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A study of response spectra for different geological conditions in Gujarat, India

Sumer Chopra*, Pallabee Choudhury

Institute of Seismological Research, Raisan, Gandhinagar 382009, Gujarat, India

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ABSTRACT

In this study, the effect of ground geology on the acceleration response spectra is studied at 32 sites in Gujarat, India. The sites are grouped into Proterozoic, Mesozoic, Tertiary and Quaternary. The normalized acceleration response spectra at 5% damping of 407 strong ground motions (horizontal and vertical components) recorded at these sites varying in magnitude from 3.0 to 5.7 are determined. The study shows that the shape of the acceleration response spectra is influenced by the regional geology and local site conditions. The peak of maximum horizontal spectral amplification is between 0.03 and 0.05 s in Proterozoic formations, 0.06 and 0.10 s in Mesozoic formations, 0.06 and 0.08 s in Tertiary and 0.12 s in Quaternary formations. The maximum vertical spectral acceleration is at 0.025 s in Proterozoic, 0.07 s in Mesozoic, 0.05 s in Tertiary and 0.10 s in Quaternary formations. The average acceleration amplification factor in all the geological formations is between 2.5 and 3.0 both in horizontal and vertical components. It has been observed that acceleration response spectra at sites having same geological formations are also influenced by local site conditions. The study shows that the acceleration response spectrum in the current Indian code applicable for the entire country underestimates the seismic forces at hard-rock sites and overestimates at soft-soil sites. Using recorded strong motion data with Mw ranging from 3.5 to 5.7, an attenuation relationship is developed at six periods to predict geometric mean of horizontal spectral amplitudes for rock and soil sites. The spectral amplitudes predicted with the attenuation relationship match well with the observed one within statistical limits for hypocentral distances less than 200 km.

1. Introduction

The importance of response spectra in earthquake engineering is well known. Its use in the design of structures of engineering importance is well recognized. It is one of the simplest methods for evaluating the response of different structures to earthquake ground motions. It gives the maximum response of different structures to earthquake ground motions. The response spectrum concept was introduced by Biot [1,2] and Housner [3]. In early days, standard spectra of Housner [4] and Newmark and Hall [5] were popular and used in many applications. Housner [4] used actual strong motion records from El Centro (1934, 1940), Olympia (1949) and Kern County (1952) earthquakes and developed average acceleration spectra for various damping values. Later on most of the development and studies of response spectra were done for nuclear reactor facilities [6–9]. It is a well known fact that an earthquake ground motion is affected by their size, the travel path and the local site effect. As more and more strong motion records were made available these aspects were studied in detail. Hayashi et al. [10] studied various accelerograms recorded on different soil conditions in Japan and divided the spectra into three groups. These groups are made as per local site conditions like stiff soil, loose soil and intermediate soil. More studies [7,11] pointed the fact that the response spectra of soils are different from that on hard rock. The loose soil influences the shape of spectra to a great extent. This site dependence of spectral shapes led to the development of spectra for different geological conditions [12]. Due to paucity of strong motion data on different geological conditions all over the world, most of the studies were done with combined data from different regions and different geological conditions [11,13–18]. With the improvement of strong motion instruments and their number all over the world, more and more strong motion records were made available.

Recent large destructive earthquakes in California, Japan, Turkey and Taiwan provided over a thousand accelerograms and some near source strong motion recordings particularly from Northridge (1999, Mw 6.7) and Chi-Chi (1999, Mw 7.6) earthquakes. Recently, Su et al. [19] studied the influence of magnitude, propagation path and local site effects on acceleration

* Corresponding author. Present address: Ministry of Earth Sciences, CGO Complex, New Delhi 110003, India. Tel.: +91 9910414038.
E-mail addresses: sumer.chopra@gmail.com (S. Chopra), pallabee.ch@gmail.com (P. Choudhury).

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