CHAPTER 3
SOILS FOR BRICK MAKING

3.1 SOILS FOR BRICK MAKING IN INDIA

India is a tropical country and there is a large variation in the type of soil available. The soils of India can be considered in two major groups: i) transported soils of the Indo-Gangetic plains and the valleys of South India and ii) residual soils of peninsular India. The transported soils are as a result of deposition of the sediment brought by streams, winds, etc. The thickness of deposit varies from place to place and they consist of sand, silt and clay with occasional deposit of clay and gravel.

The residual soils have been formed over a variety of geological formations and mostly cover the peninsular India. Residual soils can be classified as black soils, red soils, lateritic soils, red-yellow soils. Black cotton soil deposits occur in Maharashtra, Gujrat, Madhya Pradesh and part of Andhra Pradesh. Red loam or red yellow soils are found in parts of Assam, Bihar, Orissa, Andhra Pradesh, Maharashtra, Madras, Mysore and Manipur. Scattered deposits of lateritic soil occur in Kerala, parts of Andhra Pradesh, Mysore, Assam, West Bengal and Orissa.

The alluvial soils in Indo-Gangetic plain are coarse and their fineness increases as the deltas are approached. The soils in water logged areas called reh, kellar, usar is generally considered as unsuitable both for cultivation and making of bricks. In general the alluvial soils consist of illicit clay mineral and are suitable for the manufacture of various types of bricks. The transported soil called coastal alluviums is found at the strips of eastern and western parts of the country.

Black cotton soil belonging to the residual group contains high alumina, lime, and magnesia, variable amount of nitrogen and potash and fair proportion of organic matter.
Such soils are highly plastic, swell and shrink enormously after wetting and drying respectively, due to montmorillonitic mineral group. Such soils present difficulties in manufacture of consistent good quality bricks.

The red colour of red soils is mostly due to oxidation and wide diffusion of the iron content in to the material. The freshly dug red soil is soft but on dehydration it becomes hard. The soils are often coarse, loamy, calcareous and present difficulties in moulding of bricks. Bricks manufactured from red soils are porous in nature and generally of low compressive strength.

The transported soils do not form any definite group of soils, as they are mainly alluviums formed as a result of sediments brought by rivers, winds, etc. Generally the deposits consist of sand, silt and clay. The alluvial soils in the Western parts of Indo-Gangetic plain are coarse and their fineness increases as the deltas are approached. The alluvial soils basically consist of illitic clay minerals and are suitable for manufacture of bricks.[14]

\[(\text{OH})_x \, K_y \, (\text{Si}_{k-y} \, \text{Al}_y) \, (\text{Al}_4 \, \text{Fe}_4 \, \text{Mg}_4 \, \text{Mg}_6) \, \text{O}_{20} \quad \text{(3.1)}\]

\[y = 1 \text{ to } 1.5\]

The residual soils of various types, covering large area in the peninsular region, have been formed over a variety of geological formations. These soils can be classified as black soils, red soils, lateritic soils, etc.

Black cotton soil, belonging to residual group, is a clayey soil containing high alumina, lime, magnesia. Kankar content in these soils is usually high and clay mineral present is of montmorillonitic group having property of swelling considerably when wetted and cracking while drying.

\[\text{(OH)}_4 \, (\text{Al}, \, \text{Mg}, \, \text{Fe})_4 \, (\text{Si}_2 \, \text{O}_5) \, \times \, \text{H}_2\text{O} \quad \text{(3.2)}\]
Owing to the basic qualities of the black cotton soils it is difficult to manufacture good quality bricks from such soils.

Red soils are found in the areas occupying the rocks of high degree of maturity as granites and gneisses. The red colour of the soil is due to iron oxides. The composition varies considerably with the character of original rock. Red soils do not make good bricks due to their coarse and sandy nature and also low plasticity. Bricks obtained from such soils are porous and generally have poor strength.

3.2 SOILS OF MAHARASHTRA IN GENERAL AND MARATHWADA IN PARTICULAR

Maharashtra lies between 15°35’and 22°2’ North latitude and 72°45’and 80°45’East Longitude and has an area of about 1,21,310 square miles. A number of big rivers drain this area, i.e. the Bhima, the Godavari, the Tapi and their various tributaries.[103]

The most important soils of the state are a) the deep black, b) medium black, the shallow black, d) laterite and lateritic, e) the red and grey soils and f) coastal alluvium. The largest area is occupied by black soils. The colour of the black soil varies from deep black to grey. In black cotton soil, colour of the clayey fraction is black, other fraction is ashy or ashy brown. Deep black to shallow black soils are observed in most parts of Maharashtra. Laterite and lateritic soils are observed in Konkan region. Coastal alluvium is observed along the seashore. The red and grey soils are observed near hill slopes.

Figure 3.1 shows soil map of Marathwada from which it is observed that the Marathwada soils consist of coarse shallow soils red in colour (high level), medium black soils (plain), deep black soils in hill. In Marathwada deep black soils are observed in the region which are mainly developed on alluvial material along the course of river Godavari, Manjara, etc. and are observed on low lying area of flat topography. Medium black soils are
Figure 3.1: Soil map of Marathwada
Figure 3.1 (Continued) : Map of India Showing Location of Study Area
observed in the flat plains. On the hill slopes coarse shallow sandy soils are observed. These are a complex group of soils varying in depth and texture. These soils are reddish-brown to yellowish red in colour varying in depth from 75 mm to 450 mm. These are sandy loams with gravel and iron concretions. Poyta soil in very less quantity can be observed along the riverbanks.

3.3 GEOLOGY OF SOILS OF MAHARASHTRA

The rocks forming the state can be classified in to the following divisions: (i) A group of very ancient rocks partly crystalline and partly sedimentary. These include a variety of granites and gneisses, which occur in the southern districts of Kolhapur and also in parts of Rewa. (ii) An immense accumulation of volcanic rocks, principally basaltic lavas, known as Deccan trap.

The Deccan trap is the most important geological formation in the state. The term trap is applied to the step like aspect of the weathered hills of basalt, which is the most common feature in the state. In composition the basalts are singularly uniform. Augite basalts of specific gravity 2.68 are the most common. The colour of the rock is greyish-green with lighter or deeper shades. The bulk of the rock is composed of a fine-grained mixture or ground mass of feldspar or augite. Besides abundant plagioscope prisms, some times large tubular crystals of clear glassy orthoclase as phenocrysts in the ground mass are observed. Primary accessory minerals like apatite are few but secondary minerals like calcite and quartz are plenty.

3.4 MINERALOGY OF CLAY

Extensive research all over the world has established beyond doubt that the properties of soils are determined to large extent by the nature and amount of clay material present in it. The clay material is the fraction of soil having diameter of particles less than
0.002 mm. These are composed of one or more groups of aluminium silicates known as ‘clay minerals’. They originate from the decay of certain minerals from the primary constituents of igneous rocks. It is difficult to investigate the exact mineralogy of the clay minerals. X-ray diffraction, infrared spectrophotometry or Differential Thermal Analysis (D.T.A.) is needed to separate the various species. These methods are time consuming and beyond the resources of most of the brick manufacturers. These facilities are not available in almost all engineering colleges and polytechnics.

The basic rocks from which clays are formed are complex alumino silicates. During weathering, these become hydolysed, the alkali and alkaline earth’s ions form soluble salts and are leached out. The remainder consists of hydrated alumino silicates of varying composition and structure and free silica. This remainder is therefore more refractory than the original igneous rock. Unchanged rock particles e.g. feldspar, mica and quartz remain in clay too.

The process can be represented by chemical equations as under: [113]

1) \[ \text{K}_2\text{O}\text{Al}_4\text{O}_2\text{Si}_6\text{O}_{18} + 2\text{H}_2\text{O} = \text{Al}_2\text{O}_3\text{Si}_2\text{O}_6\text{H}_2\text{O} + 2\text{KOH} \] hydrolysis

2) \[ \text{Al}_2\text{O}_3\text{Si}_2\text{O}_6\text{H}_2\text{O} = \text{Al}_2\text{O}_3\text{Si}_2\text{O}_6\text{H}_2\text{O} + 2\text{SiO}_2 \] desilication

3) \[ \text{Al}_2\text{O}_3\text{Si}_2\text{O}_6\text{H}_2\text{O} = \text{Al}_2\text{O}_3\text{Si}_2\text{O}_6\text{H}_2\text{O} + 4\text{SiO}_2 \] desilication

4) \[ \text{Al}_2\text{O}_3\text{Si}_2\text{O}_6\text{H}_2\text{O} + \text{H}_2\text{O} = \text{Al}_2\text{O}_3\text{Si}_2\text{O}_6\text{H}_2\text{O} \] hydration

Kaolinite

5) \[ \text{Al}_2\text{O}_3\text{Si}_2\text{O}_6\text{H}_2\text{O} = \text{Al}_2\text{O}_3\text{H}_2\text{O} + 2\text{SiO}_2 \] desilication

6) \[ \text{Al}_2\text{O}_3\text{H}_2\text{O} + 2\text{H}_2\text{O} = \text{Al}_2\text{O}_3\text{Si}_2\text{O}_6\text{H}_2\text{O} \] hydration

Gibbsite

The hydrated silicate of aluminium is the clay substance, which gives the clays their main characteristics. One of the predominant properties of these substances is the extreme
fineness of their particles. As per Singer [113] this factor is so vital that their physico-
chemical nature, was for a long time major stumbling block to investigation. With the aid of
electron microscope, X-ray diffraction and D.T.A. it has now been established that clay
particles are extremely small flake-like particles of crystalline minerals.

The common clay minerals in soils are Kaolinite, illite, montmorillonite. These are
crystalline in nature. Very little work seems to have been done so far to ascertain the relative
proportion of clay minerals present in Indian soils. This work requires good amount of
laboratory facilities, which are rarely available. The chief one is the quartz, which together
with feldspar and mica are, unaltered remainders of the parent rocks.

3.5 STUDY OF SOILS FOR BRICK MAKING

The study of soils to be used for manufacture of bricks may be divided in two parts
in addition to the mineralogy, which has already been discussed in article 3.4.

1) Physical Analysis

2) Chemical Analysis

3.5.1 Physical Analysis

Clay is used to indicate a particle size in the mechanical analysis of sedimentary
rocks, soils etc. As a rock term, it is difficult to define precisely because of the wide variety
of materials that have been called as clays. In general the term clay implies a natural, earthy,
fine-grained material, which develops plasticity when mixed with limited quantity of water.
As a particle size term, the clay fraction is the size fraction composed of smallest particles.
The maximum size of particles in the clay size is 2 microns as per Bureau of Indian
Standards. The term clay material includes any fine-grained, natural, earthy argillaceous
material with appreciable contents of clay size grade. It is generally recognised that the
small size of particles in clay mineral is one of the reasons for their special attributes. It is
said that the particle size is the major factor and that, in fact, clays can be composed of almost any minerals if they are fine enough.

Clays perform two important functions in ceramic bodies. First, their characteristics plasticity is basic to many of the forming processes commonly used. The ability of clay water compositions to be formed and to maintain their shape and strength during drying and firing is basic to many ceramic processes. Secondly, they fuse over a temperature range depending upon their composition in such a way as to become dense and strong without losing their shape.

In short it can be said that, plasticity and fineness of particles are the two important physical properties of clay.

Plasticity - Plasticity is that property which enables a material to be deformed continuously and permanently, without rupture, during the application of a force, which exceeds the yield value of the material. Theoretically, a viscous liquid will flow with an infinitely small force. Its deformation-pressure curve passes through the zero-zero point. Plastic materials do not flow until the pressure has exceeded a certain yield value. They are then more correctly classified as solids with internal lubrication.

Fineness of clay particles - Nature in all parts of the world by common weathering processes has changed all kinds of rocks and minerals to the colloidal conditions. This is accomplished by disintegration, reduction in size and an increase in the number of particles with accompanying enormous increase in the area of surface exposed.

In all the above discussions the mention is made of clay only. It is not strictly clay as per the particle size classification. But the meaning of the clay in all above cases is brick earth- the raw material for the manufacture of burnt clay bricks.
As per IS 2117-1991 [134] the soil should preferably confirm to the following requirements:

Clay : 20 to 30 percent by weight.
Silt : 20 to 35 percent by weight.
Sand : 35 to 50 percent by weight.

Out of the above, clay is the most important item which will determine the most of the qualities of the bricks after all the processes.

3.5.2 Chemical Analysis

It consists of determination of the chemical composition of brick earth. The chief constituents of the brick making soil are as under:

(1) Kaolin (Al₂O₃·2SiO₂·2H₂O)

A principal constituent of igneous rocks is the feldspar, which may constitute up to 60 percent of this family of minerals. Orthoclase feldspar (K₂O·Al₂O₃·6SiO₂) is mainly responsible for yielding kaolin. Feldspar from igneous rocks under weathering action of atmosphere and water decomposes to give kaolinite (Al₂O₃·2SiO₂·2H₂O), which is same as kaoline. It can thus be seen that it is composed mainly of Alumina and Silica, which are the principal components of brick earths.

(2) Lime and Magnesia

Igneous rocks on decomposition also yield silicates of calcium and magnesium such as hornblende, pyroxene and lime feldspar. Lime and Magnesia are usually in the carbonate form, but silicates of lime and magnesium are also commonly found.

(3) Iron Oxide

Iron oxide is present in clays as a result of disintegration of rock minerals. These minerals vary in the size from colloidal to nodular dimensions.
(4) Uncombined silica (SiO₂) or free sand

Sand exists in the form of silicates and in addition also in free state when it is called as flint. Free sand is produced from quartz contained in igneous rocks. This is a result of disintegration of rocks. Sand varies in size from 0.075 mm to 4.75 mm and depending upon it the sand is termed as very fine, medium and coarse.

(5) Other minerals

It also involves finding the properties of soluble salts such as sulphates, chlorides, carbonates, bicarbonates, nitrate.

3.6 FIELD TESTS FOR SOIL FOR MANUFACTURE OF BURNT BRICK

3.6.1 General

In actual practice no testing is done for ascertaining the chemical composition of the soil to be used for the purpose of manufacture of bricks. People generally rely on their judgement for this purpose. This, however, sometimes, fails and the final product gets fused, cracked or warped.

The facilities for chemical testing will not be within the reach of the manufacturers of bricks. However, there are scientific methods suggested in the manual of brick making and IS 2117-1991 [131] for testing of the soils for manufacture of bricks.

3.6.2 Testing as per Bureau of Indian Standards

As per the Bureau of Indian Standards the tests are divided in to two types:

1.) Testing of soil for drying shrinkage

2.) Testing of soil for moulding characteristics

3.6.2.1 Testing of soil for drying shrinkage

The soil should be ground to a fine powder and mixed with sufficient quantity of water gradually so that it becomes plastic and can be moulded with hands. It must be
remembered that not more than the required quantity of water should be added otherwise it would not be possible to mould the bricks.

A handful of soil is taken from this plastic soil and formed into ball. This ball is kept in sun for drying and following observations are made and conclusions drawn.

i) If the ball gets deformed on drying and crumbles easily, it may be inferred that the sand content of the soil is excessive and bricks cannot be moulded from such soils as it is, and needs modification.

ii) If the ball is hard but shows cracks on the surface, the sand content in the soil is insufficient.

iii) If the ball does not get deformed on drying and does not show any cracks or shows very little cracking on its surface, it can be inferred that the soil is suitable for brick making.

If the soil is found to be unsuitable, as in i) or ii) above, the test is redone after modifying the composition of the soil suitably by mixing two soils or by addition of sand, stone dust, etc.

3.6.2.2 Testing of soil for moulding characteristics

It is not certain that the soil, which has been found to be suitable in the first test, may be good for brick moulding.

i) The soil, used for the ball, which does not lose the shape or shows very little cracking is taken for this test. The proportion of different soils and water should be same as used for obtaining good quality balls in first test.

ii) The soil mixture with the required quantity of water, is kneaded well so as to obtain a plastic consistency. It should be possible to roll threads of about 3 mm diameter out of the kneaded soil.
iii) Bricks of standard size should be actually moulded from the above soil. These bricks should have sharp edges and corners in dried condition.

iv) If the edges and corners are not sharp, the test should be repeated by varying the percentage of water so that finally satisfactory results are obtained. Generally for proper moulding of the bricks some additional quantity of water is required as compared to one in the first test.

v) The bricks so obtained are left to dry for four days in the sun and examined for shrinkage cracks. If there are no cracks after drying of the bricks, the soil is said to be good for brick making.

The composition of soils is likely to change from place to place and also at different depths. It is advisable to carry out at least the preliminary tests suggested above to check the suitability of soils in every batch so that the necessary modifications can be made at the proper time. It can be seen that the above tests can be done at the site and does not require any special equipment. If the above test show that the soil will not yield good bricks it is better to reject the soil in the beginning only, rather than getting fused, cracked or warped bricks after burning.