Engineering
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CROSS-HOLE RADAR USED TO LOCATE MINED-OUT AREAS

MEA was contacted to conduct a geophysical investigation to determine if undermining occurred at a project site located along a river in north central Illinois. A parking lot between two businesses was damaged by slope instability; other areas in the immediate vicinity were noted to have damage as well.

Based on available coal mining records, the project site was not undermined, but there was a possibility that the areas subjacent to the site could have been mined-out. If the site was undermined, subjacent mine instability could have played a part in the resultant sliding. Therefore, this investigation was critical to determine whether or not an underground mine existed. For this particular project, cross-hole radar was chosen because of its cost-effective reliability in an investigation of this type.

A coal seam is bounded above and below by materials with different electrical properties than that of the coal. Because of this, it is possible to use electromagnetic (radio) waves to detect anomalies in the coal seam, such as air or water filled voids.

The cross-hole radar process begins with two antennas being lowered down boreholes to the region of the coal seam; the center of the seam is preferable. A radio signal is transmitted from one antenna and propagates through the coal to a receiving antenna with a certain attenuation rate. The rate of attenuation is typically determined by properties of the coal. In a solid coal seam, the attenuation rate is a function of the distance between the two antennas and is a linear relationship. The attenuation rate can be significantly altered by naturally occurring anomalies such as faults, sandstone channels, variations in seam thickness, and variance of moisture content. The presence of mined-out areas, or voids, will produce a greater attenuation for the ray path in, or in the vicinity of, the void (see Figure 1). If a void is filled with either air or water, there will be an increased attenuation with the water-filled void being of the highest attenuation.
By evaluating the strengths of signals transmitted along different ray paths between pairs of

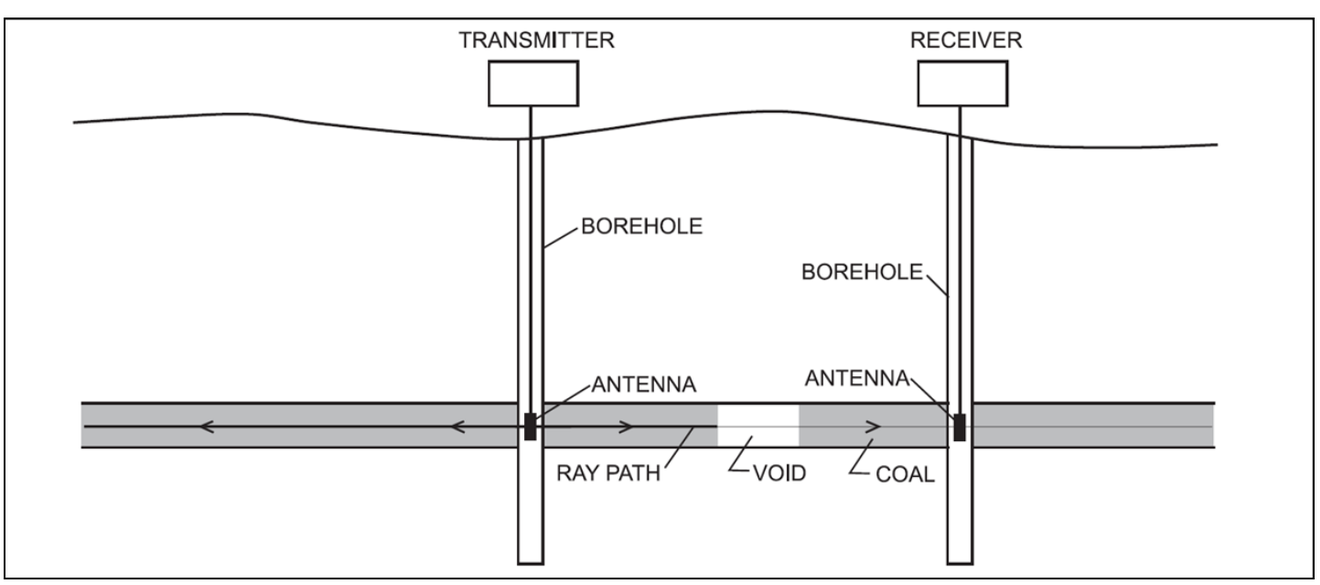

FIGURE 1 BOREHOLE RADAR SYSTEM SHOWING RAY PATHS AND ATTENUATION BY A VOID IN THE COAL SEAM

boreholes, an average attenuation rate of the solid coal be established. Once established, the attenuation rate can be used to determine if the presence of a void is probably in the ray path.

Five borings were drilled and cased with 3-inch PVC pipe though the Herrin No. 6 Coal on the project site. The Herrin No. 6 Coal was the nearest seam that was prospected in mines closest to the site. The depth to the top of the coal ranged form 60 to 65 feet with a seam thickness of 4.8 to 5.3 feet. The cross-hole radar survey was conducted between the five different borings on site with the path between Borings 1 and 2 being the calibration path; the site layout and ray paths can be seen on Figure 2.

The relationship between received signal strength versus the distances between borings can be seen on Figure 3. An average line has been drawn in between the points with an average attenuation rate of 35.0 dB per 100 feet; this attenuation rate is consistent with those measured in solid coal at other sites. The relationship of the points to one another on the plot are very close to a straight line. The deviation of points from the average is very minimal, no point deviating more than a couple dB per path. If a void were present, either water or air filled, a significant deviation from the average line would be present. These measurements are consistent with that of a solid coal seam containing no voids. With no voids being detected, the coal mining was clearly not a contributor to the landsliding.

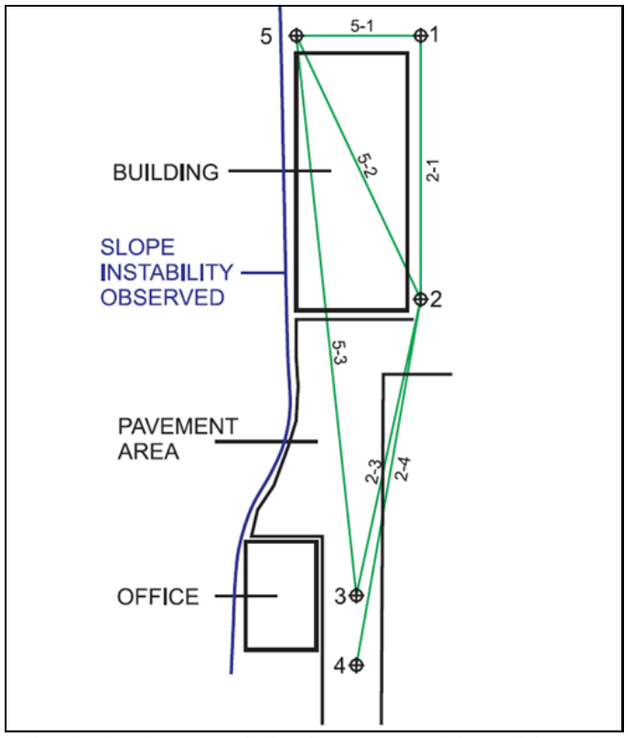

FIGURE 2 DRAWING OF SITE WITH BORINGS AND SIGNAL PATHS SHOWN

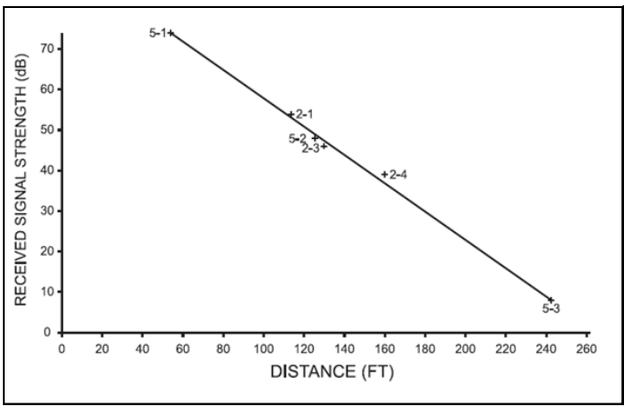

FIGURE 3 RECEIVED SIGNAL STRENGTHS VERSUS DISTANCES FOR RADAR PATHS

Other Engineering UPDATES of Interest:

UPDATE 27: Borehole Radar Used to Identify Deep Coal Pillars

UPDATE 10: Borehole Radar Determines Solid Coal and Mined-Out Areas

UPDATE 1: Successful Deep Mine Backfilling to Mitigate Mine Subsidence

ABOUT MEA: Marino Engineering Associates, Inc. focuses on engineering research, practice and expert evaluations and is licensed in 24 states in the U.S. Our projects primarily have an emphasis on Geotechnical Engineering, however, we also have significant experience in projects involving transportation, subsidence engineering, laboratory testing, training, and geophysical exploration. Gennaro G. Marino, Ph.D., P.E., D.GE is president and principal engineer of Marino Engineering Associates, Inc., and has been a licensed professional engineer since 1984. To obtain additional information on MEA, one can also visit our website at www.meacorporation.com.

FOR MORE INFORMATION: There is a significant amount of additional information that is available on the above subject. For more information, please contact Dr. Marino at the address listed below.

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