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GEOTECHNICAL INVESTIGATION OF DRAGLINE DUMP OF JAYANT OPEN CAST MINES

Amit Golder*[1] and Indrajit Roy[2]

[1]Assistant Professor, Jharkhand Rai University, Ranchi, Jharkhand, India.

[2]Associate Professor, Civil and Environmental Engineering Department Birla Institute of Technology, Mesra.

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***Corresponding Author**

Amit Golder

Assistant Professor,

Jharkhand Rai University,

Ranchi, Jharkhand, India.

ABSTRACT

Surface mining operation often results in removal of huge quantities of waste material and subsequently dumping it outside quarry areas or back filling in the excavated areas as the case may be. In recent years the unprecedented increase in the rate of accumulation of waste dumps has been a great environmental concern because this leads to more frequent large/small dump failures. General increase in environmental awareness has given rise to concern about safe and economic design of waste dump both during mining and following mine closure. On the one hand, stable slopes are essential for safety of men and machine and on the other hand vast amount of land and money can be saved by optimizing slope geometry of dump. It is therefore, a technical and economic necessity that the most efficient compromise be achieved, in the light of these two conflicting requirement; by optimizing the slope that is steep enough to be economically acceptable and flat enough to be safe. The intension has been to produce design graphs and tables covering wide range of each controlling parameter for mine planners and operators to select optimum slope geometry of waste dumps.

KEYWORDS: Slope Stability, Dump Slope Stability, Geo-Technical Engineering, Soil Mechanics, Ground Control in Mining, Mine Planning.

1. INTRODUCTION

Instability of both natural and manmade slopes contributes a major share of Civil Engineering failure. The need to treat uncertainties in assign or assessment of slope stability today includes a lot of concern in order to insure the safety at different working levels. The value of almost any quantity of interest measured in civil engineering is to a certain extent uncertain, and hence may be considered as an uncertain variable. In present scenario India has 3rd rank in coal production in all over world and opencast mines provides a major portion up to 89% for completing this demand. The rising need have been pushed to its limit, the mining industry need to increase the production to fulfill the demands. The heavy machinery adopted for the extraction of the minerals has been producing huge wastes in the form of waste rocks, the management of which is again of prime importance. To deal with these stability of slopes issues different methods have been assumed and advanced over the years.

In Indian scenario very recently, JAYANT OPENCAST MINE of Northern Coalfields Limited, Singrauli experiencing frequent dragline dump slope failures in recent years including a fatal accident of 5 mine employees in December, 2008. The main reason behind accident was sudden failure of waste dump which was situated near to working area of mine operators.

The main intension of this study is to provide the safety working environment for the mine operators on the one hand and other hand optimization of land money can be done by proper management of these dump slopes. So these two requirements could achieve their goal.

2. OBJECTIVE

Slope stability analysis forms integral part of the opencast mining operations during the life cycle of the project. During the past four decades the method of analysis for slope stability have emerged within the field of rock engineering to identify the problems of design and stability of excavated slopes. The basic of the project is primarily confronted towards:-

- Understand the different types and mode of failure.
- Development of new guidelines for safe drag line dump profile under varying geo-engineering condition in Jayant Opencast Mine of Northern Coalfields Limited considering past work done and history of slope failure.
- To determine geo-technical properties of the dump material in laboratory analyze Slope Stability problem for predicting the value of factor of safety.

3. BACKGROUND OF SITE

Location: The Jayant Opencast Project of Northern Coalfields Limited (NCL) is located in Singrauli Coalfields which is situated in Sidhi district of Madhya Pradesh. The nearest railway station is Shaktinagar at a distance of about 5 kms, from project on Chopan-Katni (KBJ Line) railway line of East-Central Railway.

Mineable Reserves: The total mineable reserves are estimated as 348.93 MT and the total volume of OB is estimated at 907.20 Mm^3 with average stipping ratio of 2.60 m^3/t. There is Turra Seam, Purewa Bottom Seam & Purewa Top Seam. Jayant Opencast Project has produced 193.40 Mt. of coal till March, 2007.

Programme of excavation: Jayant Expansion OCP has been planned to produce total 150.88 Mt coal & 361.61 Cum O.B from 2007-08 to 2020-21.

Mining Details: Stripping ratio (mineral in tones to over burden in m^3) - 2.39 m^3/t (for balance life). Ultimate working depth - 165m, Present working depth existing mine- 125m, Thickness of top soil 7m (3-12m), Thickness of overburden 125 m (110 – 140m).

Topography: Project is situated on plateau with elevations varying from 375 m. to 425 m. above Mean Sea Level (MSL) except one hill in the North West corner having an altitude of 500 m above MSL.

Climate: The area receives mostly south western monsoon and average annual rainfall is about 1105 mm. The lowest temperature recorded is 4^oC and the highest temperature 48^oC during last 15 years.

Mode of excavation: Merry go around.

Method of mining: Shovel – Dumper – Dragline Combination.

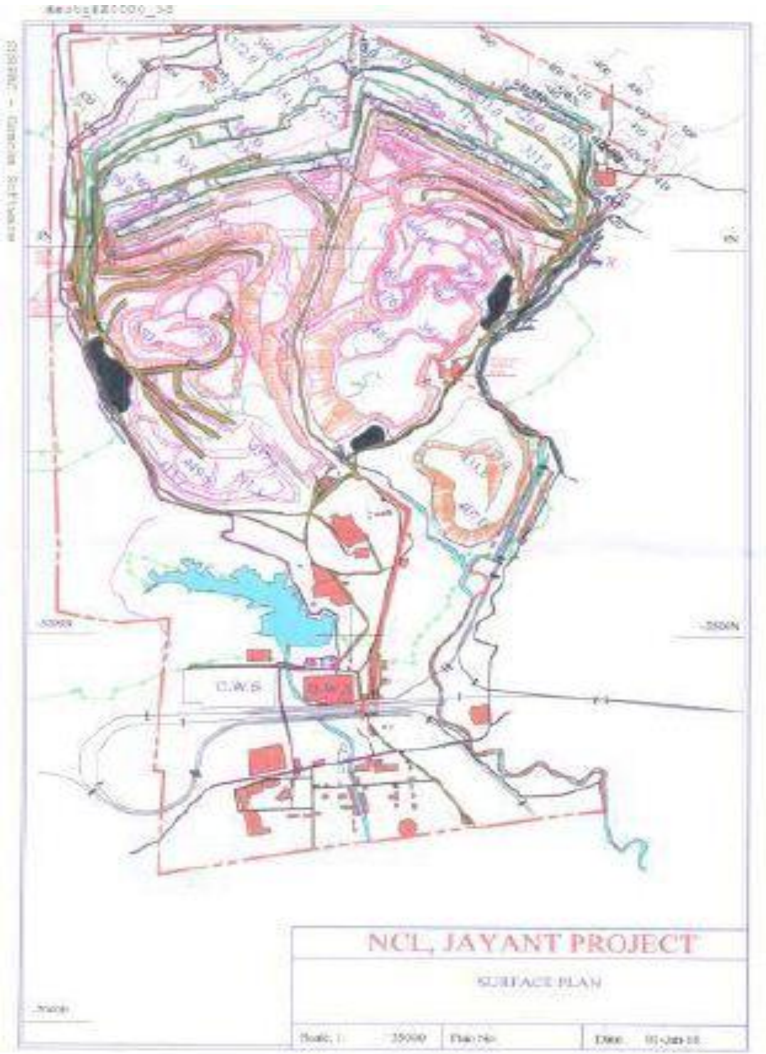

Figure 1: Working Plan of Jayant Project, NCL.

4. TYPES OF LANDSLIDES AND SLOPE MOVEMENTS

The types of failure that basically occur can be classified as:

(i) Rotational Slide

(ii) Slope Failure

(iii) Toe Failure

(iv) Base Failure.

This method takes into account the forces acting on the vertical sides of slices in the development of an equation for determining the factor of safety. Factor of Safety is defined as the ratio of Disturbing force to Resisting Force. Different method of slope stability,

(i) Fellenius method

(ii) Bishop's method

(iii) Other methods of circular arc analysis.

5. SAMPLE COLLECTION AND SAMPLE TESTING

The rock sample are taken at different height of dump mass, and collected in plastic cement bags. On other hand information like height of dump, location of water table, face angle, and type of dumper working over there. Around 500 kg broken sample of dragline dump and 500 kg crushed rock sample from interface material were collected and transported to BIT, Mesra laboratory. Then the dump and interface material were compacted at 100 kN/m2, 200 kN/m2, 300kN/m2, 400 kN/m2, 500 kN/m2. Water are also added to achieve moisture contents of 7%, 12% for dump and interface material for simulations of actual site conditions. In B.I.T Mesra there is a separate computer controlled large scale shear box test machine have been installed in which the sample have been tested at different degree of saturation for calculating the value of cohesion *(c)* and angle of internal friction *(ϕ)*.

(i) Cohesion and angle of internal friction of dragline dump mass determined at the laboratory, using Large Box Shear Test.

(ii) Laboratory determined bulk density of saturated dump mass compacted.

(iii) Laboratory determined cohesion of slushy material *i.e.* interface material [The interface material lies at the floor of the mine above which the dump is formed. At the laboratory, the interface material was submerged under water for 24 hours and compacted at compacting stress of 1600(80x20) kN/m2 as the interface material is under full height of dump].

(iv) Similarly, angle of internal friction of interface material is determined by simulating the field condition as explained above.

Figure 2: Large Box Shear Test Arrangement.

Figure 3: Large Box Shear Test Arrangement.

6. LABORATORY ANALYSIS AND RESULT

Geo-technical parameters like shear strength parameters and bulk density. Shear strength parameters i.e.

(i) Cohesion

(ii) Angle of friction

These parameters were determined by ‘Large Box Shear Test’ using large box shear apparatus and sample collected (waste dump material) from Jayant Open Cast Mines. Demonstrating the physical properties of collected samples and direct shear test report of dump material of Jayant opencast mine, NCL, Singrauli. Test report for different normal stress is 100kN/m^2, 200kN/m^2, 300kN/m^2 and 400kN/m^2 mention in Table 1 and Figure 4.

Table 1: Result Obtained.

Sl. No	Normal Stress	Shear Stress
1.	400	216.89
2.	300	128.64
3.	200	108.56
4.	100	84.23

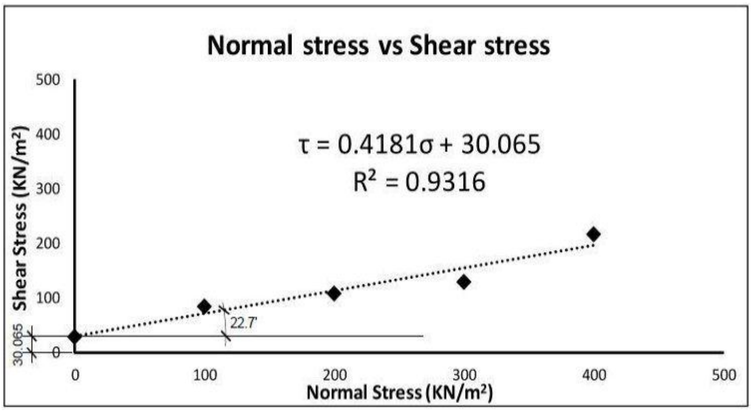

Figure 4: Graph plotted between Normal Stress vs. Shear Stress.

Shear strength parameters and their values after plotted in graph.

(i) Cohesion(c) = 30.065kN/mm^2

(ii) Angle of friction = 22.7^0

7. CALCULATION

Calculation of Factor of Safety using Fellenius method for different alternative (Width of dragline sitting level) are shown in Table 2.

Determination of FOS by Fellenius Method (with seismicity):-

Frictional Force = $[W\sin\theta - SW\cos\theta]\ X\ \tan\phi$

Where, S = Seismicity Factor

Cohesive Force, $C = \theta\ X\ c\ X\ r\ X$ *width of slice*, where c = Cohesion and r = radius

Disturbing Force = $[W\cos\theta + SW\sin\theta]$

$$\text{i.e,}\quad \text{FOS} = \frac{\text{Frictional Force} + \text{Cohesive Force}}{\text{Disturbing Force}}$$

$$\text{FOS} = \frac{\text{Resisting Force}}{\text{Disturbing Force}}$$

Table 2: Recommended Factor of Safety.

Sl.No	No. of Alternatives	Overall Slope Angle	FOS
1.	At 25m	28^0	1.419
2.	At 20m	29^0	1.263
3.	At 15m	*31^0*	*1.256*
4.	At 10m	32^0	1.235
5.	At 5m	33^0	1.169

Recommended Factor of Safety is shown in *yellow*.

8. CONCLUSION

The dragline dumps of Jayant open cast mine are safe in present scenario and it is recommended to maintain Factor of safety above stipulated one in future mining operation.

For monitoring such profile, following measures are undertaken:-

a) Height of dragline dump is restricted to 81m.

b) Overall slope angle of dragline dump is not steeper than 32°.

c) Two corridors at dragline sitting level of not less than 15m and another at coal rib level of not less than 14m is maintained.

d) Embankment is provided at the toe of the dump and at the outer edge of the coal roof corridor to arrest any rolling boulder from the slope.

e) Floor gradient of the coal seam is maintained such as to ensure consistent natural gravitational flow of water towards sump.

f) The design process necessary involves personnel who are engaged in day to day operation and while operation there must not be any deviation from designed parameters.

g) No low bearing capacity soil is allowed to be dumped on the floor of de-coaled area so as to form the base of the dump.

h) Top soil is dumped separately as far as possible much away from the site of active internal dumping.

The initial goal was to investigate the problem of slope stability from the perspective of a opencast mine system, to quantify the status of stability and investigate the relative importance of the parameters involved in slope stability assessment factor of safety.

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