Seismic Ground Response Analysis of Some Typical Sites of Guwahati City

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ABSTRACT

In this study, one dimensional equivalent–linear ground response analyses were performed for some typical sites in the Guwahati city, India. Six bore locations covering about 250 km$^2$ area of the city were considered for the analyses. As the strong motion significantly influences the ground response, seven different recorded ground motions, varying in magnitude (6.1 to 8.1) and other ground motion parameters, were adopted. Seismic site analyses were carried out for all layers of borelogs using all the seven earthquakes. Results are presented in terms of surface acceleration histories, strain and shear stress ratio variation, response spectrum, Fourier amplitude ratio versus frequency. The results indicate that accelerations were amplified the most at the surface level. The range of peak ground acceleration (PGA) values obtained at the ground surface is about 0.2 g to 0.79 for a range of PGA considered at bedrock level (rigid half space at bottom of borelog) of 0.1 g to 0.34 g. The Fourier amplifications of ground motion at surface are in the range of 4.14 – 8.99 for a frequency band of 1.75 Hz to 3.13 Hz. The maximum spectral acceleration at six locations varies in the range of 1.0 g – 4.71 g for all the seven earthquakes. The study clearly demonstrated the role for site effect and the type of ground motion on the ground response. For a given earthquake motion, amplification factors at surface level change by almost about 20% to 70% depending on local site conditions.

Keywords: Amplification Factor, Deep soil, Equivalent Linear Method, Ground Response Analysis, Spectral Acceleration

INTRODUCTION

An earthquake causes rupture along a fault plane and the generated seismic waves propagate through underlying bedrock and reach the earth’s surface. The amplification and de-amplification of ground motion from the bedrock to the surface depend on various stratification or geological parameters. For design of any earthquake resistant structure, selection of design ground motion play an important role. The design ground motion at bedrock level depends on various parameters like: faulting mechanism and its seismicity, local geology, surface topography, type of bed rock and dynamic properties of the soil medium.

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through which the seismic waves travel. Ground response analyses (GRA) need to be performed for obtaining ground motions at surface level for a chosen bed rock motion. Ground response analysis can be performed by using one dimensional, two dimensional and three dimensional methods (Kramer, 1996). Further GRA also helps in development of design response spectra; to evaluate dynamic stress and strain for liquefaction hazard evaluation and to determine the earthquake induced forces that can lead to instability of various structures.

Several studies were reported in literature on seismic ground response analyses for Indian cities. Ranjan (2005) carried out seismic response analysis of Dehradun city and reported that the range of spectral acceleration was 0.06 g – 0.37 g at frequency range 1 Hz –10 Hz. Pallav et al. (2010) simulated 1869 Cachar earthquake rock level ground motion at Imphal city (PGA lies between 0.1 g – 0.16 g) and also estimated amplification factors at ground level which were in the order of 1.5 – 2.0. Govindaraju and Bhattacharya (2011) carried out site-specific earthquake response study for hazard assessment in Kolkata city. They observed that the amplification of ground motion were in the range of 4.46–4.82 with the fundamental period ranging from 0.81 s to 1.17 s and the maximum spectral accelerations were in the range of 0.78 g –0.95 g. Phanikanth et al. (2011) performed equivalent linear ground response analyses for Mumbai city.

Estimation of ground motion amplification due to the local soil sites is a complex problem to the designers and more important for fast growing cities like Guwahati in India. Northeast India is one of the most seismically active regions of the world. As per Seismic hazards zonation map by the Bureau of Indian Standards (IS 1893), Guwahati city comes under zone V (i.e., very severe zone) with a zone factor 0.36. Guwahati city had experienced many major earthquakes in the past. Among them the 1897 Assam earthquake and 1950 Assam earthquake are the most historical disasters. Ambraseys and Bilham (2003) reported the earthquake MSK intensity (Medvedev–Sponheuer–Karnik) of 8 for Guwahati city during the great 1897 Assam intraplate earthquake which also exhibited widespread liquefaction. Reddy et al. (2009) carried out extensive field investigations in the meizo-seismal area of the great Assam 1950 earthquake to explore the paleo-seismic history of the North-East region through documentation of liquefaction features. They reported that the intensity of the 1950 Assam Earthquake lies between IX – X.

With this seismic history, few studies related to seismic aspects of Northeast India covering Assam state, especially referring to Guwahati city were reported in literature. Nath et al. (2008a) carried out the site response analysis of Guwahati city and reported that the variation of peak ground acceleration (PGA) and site amplification factor of the region are in the order of 0.22 g – 1.27 g and 2–10 respectively. Raghukanth and Dash (2010a) reported that the plain land of Guwahati city belongs to E –type according to IBC (2006), E – type soil sites are more susceptible to liquefaction and ground failure. They simulated ground motions during six past devastating earthquakes and one possible future event of magnitude > 8 (i.e. Future probable earthquake in the Assam Gap reported by Khattri and Wyas, 1978) in the north-eastern part of India by seismological methods.. The rock level PGA reported by Raghukanth and Dash (2010b) at Guwahati city are in the range of 0.10 g to 0.22 g for the seven earthquakes considered. Nath and Thingbaijam (2011) assessed seismic site conditions of Guwahati city through five micro-tremor recordings of small to moderate magnitude (body wave magnitude, $M_b$ = 4.8 to 5.4) earthquakes and reported that the site amplification factor varies 4–6 with frequency range 1.2–5.0 Hz at the site class E and F and 5.5–7.5 at frequency 2 Hz at rock site.

In this study an attempt is made to analyze the seismic site responses of some selected sites in Guwahati city. In general, seismic site response depends on the soil profile at the location and the bed rock motion or strong ground motion to which the site is subjected to. To analyze the seismic ground responses of Guwahati city, six different soil profiles at
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