YILDIZ TECHNICAL UNIVERSITY – DEPARTMENT OF ARCHITECTURE
2017 -2018 ACADEMIC YEAR – SPRING SEMESTER
BUILDING MATERIALS LECTURE NOTES / Dr. Polat DARÇIN

BASIC MATERIALS – 3

CLAY and CLAY BASED MATERIALS

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 its 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.

kaolinite

quartz

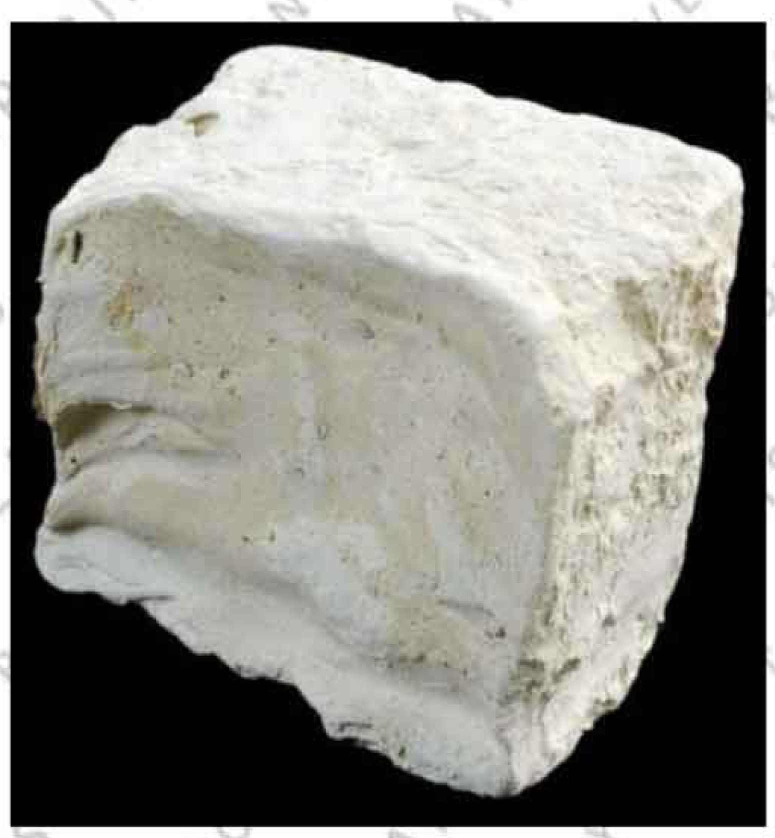
mica

feldspar

calcite

magnesite


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.


residual clay


sedimentary clay

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 Fe_2O_3, 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.

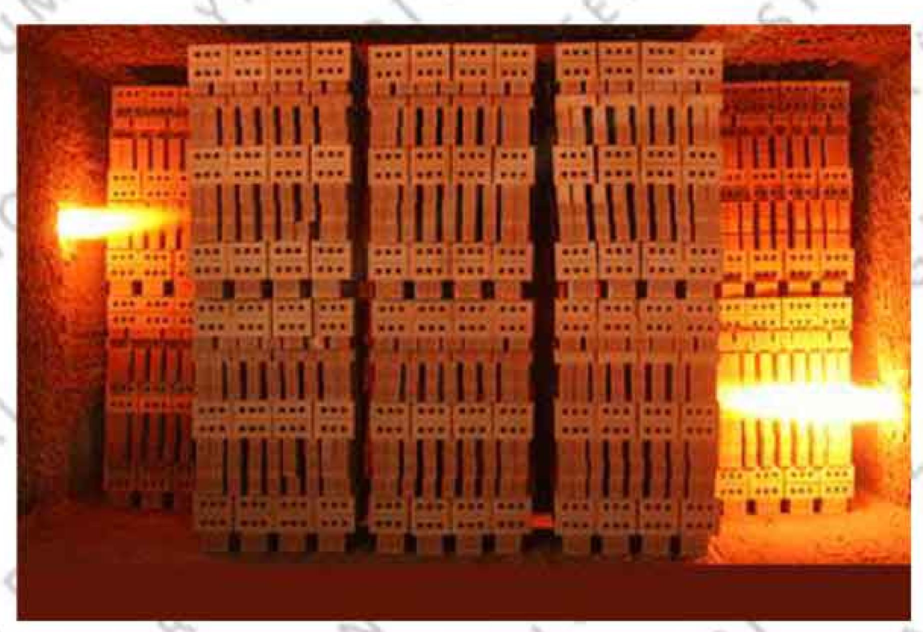
Admixtures are added to clay to improve its properties, if desired.

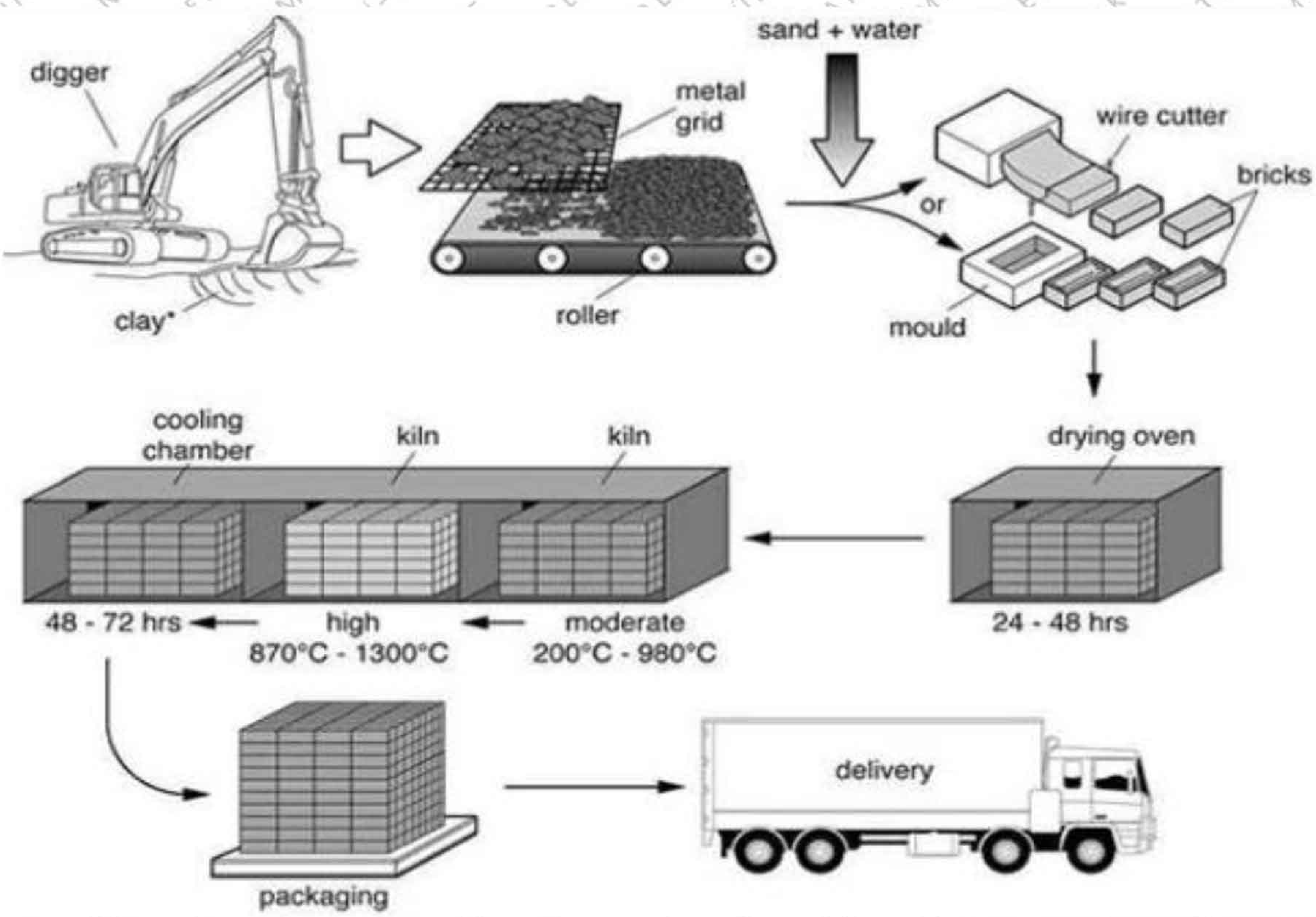
- **Highly plastic clays** which require mixing water up to 28 %, give high drying and burning shrinkage, call for addition of **lean admixtures** or **non-plastic substances** such as quartz sand, chamottee, ash, etc.
- Items of **lower bulk density** and **high porosity** are obtained by addition of admixture that burn out. The examples of **burning out admixtures** are sawdust, coal fines, pulverized coal, etc.
- Acid resistance items and facing tiles are manufactured from clay by addition of water-glass or alkalis.

Clay products or building ceramics are basically selam arkadaşlar fabricated by molding, drying and burning clay mass. Higher the bulk specific gravity, the stronger is the clay product.


molding


drying

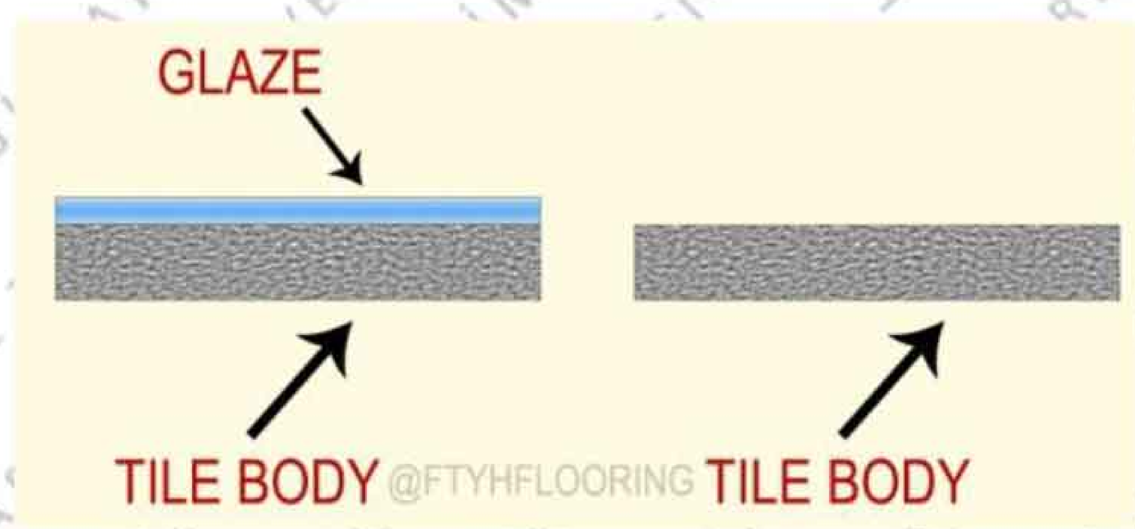

burning



Clay products can be used as vitrified or unglazed.


vitrified


unglazed

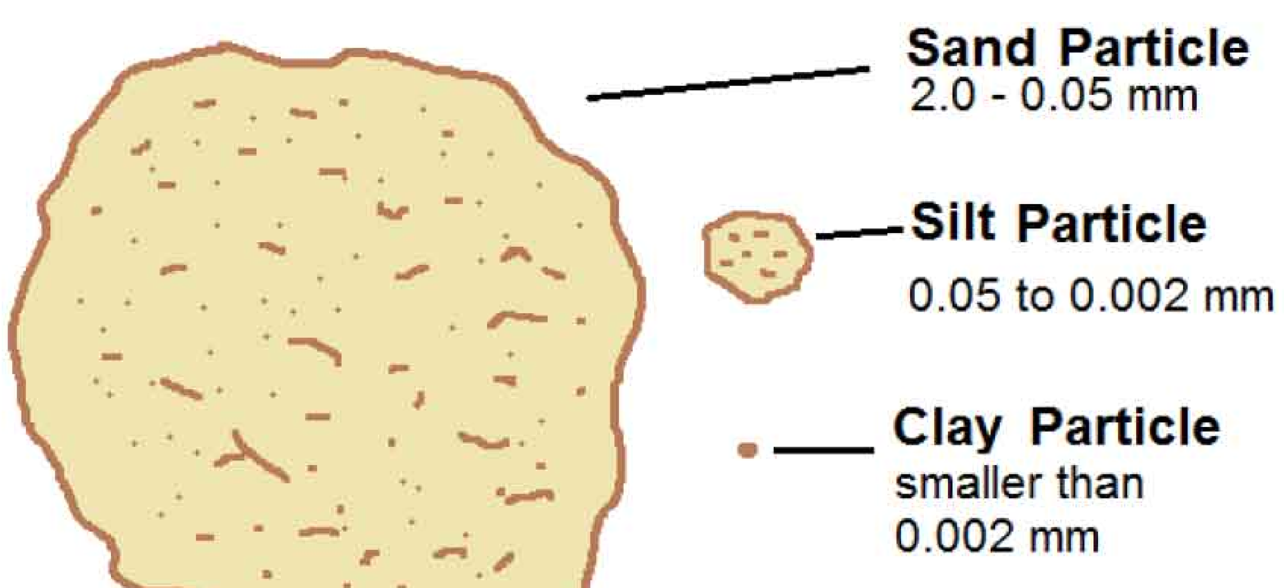


Properties of Clay Products

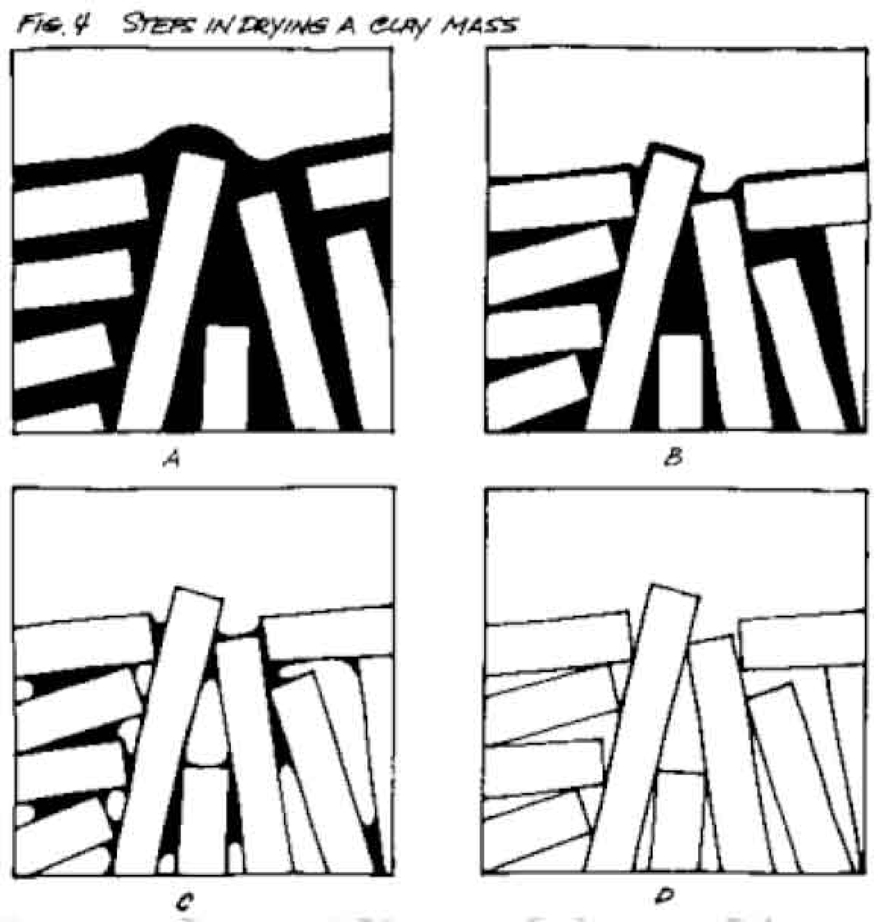
Plasticity, tensile strength, texture, shrinkage, porosity, fusibility and color after burning are the physical properties which are the most important in determining the value of clay.

Plasticity is the property which wetted clay has of being permanently deformed without cracking. The amount of water required bu haftadan itibaren bilmecenin çözümü için şifrelere başıyoruz by different clays to produce the most plastic condition varies from 15 to 35 %. Since clay ware is subjected to considerable stress in molding, handling and drying, a high tensile strength is desirable.

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.



The temperature at which clay fuses is determined by the proportion of fluxes, texture, homogeneity of the material, character of the flame and its mineral constitution. Owing to non-uniformity in composition, parts of the clay body melt at different rates so that the softening period extends over a considerable range both of time and temperature.

The clay used for various building products consists mainly of silica and alumina mixed in such a proportion that the clay becomes plastic when water is added to it. It also consists of small proportions of lime, iron, manganese, sulfur, etc. The proportions and functions of various ingredients are as follows:

silica (50-60%): It enables the product to retain its shape and imparts durability, prevents shrinkage and warping. Excess of silica makes the product brittle and weak on burning. A large percentage of sand or uncombined silica in clay is undesirable. However, it is added to decrease shrinkage in burning and to increase the refractoriness of low alumina clays.

alumina (20-30%): absorbs water and renders the clay plastic. If alumina is present in excess of the specified quantity, it produces cracks in brick on drying. Clays having exceedingly high alumina content are likely to be very refractory.

lime (10%): in clay reduces the shrinkage on drying, causes silica in clay to melt on burning and thus helps to bind it. In carbonated form, lime lowers the fusion point. Excess of lime causes the product to melt and lose its shape.

magnesia (1%): affects the color and makes the product yellow, in burning; it causes the clay to soften at slower rate than in most case is lime and reduces warping.

iron oxide (7%): Gives red color on burning when excess of oxygen is available and dark brown or even black color when oxygen is insufficient, however, excess of ferric oxide makes the product dark blue. Improves impermeability and durability. Gives strength and hardness.

alkaline salts (10%): are of great value as fluxes, especially when combined with silicates of alumina. These are mainly in the form of soda or potash. However, when present in excess, alkali makes the clay unsuitable for products. When products come in contact with moisture, water is absorbed and the alkalis crystallize. On drying, the moisture evaporates, leaving behind grey or white powder deposits on the product which spoils the appearance. This phenomenon is called **efflorescence**.

Fire Clay (Refractory Clay)

Fire-clay is a term, including sedimentary or residual clays which vitrify at a very high temperature and which, after burning, possess great resistance to heat. These are pure hydrated silicates of alumina and contain a large proportion of silica 55–75%, alumina 20–35%, iron oxide 2–5% with about 1 % of lime, magnesia and alkalis. The greater the percentage of alumina, the more refractory the clay will be. Fire clays are capable of resisting very high temperatures up to 1700°C without melting or softening. The presence of a small percentage of lime and magnesia and alkalis help to melt the clay particles more firmly, whereas a large percentage of lime and magnesia tend to melt the clay at low temperatures. Iron oxide or other alkalis reduce refractory qualities of fire clay.

Porcelain

A high grade ceramic ware having white color, zero water absorption and glazed surface consists of finely dispersed clay, kaolin, quartz and feldspar, baked at high temperature and covered with a colored or transparent glaze. The glazing material is applied before firing. At high temperatures, the feldspar particles fuse and bind the other constituents into a hard, dense, and vitreous mass. High temperature ensures non-porosity and a better product. Because of white color, it is also called white ware. Porcelain is used for manufacturing sanitary wares, containers and crucibles, reactor chambers and electric insulators.

Stoneware

A hard ceramic material resembling porcelain with a different color, usually grey or brownish is made from refractory clay mixed with crushed pottery, stones and sand burned at high temperatures and cooled slowly. The clay used for making stoneware consists of about 75 %silica and 25 %alumina. Iron oxide is added to give color. It is hard, compact, strong and durable and glazed stoneware becomes resistant to chemical and weathering action. Stonewear can be used for sanitary ware, drain pipes and fittings, flooring and wall tiles.

Earthenware

These are made by burning the ordinary clay at low temperature and cooling slowly. To check shrinkage, sand and crushed pottery are mixed with clay. This also increases the toughness, hardness and strength of the ware. Earthenware products are generally soft, porous and weak. If glazed, it becomes resistant to weathering effects. It can be used to produce drain pipes, lavatory fittings and partition wall pieces.

Glazing

Bricks, tiles, earthenwares and stonewares are glazed by an impervious film to protect the surface from chemical attack and other weathering agencies.

transparent glazing: There are many methods for imparting transparent glazing, but salt glazing is most commonly used, since this makes the items impermeable. It consists of throwing sodium chloride in the kiln when burning is at peak (1200°–1300°C). The heat of the kiln volatizes the salt, which enters into the pores of the burning item and combines with the silica in clay to make soda silicate. The soda silicate combines with alumina, lime and iron in the clay to form a permanent thin, transparent surface coating.

opaque glazing: This is also known as enameling. Borax, kaolin, chalk and coloring matter is fired with total or a part of feldspar, flint, and lead oxide. The resulting molten glass is poured into water to give shattered frit. The frit is then ground with remaining materials and water; this substance is known as slip. Fully burnt earthenwares known as biscuits are dipped in the slip. The biscuits absorb water and form thin layer of glaze on the surfaces. After drying the products, these are once again fired to a lower temperature so as to fuse the glaze.