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Estimation of Vertical Distance and Reduce Level using Modern Mine Survey Equipments (Total Station) at Sub Level in Maddhapara Granite Mine, Bangladesh

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ABSTRACT

An underground mine survey work was done using Total Station (TS) at sub-level (third drilling drift to cage shaft) in Maddhapara Granite Mine (MGM). The MGM is situated at Maddhapara in Dinajpur district, NW Bangladesh. Room and pillar sub-level stoping underground mining method applied in MGM and extracted economic minerals (granite, granodiorite, diorite etc) from five stopes. Ordinary survey equipments (measuring tape, staff, compass, ranging rod, automatic level, automatic theodolite) were used in MGM during the development period for the constructions of shafts, underground roadways, drilling drifts, sumps, loading bunker, cross cuts, stopes etc. MGM contains two vertical shaft and three underground levels; ventilation level used for mine air ventilation, sub-level for drilling or blasting and production level used for production of mineral ores. The dimension (l×h×w) of each stope is 276,000 m^3 (230 m × 60 m × 20 m) as per design. Modern mine surveying in MGM reduce the error survey data which were used to develop the further constructions as per design and also monitor the weak zones or mine subsidence rate to minimize mine accidents. During the year of 2008-2009, Reduce Level (RL) was calculated at various points. The first R.L in the mouth of third drilling drift is -247.267 m and last RL near the cage shaft is -246 m. The vertical distance was also calculated with taping method from surface (mean sea level) to ventilation level, sub level and production level is -228 m, -246 m and -270 m respectively. Regular monitoring with TS and other modern survey accessories in MGM may give the actual survey results which may helps to identify the underground weak zones (if detect) and recommends for underground mine supporting system and finally MGM diminish mine accidents.

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1. INTRODUCTION

Maddhapara Granite Mine (MGM) is situated at Maddhapara in Dinajpur district, NW Bangladesh with an area of about 1.44 km², between latitude 25º33´15´´ to 25º34´15´´ N and longitude 89º03´30´´ to 89º04´53´´ E (Figure 1). In 1974, Geological Survey of Bangladesh ran an exploration survey in Madhyapara and basement rock is encountered at a depth of 130 m with estimated reserve of 174 million tons of Pre-Cambrian hard rock (granite, granodiorite, diorite etc.). MGM is the first experience of underground hard rock mining and the second major mining project in Bangladesh [7]. Room and pillar sub-level stoping underground mining method is used in MGM for the extraction of different types of hard rock from stopes.

Stopes (230 m × 60 m × 20 m) were developed as per design by the help of survey equipments in MGM for mineral extraction. There are five stopes in MGM, two are in the southern side and three are in the northern side of the mine area. During the development work of MGM, surface and underground constructions were completed as per design with ordinary survey instruments like measuring chain, measuring tape, Compass, Automatic level and theodolites. Using these types of survey instruments gave the error results (distance and angles). As a result MGM faced some problems to construct the development works as per design. This study introduces modern survey equipment in MGM like Total Station (TS). Digital Theodolite, Digital Leveling, GPS (Global Positioning System), RAB code staff and other modern survey accessories which are also used for mine surveying for accurate survey results. In MGM, yearly/every six months mine surveying by these modern survey equipments (TS), mine accidents will be reduce and successfully complete the extraction process of mineral deposits within the mine life time.

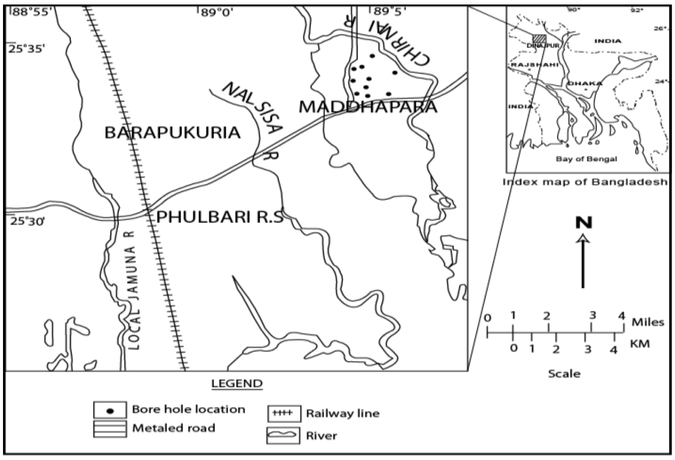

Figure 1. Location map of MGM area (modified after [6], [7])

The main target of surveying is to determine the relative positions of points above, on or beneath the earth's surface and locating the point in the field. Mine surveying is also concerned with surveys on the land surface and underground during the prospecting and extraction of economic mineral deposits and the construction of mining plants, the results of surveys are then used for plotting the plants of mining works and bedding conditions of deposits and also for the solution of various problems of the mining geometry [5]. These mine surveys ensure the safe and efficient exploitation of mineral deposits on the bases of the instrumental measurements performed under particular mining and geological conditions of mining plants. Mine surveying is used not only before a mine development but also monitoring during mine life time. Modern mine surveying has to deal with more diversified and complex problems. Field measurements and office work in mine surveying are now carried out with use of diverse and rather complicated instruments and devices, solving an important group of problems associated with the investigation of the configurations in special graphs. Many mine specialist worked on the petrography of basement complex, alternative ventilation shaft construction for proper mine ventilation and optimum support design in production level of Maddhapara Granite Mine [3], [7]-[8]. There was no research work on modern mine surveying in Maddhapara Granite Mine. This mine survey works was done after the development of MGM. In the early period mining, mine surveyor were used ordinary survey instruments for measuring points, distances and angles which were full of error survey data. As a result mine engineer faced different types of mine accidents both in surface and underground mines. P.P. Bahuguna and D. Kumar (2008) suggest for using robotic total stations and GPS, digital photogrammetric techniques, high resolution satellite imagery, satellite, airborne and terrestrial laser scanners devices to use real-time monitoring systems in mines [2]. The coming of GPS, TS and digital theodolites has made the acquisition of data much simpler and faster. The use of latest mapping technology like Geographical Information System (GIS) and Remote Sensing is growing in Indian Mines [2]. P.P. Bahuguna (2003) also demonstrated how to transfer the center of a mine shaft from the surface to different seams in the underground mine with the help of modern instruments and techniques using laser beam, digital theodolite [1]. In 2013, V. R. Rakhimov and D.I Mingbaev stated that based on accuracy criteria, horizontal displacements were measured using modern geodetic electronic optical instruments (TS) in mines [9]. Z. Zeng and Y. Wang (2012) concluded for using TS survey in underground roadway heading, to solve the mine problems and accidents [10].

The aims of this study are to introduce TS in MGM and calculate the vertical distance from surface (mean sea level) to ventilation level, sub-level and production level and also calculate some RL values from third no. drilling drift to cage shaft in sub-level to identify all underground mine constructions are leveled or not as per design. This study also demonstrate its potential as a complementary or alternate method to conventional geodetic subsidence detection and monitoring in MGM regularly using TS mine survey system, and finally recommend for mine subsidence or other mine accidents will be controlled or not.

2. MINE SURVEYING WITH TS

TS is used to measure horizontal and vertical angles with distances during surveying in MGM which can be utilized in various situations for its easy operation and more accurate results by a systematic way. It is an electronic or optical instrument used in modern surveying. It is also an electronic theodolite (transit) integrated with an electronic distance meter (EDM) to read slope distances from the instrument to a particular point. The benefits of TS will outweigh the downsides, in most cases, because of its all-inclusive features and digital integration (Figure 2). It integrates theodolite functions in order to measure angles and distance with an EDM (electronic distance meter). It also uses a system of prisms and lasers to develop digital readings of all the measurements. All of the information gathered with the TS is stored in an external computer where data can be manipulated and added to CAD programs. The measuring sequence is initiated and a signal is sent to the reflector (one set or three set prism) and a part of this signal is returned to the TS. This signal is then analyzed to calculate the slope distance together with the horizontal and vertical angles. TS can also be used without reflectors and the telescope is pointed at the point that needs to be measured. It is leveled and centered in the same way as a theodolite. Most TS have a distance measuring range of up to a few km, when using a prism, and a range of at least 100m in reflector less mode and an accuracy of 2-3 mm at short ranges, which will decrease to about 4-5mm at 1km (Figure 2). When a distance is measured with TS, an electromagnetic wave or pulse is used for the measurement which is propagated through the atmosphere from the instrument to reflector or target and back during the measurement. It is activated through its control panel, which consists of a keyboard and multiple lines LCD 1km (Figure 2). A number of instruments have two control panels, one on each face, which makes them easier to use (Figure 2). Important keys and its functions of TS are shown in Table 1.

Table 1. The common keys, name and its functions of TS

Keys	Name	Function
Angl	Angle Meas. Key	Angle Measurement mode (▲ Up)
◢	Distance Meas. Key	Distance Measurement mode (▼ Down)
↙	Coordinate Meas. Key	Coordinate Measurement mode (▶ Left)
Menu	Menu Key	Switch menu mode and Normal mode (◀ Right)
Esc	Escape Key	Return to the meas. Mode or previous layer mode.
Power	Power Key	For On/Off source.
F1-F4	Soft Key (Function Key)	Display Corresponding soft key message.
0-9	Number key	Input number, Characters, points, minutes etc.
★	Start Key	Enter Start mode.

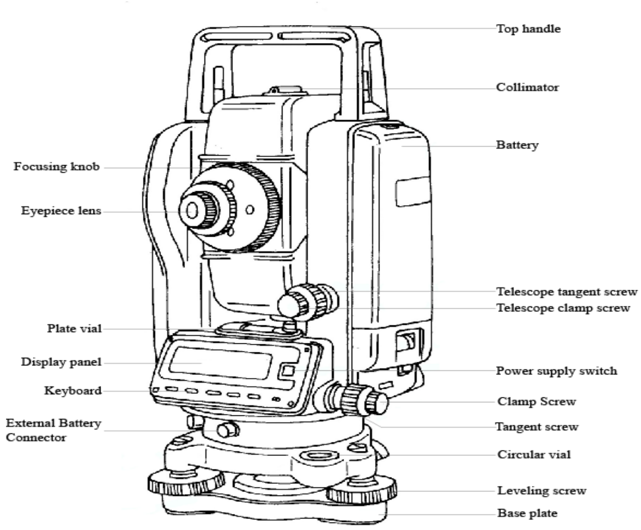

Figure 2. Total station and its different parts

3. RESULTS AND DISCUSSION

3.1. Transferring a Height into Ventilation Level, Sublevel and Production Level in MGM

Vertical distance along the cage shaft in MGM is carried out from surface (mean sea level) to sublevel by a systematic way. Upon deepening the cage shaft about 40-50 m, auxiliary point 1 is placed on the wall of shaft, and then vertical distance h_1 between point X and 1 is measured with still tape (Fig. 3). Upon deepening the mine shaft about 40-50 m from point 1 auxiliary point 2 is placed on the wall of the shaft, and then vertical distance h_2 is measured with still tape. Cage shaft lift is used for measuring these vertical distances. In this way the total vertical distance is measured until the ventilation level, sub level, and production level by the following equations.

The depth of vertical shaft is as follows:

$$\Delta H = h_1 + h_2 + \ldots\ldots\ldots + h_n \qquad \text{(I)}$$

The height of BM in the mine is calculated as follows:

$$Z_{BM} = Z_A - \Delta H \;\; \ldots\ldots\ldots \qquad (2)$$

In case of MGM it will be:

$Z_x = 31.2\text{m}, \;\; \Delta H = 301.2\text{m}$

Using equation (2) the vertical distance in the production level is measured.

$Z_{BM} = Z_x - \Delta H = 31.2\text{ m} - 301.2\text{ m} = -270\text{ m}$

Similarly, the vertical distance is measured in the ventilation level is -228 m, sub level is -246 m. During the developing period of MGM mine shaft, the vertical distance from the surface (mean sea level) to ventilation level, sub level and production level was -228 m, -246 m and -270 m respectively which is same as the recent survey results. This indicates that no vertical displacement is occurred along the cage shaft and this cage shaft is safe for mining operations.

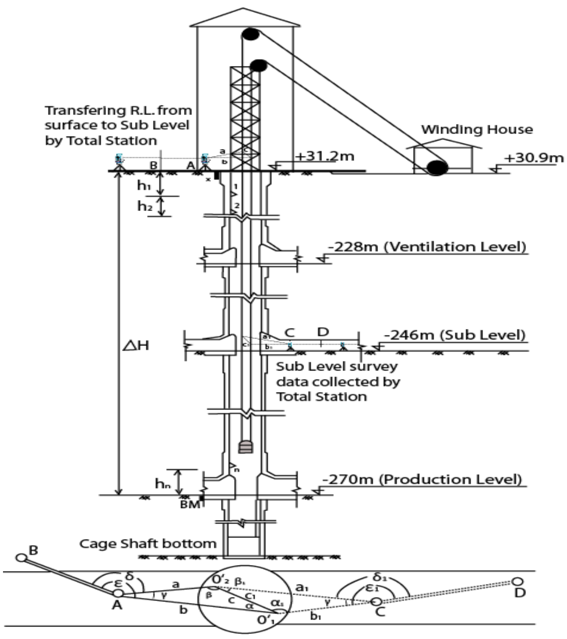

Figure 3. Transfer RL from surface to sub level (modified after [5])

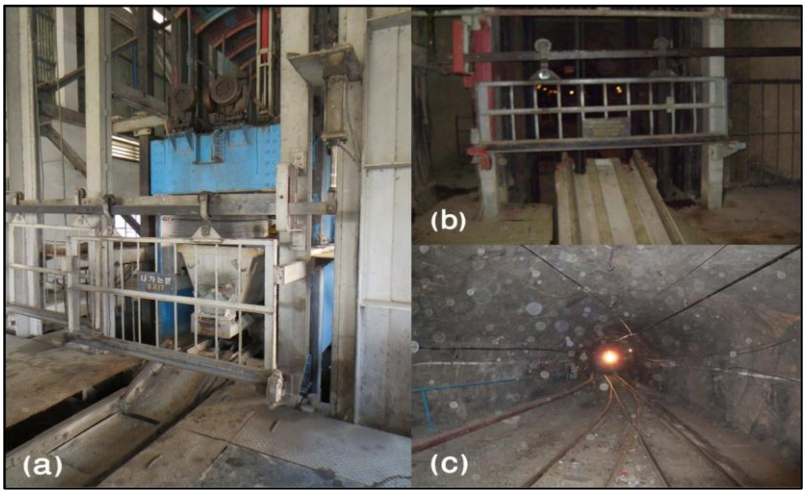

Figure 4. (a) MGM cage shaft at surface; (b) MGM cage shaft at -246m (sub-level); (c) MGM underground roadway near third drilling drift

3.2. Horizontal Connection Survey into Sublevel in MGM

During mine surveying in MGM a horizontal connection survey into sublevel is performed in to a systematic way. Coordinates transferred into the underground with TS by set up it near the cage shaft and measuring the reading (Figure 3, 4). According to coordinates transferred into the mine, there are horizontal and vertical connections (Figure 3). Approach point B is established on the surface at a distance not more than 300 m from the shaft collar. Permanent points C and D are established in the workings of the mine level to be oriented (Figure 3).

A, B = fixed points on the surface (given points)
C, D = fixed points in the workings (Sub level).
a, b, c = measured lengths of side of the surface.
a_1, b_1, c_1 = measured lengths of sides in the underground workings.
ε, δ, γ = measured angles on the surface.
ε_1, δ_1, γ_1 = measured angles in the workings.

All horizontal or vertical distance and horizontal or vertical angles are measured in the sub level at certain duration of points from third no. drilling drift to the cage shaft with TS which are automatically calculated and visible on the LCD display board (Figure 2). During the set up of TS at the first station point, carefully set on the tripod and leveling the instrument with the help of bubble centering. Then taking back sight reading, intermediate sight reading and fore sight reading. When TS are changed in another position, previous fore sight reading is the same point for back sight reading and this is called changing point. Similarly all the readings are collected and put on the survey table (Table 2).

The RL value in the cage shaft point is -246 m and rest of the RL values are calculated (Table 2). The studied R.L values are also compared with seven points which are coinciding with the previous survey reading position (Table 3). The results of R.L value of those points are varying due to using modern TS survey instruments. If MGM authority takes initiative in every year using modern mine surveying, mine subsidence or other mine accidents will be controlled and mine supporting system should be redesign.

Table 2. MGM underground mine survey reading and Reduce Level (R.L) in the sub level from drilling drift to cage shaft

Number of Reading	Reading Distance	Back Sight Reading (m)	Intermediate Sight Reading(m)	Fore Sight Reading (m)	Height of Instruments (-m)	Reduce Level (-m)	Comments
1.		0.466			248.495		
2.	0		1.228		248.495	247.267	
3.	15		1.167		248.495	247.328	
4.	30	1.1		1.17	248.425	247.325	1st Changing point
5.	45		1.171		248.425	247.254	
6.	60		1.271		248.425	247.154	
7.	75		1.294		248.425	247.131	
8.	90		1.359		248.425	247.066	
9.	105	0.9		1.412	247.913	247.013	2nd Changing point
10.	120		0.97		247.913	246.943	
11.	135		1.04		247.913	246.873	
12.	150		1.142		247.913	246.771	
13.	165	1.12		1.185	247.848	246.728	3rd Changing point
14.	180		1.16		247.848	246.688	
15.	195		1.207		247.848	246.641	
16.	210		1.262		247.848	246.586	
17	225		1.316		247.848	246.532	
18.	240	0.941		1.3	247.489	246.548	4th Changing point
19.	255		1.02		247.489	246.469	
20.	270		1.079		247.489	246.41	
21.	285		1.149		247.489	246.34	
22.	300	1.08		1.138	247.431	246.351	5th Changing point
23.	315		1.195		247.431	246.236	
24.	330		1.225		247.431	246.206	
25.	345	1.19		1.272	247.349	246.159	6th Changing point
26.	360		1.161		247.349	246.188	
27.	375		1.195		247.349	246.154	
28.	390		1.221		247.349	246.128	
29.	405			1.349	247.349	246.000	Sub level RL= -246m near cage shaft

Table 3. Compared Previous and Studied R.L at seven coincided points at sub level from third drilling drift to cage shaft in MGM

Number of Points	Compared Survey Points	Previous Reduce Level (-m)	Studied Reduce Level (-m)	Difference Between Previous and Studied R.L (-m)
1	00	244.449	247.267	2.818
2	45	244.648	247.254	2.606
3	90	244.822	247.066	2.244
4	120	244.923	246.943	2.02
5	150	244.107	246.771	2.664
6	330	245.723	246.206	0.483
7	360	245.808	246.188	0.38

4. CONCLUSION

Vertical or horizontal distance and angles are measured and also R.L value are calculated in various points using TS at sub-level from third drilling drift to cage shaft in MGM, Bangladesh. Room and pillar sub-level stoping underground mining method was applied in MGM and mineral deposits (Granite, Granodiorite, diorite etc) are extracted from five stopes. There are three levels (ventilation level, sub level and production level) in MGM. The dimension of each stope (l×h×w) is 276,000 m^3. Ordinary survey instruments like measuring tape, normal staff, ranging rod, automatic level, automatic theodolite were used during the construction (skip and cage shaft, underground roadway, drift, stope etc) of MGM and survey data were collected manually. As a result some problems were arisen during the construction of stopes, drilling drifts, roadways and other underground constructions. In the year of 2008-2009 an underground mine survey worked was done in the sub-level from third drilling drift to cage shaft. RL is calculated using TS at various points. The first RL in the third drift point is -247.267 m and last RL near the cage shaft is -246 m. The vertical distance is also calculated from surface (mean sea level) to ventilation level, sub level and production level is -228 m, -246 m and -270 m respectively. These types of regular modern mine survey work (using TS) should be taken for monitoring the weak zones and solve other problems to reduce mine accidents and finaly production rate will fulfill the target.

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