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Micro-structural Analysis of Fly Ash and Clay Compacts

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Abstract
Industrial waste like fly-ash is mainly used as a good building material due to its low weight. But the main disadvantage of these bricks is its low compressive strength. So, a lot of research is going on to increase the strength of these bricks. Normal clay is used for making of bricks in a cheaper sense. So, a research is carried out to develop a new systematic procedure to produce a new type of brick which will have higher compressive strength than the normal clay bricks. Here the fly-ash is mixed with clay at different compositions, sintered at different temperatures and their microstructural analysis has been carried out to find out a solution to enhance its property.

Keywords: *Fly-ash, clay, compressive strength, pozzolona*

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INTRODUCTION
With the industrialization of the country it is but natural that the power generation should also increase. It has been estimated that 70% of the total power generated in country is through thermal power generation. Generally pulverized coal, sub-bituminous coal/lignite are burnt in huge amount giving rise to two types of ashes [1]. Fly-ash is one of them resulting from combustion of coal which consists of inorganic mineral constituents of coal and organic matter that is not fully burnt. The various problems caused due to fly-ash generation are- Environment Pollution, Disposal Problem, Energy Consumption and Health Hazards etc.

So, the utilization of the material is a big issue in scientific field. Hence the present study is made to investigate the use of fly-ash and clay mixture as a construction material. This investigation aims at the study of sintering characteristics of fly-ash and clay compacts.

SWELLING OF CLAY AND ITS STABILIZATION BY FLY-ASH
Expansive soils have upon saturation exerted enormous pressure and differential movement causing extensive damages to structures founded on such soils. In India uniform quality of soil isn't available due to varying weather and geological conditions. Most of the soils are expansive in nature, so it is difficult to make good quality bricks from this soil because of high plasticity and shrinkage value.

It has been seen that the plasticity index increases in swelling potential as shown in Table 1 below:

Table 1: *Swelling Potential vs. Plasticity Index for Clays.*

Swelling Potential	Plasticity Index
Low	0–15
Medium	10–35
High	20–55
Very High	35 & above

We know fly-ash consists of large part of solid or hollow spherical particles of siliceous and aluminous glass with small proportions of thin walled multifaceted polyhedral called cenospheres high in iron and of irregular shape [2]. Fly-ash is an artificial pozzolona. Pozzolona is defined as a siliceous material which while in itself possessing no cementious properties while in finely divided form and in presence of water reacts with calcium hydroxide at ordinary temperature to form compounds possessing cementious properties. Here the fly-ash is used to improve the engineering properties of expansive soil [3, 4].

RAW MATERIAL

Fly-Ash

Fly-ash used in our project work was collected from captive power plant of Rourkela Steel Plant. Physical properties and chemical composition of the fly-ash used are as given in Tables 2 and 3 below:

Table 2: *Physical Properties of Fly-Ash.*

Particle size	100–0.5 microns
Specific gravity	1.3 to 3.0
Specific surface	150 to 1100cm^2/gm.
Morphology	Spherical

Table 3: *Chemical Composition of Fly-Ash.*

Element	Weight Percentage
SiO_2	40–80
Al_2O_3	10–20
Fe_2O_3	2–5
MgO	1–2
Cao	2–10
Na_2O	1–3
K_2O	1–2
TiO_2	1
LOI	0.18

Clay

The physical properties of the two types of clays used are as given in Table 4 below:

Table 4: *Physical Properties of Clays.*

Particle	Yellow clay	Black Clay
Particle size	<100micron	<100micron
Specific gravity	2.688	2.6
Mineralogy	Kaolinite Illite Frosterite Pyrophylite Silimanite Mg-Al Silicate Mg-Fe Silicate	Illite Pyrophylite Potassium Al silicate Kaolinite

PROCESSING OF RAW MATERIAL

Grinding

The two types of clays were taken in lump form and subjected to grinding in ball mill. Then we put them in day sunlight for drying.

Screening

We pass the clays through the sieve of size range 200 µm. Fly-ash was also made to pass through the sieve size of 150 µm.

Mixing

Mixing was done thoroughly by a mechanical vibrator to get a homogenous mixture. Fly-ash and the two types of clays were mixed in the following compositions.

-clay +0% fly-ash
-clay+25%fly-ash
-clay+50%fly-ash
-clay+75%fly-ash

Compaction

Mixture of approximately 30 gm weight is taken and few drops of water were added to it to give some extra binding property. Water content varied between 8–17 drops depending on the composition.

Then the die was cleaned with cotton followed by acetone so that all the dust is removed from the inside surface of the die and outside surface of the punch [5]. Then greasing was done to avoid sticking. Then the mixture prepared earlier was poured inside carefully. During the packing slight shaking was done to accommodate the maximum possible amount of material. Then the whole system was subjected to hydraulic seal valve made tight, mounting was done coaxially [6]. Then load of 10 tons is applied on it very slowly. During all the compactions, the load was constant at stage three stages 4, 6, 8 ton for 5 min each. Then the load was kept constant for 5 min at 10 ton [7].

Sintering

The green compacts were sintered at 510, 600, 825, 925°C for time period of 2.5 h at each step and cooled in a closed furnace [8]. These temperatures have been determined by Thermo Gravimetric Analysis. It has been observed that the compressive strength has increased with other additions to fly ash [9, 10].

PROPERTY EVALUATIONS

The fracture surfaces of some selected samples showing maximum strength were put for SEM study. First these surfaces were coated with carbon and then their scanning photographs were taken at different magnifications.

SEM IMAGES

Fig. 1: YC+0%FA, TEMP 510°C, MGF 200X.

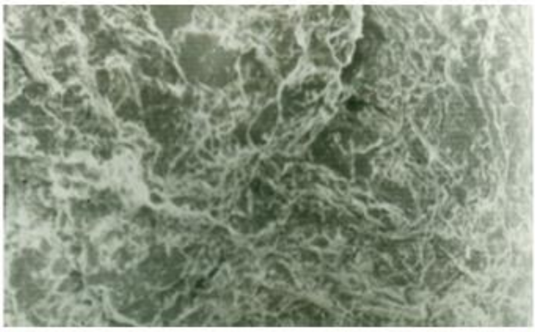

Fig. 2: YC+0%FA, TEMP 825°C, MGF 200X.

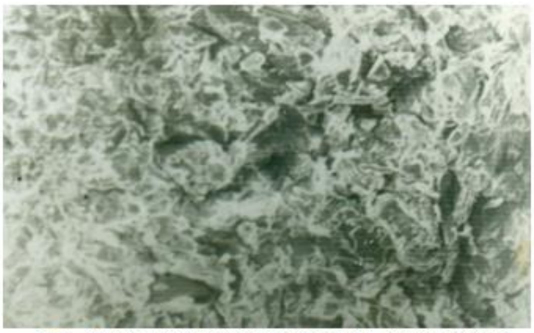

Fig. 3: YC+0%FA, TEMP 925°C, MGF 200X.

Fig. 4: YC+25%FA, TEMP 510°C, MGF 1000X.

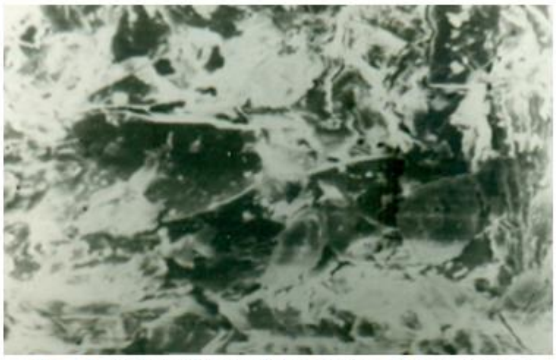

Fig. 5: YC+25%FA, TEMP 825°C, MGF 1000X.

Fig. 6: BC+0%FA, TEMP 510°C, MGF 1000X.

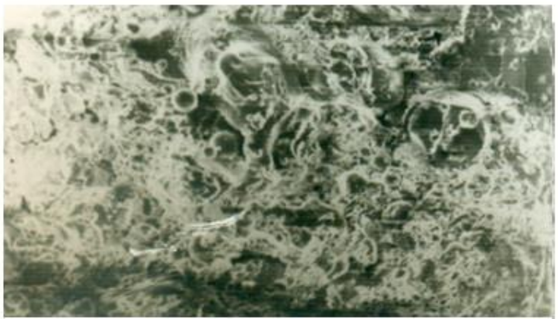

Fig. 7: BC+25%FA, TEMP 925°C, MGF 1000X.

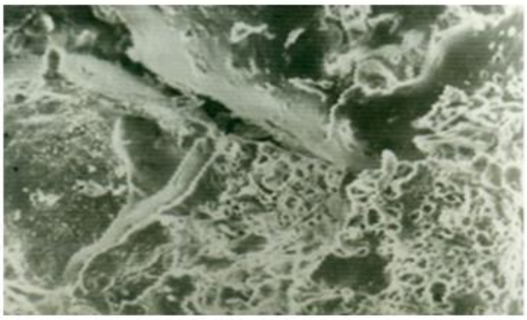

Fig. 8: BC+25%FA, TEMP 925°C, MGF 2000X.

DISCUSSION

The scanning electron microscope (SEM) fracture graph of the selected samples sintered at 510°C, 825°C, 925°C respectively are shown above in Figures 1, 2 and 3. Mullite was found to be present. Amount of mullite tends to increase with sintering temperature (825°C to 925°C). Mullite was not found for lower temperature of 510°C and 600°C. Comparing the figures it can be seen that proper densification has been obtained in all cases [11, 12]. In case of samples sintered at 510 and 925°C source more amount of porosity than that of samples sintered at 825°C. It may be due to the formation of mullite phase and/or other phases at 925°C sintering temperatures. Fusion of smaller particles to form larger grains are also noticed which is prominent at 925°C sintering temperatures. Fusion of smaller particles to form large grains are also noticed which is prominent at 925°C sintering temperatures. The cavitation cum crack has been observed along the particles boundaries [13, 14].

With the addition of fly ash to the fracture graph of yellow clay plus 25% fly ash compacts sintered at 825 and 500°C are shown in Figures 4 and 5, respectively. The shape, size and distribution of the particles are quite different. In case of the compacts sintered at 510°C shows elongated shape grains/particles and are of merely similar size range. Small cavities are homogeneously distributed comparing to Figure 5, fusion of few particles to form laths are noticed. Although the amount of cavitation is less as compared to the previous one, they are observed along the grain boundaries and triple grain junction.

CONCLUSION

In the present investigation it is seen that the mineral composition of the clay and fly ash are different and produces different transformation products at different temperatures. After sintering the compacts it is seen that the clay as well as fly ash compacts have shrunk. So at such a situation the combination of fly ash with type of clay depend on the mineral composition to produce a sintered compact with least dimensional change.

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