Seismic Microzonation of NCT Delhi

A. K. Shukla, Rajesh Prakash, Dal Singh, Ravi Kant Singh,
A. P. Pandey, H. S. Mandal and B. M. S. Nayal

Earthquake Risk Evaluation Center, India Meteorological Department, New Delhi

1. Introduction

Delhi-The National Capital of India with its long history, rich culture and strategic importance, is of prime consideration for earthquake risk reduction and hazard mitigation planning. The present state of Delhi with its 9 districts (National Capital Territory) occupies an area of 1482 sq km spreading between Lat 28°24′01″ & 28°53′00″ and Long 76°05′24″ & 77°02′37″ (Toposheets 53 D/14 & 53H/1,2,3,6, and 7). As per the 2001-based Census, the population of Delhi is 137.82 Lakhs. It is projected that the population would touch to 180 Lakhs by 2011 and 234 Lakhs by 2021.

Geologically, Delhi is located on folded crustal ramp with basement rocks of Delhi Supergroup, bounded by two regional faults viz Mahendragarh-Dehradun Fault in the west and Great Boundary Fault in the East. The ramp trending NNE-SSW across ‘fore deep’, is juxtaposed to Himalayan thrust belt. Thus, the seismic vulnerability of built environment of Delhi need be examined vis-a-vis high frequency ground motions due to events endemic to faults of Peninsular Domain and also due to frequency content of attenuated events with source zone in thrust domain of Himalayas. Fault lines of consequence in the domain are (i) Mahendragarh Fault, (ii) Great Boundary Fault, (iii) Moradabad Fault and (iv) Sohna Fault

Department of Science and Technology, GOI, had constituted a multi-disciplinary Working Group of experts from India Meteorological Department(IMD), Geological Survey of India(GSI), Central Ground Water Board(CGWB), Central Road Research Institute(CRRI), Wadia Institute of Himalayan Geology(WIHG), Delhi University(DU), I.I.T-Delhi, I.I.T-Roorkee and I.I.T-Kharagpur. Earthquake Risk Evaluation Centre (EREC), IMD, had been entrusted to collate the data, generate new inputs, integrate multi thematic data and evolve Seismic Hazard Microzonation map of NCT, Delhi.

2. Methodology

The Seismic hazard & Risk Microzonation (SHRM) requires multi-disciplinary approach and sequence of studies to generate parameters for source, travel path, ground characterization & vulnerability analysis with inputs forthcoming from 5 disciplines viz. Geosciences (geology and geophysics), Seismology, Geotechnical Engineering, Engineering Seismology and Anthropology/Civil administration. The SHRM is essentially a geoscientific endeavor where ground characterization based on geological attributes provides basic map for further multi-criteria based discretization or microzonation, delineating units of likely uniform ground response. The model adopted for seismic microzonation is given in figure-1

Work Components

Seismic Microzonation for New Delhi Capital Region was in focus for long time and Department of Science and Technology GOI, New Delhi had constituted a multi-disciplinary working group
Microzonation

involving national agencies viz. GSI, IMD, WIHG, CBRI, IIT (R), IIT (D), CGWB, DU, CRRI, SOI, etc. for collating data available with different organization and preparing 1st level seismic microzonation map of Delhi. Base map prepared by Survey of India (SOI) and Geological maps generated by Geological Survey of India (GSI) on 1:5000 scale were used as basic maps. Geological characterization of the Quaternary–Holocene litho-fill contents of the domain are of utmost importance both in soft soil amplifications and in assessment of liquefaction potential and susceptibility. Geotechnical data generated by different organizations have been collected and used for generating soil typologies, N values and interpreted shear wave maps. Significant data on ground water and bedrock depth generated by CGWB. And used for generating water table and bed rock depth maps. EREC, IMD has conducted studies on site response at about 500 sites in NCT Delhi and used for generating natural frequency and amplification maps.

A total 15 multi-thematic maps pertaining to ‘Geoscientific’, ‘Geotechnical’ and ‘Site-Response’ characterizations have been generated and integrated with ‘Bedrock depth’ as the base map. The integrated data have been further interpreted in conjunction with peak frequency & amplification maps assigning a second order ranking and liquefaction susceptibility with third order of significance. Following this hierarchical integration in GIS base, 1st level seismic microzonation map of NCT Delhi has been evolved (figure-I).

The 1st level microzonation map discretizes the territory of NCT Delhi in 9 units viz. (i) Ridge ambience of exposed rock with low hazard, (ii) Layer of impedance contrast at shallow depth (<30 m) with Moderate Hazard, (iii) Weathered rock zone with Moderate Hazard due to weathering induced pronounced ground response, (iv) Chhattarpur Basin with High Hazard due to anticipated Basin effect, (v) Central Delhi with Moderate Hazard due to amplification in mid frequency level and Basin margin effect (vi) North-West Delhi plains (Bangar) of Moderate Hazard due to thick soil cover, (vii) South Najafgarh sedimentary fill (Dabar) with Moderate Hazard due to high amplification and liquefaction, (viii) Zone of Basin margin effect west of Delhi ridge: High Hazard, (ix) Newer alluvium proximal to Yamuna river: High Hazard due to Liquefaction Potential. Hazard levels (Plate-II) have been alluded to different microzones based on anticipated amplification and liquefaction susceptibility.

With a view to application of the microzonation maps for ascertaining parameters to be used in engineering designs following two maps are derived:

1. Map showing domains of short period (<1 sec or > 1 Hz) and long period (>1 sec or <1 Hz) ground attributes for easy reference to Table-1 or Table-2 of NEHRP classification for taking amplification values for different spectral accelerations.

2. Site classification based on shear wave velocity for attributing amplifications in short and long period domains for different spectral accelerations.

Earthquake Risk Evaluation Centre is taking up further studies for Seismic Microzonation with higher precision on 1:10,000 scale. This would provide attributes of hazard for all microzones with site-specific details. The ‘Hazard’ would be integrated with results of collateral studies on ‘vulnerability analysis’ for final risk microzonation.
Components of Seismic Microzonation and Flow chart

- Source Characterization
  - Hazard Evaluation at bed rock PSHA/DSHA
- Ground Characterization
- Engineering Seismology of Built environment
- Site Characterization
- Site Response
- Basin Configuration of soft sediments
- Geotechnical characterization of soft sediments
- Geological & Geomorphologic characterization

1st Level Microzonation
2nd Level Microzonation
3rd Level Microzonation
4th Level Microzonation

Figure 1 Seismic hazard and Risk microzonation-Flow chart
Plate-II

FIRST LEVEL SEISMIC HAZARD MICROZONATION MAP OF NCT, DELHI

LEGEND
- Ridge Ambience of Exposed Rock: Low Hazard
- Layer of Impedance Contrast at Shallow Depth (>50m) Resulting Moderate Hazard
- Weathered Rock Zone: Moderate Hazard due to Weathering induced Pronounced Ground Response
- Limnetic Layer: Moderate Hazard due to Amplification in mid to low Frequencies & Basin Margin Effect
- North West Delhi Plains: Moderate Hazard due to Thick Soft Sediments
- South Najafgarh: Moderate Hazard due to High Amplification & Liquefaction
- Chhatarpur Basin: High Hazard due to Basin Effect
- Zone of Basin Margin Effect West of Delhi Ridge: High Hazard
- Newer Alluvium Proximal to Yamuna River: High Hazard due to Liquefaction Potential

N

North

North East

North East

North West

North West

West

West

Gurgaon

Gurgaon

South West

South West

South

South

Noida

Noida

Faridabad

Faridabad

Loni

Loni

Ghazibad

Ghazibad

New Delhi

New Delhi

Delhi

Delhi

Delhi

Delhi

Delhi