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Experimental research on the behaviour of high frequency fatigue in concrete

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ABSTRACT

Calculating the fatigue strength of concrete under the cyclic load of vehicles when designing bridges is an issue which is receiving more and more attention from many engineers and researchers. Based on this fact, fatigue tests of plain concrete under constant-amplitude and stepping-amplitude cyclic loads were conducted. The mechanism which damages plain concrete specimens under high frequency fatigue loads was analysed and a non-linear accumulative fatigue formula that causes the damage was proposed. A fatigue equation *P–S–N* that considers the failure probability p' was given. The results of this research are a good preparation for further studies into high frequency fatigue tests of concrete cylinders reinforced with carbon fibre.

1. Introduction

Bridges over highways and railways suffer cyclic loads from vehicles which cause the structures to fail, but the failure of these structures and their components from fatigue loads are far lower than their original strength. Failure from fatigue is often abrupt and has serious consequences.

Some researchers have already investigated the fatigue performance of concrete. Aas-Jakobsen [1] found there was a good linear relationship between the logarithm of fatigue life and stress ratio f_c^{max}/f_c (f_c^{max} = the maximum value of fatigue compressive stress, f_c = the mean value of fatigue compressive stress), and then obtained the Wohler equation in linear form. Matsushita and Tokumitsu [2] conducted fatigue tests using concrete cylinders. The probability distribution for the fatigue life of concrete was analysed and the *S–N* (*S* = stress, *N* = fatigue life) equation, which includes the lowest fatigue stress level, was put forward. Hsu [3] introduced a loading speed *T* into the series of *f–N–R* (*f* = stress level, *N* = fatigue life, *R* = correlation coefficient) equations for fatigue tests on concrete and established the *f–N–R–T* equation in 3D. He suggested the equations for high frequency fatigue and low frequency fatigue respectively. Mihashi [4] applied the stochastic process theory when estimating to the fatigue life of concrete. Liang and Zhou [5] developed a fracture mechanics based fatigue law for asphalt concrete beams. Based on damage mechanics and tensor theory, Alliche [6] established a three dimensional model for describing the behaviour of concrete fatigue. Sain and Chandra Kishen [7] concluded that for concrete suffering from fatigue, a discrete crack may be modelled as an equivalent damage zone where both correspond to the same loss of energy. Hitherto, many researches have worked on low frequency fatigue in concrete components, whereas research on high frequency fatigue is relatively recent due to limitations in the test conditions.

In this paper, fatigue tests of plain concrete under constant-amplitude and stepping-amplitude cyclic loads were carried out. The mechanism that caused the damage was analysed, a non-linear fatigue accumulative damage model was established

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