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AN ANALYTIC METHOD TO ESTIMATE THE RESPONSE SPECTRUM OF THE SYNTHETIC RECORDS WITH EVOLUTIONARY SPECTRUM

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According to Priestley (1965), a real-valued stochastic evolutionary process can be defined as in the general form of Fourier-Stieltejes as follows:

$$X(t)=\int_{-\infty}^{+\infty} A(t,\omega)\exp(i\omega t)\,dZ(\omega) \tag{1}$$

where $A(t,\omega)$ is a deterministic complex-valued modulating function and Z(ω) is a random complex-valued function. If the Fourier Transform of $A(t,\omega)\exp(i\omega t)$ on ω axis is available, Equation 1 expression can be stated in time domain by the means of the convolution integral given that:

$$a(t,\tau)=\frac{1}{2\pi}\int_{-\infty}^{+\infty} A(t,\omega)\exp\left[i\omega(t-\tau)\right]d\omega \tag{2}$$

Waezi and Rofooei (2016, 2017) introduced double frequency model (DFM) for stochastic generation of non-stationary acceleration records. The proposed model is capable of considering two large and one small dominant frequencies for efficient capturing of the recorded strong motion's power spectrum. A high-pass filtered time-varying double-frequencies model with time-variant parameters is introduced to develop a frequency-wise, non-stationary process. This model can be described by the Equation 3:

$$f(t)=m(t,\boldsymbol{\alpha})\left\{\frac{1}{\sigma(t)}\int_{-\infty}^{t} h(t,\tau)\,w(\tau)\,d\tau\right\} \tag{3}$$

where $h(t,\tau)$, $m(t)$ and $\sigma(t)$ represent the impulse response function of the filter, modulating function and the instantaneous standard deviation of the integral in the bracket, respectively: Also, $w(\tau)$ and $\sigma^2(t)$ are a white noise with power S_0 and the evolutionary variance of the process, respectively. It is shown in this paper that in case of slowly varying $H(\tau,\omega)$, which is the evolutionary transfer function of $h(t,\tau)$, one can write:

$$A(t,\omega)\cong H(t,\omega) \tag{4}$$

This simplification can be used to estimate the Evolutionary Power Spectral Density $G_{XX}(t,\omega)$. In order to estimate the response spectrum resulted from the records generated using Equation 1, the peak factor problem is considered. The following classic probability of non-exceedance of the displacement response of an SDOF subjected to synthetic acceleration from level u up to time t is used:

$$L_X(u,t) = \exp\left(-\int_0^t \eta_X(u,s)\,ds\right) \tag{5}$$

where thus $\eta_X(u,s)$ can be regarded as an occurrence rate which is equal to the conditional rate of up-crossing from level u, given that no earlier up-crossing occurrence has occurred. Three different assumptions are considered for the estimation of $\eta_X(u,s)$ which are: 1) Poisson's Assumption (Shinozuka & Yang, 1971), 2) Vanmarcke Approximation (Vanmarcke, 1975), and 3) Michaelov, Lutes and Sarkani's Method (MLS) (Michaelov et al., 2001). The estimation of $\eta_X(u,s)$ for Poisson's Assumption requires evaluation of $\sigma_X^2(t)$, $\sigma_{\dot{X}}^2(t)$, $\rho_{X\dot{X}}(t)$ and $q_X(t)$ which are the variances of the process and its derivative as well as their correlation coefficient and the bandwidth factor of the response process respectively. Using the simplification of Equation, closed form equations are proposed to evaluate these parameters in both time and frequency domain.

The accuracy of these approximate methods to estimate the response analytically have been investigated and the sensitivity of the estimation to the model parameters including the correlation and the bandwidth of the process have been assessed. Figure 1 depicts the median spectral acceleration resulted from Monte Carlo simulation against the approximate methods investigated here for a specific set of synthetic acceleration model parameters $\boldsymbol{\lambda} = \{\xi_g, f_g, \xi_{f0}, \xi_{fn}, f_{f0}, f_{fn}, \xi_c, f_c\}$.

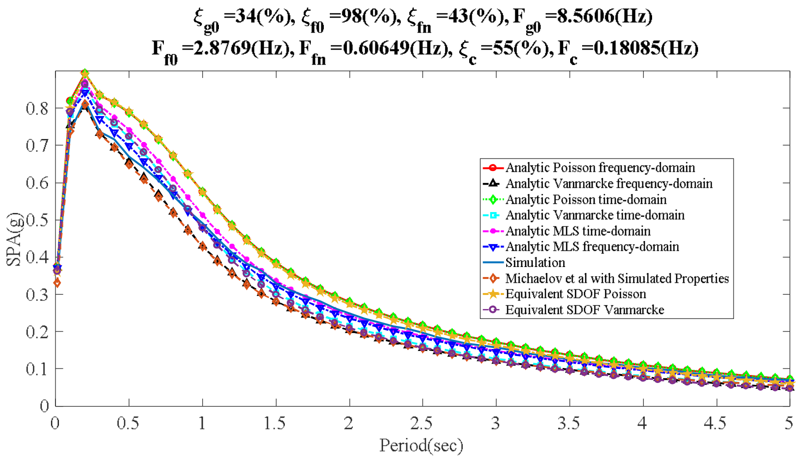

Figure 1. Comparison of different methods of median response spectrum approximation for records resulted from Double-Frequency method, using Poisson and Vanmarcke approximations using frequency-domain methods adjusted.

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