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Research on an Intelligent Detection Technology for Bridge Pier and Column Strength

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Abstract

At present, the strength detection of Bridge Pier and column is usually carried out by manual inspection by using bridge inspection vehicle. And sometimes it is difficult to reach the important part of the artificial detection, which affects the analysis and evaluation of the health of the bridge pier and column. At the same time, in order to adapt to various complex terrain, the height of bridge pier column is higher, the artificial detection period is longer, the danger is bigger, the challenge is stronger. It is an important research content to find out the structural damage and disease such as cracks, bulges and rusts of the key components of the bridge structure, and to improve the grasp of the structural state of the bridge in the process of bridge operation. With the continuous development of global intelligence, vehicle-borne bridge crack detection system, non-contact detection instrument, vehicle platform to gradually enter people's attention for the bridge pier strength detection work.

Keywords

Concrete Strength; Intelligent Detection; Method Comparison.

1. Introduction

Pier column is one of the supporting elements of bridge structure, it bears the important force from the superstructure and load of bridge. Insufficient strength of pier columns may lead to structural instability, increase the risk of structural collapse or collapse, threatening traffic safety and bridge reliability . At the same time may bring: traffic disruption and economic losses, maintenance and repair costs, environmental and social impact factors. The traditional testing methods of bridge pier column strength are: Knock Testing, ultrasonic testing, concrete core-pulling testing, static load test, finite element analysis and so on . Traditional detection methods have problems of Destructive testing, limited coverage, accuracy limitation, time and cost, safety and so on. In order to overcome the disadvantages of poor safety, high cost, long detection period and interruption of traffic, this paper develops an automatic lifting and lowering vehicle platform which can carry bridge pier and column strength detection instrument, because of its advantages of low safety risk, small size, light weight, low cost, high safety and strong mobility, it can enter the blind area of traditional detection methods for detection, and get the corresponding detection structure more quickly and accurately. And through the establishment of a data transmission system, each test results will be recorded and compared, using numerical simulation and experimental verification of the combination of technical routes, carry out the research on the automatic lifting vehicle platform which can carry the detection device.

2. Comparison of Existing Detection Methods

2.1 Rebound

Step One, get ready. In the rebound method before testing, the need to clean the surface of concrete to ensure that the surface is clean and free of debris. At the same time, it is necessary to prepare a

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springback and standard samples. The second step is to measure the standard sample. Place the springback instrument vertically on the standard sample plate, press the wrench on the instrument to make it rise and fall, and record the springback value of the springback instrument on the standard sample plate. This value is called the standard rebound value. The third step is to measure the concrete surface. Put the springback instrument vertically on the concrete surface, press the wrench on the instrument to make it rise and fall, record the springback value of the springback instrument on the concrete surface. This value is called the measured rebound value. The fourth step is to calculate the concrete strength. The strength of concrete can be calculated according to the ratio of measured rebound value and standard rebound value.

2.2 Ultrasonic Testing Method

When the ultrasonic method is used for testing, the repeated electric pulse is used to excite the transmitting transducer, and the ultrasonic wave emitted by the transmitting transducer is coupled into the concrete, after propagation in concrete, it is received by a receiving transducer and converted into an electrical signal display. The changes of sound velocity and amplitude are recorded, and the strength of concrete structure is inferred according to the positive correlation between the changes of sound velocity and amplitude and the strength of bridge concrete. Because the value of sound velocity is related to the elastic property of concrete, the higher the value of sound velocity is, the larger the elastic modulus is. In our country, the conversion formula between two kinds of sound velocity and intensity is as follows, where A and B are empirical constants:

$$f_{CN}^{C} = Av^{B}$$

$$f_{CN}^{C} = Ae^{Bv}$$

In viscoelastic media, the amplitude change of sound wave can also be used to infer the strength of concrete structure, which not only decreases with the increase of propagation distance, but also has the phenomenon of angular attenuation, therefore, the initial amplitude and the receiving amplitude of the ultrasonic wave can be used to judge the size and location of the defects in concrete.

2.3 Bridge CT Technology

The mathematical basis of the bridge CT technique is the Radon transform, in which a certain number of excitation points and geophones are arranged in l-shape in the survey area (Fig. 1) , the corresponding lines between these detectors and the firing point divide the test area into cells as shown in fig.2, the strength of the bridge concrete structure in the cell is inversed by calculating the velocity and travel time of the acoustic ray in the cell area.

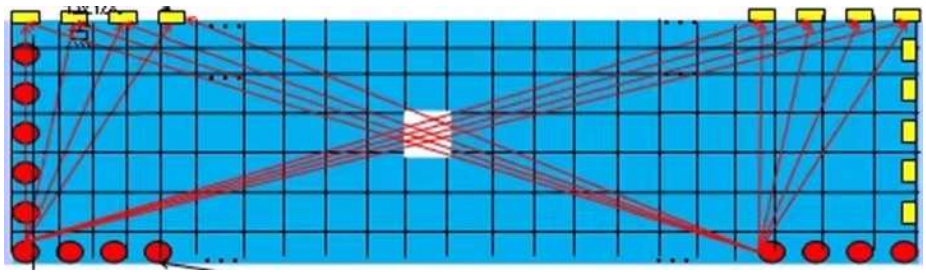

Fig. 1 distribution of excitation points and geophone

Fig. 1 the distribution of excitation points and geophones in the test area. The red dots indicate the location of the excitation points and the yellow square geophones. The key of Radon transform is to get the relationship between the travel time and the velocity in the cell by integrating the ray path of each cell, and to superimpose the travel time of each cell through which the ray passes, when there is

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enough ray density in each cell, the Ray has good orthogonality, and the total number of rays is greater than the total number of cells, the optimal solution of the physical quantity distribution, i. e. the most reasonable velocity distribution in the measuring area, can be obtained.

$$t = \int \frac{\mathrm{d}x}{v} = \sum_{j=1}^{N} l_J s_J$$

$$\frac{1}{v} = s$$

$$\begin{bmatrix} l_{11} & \cdots & l_{1n} \\ \vdots & \ddots & \vdots \\ l_{m1} & \cdots & l_{mn} \end{bmatrix} \begin{pmatrix} s_1 \\ s_m \end{pmatrix} = \begin{pmatrix} t_1 \\ t_m \end{pmatrix}$$

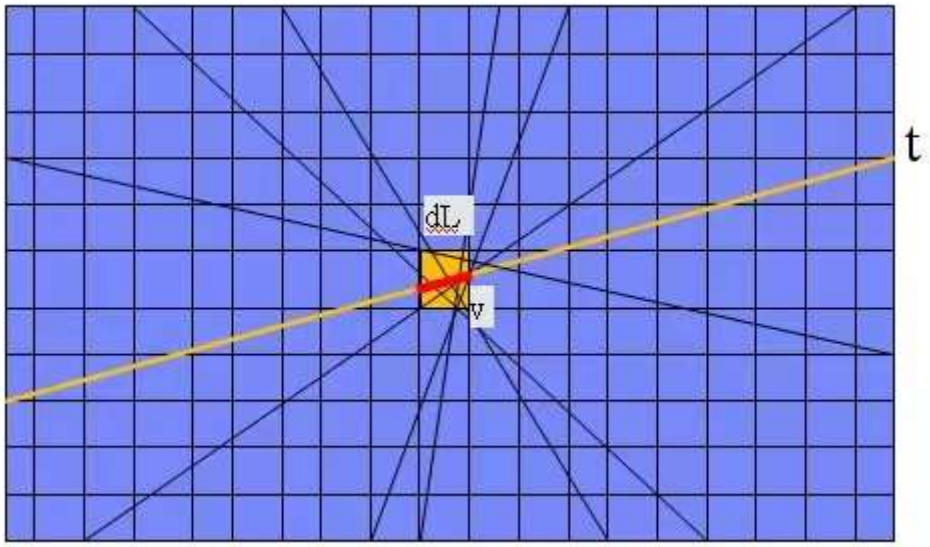

Fig. 2 Division of survey area

2.4 Existing Detection Methods are Inadequate

At present, the strength detection of Bridge Pier and column is usually carried out by manual inspection by using bridge inspection vehicle. And sometimes it is difficult to reach the important part of the artificial detection, which affects the analysis and evaluation of the health of the bridge pier and column. At the same time, in order to adapt to various complex terrain, the height of bridge pier column is higher, the artificial detection period is longer, the danger is bigger, the challenge is stronger. It is an important research content to find out the structural damage and disease such as cracks, bulges and rusts of the key components of the bridge structure, and to improve the grasp of the structural state of the bridge in the process of bridge operation.

3. Research on Intelligent Detection Technology

3.1 Development of Intelligent Testing Equipment

Taking advantage of the design advantages of similar vehicle platforms developed, a vehicle platform for detecting the strength of bridge piers and columns is designed. The vehicle platform is mainly composed of a modular climbing host, a camera, a detection device, a circular track and a visual control system. This is a vehicle platform which can be attached to the pier column of the bridge and Rise and fall automatically. It is different from the platform which moves in parallel on the ground, it needs to overcome the effect of gravity on it so as to adhere steadily to the climbing surface and achieve autonomous crawling up and down movement. It is also required to carry instruments to measure the strength of the pier column (such as the Springback HT225 or HT1000) , set the platform

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load of more than 400 kg, travel speed of less than 3 meters per second. The main hardware of the vehicle platform system is the control board, Raspberry Pie, Springback and camera. As the key component of the system, the main control board chip is used to control and drive each module and sort out the collected information, to analyze and package the data and send it to the raspberry pie, and then sent to the control platform (computer) , is to determine the system design of the various functions can ultimately be the key to its desired.

Designed for better computer education platforms, the Raspberry Pi is only about the size of a credit card, so it's called a microcomputer, and it does all the basic functions of a computer, the system is not a simplified Linux system like the one that underlies android, but is based on a full-featured Linux operating system. The overall system is outlined as follows: the control platform (computer) controls the movement of the vehicle platform and issues commands; the robot turns on the camera mounted on the raspberry pie to obtain real-time images of the bridge's surface, the FRP intranet penetration technology is used to map the raspberry pie IP to the server and realize remote image transmission to solve the problem of image loss when the robot is too far away from the control platform. According to the visual control system display of the bridge pier and column surface image, avoid loose layer, floating slurry, grease, layer, honeycomb, hemp surface and other locations, determine the detection location, turn on the springback and begin the test.

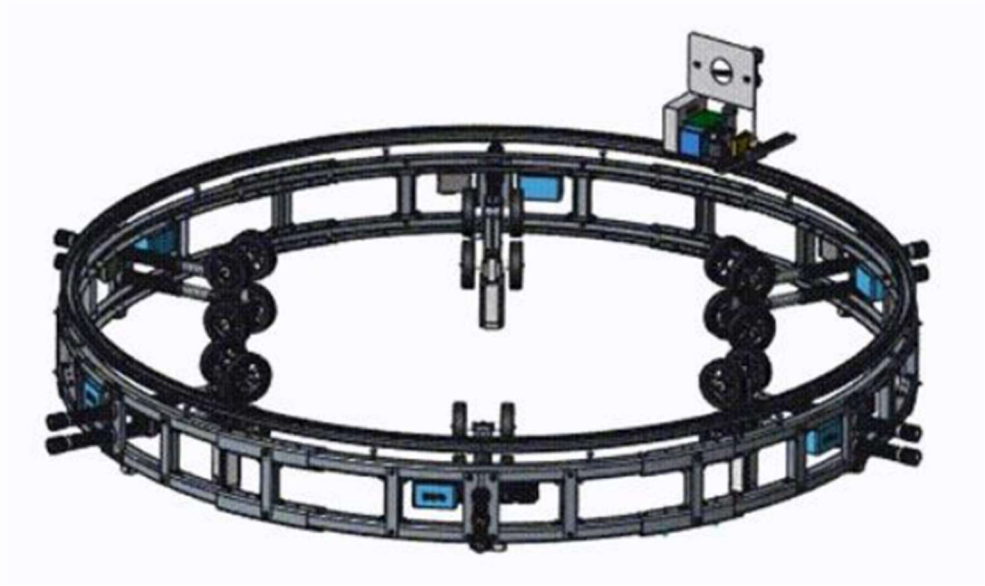

Fig. 3 Vehicle platform model

3.2 Build a Diversified Data Processing System

1) The goal of the data processing system: after importing the data of the springback value and carbonization depth measured at each point into the system, the springback strength value of each point can be obtained automatically, and the strength standard value can be judged to reach or not, and the strength detection report can be generated.

2) Design Framework: Select Database Management System (MySQL) , data integration tools (Apache NIFI,) , analysis tools (Python) , data storage (Hadoop) . The data sources are mainly the rebound strength and carbonization depth measured by the springback instrument, and the standard values are specified in the corresponding numerical manual specifications of the selected springback instrument.

3) Data pre-processing: deal with missing values, outliers, duplicate data, etc.

4) Data analysis: the values of rebound value and carbonization depth are strength values. The rebound value and carbonization depth reference values in the measuring manual are input into the

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database of the system in advance, and the measuring points that meet the requirements of the strength specification are obtained.

5) Data visualization: use the visualization tool Matplotlib to visualize the results of your analysis to make it easier to understand and use the data.

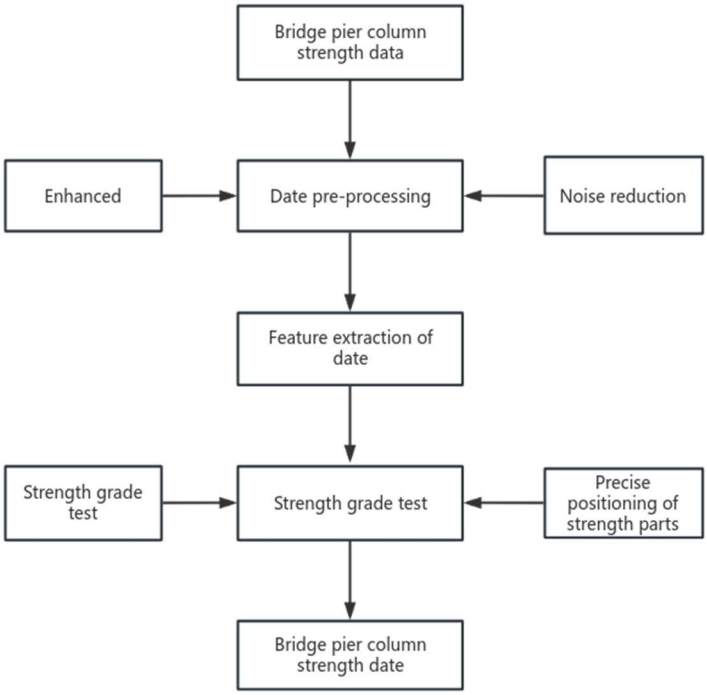

Fig. 4 data processing system workflow

3.3 Efficient Detection Process

1) adjust the diameter of the carrier platform according to the measured diameter of the bridge pier column, and fasten the carrier platform at the bottom of the bridge pier column.

2) install testing devices such as springback instrument and camera to ensure the display screen is clear and the data transmission system is normal.

3) set up the detection area, every two meters for an area of detection, each area measured 16 values.

4) the detecting device is connected with the computer terminal, and the transmitting signal and the camera position are adjusted.

5) turn on the power unit and start the test.

6) according to the image displayed on the camera screen, avoid the location of loose layer, floating slurry, oil stain, layer, honeycomb, pitting surface, etc.

7) to obtain the testing results and determine the concrete strength of each testing location. According to the different diameter size, height and service time of pier column, the strength of concrete bridge pier column is selected and compared with the results of traditional testing methods, so as to verify the practicability of the platform.

3.4 Advantages of Intelligent Detection Methods

1) Work smoothly and safely, because the bridge detection vehicle adopts the multi-layer safety control system, can make it work smoothly, and ensure the safety of staff.

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2) High efficiency, good mobility, bridge inspection vehicle detection of bridge superstructure, can easily detect the top of the bridge, can move along the main beam, covering a wide range, can carefully check the bridge bottom and other difficult to observe the position.

3) With little traffic influence, the bridge detection vehicle runs smoothly, safely and reliably after installing hydraulic support leg and counterweight. Operating only one lane, the impact on the bridge clearance is also very small, can be reduced to a very low impact on traffic.

4. Conclusion

1) The intelligent testing platform can not only carry the strength testing instruments, but also can be used as a basic platform to carry all kinds of testing instruments to accomplish various testing work.

2) Intelligent detection has great advantages in labor cost, detection period and detection safety, and it can complete all kinds of detection work without blocking traffic.

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