FLY ASH: A BILLION DOLLAR RESOURCE - WASTED SO FAR

Vimal Kumar*, Mukesh Mathur** & Preeti Sharma**

Abstract

Fly ash is a finely divided residue resulting from the combustion of bituminous coal or lignite in a thermal power plant. Indian coals have on an average 45% ash content. Currently India generates around 95 million tonne of ash per year. It is likely to reach 125 million tonne mark by 2005 and 180 million by 2012.

Research work of large number of agencies in the country and actual utilisations abroad have exhibited worth of flyash. However, may be due to lack of local experience, utilisation of flyash did not pick up in India, till a few years ago. Fly Ash Mission, established by Government of India in 1994 is providing a focussed thrust to develop local experiences and thus building up of confidence in techno- economic viability of flyash utilisations as well as safe disposal of un-utilised ashes. More than 50 technology demonstration projects implemented in the field have led to beginning of acceptance of fly ash as a resource material. Number of multiplier effects have started. Utilisation has increased from a meagre 1.5 million tonne during 1994 (3% of generation) to about 15 million tonne during the year 2000 (15% of generation).

The paper illustrates that Indian fly ashes and the utilisation avenues hold the potential to give returns worth more than a billion dollars excluding valuation of resultant cleaner environment.

I. INTRODUCTION

In India, thermal power plants account for about 65% of electricity installed capacity and 70% of electricity generation. About 230 million tonnes of coal is being currently used by thermal power stations which is also about 65% of total coal production. There are 82 thermal power plants in utility sector in the country which currently produce around 95 million tonnes of flyash per annum. Considering the growth plans of power sector, the annual fly ash generation is expected to be about double by 2012 A.D. Since low ash high-grade coal is reserved for metallurgical and other industries, thermal power plants have no choice but to use low grade coal having ash content upto 55%. Further, the deteriorating quality of coal will aggravate the situation, if clean coal technologies are not adopted at large scale.

Fly ash which is a finely divided residue resulting from the combustion of bituminous coal or sub-bituminous coal (lignite) in a thermal power plant generally consists of inorganic mineral constituents of coal. It has fineness 4000 to 8000 sq. cm. per gram and posseses pozzolanic

---

* Mission Director, Fly Ash Mission, Technology Information, Forecasting & Assessment Council, Department of Science & Technology, Government of India, New Delhi - 110 016

** Scientist `C', Fly Ash Mission, Technology Information, Forecasting & Assessment Council, New Delhi - 110 016

characteristics. This material has been extensively studied. However, for long the potential of Fly Ash as a resource material has been ignored. Various studies conducted on fly ash have proved beyond doubt that fly ash has potential to emerge not only as a valuable building / construction material but also as an agricultural input. It has got inherent characteristics for the manufacture of bricks (as substitute of scarce and fertile top soil) / hollow and solid blocks / cellular light weight concrete, partial replacement of cement, construction of roads and embankments, manufacture of sintered aggregate, wood substitute material and for use in the manufacture of emulsion / paints / buildings distempers, etc.

II. NATIONAL THRUST

As stated earlier, Fly Ash Mission is putting a focussed thrust on building confidence towards large scale utilisation of flyashes and safe management of unutilised ashes. Fly Ash Mission is being implemented by Technology Information, Forecasting & Assessment Council (TIFAC) an autonomous body of Department of Science & Technology (DST). DST is the Nodal Agency alongwith Ministry of Power and Ministry of Environment & Forests.

Technology Demonstration Projects are being executed with participation of industry / user agencies, fly ash producers, R&D and academia. There are a large number of agencies working in this is field such as CSIR laboratories, IITs, industrial research bodies, engineering colleges / research bodies, BMTPC, HUDCO, CPWD, PWD'S, state agencies and power producers, etc.

Technology Demonstrations Projects have focus in the following ten Thrust Areas:

I. Utilisation of fly ashes
- Roads & Embankments
- Building components
- Hydraulic Structures
- Agriculture Related Studies & Applications
- Underground Minefills

II. Safe management of unutilized fly ashes
- Ash Ponds & Dams
- Reclamation of Ash Ponds for Human Settlement

III. Facilitation of further work/utilisation
- Characterisation of Fly Ash
- Handling & Transportation
- Research & Development

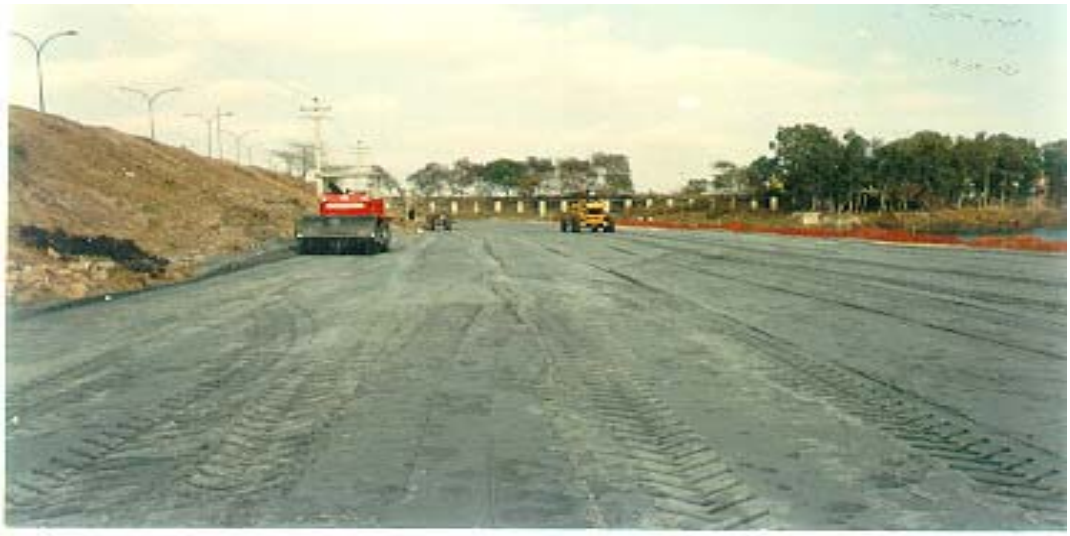
The impact of above said efforts can be seen from the considerable change in the scenario. The utilisation and safe disposal practices have gained momentum. The flyash utilisation has increased from 3% in 1993 (of about 40 million tonne produced) to nearly 15% (of approximately 95 million tonne produced) in 2000. Further, acceptance of flyash products

has started picking up and flyash is now emerging as an important resource material for the new millennium.

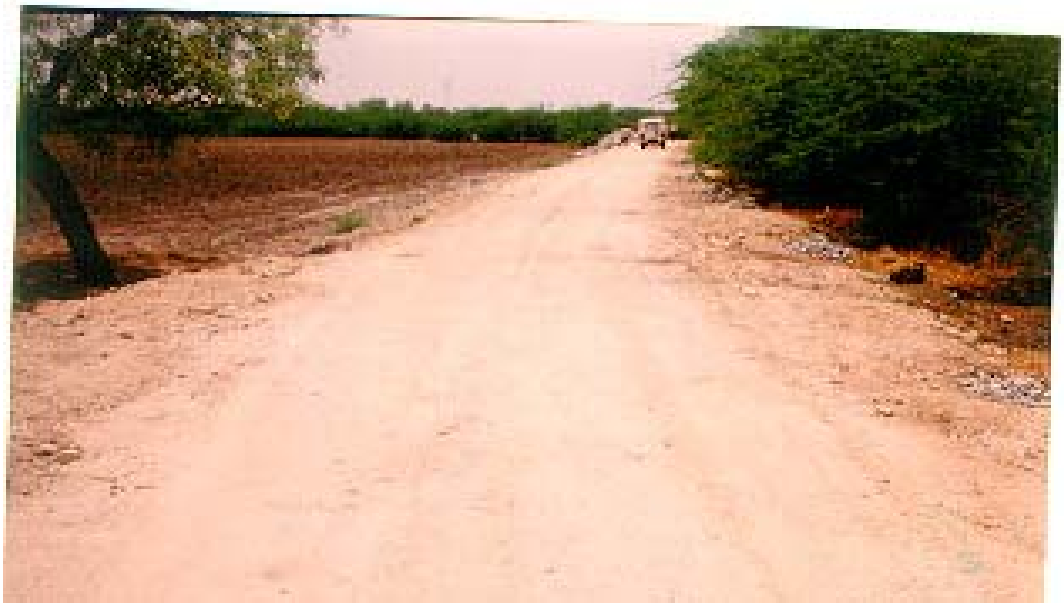
SOME HIGHLIGHTS OF TECHNOLOGY DEMONSTRATED PROJECTS ARE:

Roads & Embankments

3 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.



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



Two Km stretch of Raichur- Arsnagi road, via Yadlapur in Raichur distt. of Karnataka.
The fly ash road (in unmetaled condition) has performed well for last 3 years.

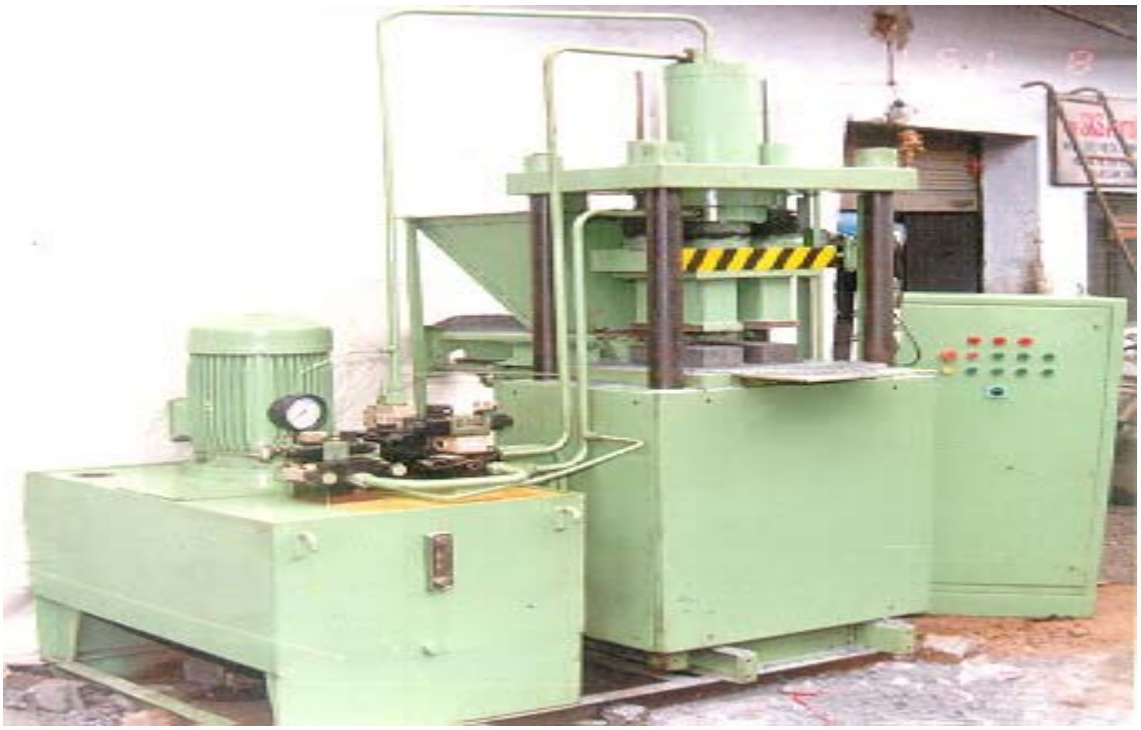
Building Components

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.

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

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

School building at American Embassy, New Delhi.



Double acting hydraulic fly ash brick press

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

Fly ash based aggregates, wood substitute and tiles

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

Use of fly ash based cellular concrete in at Chennai, Tamil Nadu

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.

Building constructed using fly ash bricks at Calcutta, West Bengal

Use of flyash based cellular light weight concrete at Hyderabad, Andhra Pradesh

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.

Cultivation of cabbage on coal ash amended soil at Dodhar, Rihandnagar (U.P.)

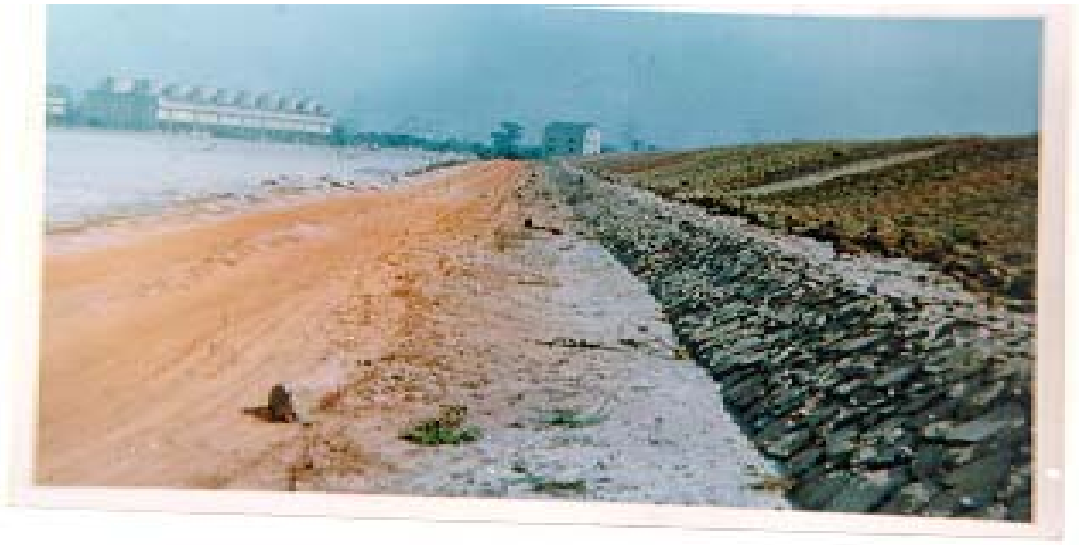
Increased seed yield of sunflower with flyash at 60 t/ha, at Raichur, Karnataka

Mustard in fly ash improved soil, Kharagpur, W. Bengal

Ash Pond and Dams

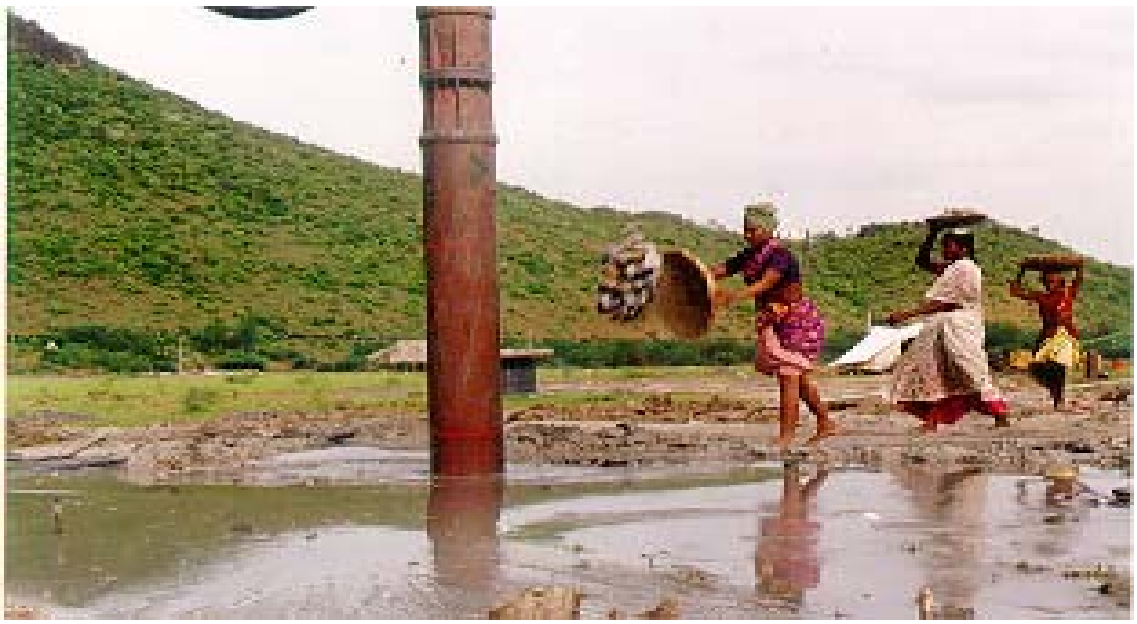
Safe management of ash pond and dams to store the unused flyashes is an important requirement. Technologies have been developed and demonstrated for construction of ash dykes using fly ash itself (in lieu of soil). In addition, densification of ash ponds have been done to make them safe under seismic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

Ash Dyke Construction



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

Densification of Ash Ponds



Densification by Vibroflotation, Vijaywada Thermal Power Station, Andhra Pradesh

Networking

In addition to working with a large number of project execution agencies across the country for technology demonstration projects, a network of 25 laboratories has been developed to provide facilitation and guidance towards safe management / utilisation of fly ashes.

Standards

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 product / utilisation which do not exists as if now.

Standardisation initiatives have focussed on :

(a) Design guidelines have been prepared and approved by Indian Roads Congress. Use of flyash in road embankments
(b) Revision of IS 3812 – the code is proposed to be brought out in 5 parts (i) for use as pozzolana & admixture in cement, mortar & concrete (under issuance), (ii) fly ash in lime pozzolana mixture applications, (iii) sintered applications, (iv) geotechnical and (v) agricultural application.
(c) Updation of IS:456 – code of practice for plain and reinforced concrete has been updated with use of flyash.
(d) Minimum and maximum percentages of flyash in PPC have been revised to 15% and 35% respectively etc.

Processing of Fly Ash

To maximize the benefits of fly ash utilisation, it is essential that fly ashes are selected appropriately for specific applications. It is well established that flyash plays an active role, as a useful raw material in each of the utilisation (hence no more to be treated as an inert or filler material). Further, the quality and properties of fly ashes can be improved, to best suit the desired utilisation, by processing or beneficiation. It is imperative that more initiatives need to be taken to make available beneficiated / segregated fly ashes in containers as well as in bagged condition to maximize the returns from this mineral source.

III. ECONOMIC WORTH OF FLY ASH ……. A GLIMPSE

Some of the details presented in the subsequent paragraphs illustrate the magnitude of economic impact that fly ash can create if utilized appropriately.

Fly Ash Based Cement

Current installed capacity of Indian cement industry is 110 MT per annum. Further, it is an established fact that the mortar and the concrete with PPC perform better on strength as well as durability parameters. 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 upto 55% utilisation of fly ash in PPC production.

Keeping in view the technical advantages use of PPC be preferred on OPC, except in cases where in early strength is very essential. 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%. It would consume around 25 MT fly ash, replacing same amount of cement clinker and resulting in net saving Rs. 2500 crore.

Roads and Embankments

Another area that holds potential for utilisation of large volumes of fly ash is road and flyover embankments. Fly ash embankments at Okhla, Hanuman Setu, Second Nizamuddin bridge in Delhi and roads at Raichur, Calcutta, Dadri etc. have established that on an average Rs. 50 to 75 per MT of earth work cost can be saved by using flyash (in lieu of soil) in such works, primarily due to reduction in excavation & transportation costs.

In view of the growing need for development of road infrastructure in the country, conservative estimates show that about 15-20 MT ash can be used in construction of road and flyover embankments per annum in the vicinity of TPPs. This would yield a saving of around Rs. 100 crore per year.

Fly Ash Bricks

Our current clay brick production exceeds 100 billion bricks a year. With the increase in population and infrastructural needs the demand is likely to increase significantly. Simultaneously, environmental consciousness would reduce demand of clay bricks and would lead to increase in demand of fly ash bricks. 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.

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 kms 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 minefills yielding a saving of about Rs. 150 crore a year.

Fly Ash in Agriculture

Use of fly ash in agriculture has also proved to be economically rewarding. The improvement in yield has been recorded with fly ash doses varying from 20 tonne / hectare to 100 tonne / hectare. On an average 20-30% yield increase has been observed.

Out of 150 million hectare of land under cultivation, 10 million hectares of land can safely be taken up for application of fly ash per year. Taking a moderate fly ash dose of 20 mt per hectare it would consume 200 million tonne flyash per year. This is more than the annual availability of fly ash, therefore the shortfalls would be met from accumulated 1500 million tonne stock of fly ash (available in ash ponds). The fly ash treated fields would give additional yield of 5 million tonne foodgrains per year valued at about Rs. 3000 crore.

Other Applications

Apart from the applications described above, there are several other applications that would use good quantity of fly ash and would yield economic returns / savings. These include use of fly ash in roller compacted concrete, hydraulic structrures, reclamation of low lying areas, fly ash based wood substitute, flyash based granite substitute, tiles, aggregates, zeolites, paints and enamels etc.

IV. CONCLUSION

It can safely be concluded that fly ash, which till recent years has been treated as a waste product of thermal power stations, is in fact a valuable resource material. Its appropriate utilisation can provide an economic bonanza worth more than a billion dollars, as summarised in the following table:

S. No.	Utilisation	Fly Ash Consumption (in Million Tonne / year)	Savings per year (Rs. in Crore.)
1	Cement production	25	2500
2	Road and embankments	15-20	100
3	Minefills	15-20	150
4	Bricks	5	20
5	Agriculture	200	3000
	Total		5770≈1.2 billion US$

If we add the value of land which would otherwise be excavated for consumption or for dumping of flyash, value of agricultural produce from this land area and environmental benefits in terms of reduction in emission of green house gases & reduction in mining activity etc., the total worth of the saving would increase phenomenally.

LET US RESOURCE A BILLION DOLLAR RESOURCE THAT HAS BEEN WASTED SO FAR.

References

1. `Characterisation of flyash – a multifacet resource material', V Kumar, M Mathur, C N Jha, G Goswami, Conference on flyash characterisation & geo-technical applications, Bangalore, 1999.

2. `Flyash Utilisation – India Scenario & Case Studies', V Kumar, K Zacharia, P Sharma, Indo-European Workshop on 'Handling & Utilisation of Coal Combustion by Products from Indian Power Station, 1999, Ropar.

3. `Flyash Management in Iron & Steel Industry', V Kumar & P Sharma, Conference on Environmental & Waste Management, Jamshedpur, 1999.

4. `Flyash – A Fortune for the Construction Industry', V Kumar, C N Jha, P Sharma, Build India 99, New Delhi.

5. 'Fly Ash Disposal: Mission beyond 2000 A. D., V Kumar, Preeti Sharma, Mukesh Mathur, Fly Ash disposal and deposition: beyond 2000 A.D. Narosa Publishing House, 1999.

6. 'Fly Ash Management – Vision for the New Millennium', Second International Conference on Fly Ash Disposal & Utilisation, February 2000 New Delhi.

7. Cement Manufacturing Association (1999).

8. 'Bharat Mien Ek Nirman – Vartaman Paristhiti Aur Sambhavana', D.K. Das, National Institute for Small Mines, Calcutta, June 2000.