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Approach for Site-Specific PGA Calculation Based on Magnitude and Distance

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Abstract: A deterministic seismic hazard analysis (DSHA) was carried out using one hundred years of earthquake data obtained from the United States Geological Survey (USGS) catalog for Nepal. The objective of this study was to evaluate site-specific seismic hazard parameters—namely Peak Horizontal Acceleration (PHA), Peak Vertical Acceleration (PVA), and Peak Ground Acceleration (PGA)—for a defined point of interest. The DSHA approach was selected to directly estimate the maximum credible ground motion expected at the site based on historical seismicity. Primary seismic data from the past century were analyzed to identify all significant earthquake events and their respective magnitudes and epicentral distances relative to the study location. The PHA for each event was determined based on its recorded or estimated ground motion characteristics. Using the empirical relationship developed by Cornell et al. (1989), the Peak Ground Velocity (PGV) values corresponding to magnitudes ranging from 3.0 to 9.0 were calculated. Consecutive PHA values from all events were then combined to represent the cumulative horizontal ground acceleration at the site. Subsequently, the Peak Vertical Acceleration (PVA) was estimated which provides a proportional link between the horizontal and vertical components of seismic motion. The final Peak Ground Acceleration (PGA) was derived using the resultant relation The study was also validated by using the relationship between variation of PGA with magnitude values (Chaullagulla et al., 2023). This combined approach provides a deterministic estimate of the total ground motion potential at the selected location.

Keywords: ***Deterministic, PGA, Ground motion, Seismic hazard.***

Introduction

Seismic hazard assessment is a fundamental aspect of earthquake engineering and disaster risk reduction. Understanding the expected level of ground motion at a particular site enables engineers and planners to design safer infrastructure and reduce potential earthquake-induced losses. Among the various methods available, Deterministic Seismic Hazard Analysis (DSHA) provides a direct approach to estimating the maximum credible ground motion that can occur at a site based on historical and geological evidence. Unlike probabilistic methods, DSHA focuses on the most significant earthquake scenarios rather than recurrence probabilities, making it particularly valuable for critical facilities and infrastructure development.

The primary objective of this study is to determine realistic deterministic ground motion parameters using long-term seismic data, which can support seismic hazard mapping, earthquake-resistant design, and regional disaster risk assessment. The findings will contribute to enhancing the understanding of local seismicity and improving engineering geological decision-making for future infrastructure planning.

Methodology

Deterministic seismic hazard analysis (DSHA)

This study applies a Deterministic Seismic Hazard Analysis (DSHA) to estimate Peak Horizontal (PHA), Vertical (PVA), and Ground (PGA) accelerations at the selected site. The process includes data collection, event selection, ground motion estimation, result synthesis, and validation.

Data collection and event selection

Earthquake records for the past 100 years were extracted from the USGS database, including magnitude, depth, coordinates, and time. Figure 1 depicts the database of seismic sources from 1925 with 100 years return period obtained from USGS which is demonstrated in Google earth imagery.

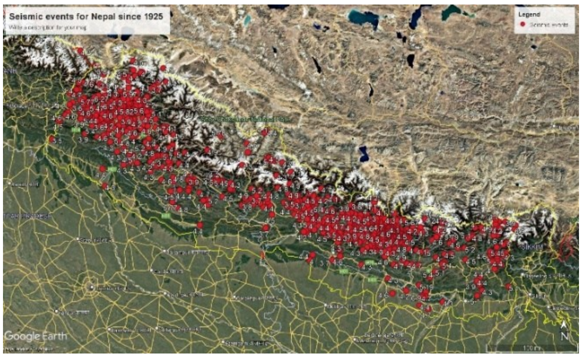

Figure 1, Seismic events for Nepal since 1925 with 100 years return period (Source: USGS).

Peak horizontal acceleration (PHA)

The PHA (Peak Horizontal Acceleration) in gals is estimated to be using the relationship from Cornell et al. (1989).

$$\ln PHA\ (GALS) = 6.74 + 0.859M - 1.80\ln(R + 25) \quad (1)$$

Peak ground velocity (PGV)

The Peak Vertical Acceleration (PVA) can be estimated from the Peak Horizontal Acceleration (PHA) using the empirical relationship from Cornell et al. (1979).

$$PVA = 0.577 - 0.673PHA \quad (2)$$

Resultant peak ground acceleration (PGA)

$$PGA = \sqrt{PHA^2 + PVA^2} \quad (3)$$

Equation (3) calculates the resultant peak acceleration, combining the horizontal (PHA) and vertical (PVA) components of ground motion.

Results

The PGA values for different magnitudes are shown in Figure 2 and Table 1.

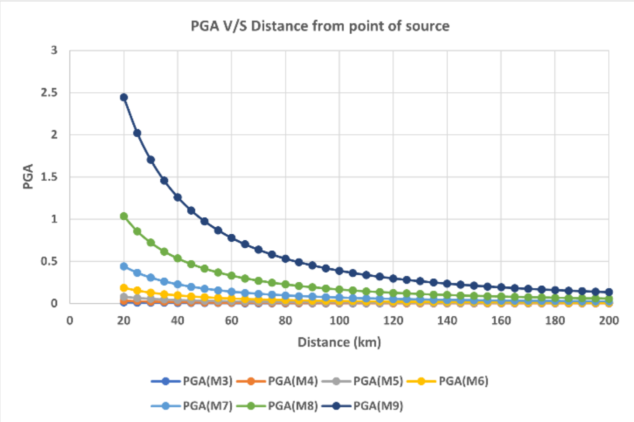

Figure 2, PGA values obtained for different magnitudes

Table 1, PGA values obtained for different magnitudes and at different distance from POI.

Distance from POI(km)	PGA (M3)	PGA (M4)	PGA (M5)	PGA (M6)	PGA (M7)	PGA (M8)	PGA (M9)
20	0.01	0.03	0.08	0.19	0.44	1.04	2.44
25	0.01	0.03	0.07	0.15	0.36	0.86	2.02
70	0.00	0.01	0.02	0.05	0.11	0.27	0.64
75	0.00	0.01	0.02	0.04	0.10	0.25	0.58
200	0.00	0.00	0.00	0.01	0.02	0.06	0.13

Validation of results

The computed PGA values were validated against the empirical relationship proposed by Challagulla et al. (2023). A comparative graph depicting the variation of PGA with earthquake magnitude was prepared, confirming consistency between the present analysis and published correlations for Himalayan seismic regions (Figure 3).

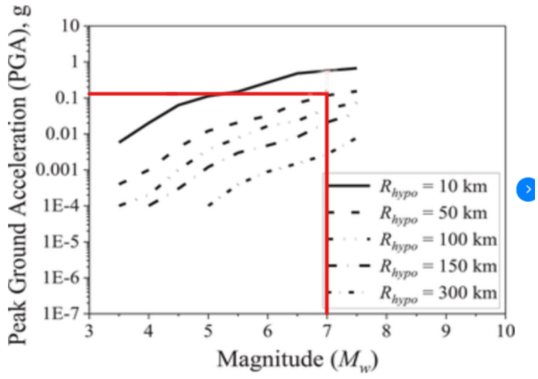

Figure 3, PGA values obtained for different magnitudes (Challagulla et al., 2023).

For a magnitude 7 earthquake at 50 km, the corresponding PGA value is approximately 0.13 g, which closely matches our result shown in Figure 3, yielding 0.11 g.

Conclusion

The deterministic seismic hazard analysis conducted for the study area provides a clear estimation of ground motion parameters based on one hundred years of USGS earthquake data. The computed PHA, PVA, and PGA values represent the maximum credible acceleration expected at the site, offering valuable input for seismic design and safety assessment. Validation with Challagulla et al. (2023) confirmed strong consistency with established empirical correlations for Himalayan regions. Overall, the study enhances understanding of local seismic response and supports safer, evidence-based infrastructure planning in Nepal.

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