EARTH WAVES GENERATED FROM QUARRY BLASTS

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The purpose of this investigation was to carefully study blast vibrations recorded from one quarry in regard to the velocity of the waves producing the prominent phases on the records and the variation of phase amplitudes with the changing of two important parameters during normal quarry operations. These parameters were the depth of the shot holes and the weight of dynamite (60% gelatin) used per blast.

Two hundred records of 40 blasts extending over a period of two years were used in this study. All of these blasts were detonated by millisecond delay at the Alpha Portland Cement Quarry of Saint Louis County, Missouri, and varied in weight of dynamite from 1,700 to 4,000 pounds per blast. These blasts occurred within two distinct sections of the quarry. The sections were about 300 feet apart with the walls of one section averaging about 90 feet in depth, whereas, the walls of the other averaged about 60 feet.

Alpha Quarry is located in the dense limestone of the Saint Louis formation of Middle Mississippian age. The formation varies in thickness from four

to 220 feet. The floor of the quarry is about 50 feet above the base of the Saint Louis formation. Deposits of glacial debris, loess, and valley fill occur sporadically to a depth of 40 feet in the region surrounding the quarry.

Prior to June 1953, all the blasts were recorded on two horizontal Wood-Anderson seismographs and one vertical Macelwane-Sprengnether seismograph at Saint Louis University plus two horizontal Wood-Anderson seismographs at Florissant. An attempt was made to correlate the phases recorded at Florissant with those recorded at Saint Louis, however, due to the difference in distance between the quarry and the two stations difficulties were encountered, since it soon became evident that the initial phases recorded at these two stations were not due to the same type of waves. The distances between Alpha Quarry and the Saint Louis and Florissant stations are respectively 15.16 and 31.57 kilometers.

After June 1953, high magnification Reeft seismographs comprising a vertical and two mutually perpendicular horizontals were installed in the Saint Louis University seismograph vault. Collection of

records from these instruments commenced in September of 1953, when the instruments were adjusted to high sensitivity. Analysis of the records disclosed well developed phases identifiable as the P, S, and Rayleigh waves. Records produced by the vertical Reeff seismograph showed a disparity in the phase characteristics, however, records produced on the horizontal instruments could be more or less typed by phase characteristics.

A comparison of the amplitudes for the P and S phases recorded on the north-south Reeff seismograph for different blasts showed the magnitude of the S phase was generally proportional to the weight of dynamite used per blast regardless of the section of the quarry in which the blast might occur. A similar comparison of the Rayleigh phase recorded on the vertical Reeff seismograph showed that the amplitude for the Rayleigh phase was independent of the weight of dynamite used per blast, but was controlled by the depth of the shot holes.

With the use of the Sprengnether Three Component instrument in regular portable recording of quarry blasts, 11 records have been made at selected sites

within 1,850 to 4,700 feet of the quarry. All of the blasts recorded on the longitudinal and vertical components of this instrument were reduced to particle motion trajectories in the hope of recognizing the initial arrival of the Rayleigh wave. It was discovered that the initial arrival of this wave could not be determined by this means.

A phase characteristic appeared consistently on the vertical component of the portable instrument which could be recognized on all of the records except one. An indirect method was used incorporating this recognizable feature to determine the most probable apparent velocity of the P, S, and Rayleigh waves in the vicinity of Alpha Quarry. This method consisted of using established ratios between the P, S, and Rayleigh waves against the observed appearance of this Rayleigh phase characteristic plus the observed Rayleigh phase recorded by the vertical Reeff seismograph at Saint Louis University. Using this argument, the apparent velocities of the P, S, and Rayleigh waves in the vicinity of Alpha Quarry were determined to be as follows: V_p = 11,500 feet per second, V_s = 6,570 feet per second, and

V_r = 6,040 to 6,280 feet per second. The decreasing speed of the Rayleigh wave with time at a given distance probably shows the dispersive nature of the Rayleigh wave.

A careful study of the Sprengnether Three Component seismograph records was made to recognize, if possible, surface waves recently identified by other authors. Positive identification of phases resulting from these waves could not be made due to lack of wave separation and consequent phase build up. The inconclusive results could be due in part to millisecond delay blasting, to underdamping of the instrument, or to the terrain.

Greater amplitudes were recorded by the portable seismograph resting on overburden than on indurated rock. This explained why larger amplitudes were recorded at one location in comparison with another for two blasts. The locations were at comparable distances from the quarry and comparable weights of dynamite were used for the blasts.