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STABILITY OF FLY ASH DYKE: A REVIEW CASE STUDY

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Abstract: The lifeblood of one's daily activities is energy in the form of electricity. Thermopower and hydropower are two of the most common methods for generating energy. Coal-fired thermal power plants provide more than 70% of the electricity in India. Despite their many advantages and benefits, coal-fired thermal power plants produce a substantial amount of solid waste, known as fly ash. In India, a large amount of fly ash is produced. There is an imbalance between the amount of ash produced and how it is used. Such a large number raises difficult issues in terms of land use, health risks, and environmental threats. This report discusses several severe issues with the integrity of the fly ash dyke at Panipat Thermal Power Station, as well as how they were resolved.

***Index Terms* – Fly Ash, Bund, Thermal Power Plant, dyke.**

I. INTRODUCTION

Because PTPS is coal-based, a large amount of fly ash is generated. The removal of fly ash and bottom ash is a difficult task. The PTPS, like other thermal power plants in India, has a wet disposal method in which fly ash is conveyed as a slurry via pipelines and disposed of in an impoundment known as a 'ash pond,' culminating in the construction of a massive mound of ash known as an ash dyke. The ash ponds for PTPS are strategically situated near the power plant to save slurry pumping costs (bottom ash mixed with water). For the ash dykes at PTPS, Panipat, the upstream construction approach was used. The following are some of the issues and noticeable locations that require attention:

a) The side slopes of the fly ash dyke are insufficient, resulting in frequent slides and damage to the embankment, including anchor blocks and pipe supports.

b) There was no provision for an impermeable membrane (plastic liner) in the inner section of the ash pond (the full bottom and upstream face) to avoid ground water contamination.

c) The initial stage of the fly ash dyke lacks an internal drainage system of toe drain and rock toe. The seepage disposal system was inadequate even in the later phases of the dyke's construction.

d) Waste water disposal is a major issue in the neighbouring low-lying community of Khukhrana. As a temporary remedy, PTPS pumps this waste water to the ash dyke on occasion, so not only adding unwanted weight to the dyke but also damaging the dyke's northern section.

e) The inhabitants use the top of the dyke's edge as a thoroughfare to get to another settlement. They usually use motorbikes and bicycles for this, causing damage to the dyke's side slope.

II. DESCRIPTION OF ASH DYKES:

Two ash dykes (one for units 1 to 6 and another for units 7 and 8) are positioned about 2 km away from the power house opposite the thermal plant on the other side of the Panipat – Assan road, near to the plant's existing raw water reservoirs/pump houses. Ash slurry from Units 1 to 6 is managed in Ash Pond 1, which has a surface size of 625 acres and a bund height of 12.25 metres. Its current capacity to handle fly ash is estimated to be 1.1 million tonnes.

Units 7 and 8 are served by Ash Pond 2, which has a surface area of 200 acres and a bund height of 15.25 metres. It has a 1.3 million tonne capacity for handling fly ash. Assuming a 50% dry ash usage rate, the existing capacity of Units 7 and 8 ash ponds might last 2.5 to 3 years, while Units 1-6 ash ponds could last 1 to 1.5 years. The following are the future plans:

• Unit 1-6 ash pond – a 4 m increase in bund height is envisaged, resulting in an additional 3.5 million tonnes of capacity.

• Ash ponds Units 7 and 8: a feasibility study to raise the bund height by 4 metres has been recommended.

a) Ash Dyke No. 1 description (For Units 1 and 6) (The Embankment of the Earth) Figure 3.1 shows how the Ash Dyke is laid out. The fourth stage/lift of the ash dyke no. 1 is now being used to dispose of bottom ash. Here's a quick rundown of the many stages/lifts of the ash dike.

• Initial stage/lift (mother or starting dyke): The dyke's first stage is 4.0 metres tall. Fly ash extracted from the lagoon (ash dyke) and a soil cover (0.5 m thick) to the embankment were employed for this stage's construction. There is no information on the depth of impermeable stratum at the location. Furthermore, an impermeable membrane (plastic liner) was not supplied in the inner section of the ash pond (the full bottom and upstream face) to prevent ground water contamination. In addition, there is no toe drain in the initial stage.

• Second stage/lift: The dyke's second stage is 4.0 metres tall. Fly ash extracted from the lagoon (ash dyke) and a soil cover (0.5 m thick) to the embankment were employed for this stage's construction. On the upstream side, there was no impervious membrane (plastic liner). An internal drainage system with a toe drain is included in the second stage/lift.

• Third stage/lift: The dyke's third level is similarly 4.0 metres high, bringing the total height to 12 metres above ground. Fly ash extracted from the lagoon (ash dyke) and a soil cover (0.5 m thick) to the embankment were employed for this stage's construction. On the upstream face, similar to the second lift, there is no impervious membrane (plastic liner). In addition, the third stage/lift features an internal drainage system (with a toe drain) that is properly linked to the second stage's drain.

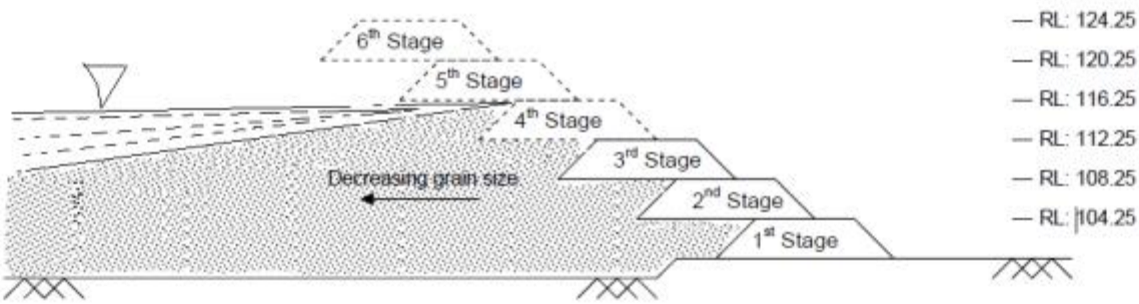

Figure 1 Layout of the fly ash dyke

• Fourth stage/lift: The dyke's fourth stage is rising to a height of 4.0 metres. Fly ash extracted from the lagoon (ash dyke) and a soil cover (0.5 m thick) to the embankment are the building materials for this stage.

• Lifts for the fifth and sixth stages/lifts proposed: The following stages/lift are planned to commence construction in the next months. The height that has been proposed is 4.0 metres. Two further 4.0 m stages/lifts (fifth and sixth stages, respectively) with appropriate berm widths are also envisaged. b) Ash Dyke No. 2 (for units 7 and 8) description (Earth Embankment) Fly ash from Units 7 and 8 is disposed of in a shared ash disposal site. The second stage/lift of the fly ash dyke is now in use for

• First stage/lift: In 2004-05, a 7.0 metre high starting dyke was built from elevation 100.25m to 107.25m, with a storage capacity of around 26.1 Lac m3. Later, to meet the increased demand for ash disposal, the height of the ash dyke was raised by another 8 metres, from 107.25 metres to 115.25 metres, increasing the storage capacity to 45.6 million m3 (40.7 million MT), and the work was finished on September 30, 2009.

• Second stage/lift: HPGCL proposes to raise the height of the current ash dyke of Units 7&8 from the bund top EL. 115.25m, as done earlier in the first stage/lift at PTPS, Panipat. The second raise in the ash dyke of unit 7&8 is currently intended to be erected from ash borrowed from the settled ash in the existing ash pond and from the stilling ponds, ranging from 115.25m to 119.25m. The ash from the stilling ponds should be removed first, followed by the ash from the ash pond. At the top of the ash bund, there will be an earth protective layer. The planned elevated ash pond would also have two collector wells, one for segment A and one for segment B, for collecting supernatant water for recycling in the pond.

III. PROBLEMS, EFFECTS AND PROBABLE CAUSES/REASONS:

In terms of the ash dyke's stability and protection, the following issues have been recognised. The issues, as well as their repercussions and possible causes/reasons, have been listed and addressed as follows:

A. The ash dyke's stability: The PTPS Panipat ash dyke is experiencing major stability issues, notably in the northern and western parts of the embankment/bund of the mother ash dyke (first stage).

These are some of them:

Internal drainage system consisting of toe drain and rock toe: In the case of the first stage of the ash dyke, an internal drainage system consisting of toe drain and rock toe is currently lacking (mother dyke). Its absence has rendered drainage inefficient, causing the phreatic line to rise and the slope's stability to deteriorate. Furthermore, because this mechanism is missing for the first stage of the dike, the subsequent stages are not connected to the first stage.

b. Seepage failures: Seepage failures have been seen at a number of spots, most notably on the ash dyke's northern bund. Because of the seepages from the ash dyke into the feeder channels, the embankment is scouring and slush is slipping into the feeder channels. Such severe seepages from the ash dyke have a significant impact on the slope stability and quality of raw water supplied to the plant via feeder channels.

The faults described above can be traced back to —

I Instead of terminating at the toe drain, the phreatic line (top seepage line from the dyke) cuts the downstream face of the dyke;

(ii) The aggregate filter at the downstream bottom section of the filter is not in place.

c. Gasket failures/joint leakages/bursting of ash slurry disposal pipes: Gaket failure, joint leakages, and rupture of ash disposal pipelines have been seen, notably on the northern bund. These are sometimes responsible for embankment breaches as well as raw water feeder channel contamination.

d. Gully formations: Gully formations have been seen in a number of places. Slope stability is substantially reduced by such formations, especially following heavy rains. Surface water flow during rainstorms and leakages from disposal pipes, a lack of grass turfing, the existence of animal burrows, and other factors are all probable causes of gully development.

e. Grass turfing on the downstream face: At various points along the embankment's downstream face, there is no or very little grass turfing. During rainstorms, the embankment is eroding, and slurry disposal pipelines are leaking or exploding. Gully development is also aided by a lack of grass turfing on downstream slopes.

f. Discharge points for ash slurry: Discharge locations for ash slurry are not uniformly distributed. While there are no more of these locations on the northern side of the dike, there are far less in the extra Disposal Area adjacent to the southern bund. As a result, the slurry is not evenly dispersed across the ash dike. In addition, the slurry is not discharged at the same time from all discharge locations.

g. Beach formation: In many places, the beach formation is improper. Increased seepage on the downstream side is a result of the shorter beach length, which might compromise the stability of the downstream slope.
h. Unauthorized entrance into the ash dyke area: Unauthorized entry of cars and animals into the disposal area (ash dyke area) has caused damage to the embankment and, as a result, has decreased its stability. Animal grazing has a number of negative effects on the stability of the ash dyke, including the removal/reduction of grass turfing, the creation of gullies as a result of animal burrows, damage to the supports and joints of the ash slurry disposal pipes, accidents, and so on.
i. Damaged berms: The movement of approved and un-authorized vehicles causes damage to the berms in various areas. Harmed berms result in embankment slopes being damaged. During the rainy season and/or when the berms are moist owing to seepage, the damage is significant.
j. Maintenance work has been delayed: It has been seen that the restoration of damaged areas of the embankment has not been completed on time. The embankment's structural issues are exacerbated by the delay.
k. Lack of streetlights or floodlights: There are no streetlights or floodlights in the dike area. These are necessary for nighttime inspections and aid in early discovery of problems and, as a result, early fixes.
l. Monitoring facilities: The monitoring facilities required for the ash dyke's functioning are insufficient. As a result, critical parameters such as phreatic line checking, internal drain efficiency, slope instability, and ash dyke lateral movement cannot be determined or recognised at an early stage.

B. Effect on raw water feeder channels:
The slide of slush in the feeder channels is caused by gasket failure, leakages in the joints, the bursting of ancient ash disposal pipes, and the scouring of the earthen embankment. The following issues have occurred as a result of this:
a. Feeder channel carrying capacity are reduced: The slippage and piling of slush has reduced the carrying capacity of the feeder channels, which has had a significant impact on the raw water supply to the Plant. In reality, the Feeder Channel-2 has become non-functional in the majority of the stretch/stage between Badshahi Drain and the current regulator due to the accumulation of slippery slush. Even the remainder of this stretch/stage is in poor condition.
b. Plant growth in feeder channels: Due to the enhanced soil and nutritional content in the form of phosphorus and nitrogen contained in the fly ash, the slid slush in the feeder channels also encourages vegetation development in the channels. This not only reduces the carrying capacity of the feeder canals, but it also increases the pollutant burden.
c. Pollution of the raw water supply: The slid slush is to blame for the plant's raw water supply becoming contaminated. In different concentrations, fly ash contains hazardous heavy metals such as aluminium, chromium, manganese, iron, cobalt, nickel, copper, zinc, arsenic, lead, and cadmium, which are detrimental to humans. Because these feeder canals also provide water to residential areas, their contamination by toxic heavy metals poses a major health risk.
d. Silting of storage ponds: The silting of storage ponds is caused by slush that has fallen into the feeder channels.

C. Problems faced by the residents of the village Khukhrana
On the Panipat-Jind Highway, Khukhrana is an ecologically challenged community located near the Panipat Thermal Power Station. The settlement stands within I00-150m of the northern side of the ash dike, which covers an area of around 800 acres. Percolating water from the dyke contains impurities that feed the area's subsurface water reservoir.
The following are some of the possible causes of the village inhabitants' problems:
• High groundwater table: During wet seasons, the natural groundwater table is just a few feet deep and practically touches the surface in a few places. This creates water logging in the region, resulting in issues such as moisture in the structures, foundation deterioration, and the formation of fractures in the buildings/houses. Weed patches appear in the residential area as a result of the creation of little pools of water. Due to waterlogging and weed growth, the people are vulnerable to skin and waterborne infections. The above-mentioned issues are exacerbated by insufficient sewage disposal and drainage systems.
• Ground water contamination caused by wet fly ash disposal: Wet fly ash disposal causes seepage of water into the ground, resulting in polluted water mixing with ground water. The Khukhrana inhabitants rely solely on ground water for drinking, feeding their livestock, and irrigation. In addition, no water treatment facility has been established for the residents. Between the soil and the ash dike, there is no liner. Lechate is formed as a result of this. Lechate combines with ground water, polluting it further.

D. Groundwater pollution:
The migration of ash water into the groundwater is a major source of groundwater contamination. It is preferred to have a somewhat impermeable layer at the bottom of the ash pond even in places away from water bodies (such as rivers, lakes, and so on), as is the case at the site in question.

E. Absence of plastic liner:
To avoid groundwater pollution, a plastic liner must be installed across the whole bottom of the ash pond and upstream face of the ash dyke. Plastic liners, on the other hand, were not provided until the third stage of the ash dyke.

F. Dust pollution:
During periods of high wind, dust pollution in the surrounding region is also a serious problem. When the building of the next stage of the ash dyke is underway, the dust pollution from the ash dyke is greater.
• Unauthorized access into the ash dyke area: Due to the lack of fencing or a boundary wall, the whole ash dyke area functions as a highway. The under-reported continuous unlawful actions are causing damage to the ash dyke's embankment/bund and reducing its stability, as well as leaving the region vulnerable to sabotage.
• Unauthorized cars readily using the ash dyke's berms/inspection roads: It has been noticed that residents of adjacent villages freely use the ash dyke's berms/inspection roads. Unauthorized vehicle movement (motorcycles, scooters, tractors, etc.) is causing damage to the ash dyke's embankment/bund.
• Grazing along the ash dyke's slopes: Animals graze freely along the ash dyke's slopes (as well as on top). Uncontrolled grazing has major consequences, including:

– The removal of grass turfing, which is critical for the embankment's stability and protection. – The construction of animal burrows, which can store water and contribute to gully formation and soil erosion along the embankment's slope. Because of the loose soil, the toe drain or drains on the downstream face of the embankment may become clogged, affecting their functionality.

— Animals in the slurry, an abandoned decanting well, or any other catastrophe might result in dike infrastructure damage or an unnecessary conflict with the locals.

- Water usage: Humans and animals should avoid drinking water near the decanting system on top of the ash dike.

THEORY AND CONCEPTS INVOLVED

The engineering solutions are based on theoretical principles of earthen embankment stability in terms of resistance to hydraulic failures. In this scenario, hydraulic failure refers to seepage of water through the embankment, causing the slope to become unstable.

Seepage or phreatic line:

The seepage or phreatic line is the line within an earthen embankment that separates the saturated and unsaturated zones. The embankment has positive hydrostatic pressures below this level. The hydrostatic pressure is equal to zero or atmospheric pressure at the phreatic line. Negative hydrostatic pressure exists above this line, and this zone is known as capillary saturation or capillary fringe. The effective weight of the soil is lowered in the positive hydrostatic zone owing to the passage of water through the embankment body, which decreases the shear strength of the soil due to pore pressure. Because capillary tension in water causes increased intergranular pressure, the capillary fringe zone has a higher shear strength. As a result, determining the seepage line in

• Determining and drawing a flow net diagram;

• Determining and drawing a line dividing the dry and wet or submerged soil in the embankment section.

• Because the seepage line does not cut the d/s face of the embankment, it can be engineered to prevent the embankment from softening or sloughing.

FAILURES AND PREVENTIONS

• Failure due to erosion of the downstream toe can be avoided by providing rip rap or d/s slope pitching; • Failure due to erosion of the d/s face by gully formation can be avoided by proper maintenance, all cuts formed should be filled as soon as possible, grass should be grown on the slope, and berms at appropriate heights. Drainage should be provided in a proper manner.

c) Seepage failures measures:

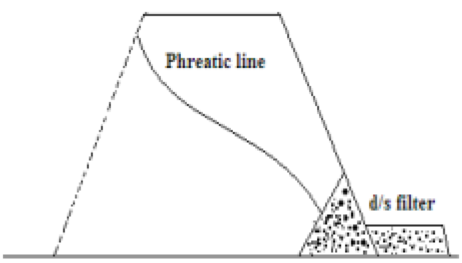

Figure 2 filter d/s of the toe

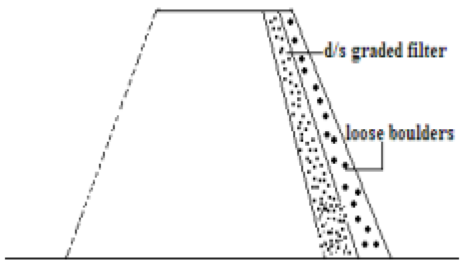

Figure 3 d/s coarse section

The following are some of the most popular strategies used to avoid seepage via dykes:

• By installing a horizontal drainage filter, you can: The horizontal drainage filter's length can range from 25% to 100% of the distance between the d/s toe of the dyke's centre line and the dyke's centre line. The following are the functions of the horizontal drainage filter:

o It delivers more seepage due to the shorter seepage route.

o The seepage or phreatic line is kept well within the embankment.

o The embankment's consolidation is expedited.

• By including a toe filter in the dike, the phreatic line is kept contained inside the embankment portion. It also has excellent drainage facilities. The toe filter should be suitably designed to meet the filter needs.

• By installing downstream filters: Cohesion-less graded particle filters should be installed in d/s to minimise excessive leakage and progressive piping through embankment fractures. The moving particles are either caught in the filter or the core material swells and seals the cracks when water runs through these pores in the core towards graded filters.

• Supplying a d/s coarse section: providing a coarse section on the d/s side of the embankment will intercept seepage through the embankment and make the d/s slope secure from piping.

b) Earthen dyke slope protection The following materials are used to protect the upstream slope from wave action and the d/s from seepage:

• Cement concrete pavement • rock riprap o dry dropped stone boulders o hand packed stone boulders

• bituminous material pavement

• brick tile pavements

• precast cement concrete blocks

OBSERVATIONS AND RECOMMENDATIONS:

The ash dike began collecting fly ash more than three decades ago and has now grown to a height of more than 15 metres. As a result, the current scenario restricts the execution of several policies. Furthermore, the effectiveness of the measures is hampered by the irrevocable lack of an impervious layer at the bottom of the mother dyke. The following are the study's main findings and recommendations:

• Observations

a) A site survey revealed that the ash dike embankment is in a decrepit state.

b) The downstream embankment does not have the appropriate slope and so has a propensity to slip on occasion.

c) Damage to anchor blocks and pipe supports occurs as a result of slope slippage.

d) Material from the embankment slides into the raw water feeder channels, contaminating the water.

• Recommendations

As a solution, the following measures should be implemented:

Engineering solutions (A).

a. Improving the embankment/bund b. Installing a toe drain in the current stage c. Installing a plastic lining

d. Maintaining the length of the beach e. Having uniformly distributed slurry discharge stations f. Using flexible hose pipes to transport fly ash slurry g. Using bottom ash

B. General solutions:

a. Turfing b. Sprinklers c. Accessible roads d. Street or flood lighting e. Boundary wall or barbed fence surrounding the ash dike

SUMMARY

The design, building, operation, and maintenance of an ash pond are all addressed in this work. The majority of the findings are based on observations made at PTPS Panipat's ash pond locations. The engineering advice and remedies for the stability concerns and protection of the fly ash dyke are discussed in this study. The current study is a referenced field-based analytical study concerning the rehabilitation of the PTPS ash dyke's earthen embankment. Despite attempts to use the fly ash created, a considerable amount of fly ash remains unutilized and must be disposed of in a safe and cost-effective manner.

REFERENCES

[1]. Dey, A. 2012 “Stability of ash dykes: Peeping through case-studies”. National Workshop Ground Improvement Techniques with Reference to NE Region (GIT-NE), 2012AEC Guwahati and IGS NE chapter.

[2]. Dikshit, Lokeshappa B, 2011 “Disposal and Management of Fly ash” International Conference on Life Science and Technology.

[3]. Gandhi S. R. 2005 “Design and maintenance of ash pond for fly ash disposal”, IGC-2005, 17-19 December 2005, Ahmadabad, India.

[4]. HPGCL, SMEC. (2010) “Rapid Social Assessment of Panipat Thermal Power Station” Final Report.

[5]. HSPCB “Action Plan for Abatement of Pollution of Panipat Town”

[6]. Mandeep Sindhu, “Study of Waste Polythene in Road Construction and its Methodologies”, IJRARInternational Journal of Research and Analytical Reviews, Volume 5 , Issue 2, April – June 2018, E ISSN 2348 –1269, P ISSN 2349-5138, 2018.

[7]. Volume-II Technical specifications “Raisings of ash dyke of unit 7&8 from el.115.25m to 119.25m including allied civil works at PTPS, Panipat” HPGCL Panipat thermal power station, Panipat”