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Neural network estimation of duration of strong ground motion using Japanese earthquake records

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ABSTRACT

The duration of strong motion has a significant influence on the severity of ground shaking. In this work, a combination of average values of four geophysical properties of site (Standard Penetration Test (SPT) blow count, primary wave velocity, shear wave velocity, and density of soil) including hypocentral distance of less than 50 km and magnitudes more than 5.0 from Japanese ground motion records were used for development of neural network model, to estimate duration of strong ground motion. Since majority of strong motion databases provide only average shear wave velocity for site characterization, an attempt has also been made to train the neural network with magnitude, hypocentral distance and average shear wave velocity as three input variables. Results obtained from this study show that the duration of strong motion is mostly dependent on average shear wave velocity rather than other geophysical properties of site.

1. Introduction

Engineers are primarily interested in strong ground motion. Ground motion associated with a peak ground acceleration of 0.05*g* or higher is considered as strong ground motion [1]. Duration of strong ground motion is one of the key parameters that will contribute to the seismic performance of structural systems. A ground motion with moderate peak acceleration and a long duration may cause more damage than a ground motion with a larger acceleration and a shorter duration [2]. An earthquake accelerogram is generally composed of rise, strong motion, and decay time. For all engineering applications, only the strong motion portion of an accelerogram is of interest. Strong-motion duration play an important role in assessing the damage potential of earthquake ground motion. Several researchers in the past have proposed procedures for computing the strong motion duration of an accelerogram [3–5, 6]. In literature, there are more than 30 definitions of strong-motion duration [7]. The most commonly used definition is the bracketed duration [8], which is defined as the time interval between the first and last exceedances of a specified acceleration (usually 0.05*g*). Another definition of duration [9] is the time interval in which significant contribution to the integral of the square of acceleration ($\int a^2\,dt$) referred to as the accelerogram intensity takes place. In this study the strong motion duration is defined as the interval between the times at which 5% and 95% contributions of the total integral is achieved.

This paper provides a neural network based approach for estimating the duration of strong ground motion based on earthquake records and site characteristics. In the foregoing sections of the paper, the compilation and processing of strong motion data for the Japanese earthquake records from Kyoshin-Net database and the application of artificial neural networks to estimate duration of strong motion have been discussed.

2. Compilation of strong motion data

The main goal of this study is to develop neural network based model to estimate the duration of strong earthquake ground motion using Japanese earthquake records. For this purpose, the first step in network training is to generate a sufficiently large database for which, compiling and processing of strong motion data is required. The ground motion records used in the study are obtained from Kyoshin Net (K-NET) database. Kyoshin Net is a dense strong-motion networking consisting of over 1000 observatories deployed all over Japan at free-field sites at intervals of approximately 25 km covering the country. A map of Japan with all K-NET station locations is presented in Fig. 1. These instruments are located on the ground surface. Each station has a digital strong-motion seismograph (accelerometer) with a wide frequency-band and wide dynamic range. In this study, a total of 84,456 horizontal components of earthquake records from 609 earthquakes of Japan have been downloaded from the internet, which have a magnitude of 5 and above. All K-NET data is openly available on registration through their Web-site [10]. The type of magnitude scale used by Kyoshin Net in Japan is the magnitude,

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