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Analysis of Blast Induced Ground Vibration under Varying Controlled Blasting Parameter

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Abstract**: *Mining activity plays a major role for economic development of any nation. The drilling and blasting are the two key operations in the mining industry. The execution of these operations generates some disturbances to the environment, like noise and vibration. Blasting is the process of reducing large rock mass into the smaller fragments for our convinces of further processing. In this study the blast induced vibrations are monitored in the form of peak particle velocity (PPV) for the different cases of varying hole spacing. In this study, the PPV was measured for the three different directions, namely, transitional, vertical and longitudinal and it was observed that the PPV for in transitional direction is decreasing with the increment in the hole spacing between two consecutive rows. Further, it was observed that peak vector sum (PVS) having an inverse relation with the hole spacing.***

Keywords* : *Peak particle velocity, Hole spacing, Blasting, Peak vector sum.

I. INTRODUCTION

Mining is the first and foremost source of minerals and commodities on which all countries depend for improving their standard of living. Mined minerals play an essential role in maintaining the living activities of the mankind. Mining creates a direct or indirect impact in every industry of a country. Therefore, it could be considered as an economic driven industry in the country. In India, the GDP contribution of the mining industry lies in between 2.2% to 2.5% [1]. In the mining industry, the under-earth minerals can be extracted by two different mining techniques, namely surface and subsurface mining [2]. In surface mining, the drilling and blasting are the two essential activities which are used for rock fragmentation. In order to get the desired size of fragmented rock the selection of an appropriated blasting is very much necessary [3]. By using suitable blasting operation, the size of the fragmented rock can be controlled. The selection of an appropriate blasting operation not only provide the required fragmented size of the rock, but it also enhances the production of mining industry [4].

On the other hand, the blasting operation produces various hazards such as noise, ground vibration, fly rock and air over pressure [5]. These hazards, reduce the moral and safety of the miners and mining industry. Among all the mention hazards the generation of ground induced vibration is more serious because it can damage the surrounding structure, rock strength and may promote the chances of subsidence [6]. Due to the severity and impact of ground induced blast vibration on rock it can play a major role in the safe operation of blasting activities. Therefore, an adequate knowledge of ground induced vibration at the time of blasting is very much necessary for the safe blasting operation. The induced ground vibration during blasting can be measured in the form of Peak Particle Velocity (PPV) [7]. This PPV is nothing but the displacement value of ground particle with reference to time. It gives the maximum rate of change of ground displacement [8].

The Peak Particle Velocity mainly affected by controlled and uncontrolled blast parameters. The controlled blast parameters are burden, spacing, type of explosive and delay sequence. However, the uncontrolled parameters are the strength of the rock the density of the rock and rock type [9]. The uncontrolled parameters are mainly affected by the physical and mechanical properties of rock, whereas the controlled parameters are affected by the blasting operation [10]. In this research paper, a field investigation has been performed to study the blast induced vibration with reference to controlled blast parameter such as spacing between two consecutive holes. This study will help in designing the appropriate blasting scheme for the particular blast site.

II. BLAST INDUCED GROUND VIBRATION

At the time of blasting, when explosive in the holes are detonated a shock waves are produced in association with the gas pressure. These shock waves are also called as an elastic wave which travels in all directions and give rise to the ground vibrate. The excess amount of shock waves may cause damage to nearby structure and rock strata [11]. The ground vibration can be estimated in term of PPV. The PPV is the most elevated speed at which an individual earth particle moves or vibrates when the waves go through that earth particle [12].

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A number of research work has been carried out to measure the peak particle velocity for the different blasting site. A study carried out on the twelve data set of a case study was analysed in order to get a get an accurate site-specific formulation for the peak particle velocity [13].

Another study reported the relationship between the PPV with charge weight for underground and surface blasting. This study has shown that the PPV is less affected by the charge weight in underground due to underground blasting whereas the PPV is strongly affected by the charge weight in the surface due to the surface blasting [14]. One more study derives a site-specific formula for the PPV with varying explosive quantities and distance (between blast face and vibration monitoring point) [15]. Similarly, in [16] a mathematical model was developed to determine the PPV value with the knowledge of mechanical and geological factor of the rock [17].

Peak particle velocity is the largest value of the vector sum of the vibration level in three different directions. The vibration levels in three directions are longitudinal, transverse and vertical which are presented in Figure 1 [18]. The longitudinal component is the forward and backward even particle advancement a comparative way that the vibration wave is travelling, and the vertical component is the to a great extent particle improvement inverse to the bearing that vibration wave is travelling. So additionally, the transverse component is the level particle advancement inverse to the bearing that the vibration wave is travelling [19].

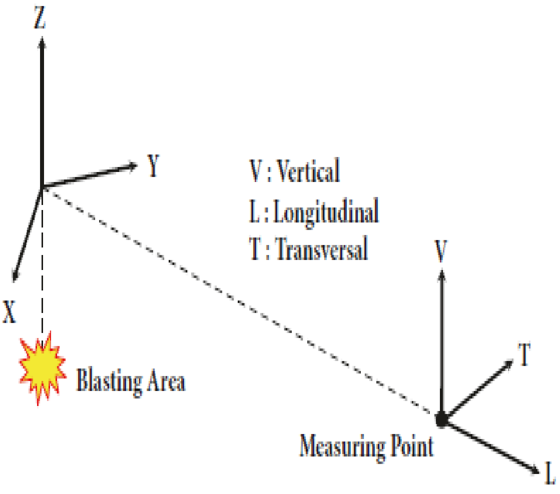

Fig.1. Diagram of blast induced vibration directions

III. AREA OF INTERESTS

An extensive field investigation was carried out in blast area A located near navy Mumbai, which is located at latitude 18° 59′ 40″ N and longitude 73° 4′ 13″ E. The selected site is mapped in Figure 2. On the selected site, the majority of the rocks block was the building related material such as Khondalite. Here, every day one blasting operation was performed for the fragmentation of rock so that the proper land development work can be carried out.

Fig. 2. Selected site for the study

IV. METHODOLOGY- FIELD OBSERVATION

The method of blasting is primarily depending on the charge pattern of holes. On the selected site the charge pattern of the hole is shown in Figure 3. The charge pattern here is based on the steaming process which consists of three main sections in the hole, namely, stemming column, explosive column and explosive cartridge. In the stemming column, the empty part of the charge case of the blast hole is filled with stemming material like sand, gravel etc. It has to be done to confine the pressure and energy released during blast an improper stemming results in blown out shot, hence proper stemming should be done to achieve optimum fragmentation.

The explosive column contains booster cartridges each cartridge is about 2.78 kgs with 83 mm diameter and 1 to 1.2 feet of length it is having a 4500 to 5000 Velocity of detonation. In the third section, the explosive cartridge with non-electrical (none) detonator is inserted and the normal tube is bunched for convenience of connecting to the trunk line. Non electrical detonator it is a flexible plastic tube has a 3mm diameter and one end of the tube is fitted with non-electrical delay detonator. This is crimped to it and the other end is sealed the end having detonator is connected to explosive cartridge and it is lowered into the hole and the sealed end is projected on top of the hole. The explosive charge per hole was maintained at 176.5 Kg.

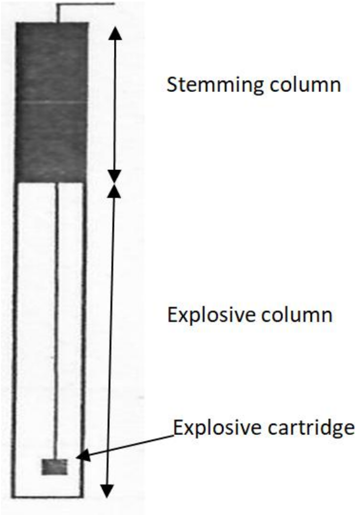

Fig. 3. Charge pattern of holes

The continuous monitoring of blast data (such as spacing, burden, height of the bench and the diameter of hole measured) at the site was performed to analyse the effect of controlled blast parameter on ground vibration. To achieve this, the blast parameter, namely holes spacing (spacing between two consecutive rows) are varied in the step of 3.0 m, 3.5 m. and 4.0 m All the three defined cases are presented in Figure 4, Figure 5 and Figure 6. In every case, the delay sequence of 25 milliseconds from hole to hole is maintained. Further, the corresponding blast data in association with peak particle velocity were monitored for every case. The recorded blast data for all the three said condition is tabulated in Table I, Table II and Table III.

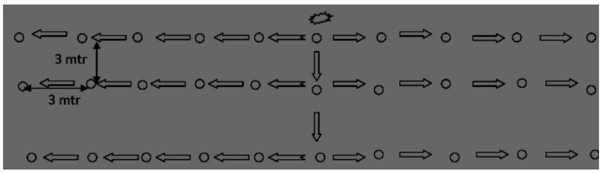

Fig. 4. Delay sequence with firing pattern for 3 m spacing

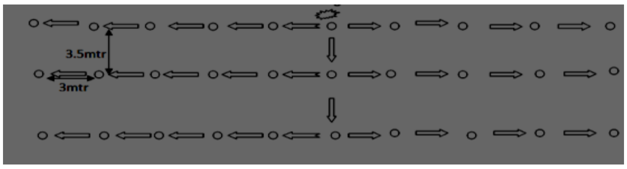

Fig.5. Delay sequence with firing pattern for 3.5 m spacing

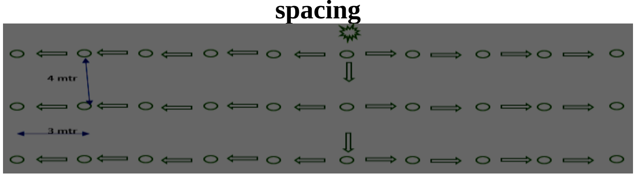

Fig.6. Delay sequence with firing pattern for spacing 4 m

Where,
✸ - Firing point
⇐ ⇒ } 25 Milli seconds
○ - Charge holes

Table- I: Blast data for 3 m spacing

S.no	Parameter	Quantity	Units
1	Hole depth	25	m
2	Bench height	25	M
3	Hole diameter	115	mm
4	No.of holes	75	number
5	Spacing×Burden	3×3	m
6	Top stemming	3	m

Table- II: Blast data for 3.5 m spacing

S.no	Parameter	Quantity	Units
1	Hole depth	25	m
2	Bench height	25	M
3	Hole diameter	115	mm
4	No.of holes	75	number
5	Spacing×Burden	3.5×3	m
6	Top stemming	3	m

Table-III: Blast data for 4 m spacing

S.no	Parameter	Quantity	Units
1	Hole depth	25	m
2	Bench height	25	M
3	Hole diameter	115	mm
4	No.of holes	75	number
5	Spacing×Burden	4×3	m
6	Top stemming	3	m

V. RESULTS AND DISCUSSION

The blast induced ground vibration was measured in the form of PPV for the three different directions (such as vertical, transitional, and longitudinal). The PPV was measured for the different spacing condition of 3.0 m, 3.5 m and 4.0 m. To measure the blast induced ground vibration at the site the instantly micrometre instrument was used which consist of two major sensors namely, Japan and microphone. The function of geophone is used for the measurement of the blast induced vibration in the three different directions and the microphone is used for the measurement of noise at time of blasting. The blast induced vibration in the form of PPV for all three directions, such as Vertical, Transverse and longitudinal was measured for the distance of 180 m from the source of blasting, under three different spacing conditions. The observed PPV readings for three different conditions are Tabulated in Table 4. The relationship between the hole spacing and the PPV can be drawn which is shown in Figure 6. Here, the peak vector sum (PVS) is also calculated for each blast, which isn't obliged to one of the three estimation directions.

The PVS may defined as the square root of the sum of the square of the transitional velocity (t), vertical velocity (v) and longitudinal (l) velocity which is given by equation (1) and is presented in Table IV.

$$PVS = \sqrt{t^2 + v^2 + l^2} \qquad (1)$$

Table- IV. Blast induced vibration under different spacing

Distance (m)	Charge per hole (Kg)	Spacing (m)	PPV (mm/s)			PVS (mm/s)
			Transitional	Vertical	longitudinal	
180	176.5	3.0	1.790	0.914	0.955	2.225
180	176.5	3.5	1.124	1.050	1.097	1.889
180	176.5	4.0	0.909	1.194	1.210	1.927

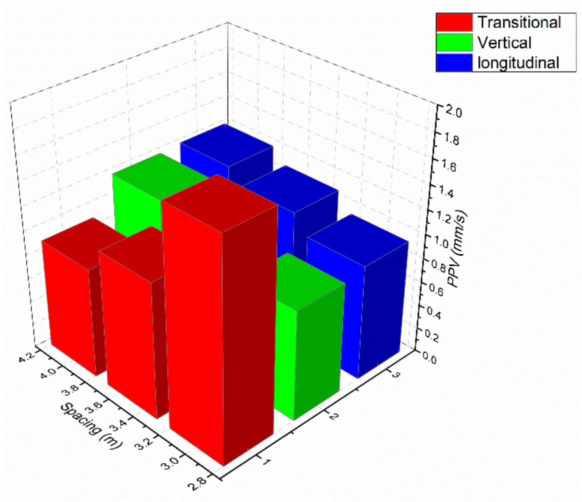

Fig.6. PPV variation with hole spacing

As shown in Figure 6, the PPV in transitional direction is inversely proportional to spacing because the reading obtained in transitional direction were decreasing with the spacing. This may be happening due to the bonding within the rock constituents which is decreased as the spacing between the holes increases. On the other, the remaining two directions such as vertical and longitudinal the induced ground vibration is directly proportional to the spacing. Here we observed that the PPV increases in these two directions by increasing the spacing.

VI. CONCLUSIONS

The blasting operation plays a vital role in the performance characteristics of any surface mines. The blasting operations induces severe ground vibration which may affect the nearby structure. Thus, its safe operation is a prime concern for every industry. Therefore, the proper information of any blasting operation is very much necessary for its safe operation. The controlled and uncontrolled parameters of blasting affect its operation. In this paper the blasting performance under the influence of controlled blast parameters was studied. The main focus of this paper is to monitor the peak particle velocity at a particular distance under the varying hole spacing condition. This study showed that the PPV of ground vibration at the time of blasting is affected by the spacing of two consecutive rows. In the present study it was reported that the peak particle velocity in transitional direction is decreasing with increment in the hole spacing between two consecutive rows, whereas the vibration in vertical and longitudinal directions are increasing with increment in spacing.

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