CHAPTER - 1
INTRODUCTION

1.1 General
There is a vast demand for materials in the construction sector due to the fast growing needs of infrastructure. Concrete as a construction material has large potential all over the world and its consumption is next only to that of water. Aggregates contribute to about 60 - 70% of concrete mass and hence there exists a great demand for them. The fast and huge infrastructural developments in India demand enormous quantity of natural sand for concrete, as fine aggregate.

Dwindling sand resources in river beds pose environmental problems and hence government has imposed restriction on the usage of sand. The huge demand due to fast development in infrastructure, scarcity of natural sand in river beds and also due to government restriction on quarrying of sand, have all led to the increased cost of natural sand. This, not only increases the cost of construction but also delays the construction in few places due to the non-availability of natural sand. This motivates researchers to take up study on alternative materials to replace the natural sand. Substitution of raw materials/constituents with alternatives is an important eco efficiency driver and is the need of the hour.

Pond ash, a twin of fly ash, both by-products of Thermal Power Stations (TPS) utilizing coal as fuel needs several avenues for its effective usage as currently the storage of pond ash has spread across thousands of hectares, which leads to land degradation, loss of soil fertilities and other environmental hazards.

Huge amount of coal ash thus generated from TPS, if utilized to make up for the scarcity of sand confronted by concrete users, offsetting traditional materials thus conserving non renewable natural resources, even if it is to a certain extent, goes a long way in solving the environmental and ecological problems. This also allows for the recovery of both energy and material from selected waste which is a step called co-processing.
1.2 Generation of Pond Ash

The requirement of power in India is rapidly increasing with increase in growth of the industrial sector. In spite of the global economic slowdown, India is still the 3rd fastest growing major economy in the world. This booming economy has kick started all industry sectors including the construction & infrastructure industry, which demands for additional 1,08,000 MW power generation to meet the growing economy needs (Malhotra, 2011). India depends on thermal power as its main source (around 80% of power produced is thermal power) and coal will be the main source of energy for the production as it is one of the cheapest sources of fuel. Coal ash is a by-product generated from the process of coal combustion at high temperature over 1600°C at these coal-fired power plants. Burning of pulverized coal in the furnace results in the generation of large quantity of ash. Coal ash can be divided into fly ash and bottom ash. This ash constitutes of 80% fly ash, one of the residues generated in combustion that comprises of fine particles that rise with the flue gases. The twenty percent of total ash produced is dry bottom ash, a dark gray, granular, porous, material that is collected in a water-filled hopper at the bottom of the furnace. Primarily, the fly ash is disposed off using either dry or wet disposal scheme.

**In dry disposal**, the fly ash is transported by truck, chute or conveyor at the site and disposed off by constructing a dry embankment (dyke).

**In wet disposal**, the fly ash is transported as slurry through pipe and disposed off in impoundment called "Ash Pond".

Most of the power plants in India use wet disposal system, and when the lagoons are full, four basic options available are

i. constructing new lagoons using conventional construction material,
ii. hauling of fly ash from the existing lagoons to another disposal site,
iii. raising the existing dyke using conventional constructional material, and
iv. raising the dyke using fly ash excavated from the lagoon ("ash dyke").

Fly ash has been recycled as an alternative to cement and other applications, while bottom ash has been disposed off using wet system in whole. Coarser ash is mixed with water and pumped out in the form of slurry to large pond and hence known as pond ash. More than 630 million m³ water is required for the disposal of coal ash in slurry form
(bottom ash) per annum. One of the important cautions of World Bank to India is that by 2015 disposal of coal ash would require 1000 square km. or one meter square of land per person (C-FARM report 2012).

1.3 Scenario of Coal Ash in India

Fly ash generation and utilization data for 1st half of the year 2010-11 (CEAI-New Delhi 2012) has been received from 90 (Ninety) coal/ lignite based thermal power stations of various power utilities in the country with a total installed capacity of about 83797 MW. Data received has been analyzed to derive conclusions on status as on April 2010-11 of fly ash utilization and compliance of MoEF Notification of 3rd Nov. 2009.

A brief summary of status of coal ash from TPS from which data have been received is as follows.

- Nos. of Coal/ Lignite based: 90 nos.
- Installed capacity : 83797 MW
- Total fly ash generated : 66.49 Million Tonne
- Total ash utilized : 36.26 Million Tonne
- Percentage Utilization : 54.53%
- Nearly 65,000 acres of land is occupied by ash ponds

The above data on utilisation pertains to fly ash and it is obvious that proportionate amount of pond ash gets generated and stored, but no data on its utilisation is available.

The objectives of core components of the National Action Plan are always on the use of coal ash adding to the emphasis on efficiency and enhancement of percentage utilization.

With this key goal and its implementation, success here depends on the effective implementation of few strategies made, which in turn depend on the feasibility of material usage which helps to overcome the shortage of natural raw materials and reduces the CO₂ release to atmosphere, contributing to sustainable construction.

1.4 Details of Thermal Power Stations – Sources of Pond Ash

The physical, chemical and morphological properties of fly ash and pond ash depend on many factors such as source and type of coal used, temperature at which coal is burnt, method of disposal of ash, its storage etc., (Ranganath R V 1997). Knowing the variation
in properties of fly ash / pond ash is important and necessary from the point of view of strength and durability of the structures, when pond ash is used as a constituent. Hence in the present research it was decided to consider pond ash from three different sources to study the extent of variation in the properties of pond ash from source to source and use it as a constituent in mortar, concrete and self compacting concrete. The sources which are considerably nearer to Bangalore (Bangalore to Raichur – 455 km, Bangalore to Bellary – 307 km, Bangalore to Mettur – 202 km) are considered for the detailed investigation. Three sources of pond ash considered for the study are

1. Raichur Thermal Power Station - RTPS, Karnataka
2. Bellary Thermal Power Station – BTPS, Karnataka
3. Mettur Thermal Power Station – MTPS, Tamil Nadu

1.4.1 RTPS - Raichur Thermal Power Station –The Raichur Thermal Power Station (RTPS), one of Karnataka's major power plants, is situated at Shakthinagar near Devasugur village about 20km north of Raichur District. Owned by state run Karnataka Power Corporation Limited (KPCL), RTPS where operations are automated (fig.1.1) consists of seven units, each capable of generating 210 MW of power, contributing to annual power generation of around 10,000 Million Units(MU). KPCL has further expanded the Thermal Power station, by adding one more Unit(8), with an installed capacity of 250 MW and 1752 MU/annum. Its total power generation at optimum capacity is 1470 MW per day. The units were commissioned during various periods starting from 1985. The station has a zero discharge water conservation system of the ash pond water. Fig. 1.2 is a view view of RTPS having eight power generating units with eight cooling towers.

![View of Automation of Operation Raichur Thermal Power Station](image_url)
**Water Requirement** - Water drawn from the Krishna River which flows adjacent to the Project, serves the plant. 150 Cusecs of water will be ultimately required and the quantity includes requirements of boiler colony, cooler and miscellaneous services for the entire plant.

**Source of Coal for RTPS** - Roughly, 7 million tonnes of coal are received every year. Coal sampling is done by mechanical augur system. Various Indian collieries (Singareni Collieries) supply the coal, which is known to have a very high ash content of almost 40 to 45 per cent. RTPS alone generates Ash of about 1.5 million tonnes annually, at the rate of at 4,000 tonnes daily (CEAI-New Delhi 2012).

**Ash Generation** - Out of total ash generated here, 80 per cent is fly ash and 20 per cent Bottom Ash. This ash needs to be disposed off on day to day basis.

The production of ash by each unit under full load conditions on 8 hour basis was estimated at 77 tonnes of bottom ash and 315 tonnes of fly ash. The ash will be disposed off in an area of about 192 hectares (Ash Pond I) and 252 Hectares (Ash Pond II of...
Capacity 26 million Cumec) reserved for the purpose towards the north side of the Plant area(fig.1.2).

Salient Features of Ash Pond II – RTPS

- Total Area 232 Hectares
- Top Bund Level 351M
- Total Holding Capacity 2.18 Million CubicM / Year
- Ash Deposited by 7 Units 2.50 Million CubicM / Year
- Life od Ash Pond
  - With 7 units discharge 12 years 2 months
  - With 8 unita discharge 11 years 9 months
- Length of Peripheral Bund 5.06 m

1.4.2 BTPS - Bellary Thermal Power Station

The Bellary Thermal Power Station (BTPS) is located at Kudatini, 22 km away from the district headquarters town of Bellary District. The power station is developed in two stages of 500 MW each. The first Stage adds 3504 MU per annum to the state grid.

Karnataka government is all set to commission third unit of 700 MW of BTPS by July, 2014 in its bid to ease the severe power shortage in the state. Currently, the first unit of 500 MW capacity and second unit is operational under BTPS and is of 700 MW capacity.

KPTCL was embarked upon an ambitious plan of adding another 10,000 mw of power before the end of 12th plan. Presently, KPCL has a power generation capacity of 5980 MW.

Source of Coal – BTPS requires about 7,000 tonnes of coal a day to operate each 500 MW unit which would be getting coal supply from exclusive mines developed in the Western Coal Fields by a private company from two coal mines located in Nagpur. The plant uses a mixture of imported coal and indigenous coal.
1.4.3 MTPS - Mettur Thermal Power Station

Mettur TPS is located near Mettur Dam, Salem District with an installed capacity of 4 x 210 MW. The power generation per day is 20.16 MU. The main plant is located on an area of 359.30 Acres. All the four units are coal based.

Source of Coal - Coal for MTPS is received from Mahanadhi coal fields Limited (Talchar & IB Valley), Orissa and Eastern coal fields Limited, Ranikanj, West Bengal. Initially ash ponds were designed to dump all the ash generated, collected and pumped into dyke. It has two ash dykes, (Upper ash dyke : 487 acres and Lower ash dyke : 781 acres). Required Coal is 14,000 MT per day, Ash Generated is 5,000 MT per day, Dry Ash collected is 3,000 MT per day, Wet Ash is 2,000 MT per day. In nineties, fine fly ash was collected from ESP hoppers and bagged to cement companies and the utilization was 50,000 MT per annum.

Mettur TPS has exceeded the target fixed in action plan for ash utilization in the last six years. The actual ash utilization was 98.26 % in 2007-2008 as against the target of 85 % in the action plan and 180.21% in 2010-2011.

1.4.4 Summary of Utilisation of Fly Ash

Fly ash utilisation during first half of the year 2011- 2012(CEAI-New Delhi 2012)

BELLARY K.P.C.L (Karnataka) - 25.56%
RAICHUR K.P.C.L(Karnataka) - 39.38 %
METTUR - T.N.G.D.C.L - 180.21%

Details of quantity of pond ash generation and its utilization is not available from the literatures, as pond ash is still in infant stage of research.

1.5 Present Work

Though a lot of research has been carried out for the effective utilization of flyash in construction industry, literature available on pond ash utilization, particularly, its use as a constituent material for concrete in construction industry is not significant. Researches on the possible utilization of pond ash as part replacement to fine aggregate in concrete is in progress in various parts of the world. Yet the results are not satisfactory as the shape of bottom ash differs according to the places of origin (of the coal used), the performance of generating facilities, and the its varying properties. (Ranganath 1997).
Based on the above, the present work consists of conducting a comprehensive research on characterisation of pond ash from different sources and to study the behaviour of mortar, concrete and SCC with pond ash as partial to full replacement to fine aggregate (sand) considering several parameters. Fruitful results will promote large scale utilisation of pond ash in construction industry which give essentially the following benefits:

a. saves fast depleting natural resource like sand, so as to contribute to sustainable construction

b. large scale utilization of industrial waste
c. facilitates human habitation, and
d. also helps to conserve the precious top soil, required for agriculture and irrigation contributing to environmental and ecological benefits.