UDC 621.9

Part 3

ASH AND SLAG HANDLING

3.7. Analytics

3.7.18. Resolution of complex issues of fly ash utilization: successful case study of India

V. Kumar, Department of Science & Technology, Govt. of India, New Dehli, India

ABSTRACT

Fly ash a residue of burning of coal / lignite in thermal power plant has traditionally been considered as a waste product. Over last few decades, in spite of fly ash being proved and demonstrated as a useful material for many applications, it's acceptance for large scale utilization has taken considerable time. Complexities of technology development, proving, transfer, resolution of mind sets of pre-conceived ideas, setting up of standards, specifications and guidelines including work manuals, etc. need to be addressed with scientific and systematic approach as well as full cognigence of human psychology and socio-economic culture. Perseverance and results of scientific evaluation play critical role. Indian experience has been quite satisfying. Fly ash utilization has increased from 1 Mn.T/year during 1994 to 100 Mn.T/year during 2011, primarily as an out come of concerted efforts under Fly Ash Mission-India.

INTRODUCTION

Coal is pre dominating the energy scenario in India. Over the decades electricity generation in the country has remained coal dependant to the extent of 60-67% as compared to global average of about 30%.

With Indian coal resources of about 300 billion tonne, and limited resources of other forms of energy, the dependence of power sector on coal is destine to continue for foreseeable future. Current annual generation of about 200 Mn. tonne fly ash from about 100 utility and 40 captive coal /lignite based thermal power plants of 120,000 MW (approx) capacity is projected to grow to around 1000 Mn. T/year by 2031-32 with expanding power sector.

It was during early 1991 that fly ash caught the attention of Department of Science & Technology, Government of India. In-depth techno-market study was undertaken. The broad objective was to document the status of existing knowledge and technologies about fly ash utilization / safe management, market acceptance levels and the threat that fly ash posses to environment, if not utilized as well as a suggested action plan.

Prior to 1990, large numbers of efforts have been made to develop and commercialize technologies for use of fly ash. Academia, national research institutes, private R&D as well as industry have worked in this area. It was first in 1970s when fly ash utilization started getting attention. Fly ash properties were researched for wide range of applications, *inter alia*, pozzolanic, geotechnical, metallurgy, ceramic and agriculture applications. Scientific results were published, laboratory trials and even a few field demonstrations were undertaken to demonstrate the beneficial applications of fly ash. However, most of the work remained confined within the academia / research arena. A few utilizations of fly ash were made primarily in mass concrete, brick / block manufacturing and reclamation of low lying areas.

Ministry of Environment & Forests (MoEF), Ministry of Power (MoP) and a few other agencies took initiatives. National Waste Management Council (NWMC) and a few other groups/committees consisting of senior officials of various Ministries/Departments, State Governments, Research and Development Institutions, Social Workers etc. were formed. Thermal Power Plants were directed to take actions to enhance ash utilizations and a few fiscal incentives such as rebate on excise duty and sales tax were declared.

It was the well researched comprehensive techno-market survey report prepared under Department of Science & Technology, Government of India, during early 1990s for safe disposal and gainful utilization of fly ash that laid the foundation of focused thrust on fly ash activities in India. The report was widely distributed and discussed among concerned agencies. It highlighted that only a meager percentage (less than 3 per cent) of ash was being utilized in the country and the balance was being stored in ash ponds through slurry discharge system. The report brought to fore that the fly ash that is being considered as a waste material, is in fact a useful material and can be put to gainful economic applications.

1. MISSION MODE PROJECT

Appreciating the overall concern for environment and the need for safe disposal and gainful utilization of fly ash, the Government of India commissioned Fly Ash Mission during 1994 as a joint activity of Ministry of Environment and Forests, Ministry of Power and Department of Science & Technology with Department of Science & Technology (DST) as the Nodal Agency. The focus is on Technology Demonstration Projects for developing confidence in fly ash technologies towards large scale adaptation.

The overall complexity of technology development, transfer, infrastructure support, inter-institutional linkages, development of market, orientation of Government policies to promote and support fly ash utilization were the challenge. Further, as no single utilization held 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 was to be evolved (considering impact timeframe, investment requirement, technical and infrastructure inputs requirements by fly ash utilization, potential and expected re-

turns, etc.). The large numbers of demonstration projects were required to build the confidence of potential user and decision makers, especially to develop a critical mass for replication. The formulation of national standards and code of practices / guidelines were essential to get wider acceptance on self sustaining principle.

2. ISSUES ADDRESSED

2.1. Sensitization of stakeholder agencies

Till early years of 1990s, the use of fly ash was very limited and primarily in (i) a few mass concrete projects to reduce the heat of hydration, (ii) low percentage blend in small quantities of Portland pozzolana cement and (iii) limited number of fly ash brick units, etc. Following the increased awareness and concerted efforts of Fly Ash Mission along with various government and non-government agencies over about last 8 years, safe disposal & effective utilization trends are gaining momentum in the country. There is greater acceptance of fly ash products & applications. This is so because the agencies involved (research institutes, academia, thermal power station, industry etc.) have been sensitized and are taking positive initiatives. Various agencies working in this area and the stake-holder groups have been brought together to a common platform. Their efforts have been catalyzed & facilitated.

The stakeholder agencies were sensitized by bringing to their notice that use of fly ash would not only conserve the top soil / sand which otherwise would be used in geotechnical applications, brick manufacturing, mine filling etc., and is already a scarce resource, but would also prevent creation of low lying areas and digging of river bed. By utilizing fly ash we would spare additional land also which currently is being used for dumping of ash. Further, it would not only save cement, but would add to its production also (when used in manufacture of PPC), without adding any greenhouse gases to the atmosphere. (One tonne of OPC production leads to generation of one tonne of CO_2 emission). It required repeated exposures / sessions with different agencies to achieve the success.

2.2. Confidence building through technology demonstration project

The confidence building exercise has been taken up through Technology Demonstration Projects (TDPs) spread through out the country (fig. 1-11). The projects have been undertaken in the field involving user agencies, industries, technology suppliers, fly ash producer, experts from academia / R&D in various areas of fly ash utilization and safe management as listed below:

i. Fly Ashes Utilization Areas:
- Roads & Embankments;
- Building components;
- Hydraulic Structures;
- Agriculture Related Studies & Applications;
- Underground Minefields.

ii. Safe management of fly ashes:
- Ash Ponds & Dams;
- Reclamation of Ash Ponds for Human Settlement;
- Handling & Transportation.

iii. Facilitation of further R&D work:
- Characterization of Fly ash;
- Research & Development.

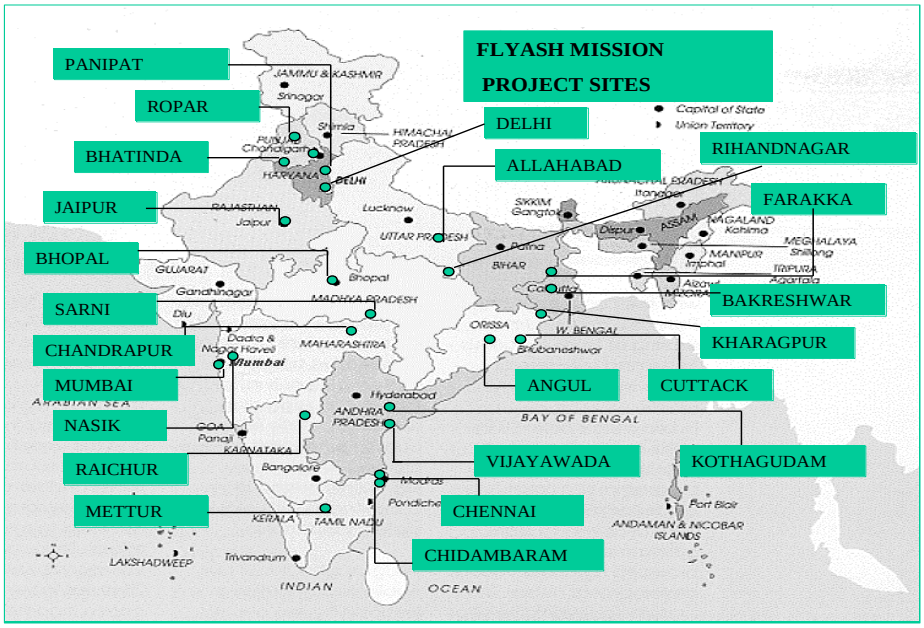

Fig.1. States in India, in which demonstration projects on beneficial use of fly ash from power generation, have been implemented

2.2.1. Some highlights of technology demonstrated projects in road construction works

Three technology demonstration projects at New Delhi, Dadri (U.P.) and Raichur (Karnataka) have been successfully completed for use of fly ash in road /

flyover embankments. Guidelines have been prepared and approved by Indian Roads Congress (IRC) as national standard. More than 10 multiplier effects have taken place across the country.

Fig.2. Nizammuddin bridge approach road embankment at New Delhi (in flood zone of river Yamuna)

Fig.3. Raichur- Arsnagi road, via Yadlapur in Raichur distt. Of Karnataka.The fly ash road (in unmetaled condition) has performed well for last 7 years

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

Fig.5. Building constructed using fly ash bricks at Kolkata, West Bengal

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2.2.2. Building Components

Fly ash bricks have started getting accepted. FAM has been working towards confidence building and facilitation in terms of availability of good quality bricks. Acceptance by agencies like IIT-Delhi, United States Embassy at New Delhi, private builders, PWD, CPWD & others.

Fly ash bricks were procured by IIT-Delhi contractor as per strict quality standards and with joint inspection at suppliers end.

Double acting hydraulic brick press developed to ensure production of high quality fly ash bricks with application of pressure on both sides and commercialization of C - brick press for production of fly ash bricks have been facilitated.

Fig.6. Double acting hydraulic fly ash brick press

Use of fly ash as part replacement of cement in concrete / mortar as well as manufacture of lightweight cellular concrete and its blocks has been facilitated. The fly ash based lightweight concrete saves about 30% of cement, makes the structure lighter resulting in structural cost savings and energy conservation.

Construction materials like fly ash aggregates, fly ash based wood substitute and tiles have been developed. These products provide eco-friendly options.

Fig. 7. Use of fly ash based cellular light weight concrete blocks

Fig.8. Use of fly ash based cellular light weight concrete at Chennai

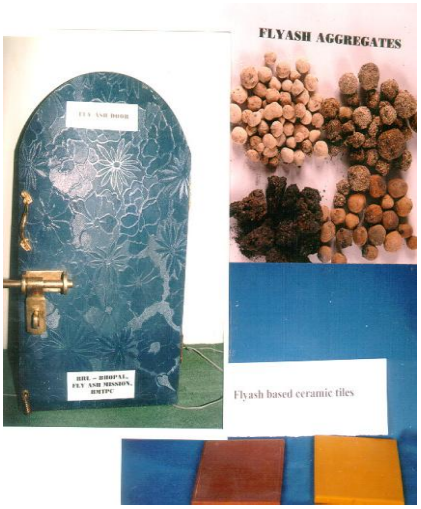

Fig.9. Fly ash based aggregates, wood substitute

2.2.3. Agriculture related studies and applications

Fly ash contains micronutrients and thus promotes growth of plants. In addition, it improves physical properties of soil viz. water holding capacity, aeration etc. Field projects at more than 50 sites covering cereals, vegetables, oilseeds, waste land reclamation, forestry and floriculture have shown encouraging results. Yields have increased on an average by about 20% and use of fly ash in conjunction with gypsum has been done for reclaiming saline alkali soils resulting in saving of 50…75 % of valuable gypsum.

2.2.4. Ash pond and dams

Safe management of ash pond and dams to store the unused fly ashes is an important requirement. Technologies have been developed and demonstrated for construction of ash dykes using fly ash itself (in lieu of soil). In addition, densifications of ash ponds have been done to make them safe under seismic conditions and also suitable for load bearing housing structures.

Fig.10. Dyke constructed with fly ash at Korba Thermal Power Station, Madhya Pradesh

Fig.11. Densification by Vibroflotation, Vijaywada Thermal Power Station, Andhra Pradesh

Fig.12. Training and capacity building

2.3. Training and capacity building

Capacity building and development of human resources is a big challenge. It is undertaken in a planned manner through two routes, namely: (i) hands on practical training for a short duration extending from a few days to a week, and (ii) on job training for a few months to year. In later case, guidance and supervision is provided for execution of fly ash utilization / safe management real-life projects in varying conditions.

2.4. Resolution of mind-sets

Human psychology and its capacity of negation are the major stumbling blocks for acceptance of any new product or technology. These issues are addressed through a combination of the following:

- Small group meetings;
- One-to-one meeting with opinion leader;
- Debate and discussion forums;
- Press conference;
- Popular articles in print and press media;
- Discussions and broadcasts through radio and TV media;
- Formation of core groups in important stakeholders' organization.

The above said action plans are implemented for each area of fly ash utilization / safe management though in different sequence as per the needs of specific group/agency.

2.5. Networking

In addition to working with a large number of project execution agencies across the country for technology demonstration projects, a network of laboratories and facilitators has been developed to provide guidance and support towards safe management / utilization of fly ashes (Fig. 13).

2.6. Making available standards, specifications, guidelines and manuals

With an objective of wider acceptance and institutionalization of demonstrated technologies, Fly Ash Mission is working very closely with Bureau of Indian Standards (BIS) for up dating the existing standards for fly ash and its products and also to prepare standards for products / utilizations which do not exists as of today.

Some of the Standardization initiatives include:

(a) Design guidelines for "Use of Fly ash in Road Embankments" that have been approved and issued by Indian Roads Congress.

(b) Manual for use of fly ash for "Construction of Rural Roads" approved and issued by Ministry of Rural Development.

(c) Revision of IS 3812 – the standards for specification of fly ash for its use in cement / mortar / concrete & fine aggregate have been revised in view of the improvements in quality of fly ash over the years. The codes for other applications of fly ash viz. for lime pozzolana mixture applications, sintered applications, geotechnical application and agricultural application are also formulated.

(d) Updation of IS: 456 – code of practice for plain and reinforced concrete with use of fly ash.

(e) Minimum and maximum percentages of fly ash in PPC have been enhanced to 15% and 35% respectively etc.

(f) Induction of use of fly ash in all codes relevant to construction of hydro-sector projects.

(g) Up-dating of all standards of Civil Engineering Council of BIS for part substitution of cement with fly ash.

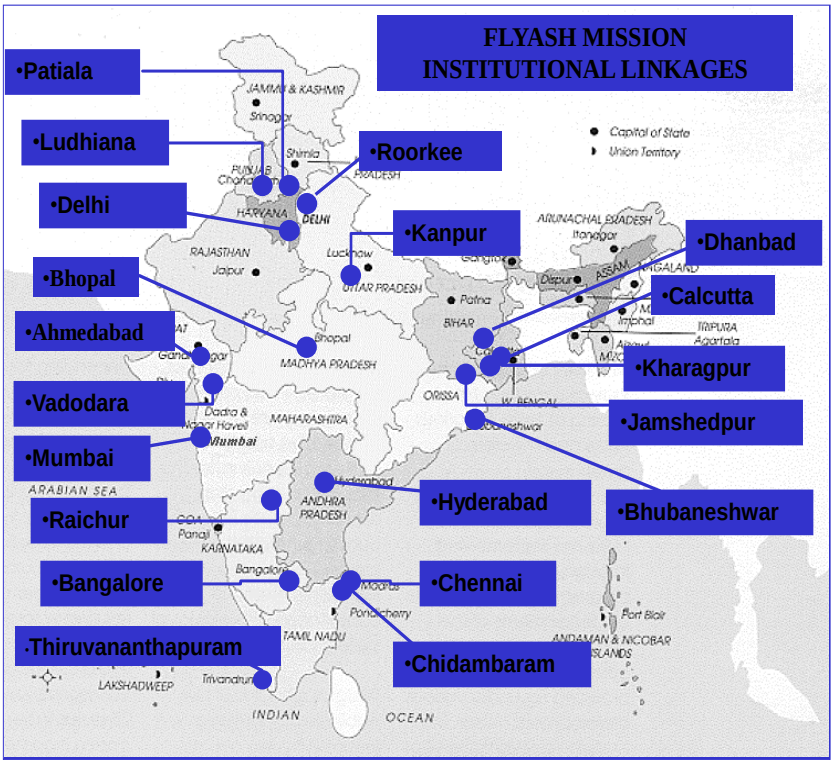

Fig.13. Network of laboratories and centres, coordinating the activity on safe management and fly ash utilization

2.7 Institutional / Govt. support mobilization

Institutionalization of use of fly ash and its products is very important and vital issue for large scale acceptance and utilization of fly ash and its products. This is addressed through special core groups created and guided in each of the centres.

- CPWD has issued orders to all the zones for constructions using fly ash bricks/ blocks and other fly ash products including cement.
- Notification has been issued by Ministry of Environment & Forests banning the use of top soil for manufacture of bricks, construction of roads and embankments and reclamation of low lying areas with in a radius of 100 kms from a thermal power station. Fly ash is to be used for these purposes.
- A number of states (Andhra Pradesh, Karnataka, Orissa and Tamilnadu) have announced fiscal and policy incentives for fly ash based products.
- Central Government has granted excise & custom duty exemptions/ reliefs.
- Ministry of Road Transport and Highways issued directive for use of fly ash in highway embankments.
- IIT-Delhi, a number of thermal power plants and mine agencies banned use of clay bricks.
- State Governments created "High Powered Groups" to facilitate use of fly ash and its products, etc.

2.8 Development of State Level Fly Ash Missions

The concerted efforts and actions undertaken by Fly Ash Mission implemented from New Delhi are replicated in three states of India to have local thrust and focus of actions. These are:

(i) "Fly Ash Mission Kota" by the State of Rajasthan
(ii) "Fly Ash Mission Chandarpur" by the State of Maharashtra
(iii) "Fly Ash and Slag Mission, Odisha" by the State of Odisha

3. IMPACT MADE

The degree of success of resolution of complex issues of fly ash utilization is evident from the impact that above said efforts have made. The impact comes out clearly, when we take a look at the scenario that prevailed prior to 1994 (pre Fly Ash Mission era) and the one that prevails today.

Table. **Overall impact made**

Select Indicator	1994 (Start of Mission Project)	2011-2012
Fly ash Utilization	1.0 million tonne /year (3 % of 40 million tonne generation)	100 million tonne / year (50 % of 200 million tonne generation)
Number of centers / agencies working on fly ash with a thrust	Very few (less than 10)	Quite a large number (hundreds)
Number of persons working in fly ash utilization / R&D area	A few (tens)	Thousands
Linkages between labs & user agencies	Were practically missing	Strong linkages have been established data & experience sharing has become common.
Confidence in fly ash technologies	Was missing	Has been established in demonstrated technologies, others are in progress / planned and standardization done.
Technologies commercialization status	Practically there was no commercialization effort or large scale use	Commercialization and large scale utilization have started. Hundreds of multiplier effects have come up, generating economic wealth more than US$ 3 billion, employing more than 1 million people and saving more than 55 MnT CO_2 per annum.
Status of standards / protocols (crucial for sustainable use)	Outdated & were not available for many applications.	Exercise to update the existing standards / make new standards has started. More than 60 stds updated and 15 new stds prepared.

4. PARADIGM SHIFT

The impact made and the considerable change in fly ash utilization scenario is evident from the fact that acceptance of fly ash products has started picking up and fly ash is now emerging as an important resource material for the new millennium. Use of fly ash in bricks, blocks, cement, in construction of roads and embankments and also in agriculture related areas are fast emerging.

The intrinsic worth of fly ash for various gainful applications is being understood. It is slowly being taken as a friendly and useful resource material than a liability. Further, good numbers of entrepreneurs, scientists and engineers have started coming forwards to work in the area of fly ash utilization / safe disposal. R&D institutions have started groups exclusively working on fly ash.

Fly ash is now treated as a "resource material" than "a waste product" considered earlier.

Indian experience, expertise and technologies of fly ash utilization / safe management are now applauded internationally and Protocol of Intensions has been signed between India and Russia on fly ash utilization and safe management on 16th December, 2011 at The Kremlin, Russia in the presence of Dr. Manmohan Singh, Prime Minister of India and Mr. Dmitry Medvedev, The President of Russia after the bilateral summit level talks between the two sides, for implementation of the mechanism similar to "Fly Ash Mission – India" in the Siberian Federal District, to facilitate development and application of technologies for utilization and safe

management of fly ash, including import of technologies from India.

5. CONCLUSION

Development of new technologies and S&T interventions are the fundamental requirements for utilization of fly ashes. The large scale acceptance primarily depends upon successful resolution of complex issues of scale up, confidence building, financing, capacity building and addressing of mind sets as well as prevailing procedures, systems and guidelines at potential user agencies.

V. Kumar. Resolution of complex issues of fly ash utilization: successful case study of India // Proceedings of the IV scientific and practical workshop "Ashes from TPPs: removal, transport, processing, landfilling", Moscow, April 19–20, 2012 — M.: MPEI-Publishers, 2012. P. 132 – 137.