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Part 3

ASH AND SLAG HANDLING

3.7. Analytics

3.7.6. Challenges, Opportunities and ways of solving the problem on ashes from TPP's in India: A successful mission mode approach

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ABSTRACT:

Coal has remained the main source of energy (65…75 %) for electric power generation in India. High ash content (about 45 %) of Indian coals along with massive plans to put up additional power stations has increased exponentially the generation of fly ash in India over last two decades and the trend is expected to continue.

Fly Ash Mission was launched by the Government of India in 1994, after a well researched study, to setup technology scale up & demonstration projects to build the confidence of stakeholder agencies in field applications of fly ash. The collaborative & participative mode of mission operations made it a success and the impact was visible as early as 1997 and by the year 2000, fly ash reached the verge of turnaround of its image, from a waste material to a resource material. Today, in 2009, it is a sought after material at preferred locations.

The paper takes us through the journey of Fly Ash Mission regarding Challenges, Opportunities and ways of solving the problem on ashes from TPP's in India.

INTRODUCTION

Nearly 63 % of India's current power generation is coal based. It has always remained so (65…75 % dependent on coal) and is projected to remain so at least upto 2031-32. Current installed capacity of 1,50,000 MW(Dec,2008) is targeted to increase to 2,00,000 MW (2012), 3,00,000 (2017) and 5,00,000 (2032). Around 90 utility thermal power stations, in addition to about 45 captive power plants, use bituminous or sub-bituminous coal and produce around 140 million tonne (Dec 2008) of flyash. High ash content of Indian coals is contributing to these large volumes of flyash. As a natural corollary to dependence of Indian Power sector on coal, flyash management would remain an important area of national concern.

The indiscriminate disposal of fly ash, the residue of the coal combustion requires large volumes of land, water and energy. The fine particles of flyash by virtue of their lightness can become air borne, if not managed well. Indian flyashes are safer than those produced in other countries (especially on account of lower content of sulphur, heavy/ toxic elements and radio nuclides), However, management of large volumes produced poses a big challenge to the country.

Fly ash as a material is siliceous with pozzolanic properties. It is refractory and alkaline in nature, having fineness in the range of 3000 - 6000 sq.cm/gm.

Fly ash can be used for multifarious applications. Starting from use in construction industry to mining sector, agriculture, wasteland reclamation and extraction of valuable minerals.

Table. **Chemical Composition of Indian Fly Ash**

Constituent	**Percentage Range (%)**
Silica (SiO_2)	49…67
Alumina (Al_2O_3)	16…29
Iron Oxide (Fe_2O_3)	4…10
Calcium Oxide (CaO)	1…4
Magnesium Oxide (MgO)	0,2…2
Sulphur (SO_3)	0,1…2
Loss on ignition	0,5…3,0

EARLY EFFORTS

A number of applications were developed by R&D laboratories and other institutes for gainful utilization of fly ash. The utilization ranged from low value added applications like use in road/embankment, minefills, lime-fly ash concrete, cement fly ash concrete, etc. to high value added utilization which have been tried at laboratory scale. These are: extraction of Alumina/Magnetite/Cenospheres, manufacture of acid resistant bricks/ tiles, fire resistant tiles/ bricks; light aggregates, etc. The intermediate class of fly ash utilization is one which has been developed and tried at commercial level. These are called "medium value added utilization" and some of the examples are: Manufacture of fly ash bricks, portland pozzolana cement, fly ash blocks, sintered fly ash light weight aggregates and concrete, etc.

Inspite of the development of a number of applications for gainful utilization of fly ash, large quantities of ash produced in thermal power plants in the country were being dumped in vast areas close to power plants. Only a very small percentage (3 to 5%) of fly ash generated in India was being used for gainful applications whereas the corresponding figure for other countries varied from 30 to 80 %.

Large scale efforts by Ministry of Environment & Forests (MOEF) and Ministry of Power(MOP) in the use of fly ash have been initiated in the earlier years. These have led to concrete steps in certain areas including Government support in the form of infrastructural and fiscal incentives.

MISSION MODE APPROACH

The overall complexity of technology proving and transfer, infrastructure support, inter-institutional linkages, development of market, orientation of Government policies to promote and support fly ash utilization, required sharply focussed efforts to promote fly ash utilization. Further, no single utilization holds the potential to provide a solution to this mammoth task of safe disposal and gainful utilization of Fly Ash . A judicious mix of a number of applications, (considering impact time frame, investment requirement, technical and infrastructure inputs, requirements by fly ash utilization potential and expected returns, etc.) was required to be evolved. A number of disposal and utilization technologies/ applications were required to be simultaneously demonstrated to increase the percentage utilization and environmentally safe

disposal of fly ash. Thus the Department of Science & Technology, Government of India identified this area for Technology Project in Mission Mode and launched Fly Ash Mission during 1994.

Various Ministries and Departments of Government of India, R&D institutions, academia and industry bodies/ associations participated in Fly Ash Mission Project. Linkages have been established and networking done with a large number of agencies/ bodies to promote large scale utilizations & safe disposal of fly ashes.

The Mission Mode Approach has given the impetus to fly ash activities across the board, irrespective of level & nature of technology and it's area of application.

Fly Ash Mission (FAM) has worked towards 'confidence building' in fly ash based technologies. 55 Technology Demonstration Projects have been undertaken at nearly 21 locations across the country in diverse areas. A national spread of project sites has been planned to reach to a larger spectrum of technologists, engineers, user agencies, entrepreneurs. Active co-operation of several Ministries, Departments, academic & research institutions, entrepreneurs etc. has been the focus of this Mission. Power utilities, National Thermal Power Corporation(NTPC) Ministry of Environment & Forests(MOEF)Ministry of Power(MOP)have contributed in a major way in participating in the 'confidence building' activities for safe disposal & utilisation technologies for flyash,

A comprehensive strategy was adopted to focus on ten select Thrust Areas simultaneously and these are:

- Fly Ash Characterisation
- Hydraulic Structures
- Handling & Transportation
- Ash Ponds & Dams
- Agriculture Related Studies & Applications
- Reclamation of Ash Ponds for Human Settlement
- Roads & Embankments
- Underground Mine Fills
- Research & Development
- Building Components

Some of the activities under selected Thrust Areas are:

Roads & Embankments: Published information reveals that the work for utilization of fly ashes (bottom ash and pond ash) was going on in Indian R&D and academic institutions for over 3 decades. Roads/ road stretches constructed in the subsequent years remained as historical places of R&D activity. The results and the experience of such efforts are quite rich and are being tapped, synergised and catalysed towards further development towards large scale utilization.

"Roads and Embankments", one of the identified thrust areas under the Mission Mode Project has successfully demonstrated the use of fly ash as a structural fill material in the construction of embankments for fly over bridges at Delhi and construction of road near Raichur.

Construction of 1,7 km long & 6…8 meter high road embankment at New Nizammuddin Bridge, New Delhi is done using 1,5 lakh m^3 of fly ashes. Calcutta Electricity Supply Company (CESC) & NTPC have constructed fly ash roads at their plants (Fig. 1).

Okhla fly over bridge New Delhi, the first project using fly ash in embankment was inaugurated on 3rd Jan. 1996. The PWD Delhi engineers and authorities convinced with the advantageous application of fly ash as compared to soil, adopted the technology for construction of embankment of Hanuman Setu, Delhi also.

The fly ash is a better geo-technical material than commonly available soils for structural fill applications especially because of its better rating of grain size, density, compaction characteristics, shear strength, permeability and ease of working. In addition fly ash is generally available free and use of fly ash saves the precious fertile land that would otherwise be used for such application.

Fig. 1. Nizammuddin bridge approach road embankment at New Delhi (in flood zone of river Yamuna)

Fly ash is suitable for use in roads and embankments in sub-base course, roads base, bearing course and for concrete roads as partial replacement to cement. Central Road Research Institute (CRRI), New Delhi the technical partner of Fly Ash Mission has developed the technologies and support can be extended to all the desirous users.

On R&D front, more and more agencies are coming forward to develop newer technologies and simultaneously to demonstrate their earlier works for large scale applications, such as production and use of light weight and sintered aggregates, use of fly ash in concrete roads etc.

Hydraulic Structures: Technology has been developed by Central Soil and Materials Research Station (CSMRS), New Delhi and University of Roorkee for construction of hydraulic structures by roller compacted concrete using high doses of fly ashes. It has potential to save up to 60…70 % cement and to complete the construction work in about 1/2 to 2/3rd of the time required for conventional construction practices. The elimination of heat of hydration, further saves the requirements of chilling plant and allows construction at a faster pace. The lower construction time makes available the construction equipment for other construction works in quick succession and thus improves considerably economics of construction.

Three dams have been constructed by roller compacted concrete technology using fly ash by Maharashtra Irrigation Department, Government of Maharashtra. Mix design, instrumentation, other aspects of the project design and implementation and training course of concern scientists and engineers were conduced Under Fly Ash Mission support and Project. These initiatives have triggered off further R&D work in this area at University of Roorkee, CSMRS, Maharashtra Engineering Research Institute (MERI), Nasik etc.

Underground Mine Fills: Technology for use of fly ash as underground mine fill material has been successfully by the participation of NTPC &Centre Mining Research Institute (CMRI).

Use of fly ash as a stowing material in addition to providing an alternative to scared river bed sand, is economical and safe material. It further helps in isolation of underground fire areas in coal mines.

The fly ash generated by 20-pit head thermal power stations can be successfully used as a stowing material. This would be an environment friendly and economical utilization of accumulating fly ashes. The technologies of use of fly ash

as a stowing material for mine fill would also enable extraction of contiguous upper and lower seams.

On R&D front, activities have heated up in the area of dense phase conveying of fly ash for mine fill, dense packing of fly ash for extraction of thick seams below highly watery strata etc.

Agriculture Related Applications: The presence of Calcium, Magnesium, Zinc, Iron etc. make fly ash a source of micro-nutrient for agriculture applications. Its application enhances the growth and yield from 15 % to more than 200 %. Fly Ash is also a good soil conditioner, ameliorant for acid soils and improves the water holding capacity and other physical properties of soil, important for plant growth (Fig. 2). The sporadic experiments and trials, done earlier, have

Fig. 2. Carnation at BTPS ash pond

now moved to the phase of systematic and scientific projects to demonstrate the gainful application of fly ashes in agriculture. 15 projects covering wide range of agro-climatic conditions, soil-crop combination have been supported under Fly Ash Mission and forestry/plantations. The Technology Demonstration Projects had focus on the data collection and analysis on the aspects of possible adverse impacts of heavy metals, toxic elements and radio activity. The analysis of fly ashes as well as the produce do not give any serious concern for the possible adverse effects, however, we need to allay the fears.

Use of fly ash as soil conditioner & mycorrhizal fungi along with flyash for forestry & plantation crops are also demonstrated under Fly Ash Mission projects.

The initiation of above referred projects has by in itself created confidence in a number of agencies who have started applying fly ash in the fields. A number of R&D and agriculture institutes have also stepped up their activities in this area including Bhaba Atomic Research Centre (BARC), Institute of Physics, Bhubaneshwar (IOP) and Indian Council for Agriculture Research (ICAR), New Delhi who have started taking more interest in radio activity aspects of use of fly ashes in agriculture applications.

Reclamation of Ash Pond for Human Settlement: Technologies for ground improvement and foundation have been successfully employed for construction of human habitat on abandoned ash pond. The Technology Demonstration Project at ash pond of National fertilizer Ltd.(NFL) Panipat was completed under the supervision and guidance of Central Building Research Institute(CBRI) Roorkee. Another project for reclamation of abandoned ash pond for housing is executed at Badarpur Thermal Power Station, New Delhi (Fig. 3).

Thus the abandoned ash ponds that had the alternatives to be converted into green areas, parking slots and parks etc., can now be developed as high value real estates also especially for the ash pond that are in the vicinity of thickly populated rural areas. Interests have been shown by industry to demonstrate the technology for construction of multi-storey building on abandoned ash pond (Fig. 4.).

Fig. 3. Forestry at BTPS ash pond

Fig. 4. storey building constructed using flyash bricks at Indian Institute of Technology, New Delhi

Ash Ponds and Dams: In near foreseeable future it is not possible to utilise 100 % fly ashes in the country. Thus it is essential that ash ponds and ash mounds are designed and managed environment safely. Technologies developed at various institutes like 11T-Madras, 11T-Kanpur, 11T-Delhi, MERI-Nashik etc. are being taken to the field for large scale utilization/ demonstration to build confidence towards large scale adoption.

Densification of ash pond by vibrofloat, blasting and mechanical means not only makes additional volumes available for ash disposal, it also makes deposited ash slurry less vulnerable to liquefaction under disturbances such as earth quakes. The consolidation along the dyke provides stable footing for further raisings (Fig. 5).

Fig. 5. Dyke constructed with fly ash at Korba Thermal Power Station, Madhya Pradesh

Technologies have also been demonstrated for raising of dyke height and thus vertical expansion of ash ponds rather than horizontal expansion that puts more demand on scarce land resource.

The integrated approach to safe management of ash pond and utilization of ashes has given birth to the concept of separate handling of fly ash and bottom ash that are separately excellent materials for different applications. Efforts have al-

so started on the preventive technologies for protection of underground water from contamination.

Off-late R&D institutes have started taking interest in dense phase conveying of ashes which conserves water, eliminates the issues of run off water and reduces to a great extent, the potential to contaminate underground water resources.

Characterisation of Fly Ash: Fly Ash which was earlier being considered as waste and environment pollutant and was being used in a limited way without developing much understanding of its useful properties has now started to be understood as a raw material for various applications. Efforts have recently started to evaluate various properties and behaviour of fly ashes through systematic characterisation studies. Realisation has started that fly ash has good potential and can be a better material for a number of applications if employed intelligently.

Efforts have also started to develop linkages between important properties of fly ash to various applications. Reference standards are being drawn up. More than a dozen of research institutes have taken major initiatives to upgrade and dedicate their facilities for fly ash characterisation and to offer their services to fly ash producers as well as users.

Trend is clear that fly ash would soon be understood as a resource material and its potential would be exploited.

Handling and Transportation: Technological developments are fast progressing in the area of safe and economical handling and transportation of fly ashes. Pneumatic conveying at thermal power stations is gainful perfection and acceptance. Slurry disposal systems are being minimized and wherever essentials, high concentration systems are being preferred.

New technologies are emerging for safe transportation of fly ashes from thermal power stations to the point of use. In addition to the closed containers that have successfully been used by other sectors of industry, jumbo bags of varying capacity have been developed for such applications.

These bags are collapsible, reusable and economical in long run. In addition the technology is environment friendly.

INTIATIVES BY STATUTARY & REGULATORY BODIES

Considering the need of the hour for utilisation of fly ash and its multifarious applications Government has taken a view to give special focus and thrust to fly ash utilisation. Some of the salient measures taken by the Government towards facilitation of use of fly ash are as follows:

1. Revision / formulation of BIS standards related to fly ash and its utilisation Second revision of IS: 3812 i.e. Specification for fly ash for use as pozzolana and admixture has been issued. In this revision rational classification for fly ash (based on end application) has been incorporated and its quality parameters have been further tightened. Similarly IS: 456 - Code of practice for plain and reinforced concrete has been updated with use of fly ash.

Looking at the technical advantages of fly ash blended cements and to enhance fly ash utilisation, minimum and maximum percentages of fly ash in PPC have raised from 10 to 15 % and from 25 to 35 % respectively..

2. Legislations: Ministry of Environment & Forest, Govt. of India has brought out a Gazette Notification for restricting the use of top soil for construction activities and to facilitate use of fly ash in building materials and construction activity. The notification makes it mandatory to use atleast 25 % ash (fly ash, bottom ash or pond ash) in manufacture of clay bricks, blocks or tiles within a radius of 50 km from coal or lignite based thermal power plants.

As per the notification every thermal power plant has to make ash available without any payment for the purpose of manufacturing ash based products such as cement, brick, blocks, roads, embankments etc. at least for ten years. All coal based power plants have to evolve an action plan for utilisation of ash produced. The PWDs, local development and housing authorities as well as National Highway Authority of India is directed to prescribe use of ash & ash based products in their respective schedules of specifications and codes of practice etc.

3. Other efforts: State governments of Orissa, Rajasthan, Andhra Pradesh, Tamil Nadu, Punjab etc, have announced various schemes/measures to promote fly ash utilisation.

Govt. of Orissa has exempted fly ash brick and other products from sales tax. A separate cell to promote use of fly ash has been created in a few states. CPWD has included fly ash bricks and blocks in their specifications and has decided to construct atleast one building using fly ash bricks in each zone. Delhi Development Authority (DDA) has included fly ash in its tender document for construction of fly over bridges in Delhi.

INDUCTION INTO ACADEMICS

The fast expanding activities in the area of safe disposal and utilization of fly ashes have triggered off interest among academic institutes also. Efforts have been mounted by Fly Ash Mission.

Elective courses in this field have been designed and inducted by institutes like IIT Delhi, Indian Institute of Sciences (IISc). Bangalore, Osmania University, Hyderabad. A few Research projects at under graduate and post graduate levels have also started. These activities are planned to be enlarged by Fly Ash Mission which would give further boost to awareness and acceptance of fly ash utilization. It would also accelerate the recent trend of technology development and adoption in the area of fly ash disposal and utilization.

CONCLUSION

Implementation of Fly Ash Mission, in India in a collaborative & participative mode with well thought of plan & Strategy with multi-pronged actions in different areas of fly ash management & utilization encompassing R&D to technology proving & transfer to industry has set a successful example of managing “Challenges, Opportunities and Problems on ashes from TPPs” and converting fly ash from a “cost centre” to a profit centre”.