# NONEL INITIATION FOR ECO-FRIENDLY BLASTING

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## ABSTRACT

**Blasting is an essential component in mining and one of the most economical method of rock excavation applicable to both surface and underground mines. The effect of blasting arising from the mining operation is one of the fundamental problems in the mining industry. Rock fragmentation also plays a pivotal role in large scale mining because of its direct effect on cost of drilling, blasting, secondary blasting, crushing and there-by affecting the overall cost of production. The research investigates the effect of initiation device on environment and the production cost. The objectives of the research were achieved through field measurement and data collection. Various informations pertaining to blasting agents and accessories used for blasting operations were also collected. The results revealed that the flyrock, noise and vibration generated during blasting with NONEL are found to be minimal as compared to the safety fuse and the electrical methods. It is also observed that NONEL initiation increases blasting efficiency and also optimize the cost of blasting.**

**Keywords: NONEL, Booster, Blast Hole Drilling, Mine – PNR Mines, ANFO, Detonators**

## INTRODUCTION

Blasting is the process of breaking of bulk rock masses into loose forms, using explosive compounds. Here, the primary role is played by the explosives. The explosives are the substances or devices used in blasting. The explosives are used to produce a volume of rapidly expanding gas that exerts sudden pressure on its surroundings and break the mass into pieces. There are three common types of explosives used for blasting as chemical, mechanical, and nuclear explosives. The first chemical explosive was gunpowder. Germans manufactured gunpowder in the early 1300s. A detonator is a device used to trigger this explosive device. Detonators can be chemically, mechanically, or electrically initiated. Different explosives require different amounts of energy to detonate. Detonation is a necessity for the explosive to get triggered for blasting.

### 1.1) NONEL INITIATION:

Non electric initiation system, NONEL, invented by Per Anders Persson (Nitro Nobel, later Dyno Nobel); introduced to market in 1972.NONEL products can be used with all cast boosters, dynamites and cap-sensitive explosives. Nonel is a shock tube detonator designed to initiate explosions, generally for the purpose of demolition of buildings and for use in the blasting of rock in mines and quarries. Instead of electric wires, a hollow plastic tube delivers the firing impulse to the detonator, making it immune to most of the hazards associated with stray electric current. To meet the ever increasing demand for many minerals, large opencast mines are being planned with high production capacities. To achieve these high production targets, huge explosive quantities are being initiated in a round. As the initiation system influences the blast results, it is necessary to select proper initiation system. Increasing economic pressures environmental constraints and safety mandates in recent years have called for precise focus on drilling and blasting operations in the mining industry. It is generally claimed by the manufacturers that non-electric shock tube system (NONEL) improves over all blasting results. As per MMR 1961, Reg.164, 1B (a) not more than of 2kg explosives per delay are used. So, with the help of NONEL blasting, this can be achieved which satisfy DGMS.

**1.2) REASON FOR SELECTING THE PROJECT:**

The effects of blasting arising from the excavations is one of the fundamental problems in the mining industry, rock fragmentation also plays a pivotal role in large scale mining because of its direct effect on cost of drilling, blasting, secondary blasting and crushing.

Thus, it is essential to consider rock fragmentation in blast design, the optimum blasting pattern to excavate a quarry efficiently and economically can be determined based on the maximum production cost which is generally estimated based on the rock fragmentation. Blasting operations need cogent measures due to its remarkable influence on the stability of rock slopes especially in situations where blasting operation is not being carried out with utmost or designed accuracy. Various ways in which blasting operations affects its environment needed to be accountable for but the most relevant is the structural damage due to vibration inductions, noise, fly off materials, air blast and shock waves resulting in the rock slope failure by creating a new joints or extension of the existing ones. Therefore it is necessary to carefully apply effective blasting techniques to achieve the desired result within the minimum possible cost as well to minimize environmental fall outs such as ground vibration, air blast and fume production.

It has been revealed that the best initiation or blasting method to apply is the non-electrical blasting method (NONEL), because of the following reasons:

1. It has safe environmental effect
2. High productivity rate.

Safe environmental effect involves bearable or minimal noise, vibration and amount of fly off rocks to the environments; different methods have been critically analysed, which are safety fuse method, electrical method and NONEL method that show various degree of fragmentations, noise produced and vibration generated, which shows that NONEL method is the safest way of carrying out blasting operation.

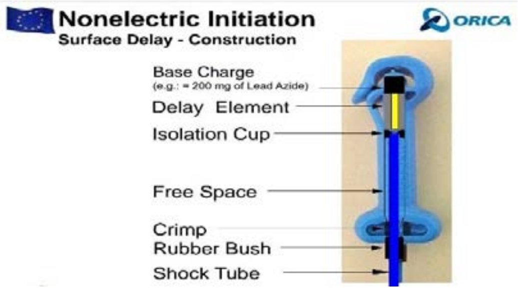



Figure 1: Nonel Initiation system.

**2.1) PROBLEM STATEMENT:**

Increasing economic pressures, environmental constraints and safety mandates in recent years have called for precise focus on drilling and blasting operations in the mining industry. With urbanization and mines getting closer to human habitation, it is important to conduct blasts with safer systems of initiation in order to control ground vibrations and noise with improved Fragmentation. It is generally claimed by the manufacturers that non-electric shock tube system (NONEL) improves over all blasting results. Down the hole initiators initiate the explosive column at a given (bottom) point .A systematic study was taken up to analyse the influence of NONELs on rock fragmentation, ground vibration and noise.

**2.2) OBJECTIVE:**

1) The main objectives of Nonel Blasting are to reduce the ground vibration, noise, flyrocks generated due to blasting operations.
2) To give high blasting efficiency and to optimize cost.

**METHODOLOGY**

**3.1) BLAST HOLE DRILLING:**

Blast hole Drilling is a technique used in mining whereby a hole is drilled into the surface of the rock, packed with explosive material, and detonated. The aim of this technique is to induce cracks in the inner geology of the surrounding rock, in order to facilitate further drilling and associated mining activity. The initial hole into which the explosives are packed is known as the “blast hole”. Blast hole drilling is one of the primary surface drilling techniques employed in mining operations today. Blast hole drilling is traditionally used wherever the mining company wants to explore the mineral composition or potential mineral yield of the area demarcated for their mining interests.

**3.2) PRIMING OF EXPLOSIVES:**

The massive use of blasting agents such as ANFO, Heavy ANFO etc., in rock breakage has brought about an important development of initiation and priming techniques. This is due to, on one hand, the relative insensitivity of these compounds and, on the other hand, a desire to obtain maximum performance from the energy released by the explosives used in the process. The detonation process requires initiation energy so that it can develop and maintain stable conditions.

**3.3) PRIMER AND BOOSTER:**

Priming a charge is simply positioning a suitable primer within a charge or column of explosives. The object is to provide the primary-initiating explosion needed to detonate the main charge efficiently. If an explosives column is not initiated properly, its optimum energy cannot be generated. The terms “primer” and “booster” are often confused. Primer is a unit of cap-sensitive explosive used to initiate other explosives or blasting agents. A primer contains a detonator or other initiating device such as detonating cord. The primer cartridge should be assembled at the work-site. The transport of cap primers is hazardous and is against the regulation of most countries. Priming should be done correctly by experienced shot-firers. The commonly used booster in Dalmia Cement Bharat Ltd. is KELVEX P. Sometimes, after detonation, a low sensitivity explosive may show signs of losing the VOD progressively along its column. This may arise when an ANFO charge is contaminated with water. The boosters can be placed at appropriate intervals (about 30 times the blast hole diameter) to increase the VOD along the explosives column. Boosters can be placed at appropriate spots where the ground is especially hard and requires extra pressure for satisfactory breakage.

**3.4) EXPLOSIVES:**

The commonly used explosive in Dalmia Cements Bharat Ltd. is Ammonium Nitrate Fuel Oil (ANFO). Ammonium nitrate (AN) based explosives are the cheapest and most frequently used commercial explosives. ANFO explosives are more frequently used for blasting than the other two types of ammonium nitrate based explosives (emulsion and slurry explosives. Satisfactory blasting performance, a relatively low price, and safety during blasting operations, simple manufacture and the possibility of mechanical loading of boreholes are the main reasons for its frequent use. A significant number of the individual factors that influence the detonation parameters of ANFO have been tested and determined. For pure ANFO, the main factors are the properties of the ANprills, the fuel/oil ratio, the density and charge diameter. It is possible to influence the detonation parameters of ANFO by adding flammable or non-flammable components. The AN/FO ratio was determined by an ANFO test, after the sample had been mixed, and was 94.5/5.5. The measured ANFO bulk density was 823 kg/m3.

**3.5) STEMMING:**

Stemming enhances fragmentation and rock displacement by reducing premature venting of high pressure explosion gases to atmosphere. Good stemming maintains high gas pressure within blast hole for longer period of time. This method helps in confine the gases within a borehole and helps to prevent high cost of blasting, air blast, excessive ground vibration, fly rock and boulders. This reduces energy waste, minimizes air blast and improper fragmentation a suitable inert incombustible material used to confine or separate explosive in a drill hole or to cover explosive in mud capping is called stemming material. Stemming is a material that is put inside of a blast hole to help prevent gases from escaping.

**3.6) BLASTING INTIATION:**

There are three NONEL-based initiation systems are available:

1) NONEL MS
2) NONEL EZTL
3) NONEL UNIDET
4) NONEL LP

NONEL MS, NONEL EZTL and NONEL UNIDET are used for bench blasting. Their delay times are therefore designed to suit the conditions that prevail in bench blasting. When blasting several rows on a bench, it is important that the rock in the first row is given enough time to move forwards before the next row starts to move. Since rock swells by approximately 50% in volume when broken up by explosives, room must be made for this expansion within a very short period of time.

Studies have shown that, ideally, the rock in a row should move forwards by 1/3 of the burden before the next row is allowed to detonate. Since the required delay time between rows can vary between 10 ms per meter of burden in hard rock to 30 ms/m in soft rock, a value of 15 ms/m can generally be used as a guideline.

**MINE VISIT**

**4.1) STUDY AREA:**

M/s Dalmia Cement (Bharat) Limited (DCBL), one of the leading cement manufacturing companies in India operating its cement plants at Tamilnadu, Andhra Pradesh, Karnataka, Orissa, Assam and Meghalaya. In Tamilnadu, two plants are located at Trichy and Ariyalur districts. The production capacity of each plant is 2.4 million and 2.0 million tonnes per annum respectively. The raw material requirements of these plants are accomplished from its captive mines operating at various locations in Trichy and Ariyalur districts. The Amalgamated Periyanagalur, Aminabad& Khairulabad Limestone Mines is located at Ariyalur district and it is planned to mine around 1.9 million tons of limestone per annum to supply cement plants located in Dalmiapuram and Ariyalur.

**4.2) MINIMATE:**

Figure 8: Minimate

The Instantel® Minimate Blaster™ vibration and overpressure monitor has the features you need for reliable blast monitoring in a simple and economical package.

**SIMPLE:**

The monitor incorporates an eight-key tactile keypad and on-board LCD, with a clearly structured, menu-driven interface - giving you complete control for quick and easy setup and operation. In addition, the Instantel® AutoRecord™ record stop mode automatically sets the record length based on vibration and overpressure activity, helping ensure that you record the entire event. It also comes with an integrated monitoring log, for compliance with many local and regional regulatory standards.

**FLEXIBLE:**

Producing professional reports is easy. Print directly from the Minimate Blaster monitor to one of many compatible printers, or transfer events directly to an Instantel Blastmate III™ monitor and print using the integrated on-board printer. Events can also be easily downloaded to a computer via a standard RS-232 interface using the included Instantel Blastware® Compliance Module software. From there, you have all the tools to generate full-page event reports and frequency analysis.

**RELIABLE:**

A vibration monitor is a necessity, so it had better work – always. That's why so many blasters trust Instantel reliability. With standard features like zero-dead-time while recording, 300-event memory, and a battery that has the capacity for 210 hours of continuous monitoring, the Minimate Blaster monitoring system gives you confidence that you will get the record every time.

**DGMS Prescribed Permissible Limit for Ground Vibration:**

| Type of structures | Dominant Excitation frequency, Hz | | |
|---|---|---|---|
| | < 8Hz | 8-25Hz | >25Hz |
| **(A) Buildings/structures not belong to the owner** | | | |
| 1. Domestic houses/structures (Kuchcha, bricks & Cement) | 5 | 10 | 15 |
| 2. Industrial building | 10 | 20 | 25 |
| 3. Objects of historical importance & sensitive Structures | 2 | 5 | 10 |
| **(B) Buildings belonging to the owner with limited span of life** | | | |
| 1. Domestic houses/structures | 10 | 15 | 20 |
| 2. Industrial buildings | 15 | 25 | 50 |
| | | | |

**DATA ANALYSIS**

**5.0) BLASTING DATA SHEET 1:**

MINE – PNR MINES (DALMIA CEMENTS)

BLOCK – F

GRADE – MEDIUM

BOOSTER – KELVEX POWER 90E

EXPLOSIVES - ANFO

| BLAST PARAMETERS | | VALUES |
|---|---|---|
| 1.NO OF HOLES | (No.) | 102 |
| 2.BURDEN*SPACING*DEPTH | (Meters) | 3*3*3.6 |
| 3.TOTAL DEPTH(in meter) | (Meters) | 370 |
| 4.EXPECTED YIELD | (Tons) | 6660 |
| 5.TOTAL EXPLOSIVES USED | (Kgs) | 1002 |
| 6.CHARGE HOLE | (Kgs) | 98 |
| 7.POWDER FACTOR | (Tons/kg) | 6.6 |
| 8.BOOSTER PERCENTAGE | (%) | 8 |
| 9.ANFO PERCENTAGE | (%) | 92 |
| 10.METHOD OF BLASTING | | NONEL |
| 11.TIME OF BLASTING | | 12.00PM |

Table 1: BLASTING DATA SHEET 1

| EXPLOSIVE PARTICULARS | | VALUES |
|---|---|---|
| 1.BOOSTERS | (Kgs) | 102 |
| 2.ANPRILLS | (Kgs) | 900 |
| 3.ED | (No.) | 04 |
| 4.SHOCK TUBE-200ms(8mts) | (No.) | 102 |

Table 2: EXPLOSIVE PARTICULARS 1

**BLASTING PATTERN:**

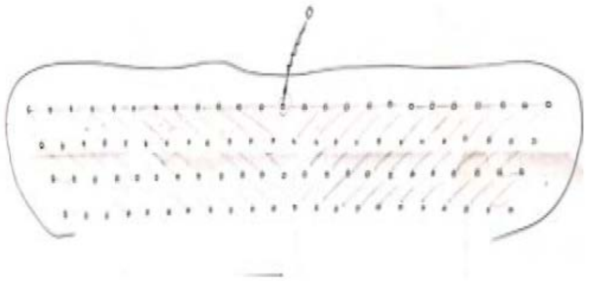
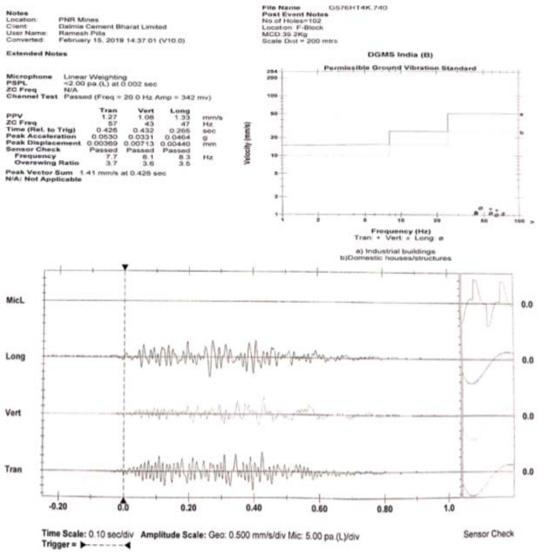


Figure 9: Blasting Pattern 1

**GROUND VIBRATION AND NOISE DATA COLLECTED USING MINIMATE:**



**COST ANALYSIS:**

| ITEMS | COSTS(Rs) |
|---|---|
| Booster (Rs.70/kg) | 7650 |
| AN Prills (RS.45/kg) | 40500 |
| DED (Rs.15) | 60 |
| Shock Tube 200ms/8m (Rs.85) | 8670 |
| Labour cost (Rs.400/each) | 2400 |
| Total costs | 59,280 |

Table 3: COST ANALYSIS 1

**5.3) BLASTING DATA SHEET 2:**

MINE – PNR MINES (DALMIA CEMENTS)
BLOCK – E
GRADE – MEDIUM
BOOSTER – KELVEX POWER 90E
EXPLOSIVES - ANFO

| BLAST PARAMETERS | | VALUES |
|---|---|---|
| 1.NO OF HOLES | (No.) | 53 |
| 2.BURDEN*SPACING*DEPTH | (Meters) | 3*3.5*5.1 |
| 3.TOTAL DEPTH(in meter) | (Meters) | 255 |
| 4.EXPECTED YIELD | (Tons) | 5355 |
| 5.TOTAL EXPLOSIVES USED | (Kgs) | 807 |
| 6.CHARGE HOLE | (Kgs) | 15 |
| 7.POWDER FACTOR | (Tons/kg) | 6.6 |
| 8.BOOSTER PERCENTAGE | (%) | 8 |
| 9.ANFO PERCENTAGE | (%) | 92 |
| 10.METHOD OF BLASTING | | NONEL |
| 11.TIME OF BLASTING | | 13.30PM |

Table 4: BLASTING DATA SHEET 2

| EXPLOSIVE PARTICULARS | | VALUES |
|---|---|---|
| 1.BOOSTERS | (Kgs) | 102 |
| 2.ANPRILLS | (Kgs) | 900 |
| 3.ED | (No.) | 04 |
| 4.SHOCK TUBE-200ms(8mts) | (No.) | 102 |

Table 2: EXPLOSIVE PARTICULARS 1

**BLASTING PATTERN:**

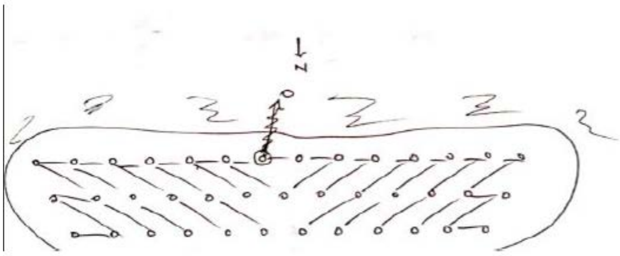
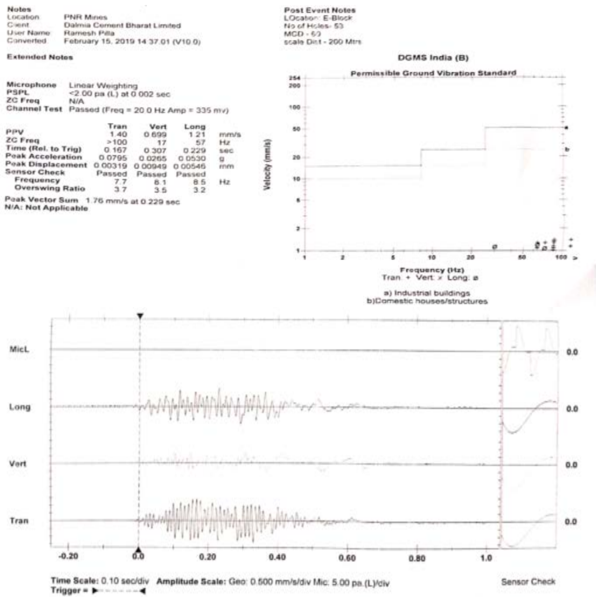


Figure 9: Blasting Pattern 1

**GROUND VIBRATION AND NOISE DATA COLLECTED USING MINIMATE:**



## COST ANALYSIS:

| ITEMS | COSTS(Rs) |
|---|---|
| Booster (Rs.70/kg) | 3990 |
| AN Prills (RS.45/kg) | 33750 |
| DED (Rs.15) | 60 |
| Shock Tube 200ms/8m (Rs.85) | 4505 |
| Labour cost (Rs.400/each) | 2400 |
| Total costs | 44,705 |

Table 6: COST ANALYSIS 2

## 5.3) BLASTING DATA SHEET 3:

MINE – PNR MINES (DALMIA CEMENTS)
BLOCK - L
GRADE – MEDIUM
BOOSTER – KELVEX POWER 90E
EXPLOSIVES – ANFO

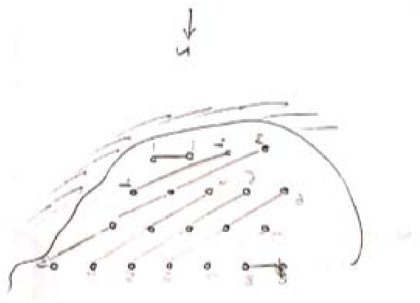
| BLAST PARAMETERS | | VALUES |
|---|---|---|
| 1.NO OF HOLES | (No.) | 20 |
| 2.BURDEN*SPACING*DEPTH | (Meters) | 3.5*4*8.1 |
| 3.TOTAL DEPTH(in meter) | (Meters) | 171 |
| 4.EXPECTED YIELD | (Tons) | 4788 |
| 5.TOTAL EXPLOSIVES USED | (Kgs) | 813 |
| 6.CHARGE HOLE | (Kgs) | 38 |
| 7.POWDER FACTOR | (Tons/kg) | 5.8 |
| 8.BOOSTER PERCENTAGE | (%) | 8 |
| 9.ANFO PERCENTAGE | (%) | 92 |
| 10.METHOD OF BLASTING | | DED |
| 11.TIME OF BLASTING | | 12.00PM |

Table 1: BLASTING DATA SHEET 1

| EXPLOSIVE PARTICULARS | | VALUES |
|---|---|---|
| 1.BOOSTERS | (Kgs) | 63 |
| 2.ANPRILLS | (Kgs) | 750 |
| 3.ED | (No.) | 20 |
| 4.DF | (Mts.) | 200 |

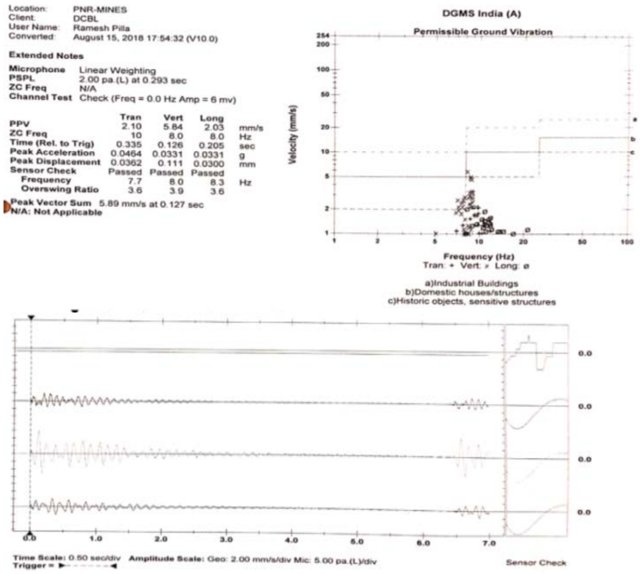
Table 5: EXPLOSIVE PARTICULARS 2

Figure 13: Blasting pattern 3



## BLASTING PATTERN:

## GROUND VIBRATION AND NOISE DATA COLLECTED USING MINIMATE:




## COST ANALYSIS:

| ITEMS | COSTS(Rs) |
|---|---|
| Booster (Rs.70/kg) | 4410 |
| AN Prills (RS.45/kg) | 33750 |
| DED (Rs.15) | 300 |
| Labour cost (Rs.400/each) | 2400 |
| Total costs | 40,860 |

Table 6: COST ANALYSIS 2

## 5.4) BLASTING DATA SHEET 4:

MINE – PNR MINES (DALMIA CEMENTS)
BLOCK - C
GRADE – MEDIUM
BOOSTER – KELVEX POWER 90E
EXPLOSIVES – ANFO

| BLAST PARAMETERS | | VALUES |
|---|---|---|
| 1.NO OF HOLES | (No.) | 48 |
| 2.BURDEN*SPACING*DEPTH | (Meters) | 3*3.5*6.6 |
| 3.TOTAL DEPTH(in meter) | (Meters) | 320 |
| 4.EXPECTED YIELD | (Tons) | 6720 |
| 5.TOTAL EXPLOSIVES USED | (Kgs) | 1196 |
| 6.CHARGE HOLE | (Kgs) | 24 |
| 7.POWDER FACTOR | (Tons/kg) | 5.6 |
| 8.BOOSTER PERCENTAGE | (%) | 8 |
| 9.ANFO PERCENTAGE | (%) | 92 |
| 10.METHOD OF BLASTING | | DED |
| 11.TIME OF BLASTING | | 13.00PM |

Table 10: BLASTING DATA SHEET 4

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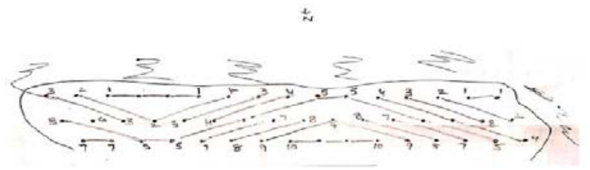
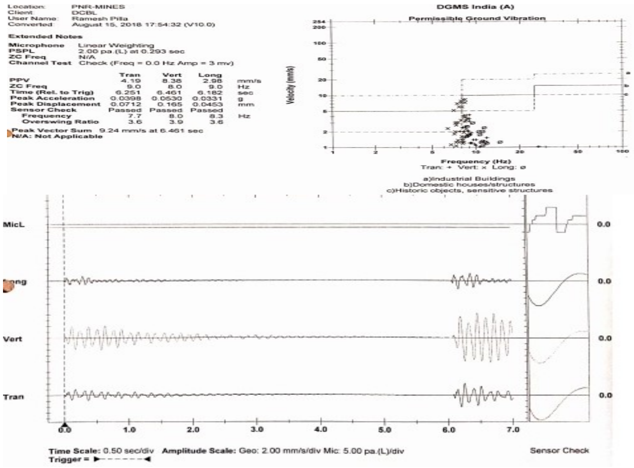
| EXPLOSIVE PARTICULARS | | VALUES |
|---|---|---|
| 1.BOOSTERS | (Kgs) | 96 |
| 2.ANPRILLS | (Kgs) | 1100 |
| 3.ED | (No.) | 48 |
| 4.DF | (Mts.) | 300 |

Table 11: EXPLOSIVE PARTICULARS 4

**BLASTING PATTERN:**



**GROUND VIBRATION AND NOISE DATA COLLECTED USING MINIMATE:**




**COST ANALYSIS:**

| ITEMS | COSTS(Rs) |
|---|---|
| Booster (Rs.70/kg) | 6720 |
| AN Prills (RS.45/kg) | 49500 |
| DED (Rs.15) | 720 |
| Labour cost (Rs.400/each) | 2400 |
| Total costs | 59,340 |

Table 12: COST ANALYSIS

**COMPARATIVE STUDY 1:**

| SI.NO | PARAMETERS | NONEL | ED |
|---|---|---|---|
| 1 | No. of holes | 102 | 20 |
| 2 | Booster used(Kgs) | 102 | 63 |
| 3 | ANprills used (Kgs) | 900 | 750 |
| 4 | Ground vibration(PPV) | 1.41mm/s | 5.89mm/s |
| 5 | Overall Cost(Rs) | 59,280 | 40,860 |

**COMPARATIVE STUDY 2:**

| SI.NO | PARAMETERS | NONEL | ED |
|---|---|---|---|
| 1 | No. of holes | 53 | 48 |
| 2 | Booster used(Kgs) | 57 | 96 |
| 3 | ANprills used (Kgs) | 750 | 1100 |
| 4 | Ground vibration(PPV) | 1.76mm/s | 9.24mm/s |
| 5 | Overall Cost(Rs) | 44,705 | 59,340 |

**Conclusion:**

Safe environmental effect involves bearable or minimal noise, vibration and amount of fly off rocks to the environments. Different methods have been critically analysed, which are electrical method and NONEL method that show various degrees of fragmentations, noise produced and vibration generated, which shows that NONEL method is the safest way of carrying out blasting operation. From the above table we have concluded that NONEL initiated blasts gives very less ground vibration. Nonel initiation provides reasonably good solution to fly rock problem. Also Noise level reduced significantly by nonel initiation system. The overall cost of blasting in NONEL is very less compared to electrical blasting and hence it optimizes the cost of blasting.

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