DESIGN, CONSTRUCTION AND MONITORING OF ASH DYKES

Implemented by

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For

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EXECUTIVE SUMMARY

The Power generation has recorded over a 50-fold increase in production of electricity in last 50 year. Due to various factors, generation of thermal power is playing prominent role in power generation programme of the country. Coal is primary source of fuel for thermal power stations and generates ashes. There are about 82 power plants in India, which produce about 85 million tonnes of ash per year. This figure is likely to go up to 100 million tones per year by the year 2000 AD which has posed serious ecological problems in addition to occupying large tracts of scarce cultivable land.

Although the beneficial usages of ash in concrete, brick making, soil stabilization treatment and other application have been recognized, only a small quantity of total ash produced in India is currently utilized in such applications. Most of the ash generated from the power plants is disposed off in the vicinity of the plant as a waste material covering several hectares of valuable land. Speedy and effective utilization of fly ash been recognized as problem of national importance, and therefore, the Government of India has constituted a Fly Ash Mission under Department of Science and Technology. The Fly Ash Mission has sponsored has a major Technology Demonstration project on ash dyke design, raising and maintenance which is being executed at IIT Kanpur with active support from National Thermal Power Corporation (NTPC).

The project was completed in several phases. As a part of this project a survey was conducted to gather information from various power plants and to compile the present state of art of ash deposition practices in India. Also, several ash pond sites were visited by the authors to investigate and to obtain in-depth information about the ash deposition practice.

In the last fifteen years, the authors have designed several ash ponds and all these designs and analyses were abstracted to formulate a design procedure for ash dykes. Also, the geotechnical test results of ashes of various thermal power plants were analysed and the results were compiled to provide the data bank of the Indian ashes.

The design details have been prepared for starter dyke and ash dyke raisings. The phenomenon of liquefaction and dynamic analysis of ash dyke raising have been discussed and procedures have been outlined for evaluating the liquefaction potential of a ash dyke facility.

The construction procedure and guideline technical specifications of all key items of the ash dyke construction and raising are included. The quality control procedures have been outlined for related construction items.

It is recommended that all sites should be properly instrumented to monitor the post-construction performance. The suggested instrumentations are survey monument, settlement plates and piezometers.
One of the major thrust of this project was post-construction monitoring. Initially, two sites KSTPP, Korba and BTPS, Badarpur were selected for post-construction monitoring. Later on, two additional sites namely, HTPS, Korba and MPEB, Korba were added. At all the four sites, SPT, PLT, and SCPT were performed and the fly ash samples were tested for geotechnical properties. Post-construction settlement of ash dyke was measured at BCPP and piezometer readings were taken in these sites. Inclinometer casings were installed at HTPS and KSTPP sites. At KSTPP site, lateral movement of ash dyke was measured by digital inclinometer for the entire ash filling of the staging of construction. Plate Load tests were conducted on the settled ash bed at BCPP site to assess the in-situ strength of the settled ash.

All the above information have been summarized in this manual. The manual has presented the most updated concepts on ash dyke design, maintenance and field monitoring in the context of ash deposition practices being followed in India. This manual is intended to provide significant guidelines to an expert geotechnical engineer familiar with ash deposition practices to design and construct an ash pond. Based on the concept of outlined in the manual and our experience, the following recommendations are provided with respect to the design of ash dykes.

1. Geotechnical and Chemical properties of Indian ashes of various power plants tested at IIT Kanpur were compiled along with the results of other sites available in the literature.

2. Indian ashes tested at IIT Kanpur and those reported in literature are found suitable for construction of starter dyke and for subsequent raising over the existing dyke.

3. There is a wide scatter in the geotechnical and chemical properties of Indian ash, and therefore, and it is recommended that site-specific tests of ash collected from various location within the existing ash pond should be performed to establish the design parameters.

4. A well-compacted fly ash exhibits strength comparable to that for soils normally used in earth fill operations.

5. For ash tested from various sites in India, it is found that a compaction at 95% of the maximum standard protector dry density would provide adequate shear strength for the design and construction of a safe ash dyke.

6. The special light weight property of ash is particularly advantageous in situations where filling operations are to be carried on relatively weak foundation materials. Such is the situation of upstream method of construction where the staged dyke is raised on loose slurried ashes.

7. It shall be useful to develop a performance specification for compaction by means of a field test section prior to full-scale construction. The number of
passes of a particular piece of compaction equipment required to achieve the desired density in the ash is determined from the results of such a test.

8. It has been demonstrated that the most satisfactory compaction results are achieved with self-propelled pneumatic-tired rollers with self propelled towed vibratory rollers. Sheep-foot rollers, smooth-wheeled rollers, and grid and vibrating plates have not been successful on fly ash.

9. Some of the specific environmental hazards associated with ash such as leachate generation, capillary action and erodibility can be controlled by implementing suitable design measures.

10. Both up-stream and down-stream method of construction can be adopted for the deposition and raising of the fly ash impoundment. The merits and demerits of both the methods have been discussed earlier. The major advantage of down stream construction is that the entire embankments constructed on a firm foundation and therefore, it can be raised relatively very high. However, in India most of raisings are done by upstream method which are founded on a very weak material, and therefore, the raisings are limited to site conditions. Also, it is very prone to earthquake loading. If the existing site conditions permit, the downstream method of ash dyke raising should be preferred.

11. The major risk associated with compacted fly ash dyke is erosion of the ash, both internally and externally. The internal erosion is control by a properly designed drainage and filter system, and the external erosion due to wind, rain and wave action is controlled by a suitable soil cover and vegetation.

12. Protection against over topping is paramount, as for any earth-fill structure, and adequate spillway or run-off diversion capacity must be provided and maintained. A minimum of 1.5 m of free broad shall be maintained during entire life of the facility.

13. In regions of moderate to high seismic zones, analysis of embankment stability should consider dynamic loads to ensure that the width of the constructed structural fill is adequate to retain the loose material behind it. The analysis must also consider liquefaction potential of the settled slurry supporting the staged portion of the embankment. Additional research and investigation should be carried out on the liquefaction potential of ash dyke and ash embankment and appropriate guidelines should be developed for designing of such structures.

14. The in-situ laboratory test and post construction monitoring of ash dykes constructed by up stream method of construction have demonstrated that by adopting suitable engineering measures, it will be possible to use the existing ash deposit of the lagoon for supporting the additional height of the dyke.
15. At many sites, the ash dykes have been raised to several stages by upstream method of construction. At KSTPP, first raising was done a decade ago and now the fifth and the final raising is being constructed. This has clearly demonstrated the success of the technology.

16. Post construction field investigations have shown marked improvement in the strength of settled ash beneath the embankment as compared to settled ash of other locations in the pond. This improvement is due to consolidation and compaction of material and dissipation of pore pressure. Shear strength properties of the settled ash beneath the embankment have been estimated from the theoretical and empirical relationships using SPT, SCPT and PLT test results and the angle of internal friction \( \Phi \) of the settled ash is found from \( 28^0 \) to \( 31^0 \) at KSTPP and BSTPP sites.

17. The \( \Phi \) value of the settled ash bed near ash slurry discharge end of BTPS pond is found to be comparatively higher than the water outlet end. This attributed to the fact that there is accumulation of finer particles near the outlet end. This can be overcome by discharging the ash in garlanding fashion so that the ash particles are distributed uniformly over the entire pond. This will lead to a relatively uniform and better foundation conditions for upstream raising of ash dykes.

18. It is estimated that total settlement of the settled ash is likely to be less than 4% due to construction of ash embankment and about 50 to 70 per cent of the total settlement likely to be completed during the construction period of ash embankment raising.

19. Inclinometer was installed at KSTPP ash dyke to monitor the lateral movement of ash embankment. Lateral movement was found to occur only during initial phases of ash slurry filling operation in the lagoon after which no appreciable movement was detected. The movement seized after complete filling of slurry ash. The total movement of the downstream side of embankment constructed on the settled ash found to be less than 0.2%.

20. The piezometer readings revealed that the phreatic line is near the drainage blanket at KSTPP and BTPS sites. The proper functioning of the internal drainage system installed within the embankment was demonstrated by piezometer readings. The piezometer reading was normally at drainage blanket levels.

21. It is to be recognized that each design should be a site specific considering all the constraints, site condition, quality of the existing dyke and the geo-technical and chemical properties of the ash produced at each site. Based on those conditions, the design should be developed by an expert geo-technical engineer knowledgeable in the design of fly ash dyke/tailings dam.