Utilisation Of Flyash In The Manufacture Of Bricks From Vindhyan Soils Of Mirzapur District, (U. P.) :

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Abstract :

Use of flyash from two thermal power plants in conjunction with ten red and black soils of varying texture, mechanical and mineralogical composition from Vindhyan region of Mirzapur district (U.P.) has been investigated to manufacture clay fly ash building bricks. Fly-ash addition to the soil modifies the drying behaviour, reduces drying shrinkage, contributes to strength development in optimum proportions depending on the plasticity, particle size, and mineralogical composition and the nature of extraneous matter present in the soil. Good quality building bricks of strength 75 to 200 kg/cm², water absorption 10 to 19 percent and bulk density 1.6 to 1.9 g/cc have been manufactured in the field by the addition of 15 to 35 percent flyash by weight of the soil at a firing temperature range of 950° – 1020°C.

The pilot plant trials and field production of such bricks were undertaken by U P.S.E.B. Kilns at Obra, National Thermal Power Corporation Ltd. at Shaktinagar and private brick manufacturers in Mirzapur district, utilising flyashes from Obra and Renusagar Thermal Power Plants. Several crores of bricks have been manufactured which show a saving of 20-25 percent coal during firing in Bull's kiln, better burning and improved quality of brick production. Small proportion of salt retention in bricks exists which is mostly in the form of calcium sulphate contributing to scum formation over the brick surfaces which becomes insignificant on hard burning.

1.0 Introduction

Thermal power plants in India are producing large and growing tonnage of flyash as waste which is costly and troublesome to dispose off. Weinhelner[1], Thorson and Nelles[2], have examined the physical and chemical properties of flyash with a view to evaluating the possibilities for commercial utilisation of this material in brick making. They have opined that this material could not compete with low cost clays. From similar investigations carried out later by Minnick and Bauer[3], Baretka and Brown[4] Butterworth[5], Watts[6]. and Various others[7–9], it has been concluded that the flyash in conjunction with surface clays or shales can be advantageously used in the manufacture of bricks provided both the materials are available from the sources within a reasonable distance. The production improvements include:

(1). Reduction of lamination in the brick body, (2). Controlling effect on drying and firing shrinkages, and (3). General deepening of colour.

Since the flyash addition to clays has a marked effect on the plasticity, particle size distribution, chemical and mineralogical composition, doubts heve been raised if flyash could be mixed in any proportion with all the clays. The feasibility of the manufacture of bricks

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from flyash in conjunction with Indian soils is therefore, being studied by Central Building Research Institute, particularly for those regions where flyash is economically available and the soils do not yield good quality, durable building bricks [10-11]. This paper details the results of investigations carried out on alluvial, red and black Vindhyan soils of Mirzapur district (U.P.) for their suitability for brick manufacture, utilising flyashes from U.P. State Electricity Board's Thermal power plant, Obra and Renusagar Power Company Ltd., Renusagar, U.P.

2.0 Characteristics of raw materials

2.1 Soils

The Vindhyan Soils from three characteristic geological formations in Mirzapur district, namely Aundi-Singrauli series, Paraspani series [12,13] and Dudhi associations [13] were selected for the investigations. The soils from sites Kota Village (K), Aundi turn at Bina-Aundi and Singnauli Pipri roads crossing (AD); Bina Village (BN) representing Aundi Singrauli series [12,13] Jayant Coalmines near Dudhichua Colony (JT) representing Dudhi Associations, and Obra (OB), Pipri (PP) sites representing Paraspani series were collected upto 2 m depths for brick making studies. These soils are residual type, sandy to clayey loam, hard, sticky, fairly sensitive and are generally weathered products of the parent rock gneisses, granites, quartzites, and sandstones [12,13] The surface soils overlying these sites are mostly blackish in colour which turn yellow to brownish red at depths depending on drainage, topographical variations etc. and invariably contain nodular concretions at depths mostly calcareous, ferruginous and siliceous in nature. The physical and chemical properties of these soils examined show that most of the soils are clayey to clayey loam with the exception of OB, which is sandy and K_1, PP are sandy loam, the organic carbon, water soluble salts and hydrogen ion concentration vary in the range of 0.18 to 0.30 per cent, 0.04 to 0.16 parcent and 6.7 to 7.8 respectively. The results of particle size analysis and mechanical analysis and plastic properties of various soils are given in table 1, which suggest that 70 to 90% of the clay associated with these soils is colloidal in nature. The results of chemical analysis and base exchange capacity of soils are given in table 2, which invairably show very high silica alumina and silica sesquioxide ratios because of the presence of high proportions of free silica and R_2O_3 in

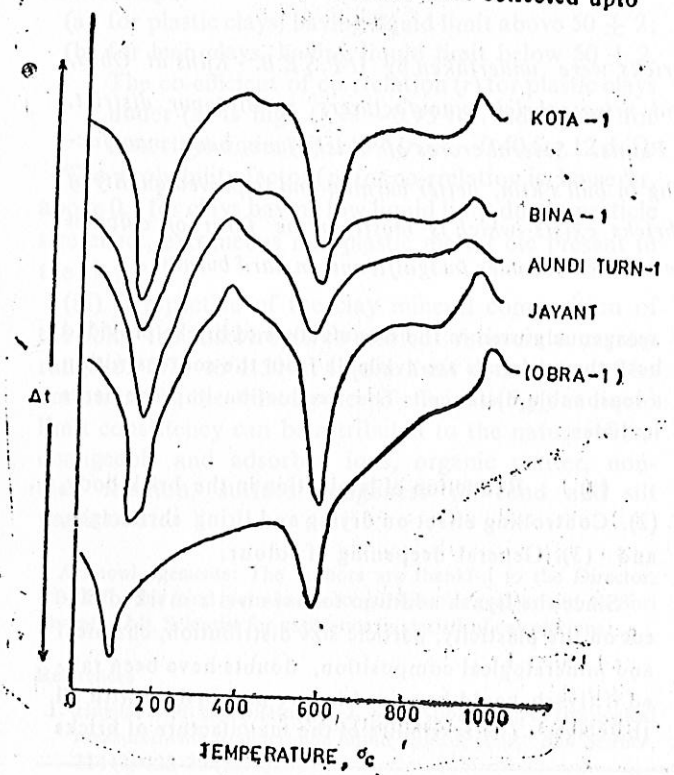


Fig.1. Thermograms of clay fractions from Vindhyan soils of Mirzapur (U.P.)

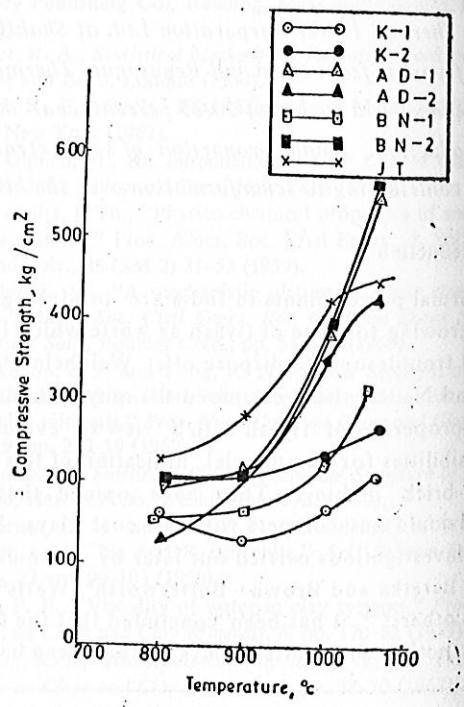


Fig.2. Plots showing compressive strength of briquettes fired at various temperatures from Vindhyan soils.

Fig.3. Plots showing water absorption of briquettes fired at various temperatures from Vindhyan soils.

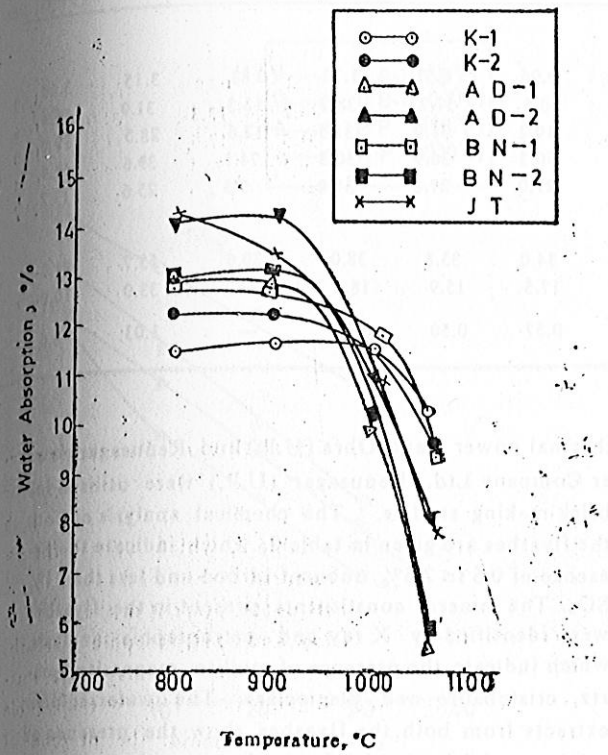
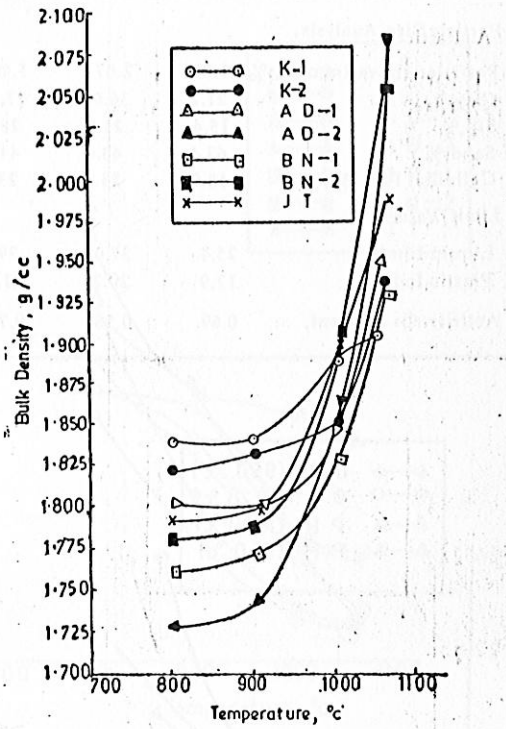


Fig.4. Plots showing bulk density of briquettes fired at various temperatures from Vindhyan soils.



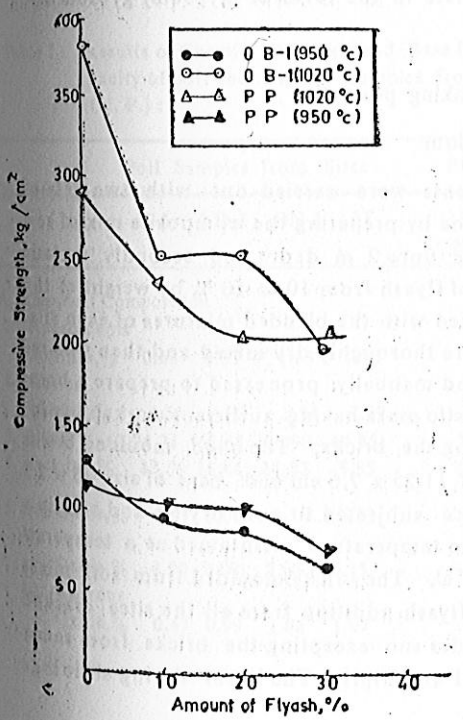


Fig.5. Plots showing compressive strength in briquettes with different proportions of flyash addition in Vindhyan soils fired at 950°C and 1020°C

the extraneous matter present in the soil. The mineralogical analysis of these soils were carried out by X-ray, differential thermal (Fig 1.) and petrographic techniques, the results of which show the presence of the following minerals in order of predominance :

Kota Soils (K1, K2)	:	Muscovite, disordered kaolin, quartz, magnetite, and orthoclase feldspar.
Aundi Turn Soils : (AD-1, AD-2)		Muscovite, disordered kaolin, quartz, magnetite, feldspar, expanding group of clay minerals, haematite.
Bina Soils (BN-1, BN-2)	:	Muscovite, disordered kaolin, montmorillonite group of clay minerals, phlogopite, haematite, quartz and plagioclase feldspar.
Jayant Soils (JT)	:	Muscovite, kaolin, quartz, haematite, feldspar.
Obra & Pipri Soils.(OB & PP)	:	Kaolin, mica, quartz, haematite, feldspar, magnetite/ haematite.

2.2 Fly Ash

The pulverised fuel ashes (flyash) from U.P.S.E.B.

Table I: Particle Size Analysis and Plastic Properties of Vindhyan Soils of Mirzapur (U.P.)

Properties Soil Sites	K-1	K-2	AD-1	AD-2	BN-1	BN-2	JT	OB-1	OB-2	PP
A. Particle Size Analysis,										
1 Particles above 1mm size%	1.83	2.07	5.46	1.16	0.96	0.51	1.78	0.88	3.15	3.60
2. Clay,%	21.2	36.0	27.4	27.6	30.5	31.2	38.2	13.3	31.9	16.6
3. Silt,%	15.4	21.0	28.5	34.9	19.2	31.9	31.5	12.6	28.5	19.0
4. Sand,%	63.4	43.0	44.1	37.5	50.3	36.9	30.3	74.1	39.6	64.4
5. Colloidal Fines%	18.9	33.2	23.3	22.6	27.0	27.8	31.8	9'3	25.6	13.2
B. Limit Values,										
1. Liquid Limit	25.4	37.0	39.7	36.9	34.0	33.8	38.0	30,6	53.7	31.0
2. Plastic Index	12.9	20.2	21.1	17.3	17.5	15.9	18.4	—	33.0	10.0
C. Activity Co.efficient,	0.69	0.56	0.77	0.62	0.57	0.50	0.48	—	1.03	0.6

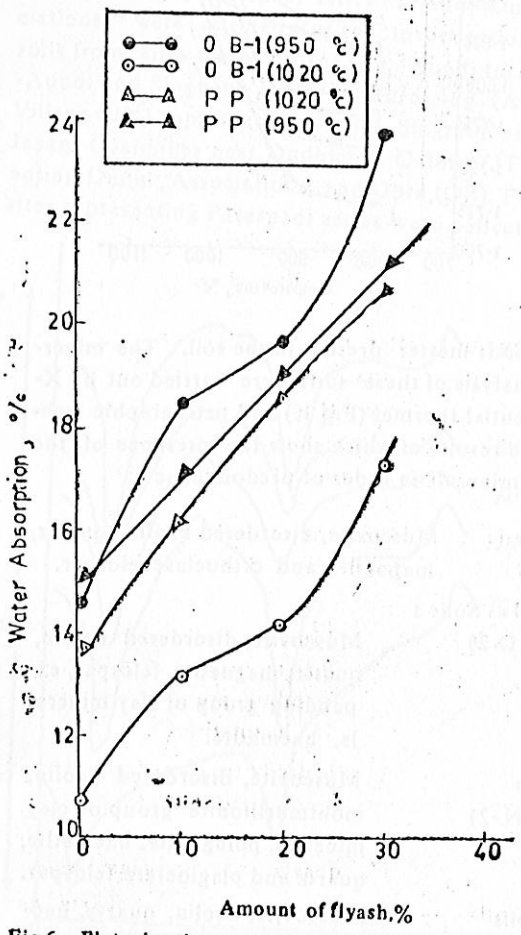


Fig.6. Plots showing water absorption in briquetts with different proportions of fly Ash addition in Vindhyan soils and fired at 950°C and 1020°C

thermal power plant, Obra (U.P.) and Renusagar power Company Ltd., Renusagar (U.P.) were utilised for brick making studies. The chemical analysis of both the flyashes are given in table 2, which indicate the presence of 0.6 to 2.5% unburnt carbon and less than 1% SO_3. The mineral constituents present in the flyashes were identified by X-ray and petrographic analysis, which indicate the presence of mullite, magnetite, quartz, cristobalite and plagioclase. The water soluble extracts from both the flyashes show the presence of calcium sulphate in the form of gypsum/ gypsum anhydride.

3.0 Brick making properties

Drying Behaviour

Experiments were carried out with two sets of mixtures. One by preparing the composite mix of soils of each site upto 2 m depth and secondly various proportions of flyash from 10 to 50 % by weight of the soil were mixed with the blended mixtures of each site. The mixes were thoroughly dry mixed and then watered sufficiently and manually processed to prepare a homogeneous plastic mass having sufficient workability for hand moulding the bricks, The hand moulded bricks of size 22.5 x 11.25 x 7.6 cm and bars of size 25 x 2.5 x 1.25 cm were subjected to sun drying and also in a constant room temperature maintained at a temperature of 27°-+2°C. The bricks moulded from soil mixes without any flyash addition from all the sites cracked on drying under sun excepting the bricks from sandy soil of Obra-1 and Pipri. The linear drying shrinkage

Fig.7. Plots showing bulk density in briquettes with different proportions of fly ash addition in Vindhyan soils, fired at 950°C and 1020°C.

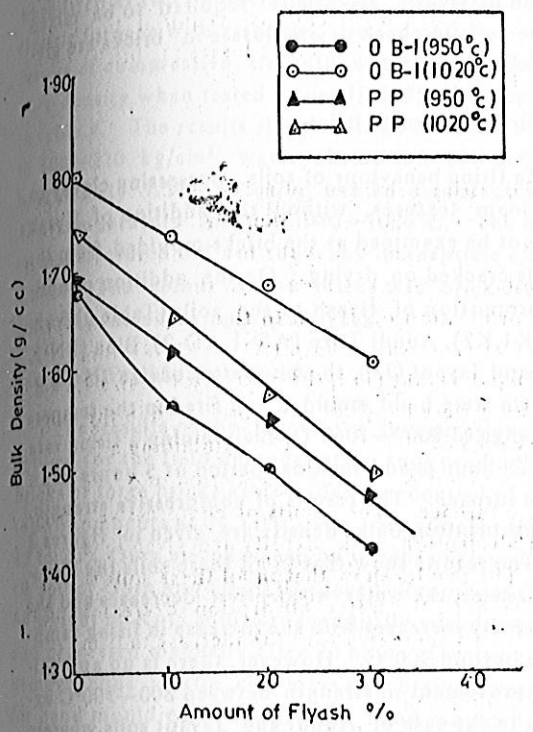


Fig. 8 Plots showing soluble salts in briquettes at various temperatures from Vindhyan soils.

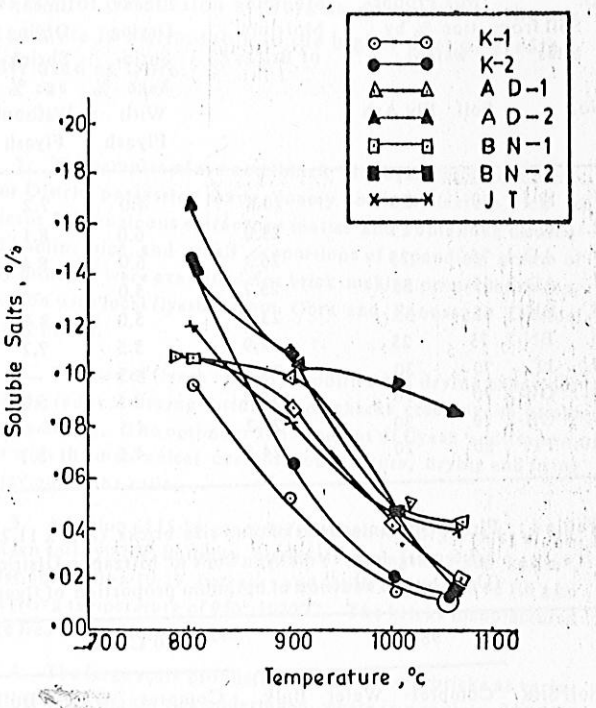


Table 2: Results of Chemical Analysis and Base Exchange Capacity of Soil and Fly-ash Samples from Mirzapur (U. P.):

Constituents	Soil Samples from Sites				Fly Ash From	
	K-1	AD-1	BN-1	JT	Renu-Sagar	Obra
A. Chemical Composition						
1. Hygroscopic Moisture,%	0.63	0.93	1.63	1.70	—	—
2. Loss on Igoition,%	4.50	6.38	5.94	7.59	0.57	2.50
3. Silica, %	74.21	62.45	68.90	64.25	55.37	56.30
4. Alumina,%	12.59	16.04	11.82	5.85	13.60	34.5.
5. Iron Oxide,%	5.37	9.06	8.70	16.22	26.91	
i). Ferric Oxide,%	4.90	8.07	7.64	15.15	—	—
ii). Ferrous Oxide,%	0.47	0.99	1.06	1.07	—	—
6. Calcium Oxide,%	1.44	1.88	1.42	2.62	1.67	2.5
7. Magnesium Oxide, %	0.27	1.33	1.08	1.44	0.29	2.0
8. Sodium Oxide, %	0.22	1.15	0.98	0.96	0.37	0.4
9. Potasium Oxide, %	0.46	1.80	1.92	1.56	0.64	0.60
10. Silica : Alumina,%	10.0	6.9	10.0	17.8	—	—
11. Silica : Sesqui-Oxide, %	8.0	5.2	6.8	6.5	—	—
B. Base Exchange Capacity meq/ 100g of clay	39.7	48.8	59.9	39.1	—	—

at the workable moulding moistures of bricks and bars from all the sites, are given in table 3, which indicate that the bricks under normal conditions of sun drying crack when the linear drying shrinkage exceeds 6%. On the addition of fly ash, the drying behaviour of soils

Table 3 : Optimum Requirement of Fly Ash addition for Moulding Bricks and Their Drying Characteristics from Vindhyan Soils of Mirzapur District (U.P.) :

Sl. No.	Soil from Sites	Mix Proportion % by weight Soil	Fly Ash	Moulding Moisture of Bricks %	Linear Drying Shrinkage % With Flyash	Linear Drying Shrinkage % Without Flyash
1.	K-1	80	20	20.8	4.0	7.2
2.	K-2	75	25	23.0	6.0	8.1
3.	AD-1	75	25	26.3	6.0	8.4
4.	AD-2	65	35	25.7	5.0	—
5.	BN-1	65	35	23.2	5.0	8.4
6.	BN-2	75	25	22.9	5.5	7.2
7.	JT	70	30	23.3	5.5	—
8.	OB-1	90	10	19.4	3.5	5.0
9.	OB-2	70	30	24 2	4.5	—
10.	PP	80	20	24.8	4.5	5.3

Table 4 : Firing Characteristics of full size bricks (22.5 x 11.25 x 7.6 cms) from Vindhyan Soils of Mirzapur District (U.P.) by the addition of optimum proportion of flyash.

Soil Site	980°C Compressive strength kg/cm²	980°C Water absorption %	980°C Bulk density g/cc	1020°C Compressive strength kg/cm²	1020°C Water absorption %	1020°C Bulk density g/cc
1. Kota Soils						
K-1	99	12.5	1.60	147	12.2	1.95
K-2	83	12.4	1.62	140	13.8	1.82
2. AundiTurn Soils						
AD-1	153	13.3	1.67	189	11.1	1.83
AD-2	167	13.9	1.58	196	10.2	1 84
3. Bina Soils						
BN-1	108	13.4	1.56	169	11.7	1.75
BN-2	143	12.7	1.68	219	10.5	1.85
4. Jayant Soils						
JT	141	12.9	1.68	180	11.2	1.79
5. Obra Soils						
OB-1	—	—	—	162	16.4	1.72
OB-2	—	—	—	151	18.3	1.54
6. Pipri Soils						
PP	—	—	—	189	19.7	1.50

from all the sites is largly modified, thereby reducing the linear shrinkage below 6% when the cracking in bricks during drying is eliminated. The optimum proportion of flyash essentially required to be mixed with the soils to check drying losses in bricks are given in table 3.

3.2. Firing Characteristics

The firing behaviour of soils, possessing clayey to clayey loam textures, without the addition of flyash could not be examined as the bricks moulded from these soils cracked on drying. On the addition of optimum proportion of flyash to the soils (Table 3) from Kota (K1,K2), Aundi Turn (AD-1,AD-2), Bina (BN-1, BN-2) and Jayant (JT), the briquettes of size 7.5 x 5.0 x 3.75 cm were hand moulded and fired in the temperature range of 800°—1060°C, maintaining a firing rate of 100°C/ hour & and soaking period of 5 hours in an electric furnace. The results of compressive strength, water absorption, bulk density are given in figures 2 to 4. The results show that in all these soils the strength increases, the water absorption decreases and the bulk density increases with the increase in firing temperature beyond 900°C. However, there is no appreciable improvement in strength between 800—900°C excepting in the case of Aundi and Jayant soils wherein steep rise in strength, and fall in water absorption occurs above 800°C. Similar behaviour has been observed in the case of Obra and Pipri soils wherein the strength increases and water absorption decreases with the increase of firing temperatures. In the case of Obra—1 and Pipri, wherein drying is no problem, flyash addition in the range of 10 to 30% by weight of the soil affects the strength and bulk density and increases the porosity. (Fig.5 to7). The salt retention in bricks containing flyash gradually decreases with the increase of firing temperature and becomes almost constant below 0.08% in the temperature range of 1000° 1060°C (Fig.-8). Most of the salts retained in the brick body are in the form of sulphates of calcium and free lime. Crystallised salts from the water soluble extracts were further identified by X ray and petrographic analysis which confirm the presence of gypsum and gypsum anhydride. These salts do not contribute to any appreciable efflorescence or deterioration of brick surfaces due to their low solubility, from the results it may be concluded that the optimum firing temperature for these bricks is 1000°±20°C.

3.3. Properties of Full Size Clay-Flyash Bricks.

Full size bricks of dimensions 22.5 x 11.25x 7.6 cm containing optimum proportions of flyash (Table 3) were fired at two temperatures 980° and 1020°C in an electric furnace with a soaking period of 5 hours. The results of compressive strength, water absorption and bulk-density when tested as per IS:3495-1976 are given in table 4. The results show that the bricks of strength 100—220 kg/cm², water absorption 10—20% and bulk density 1.50—1.95 g/cc can be manufactured in the temperature range of 980—1020°C. The bricks so manufactured did not show any perceptible efflorescence. The colour of the bricks was brick red and emitted a metallic ring when struck.

4.0 Field Production of Bricks

The results of the laboratory investigations were applied for the field demonstration and production of bricks at three bricks kilns under the control of private entrepreneurs at N.T.P.C. site, Shaktinagar (Kota). 15 to 20% Obra sieved flyash by weight of clayey plastic soil of Obra and 20—25% sieved, Renusagar flyash by weight of Kota soil were mannually mixed, watered and processed manually after 24 hours of wetting. The hemogeneous plastic clay mass so obtained was used for hand moulding of bricks. The hand moulded bricks were dried under sun and fired in Bull's kiln in the temperature range of 950°—1020°C. The drying and firing losses were minimum within 5 to 7 percent as are generally found in commercial production of conventional bricks. Fifty lakh bricks at Obra and two crore bricks at Kota were manufactured. They were classified in three grades on the basis of colour, shape and ringing sound. 70 to 75 percent of the manufactured bricks were first class, 10 to 20 percent second class and 8 to 12 percent third class. The manufuctured bricks when tested as per IS:5454—1969 showed strength 75 to 150 kg/cm² and water absorption below 16 percent from Obra soils and 80—200 kg/cm² and water absorption varying in the range of 10 to 14 percent from Kota soils. The bricks did not show any perceptible efflorescence and conform to IS :1077—1975.

The use of fly ash offers a considerable saving in coal consumption which has been found to vary in the range of 2.5—3.0 tonnes of grade I coal per lakh of bricks at Obra and 5 | 7 tonnes grade II coal per lakh of bricks at Kota.

The cost of production of clay flyash bricks during 1977 78 was comparable to that of conventional bricks and worked out to be Rs. 84/1000 bricks at Kota and Rs. 95/1000 bricks at Obra. The slightly higher cost of production at Obra as compared to the cost at Kota is attributable to the higher cost of gradre I coal used at Obra.

Conclusion

1. Ten samples of red and black Vindhyan soils from Mirzapur District possessing sandy, loamy to clayey texture, rich in siliceus & ferruginous extraneous matter and containing disordered kaolin, mica, and small proportions of expanding group of clay minerals were examined for brick making properties in conjunction with local flyashes from Obra and Renusagar Thermal Power Plants.

2. The use of flyash largely modifies the drying behaviour of soils, reduces drying shrinkage & checks cracking of bricks during drying. The optimum requirement of flyash addition varies with the mechanical composition, texture, drying and firing behaviour of the soils.

3. Addition of 15-35 percent flyash on the dry weight of Vindhyan soils yields building bricks of strength 75-200 kg/cm², water absorption 10-19 percent and bulk density 1.6 to 1.9 g/cc at a firing temperature of 950°-1020°C. The bricks manufactured were free from efflorescence.

4. The large scale production of clay flyash bricks at various kilns in the region was undertaken, where in a saving of 20-25% in coal was achieved during firing in Bull's kiln and the quality of bricks manufactured was also improved. Salt retention in the form of calcium sulphate and calcium oxide exists which do not redily efflorece, scum appears in low temperature burnt bricks, which is reduced on hard burning at 1000°-1020°C.

Acknowledgement

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