Mathematical model to predict the fatigue behavior in railway bridges

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Fatigue is the progressive, localized, permanent structural change that occurs in materials subjected to fluctuating stresses and strains that may result in cracks or fracture after a sufficient number of fluctuations. Fatigue fractures are caused by the simultaneous action of cyclic stress, tensile stress and plastic strain.

A cyclic plasticity model to predict the fatigue behavior is generated by using the fundamentals of plasticity theory such as yield criteria, flow rule, hardening rule, and other theories in plasticity. Concept here is the determination of the internal state variable of material at the place where the stresses are most severe, when it is subjected to cyclic loading. Fatigue fracture is assumed to be initiated when the internal state variables reach threshold values. Considering the material has an appreciable strain-hardening rate, it was considered the effective plastic strain as the internal state variable in the study.

Using above concepts the cyclic plasticity model was developed for the wrought iron material model, which exhibits the nonlinear Kinematic hardening. The specified wrought iron sample, which was extracted from the old railway bridge in Sri Lanka, was tested at Department of Material Engineering, Israel Institute of Technology, Haifa, Israel, (authors thank Professor Dov Sherman), following the ASTM E8 to obtain stress-strain behavior, required mechanical properties and hardening behavior of material. From that, specified hardening rules and the mathematical model for particular material was developed. Finally comparing the theoretical behavior with the actual behaviors which were obtained by experimental uniaxial loading operations such as proportional, cyclic and reverse, the verification of the mathematical model was done. Hence determined the developed material model is best suit to predict the fatigue life of structure at critical location where the stress state is known.

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