Combining Laboratory and Field Data in Rail Fatigue Analysis

by

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Abstract

Rail fatigue is one of the key factors affecting rail service life. Once a defected rail was detected, it will be replaced immediately to avoid derailment. Fatigue failures cost railroads in various aspects such as repairs, traffic delays, and accidents, and also have an impact on the reliability of rail service. The purpose of rail fatigue analysis is to provide assessment of maintenance and operations strategies in regard to rail fatigue.

Because the field data regarding rail fatigue are often limited, the model calibrated based on field data may not be reliable for predicting future deterioration conditions. In addition, the field data may be measured with error and subject to temporal correlation. Therefore, the Phoenix model which has been developed based on theories of material behavior and laboratory results was used as a supplemental tool to analyze rail fatigue. The data generated from the Phoenix model does not have the disadvantages as those in the field data. However, the Phoenix model has not yet been validated by the field data and the results could be biased. Thus, the goal of this research is to develop a reliable rail fatigue model by combining both data sources.

Assuming no spatial correlation among defects, the rail fatigue model was formulated as a spatial Poisson with a defect occurrence rate which depends on the usage of rail and factors affecting fatigue. The defect rate was also formulated to incorporate multiple failure types and dynamic explanatory variables.

The model parameters calibrated to the Phoenix output and to the field data were both in agreement with the a priori expectation of fatigue behavior. By assuming that the Phoenix model was biased, the unbiased parameters for the combined model and the biases were simultaneously estimated by pooling both data sources.

Finally, this research applies the combined model to analyze the effects of maintenance and operation practices regarding fatigue failures.

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