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Study on use of Fly ash and Pond ash for Manufacturing of Bricks

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Abstract—*This paper presents the findings of investigation carried out on bricks made using fly ash and pond ash. Bricks were cast using mixtures of pond ash, fly ash and cement by pressing and compacting by block making machine. Bricks were then tested for compressive strength, dimensional tolerance, water absorption, efflorescence, soundness and hardness. The results showed better performance compared to conventional clay bricks in the properties investigated. Compressive strength at 28 days is between 10.21 to 18.61MPa, while dimensional tolerance is well within the permissible limit for length, width and height. Water absorption is between 6.10% to 11.70% which is within permissible limit of 20 % . Efflorescence is between 2.81% to 3.33% area of the brick specimen which is well within permissible limit. Soundness and Hardness of brick specimen were also found to be satisfactory. Results for mechanical properties and cost aspect were found rewarding and promising. It is concluded that bricks developed in this study can be used as an alternative to conventional bricks and hence can contribute to sustainable development.*

Keywords:-*Pond ash Fly ash, Dimensional Tolerance, Efflorescence, Sustainable Development*

1. INTRODUCTION

The quality of coal depends upon its rank and grade. The coal rank arranged in an ascending order of carbon contents is: Peat, Lignite, sub-bituminous coal, bituminous coal, anthracite. Indian coal is of mostly sub bituminous rank followed by bituminous and lignite (brown coal).The ash content in Indian coal ranges from 35 % to 50 %. The coal properties including calorific values differ depending upon the colliery. The calorific value of the Indian coal (~ 15 MJ/Kg) is less than the normal range of 21 MJ/kg to 33 MJ/kg(gross).There are generally three categories of coal ashes available from thermal power stations:-dry fly ash collected from different rows of electrostatic precipitator in dry form. The fly ash produced from the burning of pulverized coal in a coal fired boiler is a fine grained, powdery particulate material that is carried off in the flue gas and usually collected from the flue gas by means of electrostatic precipitators, bag houses, or mechanical collection devices such as cyclones. Bottom ash collected at the bottom of the boiler furnace and is characterized by better geotechnical properties. Pond ash -fly ash and bottom ashes are mixed together with water to form slurry which is pumped to the ash pond area. In the ash pond the, ash gets settled and excess water is decanted this deposited ash is pond ash. Various scholars went through manufacturing of bricks from various waste materials such as bottom ash, rice husk ash, fly ash, paper sludge, bagasse ash etc. Mechanical properties of bricks developed from the above mentioned wastes like compressive strength, dimensional tolerance, water absorption, efflorescence, soundness and hardness were considerably promising and qualified them to be used in various civil engineering fields [1, 4, 8, 11, 17, 18, 19]. Recent scholars have detected the problems of the conventional method of bricks production such as energy consumption and greenhouse gas emission and their dangerous impacts on the environment [20].This paper presents results of the investigation on mechanical properties and cost aspect of bricks manufactured from fly ash[8, 15, 17, 18], pond ash[9] using a non-conventional method. This study may help to reduce the cost of disposal of fly ash and pond ash hence reduce the cost of treatment, decrease the consumption of virgin materials, reduce the environmental contamination and thereby contribute to sustainability.

2. EXPERIMENTAL METHODS

2.1. Materials

Portland pozzolana cement (PPC) from Lafarge Concerto, Jamshedpur Jharkhand, India was used used for all mixtures .the specific gravity of cement was 3.15 and specific surface area was 2910 cm^2/g. Fly ash and pond ash were obtained from Durgapur Steel Thermal Power Station, Andal West Bengal India. The studies carried out at IISc reveal that the major mineral found in coal ashes is quartz with lesser proportions of feldspars, carbonates and chlorites. The coal ashes exhibit both crystalline and amorphous phases. The chemical composition of fly ash and pond ash are given in Table 1.

Table1:- Range of chemical composition of Indian Coal ashes.

Compounds	Fly ash(%)	Pond ash(%)
SiO2	38–63	37.7–75.1
$Al2O_3$	27–44	11.7–53.3
TiO_2	0.4–1.8	0.2–1.4
Fe_2O_3	3.3–6.4	3.5–34.6
MnO	0–0.5	0–0.6
MgO	0.01–0.5	0.1–0.8
CaO	0.2–8	0.2–0.6
Na_2O	0.07–0.43	0.05–0.31
LOI	0.2–3.4	0.01–2.09

Mixer was well covered during the mixing process to avoid the volatility of fly ash due to its light weight. Then, water was added and mixing continued for another 2 min. The fresh mixture was then poured into brick mould of size (230 mm x110 mm x 70 mm) [7]. The bricks were prepared in block making machine by pressing and vibrating. Bricks are taken out from the mould after proper compaction and laid on non absorbent leveled surface. All the specimens were covered with wet clothes to avoid loss of moisture from the bricks for 24 hours. The specimens were transferred to tank filled up with water for curing.

2.3. Testing

Bricks were tested for compressive strength, dimensional tolerance, water.

Table 2: Range of chemical composition of PPC concerto cement from Jamshedpur, Jharkhand, India.

Compounds	PPC Cement (%)
SiO_2	28-32
Al_2O_3	7-10
Fe_2O_3	4.9-6
MgO	1-2
CaO	41-43
LOI	3-3.5

2.2. Manufacture of bricks

The mix proportions of content materials are shown in Table 3.

Table 3: Mix proportions (FA:PA:C) of trial mixes [2, 19].

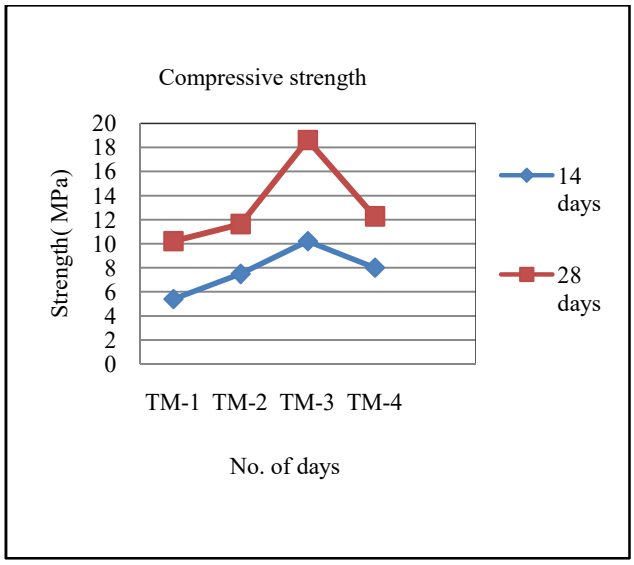
Designation of mix.	Mix proportions (FA:PA:C)
TM-1	1:1: 0.25
TM-2	1:1: 0.50
TM-3	1:1: 0.75
TM-4	1: 1.5: 0.50

The pond ash and cement were firstly mixed in the mixer in dry state for 2 min. Then, fly ash was added and mixing continued for another 2 min. Absorption, efflorescence, soundness and hardness. Compressive strength test was done using universal testing machine of 1000 KN capacity at 14 and 28days as per IS3495 (Part1) [7]. Dimensional tolerance was done according to IS12894:2002 [7] . For each unit of brick width, height and length were measured at mid width, mid height and mid absorption, efflorescence, soundness and hardness. Compressive strength test was done using universal testing machine of 1000 KN capacity at 14 and 28days as per IS3495 (Part1) [7]. Dimensional tolerance was done according to IS12894:2002 [7] . For each unit of brick width, height and length were measured at mid width, mid height and mid length respectively. Water absorption is an important factor affecting the durability of brick. The lesser the water infiltrates into brick, the higher will be the durability of bricks. The determination of water absorption was done accordingtoIS3495 (Part2)[7]**.**Efflorescence test was done according to IS3495(Part3) [7]. The specimen is kept in shallow dish with one end of brick is in the dish. Then distilled water is filled in the dish such that brick should immersed in water up to 25mm depth. Place the whole arrangement in warm ventilated room such that whole water is absorbed by the specimen and surplus water will get evaporated. Soundness test is carried out to find clear ringing sound is produced or not when two bricks are struck with each other without breaking any of the two bricks. If the two bricks are not broken after striking with each other and a clear ringing sound is produced then it means that the bricks are sufficiently sound. Hardness test is conducted by taking brick specimen and scratch was made on brick surface with the help of finger nail. If it is found no scratch on the surface of bricks it means bricks are sufficiently hard.

3. RESULTS AND DISCUSSION

3.1. Compressive strength

Compressive strength of the bricks at 14 days for trial TM-1, TM-2, TM-3 and TM-4 are 5.40 MPa, 7.49 MPa, 10.21 MPa and 8.01 MPa and at 28 days compressive strength are 10.21 MPa, 11.63 MPa, 18.61 MPa and 12.27 MPa. This indicates that the bricks produced in the investigation have satisfactory compressive strength. It can be observed that increase in pond ash and cement increases the strength for the mixtures. It is also observed that the strength is maximum when FA:PA:C ratio is 1:1:0.75. Similar findings were observed by previous works on fly ash and bottom ash [17, 18, 19].



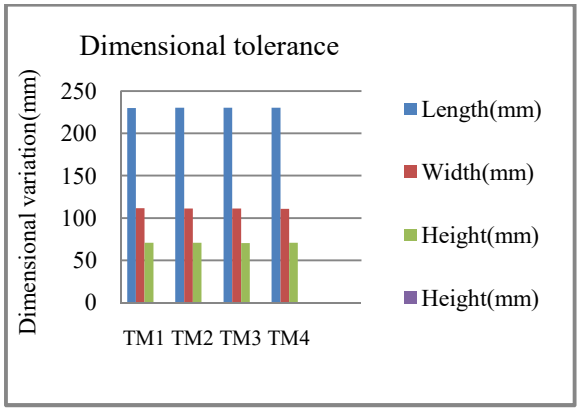
3.2. Dimensional tolerance

Dimensional variation for the TM-1, TM-2, TM-3 and TM-4 are shown in table below.

Table-4: Variation in length width and height

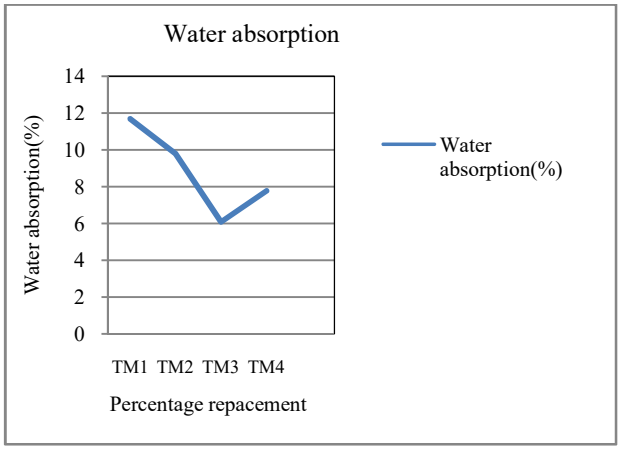
Mix designation	Length(mm)	Width(mm)	Height(mm)
TM-1	230.10	111.75	70.60
TM-2	230.26	111.05	70.67
TM-3	230.51	111.13	70.51
TM-4	230.26	110.98	70.64

It is concluded that the variation in length is within 0.51 mm, width is within 0.75mm and height is within 0.67 mm .Hence we can say that maximum allowable permissible variation criteria is satisfied [14]



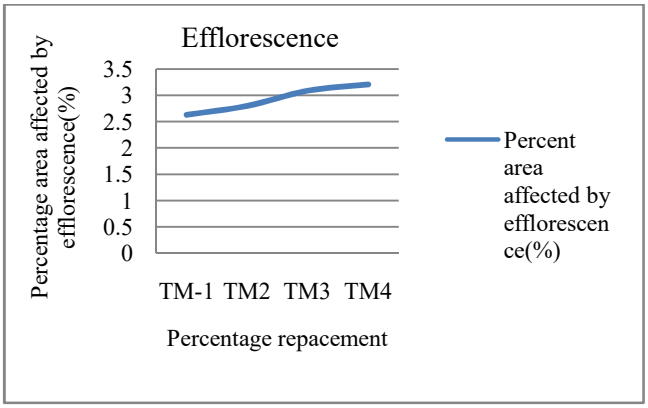
3.3. Water absorption

Water absorption for TM-1, TM-2, TM-3 and TM-4 are respectively 11.7%, 9.80%, 6.10% and 7.78% respectively [4, 8, 14]. It can be concluded that brick produced absorb moisture well within the limit of 20% .It is also observed from the figure below that the minimum absorption is when FA:PA:C ratio is 1:1:0.75. It is also seen that moisture absorption is less when the quantity of pond ash is increased.



3.4. Efflorescence

Efflorescence for TM-1, TM-2, TM-3 and TM-4 are respectively 2.81%, 3.09%, 3.20% and 3.33% area of brick specimen[1, 11]. It was observed that area affected by efflorescence decreases with the increase of fly ash content in brick specimens. It can be concluded that efflorescence is well within the permissible limit as per IS3495(Part 3).



3.5. Soundness

It can be concluded that when two bricks are struck together a clear ringing sound is produced which confirms that bricks are sufficiently sound [11].

3.6. Hardness

It can be concluded that no scratch mark were seen on the surface of brick specimens when scratch was made with the help of finger nail which confirms that bricks are sufficiently hard [11].

3.7. Cost aspect

For making 18 bricks:-

Materials	Unit	TM-1	TM-2	TM-3	TM-4
Fly ash	Kg	24.80	22.32	20.29	18.60
Pond ash	Kg	17.36	15.62	14.20	19.53
Cement	Kg	6.20	11.60	15.21	9.30
Cost of FA(70 per MT as per GOI rules)	Rs	1.73	1.56	1.42	1.30
Cost of PA (0 as per GOI rules)	Rs	0	0	0	0
Cost of cement (370 per bag from Lafarge concreto Jamshedpur, J harkhand, India)	Rs	45.80	82.58	112.5	68.82
Transport cost FA, PA and cement(100 per MTas per DSR 2016)	Rs	4.83	4.91	4.97	4.74
T. material cost including transport	Rs	52.36	89.05	118.87	74.86
Labour cost(30% of total material cost)	Rs	15.70	15.70	15.70	15.70
Total	Rs	68.06	104.75	134.59	90.56
Cost of one brick	Rs	3.78	5.81	7.47	5.03

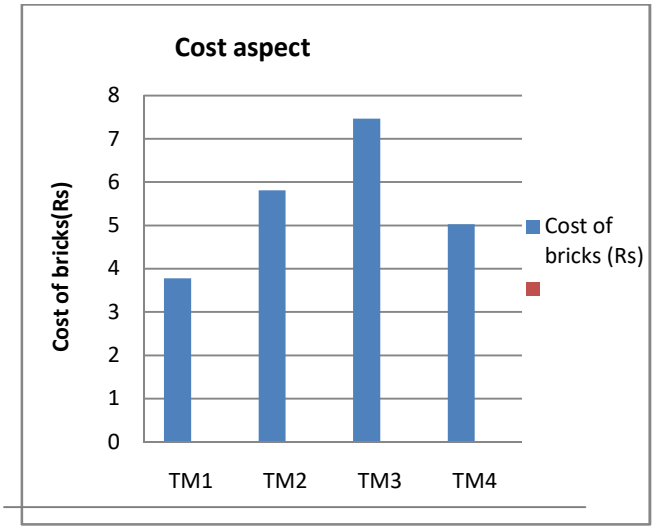


Table 5: Final table for Compressive strength, Dimensional tolerance, Water absorption, Efflorescence, Soundness, Hardness and Cost aspect

Type of test	TM-1	TM-2	TM-3	TM-4
C. strength at 28 days(MPa)	10.21	11.63	18.61	12.27
Length(mm)	230.10	230.26	230.51	230.26
	111.75	111.05	111.13	110.98
Width(mm)				
Height(mm)	70.60	70.67	70.51	70.64
Water absorption(%)	11.70	9.80	6.10	7.78
Efflorescence(%)	2.81	3.09	3.20	3.33
Soundness	Good	Good	Good	Good
Hardness	Good	Good	Good	Good
Cost aspect(Rs)	3.78	5.81	7.47	5.03

4. CONCLUSIONS

According to analysis of the results and discussion, the following conclusions can be drawn:-

1) The strength of bricks at 28 days ranged between 10.21 - 18.61 MPa for all four trial mixes. The strength of bricks of TM-1 at 28 days is 10.21 MPa.

2) Dimensional tolerance is within the permissible limit of 1.6 mm, 2.4 mm and 3.2 mm for height, width and length respectively. Water absorption range between 6.10% to 11.70% at 28 days which is within the permissible limit of 20% for all trial mixes.

3) Water absorption for TM-1 is 11.70% at 28 days which is within permissible limit of 20% .Efflorescence value ranged between 2.81% to 3.33% area of brick specimen is well within permissible limit. Soundness and Hardness of bricks specimens were also found satisfactory in the investigation.

4) Considering the criteria of compressive strength, dimensional tolerance, water absorption, efflorescence, soundness and hardness test bricks obtained from TM-1 is of 1st class.

5) It is concluded that manufacturing of bricks using pond ash and fly ash of TM-1 [pond ash=44. 50%, fly ash=44. 50%, cement-11%] is feasible. It is also seen that the brick made with fly ash and pond ash of TM-1 is most economical among all four trial mixes.

6) Fly ash and pond ash is hazardous for environment so if we can recycle it then it will be very useful for sustainable development.

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