LOW CYCLE FATIGUE OF SEISMICALLY EXCITED SYSYEMS

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Fatigue is a frequently encountered mode of failure in seismically excited structures. For this reason, there has been a good deal of experimental and theoretical research in the field of low cycle fatigue. Theoretical research in fatigue failure generally involves some kind of cumulative damage theory and is a variation of Miner's rule. However, experimental research has shown that there are many factors involved in the expected value and variance of fatigue life which are not taken into account in cumulative damage theories. Some of these may be listed as follows: shape and intensity of spectral density function of the loading, damping, mean and variance of natural frequency of the system, rate of deterioration.

Let the vibration of the considered structure be dominated by the first mode and let it be excited by an earthquake acceleration which can be represented by a stationary Gaussian band limited white noise random process. It is assumed that the predominant natural frequency of the system is a Gaussian random variable with time dependent mean and variance. Time dependence of the natural frequency is related to the deterioration rate $\lambda(t)$ which is related to ductility of the structure. $\lambda(t)$ is considered as the rate of a non-stationary Poisson process. At various non-dimensionalized times t_i, the expected frequency of exceedance of an arbitrary level 'a' of the response (stress history) of the system to the random loading are considered and compared with that of the non-deteriorated value (at t 0). The ratio r is proposed as the fatigue criterion. It should be noted that r is a relative measure.

It is concluded from the r-t relationships that for different values of S_o (intensity of the loading spectral density), β (damping coefficient), μ_w (mean of frequency), σ_w^2 (variance of frequency), λ (Poisson rate) and 'a' (stress threshold); μ_w, σ^2_w and λ may be considered as primarily influential parameters whereas S_o, β and 'a' are secondarily influential on the relative fatigue life of the structure.

It is further observed that the expected value and the variance of the crossing frequency are influenced in the same way by the above cited parameters because of the narrow band character of the response.

Experimental work is already under way to confirm theoretical results and estimate numerical values for λ as a funtion of ductility factor.

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