of being permanently deformed without cracking. The amount of water required by different clays to produce the most plastic condition varies from 15 to 35 per cent. Although plasticity is the most important physical property of clay, yet there are no methods of measuring it which are entirely satisfactory. The simplest and the most used test are afforded by feeling of the wetted clay with the fingers. Personal equation necessarily plays a large part in such determination.

Since clay ware is subjected to considerable stress in molding, handling and drying, a high tensile strength is desirable. The test is made by determining the strength of specimens which have been molded into briquette form and very carefully dried. The texture of clay is measured by the fineness of its grains. In rough work the per cent passing a No. 100 sieve is determined. No numerical limit to the grain size or desired relation between sizes has been established. Very fine grained clays free from sand are more plastic and shrink more than those containing coarser material. Knowledge of shrinkage both in drying and in burning is required in order to produce a product of required size. Also the amount of shrinkage forms an index of the degree of burning. The shrinkage in drying is dependent upon pore space within the clay and upon the amount of mixing water. The addition of sand or ground burnt clay lowers shrinkage, increases the porosity and facilitates drying. Fire shrinkage is dependent upon the proportion of volatile elements, upon texture and the way that clay burns.

By porosity of clay is meant the ratio if the volume of pore space to the dry volume. Since porosity affects the proportion of water required to make clay plastic, it will indirectly influence air shrinkage. Large pores allow the water to evaporate more easily and consequently permit a higher rate of drying than do small pores. In as much as the rate at which the clay may be safely dried is of great importance in manufacturing clay products, the effect of porosity on the rate of drying should be considered.

Clay Minerals:-

1-Kaolinite:-

Kaolinite $\{Si_2Al_2O_5(OH)_4\}$ or $Al_2O_3.2SiO_2.2H_2O$ is the most common among the minerals used in ceramics. A projection of its crystalline structure.

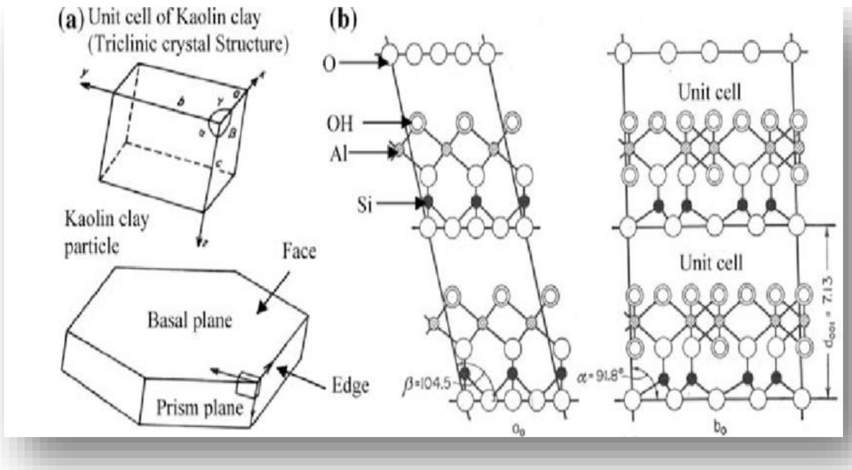

Fig.(2)

It consists of an alternate stacking of types of layers containing aluminum in an octahedral and silicon in tetrahedral coordination. Their large specific surface (10 to 100 m^2/g), there plate – like structure enable clays to form with water colloidal suspension and plastic pastes.

2-Montmorillonite Clay:-

There are two layers of tetrahedral holes to every one of octahedral ones. This clay mineral has the common properties of absorbing large quantities of water between adjacent layers, changing the basal spacing from (10 to 20 A°). The oxygen lattice is such that its spaces may be filled by different atoms the octahedral spaces may have aluminum, magnesium, ferric iron or zinc, the tetrahedral spaces may have silicon or aluminum. The charges are often unbalanced and large numbers of cations are adsorbed and may be easily exchanged figure (3).

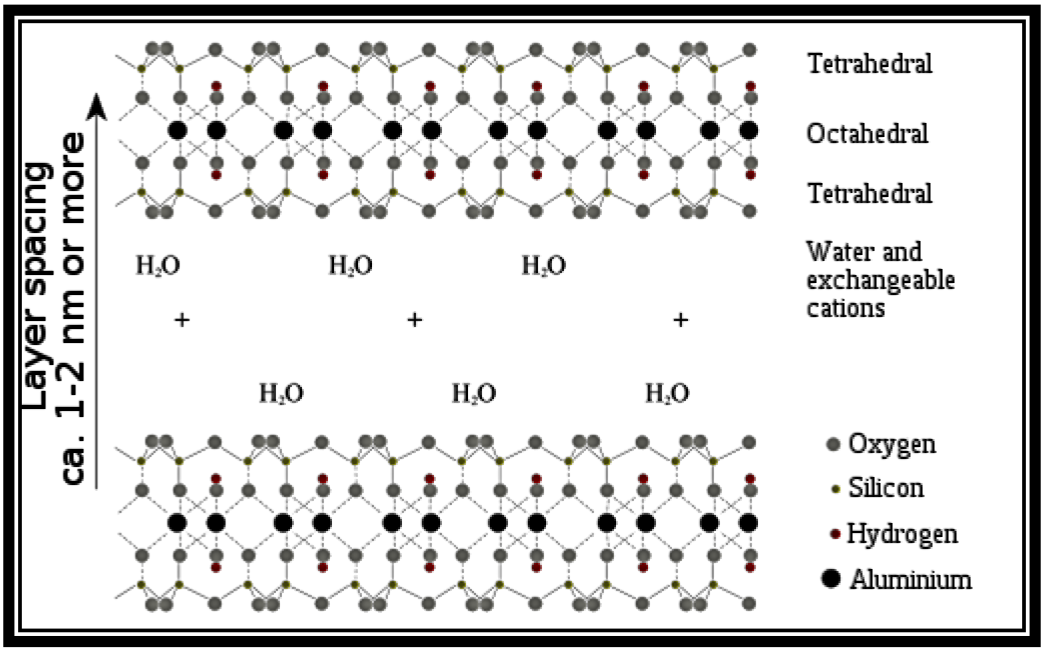

Fig.(3)

<u>3-Illite clay:-</u>

The next group of clay mineral is the illite or hydro mica group figure (4).

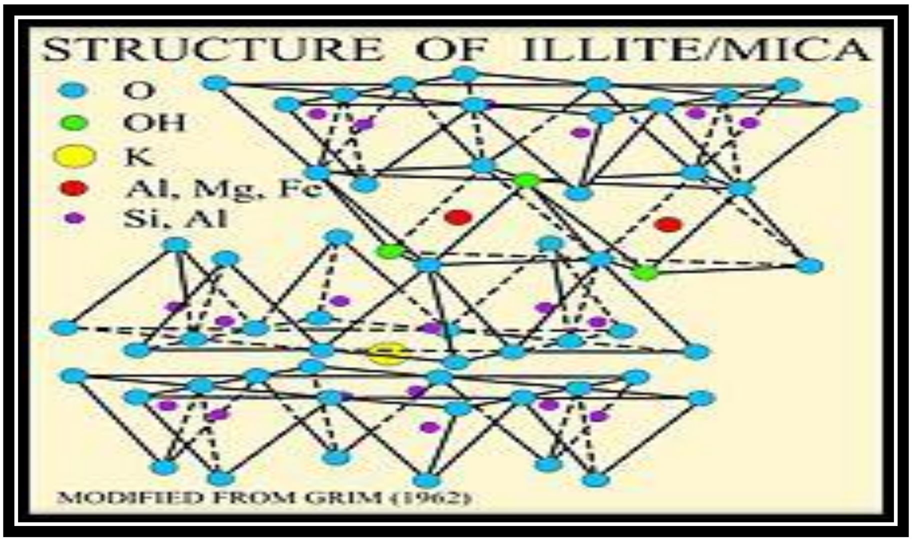

Fig.(4)

The micas have larger spaces which contain cations to keep the charge neutral. Unlike the montmorillonites water does not inter into the lattice itself and expand it, as adjacent layers are held together by potassium ions the general formula is:

$\{(OH)4K_y(Al_4.Fe_4.Mg_4.Mg_6)Si_{8-y}Al_yO_{20}\}$with (y) varying from (1 to 1.5).

<u>2- Quartz:</u>

Quartz, or α-quartz, is the mineral form of SiO2 stable at low temperatures and pressures. The English word derives from the Saxon word querkluftertz (cross-vein ore). It occurs in igneous, sedimentary, metamorphic, and hydrothermal mineral environments, particularly in continental regions. It is, however, rare in oceanic rocks. As the structure is acentric, it occurs in both left and right-handed varieties and is both piezoelectric and pyro electric. It is usually nearly pure and accepts only very limited amounts of other elements in substitution. Polymorphs include β-quartz, tridymite, cristobalite, coesite, stishovite, and keatite.

The atomic structure of quartz has been shown in consist of a three dimensional network of sio_4 tetrahedrons linked in to a compact structure, as would be expected from a high sp.gravity. the open holes in the structure are so small that other atoms cannot enter and therefore the crystal are always of high purity and with high sp.gravity (2.65) one of the most characteristic properties of quartz is the reversible inversion from the low to high form at temperature of 573°C

The action of heat on silica:

α- quartz $\xleftrightarrow{573°c}$ ß- quartz $\xleftrightarrow{873}$ $ß_2$- tridymite $\xleftrightarrow{1470}$ ß-

With increase in volume of 2%   With increase in volume of 12%

cristobalite $\xleftrightarrow{1710}$ molten

Tridymite and cristobalite have a more open structure than quartz and this account for their low sp.gravity.

Sand: is defined by the (ASTM) as granular rock particles that pass throw No. 4-mesh (4.75mm aperture) are retained on a No.200Mesh (75µm aperture sieve).

Physical Properties

The physical and optical properties of quartz are outlined in Table 1. It is generally colorless, but many colored varieties have been described, including rose quartz (pink), amethyst (purple), citrine (yellow) and smoky quartz (gray). The luster is vitreous, and there is no cleavage so it exhibits conch.oidal fracture. The hardness is seven, and the density is 2.67 g/cm3. Optically, it is uniaxial, positive with a maximal birefringence of 0.0095.

Chemical Formula	SiO_2
Optical Properties	Uniaxial positive Nω = 1.5443 Nε = 1.5538
Cleavage	None
Common crystal forms	Prism {1010} Pyramids {1011} and {0111}
Luster	Vitreous
Color, Opacity	Transparent, colorless Also gray (smoky quartz), blue, purple (amethyst), yellow (citrine), pink (rose quartz)
Hardness	7

General and Physical Properties of Quartz