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A Review Study of Managed Disposal of Fly Ash

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Abstract
One of the major disadvantages of coal-based thermal power plants is the disposal problem of Fly Ash. are working with Ministry of Environment & Forests and Ministry of Power, Government of India to formulate a strategy to find out the proper use of this waste material. As an outcome of their efforts, Fly Ash is being very effectively and economically used in building components such as bricks, doors, door-frames, etc. Fly Ash is also being used in construction of roads and embankments with some design changes. The trend is clear, Fly Ash will soon be considered as a resource material and its potential will be fully exploited. Through development & application of technologies, Fly Ash has shifted from "Waste Material" category to "Resource Material" category. The purpose of this paper is to provide an overview of disposal and utilization of Fly Ash and its beneficial potential in application of civil engineering construction as well as others.

Keywords: Fly Ash, Resource Material, Waste Material.

1. Introduction
Industrialization and urbanization are the two world wide phenomena. Though these are the necessity of the society and are mostly inevitable, one has to look into their negative impacts on the global environment and social life. The major ill effect of these global processes is the production of large quantities of industrial wastes and the problems related with their safe management and disposal. Second problem is the scarcity of land, materials and resources for ongoing developmental activities, including infrastructure. Coal-based thermal power plants have been a major source of power generation in India where about 57% of the total power obtained is from coal-based thermal power plants [1]. Fly Ash is a by-product material being generated by thermal power plants from combustion of Pulverised coal. The quantum of Fly Ash produced depends on the quality of coal used and the operating conditions of thermal power plants. Presently the annual production of Fly Ash in India is about 112 million tonnes with 65000 acre of land being occupied by ash ponds and is expected to cross 225 million tonnes by the year 2017 [3]. When pulverised coal is burnt to generate heat, the residue contains 80% Fly Ash and 20% bottom ash [4]. A huge volume of Fly Ash produced from coal-based thermal power plants may bring several problems from environmental point of view. Fly Ash particles ranging in size from 0.5 to 300 micron in equivalent diameter, being light weight, have potential to get airborne easily and pollute the environment [5]. Huge investments/ expenditures are made just to get Fly Ash out from the thermal power plants and dump it in the ponds.

2. Characteristics and Composition of Flyash
Chemically, Fly Ash is considered as amorphous and mixture of Ferro-alluminosilicate minerals. However, composition of Fly Ash depends mainly upon the geographical factors related to coal deposit, combustion conditions and the type of ash collection devices. The major constituents of Fly Ash are primarily oxides of Si, Al, Fe, Ca, and Mg which constitute about 95-99% of total constituent as given in table 1

Table 1: Chemical Composition of Fly Ash

Contents	Percentage by mass
Calcium oxide, CaO	0.37-27.68
Silicon dioxide, SiO_2	27.88-59.40
Aluminium oxide, Al_2O_3	5.23-33.99
Iron oxide, Fe_2O_3	1.21-29.63
Magnesium oxide, MgO	0.42-8.79
Sulphur Trioxide, SO_3	0.04-4.71
Sodium carbonate, Na_2O	0.20-6.90
Potassium oxide, K_2O	0.64-6.68
Titanium dioxide, TiO_2	0.24-1.73
Other alkaline & unidentified	4.0-6.0
LOI, (Loss-on-ignition)	0.21-28.37

3. Disposal and Management of Fly Ash

The flyash produced in the thermal power plant needs to be disposed outside the plant premises so that it causes least disturbance to the main plant operation. Two methods are in practice to dispose off the generated flyash. They are wet disposal and dry disposal methods with ash ponds being the most common methods of disposal in India.

In the past, Fly Ash produced from coal combustion in thermal power plants was simply dispersed into the atmosphere. At thermal power plants, Fly Ash is presently collected or disposed by using either dry or wet systems. Worldwide, more than 65% of Fly Ash is disposed in landfills and ash ponds [8]. The Fly Ash is a resource material, if not managed well, this may pose environmental and health problems.

1. Dry Fly Ash Disposal

In dry disposal system, electrostatic precipitation (ESP) is the most popular and widely used method of emission control today which enables collection of dry Fly Ash. After collecting the Fly Ash in ESP, it is then transported by trucks or conveyors at the sight and disposed of by constructing a dry embankment.

2. *Wet Fly Ash Disposal System*

In wet disposal system, the Fly Ash is mixed with water and transported as slurry through pipe and disposed of in ash ponds or dumping areas near the plants. Being cheaper than any other manner of Fly Ash removal, it is widely used method at present in India

4. Utilization of Fly Ash

Sustainable utilization of Fly Ash is one of the key concerns of NTPC. As the demand for energy grows further, production of Fly Ash is inevitable, since India has no alternative but to use its relatively vast resource of poor grade coal- washed or otherwise. In developed countries more than 80% Fly Ash is used for the manufacture of bricks, cellular concrete blocks, road construction, landfill application, ceramics, agriculture, insulating bricks, recovery of metals, and dam constructions [8]. While in India about 10% ash is utilised currently in various segments include cement, asbestos-cement products & concrete manufacturing industries, land development, road embankment, building products such as bricks/tiles/blocks, reclamation of coal mine, ash dyke construction and as a soil amender and source of micro and macro nutrients in agriculture and only about 3% ash is utilised in other construction industry. In India "Fly Ash Mission of Government of India" is the nodal agency which undertook the responsibility for safe disposal and gainful utilization of Fly Ash on sustainable basis.

a. In Agriculture

Fly Ash has a potential in agriculture and related applications. In fact, Fly Ash consists of all elements present in soil except organic carbon and nitrogen. In a research conducted by Maharashtra State Electricity Board considering all factors like soil quality, doses of chemical fertilizers, cyclic sowing of different food grains etc., it is found that with dose of 10 MT Fly Ash per hectare and just 50% dose of chemical fertilizers (as annually required) there is increase of 20% yield in terms of grain and fodder [9]. Presence of micro and macro constituents like Potassium, Boron, Calcium, Zinc etc. improves the fertility of soil. globules from Fly Ash. These globules if buried around crop, absorbs the water and retain it for longer period by resisting evaporation. This application helps to widen the gap between two watering cycles. Fly Ash improves the pH value of soil when used in low pH acidic soil. It can also be used as insecticide and if used along with bio-waste, it significantly supplements the utility of chemical fertilizers.

b. In Building Materials

Fly Ash could be used as prime component for a variety of construction materials. Since Fly Ash is a Pozzolanic material containing silica in good proportion. Some potential areas of building construction where Fly Ash can be used effectively and economically are described below:

a. Ready-Mixed Fly Ash Concrete
   The process of producing ready-mixed Fly Ash concrete consists of two operations i.e. proportioning of Fly Ash concrete mix and batching & mixing of different ingredients. Precast Fly Ash Concrete Units
b. Fly Ash can be used in production of various types of precast building units such as solid and hollow core slabs, doors and window frames etc. It can also be used in preparing of flooring and roofing units, such as cored units, channel units and cellular units by partial replacement of cement.
c. Clay Fly Ash Bricks
   Fly Ash can be used for production of bricks. When Fly Ash is used for construction of bricks, about 0.25 to 0.80 times of clay can be replaced by Fly Ash [11]. The bricks produced using Fly Ash has the advantage of being lighter in weight as the density of Fly Ash is about one half of the clay.
d. Lime Fly Ash Bricks
   Bricks of high strength possessing good quality can be produced from Fly Ash using Lime as a binder. The Fly Ash Lime building bricks can be used in all types of brick masonry. Fly Ash Lime Bricks are obtained from materials consisting of Fly Ash in major quantity, Lime and an accelerator e.g., gypsum as a catalyst. They are generally manufactured by inter-grinding or blending the various raw materials which are subsequently moulded into brick and subjected to auto-claving under saturated steam at a pressure of about 14 kg/cm2 [12].
e. Lime Fly Ash Cellular Concrete
   Light weight aerated concrete or cellular concrete can be manufactured by a process involving mixing of Fly Ash, quick lime and gypsum in a high speed mixer to form a thin slurry. Sintered Fly Ash Light Weight Aggregate
f. For conversion of Fly Ash into light aggregate there is one of the potential ways of bulk disposal of Fly Ash in an economic way. The bulk density of sintered Fly Ash light weight aggregate varies from 640 kg/m3 to 750

kg/m3 [13]. The production of sintered Fly Ash aggregate is suitable for use in the production of structural light weight concrete and free cost light weight concrete building units for use as load bearing and non-load bearing elements. It has good potential in places where Fly Ash is locally available and stone aggregates are costly.

g. G. Fly Ash Sand Lime Bricks
The Fly Ash can be used for the production of Fly Ash Sand Lime Bricks usually known as calcium silicate bricks. The cement, mortar & concrete prepared by Fly Ash gives high long term strength, low heat of hydration, low permeability and hence more durability.

c. Mine Fills

Utilization of Fly Ash in Mine fills has potential to consume large quantity of Fly Ash. This single application of Fly Ash can utilise about 1/4th of total Fly Ash generation [14].

d. Road Construction Materials

Utilization of Fly Ash in bulk quantities for road works depending on the intersection between Coal ash and sub-grade soil. Fly Ash may be used for constructing different layers of the road pavement. Utilization for stabilisation and sub-base/base construction

Sub-Base and Base layers can be constructed using coarser variety of compacted pond ash or bottom ash. Studies conducted at Central Road Research Institute (CRRI) on the effect of Lime Fly Ash stabilization on strength and other engineering properties of different types of soils have indicated as follows:

- Addition of Fly Ash or Lime Fly Ash to soil decreases the maximum dry density and increases its optimum moisture content.
- The strength of soil stabilized with Fly Ash alone or Lime Fly Ash shows significant improvement in terms of 'California Bearing Ratio' (CBR) values. The improvement in the strength characteristic depends on the proportion of the mix and the density to which mix could be compacted.
- Results of durability tests under the alternate wetting and drying cycles indicated better performance of Lime Fly Ash alluvial sill.

e. Utilization of constructing semi-rigid/rigid pavements

Fly Ash can be used for constructing semi-rigid or rigid pavements using Lime Fly Ash concrete, Lime Fly Ash bound macadam cement Fly Ash concrete, roller compacted concrete etc. About 1 tonne of Fly Ash with 400 kg of other additives like lime and gypsum can produce 150 kg of alumina and 1250 kg of Pozzolanic cement, which is a good raw material for quality bricks [15]. In addition Fly Ash based absorbents can be directly used to purify the waste water and a material for absorption for gases like ammonia from waste water.

B. The products were prepared by treating Fly Ash with upstream of air flow cottoning silanes or organic silicon.

5. Environmental Benefits of utilization Fly Ash in Construction Materials

Use of Fly ash as a green building material both requires less water in the setting process.

In the published technical literature some of the effective strategies to produce more sustainable concrete is to replace a portion of the cement conponent with one or more SCMs such as fly ash (Wilson and Tagaza,2006). The benefits of the use of fly ash towards more

sustainable construction materials include:-

- Reduction in CO2, PM emissions and embodied energy;
- Reduction in resource use;
- Reuse of industrial by-products as alternative raw materials; and
- Sustainability achieved through efficient design and enhanced durability.
- The feasibility of using fly ash as an alternative to activated carbon was examined for colour removal from synthetic dye solutions.

6. Conclusion

The literature review revealed that fly ash finds a numerous application in the cement industries, construction industry, polymer industries and in pollution control. The fly ash produced as waste materials can be a good construction material for highway or expressway embankments. The use of fly ash in the construction materials also proved to reduced the PM emission at the construction site.

While there is already awareness as to the benefits that fly ash can provide in the quest for sustainable construction material, given the volumes of fly ash being produced and technological advances in the construction industry, much potential remains to further exploit

its advantages.

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