Slime Dump Stabilization of Iron Mine by Use of Jute Geotextile - A Case Study of Noamundi Iron Mine

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Abstract. Extraction of iron ore through open cast mining technique is most common and popular practice in India. The method is also very cost effective and more profitable as entire mineral is being excavated from the mine. But it creates major environmental hazards by generation of huge quantity of mine waste & its dumping on nearby land. Mine waste is collected & stored as dump which occupies a huge space. The dumps are categorized depending on its use like, waste dump and subgrade dump. However, to produce best steel grade material, the iron ore is processed and cleaned through wet technology. The rejected waste known as slime is collected and stored in pond. After evacuation of water / moisture from the slime it is stored as slime dump for future use. In most of the cases the height of dumps reaches beyond its limit and tends to collapse. By this way in most of the cases the dumps become overburden (OB Dump) and destabilizes. Eventually, due to presence of very fine quality of material high rate of erosion takes place in slime dumps owing to precipitation and wind which further affect the stability of dump. The situation gradually becomes worst causing serious environmental pollution and degradation of nearby land. Mining can become more environmentally sustainable by developing and integrating best environmental practices in mining operations. These practices include preventing soil, air & water pollution, adoption of zero liquid discharge, reduced energy consumption, adequate waste utilization, social awareness, and conducting successful reclamation activities. In order to stabilize the OBDumps appropriate measures need to be taken for rehabilitation and ensure erosion control of slope with suitable material along with adopting bioengineering technique. Jute geotextile (JGT) an eco-friendly, cost effective, material developed by Jute Geotextile Cell (JGT) of National Jute Board, Ministry of Textiles, Govt. of India is being widely used all over the world in various forms for mitigating such soil related problems. Performance of JGT has been reported to be much superior technically to other available materials meant for erosion control works apart from its environmental advantages. It possesses high tensile strength, biodegradable characteristics and is commonly used for erosion control, road construction, hill slope management etc. The use of JGT on trial basis in Noamundi Iron Mine of TATA steel Ltd in slime dump management was undertaken for the 1st time. The results observed within a period of 3 months after

application of JGT was highly encouraging. Vegetation was grown through the openings of JGT and the slime dump was stabilized. The features of the site, methodology adopted along with properties of JGT and its effect are explained in this paper.

Keywords: Jute geotextile, Slime dump, Noamundi, sustainable mine

1 Introduction

Noamundi Iron Mine of TATA Steel Ltd. is a first five star rated iron mine of Jharkhand state as per SDF by Indian Bureau of Mines (IBM), Govt of India. It is the one of the captive iron mine of TATA Steel and is been operated from last several decades. A mine becomes sustainable when it is profitable, socially accepted (ready to run in area) and environment friendly. All the activities are interlinked and can be achieved simultaneously.

Tata Steel's Vision strikes a balance between economic value as well as ecological and societal value by aspiring to be "a Global Benchmark in Value Creation and Corporate Citizenship. Tata Steel has taken responsibility for the impact of its activities and led the way in employee welfare measures, social & community initiatives, and environment sustainability. In this regard, over the period various policies such as Environmental – Sustainability & Biodiversity policies are adopted and implemented in ground by various technological innovation practices.

In order to produce best steel grade material, the iron ore is processed and cleaned through wet technology. The rejected waste known as slime is collected and stored in pond. After evacuation of water / moisture from the slime it is stored as slime dump for other suitable usages. During dumping the slime layer after layer in many cases the height of dumps reaches beyond its limit and tends to collapse. By this way the dumps become overburden (OB Dump) and destabilizes. Eventually, due to presence of very fine quality of material high rate of erosion takes place in slime dumps owing to precipitation and wind which further affect the stability of dump. The situation gradually becomes worst causing serious environmental pollution and degradation of land nearby areas.

Bio-engineering techniques1 protect the environment and are being adopted globally in mitigating soil related problems for sustainable solution. To mitigate the erosion problem along with stabilizing dump slopes of slime, the perfect bio-engineering solution is to use of Jute Geotextiles (JGT)2. JGT made of natural jute yarns, because of its 3-D construction; it reduces the velocity of overland flow and entraps the dissociated soil particles / erodible surface materials while fostering growth of vegetation 3concurrently.

Jute possesses certain unique inherent features. Interestingly, 1 ha of jute plant can absorb 15 MT of CO2 from atmosphere and liberate 11 MT of O2. Besides being eco-concordant, it can absorb water to about five times its dry weight, can attenuate extremes of temperature and create a congenial micro-climate conducive to growth of vegetation. Jute Geotextiles are also the most adaptable among all types of geotextiles—both natural and man-made. The cover provided by JGT in the initial period also prevents significantly rain-splash detachment. By the time JGT starts biodegrading vegetation sprouts4 to take over its functions. Utilization of vegetation singly or in combination with geotechnical remediation for protection of slopes5 by reducing and controlling destabilizing factors is an approach that necessitates minimum artificial intervention and maximum natural protection. Considering all the above positive aspects of JGT it was used on trial basis in Noamundi Iron Mine of TATA steel Ltd in slime dump management. The results observed within a period of 3 months after application of JGT was highly encouraging. Vegetation was grown through the openings of JGT and the slime dump was stabilized.

2 Composition & Some Physical Features of Jute

Jute is a natural ligno-cellulosic bast fibre enriched in cellulose that facilitates absorption and retention of water. Some of its physical properties are shown in Table 1 for reference. Being textile grade fibre, it can be mechanically spun into desired quality yarn for manufacturing site-specific geotextile to control soil erosion. Varieties of open weave JGT have been developed. Technical specifications of these products are shown in Table 2. Cost-wise JGT is the cheapest among all other geotextiles available in the market for such uses.

Table 1. Properties of Jute fibre

Physical Properties	Values
Specific gravity (gm/cc)	1.48
Co-efficient of static friction	0.45-0.54
Swelling in water (Area wise)	40%
Water retention	70%
Refractive Index (cal/g/^{0}c)	1.577
Specific Heat (Cal/g/^{0}c)	0.324
Thermal conductivity (Cal / sec/sq.cm.^{0}C / cm)	0.91 X 10^{-4}
Heat of Combustion (Jules/g)	17.5
Ignition temperature (^{0}C)	193

Table 2. Specification for Open Weave JGT

Physical Properties	Values
Weights (g/m2) at 20% moisture regain	500
Threads / dm (MD X CD)	6.5X4.5
Thickness (MM) at 2 KPa	5
Width (cm)	122
Open area (%)	50
Tensile Strength (KN/m)[MD X CD]	10 X 75
Water holding capacity (%) on dry weight (gsm)	500

3 Case Study on Application of Jute Geotextile

The slime generated from the ore processing plant is separately stored in slime dam for possible future uses but after certain point of time the height of dump reaches at such a level that it becomes Over Burden and collapse. To overcome the situation the existing dam was tried for stabilizationbyplantation, butas thedumpcontains finematerial, severe erosion took place (Fig-1) and the method did not work. For this reason the TISCO authority was looking for an alternate effective methodology on trial basis for dump stabilization and approached National Jute Board (NJB), a statuary body under Ministry of Textiles, Govt. of India to study the problem with and to suggest remedial measures which was accorded by NJB. During site inspection at Noamundi by the expert of NJB along with Mine officials, it was observed that height of slime dump was about 40 m with a span over 1.5 km area (lengthwise). Angle of slope was more than 45o. Both the sides of the embankment were having sharp slopes, which was extremely vulnerable to erosion and heavy rain cut were predominant. Considering the technical features of the site it was decided to stabilize the OB Dump by using Jute Geotextile (JGT) followed by plantation as a measure of bio-engineering technique. In adopting this measure following steps were considered -

• To dress the undulated and uneven slope surface having rain cut and to bring the slope as gentle as possible preferably in the range of 25-30o with a provision of benching in the mid-way of the slope length.

• To construct a low height toe wall / gabion along the bottom of slope for lateral restraint. To compact the slope surface by ramming manually.

• To spread a thin layer of good earth of about 25 mm and also manure over the prepared slope. To install 500 gsm Open Weave JGT prior to onset of monsoon followed by plantation of locally available deep-rooted species of sapling or spreading grass seed over the prepared slope and applying water occasionally.splayed equations are centered and set on a separate line.

Fig. 1. Destabilized OB Dump of Slime

3.1 Work done

The slope angle was brought to about 40o and further below to stable condition. The angle of slope could not be made gentler because of paucity of land in the instant case. Slope surface was leveled, dressed and compacted manually. Benching was provided at the middle of inclined slope length of about 32.5 m. After applying a small dose of good earth on slope surface JGT was laid properly (Fig-2), anchored with a sideway overlap of about 10 cm. Top and bottom ends of JGT were also anchored in the trench dug for the purpose. A boulder gabion of 1m x 1m x 1m size set with wire crate was constructed about 10 m away from the bottom line of the slope. However, it was decided to construct a low height toe wall along the bottom contour line of the slope to avoid chances of lateral slide of slope particularly during monsoon. After installation of JGT dub grass seed mixed with good earth were spread on the slope surface followed by vermicomposting and watering for quick germination of local grass seeds.

Fig.2 Laying of JGT on Slope Surface

Fig.3 Stabilized OB Dump with growth of vegetation

Result, Conclusion & Recommendations

- It was observed after a gap of about 30 days of application of JGT that germination of grass started and within 45 days the entire slope surface was covered with lush of vegetation (grass) (Fig-3).
- No significant sign of erosion and rain cut was observed even after monsoon and the vulnerable slope of OB Dump became stable.
- It may be concluded from the study that use of Jute Geotextile fosters growth of vegetation even on difficult material like slime dump and is quite effective in stabilizing the O B Dump.
- Based on encouraging results of trial study, some other sites are also recommended for stabilization of slime dump in similar way. The same material can also be used for waste dump stabilization too.

Reference

[1] Howell J. H.; Sandhu S.C.; Vyas N.; Sheikh R. & Rana S.S. "Introducing Bio-Engineering to the Road Network of Himachal Pradesh". Published in Journal of the Indian Roads Congress, Vol. 67 -3(2006).

[2] BIS Guidelines for application of Jute Geotextile for rainwater erosion control in road and railway embankments and hill slopes – (IS-14986 – 2001).

[3] Rickson, R. J., "The use of Jute Geotextiles in Soil Erosion Control" Proc. Fifth Int. soil Consolidation Conf., Bankok, Vol. V, 627-633(1988) .

[4] Choudhury, P. K. Chatterjee, P. K. and Dutta, U.. "A Low Tech. Approach for Forests". 1st Asia – Pasific Conference on Water & Bioengineering for erosion control & slope stabilization (1999).

[5] Aamir Farooq, Rajesh Goyal (2017). "Stabilization of Soil by Use of Geo-Jute as Soil Stabilizer", International Research Journal of Engineering and Technology (IRJET), Vlume 04 Issue 08, Page no. 1654 to 1665.

[6] National Jute Board (2015), booklet published on "Case Studies with Jute Geotextiles (JET) in Rural Road, River Bank Erosion Control & Hill Slope Management", Saraswaty Press Ltd.