RECOMMENDATIONS

ONE DAY WORKSHOP
ON
USE OF FLY ASH AND CONSTRUCTION & DEMOLITION PRODUCTS FOR SUSTAINABLE CONSTRUCTION
21st JANUARY, 2020
NEW CUSTOM HOUSE, BALLARD ESTATE, MUMBAI

ORGANIZED BY

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

CENTRAL PUBLIC WORKS DEPARTMENT
FOREWORD

Fly ash, a residue of burning of coal in thermal power stations is increasing day by day posing serious challenge to the environment in spite of development of a large number of its applications in different sectors including construction industry. Use of C&D based products is the new area. Utilization of fly ash and C&D based products in construction industry is a way forwards for sustainable development and eco-friendly construction. It is necessary to disseminate the knowledge on these important issues and their large scale adaptation.

C-FARM and CPWD jointly took initiative to spread the knowledge, share the experiences and various technologies developed for utilization of fly ash and C&D waste through the One Day Workshop organized at Mumbai. The recommendations of the One Day Workshop are important and can make a significant and valuable impact on the development and management of fly ash and C&D based products applications.

I am glad that the issue has been successfully deliberated in the workshop and the recommendations of the One Day Workshop would help to set up the new heights in utilization of fly ash and C&D based products.

S.J. Sibal

Place: New Delhi
Date: July, 2020
CENTRE FOR FLY ASH RESEARCH & MANAGEMENT (C-FARM)

Dr. Vimal Kumar
Secretary General
[Former Mission Director & Head, Fly Ash Unit, DST, Gov]
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Email: dr.vimal.kumar@gmail.com

ACKNOWLEDGEMENT

One Day Workshop on “Use of Fly Ash and Construction & Demolition Products for Sustainable Construction” organized at New Custom House, Mumbai by Centre for Fly ash Research and Management (C-FARM) and Central Public Works Department (CPWD) on 21st January, 2020 was a great success with overwhelming response. The address by the eminent senior personnel and industry during the Inaugural Session and participation of all stakeholder groups in the proceedings and deliberations enriched the take away so. I thank all the participants, speakers and exhibitors for their valuable contributions.

I am also grateful to the Directors of C-FARM and Senior officials of CPWD for the guidance, inspiration and constructive suggestions for successful planning and conduct the workshop.

I also thank my colleagues from C-FARM, volunteers from CPWD as well as staff and officers of New Custom House, Mumbai who have contributed significantly to the success of the Workshop as well as the sponsors and the associates of the workshop.

(Vimal Kumar)
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One Day Workshop on Use of Fly Ash and Construction & Demolition Products for Sustainable Construction

### PROGRAM

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**Floor Interaction**
13:15 – 14:00 Hrs  LUNCH
14:00 - 15:45 Hrs  TECHNICAL SESSION-II:

**Use of C&D Material in Construction of Buildings, Roads and Infrastructure Projects: Technologies, Policies and Case Studies**

**Chairman** : Shri Govind Sharan, Former DG (Roads Dev.), Former Special Secretary, MoRTH and Director, C-FARM

**Co-Chair** : Shri Lorengob Dung Dung, CE, Mumbai-I, CPWD

- “A Sustainable Approach Towards the C&D Waste” by Shri Shishir Bansal, CE cum ED, CPWD, Leh - Presentation by Dr. Vimal Kumar, Former Mission Director, Fly Ash, GoI & Secretary General, C-FARM, New Delhi
- Presentation by Ms. Anjali Shirke, CE (SWM Project), MCGM
- “Building a Sustainable Future Together: Recycling Concrete from Construction Debris” by Shri Abhijit Gawde, Head, Business Development & Marketing, Godrej Construction Ltd.
- “A Way Forward for Sustainable Applications of C & D Waste Products in Construction” by Prof. S. K. Singh, Sr. Principal Scientist, AcSIR, CSIR-CBRI, Roorkee and Ms. S. K. Kirthika
- “Use of Fly Ash and C&D Waste Products for Sustainable Construction of IIT-Gandhinagar Campus” by Shri Manu Mittal, SE; Shri Roop Singh, EE, CPWD and Mr. Anil Mittal, AEE, CPWD

**Floor Interaction**

15:45 – 16:30 Hrs  CONCLUDING SESSION

**Chairperson** : Smt. Usha Batra, Special DG, CPWD

**Co-Chair** : Shri R. D. Gupta, Former Director, NTPC & Member UPERC and Director, C-FARM

- Summary of Technical Sessions by Dr. Vimal Kumar, Former Mission Director, Fly Ash, GoI & Secretary General, C-FARM, New Delhi
- **Panel discussion**
  
  Panel Members:
  - Shri K. N. Agrawal, Former DG, CPWD & Director, C-FARM
  - Dr. R.B.S. Rawat, Former PCCF (HoFF), Uttarakhand & Director, C-FARM
  - Shri Anil Kumar Pandit, ADG (Region Mumbai), CPWD
  - Shri B. B. Chugh, General Manager (Ash Utilization), NTPC
  - Ms. Anjali Shirke, CE (SWM Project), MCGM

**Floor interaction**

16:30 Hrs  HIGH TEA
One Day Workshop on
Use of Fly Ash and Construction & Demolition Products
for Sustainable Construction

PREAMBLE

Environment conservation is the foremost concern in today’s unabated development. It is the front stage agenda of all Governments across the globe. Urbanization a fall out of development as well as increasing population is driving expansion and redevelopment of urban areas. The urban population of 337 million in 2011 is expected to grow to around 590 million by 2030. The current estimates show a shortage of 10 million units of urban housing. A study by Building Material Technology & Promotion Council (BMTPC), MoHUA, GoI indicates a considerable shortage of building materials to meet the requirements (2021-2022) of 380 million tonne cement, 50 million tonne steel, 600 billion bricks, 400 million M$^3$ aggregates, 40 million M$^3$ timber, etc.

The redevelopment and expansion of urban area on one hand puts additional pressure on market demand of construction materials and on the other hand generates annually 150—175 MnT of construction and demolition waste. Indiscriminate dumping of C&D waste is a cause of environment pollution, blockage of drains, walk ways and roads, etc. Another industrial waste fly ash, a residue of burning of coal in thermal power plants being generated in large volumes of around 250 MnT/year is a menace if not utilized/managed well. Storage of un-utilized fly ash demands large stretches of land as well as poses a threat to pollute the environment.

Technologies have been developed and are in vogue for putting fly ash and C&D waste materials in use for sustainable construction. Standards, Specifications and Guidelines are in place. Fly Ash and its products are in use. It could contribute much more with appropriate motivation, facilitation and guidance through technology & policy interventions. Use of C&D waste in construction is just at the threshold to be taken forward for large scale utilization.

ABOUT THE WORKSHOP

The Workshop organized by Centre for Fly Ash Research and Management (C-FARM) and CPWD had overwhelming response with more than 150 participants from academia, R&D, Government, municipalities, statutory bodies, industry including cement & RMC
manufacturers, C&D waste processors & product manufacturers, fly ash processors, builders, contractors, architects, CPWD and other construction agencies of Government. During the workshop emphasis is laid on the need to enhance use of fly ash and its products through value addition and recycle and reuse of C&D waste materials in construction and infrastructure development projects.

Inaugural Session was followed by two technical sessions:

Technical Session-I: Use of Fly Ash in Construction of Buildings, Roads and Infrastructure Projects: Technologies, Policies and Case Studies, and


The Concluding Session had Panel Discussions and floor interactions towards drawing up of the recommendations of the Workshop. Seven papers are presented during Technical Session-I and five papers in Technical Session-II, followed by question-answer in each Technical Sessions.

INAUGURAL SESSION

Shri Ashok Khaire, Joint Commissioner (SWM), Municipal Corporation of Greater Mumbai (MCGM) inaugurated the One Day Workshop on Use of Fly Ash and Construction & Demolition Products for Sustainable Construction.

He said that the day by day increasing population of urban areas demand infrastructure which requires lot of construction materials and for materials could be used as a substitute. Shri Ashok Khaire laid emphasis on the need to recycle and re-use C&D waste, fly ash as well as other materials. He retreated that use of fly ash has proved to improve the quality of structures. Similarly, appropriate technologies need to be put in place for beneficial use of C&D waste. Further, he added that MCGM is moving ahead with commitment in this direction.
Shri Kamal Kumar Agarwal, Chief Engineer, Mumbai–II, CPWD & President, IBC
Mumbai Chapter welcomed the dignitaries and delegates. He stated that both fly ash and C&D waste generated in high volume could be used in different forms in construction projects. They are very valuable source/ raw material for the industry and also it conserves environment and natural building materials. He emphasized that workshops like this can help us to acquire good knowledge of these materials and facilitate large scale adaptation of gainful utilization of both the waste materials.

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 Workshop and its objectives. He talked about fly ash not being a waste but a useful material and also that C&D waste could be reused and recycled. Dr. Vimal Kumar said that in India we have single unit number of C&D waste processing plants while even small countries in Europe have 50-100 plants in operation. India needs more than 1000 plants for converting C&D waste into a resource.

Shri Anil Kumar Pandit, ADG (Region Mumbai), CPWD in his address emphasized on green development. He said that fly ash from thermal power stations was considered a waste but due to development of new technologies it has become a wealth. Today, fly ash is utilized in various sectors and it has a considerable scope in construction industry. It is utilized in manufacture of cement, concrete, bricks, blocks and others. The construction with fly ash based and C&D waste recycled products is sustainable and eco-friendly construction. Use of these materials is increasing at a good rate. They are environmentally sound and greener material than conventional material.
Ms. V. Rama Mathew, Principal Commissioner of Customs (General), Mumbai Custom Zone –I stated that increasing pollution is the cause of accumulated heaps of municipal solid waste as well as the industrial wastes like fly ash and construction & demolition waste. These wastes are threatening our mother nature. Fly ash is very useful and value addition item for construction as well as for agriculture and forest development. She urged upon CPWD to educate the Customs Department more about the beneficial use of fly ash and C&D wastes in construction activities and to put it in practice in their works.

Shri K.N. Agrawal, Former DG, CPWD & Director, Centre for Fly Ash Research and Management highlighted the advantageous use of fly ash and C&D waste as well as their products focusing on durability, economics and environment conservation. Use of C&D waste and fly ash means a green environment, as this activity would reduce or eliminate the pollution due to accumulated volumes of these materials as well as it would reduce the exploitation of natural resources for production of construction materials. He also shared his experience of use of fly ash bricks in construction of a hospital/ school at Dwarka/ Najafgarh at Delhi and construction of road embankments on the eastern side of river Yamuna going upto Akshardham Mandir at New Delhi. Therefore it is the faith, confidence and conviction of the project in-charge engineer to take forward and use new products/ technologies.

Smt. Usha Batra, Special DG, CPWD stated that viable and eco-friendly technologies and solutions have been developed and are further emerging with higher levels of utilization and better efficiencies. Application of technologies and utilization of fly ash has moved far head
and it’s now accepted as a viable & sustainable building construction material by and large. She highlighted the initiatives taken by CPWD for use of fly ash and C&D waste materials in construction projects. She emphasized that CPWD has incorporated these materials in schedule of rates. New applications of such materials in construction sector are also being continuously added in the SRs and are being implemented in the field by CPWD.

Shri P. C. Mathur, CE cum ED, CPWD, Mumbai proposed the vote of thanks. He said that fly ash and C&D waste are very useful in construction industry for sustainable development. Construction sector has the capacity of bulk utilization. Constructions using these materials would be durable, economically viable and eco-friendly.

TECHNICAL SESSIONS


Shri Anil Kumar Pandit, ADG (Mumbai Region), CPWD chaired the Technical Session-I and Dr. K. M. Chirutkar, Executive Director (Fly Ash & Solar), MAHAGENCO was the Co-Chairman. Seven papers were presented during the session.

The first paper “Use of Fly Ash and C&D Waste Materials in Concrete” was presented by Shri V. V. Arora, Joint Director & Head, Centre for Construction Development & Research, NCCBM. He emphasized that the important driver of Indian economy is construction sector which is resource intensive. The
natural aggregates are depleting at a high rate that led to use of alternate/ waste materials as aggregates for sustainable development. Research and field results of fly ash based concretes like PPC, HVFAC, geopolymer concrete and replacement of fine aggregate by bottom ash were presented. He analysed the basic engineering, time dependent and durability properties of Ordinary Portland Cement (OPC) and Portland Pozzolana Cement (PPC) on two different grades of concrete. The results on pre-stressed concrete beams and RCC beams indicated that with proper mix design the properties of PPC concrete can be made very similar to that of OPC concrete. Resistance to chloride ingress is more in PPC concrete. Different concrete could be used at different locations as in case of coastal environment/ aggressive environment where distress due to chloride ingress is critical, PPC is more durable than OPC. Bottom ash could be used as an alternate of natural sand in concrete was also explained. It was found that replacement of fine aggregate by bottom ash is possible up to about 50%. HVFAC using fly ash in the range of 40% to 50 % was more suitable option for concretes of higher grades. Geopolymer based concrete products are good alternative to normal cement based concrete products.

C&D waste is also studied at NCB, Ballabgarh in which concrete were prepared with natural aggregate replacement with recycled aggregate by volume in concrete in the proportions of 0%, 25%, 50%, 75% and 100% and tested. For fine aggregates, workability, strength parameters, chloride penetration and drying shrinkage are improved whereas in coarse aggregates, marginal change in workability and strength parameters is observed. He recommended that improved processes are needed for converting C&D waste into useful construction materials. Further, he suggested that specifications need to be made for different types of C&D based aggregates based on quality.

The second paper was presented by Dr. B.V.S. Viswanadham, Professor, Dept. of Civil Engineering, IIT Bombay “Use of Fly Ash as a Structural Fill in Railway Embankments”. The coal ash from thermal power plants is well used as structural fill material for construction of highway embankments at many places but the studies for its usage in construction of railway embankments are limited. Dr. Viswanadham’s research aimed to know the stability and deformation behavior of soil
confined coal ash embankments through centrifuge model tests. He elaborated that centrifuge testing is the appropriate tool for studying behavior of the embankment constructed using fly ash as structural fill as the centrifuge can study the behavior of prototype structures as scaled-down models in a controlled environment. Based on his research and analysis, he concluded that class F fly ash could be used for constructing rail embankments as a structural fill material with adequate measures. He also added that the construction in the field on pilot scale could be done for evaluating the performance of rail embankments subjected to real loading and climatic conditions and adopting instrumentation for measuring pore water pressure, inclinometers for measuring slope movements and surface settlements of the embankment.

Dr. Manish Mudgal, Senior Principal Scientist, CSIR-AMPRI, Bhopal presented the third paper “Fly Ash Based Advanced Geopolymer Concrete (Cement Free) for Infrastructure Development”. He said that due to rapid industrialization large quantities of wastes are generated creating environmental and ecological problems and also occupying large tracts of valuable cultivable land. Geopolymer concrete is the solution and material for the future, the new group of building materials that has potential to transform the building products industries. He explained the process of formation of fly ash based geopolymer. Geopolymer is developed as a novel binding material produced by polymeric reaction of alkaline liquid with silicon and aluminum rich materials like fly ash, rice husk, blast furnace slag, silica fumes etc. It has been found that higher compressive strength is easily achieved in a short period in geopolymerised concrete as compared to ordinary portland cement concrete and has an excellent resistance to acid and sulphate attack when compared to ordinary portland cement concrete. It has excellent volume stability and better durability.

Further, Dr. Manish Mudgal presented the field demonstration projects carried out by CSIR-AMPRI like rigid pavement, cast-in-situ structure, paver blocks at CSIR-AMPRI and rigid pavement at AIIMS Bhopal constructed using fly ash based geopolymer concrete.
The fourth paper of the session “Sustainable use of fly ash: A case study of MAHAGENCO/MAHAGAMS” was presented by Dr. Nitin Wagh, CGM, Environment & Safety, MAHAGENCO and COO, MAHAGAMS. He gave the overview of MAHAGENCO Ash Management Services Limited (MAHAGAMS), a subsidiary company of MAHAGENCO established in 2016 to improve the ash utilization scenario in thermal power stations of MAHAGENCO to achieve 100% ash utilization. With the current generation capacity of 13606 MW, MAHAGENCO is the second largest power generating company in India and has generated 6238781 MT of fly ash during 2018-19. Some thermal power plants of MAHAGENCO have 80-90% ash utilization but at a few stations fly ash utilization is quite low. This is where MAHAGAMS is focusing upon. He listed various important areas where fly ash has good potential to be used. MAHAGAMS is exploring different aspects of using fly ash. The possibilities of transporting fly ash from thermal power stations to the ash parks by railway are explored. MAHAGAMS is trying to create fly ash based industrial cluster near Koradi and Khaparkheda thermal power stations for which it has invited agencies to show their interest in setting up a industry based on fly ash and many agencies have responded. The cluster is expected to improve ash utilization of Koradi TPS by 33% and that of Khaperkheda TPS by 7%. MAHAGAMS is also considering setting up of cement plants near thermal power stations. It is conducting awareness programs for availability and benefits of fly ash in the local market. Mobile app for ash utilization is also being developed.

Shri Ajit Bhonsle, Millenium Multi Trade Ltd. presented the fifth paper “Processing of Fly Ash for Value Added Application”. In India, the utilization is unable to keep pace with fly ash generation. Different avenues of its utilizations are explored by many agencies and individuals. Shri Ajit Bhonsle
presented his effort to enhance usage of fly ash by the method of mechanical activation of fly ash. Mechanical activation of fly ash could increase the usage manifolds. This method reduces the particle size and enhances the pozzolanic characteristics of fly ash by increasing the surface area for pozzolanic reactions. It would not only double the lime reactivity of normal fly ash but would also result in giving packing effect to its final product there by giving the final product increased density & better strength in shorter time. The mechanism with the project viability and cost economics was illustrated. From his study, he concluded that mechanically activated fly ash is a potential and sustainable cementitious admixture which could be used in the manufacturing of blended cement, composite cement, RMC, cement grout, fly ash bricks, concrete spun pipes, cement products like paver blocks bricks. The fine fly ash can also be used in paint industry, cement roof sheeting industry. Up to 110% of strength activity index can be achieved when normal fly ash is ground to smaller size. Also the fly ash with finer particle size increases strength as well as rate of strength gain of fly ash cement mortar.

The sixth paper of the session “Geo-polymer Concrete Applications in Construction: Challenges and Opportunities” was presented by Prof. S. K. Singh, Senior Principal Scientist, AcSIR, CSIR-CBRI, Roorkee. He raised the point that global climate change is demanding alternatives for the products which increase the CO₂ emissions directly or indirectly. One of the such alternative is geopolymer concrete and in construction industry, it could be used for replacing ordinary portland cement. The geopolymer cement is an innovative material and a real alternative to conventional portland cement. His paper provided a review on the process of synthesis of geopolymer binder and various applications of geopolymer concrete with the challenges faced by the agencies. He explained that several researches carried out for development of geopolymers and found Geopolymer concrete slabs were better in ductility and energy absorption; foamed fly ash geopolymer is used as insulating materials for building applications; geopolymer concrete significantly reduced spalling and superior mechanical strength retention after exposure to fire and geopolymer concrete is used in pre-cast for infrastructure development. CSIR-CBRI also conducted a
research on geopolymer concrete and building products. Several building elements like bricks, blocks (solid and hollow), light weight geopolymer foam, sandwich composite and insulation concrete were prepared and compared with portland cement concrete; self-compacting geopolymer concrete is also developed and a pilot scale trial was carried out using concrete pump and mini batching plant. The implementation of these at CBRI, Roorkee was done laying a 50m road stretch and pavement was casted in form of slabs. The road was tested during casting and also after its construction and found satisfactory and also no cracks were observed in the slab. At NTPC- Dadri, a 100m road was constructed after this experience.

Some challenges also exist for wide application of geopolymers variability in constituent raw materials and their sources, cost economics, quality control and quality assurance as well as standardization and performance of geopolymer concrete in long term.

Shri Shakti Nanda, National Business Development Manager, RDC Concrete, Thane presented the seventh and the last paper of the session “Fly ash for sustainable development”. He gave an overview of RDC Concrete and its plants. The fly ash generated at thermal power stations had properties that are useful for concrete. High volume fly ash concrete was designated as Eco Smart or Green concrete which has structural capability, durability, cost efficiency and aesthetics. He explained fly ash is waste of thermal power plant that is a resource for construction. Fly ashes are less permeable to water adds to concrete’s durability, it last longer, reduce CO₂ emission, saves energy and high volume fly ash concrete usually costs lower than conventional concrete. The parameters affecting the performance of fly ash in concrete are fineness, LOI and reactivity. Fly ash showed positive impacts on fresh concrete and hardened concrete. Applications of high volume fly ash concrete were also given by him at the end of his presentation.

Five technical papers were presented covering C&D waste as construction material for future, its management rules, applications and case studies. This technical session was chaired by Shri Govind Sharan, Former DG (Roads Dev.) & Special Secretary, MoRTH and Director, C-FARM along with Shri Lorengob Dung Dung, Chief Engineer, Mumbai-I, CPWD as the co-chairman.

Dr. Vimal Kumar [Former Mission Director & Head, Fly Ash Unit, DST, GoI], Secretary General, C-FARM presented the first paper “A sustainable approach towards the construction & demolition waste”. He stated that the disposal in a safe environment of C&D waste which is increasing day by day is a big challenge. The amount of C&D waste in India is estimated to be 150 - 175 million tonne annually. On one hand, disposal of debris is a challenge, while on the other hand there is a severe shortage of naturally available aggregates for construction. This makes it possible to reuse and recycle the C&D waste. The need is to reduce the C&D waste and to sensitize the engineers, all stakeholders including regulatory authorities in construction industry for its reuse and recycling. Effective deconstruction plan for taking out all the possible component of building like doors, windows, bricks, reinforcements, RCC components, structural steel, etc. which could be reused to reduce the waste and the left over waste material could be recycled into useful products. 1st commercial level plant is functioning at Burari in North Delhi. The recycled C&D products include coarse aggregates, fine aggregate, concrete, bricks, tiles, timber, metals like steel and aluminium and plastic which could be used in
different applications. Guidelines to be followed for recycling of demolition waste were also elaborated in a simple mode.

Further, he discussed about the C&D waste recycling facility at New Delhi. IL&FS Environmental Infrastructure and Facilities Ltd. set up the first plant for North Delhi Municipal Corporation at Burari which is functioning. The capacity of the plant is 2000 T per day. The C&D wastes collected in the containers and are routed through the weighbridge to the processing site wherein silt and loose soil is separated to be used for land filling and rest is processed. The processed C&D waste is used for concrete, mortar, sub base of roads, making bricks, paver blocks & kerb stones, etc. 5.64 Lakh MT of C&D waste has been processed for making useful products during the last one decade. Out of this 23000 T of aggregates, 5.2 Lakh T of Granular sub-base and 16700 T of sand has been produced. Further, 1400 T of cast products and 1600 T of Ready-Mix Concrete has been produced in this plant. He concluded that to minimize the use of natural resources in construction, C&D waste reuse/recycling is a good option. But, BIS and IRC codes permit only a small percentage use of aggregate other than those obtained from natural sources. Therefore, it is time that recycled aggregate are permitted for use in higher proportions based on the quality of the processed aggregates. Municipal bye-laws are required to be reviewed and suitably modified. There should be promotion of R&D by Government, spread the information, education and communication to increase awareness in the public, provision of incentives to the users of C&D waste recycled products and most important recycling should be of high quality and should be repeatable.

Ms. Anjali Shirke, CE (SWM) Projects, Municipal Corporation of Greater Mumbai (MCGM) presented “Construction & Demolition (C&D) Waste Management in Mumbai”. She gave an overview of C&D waste generation in Mumbai from various sources and their disposal areas. MCGM’s plans for its management. 1234 MT C&D waste is generated in wards from debris on call and unclaimed C&D waste per day. Therefore MCGM has
planned a project for C&D waste processing of 1200 TPD for which it has invited E-tender for this. In this project there will be 2 Modules of 600 TPD each. Out of which land for Module 1 has been identified and for Module 2 bidders have to identify a private land. She explained the other features of the project and details of mode of operation for collection and transportation of C&D waste from the place of generation to the processing site. Also MCGM would purchase and utilize around 10-20% of the recycled products for their own construction projects, wards or garden departments. Ms. Shirke covered the technology and the process/activities involved in the processing of C&D waste. She concluded that C&D waste which is increasing everyday and cause environmental issues could be recycled and utilized into various materials of construction.

The third paper “Building a Sustainable Future Together: Recycling Concrete from Construction Debris” was presented by Shri Abhijit Gawde, Head, Business Development & Marketing, Godrej Construction Ltd. He stated that the C&D waste generated are being dumped into the landfills is a major environmental concern and the shortage of landfill sites challenged to find the adequate and effective solutions for its disposal. The ideal solution is to convert this waste to useful material. Godrej Construction established Recycled Concrete Materials (RCM) Manufacturing Plant in Vikhroli which recycle construction concrete waste and convert it to materials that can be used for production of different products in construction projects. The plant manufactures 36000 blocks and 54000 pavers per day. He explained how the manufacturing plant works from collecting the concrete waste, its processing to convert into blocks of concrete of different shapes and sizes. Recycled C&D waste could help in reduction in demand of natural resources and also the negative impact of landfills on the environment. Godrej Construction manufactures recycled concrete products known in market as ‘TUFF’ for which it received the ‘Green Pro’ certificate from Indian Green Building Council (IGBC) and also Bureau of Standards (BIS) certification for TUFF Blocks. He
winded up with saying that RCM factory is the green initiative which adopts the concept of Recover, Recycle & Rebuild.

Prof. S. K. Singh, Senior Principal Scientist, AcSIR, CSIR-CBRI, Roorkee presented the next paper “A way forward for sustainable applications of construction and demolition waste products in construction”. The paper dealt with the possible ways and measures that can help in increasing the use of different types of recycled aggregates in construction. With consumption of huge amounts of natural aggregates globally that are scarce resulted into gainful utilization of recycled aggregates. The recycled aggregates are derived from processing the C&D waste. The properties and applications of different recycled aggregates in different areas of construction were also elaborated. He stated that CSIR-CBRI, Roorkee carried out a research to study the effect of various parameters like adhered mortar, processing of recycled coarse concrete (RCA) and recycled fine concrete (RFA), mixing approach, durability under aggressive environment, various cementitious binders, etc. that influence the properties of recycled aggregate concrete in fresh as well as hardened state. Structural behaviour of RCA and RFA concrete were also evaluated and compared with natural coarse and fine aggregates based concrete. Satisfactory results were found based on existing design guidelines. Further, he also highlighted the reasons for not using RCA and RFA concrete on large scale in India are lack of awareness, government support, proper standards, technology and a kind of aversion in using processed waste material. He recommended that the government bodies, construction industries, research and academic institutions should promote the use of alternatives in construction to greater extent through their guidelines and extensive research works as re-using the C&D waste not only reduces environmental problems but also helps in manufacturing a sustainable materials/ constructions. These alternatives are even cost effective and eco-friendly.
The last paper “Use of Fly Ash and C&D Waste Products for Sustainable Construction of IIT-Gandhinagar Campus” was presented by Shri Roop Singh, EE, CPWD and Mr. Anil Mittal, AEE, IIT Gandhinagar Project Division-2, CPWD. They presented a case study of IIT Gandhinagar Campus which is being built using fly ash and C&D waste products. Different fly ash items are used in construction of the campus like fly ash for earth work, in concrete work, reinforcement cement concrete, masonry work and road work. Fly ash bricks are also used. Fly ash is used based on its effects on the properties of fresh concrete. Different levels of dosage of fly ash had been used based on the various applications. Advantages were observed by using blended fly ash than OPC. 40% to 70% fly ash can be used in brick production. Fly ash bricks are technically acceptable, economically viable and environment friendly. At IIT Gandhinagar there is construction of load bearing confined masonry buildings. They also talked about the C&D waste which causes problems in disposal, therefore, reusing and recycling it is a good option. CPWD reused C&D waste and also used C&D recycled products at different location in the campus like broken ceramic tiles for mosaic flooring, stone cuttings in footpath, kerbstones and paver blocks made from recycled aggregates are being used. CPWD mandated use of fly ash bricks/ C&D waste blocks in masonry works. They concluded that both fly ash and C&D waste be used with the help of new technologies in construction industry in place of precious natural materials. Therefore, these both are resource material.

CONCLUDING SESSION

The Concluding Session had a panel Chaired by Smt. Usha Batra, Special DG, CPWD and co-Chaired by Shri R. D. Gupta, Former Director, NTPC, Former Member, UPERC and Director, C-FARM. Shri K. N. Agrawal,
Former DG, CPWD & Director, C-FARM; Dr. R.B.S. Rawat, Former PCCF (HoFF), Uttarakhand & Director, C-FARM; Shri Anil Kumar Pandit, ADG (Region Mumbai), CPWD; Shri B. B. Chugh, GM (Ash Management), NTPC; Ms. Anjali Shirke, CE (SWM Project), MCGM and Dr. Vimal Kumar, Former Mission Director, Fly Ash, GoI & Secretary General, C-FARM were the panel members.

Brief summary highlighting the salient features of Technical Sessions-I and II was presented. It was followed by panel discussions and question-answer from the floor.

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

1. Fly ash, its products and their applications in construction industry are relatively well known and practised. A number of technologies have been developed and disseminated since start of Fly Ash Mission, G.o.I during mid 1990s.

2. Fly ash and its products provide benefits on all fronts. They are of better quality, economical, eco-friendly and durable. In spite of this apprehensions still exist about use of fly ash and its products, primarily among the new entrants in the field.

   Induction of fly ash in academic curriculum, dissemination and sharing of information through regular training programs, seminar, conference, etc. need to be facilitated.

3. The implementation of mandatory use of fly ash and its products as per various Government orders and notifications need to be guided and facilitated.

4. At certain geographical locations, there is short supply of fly ash as compared to its demand. Attention to management of fly ash within the thermal power plant and its supply system can improve the situation.

5. New and value added applications of fly ash, such as, geopolymerized fly ash, fly ash bricks/ blocks with more than 75% ash content, use of fly ash in landscaping/ horticulture and reclamation of termite affected lands and application of fine fly ashes in concrete and mortar be taken up for large scale application in construction industry.
6. BIS Standards and Specifications be released expeditiously for new applications.

7. Supply of processed/ classified fly ash of certified quality will do value addition and will also enhance the overall utilization of fly ash significantly.

8. C&D waste management is at a nascent stage in India. C&D waste management rules, 2016 are being taken up by various municipalities and concerned agencies for implementation.

9. The process of implementation of C&D waste rules, 2016 need to be expedited. The C&D waste processing plants established so far in the country are in single digit number. The realistic estimation could have expected it to be at least around 100. The quantum of generation of C&D waste in the country and the geographical coverage requires at least 1000 plants for effective and useful conversion of this waste into useful products.

10. Efficient and effective technologies need to be developed/ facilitated for production of high quality coarse and fine aggregates from C&D waste.

11. Adequate training and hand holding is recommended for segregation/ classification and processing of C&D waste as well as production of downstream products.

12. BIS Standards & Specifications may be developed for a large number of downstream products of C&D waste.

13. Downstream products of C&D waste need to be included in SR of CPWD, PWDs and other Government Departments.


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