Introduction

The analysis and design of engineering structures and systems are, in most cases, carried out with the assumption that loads, environmental factors, and material properties are deterministic quantities, though it is generally recognized that most design parameters have statistical variations.

Early experiments have already revealed a much wider scatter in fatigue test results than in most static tests and hence researchers have been concerned with the statistical interpretation of data.

Because extrapolation and interpolation based on limited experimental evidence have been the aim of most tests, attention was initially focused on various suitable methods of data plotting, curve fitting, and determination of distribution functions for fatigue life. Today regression analysis and mathematical techniques of curve fitting, aided by electronic computers, have replaced curve fitting by eye.

The use of the normal and logarithmic normal distributions has been supplemented with the extremal distributions of Weibull and Gumbel and various other transformations which either fit the data better or are based on an underlying physical process. To date proponents of various theories are not in complete agreement on the most suitable distribution functions for the description of the statistical variations of fatigue life.

Response curves and confidence bands for fatigue strength and their relationship to life distributions have also received considerable attention in the past. Methods are still being sought to determine a statistically justifiable fatigue limit based on a minimum number of test results.

The recognition of the effects of variable loads on fatigue life has led to the extensive study of random processes and their application to the description of fatigue loads produced by gusts and aircraft maneuvers, road-surface roughness, and ocean waves. Testing machines have been developed to apply such random loads to specimens, components, and complete structures and cumulative damage concepts, based on deterministic considerations, have been updated with the inclusion of probabilistic techniques concerning both loads and material response.

While in the past safety factors or scatter factors were used to take care of the variability of both strength and loads, in recent years the mathematics of reliability analysis have been adapted to fatigue design for a quantitative determination of levels of safety and reliability. These methods have given rise to the examination of the need for redundancy, establishment of realistic inspection periods, maintenance schedules, and retirement policies.

Computer simulation of the fatigue process and of crack propagation based on probabilistic considerations is a recently developed tool that has been found useful in explaining experimental results.

Though statistical design of experiments and decision theory are well known to statisticians, the use of these techniques in the planning and interpretation of fatigue tests has received wide recognition only during the last few years. These methods point the way towards the most efficient utilization of available specimens.

The probabilistic aspects of fatigue include also the establishment of realistic statistical procedures for small samples, the use of early failures in the estimation of population parameters, and the adaptation of available techniques to new materials and environments.

The 1971 Symposium on Probabilistic Aspects of Fatigue examined the most recent work in several of these areas with the aid of authors whose reputations are international.

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