A WASTE: FLY ASH UTILIZATION IN DIFFERENT AREAS

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Abstract: Energy requirements for the developing countries in particular are met from coal-based thermal power plants. The disposal of the increasing amounts of solid waste from coal-fired thermal power plants is becoming a serious concern to the environmentalists. Some of the problems associated with Fly ash are large area of land required for disposal and toxicity associated with heavy metal leached to groundwater. Fly ash, being treated as waste is in fact a resource material and has also proven its worth over a period of time. This paper presents different ways of using Fly ash in various sectors of civil engineering and construction industry. It also highlights the management of fly ash to make use of this solid waste, in order to save our environment in India.

Keywords: Fly-ash; Coal; Production; Consumption; Generation.

Introduction

Coal-based thermal power plants have been a major source of power generation in India, where 75% of the total power obtained is from coal-based thermal power plants. Fly ash is defined in Cement and Concrete Terminology (ACI Committee 116) as the 'finely divided residue resulting from the combustion of ground or powdered coal, which is transported from the fire box through the boiler by flue gases. Fly ash is fine glass powder, the particles of which are generally spherical in shape and range in size from 0.5 to 100 μ. Fly ash is classified into two types according to the type of coal used.

1. Class F Fly ash:

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 20%lime (CaO). Most effectively checks heat gain during concrete curing and is therefore considered an ideal cementitious material in mass concrete and high strength mixes. For the same reason, Class F is the solution to a wide range of summer concreting problems. Class F fly ash is often recommended for use where concrete may be exposed to sulphate ions in soil and ground water.

The utilization of fly ash will not only solve the environmental problem, but also save vast tracts of valuable agricultural & urban land. Fly ash can be disposed-off in a dry or wet state. The Fly Ash

2. Class C Fly Ash:

Class C fly ash is produced normally from lignite and sub-bituminous coals and usually contains significant amount of Calcium Hydroxide (CaO) or lime. Most useful in "performance" mixes, pre-stressed applications, and other situations where higher early strengths are important. The estimated thermal power generation, coal consumption and ash generation in India is given in Table 1.

Table 1: Thermal power generation, coal consumption and ash generation in India

Year	Thermal power generation (MW)	Coal consumption (MT)	Ash generation (MT)
1995	54,000	200	75
2000	70,000	250	90
2010	98,000	300	110
2020	137,000	350	140

generated from coal are using in different areas. The consumption of Fly Ash in different fields is shown by pie chart, which is given below-

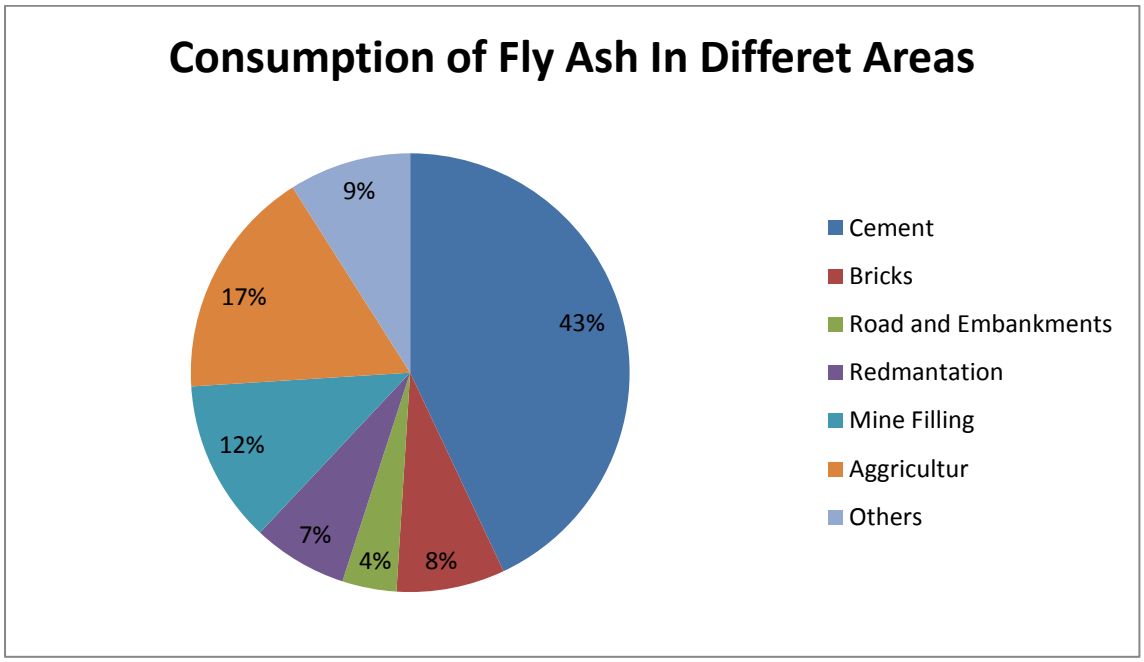

Fig 1: Consumption of Fly Ash in different areas

Government of India in 2003 made it mandatory to use at least 25% fly ash with soils within a radius of 100 Km from coal based thermal power States "The Central Public Works Department, Public Works Departments in the State Governments, Development Authorities, Housing Boards, National Highway Authority of India ... shall also prescribe the use of ash and ash-based products in their respective schedules of specifications and construction applications, including appropriate standards and codes of practice" by January 2000.

Utilization of Fly Ash in Different Areas- A lot of research has been carried out for effective utilization of fly ash in building industry. We are seeking new application areas for FA that would be utilizing by-products rather than to dump them. This paper has been initiated with the perspective of utilization of these by-products in the construction. Second benefit of the paper will be the conservation of natural clayey soil.

1. Fly Ash as Fly Ash- Sand-Lime-(Gypsum /Cement) Bricks /Blocks: Fly Ash Bricks are nowadays mostly used for construction and gaining its popularity over builders and engineers because of its high strength, uniformity and less consumption of mortar plastering. Above to this it is eco-friendly bricks which saves environmental damage caused by burnt clay bricks and saves top agricultural soil which was the main raw material plants. Power plants are required to completely phase out the dumping of fly ash within 9-12 years from 1999. So Para 43 (2) of the Notification in the burnt clay bricks. Major considerations for fly ash utilization in the production of burnt clay fly ash building products are as follows-

- Fly ash has ceramic properties and pozzalanic properties and help to get superior quality bricks and also help during construction.
- It uses fly ash, which is by –product of thermal power stations.
- Save agricultural land which is used for manufacturing of clay bricks.
- A well proven building material and can be used as an alternative of burnt clay bricks.
- High strength is achieved practically, no breakage during transport use.
- Lighter in weight and yet with higher compressive strength as compared to clay brick.
- Fly ash clay bricks are eco-friendly as it protects environment though Conservation of top soil and utilization of waste products of coal or lignite based Thermal Power Plants.
- Fly-Ash Clay Bricks is lighter than the conventional clay bricks.

2. Fly Ash as Portland Pozzolana Cement: Manufacturing of cement is the most important sector it take a lion share in fly-ash utilization in India. Owing to its pozzolanic properties fly-ash is

used as a replacement for some of the Portland cement content of concrete. Use of fly-ash as a partial replacement for Portland cement is generally limited to CLASS F Fly-ash. Up to 35% of suitable fly ash can directly be substituted for cement as blending material. Addition of fly ash significantly improves the quality & durability characteristics of resulting concrete. In India, present cement production per annum is comparable to the production of Fly Ash. Hence even without enhancing the production capacity of cement; availability of the cement (fly ash based PPC) can be significantly increased.

Table 2- Expected Fly-ash absorption in cement (million tons per annum)

(Source: WBCSD/CSI/LOW Carbon technology road map for Indian cement industry)

Serial No.	Year	Expected Fly-ash absorption in Indian Cement Industry (MT per annum)
1	2015	52.65
2	2020	73.01
3	2025	94.63
4	2030	120.50
5	2035	143.72
6	2040	158.02
7	2045	167.74

3. Fly Ash in Embankment:

Fly ash properties are somewhat unique as an engineering material. Unlike typical soils used for embankment construction, fly ash has a large uniformity coefficient consisting of clay-sized particles. Engineering properties that will affect fly ash use in embankments include grain size distribution, compaction characteristics, shear strength, compressibility, permeability, and frost susceptibility. Nearly all fly ash used in embankments are Class F Fly Ashes.

4. Fly Ash Brick uses in Construction:

- NTPC has manufactured more than 54 crores Fly Ash Bricks in its various thermal power stations and utilized in construction activities.
- NTPC township at Simhadri (Andhra Pradesh), Sipat (Chhattisgarh), Faridabad (Haryana) and Talchar (Orissa) have been constructed with fly ash bricks
- Fly Ash Bricks are being used in NTPC's power plant construction works at Rihand, Dadri (Uttar Pradesh), Talchar- Kaniha (Orissa), and Ramagundam (Tamilnadu).
- IIT Delhi has utilized these bricks for their cafeteria and Management School Building.
- Greater Noida Development Authority (GNDA) has used these bricks in Building Construction.
- Larger numbers of houses are being constructed with these bricks in various metro cities like Delhi, Pune, and Mumbai etc.
- NTPC has installed thirteen pilot plants for manufacture of ash based bricks at its various power stations. More than 1500 lakhs ash bricks have been produced so far and utilized in various construction activities in power plants.

5. Fly Ash in Road Construction:

Fly ash can be used for construction of road and embankment. This utilization has many advantages over conventional methods. Saves top

soil which otherwise is conventionally used, avoids creation of low lying areas (by excavation of soil to be used for construction of embankments). Fly Ash may be used in road construction for:

- Stabilizing and constructing sub-base or base.
- Upper layers of pavements.
- Filling purposes. Concrete with Fly Ash (10-20% by wt) is cost effective and improves performance of rigid pavement.
- Soil mixed with Fly Ash and lime increases California Bearing Ratio (CBR), increased (84.6%) on addition of only Fly Ash to soil. Addition of Fly Ash has not shown any adverse effects on the ground water quality in the vicinity of experimental plots.
- National Highway Authority of India (NHAI) is currently using 60 lakh m3 of Fly Ash and proposed to use another 67 lakhs m3 in future projects.

6. Fly Ash as Paints and Enamels:

Fly Ash used in paints and enamels with some proportions and the properties are given below-

- Fly ash exhibits better extending properties (less oil absorption)
- Fly ash percentage : 30-40 % (in paints) , 18-22% (in enamels)
- Corrosion and abrasion resistant
- Durable

7. Fly Ash as Wood substitute for doors and panels:

Fly Ash is also used as the partial replacement or full replacement of wood for doors and panels. The properties of such types of doors are as follows-

- These are 100% wood free,
- 5-7 times stronger than wood
- Resistant to weather, termite, fungus and fire (developed by RRL , Bhopal)
- Pilot plant operational at Pondicherry
- Product approved by CPWD and accepted by IIT, Delhi

8. Fly Ash in Concrete:

Though Ready Mix concrete is quite popular in developed countries but in India it consumes less than 5 percent of total cement consumption. Only recently its application has started growing at a fast rate. On an average 20% Fly ash in the country is being used which can easily go very high. In ready mix concrete various ingredients and quality parameters are strictly maintained/controlled which is not possible in the concrete produced at site and hence it can accommodate still higher quantity of fly ash.

- Increased (later) Compressive Strength
- Increased Workability
- Reduced the heat of hydration
- Increased Durability
- Decreased Permeability
- Reduced Sulfate Attack
- Decreased Bleeding & Segregation

9. Use of Fly Ash in Agriculture:

The large volume of fly ash occupies large area of land and possesses threat to environment. As such, there is an urgent and imperative need to adapt technologies for gainful utilization and safe management of fly ashes on sustainable basis. Agriculture and waste land management have emerged as prime bulk utilization areas for fly ash in the country. The field demonstration experiments carried out under varied agro-climatic conditions and soil types across the country by various R & D Institutes / Universities on the cultivation of different field crops (cereals, pulses, oil seeds, sugar cane, vegetables, etc.) and forestry species with different doses of fly ash and pond ash as soil modifier / source of economical plant nutrients with and without organic manure bio-fertilizer and chemical fertilizers in respect to crop yield, soil health, quality of crop produce, uptake of nutrients and toxic heavy metals, ground water quality etc. have revealed the following:

- It improves permeability status of soil.
- Improves fertility status of soil health / crop yield.
- Improves soil texture.
- 4. Reduces bulk density of soil.
- Improves water holding capacity / porosity.
- 6. Optimizes pH value.
- Improves soil aeration.
- Reduces crust formation.
- Provides micro nutrients like Fe, Zn, Cu, Mo, B, Mn, etc.
- Provides macro nutrients like K, P, Ca, Mg, S etc.
- Works as a part substitute of gypsum for reclamation of saline alkali soil and lime.
- Ash ponds provides suitable conditions and essential nutrients for plant growth, Helps improve the economic condition of local inhabitants.

Crops grown on fly ash amended soil are safe for human consumption & Groundwater quality is not affected. Keeping the above important findings in view, pond ash at a dose of 30-50 tonne per.

Hectare on one time basis along with recommended dose of fertilizers / manures is recommended for its use agriculture/ forestry sector/wasteland management or cultivation of different cereals / pluses/ oil seeds / vegetables etc., the repeat application of which can be made after 4-5 years as it would have significant residual effect on the yield of succeeding crops over a period of 4-5 years. The abandoned ash ponds in the Vicinity of TPPs could also be safely reclaimed via suitable amendments for forestry/floriculture purposes.

10. Fly Ash Utilization in Mines:

Fly Ash is used as filling underground surface in mines. It is used as a partial replacement of soil. The following properties are as follows-

- Mine void filling (underground)
- Reclamation of abandoned surface coal mines
- Neutralization of Acid Mine Drainage
- Stabilization of abandoned coal mines
- Haul road repair and maintenance in opencast coal mines.
- For oil and grease trap in the workshops
- For repair and maintenance of sedimentation ponds of coal handling plants.
- For surface – mine spoil reclamation
- Control of coal mine fire.

Conclusion

Proper management of solid-waste fly ash from thermal power plants is necessary to safeguard our environment. Fly Ash has become an important raw material for various industrial and construction applications. In future, large-scale application of this waste product may be possible for recovery of heavy metals, reclamation of wasteland, and floriculture. The detailed investigations carried out on fly ash elsewhere as well as at the Indian Institute of Science. This not only solves the problems associated with the disposal of fly ash but also helps in conserving the precious top soil required for growing food. The future poses challenges to the scientists, technologists, engineers towards sound management of fly ash disposal & deposition technologies. The problem is not due to lack to technical competence but more of adoption, implementation and better management of improved & appropriate technologies. On the basis of studies carried out on fly ash utilization, it is sighted that uses of fly ash in building construction possess great gains. The attempt should be to consciously reduce environmental damage to ensure more effective management of fly ash which India needs.

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