Ground Vibration and Air Blast Overpressure Assessment using Scaled Distance

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Abstract: In recent years there was a noticeable developmental activity, especially in industrial as well as construction sectors such as roads, harbours, condominiums etc. This has enhanced and developed aggregate industry and the use of modern technology for its effective operation. Blasting is being used extensively to supply rock aggregates for construction and also to drive tunnels and roads through rugged rocky terrains. There is growing concern on blasting effects on the environment such as dust, toxic gases, noise, fly rock and ground vibration. Worldwide the common allegations are mainly focused on damages to residences. Present study was carried out to monitor air blast and ground vibration due to rock blasting. Southern Highway expressway was selected to monitor above effects due to high blast frequency available and the availability of the vast data base. Geological condition of the site, including rock type, drilling and explosive parameters, and distance between blasting and monitoring location, ground vibration and air blast over pressure were recorded. The data was used to develop site specific constants useful for blast programming. By using the site factors, the quantity of explosive per delay or the vibration at particular range of distance could be predicted.

Key words: Air blast over pressure (ABOP), Ground vibration (G.V), Maximum charge per delay, Scaled distance (SD)

1. Introduction

This study focused on understanding advance principals of rock blasting, application of blasting technology with reference to site conditions and the control of its environmental impacts. The study was carried out in southern highway development route, which has a significant amount of rock blasting for highway clearance as well as for the supply of road construction material such as ABC, etc.

The study of blast impact on the surrounding environment, especially for developing guidelines for blast impact control was the main focus of this study.

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According to previous research works, the "Scaled Distance" and "Ground Vibration" is related as shown in Equation (1). This concept was used in this study to analyse results and observations. Ground vibrations and scaled distances have been plotted in the logarithmic scale. Equations (2), (3) and (4) were also used for the analysis of results according to Wilton and Johnson (1992), Blast vibration effects, measurement and control.

$V = a\,(SD)^{-b}$ 1

Maximum charge per delay = $\dfrac{\text{Amount of explosive used (ANFO + Dynamite) in Kg}}{\text{Total number of Detonators used for the blast}}$ 2

Scaled Distance (SD) = $\dfrac{\text{Separating Distance in meters (D)}}{\text{Square root of maximum charge per delay (W)}}$ 3

V - Peak particle velocity, SD - scaled distance and a, b are dimension less site factors taken from logarithmic graph, which allows for the influence of local geology and geometrical spreading upon vibration attenuation. Similarly air blast over pressure also calculated. Parameters a and b, allowable scaled distance for the site and maximum amount of explosive allowed per delay was found, thereby the ground vibration and air blast over pressure was determined.

2. Methodology

2.1 Data collection

Rock blasting data were collected from already mentioned three sites. Drill hole parameters, amount of explosive used (ANFO and Emulsion), location of the both monitoring and blasting location, geological condition of the site, blast geometry ground vibration and air blast over pressure data were collected in the following locations: Rock A (12+800 to 13+600), Rock B (11+500 to 12+300) and Rock C (8+920 to 9+280) chainage from the Kurundugaha junction surrounding Baddegama area. Rocks A and B were Quartz feldspar granulitic gneiss and Rock C was Garnet Biotite gneiss.

2.2 Plotting Graphs

Hence by tabulating data, maximum charge per delay and SD were derived for each type of blast (Bench, Boulder, Level and pre- split) separately for all the locations. Then the graphs were plotted to the log values of scaled distance and ground vibration or air blast over pressure. The site factors were derived from the graphs; hence the allowable SD and allowable maximum charge per delay were also calculated.

$V = a\,(SD)^{-b}$

$\log_{10} V = -b \log_{10}(SD) + \log_{10} a$ 4

$y \quad = -\,m\,x \quad + \quad c$ (linear equation)

3. Results and Discussion

It was assumed that the media of propagation of the vibration between the blasting and monitoring location is uniform and the climate conditions are also similar because during high rainy and lightning period the blasting is stopped for the safety purposes. For example, two of the graphs plotted for the bench blasting at Rock (A) were given in the figures 1 and 2. 24 graphs were plotted for three locations. From the graphs, the site factors "a" and "b" were derived respectively, by the intersecting point of graph at log (ground vibration or Air blast) axes and the gradient of the graph. The results derived from the graphs are given in the Table 1 according to National high way institute (1991), Rock Blasting and over brake controlling.

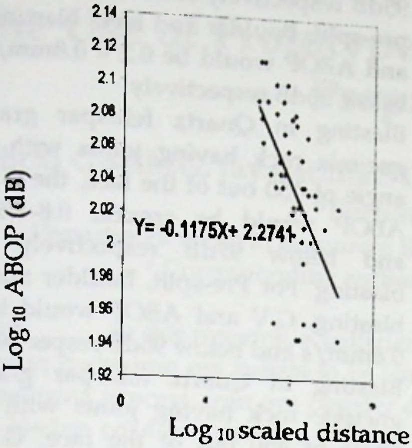

Figure 1. Log10(SD) Vs Log10(ABOP) plot at the location of Rock A (12+800-13+600) Km chain age n for bench blasting.

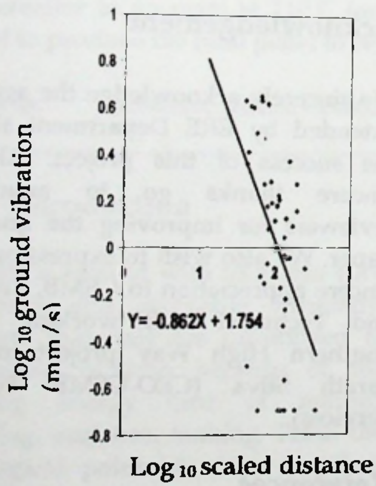

Figure 2. Log10(SD) Vs Log10(ABOP) plot at the location of Rock A(12+800-13+600) Km chain age for bench blasting

Suitable amount of explosive per delay within then range of actual distance was also calculated by the [equation 05] and the all results are in the tables2, 3 and 4.

$$Q\,(Kg) = \frac{\text{Actual distance (m)}}{\text{Scaled distance } (Kg/m^{1/2})} \quad \ldots\ldots\ldots\ldots 5$$

Table 1. Site factors a and b values for G.V and ABOP

	Type of blast		Rock A	Rock B	Rock C
Ground vibration	Bench	a	56.7545	645.505 6	68.7860
		b	0.862	1.3898	0.8493
	Level	a	80.95	23.0303	25.9179
		b	0.6686	0.6686	0.7443
	Boulder	a	62.5173	5.3530	13.9027
		b	0.7307	0.4654	0.528
	Pre-Split	a	19.48	513.807 0	472.7156
		b	1.078	1.3428	1.2266
Air blast over pressure	Bench	a	56.7545	645.505 6	68.7860
		b	0.862	1.3898	0.8493
	Level	a	19.48	23.0303	25.9179
		b	0.6686	0.6686	0.7443
	Boulder	a	62.5173	5.3530	13.9027
		b	0.7307	0.4654	0.245
	Pre-Split	a	19.48	513.807 0	472.7156
		b	1.078	1.3428	1.2266

Table 2. G.V and ABOP with respect to distance for bench, boulder, level and pre split blast in ROCK (A)

Type of Blast	Distance (m)	G.V mm/s	ABOP (dB)
Boulder	200	1.00	101.00
	400	0.61	96.00
Pre spilt	200	0.48	105.2
	400	0.23	71.07
Level	200	0.45	98.24
	400	0.28	93.62
Bench	200	1.37	96.00
	400	0.8	89.00

Table 3. G.V and ABOP with respect to distance for bench, boulder, level and pre split blast in ROCK (B)

Type of Blast	Distance (m)	G.V mm/s)	ABOP (dB)
Boulder	200	0.71	98.70
	400	0.49	95.42
Pre spilt	200	1.10	128.00
	400	0.596	103.00
Level	200	0.39	100.00
	400	0.3	90.45

Table 4. G.V and ABOP with respect to distance for bench, boulder, level and pre split blast in ROCK (C)

Type of Blast	Distance (m)	G.V mm/s)	ABOP (dB)
Boulder	200	0.39	101.70
	400	0.20	91.00
Pre spilt	200	0.87	101.00
	400	0.34	94.27
Level	200	0.52	99.00
	400	0.33	95.00
Bench	200	1.75	96.00
	400	0.97	92.00

4. Conclusion

In all three sites the amount of explosive used per delay for bench blasting was in the range of 0.1725 to 8 Kg/ delay. This shows that with pre-split, large amount of explosive could be used for greater production needs. So the ground vibration and Air blast over pressure was well contained by pre-splitting.

Following conclusion would be made for minimum ground vibration and ABOP within a radius of 200-400m for a blast at the center of the radius. For bench blasting with 1-7 Kg/ delay explosive, pre split blasting with 1-3 Kg /delay explosive and boulder and level blasting with 0.1- 0.5kg/delay explosive as the most suitable amount of explosive.

Blasting in Garnet Biotite gneissic rock having joints with dip angle of 200 out of the face, the G.V and ABOP would be around 1-2 mm/s and below 95dB respectively for bench blasting. For pre-split, Boulder and level blasting, G.V and ABOP would be 0.2 – 0.8mm/s and below 96dB respectively.

Blasting in Quartz feldspar granulitic gneissic rock having joints with g dip angle of 450 out of the face, the G.V and ABOP would be around 0.8-1.5mm/s and below 97dB respectively bench blasting. For Pre-split, Boulder and level blasting, G.V and ABOP would be 0.2-0.6mm/s and below 98dB respectively.

Blasting in Quartz feldspar granulitic gneissic rock having joints with g dip angle of 450 out of the face, G.V and ABOP would be 1-1.8mm/s and below 100dB respectively for bench blasting. For Pre-split, Boulder and level blasting, G.V and ABOP would be 0.2– 0.9mm/s and below 98dB respectively.

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