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Exploration of Flyash-Integrated Composite for Sustainable Building Materials.

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Abstract - Because it is inexpensive and readily available, industrial waste, such as fly ash, which is causing environmental issues, is largely employed as a building material. However, these bricks' primary drawback is their lack of strength. Therefore, a lot of research is being done to make these bricks stronger. The goal of the current research project is to create a novel, methodical process for making fly ash composite bricks with increased compressive strength. In order to discover a solution for the brick business, fly ash is combined with cold-setting resin in varying amounts and water treated at various temperatures. Under ideal test conditions, the fly ash-resin powder bricks' compressive strength, hardness, density, water absorption, and thermal conductivity were 11.24 MPa, 47.37 HV, 19.09%, 1.68 g/cm3, and 0.055 W/mK, respectively. Additionally, the behavior of sliding wear is examined. These composites' structure-property correlation is investigated through the use of scanning electron microscopy, FTIR analysis, and X-ray diffraction.

Key Words: Bricks, Fly ash, FTIR Analysis, X-ray..

1.INTRODUCTION

The production value of electricity and, by extension, its consumption as energy are essential to a nation's overall development. In order to meet the expectations of its citizens and achieve its goal of being a developed nation by 2020, our nation, India, need enormous power resources. The most abundant and extensively used fossil fuel is fossil fuel. India ranks third globally in terms of coal output and possesses the fourth largest coal reserves, which total approximately 197 billion tons. Contains around 90% coal. Globally, approximately 600 million tons of coal are generated annually, of which 500 MT are fly ash, accounting for 60–78% of the total ash produced [1, 2]. The current FA generation in India is approximately 180 MT/year, and it is expected to rise to 320 MT/year by 2017 and 1000 MT/year by 2032. [3] Definitely Indian coal has a low heat value and a high ash content. Many coal-based thermal power plants have been built to fulfill the increasingly difficult needs. This has led to the production of a significant amount of combusted residue in the form of bottom ash (20%) and fly ash (80%). The finely dispersed particles from the burned coal are released into the flue gases, which are mechanically separated by separators and electrostatic precipitators before being gathered in hopper fields. FA is being produced at a rapid pace and continues to rise annually. About 275 million metric tons of FA are produced annually in the US, China, and India. However, less than half of this is used in different places. The disposal of leftover waste products is the biggest obstacle facing the manufacturing and processing sectors. The detrimental effects on the environment support the need for proper fly ash disposal and support the complete use of FA when practical. Typically toxic, flammable, corrosive, or reactive waste items have negative effects on the environment. The disposal of leftover industrial waste products is a significant issue that needs to be addressed in an efficient, cost-effective, and environmentally responsible manner. Major problems and obstacles for the country's safe and sustainable development include the need for a vast storage area, the issue of safely disposing of ash without harming the environment, and the disruption of ecological equilibrium. Therefore, the government is making constant attempts to fully utilize the ash by enacting strict rules.

3. Materials

Fly ash has been widely utilized in a variety of industrial and architectural purposes. Therefore the challenges faced by coal-based TPPs for its disposal are significantly lessened by the consumption of this enormous volume of fly ash. Before using FA, an analysis of its performance in different states is basically necessary. Therefore, field domain experiments cannot be conducted to comprehend the aspects of FA. The only way to determine its significance is through a research laboratory test. The laboratory research offers a computational method for controlling a number of parameters that are encountered in practice.
This part provides an overview of the various material kinds, sample preparation, and characterization using SEM, XRD, and FTIR. It also covers mechanical and surface properties such as compressive strength, hardness and wear resistance, thermal conductivity measurement, and others.

3.1 Fly ash

The fly ash utilized in this experiment was extracted from the captive power plant's (CPP-II) electrostatic precipitators while it was dry. For subsequent usage, the fine powders were stored in an airtight bottle after being oven-dried at 110 to 160 degrees Celsius.

3.2 Mixing

Fly ash and resin powder were taken in three different weight percentages: 75%, 80%, and 85%, and 25%, 20%, and 15%, respectively. To create a uniform combination, these compositions were carefully mixed using a mechanical vibrator

(Abrasion Tester Model PEI-300). Three little bottles with various fly ash compositions and resin powder were stored. For adequate mixing, six to ten tiny steel balls are retained inside. It nearly took five hours to mix till the vibrator displayed 1000 rotations.

3.3 Compaction

The purpose of the compaction tests was to create cylindrical FA compacts. Cylindrical fly ash compacts were created using a stainless steel die and punch with a 15 mm diameter.For every composition, about 5 grams of the mixture were taken. To ensure that all of the dust was gone from the exterior of the punch and the inside of the die, the punch and die were then cleaned with cotton and then acetone. Greasing was then applied to prevent sticking. Carefully, the previously prepared liquid was poured within. A small degree of shaking was done during packaging in order to fit as much material as feasible. Ultimately, the entire system underwent coaxial mounting and a hydraulic seal valve tightening. It was subjected to a very gradual load of up to 6 tons. The device was turned off after the maximum load was reached. After five minutes of system relaxation, unloading took place. For one day, the compact was maintained in a typical atmosphere after being expelled from the die in the same direction as the compression. To harden the freshly formed compacts, a dropper was used to apply the cold setting liquid (hardener) to the surface of the compacted samples. One-sixth or one-fourth of the mixture was hardened. Twelve samples were thus created for each composition in this manner. For two days, every sample was allowed to dry in an open environment.

Figure1.. 1 Leco, LM 248AT Micro indentation Hardness Tester

3.4 Compressive Strength

INSTRON 1196 is used to test the compressive strength of both wet and dry materials. Using a Vernier caliper, the gauge length and gauge diameter of the dry and wet specimens were measured separately before testing.At room temperature (300 K), the tests were conducted with a full scale range load of 50 kN and a constant crosshead speed of 1 mm/min. When the specimens are placed through tests, this computer-integrated device immediately provides the load vs. displacement indications.

Figure 2. 2 Ball-On-Plate Wear Tester (TR-208 M1)

4. RESULTS AND DISCUSSION

Compounds	SiO_2	Al2O3	CaO	Mgo	P2O5	Fe2o3	SO_3	K_2O	LOI
Composition (%)	54.5	26.5	2.1	0.57	0.6	-	-	-	14.18

Table1

FA mainly consists Silica (Sio2), Alumina (Al2o3), Calcium Oxide (CaO), and Iron Oxide (Fe2O3).The chemical composition of Fly ash is tabulated in table

Water absorption Test

The amount of water absorbed for each FA composition is displayed in Table 4.2. FA composites have water absorption values between 15.55 and 19.09%. It is evident that every composition satisfied the absorption standards established by a number of developing nations. In India, compacts submerged for 24 hours are allowed to absorb no more than 20% of the water.

Mix Composition (Wt. %)	Weight (gm)		Water Absorption (%)	Average Water Absorption Value (%)
	Dry	Wet		
(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	

Table 1

4.1 Density Measurement

Prior to and following treatment, the samples' densities were determined. We can infer from Fig. 4.2 that when the weight % of FA increases, the density of dry compacts decreases. When the dry compacts are submerged in water at 1100–1800 degrees Celsius, capillary action fills the spaces, hardens them, and removes the porosity. Consequently, the compacts get dense, and as the FA content rises, the density eventually rises as well.

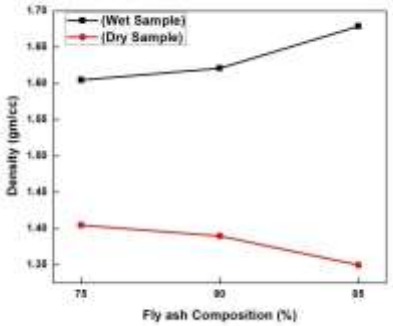

Figure 4.1 Variation in dry and wet density w.r.t FA composition

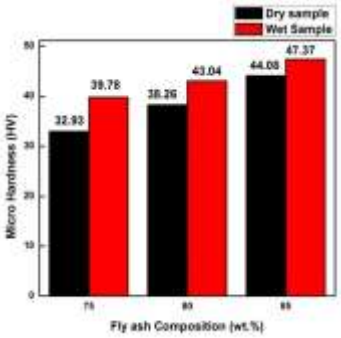

Figure 4. 2 Variation in hardness values with wt. % of FA

4.2 FTIR Analysis

The Fourier transform infrared radiation (FTIR) spectrometer plot of 100% FA and 80% FA + 20% RP mix is displayed in Fig. 4.5. It is evident that, in comparison to 100% FA, the (%) transmittance decreases for an 80% FA mix.FA and FA mix phase transformations can be identified by comparing their FTIR spectra. The band shifting ascribed to the asymmetric vibrations of Si-O-Si and Al-O-Si is the most distinctive distinction between these two FTIR spectra. In the FTIR spectra, the band broadness seemed to be around 1250 cm-1 and grew sharper in comparison to the FA mix. The production of a gel-like phase called alumino silicate, which is linked to the fly ash suspension in the strong alkaline activating solutions, is then indicated by these bands beginning to shift towards low frequencies at about 950 cm-1. About 600 cm-1 was where the stretching vibration of Si-O-Al first occurred. The stretching (-OH) and bending (H-O-H) vibrations of bound water atoms, which are surface consumed or entangled in the massive depressions of the polymeric skeleton, are responsible for the broad band groups that appear in both IR spectra in the region of 3500 cm-1 [30, 31]. Strong hydrogen bonding is indicated by this broadness.

In conclusion, one important synthesis parameter that influences their mechanical strength is the water concentration. Peaks ascribed to O-H stretching emerged at about 2400 cm-1. Water loss is confirmed by the steady decline in the band's broadness and intensity. The C-H stretching vibration of organic pollutants that may have been introduced during sample handling or any hydrocarbon found in fly ash could be the cause of the peak at 3000 cm 1 2000 cm-1.

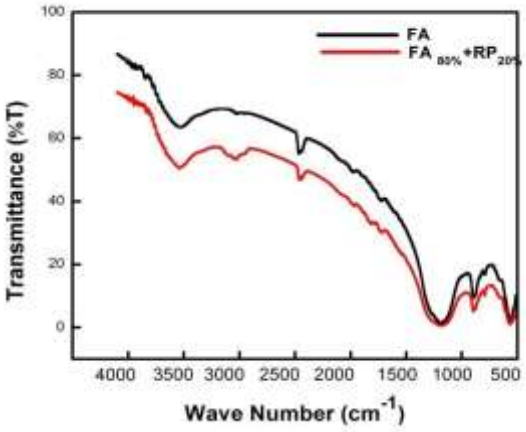

Figure 4. 2 IR spectra of the FA and FA resin Powder mix

4.3 Microstructural study of Fly ash polymer Composite

4.3 SEM Analysis

The SEM was used to examine the microstructure of the composites with 75, 80, and 85 weight percent FA plus resin powder mix at various magnifications. FA powder's particle size was also ascertained. It has been discovered that the FA particle size falls between 9.63- 47.6 μm.

Figure 4.3 (a, b) Particle size distribution of FA powder at different Magnification

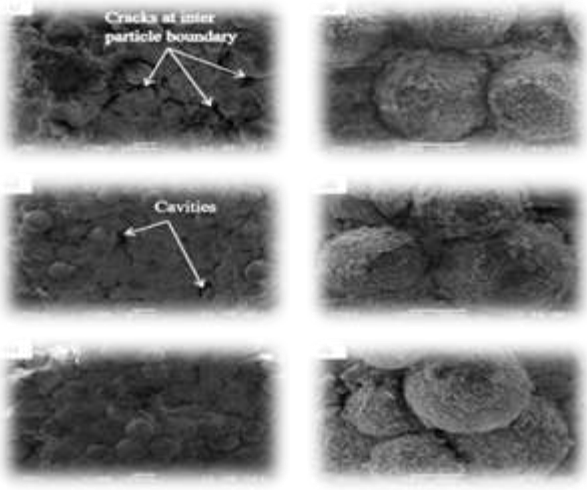

Figure 4.4 Morphology of Fly ash compacts with different composition and at different magnifications

The FESEM micrographs of the wear track along the sliding direction at various magnifications are displayed in Figure 4.13. These pictures demonstrate how wear is primarily caused by delamination, surface plowing, microcrack creation, and tribolayer rubbing. Surface wear results from microcracks that have been started perpendicular to the sliding distance, as seen in Figure 4.13 (a). The wear track of dry compacts (80% FA composition) at very low magnification is displayed in Figure 4.13 (c).

5. CONCLUSIONS

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

- Compacts treated with water exhibit favorable impacts on hardness values. FA with 85 weight percent has the highest hardness value of 44.08 HV among all dry compacts. The hardness value increased to 47.37 HV after the composites were treated in water at temperatures between 1100 and 1800C. According to XRD examination, the presence of CSH and CASH in the presence of moisture is what caused this increase in hardness value.
- The compressive strength of dry compacts drops to 6.5 MPa as the amount of polymer addition (resin powder) increases. 75 weight percent FA composition yields a lower value. In the case of wet compact, there is no discernible decrease in compressive strength.
- It is simple to correlate the hardness value with wear studies of various composites. FA with an 85 weight percent composition exhibits superior wear resistance compared to the other two compositions in both the dry and wet states. As FA content rises, wear resistance rises as well. Over the course of testing, the coefficient of friction exhibits a linear trend, decreasing as the FA percentage rises.
- While the thermal conductivity of FA rises with temperature, the conductivity of composites made of resin powder FA mixes falls with temperature. It can be used as a substitute material for clay because it has a significantly lower conductivity value.
- As the FA content rises, so does water absorption. In the case of 85 weight percent FA, no more than 19 percent water is absorbed.
- As the FA content rises, the density of dry compacts falls. In contrast, it rises as the FA content in wet compacts does.
- FA particles' morphology, which is primarily spherical in shape, was shown by SEM analysis. The interface bonding improves and fewer cracks are discovered at the interfaces when the amount of polymer added decreases, i.e., when the FA content increases.

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