Sensitivity analysis of input ground motion on surface motion parameters in high seismic regions: A case of Bhutan Himalaya

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Abstract. Historical earthquakes have demonstrated that strong motion characteristics and local soil condition when coupled ~~the combination of the characteristics of strong ground motion and local soil conditions~~ significantly influence ~~the~~ seismic site response ~~of a particular given site~~. Most of the Himalayan earthquakes have depicted anomalous behavior per the site conditions historically. Being one of the most active seismic regions on earth~~,~~, the~~The~~ eastern fringe of the Himalaya ~~Mts. is one of the most active seismic areas worldwide~~has observed many devastating earthquakes and uneven damages were extensively reported. To this end, we present quantification of surface motion parameters for a soft soil deposit located at Phuentsholing city in western Bhutan. Using one dimensional site response analysis, sensitivity of ground motion variation is estimated for Bhutan. ~~This study represents the first attempt to quantify the influence of the local site conditions on ground shaking in Phuentsholing, one of the major commercial hubs of whole Bhutan. To this end, one-dimensional (1D) ground response analysis in eight different locations were performed. According to the recent Global Seismic Hazard Map (GSHAP), Phuentsholing Thromde (city) in Bhutan is likely to be exposed to the peak ground acceleration (PGA) between 0.20 g – 0.28 g. These high acceleration values do not account for the effect of local site condition as no instrumental records of past earthquakes are available. This study represents the first attempt to quantify the influence of the local site conditions on ground shaking in Phuentsholing Thromde (city), one of the major commercial hubs of whole Bhutan. To this end, one-dimensional (1D) ground response analysis in eight different locations were performed. They~~This study accounts~~ed~~ for the earthquakes ~~with Magnitude between~~of moment magnitude between ~~M_w-~~6.6 and ~~M_w-~~7.5 with a wide variation of ~~PGA~~ peak ground acceleration (PGA) even beyond 0.28g, which is the maximum PGA range suggested by the Global Seismic Hazard Map (GSHAP). ~~In particular, to~~To ~~diagnose~~dissect the characteristics of six inputted ground motions on eight local ground conditions, ~~a~~ sensitivity analysis is performed ~~through a statistical analysis~~statistically. The statistical correlation of the response data sets and the linear regression model of the bedrock outcrop and the surface motion spectral acceleration along the stratified depth ~~was~~were examined to quantify the variation in surface motion parameters. The ~~The study~~Results highlighted thats ~~those earthquakes of~~strong motions having PGA greater than ~0.34 g demonstrate~~s~~ greater sensitivity leading to some anomalies in response parameters, resulting in attenuation of seismic site effect (amplification). The same scenario was observed for the PGA range below 0.1g. ~~with similar pattern below 0.1 g. The study shows a potential range of seismic site amplification between ~1.7 to 6.2 in Zone~~

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~~I and ~1. 8 to 5.8 in Zone II over 0.1 s and 3.0 s periods, respectively. This corresponds to the PGA earthquakes between 0.11 g and 0.33 g.~~

~~Sensitivity analysis is performed by a statistical correlation function to correlate the ground motion parameters for different earthquake shaking intensities. The amplification responses of each soil column are predicted to determine the seismic site effects. The study highlights the critical range of the fundamental natural period roughly between 0.9 s to ~ 5.0 s with the highest range of seismic wave amplification between ~ 2.8 to 6.2, suggesting a likely aggravation due to local soil condition that may lead to severe consequences of infrastructure damages.~~

Keywords: seismic site effect, amplification factor, soil fundamental period, sensitivity analysis, Bhutan.

1. Introduction

Bhutan ~~falls in Himalaya Mts.,~~is located in the eastern fringe of Hind-Kush-Himalaya. ~~an area vulnerable to multiple kind of natural hazards and among them earthquakes are one of the most devastating for the country.~~ Historical earthquakes that occurred in ~~this~~ the Hind-Kush-Himalayan region have resulted in enormous losses and damages (Gautam et al., ~~2016~~20167) and thus the impending earthquakes are certain to strike the region with detrimental consequences. The eastern fringe of Himalaya, i.e., Bhutan, and neighboring areas were strongly affected by significant earthquakes in the past, however, most of those occurred ~~in~~ until the 18th century are not well-documented. The most recent events occurred on April ~~5th~~05, 2021 (M_w 5.0) in Samtse (South Bhutan) and on September 2009 Mongar earthquake (Mw 6.7) in eastern Bhutan.~~,~~ T~~t~~he~~sey~~ earthquakes caused major damages in the eastern parts of Bhutan and considerably affected the other parts of the Country (Chettri et al., 2021b). ~~These events and historical records~~All the past earthquakes highlighted anomalous damage pattern to structures and infrastructures in various parts of the country, especially in the plain areas. Such evidence prompt indication of likely local site effects in Bhutan. So far, few studies on local seismic response have been conducted in Bhutan using a single strong motion ~~and they~~but the studies mainly focused on the role of bedrock depth on ground response parameters (see e.g., Tempa et al., 2020; Tempa, Chettri, Gurung, et al., 2021). ~~In such cases, the~~The ground motion response analysis may not adequately address the accuracy in predicting the response parameters due to limited information regarding site characteristics and their variations within the same soil column (Stevens et al., 2020). In the case of data scarce region such as Bhutan, the variation in terms of material characteristics can be possibly accounted for using sensitivity analysis. For this reason, this study ~~is an attempt to quantify~~quantifies the characteristics and effects of ~~different~~ several strong ground motions to ~~seismic responses in the area~~site effects depiction. Seismic ground response analysis fall in the Grade III approach of microzonation studies (e.g. ISSMGE 1999; Licata et al., 2018), it is ~~a~~ widely used method widely ~~used~~ by researchers for various applications in order to capture local ground effects or site conditions that can affect the estimate and prediction of ~~the~~ ground motion characteristics (Chavez-Garcia et al., 1990; Lopez-Caballero et al., 2012, Gautam and Chamlagain 2016, ~~and~~ Sil and Haloi 2018). The outcomes of such studies aim to provide local seismic hazard parameters which can be adopted for ~~earthquake-resistant~~ design of structures and infrastructures (Douglas, 2006). ~~but also, other earthquake hazards such as landslides and soil liquefaction (Bommer and Martinez-Pereira, 2000). These ground~~Ground response parameters typically characterize the complex nature of strong motion accelerograms using a simple expansion of predictive relationships. The two prominent deterministic and probabilistic approaches are widely used for seismic hazard studies globally. ~~Wyss and Rosset, (2013) stated that the standard~~

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~~probabilistic seismic hazard assessment method (PSHA) leads to an over or underestimation of the expected acceleration and intensity respectively in areas with low and high seismicity often resulting in incorrect results. Similarly,~~ Previously, Tempa, Chettri, Gurung, et al. (2021) recommended the use of ~~a~~ the deterministic approach that can ~~calculate the accelerations and losses that would occur if the maximum considered earthquake (MCE)~~estimate parameters under various earthquake occurrence scenarios. ~~occurs. In addition~~Notably, selecting a single ground motion ~~by~~ considering ~~only~~ amplitude only for seismic hazard analysis may not be a reliable approach to estimat~~eing~~ site amplification. The selection of wide amplitude range and the assessment of likely fluctuation scenario for Bhutan is not done yet. Hence, ~~the~~ ground motion parameters that are related to the amplitude are investigated to examine and predict the variability, often ~~considered~~ regarded as sensitivity, concerning mean values and associated scatter. ~~Although input motion selection is a complex procedure, a simple approach widely adopted is to is to scale ground motion records to a target spectral acceleration in the fundamental period of the structure of interest (Kramer et al., 2012).~~

~~To quantify the seismic site effects in terms of amplification of amplitude parameters, a range of time histories is selected and site response parameters are estimated.~~ In this paper, sensitivity analysis of site response for specific soil conditions in Phuentsholing, ~~(~~Bhutan~~)~~ is explored by a statistical correlation function of the ground motion parameters for different earthquake shaking intensities. The study area is ~~very significant, as Phuentsholing is~~ one of the major urban and commercial hubs in Bhutan Himalaya and seismic site effects on existing structures may have detrimental consequences due to inherent vulnerabilities of structures and infrastructures as well as due to the likely phenomenon such as amplification effects in loose soil deposits~~presence of loose soil deposits~~. To quantify the seismic site effects in terms of amplification of amplitude parameters, a range of time histories is selected, and site response parameters are estimated. ~~To quantify the seismic site effects in terms of amplification of amplitude parameters, a range of time histories is selected and site response parameters are estimated.~~

2. Seismicity and ~~geological setting~~geology of the study area

The Himalayan region is one of the most seismically active ~~zones~~ regions on earth, which observes ~~characterized by~~ both large and moderate-sized events frequently (Drukpa et al., 2006). Bhutan is located in the eastern Himalayas formed due to the subduction of the Indian plate beneath the Eurasian Plate and spans from the low-lying Brahmaputra Plain to the high Tibetan Plateau. Most of the land area of Bhutan is underlain by the Main Himalayan Thrust (MHT), which ~~covers~~ runs along the entire length of the Himalayan a~~A~~rc.

Historical earthquake catalog~~ue~~ (see Fig. 1a) indicates that Bhutan has experienced several earthquakes ~~characterized by M_w~~ of moment magnitude greater ~~higher~~ than 5.0 since early 1900, among them, ~~including~~ the 1915 Trashigang (M_w 6.6), ~~the~~ 1954 Trashiyangtse (M_w 6.4) in the 2009, Mongar (M_w 6.1) earthquake~~, which~~ that occurred at 11 km east of Bhutan are the most notable ones. The 2011 Sikkim-Nepal earthquake (M_w 6.9) ~~has alsoa~~lso caused noticeable damage to building stocks in Bhutan (Chettri et al., 2021a). The earthquakes in the vicinity of the study area (Phuentsholing) include the 1981 Dagana (M_w 5.1) earthquake and the 2003 Haa earthquake (M_w 5.5). The most recent event occurred in Samtse in ~~-~~2021 ~~Samtse~~ (M_w 5.1) ~~, which~~ affected Phuentsholing and the neighboring areas with an intensity level of IV in Modified Mercalli Intensity (MMI) scale.

Continuity of seismic activities in Bhutan is attributed to ~~The high seismicity of the Bhutan is due to~~ the presence of major shear zones such as the Main Himalaya Thrust (MHT), ~~the~~ Main Boundary Thrust (MBT), ~~the~~ Main

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Central Thrust (MCT), and the South Tibetan Detachment System (STDS) (Long & McQuarrie, 2010) as shown in Figure ~~2~~1a. The study area ~~falls under~~is within the Phuentsholing formation of Buxa group of the Lesser Himalaya mainly ~~made of~~characterized by highly weathered dark grey to black slate and phyllite, thin interbeds of limestone~~,~~ with substantial amount of cream-colored dolomite~~,~~ and fine-medium quartzite, additionally consisting fine to medium grained conglomeratic quartzite interbedded with phyllite and dolomite towards the Rinchending area of Zone II. Hence, the lithological ~~characteristic~~characteristic of the area indicates weak and highly unstable geology in the region. The p~~P~~resence of thrust faults in the proximity of the study area along the entire belt of the Lesser Himalayan units and the quaternary sediments in the south ~~impose~~ depict the area to be seismically active with the majority of the historical earthquake events ~~occurring~~ concentrated within these geological units.

~~I~~In particular, this study ~~focuses~~ focuses~~d~~ on Phuentsholing Thromde (city) ~~under~~ of Chhukha dzongkhag (district) in Bhutan (Fig. ~~3~~1c). The city is one of the major commercial hubs for trade with India. ~~making the town the gateway to Bhutan for trade with India.~~ The proposed study area is ~~challenging because of the~~observing rapid infrastructure development activities and ~~expansion of urban land~~urban expansion ~~use to cater to~~for residential, commercial, and industrial ~~transformation besides~~purposes. ~~providing a major trade network to other districts, e.g., extended Toribari township in the east and Amochu Land Development and Township Project (ALDTP) in the west.~~ The Phuentsholing city covers an area of 15.6 km^2 and is located at 26.86°E and 89.39°N. The city ~~is populated with a~~has the population of 27,658 people, mostly distributed towards the peripheral international border area with a total of 2,263 residential and commercial buildings per the 2020 statistics (~~data are referred to the year 2020;~~ http://www.pcc.bt/index.php/). The seismic site characterization includes eight locations in the regions of Dhamdhara, Toorsa, and Rinchending in Phuentsholing, Bhutan. In this study, the sites are grouped into two main zones based on the geographical location and ~~the proximity of the survey~~immediate availability of survey locations. These two ~~grouped~~ zones also refer to the Local Area Plan (LAP) of Phuentsholing. The zones are Zone I: Dhamdhara I, Dhamdhara II, Toorsa I and Toorsa II, and Zone II: College of Science and Technology (CST) Football Ground, CST Hostel, Phajoding, and Monastery area. ~~Out of~~Among the 8 ~~of these~~ LAPs, Dhamdhara and Toorsa (Zone I) ~~fall under~~are in the same region in the western part of the city and Rinchending (Zone II) in the east. ~~A similar classification was also used by Tempa et al. (Tempa, Chettri, Gurung, et al., 2021). The zones are; Zone I: Dhamdhara I, Dhamdhara II, Toorsa I and Toorsa II, and Zone II: College of Science and Technology (CST) Football Ground, CST Hostel, Phajoding, and Monastery area.~~

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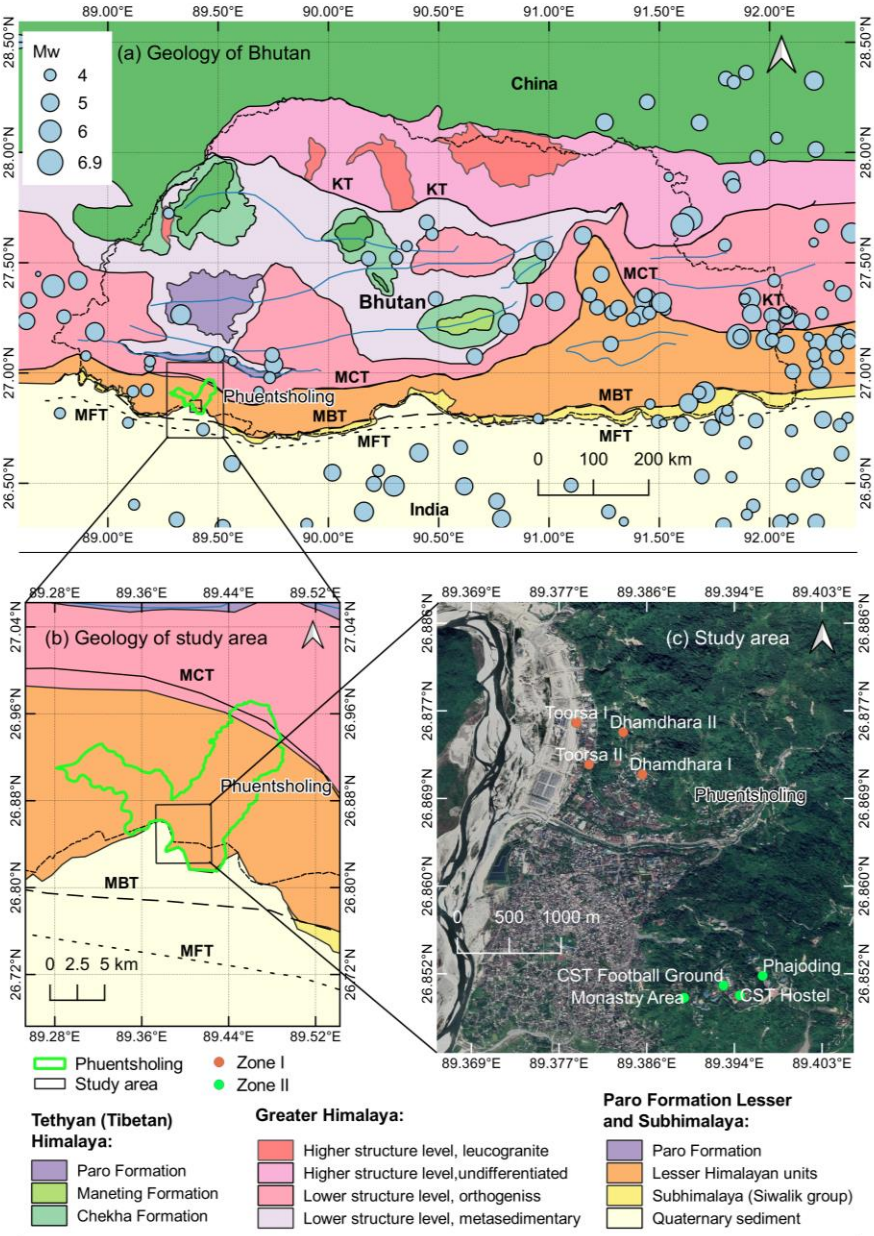

Figure 1: Geology and, seismicity and the study area:. (a) Geological map of Bhutan reproduced from McQuarrie et al. (2013) and seismicity, (b) Location of Phuentsholing and geology of the area, (c) Study area showing surveyed site using MASW (modified from Google Earth Pro 2021).

3. Materials and method

~~4.1~~3.1 Geotechnical site characterization

The geotechnical reports collected by Phuentsholing municipality ~~provided~~have 29 stratigraphic logs. From these records, the depth of the water table (GWT) was ~~derived~~demarcated. Drilling log data showed the highest depth of the water table in the Dhamdhara area at ~~a depth of~~ 12.5 m to 16~~.0~~ m, ~~while the~~whereas groundwater table in Rinchending area is at 5 m~~ underlying~~, followed by the Toorsa area at ~~between~~ 0.5 m and 3m, which is ~~below~~ located near the riverbed. The depth of the water table is one of the essential input parameters used for 1D ground response analysis. Three drill holes are presented to typically illustrate the underground stratigraphy (Figure 2). Table 1 presents a summary of soil properties from laboratory testing of in-situ samples collected from the drill holes. The number of samples in each zone represents the total number of samples collected from all drill logs at various stratigraphic depths. All laboratory tests have been verified according to the Indian Standard Codes. Testing included physical identification, Atterberg limits, grain size distribution ~~curve definition~~ and direct shear testing. Field tests such as ~~the~~ s~~S~~tandard p~~P~~enetration ~~Test~~ resistance (SPT) and c~~C~~ore c~~C~~utter t~~T~~est were performed to determine resistance to penetration (~~N-value~~SPT-N) and field density, respectively

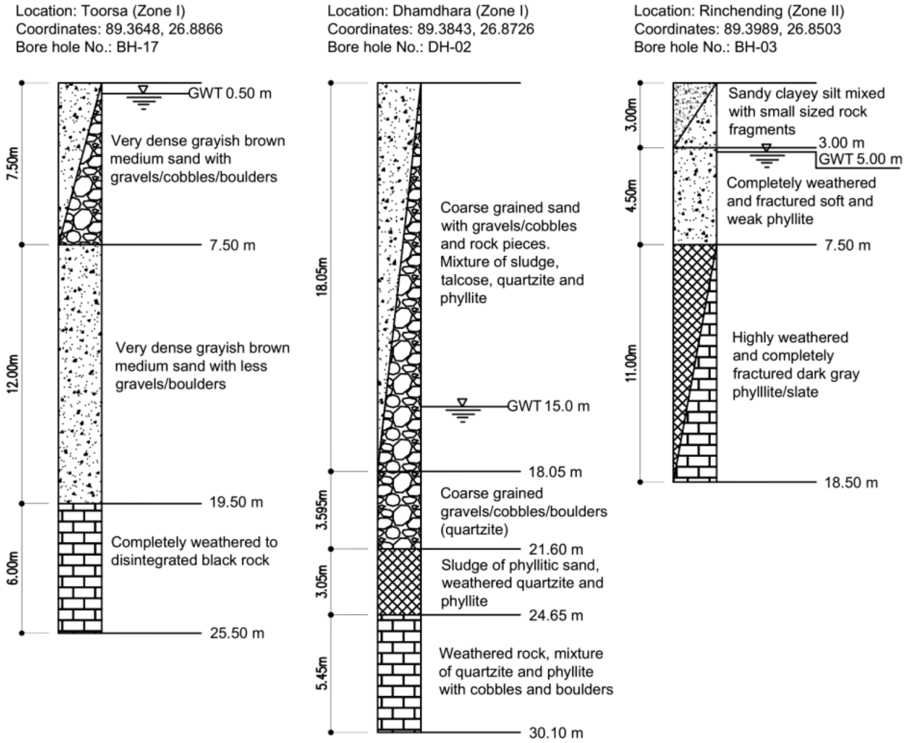

Figure 2: Typical borehole stratigraphy in Toorsa and Dhamdhara (Zone I) and Rinchingding (Zone II).

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As shown in the stratigraphic logs ~~reported in Fig. 5~~, ~~the shallow soils are~~the upper strata comprise predominantly mixed coarse-grained soils characterized by dominant sand with considerable fraction of sand. ~~consisting of mainly made of sand with a high proportion of gravel and a good proportion of fines. Something similar was also reported by some studies that were carried out in the study area indicating similar to the finding of previous studies (Tempa and Chettri, 2021; Tempa, Chettri, Sarkar, et al., 2021).~~ The soil classification of the Phuentsholing area carried out by sieve analysis highlighted that most soils consist of 22.74% gravel, 74.89% sand, and 2.37% of the silt and clay ~~fractions~~. The sieve analysis results for the respective zones are shown in Fig. ~~6~~3. The soils in Toorsa are non-plastic, as coarse~~r~~ grained soils dominate the particle distribution, while the soils in Rinchending and Dhamdhara ha~~ve~~d ~~a~~ low plasticity with a plasticity index (PI) of 6.5 and 10, respectively. The bulk density is 1.8 g/cm^3 in Toorsa, 1.64 g/cm^3 in Dhamdhara, and 1.33 g/cm^3 in Rinchending. The shear strength parameter, cohesion (c), ranges between 0-0.18 kg/cm^2, while the angle of internal friction (ϕ) in the study area is up to 35 °.

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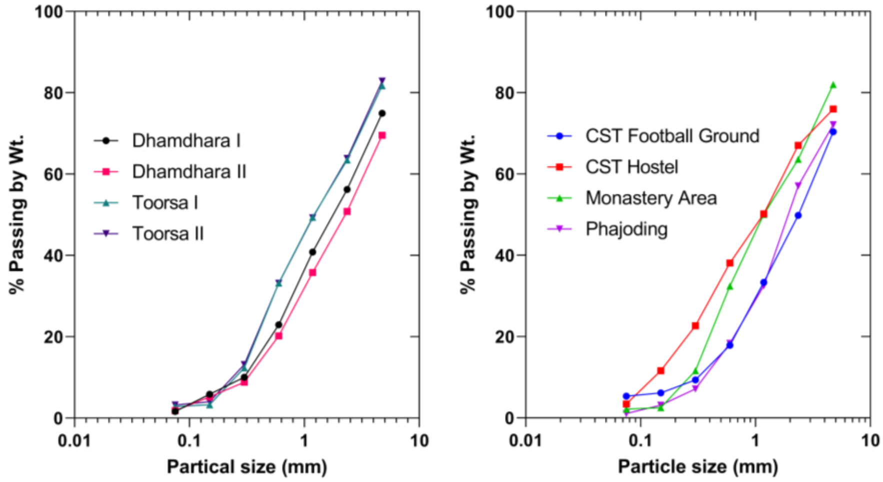

Figure ~~6~~3: ~~Results of sieve analysis showing grain size distribution curves.~~Representative grain size distribution curve for the study area.

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Table 1. Average soil parameters in the study area.

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Location	Testing methods	Soil parameters	No. of samples	Reference
Toorsa (Zone I)	Atterberg's limit	Non-plastic	86	IS: 2720 (Part 5)-1995
	Core cutter	Bulk density, γ_t = 1.8 g/cc Dry density, γ_d = 1.64 g/cc		IS:2720 (Part 29)-1975
	Direct shear	c = 0 ϕ = 35˚		IS: 2720 (Part 13)-1997
	SPT	N -value = 25 to 50		IS: 2131–1981
Dhamdhara	Atterberg's limit	Low plasticity (PI = 6.5)	28	IS: 2720 (Part 5)-1995

(Zone I)				
	Core cutter	Bulk density, γ_t = 1.64 g/cc Dry density, γ_d = 1.51 g/cc		IS:2720 (Part 29)-1975
	Direct shear	c = 0.073 kg/cm^2 ϕ = 31.44°		IS: 2720 (Part 13)-1997
	SPT	*N*-value = 19 to 37		IS: 2131–1981
Rinchending (Zone II)	Atterberg's limit	Low plasticity (PI = 10)	26	IS: 2720 (Part 5)-1995
	Core cutter	Bulk density, γ_t = 1.83 g/cc Dry density, γ_d = 1.70 g/cc		IS:2720 (Part 29)-1975
	Direct shear	c = 0.18 kg/cm^2 ϕ = 20-30°		IS: 2720 (Part 13)-1997
	SPT	*N*-value = 21 to >100		IS: 2131–1981

Shear wave velocity profiles from eight locations in the study area based on the multispectral surface wave analysis Multispectral Analysis of Surface Waves (MASW) (Fig. 7) and empirical correlation developed by Tempa et. al. (Tempa, Chettri, Gurung, et al., (2021) are used -to carry outperform ground response analysis. According to the shear wave velocity profile, the engineeringengineered bedrock (V_s > 800 m/s) lies at a depth ranging fromof 150 m to 400 m (e.g., Dhamdhara I in Zone I and Phajoding in Zone II), as shown in Fig. 84. According to the parametric analysis carried out by Tempa et al. (Tempa et al., (2020) in the study area, the site condition in the study area is classified into ground as ground type B in conjunction toper the Euro Code EC-08 and National Earthquake Hazards Reduction Program (NEHRP) with the majority of shear velocity ($V_{s,30}$) ranging between 380–470 m/s, except in for the Phajoding, which has a shear wave velocity of 584.76 m/s (Table 2). The $V_{s,30}$ can be estimated with the followingusing Equation 1.

$$V_{s,30} = 30 \Big/ \sum_{n=1}^{N} \left(\frac{h_i}{V_i} \right), \text{ m/s} \qquad (1)$$

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Table 2. Site classification as per Euro Code EC-08

Zones	Sites	$V_{s,30}$ (m/s)	Ground Type
I	Dhamdhara I	386.43	B
	Dhamdhara II	435.92	B
	Toorsa I	439.54	B
	Toorsa II	464.30	B
II	CST football ground	426.76	B
	CST hostel	426.61	B
	Monastery area	446.20	B

	Phajoding	584.76	B
All	Bedrock	>800	A

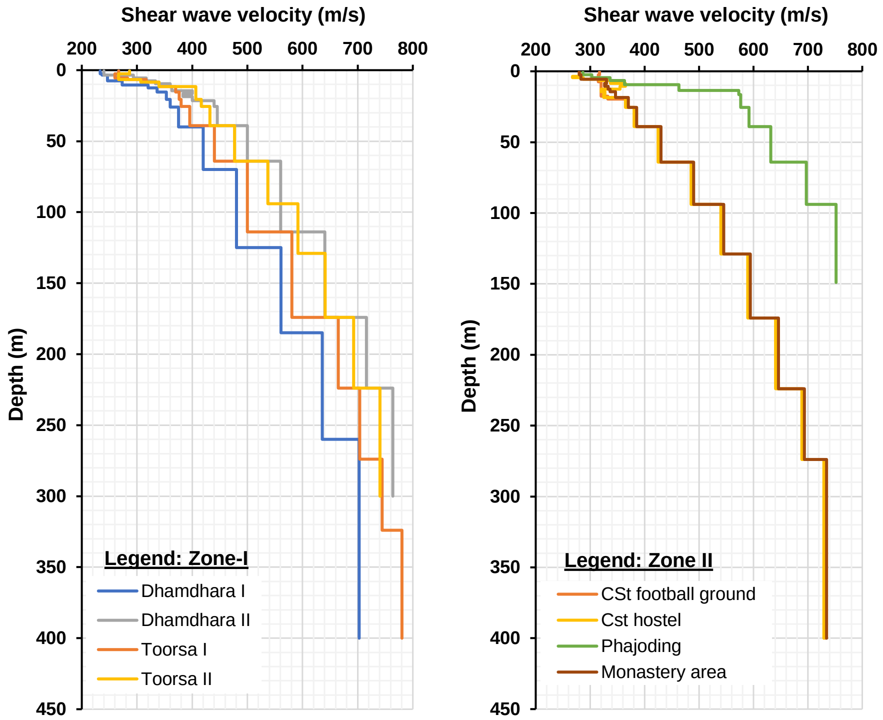

Figure ~~8~~4: Shear wave velocity profile of study locations in Phuentsholing, Bhutan.

~~To further~~Further ~~supplement to~~ complement the requirements for the ~~seismic demand~~ action and ~~damage risk, it is essential to take into account~~consideration of the subsurface conditions associated with the ~~earthquake energy~~ , ~~which~~that amplify or abbreviate the ground motion responses is imperative (Kramer, 1996). Dynamic properties of soils are influenced by shear modulus and damping and are defined by the respective degradation models, regarded as the backbone curves. Figure ~~9~~ 5 represents the dynamic soil model for sand used in this study. Degradation models are well established by many ~~researchers~~ investigators for different types of soils ~~, which influence~~affecting the response at low strain levels, (see e.g., ~~(~~Seed and Idriss, 1970; Vucetic and Dobry, 1991; Darendeli, 2001; Dobry and Vucetic, 1982; Seed et al., 1986).

A damped linear elastic model of the soil system is used for the analysis. Due to ~~the non-linearity of the~~ soil nonlinearity for which the shear modulus is strain-dependent, ProShake performs an iterative process on the linear model until both the moduli and damping ratios are compatible with the average strains and convergence is achieved ~~on~~ at the last iteration (Shafiee et al., 2011; Puri et al., 2018). The nonlinear and hysteretic stress-strain behavior of soils under cyclic loading~~s~~ is approximated as a function of G_{sec} and G_{max}. This predetermined

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estimation of G_{sec} or G and G_{max} is attributed by unit weight or bulk density, ρ, and shear wave velocity, V_s ($G_{max} = \rho V_s^2$). Similarly, damping ratios are predicted as a function of G_{sec} or G values. This estimation is achieved using ~~the~~ an iterative procedure in the Proshake 2.0 program (EduPro Civil Systems Inc., 2017).

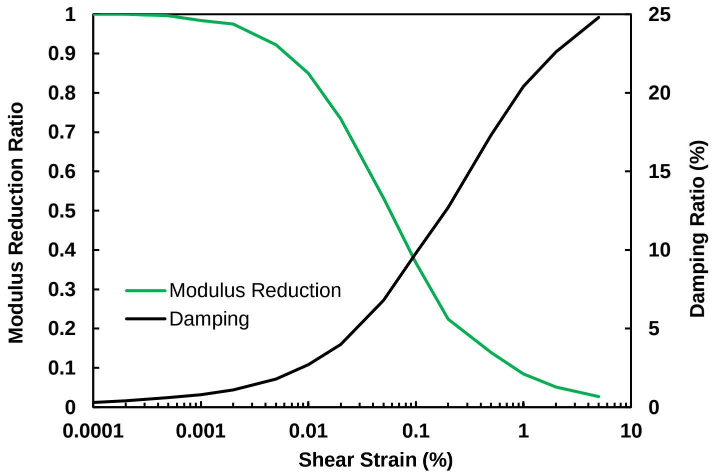

Figure ~~9~~5: Average modulus reduction ratio and damping ratio adopted for sand (Seed & Idriss, 1970).

~~4.2~~3.2 Selection of input motion

~~The definition of~~~~Defining~~ Definition of the input motion that ~~should be adopted~~ ~~assumed~~ is considered for site response analys~~i~~es of an area requires both ~~the subsoil~~ subsurface characterization and ~~a~~ careful selection of ~~accelerograms~~acceleration time histories. ~~-~~In Bhutan, records of acceleration time histories are very ~~scarce~~rare, if not absent. ~~; and in~~In the absence of a national seismic code, Bhutan is assumed to fall under Indian seismic zone IV and V, with an expected maximum PGA of 0.24 g and 0.36 g for design purposes. ~~, respectively, for Maximum Considered Earthquake (MCE) (IS:1893, 2002). and In in many cases , PGA of 0.36 g is applied uniformly across the whole country (Stevens et al., 2020).~~ For the two zones mentioned, the PGA for earthquakes with a return period of 475 years is expected to be half of the ~~MCE~~maximum considered earthquake (MCE), i.e., 0.12 g and 0.18 g. Notably, the GSHAP depicts the PGA range between 0.2-0.28g ~~From the global seismic map (GSHAP), the PGA depicted are in the~~presented range ~~from 0.20 g to 0.28g,~~ with an increasing ~~pattern~~ trend ~~to~~ in the east of the count~~ry~~ry ~~(Tempa, Chettri, Gurung, et al., 2021)~~. ~~The discrepancies in such agreements without much conformity lead to a question about how differently the earthquake scenario is differently distributed at the regional level at the current~~this ~~juncture. In this study, such observations have been~~were ~~instrumental in the~~ Considering the variations in expected PGA, we selected~~ion of~~ six acceleration time histories ~~historical global earthquakes~~ as input motions ~~having an intensity of~~with a PGA ~~intensity in the range of~~ranging from 0.067 g to 0.422 g, considering the ~~least~~ lowest and the highest range of possible earthquake scenarios (Table 3).

~~Two properties of seismic motion are most common for engineering purposes,~~ ~~Most commonly, for engineering purposes, two characteristics of earthquake motion, i.e., amplitude and frequency content of the motion at bedrock level~~ motion ~~are, of primary importance (Kirtas et al., 2015; Kramer, 1996).~~ The acceleration time histories used

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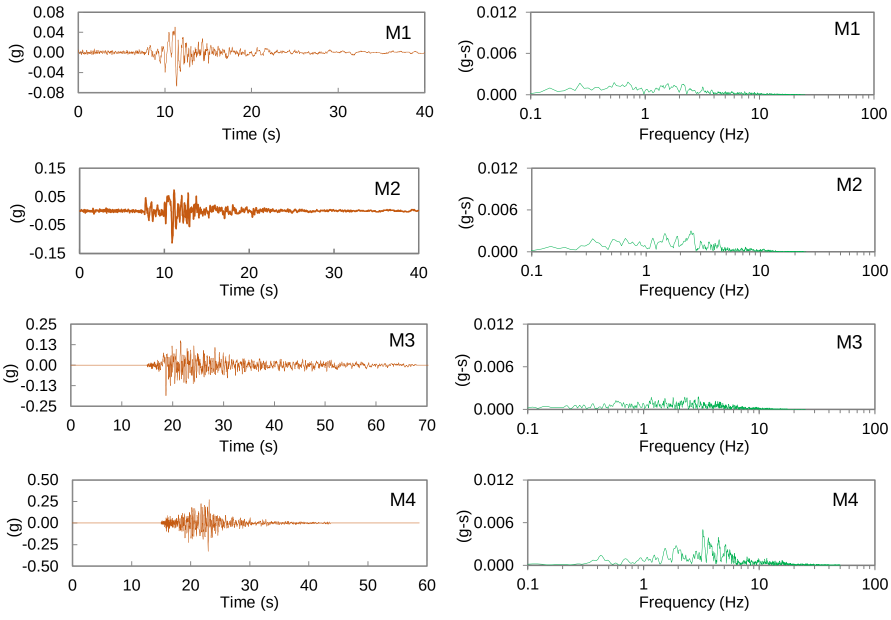
Table 3. ~~Historical earthquakes considered as input motion~~Selected strong motion records for ground response analysis.

Event	Station	Year	M_w	PGA (g)	Notation
Loma Prieta/Santa Cruz Mountains	Yerba Buena Island, CA – US Coast Guard	1989	6.9	0.067	M1
Loma Prieta	Diamond Heights	1989	6.9	0.113	M2
Taft Kern County	Taft	1952	7.5	0.185	M3
Northridge	Topanga Fire Station	1994	6.7	0.329	M4
El Centro	Imperial Valley Irrigation District	1940	6.9	0.344	M5
Petrolia	Cape Mendocino	1992	6.6	0.422	M6



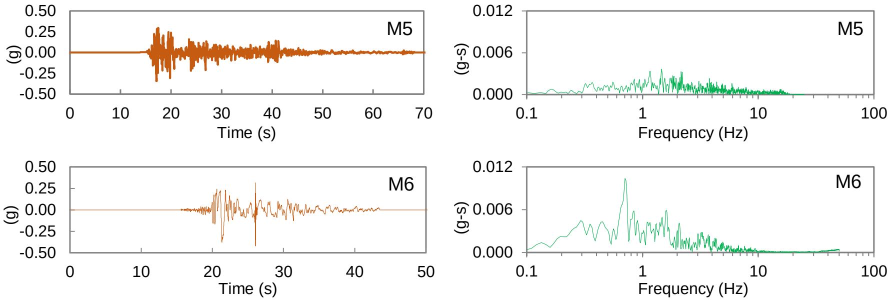


Figure ~~10~~6: ~~Plot of time histories and corresponding~~Strong motions and corresponding Fourier amplitude plots of the input ground motions.

~~4.3~~3.3 1D ground response analysis

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A 1D equivalent linear analysis was performed at eight sites in Phuentsholing, Bhutan to estimate local site effects ~~with~~ using the ProShake 2.0 program. In this study, six strong motion records were used to replicate low, medium, and high ~~earthquake~~ seismic accelerations categorize~~s~~d based on the intensity of PGA. The ProShake 2.0 program ~~offers~~ provides the flexibility to input ground motions and soil profiles and is ~~handy~~ useful ~~to~~ for ~~estimate~~ estimating the outcrop responses to input ground shaking. The improved shear wave velocity profiles down to the engineered bedrock depth (150 m and 400 m) from eight sites were used. ~~, which is reported in the study by Tempa et. al.~~ ~~The enhanced shear wave velocity profiles to the depth of the engineering bedrock (150 m and 400 m) of eight locations based on initial MASW profiles of ~ 22.2 m depth is well established in the study conducted by Tempa et. al. (Tempa, Chettri, Gurung, et al., 2021).~~ The~~se~~ deep shear wave profiles used in this study incorporate ~~are a complementary supplemental input parameter in the current study, which considers~~ the effects of depth and soil type of ~~varying~~ visco-elastic soil ~~strata~~ layers ~~underlain with by~~ above the predicted engineering bedrock. The 1D ground response analysis ~~takes into~~ accounts for wave propagation from the bedrock outcrop through the visco-elastically ~~layered~~ stratified soil deposit and provides an estimate of the ~~ground~~ surface motion parameters ~~at surface~~. The complex response method is solved by the equation of motion in the frequency domain. ~~The soil~~Soil nonlinear response ~~soil~~ is estimated by an iterative ~~,~~ quasi-linear procedure in which successive linear analyses are performed~~, with the soil~~ while updating the shear modulus and damping ratio ~~are updated~~ based on the shear strain level obtained ~~in~~ from the ~~previous~~ preceding iteration. ~~analysis.~~ Iterations continue until the strain-compatible modulus and damping converge.

~~1.~~4. Results and discussion

~~4.4~~4.1 Seismic site effects

Figure 7 shows normalized ~~surface PGAs~~PGAs on surface at two typical locations of ~~two~~ the investigated zones. The chart shows ~~approximately~~ depicts PGA of 1.2 g to 1.5 g for low ~~intensity~~ PGA earthquakes, 0.7 g to ~1.1 g for medium and high intensity PGA earthquakes.

Response parameters can be defined and characterized based on the amplitude parameters of the ground motion and the severity of the ground motion excitation in nearby structures. ~~to on the respective structure.~~ This in turn

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is a function of the amplitude or intensity, the frequency content, and the duration of the ground motion (Bradley, 2011). Natural periods or frequency domain parameters are ~~well~~ related to the seismic behavior of structures and indirectly reflect the ground motion characteristics (Zafarani et al., 2020). Hence, to commensurate this relationship, the response spectra~~um plot~~ of bedrock and surface motion ~~is~~are presented in Fig. 8 and 9. The results ~~to~~of various input ground motions indicate a higher spectral acceleration of the soil profile in the period range ~~from~~between 0.3 s to 3.0 s with the peak spectral acceleration of ~~approximately~~ 0.14 g to 1.62 g. Thus, the structures with similar fundamental vibration period are likely to be exposed to greater peak spectral acceleration. ~~peak spectral acceleration. Buildings 3 m to 30 m tall usually fall into this spectrum. In the city of Phuentsholing, buildings with 2-8 storeys can show higher values of hazard responses due to the variability of the earthquake shaking intensity and soil condition examined. Both study areas show a similar tendency of ground responses.~~

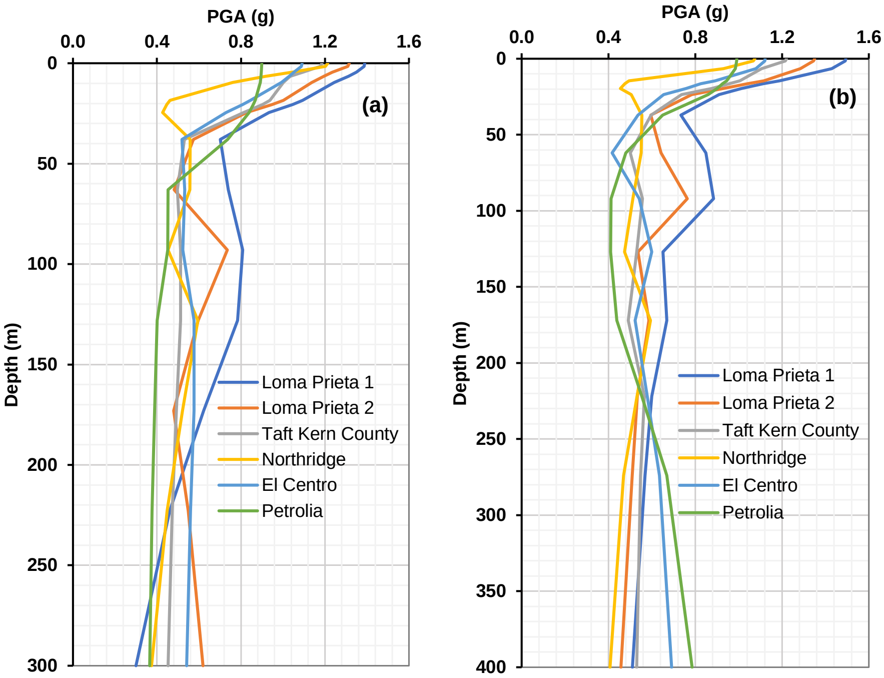


Figure 7: The typical profiles of normalized peak ground acceleration (PGA), (a) Toorsa II in Zone I, and (b) CST Football Ground in Zone II.

~~Response parameters can be defined and characterized based on the amplitude parameters of the ground motion and the severity of the ground motion to on the respective structure. This in turn is a function of the amplitude or intensity, the frequency content, and the duration of the ground motion (Bradley, 2011). Natural periods or frequency domain parameters are well related to the seismic behavior of structures and indirectly reflect the ground motion characteristics (Zafarani et al., 2020). Hence, to commensurate this relationship, the response spectrum plot of bedrock and surface motion is presented in Fig. 8 and 9. The results to various input ground~~

~~motions indicate a higher spectral acceleration of the soil profile in the period range from 0.3 s to 3.0 s with approximately 0.14 g to 1.62 g peak spectral acceleration. Buildings 3 m to 30 m tall usually fall into this spectrum. In the city of Phuentsholing, buildings with 2-8 storeys can show higher values of hazard responses due to the variability of the earthquake shaking intensity and soil condition examined. Both study areas show a similar tendency of ground responses.~~

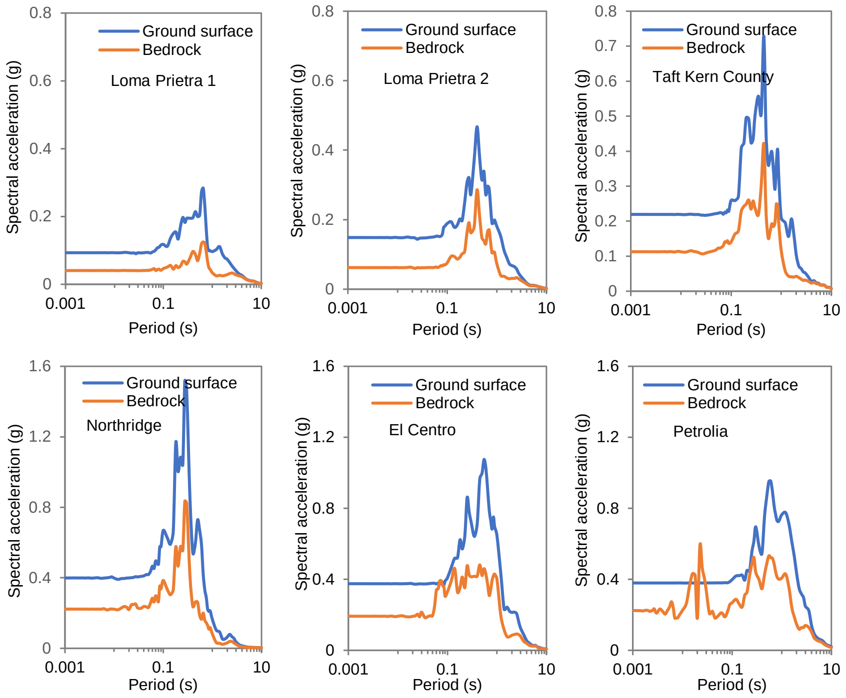
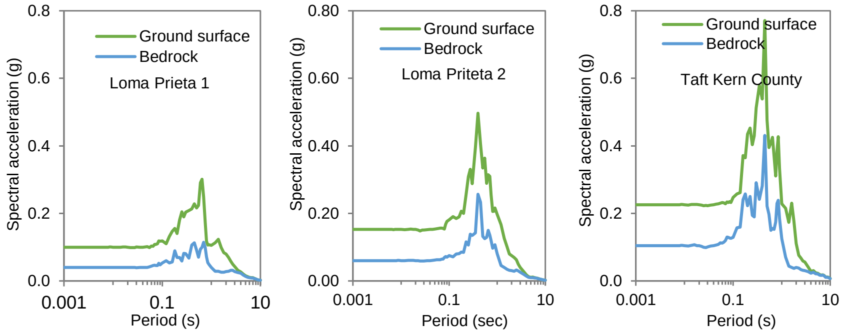


Figure 8: Typical spectral acceleration of bedrock and ground surface motion at Toorsa II in Zone I corresponding to the respective input motions.



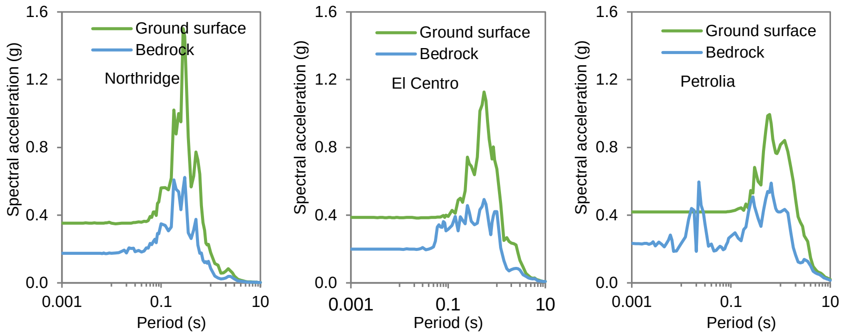


Figure 9: Typical spectral acceleration of bedrock and ground surface motion at CST Football Ground in Zone II corresponding to the respective input motions.

A key parameter to account for seismic wave modification by local site conditions is commonly represented by the amplification factor (Bhutani and Naval, 2020). Figures 10 and 11 show the results of typical amplification factors at two locations in the study area. The ratio of the spectral acceleration of the surface motion to the spectral acceleration of the bedrock provides the amplification factor, which according to Eq. 2.

$$Amp(T) = \frac{SA_{Soil}(T)}{SA_{Rock}(T)} \quad (2)$$

From the results of the ground response analysis, the amplification factors in the study areas can be roughly classified into three categories as low, medium, and high ranges, and the average values are highlighted. The amplification factors range from 0.7 to 2.7, 0.6 to 2.6, 0.75 to 2.5, and 0.7 to 3.2 for Toorsa II, Dhamdhara I, CST football ground, and Phajoding respectively for 0.01 s to 0.1 s natural period. In the natural period range from 0.1 to 1.0 s, the amplification factors are in the range from 1.1 to 3.6, 0.7 to 4.2, 1.0 to 3.7, and 1.2 to 5.2 for Toorsa II, Dhamdhara I, CST football ground, and Phajoding, respectively. In the high natural period range, the amplification factors are 5.0, 6.2, and 5.8 for Toorsa II, Dhamdhara I, and CST football ground, respectively. However, in the Phajoding the significance of the amplificationamplification factor is ~ 1.7 due to a much stiffer soil deposit ($V_{s,30}$ = 584.76 m/s) and shallow engineering bedrock at 150 m.

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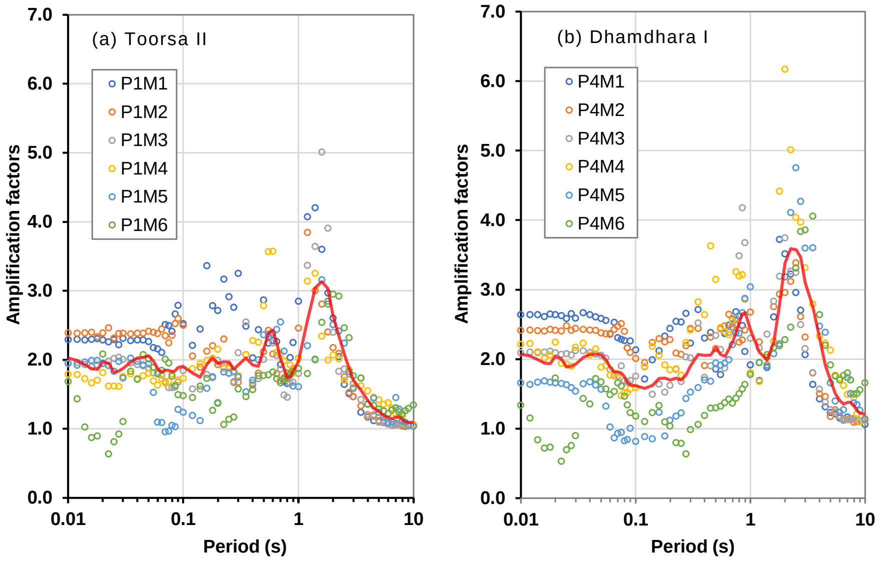

Figure 10: ~~Typical~~ Examples of amplification factors for various earthquakes at (a) Soil profile P1 at Toorsa II in Zone I, (b) Soil profile P4 at Dhamdhara I in Zone I

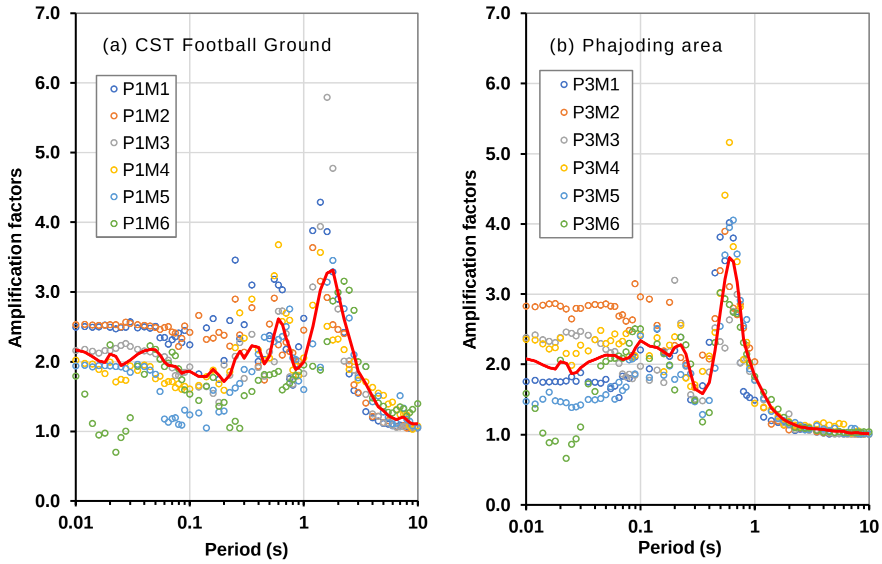

Figure 11: Examples of~~Typical~~ amplification factors for various earthquakes at (a) Soil profile P1 at CST Football Ground in Zone II, (b) Soil profile P3 at Phajoding in Zone II

~~4.5~~4.2 Correlation analysis

The main objective of this study is to demonstrate the sensitivity of ~~six earthquakes of different PGA magnitudes~~input motion amplitudes to predict the variability of seismic site effects due to local ground conditions. ~~To achieve this, we first performed a statistical analysis using the results of the 1D ground response analysis. The fundamentals of statistical analysis are to~~We aim to examine potential trends, patterns, and relationships between data sets for the results obtained from the analysis. ~~A statistical quantitative approach is implemented and the statistical data distribution of the amplitude parameters~~Using statistical analysis, variation of amplitude parameters ~~of the input ground motions is~~~~are~~is projected ~~by a~~by box plots (Figs.~~ure~~ 12 and 13). ~~Hence,~~ ~~S~~statistical correlations are fitted between p~~P~~eak g~~G~~round a~~A~~cceleration (PGA), p~~P~~eak g~~G~~round v~~V~~elocity (PGV), p~~P~~eak g~~G~~round d~~D~~isplacement (PGD), and s~~S~~pectral a~~A~~cceleration (S_a~~A~~) to determine the ~~interplay~~ correlation between the effects of strong ground motion and the local soil conditions. As anticipated, the 1992 Petrolia earthquake with 0.422 g PGA (Mw = 6.6) led to the ~~highest~~ greatest response~~;~~. However, the 1994 Northridge earthquake with a PGA of 0.329 g (Mw = 6.7) shows greater variability in spectral acceleration compared to other earthquakes. ~~This is the most relevant finding and perhaps also the most significant in the current study.~~ This is because the spectral acceleration is one of the most important response parameters corresponding to the interaction between the ground and the shaking intensity of an earthquake and is directly related to the response of equivalent SDOF systems. Therefore, from the perspectives of seismic site effects the box plot of the spectral acceleration (period or frequency domain) is highly scattered with the outliers, confirming uncertainty in the ground response characteristics in ~~both zones~~ both regions. ~~These indicates that the seismic site effects are likely to increase due to ground response~~~~local soil conditions~~ ~~and could severely affect buildings coinciding with the natural fundamental frequency.~~ The El Centro and Petrolia earthquakes, with the highest PGAs ~~in this study~~, also appear to be closely associated with spectral acceleration.

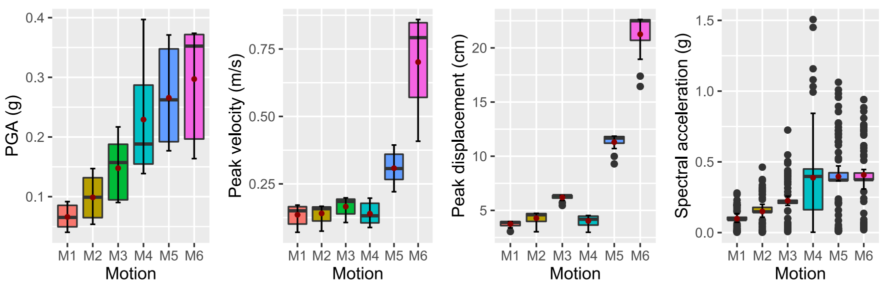

Figure ~~19~~12: Box and Whisker plot for ground motion parameters of soil profile at P1 Toorsa II in Zone I.

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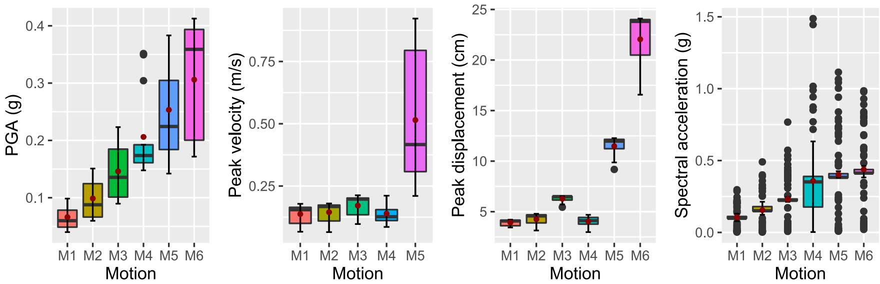

Figure ~~20~~13: Box and Whisker plot for ground motion parameters of the soil profile at P1 CST Football Ground in Zone II.

Primarily, propagating energy waves (outcrop motion) act on each stratified soil layers ~~which~~that amplifies or de-amplif~~y~~iesy the ground motion response parameters at each ~~stratified soil~~ layer. The sensitivity of the input motions is critically ~~monitored~~monitored, and enhanced correlation are ~~exploited~~developed. To ~~bring this issue to surface~~outline this, a linear regression model for bedrock outcrop motion and the predicted motion parameters as a function of bedding depth ~~was~~is developed ~~in addition to the statistical parameters presented above~~. Regression analysis is performed for one particular soil profile from two zones (Toorsa II and CST Hostel) in order to accurately substantiate ~~the~~ sensitivity analysis (Figs. 14 and 15).

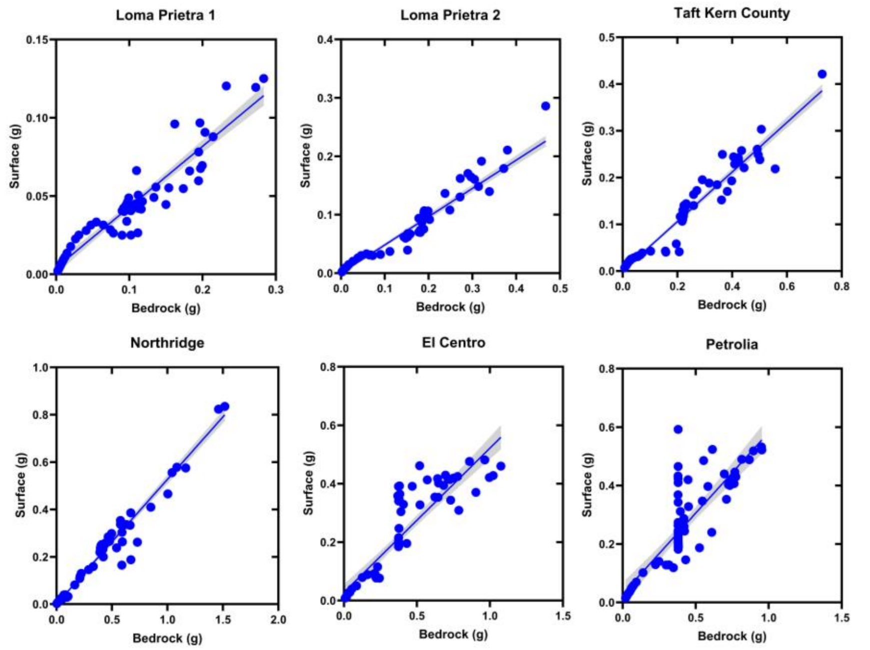

Figure 14: ~~Bedrock linear~~Linear regression model for bedrock and surface spectral accelerations for Toorsa II (Zone I)

The 95% confidence interval (CI) shows a linear relationship for the ~~historic~~ Loma Prieta 2 ~~2~~, Taft Kern County, and Northridge earthquakes~~,~~ indicate~~ing~~ a closer impact on surface motion that corresponds to outcrop motion. ~~For~~ In this case, the predominant frequency content of the input motion is between 1 and 10 Hz. ~~(see Fourier amplitude).~~ In contrast, the Loma Prietra 1, El Centro, and Petrolia earthquakes, with a predominant frequency between 0.3 and 1.2 Hz, exhibit typical nonlinearity throughout the spectral range, indicating possible damping of the spectral responses of the soil deposits.

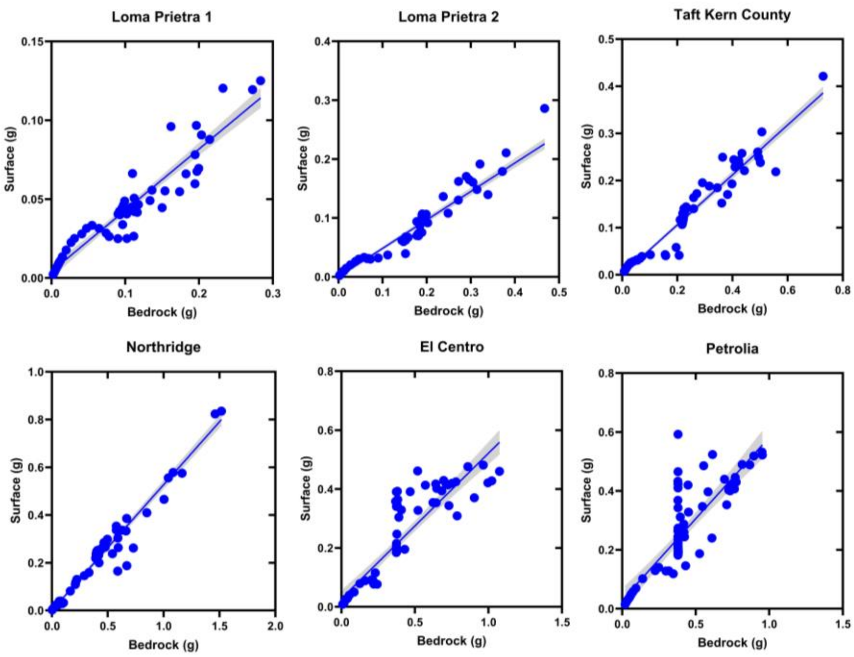

Figure ~~16~~15: ~~Bedrock linear~~Linear regression model for bedrock and surface spectral accelerations for CST Hostel (Zone II)

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~~4.7~~4.3 Sensitivity of input motion

~~The number of response parameter variations on due to different input motion provides addition insight into sensitivity. As the different seismic ground motions propagate through different soil layers, the ground surface motion response is modified in an increasing order of magnitude of PGA. As the various earthquake ground motion propagate through different soil profiles, the ground surface motion response is modified in the ascending order of the PGA of input motion.~~ Since all analysis sites ~~fall under the~~ are in t~~T~~ype B site, the trend of ground motion variation to surface is very similar, so the average values may be crucial for better implementation of the scenario-based seismic risk in the study area.~~Since all the sites fall under the type B site, the trend of the variation in the ground motion to surface is very similar, so the average values may be decisive for improving the realization of the scenario-based seismic risk in the study area.~~ Ground response parameters such as PGA and response spectrum intensity including Arias intensity show linear variations for aggregated values with while increasing intensity of earthquake shaking corresponding to a particular given soil profile. However, the predominant period opposite linear correlation with the characteristics of strong ground motion. These results were mainly observed due to change in characteristics of seismic waves propagating through different stratified soil deposits before the strong ground motion reach the ground surface. In ProShake 2.0, theThe mean, median and standard deviation of the output parameters are computed using regression statistical analysis. and tThe response spectrum intensity is computed based on Housner approach (Housner, 1959) as integral from 0.1 to 2.5 s of the pseudo-velocity spectrum that provides an indication of the average velocity for most civil engineering structures. The plot of sensitivity of various input motions on amplitude parameters to different local soils in two study zones is shown in Figs. 16 and 17.

The standard deviation is lower for a set of predominant natural periods for a soil profile compared to the response spectrum dataset and this deviation from the mean value Within the set of predominant natural periods corresponding to each input motion, the standard deviation is lower compared to the data set of the response spectrum of the soil column, which indicates a higher strength ofstronger soil response to the SDOF systems, as presented shown in Figs. 16d and 17dTable 4 and Table 5. The non-linearity of soilsSoil nonlinearity often shows a significant scatter in spectral acceleration at higher and lower periods, and therefore the practical reliability of the result is that it requires prompts more analysis with larger sets of many input motions to predict the mean (or median) response with some level of confidence (Kramer et al., 2012). Tables 4 and 5 summarize the statistical results of seismic response parameters indicating the sensitivity of various earthquake inputs at local sites in Zone I and Zone II. The additional ground response parameters are provided in Tables A1 and A2. The sensitivity of the output resultsof input motion is shown in Figs. 14 and 15 with examples from two site locationsfrom two investigated locations. The results of the correlation analysis and the sensitivity plots indicate that the Ginput motionround motion M4 (Northridge) has a significant influence on most of the response parameters and except M5 (El Centro) show a slight spread of ground response compared to other ground motionson Aries intensity. The additional ground response parameters are provided in the appendix (Tables A1 and A2).

Table 4. Descriptive sStatistics of for averaged ground response parameters in Zone I for all four soil profiles and six input ground motions.

	PGA (g)	Aries intensity (m/sec)	Response spectrum intensity (g^2)	Predominant period (sec)	Mean frequency (Hz)
Mean	0.270	1.073	2.996	0.818	3.527
Median	0.238	0.630	2.450	0.689	3.319
Standard deviation	0.121	0.765	2.013	0.468	1.097
84^{th} percentile	0.407	2.215	4.541	1.251	4.824
16^{th} percentile	0.139	0.179	1.322	0.379	2.283

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Table 5. Descriptive ~~Statistical relationship~~statistics ~~of~~ for averaged ground motion parameters in Zone II for all four soil profiles and six input ground motions.

	PGA (g)	Arias intensity (m/s)	Response spectrum intensity (g^2)	Predominant period (s)	Mean frequency (Hz)
Mean	0.271	1.079	2.985	0.812	3.814
Median	0.237	0.622	2.417	0.684	3.538
Standard deviation	0.126	0.794	2.066	0.453	1.382
84th percentile	0.411	2.226	4.541	1.243	5.330
16th percentile	0.136	0.174	1.287	0.377	2.349

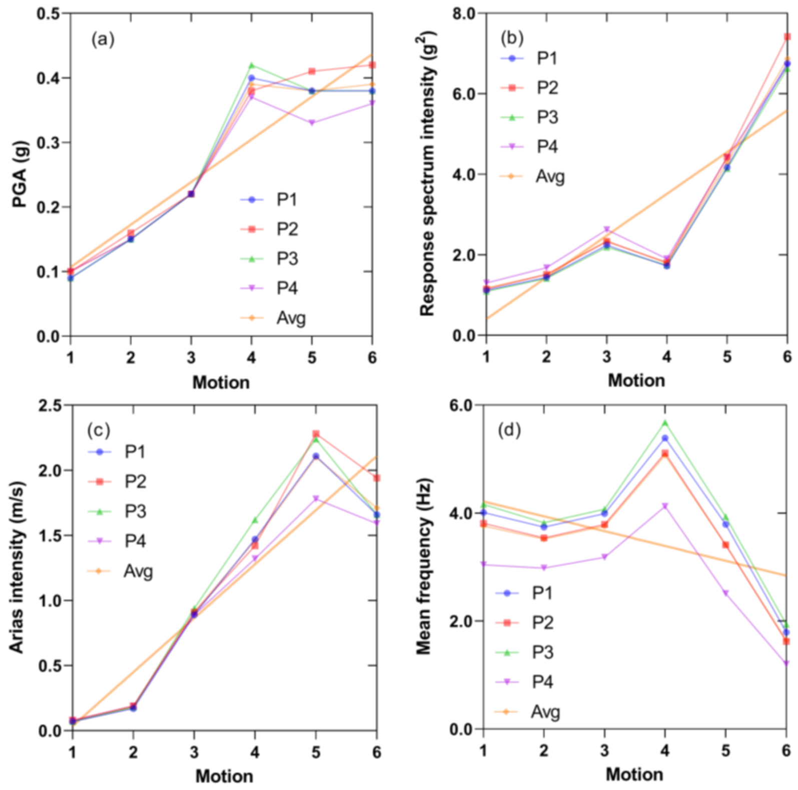

Figure 16: Sensitivity of input ground motion in Zone I. (a) Peak ground acceleration, (b) Response spectrum intensity, (c) Arias intensity, (d) Mean frequency. Soil profiles: P1 = Toorsa II, P2 = Toorsa 1, P3 = Dhamdhara II and P4 = Dhamdhara I.

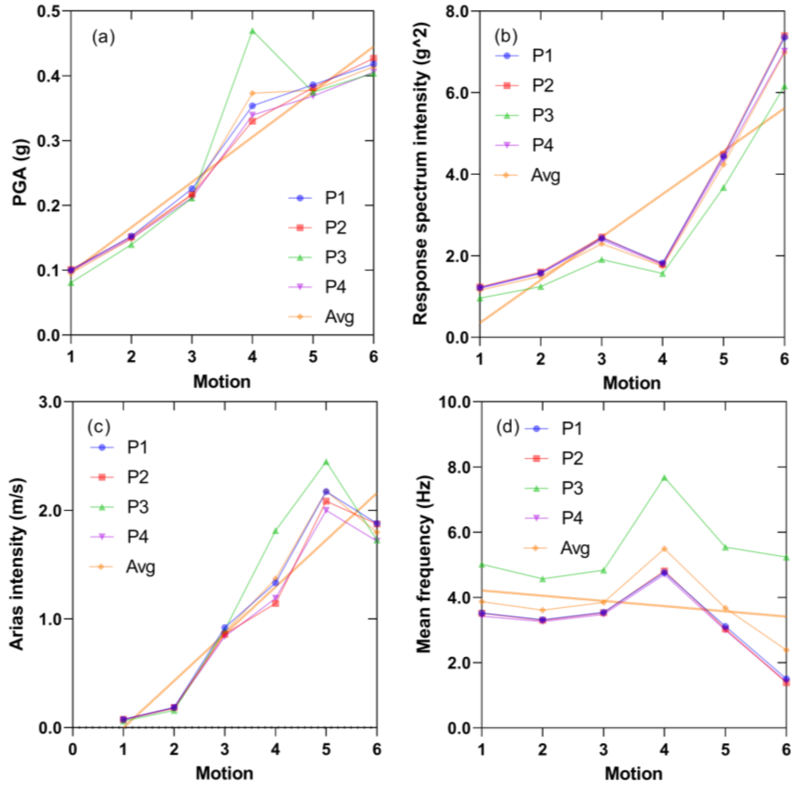

Figure 17: Sensitivity of input ground motion in Zone II. (a) Peak ground acceleration, (b) Response spectrum intensity, (c) Arias intensity, (d) Mean frequency. Soil profiles: P1 = CST Football Ground, P2 = CST Hostel, P3 = Phajoding, and P4 = Monastery area.

Now we speculate that the input motion characteristics of the Northridge earthquake are largely related to the potential seismic site effects. The study proposes the implementation of the input motion PGA in the range of 0.11 g and 0.33 g of frequency content between 1 to 10 Hz. For the current study,In this study, the PGA of M4 Northridge are mapped to show the spatial variability in two survey zones as shown in Fig. 18. The PGA in Zone I are distributed between 0.37 g to 0.42 g. The variability of PGA in Zone II is higher compared to Zone I, resulting in the range 0.33 g to 0.47 g. The resulting interplay of strong ground motion with local soil conditions primarily highlights the importance of the current study on the significance of input motion characterization.

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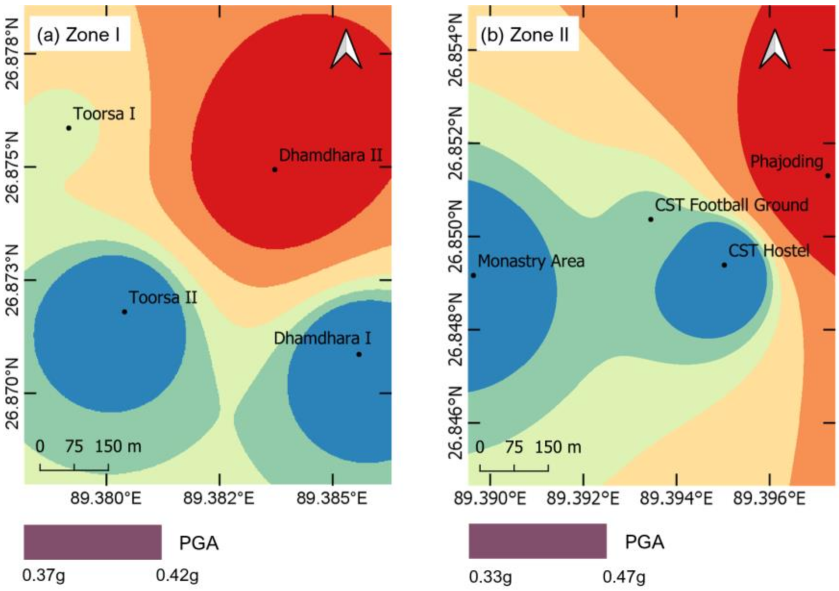

Figure 18: PGA distribution map of input motion M4 Northridge earthquake, (a) Toorsa and Dhamdhara in Zone I, (b) Rinchending in Zone II.

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~~2.~~5. Conclusions

Using 1D site response analysis, we perform sensitivity of various input motions. The study concludes the following: ~~This study shows the sensitivity of the various input motions using a 1D seismic response analysis. The overall significance of this study can be concluded as follows.~~

- The trend in the variation of ground motion parameters such as PGA, PGD, PGV~~,~~ and SA~~, as expected,~~ projects an increasing order ~~in terms of the~~with ground motion intensity as expected. The correlation analysis and linear regression models provide~~d~~ the enhanced characteristics of input motion propagation, indicating possible use of earthquake PGA between 0.11 g and 0.33 g from 1 to 10 Hz frequency ~~content~~. ~~Further, the sensitivity analysis of the ground vibration. However, the uncertainty for each parameter is widely scattered, indicating the importance of the variability due to local soil conditions~~show potential interaction of the ~~Northridge earthquake to local soils in Phuentsholing~~.
- The surface PGA in the investigation area of site classification type B shows ~~about~~ 0.1 g to 0.15 g for the earthquake of low intensity, 0.23 g to ~ 0.38 g for the earthquake of medium intensity, and more than 0.43 g for an earthquake of ~~higher intensity earthquakes such as the 1992 Petrolia earthquake~~high PGA earthquakes.

The result shows a higher spectral acceleration ~~of the soil profile~~ in a period range from 0.3 s to 3.0 sec with approximately 0.14 g to 1.62 g peak spectral acceleration.

- The critical range of the fundamental natural period is roughly between 0.9 sec to ~ 5.0 sec with the highest range of seismic wave amplification being between ~ 2.8 to 6.2. In Phajoding, the significance of amplification is comparatively less at ~ 1.7 between 0.4 s and 1.0 s due to a much stiffer soil deposit ($V_{s,30}$ = 584.76 m/s) and a shallow engineering bedrock at 150 m. ~~This suggests that the low-rise buildings are more vulnerable and can see stronger vibrations than the high-rise buildings in Phajoding, however, overall effects on tall buildings cannot be neglected.~~
- ~~In the present seismic response analysis, the ground response of various strong ground motions with varying ground shaking intensity as an input motion~~This study indicated ~~show~~ some anomalies ~~to local soils and~~in seismic site effects due to input motion. Therefore, an ~~appropiate~~appropriate ~~proper~~ ground motion characterization is recommended ~~when the input motions are selected, especially while performing a~~for site-specific seismic analysis. The high Fourier amplitude characteristics at low frequency have a ~~larger~~ greater tendency to ~~anomaliesy~~reflect anomalies in response parameters. ~~, e.g., input motion M1, M5 and M6. on bedrock response spectra have larger impacts in low periods and the response from M6 is evident from the current study. In other words, matching the frequency content and earthquake PGA gives a reliable estimate of seismic site effects.In other words, the frequency content of the ground motion and the variability of amplification would undermine the proper estimation of seismic site effects.~~

~~3.~~ Appendix A: Surface motion parameters

~~4.~~ Annotations

P = Profile number
M = Motion number
G_{rms} = Root mean square acceleration
t_a = Bracketed duration
D = Significant duration
CAV = ~~Cummulative~~Cumulative absolute velocity
SA = Spectral acceleration
StDev = Standard deviation

Table A1. Additional surface motion parameters in Zone I.

P	M	PV (m/s)	PD (m)	G_{rms} (g)	t_a (s)	D5-95 (s)	D5-75 (sec)	CAV (g-s)	SA @ 1.0 s (g)
1	1	0.173	0.040	0.022	1.360	7.980	2.660	0.209	0.096
1	2	0.170	0.048	0.033	6.000	9.080	4.100	0.318	0.181
1	3	0.201	0.064	0.043	15.580	28.740	10.200	1.116	0.214
1	4	0.200	0.046	0.100	14.160	8.530	4.450	0.934	0.166
1	5	0.397	0.120	0.071	29.340	24.580	10.420	1.580	0.649

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1	6	0.876	0.230	0.090	16.460	12.100	5.890	1.055	0.763
2	1	0.175	0.040	0.024	1.380	7.760	2.620	0.216	0.099
2	2	0.169	0.047	0.035	6.000	9.060	4.020	0.328	0.192
2	3	0.213	0.064	0.043	29.280	28.760	10.520	1.134	0.231
2	4	0.210	0.046	0.099	14.150	8.520	4.440	0.914	0.182
2	5	0.419	0.119	0.074	29.340	24.580	10.360	1.625	0.727
2	6	0.877	0.228	0.097	16.440	11.920	5.910	1.136	0.908
3	1	0.170	0.039	0.023	1.380	7.980	2.720	0.210	0.093
3	2	0.164	0.047	0.034	6.000	9.080	4.100	0.323	0.176
3	3	0.197	0.064	0.044	29.280	28.040	9.820	1.139	0.210
3	4	0.204	0.046	0.106	14.160	8.490	4.430	0.977	0.162
3	5	0.414	0.118	0.073	29.340	24.580	10.440	1.626	0.645
3	6	0.855	0.223	0.090	16.460	12.060	5.850	1.058	0.767
4	1	0.203	0.095	0.024	0.980	7.820	2.580	0.219	0.108
4	2	0.201	0.065	0.034	6.000	9.380	3.880	0.326	0.204
4	3	0.238	0.072	0.042	29.340	29.300	10.540	1.125	0.243
4	4	0.219	0.051	0.097	12.200	8.170	4.080	0.870	0.180
4	5	0.417	0.135	0.065	25.900	24.580	10.180	1.455	0.685
4	6	0.941	0.282	0.087	14.800	12.150	6.000	1.028	0.712
Mean		0.346	0.097	0.060	15.222	15.135	6.259	0.872	0.358
Median		0.283	0.078	0.053	10.276	13.150	5.545	0.703	0.269
StDev		0.256	0.071	0.029	10.088	8.330	3.021	0.472	0.271
84^{th} Percentile		0.509	0.146	0.090	30.026	22.042	9.121	1.450	0.570
16^{th} Percentile		0.157	0.042	0.031	3.517	7.845	3.371	0.341	0.127

Table A2. Additional surface motion parameters in Zone II.

P	M	PV (m/s)	PD (m)	G_{rms} (g)	t_a (s)	D5-95 (s)	D5-75 (s)	CAV (g-s)	SA @ 1.0 sec (g)
1	1	0.181	0.043	0.024	1.380	7.840	2.600	0.215	0.104
1	2	0.182	0.048	0.035	6.000	8.960	4.000	0.325	0.197
1	3	0.215	0.066	0.043	29.320	28.800	10.480	1.135	0.231
1	4	0.214	0.047	0.097	12.200	8.270	4.170	0.879	0.179
1	5	0.404	0.124	0.072	29.360	24.600	10.380	1.598	0.677
1	6	0.936	0.244	0.095	16.470	12.060	5.770	1.106	0.816
2	1	0.186	0.041	0.024	1.380	7.760	2.540	0.212	0.103
2	2	0.186	0.046	0.035	5.980	8.940	3.900	0.322	0.199
2	3	0.217	0.067	0.042	19.000	28.900	10.520	1.101	0.232
2	4	0.211	0.047	0.090	12.190	8.300	4.190	0.815	0.177

2	5	0.393	0.126	0.070	29.340	24.580	10.340	1.557	0.686
2	6	0.943	0.250	0.096	16.450	11.920	5.800	1.101	0.839
3	1	0.158	0.037	0.021	1.360	8.060	3.020	0.202	0.078
3	2	0.149	0.045	0.031	6.000	9.360	4.520	0.317	0.152
3	3	0.178	0.062	0.044	17.040	27.420	9.720	1.116	0.175
3	4	0.182	0.043	0.111	16.880	8.640	4.610	1.056	0.135
3	5	0.406	0.112	0.076	29.340	24.400	10.720	1.690	0.551
3	6	0.830	0.218	0.092	18.050	11.900	5.390	1.103	0.704
4	1	0.184	0.041	0.023	0.960	7.800	2.580	0.209	0.101
4	2	0.183	0.048	0.034	6.000	8.940	3.960	0.319	0.195
4	3	0.212	0.066	0.041	18.960	28.840	10.520	1.084	0.227
4	4	0.209	0.047	0.091	12.200	8.300	4.190	0.832	0.175
4	5	0.391	0.125	0.069	29.340	24.580	10.340	1.530	0.672
4	6	0.905	0.243	0.091	16.440	11.990	5.870	1.056	0.793
Mean		0.344	0.093	0.060	14.652	15.048	6.255	0.870	0.350
Median		0.278	0.074	0.053	10.022	13.070	5.537	0.698	0.261
StDev		0.263	0.071	0.029	9.536	8.295	3.052	0.480	0.268
84th Percentile		0.506	0.140	0.090	28.804	21.920	9.109	1.451	0.559
16th Percentile		0.153	0.039	0.031	3.487	7.793	3.365	0.335	0.122

Data availability

All the data used in this study are presented in the paper.

Author contribution

Conceptualization (KT), Data curation (KT), Formal analysis (KT), Funding ~~aqisition~~acquisition (KRA), Methodology (KT, DG and GF), Resources (KT, DG and KRA), Software and visualization (KT), Writing – original draft preparation (KT), Writing – review & editing (DG, NC, GF and KRA).

Competing interests

The authors declare that they have no competing interests.

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