Construction and Building Materials 114 (2016) 66–75

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Acoustic emission properties of concrete on dynamic tensile test

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HIGHLIGHTS

- Introducing AE technology into the research of uniaxial dynamic tension.
- The cyclic loads was applied in order to achieve different initial damages of concrete specimen.
- The concrete AE signal exhibits Kaiser effects under dynamic loading.
- Kaiser effect is determined mainly by the interior damage level of concrete specimens.

ARTICLE INFO

Article history:
Received 2 December 2015
Received in revised form 14 March 2016
Accepted 15 March 2016
Available online 31 March 2016

Keywords:
Concrete
Initial static load intensity
Initial damage
Uniaxial tension
Dynamic test
Acoustic emission

ABSTRACT

In order to real-time monitor the internal damage of concrete and discussbasic characteristics of acoustic emission (AE) of concrete prism specimens under dynamic uniaxial tension, as well as the dynamic performance and failure mechanism of concrete, effect of the dynamic performance on structure are studied thoroughly, based on the AE rise time, ringing counts, energy, duration and amplitude of 60 different initial static load and different initial damage concrete dynamic axial tensile AE characteristics tests divided into 10 groups. Results are as follows: With the increase of initial quasi-static load value, the increase rates of acoustic emission parameters for concrete under dynamic loads gradually decrease; The larger the initial quasi-static load value is, the more difficult to identify the load's stable stage according to the acoustic emission signal, and the more significant hysteresis effect of concrete damage is; Under dynamic loads, the acoustic emission signal for concrete prism specimens also accord with Kaiser effect; Kaiser effect is determined mainly by the interior damage level of concrete specimens, not by the magnitude of load; The more initial loading cycles, the higher the degree of damage of specimens is, and the less acoustic emission signals are produced within the dynamic loading stage.

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1. Introduction

The concrete damage and failure has always been the researchers' focus. Many scholars in domestic and foreign countries have analyzed the interior damage of concrete from different aspects [1,2]. In recent years, with the rapidly developing acoustic emission technique, researchers are able to capture the real-time variation inside the material, as well as monitor the degree and speed of damage inside the material [3,4], and thus many scholars can study the damage-fracture-failure process of concrete based on acoustic emission technique [5,6].

Based on acoustic emission velocity process theory, Suzuki et al., conducted quantitative assessment of damage in concrete piers, and discussed the feasibility of bridge structure monitoring with acoustic emission technique [7]. Carpinteri et al., applied acoustic emission technique to monitoring of reinforced concrete structures and ancient stone architectures, obtained the variation curves of pressure stress and acoustic emission accumulative counts along with time, and utilized acoustic emission technique to identify the defect and damage of concrete structure and masonry buildings [8]. B.K. Raghu Prasad studied the relationship between acoustic emission energy and concrete fracture energy by testing concrete specimens with different dimensions [9], and found that both acoustic emission energy and concrete fracture energy increase along as the size increase. Wang Yan et al., studied the acoustic emission of reinforced concrete beam under loading, obtained acoustic emission parameters within the whole beam

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http://dx.doi.org/10.1016/j.conbuildmat.2016.03.065
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Fig. 1. The experimental set-up.

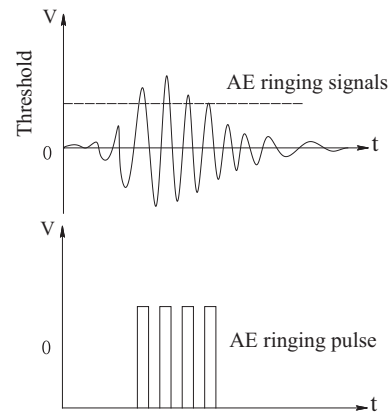

Fig. 2. AE ringing counts.

failure process, thus could accurately predict the beam capacity at stage with small loadings, and made acoustic emission source positioning more complete, more accurate, and quicker, with algorithm modification [10]. Hu et al., conducted three-point flexural concrete beam experiment and found that the acoustic emission signals can be used to identify the cracking point and instability point of concrete fracture, further more, created the constitutive relation of concrete damage according to acoustic emission parameters [11].

As a rapidly developing non-destructive testing method, acoustic emission technique has huge potential in many areas, for example, creation of the relationship between the damage and its acoustic emission parameters by studying the acoustic emission characteristics of interface between reinforcement bar and concrete [12], investigation of the evolution procedure of interior structure during fracture process with fractal theory [13], and so on. The research results showed that, the acoustic emission parameters are able to reflect the stage characteristics in concrete fracture procedure [14,15], and to verify that there is necessary correlation between concrete acoustic emission activity and concrete interior defect [16,17]. There are significant correlations among acoustic emission signals during concrete fracture procedure [18,19], and acoustic emission characteristic parameters can be used to evaluate concrete damage level [20,21].

In this paper, With reference to the related scholars' study, based on the existing research, dynamic axial tensile acoustic emission experiment was conducted on concrete prism specimens with different initial static loadings and different initial damages to study the acoustic emission characteristics of concrete prism specimens under different initial static loadings and initial damage degrees. Fundamental theoretical data are provided for dynamic failure of concrete specimens.

2. Experiment overview

2.1. Specimen designation

In this experiment, 100 mm×100 mm×510 mm molds were used to pour 60 concrete specimens divided into 10 groups in one time. To avoid the deviation of the loading of concrete specimens from central axis, a 20 mm diameter reinforcement bar was pre-embedded at each end of steel molding plate before pouring and stayed. Specimens stayed 24 h before demolting, and then covered with cloth and watered periodically in laboratory till 28 days. The initial designed strength of concrete specimen was 60 MPa, mixed from P.II 52.5 cement, fly ash, medium sand, crashed stone, water, and JM-8 admixture. All the tests were conducted on MTS-810NEW hydraulic servo test machines. Specialized rotation connection was used to connect the specimens with MTS test machine to realize axial tension during the tests. A large clip-on extensometer with measuring capacity of 250 mm and measuring range of +2.5 mm to −2.5 mm was placed, the centroids of specimen serving as symmetrical axis [22]. The clip-on extensometer was connected to the MTS test machine collection system, and realized synchronized collection of loading and strain.

2.2. Experimental equipment and procedure

The acoustic emission system used in experiment is the SAMOSTM eight-channel acoustic emission testing system made by Physical Acoustic Corporation in USA. With modern digital signal processing technique, this system is currently the leading acoustic emission processing system in the world. Its fundamental working principle is as follows: material or structure deform or fracture when subjected to exterior and interior action, and strain energy is released and spreads in material in form of elastic wave, which causes vibration on surface of the monitored specimen. When these vibrations spread to the sensors which were coupled on specimen, the crystal at the sensor's surface deform and electric charge would appear at the surface, within the electric field, the chip creates elastic deformation, this kind of vibration on specimen surface will be converted into voltage signals under the piezoelectric effect, signals are then amplified and processed with equipment and displayed in form of parameters or waveforms, so that signals can be processed.

To ensure the sensors receive better acoustic emission signals and avoid exterior interference, parts to install sensors were grinded and polished with sandpaper, and were coated with vaseline as coupling agent before acoustic emission sensors were installed. Four acoustic emission sensors were installed on the specimen's four sides and 3-D positioning was created, as shown in Fig. 1. Tapes were used when acoustic emission sensors were fixed to avoid fall-off. The threshold value in this acoustic emission experiment was set as

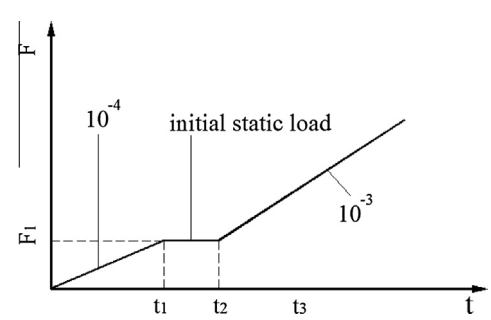

Fig. 3. The dynamic axial tensile test programs on different initial static loads of concrete.

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