Recent advances in the stochastic modelling of the seismic action and evaluation of the structural response

by

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For a number of application connected with the seismic assessment of structures it is necessary to generate accelerograms which are compatible with a design response spectrum. The solution of this inverse problem is not unique. As a consequence, several methods have been proposed in literature for coping with the generation of spectrum compatible accelerograms. Due to the widely recognized random nature of the seismic action, stochastic approach appears the more attractive strategy. In this regard, most common approaches rely on modeling the seismic action as a realization of a stationary or quasi-stationary stochastic process. In this framework, an handy expression for determining the spectrum compatible power spectral density function will be presented and its use in the structural design will be initially addressed. Stationary approach suffers the major drawback of neglecting the time variability of both intensity and frequency content characteristics of the real records. Remarkably, it is well known that the dynamic response of nonlinear structures is highly influenced by the nonstationary behavior of the input. Thus, more reliable simulations have to take into account the time variability of both intensity and frequency content of the ground motion. To this aim a method for simulating fully nonstationary spectrum compatible accelerograms (i.e. with frequency and amplitude varying with respect to time) is presented. The method assumes that the ground motion is modelled by the superposition of two contribution: the first one is a fully-nonstationary counterpart modelled by a recorded earthquake (or a set of recorded earthquakes), that takes into account the time variability of both intensity and frequency content; the second one is a corrective term represented by a quasi-stationary process adjusting the response spectrum of the nonstationary signal in order to make it spectrum compatible. Remarkably, the simulated earthquakes do not require any further iterative correction. Thus the evolutionary spectrumcompatible power spectral density (ESPSD) can be readily determined. Once determined the ESPSD a procedure for determining the random response of structural systems will be presented. The procedure is aimed to evaluate the nonstationary spectral moments useful for reliability studies. Furthermore, computational aspects related to modal truncation criteria will be dealt with. The extension of the procedure for generating fully nonstationary spectrum compatible earthquakes for taking into account of inherent ground motion spatial variability will be also discussed. Quite often, records of earthquake ground motion are very far from the site in which the structures have to be built. Due to propagation of the seismic wave, nonstationary characteristics of ground motion time histories could be very different from those of the recording station. In order to take in to account of local characteristics and soil profile underneath the foundation, site response analysis should be suitably addressed. Equivalent linear approach is certainly the easiest way for evaluating site response. However, in the case of strong ground motion input time domain analysis have to be carried out. In this regard a procedure for calibrating pertinent cyclic behaviour of soil through the Preisach formalism starting by the knowledge of modulus reduction and damping curves is also presented.