2 Day National Conference
On
Use of Fly Ash in Agriculture, Forestry and Other Applications
17th – 18th December, 2019

Professor Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad

ORGANISED BY

CENTRE FOR FLY ASH RESEARCH & MANAGEMENT (C-FARM)
NEW DELHI

PROFESSOR JAYASHANKAR
TELANGANA STATE AGRICULTURAL UNIVERSITY
FOREWORD

Fly ash generation from thermal power stations is increasing at alarming rate since past decades. Several agencies have explored various sectors which have great potential of fly ash utilization. But these areas of utilization are not able to use fly ash to its full potential. Centre for Fly Ash Research and Management (C-FARM) along with Professor Jayashankar Telangana State Agriculture University organized the 2-Day National Conference at PJTSAU, Hyderabad to bring forth various aspects of fly ash utilization vis-à-vis the Government notifications on the subject. This conference enriched the knowledge and awareness of all the participants through the technical papers on laboratory research as well as field case studies.

The knowledge and experiences deliberated in various fields of utilization of fly ash during the National Conference need to be taken forward for gainful applications. The recommendations of the National Conference are important and valuable that can make a significant impact on utilization of fly ash, inter-alia conservation of natural resources, environment protection and generation of employment through new ventures.

I send my best wishes for the successful implementation of the recommendations of the 2 Day National Conference towards scaling the new heights in fly ash utilization.

S.J. Sibal

Place: New Delhi
Date: July, 2020
Acknowledgement

We express our sincere thanks and gratitude to Honorable Shri Singireddy Niranjan Reddy, Minister for Agriculture, Government of Telangana for his candid acceptance of our request to Chair the Concluding Session. We also thank him for his valuable guidance, encouragement and foresight advice during his Concluding Session address. We thank profusely Prof. V. Praveen Rao, Vice Chancellor, PJTSAU, who has been the brain and main motivating factor behind this conference. Our special thanks to him for being the Chief Patron and valuable guidance & advice extended by him from time to time. We thank Shri S. J. Sibal, Former Dg, DGMS & Chairman, C-FARM and the Patron of the Conference for his kind encouragement, advice & support for the conference. We profusely acknowledge the valuable guidance provided by Prof. V. S. Raju, Former Director, IIT-Delhi & Director, C-FARM in his Inaugural Address.

Our special thanks to Senior officials namely: Dr. D. Rama Rao, Former Director, NAARM, Emeritus Scientist, PJTSAU & Director, C-FARM; Dr. R. Jagadeeshwar, Director of Research, PJTSAU; Dr. R.B.S Rawat, Former PCCF (HoFF), Uttarakhand & Director, C-FARM and Shri R. K. Kaushal, ADG, CPWD, Hyderabad who have continuously provided support and reviewed the progress and arrangements and also for their valuable addresses during the conference. We also thank all the speakers, eminent participants from all sectors of fly ash industry, Government, academia, R&D and others.

I take this opportunity to place on record our sincere thanks and gratitude to the staff, faculty and officers of PJTSAU who have provided inputs and extended their support and cooperation to make the Conference a great success.

I am also grateful to the Directors of C-FARM for the guidance, inspiration and constructive suggestions that enabled us to organize and conduct the conference successfully.

I take the opportunity to thank all those who have contributed directly and indirectly in making this National Conference as great success.

(Vimal Kumar)
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2-Day National Conference on Use of Fly Ash in Agriculture, Forestry and Other Applications

PROGRAM

DAY 1 : 17th December, 2019

08:30 – 09:30 Hrs   REGISTRATION

09:30 – 10:45 Hrs   INAUGURAL SESSION

- Welcome Address by Dr. S. Sudheer Kumar, Registrar, PJTSAU, Hyderabad
- Lighting of the lamp
- About the Conference by Dr. Vimal Kumar, Former Mission Director, GoI & Secretary General, C-FARM, New Delhi
- Guest of Honor Address by Dr. D. Rama Rao, Former Director, NAARM, Emeritus Scientist, PJTSAU & Director, C-FARM
- Guest of Honor Address by Shri R. K. Kaushal, ADG, CPWD, Hyderabad
- Inaugural Address by Prof. V.S. Raju, Former Director, IIT-Delhi & Director, C-FARM
- Vote of Thanks by Dr. R. Jagadeeshwar, Director of Research, PJTSAU, Hyderabad

10:45 – 11:15 Hrs   TEA BREAK

11:15 – 13:00 Hrs   TECHNICAL SESSION-I: POLICY & TECHNOLOGY PRESCRIPTIVE

Chair       : Dr. A. Padma Raju, Former VC, Acharya N G Agricultural University
Co-Chair    : Dr. D. Rama Rao, Former Director, NAARM; Emeritus Scientist, PJTSAU & Director, C-FARM
Repertoire: Dr. T. Ram Prakash, Principal Scientist, AICRP on Weed Management, PJTSAU

- “Facilitation through statutory proclamations for 100% fly ash utilization: A Review” by Mr. R.K. Khandekar, AGM, NTPC Ltd., Noida
- “Utilization of Fly Ash in the State of Telangana: Facilitations and Initiatives of Telangana State Pollution Control Board” by Mr. P. Vishwanatham, Chief Env. Engineer, TSPCB and Mr. Ramesh Gupta, Sr. Env. Engineer, TSPCB
- “Environmental aspects of fly ash disposal & utilization” by Dr. Gurdeep Singh, Former VC, Vinoba Bhave University, Hazaribagh
- “Recent advances of fly ash recycling for manufacturing hybrid
green composite materials for multifunctional applications – Opportunities for entrepreneurship” by Dr. Asokan Pappu, Senior Principal Scientist, CSIR-AMPRI

- “Use of fly ash in agriculture, forestry and other applications: Technology perspective” by Dr. Vimal Kumar, Secretary General, C-FARM, New Delhi
- “Fly Ash-Based Geopolymers for Treatment of Hazardous Wastes” by Ms. Richa Singh, Ph.D Scholar, IIT-Bombay, Mr. Bakul Rao and Shri Shyam R. Asolekar

Floor Interaction

13.00 – 13.45 Hrs LUNCH

13.45–15.30 Hrs TECHNICAL SESSION-II: AGRICULTURE WITH FLY ASH: A PERSPECTIVE

Chair : Dr. R. Jagadeeshwar, Director of Research, PJTSAU
Co-Chair : Dr. J. Satyanarayana, Dean of Agriculture, PJTSAU

Repertoire: Dr. A. Madhavi, Principal Scientist & Head, AICRP on STCR, PJTSAU

- “Impact of fly ash on soil health and plant yield: A review” by Dr. C.V. Patil, Former Director of Instructions (Agri.), Dept. of Soil Sc. & Agri. Chem., College of Agriculture, Raichur and Mr. H. Veeresh
- “Fly Ash as a Source of Silicon and Potassium for Enhancing Rice Productivity in Intensively Rice Growing Soils” by Prof. P. Balasubramaniam, Head, Dept. of Soil Sc. & Agri. Chem., Anil Dhrmalingam College Agricultural College and Research Institute, Tiruchirappalli
- “Effect of fly ash application on yield and nutrients content of crops and water use efficiency under Rice-Wheat cropping system” by Dr. S.K. Bansal, Director, PRII, Gurgaon
- “Extraction and characterization of humic acid from coal for the differential application” by Dr. T. Selvaraj, Asistant Professor (Soil Science), ICAR-KVK, TANUVAS, Kancheepuram
- “Nutritional quality of the agricultural crops produced from the fly ash amended soil” by Dr. Ananthan, Scientist D, NIN, Hyderabad and Dr. T. Longvah
- “Effect of growing media containing fly ash and press mud on growth and yield of chrysanthemum variety Basanti” by Dr. Shilpa Shree K.G., Scientist (Soil Science), ICAR-Directorate of Floricultural Research, Pune, Ms. Safeena S.A., Ms. Nitika Gupta, Mr. Tarak Nath Saha, Mr. Ganesh B. Kadam and Mr. K. V. Prasad
- “Review on zeolite synthesis from fly ash: A best alternative
towards productive use of fly ash” by Dr. V. Girija Veni, Scientist (Soil Science), ICAR-CRIDA, Hyderabad, Dr. G. Ravindra Chary, Dr. K.L. Sharma and Dr. K. Sammi Reddy

Floor Interaction

15.30 -16.00 Hrs  TEA BREAK

16.00 – 17.30 Hrs  TECHNICAL SESSION-III: FORESTRY WITH FLY ASH: A PERSPECTIVE
Chair : Dr. R.B.S. Rawat, Former PCCF (HoFF), Uttarakhand & Director, C-FARM
Co-Chair : Dr. T. Pradeep, Director (Seed), PJTSAU

Repertoire: Dr. S. Harish Kumar Sharma, Professor, SS&AC, College of Agriculture, PJTSAU

• “Impact of coal fly ash on forest plantations and nursery” by Dr. Dinesh Goyal, Former Executive Director, STEP, Thapar University, Patiala, Ms. Sudha Jala, Mr. Ajay Nioding and Mr. V. Ramamurthy
• “Forestry intervention for fly ash pond and degraded land area of thermal power station” by Dr. P. K. Das, Scientist D, Institute of Forest Productivity, Ranchi, Mr. Y. Mishra, Ms. R. Kujur and Mr. N. Kulkarni
• “Use of fly ash for rejuvenation of mine waste spoil dumps and degraded lands” by Dr. Gurdeep Singh, Former VC, Vinoba Bhave University, Hazaribagh and Dr. Vimal Kumar
• “Case study: Use of fly ash in forest nursery and plantation at Cuttack Forest Division“ by Dr. Vimal Kumar, Secretary General, C-FARM, New Delhi and Mr. Gopal Krishna Jha
• “Smart fly ash pesticides: Towards pesticides free agriculture, store godowns, forestry and urban habitations” by Prof. P. Narayanasamy, Former Dean, Agriculture, Annamalai University
• “Fly ash: A potential future green tool for insect pest management in agriculture” by Dr. S. Sithanantham, Director, Sun Agro Biotech Research Centre, Chennai, Mr. M. Prabakaran and Prof. P. Narayanasamy

Floor Interaction
DAY 2 : 18th December, 2019

09:30–11:00 Hrs

TECHNICAL SESSION-IV: PROSPECTS OF USE OF FLY ASH IN MINING SECTOR
Chair : Shri Shyam Mishra, Director, DGMS
Co-Chair : Shri P. Sathaiah, General Manager, SCCL

Repertoire:  Dr. T. Ram Prakash, Principal Scientist, AICRP on Weed Management, PJTSAU
- An Overview: Use of fly ash in mining sector” by Dr. Vimal Kumar, Former Mission Director, GoI & Secretary General, C-FARM
- “Fly ash utilization in SCCL coal mines - Sustainability” by Mr. Murali V., Additional Manager, SCCL and Mr. P. Sathaiah. Presented by Mr. Shaik Madar, Additional Manager, SCCL
- “Efforts of SCCL in the gainful utilization of fly ash generated from STPP and other nearby thermal power plants” by Mr. Md. Fazal Hussain, Additional Manager, SCCL and Mr. K. Guruvaiah
- “Conditions of extraction of pillars with sand and ash as backfilling materials vis-à-vis electronic instrumentation for evaluation of load on supports in underground coal mines” by Prof. Singam Jayanthu, Professor, NIT, Rourkela, Ms. Singam Jayadarshana and Dr. Vimal Kumar
- “Geotechnical studies on stabilization of OB dumps admixed with fly ash in open cast coal mines – A successful experimental trial” by Prof. Singam Jayanthu, Professor, NIT, Rourkela

Floor Interaction

11.00 –11.30 Hrs TEA BREAK

11.30–13.00 Hrs

TECHNICAL SESSION-V: ADAPTATION OF EMERGING TECHNOLOGIES IN CONSTRUCTION INDUSTRY (PART I)
Chair : Sri John Peter, Architect, CPWD Region, Hyderabad
Co-Chair : Dr. Vimal Kumar, Former Mission Director & Head, Fly Ash Unit, DST, GOI & Secretary General, C-FARM, New Delhi

Repertoire:  Dr. A. Madhavi, Principal Scientist & Head, AICRP on STCR, PJTSAU
- “Fly ash for sustainable high performance concrete” by Dr. N. Bhanumathidas, Director General, INSWAREB, Visakhapatnam
“Lime activation of siliceous fly ash at very high levels of cement replacement” by Prof. K. V. L. Subramaniam, Professor, IIT – Hyderabad and Mr. G.V.P. Bhagath Singh. Presented by Mr. Mude Hanuman Naik, Research Scholar, IIT – Hyderabad

“Fly ash in different concretes and in different environment” by Dr. B. K. Rao, Professor, KL (Deemed to be) University, Vaddeswaram and Dr. Vimal Kumar

“Optimization of fly ash fineness – Towards sustainable solution for fly ash utilization in cement industry” by Mr. Suresh Vanguri, Dy. Manager (CRT/CQC), NCCBM, Hyderabad, Dr. Suresh Palla, Mrs. K.V. Kalyani, Dr. S.K. Chaturvedi and Dr. B. N. Mohapatra

“Effect of temperature on behaviour of fly ash concrete” by Mr. A. Venkateswara Rao, Associate Professor, KL (Deemed to be) University, Vijayawada and Mr. K. Srinivasa Rao

Floor Interaction

13:00–13:45 Hrs  LUNCH

13:45–15:15 Hrs  TECHNICAL SESSION-VI: ADAPTATION OF EMERGING TECHNOLOGIES IN CONSTRUCTION INDUSTRY (PART II)

Chair : Dr. Vimal Kumar, Former Mission Director & Head, Fly Ash Unit, DST, GOI & Secretary General, C-FARM, New Delhi

Repertoire: Dr. S. Harish Kumar Sharma, Professor, SS&AC, College of Agriculture, PJTSAU

“Field utilization of fly ash and slag based geopolymer concrete in precast products” by Mr. Lalit Kumar, Deputy Manager, NCCBM, Ballabgarh, Mr. Amit Trivedi and Mr. V.V. Arora

“Nano concrete aggregate” by Mr. N. Kalidas, Director, INSWARE, Visakhapatnam and Dr. N. Bhanumathidas

“Self –leveling high strength geopolymer concrete: Production and application” by Prof. K. V. L. Subramaniam, Professor, IIT – Hyderabad. Presented by Mr. Anvit Gadkar, Graduate Assistant, IIT – Hyderabad

“Manufacturing and cost economics of Crusher dust based Fly ash bricks” by Dr. S. M. Mustakim, Principal Scientist, CSIR-IMMT, Bhubaneswar, Ms. Jyotirmaya Mishra and Mr. Shaswat Das

“Use of fly ash as construction material in CPWD” by Mr. C. N. Suresh, SE, CPWD, Warangal and Mr. R. K. Kaushal
Floor Interaction

15:15-16:00 Hrs PANEL DISCUSSIONS

16:00–16:45 Hrs VALEDICTORY SESSION

Chief Guest: Shri Singireddy Niranjan Reddy, Hon’ble Minister for Agriculture, Government of Telangana

- Overview of Technical Sessions by Dr. Vimal Kumar, Former Mission Director & Head, Fly Ash Unit, DST, GoI and Secretary General, C-FARM
- Panel Discussions
- Address by Chief Guest
- Vote of Thanks by Dr. R. Jagadeeshwar, Director of Research, PJTSAU, Hyderabad

16.45 Hrs HIGH TEA
2-Day National Conference on Use of Fly Ash in Agriculture, Forestry and Other Applications

PREAMBLE

Thermal power plants are the main source of electricity in India and are expected to remain so for decades. The world acclaimed initiatives of Indian R&D, academia, industry and statutory bodies through various channels including Fly Ash Mission, Government of India have made it possible to take the overall fly ash utilization for the country to more than 65%. Technology interventions of value addition to fly ash and its products are at a fast pace, whether it’s construction industry or agriculture/forestry or mining or high value products or handling and transportation of fly ash. Granulation of fly ash, high volume and high strength fly ash bricks, blocks, tiles, cements, concretes and reduced curing period for fly ash bricks, application of geo-polymerized fly ash in the field at ambient temperatures and increased level of use of roller compacted concrete technology for road construction are adding quality and value to the volume utilizations of fly ash. Innovative, economical and eco-friendly transport technologies are happening for handling and movement of fly ashes, including for large volumes at ultra mega power projects. Simultaneously, the challenges being faced by thermal power plants at remote locations and in clusters to get fly ashes utilized, practically due to absence of infrastructure and housing development projects are being squarely addressed through technologies of appropriate applications of fly ash at such remote and challenging locations. The S&T developments and their field applications are being encouraged and facilitated through statutory and advisory stimuli.

The conference organized by Centre for Fly Ash Research and Management (C-FARM) and Professor Jayashankar Telangana State Agriculture University (PJTSAU) provided a common platform where the policy makers, regulators, statutory bodies, researchers, academicians, department personnel, mining agencies, construction industry, professionals, fly ash producers (thermal power plants) and allied stakeholders met, shared their experiences and deliberated upon the developments taken place in this area and the emerging requirements including obstacles and the opportunities.

The 2-Day National Conference had deliberations on the following broad topics and the allied areas:
• Recent S&T developments and field application in the areas of fly ash utilization inter-alia handling and transportation.
• Recent statutory proclamations: facilitations and challenges.
• Field experiences, impediments and remedies regarding large volume utilization of fly ash.
• Technologies for use of pond ash, processing, value addition and reclamation of ponds.
• Design, construction and safe management of operational ash pond and safe closures.
• Fly ash utilization avenues for thermal power plants at remote locations and exploitation thereof.
• Fly ash supply chain; classification, processing, management of challenges for equitable supply across user segments.
• Economic and environmental impact of fly ash utilization interalia employment generation, potential to increase agriculture output and green cover.

All areas of fly ash utilization are addressed: Building components, cement, concrete, roads, embankments, soil stabilization, reclamation of low lying areas, waste and degraded lands, agriculture, forestry, mine filling, OB dump stabilization, haul roads, ash pond managements, value added applications as well as handling and transportation, etc.

ABOUT THE CONFERENCE

The 2-Day National Conference organized by Centre for Fly Ash Research and Management (C-FARM) and Professor Jayashankar Telangana State Agriculture University (PJTSAU) had overwhelming response of about 40 eminent expert speakers and more than 150 participants from academia, R&D institutes, Government, statutory bodies, thermal power plants, construction industry, CPWD, KVKs, etc. The conference highlighted that fly ash is no more a waste; in fact it is a resource material that has great potential to be used in different sectors. The deliberations have created intense interest to include fly ash as a substitute and a value addition product in different user agencies schedules of rates and list of accepted preferred materials.
Inaugural Session was followed by six technical sessions, on policy & technology perspective, use of fly ash in agriculture, fly ash use in forestry, use of fly ash in mining sector and two sessions on use of fly ash in construction industry. Each session was followed by the floor interactions. The Concluding Session had an address by the Chief Guest Shri Singireddy Niranjan Reddy, Hon’ble Minister for Agriculture, Government of Telangana with an overview of Technical Sessions and Panel Discussions to draw up the recommendations of the National Conference.

INAUGURAL SESSION

The 2-Day National Conference on Use of Fly Ash in Agriculture, Forestry and Other Applications was inaugurated by Prof. V. S. Raju, Former Director, IIT-Delhi & Director, Centre for Fly Ash Research and Management.

Prof. V. S. Raju stated that in this developing world, environment and natural resources which are of great importance are depleting day by day. Thermal power plants generating high amount of fly ash having various useful properties is being disposed either in ash ponds or ash mounds that requires a large area of land also cultivable land. Through Fly Ash Mission and MoEF&CC notifications, India has attained 65% of fly ash utilization, the target of 100% utilization is far off. Therefore, to attain this, we have to use fly ash in each and every possible field where it could be used and this conference helps to get to know various fields of bulk fly ash utilization. Depending upon the properties of fly ashes, it could be used in manufacturing of construction materials like fly ash bricks, blocks, tiles, etc., as cement substitute in concrete, in agriculture and forestry to improve soil health and yield of crop, in filling of mines and many more.

Dr. S. Sudheer Kumar, Registrar, PJTSAU, Hyderabad while welcoming the dignitaries and delegates stated that fly ash is a resource material which is being used as raw material for various industries and also showing its potential to be used in
agriculture and forestry applications. Thus, the high potential of fly ash utilization need to be widely spread to facilitate large scale adaptation of gainful utilization of fly ash in various sectors.

Dr. Vimal Kumar (Former Mission Director & Head, Fly Ash Unit, Department of Science & Technology, Government of India), Secretary General, Centre for Fly Ash Research and Management gave a brief outline of the Conference and its objectives. He emphasized that as the fly ash is being generated at an alarming rate, there is a need to utilize it in bulk gainfully and in a safe manner. With the bulk utilization of fly ash, environment is conserved on one hand and on other hand it also generates business and employment. He added that degraded and waste lands including sodic and saline soils can be reclaimed and vegetated by use of fly ash, in addition to many other applications in construction. Fly ash is currently saving 80 MnT CO$_2$ generation by its use in cement, concrete and brick manufacturing. Dr. Vimal Kumar said that the perception about fly ash has changed now and MoEF&CC notifications are released and implemented for use of fly ash in proper manner.

Dr. D. Rama Rao (Former Director, NAARM), Emeritus Scientist, PJTSAU and Director, Centre for Fly Ash Research and Management stated that fly ash from thermal power plants has capability to be utilized in agriculture sector. He said that in agriculture sector, use of fly ash has shown positive results in various researches. It is a good soil ameliorant and could provide a sustainable solution for agriculture lands that are getting degraded by excessive use of chemical fertilizers. It also improves yield of cultivable soils and reclams waste lands for forestry and agriculture without any significant ill effects. In spite of these positive attributes, large scale use of fly ash in agriculture and forestry has yet to take place.
Shri R. K. Kaushal, ADG, CPWD, Hyderabad supported use of fly ash and its products in construction sector. He said that fly ash makes concrete stronger and durable and its products are also economical, eco-friendly and durable. CPWD being the main construction agency of Government of India uses fly ash and its products like bricks, blocks, tiles, pavers and others in construction projects of CPWD at various locations for sustainable development.

Dr. R. Jagadeeshwar, Director of Research, PJTSAU, Hyderabad proposed the vote of thanks with the words that fly ash is a material for future as its eco-friendly and conserves natural resources and environment, it is no more a waste. He assured the support and participation of his university for promoting use of fly ash in agriculture.

**Technical Session I: Policy & Technology Perspective**

Six papers were presented covering fly ash notifications & statutory provisions, regulatory aspects & facilitation, environmental aspects, fly ash hybrid green composite materials and technology perspective including emerging technologies and products for value added and large volume utilization of fly ash. This session was chaired by Dr. A. Padma Raju, Former VC, Acharya N G Agricultural University and co-chaired by Dr. D. Rama Rao, Former Director, NAARM; Emeritus Scientist, PJTSAU & Director, C-FARM.

Shri R. K. Khandekar, AGM (EMG), NTPC Ltd., Noida presented the technical paper “Facilitation through statutory proclamations for
100% fly ash utilization: A Review”. The road map for successful utilization of fly ash developed through research and technology development under the aegis of Fly Ash Mission, Ministry of Science and Technology, Government of India and steered by fly ash notifications of MoEF&CC in 1999, 2003, 2009, 2016 as well as office memorandum of 28th August, 2019 are highlighted in the presentation. Shri R. K. Khandekar said that these measures have set the road map and facilitated development of fly ash utilization and safe management technologies as well as their implementation. He applauded harmonization efforts through each of the subsequent notifications that became essential due to fast development of technologies and market practices for different applications of fly ash. The office memorandum of MoEF&CC dated 28th August, 2019 issued Guidelines for disposal/ utilization of Fly Ash for reclamation of Low Lying Areas, stowing of abandoned mines/quarries and in agriculture. As per this, power plants can take-up ash utilization in above-mentioned areas with the permission of SPCB and no MOEF &CC clearance will be required.

Shri R. K. Khandekar also presented detailed status of fly ash utilization at NTPC and initiatives being taken towards 100% ash utilization.

“Utilization of fly ash in the State of Telangana: Facilitations and initiatives of Telangana State Pollution Control Board” is presented by Shri Ramesh Gupta, Senior Environment Engineer, TSPCB highlighting the initiatives of TSPCB to create the awareness among the stakeholders for safe management and utilization of fly ash as well as the efforts made including organization of seminars and training programs for fly ash utilization agencies. Telangana State has achieved about 80 percent of fly ash utilization. Six thermal power plants have achieved 100% ash utilization and 4 number of thermal power plants have achieved more than 50% of fly ash utilization.

TSPCB is further encouraging use of fly ash through constituting the Monitoring Committee for monitoring and facilitating the implementation of Fly Ash Notification in the State.
The technical paper “Environmental aspects of fly ash disposal & utilization” was presented by Dr. Gurdeep Singh, Former VC, Vinoba Bhave University, Hazaribagh covering a vast canvas of laboratory as well as field studies evaluating the environmental aspects of disposal/utilization of fly ash. Environmental aspects of trace elements in fly ash, leaching aspects under strong acid digest test, ASTM, shake test, modified synthetic leachate procedure as well as a few other international protocols is presented. Based on the detailed analytical results Dr. Gurdeep Singh concluded:

1. In the study period of about three years there was practically no leaching of thirteen elements namely, chromium, nickel, cobalt, cadmium, selenium, aluminum, silver, arsenic, boron, barium, vanadium, antimony and molybdenum from all the ash samples.

2. Out of the nine elements found in the leachates only calcium and magnesium were found to be leaching in the entire period. The leaching of other seven elements namely, iron, lead, copper, zinc, manganese, sodium and potassium was intermittent. The leaching of sodium and potassium practically stopped due to first flash phenomenon after 35 and 40 days, respectively.

3. The concentration of the elements in the leachates was invariably well below the permissible limits for discharge of effluents as per IS:2490.
applications” explaining the technology developed for large scale utilization of fly ash effectively in a technically feasible, economically viable and socially acceptable manner. The composites are durable, resistance to weather, corrosion, water, moisture and are fire retardant, self-extinguishing nature, cost effective, maintenance free as well as termite and fungus free. Dr. Asokan in his presentation emphasized that the green hybrid composites can be used as alternative to timber, ply wood, particle board, and plastic and FRP/GRP products as roofing sheets, false ceiling, floor tiles, wall tiles, door panels, partition wall, furniture, etc. This technology has been transferred to the industry to contribute towards employment and income generation as well as to achieve Clean India, Make in India and Skill India program.

Dr. Vimal Kumar (Former Mission Director & Head, Fly Ash Mission, DST, GoI) Secretary General, C-FARM, New Delhi presented “Use of fly ash in agriculture, forestry and other applications: Technology perspective”. He emphasized that use of fly ash in agriculture has been researched since 1995. Field demonstration and research projects undertaken in a wide range of soils, agro-climatic conditions and crop types exceeding 100 in number have shown improvement in soil texture, water holding capacity. Growth as well as yield. The yield increased is around 8-10% in cereals, 15-20% in oilseeds and more than 25% in vegetables. In depth, studies have shown no significant negative impact on soil health, runoff water, plant produce as well as plant parts on account of heavy metals and radionuclides present in traces in fly ash.

Use of fly ash in agriculture has earlier been advocated by research institutes as well as agriculture universities based on the above said studies or research work. MoEF&CC has vide its notification no. S.O.2540(E) dated 25th January, 2016 has mandated thermal power plants to transport fly ash at its cost to farmer’s field upto a distance of 100km and additional distance, if any, upto 300km may be transported in equal sharing of the transportation cost with the farmers. Vide the same notification, Ministry of Agriculture has been advised to promote use of fly ash as soil conditioner.
Dr. Vimal Kumar further highlighted that fly ash is a good soil ameliorant for use in forestry, nursery as well as plantation and also for reclamation of waste and degraded land including sodic and saline. It has been observed through nursery and field work that application of fly ash in forestry is beneficial in terms of:

(i) It substitutes nursery bed material up to 66% with improved germination, shoot formation and quality of saplings.

(ii) Pit application substituting 50-66% of soil with fly ash improves survival rate, growth & vigour as well as wood formation. This is by virtue of high water holding capacity of fly ash as well as macro (K, P, Ca, Mg, S) and micro (Fe, Zn, Cu, Mn, Mo, B) nutrients available in fly ash.

(iii) Fly ash is a good amendment for poor soils. It initiates and supports biological activities.

(iv) Application of fly ash prevents termite attack.

Development of fly ash bricks with high fly ash content up to 80% through mineralization and more than 95% through geo-polymerization, development of fly ash composite materials and usages including metallurgical and ceramic applications are highlighted. Geo-polymerized fly ash with curing at ambient temperature is being demonstrated in field as a substitute of cement, the production of which emits large volumes of CO$_2$ and is energy intensive.

The last paper of the first technical session “Fly ash-based geopolymers for treatment of hazardous wastes” is presented by Ms. Richa Singh, Ph.D Scholar, IIT-Bombay. In her study, she explains that fly ash can replace the cement binder for solidification/ stabilization (S/S) in hazardous wastes treatment to immobilize the hazardous contaminants and removing moisture. Cement production requires high energy and emits large volumes of CO$_2$ that contribute around 8% of global CO$_2$ emissions. The geopolymer uses more fly ash than the conventional cement based S/S process. After assessing their mechanical, leaching, microstructural and mineralogical properties, the waste-geopolymer matrices can be
utilized as green construction materials or can be disposed into the secured landfills. The study reports fly ash as green sustainable binder instead of cement which in turn saves energy in production of cement.

**Technical Session II: Agriculture with Fly Ash: A Perspective**

Dr. R. Jagadeeshwar, Director of Research, PJTSAU chaired this session along with Dr. J. Satyanarayana, Dean of Agriculture, PJTSAU as co-chair. The session had seven presentations on use of fly ash in agriculture for production of crops like rice, groundnut, safflower, maize and in rice-wheat system and its effect on soil health, crop yield, nutritional value, etc.

The first paper of this session “Impact of fly ash on soil health and plant yield: A review” was presented by Dr. C.V. Patil, Former Director of Instructions (Agriculture), Department of Soil Science & Agricultural Chemistry, College of Agriculture, Raichur. He highlighted the properties of fly ash which makes fly ash suitable for agriculture purposes. Different crops produced with different level fly ash amendment in different agro-climatic conditions shows improved results for soil texture, water retention capacity, crop yield, growth, nutrients, saving of fertilizers, etc. Reclamation of the problematic sodic soils can be done by using fly ash. Fly ash holds potential to increase crop yield by 10-15 per cent besides improving soil health. Present utilization of fly ash in agriculture is < 2 %. It is proposed to increase to 10 % by 2025. Dr. C. V. Patil concluded that there is an ample scope for the safe utilization of fly ash in agriculture. Further, he added that farmers need to be made aware to use fly ash in their fields and thermal power plants, State agriculture universities & State agriculture department should join hands to promote fly ash utilization in agriculture.

Prof. P. Balasubramaniam, Head, Department of Soil Science & Agricultural Chemistry, Anil Dharmalingam College Agricultural College and Research Institute, Tiruchirappalli presented the next technical paper “Fly ash as a source of silicon and potassium for enhancing rice productivity in intensively Rice growing soils”. Dr. Balasubramaniam
investigated in Cauvery Delta Zone to delineate the status of soil Si, K and its release from soil applied with graded levels of fly ash with silicate solubilizing bacteria and farm yard manure and its effects on rice under submerged conditions in low, medium and high Si soils. The soil samples collected from Cauvery Delta Zone were processed and analysed for available Si and K. An incubation experiment was conducted by using sandy loam soil to study the effect of graded levels of fly ash with and without SSB and FYM on the release of Si and K under submerged condition.

The result shows that the soils of Cauvery Delta Zone of Tamil Nadu, south India reveals 62 per cent of soil samples were low in plant available soil silicon and 30.48 percent K status. The magnitude of Si release from fly ash was higher due to addition of SSB than FYM. The availability of Si in soil increased from 15th to 60th days after incubation (DAI) thereafter, slight decrease was noticed. A consistent increase of K release was observed up to 30th day after incubation thereafter a slight decrease of K was noticed. The highest grain and straw yield were obtained by addition of SSB + FYM. Among the graded levels, application of fly ash @ 25 t/ha recorded spectacular results. The maximum Si content was observed by application of fly ash @ 100 t/ha with SSB + FYM. Though, the similar findings were observed in Si content of grain and straw due to different treatments, the content of Si in straw was more than grain. The uptake of Si was accelerated with advancement of growth stages. Graded levels of fly ash correspondingly increased the uptake of Si. The application of fly ash @ 25 t/ha with SSB + FYM registered maximum uptake of Si. Similar to the content of Si in straw, the uptake of Si in straw was also greater than grain. Yield improvement of 22.1 per cent in low Si soil, 17.4 per cent in medium Si soil and 10.6 per cent in high Si soil was observed due to the application of fly ash @ 25 t/ha with SSB + FYM.

“Effect of fly ash application on yield and nutrients content of crops and water use efficiency under Rice-Wheat cropping system” was presented by Dr. S.K. Bansal, Director, Potash Research Institute of India, Gurgaon. Soil amended with pond fly ash with measured irrigation water is used in rice-wheat system. A seven year study showed that fine pond fly ash when incorporated 25t/ha in a highly percolating sandy loam soil increases the average grain yield of rice and wheat by 8-10% over the control. Rice and wheat grown in fly ash amended sandy loam soil required 14 to 17% and 14 to 20% less irrigation water respectively.
“Extraction and characterization of humic acid from coal for the differential application” was presented by Dr. T. Selvaraj, Assistant Professor (Soil Science), ICAR-KVK, TANUVAS, Kancheepuram. Humic acid is a reactive polyelectrolytic dark fraction usually extracted in alkaline solution, which are insoluble in acid medium. Dr. T. Selvaraj explained the method of extraction of humic acid from black coal from India as the raw material and characterized it. Transmission infrared (IR) spectroscopy, Fourier transformed (FTIR) or either dispersive has been used extensively in characterization of humic substances. The Bands indicative of aliphatic C-H, carboxyl and corboxylate functional groups, aromatic C=C, and C-O stretch of polysaccharides were prominent and very well resolved. He concluded that the chemical makeup and structure of the humic substances decide the optical properties. The optical density of the organic substances is directly proportional to their conjugated double bond content. It is expected that the application of DRIFT to organic-matter research will prove especially useful for characterizing bulky heterogeneous samples such as peat and composts.

“Nutritional quality of the agricultural crops produced from the fly ash amended soil” presented by Dr. Ananthan, Scientist D, National Institute of Nutrition. His study shows that the nutrient contents of food, blood characteristics of rats upon feeding of the food emanating from fly ash applied fields indicates that the toxicological effect of such food was not noticeable. Further, more studies are to be conducted in large number and scale for concrete evidence.

“Effect of growing media containing fly ash and press mud on growth and yield of Chrysanthemum variety Basanti” by Dr. Shilpa Shree K.G., Scientist (Soil Science), ICAR-Directorate of Floricultural Research, Pune. Growing media is important for plant growth and quality, therefore it should be selected carefully. Here, fly ash and press mud is used as they contains considerable amounts of macro and micronutrients. These amendments are used in different proportions to grow Chrysanthemum. The results of different ratios of fly ash with other potting mixtures to raise chrysanthemum was encouraging to employ fly ash for potting. Out of all the media of fly ash, press mud, ccopeat and vermicompost in proportion 12.5:37.5:25:25 witnessed higher plant height, plant spread, number of primary and secondary branches, number of leaves and number of buds per plant and nutrient concentration. She said use of fly ash and press mud as growing media substrates not only ensures their safe disposal but also provide better utilization of these by-products as an input in nursery industry.
Dr. V. Girija Veni, Scientist (Soil Science), ICAR-CRIDA, Hyderabad presented the last paper of the session “Review on zeolite synthesis from fly ash: A best alternative towards productive use of fly ash”. Zeolites are naturally occurring aluminosilicates. They possess a typical structure with extensive micropore structure developed by framework of silicon and aluminum oxygen tetrahedrons. Formation of zeolite takes time which otherwise can be easily synthesized in laboratory using raw materials such as fly ash, rice husk, etc. Different types of zeolites can be produced with fly ash as raw material. She also informed that the National Environmental Engineering Research Institute (NEERI), Nagpur have formulated process for synthesis of pur zeolite phases of A and Y from fly ash and it got patented. Dr. Girija explained that the various type of zeolite obtained depends on the methodology used and optimal conditions maintained. Processes for zeolite synthesis are ultrasonic treatment, sonication and conventional hydrothermal method, alkali hydrothermal method, modified two-step hydrothermal method, introduced alkaline fusion step prior to the refluxing treatment, NaOH +100°C temperature and alkali-dissolving hydrothermal synthesis method. The synthesis of zeolite from fly ash is efficient way to reuse fly ash. This synthesis adds value to the fly ash.

Technical Session III: Forestry With Fly Ash: A Perspective

This session was chaired by Dr. R.B.S. Rawat, Former PCCF (HoFF), Uttarakhand & Director, C-FARM and co-chaired by Dr. T. Pradeep, Director (Seed), PJTSAU. Six technical papers were presented during the session.

“Impact of coal fly ash on forest plantations and nursery” was presented by Dr. Dinesh Goyal, Former Executive Director, STEP, Thapar University, Patiala. Nursery trials on Eucalyptus tereticornis and field trials on Acacia and Casuarina were conducted on 10 and 20 acre lands comprising of degraded land over eight years and analyzed further to see its impact on these plants. Coal fly ash was found to be a useful soil ameliorant which improves physical, chemical and biological properties of problematic soils alongwith supplementing macro and micronutrients to the soil. Fly ash, field soil and fly ash amended rhizosphere soil were chemically analyzed for metal content and nutrient status. N, P, K and S were found to fall within the range commonly found in the normal agricultural soil i.e. 0.01-1.0%, 0.005-0.2%, 0.04-3%, 0.01-2%, respectively. Trace
elements like As, Se and Mo were found much below their permissible limits. Heavy metals like Fe, Cr, Ni, Zn and Pb were within the normal range of 0.7-55 %, 5-3000 ppm, 10-1000 ppm, 10-300 ppm, 2-100 ppm respectively. Almost 40-50% chemical fertilizer can also be saved if 10% fly ash is mixed in soil.

Dr. Goyal emphasized that fly ash plays a positive role in plant growth at an optimum concentration of 12 – 18% and can be used as a secondary source of essential plant nutrients in plantation crops without causing any negative effect on soil health. In conjunction with organic manure and microbial inoculants, fly ash was found to enhance biomass production in the degraded lands. Fly ash at 10-20% (v/v) could be used as a good potting mix material in forestry nurseries to produce hardy seedlings in lesser time without any inputs such as chemical fertilizers farm yard manure etc.

“Forestry intervention for fly ash pond and degraded land area of thermal power station” was presented by Ms. Ruby Kujur, Scientist C, Institute of Forest Productivity (IFP), Ranchi. She elaborated on how IFP attempted to restore the abandoned ash pond and nearby degraded areas in and around Chandrapura Thermal Power Station, DVC which were soil moisture deficient, barely having fertile top soil, devoid of any vegetation and particulate matter causing air pollution.

The degraded land area of DVC, Chandrapura thermal power plant was successfully afforested by use of fly ash along with other amendments. The survival rate of the seedlings was found to be high (78.2%). She added that one and half years growth of Dalbergia sissoo, Delonix regia and Gmelina arborea on fly ash was much better. Among the 12 species planted during 2009 Acacia mangium, Albizia ordoretissima, Delonix regia, Eucalyptus hybrid and Gmelina arborea performed much better. After three years with continuous monitoring and taking remedial measure to the survival and growth of the plantation, a lush green landscape had appeared over the once barren land. Ms. Ruby Kujur concluded that afforestation of fly ash pond and nearby degraded areas can be done with proper care of the planted seedlings and amending the site pit with required materials with respect to the site characteristics.

Dr. Gurdeep Singh, Former VC, Vinoba Bhave University, Hazaribagh presented his paper “Use of fly ash for rejuvenation of mine waste spoil dumps and degraded lands” Dr. Singh presented eight case studies undertaken by various R&D institutes in the states
during the last two decades on fly ash utilizations for reclamation of low lying areas, reclamation of saline and sodic soils as well as other problematic soil and bio-reclamation of abandoned ash ponds. Dr. Gurdeep Singh said that studies on impact of soil health in terms of macro and micro nutrient availability as well as biological parameters indicated good impact. He mentioned that application of fly ash reduces fertilizer, lime/ gypsum and irrigation water requirement which also reduces costs of cultivation. He cited that parameters such as survival rate, height and girth of the plant of various species grown with fly ash are significantly improved as compared to control. Effects have also been observed with fly ash and organic matter, which not only improves the soil quality but also promotes the plant growth. The results from the field demonstration sites exhibit that fly ash could be an excellent soil conditioner/ ameliorant which could help in restoration of degraded land into arable land. Such areas could be used for forestry species or agriculture purposes.

“This Case study: Use of fly ash in forest nursery and plantation at Cuttack Forest Division” was presented by Dr. Vimal Kumar (Former Mission Director & Head, Fly Ash, DST, GoI), Secretary General, C-FARM, New Delhi. He started with overview of fly ash and its properties. Fly ash contains almost all the macro and micro nutrients and also has higher water absorption capacity, percolation rate, aeration and low density as compared to soils. In his presentation he elaborated on effect of fly ash in forest nursery, on soil fertility and development and growth of forest by use of fly ash in Cuttack forest range. *Acacia mangium*, *Emblica officinalis*, *Pongamia pinnata* and *Dalbergia sissoo* were taken up in the nursery at Angul and *Tectona grandis* at Sukinda Range of Cuttack Forest Division, Odisha. The grade of teak saplings which is the major criteria from its economic point of view has been observed to have increased by 20-25% over control.

Plantation taken up during 2009 at Tamka Range, Cuttack Forest Division, Odisha with *Tectona grandis* (Teak), *Acacia auriculiformis* (Wattle), *Peltophorum pterocarpum* (Radha chura), *Alstonia scholaris* (Chhattiyan), *Pongamia pinnata* (Karanj), *Dalbergia sissoo* (Shisham), *Emblica officinalis* (Anwla) and *Dendrocalamus strictus* (Bamboo) had 3 treatments, 0% fly ash, 25% fly ash and 50% fly ash.

Fly ash treatments supported significantly higher survival rate and biomass production during the studies. The incorporation of fly ash at 25-50% level, led to significant increase in shoot height, collar girth and number of branches per plant. Periodical
analyses of soil and plant parts indicated no adverse impact of heavy/toxic elements as well as radio nuclides.

Analytical results of heavy/toxic elements of over 2500 samples from agriculture sites using fly ash as well as a biological study at National Institute of Nutrition (NIN), Hyderabad under supervision of Indian Council of Medical Research (ICMR), Ministry of Health, Government of India wherein rat and mice were fed with food grown on fly ash treated soils with control group of animals fed with food grown on common soils indicated no significant negative impact. Animals were sacrificed; blood and organs were tested including brain, liver, etc. Indian fly ashes are quite safe for use in agriculture and forestry. Dr. Kumar suggested that scientific data on these aspects should be continued to be collected on regular basis at least in the major projects to have more validations and confidence building.

He mentioned that there is a wide scope for use of fly ash as a nursery bed material by substituting soil/sand up to 50 to 70% for nursery raising as well as for forestry plantations in addition to reclamation of waste/degraded forest lands. Enhancement of growth of tree species, reduced irrigation and fertilizer requirement are other benefits. Also it promotes large amount of carbon capturing in plants, in order to provide a more sustainable environment.

The next paper “Smart fly ash pesticides: Towards pesticides free agriculture, store godowns, forestry and urban habitations” was presented by Prof. P. Narayanasamy, Former Dean, Agriculture, Annamalai University. In his presentation, he explained that fly ash dust material could be the powerful pest killer surpassing the chemical pesticides in various crop plants. Fly ash dusts having less than 50 microns diameter were the best entity to effect highest control of the pests and their suitability to adhere firmly to the body surface of the insects and the plant canopy. Silicon dioxide (SiO₂) the major constituent of the fly ash plays its killing potential against the pests by denuding the feeding organs ultimately rendering them unfit for feeding. Fly ash was also found to be an active carrier material in the synthesis of chemical and herbal insecticides. Fly ash based chemical insecticides are highly effective against sucking and chewing/boring insect pests in rice. Fly ash based herbal are found to be effective on all pests in vegetables. Fly ash based Mycoinsecticide 50% WDP and Ultra-structured fly ash
particles based insecticides are also developed. Termiticides are also developed using fly ash.

He concluded that since annual consumption of pesticides is high around 45,619 tons, variety of fly ash based pesticides can be utilized. He recommended that Government should take steps to promote fly ash pesticides, give importance to high value-added fly ash based pesticides like mycoinsecitcides etc. through demonstrations and other awareness building measures, setting up pilot / demonstration cum production plans, provide technical support and collaboration with reputed R & D Institutions, evolving institutional arrangements for coordinating matters related to fly ash dust pesticides.

Dr. S. Sithanantham, Director, Sun Agro Biotech Research Centre, Chennai presented a technical paper “Fly ash: A potential future green tool for insect pest management in agriculture”. He said fly ash could be utilized as a pesticide and a carrier in insecticide formulation. The potential for fly ash, as silica source, could also be explored for their utility in tolerance/resistance to other biotic stresses. Higher Silica content in genetically resistant genotypes of crops plays a role in expressing resistance of plants to insect herbivores and therefore, fly ash is applied as a source of silica to withstand the damage to the crops as boring and defoliating actions due to caterpillar pests. It could also serve as a carrier for repellant or slow release formulations for insecticidal molecules against key insect pests of livestock and household. Fly ash could be used protect crops from new invading species like Fall Army worm, a recently invading pest on maize in South India.

He recommended supporting multi-disciplinary R&D towards the development of appropriate commercial products based on fly ash to cater to these diverse potential needs relating to insect pest management, besides crop protection against other biotic stresses. There is good scope to evolve win-win models of public-private R&D partnerships towards this goal.

Technical Session IV: Prospects of Use of Fly Ash in Mining

Five technical papers were presented consisting application of fly ash in back fillinf of opencast mines, underground mines and stabilization of OB dumps. The session on was
The first paper “An Overview: Use of fly ash in mining sector” was presented by Dr. Vimal Kumar, Former Mission Director, GoI & Secretary General, C-FARM, New Delhi. He highlighted a range of gainful applications of fly ash in mining sector. It included stowing of fly ash/ bottom ash/ pond ash in the underground mines, use of fly ash props for roof support, use of fly ash bricks/ blocks for construction of ventilation walls, support walls, isolation walls as well as other constructions in the underground mines. In opencast mines, the promising application of fly ash are: reclamation of opencast pits, back filling of opencast mines with fly ash and OB, stabilization of external OB dumps, construction of haul roads, construction of drainage systems, etc. In addition, fly ash has ample scope for use in construction as well as maintenance of office and housing complexes as well as bioremediation of mine spoil dumps. The technical aspects as well as case studies are illustrated. The environmental aspects as well as economics and viability including social aspects are also deliberated.

Second paper “Fly ash utilization in SCCL coal mines - Sustainability” was presented by Shri Shaik Madar, Additional Manager, Singareni Collieries Company Limited. SCCL has been operating 28 underground mines and 18 opencast mines located in 6 Districts of Telangana State. Technologies developed in SCCL for recovery from underground and opencast mines were explained. The final void left after extraction of coal can be filled using fly ash. SCCL proposes to fill the final voids of Medapalli Opencast coal mine of Ramagundam with fly ash from Ramagundam Super Thermal Power Station of NTPC. The precautions to be taken for filling activity were also mentioned. In India, mining of coal with stowing is being practiced for several decades primarily for safety and conservation. Stowing of underground mines can be done by sand and bottom ash. Nowadays, with the developing technology bottom ash is used as stowing material in mines. Bottom ash is lighter than sand and hence, requires less energy in transportation.

Mr. Md. Fazal Hussain, Additional Manager (R&D), SCCL presented the next paper “Efforts of SCCL in the gainful utilization of fly ash generated from STPP and other nearby thermal power plants”. SCCL used river sand for stowing in mines since beginning. In 1993, SCCL started putting efforts for use of ash from NTPC Ramagundam in stowing operations at GDK 3 Incline and GDK 1 Incline underground mines by mixing
50% fly ash with 50% sand with the technical assistance of CIMFR. Before using ash in stowing, Laboratory studies were carried out by CIMFR, Dhanbad to determine physical and chemical characteristics of ash and its suitability for using in underground stowing. This revealed that bottom ash can be used in underground stowing without any adverse impact on environment and safety. Pond ash of Heavy Water Plant, Manuguru used in the trial at PK 1 Incline. The experience established that ash with +53micron size is suitable for stowing in underground voids on large scale successfully. He cited that till September 2019, about 72.80 lakh cum of bottom ash was stowed in various underground mines of SCCL.

He also emphasized that SCCL is using fly ash bricks in civil construction works. A fly ash brick manufacturing unit is established in the vicinity of project site. The obtained fly ash from the power plant is effectively being processed for the manufacture of bricks, block tiles and other fly ash based products. In the last three years it has used 367 lakh no. of fly ash bricks in various areas in surface constructions as well as underground works. SCCL received National Award for the Fly Ash Utilization 2004-05 jointly awarded by Ministry of Power, Ministry of Environment & Forests and Department of Science & Technology. Finally, he said that SCCL could utilize 91% of ash generated in 2017-18 and 102% of generated in 2018-19 from STPP and taking bottom ash from nearby Thermal Power Plants for using in stowing operations.

The next paper “Conditions of extraction of pillars with sand and ash as backfilling materials vis-à-vis electronic instrumentation for evaluation of load on supports in underground coal mines” was presented by Prof. Singam Jayanthu, Professor, NIT-Rourkela. Prof. Jayanthu highlighted the major concern of mining industry that is unavailability of river sand for mine backfilling which also emphasized on development of alternative material to sand. Through experimentation, fly ash was proved to be the back filling material to replace sand which is present in abundance. He said that excavation of underground minerals causes disturbance in earth surface and could create ground subsidence problems and this problem can be countered by fly ash backfilling or sand stowing techniques. It requires meticulous monitoring of strata and support behaviour in addition to the environmental effect of the system of fly ash backfilling. For backfilling, the mine strata need to be supported by means of artificial support systems. The type of instruments for monitoring the strata behaviour and methods of pillar extraction and backfilling were explained.
Improved technology of mining/instrumentation, numerical models - computer applications for analysis of data may lead to possibility of modification in existing practices for better safety and economy of mining venture.

Prof. Singam Jayanthu concluded that increasing trend of utilization of coal for thermal power generation and production of fly ash emphasizes the urgent need of further studies through latest techniques of application surpassing the problems faced in the experimental trial and meticulous monitoring of strata/support behaviour through WSN, IoT applications etc.

Prof. Singam Jayanthu, Professor, NIT, Rourkela presented his next technical paper “Geotechnical studies on stabilization of OB dumps admixtured with fly ash in opencast coal mines – A successful experimental trial” which aims to determine stability of overburden dump formed by the utilization of fly ash in opencast coal mine at Jindal Power Limited, Tamnar, Raigarh, India. NIT-Rourkela conducted field investigations, and laboratory studies. Here, fly ash was being used at JPL along with overburden material for backfilling in the mine as per the DGMS guidelines. Samples are tested for different geotechnical investigations like grain size distribution, specific gravity, compaction characteristics and shear strength characteristics. The stability of dumped slope is analyzed by PLAXIS software, Version 9 using the geotechnical parameters. The results showed that slope stability of the overburden dump after mixing of fly ash, it was observed that on the application of 25% fly ash mixture safety factor has increased to 1.78 and this overburden does satisfy the minimum requirement and can be used along with the fly ash. He concluded that gap between fly ash generation and utilization indicates urgent need of efforts from concerned agencies for reducing this gap of about 110 million tonne of fly ash. It is recommended to undertake experimental studies for mass utilization of fly ash admixture in the OB dumps.

Technical Session V – Adaptation of Emerging Technologies in Construction Industry (Part-1)

The Technical Session V regarding use of fly ash in construction was chaired by Dr. Vimal Kumar, Former Mission Director & Head, Fly Ash Unit, DST, GOI & Secretary
General, C-FARM, New Delhi along with Sri John Peter, Architect, CPWD Region, Hyderabad as co-chair. Five technical papers were presented during the session.

The paper “Fly ash for sustainable high performance concrete” was presented by Dr. N. Bhanumathidas, Director General, INSWAREB, Visakhapatnam. High performance concrete advocates to use less cement but more cementitious input towards densification, increased strength and service life with simultaneous service to ecology and environment. Cementitious inputs like fly ash gained significance for durability. She said that the knowledge of fly ash, as pozzolanic input for cement and micro-aggregate in concrete for improving the engineering performance and durability, is not adequately percolated in academia and construction segment.

Mr. Mude Hanuman Naik, Research Scholar, IIT – Hyderabad presented the paper “Lime activation of siliceous fly ash at very high levels of cement replacement”. about replacement of cement with fly ash in concrete. His paper covered that fly ash is capable to enhance the long-term properties of concrete when used as cement replacement in proper quantities. It was shown that strength gain in concrete is related to the depletion of lime in the system, which is directly influenced by silica from by fly ash. The dissolution of Silica and Alumina from fly ash is the rate limiting step that controls the early rate of reaction and strength gain. Using quick lime, the optimal level of fly ash replacement could be determined based on reactive silica.

His study showed positive results that lime is effective in producing Calcium Hydroxide in the system that directly influences the compressive strength of concrete. Fly ash with reactive Silica of 13% can be used to produce concrete with target mean strength of 35 MPa at 70% replacement with lime activation. The findings indicate that there is a possibility of producing ultra-high volume fly ash concrete with a target strength using quick lime activation.

The next paper was presented by Dr. B. K. Rao, Professor, KL (Deemed to be) University, Vaddeswaram “Fly ash in different concretes and in different environment”. Dr. B. K. Rao explained the characteristics of two types of fly ashes and their influence on fresh and hardened concretes, the durability of concretes with addition of fly ash in different aggressive environments, the compatibility of fly ash concretes with different chemical admixtures and effect of fly ash on the properties of concrete was also
discussed. Fly ash has many advantages over ordinary portland cement to be used in concretes. Different ways of concrete mix design using fly ash are available Simple Replacement Method, Addition Method, Modified Replacement Method and Rational Proportioning Approach (Efficiency Factor Method). were also presented. He observed that the percentage replacement of cement with fly ash, without affecting the strength, varies with the water-cement ratio. The percentage replacement of cement with fly ash is higher inversely proportional to water-cement ratios. The fly ash acts as a pore-filling material. At the end, the different areas of applications of fly ash concrete were also discussed.

The paper “Optimization of fly ash fineness – Towards sustainable solution for fly ash utilization in cement industry” was presented by Mr. Suresh Vanguri, Deputy, Manager (CRT/CQC), NCCBM, Hyderabad. Cement is the major industrial sector for large scale fly ash utilization. His paper shows that the properties of fly ash can be tailored for achieving a higher value addition to the product. Mechanical activation is an effective and economical technique to enhance the fly ash characteristics as mechanical activation alters the physico-chemical properties of fly ash such as particle size distribution, surface area, surface energy, phase morphology. SEM studies explained the grinding of fly ash to higher degree resulted in disruption of spherical particles and thus increased the water demand for flow of the mortar, which may cause the decrease in the mechanical properties. Up to fineness of 400m$^2$/kg, mechanical properties of fly ash were increased after this there is only little improvement. He said that studies on the mechanical properties of PPC blends prepared using activated fly ash samples, indicated that the grinding of fly ash to higher fineness levels may not be a optimum solution to enhance the utilization of fly ash.

Mr. A. Venkateswara Rao, Associate Professor, KL (Deemed to be) University, Vijayawada presented “Effect of temperature on behaviour of fly ash concrete” about the effect on compressive strength and split tensile strength of fly ash concrete at different temperatures. He used concrete cubes that were cast by cement replaced by 30%, 40% and 50% fly ash and cured for 28 days, dried and exposed to different temperatures. The temperature ranged from 100$^\circ$C to 500$^\circ$C. He finally observed that with increase in temperature up to 300$^\circ$C, the residual compressive strength of concrete increased. But at a particular temperature, compared to that with concrete without fly ash, both the residual compressive strength residual split tensile strength increased for concrete with 30% fly ash replacement while for 40% and 50% fly ash the values are decreased. The
deterioration of concrete and temperature is proportionally related to each other. There was no sign of crack formation up to the temperature of 500°C. Based on his investigation, he concluded that replacement of cement with 30% of fly ash in concrete is preferable for structures designed for temperatures exposed to 300°C.

Technical Session VI – Adaptation of Emerging Technologies in Construction Industry (Part-II)

Five papers were presented in this session. The session was chaired by Dr. Vimal Kumar, Former Mission Director & Head, Fly Ash Unit, DST, GOI & Secretary General, C-FARM, New Delhi

Mr. Lalit Kumar, Deputy Manager, NCCBM, Ballabgarh presented the first paper “Field utilization of fly ash and slag based geopolymer concrete in precast products” of this session. He presented the development of alternative binding material to concrete in form of alkali activated concrete. The alkali activated concrete made from fly ash would be environment friendly, greener and sustainable alternative to the conventional concrete. This could also help in optimization of cost as well as effect on workability and strength of the mixes by selecting a proper activator modulus. The process and reactions for development of alkali activated concrete were explained. He also quoted some examples of structures constructed by geopolymerized fly ash concrete. He analyzed that with little modifications in testing, development and usage methodology, precast plain alkali activated products could be used as a substitute as well as supplement/compliment to conventional concrete products. He also mentioned that BIS has issued draft guidelines for production of alkali activated concrete.

The second paper presented by Mr. N. Kalidas, Director, INSWAREB, Visakhapatnam was “Nano concrete aggregate”. The nano concrete is no-aggregate concrete (NAC) means concrete without sand and stone which is claimed to be invented by Mr. N. Kalidas and Dr. Bhanumathidas in 2010 of INSWAREB. The depletion of natural stone encourage the use of alternate materials mostly which are industrial wastes and NAC is one of them. NAC is considered as a source of artificial aggregate that can serve high performance concretes by rendering better engineering properties. Nano concrete aggregate (NACA) gives higher strength (56 MPa) compared to conventional concrete.
(28 MPa). The only known form of aggregate produced from fly ash was in the form of Sintered Light Weight Aggregate (SLWA) against which Nano Concrete Aggregate (NACA) is much superior and energy-free. The cost of manufacturing and projections for its market were also discussed. The concrete with NACA is acceptable for structural application since it behaves closer to that of Natural Stone Aggregate.

Mr. Anvit Gadkar, Graduate Assistant, IIT – Hyderabad presented the next paper “Self-leveling high strength geopolymer concrete: Production and application”. He explained why and how geopolymer concrete is formed with its applications. There is lot of infrastructural development happening all over the world that requires cement and cement production involves large amount of CO2 emission. The sustainable solution in the form of alternate binders for use in construction is geopolymers, an inorganic polymer composite. Geopolymer concrete is made with fly ash powder and activators which are optimized based on the fly ash composition to achieve the required strength. Geopolymer concrete is achieved by mixing the geopolymeric binder with aggregate in the right proportion to achieve self-leveling property and high compressive strength through optimized packing. In this, the binder consisting of fly ash with the activators, was varied between 30 to 40% of the volume of the concrete. The compressive strength achieved ultimately was 60-70 MPa from the concrete by 14 days.

The next paper “Manufacturing and cost economics of Crusher dust based Fly ash bricks” was presented by Dr. S. M. Mustakim, Principal Scientist, CSIR-IMMT, Bhubaneswar. His paper explained the mineral cementation that is energy efficient and green sustainable process to manufacture cold setting building bricks and its cost economics. Presently, Portland cement or hydrated lime and gypsum is used as binder to manufacture fly ash bricks but these have certain limitations. The major advantage of mineral cementation process is that it could use all kinds of ash of both pozzolanic and non-pozzolanic nature and reduces cost. He concluded that the crusher dust based ash brick can be manufactured (up to 40% crusher dust) along with Fly ash and binding material and the cost economics calculation showed that the payback period for a brick plant of production capacity of 6,000 bricks per day is approximately 3-4 years.

The last paper of the session was presented by Mr. C. N. Suresh, SE, CPWD, Warangal “Use of fly ash as construction material in CPWD” which includes applications of fly ash in CPWD. As CPWD is a premier construction agency of Government of India under
MoHUA, it has a wide scope of utilizing fly ash in construction and CPWD also use it in its different construction projects. CPWD has taken steps to use fly ash in construction. CPWD has published “Guidelines for sustainable habitat” in 2014 which included guidelines on use of fly ash. CPWD issued circulars and instructions to utilize fly ash in construction works throughout India to achieve the goal of sustainable development. Consistent endeavour of CPWD has caused the meaningful outcome to utilize fly ash as desired. The major applications of fly ash in CPWD were explained. CPWD uses fly ash in concrete, bricks/ blocks, filling low lying areas and roads & embankments. CPWD is consuming on an average of 3,18,000 tonne of fly ash per year.

VALEDICTORY SESSION

Hon’ble Minister for Agriculture of Telangana, Shri Singireddy Niranjan Reddy was the Chief Guest of the valedictory Session. Dr. R.B.S. Rawat, Former PCCF(HoFF), Uttarakhand & Director, C-FARM; Dr. D. Rama Rao, Former Director, NAARM; Emeritus Scientist, PJTSAU & Director, C-FARM, Dr. R. Jagadeeshwar, Director of Research, PJTSAU, Hyderabad and Dr. Vimal Kumar (Former Mission Director & Head, Fly Ash Unit, DST, GoI), Secretary General, C-FARM were the panel members.

The Valedictory Session started with presentation of overview of the Technical Sessions by Dr. Vimal Kumar (Former Mission Director & Head, Fly Ash Unit, DST, GoI), Secretary General, C-FARM.

Dr. R.B.S. Rawat, Former PCCF(HoFF), Uttarakhand & Director, C-FARM and Dr. D. Rama Rao, Former Director, NAARM; Emeritus Scientist, PJTSAU & Director, C-FARM highlighted the importance and scope of fly ash utilization in various sectors and also suggested that this important and abundant resource generated by thermal power plants be used on large scale and be inducted as a subject in the universities. Intensive
floor interactions took place among the participants and the learned panelists and other experts.

The 2 Day National Conference was concluded with an address of the Chief Guest, the Hon’ble Minister for Agriculture of Telangana, Shri Singireddy Niranjan Reddy. He congratulated C-FARM and PJTSAU for organizing and conducting the National Conference on such an important theme. He said that fly ash is a resource material for different sectors like agriculture, mining, construction, etc. so why to waste it and also cited some examples. Fly ash generated at high rates causes problem in its disposal and other environmental issues, if it’s not used. Since many studies have been conducted and technologies have been developed showcasing its beneficial impacts in different sectors, it should be utilized on large scale without any fear. The Hon’ble Minister advised the Vice Chancellor of PJTSAU to include fly ash research and field applications including extension work with farmers and KVKs in the programs and activities of the university.

The panel discussions, deliberations and floor interactions concluded with the following recommendations:

A. CURRENT STATUS AND RECAP:

1. Fly ash has been proved to a resource material for various applications including agriculture, forestry, construction, mine filling, waste land development, manufacture of value added high tech products, composites and also an effluent treatment agent.

   The fly ash utilization level in the country has reach to more than 65% (160 MnT) of its annual generation of 260 MnT.
2. Beneficial Impact of use of fly ash can be enhanced significantly by increasing its utilization to 100% and also by optimizing its allocation to different utilization applications. The current utilization has resulted in benefits at the following level:

   a. Environmental Impact
      - Reduction of CO$_2$ emission by 80 Mtpa
      - Conservation of 110 Mt lime stone and 50 Mt coal per year
      - Conservation of 20,000 Ha land per year
      - Conservation of 1,000 Mm$^3$ water per year
      - Conservation of 3 Mt sand

   b. Business and Employment Generation
      - 55 Mt additional cement production per year with half the investment, half the gestation time and half the cost
      - 3 billion fly ash bricks are produced per year
      - 30 million clay-fly ash bricks are produced per year
      - Transportation of 135 Mt fly ash per year i.e., 40,000 truck trips per day
      - Employment generation for more than 1 million people.
      - Economic value of business developed is more than Rs. 30,000 crore per year

3. Notification of MoEF&CC as well as State Governments orders are in place for large scale utilization of fly ash and even mandatory use in building construction, road construction, reclamation of low lying areas and mine filling as well as free delivery of fly ash to farmers fields by thermal power plants. Most of the utilization of fly ash in construction are included in the Schedule of Rates (SR) of CPWD and most of PWDs.

4. Main impetus was provided to fly ash through Fly Ash Mission (FAM), commissioned during mid 1990s when fly ash generation was 40 MnT/year and utilization was practically NIL. FAM is implemented by Department of Science and Technology (DST) as the Nodal Agency through its autonomous body Technology Information, Forecasting and Assessment Council (TIFAC) in close association with Ministry of
Power (MoP) and Ministry of Environment and Forest (MoEF) now, MoEFCC and with participation of all stakeholder agencies from R&D, academia, industry, NGOs and the Government bodies. The functions of FAM were rechristened as “Fly Ash Utilization Program (FAUP), TIFAC” during 2003 and thereafter in 2008 as “Fly Ash Unit (FAU), DST”. FAU, DST functioned till 2013-2014.

B. ACTION ORIENTED RECOMMENDATIONS:

5. The unutilized fly ash is generally at thermal power plants located near mine heads or otherwise in remote locations. The directives of MoEF&CC notifications for mandatory use of fly ash in mine filling, low lying areas reclamation and free of cost supply to farmers’ place be implemented. The concerned regulatory and monitoring agencies as identified in MoEF&CC notifications may take appropriate action.

6. The mandatory use of fly ash based products in all constructions with 300 km of a thermal power plant as well as for road construction and reclamation of low lying areas be implemented scrupulously.

7. MoEF&CC notifications shall prevail. Various committees/ bodies may refrain from giving directions on fly ash utilization that are contradictory to the notifications, unless it is very essential in certain specific cases, that may be elaborated.

8. Percentage use of fly ash in cement and in concrete may be increased to 50% as against prevailing 35%. Sufficient scientific data exists nationally as well as internationally.

9. The percentage of fly ash in cement or concrete for roller compacted concretes be increased up to 65%.

10. Fast track evaluation, approval and field applications be taken up for high volume fly ash utilizations like polymerized fly ash concrete, self compacting polymerized fly ash concrete, light weight polymerized fly ash concrete, high performance fly ash concrete, nano-fly ash concrete/
aggregates, fly ash composite materials and fly ash bricks with 75% and more ash content.

11. Fly ash based composite materials perfected recently that are economically viable, durable, resistant to weather, corrosion, water fire resistant, self extinguishing nature as well as termite and fungus free be evaluated, approved and accepted for large scale use.

12. Farmers, KVKs, State Agriculture Departments and field staff as well as Forest Departments be reached out and awareness created about use of fly ash in agriculture, forestry and wasteland reclamation as well as about the notification of MoEF&CC regarding free supply of fly ash to farmers’ fields. Training programs be also organized on regular basis for the farmers on the subject.

13. The monitoring and statutory bodies may ensure that all mine owners use fly ash in external as well as internal dumps/ benches of OB as mandated by MoEF&CC notifications.

14. Professor Jayashankar Telangana State Agriculture University (PJTSAU) may initiate research and academic activities/ programs for the area of use of fly ash in agriculture, forestry and wasteland development.

15. Fly ash processing/ beneficiation/ classification may be done for value addition and maximization/ optimization of its use.

16. R&D, training programs, seminars/ conferences, etc.may be supported on regular basis by the thermal power plants as well as State and Centre Governments.

17. Subject of fly ash be inducted in academic curriculum of all relevant areas including material sciences and chemistry.

18. Single point agency may be established/ identified to address to all multidisciplinary aspects spread across various Ministries & Departments as well as industrial sectors.

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