Preliminary Study on Ultrasonic Method in Cement Concrete Detection of Road Top of Embankment

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Abstract. The flood control road on the top of the embankment provides convenience for the traffic, and at the same time the flood situation is convenient for rescue and relief. So a new way to build and maintain the becomes the object of concern, especially the songhua river basin, cement concrete pavement under threat of flood, and in some of the current rural built or rebuilt in levee engineering, the new road quality is not up to standard, constructed the rutted, appears phenomenon of road and road cracks, subsidence, use fixed number of year of the reach regulation, so how to optimize a new road construction technology, improve the cement concrete pavement detection methods become an inevitable requirement. This paper introduces a new fast nondestructive testing technology, ultrasonic testing, and makes a preliminary study on its application in embankment top engineering.

1. Introduction
At present, the content of concrete detection is more and more. In the past, the content of concrete test is usually limited to concrete strength, component size and so on. At present, the content of concrete detection has penetrated into concrete materials, geometric characteristics of components, physical and chemical properties of components and other aspects. The widening of concrete testing content is conducive to accurately grasping the construction situation of the project, and the testing results can verify the reliability of the project.

With the continuous development of science and technology, various concrete detection methods, cement concrete strength detection methods are also changing with each passing day, the traditional strength detection methods have been improved, such as rebound detection method, core detection method, ultrasonic rebound comprehensive detection method. The optimization effect is remarkable and the detection precision is improved.

2. Principle of ultrasonic reflection method

2.1. Common methods of ultrasonic detection
Ultrasonic detection is a non-damage detection, will not cause damage to the concrete surface, equipment is relatively simple, strong operability, not affected by the concrete surface, transmission of concrete internal defects, etc., can reflect the overall strength of concrete value. Ultrasonic method, also known as ultrasonic pulse wave method, has strong penetrating ability, high frequency, short
wavelength and high resolution [1]. It can detect the internal structure of concrete in detail. In the detection process, the ultrasonic transducer transmits a control signal, that is, a high-voltage pulse of standard width, to make the transducer generate ultrasonic waves. The amplitude and width of the pulse determine the energy size of the ultrasonic signal. During the measurement, the high voltage pulse signal width is too narrow and the voltage is relatively small, so the transducer will not get stable ultrasonic pulse. If the signal bandwidth is large or the voltage is high, the aftershock of the ultrasonic signal will be prolonged, and the velocity of the transverse wave is small, and the longitudinal wave will arrive first. It is convenient to use reflection method to measure concrete pavement on the top of embankment. Ultrasonic reflection method under ideal condition, follow the law of reflection wave, reflected p-wave arrived after the direct wave, when t read by machine, by the intensity of sound velocity, the regression equation for strength calculation, the velocity of sound value has positive correlation and concrete elastic modulus, elastic modulus value, the greater the speed of sound value is, the greater the if concrete structure layer exists defects such as cracks, water seepage, empty, but by the change of acoustic parameters are analyzed. At present, there are two conversion formulas of sound velocity and intensity in China, which are respectively and two nonlinear formulas, and A and B are empirical coefficients. Ultrasound also reduces the effect of humidity [4]. The thickness of cement concrete pavement can also be measured by reflection method.

$$H = \frac{1}{2} \sqrt{\left(V_1 t\right)^2 - L^2}$$

(1)

Where, $V_1$ represents the propagation speed of ultrasonic wave in cement concrete under test; $L$ is the distance between two transducers, and the formula can be used to calculate the thickness of concrete road at the top of embankment.

2.2. Discussion on water coupling method

Different medium, the propagation velocity of ultrasonic signal also has difference, fast drying air is only 346 m/s, but the rate of 4000 m/s in the cement concrete [3], a difference of 11.5 times, so the transducer and a new concrete pavement of the coupling is a problem that nots allow to ignore, also be the difficulty in the thickness of the test, in general, can daub oil, grease, glycerin, butter, vaseline, elimination of the probe and the air between the object to be tested, butter and vaseline can't improve the SNR of the signal, this paper discussed water coupling. In the application process of water coupling method[5,6], the reflected wave

![Figure 1. Measuring station layout (unit: mm)](image)

Propagates through the water and hits the surface of the transducer at an approximate Angle of 90 degrees. The receiver receives a strong vertical component. The interference of shear wave can be partially weakened and the test effect can be greatly improved.

The wave form of ultrasonic wave is simple harmonic wave. When the reflected p-wave arrives, it is inevitable to superimpose the waveform, the amplitude of the received signal becomes larger, and the time point of arrival of the reflected p-wave is the crest and trough, respectively.
3. Improvement of water coupling method
When the water coupling method is adopted, the receiving transducer is suspended in the air. To ensure the constant height value, the water coupling method of the fixed frame can be designed. Based on huygens-Fresnel theorem at the same time, the appropriate adjust the horizontal distance between the transducer and reduce the influence of shear wave and surface wave, a new road cement concrete thickness of 22.0 cm, wave speed of 4300 m/s, as a reflection p-wave velocity \([7]\), launch reception to 50 cm, the distance between two transducer obtained theoretical p-wave there is 154 us, because of the cement concrete the absorption and reflection of the ultrasonic signal is also have difference, high frequency of ultrasonic absorption, will reduce the reflected wave frequency\([8]\), and high strength, cement concrete internal uptake of ultrasonic frequency signal is less, The higher the frequency of the reflection, the higher the frequency. The flexural strength of cement concrete can be analyzed by multiple parameters:

\[
F = g(v, f_0)
\]  

Where, \(v\) is ultrasonic sound velocity; \(f_0\) is the main frequency of the spectrum.

4. Conclusion
(1) China has not formulated special standards for embankment traffic roads. Some of the roads on the top of the embankment are part of water conservancy projects such as river regulation. Due to the small amount of investment, they are easy to be neglected.
(2) The pavement base is made of cement stabilized graded gravel and natural gravel, and the material is low-grade semi-rigid. Bending strength and lower layer binding force, intensity is decided by the consolidation rate of cement, cement as destroyed, will not have reproducible, so after laid at the grass-roots level to be sealed by geotextile, traffic maintenance, closed for at least a week, of the reasons for damage of the cement concrete pavement is comprehensive, including the compressive strength and flexural strength of concrete is not enough. According to relevant specifications, the concrete compressive strength of foundation works such as river slope protection and road on top of embankment shall be 10MPa. Underground waterproofing works or other waterproofing structures below the water level of 10m will produce cracks of 0.1~0.2mm, and cement concrete will start to leak, which can be referred to the general standards. Can't adopt "crack to block, can't block to lay afresh" processing method, want to consider the long-term use circumstance of road surface project.

The general control standards for maximum fracture are as follows:
- No corrosive media, no waterproof requirements of 0.3~0.4mm;
- Slight erosion, no waterproof requirement, 0.2~0.3mm;
- Severe erosion, waterproof requirement, 0.1~0.2mm

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