OVERVIEW OF STRATA MONITORING TECHNIQUES USED IN OPENCAST MINES

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Abstract - *Several monitoring techniques including visual inspection, Lidar scanning, total stations, global positioning systems (GPS) to the state–of-the- art slope stability radar scanning and micro seismic monitoring are now used several mine producing countries of mine. The mineral extraction changes the stress state within the slope, making it more prone to deformation over time. This could eventually lead to the slope collapse owning movements environments making it difficult to anticipate slope failure and deformation rate. Surface mining's economics rely heavily on slope angles. Nowadays, technical advancements have made it possible to utilize this technique on a regular basis, resulting in three-dimensional quantitative information about the state of slope stability. The results of a simple numerical model of an open pit slope are addressed in light of the fact that recorded seismic events can be located hundreds of meters beyond the slope surface. Within the slope, seismic movements of recognized geological formations can be monitored and potentially utilized to assess relative stability trends. Micro seismic data should be able to reveal previously unknown structures, which can then be validated using other geotechnical techniques. The project shows that carefully analyzed data from open pit slopes can be used to gain greater insight into the effects of mining can result in more accurate assessments of slope stability.*

Keywords: *Opencast mines, slope, stability, monitoring*

1. INTRODUCTION

Mining is the process of extracting economically valuable minerals from the earth's crust for the benefit of humanity. In India, mining is a significant industry. India is a major exporter of iron ore, chromite, bauxite, mica, manganese, granite, coal, and other minerals. It ranks 6th in term of mineral production volume among mineral producing countries. The mining industry accounts for roughly 2.4 % of India's GDP, (Deshmukh, 2000).

Open cast mining or quarrying of minerals is easier than mining by underground methods. During quarrying, the alluvium and rocks beneath which the minerals are found are removed and placed in an area that will not be needed for quarrying, residential, or other purposes in the future.

A slope failure is a phenomenon that a slope collapses abruptly due to weakened self retainability of the earth under the influence of a rainfall or an earthquake, Because of sudden collapse of the slope.

The study of tracking ground movements and detecting instability before failure is known as slope stability monitoring. Monitoring is a crucial tool for evaluating design performance and failure risk, as well as reducing risk. In the risk management of large open pit slopes, slope monitoring plays a significant role. These monitoring techniques include Robotic Total Station, Lidar scanning, Global Positioning System (GPS), Slope Stability Mining Radar, Time Domain Reflectometry, Digital Photogrammetry, High Resolution Micro Seismic Monitoring, these techniques are used in several countries to monitor the slope stability. In India, open cast mines are now proposed to enormous depths, frequently exceeding the industry's operational experience and knowledge base. In the near future, new geotechnical difficulties induced by substantial in-situ stress are expected to emerge in deep open cast mines. Because of these concerns, appropriate geotechnical engineering practices must be used to mine design and general operating procedures, for safe and economic mining.

The current understanding of geotechnical conditions, slope collapse processes, and slope stability analysis applications is limited. Slope failures continue to occur, resulting in human and financial losses for any business. This project gives an insight into the recent and emerging technologies for open pit slope monitoring.

2. STARATA MONITORING TECHNIQUES USED IN OPENPIT MINES

There are various slope monitoring techniques that can be used in opencast mines. But different monitoring instruments have their own advantage and disadvantages. The pros and cons of the various techniques are presented in Table 1. The comparison of different techniques is shown in Table 2 (Lynch et al., 2005; Sakurai and Shimizu, 2006; Wesseloo and Sweby, 2008; Kumar and Villuri, 2015).

Table 1. Advantages and disadvantages of various slope monitoring techniques

S.NO	TECHNIQUES	ADVANTAGES	DISADVANTAGES
1	ROBOTIC TOTAL STATION	• The range is better than all other techniques The major advantages in prism monitoring are increased precision of the coordinates, continuous measurement in all weather conditions, and accurate measurement	• The disadvantages of prism monitoring are it requires an open sky view or the system will be affected by insufficient tracked satellites. The system can be affected by nearby machinery that affects the functioning of the system,

		with a distant reference point	Installation is difficult, time taking for installation.
2	LiDAR SCANNING	• Higher accuracy • Fast acquisition and processing • Acquisition of 1000km2 in 12Hrs. • DEM generation of 1000km2 in 24Hrs • Minimum human dependence • As most of the processes are automatic unlike photographic GPS or land surveying • Deployment easy method	• Weather or light independence. • Data collection independent of sun inclination at slightly bad weather. • HIGHER DATA DENSITY: • Up to 167000 pluses/second more than 24 points per meter can be measured. • Multiple returns to collect data in 3D.
3	GPS	• Less cost when compared to other monitoring techniques. • if you are using GPS on battery operated device, there could also be a battery failure you'll need a external power supply which isn't always possible. • Most attractive features of this system is its 100% coverage on the surface mining or open pit	• If you are using GPS on battery operated device, there could also be a battery failure you'll need an external power supply which isn't always possible. • Deployment rate is difficult to other techniques
4	DIGITAL PHOTOGREMETRY	• Labor saving • Less cost or cost saving. • Real time measurements . • Complete knowledge of slope face. • Highly accurate making it very reliable to use for mapping or other purposes.	• Major disadvantage is that the photogrammetry survey is not possible in the absence of light. • The accuracy of the measurements depends highly on the flight height. • The digital photogrammetry surveys make it susceptible to hacks and loss of data to viruses. • Costly at the time of installation. • Works on Weather dependent.
5	MICRO SESIMIC	• High accuracy level. • volume of monitoring • Better access. • Cave evolution monitoring.	• Still an evolving technology. • not a direct displacement or stress • Interpretation techniques are largely empirical.
6	TIME DOMAIN REFLECTROMETRY	• TDR is easy to monitoring in slope stability. • The equipment required is small and inexpensive. • It requires low test voltage. • It increases the value of future tests by observing changes over time. • It requires maintaining accurate data. • It locates areas of the cable system with impedance.	• It requires competent persons for monitoring of slope stability in open pit mines. • Electrical noise may interfere with the low voltage TDR signals. • Blind spot due to the ranging effect occur at the near end where the pulse is injected. • The length of the cable with in the blind spot depends on the injection and width of the pulse. • The deployment is difficult compare to other techniques
7	SLOPE STABILITY MINING RADAR	• Radar signal can penetrate insulator. • It can determine the velocity of target. • It allows for 3-D imaging based on the various angles of return. • Cheaper than other techniques. • Covers wider area. • Several industrial applications. • Fast method of calculating base maps when no detailed survey is required.	• It requires specialized training to analyze the data. • Shorter range • It can be oversensitive. • It cannot work in deep sea area. • It cannot resolve the type of object. • It is having wider beam range.

Table 2. Comparison of various slope monitoring techniques

S.NO	TECHNIQUES	COMPARISON
1	ROBOTIC TOTAL STATION	• Most range when compared to other techniques.
2	LiDAR SCANNING	• Update rate is very fast comparing to others. • The deployment rate is better than PHOTOGRAMMETRY, SSMR, MICROSEISMIC. • The deployment is easy compare to others.
3	GPS	• The update rate is very fast comparing to other. • It works on all weather conditions. • High accuracy compare to others
4	DIGITAL PHOTOGRAMMETRY	• The update rate is better than ROBOTIC TOTAL STATION. • The deployment is better than TDR,GPS,TOTALSTATION
5	MICRO SEISMIC MONITORING	• The update rate is continuous process compare to others. • The range is better than DIGITAL PHOTOGRAMMETRY. • The deployment is easy compare to GPS AND TDR. • It works on all weather conditions.
6	TIME DOMIAN REFLECTROMETRY	• The update rate is better than SSMR and DIGITAL PHOTOGRAMMETRY. • The deployment is difficult compare to other techniques. • It works on all weather conditions.
7	SLOPE STABILITY MINING RADAR	• The update rate of SSMR is better then digital photogrammetry. • The range is better than digital photogrammetry and micro seismic. • It works on all weather conditions. • The deployment is easy then others.

3. CONCLUSIONS

This paper presents brief overview of the strata monitoring techniques in open pit mines. Radar widely used in several countries for strata monitoring. The slope stability radar is a state-of-the-art development for monitoring slope movement in surface mines. It gives most accuracy results within sub-millimeters and broad area coverage of slope movements through rain, dust, smoke. It works in all weather conditions, easy to deployment. Now a day's new strata monitoring techniques are obtained. The robotic total station monitoring limited in usage when there is a presence of machinery. The range of total station is 2km. The TDR is limited in use due to its accuracy limits. It's suitable in all weather conditions. It gives faster update rate when compare to other techniques. The GPS works in all weather conditions and give accurate results. The update rate is very fast comparing to other techniques. The micro seismic works in all weather conditions. It is easy to monitoring in continuous update rate, and deployment.

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