International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2585
Volume 4, Issue 5, May-2018

Recovery and Utilization of Waste Fly Ash to Improve Environment Sustainability

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Abstract- Fly ash, a waste product which is produced by coal combustion in thermal power plants. The aim of this study to utilization of fly ash in cement replacement, fly ash bricks formation and as fertilizers to improve the strength and expediency characteristics of concrete.

Index Terms-Fly ash, cement, fly ash bricks, fertilizers, flue gases, electrostatic precipitators.

I. INTRODUCTION

The population and their life style are increasing day by day, so the demand of electricity is also increasing with the same ratio. For the satisfaction of the load demand we require large number of power plants to install. The generation of electricity more than 82% in India is produced by coal- based thermal power plants [1]. Total 1,032,647 GWh electricity is generated in India from which 948,870 GWh is Yearly gross electricity generation by coal only. There are about 151 coal based thermal power plants are established in India. On the basis of evaluations of last few years the production of fly ash is 172.75 million tons in India; where108.42 million ton fly ash is utilized. Thus the aim of this paperis uses of huge amount of fly ash by production of thermal power plants as replacement of orginary cement and bricks in our general constructions and to minimize the harmful fuel gases which are act as a major factor to cause environmental pollution [2-3].

II. IMPECT OF WASTAGE PRODUCTS OBTAINED THROUGH COAL COMBUSTION BESIDES CAUSING ATMOSPHERIC POLLUTION

India's 84 utility and more than 28 captive thermal power plants contributes more than 80% to the countries total electric power installed capacity. In fact about 250 million tons of coal is being used every year to generate electricity. It surely increase the economic growth but the coal in India, used for power generation is of poor quality, which has high ash content, low calorific value. After combustion of coal, it produce pollutions like noise, air, water, soil and emits so many flue gases which are very harmful for health and environment [4-5].

Fly ash and pollutants can be minimized by using good quality of coal. There are so many technologies are developing for safe management of fly ash and flue gases.

III. UTILIZATION OF FLY ASH

Fly ash
↓ (Aqueous NaOH solution with various liquid)
Hydrothermal curing at 363K
↓
Filtration
↓ (The product is separated by centrifugation and alkaline filtrate is thrown waste)
Washing
↓ (Residue is washed several times with distilled water; until the final filtrate reached pH=10-11)
Drying at 353K
↓
Zeolite

The conversion of fly ash into zeolites has many applications such as adsorptive, ion exchange, and molecular sieves. To diminish the issues related with destruction of wastage and to make marketable products, this conversion of fly ash into zeolites is very helpful[6].

IV. CEMENT

Fly ash is the waste material from thermal power plants or one of the by-products of burning coal. It contains heavy metals (arsenic, beryllium, boron, cadmium, chromium, cobalt, lead, manganese etc.), volatile organic compounds and radioactive solids. Due to its pozzolanic reactivity, fly ash is used in concrete in place of Portland cement [7].

Fly ash particles provide result in greater expediency of the concrete and lowering of water requirement for the same concrete consistency.

Now days, there are so many techniques have been developed in which partial cement is replaced with (HVFAC) high volume fly ash concrete where 55-65% cement replacement is made with usage of fly ash. During this process approximate 25-35 tons of CO_2 per ton of fly ash produces. Thus replacements of large portion of cement by fly ash significantly reduce carbon emission associated with construction and also help in reduction in greenhouse gas emission [9].

$$CaCO_3 \rightarrow CaO + CO_2$$

$$CaO + H_2O \rightarrow Ca(OH)_2$$

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

Table.1. comparison between fly ash cement and ordinary cement

PROPERTIES	FLY ASH CEMENT	ORDINARY CEMENT
Density(kg/m^3)	650-850	450-720
Compressive strength(kg/cm^2)	35-45	25-45
Thermal conductivity(W/mK) (Depending on density)	0.09-0.12	0.09-0.15
Eco-friendliness	Pollution free No primary energy consumption Consume fly ash(hazardous waste material)	Pollution free High energy consumption
Ingredients	Cement, fly ash, water and foam	Cement, lime, grinded sand, aeration compound

V. BRICKS

1. Raw materials for fly ash bricks

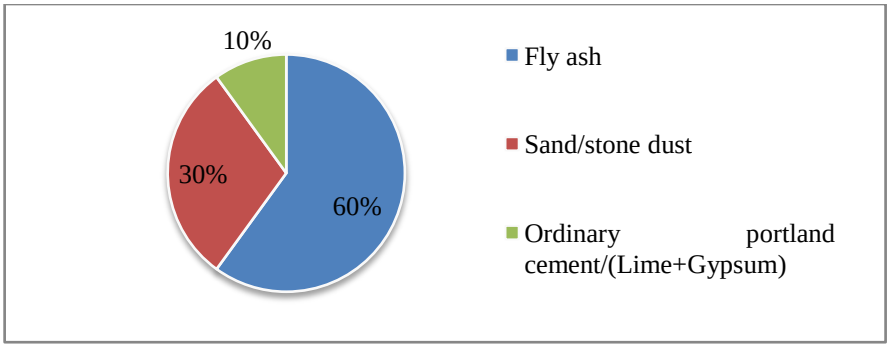

Fig.1. Raw materials for fly ash bricks

2. Composition ofraw materials for ordinary bricks

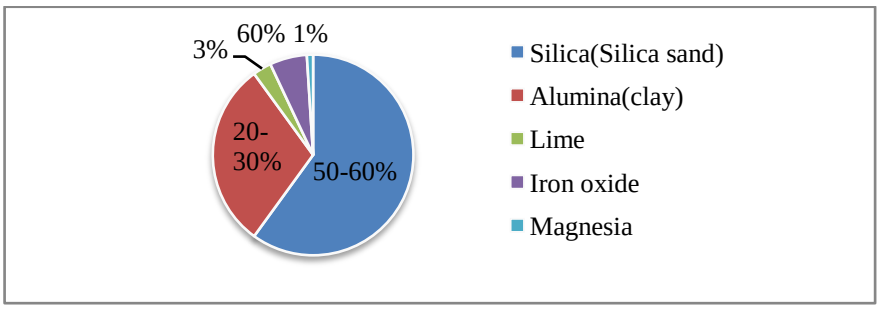

Fig.2. Composition ofraw materials for ordinary bricks

3. Silica (sand) – 50% to 60% by weight

4. Alumina (clay) – 20% to 30% by weight

5. Lime – 2 to 5% by weight

6. Iron oxide – ≤ 7% by weight

7. Magnesia – less than 1% by weight

Table.2. comparison between fly ash bricks and ordinary clay bricks

PROPERTY	FLY ASH BRICKS	CLAY BRICKS
Compressive Strength	7.5 N/mm^2 to 10 N/mm^2	3.43 N/mm^2
Density	1700-1850 kg/m^3	1550-1750 kg/m^3
Absorption	10-14%	15-25%
Tolerance Capacity	High	Very low
Ingredients	Fly ash, water, quicklime or lime sludge, cement, aluminium powder and gypsum	Silica (sand), Alumina (clay), Lime, Iron oxide, Magnesia

VI. FERTILIZERS

1) Improvement of the quality of soil by using fly ash

The fly ash having higher water holding capacity & lower bulk density, it helps to improve the texture of soil, root penetration, expediency & moisture retention capacity of soil.

2) Soil pH

Due to its acidic or alkaline nature fly ash could be useful to buffer the soil pH. The content of fly ash like hydroxide and carbonate salts give beneficial chemical applications to agricultural soil could increase the pH of soil and thereby help to neutralize acidic soil.

3) Fly ash as a source of plant nutrients

fly ash can also use as a source of plant nutrients like P, K, Ca, Mg, Cu, Zn, Fe and Mn etc. to increase the yield of crops and better nutrition quality. It also helps to minimize the demand of chemical fertilizers and pesticides.

Table.3. increment in the yield of crops by using fly ash as fertilizers

S.No.	Name of crops	Increase in yield
1	Wheat	17-24%
2	Sugarcane	22-27%
3	Banana	28-31%
4	Maize	More than 32%
5	Vegetables	12-17%

Characteristics affecting performance of ingredients of fly ash concrete/fly ash brick which help to enhance the strength of it:

1. Fineness: Availability of more surface area to react with lime, the pozzolonic activity of fly ash will be increase to get more fineness of it. According to BIS (Bureau of Indian Standards) it should be less than 320 m^2/kg.
2. Calcium (CaO) content: Higher the CaO content, the pozzolanic activity will be greater & the contribution of the strength in concrete will also be greater. Thus CaO content should be more than 10%.

VII.MINIMIZATION OF FLUE GASES

The flue gases refer to the combustion exhaust gas produce after combustion of fossil fuels at power plants. Flue gases contain oxides of Carbon, Nitrogen and Sulphur as well as fly ash, other pollutants and water vapour [10].

There are so many techniques to minimize these hazardous flue gases:

*1) Absorption process:*The hot Potassium Carbonate process is particularly attractive process to absorb at higher CO_2 contents.

$$K_2CO_3 + CO_2 + H_2O \quad \rightleftharpoons \quad 2KHCO_3$$

Addition of small amount of Boric acid to Potassium Carbonate resulted in a significant enhancement of CO_2 absorption rates. Instead of this, Mono Ethanolamine (MEA) and activated Methyl DiEthanolamine (aMDEA) can also use as a solvent in chemical absorption method.

*2) Electrostatic Precipitator:*Electrostatic electrical device could be a device that is predicated on filtrations principle and use for extraction of flue gas. It's placed at the outlet of the furnaces. There's assortment hopper through that ash is removed.

Electrostatic precipitation is mud assortment technique during which iatrogenic electricity forces are used, that consists of discharge wires and aggregation plates. Once flue gases are labor under electrostatic electrical device the concentration of ash get reduced. Afterward thanks to apply of high voltage to the discharging wires an electrical field are generated and aerosol particles within the gas are charged by ions. These charged particles are collected on the aggregation plates by Coulomb force. Therefore refined gases are found

*3) Wet scrubber:*In wet scrubber process water as well as alcohol and amines can also use as solvent. Its vapour pressure should be very low to avoid losses due to evaporation process. Scrubber use generally lime slurries of calcium hydroxide to remove the SO2 from the flue gases.

$$Ca(OH)_2\,(aq) + SO_2\,(g) \longrightarrow CaSO_3\,(g) + H_2O$$

The ph of this reaction is around 4.0-4.5. Other method includes addition of some activated metal oxides substances which react with sulphur to form less harmful compound than sulphur dioxide. After this obtain resulting sulphates being removed by electrostatic precipitation [11].

*4) Spray Dry Absorber:*in this method the sorbent is lime or calcium oxide for SO_2 absorption. By the heat of flue gas, water is evaporated and other acid gases like SO_3 and HCL react simultaneously with hydrated lime. The resulting residue is normally a mixture of Calcium Sulphates and fly ash which is less attractive irresistible productive.

VIII. COMPARATIVE STUDY OF FLY ASH PRODUCTION AND UTILISATION IN INDIA PER YEAR

Table.4. comparison in production and utilization of fly ash per year

Year	Production ,Mt	Utilisation, Mt (%of production)
2004-06	112	42(38%)
2006-08	130	60(46%)
2008-2010	180	85(49%)
2010-12	220	154(70%)
2012-14	240	210(87%)
2014-16	280	270(96%)
2016-17	300	300(100%)

IX. GRAPHICAL REPRESENTATION

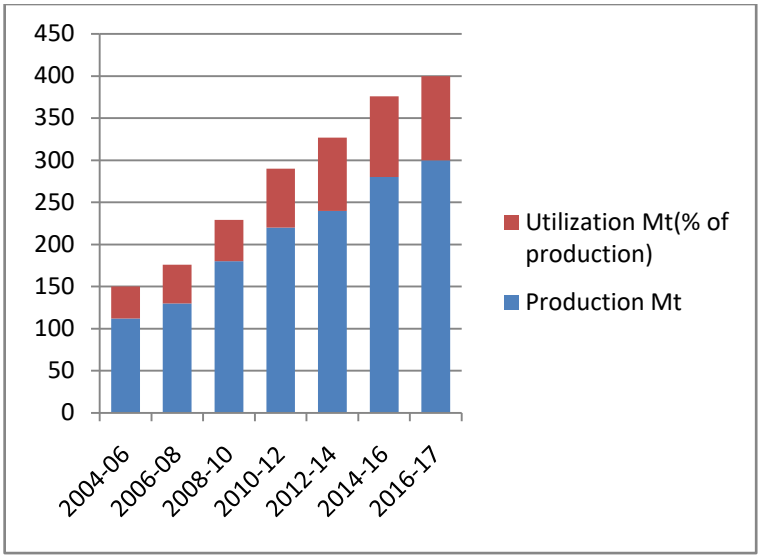

Fig.3. Graphical representation of production and utilization of fly ash per year

X. CONCLUSION

On the basis of whole study it is concluded that the compressive strength of fly ash bricks with addition of 4% and 6% cement increase more than 53% and 64% respectively. Fly ash bricks and cement are co-friendly because it helps to protect our environment and also help to utilization of waste product by coal combustion which is used in thermal power plants. It also helps to play a very important role in the moderation of harmful flue gases like CO_2, SO_2, and NO2 etc. Thus fly ash uses should be promoted for better performance as well as environment supportability.

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