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Experimental Investigation on Fly-Ash Bricks Mix Design Using Metal Chips

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Abstract:
The main objective of the project is to prepare a mix of fly ash and cement by changing their composition and adding metal chips powder into it to produce bricks of high strength and durability. The bricks so produced will have higher strength and low cost as compare to conventional Indian bricks. Utilization of fly ash can help in deceasing the problems of global warming as fly as is more environment friendly and we can also to use fly ash to produce economical products. Fly ash can be used in many ways but the most popular and suitable one is to use it as a building material.

Keywords: Fly Ash , Metal Chips / Metal Powder, Cement , Water , Compressive Strength , Water Absorption , Hardness Test , Efflorescence Test , Bricks

I. INTRODUCTION

The construction industry is booming in the developing countries resulting in the more usage of Cement as one of the main ingredients that are used to build and construct new buildings. Cement as a material emits a lot of heat which results in the increasing global warming. Global Warming is a very important factor which should not be neglected, Hence We as individuals should try to concentrate on using materials that are more environment friendly and easily available. A huge amount of CO2 (Carbon Dioxide) is emitted in the production of Cement and moreover for the production of Cement, our natural resources mainly non-renewable resources are used in huge amount. So taking into consideration the following factors, it is advisable to minimize the use of Cement and look for other alternatives which have the same properties or material usage as that of Cement. Flyash is one such material which possess pozzolanic properties and which can be replaced with Cement.

II. HOW FLYASH BRICKS ARE PREPARED

When coal is burnt, its residue which is commonly known as fly ash is taken for the construction of Flyash Bricks.The properties and the type of coal used will determine the properties and the form of Flyash produced from the coal residue. Quicklime or Portland Cement are sometimes used as a Cementing Agent in the production of Flyash Bricks. Lime is also used in some kind of fly ash bricks. Lime has settling properties and when water is added, it automatically converts into fly ash Bricks.

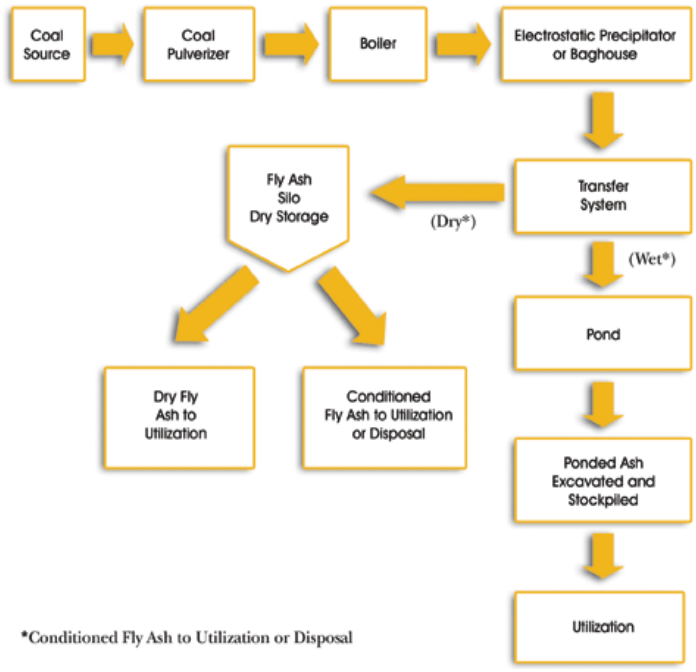
III. TYPE OF FLYASH

Fly ash can be classified in 2 classes by ASTM:
1) Class F: This type of Fly ash is produced by using bituminous coal or anthracite. This type has less than 5% CaO. Class F type fly ash has pozzolanic properties only.

2) Class C: This type of Fly ash is produced by using sub-bituminous coal or lignite. This type of Fly ash has 10% or more Cao. Class C Fly ash has pozzolanic as well as cementious properties.

Table .1. Type of Fly Ash

Chemical component	Typical Fly ash	
	Class C	Class F
Silica ($Si O_2$)	40	55
Alumina (Al_2O_3)	16	26
Ferric oxide (Fe_2O_3)	6	7
Calcium oxide (CaO)	24	9
Magnesium oxide (MgO)	2	2
Sulfate oxide (SO_3)	3	1
Loss of ignition (LOI)	6	6

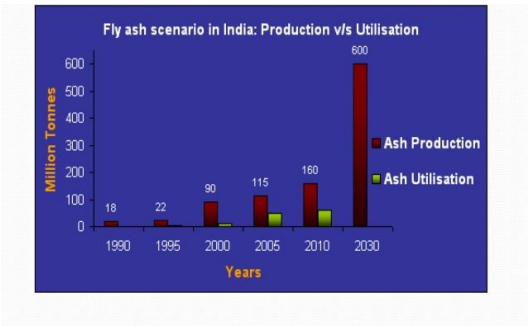


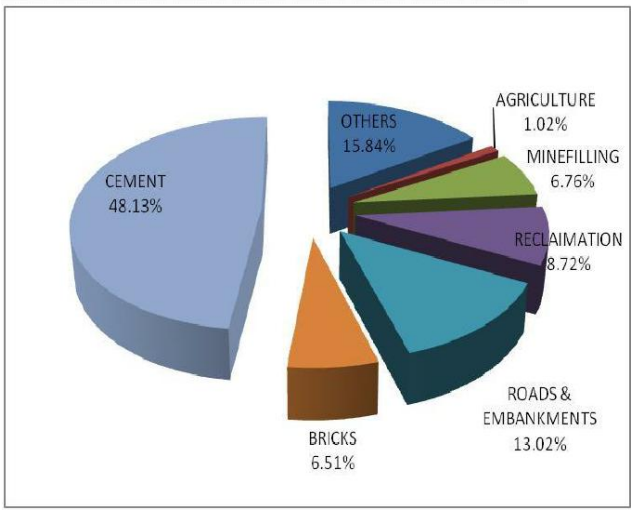
IV. PRESENT UTILISATION OF FLYASH IN INDIA

In India, the major source of Energy produced through thermal power is produced thorough Coal. Approximately 65% power in India is produced through the Thermal Power Plants.

Table.2. Present Utilization of Fly Ash
(source - Fly ash utilization Unit– DST Govt. of India)

Sector	Million Tonne	% of utilization
In production of Portland Pozzolana Cement	32	40
Cement Replacement at Concrete batching Plants (RMC)	8	10
Filling in low lying areas	14	18
Roads and Embankments	12	17
Dyke Raising	4	5
Brick Manufacturing	3	2.5
Agriculture Sector	3	2.5
Other miscellaneous uses.	4	5
	80	10





V. PROPORTIONING OF RAW MATERIALS

Proportioning of raw materials is a very important point to ensure the quality of fly ash bricks. The proportioning will depend upon the quality of the raw materials used and the class of brick we want to require. The following mix proportion is being adopted by many

Table.3. Mix Proportion

1	For sludge lime, sand, gypsum& fly ash bricks.
Fly ash	55.50 to 60.50%
Sludge Lime	15.50 to 20.50%
Stone/Sand dust	20.50 to 25.50%
Gypsum	5.50%
2	For fly ash, hydrated lime, sand and gypsum bricks.
Fly ash	60.50 to 65.50%
Sand/Stone dust	18.50 to 27.50%
Gypsum	5.50%
Hydrated Lime	8.50 to 12.50%
3.	For fly ash, cement and sand bricks
Fly ash	50 .50to 60.50%
Sand/Stone dust	32.50 to 40.50%
Cement	8.50o 10.50%

1)The bricks strength made with the the above proportion is generally of the order of 7.50 to 10.00 Newton/sq.mm after 28 days.

2) Mix proportion as suggested above can be used as guidelines. Mix proportion largely depends upon characteristics and quality of raw materials used.

VI. DETAILED DESCRIPTION OF MATERIALS USED

Material used in preparation of mix are as follows:

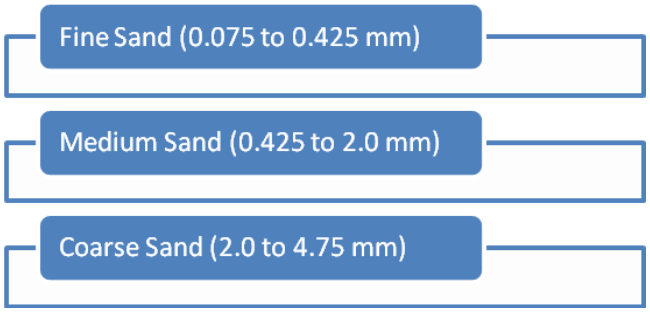
1) FLY ASH:- The fly ash we used in this project was brought from NTPC Dadri plant. Fly is a very useful building material. Use of fly ash has been incorporated in a no. of experiments and projects . 63 thermal power stations in India produce almost 30 million tones of fly ash every year. Nowadays with the increase in the usage of this material, a disposal method for the same which is eco friendly has become very important to look for. The work done on NTPC Dadri-fly ash has shown low reactivity and very less lime content. The NTPCi thermal Power station at Dadri has facilities of collecting fly ash from hoppers in dry state with the help of electrostatic precipitator. Fly ash used from NTPC Thermal Power Plant at Dadri was a Class F fly ash. It may also be noted that until very recent time, there has not been much efforts in India to classify the dry-collected fly ash or to process the bulk collected dry fly ash through removal of carbon or further size reduction. From the previous study done on the same source of fly ash the following observations can be made. Fly ash fulfill the criteria for lime reactivity specified in IS 3812-1981.It was found that fly ash particles retained on 45.00 micron sieve was very small (1.00-1.50 percent) and 90.00 percent of particles have diameter between 17.00 and 20.00 micron.

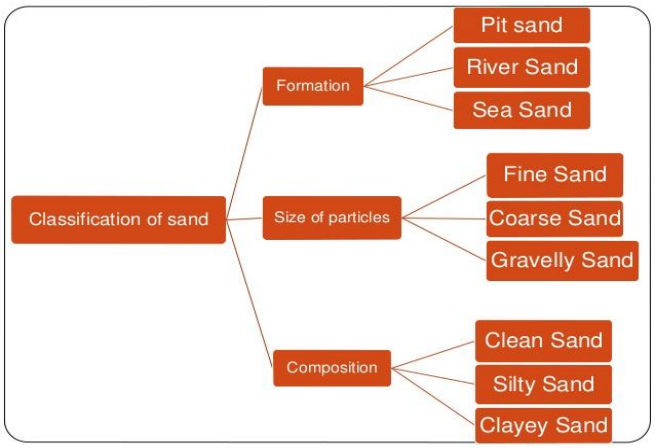
2) CEMENT:- P.P.C conforming to IS 269 and IS 4031 was used in this work.

Table.4. Cement Composition

Calcium oxide	61 to 63%
Silica oxide	17 to 21%
Aluminum Oxide	4 to 8%
Ferrous Oxide	0.5 to 0.6%
SO3	1.3 to 3.0%
Magnesium Oxide	0.1 to 4.0%
Na2 O	0.4 to 1.3%
CI	0.01 to 0.1%
Iron	0.6 to 1.75%

3) SAND (Fine Aggregates):-Natural River Sand which is available locally in the Ghaziabad region is used. The specific gravity of the same is 2.57. Fineness Modulus was also determined using 10 mm to 150 micron sieve and was found 2.972. The fineness modulus gives the idea about average size of particles in the fine aggregates .The value 2.972 indicates medium size sand. Sand is a very important building material. Sand which we use for construction therefore should be clean, should not have any impurity or stones. There are 3 types of sand ,so it is important to know which type is suitable for the construction purposes. According to the particle size, sand is classified in 3 types:





4) METALS CHIPS:- The waste material from Mechanical lab was used in mix. Metals chips are waste material produced during mechanical operations on lathe machine. The metal chips obtained was first crushed with help of hammer and then passed through 600 µm. The metal powdered was obtained then added in mix proportion.

VII. METHODOLOGY OF SAMPLE PREPRATION

1) PREPARATION OF MIX:-In the present study, work was carried out in two phases. In 1st phase the proportion of cement and fly ash was varied and in 2nd phase proportion of fly ash ,sand and cement were constant but powder of metallic chips was added in different % by weight. For each mix proportion, total no. of four bricks were prepared.

2) MIXING OF MATERIAL:- Each mix proportion prepared were properly mixed with help of mechanical mixer and then manually with hands so that uniform mix proportion will be obtained.

Table . 5. Mix proportions of bricks for Phase – I

MIX NO.	FLY ASH	CEMENT	SAND DUST
MIX 1	58 %	12%	30%
MIX 2	60 %	10 %	30 %
MIX 3	62 %	8 %	30 %
MIX 4	64 %	6%	30 %

3) ADDITION OF WATER After proper mixing of material, water was added into mix in stages so as to carry out removal of air . The water/cement ratio was taken to be constant throughout the work.

Table .6. Mix proportions of bricks for Phase – II

MIX NO.	FLY ASH	CEMENT	SAND DUST	METAL CHIPS
MIX 1	62 %	8 %	30 %	0 %
MIX 2	62 %	8 %	30 %	0.5 %
MIX 3	62 %	8 %	30 %	1.0 %
MIX 4	62 %	8 %	30 %	2.0 %

Table. 7. W/C RATIO IN MIX

MIX	W/C RATIO
MIX 1	23.44 %
MIX 2	23.44%
MIX 3	23.44 %
MIX 4	23.44%

3) CASTING OF BRICKS:- For casting of bricks, mould of size 19 cm*9 cm* 9 cm was used. The casting of bricks was carried out by filling mix proportion in mould in three stages , each compacted to thickness of 3 cm.

4) DRYING OF BRICKS Drying of bricks was carried out in two stage. In 1st stage , air drying of bricks was carried out for 3 days and in 2nd stage , oven drying of brick was done for 24 hours.

5) CURING OF BRICKS Curing of bricks was carried out as per IS 12894 . .Curing of bricks was done for at least Fifteen to Twenty days

VIII. DESIGN MIX PARAMETERS

Table .8. PHASE – I

MIX PROPORTION	FLY ASH Wt. (KG)	Sand Wt. (KG)	Cement Wt. (KG)	WATER (mll)
MIX 1	6.061	3.135	1.463	1237
MIX 2	6.270	3.135	1.045	1237
MIX 3	6.479	3.135	0.836	1237
MIX 4	6.688	3.135	0.627	1237

Total nos. of bricks casted in Phase- I = 16
Total Quantity of fly ash used in Phase-I = 25.498 kg
Total Quantity of sand used in Phase-I = 12.54 kg
Total Quantity of cement used in Phase-I = 3.971 kg
Total Quantity of water used in Phase- I = 4948 ml

Table .9. PHASE –II

MIX PROPORTION	Fly Ash Wt. (KG)	Sand Wt. (KG)	Cement Wt. (KG)	Metallic Chips Powder Wt.(gm)	WATER (ML)
MIX 1	6.479	3.135	0.836	52.25	1237
MIX 2	6.479	3.135	0.836	104.5	1237
MIX 3	6.479	3.135	0.836	156.75	1237
MIX 4	6.479	3.135	0.836	209.0	1237

Total nos. of bricks casted in Phase-II = 16
Total Quantity of fly ash used in Phase-II = 25.916 kg
Total Quantity of sand used in Phase-II = 12.54 kg
Total Quantity of cement used in Phase-II = 3.344kg
Total Quantity of metallic chips powder used =522.5 gm
Total Quantity of water used in Phase- II = 4948 ml

IX. TEST CONDUCTED AND RESULTS

A :-DIMENSION TEST

Table.10. PHASE – I

MIX PROPORTION	AVG. LENGTH (MM)	AVG. WIDTH (MM)	AVG. HEIGHT (MM)
MIX 1	3750	1780	1777
MIX 2	3756	1788	1773
MIX 3	3759	1784	1775
MIX 4	3753	1787	1773

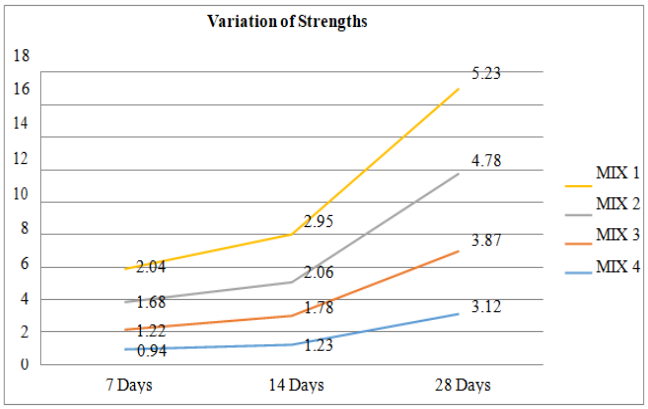
Table .11. PHASE – II

MIX PROPORTION	AVERAGE LENGTH (MM)	AVERAGE WIDTH (MM)	AVERAGE HEIGHT (MM)
MIX 1	3751	1780	1776
MIX 2	3755	1788	1773
MIX 3	3759	1784	1775
MIX 4	3753	1788	1774

B:- COMPRESSIVE STRENGTH TEST

Table .12. Phase- I

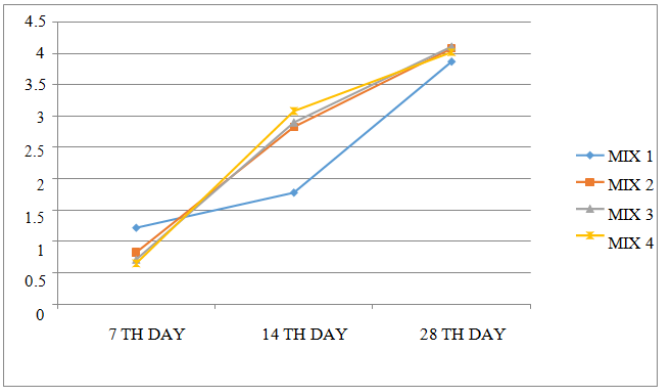
MIX PROPORTION	AVERAGE7 DAYS COMP. STRENGTH (Newton/Sq.MM)	AVERAGE14 DAYS COMP. STRENGTH (Newton/Sq.MM)	AVERAGE 28 DAYS COMP. STRENGTH (Newton/ Sq.MM)
MIX 1	2.04	2.95	5.23
MIX 2	1.68	2.06	4.78
MIX 3	1.22	1.78	3.87
MIX 4	0.94	1.23	3.12



Avg. Comp. Strength of Test brick in Phase I =1.47 Newton/Sq.MM (at seven days). Avg. Comp. Strength of Test brick in Phase I = 4.25 Newton/Sq.MM (at twenty eight days)

Table.13. Phase- Ii

MIX PROPORTION	AVG. 7 DAYS Comp. Strength(Newton/Sq.MM)	AVG.14 DAY COMP. STRENGTH (NEWTON/Sq. MM)	AVG28 DAYS COMP. STRENGTH (Newton/Sq. MM)
MIX 1	1.22	1.78	3.87
MIX 2	0.824	2.83	4.08
MIX 3	0.712	2.9	4.11
MIX 4	0.651	3.08	4.02

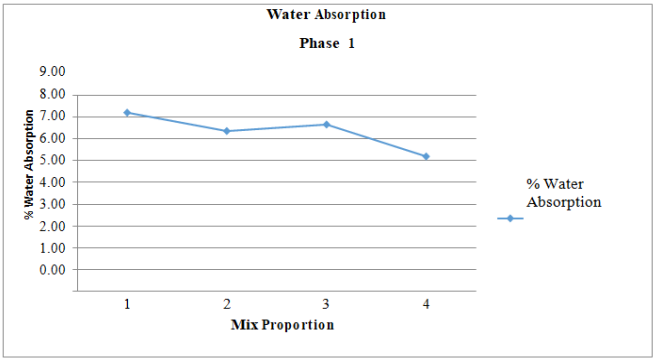


Avg. Comp. Strength of Test brick in Phase II=0.851 Newton/Sq.MM (at seven days)
Avg. Comp Strength of Test brick in Phase II = 4.02 Newton/Sq.MM (at twenty eight days**)**

C:- WATER ABSORPTION TEST

Table .14. PHASE- I

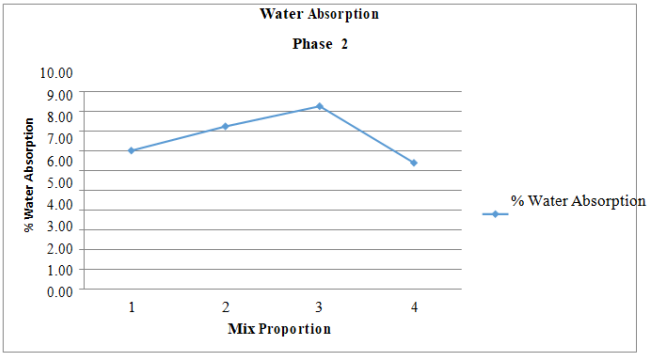
MIX PROPORTION	AVERAGE OVEN DRY WEIGHT OF BRICK (KG)	AVERAGE WET WEIGHT OF BRICK AFTER 24 hr(KG)	% OF WATER ABSORPTION
MIX 1	2.255	2.440	8.20
MIX 2	2.310	2.480	7.36
MIX 3	2.285	2.460	7.66
MIX 4	2.260	2.400	6.19



Average % of water absorption in Phase I = 7.35% .

Table.15. PHASE-II

MIX PROPORTION	AVERAGE OVEN DRY WEIGHT OF BRICK (Kg)	AVERAGE WET WEIGHT OF BRICK AFTER 24 hr(Kg)	% OF WATER ABSORPTION
MIX 1	2.355	2.520	7.00
MIX 2	2.310	2.525	9.30
MIX 3	2.380	2.610	9.66
MIX 4	2.350	2.501	6.42



Average % of water absorption in Phase II = 8.1 % .

D:- EFFLOROSCENCE TEST

No effect of efflorescence was seen when the bricks were tested in accordance with the procedure in IS 3495

E:- HARDNESS TEST

Hardness test was conducted on each of the sample bricks but no marks of scraps were seen hence it may be concluded that bricks were sufficiently hard to resist any indention

X. DISCUSSION

1. In this experimental investigation it was observed that when we add Metallic Powder in the mix, the average compressive strength of the fly ash brick at the 28th day gradually increases upto a certain limit but after that it gradually decreases.
2. In this experimental investigation it was observed that when we add Metallic Powder in the mix, the average compressive strength of the fly ash brick at the 7th day gradually decreases.
3. At 0.5 %, there is 10.8 % decrease in initial average comp. strength for seven days.
4. At 0.5% , there is 5.4% increase in average comp. strength for twenty eight days.
5. Up to 1 % , there is increase in average comp. strength(twenty eight days).

XI. CONCLUSIONS

- The comp. strength of fly ash bricks increases with addition of waste metallic powder up to 1 % by weight of total mix and further any addition of waste metallic powder results in decrease in compressive strength of fly ash brick.
- Thus we found out that optimum % for addition of metallic powder with mix is almost equal to 1 % by weight of mix.
- We have used a simple step to minimize the costs for construction with usage of waste metallic powder which is freely, cheaply and readily available.
- We have also stepped into realm of saving the environmental pollution by usage of fly ash in bricks and cement production; being our main objective as Civil Engineers.

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