particle at the source, but for other particles along the distance which are delayed in reaching corrosponding positions, we have the following equations

$$x = \frac{V}{\omega} [\sin \omega T - KD]$$

$$X = X - X[\cos(\omega t - KD)]$$

where

T = period

K = radians per unit distance

D – distance from source of explosion to corresponding position.

The absolute value of cos ine is used because it has positive and negative values which depend on distance.

## Conclusions

In surface blasting, elastic waves are traveling and represent the transfer of energy from one point of a medium to another point of the medium. The properties of rock such as high elasticity and high density increase the percentage of arriving energy at corresponding positions.

As the model indicated, the amount of energy which arrives at the near structure depended upon, distance, weight of explosive and frequency. All of these three factors are contralled by blast operator. So as long as these factors can be controlled, the practical results of this theortical study which has been presented in this paper are reasonable. This study indicates the direction of further investigations, so that reliable damage criteria, types up waves and amount of energy at corresponding positions can be established.

---

## Reference:

**1– Osanloo Morteza, "Drive an analytical model which can describe and illustrate the vibration" (motion as well as propagation) of underground mine roof and pillar as a result ot surface mining blast. The blast location is directly above the underground mine working, university of Oklahoma, 1980.**

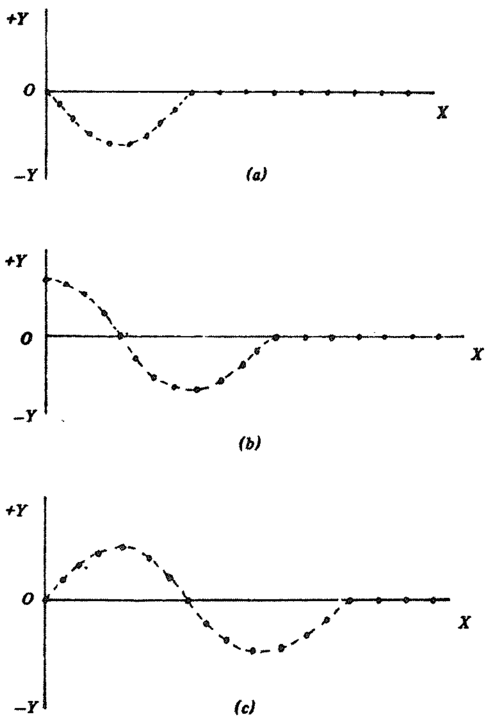


*Fig 4- Position of particles in different stages*

Initial Condition (IC): $t = 0$

boundary condition (BC): $X = 0$

At $t = 0,\ X = 0$

$$X = A\sin\omega t + B\cos\omega t$$

$0 = 0 + B \quad B = 0$ and

$$X = A\sin\omega t$$

$$\frac{dx}{dt} = V = A\,\omega\cos\omega t$$

by Applying initial condition

$$V = A\omega$$

$$A = \frac{V}{\omega}$$

So energy at souree is

$$X = A\sin\omega t = \frac{V}{\omega}\sin\omega t$$

and energy received at roof mine or near structure is:

$$X = \underbrace{An\sin\omega t + Bn\cos\omega t}_{\text{P - wave}} + C\underbrace{\sin\omega t + D\cos\omega t}_{\text{surface wave}} \quad (1)$$

initial and Boundary conditions are

$t = T \quad , \quad x = X$

Assume momentarily when the P- wave hits the near structure, $T = 0$

by applying boundry condition on above equation we will have:

$$X = An\sin\omega t + Bn\cos\omega t + C\sin\omega t + D\cos\omega t$$

$$\frac{dx}{dT} = V = An\omega\cos\omega t - Bn\omega\sin\omega t + C\omega\cos\omega t - D\omega\sin\omega t \text{ at } T = 0$$

$$\frac{dx}{dT} = V = An\omega + C\omega$$

$$C = \frac{V - An\omega}{\omega}$$

$$\frac{d^2X}{dT^2} = a$$ called acceleration

$$a = -An\omega^2\sin\omega t - Bn\omega^2\cos\omega t - C\omega^2\sin\omega t - D\omega^2\cos\omega t \text{ at } T = 0$$

$$a = Bn\omega^2 - D\omega^2$$

$$D = \left[\frac{a}{\omega^2} + Bn\right]$$

placing these coefficients in equation (1)

$$X = An\sin\omega t + Bn\cos\omega t + \left(\frac{V}{\omega} - An\right)\sin\omega t - \left[\frac{a}{\omega^2} + Bn\right]\cos\omega t$$

$$X = An\sin\omega t + Bn\cos\omega t + \frac{V}{\omega}\sin\omega t - An\sin\omega t - \frac{a}{\omega^2}\cos\omega t - Bn\cos\omega t$$

Therefore energy at near structure:

$$X = \frac{V}{\omega}\sin\omega t - \frac{a}{\omega^2}\cos\omega t \quad (2)$$

by definition $a = w^2x$ Substitue into equation (2)

$$X\ \frac{V}{\omega}\sin\omega t - X[\cos\omega t] \quad (3)$$

From previous discussion, energy at source is

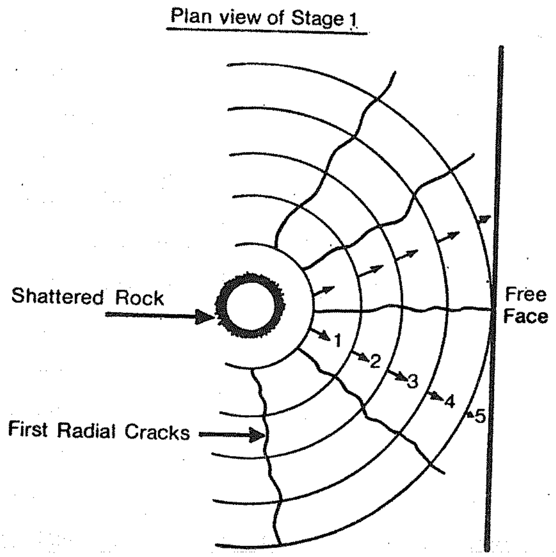
$x = \frac{v}{\omega}\sin\omega t$ (4) substitue, into equation(3) we will have amount of energy arrives at near structure

$$X = x - X[\cos\omega t] \quad (5)$$

X = energy at near structure or underground min roof

x = energy at source

equation (4) and (5) indicate the motion of the first result, immediately the rock around the explosion is crushed (fig 1) then the pressure falls very quickly and crushing stops. The remaining energy moves into unbroken rock as an elastic wave sometimes called the shock front. The major portion of this remaining energy is in form of P-wave and surface waves, because theoretical considerations have shown that for an explosion in a cylindrical borehole an ideal material only P-wave are possible, and the effects of transvers waves are insignificant and can be fairly neglected. However after the pressure falls very quickly and crushing stops. The remaining energy as a P-wave moves into the earth's medium. When the wave velocity excites, it causes motion of particales from their equilibrium position.



*1–5 Positions of the outbound compression wave.*

This is called particle velocity and usually the particle velocity is less than the wave velocity. As an example of these motion consider the more reasonable case of two dimensional X and Y-axis(fig–2).

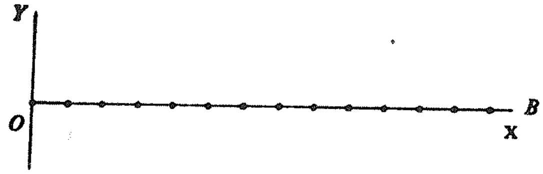


***Fig 2- Two dimensional motion of particles***

If the particle at O is displaced, particles adjacent to it will be disturbed progressively. By the time the displacement of the particale on the Y-axis is A (depends on the forces) they will be arranged as in fig 3.

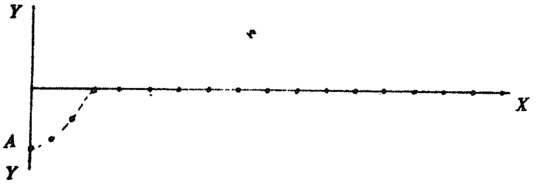


***Fig 3- displacement of particle after initial force***

But if the particle on the Y-axis is allowed to move with simple harmonic motion back through O to an equal displacement A on the opposite side and then to return to O. Successive arrangements of the adjacent particles will be as shown in Fig4- a, b, c. As the process (energy) continues each particle oscillates up and down on X and Y direction and its position at a given time is determined by:

$X = A \sin \omega t + B \cos \omega t$

where:

X= particle displacement at time t (no te: X is also called the energy introduced by the particle displacement in the wave motion) A - is wave coefficient in X, Y directions W - anglure frequence = $2\pi f$

f= Frequency, the number of Cycles completed in one second.

B - is P- wave coefficient in X, Y directions to find displacement or energy at any position initial and boundary conditions are required.

# EFFECT OF VIBRATION OF SURFACE MINING BLAST ON NEAR STRUCTURE

**Morteza Osanloo,Ph.D.**
Mining Eng. Dept. Amirkabir Univ. of Tech.

## ABSTRACT

A mathematical model has been developed to predict the effect of vibration from of surface mine blasting on underground mine roof by measuring the amount of energy that can be transformed from source to corrosponding position. As the model indicated the amount of energy which arrive at corrosponding positions depended up to three factors; distance, weight of Explosive and frequency. These are controlled by blast operator so as long as these factors controlled, the practical results of model sould be reasonable.

### Intoduction

Ever since explosive were discovered and developed for mining purposes, there has existed the problem of what effects from surface blasting on mear structures and underground mines. As a result, many investigations have been made concerning the effect of vibration from surface blasting. But still there is not available and adequate set of standards to predict the damage caused by surface blasting.

One of the first studies was made in 1927 by Rock well, he concluded that surface blasting would not cause any damage to any structures or hurt any people that were 60-90 meters from a surface blast. He believed the effect of vibration depended upon charge size and distance. Following this period, F.J. crandel in 1950 made the major contribution to the research of damage to structures. His effort was based on vibration level in the ground at the location of the structure. Between 1949-1960 interest in the problem of seismic vibration from blasting and their effects on structures gradually increase. From 1960 to 1980 demand for energy and demand for additional information on the vibration problem from strip coal mine blasting, simultaneously increased. A serious problem now existed in determining how mear to an existing structures or under ground mine, a surface mine can safely conduct blasting operations. The objective of this paper is to look at the ground vibrations resulting from surface blasting on near structures and under ground mlme roof to analysis the types of vibrations and displacement at the roof and finally from the ratio of displacement to search for the amount of energy that can be transformed from source to corrosponding position. For this purpose I have chosen a homogeneous, idealy elastic, infinite medium of density with a spherical source of energy and compressional wave velocity.

### Effect of vibration of surface Blasting on mear structure

When an explosive charge is buried in the ground and detonated, it will produce a strain in the walls of hole which the charge is placed due to the development of high pressures from the gases that form, as a