SCHOOL OF MATERIALS AND MINERAL RESOURCES ENGINEERING

UNIVERSITI SAINS MALAYSIA

THE ANALYSIS OF PARTICLE SIZE DISTRIBUTION (PSD) AFTER BLASTING USING AERIAL PHOTOGRAPHY AT FYS MARKETING SDN. BHD., BUKIT MERTAJAM, PENANG.

By

NURRAHMAN BIN JOHARI

Supervisor: Dr. Mohd Hazizan Bin Mohd Hashim

Dissertation submitted in partial fulfillment
of the requirements for the degree of Bachelor of Engineering with Honours
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DECLARATION

I hereby declare that I have conducted, completed the research work and written the dissertation entitled "**The Analysis of Particle Size Distribution (PSD) after Blasting Using Aerial Photography at FYS Marketing Sdn. Bhd., Bukit Mertajam, Penang**". I also declare that I has not been previously submitted for the award of any degree or diploma or other similar title of this for any examining body or University.

Name of student	: Nurrahman bin Johari	Signature:
Date	: 24 May 2018	

Witness by

Supervisor	: Dr. Mohd Hazizan bin Mohd Hashim	Signature:
Date	: 24 May 2018	

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LIST OF ABBREVIATIONS

PPV	Peak Particle Velocity
ANFO	Ammonium Nitrate Fuel Oil
PLT	Point Load Test
UCS	Uniaxial Compressive Strength
UAV	Unmanned Aerial Vehicle
GPS	Global Positioning System
EDV	Edge Detection Variables
VOD	Velocity of Detonation

ANALISIS TABURAN SAIZ PARTIKEL (PSD) SELEPAS PELETUPAN BERDASARKAN PENGGUNAAN FOTOGRAFI DARI UDARA DI FYS MARKETING SDN.BHD., BUKIT MERTAJAM, PULAU PINANG.

ABSTRAK

Umumnya kebanyakan analisi pemecahan batuan selepas peletupan batuan dilakukan menggunakan pengimejan pandangan paras mata. Oleh itu, kajian ini dijalankan untuk menganalisa PSD selepas peletupan dengan menggunakan teknik fotografi udara dan kesannya terhadap PSD menggunakan perisian WipFrag 2010. Pengenalan kepada *Unmanned Aerial Vehicle* (UAV) dalam kajian ini berperanan sebagai peranti kepada fotografi udara bersama-sama perisian Fotor Photo Editor untuk mempertingkatkan kualiti pengambilan gambar. Berdasarkan keputusan, terdapat perbezaan yang ketara di antara pengimejan pandangan paras mata dengan sudut pemandanagn dari udara *(aerial view)* dari aspek keseragaman hasil apabila graf PSD dianalisa. Analisa juga mendapati bahawa perubahan yang kurang signifikan apabila perbandingan dilakukan pada sudut ynag berbeza. Walau bagaimanapun, apabila kualiti imej digital ini dipertingkatkan, keputusan graf PSD menunjukkan hasil yang lebih baik. Oleh dengan itu, melalui kajian saya, ianya akan memberikan lebih pemahamn kesan terhadap sudut pemandanagan dari udara berbanding sudut pandangan atas mata berkenaan gaf PSD. Bukan itu sahaja, kajian ini juga membuktikan bahawa dengan pengenalan teknologi ke dalam industri Sumber Mineral, kajian dan pencarian baru boleh diperolehi bagi memperolehi lebih pencapaian dan keunggulan dalam industri ini.

THE ANALYSIS OF PARTICLE SIZE DISTRIBUTION (PSD) AFTER BLASTING USING AERIAL PHOTOGRAPHY AT FYS QUARRY SDN. BHD., BUKIT MERTAJAM, PENANG.

ABSTRACT

Previous researches conducted the fragmentation analysis by capturing images of the muck pile using digital camera at eye-level point of view. Therefore, this research is dedicated for analyzing the Particle Size Distribution after blasting using aerial photography as a new approach. This is to compare the results of taking digital images of the muck pile at eye-level point of view from aerial point of view. The introduction of Unmanned Aerial Vehicle (UAV) to this research which act as a device for aerial photography and not to mention Fotor Photo Editor software is to enhance the images taken to ensure good results when being analyzed using WipFrag 2010 software. Throughout findings, different point of view for image capturing can show different results. At aerial view, it shows strong consistency of results when being analyzed to the Particle Size Distribution graph. Not to mention, at any direction or angle when the being done using aerial photography, the Particle Size Distribution graph remains consistent. Furthermore, if the digital image is being enhanced with a better quality, the Particle Size Distribution graph shows a more accurate result. Therefore, through this study, there will be a much better understanding on the effect of using aerial point of view compared to an eye-level point of view on the Particle Size Distribution (PSD) graph. Not only that, this study also proves that with the introduction of technology to Mineral Resources industry, new researches and findings can be obtained to achieve and excel more in this industry.

CHAPTER 1

INTRODUCTION

1.1 Background Study

Most of the economic mineral deposits exist in association with massive hard rocks. These rock masses should be fragmented to obtain the valuables and separate the materials for further processing. Breaking a rock mass involves large energy which can only be achieved by drilling and blasting. Hence, drilling and blasting are to be considered the first phase of the production cycle in most of the mining operations. Due to the advancement in technology in several mining activities, there are a lot of improvements shown by experts in controlled blasting operations which are more beneficial not only on production point of view, but also on the safety point of view of the workers. Regardless of all the technology that can be brought into the mining and quarrying industry, there is still no alternatives to blasting or drilling.

In order to meet the demand in construction and many more industries, rocks and minerals are need as raw materials to be used in various application depending on the usage and specialty of the rock and mineral itself. Thus, mining and quarrying industry are being developed as this industry is widely ventured all over the world. In order to obtain manageable sizes of rocks which can be economically used, drilling and blasting are the most viable and economical method being executed in mines and quarries. Even drilling and blasting seems to be a chosen economical method used in quarries and mines, but there are surfaced adverted effects that cannot be avoided and eliminated. The effects are ground vibrations, fly rocks, back break, air blast, and noise. Damage in properties, injuries and death can also be caused due to unfortunate uncontrollable blasting. Among all the negative effects, ground vibration is the major concern to the planners, designers and environmentalist as human are quite sensitive to motion and noise. To minimize the ground vibration level during blasting, there are a few researched have suggested various methods. Ground vibration is directly related to the quantity of the explosives used and distance between the blast face to the monitoring point as well as geological and geotechnical conditions of the rock mass in the excavation area.

A few parameters have to be ensured to attain a good blast fragmentation such as powder factor, burden and spacing, bench height, and stemming. With these parameters being obeyed, many negative effects of blasting can be eliminated, and good fragmentation can be achieved. To prove that the fragmentation of the blasted rock mass is good, further analysis must be conducted. Various measuring methods have been proposed in order to measure the fragmentation of blasted rock. Basic analysis methods such as sieving of the blasted rocks are simply impossible due to the size of the blasted rocks and it is time consuming. The usage of unmanned aerial vehicle is recommended to ensure the overview of the muck pile can be analyzed in the fragmentation software. The UAV is being flown directly on top of the muckpile to capture the muck pile at different angles and height to ensure it is precise and then the digital images are then being analyzed to produce a precise result to define the fragmentation of the muckpile.

1.2 Problem Statement

Efficient and effective mine management is absolutely important in determining the life of mine. Proficiency in production plays a huge part in mine operation and blasting is considered to be the initiation stage of production. Proper blast design will result in adequate fragmentation, which will reduce downstream expenses associated to hauling, equipment maintenance and crushing.

The parameters that effect the propagation and intensity of ground vibration during blasting are dependent on a number of factors; controllable and uncontrollable. The majority of the controllable factors are closely regarding to blast designs of the operation with the charge weight being the most influential. Vibration and peak particle velocity are controllable blasting parameters that are able to determine the outcome of fragmentation.

Vibration intensity have to be under regulatory limitations to avoid flyrock and airblast. Vibration data on the intensity can also be used for fragmentation outcome of the operation. This research requires vibration monitoring via seismograph and fragmentation measurement via digital image analysis.

Digital images taken for analysis which is commonly capture in eye level point which that restrict the muck pile's fragments to be properly defined as a whole. An alternative image capturing method have to be used to ensure the fragmentation of the muck pile can be properly defined by bringing in Unmanned Aerial Vehicle or drone into this research.

1.3 Objectives

The objectives of this research are:

1. To analyze the effect of photograph taken at different point of view and the Particle Size Distribution (PSD) of the respective point of views.
2. To analyze the effect of direction of the drone while capturing images of muckpile and the Particle Size Distribution (PSD) of the respective images.

3. To study the effect of digital images quality and its impact towards the Particle Size Distribution (PSD) analysis using WipFrag 2010 software.

1.4 Dissertation Outline

The dissertation consists of five main chapters which are Introduction, Literature Review, Methodology, Discussion and Conclusion.

Chapter 1- Introduction

This chapter briefly explains about the background of study, problem statement, objectives of research and the scope of research work.

Chapter 2 – Literature Review

Literature review is the foundation of study. Citation from journals and articles are reviewed in this chapter in order to accomplish this project. The knowledge about blasting principle and the beneficial usage of Unmanned Aerial Vehicle (UAV) or drone are discussed in this chapter.

Chapter 3- Methodology

This chapter is more directly focus on the method of study. This project involves the usage of WipFrag 2010 software which function as a fragmentation analyser that produces Particle Size Distribution Graph, smartphone to control the drone and Fotor Photo Editor software to enhance the images for analysing. Methods of collecting blast design, blast data, colleting digital images of the muck pile, collecting rock samples and conducting Point Load Test were being discussed in this chapter.

Chapter 4- Results and Discussion

This chapter covers the outcome of the study in term of the images taken from the drone in different direction, Particle Size Distribution, enhancement of digital images and the results of the Point Load Test. The relation between these outcomes will be analysed and presented in this chapter.

Chapter 5- Conclusion

This chapter is to conclude the overall of this study, discuss on the achievable and unachievable objectives, and suggest some recommendation to improve the efficiency of the blasting in order to achieve the objectives of this study/ research.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Drilling and blasting combination is still an economical and viable method for rock excavation and displacement in quarrying and has been in the industry for years. The ill effects of blasting, i.e. ground vibrations, air blasts, fly rocks, back breaks, noises, etc. are inescapable and cannot be entirely get rid of but certainly reduced up to a permissible level to avoid damage to the surrounding environment which consist of surveillances, structures and natural elements.

Among all the ill effects, ground vibration is major concern to the planners, designers and environmentalists. Several researchers have suggested various methods to minimize the ground vibration level during the blasting. Ground vibration is directly related to the amount of explosive used and distance between blast face to monitoring point as well as geological and geotechnical conditions of the rock units in excavation area.

One of the most crucial process in most quarries production is to put to use controlled explosives during blasting due to that they are cheap in expense and rapid in production and process. There are a few manageable factors that can be found which directs the blasting process, i.e. weight per delay, type of charge used, blast pattern and design, delay time and confinement.

Very high temperature and pressure can be released in a very short time due to uncapacious explosive energy produced. High pressure gases are being released out by the explosive which cause the rock face to be burst out from a bigger volume to a smaller volume due to the powerful forces acted upon them. Ground vibrations and air blast are also the caused from the detonation of explosives which to be release to the surrounding rock body and environment.

Escaped fly rock from the blasting process creates threats to the nearby residents which can result in death, injuries and damaged infrastructure. Explosion during blasting produce wave forms that travel out to the surroundings which are body waves and surface waves

2.1 Explosives

The usage of explosives is commonly used in the quarrying sector which applies as an alternative method to break a big volume of rock to smaller volume of rock. The basic objective of drilling and blasting program by using explosives is to achieve optimum fragmentation. During the process of detonation, gases get released and expand rapidly giving off huge amount of heat and energy where oxygen is the main component of the explosive chemicals. A liter of high explosives will expand to around 1,000 liters within milliseconds (ICI 1997), creating pressures in a blast hole of the order of 10,000 MPa (1,450,000 psi).

2.1.1 Classification of explosives

Reaction rate, sensitivity (ease with which chemistry is initiated), and strength (total energy released when reactant changes to product) of explosives are one of the few characteristics that classify explosives into two main groups which are low or deflagrating explosives and high explosives or detonating explosives. Low explosives are combustible materials, containing within themselves all oxygen needful for their combustion, which burn but do not explode, and function by producing gas which produces as explosion. Low explosives undergo deflagration at rates that vary from a few centimeters per second to approximately 400 meters per seconds. Examples of low explosives are black powder and smokeless powder.

One other type is high explosives which consist of two sub-classes which are primary and secondary high explosives shown in Figure 2.1. High explosives detonate under the influence of the shock of the explosion of a suitable primary explosives. They do not function by burning; in fact, not all of them are combustible, but most of them can be ignited by a flame and in small amount generally burn tranquilly and can be extinguished easily. For primary high explosives, they are extremely sensitive to mechanical shock, friction, heat and friction, to which they will respond by burning rapidly or detonating. Secondary high explosives, are opposite of primary high explosives where they are insensitive to shock, heat and friction. Small quantities of these explosives may burn when exposed to heat and are sometimes added in small amounts to blasting cap to boost their power.

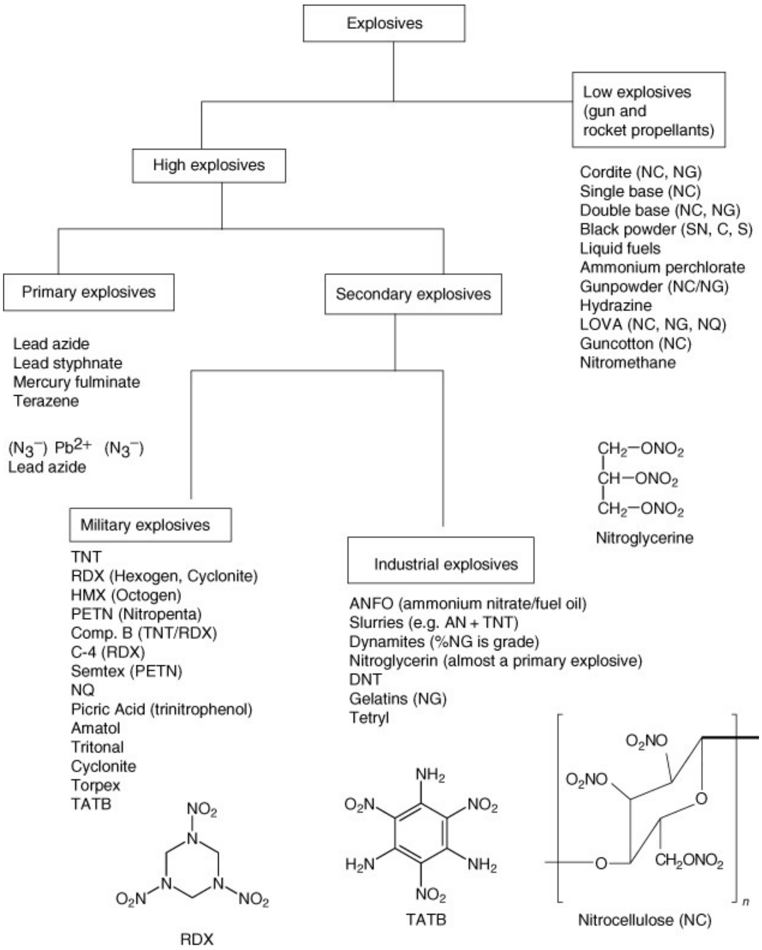

Figure 2.1: Family tree of explosives which consist of High and Low explosives.

2.1.2 Explosive Properties

The performance and selection of an explosives are influenced by these main parameters:

- Storage life;
- Water resistance;
- Fume characteristics;
- Physical characteristics;
- Effective energy;
- Velocity of detonation;
- Density;
- Detonation pressure; and
- Sensitivity.

Storage life is the ability of an explosive to remain chemically unchanged when stored. Storing the explosives for a certain duration of time, usually three to four years later and under some weather condition (hot, humid, cold etc.) might affect the condition of the explosives to be either insensitive to detonate, or more sensitive and unsafe to use.

Water resistance is the ability of an explosive to resist water and to maintain its explosive properties in the presence of water. Explosives which are not water resistance tends to absorb the surrounding water and will cause the explosive to be insensitive to detonate or unsafe to use such as ANFO (Ammonium Nitrate Fuel Oil) compared to explosive emulsion which is much reliable in wet conditions.

During detonation of explosives, water vapor, carbon dioxide and nitrogen are produced. Not only that, undesirable poisonous gases such as carbon monoxide and nitrogen oxides, which are also known as fumes are usually formed during detonation. For fumes are not an important factor when it comes to an open blasting but very crucial in confined spaces. Each type of explosive has their own special characteristics that suits their respective blasting conditions. ANFO types are loose, while emulsion type has a syrupy consistency and different physical characteristics of these explosives determined their method of handling them.

Effective energy is the explosive's ability to accomplish what is intended in the way of the energy is delivered, in another word is the ability to do work. Effective energy during blasting is where most of the energy are fully distributed to cause rock fragmentation and small amount of energy are converted to waste energy which causes noise, heat, ground vibration and air vibration.

Velocity of detonation is the rate at which the detonation wave passes through the explosive charge. The higher the VOD, the greater the 'shattering' effect of an explosive. High VOD explosives are more suitable in hard rock and low VOD for softer rocks. The VOD range in commercial explosives is 2500-7500 m/s.

Density of an explosive determines the charge weight per meter of hole. For conditions where fine fragmentations are required, a dense explosive is required. For conditions where fine fragmentations are not needed, a low-density will often suffice. Table 2.1 shows each individual explosive with their respective densities.

Table 2.1: Types of explosives with their respective densities.

Explosive	Density (g/cm^3)
ANFO	0.8 to 1.0
Watergels	1.2 to 1.4
Emulsion	1.1 to 1.3
NG-Based	1.3 to 1.6

Detonation pressure is the pressure in the reaction zone as an explosive detonates. It is an indicator of the ability of an explosive to produce a good fragmentation. A high detonation pressure is one of the desirable characteristics in a primer (Atlas 1987).

Sensitivity is a measure of the ease with which an explosive can be detonated by friction, heat or shock and of its ability to propagate that detonation. The detonation within a blast hole can be interrupted if there are gaps between charges if the sensitivity of the explosive is too low. A detonation from one hole to another is resulted by explosive that is too sensitive.

2.1.3 Types of explosives

In surface mining operation, four types of commonly used explosives are used, namely: Ammonium Nitrate Fuel Oil (ANFO), watergels, emulsion and gelignite.

- ANFO: In a stoichiometric balanced reaction, ANFO is composed of approximately 94.3% Ammonium Nitrate (AN) and 5.7% fuel oil (FO) by weight. Under most conditions is considered a high explosive; it decompose through detonation. Seems its sensitivity is generally low; it requires a booster to ensure reliable detonation.
- Gelignite: The chemical compound is being based on Nitroglycerine (NG) which are manufactured in gelatinous or semi gelatinous form. Due to their relatively high cost and uncompromising safety requirements to handle this explosive, the usage of gelignite in the mining industry has decreased.
- Watergels: This explosive also called as slurries. Watergels are developed to overcome the deficiencies of ANFO in wet conditions. This explosive contains gelatinizing agent, also known as thickener which function to modify the consistency of the explosive. Watergels are low in toxicity, safe to manufacture, transport and store.
- Emulsion: Fine droplets of oxidizer salts (ammonium, sodium or calcium nitrates) are finely dispersed into the continuous phase of fuel oil. This emulsion is stabilized against liquid separation by emulsifying agent. Emulsion have excellent performance characteristics (e.g. water resistance) and flexibility of use compared to other explosives making it a preferable choice of explosive being used.

2.1.4 Blasting agents

All blasting agent is an explosive that:

- Comprises of ingredients that by themselves are non-explosive; and
- Can only be detonated by a high explosive charge placed within it and not by a detonator.

All blasting agents contain the following essential components (ICI 1997):

1. Oxidizer: A chemical that provides oxygen for the reaction.
2. Fuel: A chemical that reacts with oxygen to produce heat.
3. Sensitizer: Provides heat source to initiate the chemical reaction of oxidizer and fuel. Generally, air bubbles within the explosives.

2.2 Blast Design

Blasting operation must be designed and arranged in such a way that the mineral stones be fruitfully separated (Javad, 2015). The parameters for a blast design are controllable and is designed by explosive engineers. The blast design, as illustrated in Figure 2.2 consist of:

- Spacing;
- Burden;
- Stemming;
- Bench Height;
- Sub-drilling;
- Hole diameter;
- Explosive charge; and
- Hole depth.

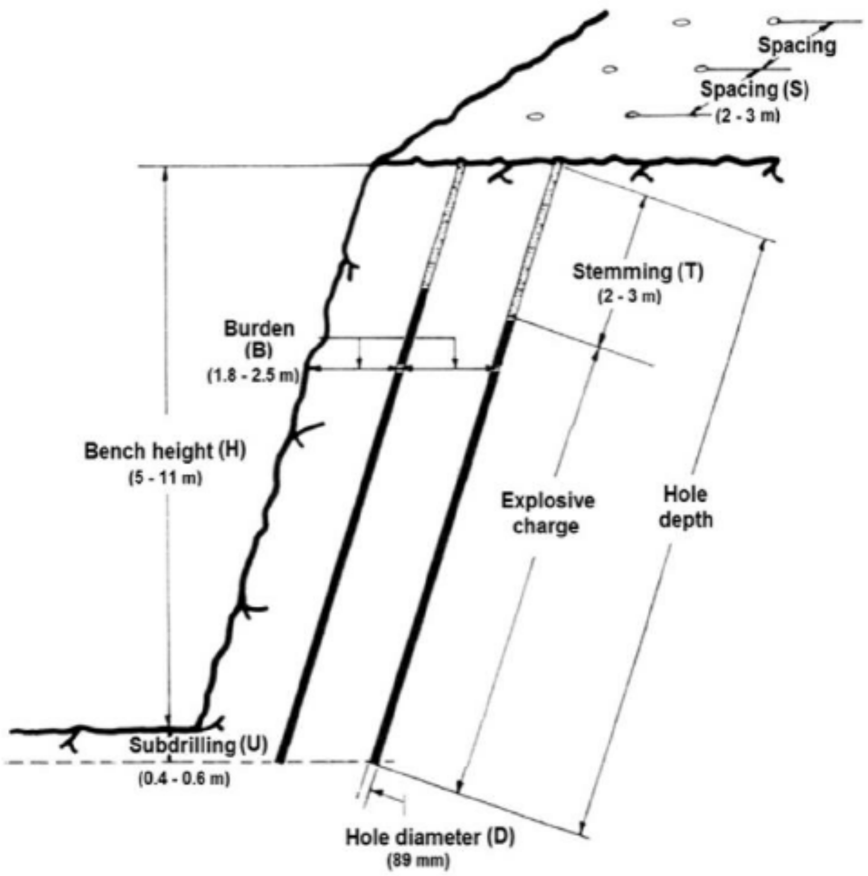

Figure 2.2: Blast Design Parameter Terminology (after Javad, 2015)

2.3 Ground Vibration

2.3.1 Generation of Blast vibration

As an explosive detonates, the blast hole was set with intense dynamic waves because of the sudden acceleration of the rock mass. The energy released by the explosive is transmitted to the rock mass as strain energy. The channeling of the energy takes place in the form of waves. These waves carry energy that crushes the rock from the rock mass to fine powders and the region involved is called shock zone which is two times the radius of the hole. After the shock zone, the energy of the waves gets weakened to some degree which causes the radial cracking of the rock mass. The gas produced as a result of blast enters into these cracks and displaces the rock farther causing its fragmentation. Such phenomenon that takes place is called transition zone where the zone's radius is twenty to fifty times the radius of the hole. As result of further weakening taking place in the transition zone, the waves although cause generation of the cracks to a lesser extent but they are not in a state to cause the permanent malformation in the rock mass positioned outside the transition zone. If these weak waves are not channeled from a free face, then they may cause vibration of rock. However, is a free face being available, the waves channeled from a free face will results in further breakage in the rock mass under the effect of the dynamic tensile stress. Transition zone and shock zone described in a pictorial representation is shown in Figure 2.3.

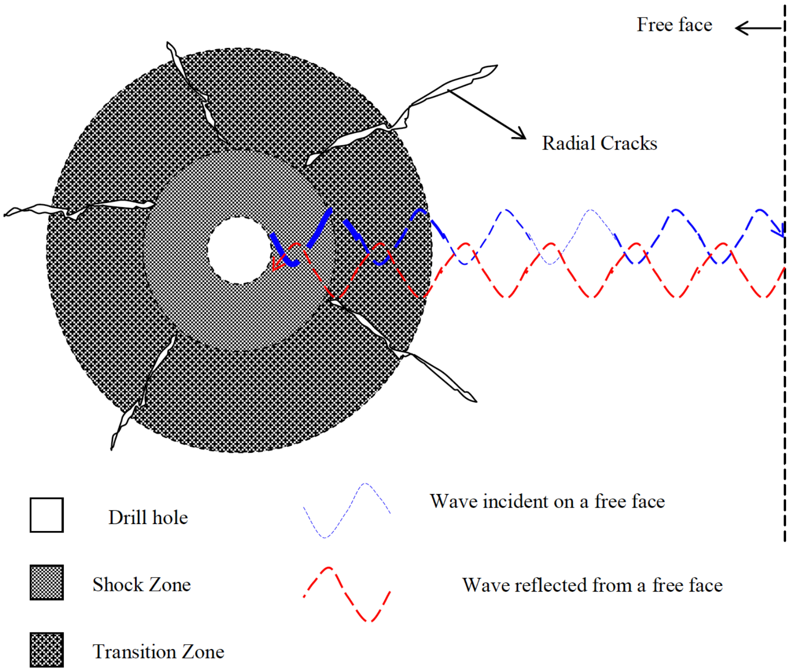

Figure 2.3: Pictorial Representation of the various zones and waves reflection phenomenon. (after Kumar, 2010)

Ground vibration increases with increased of explosives mass and reduces with distance. The relationship between explosive mass, distance and vibration can be determined from analysis and then used in predictive formula to limit and control the ground vibration.

2.3.2 Type of waves

There are different types of waves as ground vibration wave motion:

- Compression (or P) waves
- Shear (or S) waves
- Rayleigh (or R) waves

Compression waves is the fastest waves through the ground. This wave moves radially from the blast hole in all directions at velocities characteristics of the material being travelled through which is approximately 2200 m/s.

50% to 60% of the velocity of 'P' wave is where shear wave travels which is 1200 m/s. this wave is often referred to as body waves as they travel through the body of the rock in three dimensions.

The slowest wave compared to compression and shear wave is Rayleigh wave which fades rapidly with depth and propagates more slowly at a speed of 750m/s. The movement of the particles within the wave is elliptical in a vertical plane in the same direction of propagation.

2.3.3. Factors influencing propagation and intensity of ground vibrations.

There are two types of parameters which shows the control on the frequency, amplitude and duration of the ground vibration which are as follows:

a. Non-controllable Parameters; and
b. Controllable Parameters.

Uncontrollable parameters are natural phenomenon parameter that cannot be manipulated by human such as the local geological setting of the blasted site and the rock characteristics. As for the controllable parameters can be manipulated to achieve a better outcome, as they are (Kumar, 2013):

- Charge weight per delay;
- Delay interval;
- Confinement;
- Types of explosives;
- Burden, spacing and specification and specific charges;
- Coupling;
- Blast progression direction; and
- Spatial distribution of charges.

2.3.4 Reduction of ground vibration

High ground vibration detected during blasting can affect any structural buildings close to the source of blast. To protect these structures from being damage and to minimize the ground vibration from the blast, there are several acceptable techniques for the reduction and control of vibration which are (Kumar, 2013):

1. Controlling or reduce the charge per delay during blasting:
    - Reducing the hole depth
    - Using sequential blasting machine
    - Delayed initiation of deck charges in the blast holes
    - Using small diameter holes
    - Using more numbers of delay detonators series

2. The explosive confinement can be reduced by:
    - Reducing sub-grade drilling
    - Allow at least one free face
    - Buffers being removed in front of the holes
    - Excessive burden and spacing being reduced
    - Reduce the stemming but no to the extent of increasing the air-blast and fly rock
    - Drilling accurately
    - Drilling the holes in a parallel manner to the bench face.
    - Using decoupled charges

3. The explosive confinement to the bedrock have to be controlled if the burden can be excavated by other means;
4. Blasting patterns;
5. Frequency of blasting;
6. Usage of low VOD and low-density explosive;
7. Use controllable blasting techniques; and
8. Timing of the blast with high surrounding noise level.

2.4 Peak Particle Velocity

Peak particle velocity (PPV) is the maximum rate of change of displacement and the speed of excitation of a particle in the ground brought about by vibrating motion as shown in Figure 2.4. It is not the propagation velocity of wave form in the rock mass. Peak particle velocity is measured in mm/sec.

As charge per delay increases and the distance from the blast decreases will increase the vibration levels. The United States Bureau of Mines has determined the empirical formula for calculating the Peak Particle Velocity (Payle,2009):

$$V=K\left(\frac{D}{\sqrt{W}}\right)^{-\beta}$$

Where v =Peak Particle velocity measured in mm/sec.

D = distance from blast in meter

W = Maximum charge per delay in kilograms

β and K = site constant dependent on tock characteristics

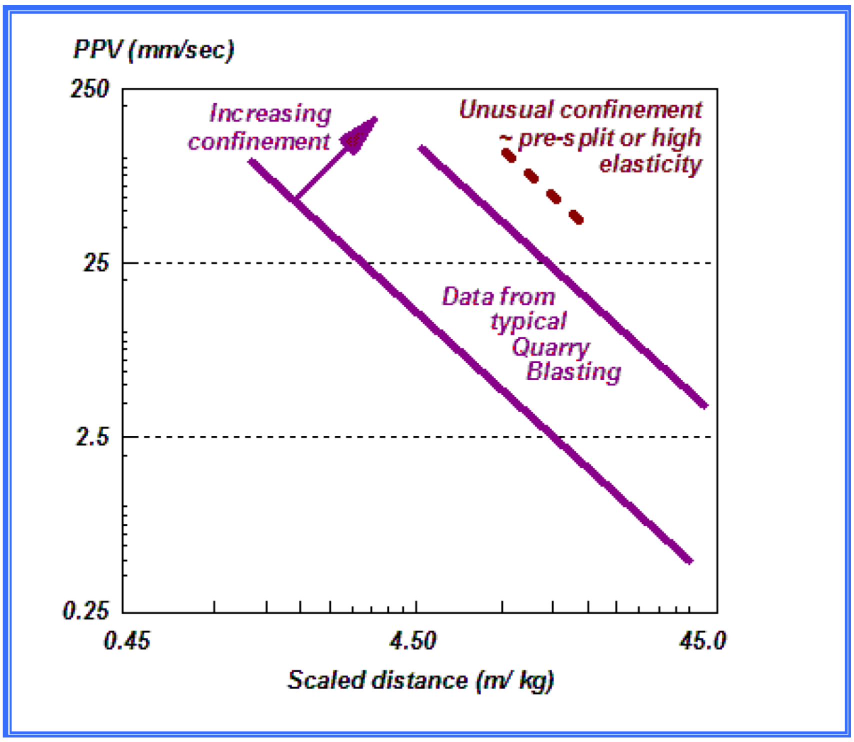

Figure 2.4: Peak Particle Velocity versus Distance (after Payle, 2009)

The values of c, W and R were measured on site while values of K and β are determined from a linear least square regression analysis of log v versus log $\left(\frac{D}{\sqrt{W}}\right)$. The available empirical formula to predict PPV does not determine the same empirical relationship, PPV predicting purposes, in other places as they only signify to their corresponding site where the blasting operation has been conducted.

2.5 Unmanned Aerial Vehicle (UAV)

Unmanned Aerial Vehicles (UAV) are small-size aircraft without a pilot controlled by a monitoring unit on the ground and can be integrated with various electric devices depending on the objectives of usage.

Drone applications in blasting operations in terms of research generally shows how automation has increased the productivity of mine site by upwards of 25 percent, and that an automated drone's ability to collect aerial data at a mine site is a game changer (Efrat Fenigson, 2017). Previously, before drone is introduced in mining industry, digital images are taken using digital camera at angles where the overall image of the muck pile cannot be access. As the images taken from the angle of a human's eye view by using digital camera are being analyzed in fragmentation software, the results cannot define the whole muckpile. These results show that there is a need of being technology into the blasting operations in mining industries.

The versatility of a drone which acts as a vehicle for the camera can also extends to valuable monitoring functions during and after blasting where experts can use the images and graphics obtained through a drone to gain a clearer understanding of sampling, measuring and quantifying the fragmentation achieved by a blast because from an aerial-scale image that a drone can deliver, making the analysis much more useful in improving future blasts. (Dylan Slater, 2017). Using drone in blasting operations breaks the barrier of limitation, where the digital image of the muckpile can be overall be seen from a bird's eye view. With this technology being introduced into the blasting operation in the mining industry, the results obtained can be fully defined.

2.5.1 UAV Technology

Unmanned Arial Vehicles (UAVs) or drones are aircraft without the presence of a human pilot aboard that are used to perform intelligence, observation, and investigation missions. UAVs have an integrated number of systems and sub-systems that include the aircraft frame, an integrated payload, a ground control station, and aircraft launching, recovery and communication systems (Austim, 2010).

2.5.2 Type of UAVs

There are two types of UAVs: with a fixed wing and with a rotary wing. UAVs with multiple rotary- wings, which can take off and land vertically in small places, and additionally it can take both vertical and tilted images as it can move in vertical and horizontal directions. Although multiple rotary win UAVs have low fuel consumptions compared to the fixed- wing UAVs, but they can only operate for a short period of time as this type of UAV uses rechargeable intelligent battery that can last for 25 minutes in flight time. Therefore, this type of UAVs is suitable for small areas where there is a limited take-off and landing space and where images have to be taken in vertical or horizontal directions. One example of a multiple rotary-wing UAV that is available in the market is the DJI Phantom 3 Standard as shown in Figure 2.5.

Figure 2.5: Multiple rotary-wing UAV (DJI Phantom 3 Standard, https://www.dji.com/phantom-3-standard).

UAVs with fixed wings are similar to passenger planes or fighter planes. One of the advantages of this type of UAV is the low rate of fuel consumptions, resulting in longer operation time per flight. However, one obvious disadvantage is its inability to take off and land vertically. Therefore, there are limitations in the use of fixed-wing UAVs during operation because they require a runway area to take off and land. Figure 2.6 is a picture of a fixed UAV currently in the market which is the Sentera Phoenix 2.

Figure 2.6: Fixed-wing UAV (Sentera Phoenix 2, http://agrireview.com/sentera-announces-debut-of-phoenix-2-fixed-wing-uav/).

2.5.3 UAV Technology and Applications

In the past, UAV technology has been typically used for military purposes which started back during World War 1; however, in this present day, it is currently used for various objectives, for example mapping of landslides affected area, 3-Dimensional Terrain model construction, to investigate traffic flow, and for analysis and survey in mining industries.

UAV technology can be integrated with many devices, such as sound recorders, transmitter or even high-resolution cameras for image capturing and recording, which allows UAVs to perform different purposes (Cavoukian,2012). Some examples of utilizing UAVs for commercial or civil purposes are the following:

1. Search and rescue; to offer support during emergency rescues.
2. Inspection of oil and gas industries; such as pipelines, wind turbines and power lines.
3. Securities; keeping securities at endangered area
4. Precision agriculture; tracking and estimating plant health in order to maximize crop yield.
5. Aerial photography; to obtain details from bird's eye view through capturing digital images.
6. Surveying/GIS; applied in the mining industry to estimate the current mining situation or volume stockpile measurement
7. Unmanned cargo system; used to deliver small parcels to reduce operation time and cost.

2.6 Point of View in Photography

In the relation to photography, 'point of view' refers to the position the camera is in when viewing a scene. There are three types of 'point of view' which are aerial view, eye level and worm's eye view.

Bird's eye view is the overall view from the top that is makes the digital image taken can defined as detail as possible as shown in Figure 2.7. This could be taken up in the sky such as flying a drone or even riding a helicopter to take images from the sky. Photographing at this point of view can make viewers feel as though they are superior to the subject.

Figure 2.7: Aerial Point of View of the blasting muckpile.

The most common way to photograph a subject is by taking an image at eye level point of view as shown in Figure 2.8. The disadvantage of taking images from eye view is that it is limited to what is in front of the viewer only and it is focus to only a subject. Eye view photographing can easily be taken by using a digital camera or even a smart phone camera.