THE EFFECT OF VARIATIONS IN TIME DELAY BETWEEN DETONATIONS ON QUARRY BLAST VIBRATIONS

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Approximately ten years ago the short delay method of blasting rock in quarries was successfully used commercially for the first time. A millisecond delay quarry blast is one in which the laterally aligned holes are successively detonated. It was found that vibrations from elastic waves emanating from short delay blasts were much less than those caused by the conventional method of blasting, in which all holes are discharged instantaneously. The degree of crushing of the rock was also found to be greater using millisecond delay rather than instantaneous methods. However, it was noticed that these two effects varied with different millisecond delays, which imposed the problem of finding the optimum time between detonations; that is, the time at which the amount of vibrations will be the least and the degree of crushing the greatest.

This work is limited to the identification and comparison of certain seismic phases on seismograms obtained 1000 to 1500 feet from quarry blasts, where the main variable is millisecond delay time between detonations of a single shot. Fourier analysis, which can analyse a portion of a seismogram regarding frequency content, and the more conventional seismic methods were employed in this study.

From the many amplitude and energy analyses made, it appeared as if high frequency energy increased and low frequency energy decreased with the increase of delay time. The Fourier analyses presented no conclusive answers, but the use of other methods confirmed the following conclusions.

The following conclusions were reached from the examination of the records:

1. Compressional energy which is devoted to the formation of body waves is increased with the increase of millisecond delay from 0.015 to 0.025 second. The greatest difference is noted between the 0.015 second delay and the 0.020 and 0.025 second delay shots.

2. Shear energy does not increase but might be decreased with the increase of millisecond delay time from 0.015 to 0.025 second. The shear energy is less for a three hole 0.030 second delay than for a single hole blast containing the same charge per hole.

These conclusions as to energy distribution actually refer to the waves as recorded; by inference it is presumed they also hold for the energy released at the source.

3. The vertical component of the Rayleigh wave is decreased with the increase of millisecond delay time from 0.015 to 0.020 second. No appreciable difference in this wave could be noticed between the 0.020 and 0.025 second delay blasts.

4. The Rayleigh and Love type surface waves are less for a three hole 0.030 second delay blast than for a single hole blast with the same charge per hole.

5. This investigation indicates that 0.015 second is near the time of separation of characteristics from instantaneous and millisecond delay blasts.

6. In two cases synthetic records of a 0.030 second delay blast were compared to the actual records. This comparison revealed that the compressional body energy from a three hole 0.030 second delay blast is greater than that produced by a synthesis of waves emitted from each hole acting individually. It also indicated that shear body energy is less than that produced by a synthesis of waves from each hole.

Upon consideration of the above results, the mechanism appears to be more complex than just the cancellation of waves, although some long period waves may be cancelled. The energy is probably redistributed from surface and possibly, shear waves to compressional, body waves.