SLOPE STABILITY STUDY OF TALANGI CHROMITE MINE

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ABSTRACT: The paper deals with geotechnical study carried out to understand the possible reasons of failure at Talangi Chromite mine, IDCOL, Odisha. It was also aimed to redesign the failed slope as well as the final slope of the open cast mine. The quarry is characterized by soft ultrabasics in the form of limonite. It is overlain by a top layer of laterite. The geomechanical properties were determined. The stability analysis was done with the help of GALENA software based by limit equilibrium method. The slope angle of the failed zone was about 44 degree. The benches in the limonite are made manually and are having less exposed width. It resulted in localized steeper slope, which was steeper for long term slope stability. The relatively steeper slope failed due to saturation after heavy rainfall and differential permeability between soft and hard lithology. An optimum slope design has been recommended for the final pit slope.

Keywords: geotechnical study, slope stability, opencast mine, slope failure

1 INTRODUCTION

The geotechnical studies were carried out to know the possible reasons of failure at Quarry No. 2 of Talangi Chromite mine, Odisha, India. A part of the western part of quarry-2 failed on 2nd August 2015. It is semi mechanized open cast mine with conventional shovel dumper combination. Usually overburden is worked by mechanized means whereas ore and adjacent rejects are mined manually. Over the last two decades, the area in which this mine is located has accounted for about 95% of the entire production of chrome ore in the country which not only meets the indigenous requirements but also gives scope of export of low grade and friable chrome ores including metallurgical products like charge chrome and ferrochrome. Presently, 4 m high benches are maintained and the lowest working level of the mine 92 mRL.

The importance of safe, properly designed and scientifically engineered slope is well known. The benefit of an openpit operation largely depends on the use of the steepest slopes possible, which should not fail during the life of the mine. So, the design engineer is faced with the two opposite requirements, stability and steepness, in designing the deep openpit slopes. Steepening the slopes, thereby reducing the amount of material to be excavated, can save a vast sum of money. 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. The Directorate of Mines Safety may even close the mine, in case unsafe conditions are created. Therefore, it is necessary that a balance between economics and safety should be achieved.

2 GEOLOGY

The quarry is characterized by soft ultrabasics in the form of limonite. It is overlain by a top layer of laterite. No dykes and shear planes are reported in the area. The stratigraphic sequence of main litho units as established from field observation is as follows.

Alluvium and Laterite

Yellow limonite

Serpentinite

Chromite

The top formation is top soil and weathered laterite. The ultramafics with pyroxenite-dunite suite of rocks have been completely altered into limonite. These are soft, yellow to brownish in colour. The chromiferrous dark brown coloured laterite occurs as a capping over a major part of the leasehold. Both the hanging wall and footwall mainly consists of limonite, which are derived from ultramafics.

3 GEO-HYDROLOGY

The average rainfall in the area is about 1300 mm/ annum. About 90% of the precipitation in the valley escapes as surface run off. There is no perennial source or channel of water near the mine. The groundwater, in virgin area, occurs under unconfined condition in the top laterite. The laterite forming the top mantle has high porosity and permeability, there by forming upper aquifer. The water generally remains in unconfined condition.

4 GEO-MECHANICAL PROPERTIES

It is prudent to know the engineering properties of the slope mass, which will influence the analysis for slope stability. The visual inspection of the existing slope was made. The samples of slope mass were collected from different parts and depths of the existing pit. The specimens were tested in the Soil & Rock Mechanics Laboratory of CIMFR. The relevant strength properties, which were determined in the soil and rock mechanics laboratory of CIMFR and subsequently used for slope stability analyses, are summarized in Table 1. The rock mass rating was also used to estimate the strength properties.

Table 1 Geo-mechanical Properties

Lithology	Bulk density (kN/m^3)	c (kPa)	Ǿ (degree)
Top soil	**14.6**		**42**
18			
Weathered laterite	**15.3**	**44**	**18**
Limonite	**14.4**	**30**	**16**
Serpentinite	**25.5**	**190**	**24**
Ore body	**16.8**	**96**	**24**

5 SLOPE STABILITY ANALYSIS

The stability analysis was done with the help of GALENA software based by limit equilibrium method with the following considerations, based on the findings of field visit and experimental work. In a single stability analysis, at least one thousand failure circles were run to determine the most critical failure circle with minimum factor of safety. The Bishop method was used for analysis.

The ore body is steeply dipping; the profitability of the mine is largely dependent on the steepest possible final slope angle. The ultimate slopes of the quarry will be mainly formed in limonite and serpentinite.

The slope stability analyses for the mine in drained condition are mentioned in Table 2. The most likely geo-mining condition of the proposed final pit would be drained condition from available information as discussed above.

Table 2. Stability Analyses of Pit Slopes

Mine details	Factor of safety	Figure no.
Collapsed zone	**0.98**	**Fig. 1**
Proposed final slope at collapsed zone	**3.05**	**Fig. 2**
Proposed final SE pit slope	**2.24**	**Fig. 3**

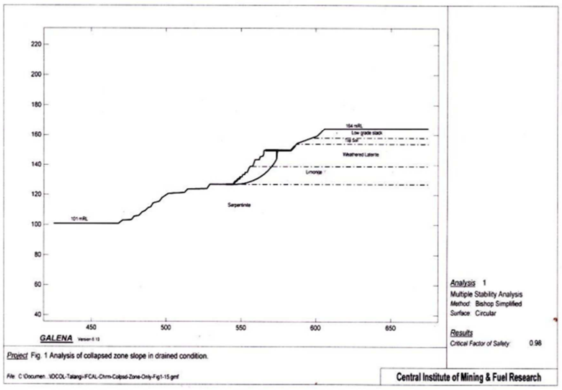

Fig. 1 Stability analyses of failed mine slope

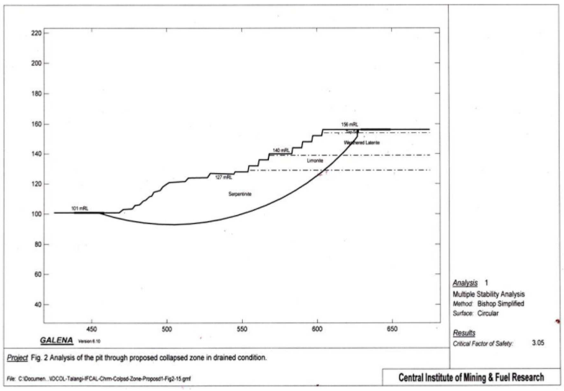

Fig. 2 Stability analyses of reformed mine slope

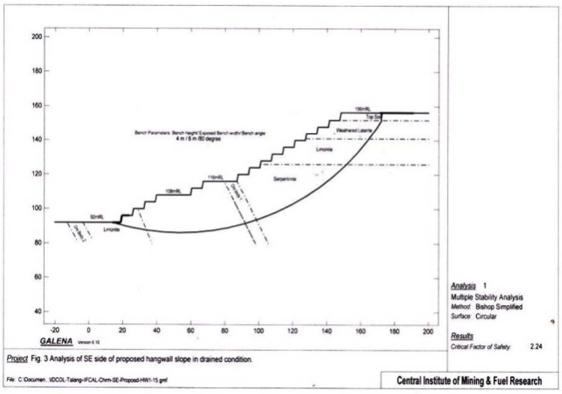

Fig. 3 Stability analyses of proposed final hangwall slope

6 RESULT AND DISCUSSION

The stability analysis shows that factor of safety of the most likely western failed slope profile just before the failure was 0.98 (Fig. 1). The minimum factor of safety for long term slope stability in mines should not be less than 1.3 (Hoek and Bray, 1981). On the basis of the failed slope profile provided by the mine management, field observation, engineering judgment, previous experiences of slope failures and failure analyses, and the possible reasons of the slope failure would have been as under.

The slope angle of the failed zone was about 44 degree. The benches in the limonite are made manually and are having less exposed width. It resulted in localized steeper slope, which was more for long term slope stability. It resulted in high stress development.

The area experienced unusual heavy downpour before failure. It shows that the heavy rainfall had occurred just before, during and after failure. It was observed that the drains along the crest and toe of the failed zone were got blocked at few locations. It would have resulted in stagnation of water at these locations, which would have been resulted in water saturation in the relatively steep slope mass. It was observed that base of failure was along the contact of loose limonite and hard serpentinite. Due to differential permeability between soft and hard lithology, the water flow through it would be slow. The contact zone would be saturated due to differential permeability between two layers. It results in saturation of soft layer along the contact of soft and hard lithology.

The relatively steeper slope failed due to saturation after heavy rainfall and differential permeability between soft and hard lithology. The failed mass should be pushed back to form new benches.

The failed zone should be reformed by pushing back the benches. The push back should be sufficient so that the final benches are formed in in-situ mass.

The analyses show that the proposed / planned bench profiles (Figs. 2 and 3) of the pits are likely to be stable. The stability analyses were done with a consideration of controlled blasting on the hard serpentinite slope faces and proper drainage for rainwater and groundwater. The optimum bench design of final slopes has been presented in Table 3.

Table 3. Optimum Design of Final Pit Slopes

Final Bench Parameters			
Bench height (m)	**Exposed width (m)**	**Angle (deg.)**	**Overall slope angle**
4	**6**	**80**	**34 deg (Pit bottom 92 mRL)**

7 CONCLUSION AND RECOMMENDATIONS

The relatively steeper slope failed due to saturation after heavy rainfall and differential permeability between soft and hard lithology. The failed mass should be pushed back to form new benches.

The proposed reformation should be done from top to bottom. The failed zone should be reformed by pushing back the benches. The push back should be sufficient so that the final benches are formed in in-situ mass.

Any open cracks should be filled, leveled and compacted. It will minimize the infiltration of water inside the cracked mass. Any water entry should be checked in to the cracks to check the instability near the preexisting cracks.

An assessment of the engineering geology, strength properties and the related geotechnical controls indicated the final pit slope design as mentioned in Table 3.

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References

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