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Full Length Research Paper

An experimental study on fibre reinforced fly ash based lime bricks

J. N. Akhtar[1]*, J. Alam[2] and M. N. Akhtar[2]

[1]Civil Engineering Section, University Polytechnic A.M.U., Aligarh India.
[2]Civil Engineering Department Aligarh Muslim University Aligarh. India.

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The fly ash of 'C' category was used as a raw material to partial replacement of clay for `making fly ash bricks. Not only the affectivity of fly ash with high replacement, but also the mechanical properties of bricks with different combination were studied. It is observed that the compressive strength of plain fly ash and treated fly ash bricks (FAB, FALB) increases linearly and found to be maximum with 5% coarse sand and 15% sand combination at 10% cement. This increase of compressive strength continues with the addition of 0.2% geo-fibre in FAB and FALB. The addition of 10% stone dust in FALSDB with and without geo-fibre shows the achievement in strength that is, maximum at 10% sand replacement. The combination of fibre reinforced fly ash lime stone dust brick (10FRFALSDB3´) was found to have highest compressive strength with 10% stone dust and sand combination at 10% cement. It is found that when the amount of treated fly ash changes with respect to the stone dust and sand replacement, the compressive strength increases and was found to be maximum at 25% stone dust-sand combination with 50% treated fly ash. With this change the enhancement of compressive strength achieved maximum which is nearly close to Indian first class brick.

Key words: Fly ash, compressive strength, lime.

INTRODUCTION

Most cement plants consume much energy and produce large amount of undesirable products, which affect the environment. In order to reduce energy consumption, CO_2 emission and increase production, cement manufacturers are blending or intergrinding mineral additions such as slag, natural pozzolana, sand and limestone (Ghrici et al., 2007). From the cement point of view the mineralogy of fly ash is important 80 - 90% of it is glass. It starts out as impurities in coal - mostly clays, shale, limestone and dolomite and since they cannot be burned, they turn up as ash. The plasticity index of mixture of fly ash and clay, decreased dramatically with increasing in replacing ratio of fly ash which was to be determined according to Xu Lingling (Xu et al., 2005).

*Corresponding author. E-mail: Jannisar_akhtaramu@rediffmail.com. Tel: 919412564055.

Against the destructive action of rain, the incorporation of fly ash in pozzolanic plaster provides a satisfactory resistance to aggressive chemicals such as sulfate, salts and acids by Degirmenci (Degirmenci and Baradan,2005). It was concluded by Mustafa Sahmaran et al (Mustafa et al., 2006) that among the mineral additives used, fly ash and limestone powder significantly increased the workability of self compacting mixtures. On the other hand, especially fly ash significantly increased the setting time of the mortars, which can, however, be eliminated through the use of ternary mixtures, such as mixing fly ash with limestone powder. The two polycarboxyl based super plasticizers (SP) yield approximately the same workability and the melamine formaldehyde based SP was not as effective as the other two. Through the experimental study by Kae (2006), the addition of MSWI slag to the mixture reduced the degree of firing shrinkage. This indicates that MSWI slag is indeed suitable for the partial replacement of clay in

Table 1. Chemical analysis of fly ash along with the range for different materials.

Components	Range of percentage of component for different materials (ASTM-C-618)				Percentage of different components in the fly ash used
	Bituminous	Sub-bituminous	Lignite	Fly ash C	
SiO_2	20 - 60	40 - 60	15 - 45	46 - 60	50.50
Al_2O_3	5 - 35	20 - 30	10 - 25	21 - 28	21.95
Fe_2O_3	10 - 40	4 - 10	4 - 15	05 - 09	8.38
CaO	1 - 12	5 - 30	15 - 40	0.5 - 6	5.17
MgO	0 - 5	1 - 6	3 - 10	0.2 - 4	3.95
SO_3	0 - 4	0 - 2	0 - 10	0 - 0.4	0.25
Na_2O	0 - 4	0 - 2	0 - 6	0 - 0.3	0.22
K_2O	0 - 3	0 - 4	0 - 4	0 - 0.2	0.15
LOI	0 – 15	0 - 3	0 - 5	0 - 0.2	0.13

bricks.

EXPERIMENTAL SET UP AND PROCEDURE

Materials used

Present fly ash conforming the properties according to I.S. 3812 (I.S. 1983, p. 3812) used in the study was the portion of the ash collected through electrostatic precipitators of Dadri Thermal Power Station, Dadri (U.P.), India. The ordinary portland cement (OPC) of 43 grade as per I.S.8112 (I.S. 1989, p. 8112-43) was used. Locally available lime was used to augment the cementitious properties of fly ash. The physical properties of different materials used in the study are given in Table 2; as the coal is supplied from different mines of Bihar, the chemical properties also vary a great extent and the results of chemical analysis of fly ash along with their range for different materials are given in Table 1. The finely ground calcium hydroxide, a laboratory reagent, was used to augment the cementitious properties of the fly ash. Its optimum amount with respect to optimum moisture contents (OMC) and maximum dry density (MDD) was determined in Table 2. It was done through Standard Proctor's Test.

Determination of OMC and MDD

Light compaction test according to IS: 2720-VII (I.S. 1983, p. 2720) was done to get the value of optimum moisture content (OMC) and maximum dry density (MDD) (Figure 2). This test conforms to the specifications of SPCT or Standard AASHTO (T-99) Test. The curve shows OMC and MDD in Figure 3.

Preparation of specimen

To determine the compressive strength, prism of 9´´ × 4½´´ × 3´´ size were prepared. The mortar mix was designed to get the compressive strength as close to standard first class brick in Indian conditions. The mix proportion for each test series is given in Tables 3 to 6. Three prism of each combination were prepared to determine compressive strength. The weighted material was placed on a level platform, geo fibre sprinkled gently on it and was mixed using mixer. Care was taken to prevent agglomeration of fibres and to ensure their uniform distribution as far as possible. The fresh mortar was poured in three equal layers in the brick mould, also properly placed and compacted.

RESULT

Compression testing of bricks

The bricks were tested in compression after proper curing for a period of 28 days as per I.S specification. The specimen under test is shown in Figure 1. The stress-strain curves of different test series of FAB, FRFAB, FALB, FRFALB, FALSDB and FRFALSDB have been plotted and shown in Figure 4. Each stress-strain curve is the average of three bricks pair. The compressive strength of FAB, FRFAB, FALB, FRFALB, FALSDB and FRFALSDB increases almost linearly with 0.2% geo-fibre (Figure 5). The compressive strength of 15FRFAB and 15FRFALB increases 15.20 and 16% respectively at 0.2% geo-fibre with respect to 15FAB and 15FALB. Further the compressive strength of 10FRFALSDB3´ increases 22, 4.0 and 12.3% with respect to 15FRFAB, 15FRFALB and 10FALSDB3 respectively. This increase in compressive strength continues and achieved maximum value with the combination of 25FRFALSDB9´ which is nearly close to SFCB.

Conclusions

(i) The addition of lime to the fly ash increases the cementitious properties of fly ash and it was found that at 1.5% of lime, the OMC is minimum and dry density is maximum.
(ii) The compressive strength of plain fly ash brick (15FAB) and treated fly ash brick (15FALB) increases linearly and maximum with 5% coarse sand and 15% sand combination at 10% cement.

Table 2. The physical properties of materials.

S. No.	Materials	Physical properties	Value
1.	Plain fly ash	Specific gravity	1.86 at 28°C
		Optimum moisture content (Standard Proctor Test) with 1.5% lime	18.0%
		Maximum dry density with 1.5% lime	1.28 g/cc
		Coefficient of uniformity, C_u	2.0
		Coefficient of curvature, C_c	1.13
		Cohesion	0.0
		Angle of shear resistance	27°
2.	Cement	Initial setting time	32 min
		Final setting time	389 min
		Normal consistency	28%
		Compressive strength	19.2 MPa (3 days)
		(1:3 cement sand mortar)	28.5 MPa (7 days)
		Tensile strength	1.90 MPa (3 days)
		(1:3 cement sand mortar)	2.45 MPa (7 days)
3.	Coarse sand	Specific gravity	2.62
		Water absorption (30 min)	0.39%
		Fineness modulus	2.87
		Silt content	2.46%
4.	Sand	Specific gravity	2.60
		Water absorption (30 min)	0.42%
		Fineness modulus	2.88
		Silt content	2.49%
5.	Stone dust	Specific gravity	2.68
		Water absorption (30 min)	0.38%
		Fineness modulus	2.89
		Silt content	2.3%
6.	Geo fibre	Diameter	30 – 40 Micron
		Cross section	Circular
		Elongation	>100%
		Length	12 mm
		Melting point	240 - 260°C
		Softening point	220°C
		Specific gravity	1.4
		Tensile strength	4000 - 6000 Kg/cm

(iii) The compressive strength of treated fly ash stone dust brick (10FALSDB3) and fibre reinforced fly ash lime stone dust brick (10FRFALSDB3') is maximum with 10% stone dust and sand combination.
(iv) Treated fibre reinforced fly ash lime stone dust brick (25FRFALSDB9') achieved highest compressive strength with 25% stone dust and sand combination at 10% cement.
(v) Fly ash is not only to enhance the mechanical properties of brick but the addition of fibre and lime correlate their gape of strength and their use in helping to reduce environmental pollution and save energy.

Figure 1. Test under progress.

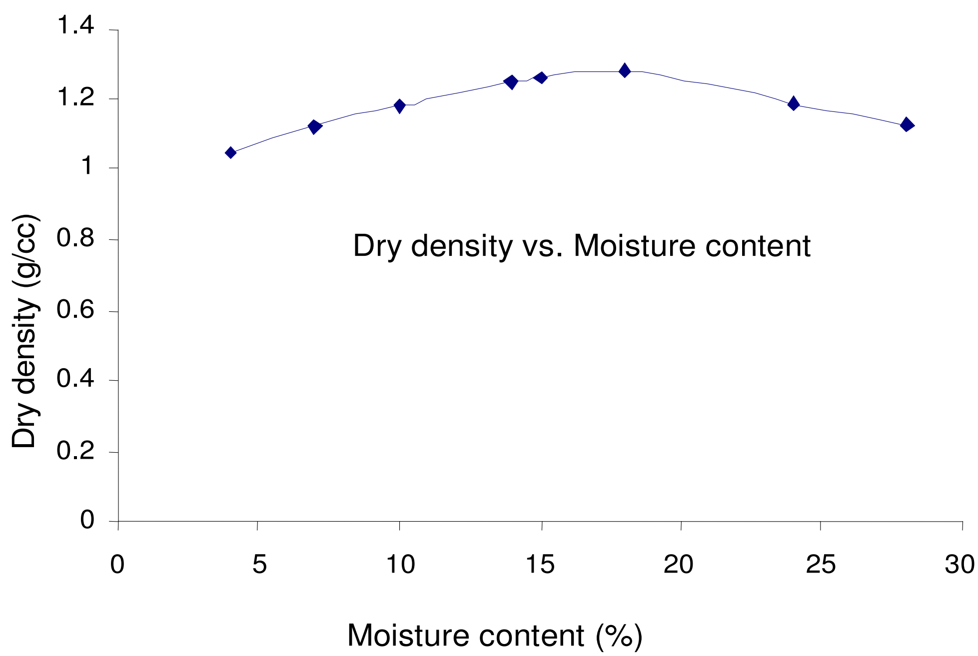

Figure 2. Dry density vs. Moisture content for plain fly ash.

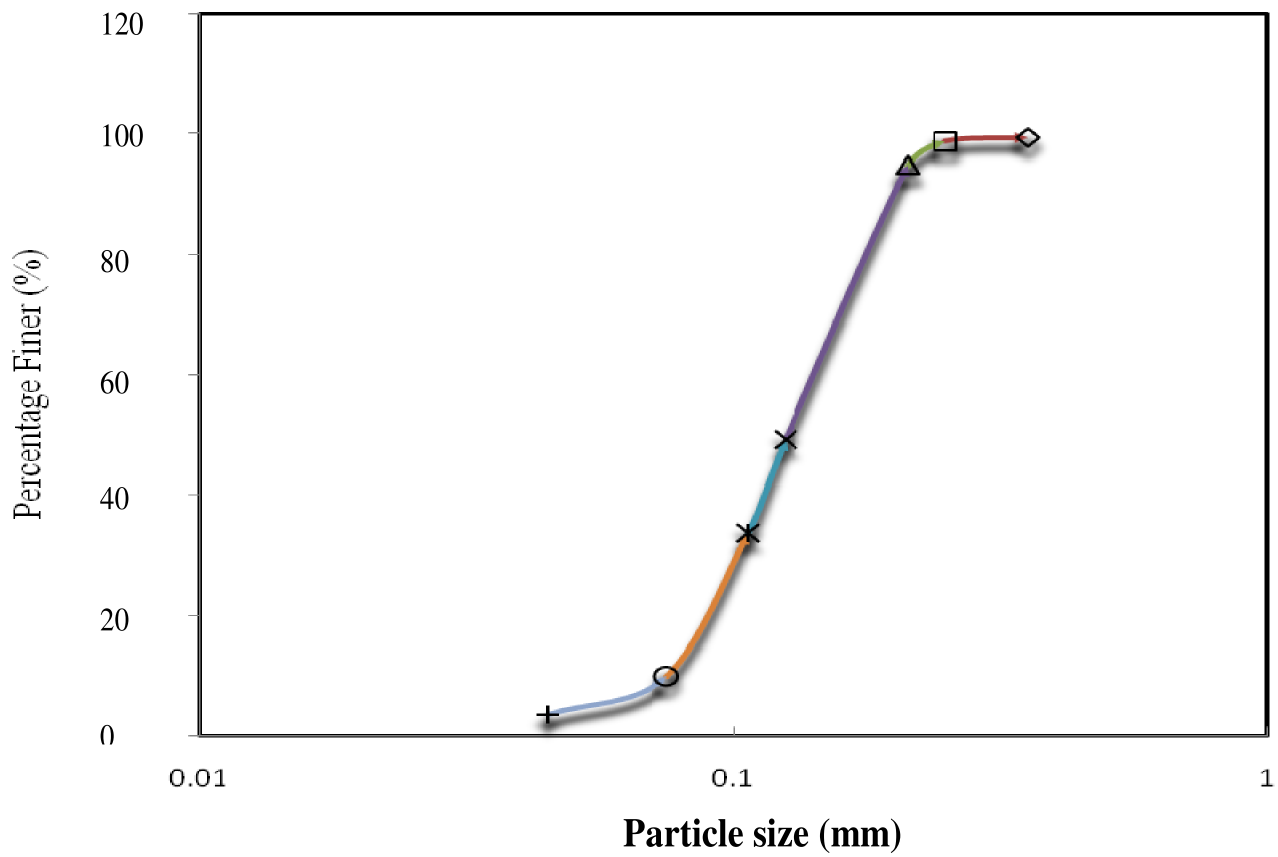

Figure 3. Particle size distribution curve of fly ash.

Table 3a. Mix proportions of FAB.

Designation	Cement (%)	Mix proportion			Stress
		Plain fly ash (%)	Coarse sand (%)	Sand (%)	(Kg/cm^2)
SFCB	-	-	-	-	105.50
00FAB	10	80	20.0	00.0	33.48
05FAB	10	80	15.0	05.0	36.90
10FAB	10	80	10.0	10.0	43.90
15FAB	10	80	05.0	15.0	53.85
20FAB	10	80	00.0	20.0	44.50

*FAB – Fly ash brick *SFCB – Standard first class brick.

Table 3b. Mix proportions of FRFAB.

Designation	Cement (%)	Mix proportion				Stress
		Plain fly ash (%)	Coarse sand (%)	Sand (%)	Geo fibre content (%)	(Kg/cm^2)
00FRFAB	10	80	20.0	00.0	0.2	37.48
05FRFAB	10	80	15.0	05.0	0.2	39.90
10FRFAB	10	80	10.0	10.0	0.2	47.90
15FRFAB	10	80	05.0	15.0	0.2	63.50
20FRFAB	10	80	00.0	20.0	0.2	47.50

*FRFAB – Fibre reinforced fly ash brick.

Table 4a. Mix proportions of FALB.

Designation	Cement (%)	Mix proportion			Stress (Kg/cm^2)
		Treated fly ash (%)	Coarse sand (%)	Sand (%)	
00FALB	10	80	20.0	00.0	36.85
05FALB	10	80	15.0	05.0	40.65
10FALB	10	80	10.0	10.0	48.65
15FALB	10	80	05.0	15.0	65.99
20FALB	10	80	00.0	20.0	45.96

* FALB - Fly ash lime brick.

Table 4b. Mix proportions of FRFALB.

Designation	Cement (%)	Mix proportion				Stress (Kg/cm^2)
		Treated fly ash (%)	Coarse sand (%)	Sand (%)	Geo fibre content (%)	
00FRFALB	10	80	20.0	00.0	0.2	41.85
05FRFALB	10	80	15.0	05.0	0.2	45.65
10FRFALB	10	80	10.0	10.0	0.2	58.50
15FRFALB	10	80	05.0	15.0	0.2	78.59
20FRFALB	10	80	00.0	20.0	0.2	54.60

* FRFALB – Fibre reinforced fly ash lime brick.

Table 5a. Mix proportion of FALSDB.

Designation	Cement (%)	Mix proportion			Stress (Kg/cm^2)
		Treated fly ash (%)	Stone dust (%)	Sand (%)	
00FALSDB1	10	80	20.0	00.0	36.660
05FALSDB2	10	80	15.0	05.0	42.350
10FALSDB3	10	80	10.0	10.0	71.560
15FALSDB4	10	80	05.0	15.0	65.690
20FALSDB5	10	80	00.0	20.0	47.906

* FALSDB - Fly ash lime stone dust brick.

Table 5b. Mix proportion of FRFALSDB.

Designation	Cement (%)	Mix proportion				Stress (Kg/cm^2)
		Treated fly ash (%)	Coarse sand (%)	Sand (%)	Geo fibre content (%)	
00FRFALSDB1´	10	80	20.0	00.0	0.2	36.660
05FRFALSDB2´	10	80	15.0	05.0	0.2	42.350
10FRFALSDB3´	10	80	10.0	10.0	0.2	81.560
15FRFALSDB4´	10	80	05.0	15.0	0.2	65.690
20FRFALSDB5´	10	80	00.0	20.0	0.2	47.906

*FRFALSDB – Fibre reinforced fly ash lime stone dust brick.

Table 6a. Mix proportion of FALSDB.

Designation	Cement (%)	Mix proportion			Stress (Kg/cm^2)
		Treated fly ash (%)	Stone dust (%)	Sand (%)	
10FALSDB6	10	80	10.0	10.0	81.60
15FALSDB7	10	70	15.0	15.0	83.30
20FALSDB8	10	60	20.0	20.0	85.20
25FALSDB9	10	50	25.0	25.0	88.90
30FALSDB10	10	40	30.0	30.0	74.80

* FALSDB - Fly ash lime stone dust brick.

Table 6b. Mix proportion of FRFALSDB.

Designation	Cement (%)	Mix proportion				Stress (Kg/cm^2)
		Treated fly ash (%)	Coarse sand (%)	Sand (%)	Geo fibre content (%)	
10FRFALSDB6´	10	80	10.0	10.0	0.2	83.15
15FRFALSDB7´	10	70	15.0	15.0	0.2	85.45
20FRFALSDB8´	10	60	20.0	20.0	0.2	86.25
25FRFALSDB9´	10	50	25.0	25.0	0.2	91.55
30FRFALSDB10´	10	40	30.0	30.0	0.2	77.55

*FRFALSDB – Fibre reinforced fly ash lime stone dust brick.

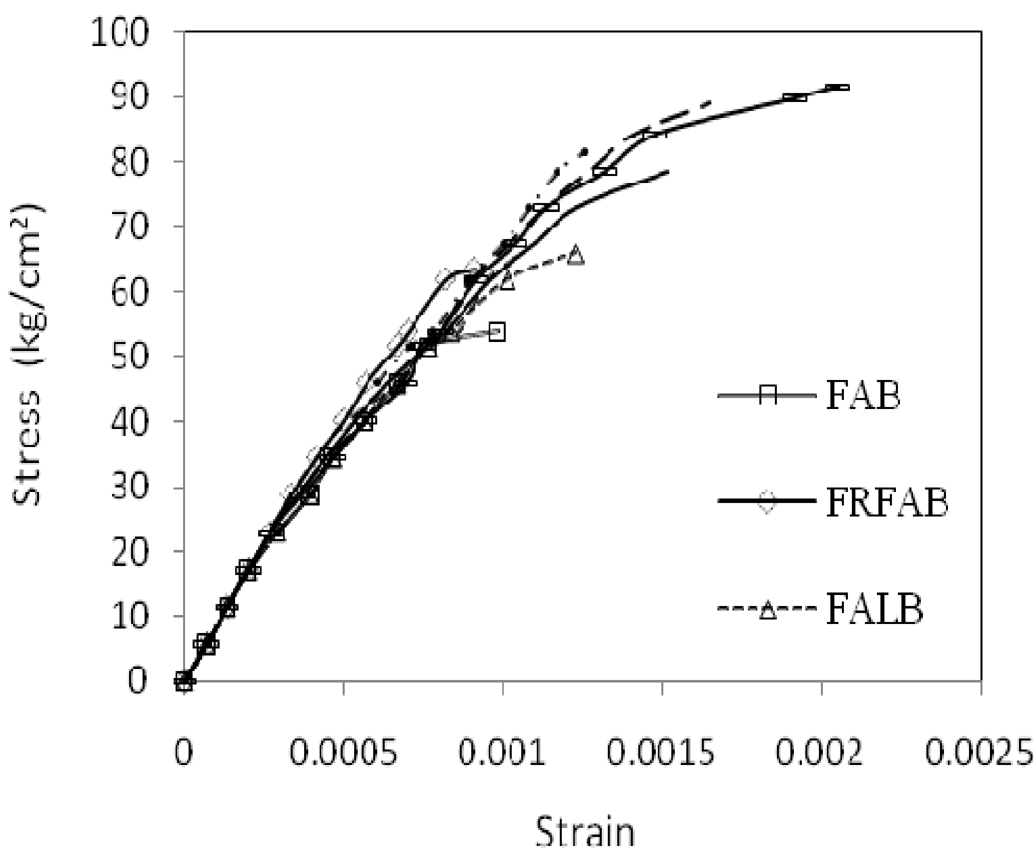

Figure 4. Stress vs. Strain variation.

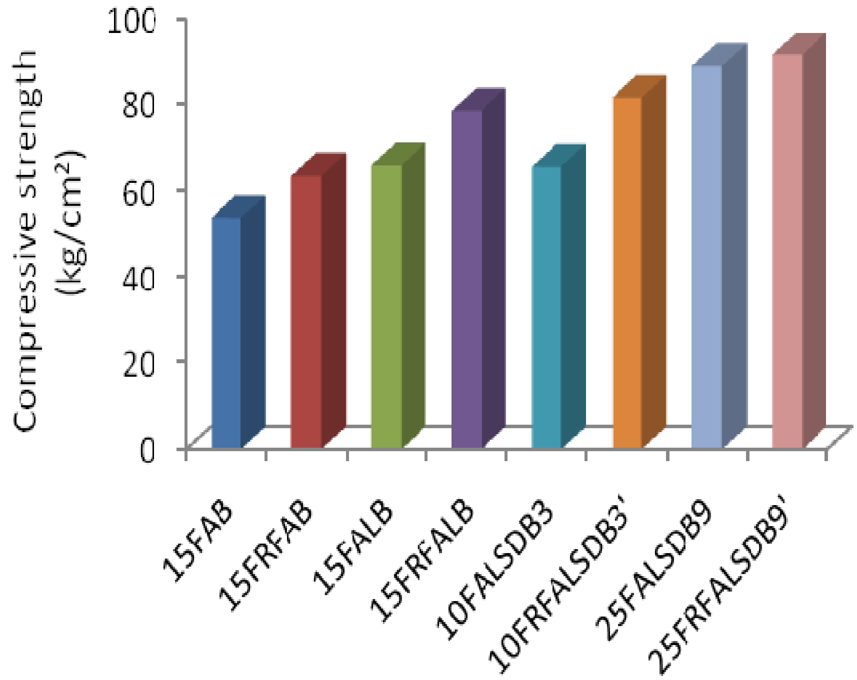

Figure 5. Compressive strength variation.

REFERENCES

Degirmenci N, Baradan B (2005). Chemical resistance of pozzolanic plaster for earthen walls. Constr. Build. Mater., 19: 536–542.

Ghrici M, Kenai S, Said-Mansour M (2007). Mechanical properties and durability of mortar and concrete containing natural pozzolana and limestone blended cements. Cement Concrete Composit., 29: 542–549.

I.S. 2720-VII Methods of Test for Soil Part VII Determination of Water content-Dry Density Relation using Light Compaction (Second Revision).1983.

I.S. 8112- 43 Grade ordinary Portland cement specification (First Revision) 1989.

I.S.3812, Specification for Fly ash as pozallana and admixture (First Revision) 1983.

Kae LL (2006). Feasibility study of using brick made from municipal solid waste incinerator fly ash slag. J. Hazardous Mater., B137: 1810–1816.

Lingling Xu, Guo W, Wang T, Yang N (2005). Study on fired bricks with replacing clay by fly ash in high volume ratio Constr. Build. Mater., 19: 243–247.

Mustafa S, Heru AC, Ismail O¨ zgu¨ r Yaman (2006). Cement Concrete Composit., 28: 432–440.