Analysis of Effect on Vibration and Air Blast in Rock Quarrying

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Abstract: Blasting induced ground vibration occurring in the quarries has become a serious environmental issue in Sri Lanka. To achieve high production targets the number of blasts has increased in the quarries and, therefore, mitigate measures to minimize the detrimental effects of the vibrations have to be identified. This research project on rock blasting was carried out to design a suitable indicating system to predict the ground vibrations and air blasts. In order to assess the variation of intensity of the ground vibration and the air blast over pressure, ground vibrations and air blasts results from two different types of explosives on different types of rocks were monitored. Statistical analysis of the data sets found a high level of confidence on the best fitting empirical relationship between peak particle velocity and scaled distance. By that two site-specific factors were established. A comparison of the analytical work revealed that the level of ground vibration varies significantly with the changing of charge weight per delay, explosive type, rock type and the distance from blasting point to monitoring point.

Key Words: Air Blast Over Pressure (ABOP), Geographic Positioning system (GPS), Peak Particle Velocity (PPV), Scaled distance (SD).

1. Introduction

In reality, ground vibration measured at a location is influenced by a number of controllable parameters, such as blast geometry, charging patterns, initiation sequence, explosive characteristics and delay timing while others like rock properties, weather conditions are not under control.

Rock mass properties such as joints, fractures, and bedding planes are causes of amplification at the vibration and air blast. The prediction of ground vibration components has a great importance in the minimization of several environmental issues. In this research, a system was designed to predict the GV or ABOP for well controlled blasts at a particular distance from the blast, when particular amount of explosive is used. The relationship between PPV and the scaled distance is well known over a long period of time and the relationship has been proven for selected quarries and quarry factors have been established to predict ground vibration and air blast at any distance.

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The investigation of the ground vibration was carried out at a quarry of Mathugama and two other locations at the Southern Transport Development Project.

This research project was carried out to understand the sophisticated principals of rock blasting, modern blast technology with respect to site conditions and the control of its environmental impacts.

2. Methodology

2.1 Field work and Data Collection

In field work rock type, state of the rock, joint pattern and slope was identified. Then the borehole pattern, borehole parameters and explosive details such as type of explosive (Emulsion, Dynamite and ANFO), amount of explosives used and the number of electric detonators used were recorded and sketched on site map. Location of the blast and the location of the monitoring points were also noted on the map. Locations at the monitoring points were in parallel and perpendicular with respect to the joint pattern.

The coordinates of the blasting points and the location of measuring points were taken by using GPS Receiver. The measurements of GV and ABOP were taken with aid of blastmates.

2.2 Data Preparation and Analyzing

The resultant "Ground Vibration (in terms of Peak Particle velocity - PPV)" has been commonly assessed using the following formula.

$$PPV = a\,SD^{-b} \quad \ldots\ldots (1)$$

$$ABOP = a\,SD^{-b} \quad \ldots\ldots (2)$$

PPV - Peak Particle Velocity in mm/s, ABOP- Air Blast Over Pressure, SD - Scaled Distance in m/kg-1/2, a & b are constants (commonly known as Quarry Factors)

Scale Distance is defined as,
For Ground Vibration,

$$SD = D/(W)^{1/2} \quad \ldots\ldots (3)$$

For Air Blast Over Pressure,

$$SD = D/(W)^{1/3} \quad \ldots\ldots (4)$$

D - Distance from Charge in m, W- Maximum charge weight per delay in kg
Equation (1) and (2) could also be written as follows,

$$\log(PPV) = -b \log(SD) + \log(a) \quad \ldots. (5)$$

3. Results

The series of monitored data was analyzed with the aid of "Minitab 15" which provided complete data analysis environment with a high accuracy. The results derived from the graphs were given in the following tables.

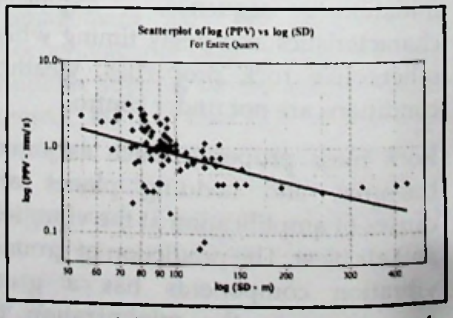

Figure 1: Scatter plot of log (PPV) Vs log (SD)

Best regression fit for vibration,

$$\text{Log (PPV)} = 2.033 - 1.051 \log (\text{SD})$$

$$\text{PPV} = 107.89\ (\text{SD})^{-1.051}$$

Table 1: Site factors for the GV

Location	a	b
Hyundai	107.89	-1.051
46+900–47+400	252.35	-1.205
49+200–49+470	1.721	-0.199

For the Air Blast Over Pressure,

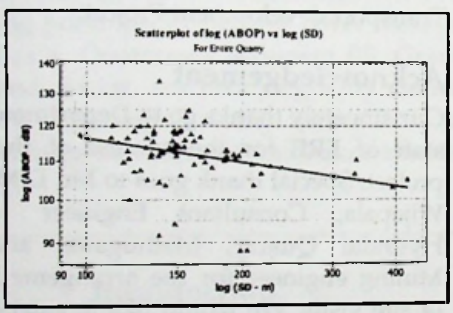

Figure 2: Scatter plot of log (ABOP) Vs log (SD)

Best regression fit for Air Blast Over Pressure,

$$\text{Log}_{10}\text{(PPV)} = 2.236 - 0.085 \log (\text{SD})$$

$$\text{ABOP} = 172.19(\text{SD})^{-0.085}$$

Table 2: Site Factors for the ABOP

Location	a	b
Hyundai	172.19	-0.085
46+900–47+400	176.20	-0.093
49+200–49+470	119.12	-0.014

The Comparison of GV in all three Quarries with respect to the distance can be graphically represented as follows.

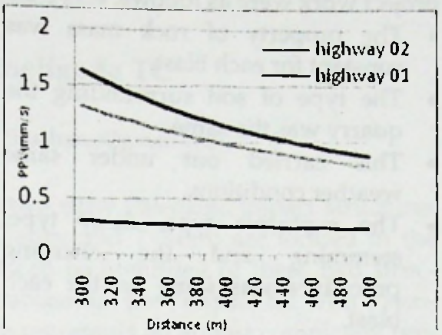

Figure: 3 Comparisons between PPV and Distance

4. Discussion

The results of highway shows higher value for GV and less value for air blast over pressure than that of the quarry. The reason for this may be, that the energy dissipate along the joint easily converts to gas pressure pulse. This does not take place when the wave moving in the perpendicular direction of joint strike. The reason for variation of results from the quarry to highway is due to the type of explosive used, safety aspects, elevation, rock type and the size of the free face.

The reasons for the selecting these formula is as it involve three important variables, namely ground vibration or air blast over pressure with distance and explosives. After deriving the site factors, maximum charge per delay can be calculated with respect to a given distance and also, the minimum distance that a residence can be established for given weight of explosive per delay.

The propagation of the shock wave depends on the properties of the medium and the gas release pulse

depends on the nature of the joints and other rock mass properties.

Assumptions made in the course of project work were as follows.

- The property of rock mass was constant for each blast.
- The type of soil surrounding the quarry was the same.
- This carried out under same weather conditions.
- The explosive type, delay type, stemming and the charging procedure was same for the each blast.

Some errors can occur during data collection which could affect the final result of the analysis. The bench to be blasted varied for each blast and three or four benches were employed with different angles. The direction of blast propagation was different according to the delay pattern. Variations in weather conditions and wind direction specially affected air blast over pressure. The soil profile variation can be seen with dumping of soil overburden around the quarry.

5. Conclusion

It was observed that highest value of ground vibration recorded was at the point along joint and the lowest was that of perpendicular to the joint plane. The values for the air blast over pressure show opposite results, that of the ground vibration.

Sometimes back side of the blasting location showed abnormal changes in monitoring. And according to the test blast which was carried out at the quarry site illustrated a higher variation between measured and mathematical value. The reason for the above observation could be the soil profile and/or the morphological differences between the blast point and the measured point.

The test blast results for air blast over pressure have reflected similar values. This was resulted from clearance of face between measured and blast point. The vibration value of the quarry always between the two vibration values of the highway. This could probably be due to the variation in compressive strength of the rocks. In addition type of explosive used also would have been a reason for the above difference. The air blast of the quarry was higher than that of the Southern Transport Development Project. This may be possibly due to the use of air blast and flyrock controlling methods, such as use of covers, sand bags, and etc in southern Transport development Project.

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