Analysis on Advantages and Disadvantages of Reflected Wave Method in Pile Quality

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Abstract

In this paper, the basic principle of low-strain reflected wave method and the method of judging the test result are introduced. The advantages and disadvantages of the method are demonstrated by engineering examples.

Keywords

Reflection, Foundation pile, Integrity defect.

1. Introduction

With the rapid development of China's real estate industry, residential floor height has been repeatedly broken, the increase of the height of the floor will inevitably lead to the increase of the load of the superstructure, which puts forward higher requirements for the bearing capacity of the foundation. The ordinary shallow foundation can no longer support the upper load. Integrity of the upper structure directly affect the stability, so the integrity of the detection of pile foundation is very important, reflected wave method in the detection of pile foundation with fast, convenient and direct advantages, is widely used in the project.

2. Fundamentals and methods of determination

2.1 Fundamental

The low-strain reflected wave method propagates the stress wave generated by the exciting force by applying the exciting force at the top of the pile,When the wave should be encountered when the concrete interface is not continuous,such as: empty, mud, cracks and other defects, or the pile body cross-sectional area changes, such as: reduction, expansion and so on, The reflected wave will reflect and transmit at the interface, at this time, the sensor placed at the top of the pile receives the reflection signal at the interface of the defect and the reflection signal at the bottom of the pile. The type of the defect and the distance from the top of the pile are obtained through analysis to achieve the purpose of detecting the pile quality [1].

2.2 Defect type judgment method [2]

Assume that pile of concrete, uniform medium, the pile body as one dimensional elastic rod (as shown in figure 1), the density of concrete ρ, pile body interface area A, pile length L, elastic modulus E, wave velocity for $C^2 = \frac{E}{\rho}$,

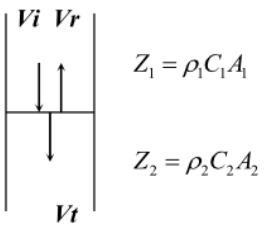

Figure 1

The wave impedance of the cross section A_1 is $Z_1 = \rho_1 C_1 A_1$

The wave impedance of the cross section A_2 is $Z_2 = \rho_2 C_2 A_2$

From continuity conditions and Newton's third law:

$$V_i + V_r = V_t \tag{1}$$

$$A_1(\sigma_i + \sigma_r) = A_2 \sigma_t \tag{2}$$

In the formula, V、σ respectively particle vibration velocity and the stress, The subscript I, r, t, respectively incident wave and reflected wave and transmission wave.By the law of conservation of energy conditions

$$\sigma_i = -\rho_1 C_1 V_i \qquad \sigma_r = \rho_1 C_1 V_r \qquad \sigma_t = -\rho_2 C_2 V_t \tag{3}$$

Substituting the above expressions into (2)

$$Z_1(V_i - V_r) = Z_2 V_t \tag{4}$$

Associated with (1) and (4)

$$F = \frac{Z_1 - Z_2}{Z_1 + Z_2} \tag{5}$$

$$T = \frac{2Z_1}{Z_1 + Z_2} \tag{6}$$

$$F = \frac{V_i}{V_r} \tag{7}$$

$$T = \frac{V_i}{V_t} \tag{8}$$

Where F represents the reflection coefficient,

T represents the transmission coefficient,

T is always positive, and the integrity of the pile is judged by the positive and negative values of F, in the following cases:

(1) When F> 0, that the reflected wave and incident wave phase, that is, 2C2A2, if A1 = A2, no change in the pile section, there are 2C2, indicating that the stress wave from the impedance of the large side of the resistance to pass to the small side, which It is equivalent to the hollow section of the pile body, mud, cracks and other defects;When 2C2, said pile medium dense, pile material without defects, there A1> A2, indicating that the stress wave is a large cross-sectional area of the side of the cross-sectional area of small side,this is equivalent to the quality of the pile body necking defects

(2) When F <0, the reflected wave and incident wave inversion phase, namely 2C2A2,If A1 = A2, no change in the pile section, there are 2C2, indicating that the stress wave is from the impedance of small cross-section to the impedance of the large cross-section, this is equivalent to the case of rock-socketed piles,when 2C2, there are A1 <A2, indicating that the stress wave is a small cross-sectional area of the side of the interface to the large area of the side,in the project is equivalent to the case of the expansion.

(3) When F= 0, Then the pile quality is complete, no defects

Determination of Pile Defect Position:

$$L_x = \frac{Ct_x}{2} \tag{9}$$

In the formula: C —The average velocity of the pile

L_x —Distance of pile defect to pile top

t_x —The reflection time from the top of the pile to the defect,

$$C = \frac{2L}{t} \tag{10}$$

t —The time of reflection from pile top to pile bottom

2.3 Classification of Pile Integrity

Table 1. Classification of pile integrity by low strain method

Category	Classification principles	Time domain signal characteristics
Class Ⅰ Piles	Pile integrity	2L / C moment before the non-defective reflected wave,a pile bottom reflected wave
Class Ⅱ Piles	The pile has a slight defect,will not affect the normal carrying capacity of the pile structure	2L / C time before the emergence of minor defects reflected wave,a pile bottom reflected wave
Class Ⅲ Piles	The pile has obvious defects,which has influence on the bearing capacity of the pile body	There are obvious defects reflected waves, other features between the class Ⅱ pile and Ⅳ class pile
Class Ⅳ Piles	There is a serious defect in the pile body	2L / C before the moment of serious defects reflected wave, or periodic reflection, no pile bottom reflected wave; Or due to serious defects in the shallow depth of the pile presents a low frequency large amplitude attenuation vibration, no pile bottom reflection wave

3. Site detection technology[3][4]

(1)Pile head treatment: Before the test to the pile head of the floating slurry removed, exposing the hard concrete surface, and then use the angle grinder to install the sensor and the hammer striking part of the polished, in order to facilitate the acquisition of the real pile bottom reflection signal;

(2)Sensor installation: the sensor should be installed on top of the vertical pile, the choice of good contact with butter or plastic mud as a coupling agent, as far as possible the thinner the better contact surface;

(3)Site test points should be based on the pile diameter to determine, greater than 0.8m should be no less than 2 measuring points, greater than 1.2m should be no less than 3 measuring points, pile diameter greater than 2m should be no less than 4 measuring points, hammer The point of installation of the touch point distance sensor shall be not less than R (R means pile diameter);

(4)Each test point should be at least three percussion, on-site observation of the consistency of three waveforms, if the waveform consistency is better, you can change a measurement point, if the consistency is poor, should identify the reasons for re-testing;

(5)If the field test for the concrete pile, pile head reinforcement should be cut away, so as not to introduce the test curve of the external interference signal;

(6)Site hammering should be used in different materials, usually with plastic head test deep defects, with the first test of aluminum shallow defects

4. Project example

By using the reflected wave method to test different types and different pile diameter pile,the advantages and disadvantages of the reflected wave method in the integrity testing of foundation piles are compared and analyzed,to provide advice and services for the construction of the project

The project is a residential building, CFG pile for foundation reinforcement, pile diameter of 0.4 meters ,the pile length of 14.5 meters, concrete strength C25,with the reflection wave method test 12 #, 14 # pile, with plastic hammer, aluminum head respectively knock Hit pile top, the measured curves are shown in Figure 2, Figure 3, Figure 4, Figure 5 shows

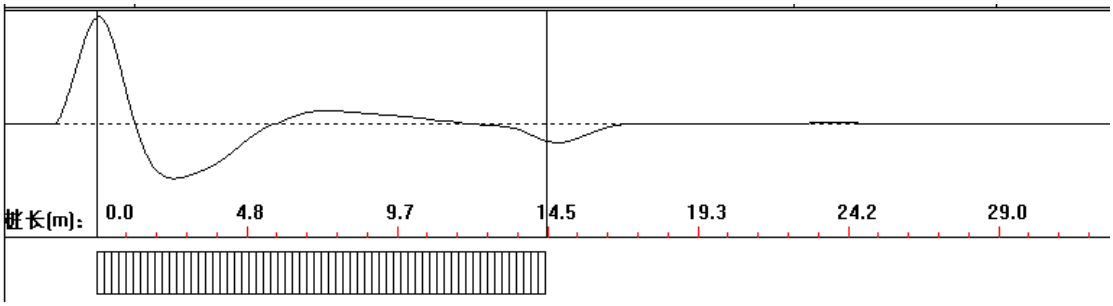

Figure 2

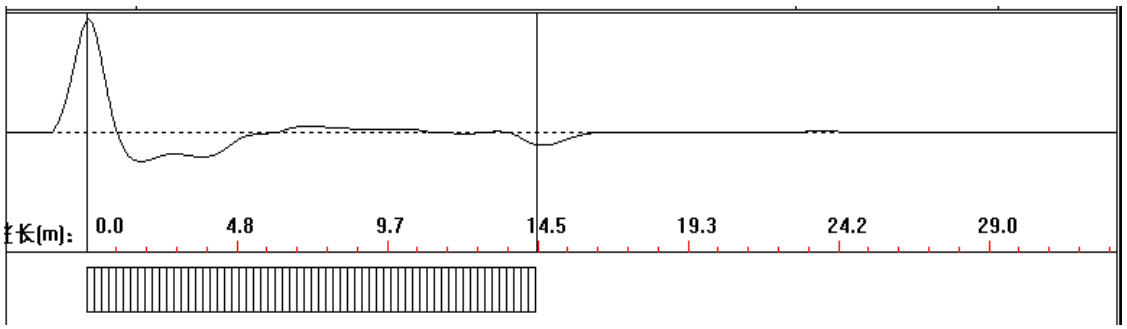

Figure 3

It can be seen from the waveform curve that the pile bottom reflection is obvious, the bottom of the reflected wave and the incident wave into the opposite phase, indicating the pile diameter, this defect in terms of foundation bearing capacity is beneficial,there is no other defect reflection wave before the low reflection wave of the pile, the results of the plastic head percussion and the aluminum head percussion are consistent, it can be judged that the pile is class Ⅰ pile;

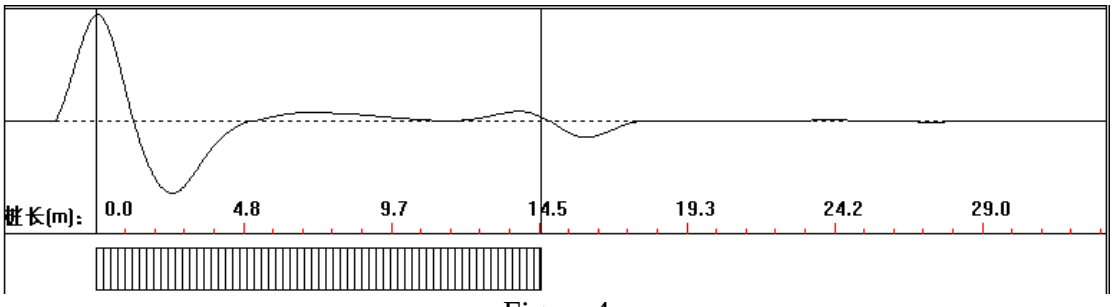

Figure 4

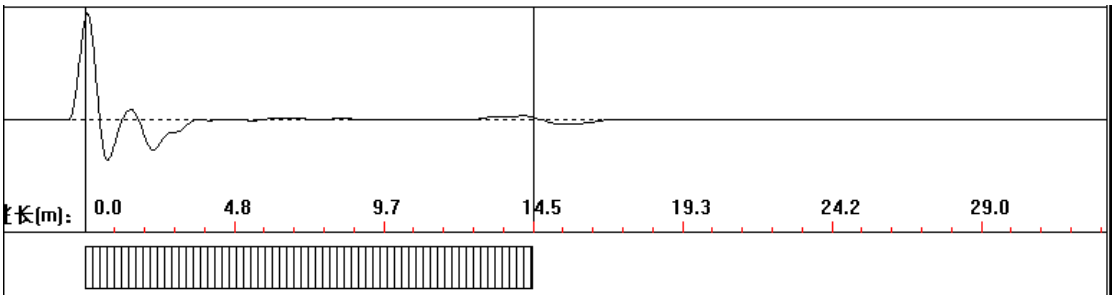

Figure 5

Figure 4 plastic hammer test curve shows that the pile pile bottom reflection is obvious, no reflection curve before the bottom of the pile reflection of defects, no deep defects in the pile body,Figure 5 we know that about 1.8 meters in the pile around the place,there are obvious defects in the reflected wave,and the incident wave phase,initially identified as necking, mud and other defects in a situation,combined with the construction process,that the foundation after the construction of large machinery through,the pile suffered heavy pressure, resulting in a slight fracture of the shallow pile,so the pile qualitative class Ⅱ pile;

The project for a highway,design pile length of 16.8 meters,pile diameter of 1.5 meters,concrete pouring pile,concrete strength class C30,low strain reflection method with a plastic head and aluminum head measured curve shown in Figure 6,7

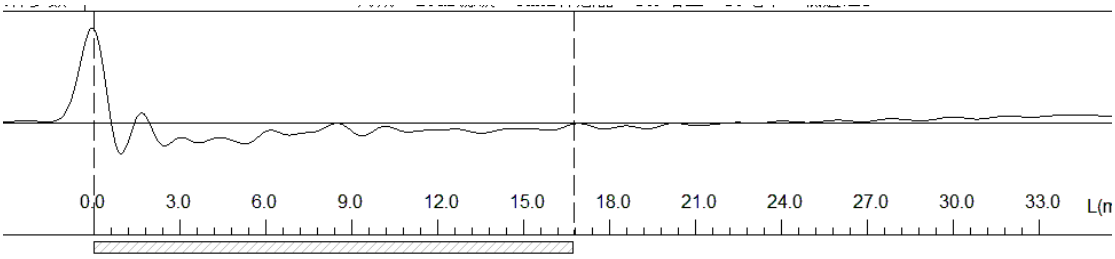

Figure 6

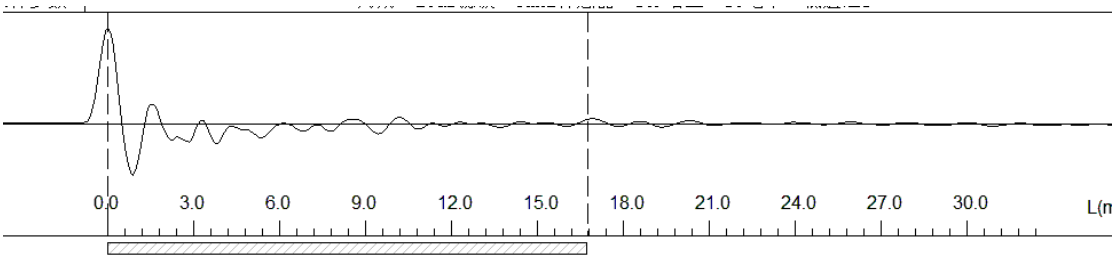

Figure 7

Through the test waveform analysis we can see: the pile can see the bottom of the pile reflection, the plastic head test curve and the aluminum head test curve in the place of about 2.0 meters appeared obvious flaws,the reflected wave and the incident wave are in phase, preliminary can be judged as empty, mud, necking in a defect,by excavation, here is due to the process of pulling too fast during the construction lead to soil inclusions, the pile is class Ⅱ.

5. Analysis of Advantages and Disadvantages of Reflected Wave

5.1 Advantage

(1) Compared with the static load test and large strain, the reflected wave method is light and convenient to carry

(2) Detection speed, in a relatively short period of time census a large number of piles

(3) The reflected wave method is a kind of nondestructive testing, and will not cause damage to the pile

5.2 Disadvantage

(1) It can only be roughly qualitative judgment of the defects of the pile, if you encounter the reflected wave and the incident wave phase with the situation, may be constricted, empty, mud in one or more of mud, which belongs to what kind of defects can not be very clear conclusion, must be combined with excavation to qualitative judgments;

(2) Reflected wave method can only detect the integrity of the pile, for the bearing capacity of the pile to determine, powerless;

(3) The method cannot quantitatively determine the size of the defect, the size of the defect to judge by means of other detection methods;

(4)For the analysis of the test curve, to combine geological conditions, piling technology, construction process, environmental factors to determine,must not just look at the test curve in vain conclusions, this may result in miscarriage of justice, to the construction of a huge loss.

6. Conclusion

Reflected wave method, as a mature pile foundation integrity detection method,has its own outstanding advantages, but also there is insufficient,which requires testing personnel with a sound professional knowledge and on-site experience, in the course of testing combined with their own professional knowledge and practical experience, the test results to make accurate judgments, come to the correct test results.

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