



**BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL
EASTERN ZONE BENCH, KOLKATA
ORIGINAL APPLICATION NO. 14 OF 2026**

IN THE MATTER OF:

Dilip Kumar Samantaray

...Applicant

-Versus-

State of Odisha & Others

...Respondent (s)

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NDoH: 15.05.2026

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Date: 13.05.2026

Place: Kolkata

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REPLY ON BEHALF OF THE RESPONDENT NO. 8, M/S VEDANTA LIMITED TO THE ORIGINAL APPLICATION

1. That the present Original Application has been instituted by the Applicant, alleging breach of the red mud pond/process water lake dyke on 15.09.2024 at the premises of Respondent No. 8, M/s Vedanta Limited [Alumina Refinery Unit], located at Lanjigarh, Kalahandi, Odisha, and its impact on the agricultural field and Bansadhara River. The Applicant further alleges that no environmental compensation has been imposed and collected from Respondent No. 8, M/s Vedanta Ltd.
2. That on 23.03.2026, this Hon'ble Tribunal admitted the Application, despite a vehement opposition with regard to the locus (Applicant is from Bhubanewar-residing around 400 km away) as well as limitation (delay of one year and four months) in approaching this Hon'ble Tribunal but also granted liberty to Respondent No. 8 [M/s Vedanta Limited, Alumina Refinery Unit] to submit a full-fledged response, including on the issue of limitation on merits.
3. That accordingly, the present Reply Affidavit is being filed by Respondent No. 8 [M/s Vedanta Limited, Alumina Refinery], to put on record the objections vis-à-vis the admissibility of the Original Application, on limitation, locus and on merits.

4. That, unless any averment made in the Application is specifically and explicitly admitted, the said contents may be deemed to be denied in their entirety as though herein specifically set forth in seriatim and traversed.
5. That it is humbly submitted that the Respondent No. 8 expresses, and has expressed in the past, deep anguish over the unfortunate accident that occurred on 15.09.2024. The accident in question was an unfortunate breach of the Process Water Lake dyke, which occurred due to unprecedented rainfall, despite the existence of safety systems and operational precautions, and was not the result of any deliberate act, omission, negligence, or recklessness on the part of Respondent No. 8. It is emphasised that the causes and contributing factors of the accident have already been investigated into by statutory and expert bodies, both by way of a preliminary investigation on the same day of the accident and through a Technical investigation carried out on a later date, by the State Pollution Control Board and the Ministry of Environment, Forest and Climate Change (MoEF&CC), whereby it has been confirmed that the breach in the Process Water Lake was due to unprecedented rainfall however, it has not resulted in any environmental damage.
6. That the Respondent No. 8 -M/s Vedanta Ltd. [hereinafter referred as the Answering Respondent] herein has complied with all the directions of the appointed Committee by restoring the affected land and payment of compensation to the affected villagers with respect to any crop damage, among other directions. The answering Respondent submits that the mere occurrence of an accident cannot be equated with wrongdoing or fault, and the Answering Respondent has placed the relevant facts, records and explanations before this Hon'ble Tribunal, which are described below. The Answering Respondent seeks to submit its Preliminary Objections and Submissions before submitting its

paragraph-wise reply to the Original Application, which in the humble opinion of the Answering Respondent, are crucial for a holistic adjudication of the case.

I. PRELIMINARY OBJECTIONS ON THE ADMISSIBILITY OF THE ORIGINAL APPLICATION

A. The Original Application is hopelessly barred by Limitation as prescribed under Section 14 of the National Green Tribunal Act, 2010

7. That the present Original Application has been filed on 19.01.2026 under Section 14 of the National Green Tribunal Act, 2010 (herein referred to as 'NGT Act'), raising grievances against an incident which occurred 1 year and four months back on 15.09.2024, and is clearly beyond the statutory limit of six months under Section 14 of the NGT Act, 2010, which expired on 15.03.2025 and not even within the ambit of the condonable period of sixty days granted by the NGT Act, 2010, which expired on 15.05.2025.
8. That this Hon'ble Tribunal and the Hon'ble Supreme Court in a catena of judgements has affirmed that any application filed before this Hon'ble Tribunal beyond the time period prescribed by the NGT Act, 2010 cannot be entertained and is liable to be dismissed. Reliance is placed on *Bharatkumar K. Patel vs. Ministry of Environment and Forests & ors., Application no. 55 of 2013 (WZ)*, *Variya Gandabhai v. Union of India & Ors. - MA 147 in Appeal No. 27 of 2014* and *Bharat Jhunjunwala v. UOI & Ors., Appeal 151 of 2016*. The five judge bench of this Hon'ble Tribunal in *Sunil Kumar Samantra v. West Bengal PCB [M.A. No. 573 of 2013]* had categorically held that NGT is a self-contained code in itself and has to adopt the limitation period within which the jurisdiction of the Tribunal gets invoked. The said Judgment of this Hon'ble Tribunal was confirmed by the Hon'ble Supreme Court in the case of *Sunil Kumar Samanta v. West Bengal Pollution Control Board [Civil Appeal No. 10009/2014]*. The cases

referred in this Response are separately compiled and submitted as a Convenience Compilation.

9. That the Applicant contends that the present *lis* constitutes a continuing cause of action, which is not envisaged under Section 14 (3) of the NGT Act, 2010. Section 14(3) of the NGT Act, 2010 is extracted below-

*“(3) No application for adjudication of dispute under this section shall be entertained by the Tribunal unless it is made within a period of six months from the date on which the **cause of action for such dispute first arose**:
Provided that the Tribunal may, if it is satisfied that the applicant was prevented by sufficient cause from filing the application within the said period, allow to to be filed within a further period not exceeding sixty days.”*

The Answering Respondent humbly submits that in the NGT Act, there is no concept of continuous cause of action, but the concept of “cause of action first arose”, and therefore the general concept of continuing cause of action is alien to the NGT Act, 2010.

10. That in fact this Hon’ble Tribunal, dealt with this question in great detail in its well settled judgement of *Forward Foundation & Ors vs State of Karnataka & Ors, OA No. 222 of 2014*, which holds the field, where it has made it clear that where the legislature specifically requires the action to be brought within the prescribed period of limitation computed from the date when the cause of action ‘first arose’, it would by necessary implication exclude the extension of limitation or fresh limitation being counted from every continuing wrong, so far , it relates to the very same wrong or breach and necessarily not a recurring cause of action. Thus, it is clear that this Hon’ble Tribunal has not recognised the concept of ‘continuing cause of action’. The said Judgment of this Hon’ble

Tribunal has been upheld by the Hon'ble Supreme Court in the case of Mantri Techzone v. Forward Foundation and Others [2019 18 SCC 494].

11. That in the present Application, the cause of action has been traced to a direction dated 17.09.2024 issued under Section 33A of the Water Act, 1974 by the Odisha State Pollution Control Board. The said Application, therefore, is totally barred by limitation under Section 14 of the NGT Act, 2010 as it was filed only on 12.01.2026 (although wrongly written as 12.01.2025, but sworn on affidavit on 12.01.2026). That the Applicant, after waiting for a period of more than a year, has filed an RTI on 29.11.2025 enquiring about the action taken with respect to the 'collapse of the red mud pond', whereas the breach, in fact, occurred in the Process Water Lake, a rainwater surface run-off storage reservoir which is an altogether separate and distinct facility from the Red Mud Pond maintained at the Answering Respondent's premises. This has clearly been done as an afterthought and cannot be considered as a fresh cause of action under Section 14 of the NGT Act, 2010. The Hon'ble Supreme Court in a catena of cases, has held that representations cannot be used for reviving matters that have become stale or barred by limitation. [C. Jacob v. Director of Geology & Mining [2008 10 SCC 115; Chief Executive Officer & Others v. S. Lalitha & Others [2025 INSC 565].

12. That the Applicant, while trying to highlight the damage caused by the breach of the Process Water Lake dyke, has referred to certain pictures showing different locations partially flooded with muddy water, and a picture of dead fish, as well as a news article trying to report the same. It is humbly submitted that the pictures are neither geotagged nor dated, and therefore the news article which is undated cannot be considered for determining the cause of action under Section 14 of the NGT Act, 2010.

13. That it is important to mention that the Applicant has not placed on record a single document evidencing that he ever visited the site of the alleged incident at Lanjigarh, Kalahandi. The Applicant is a resident of Bhubaneswar, situated approximately 400 kilometres from the Answering Respondent's premises where the incident took place. The Application does not contain any travel record, visit report, affidavit of personal inspection, or any other material demonstrating that the Applicant has first-hand knowledge of the alleged damage or has, at any point in time, made a personal visit to assess the same. The Applicant has, therefore, filed the present Original Application entirely on the basis of unverified photographs of unknown provenance, unattributed and undated newspaper clippings, and bare assertions, none of which constitute legally admissible or probative evidence before this Hon'ble Tribunal.

14. That the Applicant has clearly filed the present Original Application after 1 year and four months, with incomplete and half-baked information, for reasons best known to the Applicant. Such conduct highlights that the Applicant has a vested interest in filing such an application. Thus, in view of the abovementioned submission, the present Application is liable to be dismissed on this ground alone.

B. The Original Applicant is not an Aggrieved Person under Section 18 of the NGT Act, 2010.

15. That the Applicant is a resident of Bhubaneswar, which is around 400 kms away from the site of the accident, i.e., the Answering Respondent's Unit in Lanjigarh and does not come within the ambit of 'Aggrieved Person' under Section 18 of the NGT Act, 2010, as he has failed to establish any nexus, direct interest or the effect of the outcome of the matter on him. No material has been placed on record by the Applicant to demonstrate his *bona fides*, as well as to indicate how he is impacted or aggrieved in the present *lis*. A mere general interest in environmental

issues does not make the Applicant, who lives far away from the site of the accident, an aggrieved person and does not confer any right on him to initiate proceedings.

16. That this Hon'ble Tribunal has been very conscious of discouraging frivolous litigation by busybodies, and there is a catena of cases wherein this Hon'ble Tribunal has heavily come down on frivolous petitions. Reliance is placed on the cases of *Uttar Pradesh v. Uday Education and Welfare Trust* [2022 SCC OnLine 1469], *Anand Kumar Jha v. Union of India & Ors.* [I.A. No. 78/2021/EZ in Appeal No. 05/2021/EZ], *Rana Sengupta v. Union of India* [2013 SCC OnLine NGT 31] as well as the case of *Ankur v. Maharashtra SEIAA & Ors.* [2012 SCC OnLine NGT 53]. The Answering Respondent submits that the present application is liable to be dismissed on this ground as well.

II. PRELIMINARY SUBMISSIONS

17. That the present Original Application is baseless even on merits, as the Answering Respondent has been operating and maintaining the process water lake and its dyke in accordance with the law and in pursuance of a valid Consent to Operate from the State Pollution Control Board. All possible steps for ensuring immediate rectification of the breach of the dyke were undertaken by the Answering Respondent when the incident took place, including engagement of experts of national and international repute for testing any damage to the environment and the steps required for remediation of the same.

18. That the Answering Respondent has established and operates an alumina refinery, in the name of M/s Vedanta Ltd in Lanjigarh, Odisha, in pursuance of a valid Environmental Clearances, including those dated 22.09.2004 and 20.11.2015, as amended by the Environmental Clearance dated 06.08.2021, and the latest Consent to Operate dated 29.01.2026, , apart from other enviro-legal

compliances. It is humbly submitted that the refining process of bauxite to produce alumina is also results in bauxite residue, including wastewater. The same is managed through scientifically approved measures, including creation of ponds, a Residue Disposal Area, and a Process Water Lake (PWL) at an earmarked area outside of the factory premises on acquired land in Kothaduar & Rengopalli villages.

19. That specifically, with respect to the Process Water Lake (PWL), the Answering Respondent has maintained the PWL and the Red Mud Pond for the collection and treatment of Red Mud Slurry, and the same is being operated in pursuance of a valid Consent to Operate (CTO), the latest CTO being granted on 29.01.2026. A filter press unit is used to separate the filtrate (liquor/liquid part) from the Red Mud Slurry, and the filtered Red Mud Cake is disposed of in the Red Mud disposal area in dry form. The Process Water Lake is used to collect the surface runoff water from the red mud disposal area and recycled back into the process. Significantly, any renewal of the consent process also requires an assessment of the existing procedures and machinery, its operations, primarily based on the ground field inspection and thorough investigation.

20. It is humbly submitted that the Answering Respondent herein had taken all necessary precautions to ensure the structural integrity of the PWL dyke. Infact, the Answering Respondent had increased the height of the PWL dyke by three metres in 2021 to avoid any surface runoff in the future. On 30.10.2021, Odisha SPCB had also granted permission to the Answering Respondent to raise the height of the PWL dyke by three metres, subject to obtaining the requisite certification from IIT Bhubaneswar. Accordingly, vide Letter dated 09.05.2022, the Answering Respondent submitted the certificate granted by Dr. Hanumantha Rao of IIT Bhubaneswar, confirming the construction of PWL Dyke Strengthening and Height raising as per the design & drawing of the private

contractor, i.e. M/s Golder Associates. All documentary evidence is available for perusal of this Hon'ble Tribunal if it so desires and is not being produced to avoid any fishing and roving inquiry by the Applicant.

21. That thereafter, another report was prepared by IIT Bhubaneswar after undertaking a field visit on 22.09.2023, titled Final Report on Stability Analysis of Tailings Dams for FY 2023-24 dated June 2024, for the Answering Respondent's Unit, *inter alia*, clarifying that no sign of any seepage at any location has been observed along the periphery of the Process Water Lake at the time of the visit, and the dyke is stable. Thus, the Answering Respondent has been operating the red mud pond and PWL in accordance with the law, with all possible precautions and periodic inspections with respect to the stability of the Dyke. The full copy of the report is available for the ready reference of this Hon'ble Tribunal, if it so desires. However, some relevant extracts are being produced as part of the Inspection Report of 19.11.2025, wherein the above conclusions have been made.

22. That it is humbly submitted that, despite all the above-mentioned precautions being followed, on 15.09.2024, around 2 am, the dyke wall of the process water lake got breached following a period of unprecedented and incessant rainfall in the region during September, 2024.

23. That it is humbly submitted that upon becoming aware of the breach in the early hours of 15.09.2024, the Answering Respondent immediately activated its Environment Management Plan and Disaster Management Plan. Pursuant thereto, the Answering Respondent undertook the following measures in a prompt and systematic manner:

- a. The local District Administration Officials of both Rayagada and Kalahandi districts were informed of the breach on 15.09.2024 itself, and the Answering Respondent assured the Administration that all requisite

emergency measures were being undertaken to contain the damage and minimise any impact;

- b. Area barricading was immediately put in place and information was disseminated to the residents of surrounding villages through direct calls and public announcements;
- c. Potable drinking water was arranged and supplied to the affected areas as an immediate welfare measure;
- d. Free-of-cost medical check-ups were arranged and conducted for all affected families in the surrounding villages; and
- e. Meetings were convened with the affected villagers in the presence of the District Administration to appraise them of the steps being taken and to address their concerns.

The aforesaid measures demonstrate the Answering Respondent's *bona fides*, its commitment to community welfare, and its diligent compliance with its statutory and corporate obligations in response to the unfortunate incident.

24. That immediately on the same day, i.e., 15.09.2024, at around 8 am, the Answering Respondent informed the Odisha SPCB of the breach. due to the extensive rainfall. Further, Odisha SPCB was also informed that a preliminary investigation of the breach is underway, and the Answering Respondent is taking all steps to contain the damage and restore the breach in consultation with IIT Bhubaneswar. The True copy of the Letter dated 15.09.2024 is marked and annexed herewith as **ANNEXURE R/1**.

25. That, following the intimation of the incident to the SPCB by the Answering Respondent, a team of officials of the SPCB headed by the Regional Officer, Rayagada conducted a site visit on the same day *i.e.* 15.09.2024 to carry out preliminary inspection and assess the possible environmental damage. That apart from the Odisha SPCB, the Answering Respondent proactively requested IIT

Bhubaneswar to carry out an independent investigation of the breach and to recommend immediate corrective actions. IIT Bhubaneswar deputed Dr Hanumantha Rao on 16.09.2024 for the said investigation.

26. That thereafter, Directions were issued by the Odisha SPCB on 17.09.2024 under Section 33A of the Water Act, 1974, to the Answering Respondent to undertake corrective actions as per the site observations by the Regional Officer, Rayagada made during his site visit on the day of the incident i.e. 15.09.2024, and submit the Action Taken Report by 20.09.2024. The Answering Respondent was further directed to appear for a personal hearing before the Member Secretary of the Odisha SPCB on 21.09.2024. [Copy of the Inspection Report and the Directions are annexed in the OA as Annexure 2, Page No.(s) 24 to 26].

27. That on 20.09.2024, the Answering Respondent submitted the Action Taken Report in response to the Site Inspection Recommendations dated 15.09.2024 and Directions dated 17.09.2024 *inter alia* clarifying the steps being undertaken in collaboration with IIT Bhubaneshwar for repairing the dyke wall. The Answering Respondent also clarified that the pH & TDS of the parameters of Bansadhara river in one upstream and eight downstream accessible locations for a stretch of 5 kms at an interval of 1-10 kms is being monitored, and the requisite analysis reports will be submitted to the Board. Additionally, the Answering Respondent also evaluated the impact on the land in coordination with the Kalahandi District Administration, compensation for the loss of the standing crop and agricultural field and providing free irrigation facilities for the next two years to the impacted irrigation fields. The copy of the Action Taken Report dated 20.09.2024 is marked and annexed herewith as **ANNEXURE R/2**.

28. That based on the Action Taken report, the Answering Respondent had a personal hearing before the Odisha SPCB on 21.09.2024 and vide the said Meeting, the Odisha State Pollution Control Board directed the Answering Respondent to

undertake steps for repairment and restoration of the dyke wall, dredging/desilting of sludge, assessment of environmental damage, among other remediation steps and to submit a time-bound action plan for the same. The Odisha SPCB also noted that a team of Board officials will visit the plant and PWL to assess the scenario, and further course of action will accordingly be decided by the Board. The true copy of the Minutes of the Personal hearing dated 21.09.2024 is marked and annexed as **ANNEXURE R/3**.

29. That, in furtherance of the decision of the Odisha SPCB, the Answering Respondent had submitted the time-bound Action Plan on 22.10.2024 along with an updated status of the compliances being undertaken with the Action Plan vide Letter dated 16.11.2024, clarifying in detail that the restoration and remediation action was being undertaken for the repair of the dyke along with IIT Roorkee. The Action Plan also clarified the assessment of damages to the crops due to the breach, in consultation with the revenue department officials of Kalahandi district and the amount that has been disbursed to the members of the village community regarding the same. The copy of the said Action Plan submitted vide Letter dated 22.10.2024 along with the updated status of compliance with the Action Plan reported in the Letter dated 16.11.2024, are available and can be placed on record for the perusal of this Hon'ble Tribunal, if it so desires.

30. That further, to assess environmental damage and monitor the progress of restoration work and in pursuance of the decision taken on 21.09.2024, a comprehensive inspection was conducted on the 26 and 27th of September, 2024 by the Odisha SPCB. The water from the river Bansadhara was tested, and soil and groundwater were sampled. The inspection report *inter alia* noted that the breach of the PWL dyke was due to heavy rainfall leading to a very large quantity of runoff stormwater from Red Mud Pond to PWL. However, the possibility of sabotage by damaging the structure of the dyke or theft of the liner was also not

ruled out. Specifically on environmental damage, report further noted that the pH of the river Bansadhara ranged between 7 to 8, indicating that it was safe. Further, the soil samples indicated slight acidity with no adverse impact. Additionally, the ground water quality was meeting drinking water quality standards with respect to pH, TDS and Total Alkalinity. Thus, the Odisha SPCB report found all the water and soil parameters of the area impacted by the breach to be compliant with the statutory norms and standards. The Report, however, recommended additional actions to be undertaken by the Answering Respondent to assess any ecological damage due to the breach, including bi-annual bio-monitoring of the river. The true copy of the report of the Odisha SPCB dated 19.11.2024 is marked and annexed as **ANNEXURE R/4**.

31. That thereafter, vide Letter dated 17.12.2024 of the Odisha SPCB, the Answering Respondent was called upon for another personal hearing on 21.12.2024 for verifying the status of the rectification of the dyke wall, compliance with the Action Taken Report, among other actions directed by the Odisha SPCB for compliance by the Answering Respondent in the abovementioned letter. The Answering Respondent accordingly presented in detail the compliance status with the Action Plan in the hearing on 21.12.2024 before the Odisha SPCB. Based on the submissions of the Answering Respondent, the Odisha SPCB had prescribed additional actions to be undertaken for facilitating the restoration of the dyke wall, bio -monitoring of the river, stabilising the stretch of the bund, among others. The Proceedings of the Personal hearing of 21.12.2024 are marked and annexed as **ANNEXURE R/5**.

32. That two additional experts, IIT Roorkee, as well as M/s Geotheta, also undertook a detailed site inspection and facilitated the preparation of the final restoration report and scheme of the breached portion based on approved drawings and geotechnical studies. Finally, on 30.07.2025, the Certificate for

confirmation for the construction of dyke restoration job for the process water lake was given by IIT Roorkee to the Answering Respondent, confirming the stability and the construction design of the restored dyke wall. The certification and report of IIT Roorkee and M/s Goethe are available for the perusal of this Hon'ble Tribunal, if it so desires.

33. That thereafter, on 02.08.2025, the Answering Respondent had written to the Odisha SPCB clarifying that the PWL dyke wall has been restored with the help of IIT Roorkee and the certificate of stability by IIT Roorkee, as well as M/s Goetha regarding the same, was also submitted. Further, in the updated status of the time-bound action plan, the Answering Respondent has clarified that the Bio-monitoring study has been conducted by the School of Life Science Department of Sambalpur University for pre-monsoon and post-monsoon. The copy of the Letter dated 02.08.2025 is marked and annexed as **ANNEXURE R/6**.

34. That on 13.11.2025, the Odisha State Pollution Control Board in response to the said Letter dated 02.08.2025, has noted the compliance status provided by the Answering Respondent and allowed the Answering Respondent to utilise the PWL Dyke to receive the water from the red mud pond, subject to certain conditions. In fact, on 29.01.2026, the Answering Respondent received the Consent for disposal of sewage and trade effluent, including the disposal of the red mud in the red mud pond. The true Copy of the Letter dated 13.11.2025 is marked and annexed as **ANNEXURE R/7**.

35. That specifically on the issue of damage assessment to crops, it is humbly reiterated that a damage assessment study was conducted by the Revenue Officials, comprising the Tahsildar, Lanjigarh and District Agriculture Officers and an Impact Assessment Report was submitted to the Additional District Magistrate, Kalahandi. Based on the said report, the District Administration issued a direction to the Answering Respondent vide letter dated 24.09.2024, for

providing compensation to the impacted stakeholders ranging from INR 14,164.30 to INR 1,01,173.61, depending on the type of crop impacted. Accordingly, the Answering Respondent successfully disbursed compensation as claimed, and the same was communicated to the Tehsildar, Lanjigarh, vide letter dated 18.09.2025, which has been acknowledged by the Odisha SPCB in its Letter dated 13.11.2025 to the Answering Respondent.

36. That in view of the facts above, the Answering Respondent submits that the Odisha SPCB had taken all the possible and necessary actions as prescribed by law and has been periodically monitoring the compliance of the remedial action which is being carried out. The Answering Respondent has been duly complying with the Odisha SPCB's directions and cooperating with it to expedite remedial action. Thus, the allegations of inaction on the part of the Odisha SPCB against the Answering Respondent are incorrect and incomplete in light of the same.

II. PARA-WISE RESPONSE ON MERITS

37. In view of the above stated facts and without prejudice to the preliminary contentions raised hereinabove by the answering Respondent, the answering Respondent craves the leave of this Hon'ble Tribunal to submit its para-wise reply as under:

38. That the contents of paragraphs 1 to 3 do not merit any response and are borne by record. However, qua limitation and locus, the content of para is reiterated herein in response to the said paras.

39. In reply to the contents of paragraph 4, at the cost of repetition, Answering Respondent herein reiterates that, the Applicant is not an 'any aggrieved person' under Section 18 of the NGT Act. The contents of the Preliminary Objections on Locus may be read as a response to this paragraph.

40. That the contents of paragraph 5 are misconceived, misleading and denied, the Answering Respondent also submits that it has taken prompt and substantial

steps to provide financial relief to the families and affected stakeholders, as directed by the district authorities. The Odisha SPCB water sample analysis has confirmed that there was no adverse impact on the water quality from the breach, and all the parameters were within the prescribed statutory norms and accordingly allowed the Answering Respondent to continue with the operation of the red mud pond and the process water dyke. Further repairs and monitoring were also being carried out as stated above and may be read as a response to this paragraph.

41. That in reply to the contents of paragraph 6, the same are denied as being misconceived, misleading and mere assertions by the Applicant. It is specifically denied that there was a breach in the Red Mud Pond, which severely impacted the river water and regional ecology. As stated earlier, it was not the Red Mud Pond but the PWL that was breached. Further, the Inspection Report submitted by the OPCB dated 19.11.2024, makes it evident beyond doubt, that no severe impact was observed in the river or the soil in the affected area.

42. That the contents of paragraph 7 are denied insofar as they seek to attribute the death of numerous fish and contamination of the river water to the unfortunate incident in question. The averment is baseless and made without any proof to substantiate the same. The Applicant has failed to share appropriate material to support its allegations regarding the death of a large number of fish and other aquatic creatures. The Applicant has merely provided an undated picture of a dead fish without any geo-tag. The allegation of the breach disrupting the river ecosystem also stands to be incorrect, as the inspection report dated 19.11.2024 had observed that the water in the river was safe. The impact on the river was said to have immediately dissipated due to heavy rain and high velocity of water in the river. No independent assessment or study has been produced by the Applicant in support of his claims. Further, the villages of Bangguda, Turguda

and Basantpada are upstream of the PWL Dyke and have not been impacted by the breach.

43. In reply to the contents of paragraph 8, the same are denied as being misconceived. The Applicant has failed to substantiate his allegations and averments with any proper supporting material. It is reiterated that more than one official inspection was conducted following the unfortunate incident, and none of the reports discloses loss of livestock or loss of aquatic organisms. In fact, the report filed by Odisha SPCB states that there was a negligible impact on the river due to heavy rainfall, causing dilution of water from PWL.

44. That the contents of paragraph 9 are denied as being false and mere assertions of the Applicant. The Answering Respondent herein specifically denies the allegation that skin rashes, itching and irritation after bathing in the river, and abnormal behaviour and illness among livestock consuming river water, indicating acute chemical contamination likely due to caustic soda and other alkaline constituents of red mud effluent, as wholly unsubstantiated. On the contrary, the Answering Respondent herein, acting out of abundant caution and a sense of responsible corporate body, arranged and provided free-of-cost medical check ups to all the affected families in the surrounding villages. Not a single case of skin rash, irritation, or any ailment attributable to the incident was reported or recorded in the course of the said medical examination. This allegation is completely misfounded and false, fabricated and is a figment of the Applicant's imagination created out of thin air, manufactured to lend colour to an otherwise untenable application. The Photographs are available for the perusal of this Hon'ble Tribunal, if it so directs.

45. That the contents of paragraph 10 are denied to the extent that there was a lack of assessment of the toxicity of released water, soil contamination and other aspects is denied, as there is another Inspection Report of Odisha SPCB dated

19.11.2024, which records such assessment, has been discussed detail in the Preliminary Submissions and is not being repeated for the sake of brevity.

46. That the contents of paragraph 11 merit no response and are a matter of record.

However, it is unexplained as to why a representation has been submitted after more than one year and two months, making totally barred by time under the NGT Act, 2010. The content of the Preliminary Objections is to be read as a response to this paragraph and is not being reproduced for the sake of brevity.

47. That the grounds from Para No. 12 (A) to (E) are summarily denied, and the

Preliminary Submission and Objections may be read as a response to the same.

Specifically, in response to Para No. (D), It is submitted that the Answering Respondent has ensured due compliance with the CPCB Guidelines for handling and management of red mud ponds. In the present case the breach pertained to PWL dyke and not the red mud pond. Further, the management of the red mud pond and the PWL has been affirmed by the Odisha SPCB vide multiple inspections as well as by an expert of national repute, specifically IIT Bhubaneswar. The breach of the PWL dyke was an Act of God, and the Answering Respondent has taken all possible steps for immediate rectification of the breach and remediation of any impact from the outflow of the PWL Dyke.

48. That in the light of the abovementioned facts and circumstances, it is therefore

prayed that this Hon'ble Tribunal may be pleased to dismiss the present Original Application with exemplary costs and pass such order or other orders as this Hon'ble Tribunal deems fit and proper in the circumstances of the case.

Date: 13.05.2026

Place: Kolkata

DRAWN AND FILED BY:

Mbachani

Mansi Bachani, Gitanjali Sanyal,
Huma Fareed & Anubhav Anand

SETTLED BY:

Shri Sanjay Upadhyay
[Senior Advocate]

**IN THE NATIONAL GREEN TRIBUNAL
EASTERN ZONE BENCH, KOLKATA**

ORIGINAL APPLICATION NO. 14 OF 2026/EZ

IN THE MATTER OF:

Dilip Kumar Samantaray

...Applicant

-Versus-

State of Odisha & Ors.

...Respondent (s)

AFFIDAVIT

I, Satyapriya, S/o Shri Arvind Shankar Singh, aged about 50 years, am the authorized signatory for M/s Vedanta Limited Core-6, 3rd Floor, Scope Complex, 7, Lodhi Road, New Delhi-110003, do hereby solemnly affirms and declares as under:

1. That I am fully conversant of the facts and circumstances of the matter and am competent to swear this affidavit.
2. The contents of the accompanying Reply are true and correct to the best of my knowledge and have been drafted by the counsel on my instructions and nothing material has been concealed therefrom.
3. That the Annexures in the Reply are true and correct to the best of my knowledge.

I identified the deponent who has signed in my presence

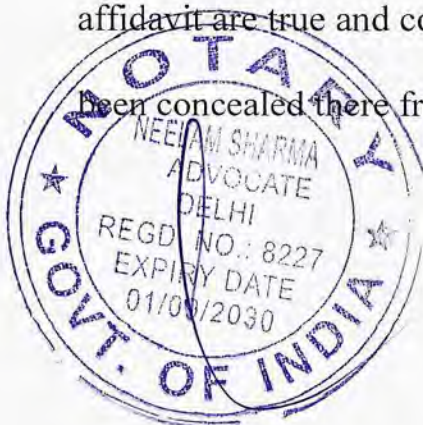
Mr. Arvind
D/85/12/2018


DEPONENT

VERIFICATION:

13 MAY 2026

Verified at New Delhi on this _____ day of May 2026 that the contents of the above affidavit are true and correct to my knowledge and belief and nothing materials has been concealed there from.



ATTESTED


NOTARY (Govt. of India)
Neelam Sharma, Advocate
Enrol. No.-D1281/2001
Ch. No. 165A, Gate No. 11
Patiala House Courts,
New Delhi-110001
(M): 9899408301


DEPONENT

13 MAY 2026



VLL/HSE/ENV/2024/1664

15.09.2024

To
The Regional Officer,
State Pollution Control board,
1st Lane, Kasturinagar,
Rayagada, Odisha

Sub: Rain runoff water lake breach at Vedanta Limited, Lanjigarh.

Dear Sir,

This is to inform on the captioned subject that in the early hours of 15th September 2024, at around 2 am, Vedanta Limited Lanjigarh suffered a breach of a portion of the dyke wall pertaining to the rain runoff water lake. The approximate release of water is close to about 4 Lakh cum.

While we are reviewing and investigating the breach of the dyke wall of the PWL in the said incident, we have immediately started taking measures necessary to contain the damage. The breached dyke restoration work has started for which 4 excavators and 16 hyvas have been engaged. The restoration work is being established in consultation with IIT, Bhubaneswar.

This if for your kind information and record please.

Thanking you.

Yours faithfully,

For Vedanta Limited, Lanjigarh.



Harshvardhan Pande
(Head HSE & Sustainability)

Cc: The Member Secretary, State Pollution Control Board, Paribesh Bhawan, Bhubaneswar



PO: Lanjigarh, Dist: Kalahandi, Odisha, India - 766 027
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Mumbai 400093, Maharashtra, India T +91 22 6643 4500 F +91 22 6643 4530

CIN: L13209MH1965PLC291394

-TRUE COPY-

VLL/HSE/ENV/2024/1665

20.09.2024

To

The Member Secretary
 Odisha State Pollution Control Board
 Parivesh Bhawan, Nilakantha Nagar
 Bhubaneswar - 751012

Sub: Direction under Section 33A of The Water (PCP) Act, 1974

Ref: OSPCB Letter No. 14764/Ind-I-Con-5436 dtd 17.09.2024

Respected Sir,

We are in receipt of the above referred letter from your good office through email on 17.09.2024.

In this regard, we would like to humbly submit that the Process Water Lake (PWL) has been designed as per internationally accepted specifications. There is monitoring of PWL stability through a digital piezometer and inclinometer daily and satellite imagery once every month. No abnormalities were found with this ongoing surveillance. PWL stability analysis has also been conducted annually. Additionally, continuous monitoring of the drainage system is being conducted by the facilities operating team. The most recent assessment of the PWL showed no signs of seepage, although, we do not rule out any possibility of sabotage, this unfortunate incident of breach in the portion of the dyke wall of the PWL on 15.09.2024 may have resulted due to unprecedented incessant rain occurring at Lanjigarh and the surrounding areas during this monsoon season which is an Act of God.

We immediately addressed the situation and took all emergency measures to contain the damage in close coordination with the District Administration and Environmental Authorities. We hereby submit the below action taken report for your kind perusal.

SN	Condition	Compliance status
i)	All the run-off generated from the red mud pond shall be stored in RMP and under no circumstance there shall be release of any water to PWL	We clarify that all the run-off generated from the Red Mud Pond (RMP) is being stored within the RMP only. Further, the input to PWL from RMP passing through gravity pipelines have been closed. (ANNEXURE-1)
ii)	The use of Process Water Lake (PWL) shall be stopped forthwith till it is	We have stopped the use of PWL. We submit that the immediate dyke breach

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1 of 7

	<p>repaired, restored to the original condition and duly verified by the Board. The Process Water Lake (PWL) shall be taken use with prior permission from the Board.</p>	<p>containment is currently being done under the direct supervision and directions of Dr. Hanumantha Rao, IIT, Bhubaneswar. We request that the permission from the Board is given for temporary repair of the portion of PWL dyke under the design and supervision of IIT, Bhubaneswar to handle urgent and emergent situation of excessive rainwater run-off collection in RMP which may be detrimental to the stability of the RMP.</p>
iii)	<p>In case you need to operate the plant by-passing the PWL, the process flow shall be intimated to the Board.</p>	<p>We clarify that PWL is not a part of plant operations, and it is only used to collect rainwater run-off of the RMP and surrounding area.</p>
iv)	<p>The restoration and repair work shall be done in accordance to the original drawing, design, specification and methodology of M/s. Golder Associates Consulting (India) Pvt Ltd and IIT Bhubaneswar and under their direct supervision.</p>	<p>We will be getting the original drawing, design, specification, methodology and the reason for breach of the dyke assessed through a reputed global engineering solutions consultancy company.</p> <p>Thereafter, the PWL dyke will be restored and repaired based on verified drawing, design etc. under the periodic supervision and guidance of IIT Bhubaneswar.</p>
v	<p>The damaged portion of public road due to dyke breach shall be repaired with consultation and permission from competent authority</p>	<p>We have repaired the affected portion of the public road shoulder temporarily and will ensure the repair with consultation and permission of the competent authority. (ANNEXURE-2)</p>
vi	<p>Till the restoration work is complete, river water quality monitoring of Banshadhara river shall be done on daily basis for a stretch of 10 km at every 1 km interval in the downstream of Process Water Lake and submit</p>	<p>We are monitoring the pH & TDS parameters of Bansadhara river in one Upstream and eight Downstream accessible locations for a stretch of 50 kms at an interval of 1-10 kms, and we humbly seek approval of the Board for the same:</p>

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 CIN : L13209MH1965PLC291394

	analysis report to the Board with respect to pH and TDS.	[(U/S):- Narayanpur] [(D/S):- Chhatrapur, Ragunathpur, Patrapada, Niali, Paik Ranipinda, Station Dahikhal, Kumdabali and Kutragarh). We will submit the Analysis Report with respect to pH & TDS in due course.
vii	Action shall be taken to assess the environmental damage due to breach of dyke and release of water and submit report regarding restoration work undertaken till date.	We submit the following actions that have been taken to assess the environmental damage: <ul style="list-style-type: none"> a) We are monitoring the pH & TDS parameters of river Bansadhara at one Upstream and eight Downstream locations for a stretch of 50 kms. b) The input to PWL passing through gravity pipelines has been closed. c) Dyke restoration work has started in the presence of IIT Bhubaneswar officials under the guidance of Dr. Hanumantha Rao. d) We will be getting the original drawing, design, specification, methodology and the reason for breach of the dyke assessed through a reputed global engineering solutions consultancy company. e) We have repaired the affected portion of the public road shoulder temporarily and will ensure the repair with consultation and permission of the competent authority. In addition to the above, following actions have been taken for providing relief to the community:

Vedanta Limited

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3 of 7

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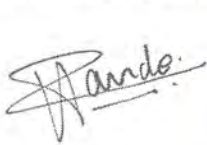
		<p>f) The evaluation of impacted land is being done in coordination with District Administration.</p> <p>g) Compensation for the loss of standing crop and agricultural field is being disbursed to the affected Landowners.</p> <p>h) We will be providing free irrigation facilities for the next two (02) years to all impacted agricultural fields.</p>
--	--	---

Looking forward to your continued guidance and support.

Thanking you.

Yours faithfully,

For Vedanta Limited, Lanjigarh.




Harshvardhan Pande
(Head HSE & Sustainability)

Cc: The Regional Officer, State Pollution Control board, 1st Lane, Kasturinagar, Rayagada.

Vedanta Limited

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ANNEXURE - 1



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CIN : L13209MH1965PLC291394

ANNEXURE – 2



VEDANTA LIMITED

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6 of 7

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**VEDANTA LIMITED**

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CIN : L13209MH1965PLC291394

-TRUE COPY-



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ANNEXURE R/3 114

Tel : 2564033/2563924

EPABX : 2561909/2562847

E-mail: paribesh1@ospcboard.org

Web site : www.ospcboard.org

STATE POLLUTION CONTROL BOARD, ODISHA

(Department of Forest, Environment & Climate Change, Govt. of Odisha)

Paribesh Bhawan, A/118, Nilakantha Nagar, Unit-VIII

Bhubaneswar – 751012

No. 16063 /

IND-I-CON-5436(Vol-VII)

Dt. 07.10.2024 /**MINUTES OF THE PERSONAL HEARING OF M/S VEDANTA LIMITED (ALUMINA REFINERY UNIT), LANJIGARH, KALAHANDI**

1.	Name of the Industry	Vedanta Limited (Alumina Refinery Unit), Lanjigarh, Kalahandi	
2.	Date & Time	21.09.2024 at 4:30 PM	
3.	Venue	Conference Hall, SPC Board, Odisha, Bhubaneswar	
4.	Participation	i. Dr. K. Murugesan, Member Secretary	State Pollution Control Board, Odisha
		ii. Dr. N. R. Sahoo, CEE	
		iii. Er. Sitikantha Sahu, ACEE	
iv. Er. B K Sethi, Env. Engineer			
v. Shri Ashok Kumar Bhoi, Regional Officer (Attended through VC)			
vi. Ms. Subhadra Majhi, Asst. Env. Scientist			
		i. Dr. B. Hanumantha Rao, Associate Professor, School of Infrastructure, Research Interests	Indian Institute of Technology Bhubaneswar
		i. Shri Harshvardhan Papde, AVP	M/s Vedanta Limited (Alumina Refinery Unit), Lanjigarh, Kalahandi
		ii. Shri B. Kiran Kumar, Head (BRDA)	
		iii. Sri Debi Pattanaik, Head-Infrastructure (Projects)	
		iv. Shri Sanjeev Kumar, (Commissioning)	
		v. Shri K. Ramu Naidu, Dy. Head (Env.)	

BACKGROUND:

The alumina refinery has obtained EC and CTE for production of 6.0 MTPA alumina and 285 MW CPP in 3 phases. They are now operating with a capacity of 4.0 MTPA alumina (Calciner-I, II, III & IV) and 125 MW (75 + 50) CPP and the CTO is valid for this capacity upto 31.03.2026. The red mud generated from the plant was initially disposing off in the Red Mud Pond (RMP area of 9.6 Lakh m²) located at a distance of nearly 1 Km from the Alumina Refinery in HCSD (High Concentration Slurry Disposal) system from 2007 to 2013. The decanted water of the red mud pond was taken to the Process Water Lake and the water was recirculated back to the plant for reuse.

However, in 2013, the plant installed Red Mud Filtration (RMF) unit to dewater the red mud slurry. The dry red mud cake is transported to the red mud pond and spread over with dozer and compacted with sheep roller. All the surface runoff of the red mud pond is discharged to Process Water Lake (PWL) by gravity through 4 nos. of pipelines of 18 inch dia at a distance of 900 meter. The area of the PWL is 39.43 Acre. The starter dyke was designed by IISC, Bangalore and became operational in March, 2008.

The subsequent dyke height raising by 3 mtr. was designed by M/s Golder Associates Consulting India Pvt. Ltd. and vetted through IIT, Bhubaneswar in 2019-20. They got the permission for dyke height raising from the Board on 30.01.2021 from 445 mtr. RL to 448 mtr. RL subject to certain conditions.

An incident of breach of PWL occurred during night hours on 15.09.2024 and the same was informed by the industry in the morning of 15.09.2024. The alleged site was immediately visited by the Board Officials from the Regional Office, Rayagada on 15.09.2024. based on the observation made in the inspection report a direction under Section 33A of Water (PCP) Act, 1974 was issued to the industry on 17.09.2024 to stop discharge of any water to the PWL forthwith till it is repaired, restored and verified by the Board. The industry was directed to furnish an action taken report by 20.09.2024 and appear for a personal hearing on 21.09.2024 at 4.30 PM. The industry has submitted the action taken report in compliance to the above direction on 20.09.2024. The list of members attended the meeting is annexed as **Annexure-I**.

RECORD OF PROCEEDING:

Initiating the hearing, the Member Secretary requested the industry representative to explain the reason for breach and dyke, status & repair / restoration and action plan for recommissioning of PWL. The industry representative made a power point presentation regarding the above issues and the progress of action taken to commence / resume the PWL. It was informed by the industry that all the runoff generated from the RMP is stored within the RMP only and the inflow from the RMP to PWL

has been stopped as per the direction of the Board. They have stopped using the PWL and repair of the breached portion of the dyke is under progress under direct supervision of Dr. Hanumanth Rao of IIT, Bhubaneswar. They have carried out water quality monitoring of Vansadhara river at one location on the upstream and 8 locations on the downstream of the PWL. The damage to the land has been evaluated in coordination with District Administration and compensation as estimated by the District Administration is being disbursed to the affected land owners. They requested the Board to allow them to use the PWL after the repair work of damaged portion of the dyke is completed.

After detailed discussion, the following decisions were taken:

1. The breached portion of the dyke of the PWL shall be repaired and restored to its original shape as per the design of M/s Golder Associates Consulting India Pvt. Ltd. under direct supervision of Experts from IIT, Bhubaneswar.
2. The industry shall carry out dredging / desilting of sludge deposited in the PWL in order to increasing the ponding capacity of the PWL.
3. The industry shall replace all the damaged impervious liner and care shall be taken to prevent the seepage of water into the dyke.
4. The industry shall come out with a proposal for providing a settling arrangement with recirculation system in between RMP and PWL in order to reduce the sludge load on PWL.
5. The industry shall explore the possibility of reutilizing the water from PWL for plant use by relooking into the water balance.
6. The industry shall explore alternative arrangement for reducing the volume of water in the PWL such as forced evaporation etc.
7. The industry shall find out the scope for using the red mud cake in cement plants to reduce the volume of dry stacking of red mud cake in RMP.
8. The industry shall assess the environmental damage cost due to the breach (its extent and remediation).

9. The industry shall submit a time bound action plan for the above points to the Board within 15 days time.
10. A team of Board Officials from its Head Office at Bhubaneswar shall visit the plant and the PWL to assess the present scenario and based on their observations, further course of action will be decided.

The meeting ended with a vote of thanks to the Chair.

By the Order of Member Secretary

CHIEF. ENV. ENGINEER (M)

Memo No. 16064 Date 07.10.2024 /

Copy forward to the Regional Officer, SPCB, Rayagada for information and necessary action.

CHIEF. ENV. ENGINEER (M)

Memo No. 16065 Date 07.10.2024 /

Copy forwarded the GM-Head MSE & Sustainability, Vedanta Limited (Alumina Refinery Unit), Lanjigarh, Kalahandi-766027 (E-mail:Headhse.VLL@vedanta.co.in) for information and necessary action. He is requested to furnish a compliance report to the decision taken in the personal hearing meeting within 15 days.

CHIEF. ENV. ENGINEER (M)

Annexure-I



EPABX : 2561909/2562847
Tel : 2562822/2560955
E-mail: paribesh1@ospcbboard.org
Website: www.ospcbboard.org

STATE POLLUTION CONTROL BOARD, ODISHA

[DEPARTMENT OF FOREST, ENVIRONMENT & CLIMATE CHANGE, GOVERNMENT OF ODISHA]



Paribesh Bhawan, A/118, Nilakantha Nagar, Unit – VIII,
Bhubaneswar – 751 012, INDIA

ATTENDANCE SHEET FOR PERSONAL HEARING OF M/S VEDANTA LIMITED (ALUMINA REFINERY UNIT), LANJIGARH, KALAHANDI

Venue: Conference Hall, SPC Board, Odisha, Bhubaneswar

Date: 21.09.2024 (04.30 PM)

SL. No.	Name & Designation	Organisation	Mobile Number & E-mail ID	Signature
1.	Dr. K. Murugesan, IFS Member Secretary	SPCB, Odisha		
2.	Dr. N. R Sahoo, Chief Env. Engineer	SPCB, Odisha		
3.	Er. S. K. Sahu Addl. Chief Env. Engineer	SPCB, Odisha		
4.	Er. B. K. Sethi Sr. Env. Engineer	SPCB, Odisha		
5.	Shri Ashok Kumar Bhoi, Regional Officer	Regional Office, Rayagada		Attended through VC
6.	Ms. Subhadra Majhi Asst. Env. Scientist	SPCB, Odisha		
7.	B. Kiran Kumar Head BRDA	M/s Vedanta Limited (Alumina Refinery Unit), Lanjigarh, Kalahandi	9937292847 b.kiran.kumar @vedanta.co.in	
8.	Debi Pattanaike Head - Infra (Projects)	M/s Vedanta Limited (Alumina Refinery Unit), Lanjigarh, Kalahandi	7328814809 debi.pattanaike @vedanta.co.in	
9.	Sanjeev Kumar (Commissioner)	M/s Vedanta Limited (Alumina Refinery Unit), Lanjigarh, Kalahandi	9937251256 Sanjeev.Kumar @vedanta.co.in	
10.	HARSHVARDHAN SINGH APP VEDANTA LANJIGARH	M/s Vedanta Limited (Alumina Refinery Unit), Lanjigarh, Kalahandi		

SL. No.	Name & Designation	Organisation	Mobile Number & E-mail ID	Signature
11.	Dr. B. Hanumantha Rao, Associate Professor, School of Infrastructure, Research Interests	Indian Institute of Technology Bhubaneswar	9439739910 bh800@iitbbs. ac.in	
12.	K. Ramu Naidu Dy. Head - Env	M/s Vedanta Limited (Alumina Refinery Unit), Lanjigarh, Kalahandi	K. Ramu Naidu	
13.		M/s Vedanta Limited (Alumina Refinery Unit), Lanjigarh, Kalahandi		
14.		M/s Vedanta Limited (Alumina Refinery Unit), Lanjigarh, Kalahandi		
15.		M/s Vedanta Limited (Alumina Refinery Unit), Lanjigarh, Kalahandi		



**Inspection Report of M/s Vedanta Limited (Alumina Refinery Unit),
Lanjigarh, Kalahandi**

Background:

The alumina refinery unit of M/s. Vedanta Ltd. is operating at Lanjigarh of Kalahandi district. Consent to Operate has been granted to this industry for the following facilities:

Sl. No.	Product	Quantity
Module-I		
01	Calcined Alumina (Calciner-I & II)	2.0 Million MT/Annum
02	Thermal Power	75 MW
03	Vanadium (By-product)	3,000 MT/Annum
04	Calcined Alumina (Calciner-III & IV)	2.0 Million MT/Annum
Module-II		
01	Thermal Power	80 MW (50 MW + 30 MW)

Consent to Operate is valid for the period upto 31.03.2026 for Module-I and 31.03.2025 for Module-II. All the units of the plant are being operated at present.

On refining process of bauxite to produce alumina, bauxite residue is generated. The bauxite residue is being disposed at an earmarked area outside of the factory premises on acquired land in Kothduar & Rengopalli village. The Red Mud (Bauxite Residue) is alkaline in nature having pH value of 10 to 12 and the main composition is around SiO₂ (5% to 7%), Al₂O₃ (10% to 15%), Fe₂O₃ (50% to 60%), Na₂O (3% to 5%), TiO₂ (6% to 8%) depending on the source of the Raw Material. It also contains trace amount of toxic heavy metals such as (chromium, Arsenic, Cadmium etc.) and radionuclides. The Hazardous and Other waste (Management and Transboundary Movement) Rules, 2016 exempts Red mud from scheduled category of hazardous waste and instead classifies it as a “High Volume Low Effect Waste”. Hence it is being stored in a protective manner.

Initially the red mud used to be discharged to the disposal area in High Concentration Slurry form, and the supernatant water (liquor) was collected in a pond by gravity through 4 nos. of 18”dia pipeline. This pond was designated as Process Water Lake (PWL). The collected liquor in PWL used to be recycled back into process. This practice continued up to 2013, but subsequently a filter press unit was installed to separate the filtrate (liquor/liquid part) from the Red Mud Slurry and the filtered Red Mud Cake is disposed in Red Mud disposal area in dry form. The process water lake was subsequently used for collecting the surface runoff water from the red mud disposal area and used back into the process.

An incident of breaching of Process Water Lake was reported by the industry on 15.09.2024 at about 8 AM to the Regional Officer, Rayagada and Head Office, SPCB, Bhubaneswar. The incident reportedly occurred at about 2.00 AM on 15.09.2024. A preliminary inspection was conducted by Regional Officer, Rayagada on 15.09.2024. Based on the preliminary report, a Direction was issued to the industry vide Board's Letter No.14764, dated 17.09.2024 under Section 33A of Water (PCP) Act, 1974 to stop the use of process water lake forthwith and undertake the restoration work. At the same time, they were also directed to conduct water quality monitoring of Banshadhara river alongwith assessment of environmental damage due to breach of dyke and release of water.

In order to assess the environmental damage due to the incident and monitor the progress of restoration work, another comprehensive inspection was conducted by a team of Officials from Head Office and Regional Office on 26th-27th September, 2024. The following Board Officials are included in the team.

1. Er. B. K. Sethi, SEE, HO, SPCB, Odisha
2. Er. P. K. Behera, SEE, HO, SPCB, Odisha
3. Sri A. K. Bhoi, RO, SPCB, Rayagada
4. Er. R. K. Sahu, DEE, SPCB, Rayagada
5. Er. P. D. Behera, AEE, SPCB, Rayagada

The following Officials from Industry accompanied the inspection team.

1. Sri. Harshvardhan Pande - Chief HSES Officer, VL Lanjigarh
2. Sri. B Kiran Kumar - Head O&M Bauxite Residue Area and PWL
3. Sri. Kolli Ramu Naidu - Dy Head Environment, VL Lanjigarh
4. Sri. Subhendu Sekhar Panda - Head Bauxite Residue Projects, VL Lanjigarh

The objective of this site visit was to:

1. Make an assessment of environmental impact of the breach on water, ground water and soil.
2. Determine probable reasons of dyke failure and suggest measures to prevent similar incidents to occur in future.
3. Make an assessment of the restoration work being undertaken the industry for restoring the damaged environment and the Process Water Lake (PWL).

4. Status verification of isolation of process water lake and present practice of management of runoff water in red mud pond area after isolation.

In order to realize the above objectives, the following aspects were examined by the team and the findings are explained in detail in the subsequent sections of this report.

- A. Function of different ponds in the process.
- B. Construction Process of dyke and its subsequent raisings.
- C. Surveillance facility for checking up the dyke health.
- D. Dyke breach incident description and immediate actions.
- E. Monitoring of water and soil quality.
- F. Restoration work undertaken post breaching.
- G. Practice of Red mud disposal catchment area runoff water after the PWL is isolated.
- H. Analysis of dyke failure.

A. Function of different ponds in the process:

In order manage the wastewater generated from the refining of bauxite, the following ponds are in use by the industry. Purpose of the ponds is explained below;

1. **Caustic Water Pond / Dirty water pond (Capacity-94,350 m³):**Caustic and High pH water from the process areas of the alumina refinery generated due to process washes, spillages, rainfall, etc. in process areas of the plant are collected at respective locations and transferred through caustic drains to the caustic water Pond. This water is recirculated and used in the process. This pond is located inside the plant premises.
2. **Bauxite Residue Disposal Area (BRDA) / Red Mud Pond (RMP):**During the wet disposal of Bauxite Residue in Bayers Process, the High Concentration Slurry from the Refinery was disposed in the tailings called as Red Mud Pond. It consists of East Cell (480000 Sqm) and West Cell (300000 Sqm). Post 2013, wet disposal was discontinued and dry disposal after filtration was started. After filtration, the dry cake of red mud residue is being stacked in separate area in the pond. With expansion, the area of the BRDA / RMP has been increased to accommodate higher volumes of red mud. Total area of BRDA / RMP is around 235 Acre.
3. **Process Water Lake (PWL) - (Capacity-21.0 Lakh m³):** Initially during wet disposal, the supernatant liquor from the red mud pond and rainwater of the area was being transferred by gravity through 4 nos. of 18" dia pipeline and stored in the

Process Water Lake (PWL). After Dry Stacking, only rain runoff from RMP is being transferred to the PWL. The stored water in the PWL is transferred back to the refinery and reused in the process.

The position of different ponds and red mud disposal is shown in **Figure:1**.

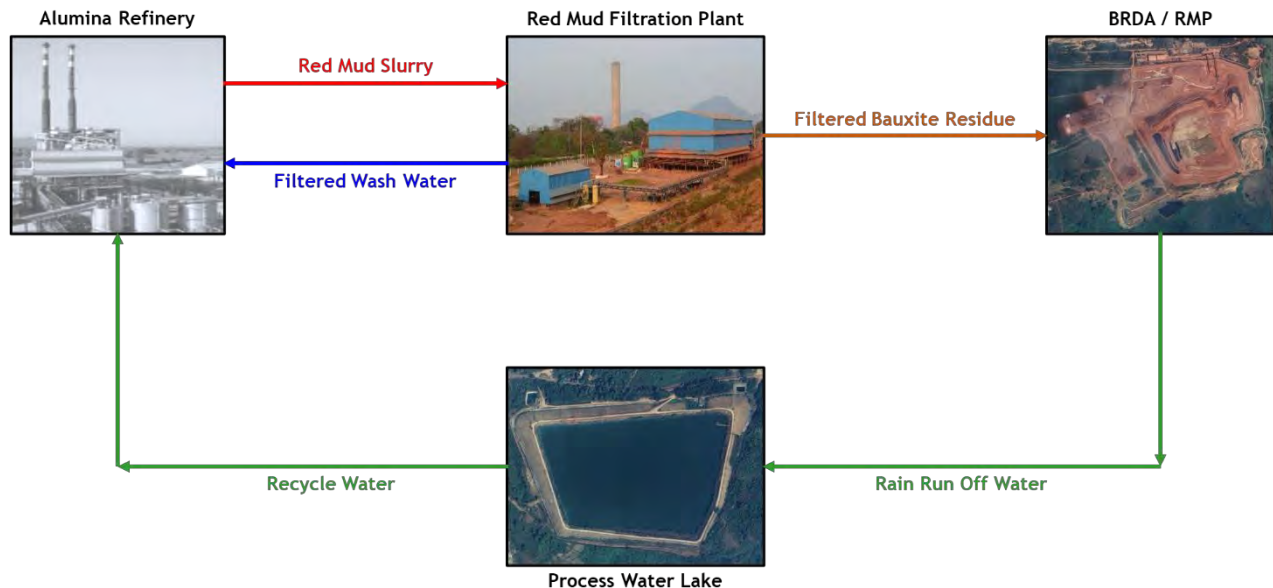


Figure-1 : Circuit of Red Mud Filtration and Disposal of Red Mud

B. Construction Process of dyke as per the M/s Golder design:

With the expansion of the Red Mud Disposal Area, there was an increase in the rain runoff water in the catchment of the RMP. On multiple occasions, the PWL filled upto brim creating hazard of overflow. In order to alleviate such possibility, another dyke raising by 3m, upto 448m RL, was suggested. This dyke radius was designed by M/s Golder Associates Consulting (India) Pvt. Ltd. and was vetted by IIT, Bhubaneswar in 2019-20. Construction for dyke raising from 445 m RL to 448 m RL was taken up as per design and was completed in March 2022. After the raising the holding volume of the PWL was increased to 21 lakh m³ from 15.7 lac m³.

The permission for dyke raising was accorded by the Board vide letter No. 11692, dated 30.12.2021 to carry out the work as per the drawing and design by the expert agencies as mentioned above and under their direct supervision. During and after the construction of dyke raising, the construction activity was supervised by IIT, Bhubaneswar and they certified that the

dyke was constructed as per design. The dyke completion certificate by IIT, Bhubaneswar is enclosed (**Annexure-I**).

The Process Water Lake was initially constructed as per design of M/s Indian Institute of Science (IISc), Bangalore in 2007 up to the crest level of 443m RL, and became operational on 10.03.2008. The original holding capacity of the PWL was 12.24 lac m³. In 2010, the crest level of PWL was raised by 2m to 445m RL that increased the capacity from 12.24 lac m³ to 15.7 lac m³. Over a period of time there was considerable deposit of Red Mud Silt in the PWL (around 10 Lac m³) carried by the decanting water from the RMP which led to considerable decrease in the holding capacity of the PWL. Silt removal by dredging was attempted in 2019, and about 2 lac m³ of deposited silt was removed. However further removal of silt was hampered by hardened silt deposits impacting liners while removal, and due to the global Covid Pandemic in 2020 and 2021.

According to the final report of Design Vetting of PWL by IIT, Bhubaneswar, submitted during 2019, the PWL was lined with HDPE geo-membrane liner which was subsequently covered with approximately 1.0m protective soil layer. Subsequently the dyke went under modification and crest was raised by 2.0 m in 2010. The IIT, Bhubaneswar observed red mud deposition over liner range from 1.0m to 6.0m with an average depth of 3.5m. Therefore the dyke was raised by another 3.0m. Construction of the Raiser Dyke of PWL was done by laying a bottom layer of 200mm of Graded Sand bed, over which 500mm thick 20mm minus crushed rock or gravel aggregate layer was put and another layer of 200mm Graded sand filter is laid over it. Over this, ash was put in layers of 300mm across the width of the dyke with 3m Soil layer at both the edges. This layer was then compacted with the help of sheep rollers and the process repeated till the height of the dyke was reached 448 RL. Side slopes on both upstream (1:2) and downstream (1:3) were achieved by compacting with excavators. Grass turfing was laid on the outer side of the dyke and stone pitching was done at the bottom.

Liners were then installed on the inside of the dyke and anchored in trench on top and soil of around one meter is put on the top part of the dyke and compacted. It has a toe drain along with catchment pits for collection of runoff and seepage water of the dyke. The toe drain is of length 2200 m and the catchment pits or seepage ponds in east and west side having holding

volume of 1800 m³ and 2400 m³ respectively. It may be noted that the filler material of dyke raising is fly ash which is indicated in **Figure-3**.

The location of PWL relative to the plant is shown in Google map is shown in **Figure-2**.



Figure-2: Location of PWL and the Refinery Plant

The indicative cross-sectional view of the dyke is furnished below:

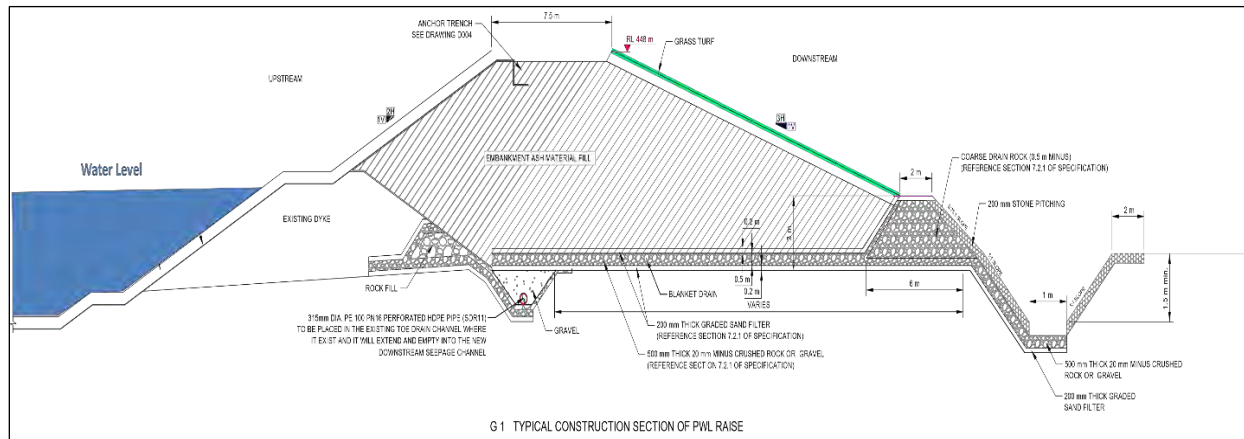


Figure-3: General cross section of PWL dyke

The Design Drawings and cross section views of PWL dyke raising are shown in **Figure-3** and details are attached as **Annexure-II**.

On examining, the drawing design, the following salient features of the dyke are obtained and presented in **Table:1**:

Table-1: Dimension of dykes of PWL

Sl.	Features	Dimension
1.	Bottom RL	Varies from RL432 (North Dyke)-RL445 (South Dyke), RL 432 (East Dyke) - RL 440 (West Dyke)
2.	Top RL	All dyke Top RL448
3.	Initial height of the dyke before 2019	Varies from Average dyke height 2M (South Dyke) to 12M (North Dyke)
4.	Final height of the dyke after March, 2022	Varies from Average Dyke height 5M (South Dyke) to 15M (North Dyke)
5.	Initial width of the dyke base	Varies bottom dyke width 16M (South Dyke) to 56M (North Dyke)
6	Final width of the dyke base after March, 2022	Varies bottom Dyke width 32M (South Dyke) to 82M (North Dyke)
7.	Impervious liner material, thickness of the liner	HDPE Liner (1.5mm thick)
8	Overall Slope	Inside (Up Stream) Slope-1:2 & Outer (Down Stream) Slope-1:3
9.	Construction material and use of ratio in the dyke	Starter Dyke- Soil Only till 2019 Dyke Height Raise-80% fly ash (Inner Core) & 20% Soil (Outer Core) in 2022
10.	Holding volume	Till 2019: 15.7 Lakh CuM, After dyke height raise 2022: 21 Lakh CuM
11	Dyke Dimension	Dyke top North side -705 mtrs South side - 440 mtrs East side - 600 mtrs West side - 440 mtrs

C. Surveillance facility for checking up the dyke health:

The important factors that cause instability in a slope and lead to failure are gravitational force, force due to seepage water, erosion of surface of the slopes due to flowing water, sudden lowering of water adjacent to a slope, forces due to earthquake and rapid loading in a short period of time. A series of surveillance instruments have been installed by the industry. Piezometers, Inclinometers, and Survey Monuments have been installed in the dyke at various locations to monitor the health of the dyke.

VW Piezometer Instrument : Vibrating wire piezometers are used for measurement and control of pore water pressure in all structures, embankments and in ground to monitor water table.

Inclinometer Instrument: Inclinometer system measures and monitors the lateral deflection in in X-Y plane of embankments, dams (Soil/rock). It can be used in monitoring lateral movement, horizontal movement and inclined movement.

Survey monument: This system measures and monitor movements in embankment or underground activities, slope stability, settlement in Dams/Earther dykes etc.

Detail of the above monitoring facility installed for surveillance of stability and safety of the dykes of PWL is furnished below in **Table-2** ;

Table-2: Details of surveillance instrument in PWL

Sl	Instrument	Manual instrument	Digital instrument	Monitoring parameter	Monitoring frequency
1	Piezometer	5 No	3 No	Pore water pressure	Daily
2	Survey monument	5 No	3 No	Vertical displacement	Daily
3	Inclinometer	--	2 No	Horizontal displacement	Fortnightly

The position of piezometer in north dyke and observation borewell of PWL is shown below in **Figure-4**.

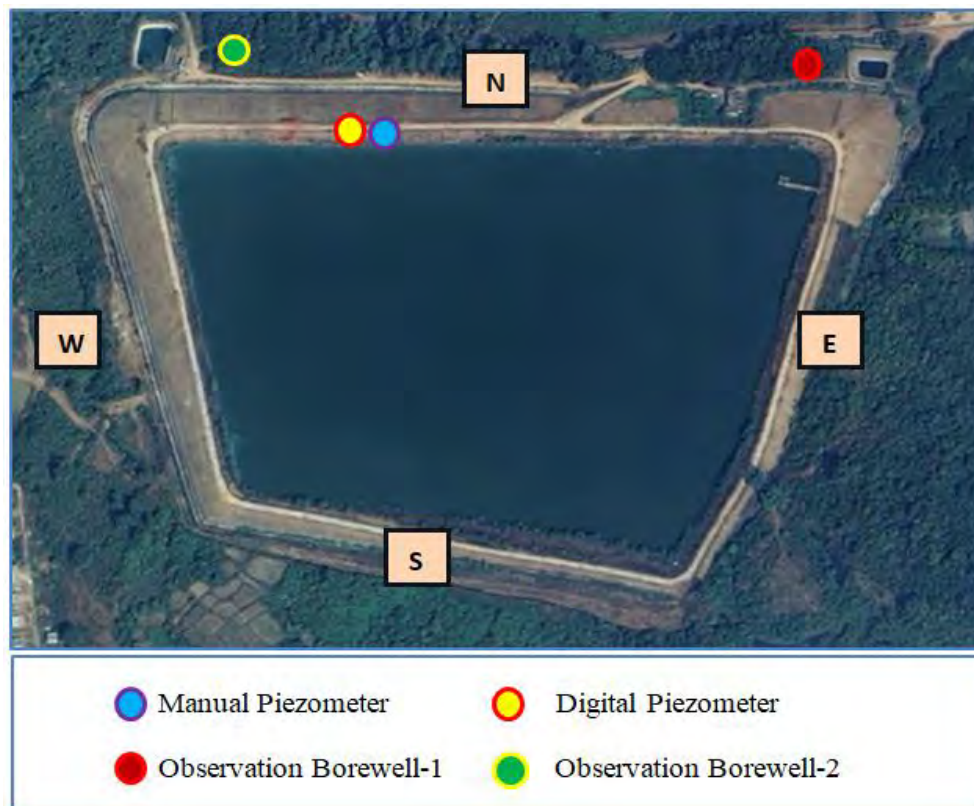


Figure-4: Digital & Manual Piezometer Positions of PWL Dyke

D. Dyke breach incident description

A portion of the dyke in the north side failed approximately 15 m in length and 7 meter in height releasing approximately 4 Lac M³ of alkaline water to the ground adjacent to the PWL and finally entering the Banshadhara River at around 850m from the point of breach. The goggle image is presented in **Figure-5**.



Figure-5 : Affected Area Photo

As mentioned in the report by the industry and as interviewed on site, the event timelines is established as explained in **Table-3** :

Table-3 : Breach Incident Description

Date	Time	Event description
15-09-24	02:10	Loud sound heard near PWL entry by night operator and guard stationed nearby. They rushed to site and found water flowing out of the dyke. They immediately informed the Shift Incharge and other relevant people.
15-09-24	02:15	Waterflow from Dyke increased and section of dyke collapsed leading to high flow of water. A portion of the dyke in the north side failed 15m in length and 7 meter in height releasing approximately 4 Lac m ³ of alkaline water
15-09-24	02:25	Flow of water from RMP to PWL stopped
15-09-24	06:00	Water flow stopped from the dyke as level of water decreased and soil and bags placed

The picture of breached dyke is shown in **Figure-6**.



Figure-6 : Dyke Breach photograph

Before the breach, the free board of the pond was reported to be about 4.0 meters, thus the total volume of the water in the pond is estimated as 4.8 Lac m³. The calculation sheet submitted by the industry is annexed as **Annexure-III**.

Immediate Actions:

The immediate actions taken as reported by the industry, are as explained in **Table-4**:

Table-4: Immediate actions taken by Industry after Breach of dyke

Date	Time	Event description
15-09-24	02:25	Flow of water from RMP to PWL stopped
15-09-24	02:30	Informed IIC Lanjigarh and Local villagers regarding incident + Road Blocked + Power Line isolated
15-09-24	02:50	Deployed Fire and Rescue team along with External Affair personnel to engage physically in villages to make people aware of the issue
15-09-24	05:00 to 08:00	Informed all the regulatory authorities including DM, SP, SPCB and local stakeholders
15-09-24	08:00	Organized Drinking water facility to immediate close by villages through available 3 tankers
15-09-24	10:00	Discussions with local stakeholders in presence of district administration initiated for evaluation of affected land, compensation, corrective actions.
15-09-24	10:30	Requested Expert support from IIT Bhubaneswar to be present on site. Arrived at night and started inspection
15-09-24	13:15	Sampling of water at nearby points in the stream started in presence of Regional Officer - Rayagada

The photograph of isolation of PWL from BRDA is presented below in **Figure-7**.



Figure-7: Isolation of intake to PWL

E. Monitoring of Water and Soil Quality

A monitoring program was designed to examine the following aspects:

1. Water quality of river Banshadhara was monitored by the Board at five (5) locations to assess the impact of breach of PWL dyke, on Banshadhara river. For a more comprehensive assessment the industry was also directed to monitor the river water quality in downstream upto 10 Km at an interval of 1 km on daily basis till the restoration work is complete.

The analysis report of the Regional Officer, Rayagada conducted on 15th to 17th September 2024 and monitoring conducted from 15th to 27th September 2024 by the industry are appended to this report as **Annexure-IV** and **Annexure-V** respectively.

Another set of samples were also collected during this inspection. The results are presented as **Table-5**:

Table-5: Analysis result of water quality of river Banshadhara conducted on 26th September, 2024

Sl. No.	Parameter, Unit	Water samples from river Banshadhara		Tolerance Limit for Class 'C' River (IS 2296:1982)
		U/S of Narayanpur Culvert	D/S Batelima Culvert	
		Results		
1.	pH	7.6	7.8	6.5-8.5
2.	Electrical Conductivity (EC), $\mu\text{S}/\text{cm}$	194.0	241.0	-
3.	Turbidity, NTU	12.0	17.0	-
4.	Total Suspended Solids (TSS), mg/L	20.0	27.0	-
5.	Total Dissolved Solids (TDS), mg/L	116.0	-	1500, max
6.	Dissolved Oxygen (DO), mg/L	6.3	6.1	4.0, min
7.	Biochemical Oxygen Demand (BOD, 3 days at 27 ⁰ C), mg/L	1.2	1.3	3.0, max
8.	Total Alkalinity as CaCO ₃ (T. Alka), mg/L	80.0	-	-

In the analysis the key parameters are pH and Total Dissolved Solids (TDS). Since the water stored in PWL was of high pH (in the range of 13.0) and the analysis reports of the three independent sampling shows that the pH of river Banshadhara range between 7 to 8. This indicates that this water is now safe. Whatever impact the river had immediately after breaching, was dissipated quickly possibly due to heavy rain and high velocity of water in the river.

- Secondly, the water quality of accumulated water near the breach area was sampled by RO and analyzed to assess the impact of breach on the land between the PWL and the river. The analysis result is presented in **Table-6**.

Table-6: Analysis result of accumulated discharged water/runoff water in affected area

Monitoring Location	pH	SS (mg/l)	TDS (mg/l)
	15.09.2024	15.09.2024	15.09.2024
Accumulate runoff water sample collected from the road side (i.e. one side of the road) adjacent to the Breached part of the PWL dyke.	11.0	166	310
Accumulate runoff water sample collected from the road side (i.e. one side of the road) adjacent to the Breached part of the PWL dyke.	11.0	152	312

The result of accumulated water in PWL exhibit high pH, indicating possibility alkalization of land between PWL and the river.

In order to assess the impact on the soil, within the area between the PWL and the river, soil samples were also collected. The results of soil analysis are presented in **Table-7**.

Table-7: Analysis Report of Soil Sample

Sl. No.	Parameter, Unit	Sampling Locations							
		Near Nursery (Control) (Land other than affected area)		110mtrs. distance from PWL		120mtrs. distance from PWL		130mtrs. distance from PWL	
		(L0- 15 cm from Top)	L0- Composite	(L1- 15 cm from Top)	L1- Composite	(L2- 15 cm from Top)	L2- Composite	(L3- 15 cm from Top)	L3- Composite
1.	pH (1:2.5 ratio)	6.86	7.25	7.79	6.81	5.93	4.79	7.35	7.30
2.	Electrical Conductivity (1:2 ratio), $\mu\text{S}/\text{cm}$	79.47	103.5	115.4	150.8	70.79	104.7	139.9	89.92
3.	Moisture, %	15.17	15.50	14.03	14.90	13.66	15.11	12.35	13.48
4.	Bulk Density, gm/cc	1.250	1.177	1.409	1.393	1.432	1.363	1.429	1.334
5.	Alkalinity, mg/kg	240.67	275.52	477.46	167.29	103.1	33.81	277.92	316.31
6.	SAR	0.360	0.406	0.307	0.409	0.756	0.728	0.598	0.367

The soil samples were taken at 15, 30 and 45 cm depth. The results however indicate that it remains slightly acidic indicating no adverse impact.

Considering the fact that when the breach occurred it was raining in a foothill, the alkaline water of PWL quickly rushed to the river and was also greatly diluted due to heavy rain.

3. In order to assess the impact on the ground water, two sets of sample from the observation well of PWL were taken. The results are presented in **Table-8**.

Table-8: Analysis result of groundwater samples collected from observation borewells of PWL

Sl. No.	Parameter, Unit	Sampling Locations		Standards/Regulatory Limits as per Drinking water specification, IS 10500:2012	
		Process water lake observation Borewell-01 (NE Side)	PWL observation Borewell-02 (NW Side)	Requirement (Acceptable limit)	Permissible limit in the absence of alternate source
1.	pH	7.3	12.0	6.5-8.5	No relaxation
2.	Total Dissolved Solids (TDS), mg/L	88.0	4768.0	500, max	2000, max
3.	Total Alkalinity as CaCO ₃ (T. Alka), mg/L	48.0	1968.0	200, max	600, max

Further ground water samples were also taken from RMP area. The analysis result is given below **Table-9**;

Table-9: Analysis result of ground water samples from observation borewell of RMP area and surrounding

Sl. No.	Parameter, Unit	Sampling Locations			Standards/ Regulatory Limits as per Drinking water specification, IS 10500:2012	
		Observation Bore well (RMP west side)	From the observation borewell East dyke	Borewell near Siva Temple at Basantapada village	Requirement (Acceptable limit)	Permissible limit in the absence of alternate source
1.	pH	7.2	8.1	12.0	6.5-8.5	No relaxation
2.	Total Dissolved Solids (TDS), mg/L	1416.0	172.0	3556.0	500, max	2000, max
3.	Total Alkalinity as CaCO ₃ (T. Alka), mg/L	728.0	68.0	1464.0	200, max	600, max

Since ground water sample are showing high level of pH at some points, hence it was decided to conduct atleast two more sets of ground water samples to determine the real status of ground water at the sites of the industry. The sampling was conducted by Central Lab of SPCB on 05.11.2024 and 07.11.2024. The analysis result is as presented below in **Table-10** and **Table-11**.

Table-10: Analysis result of ground water samples from PWL observation borewells on 05.11.2024 and 07.11.2024

Sl. No.	Parameter, Unit	Sampling Locations				Standards/Regulatory Limits as per Drinking water specification, IS 10500:2012	
		Process water lake observation bore well-01 (NE Side)		PWL observation bore well – 02 (NW Side)		Requirement (Acceptable limit)	Permissible limit in the absence of alternate source
		Date : 05.11.2024	Date : 07.11.2024	Date : 05.11.2024	Date : 07.11.2024		
1.	pH	6.5	6.9	6.3	6.6	6.5-8.5	No relaxation
2.	Total Dissolved Solids (TDS), mg/L	196	132	68	64	500, max	2000, max
3.	Total Alkalinity as CaCO ₃ (T. Alka), mg/L	132	56	44	40	200, max	600, max

Table-11: Analysis result of ground water samples from observation borewell of RMP area and surrounding on 05.11.2024 and 07.11.2024

Sl. No.	Parameter, Unit	Sampling Locations						Standards/Regulatory Limits as per Drinking water specification, IS 10500:2012	
		Observation Borewell (RMP west side)		From the observation Borewell East dyke		Borewell near Siva Temple at Basantapada village		Requirement (Acceptable limit)	Permissible limit in the absence of alternate source
		Date : 05.11.2024	Date : 07.11.2024	Date : 05.11.2024	Date : 07.11.2024	Date : 05.11.2024	Date : 07.11.2024		
1.	pH	6.6	6.7	6.6	6.8	6.9	6.9	6.5-8.5	No relaxation
2.	Total Dissolved Solids (TDS), mg/L	168	172	80	84	164	160	500, max	2000, max
3.	Total Alkalinity as CaCO ₃ (T. Alka), mg/L	112	108	36	40	112	100	200, max	600, max

It may be seen in the above analysis report that the ground water quality is meeting drinking water quality with respect to pH, TDS and Total Alkalinity. It shows no impact of Red mud disposal area on ground water quality in the surrounding.

F. Analysis of dyke failure

In order to find out the possible causes of dyke failure, the following facts and figures are analyzed;

1. Overall structural design and breach point in the dyke
2. Readings of surveillance equipment
3. Stability analysis of by IIT, Bhubaneswar
4. Failure Analysis report of PWL dyke breach by IIT, Bhubaneswar

The stability analysis of all tailing dams for Vedanta Ltd, Lanjigarh including the Process Water Lake (PWL) were conducted by IIT, Bhubaneswar for the period 2023-24 and is annexed as **Annexure-VI**. The FOS of process waterlake is as follows (Page No. 58 of the report)

Sections	Without Seepage	Static	Dynamic	With Seepage
S1	1.279	2.562	2.234	1.279

The observations given by Dr. B. Hanumanta Rao, Professor, IIT, Bhubaneswar in his stability report are as follows:

1. Physical inspection showed no sign of seepage at any location along the periphery of PWL at the time of visit on 17th May 2024.
2. Stability analysis carried out at different locations of the dyke along its periphery shows the dike is stable.

Also as highlighted in the Stability report, it is mentioned that an issue related to seepage was reported on 14 Nov-2023 in PWL at the NW side of the dyke. In this regard, a site visit was made on 17-Nov-23 to examine the seepage condition and its implication on the dyke stability. PWL was operational at the time of visit. However, no seepage has been noticed during the site visit by IIT, Bhubaneswar on 17.5.2024.

After the breach on the 15.09.24 morning, Dr. B. Hanumanta Rao, visited the site on 16.09.24 to check the incident location, investigate the breach and suggest way forward to the industry. He has given preliminary report on the incident which is attached as **Annexure – VII**.

Based on the investigation report by Dr. B. Hanumanta Rao, the most likely reason for the breach of the dyke has been attributed to a series of events as listed below:

1. A heavy rainfall of 231.4 mm per day on 10.09.24 led to a very large quantity of runoff stormwater from RMP to PWL which led to sudden rise in water level causing an inherent head thrust on the old dyke top.
2. The sudden surge of water might have created a slip in the weak section of the liner (weakened due to natural causes such as dislodgement of thermal bonding of joints caused by constant interaction with caustic liquor for a long period) and come in contact with the inner core of the dyke causing seepage.
3. High level of water caused accelerated seepage through an already porous soil with water coming above the rock toe as against exiting through it and thereby eroding the inner core of the dyke causing piping phenomenon and ultimately failure of the dyke.
4. Dr. B. Hanumanta Rao also gives emphasis on the possibility of sabotage either damaging the structure of the dyke or theft of Liner which could have contributed to a similar set of events causing accelerated seepage and finally piping failure leading to breach.

Though it is difficult to attribute a particular cause for the dyke breach, the analysis reveals that a particular combination of factors including high water level, presence of porous soil and damage to HDPE liner joints together might have caused the dyke breach.

As per the Digital Piezometer reading for last three months, it is evident that during the heavy rains, there is a slight spike in the readings of the Piezometer which is in line with the observations concluded by IIT, Bhubaneswar regarding seepage due to sudden rise in water level in PWL casing a series of events as mentioned above.

There was heavy rainfall of 231.4 mm on the 10th of Sep 24 (as recorded by the Odisha Weather Monitoring System) recorded in Lanjigarh preceded by 76.8 mm rainfall on the 09th of

Sep 24. The screenshot of the rainfall recorded in the Odisha Weather Monitoring System is presented below in **Figure-8**.

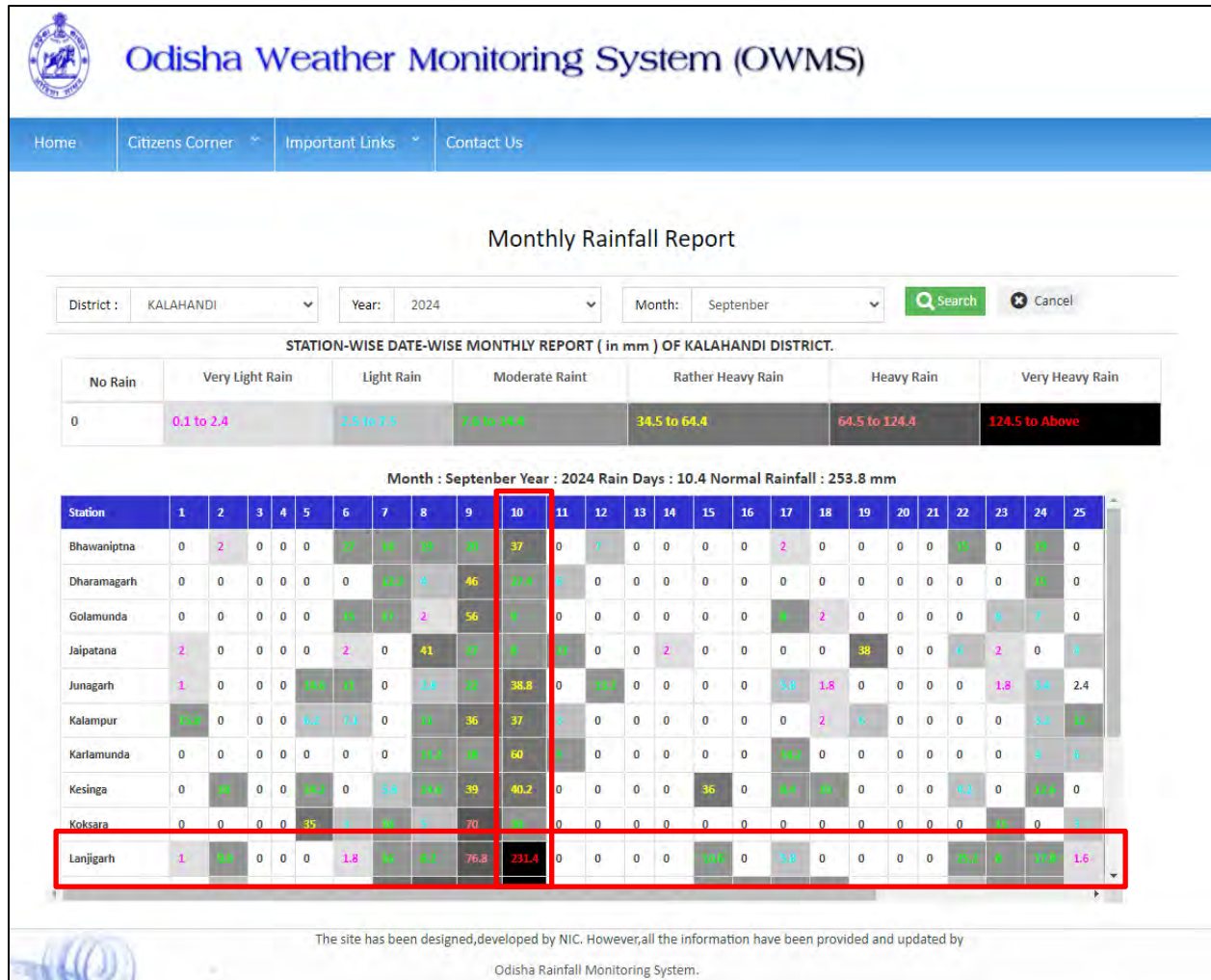


Figure-8 : Rain fall data
<https://rainfall.nic.in/rainfallnew/PublicDistWiseMonthlyReport.aspx>

As reported by the industry during site visit, around 180mm rainfall was recorded in just 3 Hours causing massive flooding in all areas including plant and outside.

Due to this extensive and heavy rainfall, a very large quantity of runoff stormwater from the Red Mud Pond went to the Process Water Lake (PWL) which led to sudden rise in water level within the PWL. Site visit inspection on 16.09.2024 by Dr. B. Hanumanta Rao from IIT, revealed water level marks nearly to the top of the old dyke i.e. RL 445.00. The gush of rain runoff from RMP and increase in header due to rain on the PWL, lead to sudden high-water level

in the PWL which because of its inherent head thrust, damaged the Liner at locations where welding bonds may have been weak.

The breach has occurred on the North Dyke around 330 M from the North-West Corner and 235 M from the North-East Corner. The nearby piezometer installed towards breach point are Digital Piezometer (DP1) and Manual Piezometer (MP2) located around 70 M from the center of the breach area. The monitoring results for the period July 24 to September 24 of Digital piezometer is obtained from the unit and is presented as graph in **Figure-9**.

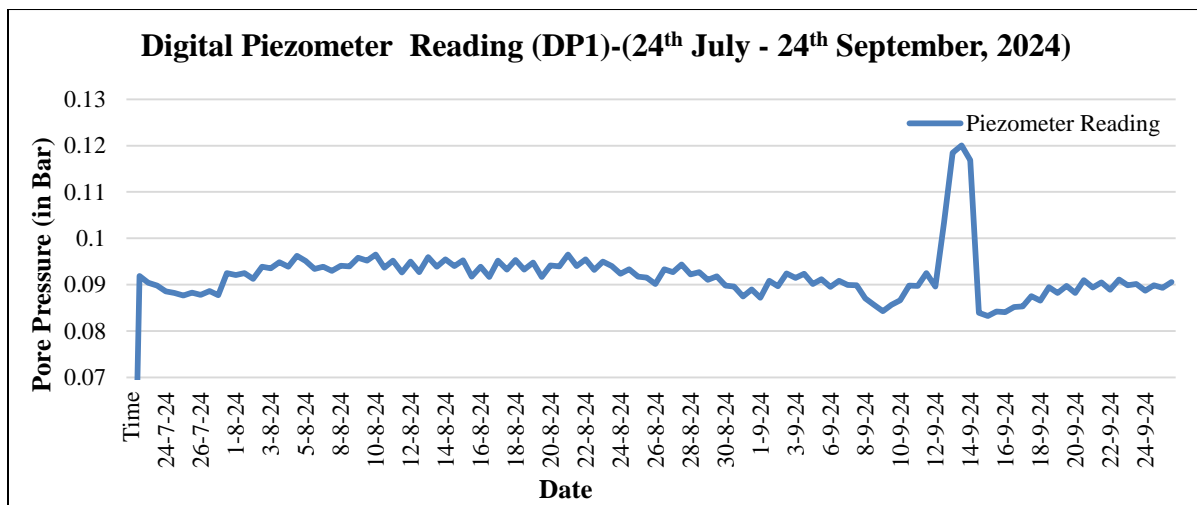


Figure-9: Digital Piezometer reading of DP1 from 24 .7.2024 to 24.09.2024

This high level of water rise in the PWL may have led to increase in water seepage to the dyke which is also indicated by the small spike in Piezometer readings on the 09th and 10th Sep 24.

The increased level of water in the PWL may have accelerated the water penetration within the dyke. Whereas dyke breach had occurred in the early hours of 15th September 2024, there was a time lapse of nearly 4 days leading to saturation of the dyke body before exiting through the permeable membrane.

The sudden surge of water might have exited well above the rock toe as against exiting through the rock toe. Exiting of water from above the rock toe, which is not a common phenomenon, might have eroded the soil particles first followed by ash particles, leading to piping phenomenon and ultimately failure of the dyke.

It is felt that there is operational failure in level of seepage monitoring and response action for seepage control in the dyke, which ultimately led to the breach incident.

G. Restoration Work Undertaken Post Breaching:

The industry has commenced the following restoration work action after the breach incident;

1. Drinking water supply to the affected villages or villages depending upon river Banshadhara within radius of 16 km i.e. covering 15 villages benefiting 600 families through 174 trips of mobile water tankers.
2. Medical Checkup of personnel in surrounding villages. Around 236 trips in 115 villages benefiting 6740 beneficiaries to evaluate the impact.
3. Assessment of damage to the land and restoration of land due to discharge of highly alkaline water of PWL.
4. Disbursement of compensation to the affected land owners.
5. Repair of damaged dyke.
6. Repair of damaged public road.

Immediately after the event, industry communicated to the impacted villages regarding the incident and provided facilities of Drinking water and Medical Check Facilities to evaluate any impact on the same. Photographic evidences as reported by the industry are presented at **Figure-10**.



Figure-10 : Disbursement of Medical Aid and Drinking Water

Discussions were held between Industry, District Administration and stakeholders and a resolution was agreed upon. As agreed in the resolution, industry has initiated work for topsoil replacement with fertile soil as indicated in below photographs. During the visit, about 5 acre land is under renovation and as on 23.10.2024, about 60 acres of land was restored as reported by the industry. A damage assessment study was done by the Revenue Officials comprising the Tahsildar, Lanjigarh and District Agriculture Officers and impact assessment report submitted to Additional District Magistrate, Kalahandi and copy attached as **Annexure-VIII**. About **152.02 Acre** land was identified as impacted. Based on the report, District Administration issued direction to industry for providing compensation to impacted stakeholders ranging from INR 14,164.30 to INR 1,01,173.61 depending on the type of crop impacted. The copy of the Direction is attached as **Annexure-IX**. Reportedly, Compensation for 97.93 Acre has been dispersed upto 20.10.2024 and remaining in progress.

The picture of site under land restoration is shown in **Figure-11**.



Figure-11 : Top Soil replacement of affected land with Fertile Soil

Emergency restoration of the damaged dyke was carried out by compacting soil layers on the breached part to stop further flow of water outside the dyke. Flow of Water from the RMP to the PWL was stopped and not yet resumed. The restoration work is done upto 4M height from bottom of damaged section. The dyke was undisturbed upto 8 M from base after the breach, as 7m height of the dyke was breached from top. The restored part is laid with HDPE liner at inner face. The figure of the restored dyke is shown below in **Figure-12**.



Figure-12 : Dyke Repair

The industry is working with IIT Bhubaneswar for preliminary investigation and immediate repair philosophy of the Breached dyke to prevent PWL water from discharging outside as well as to take care of any emergent situation arising out of sudden heavy rains which may increase level of water stored in the RMP leading to stability issues of RMP dyke.

Further Industry is engaging IIT Roorkee for detailed design and construction philosophy for the permanent restoration of the dyke along with health condition check of all remaining sections of the dyke through Geotechnical Studies. They have also engaged Global benchmarked firm to carry out validation of this design and provide continuous consultancy for monitoring the condition of the dyke in operation. The full restoration of breached dyke to its original strength will take around 9 months after monsoon as informed by the industry.

The affected portion of the Public Road shoulder has been repaired.

H. Practice of Red mud disposal catchment area runoff water after the PWL is isolated

After the incident direction was issued to industry by Board vide Letter No.14764, dated 17.09.24 to stop taking water in the PWL. Since then, industry is storing the RMP rain run-off in the RMP Catchment. Currently around 2.5 lac CuM of rain runoff is being stored in the RMP Catchment in the west cell. The estimation sheet is submitted by the industry and annexed as **Annexure-X**. Water from the west cell is being diverted to the Refinery for utilization in the process. The rate of water evacuation from RMP is around 500 m³/hr. However, the water pumping capacity of RMP and consumption ability of Refinery is limited. In case of sudden heavy rainfall, the level of water in the RMP catchment may further increase.

During visit, a seepage is noticed from the South-east side dyke of dry red mud disposal area which is collected on catchment pit through toe drain. A water sample was collected from the seepage water. The analysis result is given below in **Table-12**;

Table-12: Analysis result of Seepage water near gabion wall i.e. SE corner of East dyke of dry Red Mud disposal area

Sl. No.	Parameter, Unit	Results
1.	pH	13.0
2.	Turbidity, NTU	-
3.	Total Dissolved Solids (TDS), mg/L	696.0

There one digital and one manual piezometer installed in North dyke of west cell of RMP area. The reading in digital parameter was 0.34 bar (3.4m) and manual measurement is 3.95m. The depth of piezometer is reported to be 18.29m and dyke height is 17m. A water sample was collected from piezometer well-02 installed in North dyke of the west cell of RMP area. The analysis result of piezometer well of the RMP area reveals pH of 10 and TDS of 2080 mg/l, which indicates the seepage water in the well from the RMP area. In order to ascertain the seepage of water in dyke, another set of sampling was done in the piezometer on 5th and 7th of November 2024. The analysis result is presented in **Table-13**, shows that the pH was within acceptable range.

Table-13: Analysis result of ground water sample from piezometer in north dyke of west cell of RMP area

Sl. No.	Parameter, Unit	Ground water sample from piezometer in north dyke of west cell of RMP area		Standards/ Regulatory Limits as per Drinking water specification, IS 10500:2012	
		Date : 05.11.2024	Date : 07.11.2024	Requirement (Acceptable limit)	Permissible limit in the absence of alternate source
1.	pH	6.4	6.9	6.5-8.5	No relaxation
2.	Total Dissolved Solids (TDS), mg/L	744	252	500, max	2000, max
3.	Total Alkalinity as CaCO ₃ (T. Alka), mg/L	44	116	200, max	600, max

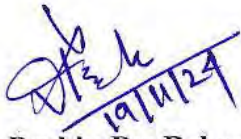
However the industry needs to study the health of dyke engaging an expert agency, a matter of abundant precaution.

Conclusion:

Based on the above discussion on dyke breach incident, the following actions are suggested;

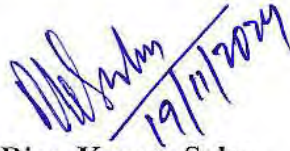
1. Industry shall immediately repair the damaged dyke of the PWL to take water from the RMP Catchment in consultation with reputed institute who have expertise in the field. Design philosophy and stability certification after completion shall be submitted to Board.
2. The industry shall carry out detailed analysis through Geotechnical Studies to evaluate the structure stability and condition of the remaining dyke and take up necessary actions against recommendations.
3. Industry shall carry out permanent restoration of the dyke to original or better design after detailed evaluation from reputed national / global engineering solution firms under their technical supervision through experienced and reputed construction partners before next monsoon and submit stability analysis report.
4. The nos. of surveillance monitoring facility and their readings shall be audited independent reputed institutes having core competency in the field in order to ascertain the health of the dykes.
5. A SOP shall be prepared for seepage observation and response action for seepage control in the dyke to ascertain the health of the dyke and shall be vetted through competent authority of Govt. The SOP shall be practiced to avoid operational failures in seepage control in dyke and possible dyke failure.
6. Calibration of digital piezometer shall be done in order to ensure correct readings.
7. Bushes are observed in the toe drains of PWL in eastern and southern side and the same shall be cleaned. Vegetation has also been developed in southern part of PWL near the dyke, which needs cleaning, as it may lead to damage of the liners.
8. Industry shall carry out full restoration of the impacted land as identified by District Administration and complete the compensation dispersion to the impacted stakeholders.

9. The health of the liner in red mud pond shall be checked and the report shall be submitted to the Board in this regard.
10. The industry may institute a study to assess ecological damage to the river due to breach. Bio-monitoring of the river shall be taken up twice a year.



Er. Prabhu Dev Behera
Asst. Env. Engineer

Asst. Environmental Engineer
State Pollution Control Board, Odisha
Rayagada



Er. Ripu Kumar Sahu
Dy. Env. Engineer

Dy Environmental Engineer
State Pollution Control Board, Odisha
Rayagada

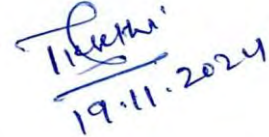


Ashok Kumar Bhoi
Regional Officer, Rayagada

Regional Officer
State Pollution Control Board
Rayagada



Er. Pramod Kumar Behera
Sr. Env. Engineer



Er. Bijaya Kumar Sethi
Sr. Env. Engineer

VLL/HSE/ENV/2022/1422

9th May, 2022

To
The Member Secretary,
State Pollution Control Board, Paribesh Bhawan,
A/118, Nilakantha Nagar, Unit-VIII,
Bhubaneswar, Odisha- 751012

Sub: Submission of Certificate from Indian Institute of Bhubaneswar, for Construction of Dyke strengthening & height raising of Process Water Lake .

Ref : Your Ref. letter no. 16692, Dated 30.10.2021

Dear Sir,

As desired, we are herewith submitting a copy of the certificate obtained from Dr. Hanumatha Rao of IIT Bhubaneswar regarding construction of Process Water Lake Dyke height raising as per the design & drawing of M/s. Golder Associates.

This is for your kind information and necessary record.

Kindly acknowledge the receipt of this letter.

Thanking You.

Yours Faithfully,
For Vedanta Limited, Lanjigarh



Harshvardhan Pande
(Head HSE&S)



Encl : Certificate of construction

CC: The Regional Officer, State pollution control board, 1st Lane, Kasturinagar, Rayagada, Odisha

Vedanta Limited

PO : lanjigarh, Dist. : kalahandi, Odisha, India - 766 027

T +91-6677 247312 - 15, Fax +91-6677 247311, Website : www.vedantalimited.com

Registered Office : Vedanta Limited 1st Floor, 'C' wing, Unit 103, Corporate Avenue, Atul Projects, Chakala, Andheri (East), Mumbai 400093, Maharashtra, India.

CIN : L13209MH1965PLC291394



भारतीय प्रौद्योगिकी संस्थान भुवनेश्वर

INDIAN INSTITUTE OF TECHNOLOGY BHUBANESWAR

Dtd.05th March'22

TO WHOM SO EVER IT MAY CONCERN

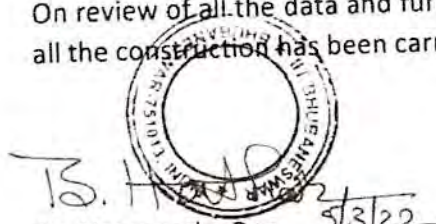
Subject: Certificate of confirmation for Construction of Process Water Lake (PWL) Dyke Strengthening and Height Raising by M/s Vedanta Limited, Lanjigarh as per the design.

M/s Indian Institute of Technology, Bhubaneswar (M/s IIT, BBSK) has been engaged by M/s Vedanta Limited for the vetting of design drawing prepared for dyke strengthening & height raising of the Process water lake (PWL) for Alumina Refinery Plant at Lanjigarh, Kalahandi, Odisha.

M/s IIT, BBSR had vetted all detail construction drawings, specification, and methods (Ref. Drawing No. D001 to D009 and Vetting Report) and submitted to VLL for doing the construction of the above facilities by engaging a contractor.

The height of the dyke raised from RL.445 to RL.448 with downstream method of construction as per the design vetted by the M/s IIT, BBSR considering strengthening of the existing dyke. The volume of the PWL enhanced by additional 10 lakh cum. Vedanta submitted all test reports and drawings to M/s IIT, BBSR for verification and advice.

On review of all the data and further site visit on dtd.05.03.2022, it is confirmed that all the construction has been carried out as per the agreed design.


 Dr. Hanumatha Rao 5/3/22
 Department of Infrastructure
 Indian Institute of Technology
 Bhubaneswar, Odisha



Handwritten signatures and stamps:
 - Signature: *Arando*
 - Signature: *M. Perumal*
 - Stamp: **VEDANTA LIMITED** Lanjigarh

0	2019-02-07	ISSUED FOR CONSTRUCTION
A	2018-09-28	ISSUED FOR DRAFT

NM	PKA	TM	TM
NM	PKA	TM	TM

CLIENT
VEDANTA LIMITED LANJIGARH

CONSULTANT



Accra Office
1st Floor Densu Points Building
3 Fofa Link, North Dzorwulu
Ghana
(+233) 302 978 819/823
www.golder.com

PROJECT
LANJIGARH PROCESS WATER LAKE
RAISE DESIGN

TITLE
**PWL GENERAL ARRANGEMENT PLAN - EXISTING
CONDITIONS**

PROJECT NO. 18103964	SHEET 100	REV 0	DATE	DRAWING D001
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Tel: 06856-223073
 Email: rospcb.rayagada@ospcbboard.org
 Website: www.ospcbboard.org



**OFFICE OF THE REGIONAL OFFICER
 STATE POLLUTION CONTROL BOARD, ODISHA**

[DEPARTMENT OF FOREST, ENVIRONMENT & CC. GOVT. OF ODISHA]
 Plot No 287/A, 1st Lane, Kasturi Nagar, Rayagada, 765001

ANALYSIS REPORT OF WATER SAMPLE

Lab Ref No.24(II)/OW/2024-25

Dtd.17.09.2024

Name & Address of Industry : M/s Vedanta Limited (Refinery)
 At. Lanjigarh, Dist.Kalahandi.

Date of sample collection : 15.09.2024

Sample submitted by : Sri A.k Bhoi, RO &
 Er.R.k.Sahu, DEE

Sl. No.	Location of sampling point	All parameters are in mg/ l except pH		
		pH	SS	TDS
01	River Vansodhara U/s of the unit (near Narayanpur culvert)	7.1	79	145
02	River Vansodhara D/s of the unit (near Baterlima culvert)	7.3	88	161
03	River Vansodhara Confluence point of discharge of Runoff water (i.e 200 mtrs away from the Narayanpur culvert)	7.2	81	153
Method of Analysis		Potentiometric	Gravemetric after Filtration	Gravemetric after Filtration

Analysed by

Reeta Jena
 17.09.2024
 Field Asst.

S. K. Bhoi
 17/09/2024
 Asst. Env. Scientist
 Asst. Environmental Scientist
 State Pollution Control Board, Odisha
 Rayagada

[Signature]
 17.09.24
 Regional Officer
 Regional Officer
 State Pollution Control Board
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Tel: 06856-223073
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 Website: www.ospcbboard.org



**OFFICE OF THE REGIONAL OFFICER
 STATE POLLUTION CONTROL BOARD, ODISHA**

[DEPARTMENT OF FOREST, ENVIRONMENT & CC, GOVT. OF ODISHA]
 Plot No 287/A, 1st Lane, Kasturi Nagar, Rayagada, 765001

ANALYSIS REPORT OF WATER SAMPLE

Lab Ref No.25/OW/2024-25

Dtd.18.09.2024

Name & Address of Industry : M/s Vedanta Limited (Refinery)
 At. Lanjigarh, Dist.Kalahandi.

Date of sample collection : 16.09.2024

Sample submitted by : Sri A.k Bhoi, RO &
 Er.R.k.Sahu, DEE

Sl. No.	Location of sampling point	All parameters are in mg/ l except pH		
		pH	SS	TDS
01	River Vansodhara U/s of the unit (near Narayanpur culvert)	7.1	68	143
02	River Vansodhara D/s of the unit (near Baterlima culvert) chhatrapur	7.5	73	149
03	Raghunathpur	7.6	61	141
04	Patrapada	7.9	79	139
Method of Analysis		Potentiometric	Gravimetric after Filtration	Gravimetric after Filtration

Analysed by

Reeta jena
 18.09.2024
 Field Asst.

G. S. Sahu
 18/09/2024
 Asst. Env. Scientist
 Asst. Environmental Scientist
 State Pollution Control Board, Odisha
 Rayagada

[Signature]
 18/09/24
 Regional Officer
 Regional Officer
 State Pollution Control Board
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Tel: 06856-223073
 Email: rospcb.rayagada@ospcboard.org
 Website: www.ospcboard.org



OFFICE OF THE REGIONAL OFFICER
STATE POLLUTION CONTROL BOARD, ODISHA
 [DEPARTMENT OF FOREST, ENVIRONMENT & CC, GOVT. OF ODISHA]
 Plot No 287/A, 1st Lane, Kasturi Nagar, Rayagada, 765001

ANALYSIS REPORT OF WATER SAMPLE

Lab Ref No.26/OW/2024-25

Dtd.19.09.2024

Name & Address of Industry : M/s Vedanta Limited (Refinery)
 At. Lanjigarh, Dist.Kalahandi.

Date of sample collection : 17.09.2024

Sample submitted by : Sri A.k Bhoi, RO &
 Er.R.k.Sahu, DEE

Sl. No.	Location of sampling point	All parameters are in mg/ l except pH		
		pH	SS	TDS
01	River Vansodhara D/s of the unit (near Baterlima culvert)	7.7	69	138
02	Raghunathpur	7.6	72	141
03	Patrapada	7.8	68	144
Method of Analysis		Potentiometric	Gravimetric after Filtration	Gravimetric after Filtration

Analysed by

Reeta Jena
 19.09.2024
 Field Asst.

Sudhany
 19/09/2024
 Asst. Env. Scientist
 Asst. Environmental Scientist
 State Pollution Control Board, Odisha
 Rayagada

[Signature]
 Regional Officer
 Regional Officer
 State Pollution Control Board
 Rayagada

Vedanta Limited Lanjigarh
River Water Monitoring Results of pH & TDS

Date	Para	LOCATION								
		Narayanpur (U/S)	Chhatrapur (D/S)	Ragunathpur	Patrapada	Niali	Paik Ranipinda	Station Dahikhal	Kumdabali	Kutragarh
15-09-24	pH	7.18	7.48	7.43	7.35	7.48	7.21	7.47	7.38	7.39
	TDS	152	210	198	188	172	162	152	140	136
16-09-24	pH	7.17	7.29	7.28	7.32	7.3	7.31	7.27	7.24	7.3
	TDS	134	146	142	136	136	134	126	124	124
17-09-24	pH	7.05	7.25	7.25	7.28	7.22	7.27	7.25	7.29	7.2
	TDS	124	136	138	148	126	126	124	128	120
18-09-24	pH	7.17	7.13	7.13	7.19	7.19	7.16	7.23	7.24	7.21
	TDS	128	136	134	136	130	128	126	124	124
19-09-24	pH	7.14	7.22	7.15	7.17	7.14	7.17	7.23	7.25	7.2
	TDS	128	130	132	128	128	126	124	128	124
20-09-24	pH	7.0	7.16	7.18	7.25	7.2	7.2	7.18	7.2	7.19
	TDS	132	134	128	126	126	126	128	128	124
21-09-24	pH	7.05	7.22	7.16	7.17	7.15	7.18	7.16	7.22	7.2
	TDS	124	128	134	128	124	128	130	128	120
22-09-24	pH	7.16	7.3	7.14	7.2	7.1	7.16	7.18	7.23	7.23
	TDS	128	130	124	124	126	120	126	128	124
23-09-24	pH	7.08	7.26	7.25	7.22	7.17	7.19	7.23	7.2	7.21
	TDS	124	132	128	122	128	124	128	128	124
24-09-24	pH	7.1	7.37	7.17	7.24	7.26	7.23	7.24	7.25	7.2
	TDS	123	127	130	131	126	128	126	128	126
25-09-24	pH	7.19	7.32	7.2	7.24	7.21	7.24	7.22	7.24	7.19
	TDS	128	134	130	132	124	126	120	122	128
26-09-24	pH	7.08	7.15	7.1	7.21	7.2	7.2	7.19	7.19	7.17
	TDS	131	134	128	124	128	130	124	118	124
27-09-24	pH	7.12	7.24	7.24	7.28	7.23	7.22	7.18	7.15	7.16
	TDS	128	127	132	132	126	128	128	126	126



 H. Pandey



Final Report on

Stability Analysis of Tailings Dams for FY 2023-24

For

M/s Vedanta Limited
Lanjigarh, Odisha



Submitted by:

Dr. B. Hanumantha Rao
School of Infrastructure
Indian Institute of Technology Bhubaneswar
At/Po: Argul, Odisha
June-2024

File No.: IITBBSR/SIF/BHR/VL/Stab/2023-244/001



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Stability Analysis of Tailings Dams

Chapter-1

Preamble

1.1 General

M/s. Vedanta Alumina Refinery, Lanjigarh, Odisha, awarded a consultancy project to the School of Infrastructure at Indian Institute of Technology Bhubaneswar vide PO No.: 3600005253 dated: 06-Oct-2023. The scope of the work includes (a) analyzing the stability of tailings dams and (b) measurement of FOS in their existing condition and determining the factor of safety of dykes of different tailings facility. Referring to above work order, this report is being submitted after analyzing the stability of dykes of different tailings dams facility within the scope of the work. The purpose of this report is to give factual information on stability of different tailings dams (viz., red mud pond (RMP), fly ash pond (FAP), process water lake (PWL), caustic pond (CP) and fresh water pond (FWP)).

Towards the preparation of stability analysis report and preparedness for the upcoming monsoon season, a site visit was made on 22.09.2023. During the visit, all tailings facilities were visited and examined for any anomalies.





Chapter 2

Stability Checking of Tailings Dams

2.1 Slope Stability

Slope stability is an extremely important consideration in the design and construction of embankments and earth dams. Slope stability analysis should be carried out to design stable slopes for the formation of the embankment. Usually, slopes with 2H:1V to an embankment height of 6.0 m would be safe for most of the soils. The general analysis of slope stability problems can be carried out with the help of two dimensional limit equilibrium methods in order to determine the factor of safety against instability of a slope using the method of slices. The results of a slope failure can often be catastrophic, involving the loss of considerable property and many lives. It can become hazardous if it occurs for tailings dams. The important factors that cause instability in a slope and lead to failure are: Gravitational force, Force due to seepage water, Erosion of the surface of slopes due to flowing water, Sudden lowering of water adjacent to a slope, Forces due to earthquakes and Rapid loading in short period of time.

2.2 Tailings Dams

Tailings dams are used to impound waste tailings generated by the industry. They can store a range of wastes (viz., red mud, fly ash, etc.) and wastewater/processed water. The tailings material is fine-grained particles. However, their behavior significantly varies from waste to waste. The tailings reservoirs are an important part of the industry. It is necessary to raise the height of tailings dam with an increase in generation of solid waste or process water. The safe operation of the tailings reservoir is the most important aspect of any industry. Once there happens an accident, which proves to be devastating, not only causing direct economic losses, it will also lead to a lot of property damage, casualties, serious environmental pollution and other issues. Currently, there are some security risks about many domestic Tailings at different degrees.

2.3 Computer Programme

Computer programs such as *GEOSLOPE* are available and can be used effectively for analyzing the stability of slopes. The analyses are performed by means of the finite-element method



through the GEO-SLOPE program. Bishop's method of slices and Morgenstern and Price methods are widely used methods for analyzing the factor of safety value. Bishops' method of slices is widely used method for analyzing the stability of embankment slopes. Whereas, Morgenstern and Price method is commonly employed method for tailings dams. In this report, stability analysis has been carried out using *GEOLSOPE* software in accordance with Bureau of Indian Standard Guidelines and as per the Morgenstern and Price method.

2.4 Conditions of Analysis

An earth embankment should be safe and stable during all phases of construction and operation of the reservoir. Hence the analysis shall be done for the most critical combination of external forces which are likely to occur in practice. The following conditions are usually critical for the stability of an earth dam:

Case I - Construction condition with or without partial pool for upstream and downstream slopes)

Case II- Reservoir partial pool (for upstream slope)

Case III- Sudden drawdown (for upstream slope)

Case IV- Steady seepage (for downstream slope)

Case V - Steady seepage with sustained rainfall (for downstream slope) (where annual rainfall is 200 cm or more)

Case VI- Earthquake condition (for upstream and downstream slopes)

Tailings dams are analyzed according to their present situation and the physical and mechanical parameters. The structural safety of each tailing dam is assessed for the cross-sections provided by M/s. Vedanta Limited with a minimum factor of safety at its present state. The following conditions were considered in the analysis:

- Detailed slope stability analysis is carried out for usual load combination coming from each raising.
- Where seepage has been noticed during the filed visit, steady state seepage analysis coupled with stability analysis is performed.





- The starter dike and subsequent raisings were constructed at different timings. The analysis is done considering time required for construction of each dike and time-lapse post-construction of each raising.
- No consolidation and earthquake analyses were considered rather pseudo-dynamic analysis is performed.
- Normal operating conditions of the dam were taken into considered
- The water level in each tailing dams was taken as per the data provided by the client

2.5 Steady State Seepage

The condition of steady seepage arises when the soil below the top flow line in the fully saturated state. This condition must be analyzed in terms of effective stress with values of pore pressure being determined from the flow net. Values of r_u up to 0.45 are possible in homogeneous dams, but much lower values can be achieved in dams having internal drainage. The steady state seepage condition was considered for RMP, FAP and PWL, with r_u value of 0.25, only

2.6 Codes, Standards, Design Assumptions & Documents Reviewed

- a) IS: 7894 1975, "Code of practice for stability of earth dams".
- b) IS: 12169 1987, "Criteria for design of small embankment dams".
- c) IS 8237 1985, "Code of practice for protection of slope for reservoir embankment".
- d) IS 6403 1981, Code of practice for determination of bearing capacity of shallow foundations".
- e) NV Nayak, "Foundation Design Manual"
- f) Manual of US Army Corps of Engineers
- g) FHWA NHI 00 043, US Department of Transportation Manual
- h) IS 9429 1999, "Drainage system for earth and rock fill dams code of practice".
- i) IS 10635 1993, "Free board requirement in embankment dams- guidelines"
- j) User manual of GeoSlope



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2.7 Bishop's simplified method of slices for stability calculation

Bishop's method of slices (1955) is useful if a slope consists of several types of soil with different values of c & ϕ and if the pore pressures u in the slope are known or can be estimated.

ASSUMPTIONS:

- a) No shearing stresses act across the plane of the cross section and the analysis is treated as two dimensional.
- b) The section of the embankment analyzed is of unit thickness.
- c) The sliding mass is divided into a convenient number of slices and each slice is assumed to act independently of its adjoining slices and the forces acting on the sides of a slice have no influence on the shear resistance which may develop on the bottom of the slice.
- d) The shear strength of the various zones along the potential failure surface is mobilized simultaneously.

Figure 1 gives a section of an earth dam having a sloping surface AB . ADC is an assumed trial circular failure surface with its center at O . The soil mass above the failure surface is divided into a number of slices. The forces acting on each slice are evaluated from limit equilibrium of the slices. The equilibrium of the entire mass is determined by summation of the forces on each of the slices.

Consider for analysis a single slice $abcd$, which is drawn to a larger scale in Fig. 1(b). The forces acting on this slice are

W = weight of the slice

N = total normal force on the failure surface cd

U = pore water pressure = ul on the failure surface cd

F_R = shear resistance acting on the base of the slice

E_1, E_2 - normal forces on the vertical faces be and ad

T_1, T_2 = shear forces on the vertical faces be and ad

θ = the inclination of the failure surface cd to the horizontal

The system is statically indeterminate. An approximate solution may be obtained by assuming that the resultant of E_1 and T_1 is equal to that of E_2 and T_2 , and their lines of action coincide. For equilibrium of the system, the following equations hold true.



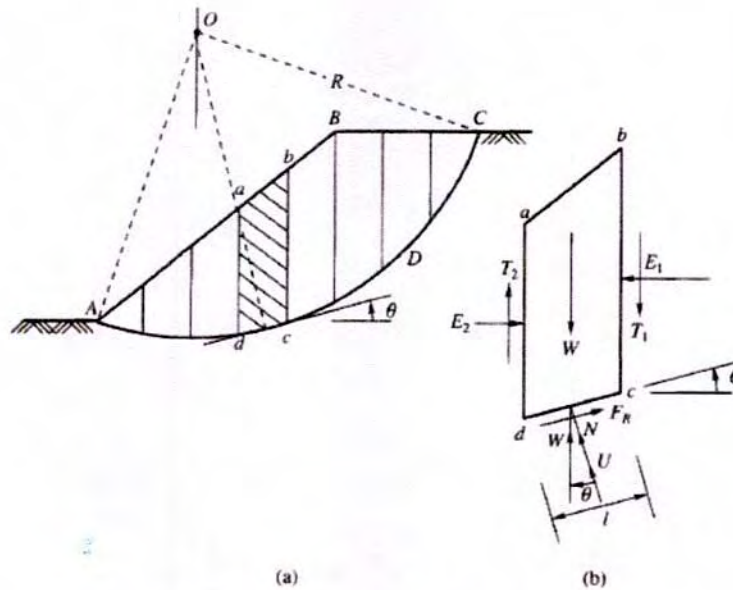


Figure 1 Bishop's simplified method of analysis

The factor of safety F_s is then given as:

$$F_s = \frac{F_R}{F_t} = \frac{[c'l + (W \cos \theta - ul) \tan \phi']}{W \sin \theta} \quad [1]$$

The above equation is similar to conventional method of analysis. Bishop (1955) suggests that the accuracy of the analysis can be improved by taking into account the forces E and T on the vertical faces of each slice. For the element in Fig. 2(b), we may write an expression for all the forces acting in the vertical direction for the equilibrium condition as:

$$N' \cos \theta = W + (T_1 - T_2) - ul \cos \theta - F_R \sin \theta \quad [2]$$

If the slope is not on the verge of failure ($F_s > 1$), the tangential force F_t is equal to the shearing resistance F_R on cd divided by F_s .

$$F_R = \frac{c'l}{F_s} + N' \frac{\tan \phi'}{F_s} \quad [3]$$

where, $N' = N - U$, and $U = ul$.

Substituting the Eq. [3], into Eq. [2] and solving for N' we obtain

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$$N' = \frac{W + \Delta T - U \cos \theta - \frac{c'l}{F_s} \sin \theta}{\cos \theta + \frac{\tan \phi' \sin \theta}{F_s}}$$

$$\text{where, } \Delta T = T_1 - T_2 \quad [4]$$

For equilibrium of the mass above the failure surface, we have by taking moments about O

$$W \sin \theta R = F_R R \quad [5]$$

By substituting Eqs. [3] and [4] into Eq. [5] and solving we obtain an expression for F_s as:

$$F_s = \frac{\sum \{c'l \cos \theta + [(W - U \cos \theta) + \Delta T] \tan \phi'\} \frac{1}{m_\theta}}{\sum W \sin \theta}$$

$$\text{where, } m_\theta = \cos \theta + \frac{\tan \phi' \sin \theta}{F_s} \quad [6]$$



Chapter 3 Data for Stability Checking

3.1 General

The dykes of tailings facility can be built with variety of natural and waste materials. Accordingly, the material properties have been defined based on thorough field and laboratory investigations carried out by M/s. Vedanta Limited.

Table 3.1 Geometric details of various tailings dams at Vedanta Limited

DESCRIPTION	DYKE LENGTH (In Meter)					Avg Ht.	AREA (In Sqm)	AREA (In Acre)
	East Dyke	North Dyke	West Dyke	South Dyke	TOTAL			
Red Mud Pond (West Cell)	367	600	620	698	2285	15	300000	74.131
Red Mud Pond (East Cell)	825	700	540+367	380	2812	7.715	480000	118.61
Process Water Lake	420	570	327	400	1717	7.628	160000	39.43
Ash Pond (Cell-A)	A1-A2 - 384m, A2-A3 - 154m, A3-A5 - 335m, A5-A6 - 141m, A6-A7 - 307m, A7-A8 - 87m, A8-A9 - 222M, A9-A10 - 138m. A10-A12 - 191m, A12-A1 - 206m				2422	7.27	357500	88.34
Ash Pond (Cell-B)	B1-B2 - 192m, B2-B3 - 198m, B3-B4 - 358m, B4-B5 - 111m, B5-B6 - 181m, B6-B7 - 52m, B7-B10 - 244m, B10-B1 - 184m				1520	5.22	149300	36.89

Table 3.2 Time history of tailings dams construction

SL No.	Tailings Dams	Raising Type	Modification Details	Height Raise	Designer	Design FY	Completion FY
1	RMP (West Cell)	Initial (Phase-1)	Original Dyke	NA	M/s IISC, Bangalore	2005-06	2006-07
		Phase-2	D/s dyke height raise	3M		2008-09	2009-10
		Phase-3	U/s dyke height raise	4M		2011-12	2011-12
		Phase-4	Centreline Method	4M	M/s NIT, Rourkela	2016-17	2019-20



2	RMP (East Cell)	Initial (Phase-1)	Original Dyke	NA	M/s IISC, Bangalore	2005-06	2011-12
3	Process Water Lake	Initial (Phase-1)	Original Dyke	NA	M/s Golder (Vetting by M/s IIT, BBSR)	2005-06	2007-08
		Phase-2	D/s dyke height raise	3M		2019-20	15 th Jan-2022
4	Ash Pond (Cell-A)	Initial	Original Dyke	NA	M/s IISC, Bangalore	2005-06	2006-07
		Phase-1(A10-A11-A12-A1-A2)	D/s dyke height raise	5M		2011-12	2012-13
		Phase-1(A2-A3-A4-A5-A6)	D/s dyke height raise	5M			2014-15
		Phase-1(A6-A7-A8-A9-A10)	Centreline Method	3M		M/s IIT, BBSR	2016-17
5	Ash Pond (Cell-B)	Initial	Original Dyke	NA	M/s IISC, Bangalore	2005-06	2006-07

Table 3.3 Current height of dikes of different tailings das

Si. No.	Tailings Dams	Top RL	Height (m)	
1	RMP (West Cell)	Borehole location: S1	467	10
		Borehole location: S2	436	8
		Borehole location: S3	464	15
		Borehole location: S8	468	12
2	RMP (East Cell)	Borehole locations: S4, S5, S7	Gone up to stage-IV	
3	Caustic pond	Depth: 5-6 m	Natural ground level	
4	Fresh water lake	Depth: 8-9 m	Natural ground level	



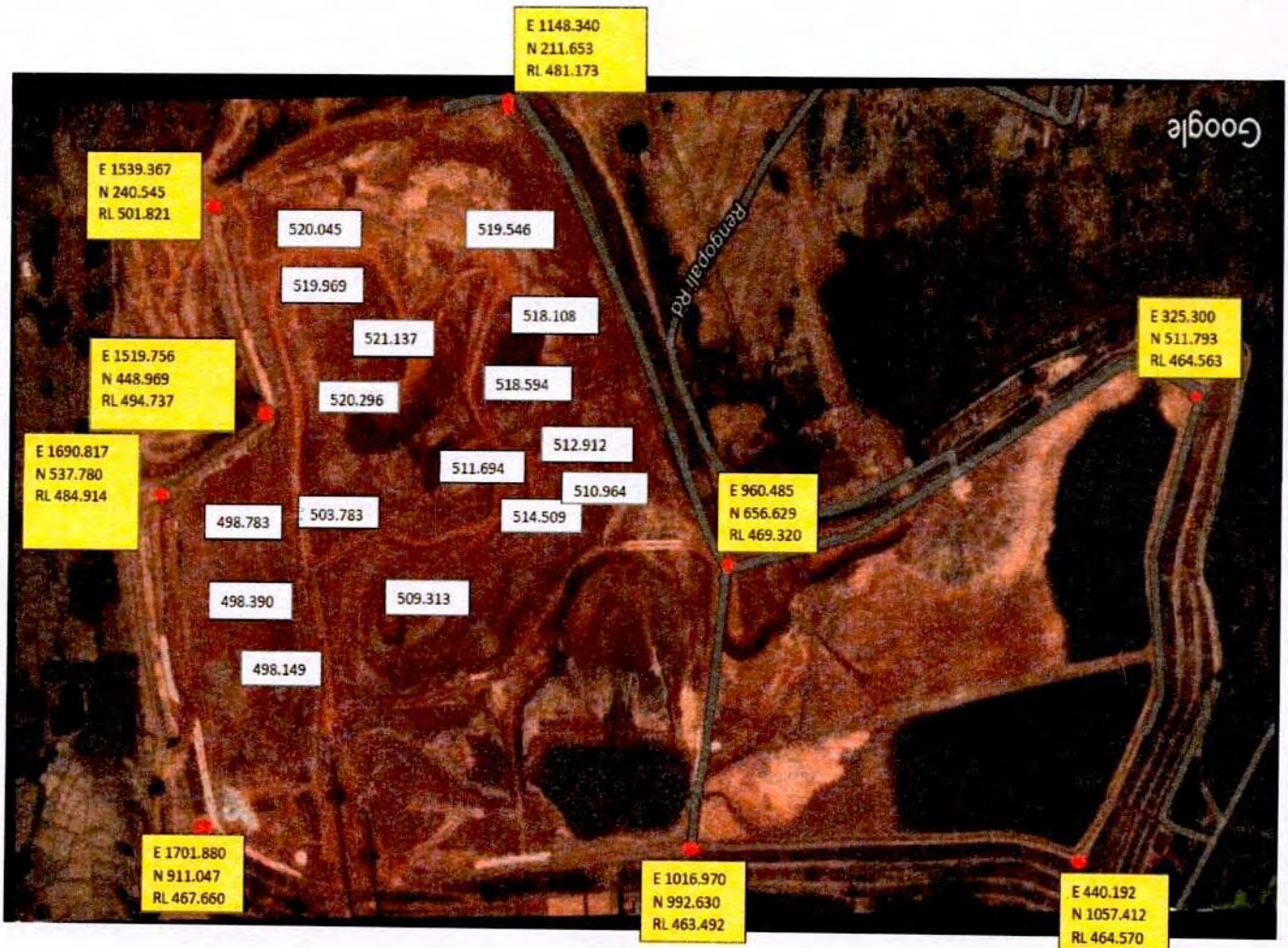


Figure 3.1 Elevations of red mud stack as on 31.12.2023

3.2 Soil Investigation on RMP

Based on the field visit on 13.12.2017, a few locations were identified as critical sections where stability of RMP would be a concern. M/s. Vedanta Limited has been informed to carry out the soil investigation and prepare a borelog details at these sections. Fig. 3.2 shows the locations of boreholes for the purpose of soil investigation. They were made up to a depth of 20 m below the original ground level.





Fig. 3.2 An image showing locations of borelogs for soil investigation on the RMP

Table 3.4 Summary of soil properties defined in the stability analysis of RMP

Borehole No.	Depth (m)	Soil type	Property
BH-01	0 to 1.9	Red clay	γ (kN/m ³)=18.04 C (kPa)=21 ϕ° =5
	1.9 to 3.0	Rock (filling)	γ (kN/m ³)=18.20 C (kPa)=22 ϕ° =5
	3.0 to 6.0	Clayey sand	γ (kN/m ³)=18.44 C (kPa)=2 ϕ° =32
	6.0 to 15.0	Clay with boulders	γ (kN/m ³)=18.80 C (kPa)=2 ϕ° =32
Compacted earth in embankment			γ (kN/m ³)=19 C (kPa)=55 ϕ° =28
Settled red mud-compacted			γ (kN/m ³)=15.5 C (kPa)=30 ϕ° =18



Settled red mud-slurry			γ (kN/m ³)=13 C (kPa)=5 ϕ° =0
BH-02	0.0 to 3.0	Reddish Clay	γ (kN/m ³)=18.05 C (kPa)=21 ϕ° =5 K=2.1e-5 m/s
	3.0 to 10.5	Clayey sand	γ (kN/m ³)=18.60 C (kPa)=20 ϕ° =15 K=2.24e-5 m/s
	10.5 to 15.0	Clay with boulders	γ (kN/m ³)=18.84 C (kPa)=10 ϕ° =32 K=1.6e-5 m/s
Embankment Compacted soil			γ (kN/m ³)=18 C (kPa)=100 ϕ° =32
BH-03	0.0 to 1.8	Clay with boulders	γ (kN/m ³)=18.10 C (kPa)=10 ϕ° =32
	1.8 to 3.6	Reddish clay	γ (kN/m ³)=18.25 C (kPa)=20 ϕ° =5
	3.6 to 15.0	Reddish clay with pebbles	γ (kN/m ³)=18.70 C (kPa)=20 ϕ° =25
Compacted earth in embankment			γ (kN/m ³)=19 C (kPa)=55 ϕ° =28
Settled red mud			γ (kN/m ³)=15.5 C (kPa)=30 ϕ° =18
Settled red mud-slurry			γ (kN/m ³)=13 C (kPa)=5 ϕ° =0
Compacted soil			γ (kN/m ³)=18 C (kPa)=150 ϕ° =38
Red mud			K=1.5e-9 m/s Volumetric water content=55% Residual moisture content=0.05



		$\phi' = 38^\circ$ cohesion, $c' = 79.5$ kPa.
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Table 3.5 Summary of soil properties defined in the stability analysis of PWL

BH-03	0.0 to 1.8	Clay with boulders	γ (kN/m ³)=18.10 C (kPa)=50 $\phi^\circ=25$
	1.8 to 3.6	Reddish clay	γ (kN/m ³)=18.25 C (kPa)=40 $\phi^\circ=15$
	3.6 to 15.0	Reddish clay with pebbles	γ (kN/m ³)=18.70 C (kPa)=38 $\phi^\circ=32$
Compacted earth			γ (kN/m ³)=19 C (kPa)=45 $\phi^\circ=25$
HDPE membrane			Tensile strength=20 kN/m Interface adhesion=15 kPa Interface friction angle=27°

BH-04	0.0 to 1.8	Clay with boulders	γ (kN/m ³)=18.10 C (kPa)=4 $\phi^\circ=32$
	1.8 to 3.6	Reddish clay	γ (kN/m ³)=18.25 C (kPa)=20 $\phi^\circ=4$
	3.6 to 15.0	Reddish clay with pebbles	γ (kN/m ³)=18.70 C (kPa)=2 $\phi^\circ=28$
Compacted earth			γ (kN/m ³)=19 C (kPa)=45 $\phi^\circ=25$
HDPE membrane			Tensile strength=20 kN/m Interface adhesion=15 kPa Interface friction angle=27°





Chapter 4 Stability Checking of Red Mud Pond

4.1 RED MUD POND, RMP

Type: Earthen dike, the embankments were built with a suitable natural soil. It has been informed that red mud was not admixed with natural soil for construction of dikes. As on 31.12.2023, a few raisings were constructed on top of the starter dike (refer to Fig. 4.1) at different locations.

Table 4.1 Details of RMP

SI No.	Item	Details
1	No of cells	Two (East and West)
2	No of raisings as on 31.12.2023	Four on West cell and one on East cell
3	Bottom RL of the pond (lowest)	436
4	Top RL of the pond (highest)	457
5	Top RL maintained for dry red mud disposal	520
6	Bottom RL for dry red mud disposal	463
7	Total height of dry red mud disposal	50 m
8	Height of East cell (highest)	25 m
9	Height of West cell (highest)	At RL 520 is 24 m

4.2 Consolidation of the Red Mud

Recent investigations done by M/s. Vedanta Limited revealed that the red mud in the pond has not undergone uniform consolidation. The hatched portions in Fig. 4.2 indicate the red mud yet in slurry state, while in the remaining locations it was consolidated. However, consolidation was reported to be different degree at different places. One of the prime reasons wherein the red mud yet found in slurry state attributed to stagnation of caustic liquor. The ponding of it appears to be necessary in order to avoid lifting of dust problem, especially during winds in summer season. The availability of caustic liquor maintaining fully saturated condition might be a cause for the red mud not to under consolidation process.

PVD technology has been adopted in east cell to accelerate the consolidation. Phase-I has been successfully implemented in the year 2020 and a portion of red mud slurry in east cell has successfully converted into consolidated mud. In the year 2022, PVDs have been installed in the left over portion in the east cell to accelerate the consolidation process.

Provision of HDPE membrane on the upstream side and stone pitching or grass turfing on the downstream side has not been noticed along the periphery of the dikes.





RMP is basically divided in to two cells i.e. East cell and West cell. Seepage collection well or relief well was built on the North side of West cell. There is an another seepage collection pit on the west side of west cell. The maximum height of embankment at this location is around 25 m. an extreme seepage was recorded in the year 2023 during the mid-rainy season. The cause of occurrence of such high seepage is related to excess storage of caustic liquor for about 4-5 m. The abnormally high heads might have caused excess seepage. A site visit was made during the occurrence of seepage and had been advised the engineers to lower down the levels of caustic in it at the earliest. However, in the same cell, a constant seepage of caustic liquor was noticed on the west side, towards Narayanpur village, at the interface between 2nd and 3rd raisings. Seepage has been noticed over a stretch of 100 m, however, only at second raising level. Caustic liquor up to a depth of 0.5m was kept stagnated on the upstream side primarily to arrest lifting of dust by air or wind. Toe drain or rock toe over this stretch for collection of seeping liquor was provided. There was also settlement or subsidence probably indicating a slope failure on the U/S side of the pond area was noticed. It has been informed that 3rd raising (height 4m) was built over the second raising by adopting to upstream method. Only half the bottom width of 3rd raising was resting on the 2nd raising and remaining half-width was extended inside the pond area over a 500 mm thick soil filling using geocell on the red mud. Seepage over this stretch might be due to the availability of shortened path at the interface.

At present, expansion of RMP is being carried out near the Rengapoli village side. The village has been evacuated. As a part of expansion project, cell-1 has been made ready and made it operational. At the time site visit on 17.05.2024, the cell-1 of expansion project is under operational. Before, the expansion was taken place, a constant seepage of caustic liquor used to be noticed in the East cell through the starter dike, towards West side near the Rengopali village or on the extreme upstream side where East and West cells are merging. However, the seepage appears to be induced seepage because of dry stacking of red mud up to a height of 35 m over the old pond which has been filled with the red mud already to a height of 30 m. As such, the state of the red mud in the old pond noticed to be in slurry state, with holding a lot caustic in the pore spaces. It can be understood that up to a height of 30 m, slurry disposal was practiced and for the remaining 35 m dry disposal is being practiced. The dry stacking of red mud to a height of 35 m seems acts as an overburden pressure, causing the liquor to expel out from the voids. The place where dry stacking is being practiced, red mud is yet in slurry form over a depth of 7 to 10 m below the surface of old bund in east cell. It has been appraised that a permanent underground drainage system has been provided to channelize the seepage into a dug well and from there, it is being pumped daily.



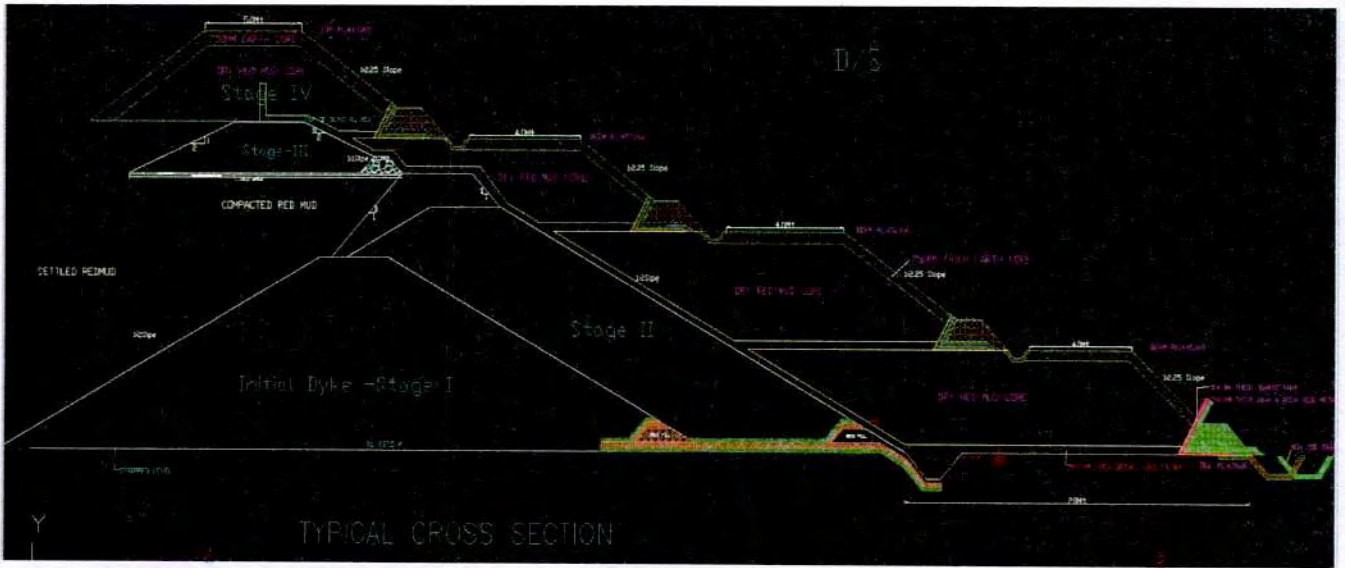


Fig. 4.1a Typical cross section of the red mud pond

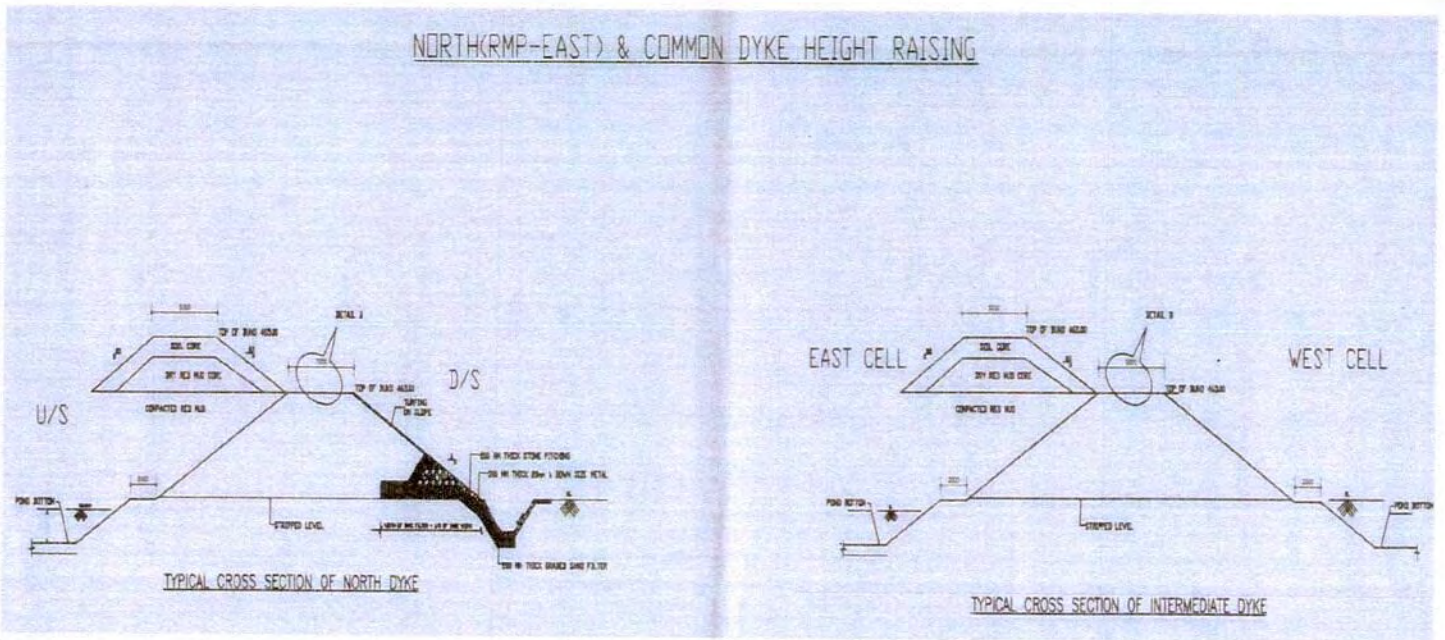


Fig. 4.1b Typical cross section of the red mud pond



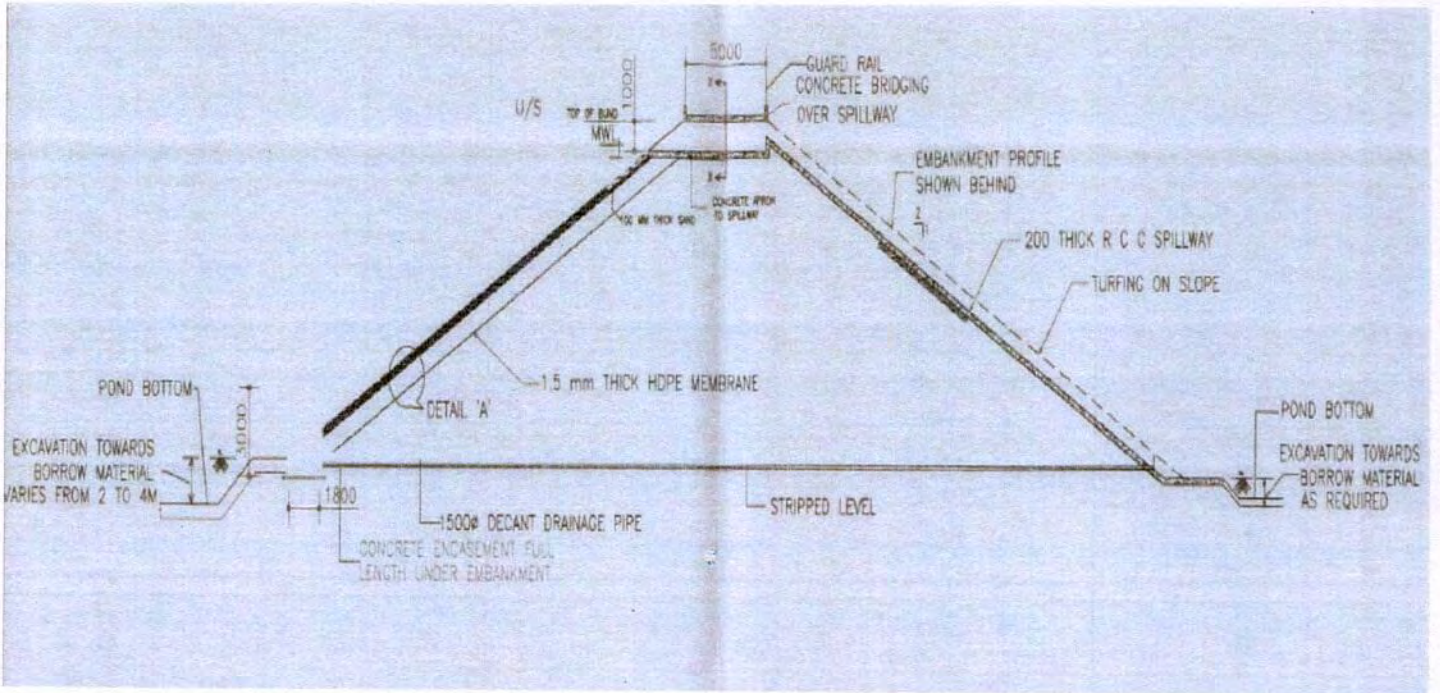


Fig. 4.1c Typical cross section of the red mud pond

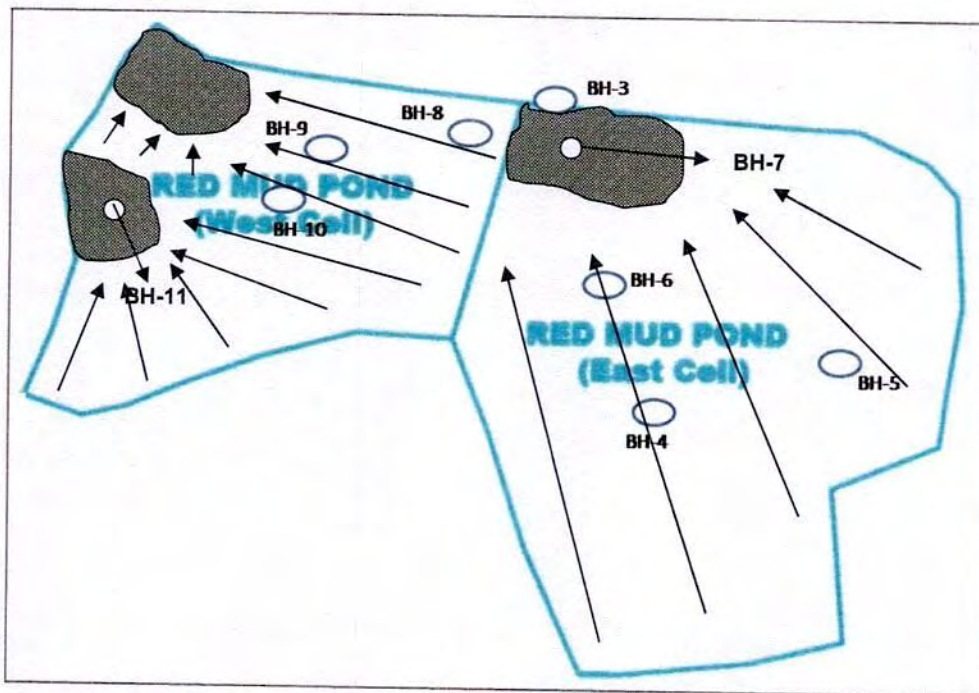


Fig. 4.2 Hatched area indicating the existence of red mud in its slurry state





4.3 Sections for stability analysis

Dyke sections at locations shown in Figure 4.3 have been chosen for stability analysis purpose. Except at locations S1, S8 and S9, there is no change in height of red mud stack at other locations. Reinforced soil wall (RSW) with varying height from 10 m to 18.5 m has been constructed on East side, from S1 to S9, of east cell over a length of 700 m. The approximate height of RSW at S9 location is 12.5 m. At this location, two raisings of dry stack each with height of 6 m was made in the year 2022.

The red mud slurry at location S2 is relatively consolidated because herein this location slurry has been consolidated by resorting to PVD technology.

There is no change in dyke conditions at location S2, S3, S4, S5, and S7. However, there is a continuous seepage at S4 and S8 locations.

Near to the location S8, PVDs have been installed in the year 2022.

Fig. 4.1 presents typical cross sections of dykes at these locations. These sections were used for analysing the stability of dykes and determining the factor of safety.

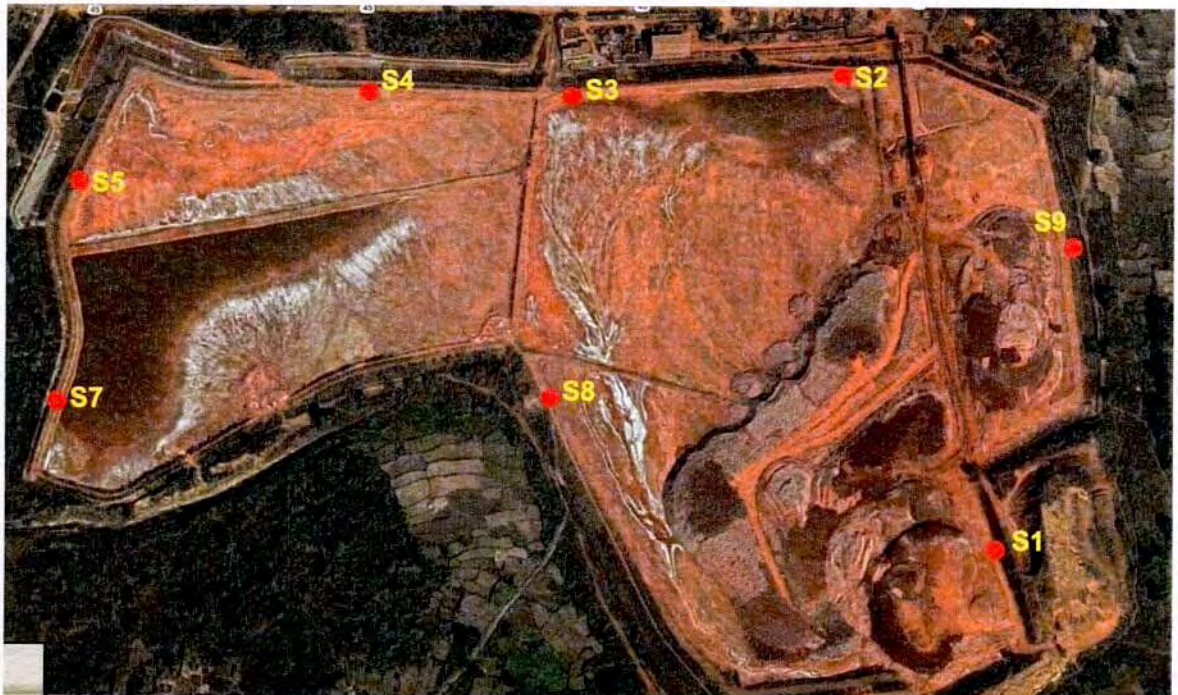


Fig. 4.3 Google earth image showing locations selected for stability analysis



4.4 Observations and Recommendations

The summary of FOS obtained from analysis is presented in Table 4.2.

Table 4.2 Summary of FS values obtained from stability analysis

Sections	Without Seepage	Static	Dynamic	With Seepage
S1	2.077	2.081	1.401	1.918
S2	1.921	1.919	1.212	1.625
S3	1.785	1.783	1.117	1.513
S9	2.184	2.186	1.234	1.832
S4	2.479	2.478	1.702	2.222
S5	2.969	2.926	1.998	2.886
S7	2.608	2.618	1.826	2.602
S8	2.617	2.611	1.826	2.602
S9	2.03	2.09	1.331	1.734
S10	2.153	2.172	1.413	1.928

Based on the analyses, it is concluded that the structural safety of the RMP dykes in both East and West cell are stable against slope failure.

It is strongly advised to evacuate the caustic from the pond in order to avoid seepage induced failure of the slope. It is also advised to look for alternative solutions for preventing dust by spreading chemicals like surfactants or some kind of binding materials.

It is also strongly advised to stabilize the stretch of a bund over which settlements has been noticed by buttressing from downstream side. At this juncture, stabilizing the slopes using geosynthetic materials is highly recommended.

It is also recommended to build toe drain and rock toe over the stretch where seepage is prominent and where they are absent. This could avoid future slope failure.



4.5 Results of Analysis

SECTION 1

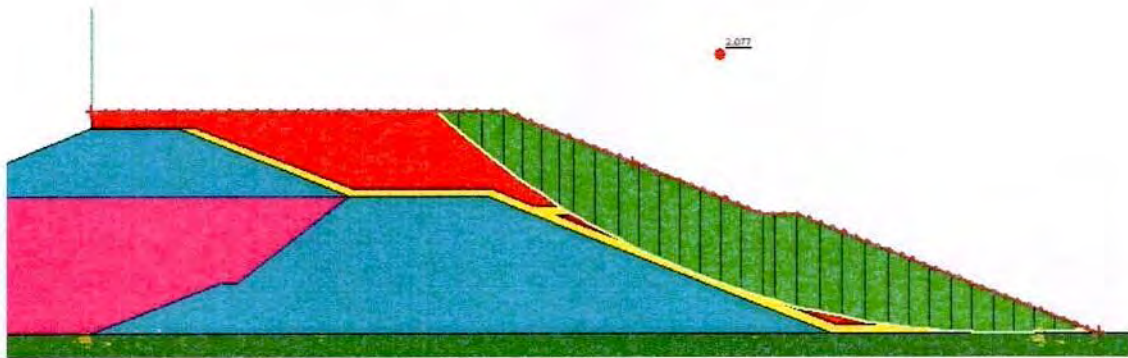


Figure 4.4: Slope Failure of section 1 (FS = 2.077)

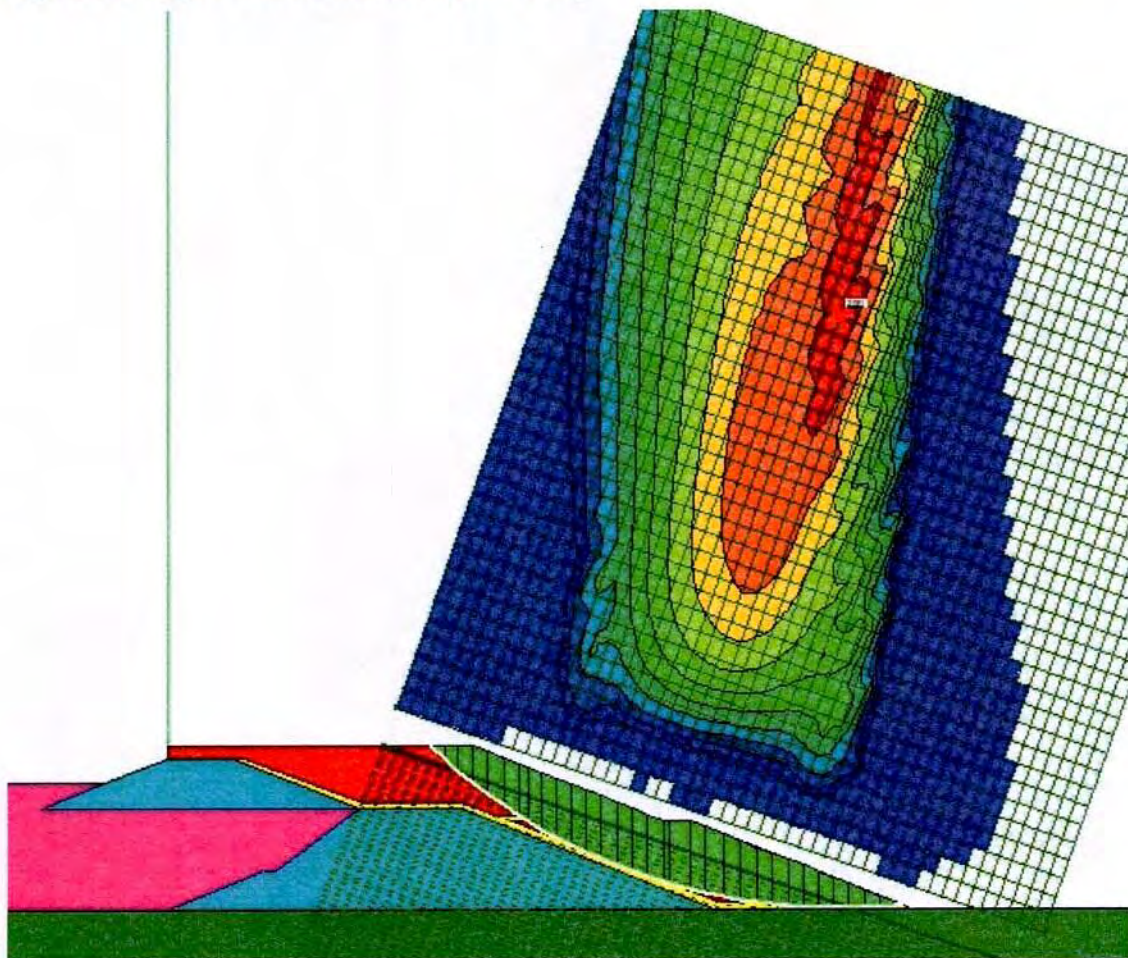


Figure 4.5: Static Analysis of section 1 (FS = 2.081)

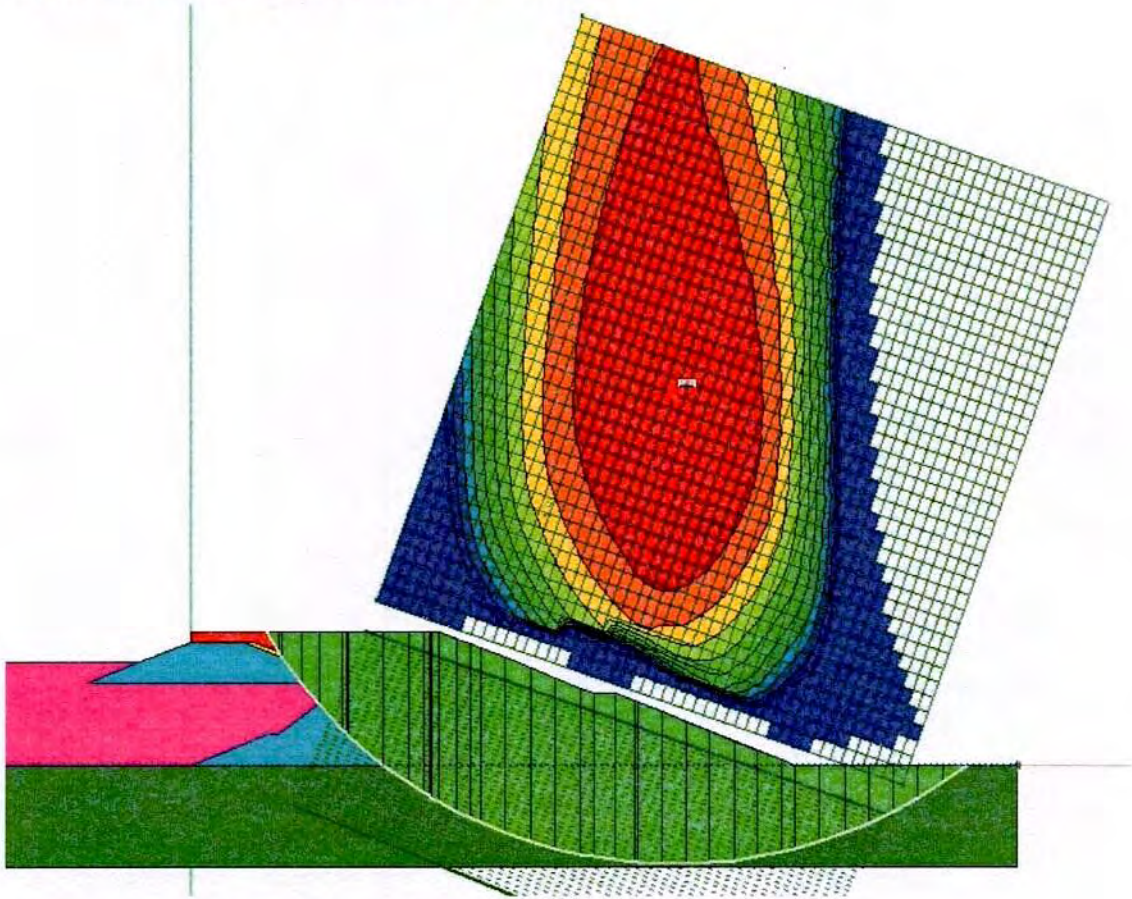


Figure 4.6: Dynamic Analysis of section 1 (FS = 1.401)

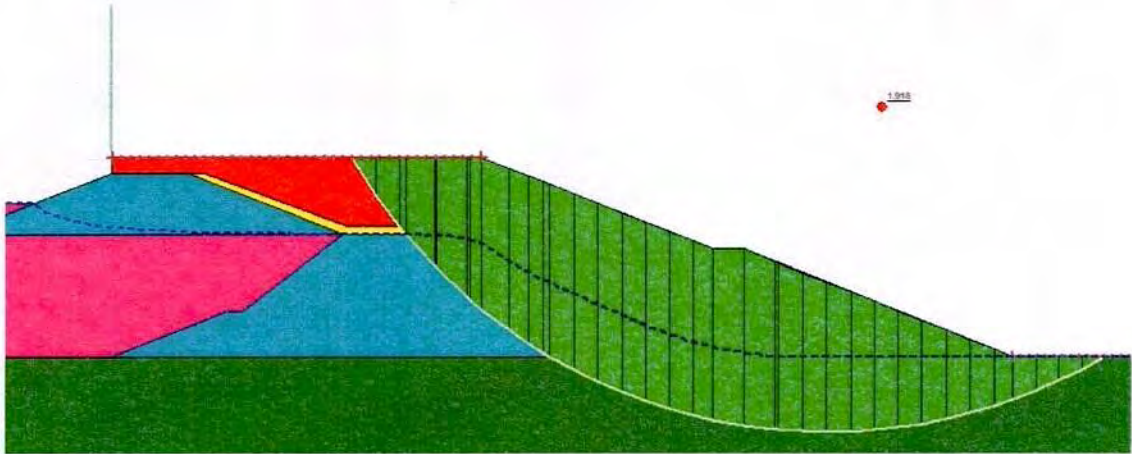


Figure 4.7: Overall Failure of section 1 (FS = 1.918) with seepage



SECTION 2

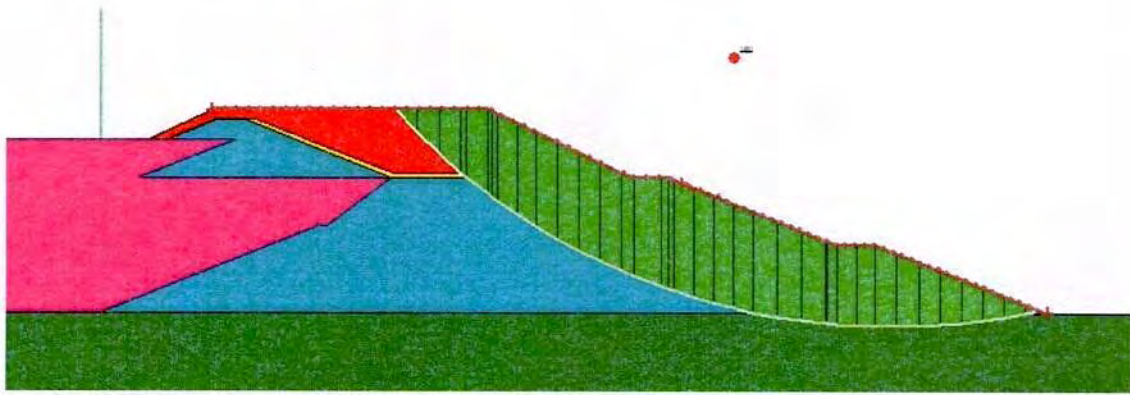


Figure 4.8: Slope Failure of section 2 (FS = 1.921)

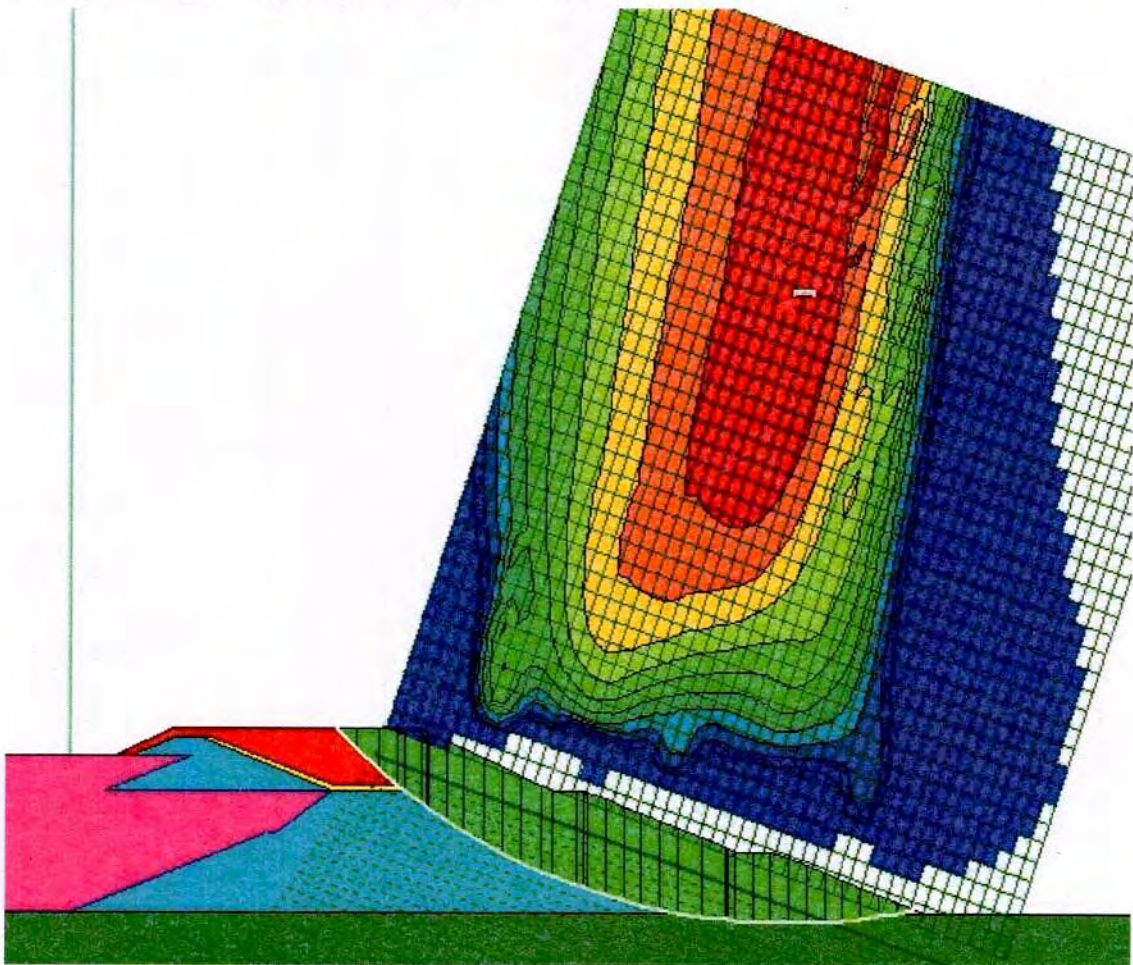


Figure 4.9: Static Analysis of section 2 (FS = 1.919)

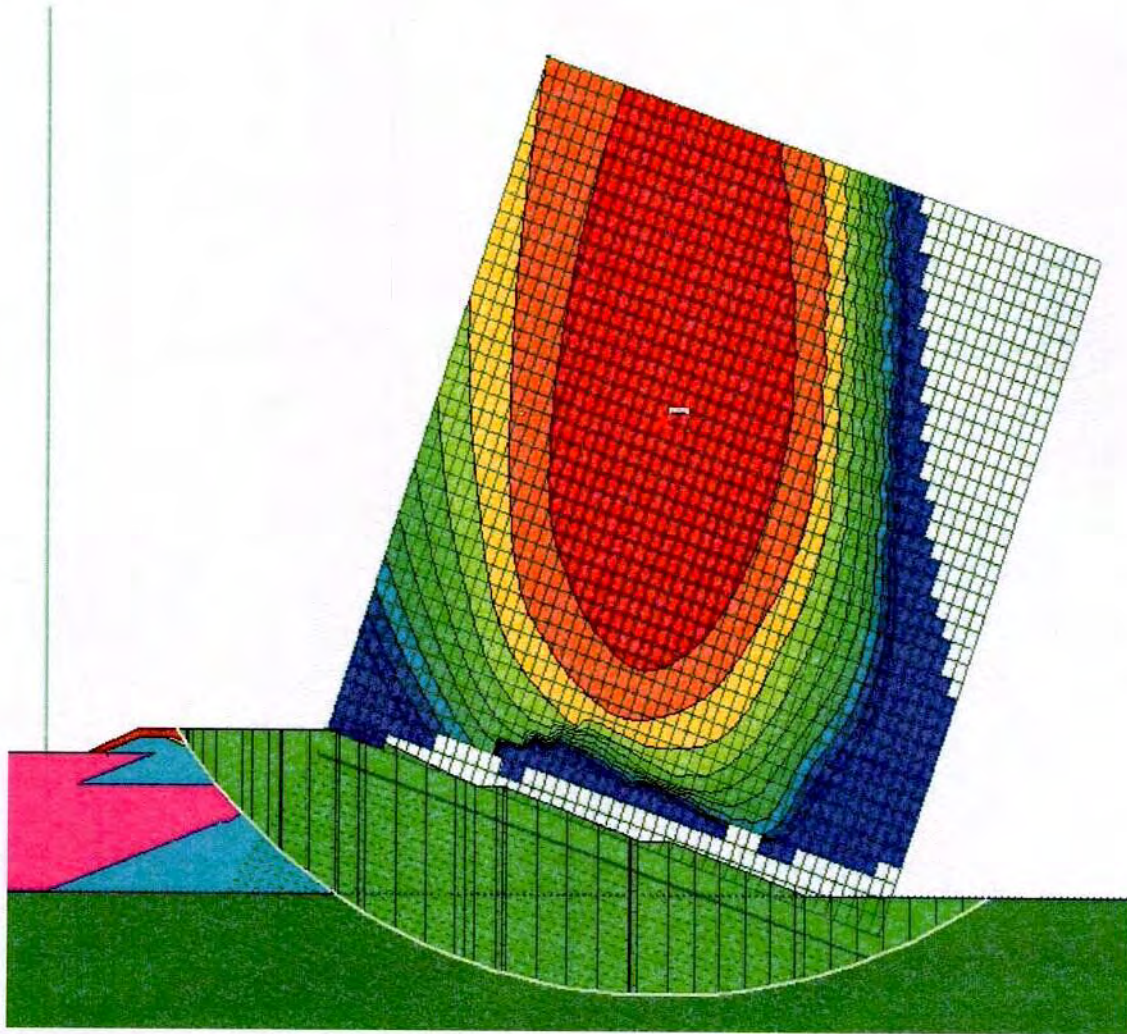


Figure 4.10: Dynamic Analysis of section 2 (FS = 1.212)



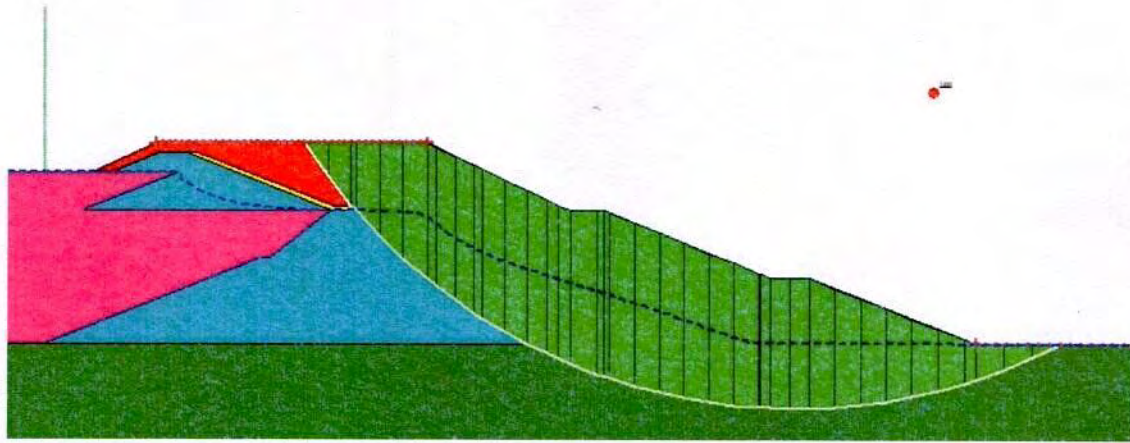


Figure 4.11: overall Failure of section 2 (FS = 1.625) with seepage

SECTION 3

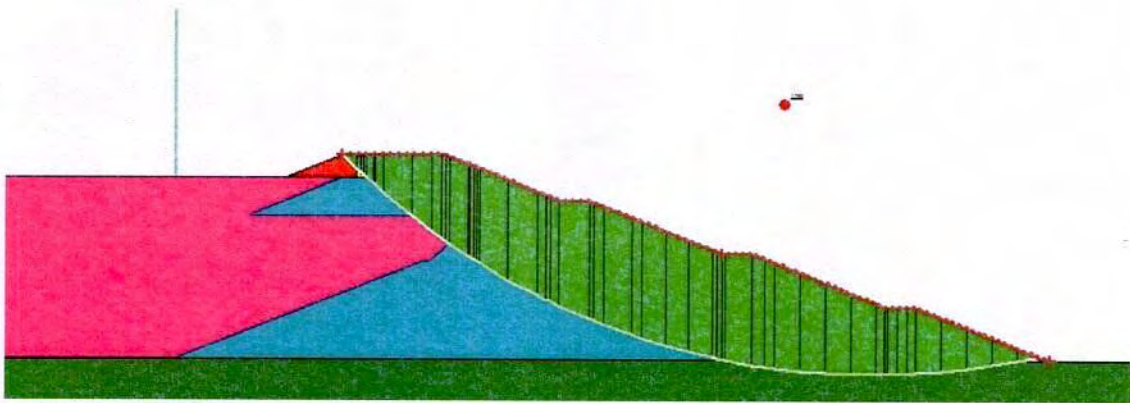


Figure 4.12: Slope Failure of section 3 (FS = 1.785)



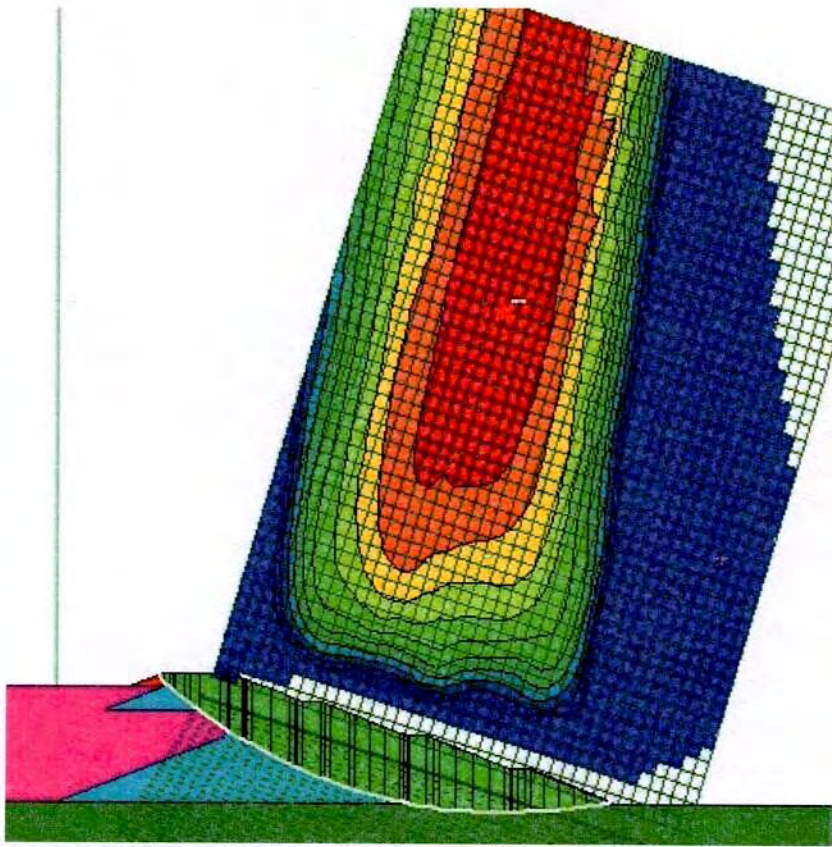


Figure 4.13: Static Analysis of section 3 (FS = 1.783)



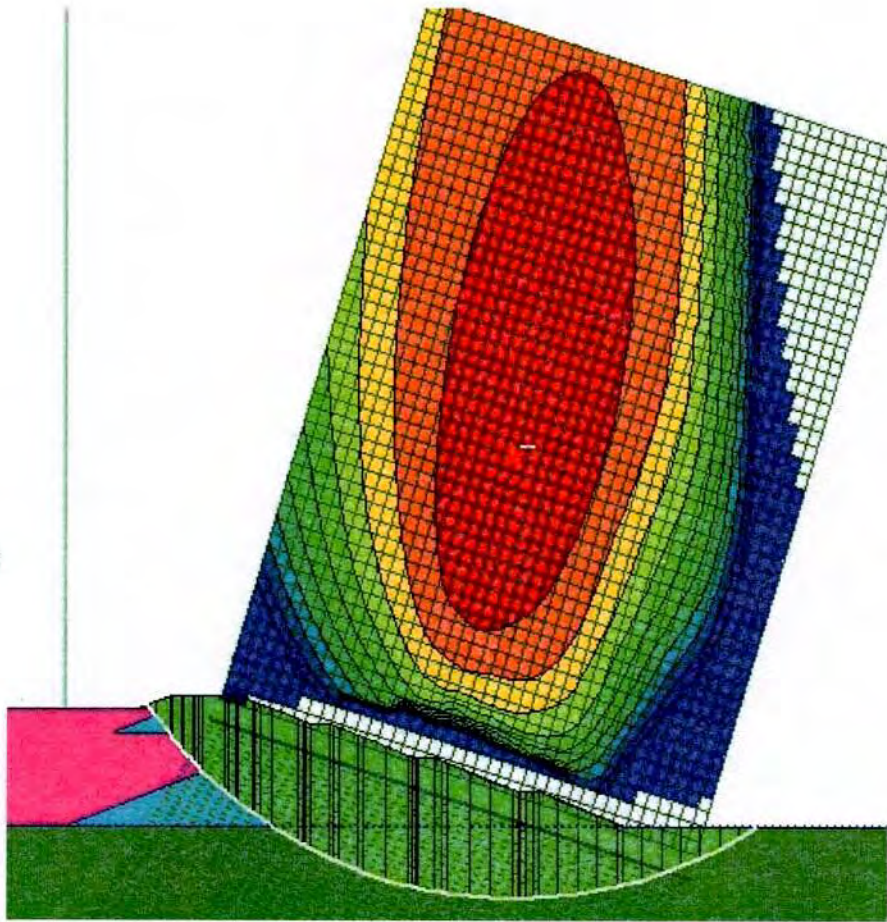


Figure 4.14: Dynamic Analysis of section 3 (FS = 1.117)

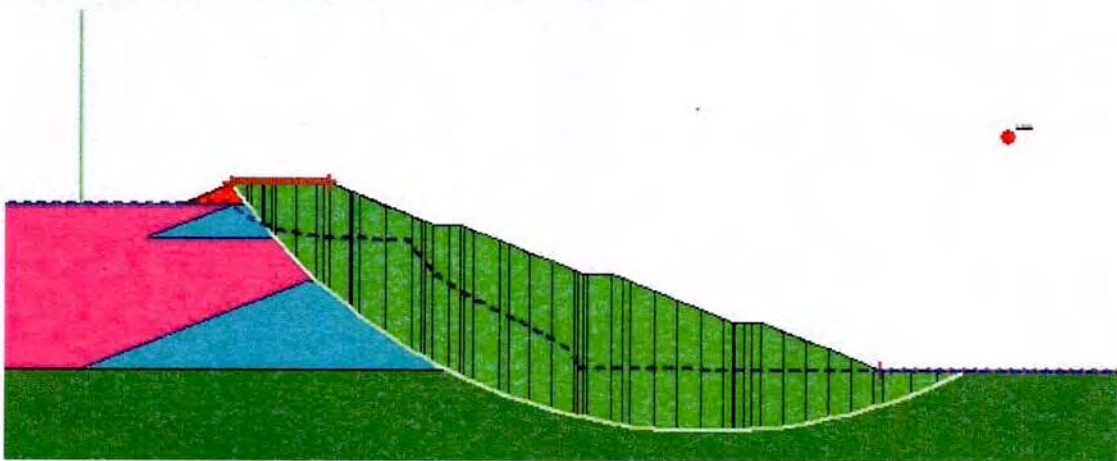


Figure 4.15: Overall Failure of section 3 (FS = 1.513) with seepage





SECTION 4

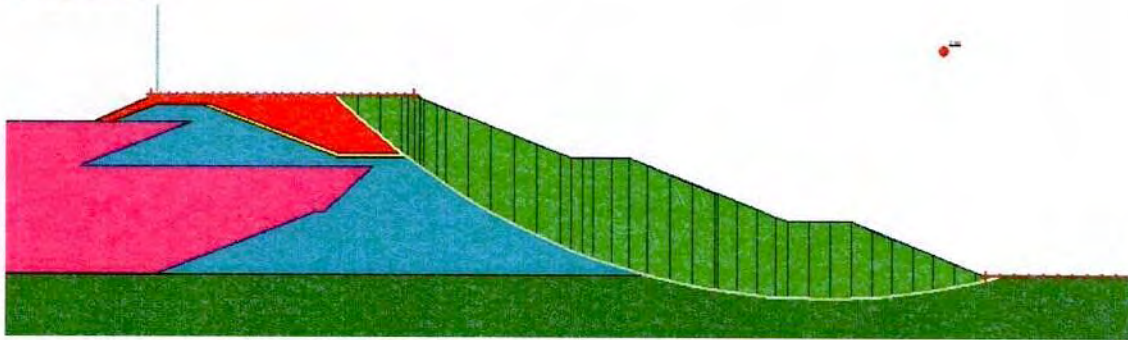


Figure 4.16: Overall Failure of section 4 (FS = 2.184)

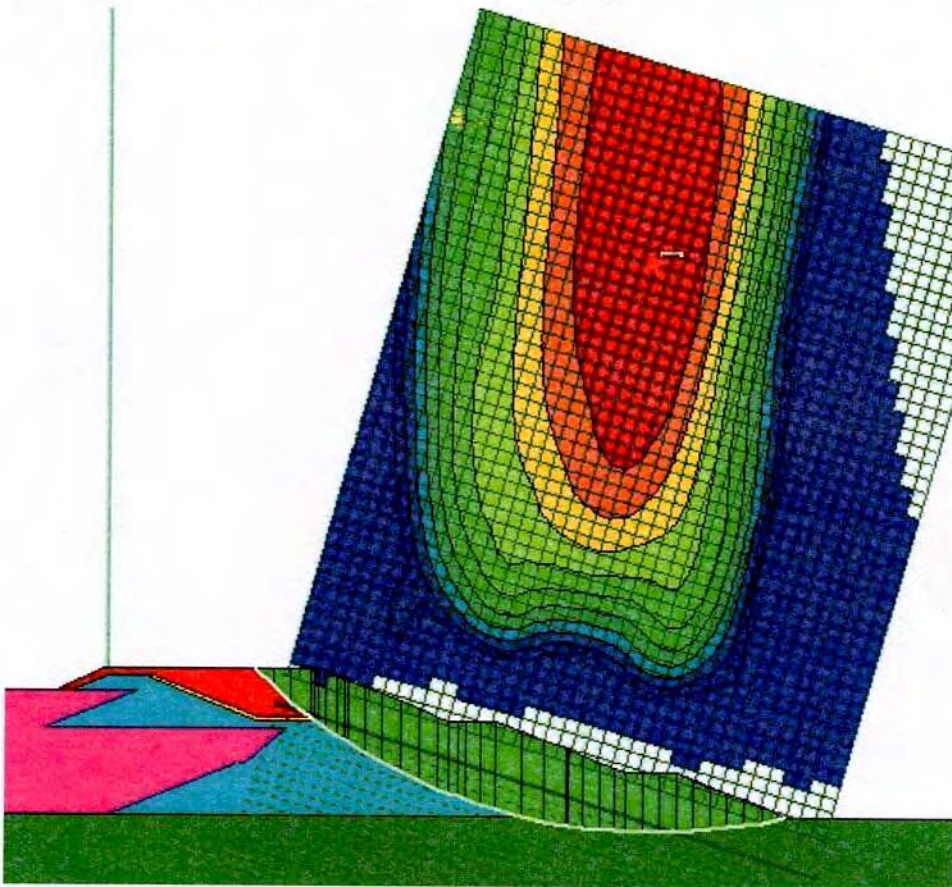


Figure 4.17: Static Analysis of section 4 (FS = 2.186)



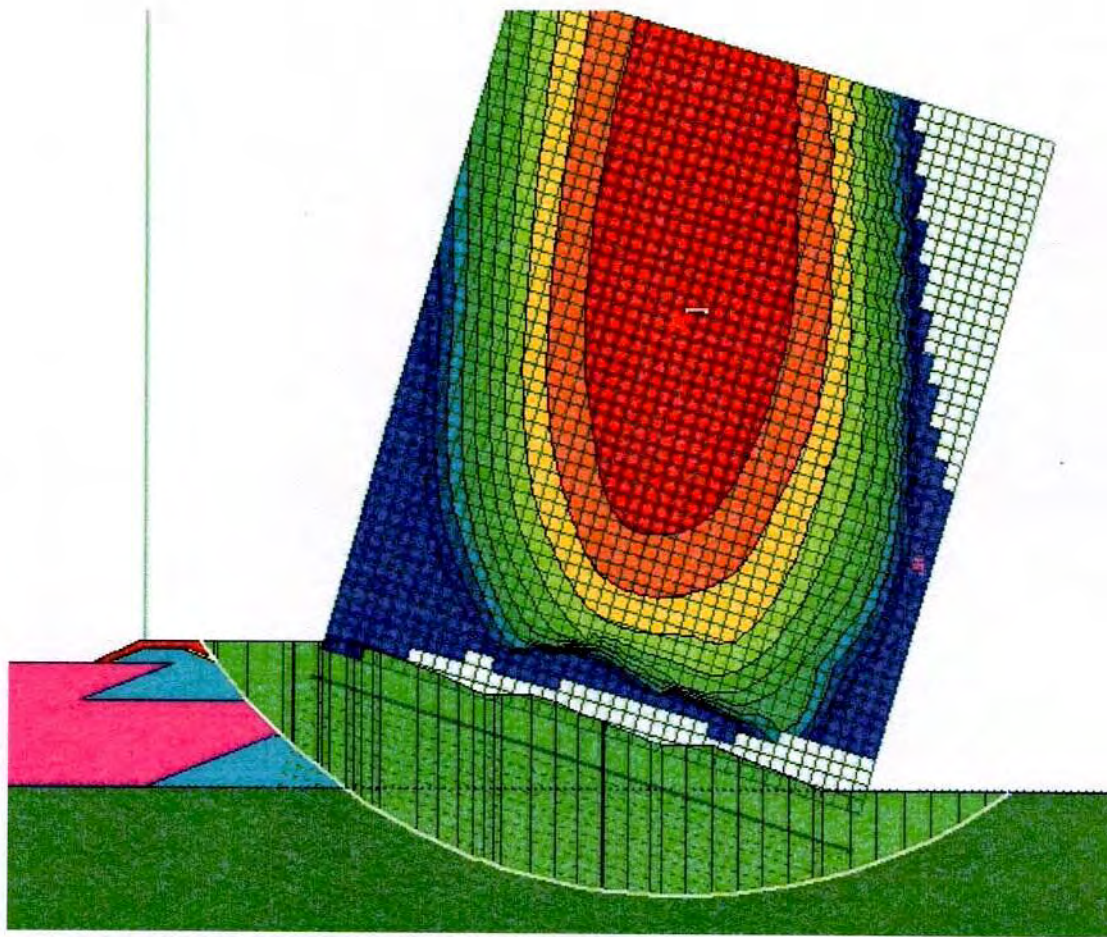


Figure 4.18: Dynamic Analysis of section 4 (FS = 1.234)

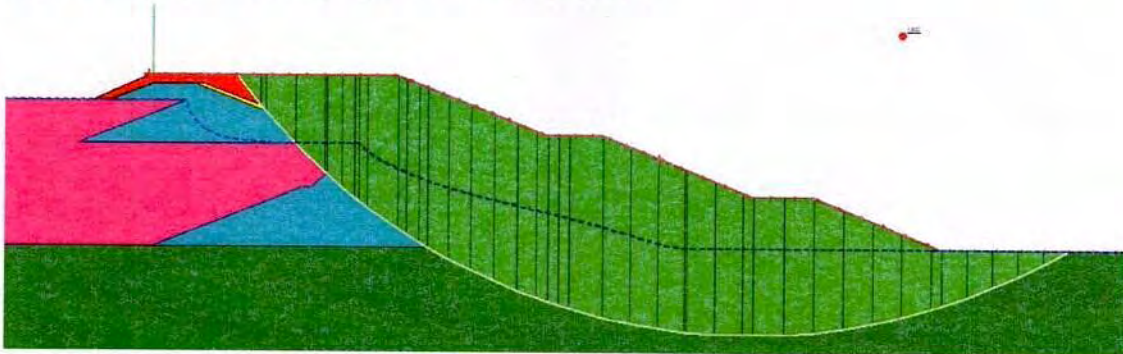


Figure 4.19: Base Failure of section 4 (FS = 1.832) with seepage

SECTION 5



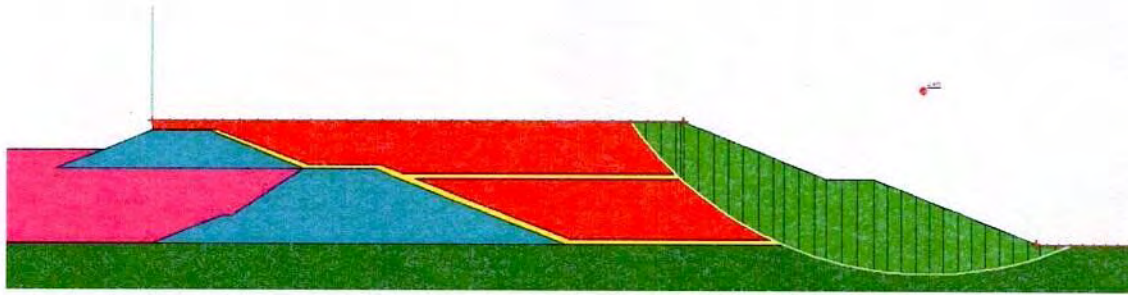


Figure 4.20: Base Failure of section 5 (FS = 2.479)

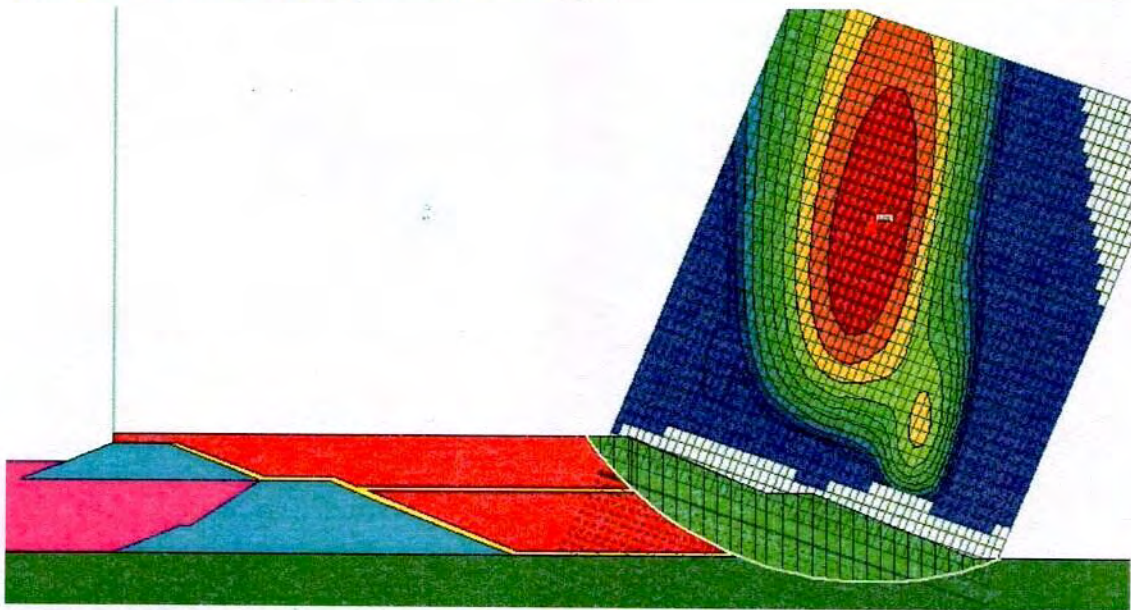


Figure 4.21: Static Analysis of section 5 (FS = 2.478)



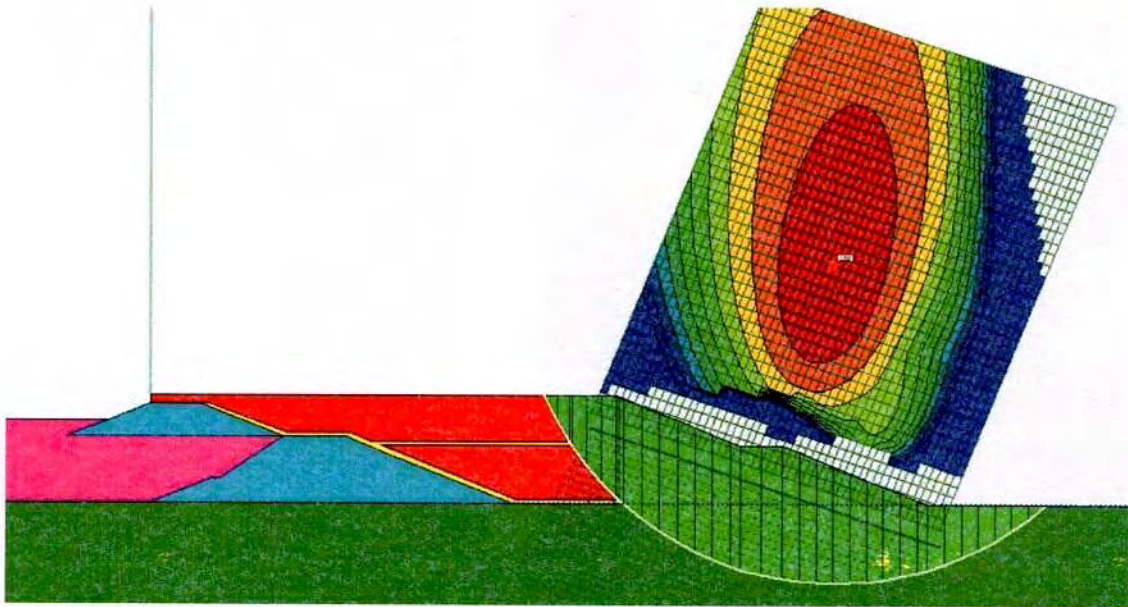


Figure 4.22: Dynamic Analysis of section 5 (FS = 1.702)

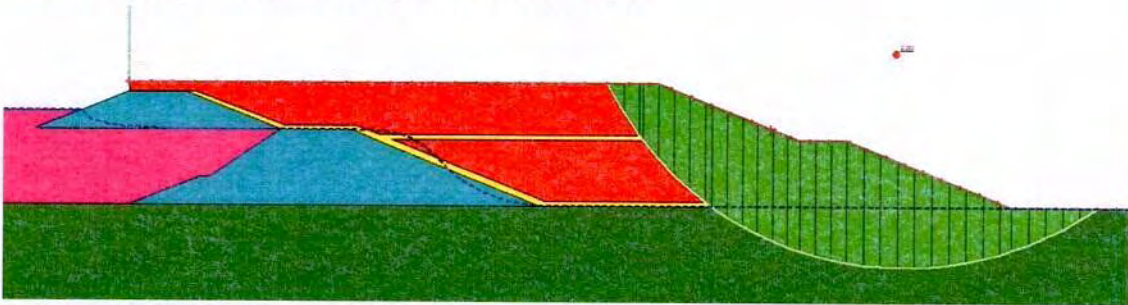


Figure 4.23: Base Failure of section 5 (FS = 2.222) with seepage

SECTION 6

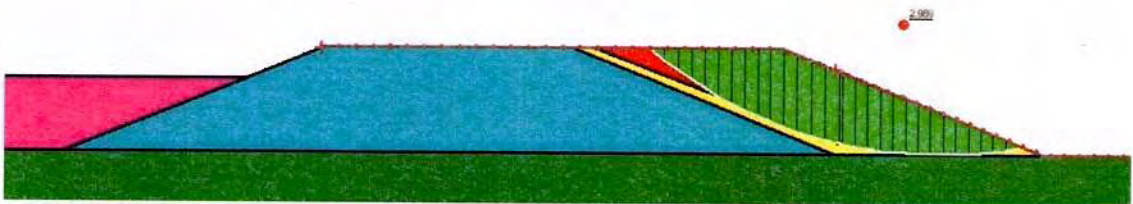


Figure 4.24: Base Failure of section 6 (FS = 2.969)



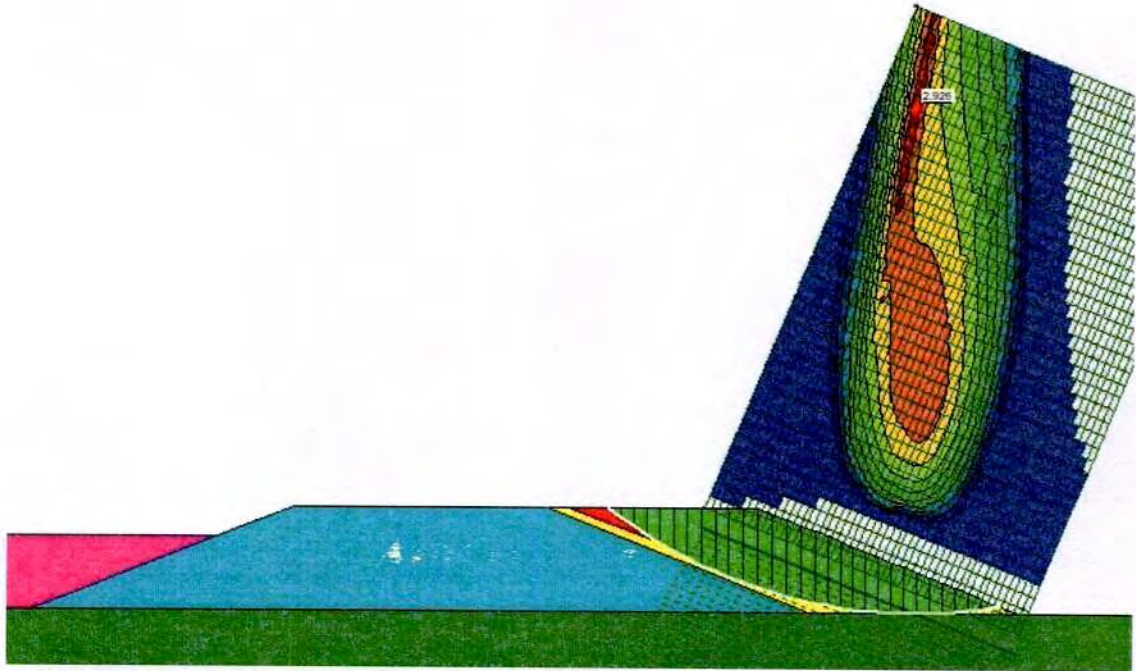


Figure 4.25: Static Analysis of section 6 (FS = 2.926)

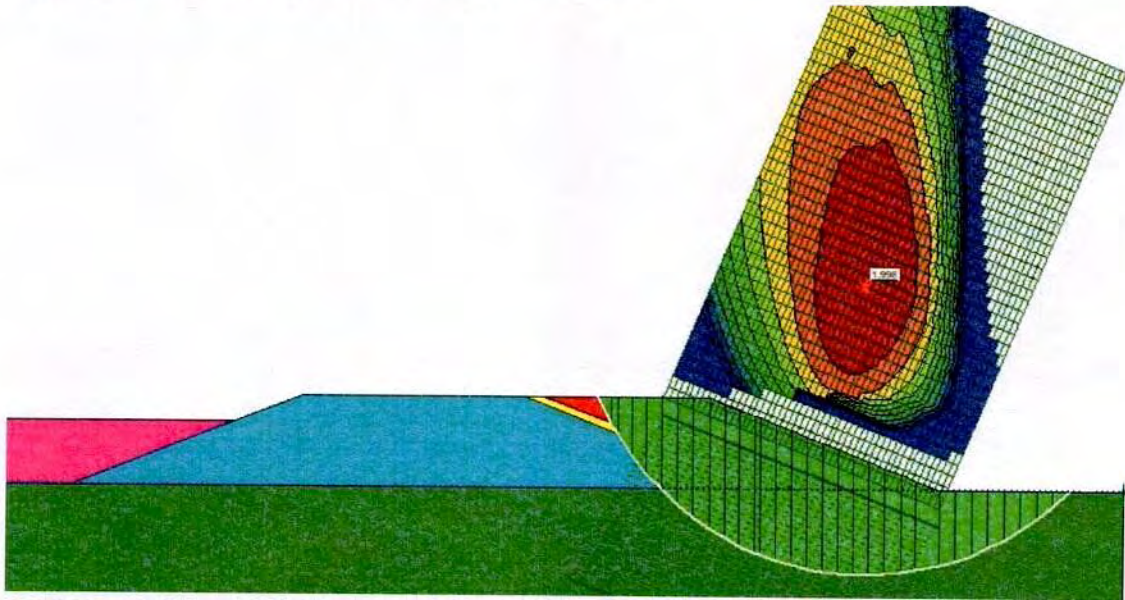


Figure 4.26: Dynamic Analysis of section 6 (FS = 1.998)



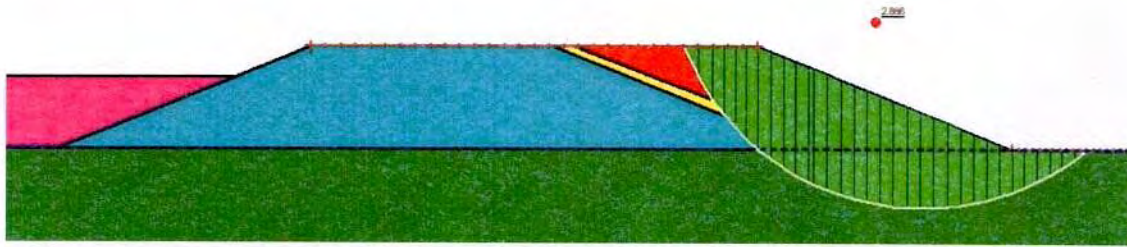


Figure 4.27: Overall Failure of section 6 (FS = 2.886) with seepage

SECTION 7

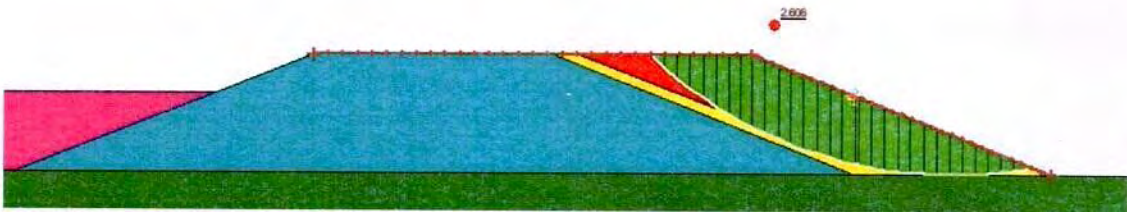


Figure 4.28: Slope Failure of section 7 (FS = 2.608)

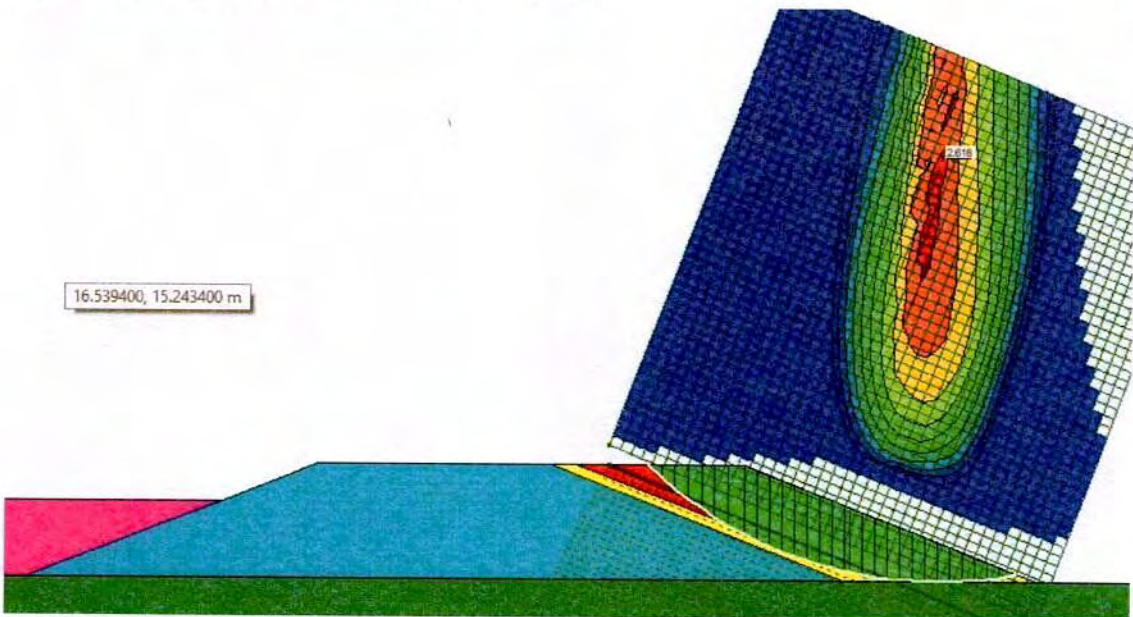


Figure 4.29: Static Analysis of section 7 (FS = 2.618)



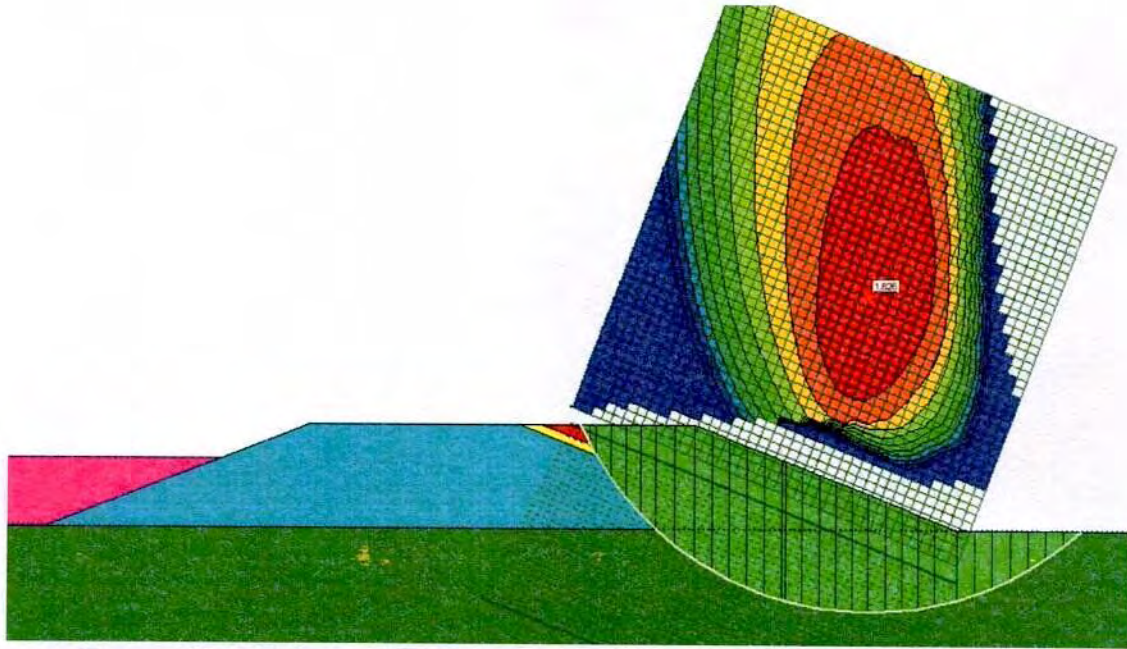


Figure 4.30: Dynamic Analysis of section 7 (FS = 1.826)

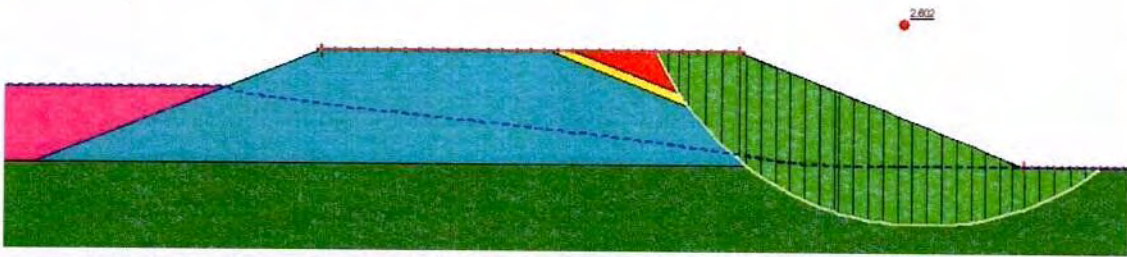


Figure 4.31: Overall Failure of section 7 (FS = 2.602) with seepage

SECTION 8

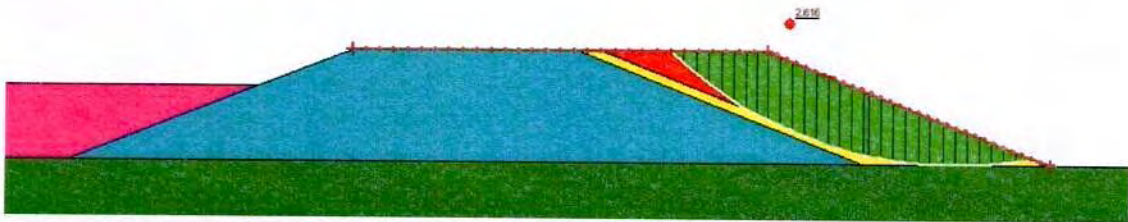


Figure 4.32: Slope Failure of section 8 (FS = 2.616)



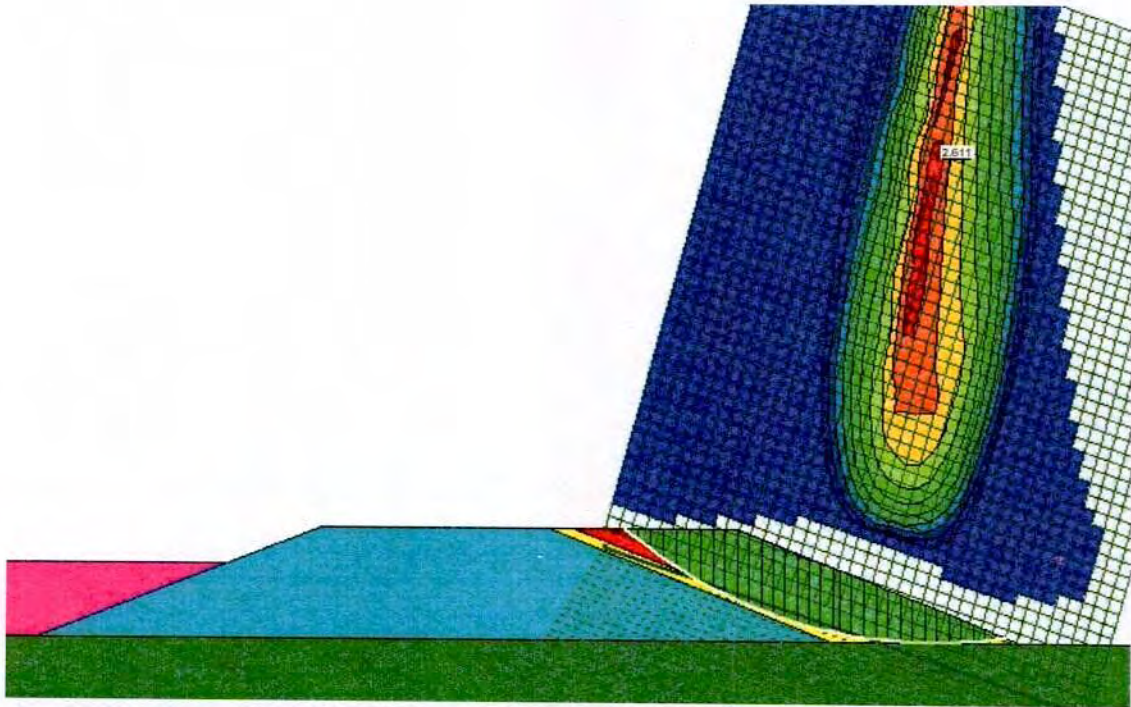


Figure 4.33: Static Analysis of section 8 (FS = 2.611)

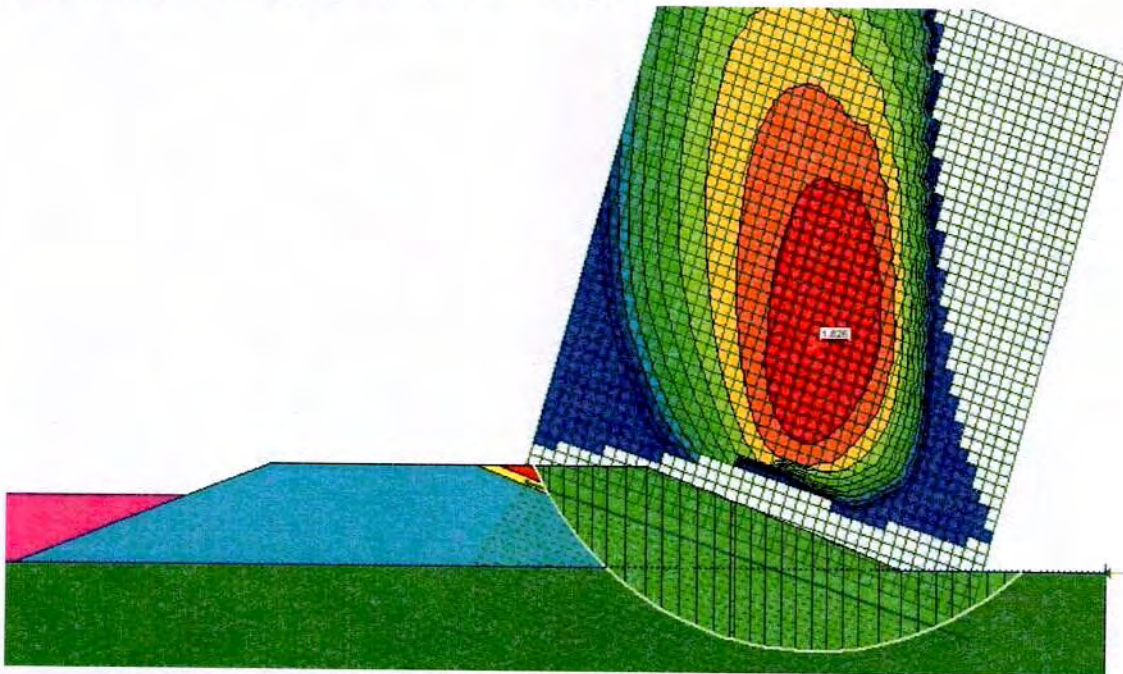


Figure 4.34: Dynamic Analysis of section 8 (FS = 1.826)



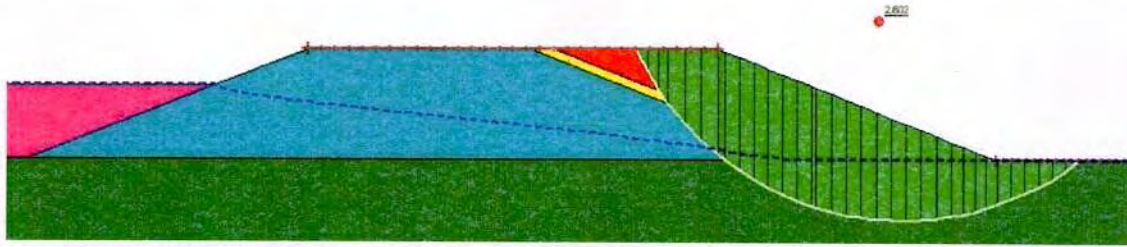


Figure 4.35: Overall Failure of section 8 (FS = 2.602) with seepage

SECTION 9

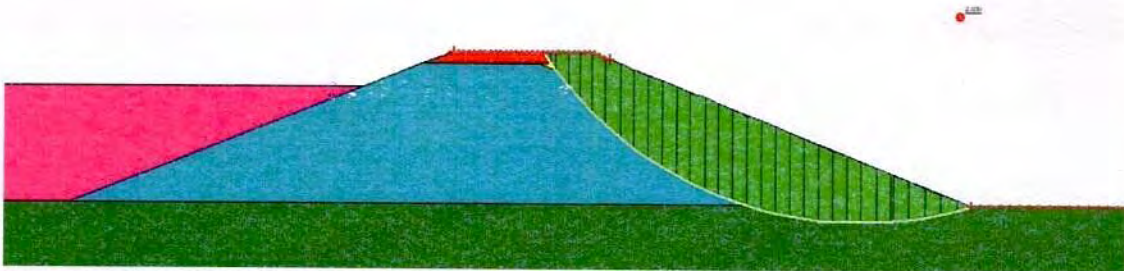


Figure 4.36: Base Failure of section 9 (FS = 2.03)

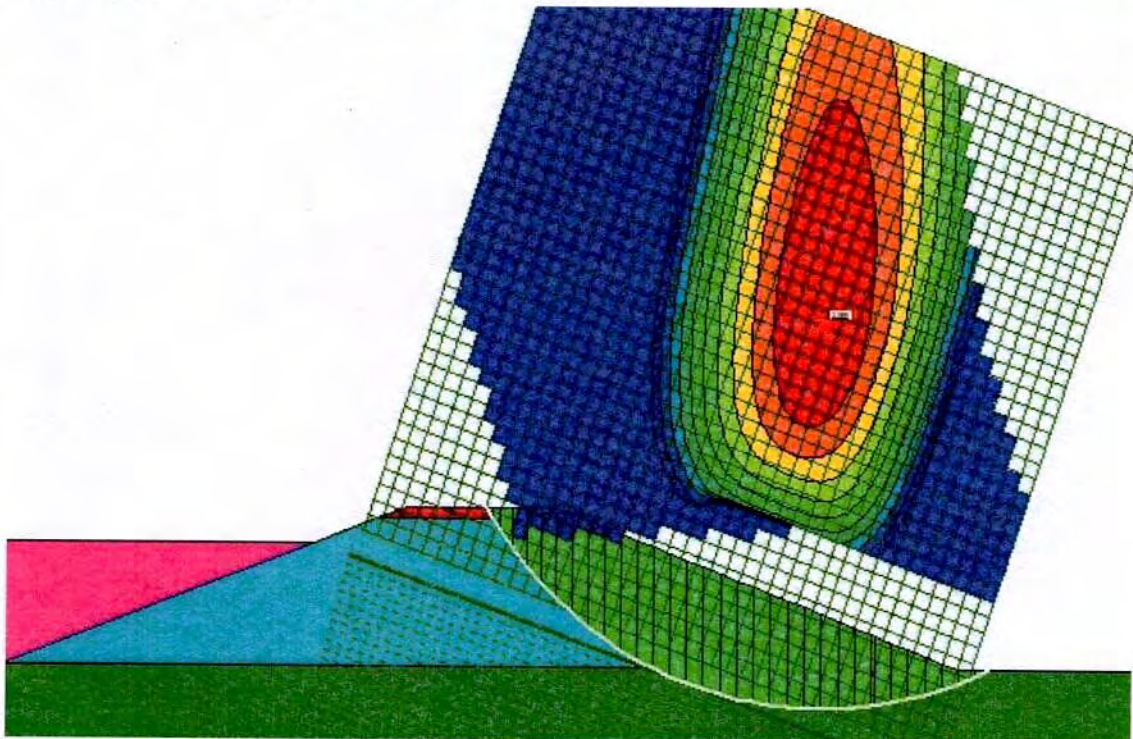


Figure 4.37: Static analysis of section 9 (FS = 2.089)



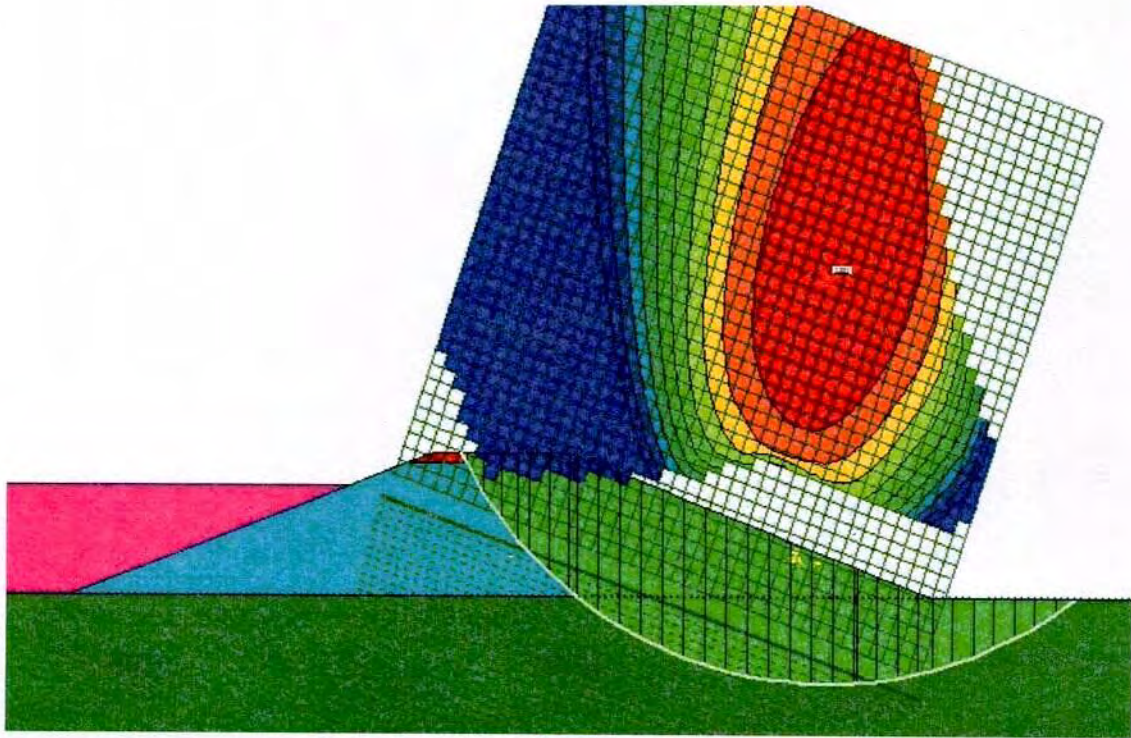


Figure 4.38: Dynamic Analysis of section 9 (FS = 1.331)

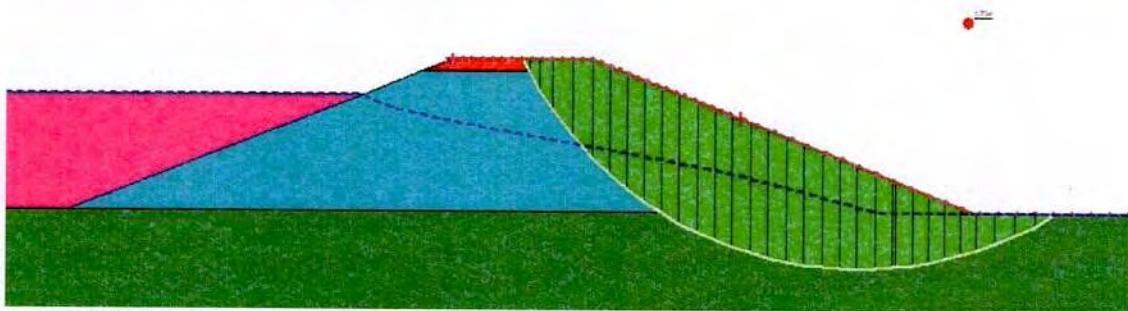


Figure 4.39: Base Failure of section 9 (FS = 1.734) with seepage

SECTION 10

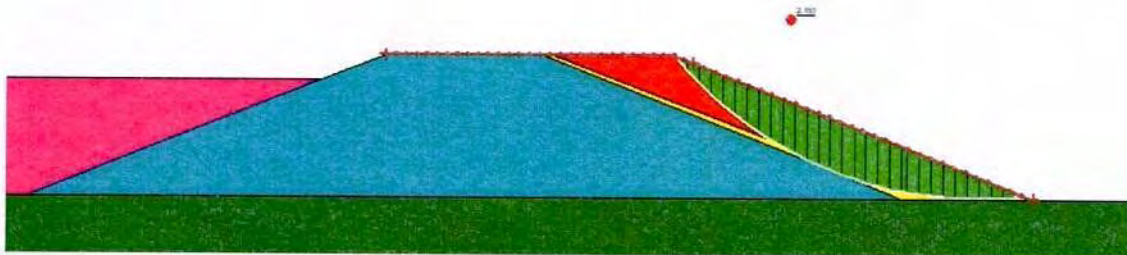


Figure 4.40: Slope Failure of section 10 (FS = 2.153)

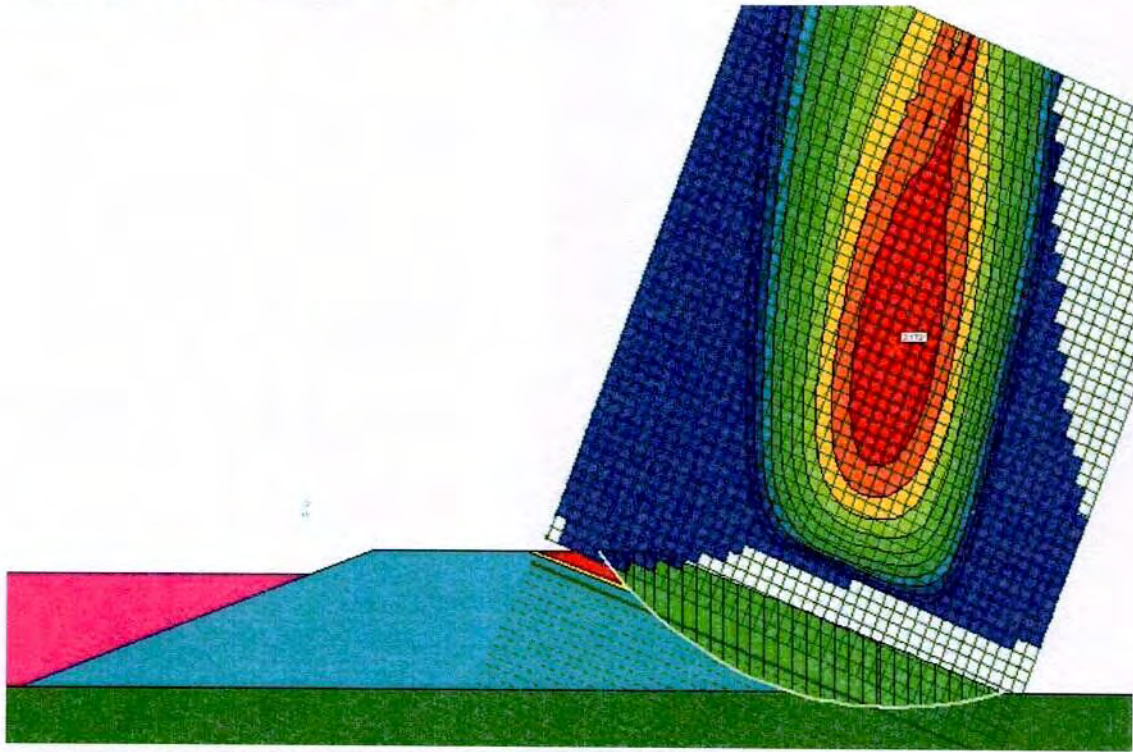


Figure 4.41: Static Analysis of section 10 (FS = 2.172)

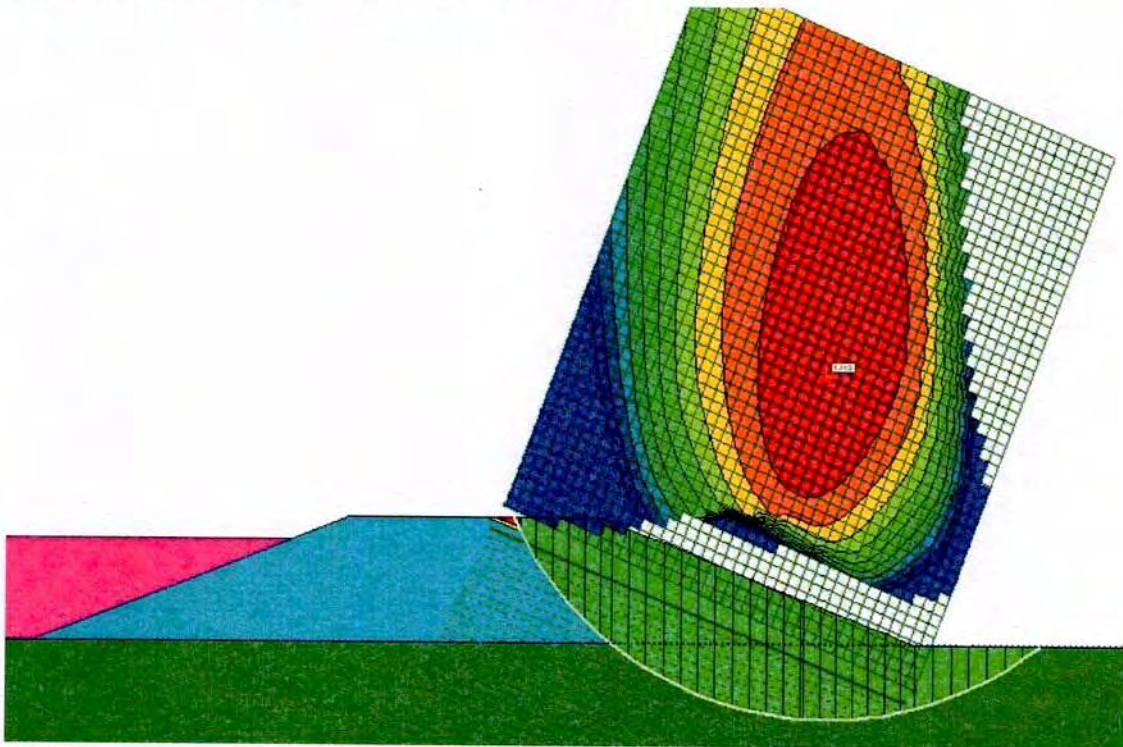


Figure 4.42: Dynamic Analysis of section 10 (FS = 1.413)

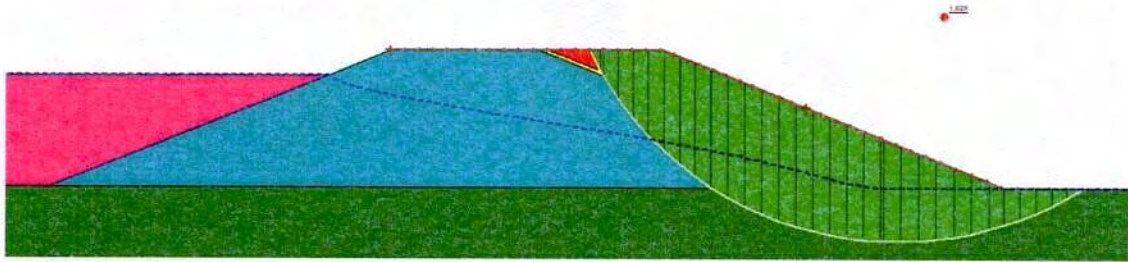


Figure 4.43: Base Failure of section 10 (FS = 1.928) with seepage



Chapter 5 Stability Checking of Fly Ash Pond

5.1 General

Type: Earthen bund. The embankment is made of composite materials. The core of it is compacted with fly ash and the surrounding ash is covered with 1 m thick soil. No HDPE membrane in upstream side, and stone pitching or grass turfing on downstream slope faces have been noticed to the periphery of dikes.

The pond is currently operational and no raisings were made over starter dike as of now. There is water no stagnation at any location within the ash pond.

CELL-A:

Due to OGL gradient from N-side to S-side, the bottom of the dyke RL varies from RL 432 to RL 425. The dyke Top RL fixed with RL 433. Find below the details of dyke constructed in cell-A:

Table 5.1 Geometric details of ash dyke sections

SL No.	Dyke Description	Dyke Length (in m)	Average Height of dyke (in m)	Remarks
1	A1-A2	384	1.5	Filter Layer in bottom
2	A2-A3	154	2	Filter Layer in bottom
3	A3-A4-A5	335	2.5	Filter Layer in bottom
4	A5-A6	141	3	Filter Layer in bottom
5	A6-A7	307	5	Common Dyke & Decant Tower
6	A8-A9	87	7	Filter Layer in bottom
7	A9-A10	138	8	Filter Layer in bottom
8	A10-A11-A12	191	2	Filter Layer in bottom
9	A12-A1	206	1	Filter Layer in bottom



Table 5.2 The current top and bottom RLs from section A1 to A12 of ash pond

SL No.	Dyke Description	Bottom RL	Top RL
1	A1	435	440
2	A2	437	442
3	A3	434	439.5
4	A5	431	436.5
5	A6	431.5	436.5
6	A7	429	438
7	A8	427	438
8	A9	425	438
9	A10	435	440
10	A11	434.7	439.7
11	A12	433.5	438.5

CELL-B:

The OGL of the cell-B almost same in all around the pond have average RL 428. Initial dyke constructed with design top RL 436. As Cell-B close to our airstrip and DGCA stipulation prevents us to increase further height. So, the top RL of the dyke restricted to top RL 434. Find below the details of the dyke constructed in cell-B.

SL No.	Dyke Description	Dyke Length (in m)	Average Height (in m)	Remarks
1	B1-B2	192	5.5	Presence of Filter Layer in bottom
2	B2-B3	198		Spillway Location
3	B3-B4	358		Presence of Filter Layer in bottom
4	B4-B5	111		Presence of Filter Layer in bottom
5	B5-B6	181		Presence of Filter Layer in bottom
6	B6-B7	52		Presence of Filter Layer in bottom
7	B7-B10	244		Presence of Filter Layer in bottom
8	B10-B1	184		Presence of Filter Layer in bottom



Figure 5.1 presents the general layout of ash pond. The pond is divided into two cells, Cell-A and Cell-B. At present, Cell-A is only operational. Cell-B is currently empty. From power plant ash disposed to cell-A by HCSD method through 5" seamless Steel Pipe of approximately 4 km of length. The ash slurry composes 60% solid, out of which 70% is fly ash and 30% bottom ash, and 40% water. The density of ash is 1.3-1.4 kg/Cum. Ash disposal pipe line entry to cell-A in between the dyke A9 to A10 and disposal point nearer to A10.

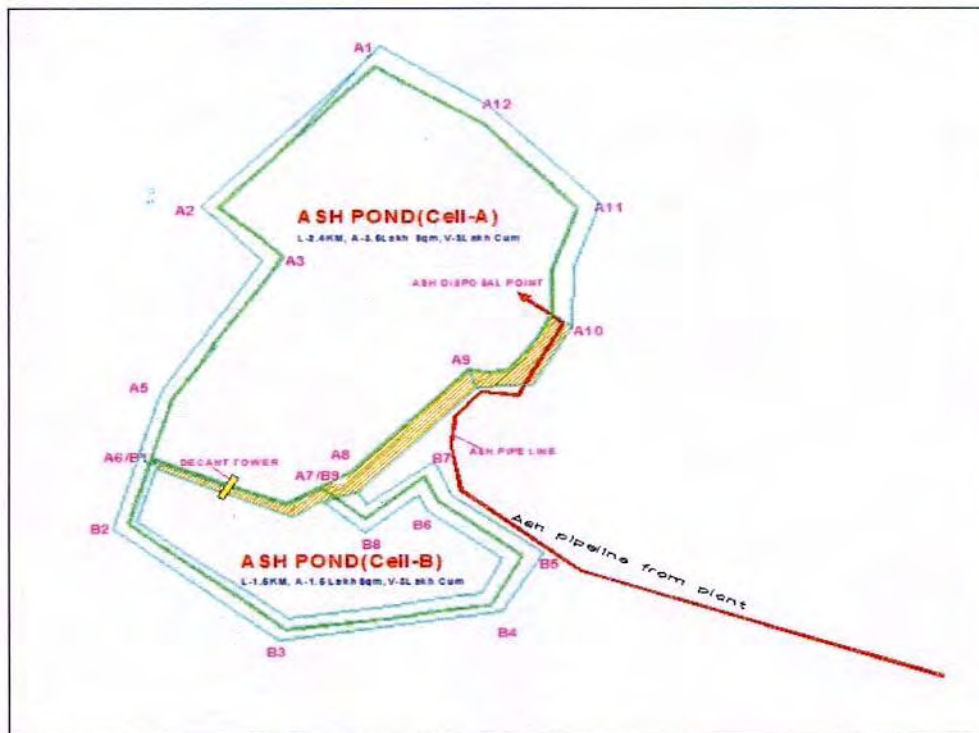


Fig. 5.1 Layout of the fly ash pond

As per the Table 5.1, the height of dyke is different at different sections. The minimum height is maintained at section A1, while height is maximum A7 to A10 sections. Typical cross section of dyke at A8 section where the height is maximum is shown in Fig. 5.2. The same section used for stability analysis and factor of safety determination. Table 5.3 lists out physical and geotechnical properties feed as input parameters for analysis purpose.



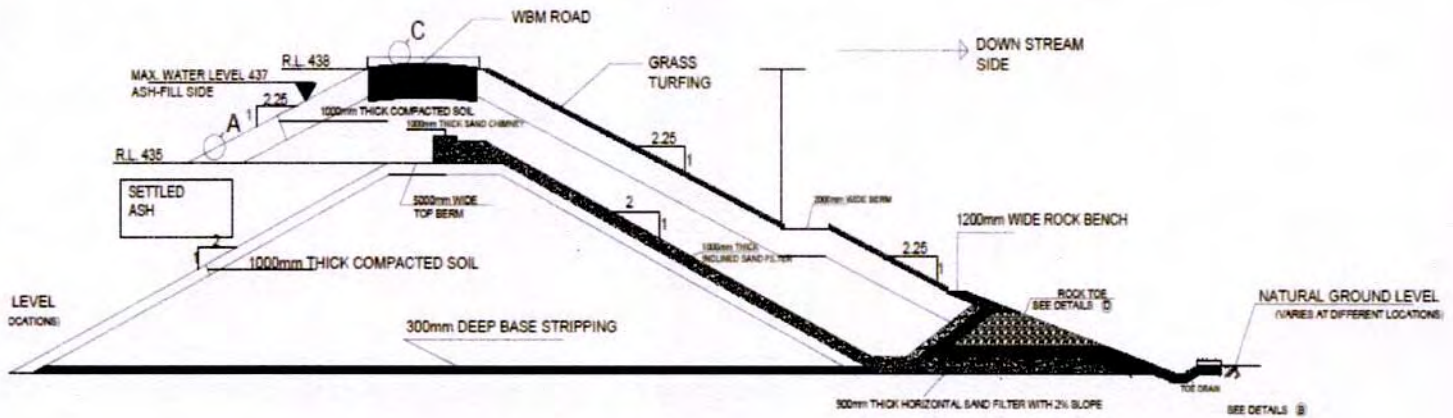


Fig. 5.2 Typical cross section details of fly ash pond

Table 5.3 Physical properties of fly ash used for stability analysis

Parameter	Value
Fly ash compacted	
Dry density	1.14 g/cc
Undrained cohesion, c_u	3 kPa
Angle of internal friction, ϕ	21°
m_v	1.5×10^{-4} /kPa
k	2.1×10^{-6} m/s
R_u	0.25
Total unit weight	11.4 kN/m ³
Saturated unit weight	13 kN/m ³
Settled ash	
Undrained cohesion, c_u	0 kPa
Angle of internal friction, ϕ	29°
m_v	
k	
R_u	0
Total unit weight	11 kN/m ³
Saturated unit weight	14 kN/m ³
Sand	
Dry density	1.75 g/cc
Undrained cohesion, c_u	0 kPa
Angle of internal friction, ϕ	35°
m_v	1×10^{-4} /kPa
k	0.01 m/s
R_u	0



Total unit weight	
Saturated unit weight	
Foundation soil	
Dry density	2.0 g/cc
Undrained cohesion, c_u	25 kPa
Angle of internal friction, ϕ	30°
m_v	1.2×10^{-4} /kPa
k	1.1×10^{-7} m/s
R_u	0
Total unit weight	20 kN/m ³
Saturated unit weight	22 kN/m ³
Compacted soil	
Dry density	1.77 g/cc
Undrained cohesion, c_u	55 kPa
Angle of internal friction, ϕ	8°
Drained cohesion, c'	10 kPa
Angle of internal friction, ϕ'	34°
m_v	1.8×10^{-4} /kPa
k	2.66×10^{-8} m/s
R_u	0.25
Total unit weight	20.9 kN/m ³
Saturated unit weight	22 kN/m ³

5.2 Seepage through the dikes

Occurrence of seepage for the section of A8-A9 at two locations has been noticed during the site visit. However, the seepage flow is constant at one of these locations, regardless of seasonal variation. Though, seepage occurrence is constant, incidentally, there is no ponding of water on the upstream side of the dike. In order to quantify the seepage volume, discharge is measured with time and the measured flow values given below:

Seepage point 1:





Fig. 5.3 Seepage point location 1 between section A8-A9

Time-32 Seconds

Water collection-5450 ml

Flow- $5450/32=170.31 \text{ ml/sec}=0.00017031 \text{ m}^3/\text{sec}$

Seepage point no-2



Fig. 5.4 Seepage location-2 between section A8-A9

Time-45 Seconds



Water collection-3179 ml

Flow- $3179/45=70.64 \text{ ml/sec}=7.064 \times 10^{-5} \text{ m}^3/\text{sec}$

A marginal seepage was also observed at the other locations. However, the seepage in these locations is sporadic and highly depended on seasonal variance. A typical flow is measured at these locations is $7.064 \times 10^{-5} \text{ m}^3/\text{sec}$

5.3 Observations and Recommendations

Based on the analysis carried out, summary of factor of safety obtained is presented in Table 5.4.

Table 5.4 Summary of FS values obtained from stability analysis

SI No.	Location	FS
1	A1 to A2	1.622
2	A2 to A3	1.622
3	A3 to A5	1.622
4	A6 to A7	1.612
5	A7 to A8	1.625
6	A8 to A9	1.285
7	A11 to A12	1.623

Based on the analyses, it is concluded that the structural safety of the fly ash dike of Cell-A and Cell-B are stable against slope failure and are sufficient for both usual load combinations at its current condition. Also, there is no sign of seepage has been observed at any location along the circumference of the ash dike during the visit. However, it is advised to keep monitoring and measuring the seepage in the section A8 to A9 for future reference purpose.



5.4 Results of Stability analysis

Section A6 – A8

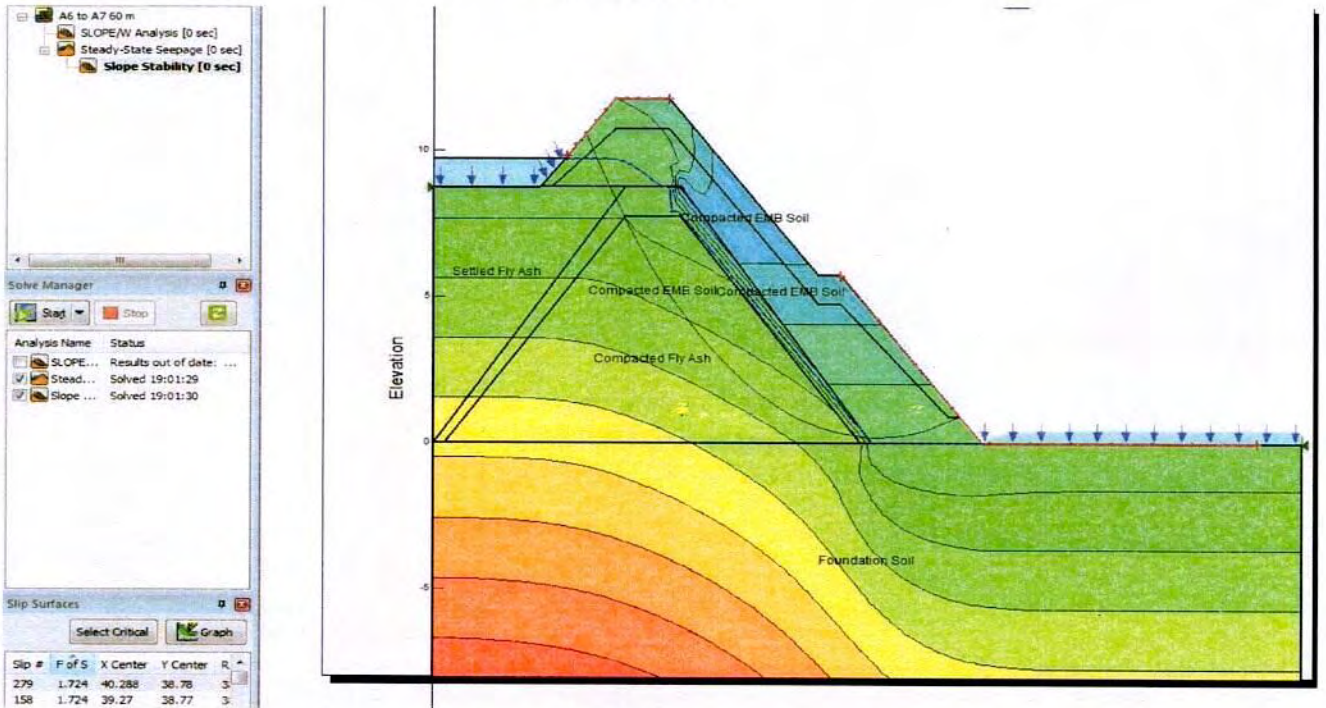


Fig. 5.5a Stability against global failure of ash dike section from A7 to A8 (coupled seepage and stability analysis) FOS=1.724



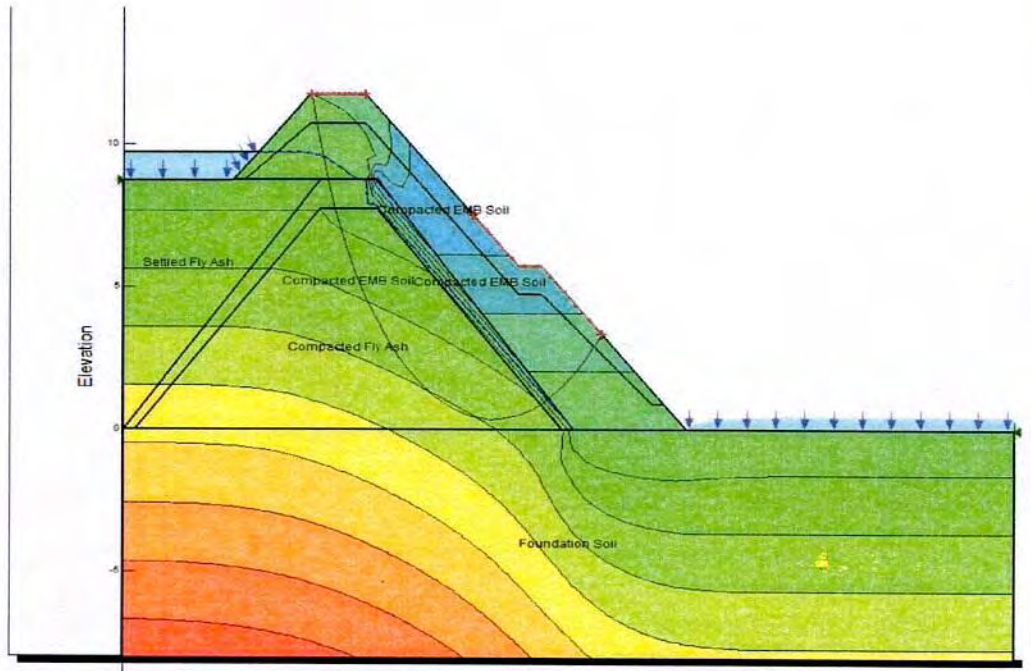
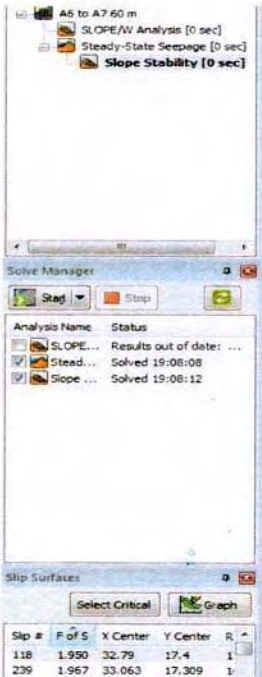


Fig. 5.5b Stability against local/slope failure of ash dike section from A7 to A8 (coupled seepage and stability analysis) FOS=1.950

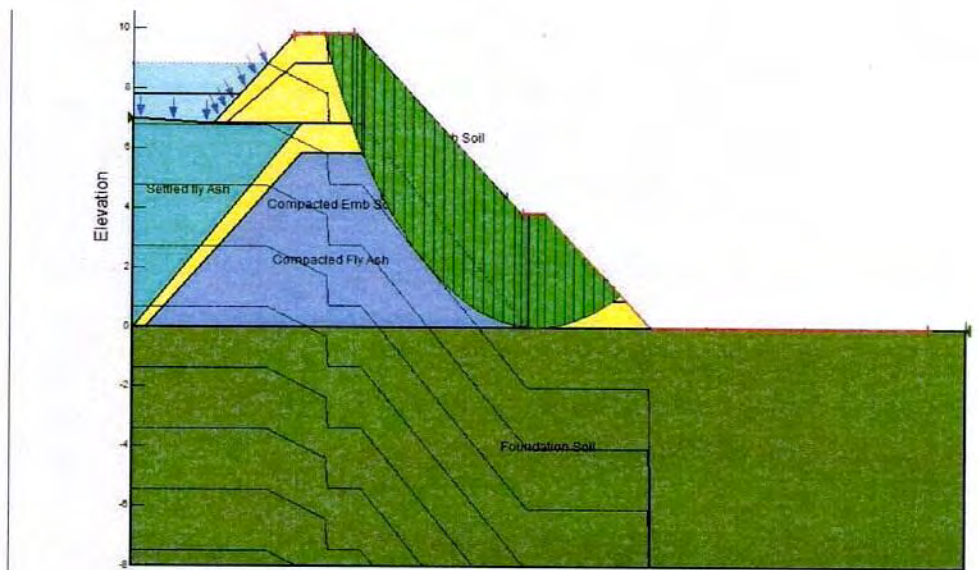
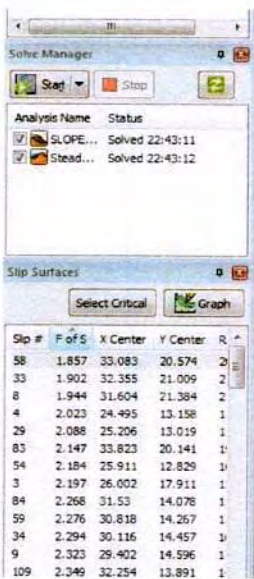


Fig. 5.5c Stability against local/slope failure of ash dike section from A6 to A7 (coupled seepage and stability analysis) FOS=1.857



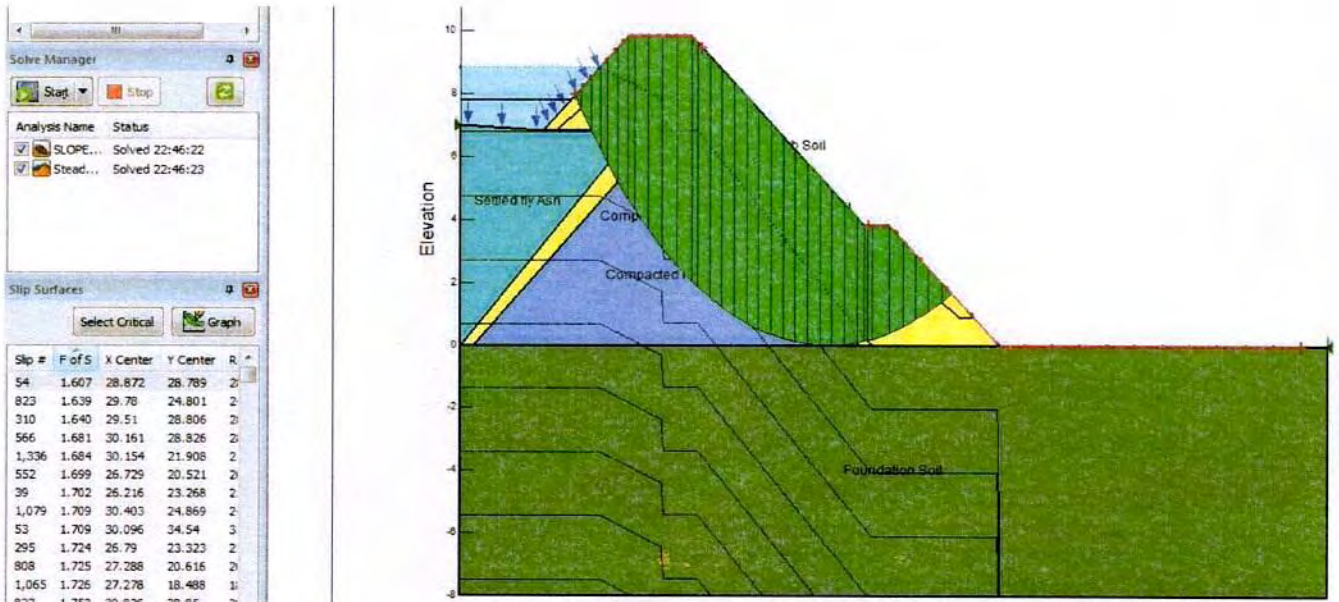


Fig. 5.5d Stability against global failure of ash dike section from A6 to A7 (coupled seepage and stability analysis) FOS=1.607

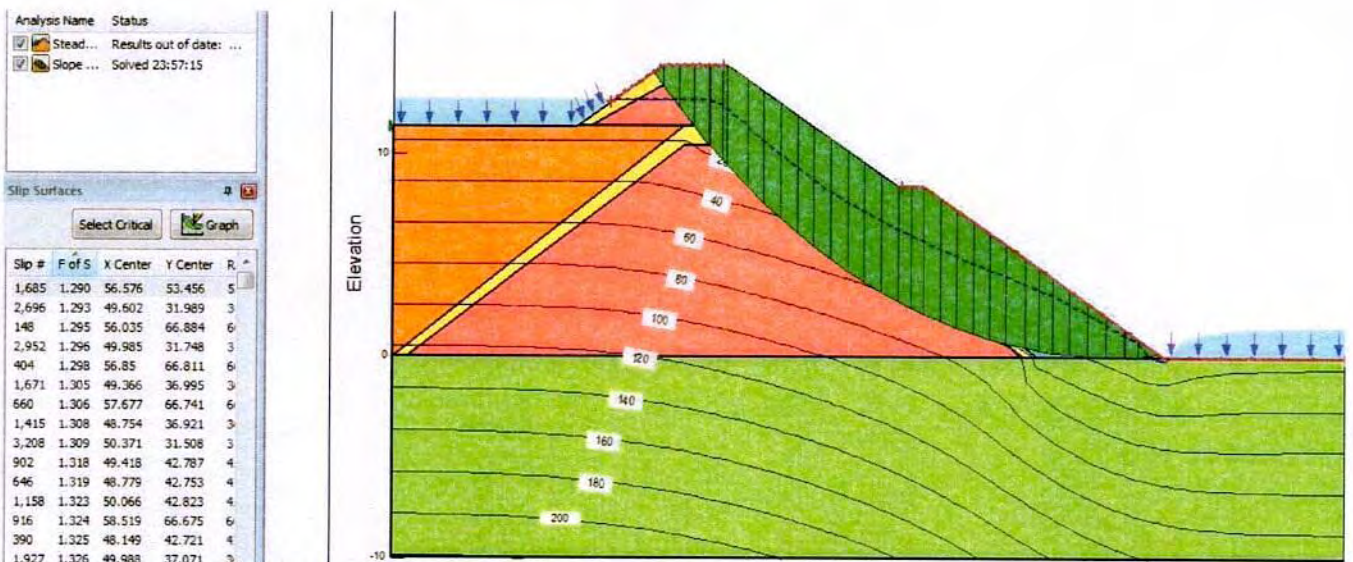


Fig. 5.5e Stability against global failure of ash dike section from A8 to A9 (coupled seepage and stability analysis) FOS=1.290



Analysis Name	Status
Stead...	Solved 23:58:42
Slope ...	Solved 23:58:50

Slip #	F of S	X Center	Y Center	R
250	1.401	46.973	24.518	2
763	1.414	46.743	22.208	2
506	1.418	47.279	24.389	2
235	1.441	45.501	22.181	2
249	1.441	47.971	27.026	2
491	1.451	45.803	22.077	2
1,019	1.452	46.955	21.986	2
234	1.459	46.31	24.222	2
748	1.460	45.408	20.27	2
507	1.462	46.438	22.311	2
1,275	1.463	47.086	21.661	2
762	1.466	47.587	24.261	2
1,531	1.475	47.216	21.335	2
490	1.476	46.616	24.093	2
747	1.478	46.107	21.974	2

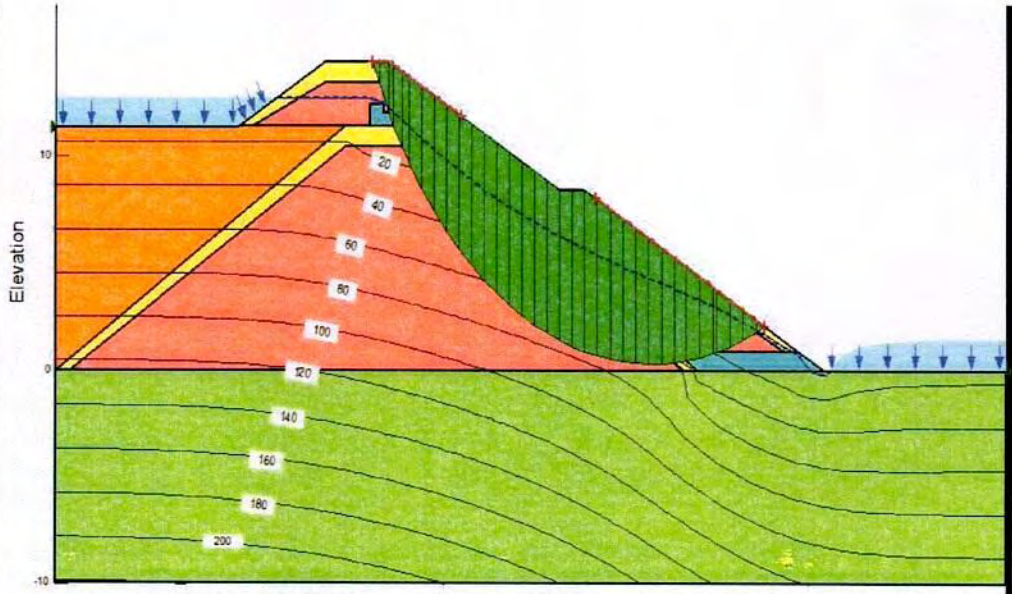


Fig. 5.5f Stability against local/slope failure of ash dike section from A8 to A9 (coupled seepage and stability analysis) FOS=1.401



Chapter 6

Stability Checking of Process Water Lake (PWL)

6.1 General

Dyke is made of earthen bund. HDPE membrane on the upstream side and stone pitching on the downstream slope faces has not been provided along the periphery of the dike. However, whole of the upstream inner area is very well lined with cement in order to arrest the seepage. PWL is operational at the time of visit and no sign of seepage has been noticed during the visit.

An issue related to seepage has been reported on 14 Nov-2023 of PWL. In this regard, a site visit was made on 17-Nov-23 to examine the seepage condition and its implication on the dyke stability. PWL is found operational at the time of visit. However, no seepage has been noticed during the site visit on 17.05.2024.

6.2 Sections for stability analysis

Figure 6.1 shows that google earth image with selected locations that were considered for stability analysis. Figure 6.2 shows the typical cross section of dyke.





Fig. 6.1 Google earth image showing selection of locations for stability analysis

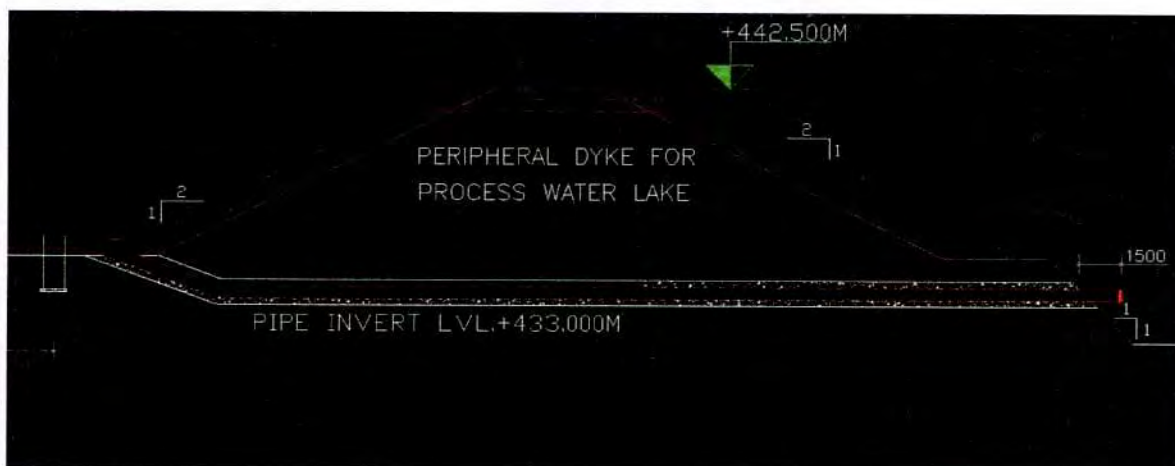


Fig. 6.2 Typical cross section of a PWL pond

6.3 Observations and Recommendation

Physical inspection showed no sign of seepage at any location along the periphery of PWL pond at the time of visit.



Stability analysis carried out at different locations of the dike along its periphery shows the dike is stable.

However, it is advised to be cautious in relation to seepage in the future. The problem of seepage, if any, found in the future is need to be prevented immediately by adopting suitable measure or advised to consult an expert.



Chapter 8

Seepage Control Measures for Tailings Dams

8.1 General

Seepage control is an important aspect in the design, construction, and operation of tailings dams. Seepage problem becomes critically important specifically during the operation of tailings dams. Uncontrolled seepage can lead to such problems as piping, slope instability and heaving, and excess water losses. Seepage control measures unquestionably add to the total costs of the tailings storage facilities. However, they greatly increase the overall safety of the tailings dams and when properly designed and constructed satisfy both the safety and pollution control requirements of the regulatory agencies. The additional costs associated with constructing adequate seepage control measures should be considered a necessary part of the cost of building and operating tailings dams in today's society.

There are three basic defenses used for the control of seepage. These are:

- a) **Filters:** to prevent piping and heaving. Basically, filters are designed to permit the free discharge of the seepage water but to prevent the movement of soil particles. (The basic rules for design of filters are presented in the following section).
- b) **Seepage Reduction:** to reduce water pressures and seepage forces in the critical exit areas downstream of the dam. The methods used include: **impervious cutoffs, grout curtains, and upstream impervious blankets.**
- c) **Drainage:** to reduce water pressures in the embankment and foundation soils. The methods used include: internal vertical interceptor drains, horizontal blanket drains, strip drains, toe drains, and relief wells.

Normally, the above three methods of seepage control are used in combination. For example, the seepage reduction methods used must almost be perfect, if they are to greatly reduce downstream seepage flows and pressures. As this is seldom possible to achieve, the seepage reduction



methods are usually combined with downstream drainage to ensure the desired end-result. Similarly, all drains must be designed to meet the filter requirements as their function is to get the water out of the surrounding soil without loss of soil particles.

In those instances where the effluent seepage is considered harmful, extensive cutoff and seepage collection facilities may be required to prevent seepage from reaching and contaminating the surface and groundwaters of the area.

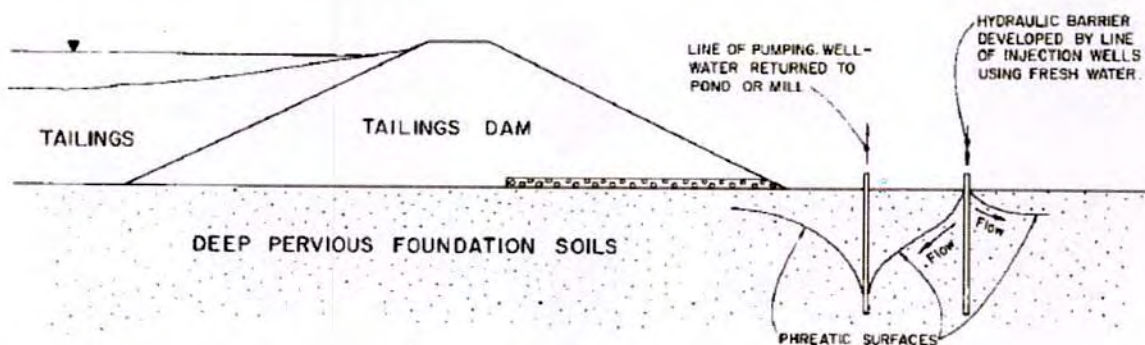
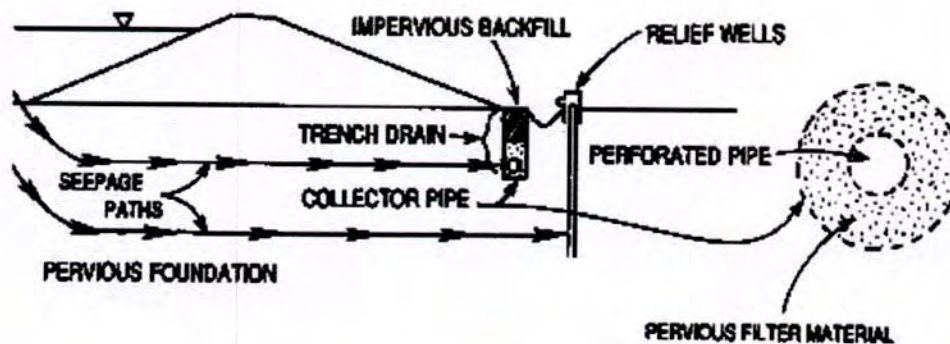


Fig. 8.1 Hydraulic barrier- used to prevent seepage downstream of dam

8.2 Relief wells

Relief wells are used as a means of relieving uplift pressures in pervious foundation soils that pass beneath the dam. Quite often relief wells are used in conjunction with one of the seepage reduction measures (grouting, upstream impervious blanket, etc.) to control seepage gradients at the downstream toe of the dam.

FIGURE II-13. TRENCH DRAIN USED IN CONJUNCTION WITH RELIEF WELLS



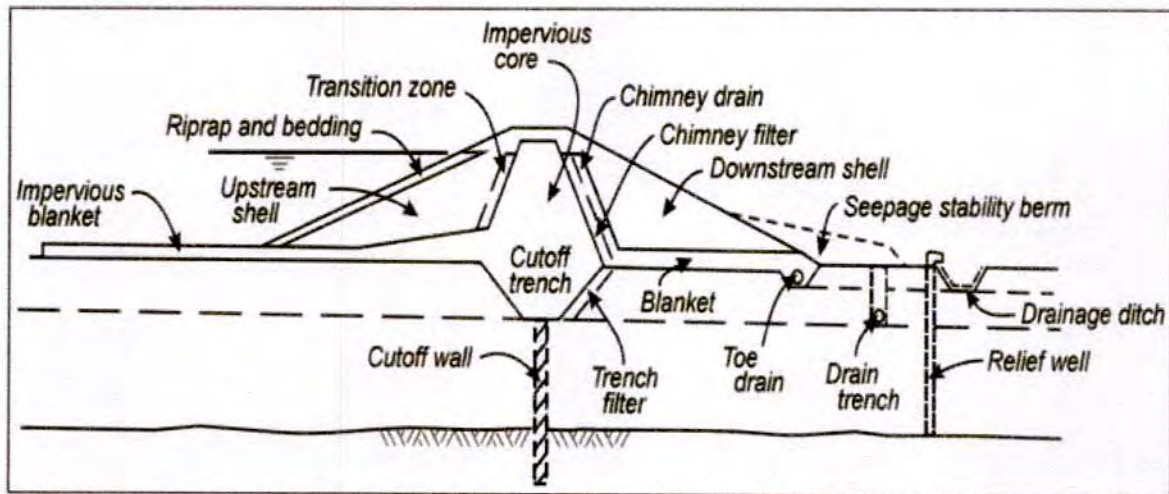


Fig. 8.2 Trench drain in conjunction with relief well for relieving the uplift pressure

8.3 Rock Foundation

Where the foundations and/or abutments are pervious bedrock, grouting may be required to seal off the rock beneath the impervious zone of the starter dam. The grouting program usually involves one or more of three basic types of treatment. These are:

Surface Treatment: used to seal up fissures and joints in the exposed rock surface. Slush grouting or shotcreting is normally used for this purpose.

Blanket Grouting: used to seal shallow fissures and joints that extend below surface of the rock. Grouting, using low pressures and holes drilled to shallow depth (20') and spaced on a grid at about 10' centres, is normally used for this purpose.

Curtain Grouting: used to seal pervious rock to great depths. One or more lines of deep drill holes are grouted under high pressure until no more grout is accepted by the rock. This is a complex and expensive foundation treatment and is not normally used with tailings dams.



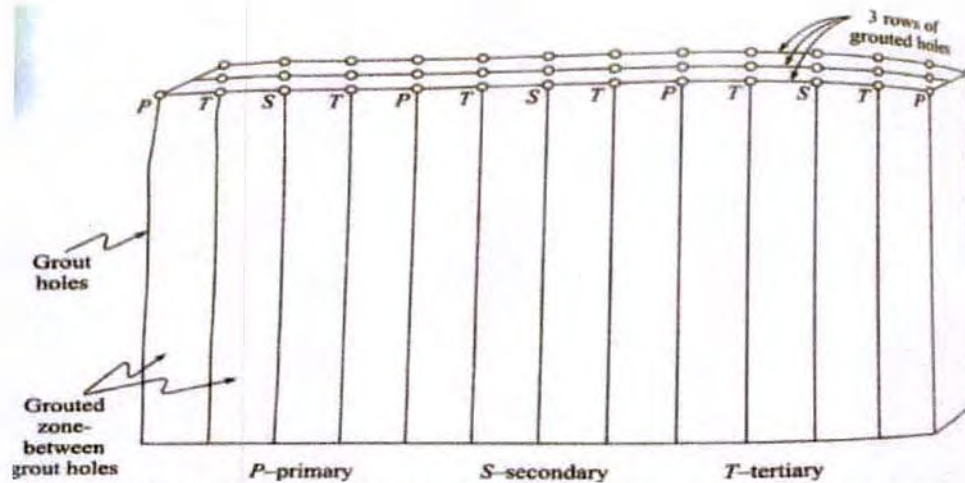


Fig. 8.3 Typical section showing curtain grouting beneath tailings dams

8.4 Downstream Seepage Recovery Dam

A seepage recovery dam is required immediately downstream of the main tailings dam to collect and store, for ultimate pumping back into the tailings pond, all seepages that emerge downstream of the tailings dam. The seepage recovery dam is designed as a conventional water storage dam and must have impervious foundations and abutments to ensure that none of the intercepted water escapes.

8.5 Embankment Barriers

Embankment barriers are installed below the impoundment and include cutoff trenches, slurry walls, and grout curtains. An impervious layer of fill is generally required between them and the tailings. Barriers are installed underneath the upstream portion of a downstream embankment and the central portion of centerline embankments; they are not compatible with upstream embankments. A good water-quality monitoring program is needed when using embankment barriers to ensure that they are completely effective in intercepting flows and also that seepage is not moving downward and contaminating the ground water.

Cutoff trenches: usually 5 to 20 feet in depth, are the most widely used type of embankment barrier for tailings dams, especially in areas with large volumes of natural clays. Dewatering may be necessary during the installation of cutoff trenches when they are installed below the ground water table.



Slurry walls: are narrow trenches that are best suited to sites with a level topography and containing saturated or fine-grained soils. They are not compatible with fractured bedrock systems. The slurry walls are installed by excavating a trench to a zone of low permeability material and filling the trench with a soil/bentonite slurry which is then allowed to set to a consistency of clay. Depths average 40 feet and permeabilities obtained can be as low as 10^{-7} cm/sec.

Grout curtains: use cement, silicate materials, or acrylic resins as a barrier to seepage movement. They are limited to sites with coarse-grained material (medium sands to gravel or fractured rock with continuous open joints) and can extend to depths of more than 100 feet. Permeabilities obtained can be as low as 10^{-8} cm/sec. However, leaks can occur through curtain joints or by subsequent corrosion of the curtain.

Rather than simply intercepting and containing seepage flows, barriers may have gravel (or other pervious material, appropriately filtered) drains immediately upgradient to allow seepage to be removed or directed to embankment underdrains. Barriers and seepage collection systems also may be used downgradient of embankments to prevent further environmental releases.

8.6 Bentonite Barrier

As a measure to control the seepage from the upstream side of the embankment, bentonite powder may be sprinkled on the sloping surface at the upstream side covering reasonably large area. The water level may sufficiently be lowered to expose the almost whole surface area so that spreading the bentonite powder becomes easy and could cover over the larger area. This can possibly plug the voids and thereby, minimize the seepage. The sprinkling of bentonite powder may be repeated intermittently by simultaneously making visual observations of the seepage water and its colour or other characteristics at the downstream side.



Chapter 9

Slope Protection and Erosion Control Measures

9.1 Protection of Embankment Slopes

The objective of the erosion control practices should be, in order of priority:

- To protect the rail infrastructure so that it continues its function of permitting uninterrupted flow of traffic at design speed and safety.
- To protect and preserve the earth work in fill and side cuts.
- To prevent damage to land adjacent to the rail structure in fact quite often, the neglect of control measures on adjacent land creates serious problems of erosion within the rail land.
- To reduce the soil loss from the railway embankment, which sits up drainage channel, water ways of cross drainage structures and pollute rivers.
- To contribute to the improvement of the aesthetics of the landscape.
- To avoid accidental falling of debris.

9.2 Different Methods to Control Soil Erosion

The various options available to mitigate erosion related problems due to water or wind are as follows:

- Simple vegetative turfing
- Transplantation of readymade turfs of grass
- Application of mulch
- Hydro seeding hydro mulching
- Promotion of vegetative turfing by using jute netting
- Use of soil netting
- Erosion control by using two dimensional synthetic materials
- Three-dimensional erosion control mats (Geocells)
- Erosion control by Armour system
- Conventional stone pitching



Report on
Failure Analysis of PWL Dye Breach
M/s. Vedanta Limited, Alumina Refinery
Lanjigarh, Odisha

27.09.2024

Introduction:

During Wet disposal of Red Mud, Process Water Lake (PWL) was meant to store supernatant liquor decanted from the red mud slurry dumped in the red mud pond in addition to rain runoff water from the red mud pond.

However, after adopting the filtration system, bauxite residue being stored in dry form in red mud pond and PWL is mainly storing rain runoff coming from the red mud pond catchment area. Figure 1 shows birds view of the PWL. The pond was made of earthen embankment with HDPE liner at bottom and sides. Recently, dyke height raising to a height of 3 m was carried out. The dyke height raising work was completed in the year 2022. Raising was done by centre-line method. The upstream side of the pond is lined with HDPE membrane and at some locations cement concrete was placed on top of the HDPE liner as an additional protection mechanism. Stone pitching on the downstream slope faces has been provided along the periphery of the dike.

An issue related to dyke breach of PWL has been reported on 15th Sept 2024 of PWL. In this regard, a site visit was made on 16-Sept-24 to examine the failed dyke of PWL and to find out the root cause for the dyke breach. PWL was closed at the time of visit due to the breach.

Site Visit

A site visit was made on 16th Sept 2024 to the location of breached dyke of PWL. The details are as follows:

Dyke breach location is shown in Fig. 1. The width of the breach is approximately 15-20 m. It is appraised that approximately 4 lakh m³ of RMP Rain runoff water was flown out of the PWL due to the breach. The released water flooded approximately 51 acres of land. The flooded land includes both barren and agricultural land. All the released water eventually entered into the Vamsadhara river located at distance of 850 m from the breach location.

Dyke breach has occurred on the north side of the dyke, nearly middle of the dyke. No occurrence of seepage was noticed at the breach location though a seepage had noticed majorly at NW corners on 17th Nov 23 and these locations are at a distance of 300-400 m away. A piezometer was located at a distance of 70 m from the breached dyke. However, no significant water level rise in it was recorded from 1st Sept to 14th Sept 2024.



4. The soil on the upstream side might have become porous due to constant interaction of caustic liquor over a prolonged period. The porous soil might have accelerated the seepage path into the dyke body.
5. Due to this sudden surge seepage water might have exited well above the rock toe as against exiting through the rock toe. Exiting of water from above the rock toe, which is not a common phenomenon, might have eroded the soil particles first followed by ash particles, leading to piping phenomenon and ultimately failure of the dyke.
6. There was a gap of 4 days from the day of heavy rain and final breach. The sudden increase in the water level in the PWL due to heavy rains may have accelerated the seepage which continued for 4 days leading to piping failure and breach.
7. The possibility of sabotage leading to damage to the dyke in the upstream can also contribute to a similar set of events causing accelerated seepage and finally piping failure leading to breach.

Though it is difficult to attribute a particular cause for the dyke breach, the analysis reveals that a particular combination of factors including high water level, presence of porous soil and damage to HDPE liner joints together might have caused the dyke breach.



Fig. 2a: Dyke breach area



Fig. 2b: Temporarily closing of breach with locally available soil



Fig. 2c: High water level mark on the upstream side of north dyke due to heavy rainfall

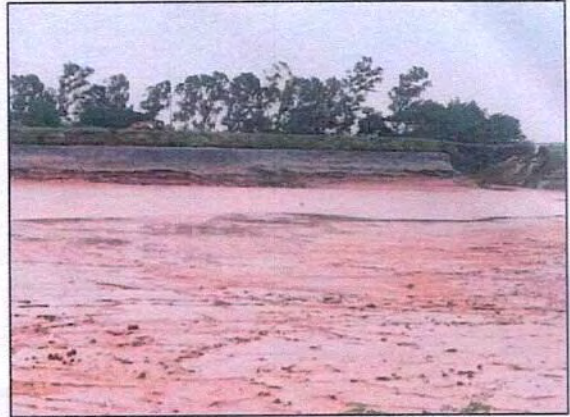


Fig. 2d: High water level mark on the upstream side of north dyke near the breached dyke location

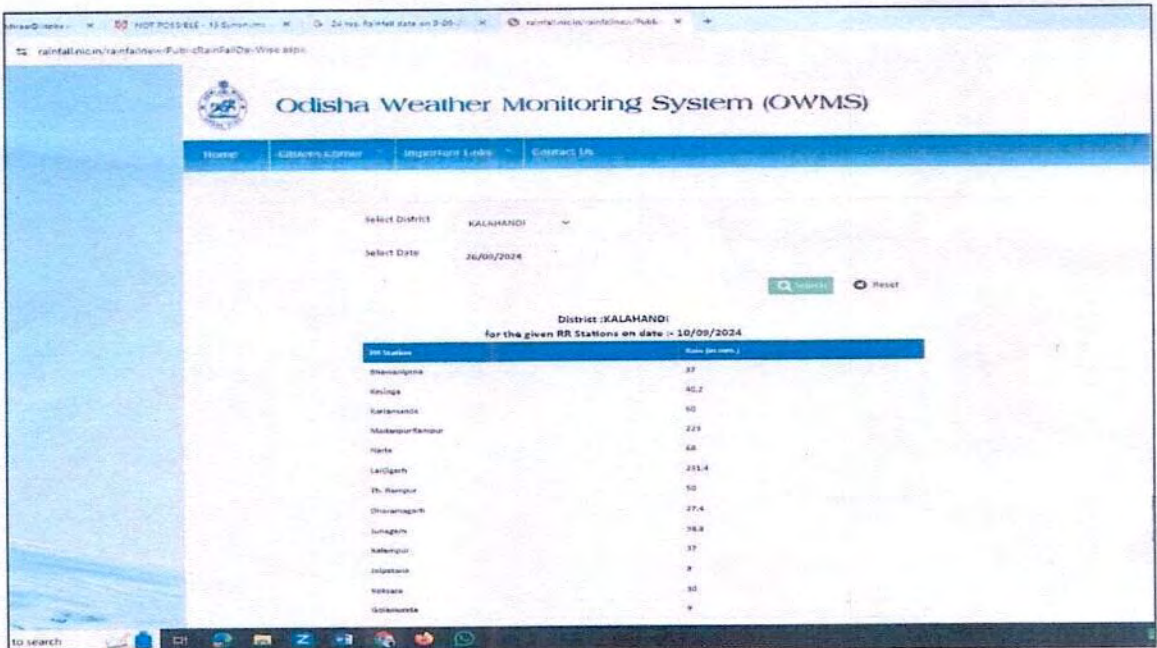


Fig. 2e: Rainfall intensity of 231.4 mm on 10th Sept 2024 at lanjigarh location

B.H.

Suggestions and Recommendations

- 1) First, the breach portion of dyke shall be repaired by filling it with suitable soil temporarily in order to avoid further out flow of water having a caustic nature into the land that not belong to Vedanta.
- 2) A detailed geotechnical study to be done to estimate the actual reason of the failure, check the stability of the entire dyke and incorporate both national and international standards of tailing management for developing the design to strengthen the weak portion of the dyke and seepage prevention methodology.
- 3) **HDPE liner:** It is suggested to ascertain intactness of HDPE liner on the upstream side of the PWL on all four sides and at the bottom of the pond by visual inspection and with some experimental checks. If any damage is found, it is advised to repair the same with immediate effect. If there is a necessity, it is suggested to replace the old HDPE liner with new one.
- 4) No repairing or reconstruction of dyke shall be undertaken without proper design that inbuilt seepage control measures.
- 5) Amount of water stored in the RMP catchment area to be reduced to as low as possible to ensure there is no extra pressure on the RMP Dyke.

B. H. S.



SCHOOL OF INFRASTRUCTURE
IIT BHUBANESWAR



195

ANNEXURE R/5 219

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Web site: www.ospcboard.org

STATE POLLUTION CONTROL BOARD, ODISHA

(DEPARTMENT OF FOREST, ENVIRONMENT & CLIMATE CHANGE, GOVT. OF ODISHA)

Paribesh Bhawan, A/118, Nilakantha Nagar, Unit-VIII

Bhubaneswar – 751012

No. 1406 / Ind-I-Con-5436 (Vol-VII) Date 22.01.2025

MINUTES OF THE PERSONAL HEARING OF M/S VEDANTA LIMITED (ALUMINA REFINERY UNIT), LANJIGARH, KALAHANDI

1.	Name of the Industry	Vedanta Limited (Alumina Refinery Unit), Lanjigarh, Kalahandi		
2.	Date & Time	21.12.2024 at 4:00 PM		
3.	Venue	Conference Hall, SPC Board, Odisha, Bhubaneswar		
4.	Participation	i.	Dr. K. Murugesan, Member Secretary	State Pollution Control Board, Odisha
		ii.	Dr. N. R. Sahoo, CEE	
		iii.	Er. Sitikantha Sahu, ACEE	
		iv.	Er. B. K. Sethi, Sr. Env. Engineer	
		v.	Shri Ashok Kumar Bhoi, Regional Officer (Attended through VC)	
		vi.	Ms. Subhadra Majhi, Asst. Env. Scientist	
		i.	Shri Sanjeev Kumar, Dy. COO (Commissioning)	M/s Vedanta Limited (Alumina Refinery Unit), Lanjigarh, Kalahandi
		ii.	Shri Harshvardhan Pande, AVP	
iii.	Sri Debi Pattanaik, Head-Infrastructure (Projects)			
iv.	Shri K. Ramu Naidu, Dy. Head (Env.)			

BACKGROUND:

An incident of breach of Process Water Lake (PWL) occurred during night hours on 15.09.2024 and the same was informed by the industry in the morning of 15.09.2024. The alleged site was immediately visited by the Board Officials from the Regional Office, Rayagada on 15.09.2024 and based on the observation made in the inspection report, a direction under Section 33A of Water (PCP) Act, 1974 was issued to the industry on 17.09.2024 to stop discharge of any water to the PWL forthwith till it is repaired, restored and verified by the Board. The industry was

directed to furnish an action taken report by 20.09.2024 and appear for a personal hearing on 21.09.2024 at 4.30 PM.

The industry has submitted the action taken report in compliance to the above direction on 20.09.2024. As per the decisions in personal hearing held on 21.09.2024, a joint inspection was carried out by the Board Officials from Head Office & Regional Office, Rayagada on 26th & 27th Sept, 2024 to assess the environmental damage caused due to breach of PWL, monitor the progress of restoration work and carryout comprehensive water quality monitoring in and around the plant to assess the extent of damage. The joint inspection team has suggested certain action points. The industry submitted a time bound action plan in response to the decision taken in the personal hearing held on 21.09.2024, preparedness plan for management of surface runoff during heavy rains, Failure Analysis Report on PWL dyke breach by IIT, Bhubaneswar and the Stability Analysis Report of Tailing Dams for the year 2023-24 by IIT, Bhubaneswar. As observed during visit, the breached portion of the PWL dyke has been restored temporarily by putting soil as recommended by IIT, Bhubaneswar. However, the final scheme for restoration of the breached portion of the dyke will be provided by IIT, Roorkee followed by validation by a reputed firm for dyke restoration.

Further it has been proposed to finish the restoration and repair job of PWL dyke by May-2025. The report has been communicated to the industry on 17.12.2024 with directions to carry out certain jobs in time-bound manner. Hence the industry was called for a meeting on 21.12.2024 to review the progress of actions taken for restoration activity and compliance report to the other action points.

The meeting was held on scheduled date and time. The list of members attended the meeting is annexed as **Annexure-I**.

RECORD OF PROCEEDING:

Initiating the hearing, the Member Secretary requested the industry representative to explain the status of repair / restoration and action plan for recommissioning of PWL. The industry representative made a power point presentation regarding the above issues and apprised the progress of action taken by them to commence / resume the operation of PWL. It was informed by the industry that all the runoff generated from the RMP is stored within the RMP only and the inflow from the RMP to PWL has been stopped as per the direction of the Board. The progress of various actions explained by the industry and observation of Board is presented in Table No.1.

Table No. 1: Progress status of action points as per Time bound action plan submitted on 22.10.2024 in compliance to personal hearing held on 21.09.2024.

Sl. No	Time bound action point	Progress report submitted by the industry	Observation /decision by the Board
1	<p>Submission of geotechnical study & detail design for breached dyke restoration by IIT, Roorkee, validation of the report by Geotechnical firm M/s Geotheta (Africa) and submission of the same to Board.</p>	<p>IIT, Roorkee on boarded for final restoration scheme of the breached portion based on approved drawings and geotechnical studies.</p> <p>IIT Roorkee visited the site on 9th Nov 2024 and suggested to carry out standard penetrating test (SPT) to confirm the health of the other three sides of the dyke and determine corrective actions required, if any. SPT is completed at 8 locations out of 13 and that in rest locations will be finished by 26th Dec 2024.</p> <p>Drawings for restoration work will be received from IIT, Roorkee by end of December, 2024.</p> <p>M/s. Geotheta (Africa), carried out the site visit on 2nd Dec 2024 for preliminary assessment. Finally this firm will validate the dyke restoration design provided by IIT and conduct independent assessment of the facility.</p> <p>Final scheme for restoration</p>	<ol style="list-style-type: none"> 1. The SPT test shall be carried out with utmost care to avoid damage to the liners. 2. The expert agencies engaged in work may be asked to study the health of the liners. 3. The restoration work shall be carried out and completed in a time bound manner as stated and the whole restoration work shall be completed by June, 2025.

Sl. No	Time bound action point	Progress report submitted by the industry	Observation /decision by the Board
		<p>of the dyke and validation by Geotheta to be submitted to the Board by 15th January, 2025.</p> <p>The Final completion certificate of the dyke shall be validated by IIT, Roorkee. The whole restoration process is expected to be completed by June, 2025.</p>	
2	Dredging and Desiltation of sludge deposit in the PWL.	<p>The process of awarding the job for dredging and desilting of PWL is in progress and will be finalized by 31.12.24. About 4 lakh m³ of deposited red mud/sludge is proposed to be desilted. Mobilization period is one month and work will be completed by May, 2025.</p>	<p>Dredging activity shall be carried with utmost care to prevent damage to bottom liner. The dredged red mud shall be handled and disposed off in environmentally sound manner. This work shall be completed by May, 2025.</p>
3	Replacement of all damaged liner with new liners.	<p>As recommended by IIT Roorkee, all damaged liners will be replaced by new liners to prevent seepage of water into the dyke. The entire work shall be completed by June, 2025</p>	<p>The over lapping and joint of liners shall be properly welded and anchored on top. The selection of liner material and laying of the same shall be done carefully. The work shall be completed by June, 2025.</p>
4	Dispersion of compensation to the affected people as per the direction of district administration.	<p>Compensation for an amount of Rs.45 lakhs has been dispersed to affected people as per the direction</p>	<p>The process of disbursement of compensation shall be completed as soon as</p>

Sl. No	Time bound action point	Progress report submitted by the industry	Observation /decision by the Board
		from State Govt.	possible in consultation with District Administration.
5	Installation of required number of the surveillance monitoring facilities in the PWL shall be checked and validated before start of operations of the PWL by an independent reputed institute having core competency in the field. After start of operation, the readings from these facilities shall be analysed once every 3 months by a competent external agency and reports to be submitted to the Board.	IIT, Roorkee will provide the required surveillance monitoring facilities and shall be validated by M/s Geotheta. Installation to be completed by June, 2025.	The exact number of surveillance monitoring facilities shall be found out in consultation with IIT, Roorkee and shall be installed by June, 2025.
6	Bio-monitoring of Bansadhara river to assess the ecological condition of river in the upstream and downstream of the plant. The bio-monitoring shall be done at least twice in a year – pre-monsoon and post-monsoon specifically determining saprobic index and diversity index.	Scope finalization in progress. Discussion with multiple expert agencies going on. Ordering expected to be completed by February, 2025.	The time line suggested for the job is accepted.
7	Advised to stabilize the stretch of a bund over which settlements has been noticed by buttressing from downstream side. At this juncture, stabilizing the slopes using geosynthetic	Status: In Progress Strengthening design with reinforced soil has been provided by M/s IIT, Bhubaneswar. Project is being executed accordingly and will be completed by	The reinforcing activity shall be carried out under the supervision of IIT, Bhubaneswar and shall be completed by 30.06.2025.

Sl. No	Time bound action point	Progress report submitted by the industry	Observation /decision by the Board
	materials is highly recommended.	30 th June, 2025.	

Besides the above, they made a presentation on compliance to the recommendation and suggestions made in the stability analysis report, failure analysis report prepared by IIT, Bhubaneswar. It was decided that the industry will follow and complete the jobs within the time frame as per the reports as well as suggested by the industry in their presentation.

The meeting ended with a vote of thanks to the Chair.

[Signature]
22/01/25

MEMBER SECRETARY

Memo No. 1407 Date 22.01.2025 /

Copy forward to the Regional Officer, SPCB, Rayagada for information and necessary action.

[Signature]
22/01/25

CHIEF. ENV. ENGINEER (M)

Memo No. 1408 Date 22.01.2025 /

Copy forwarded to the GM-Head MSE & Sustainability, Vedanta Limited (Alumina Refinery Unit), Lanjigarh, Kalahandi-766027 (E-mail: Headhse.VLL@vedanta.co.in) for information and necessary action. He is requested to furnish a compliance report to the decision taken in the personal hearing meeting within 15 days.

[Signature]
22/01/25

CHIEF. ENV. ENGINEER (M)



Annexure-I

EPABX : 2561909/2562847
 Tel : 2562822/2560955
 E-mail: paribesh1@ospcbboard.org
 Website: www.ospcbboard.org

STATE POLLUTION CONTROL BOARD, ODISHA

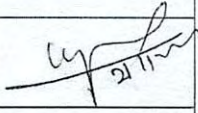
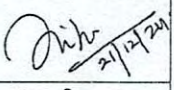
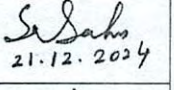
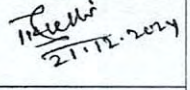
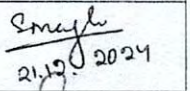
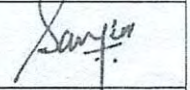
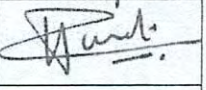
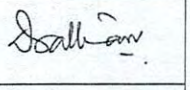
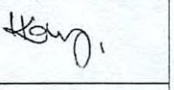
[DEPARTMENT OF FOREST, ENVIRONMENT & CLIMATE CHANGE, GOVERNMENT OF ODISHA]

Paribesh Bhawan, A/118, Nilakantha Nagar, Unit - VIII,
 Bhubaneswar - 751 012, INDIA

ATTENDANCE SHEET FOR THE MEETING WITH M/S VEDANTA LIMITED (ALUMINA REFINERY UNIT), LANJIGARH, KALAHANDI

Venue: Conference Hall, SPC Board, Odisha, Bhubaneswar

Date: 21.12.2024 (04.00 PM)

SL. No.	Name & Designation	Organisation	Mobile Number & E-mail ID	Signature
1.	Dr. K. Murugesan, IFS Member Secretary	SPCB, Odisha		
2.	Dr. N. R Sahoo, Chief Env. Engineer	SPCB, Odisha		
3.	Er. S. K. Sahu Addl. Chief Env. Engineer	SPCB, Odisha	9437205463.	
4.	Er. B. K. Sethi Sr. Env. Engineer	SPCB, Odisha		
5.	Shri Ashok Kumar Bhoi, Regional Officer	Regional Office, Rayagada		Attended through VC
6.	Ms. Subhadra Majhi Asst. Env. Scientist	SPCB, Odisha	7978936212	
7.	Mr. Sanjeev Kumar Dy. COO. Commsy	M/s Vedanta Limited (Alumina Refinery Unit), Lanjigarh	9937251256	
8.	Harshvardhan P Asst. Vice President Head MS&C Sust	M/s Vedanta Limited (Alumina Refinery Unit), Lanjigarh	9937294152	
9.	Debi Pattnaik Head - Infra Proj.	M/s Vedanta Limited (Alumina Refinery Unit), Lanjigarh	7328314809.	
10.	K. Ramu Naik Dy. Head Environ	"	8093092596	
11.				



OSPCB-CTO-MISC-0076-2024/10/2025

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-TRUE COPY-

VLL/HSE/ENV/2025/1770

02.08.2025

To
The Member Secretary
Odisha State Pollution Control Board
Paribesh Bhawan, Nilakantha Nagar
Bhubaneswar - 751012

Sub: Minutes of the Personal Hearing of M/s. Vedanta Limited (Alumina Refinery Unit), Lanjigarh, Kalahandi.

Ref: (i) OSPCB Letter No 12607/Ind-I-Con-5436 dtd 07.07.2025

(ii) Minutes of personal hearing communicated vide Board's Memo No. 1408 dtd 22.01.2025.

(iii) Consent to Operate granted vide Board's Letter No. 6802, dated 30.03.2025

Respected Madam,

We are in receipt of the above letter **12607/Ind-I-Con-5436 dtd 07.07.2025** on minutes of the personal hearing with respect to restoration of PWL dyke breach at our location.

In reference to the subject matter, we inform your good office that as committed by Vedanta, we had engaged IIT Roorkee for the design of restoration of the damaged portion of the PWL dyke. The detailed restoration design was developed by IIT Roorkee, incorporating a multilayer protection system to prevent water seepage from the pond into the dyke. The inner surface of the dyke has been lined with a 6 – 7 mm thick geosynthetic clay liner, followed by the installation of 1.5 mm thick double-sided textured HDPE geomembrane. This is further covered with 500 mm thick soil layer, over which 400 GSM non-woven geotextile membrane is placed. Finally, 230 mm thick stone pitching has been carried out across the entire restored dyke section.

As per design, the inner (upstream) slope of the dyke has been maintained at 1:2 gradient, while the outer (downstream) slope has been constructed with 1:3 gradient, ensuring structural stability. Horizontal blanket filter layer of 900 mm thickness has been placed all along the restored stretch of dyke to ensure continuity of filter media of starter dyke. Additionally, sand chimney of 750 mm thickness has been constructed along the outer slope of starter dyke & it has been integrated with horizontal blanket filter media. The purpose of sand chimney is to bring down the phreatic level if any seepage occurs through the dyke & provide easy seepage path through the blanket filter which will ultimately lead to exit of seepage water in toe drain. It will avoid saturation of downstream dyke core which will result in enhanced stability in seepage condition there by maintaining the Factory of Safety (FOS) value.

Vedanta Limited

PO : Lanjigarh, Dist. : Kalahandi, Odisha, India - 766 027

T +91-6677247312-15, Fax +91-6677247311, Website : www.vedantalimited.com



Page 1 of 3

The outer rock toe has been constructed with horizontal filter media at both the base and the inner slope, incorporating geosynthetic materials such as geotextile and geogrid for enhanced stability and filtration. Additionally, a toe drain has been constructed using stone masonry, lined with LDPE, and finished with IPS flooring to ensure effective drainage and structural integrity.

Based on structural stability report of remaining dyke, prepared by IIT Roorkee, repair work has also been carried out for 320 meters at North dyke and 180 meters at West dyke in continuation to the breached portion. This repair has also enhanced the strength of North-West corner of the dyke which is typically the lowest portion of the pond where maximum water pressure is concentrated. This repair is inline with the design philosophy of the repaired section of the dyke which was breached.

The restoration of the damaged portion of the dyke has been completed up to 445 RL. The timeline for achieving this milestone was extended beyond the initial target due to unexpected intermittent rainfall between January to June 2025. During this period, the region received a total of 588 mm of rainfall, significantly higher than the 273 mm recorded in the corresponding period of the previous year.

Around 152000 MT of silt was removed from the bottom of the pond. During inspection of liner condition post various tests, desilting, restoration of damaged dyke and repair of weak sections of the dyke, around 100000 SQM liner was identified to be replaced and as such the repair and replacement works have been completed.

VLL requested IIT Roorkee to conduct site visit to assess the restoration work carried out on the PWL dyke. The inspection took place on 30th July 25. Following the visit, IIT Roorkee certified that the dyke restoration up to 445 RL complies with the approved design specifications (**Annexure-I**). Considering a freeboard of 2.0 meters from 445 RL, the Engineer of Record (M/s. Geotheta) has determined the cumulative volume of the PWL at 443 RL to be 7,69,515 m³ (**Annexure-II**).

We aim to reduce the water load on the Red Mud Pond (RMP) where currently 250000 m³ water is stored. We are consuming around 7,000 m³ of RMP water daily in our refinery process. With each mm of rain fall, theoretically, around 930 m³ of water gets added in the RMP water storage. With this usage, we have been able to reduce the water level on the RMP by around 60000 m³ in the month of July'25. However, looking at the upcoming monsoon season and to ensure water evacuation from RMP in case of heavy rainfall, we would need to transfer water from RMP to Process Waste Lake (PWL).

The operation of the PWL will be done based on the most stringent Global Industry Standard on Tailings Management (GISTM) guidelines which have been incorporated by Vedanta Group. Under these guidelines, M/s. Geotheta, a global benchmarked geotechnical firm, has been onboarded as the Engineer of Record (EoR) and M/s. SRK Consulting has been appointed as the Independent Tailings Review Board (ITRB). We have also onboarded a global dam specialist on role as Head - Tailing Management to guide us on effective tailings management.

Vedanta would like to assure your good office that all necessary steps and utmost care has been taken by us to prevent any kind of damage to the environment and we have been fully complaint


H. Pandey


VEDANTA
Lanjigarh
LIMITED

Page 2 of 3

with all the environmental regulations and parameters. We humbly submit the progress made on the pointwise, time-bound action items for your kind perusal (**Annexure-III**).

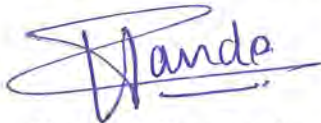
As mentioned above, PWL has been completed up to 445RL for which IIT Roorkee has given the completion certificate against their design which was vetted by Geotheta. We would sincerely request your good office to kindly grant us permission to take water into PWL from RMP thereby reducing water level at RMP and enable us to be ready for heavy rainfall during the season.

We look forward to your continued guidance and support.

Thank you.

Yours faithfully,

For **Vedanta Limited, Lanjigarh.**



Harshvardhan Pande
(Head HSE & Sustainability)



CC: The Regional Officer, State Pollution Control board, 1st Lane, Kasturi Nagar, Rayagada.

PWL Dyke Restoration Construction Photos

Silt Removal



Sand bed preparation



Sensitivity: Internal (C3)

M. Panda
VEDANTA
Lanjigarh
LIMITED

HDPE Liner Laying



Soil overburden on HDPE liner



Panda
Mr. Panda

Sensitivity: Internal (C3)





PWL Dyke Restoration- Upstream

Slope Dressing & Soil Compaction



Geosynthetic Caly Liner (GCL) Laying



Panda
Mr. Panda



HDPE Liner Laying & Soil Over Burden



Geotextile & Stone pitching



Kashibadi, Odisha, India
P94h+5q, Kashibadi, Odisha 766027, India
Lat 19.703515° Long 83.378061°
24/06/2025 10:22 AM GMT+05:30

Wanda
K. Bunde

VEDANTA
Lanigam
LIMITED

Sensitivity: Internal (C3)

-TRUE COPY-



EPABX : 2561909/2562847
E-mail: paribesh1@ospcboard.org
Website: www.ospcboard.org

STATE POLLUTION CONTROL BOARD, ODISHA

DEPARTMENT OF FOREST, ENVIRONMENT & CLIMATE CHANGE, GOVERNMENT OF ODISHA
Paribesh Bhawan, A/118, Nilakantha Nagar, Unit - VIII
Bhubaneswar - 751 012, INDIA

No 20187 / IND-I-CON- 5436

Dt 13.11.2025

(Speed Post/ E-Mail)

To

The Whole Time Director and Chief Executive Officer,
M/s. Vedanta Limited (Alumina Refinery Unit),
AT/PO- Lanjigarh, Via- Viswanathpur,
Dist. - Kalahandi, Odisha, Pin- 766027
Email- Headhse.VLL@vedanta.co.in

Sub- Permission to use Process Water Lake (PWL) for receiving water from Red Mud Pond (RMP) area by M/s. Vedanta Limited, Alumina Refinery, Lanjigarh, Dist. - Kalahandi- reg. Sir,

With reference to the subject cited above, it is to intimate that there was an incident of breach of the Process Water Lake (PWL) of your Alumina Refinery at Lanjigarh on 15.09.2024 and subsequently a direction under Section 33A of the Water (Prevention and Control of Pollution) Act, 1974 was issued on 17.09.2024, instructing stoppage of discharge to the PWL forthwith until it is repaired, restored and verified by the Board.

Accordingly, you submitted a time-bound action plan and undertook restoration of the PWL dyke under the technical supervision of IIT Roorkee (design) and IIT Bhubaneswar (stability analysis), with design validation by M/s Geotheta, a geotechnical firm.

IIT Roorkee, vide its certificate dated 30.07.2025, has certified that restoration up to RL 445 was completed as per the approved design. The Regional Officer, Rayagada, during his inspections on 25.07.2025 and 11.08.2025 has also observed that the restoration of the damaged portion of PWL has been completed.

The industry has also completed dispersion of compensation to the affected people as per the direction of District Administration.

In view of the above, the Board hereby allows the Alumina Refinery of M/s. Vedanta Limited, Lanjigarh, to use the Process Water Lake (PWL) for receiving water from the Red Mud Pond (RMP) area, subject to the following conditions:

1. A minimum freeboard of 2.0 metres shall be maintained in the PWL at all times.
2. Water from the PWL shall be recycled back into the process; no discharge outside the plant premises shall be permitted.
3. The industry shall prepare and implement an Operational and Safety Manual for the safe management and operation of the PWL.
4. A dedicated inspection and monitoring team shall be constituted to conduct regular checks on:
 - a. Dyke Stability- to detect cracks, erosion or deformation;
 - b. Linear integrity- to identify punctures or deterioration;
 - c. Water management- to monitor water levels, leakage or seepage.
5. The industry shall install and operationalize all surveillance monitoring instruments as recommended by IIT Roorkee and ensure quarterly data analysis by a competent external agency with reports submitted to the Board.
6. The industry shall strictly follow the recommendations made in the study reports of IIT, Roorkee for design & drawing of dyke restoration and stability analysis study of tailing dams by IIT, Bhubaneswar.
7. Biomonitoring of Bansadhara river to assess the ecological condition of river in the upstream and downstream of the plant. The biomonitoring shall be done at least twice in a year- pre- monsoon and post- monsoon specifically determining saprobic index and diversity index.

This permission is issued based on the satisfactory compliance of the unit as verified by the Regional Officer, Rayagada, and the technical validation of restoration works by IIT Roorkee. Any deviation or non-compliance with the above conditions shall render this permission liable for withdrawal and attract action under the provisions of the Water (Prevention and Control of Pollution) Act, 1974.

Yours faithfully,


MEMBER SECRETARY

Memo No. 20188 /Dt. 13.11.2025 /

Copy forwarded to:

- i) Regional Officer, SPC Board, Rayagada
- ii) District Collector, Kalahandi
- iii) DFO, Kalahandi
- iv) Deputy Director of Mines, Bhawanipatna
- v) CES, Central Laboratory, SPC Board, Bhubaneswar
- vi) Guard File

S. Saha
13/11/2025

ADDL. CHIEF ENV. ENGINEER





Service in Dilip Kumar Samantaray Vs. State of Odisha & Ors. [OA. No. 14 of 2026]

1 message

ELDF <eldflegal@gmail.com>

Thu, May 14, 2026 at 6:45 PM

To: "Akhand." <akhand111@gmail.com>, Dipanjan Ghosh <dpnjnghsh0@gmail.com>, ASHOK PRASAD <ashokadvhc@gmail.com>, Utkarsh Chandra <chandra.utkarsh06@gmail.com>, MOEF <secy-moef@nic.in>
Cc: Mansi Bachani <mansi@eldfindia.com>, Gitanjali Sanyal <gitanjali@eldfindia.com>

Dear Sir/Ma'am

Please find attached copy of the Reply Affidavit filed on behalf of Respondent No. 08 Vedanta Ltd. in the above mentioned case.

Thanks & Regards

--

Sameer Manher

Clerk

Enviro Legal Defence Firm

29, Presidential Estate LGF,

Nizamuddin East New Delhi – 110013

Ph. No. 011-40573181



Reply.pdf