eNergetics 2020

SEISMIC WAVES INCURRED AS A RESULT OF BLASTING OPERATIONS

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INTRODUCTION

Depending on the distance from the center of the explosion, there are different changes noticed in the rock mass. In homogeneous and isotropic environments, three zones can be distinguished: crumbling zone, destruction zone and quake (vibration) zone [1].

Crumbling zone –In this zone, the breaking of the rock is the most intense and the largest amount of available energy is consumed.

Destruction zone – In this zone, the shock wave is significantly weakened and moves at the speed of sound. It causes stresses in the surrounding rock material which result in the creation of cracks of different directions and orientations.

Seismic vibration (quake) zone – In this zone, there is no destruction but the movement of particles of rock masses can make it feel like a quake.

TYPES OF SEISMIC WAVES

According to their behavior and propagation, seismic waves can be divided into two groups:

– *spatial or volumetric waves* - which extend through the rock mass and

– *surface waves* - which spread over the surface of the terrain.

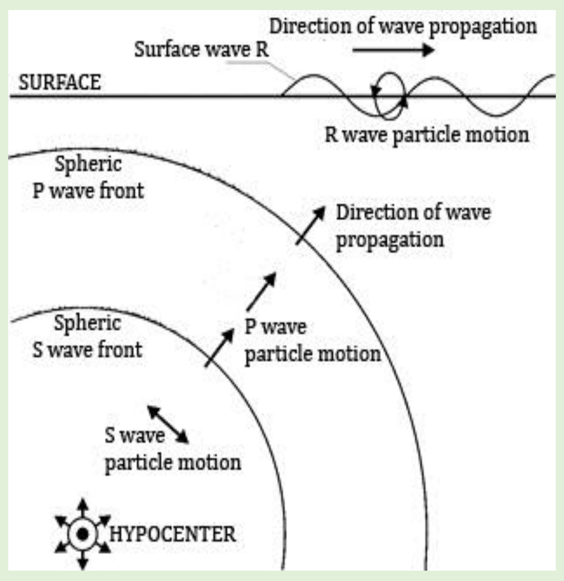


Figure 1. Schematic representation of the propagation of seismic waves

Spatial longitudinal seismic, P wave – which propagates through the rock mass and leads directly to the observed point;

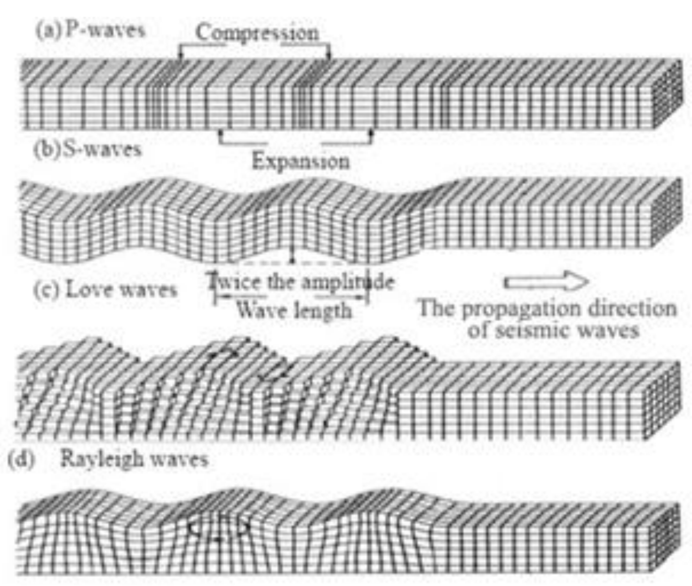


Figure 2. Schematic representation of deformations of rock material

under the influence of seismic waves:

a – influence of longitudinal (pressure-tension) wave,

b – influence of transverse (shear) wave,

c – influence of surface Love wave, and

d – influence of surface Rayleigh wave [3]

PARAMETERS OF ROCK MASS OSCILLATION

The intensity of the quake (seismic vibration) caused by blasting can be determined by measuring one of the three basic parameters that characterize the oscillation of the aroused (excited) soil, and they are:

– displacement of rock mass particles x - the distance at which the particle moves away from its equilibrium position during oscillation,

– ground particle oscillation velocity v - particle velocity during oscillation, and

– acceleration of particles of the aroused environment a - shows the change in oscillation speed, i.e. particle motions.

RECORDING ROCK MASS OSCILLATION VELOCITY

Maximum oscillation speed of the rock mass $v_{\max}$ is determined by the formula:

$$v_{\max} = \sqrt{v_t + v_l + v_v},$$

where:

v_t – transverse component of rock mass oscillation velocity,

v_l – longitudinal component of the rock mass oscillation velocity,

v_v – vertical component of rock mass oscillation velocity.

INFLUENCING FACTORS ON SEISMIC VIBRATIONS

- ENERGY OF SEISMIC VIBRATIONS

The energy of the seismic wave E_{uk} which reaches the observed point, can be expressed as the sum of the kinetic E_k, and the potential energy E_p available to the seismic wave:

$$E_{uk} = E_k + E_p = \rho \cdot \delta \cdot v^2 \cdot \sin^2 \frac{2\pi}{T}\left(t - \frac{x}{c}\right),$$

- PROPERTIES OF ROCK MASS THROUGH WHICH A SEISMIC WAVE PASSES

The energy along seismic wave E is given in the following equation:

$$E = v^2 \cdot c \cdot \rho$$

Energy on both sides of the boundary plane, i.e. the surface separating the different elastic media, is equal and is given by expression:

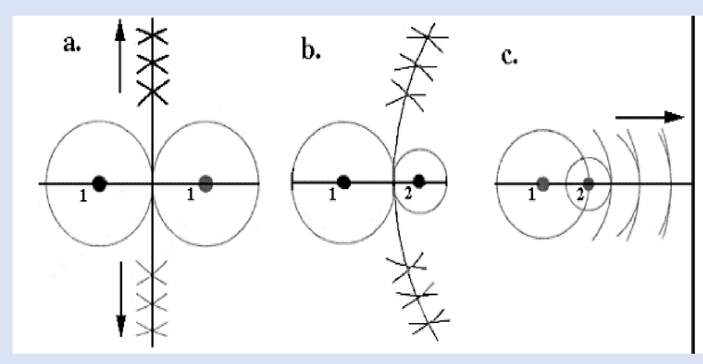
$$E_1 = E_2 = v_1^2 \cdot c_1 \cdot \rho_1 = v_2^2 \cdot c_2 \cdot \rho_2,$$

- IMPACT OF DISTANCE ON SEISMIC VIBRATIONS

One of the most commonly used models is the M.A. Sadovskii which defines the change in the speed of oscillation depending on the distance, the amount of explosives and the way of performing blasting.

$$v = K \cdot R^{-n} = K \cdot \left(\frac{r}{\sqrt[3]{Q}}\right)^{-n}$$

- INFLUENCE OF DELAY INTERVAL ON SEISMIC VIBRATIONS



View of the encounter of waves when activating blast-holes: a) – instantaneous activation, b), c) – delay activation, 1 – currently-activated mine, 2 – mine activated with delay [6]

CONCLUSION

This paper describes the mechanism of generating seismic waves caused by blasting as well as the factors that determine the intensity of seismic vibrations. Based on precisely defined parameters of rock mass oscillation, as well as on knowledge of factors that affect the strength of seismic vibrations, it is possible to optimally use the energy of explosives and minimize the negative effects of blasting.

References

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