JSW Steel Limited
Regd. Office: JSW Centre
Bandra Kurla Complex,
Bandra (East), Mumbai – 400 051
CIN : L27102MH1994PLC152925
Phone : +91 22 4286 1000
Fax : +91 22 4286 3000
Website : www.jsw.in

No. JSW/S/CO/2023/301 Date: 30/05/2023

To,
Deputy Director General of Forests (C),
Ministry of Environment, Forest and Climate Change,
Regional Office (Eastern Zone),
A/3, Chandersekharpur, Bhubaneswar – 751023

Sub: - Submission of Six-monthly EC compliance report in respect of **Narayanposhi Iron & Manganese Ore Mine of M/s JSW Steel Ltd for the period October 2022 to March 2023**.

Ref: -1. Environment Clearance Letter dated 18.06.2019 issued by MOEF&CC, GOI.

Dear Sir,

We are submitting herewith six-monthly EC compliance report of Jajang Iron Ore Mine, M/s JSW Steel Ltd. for the period October 2022 to March 2023 as per EIA notification 2006.The same is also attached in Soft copy to your good office on e-mail to roez.bsr-mef@nic.in; for your ready reference.

We trust that the measures taken towards environmental safeguards comply with the stipulated conditions. We look forward to your guidance which shall certainly help us in our endeavor for improving upon our environmental management practices.

Seeking your co-operation as always.

Thanking you,

Yours Faithfully
For JSW Steel Ltd

Mrutyunjaya Mahapatra

MrutyunjayaMahapatra
(Authorized Signatory)

Encl: As above

Steel Limited

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Copy to:

1. Zonal Office Kolkata, Central Pollution Control Board, South end Conclave, Block 502, 5th and 6th Floors, 1582 Razidanga Main Road, Kolkata, West Bengal 700107.
2. The Member Secretary, State Pollution Control Board, A/118, Nilakantha Nagar, Bhubaneswar, Odisha-751012.
3. The Regional Officer, Regional Office, Rourkela Office of the State Pollution Control Board Rourkela Town Engineering Office Premises, Sector – 5, Rourkela – 769 002, Odisha

ENVIRONMENT CLEARANCE COMPLIANCE STATUS – NARAYANPOSHI MINE

Compliance report of Environmental Clearance for Narayanposhi Iron & Manganese Ore Mine, JSWSteel Ltd.

Reference letter from MoEF&CC, New Delhi- J-11015/288/2008-IA.II(M), Dtd. 18.06.2019.

Capacity- 6.0 MTPA Iron Ore (ROM) & 0.036 MTPA Mn Ore and 2 MTPA Beneficiation Plant.

Sl. No.	Stipulated conditions		Compliance
	A. Specific Conditions	**Self-Declaration**	**Compliance Reamrks**
1	The enhanced production shall be on pro-rata basis for the effective period of valid environment clearance granted herein. The PP shall ensure its compliance by getting concurrence in mining plan approved by concern authority in this regard.	Being Complied	Detail of production are for 2020-21 is Iron 4.48 MT, Mn 0.0004 MT and for 2021-22 Iron 5.443 MT and Mn 0.0047 MT. EC accorded for 6.0MTPA(ROM) of iron ore and existing 0.036MTPA Mn ore along 2.MTPA beneficiation plant.
2	This EC for expansion proposal (iron ore production from 3.0 MTPA to 6.0 MTPA (ROM) and existing 0.036 MTPA Manganese ore and establishment of Beneficiation Plant with capacity of 2.0 Million TPA along with crusher and screening plant within the mine lease area) shall be operational after submission of an undertaking through affidavit to MoEF& CC within 15 days of receipt of this letter, for compliance of all the conditions prescribed herein.	COMPLIED	EC capacity of 6.0 MTPA was accorded to ex-lease in the year 2019 in the name of M/s Aryan Mining & Trading Corp. Pvt. Ltd. Vesting order was given to M/s. JSW Steel Limited from Steel & Mines Department, Government of Odisha vide Order no. 4212/SM, dated 30th May 2020 as per MMDR Act, 1957 and Mineral concession Rules, 2016. Further it was vested for 50 years vide order no. 1335/ 1V (B) SM -21/2020. Vesting order copy is attached as **ANNEXURE 1**
3	Project Proponent and Department of Steel &Mines, Govt. of Odisha shall ensure the implementation of recommendations of carrying capacity study report conducted by CSIR-NEERI w.r.t. mining proposal of iron Ore and/or manganese in the State of Odisha.	COMPLIED	Recommendation of NEERI such as quantification of air emission load, mobile water sprinkler at haul road, dry fog type dust suppression system material handling plants (crusher and screen) to minimize air pollution has been implemented. Monitoring of ambient air and fugitive emission data has been implemented and report for the same is attached as **Annexure II**. Ambient air quality is being monitored at buffer zone. CO is being measured as a parameter of ambient air quality. PUC check is being conducted for the vehicles. Noise level monitoring is being carried out. Flow rate measurement of perennial nala is being done. Oil and grease trap has been provided at the vehicle washing bay. Environmental sustainability report has also been attached with the NEERI report. 2 nos. of Mechanised wheel washing has been installed near exit and entry gate. Photos for the same is attached as **ANNEXURE III**. Along with this NEERI Compliance is attached as **ANNEXURE IV**
4	Department of Steel & Mines, Govt. of Odisha should prepare 5 years' regional plan for annual iron ore requirement from the state, which in turn shall be met from different mines/zones (e.g. Joda, Koira.) in the state. Accordingly, sustainable annual production (SAP) for each zone/mine may be followed adopting necessary environmental protection measures	Agreed to comply	Detail of production furnished for 2020-21 is Iron 4.48 MT, Mn 0.0004 MT and for 2021-22 Iron 5.443 MT and Mn 0.0047 MT. EC accorded for 6.0MTPA(ROM) of iron ore and existing 0.036MTPA Mn ore along 2. 0 MTPA beneficiation plant. Department of Steel & Mines, Govt. of Odisha has prepared 5 years' regional plan for annual iron ore requirement from the state, which are being met from different mines/zones (e.g. Joda, Koira.) in the state. Accordingly, sustainable annual production (SAP) for each zone/mine are being followed. Report for the same is attached as **ANNEXURE V**
5	Project Proponent shall construct the cement concrete road from mine entrance and exit to the main road with proper drainage system and green belt development along the roads and also construction of road with minimum 300 m	COMPLIED	Cement concrete road at the mine entrance has been provided for Iron ore Mining Near gate no. 1 & 2. Photo for the same is attached as **ANNEXURE VI**

	inside the mine. This should be done within one year for existing mines and new mine should have since beginning. The Department of Steel & Mines, Govt. of Odisha should ensure the compliance and should not issue the Mining Permits, if mine lease holder has not constructed proper cement concrete road as suggested. This Environmental Clearance for the expansion project shall be operated only after the compliance of the above-mentioned specific condition.		
6	The Committee observed that as per the recommendations of NEERI report the PP needs to do regular vacuum cleaning of all mineral carrying roads aiming at “zero dust re-suspension” within 3 months. This Environmental Clearance for the expansion project shall be operated only after the compliance of the above-mentioned specific condition.	COMPLIED	One vacuum sweeping machine has been provided. Fixed water sprinkler of 1.2 Km has been provided in the haul road. Water sprinkling is being carried out along the haul road by two number of truck mounted tanker of reported capacity 50 Kl and 16 KL. Photos for the same is attached as **Annexure VII**
7	Project Proponent shall monitor the environmental quality parameters as per EC and CTE/CTO conditions, and implementation of suggested measures for control of road dust and air pollution. Odisha State Pollution Control Board has to ensure the compliance of CTE/CTO. Regional office of the MoEF&CC, Bhubaneswar shall monitor the compliance of the EC conditions. Regional office of the Indian Bureau of Mines (IBM) shall monitor the compliance of mining plan and progressive mine closure plan. Any violation by mine lease holder may invite actions per the provisions of applicable Acts.	COMPLIED	Environmental quality parameter such as ambient air quality, Fugitive emission, Noise level, Surface water quality, Ground water quality etc are being monitored by ECOMEN. Compliances are being monitored by IBM and MoEF&CC through various site visits and inspections. Report for the same has been attached as **Annexure II**
8	Project Proponent shall ensure the compliance of Suggested Ore Transport Mode (SOTM) with association of the State Government of Odisha. All existing mines should ensure adoption of SOTM within next 5 years. New mines or mines seeking expansion should incorporate provision of SOTM in the beginning itself, and should have system in place within next 5 years.	Being complied	Ore transportation through dumper truck has been observed. 24 percent ore are being transported to railway siding (located at a distance of 10 km to 25 km approx.), 51 percent for shipping (located at a distance 300 km approx.) and to the end user (25% located at a distance of 200 km. approx) by dumper. EC was accorded in the year 2019 and period of 5 year yet to be completed.
9	The State Govt. of Odisha shall ensure dust free roads in mining areas wherever the road transportation of mineral is involved. The road shoulders shall be paved with fence besides compliance with IRC guidelines. All the roads should have proper drainage system and apart from paving of entire carriage width the remaining right of way should have native plantation (dust capturing species). Further, regular maintenance should also be ensured by the Govt. of Odisha. Progress on development of dust free roads, implementation of SOTM, increased use of existing rail network, development of additional railway network/conveyor	Being Complied	Paved road has been provided for transportation of ore through the NH. Natural Plantation along the road has been carried out. 1 road sweeping along with dedicated 18 KL water tanker has been deployed for controlling the dust on the transportation road. SOTM will be implemented once EC for expansion gets approved. Till now we have laid 60 km of slurry pipeline out of 300 Km from Nuagaon to Paradeep.

	belt/ pipelines etc. shall be submitted periodically to Regional office of the MoEF&CC.		
10	Project Proponent shall develop the parking plazas for trucks with proper basic amenities/ facilities inside the mine. This should be done within one year for existing mines and new mines should have since beginning. This Environmental Clearance for the expansion project shall be operated only after the compliance of the above-mentioned specific condition.	COMPLIED	Parking plaza of capacity of 200 trucks has been developed at the site along with facilities such as toilet and rest area. Pavement of the parking plaza has also been done. Photos for the same is attached as **Annexure VIII**.
11	Department of Steel & Mines shall ensure the construction of NH 215 as minimum 4 lane road with proper drainage system and plantation and subsequent regular maintenance of the road as per IRC guidelines. Construction of other mineral carrying roads with proper width and drainage system along with road side plantation to be carried out. This shall be completed within 2 Years.	COMPLIED	4 lane road on NH 215 with proper drainage system and plantation has been constructed by State government and subsequent regular maintenance are being carried out.
12	Regular vacuum cleaning of all mineral carrying roads aiming at "Zero Dust Re-suspension" shall be adopted by PWD / NHAI/ Mine Lease Holders within a time Period of 3 months for existing roads. This Environmental Clearance for the expansion project shall be operated only after the compliance of the above-mentioned specific condition.	COMPLIED	One vacuum sweeping machine has been provided. Wheel washing has been provided at entry and exit gate of. Fixed water sprinkler of 1.2 Km has been provided in part of the haul road. Water sprinkling is being carried out along the haul road by two number of truck mounted tanker of capacity 50Kl and 16 KL.
13	In case the total requirement of iron ore exceeds the suggested limit for that year, permission for annual production by an individual mine may be decided depending on approved EC capacity (for total actual dispatch) and actual production rate of individual mine during last year or any other criteria set by the State Govt., i.e. Dept. of Steel & Mines. Department of Steel and Mines in consultation with Indian Bureau of Mines-RO should prepare in advance mine-wise annual production scenario so that demand for iron ore can be anticipated, and actual production/dispatch does not exceed the suggested annual production.	Agreed Upon	Detail of production furnished for 2020-21 is Iron 4.48 MT, Mn 0.0004 MT and for 2021-22 Iron 5.443 MT and Mn 0.0047 MT. EC accorded for 6.0MTPA(ROM) of iron ore and existing 0.036MTPA Mn ore along 2.MTPA beneficiation plant
14	R&D studies towards utilization of low-grade iron ore should be conducted through research/academic institutes like IMMT, Bhubaneswar, NML, Jamshedpur, and concerned metallurgical departments in IITs, NITs etc., targeting full utilization of low-grade iron ore (Fe content up to 45% by 2020 and up to 40% by 2025). In fact, life cycle assessment of whole process including environmental considerations should be done for techno-economic and environmental viability. R&D studies on utilization of mine waste water having high concentration of Fe content for different commercial	Complied	Report on washing and de-sliming of iron ore fines of Nuagaon mines prepared by IMMT Bhubaneswar has been carried out and is attached as **Annexure IX**

	applications in industries such as cosmetics, pharmaceutical, paint industry should also be explored. Responsibility: IBM, Dept. of Steel & Mines, Individual Mine Lease Holders.		
15	The mining activity in Joda-Koira sector is expected to continue for another 100 years, therefore, it will be desirable to develop proper rail network in the region. Rail transport shall not only be pollution free mode but also will be much economical option for iron ore transport. The rail network and/or conveyor belt system up to public railway siding needs to be created. The total length of the conveyor belt system/ rail network to be developed from mines to nearest railway sidings by 11 mines in Joda region is estimated to be about 64 km. Similarly, in Koira region, total length of rail network/ conveyor system for 8 mines (under SOTM 1 & 2) is estimated to be around 95 km. Further, it is suggested to develop a rail network connecting Banspani (Joda region) and Roxy railway sidings in Koira region. Responsibility: Dept. of Steel & Mines, Govt. of Odisha and Concerned Mines along with Indian Railways. Time Period: Maximum 7 years (by 2025). The Department of Steel & Mines, Govt. of Odisha should follow-up with the concerned Departments and railways so that proposed proper rail network is in place by 2025.	Being Complied	Ore transportation through dumper truck has been observed. 24 percent ore are being transported to railway siding (located at a distance of 10 km to 25 km approx.), 51 percent for shipping (located at a distance 300 km approx.) and to the end user (25% located at a distance of 200 km. approx) by dumper. EC was accorded in the year 2019 and period of 5 year yet to be completed.
16	State Govt. of Odisha shall make all efforts to ensure exhausting all the iron & manganese ore resources in the existing working mines and from disturbed mining leases/zones in Joda and Koira region. The criteria suggested shall be applicable while suggesting appropriate lease area and sustainable mining rate. Responsibility: Dept. of Steel & Mines, Govt. of Odisha.	Agreed Upon	We ensure to exhaust all the Iron ore and Mn Ore resources in the site.
17	**Mining Operations/Process Related:** Project Proponent shall implement the following mitigation measures: (i) Appropriate mining process and machinery (viz. right capacity, fuel efficient) should be selected to carry out various mining operations that generate minimal dust/air pollution, noise, wastewater and solid waste. e.g. drills should either be operated with dust extractors or equipped with water injection system. (ii) After commencement of mining operation, a study should be conducted to assess and quantify emission load generation (in terms of air pollution, noise, waste water and solid waste) from each of the mining activity (including transportation) on annual basis. Efforts should be made to further eliminate/ minimize generation of air pollution/dust, noise, wastewater, solid waste generation	COMPLIED	Drilling is equipped with wet drilling along with dust extractor. Dust load calculation has been carried out and report is attached with NEERI compliance report as ANNEXURE IV. Inspection and maintenance of all the machineries/ equipment/ transport vehicles are being followed as per manufacturer's instructions/ recommended time schedule and records are being maintained. Dept. PUC check for vehicles are being carried out annually. Land use land cover map based on drone image certified by ORSAC is attached as **ANNEXURE X.**

	in successive years through use of better technology. This shall be ensured by the respective mine lease holders. (iii) Various machineries/equipment selected (viz. dumpers, excavators, crushers, screen plants etc.) and transport means should have optimum fuel/power consumption, and their fuel/power consumption should be recorded on monthly basis. Further, inspection and maintenance of all the machineries/ equipment/ transport vehicles should be followed as per manufacturer's instructions/ recommended time schedule and record should be maintained by the respective mine lease holders. (iv) Digital processing of the entire lease area using remote sensing technique should be carried out regularly once in 3 years for monitoring land use pattern and mining activity taken place. Further, the extent of pit area excavated should also be demarcated based on remote sensing analysis. This should be done by ORSAC (Odisha Space Applications Centre, Bhubaneswar) or an agency of national repute or if done by a private agency, the report shall be vetted/ authenticated by ORSAC, Bhubaneswar. Expenses towards the same shall be borne by the respective mine lease holders. Responsibility: Individual Mine Lease Holders.		
18	**Air Environment Related**: Project Proponent shall implement the following mitigation measures: (i) Fugitive dust emissions from all the sources should be controlled regularly on daily basis. Water spraying arrangement on haul roads, loading and unloading and at other transfer points should be provided and properly maintained. Further, it will be desirable to use water fogging system to minimize water consumption. It should be ensured that the ambient air quality parameters conform to the norms prescribed by the CPCB in this regard. (ii) The core zone of mining activity should be monitored on daily basis. Minimum four ambient air quality monitoring stations should be established in the core zone for SPM, PM10, PM2.5, SO2, NOx and CO monitoring. Location of air quality monitoring stations should be decided based on the meteorological data, topographical features and environmentally and ecologically sensitive targets and frequency of monitoring should be undertaken in consultation with the State Pollution Control Board (based on Emission Load Assessment Study). The number of monitoring locations may be more for larger capacity mines and working in larger area. Out of four	COMPLIED	Fugitive emission monitoring is being carried out at 6 different locations i.e. Screen Plant, waste dump, mines face bench, Crusher plant, loading point and Mines haulage road. Fixed water spraying arrangement of around 1.2 Km has been provided, water tanker two no to suppress dust at the haul road has also been provided. Ambient air quality monitoring are being carried out at four different locations for PM10, PM2.5, SO2, NO2 and CO.. Three online ambient air quality monitoring station has been installed for monitoring of PM10, PM2.5, SO2, NO2 and CO. Monitoring of buffer zone are being carried our in four location i.e Koira Basti, Bhanjpali village, Kashira Basti and Segasagi village for PM10, PM2.5, SO2, NO2 and CO. PUC check are being carried out and transportation is being done through covered trucks, along with this overloading are being rectified by automated weighbridges. Photos of covered trucks is attached as <u>**ANNEXURE XI.**</u>

	stations, one should be online monitoring station in the mines having more than 3 MTPA EC Capacity. (iii) Monitoring in buffer zone should be carried out by SPCB or through NABET accredited agency. In addition, air quality parameters (SPM, PM10, PM2. 5, 5O2, NOx and CO) shall be regularly monitored at locations of nearest human habitation including schools and other public amenities located nearest to source of the dust generation as applicable. (iv) Emissions from vehicles as well as heavy machinery should be kept under control and regularly monitored. Measures should be taken for regular maintenance of vehicles used in mining operations and in transportation of mineral. (v) The vehicles shall be covered with a tarpaulin and should not be overloaded. Further, possibility of closed container trucks should be explored for direct to destination movement of iron ore. Air quality monitoring at one location should also be carried out along the transport route within the mine (periodically, near truck entry and exit gate), Responsibility: Individual Mine Lease Holders and SPCB.		
19	**Noise and Vibration Related**: Project Proponent shall implement the following mitigation measures: (i) Blasting operation should be carried out only during daytime. Controlled blasting such as Nonel, should be practiced. The mitigation measures for control of ground vibrations and to arrest fly rocks and boulders should be implemented. (ii) Appropriate measures should be taken for control of noise levels below 85 DB in the work environment. Workers engaged in operations of HEMM, etc. should be provided with ear plugs/muffs. (iii) Noise levels should be monitored regularly (on weekly basis) near the major sources of noise generation within the core zone. Further, date, time and distance of measurement should also be indicated with the noise levels in the report. The data should be used to map the noise generation from different activities and efforts should be made to maintain the noise levels with the acceptable limits of CPCB (CPCB, 2000) (iv) Similarly, vibration at various sensitive locations should be monitored at least once in month, and mapped for any significant changes due to successive mining operations. Responsibility: Individual Mine Lease Holders.	COMPLIED	Blasting operation are being carried out on day time only and controlled blasting is being practiced by using nonel. However, blasting study are being carried out monthly. Blasting report along with mapping of the significant changes or variation in ppv graph is attached as **<u>ANNEXURE XII</u>**. Ambient Noise level monitoring are being carried out at 4 different locations in core zone as well as 4 locations in buffer zone. Along with this Source noise monitoring are carried out at 15 different locations.
20	**Water/Wastewater Related**: Project Proponent shall implement the following mitigation measures: (i) In general, the mining operations should be restricted to above ground water table and it should not	Complied	The ground water table has been intersected only in the manganese quarry. There is no Obstruction to natural water course. Monitoring of Surface water flow rate and quality of upstream and downstream of of Karo river and Orahari nala. Ground water level

	intersect groundwater table. However, if enough resources are estimated below the ground water table, the same may be explored after conducting detailed geological studies by GSI and hydro-geological studies by CGWB or NIH or institute of national repute, and ensuring that no damage to the land stability/ water aquifer system shall happen. The details/ outcome of such study may be reflected/incorporated in the EIA/EMP report of the mine appropriately. (ii) Natural watercourse and/or water resources should not be obstructed due to any mining operations. Regular monitoring of the flow rate of the springs and perennial nallas should be carried out and records should be maintained. Further, regular monitoring of water quality of nallas and river passing thorough the mine lease area (upstream and downstream locations) should be carried out on monthly basis. (iii) Regular monitoring of ground water level and its quality should be carried out within the mine lease area by establishing a network of existing wells and constructing new piezometers during the mining operation. The monitoring should be carried out on monthly basis. (iv) In order to optimize water requirement, suitable conservation measures to augment ground water resources in the area should be undertaken in consultation with Central Ground Water Board (CGWB). (v) Suitable rainwater harvesting measures on long term basis should be planned and implemented in consultation with CGWB, to recharge the ground water source. Further, CGWB can prepare a comprehensive plan for the whole region. (vi) Appropriate mitigation measures (viz. ETP, STP, garland drains, retaining walls, collection of runoff etc.) should be taken to prevent pollution of nearby river/other water bodies. Water quality monitoring study should be conducted by State Pollution Control Board to ensure quality of surface and ground water sources on regular basis. The study can be conducted through NABL/ NABET approved water testing laboratory. However, the report should be vetted by SPCB. (vii) Industrial wastewater (workshop and wastewater from the mine) should be properly collected, treated in ETP so as to conform to the discharge standards applicable. (viii) Oil and grease trap should be installed before discharge of workshop effluents. Further, sewage treatment plant should be installed for the employees/colony, wherever applicable. (ix) Mine lease holder should ensure that no silt originating due to mining activity is transported in the surface water course or any other water body. Appropriate measures for prevention and control of soil		and quality monitoring data are also being carried out. ETP of 15 KL with oil and grease trap system and STP of 30 KL has been installed at workshop area and Operator colony respectively. Garland drain of 2 Km and retaining wall of 900m has been provided for collection of runoff. Around 5 settling ponds of different dimensions has been constructed within the mine lease area. Coir mat of around 16000 sqm has been installed. Photos of garland drain, settling pond, Coir mat and rain water harvesting structure **ANNEXURE XIII**.

	erosion and management of silt should be undertaken. Quantity of silt/soil generated should be measured on regular basis for its better utilization. (x) Erosion from dumps site should be protected by providing geo-textile matting or other suitable material, and thick plantation of native trees and shrubs should be carried out at the dump slopes. Further, dumps should be protected by retaining walls. (xi) Trenches/ garland drain should be constructed at the foot of dumps to arrest silt from being carried to water bodies. Adequate number of check dams should be constructed across seasonal/perennial nallas (if any) flowing through the mine lease areas and silt be arrested. De-silting at regular intervals should be carried out and quantity should be recorded for its better utilization, after proper soil quality analysis. (xii) The water so collected in the reservoir within the mine should be utilized for the sprinkling on hauls roads, green belt development etc. (xiii) There should be zero waste water discharge from the mine. Based on actual water withdrawal and consumption/ utilization in different activities, water balance diagram should be prepared on monthly basis, and efforts should be made to optimize consumption of water per ton of ore production in successive years. Responsibility: Individual Mine Lease Holders, SPCB and CGWB.		
21	**Land/Soil/Overburden Related**: Project Proponent shall implement the following mitigation measures: (i) The top soil should temporarily be stored at earmarked site(s) only and it should not be kept unutilized for long (not more than 3 years or as per provisions mentioned in the mine plan/ scheme). The topsoil should be used for land reclamation and plantation appropriately. (ii) Fodder plots should be developed in the non-mineralised area in lieu of use of grazing land, if any. (iii) Over burden/ low grade ore should be stacked at earmarked dump site (s) only and should not be kept active for long period. The dump height should be decided on case-to-case basis, depending on the size of mine and quantity of waste material generated. However, slope stability study should be conducted for larger heights, as per IBM approved mine plan and DGMS guidelines. The OB dump should be scientifically vegetated with suitable native species to prevent erosion and surface run off. In critical areas, use of geo textiles should be undertaken for stabilization of the dump. Monitoring and management of rehabilitated areas should continue until the vegetation becomes self-sustaining. Proper records should be maintained regarding species, their growth,	COMPLIED	There is no Top soil dump within the mine lease area, once it generated it will be stored at earmarked location. There is no use of grazing land. Over burden, low grade ore stacked in the earmarked area. Slope stability study has been conducted through NIT Rourkela. Backfilling has not been carried out. The mine has five settling ponds three with dimensions approx. 4m x 4m x 3m each and other two with dimensions 20m x 15m x 6m and 15m x 12m x 5m respectively. Garland drain of 2 Km and retaining wall of 900m has been provided for collection of runoff. Hazardous waste authorization was granted vide authorization number IND-IV-HW-1349/8185 dated 23-05-2023 for waste oil, lubricants, etc. which are being disposed of through authorized recycler. Form HWA and manifesto has been attached as **ANNEXURE XIV.** .

	area coverage etc. (iv) Catch drains and siltation ponds of appropriate size should be constructed to arrest silt and sediment flows from mine operation, soil, OB and mineral dumps. The water so collected can be utilized for watering the mine area, roads, green belt development etc. The drains should be regularly de-silted, particularly after monsoon and should be maintained properly. Appropriate documents should be maintained. Garland drain of appropriate size, gradient and length should be constructed for mine pit, soil, OB and mineral dumps and sump capacity should be designed with appropriate safety margin based on long term rainfall data. Sump capacity should be provided for adequate retention period to allow proper settling of silt material. Sedimentation pits should be constructed at the corners of the garland drains and de-silted at regular intervals. (v) Backfilling should be done as per approved mining plan/scheme. There should be no OB dumps outside the mine lease area. The backfilled area should be afforested, aiming to restore the normal ground level. Monitoring and management of rehabilitated areas should continue till the vegetation is established and becomes self-generating. (vi) Hazardous waste such as, waste oil, lubricants, resin, and coal tar etc. should be disposed off as per provisions of Hazardous Waste Management Rules, 2016, as amended from time to time. Responsibility: Individual Mine Lease Holders.		
22	**Ecology/Biodiversity (Flora-Fauna) Related**: Project Proponent shall implement the following mitigation measures: (i) All precautionary measures should be taken during mining operation for conservation and protection of endangered fauna namely elephant, sloth bear etc. spotted in the study area. Action plan for conservation of flora and fauna should be prepared and implemented in consultation with the State Forest and Wildlife Department within the mine lease area, whereas outside the mine lease area, the same should be maintained by State Forest Department. (ii) Afforestation is to be done by using local and mixed species saplings within and outside the mining lease area. The reclamation and afforestation is to be done in such a manner like exploring the growth of fruit bearing trees which will attract the fauna and thus maintaining the biodiversity of the area. As afforestation done so far is very less, forest department needs to identify adequate land and do afforestation by involving local people in a time bound manner. (iii) Green belt development carried out by mines should be monitored	Being Complied	Site Specific conservation plan for schedule - 1 species was prepared and got approved from PCCF (WL) & Chief Wildlife Warden The approved budget of Rs. 288 lakhs (Rs. 92 lakhs for activities within the project area to be spent by the proponent + Rs. 196 lakhs for activities in the Project Impact Zone) is already deposited vide memo no-6260 Dated-04/09/2010 & deposited vide DD No–045122 (by HDFC BANK), dated 10th Sept 2010 with DFO, Bonai MS-CAMPA account to undertake activities both inside the project area & project impact area. SSWLCP letter is attached as **ANNEXURE XV** Approx. 12600 sampling has been planted during FY 2021-22 and FY: 2022-23 to develop green belt area in 5 Ha. Along with this 500 nos. of vetiver plantation has been done. Photos of plantation is attached as **ANNEXURE XVI**

	regularly in every season and parameters like area under vegetation/plantation, type of plantation, type of tree species /grass species/scrubs etc., distance between the plants and survival rate should be recorded. (iv) Green belt is an important sink of air pollutants including noise. Development of green cover in mining area will not only help reducing air and noise pollution but also will improve the ecological conditions and prevent soil erosion to a greater extent. Further, selection of tree species for green belt should constitute dust removal/dust capturing plants since plants can act as efficient biological filters removing significant amounts of particulate pollution. Thus, the identified native trees in the mine area may be encouraged for plantation. Tree species having small leaf area, dense hair on leaf surface (rough surface), deep channels on leaves should be included for plantation. (v) Vetiver plantation on inactive dumps may be encouraged as the grass species has high strength of anchoring besides medicinal value. (vi) Details of compensatory afforestation done should be recorded and documented by respective forest divisions, and State Forest Department should present mine-wise annual status, along with expenditure details. Responsibility: Individual Mine Lease Holders and State Forest & Wildlife Department.		.
23	**Socio-Economic Related**: Project Proponent shall implement the following mitigation measures: (i) Public interaction should be done on regular basis and social welfare activities should be done to meet the requirements of the local communities. Further, basic amenities and infrastructure facilities like education, medical, roads, safe drinking water, sanitation, employment, skill development, training institute etc. should be developed to alleviate the quality of life of the people of the region. (ii) Land outees and land losers/affected people, if any, should be compensated and rehabilitated as per the national/state policy on Resettlement and Rehabilitation. (iii) The socio-economic development in the region should be focused and aligned with the guidelines/initiatives of Govt. of India/ NITI Aayog around prosperity, equality, justice, cleanliness, transparency, employment, respect to women, hope etc. This can be achieved by providing adequate and quality facilities for education, medical and developing skills in the people of the region. District administration in association with mine lease holders should plan for "Samagra Vikas" of these blocks well as other blocks of the district. While planning for different	COMPLIED	Public interactions are being carried out on regular basis and social welfare activities are being done to meet the requirements of the local communities Activities like education, medical, roads, safe drinking water, sanitation, employment, skill development, training institute etc. has been developed to alleviate the quality of life of the people. Details of social development activities along with photos has been attached as **ANNEXURE XVII.**

	schemes in the region, the activities should be prioritized as per Pradhan Mantri KhanijKshetra Kalyan Yojna (PMKKKY), notified by Ministry of Mines, Govt. of India, vide letter no. 16/7/2017-M.VI (Part), dated September 16, 2015. Responsibility: District Administration and Individual Mine Lease Holders.		
24	**Road Transport Related**: Project Proponent shall implement the following mitigation measures: (i) All the mine lease holders should follow the suggested ore transport mode (SOTM), based on its EC capacity within next 5 years. (ii) The mine lease holders should ensure construction of cement road of appropriate width from and to the entry and exit gate of the mine. Further, maintenance of all the roads should be carried out as per the requirement to ensure dust free road transport. (iii) Transportation of ore should be done by covering the trucks with tarpaulin or other suitable mechanism so that no spillage of ore/dust takes place. Further, air quality in terms of dust, PM:10 should be monitored near the roads towards entry & exit gate on regular basis, and be maintained within the acceptable limits. Responsibility: Individual Mine Lease Holders and Dept. of Steel & Mines.	COMPLIED	Cement road has been constructed at the entry gate. Road sweeping machine has been provided to ensure dust free road transport. Transportation of ore are being carried out through covered truck. Air quality has been monitored near entry and exit gate.
25	**Occupational Health Related**: Project Proponent shall implement the following mitigation measures: (i) Personnel working in dusty areas should wear protective respiratory devices and they should also be provided with adequate training and information on safety and health aspects periodically. (ii) Occupational health surveillance program for all the employees/workers (including casual workers) should be undertaken periodically (on annual basis) to observe any changes due to exposure to dust, and corrective measures should be taken immediately, if needed. (iii) Occupational health and safety measures related awareness programs including identification of work related health hazard, training on malaria eradication, HIV and health effects on exposure to mineral dust etc., should be carried out for all the workers on regular basis. A full time qualified doctor should be engaged for the purpose. Periodic monitoring (on 6 monthly basis) for exposure to respirable minerals dust on the workers should be conducted, and record should be maintained including health record of all the workers. Review of impact of various health measures undertaken (at an interval of 3 years or less) should be conducted followed by follow-up of actions, wherever required.	COMPLIED	Total 750 numbers of PPEs like safety shoes, reflective jacket, safety glass, ear plugs, helmets etc. have been distributed. Personnel working in dusty areas wear protective respiratory devices and vocational training and information on safety and health aspects are being given to them periodically. Total number of 2522 Vocational trainings has been carried out. 708.numbers of IME has been conducted for Narayanposhi Iron and Mn Ore mines. IME form O are attached as **ANNEXURE XVIII**.

	Occupational health centre should be established near mine site itself. Responsibility: Individual Mine Lease Holders and District Administration (District Medical Officer).		
	B. Standard Conditions **I. Statutory Compliance**		
1	This Environmental Clearance (EC) is subject to orders/judgment of Hon'ble Supreme Court of India, Hon'ble High Court, Hon'ble NGT and any other Court of Law, Common Cause Conditions as may be applicable.	Agreed to comply	Agree to abide by the condition
2	This EC is valid up to 31.03.2020 as the lease validity i.e. valid up to 31st March 2020 as per the Amended MMDR Act. 2015	Agreed Upon	EC has been vested to JSW Steel Ltd for 2 years and then further for 50 years. As per MOEF&CC OM dated 13.07.2021, EC transfered till life of the mine..
3	The Project proponent complies with all the statutory requirements and judgment of Hon'ble Supreme Court dated 2nd August, 2017 in Writ Petition (Civil) No. 114 of 2014 in matter of Common Cause versus Union of India &Ors. before commencing the mining operations.	Agreed to comply	Agree to abide by the condition
4	The State Government concerned shall ensure that mining operation shall not be commenced till the entire compensation levied, if any, for illegal mining paid by the Project Proponent through their respective Department of Mining & Geology in strict compliance of Judgment of Hon'ble Supreme Court dated 2nd August, 2017 in Writ Petition (Civil} No. 114 of 2014 in matter of Common Cause versus Union of India & Ors.	Being Complied	State Government (Steel & Mines Department) has given vested order in favour of M/s. JSW Steel Limited vide No. 1335/SM, dated 15.02.2022 for grant of mining lease for 50 years and all clearances, vested under section-8A, Sub section-2 of Mines and Mineral Development Regulation Act, 1957.
5	This Environmental Clearance shall become operational only after receiving formal NBWL Clearance from MoEF&CC subsequent to the recommendations of the Standing Committee of National Board for Wildlife, if applicable to the Project.	Being Complied	As per the information furnished No Wild Life Sanctuary/Tiger Reserve/National Park/ within the core as well as within the buffer zone of the project.
6	This Environmental Clearance shall become operational only after receiving formal Forest Clearance (FC) under the provision of Forest Conservation Act, 1980, if applicable to the Project.	Being Complied	As per the EC accorded total forest area is 259.191Ha. Forest Clearance accorded for 244.327 Ha to M/s JSW Steel Ltd. 19.25 Ha yet to diverted. (As reported by PP) out of 244.327 Ha ,184.591 Ha has been transferred to the new lessee. FC transfer letter is attached as **ANNEXURE XIX**
7	Project Proponent (PP) shall obtain Consent to Operate after grant of EC and effectively implement all the conditions stipulated therein. The mining activity shall not commence prior to obtaining Consent to Establish / Consent to Operate from the concerned State Pollution Control Board/Committee.	Complied	Consent to establish has been accorded vide letter no 536/IND-II-CTE-6207 dated 14.01.2019 and Consent to operate accorded by Odisha Pollution Control Board vide letter no 4987/IND-I-CON-2258 dated 29.03.2022 valid up to 31.03.2024.
8	The PP shall adhere to the provision of the Mines Act, 1952, Mines and Mineral (Development & Regulation), Act, 2015	Agreed upon	Agreed to comply

	and rules & regulations made there under. PP shall adhere to various circulars issued by Directorate General Mines Safety (DGMS) and Indian Bureau of Mines from time to time.		
9	The Project Proponent shall obtain consents from all the concerned land owners, before start of mining operations, as per the provisions of MMDR Act, 1957 and rules made there under in respect of lands which are not owned by it.	Complied	Present mining operation has been restricted within vested lease granted over 347.008 ha (as per DGPS)
10	The Project Proponent shall follow the mitigation measures provided in MoEFCC's Office Memorandum No. Z-11013/57/2014-IA.II (M), dated 29th October, 2014, titled "Impact of mining activities on Habitations-Issues related to the mining Projects wherein Habitations and villages are the part of mine lease areas or Habitations and villages are surrounded by the mine lease area".	Complied	As per the Office Memorandum No. Z-11013/57/2014-IA.II (M), dated 29th October, 2014, titled "Impact of mining activities on Habitations-Issues of MoEFCC's, mitigative measures are being taken care of. This includes construction of garland drains, check dams, retaining walls and settling ponds. OM also states about the regular monitoring of natural stream, illumination survey and others which are being carried out.
11	The Project Proponent shall obtain necessary prior permission of the competent authorities for drawl of requisite quantity of surface water and from CGWA for withdrawal of ground water for the project.	Being complied	NOC from CGWA for 1715 m3/day is already vested to JSW which was valid upto 18.01.2022. New application for the NOC has been applied vide application no. CGWA/NOC/MIN/REN/1/2019/5586 which is awaited.
12	A copy of EC letter will be marked to concerned Panchayat / local NGO etc. if any, from whom suggestion / representation has been received while processing the proposal.	Complied	Copy of EC letter has been marked to concerned Panchayat office.
13	State Pollution Control Board/Committee shall be responsible for display of this EC letter at its Regional office, District Industries Centre and Collector's office/ Tehsildar's Office for 30 days.	Complied	State Pollution Control Board/Committee has displayed EC letter at its Regional office, District Industries Centre and Collector's office/ Tehsildar's Office
14	The Project Authorities should widely advertise about the grant of this EC letter by printing the same in at least two local newspapers, one of which shall be in vernacular language of the concerned area. The advertisement shall be done within 7 days of the issue of the clearance letter mentioning that the instant project has been accorded EC and copy of the EC letter is available with the State Pollution Control Board/Committee and web site of the Ministry of Environment, Forest and Climate Change (www.parivesh.nic.in). A copy of the advertisement may be forwarded to the concerned MoEFCC Regional Office for compliance and record.	Complied	EC letter has been published by ex-lessee AMTC in the 2 local newspapers.
15	The Project Proponent shall inform the MoEF&CC for any change in ownership of the mining lease. In case there is any change in ownership or mining lease is transferred than mining operation shall only be carried out after transfer of EC as per provisions of the para 1I of EIA	COMPLIED	EC has been accorded to M/s Aryan Mining & Trading Corporation Pvt. Ltd. Subsequently the due to expiry of lease on 31.03.2020 has been auctioned and M/s JSW has been declared as preferred bidder. Acknowledge letter has been accorded by MOEFCC vide letter dated 11/12/2021.

	Notification, 2006 as amended from time to time		Copy for the same is attached as **ANNEXURE XX.**
	II. Air quality monitoring and preservation		
16	The Project Proponent shall install a minimum of 3 (three) online Ambient Air Quality Monitoring Stations with 1 (one) in upwind and 2 (two) in downwind direction based on long term climatological data about wind direction such that an angle of 120° is made between the monitoring locations to monitor critical parameters, relevant for mining operations, of air pollution viz. PM10, PM2.5, NO2, CO and SO2 etc. as per the methodology mentioned in NAAQS Notification No. B-29016/2o/go/PCI/I, dated 18.11.2009 covering the aspects of transportation and use of heavy machinery in the impact zone. The ambient air quality shall also be monitored at prominent places like office building, canteen etc. as per the site condition to ascertain the exposure characteristics at specific places. The above data shall be digitally displayed within 03 months in front of the main Gate of the mine site.	Complied	In consultation with SPCB, three numbers of Continuous ambient air monitoring stations (CAAQMS) has been installed for PM10, PM2.5, NO2, CO and SO2, maintaining an angle of 120^0 Location are as below- CAAQMS 1. Narayanposhi_Mines Office CAAQMS 2 Gate No. 1 CAAQMS 3. Baba math area Digital Display Board- Near Gate No. 2 . Photos and letter of communication for the same is attached as **Annexure XXI.**
17	Effective safeguard measures for prevention of dust generation and subsequent suppression (like regular water sprinkling, metalled road construction etc.) shall be carried out in areas prone to air pollution wherein high levels of PM10 and PM2.5 are evident such as haul road, loading and unloading point and transfer points. The Fugitive dust emissions from all sources shall be regularly controlled by installation of required equipment's/ machineries and preventive maintenance. Use of suitable water-soluble chemical dust suppressing agents may be explored for better effectiveness of dust control system. It shall be ensured that air pollution level conform to the standards prescribed by the MoEFCC/ Central Pollution Control Board.	Complied	Fugitive emission monitoring is being carried out at 6 different locations i.e. Screen Plant, waste dump, mines face bench, Crusher plant, loading point and Mines haulage road. Fixed water spraying arrangement of around 1.2 Km has been provided, water tanker two no to suppress dust at the haul road has also been provided. Regular water sprinkling through mobile water sprinkler tankers being carried out on haul roads with dedicated 50 KL and 16 KL. Water soluble chemicals after addition with the water tankers are also being used on the haul roads.
	III. Water quality monitoring and preservation		
18	In case, immediate mining scheme envisages intersection of ground water table, then Environmental Clearance shall become operational only after receiving formal clearance from CGWA. In case, mining operation involves intersection of ground water table at a later stage, then PP shall ensure that prior approval from CGWA and MoEFCC is in place before such mining operations. The permission for intersection of ground water table shall essentially be based on detailed hydro-geological study of the area.	Being Complied	NOC from CGWA for 1715 m3/day is already vested to JSW which was valid upto 18.01.2022. New application for the NOC has been applied vide application no. CGWA/NOC/MIN/REN/1/2019/5586 which is awaited.

19	Regular monitoring of the flow rate of the springs and perennial nallahs flowing in and around the mine lease shall be carried out and records maintain. The natural water bodies and or streams which are flowing in an around the village, should not be disturbed. The Water Table should be nurtured so as not to go down below the pre-mining period. In case of any water scarcity in the area, the Project Proponent has to provide water to the villagers for their use. A provision for regular monitoring of water table in open dug wall located in village should be incorporated to ascertain the impact of mining over ground water table. The Report on changes in Ground water level and quality shall be submitted on six- monthly basis to the Regional Office of the Ministry, CGWA and State Groundwater Department / State Pollution Control Board		Monitoring of surface water flow rate and quality monitoring data of upstream and downstream of Karo river and Orahari nala. Ground water level and quality monitoring are being carried. Report are attached as **ANNEXURE II** .
20	Project Proponent shall regularly monitor and maintain records w.r.t. ground water level and quality in and around the mine lease by establishing a network of existing wells as well as new piezo-meter installations during the mining operation in consultation with Central Ground Water Authority/ State Ground Water Department. The Report on changes in Ground water level and quality shall be submitted on six-monthly basis to the Regional Office of the Ministry, CGWA and State Groundwater Department / State Pollution Control Board.	Complied	Monitoring of surface water flow rate and quality monitoring data of upstream and downstream of Karo river and Orahari nala. Ground water level and quality monitoring are being carried. Report are attached as **ANNEXURE II** . Variation in Ground water level is attached as **ANNEXURE XXII**
21	The Project Proponent shall undertake regular monitoring of natural water course/ water resources/ springs and perennial nallahs existing/ flowing in and around the mine lease and maintain its records. The project proponent shall undertake regular monitoring of water quality upstream and downstream of water bodies passing within and nearby/ adjacent to the mine lease and maintain its records. Sufficient number of gullies shall be provided at appropriate places within the lease for management of water. PP shall Carryout regular monitoring w.r.t. pH and included the same in monitoring plan. The parameters to be monitored shall include their water quality vis-à-vis suitability for usage as per CPCB criteria and flow rate. It shall be ensured that no obstruction and/or alteration be made to water bodies during mining operations without justification and prior approval of MoEFCC. The monitoring of water courses/ bodies existing in lease area shall be carried out four times in a Year viz. pre- monsoon (April-May). monsoon (August), post-monsoon (November) and winter (January) and the record of monitored data may be sent regularly to Ministry of Environment,	Complied	Regular monitoring of water quality of upstream and downstream being carried out and Monitoring Reports are attached as **Annexure II** by ECOMEN. Flow rate of the nearby nallas and river are being measured. No natural watercourse and water resources are obstructed due to mining operations & the same will be taken care of. Existing check dams being maintained to prevent any pollution of the nearby water bodies. 2 piezometers has been installed within the mines lease area in consultation with CGWA, data for the same is attached as **ANNEXURE XXIII**.

	Forest and Climate Change and its Regional Office, Central Ground Water Authority and Regional Director, Central Ground Water Board, State Pollution Control Board and Central Pollution Control Board. Clearly showing the trend analysis on six-monthly basis.		
22	Quality of polluted water generated from mining operations which include Chemical Oxygen Demand (COD) in mines run-off; acid mine drainage and metal contamination in runoff shall be monitored along with Total Suspended Solids (TDS), Dissolved Oxygen (DO), pH and Total Suspended Solids (TSS). The monitored data shall be uploaded on the website of the company as well as displayed at the project site in public domain, on a display board, at a suitable location near the main gate of the Company. The circular No. J-20012/1/2006- IA.II (M) dated 27.05.2009 issued by Ministry of Environment, Forest and Climate Change may also be referred in this regard.	Complied	Display board has been provided near the gate. Monitored data uploaded in the website of the company along with six monthly compliances of Apr22 to Sep 22. No polluted water generated from the Mine. Link of the company website is mentioned below. **https://www.jswsteel.in/investors/jsw-steel-investor-information-environmental-clearances**
23	Project Proponent shall plan, develop and implement rainwater harvesting measures on long term basis to augment ground water resources in the area in consultation with Central Ground Water Board/ State Groundwater Department. A report on amount of water recharged needs to be submitted to Regional Office MoEFCC annually.	Complied	Mine sump of dimension (200x150x7) has been used as rain water harvesting measure. A rain water harvesting pond has also been provided. Hydrology study carried out by accredited agency as per CGWB guideline.
24	Industrial waste water (workshop and waste water from the mine) should be properly collected and treated so as to conform to the notified standards prescribed from time to time. The standards shall be prescribed through Consent to Operate (CTO) issued by concerned State Pollution Control Board (SPCB). The workshop effluent shall be treated after its initial passage through Oil and grease trap.	Complied	Workshop along with ETP/Oil Grease Trap System developed in the mine. No process water being discharged from the mine. The waste water generated from workshop being treated by ETP/Mechanized Oil Grease Trap System with recirculation facility. Regular Monitoring of water quality parameters being carried out by NABET Accredited laboratory. Report for the same is attached as **ANNEXURE II**
25	The water balance/water auditing shall be carried out and measure for reducing the consumption of water shall be taken up and reported to the Regional Office of the MoEF&CC and State Pollution Control Board/Committee.	Complied	Total water requirement for Nuagaon Iron Ore mines is 1715 KLD. Rain water collected in pits are being utilizing for dust suppression in the mining operations. Fixed water sprinklers, pressurized mobile water tankers get utilized for dust suppression arrangement for reducing water requirement. Complete water balance diagram is attached as **ANNEXURE XXIV**
	IV. Noise and vibration monitoring and prevention		
26	The peak particle velocity at 500m distance or within the nearest habitation, whichever is closer shall be monitored periodically as per applicable DGMS guidelines.	Complied	Peak particle velocity are being monitored at 500m distance.
27	The illumination and sound at night at project sites disturb the villages in respect	Complied	Mining is being carried out in the already broken up area as per approved mine plan. Illumination and

	of both human and animal population. Consequent sleeping disorders and stress may affect the health in the villages located close to mining operations. Habitations have a right for darkness and minimal noise levels at night. PPs must ensure that the biological clock of the villages is not disturbed; by orienting the floodlights/ masks away from the villagers and keeping the noise levels well within the prescribed limits for day /night hours.		sound is restricted into core zone only. No project sites disturb the villages in respect of both human and animal population. Ambient Noise level monitoring are being carried out at 4 different locations in core zone as well as 4 locations in buffer zone. Along with this Source noise monitoring are carried out at 15 different locations.
28	The Project Proponent shall take measures for control of noise levels below 85 dBA in the work environment. The workers engaged in operations of HEMM, etc. should be provided with ear plugs /muffs. All personnel including labourers working in dusty areas shall be provided with protective respiratory devices along with adequate training, awareness and information on safety and health aspects. The PP shall be held responsible in case it has been found that workers/ personals/ labourers are working without personal protective equipment.	Complied	As per the observation from noise monitoring regularly carried out, noise level is observed to be below 85dBA in the work zone area. 750 no PPE set (including helmet, safety shoe, safety jacket, ear muffs, and dust musk) has been issued. Workers are equipped with PPEs in the working zone.
	V. Mining Plan		
29	The Project Proponent shall adhere to the working parameters of mining plan which was submitted at the time of EC appraisal wherein year-wise plan was mentioned for total excavation i.e. quantum of mineral, waste, over burden, inter burden and top soil etc. No change in basic mining proposal like mining technology, total excavation, mineral & waste production, lease area and scope of working (viz. method of mining, overburden & dump management, O.B & dump mining, mineral transportation mode, ultimate depth of mining etc.) shall not be carried out without prior approval of the Ministry of Environment, Forest and Climate Change, which entail adverse environmental impacts, even if it is a part of approved mining plan modified after grant of EC or granted by State Govt. in the form to Short Term Permit (STP), Query license or any other name.	Being Complied	The production is Iron 4.48 MT, Mn 0.0004 MT, for 2020-21 and Iron 5.443 MT, Mn 0.0047 MT for 2021-22 and Iron 5.296 MTPA(Iron Ore) and 0.0052 (Mn Ore) for 2022-23.
30	The Project Proponent shall get the Final Mine Closure Plan along with Financial Assurance approved from Indian Bureau of Mines/Department of Mining & Geology as required under the Provision of the MMDR Act, 1957 and Rules/ Guidelines made there under. A copy of approved final mine closure plan shall be submitted within 2 months of the approval of the same from the competent authority to the concerned Regional Office of the Ministry of Environment, Forest and Climate Change for record and verification.	AGREED UPON	Agreed to abide by the condition.

31	The land-use of the mine lease area at various stages of mining scheme as well as at the end-of-life shall be governed as per the approved Mining Plan. The excavation vis-â-vis backfilling in the mine lease area and corresponding afforestation to be raised in the reclaimed area shall be governed as per approved mining plan. PP shall ensure the monitoring and management of rehabilitated areas until the vegetation becomes self-sustaining. The compliance status shall be submitted half-yearly to the MoEFCC and its concerned Regional Office.	Complied	All the mining operations are being carried out as per approved Mine Plan including excavation and backfilling.
	VI. Land Reclamation		
32	The Overburden (O.B.) generated during the mining operations shall be stacked at earmarked OB dump site(s) only and it should not be kept active for a long period of time. The physical parameters of the OB dumps like height, width and angle of slope shall be governed as per the approved Mining Plan as per the guidelines/circulars issued by D.G.M.S w.r.t. safety in mining operations shall be strictly adhered to maintain the stability of top soil/OB dumps. The topsoil shall be used for land reclamation and plantation.	Complied	Over burden being stacked at earmarked site and after maturity same will be stabilized with plantation. There is no top soil within the mine lease area. Height of the dump reported to be 20m, 27m,12m, width 240m, 170m, 150m and slope 31^o, 22^0 and 18^0 respectively. Coir matting of 8500 m2 (in 1st phase) and 7800 m2 (in 2nd phase) has already been completed, followed by plantation with native species.
33	The reject/waste generated during the mining operations shall be stacked at earmarked waste dump site(s) only. The physical parameters of the waste dumps like height, width and angle of slope shall be governed as per the approved Mining Plan as per the guidelines/circulars issued by DGMS w.r.t. safety in mining operations shall be strictly adhered to maintain the stability of waste dumps.	Complied	Over burden being stacked at earmarked site and after maturity same will be stabilized with plantation. There is no top soil within the mine lease area. Height of the dump reported to be 20m, 27m,12m, width 240m, 170m, 150m and slope 31^o, 22^0 and 18^0 respectively.
34	The reclamation of waste dump sites shall be done in scientific manner as per the Approved Mining Plan cum Progressive Mine Closure Plan.	Agreed to comply	Reclamation will be done as per approved mine plan
35	The slope of dumps shall be vegetated in scientific manner with suitable native species to maintain the slope stability, prevent erosion and surface run off. The selection of local species regulates local climatic parameters and help in adaptation of plant species to the microclimate. The gullies formed on slopes should be adequately taken care of as it impacts the overall stability of dumps. The dump mass should be consolidated with the help of dozer/ compactors thereby ensuring proper filling/ levelling of dump mass. In critical areas, use of geo textiles/ geo-membranes / clay liners / Bentonite etc. shall be undertaken for stabilization of the dump.	Being complied	Plantation has been carried out in part of the dump. Backfilled dump is in active state and reclamation will be done as per the Approved mining plan & progressive mine closure plan.
36	The Project Proponent shall carry out slope stability study in case the dump height is more than 30 meters. The slope stability	Complied	Slope stability study has been done. Copy of the report of NIT Rourkela has been submitted to Regional

	report shall be submitted to concerned regional office of MoEF&CC.		Office. Report is attached as **ANNEXURE XXV**
37	Catch drains, settling tanks and siltation ponds of appropriate size shall be constructed around the mine working, mineral yards and Top Soil/OB/Waste dumps to prevent run off of water and flow of sediments directly into the water bodies (Nallah/ River/ Pond etc.). The collected water should be utilized for watering the mine area, roads, green belt development, plantation etc. The drains/ sedimentation sumps etc. shall be de-silted regularly, particularly after monsoon season, and maintained properly.	Complied	Five settling ponds three with dimensions approx. 4m x 4m x 3m each and other two with dimensions 20m x 15m x 6m and 15m x 12m x 5m respectively. Garland drain of 2 Km and retaining wall of 900m has been provided for collection of runoff. Coir mat of around 16000 sqm has been installed. Photos of garland drain, settling pond, Coir mat and rain water harvesting structure **ANNEXURE XIII**.
38	Check dams of appropriate size, gradient and length shall be constructed around mine pit and OB dumps to prevent storm run-off and sediment flow into adjoining water bodies. A safety margin of 50% shall be kept for designing of sump structures over and above peak rainfall (based on 50 years' data) and maximum discharge in the mine and its adjoining area which shall also help in providing adequate retention time period thereby allowing proper settling of sediments/ silt material. The sedimentation pits/ sumps shall be constructed at the corners of the garland drains.	Complied	Five settling ponds three with dimensions approx. 4m x 4m x 3m each and other two with dimensions 20m x 15m x 6m and 15m x 12m x 5m respectively. Garland drain of 2 Km and retaining wall of 900m has been provided for collection of runoff. Coir mat of around 16000 sqm has been installed. Photos of garland drain, settling pond, Coir mat and rain water harvesting structure **ANNEXURE XIII**.
39	The top soil, if any, shall temporarily be stored at earmarked site(s) within the mine lease only and should not be kept unutilized for long. The physical parameters of the top soil dumps like height, width and angle of slope shall be governed as per the approved Mining Plan and as per the guidelines framed by DGMS w.r.t. safety in mining operations shall be strictly adhered to maintain the stability of dumps. The topsoil shall be used for land reclamation and plantation purpose.	Complied	There is no top soil within the mine lease area. PP stated that top soil has been utilized in developing green belt.
	VII. Transportation		
40	No Transportation of the minerals shall be allowed in case of roads passing through villages/ habitations. In such cases, PP shall construct a 'bypass' road for the purpose of transportation of the minerals leaving an adequate gap (say at least 200 meters) so that the adverse impact of sound and dust along with chances of accidents could be mitigated. All costs resulting from widening and strengthening of existing public road network shall be borne by the PP in consultation with nodal State Govt. Department. Transportation of minerals through road movement in case of existing village/ rural roads shall be allowed in consultation with nodal State Govt. Department only after required strengthening such that the carrying capacity of roads is increased to handle the	Complied	No transportation of the minerals is allowed through the roads passing through villages/ habitations. Dispatch is done only through NH. PUC check are being done on regular basis.

	traffic load. The pollution due to transportation load on the environment will be effectively controlled and water sprinkling will also be done regularly. Vehicular emissions shall be kept under control and regularly monitored. Project should obtain Pollution Under Control (PUC) certificate for all the vehicles from authorized pollution testing centres.		
41	The Main haulage road within the mine lease should be provided with a permanent water sprinkling arrangement for dust suppression. Other roads within the mine lease should be wetted regularly with tanker-mounted water sprinkling system. The other areas of dust generation like crushing zone, material transfer points, material yards etc. should invariably be provided with dust suppression arrangements. The air pollution control equipment's like bag filters, vacuum suction hoods, dry fogging system etc. shall be installed at Crushers, belt-conveyors and other areas prone to air pollution. The belt conveyor should be fully covered to avoid generation of dust while transportation. PP shall take necessary measures to avoid generation of fugitive dust emissions.	Complied	Fixed water sprinkler of around 1.2 Km has been provided in part of the haul road. Water sprinkling are being doone along the haul road by two number of truck mounted tanker of reported capacity 50Kl and 16 KL Dust Suppression System (Dry fog system) has been provided at crusher and screening plant. Generation of fugitive dust emissions are controlled by regular water sprinkling on haul roads and mechanical road sweepers on concrete road, paved areas. Water sprinkling are being done on the haul road and vacuum sweeping on the national Highway to control fugitive dust.
	VIII. Green Belt		
42	The Project Proponent shall develop greenbelt in 7.5m wide safety zone all along the mine lease boundary as per the guidelines of CPCB in order to arrest pollution emanating from mining operations within the lease. The whole Green belt shall be developed within first 5 years starting from windward side of the active mining area. The development of greenbelt shall be governed as per the EC granted by the Ministry irrespective of the stipulation made in approved mine plan.	Complied	Approx. 12600 sampling has been planted during FY 2021-22 and FY: 2022-23 to develop green belt area in 5 Ha. Along with this 500 nos. of vetiver plantation has been done. Photos of plantation is attached as **ANNEXURE XVI**
43	The Project Proponent shall carryout plantation/ afforestation in backfilled and reclaimed area of mining lease, around water body, along the roadsides, in community areas etc. by planting the native species in consultation with the State Forest Department/ Agriculture Department/ Rural development department/ Tribal Welfare Department/ Gram Panchayat such that only those species be selected which are of use to the local people. The CPCB guidelines in this respect shall also be adhered. The density of the trees should be around 2500 saplings per Hectare. Adequate budgetary provision shall be made for protection and care of trees.	Complied	Approx. 12600 sampling has been planted during FY 2021-22 and FY: 2022-23 to develop green belt area in 5 Ha. Along with this 500 nos. of vetiver plantation has been done. Photos of plantation is attached as **ANNEXURE XVI**
44	The Project Proponent shall make necessary alternative arrangements for livestock feed by developing grazing land	Being complied	There is no grazing land within the mine lease area.

	with a view to compensate those areas which are coming within the mine lease. The development of such grazing land shall be done in consultation with the State Government. In this regard, Project Proponent should essentially implement the directions of the Hon'ble Supreme Court with regard to acquisition of grazing land. The sparse trees on such grazing ground, which provide mid-day shelter from the scorching sun, should be scrupulously guarded/ protected against felling and plantation of such trees should be promoted.		
45	The Project Proponent shall undertake all precautionary measures for conservation and protection of endangered flora and fauna and Schedule-I species during mining operation. A Wildlife Conservation Plan shall be prepared for the same clearly delineating action to be taken for conservation of flora and fauna. The Plan shall be approved by Chief Wild Life Warden of the State Govt.	Being complied	Site Specific conservation plan for schedule - 1 species was prepared and got approved from PCCF (WL) & Chief Wildlife Warden The approved budget of Rs. 288 lakhs (Rs. 92 lakhs for activities within the project area to be spent by the proponent + Rs. 196 lakhs for activities in the Project Impact Zone) is already deposited vide memo no-6260 Dated-04/09/2010 & deposited vide DD No–045122 (by HDFC BANK), dated 10th Sept 2010 with DFO, Bonai MS-CAMPA account to undertake activities both inside the project area & project impact area.
46	And implemented in consultation with the State Forest and Wild Life Department. A copy of Wildlife Conservation Plan and its implementation status (annual) shall be submitted to the Regional Office of the Ministry.	Complied	Copy of Wildlife Conservation Plan has been furnished to the Regional office.
	IX. Public hearing and human health issues		
47	The Project Proponent shall appoint an Occupational Health Specialist for Regular as well as Periodical medical examination of the workers engaged in the mining activities, as per the DGMS guidelines. The records shall be maintained properly. PP shall also carryout Occupational health check-ups in respect of Workers which are having ailments like BP, diabetes, habitual smoking, etc. The check-ups shall be undertaken once in six months and necessary remedial/ preventive measures be taken. A status report on the same may be sent to MoEFCC Regional Office and DGMS on half-yearly basis.	Complied	708.numbers of IME has been conducted for Narayanposhi Iron and Mn Ore mines. Regular checkup of BP, diabetes, habitual smoking, etc. are being carried out. IME form O are attached as **ANNEXURE XVIII**.
48	The Project Proponent must demonstrate commitment to work towards 'Zero Harm' from their mining activities and carry out Health Risk Assessment (HRA) for identification workplace hazards and assess their potential risks to health and determine appropriate control measures to protect the health and wellbeing of workers and nearby community. The proponent shall maintain accurate and systematic records of the HRA. The HRA for neighbourhood has to focus on Public Health Problems like Malaria, Tuberculosis, HIV, Anaemia, Diarrhoea in children under five, respiratory infections	Complied	Health Risk Assessment (HRA) for identification workplace hazards has been carried out.

	due to bio mass cooking. The proponent shall also create awareness and educate the nearby community and workers for Sanitation, Personal Hygiene, Hand washing, not to defecate in open, Women Health and Hygiene (Providing Sanitary Napkins), hazard of tobacco and alcohol use. The Proponent shall carryout base line HRA for all the category of workers and thereafter every five years.		
49	The Proponent shall carry out Occupational health surveillance which be a part of HRA and include Biological Monitoring where practical and feasible, and the tests and investigations relevant to the exposure (e.g. for Dust a X-Ray chest; For Noise Audiometric; for Lead Exposure Blood Lead, For Welders Full Ophthalmologic Assessment; for Manganese Miners a complete Neurological Assessment by a Certified Neurologist, and Manganese (Pin) Estimation in Blood; For Inorganic Chromium- Fortnightly skin inspection of hands and forearms by a responsible person. Except routine tests all tests would be carried out in a Lab accredited by NABH. Records of Health Surveillance must be kept for 30 years, including the results of and the records of Physical examination and tests. The record of exposure due to materials like Asbestos, Hard Rock mining, Silica, Gold, Kaolin, Aluminium, Iron, Manganese, Chromium, Lead, Uranium need to be handed over to the Mining Department of the State in case the life of the mine is less than 30 years. It would be obligatory for the State Mines Departments to make arrangements for the safe and secure storage of the records including X- Ray. Only conventional X-Ray will be accepted for record purposes and not the digital one). X-Ray must meet ILO criteria (17 x14 inches and of good quality).	Complied	708.numbers of IME has been conducted for Narayanposhi Iron and Mn Ore mines. The X-ray test, audiometry test , neurological test are being conducted. Only 12 employees are exposed to the manganese, whose records are being maintained.
50	The Proponent shall maintained a record of performance indicators for workers which includes (a) there should not be a significant decline in their Body Mass Index and it should stay between 18.5 - 24.9, (b) the Final Chest X-Ray compared with the base line X-Ray should not show any capacities ,(c) At the end of their leaving job there should be no Diminution in their Lung Functions Forced Expiratory Volume in one second (FEVI),Forced Vital Capacity (FVC), and the ratio) unless they are smokers which has to be adjusted, and the effect of age, (d) their hearing should not be affected. As a proof an Audiogram (first and last need to be presented), (e) they should not have developed any Persistent Back Pain, Neck Pain, and the movement of their Hip, Knee and other	Complied	The X-ray test, audiometry test, neurological test are being conducted. The employees have not developed any Persistent Back Pain, Neck Pain, and the movement of their Hip, Knee and other joints. Doctor’s undertaking is attached as **ANNEXURE XXVI**

	joints should have normal range of movement, (f) they should not have suffered loss of any body part. The record of the same should be submitted to the Regional Office, MoEFCC annually along with details of the relief and compensation paid to workers having above indications.		
51	The Projects Proponent shall ensure that Personnel working in dusty areas should wear protective respiratory devices and they should also be provided with adequate training and information on safety and health aspects.	Compied	Personnel working in dusty areas are provided with nose mask, safety glass and ear plug with proper safety training. Vocational training is being conducted by PP. Till now we have conducted 2522 nos. of vocational trainings.
52	Project Proponent shall make provision for the housing for workers/labours or shall construct labour camps within/outside (company owned land) with necessary basic infrastructure/ facilities like fuel for cooking, mobile toilets, mobile STP, safe drinking water, medical health care, crèche for kids etc. The housing may be provided in the form of temporary structures which can be removed after the completion of the project related infrastructure. The domestic waste water should be treated with STP in order to avoid contamination of underground water.	Complied	Provision of Toilets, drinking water, health care facilities has been developed for the workers and truck drivers. associated in mining operation. Labor camp has been provided with all basic amenities including 30 KL STP.
53	The activities proposed in Action plan prepared for addressing the issues raised during the Public Hearing shall be completed as per the budgetary provisions mentioned in the Action Plan and within the stipulated time frame. The Status Report on implementation of Action Plan shall be submitted to the concerned Regional Office of the Ministry along with District Administration.	Being Complied	Details of implementation of action plan prepared for addressing the issues raised during the Public Hearing has been attached as **ANNEXURE XXVII**.
	X. Corporate Environment Responsibility (CER)		
54	The activities and budget earmarked for Corporate Environmental Responsibility (CER) as per Ministry's 0. M No 22-65/20 17-IA. II (M) dated 01.05.2018 or as proposed by EAC should be kept in a separate bank account. The activities proposed for CER shall be implemented in a time bound manner and annual report of implementation of the same along with documentary proof viz. photographs, purchase documents, latitude & longitude of infrastructure developed & road constructed needs to be submitted to Regional Office, MoEF&CC annually along with audited statement.	Being Complied	Details of expenditure on Corporate Environmental Responsibility is attached as **ANNEXURE XXVII.**
55	Project Proponent shall keep the funds earmarked for environmental protection measures in a separate account and refrain from diverting the same for other purposes. The Year wise expenditure of such funds should be reported to the MoEF&CC and	Complied	An expenditure of Rs 2.00 Crduring the period of April 2021 to March 2022 has been incurred on dust suppression, fixed water sprinkling, online monitoring, water sprinkling on NH , OB Dump management etc.

	its concerned Regional Office.		
	XI. Miscellaneous		
56	The Project Proponent shall prepare digital map (land use & land cover) of the entire lease area once in five Years purpose of monitoring land use pattern and submit a report to concerned Regional Office of the MoEF&CC.	Complied	Land use land cover map based on drone image certified by ORSAC is attached as **ANNEXURE X.**
57	The Project Authorities should inform to the Regional Office regarding date of financial closures and final approval of the project by the concerned authorities and the date of start of land development work.	Agreed to comply	The project authority will inform to the regional officer regarding the date of final closure of the project.
58	The Project Proponent shall submit six monthly compliance reports on the status of the implementation of the stipulated environmental safeguards to the MOEFCC & its concerned Regional Office, Central Pollution Control Board and State Pollution Control Board.	Complied	Six-monthly compliance for the period Apr22 to Sep22 has been submitted to the Regional office vide letter no. JSW/S/CO/2022/840 dated 30/11/2022
59	A separate Environmental Management Cell' with suitable qualified manpower should be set-up under the control of a Senior Executive. The Senior Executive shall directly report to Head of the Organization. Adequate number of qualified Environmental Scientists and Mining Engineers shall be appointed and submit a report to RO, MoEF&CC.	Complied	Environment Management Cell (EMC) structure has been attached as **ANNEXURE XXVIII**
60	The concerned Regional Office of the MoEF&CC shall randomly monitor compliance of the stipulated conditions. The project authorities should extend full cooperation to the MoEF& CC officer(s) by furnishing the requisite data / information /monitoring reports.	Agreed Upon	Agreed to comply

Government of Odisha
Steel and Mines Department

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VESTING ORDER

No. 4212 /SM Dated the 30 May 2020
IV(B)SM-21/2020

Whereas a mining lease of the following description, which was held by M/s Aryan Mining & Trading Corporation Pvt. Ltd. (hereinafter referred to as the previous lessee) with validity period upto 31.03.2020 has been auctioned and M/s JSW Steel Ltd., has been declared as the preferred bidder of the said mine.

Description of the Mining Block

- Name of Mineral(s) – Iron & Manganese
- Name of Mining lease - Narayanposhi Iron & Mn Block.
- Address/location of mining lease - Village Koira, Kashira and Kathamala RF under Koira Tahasil of Sundergarh district.
- Area of lease – 347.008 hects (As per DGPS)/ 349.254 hects(As per ROR).

And whereas, a letter of intent bearing no 2288 dated 02.03.2020 has been issued in favour of the preferred bidder for grant of mining lease for the above mentioned mining block;

And whereas, in terms of section 8B(2) of the MMDR Act, 1957 read with rule 9A(4) of the Mineral (Other than Atomic and Hydrocarbon Energy Minerals) Concession Rules, 2016 [herein after called the Rules'2016], the holder of the letter of intent for the said mining block shall be deemed to have acquired all valid rights, approvals, clearances, licenses and the like vested with the previous lessee.

Now therefore, the undersigned being the Nodal Officer for the State of Odisha having been nominated under rule 9A(1) of the Mineral (Other than Atomic and Hydrocarbon Energy Minerals) Concession Rules, 2016 [herein after called the Rules,2016], do hereby, pursuant to the provisions contained in rule 9A(2) of the Rules,2016 order that all the valid rights, approvals, clearances, licenses and the like vested in the previous lessee in respect of the aforementioned mining block are deemed to have vested in favour of the holder of the letter of intent on the same terms and conditions of every rights, approvals, clearances, licenses, and the like which vested with previous lessee.

Without prejudice to the generality of the provisions of section 8B(2) of the MMDR Act, 1957, the details of the valid rights, approvals, clearances, licenses, and the like held by the previous lessee and vested in favour of the holder of the Letter of Intent are given in the Annexure-I to this order.

This vesting order is valid for a period of two years from the date of execution of lease deed or till the date of getting fresh approvals, clearances, licenses, permits, and the like, whichever is earlier

(**S. K. Popli**) 30/5/2020
Nodal Officer-cum-Special Secretary to Government

Memo No. 4213 / SM Dated: 30 May 2020

Copy to alongwith Annexure-I forwarded to M/s JSW Steel Ltd, JSW Centre, Bandra Kurla Complex, Bandra (East), Mumbai- 400051 for information and necessary action. It is requested that one copy each of the documents mentioned in the Annexure-I may be collected from the office of the Director Mines, Odisha, Bhubaneswar during office working hours.

Nodal Officer 30/5/2020

Memo No. 4214 /SM Dated: 30 May 2020

Copy to alongwith Annexure-I forwarded to M/s Aryan Mining & Trading Corporation Pvt. Ltd., Aryan House, 8th Floor, P1- Hide Lane, Kolkata- 700073 for information and necessary action.

Nodal Officer 30/5/2020

Memo No. 4215 / SM Dated: 30 May 2020

Copy alongwith Annexure-I forwarded to Indian Bureau of Mines, Bhubaneswar/ MoEF & CC, 534, Paryavaran Bhawan, CGO Complex, Lodhi Road, New Delhi 110003/ MoEF & CC (FC Divison), Indira Paryavaran Bhawan, Aliganj, Jorbagh Road, New Delhi 110003/ SPCB, Parivesh Bhawan, A/118, Nilakantha Nagar, Unit-VIII, Bhubaneswar, Odisha, 751012/ Director General of Mines Safety, Chaibasa Regiona, Chaibasa, 833201 /Ministry of Water Resource, River Development and Ganga Rejuvenation, West Block-2, Wing 3, Sector-1, R.K. Puram, New Delhi-110066 for information and necessary action.

Nodal Officer 30/5

Memo No. 4216 / SM Date: 30 May 2020

Copy alongwith Annexure-I forwarded to Director of Mines, Odisha, Bhubaneswar for information and necessary action. He is requested to provide one copy each of the documents described in the Annexure-I to the authorized representative of the LoI holder with proper acknowledgement and forward a copy of acknowledgement to the Department for record.

Nodal Officer
30/5

Memo No. 4217 / SM Date: 30 May 2020

Copy alongwith Annexure-I forwarded to Collector, Sundergarh/ Deputy Director of Mines, Koira / DFO, Bonai for information and necessary action.

Nodal Officer
30/5

Memo No. 4218 / SM Date: 30 May 2020

Copy alongwith Annexure-I forwarded to Forest and Environment Department/ PCCF(Nodal), Bhubaneswar for information and necessary action.

Nodal Officer
30/5

ANNEXURE-I

Name of the Block : **Narayanposhi Iron & Manganese ore Block**

LoI Holder : **JSW Steel Ltd.**

Area of the Lease : **349.254 Hects (As per ROR)**

347.008 hects (As per DGPS)

SL No	Nature of approval clearance etc	Issuing officer/authority	Reference No./ Date of Issue
1	Mining Plan	Regional Controller of Mines, Bhubaneswar, Govt. of India	MSM/FM/40/ORI/BHU/2015-16, Dated 02.06.2016
2	EC	MoEF & CC, Govt. of India	J-11015/288/2008-IA.II(M), Dtd 18.06.2019
3	FC	MoEF & CC, Govt. of India,	F. No. 8-34/2000-FC (Vol-I), Dtd. 15.11.2007 over 244.327 hects
4	Consent to Establish	State Pollution Control Board, Odisha	536/IND-II-CTE-6207, Dated 14.01.2019
5	Consent to Operate	State Pollution Control Board, Odisha	6785/IND-I-CON-2258, Dated 08.07.2019
6	Surface Right	District Collector, Sundargarh	Surface Right granted over 324.800 hects
7	Deep Hole Blasting & use of HEMM	Directorate General of Mines Safety, Chaibasa Region, Chaibasa, Govt. of India	[29020/45/2014/RC(SEZ)] No. 2410, Dated 23.12.2015
8	Ground Water Withdrawal	Member Secretary (CGWA), Central Ground Water Authority, Govt. of India	CGWA/NOC/MIN/REN/1/2019/5586 Dtd. 09.10.2019

1. Vesting of clearances/approvals/licences/permissions /rights as above does not have the effect of transfer of ownership of infrastructure established and the ore & minerals raised by the ex-lessee which shall be governed by the provisions of the rules 12(1)(gg) and 12(1)(hh) of the Minerals Concession Rules, 2016. However, on acquisition of such infrastructure from the ex-lessee and submission of evidence thereof, the new lessee may be vested with related clearances/ approvals etc at the relevant time.
2. Vesting of Forest Clearance is subject to payment of NPV as prescribed in letter dtd. 31.03.2020 of Government of India, Ministry of Environment, Forest & Climate Change.

30/5/ …

GOVERNMENT OF ODISHA
STEEL AND MINES DEPARTMENT
*****

ORDER

No. 1335 /SM, Dated 15.02.2022
IV(B)SM-21/2020

Whereas, in pursuance to the "invitation of bids for grant of Mining Lease for Iron ore" dated 06.12.2019 issued by the Government and subsequent auction held on dated 01.02.2020, M/s JSW Steel Ltd., the successful bidder has been granted a mining lease for Iron ore in respect of Narayanposhi Iron & Manganese ore block over an area of 347.008ha (as per DGPS) / 349.254ha (as per RoR) in village Koira, Kashira & Kathamala R.F. under tahasil Koira of Sundergarh district for the period of 50(Fifty) years as provided under section 8A, sub-section 2 of the Mines and Minerals Development and Regulation Act, 1957 vide order No.5425/SM dated 26.06.2020.

And whereas, the lease deed has been executed and registered by the lessee.

And whereas, the new lessee was vested with all the valid rights, approvals, clearances, licences and the like vested in the previous lessee for a period of 2 (Two) years vide vesting order No.4212/SM dated 30.05.2020, No.9815/SM dated 13.11.2020 & No.462/SM dated 13.01.2021.

And whereas, in the meantime section 8B of the MMDR Act, and Rule 9A of M.C. Rules, 2016 have been amended w.e.f. 28.03.2021 and 02.11.2021 respectively as noted below.

"8B (1); Notwithstanding anything contained in this Act or any other law for the time being in force, all valid rights approvals, clearances, licenses and the like granted to a lessee in respect of a mine (other than those granted under the provisions of the Atomic Energy Act, 1962 and the rules made thereunder) shall continue to be valid even after expiry or termination of lease and such rights, approvals, clearances, licenses and the like shall be transferred to and vested, subject to the conditions provided under such laws, in the successful bidder of the mining lease selected through auction under this Act."

"Rule 9A(1) in subrule (1), for "in respect of leases expiring under the provisions of sub-sections (5) and (6) of section 8A of the Act, within one week from the date of the notification of the minerals other than Atomic and Hydro Carbons Energy Minerals) Concession (Amendment) Rules, 2020" the words figure and letter, "for the purpose of issuing vesting order for transfer and vesting of all valid rights, approvals, clearances, licences and the like in accordance with sub section (1) of section 8B" shall be substituted,

Rule 9A (5); It shall be lawful for the new lessee to commence and continue mining operation on the land in which mining operations were being carried out by the pervious lessee, after the execution of the lease deed till expiry or termination of mining lease granted."

And whereas, the Director of Mines vide letter No.10120/DM dated 22.12.2021 has proposed to issue the modified vesting and transfer order in respect of Narayanposhi Iron & Manganese mining lease.

Now therefore, in partial modification of the orders as communicated vide vesting orders No.4212/SM dated 30.05.2020, No.9815/SM dated 13.11.2020 & No.462/SM dated 13.01.2021, the undersigned being the Nodal Officer for the State of Odisha having been nominated under rule 9A(1) of the Mineral (Other than Atomic and Hydrocarbon Energy Minerals) Concessions Rules, 2016 (herein after called the Rules 2016), do hereby, pursuant to the provisions contained in rule 9A(2) of the Rules, 2016 issue this order that all the valid rights, approvals, clearances, licences and the like vested in the previous lessee in respect of the aforementioned mining block are now deemed to have been vested and transferred in favour of the holder of the letter of intent on the same terms and conditions of every rights, approvals, clearances, licences and the like which vested with previous lessee till expiry or termination of mining lease granted.

15/2/2022

(Sri Deepak Mohanty)
Nodal Officer & OSD-cum-Special Secretary to Government

Memo No. 1336 **/ SM** **Dated:** 15.02.2022

Copy to forwarded to M/s JSW Steel Ltd, JSW Centre, Bandra Kurla Complex, Bandra (East), Mumbai-400051 for information and necessary action.

15/2/2022

Nodal Officer

Memo No. 1337 **/ SM** **Date:** 15.02.2022.

Copy forwarded to Director of Mines, Odisha, Bhubaneswar for information and necessary action.

15/2/2022

Nodal Officer

Memo No. 1338 **/ SM** **Date:** 15.02.2022

Copy forwarded to Collector, Sundergarh / DFO,Bonai / Deputy Director of Mines, Koira for information and necessary action.

15/2/2022

Nodal Officer

Memo No. 1339 **/ SM** **Date:** 15.02.2022

Copy forwarded to Forest and Environment Department / PCCF(Nodal), Bhubaneswar / Regional Controller of Mines, Indian Bureau of Mines, Bhubaneswar for information and necessary action.

15/2/2022

Nodal Officer

SUMMARY

OF

ENVIRONMENTAL MONITORING REPORT

(October 2022 TO March 2023)

FOR

NARAYANPOSHI IRON & MANGANESE ORE MINE

DISTRICT—SUNDARGARD, ODISHA

OF

M/S JSW STEEL LIMITED, ODISHA

ENV MONITORING CARRIED OUT

BY

ECOMEN LABORATORIES PVT.LTD

Ecomen Laboratories Pvt. Ltd.
(An approved Laboratory from MoEF & CC & NABL)
B-1/8, Sector-H, Aliganj, Lucknow 226 024 (U.P.)
Phone No.: (91-522) 2746282; Fax No.: (91-522) 2745726
E-mail: contactus@ecomen.in

Environmental Monitoring Report- Narayanposhi Iron & Manganese Ore Mine of M/s JSW Steel Limited, Odisha during the period (October 2022 to March 2023)

1. Ambient Air Quality Lease Area

Sl. No.	Location	Month	Concentration	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	SO_2 µg/m^3	NO_2 µg/m^3	CO mg/m^3
1.	Gate No-1	October'22	Maximum	55.2	29.5	16.4	26.0	0.95
			Minimum	42.6	16.1	9.0	12.0	0.31
			Average	42.8	21.5	12.4	18.5	0.59
		November'22	Maximum	64.2	23.4	15.8	21.5	0.71
			Minimum	49.3	14.6	9.3	13.2	0.40
			Average	58.3	18.8	12.6	17.5	0.58
		December'22	Maximum	62.5	22.6	14.2	21.4	0.62
			Minimum	43.5	14.6	8.2	10.7	0.36
			Average	55.6	18.2	11.1	15.7	0.49
		January'23	Maximum	56.3	20.4	16.3	20.4	0.56
			Minimum	41.6	14.2	9.3	10.2	0.39
			Average	49.8	17.2	12.0	14.2	0.48
		February'23	Maximum	49.5	16.5	16.6	15.3	0.49
			Minimum	40.3	11.2	11.6	10.5	0.31
			Average	45.9	13.7	13.9	12.7	0.42
		March'23	Maximum	56.7	17.9	15.9	18.9	0.6
			Minimum	51.1	14.1	13.1	15.1	0.48
			Average	53.9	16.1	14.5	16.8	0.54
		Oct'22	Maximum	76.8	30.2	17.3	15.3	0.89
			Minimum	39.6	16.0	10.3	10.3	0.30
			Average	57.9	22.2	13.0	12.5	0.62

Sl. No.	Location	Month	Concentration	PIlio µg/m³	PM2.5 µg/m³	SO2 µg/m³	NO2 µg/m³	CO mg/m³
2.	Near Babamath Area	Nov'22	Maximum	68.1	26.5	15.6	15.3	0.74
			Minimum	55.4	15.4	10.1	10.4	0.45
			Average	62.0	21.1	13.1	13.0	0.60
		Dec'22	Maximum	63.6	22.4	14.7	19.1	0.69
			Minimum	42.3	16.3	9.1	10.2	0.42
			Average	55.2	18.5	12.1	12.8	0.54
		Jan'22	Maximum	55.8	21.4	13.9	18.1	0.57
			Minimum	42.2	14.6	10.3	9.8	0.44
			Average	49.0	17.4	11.9	12.7	0.50
		Feb'22	Maximum	49.8	18.2	14.4	16.4	0.49
			Minimum	40.2	12.1	9.4	11.2	0.40
			Average	44.1	15.0	12.2	13.2	0.45
		Mar'22	Maximum	56.8	18.2	15.9	18.7	0.61
			Minimum	51.0	14.2	13.1	15.1	0.49
			Average	54.2	16.4	14.4	16.9	0.54
3.	Near Mines office	Oct’22	Maximum	60.3	30.5	16.0	19.0	0.89
			Minimum	45.2	14.6	10.3	11.7	0.30
			Average	53.3	22.1	12.9	16.0	0.59
		Nov’22	Maximum	60.3	27.4	15.2	15.9	0.65
			Minimum	51.5	13.4	10.4	11.5	0.48
			Average	56.9	19.4	12.9	13.3	0.57
		Dec’22	Maximum	62.5	24.2	13.7	14.5	0.61
			Minimum	40.5	15.4	9.8	9.4	0.41
			Average	52.8	19.7	11.9	12.4	0.50
		Jan’23	Maximum	56.0	21.4	14.2	14.5	0.55
			Minimum	42.2	15.3	10.2	10.1	0.39
			Average	48.8	18.3	12.0	12.2	0.46

Sl. No.	Location	Month	Concentration	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	SO_2 µg/m³	NO_2 µg/m³	CO mg/m³
		Feb'23	Maximum	48.3	18.5	13.4	14.9	0.49
			Minimum	40.2	12.5	10.1	10.3	0.40
			Average	43.7	15.0	12.3	12.1	0.44
		Mar'23	Maximum	56.6	18.2	15.9	19.2	0.61
			Minimum	51.3	14.1	13.2	15.3	0.48
			Average	54.3	15.9	14.3	17.3	0.55
4.	Rest Shelter	Oct'22	Maximum	80.3	35.0	17.6	36.3	0.84
			Minimum	52.5	18.3	11.0	11.8	0.25
			Average	63.6	27.6	13.5	17.5	0.60
		Nov'22	Maximum	74.8	27.1	18.3	22.4	0.69
			Minimum	52.1	16.2	10.6	10.5	0.45
			Average	62.9	22.6	13.7	15.2	0.56
		Dec'22	Maximum	64.9	23.8	15.1	20.2	0.6
			Minimum	41.5	13.2	10.1	11.2	0.38
			Average	55.1	18.5	12.2	14.6	0.52
		Jan'23	Maximum	58.2	21.8	14.1	19.2	0.59
			Minimum	42.1	12.7	10.1	10.2	0.39
			Average	51.6	17.5	12.1	13.9	0.51
		Feb'23	Maximum	49.3	17.5	14.1	15.3	0.49
			Minimum	40.2	11.3	10.1	9.7	0.39
			Average	43.7	14.1	12.5	12.5	0.44
		Mar'23	Maximum	56.9	17.9	15.7	18.9	0.61
			Minimum	51.3	14.2	13.0	15.2	0.50
			Average	54.4	16.1	14.4	17.3	0.55
CPCB Standard			**24 Hrly**	**100**	**60**	**80**	**80**	**4 (1Hrly)**

2. Ambient Air Quality Buffer Area

Sl. No.	Location	Month	Concentration	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	SO_2 µg/m³	NO_2 µg/m³	CO mg/m³
1.	Koira Basti	Oct'22	Maximum	66.4	24.4	14.4	18.3	0.84
			Minimum	56.4	19.4	11.3	14.2	0.48
			Average	60.8	22.0	12.8	16.0	0.66
		Nov'22	Maximum	68.3	21.6	14.1	15.7	0.65
			Minimum	58.5	17.2	10.5	11.3	0.44
			Average	62.4	19.9	12.9	13.6	0.57
		Dec'22	Maximum	67.6	22.1	15.9	14.7	0.61
			Minimum	52.1	18.3	10.6	11.2	0.46
			Average	61.3	19.7	12.8	13.0	0.53
		Jan'23	Maximum	58.7	20.1	14.9	14.5	0.59
			Minimum	42.1	17.3	10.3	10.9	0.44
			Average	52.2	18.6	12.4	12.6	0.53
		Feb'23	Maximum	49.2	16.3	16.4	13.5	0.48
			Minimum	40.7	11.2	12.3	10.1	0.41
			Average	45.4	13.4	14.9	11.7	0.44
		Mar'23	Maximum	56.3	17.8	16.1	18.9	0.59
			Minimum	51.2	14.3	13.1	15.5	0.48
			Average	54.2	16.0	14.4	17.6	0.54
		Oct'22	Maximum	62.3	27.0	13.4	19.4	0.63
			Minimum	48.6	16.4	11.2	12.9	0.39
			Average	56.0	21.5	12.3	15.5	0.52

NARAYANPOSHI IRON & MANGANESE ORE MINE

Sl. No.	Location	Month	Concentration	PM10 µg/m³	PM2.5 µg/m³	SO2 µg/m³	NO2 µg/m³	CO µg/m³
2.	Kashira Basti	Nov'22	Maximum	59.3	21.1	14.2	19.1	0.6
			Minimum	51.8	16.6	11.2	11.5	0.49
			Average	55.1	18.6	12.4	14.9	0.56
		Dec'22	Maximum	56.1	20.7	13.8	15.5	0.59
			Minimum	49.1	16.6	10.5	11.4	0.43
			Average	52.6	18.4	12.0	13.8	0.53
		Jan'23	Maximum	55.1	19.7	14.5	14.5	0.57
			Minimum	49.1	15.9	11.1	10.4	0.48
			Average	53.0	17.5	12.6	12.8	0.53
		Feb'23	Maximum	49.2	15.8	15.2	13.7	0.49
			Minimum	40.5	12.8	12.1	11.2	0.4
			Average	44.6	14.1	13.8	12.3	0.45
		Mar'23	Maximum	56.1	16.6	14.2	19.2	0.59
			Minimum	51.1	14.1	12.1	15.5	0.51
			Average	54.1	15.4	13.2	17.3	0.54
3.	Bhanjpali Village	Oct'22	Maximum	67.9	24.5	14.0	17.7	0.98
			Minimum	38.9	17.3	11.3	14.9	0.38
			Average	59.3	21.9	12.6	16.4	0.61
		Nov'22	Maximum	67.1	22.6	14.6	16.1	0.58
			Minimum	48.6	15.3	11.1	12.5	0.49
			Average	61.6	20.1	13.2	14.3	0.53
		Dec'22	Maximum	64.6	21.9	14.1	15.5	0.55
			Minimum	46.5	15.7	11.2	11.2	0.47
			Average	59.5	19.5	12.6	13.1	0.51
		Jan'23	Maximum	56.5	21.5	14.1	14.3	0.54
			Minimum	50.8	16.7	11.2	11.2	0.44
			Average	53.2	19.1	12.6	12.3	0.50

Sl. No.	Location	Month	Concentration	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	SO_2 µg/m³	NO_2 µg/m³	CO mg/m³
		Feb'23	Maximum	49.4	17.4	14.7	13.5	0.49
			Minimum	41.5	12.1	11.4	10.5	0.41
			Average	46.0	15.7	12.8	12.1	0.44
		Mar'23	Maximum	56.5	17.8	14.2	18.9	0.6
			Minimum	51.2	14.1	12.5	15.1	0.49
			Average	53.3	16.2	13.3	17.0	0.55
4.	Segasagi village	Oct'22	Maximum	57.9	21.1	15.1	19.8	0.6
			Minimum	42.1	17.0	12.0	13.6	0.38
			Average	52.0	19.9	13.1	16.2	0.54
		Nov'22	Maximum	59.1	21.7	14.1	14.7	0.61
			Minimum	49.8	16.5	11.9	11.6	0.41
			Average	54.5	19.2	13.0	12.9	0.52
		Dec'22	Maximum	55.4	20.9	13.5	15.7	0.6
			Minimum	44.4	16.3	11.2	11.6	0.39
			Average	52.0	18.5	12.6	13.2	0.50
		Jan'23	Maximum	48.6	19.9	14.5	14.7	0.52
			Minimum	42.2	15.3	10.8	10.6	0.38
			Average	44.6	17.5	12.3	12.8	0.47
		Feb'23	Maximum	45.9	15.1	16.6	14.7	0.48
			Minimum	40.1	10.6	11.3	10.5	0.4
			Average	43.1	12.8	13.4	12.1	0.43
		Mar'23	Maximum	56.8	16.8	13.9	18.7	0.59
			Minimum	51.5	13.8	12.3	15.2	0.49
			Average	53.9	15.2	13.0	17.2	0.53
			24 Hrly	**100**	**60**	**80**	**80**	**4 (1Hrly)**

3. Fugitive Emission Monitoring (μg/m³)

Sl. No.	Month	Screen Plant		Crusher Plant		Ore Storage & Loading Point	
		Max	Min	Max	Min	Max	Min
1.	Oct'22	954.0	692.0	932.0	609.0	956.0	570.7
2.	Nov'22	930.2	762.8	926.4	769.0	930.3	728.6
3.	Dec'22	915.3	515.2	907.5	501.5	899.5	507.3
4.	Jan'23	694.3	536.2	695.4	601.5	699.5	619.4
5.	Feb'23	589.9	502.2	586.7	517.3	593.7	502.6
6.	Mar'23	696.7	611.7	699.3	570.7	696.6	603.5
Six Month Average		**796.7**	**603.4**	**791.2**	**594.8**	**795.9**	**588.7**

Sl. No.	Month	Mines Haulage Road		Mines Face Bench		Waste Dump	
		Max	Min	Max	Min	Max	Min
1.	Oct'22	949.0	665.0	920.0	629.0	937.0	609.0
2.	Nov'22	939.9	691.4	923.4	723.4	919.9	815.2

3.	Dec'22	897.3	538.6	898.4	520.2	895.4	522.3
4.	Jan'23	697.3	535.6	698.4	523.8	696.5	562.3
5.	Feb'23	597.4	535.5	599.0	515.6	599.5	502.3
6.	Mar'23	698.4	604.1	697.4	606.2	697.7	605.5
Six Month Average		796.6	595.0	789.4	586.4	791.0	602.8

4. ILLUMINATION MONITORING (Lux)

	OCT 22		NOV 22		DEC 22	
LOCATION	**Horizontal**	**Vertical**	**Horizontal**	**Vertical**	**Horizontal**	**Vertical**
Workshop Area	52	70	73	60	60	117
Screen Plant	55	123	30	82	37	49
Haul Road	54	36	42	53	52	32
Loading Point	59	78	31	49	21	34
Crusher Plant	41	20	31	49	22	51
Parking Yard	56	40	54	83	25	42
Permanent Path	92	142	40	59	18	45
Electric Substation	71	55	62	101	32	67
Rest Shelter	8	12	7	3	32	22
Mines Bench Foot Path	33	14	27	34	38	47
	JAN 23		**FEB 23**		**MARCH 23**	
LOCATION	**Horizontal**	**Vertical**	**Horizontal**	**Vertical**	**Horizontal**	**Vertical**
Workshop Area	165.2	63.9	124.2	59.9	73	63.9
Screen Plant	59.4	13.1	120.4	171.1	30	13.1
Haul Road	46.4	37.7	38.4	86.7	42	37.7
Loading Point	21.3	30.7	31.3	45.7	31	30.7
Crusher Plant	67.1	34.5	68.1	43.5	31	34.5
Parking Yard	41.3	27.4	58.3	31.4	54	27.4
Permanent Path	38.7	23.5	29.7	26.5	40	23.5
Electric Substation	129.7	53.1	129.7	103.1	62	53.1
Rest Shelter	45.5	27.2	126.5	60.2	7	27.2
Mines Bench Foot Path	17.4	13.7	86.4	92.7	27	13.7

5. Noise Level {dB(A)}

A. Ambient Noise Monitoring

Location	OCT 22		NOV 22		DEC 22		Standards	
	Leq Day	Leq Night	Leq Day	Leq Night	Leq Day	Leq Night	Leq Day	Leq Night
KASHIRA BASTI	50.1	40.2	54.6	39.7	53.6	37.1	55 dB(A)	45 dB(A)
KOIRA BASTI	50	47	52.3	45.1	53.7	43.8	55 dB(A)	45 dB(A)
EAST BOUNDARY	65	64	63.9	57.1	64.2	55.1	75 dB(A)	70 dB(A)
WEST BOUNDARY	72	59	73.2	57.1	70.5	56.7	75 dB(A)	70 dB(A)
NORTH BOUNDARY	74	70	71.7	67.1	73.8	62.4	75 dB(A)	70 dB(A)
SOUTH BOUNDARY	72	52	72.6	50.7	69.3	48.2	75 dB(A)	70 dB(A)
Location	**JAN-23**		**FEB-23**		**MARCH-23**		**Standards**	
	Leq Day	Leq Night	Leq Day	Leq Night	Leq Day	Leq Night	Leq Day	Leq Night
KASHIRA BASTI	52.7	41.8	51.7	42.8	52.4	48.2	55 dB(A)	45 dB(A)
KOIRA BASTI	54.1	42.6	53.1	41.6	54.5	41.5	55 dB(A)	45 dB(A)
EAST BOUNDARY	62.1	58.4	61.1	59.4	63.9	58.4	75 dB(A)	70 dB(A)
WEST BOUNDARY	71.6	59.2	70.6	58.2	73.2	59.2	75 dB(A)	70 dB(A)
NORTH BOUNDARY	72.4	64.9	71.1	63.7	71.7	64.9	75 dB(A)	70 dB(A)
SOUTH BOUNDARY	67.1	49.7	68.1	50.7	72.6	49.7	75 dB(A)	70 dB(A)

B. Source Noise Monitoring

CORE ZONE	OCT-22				NOV-22			
	Week-1	Week-2	Week-3	Week-4	Week-1	Week-2	Week-3	Week-4
	Leq				Leq			
Magazine Area	70	70.5	58.4	62	72.6	71.7	69	69.3
ML Boundary Pillar No.1	55	62.2	61.2	67.2	70.4	69.6	71.9	72.4
Mile Face / Bench	71	72.4	65	66.9	71.7	68.1	68.9	72.5
Haulage Road	65	69.2	65.2	70.4	69.7	72.8	71.9	72.7
Crusher Plant	69	70.4	48.8	71	71.5	72.8	69.0	70.1
Screen Plant	58	69	67.2	68.2	68.5	71.2	72.2	68.2
Ore Storage & Loading Point	62	73.5	70.4	61.4	68.1	68.4	71.9	70.0
Waste Dump	75	65.2	65	67.6	71.2	72.2	68.6	69.5

CORE ZONE	DEC-22				JAN-23			
-	Week-1	Week-2	Week-3	Week-4	Week-1	Week-2	Week-3	Week-4
-	Leq				Leq			
Magazine Area	69.5	71.7	70.4	71.1	68.5	70.5	70.6	70.7
ML Boundary Pillar No.1	68.5	69.2	70.1	72.2	69	68.3	71.8	71.6
Mile Face / Bench	70.3	68.5	72.9	70.5	69.1	69.6	71.4	70.5
Haulage Road	69.6	71.6	72	72.2	70.8	69.4	69.1	69.4
Crusher Plant	71.3	68.9	70.7	68.5	72.2	70.7	72.3	72.1
Screen Plant	70.6	70.2	68.7	71.9	71.7	71.8	72.5	72.2
Ore Storage & Loading Point	72.1	69.7	72.7	69.1	70.4	68.6	70.6	69
Waste Dump	70.4	69.8	68.3	69.9	69.6	68.1	68.7	68.5
CORE ZONE	FEB-23				MARCH-23			
-	Week-1	Week-2	Week-3	Week-4	Week-1	Week-2	Week-3	Week-4
-	Leq				Leq			
Magazine Area	67.5	69.5	71.6	71.7	70.5	69.5	69	70.5
ML Boundary Pillar No.1	68	67.3	70.8	70.6	62.2	67.3	71.9	72.2
Mile Face / Bench	67.1	70.6	72.4	71.5	72.4	70.6	68.9	68.5
Haulage Road	71.8	68.4	70.1	70.4	69.2	68.4	71.9	71.9
Crusher Plant	70.2	71.7	69.3	69.1	70.4	71.7	69	69.1
Screen Plant	72.7	70.8	71.5	71.2	69	70.8	72.2	69.9
Ore Storage & Loading Point	69.4	69.6	71.6	72	73.5	69.6	71.9	70.6
Waste Dump	70.6	67.1	69.7	69.6	65.2	67.1	68.6	68.7

6. Surface Water Quality

NARAYANPOSHI IRON ORE MINE								
Karo River UpStream								
Parameter	**Units**	**OCT-22**	**NOV-22**	**DEC-22**	**JAN-23**	**FEB-23**	**MARCH-23**	**Limits for Stream Water Standards**
PH	-	6.85	6.87	6.85	6.7	6.74	6.82	6.5-8.5
Total Dissolved Solids	**mg/l**	218	192	218	184	194	185	1500
Chlorides	**mg/l**	20	22	20	28	20	30	600
Iron	**mg/l**	0.25	0.22	0.25	0.14	0.15	0.16	50
Fluorides	**mg/l**	0.36	0.33	0.36	0.3	0.34	0.27	1.5
BOD	**mg/l**	16	12	16	10	8	7	3
DO	**mg/l**	5.3	5.1	5.3	5	5.2	6.2	4
Karo River DownStream								

NARAYANPOSHI IRON & MANGANESE ORE MINE

Parameter	Units	OCT-22	NOV-22	DEC-22	JAN-23	FEB-23	MARCH-23	Limits for Stream Water Standards
PH	-	7.2	6.94	7.2	6.92	6.83	7.68	6.5-8.5
Total Dissolved Solids	mg/l	242	192	242	209	216	243	1500
Chlorides	mg/l	30	24	30	32	36	34	600
Iron	mg/l	0.27	0.27	0.27	0.24	0.27	0.26	50
Fluorides	mg/l	0.3	0.3	0.3	0.37	0.37	0.33	1.5
BOD	mg/l	20	16	20	12	14	10	3
DO	mg/l	5	5	5	4.8	4.5	6.8	4
Orhari Nala Upstream								
Parameter	**Units**	**OCT-22**	**NOV-22**	**DEC-22**	**JAN-23**	**FEB-23**	**MARCH-23**	**Limits for Stream Water Standards**
PH	-	6.55	6.35	6.59	6.65	6.71	6.57	6.5-8.5
Total Dissolved Solids	mg/l	148	147	148	165	182	187	1500
Chlorides	mg/l	20	20	20	20	20	16	600
Iron	mg/l	0.24	0.13	0.16	0.17	0.15	0.12	50
Fluorides	mg/l	0.24	0.23	0.24	0.31	0.3	0.26	1.5
BOD	mg/l	8.5	5	8.5	4	4.4	5.8	3
DO	mg/l	5.4	5.1	5.4	5.5	5.4	3.2	4
Orhari Nala Downstream								
Parameter	**Units**	**OCT-22**	**NOV-22**	**DEC-22**	**JAN-23**	**FEB-23**	**MARCH-23**	**Limits for Stream Water Standards**
PH	-	6.9	6.98	6.77	7.08	7.23	7.28	6.5-8.5
Total Dissolved Solids	mg/l	160	156	160	172	210	202	1500
Chlorides	mg/l	36	26	36	34	30	26	600
Iron	mg/l	0.24	0.17	0.2	0.19	0.22	0.23	50
Fluorides	mg/l	0.24	0.2	0.24	0.26	0.26	0.27	1.5
BOD	mg/l	14	10	14	8.5	9.4	8.2	3
DO	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	4
Manganese Quarry								
Parameter	**Units**	**OCT-22**	**NOV-22**	**DEC-22**	**JAN-23**	**FEB-23**	**MARCH-23**	**Limits for Stream Water Standards**
PH	-	6.55	6.91	7.1	6.44	6.49	6.42	6.5-8.5
Total Dissolved Solids	mg/l	148	129	133	154	166	165	1500
Chlorides	mg/l	20	22	34.2	20	20	21	600
Iron	mg/l	0.16	0.12	0.19	0.1	0.14	0.16	50

Fluorides	**mg/l**	0.24	0.21	0.25	0.25	0.24	0.21	1.5
BOD	**mg/l**	8.5	5.8	5.5	5.2	5.8	5.2	3
DO	**mg/l**	5.4	5.6	6.1	5.2	5	4.8	4
Kashira nala								
Parameter	**Units**	**OCT-22**	**NOV-22**	**DEC-22**	**JAN-23**	**FEB-23**	**MARCH-23**	**Limits for Stream Water Standards**
PH	**-**	6.8	6.77	6.82	6.65	6.57	6.72	6.5-8.5
Total Dissolved Solids	**mg/l**	236	259	236	198	190	231	1500
Chlorides	**mg/l**	32	12	32	16	18	12	600
Iron	**mg/l**	0.12	0.07	0.12	0.13	0.15	0.12	50
Fluorides	**mg/l**	0.35	0.3	0.35	0.36	0.35	0.32	1.5
BOD	**mg/l**	8	7	8	6	5.2	5.1	3
DO	**mg/l**	5	5.7	5	5.5	5.6	4.8	4

7. Surface Water Flow Rate

LOCATION NAME	OCT-22	NOV-22	DEC-22	JAN-23	FEB-23	MARCH-23
Karo River Upstream	0.58	0.59	0.57	0.52	0.65	0.62
Karo River Downstream	0.58	0.59	0.57	0.52	0.65	0.58
Orahari Nala Upstream	0.46	0.41	0.51	0.51	0.7	0.42
Orahari Nala Downstream	0.46	0.41	0.51	0.51	0.7	0.50
Kashira Nala Upstream	0.67	0.36	0.41	0.41	0.43	0.42
Kashira Nala Downstream	0.67	0.36	0.41	0.41	0.43	0.38

8. Ground Water Quality

Location		Bore well Near Gate No.2	Near 650 Crusher (PZ-2)	Kashira Village	Koira Basti
Parameter	**Units**	**NOV-22**			
PH	-	6.78	7.14	6.96	0.89
Total Hardness	**mg/l**	60	76	68	80
Iron	**mg/l**	0.1	0.12	0.13	0.11
Chlorides	**mg/l**	14	16	16	16
Total Dissolved Solids	**mg/l**	152	174	178	193
Sulphates	**mg/l**	13.2	19.2	15.4	16.7
Fluoride	**mg/l**	0.2	0.2	0.19	0.28

9. Drinking Water Quality

Near Mines Office									
Parameter	**Units**	**OCT-22**	**NOV-22**	**DEC-22**	**JAN-23**	**FEB-23**	**MARCH-23**	**Acceptable Limits**	**Permissible Limits**
PH	-	7.04	6.97	6.94	6.83	6.72	7.04	**6.5-8.5**	**No Relaxation**
Total Hardness	mg/l	72	64	60	64	56	70	**200**	**600**
Iron	mg/l	0.18	0.05	0.08	0.15	0.08	o.08	**1**	**No Relaxation**
Chlorides	mg/l	12	10	14	18	10	12	**250**	**1000**
Total Dissolved Solids	mg/l	156	167	154	138	166	154	**500**	**2000**
Sulphates	mg/l	17.2	15.1	17.8	16.2	14	17.1	**200**	**400**
Fluoride	mg/l	0.17	0.11	0.15	0.21	0.12	0.17	**1**	**1.5**

10. ETP Monitoring (Inlet & Outlet)

Parameter	**Units**	**OCT-22**	**NOV-22**	**DEC-22**	**JAN-23**	**FEB-23**	**MARCH-23**	**Acceptable Limits**
ETP Inlet								
pH	-	6.46	6.42	6.54	6.58	6.38	6.46	**6.5-9.0**
Total Suspended Solid as TSS	**mg/l**	78.8	82.2	76.9	76	88	82	**100.0**
Total Dissolved Solids as TDS	**mg/l**	613	683	662	645	748	452	**-**
Biochemical Oxygen Demand as BOD 3days at 27^{0}C	**mg/l**	40	42	43	38	44	38	**30.0**
Chemical Oxygen Demand as COD	**mg/l**	256	280	288	270	284	212	**250.0**
Oil & Grease as O & G	**mg/l**	7.78	7.9	8.5	7.4	8	7.21	**10.0**
Parameter	**Units**	**OCT-22**	**NOV-22**	**DEC-22**	**JAN-23**	**FEB-23**	**MARCH-23**	**Acceptable Limits**
ETP Outlet								
pH	**-**	7.18	7.22	7.33	7.32	7.49	7.22	**6.5-9.0**
Total Suspended Solid as TSS	**mg/l**	37.3	29.1	32.9	26.6	28.8	26.1	**100.0**
Total Dissolved Solids as TDS	**mg/l**	567	590	613	620	652	412	**-**
Biochemical Oxygen Demand as BOD 3days at 27^{0}C	**mg/l**	18	15	17	16	14	14	**30.0**
Chemical Oxygen Demand as COD	**mg/l**	164	148	156	132	124	110	**250.0**
Oil & Grease as O & G	**mg/l**	BDL	BDL	BDL	BDL	BDL	BDL	**10.0**

11. Soil Monitoring

Sl. No.	Parameters	Unit	kashira	segasahi	back side mines office	dump 2/ magazine area
1.	pH	-	6.42	4.94	4.89	5.59
2.	Electrical Conductivity	µmhos/cm	104	34.06	65	45
3.	Total Soluble Solid	mg/kg	163	149	101	126
4.	Nitrogen (N)	mg/kg	192	245	153	207
5.	Av. Phosphorous (P_2O_5)	kg/ha	22	37.2	18.6	38.2
6.	Av. Potassium (K_2O)	mg/kg	168	286	169	266
7.	Av. Sodium (Na_2O)	mg/kg	138	105	98.6	86
8.	Av. Calcium as Ca	mg/kg	656	1320	716	820
9.	Av .Magnesium as Mg	mg/kg	204	436	148	240
10.	Chloride (Cl)	mg/kg	22	40	56	40
11.	Copper (Cu)	mg/kg	0.92	0.49	0.12	0.16
12.	Zinc (Zn)	mg/kg	0.99	1.01	0.19	0.27
13.	Iron (Fe)	mg/kg	17.23	18.55	5.88	6.45
14.	Manganese (Mn)	mg/kg	27.67	17.88	1.63	11.99
15.	Organic Carbon	%	0.29	0.33	0.16	0.18
16.	Sodium Absorption ratio (SAR)	-	0.44	0.64	0.31	0.24
17.	Grain Size Distribution					
a	Textural Class	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
b	Sand	%	63	52	65	62
c	Silt	%	27	30	20	20
d	Clay	%	10	18	15	18

12. Vibration Monitoring

Sl no.	Station Name	Instrument location	Season (Summer/Winter/Monsoon/post monsoon	Peak particle velocity	Air Over pressure	Frequency	Remark
1	RF Quarry	Mines view point	autumn	3.15mm/s	128.0dbl@0Hz/.0145kpa	3.8Hz	Permisible limit
2	RF Quarry(RL-621)	Mines view point	autumn	22.15mm/s	88.0dbl@0Hz/.0005kpa	128.0Hz	Permisible limit
3	Quarry-4	Rest shelter	Winter	8.42mm/s	133.3dbl@32Hz/.927kpa	26.9Hz	Permisible limit
4	RF Quarry	Mines rest shelter	Winter	7.66mm/s	128.0dbl@8.3Hz/.05kpa	7.9Hz	Permisible limit

Verified By

Vikaskumar

Technical Manager

Authorized By

Reena

Quality Manager

Ecomen Laboratories Pvt. Ltd.
Second Floor Hall, House No. B-1/8,
Sector-H, Aliganj, Lucknow-226024

----End of Report----

WHEEL WASHING

JSW Steel Limited

Regd. Office: JSW Centre
Bandra Kurla Complex,
Bandra (East), Mumbai – 400 051
CIN : L27102MH1994PLC152925
Phone : +91 22 4286 1000
Fax : +91 22 4286 3000
Website : www.jsw.in

No. JSW/S/O/2022/364

Date: 31/05/2022

To,
The Member Secretary
State Pollution Control Board, Odisha,
Paribesh Bhawan, A/118, Nilakantha Nagar, Unit-8,
BHUBANESWAR- 751012

Sub: - Submission of 9 Points NEERI Compliance Status Report of FY 2021-22 for **Narayanposhi Iron & Manganese Ore Mine of M/s JSW Steel Ltd.**

Ref: - 1. Vested Consent Order No 1008 vide letter no 6785/IND-I-CON-2258, dated 08.07.2019
2. New Consent Order No 2944 vide letter no 4987/IND-I-CON-2258 dated 29.03.2022.

Dear Sir,

With reference to aforesaid subject, please find enclosed herewith the 9 Points NEERI Compliance Status Report of FY 2021-22 for **Narayanposhi Iron & Manganese Ore Mine of M/s JSW Steel Ltd**.

Seeking your co-operation as always.

Thanking you,

Yours Faithfully
For JSW Steel Ltd

Baswaraj M Dalgade
(Authorized Signatory)

Encl: As above

Copy to- The Regional Officer, Regional Office, Rourkela, Office of the State Pollution Control Board, Rourkela Town Engineering Office Premises, Sector – 5, Rourkela – 769 002, Odisha

NEERI REPORT COMPLIANCE STATUS –NARAYANPOSHI MINE

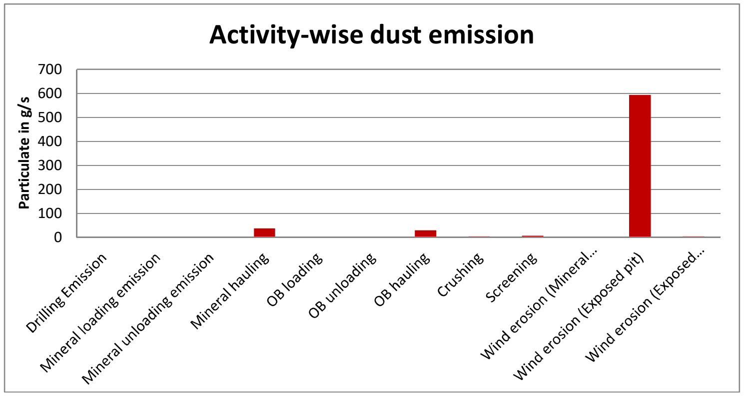
Sl. No.	Recommendation by CSIR-NEERI	Action Taken
1	The individual lease holders shall make assessment and quantification of emission load generation (in terms of air pollution, noise, wastewater and solid waste) from each of the mining activity (including transportation) for the period starting from 1st April to 31st March and submit report by June of every year. Efforts should be made to further eliminate/ minimize generation of air pollution/ dust, noise, wastewater, solid waste generation in successive years through use of better technology. Necessary guidance many be sought from Regional Officer, SPCB on load calculation.	The project has already been practicing different environmental safeguard measures for prevention of the air pollution. The measures are- 1. Mobile water sprinkling arrangement has been provided for the haul roads, processing area and loading / unloading points to minimize dispersion of air borne dust particles. 2. Existing Fixed water sprinkling being maintained and operated. 3. Wet drilling arrangement with acoustic enclosure is in practice to control dust right at the source. 4. Dust Suppression System (Dry fog system) being provided at all appropriate places of mineral handling plants (crusher & screening plant) and other areas. Same are being maintained for proper dust control. Regular Monitoring of ambient air quality parameters being carried out through M/s BS Envi tech. Monitoring reports of FY 2021-22 were submitted in your good office vide our letter dated 31.05.2022. 5. No process water being discharged from the mine. Regular Monitoring of water quality parameters being carried out and Monitoring reports of FY 2021-22 were submitted in your good office vide our letter dated 31.05.2022. 6. Noise producing equipment's are covered as far as practicable. Workers engaged in Operations are provided with ear plugs / muffs. Besides this, acoustic enclosures are provided for all machines operating within the mines. Regular Noise Monitoring being carried out and Monitoring reports of FY 2021-22 were submitted in your good office vide our letter dated 31.05.2022. 7. The overburden generated as solid waste is stacked at the earmarked areas and are covered by Coir matting. Additional coir-matting is being done as per requirement which will be followed by tree plantation after arrival of monsoon. 8. The vehicles carrying the loaded materials are being covered with tarpaulin.

		9. Annual Assessment and quantification of emission load generation (in terms of air pollution, noise, waste water and solid waste) as per prescribed standards is enclosed as **Annexure 1.**
2	Monitoring of ambient air and fugitive emission in core zone shall be carried out on daily basis. Minimum four ambient air quality monitoring stations shall be installed in the core zone. Out of four, at least one on-line monitoring station shall be installed in case of mines having EC capacity of 3 MTPA of more. Moreover, one station should be located near the ore carrying truck entry and exit gate of mine. A letter in this regard has already been communicated to individual lease holder of capacity 3 MTPA and above vide Board's Letter no-7807, dt. 30.06.2018.	Regular monitoring of ambient air and fugitive emission is being carried out through M/s BS Envitech P Ltd. and Monitoring reports of FY 2021-22 were submitted in your good office vide our letter dated 31.05.2022. We have installed Three Continuous Ambient Air Quality Monitoring Stations (CAAQMS) and Digital Display Board in consultation with Regional Officer, Keonjhar. All 3 CAAQMS are equipped with data transfer facility to SPCB and we have authorized Phoenix Robotix Pvt. Ltd. (Datoms) for transmitting data to OSPCB and already completed the necessary setup for data transfer from all 3 locations to OSPCB Server.
3	Monitoring in buffer zone shall be carried out by through NABET accredited agency preferably, at locations of nearest human habitation including schools and other public amenities located nearest to source of dust generation as applicable. The monitoring station shall be installed in core and buffer zone in consultation with Regional Officer, SPCB.	Regular Monitoring in buffer zone is being carried out at locations of nearest human habitation (residential area) engaging an NABET Accredited laboratory (B.S Envi Tech P. Ltd, Hyderabad). Monitoring reports of FY 2021-22 were submitted in your good office vide our letter dated 31.05.2022.
4	Monitoring stations shall be facilated for measurement of CO as an additional parameter to the other parameters SPM, PM_{10}, $PM_{2.5}$, SO_2 and NO_2. The monitoring result shall be compiled and submitted to Board on annual basis.	Regular Monitoring of CO as an additional parameter being carried out along with other AAQ data. Monitoring reports of FY 2021-22 were submitted in your good office vide our letter dated 31.05.2022.
5	All the vehicles engaged in mining and transporting activity in the mine shall have Pollution under Control (PUC) certificate. A record of the same shall be maintained for verification of inspecting agency.	Mineral carrying trucks are not allowed to go out of the lease area without tarpaulin cover and is being monitored by security personnel at the exit gate. Similarly, Security personnel are also do not allow the vehicles to enter into the mines without having valid PUC.
6	Noise level should be monitored near the major sources of noise generation within the core zone once in week and	Weekly Noise monitoring is being carried out through M/s BS Envitech P Ltd. (Accredited Laboratory). Monitoring reports of FY 2021-22

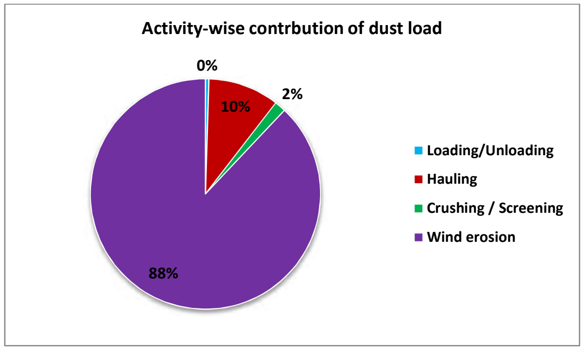
	submit the report annually. Further, date, time and distance of measurement shall also be indicated with the noise levels in the report. The data shall be used to map the noise generation from different activities and efforts should be made to maintain the noise levels with the acceptable limits of CPCB. The monitoring schedule shall be informed to Regional Officer, SPCB in order to ensure his presence 25% of the monitoring programme.	were submitted in your good office vide our letter dated 31.05.2022.
7	Measurement of flow rate of the springs and perennial nallah passing through the mining lease area shall be done on monthly basis. Identification of the perennial streams to be brought under the monitoring programme and the location the flow measurement shall be determined in consultation with Regional Officer, SPCB. The consolidated report shall be submitted to Board on annual basis.	No natural watercourse and water resources are obstructed due to mining operations & the same will be taken care of. Monitoring of flow rate measurement of the different water bodies is being carried out through M/s BS Envitech P Ltd. Monitoring reports of FY 2021-22 were submitted in your good office vide our letter dated 31.05.2022.
8	Effort shall be made to recycle or reuse the treated waste water from ETP of work shop and STP of residential colony instead of discharging to outside.	No colony provided in the working lease area. STP will be provided during colony construction. Workshop with Oil & Grease trap system will be provided in the mine area.
9	Annual environmental sustainability report (ESR) shall be made highlighting the efforts made towards environmental protection with respect to different environmental components vis-à-vis production performance of the mine on monthly basis. The data collected as per EC and CTE/CTO conditions should be utilized to prepare the annual sustainability report. The report shall be submitted to SPCB and RO, MoEF&CC by June of every year.	Narayanposhi Mine started operations since July 2020. Annual environmental sustainability report (ESR) is enclosed as **Annexure 2.**

RESULTS OF DUST LOAD CALCULATIONS

	Particulate matter in (g/s)	Particulate matter in (kg/d)	Particulate matter (kg per ton of ore)
Drilling Emission	0.06679882	5.771418206	0.000363273
Mineral loading emission	1.75785308	151.8785065	0.00955977
Mineral unloading emission	0.43629357	37.6957648	0.002372705
Mineral hauling	38.4323932	3320.558774	0.209007703
OB loading	0.70290758	60.73121467	0.003822637
OB unloading	0.46745375	40.38800417	0.002542164
OB hauling	29.6218769	2559.330164	0.161093284
Crushing	4.07407407	352	0.022156124
Screening	6.66666667	576	0.036255475
Wind erosion (Mineral stack)	2.00442273	173.1821241	0.010900695
Wind erosion (Exposed pit)	593.724994	51297.83944	3.228867279
Wind erosion (Exposed OB dump)	3.40762734	294.4190019	0.018531772
Total	**681.3634**	**58869.794**	**3.7054729**



Major Activity	Dust load (kg/day)
Loading/Unloading	290.69349
Hauling	5879.88894
Crushing / Screening	928
Wind erosion	51765.4406



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Annual Environmental Sustainability Report (ESR) for Narayanposhi Iron & Manganese Ore Mine of M/s JSW Steel Ltd.

Introduction-

The Narayanposhi Iron and Manganese Ore mine (erstwhile lessee M/s Aryan Mining & Trading Corporation Pvt. Limited) was one of the mines whose lease expired on 31.03.2020. The lease area is located in villages Harischandrapur, Koira, Kashira, Kusumdihi and Kathamala RF villages under Koira tehsil of Sundergarh district, Odisha state.

In pursuant to the Mines and Minerals (Development and Regulation) Act, 1957 and the Mineral (Auction) Rules, 2015, Govt. of Odisha issued the notice inviting tender dated December, 2019 for commencement of the auction process to grant the mining lease in respect of Narayanposhi Iron & Manganese Ore Block over an area of 349.254 Ha as per ROR (347.008 Ha as per DGPS computation) in villages Harischandrapur, Koira, Kashira, Kusumdihi and Kathamala RF of Sundargarh District, Odisha for a resource size of about 186.05 Million tonnes (Mt). The e-auction process was conducted in accordance with the tender document and the mineral auction rule, 2015 for the said mineral block and M/s JSW Steel Limited was declared as the preferred bidder under Rule 9(9)(iii) of Mineral (Auction) Rules 2015.

Without prejudice to the generality of the provisions of section 8B(2) of the MMDR Act, 1957, the details of the valid rights, approvals, clearances, licenses and the like held by the previous lessee are vested in favor of M/S JSW Steel Ltd by the Govt. of Odisha for a period of 2 years from the date of execution of lease deed or till the date of getting fresh approvals, clearances, licenses, permits, and the like, whichever is earlier vide order No-4212/SM, dated **30.05.2020**. M/s JSW Steel Limited being successful bidder upon execution of mining lease deed, the successful bidder shall immediately, but not later than one hundred twenty days from the date of execution of mining lease, apply afresh for all necessary rights, approvals, clearances, licenses and the like under the applicable statutes, rules or regulations, as the case may be, for obtaining the necessary clearances to enable further continuance of the mining operations beyond two years and vesting order shall be valid for a period of two years from the date of execution of new lease deed or till the date of getting all fresh approvals, clearances, licenses, permits, and the like, whichever is earlier.

On 10.06.2020, JSW has deposited INR 19,30,88,250/- towards the Advance Net Present Value [NPV] in CAMPA against the demand note raised by DFO, Bonai, Sundargarh District. The Mining Lease was granted in favor of M/s JSW Steel Limited for a period of 50 years w.e.f 26.06.2020. Subsequent to signing of the MDPA with the Collector, Sundargarh**, M/s JSW Steel Limited** has made payment of the third instalment being the eighty percent of the upfront value and executed and registered the mining lease with the Government of Odisha on 27.06.2020.

Indicative Coordinates Range of the Narayanposhi Iron & Manganese Ore Mine

Latitudes	:	21°54’46.07” N - 21°56’23.13” N
Longitudes	:	85°13’41.16” E - 85°14’56.56” E

Fully mechanized open cast method of mining by drilling and blasting and by deploying HEMM equipment’s like hydraulic drills and excavators, wheel loaders, dumpers, will be undertaken. The height and width of the benches for iron ore will be kept at 9 m and 15 m respectively. The working of benches will be commenced from top and extended to bottom benches. The excavated ROM ore is proposed to be processed in the crushing and screening plants to obtain the lump and fine ore as product mix. The iron ore lumps and iron ore fines extracted from the mine will be transported through railway/port/road to JSW Steel Plants.

Production in FY 2021-22

Narayanposhi mining operations started from 01.07.2020 based on the vested approvals. From April 2021 to March 2022, Narayanposhi Mine has produced 5794096.00 Mt Iron Ore (ROM) & 4754.284 Manganese Ore and same are dispatched to steel plants.

Environment Management in Narayanposhi Mine

Air Management-

Blasting Operation

- Controlled blasting method is in practice by restriction of explosive charge in the holes.
- Well-designed blast by effective stemming and use of mili second delay detonators, Proper blasting designing to see that the optimum breakage occurs.
- To control ground vibrations and arrest fly rocks, advanced initiation system is being used for blasting
- Ground vibrations are also being monitored and the results are well within limits.

Excavation, Hauling and Crushing & Screening

- Dry fog system for crusher & screen plants are provided.
- Proper maintenance of HEMM
- Using sharp teeth for shovels and other soil excavation equipment, and their periodical replacements.
- Acoustic enclosures for operator cabin.
- Avoiding overloading of dumpers
- Provision of dust filters / masks to workers working at highly dust prone and affected areas
- Imparting sufficient training to operators on safety and Environmental parameters.

Transportation

- Regular water sprinkling is being carried out by engaging mobile water tankers on the mine benches, mine haul, loading and unloading points and transfer points for dust suppressions.
- Maintenance of haul road by regular grading is carried out through grader, dozer.
- Ensuring that all mineral trucks are covered by tarpaulin.
- Vehicular emissions controlled through regular and proper preventive maintenance schedules.
- It is ensured that there is no overloading of trucks by having Quick Dispatch system at the weigh bridge near the dispatch gate.
- Regular water sprinkling arrangements have been made on the transportation roads/public road through mobile water tankers.

Wet Drilling and Dust Extractor System in Drilling Operation

Quick Dispatch System

Existing Fixed Sprinkling System

Water Tanker Arrangement For Haul Road Dust Suppression

Dry Fog System in Mineral Handling Plants

Consolidated Air Quality Monitoring Data of FY 2021-2022

NARAYANPOSHI IRON ORE MINES										
AAQ DATA FOR THE PERIOD APRIL 2021 TO MARCH 2022										
	PM10 [µg/m3]		**PM2.5 [µg/m3]**		**SO2 [µg/m3]**		**NO2 [µg/m3]**		**CO [mg/m3]**	
	Maximum	**Minimum**	**Maximum**	**Minimum**	**Maximum**	**Minimum**	**Maximum**	**Minimum**	**Maximum**	**Minimum**
CORE ZONE										
Near Mines Office	78	30	30	11	12.1	7.5	13.7	8.9	0.71	0.25
Near 50 TPH	79	48	28	15	13.1	9	14.9	10.3	0.66	0.13
Workshop Area	87	59	33	21	13.2	9.7	14.8	11.2	0.77	0.36
Gate No-02	91	35	35	11	13.1	9.3	14.5	10.7	0.82	0.4
Gate No-01	93	35	35	12	13.6	8.8	14.7	10.4	0.83	0.37
Rest Shelter	81	31	31	11	12.4	8.3	13.7	9.8	0.79	0.37
Near Baba Math Area	73	34	26	11	11.9	8.5	13.3	9.9	0.67	0.32
BUFFER ZONE										
KASIRA BASTI	70	34	27	11	11.7	8.2	13.1	9.8	0.69	0.31
KOIRA BASTI	73	38	28	13	12.8	8.9	14.4	10.3	0.73	0.41
SEGASAHI VILLAGE	68	30	26	11	11.6	7.5	13.3	8.8	0.62	0.25
BHANJPALI VILLAGE	73	35	27	12	12.1	7.9	13.7	9.3	0.71	0.33
NAAQ standards for Industrial, residential, Rural and Other Areas (24 hourly standard)	**100 [µg/m3]**		**60 [µg/m3]**		**80 [µg/m3]**		**80 [µg/m3]**		**2 [mg/m3] (8 hourly)**	

Water & OB Dump Management

- Garland drains maintained of suitable size around mine area and dump with proper gradients to prevent rain water descent into active mine area.
- Settling ponds maintained to prevent flow of fine particles from OB / Waste dumps, check dams, parapet / retaining walls & garland drains.
- Usage of stored water in the settling ponds for watering of haul roads, vehicle washing and green belt development etc.
- De- silting of garland drains & settling ponds are being carried out at regular intervals.
- Maintenance of all the runoff management structures.

Retaining Wall

Settling Pond

Dump Plantation

Consolidated Ground Water Quality Monitoring Data of FY 2021-2022

NARAYANPOSHI IRON & Mn ORE MINES					
Dugwell at Koira Basti					
Parameter	**Units**	**Max**	**Min**	**Acceptable Limits**	**Permissible Limits**
PH	-	6.92	6.77	**6.5-8.5**	**No Relaxation**
Total Hardness	mg/l	76	60	**200**	**600**
Iron	mg/l	0.09	0.07	**1**	**No Relaxation**
Chlorides	mg/l	64	56	**250**	**1000**
Total Dissolved Solids	mg/l	252	220	**500**	**2000**
Sulphates	mg/l	32	27	**200**	**400**
Fluoride	mg/l	0.41	0.37	**1**	**1.5**
Dugwell at Kasira Basti					
Parameter	**Units**	**Max**	**Min**	**Acceptable Limits**	**Permissible Limits**
PH	-	6.86	6.81	**6.5-8.5**	**No Relaxation**
Total Hardness	mg/l	120	90	**200**	**600**
Iron	mg/l	0.09	0.07	**1**	**No Relaxation**
Chlorides	mg/l	64	58	**250**	**1000**
Total Dissolved Solids	mg/l	300	264	**500**	**2000**

Sulphates	mg/l	39	36	**200**	**400**
Fluoride	mg/l	0.47	0.42	**1**	**1.5**
Site Services Area (Piezometer-1)					
Parameter	**Units**	**Max**	**Min**	**Acceptable Limits**	**Permissible Limits**
PH	-	6.92	6.77	**6.5-8.5**	**No Relaxation**
Total Hardness	mg/l	76	60	**200**	**600**
Iron	mg/l	0.09	0.07	**1**	**No Relaxation**
Chlorides	mg/l	64	56	**250**	**1000**
Total Dissolved Solids	mg/l	252	220	**500**	**2000**
Sulphates	mg/l	32	27	**200**	**400**
Fluoride	mg/l	0.41	0.37	**1**	**1.5**
Near 650 Crusher (Piezometer-2)					
Parameter	**Units**	**Max**	**Min**	**Acceptable Limits**	**Permissible Limits**
PH	-	6.94	6.83	**6.5-8.5**	**No Relaxation**
Total Hardness	mg/l	86	76	**200**	**600**
Iron	mg/l	0.12	0.09	**1**	**No Relaxation**
Chlorides	mg/l	71	62	**250**	**1000**
Total Dissolved Solids	mg/l	292	285	**500**	**2000**
Sulphates	mg/l	41	34	**200**	**400**
Fluoride	mg/l	0.49	0.43	**1**	**1.5**
Crusher Plant Area (Piezometer-3)					
Parameter	**Units**	**Max**	**Min**	**Acceptable Limits**	**Permissible Limits**
PH	-	6.94	6.83	**6.5-8.5**	**No Relaxation**
Total Hardness	mg/l	86	76	**200**	**600**
Iron	mg/l	0.12	0.09	**1**	**No Relaxation**
Chlorides	mg/l	71	62	**250**	**1000**
Total Dissolved Solids	mg/l	292	285	**500**	**2000**

Sulphates	mg/l	41	34	**200**	**400**
Fluoride	mg/l	0.49	0.43	**1**	**1.5**

Consolidated Surface Water Quality Monitoring Data of FY 2021-2022

NARAYANPOSHI IRON & Mn ORE MINES				
Orahari Nala UpStream				
Parameter	**Units**	**Max**	**Min**	**Limits for Stream Water Standards**
PH	-	6.92	6.63	**6.5-8.5**
Total Dissolved Solids	mg/l	158	82	**1500**
Chlorides	mg/l	30	9.1	**600**
Iron	mg/l	0.26	0.12	**50**
Fluorides	mg/l	0.2	0.1	**1.5**
BOD	mg/l	8	2	**3**
DO	mg/l	5.6	4.2	**4**
Orahari Nala DownStream				
Parameter	**Units**	**Max**	**Min**	**Limits for Stream Water Standards**
PH	-	6.89	6.72	**6.5-8.5**
Total Dissolved Solids	mg/l	194	98	**1500**
Chlorides	mg/l	40	12	**600**
Iron	mg/l	0.36	0.19	**50**
Fluorides	mg/l	0.28	0.14	**1.5**

BOD	mg/l	12	4	**3**
DO	mg/l	5.1	4.1	**4**
Karo River UpStream				
Parameter	**Units**	**Max**	**Min**	**Limits for Stream Water Standards**
PH	-	6.75	6.42	**6.5-8.5**
Total Dissolved Solids	mg/l	166	94	**1500**
Chlorides	mg/l	30	8.2	**600**
Iron	mg/l	0.24	0.1	**50**
Fluorides	mg/l	0.2	0.11	**1.5**
BOD	mg/l	7	2	**3**
DO	mg/l	5.9	5.2	**4**
Karo River DownStream				
Parameter	**Units**	**Max**	**Min**	**Limits for Stream Water Standards**
PH	-	6.85	6.69	**6.5-8.5**
Total Dissolved Solids	mg/l	205	118	**1500**
Chlorides	mg/l	40	12	**600**
Iron	mg/l	0.29	0.19	**50**
Fluorides	mg/l	0.23	0.12	**1.5**
BOD	mg/l	9	4	**3**
DO	mg/l	5.3	4.8	**4**
Kasira Nala				
Parameter	**Units**	**Max**	**Min**	**Limits for Stream Water Standards**

PH	-	6.82	6.58	**6.5-8.5**
Total Dissolved Solids	mg/l	186	124	**1500**
Chlorides	mg/l	27	13	**600**
Iron	mg/l	0.2	0.1	**50**
Fluorides	mg/l	0.26	0.16	**1.5**
BOD	mg/l	7	3	**3**
DO	mg/l	5.7	4.5	**4**

Noise Management

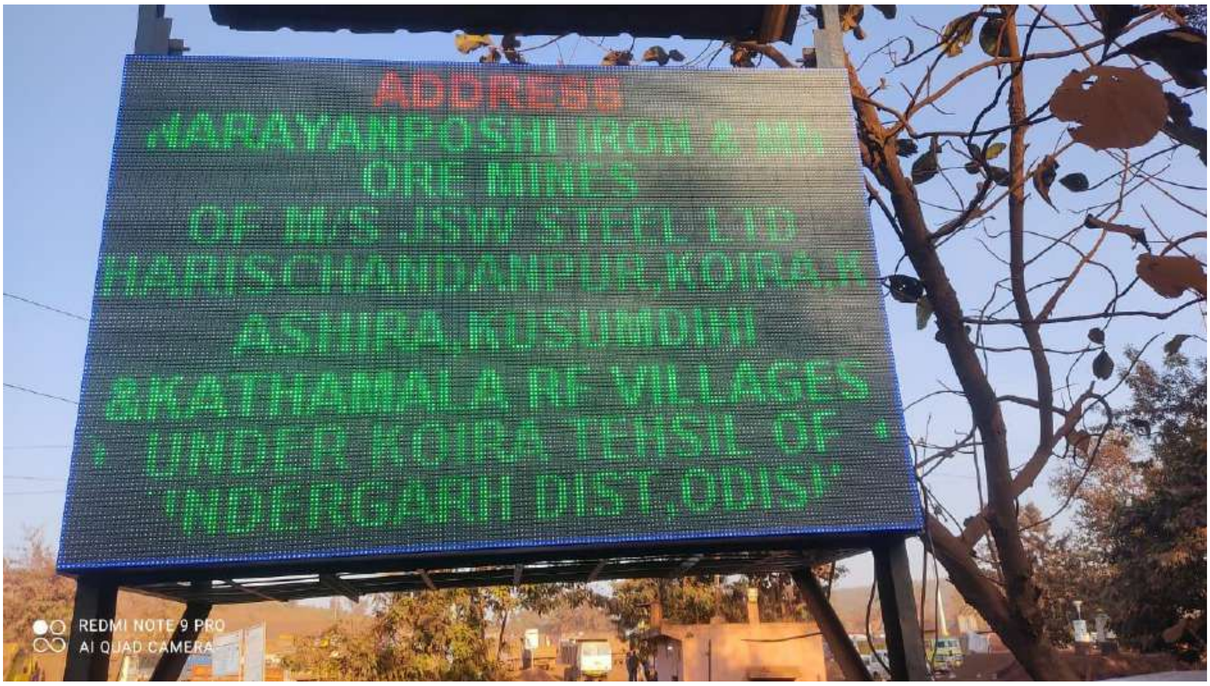
- Providing sound proof operator's cabin for equipment like dumpers, shovel, tippers, etc.
- Planting trees at various places within the lease area to act as acoustic barriers.
- Proper and regular maintenance of vehicles, machinery and other equipment. All HEMMs are monitored for any abnormal sound and rectified with due precaution by maintenance personnel.
- Providing workers with ear muffs & earplugs against high noise levels.
- Conducting regular health check-ups of workers including Audiometry test
- Controlling the time of exposure of workers towards high noise areas.

Consolidated Noise Quality Monitoring Data of FY 2021-2022

Narayanposhi Iron & Mn Ore Mines			
CORE ZONE	**Max**	**Min**	**Standards**
MAGAZINE AREA	66.9	52.7	**85 dB(A)**
ML BOUNDARY PILLAR NO-1	68.9	52.4	
MINES FACE/BENCH	79.9	72.7	
HAULAGE ROAD	79.9	74.9	
CRUSHER PLANT	81.1	77.7	
SCREEN PLANT	79.1	76.2	
ORE STORAGE & LOADING POINT	80.8	77.7	

WASTE DUMP	71.7	58.8	

CORE ZONE	Leq Day		Leq Night		Standards
KOIRA BASTI	Max	Min	Max	Min	85 dB(A)
KASIRA BASTI	53.6	51.1	43.4	40.6	
EAST BOUNDARY	53.6	49.4	43.4	37.7	
WEST BOUNDARY	64.9	61.7	59.4	53	
NORTH BOUNDARY	63.1	60.4	56	52.2	
SOUTH BOUNDARY	69.2	64.4	57.3	55.7	



Electronic Digital Display Board at Narayanposhi Mine Gate

<u>Narayanposhi Environmental Protection Measures Expenditure (head wise breakup) incurred from April 2021 to March 2022-YTD</u>

Particulars	**Approximately Cost incurred (in Crores)**
Dust Suppression (Wet Drilling, Dry Fog System, Mobile Haul road water sprinkling system, etc.)	0.20
Fixed Water Sprinkling Project	0.20
Online Environmental Monitoring System (CAAQMS & Digital Display Board)	1.25
Manual Environment Monitoring	0.15
Water Sprinkling on National Highway/nearby village/transportation roads	0.10
OB Dump & Surface Run-off Management	0.05
Environment Awareness in MEMC Week 2021-22	0.05
Grand Total (Rs. in Cr.)	**2.00**

Chapter 12

Recommendations for Sustainable Mining

The Central Government, in the Ministry of Mines, vide Notification No.S.O.2817 (E) dated 22nd November, 2010 had appointed a Commission of Inquiry consisting Justice M.B. Shah, retired Judge of the Supreme Court of India, for the purpose of making an inquiry into mining of iron ore and manganese ore in contravention of the provision of various Statues and the rules and regulations issued there under, in various States including the State of Odisha.

In view of Justice Shah Commission report (2013), the Ministry of Environment, Forest and Climate Change (MoEF&CC) desired to conduct a Carrying Capacity Study with an objective to develop (i) a sustainable development plan for mining activities in the impact area of about 1000 sq.km. in the State of Odisha and (ii) an environmental management plan for current as well as future developmental scenario.

Keeping in view the study objectives, CSIR-NEERI conducted the study encomassing collection of primary data for various environmental components (viz. air, noise, water, soil/ land, biological and socio-economic aspects), collection and analysis of environmental quality data by different mines in the region, modelling for transport scenario and infrastructure need assessment, and meetings/workshops with different stakeholders (like Department of Steel & Mines, Directorate of Mines, IBM-HQ & Regional Office, SPCB, GSI, MoEF&CC, State Forest Dept. etc. as well as senior executives from respective mines).

Based on the study conducted by CSIR-NEERI and analysis of inputs received from various Govt. departments and mine lease holders, the following recommendations are made:

Overall responsibility for implementation of all the recommendations shall be of State Government of Odisha through Department of Steel & Mines and other concerned State Govt. departments, viz. State Pollution Control Board, State Forest Department, District Administration etc. along with individual mine lease holders. Department of Steel & Mines shall be the nodal agency to coordinate with other concerned departments.

Financial arrangement: In the overall interest of the people of the region, the expenditure towards the implementation of various recommendations (common infrastructure and road/rail network development should be borne from District Mineral Funds being collected from different mines in the region by the Dept. of Steel & Mines, Govt. of Odisha, whereas expenditure towards recommendations applicable to individual mines shall be borne by individual mine lease holders.

The expenditure towards various regional development schemes by District Mineral Foundations (DMFs) should be in accordance with the Pradhan Mantri Khanij Kshetra Kalyan Yojna (PMKKKY), notified by Ministry of Mines, Govt. of India, vide letter no. 16/7/2017-M.VI (Part), dated September 16, 2015. Further, any other statute notified by Central/State Govt. in this regard shall also be followed.

12.1 Environmental Carrying Capacity Indicator (EC Capacity V/s Actual Production)

Availability of total reserves, annual production and estimation of additional resources in the working mines in the study region for last 10 years (during 2006-07 to 2015-16) indicated that during the last 10 years period, total 715.5 MT of iron ore were produced, whereas 1037.1 MT new resources were identified. Thus adding a total of 321.6 MT in the resources, and more resources can be estimated with additional exploration. Annual iron ore production has been in the range of 53.3 MT in 2014-15 to 81.582 MT in 2015-16, whereas, earlier maximum production of 80 MT was observed during 2009-10.

At present, total EC capacity of working 57 mines is 160.310 MTPA, whereas the actual production was 51.124 MT (32%) during 2014-15 and 81.582 MT (50.9%) during 2015-16.

Further, total production during 2016-17 was 102.663 MT (64.0%), whereas total permitted dispatch was 120.116 MT (74.9%).

Looking into the mining practices in Odisha region, it is found that Environmental Carrying Capacity can be better co-related with actual production rate rather than EC Capacity.

Therefore, State Govt. should prepare 5 years regional plan for annual iron ore requirement from the state, which in turn shall be met from different mines/zones (e.g. Joda, Koira..) in the state. Accordingly, sustainable annual production (SAP) for each zone/mine may be followed adopting necessary environmental protection measures (as suggested in **Sub-Sections 12.4, 12.5 & 12.6**). It will not have any bearing on the grant of EC.

Responsibility: Department of Steel & Mines, Govt. of Odisha

12.2 Applicability of Environmental Carrying Capacity

12.2.1 Manganese Ore Mines

Out of total 57 working iron ore and manganese mines, total EC capacity of Mn ore mines (13 exclusive Mn mines and 7 associated with iron ore) is only 1.604 million tons, whereas total production during 2014-15 and 2015-16 was only 0.357 million tons (22.2%) in each year. Therefore, further expansion or opening of new manganese ore mines may be considered only when the actual production of about 80% is achieved.

Further, the mines that have not produced Mn ore for last two years, and have no commitment in the current year as well; EC capacity in such cases may be reviewed. The Department of Steel & Mines, Govt. of Odisha shall submit the Annual Report on this issue to the MoEF&CC for further necessary action.

12.2.2 Iron Ore Mines

In view of very limited Mn ore mining activity in the study region, environmental carrying capacity shall mainly be applicable for iron ore mining activities in the study region of Joda, Koira and Baripada blocks. Daitari block of Jajpur district is included for the completeness of iron ore mining in the Odisha state.

12.2.2.1 Daitari, Jajpur District

Out of 57 working mines, the only mine at Daitari, Jajpur district (OMC Mine – 3 MTPA) is far away from Joda-Koira area (more than 150 km), hence is being excluded from the present analysis.

Further, expansion of this mine, and new mines in Jajpur district can be considered with proper EIA study (as per the provisions of the EIA Notification 2006, as amended from time to time) of individual mine, upto total 11 MT by 2021.

Regional carrying capacity study may be required, if more number of mines are likely to come up in the Daitari region/Jajpur district.

12.2.2.2 Baripada/Rairangpur, Mayurbhanj District

Out of the 3 working mines at Rairangpur/ Baripada Sector; two mines, GS Mishra & Sons, Gorumahisani and Lal Traders Agencies, Badampahar have EC capacity of 0.75 MTPA and 0.72 MTPA and use public railway sidings located in the close proximity of the mine for ore transport. Third mine of S.A. Karim is very small (1.157 ha), and is producing only about 10,000 tons of iron ore per year (EC capacity - 18000 TPA).

Therefore, these 3 mines in Mayurbhanj district are excluded, and further expansion of these mines and new mines in Mayurbhanj district can be considered with proper EIA study (as per the provisions of the EIA Notification 2006, as amended from time to time), upto 10 MT by 2021.

12.2.2.3 Joda Sector (Keonjhar District) and Koira Sector (Sundargarh District)

In view of limited iron ore mining activity in Mayurbhanj and Jajpur districts, the major iron ore producing areas that need special attention are Joda-Barbil (Keonjhar district) and Koira Sector (Sundargarh district).

At present, Joda-Barbil Sector has total 27 working mines (22 iron ore mines and 5 exclusive Mn ore mines) and Koira Sector has total 26 mines (18 iron ore mines and 8 exclusive Mn ore mines). Thus, the total iron ore mines (including 7 Mn ore associated mines) in Joda-Koira Sector are 40 only.

The total EC Capacity of these 40 mines is 155.519 MT, whereas actual production was 48.087 MT (30.9%) during 2014-15 and 77.907 MT (50.1%) during 2015-16. Total production from Joda and Koira region during 2016-17 was 98.38 MT (63.3%), whereas total permitted dispatch was 115.541 MT (74.3%).

Joda-Barbil, Keonjhar District

At present total EC Capacity of 22 iron ore mines in Joda-Barbil Sector is 106.631 MT, whereas actual production during 2014-15 was 34.420 MT (32.3%) and 55.318 MT (51.9%) during 2015-16.

Total production from Joda region during 2016-17 was 70.291 MT (65.9%), whereas total permitted dispatch was 79.575 MT (74.6%).

Koira Sector, Sundargarh District

At present total EC Capacity of 18 iron ore mines in Koira Sector is 49.209 MT, whereas actual production during 2014-15 was 13.667 MT (27.8%) and 22.589 MT (45.9%) during 2015-16.

Total production from Koira region during 2016-17 was 28.089 MT (57.0%), whereas total permitted dispatch was 35.966 MT (73.1%).

12.3 Continuation of Iron Ore Mining Activity

Analysis of baseline environmental quality data for the year 2014 and 2016 indicates that existing mining activities appear to have little / no potential impact on environmental quality, except on air environment, which was mainly due to re-suspension of road dust. Therefore, all the working mines can continue to operate with strict compliance to monitoring of environmental quality parameters as per EC and CTE/CTO conditions of the respective mine, and implementation of suggested measures for control of road dust and air pollution, as given in **Sections 4.6.2, Section 4.7 and Section 10.7**.

Odisha State Pollution Control Board has to ensure the compliance of CTE/CTO. Regional office of the MoEF&CC, Bhubaneswar shall monitor the compliance of the EC conditions. Regional office of the Indian Bureau of Mines (IBM) shall monitor the compliance of mining plan and progressive mine closure plan. Any violation by mine lease holder may invite actions per the provisions of applicable acts.

12.4 Suggested Sustainable Annual Production (SAP)

Considering the existing environmental quality, EC capacity, production rate, iron ore resources availability and transport infrastructure availability, the share of Joda and Koira sector works out to be 70% and 30% respectively for the existing scenario for the year 2015-16. However, for additional EC capacity, it can be 50:50 subject to commensurate infrastructure improvement (viz. SOTM, pollution free road transport, enhancement of rail network etc.) in the respective regions.

Accordingly, year-wise sustainable annual production from Joda and Koira area and jointly for both the regions upto 2020-21 is estimated to be as given in **Table 12.1**, **12.2** and **12.3** respectively.

Table 12.1: Actual/Suggested Sustainable Annual Production in Joda Sector (Keonjhar District) up to 2020-21

Sr. No.	Year	Horizon	Actual/Suggested Sustainable Annual Production (MT)	Mine Source with EC Capacity
1.	2015-16	Base Year	56	Total 22 iron ore mines in Joda Sector with total EC Capacity of 106.6 MTPA (already permitted/ working mines)
2.	2016-17	Ist Year	66 (56+10) (Actual production – 70.291 MT)	Existing 22 iron ore mines upto March 2016 (EC Capacity 106.6 MTPA) or Additional 10 MT from further expansion or new mines
3.	2017-18	2nd Year	76 (66+10)	Existing iron ore mines upto March 2017 or Additional 10 MT from further expansion or new mines
4.	2018-19	3rd Year	86 (76+10)	Existing iron ore mines upto March 2018 or Additional 10 MT from further expansion or new mines
5.	2019-20	4th Year	96 (86+10)	Existing iron ore mines upto March 2019 or Additional 10 MT from further expansion or new mines
6.	2020-21	5th Year	106 (96+10)	Existing iron ore mines upto March 2020 or Additional 10 MT from further expansion or new mines

Table 12.2: Actual/Suggested Sustainable Annual Production in Koira Sector (Sundargarh District) up to 2020-21

Sr. No.	Year	Horizon	Actual / Suggested Sustainable Annual Production (MT)	Mine Source with EC Capacity
1.	2015-16	Base Year	24	Total 18 existing iron ore mines in Koira Sector with total EC Capacity of 49.2 MTPA (already permitted/ working mines)

2.	2016-17	1st Year	34 (24+10) (Actual production – 28.089 MT)	Existing iron ore mines upto March 2016 or Additional 10 MT from further expansion or new mines
3.	2017-18	2nd Year	44 (34+10)	Existing iron ore mines upto March 2017 or Additional 10 MT from further expansion or new mines
4.	2018-19	3rd Year	54 (44+10)	Existing iron ore mines upto March 2018 or Additional 10 MT from further expansion or new mines
5.	2019-20	4th Year	64 (54+10)	Existing iron ore mines upto March 2019 or Additional 10 MT from further expansion or new mines
6.	2020-21	5th Year	74 (64+10)	Existing iron ore mines upto March 2020 or Additional 10 MT from further expansion or new mines

Table 12.3: Actual/Suggested Sustainable Annual Production in Joda-Koira Sector (Keonjhar & Sundargarh districts) up to 2020-21

Sr. No.	Year	Horizon	Actual / Suggested Sustainable Annual Production (MT)	Mine Source with EC Capacity
1.	2015-16	Base Year	80	Total 40 iron ore mines in Joda-Koira Sector (Keonjhar and Sundargarh districts) with total EC Capacity of 156 MTPA (already permitted/ working mines)
2.	2016-17	1st Year	100 (80+20) (Actual production – 98.38 MT)	Existing 40 iron ore mines upto March 2016 (EC Capacity 156 MTPA) or Additional 20 MT from further expansion or new mines
3.	2017-18	2nd Year	120 (100+20)	Existing iron ore mines upto March 2017 or Additional 20 MT from further expansion or new mines
4.	2018-19	3rd Year	140 (120+20)	Existing iron ore mines upto March 2018 or Additional 20 MT from further expansion or new mines
5.	2019-20	4th Year	160 (140+20)	Existing iron ore mines upto March 2019 or Additional 20 MT from further expansion or new mines
6.	2020-21	5th Year	180 (160+20)	Existing iron ore mines upto March 2020 or Additional 20 MT from further expansion or new mines

Accordingly, by 2021, the total iron production capacity can be 201 MT (Joda Sector - 106 MT; Koira Sector 74 MT, Baripada Sector - 10 MT and Jajpur Sector - 11 MT), as summarized in **Table 12.4**. However, the capacity enhancement will be subject to certain pre-requisites as listed in next point (**Section 12.5**).

Table 12.4: Summary of Suggested Sustainable Annual Production in Odisha State upto 2020-21

Sr. No.	Year	Horizon	Suggested Sustainable Annual Production (MT)				
			Joda, Keonjhar	Koira, Sundargarh	Baripada, Mayurbhanj	Daitari, Jajpur	Total (approx.)
1.	2015-16	Base year	56	24	2	3	85
2.	2016-17	1st Year	66	34	2	3	105*
3.	2017-18	2nd Year	76	44	4	5	129
4.	2018-19	3rd Year	86	54	6	7	153
5.	2019-20	4th Year	96	64	8	9	177
6.	2020-21	5th Year	106	74	10	11	201

The values are rounded off.

* Actual total production during 2016-17 was 102.7 MT, whereas total dispatch was about 120 MT. Total EC capacity is 160.31 MTPA.

Note: It is emphasized again and envisaged that preparation of 5 years regional annual plan for iron ore requirement/demand based on approved mining plan by Govt. of Odisha through Department of Steel & Mines shall streamline the iron and manganese ore mining activities in the region.

It is to be noted that as per the National Steel Policy (May 8, 2017 Notification), it is projected that total installed crude steel capacity will be about 300 MT by 2030-31, wherein total requirement of iron ore will be about 437 MT (or say 450 MT, depending on steel making route chosen).

In the draft steel policy (Page 9), it was mentioned that steel requirement will be about 144 MT by 2020-21, about 236 MT by 2025-26, and about 300 MT by 2030-31. Considering iron ore requirement of 1.5 MT per MT of crude steel, the corresponding iron ore requirement works out to be about 216 by 2020-21, 354 MT by 2025-26 and 450 MT by 2030-31 for the entire country.

In the present study on sustainable iron ore mining in Odisha State, 201 MT is suggested as sustainable annual production from Odisha by 2020-21, which is approximately 93% of the total requirement of the whole country by 2020-21; however such a mining rate is subject to certain pre-requisites, as given in the next section.

However, in case, the demand for iron ore from the State exceeds the suggested annual production by 2021, a feasibility study involving environmental sustainability considerations should be conducted.

12.5 Pre-requisites for Implementation of Suggested Sustainable Annual Production

12.5.1 Continuous monitoring of different environmental quality parameters as per EC and CTE/CTO conditions with respect to air, noise, water (surface & ground water) and soil quality in each region shall be done. The environmental quality parameters should not indicate any adverse impact on the environment. Monitoring within the mines should be done by individual mine lease holders, whereas outside the mine lease area, monitoring should be done by the Govt. of Odisha through various concerned departments/ authorized agencies. Various monitoring/ studies should be conducted through national reputed institutes, NABET/ MoEF&CC accredited laboratories/organizations.

The reports submitted by individual mine lease holders and study reports prepared by other concerned departments/agency for each of the regions should be evaluated and examined by SPCB/ MoEF&CC.

12.5.2 Construction of cement concrete road from mine entrance and exit to the main road with proper drainage system and green belt development along the roads and also construction of road minimum 300 m inside the mine should be done. This should be done within one year for existing mines and new mine should have since beginning. The concerned departments should extend full support; wherever the land does not belong to the respective mine lease holders.

The Department of Steel & Mines, Govt. of Odisha should ensure the compliance and should not issue the Mining Permits, if mine lease holder has not constructed proper cement concrete road as suggested above.

12.5.3 In view of high dust pollution and noise generation due to road transport, it is proposed to regulate/guide the movement of iron and manganese ore material based on the EC capacity of the mines. Accordingly, ore transport mode has been suggested, as given below in **Table 12.5**.

Table 12.5: EC Capacity based Suggested Ore Transport Mode (SOTM)

Code	EC Capacity	Suggested Ore Transport Mode
SOTM 1	≥ 5 MTPA	100% by private railway siding or conveyor belt up to public railway siding or pipeline for captive mines and 70% for non-captive mines
SOTM 2	Between 3 and <5 MTPA	Minimum 70% by public railway siding, through conveyor belt and maximum 30% by road - direct to destination or other public railway siding or above option
SOTM 3	Between 1 and < 3 MTPA	Minimum 70% by public railway siding and maximum 30% by road - direct to destination or by other public railway siding or above options
SOTM 4	<1 MTPA	100 % by 10/17 Ton Trucks or above options

It is mentioned by State Govt. of Odisha that currently about 45% of the iron ore is despatched using rail network and progressively it will be increased to about 60% by rail/slurry over a period of 5 years, taking into account time required to set up more railway sidings.

In view of present ore transport practices and practical limitations, all the existing mines should ensure adoption of SOTM within next 5 years.

New mines or mines seeking expansion should incorporate provision of SOTM in the beginning itself, and should have system in place within next 5 years.

However, the State Govt. of Odisha shall ensure dust free roads in mining areas wherever the road transportation of mineral is involved. The road shoulders shall be paved with fence besides compliance with IRC guidelines. All the roads should have proper drainage system and apart from paving of entire carriage width the remaining right of way should have native plantation (dust capturing species). Further, regular maintenance should also be ensured by the Govt. of Odisha.

Transportation of iron & manganese ore through river (jetty) to nearest Sea port (Sea cargo option) may be explored or connecting Sea ports with Railway network from the mines to be improved further so that burden on existing road and rail network and also pollution thereof can be minimized.

Progress on development of dust free roads, implementation of SOTM, increased use of existing rail network, development of additional railway network/conveyor belt/ pipelines etc. shall be submitted periodically to MoEF&CC.

Responsibility : Department of Steel & Mines, Govt. of Odisha
Time Period: 5 Years for developing railway/ conveyor belt facilities

12.5.4 Development of parking plazas for trucks with proper basic amenities/ facilities should be done inside mine as suggested in **Fig. 12.1**. This should be done within one year for existing mines and new mines should have since beginning.

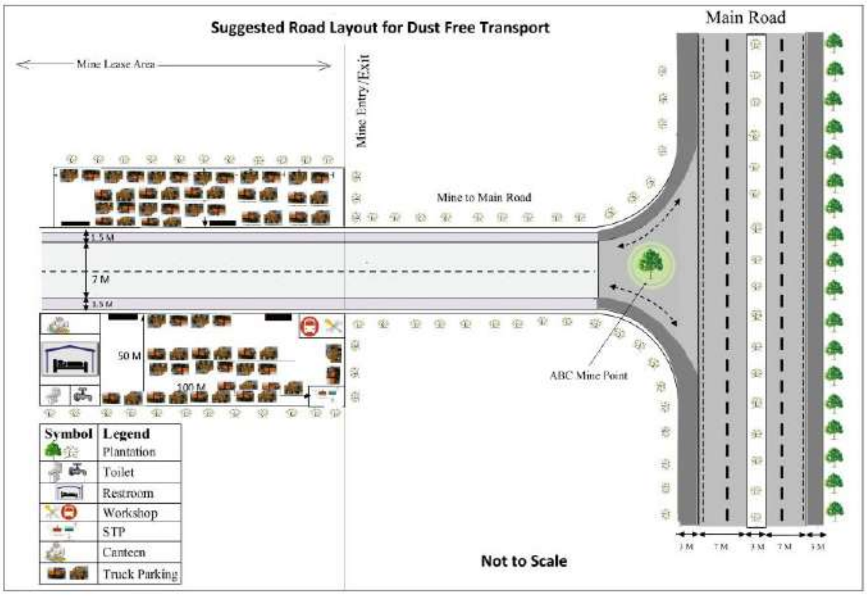


Fig. 12.1: Schematic Diagram of Suggested Parking Plazas Inside the Mining Lease Area with Connectivity to Main Road from Mine to Main Road

Small capacity mines (in terms of lease area or production) not having enough space within the mine lease areas should develop parking plaza at a common place within the region with requisite facilities.

Responsibility: Individual Mine Lease Holders

Time Period: 1 Year

12.5.5 Construction of NH 215 as minimum 4 lane road with proper drainage system and plantation and subsequent regular maintenance of the road as per IRC guidelines. Construction of other mineral carrying roads with proper width and drainage system along with road side plantation to be carried out.

Responsibility: Department of Steel & Mines with PWD / NHAI

Time Period: 2 Years

12.5.6 Regular vacuum cleaning of all mineral carrying roads aiming at “Zero Dust Re-suspension” may be considered.

Responsibility: PWD / NHAI/ Mine Lease Holders

Time Period: 3 months for existing roads

12.5.7 Expansion of existing mines and new mines should be considered after conducting recent EIA Study (as per the provisions of EIA Notification 2006, as amended time to time) with proper justification on demand scenario for iron ore requirement and availability of pollution free transport network in the region.

Responsibility: IBM, Department of Steel & Mines and MoEF&CC, New Delhi

12.6 Mine-wise Allocation of Annual Production

In case the total requirement of iron ore exceeds the suggested limit for that year, permission for annual production by an individual mine may be decided depending on approved EC capacity (for total actual dispatch) and actual production rate of individual mine during last year or any other criteria set by the State Govt., i.e. Dept. of Steel & Mines.

Department of Steel and Mines in consultation with Indian Bureau of Mines-RO should prepare in advance mine-wise annual production scenario as suggested in **Table 12.6**, so that demand for iron ore can be anticipated, and actual production/dispatch does not exceed the suggested annual production.

Table 12.6: Allocation of Production to Different Mines for 5 Years (as per approved Mining Plan)

Mine Lease	EC Capacity (MTPA)	Suggested Annual Production (MT)				
		2016-17	2017-18	2018-19	2019-20	2020-21
		Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Mine 1	X1					
Mine 2	X2					
Mine 3	X3					
Mine n	Xn					
Total	160 + dX	105	129	153	177	201

Next year allocation = Average of EC Capacity and Last year production

12.7 Expansion of Existing Mines having Validity up to 2020

In view of implementation of MMDR Act 2015, wherein many non-captive mines are expected to be closed by March 2020, total iron ore production scenario has been prepared (**Section 2.4.7**). It is expected that the non-captive mines having validity till 2020 shall try to maximize their production (limited to EC capacity) in the remaining period. Further, depending upon availability of iron ore resources, these mines may also seek expansion of EC capacity.

It may be noted here that total EC capacity of existing 25 working mines having validity upto 2020 is about 85 MTPA, whereas actual production from these mines has been only 44.677 MT (52.6%) during 2015-16 and 57.07 MT (67.1%) during 2016-17. Also, it is expected that these mines would not even be able to achieve ore production as per existing EC capacity till March 2020. Therefore, these existing mines should go for production to the fullest extent to meet the requisite demand from the State. However, where EC limit is exhausted, application for expansion may be considered.

Further, the EC process (i.e. Grant of TOR, Baseline data collection, Mining plan/ scheme approval, Public hearing, preparation of EIA/EMP Report, Appraisal by the EAC and grant of EC) takes about one year time. Under such circumstances, it is suggested that further applications for grant of TOR or grant of EC for expansion of production capacity of the mine should be considered for those existing mines, which have exhausted their capacity subject to consideration of all environmental aspects.

Responsibility: Department of Steel & Mines and MoEF&CC, New Delhi

12.8 Sustained Iron Ore Production beyond 2020

12.8.1 Considering the implementation of MMDR Act 2015, total production of iron ore in Odisha State is anticipated to be about 111 MT during 2016-17 (actual production was – 102.663 MT), 136 MT during 2017-18, 146 MT during 2018-19 and 146 MT during 2019-20. Then there will be substantial drop in total production (to the tune of 73 MT during 2020-21 onwards) due to closure of mines, which are valid up to 2020 (**Section 2.4.7**).

Therefore, in order to maintain operation/sustained growth of downstream industries, iron ore mining in the region needs to be continued at a sustainable rate. The State Govt. through Department of Steel and Mines should initiate appropriate action to ensure continued availability of iron ore from the region, as per suggested sustainable annual production (**Section 12.2** and **Section 12.4**).

12.8.2 Reserves Estimation – Mining Plan and Exploration

Appropriate actions (geo-technical investigation for qualitative and quantitative resource estimation & other preparations for auction of mines), may be initiated taken into account the existing working mines, and the mines which were operational at some point of time (but closed presently due to various reasons).

The total iron ore reserves/ resources available within the total lease area of each mine should be estimated by State Govt./NMET/ GSI (or any other approved agency) with respect to:

- Total lease area of mine (surface)
- Maximum depth to which resources could be available
- Resources below the ground water table (if intersected)
- Reserves are to be estimated as per UNFC code with respect to quantity and quality (% Fe content)
- Maximum mining rate and area for auction (after 2020) will be calculated based on total resources available and proposed life of mine leading to closure of mine in a stipulated time period

  Responsibility: Department of Steel & Mines, IBM and GSI

  Time frame: 1 year for the mines to be auctioned for next 2 years

  The above mentioned organizations shall ensure the compliance with respect to timelines for implementations.

12.8.3 Depending upon availability of extractable iron ore resources within a mine, mining below the ground water table may be permitted after conducting necessary geological and hydro-geological study by GSI and requisite approval from the CGWB/CGWA (Central Ground Water Board/Authority). This can be explored at least in few mines on trial/pilot basis.

Further, within a mine, it will be desirable to operate one pit at a time, and next pit should be opened after extracting maximum possible resources from the first pit, so that the exhausted pit can be used for back filling/ storing of low grade iron ore. However, depending upon the quantity and/or quality of iron/ manganese ore, other mine pits in the same mine lease may also be opened for sustainable scientific mining, as per approved mining plan/scheme of mining by IBM.

The Department of Steel & Mines, Govt. of Odisha should initiate the pilot project so that minerals are fully utilized.

12.8.4 Commercial Utilization of Low Grade Ore

R&D studies towards utilization of low-grade iron ore should be conducted through research/academic institutes like IMMT, Bhubaneswar, NML, Jamshedpur, and concerned metallurgical departments in IITs, NITs etc., targeting full utilization of low-grade iron ore (Fe content upto 45% by 2020 and upto 40% by 2025). In fact, life cycle assessment of whole process including environmental considerations should be done for techno-economic and environmental viability.

R&D studies on utilization of mine wastewater having high concentration of Fe content for different commercial applications in industries such as cosmetics, pharmaceutical, paint industry should also be explored.

Responsibility: IBM, Dept. of Steel & Mines, Individual Mine Lease Holders

12.8.5 The mining activity in Joda-Koira sector is expected to continue for another 100 years, therefore, it will be desirable to develop proper rail network in the region. Rail transport shall not only be pollution free mode but also will be much economical option for iron ore transport. The rail network and/or conveyor belt system upto public railway siding needs to be created as detailed in **Section 10.6.1**. The total length of the conveyor belt system/ rail network to be developed from mines to nearest railway sidings by 11 mines in Joda region is estimated to be about 64 km. Similarly, in Koira region, total length of rail network/ conveyor system for 8 mines (under SOTM 1 & 2) is estimated to be around 95 km. Further, it is suggested to develop a rail network connecting Banspani (Joda region) and Roxy railway sidings in Koira region, as shown in **Fig. 12.2**.

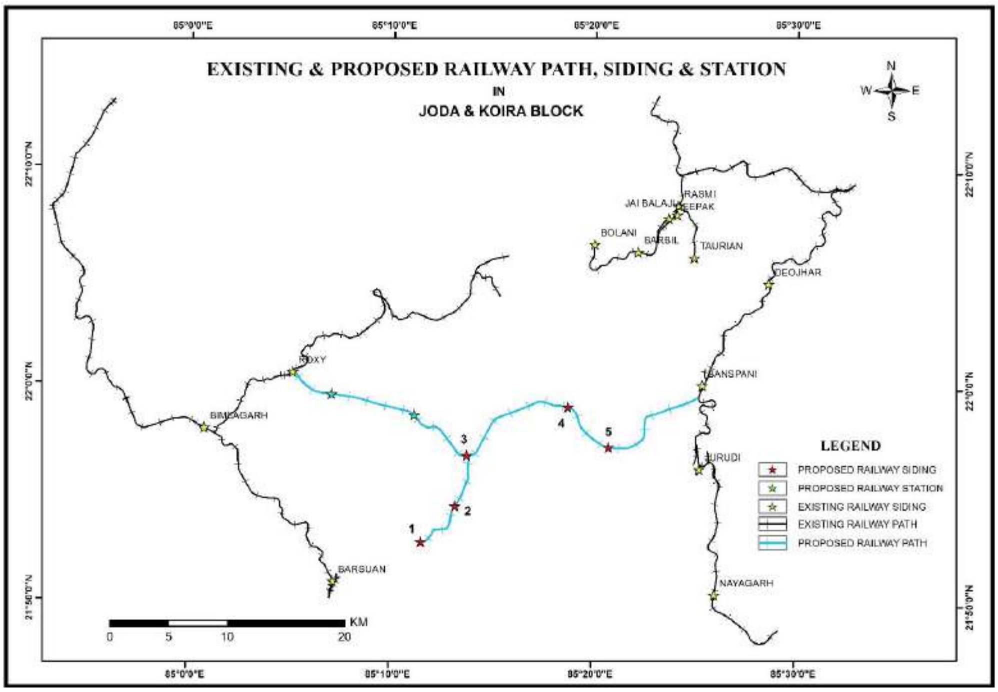


Fig. 12.2: Existing (Black in colour) and Proposed Rail Network (Blue in colour) Connecting Banspani and Roxy Railway Sidings

Responsibility: Dept. of Steel & Mines, Govt. of Odisha and Concerned Mines along with Indian Railways

Time Period: Maximum 7 years (by 2025)

The Department of Steel & Mines, Govt. of Odisha should follow-up with the concerned Departments and railways so that proposed proper rail network is in place by 2025.

12.8.6 State Govt. of Odisha shall make all efforts to ensure exhausting all the iron & manganese ore resources in the existing working mines and from disturbed mining leases/zones in Joda and Koira region. The criteria suggested in **Section 12.8.2** shall be applicable while suggesting appropriate lease area and sustainable mining rate.

Responsibility: Dept. of Steel & Mines, Govt. of Odisha

12.8.7 Large and medium mine leases contribute to better implementation of reclamation and rehabilitation plans to sustain the ecology for scientific and sustainable mining. The small leases do not possess scientific capability of environmentally sustainable mining. Therefore, new mine leases having more than 50 ha area should be encouraged, as far as possible. This will ensure inter-generational resource availability to some extent.

Responsibility: Dept. of Steel & Mines, Govt. of Odisha

12.8.8 Further, regional carrying capacity study must be conducted for each of the regions (Joda, Koira & Bripada) on a regular interval of 5 years to ensure adoption of sustainable mining practices with expected/committed societal development in the region.

Responsibility: Department of Steel & Mines and MoEF&CC, New Delhi.

Environmental Protection Measures

12.9 Mining Operations/Process Related

12.9.1 Appropriate mining process and machinery (viz. right capacity, fuel efficient) should be selected to carry out various mining operations that generate minimal dust/air pollution, noise, wastewater and solid waste. e.g. drills should either be operated with dust extractors or equipped with water injection system.

12.9.2 After commencement of mining operation, a study should be conducted to assess and quantify emission load generation (in terms of air pollution, noise, waste water and solid waste) from each of the mining activity (including transportation) on annual basis. Efforts should be made to further eliminate/ minimize generation of air pollution/dust, noise, wastewater, solid waste generation in successive years through use of better technology. This shall be ensured by the respective mine lease holders.

12.9.3 Various machineries/equipment selected (viz. dumpers, excavators, crushers, screen plants etc.) and transport means should have optimum fuel/power consumption, and their fuel/power consumption should be recorded on monthly basis. Further, inspection and maintenance of all the machineries/ equipment/ transport vehicles should be followed as per manufacturer's instructions/ recommended time schedule and record should be maintained by the respective mine lease holders.

12.9.4 Digital processing of the entire lease area using remote sensing technique should be carried out regularly once in 3 years for monitoring land use pattern and mining activity taken place. Further, the extent of pit area excavated should also be demarcated based on remote sensing analysis.

This should be done by ORSAC (Odisha Space Applications Centre, Bhubaneswar) or an agency of national repute or if done by a private agency, the report shall be vetted/ authenticated by ORSAC, Bhubaneswar. Expenses towards the same shall be borne by the respective mine lease holders.

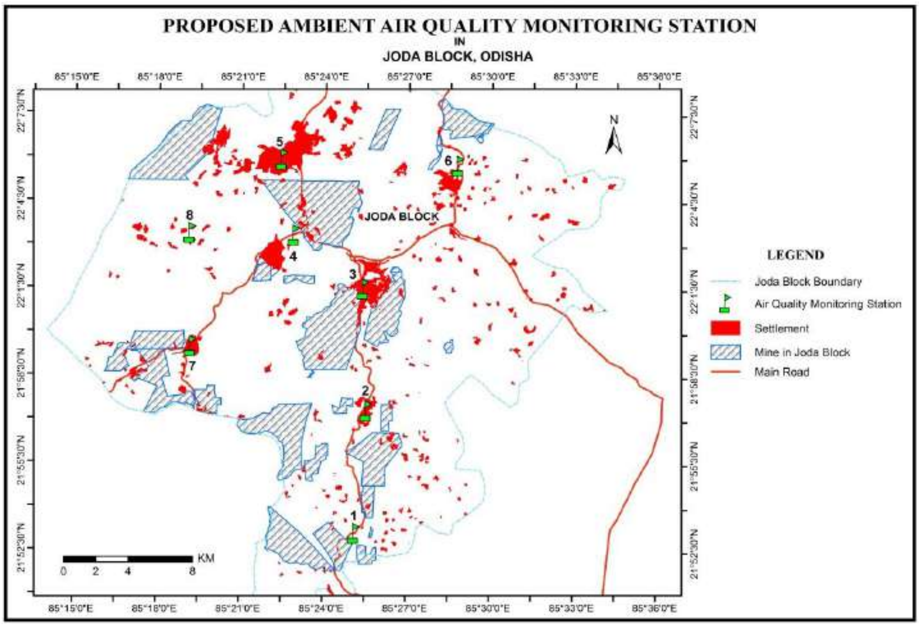
Responsibility: Individual Mine Lease Holders

12.10 Air Environment Related

12.10.1 Fugitive dust emissions from all the sources should be controlled regularly on daily basis. Water spraying arrangement on haul roads, loading and unloading and at other transfer points should be provided and properly maintained. Further, it will be desirable to use water fogging system to minimize water consumption. It should be ensured that the ambient air quality parameters conform to the norms prescribed by the CPCB in this regard.

12.10.2 The core zone of mining activity should be monitored on daily basis. Minimum four ambient air quality monitoring stations should be established in the core zone for SPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and CO monitoring. Location of air quality monitoring stations should be decided based on the meteorological data, topographical features and environmentally and ecologically sensitive targets and frequency of monitoring should be undertaken in consultation with the State Pollution Control Board (based on Emission Load Assessment Study). The number of monitoring locations may be more for larger capacity mines and working in larger area. Out of four stations, one should be online monitoring station in the mines having more than 3 MTPA EC Capacity.

12.10.3 Monitoring in buffer zone should be carried out by SPCB or through NABET accredited agency. In addition, air quality parameters (SPM, PM_{10}, $PM_{2.5}$, SO_2, NO_x and CO) shall be regularly monitored at locations of nearest human habitation including schools and other public amenities located nearest to source of the dust generation as applicable. Further, 11 continuous air quality monitoring systems may be installed in Joida and Koira regions and one in Baripada/ Rairangpur region as suggested in **Section 10.7,** and shown in **Fig. 12.3**.



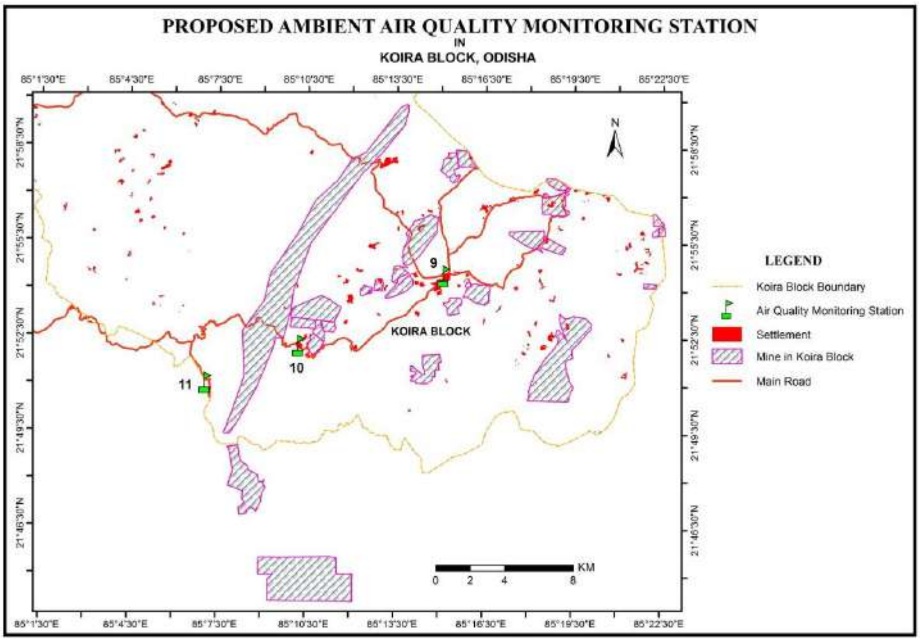


Fig. 12.3: Suggested Online Air Quality Monitoring Stations in Joda and Koira Regions (Outside the Mine Lease Areas)

12.10.4 Emissions from vehicles as well as heavy machinery should be kept under control and regularly monitored. Measures should be taken for regular maintenance of vehicles used in mining operations and in transportation of mineral.

The vehicles shall be covered with a tarpaulin and should not be overloaded.

Further, possibility of using closed container trucks should be explored for direct to destination movement of iron ore.

Air quality monitoring at one location should also be carried out along the transport route within the mine (periodically, near truck entry and exit gate).

Responsibility: Individual Mine Lease Holders and SPCB

12.11 Noise and Vibration Related

12.11.1 Blasting operation should be carried out only during daytime. Controlled blasting such as Nonel, should be practiced. The mitigation measures for control of ground vibrations and to arrest fly rocks and boulders should be implemented.

12.11.2 Appropriate measures (detailed in Section 5.4) should be taken for control of noise levels below 85 dBA in the work environment. Workers engaged in operations of HEMM, etc. should be provided with ear plugs/muffs.

12.11.3 Noise levels should be monitored regularly (on weekly basis) near the major sources of noise generation within the core zone. Further, date, time and distance of measurement should also be indicated with the noise levels in the report. The data should be used to map the noise generation from different activities and efforts should be made to maintain the noise levels with the acceptable limits of CPCB (CPCB, 2000).

12.11.4 Similarly, vibration at various sensitive locations should be monitored atleast once in month, and mapped for any significant changes due to successive mining operations.

Responsibility: Individual Mine Lease Holders

12.12 Water/Wastewater Related

12.12.1 In general, the mining operations should be restricted to above ground water table and it should not intersect groundwater table. However, if enough resources are estimated below the ground water table, the same may be explored after conducting detailed geological studies by GSI and hydro-geological studies by CGWB or NIH or institute of national repute, and ensuring that no damage to the land stability/ water aquifer system shall happen. The details/ outcome of such study may be reflected/incorporated in the EIA/EMP report of the mine appropriately.

12.12.2 Natural watercourse and/or water resources should not be obstructed due to any mining operations. Regular monitoring of the flow rate of the springs and perennial nallas should be carried out and records should be maintained. Further, regular monitoring of water quality of nallas and river passing thorough the mine lease area (upstream and downstream locations) should be carried out on monthly basis.

12.12.3 Regular monitoring of ground water level and its quality should be carried out within the mine lease area by establishing a network of existing wells and constructing new piezometers during the mining operation. The monitoring should be carried out on monthly basis.

12.12.4 In order to optimize water requirement, suitable conservation measures to augment ground water resources in the area should be undertaken in consultation with Central Ground Water Board (CGWB).

12.12.5 Suitable rainwater harvesting measures on long term basis should be planned and implemented in consultation with CGWB, to recharge the ground water source. Further, CGWB can prepare a comprehensive plan for the whole region.

12.12.6 Appropriate mitigation measures (viz. ETP, STP, garland drains, retaining walls, collection of runoff etc.) should be taken to prevent pollution of nearby river/other water bodies. Water quality monitoring study should be conducted by State Pollution Control Board to ensure quality of surface and ground water sources on regular basis. The study can be conducted through NABL/ NABET approved water testing laboratory. However, the report should be vetted by SPCB.

12.12.7 Industrial wastewater (workshop and wastewater from the mine) should be properly collected, treated in ETP so as to conform to the discharge standards applicable.

Oil and grease trap should be installed before discharge of workshop effluents. Further, sewage treatment plant should be installed for the employees/colony, wherever applicable.

12.12.8 Mine lease holder should ensure that no silt originating due to mining activity is transported in the surface water course or any other water body. Appropriate measures for prevention and control of soil erosion and management of silt should be undertaken. Quantity of silt/soil generated should be measured on regular basis for its better utilization.

Erosion from dumps site should be protected by providing geo-textile matting or other suitable material, and thick plantation of native trees and shrubs should be carried out at the dump slopes. Further, dumps should be protected by retaining walls.

12.12.9 Trenches / garland drain should be constructed at the foot of dumps to arrest silt from being carried to water bodies. Adequate number of check dams should be constructed across seasonal/perennial nallas (if any) flowing through the mine lease areas and silt be arrested. De-silting at regular intervals should be carried out and quantity should be recorded for its better utilization, after proper soil quality analysis.

The water so collected in the reservoir within the mine should be utilized for the sprinkling on hauls roads, green belt development etc.

12.12.10 There should be zero waste water discharge from the mine. Based on actual water withdrawal and consumption/ utilization in different activities, water balance diagram should be prepared on monthly basis, and efforts should be made to optimize consumption of water per ton of ore production in successive years.

Responsibility: Individual Mine Lease Holders, SPCB and CGWB

12.13 Land/ Soil/ Overburden Related

12.13.1 The top soil should temporarily be stored at earmarked site(s) only and it should not be kept unutilized for long (not more than 3 years or as per provisions mentioned in the mine plan/ scheme). The topsoil should be used for land reclamation and plantation appropriately.

12.13.2 Fodder plots should be developed in the non-mineralised area in lieu of use of grazing land, if any.

12.13.3 Over burden/ low grade ore should be stacked at earmarked dump site(s) only and should not be kept active for long period. The dump height should be decided on case to case basis, depending on the size of mine and quantity of waste material generated. However, slope stability study should be conducted for larger heights, as per IBM approved mine plan and DGMS guidelines.

The OB dump should be scientifically vegetated with suitable native species to prevent erosion and surface run off. In critical areas, use of geo textiles should be undertaken for stabilization of the dump. Monitoring and management of rehabilitated areas should continue until the vegetation becomes self-sustaining. Proper records should be maintained regarding species, their growth, area coverage etc.

12.13.4 Catch drains and siltation ponds of appropriate size should be constructed to arrest silt and sediment flows from mine operation, soil, OB and mineral dumps. The water so collected can be utilized for watering the mine area, roads, green belt development etc. The drains should be regularly de-silted, particularly after monsoon and should be maintained properly. Appropriate documents should be maintained.

Garland drain of appropriate size, gradient and length should be constructed for mine pit, soil. OB and mineral dumps and sump capacity should be designed with appropriate safety margin based on long term rainfall data.

Sump capacity should be provided for adequate retention period to allow proper settling of silt material. Sedimentation pits should be constructed at the corners of the garland drains and de-silted at regular intervals.

12.13.5 Backfilling should be done as per approved mining plan/scheme. There should be no OB dumps outside the mine lease area. The backfilled area should be afforested, aiming to restore the normal ground level. Monitoring and management of rehabilitated areas should continue till the vegetation is established and becomes self-generating.

12.13.6 Hazardous waste such as, waste oil, lubricants, resin, and coal tar etc. should be disposed off as per provisions of Hazardous Waste Management Rules, 2016, as amended from time to time.

Responsibility: Individual Mine Lease Holders

12.14 Ecology/ Biodiversity (Flora-Fauna) Related

12.14.1 As per the Red List of IUCN (International Union for Conservation of Nature), six floral species and 21 faunal species have been reported to be under threatened, vulnerable & endangered category. Protection of these floral and faunal species should be taken by the State Forest & Wildlife Department on priority, particularly in the mining zones, if any.

12.14.2 The mines falling within 5-10 km of the Karo-Karampada Elephant corridor buffer need to take precautionary measures during mining activities. The forest and existing elephant corridor routes are to be protected and conserved. Improvement of habitat by providing food, water and space for the elephants is required to be ensured to avoid Man-Elephant conflicts.

Though as per the records of State Forest Department, movement of elephants in the Karo-Karampada elephant corridor within 10 km distance from the mines in Joda and Koira is not observed, the Forest Department shall further record and ensure that elephant's movement is not affected due to mining activities.

12.14.3 All precautionary measures should be taken during mining operation for conservation and protection of endangered fauna namely elephant, sloth bear etc. spotted in the study area. Action plan for conservation of flora and fauna should be prepared and implemented in consultation with the State Forest and Wildlife Department within the mine lease area, whereas outside the mine lease area, the same should be maintained by State Forest Department.

12.14.4 Afforestation is to be done by using local and mixed species saplings within and outside the mining lease area. The reclamation and afforestation is to be done in such a manner like exploring the growth of fruit bearing trees which will attract the fauna and thus maintaining the biodiversity of the area. As afforestation done so far is very less, forest department needs to identify adequate land and do afforestation by involving local people in a time bound manner.

12.14.5 Green belt development carried out by mines should be monitored regularly in every season and parameters like area under vegetation/plantation, type of plantation, type of tree species /grass species/scrubs etc., distance between the plants and survival rate should be recorded.

12.14.6 Green belt is an important sink of air pollutants including noise. Development of green cover in mining area will not only help reducing air and noise pollution but also will improve the ecological conditions and prevent soil erosion to a greater extent. Further, selection of tree species for green belt should constitute dust removal/dust capturing plants since plants can act as efficient biological filters removing significant amounts of particulate pollution. Thus, the identified native trees in the mine area may be encouraged for plantation. Tree species having small leaf area, dense hair on leaf surface (rough surface), deep channels on leaves should be included for plantation.

12.14.7 Vetiver plantation on inactive dumps may be encouraged as the grass species has high strength of anchoring besides medicinal value.

12.14.8 Details of compensatory afforestation done should be recorded and documented by respective forest divisions, and State Forest Department should present mine-wise annual status, along with expenditure details.

12.14.9 Similarly, Wildlife Department is also required to record and document annual status of wildlife in the region and should identify the need for wildlife management on regional level.

12.14.10 Maintenance of the ecology of the region is prime responsibility of the State Forest and Wildlife Department. They need to periodically review the status and identify the need for further improvement in the region. The required expenditure may be met from the funds already collected in the form of compensatory afforestation and wildlife management. Further, additional fund, if required can be sought from DMF.

Responsibility: Individual Mine Lease Holders and State Forest & Wildlife Department

12.15 Socio-Economic Related

12.15.1 Public interaction should be done on regular basis and social welfare activities should be done to meet the requirements of the local communities.

Further, basic amenities and infrastructure facilities like education, medical, roads, safe drinking water, sanitation, employment, skill development, training institute etc. should be developed to alleviate the quality of life of the people of the region.

12.15.2 Land outees and land losers/affected people, if any, should be compensated and rehabilitated as per the national/state policy on Resettlement and Rehabilitation.

12.15.3 The socio-economic development in the region should be focused and aligned with the guidelines/initiatives of Govt. of India/ NITI Aayog / Hon'ble Prime Minister's Vision centring around prosperity, equality, justice, cleanliness, transparency, employment, respect to women, hope etc. This can be achieved by providing adequate and quality facilities for education, medical and developing skills in the people of the region. District administration in association with mine lease holders should plan for "***Samagra Vikas***" of these blocks well as other blocks of the district.

While planning for different schemes in the region, the activities should be prioritized as per Pradhan Mantri Khanij Kshetra Kalyan Yojna (PMKKKY), notified by Ministry of Mines, Govt. of India, vide letter no. 16/7/2017-M.VI (Part), dated September 16, 2015 (Annexure II).

Responsibility: District Administration and Individual Mine Lease Holders

12.16 Road Transport Related

12.16.1 All the mine lease holders should follow the suggested ore transport mode (SOTM), based on its EC capacity within next 5 years.

12.16.2 The mine lease holders should ensure construction of cement road of appropriate width from and to the entry and exit gate of the mine, as suggested in Chapter 10. Further, maintenance of all the roads should be carried out as per the requirement to ensure dust free road transport.

12.16.3 Transportation of ore should be done by covering the trucks with tarpaulin or other suitable mechanism so that no spillage of ore/dust takes place. Further, air quality in terms of dust, PM_{10} should be monitored near the roads towards entry & exit gate on regular basis, and be maintained within the acceptable limits.

Responsibility: Individual Mine Lease Holders and Dept. of Steel & Mines

12.17 Occupational Health Related

12.17.1 Personnel working in dusty areas should wear protective respiratory devices and they should also be provided with adequate training and information on safety and health aspects periodically.

12.17.2 Occupational health surveillance program for all the employees/workers (including casual workers) should be undertaken periodically (on annual basis) to observe any changes due to exposure to dust, and corrective measures should be taken immediately, if needed.

12.17.3 Occupational health and safety measures related awareness programs including identification of work related health hazard, training on malaria eradication, HIV and health effects on exposure to mineral dust etc., should be carried out for all the workers on regular basis. A full time qualified doctor should be engaged for the purpose.

Periodic monitoring (on 6 monthly basis) for exposure to respirable minerals dust on the workers should be conducted, and record should be maintained including health record of all the workers.

Review of impact of various health measures undertaken (at an interval of 3 years or less) should be conducted followed by follow-up of actions, wherever required. Occupational health centre should be established near mine site itself.

Responsibility: Individual Mine Lease Holders and District Administration (District Medical Officer)

12.18 Reporting of Environmental Sustainability Achievement

All the mines should prepare annual environmental sustainability report (ESR), highlighting the efforts made towards environmental protection with respect to different environmental components vis-à-vis production performance of the mine on monthly basis. The data collected as per EC and CTE/CTO conditions should be utilized to prepare the annual sustainability report.

The mines performing high with effective environmental safeguards may be suitably recognized/rewarded. "Star Rating Format" formulated by the Ministry of Mines along with environmental sustainability report may be used.

12.19 Environmental Monitoring Requirements at Regional Level

Apart from strict compliance and monitoring by individual mine lease holder, there is a need for simultaneous monitoring in each of the regions by competent expert agencies under the guidance/ supervision of concerned regulatory agency. Details of the studies required to be done on regular basis (continuously for 5 years) through responsible agency (organization of national/state repute) and time frame are suggested in **Table 12.7**.

Table 12.7: Suggested Environmental Monitoring Requirements and Action Plans at Regional Level

Sr. No.	Study Component/ Action Plan	Responsibility	Monitoring and Reporting Time Frame (Approx.)
1.	Environmental Quality Monitoring with respect to Air, Water, Noise and Soil Quality in each region (Joda, Koira and Baripada/Rairangpur) as per specified frequency shall be done by a third party (preferably Govt.) and/or laboratory approved/ recognized by NABET/ CPCB/ SPCB/ MoEF&CC. All the water bodies (rivers, nallas, ponds etc.) shall be monitored. National/State level research/ academic institutes may be involved initially for couple of years to streamline the activity. The report shall be brought out annually by June each year. The study shall be conducted in consultation with MoEF&CC-RO.	SPCB	Continuous Annually
	Installation of online ambient air quality monitor for PM_{10}, $PM_{2.5}$, SOx and NOx within the mine having more than 3 MTPA EC Capacity	Respective Mine Lease Holders	Continuous Annually
	Installation of online ambient air quality monitor for PM_{10}, $PM_{2.5}$, SOx and NOx in the Joda and Koira Region (total 11 locations as suggested in **Section 12.10.3** and **Fig. 12.3**)	SPCB	Continuous Annually

2.	Status of flora and fauna in each of the regions shall be assessed on annual basis. Changes, if any, taking place in the region shall be brought out clearly. The study shall be conducted in consultation with State Forest and Wildlife Department.	State Forest & Wildlife Dept.	Annually in mining zone and once in 3 years in the region
3.	Socio-economic study incorporating developments taking place in each of the region, CSR initiatives made by the mining companies shall be conducted on annual basis. Further, micro level developmental needs shall be clearly brought out in the report for each region. The study shall be conducted in consultation with district administration.	Respective District Administration	Annually
4.	A detailed hydro-geological study in each of the regions shall be conducted in an integrated manner in consultation with Regional Director, Central Ground Water Board. Accordingly, all project proponents shall implement suitable conservation measures to augment ground water resources in the area.	SPCB	Once in 2 years
5.	The State Govt. shall ensure construction and maintenance of dust free common roads/ appropriate rail network for transport of ore from mines to the consumer end.	Dept. of Steel & Mines	12 months for road network and 5-7 years for rail network
6.	Construction and maintenance of dust free roads from respective mine to the main road	Respective Mine Lease Holders	Continuous 6 months
7.	Traffic/road inspection study addressing the condition of traffic/roads leading to different mines and connecting to different railway sidings shall be undertaken on annual basis. Further, detailed traffic study shall be undertaken on every 5 yearly basis to ensure adequacy of road/rail infrastructure in each of the regions. The study can be undertaken through national/ state level research/ academic institute (such as CSIR-CRRI, New Delhi).	Dept. of Steel & Mines	Continuous 6 months
8.	Assessment of landuse/ landcover changes in each of the regions, with particular focus on mining areas, afforestation activities, variation in flow path of various water bodies etc. using remote sensing data	ORSAC	Annually
9.	R&D Studies for utilization of low-grade iron ore	Dept. of Steel & Mines through R&D / Academic Institutes	Upto 45% by 2020 and upto 40% by 2025

The data so generated for the region should be made available on the website of Department of Steel & Mines and also at MoEF&CC website, so that it can be effectively utilized by Individual Mine Lease Holders for preparing EIA/ EMP reports. This will meet the requirement for separate one season baseline environmental quality data collection by the individual proponents, if the mine proposed is in the same study region.

Further, MoEF&CC (through EAC) can also utilize the data base available in evaluating the proposals for expansion of existing mines or new mines while granting ToR or EC to the mine, taking an holistic view of the region.

State Govt. of Odisha should bring out an integrated environmental sustainability report for each of the regions (mainly for Joda and Koia region) incorporating ESR of individual mines and data collected in the region through various agencies, once in 5 years, to plan level of scientific and sustainable mining for the next 5 years.

12.20 Institutional Mechanism for Implementation of Environmentally Sustainable Mining

The present study is not a one-time study, but a process to ensure environmentally sustainable mining activities in the region on long term basis. Looking into the large-scale mining activities and long term perspective for mining vis-à-vis environmentally sustainable mining and upliftment of people of the region, there is a need to create an agency, who will integrate all the aspects relating to sustainable mining in the region on long term basis. It could be a SPV of Govt. of Odisha or a cell within the overall control and supervision of Dept. of Steel & Mines, with members from IBM, GSI, OSPCB, MoEF&CC-RO and other concerned Departments and Mine Owners (EZMA), District Administration.

It is found that the strong database available for the region needs to be taken into account to map and establish environmental quality of the region on daily, monthly, seasonal and annual basis. Further, the efforts and initiatives of the mines towards environmental protection as well as upliftment of the people of the region are required to be integrated, and a systematic plan at the block/regional level needs to be framed for the overall benefit of the local society, region, district, state and the country as a whole.

It will be desirable to have proper environmental quality data management and analysis by NEERI or any other agency for next 5 years (six monthly compliance reports followed by field verification) ensuring sustainable mining practices in the region leading to an overall development of the region.

District Mineral Funds should be utilized appropriately for various developmental activities/needs of the region. Further, an environmental sustainability report incorporating environmental status of region coupled with social upliftment may be brought out by SPCB or any other authorized agency on annual basis. This report can be used for supporting the regional EIA study, and also need for environmental quality monitoring by individual mine seeking environmental clearance for new mine/ expansion of mine, including public hearing.

Since, outcome of the above study reports shall be in the overall interest of all the stakeholders (including local population) of the region, further planning for the region shall warrant cooperation and assistance of all the stakeholders (mine operators, industries, transporters, State & Central Governmnet Offices, MoEF&CC, CPCB, SPCB, Dept. of Steel & Mines, IBM, IMD, NGOs and local people) in sharing the relevant data/

information/ reports/documents etc. to continuosly improve upon the environmentally sustainable development plan for economic growth in mining sector as well as for improvement in quality of life of the people of the region.

At present, in order to ensure the implementation of various recommendations of the report prepared by CSIR-NEERI, it is proposed that a High Level Committee may be constituted under the Chairmanship of the Chief Secretary of the Govt. of Odisha. The composition of the committee may be as follows:

- **Chairman -** Chief Secretary, Govt. of Odisha
- **Vice-Chairman -** Principal Secretary, Dept. of Steel & Mines, Govt. of Odisha
- **Member Secretary –** Director Mines, Directorate of Mines, Govt. of Odisha
- **Members -**
    - Principal Secretary, Forest Department, Govt. of Odisha
    - Principal Secretary, Environment Department, Govt. of Odisha
    - Regional Controller of Mines, Indian Bureau of Mines, Bhubaneswar
    - Member Secretary, State Pollution Control Board, Bhubaneswar
    - Principal Chief Conservator of Forest & Wildlife - Forest Department, Bhubaneswar
    - Regional Officer – MoEF&CC, Bhubaneswar
    - Director, Department of Mines, Govt. of Odisha
    - Regional Director, Geological Survey of India, Bhubaneswar
    - Regional Director, Central Ground water Board/Authority, Bhubaneswar
    - Chief Executive, Odisha Space Applications Centre, Bhubaneswar
    - District Collectors of Respective Districts (Keonjhar & Sundargarh)
    - President, Eastern Zone Mining Association (EZMA)
    - NGOs working on Social Development Activities (one each from Joda and Koira region)
    - Opted Members from CSIR Research Institutes like NEERI, Nagpur, CIMFR, Dhanbad, IMMT, Bhubaneswar, NML, Jamshedpur, CRRI, New Delhi.

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IN

ROAD SWEEPING

FIXED SPRINKLER

50 KL water tanker

16 KL water tanker

PARKING PLAZA

Washing and Desliming of Iron Ore Fines of Nuagaon and Narayanposhi Mines

Submitted to

M/s. JSW Steel Ltd.
Mines Division
Odisha

Prepared by

Mineral Processing Dept.
CSIR-Institute of Minerals & Materials Technology
Bhubaneswar-751013

Foreword

I am happy to forward the report on "Washing and Desliming of Iron Ore Fines of Nuagaon and Narayanposhi Mines" prepared for M/s. JSW Steel Ltd., Mines Division, Odisha. This report includes the mineralogical, physical and chemical characteristics of two iron ore samples as well as physical beneficiation, settling and filtration studies of finer size range of particles to generate the concentrate as sinter and pellet feed material. Mineralogical, physical and chemical studies provide the valuable information to develop the conceptual process flowsheet. Suitable washing and desliming process flowsheet was developed to utilize this low grade iron ores with predominant association with clay minerals. It is possible to get concentrate having more than 62.5% Fe with around more than 82% yield and less than 2.5% alumina in combination of scrubbing, classification and beneficiation of fine range particles using high intensity magnetic separator.

I wish that these findings can be utilised by M/s. JSW Steel Ltd., Mines Division, Odisha for utilization of low grade iron ore fines.

Director
CSIR-Institute of Minerals and Materials Technology
Bhubaneswar

प्रस्तावना

मैसर्स जे.एस.डब्ल्यू स्टील लिमिटेड, खान प्रभाग, ओडिशा के लिए तैयार "नुआगांव और नारायणपोशी खानों के लौह अयस्क फाइन्स की धुलाई और डीस्लिमिंग" पर रिपोर्ट को अग्रेषित करते हुए मुझे खुशी हो रही है। । इस रिपोर्ट में दो लौह अयस्क नमूनों की खनिज, भौतिक और रासायनिक विशेषताओं के साथ-साथ भौतिक लाभकारी, कणों के महीन आकार की सीमा के निपटान और निस्पंदन अध्ययन शामिल हैं ताकि सिंटर और पेलेट फीड सामग्री के रूप में ध्यान केंद्रित किया जा सके। खनिज, भौतिक और रासायनिक अध्ययन वैचारिक प्रक्रिया फ्लोशीट विकसित करने के लिए बहुमूल्य जानकारी प्रदान करते हैं। क्ले मिनरल्स खनिजों के साथ प्रमुख सहयोग के निम्न श्रेणी के लौह अयस्कों का उपयोग करने के लिए उपयुक्त धुलाई और डीस्लिमिंग प्रक्रिया फ्लोशीट विकसित की गई। उच्च तीव्रता वाले चुंबकीय विभाजक का उपयोग करके महीन श्रेणी के कणों के स्क्रबिंग, वर्गीकरण और लाभकारी के संयोजन में लगभग 82% से अधिक उत्पादकता और 2.5% से कम एल्यूमिना के साथ 62.5% Fe से अधिक सांद्रता प्राप्त करना संभव हो पाया।

मेरी इच्छा है कि इन निष्कर्षों का उपयोग मैसर्स जेएसडब्ल्यू स्टील लिमिटेड, खान प्रभाग, ओडिशा द्वारा निम्न ग्रेड लौह अयस्क फाइन के उपयोग के लिए किया जा सकता है। ।

रामबसु

निदेशक

सीएसआईआर-खनिज और पदार्थ प्रौद्योगिकी संस्थान, भुवनेश्वर

Washing and Desliming of Iron Ore Fines of Nuagaon and Narayanposhi Mines

Submitted to

M/s. JSW Steel Ltd.

Mines Division

Odisha

Prepared by

CSIR-Institute of Minerals and Materials Technology
Bhubaneswar-751013, India

Foreword

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I wish that these findings can be utilised by M/s. JSW Steel Ltd., Mines Division, Odisha for utilization of low grade iron ore fines.

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Executive Summary

As per the recent National Steel Policy of Govt. of India, steel production will be enhanced to 300 MTPA in 2030 from current production of 115 MTPA to increase per capita consumption from 65kg to 160kg against the world average 218kg. For the production of 300 MTPA, the country needs high-quality ore around 450 MTPA in form of calibrated ore, sinter and pellet to meet the requisite demand. To catering 450 MPTA, around 750-800 MPTA ores are to be mined.

M/s. JSW Steel Ltd. Mines Division, Odisha was interested to carry out the beneficiation studies of iron ores from their captive mines i.e., Nuagaon and Narayanposhi. CSIR-IMMT, Bhubaneswar has taken the responsibility to carry out characteristics and beneficiation studies to achieve the concentrate as sinter and pellet feed material.

The mineralogical and chemical analysis of Nuagaon iron ore mines was carried out. The Fe content in the bulk sample is 60.27%. The alumina, silica and LOI of the sample are 4.46%, 3.36% and 5.31% respectively. The Bond work index was carried out as per the standard procedure. The Bond work index of the bulk sample is 9.7 kWh/tonne. After desliming by using screw scrubber, the Bond work index was enhanced to 11.00 kWh/tonne. The desliming study of ore was carried out using screw scrubber to classify 100 micron particles as screw scrubber overflow. The water and solid ratio was maintained around 7:3. The overflow percentage with respect to feed was 40%. The Fe content of underflow of screw scrubber could be enhanced to 63.61%. The underflow of screw scrubber was also treated in gravity separation process using jig and spiral concentrator to enhance the Fe content. As grinding system is not available in this circuit, the jig and spiral concentrator tailings cannot be rejected due to high Fe content. Hence the screw scrubber underflow product was considered as one of the products. The Fe content in overflow of screw scrubber is 55.31%. The overflow was treated in magnetic separator to recover iron values from slimes. The Fe content in magnetic concentrate is 61.99%. This is the second product of the process. The overall yield of the process is 82.65% with 63.17% Fe, 1.73% Al_2O_3, 2.59% SiO_2 and 4.57% LOI.

The mineralogical and chemical analysis of Narayanposhi iron ore mines was carried out. The Fe content in the bulk sample is 60.76%. The alumina, silica and LOI of the sample are 4.16%, 2.75% and 6.18% respectively. The Bond work index was carried out as per the standard procedure. The Bond work index of the bulk sample is 11.5 kWh/tonne. After desliming by using screw scrubber, the Bond work index was enhanced to 12.40 kWh/tonne. The desliming study of ore was carried out using screw scrubber to classify 100 micron particles as screw scrubber overflow. The water and solid ratio were maintained around 7:3. The overflow percentage with respect to feed was 19.10%. The Fe content of underflow of screw scrubber could be enhanced to 62.47%. Hence it was considered as one of the products. The Fe content in overflow of screw scrubber is 53.61%. The overflow was treated in rougher and scavenger magnetic separators to recover iron values from slimes. The Fe content in rougher magnetic concentrate is 62.15% and 58.66 % Fe in scavenger magnetic concentrate. Magnetic concentrate is the second product of the process. The overall yield of the process is 91.93% with 62.32% Fe, 2.92% Al_2O_3, 1.81% SiO_2 and 5.86% LOI.

In overall study of beneficiation of screw scrubber overflow was done by magnetic separation process but in commercial plant, the hydrocyclone provision should be there to make further classification before magnetic separator in case of the low grade ore contains less than 58% Fe.

The concentrate and tailings of Nuagaon iron ore sample were taken for the settling study to provide the basic data for design of thickeners. A commercial anionic flocculent was used for settling of fine particles in the present study. The settling study of the concentrate was carried out at different solid concentration from 20 to 35% at 5% interval. The settling study of the tailings were carried out at the solid concentration of 5-10%. The pressure filtration of concentrates and the tailings were carried out using pilot scale filter press. During filter press operation, the cycle time was 22 minutes for filtration of concentrate and 35 minutes for the tailings. It is possible to achieve around 16% moisture in the filter cake for the concentrate and around 21-22% moisture for the tailings. Similarly, the settling and filtration studies of Narayanposhi iron ore sample was carried out.

Acknowledgements

Institute of Minerals and Materials Technology (IMMT), Bhubaneswar, has promoted a vision of Mineral Processing in India and abroad that lowers energy cost, reduces economic risk through improved processing, conserves resources and protects the environment. With this vision we took up to carry out research to carry out the beneficiation study of BMQ sample from M/s. JSW Steel Ltd., Mines Division, Odisha. We would like to express our sincere thanks to Mr. Ranjan Kumar Nayak, COO; Mr. James John, AVP; Mr. Swatantra Kumar, Sr. Manager; and Mr. Puneeth Rao Pawar, Manager; and also the Management of M/s. JSW Steel Ltd., Mines Division, Odisha for providing an opportunity to work on this project specially. We thank all the scientists and staff members in MP Dept. of CSIR-IMMT who have supported directly/indirectly to complete this project.

Investigators

Investigators

1. Dr. S. K. Biswal, Head & Chief Scientist, MP Department
2. Dr. A. K. Sahu, Chief Scientist
3. Dr. P. C. Beuria, Senior Principal Scientist
4. Dr. S. P. Das, Senior Principal Scientist
5. Dr. Alok Tripathy, Senior Scientist
6. Mr. S. N. Sahu, Senior Scientist & PL

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Number of Figures	: 37
Number of Tables	: 66

Content

Chapter 1
Introduction

1.1 Background

Iron ores are valuable natural resources being finite and non-renewable. Iron ore is one of the basic raw materials for iron and steel industries. The production of iron and steel has significantly expanded in recent years, particularly in China and India. It is predicted that the steel production may reach more than 2600 million tonnes in 2030. The recycle in form of iron scrap may meet around 650 million tonnes per annum. The remaining more than 3200 million tonnes per annum will be met through fresh iron ore. This has resulted in a large increase in the demand for iron ore. The quality of iron ore deposits, however, has deteriorated worldwide because of long-term mining, and the existing mines are having increasing difficulty in producing ore with a high grade of iron ore by simple crushing and screening. It is great concern for steel industries to either receive suitable quality iron ore in form of lumpy or sinter/pellet.

Australia and Brazil are among the world's largest iron ore producers and hold a large portion of the world's iron ore reserves. India is the 4^{th} largest iron ore producer next to Australia, Brazil and China. India produced 209 million tonne during 2019-20 financial years. As per the recent National Steel Policy of Govt. of India, steel production will be enhanced to 300 MTPA in 2030 from current production of 115 MTPA to increase per capita consumption from 65kg to 160kg against the world average 218kg. For the production of 300 MTPA, the country needs high-quality ore around 450 MTPA in form of calibrated ore, sinter and pellet to meet the requisite demand. To catering 450 MPTA, around 750-800 MPTA ores are to be mined as shown in Fig.1.1.

1.2 Status of Iron Ore in India

India has 33 billion tonnes of primary iron ore resources like hematite and magnetite based minerals. Out of this, around 10.5 billion tonnes BMQ is available in India as on 1.4.2015 as per Mineral Year Book 2018 published by IBM, Nagpur. Remaining resources comes under hematite category. India's 98% magnetite reserves/resources in form of magnetite or BMQ are located in five States, namely, Karnataka (7,802 million tonnes or 72%) followed by Andhra Pradesh (1,392 million tonnes or 13%), Rajasthan (617 million tonnes or 6%), Tamil Nadu (507 million tonnes or 5%) and Goa (226 million tonnes or 2%). Similarly, the total reserves/resources of haematitic ore as on 1.4.2015 have been estimated at 22.5 billion tonnes. Major reserves/resources of hematitic ore are located in Odisha (7,559 million tonnes or 34%), Jharkhand (5,286 million tonnes or 23%), Chhattisgarh (4,858 million tonnes or 22%), Karnataka (2,467 million tonnes or 11%) and Goa (1,189 million tonnes or 5%). The threshold value of hematite iron ore is 45% Fe whereas 35% for siliceous hematite ore available in State of Goa.

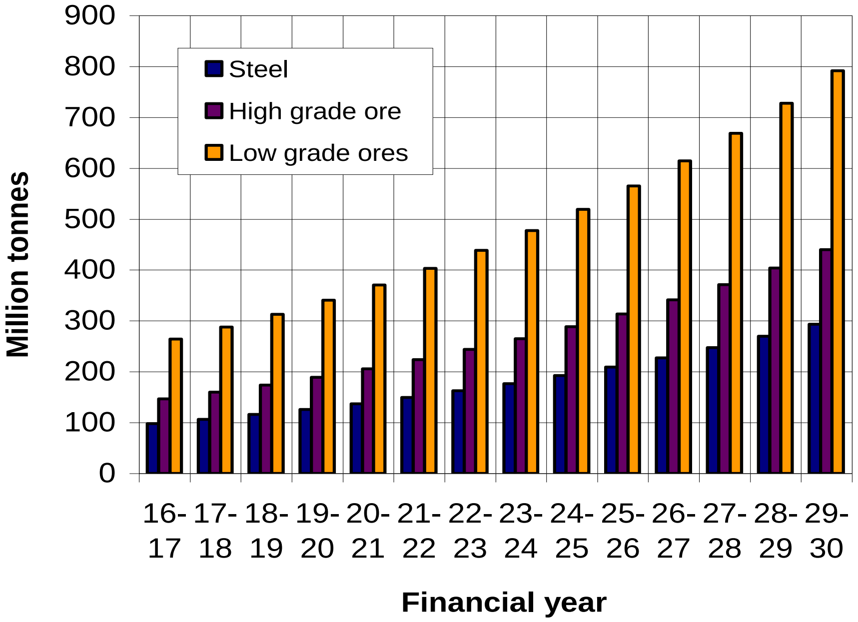

Fig. 1.1 Production of steel, high grade ores and low grade ores for beneficiation

1.3 Characteristics of Indian Ore

Indian hematitic iron ore deposits are soft and friable in nature because it is associated with goethite. During mining, it has been reported that the ratio between fines and lump ores is 2:1. Additionally, generation of fines happens due to mechanised mining and also preparation of sized ores by crushing and screening. Hence 50-70% fines (both high and low grades) are generated during mining and preparation of ore activities. The country is not endowed with high-grade requisite iron ore resources. It is, therefore, imperative to achieve the best use of available low-grade iron ore resources through scientific methods of beneficiation and pelletisation. Challenges and solutions are needed to be focussed for upgradation of Indian low-grade hematite iron ore in association of goethite, kaolinite and gibbsite minerals. The recovery of micro fines of iron phase minerals from slimes/tailings from iron ore washing/beneficiation plants should be taken seriously to maximize the utilization of these resources for long-term sustainability. Nature of iron phase minerals and associated gangue minerals decide the process flowsheet of iron ore beneficiation to be adopted. Utilization of low-grade iron ores through beneficiation and pelletisation is closely interlinked with the environmental impact on the surrounding of the mines. Both aspects have to be properly coordinated to facilitate and ensure a sustainable development of beneficiation and pelletisation processes for utilization of iron ores in harmony with the environment.

1.4 Problems and Challenges of the Indian Iron Ore

In general, Indian hematite ore contains a good amount of clay minerals, which affects the process fluid dynamics due to their swelling properties. It increases the viscosity of the slurry; hence it affects the grinding as well as separation units. These ores are more fragile in nature due to presence of goethite phase. As a result, the ultra fine generation in the grinding circuit is more and ultimately it increases the Blaine number which has negative impact in the pelletisation plant. Percentage of goethite increases when Fe content of the ore decreases and other gangues minerals increases simultaneously. As per commercial plant observation, below 55% Fe content of ore does not respond well to the conventional beneficiation process.

1.5 Present Practice

At present practice in India, the ROM ore is crushed and classified into different size fractions either in dry or wet process. Most of the mines are operated in a dry process using hard ore by selective mining to cater the calibrated iron ore need of iron and steel industries. It is crushed to below 40/30 mm or 18mm size and classified at 10 mm/5mm size to provide the suitable size of calibrated ore (40/30+10 mm) or (-18+5 mm) to blast furnace/DRI operation respectively if the ore meets requisite metallurgical, physical and chemical properties. Whatever fine ore is generated due to crushing and classification processes, it may be utilized in sintering plant of integrated steel plants if it meets the required specification. The low grade ore is subjected to the physical beneficiation to recover the iron values, otherwise, it is dumped in mine site as rom fine dumps as shown in Fig.1.2. In the same time, percentage of low-grade fines increases day-by-day due to depletion of high-grade iron ore. It also creates environmental impact in air and water body in the surrounding of the mine. Utilization of these fines is the need of hour to maximize the iron recovery through suitable beneficiation process which should hold up the economic feasibility and environmental sustainability. Some of the iron ore mining industries are still making the washing of coarse particles and putting the slimes in the pond as shown in Fig. 1.3. These slimes also contain good amount of Fe values.

Fig. 1.2 Iron ore low grade dump fines

Fig. 1.3 Iron ore slimes pond

1.6 Appropriate Approach for Iron Ore Beneficiation

- Percentage of goethite increases when Fe content of the ore decreases and simultaneously other gangues minerals increases. When the ore contains less than 55% Fe, it has been noted that goethite percentage is more than 50%. Hence this ore does not respond well to the conventional beneficiation process using gravity and magnetic separation techniques using physical properties. As the Indian hematite ore contains good amount of clay, it should be removed at the beginning of the process using scrubbing equipment like screw scrubber/screw classifier, reflux classifier or drum scrubber. Hence the effect of slimes in the grinding and separation units in the process can be minimised.

- During grinding of the ore, proper classification unit with closed circuit grinding is very indispensable to reduce the generation of ultra-fine.
- Grinding product and desliming product should be treated separately to avoid the selectivity of the particles during separation process.
- If more goethite presents in the ore or liberated goethite is more, reduction roasting process may be adopted to maximise the recovery of the iron values.

1.7 Objective of the Project

M/s. JSW Steel Ltd., Mines Division, Odisha is planning to set up Washing and Desliming Iron Ore Plant to generate concentrates for sinter and pellet feed material from 58-60% Fe from Nuagaon and Narayanposhi mines.

The scopes of the work involved in this study:

(i) Sample preparation
(ii) Size analysis of as received sample
(iii) Detail chemical analysis of as received sample
(iv) Fe analysis of each size fractions
(v) Washing study by screw scrubber
(vi) Desliming study by hydrocyclone
(vii) Detail chemical analysis of screw scrubber product, hydrocyclone underflow and overflow
(viii) Settling study of cyclone overflow and underflow
(ix) Filtration study of hydrocyclone underflow
(x) Material (solid and water) balance of process
(xi) Report preparation

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Chapter 2
Characterization, Beneficiation and Dewatering Studies of Nuagaon Sample

2.1 Introduction

Around 1 tonnes of Iron ore below 10 mm sample was received from Nuagaon Iron ore mines, Barbil, Odisha to carry out the desliming and beneficiation study to develop the suitable process flowsheet for production of high-grade iron ore concentrate. Around 100 kg representative sample was taken by standard coning and quartering method for size analysis, chemical analysis, bond work index, mineralogical studies and bulk density of bulk sample. The remaining sample was processed for desliming and beneficiation studies.

2.2 Characterisation Study

2.2.1 Size & Fe Analysis of Bulk Sample

The total sample of around 1 tonnes was thoroughly mixed and representative sample was drawn by coning and quartering method for size analysis. Then the size analysis with respective Fe analysis of bulk sample was carried out and the result is given in Table 2.1. The remaining sample was subjected to beneficiation studies.

Table 2.1
Size and Fe analysis of bulk sample

Size, mm	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
+10	3.50	3.50	63.34	63.34
+6	14.25	17.75	63.99	63.86
+3	12.65	30.40	64.18	63.99
+2	4.79	35.19	63.94	63.99
+1	9.11	44.30	63.52	63.89
+0.850	5.14	49.44	61.99	63.69
+0.500	3.80	53.24	61.71	63.55
+0.300	3.67	56.91	62.11	63.46
+0.210	4.40	61.31	61.71	63.33
+0.150	2.81	64.12	62.06	63.28
+0.100	2.03	66.15	61.15	63.21
+0.075	1.38	67.53	62.27	63.19
+0.045	3.71	71.24	61.71	63.12

-0.045	28.76	100.00	53.17	60.26
Total	100.00		60.26	
Bulk			60.27	

2.2.2 Detail Chemical Analysis

The detailed chemical analysis, LOI along with the trace elements of the bulk sample was carried out. The result is given in the Table 2.2. The major impurity is quartzite and aluminum oxide. The hematite percent in the ore is about 86.19 %.

Table 2.2
Detail chemical analysis of the bulk sample

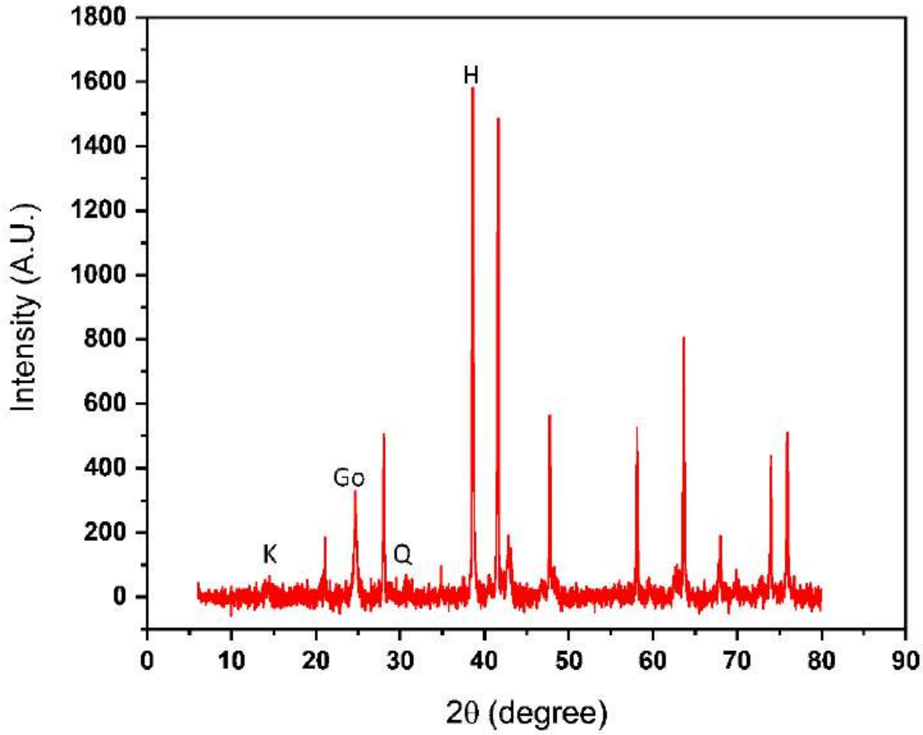
Details	Percentage
Fe (T)	60.27
Fe_2O_3	86.19
SiO_2	3.36
Al_2O_3	4.46
CaO	0.13
Cr_2O_3	0.006
CuO	0.005
K_2O	0.066
MgO	0.032
MnO_2	0.029
Na_2O	0.01
NiO	0.004
P_2O_5	0.004
PbO	0.008
TiO_2	0.126
V_2O_5	0.018
ZnO	0.014
LOI	5.31

2.3 Mineralogical Study

Mineralogical study of the bulk sample was carried out by using X-ray diffraction study. This study gives the qualitative mineralogical identification of different phases present with their textures.

2.3.1 XRD Study

XRD study was carried out on the representative bulk sample to determine the major minerals present in the sample. The XRD result is shown in Fig. 2.1 It indicates that the bulk sample have hematite as the major mineral phase and other minerals are goethite, quartz and kaolinite.



H: Hematite, Go: Goethite, Q: Quartz, K: Kaolinite

Fig. 2.1 XRD study of bulk sample

2.4 Sequential Heating Analysis of Bulk Sample

The sequential heating at different temperature was carried out using muffle furnace for bulk sample to determine the association of minerals like goethite, gibbsite, kaolinite and overall LOI content. The result of sequential heating is given in Table 2.3. Based on weight loss at different temperatures, percentage of goethite, gibbsite and kaolinite were calculated. The percentage of water loss during 108ºC to 450ºC is used to calculate the percentage of goethite and gibbsite mineral. The percentage of water loss during 450ºC 850ºC is used to calculate the percentage of kaolinite mineral. The percentage of water loss during 850ºC 950ºC is used to calculate the percentage of carbonate minerals.

Mineralogical characteristion study carried out by using both heating cycle and chemical analysis is given Table 2.4.

Table 2.3
LOI at different temperature by sequential heating cycle of bulk sample

400°C	850°C	950°C	Total LOI, %
4.11	1.15	0.05	5.31

Table 2.4
Mineralogical characteristics study by using heating cycle and chemical analysis

Heating Cycle Analysis	Hematite, %	Goethite, %	Kaolinite, %	Gibbsite, %
	55.86	33.92	8.24	1.92
Chemical Analysis	Fe(T), %	LOI, %	Al_2O_3, %	SiO_2, %
	60.27	5.31	4.46	3.36

2.5. Estimation of Bond Work Index

2.5.1 Sample Preparation

Around 30 kg of representative bulk sample was taken and screened at 3.36 mm size. The +3.36 mm size was crushed to below 3.36 mm size by using roll crusher. Then, it was thoroughly mixed and the representative sample was drawn for grindiability study for determination of Bond Work Index (BWI).

2.5.2 Ball Mill Grindiability Process

Grindiability study was carried out as per the standard procedure described by Bond. The Bond ball mill work index determination is carried out in a standard test mill and under standard conditions. The test mill has an internal diameter of 12 inch and length is also 12 inch. It has a smooth lining with rounded corners, no lifters except for a 4" X 8" hand hole lid for charging.

It has a revolution counter and runs at 70 rpm. The grinding charge consists of 285 iron balls weighing 20.125 kg. It consists of about 43 numbers of 1.45" balls, 67 numbers of 1.17" balls, 10 numbers of 1" balls, 71 numbers of 0.75" balls and 94 numbers 0.61" balls with a calculated surface area of 842 sq inch.

The standard feed was prepared by passing all through 3.36 mm size. It was packed by shaking in a 1000 cc graduated cylinder, and the weight of 700 cc was placed in the mill and ground dry at 250 percent circulating load. After the first grinding period of 100 revolutions, the mill was dumped; the ball charge was screened out and 700 cc of material was screened on 150 mesh (100 micron) with coarser protecting sieves if necessary. The undersize was weighed and fresh unsorted feed was added to oversize to bring its weight back to that of original charge. Then it was returned on to the balls in the mill and ground for the number of revolutions calculated from the results of the previous period to produce sieve undersize equal to 1/3.5 of the total charge in the mill. The grinding period cycles were continued until the net grams of sieve undersize produced per mill revolution reaches equilibrium and reverses its direction of increase or decrease. Then the undersize product and circulating load were screen analyzed, and the average of the last three net grams per revolution (G_{bp}) was the mill grindiability. When F is the size in microns which 80 percent of the new ball mill feed passes, P is the microns which 80 percent of the last cycle sieve undersize product passes, and P_1 is the opening in microns of sieve size tested (100 micron), then the ball mill work index W_i is calculated from the following revised equation;

$$W.\ I. = 44.5 / \{(P_i)^{0.23} X (G_{bp})^{0.82} X\ 10\ (1 / \sqrt{P} - 1/\sqrt{F})\} \qquad \textbf{(2.1)}$$

2.5.3 Bond Work Index of Bulk Sample

The representative iron ore bulk sample was taken for grindability study as per Bond's method. The size analysis of the crushed product for grindability study was carried and the results are given in the Table 2.5. It was found that d_{80} of the feed material was 1860 micron. The grindability study was carried for 100 micron test sieve. The weight of the 700 cc of material was 1630 gm. For 250 percent circulating load, 466 gm of -100 micron particles are to be produced at equilibrium revolution. To reach the equilibrium revolution a number of tests were carried out. At the equilibrium stage, G_{bp} was 2.27.

The size analysis of -100 micron product was carried out. The size analysis of product is given in the Table 2.6. The overall grindability result of bulk Sample is given in Table 2.7. The particle size distribution of feed and product is depicted in Fig. 2.2 and 2.3 respectively. The d_{80} of the ball mill product was 78.5 micron. Then according to Equation, W.I. was calculated and it was found 8.8 kWh/short ton. It was converted to normal tonne and WI value is 9.7 kWh/tonne.

$Wi = (44.5)/((P_1)^{0.23} \times (Gbp)^{0.82} (10/\sqrt{P} - 10/\sqrt{F}))$

$=(44.5)/((100)^{0.23} \times (2.27)^{0.82} (10/\sqrt{78.5} - 10/\sqrt{1860}))$

= 8.8 kWh/short ton

= 8.8 X 1.1 = **9.7 kWh/tonne**

The bond work index of the sample is determined to be 9.7 kWh/tonne.

Table 2.5
Feed size analysis

Size, micron	Cum. Wt., % Passing
3360	100.00
2000	83.40
1400	64.51
1000	55.85
850	48.64
500	40.71
212	33.92
150	27.97
100	23.80

Table 2.6
Size analysis of ground product

Size, micron	Cum Wt., % Passing
100	100.00
75	76.50
63	57.00
45	39.50
38	22.50

Table 2.7
Results of gram per revolution

No. of revolutions	100micron produced (g)	100micron in the feed (g)	Net -100micron produced (g)	Grindability (g/rev.)
100	632	268	364	3.640
100	458	103.9	354	3.558
110	398	75.3	323	2.937
136	414	65.4	349	2.555
156	436	68.1	368	2.361
167	452	71.7	380	2.276
172	462	74.3	388	2.252
173	471	76.0	395	2.280

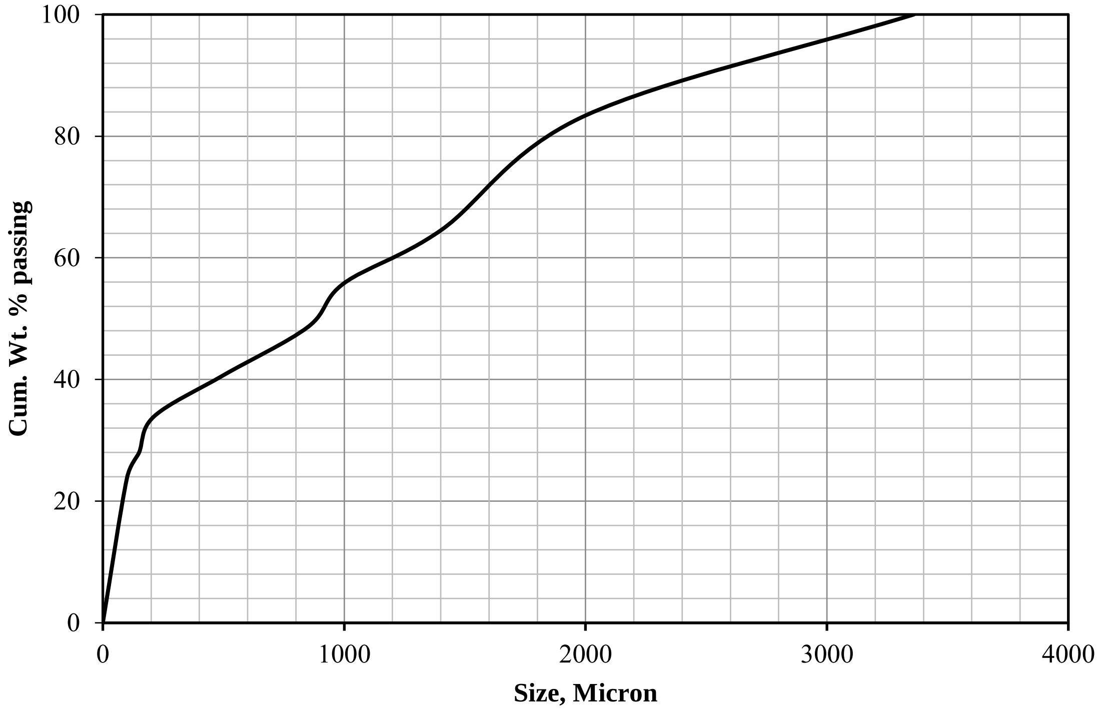


Fig. 2.2 Particle size distribution of feed

Fig. 2.3 Particle size distribution of product

2.5.4 Bond Work Index of Screw Scrubber Underflow Sample

The representative screw scrubber underflow sample was taken for grindability study as per Bond’s method. The size analysis of the crushed product for grindability study was carried and the result is given in the Table 2.8. It was found that d_{80} of the feed material was 1870 micron. The grindability study was carried for 100 micron test sieve. The weight of the 700 cc of material was 1610 gm. For 250 percent circulating load, 460 gm of below 100 micron particles are to be produced at equilibrium revolution. To reach the equilibrium revolution a number of tests were carried out. At the equilibrium stage, G_{bp} was 1.972.

The size analysis of below 100 micron product was carried out. The size analysis of product is given in the Table 2.9. The overall grindability result of screw scrubber underflow is given in Table 2.10. The particle size description of feed and product is depicted in Fig. 2.4 and 2.5 respectively. The d_{80} of the ball mill product was 80 micron. Then according to equation, W.I. was calculated and it was found 10.0 kWh/short ton. It was converted to normal tonne and WI value is 11.0 kWh/tonne.

$$Wi = (44.5)/((P_1)^{0.23} \times (Gbp)^{0.82} (10/\sqrt{P} - 10/\sqrt{F}))$$

$$=(44.5)/((100)^{0.23} \times (1.972)^{0.82} (10/\sqrt{80} - 10/\sqrt{1870}))$$

$$= 10.0 \text{ kWh/short ton} = 10.0 \times 1.1 = \mathbf{11.0\ kWh/tonne}$$

The bond work index of the sample is determined to be 11.0 kWh/tonne.

Table 2.8
Feed size analysis

Size, micron	Cum. Wt., % Passing
3360	100.00
2000	83.09
1400	56.91
1000	43.09
850	33.70
500	25.80
212	15.93
150	10.12
100	6.42
-100	0.00

Table 2.9
Size analysis of ground product

Size, micron	Cum Wt., % Passing
100	100.00
75	74.50
63	55.00
45	39.00
38	27.50
-38	0.00

Table 2.10
Results of gram per revolution

No. of revolutions	100micron produced (g)	100micron in the feed (g)	Net -100micron produced (g)	Grindability (g/rev.)
100	332	156	176	1.760
243	512	32.2	480	1.972
208	458	49.6	408	1.960
212	462	44.4	418	1.967
211	461	44.8	416	1.970
211	461	44.7	416	1.972
211	460	44.7	415	1.970
211	460	44.6	415	1.968
210	460	44.8	415	1.977

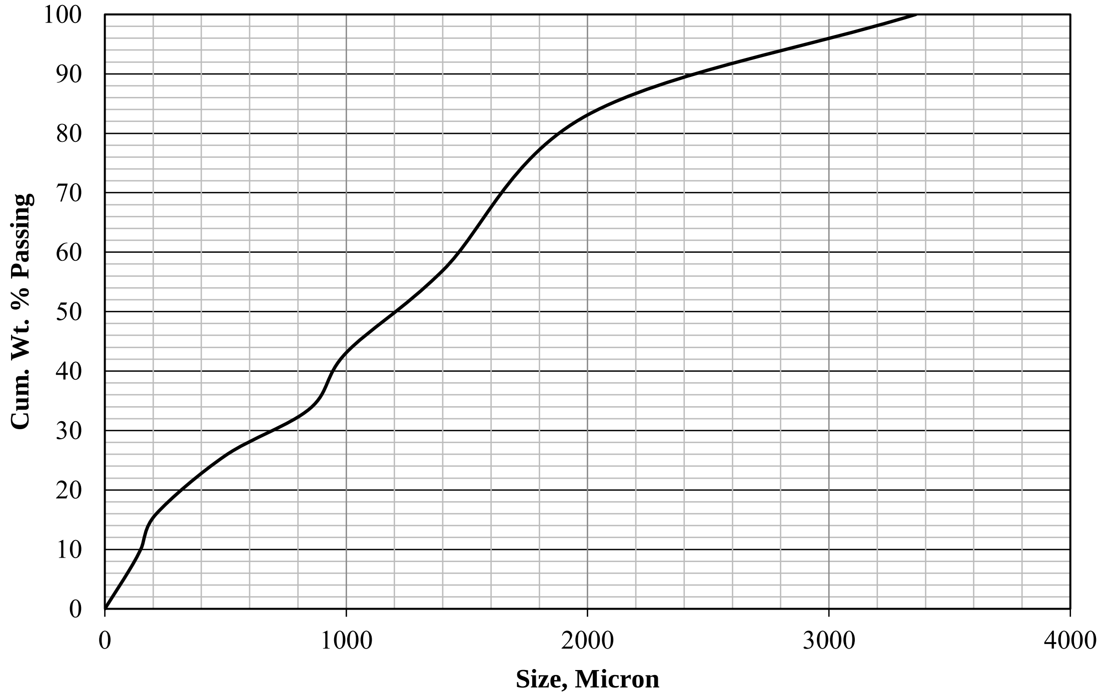


Fig. 2.4 Particle size distribution of feed

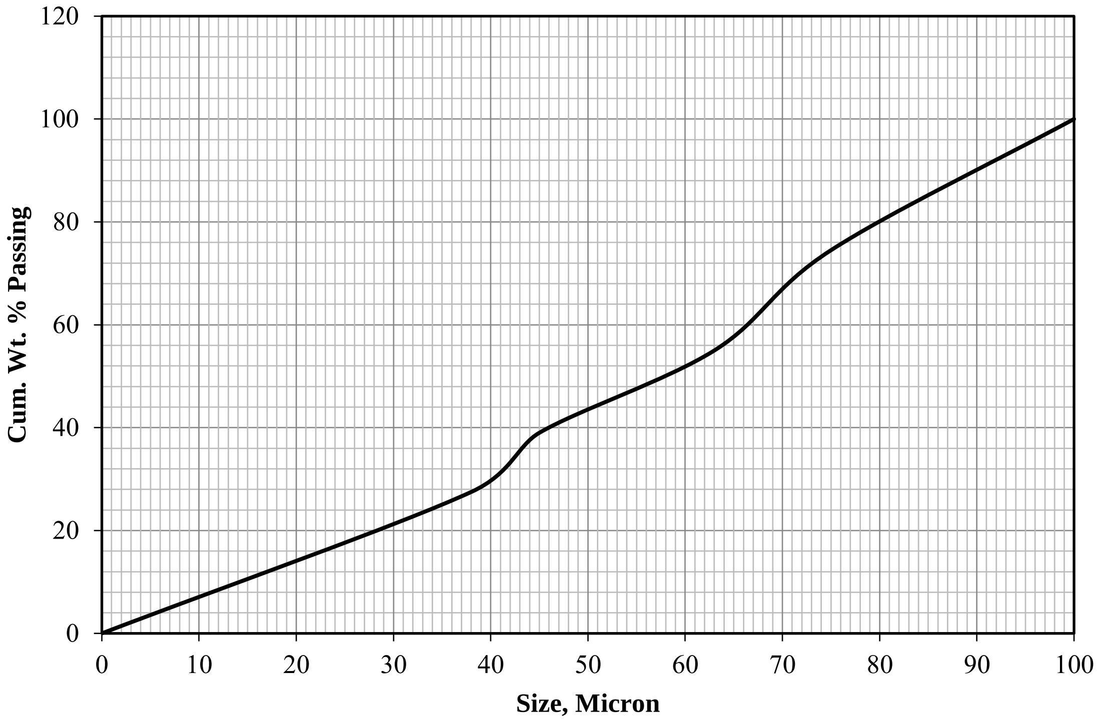


Fig. 2.5 Particle size distribution of product

2.6 Bulk Density

Bulk density is the weight of material in air per unit volume. It is measured by the help of a square sized metal container having length of each side 300 mm. Bulk density is evaluated by weighing a precisely measured known volume of ore sample. Natural moisture content is determined as per IS: 2720 (part 2) -1973. The bulk density of -10 mm sized sample is 1.997 kg/m^3 and its bulk density after being tapped is 2.242 kg/m^3.

2.7 Beneficiation Studies

The beneficiation study of the iron ore sample was carried out based on their mineralogy. According to size analysis studies, it contains good number of fine particles which may be iron phase minerals along with clay particles. In general, the fine clay particles are coated on the surface of the coarse particles. These clay minerals are responsible to increase the viscosity of slurry due to their swelling characteristics during the beneficiation process. Hence, it is essential to remove at the beginning of the process by scrubbing technique and discard as the reject. Hence the remaining materials can be processes smoothly for upgradation of iron values by physical beneficiation. As it contains 28.76% of below 45 microns and the top size is below 10mm, hence for attrition of particles, screw scrubber process is most suitable. This equipment also classifies simultaneously the fine particles in a single stage. The laboratory screw scrubber was used for desliming the slime particles at the feed rate of 200 kg/hr using water to solid ratio of 70:30. The screw scrubber gives two products i.e., overflow (slimes) and underflow (coarse particles). The sample was fed to the screw scrubber. The Fe content of scrubber underflow could be achieved to 63.61% with overall yield of 60.00% and overflow fraction contained 55.31% Fe with overall yield of 40.00%. The result of screw scrubber is given in the Table 2.11. The result shows that screw scrubber underflow is one of the final product and overflow need to be further processed. Attempt was made to enhance the grade of scrubber underflow by further process.

Table 2.11

Screw scrubber study of bulk sample

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Underflow	60.00	60.00	63.61	63.61
Overflow	40.00	100.00	55.31	60.29
Total	100.00		60.29	

The underflow of screw scrubber was further classified into two different size fractions viz. (-10+1mm, and -1mm). The Fe content of -10+1 mm size could be achieved to 63.95% with overall yield of 36.16%. The Fe content of -1 mm size could be achieved to 63.10% with overall yield of 23.84%. The result of classified sample is given in Table 2.12. The result shows -10+1 mm is having slightly more higher Fe value compared to -1mm size fraction.

Table 2.12

Size classification of screw scrubber underflow

Size, mm	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
-10+1	36.16	36.16	63.95	63.95
-1	23.84	60.00	63.10	63.61
Total	60.00		63.61	

The -10+1 mm size fraction of sample was processed in the batch type laboratory jig (Supplied by All Minerals, Germany). In each batch around 50kg sample was taken during experiment. It is a hydraulic jig operated with pneumatic control pulsating system. The pulse frequency was kept 60 cycle per minute and air flow rate 0.3 to 0.4 bar. The screen aperture used for bed was 1 mm size. After 30 minutes the material was collected from the chamber in layer by layer from top to bottom at particular thickness. The concentrate (Layer 1, Layer 2 and Layer 3) obtained by jigging of -10+1 mm fraction contains 64.68% Fe with yield of 39.15% and tailings contains 46.88% Fe with yield of 1.68%. The jigging study of -10+1 mm sample is given in the Table 2.13.

Table 2.13

Jigging study on -10+1 mm size fraction material

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Layer 1	28.09	28.09	65.26	65.26
Layer 2	8.07	36.16	63.51	64.87
Layer 3	2.99	39.15	62.36	64.68
Layer 4	1.68	40.82	46.88	63.95
Total	36.16		63.95	

The -1 mm size samples was processed in the spiral concentrator. Roughing and cleaning operations were carried out to enrich the concentrate grade. In both operations of roughing and scavenging, 30% solid concentration was maintained. The capacity of spiral concentrator is 1 tonne per hour. The Fe content of rougher concentrate could be achieved to 64.36% with overall yield of 19.51%. The Fe contains of scavenging concentrate, scavenging tailings and tailing fines could achieved 62.65%, 59.82% and 54.87% with overall yield 0f 4.33%, 3.94 % 1.18% respectively. The result of spiral concentrator is given in the Table 2.14.

Table 2.14

Spiral study of -1mm size fraction material

Details	Wt., %	Cum Wt., %	Fe, %	Cum. Fe, %
Rougher Concentrate	19.51	19.51	64.36	64.36
Scavenging Concentrate	4.33	23.84	62.65	64.05
Scavenging Tailings	3.94	27.78	59.82	63.45
Tailing Fines	1.18	28.97	54.87	63.10
Total	23.84		63.10	

The -10+1 mm size was further classified in two different size fractions viz. (-10+5 mm, and -5+1mm). The Fe content of -10+5 mm size could be achieved to 64.5% with overall yield of 18.12%. The Fe content of -5+1 mm size could be achieved to 63.40% with overall yield of 18.04%. The result of classified sample is given in Table 2.15.

Table 2.15
Size classification of -10+1 mm fraction

Size, mm	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
-10+5	18.12	18.12	64.50	64.50
-5+1	18.04	36.16	63.40	63.95
Total	36.16		63.95	

The -10+5 mm and -5+1 mm size fraction of samples were processed in the batch type laboratory jig. In each batch around 50kg sample was taken for experiment. The pulse frequency was kept 60 cycle per minute and air flow rate 0.3 to 0.4 bar. The screen aperture used for bed was 1 mm size. After 30 minute the material was collected from the chamber in layers from top to bottom at particular thickness. The concentrate (Layer 1, Layer 2 and Layer 3) obtained by jigging of -10+5 mm fraction contains 65.23% Fe with yield of 17.44% and tailings contains 46.10% Fe with yield of 0.69%. The jigging study of -10+5 mm sample is given in Table 2.16. The concentrates (Layer 1, Layer 2 and Layer 3) obtained by jigging of -5+1 mm fraction contains 64.62% Fe with yield of 16.80% and tailings contains 46.81% Fe with yield of 1.24%. The jigging study of -5+1 mm sample is given in Table 2.17.

Table 2.16
Jigging study on -10+5 mm size fraction material

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Layer 1	13.88	13.88	65.51	65.51
Layer 2	2.53	16.41	64.70	65.39
Layer 3	1.03	17.44	62.71	65.23
Layer 4	0.69	18.12	46.10	64.50
Total	18.12		64.50	

Table 2.17
Jigging study on -5+1 mm size fraction material

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Layer 1	12.91	12.91	65.1	65.10
Layer 2	2.09	15.00	63.5	64.88
Layer 3	1.80	16.80	62.52	64.62
Layer 4	1.24	18.04	46.81	63.40
Total	18.04		63.40	

The overflow of screw scrubber is to be deslimed by hydrocyclone to remove the ultrafine gangue minerals directly. The screw scrubber overflow sample was fed to the rougher hydrocyclone. The hydrocyclone gives two products i.e., overflow (very ultrafine slimes particle) and underflow (fine coarse particles). The Fe content of hydrocyclone underflow could be achieved to 60.71% Fe with overall yield of 20.93% and overflow fraction contained 49.39% Fe with overall yield of 19.07%. The rougher hydrocyclone overflow sample was fed to the scavenging hydrocyclone at the density 1040 kg/m^3. The Fe content of scavenger hydrocyclone underflow could be achieved to 56.98% Fe with overall yield of 6.54% and overflow fraction contained 45.43% Fe with overall yield of 12.52%. The rougher and scavenging hydrocyclone study are given in Table 2.18 and 2.19.

Table 2.18

Rougher hydrocyclone study of screw scrubber overflow

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Underflow	20.93	20.93	60.71	60.71
Overflow	19.07	40.00	49.39	55.31
Total	40.00		55.31	

Table 2.19

Scavenging hydrocyclone study

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Underflow	6.54	6.54	56.98	56.98
Overflow	12.52	19.07	45.43	49.39
Total	19.07		49.39	

If the overflow of hydrocyclone contains ultrafine hematite particles and are not the discardable, then the screw scrubber overflow will be beneficiated directly using WHIMS/HGMS.

The overflow of screw scrubber was fed to HGMS (supplied by LONGI). The magnetic intensity of LONGI is 12000 gauss. The feed density was kept at 1.06 kg/m^3. The Fe content of the rougher magnetic fraction of LONGI could be achieved to 61.99% Fe with overall yield of 22.65% whereas non-magnetic fraction contains 45.04% Fe with overall yield of 13.12%. The rougher non-magnetic fraction was fed to the scavenging LONGI. The Fe content of the scavenging magnetic fraction of LONGI could be achieved to 56.10% Fe with overall yield of 1.04% and non-magnetic fraction contains 41.02% Fe with overall yield of 2.60%. The rougher and scavenging magnetic separation results are given in Table 2.20and 2.21.

Table 2.20
LONGI study of screw scrubber overflow

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Concentrate	22.65	22.65	61.99	61.99
Middlings	4.23	26.88	51.45	60.33
Tailings	13.12	40.00	45.04	55.31
Total	40.00		55.31	

Table 2.21
LONGI scavenging study

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Concentrate	3.15	3.15	56.10	56.10
Middlings	2.10	5.25	43.51	51.06
Tailings	7.87	13.12	41.02	45.04
Total	13.12		45.04	

The rougher and scavenging hydrocyclone underflow were blended together and given in Table 2.22. The blended material fed to LONGI. The intensity of magnetic separator (Longi) having 12000 gauss in pilot scale. The result of rougher LONGI study is given in the Table 2.23. The Fe content of the rougher magnetic fraction could be enhanced to 63.83%Fe with overall yield of 19.21%. The rougher middling could be achieved 62.97%Fe with overall Yield of 2.59% and non-magnetic fraction from rougher tailings contains 44.80%Fe with overall yield of 5.67%. The rougher tailings of LONGI was further fed to scavenger stage of LONGI. The Fe content of the scavenging magnetic fraction could be enhanced to 58.69%Fe with overall yield of 2.46%. The scavenging middling contains 45.31%Fe with overall Yield of 0.45% and non-magnetic fraction from scavenging tailings contains 32.39%Fe with overall yield of 2.77%. The result of scavenger LONGI is given in the Table 2.24.

Table 2.22
Blending of hydrocyclone underflows

Details	Wt., %	Cum Wt., %	Fe, %	Cum. Fe, %
Rougher hydrocyclone underflow	20.93	20.93	60.71	60.71
Scavenging hydrocyclone underflow	6.54	27.48	56.98	59.82
Total	27.48		59.82	

Table 2.23
LONGI study of blended product

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Concentrate	19.21	19.21	63.83	63.83
Middlings	2.59	21.80	62.97	63.73
Tailings	5.67	27.48	44.80	59.82
Total	27.48		59.82	

Table 2.24
LONGI scavenging study

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Concentrate	2.46	2.46	58.69	58.69
Middlings	0.45	2.90	45.31	56.63
Tailings	2.77	5.67	32.39	44.80
Total	5.67		44.80	

The overflow of hydrocyclone was fed to LONGI. The magnetic intensity of LONGI is 12000 gauss. The result of rougher LONGI study is given in the Table 2.25. The Fe content of the rougher magnetic fraction could be enhanced to 53.35%Fe with overall yield of 3.37%. The rougher middling could be achieved 48.52%Fe with overall Yield of 0.72% and non-magnetic fraction from rougher tailings contains 42.00%Fe with overall yield of 8.43%. The rougher tailings of LONGI was further fed to scavenger LONGI. The Fe content of the scavenging magnetic fraction could be enhanced to 47.47%Fe with overall yield of 1.92%. The scavenging middling contains 42.27%Fe with overall Yield of 0.55% and non-magnetic fraction from scavenging tailings contains 40.21%Fe with overall yield of 5.96%. The result of scavenger LONGI is given in the Table 2.26.

Table 2.25
LONGI study of hydrocyclone overflow

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Concentrate	3.37	3.37	53.35	53.35
Middlings	0.72	4.09	48.52	52.50
Tailings	8.43	12.52	42.00	45.43
Total	12.52		45.43	

Table 2.26
LONGI scavenging study

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Concentrate	1.92	1.92	47.47	47.47
Middlings	0.55	2.47	42.27	46.31
Tailings	5.96	8.43	40.21	42.00
Total	8.43		42.00	

Based on the above study and considering on the quality and quantity on the final product, following process were carried out. The beneficiation study was carried out by using screw scrubbing of the ROM sample followed by the magnetic separation of the screw scrubber overflow. The results are given in the Table 2.27 and Table 2.28. The overall product is given in the Table 2.29 and the overall reject is given in the Table 2.30. The chemical analysis of the product and reject are given in the Table 2.31 and 2.32 respectively and the process flowsheet is shown in Figure 2.8.

Table 2.27
Scrubbing study of bulk sample

Details	Wt., %	Cum Wt., %	Fe, %	Cum. Fe, %
Underflow	60.00	60.00	63.61	63.61
Overflow	40.00	100.00	55.31	60.29
Total	100.00		60.29	

Table 2.28
Magnetic separation study of screw scrubber overflow

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Mag	22.65	22.65	61.99	61.99
Middling	4.23	26.88	51.45	60.33
Non-Mag	13.12	40.00	45.04	55.31
Total	40.00		55.31	

Table 2.29
Overall products

Details	Wt., %	Fe, %
Screw Scrubber underflow	60.00	63.61
Rougher MS Conc.	22.65	61.99
Total	82.65	63.17

Table 2.30
Overall rejects

Details	Wt., %	Fe, %
Rougher Middling	4.23	51.45
Rougher Tailings	13.12	45.04
Total	17.35	46.60

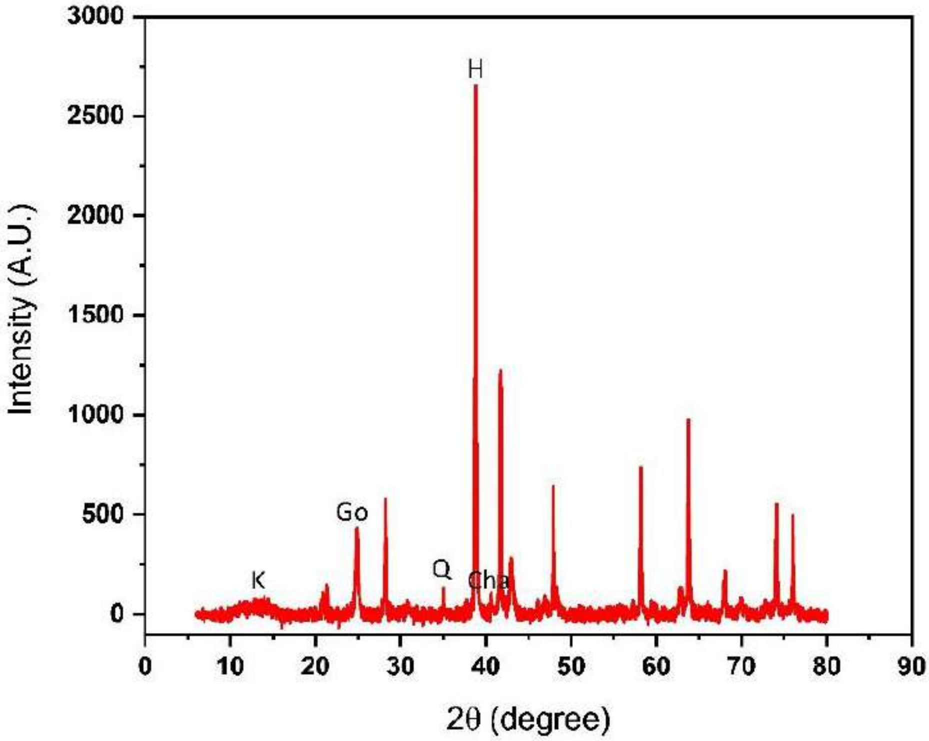
Table 2.31
Chemical analysis of the product

Details	Scrubber U/F	Magnetic Conc.	Overall
Fe (T)	63.61	61.99	63.17
Fe_2O_3	90.96	88.65	90.33
SiO_2	2.23	3.55	2.59
Al_2O_3	1.61	2.06	1.73
LOI	4.37	5.09	4.57

Table 2.32
Chemical analysis of the reject

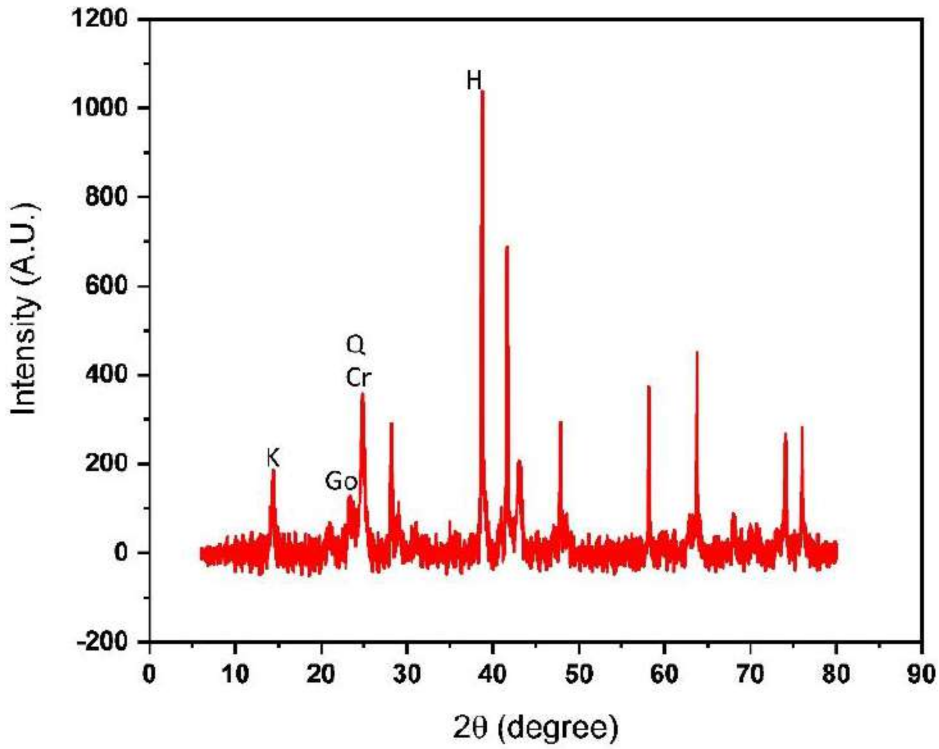
Details	Percentage
Fe (T)	46.60
Fe_2O_3	66.64
SiO_2	7.03
Al_2O_3	17.46
LOI	8.80

XRD study was carried out on the product and reject sample to determine the major minerals present in the samples. The XRD results are shown in Fig. 2.6 and 2.7. It indicates that the product sample have hematite as the major mineral phase and other minerals are goethite, quartz and kaolinite; while the reject sample have hematite as the major mineral phase and other minor minerals are quartz, goethite, cristobilite and quartz.



H: Hematite, Go: Goethite, Q: Quartz, K: Kaolinite; Ch: Chantalite

Fig. 2.6 XRD study of product sample



H: Hematite, Go: Goethite, Q: Quartz, K: Kaolinite, Cr: Cristobilite

Fig. 2.7 XRD study of reject sample

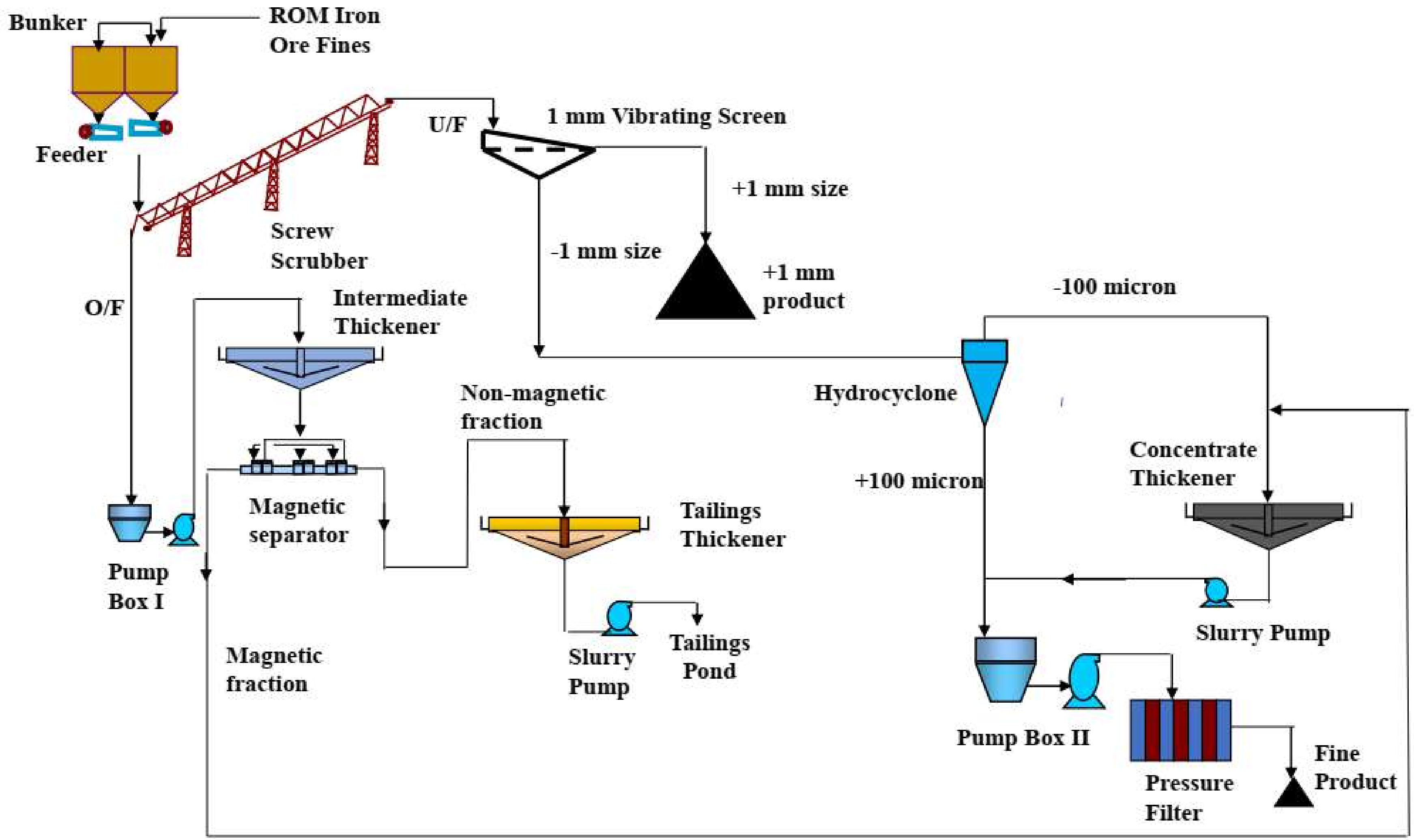


Fig. 2.8 Process flowsheet for washing of low grade iron ore of Nuagoan

2.8 Pressure Filtration Study

The pressure filtration study of magnetic separation concentrate and magnetic separation tailings were carried out by using Diemme Filter press and the results are given in Table 2.32 and Table 2.33 respectively.

Fig. 2.9 Pilot scale pressure filter set up

Table 2.32
Pressure filtration result of magnetic separation concentrate

Parameters	Exp. 1
Solid % in feed	60
Feeding time, min	11
Feeding pressure, bar	6
Air purging time, min	9
Air purging pressure, bar	7
Squeezing time, min	5
Squeezing pressure, bar	11
Total filtration time, min	22
Weight of cake (Wet), Kg	66
Cake Thickness, mm	25
Filtrate (water)	35
Cake moisture, %	16

Table 2.33
Pressure filtration result of magnetic separation tailings

Parameters	Exp. 1
Solid % in feed	30
Feeding time, min	15
Feeding pressure, bar	7
Air purging time, min	10
Air purging pressure, bar	8
Squeezing time, min	10
Squeezing pressure, bar	13
Total filtration time, min	35
Weight of cake (Wet), Kg	25
Cake Thickness, mm	18
Filtrate (water)	40
Cake moisture, %	21.6

2.9 Settling Studies

2.9.1 Materials Preparation

After processing of the iron ore, the tailing and concentrate samples were taken for the settling study to provide the basic data for design of thickeners for tailings and concentrate.

2.9.2 Experimental Method

The settling study was carried out in a graduated measuring cylinder of 1 liter capacity. Different solid concentration like 20% to 35% in increment of 5% of concentrate and 5% to 10% in the increment of 2.5% tailing samples are prepared. The pH of the concentrate sample was maintained at 6.5 and the pH of tailing is 6.5. This is due to pH as the received in the process. The interface height was observed against the time intervals. The interface level with respect to time was recorded in each case.

2.9.3 Results and Discussion

The settling study was carried out on concentrate sample at different solids concentration of 20%, 25%, 30% & 35%. The pH of the sample was kept at 6.5 as the sample was received from the process at the same pH. The results of experiments were shown in Figures 2.10 to 2.14. It has been observed that the settling rate decreases with increasing of solid percentage. In case of 20% of solid concentration, the settling rate is 2.0 m/hr. Different dosses of flocculent was used to enhance the settling rate of solid. Very low doses of flocculent is required at lower solid concentration to get satisfactory results to design the conventional thickener. At higher solid concentration, the flocculent dosage requirement is little high.

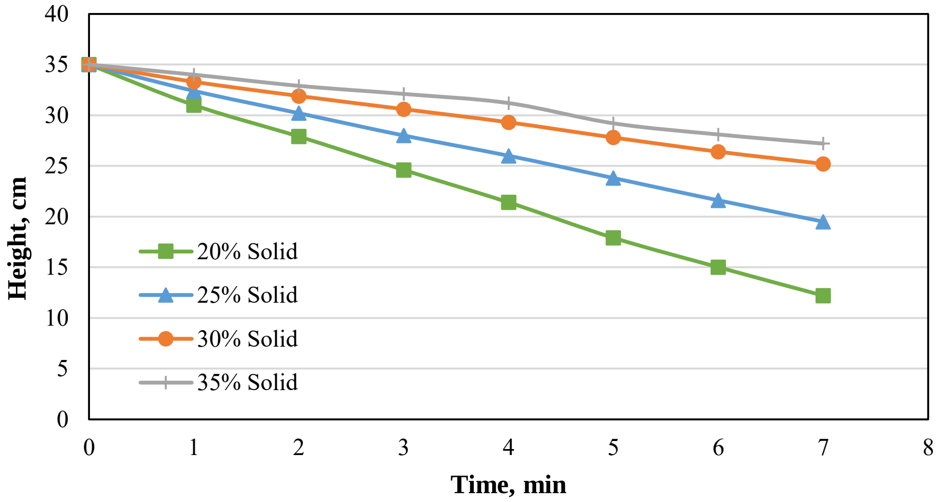


Fig. 2.10 Settling study of iron ore concentrate at different solid concentration

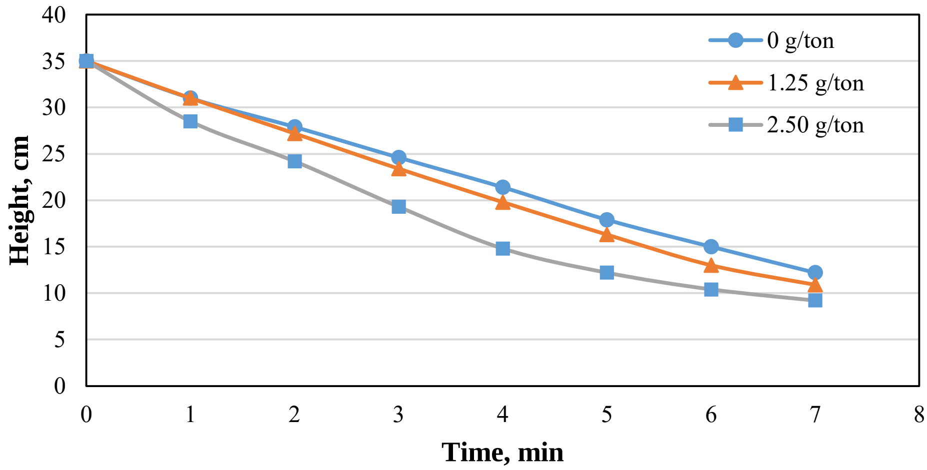


Fig. 2.11 Iron ore concentrate settling study at 20% solid concentration with different doses of flocculent

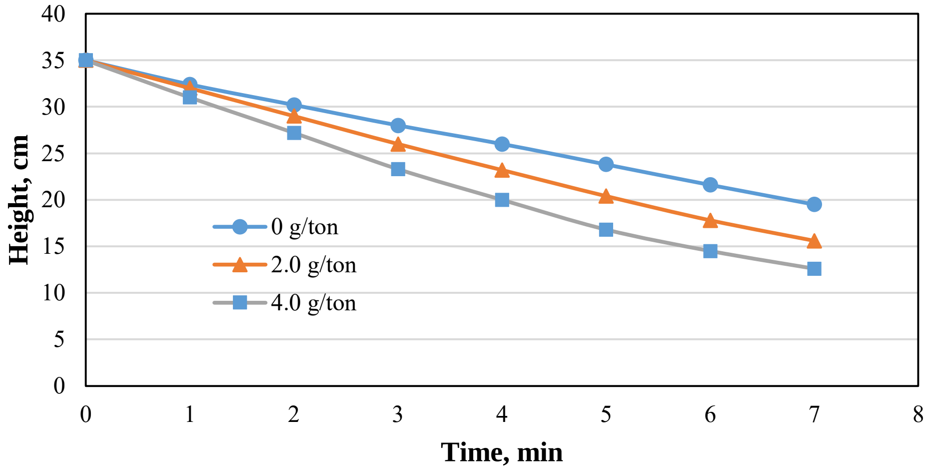


Fig. 2.12 Iron ore concentrate settling study of 25% solid concentration with different doses of flocculent.

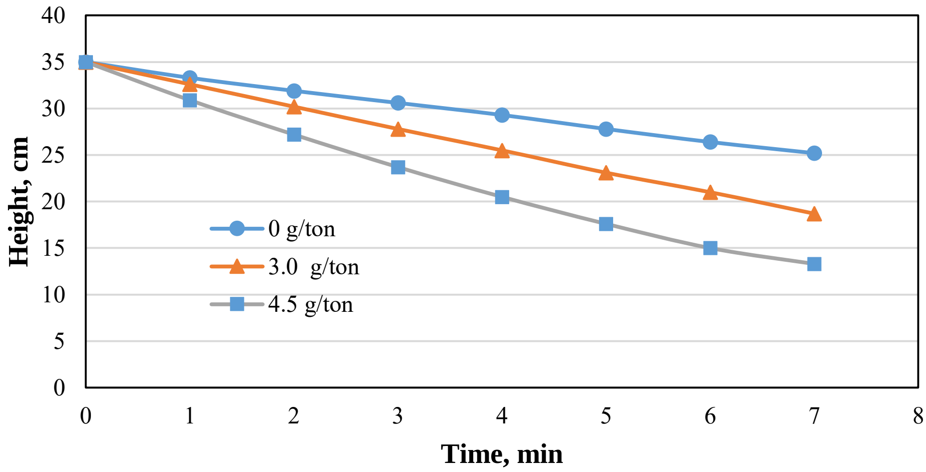


Fig. 2.13 Iron ore concentrate settling study of 30% solid concentration with different doses of flocculent.

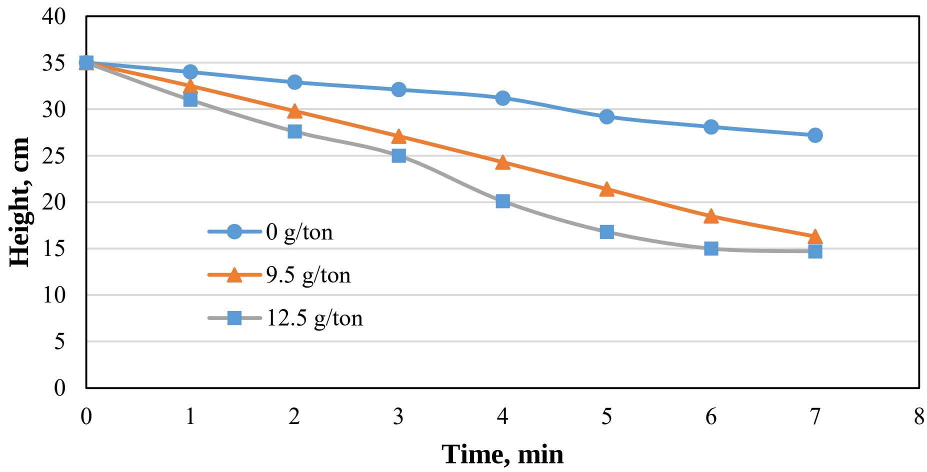


Fig. 2.14 Iron ore concentrate settling study of 35% solid concentration with different doses of flocculent

Similarly settling studies of iron ore tailings were carried out at different concentration of 5%, 7.5% and 10%. The tests were carried out without and with addition of flocculent. The tests results are shown in Figure 2.15 to 2.18. It has been observed that the settling rate decreases with increasing of solid percentage. In case of 5% of solid concentration, the settling rate is 2 m/hr whereas in case 15 %, the settling rate is 0.8 m/hr. The flocculent rate was varied from 6.52 gm/tonne to 30 gm/tonne of solid. The settling rate with flocculent is very high at lower solid concentration. It indicates that after 5% solid concentration, the flocculent may require at lower dosage to enhance the settling rate. At higher solid concentration, the flocculent dosage requirement is high. At 10% solid concentration, the settling rate is very poor even after adding the flocculent.

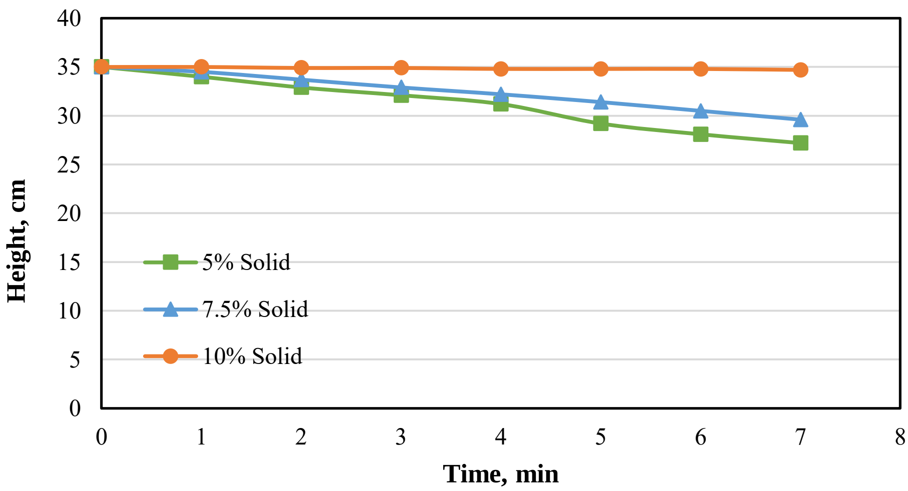


Fig. 2.15 Iron ore tailings settling study of different solid concentration

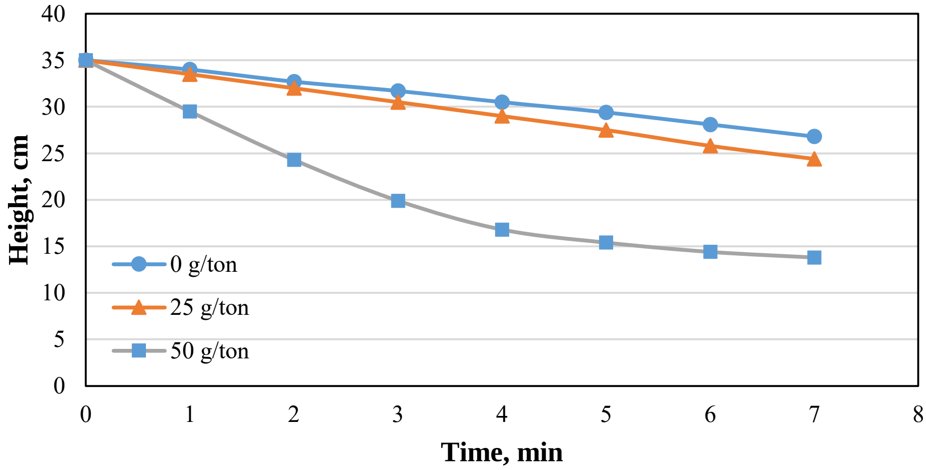


Fig. 2.16 Iron ore tailings settling study at 5% solid concentration with different doses of flocculent

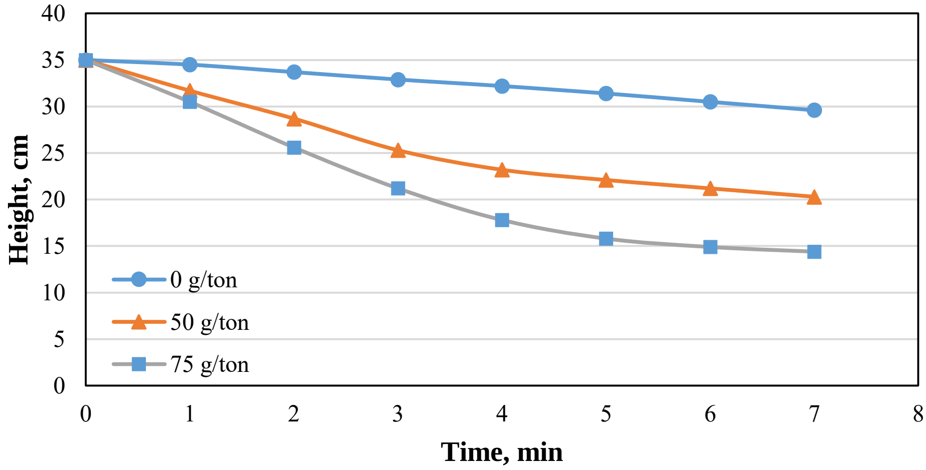


Fig. 2.17 Iron ore tailings settling study at 7.5% solid concentration with different doses of flocculent

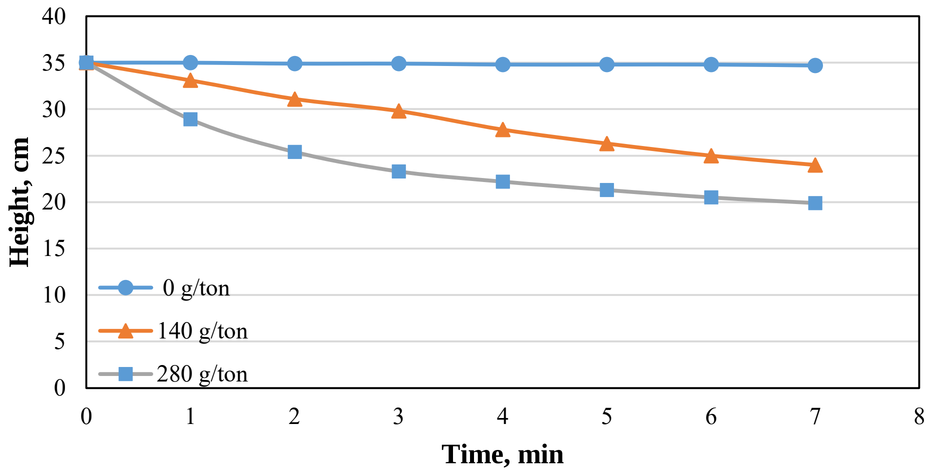


Fig. 2.18 Iron ore tailings settling study at 10% solid concentration with different doses of flocculent

2.10 Conclusions

The results of settling studies indicate the following observations;

1. The settling rate in case of tailings sample is very slow due to presence of ultra-fine clay minerals. Because of its surface charge, those try to remain in dispersion mode. The flocculent helps to neutralize the surface charge and make agglomerates the ultra-fine particles, as a result, the settling rate enhances.
2. The settling rate for conventional thickener design is required around 20 cm within 5-6 minutes. The above results are matching these phenomena.
3. For concentrate sample, small dose of flocculants was required to be added as there was less clay mineral compared to the tailings.

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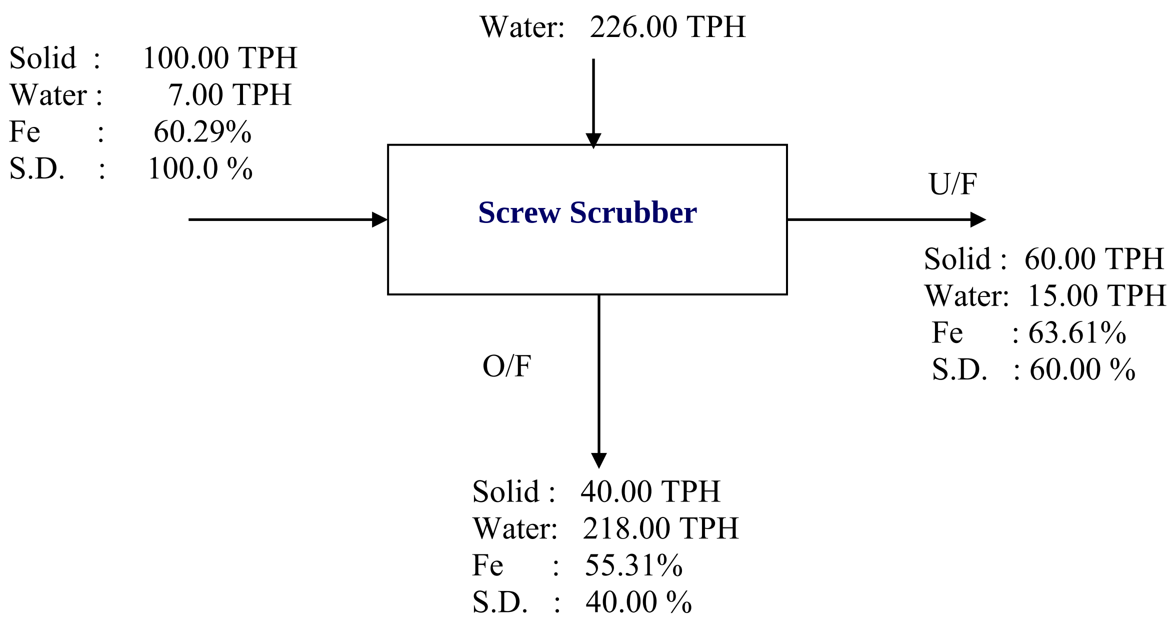
Annexure I.A

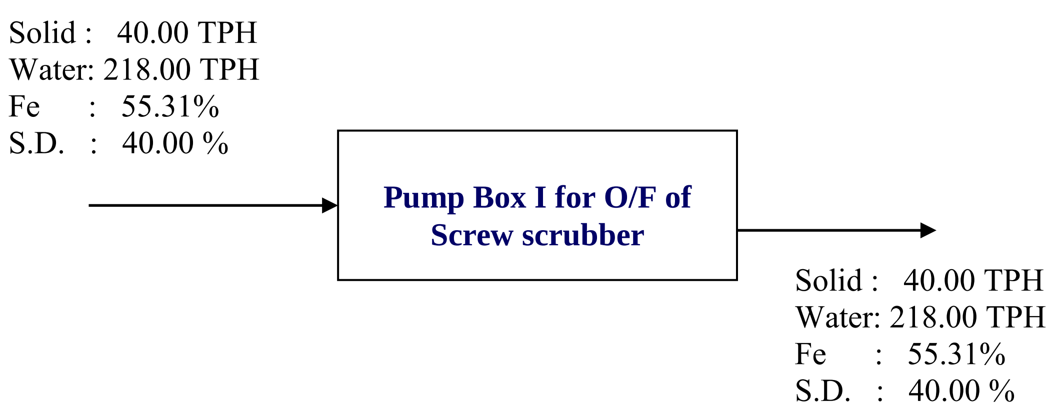
Material Balance of Process (Nuagaon Iron ore)

Basis: 100 TPH

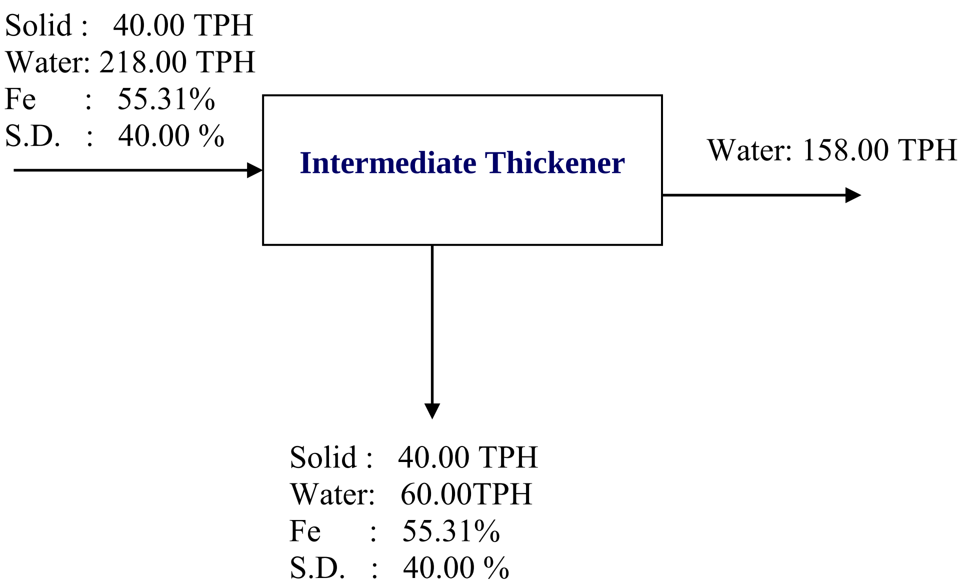
1. Screw Scrubber



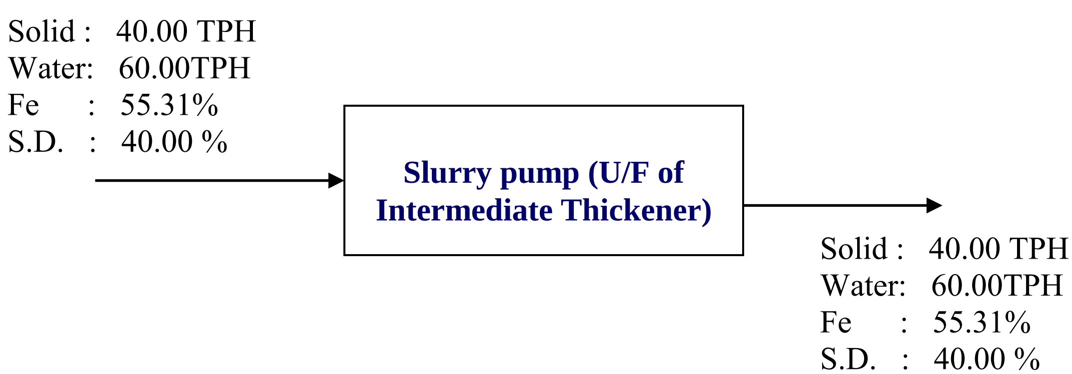
2. Pump Box I (O/F of Screw scrubber)



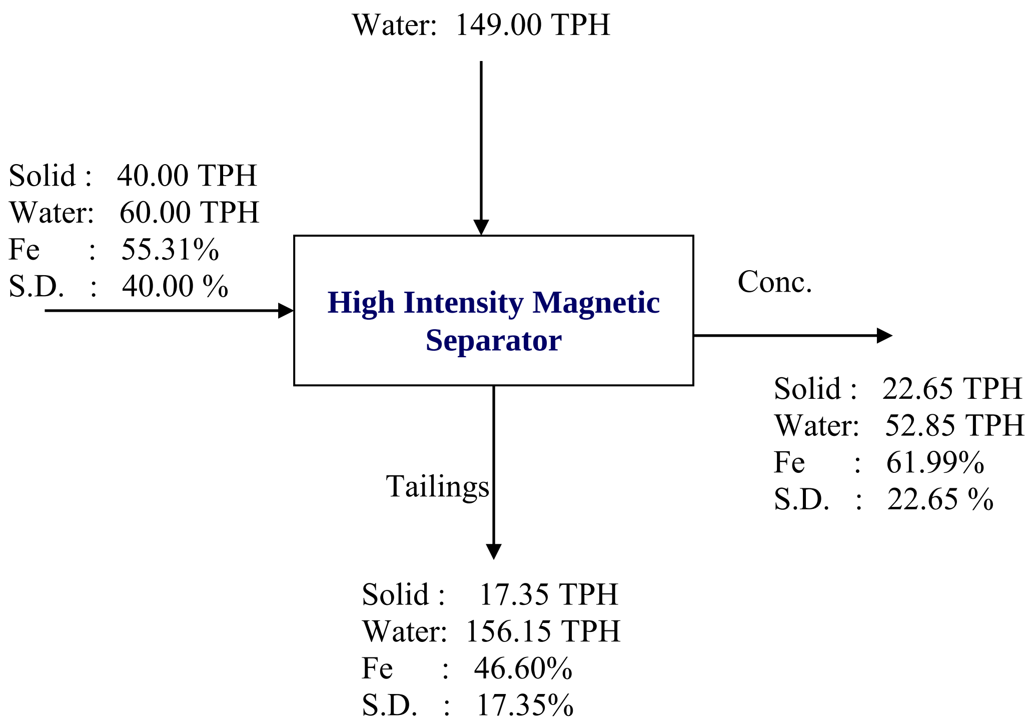
3. Intermediate Thickener



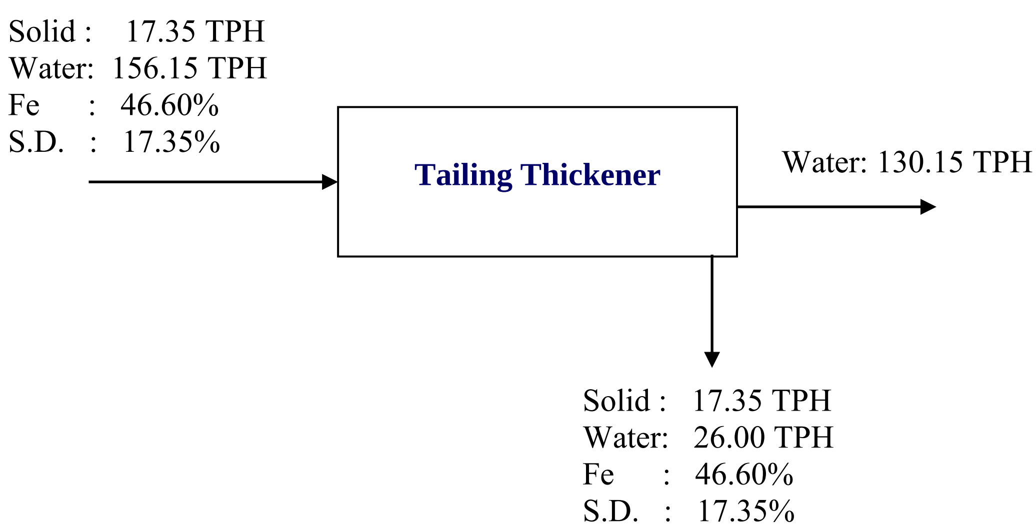
4. Slurry Pump I (U/F of intermediate thickener)



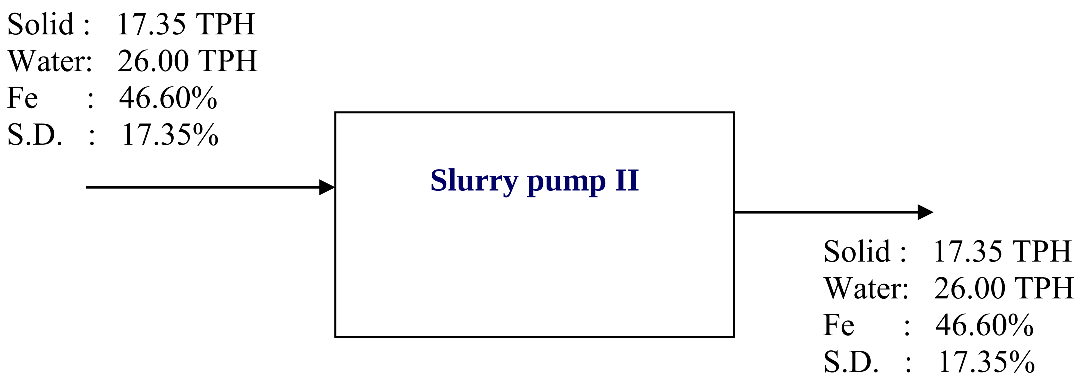
5. High Intensity Magnetic Separator



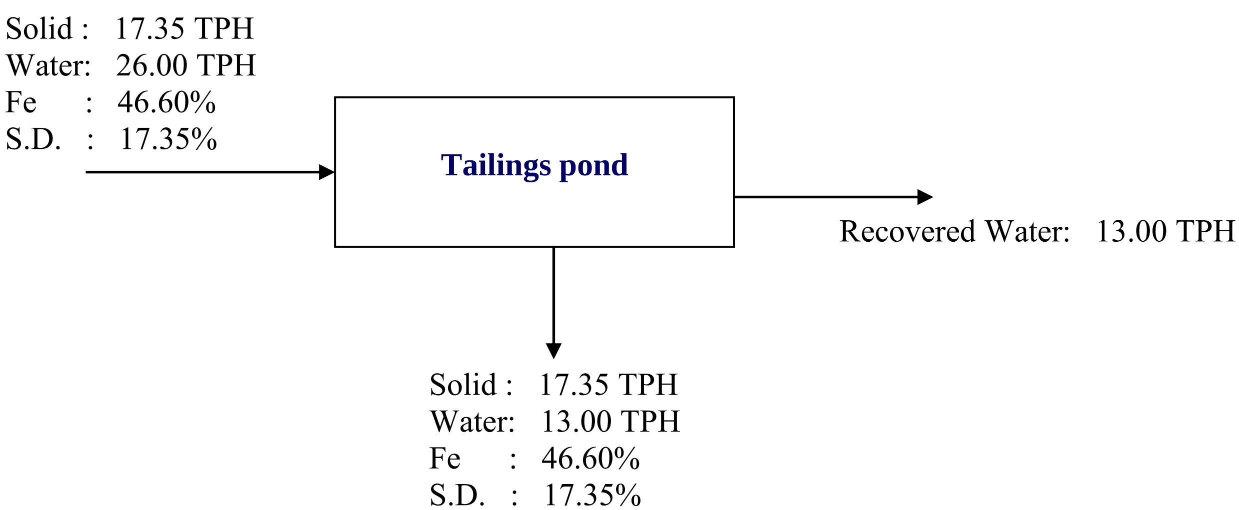
6. Tailing Thickener



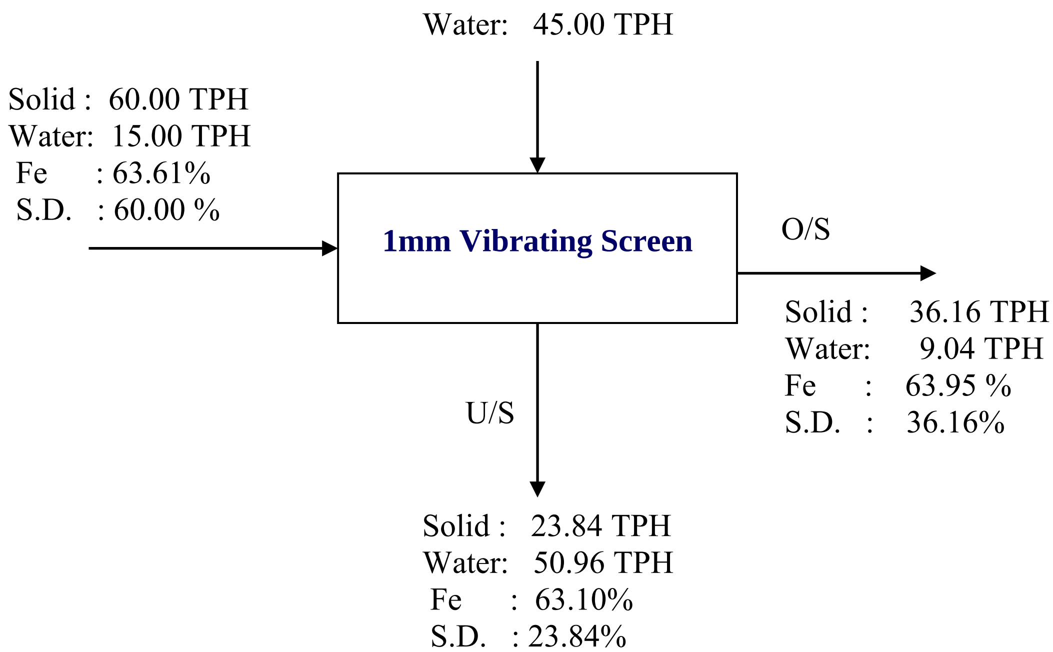
7. Slurry Pump II



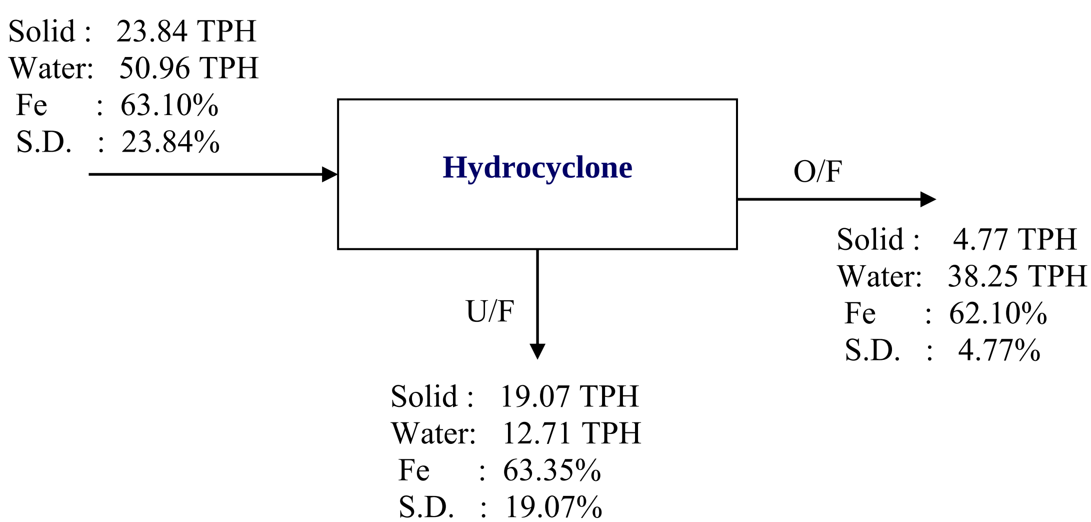
8. Tailings Pond



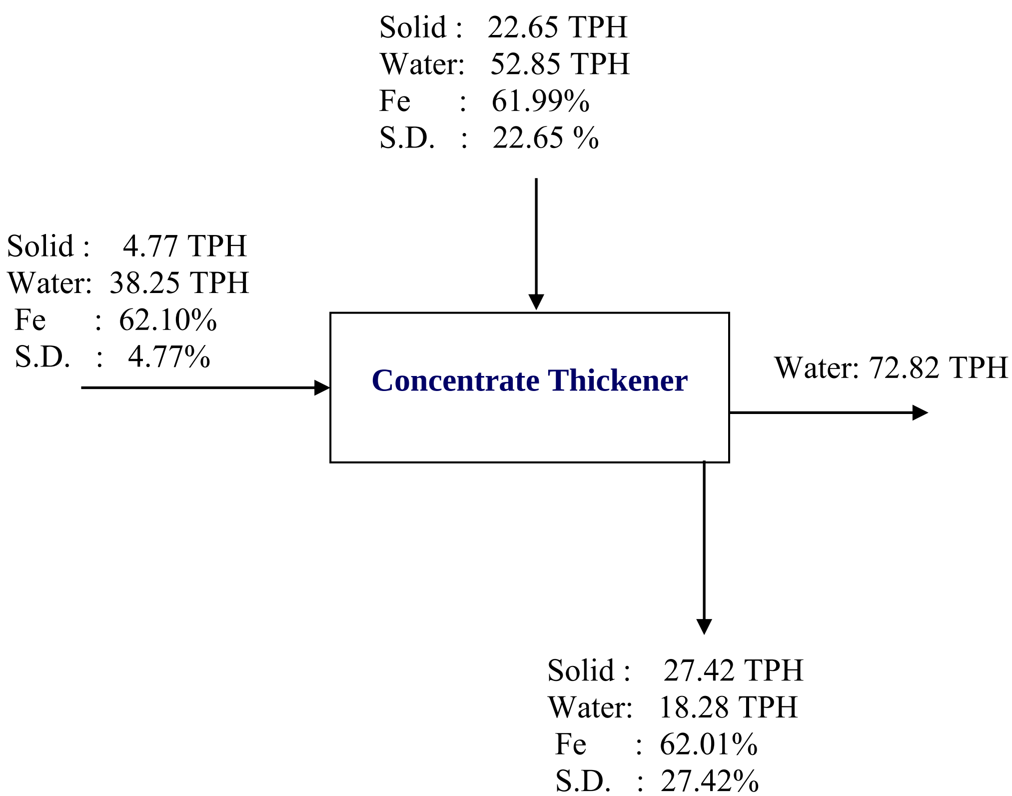
9. Vibrating Screen (1 mm size)



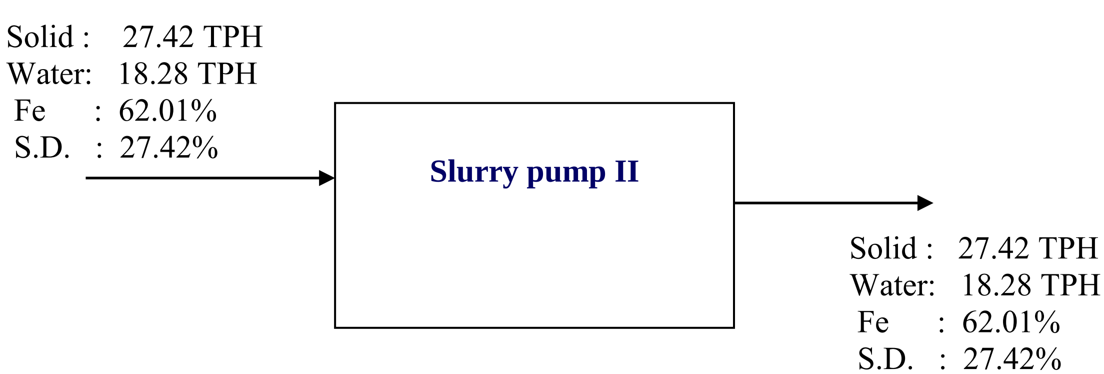
10. Hydrocyclone



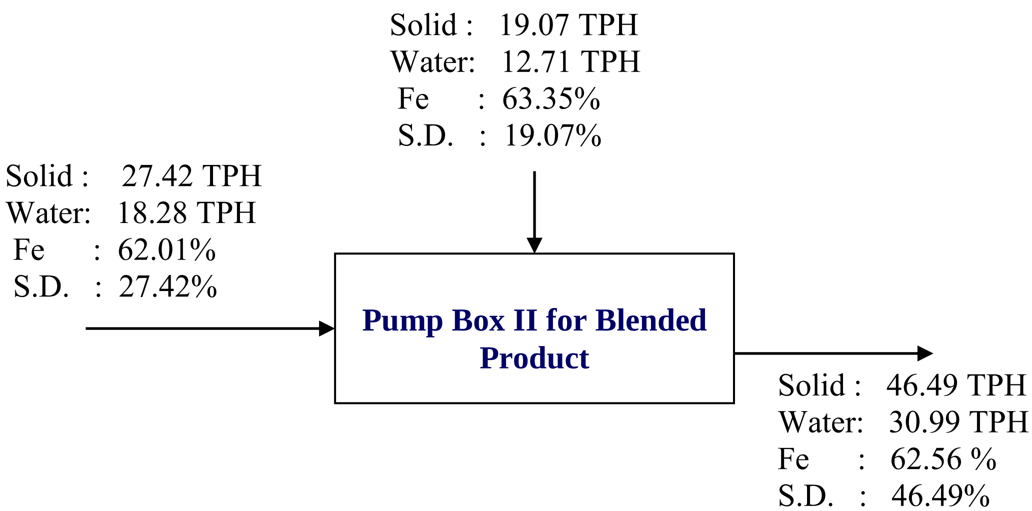
11. Concentrate Thickener



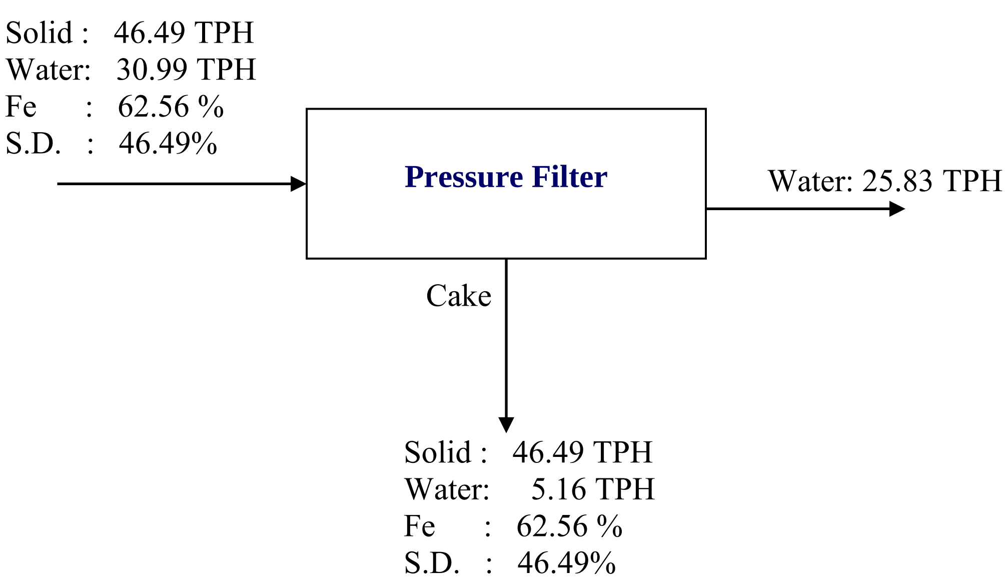
12. Slurry Pump II for Concentrate Thickener



13. Pump Box II (Blended Product)



14. Pressure Filter



Water Balance

A. Water Handling

Sl. No.	List of Equipment	Water Addition, TPH
1	Bulk Sample	7.00
2	Screw Scrubber	226.00
3	Vibrating Screen	45.00
4	Magnetic Separator	149.00
Total		**427.00**

B. Water Recovered

Sl. No.	List of Equipment	Water recovered, TPH
1	Intermediate Thickener	158.00
2	Concentrate Thickener	72.82
3	Pressure Filter	25.83
4	Tailings Thickener	130.15
5	Tailing Pond	13.00
Total		**399.80**

C. Water Contains in Products

Sl. No.	Name of the Product	Water Contain, TPH
1	Pressure Filter	5.16
2	Vibrating screen	9.04
3	Tailing pond	13.00
Total		**27.20**

D. Make up water

Sl. No.	Name of the Product	Water Contain, TPH
1	Water content in products	14.20
2	Water content in tailings	13.00
3	1% of handling loss	4.27
Total		**31.47**

Annexure I.B

Material Balance of Process (Nuagaon Iron ore)

Basis: 650 TPH

1. Screw Scrubber

Water: 1469.00 TPH

Solid : 650.00 TPH
Water : 45.50 TPH
Fe : 60.29%
S.D. : 100.0 %

Screw Scrubber

U/F

Solid : 390.00 TPH
Water: 97.50 TPH
Fe : 63.61%
S.D. : 60.00 %

O/F

Solid : 260.00 TPH
Water: 1417.00 TPH
Fe : 55.31%
S.D. : 40.00 %

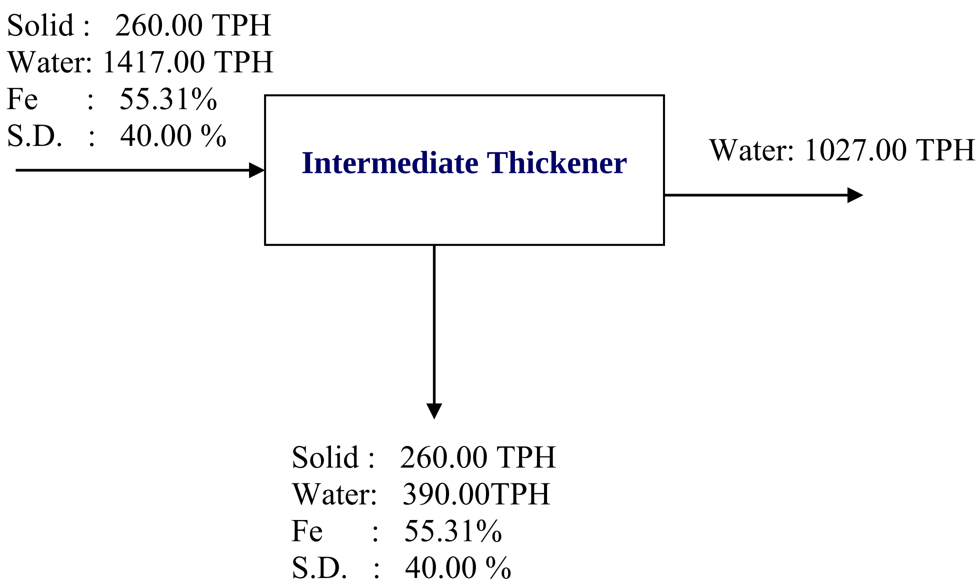
2. Pump Box I (O/F of Screw scrubber)

Solid : 260.00 TPH
Water: 1417.00 TPH
Fe : 55.31%
S.D. : 40.00 %

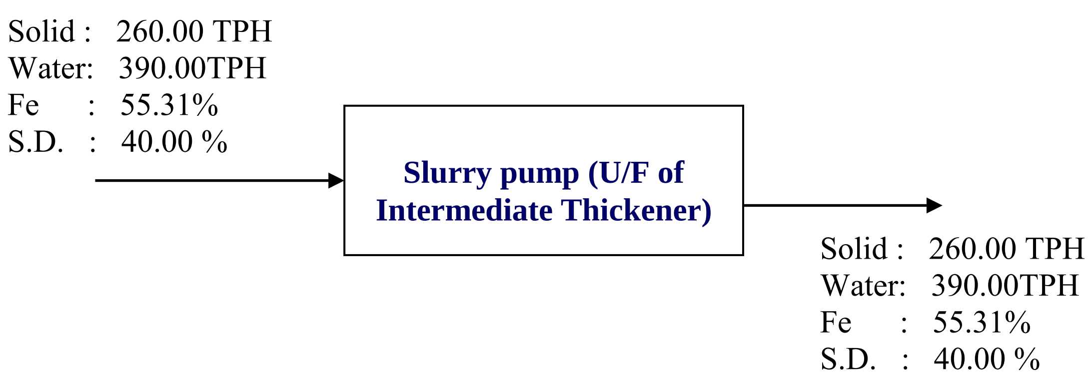
Pump Box I for O/F of Screw scrubber

Solid : 260.00 TPH
Water: 1417.00 TPH
Fe : 55.31%
S.D. : 40.00 %

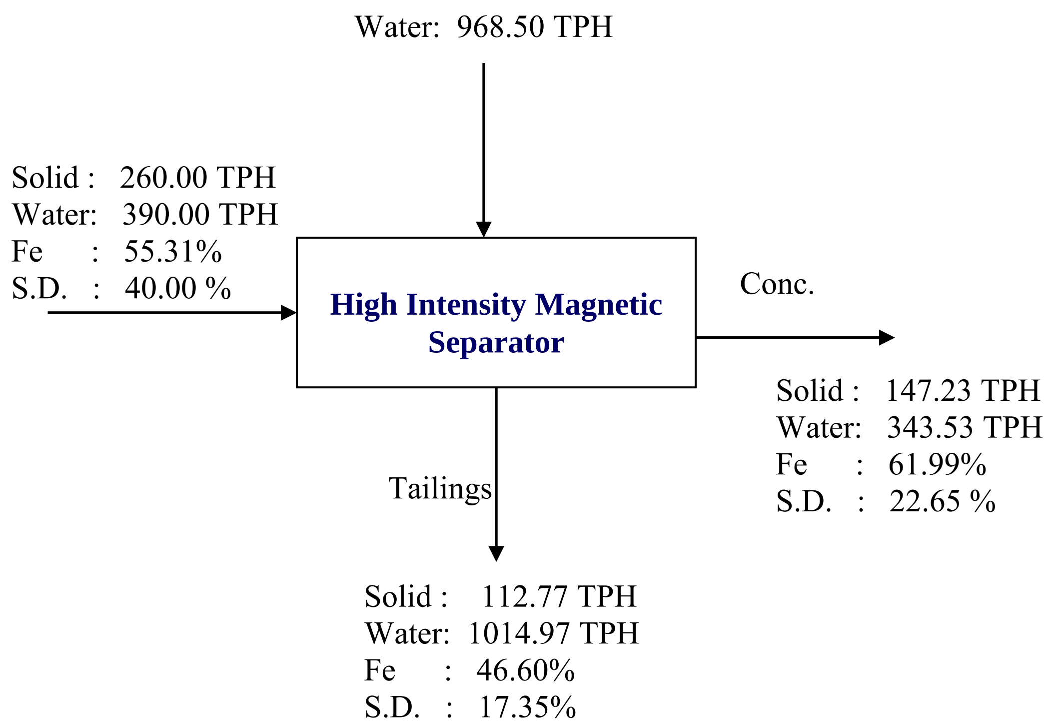
3. Intermediate Thickener



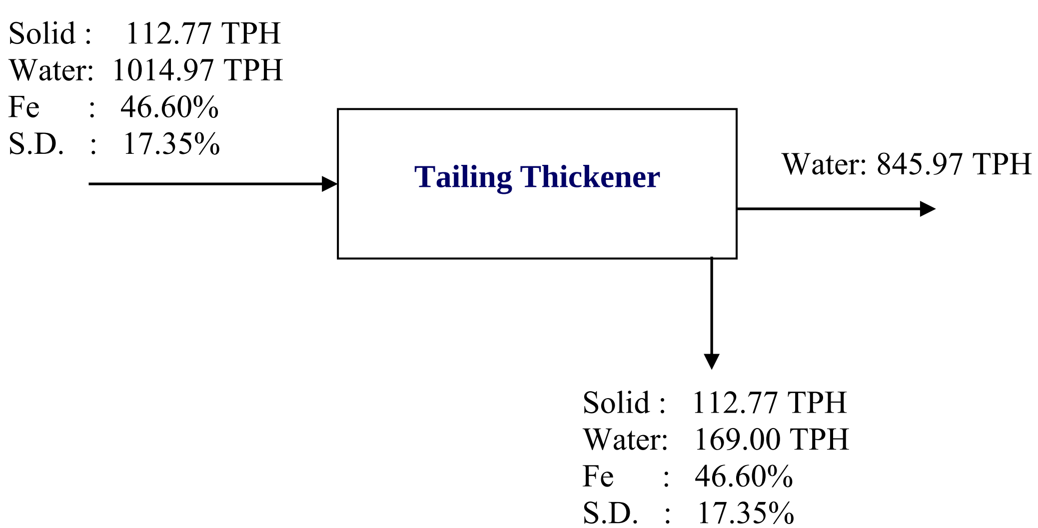
4. Slurry Pump I (U/F of intermediate thickener)



5. High Intensity Magnetic Separator



6. Tailing Thickener



7. Slurry Pump II

Solid : 112.77 TPH
Water: 169.00 TPH
Fe : 46.60%
S.D. : 17.35%

Slurry pump II

Solid : 112.77 TPH
Water: 169.00 TPH
Fe : 46.60%
S.D. : 17.35%

8. Tailings Pond

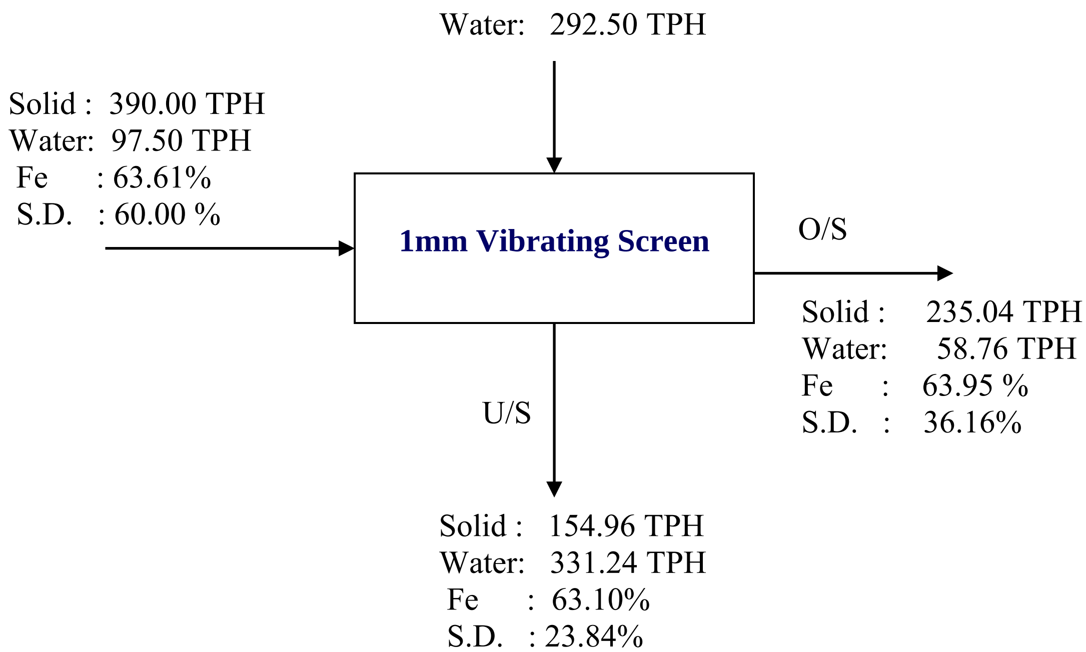
Solid : 112.77 TPH
Water: 169.00 TPH
Fe : 46.60%
S.D. : 17.35%

Tailings pond

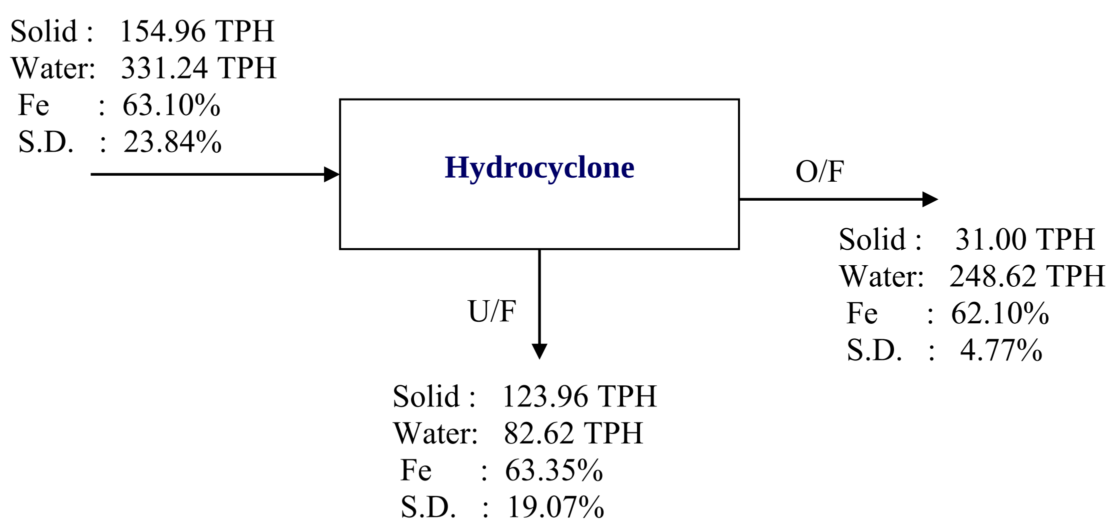
Recovered Water: 84.50 TPH

Solid : 112.77 TPH
Water: 84.50 TPH
Fe : 46.60%
S.D. : 17.35%

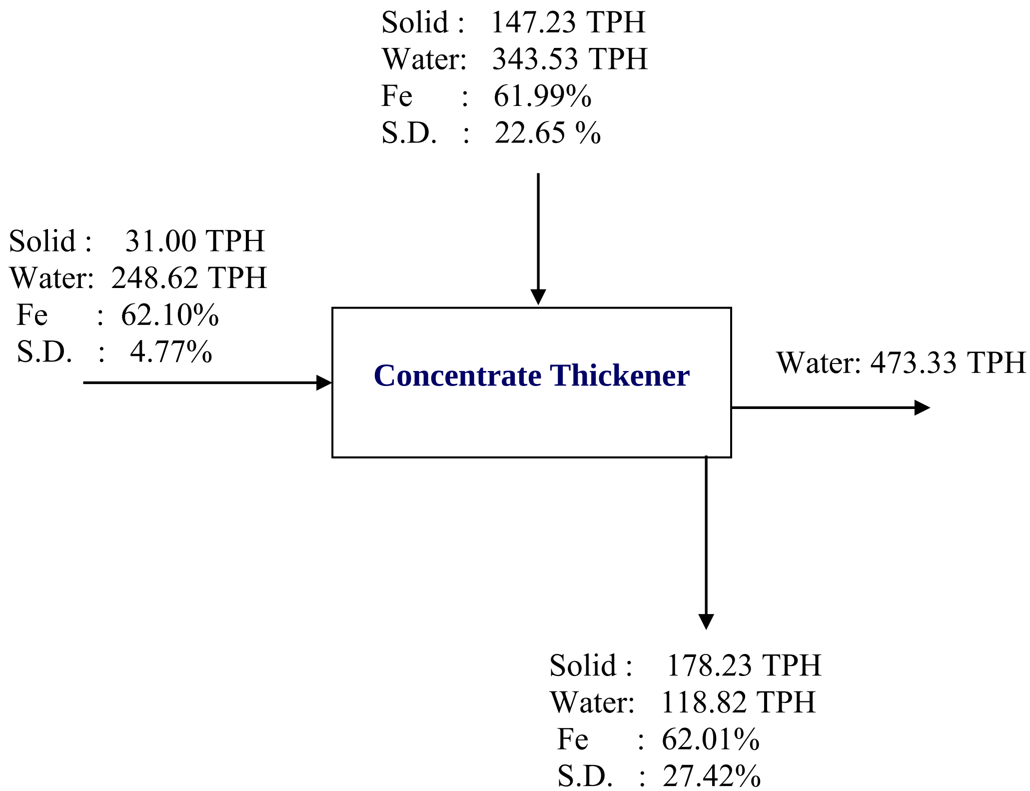
9. Vibrating Screen (1 mm size)



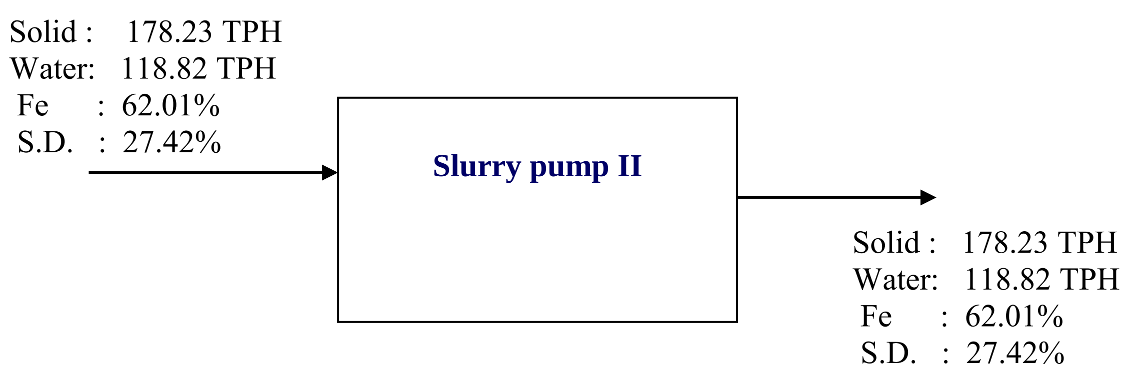
10. Hydrocyclone



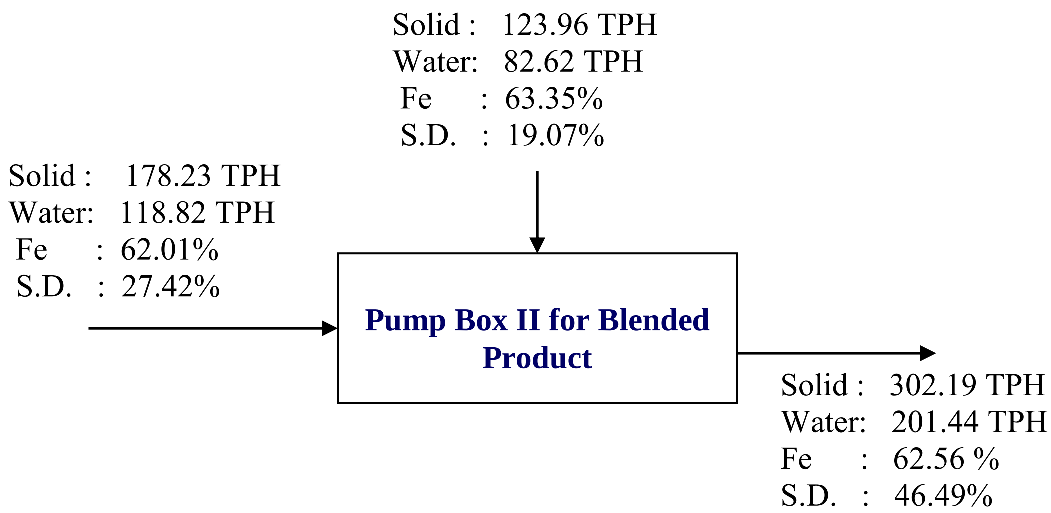
11. Concentrate Thickener



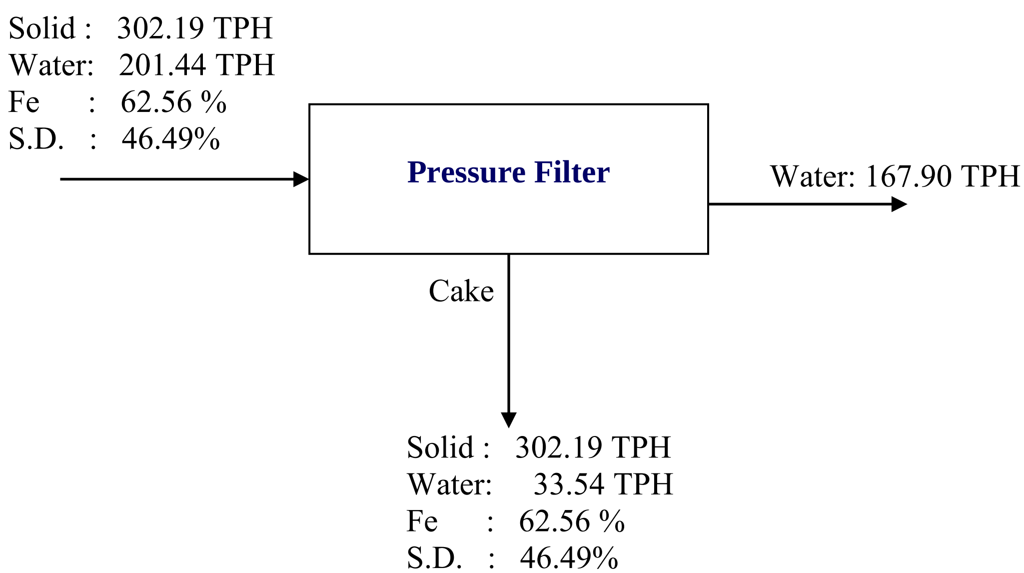
12. Slurry Pump II for Concentrate Thickener



13. Pump Box II (Blended Product)



14. Pressure Filter



Water Balance

A. Water Handling

Sl. No.	List of Equipment	Water Addition, TPH
1	Bulk Sample	45.50
2	Screw Scrubber	1469.00
3	Vibrating Screen	292.50
4	Magnetic Separator	968.50
Total		**2775.50**

B. Water Recovered

Sl. No.	List of Equipment	Water recovered, TPH
1	Intermediate Thickener	1027.00
2	Concentrate Thickener	473.33
3	Pressure Filter	167.90
4	Tailings Thickener	845.97
5	Tailing Pond	84.50
Total		**2598.7**

C. Water Contains in Products

Sl. No.	Name of the Product	Water Contain, TPH
1	Pressure Filter	33.54
2	Vibrating screen	58.76
3	Tailing pond	84.50
Total		**176.8**

D. Make up water

Sl. No.	Name of the Product	Water Contain, TPH
1	Water content in products	92.30
2	Water content in tailings	84.50
3	1% of handling loss	27.76
Total		**204.56**

Chapter 3
Characterization, Beneficiation and Dewatering Studies of Narayanposhi Sample

3.1 Introduction

Around 1 tonnes of Iron ore below 10 mm sample was received from Narayanposhi Iron ore mines, Barbil, Odisha to carry out the desliming and beneficiation study to develop the suitable process flowsheet for production of high-grade iron ore concentrate. Around 100 kg representative sample was taken by standard coning and quartering method for size analysis, chemical analysis, bond work index, mineralogical studies and bulk density of bulk sample. The remaining sample was processed for desliming and beneficiation studies.

3.2 Characterisation Study

3.2.1 Size & Fe Analysis of Bulk Sample

The total sample of around 1 tonnes was thoroughly mixed and representative sample was drawn by coning and quartering method for size analysis. Then the size analysis with respective Fe analysis of bulk sample was carried out and the result is given in Table 3.1. The remaining sample was subjected to beneficiation studies.

Table 3.1
Size and Fe analysis of bulk sample

Size, mm	Wt., %	Cum Wt., %	Fe, %	Cum. Fe, %
+10	9.48	9.48	63.05	63.05
+6	20.03	29.51	62.83	62.90
+3	17.30	46.81	61.70	62.46
+2	7.09	53.90	61.51	62.33
+1	13.20	67.09	61.13	62.10
+0.850	5.68	72.77	60.03	61.93
+0.500	3.84	76.62	61.64	61.92
+0.300	3.03	79.65	61.43	61.90
+0.210	2.93	82.58	60.14	61.84
+0.150	1.79	84.37	60.24	61.80
+0.100	1.24	85.61	60.34	61.78
+0.075	0.45	86.06	60.56	61.78
+0.045	0.98	87.04	60.22	61.76
-0.045	12.96	100.00	54.21	60.78
Total	100.00		60.78	
Bulk			60.76	

3.2.2 Detail Chemical Analysis

The detailed chemical analysis, LOI along with the trace elements of the bulk sample was carried out. The result is given in the Table 3.2. The major impurity is quartzite and aluminum oxide. The hematite percent in the ore is about 86.88 %.

Table 3.2
Detail chemical analysis of the bulk sample

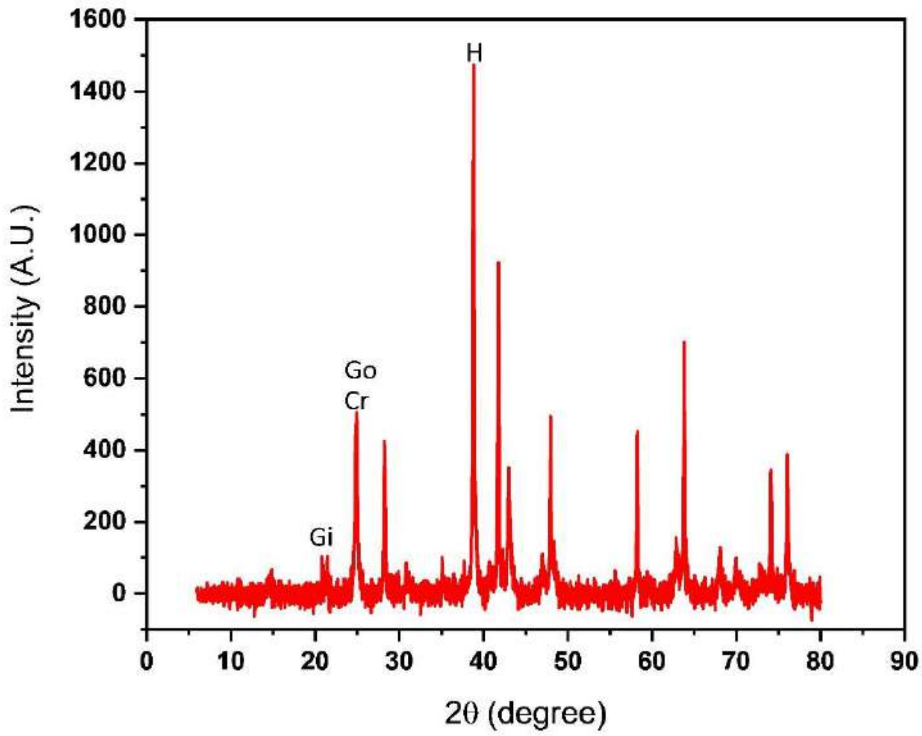
Details	Percentage
Fe (T)	60.76
Fe_2O_3	86.88
SiO_2	2.75
Al_2O_3	4.16
CaO	0.014
Cr_2O_3	0.020
CuO	0.006
K_2O	0.057
MgO	0.048
MnO_2	0.072
Na_2O	0.015
NiO	0.004
P_2O_5	0.004
PbO	0.006
TiO_2	0.004
V_2O_5	0.013
ZnO	0.014
LOI	6.18

3.3 Mineralogical Study

Mineralogical study of the bulk sample was carried out by using X-ray diffraction study. This study gives the qualitative mineralogical identification of different phases present with their textures.

3.3.1 XRD Study

XRD study was carried out on the representative bulk sample to determine the major minerals present in the sample. The XRD result is shown in Fig. 3.1 It indicates that the bulk sample have hematite as the major mineral phase and other minerals are goethite, gibbsite and chromite.



H: Hematite, Go: Goethite, Gi: Gibbsite, Cr: Chromite

Fig. 3.1 XRD study of bulk sample

3.4 Sequential Heating Analysis of Bulk Sample

The sequential heating at different temperature was carried out using muffle furnace for bulk sample to determine the association of minerals like goethite, gibbsite, kaolinite and overall LOI content. The result of sequential heating is given in Table 3.3. Based on weight loss at different temperatures, percentage of goethite, gibbsite and kaolinite were calculated. The percentage of water loss during 108°C to 450°C is used to calculate the percentage of goethite and gibbsite mineral. The percentage of water loss during 450°C 850°C is used to calculate the percentage of kaolinite mineral. The percentage of water loss during 850°C 950°C is used to calculate the percentage of carbonate minerals. Mineralogical characteristion study carried out by using both heating cycle and chemical analysis is given Table 3.4.

Table 3.3
LOI at different temperature by sequential heating cycle of bulk sample

400°C	850°C	950°C	Total LOI, %
5.42	0.71	0.05	6.18

Table 3.4
Mineralogical characteristics study by using heating cycle and chemical analysis

Heating Cycle Analysis	**Hematite, %**	**Goethite, %**	**Kaolinite, %**	**Gibbsite, %**
	48.16	43.32	5.12	2.97
Chemical Analysis	**Fe(T), %**	**LOI, %**	**Al_2O_3, %**	**SiO_2, %**
	60.76	6.18	4.16	2.75

3.5. Estimation of Bond Work Index

3.5.1 Sample Preparation

Around 30 kg of representative bulk sample was taken and screened at 4.36 mm size. The +3.36 mm size was crushed to below 3.36 mm size by using roll crusher. Then, it was thoroughly mixed and the representative sample was drawn for grindiability study for determination of Bond Work Index (BWI).

3.5.2 Ball Mill Grindiability Process

Grindiability study was carried out as per the standard procedure described by Bond. The Bond ball mill work index determination is carried out in a standard test mill and under standard conditions. The test mill has an internal diameter of 12 inch and length is also 12 inch. It has a smooth lining with rounded corners, no lifters except for a 4” X 8” hand hole lid for charging.

It has a revolution counter and runs at 70 rpm. The grinding charge consists of 285 iron balls weighing 20.125 kg. It consists of about 43 numbers of 1.45” balls, 67 numbers of 1.17” balls, 10 numbers of 1” balls, 71 numbers of 0.75” balls and 94 numbers 0.61” balls with a calculated surface area of 842 sq inch.

The standard feed was prepared by passing all through 3.36 mm size. It was packed by shaking in a 1000 cc graduated cylinder, and the weight of 700 cc was placed in the mill and ground dry at 250 percent circulating load. After the first grinding period of 100 revolutions, the mill was dumped; the ball charge was screened out and 700 cc of material was screened on 150 mesh (100 micron) with coarser protecting sieves if necessary. The undersize was weighed and fresh unsorted feed was added to oversize to bring its weight back to that of original charge. Then it was returned on to the balls in the mill and ground for the number of revolutions calculated from the results of the previous period to produce sieve undersize equal to 1/3.5 of the total charge in the mill. The grinding period cycles were continued until the net grams of sieve undersize produced per mill revolution reaches equilibrium and reverses its direction of increase or decrease. Then the undersize product and circulating load were screen analyzed, and the average of the last three net grams per revolution (G_{bp}) was the mill grindiability. When F is the size in microns which 80 percent of the new ball mill feed passes, P is the microns which 80 percent of the last cycle sieve undersize product passes, and P_1 is the opening in microns of sieve size tested (100 micron), then the ball mill work index W_i is calculated from the following revised equation;

$$W.\,I. = 44.5 /\{ (P_i)^{0.23} \text{ X } (G_{bp})^{0.82} \text{ X } 10\, (1 / \sqrt{P} - 1/\sqrt{F})\} \qquad \textbf{(3.1)}$$

3.5.3 Bond Work Index of Bulk Sample

The representative iron ore bulk sample was taken for grindability study as per Bond's method. The size analysis of the crushed product for grindability study was carried and the results are given in the Table 3.5. It was found that d_{80} of the feed material was 2100 micron. The grindability study was carried for 100 micron test sieve. The weight of the 700 cc of material was 1610 gm. For 250 percent circulating load, 460 gm of -100 micron particles are to be produced at equilibrium revolution. To reach the equilibrium revolution a number of tests were carried out. At the equilibrium stage, G_{bp} was 1.867.

The size analysis of -100 micron product was carried out. The size analysis of product is given in the Table 3.6. The overall grindability result of bulk Sample is given in Table 3.7. The particle size distribution of feed and product is depicted in Fig. 3.2 and 3.3 respectively. The d_{80} of the ball mill product was 79.5 micron. Then according to Equation, W.I. was calculated and it was found 10.2 kWh/short ton. It was converted to normal tonne and WI value is 11.3 kWh/tonne.

$Wi = (44.5)/((P_1)^{0.23} \text{ X } (Gbp)^{0.82} (10/\sqrt{P} - 10/\sqrt{F}))$

$=(44.5)/((100)^{0.23} \text{ X } (1.867)^{0.82} (10/\sqrt{79.5} - 10/\sqrt{2100}))$

= 10.2 kWh/short ton

= 10.2 X 1.1 = **11.5 kWh/tonne**

The bond work index of the sample is determined to be 11.5 kWh/tonne.

Table 3.5

Feed size analysis

Size, micron	Cum. Wt., % Passing
3360	100.00
2000	77.76
1000	52.80
850	40.25
500	31.68
300	25.09
212	17.27
150	12.80
100	9.69

Table 3.6

Size analysis of ground product

Size, micron	Cum Wt., % Passing
100	100.00
75	75.00
63	53.00
45	35.75
38	24.25

Table 3.7

Results of gram per revolution

No. of revolutions	100micron produced (g)	100micron in the feed (g)	Net -100micron produced (g)	Grindability (g/rev.)
100	398	156	242	2.420
174	410	38.6	371	2.130
197	420	39.7	380	1.926
218	448	40.7	407	1.868
223	460	43.4	417	1.866
223	461	44.6	416	1.869
222	460	44.7	415	1.867
223	460	44.6	415	1.865

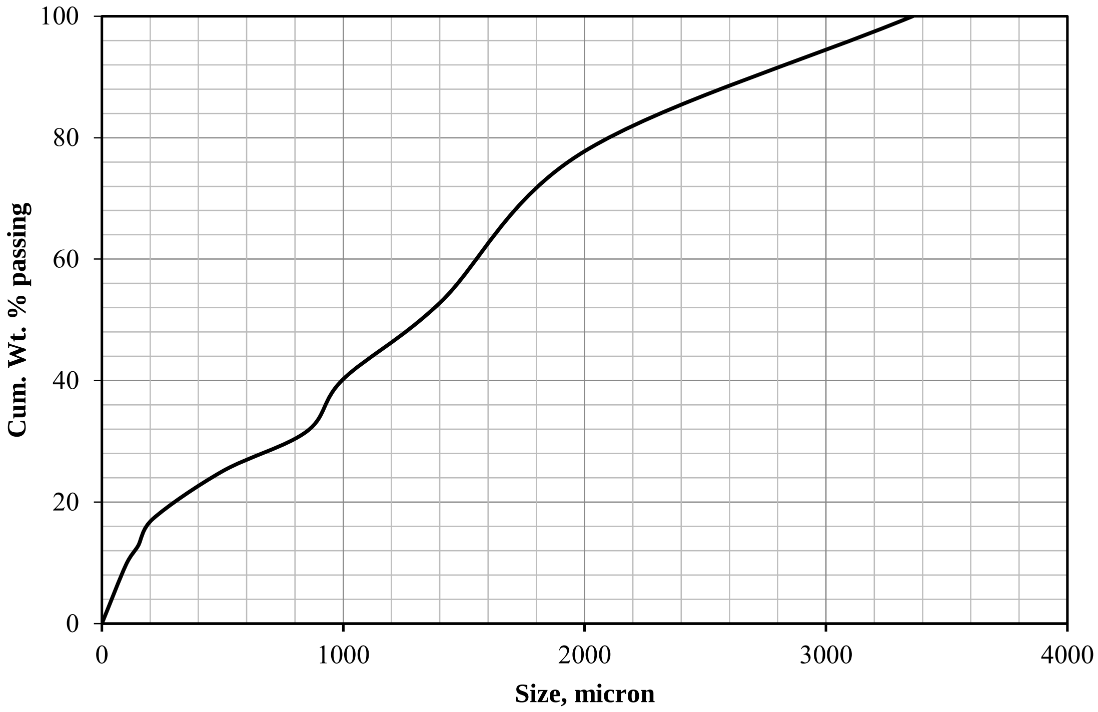


Fig. 3.2 Particle size distribution of feed

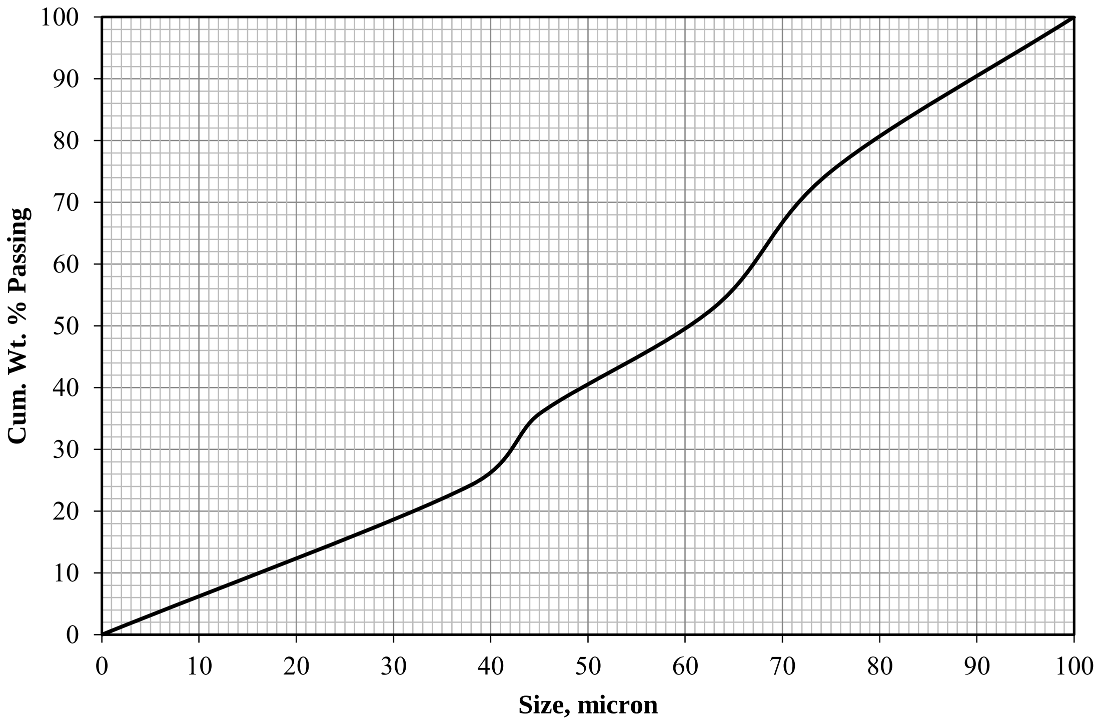


Fig. 3.3 Particle size distribution of product

3.5.4 Bond Work Index of Screw Scrubber Underflow Sample

The representative screw scrubber underflow sample was taken for grindability study as per Bond's method. The size analysis of the crushed product for grindability study was carried and the result is given in the Table 3.8. It was found that d_{80} of the feed material was 2030 micron. The grindability study was carried for 100 micron test sieve. The weight of the 700 cc of material was 1580 gm. For 250 percent circulating load, 452 gm of below 100 micron particles are to be produced at equilibrium revolution. To reach the equilibrium revolution a number of tests were carried out. At the equilibrium stage, G_{bp} was 1.647.

The size analysis of below 100 micron product was carried out. The size analysis of product is given in the Table 3.9. The overall grindability result of screw scrubber underflow is given in Table 3.10. The particle size description of feed and product is depicted in Fig. 3.4 and 3.5 respectively. The d_{80} of the ball mill product was 78.5 micron. Then according to equation, W.I. was calculated and it was found 11.3 kWh/short ton. It was converted to normal tonne and WI value is 12.4 kWh/tonne.

$$Wi = (44.5)/((P_1)^{0.23} \times (Gbp)^{0.82} (10/\sqrt{P} - 10/\sqrt{F}))$$

$$=(44.5)/((100)^{0.23} \times (1.647)^{0.82} (10/\sqrt{78.5} - 10/\sqrt{2030}))$$

$$= 11.3 \text{ kWh/short ton} = 11.3 \times 1.1 = \mathbf{12.4\ kWh/tonne}$$

The bond work index of the sample is determined to be 12.4 kWh/tonne.

Table 3.8
Feed size analysis

Size, micron	Cum. Wt., % Passing
3360	100.00
2000	79.24
1400	47.59
1000	32.15
850	21.90
500	15.32
212	8.86
150	5.95
100	4.18

Table 3.9
Size analysis of ground product

Size, micron	Cum Wt., % Passing
100	100.00
75	76.00
63	55.50
45	41.00
38	29.50

Table 3.10
Results of gram per revolution

No. of revolutions	100micron produced (g)	100micron in the feed (g)	Net -100micron produced (g)	Grindability (g/rev.)
100	268	66	202	2.020
218	604	11.2	593	2.717
157	488	25.2	463	2.947
146	316	20.4	296	2.019
217	396	13.2	383	1.762
247	428	16.6	411	1.665
261	450	17.9	432	1.658
261	450	18.8	431	1.651
262	451	18.8	432	1.647
263	451	18.9	432	1.644

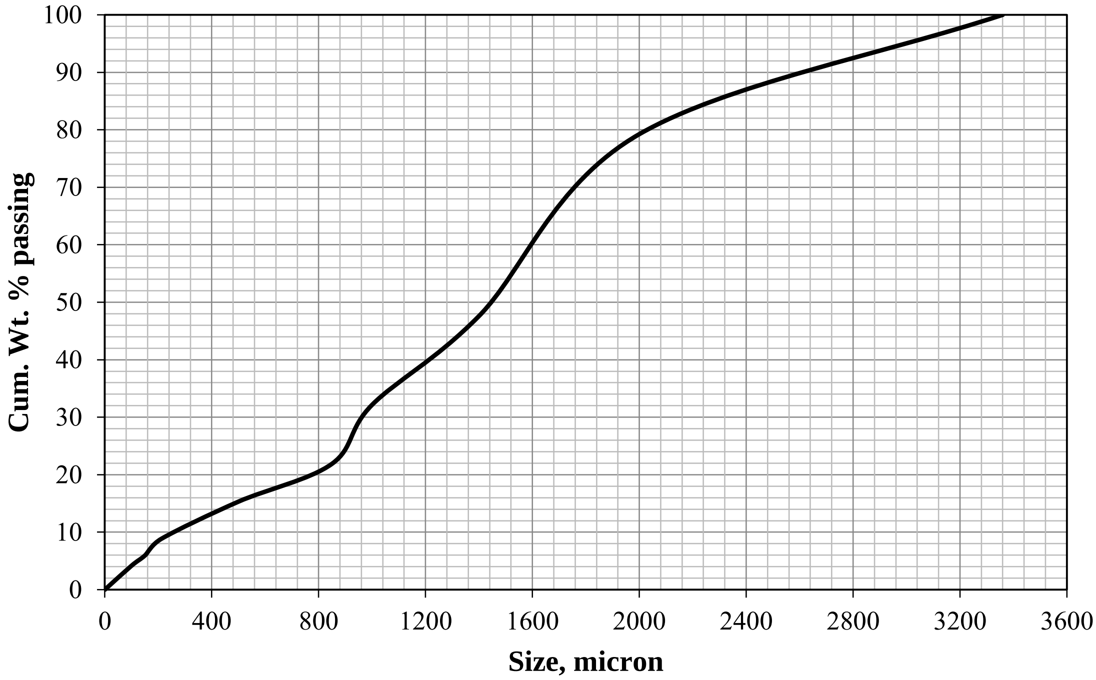


Fig. 3.4 Particle size distribution of feed

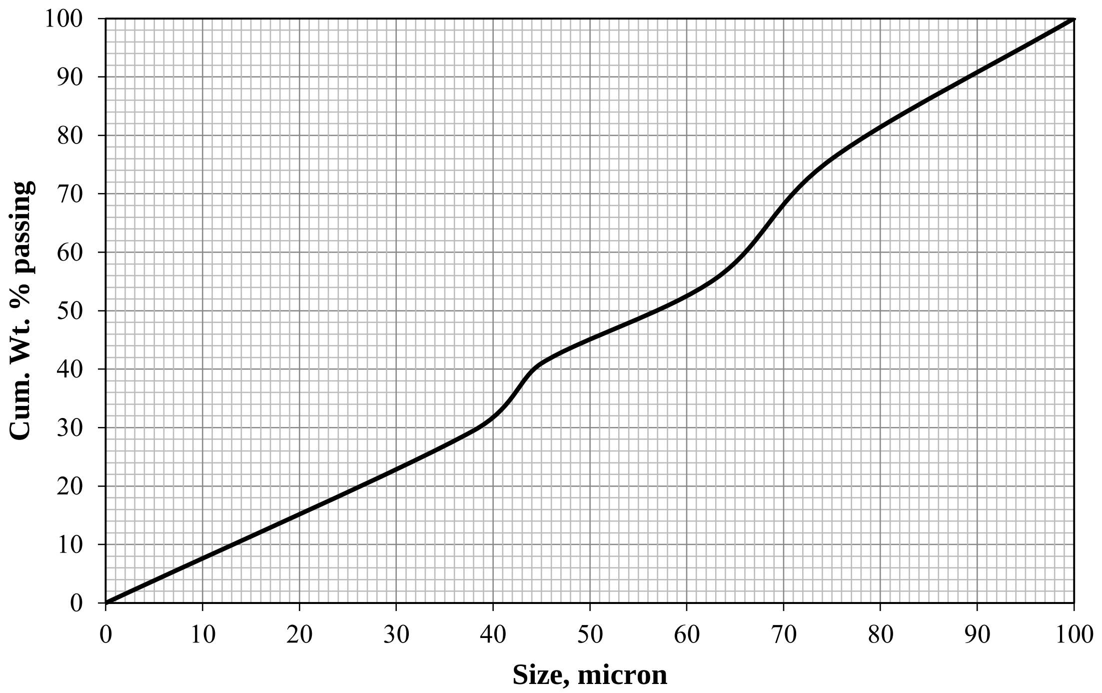


Fig. 3.5 Particle size distribution of product

3.6 Bulk Density

Bulk density is the weight of material in air per unit volume. It is measured by the help of a square sized metal container having length of each side 300 mm. Bulk density is evaluated by weighing a precisely measured known volume of ore sample. Natural moisture content is determined as per IS: 2720 (part 2) -1973. The bulk density of -10 mm sized sample is 1.982 kg/m^3 and its bulk density after being tapped is 3.178 kg/m^3.

3.7 Beneficiation Studies

The beneficiation study of the iron ore sample was carried out based on their mineralogy. According to size analysis studies, it contains good number of fine particles which may be iron phase minerals along with clay particles. In general, the fine clay particles are coated on the surface of the coarse particles. These clay minerals are responsible to increase the viscosity of slurry due to their swelling characteristics during the beneficiation process. Hence, it is essential to remove at the beginning of the process by scrubbing technique and discard as the reject. Hence the remaining materials can be processes smoothly for up-gradation of iron values by physical beneficiation. As it contains 12.96% of below 45 microns and the top size is below 10mm, hence for attrition of particles, screw scrubber process is most suitable. This equipment also classifies simultaneously the fine particles in a single stage. The laboratory screw scrubber was used for desliming the slime particles at the feed rate of 200 kg/hr using water to solid ratio of 70:30. The screw scrubber gives two products i.e., overflow (slimes) and underflow (coarse particles). The sample was fed to the screw scrubber. The Fe content of scrubber underflow could be achieved to 62.47% with overall yield of 80.90% and overflow fraction contained 53.61% Fe with overall yield of 19.10%. The result of screw scrubber is given in the Table 3.11. The result shows that screw scrubber underflow is one of the final product and overflow need to be further processed. Attempt was made to enhance the grade of scrubber underflow by further process.

Table 3.11
Screw scrubber study of bulk sample

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Underflow	80.90	80.90	62.47	62.47
Overflow	19.10	100.00	53.61	60.78
Total	100.00		60.78	

The underflow of screw scrubber was further classified into two different size fractions viz. (-10+1mm, and -1mm). The Fe content of -10+1 mm size could be achieved to 62.64% with overall yield of 59.42%. The Fe content of -1 mm size could be achieved to 62.01% with overall yield of 21.48%. The result of classified sample is given in Table 3.12. The result shows -10+1 mm is having slightly more higher Fe value compared to -1mm size fraction.

Table 3.12
Size classification of screw scrubber underflow

Size, mm	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
-10+1	59.42	59.42	62.64	62.64
-1	21.48	80.90	62.01	62.47
Total	80.90		62.47	

The -10+1 mm size fraction of sample was processed in the batch type laboratory jig (Supplied by All Minerals, Germany). In each batch around 50kg sample was taken during experiment. It is a hydraulic jig operated with pneumatic control pulsating system. The pulse frequency was kept 60 cycle per minute and air flow rate 0.3 to 0.4 bar. The screen aperture used for bed was 1 mm size. After 30 minutes the material was collected from the chamber in layer by layer from top to bottom at particular thickness. The concentrate (Layer 1, Layer 2 and Layer 3) obtained by jigging of -10+1 mm fraction contains 63.19% Fe with yield of 65.79% and tailings contains 55.40% Fe with yield of 4.94 %. The jigging study of -10+1 mm sample is given in the Table 3.13.

Table 3.13
Jigging study on -10+1 mm size fraction material

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Layer 1	51.93	51.93	64.14	64.14
Layer 2	7.49	59.42	60.23	63.65
Layer 3	6.37	65.79	58.89	63.19
Layer 4	4.94	70.73	55.40	62.64
Total	59.42		62.44	

The -1 mm size samples was processed in the spiral concentrator. Roughing and cleaning operations were carried out to enrich the concentrate grade. In both operations of roughing and scavenging, 30% solid concentration was maintained. The capacity of spiral concentrator is 1 tonne per hour. The Fe content of rougher concentrate could be achieved to 63.22% with overall yield of 18.13%. The Fe contains of scavenging concentrate, scavenging tailings and tailing fines could achieved 60.18%, 59.17% and 52.33% with overall yield of 3.36 %, 2.53 % 0.90% respectively. The result of spiral concentrator is given in the Table 3.14.

Table 3.14
Spiral study of -1mm size fraction material

Details	Wt., %	Cum Wt., %	Fe, %	Cum. Fe, %
Rougher Concentrate	18.13	18.13	63.22	63.22
Scavenging Concentrate	3.36	21.48	60.18	62.75
Scavenging Tailings	2.53	24.01	59.17	62.37
Tailing Fines	0.90	24.91	52.33	62.01
Total	21.48		62.01	

The -10+1 mm size was further classified in two different size fractions viz. (-10+5 mm, and -5+1mm). The Fe content of -10+5 mm size could be achieved to 63.12% with overall yield of 30.17%. The Fe content of -5+1 mm size could be achieved to 62.14% with overall yield of 29.25 %. The result of classified sample is given in Table 3.15.

Table 3.15
Size classification of -10+1 mm fraction

Size, mm	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
-10+5	30.17	30.17	63.12	63.12
-5+1	29.25	59.42	62.14	62.64
Total	59.42		62.64	

The -10+5 mm and -5+1 mm size fraction of samples were processed in the batch type laboratory jig. In each batch around 50kg sample was taken for experiment. The pulse frequency was kept 60 cycle per minute and air flow rate 0.3 to 0.4 bar. The screen aperture used for bed was 1 mm size. After 30 minute the material was collected from the chamber in layers from top to bottom at particular thickness. The concentrate (Layer 1, Layer 2 and Layer 3) obtained by jigging of -10+5 mm fraction contains 62.74% Fe with yield of 28.06% and tailings contains 53.23% Fe with yield of 2.11%. The jigging study of -10+5 mm sample is given in Table 3.16. The concentrates (Layer 1, Layer 2 and Layer 3) obtained by jigging of -5+1 mm fraction contains 62.74 % Fe with yield of 27.41 % and tailings contains 53.23% Fe with yield of 1.84%. The jigging study of -5+1 mm sample is given in Table 3.17.

Table 3.16
Jigging study on -10+5 mm size fraction material

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Layer 1	22.15	22.15	64.12	64.12
Layer 2	3.19	25.35	60.08	63.26
Layer 3	2.72	28.06	59.07	62.74
Layer 4	2.11	30.17	53.23	62.14
Total	30.17		62.14	

Table 3.17
Jigging study on -5+1 mm size fraction material

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Layer 1	18.89	18.89	64.12	64.12
Layer 2	5.09	23.98	60.08	63.26
Layer 3	3.43	27.41	59.07	62.74
Layer 4	1.84	29.25	53.23	62.14
Total	29.25		62.14	

The overflow of screw scrubber is to be deslimed by hydrocyclone to remove the ultrafine gangue minerals directly. The screw scrubber overflow sample was fed to the rougher hydrocyclone. The hydrocyclone gives two products i.e., overflow (very ultrafine slimes particle) and underflow (fine coarse particles). The Fe content of hydrocyclone underflow could be achieved to 57.52% Fe with overall yield of 11.33% and overflow fraction contained 47.90% Fe with overall yield of 7.77%. The rougher hydrocyclone overflow sample was fed to the scavenging hydrocyclone at the density 1040 kg/m^3. The Fe content of scavenger hydrocyclone underflow could be achieved to 54.45% Fe with overall yield of 1.26% and overflow fraction contained 46.63% Fe with overall yield of 6.51%. The rougher and scavenging hydrocyclone study are given in Table 3.18 and 3.19.

Table 3.18

Rougher hydrocyclone study of screw scrubber overflow

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Underflow	11.33	11.33	57.52	57.52
Overflow	7.77	19.10	47.90	53.61
Total	19.10		53.61	

Table 3.19

Scavenging hydrocyclone study

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Underflow	1.26	1.26	54.45	54.45
Overflow	6.51	7.77	46.63	47.90
Total	7.77		47.90	

If the overflow of hydrocyclone contains ultrafine hematite particles and are not the discardable, then the screw scrubber overflow will be beneficiated directly using WHIMS/HGMS.

The rougher and scavenging hydrocyclone underflow were blended together and given in Table 3.20. The blended material fed to LONGI. The intensity of magnetic separator (Longi) having 12000 gauss in pilot scale. The result of rougher LONGI study is given in the Table 3.21. The Fe content of the rougher magnetic fraction could be enhanced to 62.15% Fe with overall yield of 8.22%. The rougher middling could be achieved 57.44% Fe with overall Yield of 1.00 % and non-magnetic fraction from rougher tailings contains 45.10% Fe with overall yield of 3.37%. The rougher tailings of LONGI was further fed to scavenger stage of LONGI. The Fe content of the scavenging magnetic fraction could be enhanced to 56.39% Fe with overall yield of 1.00%. The scavenging middling contains 44.79% Fe with overall Yield of 0.26% and non-magnetic fraction from scavenging tailings contains 39.79%Fe with overall yield of 2.11%. The result of scavenger LONGI is given in the Table 3.22.

Table 3.20
Blending of hydrocyclone underflows

Details	Wt., %	Cum Wt., %	Fe, %	Cum. Fe, %
Rougher hydrocyclone underflow	11.33	11.33	57.52	57.52
Scavenging hydrocyclone underflow	1.26	12.59	54.45	57.21
Total	12.59		57.21	

Table 3.21
LONGI study of blended product

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Mag	8.22	8.22	62.15	62.15
Middling	1.00	9.22	57.44	61.64
Non-Mag	3.37	12.59	45.10	57.21
Total	12.59		57.21	

Table 3.22
LONGI scavenging study

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Mag	1.00	1.00	56.39	56.39
Middling	0.26	1.26	44.79	54.00
Non-Mag	2.11	3.37	39.79	45.10
Total	3.37		45.10	

The overflow of hydrocyclone was fed to HGMS (supplied by LONGI). The magnetic intensity of LONGI is 12000 gauss. The feed density was kept at 1.06 kg/m^3. The Fe content of the rougher magnetic fraction of LONGI could be achieved to 57.78 % Fe with overall yield of 1.81% whereas non-magnetic fraction contains 41.58% Fe with overall yield of 4.24 %. The rougher non-magnetic fraction was fed to the scavenging LONGI. The Fe content of the scavenging magnetic fraction of LONGI could be achieved to 43.21% Fe with overall yield of 0.82% and non-magnetic fraction contains 41.12% Fe with overall yield of 3.06%. The rougher and scavenging magnetic separation results are given in Table 3.23 and 3.24.

Table 3.23
LONGI study of hydrocyclone overflow

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Mag	1.81	1.81	57.78	57.78
Middling	0.46	2.27	49.28	56.06
Non-Mag	4.24	6.51	41.58	46.63
Total	6.51		46.63	

Table 3.24
LONGI scavenging study

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Mag	0.82	0.82	43.21	43.21
Middling	0.35	1.18	41.76	42.78
Non-Mag	3.06	4.24	41.12	41.58
Total	4.24		41.58	

Based on the above study and considering on the quality and quantity on the final product, following process were carried out. The beneficiation study was carried out by using screw scrubbing of the ROM sample followed by the Magnetic separation of the screw scrubber overflow and scavenging magnetic separation of rougher non-magnetic fraction. The results are given in the Table 3.25 to Table 3.27. The overall product is given in the Table 3.28 and the overall reject is given in the Table 3.29. The process flowsheet is shown in Figure 3.7. The chemical analysis of the product and reject are given in Table 3.30 and 3.31 respectively.

Table 3.25
Scrubbing study of bulk sample

Details	Wt., %	Cum Wt., %	Fe, %	Cum. Fe, %
Underflow	80.90	80.90	62.47	62.47
Overflow	19.10	100.00	53.61	60.78
Total	100.00		60.78	

Table 3.26
Rougher magnetic separation study of screw scrubber overflow

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Mag	10.03	10.03	61.36	61.36
Middling	1.46	11.49	54.87	60.54
Non-Mag	7.61	19.10	43.14	53.60
Total	19.10		53.61	

Table 3.26
Rougher magnetic separation study of screw scrubber overflow

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Mag	8.22	8.22	62.15	62.15
Middling	1.46	9.68	55.87	61.18
Non-Mag	9.42	19.10	45.80	53.61
Total	19.10		53.61	

Table 3.27
Scavenging magnetic separation study of rougher non-magnetic fraction

Details	Wt., %	Cum. Wt., %	Fe, %	Cum. Fe, %
Mag	2.81	2.81	58.66	58.66
Middling	0.61	3.42	45.66	56.34
Non-Mag	7.46	10.88	42.94	47.15
Total	10.88		47.15	

Table 3.28
Overall products

Details	Wt., %	Fe, %
Screw Scrubber underflow	80.90	62.47
Rougher MS Conc.	8.22	62.15
Scavenger MS Conc.	2.81	58.66
Total	91.93	62.32

Table 3.29
Overall rejects

Details	Wt., %	Fe, %
Scavenger Middling	0.61	45.66
Scavenger Tailings	7.46	42.94
Total	8.07	43.15

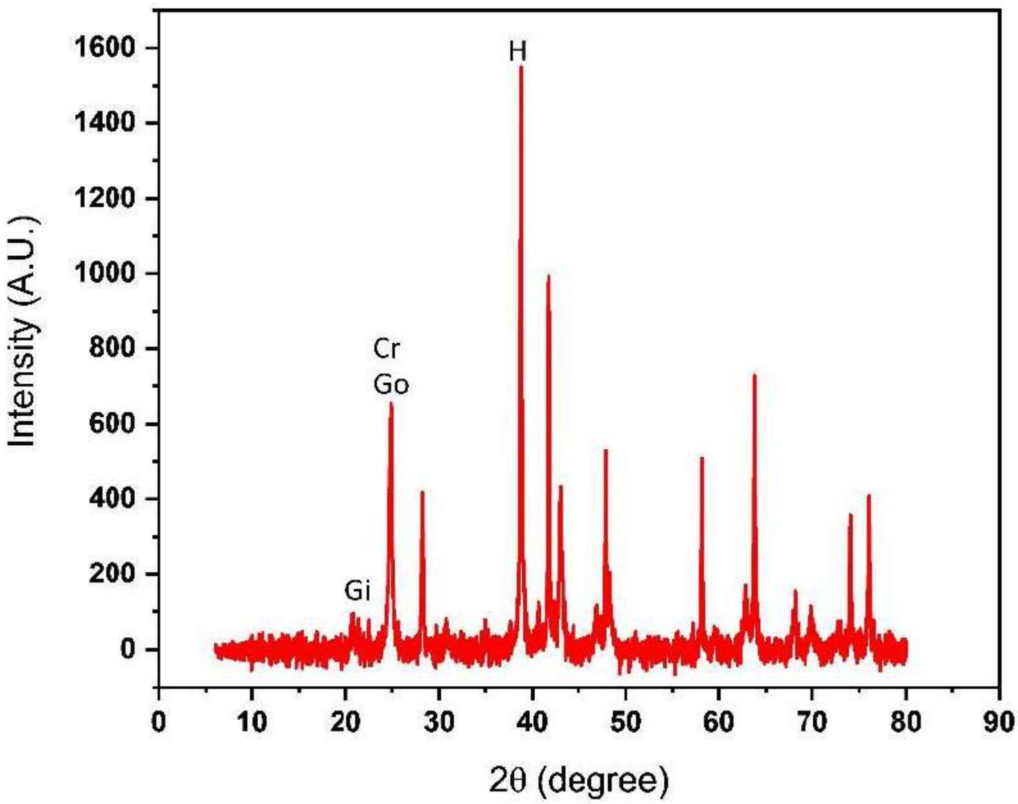
Table 3.30
Chemical analysis of the product

Details	Scrubber Underflow	Rougher Mag.	Scavenger Mag.	Overall Product
Fe (T)	62.47	62.15	58.66	62.32
Fe_2O_3	89.33	88.87	83.88	89.12
SiO_2	1.75	1.9	3.29	1.81
Al_2O_3	2.74	3.41	6.58	2.92
LOI	5.85	5.79	6.23	5.86

Table 3.31
Chemical analysis of the reject

Details	Percentage
Fe (T)	43.00
Fe_2O_3	61.49
SiO_2	13.72
Al_2O_3	17.70
LOI	7.01

XRD study was carried out on the product sample to determine the major minerals present in the samples. The XRD results is shown in Fig. 3.6. It indicates that the product sample have hematite as the major mineral phase and other minor minerals are quartz, goethite, cristobilite and quartz.



H: Hematite, Go: Goethite, Gi: Gibbsite, Cr: Cristobilite

Fig. 3.6 XRD study of product sample

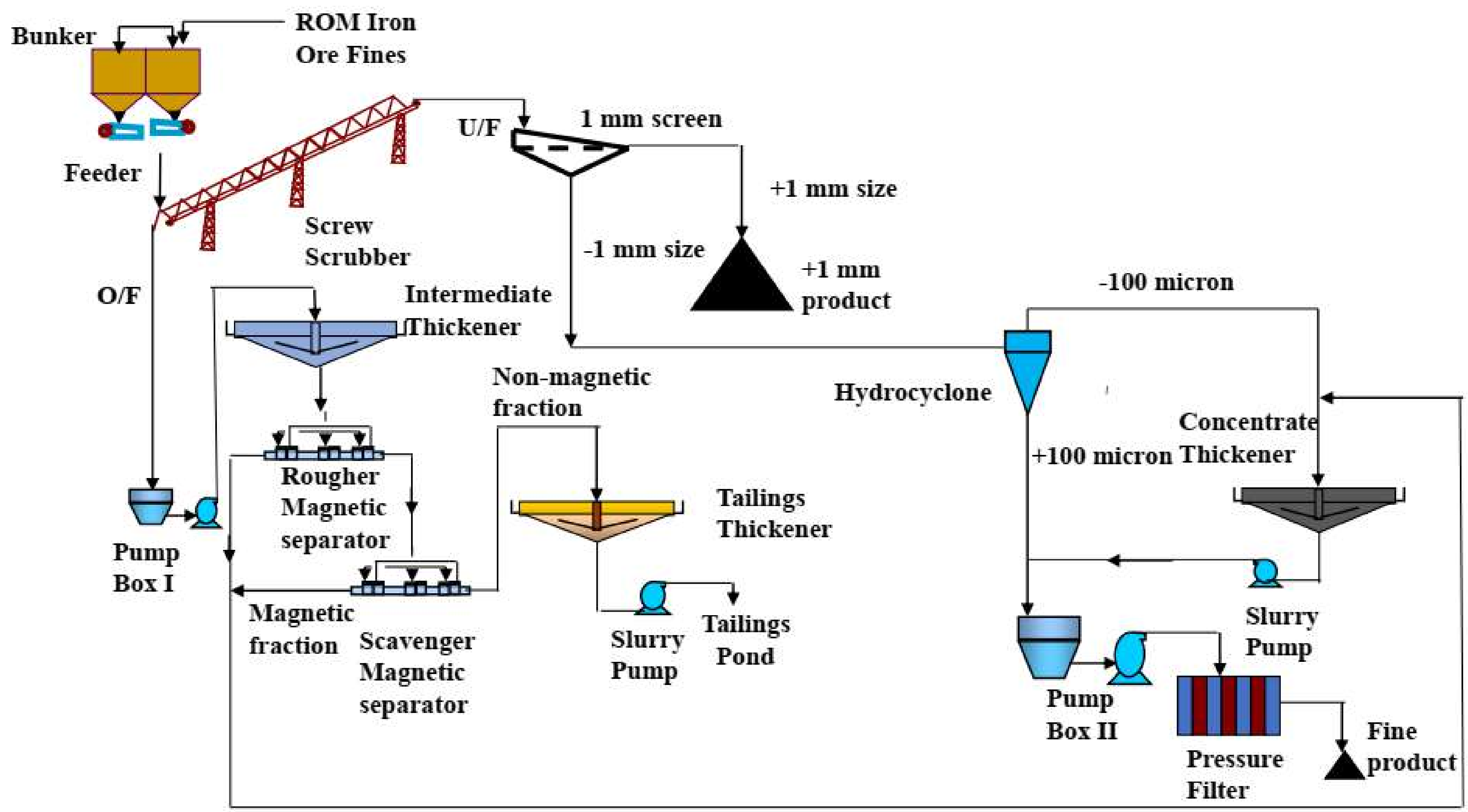


Fig. 3.7 Process flowsheet for washing of low-grade iron ore of Narayanposhi

3.8 Pressure Filtration Study

The pressure filtration study of magnetic separation concentrate and tailings were carried out by using Diemme Filter press and the results are given in Table 3.32 and 3.33. The pressure filter used for experiment is shown in Fig. 3.8.

Fig. 3.8 Pilot scale pressure filter set up

Table 3.32
Pressure filtration result of magnetic separation concentrate

Parameters	Exp. 1
Solid % in feed	60
Feeding time, min	15
Feeding pressure, bar	6
Air purging time, min	7.5
Air purging pressure, bar	8
Squeezing time, min	7.5
Squeezing pressure, bar	11
Total filtration time, min	30
Weight of cake (Wet), Kg	45.5
Cake Thickness, mm	20
Filtrate (water)	30
Cake moisture, %	17.2

Table 3.33
Pressure filtration result of magnetic separation tailings

Parameters	Exp. 1
Solid % in feed	32
Feeding time, min	15
Feeding pressure, bar	7
Air purging time, min	10
Air purging pressure, bar	8
Squeezing time, min	10
Squeezing pressure, bar	13
Total filtration time, min	35
Cake Thickness, mm	18.0
Cake moisture, %	21.8

3.9 Settling Studies

3.9.1 Materials Preparation

After processing of the iron ore, the tailing and concentrate samples were taken for the settling study to provide the basic data for design of thickeners for tailings and concentrate.

3.9.2 Experimental Method

The settling study was carried out in a graduated measuring cylinder of 1 liter capacity. Different solid concentration like 20% to 30% in increment of 5% of concentrate and 5% to 10% in the increment of 2.5% tailing samples are prepared. The pH of the concentrate sample was maintained at 6.5 and the pH of tailing is also 6.5. This is due to pH as the received in the process. The interface height was observed against the time intervals. The interface level with respect to time was recorded in each case.

3.9.3 Results and Discussion

The settling study was carried out on concentrate sample at different solids concentration of 20%, 25% and 30%. The pH of the sample was kept at 6.5 as the sample was received from the process at the same pH. The results of experiments were shown in Figures 3.9 to 3.12. It has been observed that the settling rate decreases with increasing of solid percentage. In case of 20% of solid concentration, the settling rate is 1.5 m/hr. Different dosses of flocculent was used to enhance the settling rate of solid. Very low doses of flocculent is required at lower solid concentration to get satisfactory results to design the conventional thickener. At higher solid concentration, the flocculent dosage requirement is little high.

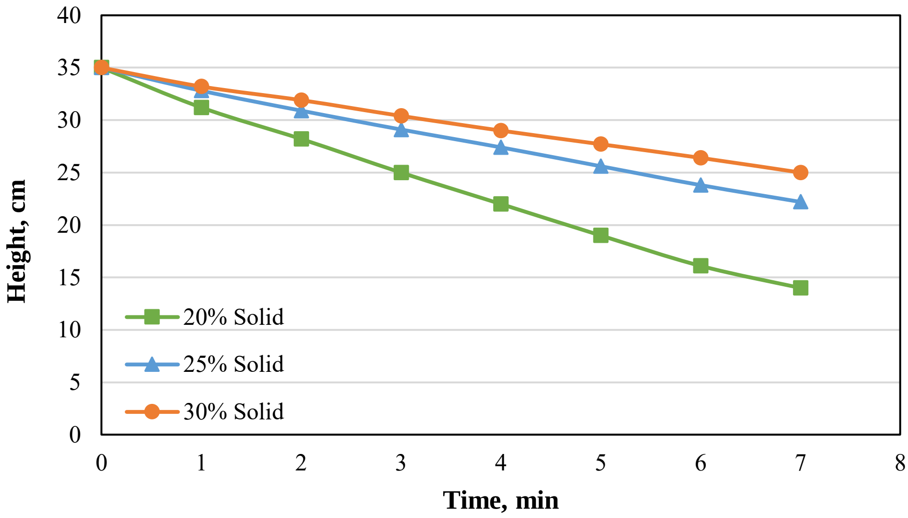


Fig. 3.9 Settling study of iron ore concentrate at different solid concentration

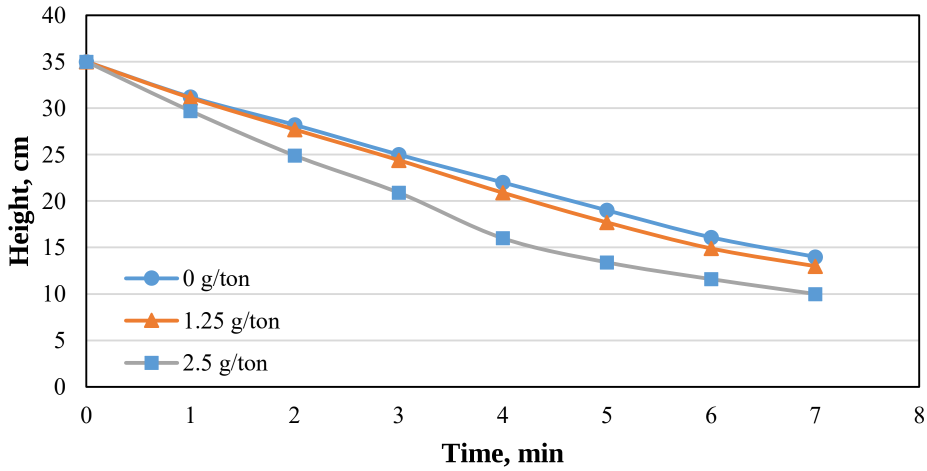


Fig. 3.10 Iron ore concentrate settling study at 20% solid concentration with different doses of flocculent

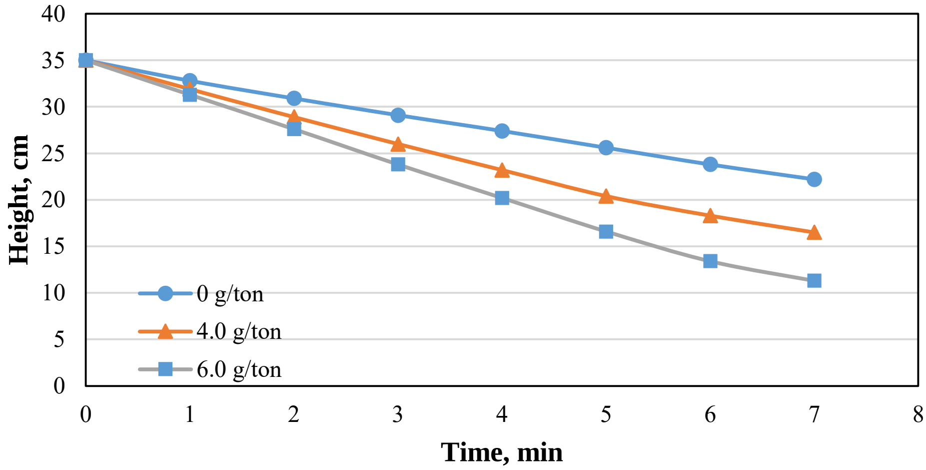


Fig. 3.11 Iron ore concentrate settling study of 25% solid concentration with different doses of flocculent.

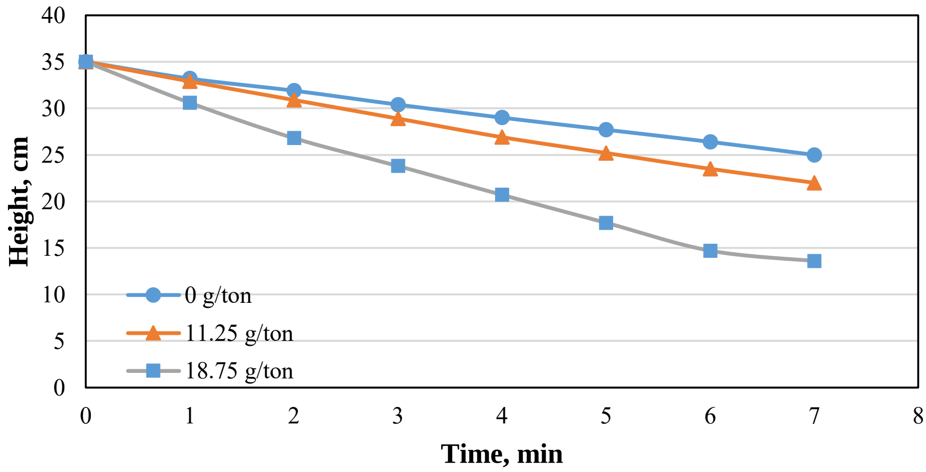


Fig. 3.12 Iron ore concentrate settling study of 30% solid concentration with different doses of flocculent.

Similarly settling studies of iron ore tailings were carried out at different concentration of 5%, 7.5% and 10%. The tests were carried out without and with addition of flocculent. The tests results are shown in Figure 3.13 to 3.16. It has been observed that the settling rate decreases with increasing of solid percentage. In case of 5% of solid concentration, the settling rate is 2 m/hr whereas in case 15 %, the settling rate is 0.8 m/hr. The flocculent rate was varied from 6.52 gm/tonne to 30 gm/tonne of solid. The settling rate with flocculent is very high at lower solid concentration. It indicates that after 5% solid concentration, the flocculent may require at lower dosage to enhance the settling rate. At higher solid concentration, the flocculent dosage requirement is high. At 10% solid concentration, the settling rate is very poor even after adding the flocculent.

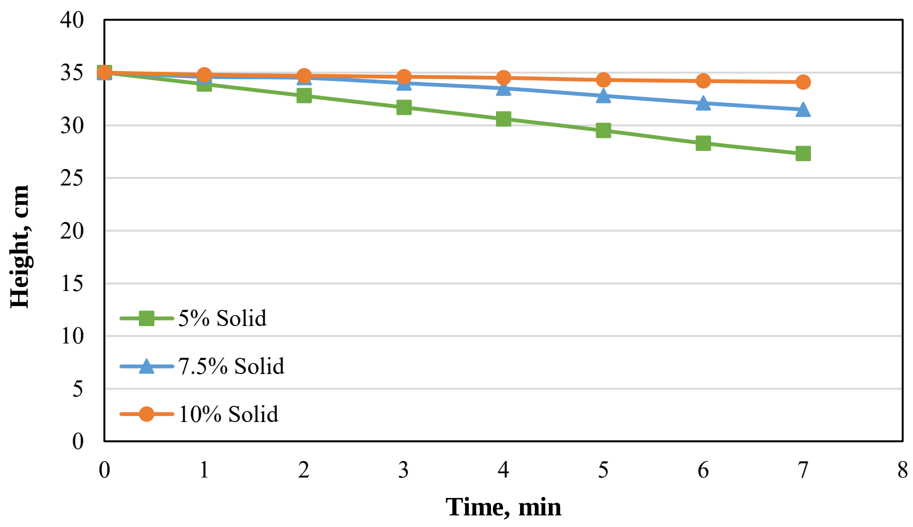


Fig. 3.13 Iron ore tailings settling study of different solid concentration

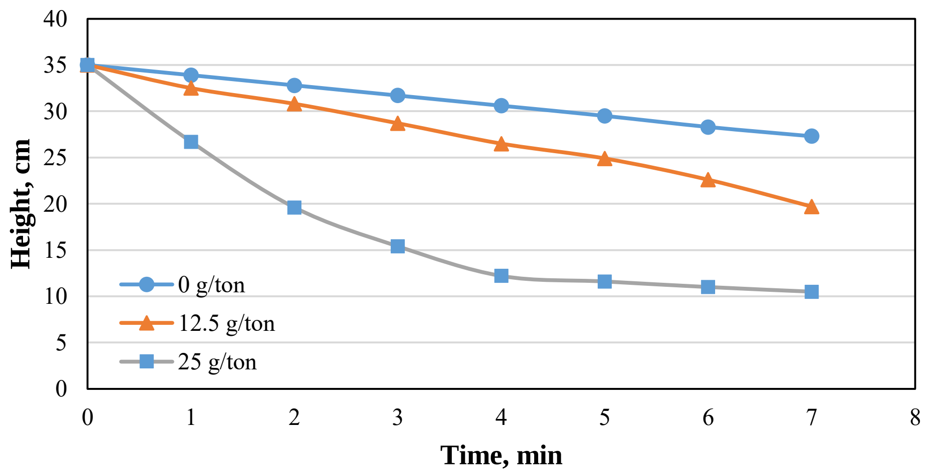


Fig. 3.14 Iron ore tailings settling study at 5% solid concentration with different doses of flocculent

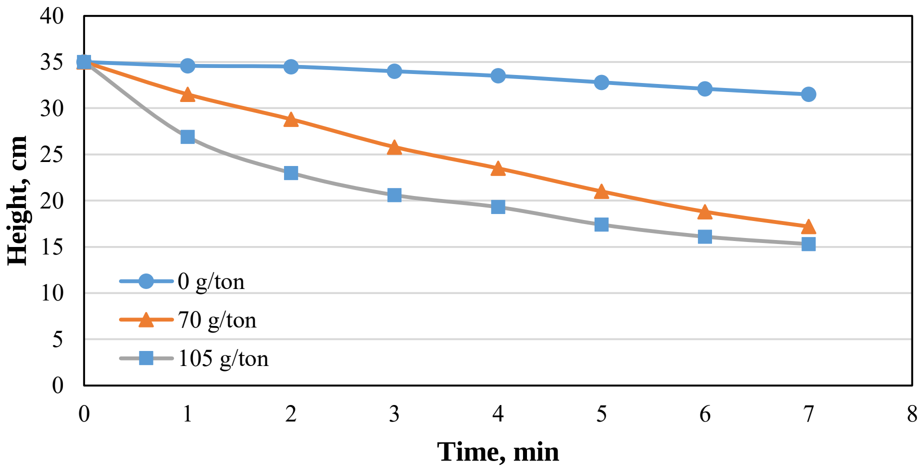


Fig. 3.15 Iron ore tailings settling study at 7.5% solid concentration with different doses of flocculent

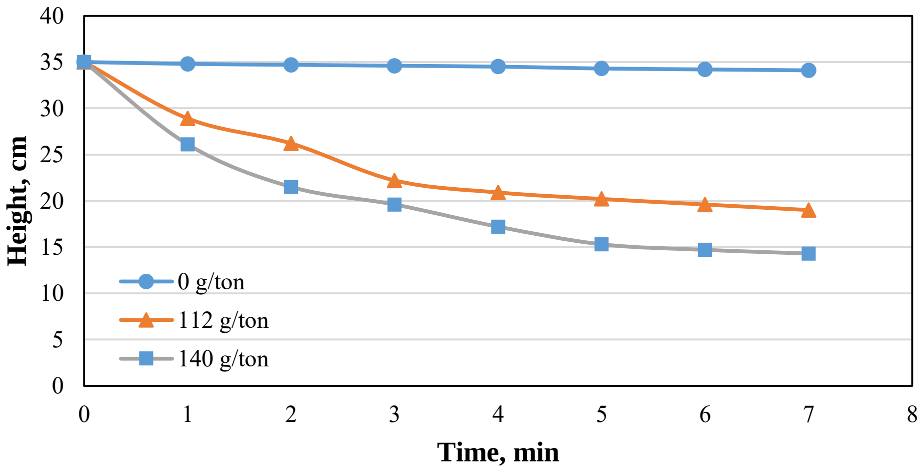


Fig. 3.16 Iron ore tailings settling study at 10% solid concentration with different doses of flocculent

3.10 Conclusions

The results of settling studies indicate the following observations;

1. The settling rate in case of tailings sample is very slow due to presence of ultra-fine clay minerals. Because of its surface charge, those try to remain in dispersion mode. The flocculent helps to neutralize the surface charge and make agglomerates the ultra-fine particles, as a result, the settling rate enhances.

2. The settling rate for conventional thickener design is required around 20 cm within 5-6 minutes. The above results are matching these phenomena.
3. For concentrate sample, small dose of flocculants was required to be added as there was less clay mineral compared to the tailings.

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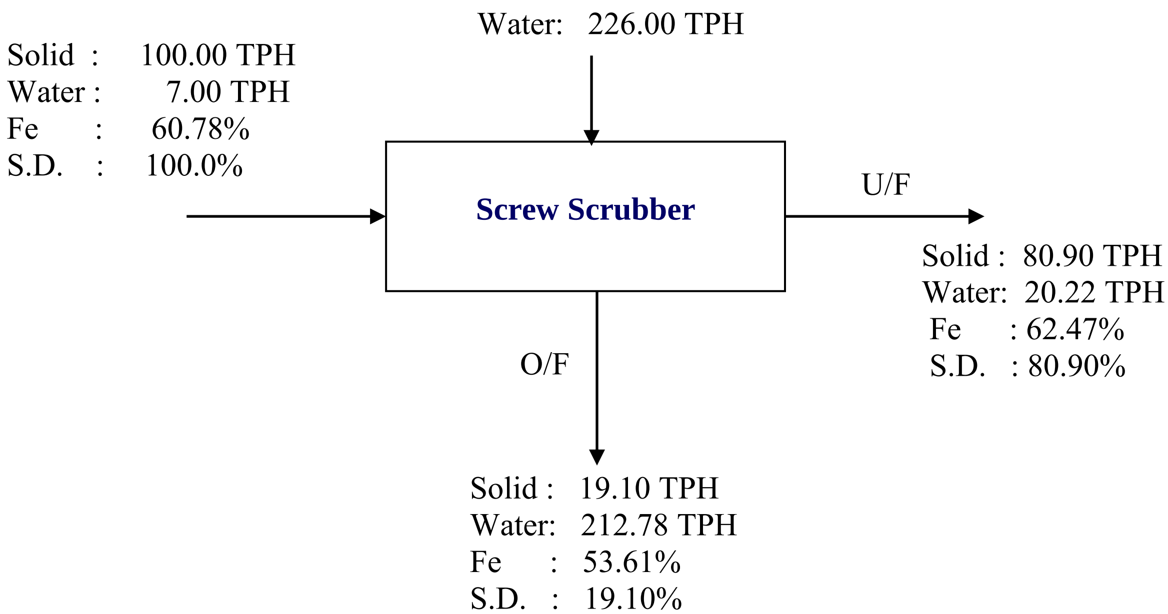
Annexure II.A

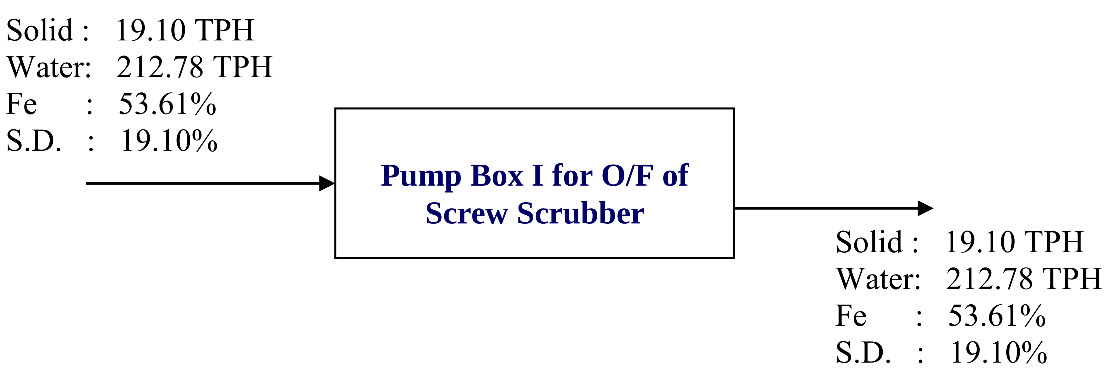
Material Balance of Process (Narayanposhi Iron ore)

Basis: 100 TPH

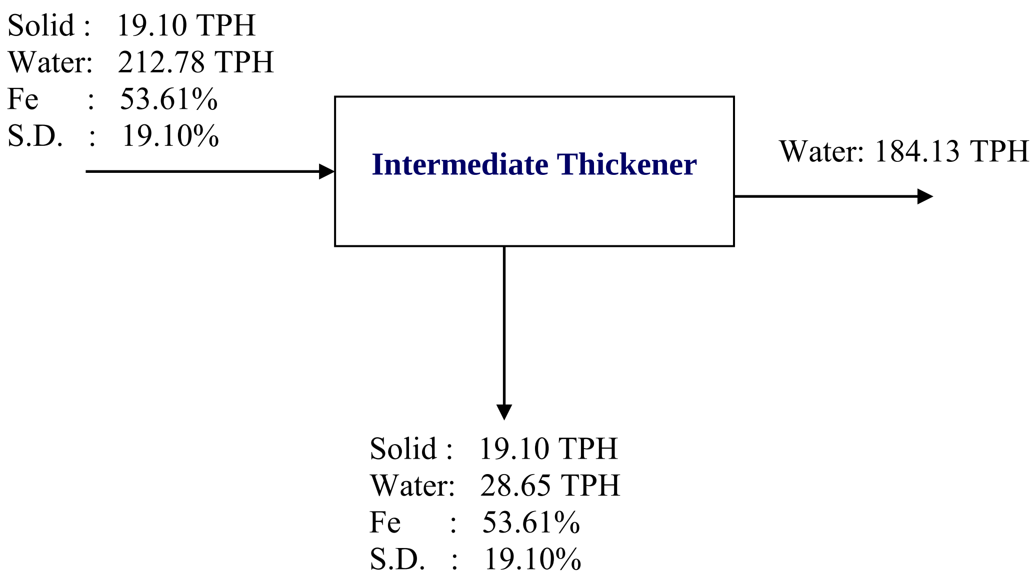
1. Screw Scrubber



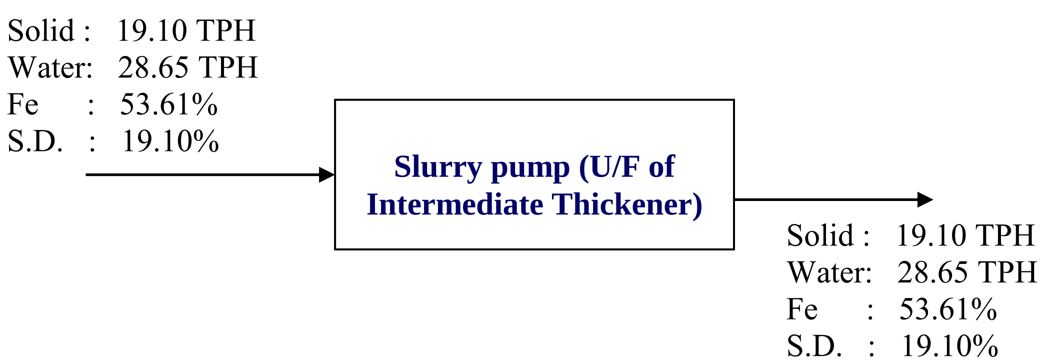
2. Pump Box I (O/F of Screw Scrubber)



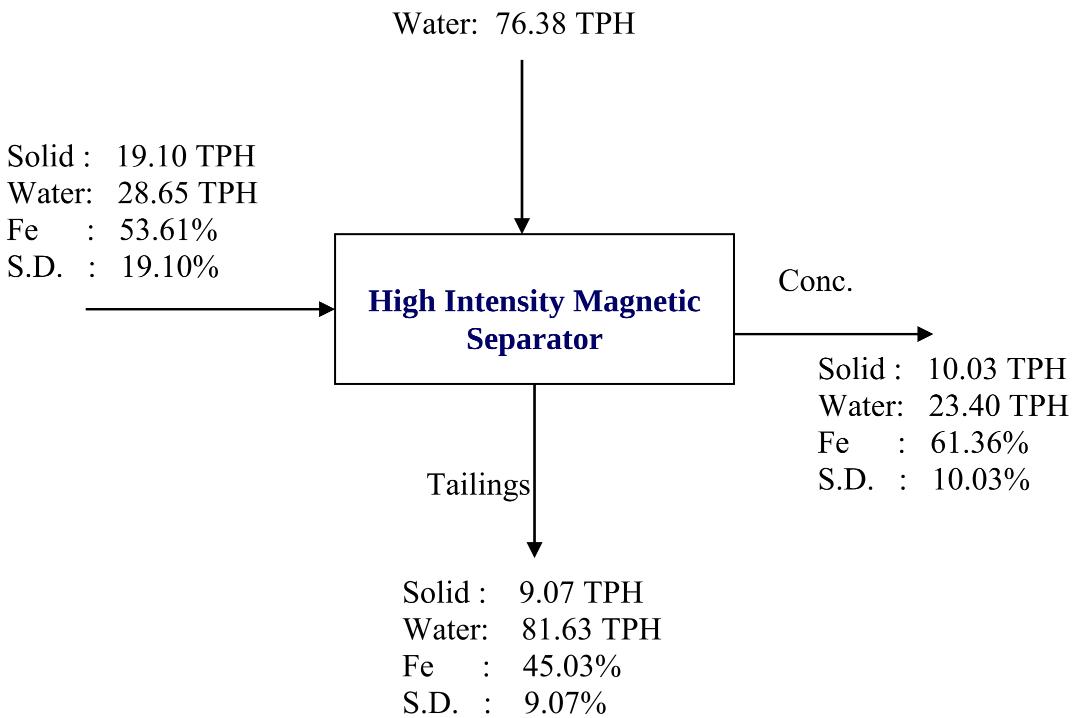
3. Intermediate Thickener



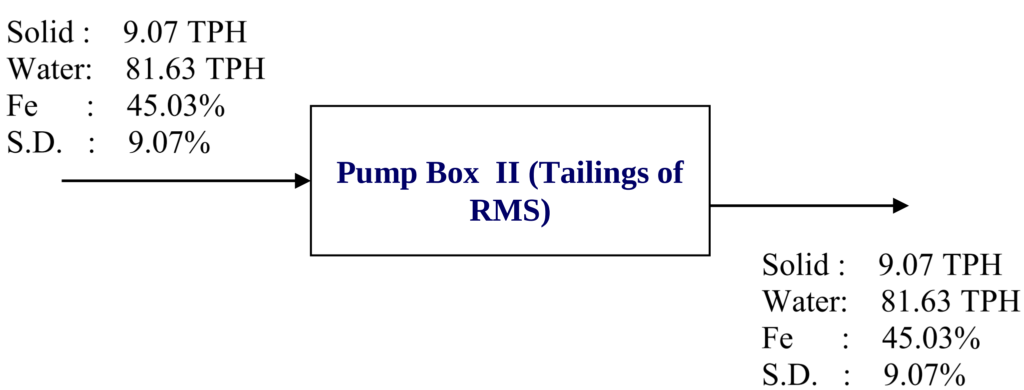
4. Slurry Pump I (U/F of intermediate thickener)



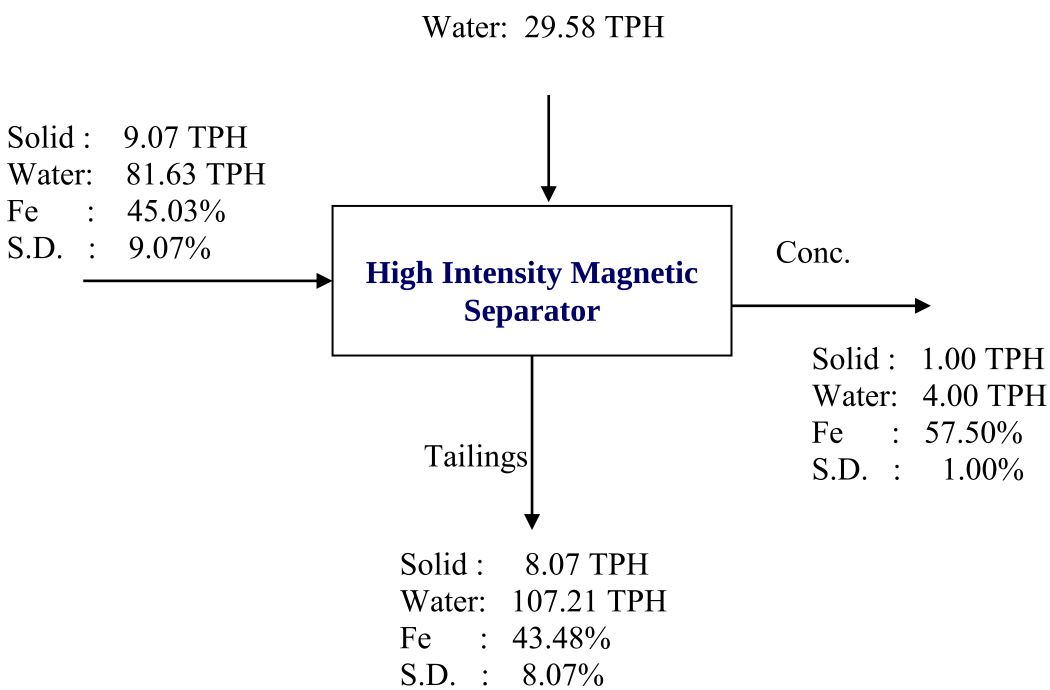
5. High Intensity Rougher Magnetic Separator



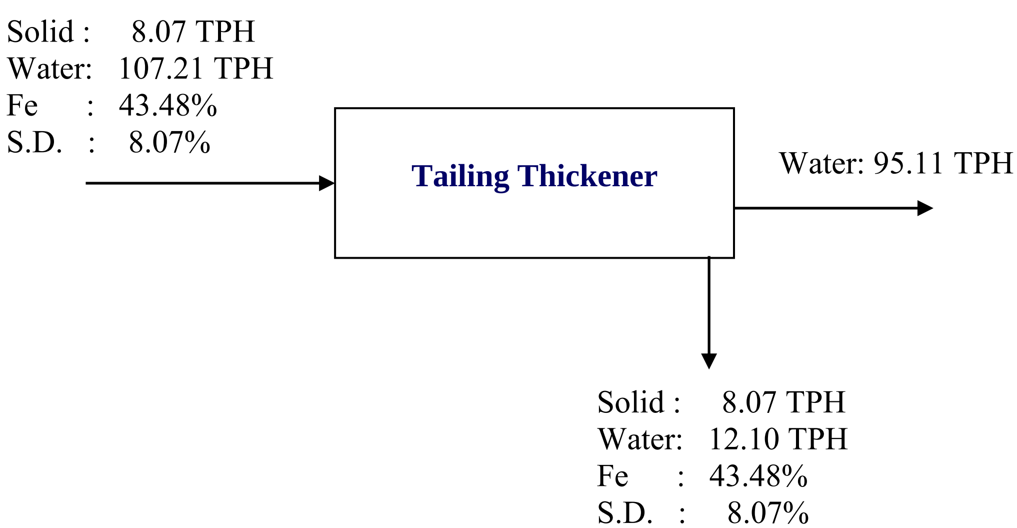
6. Pump Box II (Tailings of RMS)



7. High Intensity Scavenging Magnetic Separator



8. Tailing Thickener



9. Slurry Pump II

Solid : 8.07 TPH
Water: 12.10 TPH
Fe : 43.48%
S.D. : 8.07%

Slurry pump II

Solid : 8.07 TPH
Water: 12.10 TPH
Fe : 43.48%
S.D. : 8.07%

10. Tailings Pond

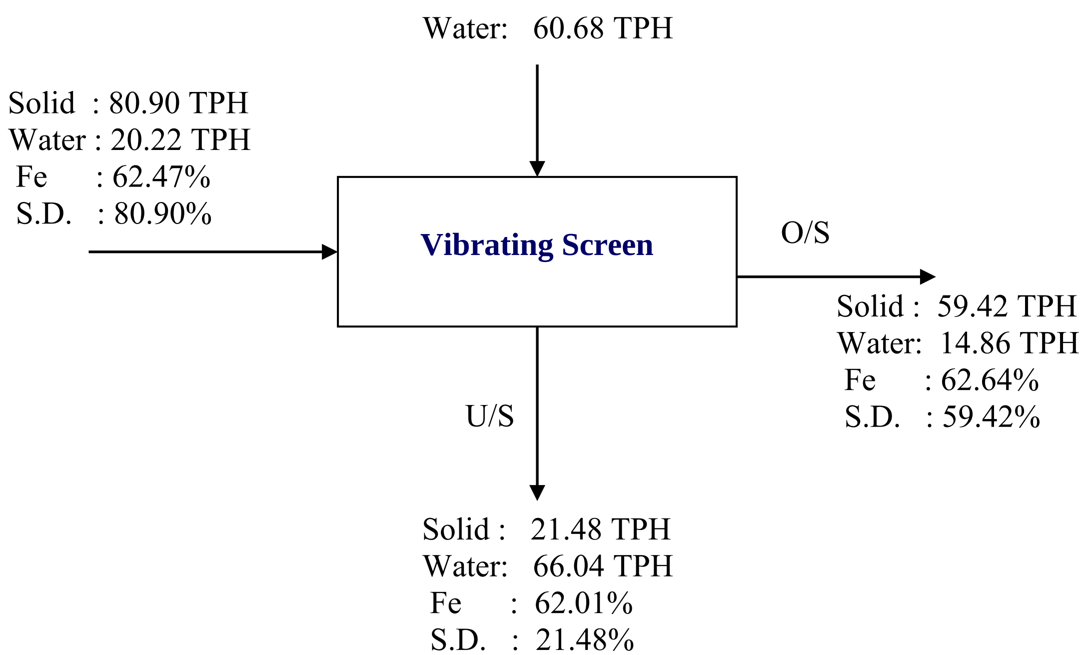
Solid : 8.07 TPH
Water: 12.10 TPH
Fe : 43.48%
S.D. : 8.07%

Tailings pond

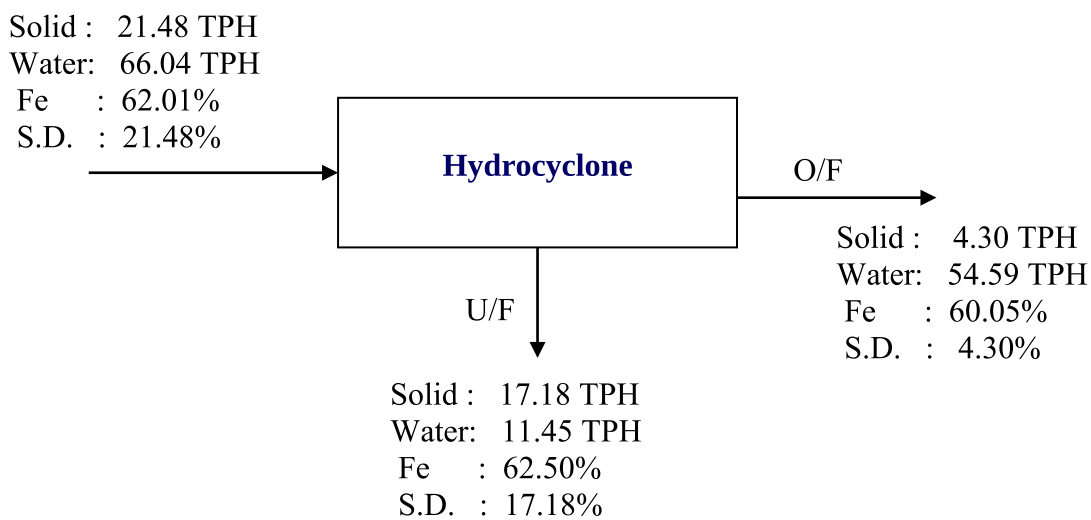
Recovered Water: 6.05 TPH

Solid : 8.07 TPH
Water: 6.05 TPH
Fe : 43.48%
S.D. : 8.07%

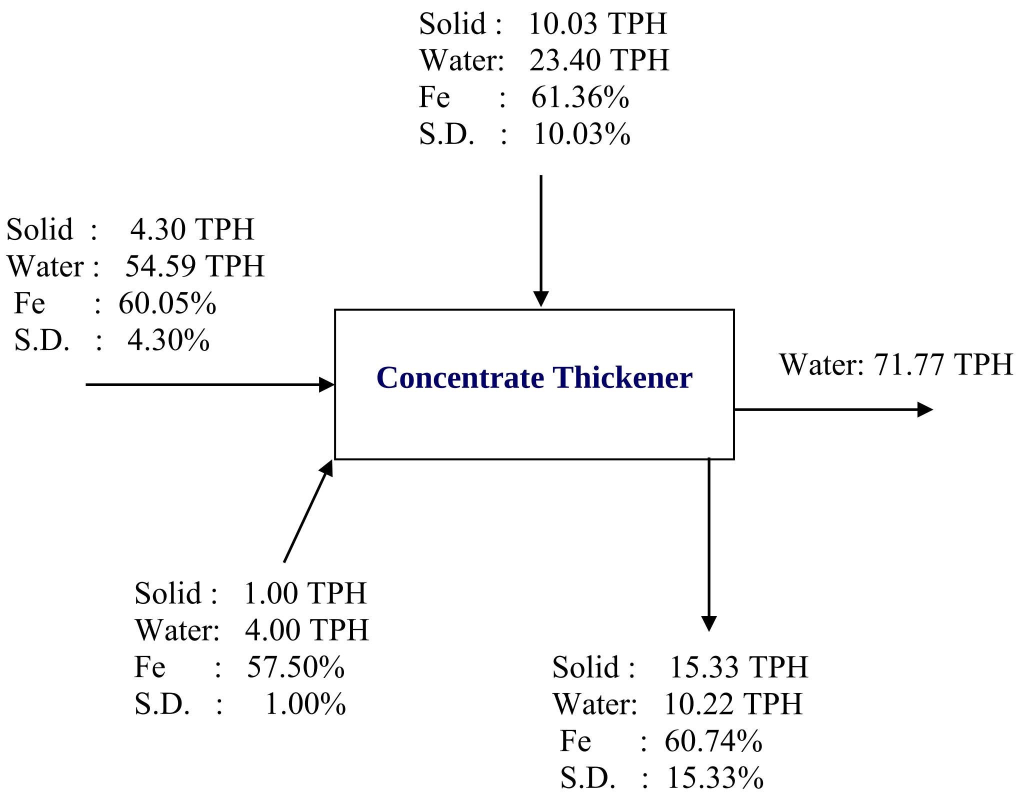
11. Vibrating Screen (1 mm size)



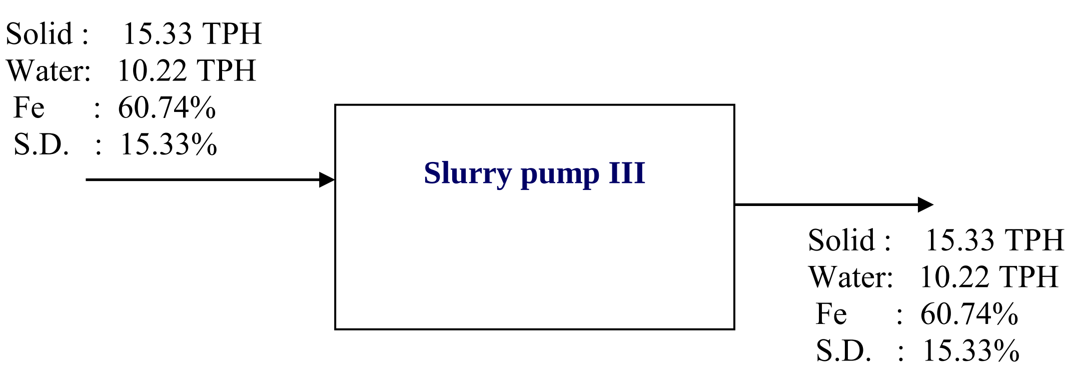
12. Hydrocyclone



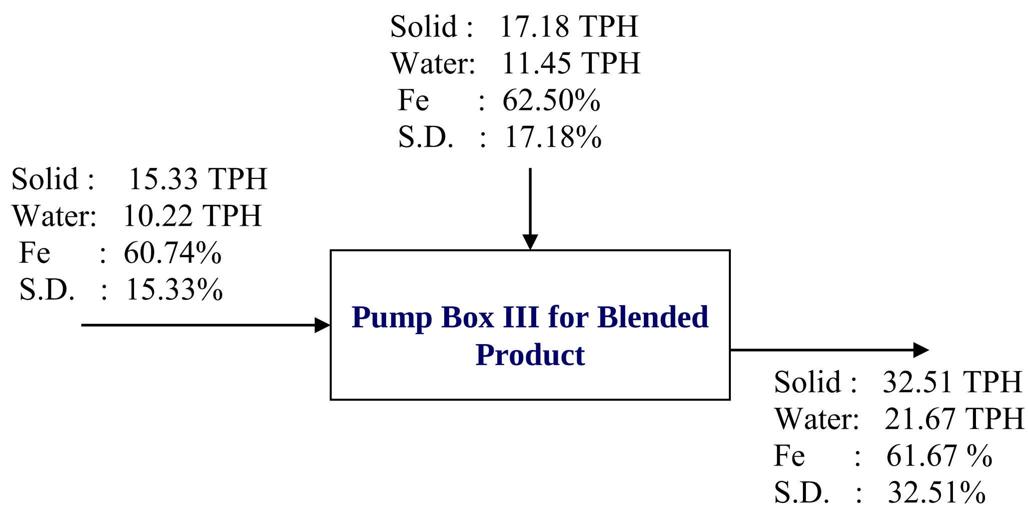
13. Concentrate Thickener



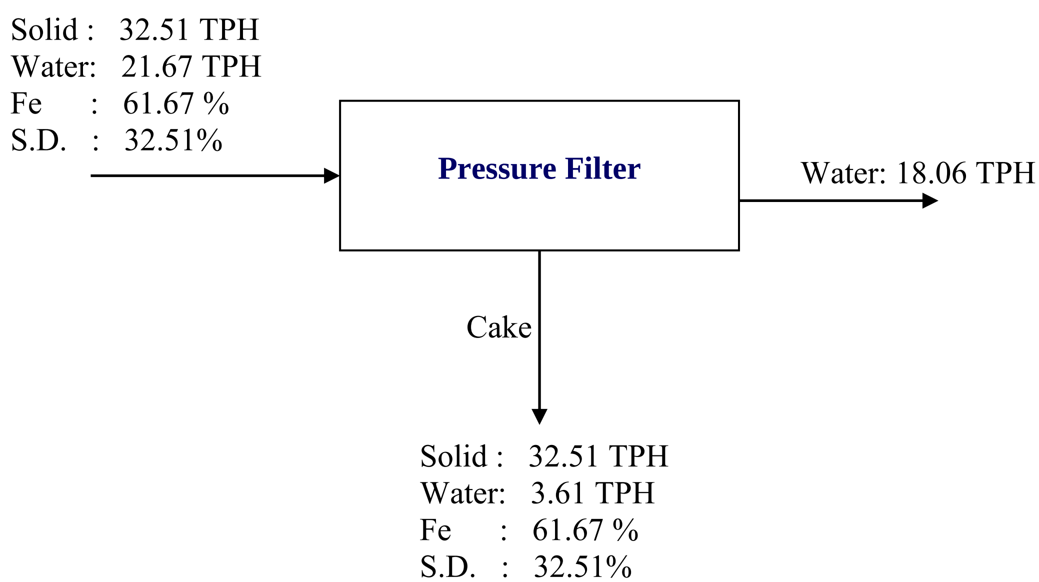
14. Slurry Pump III (Underflow of CT)



15. Pump Box III (Blended Product)



16. Pressure Filter



Water Balance

A. Water Handling

Sl. No.	List of Equipment	Water Addition, TPH
1	Bulk Sample	7.00
2	Screw Scrubber	226.00
3	Vibrating Screen	60.68
4	Rougher Magnetic Separator	76.38
5	Scavenger Magnetic Separator	29.58
Total		**399.64**

B. Water Recovered

Sl. No.	List of Equipment	Water recovered, TPH
1	Intermediate Thickener	184.13
2	Concentrate Thickener	71.77
3	Pressure Filter	18.06
4	Tailings Thickener	95.11
5	Tailing Pond	6.05
Total		**375.12**

C. Water Contains in Products

Sl. No.	Name of the Product	Water Contain, TPH
1	Pressure Filter	3.61
2	Vibrating screen	14.86
3	Tailing pond	6.05
Total		**24.52**

D. Make up water

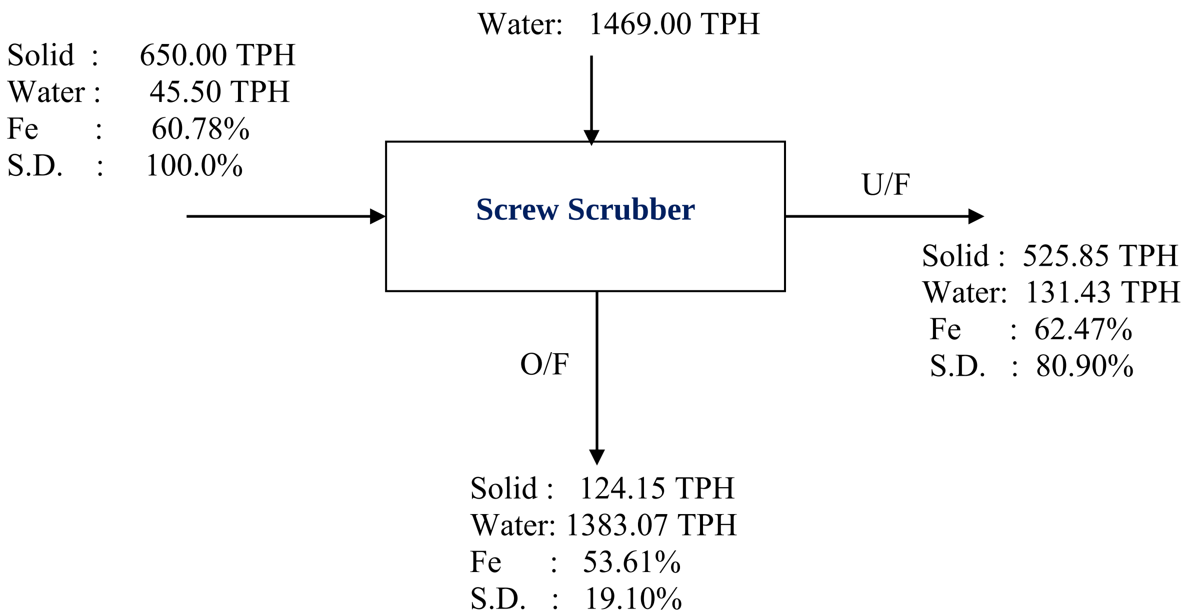
Sl. No.	Name of the Product	Water Contain, TPH
1	Water content in products	18.47
2	Water content in tailings	6.05
3	1% of handling loss	4.00
Total		**28.52**

Annexure II.B

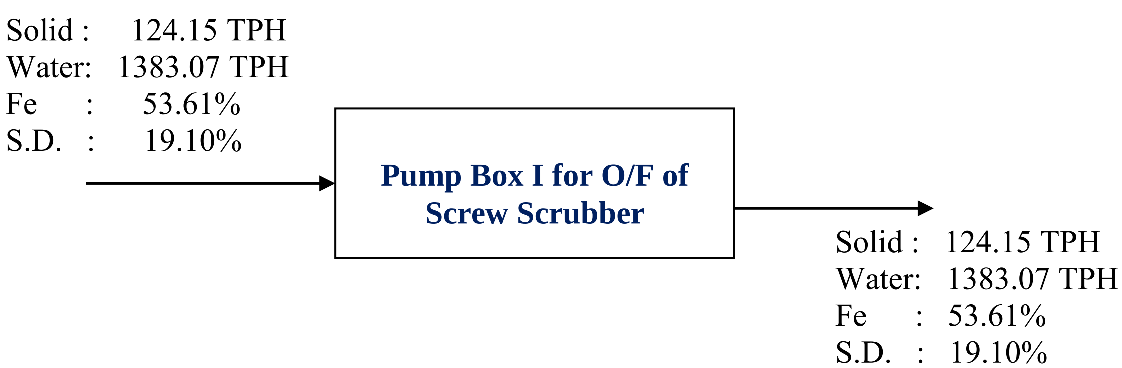
Material Balance of Process (Narayanposhi Iron ore)

Basis: 650 TPH

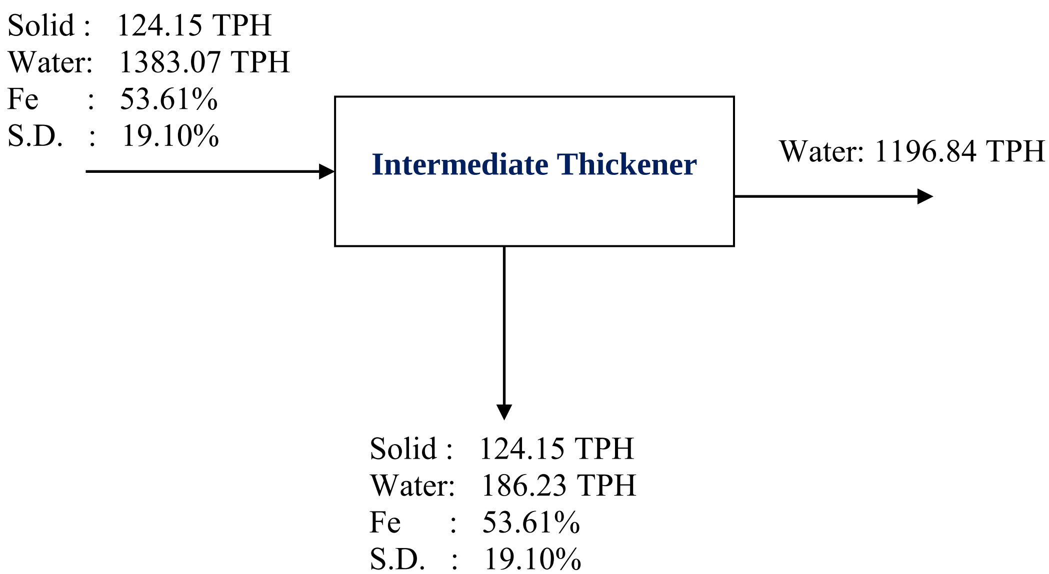
1. Screw Scrubber



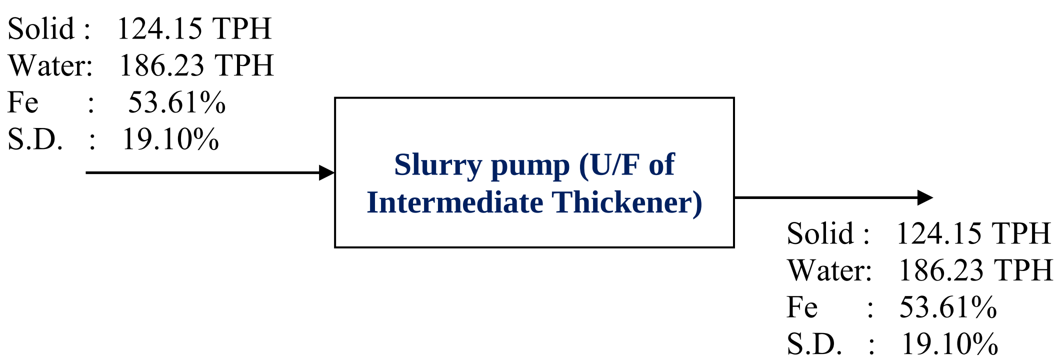
2. Pump Box I (O/F of Screw Scrubber)



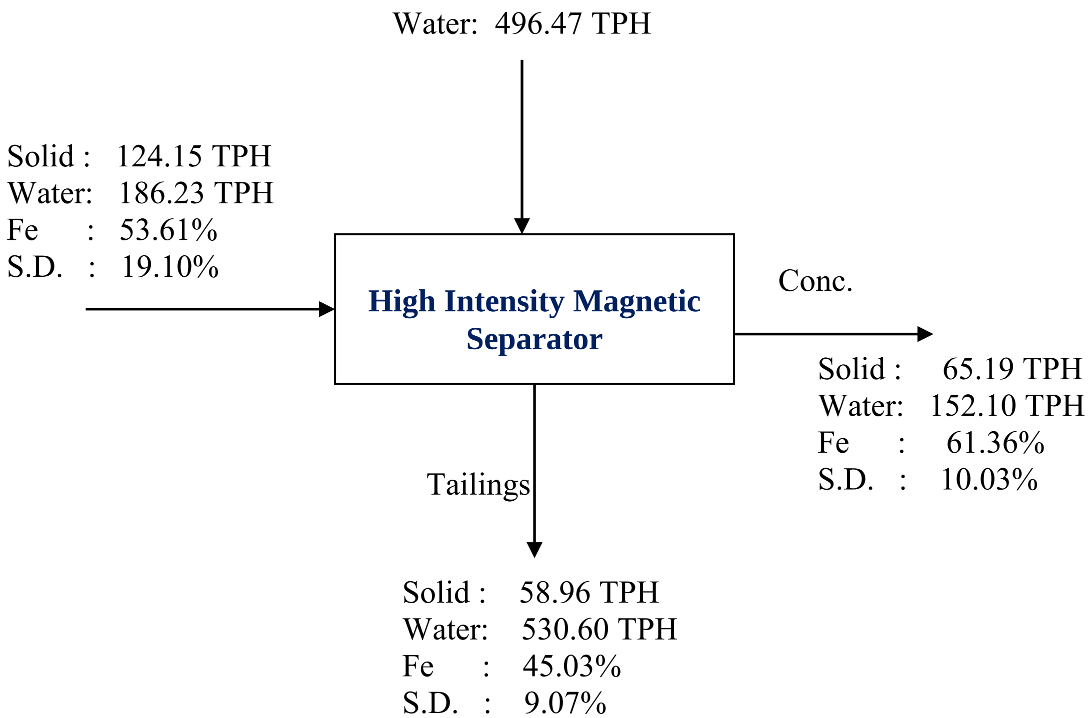
3. Intermediate Thickener



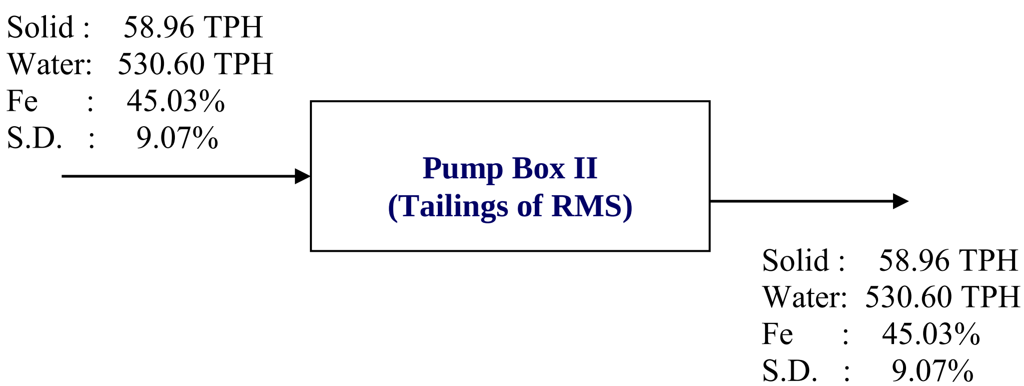
4. Slurry Pump I (U/F of intermediate thickener)



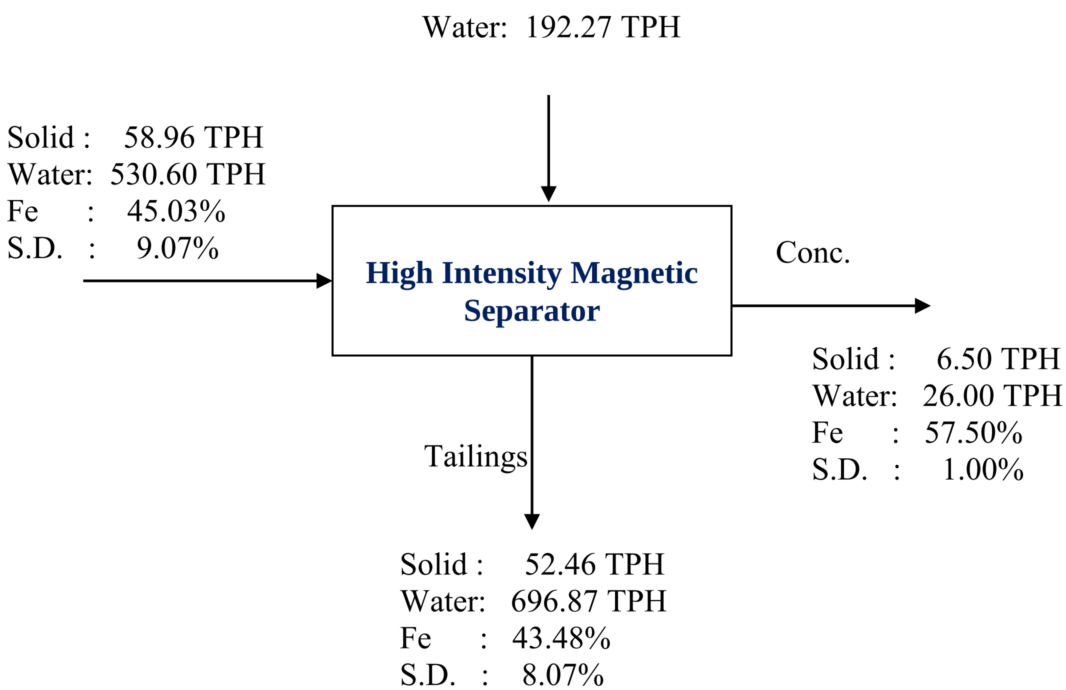
5. High Intensity Rougher Magnetic Separator



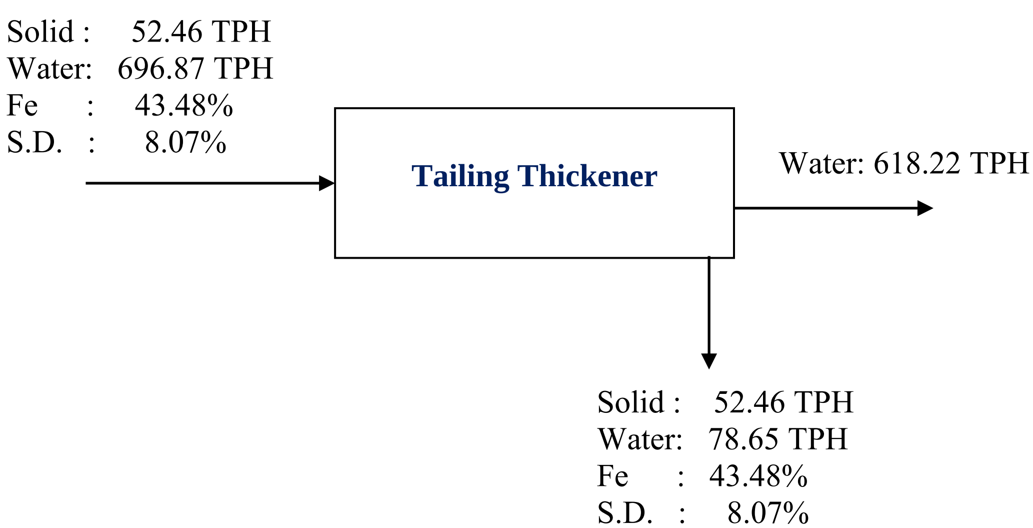
6. Pump Box II (Tailings of RMS)



7. High Intensity Scavenging Magnetic Separator



8. Tailing Thickener



9. Slurry Pump II

Solid : 52.46 TPH
Water: 78.65 TPH
Fe : 43.48%
S.D. : 8.07%

Slurry pump II

Solid : 52.46 TPH
Water: 78.65 TPH
Fe : 43.48%
S.D. : 8.07%

10. Tailings Pond

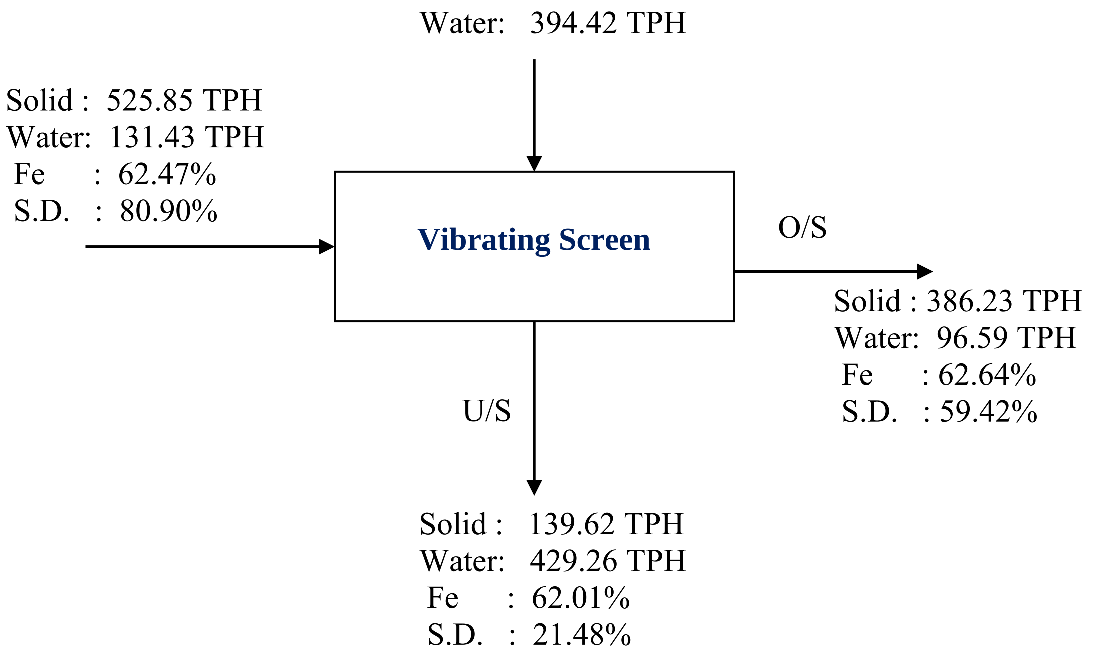
Solid : 52.46 TPH
Water: 78.65 TPH
Fe : 43.48%
S.D. : 8.07%

Tailings pond

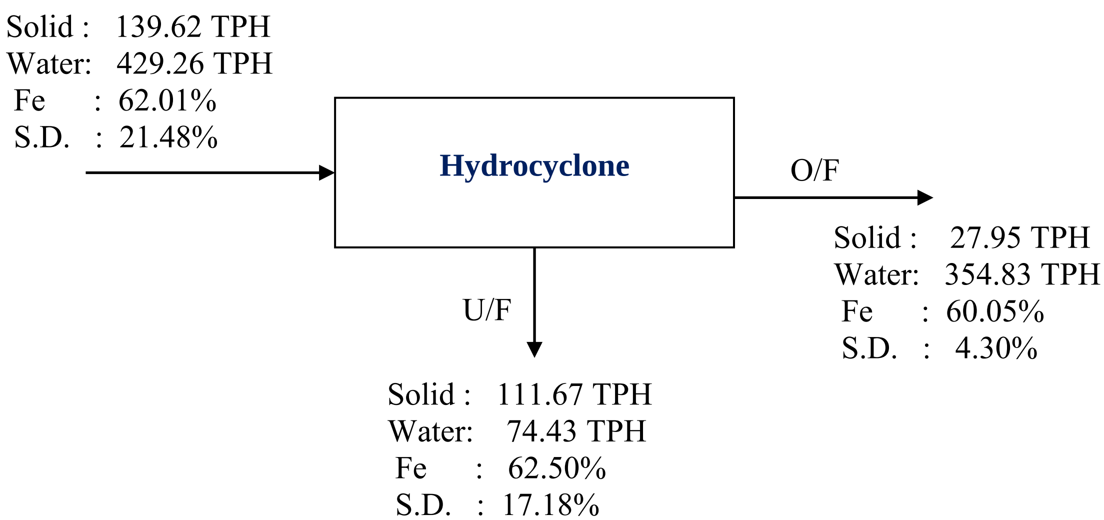
Recovered Water: 39.32 TPH

Solid : 52.46 TPH
Water: 39.33 TPH
Fe : 43.48%
S.D. : 8.07%

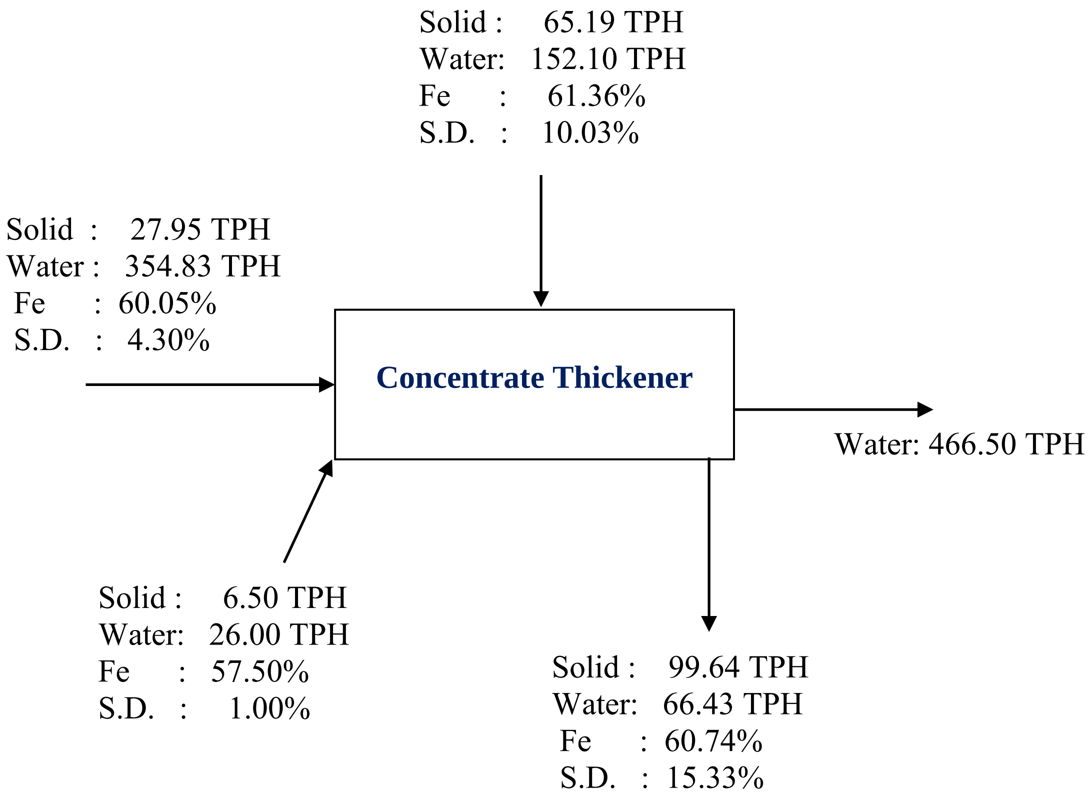
11. Vibrating Screen (1 mm size)



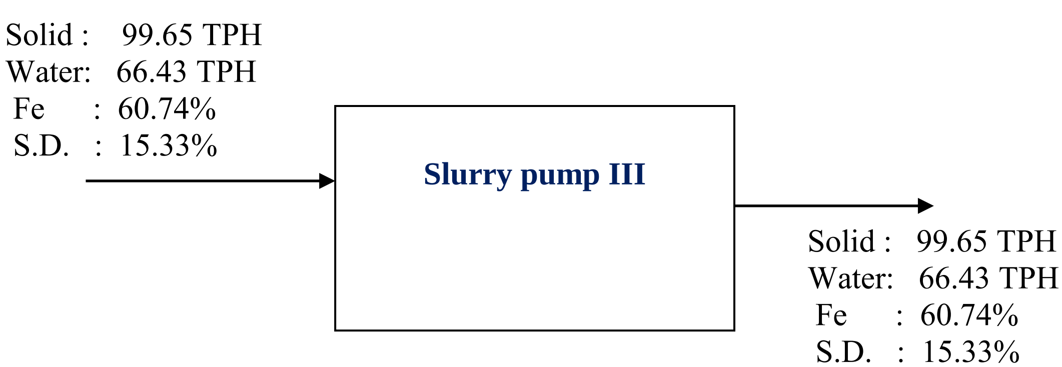
12. Hydrocyclone



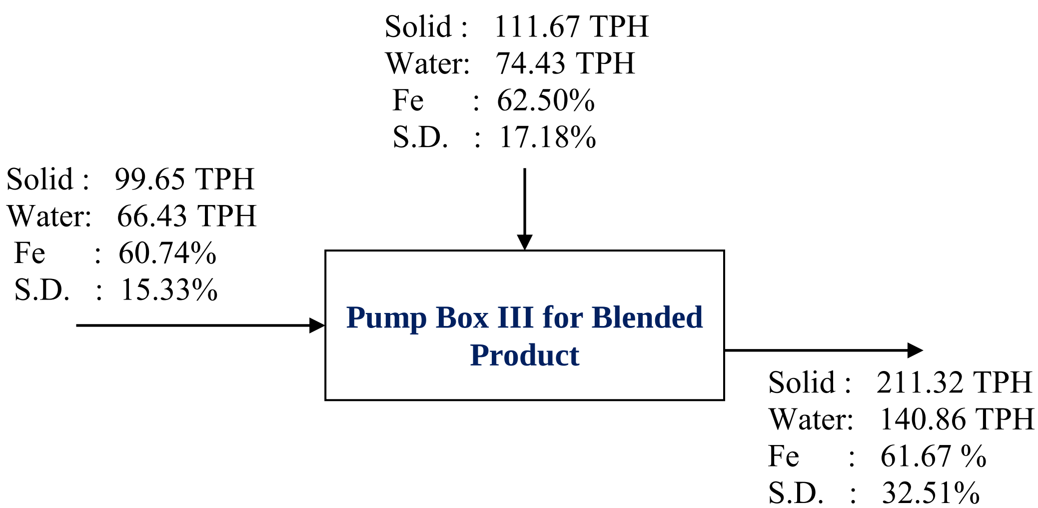
13. Concentrate Thickener



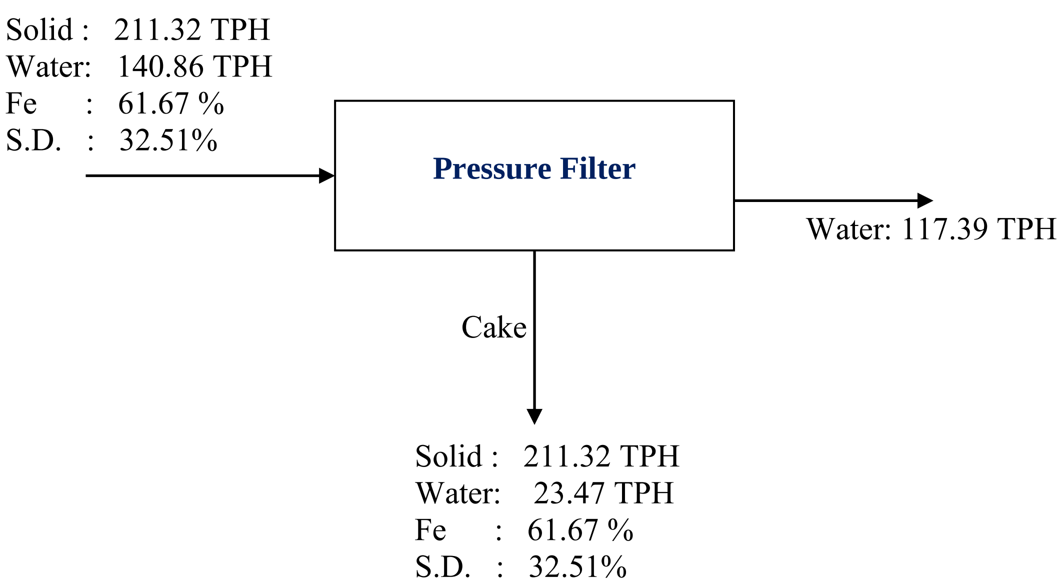
14. Slurry Pump III (Underflow of CT)



15. Pump Box III (Blended Product)



16. Pressure Filter



Water Balance

A. Water Handling

Sl. No.	List of Equipment	Water addition, TPH
1	Bulk Sample	45.50
2	Screw Scrubber	1469.00
3	Vibrating Screen	394.42
4	Rougher Magnetic Separator	496.47
5	Scavenger Magnetic Separator	192.27
Total		**2597.66**

B. Water Recovered

Sl. No.	List of Equipment	Water recovered, TPH
1	Intermediate Thickener	1196.84
2	Concentrate Thickener	466.50
3	Pressure Filter	117.39
4	Tailings Thickener	618.22
5	Tailing Pond	39.32
Total		**2438.27**

C. Water Contains in Products

Sl. No.	Name of the Product	Water contain, TPH
1	Pressure Filter	23.47
2	Vibrating screen	96.59
3	Tailing pond	39.33
Total		**159.39**

D. Make up water

Sl. No.	Name of the Product	Water contain, TPH
1	Water content in products	120.06
2	Water content in tailings	39.33
3	1% of handling loss	26.00
Total		**185.39**

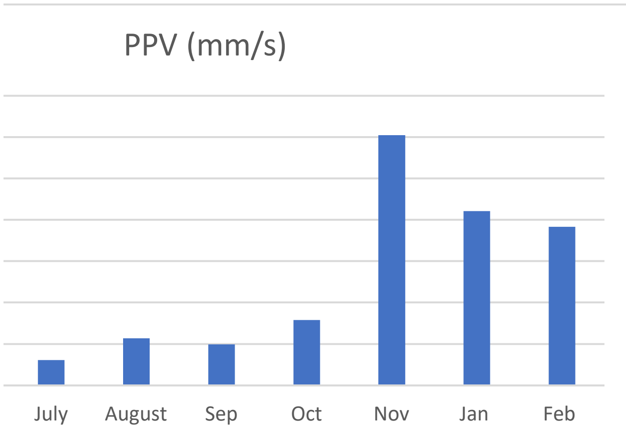
LANDUSE / LANDCOVER MAP OF NARAYANPOSI IRON & MN ORE MINE IN SUNDERGARH DISTRICT OF M/S JSW STEEL LTD.


realme
Shot on realme 8 5G
2023 03 25 11:06

NARAYANPOSHI IRON

Month	PPV (mm/s)
May	**2.44**
June	**1.63**
July	**1.22**
August	**2.28**
Sep	**1.98**
Oct	**3.15**
Nov	**12.1**
Jan	**8.42**
Feb	**7.66**

& Mn ORE MINES



Coir Matting

Rain Water Harvesting


GPS Map Camera

ODISHA

Tel : 2564033/2563924
EPABX : 2561909/2562847
E-mail: hwmd@ ospcboard.org / paribesh1@ ospcboard.org
Website: www.ospcboard.org

STATE POLLUTION CONTROL BOARD, ODISHA

[FOREST, ENVIRONMENT AND CLIMATE CHANGE DEPARTMENT, GOVERNMENT OF ODISHA]
Paribesh Bhawan, A/118, Nilakantha Nagar, Unit – VIII
Bhubaneswar – 751012, INDIA

BY SPEED POST

FORM 2
[See rule 6(2)]

RENEWAL OF AUTHORISATION BY STATE POLLUTION CONTROL BOARD, ODISHA TO THE OCCUPIER UNDER HAZARDOUS AND OTHER WASTES (MANAGEMENT AND TRANSBOUNDARY MOVEMENT) RULES, 2016

1. Number of authorization: **IND-IV-HW-1349/** 8185 and date of issue: 23-05-2023
2. Reference of application (No. and date): **4562849, dtd. 26-12-2022/16-05-2023.**
3. **Narayanposhi Iron & Manganese Mine of M/s JSW Steel Ltd.** is hereby granted an authorizationbased on the enclosed signedinspectionreportfor generation, storage,transport, reuse,utilization, disposal or any other use of hazardous or other wastes or both in the premises situated **At/PO -Koira, Dist - Sundargarh, Odisha.**

Details of Authorization

Sl. No	Category of Hazardous Waste as per the Schedules I, II and III of these Rules	Waste Description	Quantity	Authorized Mode of Disposal or Recycling or utilization or Co-processing, etc.
1.	Schedules - I Stream - 5.1	Used / Spent Oil	150T/A	Storage in containers over impervious floor under well ventilated covered shed followed by disposal through Actual Users authorized by SPCB, Odisha
2.	Schedules - I (Stream –3.3, 5.2& 33.2)	Wastes / Residue Containing Oil	100 T/A	Storage in impervious pits / containers under well ventilated covered shed followed by Co-processing in Cement Kiln Authorized by SPCB, Odisha / disposal in Authorized Hazardous Waste Incinerator / Common Hazardous Waste Treatment Storage Disposal Facility (CHWTSDF)

Sl. No	Category of Hazardous Waste as per the Schedules I, II and III of these Rules	Waste Description	Quantity	Authorized Mode of Disposal or Recycling or utilization or Co-processing, etc.
3.	Schedules - I Stream - 33.1	Empty Barrels	100 T/A	Storage on impervious floor under well ventilated covered shed followed by captive reuse / disposal through original supplier /Actual Users authorized by SPCB, Odisha

(1) The authorization shall be valid up to **31-03-2024**.

(2) The authorization is subject to the following general and specific conditions.

A. General Conditions of authorisation:

1. The authorized person shall comply with the provisions of the Environment (Protection) Act, 1986, and the rules made there under.

2. The authorization or its renewal shall be produced for inspection at the request of an officer authorized by the State Pollution Control Board.

3. The person authorized shall not rent, lend, sell, transfer or otherwise transport the hazardous and other wastes except what is permitted through this authorization.

4. Any unauthorized change in personnel, equipment or working conditions as mentioned in the application by the person authorized shall constitute a breach of his authorization.

5. The person authorized shall implement Emergency Response Procedure (ERP) for which this authorization is being granted considering all site specific possible scenarios such as spillages, leakages, fire etc. and their possible impacts and also carry out mock drill in this regard at regular interval of time.

6. The person authorized shall comply with the provisions outlined in the Central Pollution Control Board guidelines on "Implementing Liabilities for Environmental Damages due to Handling and Disposal of Hazardous Waste and Penalty"

7. It is the duty of the authorized person to take prior permission of the State Pollution Control Board to close down the facility.

8. The imported hazardous and other wastes shall be fully insured for transit as well as for any accidental occurrence and its clean-up operation.

9. The record of consumption and fate of the imported hazardous and other wastes shall be maintained.

10. The hazardous and other waste which gets generated during recycling or reuse or recovery or pre-processing or utilization of imported hazardous or other wastes shall be treated and disposed of as per specific conditions of authorization.

11. The importer or exporter shall bear the cost of import or export and mitigation of damages if any.

12. An application for the renewal of an authorization shall be made as laid down under these Rules.

13. Any other conditions for compliance as per the Guidelines issued by the Ministry of Environment, Forest and Climate Change or Central Pollution Control Board from time to time.

14. Annual return shall be filed by June 30th for the period ensuring 31st March of the year.

B. Specific Conditions:

1. Authorization granted herewith does not relieve you in complying with other provision laid down under Water (PCP) Act, 1974, Air (PCP) Act, 1981 and Environment (Protection) Act, 1986, and the Rules made there under.

2. This authorization is subject to statutory and other clearances from Govt. of Odisha and / or Govt. of India as and when applicable.

3. In case the quantity of generation of hazardous Waste exceeds the Authorized quantity, the mine shall apply for amendment of Authorization order.

4. The mine shall strictly comply to the provisions of Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 and amendments made thereafter.

5. Annual returns in Form - 4 (See Rules- 6 (5), 13 (8), 16 (6) & 20 (2)) shall be submitted to the Board for the financial year by 30^{th} June of every year. It shall contain the detail quantities of generation, storage and disposal of different type of hazardous wastes such as recyclable, incinerable, land disposable.

6. Steps shall be taken for reduction and prevention of the hazardous waste generated or for recycling or reuse.

7. Environmental Information with respect to Air, Water, Hazardous Waste and Hazardous Chemicals shall be displayed at the main gate for public view.

8. The transport of the hazardous and other waste shall be in accordance with the provisions of the Rule, 2016 and the rules made by the Central Government under the Motor Vehicles Act, 1988 and the guidelines issued by the Central Pollution Control Board from time to time in this regard.

9. The occupier shall provide the transporter with the relevant information in **Form 9**, regarding the hazardous nature of the wastes and measures to be taken in case of an emergency and shall label the hazardous and other wastes containers as per **Form 8**.

10. In case of transportation of hazardous waste and other wastes for recycling or utilization including co-processing to outside the state, the sender shall intimate both the State Pollution Control Boards before handing over the waste to the transporter.

11. Manifest system (Movement document) shall be strictly followed as per Rule-19 and to be submitted to this office as per the Rule. The mine shall check the authenticity of the weigh bill of the transport vehicle to ensure supply of hazardous waste to the authorized destination.

12. The hazardous waste shall be sold if required only to Actual User having valid authorization from the State Pollution Control Board, Odisha and concerned SPC Board. Details of such wastes shall be entered in the passbook issued by respective SPCB.

13. All the hazardous waste shall be stored in impervious pits / containers / floors under cover shed with adequate capacity having spill containment facility. The spilled hazardous waste shall be re-collected and stored in impervious pits / containers / floors under cover shed prior to sale / disposal.

14. The schedule of hazardous waste and the quantity as specified shall only be disposed off as per the stipulation prescribed in this authorization.

15. This authorization does not permit you to either receive and process or generate hazardous waste in case validity of Consent to Operate of your industry / mine ceases. However you can carry out handling, storage, treatment, transport and disposal of hazardous waste and other wastes generated previously during such period to avoid accumulation of hazardous waste.

16. The mine shall store the accumulated hazardous waste for a period not exceeding 90 days and shall dispose as per the stipulation prescribed in this authorisation order. In case, generation of any category of Hazardous Waste is less than 10 T/A, then such waste can be stored up to a period of 180 days before disposal. In case of any violation, authorization granted shall be suspended / cancelled.

17. The mine shall apply for renewal of authorization in Form - 1, 120 days before expiry of this authorization order enclosing Annual Return in Form - 4, Manifest copies in Form - 10 and compliance to the conditions stipulated in this order along with adequate processing fees.

18. In case of transportation of hazardous and other waste, the responsibility of safe transport shall be either of the sender or the receiver whosoever arranges the transport and has the necessary authorization for transport from the concerned State Pollution Control Board. This responsibility should be clearly indicated in the manifest.

19. Hazardous Wastes having calorific value of more than 2500 Kcal/Kg shall not be land filled. It can only be disposed through authorized actual users or incinerated in authorized Hazardous Waste incinerator or co-processing in authorized cement kiln.

20. The mine shall follow On-site and Off-site Emergency plan during all activities involving hazardous wastes to avert accidents, fire and other environmental damages.

21. The mine shall follow all safety protocols during handling, transportation and disposal of hazardous wastes.

Member Secretary

To

The Deputy Managing Director
Narayanposhi Iron &Manganese Mine
of M/s JSW Steel Ltd.,
At /PO – Koira
Dist- Sundargarh, Odisha

Memo No. ________________ Dt. ________________
Copy to the :

1. Collector & District Magistrate, **Sundargarh.**
2. Director, Factories & Boilers, Odisha, **Bhubaneswar.**
3. Regional Officer, State Pollution Control Board, Odisha, **Sundargarh.**
4. Guard file.

Additional Chief Environmental Engineer

FORM 10

[See rules 19(1)]

MANIFEST FOR HAZARDOUS AND OTHER WASTE

1.	Sender's Name & Mailing Address (Including Phone No & email)	:	M/S JSW Steel Ltd. Plot-No. 49 P Khata No- 152. Mouza- Kotra, Narayani Poshi Iron MN Mine, Sundargarh.
2.	Senders authorization No.	:	IND-IV-HW-1349/5402 dt 31-03-22
3.	Manifest Document No.	:	
4.	Transporter's Name & Address (including Phone No. and email)	:	Self
5.	Type of Vehicle	:	(~~Truck~~ / Tanker / Special Vehicle)
6.	Transporter's Registration No.	:	NIL
7.	Vehicle. Registration No.	:	OR-01-V-4646
8.	Receiver's Name & mailing Address (Including phone No and email)	:	M/S. Raj Lubricants. At/Po- Janugani Dist- Balasore. odisha - 756019 rajlubricants212@gmail.com
9.	Receiver's authorisation No.	:	IND-IV-HW-210/10244 dt 26.7.21
10.	Waste Description	:	Used/Waste Lub oil.
11.	Total Quantity No. of Containers	:	3.906 KL ~~m3~~ or MT or KL 18 Nos.
12.	Physical form	:	Solid/Semi-Solid/Sludge/~~Oily~~/Tarry/Slurry/Liquid
13.	Special handling instructions and additional information	:	a) Keep the material dry b) Never transport while hot and wet c) Avoid skin and eye contact d) Store in a dry and covered area e) Use safety shoes, helmet and goggles
14.	Sender's Certificate	:	I hereby declare that the contents of the consignment are fully and accurately described above by proper shipping name and are categorized, packed, marked and labeled, and are in all respect in proper condition for transport by road according to applicable national government regulations.
	Types Name & Stamp (JSW STEEL LIMITED BARBIL) — Signature		Month 02 Day 06 Year 2023
15.	Transporter Acknowledgment of Receipt of Wastes		
	Name & Stamp (RAJ LUBRICANTS ODISHA JANUGANJ BALASORE 756019) — Signature Pattanayak		Month 02 Day 06 Year 2023
16.	Receivers Certification for Receipt of Hazardous and other waste		
	Name & Stamp (RAJ LUBRICANTS ODISHA JANUGANJ BALASORE 756019) — Signature Pattanayak		Month 02 Day 06 Year 2023

FORM 9

[See rule 18 (2)]

TRANSPORT EMERGENCY (TREM) CARD

[To be carried by the transporter during transportation of hazardous and other wastes, provided by the sender of waste]

1. Characteristics of hazardous and other wastes:

Sl. No	Type of waste	Physical properties	Chemical properties	Exposure hazardous	First Aid requirements
1	Used Oil	1.Colour- Black 2.Lube oil 3.Viscois in nature	Branched Alkanes, Cycloalkanes, Benzene, Polly Aromatic Hydro carbons, decomposition products	Skin corrosion/ Irritation, Sensitization- Respiratory, Carcinogenicit y	IF INHALED: Remove person to fresh air and keep comfortable for breathing. IF ON SKIN: Wash with plenty of soap and water. IF IN EYES: Rinse cautiously with water for several minutes. IF SWALLOWED: Immediately call poison centre / doctor/ physician.

2. Procedure to be followed in case of fire: Move to safe distant place and immediately inform to the nearest fire station.
3. Procedure to be followed in case of spillage/ accident/ explosion: Move to a safe distant place and immediately inform to the nearest fire station.
4. For expert service, please contact:

(i) Name and Address

(ii) Telephone No.

: Niranjan Barik
9556130867
Naryan Poshi Mines, JSW Ltd.

(Name, contact number & signature of sender)

JSW STEEL LIMITED ★ BARBIL ★

Date: 06.02.23

Place: Koira (Odisha)

Passbook for Maintenance of Records of Hazardous and Other Wastes purchased by the Actual User

[See Rule – 6(7& 8) of Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016]

Name and Address of the Actual User: M/S Raj Lubricants
At/Po - Januganj, Dist- Balasore

Telephone No.: 9437041703 E-mail: rajlubricants2012@gmail.com
9776663975

Reference of Authorisation No. 10244 Date : 26-07-2021

Passbook No : IND/IV/HW/210/03/2022 Date : 29.04.2022

Validity Till : As per validity of Authorization Order.

Type & Quantity of Hazardous and Other WastesPermitted for Procurement and processing for Reuse, Recycling, Recovery, Preprocessing, Utilisation including Co-Processing

Sl. No	Type of Hazardous and Other Wastes	Quantity
1.	Used / Spent Oil	1500T/A

This Passbook is valid till Authorisation under Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 is valid. Therefore, both Authorisation Order as well as Passbook shall be produced before the occupier of an establishment who generates Hazardous and Other Wastes for procurement.

Member Secretary

Seal:

Member Secretary
State Pollution Control Board

Endorsement by the Auctioneer/Seller (Except Column No. 6 & 7)
(See Rule – 6(7 & 8) of Hazardous and Other Wastes
(Management and Transboundary Movement) Rules, 2016)

Sl. No.	Date	Address of the Auctioneer/ Seller	Type & Quantity of Hazardous and Other Wastes sold/ Auctioned	Signature & seal of the Auctioneer/ Seller with date	Date of arrival in the premises of actual user &Challan No.	Balance Quantity (Permitted - Procured till date)	Signature of Actual User
(1)	(2)	(3)	(4)	(5)	(6)	(7)	
15	07-12-2022	Bhubaneswari Coal mining Ltd. Talcher	Barrel/Waste/used oil 20.580 KL	Rajguru			
16	14.12.2022	M/s Rungta Mines Ltd. (Kamanda Steel Plant)	Used oil - 3.6 KL				
17.	13-01-2023	Sarda Mines Pvt. Ltd. Barbil	scrap wased KL Used oil, 9.240 KL 44 Barrel				
18	14-01-2023	JSW Steel Ltd. Jajang Keonjhar. odisha	Used Lub oil 19.964 KL (92 Barrel)				
19.	24-01-2023	TCS. Chandaka Ind. Estate. BBSR. odisha	Used Lub oil 2.3 KL				
20	27-01-23	JSW Steel Ltd Nuagaon Iron ore mines	Used Lub oil 9.114 KL (42 drum)				
21	06-02-2023	JSW Steel Ltd Narayani posi IMN	Used Lub oil 3.906 KL (19 drum)				

OFFICE OF THE PRINCIPAL CCF (WILDLIFE) & CHIEF WILDLIFE WARDEN, ORISSA 5TH FLOOR, B.D.A. APARTMENT, PRAKRUTI BHAWAN, NILAKANTHA NAGAR, BHUBANESWAR- 751012.

Memo No. 6257 Dt. 04. 9. 2010
1WL-C-SSP- 260/2010

The Chief Conservator of Forests (Nodal),
O/o the Principal CCF, Orissa, Bhubaneswar.

Sub: Approval of Site Specific Wildlife Conservation Plan for Iron & Manganese Ore mining in village Koira & Kasira(Narayanposi mines) of Bonai Forest Division in Sundargarh district.

Sir,

I am directed to inform you that the Site Specific Wildlife Conservation Plan for Iron & Manganese Ore mining in village Koira & Kasira (Narayanposi mines) of Bonai Forest Division in Sundargarh district has been approved by PCCF(WL) & Chief Wildlife Warden, Orissa with financial forecast of Rs.288.00 lakhs for the following activities.

1. For activities in project area		Rs.92.00 lakhs.
2. For activities in project impact area.	------	Rs.196.00 lakhs.
	Total	**Rs. 288.00 lakhs**

User Agency will deposit entire amount of Rs.288.00 lakhs with DFO, Bonai Division under CAMPA account for activities to be taken up by the DFO as all the activities both inside the project area and in project impact area are very technical in nature involving habitat management for wildlife. The activities to be executed by DFO, Bonai Division under the guidance of CF, Rourakela.

Conservator of Forests (WL)

Memo No. 6258 dt. 04. 9. 2010

Copy forwarded to the DFO, Bonai Division for information & necessary action with reference to Memo No. 2870 dt. 26.6.10 of CF., Rourakela Circle.

Enc: One approved SS. WL Conservation Plan.

Conservator of Forests (WL)

Memo No. 6259 Dt. 04. 9. 2010

Copy forwarded to CF, Rourkela Circle for information & necessary action with reference to his office Memo No. 2868 dt.26.6.10.

Conservator of Forests (WL)

Memo No. 6260 dt. 04. 9. 2010

Copy forwarded to the Project Proponent for information & necessary action with reference to their letter No.25/PCCF(WL)/10-11 dt. 28.8.10.

Conservator of Forests (WL)

Greenbelt Development

JSW Steel Limited

Regd. Office: JSW Centre
Bandra Kurla Complex,
Bandra (East), Mumbai – 400 051
CIN : L27102MH1994PLC152925
Phone : +91 22 4286 1000
Fax : +91 22 4286 3000
Website : www.jsw.in

NARAYANPOSHI IRON & MANGANESE ORE MINES

SOCIAL ACTIVITIES

At Narayanposi mines, we have appointed two village level coordinators who are constantly interacting with the community and overseeing development activities in six thematic areas: sports, livelihood, rural infrastructure, education, health, and wildlife.

To promote sports in Narayanposi, we have assigned a dedicated football coach to train athletes while also providing regular sports kits.

Our efforts to enhance the livelihoods of the community in the region include promoting skill-based and agriculture-based opportunities. To achieve this, we are providing driver training, AC repair training, and food and beverage training for those seeking skill-based livelihoods. In addition, we have partnered with the well-known organization BAIF to promote both farm and non-farm based livelihoods in the region.

As part of our efforts to improve the living conditions in the area, we have constructed road and installed solar street lights. We are also ensuring access to safe drinking water by continuing to provide water tanker services and installing solar-based bore wells in needy locations. Moreover, we have installed water filters for water purification at public places. Additionally, we are rejuvenating ponds to improve pond life in the region.

To improve the quality of education in the area, we have deployed teachers to schools and are currently developing school infrastructure. In addition, we have partnered with the pioneering organization named Magic Bus Foundation to promote life skills and academic skills for students in grades 6-10.

To improve the health and medical facilities in the area, we have organized health camps at the village level through MBBS doctors and their teams. Additionally, there is a 24-hour dispensary service available in Narayanposi, along with 24-hour ambulance services in the periphery villages. Furthermore, we are working towards developing infrastructure for a CHC hospital at Koida.

To mitigate human-elephant conflict in the region, we have partnered with the WRCS. This partnership aims to minimize casualties on both sides and protect the crops of farmers through strategic interventions.

Regd. Office: JSW Centre
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Website : www.jsw.in

Mrutyunjaya Mahapatra

Mrutyunjaya Mahapatra
(Authorized Signatory)
JSW Steel Ltd

Steel Limited

Regd. Office: JSW Centre
Bandra Kurla Complex,
Bandra (East), Mumbai – 400 051
CIN : L27102MH1994PLC152925
Phone : +91 22 4286 1000
Fax : +91 22 4286 3000
Website : www.jsw.in

ANNEXURE 14

(FORM - O)

(See rule 29F (2) and 29L)
Report of Medical Examination under rule 29B
(To be issued in Triplicate)

Certificate No. 78W | Sushanta

Certified that Shri/Shrimati* Sushanta Bhoi

employed as SR. Engg in Nhagaon mines

Form A No .... has been examined for an Initial / Periodical medical examination. He/she* appears to be 35 years of age. The findings of the examining authority are given in the attached sheet. It is considered that Shri/Shrimati* Sushanta Bhoi

(a)* is medically fit for any employment/graduate/technician apprentice training in mines,

(b)* is suffering from .... and is medically unfit for

(1) any employment in mine : or

(2) any employment below ground : or

(3) any employment or work........

(c)* is suffering from .... and should get this disability* cured-controlled and should be again examined within a period of .... months. He/She will appear for re - examination with the result of test of .... and the opinion of .... Specialist from .... He/She* may be permitted/not* permitted to carry on his duties during this period.

Dr. Arabinda Satpathy
MBBS, DPHK, DIH, DMCH
Retd. CMO, MCL, Burla
Sambalpur
Regd. No. 11605/BCMR/75

Signature of the Examining Authority

Dr ARABINDA SATPATHY

(Name and Designation in Block letters)

Place : Nhagaon

Date : 16.11.22

* Delete whatever is applicable.

** One copy of the certificate shall be handed over to the person concerned and another copy shall be sent to the manager of the mine concerned by registered post : and the third copy shall be retained by the examining authority.

Report of Medical Examination as per the recommendations of National Safety Conferences in Mines

(To be used in continuation with Form O)

Certificate No. 1416
Name : Sushanta Bhoi
Identification Marks : A cut mark on Forehead.

1. Cardio Logical Assessment :

Auscultation	S1	Normal
	S2	"
	Additional Sound	NO
Electrocardiograph (12 leads) findings		Normal / Abnormal

Enclosed ECG yes

2. Neurological Assessment :

Findings	Normal / Abnormal
Superficial Reflexes	Normal
Deep Reflexes	"
Peripheral Circulation	"
Vibrational Syndromes	NO

3. ILO Classification of Chest Radiograph :

	Grade	Types
Profusion of Pneumoconiosis opacities		
Present / Absent		

Enclosed Chest Radiograph

4. Audiometry Findings :

Conduction Type	Left Ear	Right Ear
Ear Conduction	Normal / Abnormal	Normal / Abnormal
Bone Conduction	Normal / Abnormal	Normal / Abnormal

Enclosed Audiometry Report yes

5. Pathological / Microbiological Investigations :

Sl. No.	Tests	Findings
1.	Blood-Tc, Dc, Hb, ESR, Platelets	WNL/Abnormal
2.	Blood Sugar - Fasting & PP	WNL/Abnormal
3.	Lipid Profile	WNL/Abnormal
4.	Blood Urea, Creatinine	WNL/Abnormal
5.	Urine Routine	WNL/Abnormal
6.	Stool Routine	WNL/Abnormal

Enclosed Investigation Reports. yes

6. Special Tests for MN exposure :

Behavioral Disturbances		Present / Not Present
Speech Defect		Present / Not Present
Neurological Disturbances	Tremor	Present / Not Present
	Adiadocokinesia	Present / Not Present
	Emotional Changes	Present / Not Present

7. Any other Special Test Required : NO

Dr. Arabinda Satpati
MBBS, DPHA, DIH, DMCH
Signature of the ...
Sambalpur
Regd. No. 12605/BCMR/75

1

Report of Medical Examination Under Mines Rule 29B
(To be used in continuation with Form 'O')

Certificate No. 1416

Name: Sushanta Bhoi.

Identification Marks: A cut mark on forehead.

Result of Lung Function Test (Spirometry)

Parameters	Predicted Value	Performed Value	% of Predicted
Forced Vital Capacity (FEV)	03.82	03.76	098
Forced Vital Capacity 1 FEVI	03.18	03.31	104
FEVI/FVC	83.25	88.03	106
Peak Expiratory Flow	09.45	08.10	086

Spirometry Report enclosed: yes.

Dr. Arabinda Satpathy
MBBS, DPHA, DIH, DMCH
Retd. CMO, MCL, Burla
Sambalpur
Regd. No. 12605/BCMR/75

Signature of the Examination Authority

By Speed Post/ e-mail

GOVERNMENT OF ODISHA

FOREST, ENVIRONMENT & CLIMATE CHANGE DEPARTMENT

*****

No.FE-DIV-FLD-0067-2022- 17050 /FE&CC, Date 22.09.22

10F (Cons) 135/2015

From

Sri Lingaraj Otta,

OSD-cum-Special Secretary to Government

To

The Principal Chief Conservator of Forests & HoFF, Odisha,

Bhubaneswar.

Sub: Transfer of FC approval granted under the Forest (Conservation) Act, 1980 for mining lease from Old Lessee M/s AMTC (P) Ltd. to New Lessee M/s JSW Steel Ltd. as per the provision of the Mines and Minerals (Development and Regulation) Amendment Act, 2021 in respect of Narayanposhi Iron & Manganese Ore Block under Bonai Forest Division, Koira Tahasil, Sundargarh District for diversion of 244.327 ha of forest land-Compliance of Final approval order regarding.

Sir,

I am directed to invite a reference to your letter No.14351/9F(MG)-29/2022 dtd.21.07.2022, seeking transfer of FC approval granted under the Forest (Conservation) Act, 1980 for mining lease from Old Lessee M/s AMTC (P) Ltd. to New Lessee M/s JSW Steel Ltd. as per the provision of the Mines and Minerals (Development and Regulation) Amendment Act, 2021 in respect of Narayanposhi Iron & Manganese Ore Block under Bonai Forest Division, Koira Tahasil, Sundargarh District for diversion of 244.327 ha of forest land and with reference to letter File No.FC-11/112/2020-FC (Pt) dtd.07.07.2021 of Govt. of India, MoEF&CC, FC Division, New Delhi.

After careful consideration of the proposal of PCCF & HoFF, Odisha and in pursuance of the guidelines issued by Govt. of India, MoEF&CC vide File No. FC-11/112/2020-FC (Pt) Dated 7th July, 2021, the transfer of approval granted by Govt. of India, Ministry of Environment & Forests under Section-2 of the Forest (Conservation) Act, 1980 vide Letter F.No.8-34/2000-FC (Vol-I) dtd.15.11.2007 with additional condition imposed by Govt. of India, MoEF, Eastern Regional Office in their letter No.8(21)3/2000-

d

FCE dtd.12.12.2007 from the erstwhile User Agency M/s AMTC (P) Ltd. to the new lessee M/s JSW Steel Ltd. is hereby accorded by the State Govt. for non-forestry use of 184.59 ha (out of 238.201 ha eligible diverted forest land as per the land scheduled of new Mining Lease) of forest land for mining in Narayanposhi Iron and Manganese Block under Bonai Forest Division, Koira Tahasil, Dist-Sundargarh, Odisha subject to fulfilment of the following conditions.

i. DGPS Survey and demarcation of 184.591 ha part diverted forest area shall be done by the User Agency and the same may be ensured by DFO, Bonai Forest Division in the field before handing over the said area.

ii. The DFO, Bonai Forest Division shall upload the KML files of the area under diversion and the non-forest land for Compensatory Afforestation in the E-Green Watch portal of FSI before handing over forest land to the new lessee.

iii. Old lessee has deposited the NPV over 259.191 ha forest area (as per old mining lease) which includes the NPV of diverted forest area of 244.327 ha. The amount deposited by the new lessee @ Rs.7.50 Lakh per ha is the lumpsum amount realized by State Government on issue of LoI (for the total forest area within the mining lease), which may be adjusted towards balance CA and any compensatory levies payable in future.

iv. The new lessee shall furnish an undertaking to pay the additional NPV, if so determined, as per the decision of the Hon'ble Supreme Court of India.

v. The new lessee shall also comply the non-complied conditions and if any pointed out by the Govt. of India, MoEF&CC, IRO, Bhubaneswar, after conducting the inspection of the area for the appraisal of compliance of approval granted under Forest (Conservation) Act, 1980.

vi. The new lessee, after ceasing mining operation shall undertake re-grassing the mining area and any other areas which may have been disturbed due to their mining activities and restore the land to a condition which is fit for growth of fodder, flora, fauna etc.

vii. Forest Clearance of balance 53.61 ha (238.201 ha – 184.591 ha) diverted forest land will be transferred to the new lessee after providing non-forest CA land and acceptance of CA land by DFO, Bonai Forest Division as per the extant procedure for acceptance of CA land.

viii. The new lessee has to submit the fresh diversion proposal for obtaining approval under Section 2 (ii) of FC Act, 1980 for the balance forest area of 19.25 ha (257.451 ha – 238.201 ha).

ix. Execution of project activities by the new lessee will be subject to availability of all other statutory clearances required under relevant Acts/ Rules for this mining project and compliance of Court's order, if any.

Yours faithfully,

22/9/2022

OSD-cum-Special Secretary to Government

Memo No. 17051 /FE&CC, Date 22.09.22

Copy forwarded to the Assistant Inspector General of Forests (FC), Government of India, Ministry of Environment, Forests & Climate Change (F.C. Division), Indira Paryavaran Bhawan, Aliganj, Jor Bagh Road, New Delhi-110003 for information and necessary action.

Sd/- 22/9/2022

OSD-cum-Special Secretary to Government

Memo No. 17052 /FE&CC, Date 22.09.22

Copy forwarded to the Deputy Director General of Forests (Central), Govt. of India, MoEF&CC, IRO, A/3, Chandrasekharpur, Bhubaneswar for information and necessary action.

Sd/- 22/9/2022

OSD-cum-Special Secretary to Government

Memo No. 17053 /FE&CC, Date 22.09.22

Copy forwarded to the Principal Chief Conservator of Forests (Wildlife) & Chief Wildlife Warden, Odisha/ Chief Conservator of Forests (FD&NO), FC Act, O/o PCCF & HoFF, Odisha for information and necessary action.

Sd/- 22/9/2022

OSD-cum-Special Secretary to Government

Memo No. 17054 /FE&CC, Date 22.09.22

Copy forwarded to the Regional Chief Conservator of Forests, Rourkela Circle/ Divisional Forest Officer, Bonai Forest Division for information and necessary action.

Sd/- 22/9/2022

OSD-cum-Special Secretary to Government

Memo No. 17055 /FE&CC, Date 22.09.22

Copy forwarded to Steel & Mines Department/ R&DM Department/ Director Environment-cum-Special Secretary to Government, FE&CC Department/ Director of Mines, Odisha/ Member Secretary, SPCB, Odisha/ Collector, Sundargarh for information and necessary action.

Sd/- 22/9/2022

OSD-cum-Special Secretary to Government

Memo No. 17056 /FE&CC, Date 22.09.22

Copy forwarded to the Authorized Signatory, M/s JSW Steel Ltd, Plot No.3, Forest Park, Sishu Bhawan Square, Bhubaneswar-751009 for information and necessary action.

Sd/- 22/9/2022

OSD-cum-Special Secretary to Government

Government of India
Ministry of Environment, Forest and Climate Change
(Impact Assessment Division)

PARIVESH

(Pro-Active and Responsive Facilitation by Interactive, and Virtuous Environment Single-Window Hub)

File No. : werw
EC Identification No. EC21A001OR114614
Proposal No. IA/OR/MIN/8345/2008
Date:11/12/2021

ACKNOWLEDGEMENT

This is to acknowledge that JSW STEEL LIMITED has been registered in the PARIVESH Portal in respect of transfer of EC vested with previous lessee under the provisions of S.O 2817 (E) dated 13th July , 2021.

Therefore, the prior Environmental Clearance vested with the previous lessee Aryan Mining & Trading Corporation Pvt Ltd. shall be deemed to have been transferred during its validity period in terms of the Mines and Minerals (Development and Regulation) Act, 1957 (67 of 1957) as amended by the Mines and Minerals (Development and Regulation) Amendment Act, 2021 (16 of 2021) to the successful bidder of the mining leases (JSW STEEL LIMITED), from the date of commencement of new lease for the remaining validity period (Up to 17/06/2049), subject to comply with all the terms and conditions of the Environmental Clearance granted to previous lessee including non-compliance of EC conditions by the previous lessee, if any,

However, if on verification the Ministry or IRO or SPCB or UTPCC, holds that the information submitted found to be false or misleading at any stage, the transfer of EC shall stand revoked.

Remarks by Member Secretary :- werwef

Report URL is Enclosed below :

http://environmentclearance.nic.in/user/MineLease_FormReport.aspx?pid=155788&status=1

Date: 11/12/2021

(e-signed)
Pankaj Verma
Member Secretary
IA - (Non-Coal Mining sector)

Signature Not Verified
Digitally signed by Pankaj Verma
Director
Date: 12/11/2021 2:14:16 PM

JSW Steel Limited
Regd. Office: JSW Centre
Bandra Kurla Complex,
Bandra (East), Mumbai – 400 051
CIN : L27102MH1994PLC152925
Phone : +91 22 4286 1000
Fax : +91 22 4286 3000
Website : www.jsw.in

O/C

No. JSW/S/O/2021/94

Date: 08/04/2021

To,
The Member Secretary
State Pollution Control Board, Odisha,
Paribesh Bhawan, A/118, Nilakantha Nagar, Unit-8,
BHUBANESWAR- 751012

Sub: - Request to provide updated or create new CAAQMS Credentials details in the OSPCB, Portal for compliance of CTO Special Condition S. No. 19 & 33 dated 31.03.2021 for **Narayanposhi Iron & Manganese Ore Mine of M/s JSW Steel Ltd.**

Ref: - Consent Order No 2944 vide letter no 5453/IND-I-CON-2258 dated 31.03.2021.

Dear Sir,

With reference to aforesaid subject, we would like to submit that we have installed Three Continuous Ambient Air Quality Monitoring Stations (CAAQMS) and Digital Display Board in consultation with Regional Officer, Rourkela in Narayanposhi Iron & Manganese Ore Mine of M/s JSW Steel Ltd for compliance of CTO Special Condition S. No. 19 & 33. The Locations of the installed CAAQMS and digital display board are as below-

CAAQMS 1. Narayanposi_Mines_Office_AAQMS_01
CAAQMS 2. Narayanposhi_Gate_no_1_AAQMS_02
CAAQMS 3. Narayanposi_Gate_No._2 (New_BabaMath)_AAQMS_03
Digital Display Board- Near Gate No. 6 area

The above three CAAQMS are equipped with data transfer facility to SPCB and we have authorized Phoenix Robotix Pvt. Ltd. (Datoms) for transmitting data to OSPCB and already completed the necessary setup for data transfer from all 3 locations to OSPCB Server. However, the credentials available are in the name of erstwhile lessee i.e. Aryan Mining & Trading Company Ltd.

In view of the above, we humbly request you to **please provide the updated or create new credentials details (like site ID, station name, AES Encryption key, site private key, site public key, server public key etc) of Narayanposhi Iron & Manganese Ore Mine in the name of M/s JSW Steel Ltd** for all three CAAQMS in OSPCB portal for compliance of CTO Special Condition S. No. 19.

Seeking your co-operation as always.

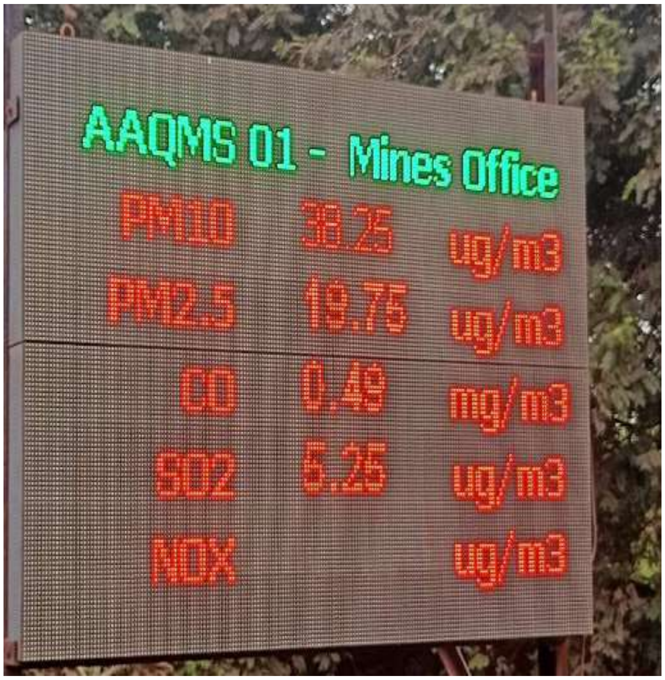
Thanking you,
Yours Faithfully
For JSW Steel Ltd

Baswaraj M Dalgade
(Authorized Signatory)
Encl: As above

Received 9/4/2021

09 APR 2021
S.P.C. BOARD
BHUBANESWAR

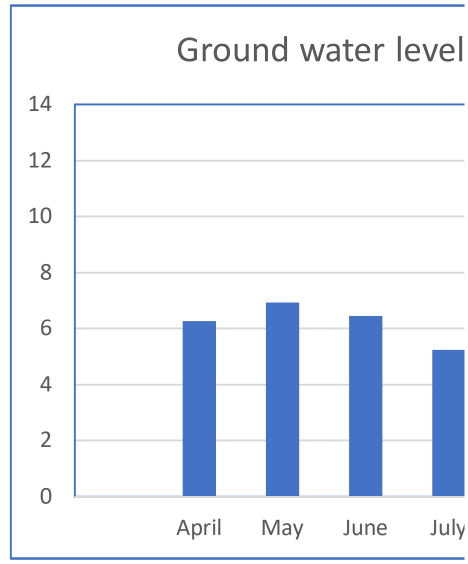
Copy to- The Regional Officer, Regional Office, Rourkela, Office of the State Pollution Control Board, Rourkela Town Engineering Office Premises, Sector – 5, Rourkela – 769 002, Odisha


AAQMS 01 - Mines Office
PM10 38.25 ug/m3
PM2.5 19.75 ug/m3
CO 0.49 mg/m3
SO2 5.25 ug/m3
NOX ug/m3

Bar Graph for Ground water level in the nearby villages of Narayanposhi Mines

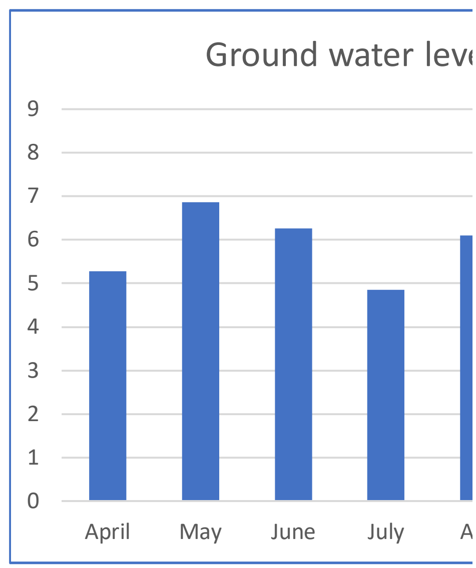
Village 1 Kashira Village

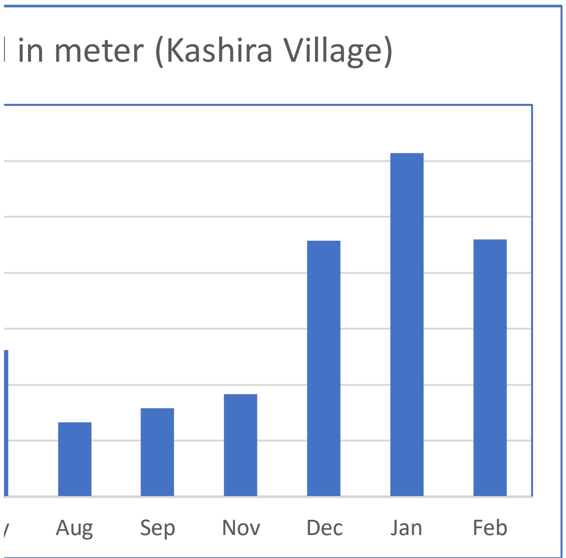
Month	Ground water level in meter (Kashira Village)
April	6.25
May	6.92
June	6.44
July	5.23
Aug	2.64
Sep	3.15
Nov	3.65
Dec	9.14
Jan	12.27
Feb	9.18

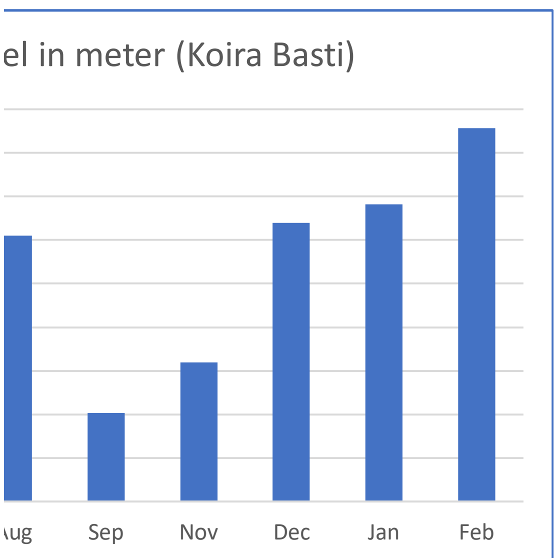


Village 2 Koira Basti

Month	Ground water level in meter (Koira Basti)
April	5.27
May	6.85
June	6.25
July	4.84
Aug	6.1
Sep	2.02
Nov	3.19
Dec	6.39
Jan	6.81
Feb	8.56




l in meter (Kashira Village)
Aug
Sep
Nov
Dec
Jan
Feb


el in meter (Koira Basti)
Sep
Nov
Dec
Jan
Feb

DateTime	WATER LEVEL (mWC)
12/1/2020 9:00	-13.55
12/1/2020 21:00	-13.45
12/2/2020 9:00	-13.55
12/2/2020 21:00	-13.45
12/3/2020 9:00	-13.55
12/3/2020 21:00	-13.45
12/4/2020 9:00	-13.55
12/4/2020 21:00	-13.45
12/5/2020 9:00	-13.56
12/5/2020 21:00	-13.46
12/6/2020 9:00	-13.56
12/6/2020 21:00	-13.46
12/7/2020 9:00	-13.56
12/7/2020 21:00	-13.46
12/8/2020 9:00	-13.56
12/8/2020 21:00	-13.46
12/9/2020 9:00	-13.57
12/9/2020 21:00	-13.47
12/10/2020 9:00	-13.57
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12/20/2020 9:00	-13.57
##############	-13.47
12/21/2020 9:00	-13.57
##############	-13.52
12/22/2020 9:00	-13.6
##############	-13.58

12/23/2020 9:00	-13.61
##############	-13.6
12/24/2020 9:00	-13.62
##############	-13.82
12/25/2020 9:00	-13.92
##############	-13.59
12/26/2020 9:00	-13.69
##############	-13.64
12/27/2020 9:00	-13.72
##############	-13.7
12/28/2020 9:00	-13.73
##############	-13.72
12/29/2020 9:00	-13.74
##############	-13.94
12/30/2020 9:00	-13.79
##############	-13.57
12/31/2020 9:00	-13.67
##############	-13.62
1/1/2021 9:00	-13.7
1/1/2021 21:00	-13.68
1/2/2021 9:00	-13.71
1/2/2021 21:00	-13.7
1/3/2021 9:00	-13.72
1/3/2021 21:00	-13.92
1/4/2021 9:00	-14.02
1/4/2021 21:00	-13.69
1/5/2021 9:00	-13.79
1/5/2021 21:00	-13.74
1/6/2021 9:00	-13.82
1/6/2021 21:00	-13.8
1/7/2021 9:00	-13.83
1/7/2021 21:00	-13.82
1/8/2021 9:00	-13.84
1/8/2021 21:00	-14.04
1/9/2021 9:00	-13.89
1/9/2021 21:00	-13.68
1/10/2021 9:00	-13.78
1/10/2021 21:00	-13.73
1/11/2021 9:00	-13.81
1/11/2021 21:00	-13.79
1/12/2021 9:00	-13.82
1/12/2021 21:00	-13.81
1/13/2021 9:00	-13.83
1/13/2021 21:00	-14.03
1/14/2021 9:00	-14.13
1/14/2021 21:00	-13.8
1/15/2021 9:00	-13.9

1/15/2021 21:00	-13.85
1/16/2021 9:00	-13.93
1/16/2021 21:00	-13.91
1/17/2021 9:00	-13.94
1/17/2021 21:00	-13.93
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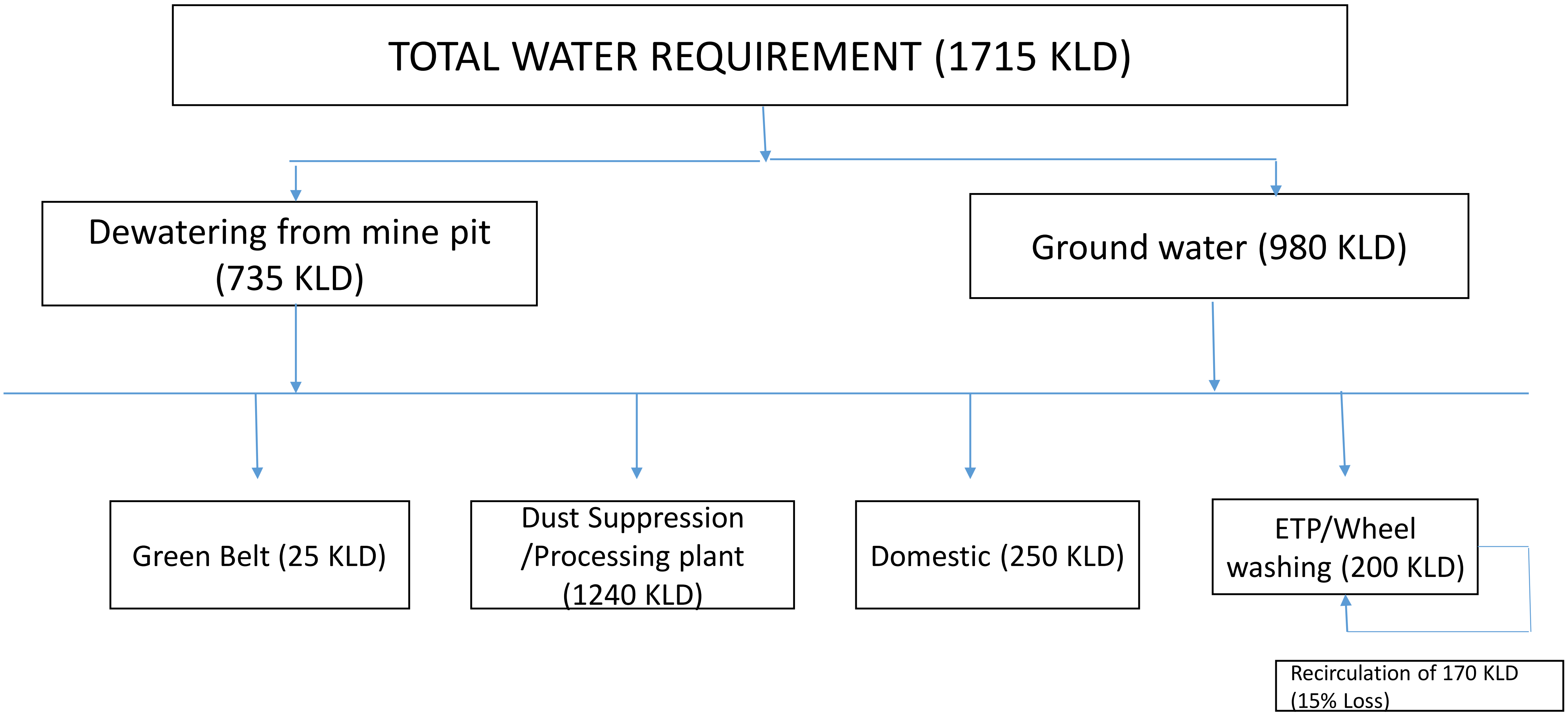
WATER BALANCE DIAGRAM
NARAYANPOSHI IRON & Mn ORE MINES



Investigation

On

Slope Stability Study – JSW Narayanposhi Iron Ore Mines

Work order no. Odisha Mines/118402/SER/4500141067 **date.** 16-04-2022

(Source: https://earth.google.com/web)

Dept. of Mining Engineering
National Institute of Technology, Rourkela

March 2023

1.0 Introduction

Surface mining operation is major and popular process to excavate earth materials. Though this approach is relatively simple and fast, yet it often endangers the men and machines, and thus its economics, unless scientifically planned. Bench mining or slope system is a major part of the surface excavation system. Correct slope design and its stability has been a major challenge to mine operation. The slope design involves knowledge of geotechnical parameters, geological influences, correct slope height, slope angle and overall angle. Government regulation also warrants carrying out slope design as a part of statutory requirement.

1.1 Brief Description of the Project

NIT Rourkela received a work order vide purchase order no Odisha Mines/118402/SER/4500141067 dated 16-04-2022 from JSW Steel Ltd., Barbil, Odisha for scientific study of the stability of pit slope and dump slope in iron ore mines in Odisha. This is an assignment that originated in 01-09-2020 from JSW Steel, Delhi. NIT Rourkela accepted the order on 2nd June, 2022 and initiated investigation. As a part of the investigation, the team initiated the investigation in June-2022 and made many visits to the mine. It discussed with mine officials, inspected the area, carried out geological study, identified a few sample location of the iron ore deposit at the Narayanposhi Iron Ore region.

1.2 Scope of work

The aim of the investigation was to carry out scientific study of the stability of pit slope and dump slope in iron ore mines in Odisha, JSW Steel Ltd., Barbil, Odisha. The scope of work as outlined in the work order was.

i. To undertake the study of slope stability to arrive ultimate pit slope and dump slope for long term safety.
ii. Suggest methods for dump slope monitoring.
iii. Suggest best practices for slope maintenance and its stabilization.
iv. Optimization of dump slope parameters for capacity maximization.
v. Recommendation for following, considering geotechnical characteristics of deposit:
    a) Slope angle for working and final pit
    b) Dump design parameters (Dump height and slope; bench height and slope angle)
    c) Monitoring method of PIT and dump slope stability

1.2.1 Background of the problem

The concerned mine belonging to JSW Steel Limited is a Category – A (fully mechanized category) mine and is worked by opencast mining method with formation of benches by drilling and blasting. It results in higher rates of recovery from the mine with an increased percentage of iron ore recovery, thereby improving productivity and sales. The analysis investigation of the prevalent geo-mining conditions of the mine, collection of pertinent geotechnical data, and their influence. Thereafter, a suitable rock mass classification system was adopted to classify the rock based on its physical properties followed by reducing the strengths of the material cover present at the site by their visible characteristics following scientific approaches and lastly, numerical modelling was adopted to simulate the models of failure in determining safety factors.

1.3 Geology of the area

Narayanposhi Iron and Manganese Ore Mine are in the southern end of the western limb of the Horse-shoe shaped Iron Ore Range of West Singhbhum-Keonjhar-Sundargarh district of Jharkhand & Odisha. The rock types found within the leasehold belong to Banded Iron Formation of Koira Group. The main litho units mapped in this area are laterite, Banded Hematite Jasper, shale of different nature and cherty phyllite. Alluvium occupies especially the low-lying areas. This is a meta-sedimentary deposit of Bonaisynclinorium.

1.3.1 Geological Setting

Based on the field studies, the stratigraphic sequence of different litho assemblages of the area is interpreted as follows:

	Soil & Alluvium
	Float ore (with Laterite/Conga ore)
Iron Ore Group	Ferruginous laterite
	Manganiferous shale with Mn-ore
	In-situ Iron Ore (with float at places)

Soil & Alluvium: Traverses along and across the leasehold, however, show that alluvial soil covers a sizeable portion of the area. The alluvium occupies especially the low lying area. These areas are appeared to be barren where village site and low yielding agricultural fields are seen.

Ferruginous Laterite: Ferruginous laterites occur as intermediate waste and capping at places on the in-situ Iron ore horizons having Fe content or less than 55% and contain both hematite and goethite.

Float Iron Ore: The float iron ore zones may be considered of two types. The ores are mostly of massive type with big lumps and occur along with lateritic horizons. Float zone continues up to 5-7 m from surface level which is seen in quarry 5 & 6. The second variety of float ore over (+) 10 to (-)40mm size with laterite, which is observed in Quarry-1.

Conga Zone: In the north eastern corner and western part of the area, conga zones are exposed consisting of boulders, cobbles and pebbles of iron ores re-cemented by lateritic materials. These materials are seen in and around Quarry-4 (old) & Quarry-5.

In-situ Iron Ore: Below the float ore zone, in-situ ore exists and proved up to a depth of 60m from surface level. Because of its boulder nature, it is sometimes mistaken as float ore. An in-situ ore zone is delineated covering all in-situ ore working quarries like Q-1, 3, 4, 7 etc. However, on the basis of depth persistence, in-situ ore zone is delineated around the Q-1, 2, 3, 4, 6 & 7.

Manganiferous Shale: Most of the workable manganese ore deposits occur within this formation. The shale is mostly ferruginous, grey, pink in colour with white streaks. These coloured members do not occur in conspicuous band rather than they are highly mixed up. Manganese bodies usually occur on the crest of the domes in the variegated shale formed due to the superposed folding.

1.3.2 Structure (Dip and Strike)

The litho units of BIF usually trend in a NE-SW to NNE-SSW direction with westerly dips varying from 20˚ to 70˚.

1.4 Mining Methodology

The mine is operated by the opencast fully mechanized method. There are 2 major well-developed mechanized iron-ore and manganese quarries as Quarry-3 &4 and RF Quarry. In all quarries, bench height is maintained up to 9 m and width up to 12 m, adhering to the MMR-2016 guidelines. During the proposed period of mining operation, excavation for iron ore is done in both of the quarries. Production capacity per annum of the mine is envisaged as 6 million tons per year from the in-situ reserve.

Drilling was carried out using 115mm diameter drills with 10% subgrade drilling to avoid toe formation. Blasting was by SME (Site Mixed Emulsion Explosives) and accessories (NONEL) manufactured and supplied by Solar Industries India Ltd., Nagpur, Maharashtra. Its VOD ranges from 4000±500 m/sec, and the final density ranges from 1.15±0.005 g/cc. The mines used 17 and 25 milliseconds for the Trunk-Line-Delay and 250 milliseconds for the Down-The-Hole delay. Series pattern was adopted to reduce the maximum charge per delay. Controlled blasting along with a shock tube initiation system/NONEL system was practiced to get optimum blast results and minimize hazards. Boulders generated during the course of blasting are broken into smaller pieces by mainly using a rock breaker. The design parameters of the mine are in table 1.

Table1. Design Features

Sl. No.	Salient Feature	Description
1	Method of Mining	Fully mechanized
2	Production	6 Mt/yr Iron ore (ROM)
3	Means of Raising	Drilling, blasting, excavation, processing, etc
4	Bench Height	upto 9 m
5	Bench Width	12 m
6	Bench Angle	85^0
7	Overall Slope	33^0
8	Transportation of ore to the stacking yard	Through dumpers and tippers
9	Blasting Proposal	Deep hole blasting is carried out to dislodge the boulders

1.5 Safety Factor Analysis

The stability of rock slopes depend on behaviour of the shear strength created along the sliding surfaces. In general rock or rock material, is assumed to follow the Mohr Coulomb criteria and the strength is expressed in terms of cohesion ‘c’ and friction angle $'\emptyset'$ and is expressed mathematically as $\tau = c + \sigma' tan\emptyset$ [τ = shear strength, c = cohesion, σ' = effective normal stress, and ∅ = friction angle]

The effective normal stress is the difference between the stress due to the weight of the rock lying above the sliding plane and the uplift due to any water pressure acting on this surface.

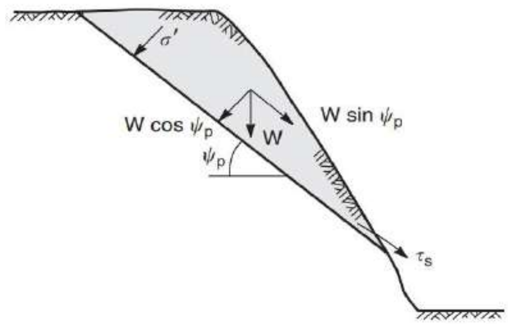


Figure II. Slope Block Analysis[12]

The stability of the block can be quantified by the ratio of the resisting and driving forces, which is termed the factor of safety (FOS). And is given by

$$FOS = \frac{\text{Resisting Forces}}{\text{Driving Forces}}, or$$

$$FOS = \frac{cA + W\cos\psi_p \tan\emptyset}{W\sin\psi_p}$$

The resisting strength is more than the displacing stress for stability of the slope.. The FOS equation at equilibrium is

$FOS = \frac{\cos\psi_p \tan\emptyset}{\sin\psi_p}$ or, $FOS = 1$ When $\psi_p = \emptyset$

It shows that when there are no in-filling materials, the block of rock will slide when the dip angle of the sliding surface equals the friction angle of this surface, and the stability is independent of the size of the sliding block. The block is at a condition of "limiting equilibrium" when the driving forces are exactly equal to the resisting forces and the factor of safety is equal to 1.0. Therefore, the method of slope stability analysis is termed limit equilibrium analysis. For the investigation of stability of the existing slopes, the minimum factor of safety is from 1.3 to 1.5 [3]

The Limit Equilibrium Method (LEM) is a well-known computational methodology for evaluating the Factor of Safety (FOS) and stability degree of slopes (Duncan, 1996, Krahn 2003). Limit equilibrium is the method where limit state conditions are assumed. The limited equilibrium methods (LEMs) are popular to assess the slope stability of mine geological sections.

In this slope stability investigation project, a dedicated software for LEM code Slide2D (RocScience Inc., Canada) used. Slide 2 is a two-dimensional limit equilibrium slope stability analysis program for evaluating the probability of failure of geological transverse and geological sections by identifying circular or non-circular failure-prone surfaces in soil or rock slopes. It analyzes the stability of slip surfaces using vertical slice or non-vertical slice limit equilibrium methods. This code has extensive probabilistic analysis capabilities that can be utilized to assign statistical distributions to almost any input parameters, including material properties, support properties, loads, and water table location. The probability of failure/reliability index is determined, providing a measure of the risk factor associated with a slope design.

The evaluation needs geotechnical data that were obtained from laboratory testing through the samples supplied.

1.6 Geotechnical Investigation

For a planned excavation or for an engineered earth-system design, the most important consideration is the reaction of the rocks to the changes in stresses due to the proposed excavation provided that the resultant strain is within the tolerable limit of the engineering design. Typically, the behavior of rocks is determined from unbroken rock pieces, i.e., intact rock or rock core through rocks are heterogenous, anisotropic and inelastic. The geotechnical investigation of core specimen includes the laboratory determination of the pertinent parameters.

1.6.1 Location of sample collection points

Slope stability analysis involves understanding and dealing with the behavior of earth materials at specific locations e.g. face, bench, strata, etc. The behavior of materials are scientifically represented by its geotechnical properties as cohesion, density, angle of internal friction, compressive strength, etc. it needs sample collection and testing by established processes.

The locations of samples were collected were carefully chosen depending upon site characteristics. It was made sure that the samples were collected from the bench faces. Fresh samples were collected freshly exposed as so after blasting. The information from the result of any test depends on the health of the sample or specimen tested for the purpose. In this investigation samples for various parameters have been prepared from the samples collected. In absence of regular core logs, boulders of adequate sizes of about 900cm^3 each were collected and transported to the laboratory. NX core samples were prepared from those boulders. Soft material as alluvium, laterite and ochre were collected in air tight bags and processed for shear testing. The following sections discuss the procedure adopted for testing. The test specimens were obtained by cutting the core samples perpendicular to the cylindrical axis with the help of a rock cutting machine fitted (make: AIM 202, AIMIL, India). The length to diameter ratio was kept between 2.0 to 2.5 for the samples for determination of Compressive Strength and at 0.5 for tensile Strength. The loading surfaces of the test specimen were made flat within ± 0.01mm.The following photographs are provided below.

Figure III. Sample collection

1.6.2 Testing Procedures:

The determination of different physical and mechanical properties were carried out by IS guidelines as mentioned against each type of test and described below.

a. Density	IS: 13030-1991 (Reaffirmed 1996)
b. Compressive Strength	IS: 9143-1979 (Reaffirmed 1996)
c. Triaxial Strength	IS: 13047-1991 (Reaffirmed 2001)

d. Shear Strength IS: 2720-part13-1986 (Reaffirmed 2002)

Figure IV. Coring operation and cored specimen

1.6.2.1 Density

Density reflects the information about the mineralogical or grain constituents. For determination of density Indian Standard 13030:1991 has been followed. Each specimen was machined to conform closely to the geometry of a right cylinder. The mass of each specimen was typically more than 600g. Each sample was put in an oven maintained at a temperature of $105^0 \pm 3^0$C for 24 hours. The samples were removed from the oven after 24 hrs and placed in desiccators for cooling. Each sample was brushed to remove loose material sticking to it. The external dimension of each specimen was determined using a digital caliper (make: Mitutoyo, Japan) with an accuracy of 0.01mm. Average of three readings each for the length and diameter were taken for calculation of volume (V). The mass (M) of each specimen was determined using a digital balance (make: Contech, India) with an accuracy of 0.001g. The density (ρ) was determined using the formula $\rho = M/V$ where M and V are Mass and volume of the sample respectively.

1.6.2.2 Uniaxial Compressive Strength

In most of the engineering design the compressive strength (UCS) of rock is one of the most important input parameter. It reflects the ultimate bearing capacity before the rock fails i.e. the total loss of integrity in the sample. The compressive strength of the test specimen was determined following IS:9143-1979. The selected specimen of length to diameter ratio between 2 to 2.5 was wiped clean and the dimensions were measured with the help a digital caliper. The measurement of diameter was carried out by taking the average of four reading obtained at about upper height, two mid-heights and lower height. The cross-sectional area was calculated from this measurement.

Figure V. Determining UCS of rock sample

The surfaces of the two bearing discs and the test specimen were wiped clean. The specimen was placed between the two platens. The upper disc was then gradually lowered onto the specimen. Care was taken to see that the axis of the specimen was properly aligned with the discs. The loading machine was operated at a stress level, typically between 0.5 to 1 MPa/sec so that the sample fails within 8 to 12 minutes of test. Load was then continuously applied at a constant rate till failure occurred and the maximum load on the specimen was recorded. The compressive strength is determined from the relation as given by the equation $\sigma_c = \frac{F}{A}$ where

σ_c is UCS; F is Failure load; and A is the cross sectional area of the sample

1.6.2.3 Triaxial Compression Test

Rock exhibits higher bearing capacity when the same is confined. The failure load varies with confinement pressure. Triaxial compression refers to a test with simultaneous compression of a rock sample and application of axisymmetric confining pressure. The triaxial Compressive Strength of rock samples was determined following IS 13047:1991. The result shows the cohesion and friction angle. The test sample was wiped clean and its diameter was measured at upper, two-mid and lower heights respectively. The average value was used to calculate the cross sectional area of the test sample. The sample was then put in the triaxial cell (make: AIMIL, India).

Fig VI: Triaxial Setup and Fractured Sample

The specimen, the platens and the spherical seat were accurately aligned to ensure that they are coaxial with others. The cell was then filled up with hydraulic oil, allowing the air to escape through an air bleeder valve. The air bleeder valve was then closed. The cell was then placed into the axial loading device. The axial load and the confining pressure were increased simultaneously in such a way that axial stress and confining pressure were approximately equal and until the predetermined test level for the confining pressure reached. The axial load was then increased continuously without shock to produce an approximately constant rate of load for deformation. The maximum axial load and the corresponding confining pressure were recorded. Then the confining pressure and corresponding longitudinal failure strength were plotted in the same scale to plot Mohr analysis for the determination of cohesion and angle of internal friction. The lateral confinement was provided between 0.0 and 3.92 MPa.

1.6.2.4 Shear Strength Test

The top layers of the strata consist of different varieties of soil as yellow, yellow loamy, brown, of varying grain sizes, etc. The parameters that would govern its engineering behaviour are cohesion and the angle of internal friction apart from the unit weight. Those are typically determined from the direct shear strength test. The test involves applying horizontal load on the soil specimen so as to undergo sharing with a constant the vertical normal load. The relationship between normal stress and shear stress at failure provide the shear strength parameters (cohesion and internal friction angle). The specimen and testing of shear strength parameters was carried out as per IS:2720 (Part # 13, 1986 (Reaffirmed 2002)).

Fig VII: Direct Shear test

The joint in rock cores didn’t exhibit any regular pattern, thickness, and presence. Hence the shear strength tests of the rock cores have not been performed to know the characteristics of joint filling material.

1.6.2.5 Test Results:

The results of the different tests carried out on the rock cores are reported in following pages. Density values represent the average values of the particular rock type. The photographs of testing arrangement, some typical failure profiles obtained during the testing have been given in figures below for the rock in compression, tensile, shear, and triaxial testing.

1.6.3 Rock Mass Classification

Cylindrical rock cores or samples of intact rocks are tested in the laboratory to determine their properties. However, such experimentations only reveal the strength of the intact rock masses and the data exhibited in the field often do not confirm to that in the laboratory tests. This is mainly due to the presence of discontinuities that causes instability to the rocks in the form of planes of weaknesses. One such approach by which the strengths of the rocks are reduced by visibly observing the discontinuities present in them is the Geological Strength Index (GSI), wherein the strength parameters of the rocks are considerably reduced to confirm to that of the rock masses exhibited in the field.

1.6.4 GEOLOGICAL STRENGTH INDEX (GSI)

A new rock mass classification scheme was introduced by Hoek and Brown (1997) based on visual observations of geological conditions making it simple, fast and reliable. It is called the Geological Strength Index (GSI). It reflects the property of a discontinuous or jointed rock mass which influences its strength and deformability. GSI considers the shapes of contact rock pieces as represented by its boundaries and degree of interlocking as well as the conditions on the surface separating those. The surface conditions vary from very good to very poor with GSI values between 100 and 0 respectively. The interlocking blocks vary between intact or massive to laminated or sheared (*Figure VIII*).

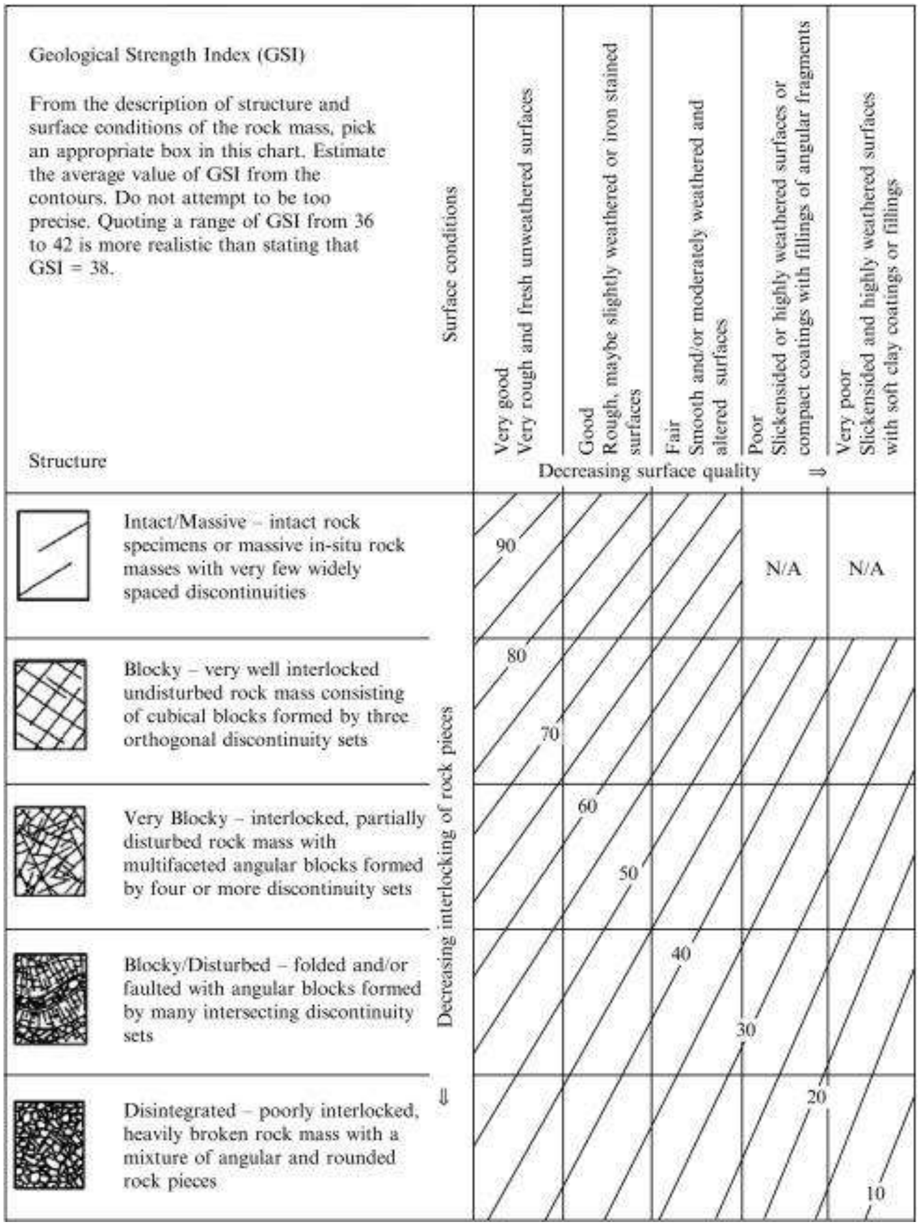


Fig. VI: The Geological Strength Index (GSI) chart used for rock mass

1.7 Slope Design, Modelling and Boundary Conditions

The shear strength of the rock mass including that of the joints and discontinuities typically influence stability of slopes. The determination of the rock behavior subjected to deformation including that of the joint and joint filling materials is a complex phenomenon. Hence, those are determined indirectly involving both laboratory data and test data. A number of such approaches exist for the determination of slope stability, however, intact rock criteria, Mohr-Coulomb (MC) and Hoek-Brown are the most popular approaches that are evaluated here. MC considers a linear relationship between shear strength and gravitational loading whereas HB considers a non-linear relationship. A few of those approaches for slope design are discussed below are used to find the shear strength as cohesion ‘c’ and angle of internal friction ‘φ’.

I. Mohr-Coulomb Approach:

It used the intact rock strength parameters i.e., cohesion and friction angle to find the factor of safety. It overestimates the rock mass strength or behavior in field conditions.

II. Generalized Hoek-Brown Approach:

It considers rock mass parameters like mineralogy, composition, grain size influence, degree of fracture, site influence, disturbance expected due to blasting and stress relief as well as visual observation data. The following are some of the empirical equations used to predict the rock mass parameters:

$$m_b = m_i \exp\left(\frac{GSI - 100}{28 - 14D}\right)$$

$$s = \exp\left(\frac{GSI - 100}{9 - 3D}\right)$$

$$a = \frac{1}{2} + \frac{1}{6}\left(e^{-\frac{GSI}{15}} - e^{-\frac{20}{3}}\right)$$

$$\sigma_{cm} = \frac{2c' cos\varphi'}{1 - sin\varphi'}$$

$$\sigma_{tm} = \frac{2c' cos\varphi'}{1 + sin\varphi'}$$

$$\sigma_{tm} = -\frac{s.\sigma_{ci}}{m_m}$$

Where, σ_{cm}, σ_{tm}, σ_{ci}, c' and φ' are uniaxial compressive strength of rock mass, tensile strength of rock mass, uniaxial compressive strength of intact rock, cohesion and angle of internal friction of rock mass respectively. The other parameter D is a factor for near surface blast damage and stress reduction, m_m, and $m_i$are Hoek and Brown parameter for rock mass and intact rock respectively depending on mineralogy, composition and grain size influence, s is a rock mass characteristic, i.e., how fractured the rock mass is with typical values in the range of 0.001 to 1 and a is a site constant for quality of rock, about 0.5. in this investigation. The surface mine would require blasting for excavation process. Therefore the value of D is considered to be 1 for such conditions where production blasting is carried out, and 0.7 where the rock mass can be extracted by mechanical excavations. The compressive and tensile strength values exhibited at the field are much less than that obtained in the laboratory testing. The effective uniaxial compressive strength value of the rock mass is determined from the empirical equation proposed by Marinos and Hoek (2001) as below:

$$\sigma_{cm} = 0.0034 m_i^{0.8} \sigma_{ci} (1.029 + 0.025 e^{-0.1 m_i})^{GSI}$$

III. Mohr-Coulomb Rock Mass Parameter Approach:

Mohr-Coulomb approach is quite popular and the various rock mass parameters such as cohesion, c' and angle of internal friction, φ' have been developed from the Hoek-Brown approach using the following relations (Hoek et al, 2002).

$$sin\varphi' = \frac{6am_m(s + m_m\sigma'_{3n})^{a-1}}{2(1+a)(2+a) + 6am_m(s + m_m\sigma'_{3n})^{a-1}}$$

$$\frac{c'}{\sigma_{ci}} = \frac{[(1+2a)s + (1-a)m_m\sigma'_{3n}](s + m_m\sigma'_{3n})^{a-1}}{(1+a)(2+a)\sqrt{\frac{1 + \left(6am_m\left(s + m_m{\sigma'_{3n}}^{a-1}\right)\right)}{(1+a)(2+a)}}}$$

$$\sigma'_{3n} = \sigma'_{3,\max}/\sigma'_{ci}$$

Where, $\sigma'_{3,\max}$ is maximum value of lateral stress. It is related to slope height H and unit weight γ of the rocks. The effective maximum lateral stress of the rock is given by the relation as below:

$$\frac{\sigma'_{3,\max}}{\sigma'_{cm}} = 0.72\left(\frac{\sigma'_{cm}}{\gamma H}\right)^{-0.91}$$

The design has considered the average values of the geotechnical parameters as determined from various approaches each with respective factor of safety with the application of gravitational force on the models created for analysis. The failure plane has been analyzed for wide variations in its locations and safety factors associated with the most critical plane is determined.

1.8 Failure consideration of the Ore Body slope

Slope failures in surface operations involving hard rocks primarily depend on the characteristics of the rocks and the behavior of the geological features as well as the interaction between the geology and the rock characteristics. Soil or heavily fractured earth materials typically fail by circular failure whereas rock geometry fails by circular failures if there is any intrusion of weak layers incorporated into the rock mass or typically rock geometry fails by plane, wedge or toppling modes. The stability of the slope is generally controlled by the shear strength parameters along with others. Stability analysis typically follows the limit equilibrium method. In limit equilibrium method, failure or sliding occurs when a limit equilibrium condition is reached i.e., when the resisting forces balance the driving forces such that any disturbances in the balance between them causes the slope to undergo failure. These design methods are widely accepted and are also commonly used and enable moderation of the slope performances with the variations in the parameters involved in slope design. The primary idea behind the limit equilibrium approach is to determine a state of stress along the surface which is likely to fail such that the free body, along with the slip surface and the free ground surface remains in static equilibrium. The state of stress is then compared with the available strength, which is the stress required to cause failure along the slip surface.

Thus, the analysis involves determination of the factor of safety against sliding for an unstable block of rock mass, represented by, FOS = F_r/ $F_{s,}$ where F_r is the total resisting force available against sliding and F_s is the driving force that induces the sliding. The analysis involves developing the model, assigning rock properties, specifying the boundary conditions followed by analyzing the whole of slope geometry to determine the location that would exhibit the lowest factor of safety.

1.8 Metal Mines Regulations, 2019(reproduced verbatim)

The Metal Mines Regulations (MMR) as prescribed by the Directorate General of Mines Safety (DGMS) lays the following guidelines in Section 116 and 118 in accordance to the stability of slopes those are reproduced verbatim below.

116. Mechanised Opencast working:

(1) The height of the benches in overburden consisting of alluvium soil, morum, gravel, clay, debris, soft ore body or other similar ground shall not exceed three meters and the width thereof shall not be less than three times the height of the bench or three times the width of the dumper if dumpers ply on the bench or as determined by the scientific study, whichever is more.

(2) The height of the benches in hard and compact ore body and overburden of rock formation other than that mentioned in sub-regulation (4) shall not be more than the digging height or reach of the excavation machine in use for digging, excavation or removal, and the width thereof shall not be less than -

(a) The width of the widest machine plying on the bench plus two meters; or

(b) If dumpers ply on the bench, three times the width of the dumper; or

(c) The height of the bench; or

(d) As determined by the scientific study whichever is more.

118. Spoil-banks and dumps.

(1) While removing overburden, the top soil shall be stacked at a separate place, so that, the same is used to cover the reclaimed area.

(2) The slope of a spoil bank shall be determined by the natural angle of repose of the material being deposited but, in any case, shall not exceed 37.5 degrees from the horizontal or an angle in excess of natural angle of repose or as determined by the scientific study, whichever is less and such spoil bank shall not be retained by artificial means: Provided that where in any mine, a steeper slope of a spoil bank in excess of 37.5 degrees or natural angle of repose has been recommended as a result of a scientific study by any scientific agency or institution, having expertise in slope stability, the Regional Inspector may, by an order in writing and subject to such conditions as he may specify therein, permit a steeper slope of the spoil bank.

(4) Any spoil bank exceeding 30m in height shall be benched so that no bench exceeds 30m in height and the overall slope shall not exceed 1 vertical to 1.5 horizontal: Provided that, the Regional Inspector may, by an order in writing and subject to such conditions as he may specify therein, restrict height and overall slope of the spoil bank.

(5) The toe of a spoil bank shall not extend to any point within a distance equal to height of the spoil bank from a mine opening, railway or other public works, public road or other permanent structure not belonging to the owner: Provided that, the Regional Inspector may, by an order in writing and subject to such conditions as he may specify therein, may increase the distance in variance of the above.

1.8.2 Safety Analysis of Slope Profiles

The geological transverse sections for Narayanposhi provided by JSW Steel Limited have been considered and those slope profiles were analysed. Each material present have been assigned suitable strength characteristics as obtained from laboratory testing and field observations and the factor of critical safety value is computed. A number of such sections have been analysed that are represented below. Ground water table is present well below the slope forming materials and hence is assumed to have no effect on the stability of the slopes that have been considered for stability analysis.

For Rock samples, the cores were used to determine its representative UCS values and for the loose rock mass the samples, their cohesion and internal friction were calculated by direct shear test. However these values are much higher and it’s not a reliable demonstration of the field condition. Therefore the GSI value is incorporated in the determination of cohesion and friction angle which is a much better representation of the field situation. Here, The GSI values were obtained from the on-site survey of the undisturbed exposed mineral outcrop. The m_i values were determined from the predefined values which best represents the rock strength. The Disturbance factor is considered 1 or 0.7 as per the mine practice.

Table 1 Geotechnical parameters of rock samples

ORE TYPE	GSI	UCS (MPa)	MC Rock Mass Parameters		HB Rock Mass Parameters		Average Density (g/cc
			Cohesion (MPa)	Friction Angle (Degree)	Cohesion (MPa)	Friction Angle (Degree)	
BHJ/BHQ	65	180	1.080	63	0.89	68	2.8
Lateritic Ore	55	35	0.131	53	0.079	67	1.83
Hard Laminated Ore	75	85	1.256	61	1.02	68	4.89

Table 2 Dry Rock Mass parameters

ORE TYPE	GSI	MC Rock Mass Parameters		Average Density (g/cc)
		Drained		
		Cohesion (MPa)	Friction Angle (Degree)	
SLO	46	0.07	39	3.26
Laterite	40	0.032	39	2.74
Blue Dust	39	0.03	28	2.95
Shale	60	0.017	35	1.87

Table 3 Saturated Rock Mass parameters

ORE TYPE	GSI	MC Rock Mass Parameters		Average Density (g/cc)
		Undrained		
		Cohesion (MPa)	Friction Angle (Degree)	
SLO	46	0.041	30	2.97
Laterite	40	0.027	39	2.47
Blue Dust	39	0.028	26	2.634
Shale	60	0.014	32	1.66

QUARRY 3&4

200N

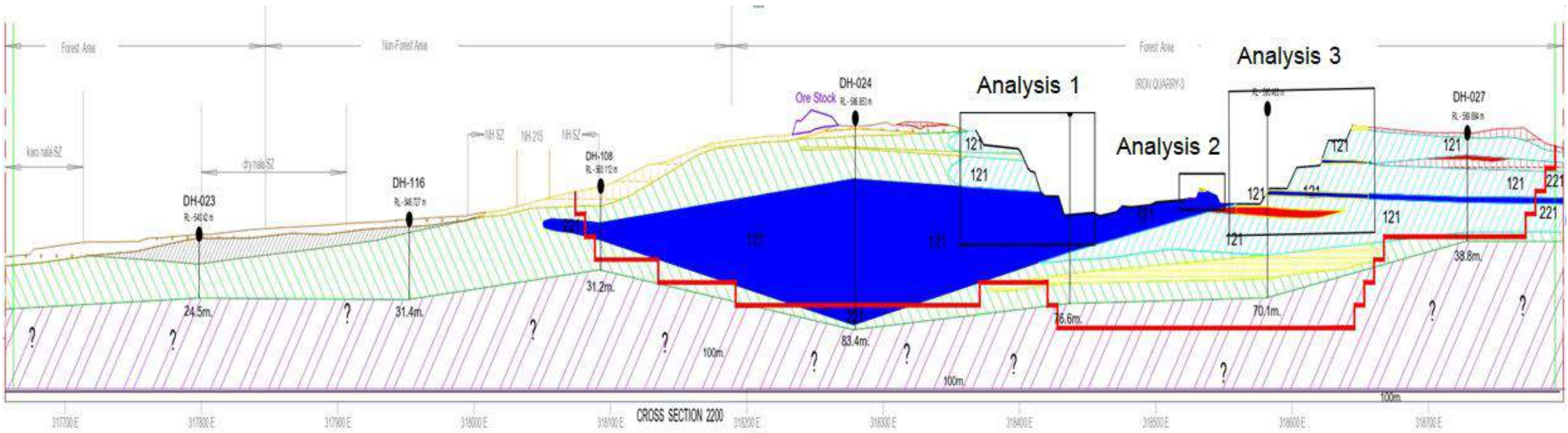


Figure 1 Narayanposhi section 2200N

HARD LAMINATED ORE

FRIABLE ORE

SHALE

LIMONITE

LATERITE

LATERITIC IRON ORE

GEOTHITE

BHJ-BHQ

SOFT LAMINATED ORE

Analysis 1- 318400E (CROSS SECTION 2200)

1.1 Field condition

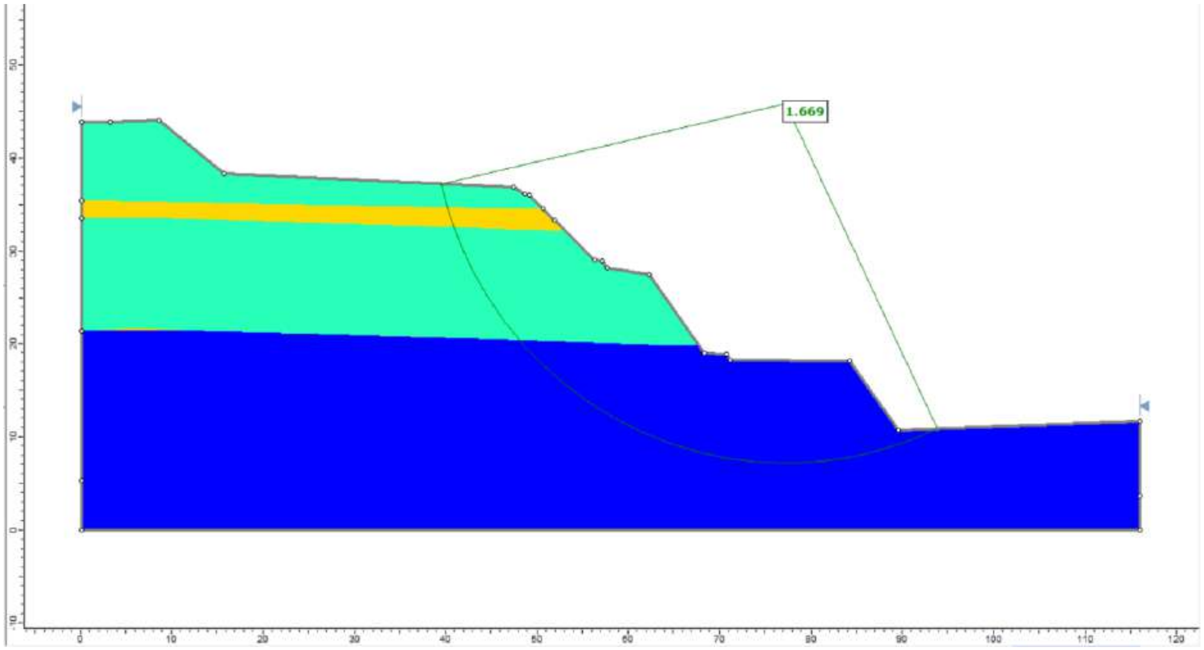


Figure 2 slope stability analysis of a shale, laterite and friable ore slope showing FOS of 1.669

1.2 Saturated condition

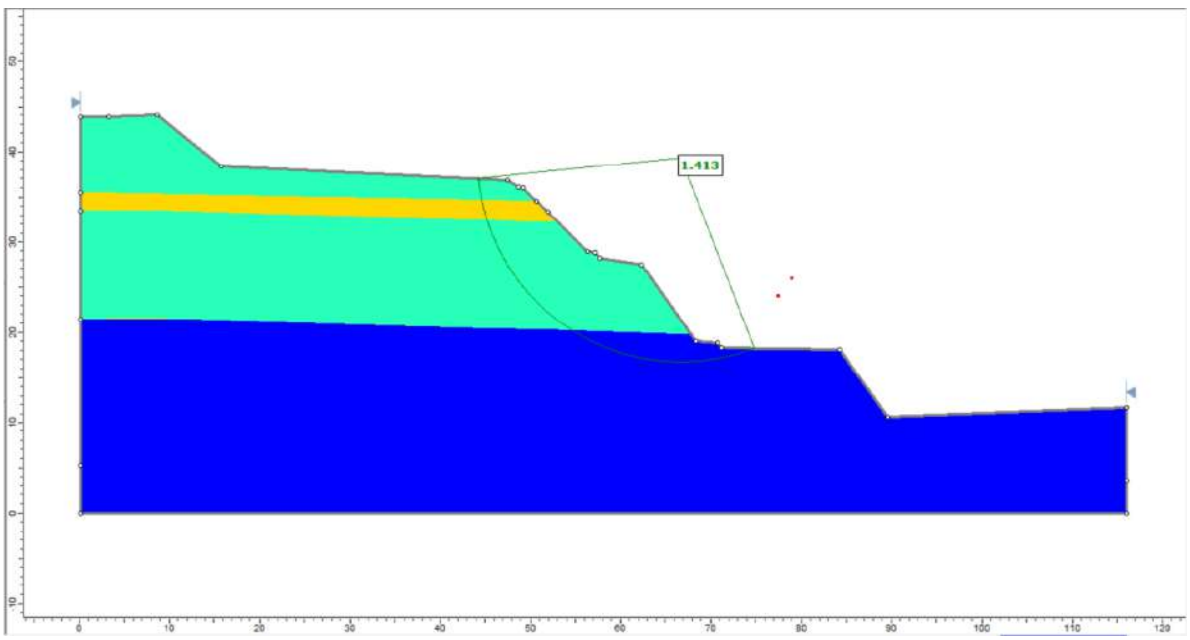


Figure 3 slope stability analysis of a shale, laterite and BHJ slope showing FOS of 1.413

Analysis 2- 318500E

2.1 Field condition

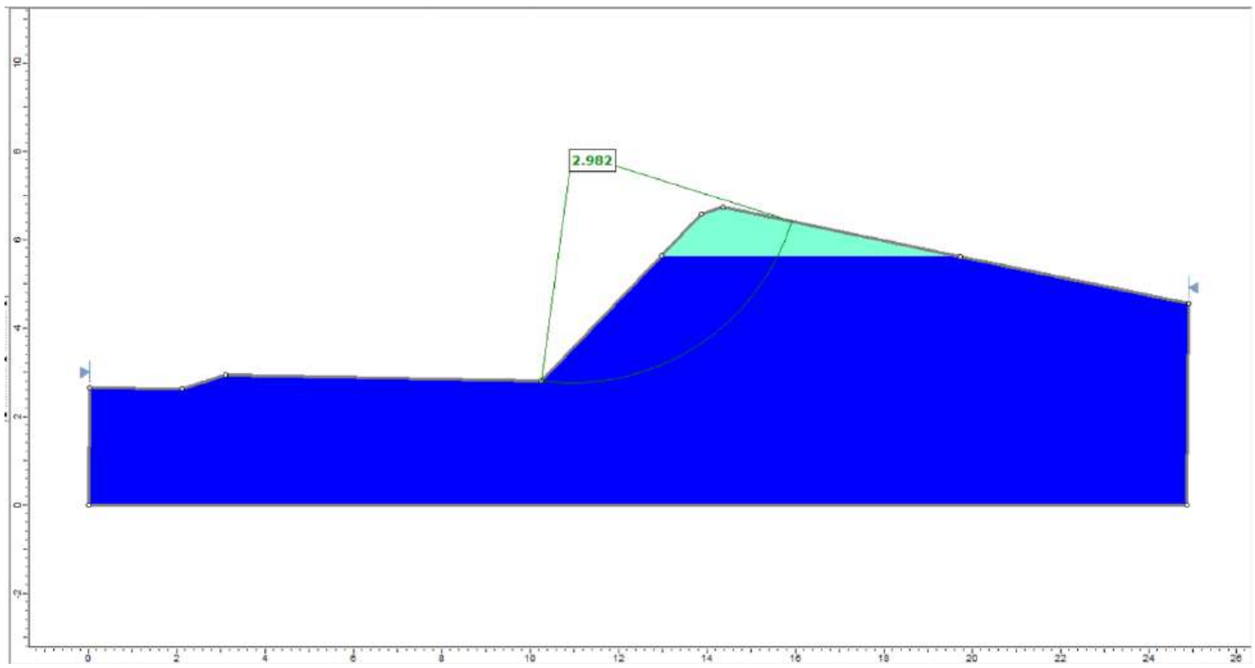


Figure 4 slope stability analysis of a SLO and friable ore slope showing FOS of 2.982

2.2 Saturated condition

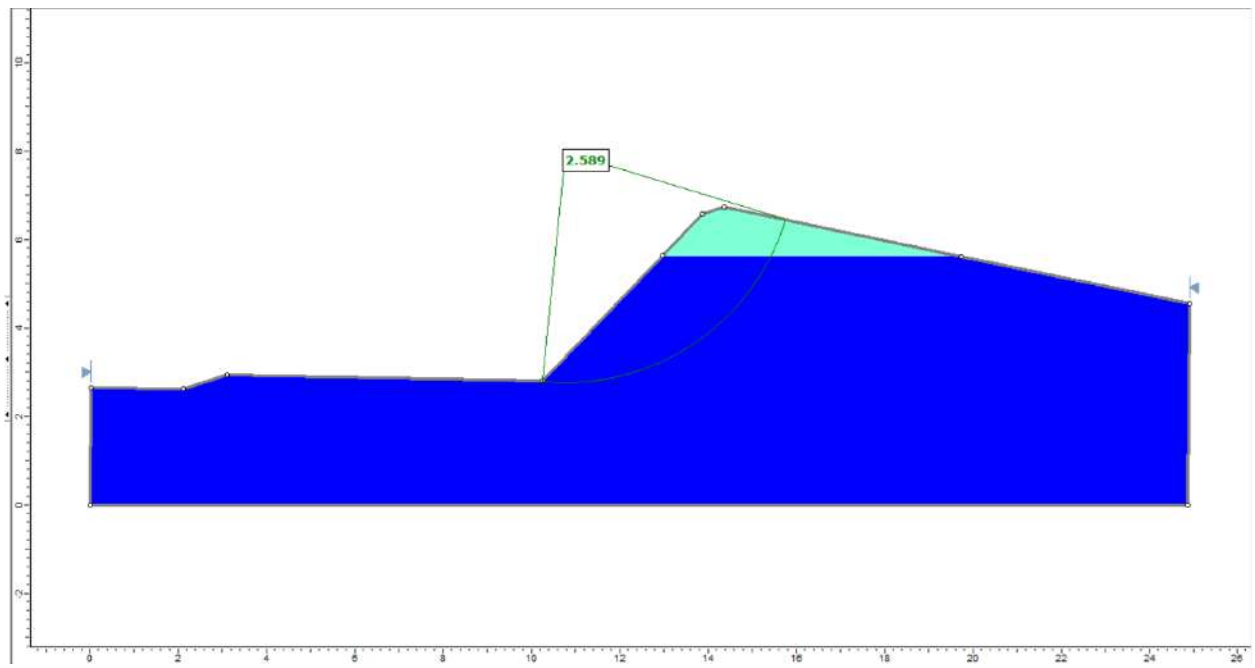


Figure 5 slope stability analysis of a SLO and friable ore slope showing FOS of 2.589

Analysis 3-318600E

3.1 Field condition

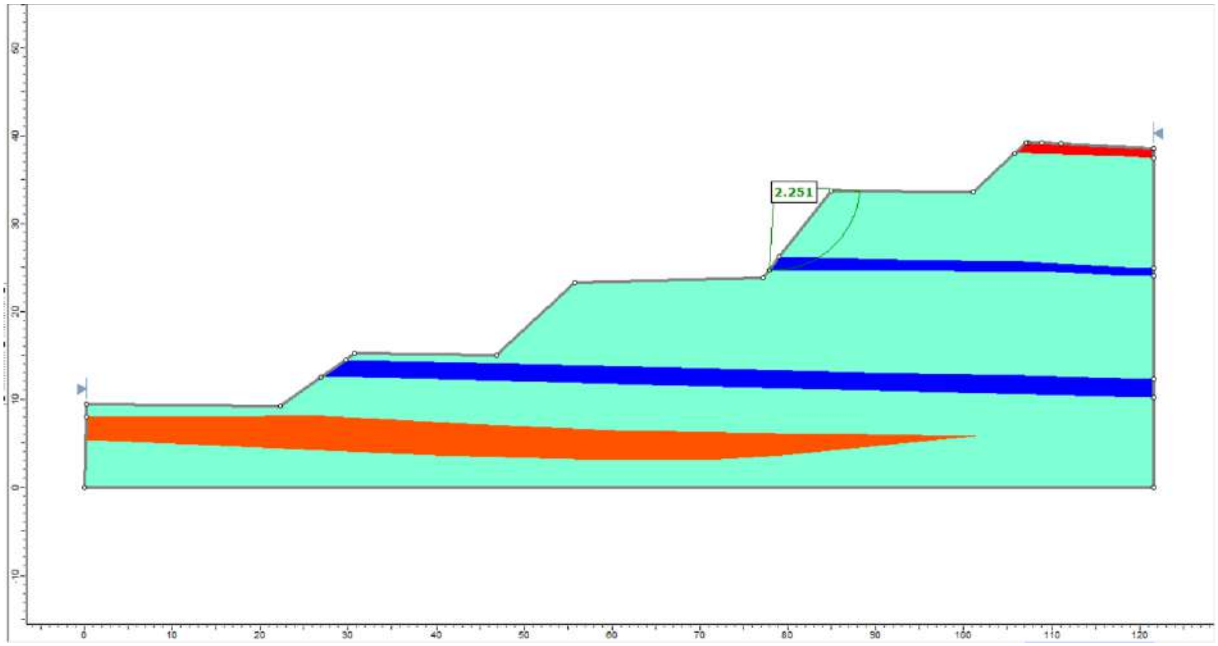


Figure 6 slope stability analysis of a SLO and friable ore slope showing FOS of 2.251

3.2 Saturated condition

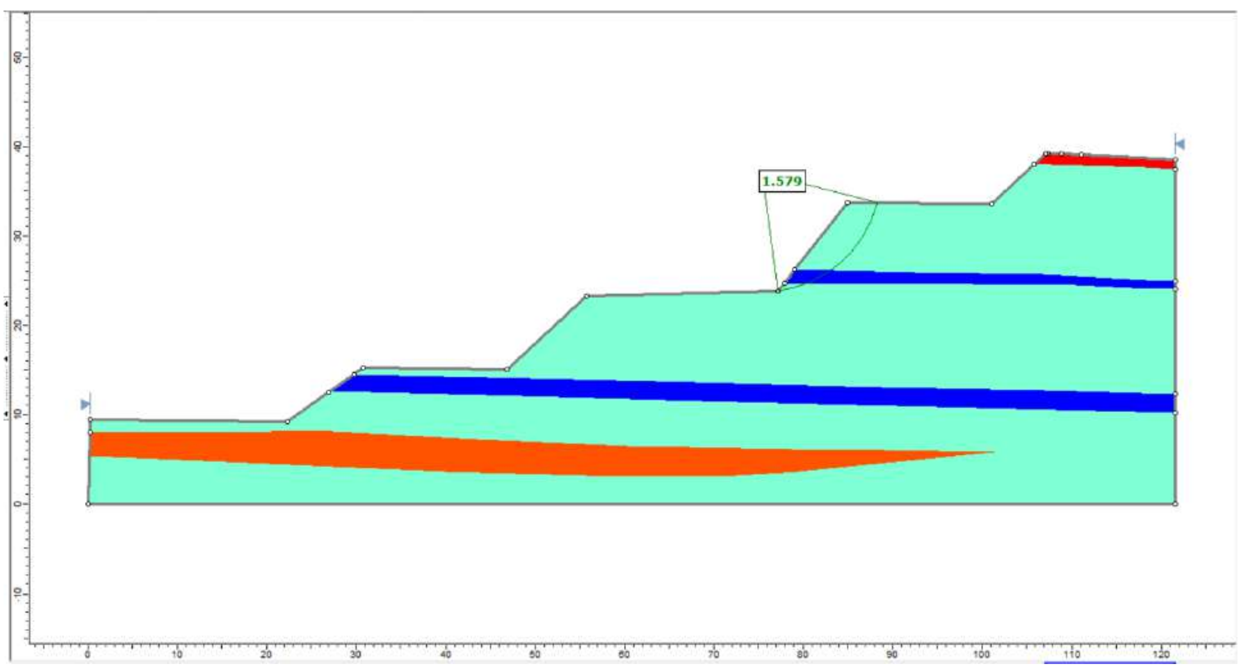


Figure 7 slope stability analysis of a SLO and friable ore slope showing FOS of 1.579

2000N

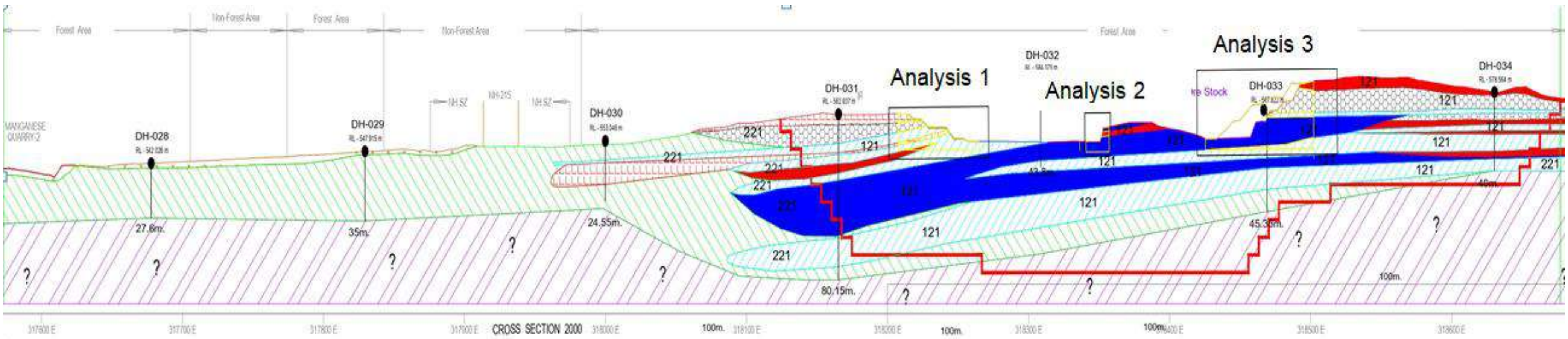


Figure 8 Narayanposhi section 2000N

HARD LAMINATED ORE
FRIABLE ORE
SHALE
LIMONITE
LATERITE
LATERITIC IRON ORE
GEOTHITE
BHJ-BHQ
SOFT LAMINATED ORE

Analysis 1 - 318250E (CROSS SECTION 2000)

1.1 Field conditions

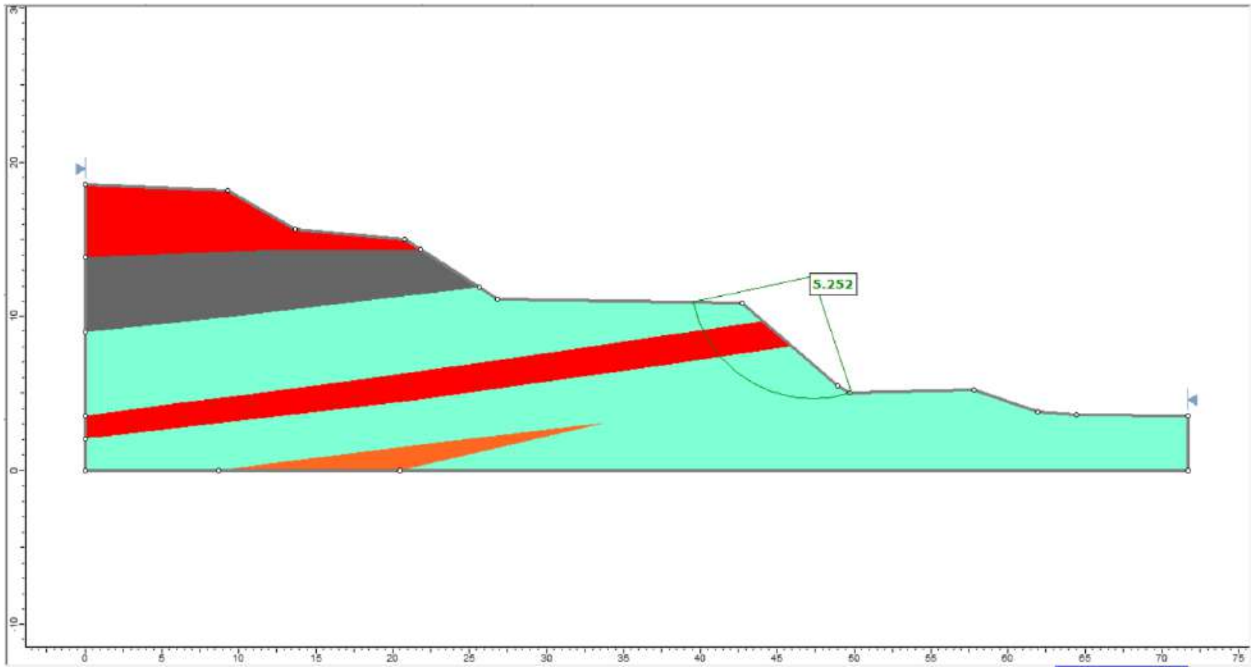


Figure 9 slope stability analysis of a SLO and lateritic ore slope showing FOS of 5.252

1.2 Saturated condition

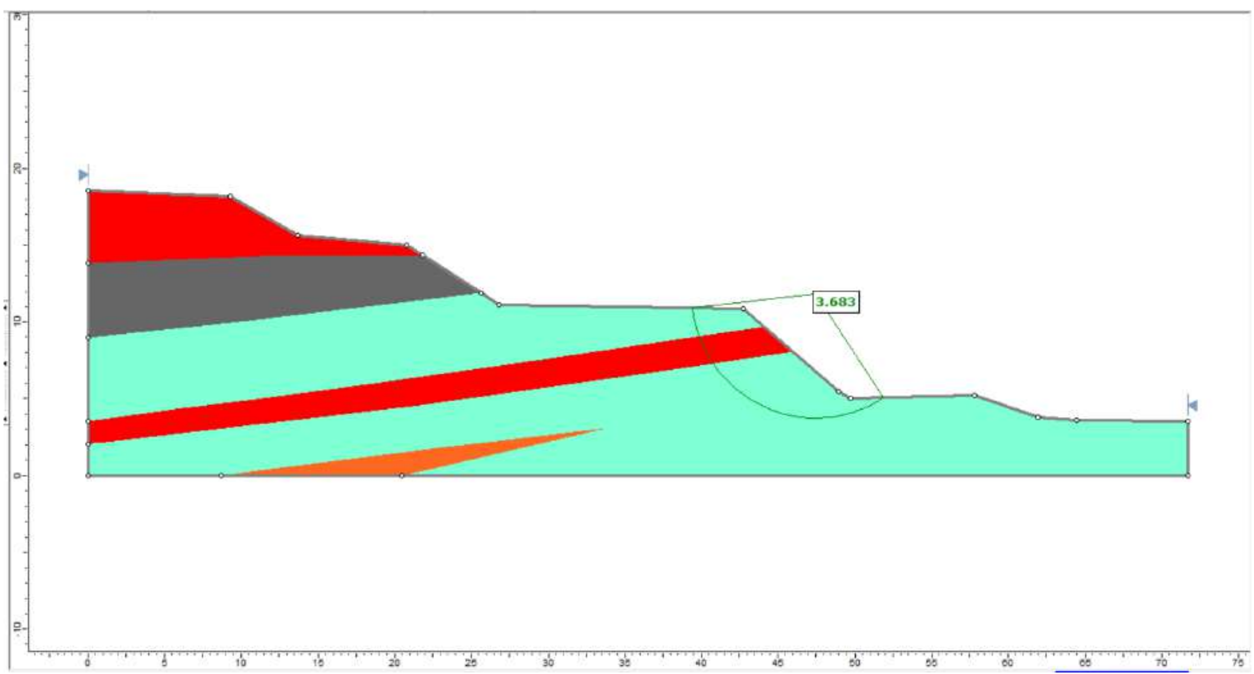


Figure 10 slope stability analysis of a SLO and lateritic ore slope showing FOS of 3.683

Analysis 2 - 318350E

2.1 Field conditions

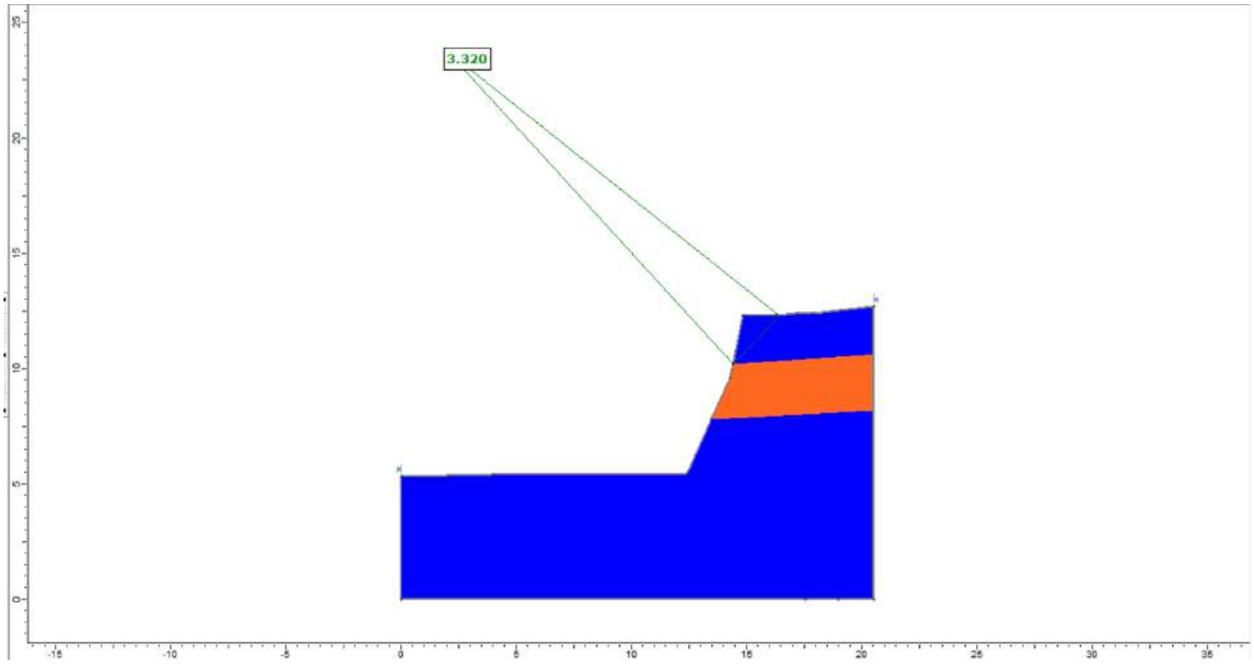


Figure 11 slope stability analysis of a friable ore slope showing FOS of 3.320

2.2 Saturated conditions

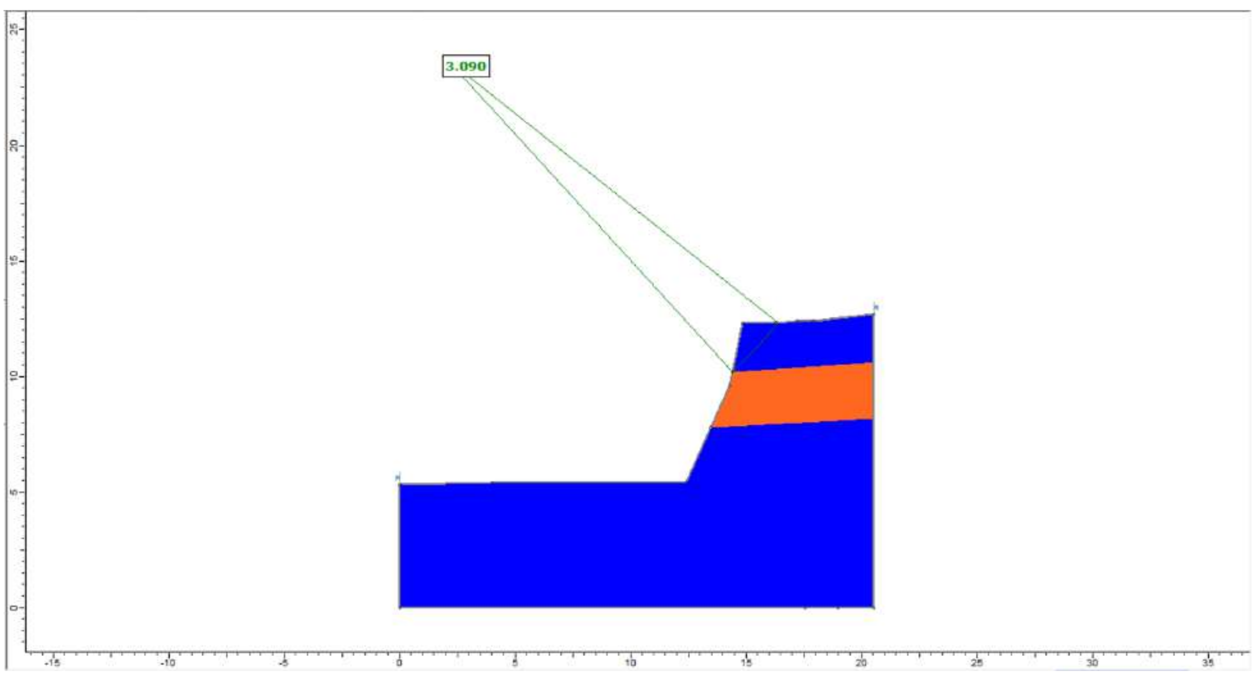


Figure 12 slope stability analysis of a friable ore slope showing FOS of 3.090

Analysis 3 - 318500E

3.1 Field conditions

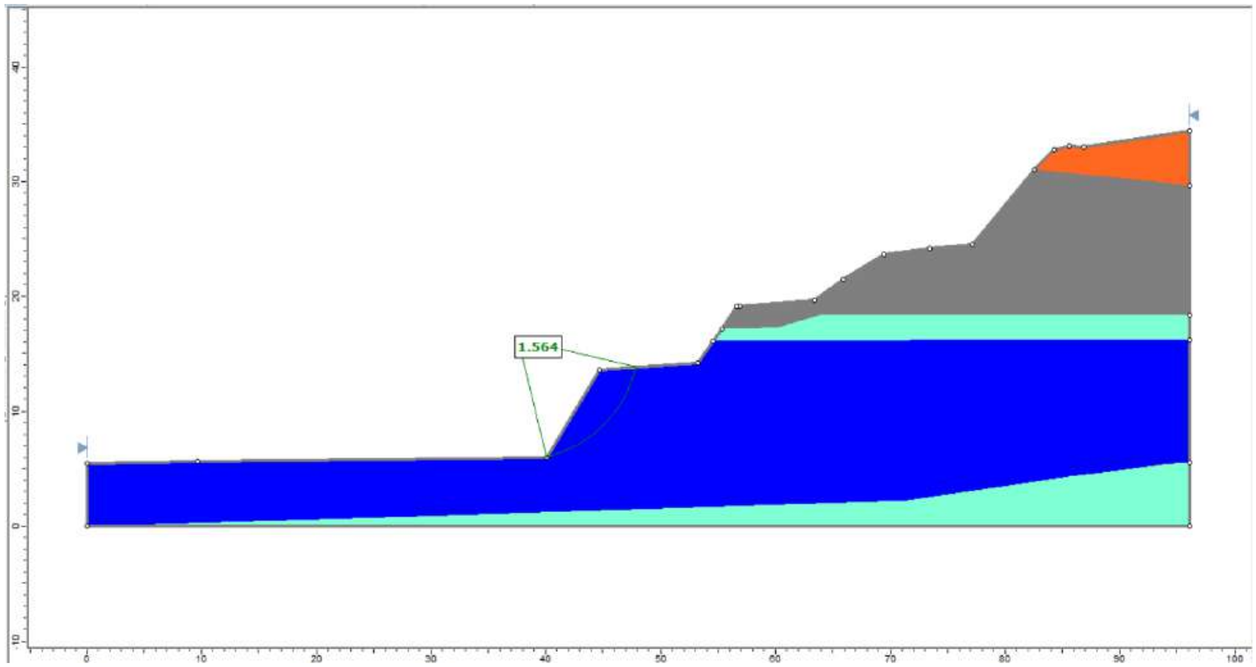


Figure 13 slope stability analysis of a friable ore slope showing FOS of 1.564

3.2 Saturated conditions

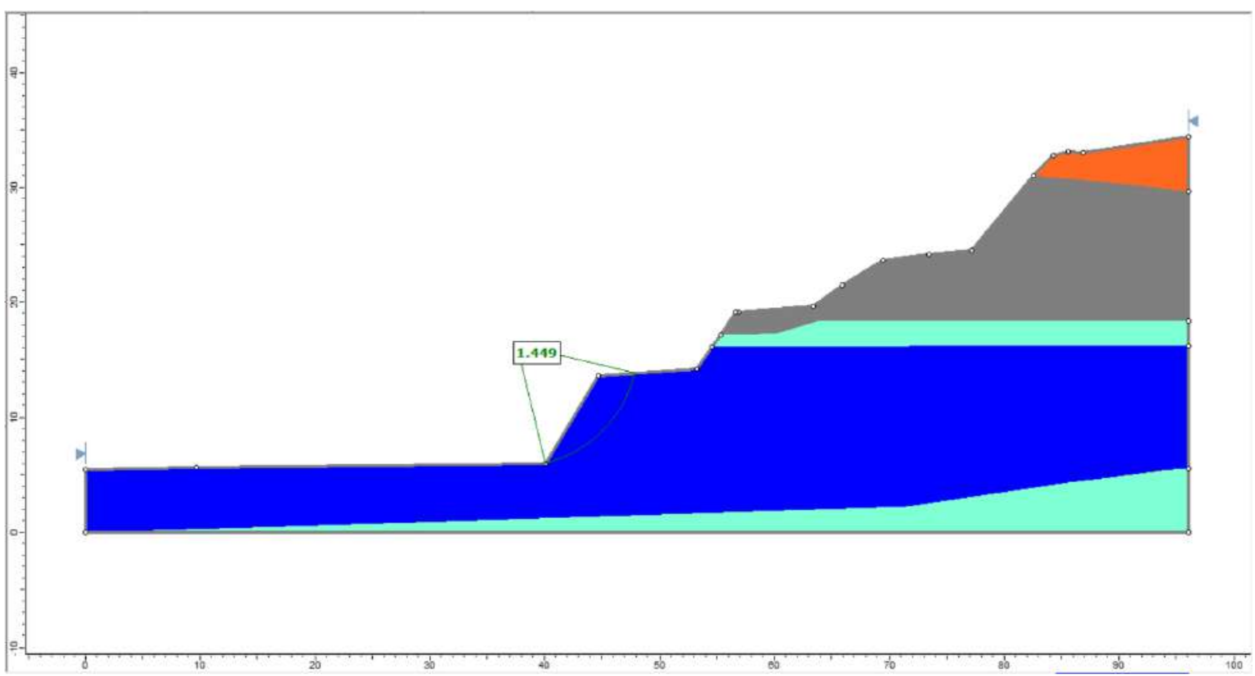


Figure 14 slope stability analysis of a friable ore slope showing FOS of 1.449

1900N

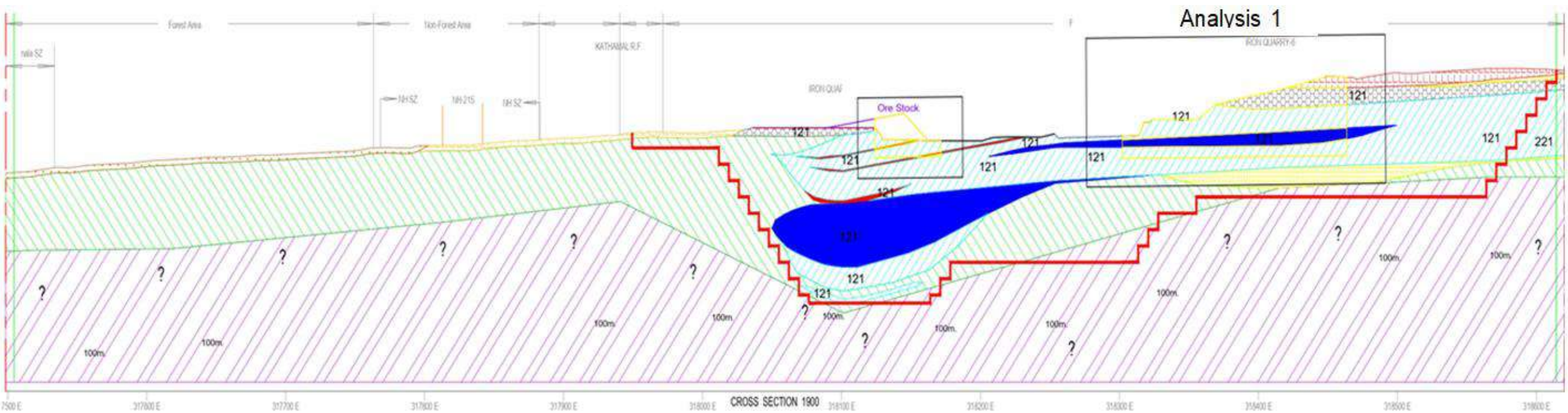


Figure 15 Narayanposhi section 1900N

HARD LAMINATED ORE
FRIABLE ORE
SHALE
LIMONITE
LATERITE
LATERITIC IRON ORE
GEOTHITE
BHJ-BHQ
SOFT LAMINATED ORE

Analysis 1 - 318400E (CROSS SECTION 1900)

1.1 Field condition

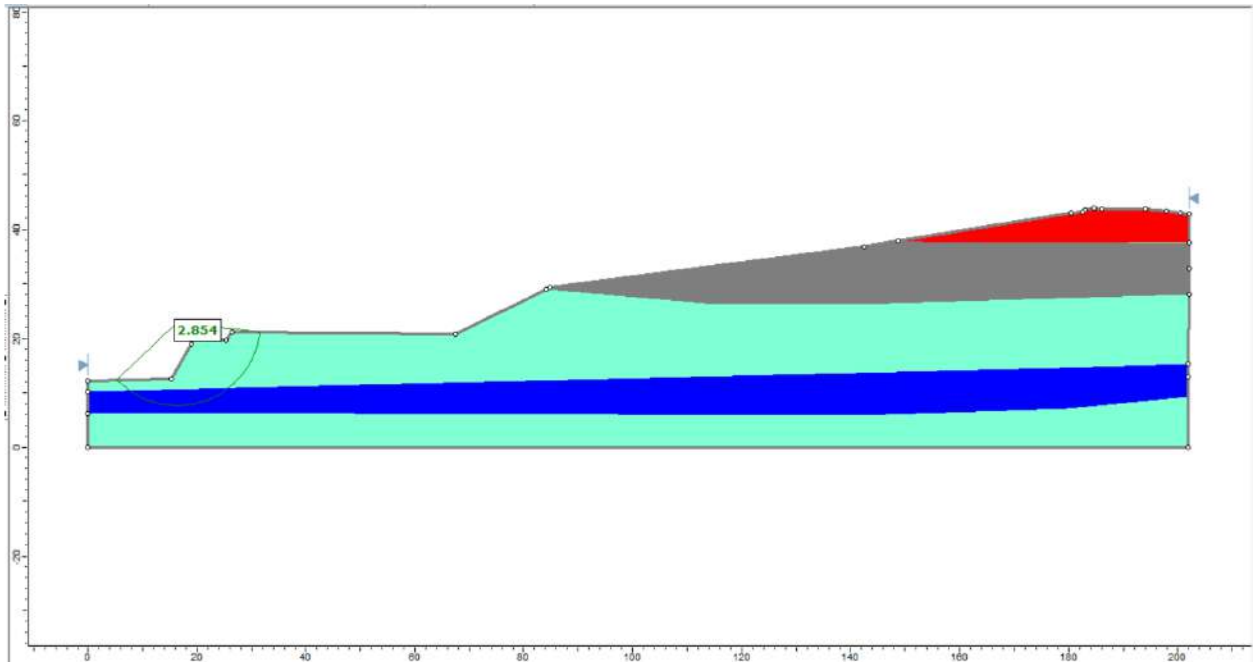


Figure 16 slope stability analysis of a SLO slope showing FOS of 2.854

1.2 Saturated condition

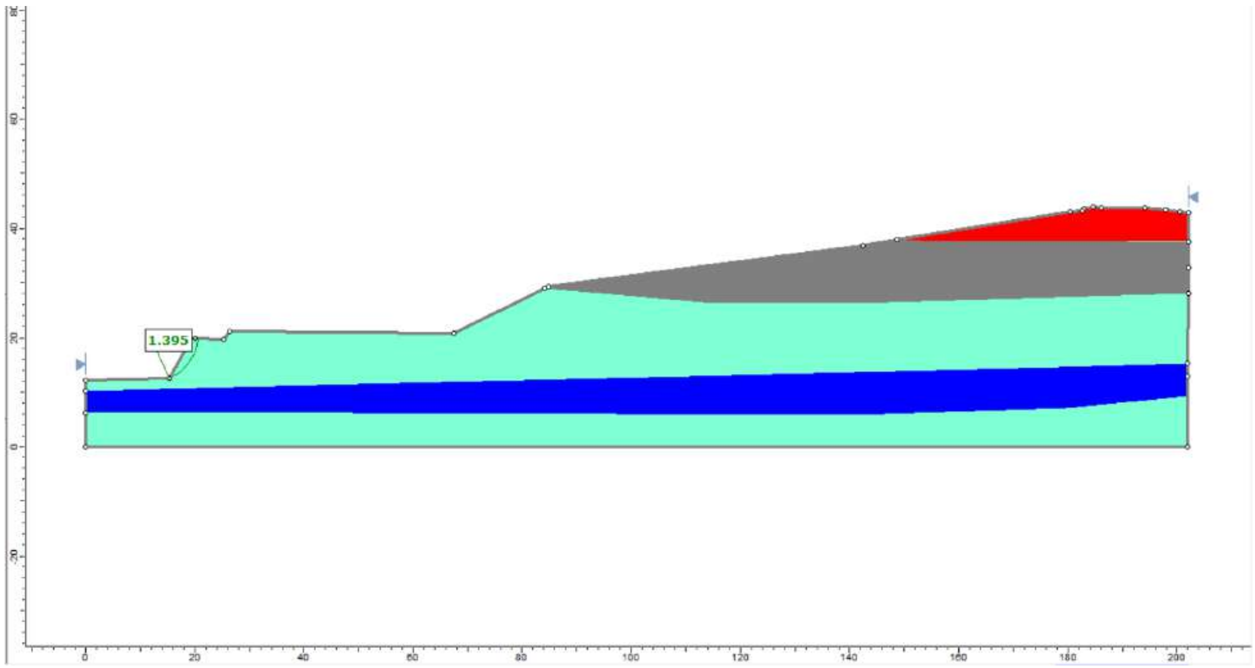


Figure 17 slope stability analysis of a SLO slope showing FOS of 1.395

1800N

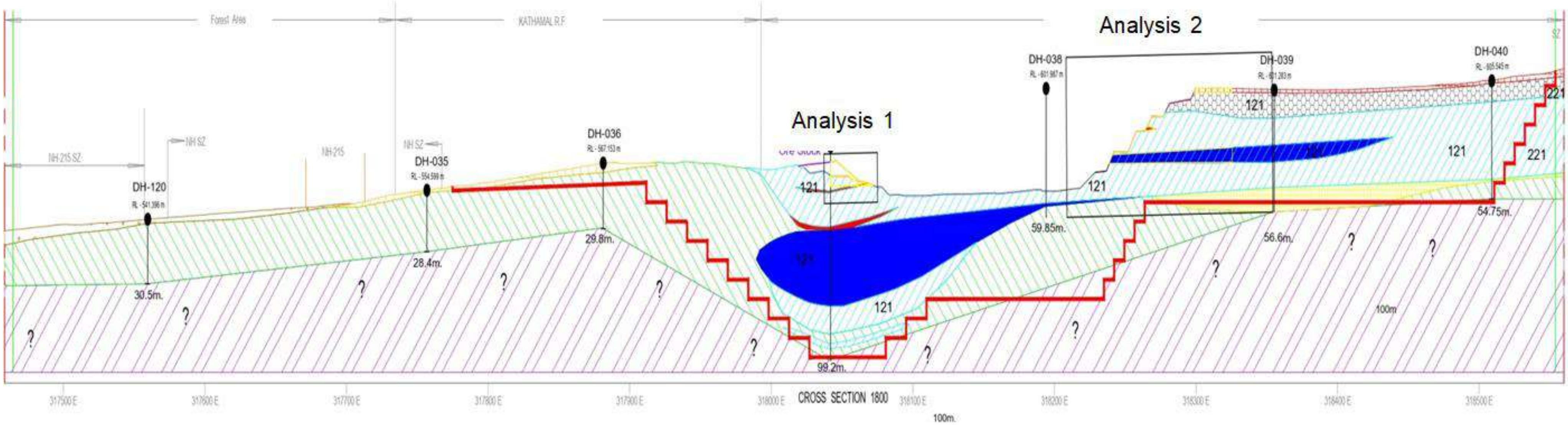


Figure 18 Narayanposhi section 1800N

Analysis 1 - 318050(CROSS SECTION 1800)

1.1 Field condition

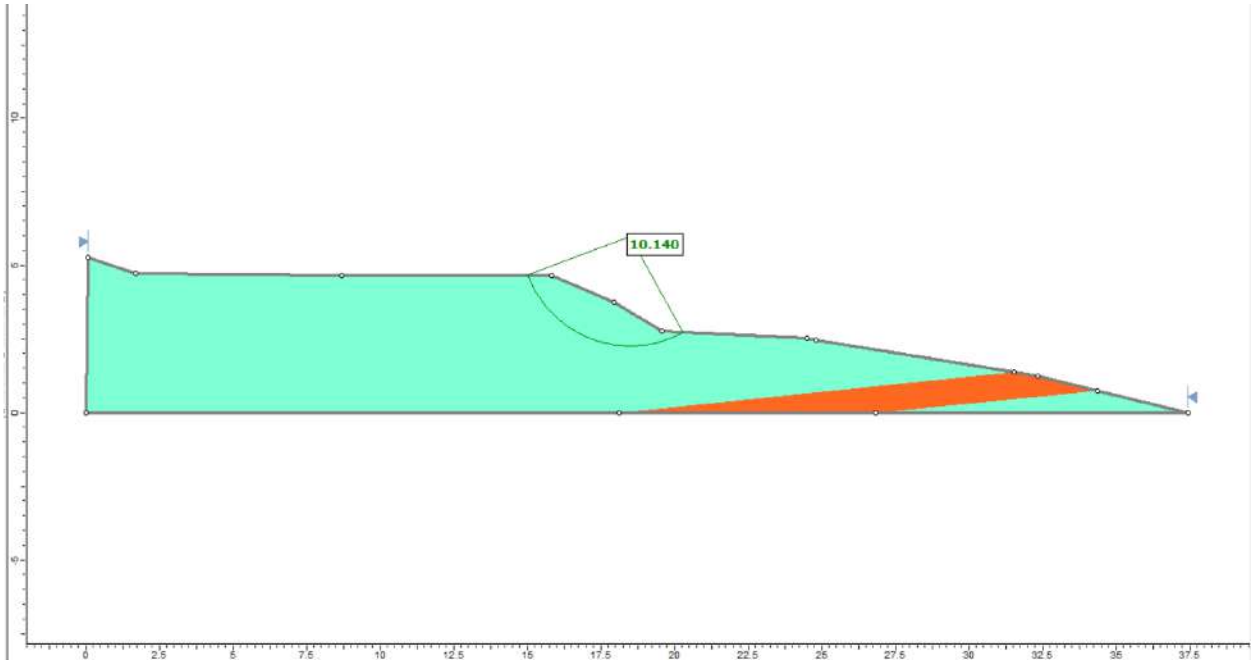


Figure 19 slope stability analysis of a SLO slope showing FOS of 10.140

1.2 Saturated condition

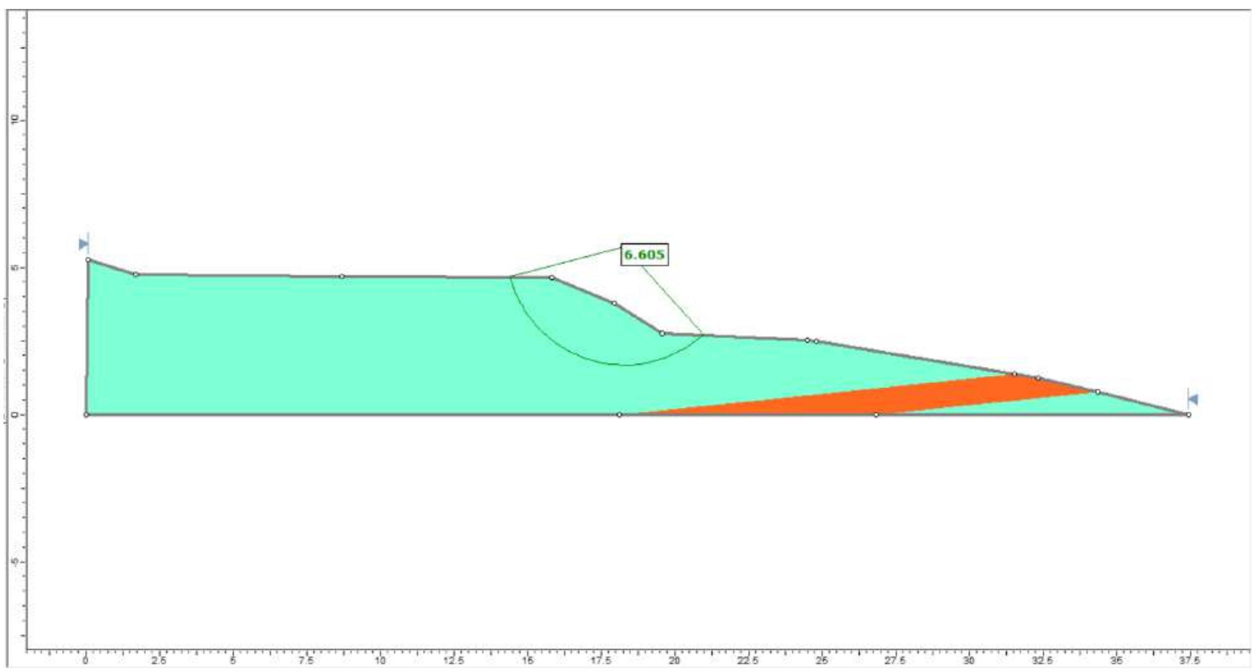


Figure 20 slope stability analysis of a SLO slope showing FOS of 6.605

Analysis 2- 318300E

2.1 field conditions

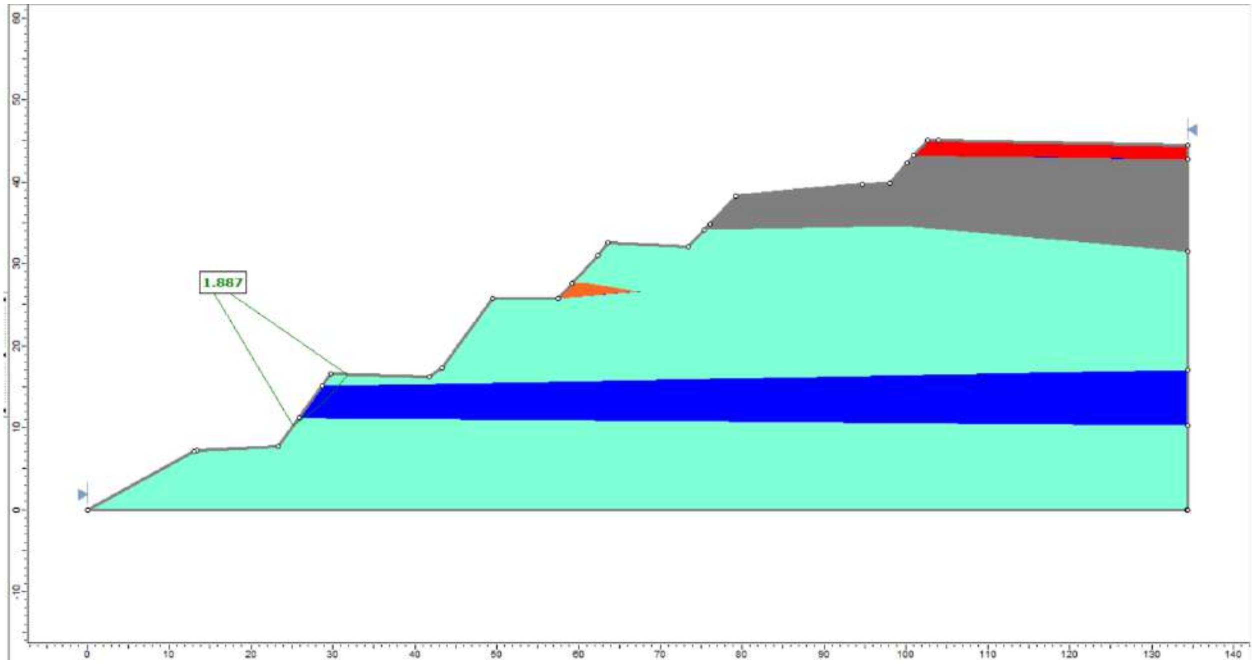


Figure 21 slope stability analysis of a friable ore and SLO slope showing FOS of 1.887

2.2 saturated conditions

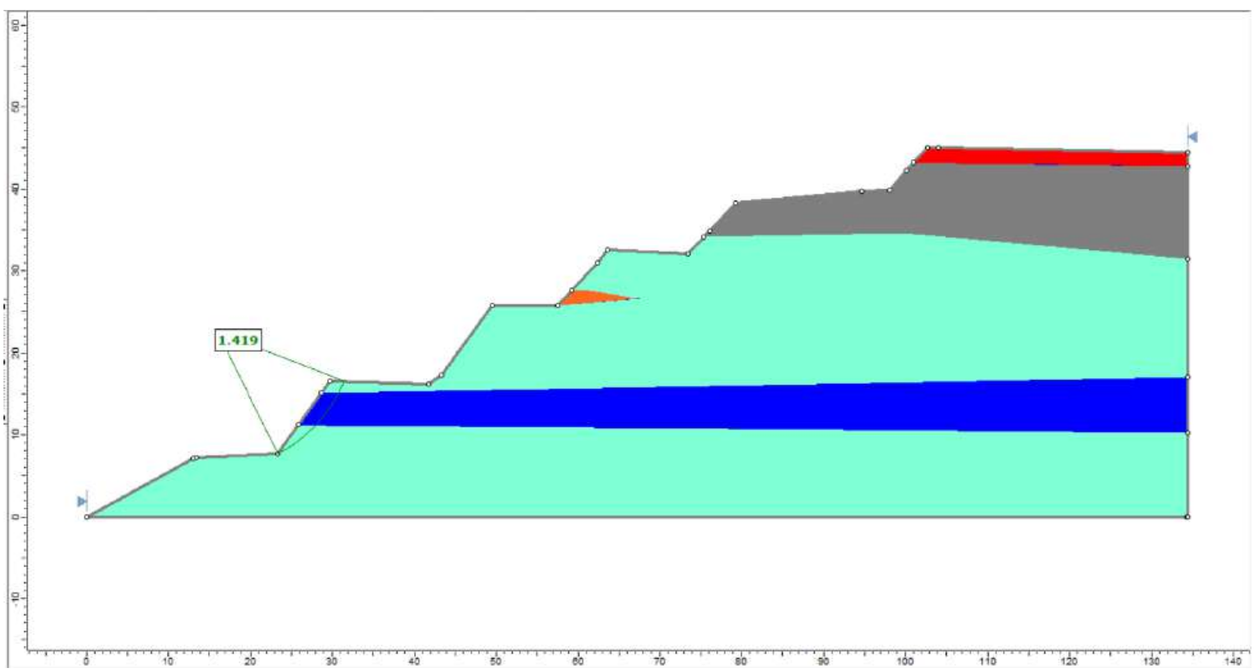


Figure 22 slope stability analysis of a friable ore and SLO slope showing FOS of 1.419

QUARRY RF

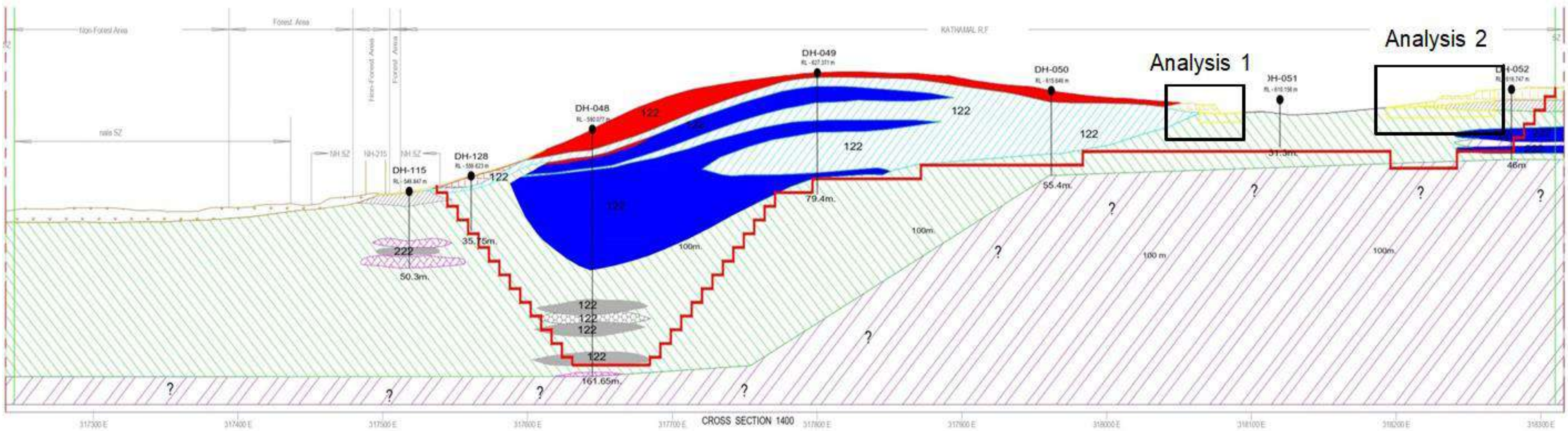


Figure 23 Narayanposhi section 1400N

HARD LAMINATED ORE
FRIABLE ORE
SHALE
LIMONITE
LATERITE
LATERITIC IRON ORE
GEOTHITE
BHJ-BHQ
SOFT LAMINATED ORE

Analysis 1 - 318100E (CROSS SECTION 1400)

1.1 Field conditions

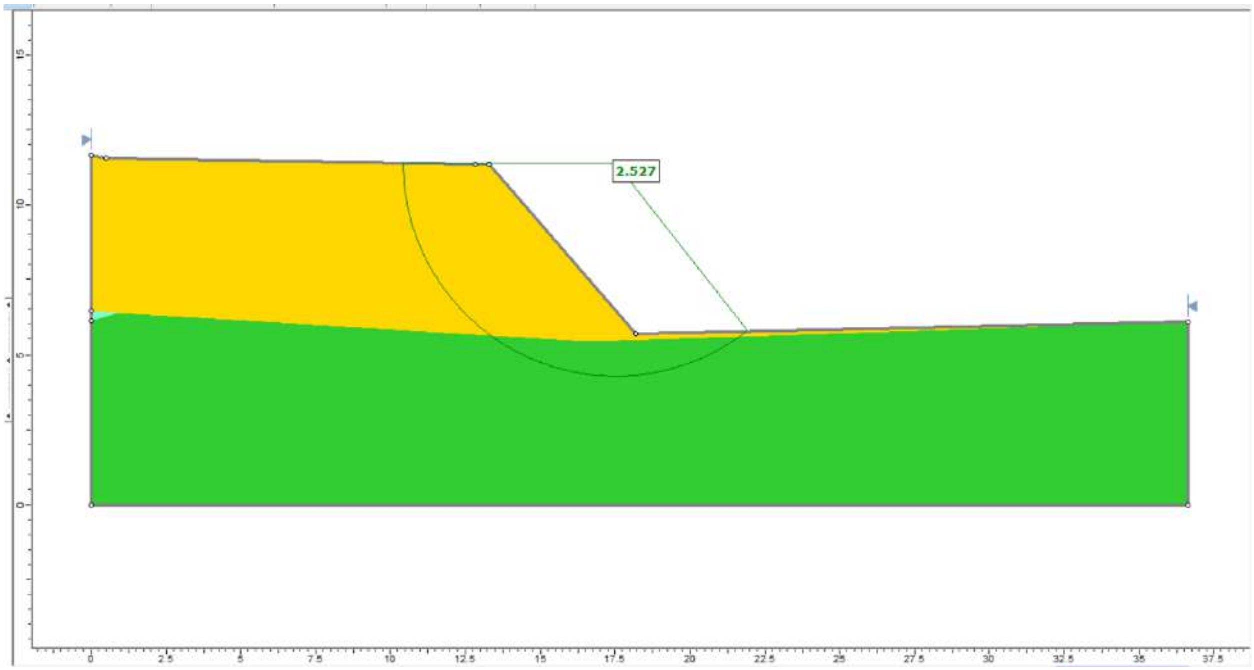


Figure 24 slope stability analysis of a laterite and shale slope showing FOS of 2.527

1.2 Saturated conditions

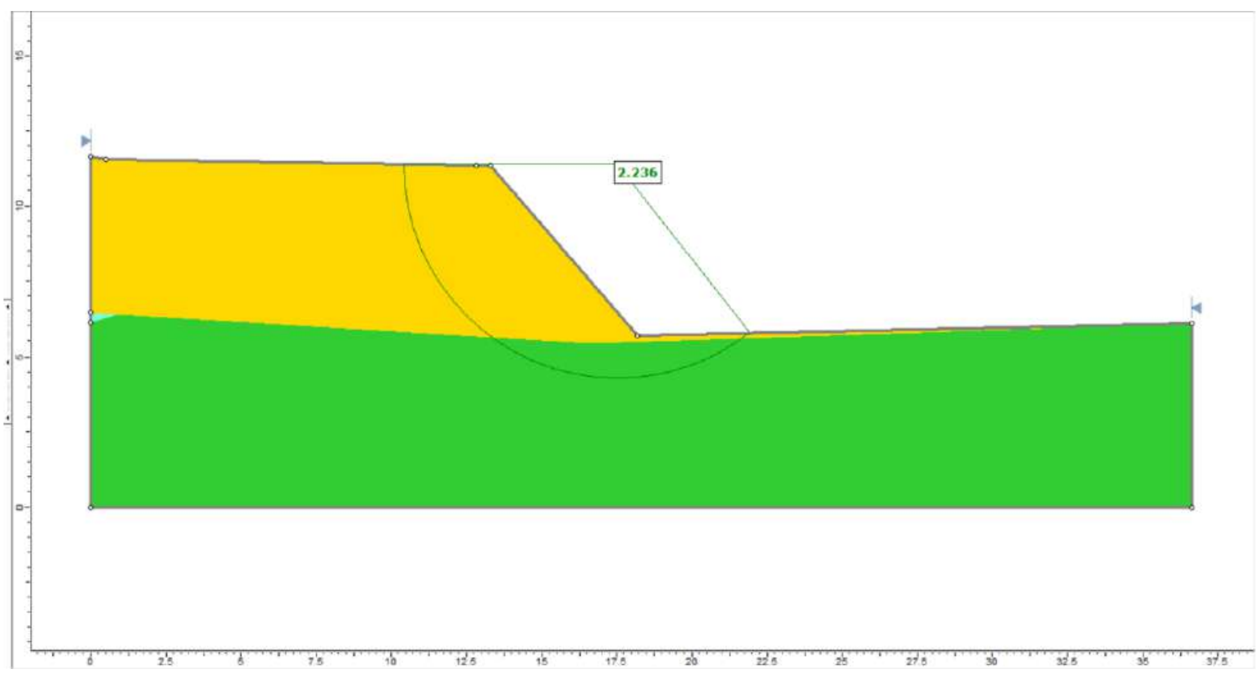


Figure 25 slope stability analysis of a laterite and shale slope showing FOS of 2.236

Analysis 2 - 318250E

2.1 Field conditions

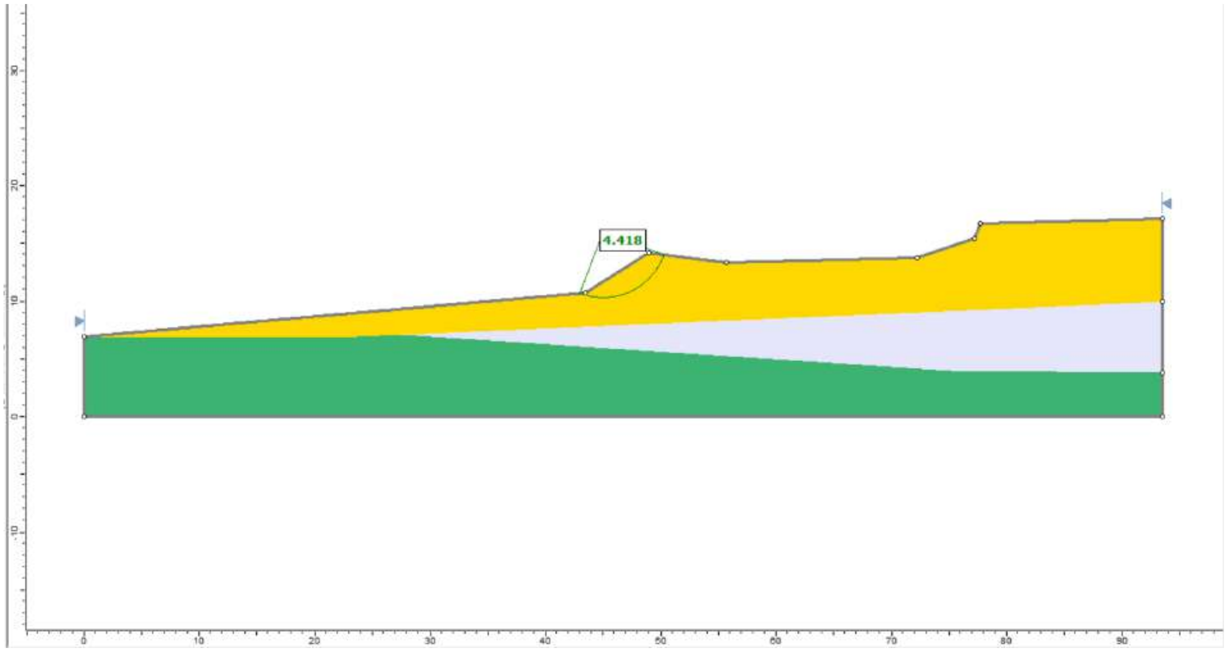


Figure 26 slope stability analysis of a laterite slope showing FOS of 4.418

2.2 Saturated conditions

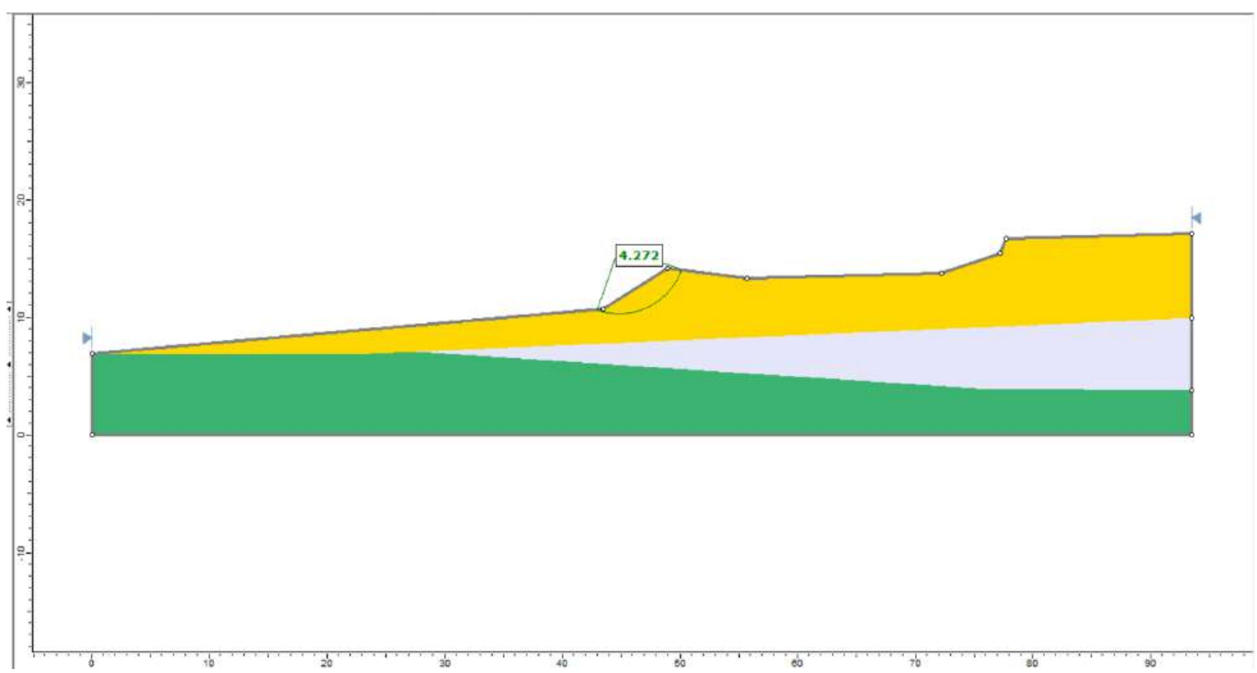


Figure 27 slope stability analysis of a laterite slope showing FOS of 4.272

1300N

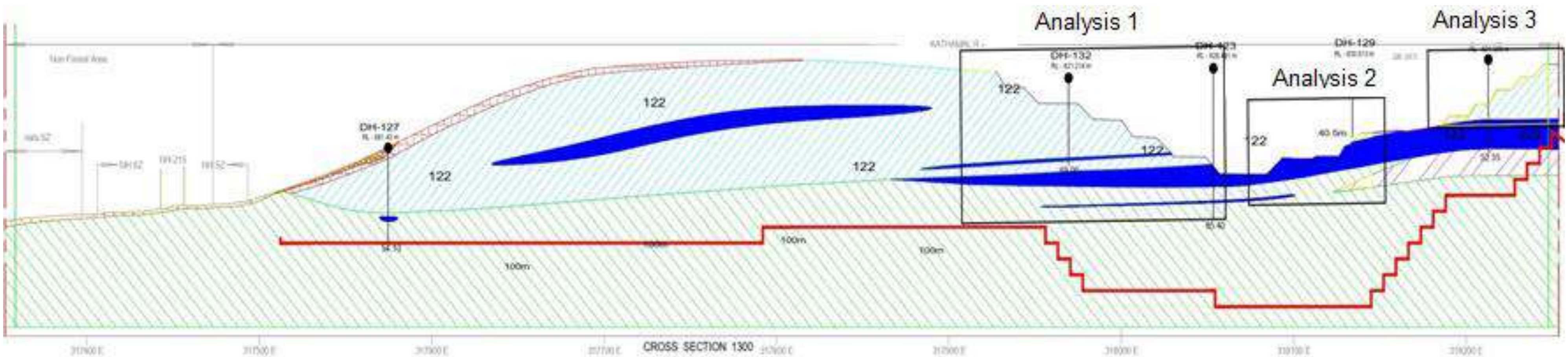


Figure 28 Narayanposhi section 1300N

HARD LAMINATED ORE
FRIABLE ORE
SHALE
LIMONITE
LATERITE
LATERITIC IRON ORE
GEOTHITE
BHJ-BHQ
SOFT LAMINATED ORE

Analysis 1 - 318000E CROSS SECTION 1300

1.1 Field condition

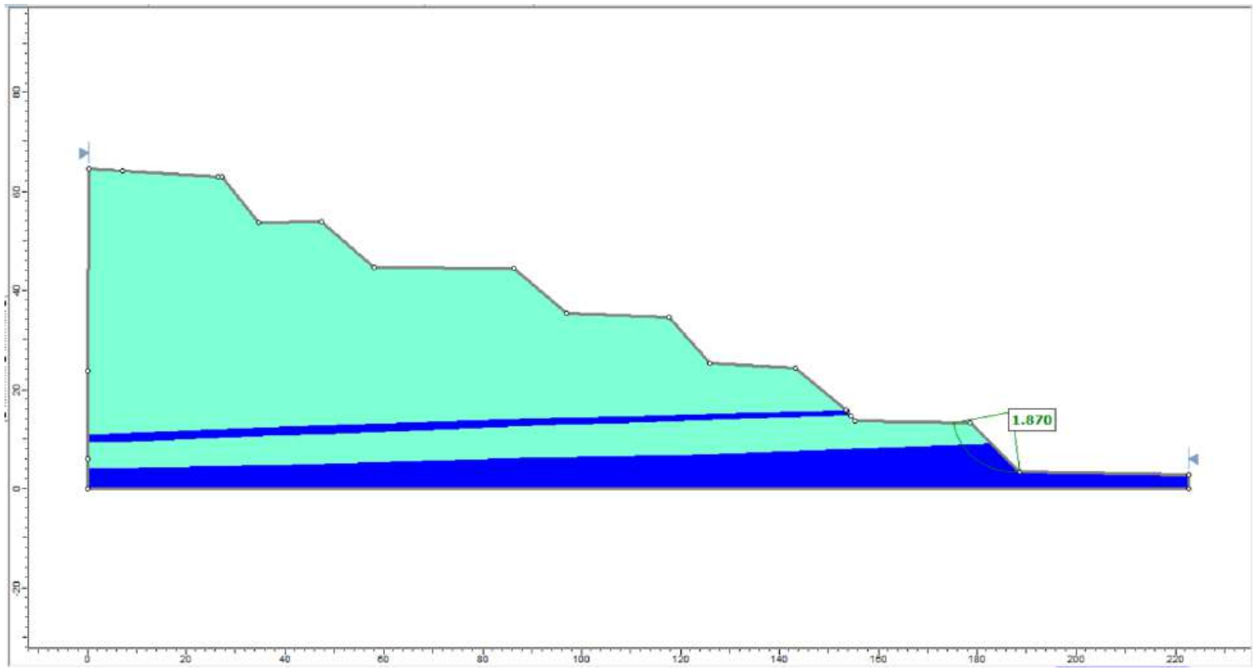


Figure 29 slope stability analysis of a SLO and friable ore slope showing FOS of 1.870

1.2 Saturated condition

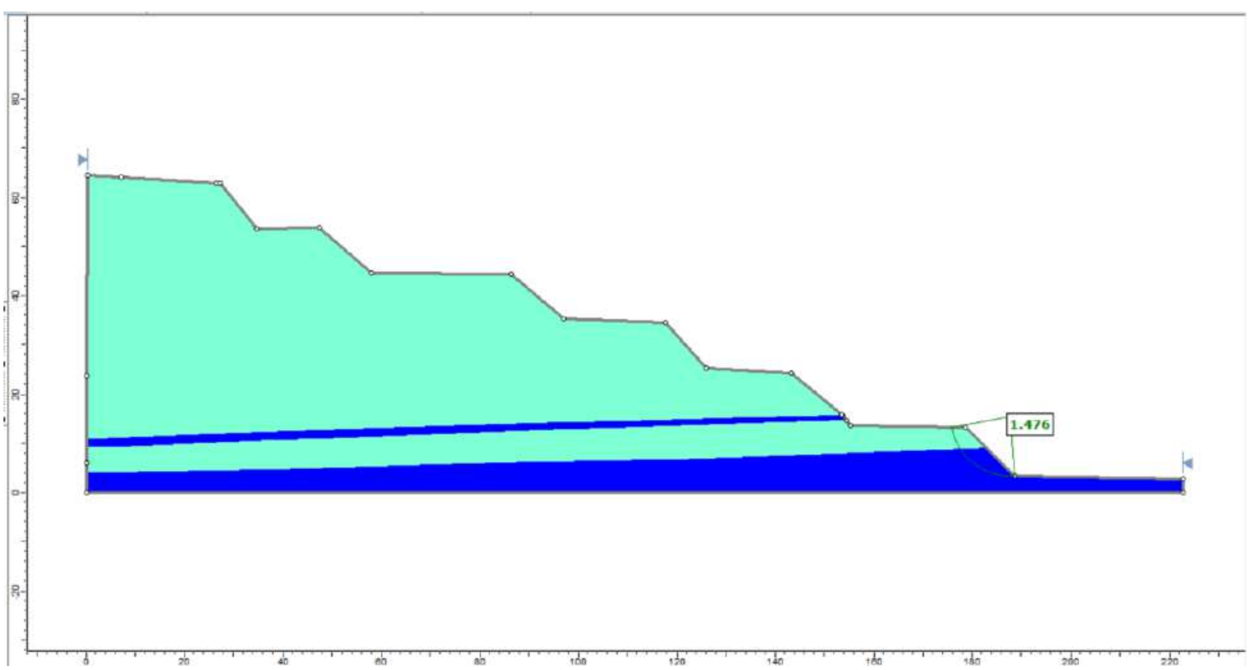


Figure 30 slope stability analysis of a SLO and friable ore slope showing FOS of 1.476

Analysis 2 - 318100E

2.1 Field condition

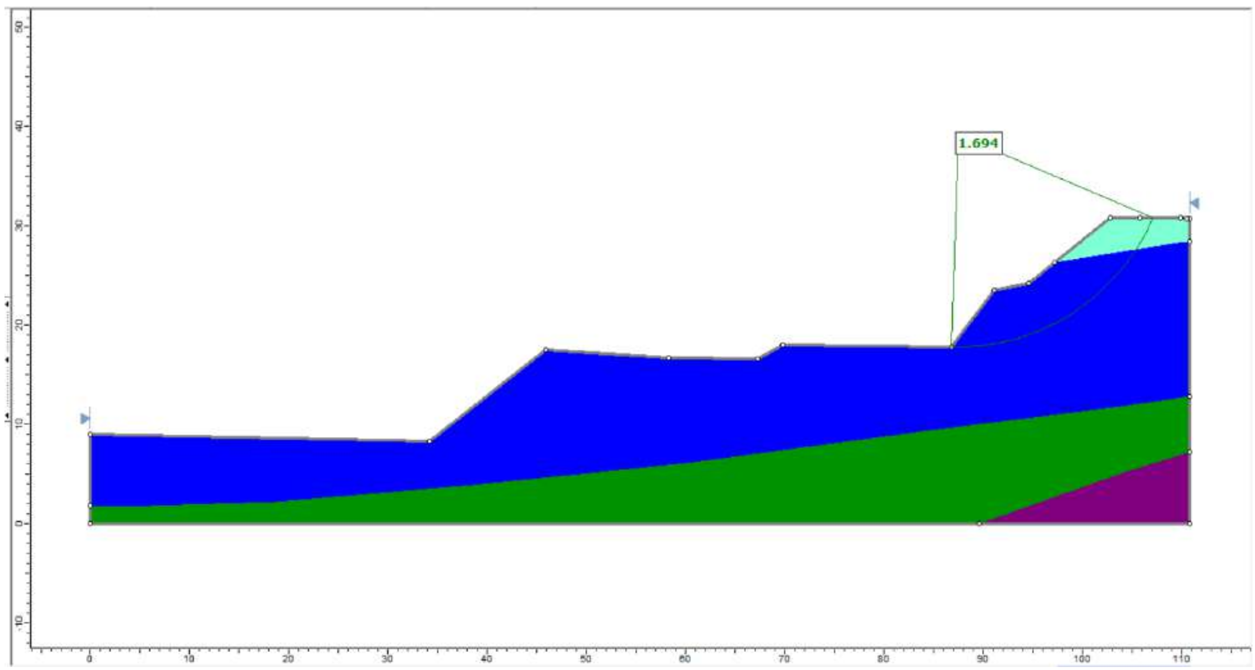


Figure 31 slope stability analysis of a SLO and friable ore slope showing FOS of 1.694

2.2 Saturated condition

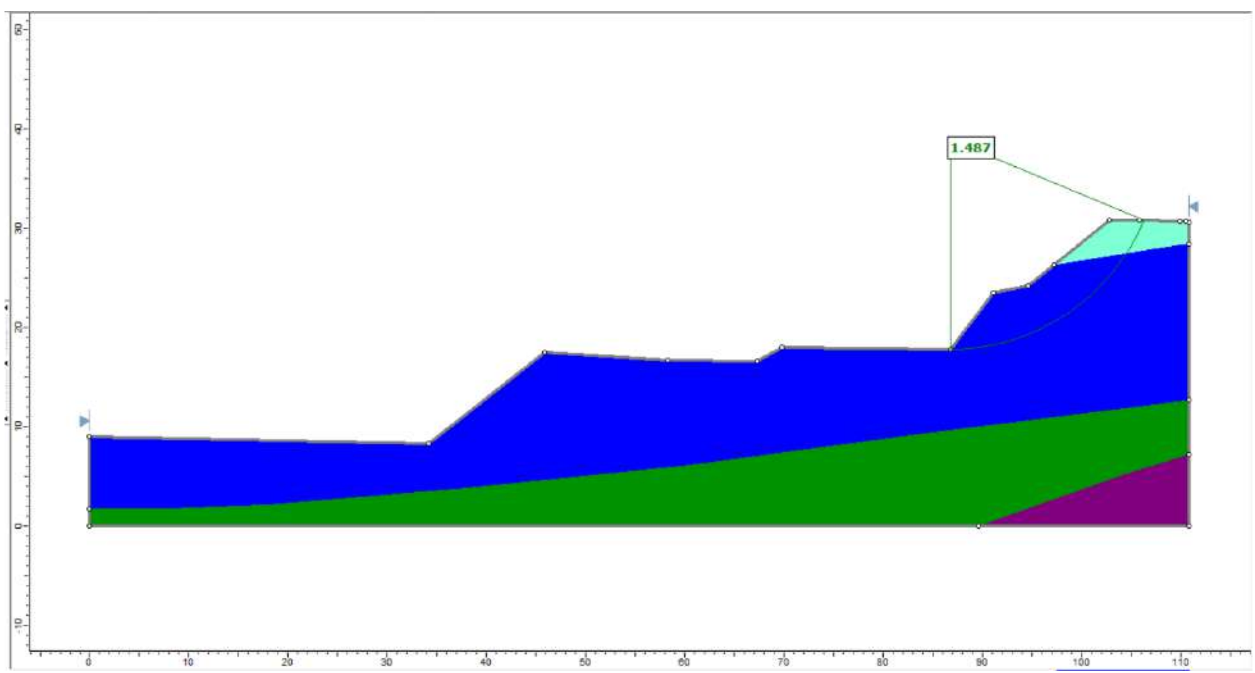


Figure 32 slope stability analysis of a SLO and friable ore slope showing FOS of 1.487

Analysis 3 - 318200E

3.1 Field condition

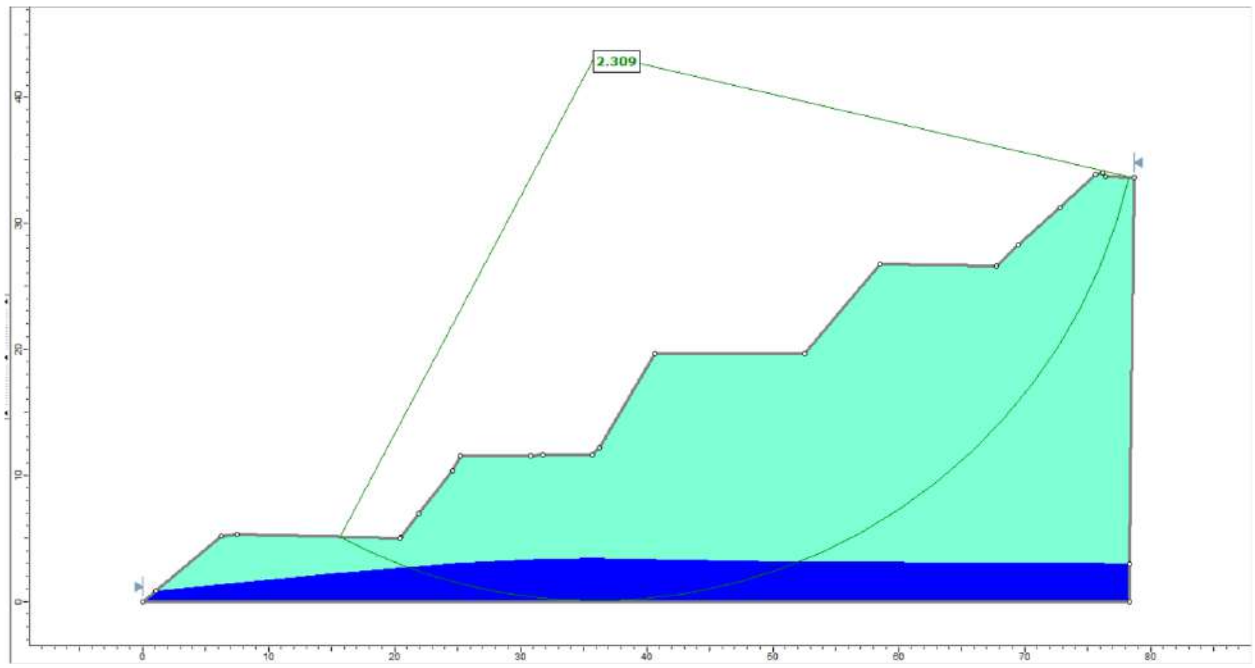


Figure 33 slope stability analysis of a SLO and friable ore slope showing FOS of 2.309

3.2 Saturated condition

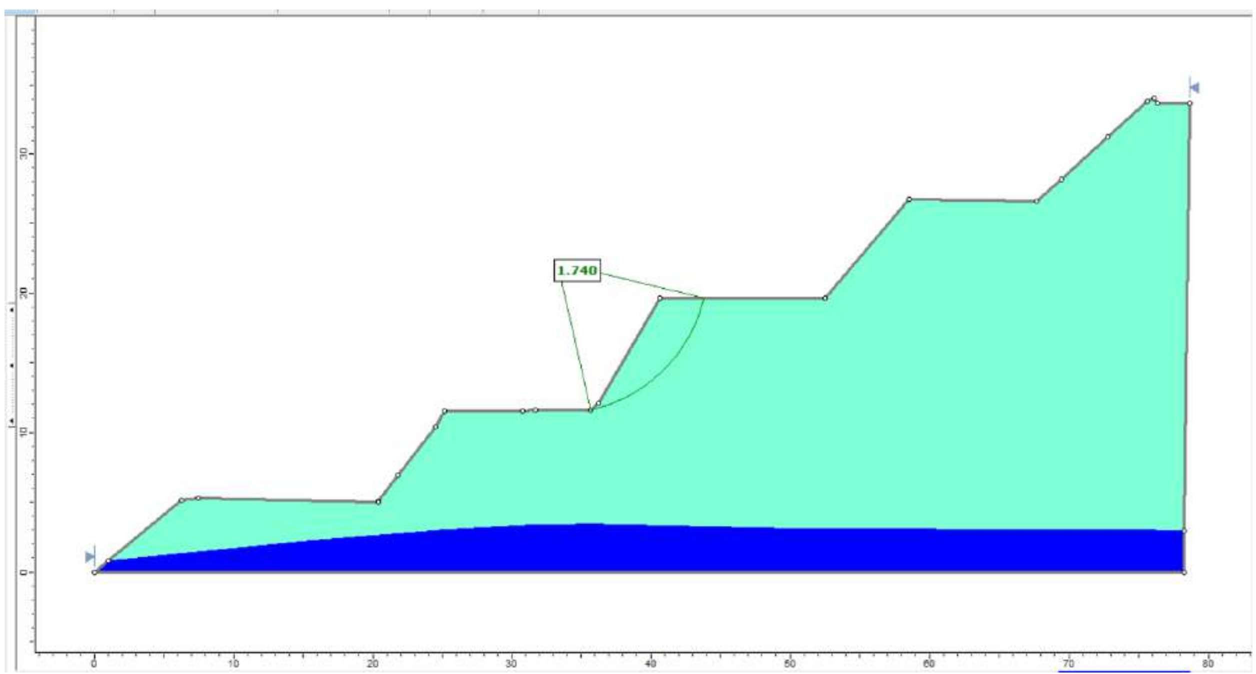


Figure 34 slope stability analysis of a SLO and friable ore slope showing FOS of 1.740

1200N

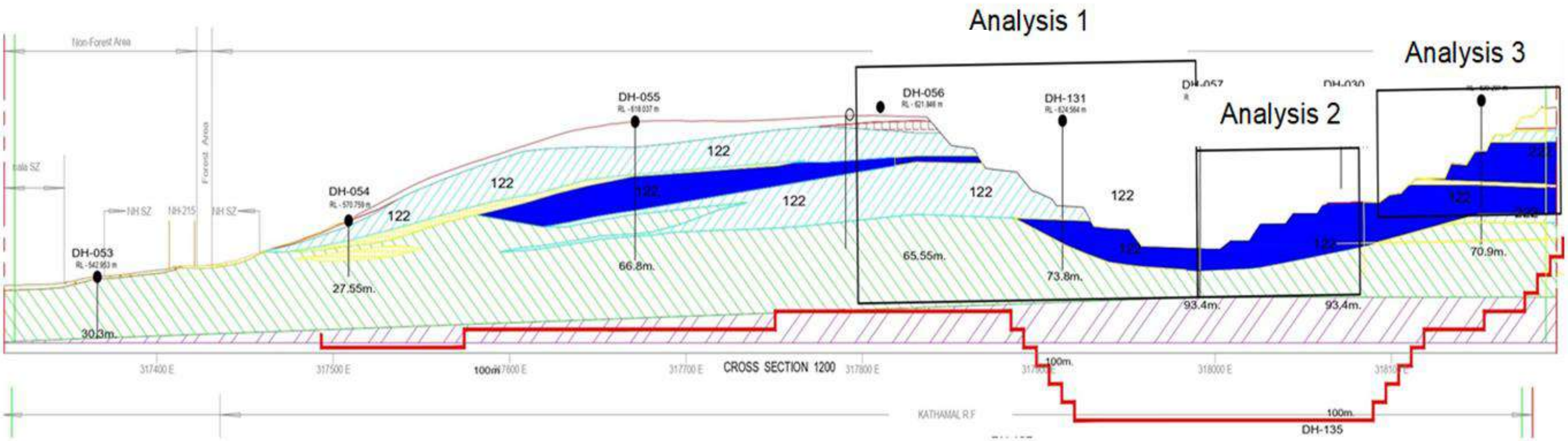


Figure 35 Narayanposhi section 1200N

HARD LAMINATED ORE
FRIABLE ORE
SHALE
LIMONITE
LATERITE
LATERITIC IRON ORE
GEOTHITE
BHJ-BHQ
SOFT LAMINATED ORE

Analysis 1- 317900E CROSS SECTION 1200

1.1 Field condition

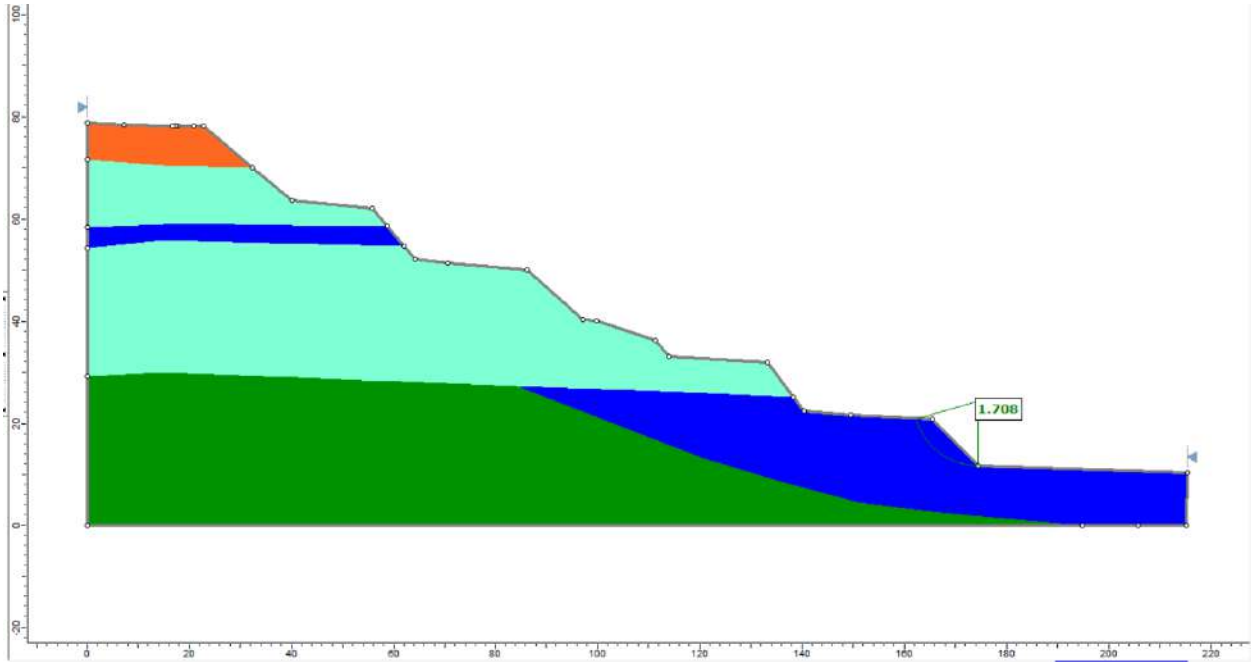


Figure 36 slope stability analysis of a friable ore slope showing FOS of 1.708

1.2 Saturated condition

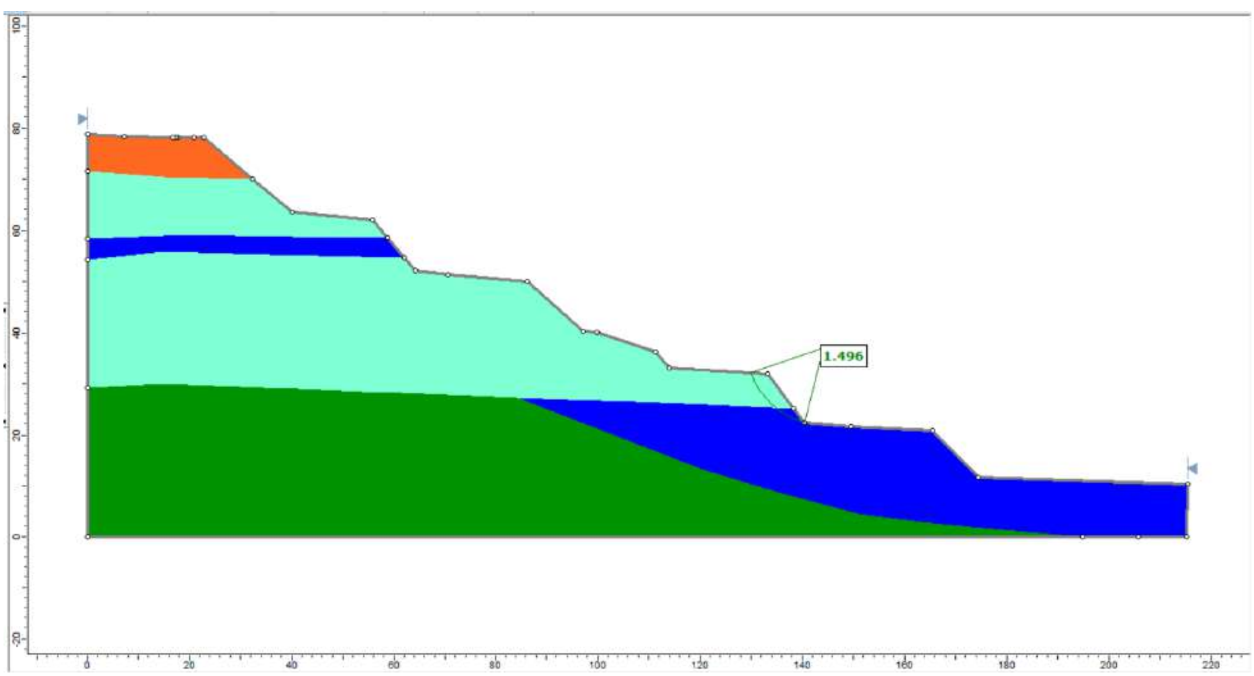


Figure 37 slope stability analysis of a SLO and friable ore slope showing FOS of 1.496

Analysis 2 - 318000E

2.1 Field condition

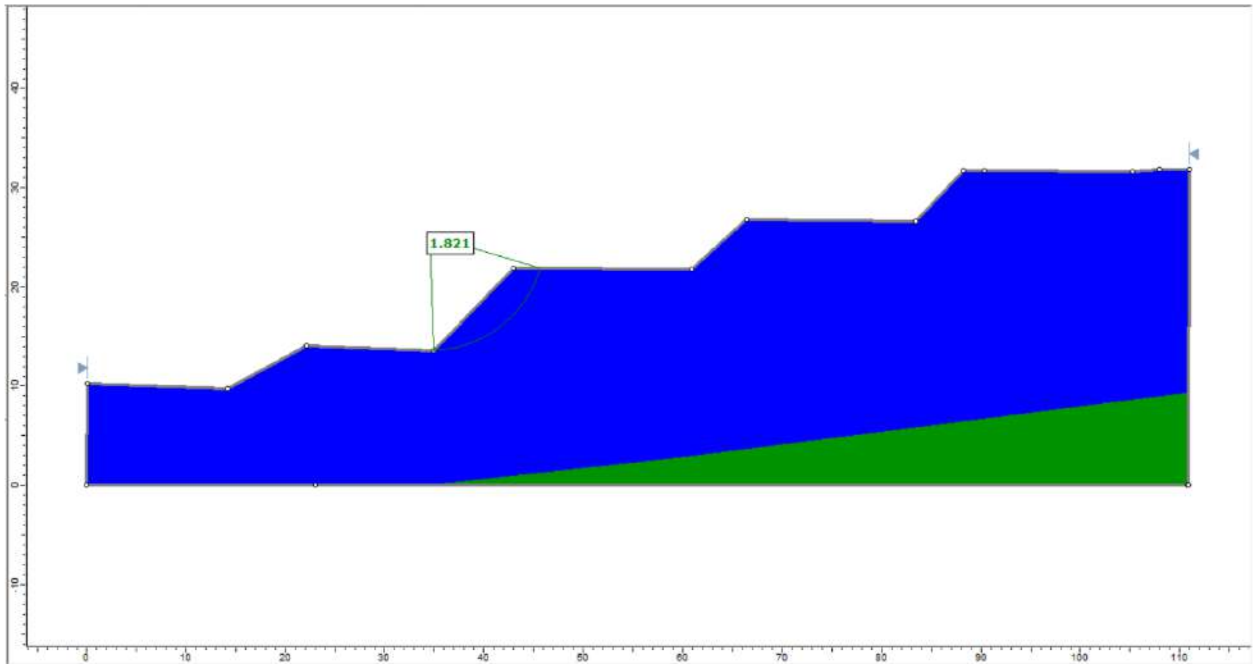


Figure 38 slope stability analysis of a friable ore slope showing FOS of 1.821

2.2 Saturated condition

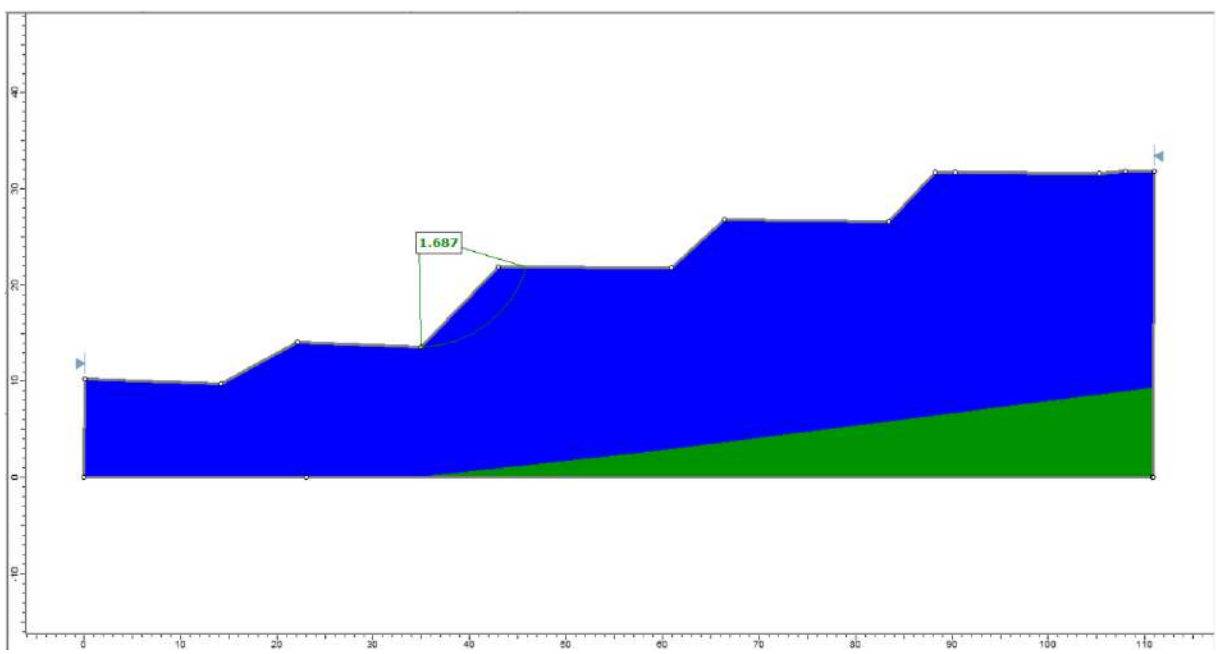


Figure 39 slope stability analysis of a friable ore slope showing FOS of 1.687

Analysis 3 - 318100E

3.1 Field condition

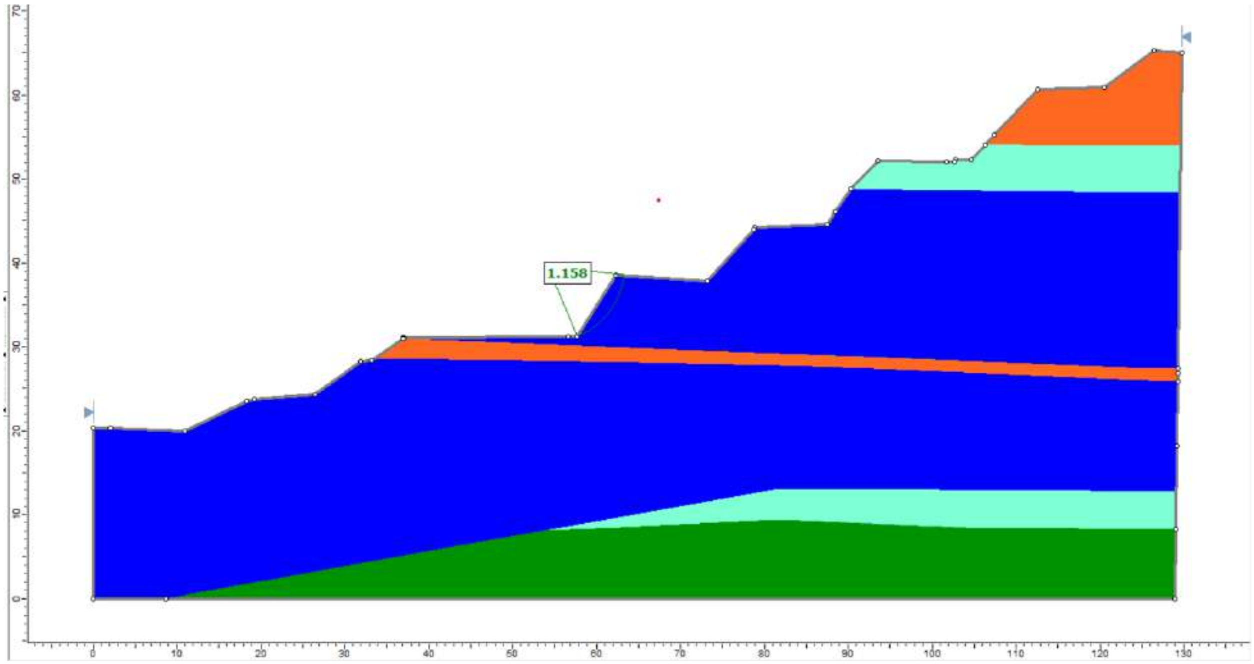


Figure 40 slope stability analysis of a friable ore slope showing FOS of 1.158

1.2 Saturated condition

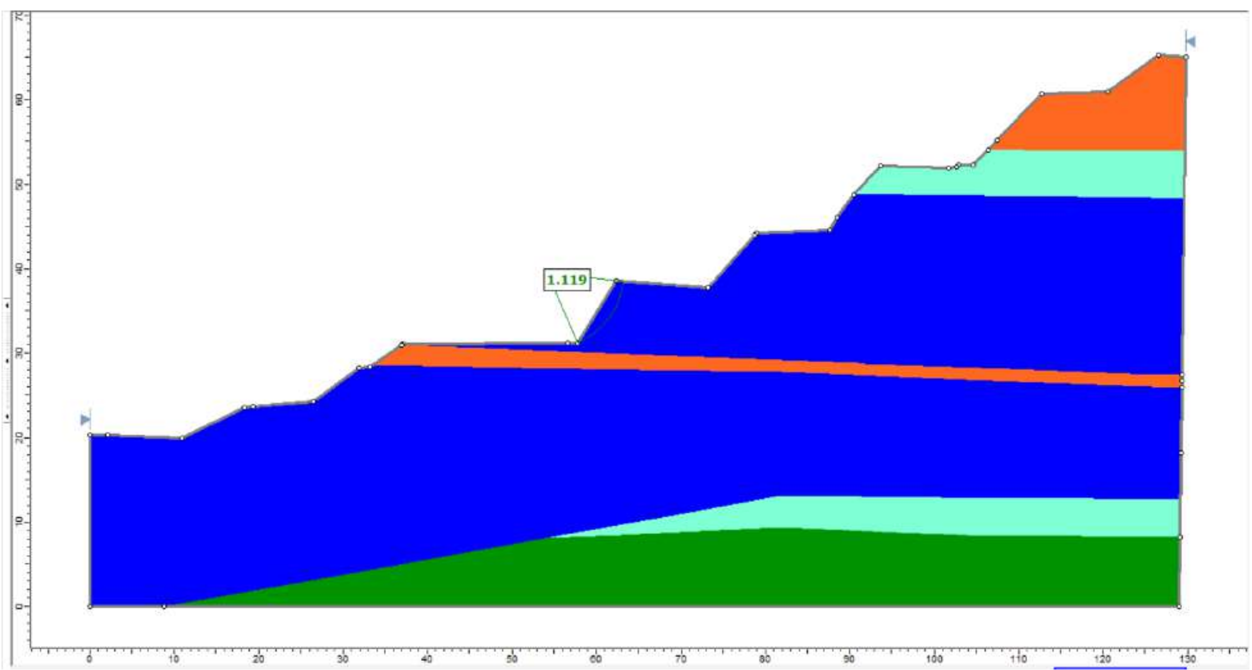


Figure 41 slope stability analysis of a friable ore slope showing FOS of 1.119

1100N

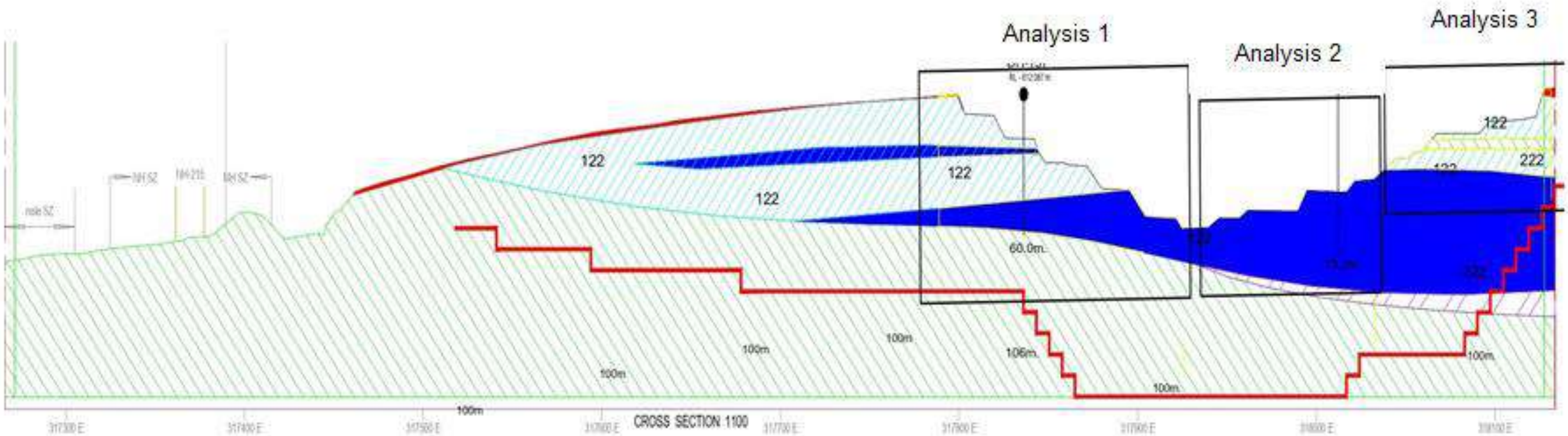


Figure 42 Narayanposhi section 1100N

HARD LAMINATED ORE
FRIABLE ORE
SHALE
LIMONITE
LATERITE
LATERITIC IRON ORE
GEOTHITE
BHJ-BHQ
SOFT LAMINATED ORE

Analysis 1 - 317850E CROSS SECTION 1100

1.1 Field condition

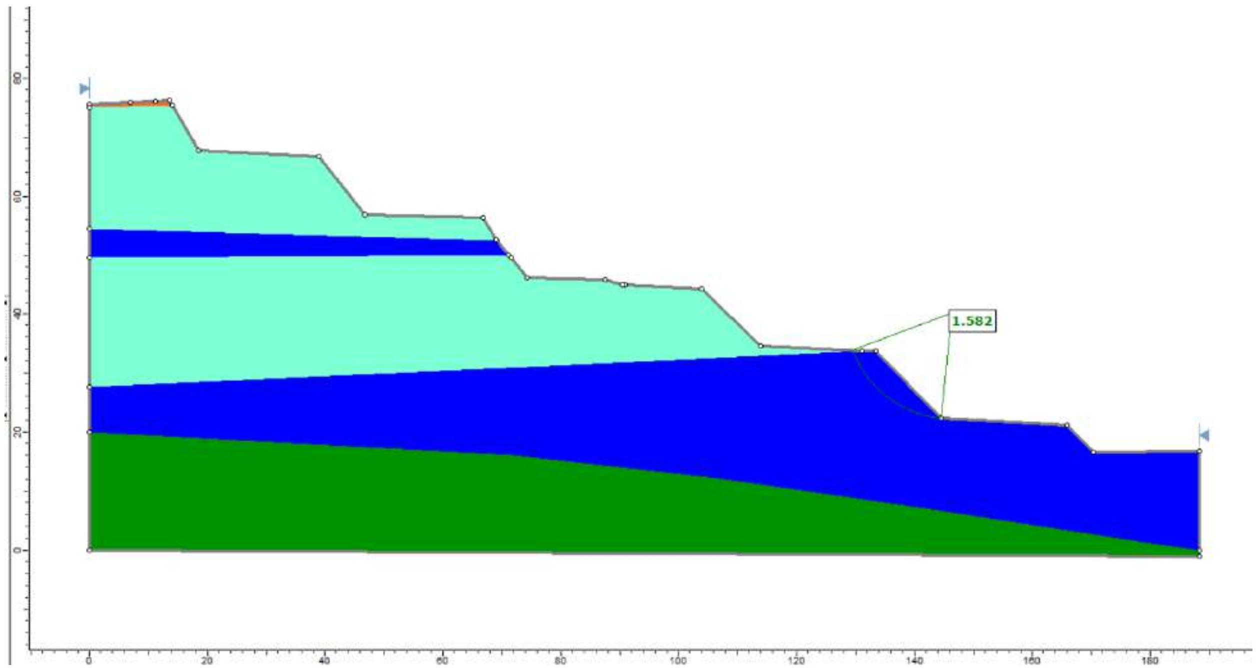


Figure 43 slope stability analysis of a SLO and friable ore slope showing FOS of 1.582

1.2 Saturated condition

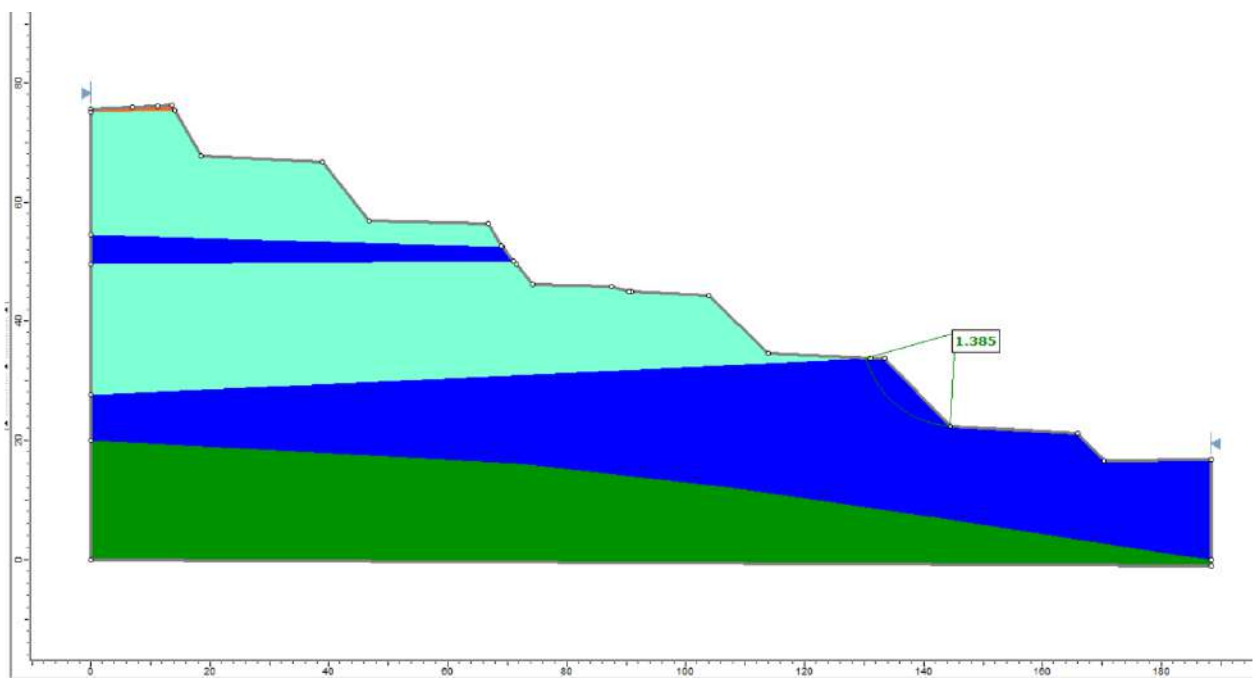


Figure 44 slope stability analysis of a SLO and friable ore slope showing FOS of 1.385

Analysis 2- 318000E

2.1 Field condition

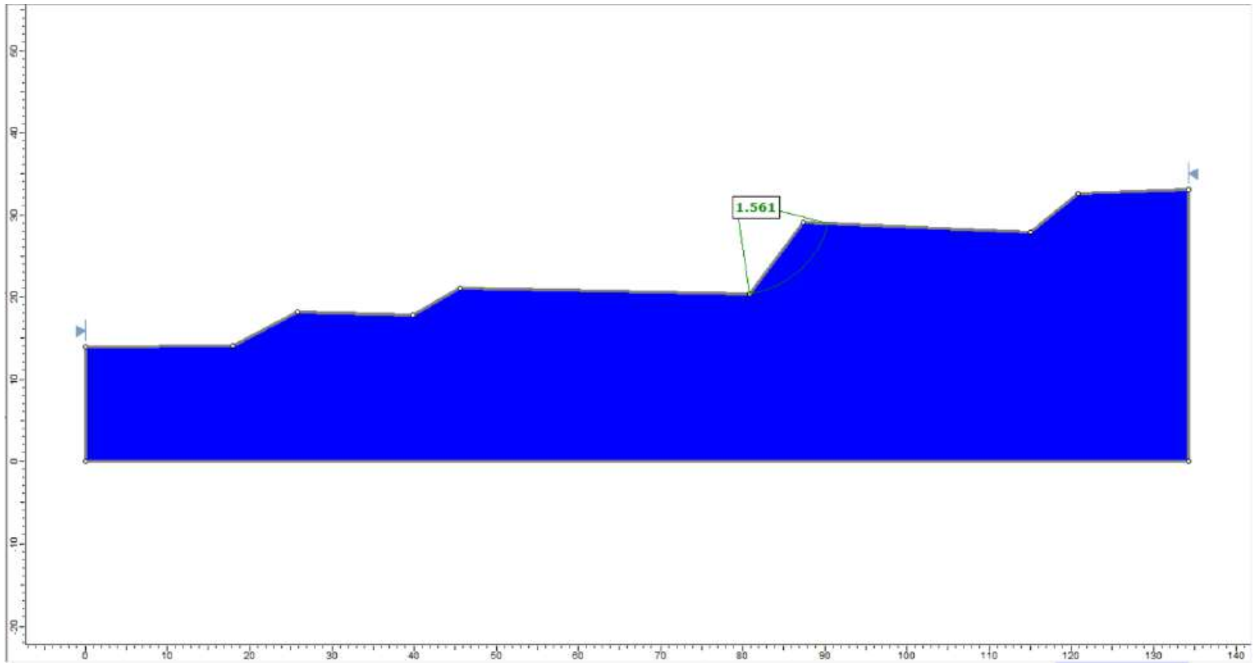


Figure 45 slope stability analysis of a friable ore slope showing FOS of 1.561

2.2 Saturated condition

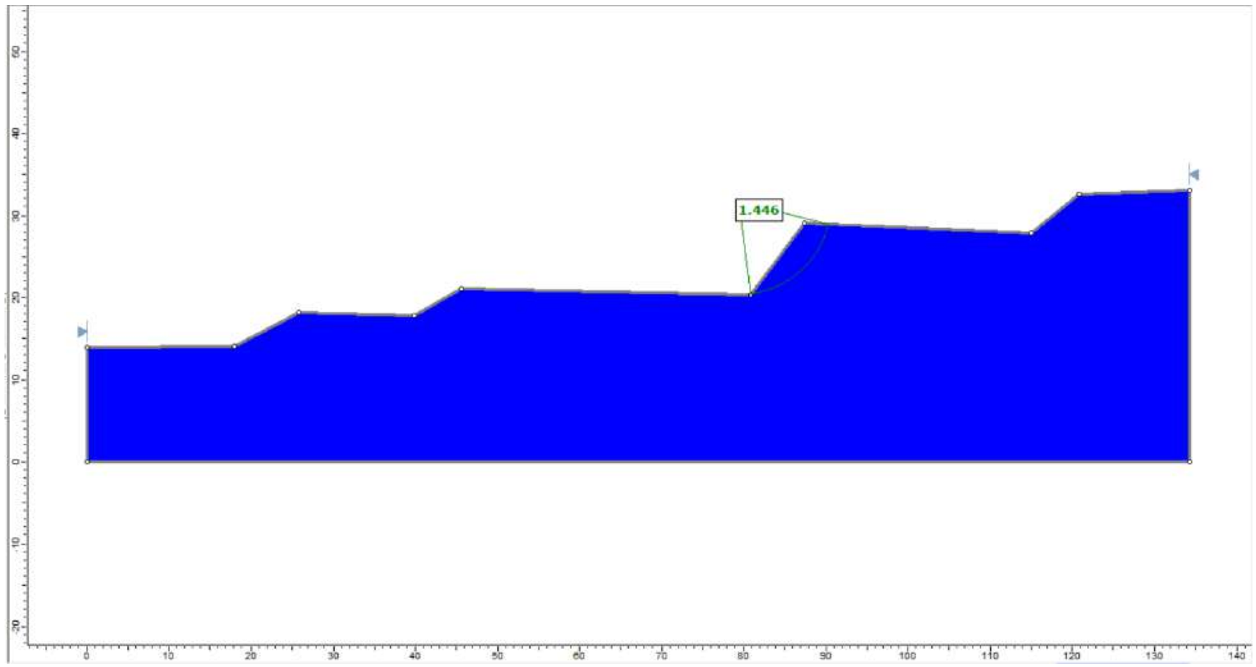


Figure 46 slope stability analysis of a friable ore slope showing FOS of 1.446

Analysis 3 - 318100E

3.1 Field condition

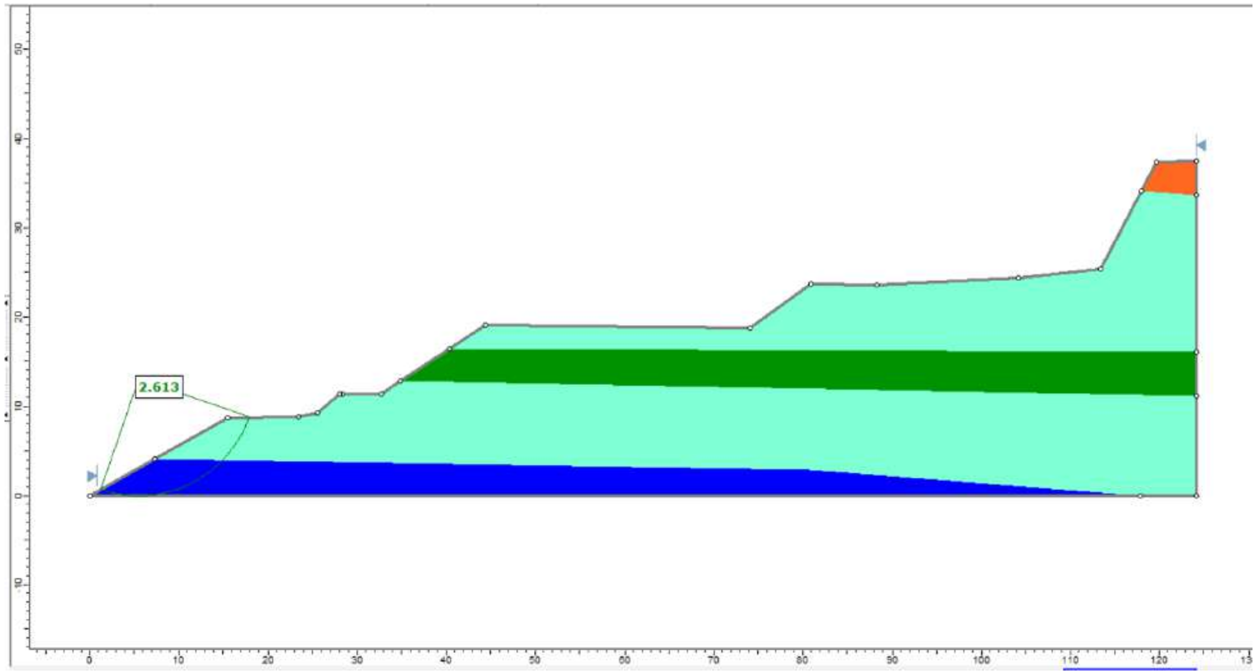


Figure 47 slope stability analysis of a SLO and friable ore slope showing FOS of 2.613

3.2 Saturated condition

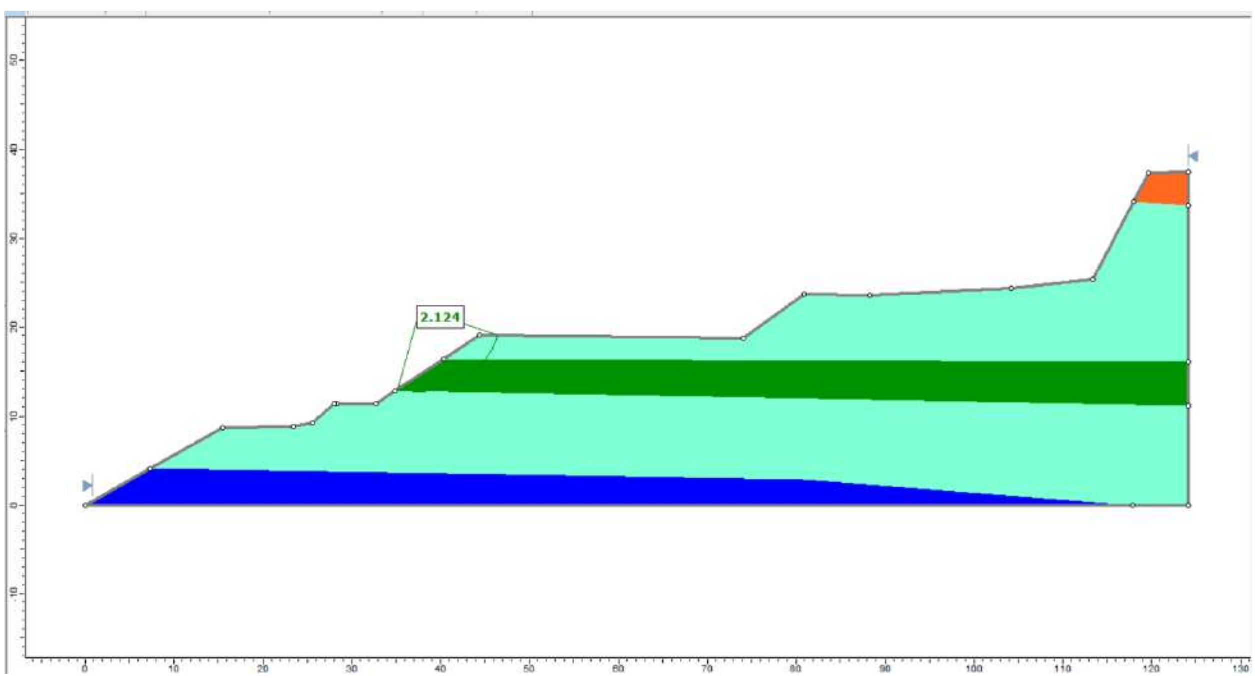


Figure 48 slope stability analysis of a SLO and friable ore slope showing FOS of 2.124

1000N

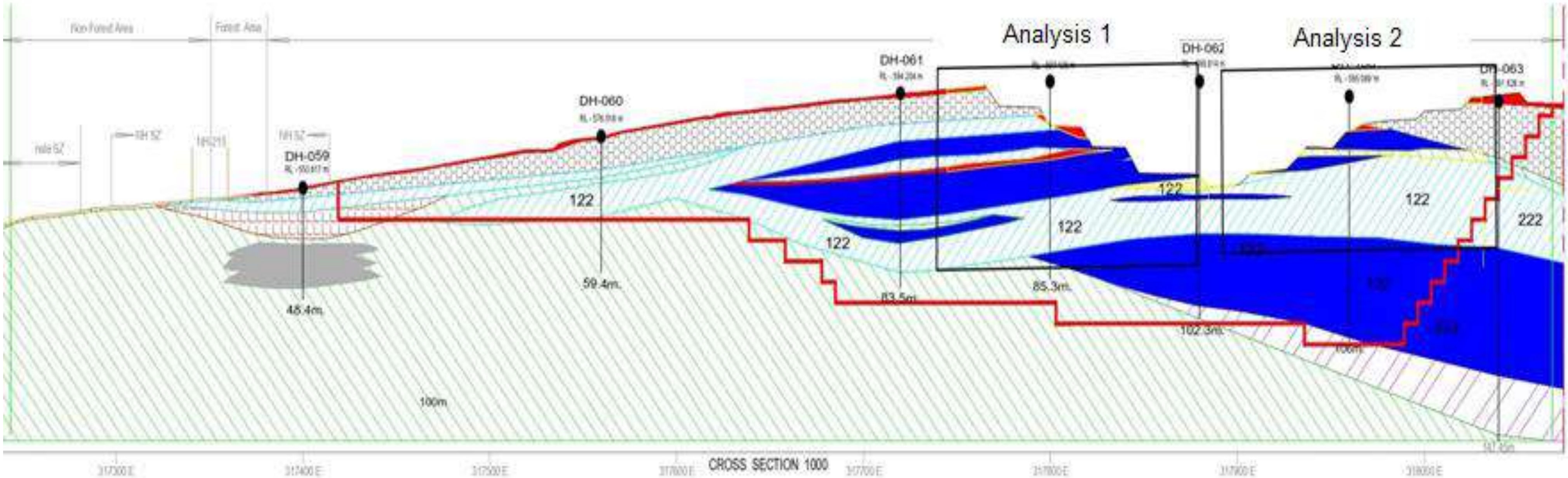


Figure 49 Narayanposhi section 1000N

HARD LAMINATED ORE
FRIABLE ORE
SHALE
LIMONITE
LATERITE
LATERITIC IRON ORE
GEOTHITE
BHJ-BHQ
SOFT LAMINATED ORE

Analysis 1 - 317800E CROSS SECTION 1000

1.1 Field condition

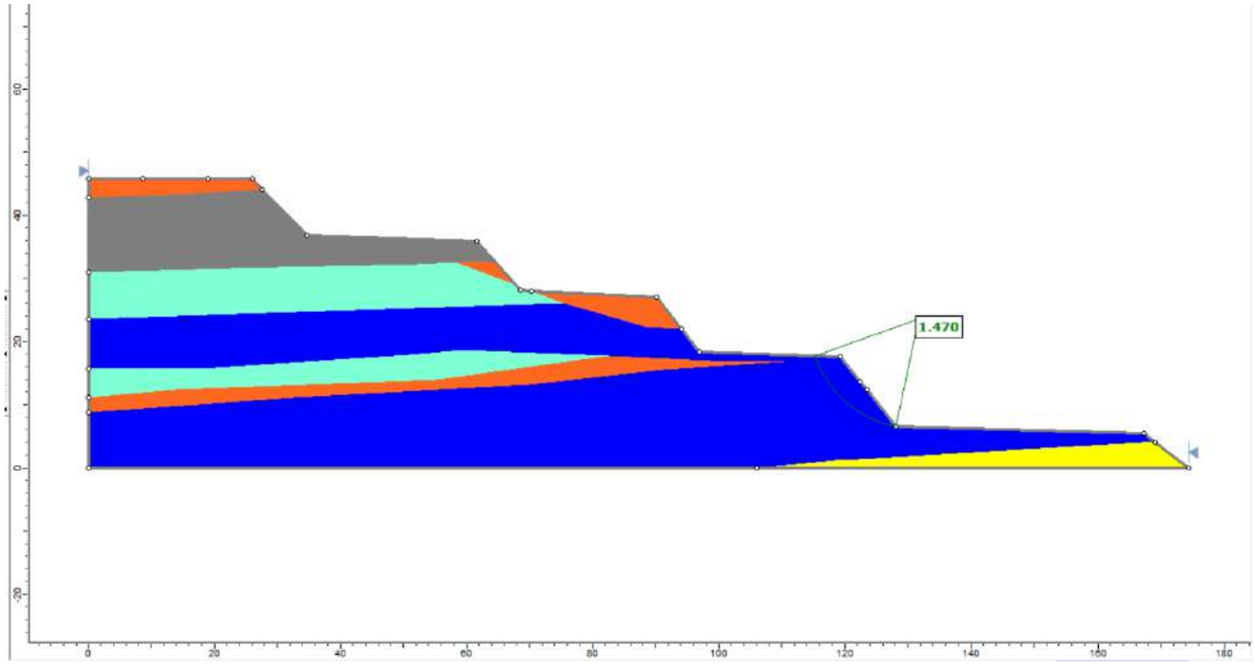


Figure 50 slope stability analysis of a friable ore slope showing FOS of 1.470

1.2 Saturated condition

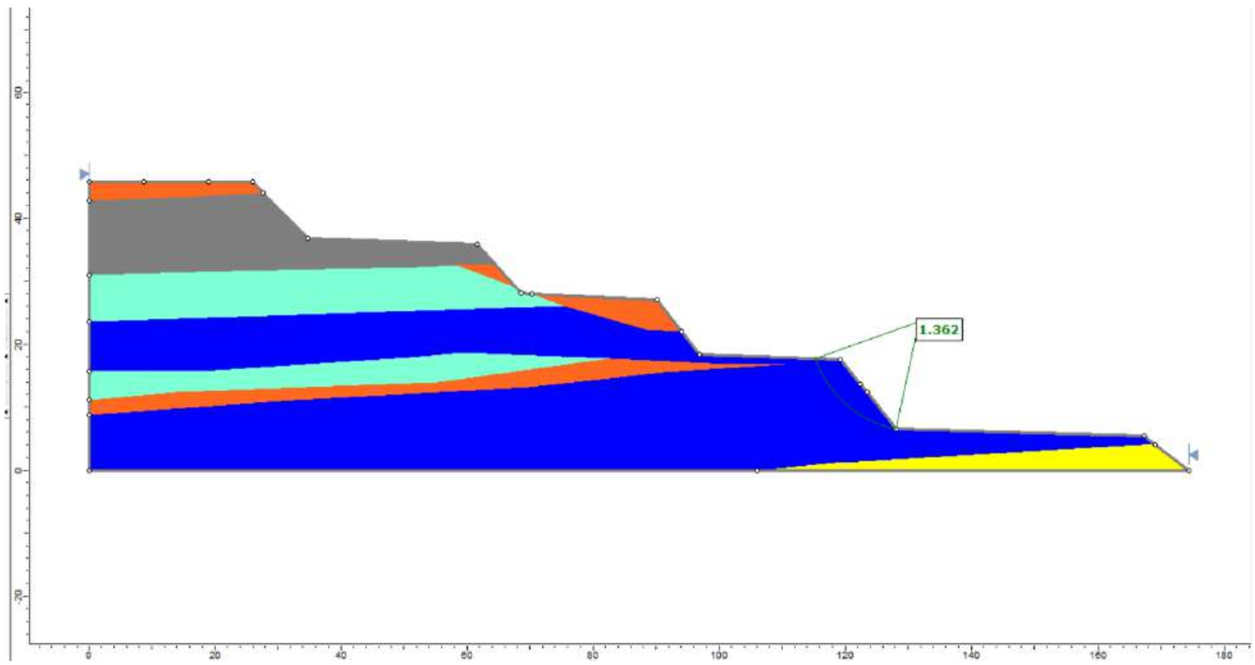


Figure 51 slope stability analysis of a friable ore slope showing FOS of 1.362

Analysis 2

2.1 Field condition

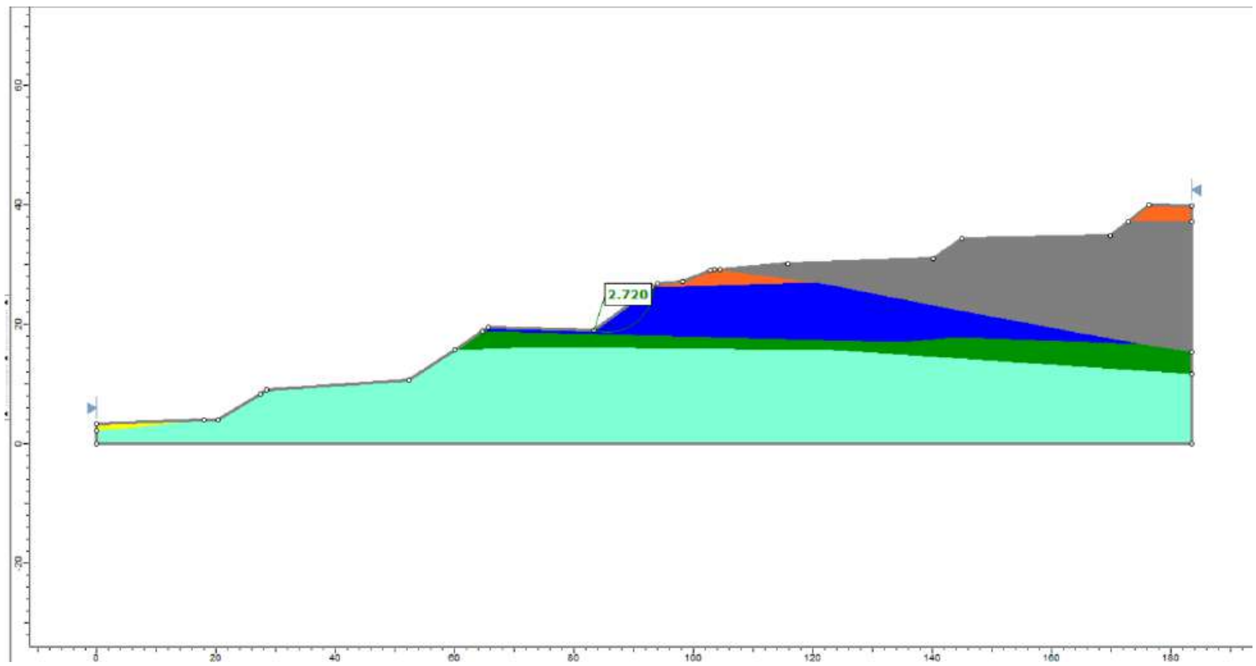


Figure 52 slope stability analysis of a Shale and friable ore slope showing FOS of 2.720

2.2 Saturated condition

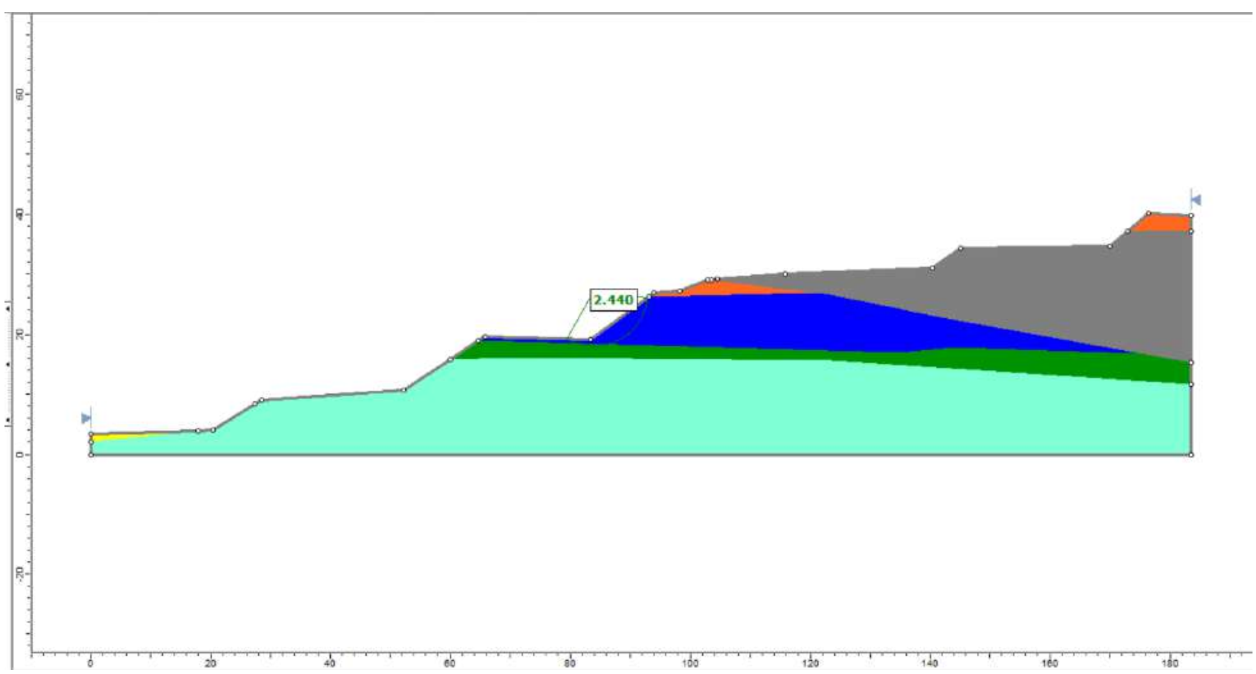


Figure 53 slope stability analysis of a Shale and friable ore slope showing FOS of 2.440

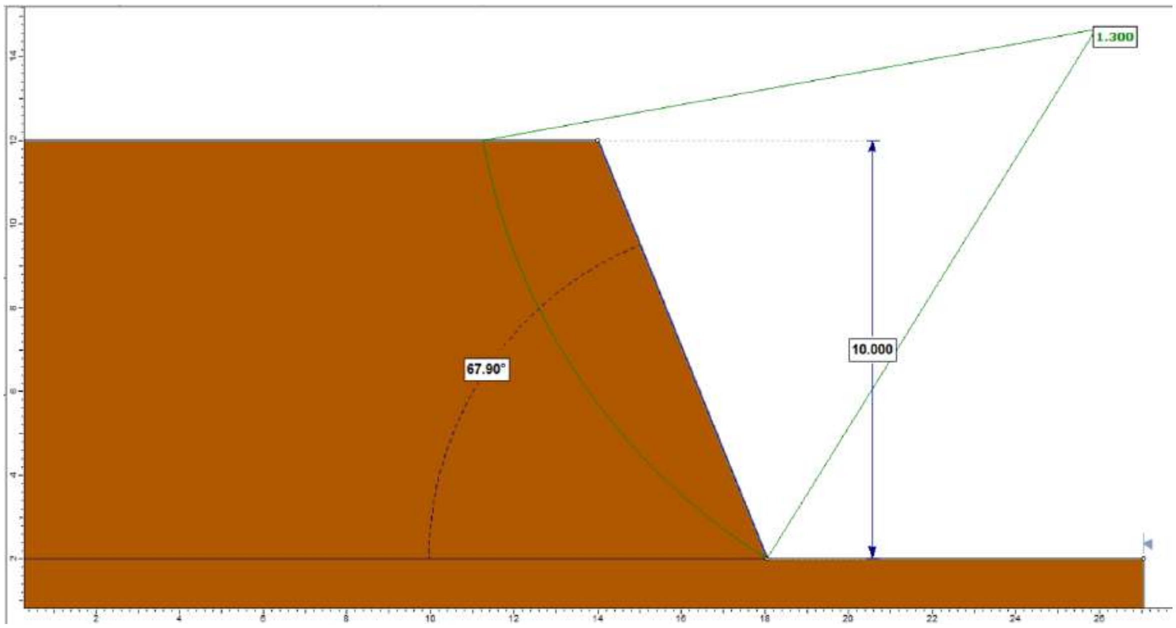
Section	Analysis	Failure Material	FOS	Figure
2200	1.1 Dry conditions	Shale+Laterite+Friable Ore	1.669	2
	1.2 Saturated conditions	Shale+Laterite+Friable Ore	1.413	3
	2.1 Dry conditions	Shale+ Friable Ore	2.982	4
	2.2 Saturated conditions	Shale+ Friable Ore	2.589	5
	3.1 Dry conditions	Shale+ Friable Ore	2.251	6
	3.2 Saturated conditions	Shale+ Friable Ore	1.579	7
2000	1.1 Dry conditions	SLO + Lateritic Ore	5.252	9
	1.2 Saturated conditions	SLO + Lateritic Ore	3.683	10
	2.1 Dry conditions	Friable Ore	3.320	11
	2.2 Saturated conditions	Friable Ore	3.090	12
	3.1 Dry conditions	Friable Ore	1.564	13
	3.2 Saturated conditions	Friable Ore	1.449	14
1900	1.1 Dry conditions	SLO	2.854	16
	1.2 Saturated conditions	SLO	1.395	17
1800	1.1 Dry conditions	SLO	10.140	19
	1.2 Saturated conditions	SLO	6.605	20
	2.1 Dry conditions	SLO + Lateritic Ore	1.887	21
	2.2 Saturated conditions	SLO + Lateritic Ore	1.419	22
1400	1.1 Dry conditions	Laterite + Shale	2.527	24
	1.2 Saturated conditions	Laterite + Shale	2.236	25
	2.1 Dry conditions	Laterite	4.418	26
	2.2 Saturated conditions	Laterite	4.272	27
1300	1.1 Dry conditions	SLO + Friable Ore	1.870	29
	1.2 Saturated conditions	SLO + Friable Ore	1.476	30

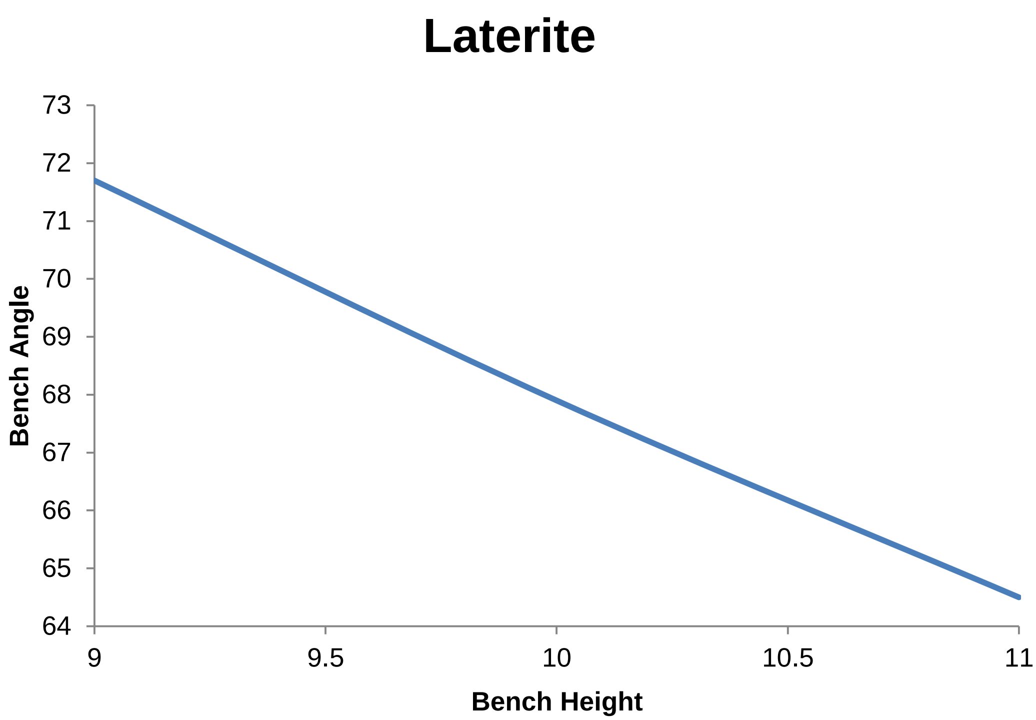
	2.1 Dry conditions	SLO + Friable Ore	1.694	31
	2.2 Saturated conditions	SLO + Friable Ore	1.487	32
	3.1 Dry conditions	SLO + Friable Ore	2.309	33
	3.2 Saturated conditions	SLO + Friable Ore	1.740	34
1200	1.1 Dry conditions	Friable Ore	1.708	36
	1.2 Saturated conditions	SLO + Friable Ore	1.496	37
	2.1 Dry conditions	Friable Ore	1.821	38
	2.2 Saturated conditions	Friable Ore	1.687	39
	3.1 Dry conditions	Friable Ore	1.158	40
	3.2 Saturated conditions	Friable Ore	1.119	41
1100	1.11 Dry conditions	SLO+ Friable Ore	1.582	43
	1.2 Saturated conditions	SLO+ Friable Ore	1.385	44
	2.11 Dry conditions	Friable Ore	1.561	45
	2.2 Saturated conditions	Friable Ore	1.446	46
	3.11 Dry conditions	SLO+ Friable Ore	2.613	47
	3.2 Saturated conditions	SLO+ Friable Ore	2.124	48
1000	1.11 Dry conditions	Friable Ore	1.470	50
	1.2 Saturated conditions	Friable Ore	1.362	51
	2.11 Dry conditions	Shale + Friable Ore	2.720	52
	2.2 Saturated conditions	Shale + Friable Ore	2.440	53

RECOMMENDATIONS

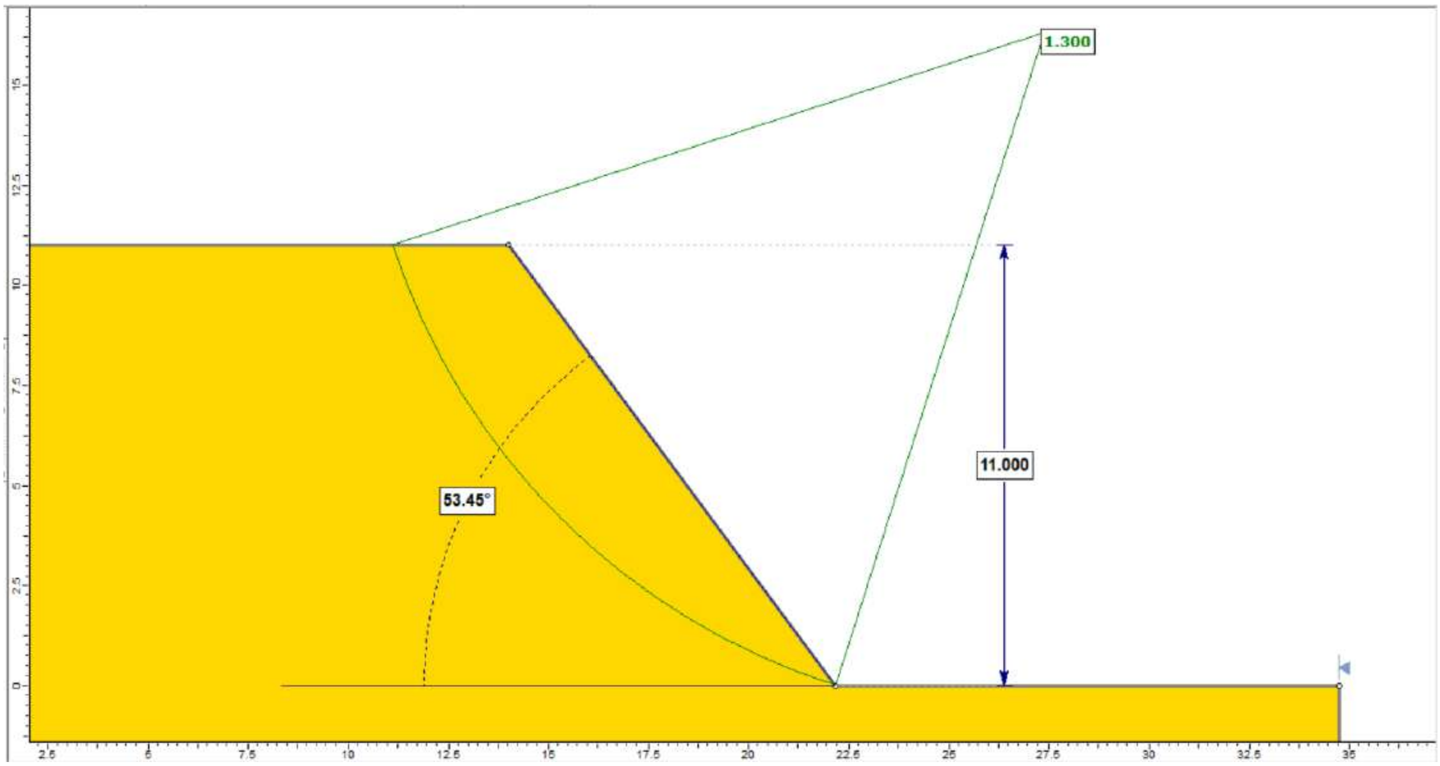
The objective is to find the ideal bench parameters for probable failure material profiles. Models were designed and analyzed to achieve optimum bench dimensions for the specific material profile. The characteristic Models with a constant bench height having a safety factor of 1.3 are shown below with their corresponding slope angles. Additionally, graphs were attached to showcase a relation between optimum bench parameters and FOS. With the help of the trend line, the optimal bench angle corresponding to the existing bench height to attain a safety factor of 1.3 can be determined.

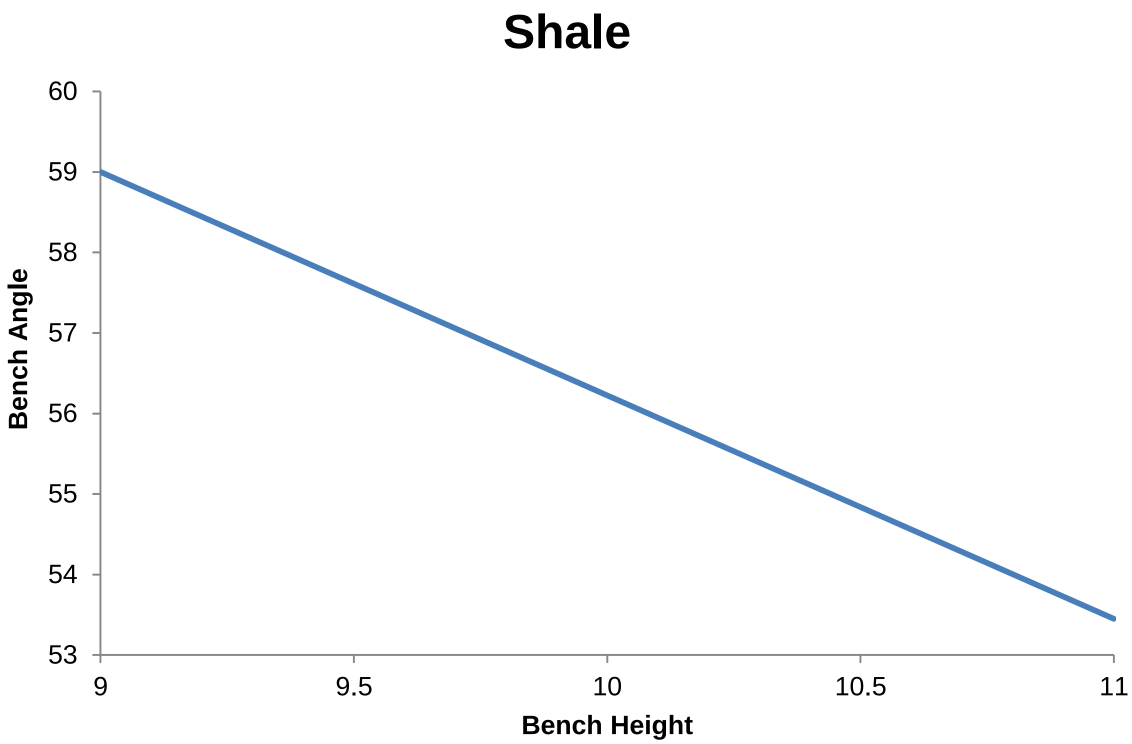
<u>LATERITE</u>



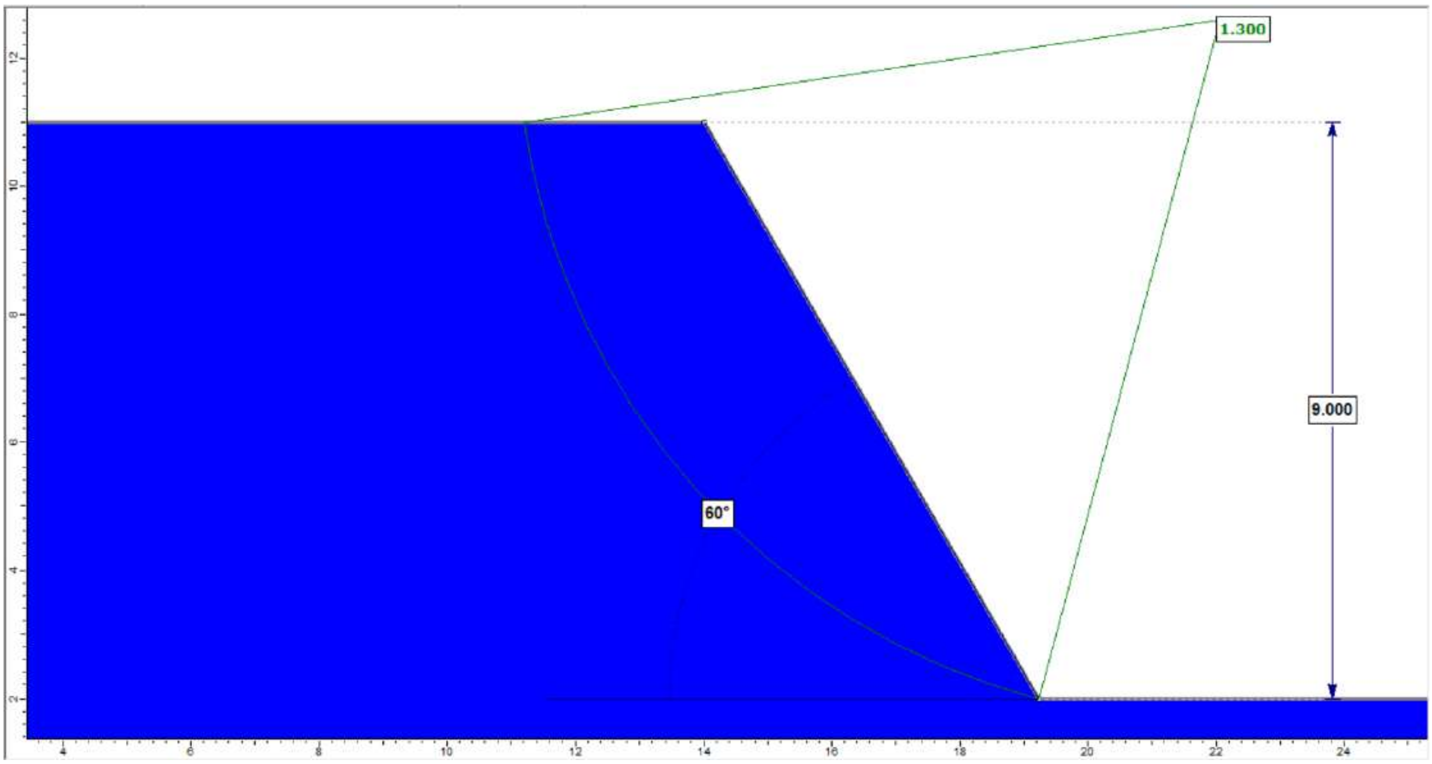


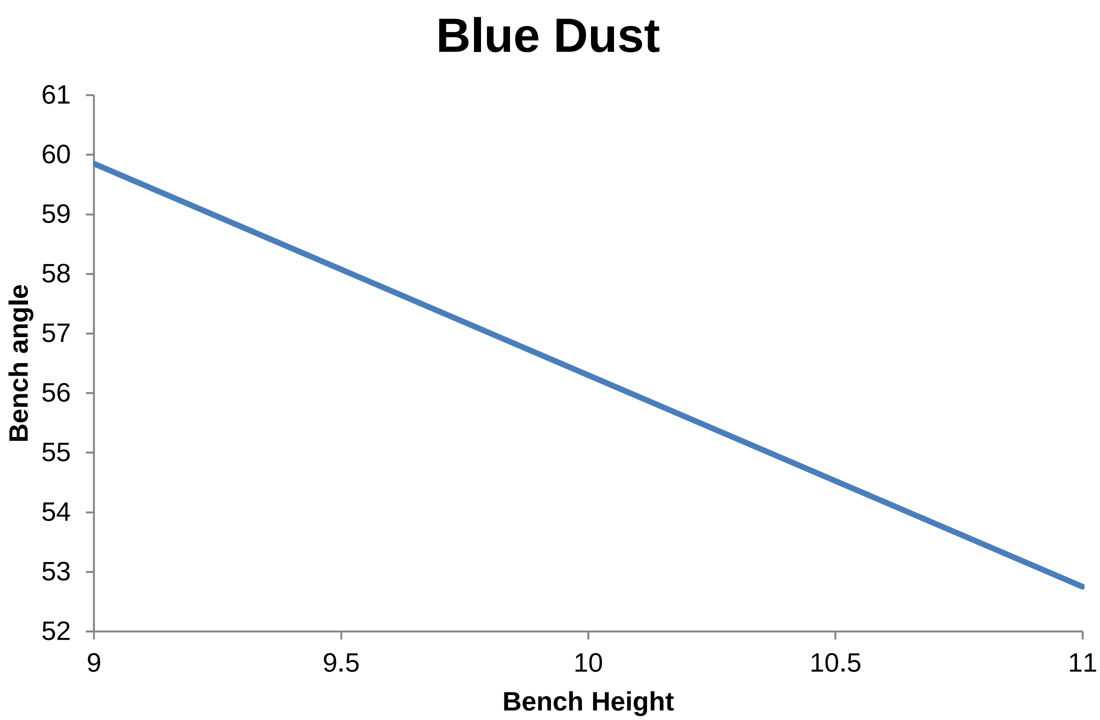
SHALE


1.300
11.000
53.45°
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25
27.5
30
32.5
35

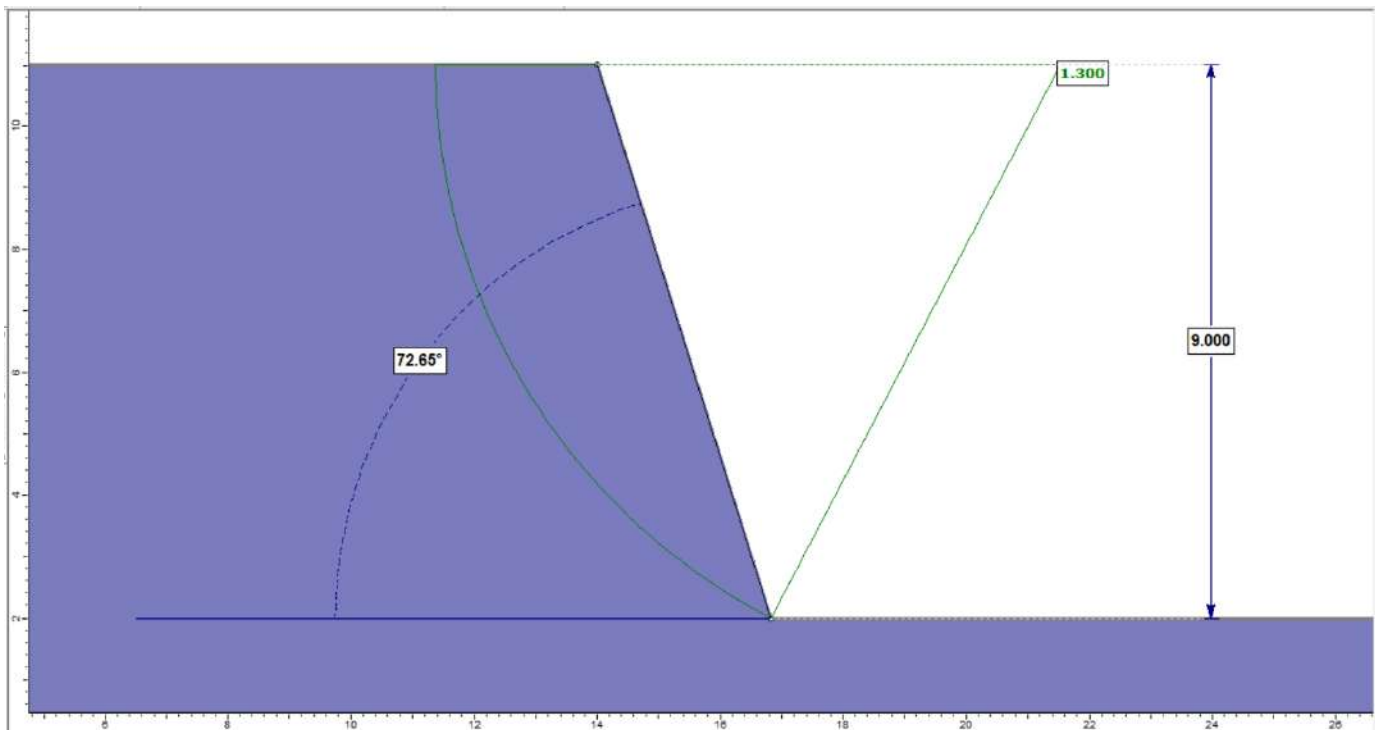

Shale
Bench Angle
Bench Height
60
59
58
57
56
55
54
53
9
9.5
10
10.5
11

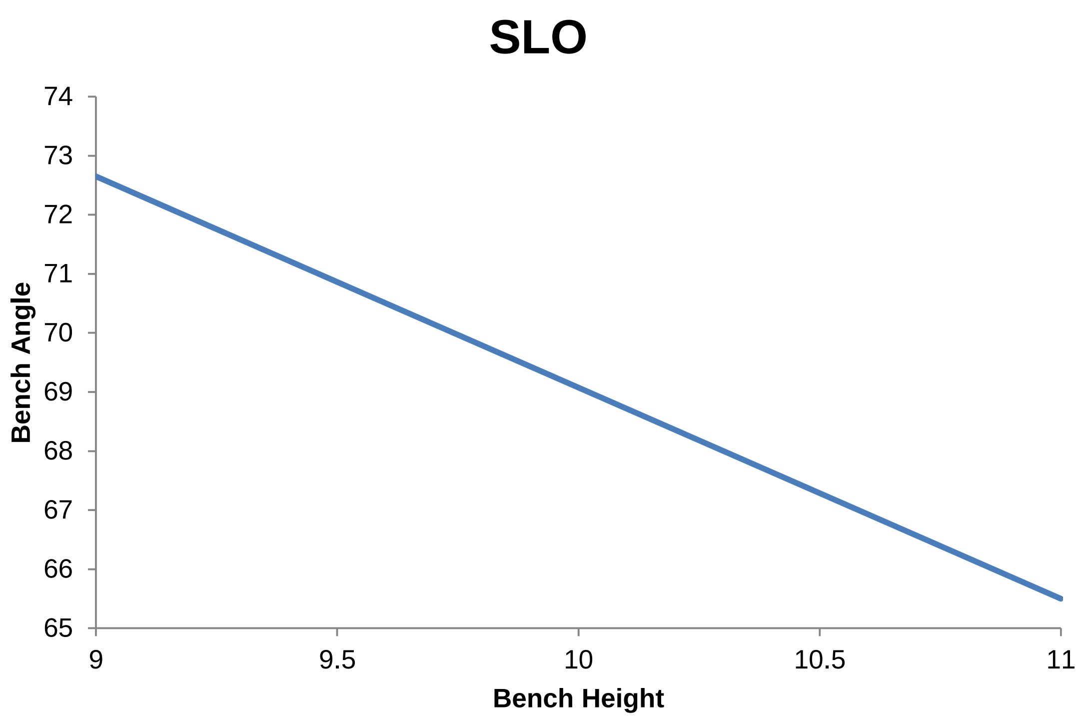
<u>BLUE DUST</u>


1.300
9.000
60°


Blue Dust
Bench angle
Bench Height
61
60
59
58
57
56
55
54
53
52
9
9.5
10
10.5
11

SLO


1.300
72.65°
9.000
6
8
10
12
14
16
18
20
22
24
26
2
4
6
8
10


SLO
Bench Angle
Bench Height
74
73
72
71
70
69
68
67
66
65
9
9.5
10
10.5
11

Precautionary Measures

Unanticipated movement on the ground can pose hazardous condition that may harm lives, equipment and properties. There are several ways to reduce chances of surface ground failure as (a) safe geotechnical design, (b) secondary support or rock fall catchment system, and (c) maintaining devices for advance warning of impending failure. Proper bench design can minimize rock fall hazards. Certain support system may enhance overall rock mass strength. The analysis shows that no large scale failure is possible thoughlocalised bench failure cannot be ruled out. Those should be arrested by lower benches and hence access of machineries should be maintained.

2.1 Drainage and Water Management

Rainwater plays a adverse role in mine slope stability. So care should be made to avoid entry of rainwater in the slope. So, suitable drainage facility should be made in and around the mine and waste dump. Drains should be properly maintained. Drain channels should be inspected regularly to keep the path free from debruises. Effectiveness of drainage may be maintained by piezometers and other instruments to check the functioning.

Rainwater should not be allowed to accumulate or left unattended. Effective garland drain should be provided around pit and waste dumps. Maintaining a proper gradient should help in quick run off of water. Surface run off and sub surface water adds to instability.

Grasses have very high binding capacity and help in long term stabilisation. It also helps in reducing the water pressure due to evapo-transmission.

2.2 Water management

Rainwater of the adjacent areas should not be allowed to enter the mine pit. It would cause erosion and deep gullies. So rainwater catchment area should be channelled away to other areas. The upper surface of the mine and dump should be adequately graded to divert he run off of rain water away. Therefore, proper levelling and grading of surface should be carried out. Regular and continuous maintaining should be done to check the flow path of rainwater and to take immediate remedial measures. Rainwater in the dump should be channel down effectively through effective toe drain arrangement.Subsurface drainage system or sub drains should remove subsurface water directly from an unstable slope, to redirect adjacent ground water sources away and to reduce hydrostatic pressure.

2.3 Stability of Benches

Pit walls often experience vibration due to poor blasting operations. Uncontrolled blasting results in over brakes, widening of existing cracks/joints, creation of fresh cracks etc. Those become critical to the stability of pit slopes. Therefore, a properly designed and controlled blasting should be carried out. Controlled blasting with closely spaced or carefully designed drill holes, properly selected explosives, and sequential detonation should be adopted.   The control blasting can be achieved by broadly by (i) using an explosive with a relatively low detonation velocity, and (ii) maintaining air gap between the explosive and the wall of drill hole. The mine authority is recommended to go for scientific study for this.

2.4 Slope Monitoring

Three general principles of slope geo-mechanics that govern slope stability are (Kliché, 1999)

a. Slope failures do not occur spontaneously
b. Most slope failures tend towards equilibrium
c. A slope failure does not occur without warning

The slope should be regularly monitored to observe any instability in advance so as to avoid any damage to men and machineries. The instability if detected at early stage can be addressed by adopting suitable remedial measure. In general, slope stabilisation involves continuous monitoring of the slopes to detect any movement. The guidelines given in the gazette of Indian extraordinary part –II, section 3, Subsection-1, New Delhi Feb 21, 2020 for mine workings should be followed. There should be a team of dedicated skilled persons with proper training for slope monitoring exercises. Slope stabilisation schemes as grading, serrating, benching, arresting rock falls, and other measures should be adopted. Slope monitoring mechanism varies widely from a simple visual observation of signs of instability to use of state of art instrumentation. Regular surveying of other benches and their movement both horizontal and vertical can be carried out to determine potential instability.

Determination of simple displacement by tension cracks mapping, extensometers and survey points are some of the cost effective monitoring method. Typically, all these methods should be adopted as no single method represent the whole behaviour accurately. Systematic mapping of tension cracks show geometry of the failure more effectively. All cracks should be mapped regardless of apparent cause. The end of the cracks should be flagged or marked so that new cracks or extensions of existing cracks can be identified. Portable wire extensometers provide monitoring in areas of active instability across tension cracks. The extensometers should be positioned on stable ground behind the last visible tension crack and the wire should extend to the unstable area. Anyone working in the area can check on slope movement by inspecting the instruments. The monitoring of prism targets with the total station provide detailed movement history for displacement and rates in the unstable areas.

2.5 Monitoring Schedule

A well designed and developed monitoring schedule should be established. Frequency of monitoring depends on precision, rate of movement and how critical the area is. If there is heavy rain or a large blast in the area, additional measurement should be made. Mines should attempt to establish measurement of surface movement through survey network. The network should consist of target areas/locations/sections (e.g. prism shape) placed on and around area of anticipated instability on slopes and one or more non-moving contact points for survey stations. The angles and distances from the survey stations to the locations/areas/sections should be measured on regular basis to establish history of movement on slope. The permanent control points for the survey stations should be placed on stable ground.

2.6 Tension Cracks

The formation of cracks at the top of a slope, specifically on dump sections exhibits the sign of instability. The measurement and monitoring of the changes to crack width and its direction of propagation establish the extent of the unstable area. Existing cracks may be identified with clear identification so that new cracks can be easily identified.

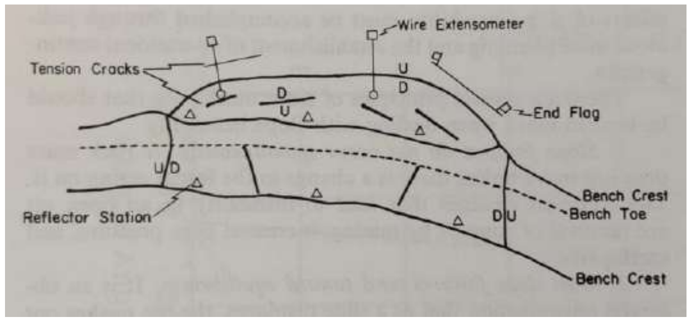


Figure 17. Methodology to measure tension crack (after Call, 1982)

Measurements of tension cracks can be carried out simply by driving two stakes or either side of it and measuring its separation over time. Portable wireline extensometer is another method of monitoring tension crack behaviour.

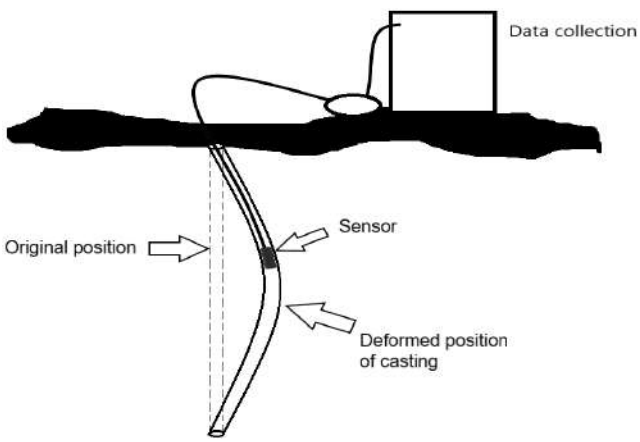


Figure 18: Cross-sectional schematic of typical traverse-probe inclinometer system

Inclinometer is another equipment to monitor ground movement specifically in horizontal direction (fig 16, pp). The end of the casing is fixed to a stable part. The groves has sensing units and the deflection of casing reflects the movement of rock mass. Inclinometers provide information on

- Location of shear zones
- Natures of shear along the zone plan rotational

- Measurement along shear zones and predict its rate i.e. constant, accelerating or decelerating

Borehole extensometer is another technique to monitor slope movement. It consists of tensioned rods anchored at varying points in the borehole (Fig 18). Changes in the distance between the anchor and the rod head give the movement information for rock mass.

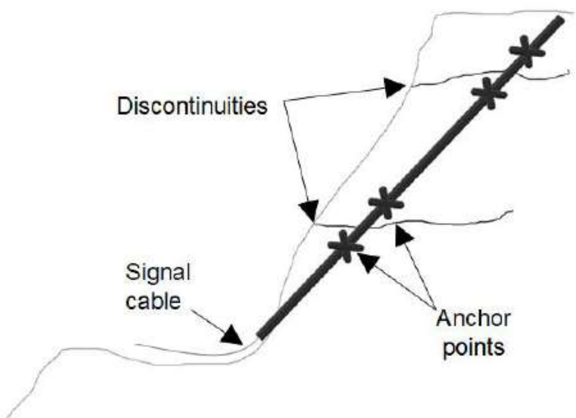


Figure 19: Multi-point borehole extensometer

TDR (Time Domain Reflectometry) is a recent approach that uses electronic pulses through coaxial cable. Signal at the deformation or break in cable position gives information on the subsurface rock mass behaviour.

2.7 <u>Piezometers</u>

The effectiveness of mine dewatering schemes and the effects of seasonal variations can be determined by piezometers. Excessive pore pressure, water infiltration in particular at geological boundaries cause slope failures. So data on water pressure development should be maintained regularly. Highwalls and other potential faces should be examined regularly for new seeps or changes in water flow rate.

Stress, gravity loading, rock mass strength, geology, pore pressure as well as many other factors contribute to slope failure. Complete attention to monitor each and every potential failure block is neither feasible not economical and often not attainable with conventional point displacement monitoring techniques. As mining activities progress, it becomes important to monitor different sections of the pit walls. So, frequent relocation of survey devices can be challenging. One recent advancement that is being experimented with success is synthetic aperture radar (SAR). It can generate high quality digital elevation maps (DEMs) and detect disturbances of earth's surfaces. There are a few variations of the same that are being developed that can take continuous images in almost all weather and time conditions. Those may be explored by the mine management.

3.0 Conclusions and Recommendations

The following conclusion and recommendations are made with reference to the slope stability investigation carried for Narayanposhi iron ore mine.

1. There is no challenge due to ground water at the mine. However, steps are recommended to have an effective garland drain / bund all around to collect/ divert run off rain-water of the catchment area before it reaches the mine slopes. The drains should be kept clear of silt and debris.

2. There should be regular mapping of the weak zones, faults and bedding planes of the pit by geologist and data should be used for further analysis of slope stability for different geo-mining condition. It will facilitate to detect any unfavorable conditions at different stages of mining.

3. Mining and excavation activities change the physical dimension of the system. So regular scientific study should be carried out for safety factor analysis of the pit as well as dump sections, say every 5 to 6 years or if significant alteration of system happens or change in geological structural features observed.

4. Mine management should make a dedicated team of trained and competent persons for slope monitoring with clearly defined duties and responsibilities DGMS (Tech). Circular No. 2 of 2020 dated 09.01.2020. The monitoring should be done periodically at least once a month and the results of the monitoring should be recorded. The monitoring data should be regularly

analyzed to predict the slope movement or instability well in advance. In case of need/ help or advice may be sought from expert agencies in the field of slope stability and slope monitoring.

5. The open cracks, whenever develop, the partially consolidated new pump mass should be consolidated with the help of dozer/ compactor followed by proper levelling of the benches so that entry of water in cracks is minimized. It will help to consolidate the dumped material and will minimize filtration of water inside slopes.

6. During rainy season, an officer should be deputed for regular visual observation around the mine and dump to see the effectiveness of drains. If any blockage is observed, immediately steps should be taken to make it effective. If any tension crack is detected in the pit/dump, the entry of water inside the crack should be checked.

7. Recommendations stipulated in the report should be implemented in total and under the supervision of a competent scientific agency.

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Occupational Health Centre

JSW, JAJANG
BARBIL, KEONJHAR
REG NO- KEO/00036/2022

JSW Steel Limited

Regd. Office: JSW Centre
Bandra Kurla Complex,
Bandra (East), Mumbai – 400 051
CIN : L27102MH1994PLC152925
Phone : +91 22 4286 1000
Fax : +91 22 4286 3000
Website : www.jsw.in

NARAYANPOSHI IRON AND MANGANESE ORE MINES

Medical Examination

1. After medical examination, it has been found that none of the employee has developed any Persistent Back Pain, Neck Pain, and the movement of their Hip, Knee and other joints have also been found to be normal
2. None of them have found to suffer loss of any body part.
3. It has also been found that no person working within mine lease was suffering from hearing loss.

Dr. Arabinda Satpathy
MBBS, DPHA, DIH, DMCH
Retd. CMO, MCL, Burla
Sambalpur
Regd. No- 12605/BCMR/75

Steel Limited

Regd. Office: JSW Centre
Bandra Kurla Complex,
Bandra (East), Mumbai – 400 051
CIN : L27102MH1994PLC152925
Phone : +91 22 4286 1000
Fax : +91 22 4286 3000
Website : www.jsw.in

NARAYANPOSHI IRON & MANGANESE ORE MINES

SL No.	Commitment Done by AMTC (ex-lessee) during PH	Budget allocated by AMTC	Expenditure by JSW Steel Ltd as on date
1.	Financial provision of Rs. 344.00 lakhs is made for various environmental control measures proposed in this report under capital cost	344 Lakhs	
	a) Air pollution control measures		25 Lakhs
	b) Water pollution control measures		73 Lakhs
	c) Dump management		46 Lakhs
2.	Parking Plaza	15 Lakhs	15 Lakhs
3.	constructing additional 6 new Deep bore Wells	22.5 Lakhs	35 Lakhs
4.	Community Sanitary Toilets and Individual Toilets.	6.5 Lakhs	Proposed in this FY
5.	Education facilities	41 Lakhs	35 Lakhs
6.	School Bus	20 Lakhs	20 Lakhs
7.	Sewing machine and training	18 Lakhs	Proposed in this FY
8.	SHG	18 Lakhs	30 Lakhs
9.	Solar Street Lights	30 Lakhs	15 Lakhs
10.	Upgradation of existing dispensary	47.5 Lakhs	40 Lakhs
11.	Health Clinic Van	20 Lakhs	20 Lakhs

Steel Limited

Regd. Office: JSW Centre
Bandra Kurla Complex,
Bandra (East), Mumbai – 400 051
CIN : L27102MH1994PLC152925
Phone : +91 22 4286 1000
Fax : +91 22 4286 3000
Website : www.jsw.in

OFFICE ORDER

Letter No. JSW/S/CO/23/228

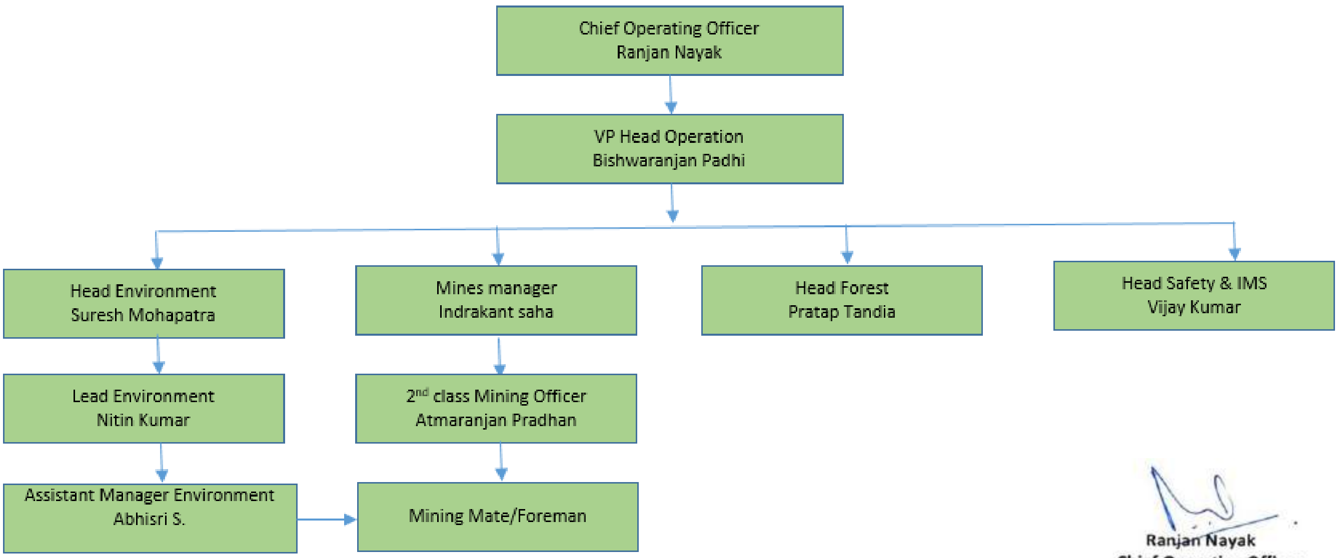
NARAYANPOSHI IRON AND MANGANESE ORE MINES

Environment Management Cell

Environment management cell (EMC) working for the management of Environmental monitoring of the mines and to act upon mitigation measures on the impacts of the production of mine with its surrounding environment so that pollution load, water and air quality can be maintained. Key functioning of EMC would be for compliance monitoring and to adhere with Environmental aspects and issues of the project during operation phase. EMC created with an objective of organizational framework for operating Environment Management System (EMS) and other functions of responsibilities for environmental betterment; and formulating Environmental Action Plans (EAPs) which specify mitigation, periodic and annual monitoring activities during project implementation and operation phase of mining.

The potential activities structured for the control mechanism by EMC, such activities are: Air pollution due to the emission of particulate matter, Gaseous pollutants and fugitive emissions; Noise pollution due to various noise generating equipment and mining activities; Wastewater generation from domestic activities; and Solid waste disposal. In order to minimize these impacts and to ensure that the environment in and around the project site as well as the neighboring population is well protected; an effective environment management plan to be developed and maintained by Environment management cell.

Organogram



Ranjan Nayak
Chief Operating Officer