Abstract

Analysis of dynamic structural response to time-discontinuous stochastic excitations

This thesis deals with the dynamic response of linear and non-linear systems to time-discontinuous stochastic excitations in form of a random train of events. Problems considered are the dynamic response of non-linear systems to random trains of impulses driven by Erlang renewal processes and the dynamic response of linear systems (models of a bridge structure) to the train of moving loads driven by Erlang renewal processes. Mathematical fundamentals of applied methods are also covered, concerning stochastic point processes, non-diffusive Markov processes and asymptotic expansions of probability density functions.

Non-linear systems considered are those with polynomial non-linearity, which results from geometric structural non-linearity. The theory of general continuous-jump Markov processes and the existing method of differential equations for moments of response of dynamic systems to non-Poisson trains of impulses are used. In order to obtain an effective solution of these equations the cumulant-neglect and quasi-moment neglect closure techniques are applied and some special, modified cumulant-neglect and quasi-moment neglect closure techniques have been devised. For the system with cubic non-linearity (Duffing oscillator) equations for moments up to the fourth order have been derived and for the appearing fifth- and sixth-order moments the closure techniques have been used. Computations have been carried out for Erlang renewal processes with parameters $k = 2, 3$ and 4. Accuracy of the obtained approximate results for the mean value and the variance of the response (displacement) has been verified against numerical Monte Carlo simulations.

Linear system considered is a beam (model of a bridge) subjected to a random train of moving loads (idealized as point-wise forces) driven by Erlang renewal processes. Theory of filtered renewal processes has been applied. For Erlang renewal processes with parameters $k = 2, 3$ and 4 the exact mean value and variance of the response (displacement) have been determined by numerical evaluation of pertinent integrals. Analysis has been carried out for trains of vehicles moving with different velocity and for different highway traffic conditions (intensity).

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