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Seismic site characterization in the region near Korba coalfield, Chhattisgarh (India)

Tushar Singhania[1,2], Niptika Jana[1*] and Sanjit Kumar Pal[1]
[1]Department of Applied Geophysics, Indian Institute of Technology (Indian School of Mines)
Dhanbad, Dhanbad-826004, Jharkhand, India
[2]Department of Civil and Infrastructure Engineering, Indian Institute of Technology Jodhpur, Jodhpur District-342030, Rajasthan, India
Corresponding author: niptika.jana.1201@gmail.com

ABSTRACT

This study employs seismic techniques for the site characterization of the Korba region in Chhattisgarh, India. Seismic activity has been reported in this region lately, classifying this region in seismic zone III, according to the Building Materials and Technology Promotion Council (BMTPC) assessment (2006). We gather data from 30 different locations in the Korba region, using the Tromino instrument. We estimate the fundamental frequency, construct shear wave velocity for subsurface classification of the Korba region, and develop Horizontal-to-Vertical Spectral Ratio (HVSR) curves for ambient noise data in accordance with the National Earthquake Hazards Reduction Programme (NEHRP) criteria. We calculated the liquefaction vulnerability index (Kg), amplification value, and peak resonant frequencies from the HVSR curve. Amplification factors range from 1.18 to 10.02, while the peak resonant frequencies span from 1.146 to 15.062 Hz. Vs30 for the region varies between 140.06 and 646.90 m/s. These findings indicate presence of soft soil in the western portion of the region, which is situated along the Hasdeo River's bank. In majority of the places, we discovered that the Kg value was less than 10, indicating low liquefaction vulnerability in the examined area.

Keywords: Horizontal-to-vertical spectrum (HVSR), Shear wave velocity, Peak resonant frequency, Site characterization, Liquefaction vulnerability index (Kg), Digital Elevation Model (DEM).

INTRODUCTION

Classification of the nature of subsurface, plays a major role in generating seismic damage risks (Gupta et al. 2021), as soil properties influence the likelihood and severity of an earthquake in a particular region (Akkaya and Ozvan, 2019). Earthquakes produce strong and dynamic forces that travel through the earth as seismic waves. These waves have the potential to induce seismic activity, resulting in vibrations that can impact structures and their foundations. Comprehending the soil's response to these dynamic stresses, is crucial as it differs significantly from its behaviour under static loads, such as the weight of a structure (Farrugia et al., 2016). Understanding the behaviour of soil under dynamic loads, helps in selecting suitable structures that can withstand seismic forces and implementation of appropriate mitigation measures. The soft soil layer's resonance frequency and shear wave velocities (V_S), are crucial for predicting ground motion and effectively preventing or mitigating seismic catastrophes (Farrugia et al., 2016). Comprehending the geographical variances is crucial for evaluating earthquake hazards, preparing for them, and designing robust infrastructure (Ansal, 1999).

Many studies have been conducted on seismic site characterization in various regions (Picozzi et al., 2009; Foti et al., 2011; Gupta et al., 2019; Cultrera et al., 2021; Gupta et al., 2021; Vijayan et al., 2022). However, no similar study has been conducted in the surrounding areas of the Korba region. The current increase in seismic activity in several districts of Chhattisgarh, including Korba, highlights the need to understand the subsurface dynamics for upcoming developmental projects (Parashar, 2023).

The studied region lies under seismic zone 'III' of India, which is a moderate-intensity zone that is assigned under zone factor 0.16. (BMTPC 2nd edition). The Hasdeo river flows in the southern part of the Korba, which divides it into two parts (Singh et al., 2016). The coal mines of Korba include Manikpur, Gevra, Dipka, Kusumunda, Laxman, Pavan, Rajgamar, Balig, Banki, and Surakachhar, out of which Manikpur, Gevra, Dipka and Kusumunda are operated as open cast mines (Singh et al., 2016).

The current population of the Korba region is approximately 5,00,000, which has increased by 1.86% since 2022 (Census of India, 2011). With the increase in population, more construction work is happening in this region. The Korba region lies in seismic zone III, where an earthquake up to magnitude 6 can be expected (Sairam et al., 2011). This would have the potential to damage single-story or multi-story buildings. Therefore, any development in this region should be done by taking into consideration the seismic parameters to mitigate potential damages and ensure resilient development of projects.

Seismic site characterization is often used to identify the sub-surface material properties of the earth. Parameters that are used to define these material properties are, the shear modulus and shear wave velocity, among others (Pandey et al., 2016). Vs 30 value varies with depth as the subsurface profile changes, so thereby with the application of site characterization, we can identify the material properties of any zones as well (Gupta et al., 2019). Many site characterisation techniques are used to identify the characteristics of a site to facilitate ground response analysis, such as Horizontal-to-vertical spectral ratio (HVSR) (Nakamura, 1989), Multichannel analysis of surface