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A study on the utilization of fly ash in concrete

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ABSTRACT

In modern decades, the industrialization and urbanization are the two phenomena that are spreading all over the world. Apart from the requirement of these phenomena, there should also be investigation into their negative impacts on the worldwide environment and common life. Most important poor effect of these international processes has been the production of large quantities of industrial wastes. Therefore, the problems related with their safe management and dumping has turned into a major test to environmentalists and scientists. Another problem is the stress on land, materials and resources to sustain the developmental activities, including infrastructure.

The thermal power plants produce considerably large quantities of solid byproduct namely fly ash. At present, the dumping of generated fly ash is by either wet disposal or dry disposal. It is *also* widely used for a variety of construction materials. However, there is a requirement to address the problems encountered during the disposal or recycle fly ash in construction materials.

An attempt has been made in this present paper to highlight utilization in construction activities by replacing sand by fly ash in concrete. The scope of this paper is restricted to fly ash from thermal power plants. Fly ash is produced as a result of coal combustion in thermal power plants. Fly ash is defined as a heterogeneous mixture of amorphous and crystalline phases and is generally fine powdered ferro-alumino silicate material with Al, Ca, Fe, Na and Si as the predominant elements. Bottom ash and slag as well as fly ash generated from other industrial sources are beyond the scope of this paper.

INTRODUCTION

Coal ash is the mineral residue that is obtained as a byproduct of the combustion of coal for the production of electricity. Two types of coal ash are obtained i.e. fly ash and bottom ash.

Fly ash is a finely divided residue resulting from the combustion of ground or powdered bituminous coal or sub-bituminous coal (lignite) and transported by the flue gases of boilers fired by pulverized coal or lignite. It is available in large quantities in the country as a waste product from a number of thermal power stations and industrial plants using pulverized coal or lignite as fuel for the boilers.

Utilization of fly ash depends on the local condition. The formation of fly ash has three parameters: Oxygen, temperature & time. It can be used for various purposes. The major use of fly ash is as concrete additive. In concrete fly ash can be used as partial replacement of cement and/or sand to enhance workability of fresh concrete, to reduce heat of hydration and to improve concrete impermeability and resistance to sulfate attack.

The utilization of fly ash as sand will lead to not only saving of scarce construction materials but also assist in solving the problem of disposal of this waste product from thermal power stations. The recent investigations have also indicated the necessity to provide proper

collection methods for fly ash so as to yield fly ash of quality and uniformity which are prime requirements of fly ash for use as a construction material[1].

In order to provide momentum of fly ash utilization, Ministry of Environment and Forests (Moef), Govt. of India has taken initiative & issued Gazette Notification on ash utilization on 14th September 1999. In this gazette notification within 50 km radius of any coal based thermal power stations, use of 25% fly ash with soil on weight to weight basis in clay bricks/tiles/blocks making was made compulsory. Thermal power stations were asked to make fly ash available at free of costs to users. Construction departments like CPWD, PWD, builders, Housing boards etc. were asked to incorporate use of fly ash and fly ash based products in their respective schedule of specifications & construction applications.

In August 2003, amendment to above notification was issued. In this amendment, the mandate of compulsory use of 25% fly ash was increased to 100 km radius of any coal based thermal power stations.

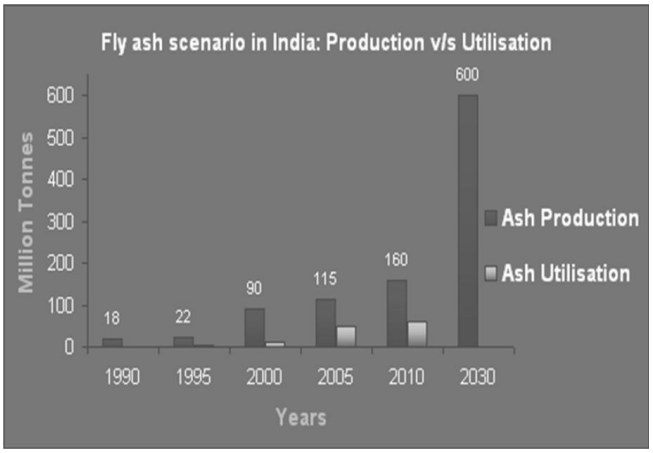

Figure 1 : Fly ash scenario in India: Production v/s Utilisation; (Source: http://www.cbrienvis.nic.in/flyash_generation.htm)

In this paper, work has been summarised for the replacement of sand in the concrete block by the fly ash sample and their concrete strength has been measured.

The use of fly ash in concrete has reached significant attention over the recent years due to environmental concerns regarding its disposal from one hand and significant benefits to concrete on the other, when it is used as a supplementary material.

Objective of this study was to demonstrate the strength of different fly ash concrete cubes with the beneficial effects of different proportion of different constituent.

EXPERIMENTAL

Experimental work is divided into two parts. First part has comparative study of clay bricks with fly ash bricks. Second part contains formation of different concrete blocks by varying percentage of fly ash and study of their compressive strength

EXPERIMENTAL PART I: COMPARATIVE STUDY OF CLAY BRICKS WITH FLY ASH BRICKS

Sample collection

Fly ash bricks have been collected from Janki Industries which is situated in Bhagalpur, Bihar. The primary content of the bricks which is fly ash is from NTPC Kahalgaon. The size of the bricks is 5cm x 12cm x 7cm and made by automated machines and moulds.

CHNS analysis

The fly ash sample has been characterized by CHNS analysis to find out the percentage of Carbon, Hydrogen, Nitrogen and Sulphur. The analysis has been done at Sophisticated Analytical Instrument Facility (SAIF), IIT Mumbai.

The results are as follow:

TABLE 1 : Results of CHN analysis

Carbon (%)	Hydrogen (%)	Nitrogen (%)
4.378%	0.177%	1.006%

The percentage of carbon is very less in the sample, so it is clear that it will not give any adverse effect over concrete strength of fly ash.

Comparative study of clay bricks with fly ash bricks

Sand in clay bricks prevents shrinkage cracking but too much of sand makes the bricks brittle. Using the fly ash in bricks and reducing the percentage of sand is the best way to impart strength to the bricks.

Strength of clay bricks

The crushing strength of Indian bricks is very much

variable. The compressive strength has been measured on compression testing machine of capacity 200 tons, model name soiltest Model CT-920M.

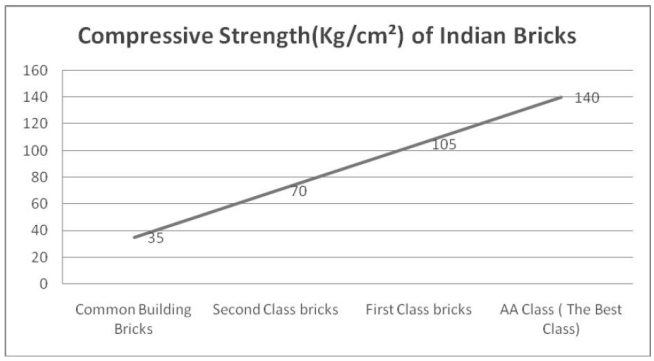

Figure 2 : Compressive strength of Indian Bricks

Fly ash can be used as a part replacement of sand in bricks to make use of its pozzolanic properties. The requisite fineness of fly ash is 150 mesh sieve.[2]

Results & discussions

The compressive strength of fly ash bricks is measured and results are given in following TABLE-2.

Figure 3 : Fly ash brick

Observations

- This can be seen from the table that compressive strength of fly ash bricks (average 180 Kg/cm^2) is more than the highest quality of clay bricks (i.e. AA class) i.e 140 Kg/cm^2.
- These bricks are lighter in weight than ordinary clay bricks.
- It can save up to 30% in mortar and plaster.
- Due to high strength, practically there is no breakage during transport and use.

EXPERIMENTAL PART II: COMPRESSIVE STRENGTH OF FLY ASH CUBES UNDER DIFFERENT CONDITION

The fly ash cubes have been cast at Irrigation research Institute, Khagaul, water resources department, Government of Bihar, with varying composition of fly ash, cement and water.

Casting of concrete cubes made of fly ash

Results & discussions

In order to evaluate the mechanical and durability related properties, we had prepared different set of concrete blocks under different percentage of fly ash, water and cement and observed their strength under different period. All the results are tabulated.

Following table shows composition of seven different types of Fly Ash made concrete cubes with different ratios of cement, fly ash and water content:

The compressive strength of these fly ash concrete cubes under different ratio is measured at Research and

TABLE 2 : Results of physical properties of fly ash bricks

Sl. No.	Physical Properties of fly ash brick	Observation
1.	Colour	Uniform
2.	Shape	Uniform faces
3.	Edges	Sharp straight/Right angled
4.	Texture after breaking	Uniform & Compact
5.	Three readings of Compressive strength (Kg/cm^2)	a.183.33 b.176.67 c.140
6.	Tolerance on Dimension	L=(+1.0);W =(±0); H=(+0.5)

Figure 4 : Concrete cubes made up of fly ash under different conditions

TABLE 3 : Different ratio of cement, fly ash and water

Sl. No.	Cement (wt. in gm)	Fly ash (gm)	Water (cc)
1.	200	600	200
2.	200	600	180
3.	200	600	180
4.	200	600	150
5.	150	450	120
6.	150	450	130
7.	150	450	140

Training Division no.2, Irrigation Research Institute.

Observation

The results have shown that the effect of curing days over the compressive strength of concrete made up of fly ash.

It is expected India will produce 300-400 Million tons per year which is approximately double the quatity it is produced3. Following figure is just a depiction to use fly ash majorly in the building material as these have many advantages like it reduces green house emission and reduces energy requirements.

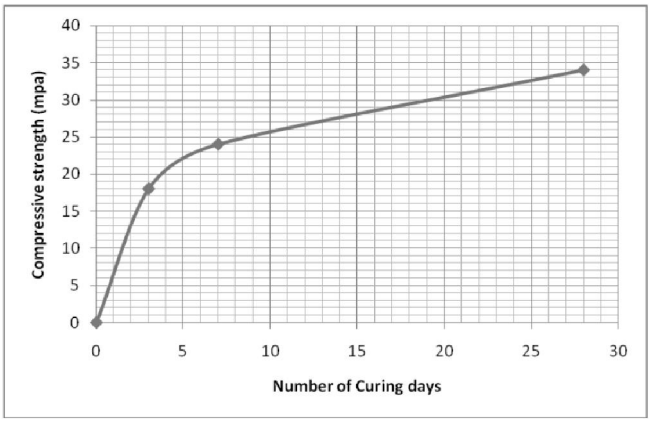

Figure 5 : Compressive strength of concrete cubes over periods of curing

The compressive strength of concrete cubes made with Fly ash was determined at the period of 3 days, 7 days and 28 days, results is shown in TABLE 4 as well as in the above graph. From the test results it is observed that the compressive strength increased by 18 mpa to at 24 mpa and 24 mpa to 34 mpa for 3 to 7 days and 7 days to 28 days.

SUMMARY & CONCLUSION

Based on the experiments done following conclusion may be drawn:

- The current worldwide production of the fly ash is more than 700 million tons.
- In India, about 120 coal based thermal power plants are producing nearly about 112 million tons of coal fly ash per annum.

TABLE 4 : Results of compressive strength for different days

Sl no.	Nature of test	Laboratory results
1.	Fineness by residue by B.S.S. 170 no. mesh	8.5%
2.	Compressive strength when mixed with 3 parts of fly ash in place of sand at	
	a.3 days	18 mpa
	b. 7 days	24 mpa
	c.28 days	34 mpa
	Setting time	
3.	Initial setting time	80 min
	Final setting time	140 min
4.	Slag Cement	33 grade

- Fly ash is a potential source of pollution not only for the atmosphere but also for the other components of the environment.
- Fly ash is valuable substances which confers certain desirable characteristics in its many applications.
- Utilization of fly ash is well established as a substitute in brick making and concrete strength.
- Replacement of sand by fly ash can be possible in bricks and concrete with higher compressive strength.
- The data presented in this project show that there is great potential for utilization of fly ash in concrete in several forms. It is considered that this would provide much greater opportunities for value adding, cost recovery and reduce the environmental pollution near power plant where the fly ash are carried for dumping.

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