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Research status and Prospect of Concrete acoustic emission technology

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Abstract. By discussing the current research status of the concrete acoustic emission technology from four aspects as: the concrete acoustic emission of different conditions; the characteristics of the concrete acoustic emission; the Kaiser effect and Felicity effect of the concrete acoustic emission and the analysis of the concrete acoustic emission data. The concrete acoustic emission research should be done with the practical project, and establish effective processing and analyzing technology of the concrete acoustic emission, to apply the concrete acoustic emission technology better to the measurement of real project.

Introduction

Nondestructive testing technology means to test the internal character without destructing the external form of the object. With the constructive development of the large buildings, bridges and highways, the nondestructive testing technology had been developed very fast, which can be used in the quality test of such projects. The nondestructive testing technology usually consists of Visual Test（VT）, Magnetic testing（MT）, Eddy current testing（ET）, Ultrasonic testing（UT）, Penetrate testing(PT), acoustic emission(AE), etc. The acoustic emission testing technology (AE) refers to the phenomenon that transient elastic waves occurred because the fast energy releases of partial material; the acoustic emission is also stress wave emission. The main source of material acoustic emission was from the plastic deformation, and the concrete material will have some distortions such as dislocation and gliding motions during the destructive process, thus such distortions will bring acoustic emission, which can be used in testing of the concrete material. In the year 1959, R sch had applied the acoustic emission technology to the study of concrete. The acoustic emission technology possessed the dynamic detection characteristics when compared to the other nondestructive testing technologies, thus it is more suitable to the detective test for the concrete material.

The Current Research Status of Concrete acoustic emission technology

Currently, there are more and more concrete testing technologies, and the concrete test were mostly done by ultrasonic testing, which is a way of static testing, that can not test the development of cracks inside the concrete material. The requirements of the testing technologies levels are becoming higher and higher and need dynamic testing technologies to test the concrete material, the acoustic emission technology is very suitable for the non-destructive testing of the concrete and the researchers had done a lot of studies on concrete acoustic emission. At the present stage, the researchers are studying the concrete acoustic emission technologies mostly from the following four aspects:

The study on concrete acoustic emission technology of different stages

When there are differences in aggregate size, gradation method or water cement ratio, the cracking method of the concrete is different, the acoustic emission signals of the concrete are different, too. Reference [1] studied that the aggregate size had relevance with the acoustic emission signals, the bigger of the water cement ratio, the weaker of the acoustic emission ratio; the water cement ratio is relevant to the acoustic emission ratio. Thus, to study the concrete acoustic emission technology, firstly we should assure the status of the raw material, which can confirm better the internal characteristics of the concrete. Reference [2] studied the acoustic emission of ordinary concrete and rubber concrete material of the same label in the destructive process, when under the same bending load conditions. For the bending strength of rubber concrete is higher than the regular concrete of the same label, its acoustic emission ratio is lower than the regular ones. Reference [3] had studied the mechanical properties of layer hybrid fiber reinforced concrete through the acoustic emission technology; the raise of mechanical properties of layer hybrid fiber reinforced concrete can be represented by the study of acoustic emission. The above studies showed us that there are different characters of the concrete and different types of concrete material had different acoustic emission ratios, and before study the concrete acoustic emission, first we should assure the character of the concrete.

The study on characters of concrete acoustic emission technology

Researchers had done a large amount of experiments on the concrete material or concrete element to analyze the concrete acoustic emission based on the data achieved. Reference [4] had done research on the concrete acoustic emission through concrete axial tensile test, the acoustic emission ratio is rare when concrete is in the initial state of tensile load, when in the middle stage of tensile load effect, that is the tensile load reached 35% and no more than 70%of the concrete's ultimate load, the concrete acoustic emission ratio is growing larger when the tensile load is increase, when it go beyond 70% of the concrete's ultimate load, the concrete acoustic emission ratio is increasing vastly, when it achieve 95% of the ultimate load, the acoustic emission ratio will increase suddenly. This conclusion showed that the concrete acoustic emission is produced by the concrete plastic deformation. At the initial stage of the concrete was loaded, basically it belonged to the elastic deformation stage, and there is no fault movement and other deformations inside, thus the acoustic emissions are mainly not happen; with the increasing of the load, the plastic deformation become more obvious, and the acoustic emission rate become higher, and when the load intensity of the concrete arrived 70% of the ultimate load and above, the concrete material wound be in unstable crack development period, the sudden widen and extension of the crack would increasing the acoustic emission rate very quick, approximately like index increases, and when the load intensity rise to 95%, the incident rate become the biggest, which identified the basic theory that the concrete crack was in three stages, such as the relative stable period of micro crack, the develop period of stable crack and unstable crack development.

The study on Kaiser effect and Felicity effect of concrete acoustic emission technology

Repeated load the material before achieve the previous maximum load level, the acoustic emission phenomenon is not so obvious, this irreversible nature of the acoustic emission was called Kaiser Effect. When the material was load repeatedly before it achieve the previous maximum load, and the obvious acoustic emission phenomenon happened, it is called Felicity effect. Reference [5] had taken thorough research on the Kaiser Effect and Felicity Effect of concrete material, and the results of the experiment identified that the concrete material possess the character of Kaiser Effect, however, the Kaiser Effect of concrete acoustic emission need to satisfy a certain conditions, only the concrete stress level achieved 40% to 80% of its ultimate stress level, the acoustic emission of the concrete possess the Kaiser effect, when the stress level was not in this scope, it may reflect the Felicity effect, and still other researchers had done a large amount of experiments, the results they had got were almost the same with the research, the Kaiser Effect study is a very favorable tool for the testers to test the concrete material, we can judge the stress historic level of concrete material through the Kaiser effect, and can make deeper study on concrete acoustic emission technology by using the Kaiser effect.

The analysis on concrete acoustic emission technology

We have done sound emission data receiving of the concrete cracking process through sound emission receiver apparatus, and have got the sound emission data curve, and through which judge the destructive condition of the concrete, and adopted the reinforcement measures of the concrete according to the results we've got, thus we have to analysis the data we received. Reference [6] established the relation equation of acoustic emission event rate and the concrete material's stress and strain parameter through coupling constitutive model, which can make use of the stress level of the concrete to judge the acoustic emission event rate of the concrete, however, the use effect of the equation will need more experiments and practical engineering to test. The ascertain of the fracture process zone of the concrete in the sound emission technology is very difficult problem, the researchers have made sound emission three dimensional positioning technology to judge the fracture process zone, provided new ways for the sound emission technology of the concrete.

Prospect of the sound emission technology of the concrete material

The study of the sound emission technology of the concrete material had got some achievements by the large amount of experiments of the researchers. Now because the building of the large-scale house, bridge, tunnel and other objects, and the appearance of more and more long service life constructions, the need for reliability of the buildings become more urgently, which concerns people's life and property security, concerns the harmonious development of the society. With the development of the concrete sound emission technology study, people are realizing the importance of it to the testing of the concrete increasingly. However, the sound emission technology of the concrete need to take further and deeper research form the practical theory of the testing person and work for the actual engineering, the study of the sound emission technology of the concrete should be improved from the following aspects, to make it form the norm and adopted by the engineering technical personnel:

The research environment should convert to the practical engineering

The research of sound emission technology of the concrete were mostly done in the laboratory, take the concrete member to take monopodium tension, compression or bending damage test, and got the sound emission data curve of the concrete material. However, the sound emission phenomenon of the concrete material is a very complex process, the development situation of the inner crack is also very complex, which need a large amount of data for the study and establish the sound emission data model and formula. Currently, the study of the concrete acoustic emission were mostly done in the laboratory, the researchers had done little on the concrete acoustic emission of practical project, however, only using the data from laboratory study cannot completely and actually reflect the real mechanical effect of the concrete, the research direction should be more combined with the practical projects, and we should do large amount of practical engineering monitor and data analysis, combined with the experiment data in the laboratory, can embody the real status of the concrete material, which is favorable for achieve the universal theory and formula and adopted by the practical project researchers.

The sound emission technology data curve of the concrete should be improved

In the process that we apply the sound emission technology to the testing of practical engineering concrete material, the noise will occur, which would disturb the sound emission data curve, thus we have do get rid of the noise before we analyze the sound emission curve, the sound emission data we got will reflect the real condition of the concrete material. Researchers had done little work on the processing work of concrete sound emission data. The signal processing method of the concrete sound emission is comparatively singular; the analysis way most researchers had adopted basically was the wavelet theory, and other signal processing technologies were not adopted. With the development of the information professional technology, the signal processing technology has become the major component of the science and technology development. The mostly applied methods concludes the wavelet theory analysis method, neural network analysis method, spectrum analysis method, gray relational analysis method, fuzzy analysis method and mode identification method, etc. The researchers should adopt many ways to get rid of the noise of the concrete sound emission signals, and compare which one is will eliminate the noise effectively, the curve after noise reduction would truly reflect the stress effect of the real constructions, and can establish the computer software programme by the results and provide service for the actual engineering data.

Analyzing technology of rock acoustic emission character had been expanded

Researchers did the character analysis on the sound emission data of concrete material are basically divided the data character into three sections, and judged the acoustic emission event rate through the cracking condition of the concrete material, forecasted the destruction of the concrete material by the change of sound emission activity frequency of the concrete, and did not connect the sound emission data curve with the concrete stress condition. Different from the way to assure real stress condition of the concrete by the sound emission data curve, the concrete sound emission study should be improved in the analysis technology, use many ways to analyze the concrete emission data curve, and set up reliable connections of the sound emission curve and the concrete stress through research, and got comparatively reliable counting formula, so that to make great development of the concrete sound emission technology, to apply to the practical engineering and solve the safety problem.

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