Combined numerical experimental methodology for characterizing the concrete fatigue behavior considering the loading sequence effect

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ABSTRACT

Concrete fatigue behavior is usually studied for loading scenarios with constant amplitude. However, in reality the loading can have variable amplitudes ordered in different sequences. Without studying the effect of load sequencing and variable amplitudes, the safety factors may be set uneconomically large or dangerously low. The well-known Palmgren-Miner (P-M) rule applied in the current design codes considering linear damage accumulation should be critically scrutinized.

The high complexity of the problem behind the fatigue order effect and high cost demand for experimental investigations are the reasons why there is only a limited amount of experimental data available as a basis for the definition of sound engineering design rules for concrete fatigue. Therefore, a combination of numerical and experimental investigations is necessary to get a deeper insight into the phenomenology of the fatigue behavior of concrete under a wide range of loading scenarios.

In this paper, a refined engineering rule for the prediction of remaining fatigue life of concrete under compressive cyclic loading with varying amplitude is proposed. The rule has been derived based on a combined numerical and experimental investigations of the fatigue order effect. A modeling approach based on continuum damage mechanics has been used to simulate the concrete fatigue behavior [1]. The applied fatigue damage model uses the rate of the equivalent tensile strain as a state variable driving the fatigue damage upon loading and reloading at subcritical load levels [2]. A systematic calibration and validation procedure of the numerical model was performed based on available experimental results in the literature. The validated numerical model has been used for further numerical investigations of concrete fatigue behavior under varied loading ranges applied in different sequences. The obtained numerical results have been evaluated and compared to the available damage accumulation rules for predicting the concrete fatigue life under varying loading ranges. Validation of the proposed rule has been provided for several loading scenarios.

REFERENCES

[1] Alliche, A., Damage model for fatigue loading of concrete, *International Journal of Fatigue* (2004) **26**:915–921.

[2] Marigo, J., Modelling of brittle and fatigue damage for elastic material by growth of microvoids, *Engineering Fracture Mechanics* (1985) **21**(4) 861–874