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Concrete Non-destructive Testing Technology and Its Application

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Abstract: Nondestructive testing of concrete has a very important position in the construction industry, this paper explains the nondestructive testing, introduces the necessity of nondestructive testing in a number of aspects, classifies the nondestructive testing technology of concrete, introduces the characteristics of several types of nondestructive testing, explains the current application of nondestructive testing in various fields of construction, the problems of nondestructive testing.

Keywords: Nondestructive testing; Concrete; Strength testing; Defect detection.

1. Introduction

In recent years, China's construction quality accidents are increasing, China has further strengthened the management of the quality of construction projects and the quality of the existing building inspection, concrete quality as an important indicator of building quality assessment, the quality of the building has a decisive role, the existing concrete strength testing is divided into micro-breakage detection and non-destructive testing, non-destructive testing with its low cost of testing, no damage to the building itself, the characteristics of the building industry is highly favoured.

Non-destructive testing of concrete refers to the mechanical properties of concrete, internal defects, compositional changes, etc. without affecting the structural strength of concrete and less impact on the appearance of concrete, and finally make a judgement on the quality of concrete through the overall assessment of these indicators.

2. Necessity of Non-destructive Testing

Concrete testing for the control of construction quality has a very important role, at present, whether it is the construction unit or quality inspection department for the evaluation of concrete construction quality are relying on the site of the reserved concrete test blocks, through the reserved standard cubic test block destructive test, as a check and the final acceptance of the concrete structure based on, although this way to get the test results are intuitive and less discrete, but there are also its limitations.

(1) There is a difference in the curing environment, the standard test specimen is cured in the concrete curing room, while the site of the concrete components of the curing environment does not meet the conditions of the curing room, different curing environments under the strength of the concrete values are bound to be different, and can not accurately get the value of the strength of the concrete in the components.

(2) Even if the curing conditions of some components on site are the same as those in the curing room, the strength of concrete will still be different due to its forming process and different vibration methods. Therefore, the standard specimen only reflects the concrete strength value of a specific construction component under specific conditions, and does not reflect the overall situation of the component.

(3) For some old buildings and some buildings that have been built for a long time, it is impossible to assess the structural concrete strength value through the reserved specimen blocks. After a certain age, there is a big difference between the standard test block and the strength value of concrete in the structure.

(4) The reserved specimen involves various units, sometimes it may not be able to evaluate the concrete strength value impartially, and there may be cases such as specimen replacement, which makes the test meaningless.

The use of non-destructive testing technology can directly evaluate the concrete on site, which greatly guarantees the quality of the project and has been adopted by more and more units.

2.1. Classification of NDT techniques

As concrete material is a complex mixture of materials, its components and the proportion of each component will affect the concrete performance, researchers boring also in acoustic, optical, electrical and physical properties of many areas of non-destructive testing technology, so produced a number of non-destructive testing methods. According to its main test of the different properties of concrete can be divided into two categories, one is to detect the performance of concrete, which is mainly to detect the mechanical properties of concrete, generally through the results of the test to establish a relationship with the strength of the concrete, and then make an overall assessment of the concrete. There is also a class of detection technology is the detection of internal defects in concrete, generally speaking, through the test results can be directly derived from the internal structure of concrete. The following is an introduction to some of the non-destructive testing methods for concrete.

2.2. Surface hardness method

The principle of the surface hardness method is to establish an empirical correlation between the concrete strength properties and the surface hardness car measurements, of which the rebound method is one of the most widely used non-destructive testing methods nowadays, the test was developed by the Swiss engineer Ernst Schmidt in 1948, often referred to as the Schmidt rebound hammer, which is used by the rebound hammer in the impact with the surface of the concrete, the rebound hammer to record a rebound number, which is expressed by referring to the The rebound number is

expressed by reference to an established empirical correlation between the strength properties of the concrete and the rebound number. Prior to testing, the concrete surface should be visually inspected to determine a smooth surface suitable for testing. The key lies in the measurement of carbonation depth, which will directly affect the accuracy of the test. Li Bei et al. based on the changing law of carbonation depth, the non-destructive testing of various types of required carbonation depth is discussed, and the carbonation depth can be measured by the method of resistivity and air permeability.

2.3. Maturity method

The maturity method is a non-destructive testing technique based on the measurement of temperature history during the curing process to determine the strength gain of concrete. A maturity function is proposed to quantify the effects of time and temperature. The resulting maturity factor is then used to determine the strength of the concrete based on the established correlation. The maturity method has various applications in concrete structures, such as during formwork removal. It is now primarily used to record temperature versus time by means of thermocouples inserted into the fresh concrete. The measured time can be used to calculate a maturity index, which provides a reliable estimate of the strength of early concrete as a function of time. Factors contributing to test variability are aggregate properties, cement properties, water-cement ratio and curing temperature. Before attempting to estimate the strength of concrete, laboratory tests must be carried out on concrete samples with similar characteristics to develop the correct maturity function while minimising the effects of the above factors. Temperature probe locations must be carefully selected to measure representative temperatures across the entire concrete section.

2.4. Ultrasonic pulse velocity method

The ultrasonic pulse velocity method utilises the velocity of ultrasonic wave propagation through a solid while measuring the time it takes for the wave to travel between the sending and receiving points. The characteristics of ultrasonic wave propagation can be used to characterise the composition, structure, elastic properties, density and geometry of a material using previously established correlations, known patterns and mathematical correlations. This NDT technique is also used to detect defects and internal structural conditions by observing the scattering of ultrasonic waves in concrete. The principle of the ultrasonic pulse velocity method is that voltage pulses are converted into ultrasonic pulses and returned to the transmitting and receiving transducers respectively. The transmitting transducer is placed on the surface of the concrete and allows the transmission of ultrasonic pulses through the specimen medium. The ultrasonic pulse travels through the concrete specimen and is detected by the receiving transducer at the other end which converts the ultrasonic pulse into a voltage pulse. Knowing the distance between the two points, the velocity of the wave pulse can be determined, which in turn provides a basic understanding of the concrete. Aggregate properties, cement type, water-cement ratio, admixtures and age of the concrete affect the speed of propagation of ultrasonic waves in concrete.

2.5. Impact echo method

The impact echo system is the latest development in ultrasonic methods and can be used to measure internal defects and thickness of concrete. It can also be used to locate cracks, voids and delamination. It is based on monitoring concrete surface movements caused by short-term mechanical impacts. Specifically, the test measures the amplitude of reflected shock waves to detect defects in concrete. The impact echo system utilises short pulses of ultrasonic stress waves, which propagate into the concrete structure with different constituents with different density and elastic properties having different stress pulses at the member boundaries. An oscilloscope displays the received signal and electronically measures the round trip travel time of the pulse. The thickness of the concrete can be determined, generally more often for concrete slabs. The advantage is that the test is intuitive and can be performed on a single side.

Most NDT methods compare the test parameters with established correlations so that the properties of the concrete being tested can be inferred from the existing relationships. There are many non-destructive testing methods, and different testing methods focus on different concrete properties, so it is very important to choose the right testing method for concrete testing.

3. The Application of Non-destructive Testing Technology of Concrete Strength

Nondestructive testing technology in the field of construction engineering has many applications, basically throughout the construction industry, mainly used in the following aspects:

(1) The existing building transformation strength assessment and the reliability assessment of the old building

In recent years, a number of accidents have occurred in China due to improper transformation, which has aroused widespread concern among all parties. China has also introduced the “General Specification for Maintenance and Renovation of Existing Buildings “GB 55022-2021, which mandates that existing buildings shall not be remodelled without approval, and concrete strength is an important indicator of building reliability, and non-destructive testing is therefore widely used in building assessment. With the development of time, some old concrete buildings gradually aging, there are safety hazards, the need for its safety reinforcement, then the need for strength assessment of its key components, but also the degree of aging and the subsequent use of the life of the expected, but also can bring great economic benefits.

(2) Reliability analysis of disaster-resistant and post-disaster buildings

China is an earthquake-prone country, the seismic capacity of the housing appraisal more and more attention has been paid to the existing building quality testing has become an important part of some regions of China from time to time some small-scale earthquakes, although a short period of time on the building is basically no damage, but a long period of time will inevitably have an impact on the accumulation of the building, so it is very important to do some regular testing of these buildings. For the identification of the house after the fire is also very important, can be detected through non-destructive testing of concrete and reinforcing steel damage after the disaster, can save a lot of building reconstruction costs.

(3) For the detection of foundation

China's geological situation in many areas of complexity and change, foundation is the top priority of the whole building, there is wet subsidence loess in the Northwest, the southern expansion of soil, frozen soil in the north, coastal areas, more soft soil, these complex areas are prone to tilt foundations, cracks and other problems, the main reason for this is that the foundation of the construction of the reasons for the foundation of the test is very important.

(4) The application of construction in the construction of buildings

Non-destructive testing for construction of the most widely used, for reinforced concrete buildings can be said that each part of the need for acceptance, non-destructive testing plays a very important role for quality control and subsequent construction has an important significance for some key buildings, and even need to be tested as a whole.

(5) The identification of building safety accidents

China has a lot of construction accidents every year, there are affected by the environment and also thought to be caused by improper construction, commissioned by the identification of the building to determine the cause of its destruction, due to which a variety of situations are more complex, the need to use non-destructive testing techniques, the cause of the destruction of identification.

4. Problems with NDT

Any testing method has advantages and disadvantages, so does nondestructive testing, compared with the breakability test of nondestructive testing, nondestructive testing relies on the correlation between the detection index and concrete strength, the moisture content of concrete, compositional differences, etc. will affect the detection.

(1) In order to make nondestructive testing more standardised, China has introduced relevant norms, such as the rebound method, which explains the rebound method for the age of concrete and the requirements of the concrete strength level, for the high age, high strength of the concrete can not be derived from the standard method, and in addition, for some of the addition of the concrete of the reference material does not have the relevant provisions.

(2) For some ultra-high-rise buildings, which often use I-beam instead of reinforcing steel, which brings some difficulties to the nondestructive testing, for some complex concrete structures will also bring some impact on the nondestructive testing.

(3) NDT is also a high requirement for inspectors, who must be familiar with the relevant national specifications, choose the appropriate detection method according to the different concrete conditions on site, and also require inspectors to have a certain knowledge of statistics in order to better assess the strength of concrete.

4.1. Concluding remarks

Nondestructive testing technology in the rapid development of detection accuracy is also increasingly high, the detection process is also increasingly standardised to cope with the diversification of engineering and construction, although a single nondestructive testing method of concrete soil has certain limitations, but through a variety of nondestructive testing methods can be verified with each other to get more accurate results, ultrasonic rebound method is a good example of the application of the method, through the continuous optimization of the innovation, nondestructive testing will bring more help to the construction industry.

References

[1] WANG Qingyan, WANG Haocheng, YU Mingli. Application of non-destructive testing technology in concrete performance testing[J]. China Building Materials Technology, 2022, 31(03): 134-136.

[2] ZHANG Keqiang,YANG Bo. Non-destructive testing method of concrete and its new development[J]. Concrete,2007(05): 99-101.

[3] Wang Bo. Application of non-destructive testing technology in concrete inspection[J]. Construction Technology Development, 2022, 49(06):70-72.

[4] LI Bei,LI Xinyao,JIN Nanguo,et al. Exploration of non-destructive testing technique to assess the depth of carbonation of concrete_Li Bei[J]. Concrete, 2021, (4): 140-145.

[5] J. Helal, M. Sofi, P. Mendis. Non-Destructive Testing of Concrete: A Review of Methods[J]. Electronic Journal of Structural Engineering 14(1) 2015.

[6] Luo, X. S.. Research on the development and application of non-destructive testing technology for concrete_Ro Xing Sheng [D]. Chongqing University, 2008.

[7] GUO Meixian. Research on non-destructive testing method of concrete strength under different conditions and its application[D]. South China University of Technology,2011.