CLAY BONDED FLY ASH BRICKS FROM PALTA SILT

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Introduction

Palta silt is formed as a result of sedimentation from large quantity of Gangetic water stored in the tanks of Palta Water Works, Calcutta. Presently, the silt is being used for the manufacture of building bricks. As the silt is quite plastic, it is being mixed with sand before making bricks. Bandel fly ash is also available at the nearby site of Palta silt deposition. This article presents the possibilities of making clay bonded fly ash bricks from Palts silt, hereafter referred to as Palta clay due to its plastic nature, using two different fly ashes A and B.

The earlier work[1,2,3] on making clay-fly ash bricks from soils of various places like Delhi, Faridabad, Madras, Nasik, Kanpur, Kothagudam and Durgapur and fly ashes available at nearby thermal power stations showed that by mixing fly ashes in suitable proportion, a major economy in coal consumption and removal of drying problem could be achieved during manufacture of clay bonded fly ash bricks. The addition of fly ash in Palta clay in this light can serve as a better substitute for sand which is being used presently to bring down the high plasticity of the clay.

Experimental work

Various physico-chemical properties like mechanical analysis Atterberg's limit, Cation capacity of Palta clay were determined as per standard procedures laid down in IS: 2720 (part IV, V) – 1965 and Part XXV-1967. The results obtained have been given in Table 1. Bulk density, loss on ignition and surface area of both the fly ashes were also determined and are given in Table 2.

Differential thermal analysis of Palta clay was also carried out by raising the temperature of the furnace at a constant rate of 10+2° C/min using Leeds and Northrup programme controller. The differential temperature was measured using Chromel-alumel thermocouples for both furnace and differential temperatures and recorded by D. C. microvoltmeter. The thermogram obtained has been given in *Fig. 1.*

Palta clay was mixed with 0-80% of fly ash from two different places and briquettes and bricks were moulded from different mixes containing optimum amount of water. These dried briquettes and bricks were fired at 900-920° C in the laboratory furnace. The results obtained are given in Tables 3-5.

RESULTS AND DISCUSSION

Differential Thermal Analysis

D.T.A. of Palta clay (Fig. 1) shows an endothermic peak at 110°C due to removal of absorbed water, an exothermic peak between 250-450°C due to oxidation of organic matter followed by another endothermal effect of medium intensity at 550°C due to dehydroxylation in clay mineral. Another endothermal effect at 750°C is due to the presence of magnesium and calcium carbonates.[4] After the completion of this effect at 800°C, there is considerable base line shift with further rise in temperature showing an exothermal trend. This shows progressive fusion as was evident by the formation of hardmass on the thermocouple bead.

The results of D.T.A., high cation exchange capacity of clay fraction (60 meq/100g) and SiO_2/Al_2O_3 ratio, of 3.25 determined on clay suggests that the predominant clay mineral present in Palta clay is poorly crystallised illite. Presence of appreciable amount of alkalies (2.3 per cent) further supports this.

Chopra, Ramchandran and Kishan Lal[5] had shown that Palta clay exhibits good bloating characteristics when fly ash fired at 1100°C. Hence in order to avoid any chances of bloating in the bricks a 24 hours slow firing cycle was maintained in the electric furnace.

First two trials carried out at 950 and 1000°C showed that all the bricks either cracked, partly bloated or fused at these temperatures (soaking period 2 hours). Hence next firing was carried out at 900-920°C. The results obtained show (Table 3) that bricks made with

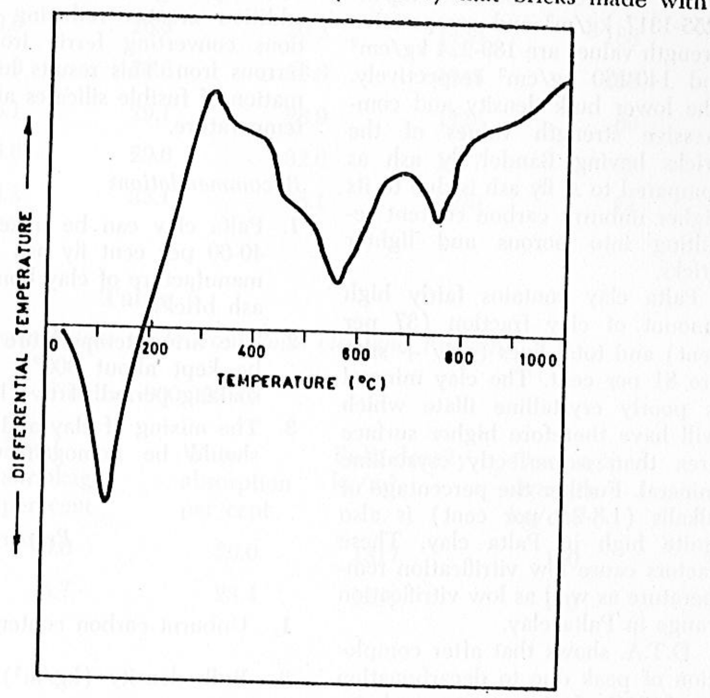

FIG. 1 D.T.A. OF PALTA CLAY

pure Palta clay cracked and bloated along with those containing fly ash upto 30 per cent. However, bricks in which 40-80 per cent fly ash was incorporated neither cracked nor bloated.

With the addition of fly ash A upto 80 per cent drying shrinkage of bricks decreases from 25.0 to 7.5 per cent. However, the firing shrinkage of bricks increases and reaches 22.5 and 35.0 at 70 and 80 per cent addition of fly ash A respectively due to better burning of bricks and higher temperature while on the addition of fly ash B (unburnt carbon 10 per cent) the firing shrinkage of briquettes increases from 10.0 to 24.0 with the increase in proportion of fly ash due to the increase in unburnt carbon in the brick body (Table 4). The total shrinkage in bricks having fly ash A between 40-60 per cent is more or less same (25 per cent) and with fly ash B it varies between 15-19 per cent. The water absorption values of bricks having fly ash A (40-60 per cent) are 7.7-8.5 per cent while the bricks having fly ash B, these values are between 20-23.4 per cent due to higher unburnt carbon content of this fly ash.

Bulk density of bricks containing 40-60 per cent A and B fly ashes varies between 1350-1400 kg/m^3 1255-1317 kg/m^3 and compressive strength values are 189-224 kg/cm^2 and 140-150 kg/cm^2 respectively. The lower bulk density and compressive strength values of the bricks having Bandel fly ash as compared to A fly ash is due to its higher unburnt carbon content resulting into porous and lighter bricks.

Palta clay contains fairly high amount of clay fraction (37 per cent) and total fines (clay + silt) are 81 per cent. The clay mineral is poorly crystalline illate which will have therefore higher surface area than a perfectly crystalline mineral. Further the percentage of alkalis (1.8-2.9 per cent) is also quite high in Palta clay. These factors cause low vitrification temperature as well as low vitrification range in Palta clay.

D.T.A. shows that after completion of peak due to decarbonation at 800°C, fusion starts and increases with further rise of temperature. Hence an impervious layer of glassy material formed on the surface of the bricks at 800°C and above might entrap carbon dioxide gas released from the central portion of the brick body which is at lower temperature. This results into bloating and cracking in the bricks produced from original Palta clay. Hence it is impossible to produce bricks from this clay either by hand moulding or by extrusion process unless the properties of clay are modified either through mixing sand or fly ash. Fly ash A shows vitrification at 1250°C but it is evident from the results that lower additions upto 30 per cent are not able to control the cracking and bloating. A minimum addition of 40 per cent fly ash is necessary to lower the percentage of clay and alkalis in clay. This raises the vitrification temperature as well as vitrification range allowing the gas to escape (700-800°C) much before the formation of glassy material. This has been verified experimentally. Addition of 70-80 per cent of Delhi fly ash results into excessive firing shrinkage (22.5-35 per cent), which may be due to two factors. First is that high amount of fly ash addition produces higher temperature in the brick body causing vitrification. Secondly large amount of fly ash addition creates reducing conditions converting ferric iron into ferrous iron. This results into formation of fusible silicates at lower temperature.

Recommendations

1. Palta clay can be mixed with 40-60 per cent fly ash for the manufacture of clay bonded fly ash bricks.
2. The firing temperature should be kept about 900°C with a soaking period of two hours.
3. The mixing of clay and fly ash should be homogeneous preferably carried out in a mechanical mixer.

Acknowledgement

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References

1. Kacker, K. P., Dinesh Chandra and Ahmad, F. U. – Use of Delhi Fly Ash for Making clay Bonded Lighter Bricks. Bull. Builders Association of India, 5, 1972, 23-28.
2. Technical Note No. 37 – Production of clay Bonded Fly Ash Bricks, CBRI, Roorkee.
3. Techno-Economic Feasibility Report on clay Bonded Fly Ash Bricks – CBRI, Roorkee (1973).
4. Kacker, K. P., Satiya, R. C. & Dinesh Chandra – Effect of clay Minerals on the Thermal Decomposition of Limestone and Dolomite – Zement-Kalk-Gips, January 1972, p. 37.
5. Chopra, S. K., Kishan Lal and Ramachandran, V. S. – Gas Producing Agents in the Production of Lightweight Aggregates – J. Appld. Chem., 1 ,1964, 181.

Table 1

Physico-Chemical Properties of Palta Clay

Mechanical Analysis

Clay fraction	37 per cent
Silt	44 per cent
Sand	19 per cent
Liquid Limit	59.7 per cent
Plastic Limit	27.3 per cent
Plasticity Index	32.4 per cent
Cation Exchange Capacity (Clay Fraction)	60.6 m.eq./ 100gm

Chemical Analysis

SiO_2	58.5 per cent
Al_2O_3	18.0 -do-
Fe_2O_3	7.5 -do-
CaO	2.7 -do-
MgO	2.3 -do-
SO_3	Trace
Alkalis	2.3
Loss on Ignition	8.3
Organic Matter	2.5

Table 2

Properties of A and B Fly Ashes

		A	B	Palta Clay
1.	Unburnt carbon content (%)	4-5	9-10	–
2.	Bulk density (kg/m^3)	750	850	13.40
3.	Surface Area (cm^2/g)	4470	4910	–

Table 3

Properties of Clay Bonded Fly ash Bricks obtained from Palta Clay and Fly Ash (A)

Firing temperature 900-920°C

Composition per cent by volume Clay	Flyash	Drying Shrinkage per cent	Firing Shrinkage per cent	Total Shrinkage per cent	Water Absorption per cent	Bulk Density kg/m³	Compressive strength kg/cm²
100	0	cracked during drying					
80	20	-do-			cracked and bloated		
70	30	19.7	-do- firing				
60	40	17.9	7.5	35.4	8.5	1400	180
50	50	15.5	10.2	25.7	7.5	1380	224
40	60	13.5	12.0	25.5	7.7	1350	200
30	70	10.3	22.5	32.8	5.7	1550	270
20	80	7.5	35.0	42.5	5.0	1680	337

Table 4

Properties of clay Fly Ash Briquettes obtained from Palta clay and Fly Ash (B)

Firing Temp. 900-920°C

Composition per cent by volume Clay	Fly Ash	Drying shrinkage per cent	Firing shrinkage per cent	Total shrinkage per cent	Water absorption per cent	Bulk density kg/m³	Compressive strength kg/cm²
100	—						
70	30	17.9	7.5	25.4	18.7	1486	163
60	40	16.3	10.0	26.3	20.2	1438	188
50	50	15.0	11.6	26.6	23.8	1345	168
40	60	13.0	16.1	29.1	28.9	1226	89
30	70	10.9	18.6	29.6	32.0	1177	62
20	80	8.9	24.2	33.1	38.1	1070	24

Table 5

Properties of Full size Bricks made from Palta clay and Fly ash

Fired at 900-920°C

Composition per cent by volume Clay	Fly ash	Total shrinkage per cent	Water absorption per cent	Bulk density kg/m³	Compressive strength kg/cm²
60	40	19.0	20.0	1317	150
50	50	15.7	23.4	1255	140