LOAD TOLERANCE ESTIMATION IN FATIGUE RELIABILITY DESIGN

Haoyu Wang[a], Nam-Ho Kim[b], Yoon-Jun Kim[c]

[a,b]Department of Mechanical and Aerospace Engineering, University of Florida, Gainesville, FL 32611
[a]hyw@ufl.edu,[b]nkim@ufl.edu
[c]Caterpillar Inc., Technical Center, P.O. Box 1875, Peoria, IL 61656-1875
Kim_Yoon-Jun@cat.com

This paper presents an efficient technique to estimate the load tolerance, which shows a capacity of the current design, a future reference for design upgrade, maintenance and control. A reliability-based load design method is applied in fatigue reliability design, which provides the load tolerance for a structure subject to the fatigue failure mode. Load capacity coefficient α is introduced as a random parameter to define the load capacity. The range of the mean of α is regarded as a load tolerance. Equations (1) and (2) show how α is defined for the load amplitude and the mean cases, respectively.

$$f(t) = (1-\alpha) f_{\text{mean}} + \alpha f_0(t) \tag{1}$$

$$f(t) = (\alpha - 1) f_{mean} + f_0(t) \tag{2}$$

where $f_0(t)$ is the initial dynamic load history (peak and valley), f_{mean} is the mean value of f_0. When $\alpha = 1$, the applied load is identical to the original load history and α can not be negative.

The stochastic response surface method is used to predict the relationship between the logarithmic fatigue life and the load capacity coefficient. Reliability analysis is then carried out using the first-order reliability method (FORM) based on the stochastic response surface. Applications of load tolerance estimation with respect to the reliability measure of fatigue life performance are developed. When the relationship between the reliability measure of the system and applied loads is linear or mildly nonlinear, a linear assumption turns out to be accurate and effective. Using the sensitivity information provided by FORM and the linear approximation, the critical value of the mean of α can be estimated to meet the probability requirement. The accuracy of the estimated result is also verified as shown in Figure 1 (load amplitude effect).

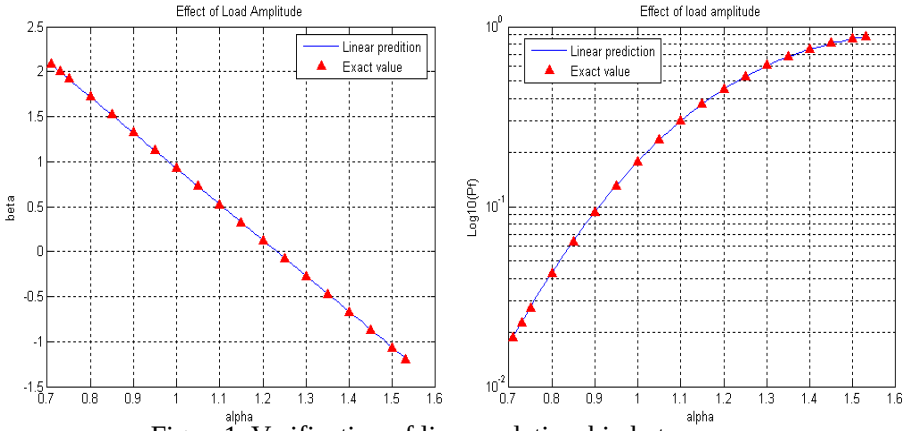

Figure1. Verification of linear relationship between probability measure β and load capacity coefficient α

In practical applications the information of random parameters and distribution types is often unavailable, especially for dynamic loads. Engineers are often more interested in the effect of these parameters. Using the sensitivity and linear approximation, it is possible to predict which distribution type has a significant effect on the load tolerance. After dominant distribution type is selected, the detailed load tolerance is constructed to make the estimation conservative.

References

[1] B.Kwak and J.Kim, Concept of Allowable Load Set and Its Application for Evaluation of Structural Integrity, *Mechanics of Structures and Machines*, 30(2), 213-247, 2002.