vedanta
transforming elements

FACOR
FERRO ALLOYS DIVISION

OCM/ENV/503/2021

Dated: 01.11.2021

To

The Joint Director(s)
Ministry of Environment, Forest & Climate Change,
Eastern Regional Office,
Bhubaneswar

Sub.: Submission of Six-monthly compliance report to the conditions stipulated in the grant order of Environmental Clearance (EC) pertaining to Ostapal Chromite Mines of M/s FACOR LTD.

Ref.: MoEF EC Letter No.: J-11015/38/2006-IA II(M) dtd.06-12-2006

Dear Sir,
With reference to the captioned subject & cited reference, we are herewith submitting six monthly compliance reports pertaining to Ostapal Chromite Mines of M/s FACOR Ltd for the period from April'2021 to September'2021 for your kind perusal.
The Weekly, Monthly & quarterly Environmental monitoring data for the period April'2021 to September'2021 comprising AAQ, Water, Noise & Soil are enclosed herewith as Annexures.

This is for your Kind information & necessary action.

Thanking You

Yours faithfully,
for Ferro Alloys Corporation LTD

MINES MANAGER
Ostapal Chromite Mine

Encl.: A/a

GOVT. OF INDIA
MoEF & CC Integrated R.O.
Bhubaneswar-751023
02 NOV 2021
RECEIVED

VEDANTA LIMITED (Formerly known as Sesa Sterlite Limited/Sesa Goa Limited)
Ferro Alloys Corporation Limited, Charge Chrome Plant, D.P. Nagar, Randia - 756 135,Dist. Bhadrak, Odisha, India. Phone : 06784 240320/240347/240272, Fax : 06784 240626.
E-Mail : Facor.corporate@vedanta.co.in | Website : www.facorgroup.in

Name of the Project : **OSTAPALCHROMITEMINES, M/S.FACORLTD.**

Project Code : **Mining (Non-Coal)**

Clearance Letter No. With date : **No.J-11015/38/2006-IA-II (M) dt.06-12- 2006**

Period of Compliance Report : **April'2021 to September, 2021**

Specific Condition:

Sl. No.	Condition	Compliance Status
1.	All the conditions stipulated by the State Pollution control Board, in their Consent to establish should be effectively implemented.	All the stipulated conditions are being effectively implemented.
2.	Necessary forestry clearance under the Forest (Conservation) Act, 1980 for an area of 4.07 hectares forest land shall be obtained before starting mining operation in that area. Till such time mining activities shall be restricted to an area of 64.354 ha for which in principle forestry clearance has been obtained from the Ministry on 03.10.2005	This area is left as Safety Zone area for greenbelt around periphery of forest land of M.L. area and mining operations in this area will not be done.  **Plantation In Safety Zone**
3.	Topsoil should be stacked properly with proper slope at earmarked site(s) with adequate measures and should be used for reclamation and rehabilitation of mined out area.	No topsoil has been generated during the period April'2021 to Sept'2021
4.	Over burden shall be stacked at earmarked dump site(s) only and should not be kept active for long period. The total height of the dump(s) should not exceed 45m in three stages of 15 m each, keeping overall slope of the dumps below 28^0. The proponent shall carry out slope stability study and submit report to the Ministry. The OB dumps should be scientifically vegetated with suitable native species to prevent erosion and surface run off. In critical areas, use of geo textiles shall be taken for stabilization of the dump. Monitoring and management of rehabilitated areas should continue until the vegetation becomes self - sustaining.	The OB is being dumped at earmarked site only & as per the approved Mining Plan. Technical study is also carried out by CIMFR & all the recommendations are implemented. Overall slope is about 27^0. The report has been enclosed as Annexure **No.-1** The inactive benches are being vegetated by suitable native species and massive grass plantation to prevent erosion & surface runoff. The management of the rehabilitated areas of the dumps has been continuing until the vegetation becomes self-sustaining. Further, in the weaker zone/part of the dump is being covered with Geo-textile to prevent erosion & to make it stable by planting the native species scientifically as follows: 

	Compliance status should be submitted to the Ministry of Environment & Forests on six monthly basis.	 **Plantation in Dump**
5.	Trace Metals such as Ni,Co,As, and Hg should be analyzed in dust fall and soil samples for at least one year during summer, monsoon and winter seasons. If concentrations of these metals are found below the standards, then with prior approval of MOEF this specific monitoring could be discontinued.	Collection and analysis of dust & soil samples is done, and the test reports are enclosed in **Annexure No.2.**
6.	Catch drains and siltation ponds of appropriate size should be constructed to arrest silt and sediment flows from soil, OB and mineral dumps. The water so collected should be utilized for watering the mine area, roads, plantation etc. The drains should be regularly de -silted and maintained properly. Garland drain (size, gradient and length) shall be constructed for both mine pit & waste dump and sump capacity should be designed keeping 50% safety margin over and above peak sudden rainfall (based on 50 years data) and maximum discharge in the area adjoining the mine site. Sump capacity should also provide adequate retention period to allow proper settling of silt material. Storm water return system should be provided. Storm water should not be allowed to go to the effluent treatment plant during high rainfall / super cyclone period. A separate storm water sump for this purpose should be created.	Catch drains around OB dumps and mineral stockyard have already been constructed with siltation ponds at regular intervals to arrest silt and sediments. Whenever required the silts and sediments are being cleaned from catch drains and siltation ponds and maintained regularly. Mine pumped out water is sufficient for dust suppression and plantation purposes. Hence catch drain water is dis-charging outside M.L. area through ETP process. Hence there is no need for collection of water from catch drains from mine area, roads, plantation etc. Garland drains of width 2m, depth 1.5m and length 3424 m with gradient have been constructed for maximum discharge of rainfall in the adjoining areas. There is no chance of flow of storm water into the effluent treatment plant during high rain fall/super cyclone period became the plant is at high reduced level (RL). Hence storm water return system is not required.  **Garland Drain with Check Dam**

7.	Dimensions of retaining wall at the toe of OB dumps & benches within the mine to check run -off and siltation should be based on the rain fall data.	Retaining wall of width 1.5m and height 1.2m has already been constructed all around the toe of dumps up to a length of 3424 m to check the run -off and siltation.  **Retaining Wall**
8.	Effluents containing of Cr^{+6} shall be treated to meet the prescribed standards before reuse/discharge. Effluent Treatment plant should be provided for treatment of mine water discharge and wastewater generated from the workshop and mineral separation plant. Run off from OB dumps and other surface run off should be analyzed for Cr^{+6} and in case its concentration is found higher than the permissible limit the water should be treated before reuse/discharge.	An Effluent Treatment Plant is operating for treatment of Mines discharge water. The conc. of Cr^{+6} in treated discharge water is <0.05mg/l.  **ETP Outlet Cr^{+6} conc. data** The tailing water (waste water of mineral separation plant) also is being treated by adding $FeSO_4$ before discharge into tailing pond. The treated tailing pond water is being collected in an intake pond and being re -used in beneficiation plant. Thus, zero discharge from Beneficiation Plant is being maintained. Almost all mining machineries and transporting vehicles are being engaged on contract basis for transportation of OB and chrome ore. The company has few nos. of vehicles. The major repairing of these vehicles is being done at outside workshop and minor repairing is being done in our garage. Hence, discharge of workshop effluent is nil. The total surface runoff water is being collected in settling pond which are pumped to the ETP for treatment before final discharge.
9.	Separate impervious concrete pits for disposal of sludge shall be provided for the safe disposal of sludge generated from the mining operations.	The sludge generated from mining operations contains chrome ore. It is being fed in Beneficiation Plant to separate the Chrome.

10.	The Project proponent shall ensure that the quality of decanted effluents from the tailing pond confirm to the prescribed standards before discharge.	The effluents from tailing pond are not discharged outside. The supernatant water of the tailing pond is being collected in a sump adjacent to the tailing pond and re-circulated in Beneficiation Plant.
11.	The Project proponent shall explore the possibility to reduce concentration of Cr^{+6} in the tailing pond in consultation with an Expert Scientific Institution like NEERI.	The Conc. of Cr^{+6} in tailings is being reduced by adding $FeSO_4$ solution and disposed in the tailing pond. Further, we are on the process of engaging BHU professor for adopting suitable technology to reduce the Cr+6, if any available.
12.	Plantation shall be raised in an area of 33.02 Ha including green belt in an area of 6.56 Ha by planting native species around ML area, OB dumps, and roads around worked out area etc. in consultation with local DFO/Agriculture Department . The density of the trees should be around 2000 plant species per hectare.	Plantation has been done over inactive/dead benches of OB dumps, Roadside, around C.O.B. Plant and other places in an area of 34.92 Ha. Plantation is being carried out in consultation with local Forest Department.  **Plantation in Benches of the Inactive/dead dump**  **Plantation along the haul road**
13.	Regular monitoring of ground water level & quality should be carried out by establishing a network of existing wells and constructing new piezometers during the mining operation. The monitoring should be carried out four times in a year– pre-monsoon (April -May), monsoon (August), post - monsoon (November) and winter (January) and the data thus collected may be sent regularly to MOEF, Central Ground Water Authority and Regional Director Central Ground Water Board.	Monitoring of ground water level & quality is being carried out third party accredited agency. Further, DWLR with telemetry system fitted in Piezometer holes to carried out the real time monitoring of Ground water level.  The Monitoring reports has been sent & the monitoring report for the period from April'2021 to September'2021 is enclosed as: Ground water level & Quality : **Annexure No.-3 & 4**

14.	The project proponent shall carry out regular monitoring of ground water quality in all the 14 wells. The frequency of monitoring in 8 wells where concentration of Cr^{+6} is within permissible limits, will be quarterly while in the remaining 6 wells it will be on monthly basis.	The monitoring test reports of ground water quality in 9 wells have been analyzed & concentration of Cr^{+6} are within the limit. Copy enclosed as **Annexure No. - 5.**
15.	Project Authorities should meet water requirement of the peripheral village(s), especially, if the village wells go dry due to mine de - watering.	As a part of peripheral development nos. of borewell have been constructed in nearby villages and also potable water is being provided to nearby villages by water tankers. Reading of the abstraction structures, used for water supply to local community are enclosed for reference as **Annexure No.:6**   **Water provided to nearby village by tankers**
16.	Permission from the competent authority should be obtained for drawl of ground water for domestic use.	NOC has been obtained from Central Ground Water Authority, Ministry of Water Resources, New Delhi vide letter no.21 - 4/1456/OR/MIN/2017 -1735 dated 28.08.2018 for ground water withdrawal. Renewal of NOC is under process.

17.	Suitable rain water harvesting measures on long-term basis shall be planned and implemented in consultation with Regional Director, CGWB.	Rainwater has been collected in different pits for suitable rain water harvesting measures.  **Rooftop Rain-Water Harvesting**  **Garland drain**
18.	Drills should be wet operated or operated with dust extractors.	Wet Drilling is being practiced.
19.	Blasting operation should be carried out only during the daytime. Controlled blasting should be practiced. To mitigate measures for control of ground vibrations and to arrest fly rocks and boulders should be implemented.	Blasting operation is being carried out in day time only. Controlled blasting is being practiced by following Nonel & muffle blasting. Delay detonators are used for providing delay timings between rows and within rows of holes. Numbers of rows in a blast are restricted to less than three to get good fragmentation and to reduce fly rocks and ground vibration.
20.	The voids created at the end of mining shall be converted into water Body with shallow depths not exceeding 30m.The higher benches of the excavated void/mine pit shall be terraced and plantation done to stabilize the slopes. Peripheral fencing shall be done along the excavated area.	The same will be implemented at the end of mining operation. It has already been prepared in Mining Plan & submitted to IBM, Bhubaneswar
21.	Vehicular emissions should be kept under control and regularly monitored. Measures shall be taken for maintenance of vehicles used in mining operations and in transportation of mineral. The vehicles should be covered with a tarpaulin and shall not be overloaded.	Vehicular emission of all machinery used in mining operations are being monitored regularly and kept under control of rigorous maintenance of all engines and changing of lubricants as per the recommendation of the manufacturer. HEMMs have valid PUC Certificate which is only allowed for operation inside the Mines. All the transporting vehicles are being covered with tarpaulin and over loading are strictly avoided.
22.	Consent to operate should be obtained from SPCB before enhancing Production capacity of the mine.	Consent to operate has been obtained from SPCB, Bhubaneswar. There is no proposal of enhancing the production capacity of the mine. CTO has been enclosed for as **Annexure No.-7**

23.	Sewage treatment Plant should be installed for the colony. ETP should also be provided for workshop and wastewater generated from Mining operations.	There is no colony inside the ML area. Almost all mining machineries and transporting vehicles are being engaged on contract basis for transportation of OB and chrome ore. The company has few Nos. Of vehicles. However, major repairing of the vehicles is being done at outside workshop and minor repairing is being done in our garage. Hence, discharge of workshop effluent is nil. An ETP has already been established for treatment of mines water.   **Effluent Treatment Plant**
24.	A final mines closure plan along with details of corpus fund should be submitted to the Ministry of Environment & Forests 5 years in advance of final mine closure for approval.	The same will be submitted in due time to MOEF for approval.

GENERAL CONDITIONS:

Sl. No.	Condition	Compliance Status
1	No change in mining technology & scope working should be made without prior approval of the MoEF.	The Mining technology & scope of working has not been changed.
2	No change in the calendar plan including excavation, quantum of mineral Chromite and waste should be made.	The calendar plan including excavation, quantum of mineral Chromite and waste over burden has not been changed. The calendar plan including excavation, quantum of mineral chromite and waste over burden has been generated during the period (April 2020 to March, 2021) is given in **Annexure No. -8**.
3	Conservation measures for protection of flora & fauna in the Core & Buffer Zone should be drawn up in consultation with local forest & wildlife department.	As per the advice of Forest Department, we are maintaining vehicles, watchman and infrastructural facility as measures to protect Flora & Fauna in core & buffer zone.
4	Four ambient air quality -monitoring stations should be established in the Core zone as well as in the Buffer zone for RPM, SPM, SO_2& NO_x monitoring. Location of the stations should be decided based on the meteorological data, topographical features, and environmentally and ecologically sensitive targets in consultation with the State Pollution Control Board.	Ambient Air quality monitoring stations has already been established in consultation with SPCB.  **Ambient Air Quality Monitoring System**
5	Data on ambient Air Quality (RPM, SPM, SO_2 & NO_x) should be regularly submitted to the Ministry including its Regional Office at Bhubaneswar and the State Pollution Control Board / Central Pollution Control Board once in six months.	Test reports on Ambient Air Quality monitoring viz., PM_{10}, $PM_{2.5}$, SO_x, NO_x & CO is being monitored & submitted regularly. Monitoring report for the period April, 2021 to Sept, 2021 is enclosed as follows: **Annexure No.-9 : Core Zone** **Annexure No.-10 : Buffer Zone**

6	Fugitive dust emissions from all the sources should be controlled regularly. Water spraying arrangement on haul roads, loading & unloading and at transfer points should be provided and properly maintained.	Control of fugitive dust emissions is being carried out by water spraying on haul roads, Ore handling yard, loading and unloading points regularly. The test report of the same is enclosed as **Annexure No.-11**.  **Water sprinkling in haul road**
7	Measures should be taken for control of noise levels below 85 dB (A) in work environment. Workers engaged in operations of HEMM, etc. should be provided with ear plugs / muffs.	Control measures such as maintenance of all machines including checking of silencers regularly, controlled blasting using delay detonators, installing immovable machinery on foundations with suitable rubber pad and closed rooms is being followed -up. The workers engaged at noise generating areas are allowed to work on rotation basis with providing earplugs/muffs. Location wise noise level at work environment is enclosed as **Annexure No. -12**.
8	Industrial wastewater (workshop & wastewater from the Mine) should be properly collected, treated so as to conform to the standards prescribed under GSR 422 (E) dated 19th May 1993 and 31st December 1993 or as amended from time to time. Oil & grease trap should be installed before discharge of workshop effluents.	The Mines wastewater is being pumped out directly in to the intake tank of the ETP for treatment of Cr^{+6} and part of the treated water is used for plantation, dust suppression and surplus treated water is finally discharged to outside ML area. The analysis of this water shows that all parameters are well within the prescribed limit. The analysis report of Mines final discharge water after treatment in E.T.P., for the period April, 2021 to Sept, 2021 is enclosed as **Annexure No.-13.** Almost all mining machineries and transporting vehicles are being engaged on contract basis for transportation of OB and chrome ore. The company has few nos. of vehicles. The major repairing of these vehicles is being done outside mines and minor repairing is being done in our garage. Hence, discharge of workshop effluent is not envisaged.

9	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. Occupational health surveillance program of the workers should be undertaken periodically to observe any contractions due to exposure to dust and take corrective measures, if needed.	In addition to water spraying to suppress dust generation, workers engaged in dusty areas such as drillers, dumper drivers, HEMM Operators are being provided with nose masks as precautionary measure. Training & information on safety, health hazards are being given to all categories of deserved workers. Occupational health surveillance program to all categories of workers and employees are being conducted.
10	A separate Environment Management Cell with suitable qualified personnel should be set -up under the control of a Senior Executive, who will report directly to the Head of the Organization.	A separate Environment Management Cell with qualified personnel and well-equipped Environment Engineering Laboratory is functioning under the control of a Senior Executive. Besides we are carrying out all Environmental monitoring & analysis through a MoEF & NABL accredited laboratory M/S VisionTek Consultancy Services Pvt. Ltd., Bhubaneswar & the monitoring reports are enclosed as Annexures.
11	The Project authorities should inform to the Regional Office located at Bhubaneswar regarding date of financial closures and final approval of the Project by the concerned authorities and the date of start of land development work.	The final approval of the Project is 06.12.2006. It is a mining industry. Hence, land development work is a continuous process.
12	The funds earmarked for environmental protection measures should be kept in separate account and should not be diverted for other purpose. Year wise expenditure should be reported to the Ministry and its Regional Office located at Bhubaneswar.	Separate funds provision is made to carryout environmental protection measures. Details of expenses during the year 2021-22 is given in **Annexure No. -14**

Annexure No.-1

CSIR-CENTRAL INSTITUTE OF MINING AND FUEL RESEARCH, BARWA ROAD, DHANBAD

REPORT ON

SCIENTIFIC STUDY FOR OPTIMAL DESIGN AND STABILITY ANALYSIS OF PIT AND OVERBURDEN DUMP AT OSTAPAL CHROMITE MINE, VEDANTA (FACOR MINES) LTD

SPONSORED BY:

M/s VEDANTA (FACOR MINES) LTD

JUNE 2021

CSIR-CENTRAL INSTITUTE OF MINING AND FUEL RESEARCH, BARWA ROAD, DHANBAD
(Council of Scientific and Industrial Research)

Project Title : Scientific Study for Optimal Design and Stability Analysis of Pit and Overburden Dump at Ostapal Chromite Mine, Vedanta (FACOR Mines) Limited.

Project Number : CNP/5033/2020-21

Project Leader : Ajit Kumar

Project Co-ordinator : Jitendra Kumar Singh

Project Collaborators: :
Sanjay Kumar Roy
Kartik Varwade
Rakesh Kumar Singh
Manish Kumar
Prince Kumar
Swapan Mahato

June 2021

Note:

1. The report is meant only for internal use of the sponsor and it should not be published in full or part by the sponsor or any of its staff members. It should not be communicated or circulated to outside parties except concerned Government department. CIMFR reserves the right to publish the results in a general way for the benefit of industry without disclosing the name of the sponsor.
2. Recommendations stipulated in the report should be implemented under the supervision of a competent agency and strictly be followed.

Project Leader **(Ajit Kumar)** Chief Scientist Slope Stabilisation and Landslide Management	Project Coordinator **(Jitendra Kumar Singh)** Chief Scientist & HORG Slope Stabilisation and Landslide Management

CSIR-CIMFR Authorised Signatories

(P K Mishra) Sr. Principal Scientist & HOS Project Planning and Monitoring	**(R V K Singh)** Chief Scientist & Coordinator Project Planning and Industry Interface

SCIENTIFIC STUDY FOR OPTIMAL DESIGN AND STABILITY ANALYSIS OF PIT AND OVERBURDEN DUMP AT OSTAPAL CHROMITE MINE, VEDANTA (FACOR MINES) LTD

INTRODUCTION

M/s Vedanta (FACOR Mines) Ltd entrusted the work for carrying of Slope Stability Studies of Pit Slope and Dump Slope of Ostapal Chromite Mine located in Odisha to CSIR-Central Institute of Mining and Fuel Research (CSIR-CIMFR), Dhanbad. Objective of study was to carry out the slope design of pit for ultimate planned pit depth, and dump design for ensuring safety of pit and dump. A combined analysis of pit and dump as composite slope was also to be done as the external OB dump was close to pit. Pit slope dewatering or depressurization scheme along with other recommendations were to be suggested for ensuring safety of men and machineries with reference to slope stability of pit and dump.

CSIR-CIMFR took up the work of scientific study and carried out field investigation, geomechanical testing of pit and dump materials, and slope stability analysis. The outcome of scientific study along with pit and dump slope design along with appropriate recommendations for ensuring safety and stability of Pit and OB dump have been presented in this report.

LOCATION & COMMUNICATION

Ostapal Chromite Mine, in Sukinda ultramafic complex, is located in Kaliapani village of Jajpur district of Odisha. Mining lease was granted in the year 1985 and subsequently mining was started using opencast method with HEMM deployment and is continuing till date. The mine is connected with the nearest rail head at Jajpur-Keonjhar Road Railway Station on Howrah–Bhubaneswar–Chennai line of SE railway by an all weather road of 100 km via Duburi and Tomka. The leasehold area is linked with Daitari-Paradeep Express Highway. State capital at Bhubaneswar and district head quarter at Jajpur is located at road distances of 150 km and 53 km respectively from leasehold area of Ostapal Mine.

A location map of Jajpur district of Odisha in which Ostapal Chromite Mine of M/s Vedanta Ltd is located is given in Fig. 1 and 2.

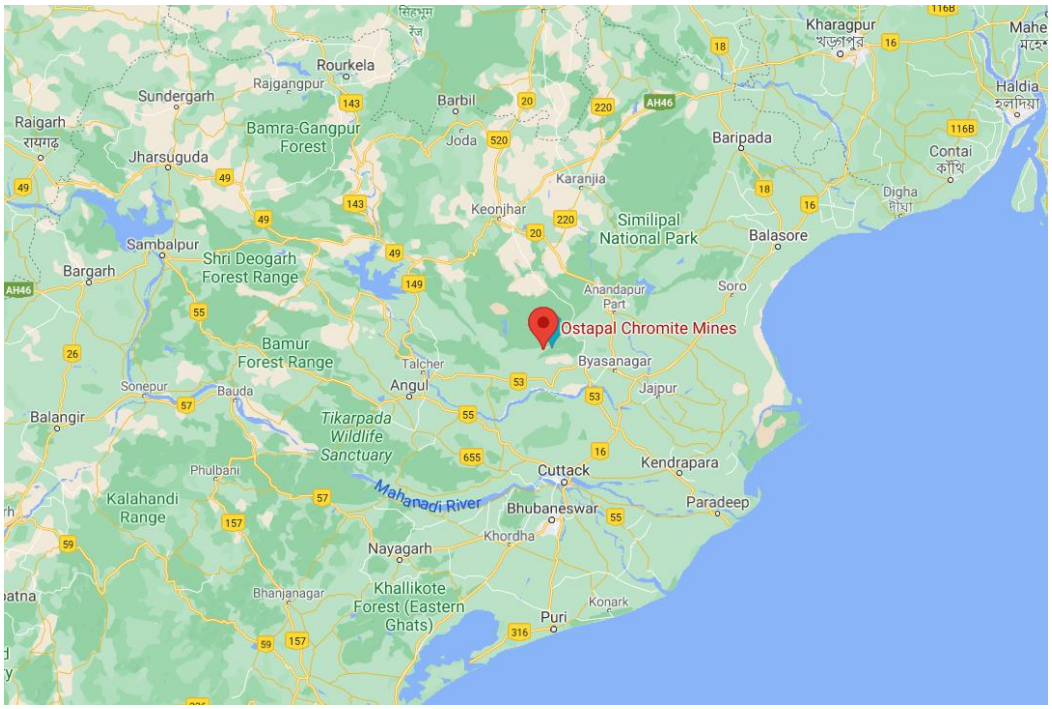

Fig 1: Location Map of Ostapal Chromite Mine

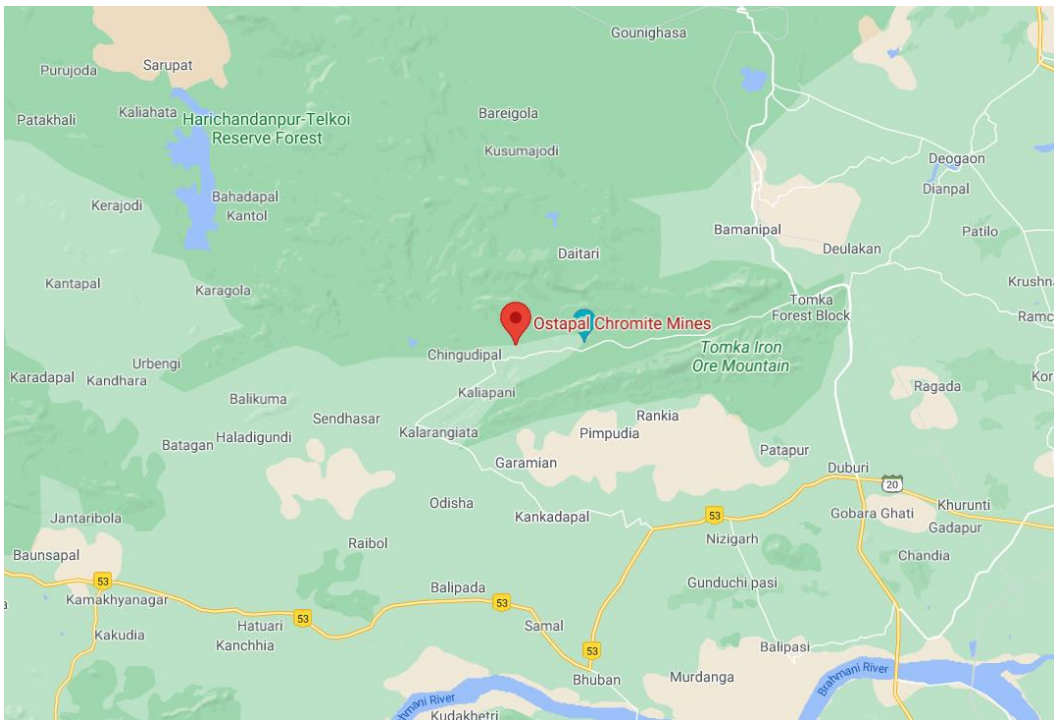

Fig 2: Location Map of Ostapal Chromite Mine (Close View)

PHYSIOGRAPHY & DRAINAGE

The Sukinda valley area comprises of hilly and undulating terrain. The northern part of the Sukinda Valley is marked by Daitari hill range which rises sharply from about 140 m above mean sea level to more than 600 mRL. There are peaks exceeding 800 mRL in Daitari hill range. At places hills are marked by very steep escarpments. The southern part of the valley is bounded by Mahagiri hill range, which is also very steep and rises to more than 300 mRL. In Mahagiri hill range also there are a few bare rocky cliffs. The hills are densely forested. The south-west and slopes from north to south.

The entire lease area of Ostapal is flat terrain having a gentle slope of about 2^0 from North to South. The highest ground elevation in this area is lying in the Northern Part of the lease area at an altitude of 158 mRL and the lowest relief in this area is 135 mRL in the southern part.

The principal drainage channel of the Sukinda valley is DamsalNala which flows from east to west. Several seasonal and perennial channels flow down from the Daitari hill range and the Mahagiri hill range to join the DamsalNala. A few of the drainage channels emerging from Mahagiri hill range flow north and north-west to join DamsalNala. DamsalNala gradually bends towards the south-west and on emerging from the Sukinda valley turns south to join the Brahmani River.

CLIMATE & RAINFALL

The climate of the region in tropical humid with mild cold The study area lies in tropical region where climate is characterized by very hot summers and cool winters. Summer is typically from March to June when daily average maximum temperature ranges from a maximum of 43°C during daytime to a minimum of 16^{o}C at night. Winter is from November to February when daily average maximum temperature during day goes up to 30^{o}C and minimum temperature at night becomes as low as 10^{o}C. The Southwest monsoon lasts from mid-June to mid-September and the area gets more than 75% of the annual rainfall during this period. The average annual rainfall for the past 10 years (2010-2019) was recorded as 1678 mm. The maximum rainfall 2312 mm was recorded during the year 2019 and minimum 1093mm in 2010.

GEOLOGY & OREBODY

The chromite deposit of Ostapal Chromite Mine forms a part of famous chromite bearing Sukinda ultramafic complex. The Sukinda ultramafics belong to the metamorphosed rocks of Pre-Cambrian age. Sukinda ultramafics form a major intrusive into the older rocks and occur as intrusive. The intrusive has width of 2-5 km and extends for about 20 km in ENE-WNW direction from Kansa in the east to Maruabil and beyond in the west. The ultramafic body consists essentially of magnesium-rich dunite devoid of chromite bands and subordinate amount of pyroxenite devoid of chromite mineralization. The pyroxenite is relatively fresh but the dunite–peridotite members are highly serpentinised and intensely laterised. The granite is exposed at several places. However, generalized Stratigraphy of Sukinda ultramafic complex is shown in Table 1 as follows:

Table 1: Generalised Stratigraphy of Sukinda Ultramafic Complex

Recent to Pleistocene		Soil, Alluvium, Laterities
----------Unconformity----------		
		Dolerite, Granite, Gabbro-diorite
Precambrian	Ultramafics	Pyroxenite, Dunite-peridotite with chrome ore
	Meta-sediments and meta-volcanics	Gritty quartzite Meta-Volcanics
Base not seen		

Small exposures of diorite rocks are found in Kathpal and Bhimtanagar. Besides, several dolerite dykes have intruded into the ultramafics, quartzites as well as the granites. This happens to be the last stage of igneous activity in this Precambrian terrain. Soil, alluvium and laterite of recent origin are overlying the ultramafics unconformably.

Structurally, the lower sequence of the Iron ore super group has been folded into a broad syndrome plunging at a low angle of 15^0 to 20^0 based on the direction derived from the cross beddings. The Sukinda syndrome is established as asymmetrically syncline with apex of the fold centering around Kansa village. As a result, the ore bodies of the region represent a horse shoe shaped structure. The whole group of rocks was affected by two boundary faluts running with the northern and southern margins of the ultramafic body. Rocks of the area have

undergone tectonic deformation resulting in the development of asymmetrical syncline and realignment of Chrome ore bodies dictated by pressure.

The Serpentinised dunite-peridotite members have been subjected to intense chemical weathering resulting in the formation of nickel rich limonite cover with relics of serpentinite and talc schist. The primary Chrome ore bodies confined to these serpentinite–limonite horizons have also undergone weathering and given rise to friable Chrome ore. The laterised ultramafics have been silicified giving rise to distinct cherty horizons. It has been found that weathered and altered zone extends down to a depth of 70m in some places while in other places it has extended down to a depth of 200m from surface. However, some bore hole data reveals that below 70m depth is the possibility of meeting hard formation continuously downward. Due to weathering some alteration has taken place in the original rock resulting in formation of brown serpentinite, green pyroxenite, yellowish brown to reddish brown nickeliferous limonite and dark brown to grayish brown dolerite. There has been large scale ferrugination of the rocks and Chrome ore bodies and silicification of the rocks in the region. As a result ultramafics are highly limonised. In certain places talc-serpentine schist have been converted into sticky clay. Granite rocks are also exposed in many areas in this region.

METHOD OF MINING

The opencast mining of chromite ore is being carried out by removing the overburden, side burden / intermediate burden by making suitable benches in all direction of the quarry. Waste materials are removed from the quarry directly by shovel/dumper/dozer combination to the dump yard. Similarly, ores are removed from the quarry. Hard portion of the quarry which cannot be directly excavated by the machines requires drilling and blasting with large diameter holes. Blasted fragments are removed by the machine to the waste dump yard. Shovels are utilized with bucket capacity of 1.5 m^3 with digging height capability up to 10m. 110mm diameter drilling machine is used for drilling of shot holes. Plaster shooting/pop shooting is done for secondary blasting. Tire mounted front end loader is used for re-handling purposes. Other machineries which are utilised in the mine are compressor, diesel and electric pumps, explosive van, etc.

The bench height are typically kept with 7-8m height, 10-12m width and overall slope of 26^0 to 30^0. Drains and barriers are constructed all along the longitudinal direction of one side of the bench edge for smooth flow of water to next lower bench and safe running of vehicles on

the quarry benches. The process continues till reaching pit bottom. Benches are connected with each other with short ramps of 1 in 10 gradient. Main ramps/ haul roads are kept with 1 in 14 gradient. Sufficient side drains and cross drains are also provided to keep the road dry in all seasons including rainy season. It is advisable to continue this opencast method of mining along with design and recommendations provided in this report.

SLOPE STABILITY

The importance of safe, professionally designed and scientifically engineered slopes of the mine and dumps are well known. The benefit of an open pit operation largely depends on the use of the steepest possible slopes for pit and dumps, which should not fail during the intended life. So, the design engineer is faced with the two opposite requirements, stability and steepness, in designing the deep open pit slopes or high and steep overburden dumps. Steepening the slopes of a mine, thereby reducing the amount of material to be excavated, can save a vast sum of money. Similarly steepening and heightening of overburden dumps with adequate precautionary measures permits high quantity of OB material to be accommodated in less land area for dumping. At the same time excessive steepening may result into slope failure leading to loss of production, extra stripping costs to remove failed material, reforming of benches, rerouting of haul roads and production delays. Directorate of Mines Safety may even close the mine or dumping operation on dump in case unsafe conditions are created. Therefore, it is necessary that a balance between economics and safety should be achieved.

The slope stability department of CSIR-CIMFR is rendering its services for optimum and safe slope designs of mines and dumps for different mining companies all over India. During last about 30 years, CIMFR has completed hundreds of slope design and safety monitoring projects in coal and non-coal sectors for pits and dumps.

The stability of the slope primarily depends on the slope geometry and strength properties of the slope materials. Ground water and surface water flow conditions also plays a critical role on the stability of dump and pit slopes. The orientation and other properties of discontinuity planes in rock mass with respect to slope face determines the types of failure possible within that slope. Generally, plane, wedge, circular and toppling types of failure occur in rock slopes as shown in figure 3, 4 and 5, while in soil slopes and weathered / highly fractured rock slopes circular failure is the main type of failure. After identifying

kinematically possible failure modes, detailed slope stability analysis is carried out by limit equilibrium method for optimum slope design.

Fig.3: Plane failure

Fig. 4: Wedge Failure

Fig. 5: Circular failure

GEO-TECHNICAL PROPERTIES OF PIT AND DUMP

Engineering properties of materials of Pit and OB dump will influence the analysis for slope stability. The average value of relevant strength properties, which were determined in the soil and rock mechanics laboratory of CIMFR and subsequently used for slope stability analyses of the Pit and Dump of Ostapal Chromite Mine of M/s Vedanta Ltd are summarized in Table 2. The properties were determined on the samples collected from the existing benches of pit and OB dump. Properties along with sound engineering judgement was used in the process of analysing and evaluating the stability of pit and OB dump under different geometrical configurations.

Table 2. Geo-Mechanical Properties of Material

Sr. No.	*Lithology*	*Cohesion (kPa)*	*Friction angle (degree)*	*Density (kN/m^3)*
1.	Laterite	125	32	18.2
2.	Medium Hard Serpentinite	190	31	19.6
3.	Orebody	150	32.5	20.4
4.	Quartz/ Hard Rock	290	33	23.7
5.	OB Dump Material	85	28.0	16.0

SLOPE STABILITY ANALYSIS

The limit equilibrium method is widely accepted and commonly used design tool in slope engineering. The failure analysis was done by GALENA software, which is based on limit equilibrium method**.** In this method, it is assumed that sliding occurs when a limit equilibrium condition is reached, i.e., when the resisting forces balance the driving forces. These methods are the most widely accepted and commonly used design methods and they permit a quantification of slope performance with the variations in all the parameters involved in the slope design. The basic idea behind the limit equilibrium approach is to find a state of stress along the failure surface so that the free body, within the slip surface and the free ground surface, is in static equilibrium. This state of stress is known as the mobilized stress, which may not be necessarily the actual state along this surface. This state of stress is then compared with the available strength, i.e., the stress necessary to cause failure along the slip surface.

Limit equilibrium analysis considers the slope performance only at the equilibrium condition between the resisting and disturbing forces for sliding. To represent the slope performance other than the equilibrium condition, it is necessary to have an index and the widely used index used to be factor of safety. Factor of safety is calculated as the ratio of shear strength to the available shear stress required for equilibrium, integrated through the whole slide. It is assumed to be constant throughout the potentially sliding mass. Due to scatter of test results and the uncertainty of these input parameters, a cut-off value of 1.3 safety factor is recommended for pit slope stability analysis on the basis of the long term stability (Hoek and Bray, 1981), however we have kept a safety factor of more than 1.5 keeping in view the DGMS circular no. 03 of 2020, dated 16-01-2020.

Water table within the slope mass and the implementation of different remedial drainage measures and water management measures have been taken into consideration in the process of slope design. It is one of the principles of the open pit design that some localized instability may occur, which will influence a relatively small area especially during monsoon. This is consistent with the mining environment. It should be acknowledged that some clean-up may be required within the pit or dump, particularly after the monsoon season.

The slope stability analyses of planned, and ultimate pit and dump slopes have been done on representative cross sections provided by the mine management using GALENA software**.** Surface plan of the mine showing pit and dumps and locations of sections is given in Fig. 6 and 7. The existing transverse sections have been shown in fig. 8 to 13 and longitudinal section along LL' is shown in Fig. 14. Locations of these sections have been shown on plan in fig. 7. Transverse sections along Sect-4 and Sect-5 are deeper planned sections hence stability analysis for factor of safety of hangwall and footwall slopes have been done along Section 4 and 5. Stability analysis has also been performed for longitudinal section along LL'. Results of slope stability analysis and design of slopes have been presented in Fig. 15 to 22.

Fig: 6: Surface Plan of pit and dump of Ostapal Pit

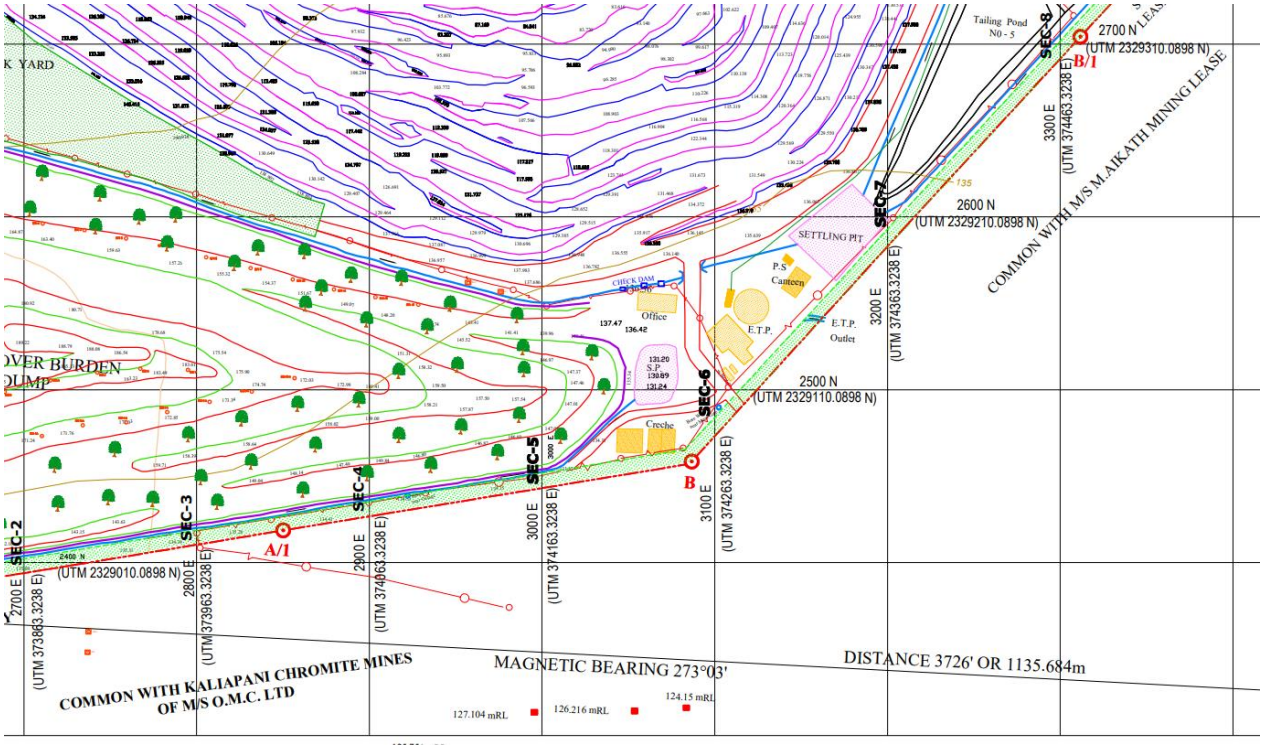

Fig: 7: Surface Plan showing locations of Transverse Sections 4 and 5 of Ostapal Pit

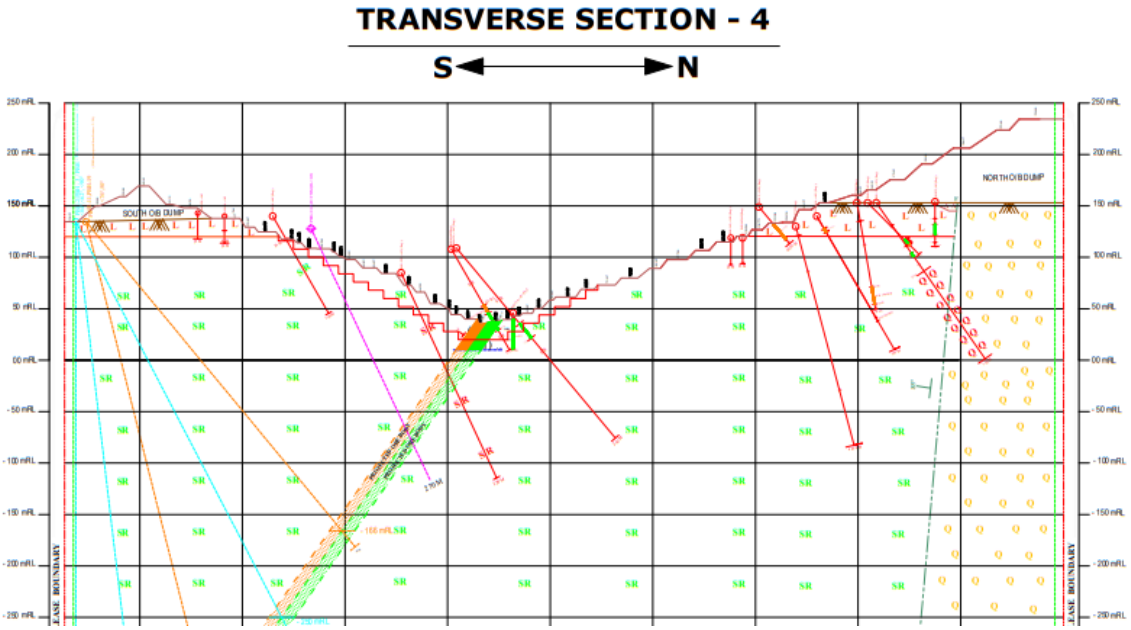

Fig.8: Transverse Section-4 of Ostapal Chromite Mine (Overall View)

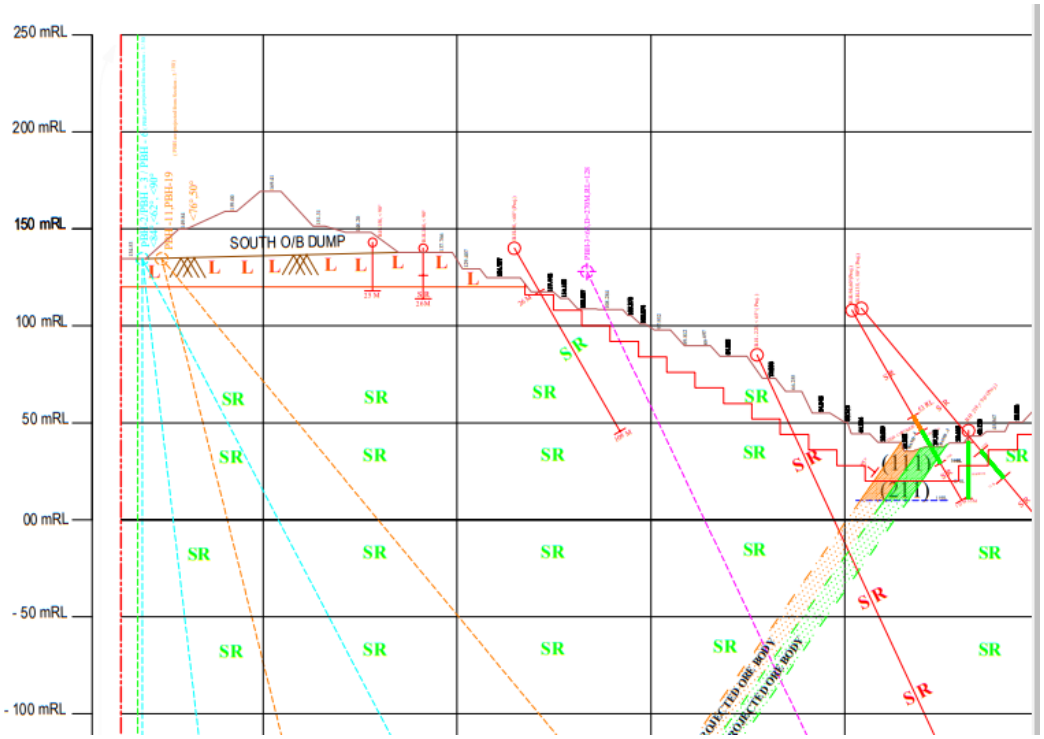

Fig. 9: Hangwall Slope (Existing and Planned) of Transverse Section-4 of Ostapal Chromite Mine

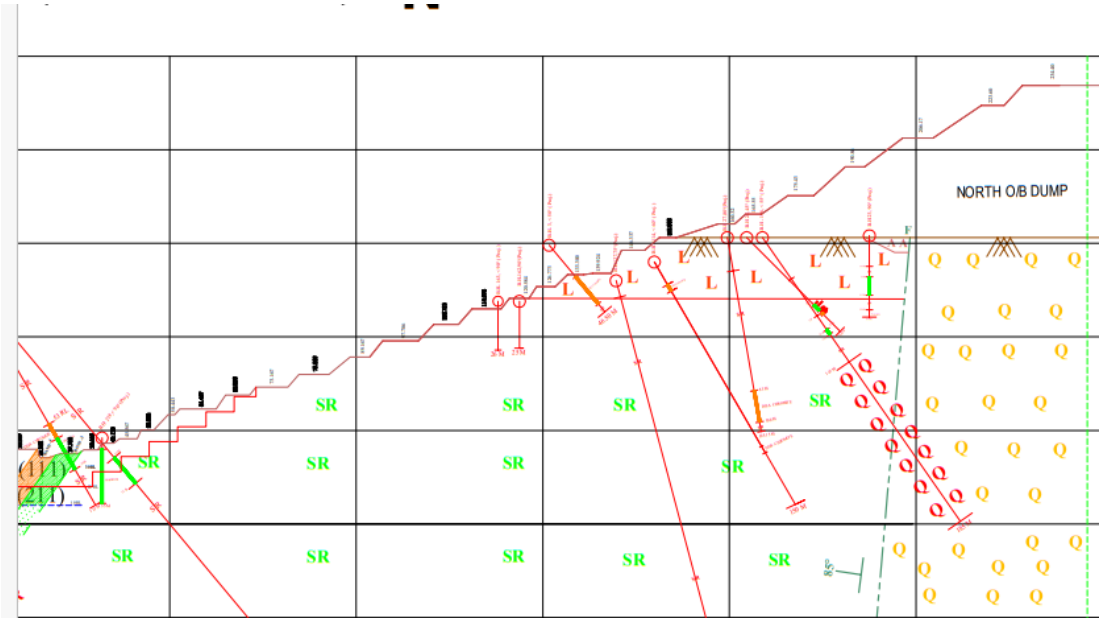

Fig. 10: Sect-4 FW Part

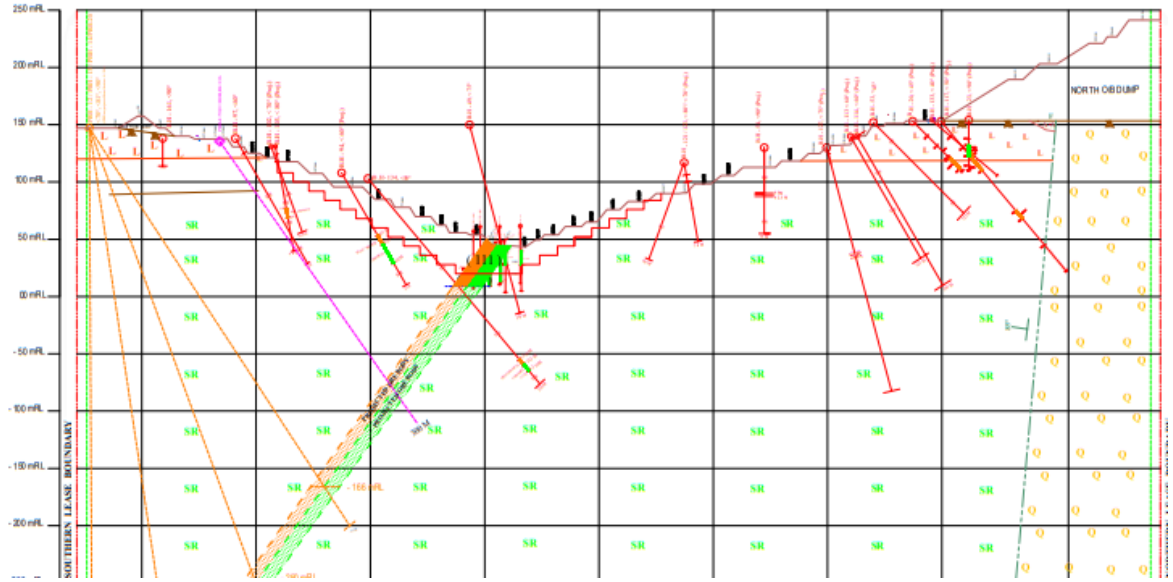

Fig. 11: Ostapal mine Sect-5 (Overall View)

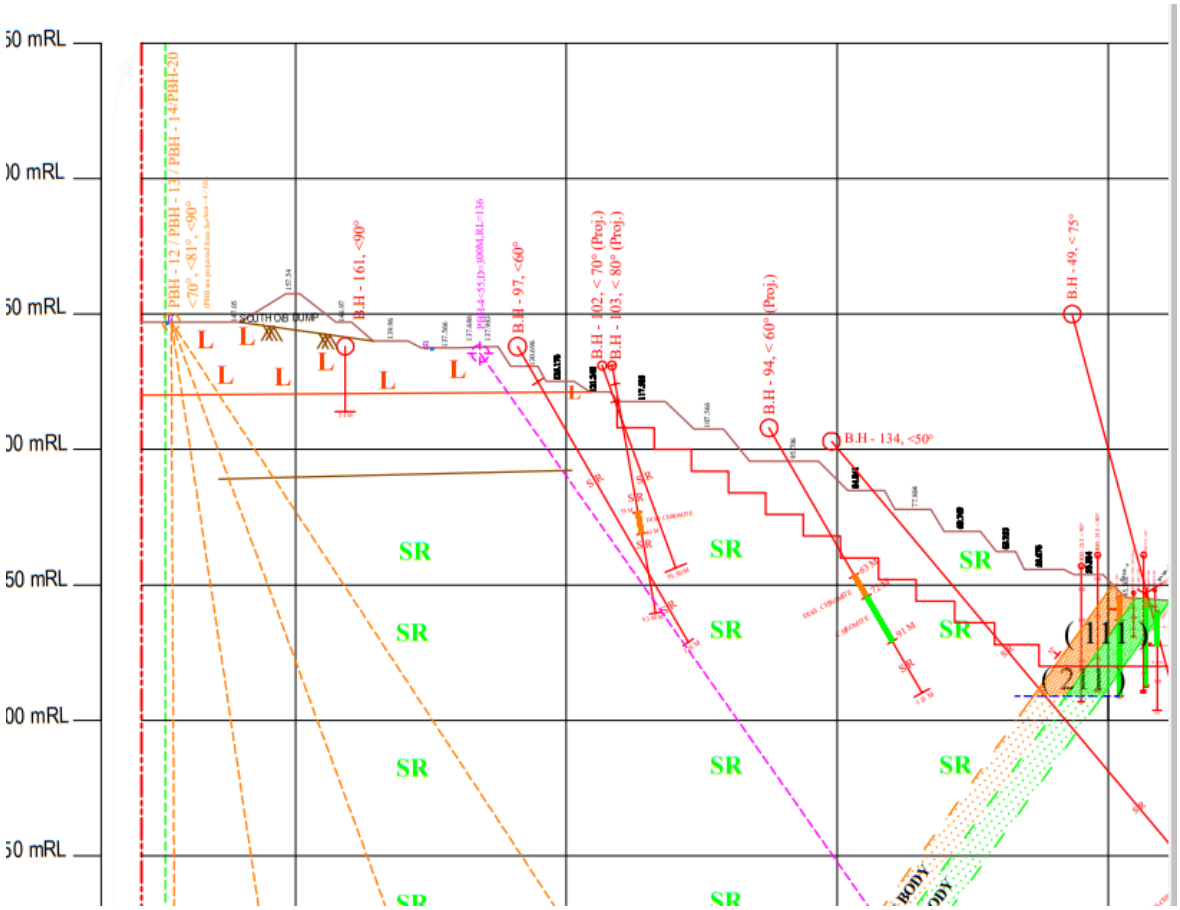

Fig. 12: Sect-5 HW Side (Existing Slope and Planned for the year 24-25)

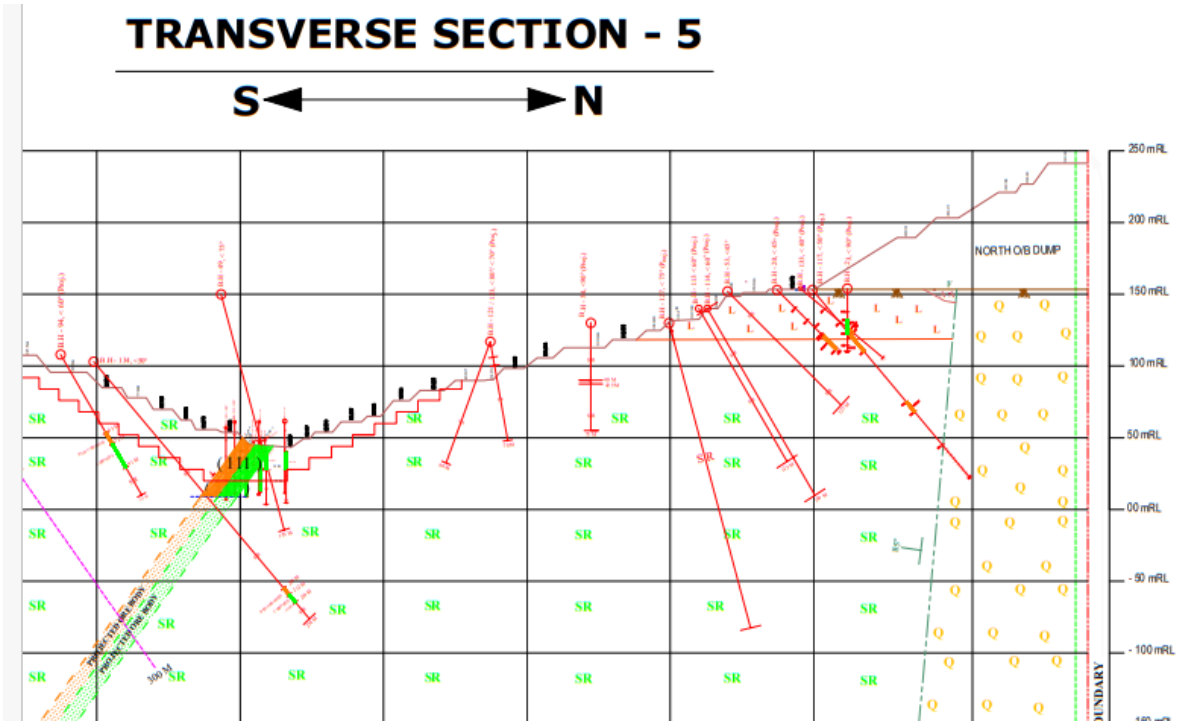

Fig. 13: Transverse Section Sect-5 Footwall Side

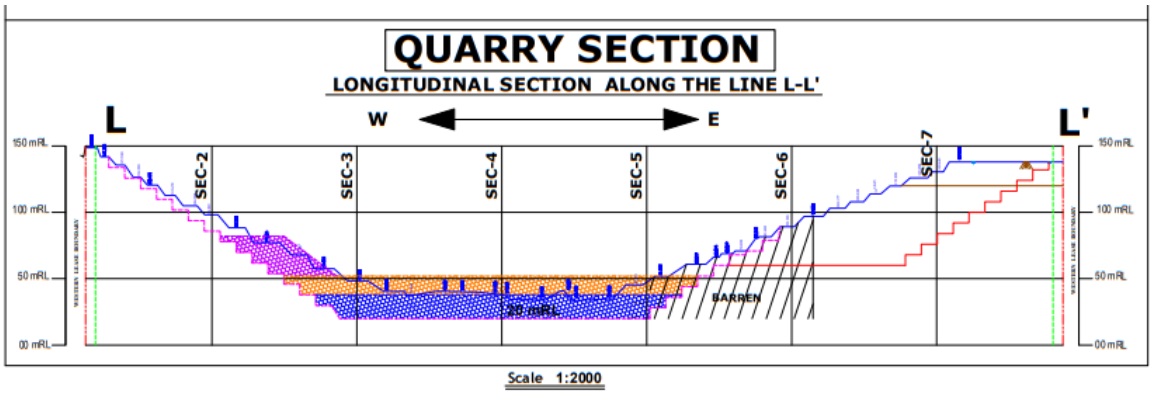

Fig. 14: Longitudinal Section LL' of Ostapal Pit

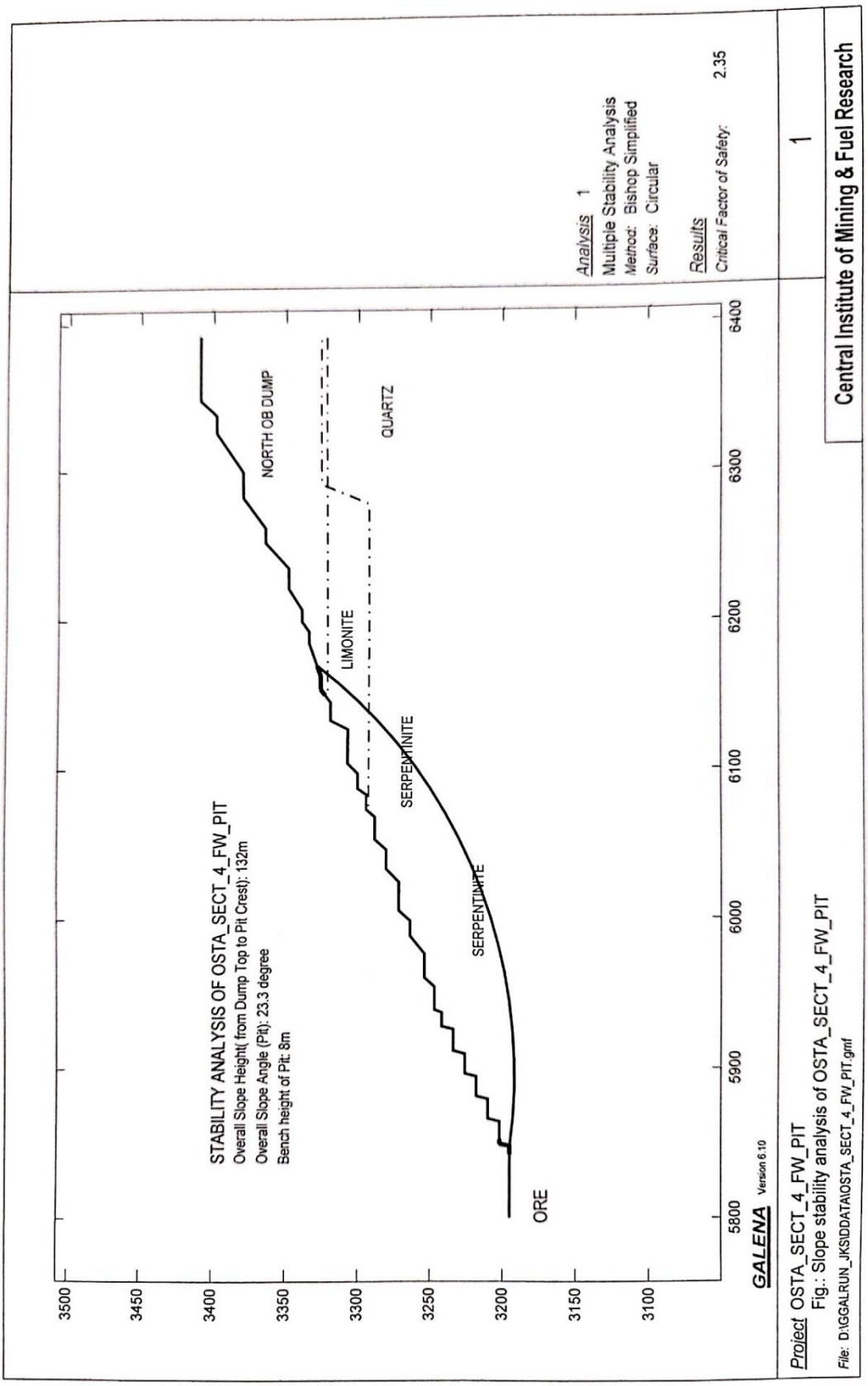

Fig. 15: Slope stability analysis of Footwal Pit along Section Sect-4

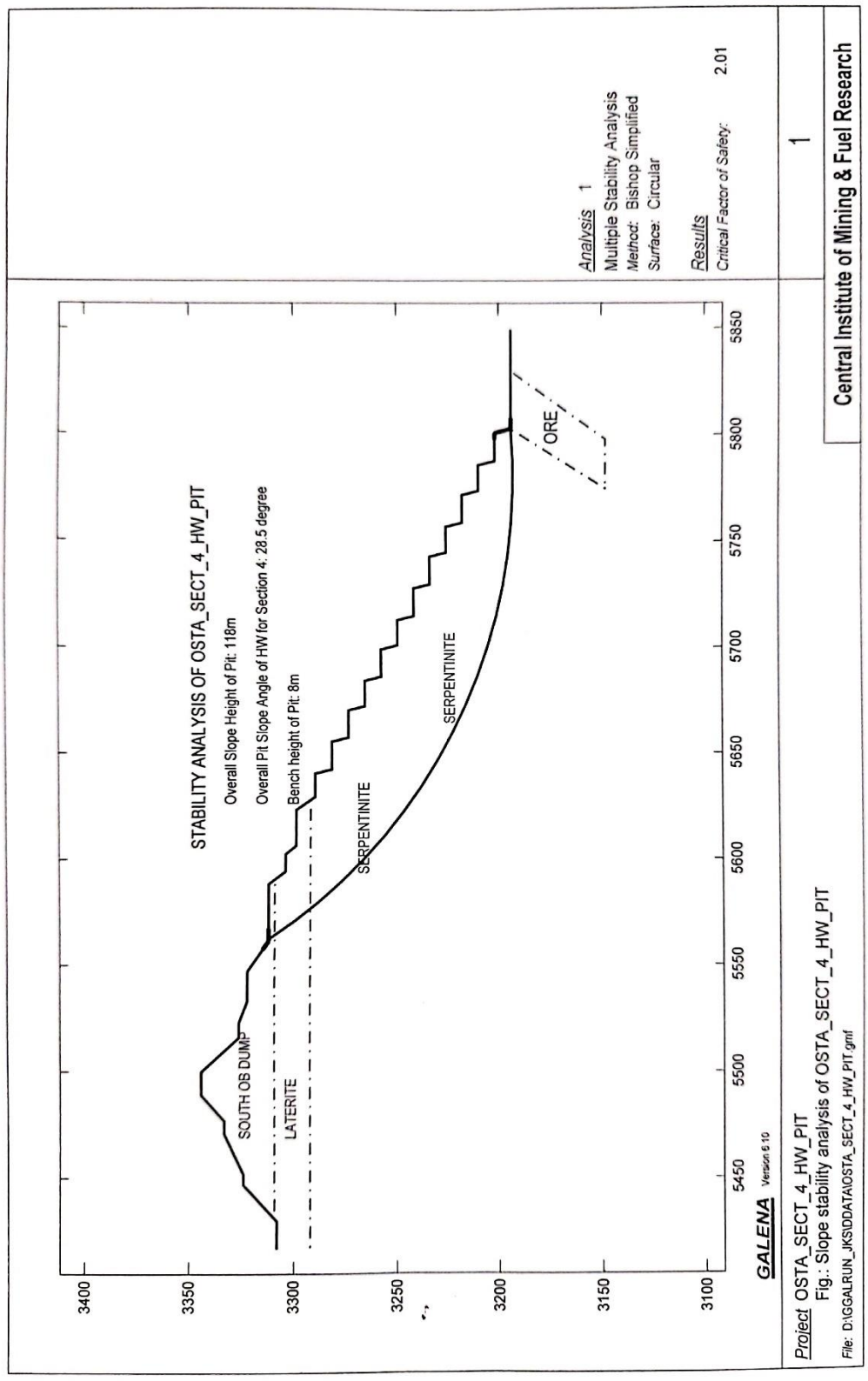

Fig. 16: Slope stability analysis of Hangwall Pit along Section Sect-4

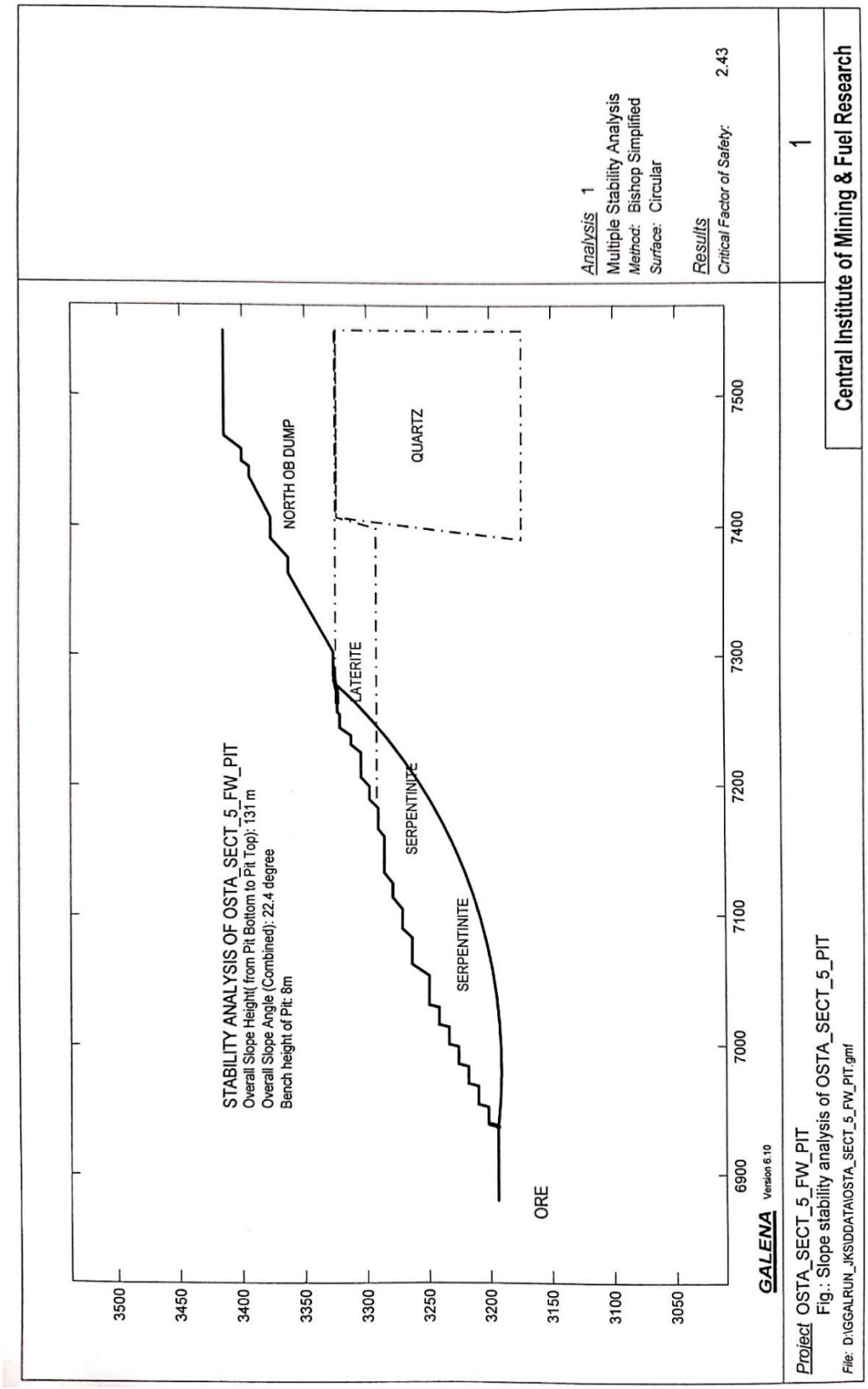

Fig. 17: Slope stability analysis of Planned Footwal Pit along Section Sect-5

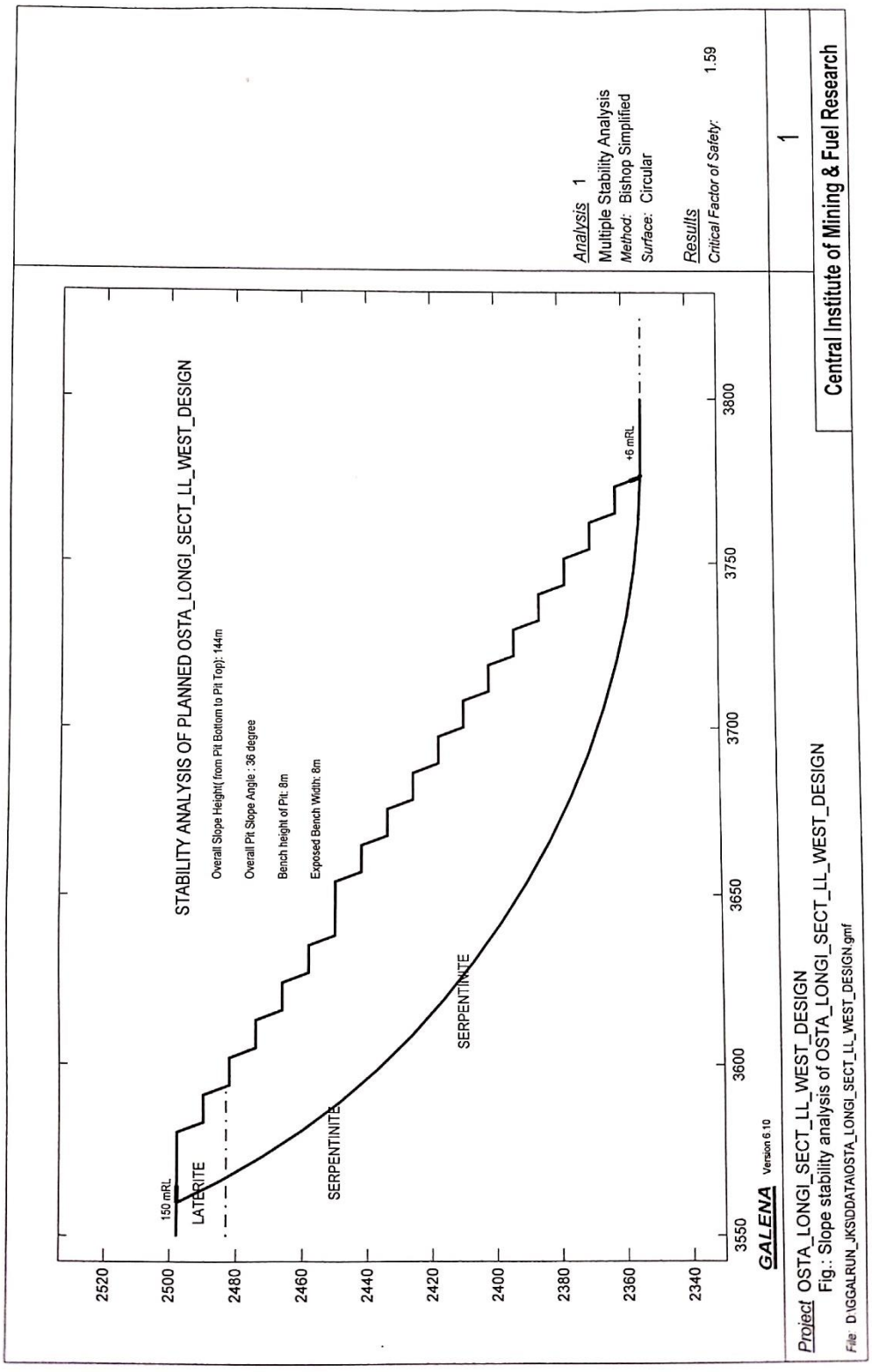

Fig. 18: Slope stability analysis and Design of Ultimate Longitudinal Section along LL'

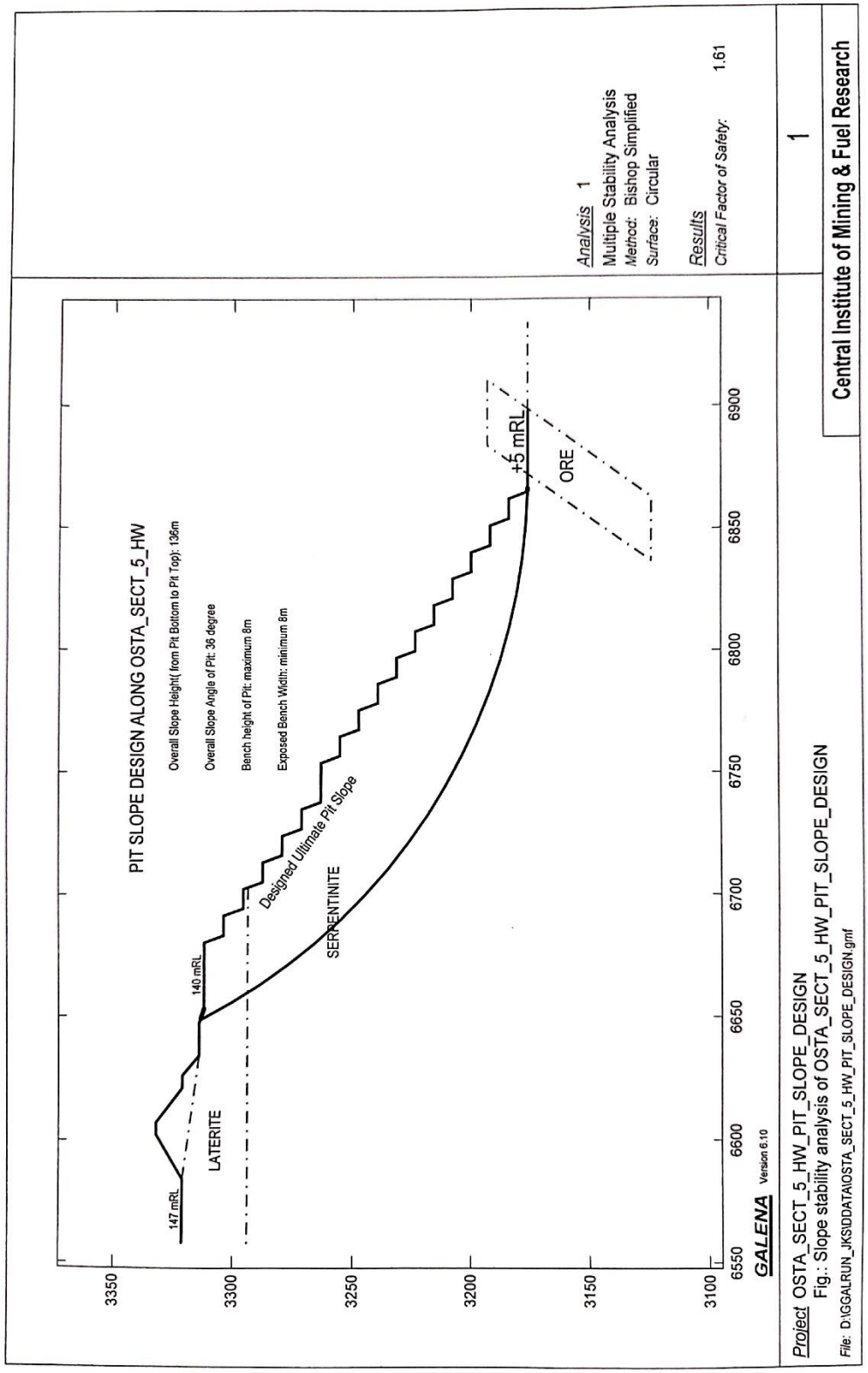

Fig. 19: Design of Ultimate Hangwall Pit along Section Sect-5

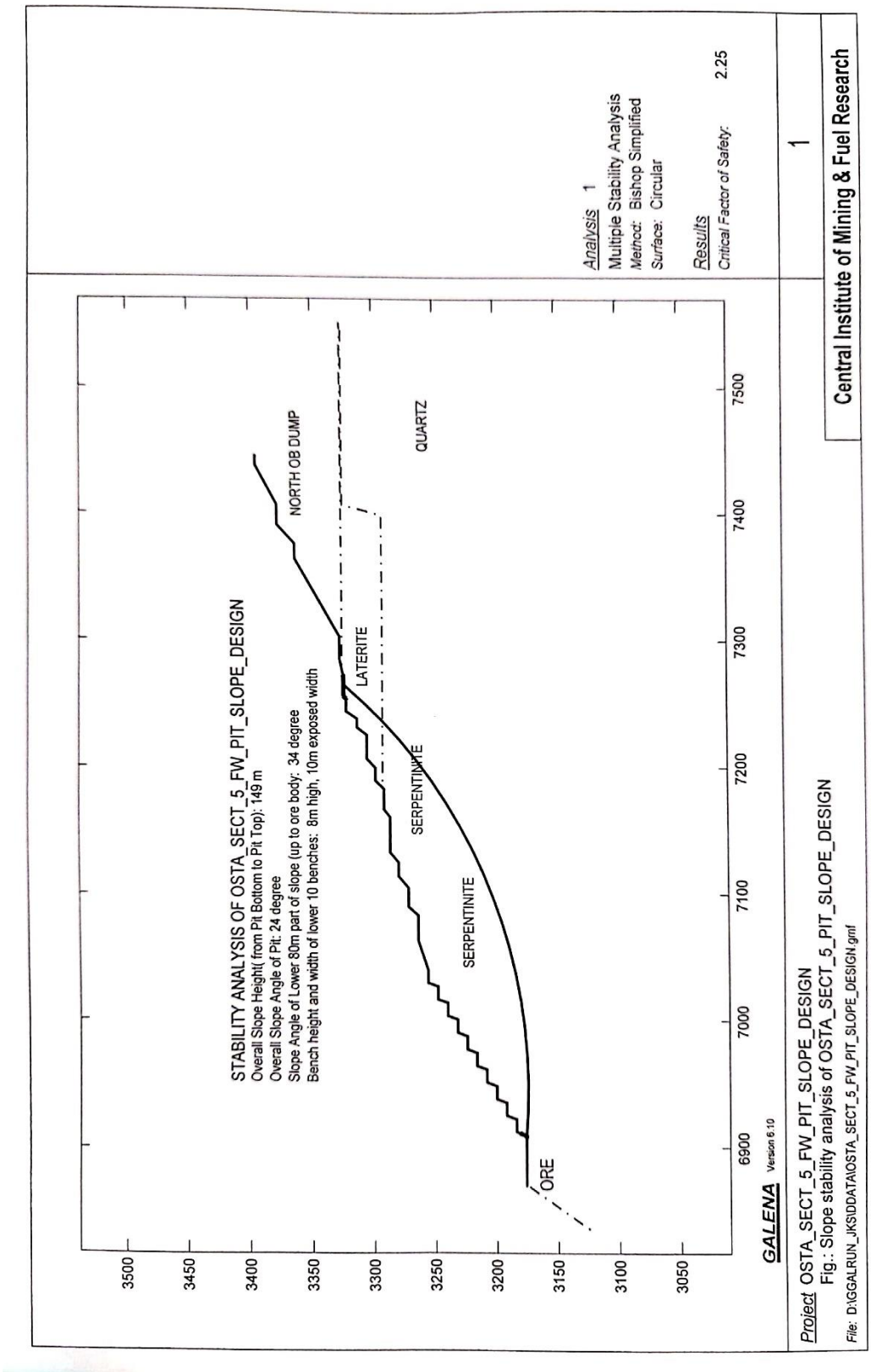

Fig. 20: Design of Ultimate Footwal Pit along Section Sect-5

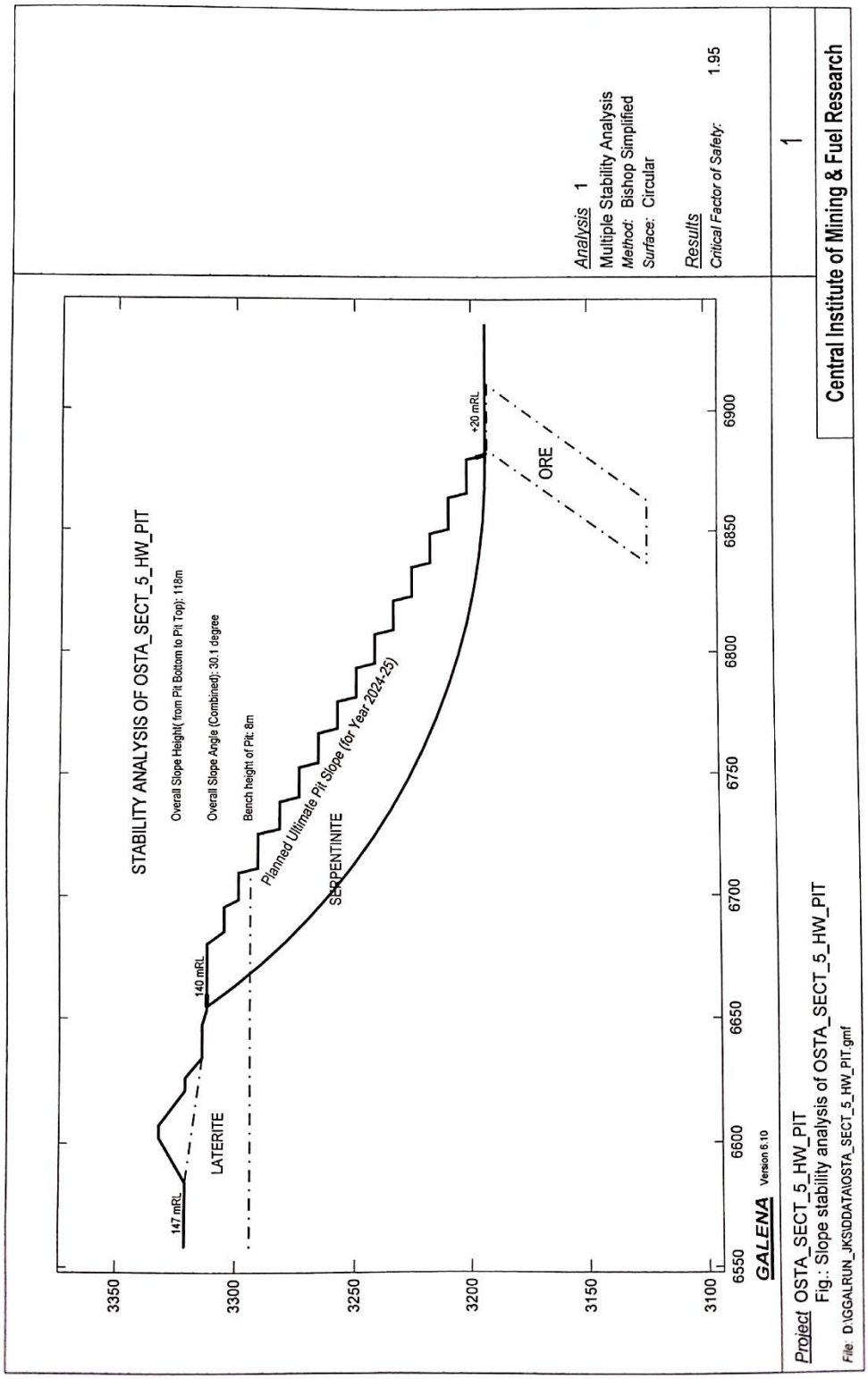

Fig. 21: Stability analysis of planned Hangwall Pit along Section Sect-5

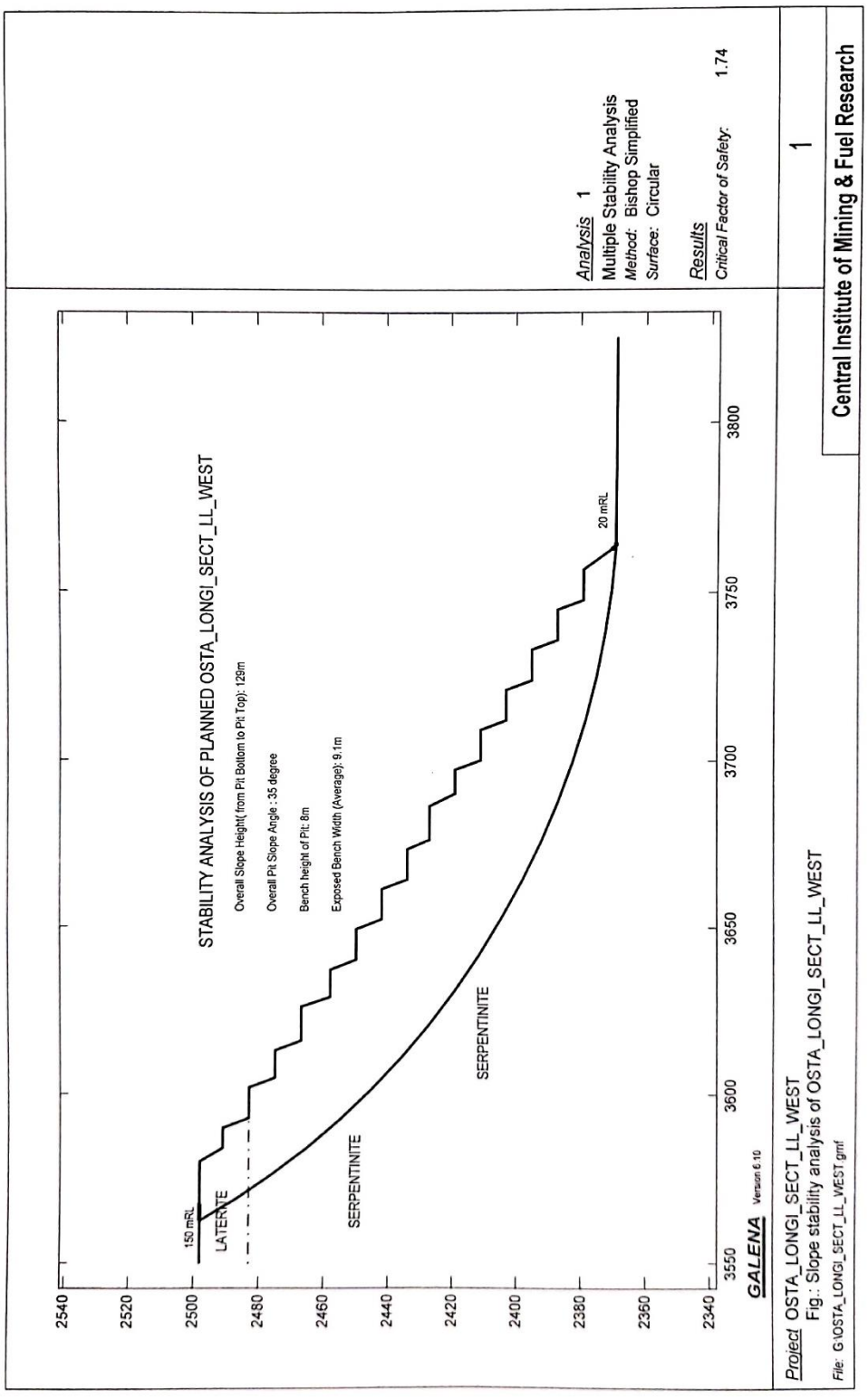

Fig 22: Slope stability analysis of Longitudinal Section LL' West Side

SLOPE STABILITY ANALYSIS OF OVERBURDEN DUMP

Existing OB dump plan of North and South OB Dump has been given in Fig. xxx and xxx and the sections of north and south dump at different locations have been shown in Fig. xxx. Magnified Views of some of these existing and planned sections of dump have been provided in Fig. 25 to 29. Stability analysis of different sections of dumps have been given in Fig. 30 to 34. Maximum dump height existing is 80-85m. Analysis of dump slope stability for dump design was performed for maximum planned height of 90m and the result is shown in Fig. 30 to 34.

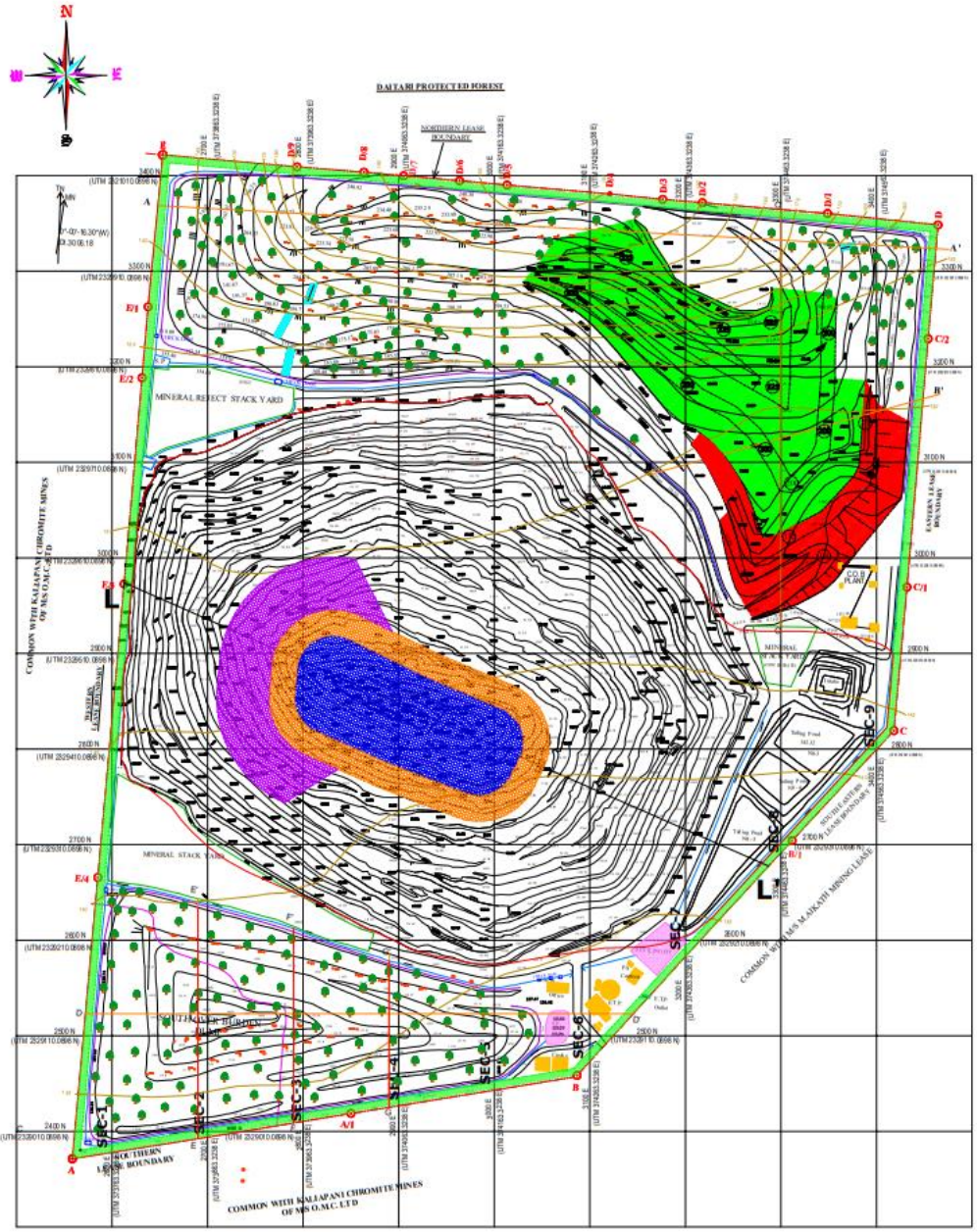

Fig. 23: Plan of North and South Dumps of Ostapal Chromite Pit

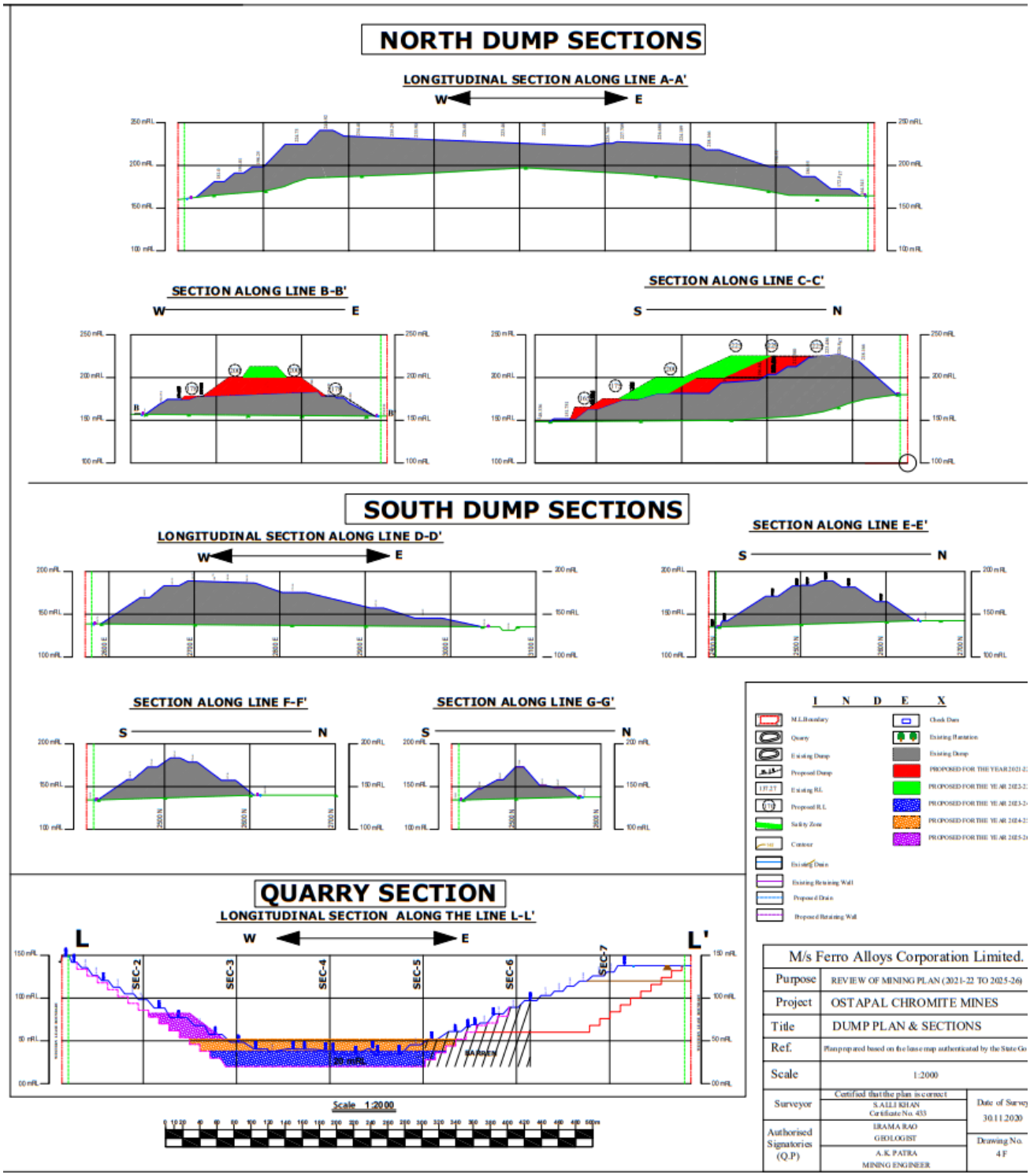

Fig. 24: Sections of North and South OB Dumps

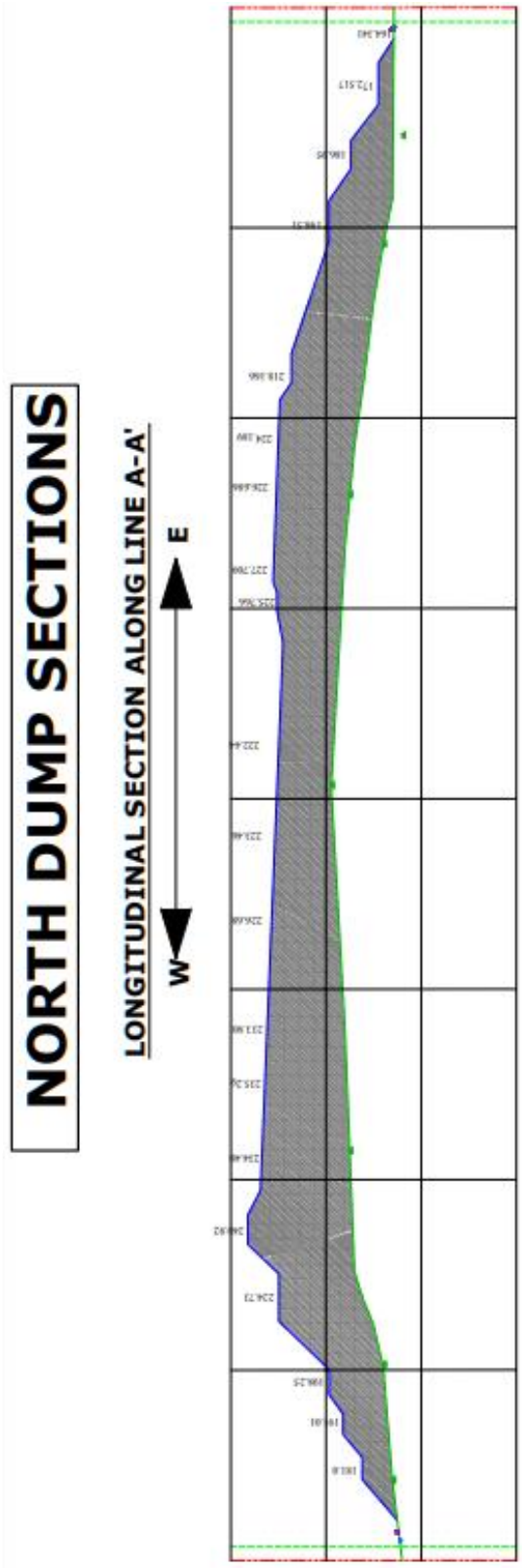

Fig. 25: Longitudinal Section of North OB Dump along Section AA'

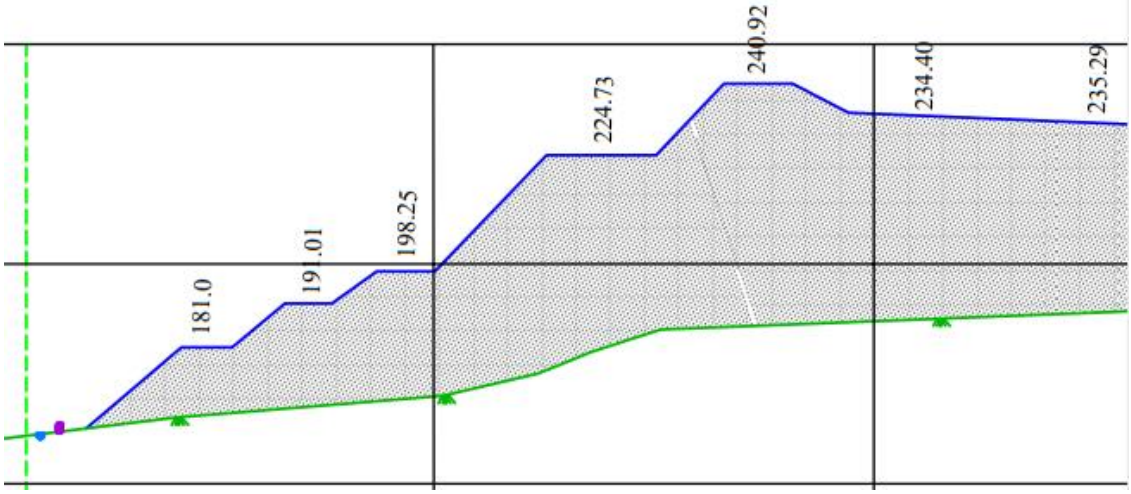

Fig. 26: Western Part of Section AA' of North Dump

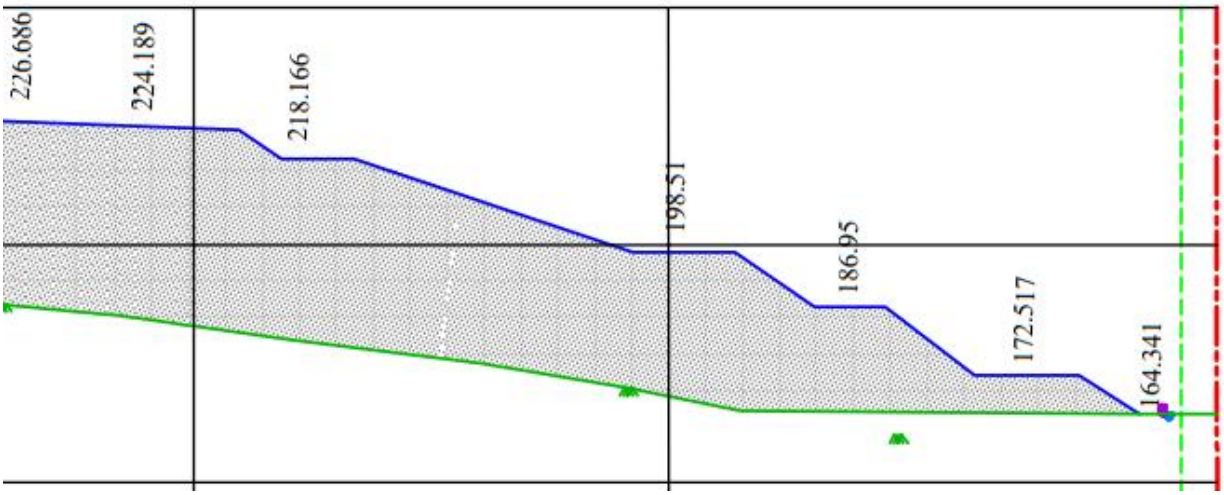

Fig. 27: Eastern_Part of North Dump along Section AA'

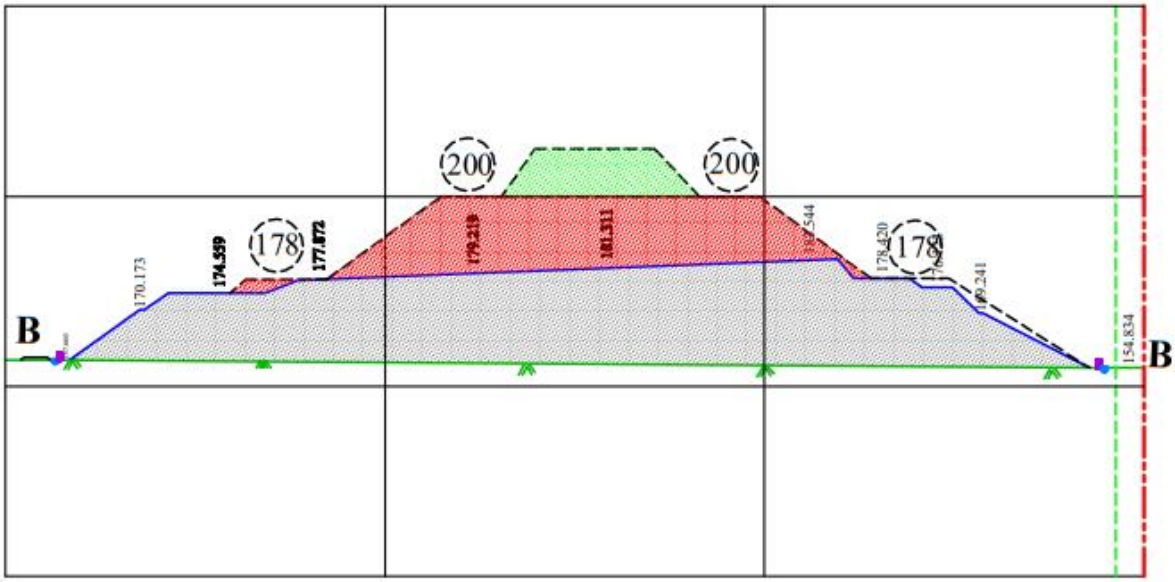

Fig. 28: Planned Section along BB'

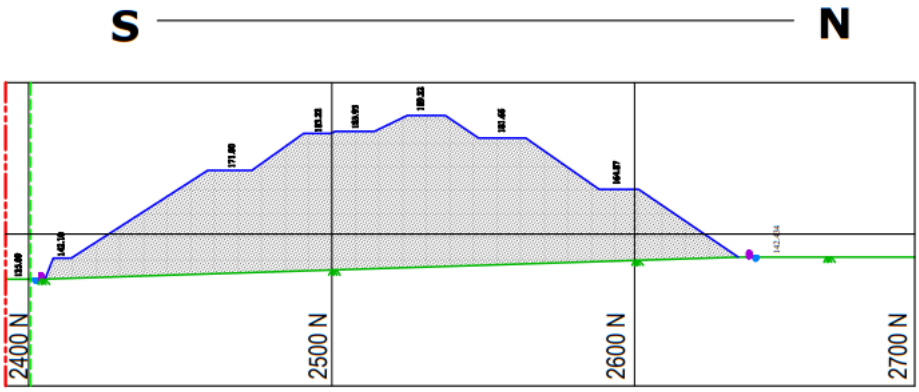

Fig. 29: Ostapal Dump_Section along EE'

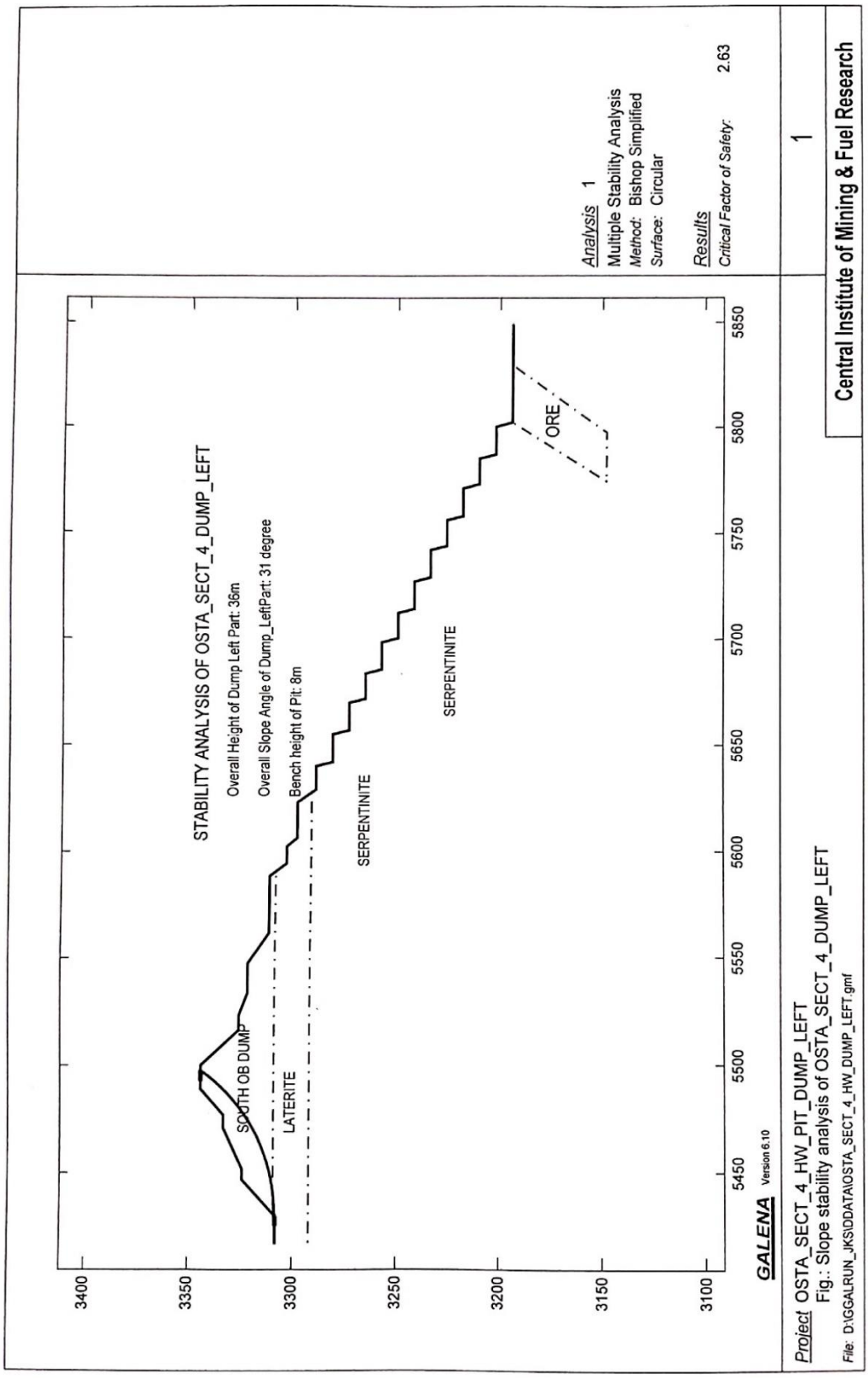

Fig 30: Slope stability analysis of South OB Dump (Left Part) along Section-4

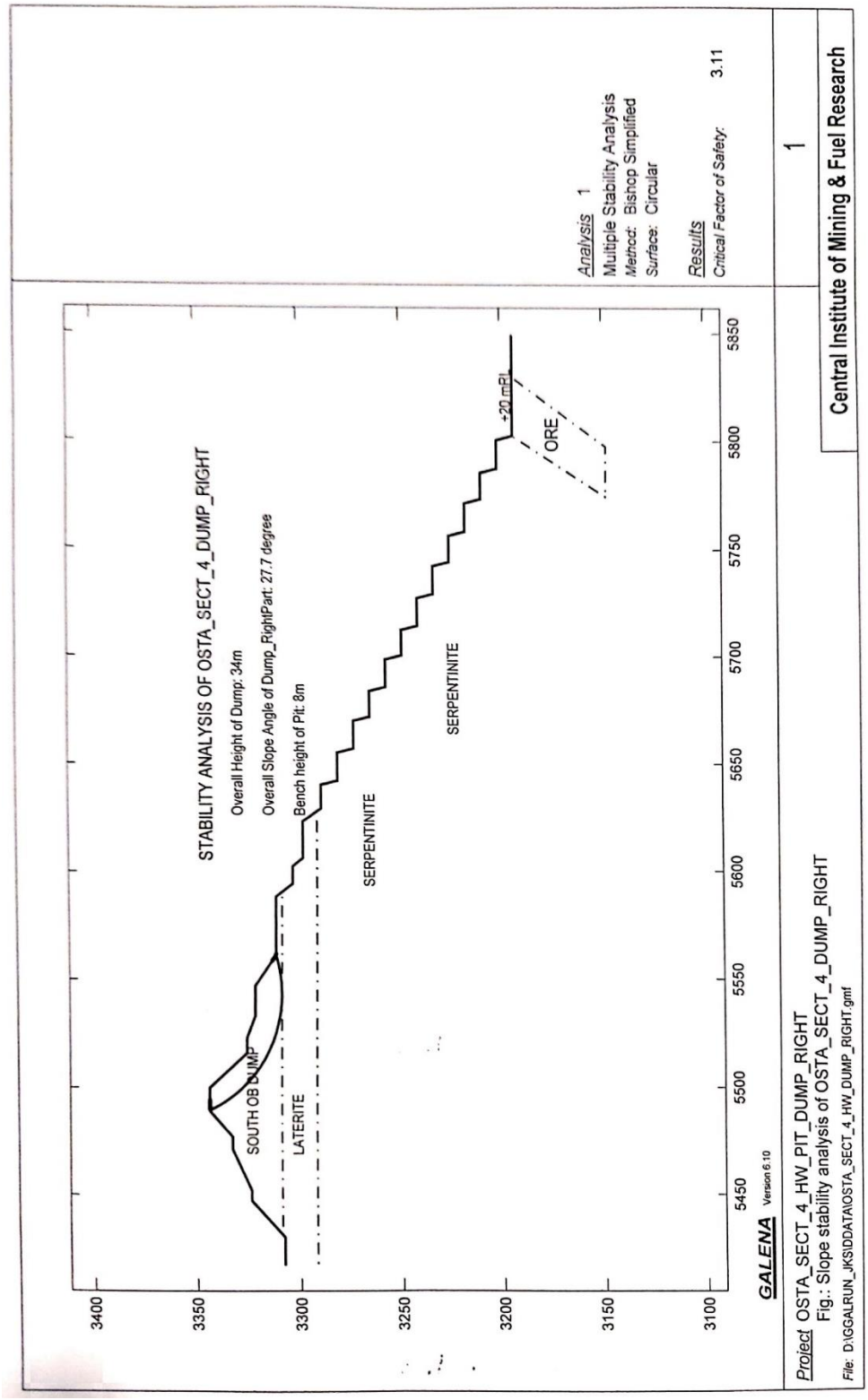

Fig. 31: Slope stability analysis of South OB Dump (Right Part) along Section-4

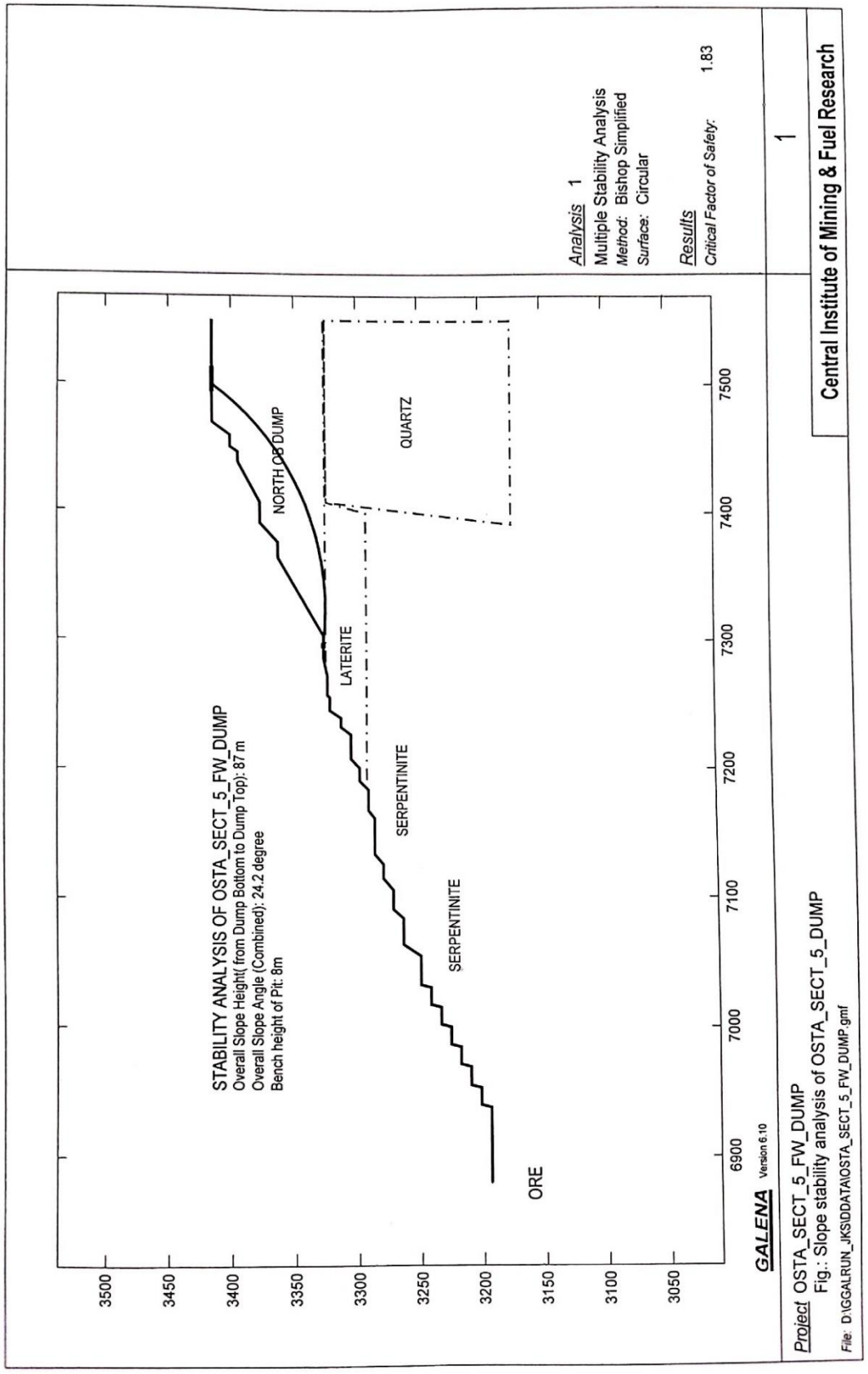

Fig. 32: Slope stability analysis of North OB Dump along Section-5

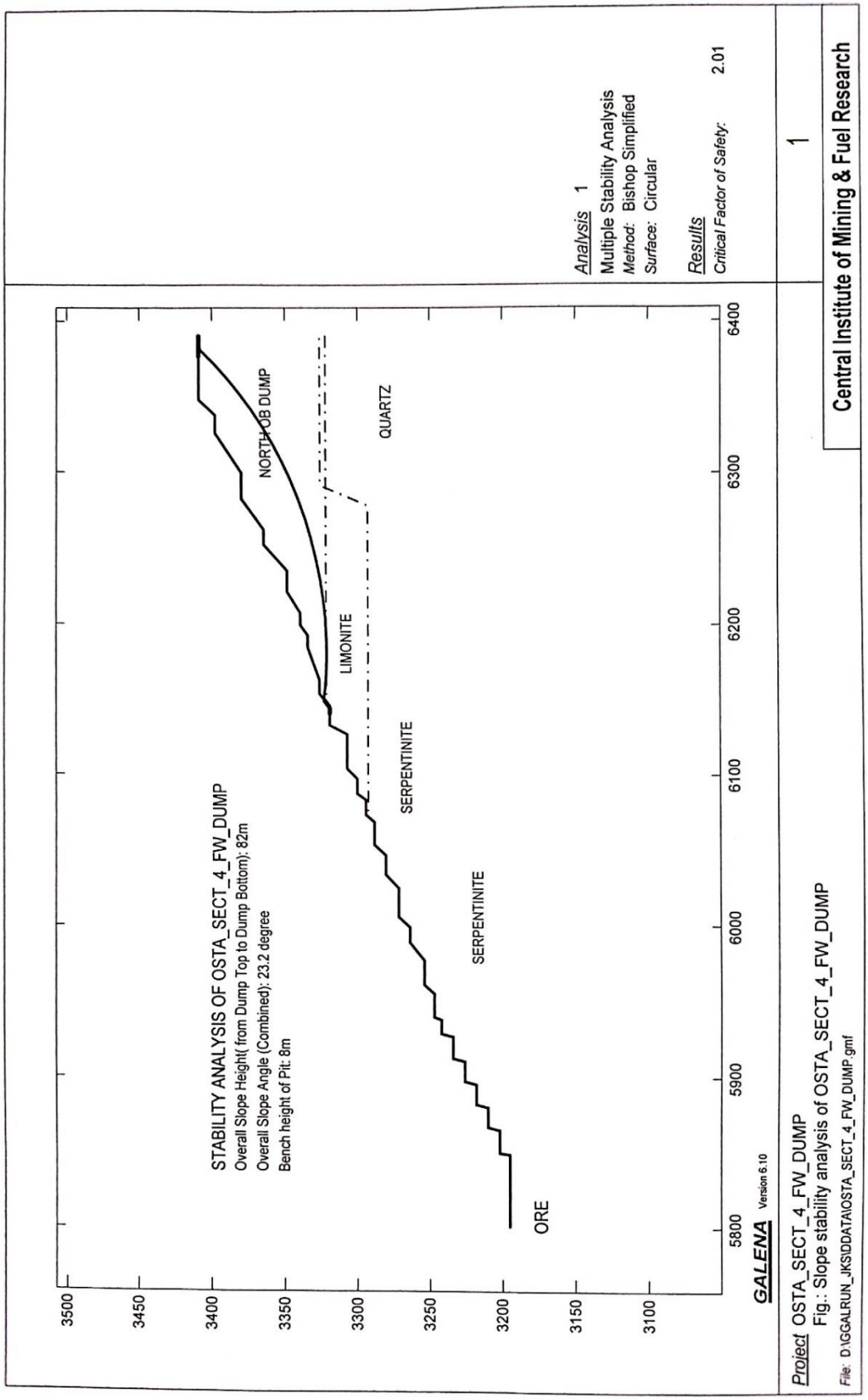

Fig. 33:: Slope stability analysis of OB Dump on Footwall Slope of Section-4

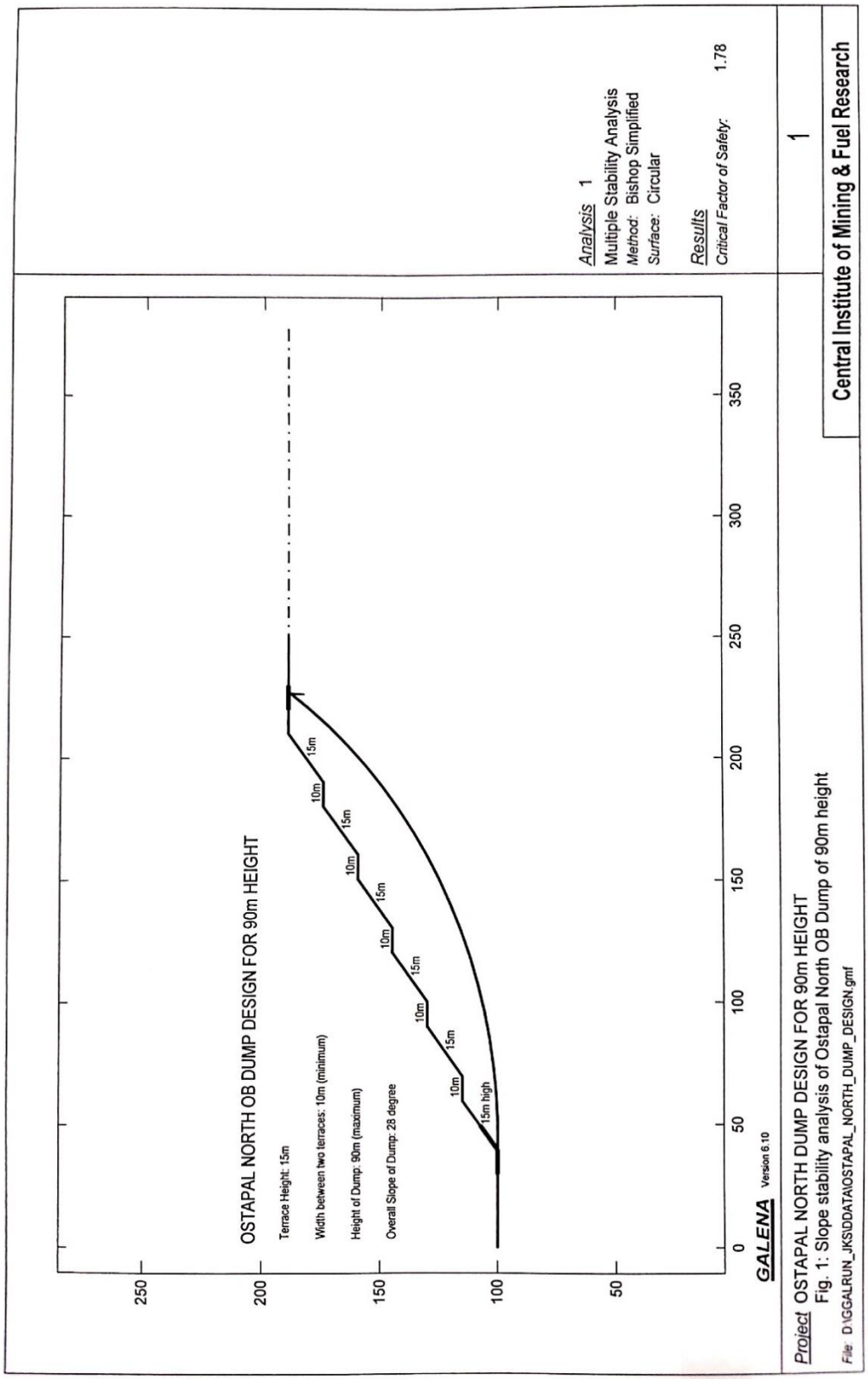

Fig. 34: Stability Analysis and Design of 90m high North Dump of Ostapal Chromite Mine

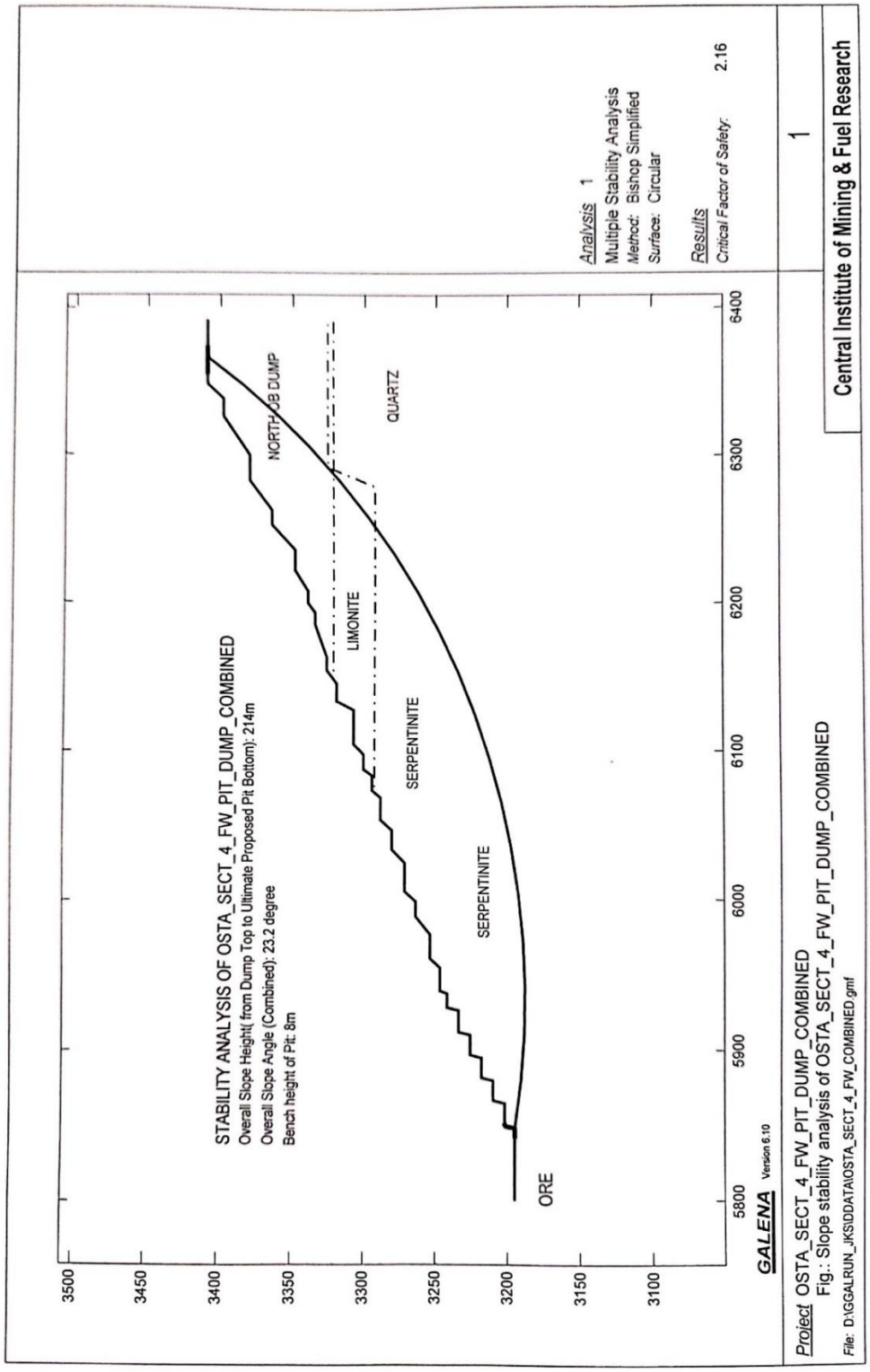

Fig. 35: Stability analysis of Pit and Dump combined slope along Sect-4 Fotwall

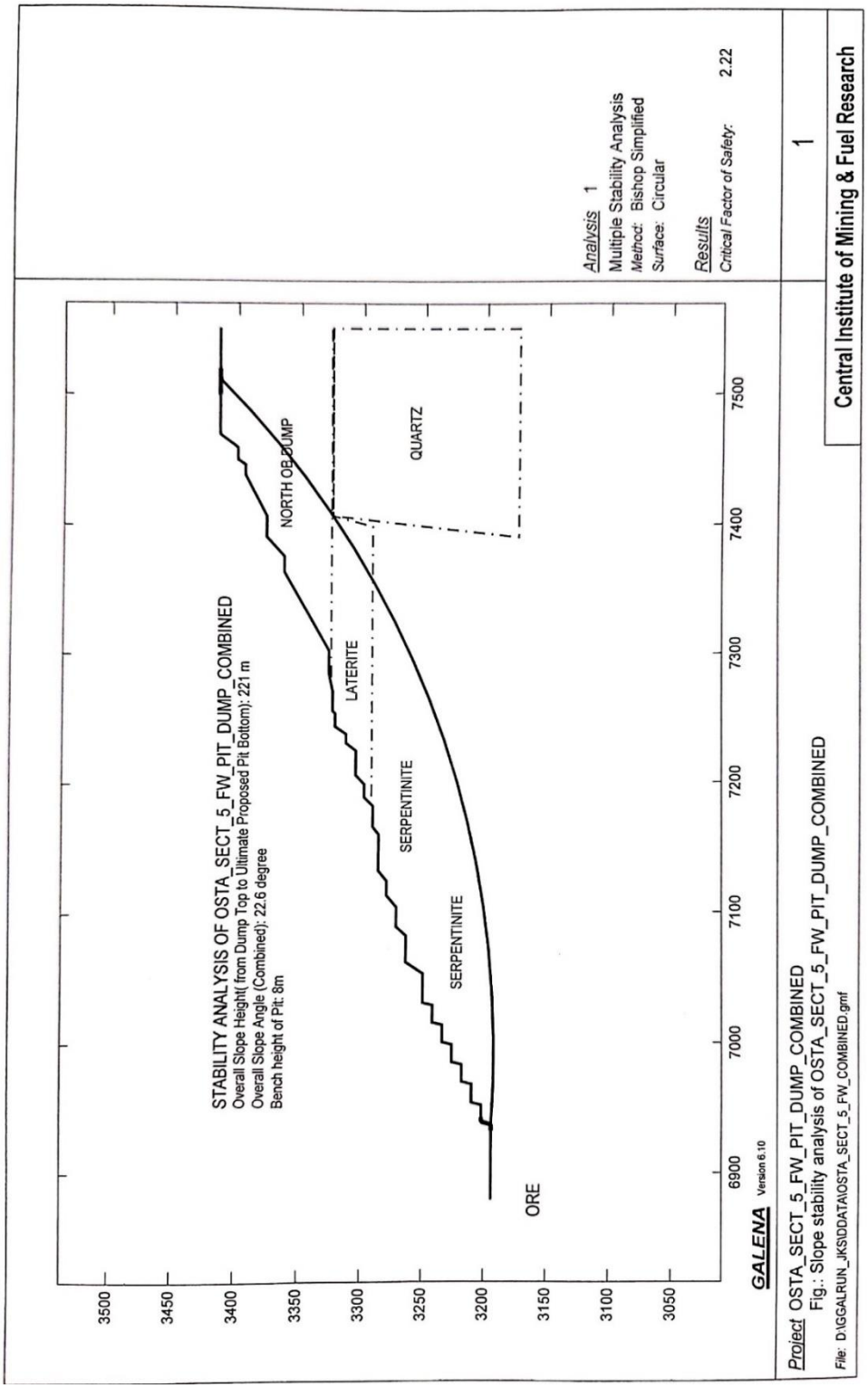

Fig. 36: Stability analysis of Pit and Dump combined slope along Sect-5 Fotwall

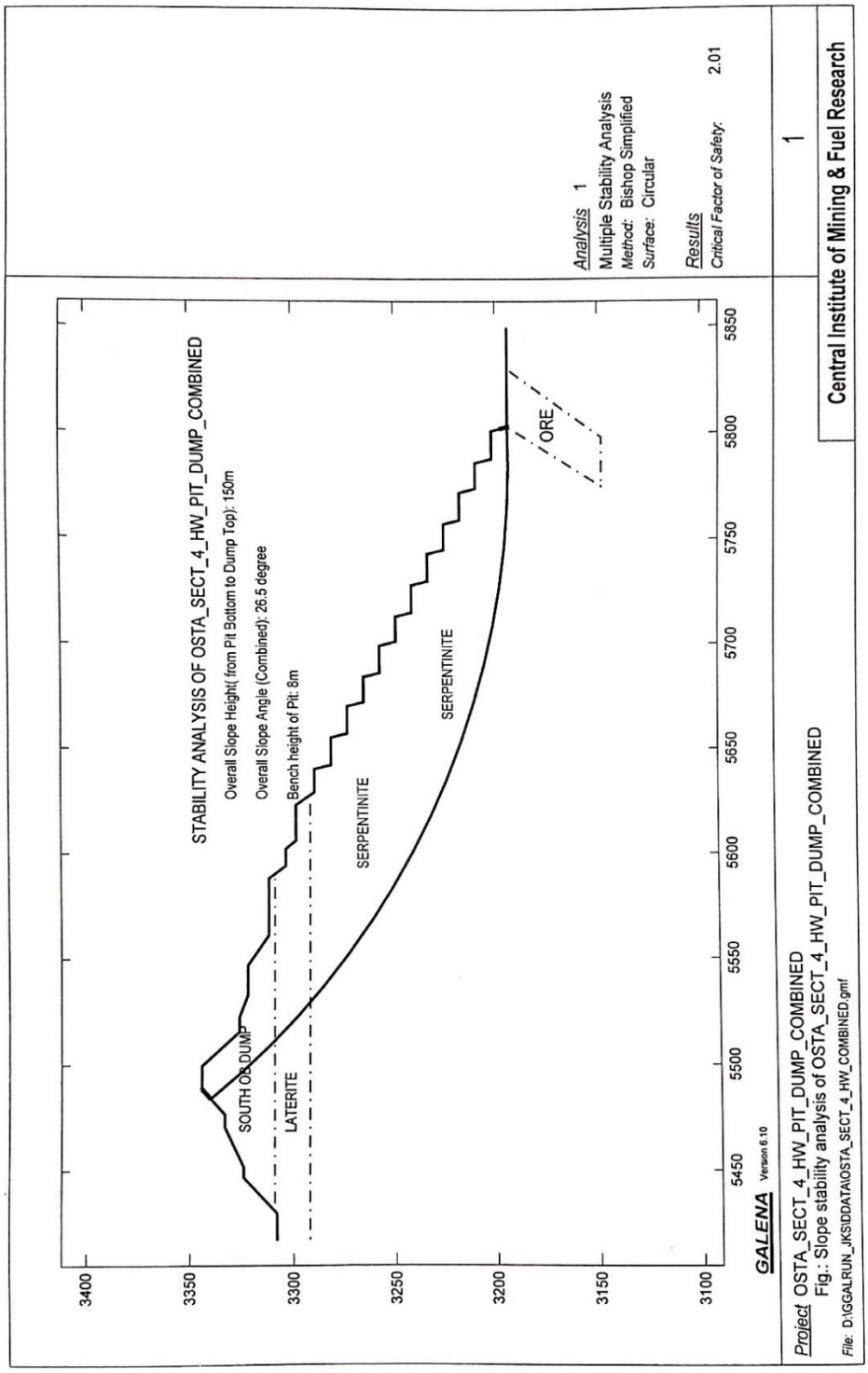

Fig. 37: Stability analysis of Pit and Dump combined slope along Sect-4 Hangwall

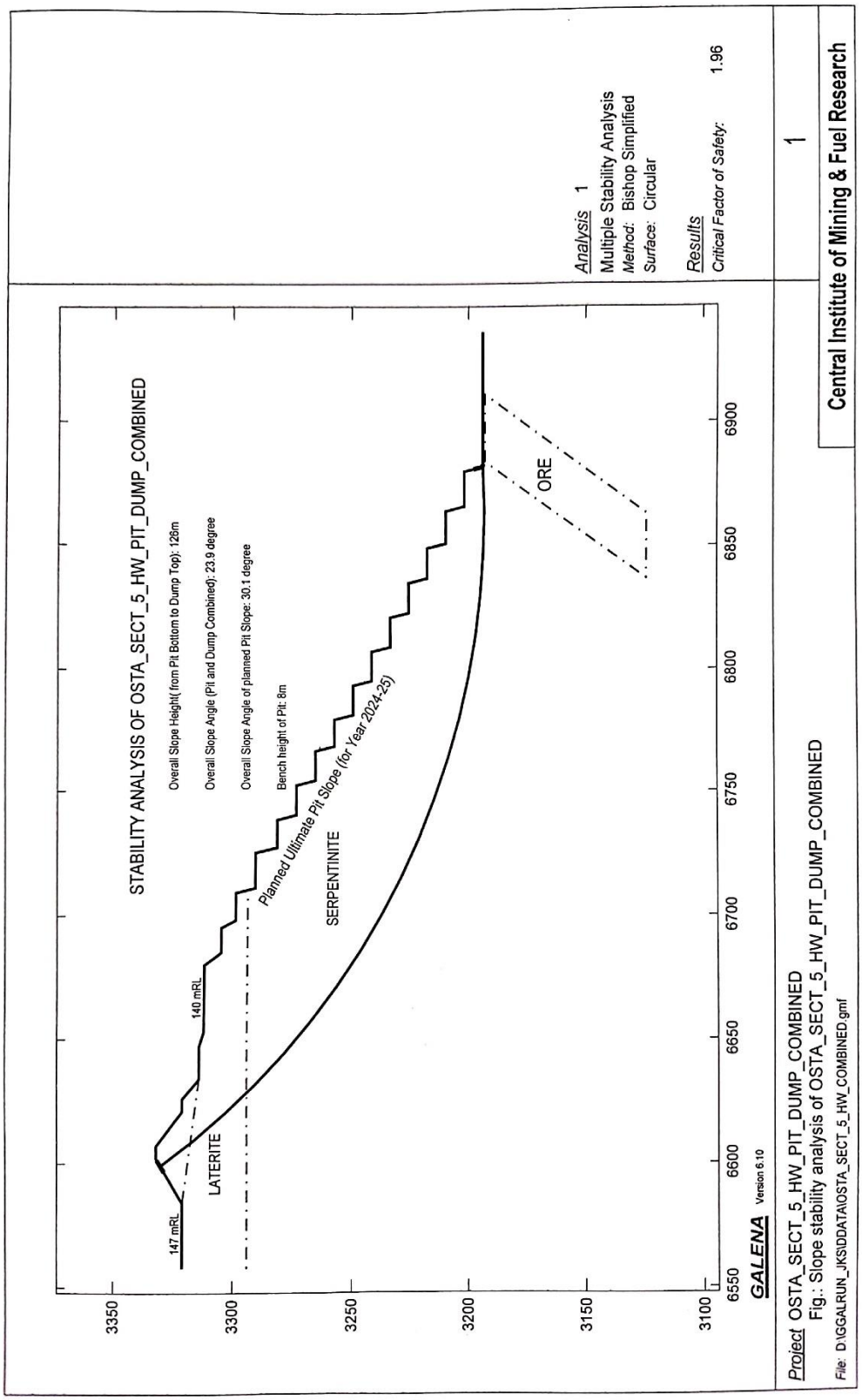

Fig. 38: Stability analysis of Pit and Dump combined slope along Sect-5 Hangwall

COMBINED ANALYSIS OF PIT AND DUMP

Combined pit and dump sections were analysed for stability along footwall slope and hangwall slopewith North OB dump and South OB dump. Analysis results along sections Sect-4 and Sect-5 have been shown in Fig. 35 to 38.

The analysed factor of safety of the proposed ultimate Pit, Dump, and Combined Pit and Dump along different sections have been summarized in Table 3.

Table 3: Slope Stability Analyses of Ultimate Pit Slopes, Dump Slopes and Combined Slopes

Sl No.	Description	FOS	Figure
1	Stability Analysis of Planned Footwall Pit along Section Sect-4	2.35	Fig. 15
2	Stability Analysis of Planned Hangwall Pit along Section Sect-4	2.01	Fig. 16
3	Stability Analysis of Planned Footwall Pit along Section Sect-5	2.43	Fig. 17
4	Stability Analysis and Design of Ultimate Pit Slope along LL’	1.59	Fig. 18
5	Stability Analysis and Design of Ultimate H/Wl Pit Slope along Sect-5	1.61	Fig. 19
6	Stability Analysis and Design of Ultimate F/W Pit Slope along Sect-5	2.25	Fig. 20
7	Stability Analysis of Planned Hangwall Pit along Section Sect-5	1.95	Fig. 21
8	Stability Analysis of Planned Pit Slope along section LL’ west	1.74	Fig. 22
9	Stability Analysis of Existing South Dump Slope (left) along Sect-5	2.63	Fig. 30
10	Stability Analysis of Existing South Dump Slope (right) along Sect-5	3.11	Fig. 31
11	Stability Analysis of North OB Dump along Sect-5	1.83	Fig. 32
12	Stability Analysis of North OB Dump along Sect-4	2.01	Fig. 33
13	Stability Analysis and Design of 90m high North OB Dump	1.78	Fig. 34
14	Stability Analysis of combined pit and dump along Sect-4 Footwall	2.16	Fig. 35
15	Stability Analysis of combined pit and dump along Sect-5 Footwall	2.22	Fig. 36
16	Stability Analysis of combined pit and dump along Sect-4 Hangwall	2.01	Fig. 37
17	Stability Analysis of combined pit and dump along Sect-5 Hangwall	1.96	Fig. 38

The analysis shows that the large-scale failure is unlikely for planned pit and dump but small-scale failure cannot be completely ruled out. The main philosophy in slope design is to avoid large-scale failure. Localised bench failure does not cause great concern as it can be arrested on the lower benches, which can be cleaned. So, machinery access on the benches must be maintained.

It may be noted that a few small-scale failures may subsequently cause a big failure. If about three benches are made steeper at any level in any part of the pit then it may initiate failure. Although the overall slope angle may be quite low but the steeper slope angle of three benches may increase the stress at the toe of relatively steeper part of the slope, which may cause failure. Two or three such small failures may cause a big failure. So, benching should be done properly from top to bottom.

Attention must be paid to avoid entry of rainwater in the slopes by providing suitable drainage in and around the mine and dump. The rainwater should not be left to flow in/ along the slopes in an uncontrolled manner. It should be taken up well before the onset of monsoon for existing and the final slopes both.

Table 4: Design of North Dump of Ostapal Chromite Mine

Dump Parameters		
Maximum Terrace Height (m)	**Minimum Exposed** Terrace Width (m)	Angle of repose (deg.) for each terrace
15	10m between different terraces	**37**

Salient Designed Parameters are summarized as:

- Maximum height of dump: 90m
- Maximum height of each terrace: 15m
- Fourth terrace: Height 15m
- Minimum Terrace Wdth: 10m between consecutive terraces.
- Bench slope angle of one lift: 37 degree
- Overall Slope of 90m high OB dump: $\leq$ 28 degree

Table 5: Design of Ultimate Pit Slope of Ostapal Chromite Mine upto +5 mRL

Salient Designed Parameters are summarized as:

- Maximum Bench Height: 8m
- Minimum Exposed Bench Width: 8m
- Bench Slope Angle: not more than 70 degree
- Overall designed pit slope height (from surface to +5 mRL):

  Maximum 136m on Hangwall side,

  Maximum 149m on Footwal side.
- Overall Pit Slope Angle Recommended:

  Hangwall Slope: $\leq$ 36 degree

  Footwall Slope : $\leq$ 24 degree

  East and West Sides: 36 degree

If the pit and dump slopes are not kept in drained condition then the factor of safety would reduce substantially. However, it may be recalled that the most likely condition of the slope was already adjudged to be drained condition through implementing drainage, water management and slope depressurization measures as recommended. Under drained condition, dump slopes are likely to be stable with available shear strength of the dump material. In order to avoid undrained condition, attention must be paid to avoid entry of rain / surface water in the slope or dump mass by providing suitable drainage in and around the dump, failing which the dump slope may become unstable.

Drainage and water management

The rainwater of the adjacent catchments area should not be allowed to enter in to pit in an uncontrolled way. It causes erosion and deep gullies in the weak formations, which in turn may result in failure in due course of time. So, the rainwater of the catchments area should be directed away from the pit or dump. Effective garland drain should be provided around pit and dump.

The influence of water is alarming; hence every attempt should be made to divert the water away from the pit and proper drainage pattern should be effectively maintained. A proper gradient helps for quick run-off of water.

The upper surface of the pit and dump should be properly graded to divert the run-off of rainwater away from the pit and dump. The proper leveling and grading of benches (for about 2 to 3 degrees) should be done for quick run-off of rainwater. During rains, one person should check the flow path of the rainwater to make the existing drainage system more effective. Rainwater of the dump need to be taken down the dump in a controlled manner through effective toe drain on each lift of dump. Such toe drain may be made up of RCC or any impervious material such as geomembrane to channelize the water. HDPE/ PVC pipe may also be used to bring pit and dump water from one level to lower level. Adequate precautions should be taken to avoid clogging of the pipe by sediments of dump material. Drains / water channels should be cleaned periodically to keep them effective.

Management of Water through Horizontal Drain Holes For Ostapal Chromite Pit

Based on analysis of physical observations of water seepage conditions at Ostapal Chromite Mine, hydrological report of the mine, and additional inputs provided by mine management on seepage locations, CSIR-CIMFR recommends the slope water management plan as for slope depressurization as follows. It is advisable to implement the recommendations at the earliest to improve the condition of slope stability at the mine. Water seepage and wet slope wall problems existing at Ostapal Chromite mine can be seen from through figures 39,40 and 41.

Fig. 39: Water seepage from slope wall

Fig 40: Water seepage from several places of slope wall

Fig 41: Moist slope wall due to presence of water in slope.

Slope depressurization through horizontal drains will also provide opportunity of further steepening of the slope from existing slope angle. Slope depressurization through a system of horizontal drains as suggested will improve the slope stability significantly.

Five water seepage locations (S/1, S/2, S/3, S/4 and S/5) were identified at Ostapal Chromite Mine whose locations (Easting, Northing and RL) have been shown in fig. 42 and Table 6. Horizontal drainage holes are recommended for depressurization of slope walls and for pushing back the phreatic surface away from slope walls of pit. This will improve the stability of slope and the steepening of slope will be feasible due to increase in shear strength of slope walls. Position and orientation of the horizontal holes are shown in Fig. 44, 45 and 46 and Table 7. Schematic sectional view of horizontal drainage holes (4 inch diameter hole with about 3 inch slotted or perforated PVC casing) is shown in Fig. 43. Drainage holes should be kept inclined upward at 5 degree from horizontal.

TABLE 6: LOCATIONS OF 5 MAJOR SEEPAGE POINTS OF OSTAPAL CHROMITE MINE

SEEPAGE POINT	LOCATION		
	X	Y	RL (m)
S/1	2695	3020	115
S/2	2676	2984	115
S/3	2675	2836	106
S/4	2731	3000	97
S/5	3160	2837	97

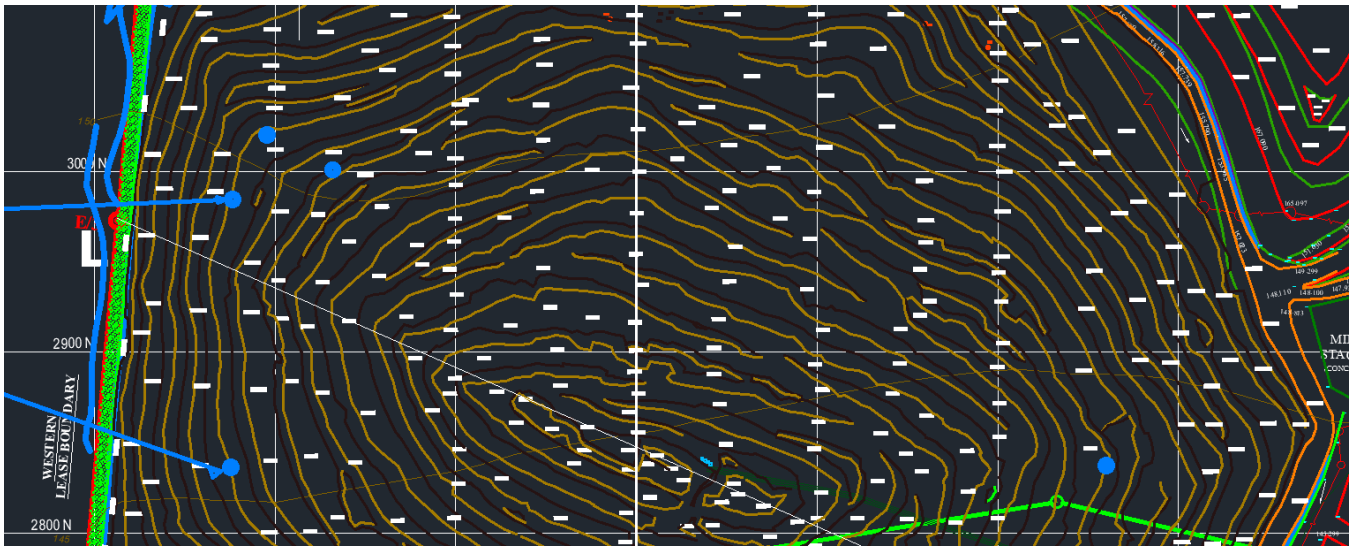

Fig.42: Five Major Seepage Zones of Ostapal Chromite Mine (shown by Blue Circles).

TABLE 7: COLLAR POSITION, FAR-END COORDINATES, AND LENGTHS FOR RECOMMENDED 15 NUMBER OF HORIZONTAL DRAIN HOLES (5 Degree Inclined).

DRAIN HOLE IDENTIFICATION	COLLAR POSITION OF DRAINS			FAR-END OF HORIZONTAL DRAIN			LENGTH OF HOLE (M)
	X	Y	RL	X	Y	Inclination (Degree)	
DH/1	2699	3023	115	2656	3069	5	60
DH/2	2695	3020	115	2646	3055	5	60
DH/3	2691	3016	115	2639	3039	5	55
DH/4	2678	2989	115	2634	3022	5	55
DH/5	2676	2984	115	2628	3008	5	55

DH/6	2674	2980	115	2625	2990	5	50
DH/7	2675	2841	106	2621	2857	5	60
DH/8	2675	2836	106	2616	2835	5	60
DH/9	2675	2831	106	2617	2815	5	60
DH/10	2735	3003	97	2661	3077	5	105
DH/11	2731	3000	97	2645	3050	5	100
DH/12	2727	2997	97	2638	3031	5	95
DH/13	3159	2842	97	3245	2875	5	95
DH/14	3163	2837	97	3255	2845	5	95
DH/15	3160	2832	97	3250	2822	5	95

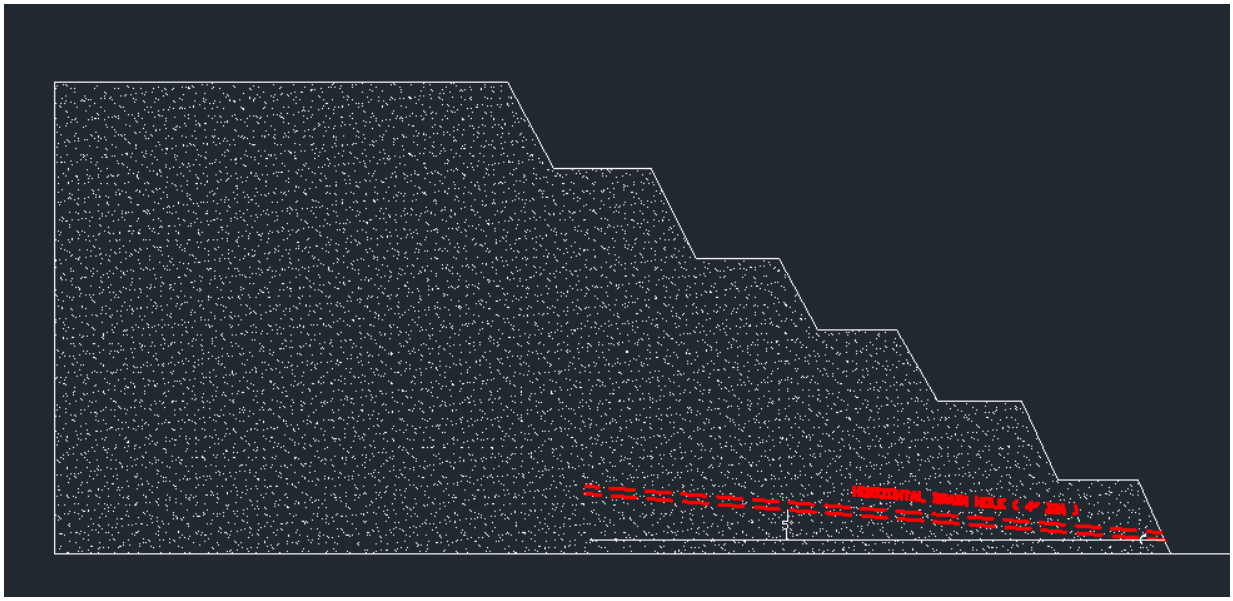

Fig. 43: Schematic Diagram for Sectional View of Horizontal Drain Hole (4 inch Dia, inclined at 5 degree)

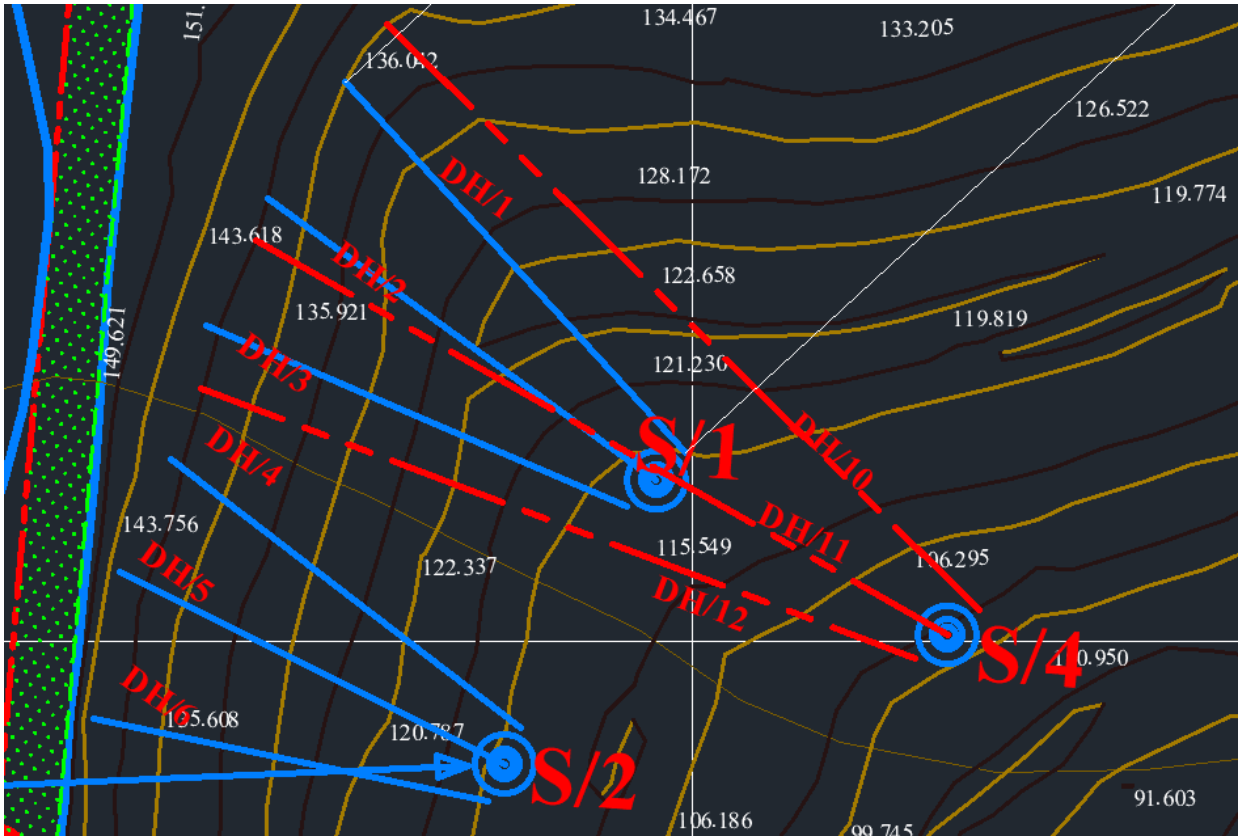

Fig. 44: Horizontal Drain Holes - 3 in numbers near each major seepage Locations S/1, S/2 and S/4. Identification Numbers are shown as DH/1 to DH/6, and DH/10 to DH/12. Set of three holes at each seepage zone will be separated horizontally by 5 to 10m.

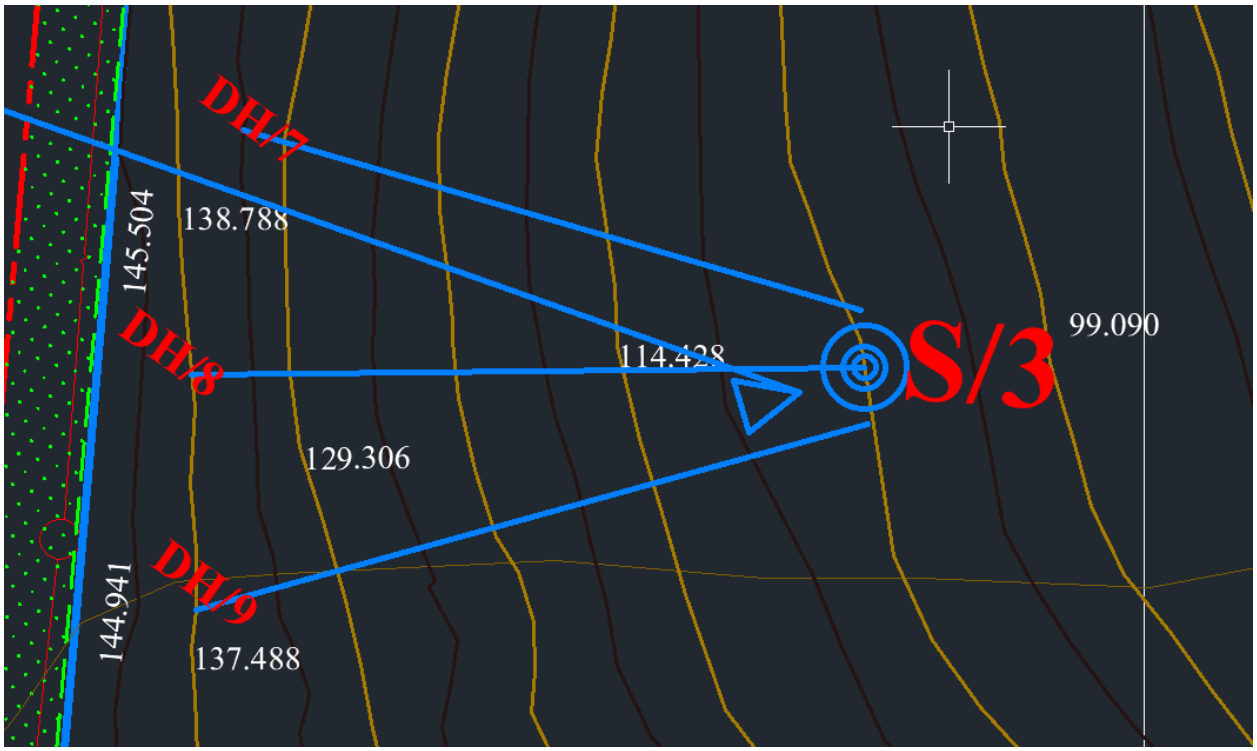

Fig. 45: Horizontal Drain Holes DH/7, DH/8 and DH/9 near Seepage Zone S/3

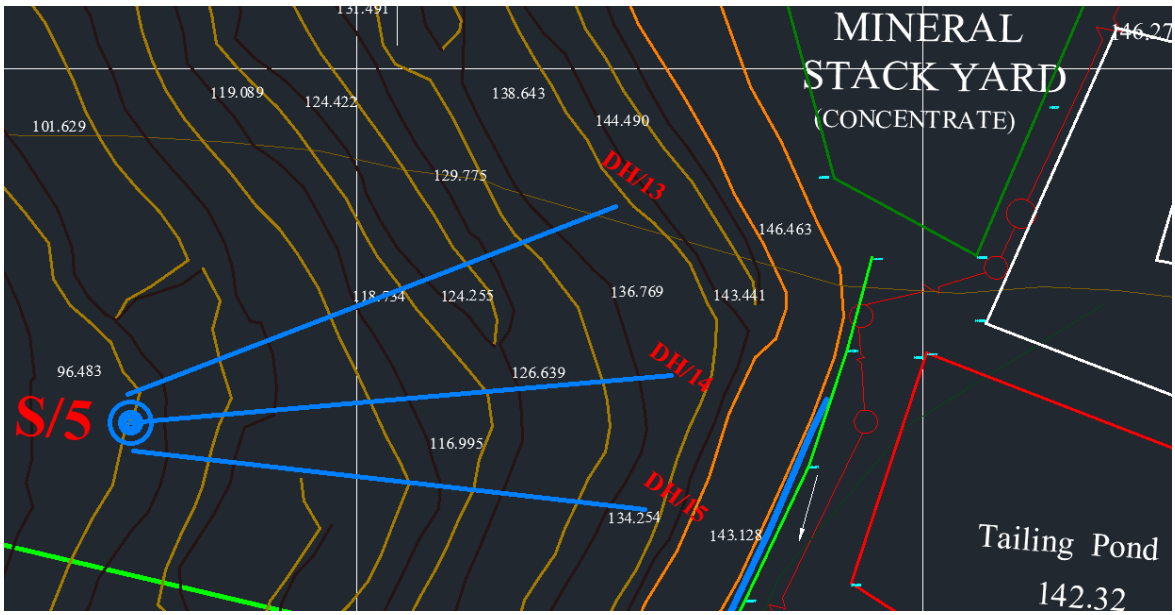

Fig. 46: Horizontal Drain Holes (DH/13, DH/14 and DH/15) near Seepage Zone S/5

Water collected from Horizontal drain holes from a particular zone should be collected and channelized in cemented toe drains so as not to allow percolation of this water into pit slope surface. This channelized water and any additional rain water need to be guided to pit bottom in a controlled way through use of hume pipes/ HDPE pipe (for road crossing) and cemented toe drains on lower levels. Water needs to be guided to pit bottom in such a way that it does not create damage to slope surface. All necessary precautions need to be taken to prevent clogging of hume pipes/ HDPE pipes.

Vibrating wire piezometer should be installed in vertical borehole to monitor the drop in phreatic surface due to depressurization taking place from horizontal drain holes. To start with, one piezometer should be installed near seepage points S/1, S/2 and S/4 towards crest of pit. Another piezometer should be installed towards crest of pit near seepage location S/5. A third piezometer may be installed near seepage zone S/3. Periodical monitoring of piezometers and flow of water through different drain holes will be useful in management of water for Ostapal Chromite mine.

Slope Monitoring

The main objective of slope monitoring study is to detect any instability well in advance so that any damage to men and machineries can be avoided. If the failure is unavoidable then it can be brought down in a predictable manner. The instability detected in the early stage can be stabilized by applying a suitable remedial measure. If the instability is detected at a later stage then it will be very difficult to check the instability.

The early identification of movement zones allows steps to be taken to minimize the impact of mining on stability by the implementation of corrective measures and at the same time provides for optimum minerall extraction. The system contrasts strongly with more common 'passive' systems that frequently only record the occurrence of an event for subsequent post-mortem examination. The active monitoring system permits early and confident decision making by management both for safety purposes and for optimum excavation sequencing.

All geotechnical investigations aimed at collecting input design parameters, however complete, involve an inherent risk of inaccuracy. Hence, any attempt of slope stability analyses and evaluation need to be supported by a sound slope monitoring programme in order to ensure the safe and smooth mining operations.

The continuous mining operation, blasting and changes in groundwater conditions continuously disturb the existing stress condition in the field. The whole system tries to come into equilibrium by stress redistribution and adjustment, which results into movement of the slope. Hence, it is advisable to monitor the slopes regularly to detect any movement. DGMS(Tech.) Circular No. 2 of 2020 dated 09.01.2020, mine manager should have a structured team of trained competent persons for slope monitoring headed by a slope monitoring officer with clearly defined duties and responsibilities.

The slope monitoring method allows failures to be predicted for ensuring safe working conditions. Slope monitoring can be used to confirm failure mechanisms. The review of monitoring results, visual inspection and regular briefing of field people help to detect the onset of failure.

The first sign of instability is a tension crack. So, it is important to carry out regular inspection to detect the development of tension cracks on the crest of the slope as well as on benches and to carry out prompt remedial measure. They may develop as a function of high stresses in the slopes. The opening of cracks will tell whether any deep - seated failure can occur or not. Tension cracks should be filled and sealed to prevent the entry of water, which may cause failure.

Monitoring Systems

The slope monitoring techniques vary widely ranging from simple visual observations of signs of potential instability such as slope bulging, surface fretting and the formation of tension cracks to the use of somewhat complex instrumentation. The scale of the mining operation, transport system and the nature and location of the potential slope failure decides the application of a particular technique.

Survey based methods can be used for absolute monitoring, that is determining the movement of a point or points relative to some datum believed to be outside the zone of potential deformation. These include:

(a) Total station – Precise level-based monitoring,

(b) Tension crack monitors.

Other monitoring methods which are used for more critical slopes are:

(c) Robotic Total station Based Monitoring using Fixed Prisms.

(d) 3D- Terrestrial Laser Scanning for Slope Monitoring in periodical or continuous monitoring mode.

(e) Slope stability radar for continuous monitoring.

Whichever is the technique used for slope monitoring, the objective is to predict future slope instability by appropriate interpretation of Displacement - Time data and analyses of failure mechanism.

The slope monitoring based on standard surveying techniques have found wide acceptance because of the ability to remotely monitor a wall following the establishment of

targets. Use of Total Station techniques along with angular measurements have become most popular because of the perceived advantage of only having to monitor from one location.

The latest methods are emerging to monitor pit slopes in open pit mines. These methods are based on various technologies such as:

Automated total station networks (robotics);
Terrestrial Laser Scanning for Slope Monitoring
Slope Stability Radar (SSR);

The large open-pit mines have begun using one or more of these new methods to monitor pit slopes. For example, a network of automated total stations and reflective prisms installed at Codelco's Chuquicamata copper mine in northern Chile assists in monitoring pit slopes continuously. The network provides reliable quantitative information, allowing mine engineers to monitor and reasonably predict the behavior of rock masses and geologic structures on pit slopes.

Slope stability radar technology provides complete slope face coverage from a remote location without need of reflective prisms. This mobile system can easily be moved into a pit to provide high-precision monitoring of a slope face up to 850m away. Customized software processes the radar data to display slope movement and acceleration on a high-resolution CCD camera image. The unit can provide continuous coverage in all weather conditions, including dust and fog, and can be monitored via radio link and the Internet from remote locations.

A slope stability monitoring system based on Terrestrial Laser Scanning technology has been researched and developed at the Colorado School of Mines. Kennecott Energy and 3D-P are funding this program to determine applicability and potential use of inexpensive 3-D Lidar scanners for monitoring high walls in surface coal mines. CSIR-CIMFR is also having one of the most advanced Terrestrial Laser Scanner for slope monitoring, 3D mine surface modeling, and other applications. Terrestrial Laser Scanner (TLS) can be used for slope monitoring in both methods – Periodical Monitoring, and Continuous Monitoring. Current progress indicates that 3-D TLS used with customized software may provide a highly cost-effective means of monitoring with centimeter accuracy in applications that include pit slopes, highwall, waste dumps and stockpiles.

THE SUGGESTED SLOPE MONITORING SCHEME FOR PIT AND DUMP OF OSTAPAL CHROMITE MINE

Continuous slope monitoring of pits and dumps of Ostapal Chromite Pit and Dump should be done with the application of pit slope stability monitoring RADAR of any type. Additionally, total station based monitoring should be done by installing monitoring stations all around the crest and benches of pit and dump. The monitoring stations should be located at about 30 m interval. In the zones of mines or dumps which are assessed by mine management as less susceptible zone from instability point of view through visual inspection of instability signs, the spacing between monitoring pillars may be kept as 40m. Monitoring pillars should be installed all along the topmost bench of pit and dump. Similarly, monitoring stations should be installed on alternate benches of pit and dump. Base station should be located at stable ground in opposite side of the monitoring stations. All the monitoring stations should be visible from the base stations. One or more base stations could be erected to cover all the area. The base station and monitoring stations should be so located that inter-visibility should be there. The gap between the stations can be increased or decreased for clear visibility. It is a general guideline, which may be changed to meet the local requirement. As per DGMS(Tech.) Circular No. 2 of 2020 dated 09-01-2020, mine manager should have a structured team of trained competent persons for slope monitoring headed by a slope monitoring officer with clearly defined duties and responsibilities.

The monitoring should be done periodically at least once in a month using total station and the results of monitoring should be recorded in a bound-paged register or in a tamper proof electronic form. These data should be regularly analysed to predict the slope movement or instability well in advance.

In addition to above two methods, visual observations of dump and pit for prominent sign of instability should be done by geotechnical person of the mine on monthly basis and the observations related to slope stability should be recorded in a bound register for periodical analysis.

Warning level / withdrawal of slope movement is site-specific and can be decided based on analysis of actual monitoring data over a long period only. However, if mine management observes average rate of slope movement of more than 1 mm/ day over a period of at least three months in majority of pillars of a zone of pit or dump, then the mine management should increase the monitoring frequency to weekly and consult scientific/expert agencies expert in the slope stability and slope monitoring for remedial measures or failure predictions and guidance.

Conclusions and Recommendations

- An assessment of the proposed dump and pit plans and sections, engineering geology, strength properties and the related geotechnical controls indicated in the report the following ultimate dump and pit slopes are recommended for Ostapal Chromite Mine.

PIT SLOPE PARAMETERS

Salient Designed Parameters are summarized as:

- Maximum Bench Height: 8m
- Minimum Exposed Bench Width: 8m
- Bench Slope Angle: not more than 70 degree
- Overall designed pit slope height (from surface to +5 mRL):

  Maximum 136m on Hangwall side,

  Maximum 149m on Footwal side.
- Overall Pit Slope Angle Recommended:

  Hangwall Slope: $\leq$ 36 degree

  Footwall Slope : $\leq$ 24 degree

  East and West Sides: 36 degree

Dump Parameters		
Maximum Terrace Height (m)	**Minimum Exposed** Terrace Width (m)	Angle of repose (deg.) for each terrace
15	10m between different terraces	**37**

Salient Designed Parameters are summarized as:

- Maximum height of dump: 90m
- Maximum height of each terrace: 15m
- Minimum Terrace Width: 10m between consecutive terraces.
- Bench slope angle of one lift: 37 degree
- Overall Slope of 90m high OB dump: $\leq$ 28 degree

- The mine should 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. It is essential that these drains should be kept clear of silt and debris. Effective water management is essential to maximise the stability and safety of pit as well as dump. Water should not be allowed to stagnate on pit and dump surface. They should be diverted or brought down in a controlled manner without damaging the slope surface.
- Recommendations on water management and slope depressurization through horizontal drain holes as mentioned should be implemented for safety of slope.
- The mapping of weak zones, faults and bedding planes of pit part should be a regular process by the departmental geologist. The generated data may be used as an input parameter to reanalyze the stability as per requirement.
- Mine management should make a structured team of trained competent persons for slope monitoring headed by a slope monitoring officer with clearly defined duties and responsibilities as per DGMS (Tech.) Circular No. 2 of 2020 dated 09.01.2020. The slope monitoring should be done in a continuous mode using some type of RADAR for ensuring safety of pit and dumps. Additionally, Total Station based monitoring should also be done periodically at least once in a month and the results of monitoring should be recorded in a bound-paged register or in a tamper proof electronic form. These monitoring

data should be regularly analyzed to predict the pit and dump slope movement or instability well in advance. In case of need, help/advice may be sought from expert agencies in the field of slope stability and slope monitoring.

- The open cracks, whenever develop, in the partially consolidated new dump mass should be consolidated with the help of dozer/ compactor followed by proper leveling of the benches so that entry of water in cracks is minimised. It will help to consolidate the dumped material and will minimise infiltration of water inside slopes.
- During the 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 deep tension crack is detected in the pit/dump, the entry of water inside the crack should be checked.
- Recommendations stipulated in the report should be implemented in total.

Acknowledgements

Authors are thankful to the mine management for providing all facilities, information and helpful discussion during the period of study.

Bibliography

Bandis, S.C., 1990. Mechanical properties of rock joints, Proc. Int. Symp. Rock Joints, Norway, eds. N. Barton and Ove Stephansson, A.A. Balkema, Rotterdam, 125- 140.

Barton, N., 1973. Review of a new shear strength criteria for rock joints, Eng. Geol., Vol. 7, pp. 287-330.

Barton, N. and Choubey, V., 1977. The shear strength of rock joints in theory and practice, Rock Mech., Vol. 10, pp. 1-54.

Bieniawski, Z.T., 1989. Engineering rock mass classification, John Wiley and Sons.

DGMS, 2017, Coal Mines Regulation, 2017

DGMS(Tech.) Circular No. 2 of 2020 dated 09.01.2020

DGMS(Tech.) Circular No. 3 of 2020 dated 16.01.2020.

Hoek, E. and Bray, J.W., 1981. Rock Slope Engineering, 3rd ed., Inst. Min. Met., London.

Hoek, E. and Brown, E.T., 1998. Practical estimates of rock mass strength, Intnl. J. Rock Mech. Min. Sci., Vol. 34, No. 8, pp. 1165-1186.

Hoek, E. and Londe, P., 1974. The design of rock slopes and foundations. General report 3rd Cong. ISRM, Denver, pp. 1-40.

ISRM, 1978. Suggested methods for the quantitative description of discontinuities in rock masses. Commission on the standardization of laboratory and field tests in rock mech.

Langefors, U. and Kihlstrom, B. (1963) The modern technique of rock blasting, John Wiley & Sons Inc., New York.

Pit Slope Manual, CANMET, Ottawa, Canada, (Chapter- Monitoring), 1977.

Singh, V.K., Influence of the geotechnical parameters on slope stability, Ph.D. thesis, 1992.

Annexure No.-1

Analysis of Dust Fall

Visiontek Consultancy Services Pvt. Ltd.

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&
Microbiology Lab

Ref : Envlab/21/R-5107 **Date : 06.10.2021**

DUST FALL ANALYSIS REPORT- SEPTEMBER- 2021

1. Name of Client : **M/s FERRO ALLOYS CORPORATION LIMITED , BHADRAK**
2. Name of the Project : **OSTAPAL CHROMITE MINES , KALIAPANI, JAJPUR**
3. **Sampling Location : DF1- Near Roof Top of Office Building**
4. **Date of Sampling : 14.09.2021**
5. Sample Collected by : VCSPL Representative in presence of Client's Representative

SL.No.	Parameters	Unit (mg of deposit per square meter per day)	Analysis Result DF1
1	Mercury as Hg	mg/m^2d	ND
2	Nickel as Ni	mg/m^2d	ND
3	Cobalt as CO	mg/m^2d	ND
4	Arsenic as As	mg/m^2d	ND

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Annexure No.-2

Analysis of Soil Sample

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Mineral Lab
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Microbiology Lab

Ref : Envlab/21/R-5103 **Date : 06.10.2021**

SOIL QUALITY ANALYSIS REPORT- SEPTEMBER- 2021

1. Name of Client : **M/s FERRO ALLOYS CORPORATION LIMITED , BHADRAK**
2. Name of the Project : **OSTAPAL CHROMITE MINES , KALIAPANI, JAJPUR**
3. Sampling Location : **S1 : East Side Quarry**
   S2 : West Side Quarry
   S3 : North Side Quarry
   S4 : South Side Quarry
4. **Date of Sampling : 14.09.2021**
5. Date of Analysis : **15.09.2021 TO 17.09.2021**
6. Sample Collected by : VCSPL Representative in presence of Client's Representative

Sl. No.	Name of the Parameters	Unit	Testing Method	Analysis Result			
				S1	S2	S3	S4
1	Mercury as Hg	mg/kg	EPA 3050B, 7000B Rev 02, 1996	ND	ND	ND	ND
2	Nickel as Ni	mg/kg	EPA 3050B, 7000B Rev 02, 1996	ND	ND	ND	ND
3	Cobalt as CO	mg/kg	EPA 3050B, 7000B Rev 02, 1996	ND	ND	ND	ND
4	Arsenic as As	mg/kg	EPA 3050B, 7000B Rev 02, 1996	ND	ND	ND	ND

BDL Value : Ni <50 mg/kg, Co< 10 mg/kg, As < 10 mg/kg, Hg <10 mg/kg

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Annexure No.-3

GROUND WATER LEVEL MEASUREMENT

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- Information Technology
- Public Health Engineering
- Mine Planning & Design
- Mineral/Sub-Soil Exploration
- Waste Management Services

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Mineral Lab
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Microbiology Lab

Ref : Envlab/21/R-5105 **Date : 06.10.2021**

GROUND WATER LEVEL REPORT- SEPTEMBER-2021

1. Name of Client : **M/s FERRO ALLOYS CORPORATION LIMITED , BHADRAK**
2. Name of the Project : **OSTAPAL CHROMITE MINES , KALIAPANI, JAJPUR**
3. **Date of Sampling : 14.09.2021**
4. Sample Collected by : VCSPL Representative in presence of Client's Representative

SL. No.	Locations	Unit	DOS	Analysis Result
1	Bore well Near Workshop of Mines	mt/bgl	14.09.2021	10.2
2	Bore well Near Main Gate of OCM	mt/bgl	14.09.2021	10.6
3	Open Well Near Ostia Village	mt/bgl	14.09.2021	3.6
4	Open Well Near Ostapal Village	mt/bgl	14.09.2021	5.2
5	Tube well inside Shiva Temple of the Village Gurujanga	mt/bgl	14.09.2021	10.6
6	Tube well outside Shiva Temple of the Village Gurujanga	mt/bgl	14.09.2021	11.2
7	Eastern side of the Quarry (PZ-1)	mt/bgl	14.09.2021	4.2
8	Southern side of the Quarry (PZ-2)	mt/bgl	14.09.2021	4.4
9	Watstern side of the Quarry (PZ-3)	mt/bgl	14.09.2021	4.2

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Annexure No.-4

GROUND WATER QUALITY

Visiontek Consultancy Services Pvt. Ltd.

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Ref : Envlab/21/R-5099 **Date : 06.10.2021**

GROUND WATER QUALITY ANALYSIS REPORT- SEPTEMBER- 2021

1. Name of Client : **M/s FERRO ALLOYS CORPORATION LIMITED , BHADRAK**
2. Name of the Project : **OSTAPAL CHROMITE MINES , KALIAPANI, JAJPUR**
3. Sampling Location : **GW4:** Open Well Near Ostapal Village
   GW5: Tube Well inside the Shiva Temple of Village Gurujanga
   GW6: Tube Well outside Shiva Temple of Village Gurujanga
4. Method of Sampling : **APHA 1060 B**
5. **Date of Sampling** : **14.09.2021**
6. Date of Analysis : **15.09.2021 TO 21.09.2021**
7. Sample Collected by : VCSPL Representative in presence of Client's Representative

Sl. No.	Parameter	Testing Method	Unit	Standard as per IS -10500:2012 Amended on 2015 & 2018		Analysis Result		
				Acceptable Limit	Permissible Limit	GW4	GW5	GW6
Essential Characteristics								
1	Colour	**Visual Comparison Method** APHA 23RD Ed.2017 : 2120 B, C	Hazen	5	15	<5	<5	<5
2	Odour	**Threshold Odour Test** APHA 23RD Ed.2017 :2150 B	--	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
3	Taste	**Flavor Threshold Test** APHA 23RD Ed.2017 : 2160 C	--	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
4	Turbidity	**Nephelometric Method** APHA 23RD Ed.2017 :2130 B	NTU	1	5	6.5	6.8	7.2
5	pH Value	**pH Meter** APHA 23RD Ed.2017 : 4500H+ B	--	6.5-8.5	No Relaxation	7.36	7.54	7.42
6	Total Hardness (as $CaCO_3$)	**EDTA Titrimetric Method** APHA 23RD Ed.2017 : 2340 C	mg/l	200	600	112	92	70
7	Iron (as Fe)	**By AAS Method** APHA 23RD Ed.2017 : 3111, B	mg/l	1.0	No Relaxation	0.21	0.18	0.16
8	Chloride (as Cl)	**Argentometric Method** APHA 23RD Ed.2017 : 4500CI B	mg/l	250	1000	42	46	48
9	Residual, free Chlorine	**Iodometric Method** APHA 23RD Ed.2017 : 4500Cl, B	mg/l	0.2	1	ND	ND	ND
Desirable Characteristics								
10	Dissolved Solids	**Gravimetric Method** APHA 23RD Ed.2017 : 2540 C	mg/l	500	2000	180	112	90
11	Calcium (as Ca)	**EDTA Titrimetric Method** APHA 23RD Ed.2017 : 3500Ca B	mg/l	75	200	44	32	28
12	Magnesium (as Mg)	**Calculation Method** APHA 23RD Ed.2017 : 3500Mg B	mg/l	30	100	20.8	11.9	10.8
13	Copper (as Cu)	**By AAS Method** APHA 23RD Ed.2017: 3111 B	mg/l	0.05	1.5	<0.05	<0.05	<0.05
14	Manganese (as Mn)	**Persulfate Method** APHA 23RD Ed.2017: 3500Mn B	mg/l	0.1	0.3	<0.05	<0.05	<0.05
15	Sulphate (as SO_4)	**Turbidimetric Method** APHA 23RD Ed.2017: 4500 $SO4^{2-}$ E	mg/l	200	400	4.6	4.4	4.0
16	Nitrate (as NO_3)	**By UV-Screen Method** APHA 23RD Ed.2017: 4500 NO_3^- E	mg/l	45	No Relaxation	1.6	0.81	0.62
17	Fluoride (as F)	**Distillation followed by Spectophotometric Method** APHA 23RD Ed.2017: 4500F- C	mg/l	1.0	1.5	0.012	0.015	0.011
18	Phenolic Compounds (as C_6H_5OH)	**Chloroform Extraction by Colorimric Method** APHA 23RD Ed.2017: 5530 B,D	mg/l	0.001	0.002	<0.001	<0.001	<0.001
19	Mercury (as Hg)	**AAS Method** APHA 23RD Ed.2017: 3112 B	mg/l	0.001	No Relaxation	<0.001	<0.001	<0.001
20	Cadmium (as Cd)	**AAS Method** APHA 23RD Ed.2017: 3111 B	mg/l	0.003	No Relaxation	<0.001	<0.001	<0.001
21	Selenium (as Se)	**By AAS Method** APHA 23RD Ed.2017: 3500 Se C	mg/l	0.01	No Relaxation	<0.01	<0.01	<0.01
22	Arsenic (as As)	**By AAS Method**	mg/l	0.01	No	<0.01	<0.01	<0.01

Annexure No.-4

Visiontek Consultancy Services Pvt. Ltd.

(Committed For Better Environment)

Certified for : ISO 9001:2015, ISO 14001:2015, ISO 45001:2018 (OH&S), ISO/IEC 17025:2017

Accredited by : NABET-A Grade, MOEF & CC/CPCB & SPCB-A Grade

- Infrastructure Enginering
- Water Resource Management
- Environmental & Social Study
- Surface & Sub-Surface Investigation
- Quality Control & Project Management
- Renewable Energy
- Agricultural Development
- Information Technology
- Public Health Engineering
- Mine Planning & Design
- Mineral/Sub-Soil Exploration
- Waste Management Services

Laboratory Services
Environment Lab
Food Lab
Material Lab
Soil Lab
Mineral Lab
&
Microbiology Lab

		APHA 23RD Ed,2017: 3114 B			Relaxation			
23	Cyanide (as CN)	**Distillation followed by Spectophotometric Method** APHA 23RD Ed,2017: 4500 CN- C,D	mg/l	**0.05**	**No Relaxation**	<0.05	<0.05	<0.05
24	Lead (as Pb)	**By AAS Method** APHA 23RD Ed,2017 3111 B	mg/l	**0.01**	**No Relaxation**	<0.01	<0.01	<0.01
25	Zinc (as Zn)	**By AAS Method** APHA 23RD Ed,2017: 3111 B	mg/l	**5**	**15**	2.1	2.8	3.2
26	Anionic Detergents (as MBAS)	**Anionic Surfactants as MBAS** APHA 23RD Ed,2017: 5540 C	mg/l	**0.2**	--	ND	ND	ND
27	Chromium (as Cr^{+6})	**Diphenyl Carbazide Method** APHA 23RD Ed,2017: 3500Cr B	mg/l	--	--	0.012	0.011	0.010
28	Mineral Oil	**Partition-Gravimetric Method** APHA 23RD Ed,2017: 5520 B	mg/l	**0.5**	**No Relaxation**	ND	ND	ND
29	Alkalinity	**Titration Method** APHA 23RD Ed,2017:2320 B	mg/l	**200**	**600**	82	28	20
30	Aluminium as(Al)	**AAS Method** APHA 23RD Ed,2017: 3111 D	mg/l	**0.03**	**0.2**	<0.01	<0.01	<0.01
31	Boron (as B)	**Curcumin Method** APHA 23RD Ed,2017: 4500B, B	mg/l	**0.5**	**2.4**	<0.1	<0.1	<0.1
32	Total Coliform as TC	**MPN Method** APHA 23RD Ed,2017 : 9221 b	MPN/ 100ml	Shall not be detectable in any 100ml sample	--	<1.8	<1.8	<1.8

CL – Colourless, U/O – Unobjectionable, ND – Not detected.
BDL (Below detection limit) Values :(Cu<0.05 mg/l , Mn<0.005 mg/l, C_6H_5OH<0.001 mg/l, Hg<0.005mg/l, Cd<0.001 mg/l ,Se<0.001 mg/l, As<0.001 mg/l,Pb<0.01 mg/l, Zn<0.05 mg/l, Cr^{+6}<0.05 mg/l, Al<0.001 mg/l , B<0.01 mg/l, NO_3<0.01 mg/l)

VISIONTEK CONSULTANCY SERVICES PVT. LTD.

Reviewed By

VISIONTEK CONSULTANCY SERVICES PVT. LTD.

Approved By

Annexure No.-4

Visiontek Consultancy Services Pvt. Ltd.

(Committed For Better Environment)

Certified for : ISO 9001:2015, ISO 14001:2015, ISO 45001:2018 (OH&S), ISO/IEC 17025:2017

Accredited by : NABET-A Grade, MOEF & CC/CPCB & SPCB-A Grade

- Infrastructure Engineering
- Water Resource Management
- Environmental & Social Study
- Surface & Sub-Surface Investigation
- Quality Control & Project Management
- Renewable Energy
- Agricultural Development
- Information Technology
- Public Health Engineering
- Mine Planning & Design
- Mineral/Sub-Soil Exploration
- Waste Management Services

Laboratory Services: Environment Lab, Food Lab, Material Lab, Soil Lab, Mineral Lab & Microbiology Lab

Ref : Envlab/21/R-5100 **Date : 06.10.2021**

GROUND WATER QUALITY ANALYSIS REPORT- SEPTEMBER- 2021

1. Name of Client : **M/s FERRO ALLOYS CORPORATION LIMITED , BHADRAK**
2. Name of the Project : **OSTAPAL CHROMITE MINES , KALIAPANI, JAJPUR**
3. Sampling Location : **GW7:** Eastern Side of the Quarry (PZ-1)
   GW8: Southern Side of the Quarry (PZ-2)
   GW9: Western Side of the Quarry (PZ-3)
4. Method of Sampling : **APHA 1060 B**
5. **Date of Sampling** : **14.09.2021**
6. Date of Analysis : **15.09.2021 TO 21.09.2021**
7. Sample Collected by : VCSPL Representative in presence of Client's Representative

Sl. No.	Parameter	Testing Method	Unit	Standard as per IS :-10500:2012 Amended on 2015 & 2018		Analysis Result		
				Permissible Limit	Permissible Limit	GW7	GW8	GW9
Essential Characteristics								
1	Colour	**Visual Comparison Method** APHA 23RD Ed.2017 : 2120 B, C	Hazen	5	15	<5	<5	<5
2	Odour	**Threshold Odour Test** APHA 23RD Ed.2017 :2150 B	---	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
3	Taste	**Flavor Threshold Test** APHA 23RD Ed.2017 : 2160 C	---	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
4	Turbidity	**Nephelometric Method** APHA 23RD Ed.2017 :2130 B	NTU	1	5	6.9	7.4	7.8
5	pH Value	**pH Meter** APHA 23RD Ed.2017 : 4500H+ B	---	6.5-8.5	No Relaxation	7.31	7.46	7.42
6	Total Hardness (as $CaCO_3$)	**EDTA Titrimetric Method** APHA 23RD Ed.2017 : 2340 C	mg/l	200	600	118	114	80
7	Iron (as Fe)	**By AAS Method** APHA 23RD Ed.2017 : 3111, B	mg/l	1.0	No Relaxation	0.31	0.21	0.16
8	Chloride (as Cl)	**Argentometric Method** APHA 23RD Ed.2017 : 4500Cl- B	mg/l	250	1000	40	38	34
9	Residual, free Chlorine	**Iodometric Method** APHA 23RD Ed.2017 : 4500Cl, B	mg/l	0.2	1	ND	ND	ND
Desirable Characteristics								
10	Dissolved Solids	**Gravimetric Method** APHA 23RD Ed.2017 : 2540 C	mg/l	500	2000	210	188	142
11	Calcium (as Ca)	**EDTA Titrimetric Method** APHA 23RD Ed.2017 : 3500Ca B	mg/l	75	200	44	38	32
12	Magnesium (as Mg)	**Calculation Method** APHA 23RD Ed.2017 : 3500Mg B	mg/l	30	100	21.2	10.8	9.8
13	Copper (as Cu)	**By AAS Method** APHA 23RD Ed.2017: 3111 B	mg/l	0.05	1.5	<0.05	<0.05	<0.05
14	Manganese (as Mn)	**Persulfate Method** APHA 23RD Ed.2017: 3500Mn B	mg/l	0.1	0.3	<0.05	<0.05	<0.05
15	Sulphate (as SO_4)	**Turbidimetric Method** APHA 23RD Ed.2017: 4500 $SO4^{2-}$ E	mg/l	200	400	3.6	4.2	3.6
16	Nitrate (as NO_3)	**By UV-Screen Method** APHA 23RD Ed.2017: 4500 NO_3^- E	mg/l	45	No Relaxation	1.62	0.81	0.77
17	Fluoride (as F)	**Distillation followed by Spectrophotometric Method** APHA 23RD Ed.2017: 4500F- C	mg/l	1.0	1.5	0.012	0.014	0.013
18	Phenolic Compounds (as C_6H_5OH)	**Chloroform Extraction by Colorimric Method** APHA 23RD Ed.2017: 5530 B,D	mg/l	0.001	0.002	<0.001	<0.001	<0.001
19	Mercury (as Hg)	**AAS Method** APHA 23RD Ed.2017: 3112 B	mg/l	0.001	No Relaxation	<0.001	<0.001	<0.001
20	Cadmium (as Cd)	**AAS Method** APHA 23RD Ed.2017: 3111 B	mg/l	0.003	No Relaxation	<0.001	<0.001	<0.001
21	Selenium (as Se)	**By AAS Method** APHA 23RD Ed.2017: 3500 Se C	mg/l	0.01	No Relaxation	<0.01	<0.01	<0.01

Annexure No.-4

22	Arsenic (as As)	**By AAS Method** APHA 23RD Ed,2017: 3114 B	mg/l	**0.01**	**No Relaxation**	**<0.01**	**<0.01**	**<0.01**
23	Cyanide (as CN)	**Distillation followed by Spectophotometric Method** APHA 23RD Ed,2017: 4500 CN C,D	mg/l	**0.05**	**No Relaxation**	<0.05	<0.05	<0.05
24	Lead (as Pb)	**By AAS Method** APHA 23RD Ed,2017 3111 B	mg/l	**0.01**	**No Relaxation**	<0.01	<0.01	<0.01
25	Zinc (as Zn)	**By AAS Method** APHA 23RD Ed,2017: 3111 B	mg/l	**5**	**15**	3.1	4.1	4.4
26	Anionic Detergents (as MBAS)	**Anionic Surfactants as MBAS** APHA 23RD Ed,2017: 5540 C	mg/l	**0.2**	--	ND	ND	ND
27	Chromium (as Cr^{+6})	**Diphenyl Carbazide Method** APHA 23RD Ed,2017: 3500Cr B	mg/l	--	--	0.018	0.021	0.016
28	Mineral Oil	**Partition-Gravimetric Method** APHA 23RD Ed,2017: 5520 B	mg/l	**0.5**	**No Relaxation**	ND	ND	ND
29	Alkalinity	**Titration Method** APHA 23RD Ed,2017:2320 B	mg/l	**200**	**600**	50	42	26
30	Aluminium as(Al)	**AAS Method** APHA 23RD Ed,2017: 3111 D	mg/l	**0.03**	**0.2**	<0.01	<0.01	<0.01
31	Boron (as B)	**Curcumin Method** APHA 23RD Ed,2017: 4500B, B	mg/l	**0.5**	**2.4**	<0.1	<0.1	<0.1
32	Total Coliform as TC	**MPN Method** APHA 23RD Ed,2017 : 9221 b	MPN/ 100ml	Shall not be detectable in any 100ml sample	--	<1.8	<1.8	<1.8

CL – Colourless, U/O – Unobjectionable, ND – Not detected.

BDL (Below detection limit) Values :(Cu<0.05 mg/l , Mn<0.005 mg/l, C_6H_5OH<0.001 mg/l, Hg<0.005mg/l, Cd<0.001 mg/l ,Se<0.001 mg/l, As<0.001 mg/l,Pb<0.01 mg/l, Zn<0.05 mg/l, Cr^{+6}<0.05 mg/l, Al<0.001 mg/l , B<0.01 mg/l, NO_3<0.01 mg/l)

Reviewed By

Approved By

Annexure No.-5

Visiontek Consultancy Services Pvt. Ltd.

(Committed For Better Environment)

Certified for : ISO 9001:2015, ISO 14001:2015, ISO 45001:2018 (OH&S), ISO/IEC 17025:2017

Accredited by : NABET-A Grade, MOEF & CC/CPCB & SPCB-A Grade

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- Renewable Energy
- Agricultural Development
- Information Technology
- Public Health Engineering
- Mine Planning & Design
- Mineral/Sub-Soil Exploration
- Waste Management Services

Laboratory Services
Environment Lab
Food Lab
Material Lab
Soil Lab
Mineral Lab
&
Microbiology Lab

Ref : Envlab/21/R-5108 **Date : 06.10.2021**

MEASUREMENT OF GROUND WATER QUALITY ANALYSIS REPORT SEPTEMBER- 2021

1. Name of Client : **M/s FERRO ALLOYS CORPORATION LIMITED , BHADRAK**
2. Name of the Project : **OSTAPAL CHROMITE MINES , KALIAPANI, JAJPUR**
3. Sampling Location : **GW1:** Bore well Near Workshop of the Mines
   GW2: Bore well Near Main Gate
   GW3: Open Well Near Ostia Village
   GW4: Open Well Near Ostapal Village
   GW5: Tube Well Inside Shiv Temple of Gurujanga Village
4. Method of Sampling : **APHA 1060 B**
5. **Date of Sampling** : **15.09.2021**
6. Date of Analysis : **16.09.2021**
7. Sample Collected by : VCSPL Representative in presence of Client's Representative

Sl. No.	Parameter	Testing Method	Unit	Standard as per IS -10500:2012 Amended on 2015 & 2018		Analysis Result				
				Acceptable Limit	Permissible Limit	GW1	GW2	GW3	GW4	GW5
1	Hexavalent Chromium as Cr^{6+}	By AAS Method APHA 23RD Ed.2017: 3500 Cr B	mg/l	--	--	<0.01	<0.01	<0.01	<0.01	<0.01

Reviewed By

Approved By

Annexure No.-5

Visiontek Consultancy Services Pvt. Ltd.

(Committed For Better Environment)

Certified for : ISO 9001:2015, ISO 14001:2015, ISO 45001:2018 (OH&S), ISO/IEC 17025:2017

Accredited by : NABET-A Grade, MOEF & CC/CPCB & SPCB-A Grade

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Laboratory Services
Environment Lab
Food Lab
Material Lab
Soil Lab
Mineral Lab
&
Microbiology Lab

Ref : Envlab/21/R-5109 **Date : 06.10.2021**

MEASUREMENT OF GROUND WATER QUALITY ANALYSIS REPORT SEPTEMBER- 2021

1. Name of Client : **M/s FERRO ALLOYS CORPORATION LIMITED , BHADRAK**
2. Name of the Project : **OSTAPAL CHROMITE MINES , KALIAPANI, JAJPUR**
3. Sampling Location : **GW6 :** Tube Well Outside Shiv Temple of Gurujanga Village
   GW7: Eastern Side of the Quarry (PZ-1)
   GW8: Southern Side of the Quarry (PZ-2)
   GW9: Western Side of the Quarry (PZ-3)
4. Method of Sampling : **APHA 1060 B**
5. **Date of Sampling** : **14.09.2021**
6. Date of Analysis : **15.09.2021 TO 18.09.2021**
7. Sample Collected by : VCSPL Representative in presence of Client's Representative

Sl. No.	Parameter	Testing Method	Unit	Standard as per IS -10500:2012 Amended on 2015 & 2018		Analysis Result			
				Acceptable Limit	Permissible Limit	GW6	GW7	GW8	GW9
1	Hexavalent Chromium as Cr^{6+}	By AAS Method APHA 23RD Ed.2017: 3500 Cr B	mg/l	--	--	<0.01	<0.01	<0.01	<0.01

Reviewed By

Approved By

Annexure No.-6

GROUND WATER ABSTRACTION DATA FROM ABSTRACTION STRUCTURE FOR THE YEAR 2021-22 OSTAPAL CHROMITE MINES,M/s FACORL TD							
Month	Bore Well -1 (Near Main Gate)			Bore well -2 (Near Mechanical Workshop)			TOTAL Withdrawal (A+B) in KL
	Initial Reading	Final Reading	A.Total withdrawal (In KL)	Initial Reading	Final Reading	B.Total withdrawal (In KL)	
April'21	78488	80269	1781	85868	86990	1122	2903
May'21	80269	82301	2032	86990	87949	959	2991
June'21	82301	84302	2001	87949	88891	942	2943
July'21	84302	86389	2087	88891	89861	970	3057
Aug'21	86389	86737	348	89861	90141	280	628
	0	808.455	808.455	0	459.55	459.55	1268.005
Sub-total August			1156.455			739.55	1896.005
Sept'21	808.455	1959.236	1150.781	459.55	1192.154	732.604	1883.385
TOTAL			10208.24			5465.154	15673.39
Avg. withdrawal per day is 86 KL							

Drinking Water Supply to Nearby Villages Ostapal Chromite Mines				
Month	**No. of trips supply to Ostapal Villages**	**No. of trips supply to Gurujanga & Ostia Villages**	**Total trip Supply to nearby villages**	**Total Supply (in KL)**
April'2021	23	31	54	540
May'2021	74	86	160	1600
June'2021	60	86	146	1460
July'2021	54	81	135	1350
Aug'2021	38	91	129	1290
Sept'2021	46	71	117	1170
Total	295	446	741	7410

Annexure No.-7

BY REGD. POST WITH AD

STATE POLLUTION CONTROL BOARD, ODISHA

A/118, Nilakantha Nagar, Unit-VIII, Bhubaneswar-751012
Phone-2561909, Fax: 2562822, 2560955

CONSENT ORDER

No. 5320 / IND-I-CON- 1163 Dt. 27.03.2021

CONSENT ORDER NO. 366

Sub: **Consent for discharge of sewage and trade effluent under section 25/26 of Water (PCP) Act, 1974 and for existing / new operation of the plant under section 21 of Air (PCP) Act, 1981.**

Ref: **Your online application No. 3216555 dated 28-11-2020 and Online reply dated 30.12.2020**

Consent to operate is hereby granted under section 25/26 of Water (Prevention & Control of Pollution) Act, 1974 and under section 21 of Air (Prevention & Control of Pollution) Act, 1981 and rules framed thereunder to

Name of the Industry: OSTAPAL CHROMITE MINES OF M/S. FACOR LTD.

Name of the Occupier & Designation: SRI SAUVICK MAZUMDAR, DIRECTOR

Address: AT: GURUJANG, PO: KALIAPANI, DIST: JAJPUR

This consent order is valid for the period up to 31.03.2022 from the date of issue of this order.

This consent order supersedes the earlier consent order issued vide letter No. 2430 dated 5.02.2016.

Details of Products Manufactured

Sl. No	Product	Quantity
01.	Chrome ore(ROM)	0.2 MTPA

Details of Mineral Handing Plants/Units

01.	Operation of COB Plant of capacity	0.1 MTPA (chrome ore concentrate)

This consent order is valid for the specified outlets, discharge quantity and quality, specified chimney/stack, emission quantity and quality of emissions as specified below. This consent is granted subject to the general and special conditions stipulated therein.

Annexure No.-7

A. Discharge permitted through the following outlet subject to the standard

Outlet No.	Description of outlet	Point of discharge	Quantity of discharge KL/hr	Pre-scribed Standard						
				pH	TSS (mg/l)	BOD (mg/l)	COD (mg/l)	Oil & Grease (mg/l)	Cr+6 (mg/l)	Total Chromium (mg/l)
01.	*Septic tank (Domestic effluent)*	*Soak pit*	--	*5.5 to 9.0*	*200*	*100*	--	--	--	--
02.	*Mine drainage water / surface run off/ other wastewater*	*On land / inland surface water body*	*5205.09 KLD(Max.)*	*5.5 to 9.0*	*100*	--	--	*10*	*0.05*	*2.0*

B. Emission permitted through the following stack subject to the prescribed standard

Chimney Stack No.	Description of Stack	Stack height (m)	Quantity of emission	Prescribed Standard				

C. Disposal of solid waste permitted in the following manner

Sl. No.	Type of Solid waste	Quantity generated (TPD)	Quantity to be reused on site(TPD)	Quantity to be reused off site(TPD)	Quantity disposed off (TPD)	Description of disposal site.
01.	Top soil / overburden	As per approved mining plan	--	--	--	As per approved mining plan

Annexure No.-8

EXCAVATION PLAN FY 2021-22
OSTAPAL CHROMITE MINES

Particulars	Approved quantity Per Annum	Achieved FY 2021-22 (Till Sept'2021
Over burden (Lac Cub Mt)	4.78	1.600
ROM Production (Lac metric tonne)	2.00	1.007

Annexure No.-9

AMBIENT AIR QUALITY MONITORING REPORT OF CORE ZONE

Visiontek Consultancy Services Pvt. Ltd.

(Committed For Better Environment)

Certified for : ISO 9001:2015, ISO 14001:2015, ISO 45001:2018 (OH&S), ISO/IEC 17025:2017

Accredited by : NABET-A Grade, MOEF & CC/CPCB & SPCB-A Grade

- Infrastructure Engineering
- Water Resource Management
- Environmental & Social Study
- Surface & Sub-Surface Investigation
- Quality Control & Project Management
- Renewable Energy
- Agricultural Development
- Information Technology
- Public Health Engineering
- Mine Planning & Design
- Mineral/Sub-Soil Exploration
- Waste Management Services

Laboratory Services: Environment Lab, Food Lab, Material Lab, Soil Lab, Mineral Lab & Microbiology Lab

Ref : Envlab/21/R-5095 **Date : 06.10.2021**

AMBIENT AIR QUALITY (CORE ZONE) MONITORING REPORT- SEPTEMBER-2021

1. Name of Client : **M/s FERRO ALLOYS CORPORATION LIMITED , BHADRAK**
2. Name of the Project : **OSTAPAL CHROMITE MINES , KALIAPANI, JAJPUR**
3. Monitoring Instruments : RDS (APM 460 BL), FPS (APM 550) Envirotech, CO Monitor, VOC Sampler
4. Sample Collected by : VCSPL Representative in presence of Client's Representative

Monitoring Date	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	SO_2 (µg/m³)	NO_x (µg/m³)	CO (mg/m³)	O_3 (µg/m³)	NH_3 (µg/m³)	C_6H_6 (µg/m³)	BaP (ng/m³)	Pb (µg/m³)	Ni (ng/m³)	As (ng/m³)
	AAQMS-1: Near Dispensary											
03.09.2021	70.8	42.5	10.8	14.1	1.18	5.2	20.2	BDL	BDL	BDL	BDL	BDL
07.09.2021	51.8	31.1	9.2	10.6	1.02	4.6	19.6	BDL	BDL	BDL	BDL	BDL
10.09.2021	70.8	42.5	11.2	14.2	1.08	4.8	21.2	BDL	BDL	BDL	BDL	BDL
14.09.2021	44.6	26.8	9.1	12.1	0.88	<4	19.1	BDL	BDL	BDL	BDL	BDL
17.09.2021	66.8	40.1	10.6	11.9	0.96	4.1	21.6	BDL	BDL	BDL	BDL	BDL
21.09.2021	66.2	39.7	10.8	11.6	0.92	4.6	21.8	BDL	BDL	BDL	BDL	BDL
24.09.2021	55.2	33.1	9.3	10.2	0.91	4.4	19	BDL	BDL	BDL	BDL	BDL
28.09.2021	49.2	29.5	10.2	11.1	0.96	4.1	19.2	BDL	BDL	BDL	BDL	BDL
Monthly Average	**59.4**	**35.7**	**10.2**	**12.0**	**0.99**	**4.54**	**20.2**	**BDL**	**BDL**	**BDL**	**BDL**	**BDL**
NAAQ Standard	100	60	80	80	4	100	400	5	01	01	20	06
Monitoring Date	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	SO_2 (µg/m³)	NO_x (µg/m³)	CO (mg/m³)	O_3 (µg/m³)	NH_3 (µg/m³)	C_6H_6 (µg/m³)	BaP (ng/m³)	Pb (µg/m³)	Ni (ng/m³)	As (ng/m³)
	AAQMS-2: Near Weighbridge											
03.09.2021	42.2	25.3	9.1	6.8	1.11	4.4	16.8	BDL	BDL	BDL	BDL	BDL
07.09.2021	31.2	18.7	8.8	6.2	0.96	4.1	16.6	BDL	BDL	BDL	BDL	BDL
10.09.2021	44.6	26.8	8.2	6.1	0.92	4.2	15.8	BDL	BDL	BDL	BDL	BDL
14.09.2021	26.8	16.1	6.8	7.4	0.91	4.1	15.9	BDL	BDL	BDL	BDL	BDL
17.09.2021	33.8	20.3	6.2	7.6	0.89	4.8	14.6	BDL	BDL	BDL	BDL	BDL
21.09.2021	34.6	20.8	8.9	7.8	0.82	4.2	14.8	BDL	BDL	BDL	BDL	BDL
24.09.2021	36.8	22.1	9.2	8.1	0.78	4.1	15.2	BDL	BDL	BDL	BDL	BDL
28.09.2021	28.8	17.3	9	8.8	0.81	4.2	15.6	BDL	BDL	BDL	BDL	BDL
Monthly Average	**34.9**	**20.9**	**8.3**	**7.4**	**0.90**	**4.26**	**15.7**	**BDL**	**BDL**	**BDL**	**BDL**	**BDL**
NAAQ Standard	100	60	80	80	4	100	400	5	01	01	20	06
Testing Method	Gravimetric	Gravimetric	Improved West and Geake method	Modified Jacob & Hochheiser (Na-Arsenite)	NDIR Spectroscopy	Chemical Method	Indo Phenol Blue Method	Absorption & Desorption followed by GC	Solvent Extraction Followed by GC	AAS Method	AAS Method	AAS Method

Reviewed By

Approved By

Plot No.- M-22 & 23, Chandaka Industrial Estate, Patia, Bhubaneswar, Khurda, Odisha-751024, India Tel.: 0674-3511721
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Annexure No.-9

Visiontek Consultancy Services Pvt. Ltd.

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Certified for : ISO 9001:2015, ISO 14001:2015, ISO 45001:2018 (OH&S), ISO/IEC 17025:2017

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- Agricultural Development
- Information Technology
- Public Health Engineering
- Mine Planning & Design
- Mineral/Sub-Soil Exploration
- Waste Management Services

Laboratory Services: Environment Lab, Food Lab, Material Lab, Soil Lab, Mineral Lab & Microbiology Lab

Ref : Envlab/21/R-5096 **Date : 06.10.2021**

AMBIENT AIR QUALITY (CORE ZONE) MONITORING REPORT- SEPTEMBER-2021

1 .Name of Client : **M/s FERRO ALLOYS CORPORATION LIMITED , BHADRAK**
2. Name of the Project : **OSTAPAL CHROMITE MINES , KALIAPANI, JAJPUR**
3. Monitoring Instruments : RDS (APM 460 BL), FPS (APM 550) Envirotech, CO Monitor, VOC Sampler
4. Sample Collected by : VCSPL Representative in presence of Client's Representative

Monitoring Date	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	SO_2 (µg/m³)	NO_x (µg/m³)	CO (mg/m³)	O_3 (µg/m³)	NH_3 (µg/m³)	C_6H_6 (µg/m³)	Bap (ng/m³)	Pb (µg/m³)	Ni (ng/m³)	As (ng/m³)
	AAQMS-3: At the Middle of the Open Cast Quarry											
03.09.2021	58.8	35.3	10.2	13.1	1.08	5.1	20.2	BDL	BDL	BDL	BDL	BDL
07.09.2021	44.6	26.8	10.1	12.8	0.89	5.2	19.6	BDL	BDL	BDL	BDL	BDL
10.09.2021	61.2	36.7	9.6	12.6	0.94	4.9	19.2	BDL	BDL	BDL	BDL	BDL
14.09.2021	40.8	24.5	9.4	12.1	0.95	4.8	18.9	BDL	BDL	BDL	BDL	BDL
17.09.2021	61.6	37.0	9.2	10.6	0.96	4.6	18.8	BDL	BDL	BDL	BDL	BDL
21.09.2021	60.8	36.5	10.1	11.2	0.92	4.1	19.1	BDL	BDL	BDL	BDL	BDL
24.09.2021	55.2	33.1	9.8	11.4	0.89	5.2	20.1	BDL	BDL	BDL	BDL	BDL
28.09.2021	51.9	31.1	9.6	10.2	0.88	4.4	19.4	BDL	BDL	BDL	BDL	BDL
Monthly Average	**54.4**	**32.6**	**9.8**	**11.8**	**0.94**	**4.79**	**19.4**	**BDL**	**BDL**	**BDL**	**BDL**	**BDL**
NAAQ Standard	100	60	80	80	4	100	400	5	01	01	20	06
Monitoring Date	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	SO_2 (µg/m³)	NO_x (µg/m³)	CO (mg/m³)	O_3 (µg/m³)	NH_3 (µg/m³)	C_6H_6 (µg/m³)	Bap (ng/m³)	Pb (µg/m³)	Ni (ng/m³)	As (ng/m³)
	AAQMS-4: At the Middle of the COB Plant											
03.09.2021	66.4	39.8	10.2	14.2	1.08	5.6	20.8	BDL	BDL	BDL	BDL	BDL
07.09.2021	61.2	36.7	9.8	13.6	1.02	5.1	21.2	BDL	BDL	BDL	BDL	BDL
10.09.2021	68.2	40.9	9.6	13.8	0.89	4.9	21.6	BDL	BDL	BDL	BDL	BDL
14.09.2021	54.6	32.8	9.2	13.2	0.78	4.4	22.4	BDL	BDL	BDL	BDL	BDL
17.09.2021	66.8	40.1	10.2	12.2	0.82	4.6	22.6	BDL	BDL	BDL	BDL	BDL
21.09.2021	67.4	40.4	9.4	12.4	0.81	5.2	23.2	BDL	BDL	BDL	BDL	BDL
24.09.2021	65.8	39.5	9.6	12.1	0.77	4.8	23.8	BDL	BDL	BDL	BDL	BDL
28.09.2021	61.9	37.1	9.1	12.1	0.72	4.4	22.4	BDL	BDL	BDL	BDL	BDL
Monthly Average	**64.0**	**38.4**	**9.6**	**13.0**	**0.86**	**4.88**	**22.3**	**BDL**	**BDL**	**BDL**	**BDL**	**BDL**
NAAQ Standard	100	60	80	80	4	100	400	5	01	01	20	06
Testing Method	Gravimetric	Gravimetric	Improved West and Geake method	Modified Jacob & Hochheiser (Na-Arsenite)	NDIR Spectroscopy	Chemical Method	Indo Phenol Blue Method	Absorption & Desorption followed by GC	Solvent Extraction Followed by GC	AAS Method	AAS Method	AAS Method

Reviewed By

Approved By

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Annexure No.-10

AMBIENT AIR QUALITY MONITORING REPORT OF BUFFER ZONE

Visiontek Consultancy Services Pvt. Ltd.

(Committed For Better Environment)

Certified for : ISO 9001:2015, ISO 14001:2015, ISO 45001:2018 (OH&S), ISO/IEC 17025:2017

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- Information Technology
- Public Health Engineering
- Mine Planning & Design
- Mineral/Sub-Soil Exploration
- Waste Management Services

Laboratory Services: Environment Lab, Food Lab, Material Lab, Soil Lab, Mineral Lab & Microbiology Lab

Ref : Envlab/21/R-5097 **Date : 06.10.2021**

AMBIENT AIR QUALITY (BUFFER ZONE) MONITORING REPORT- SEPTEMBER-2021

1. Name of Client : **M/s FERRO ALLOYS CORPORATION LIMITED , BHADRAK**
2. Name of the Project : **OSTAPAL CHROMITE MINES , KALIAPANI, JAJPUR**
3. Monitoring Instruments : RDS (APM 460 BL), FPS (APM 550) Envirotech, CO Monitor, VOC Sampler
4. Sample Collected by : VCSPL Representative in presence of Client's Representative

Monitoring Date	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	SO_2 (µg/m³)	NO_x (µg/m³)	CO (mg/m³)	O_3 (µg/m³)	NH_3 (µg/m³)	C_6H_6 (µg/m³)	Bap (ng/m³)	Pb (µg/m³)	Ni (ng/m³)	As (ng/m³)
	AAQMS-1: Near Village Ostia											
16.09.2021	60.8	38.8	8.1	13.8	0.51	6.1	BDL	BDL	BDL	BDL	BDL	BDL
	AAQMS-2: Near Village Kaposi											
17.09.2021	52.8	32.2	8.4	13.4	0.56	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	AAQMS-3: Near Village Kaliapani Township											
17.09.2021	60.2	40.9	8.9	14.2	1.18	6.4	20.9	BDL	BDL	BDL	BDL	BDL
	AAQMS-4: Near Village Ostapal											
16.09.2021	54.6	39.2	7.9	11.2	0.49	5.1	BDL	BDL	BDL	BDL	BDL	BDL

Reviewed By *Approved By*

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Annexure No.-11

FUGITIVE EMISSION ANALYSIS REPORT

Visiontek Consultancy Services Pvt. Ltd.

(Committed For Better Environment)

Certified for : ISO 9001:2015, ISO 14001:2015, ISO 45001:2018 (OH&S), ISO/IEC 17025:2017

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- Agricultural Development
- Information Technology
- Public Health Engineering
- Mine Planning & Design
- Mineral/Sub-Soil Exploration
- Waste Management Services

Laboratory Services: Environment Lab, Food Lab, Material Lab, Soil Lab, Mineral Lab & Microbiology Lab

Ref : Envlab/21/R-5106 **Date : 06.10.2021**

FUGITIVE EMISSION ANALYSIS REPORT- SEPTEMBER- 2021

1. Name of Client : **M/s FERRO ALLOYS CORPORATION LIMITED , BHADRAK**
2. Name of the Project : **OSTAPAL CHROMITE MINES , KALIAPANI, JAJPUR**
3. Sampling Location : **F1**- Near Mines Ore Plot Area
   F2- Near COB Plant Area
   F3- Near Mines Loading & Unloading Point
4. Method of Sampling : IS 5182(P-5) 1975 RA 2014
5. Date of Sampling : 14.09.2021
6. Date of Analysis : 15.09.2021
7. Sample Collected by : VCSPL Representative in presence of Client's Representative

SL. No.	Test Parameters	Test Method	Unit	Analysis Result		
				F1	F2	F3
1	Suspended Particulate Matter as SPM	IS 5182 (P-4)1999 RA 2014 Gravimetric Method	$\mu g/m^3$	126	224	181

Reviewed By *Approved By*

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Annexure No.-12

NOISE LEVEL SURVEY REPORT

Visiontek Consultancy Services Pvt. Ltd.

(Committed For Better Environment)

Certified for : ISO 9001:2015, ISO 14001:2015, ISO 45001:2018 (OH&S), ISO/IEC 17025:2017

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- Renewable Energy
- Agricultural Development
- Information Technology
- Public Health Engineering
- Mine Planning & Design
- Mineral/Sub-Soil Exploration
- Waste Management Services

Laboratory Services: Environment Lab, Food Lab, Material Lab, Soil Lab, Mineral Lab & Microbiology Lab

Ref : Envlab/21/R-5104 **Date : 06.10.2021**

NOISE QUALITY ANALYSIS REPORT- SEPTEMBER-2021

1. Name of Client : **M/s FERRO ALLOYS CORPORATION LIMITED , BHADRAK**
2. Name of the Project : **OSTAPAL CHROMITE MINES , KALIAPANI, JAJPUR**
3. **Date of Sampling : 14.09.2021**
4. Sample Collected by : VCSPL Representative in presence of Client's Representative

Location ID	Location		Result in dB (A)	
			Day Time (6.00 am to 10.00pm)	Night Time (10.00pm to 6.00 am)
N1	**Open Cast Quarry**	Ambient	71	62
N2	**COB Plant**		64	58
N3	**Mines Loading & Unloading**		69.6	63.8

AMBIENT NOISE LEVEL STANDARD

Category Area/Zone	Limit in dB (A)	
	Day Time (6.00 am to 10.00pm)	Night Time (10.00pm to 6.00 am)
Industrial Area	75	70
Residential Area	55	45
Commercial Area	65	55
Silence Zone	50	40

Reviewed

Approved By

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Annexure No.-13

Visiontek Consultancy Services Pvt. Ltd.

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- Quality Control & Project Management
- Renewable Energy
- Agricultural Development
- Information Technology
- Public Health Engineering
- Mine Planning & Design
- Mineral/Sub-Soil Exploration
- Waste Management Services

Laboratory Services: Environment Lab, Food Lab, Material Lab, Soil Lab, Mineral Lab & Microbiology Lab

Ref : Envlab/21/R-5101 **Date : 06.10.2021**

EFFLUENT WATER DISCHARGE ANALYSIS REPORT- SEPTEMBER- 21

1. Name of Client : **M/s FERRO ALLOYS CORPORATION LIMITED , BHADRAK**
2. Name of the Project : **OSTAPAL CHROMITE MINES , KALIAPANI, JAJPUR**
3. Sampling Location : **EW1:** ETP Outside Discharge Point
4. Method of Sampling : **APHA 1060 B**
5. **Date of Sampling** : **14.09.2021**
6. Date of Analysis : **15.09.2021 TO 21.09.2021**
7. Sample Collected by : VCSPL Representative in presence of Client's Representative

Sl. No.	Parameters	Testing Methods	Unit	Standards (In Inland Surface water)	Analysis Results EW-1
1	Colour	Visual Comparison Method APHA 2120 B; 23rd Edition, 2017	Hazen	Colourless	5
2	Odour	Threshold Odour Method APHA 2150 B; 23rd Edition, 2017	–	Odourless	Pungent Smell
3	pH at 25°C	pH Meter APHA 4500 H+ B; 23rd Edition, 2017	–	5.5-9.0	7.81
4	Total Suspended Solids	Gravimetric Method APHA 2540 D; 23rd Edition, 2017	mg/l	100	18
5	Copper as Cu	By AAS Method APHA 3111 B; 23rd Edition, 2017	mg/l	3	<0.05
6	Fluoride as F	Distillation followed by Spectrophotometric Method APHA 4500 F- C,D; 23rd Edition, 2017	mg/l	2	0.21
7	Total Residual Chlorine	Iodometric Method APHA 23RD Ed.2017 : 4500Cl- B	mg/l	1	ND
8	Iron as Fe	By AAS Method APHA 3111 B; 23rd Edition, 2017	mg/l	3	0.52
9	Manganese as Mn	By AAS Method APHA 3111 B; 23rd Edition, 2017	mg/l	2	<0.05
10	Nitrate as NO_3	By UV-Screen Method APHA 4500 NO_3^- B; 23rd Edition, 2017	mg/l	10	7.1
11	Phenolic Compounds as C_6H_5OH	Distillation Followed by Spectrophotometric Method APHA 5530-B, D; 23rd Edition, 2017	mg/l	1	<0.001
12	Selenium as Se	By AAS Method APHA 3500 Se C; 23rd Edition, 2017	mg/l	0.05	<0.01
13	Cadmium as Cd	By AAS Method APHA 3111 B; 23rd Edition, 2017	mg/l	2.0	<0.001
14	Cyanide as CN	Distillation Followed by Spectrophotometric Method APHA 4500 –CN-C,E; 23rd Edition, 2017	mg/l	0.2	<0.05
15	Lead as Pb	By AAS Method APHA 3111 B; 23rd Edition, 2017	mg/l	0.1	<0.01
16	Mercury as Hg	By AAS Method APHA 3112 B; 23rd Edition, 2017	mg/l	0.01	<0.001
17	Nickel as Ni	By AAS Method APHA 3111 B; 23rd Edition, 2017	mg/l	3	<0.05
18	Arsenic as As	By AAS Method APHA 3114 B; 23rd Edition, 2017	mg/l	0.2	<0.05
19	Total Chromium as Cr	By AAS Method APHA 3111 B; 23rd Edition, 2017	mg/l	2	0.31
20	Zinc as Zn	By AAS Method APHA 3111 B; 23rd Edition, 2017	mg/l	5	0.022
21	Hexavalent Chromium as Cr^{+6}	By AAS Method APHA 3500 Cr B; 23rd Edition, 2017	mg/l	0.1	<0.001
22	Vanadium as V	By AAS Method APHA 3500 V; 23rd Edition, 2017	mg/l	0.2	<0.001
23	Temperature	By Thermometer APHA 2550 B; 23rd Edition, 2017	°C	Shall not exceed 5°C above the receiving water temperature	34
24	Dissolved Oxygen	Modified Winkler Method	mg/l	–	6.2

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Laboratory Services
Environment Lab
Food Lab
Material Lab
Soil Lab
Mineral Lab
&
Microbiology Lab

		APHA 4500 O. C; 23rd Edition, 2017			
25	Biochemical Oxygen Demand as BOD	Oxygen Depletion Method IS 3025 (Part 44):2003	mg/l	**30**	3.8
26	Chemical Oxygen Demand as COD	Open Reflux Method APHA 5220 B; 23rd Edition, 2017	mg/l	**250**	14
27	Oil & Grease	Gravimetric Method (Solvent Extraction) APHA 5520 B; 23rd Edition, 2017	mg/l	**10**	4.6
29	Ammonical Nitrogen as N	By TKN Method APHA 4500-NH_3 C; 23rd Edition, 2017	mg/l	**50**	1.2
30	Total Kjeldahl Nitrogen as N	By TKN Method APHA 4500-N_{org} C; 23rd Edition, 2017	mg/l	**100**	4.6
31	Sulphide as S	By Methylene Blue Method APHA 4500-S D; 23rd Edition, 2017	mg/l	**2**	<0.001
32	Free Ammonia as NH_3	By Calculation	mg/l	**10**	4.1
33	Particulate Size of Suspended Solids	Gravimetric Method APHA 2540 D; 23rd Edition, 2017	µ	**Shall pass 850 micron IS Sieve**	<850
34	Bio-assay Test	Evaluating Acute Toxicity IS 6582 (P-2) 2008	%	**90% survival of fish after 96 hours in 100% effluent**	96% Survival of Fish after 96 Hrs in 100% Effluent

VISIONTEK CONSULTANCY SERVICES PVT. LTD.

Reviewed By

VISIONTEK CONSULTANCY SERVICES PVT. LTD.

Approved By

Annexure No.-14

Expenses for Environmental Protection Measures FY 2021-22(Till 30.09.2021) Ostapal Chromite Mines		
Sl No	**ITEM**	**Expenses in Rs**
1	**Afforestation FY 2021-22 2997 nos planted (Inside 2897 nos. & Outside 100nos.)**	
a)	Seedling @65 each	194805
b)	Fertilizer/Insectiside/Cowdung @ 25 /plant	74925
c)	Digging of Pits/Planting (Labor cost) @ 35	104895
d)	Post plantion care @ 120/ (Watering,Weeding,basin making)	359640
e)	Supervising	180000
	Sub-total	**914265**
2	**Water Management & Treatment**	
a)	ETP Operation &Maintenance (Including costs of chemical)	291271
b)	Man power for ETP operation & maintenance cost	1120540
c)	Power Consumption	385480
d)	ETP sludge Disposal	79254
e)	Water Sample Analysis	35580
f)	Water Tax	186600
g)	Impact Assessment Study Ground water	755200
	Sub-total	**2853925**
3	**Dust Suppression & Air, Noise & Soil Monitoring**	
a)	Water sprinkling by water tanker 1379 trips	413700
b)	Air Monitoring Charges	675670
c)	Noise level measurement	1062
d)	Soil sample analysis	10384
	Sub-total	**1100816**
	G.TOTAL	**4869006**