

# Ash utilization in National Thermal Power Corporation

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## ABSTRACT

*This paper touches upon the positive responses taken up by National Thermal Power Corporation in promotion and Utilization of fly ash with the adoption of favourable policies. The use of fly ash in various areas viz., construction of embankments, land fills, road sub-base, manufacture of Pozzolana cement, cement concrete, alum, alumina, paint and value added ceramic products is briefly described. Environmentally safe practices in transportation and disposal of unutilised fly ash at NTPC have also been discussed.*

*Key words : Fly ash utilisation, NTPC, Coal ash*

## 1.0 INTRODUCTION

Traditionally, the ash generated in power plants are mixed with water to form slurry and is pumped either to some low lying areas or specially constructed ash dump areas. In these ash dump areas, the ash is allowed to settle and decanted water is allowed to meet nearby natural watercourse. With the increase in thermal power stations, the need for more and land for ash dumping has put tremendous pressure on availability of land and it has become more important to find alternative ways of managing ash.

## 2.0 PROPERTIES OF COALASH

Three types of ash are found in modern thermal power stations i.e., Bottom ash, Fly ash and pond ash.

The bottom ash is collected at the bottom of furnace whereas fly ash is collected from different rows of Electro-Static-Precipitators. The bottom ash being coarse material can be gainfully used as fill material especially for road embankments and works as good drainage material.

The fly ash is in a very fine powder form. the size varying from about one micron to 300 microns. The ash in dry form has pozzolanic properties, which helps it to react with free lime to be eligible for becoming a good construction material. Considering this property of ash, awareness has now come to collect these two types of ashes separately in dry form and manage it for various useful purposes discussed separately in this paper.

Since the ash generated is quite high as compared to its utilisation at present, the balance unutilised ash (both bottom and fly ash) is mixed with water and pumped to the

designated ash dump areas. In the ash pond area, the ash gets settled and excess water is decanted. This settled ash is known as *Pond ash* and is a mixture of bottom and fly ash. In the process of getting mixed with bottom ash (having more un-burnt carbon) and water in slurry form, the pozzolanic properties of dry ash gets reduced. However, this pond ash is still very useful as filling material and other uses.

Looking to the various useful properties of ash, the Bureau of Indian Standards (BIS) has released IS-10153 indicating various uses of ash. For using ash as pozzolanic material IS-3812 specifies various physical and chemical properties of ash of grade I and grade II as shown in Table - 1a & 1b.

**Table 1a and 1b : Chemical and Physical Requirements of Fly Ash for Pozzolamic materials**

**Chemical Requirements**

S.No.	Characteristics	Requirement
i)	Silicon dioxide ( $\text{SiO}_2$ ) plus aluminium oxide ( $\text{Al}_2\text{O}_3$ ) plus iron oxide ( $\text{Fe}_2\text{O}_3$ ), percent by mass, Min.	70.0
ii)	Silicon dioxide ( $\text{SiO}_2$ ), percent by mass, Min.	35.0
iii)	Magnesium Oxide ( $\text{MgO}$ ), percent by mass, Min.	5.0
iv)	Total sulphur as sulphur trioxide ( $\text{SO}_3$ ), percent by mass, Max.	3.75
v)	Available alkalis as sodium oxide ( $\text{Na}_2\text{O}$ ), percent by mass, Max.	1-5
vi)	Loss on ignition, percent by mass, Max.	12.0

Note 1 : Applicable only when reactive aggregates are used in concrete and are specially requested by the purchaser

Note 2 : For determination of available alkalis, IS : 4032-1968 'Methods of chemical analysis of hydraulic cement' shall be referred to .

**Physical Requirements**

S.No.	Characteristics	Requirement Grade of fly Ash	
		I	II
i)	Fineness-Specific surface in $\text{m}^2/\text{kg}$ by Blaine's permeability methods, Min.	320	250
ii)	Lime reactivity-Average compressive strength in $\text{N}/\text{mm}^2$ , Min.	4.0	3.0
iii)	compressive strength at 28 days in $\text{N}/\text{mm}^2$ , Min	not less than 80 percent of the strength of corresponding plain cement mortar cubes	
iv)	drying shrinkage, percent, Max.	0.15	0.10
v)	Soundness by autoclave test expansion of specimens, percent, Max.	0.8	0.8

### 3.0 COALASH ASH AS RESOURCE

In view of various useful properties, the coal ash is a resource and is a versatile material for use in :

- a) Construction of embankments, land fills and road sub-base & base course.
- b) Manufacture of Portland Pozzolana Cement.
- c) Cement concrete and Mortar as partial replacement of cement
- d) Manufacturing ash bricks / blocks, Aerated Concrete Blocks, Lightweight aggregates etc.
- e) Controlled Low Strength Fill Materials (CLSM)
- f) Reclamation of empty mines
- g) Improvement of soil condition for Agricultural purpose
- h) Manufacture of Alum, Alumina, Paints, Ceramics and other high value added items.

NTPC has taken initiatives to ensure that the ash produced is utilised to the maximum extent. As a first step towards this, NTPC has taken a policy decision to (1) provide for dry ash collection system for all its new projects, (2) use fly ash based Portland pozzolona cement for all expansion works of thermal power stations. A partial dry ash collection system is also being provided in all its existing stations. This ash is provided free of cost to all perspective users.

Let us examine these uses of ash enlisted above in more detail:

#### 3.1 Construction of embankments, land fills road base and base course

The pond ash has been found to be a very useful construction material (in place of soil traditionally used) for making of embankments and for raising of outer bunds of ash dump areas. NTPC has done pioneering works in association with IIT Kanpur. NTPC has utilised about 6.28 lakh tonnes of ash for raising of the ash dykes at Korba, BCPP and Badarpur during 1997-98. A typical section of raising the bund with ash is shown in Figure 1. At Korba, four such raisings have been successfully completed and fifth raising is in progress.

In Delhi, about 1.5 lakh tonnes of ash has been used for widening the approach embankments of Nizamuddin bridge. This embankment is in the flood plains of Yamuna river and a soil cover of about one meter has been provided to protect the ash filling. Ash has also been used for approach embankments for various fly-over bridges in Delhi.

Ash is also a good filling material. About 3.0 lakh tonnes of ash from NTPC's Badarpur station was used for filling of low lying area allotted to M/s IOC for their bottling plant in Delhi. NTPC has used about 8.94 lakh tonnes of ash for various land filling projects during 1997-98.

Bottom ash has been used successfully as sub-base course for roads at NTPC's project at Dadri in association with Central Road Research Institute (CRRI). Ash from NTPC's

station at Ramagundum is being utilised for construction of roads in that region. About 25,000 tonnes of ash has been used by NTPC for road works at its Dadri and Farakka stations during 1997-98.

### **3.2 Cement Manufacture of Portland Pozzolana**

IS-3812 provides for the specifications of Grade I and II of fly ash suitable for use as pozzolana in manufacturing Pozzolana Portland Cement (PPC). Fly ash based PPC is being manufactured in India as per provisions of IS-1489-Part I. This PPC is becoming widely available and has following advantages over Ordinary Portland Cement (OPC).

- \* Improved workability.
- \* Reduced heat of hydration.
- \* Increased sulphate resistance.
- \* Reduced alkali- aggregate reaction.
- \* Increased corrosion resistance.
- \* Greater long term strength.

About 9.14 lakh tonnes of ash have been issued to various cement manufacturing units from NTPC stations during 1997-98. The grinding units for manufacturing fly ash based PPC are being set up near Unchahar by private parties.

### **3.3 Cement concrete and mortar as partial replacement of cement**

Ash being a very fine material and having pozzolanic properties is found to be very useful for filling voids in concrete and is prescribed by Bureau of Indian Standard as per IS-456. National council for Cement & Building Material (NCCBM) at Ballabgarh has found that Cement varying from 15 to 25% for normal concrete and even more for mass concrete works can be replaced by ash without impairing the total compressive strength.

Recently, reputed construction companies like DLF and Unitech Prefab have utilised ash from NTPC's Dadri station for concrete works in their multistoried housing projects in Gurgaon (Haryana)

### **3.4 Manufacturing ash bricks / blocks, Aerated Concrete Blocks, Lightweight aggregates etc.**

Ash has also been found to be a good resource for making bricks. There are various methods of manufacturing ash bricks with ash content varying from 30% for ash-clay bricks to 80% for flyash-lime-gypsum bricks. Fly ash - lime bricks have shown better crushing strength than clay bricks. These ash bricks are more resistant to salinity and water. IS-12984 provides for the specifications for fly ash lime-bricks. CPWD has incorporated in their specifications for use of ash bricks in all types of constructions.

NTPC has used 14,302 m<sup>3</sup> of ash for manufacturing about 7 million bricks during 1997-98. About 24 million of ash bricks have been manufactured till date and used for various construction activities.

### **3.5 Controlled Low Strength Fill Materials (CLSM)**

Traditionally, locally available soil is used for all backfilling works but its proper compaction is a tedious process. It takes a long time for final settlement. Ash mixed with small quantity of cement (5 to 10%) in slurry form, when used for filling works has shown encouraging results and is known as Controlled Low Strength Material (CLSM). The ash along with cement (5 to 10%) mixed with sufficient water to form a slurry in a concrete mixer can be easily poured in 'all difficult to reach' cavities and settles within 24 hours and no settlement is observed after the initial settlement takes place. It can be easily excavated whenever needed.

Ash mixed with 6% cement is being used as CLSM in the switchyard of NTPC's Kahalgaon station for controlling growth of wild grass ( a fire hazard). This is also being used by other projects like Dadri, Vindhyachal etc., for their filling requirements.

### **3.6 Reclamation of empty mines**

Sand is normally used for stowing underground mines. NTPC, in association with Central Mining Research Institute (CMRI), Dhanbad has successfully completed a pilot project at its Ramagundam station to use bottom ash for stowing into the underground mine. About 60,000 m<sup>3</sup> of bottom ash has been used for the purpose. Use of further ash for stowing work is also planned in near future.

Proposals for using ash for reclaiming open cast are also being studied. The effects of leachate water on underground water resource and most economic mode of transporting ash to the open cast mines are being studied.

### **3.7 Improvement of soil condition for Agriculture purpose**

Fly ash is useful in improvement of soil conditions and good source of essential plant nutrients like Ca, Mg, K,P, Cu, Zn and Fe. Field studies at NTPC's stations at Rihand and Farakka through Regional Research Laboratory, Bhopal and Central Fuel Research Institute, Dhanbad respectively-using ash mixed with soil upto 200 tonnes of ash per hectare have shown an increase in the crop yield. Further, longterm effect on crop is being studied at both these stations under Fly Ash Mission.

Ash has also been found to improve the soil fertility in many cases.

### **3.8 Manufacture of Alum, Alumina, Paints, Ceramics and other high value added items**

Ash contains about 23% of Alluminium oxide as a part of the inert materials. This constituent has been successfully utilised to manufacture Alum and a private entrepreneur has set up an Alum manufacturing plant at NTPC's Farakka station. An Alumina extraction plant has also been set up in Maharashtra. Ash has also been successfully used to manufacture many other high value items like paints, ceramics, brake-shoes etc.

#### 4.0 ECONOMICS OF ASH UTILIZATION

Like in any other activity, Ash Utilisation also can be successful only if it is economically viable vis-a-vis conventional existing practices and materials.

It is well established that ash can be utilised in bulk quantities in landfills, structural fills, embankments and mine filling. In these applications, it seeks to replace the traditionally used materials such as naturally available resources like soil or sand. Unless the transportation distance between the ash source and such work site is comparable to that from soil / sand source, it would not be economically viable to use ash in such works.

Using ash for manufacture of Pozzollona Portland Cement is economically advantageous to the cement manufacturers provided ash source is not too far off from their cement plants. In some cases, cement plants are taking ash from a distance up to 200-300 kms. Some times it is advantageous to set up a cement grinding unit near power stations, especially those near urban centres, and produce PPC by grinding clinkers transported from their units located far off.

With the current annual production of about 75 million tonnes of cement in the country, it can very well be realised that utilisation of ash in production of PPC is limited. Use in concrete works will be more feasible in batch mixing plants and Ready Mixed Concrete (RMC) plants.

One of the reasons for very limited utilisation of ash in manufacture of building materials like ash bricks, lightweight aggregate etc. is the large capital cost involvement. The capital investment required for converting all ash generated from a 2,000 MW thermal power station into different building products is given in Table 2.

**Table 2 : Cost of converting ash to resource (For 2,000MW generating station)**

S. No.	Manufacturing unit for	Capacity	Capital cost (in crores)	Ash Utilisation (tonne/day)	No. of units required for total ash utilisation	Total Cost (in crores)
1.	Ash bricks* (Small unit)	1,00,000	7-10	200	50	350-500
2.	Ash Bricks* (Large unit)	3,60,000	30-35	600	17	510-595
3.	Light weight Aggregates (Cold bonded)	650 tonne	25	600	17	425
4.	Light weight Aggregates (Sintered)	1,000 tonne	30	1,000	10	300

In view of the high capital cost and requirement of costly raw materials like lime / cement etc., for manufacturing building products like bricks, aggregates etc., are in general, costlier than the traditionally used materials especially in Northern parts of India. In eastern parts, where cost of clay bricks and aggregates are higher, use of ash based building materials is becoming more viable. In Delhi area also the cost of clay bricks is increasing because of the ban order on brick kilns. Use of sludge lime and gypsum has reduced the cost of ash bricks to some extent and their use is now becoming viable in Delhi region also.

Another major factor for less ash utilisation is the lack of awareness and acceptability of ash bricks in general public. However the situation is improving slowly and ash based products are becoming more acceptable these days.

## **5.0 MANAGEMENT OF UNUTILISED COAL ASH**

It is important to handle and dispose the unutilised ash ( around 90%) in an environmentally safe and economic manner.

### **5.1 Wet Ash Handling**

Traditionally, all coal ashes are mixed together with sufficient water and is pumped in slurry form to the nearby low lying areas or specially constructed ash bunds. This traditional method of ash storage / deposition requires about 1 acre per MW of installed capacity for about 25 years of plant life. The capital investment for developing a suitable ash deposition system including cost of land, construction of bunds, pumps, pipelines etc., for a 2,000 MW power plant is around 100 crores.

Ash transported in slurry form for storage in large ash pond areas poses the following problems :

- Decanted water is left with suspended solids which pollutes the surface water resources.
- Leachate water which may contain some heavy metals or toxic materials is likely to contaminate under-ground water resources.
- When the top surface becomes dry, ash becomes air borne and pollutes the air.
- Requires large areas of land for disposal.

Modern thermal power plants of large capacity are using multi-lagoon system of ash disposal as shown in figure 1. The decanted water is first transferred to the overflow lagoon. From the overflow lagoon, the water can either be pumped back for re-circulation or it may be discharged to meet nearby natural watercourse depending on the quality of discharge water.

In order to avoid the possibility of any area becoming dry, ash is discharged from multi-discharge points through a garlanded scheme of discharge water line (figure 1). This ensures uniform filling of ash in lagoon which helps to keep all the area wet and avoid the possibility of ash becoming air borne.

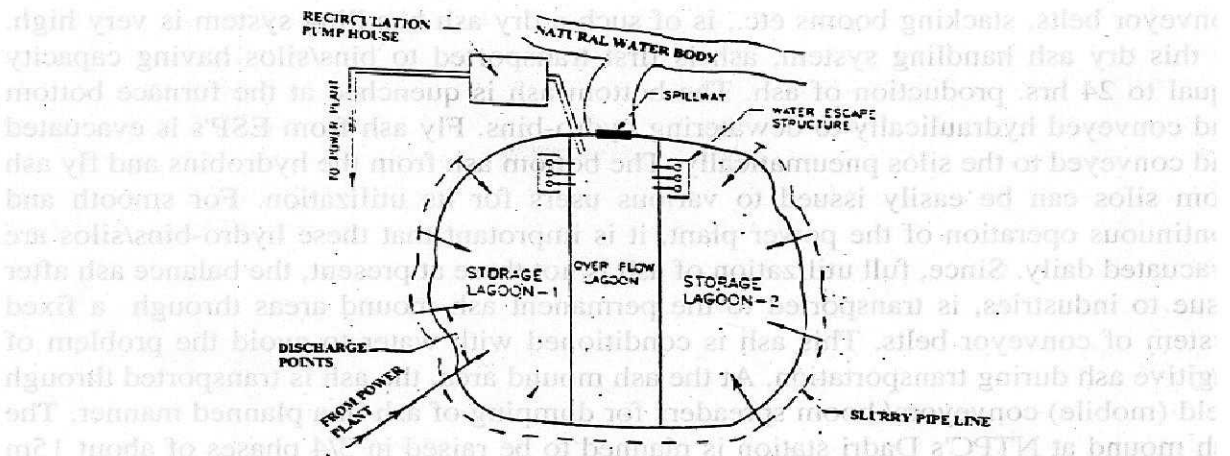


Fig. 1 : Multilagoon arrangement

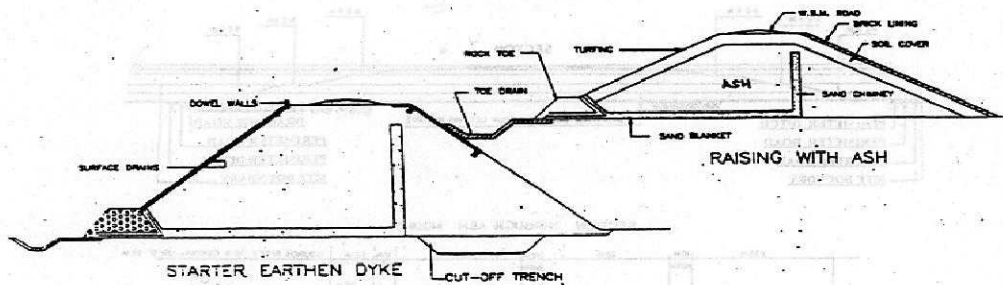


Fig. 2 : Typical section of ash dyke

The ash ponds are raised in height by raising bunds as shown in figure 2. Five such raising of 3m each have been done at NTPC's Korba project. Increased height of ash dump areas limits the need for land to a great extent.

Studies were conducted in some of the ash pond areas for ground water contamination and generally it was found that there is no contamination in view of the soil conditions at pond sites. Necessary care is taken to select a proper site for ash disposal in the initial stage itself.

## 5.2 Dry Ash Handling

Ash can also be transported in dry form and stored in a hillock form. Ash from NTPC's Dadri project is being transported in dry form to make a hillock of 55m ultimate height.

The land requirement for such a dry ash deposition system is about half of the traditional wet disposal systems. The capital investment required for various equipment like



conveyor belts, stacking booms etc., is of such a dry ash handling system is very high. In this dry ash handling system, ash is first transported to bins/silos having capacity equal to 24 hrs. production of ash. The bottom ash is quenched at the furnace bottom and conveyed hydraulically to dewatering hydro-bins. Fly ash from ESP's is evacuated and conveyed to the silos pneumatically. The bottom ash from the hydrobins and fly ash from silos can be easily issued to various users for its utilization. For smooth and continuous operation of the power plant, it is important that these hydro-bins/silos are evacuated daily. Since, full utilization of ash is not there at present, the balance ash after issue to industries, is transported to the permanent ash mound areas through a fixed system of conveyor belts. This ash is conditioned with water to avoid the problem of fugitive ash during transportation. At the ash mound area, the ash is transported through field (mobile) conveyors/ boom spreaders for dumping of ash in a planned manner. The ash mound at NTPC's Dadri station is planned to be raised in 3/4 phases of about 15m each upto an ultimate height of 55m with side slopes of 1:4. At each level of 15m, a berm of about 10m is being provided (figure 3&4) . The final surface of the ash mound will be planted with natural vegetation to provide a self-perpetuating surface, which will provide side protection and stability.

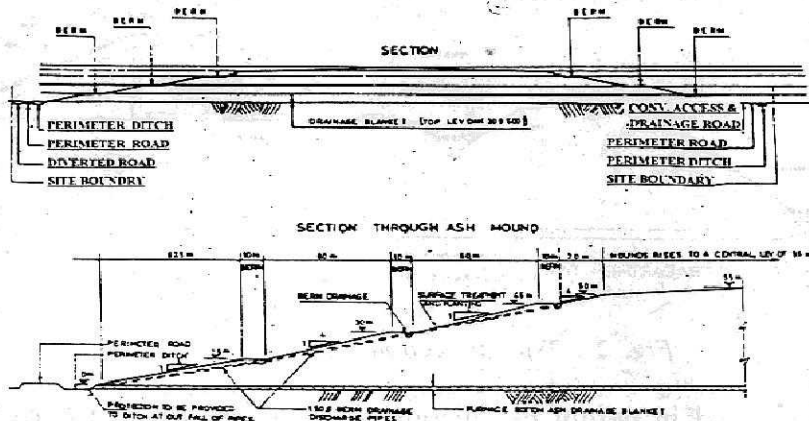


Fig. 3 : Ash mound section

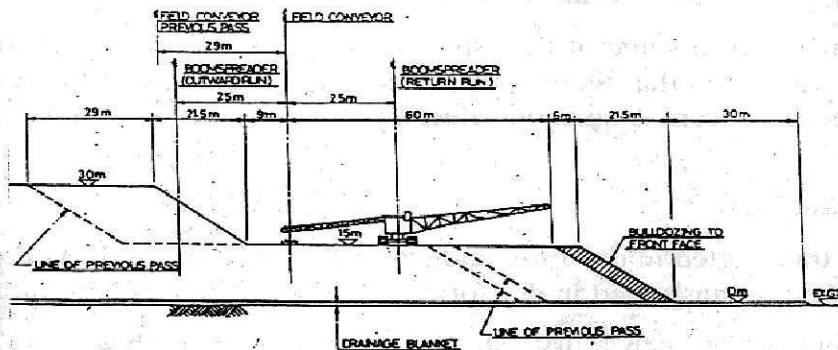


Fig. 4 : Boom stacker typical placing activity

For stability of the ash mound, a proper drainage blanket of bottom ash is provided at the base of ash mound area. To prevent pollution of the area drain, run off from active ash disposal areas of ash mound is collected by a perimeter drain and conveyed to the settling lagoon. The decanted water from this lagoon is transferred to the nearby natural drain by gravity using floating arms draw off.

### 6.0 CONCLUSION

To accomplish an environmentally sustainable industrial development, NTPC is responding positively in promoting utilization of ash by adopting favourable policies. Also NTPC is adopting environmentally safe practices in transportation and disposal of unutilised ash.