MD-Vol. 94, Proceedings of the ASME Materials Division — 2000
Book of Abstracts
ASME 2000

Fatigue Reliability Under Corrosion, Creep, and Fretting Damage

Sankaran Mahadevan

Department of Civil and Environmental Engineering
Box 6077-B, Vanderbilt University, Nashville, TN 37235
Phone: 615-322-3040, Fax: 615-322-3365, Email: sankaran.mahadevan@vanderbilt.edu

Abstract

This paper presents probabilistic methodologies being developed at Vanderbilt University for the reliability analysis of aging structures. Several deterioration mechanisms such as fatigue, corrosion, creep, and fretting are considered, and probabilistic models are developed. Interactions between the different mechanisms are considered. The effects of various uncertain parameters on the overall life prediction estimates are quantified.

The fatigue damage process induced by pitting corrosion in aging aircraft is composed of seven stages: pitting nucleation, pit growth, transition from pit growth to short crack, short crack growth, transition from short crack to long crack, long crack growth and fracture. A comprehensive mechanics-based probabilistic model for pitting corrosion fatigue life prediction by including all the stages is presented. Analytical FORM/SORM methods as well as advanced Monte Carlo simulation methods are implemented with the proposed model, and probabilistic sensitivity analysis and parametric studies are performed.

Fretting fatigue is one of the main mechanisms of the formation of cracks in riveted lap joint assemblies in aging aircraft and can reduce the fatigue life significantly. A macro-mechanics-based probabilistic model is developed to give the quantitative description of crack nucleation life. Fretting conditions in an idealized, cyclic-loaded pinned connection having dimensions typical of riveted panels are studied. ANSYS finite element analysis is applied to provide the stress, displacement and strain fields in the neighborhood of the contacts between the panel and pin.

Creep is one of the principal damage mechanisms for materials operating at elevated temperatures, such as in aircraft and space propulsion engines. It can produce larger strain deformation, stress relaxation, and crack initiation and growth. Current creep-fatigue life prediction methods use a code-specified bilinear model that has several uncertainties and assumptions regarding material behavior. A new continuous creep-fatigue failure criterion function is introduced directly based on experimental data to facilitate analytical reliability approximations. Such a model is advantageous for new high performance materials where previous experience is limited. A linear damage accumulation rule is used. The use of analytical and simulation methods for reliability analysis with the proposed model is investigated. The effects of the scatter and distributions of different random variables on the creep-fatigue life are studied.

This study is supported by funds from the National Science Foundation.