

Application of Ground Penetrating Radar in Deep Detection of Crushed Stone Pile Foundation

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Abstract: In order to truly and intuitively reflect the construction quality of Vibro-sinking gravel pile foundation, improve construction efficiency and reduce manual investment, in this paper, the application of ground penetrating radar (GPR) in the depth detection of Vibro-sinking gravel pile foundation is discussed based on the exploration geophysics and geological engineering technology, the geological characteristics of Yibin area and the measurement data of intelligent monitoring system of Vibro-sinking gravel pile machine.

1. Gravel pile

Ground treatment is carried out in the karst geomorphic limestone area, and detailed engineering surveys are carried out before the construction process, even if the survey work is done very carefully. However, when the actual construction was carried out on each gravel pile, the preliminary survey data appeared to be stretched. In the process of pile foundation construction, it is very important to ensure that the end of each pile is embedded in a stable soil layer with a certain bearing capacity thickness, and whether there is an unstable geological body at the bottom of the pile becomes very important.

Gravel pile composite foundation is a composite foundation formed by compacting sand and gravel into holes in soft foundation by vibration, impact or water flushing according to certain spacing and distribution of gravel pile. Its inspection and evaluation are mainly divided into two aspects: one is the inspection and evaluation of pile quality. It mainly inspects and evaluates the uniformity and compactness of gravel pile. The second is the inspection and evaluation of gravel pile composite foundation to verify whether it can meet the design requirements of bearing capacity. A large number of engineering practices show that the bearing capacity of gravel pile composite foundation can easily meet the design requirements. Therefore, strengthening the control of the quality of the gravel pile body is the key to ensure the quality of the gravel pile composite foundation. Heavy-duty power probe technology has the characteristics of low cost, quick effect and simple construction. JTG F10-2006 ((Technical Specification for Highway Subgrade Construction) applies this technology to the quality inspection of gravel piles, and stipulates that when the penetration is 10cm, the number of hammers is more than 5 times. However, in actual inspection, often It will encounter a phenomenon that the hammering number of a 10cm penetration pile is less than 5 times. If this is regarded as an unqualified pile, the pile body quality of the gravel pile will be greatly underestimated, resulting in a large number of piles with good performance being misjudged as not. Qualified piles cause waste of engineering.

Conventional methods for quality inspection of gravel piles include sonic method and core drilling method. Due to the low frequency of the acoustic wave method, the resolution of the target body is not high, and the method is discontinuous at a single point detection location, which is likely to cause large errors. Although borehole core sampling and dynamic penetration method have the characteristics of intuition, reliability and high accuracy, they have the limitations of damaged pile foundation, poor representation, low efficiency and high detection cost.

2. Ground penetrating radar

Ground Penetrating Radar (GPR) testing technology is to use high frequency electromagnetic wave in the form of broadband short pulse. On the ground, the signal is sent to the ground by transmitting antenna, and then it is reflected back to the ground by the stratum interface or the target body. Then it is twisted by receiving antenna to receive the reflected signal of electromagnetic wave. A method for understanding the characteristics of the formation or the target by analyzing the time-frequency characteristics and amplitude characteristics of the reflected signals of the electromagnetic waves (Fig. 1) [1]. Due to the high resolution of the high-frequency electromagnetic wave, the abnormal advantage of detecting the shallow part is obvious, and the scale of the abnormality can be visually and quantitatively identified.

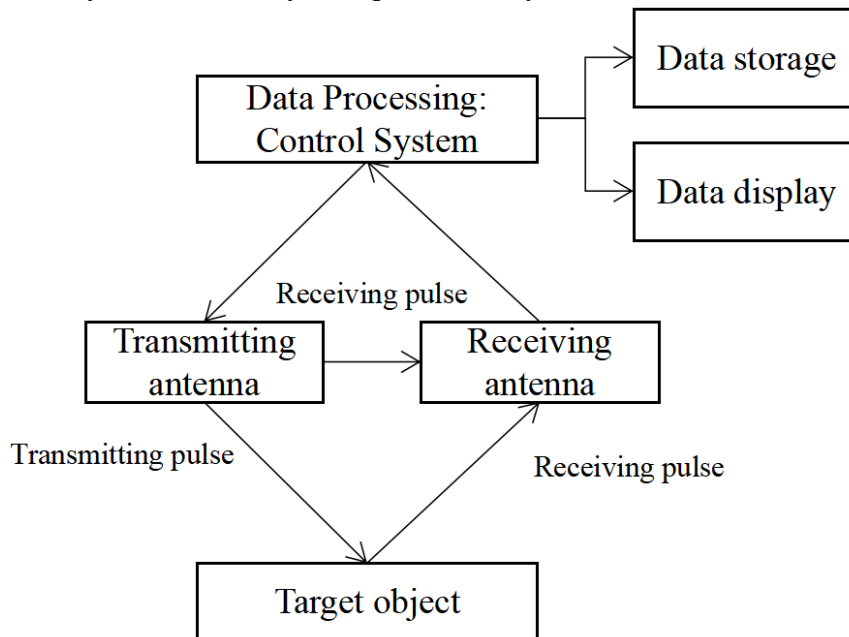


Fig. 1. Working Principle of Ground Penetrating Radar

3. Reconnaissance mode

Ground penetrating radar (GPR) detection technology usually divides the mobile antenna mode of ground penetrating radar (GPR) into common drag antenna Time-Reading mode, antenna specific point mode and common midpoint mode according to the characteristics of buried targets, field conditions and research purposes [2].

(1) Reading mode when the antenna is dragged: it is the transmitting antenna and the receiving antenna moving at a specific pitch for surveying. When dragging the antenna, the result of the read mode survey can be expressed by the time profile image, which records the antenna's position before and after transmission, thus converting it into the depth of the target (Fig. 2).

(2) Antenna Specific Point Mode: It surveys the propagation velocity of electromagnetic wave between the ground and the target body by single point transmission. That is to say, in the survey process, the center position of the transmitting antenna and the receiving antenna is kept fixed, and the propagation speed of each electromagnetic wave is recorded, thereby being converted into the depth of the survey target (Fig. 3).

(3) CMP (common midpoint) mode: It refers to the collection of CMP (common midpoint) points (Figure 4).

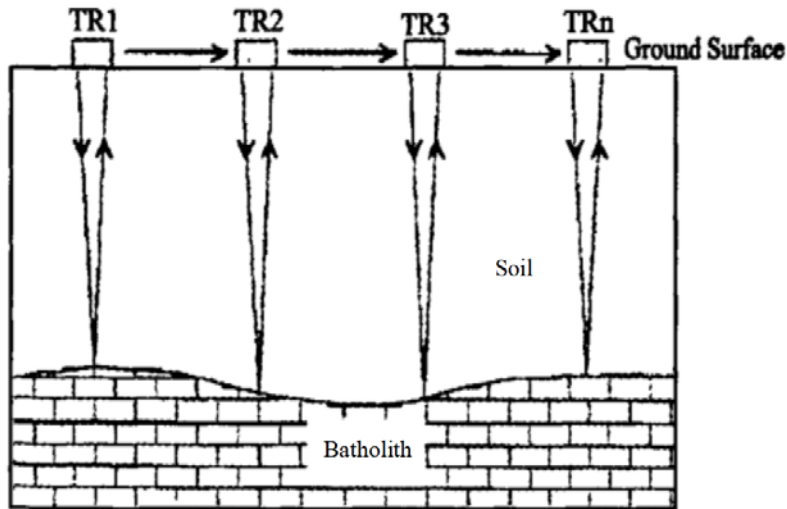


Fig.2. Read mode when dragging antenna

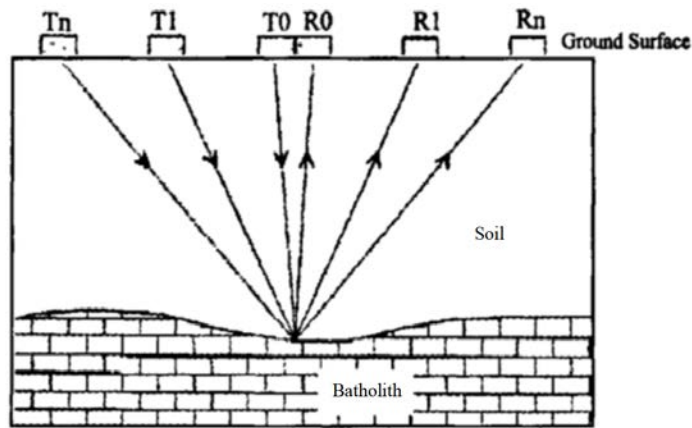


Fig.3. Antenna Specific Point Mode

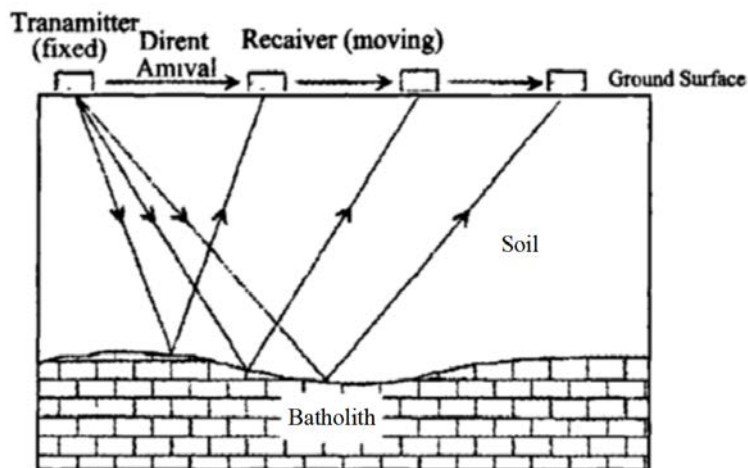


Fig.4. CMP (common midpoint) mode

4. Data processing

Because the propagation form of electromagnetic wave in underground is very similar to seismic wave, and the data profile of ground penetrating radar is similar to that of reflection seismic data, many effective techniques of reflection seismic data processing can be used in the data processing of ground penetrating radar. In the drag antenna mode and the specific point mode, since the

antenna spacing is constant during the movement, the complexity of the underground medium composition and the difference of the electromagnetic wave absorption degree of different media. When the radar wave reaches the receiving antenna, the amplitude is reduced and the waveform is disordered, which is quite different from the original transmitted waveform [3]. In addition, various interference noises also distort the formation reflection information.

Therefore, according to the investigation of site survey and construction conditions, select the appropriate ground penetrating radar instrument and conduct on-site test in the established detection zone. Determine reasonable acquisition parameters, including antenna type, acquisition mode, number of scan samples, scan rate, scan time window, and gain mode. Then, according to the prescribed line, radar observation and data acquisition are carried out for highway cast-in-place gravel pile and work area. During acquisition, the radar antenna is placed on the ground, moving horizontally and uniformly in a straight line along the measuring line, and high-density CT scanning is carried out during the course of moving, so as to obtain the precise image of electromagnetic reflection wave.

5. Deep Detection of Crushed Stone Pile Foundation

In general, the purpose of using cast-in-place gravel pile in soft roadbed section of highway is to prevent settlement and slip of roadbed and enhance the bearing capacity of roadbed. The dielectric constant of soft clay and wet silt is usually greater than 12, while that of cast-in-place gravel pile is usually less than 8. In addition, during the construction process, the mechanical properties and structure of the rock and soil are greatly damaged. As a result, there is a large electrical difference or wave impedance difference between the gravel pile and the surrounding rock undisturbed soil and the underlying intact hard foundation. This provides a good earth for the non-destructive testing of the road-filled gravel pile by ground penetrating radar. Physical conditions [4]. The survey process is (Figure 5):

- (1) Emission of electromagnetic waves. The transmitter in the radar system emits electromagnetic waves underground through a wide-band transmitting antenna
- (2) Reflection or refraction occurs. During the propagation process, electromagnetic waves are reflected or refracted when they encounter different electrical media interfaces, and the waves are transmitted back.
- (3) Receiving signals. The receiving antenna receives the return signal, then converts the return signal into digital information and transmits it to the host.
- (4) Data image processing. The computer processes the return information of the receiving antenna, transforms it into data and images, and calculates some parameters of the reflecting medium, so as to zone the medium interface and calibrate the medium strength accurately.

Compared with conventional methods, ground penetrating radar (GPR) detection technology has the characteristics of nondestructive, efficient, simple, continuous, fast and safe, and can display high-resolution continuous profiles. Furthermore, it provides a large amount of information about underground fine elements. This technology has broad application prospects in the quality inspection of pile foundation and composite foundation engineering.

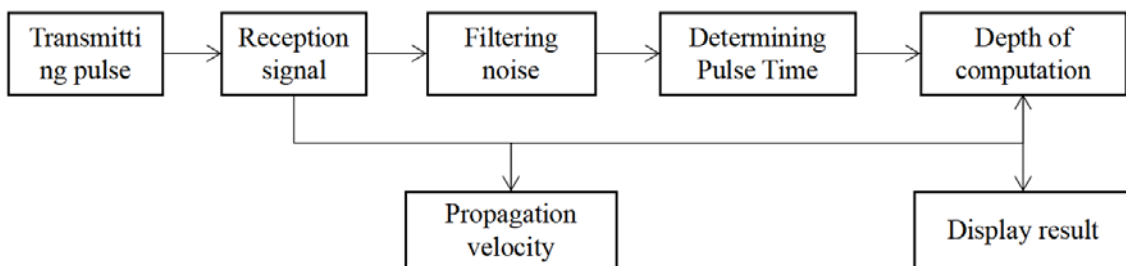


Fig.5. Flow chart of radar intensity measurement

6. Conclusion

According to the basic geological data in Yibin area, the bottom-sounding radar measurement scheme is formulated, the vertical and horizontal resolution of electromagnetic wave frequency in the area are analyzed, and the central frequency of antenna and the mode of mobile antenna are selected. Combined with the measurement data of the intelligent monitoring system of the vibrating sinking gravel pile machine, the application of ground penetrating radar in the depth detection of the vibrating immersed gravel pile foundation is discussed.

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