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Utilization of Fly Ash in Civil Engineering- A Review Study

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Abstract —*Large amount of fly ash discharged from coal-fired power stations is a major problem. Amount of fly ash available can be recycled, mainly by adding fly ash to cement. However, the addition of fly ash to cement is limited because the production rate of cement is leveled off, and also the concentration of fly ash in cement is limited. Researchers have studied the aspect of particle size distribution, permeability, slurry flow characteristics, settling characteristics, slump characteristics and so on for mill tailings. Fly ash in terms of particle size and mineralogical composition is similar to mill tailings. There is however not much literature available on direct placement of fly ash as a fill material. Investigations on the fly ash have been largely confined to determining physico-chemical properties, strength properties (as cement substitute or with binders). The present study therefore makes use of literature available in terms of fly ash, to design and conduct different experiments on settling rate and hydraulic transportation aspects of fly ash. Different experiments were conducted to find the pH at different levels of lime, cement and gypsum. These were done to further utilize the cementing property of fly ash and its use for support and fill the mine voids as well as construction of cement of different strength levels. It was observed that the strength level increase with the increase in the percentage of lime and it was observed to be maximum at 4% of lime and 8 % cement and 4%gypsum. Thus as pH is directly related to strength so it indicated that the strength characteristics was further enhanced using theaforesaid composition. The SEM of the samples were done to study the characteristics of individual elements as the element having spherical haps showed maximum pozzolanic character.*

Keywords-*Fly Ash, Classification, Effects, Utilization,*

I. INTRODUCTION

The combustion of pulverized coal at high temperatures and pressures in power stations produces different types of ash. The 'fine' ash fraction is carried upwards with the flue gases and captured before reaching the atmosphere by highly efficient electro static precipitators. This material is known as Pulverized Fuel Ash (PFA) or 'fly ash'. It is composed mainly of extremely fine, glassy spheres and looks similar to cement. The coarse' ash fraction falls into the grates below the boilers, where it is mixed with water and pumped to lagoons. This material, known as Furnace Bottom Ash (FBA) has a gritty, sand-like texture.

Fly ash closely resembles volcanic ashes used in production of the earliest known hydraulic cements about 2,300 years ago. Those cements were made near the small Italian town of Pozzuoli - which later gave its name to the term "pozzolana." A pozzolana is a siliceous or siliceous / aluminous material that, when mixed with lime and water, forms a cementations' compound. Fly ash is the best known, and one of the most commonly used, pozzolanas in the world.

Instead of volcanoes, today's fly ash comes primarily from coal -fired electricity generating power plants. These power plants grind coal to powder fineness before it is burned. Fly ash -the mineral residue produced by burning coal - is captured from the power plant's exhaust gases and collected for use.

Fly ash is a fine, glass powder recovered from the gases of burning coal during the production of electricity. These micron-sized earth elements consist primarily of silica, alumina and iron. The difference between fly ash and Portland cement becomes apparent under a microscope. Fly ash particles are almost totally spherical in shape, allowing them to flow and blend freely in mixtures. That capability is one of the properties making fly ash a desirable admixture for concrete.

Fly ash is one of the residues generated in the combustion of coal. Fly ash is generally captured from the chimneys of coal-fired power plants, whereas bottom ash is removed from the bottom of the furnace. In the past, fly ash was generally released into the atmosphere, but pollution control equipment mandated in recent decades now requires that it be captured prior to release. Depending upon the source and makeup of the coal being burned, the components of the fly ash produced vary considerably, but all fly ash includes substantial amounts of silicon dioxide ($SiO2$) (both amorphous and crystalline) and calcium oxide (CaO). Fly ash is commonly used to supplement Portland cement in concrete production, where it can bring both technological and economic benefits, and is increasingly finding use in the synthesis of geopolymers and zeolites.

II. CLASSIFICATION OF FLY ASH

Dry fly ash was collected from the first three fields of the ESPs of the TS - TI (thermal power station 11) of NLC, blended and stored in air tight containers. Samples were collected at different periods of time, spanning over six months for analyzing their physical and chemical properties.

2.1 Coal Ash and Earthen Materials

Earthen materials are widely variable in physical and chemical properties and "in-place" strata conditions. Soil engineering methods have been developed that can be applied to coal ash as shown by decades of academic evaluation and practical experience in the Commonwealth of Pennsylvania. For purposes of engineering, uniformly placed coal ash can is considered as an artificial "soil" type that is usually more uniform than a natural soil layer. Additional testing is needed if different coal types, sources or burning processes may have generated the coal ash being evaluated, and also in the event of visible changes in natural soil types. For example, some coal fired boilers segregate lighter "fly ash" from the heavier "bottom ash" that falls to the bottom of the combustion unit during the combustion process. The physical properties of the segregated ash differ because of the different sizes and shapes of fly ash as compared to bottom ash. Therefore, the DEP regulations differentiate between several potential beneficial uses of the coal fly ash and bottom ash in 25 Pa. Code §287.665 (other beneficial uses of coal ash) because of the different properties. The pH of the coal ash is less important for foundation engineering purposes than the other mechanical properties of the coal ash, but is considered in the design process for any given usage per good engineering practice.

In general, coal ashes can be classified into coal source types (bituminous or anthracite), coal ash source (segregated or unsegregated fly and bottom ash), coal ash "gradation" (classification based upon the sizes of the ash particles), and other coal ash properties such as pH53 (relative "acidity" or "alkalinity") relevant to the proposed usage. Engineering methods to determine gradation generally classify a soil or coal ash by the percentages of particles that can pass through standardized sieve opening sizes via comparison to a USDA Soil Triangle Classification Chart (Fig. 3.1). Coal ash generally contains approximately 60 to 70 percent silt, and 30 to 40 percent sand size particles depending on the characteristics of the fuel burned by the plant (see Table 7.4 in Chapter 7). The coal ash classification is normally that of a silt loam. Other nationally recognized standard test methods then determine the properties of the coal ash relevant to the proposed engineering use or project as further described below. Continued testing is required for both soils and coal ash to ensure that the materials remain consistent with any required engineering specifications or design assumptions. For example, weathered coal ash may have lost the cementing ("pozzolanic") coal ash properties desired in some applications.

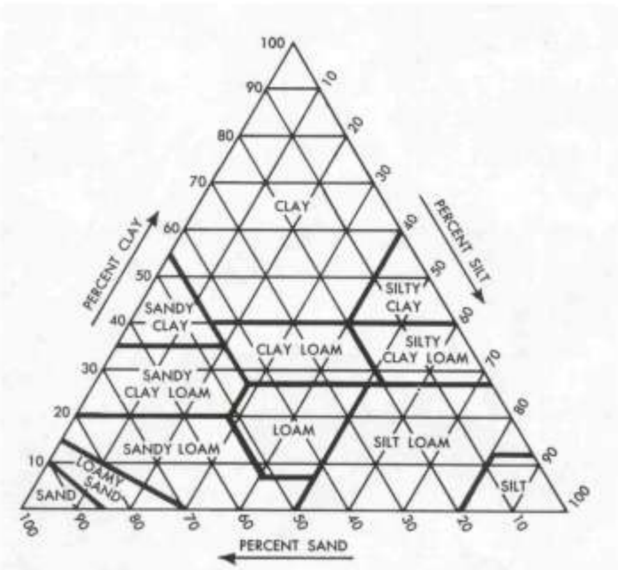


Figure 1: USDA Soil Triangle Classification Chart (The Asphalt Institute, 1978).

2.2 Boiler Ash

Boiler ash is a generic term applied to many types of ash produced by the burning of various materials. They are 4 general types of boiler ash commonly available, each with its own chemical and environmental characteristics:

Wood Ash – Clean pure wood ash can be beneficial as a soil amendment replacing lime and providing many trace elements. The chemical and physical properties vary greatly depending on the species of wood burned and the temperature at which it is burned. Most of the wood ash produced (over 80%) is land applied in the Northeast United States and very little elsewhere. The first problem occurs since the nutrients in ash can easily leach and pollute waterways. The ash dust is also toxic if breathed which is common. Even though it is illegal, it is very common for CCA, Creosote and Penta (pentachlorophenol) treated wood to be burned or ground up and used in mulch (or compost). The copper, chromium and arsenic levels concentrate in the ash and are toxic.

Coal Ash – This type of ash is produced from burning coal for electrical power generation and is the waste product that results. There are two primary forms, bottom ash and fly ash. Bottom ash accumulates at the bottom of the burner while fly ash is collected in the smoke stack scrubber. They have very different chemical and physical properties and are the inorganic constituents of the burned fuel that are not completely combusted. Beneficial uses include making portland cement, mixing with concrete, and stabilizing soils for road base.

Tire Ash – produced from burning shredded tires for fuel in generating plants Incinerator Ash – produced from burning MSW (Municipal Solid Waste, i.e. Garbage) as a waste disposal method

Incinerator Ash – This type of ash is produced from burning MSW (Municipal Solid Waste, i.e. Garbage) as a waste disposal method by primarily converting many of the solids to gases which are discharged into the air resulting in a large volume reduction of the material. The garbage is burned at a temperature of 1600-18000 F which combusts most of the material destroying many toxic organics. The resulting ash is a Type II material and is a mixture of many chemicals from the plastic, batteries, etc. that were in the garbage. It also contains non-combustibles such as metals, glass, concrete, brick, etc. Often dioxins are formed in the ash. Currently thesh has no beneficial re-use and is disposed of at special landfills at a cost of $30-40 per ton. Chambers County has the only incinerator in this area and all the ash is disposed of at their county landfill. Tire Ash – Used tires can no longer be disposed of in a landfill hence they must be handled by alternate disposal methods. One of these methods is to grind them up and burn them for fuel. Tires are made up of many chemicals some of which are toxic as well as the metals from the steel belts to high levels of zinc. All the chemicals become concentrated in the ash. As a result of chemical leaching, phytotoxic effects are to be expected from the ash and permanent damage to your soil would be expected. Typically, an ash residue is left behind, composed mainly of zinc oxide, titanium dioxide, iron, carbon and other materials.
The Seattle Times in July 1997 exposed the growing national practice of recycling industrial wastes - many containing toxicants, dioxin and even radioactive material - into agricultural fertilizers. Before The Times' series, few farmers were aware of the practice. Tire ash and fertilizers both fail tests for cadmium, which can be readily absorbed by plants and concentrates in leaves, grain and fleshy fruits. The ash is a good source of zinc, which helps plants grow - but it also contains the poisonous elements lead and cadmium. Millions of discarded tires from the East Coast ended up in fertilizer sold in the West and three foreign nations, in violation of federal hazardous-waste laws. The ash is mixed with sulfuric acid and water to produce fertilizer granules sold to distributors who mixed it in blended products for farmers, nurseries and home gardeners. The buyers are not told the fertilizer was made from recycled waste. The granules are 20 percent zinc, which is commonly used in plant food. But lead and cadmium, heavy metals of no benefit to plants or animals, are also included. They weren't listed on the label or tested by regulators in any of the 10 states in which the product was sold.

Fly Ash – The scrubbers in the flue use lime slurry to reduce the amount of sulfur dioxide (SO 2) escaping to the atmosphere and other toxic materials. Arsenic, cadmium, copper, gallium, lead, antimony, selenium, zinc and other chemicals are commonly found to concentrate in fly ash. Due to the lime slurry used fly ash tends to be very alkaline (toxic). Also studies have found that as little as 8% fly ash by weight mixed with soil can increase the salinity 5- 6 times in a short period of time. It has also been found depending on application rates that fly ash suppresses beneficial microbes in the soil and as little as 10% can cause a 50% reduction in microbial activity. In a few limited cases the boron present can prove beneficial in deficient soils when applied in small amounts. The exact properties vary with the type coal burned and the type equipment used.

Bottom Ash – This is the most common type of ash as it is produced in very large quantities. About 12% of the coal burned ends up as bottom ash. Coal ash is toxic (mutagenic and carcinogenic) and contains many radioactive elements like uranium and thorium along with arsenic and mercury. When used as a soil amendment many species of plants suffer growth problems. Some plants have been found to accumulate toxic amounts of selenium, manganese, aluminum and boron in their tissues. Small amounts of ash when leached have been found toxic to many animal species (fish and others) leading to deformities and death. Toxic material from coal ash has also been found in drinking water from wells.
Fly ash material solidifies while suspended in the exhaust gases and is collected by electrostatic precipitators or filter bags. Since the particles solidify while suspended in the exhaust gases, fly ash particles are generally spherical in shape and range in size from 0.5 µm to 100 µm. They consist mostly of silicon dioxide (SiO2), which is present in two forms: amorphous, which is rounded and smooth, and crystalline, which is sharp, pointed and hazardous; aluminum oxide (Al2O3) and iron oxide (Fe2O3). Fly ashes are generally highly heterogeneous, consisting of a mixture of glassy particles with various identifiable crystalline phases such as quartz, mullite, and various iron oxides.
Two classes of fly ash are defined by ASTM C618: Class F fly ash and Class C fly ash. The chief difference between these classes is the amount of calcium, silica, alumina, and iron content in the ash. The chemical properties of the fly ash are largely influenced by the chemical content of the coal burned (i.e., anthracite, bituminous, and lignite).

Not all fly ashes meet ASTM C618 requirements, although depending on the application, this may not be necessary. Ash used as a cement replacement must meet strict construction standards, but no standard environmental standards have been established in the United States. 75% of the ash must have a fineness of 45 µm or less, and have carbon content, measured by the loss on ignition (LOI), of less than 4%. In the U.S., LOI needs to be fewer than 6%. The particle size distribution of raw fly ash is very often fluctuating constantly, due to changing performance of the coal mills and the boiler performance. This makes it necessary that fly ash used in concrete needs to be processed using separation equipment like mechanical air classifiers.

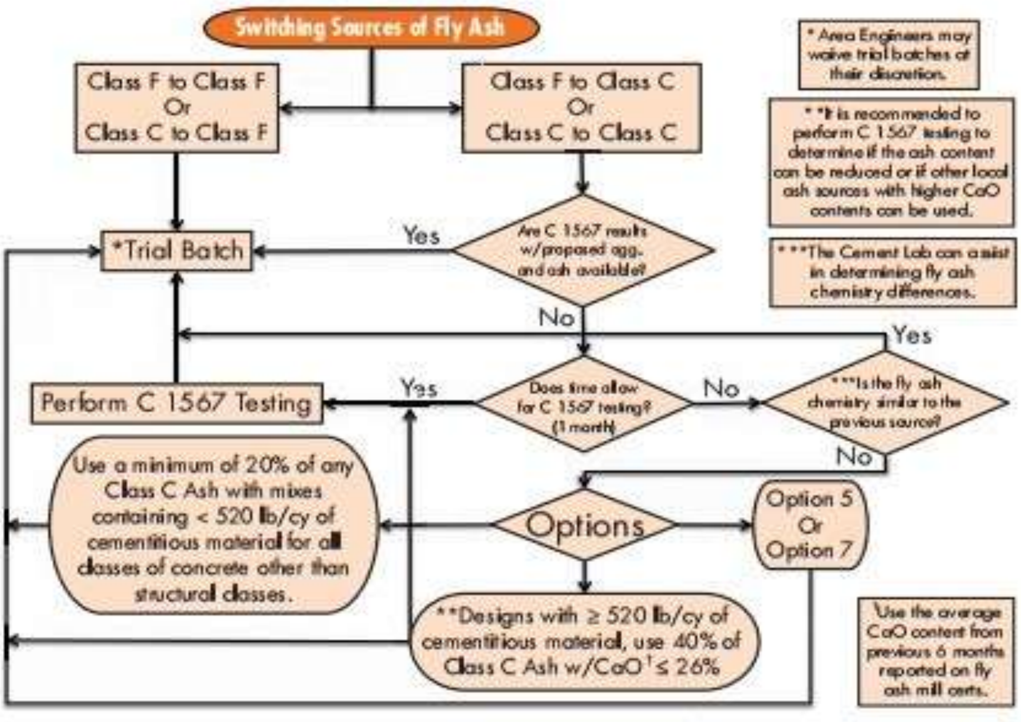


Figure 2: Sources of Fly Ash

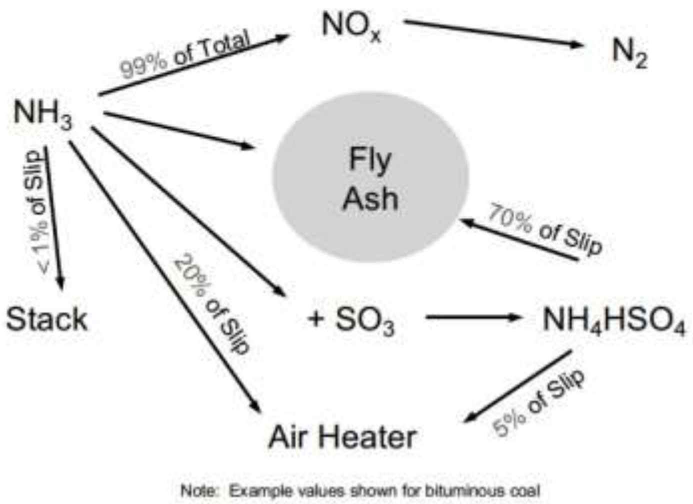
2.3 Class F Fly Ash

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 10% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds. Alternatively, the addition of a chemical activator such as sodium silicate (water glass) to a Class F ash can leads to the formation of a geopolymer.

Figure 3: Section with Class F Fly Ash

2.4 Ammonia Deposition Mechanisms on Coal Ash

Unreacted ammonia slip typically represents less than 1% of the injected ammonia. In conditions where there is adequate sulfur present (from coal or sulfur burners for ESP performance), shows that the majority of sulfur will form ammonium bisulfate, which is a sticky liquid that adheres to the surface of fly ash or to downstream equipment such as air pre heaters. For sub bituminous coal, ammonia does not have an affinity for the alkaline Class C ash. In such cases, most of the ammonia slip goes up the stack.



Fate of ammonia in flue gas

Figure 4: Ammonia Deposition Mechanisms on Coal Ash

2.5 Ammonia Deposition Mechanisms

Spherical shape: Fly ash particles are almost totally spherical in shape, allowing them to flow and blend freely in mixtures.

Ball bearing effect: The "ball-bearing" effect of fly ash particles creates a lubricating action when concrete is in its plastic state.

Higher Strength: Fly ash continues to combine with free lime, increasing structural strength over time.

Decreased Permeability: Increased density and long term pozzolanic action of fly ash, which ties up free lime, results in fewer bleed channels and decreases permeability Increased Durability. Dense fly ash concrete helps keep aggressive compounds on the surface, where destructive action is lessened. Fly ash concrete is also more resistant to attack by sulfate, mild acid, soft (lime hungry) water, and seawater.

Reduced Sulfate Attack: Fly ash ties up free lime that can combine with sulfate to create destructive expansion.

Reduced Efflorescence: Fly ash chemically binds free lime and salts that can create efflorescence and dense concrete holds efflorescence producing compounds on the inside.

Reduced Shrinkage: The largest contributor to drying shrinkage is water content. The lubricating action of fly ash reduces water content and drying shrinkage.

Reduced Heat of Hydration: The pozzolanic reaction between fly ash and lime generates less heat, resulting in reduced thermal cracking when fly ash is used to replace portland cement.

Reduced Alkali Silica Reactivity: Fly ash combines with alkalis from cement that might otherwise combine with silica from aggregates, causing destructive expansion.

Workability: Concrete is easier to place with less effort, responding better to vibration to fill forms more completely. Ease of Pumping. Pumping requires less energy and longer pumping distances are possible.

Improved Finishing: Sharp, clear architectural definition is easier to achieve, with less worry about in-place integrity.

Reduced Bleeding: Fewer bleed channels decreases porosity and chemical attack. Bleed streaking is reduced for architectural finishes. Improved paste to aggregate contact results in enhanced bond strengths.

Reduced Segregation: Improved cohesiveness of fly ash concrete reduces segregation that can lead to rock pockets and blemishes.

Reduced Slump Loss: More dependable concrete allows for greater working time, especially in hot weather.

III. Effects on Utilization Applications

Early results from the U of K project funded by DOE indicate that mortar specimens do indeed evolve ammonia under high pH conditions, although the evolution rate is significantly slower than original expectations. As an example, after 500 hours, almost 80% of the initial ammonia was still present in these samples. (Note that EPRI project results (Ref. 2, 3) indicate a much faster evolution rate for actual concrete specimens.) Recommendations from this work include a limit of 100 pp mw ammonia for ash used in concrete placed in unvented areas. For well-ventilated areas, the recommended limit is 200 pp mw ammonia. Figure 5 presents a consensus of industry opinions on recommended limits and actions for fly ash containing various levels of Note that no results have been reported which indicate decreased performance of concrete or other products containing ammoniated ash.

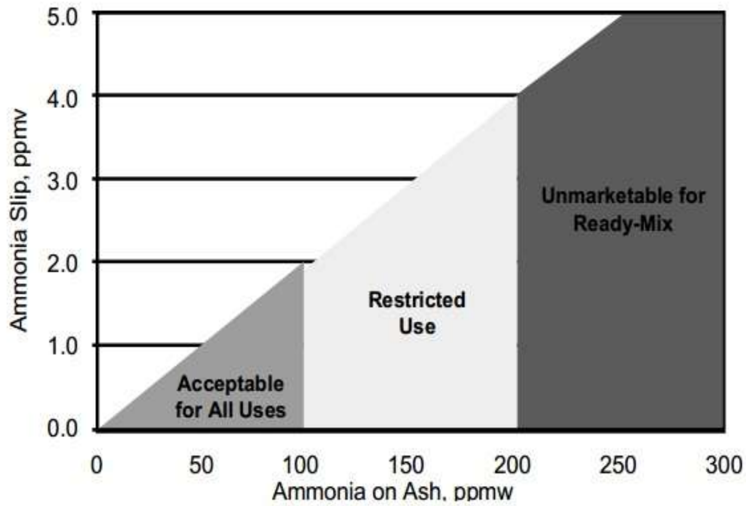


Figure 5: Ammonia on Ash

To keep costs down and profits up some producers of mulch, compost, and other bagged soil amendments use various types of "fillers." These include sawdust, ground pallets, plywood and glue board dust (may contain dangerous chemicals), spent mushroom substrate that is called compost for marketing (high salts), paper mill sludges, bottom and fly ash from boilers (turns material black), etc. Boiler Ash (bottom ash) from coal is the most commonly used toxic industrial waste in the Houston area. It is so alkaline it will chemically burn mulch black in a few days. It is applied to organic waste from pine bark to ground up wood to make it look black or composted Boiler ash tends to be high in salts and extremely alkaline. The products produced tend to be alkaline with high salt, with very high carbon to nitrogen ratios. Some ashes may contain large amounts of heavy metals that contaminate the mulch exceeding federal regulatory levels for safety. These mulch products will often turn a bleached grayish color in a few weeks after exposure to sunlight as the toxic chemicals leach into the soil.

Also many dealers and producers will use incorrect or misleading terminology. Some producers sell products that use words like "Black" and "Humus" in their names. These products are often made from fresh pine bark fines, do not contain any humus, and are chemically burned to turn it black by adding the very alkaline chemicals (i.e. it is mixed with boiler ash which is very alkaline and contains high levels of salts). Other dealers will grind up old pallets, scrap wood, trees, etc. and mix it with fly ash or bottom ash then sell it as black hardwood mulch. These type products are very poor mulch choices and are often toxic to many plants as well as people and pets. People use them, but when the plants get sick and die, they think "I just do not have a green thumb." People buy them because they are often sold at bargain prices...but they are not very cost effective. Black only occurs in nature when anaerobic conditions occur (i.e. fermentation). When anaerobic decay occurs the good microbes die and pathogens grow in their place. Alcohols are produced which are highly toxic to plant roots. Only 1 ppm (1 part per million) alcohol will kill plant roots! Good compost which is often called Black Gold is actually a deep chocolate brown when dry, the color of humus. As in all things, one gets what you pay for. As one crop and soil scientist (Texas A&M) says, "When dealing with bargains, let the buyer beware."

IV. DESCRIPTION OF FLY ASH

4.1 Fly Ash

Fly ash is a fused residue of clay minerals present in coal. The high temperature generated when coal burns in thermal power plants, transforms the clay minerals in coal powder into a variety of fused fine particles of mainly aluminum silicate composition.

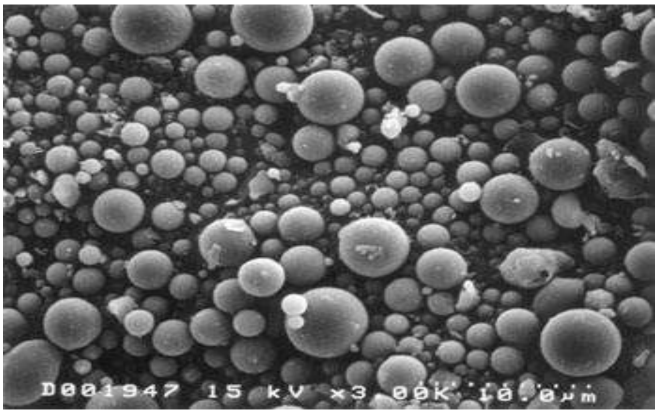


Figure 6: Photomicrograph made with a Scanning Electron

4.2 Purpose of FLY ASH

To formalize through regulation DEP's policies on coal ash certification and use at mine sites;
Adopts the recommendations of the National Academy of Sciences in their 2006 report, Managing Coal Combustion Residues in Mines

4.3 Utilization potential of Fly ash

Depends on characteristics of available fly ash from different power plants
Typical Characteristics of Indian Fly ash:
SiO_2: 49-67%, Al_2O_3: 16-29%, Fe_2O_3: 4-10%, CaO: 1-4%, MgO: 0.2-2%, TiO_2: 1-2%, SO_3: 0.1-2% alkalies: 1-2%, Unburned Carbon: 0.1 – 15%, Density (gm/cc): 1.9 -2.4; Particle size (micron): 8-22

4.4 Ash Collection

Ash can be collected in following categories

a) Dry Fly Ash Dry ash is collected from different rows of electrostatic precipitators. It is available in two different grades of fineness in silos for use as resource material by different users.
b) Bottom Ash Bottom ash is collected from the bottom of the boiler and transported to hydro bins and then ash mound for use in road embankment.
c) Conditioned Fly Ash Conditioned fly ash is also available in ash mound for use in landfills and ash building products.

V. APPLICATIONS OF FLY ASH

5.1 Fly ash in Portland cement concrete

Fly ash can be used in Portland cement concrete to enhance the performance of the concrete. Portland cement is manufactured with calcium oxide (CaO), some of which is released in a free state during hydration. As much as 20 pounds of free lime is released during hydration of 100 pounds of cement. This liberated lime forms the necessary ingredient for reaction with fly ash silicates to form strong and durable cementing compounds, thus improves many of the properties of the concrete. Some of the resulting benefits are:

- Higher ultimate strength
- Increased durability
- Improved workability
- Reduced bleeding
- Increased resistance to sulfate attack
- Increased resistance to alkali-silica reactivity
- Reduced shrinkage.

5.2 Fly Ash for Roads

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)
- Avoids recurring expenditure on excavation of soil from one place for construction and filling up of low lying areas thus created.
- Does not deprive the nation of the agricultural produce that would be grown on the top soil which otherwise would have been used for embankment construction.
- Reduces the demand of land for disposal/deposition of fly ash that otherwise would not have been used for construction of embankment.
- Controls the source of pollution.
- Roller compacted concrete

Another application of using fly ash is in roller compacted concrete dams. Many dams in the US have been constructed with high fly ash contents. Fly ash lowers the heat of hydration allowing thicker placements to occur. Data for these can be found at the US Bureau of Reclamation. This has also been demonstrated in the Ghatghar Dam Project in India.

5.3 Charecteristics of Fly Ash Slurry
The ash is characterized by its physical (lightweight, small spherical particles, hardness) and chemical (cement-like) properties that gives it with an economic value as a raw material in many applications.

Physical Properties
Fly ash particles are very fine, light weight (density 1.97-2.89 g/cc) and spherical (specific surface area 4000-10,000 cm2/g; diameter, 1-150µ), refractory and have pozzolanic ability. Fly ash grey to blackish grey and is dependent on coal type and combustion process. Fly ash has dielectric property (dielectric constant, 104) and can be used in electronic application.

Chemical Properties
Chemical composition of fly ash is as follows: SiO2, 59.38; Fe2O3, 6.11; CaO, 1.94; MgO, 0.97; SO3, 0.76; alkalies, 1.41; and unburn Sulphur and moisture, 3.74%. According to ASTM C618 fly ash is classified into two classes (C & F) based on the amount of lime present. Class C lignite and sub-bituminous coal (>10% CaO) whereas class F is bituminous or anthracite coal (<10% CaO). Oxides of silicon, aluminum, calcium and iron in fly ash are responsible for pozzolanic activity, which decreases by loss of ignition. Fly ash contain following toxic metals Hg, 1; Cd, Ga, Sb, Se, Ti and V, 1 -10; As, Cr, La, Mo, Ni, Pb, Th, U and Zn, 10-100; and B, Ba, Cu, Mn and Sr, 100-1000 mg/kg. Heavy metals (As, Mo, Mn and Fe) show leaching with concentration above permissible limits.

V. UTILIZATION OF FLY ASH

Fly ash can be sourced from all the thermal power plants. Fly ash is most commonly used as a pozzolana in PCC applications. Pozzolanas are siliceous or siliceous and aluminous material, which in a finely divided form and in the presence of water, react with calcium hydroxide at ordinary temperatures to produce cementitious compounds.

5.1 Carbon Credits
Carbon credits are certificates awarded to countries that are successful in reducing the emissions that cause global warming. For trading purposes, one credit is considered equivalent to one tonne of carbon dioxide emission reduced. Such a credit can be sold in the international market at a prevailing market rate. The trading can take place in open market. Developed countries that have exceeded the levels can either cut down emissions, or borrow or buy carbon credits from developing countries. However there are two exchanges for Carbon credit viz Chicago Climate Exchange and the European Climate Exchange.
Fly ash utilization, especially in concrete, has significant benefits including: (1) increasing the life of concrete roads and structures by improving concrete durability, (2) net reduction in energy use and greenhouse gas and other adverse air emissions when fly ash is used to replace or displace manufactured cement, (3) reduction in amount of coal combustion products that must be disposed in landfills, and (4) conservation of other natural resources and materials. Typically, 15 to 30 percent of the Portland cement is replaced with fly ash.
Fly ash disposal is combined with the rehabilitation and reclamation of land areas desecrated by other operations. Fills can be constructed as structural fills where the fly ash is placed in thin lifts and compacted. Structural fly ash fills are relatively incompressible and are suitable for the support of buildings and other structures. Non-structural fly ash fill can be used for the development of parks, parking lots, playgrounds and other similar lightly loaded facilities. One of the most significant characteristics of fly ash in its use as a fill material is its strength. Well-compacted fly ash has strength comparable to or greater than soils normally used in earth fill operations. In addition, fly ash possesses self-hardening properties which can result in the development of shear strengths. The addition of illite or cement can induce hardening in bituminous fly ash

which may not self-harden alone. Significant increases in shear strength can be realized in relatively short periods of time and it can be very useful in the design of embankments.

5.2 Fly ash generation and utilization in different country

S. NO.	Country	Annual ash production, MT	Ash utilization %
1	INDIA	112	38
2	CHINA	100	45
3	USA	75	65
4	GERMANY	40	85
5	UK	15	50
6	AUSTRALIA	10	85
7	CANADA	6	75
8	FRANC	3	85
9	DENMARK	2	100
10	ITALY	2	100
11	NETHERLANDS	2	100

As per estimate, the annual fly ash generation in the country in 2007-2008[data of 2008-2009tonnes]was about 125 million tones fly ash recycled is about 30% i.e. about 40 millions tones. Out of this the cement industry consumes around 28-30 millions tones which is above 70% of the recycled ash. Another approximately 78000 mw of new power generation capacity is expected to come up in the country within three four years. Estimated generation of fly ash till 2012 would be 175 million tones, which again would pose a serious problem of disposal. As per the table Utilization of fly ash in the cement industry in manufacturing ppc cement is increasing on yearly basis. Further motivation and freight equalization to cement industry can most ecofriendly manner.

5.3 Utilization is a viable alternative to dumping

Several factors have impeded fly ash utilization in India, while it is being extensively used globally. Coal-based thermal power stations have been operational for more than 50 years but the concept of developing environment friendly solutions for fly ash utilization is only about 15 years old. Overall fly ash utilization in India stands at a fairly low level of about 15 per cent of the quantity generated. Various possibilities for its use are under research. Among numerous factors that account for the low level of utilization, the chief factors are:

- Poor understanding of the chemistry of fly ash and its derivatives for proper end applications
- Absence of standards and specifications for fly ash products
- Lack of reliable quality assurance for fly ash products
- Poor public awareness about the products and their performance
- Non-availability of dry fly ash collection facilities
- Easy availability of land with top soil at cheap rates for manufacturing conventional bricks
- Lack of proper coordination between thermal plants and ash users.

Fly ash utilization in the country is gaining momentum owing to the stringent regulations that the Mo EF has stipulated, as also to increased awareness about the benefits of using fly ash for various products. Fly ash from coal-fired thermal power stations is an excellent potential raw material for the manufacture of construction material like blended cement, fly ash bricks, mosaic tiles and hollow blocks. It also has other, high volume applications and can be used for paving roads, building embankments, and mine fills.

Fly ash products have several advantages over conventional products. The use of cement in the manufacture of construction products can be reduced by substitution with fly ash. While the use of cement cannot be completely avoided, for certain products like tiles, the substitution can go up to 50 per cent. These products are known to be stronger and more cost-effective because of substantial savings on raw material. Fly ash products are also environment-friendly. A case in point is fly ash bricks. The manufacture of conventional clay bricks involves the consumption of large amounts of clay. This depletes topsoil and degradation of agricultural land. Fly ash bricks do not require clay and serve two purposes; preservation of topsoil and constructive utilization of fly ash.

5.4 Area of utilization

E-60 grade of fly ash will be used as a replacement of cement for all grades of concrete.

E-30 grade of fly ash will be used for all building construction purpose for plastering, brick work, tilling and many other purposes.

E-10 grade of fly ash is mainly used for brick manufacturing &also can be used as 50% replacement as sand for all construction activity, such as brick work & mainly for plastering.

Ecoplast: This will be our unique product as a ready mixed plastering material. This will contain the graded dry quality sand with coarse fly ash to give smooth finished, crackles plaster. This product will be economical, quality oriented & ultimately ecofriendly solution in the crisis of natural products like sand.

Utilizaton

- Cement blending,
- Building materials
- Mine filling
- Road and pavement construction
- Agriculture/soil amendment
- Concrete and mortar
- Light weight aggregate
- Manufacture of asbestos products
- Embankment / Land development
- Floor and wall tiles
- Refractory bricks / tiles
- Paint Industry
- Domestic scouring Powder ,etc

VI. CONCLUSION

Fly Ash can be used as a resource material for alumina magnetite, carbon, cenospheres, mineral fillers, enhanced pozzolana and other and other minor and trace items. FA, as a raw material can be used in manufacture of high wear resistant ceramic tile, mineral wool, glazed floor and wall tiles, ash alloys, synthetic wood, decorative glass and fire abatement application. It can be used as absorbent for toxic organic, in foam insulation products, ceramic fiber, distemper, continuous casting mould powder, FA based Zeolite-Y and ultra-light hollow sphere for arid zone cultivation. Fal-G bricks manufacturing technology, developed by Institute for solid waste research and ecological balance (INSWAREB), consists of bricks produced from a combination of FA, lime and gypsum. Fall-G bricks, about 4 billion produced annually, are light, durable and suitable replacement for conventional concrete bricks for building construction.

A few generalized conclusions are summarized below:

Fly ash has become an important raw material for various industrial and construction of bricks, cement, asbestos-cement products and roads/embankments. Fly ash is being studied for improvement of agricultural crops, wastelands, and zeolites. Fly ash has found application in domestic and wastewater treatment and purification, and paint and enamel manufacturing. In future, large- scale application of Fly ash may be possible for recovery of heavy metals, reclamation of wasteland, and floriculture.

Existing coal based power plants being monitored by the regulatory agencies and directions are issued

- Use of Beneficiated Coal in Thermal Power Plants
- Emphasis on clean technology for new plants
- Emphasis on utilization of fly ash
- Emphasis on non-carbon/low carbon based technologies for power sector
- Emphasis on on cogeneration

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