Frequency effect on the fatigue life of plain and fiber-reinforced concrete

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Summary

This paper presents very recent experimental results aimed at disclosing the loading frequency effect on the fatigue behavior of a plain concrete and two types of fiber-reinforced concretes, using polypropylene and steel fibers. Compressive fatigue tests were conducted on 120 cubic specimens (100 mm in edge length). Four different loading frequencies were set as 4 Hz, 1 Hz, 0.25 Hz and 0.0625 Hz, respectively. The maximum stress applied on the specimen was 85% of the compressive strength and the stress ratio was set constant as 0.3. The results show that the loading frequency effect on the fatigue behavior of the plain concrete is pronounced. The fatigue life (the number of cycles to failure) at the lower frequencies is less than that at higher frequencies. However, the fibers can improve the fatigue behavior significantly under low loading frequencies. Such trend can be attributed to the effectiveness of the fibers in bridging the cracks, and thus inhibiting crack extension during the load cycles.

Key words: Fatigue, compression, fiber reinforced concrete, loading frequency.

1. Introduction

Interest in the fatigue of concrete began more than a hundred years ago with the development of reinforced concrete beans. With the technological development in high-strength concrete (HSC), HSC is very often used in modern complicated structures of considerable height and span. However, HSC is more brittle than conventional concrete, so, an alternative method is performed to introduce more ductility by adding fibers into the concrete matrix, thus, a type of fiber-reinforced concrete (FRC) is made. Nowadays, the fatigue behavior of FRC is also getting more and more attention.

Since the beginning of researches on fatigue behavior of concrete, numerous experiments have been conducted to study the influence of different fatigue parameters [1-18] and references within. These parameters are either set by the fatigue test conditions, such as the minimum stress σ_{min}, the maximum stress σ_{max} and the loading frequency f, or determined by material properties, for example the static material strength σ_c, which can be the compressive strength f_c or the tensile strength f_t, or any other critical stress defined accordingly. Other parameters include the stress ratio R, defined as $\sigma_{min}/\sigma_{max}$, or the stress level S, defined as σ_{max}/σ_c.

Regarding the effect of loading frequency f on the fatigue life (the number of cycles N resisted before failure) of plain concrete, the first studies [1, 2] show that when f was between 4.5 Hz and 7.5 Hz, the loading frequency had slight effect on the fatigue life N, however, when f was lower than 0.16 Hz, the fatigue life decreased. Some other researches [6, 10] suggested that the loading frequency had minor influence on the fatigue life when the loading frequency was between 1 Hz and 15 Hz, and the maximum stress S_{max} was less than 75% of the compressive strength f_c. After that, it was shown [19] that when S_{max} was greater 75% f_c, the loading frequency influenced N strongly.

The classical fatigue equation [7] has evolved accordingly to illustrate the role of some common fatigue test parameters:

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