Abstract

Seismic microzonation and hazard mitigation focus strategic research leading to preparation of user-friendly maps describing the current state-of-the-art knowledge about site specific ground shaking with their duration, frequency content, peak ground acceleration and velocity as well as the energy attenuation as a function of earthquake magnitude, epicentral distance, faulting mechanism and the local site conditions. An attempt has been made in the present dissertation to perform a detailed analysis on various site response estimation techniques with special emphasis to site amplification studies in and around Delhi region, the Garhwal Himalaya and in the Sikkim Himalaya, to assess seismic hazard scenario in the Sikkim Himalaya from seismotectonic spectral amplification, source parameterization and spectral attenuation laws using strong motion seismometry and seismic microzonation in the Sikkim Himalaya on a GIS platform through integration of ground motion attributes with the geomorphological, seismological and local site conditions with 10% probability of exceedance in 50 years.

Site response in and around Delhi is studied using digital seismograms recorded by a thirteen-station VSAT-based 24-bit digital Delhi telemetry network of India Meteorological Department. Nine local ($M_L \geq 2.3$) and nine regional ($M_L \geq 3.9$) earthquakes have been selected for the estimation of site amplification factor using the classical standard spectral ratio for regional events, normalized standard spectral ratio for local events, horizontal-to-vertical spectral ratio or receiver function and the generalized inversion techniques in the frequency range of 0.5 to 7.5 Hz. A comparison of the site response values obtained by the generalized inversion with those computed using receiver function technique show a large scatter even though the pattern of the curves remain more or less similar. However, the site effects computed by generalized inversion and standard spectral ratio exhibit a good 1:1 correspondence. It is evident that the softer fluvial deposits of the newer alluvium of the east Yamuna sector show steeper site amplification gradient at lower frequencies, while the greater Delhi experiences moderate site amplification.

Site response in the Garhwal Himalaya is studied using digital seismograms recorded by a five-station 24 bit digital microearthquake network established to monitor the aftershocks of the March 28, 1999 Chamoli earthquake (M_b=6.3). Fifteen aftershocks ($M_d \geq 2.0$) are chosen for the site response estimation using horizontal-to-vertical spectral ratio and generalized inversion techniques. Site response curves at all the five sites show station to station variation of the site factor reflecting the changes in geologic/geotectonic/soil conditions.

The Sikkim Himalaya which is part of the northeast India is seismically one of the six most active regions of the world being placed in zone V with PGA > 0.4g. In this present work an attempt has been made to put forth a composite investigation towards: 1) prediction of Maximum Credible Earthquake (MCE) in the region from GSHAP consideration, 2) seismotectonic study from the strong motion seismometry recorded by the nine station Sikkim Strong Motion Array (SSMA) and its correlation with the findings of micro-earthquake survey, 3) to work out a power law relationship of Q_S with frequency to represent the overall attenuation of seismic wave energy in the region from the events with focal depth less than 35 km and thus defining the path effect precisely, 4) detailed analysis of Site Response (SR) at all the recording stations by receiver function analysis (HVSR) and generalized inversion (GINV) techniques, their comparison and the dependency of SR on the source azimuthal variation, 5) simulation of source spectra and hence the spectral acceleration at various sites for different magnitude so that the source parameterization could be carried out, new empirical relations developed between various source parameters, namely, M_0 & M_W and f_c & M_W for further simulation of spectral acceleration for greater magnitude earthquakes representing MCE of the region for a scenario due to Brune omega-squared circular-crack source model source on MBT, and 6) to develop regional as well as site specific local spectral attenuation laws at different geometrically central frequencies in the low, moderate and high frequency bands. This combined analysis is a maiden effort to address the seismic hazard potential of the Sikkim Himalaya.

The seismic ground motion hazard is mapped in the Sikkim Himalaya with local and regional site conditions incorporated through Geographic Information System (GIS). The geomophological themes with inputs from IRS–1C LISS III digital data, topo-sheets, geographical boundary of the State of Sikkim, surface geological maps, soil taxonomy map in 1:50,000 scale and seismic refraction profiles, are overlaid, united and integrated to form the base site condition coverage of the region. The seismological themes, namely, Site Response (SR), Peak Ground Acceleration (PGA), Predominant Frequency (PF) are assigned normalized weights and feature ranks following a pair-wise comparison hierarchical approach and later integrated to evolve the seismic hazard map. The overall SR, PGA and PF show an increasing trend in the NW-SE direction peaking at Singtam in the lesser Himalaya. In the microzonation vector layer of the integrated seismological and geomorphological themes, six major seismic hazard (H) zones are mapped, namely very low ($H < 0.20$), low ($0.20 \le H < 0.35$), moderate ($0.35 \le H < 0.50$), high ($0.50 \le$

H < 0.65), very high (0.65 ≤ H < 0.80) and severe (0.80 ≤ H ≤ 0.92) at low frequency end, with 10% probability of exceedance in 50 years.

Keywords

Amplitude Spectrum, Attenuation relation, Source azimuth, b-value, Corner frequency, Garhwal Himalaya, Sikkim Himalaya, Generalized inversion, Geographic Information System (GIS), Geometrically central frequency, Ground motion, GSHAP, Gumbel's method, Gutenberg-Richter relation, Main Boundary Thrust (MBT), Main Central Thrust (MCT), Maximum Credible Earthquake (MCE), Moment magnitude, Path effect, Seismic gap, Peak Ground Acceleration (PGA), Plane of detachment, Probability of exceedance, Receiver function, Reference site, Predominant Frequency (PF), Seismic hazard, Seismic microzonation, Sikkim Strong Motion Array (SSMA), Site amplification, Source spectra, Spectral attenuation, S-wave, Standard spectral ratio.