Identification of Influence Factors on Accuracy Control of Non-Destructive Testing for Embedded Depth of Highway Guardrail Column

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Abstract. Combined with the project example of column buried depth nondestructive testing, the influence factors of signal-to-noise ratio of column buried depth nondestructive testing are analyzed. At the same time, the control measures to improve the accuracy are put forward according to the influencing factors.

1. Introduction
With the rapid economic growth of our country, the construction of the expressway infrastructure has made great progress. The corrugated beam steel guardrail is the last barrier in the safety system, which is very important in the engineering construction. The buried depth of the steel column in the subgrade of the expressway is directly related to the safety of the driver's life and property [1]. At present, there are two methods to detect the buried depth of the steel guardrail column, namely, on-site pile pulling method and impact elastic wave nondestructive testing. As a non-destructive testing technology, elastic wave method is easy to operate and can reduce a lot of manpower and material resources [2]. For the expressway in operation period, there are times, uncertainties, changeability and other characteristics, which bring great challenges to the detection of column buried depth. It is very important to identify the influencing factors of the accuracy control of the non-destructive testing of the embedded depth of the highway guardrail column and put forward the control measures.

2. Influence factors of non-destructive testing technology for buried depth of highway guardrail column
Combined with the field engineering example, the paper analyzes the existing testing data, and analyzes the influencing factors of signal-to-noise ratio for the non-destructive testing of the buried depth of highway guardrail column. The natural factors that affect the accuracy control of the embedded depth of guardrail columns include highway grade, surrounding traffic environment, column connection mode, subgrade soil characteristics, column parameters, etc; The human factors include professional quality of testing personnel, sensor installation, excitation energy, data acquisition and processing, column construction mode, etc.

2.1. Highway grade
According to Technical Standard of Highway Engineering (JTG01-2014), the highway is divided into five technical grades: expressway, class I highway, class II highway, class III highway and class IV highway.
The expressway is a multi lane road for cars to drive in different directions and lanes and to control the access of all vehicles. The annual average daily design traffic volume of the expressway is more than 15000 passenger cars. The class I highway is a multi lane highway for vehicles to drive in different directions and lanes, and access can be controlled as required. The annual average daily design traffic volume of class I highway should be more than 15000 passenger cars. The class II highway is a two lane road for cars. The annual average daily design traffic volume of the secondary highway should be 5000-15000 passenger cars. The class III highway is a two lane highway for mixed driving of automobile and non automobile traffic. The annual average daily design traffic volume of class III highway should be 1000-6000 passenger cars. The class IV Highway is a two lane or single lane highway for mixed driving of automobile and non automobile traffic. The annual average daily design traffic volume of two lane class IV highway should be less than 2000 passenger cars; the annual average daily design traffic volume of single lane class IV highway should be less than 400 passenger cars.

2.2. Impact of surrounding traffic environment
The surrounding environment is mainly the influence of surrounding media and other parameters on the detection technology [3]. For example, after the column is buried in the foundation, when the elastic wave generated during the excitation enters the underground part of the column, its energy leaks into the surrounding media, and with the passage of time, it continuously attenuates. On the reflection waveform, that is, the amplitude of the elastic wave decreases with the extension of time. Therefore, when we collect information through sensors in the detection process, the surrounding environment will affect our collection way and collection quality, and even change our correct information to convey the wrong information under certain circumstances, which requires us to investigate the surrounding environment, as well as to set and reference the surrounding parameters.

2.3. The influence of connection mode between guardrail and column
The guardrail device must be set before the test. In order to reduce the occurrence rate of major accidents of Expressway vehicles, the post after the construction is generally connected with the guardrail device through the anti blocking block and connecting bolt. There are generally two conditions for this connection. One is that the post is connected with the guardrail plate in a non overlapping position, and the other is that the post is connected with the guardrail plate in a non overlapping position [4]. The connection between the column and the guardrail plate is in the overlapping position. These two conditions have different effects on the results of nondestructive testing of column buried depth, so we should test and study two different column states respectively. Therefore, the connection mode of guardrail and column is also one of the important factors for us to carry out the nondestructive testing technology of the buried depth of highway column.

2.4. Influence of subgrade soil properties
The physical and mechanical parameters of subgrade soil will directly affect the embedded coupling characteristics of columns [5], and the subgrade soil of the new expressway will change its compactness with the running time. Macroscopically, it is reflected in the compactness of soil and column.

2.5. Column parameters
The parameters of highway guardrail column mainly include column material, column diameter, column wall thickness and column buried depth [6]. The material of the column is directly reflected in the propagation speed of the shock elastic wave; the diameter of the column mainly affects the reflection and diffraction characteristics of the elastic wave propagation, which will produce tiny resonance in the column hollow pipe; the thickness of the column wall and the buried depth of the column are very important for the selection of the exciter, and the appropriate excitation energy will
collect the signal-to-noise better signal, which is easy to judge the reflection of the pile bottom, so as to prevent misjudgment. Wrong judgment, etc.

2.6. Effects of sensors
Sensor is one of the influencing factors in the nondestructive testing technology [7]. As a testing device, the sensor senses the measured information, and transmits the obtained information to the outside through certain ways and rules, while the receiver in the outside stores and records the information transmitted by the sensor. Sensors have many characteristics, such as miniaturization, digitalization, intelligence, multi-function, systematization and networking. They have the new characteristics of equipment in the new era and are important information acquisition equipment in non-destructive testing technology.

2.7. Effect of excitation
Vibration excitation is composed of a certain vibration test system. Through the vibration test, we can detect whether it affects the buried depth distance of the guardrail column [8], and the vibration exciter is a device that uses mechanical vibration attached to some machinery and equipment, and judges and tests the information by the vibration intensity and size of the object. There are different types of vibration exciter. According to the specific situation, we can choose different excitation machines to serve our detection. At the same time, it is a good method to detect the embedded depth of guardrail column by using the corresponding excitation theory and signal.

2.8. Data acquisition and processing
Field test and detection have strict requirements on data collection, and the quality of data directly affects the determination of results [9]. This requires the inspection personnel to strengthen the proficiency in the operation of field test and detection instruments. At the same time, in the field data collection, the advantages and disadvantages of the data can be preliminarily determined, and the data signal-to-noise ratio can be well saved, which is convenient for the data processing in the field. The most important influence condition of data processing is to determine the reflection position of pile bottom.

2.9. Column construction method
The pile driver is often used to drive the column into the subgrade soil directly. The mechanized construction has the advantages of fast and accurate, which is conducive to the positioning and quality control of the column [10]. However, the construction method of digging holes and embedding columns will inevitably appear in the field column construction. In the field test and detection process, it is necessary to record the construction process, construction method (Fig.1), column driving time and other parameters in detail.

![Figure 1. Pile driver driving into column](image-url)
3. Control measures of non-destructive testing technology for buried depth of highway guardrail column

3.1. Preparation before testing
In the formal testing work, some preparations need to be done. The first is the treatment of the top of the column. As the premise of the whole inspection work, the top of the column plays a crucial role. The top of the column should be cleaned to reduce the influence of other factors, so that it can be connected with the sensor smoothly and closely, and at the same time, ensure that the original information will not be interfered by other factors. After a certain treatment on the top of the column, to set the parameters of the acquisition instrument, it is necessary to make the acquisition instrument accurately, continuously and completely convey the information without damage in the middle of the process. At the same time, setting the parameters reasonably is also of great importance to our detection work.

3.2. Reasonable selection and operation of vibrating hammer
The selection and operation of the vibrating hammer is very important. The vibrating hammer is an important tool for generating signals [11]. It must be ensured that when vibrating, the vibrating hammer can accurately transmit the signals to the top of the column, and at the same time transmit them to the sensor for information collection (Fig.2). In different environments, we need to select different vibrating hammers to ensure the quality of percussion, and at the same time, professional and skilled operators are required to operate them to ensure the results of our collection of information.

![Elastic wave generated by strike](image)

**Figure 2.** Elastic wave generated by strike

3.3. Sensor type and installation selection
There are many sensors in the market. It is necessary to select reasonable and appropriate sensors for detection. When selecting sensors, it is necessary to pay attention to whether the parameters of the sensors meet the detection requirements, whether they have good anti-interference ability, and judge whether they are suitable for the detection system from their volume and weight. The installation position of the sensor is also crucial. Generally, the closer the miniature sensor is to the ground, the clearer the information of signal acquisition will be. At the same time, it is necessary to check whether the installation of the sensor is connected stably to ensure its signal transmission. The sensor is generally installed at the top of the column to collect the signal from the vibration hammer [12].

3.4. Use of columns
The use of the column is mainly divided into two aspects, one is the use of the column when it is not connected with the guardrail, and the other is the use of the column when it is connected with the
guardrail. In the first case, through the test, we can get a clear conclusion that the signal given by the sensor is different at the top and side of the column. At the top of the column, the signal is obvious and easy to analyze, but at the side of the column, the signal is obviously weakened and there are other interference. The main reason for this difference is that when the vibrating hammer excites the vibration at the top of the column, when the signal received by the sensor is mostly the longitudinal wave transmitted along the column body to the ground and reflected back to the top of the column, while when the vibration is excited at the top side of the column, the sensor not only receives the reflected longitudinal wave from the bottom of the column, but also receives the transverse wave reflection generated by the peripheral excitation, so the signal received by the sensor is disordered, which is not conducive to the analysis of the wave form. Therefore, the sensor is generally installed on the top of the column. But there is a certain time error in this case, which will lead to the deviation of the test results. In the second case, the barrier block is added beside the column to connect the guardrail, and the detection is carried out at the same time. In this case, the conclusion is that the detection frequency will be reduced after the guardrail is installed, but the detection frequency is generally within a range. If the detection frequency before the guardrail is not installed is used to calculate the length of the column, the calculated theoretical column length is similar to the actual column length great difference. In order to solve the problem encountered in the actual detection of the project, the test data of different relative positions of column and guardrail, that is, non-overlapping position and overlapping position, are analyzed and calculated, and the correction factor $\psi$ is introduced. The use of columns shall be carried out according to different environments. Through the above two cases, we improved the use of columns, and also confirmed the use effect of columns in different cases (Fig.3).

![Figure 3. Non-destructive test for buried depth of newly driven column](image)

3.5. Control of surrounding environment

The column is usually buried in the soil, which will have different influences from the ground. Therefore, it is necessary to pay attention to whether the signal reflected by the column in the soil is affected by other substances in the soil, and the speed and direction of the signal wave will change when it is transmitted to the soil [13]. Therefore, the influence of the medium in the detection technology must be considered to avoid errors. At the same time, for the influence of geographical environment and temperature, we should consider and deal with it comprehensively to ensure the correctness of the test results. It is necessary to set the parameters of the signal according to the structure of the column and select a higher sampling frequency as much as possible to better identify the reflected signal.
3.6. Training of professional and technical personnel

Many professional instruments and equipment are needed for the nondestructive testing technology of the buried depth of highway guardrail column, which requires different professionals to operate. If inexperienced employees are used, it will not only damage the equipment, but also take time and effort. Therefore, it is necessary to cultivate professional personnel who can use the equipment, encourage our employees to actively train and learn new skills, and improve the comprehensive ability of our employees quality, improve their skills, but also let employees have a broader space for development. Enterprises also need to organize and train according to specific conditions, so that technicians can fully understand the principle and operation process of elastic wave method, the professional installation and selection of sensors, the professional operation and experiment of vibrating hammer, and relevant professional knowledge. The training of a group of professional technicians can save time and cost in the process of operation and improve the quality of the project [14]. Different lapping positions and different types of equipment will have an impact on our test results. It is necessary to establish a perfect system test, improve the deficiencies, and find out the causes of the deviation at the same time, so as to have a more profound exploration and discussion on the number of non-destructive testing and the influencing factors of the column buried depth of the highway guardrail.

4. Conclusion

Combined with the project example of column buried depth nondestructive testing, the influence factors of signal-to-noise ratio of column buried depth nondestructive testing are analyzed. From the two aspects of natural factors and human factors, it is concluded that the natural factors affecting the accuracy control of the embedded depth of guardrail columns include highway grade, surrounding traffic environment, column connection mode, subgrade soil characteristics, column parameters, etc.; human factors include the professional quality of detection personnel, sensor installation, excitation energy, data collection and processing, column construction mode, etc. At the same time, the control measures to improve the accuracy are put forward according to the above influencing factors, mainly including preparation before detection, reasonable selection and operation of vibration damper, sensor type and installation selection, use of column, control of surrounding environment and training of professional personnel, etc.

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