Calculation Stochastic Input energy Spectra from Frequency Amplitude Spectra

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Abstract

A theoretically relation is presented between the seismological Fourier amplitude spectrum and the elastic input energy spectrum. The presented relationship provides an important basis for better understanding of the relationship between input energy spectra and other seismological variables, such as magnitude, focal distance, path, and site effects. In this study, the contribution of these sources of variability to the uncertainty in input energy is examined using stochastic analysis, Monte Carlo simulation, to compare the effect of these earthquake ground motion parameters. Analytical results show that the influence of earthquake magnitude, focal distance, and soil condition are important for the shape and amplitude of input energy spectra.

Keywords: Input energy, seismological, sensitivity, Monte-Carlo simulation.

1. INTRODUCTION

Hudson and Housner, at the end of 1950s, demonstrated that structures failed when the energy demand imposed by an earthquake exceeded the energy supply, determined by structural properties [1, 2]. Most energy design methods are based on the premise that the energy demand can be predicted, therefore, suitable member sizes can be provided to dissipate the input energy within an acceptable limit state [3]. The input energy to a structure during an earthquake is an important measure of both the ground motion characteristics and structural properties. The earthquake input energy transmitted to a structure consists of the kinetic energy, elastic strain energy, damping energy, and hysteretic energy [4]. However, damage to structures is related absorption in the inelastic range, but a relation between elastic and inelastic input energies has been presented [5]. Akiyama [4], McKevitt et al. [6], Zahrah and Hall [7], and Nakashima et al. [8] believe that ductility and damping do not have a significant influence on the earthquake input energy. Therefore, in developing an energy-based design approach and assessing the damage potential of structures, one must know the earthquake input energy.

The earthquake input energy has usually been computed in the time domain. The time-domain approach has several advantages, e.g. the availability for non-linear structures, the description of the time-history response of input energy, the possibility of expressing the input energy rate. On the other hand, the time domain approach is not necessarily appropriate for probabilistic analyses. For that purpose, the frequency domain approach is suitable because it use the Fourier amplitude spectrum of input ground accelerations and the time invariant transfer functions of the structure [9-14]. It was demonstrated that input energy spectrum could be exactly made with the Fourier amplitude spectrum and without information of phases [11, 15].

It can be shown that the formulation of the earthquake input energy in the frequency domain is essential to evaluate the contribution of ground motion parameters in input energy spectra. This is because, the formulation in the frequency domain only requires the computation of the Fourier amplitude spectrum of ground motion, which Fourier amplitude spectra can be calculated based on seismological method. One of the essential characteristics of the seismological method is that it distills what is known about the various factors affecting ground motions (source, path, and site) into simple functional forms.

This paper presents a study of the effect of the variability in earthquake ground motion parameters such as magnitude, focal distance, soil condition, focal mechanism on the stochastic input energy of single degree of freedom. The standard deviations of total input energy are evaluated by using a Monte Carlo-based analysis. Contributions of these sources of variability to overall variability in input energy are assessed.