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Development of a New Laboratory Technique for Reducing the Peak Particle Velocity Arising from the Blast

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Abstract: Certain vibrational waves are formed as a result of open quarry blasts. The peak particle velocity occurred by these waves provides that structures and people present around the blast point are negatively affected. Thus it is very important that the peak particle velocity is minimum value. In this study, a new laboratory blast technique has been presented for reducing the peak particle velocity formed by vibrational waves occurring as a result of the blast. Two different experiments were carried out in the laboratory. In the first experiment, three peak particle velocities were measured normally. But, in the second experiment, the peak particle velocity value was measured by using the laboratory technique proposed. After that two experiments are compared each other. As a result of the study, it is realized that the proposed technique has considerably reduced the peak particle velocity values.

Introduction

A large part of the production in the open quarries is provided by the blast operations. As a result of the blast operations, vibrational waves are formed and are called as body and surface waves in general. Body waves are divided into two groups as P-waves (primary) and S-waves (secondary). P-waves move in the direction of progression of the vibration (in direction of pressure and tension waves) while S-waves move perpendicularly to the direction of progression of the vibration (Fig. 1).

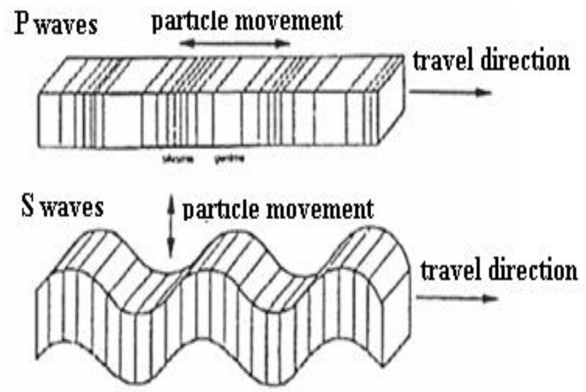

Fig.1 Directions of P and S waves (Bullen and Bolt Bruce, 1985).

Surface waves occur after the body waves and move in close to the surface. They can be divided into two groups as Love and Rayleigh waves. Love (L) waves progress along the line while Rayleigh waves progress in the vertical axis and with reverse return (Siskind etal., 1989). The progression types of these waves are given in Figure 2.

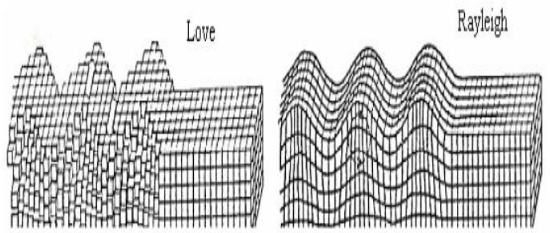

Fig.2 Directions of Love and Rayleigh waves (Bullen and Bolt Bruce, 1985).

The particle velocities are caused by all of these waves and damage to the structures in close places of the blast. Among them the peak particle velocity is used as damage criteria. Thus, it is very important that the peak particle velocity is minimum value during a blast. It was emphasized by the researchers that the peak particle velocity depends on the amount of explosive per delay, the delay interval, the distance between the point of origin of the vibrational source and the point of measurement of peak particle velocity value and the site/damping coefficient (Duvall and Fogelson, 1962; Ambraseys and Hendron, 1968; Longefors and Khilstorm, 1978; Ghosh and Samaddar, 1984; Pal Roy, 1991; Singh et al., 2002; Kahriman, 2002). Suitable blast hole mechanisms are arranged by using the said parameters for reducing the peak particle velocity caused by the vibrational waves. In these methods, the amount of explosive is used either in small quantities or it is ensured that the delay intervals between the blast holes are kept long. However, if the amount of explosive used per delay is limited, suitable particle size cannot be obtained. This situation causes an increase in the costs of loading, transportation and crushing operations that are the subsequent phases of the production. The technique of keeping the delay intervals long between the blast holes is not also sufficient, even if it endures the damping of a certain amount of waves.

In this study, a new technique tested at the laboratory for reducing the peak particle velocity arising from the vibrational waves. Two different types of tests were performed in the laboratory. In the first test, three peak particle velocities were determined according to the method used in general. However, in the second one, the peak particle velocity value was measured according to the technique proposed in the laboratory envsteelment. After that two tests are compared with each other and it is seen that the proposed technique has considerably reduced the peak particle velocity value at the end of the study.

Definition of the Proposed Technique

In the blasts where the delay system is used, the blast holes are not blasted simultaneously but consecutively with certain delays. The peak particle velocity is directly proportional to the amount of explosive. While, the peak particle velocity is low in the blast holes containing small quantities of explosives. However, in the holes containing more explosives, the peak particle velocity is higher. From this point of view, the blast holes can be designed by the least amount in the blast hole to be blasted first, a little more than the previous one in the holes to be blasted subsequently according to the length of the delay and the maximum amount of explosives in the last hole to be blasted. Thus, the vibrational waves created by the blast holes blasted with certain periods one after another can dampen the waves by catching each other along the propagation. In this way, the peak particle velocity occurring as a result of blast can be reduced considerably. Table 1 gives as an example the delay intervals and the amount of explosives used in the proposed technique. These values were only presented for expressing the logic of the technique.

Table 1 The using logic of proposed technique and presented.

The delay intervals of blast holes	The amount of explosive material of the blast holes	Blast sequence
First blast hole, 25 ms	1 unit explosive material	1
Second blast hole, 50 ms	1.1 unit explosive material	2
Third blast hole, 75 ms	1.2 unit explosive material	3
Fourth blast hole, 100 ms	1.3 unit explosive material	4

An object free fall method was used in order to ensure the application of the technique explained above. Thus, the formation of the vibrational waves caused by the explosive blasted per delay was ensured onsite. As known, the square of an object’s fall time from a certain elevation due to free fall technique is directly proportional to its falling elevation. In other words, an object falling from a higher point will be dropped to the ground in a longer period of time. This condition has also caused the formation of the delay intervals. Again according to the free fall technique, the amount of energy created by the object left to ground from a point higher than the free fall technique is higher. The usage of different elevations also means different amounts of explosives blasted per day onsite.

Laboratory Studies

It was ensured that the site/damping coefficients are fixed in the tests by measuring the peak particle velocity values always in the same direction. Also, the distance between the point of origin of the vibration source and the point of measurement of the peak particle value was always taken as 60 cm. Thus, the peak particle values only depend on the size of energy and the delay interval creating the vibrational waves.

Two different types of tests were performed in the laboratory envsteelment. In the first of them, a steel ball weighting 242.5 gram was dropped to the ground with the free fall technique from the elevations of 30, 40, and 50 cm and three different vibration sources were created separately. In the tests, three different peak particle velocity values were measured by placing the geophone to the point 60 cm away from the point, where the source of vibration was created (Table 2). The vibration measuring device and steel ball used in the tests are seen in Figure 3. In Figure 4, the point of origin of the vibration source and the measuring points are seen.

Table 2. The results of tests.

The distance of steel ball dropped (h, cm.)	The distance between the point of origin of the vibration source and the point of measurement of the peak particle value (R, cm.)	The peak particle velocity measured (V, cm/s.)
The first type test		
30		0.105
40	60	0.120
50		0.145
The second type test		
30		
40	60	0.065
50		

However, in the second test, three steel balls having the same weight (242.5 g) were dropped to the ground simultaneously again with the same free fall technique from the elevations of 30, 40, and 50 cm in order to obtain suitable delay systems. At this point, while the energy and the delay interval created by the steel ball dropped to the ground from an elevation of 50 cm has been the highest, the energy and the delay interval of the steel ball dropped to the ground from an elevation of 30 cm has been the lowest. In this test, the peak particle velocity value was measured again at the point

60 cm away from the point of origin of the vibration source. Obtained results are given in Table 2.

Fig. 3 Vibration device and the steel ball used in the tests.

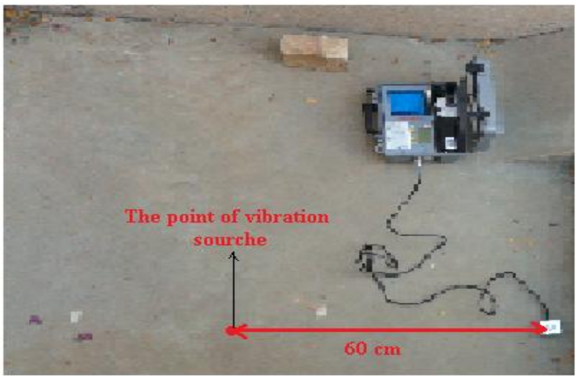

Fig. 4 The point of vibration source and the point of peak particle velocity measured.

Evaluation

As also seen from Table 2, the peak particle velocity value formed when three steel balls having the same weight are dropped simultaneously from the elevations of 30, 40, and 50 cm was measured as 0,065 cm/s. This value is considerably lower than peak particle velocity value formed by the steel ball dropped from the elevation of 30 cm, where the lowest energy was created (0,105 cm/s). This condition shows that the proposed technique reduces the vibrational waves.

This proposed technique must be applied in the site conditions and the results must be evaluated. Also, in the site conditions, the explosive amount and the delay period needed by the blast holes must be determined in order to obtain the minimum particle velocity value.

Conclusion

In this study, a new laboratory technique was developed for reducing the peak particle velocity arising from the blast and the tests of the technique were performed in the laboratory. Two different types of tests were performed in the laboratory. In the test of the first type, three peak particle velocities were determined normally. However, in the second one, the proposed technique was applied and peak particle velocity value was measured. The results obtained from both test types were compared with each other. During the comparison, it was concluded that the peak particle velocity value belonging to the test performed by the developed technique (0,065 cm cm/s) was considerably lower than the peak particle value (0,105 cm) determined without applying the technique. The distance between the point of origin of the vibrational source and the point of measurement of the particle velocity were taken always the same (60 cm). Also, it was ensured that the site/damping coefficients are kept fixed again by performing all tests always in the same direction.

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