Research status of fatigue performance of concrete structures

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Abstract

The research trends of fatigue performance of concrete structures at home and abroad are described in detail.This paper mainly describes the fatigue research of reinforced concrete and fiber concrete.Through the analysis of the present situation of the research on the fatigue performance of various kinds of structural concrete in China, it is expected to be helpful to the research on the fatigue performance of concrete in the future.Finally put forward their own views.

Keywords

Fatigue performance;Reinforced concrete; Fiber concrete.

1. Introduction

Do not number your paper: All manuscripts must be in English, also the table and figure texts, otherwise , Fatigue refers to the internal performance change process of materials under the repeated action of loads less than the static load strength, which may be caused by further crack propagation caused by damage or complete fracture after loads reach enough times of repetition. It is one of the most important failure forms of materials, components and structures.

2. Research on fatigue failure of reinforced concrete

Fatigue study begins with the study of metal fatigue. At the earliest, in the mechanical industry, engineers found that many metal structures would be damaged under the strength of materials, and then conducted targeted experimental research on this phenomenon. After the research of metal fatigue, the research of concrete structure fatigue failure gradually becomes a hot spot. The performance change of concrete material under fatigue load is a gradual process. Due to the heterogeneity and nonlinearity of concrete material, the failure process is very complex.

The following is the research on fatigue performance of ordinary concrete by scholars at home and abroad.

Lv peiyin et al. [1] studied the fatigue performance of concrete under constant amplitude and repeated load at different temperatures. The laws of tensile fatigue strength and stiffness deformation of concrete at different temperatures are studied and analyzed. The fatigue equation considering the influence of temperature and the expressions of tensile fatigue strain and secant modulus are given. The results are compared with those obtained at room temperature.

Chen Haojun [2] conducted a constant amplitude fatigue load test on cold-rolled ribbed reinforced concrete simply supported beams with reinforcement ratios of 0%, 0.29%, 0.487%, 0.934% and 1.946%, respectively. According to the reason that the failure forms are fracture failure, flexural failure and shear pressure failure, the concept of the limit reinforcement ratio and the fatigue equation of different reinforcement ratio are put forward.

Liang junsong et al. [3] proposed a fatigue analysis method based on damage mechanics, By introducing the fatigue damage constitutive model to describe the deterioration process of concrete

materials under the action of fatigue load, In order to improve the computational efficiency, a cyclic jump fatigue acceleration algorithm is developed by combining the constitutive model with the nonlinear finite element method. This method is used to simulate the fatigue failure process of concrete and reinforced concrete beams, The results are compared with the fatigue test data.The results show that the fatigue failure process of concrete structures can be simulated efficiently and accurately by combining the fatigue damage constitutive model and fatigue acceleration algorithm.

Zhu hongbing et al. [4] conducted constant amplitude fatigue loading test on 5 test beams in the laboratory, and found the rule of fatigue damage in three stages of reinforced concrete T beams, respectively: the damage develops rapidly in the early and later stages of fatigue test, but the damage develops relatively steadily in the middle stage of fatigue test.

Qin feng et al. [5]conducted research on the corrosion of pier of cross-sea Bridges at home and abroad. Combined with the experimental study, the corrosion fatigue performance of reinforced concrete structures is summarized. The measures to improve the durability of structures are summarized in comparison with the existing and under construction cross-sea Bridges.

Yi jin et al. [6] conducted fatigue and static loading tests on 8 reinforced concrete beams with different strengths, Under the action of fatigue load, the crack of corroded reinforced concrete beam develops faster and the distribution area is more concentrated than that of uncorroded beam.The yield load of corroded beams can be improved by increasing the strength of concrete.

Ma zhilian [7] studied the fatigue failure of reinforced concrete bridge deck in 2018. The study showed that with the increase of the number of load cycles, the deformation modulus of concrete decreases, the stress of concrete and steel decreases, the strain increases, and the stiffness of components decreases. The inherent life loss of materials is the essential cause of structural fatigue failure.

Research status of fatigue performance of fiber concrete

Steel fiber reinforced concrete (SFRC) is characterized by light weight, high strength and high fracture toughness.t has good bending, tensile and fatigue resistance. Reinforced steel fiber reinforced concrete members can not only improve the mechanical properties of concrete members, but also improve the fatigue performance, so it is widely used.

Zhao yanru et al. [8] analyzed the change rules of strain of concrete and steel bars by conducting bending static load and constant amplitude fatigue tests on reinforced concrete beams with different steel fiber content. The effects of fiber content on bending deformation and fatigue properties of beams are studied. The results show that adding steel fiber can delay the rise of neutral axis and improve the deformation performance of beam.The fatigue life of steel fiber reinforced concrete beams is higher than that of ordinary reinforced concrete beams under the same stress.

In 2012, Macrae[9] conducted fatigue tests on concrete beams with stress ratios ranging from 0.26 to 0.616 and steel fiber content of 0, 20kg/m3 and 60kg/m3 respectively. It is concluded that increasing the steel fiber content can improve the fatigue performance of the specimens, but high fiber content has a certain negative effect on the fatigue life under high stress ratio.

In 2015, Parvez and Foster[10] studied the fatigue performance of reinforced steel fiber concrete, taking the volume rate of steel fiber (0,0.4%, 0.8%) and the size of specimen (300×180×3000mm, 200×100×1200mm) as variables, and described the test phenomenon in detail. Finally, it is concluded that the fatigue life of steel fiber reinforced concrete with volume ratio of 0.4% and 0.8% increases by 0.47 and 1.82 times respectively compared with ordinary reinforced concrete under fixed stress. Steel fibers extend the fatigue life of SFRC beams by reducing the stress level in the tensile reinforcement.

Academician sun wei's team [11] has done a lot of research on the fatigue performance of steel fiber reinforced concrete. Through the fatigue test of steel fiber concrete, it is concluded that the characteristic value of steel fiber has great influence on the fatigue performance of steel fiber concrete. When the stress ratio is constant, the fatigue life of steel fiber can be increased by 1 ~ 2 times with the increase of the characteristic value of steel fiber. The influence rule of fiber volume rate and

length-diameter ratio on folding and fatigue performance is analyzed, and the fatigue life equation is given:

$$S = (0.944 - 0.771gN)(1 + 0.4079V_f l_f / d_f)$$

Deng zongcai et al. [12,13] studied the mechanical properties of steel-fiber reinforced concrete (SFRC) with curved hook under low cyclic loading, and studied the failure mechanism of plain concrete and SFRC under axial fatigue load. The effects of steel fiber varieties, fiber content and loading stress level on fatigue life and energy absorption were studied through experiments. The results show that the fatigue life and energy absorption of steel fiber reinforced concrete (SFRC) increase significantly at lower stress level than at higher stress level.

Xie jianbin et al. [14] conducted an experimental study on bending fatigue of steel fiber reinforced concrete materials used for pavement. The flexural fatigue life of steel fiber reinforced concrete (SFRC) for road surface is determined to conform to weibull distribution of two parameters. The double logarithmic fatigue equation and single logarithmic fatigue equation considering survival rate were established.The results show that the bending resistance and bending fatigue life of SFRC are significantly higher than those of ordinary concrete. The three - stage development law of maximum tensile strain sum of steel fiber reinforced concrete is obtained.

Zhang xiaohui [15] studied the fatigue damage characteristics and microscopic strength of steel fiber reinforced concrete. The fatigue life equation and bending fatigue damage evolution equation of steel fiber reinforced concrete are deduced by statistical theory, According to the interface bonding theory, the tensile initial crack strength and ultimate strength are deduced.

In 2007, zhang xinghu et al. [16] from xi 'an university of architecture and technology studied the fatigue performance of railway Bridges reinforced with carbon fiber cloth. The test results show that the strength and stiffness of the reinforced concrete beams do not decrease after 2 million times of fatigue, and there is no spalling and brittle fracture.

In 2008, shi qiyin et al. [17] from jiangsu university studied the flexural fatigue resistance of reinforced concrete crane beams reinforced with carbon fiber cloth. The research shows that after strengthening with CFRP, the crack width of members decreases by 50.2% to 66%, the development speed is also controlled, the steel stress decreases by 24.1% to 28.2%, and the stiffness of members increases by 14.9% to 16.1%.At the same time, the fatigue stiffness and life of the reinforced concrete crane beam reinforced by carbon fiber cloth are calculated and analyzed according to the test results and the existing methods of stiffness calculation and life analysis.

Prospect

1)A large number of experimental studies at home and abroad show that the factors affecting the fatigue performance of reinforced SFRC beams include: stress ratio, reinforcement ratio, reinforcement strength, steel fiber content, loading mode, loading frequency, etc. The effects of multiple factors on fatigue performance should be further compared and analyzed to make the test more comprehensive.

2)In the future experiments, more gradients of fiber volume rate can be set up, and a computational model can be established to obtain the optimal fiber volume rate, which will be of great guiding significance to practical engineering.

3)In engineering practice, very few structures bear constant amplitude and frequency cyclic load, and the influence of variable amplitude and frequency conversion load on structural fatigue performance can be further studied. In addition, the dispersion of fatigue test data is large, so the sample size can be increased in future tests to obtain more accurate test data and establish more accurate calculation model.

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