

Influence of loading frequency on micromechanics of concrete fatigue fracture

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Abstract:

Several parameters, including material, geometrical, and loading, govern the fatigue behavior of concrete. The loading frequency shows a counter-intuitive trend of increased fatigue life with an increase in loading frequency. This trend is observed irrespective of different loading modes such as compressive or tensile, or flexural fatigue loading¹. While the fatigue experiments and models illustrating this counter-intuitive trend in concrete are well documented in the literature^{2,3}, the underlying physical mechanisms are not yet fully understood, which forms the main objective of this research. Fatigue crack propagates at load (or stress) amplitude lower than critical load. It is characterized by a three-stage damage evolution, which manifests slow and progressive cracking at nano\micro scales within the fracture process zone (FPZ). In this research, we analyze the effect of loading frequency in the formation of FPZ through a comprehensive experimental and analytical investigation. Concrete beams are tested under flexural fatigue in a three-point configuration with three different loading frequencies. The acoustic emission (AE) and digital image correlation (DIC) techniques evaluate the micro and macro cracking mechanisms. The experimental investigations reveal that the FPZ width increases with an increase in loading frequency. An analytical model encapsulating the localized fatigue damage phenomenon and loading frequency effects is proposed to predict concrete fatigue life. The model unifies damage and fracture mechanics theories through a thermodynamic framework. It is used in conjunction with dimensional analysis and similitude concepts.

¹ Rios, J., Cifuentes, H., Yu, R., Ruiz, G. (2017). *Probabilistic flexural fatigue in plain and fiber-reinforced concrete*. Materials 10 (7), 767.

² Chen, X., Bu, J., Fan, X., Lu, J., Xu, L. (2017). *Effect of loading frequency and stress level on low cycle fatigue behavior of plain concrete in direct tension*. Construction and Building Materials 133, 367-375.

³ Saucedo, L., Rena, C. Y., Medeiros, A., Zhang, X., Ruiz, G. (2013). *A probabilistic fatigue model based on the initial distribution to consider frequency effect in plain and fiber reinforced concrete*. International Journal of Fatigue 48, 308-318.