A STUDY ON DURABILITY OF FLY ASH MIXED POLYMER CONCRETE BRICKS

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Abstract:
Commercial left-over fly ash which is creating environmental problem, is mainly used as a building material due to its cost and easy available but the main disadvantage of these bricks is its low strength. So a lot of research going on to increase the strength of these bricks. The present research work is carried out to develop a new systematic procedure to produce fly ash composite bricks which will have higher compressive strength. Here the fly ash is mixed with cold setting resin at different proportions and water treated at different temperature to find out a solution to the brick industry. The compressive strength, Hardness, water absorption, Density and thermal conductivity of the fly ash resin powder bricks obtained under optimum test condition are 12 MPa, 47.3 HV, 19.09%, 1,68gm/cm3 and 0.055W/mK respectively. The sliding wear behaviour is also investigated. The structure property correlation of these composites are studied using X-ray diffraction, FTIR analysis and scanning electron microscopy.

Keywords: fly ash, X-ray diffraction, FTIR analysis and SEM

1. INTRODUCTION

The entire development of a country depends on the production value of power and consequently its consumption as energy. Our country, India needs huge power resources to meet the expectation of its occupant as well as its aim to be a developed nation by 2020. Fossil fuel plays an important part in meeting the demand for power generation. Coal is considered to be on of the world's richest and widely distributed fossil fuel. Around the world, India dominates the third position in the largest production of coal and has the fourth largest coal reserves approx.(197BillionTons).It has been estimated that 75% of India's total installed power is thermal of which the share of coal is about 90%. Nearly about 600 million tons of coal is produced worldwide every year, with Fly ash generation is about 500 MT at (60-78%) of whole ash produced. In India, the current generation fFA is nearly about 180 MT/year and is probable to increase about 320MT/ year by 2017and 1000MT/year by 2032. No doubt Indian coal has high ash content and low heat value. In order to meet the increasing challenging demands, many coal based thermal power plants have been constructed. As a result of which huge amount of combusted residue in the form of Fly ash (80%), and Bottom ash (20%) has been produced

Objective of the Present work

The aim of the present work is to fabricate Fly ash polymer composite at different proportions of polymer and to study physic mechanical, thermal conductivity and wear behaviour. In present project an attempt was made to increase the density and hardness of the water cured cylindrical samples. SEM, XRD and FTIR analysis were also done to investigate the micro structural changes

2. LITERATURE REVIEW:

Vittal (2001) stated that few embankments have already been constructed using pond ash in India. According to IRC, 2001 (a working body of Indian govt.) has proposed strategies to use fly ash in road embankments. Fly ash shows self - hardening behavior and can be utilized in construction over wide range. This property is due to the availability of free lime .The properties of it depends on various characteristics out of which some are characterization of coal, fineness of pulverization, furnace type and temperature of firing. McLaren and Digioiab presented that the specific gravity of Fly ash is relatively lower than that of soils .The density of the ash fills gets reduced which is a major advantage in terms of its use as various filler materials. Now these fillers can be used in spongy walls and ridges particularly when the foundation is weak. Sridharan et al., studies the micrographs of FA particles through SEM. These particles are mostly solid spheres with glassy appearance, hollow spheres with smooth-edged porous grains, asymmetrical agglomerates and irregular absorbent scraps of unburnt carbon. Presence of iron particles which are dark grey in color can be identified as pointed grains. According to Mohini Saxena and P.Asokan a lot of multidisciplinary tests on coal ash have been conducted at various lab centers. Regional Research laboratory, Bhopal has worked a lot on FA and enhanced the various methodologies for pilot scale demonstration. They cultivated Crops, vegetables and cereals and reported that the yield increases greater than before by FA utilization with no toxicity. They also developed paints using FA and epoxy systems for safety and embellishment. These FA paints has improved resistance to rust, abrasion and wear. Mitchell and Brown said that the soil, FA and lime displays unique behavior and are much more dependent on the physicochemical properties of the fly ash and soil like porosity, segregation, lime content ,time and pressure applied during compaction.

3. METHODOLOGY:

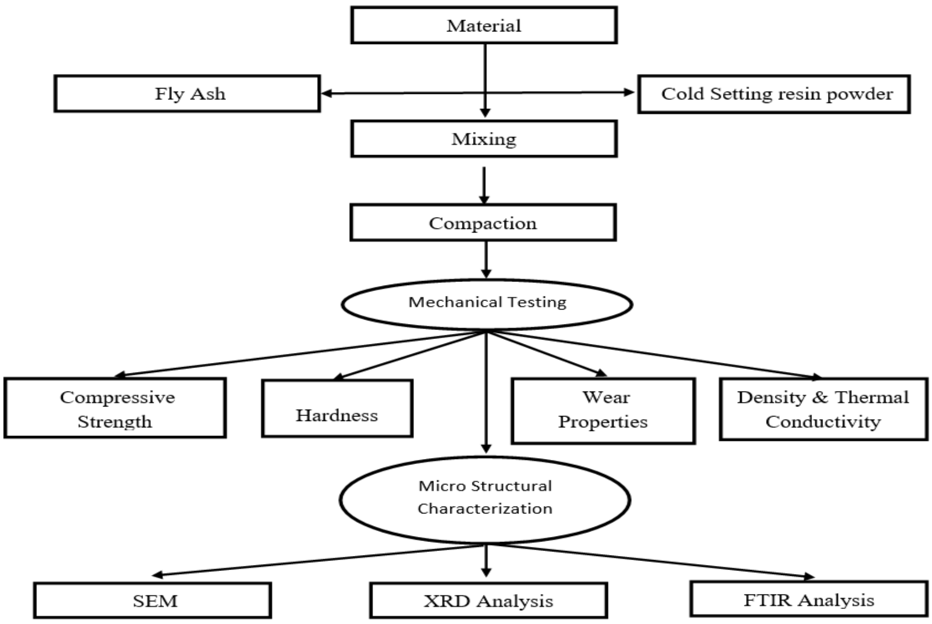

Fig 1: Design flow chart

Experimental Methods

Three different weight percentages of Fly ash and resin powder with (75%, 80% and 85%) and (25%, 20% and 15%) were taken respectively. These compositions were mixed thoroughly by a mechanical vibrator (Abrasion Tester Model PEI-300), to get a homogenous mixture. Different compositions of Fly ash along with resin powder were kept in three different small size bottles. Around 6-10 small steels balls are kept inside for proper mixing. Mixing was done till the vibrator shows 1000 revolutions which almost took five hours.

Compaction

The compaction experiments were executed to make cylindrical FA compacts. Cylindrical die and punch having 15 mm diameter made of stainless steel was used to make cylindrical Fly ash compacts. Mixture of approximately 5gm. Was taken for each composition. The whole system was relaxed for 5 minutes which then followed by unloading. Compact was ejected from the Die in the same direction as the compression and was kept in normal atmosphere for 1 day. The cold setting liquid (hardener) was applied on the surface of the compacted samples with the help of a dropper, so as to harden the newly made compacts. The amount of Hardener used was 1/6th or 1/4th of the mixture. Hence in this way twelve samples for each composition were made. All the samples were dried in open atmosphere for 2 days.

Determination of Mechanical properties

Hardness

Vickers hardness tester (LECO, LM 248 AT) as shown in Figure3.1, was used to find the hardness values of all the dry and wet samples using 20gf Load for a dwell time of 15 seconds. At least eight measurements were taken at different position for each sample in order to get constant result.

Compressive Strength

In order to measure the compressive strength of dry and wet samples INSTRON1196. Prior to test gauge length and gauge diameter of the dry and wet specimens were measured individually by the aid of Vernier caliper. The tests were carried out at room temperature (300K) with a constant cross head speed of 1 mm/min and the full scale range load of 50 kN. This computer Integrated machine gives the Load vs. displacement signals directly when the specimens were subjected to tests

Water Absorption

The cylindrical compacts were tested for water absorption according to ASTMC642. The weights of all the samples were taken. The compacts were first dried in an oven at 1000C-1200C ensuring removal of moisture and hence allowed it to cool at room temperature. The weights were taken after drying and the variation in weight was less than 5%, considered it as dry.

Micro structural Characterization

SEM Study

In present study, AJEOL 6480LV Scanning Electron Microscope (Fig.3.4) was used for the characterization of micro structural changes (pits, cavities, and porosity), determination of particle size and morphology of FA compacts. To get the better image resolution, secondary electron imaging with accelerating voltage of 15KV was used

XRD Study

The mineralogical composition of Fly ash and the different phases present was determined by XRD analysis in a Philips X-pert multipurpose ex-ray diffract to meter (shown in figure.3.5) using Cu Kα (λ=1.5418Ao) radiation. The patterns were examined by comparing the positions of peak and intensities of the samples with those in the (JCPDS) data files. The diffraction patterns were recorded in the scanning range of 200-80o with as temp size of 20C per minute

FTIR Study

FTIR spectroscopic technique is used to understand the chemistry of surface for fly ash in thermally active state along with different state of mineral phases, H2O and–OH group on silica and alumina. Fourier transforms infrared radiation (FTIR) spectrometer is used to calculate the transmission percentage of infrared. In order to prepare pellet little quantity of potassium bromide (KBr) was segregated with powder sample and after that pressing of mixture was done. Analysis of that pellet was done using FTIR by keeping the pellet in sample holder.

Fig 2: Perkin-Elmer Spectrum R XI (FTIR) Spectrometer

4.0 RESULTS AND DISCUSSIONS

Water Absorption Test

Table shows the amount of water absorbed corresponding to different FA composition. The water absorption values of FA composites lie in the range of 15.55% to19.09%. It can be seen that all the composition met the absorption criteria set by several developing countries. India permits the maximum of 20 % water absorption when compacts are immersed for 24 hours

Table 1: Percentage (%) water absorbed by various FA polymer compacts

Mix Composition (Wt %)	Weight (gm)		Water Absorption (%)	Average Water Absorption Value(%)
(FA)75%+(RP)25%	4.579	5.302	15.78	15.55
	4.630	5.340	15.33	
(FA)80%+(RP)20%	4.452	5.151	15.70	16.61
	4.642	5.456	17.53	
(FA)85%+(RP)15%	4.502	5.356	18.96	19.09
	4.329	5.162	19.23	

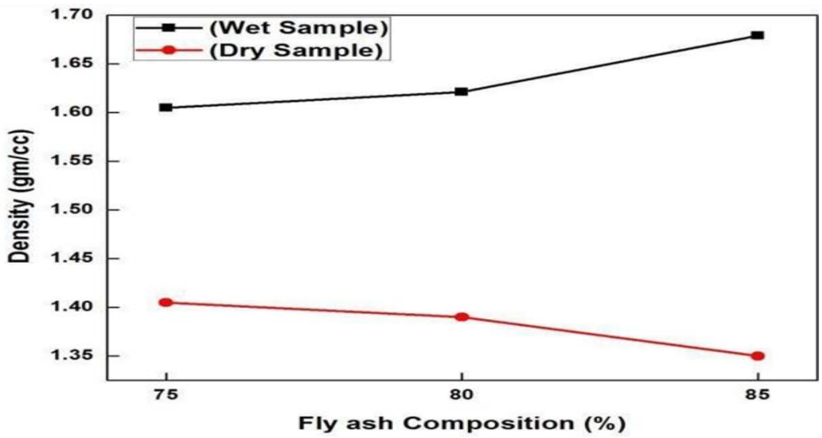

Fig 3: Water absorption and density as a function of FA Composition

Hardness Measurement

Hardness values of all the Fly ash polymer composite of different compositions, both in dry and wet state, were measured by the help of LECO, LM248ATVickers hardness tester. The Hardness values as obtained are shown in Table values of hardness are in the range of 32.93HV–44.08HV for dry composites and 39.78HV–47.37HV for wet FA composites respectively.

Table 2: Hardness values of various FA resin mix compacts

Sl NO	Mix Composition (Wt%)	Micro Hardness Value (HV)	
		Dry	Wet
1	(FA)75%+(R p) 25%	32.93	39.78
2	(FA)80%+(R p) 20%	38.26	43.04
3	(FA)85%+ (R P) 15%	44.08	47.37

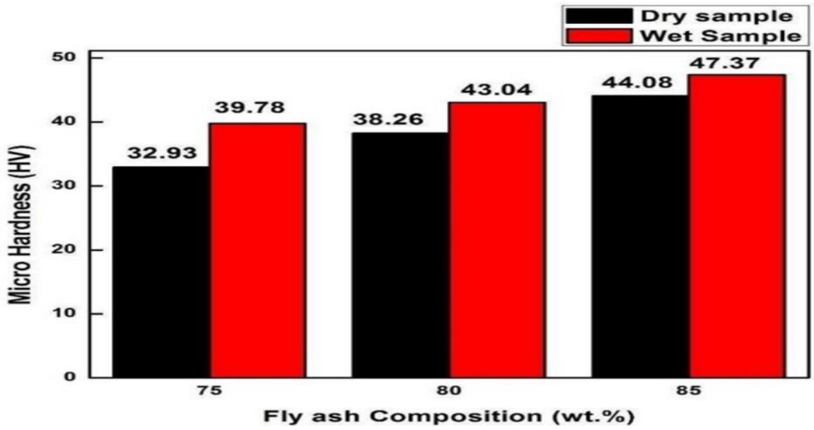

Fig 4: Variation in hardness values with wt.% of FA

XRD Analysis

It has been found that in the presence of moisture, pozzolanic action occurs that leads to the formation of new phase i.e. calcium silicate hydrate (CSH) and calcium aluminate silicate hydrate (CASH). These phases are responsible for solidification of unfired compacts and hence creating strong structures, excellent inter particle. It is evident from the XRD analysis as shown in fig

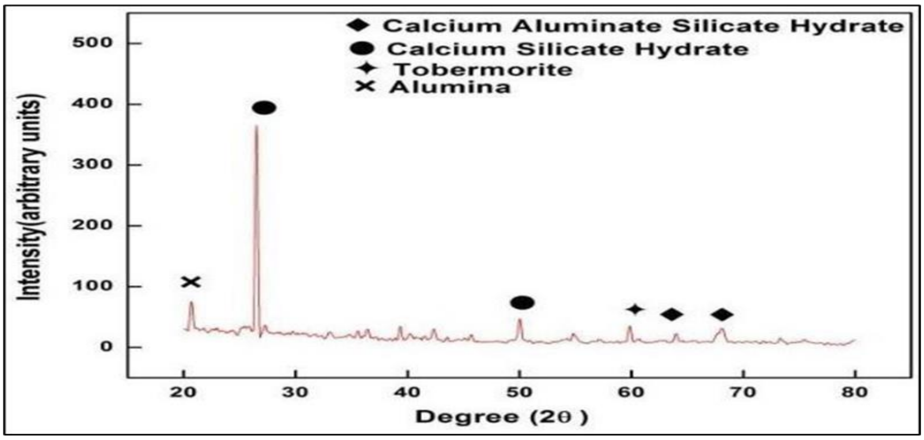

Fig 5: (a) XRD analysis of Fly ash

FTIR Analysis

Fig shows the Fourier transforms infrared radiation (FTIR) Spectro meter plot of 100% FA Along with 80% FA+ 20% RP mix. It can be seen that for 80% FA mix the (%) transmittance is getting decreased with respect to 100% FA. With comparison of FTIR spectrum phase transformation of FA and FA mix can be recognized. The most characteristic difference between the FTIR spectrums of these two is the shifting of band attributed to the symmetric vibrations of Si-O-Si and Al-O-Si. The broadness in band appeared to be around 1250cm-1 in the FTIR spectrum, which became sharper as compared to FA mix.

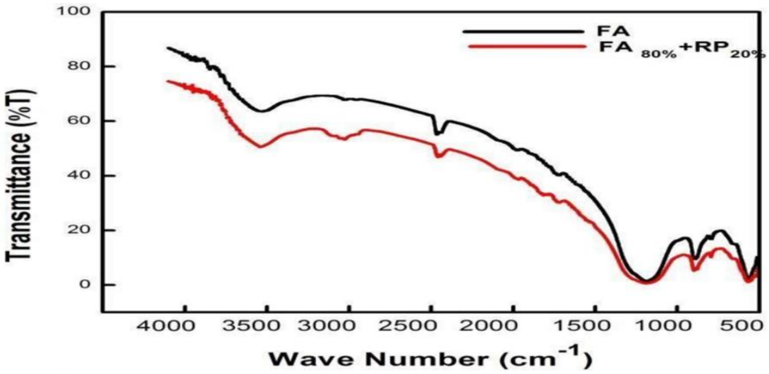

Fig 6: IR spectra of the FA and FA resin Powder mix

Determination of Compressive Strength

The compressive strength measurement of the cylindrical samples was done as per-standard practiced. Test was conducted on the three samples of each composition and the average value of all is evaluated. Table 4.5 shows the strength values of different compositions of FA, both in dry and wet state. For dry composites, the Compressive strength value lies in the range of 6.5 to 11.28 MPa.85 wt. % FA compositions have got the highest strength value while the lowest strength value of 6.5MPa was gained by75wt.% FA composition.

Table 3: Compressive strength values of different FA resin mix compacts

Sl NO	Mix Composition (Wt %)	Micro Hardness Value (HV)	
		Dry	Wet
1	(FA)75%+(R p) 25%	6.5	5.52
2	(FA)80%+(R p) 20%	8.73	7.98
3	(FA)85%+ (R P) 15%	11.28	9.43

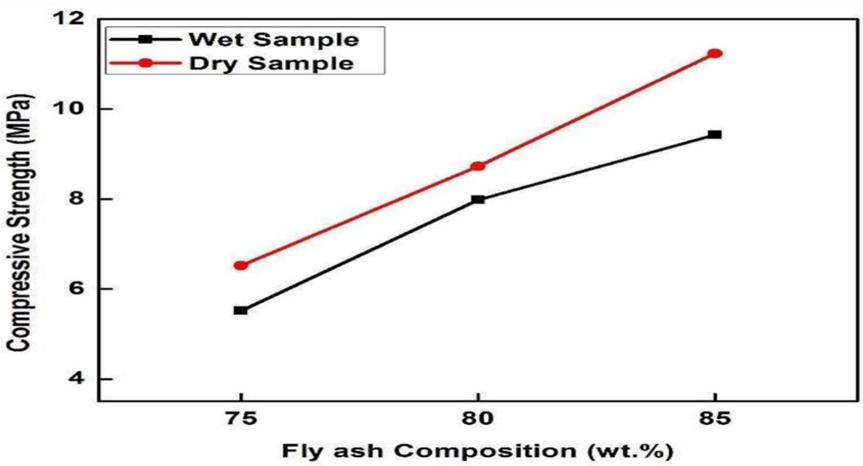

Fig 7: Compressive Strength of Compacts at different FA compositions

SEM Analysis

Micro structure of the composites with 75, 80 and 85wt.% FA plus resin powder mix was studied by the SEM at different magnifications. Particle size of FA powder was also determined. It has been found that the particle size of FA lies in the range of 9.63-47.6μm

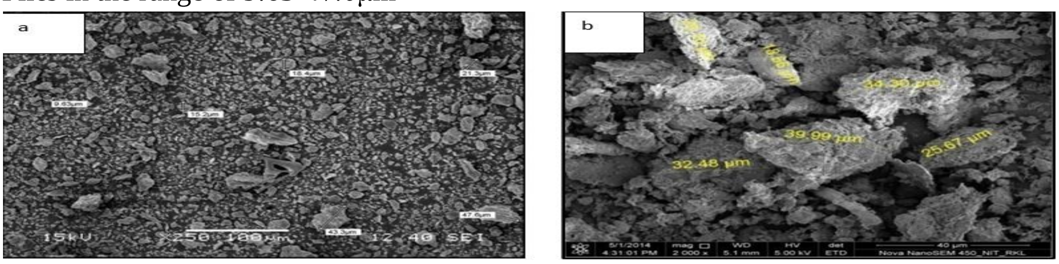

Fig 8: (a,b) Particle size distribution of FA powder at different Magnification

From the SEM micro graphs it has been observed that FA particles are mostly spherical, messy and irregular in shape. FA particle are formed Coagulated junks. In case of 75wt. % FA composition as shown in Figure (a) the cracks at the inter particle boundary seems, pore type of interface periphery. With decrease in polymer addition i.e .increase in Fly ash amount it is seen that the interface bonding becomes better and less amount of cracks at the inter faces. With further decrease in resin addition, although there is good compaction but elongated cracks/cavities are found along the boundaries.

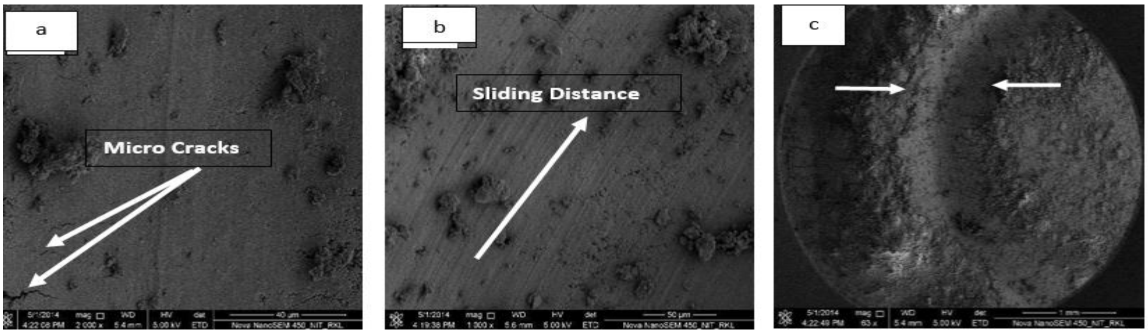

Fig 9: FESEM image of wear track at different magnification

5. Conclusions

On the basis of present study following conclusion can be drawn:

- Water tested compacts shows positive effects on the hardness values. Out of all dry compacts, FA with 85wt.% possesses a higher hardness value of 44.08 HV. Much improvement in the hardness value is achieved when the composites are treated in water at 110^0-180^0C and this value rose to 47.37 HV. This increment in hardness value is due to the presence of CSH and CASH in the presence of moisture as obtained from XRD analysis.
- With an increase in polymer addition (resin powder), the compressive strength of dry compacts decreases to a lower value of 6.5 MPa. Composition of 75wt.% FA shows lower value. No significant reduction in Compressive strength is achieved in the case of wet compact.
- Wear study of different composites can easily be-correlated with the hardness value. In both the dry and wet state, FA with 85wt.% composition shows better resistance to wear than other two compositions. Wear resistance increases with increase in FA content. The co-efficient of friction decreases with increase in FA percentage and follows a linear trend throughout the time of testing.
- Thermal conductivity of FA increases with increase in temperature, where as in case of resin powder FA mixes, the conductivity of composite decreases with increase in temperature. A much lower conductivity value is obtained and hence can be used as a substitute material with respect to clay.
- Water absorption increases with increase in FA content. Maximum of 19% water is absorbed in case of 85 wt% FA.
- Density of dry compacts decreases with increase in FA content. While in case of wet compacts, it increases with increase in FA content.
- SEM analysis revealed the morphology of FA particles that are mostly spherical in shape. With decrease in polymer addition i.e. increase in FA content the interface bonding becomes better and less amount of cracks were found at the interfaces.
- XRD analysis revealed that FA particles mostly consist of Silica and alumina with less percentage of $Fe2O3$, Cao and others

The Fly ash–resin powder composite produced in the present study seem to be appropriate for use as construction material. The production of this type of composite will certainly contribute to the use of fly ash for value added products. On the other hand, the reduction in clay usage for the production of conventional clay bricks will help to protect the environment.

6.References

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