LOW CYCLE FATIGUE LIFE PREDICTION OF EXISTING RAILWAY BRIDGES

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Many of the engineering structures in today's world are getting old and a very large existing stock of civil infrastructures is in need of maintenance, rehabilitation or replacement. Among these, the existing railway bridges are most liable to suffer from fatigue and their highly stressed locations are subjected to multiaxial variable amplitude loading which may also be nonpropotional. But the lack of fatigue life prediction techniques which can handle multiaxial loading has hindered the quantitative assessment of engineering components subjected to more than one loading mode of random amplitude nature. This study presents a mathematical model to describe the low cycle fatigue behaviour of a nonlinear kinematic hardening material when it is subjected to multiaxial variable amplitude loading.

The fatigue model is generated using the fundamentals of two surface plasticity theory. Concept behind the methodology 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 would initiate at such places when the internal state variables reach threshold values. Assuming that the kinematic hardening material has an appreciable strain-hardening rate, effective plastic strain is proposed as the critical internal state variable in this model.

Using above concepts, a low cycle fatigue model was developed for wrought iron. The specified wrought iron sample which was extracted from one of the major railway bridges in Sri Lanka, was tested to obtain the required mechanical properties and hardening behaviour of the material. From that, specified hardening rules and the mathematical model for particular material was developed. Finally comparing the theoretical behaviour with the actual behaviours, verification of the mathematical model was done. The comparison revealed that the model prediction has a reasonable agreement with real behaviour of the material and it is validated the applicability of the proposed model in fatigue life prediction.

The developed model was used to determine the remaining fatigue life of the considered bridge. From the initial analysis it revealed that some locations in the connected members were subjected to multi axial stress states and von Mises stress could exceed even the yield stress of the material in some cases. Such cases, which can be subjected to low cycle fatigue, were selected for life estimation. Since the major criteria behind the life estimation is the determination of the effective plastic strain at the critical location, an elastoplastic FE analysis, with proposed model was performed.

From the results, it was noticed that even though the estimated numerical values related to the remaining lives are within the safe margin, they are not realistic, since the FE program used, lack facility to handle the monotonic variable amplitude loading. Finally it was concluded that this model based remaining life estimation technique of existing bridges is considered as one bounding approach which is not dependent on complex experimental work.

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