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A Study of Potential Application for Coal Ash Production as a Raw Material

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***Abstract*—Now a day 73% of the country's total installed power generation capacity is thermal and this power coal-based generation is 90% and also the some 85% thermal power stations, besides several captive power plants use bituminous and sub-bituminous coal and produce large amount quantities of fly ash. The maximum amount of ash content (30% - 50%) coal contributes to large quantity volumes of fly ash because the large amount of ash deposition is responsible for increasing the fly ash quantity. The whole country's dependence on coal for power generation has unchanged. Thus fly ash management is a cause of concern for the future. The aim of this thesis is to find that the exact utilization for a particular fly ash sample depending upon its geotechnical properties and thus reduce the need for waste areas for disposal of fly ash to reduce pollution which in turn causes considerable damage to the environment. In this thesis some of them are Standard Procter Compaction test, Liquid limit test, Permeability study, unconfined compressive strength study etc. Based on the results obtained from these experiments, a suitable end use for the fly ash based on the characteristics of the sample is ascertained. The results receives geotechnical experiments from different research papers give the help in determining the potential of the fly ash for use, in highway embankments, in construction of bricks, as an aggregate material in Portland cement, filling of low lying areas etc. The results obtained it was found that the fly ash can be compacted over a large moisture content range thus it has a potential to be used in fills and embankments and to use various industry product. The fly ash is having low permeability thus it further benefits the use in fills and embankments by reducing the chances of damage to the ground water resources. The aim of these thesis to utilization of ash to reduces the problem of former, and give the good living environment.**

***Index Terms*—Fly ash, Coal fired boiler, Geotechnical experiments, water resources**

I. Introduction

India is the third largest producer of coal and coal based thermal power plant installations in India contribute about 70% of the total installed capacity for power generation. However, the bituminous and sub-bituminous coals used contain over 40% ash content. At present, 120-150 million tons of coal fly ash is generated from 120 existing coal based thermal power plants in India Coal fly ash is an industrial waste generated from coal combustion process in thermal power plants. It is a fly ash, a coal combustion residue having a complex heterogeneous mixture of amorphous and crystalline phases and is generally fine powdered ferro-alumino silicate material with Al, Ca, Mg, Fe, Na and Si as the predominant elements. The coal fly ash also contains significant amounts of toxic metals such as As, Ba, Hg, Cr, Ni, V, Pb, Zn and Se characteristically enriched in coal fly ash particles [3-5]. The coal fly ashes occupy more space in the premises of industrial plants and are mixed with water to discharge into fly ash settling ponds or landfills. Large quantities of coal fly ashes are stored in the form of waste heaps or deposits, whose contamination poses a serious threat to the environment as a major source of inorganic pollution. The behavior of many metal pollutants and the release of such metals during storage can have deleterious effects on the environment as well as on human health. Metals present in the ashes are originated from the composition of the coal used in combustion, combustion conditions, and removal efficiency of air pollution control device and method of coal fly ash disposal.

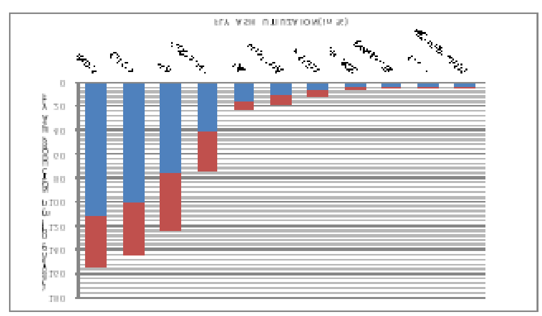

Fig. 1. Countries

Metals present in the ashes are originated from the compo-Large number of innovative alternate building materials and low cost construction techniques developed through intensive research efforts during last three to four decades satisfies functional as well as specification requirements of conventional materials techniques and provide an avenue for bringing down the construction cost. Fly Ash, an industrial by-product from Thermal Power Plants (TPPs), with current annual generation of approximately 112 million tones and its proven suitability for variety of applications as admixture in cement/concrete/mortar, lime pozzolana mixture (bricks/blocks) etc. Cement and Concrete Industry accounts for 50% Fly Ash utilization, the total utilization of which at present stands at 30MT (28%). The other areas of application are Low-lying area fill (17%), Roads

& Embankments (15%), Dyke Raising (4%), Brick manufacturing (2%) and other new areas for safe disposal of fly ash is in paint industry, agriculture etc.

A. Effluent and Disposal

Disposal and management of fly ash is a major problem in coal-fired thermal power plants. Fly ash emissions from a variety of coal combustion units show a wide range of composition. All elements below atomic number 92 are present in coal ash. A 500 MW thermal power plant releases 200mt SO2, 70 t NO2 and 500 t fly ash approximately every day. Particulate matter (PM) considered as a source of air pollution constitutes fly ash. The fine particles of fly ash reach the pulmonary region of the lungs and remain there for long periods of time; they behave like cumulative poisons. The submicron particles enter deeper into the lungs and are deposited on the alveolar walls where the metals could be transferred to the blood plasma across the cell membrane (fig. 2). The residual particles being silica (40–73%) cause silicosis. All the heavy metals (Ni, Cd, Sb, As, Cr, Pb, etc.) generally found in fly ash are toxic in nature [9]. Fly ash can be disposed-off in a dry or wet state. Studies show that wet disposal of this waste does not protect the environment from migration of metal into the soil. Heavy metals cannot be degraded biologically into harmless products like other organic waste. Studies also show that coal ash satisfies the criteria for landfill disposal, according to the Environmental Agency of Japan. According to the hazardous waste management and handling rule of 1989, fly ash is considered as non-hazardous. With the present practice of fly-ash disposal in ash ponds (generally in the form of slurry), the total land required for ash disposal would be about 82,200 ha by the year 2020 at an estimated 0.6 ha per MW. Fly ash can be treated as a by-product rather than waste.

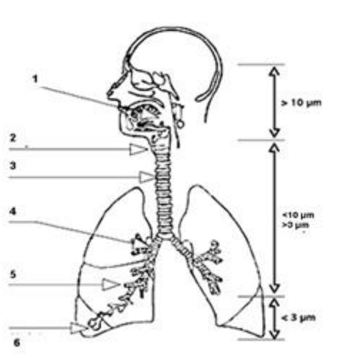

Fig. 2. Penetration of tiny particles into the lungs

B. Classification of Fly Ash

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, mullet, 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).

a) A Class C Fly Ash   b) A Class F Fly Ash

Fig. 3. Classes of fly ash

Fly ash produced from the burning of younger lignite or sub bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash will harden and gain strength over time. Class C fly ash generally contains more than 20% lime (CaO). Unlike Class F, self-cementing Class C fly ash does not require an activator. Alkali and sulfate (SO4) contents are generally higher in Class C fly ashes [12]. 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 cementations compounds. Alternatively, the addition of a chemical activator such as sodium silicate (water glass) to a Class F ash can lead to the formation of a geopolymer.

C. Fly Ash Utilization

During the last 30 years, extensive research has been carried out to utilize the fly ash in various sectors, as this is not considered as hazardous waste. Broadly, fly ash utilization programmers can be viewed from two angles, i.e. mitigating environmental effects and addressing disposal problems (low value–high volume utilization).

D. Ecological Balance

The Ecological balance evaluates the environment effects of a product during its complete service life in respect of the different environment aspects. From the extraction of the raw materials to their disposal, fly Ash, Lime, Gypsum & others.

E. Fly Ash-Based Ceramics

The National Metallurgical Laboratory, Jamshedpur has developed a process to produce ceramics from fly ash having superior resistance to abrasion [9]. Waste utilization activities involve the use of fly ash, red mud and blast furnace slag for the production of cheap and useful products for use by the industry and society at large. These materials have been successfully used to make wear resistant ceramics, ceramic floor and wall tiles, synthetic granite tiles, blended cement and geopolymer. Other activities involved recycling and reuse of electronic waste, purification of waste water and Industrial effluents.

F. Geo Polymer Pavement Tiles

Developed at NML using fly ash as main raw material. These tiles exhibit high strength and are ready to use in one week. Based on the merit of this work, Fly Ash Unit, Department of Science & Technology, Govt. of India granted a project to NML to translate this process into technology by setting up a 3 tons/day capacity pilot plant. Once it is developed at pilot scale, the technology will be ready for commercialization. We are looking for industrial participation for this development.

G. Major Facilities

Particle characterization facilities such as laser particle size analyzer, zeta meter, BET surface area analyzer, Rheometer, Isothermal conduction calorimeter, Mechanical activation devices such as attrition mill, jet mill, eccentric vibratory mill, planetary mill Ceramic, cement and geopolymer processing facility such as ball mill, hydraulic press, airless dryer, curing chamber, humidity cabinet, high temperature furnaces Thermo mechanical characterization using TG/DTA, Hot MOR, Creep.

Fig. 4. Fly ash treatments

H. Ready Mixed Fly Ash 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 (of cementitious material) 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

I. Minefills

Nearly one third of our thermal power stations are at or near to pit heads. Most of these mines cart sand for backfilling from river beds, which are normally 50-80 Km away. Apart from the royalty, huge amount of expenditure is incurred on transportation of sand. It is estimated that about 15-20 million tonne of ash per annum can be safely consumed in mine fills yielding a saving of about Rs. 150 crore a year.

II. PROBLEM DESCRIPTION

Our research is based on fly ash production due to combustion in the furnace and proper utilization of the fly ash produce in Sant Singaji Power Plant Mundi, Khandwa. The purpose of this thesis is to find a suitable utilization for a particular fly ash sample depending upon its geotechnical properties and thus reduce the need for vast areas for disposal of fly ash which in turn causes considerable damage to the environment and nearby village of the plant. They are reported on Standard Procter Compaction test, Liquid limit test, Permeability study, unconfined compressive strength study etc. Based on the results obtained from these experiments, a suitable end use for the fly ash based on the characteristics of the sample is ascertained. The results from the geotechnical experiments help in determining the potential of the fly ash for use, in highway embankments, in construction of bricks, as an aggregate material in Portland cement, filling of low lying areas etc. From the results obtained it was found that the fly ash can be compacted over a large moisture content range thus it has a potential to be used in fills and embankments. Also since fly ash is having low permeability thus it further benefits the use in fills and embankments by reducing the chances of damage to the ground water resources. The low specific gravity of fly and the pozzolanic activity of fly ash aids for its use along-with cements for construction purposes and also in manufacturing of bricks

The main objective are:

1. The production of fly ash in Sant Singaji Power Plant.
2. The necessity for the utilization of fly ash.
3. Disposal methods of fly ash.
4. Characterization of different types of fly ash.
5. Find out a particular end use for a particular waste generated during any of the processes involved.
6. To reduce the toxicity of hazardous wastes or to minimize its impacts on the environment

Find out an alternative method of disposal of potentially harmful wastes.

A. Fly Ash Generation

The fly ash produced from the burning of pulverized coal in a coal-fired boiler is a fine-grained, powdery particulate material that is carried off in the flue gas and usually collected from the flue gas by means of electrostatic precipitators, baghouses, or mechanical collection devices such as cyclones.

In general, there are three types of coal-fired boiler furnaces used in the electric utility industry. They are referred to as dry-bottom boilers, wet-bottom boilers, and cyclone furnaces. The most common type of coal burning furnace is the dry-bottom furnace. When pulverized coal is combusted in a dry-ash, dry-bottom boiler, about 80 percent of all the ash leaves the furnace as fly ash, entrained in the flue gas. When pulverized coal is combusted in a wet-bottom (or slag-tap) furnace, as much as 50 percent of the ash is retained in the furnace, with the other 50 percent being entrained in the flue gas. In a cyclone furnace, where crushed coal is used as a fuel, 70 to 80 percent of the ash is retained as boiler slag and only 20 to 30 percent leaves the furnace as dry ash, in the flue gas. A general flow diagram of fly ash production in a dry-bottom coal-fired utility boiler operation is presented in Fig. 4.

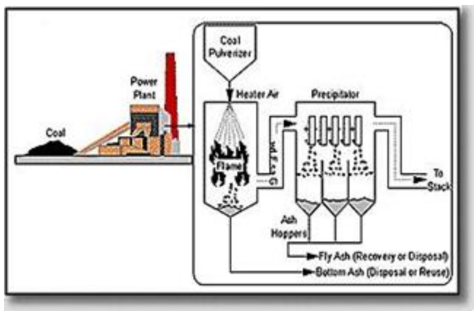

Fig. 4. Generation of ash at the power plants

B. *Transportation*

Fly ash can be supplied in four forms well as the foundation structure will be less. The other application areas include embankments especially on weak foundation soils, reclamation of low-lying areas, etc. The variation of specific gravity of the coal ash is the result of a combination of many factors such as gradation, particle shape and chemical composition. It is known that coal ash comprises mostly glassy cenospheres and some solid spheres. The reason for a low specific gravity could either be due to the presence of large number of hollow cenospheres from which the entrapped air cannot be removed, or the variation in the chemical composition, in particular iron content, or both. The investigations show that the specific gravity generally lies between 1.46 and 2.66. In most of the cases, fly ash will have higher specific gravity compared to pond and bottom ashes of the same locality. When the particles are crushed, they show a higher specific gravity compared to the uncrushed portion of the same material.

C. *Grain Size Distribution*

Grain size distribution indicates if a material is well graded, poorly graded, fine or coarse, etc. and also helps in classifying the coal ashes. Coal ashes are predominantly silt sized with some sand-size fraction. Leonards and Bailey have reported the range of gradation for fly and bottom ashes which can be classified as silty sands or sandy silts.

The extensive investigation carried out on Indian coal ashes demonstrates that the fly ashes consist predominantly of silt-size fraction with some clay-size fraction. The pond ashes consist of silt-size fraction with some sand-size fraction. The bottom ashes are coarser particles consisting predominantly of sand-size fraction with some silt-size fraction. Based on the grain-size distribution, the coal ashes can be classified as sandy silt to silty sand. They are poorly graded with coefficient of curvature ranging between 0.61 and 3.70. The coefficient of uniformity is in the range of 1.59–14.

D. *Specific Surface*

The study of specific surface of soils is widely recognized as a means to understand their physical and engineering behavior. Even though coal ashes are primarily silt/sand-sized particles and their specific surface is expected to be very low, results need be obtained for completeness and for use in certain cases. With this in mind, the surface area measurements were made using Desiccator method and Blaines Air Permeability method.

E. *Classification*

For an effective and efficient use of coal ashes in geotechnical engineering practice, their classification from geotechnical engineering point of view is important. While a number of studies have been made on the physical and engineering properties of coal ashes and their utilization in geotechnical engineering practice, no information is available with respect to their classification.

F. *Chemical Properties*

The chemical properties of the coal ashes greatly influence the environmental impacts that may arise out of their use/disposal as well as their engineering properties. The adverse impacts include contamination of surface and subsurface water with toxic heavy metals present in the coal ashes, loss of soil fertility around the plant sites, etc.

G. *Chemical Composition*

Chemical composition suggests the possible applications for coal ash. The investigations carried out on Indian fly ashes show that all the fly ashes contain silica, alumina, iron oxide and calcium oxide. The silica content in fly ashes is between 38 and 63%, 37 and 75% in pond ashes, and 27 and 73% in bottom ashes. The alumina content ranges between 27 and 44% for fly ashes, 11 and 53% for pond ashes and 13 and 27% for bottom ashes. The calcium oxide is in the range of 0 to 8% for fly ashes, 0.2 to 0.6% for pond ashes and 0 to 0.8% for bottom ashes. It is found that all the Indian coal ashes satisfy the chemical requirements for use as a pozzolona. According to ASTM classification, only Neyveli fly ash can be classified as Class C fly ash and all other coal ashes fall under Class F.

H. *X-ray Diffraction*

X-ray diffraction studies are carried out primarily to identify the mineral phases. The studies carried out indicate that coal ashes predominantly consist of quartz and feldspar minerals. The studies carried out at IISc reveal that the major mineral found in coal ashes is quartz with lesser proportions of feldspars, carbonates and chlorites. The coal ashes exhibit both crystalline and amorphous phases.

III. METHODOLOGY

Our research is based on fly ash production due to combustion in the furnace and proper utilization of the fly ash produce in Sant Singaji Power Plant Mundi, Khandwa. The purpose of this thesis is to find a suitable utilization for a particular fly ash sample depending upon its geotechnical properties and thus reduce the need for vast areas for disposal of fly ash which in turn causes considerable damage to the environment and nearby village of the plant. They are reported on Standard Procter Compaction test, Liquid limit test, Permeability study, unconfined compressive strength study etc. Based on the results obtained from these experiments, a suitable end use for the fly ash based on the characteristics of the sample is ascertained. The results from the geotechnical experiments help in determining the potential of the fly ash for use, in highway embankments, in construction of bricks, as an aggregate material in Portland cement, filling of low lying areas etc. From the results obtained it was found that the fly ash can be compacted over a large moisture content range thus it has a potential to be used in fills and embankments. Also since fly ash is having low permeability thus it further benefits the use in fills and embankments by reducing the chances of damage to the ground water resources. The low specific gravity of fly and the pozzolanic activity of fly ash aids for its use along-with cements for construction purposes and also in manufacturing of bricks.

The main objective are:

A. Production of Fly Ash in Sant Singaji Power Plant

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 (SiO_2), which is present in two forms: amorphous, which is rounded and smooth, and crystalline, which is sharp, pointed and hazardous; aluminum oxide (Al_2O_3) and iron oxide (Fe_2O_3). Fly ashes are generally highly heterogeneous, consisting of a mixture of glassy particles with various identifiable crystalline phases such as quartz, mullet, 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).Fly ash produced from the burning of younger lignite or sub bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash will harden and gain strength over time. Class C fly ash generally contains more than 20% lime (CaO). Unlike Class F, self-cementing Class C fly ash does not require an activator. Alkali and sulfate (SO_4) contents are generally higher in Class C fly ashes.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 cementations 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.

B. The Necessity for the Utilization of Fly Ash

During the last 30 years, extensive research has been carried out to utilize the fly ash in various sectors, as this is not considered as hazardous waste. Broadly, fly ash utilization programmers can be viewed from two angles, i.e. mitigating environmental effects and addressing disposal problems (low value–high volume utilization).

C. Fly Ash Based Cement

As per the specifications of Bureau of Indian Standards fly ash upto 35% can be used in manufacture of PPC, while worldwide there are examples of countries that permit up to 55% utilization of fly ash in PPC production. Setting aside 25% of cement production for OPC for such applications, the balance 75% can be PPC with an average fly ash content of 30% [14]. It would consume around 25 MT fly ash, replacing same amount of cement clinker and resulting in net saving Rs. 2500 crore.

D. Role of Bio-Amelioration of Fly Ash on Soil

Recent investigations suggest that FA can find better application if combined with organic amendments such as cow manure, press mud, paper factory sludge, farmyard manure, sewage sludge, crop residues and organic compost for improvement of degraded/marginal soil. Few beneficial combined effects of FA and organic matter on soil have been found such as reduced heavy-metal availability and killing pathogens in the sludge improved soils through higher nutrient concentrations, better texture, lower bulk density, higher porosity and mass moisture content and higher content of fine-grained minerals enhanced the biological activity in the soil reduced the leaching of major nutrients and beneficial for vegetation. Use of swine manure with FA increased the availability of Ca and Mg balancing the ratio between monovalent and bivalent cations ($Na++ K+/Ca_2+ Mg_2+$), which otherwise proves detrimental to the soil Co-utilization of ‘slash’ a mixture of FA, sewage sludge and lime in the ratio of 60:30:10 had beneficial soil ameliorating effect. ‘Slash’ incorporation in soil showed positive effects on soil pH and Ca, Mg and P content and reduction in the translocation of Ni and Cd and enhanced growth and yield of corn, potatoes and beans in pot trials. So, amendment with FA will enhance agricultural sector for crop production. Further, organic amendment application will provided anchorage and growth of the plant on a FA dumping site.

E. Fly Ash Bricks

The Central Fuel Research Institute, Dhanbad has developed a technology for the utilization of fly ash for the manufacture of building bricks [9]. Fly Ash can be used in the range of 40-70%. Our current clay brick production exceeds 100 billion bricks a year. In such circumstances and when fly ash brick is technically acceptable, economically viable and environment friendly, it may not be wrong to target to produce at least 2 billion fly ash bricks per year. It would consume about 5 million tonne of flyash/year, yielding a net saving of around Rs. 20 crores per annum. Fly ash bricks have a number of advantages over the conventional burnt clay bricks. Unglazed tiles for use on footpaths can also be made from it. Awareness among the public is required and the Government has to provide special incentives for this purpose.

Fig. 5. Production of bricks (MPPGCL, MUNDI)

There are two main institutions of the Government of India namely (I) Central Fuel Research institute Dhanbad and (ii) Central Building Research Institute Roorkee. Central Fuel Research institute has developed technology for manufacture of fly ash lime bricks. In the technology involved by the Central Fuel Research Institute Dhanbad as following:

- Fly ash 60%
- Lime 15%
- Sand/slag 25%
- Activator 05%

Ratio of above would also depend upon the quality of each of these materials and may be adjusted accordingly to achieve the desire strength and suitable in cost also.

F. Disposal Methods of Fly Ash (Past Method)

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. The Fly Ash is a resource material, if not managed well, this may pose environmental and health problems. 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.

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.

The environmental aspect of Fly Ash disposal aims at minimizing air and water pollution. Directly related to these concerns is the additional environmental goal of aesthetically enhancing ash disposal facilities. The Fly Ash produced by thermal power plants can cause all three environmental risks- air, surface water and ground water pollution.

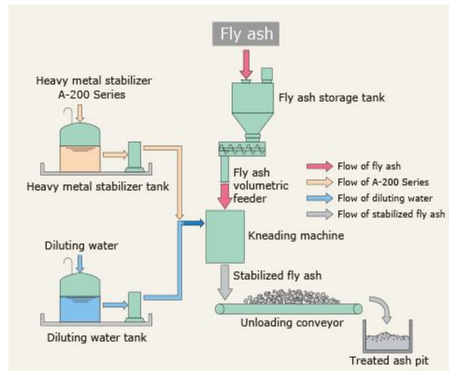

Fig. 6. Fly ash deposition

The first step of this work consists of the reduction of volume by combustion of carbon present in fly ash. Fig. 7. Shows the system based on plasma arc technology used for this step. The thermal plasma system consists of two plasma-reaction chambers, one for pyrolysis and the second for final combustion. The system also contains a loading system, a working gas unit, a cooling water unit, a power supply system, and a gas cleaning system. In the two plasma-reaction chambers, the working gas is air and is injected axially into the two plasma torches at a flow rate of 45 m^3/h. The current intensity and the voltage for the pyrolysis and combustion plasma torches are 100 A/220 V and 150 A/220 V, respectively. A hydro filter is used for purification of the exhaust flow from mechanical impurities, sprays, vapors, and gas impurities. The feeder is filled with fly ash, and will mechanically provide for loading 25 kg/h into the plasma-reaction chamber. In the second step, the treated fly ash (product) was vitrified in the system shown in Fig. 2. The torch was mounted above a crucible filled with the product and a glass frit (to increase the mass of Si in the product). The water-cooled stainless steel crucible is set just under the coupling zone of the plasma torches. During the experiments reported here, the current intensity is 100 A and the voltage is 220 V. In this step an inert gas (argon) is used as working gas at a flow rate of 45 m^3/h.

The surface of the fly ash before (feed) and after treatment (product) were characterized using scanning electron microscopy (FEI INSPECT-F50-SEM, Netherlands). Chemical composition of feed and product were measured by X-ray fluorescence measurements (Shimadzu XRF-1800 Sequential X-Ray Fluorescence Spectrometer, Japan). The carbon content in the feed and the product were determined using a CHN analyzer (ELTRA CW multiphase-determinate, Germany). The concentrations of elements presents in the feed, product, and the pulverized slag were analyzed using inductively coupled plasma atomic emission spectroscopy (ICP-AES). The leaching behavior of heavy metals in the slag and fly ash was measured ac-cording to “Method 1311 Toxicity Characteristic Leaching Procedure” of the United States Environmental Protection Agency (EPA TCLP 1311). In the beginning of the leaching analysis, the amount of solids in the sample was specified. A sample that contains less than 0.5% dry solid material is considered as TCLP extract.

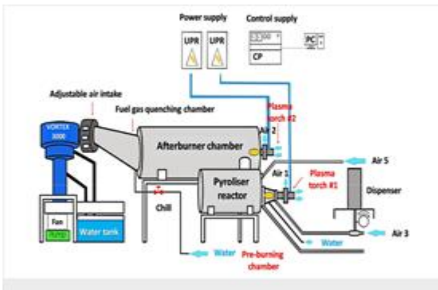

Fig. 7. Plasma method

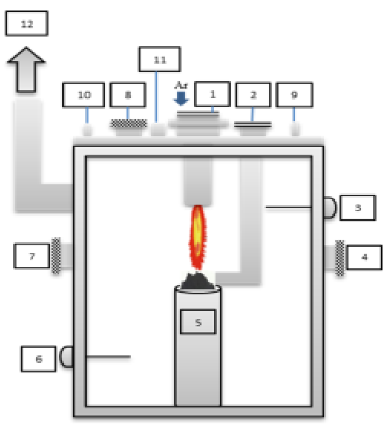

Fig. 8. Verification plasma system

1 - Torch ,2 – Feeder, 3 and 6 – Thermocouples ,4 and 7—Windows, 5 Crucible ,8--Inspection window, 9 Water inlet, 10,Water outlet, 11--Pressure sensor,12--Exhaust.

G. Determination of Specific Gravity

Objective: To determine the specific gravity of soil fraction passing 4.75 mm I.S sieve by density bottle.

Need and Scope of the Experiment: The knowledge of specific gravity is needed in calculation of soil properties like void ratio, degree of saturation etc.

Apparatus Required:

Density bottle of 50 ml with stopper having capillary hole, Balance to weigh the materials (accuracy 10gm). Wash bottle with distilled water, Alcohol and ether.

Procedure:

1) Clean and dry the density bottle.
   a) Wash the bottle with water and allow it to drain.
   b) Wash it with alcohol and drain it to remove water.
   c) Wash it with ether, to remove alcohol and drain ether.
2) Weigh the empty bottle with stopper (W1)
3) Take about 10 to 20 gm of oven soil sample which is cooled in a desiccators. Transfer it to the bottle. Find the weight of the bottle and soil (W2).
4) Put 10ml of distilled water in the bottle to allow the soil to soak completely. Leave it for about 2 hours.
5) Again fill the bottle completely with distilled water put the stopper and keep the bottle under constant temperature water baths (Tx0).
6) Take the bottle outside and wipe it clean and dry note. Now determine the weight of the bottle and the contents (W3).
7) Now empty the bottle and thoroughly clean it. Fill the bottle with only distilled water and weigh it. Let it be W4 at temperature (Tx0 C).

Repeat the same process for 2 to 3 times, to take the average reading of it.

Observations & Calculations:

Specific gravity of Soil = Density of water at 27o C/ Weight of Water of equal volume

W2-W1/ (W4-W1) – (W3-W2) (1)

Interpretation and Reporting:

Unless or otherwise specified specific gravity values reported shall be based on water at 270C. So the specific gravity at 270C = K Sp. gravity at Tx0C

Where K is the ratio of density of water at temperature at TxoC and density of water at temperature at TyoC

The specific gravity of the soil particles lie with in the range of 2.65 to 2.85. Soils containing organic matter and porous particles may have specific gravity values below 2.0. Soils having heavy substances may have values above 3.0.

Result:

The specific gravity of the samples was found out to be:
Sample from ICCL = 2.12 g/cm^3
Sample from RSP, CPP I= 2.46 g/cm^3

H. Fly Ash Calculation

In steady state flow, the total mass of material entering a reactor must equal to total mass leaving the reactor.

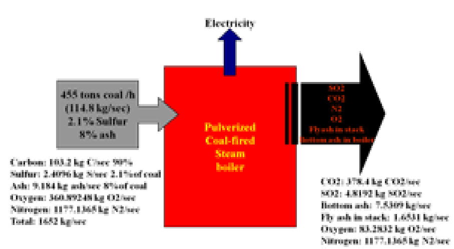

Fig. 9. Fly ash chemical composition

Where,
m = mass of coal burn per kg

H = Total heat in kcal/kg
hw = Enthalpy of water evaporated in kcal/kg
ηboiler = Efficiency of boiler
G.C.V = Gross calorific value of coal
Coal Requirement (kg/hr) = [m (H-hw)/ ηboiler x G.C.V]
Ton of Coal requirement per annum = [Coal Requirement (kg/hr) x 24 x 300]/[1000]].

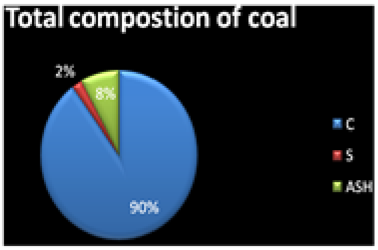

Fig. 10. Total composition of coal

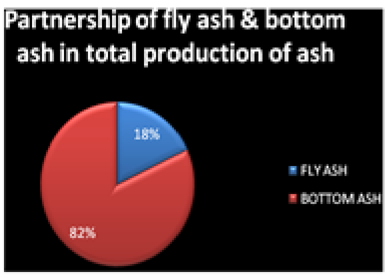

Fig. 11. Partnership of fly ash and ash in total production of ash

IV. CONCLUSION

It has been recognized worldwide that the utilization of an enormous amount of fossil fuels has created various adverse effects on the environment, including acid rain and global warming. An increase in the average global temperature of approximately 0.56 K has been measured over the past century (global warming). Gases with three or more atoms that have higher heat capacities than those of O2 and N2 cause the greenhouse effect. Carbon dioxide (CO2) is a main greenhouse gas associated with global climate change. The disposal, management and proper utilization of waste products has become a concern for the scientists and environmentalists. Proper management of solid-waste fly ash from thermal power plants is necessary to safeguard our environment. Because of high cost involved in road transportation for the dumping of fly ash, it is advisable to explore all its possible applications. Fly ash is a potential source of pollution not only for the atmosphere but also for the other components of the environment. Deposition in storage places can have negative influences on water and soil because of their granulometric and mineral composition as well morphology and filtration properties. This waste has found application in domestic and wastewater treatment, purification, paint and enamel manufacturing. 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 show that fly ash has good potential for use in highway applications. Its low specific gravity, freely draining nature, ease of compaction, insensitiveness to changes in moisture content, good frictional properties, etc. can be gainfully exploited in the construction of embankments, roads, reclamation of low-lying areas, fill behind retaining structures, etc.

The results shows that it is possible to achieve desired strength in concrete by replacing cement upto 40% by Fly Ash, Brick Dust and Rice Husk Ash.

The conclusion is as follows:

1. Fly Ash and Brick Dust concrete shows more strength as compare to Rice Husk Ash concrete.
2. Rice Husk Ash makes concrete light in weight as compared to Fly Ash and Brick Dust concrete. So it will be helpful in reducing dead load of the construction.
3. Brick Dust makes concrete heavier so it will be helpful in using it in foundation work and making earthen dams etc where heavy weight is essential for the structure.
4. There is 33-40% reduction in cost of concrete by using these industrial wastes (FA, RHA and BD).
5. There is 7% reduction in the cost of concrete when using Rice Husk Ash and Brick Dust in Bhopal Region as compared to Fly Ash concrete.

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