REPORT OF THE COMMITTEE TO ENCOURAGE THE UTILIZATION OF FLY ASH IN CONSTRUCTION OF HYDRO POWER PROJECTS

हाइड्रो पावर प्रोजेक्ट के निर्माण में फ्लाई ऐश के उपयोग को प्रोत्साहित करने हेतु समिति की रिपोर्ट

भारत सरकार
Government of India

विद्युत मंत्रालय
Ministry of Power

नई दिल्ली
New Delhi

केन्द्रीय विद्युत प्राधिकरण
Central Electricity Authority

जल विद्युत अभियांत्रिकी एवं नवीनीकरण व आधुनिकीकरण प्रभाग
Hydro Engineering and Renovation & Modernisation Division

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1. EXECUTIVE SUMMARY

In India, presently 56 % of the electricity generation, is from Coal/Lignite based generating stations. The coal used in TPPs have high ash content of the order of 30-45%, which generates large quantity of fly ash. Presently out of total generated fly ash, 67% of fly ash is utilized in various modes like cement industries, mine filling, bricks and other construction activities. Thus at present, the ash utilization is lower than the ash generation on all India basis. As a result, there is surplus ash stock, which is increasing every year. The management of fly ash has thus become a matter of concern as it requires large area of land for its disposal because of its potential of causing pollution of air and water.

The Hydroelectric Projects involve huge amount of civil works and thus have a great potential for utilization of the Fly Ash. Chairperson, CEA constituted a committee having representatives from various Ministries/Department/Public Sector Organizations under Chairmanship of Chief Engineer (HE&RM), CEA with following terms of reference:

i) To take stock of areas, proven technologies and construction materials in the country and abroad to facilitate the use of fly ash in civil works of hydro power projects including dam.

ii) To advise on the policy decision & the modalities including a mechanism for resolution of technical, scientific and logistic impediments, to encourage and facilitate the use of fly ash in construction of hydro power projects.

iii) To organize seminars/conferences/workshop etc. to discuss the related issues and disseminate the information, technologies and the case studies, etc. with a view of encouraging the use of fly ash.

The committee held five meetings and based on the deliberations of these meeting, major recommendations proposed by the committee are as follows:

i) As far as possible High volume Fly Ash Roller Compacted Concrete should be preferred for concrete Dam. Quantification of Fly Ash in concrete shall be done at DPR stage of Hydro Power Project by the Project authority.

ii) Ongoing Projects can use Fly Ash if found technically and financially feasible, after making suitable amendments in technical specifications and tender documents for construction of these Projects under the contractual guidelines

iii) BIS to consider amending the fineness value (calculated by Blaine's permeability method) from 320 sqm/kg to 280-300 sqm/kg in IS 3812(Part-I) for those which qualifies all the criteria as per IS 3812(Part-I):2013, including lime reactivity for utilization of fly ash.

iv) Power plants should formulate a programme/guideline for collection and storage of fly ash with an objective to utilize 100% of ash produced.

2. Introduction

In India, presently 56 % of the electricity generation, is from Coal/Lignite based generating stations. In near future also the coal-based generation is likely to remain substantial. The Indian coal is of low grade, having high ash content of the order of 30-45%, which generates large quantity of fly ash at coal/lignite based Thermal Power Stations. Thus at present, the Ash utilization is lower than the ash generation on all India basis. As a result, there is surplus ash stock, which is increasing every year. The management of fly ash has thus become a matter of concern as it requires large area of land for its disposal because of its potential of causing pollution of air and water.

The above matter is a great concern. To address the above concerns, Ministry of Environment, Forest and Climate Change (MoEF&CC) has issued various Notifications on fly ash utilization prescribing therein the targets for fly ash utilization for Coal/Lignite based Thermal Power Stations with an aim to achieve 100% utilization in a phased manner. Central Electricity Authority (CEA) has been monitoring the status of fly ash generation and its utilization in the country since 1996.

The utilization of fly ash has increased from 7 million tons in 1996-97 to a level of 132 million-ton in 2017-18. The percentage of fly ash utilization during 2017-18 is 67% of the ash generation, which is less than the target set by MoEF&CC of 100% fly ash utilization by 31st December, 2017. To materialize 100% utilization of fly ash on all India basis, extra efforts are needed to increase the fly ash utilization in existing modes of utilization including hydro power projects.

India has Hydro-electric potential of the order of 1,50,000 MW. Out of which so far only around 43,000 MW has been harnessed. Harnessing of vast Hydro potential in the country is the priority of the Government. The Hydroelectric Projects involve huge amount of civil works and thus have a great potential for utilization of the Fly Ash generated in coal/lignite based Power stations. This may involve

chalking out multi-pronged strategy as well as policy decision on the issues related with Fly Ash utilization in the country. It was envisaged to encourage the Fly Ash utilization in construction of Hydro-Power Projects including dams, as one of the strategies.

3. The Committee

Chairperson, CEA during a workshop organized to launch "Web based Monitoring system and a mobile application for Fly Ash generation/utilization" emphasized the need of increasing fly ash utilization for construction in all sectors especially the hydro-power sector.

In compliance, a committee having representatives from various Ministries/Department/Public Sector Organizations was constituted under Chairmanship of Chief Engineer (HE&RM), CEA with following terms of reference:

i) To take stock of areas, proven technologies and construction materials in the country and abroad to facilitate the use of fly ash in civil works of hydro power projects including dam.

ii) To advise on the policy decision & the modalities including a mechanism for resolution of technical, scientific and logistic impediments, to encourage and facilitate the use of fly ash in construction of hydro power projects.

iii) To organize seminars/conferences/workshop etc. to discuss the related issues and disseminate the information, technologies and the case studies, etc. with a view of encouraging the use of fly ash.

The committee was constituted having representatives from following Ministries/Department/Public Sector Organizations:

i) Chief Engineer, HE&RM, CEA - Chairman
ii) Director, TCD Division, CEA - Member
iii) Representative of CWC - Member

iv) Representative of Dept. of Science & Technology - Member
v) Representative of CSMRS - Member
vi) Representative of MoEF& CC - Member
vii) Representative of Bureau of Indian Standards - Member
viii) Representative of NTPC - Member
ix) Representative of NHPC - Member
x) Representative of Dept. of Water Management and Command area development, Govt. of Maharashtra- Member
xi) Director, HERM, CEA -Member Secretary

Five meetings of the committee were held on following dates:

1st Meeting 23.03.2018
2nd Meeting 20.06.2018
3rd Meeting 12.09.2018
4th Meeting 20.11.2018
5th Meeting 24.07.2019

In the second meeting of the committee, it was felt necessary to invite/induct members/representatives from the organizations like National Council for Cement and Building Materials (NCCBM), Central Road Research Institute (CRRI), Delhi Metro Rail Corporation (DMRC). Representatives from NCCBM participated in discussions held from third committee meeting onwards.

4. Role of CEA in Fly Ash Utilization Monitoring

Central Electricity Authority as part of its various activities monitors the annual generation & utilization of Fly Ash in the country since 1996-97.

Use of Fly Ash conserves the scarce natural resources on one hand & on the other hand saves the precious land and along with that it helps in many environmental issues related to the deposited ash. Many useful applications of Fly Ash have been established internationally and in India also these are in vogue for more than five decades.

The annual generation of Fly Ash (including bottom ash) during 2017-18 as per Central Electricity Authority report was 196.44 million tonnes & utilization was 131.87 million tonnes (67.13%).

The mode of utilization of Fly Ash during year 2017-18, is as below;

Table-1

Sl. No.	Mode of Utilisation	Quantity of Fly Ash utilised in the mode of utilisation	
		Million Ton	Percentage (%)
1	Cement	50.299	25.60
2	Mine Filling	12.5159	6.37
3	Brick & Tiles	17.6943	9.01
4	Reclamation of low lying area	20.5779	10.48
5	Ash Dyke Raising	13.5500	6.90
6	Roads & Flyovers	6.6733	3.40
7	Agriculture	0.5732	0.29
8	Concrete	1.2974	0.66
9	**Hydro-Power Sector**	**0.0077**	**0.004**
10	Others	8.6857	4.42
	Utilised Fly Ash	131.8663	67.13
	Unutilised Fly Ash	64.5747	32.87
	Total Fly Ash Generated	**196.4410**	**100.00**

Source: CEA Report

As per CEA's Annual reports on fly ash, annual fly ash generation and its utilization in hydro sector for the period 2014-15 to 2017-18 are as under: -

Table-2

Sl. No.	Year	Total fly ash generation (MT)	Total fly ash utilization (MT)	Fly ash utilization in Hydro Sector (in MT)	Percentage utilization of fly ash in Hydro Sector.
1.	2014-15	184.14	102.54	0.0054	0.003
2.	2015-16	176.74	107.77	0.0375	0.021
3.	2016-17	169.25	107.10	0.0197	0.011
4.	2017-18	196.44	131.87	0.0077	0.004

It is evident from above Table-2 that direct utilization of Fly Ash in Hydro-Power Sector is almost negligible. Fly Ash as component of PPC cement utilized in Hydro Power Plant has not been accounted in fly ash utilisation in hydro power plant or hydro sector.

5. Initiative taken by MoEF & CC

In order to reduce the requirement of land for disposal of Fly Ash in ash ponds and to address problem of pollution caused by Fly Ash, Ministry of Environment, Forest and Climate Change (MoEF&CC) has issued various Notifications on Fly Ash utilisation. MoEF&CC issued the first Fly Ash notification on 14th September, 1999, which has subsequently been amended in 2003, 2009 and 2016. The Fly Ash notifications mandate the use of fly ash for the purpose of manufacturing ash-based products such as cement, concrete blocks, bricks, panels or any other material or for construction of roads, embankments, dams or for any other construction activity within a radius of 300 km from Thermal Power Plants (TPPs). Besides, it is also mandatory to use fly ash in the external overburden, mines backfilling or stowing of mines within a distance of 50 km. Minimum fly ash content for building materials or products to qualify as “fly ash based products” category shall be as given in the Table-3 below:

Table-3

Sl. No.	**Building Materials or products**	**Minimum % of Fly Ash by weight & related Indian Standards**
1.	Bricks, blocks, tiles, etc. made with Fly Ash, lime, gypsum,stone dust etc. (without clay)	50% of total input materials (IS -12894)
2.	Paving blocks, paving tiles, chequered tiles, mosaic tiles, roofing sheets, precast elements, etc, wherein cement is used as binder.	Use of Portland Pozzolana Cement (PPC) lS-1489: Part-I or Portland Slag Cement (PSC) (IS-455) or 15% of Ordinary Portland Cement(OPC*) (IS-269/8112/12269)- content.
3.	Cement	15% of total raw materials

4.	Clay based building materials such as bricks, blocks, tiles etc.	25% of total raw materials (IS- 13757)
5.	Concrete, Mortar and plaster	Usages of PPC (IS-1489: Part - 1) or PSC (IS-455) or 15% of OPC* (IS-269 /8112/12269) content.

* The Indian standard for OPC namely IS 269 for 33 grade, IS 8112 for 43 grade and IS 12269 for 53 grade have since been merged as IS 269: 2015 incorporating all the three grades.

It is also mandatory for all construction agencies/Government Departments as well as local authorities, undertaking road projects, fly over/ bridges to make provisions for use of fly ash in their tender documents and schedule of material and rates. The notification also prescribes the targets for Fly Ash utilization in a phased manner for all Coal/Lignite based TPPs in the country so as to achieve 100% utilization of fly ash. The notification further prescribes to constitute a Monitoring Committee at the Central level and State level to monitor the implementation of provisions of fly ash notifications.

The implementation of these Notifications has resulted in steady increase in the utilization of fly ash. However, the utilization has not reached to 100% and certain additional measures are required to be taken to promote and facilitate its use. In the recently amended notification dated 25.01.2016, the scope of the notification is broadened to enhance the utilization of the fly ash for various gainful activities and to promote and facilitate utilization of ash based products in construction activities. The Salient features of the fly ash notification 2016 are as given below:

i) The cost of transportation of ash for road construction projects or for manufacturing of ash based products or use as soil conditioner in agriculture activity within a radius of hundred kilometers from a coal/lignite based thermal power plant shall be borne by such owner thermal power plant and the cost of transportation beyond the radius of hundred kilometers and up to

three hundred kilometers shall be shared equally between the user and the thermal power plant owner.

ii) The coal/lignite based thermal power plants shall promote, adopt and assist in setting up (financial and other associated infrastructure) the ash based product manufacturing facilities within their premises or in the vicinity of their premises so as to reduce the transportation of fly ash.

iii) The coal/lignite based thermal power plants in the vicinity of the cities shall promote, support and assist in setting up of ash based product manufacturing units so as to meet the requirements of bricks and other building construction materials and also to reduce the transportation.

iv) To ensure that the contractor of road construction shall utilizes the fly ash in the road construction, the Authority concerned shall link the payment of contractor with the certification of ash supply from the thermal power plants.

v) The coal /lignite based thermal power plants shall within a radius of three hundred kilometers bear the entire cost of transportation of ash to the site of road construction projects under Pradhan Mantri Gramin Sadak Yojna and asset creation programmes of the Government of India involving construction of buildings, road, dams and embankments.

vi) Every coal /lignite based thermal power plants (including captive and or co-generating plants) shall, within three months from the date of notification, upload on their website the details of stock of each type of fly ash available with them and thereafter shall update the stock position at least once a Month.

vii) Every coal/lignite based thermal power plants shall install dedicated dry ash silos having separate access roads so as to ease the delivery of fly ash.

viii) The concerned Authority shall ensure mandatory use of ash based bricks or products in all Government Scheme or programmes e.g. Mahatma Gandhi National Rural Employment Guarantee Act, 2005 (MNREGA), Swachh Bharat Abhiyan, Urban and Rural Housing Scheme, where built up area is more than 1000 square feet and in infrastructure construction including buildings in designated industrial Estates or Parks or Special Economic Zone.

ix) The Ministry of Agriculture may consider the promotion of ash utilization in agriculture as soil conditioner.

x) The coal/lignite based thermal power plants shall comply with the provision of 100 % utilization of fly ash generated by 31st December, 2017.

6. Discussions

The committee held five meetings to discuss the measures to encourage the Fly Ash utilization in construction of Hydro Power Projects including dam.
The summary of the points discussed is given as follows:

i) The main objective of the committee is to encourage and facilitate the use of Fly Ash in construction of Hydro Power Projects including the dams. At present the utilization of Fly Ash in Hydro Power Projects is negligible in spite of the fact that there is a large potential of its utilization in Hydro-Power Projects. The main concern for utilization of Fly Ash is the transportation from Thermal Power Plant to Project site which needs to be cost effective as Hydro-Project are located far away from thermal Plants. Mapping of Thermal Power Plants is essential for supply of required quality of Fly Ash for Hydro-Power Projects and linking of under construction Hydro Power Projects with these Power stations as per the availability of Fly Ash and earmark the plan from where & how Fly Ash will be collected for construction of future HPP.

ii) TCD Division, of CEA made a presentation highlighting the various steps taken by the government for increasing the utilization of Fly Ash in the country including launching of the ASH TRACK App. It was presented that during 2016-17 only 63% of total generated Fly Ash was utilized in different areas. Presently the Fly Ash utilization in Hydro-Power Projects is only 0.01 %. The Fly Ash utilization in Hydro-Power Projects has further decreased to 0.004% during year 2017-18.

iii) The representative from Water Resource Department (WRD), Maharashtra shared the experience of use of Fly Ash in construction of dams in Maharashtra and stated that Fly Ash was used in construction work of Saddle Dam, Lower Dam and Upper Dam of Ghatghar HEP.

Maharashtra Engineering Research Institute (MERI), Nashik has carried out study on use of Fly Ash and it is noted that use of Fly Ash reduces the Heat of Hydration of cement in mass concreting and hence reduces possibility of cracking. It improves workability and homogeneity of the concrete and thus reduces leakages in the concrete. However, the use of Fly Ash increases curing time and hence the cost increases.

In Ghatghar Project the Roller Compaction Technology was used in construction of the dams with layers of 300 mm of concrete utilizing 60% Fly Ash.

The limitation observed in use of Fly Ash in construction of RCC Dams are as under:

a) Need for good foundation (unlike Earth fill dams).
b) Overall good control required during construction.
c) Flow of material supply should be continuous and uninterrupted for construction. Hence, large stock piles of materials are required.
d) Proper Transportation and storage of cementitious material.

e) Fly Ash is Temperature sensitive and therefore require more curing time.

Fly Ash was also utilized in grouting work with 18% Fly Ash and 2% Admixture in Temghar dam rehabilitation and Varsgaon dam repairs.

It was informed that Fly Ash was used in construction of Ghatghar Hydro-Project. Construction quality of Ghatghar Project is very good and there is no seepage or any problem in the Project civil structure. There are no adverse effects due to use of Fly Ash in construction. Dam height of Middle Vaitarna is 102 meter and that of Ghatghar HEP is approx.60 meter.

iv) The representative from NHPC deliberated that Fly Ash is being used in Hydro-Projects through maximum uses of PPC as recommended in IS:1489 (Part-1) which contains Fly Ash (15%-35%). The concrete strength requirement is based on 28 days strength criterion. Apart from that, in order to control Heat of Hydration generated in mass concrete in concrete dams, lesser quantity of PPC is used wherein the concrete strength requirement is based on 90 days strength criterion. However, to increase utilization of Fly Ash in Hydro-Projects, it is necessarily required to explore the possibility of increasing Fly Ash content beyond 35% (the present limit of PPC in IS 1489 part-1, Clause-5). For this extensive R&D is required. It was impressed upon that, nevertheless, increase in Fly Ash content in cementitious material will result in increase in initial setting time, but still can be used if the activity does not fall in critical path/ does not hamper the overall construction schedule. Again if construction schedule permits, the use of cement with higher Fly Ash content may be extended for construction of Tunnel, shafts, Power House structures etc.

v) The standard for quality of Fly Ash and the composite cement made using Fly Ash and slag was also discussed and the BIS representative clarified that the quality of Fly Ash is governed by

the standard IS 3812 (Part 1):2013 which is mixed with slag and OPC/Clinker through intimate blending or inter-grinding to make composite cement. The BIS standard IS 16415:2015 pertains to Composite Cement which comprises slag, Fly Ash and cement wherein Fly Ash content is 15%-35% (similar to PPC).

vi) The NHPC representative also expressed concerns that PPC [IS 1489 (Part 1)] and Composite Cement (IS: 16415) both containing maximum Fly Ash content of 35% may not serve the purpose of maximizing the use of Fly Ash. As such new guidelines are needed to be developed for cement with higher Fly Ash content. Hence it is required that BIS should make a different IS standard for cement comprising of more Fly Ash percentage. Keeping in view the availability of Fly Ash, transportation cost, quality control etc., direct mixing of Fly Ash with cement at the work site is not advisable. So the cement with higher Fly Ash content should be produced at cement factory itself and supplied to Projects site for further use. However, it was noted that, as already discussed, for this, extensive R&D studies would be required before considering development of such a standard/provisions in the existing standards. Research bodies should carry out extensive research and furnish detailed data for the purpose.

It was also pointed out that main concern is the quality of Fly Ash. Quality of Fly Ash from the same Plant may not be consistent due to various reasons and sometimes does not comply the qualifying criteria. Quality of Fly Ash depends on quality of coal, method of coal extraction and burning of coal etc. Fly Ash for Teesta Low Dam Project was taken from Kahalgaon and Farakka Thermal Power Plants and the quality of Fly Ash met the standards, however few of the samples of Fly Ash were not meeting the minimum standard while exploring for the Dibang Hydro-Project. It was further pointed out that utilization of Fly Ash in Hydro-Projects may have some limitations as under:

a) Most Thermal Power Plants are located far away from the construction sites so transportation and to ensure uninterrupted supply of Fly Ash is a great challenge.

b) Ensure consistency in terms of quality of Fly Ash.

It was further deliberated that, abroad, High-Volume Fly Ash (HVFA) cement with mixture of 50:50 and 60:40 of Fly Ash and cement content have been developed and is being widely used in construction of roads, under sea water structures etc. It is found from the research work that the compressive strength of HVFA concrete reaches the same compressive strength of PCC concrete after certain period around 40 to 60 days which varies with the quantity of Fly Ash in cement. It was also reiterated that construction schedule vis-à-vis progress of work needs to be closely checked with use of HVFA concrete. Like other countries, India also needs to explore HVFA cement with high ratio of Fly Ash which can be used in infrastructure works vis-à-vis dam works. It was suggested by NHPC that new BIS standard for using HVFA cement should be prepared. HVFA cement if produced in factory and supplied to various sites may have the following advantages:

a) HVFA cement will be economical as TPPs and cement factories are easily accessible and transportation cost will be significantly less as compared with the transportation cost of Fly Ash from TPPs to the Project sites which are mostly in remote locations. CE, HE&RM said that Fly Ash will be beneficiated in the cement factory through the process of grinding of Fly Ash along with clinkers. Therefore, Fly Ash which do not confirm BIS standard IS 3812 (Part-1):2013 mainly with respect to fineness (320 Sqm/ kg) can also be suitably utilized in the cement factory.

b) HVFA cement if produced with BIS certification and available in market for use shall have wide acceptance as a reliable product.

c) HVFA cement may result in use of Fly Ash more effectively.

However, it was noted that, as already agreed, this would require extensive R&D studies before considering development of a standard on HVFA cement, apart from ensuring availability of requisite quality of Fly Ash indigenously conforming to IS 3812 (Part 1):2013. Thermal Power Plants and research bodies need to work for this purpose.

vii) NTPC representative expressed that they are using Fly Ash in their Hydro-Projects through optimized use of PPC, which contains Fly Ash to the extent of 15 – 35%. Keeping in view the huge consumption of PPC in Hydro Power Projects, increase in the Fly Ash content in PPC would be one of the solutions to enhance the usage of Fly Ash in Hydro Power Projects. However, this would require extensive R&D studies and subsequent compatible changes in relevant IS code. NTPC is using Fly Ash in other construction activities like rail embankment, road embankment, ash bricks, interlocking paver tiles, filling of low-lying areas and mines etc. NTPC is having a Fly Ash Utilization Division (AUD) which proactively formulates policies, plans and programs for ash utilization. It further monitors the progress in these activities and works for developing new segments of ash usage. Since, infrastructure works are an integral part of a Hydro Power Projects, therefore use of Fly Ash may be recommended for construction of roads (pavements), precast concrete, bricks, concrete blocks and RCC works in buildings.

NTPC representative stated that in Thermal Power Plants, Fly Ash is collected from ESP and thereafter Fly Ash is disposed through two systems namely ash slurry disposal system and dry ash extraction system. In dry ash extraction system Fly Ash collected from ESP is transported in dry form and stored in silos. From these silos Fly Ash is given to cement industries requiring Fly Ash in dry form. Balance Fly Ash is disposed in slurry form to ash pond which is used in filling of low lying areas, mine filling and filling works in road construction. In FY 2017-2018 NTPC

produced 66 million tons of Fly Ash, out of which around 36.5 million tons of Fly Ash was utilized. Representative from NTPC told that quality and quantity of Fly Ash depends on type/source of coal and even coal from same source may yield varying quality of Fly Ash. European coal is primarily lignite based having ash content to the extent of 12-14% and ash produced is of class C-type (Calcareous Fly Ash) whereas ash content of Indian coal ranges from 30% to 40%. At present 12 % of Fly Ash generated from NTPC TPPs is consumed by cement industry.

Committee members stressed upon the need for collection of percentage wise data for Bottom ash, Fly Ash from ESP field 1 and Fly Ash from ESP field 2.In this context NTPC informed that in total ash produced, there is about 16-20 % quantity of bottom ash. Approximately 70-80 % quantity of total Fly Ash is collected in field 1 ESP hoppers. Approx. 10-15% of total ESP fly ash is collected in 2nd field of ESP hoppers and balance fly ash is collected in ESP field 3 onwards.

Presently fly ash is not being collected field wise at silos at NTPC stations. However, field wise segregation of fly ash can be done at stations if bulk and sustainable demand for fine fly ash is raised by the users. Alternatively, by mechanical activation/grinding, fly ash can be converted to fine ash of desired quality.

viii) <u>R&D requirement in respect of concrete with higher Fly Ash content:</u>

The strength of concrete depends on various components like cementitious contents, water and cement ratio, admixtures, placement temperature etc. Considering above, R&D is required to establish Fly Ash contents for different grade of concrete i.e. varying strength of concrete with its initial vis-à-vis final setting time. It is pertinent to mention that Fly Ash properties should strictly meet the IS:3812 (Part-I):2013 standards. It is also apprehended that quality of Fly Ash generated from some of TPPs is not in compliance with IS:3812 (Part-I): 2013.

ix) Representative from MoEF&CC informed that the Ministry of Environment, Forest and Climate Change has issued various Notifications on Fly Ash utilization, first Notification was issued on 14th September, 1999 which has been subsequently amended in 2003, 2009 and 2016 vide Notifications dated 27th August, 2003, 3rd November, 2009 and 25th January, 2016 respectively. The para 2 (14) of Fly Ash notification, 2016 mandates use of Fly Ash based products in road construction Projects under Pradhan Mantri Gramin Sadak Yojna (PMGSY) and asset creation programs of the government involving construction of building road and dams. The entire cost of transportation of ash to these Project sites within 300 Km shall be borne by TPPs.

x) It also mandates use of Fly Ash based products in construction activities up to 300 km from TPPs. TPPs shall bear the cost of transportation of ash for manufacturing of ash based products, road construction Projects and for use as soil conditioner in agriculture activity up to 100 km distance. Beyond the distance of 100 km and up to 300 km, the transportation cost shall be shared equally between the user and the TPPs.

xi) Representative from CWC emphasized on using the Fly Ash in construction of RCC dams in Hydro Power Projects which fulfill the criteria of IS 3812 (Part-I):2013. Because RCC dams are less costlythan the conventional concrete dams. Cost of Transportation of Fly Ash from Thermal Power Plant to Hydro-Power Project sites is a factor which needs to be taken care of.

xii) Representative from BIS informed that as per IS 456, (along with 5 Amendments), the addition of Fly Ash exceeding the limit specified in IS 1489 (Part 1) is permissible in concrete, albeit, such additions shall not be considered as cementitious materials for the purpose of calculation against the requirement of minimum cement content. So the existing IS 456 does not prohibit the use of higher Fly Ash content in concrete.

xiii) Representative from CSMRS told that research work has been done by Department of Science and Technology in the field of Fly Ash utilization in different areas which can be used in making standard for utilization of Fly Ash. Representative from CWC said that the quality of the coal used in TPPs varies from Plant to Plant. There are two existing parts of standard for using Fly Ash. IS 3812 (Part 1): 2013 which covers the physical and chemical requirement of pulverized Fly Ash for use as pozzolana for manufacturing of cement and IS 3812 (Part 2):2013 which covers the physical and chemical requirements of pulverized Fly Ash for use as admixture in cement mortar and concrete. Fly Ash which complies with all the requirements of these standards should only be used for construction in Hydro Power Projects. Fly Ash should be rejected if it does not comply with any of the parameters prescribed in the above Indian Standards. Concrete mix design for mass concreting in Hydro Power Projects generally contains more than 200 kg/cum of cementitious material component. There are two types of concreting methods, Conventional Concreting and Roller Compacted Concrete (RCC). Fly Ash and OPC concrete mix design can be used in both concreting methods. Lakhwar and Dibang Hydro Projects are RCC concrete approved dams. Ghatghar and Middle Vaitrna Hydro Power Projects have been designed on the similar concrete mix design of more than 200 kg/cum of cementitious material contents. Quantification of Fly Ash in mixed concrete design may be mentioned at design stage of Hydro Power Project. BIS informed that the Indian Standard, IS 10262:2019 'Guidelines for Concrete Mix Proportioning (*second revision*)' covers concrete mix design for mass concrete used for dams and other massive structures, which should be copiously referred and used. The standard covers mix design using Fly Ash along with illustrative example thereof.

BIS further informed that they have revised the Indian Standard, IS 1199 which has been published in various parts. IS 1199 (Part 2):2018 deals with determination of consistency of fresh concrete. In this standard, modified Vee bee consistometer test

has been included for the determination of consistency and density. The test method is prescribed for use in testing of very stiff, dry, non-slump or near-zero and/or zero slump concretes such as Dry Lean Concrete (DLC), roller compacted concrete, no-slump concrete, dry cast concrete, cement treated aggregates (used in pavements) and mixtures of similar types.

xiv) Representative from National Council for Cement and Building Materials (NCCBM) apprised that there are 2 type of Fly Ash produced in Power Plants.

a) Siliceous (Class F) Fly Ash:– The burning of harder, older anthracite and bituminous coal typically produces siliceous Fly Ash. It contains less than 10 % lime (CaO). Fly Ash produced from Indian coal is mainly siliceous Fly Ash. The quality of Fly Ash depends on two things first is grinding of coal and second is method of collection of Fly Ash from ESPs (Electro Static Precipitators).

b) Calcareous (Class C) Fly Ash:-This Fly Ash produced from the burning of younger lignite or sub-bituminous coal contains more than 10 % lime (CaO).

In TPPs Fly Ash collected in ESP hoppers of fields 2 onwards is of fairly good quality. It has higher cementitious properties and can be used in manufacturing of cement (PPC) and construction of Dams and mass concreting, because most of the time it meets the criteria of IS 3812 (Part-1):2013 specifications.

In Hydro Power Projects, when aggregates are reactive, there is a problem of Alkali Silica Reaction (ASR). When Fly Ash above 25 % of cementitious material is used, it mitigates the problem of ASR. In mass concrete Fly Ash more than 35% can be used as in Ghatghar (60-65% Fly Ash is used) as roller compacted high volume Fly Ash concrete.

Bottom ash and Fly Ash collected in ESP field 1 can be used in filling of low lying areas, makings bricks and can also be used by cement industries after fine grinding (mechanical activation) of that Fly Ash along with clinkers. Bottom ash can also be used as a fine aggregate. NTPC, NETRA has started a Project in collaboration with NCCBM to formulate standard and specification for the bottom ash to be used as fine aggregate in RCC. It was mentioned that BIS has now brought out IS 383:2016, which covers use of bottom ash as fine aggregate in PCC in limited percentage. BIS also informed that IS 9142 (Part 1 & 2):2018 has been formulated giving quality requirements for Fly Ash based light weight sintered aggregate.

xv) Main stress of using Fly Ash in mass concreting in Hydro-Power Project is due to constraint of specific requirement of Fly Ash quality as per IS 3812 (Part-1):2013. Representative from NCCBM stated that there is no restriction of Fly Ash in combination with PPC in mass concreting but for more thermal benefits in concreting and cost effectiveness Fly Ash should be used with OPC. Higher utilization of Fly Ash can be achieved when it is used in combination with OPC. In case of non-availability of OPC, Fly Ash can be used in combination with PPC also. Moreover, Fly Ash contents in PPC are up to 15-35% of total mass in PPC. No cement manufacturer shall provide PPC with high Fly Ash contents say up to 65% in it. So, for higher utilization of Fly Ash up to 65% in construction of Hydro-Power Projects, Fly Ash should be used with OPC in mass concreting. Fly Ash in combination with PPC should always be used in consultation with concrete mix design specialist.

Therefore, main focus for Fly Ash utilization in Hydro-Power Project construction should be in mass concreting as apart from scope of higher Fly Ash utilization, use of Fly Ash is beneficial in many ways like, low heat of hydration, ease and speed of construction, low alkali silica reaction problem, better compaction leading to low seepage, cost effectiveness etc. So Fly Ash should be used in construction of Hydro-Projects even if it is transported

to construction site from very far off distances. Fly Ash usage is more economical when it is used with OPC concrete mix design. Fly Ash is also used to mitigate ASR problem in high strength concrete.

xvi) Committee members opined that authentic data should be available on separation of Fly Ash from different ESP fields 1,2,3… etc. As the Fly Ash available in different fields have different fineness and quality, therefore it is necessary that data on availability of Fly Ash from mapped Power stations should contain quantity and quality of Fly Ash collected from different fields separately.

xvii) Representative from TCD Division, CEA informed that during the year 2017-18 Fly Ash was used in construction of two Dam Projects in Madhya Pradesh namely Mahanpura and Kundalia Dam Projects.

xviii) There are 37 number of new Hydro-Power Projects targeted for commissioning up to year 2022-23. Use of Fly Ash in these Project may be recommended at the concrete mix design stage. Ongoing Projects can use Fly Ash only after making amendments in tender documents specifications for construction of these Projects. They may be advised to revise the tender document/Specifications to accommodate utilization of Fly Ash.

xix) Committee members discussed that there is lack of knowledge in institutions/organizations in the country for use of Fly Ash for construction for mass concreting. Awareness about utilization of Fly Ash is also low and knowhow available is not percolating down the line in the institutions/organizations. CWC representative stated that as per available information probably some of the tests particularly shear panel test is not carried out in the country labs.

xx) Sometimes Fly Ash passes all the criteria as per IS 3812 (Part-I): 2013 including lime reactivity but fails to pass fineness test. BIS

was requested to investigate in this regard and may amend the fineness value to 280-300 from 320 in IS 3812 (Part-1):2013 standard, if Fly Ash quality for use in mass concrete does not have adverse effect.

In this context, BIS informed that as per IS 3812 (Part 1):2013, fly ash as collected, if does not conform to the requirements of this standard or if required otherwise, may be processed and/or beneficiated and/ or segregated to modify its physical or chemical characteristics to meet the requirements given in the standard, in accordance with the limitations/provisions given in the standard. It further specifies that appropriate technologies may be applied for beneficiation, segregation and processing of fly ash to improve its properties, such as lime reactivity, loss on ignition, particle size distribution and any of other physical and/or chemical properties. Some of the technologies presently in use are burning/removal of unburnt carbon, sieving/grading of fineness, grinding/attrition for reducing particle size, thermal treatment and blending of fly ash of different qualities.

xxi) Storage of Fly Ash at construction site should be done as per the guidelines for storage of cement. Duration for which Fly Ash can be stored without losing its properties may be specified. Fly Ash may preferably be stored after testing sample of each batch of Fly Ash as per IS 3812 (Part-1):2013 at site itself. However, it was noted that IS 3812 read along with IS 4082 gives guidelines for storage of Fly Ash. Random sample testing of stored Fly Ash should be carried out before use for assurance of retention of fly ash quality during storage period at construction site.

xxii) For availability of Fly Ash testing facility at Power Plants producing Fly Ash, it was discussed that Power station should make available the quality of Fly Ash produced by them complying with the Indian Standard and may be provided to customers with specifications of Fly Ash available. Availability of different qualities of Fly Ash should be reflected separately so that

customers may be allocated the required quality of Fly Ash as per availability.

Power stations should have provision of full Fly Ash collection in dry form along with suitable storage system with facility of separation of fine Fly Ash & storage of fine ash and coarse Fly Ash in separate silos; and provision for loading of Fly Ash into railway wagons/ tankers/bulkers/bags from silos.

Power stations should install their own Dry Ash Evacuation System (DAES) and shall commission the DAES along with the commissioning of the main Plant.

Provisions should be made for weighing of Fly Ash loaded into tankers/ railway wagons/bulkers etc under the silo wherever feasible.

There is a need to develop standard layout for ash evacuation system for all Thermal Power Plants indicating facilities near silo such as access road for easy movement of bulker/larger capacity truck, including railway line for wagon loading, compressed air for cleaning, service water, staff rooms, weighing facility, type of weigh bridge and a number of weigh bridges should be installed for weighing empty and filled bulkers/ tankers/wagons so that in a minimum possible time the ash filled truck /bulker/tanker/wagons etc can exit from Plant.

Existing Thermal Power Plants, should facilitate increased and easy offtake of Fly Ash. Rail loading/ railway siding facility, widening/ strengthening of road, new approach road, and modification in silo for pneumatic loading of Fly Ash in railway wagons/ jumbo bags etc.should be developed wherever feasible.

xxiii) Committee members discussed that National Green Tribunal (NGT) vide its order dated 20.11.2018 directed all Thermal Power Stations who have failed to dispose of 100% fly ash upto

31.12.2017, to deposit damages for environment restoration as follows:

Sl.No.	Capacity of Thermal Power Plant	Cost of damages
1.	Thermal Power Plants upto the capacity of 500 MW	Rs. 1 Crore
2.	Thermal Power Plants upto the capacity of 1000 MW	Rs. 3 Crore
3.	Thermal Power Plants beyond the capacity of 1000 MW	Rs. 5 Crore

Committee noted that NTPC vide its Petition No. 172/MP/2016 approached Central Electricity Regulatory Commission (CERC) for reimbursement of transportation cost of fly ash incurred by them in compliance to MoEF&CC Notifications. CERC agreed that the actual additional expenditure incurred by the petitioner towards transportation of ash in terms of the MoEF&CC Notification is admissible under " Change of Law" as additional O&M Expenses. However, the admissibility of the claims is subject to prudence check of the following conditions on case to case basis for each station:

a) Award of fly ash transportation contract through a transparent competitive bidding procedure, Alternatively, the schedule rates of the respective State Governments, as applicable for transportation of fly ash.

b) Details of the actual additional expenditure incurred on Ash transportation after 25.01.2016, duly certified by auditors.

c) Details of the Revenue generated from sale of fly ash/fly ash products and the expenditure incurred towards Ash utilization up to 25.01.2016 to till date, separately.

d) Revenue generated from fly ash sales maintained in a separate account as per the MoEF&CC notification.

xxiv) Committee during deliberation concluded that:

a) Technologies, construction materials and required standards in the country are available for use of fly ash in civil works of Hydro Power Projects.

b) MoEF&CC notification dated 14th September, 1999 and subsequent amendments dated 27th August, 2003, 3rd November, 2009 and 25th January, 2016 have adequate provision to address bottlenecks likely to hamper the use of fly ash in construction of Hydro Power Projects.

c) Excellence Enhancement Centre (EEC) West Block, R. K. Puram may be entrusted the issues related to organizing seminars/conferences/workshop etc. to disseminate the information/technologies/case studies etc. with a view of encouraging the use of fly ash.

7. Recommendations

In view of above deliberations, following recommendations were drawn by the committee in line with MoEF&CC Notification No.563, dated 14th September, 1999, Notification No. 773, dated 27th August 2003, Notification No. 1799, dated 3rd November 2009 and as amended till Notification No. 225, dated 25th January 2016 for enhancing the use of Fly Ash in Hydro Power Projects: -

i) Concrete mix design for Hydro Projects

High volume Fly Ash Roller Compacted Concrete (RCC) technology may be preferred for construction of concrete Dam. Quantification of Fly Ash in concrete may be done at DPR stage of Hydro Power Project by the Project authority. The Indian Standard, IS 10262:2019 'Guidelines for Concrete Mix Proportioning (*second revision*) which covers concrete mix design for mass concrete used for dams should be referred. However, BIS is requested to formulate guidelines on mix design, production and placement of Roller Compacted Concrete specifically for Dam construction.

ii) Incorporation of clause regarding utilization of Fly Ash in construction of Dams, design of structure:

Projects can use Fly Ash if found technically and financially feasible, after making suitable amendments in technical specifications and tender documents for construction of these Projects under the contractual provisions.
Fly ash can also be utilized in construction of buildings, roads, embankment, pavement, landfilling, canal construction in Hydro Power Projects.

iii) Requirement of amendment in fineness value of Fly Ash from 320sqm/kg to 280-300 sqm/kg in IS 3812 (Part-1)

Committee recommends to BIS to look into the possibility of amending the fineness value (calculated by Blaine's permeability method) from 320 sqm/kg to 280-300 sqm/kg in IS 3812 (Part-1):2013 standard after due validation process. Research bodies may take up research and provide feedback in this regard to BIS.

iv) Updating of ASHTRACK Application

Fly ash availability Data on "ASHTRACK" mobile App may be updated on regular basis to facilitate users of Fly Ash.

v) Organizing Seminar, Conference, Workshop etc. to disseminate the information/technologies/case studies etc. with a view of encouraging the use of Fly Ash

Suitable organization like Central Board of Irrigation and Power (CBIP), Excellence Enhancement Centre (EEC) etc. may be entrusted the issues related to organizing seminars, conferences, workshop etc. to disseminate the information, technologies, case studies etc and latest technological development in this area from time to time.

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8. References

1. Ministry of Environment, Forest and Climate Change (MoEF&CC) Notifications-1999 &subsequent amendment in 2003, 2009 and 2016.

2. CEA Report on Fly ash generation at Coal/Lignite based Thermal Power Stations and its utilization in the Country.

3. Policy guidelines on utilization of Ash by NTPC, Ash Policy 2015, NTPC Ltd.

4. IS 3812 (2013): Specification for Pulverized Fuel Ash.

5. IS 456 (2000): Plain and Reinforced Concrete - Code of Practice.

6. IS 1489-1 (1991) : Specification for Portland Pozzolana Cement, flyash based.

7. IS 1489-2 (1991): Specification for Portland-Pozzolana Cement, calcined clay based.

8. IS 16415 (2015): Specification for Composite Cement.

9. IS 10262(2019) :Guidelines for Concrete Mix Proportioning.

10. IS 383 (2016): Coarse and Fine Aggregate for Concrete – Specification.

11. IS 9142-Part 1 & 2(2018): Specification for Artificial Light weight Aggregates for Concrete Masonry Units

12. IS 4082: Recommendations on stacking and storage of construction materials and components at site

13. IS 1199-Part 2 (2018) Methods of Sampling, Testing and Analysis, Determination of Consistency of Fresh Concrete

9. Abbreviations

ASR	Alkali Silica Reaction
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CRRI	Central Road Research Institute
CSMRS	Central Soil and Materials Research Station
CWC	Central Water Commission
DAES	Dry Ash Evacuation System
DMRC	Delhi Metro Rail Corporation
DPR	Detail Project Report
ESP	Electrostatic Precipitator
HVFA	High Volume Fly Ash
MERI	Maharashtra Engineering Research Institute
MoEF&CC	Ministry of Environment & Forest and Climate Change
MT	Metric Ton
NCCBM	National Council for Cement and Building Materials
NGT	National Green Tribunal
NHPC	National Hydro Power Corporation
NTPC	National Thermal Power Corporation
OPC	Ordinary Portland Cement
PPC	Portland Pozzolana Cement
RCC	Roller Compacted Concrete
TCD	Thermal Civil Design
TEC	Techno-Economic Clearances
TPP	Thermal Power Plant
WRD	Water Resource Department

The report of the committee is presented to Chairperson, CEA with the recommendations of the following committee members:

Sr No	Name	Organisation	Signature
1.	Shri Saumen Biswas, Chief Engineer (HE&RM) (Chairman of the Committee)	Central Electricity Authority	
2.	Shri R.S Ram , Chief Engineer (TCD)	Central Electricity Authority	
3.	Shri P.N. Ojha, General Manager	National Council for Cement and Building Materials	
4.	Shri VivekTripathi, Director CMDD (E&NE)	Central Water Commission	14/10/19
5.	Shri S.C.Joshi, Chief Engineer (D&E)	National Hydro Power Corporation	14-10-19
6.	Shri A.N. Singh, Additional Director	Ministry of Environment & Forest and Climate Change	14/10/19
7.	Shri Sanjay Pant, Head (Civil Engg.) Alternate Member: Smt Rachna Sehgal, Head (Water Resources)	Bureau of Indian Standards	14/10/2019 14/10/2019
8.	Shri Vijay Thorat, Superintending Engineer (Civil)	Water Resources Department, Govt. of Maharashtra	14/10/19
9.	Shri Sudhir Srivastav (AGM) (Engg) Shri Manmeet Bedi (AGM Engg)	National Thermal Power Corporation	
10.	Shri Pawan Kumar, Scientist D	Dept. of Science and Technology	
11.	Dr R Chitra, Scientist E Dr. Manish Gupta, Scientist E	Central Soil & Material Research Station	14/10/2019