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# *SITE EFFECTS OF SOFT SOIL DEPOSIT ON GROUND MOTION IN KATHMANDU VALLEY*

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***Abstract*— As valley have faced major seismic shock of major three earthquakes 1934, 1988 and 2015 A.D. and have proved that the valley has been suffering from site effects as it is rich in equestrian soil. The recent earthquake has massive destruction in Gongabu, Balaju area where it has mercy in Balkumari area. Among major populated area of valley Balaju and Gongabu have gray loose silty sand and black cotton soil up to 10-15 m which are a major cause for amplification of earthquake waves and for a Balkumari there is stiff clay soil and rock is in lower depth and it has been proved by 1-D analysis by using DEEPSOIL software. Response spectra, peak ground acceleration and column -displacement animation analysis for equivalent mode were established. This paper mainly highlights the effects of surface and lower layers of soil in the planning and designing of infrastructures in the Kathmandu Valley**

***Keywords—Earthquake, Gray loose soil, Site Effect, Kathmandu valley, Deep soil, Planning and Designing***

## I. INTRODUCTION

Kathmandu valley capital city of Nepal, where 2.5 million people (census 2011) are residing for a various purpose, but the thing is that Nepal being located in the central part of the seismically active Himalayan and had witnessed various earthquakes (Pandey et al., 1995). Major historical earthquake damage in the valley was reported in 1255, 1408, 1681, 1803, 1810, 1833 and 1866 (Bilham et al., 1995; Chitrakar and Pandey, 1986; Pandey et al., 1995) and recent are 1934, 1988 and 2015 which crushed a large number of lives. Recorded strong shaking was experienced on 15 January 1934 during an Mw = 8.1 earthquake (Hough and Bilham, 2008) .The 1934 earthquake had a maximum intensity of X on the MMI scale in the Kathmandu Valley and destroyed about 19% and damaged about 38% of the buildings in the valley (Pandey and Molnar, 1988; Rana, 1935).As before 2015, researcher used to say that Nepal's fault has not released large amount of accumulated energy for a very long time and as a result Nepal faced earthquake of magnitude of 7.8(USGS) and intensity level IX (Mercalli intensity) at the date of April 2015 Nepal earthquake (also known as the Gorkha earthquake) which killed nearly 9,000 people and injured nearly 22,000 and scientist are saying that only half energy is released and Gorkha earthquake has an overall PGA of 0.164g in horizontal direction and 0.186g in vertical direction. As Geological exploration has revealed that the Kathmandu Valley is an ancient lake deposit, which measures several hundred meters at the deepest point and is made up of thick layers of clay, silt, sand, and gravel in irregular layers of deposition ranging in age from the late Pliocene era to the present (Dongol, 1985; Fujii and Sakai, 2002; Moribayashi and Maruo, 1980; Sakai et al., 2001; Yoshida and Igarashi, 1984; and Dahal and Aryal, 2002). Based on a gravity measurement study, Moribayashi and Maruo (1980) have estimated the maximum depth of the Kathmandu basin-fi LL sediments to be about 650 m. In the central part of the valley, however, a drill-well was found to hit the basement rock at a depth of about 550 m (Fujii and Sakai, 2002).

. Most of the past studies have revealed that the distribution of earthquake damage in a particular area is correlated with its fundamental frequency (e.g., Gosar, 2007; Teves-Costa et al., 2007). However, some studies also indicate that depending upon the soil conditions of underlain strata, a second amplified frequency is locally revealed, which can play an important role in creating a resonance with the structures built over the ground during an earthquake (such as Fäh et al., 1994; Toshinawa et al., 1997; Guéguen et al., 1998, 2000). As mentioned previously, the geological structure and sediment depositional environment in the Kathmandu Valley consists of many strata of sand, silt and clay sediments, which bring forward a possibility that two or more amplified frequencies occur during an earthquake. As the valley accommodates a number of low-rise to medium-rise buildings, historically important places and monuments, there are possibilities during an earthquake that the multiple amplified frequency may cause a resonance with structures in a broad frequency range, leading to an enhanced vibration of the structures and possible collapse. As our study area occupies large number population and large area so journal focuses on deep analysis, and reformation in chordal provision in the design of structures in these areas.".

## II. MATERIALS AND METHODS

### A. *Study area*

Kathmandu valley is bowl-shaped. Its central lower part stands at 1,425 meters (4,675 ft) above sea level. Kathmandu valley is surrounded by four mountain ranges: Shivapuri (at an elevation of 2,800 meters or 9,200 feet), Phulchowki (2,795 metres or 9,170 feet), Nagarjun (2,825 metres or 9,268 feet) and Chandragiri (2,551 metres or 8,369 feet). The major river flowing through the Kathmandu Valley is the Bagmati. The valley is made up of the Kathmandu District, Lalitpur District and Bhaktapur District covering an area of 220 square miles (570 km$^2$).

### B. *Tools*

Deep soil v6. 1, Grapher v9. 0

### C. *Priniple*

Frequency domain analysis refers to the analysis of mathematical function or signals with respect to frequency rather than time.

Equivalent linear analysis employs an iterative procedure in the selection of the shear modulus and damping ratio soil properties in program shake.

*D. Experimental procedure*

Bore hole log of were collected in a number of 5 of each places and then they shear wave velocity were calculated using $V_s = 97N^{1/3}$, then those shear wave velocities were used in deep soil for the and response of soil was analyzed for the input motion of Gorkha earthquake motion recorded in 4 stations in Kathmandu valley namely Kirtipur station, Tribhuvan university station, patchwork station and time station and following processes were done which are shown in figure format.

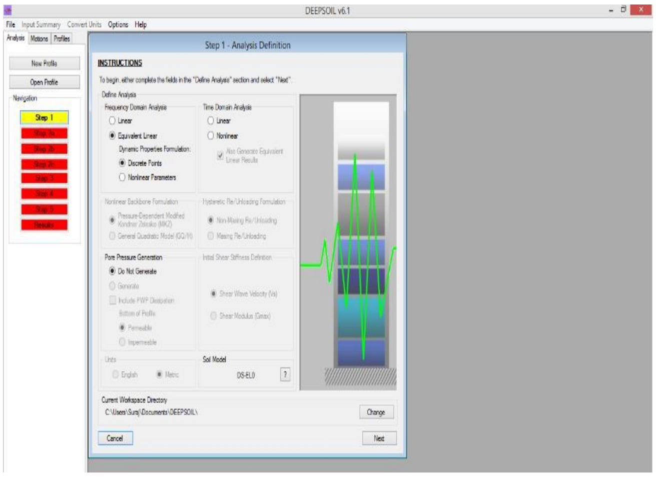

Fig. 1. Steps Showing Analysis

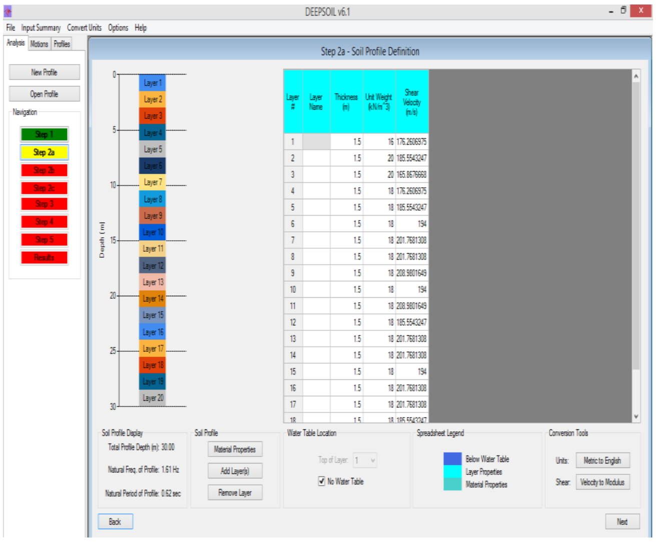

Fig. 2. Steps showing input of shear velocity

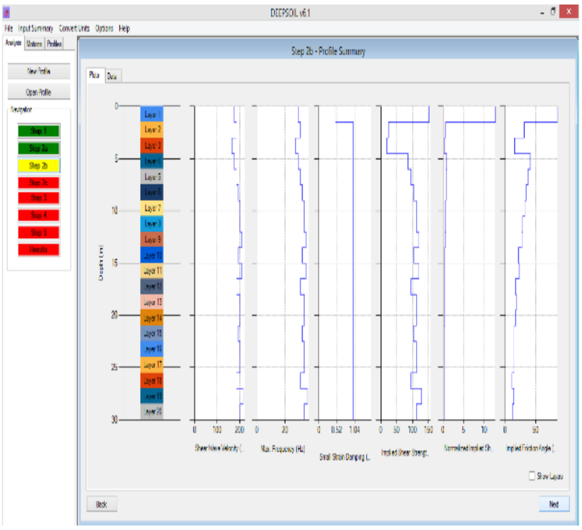

Fig. 3. Soil Profile

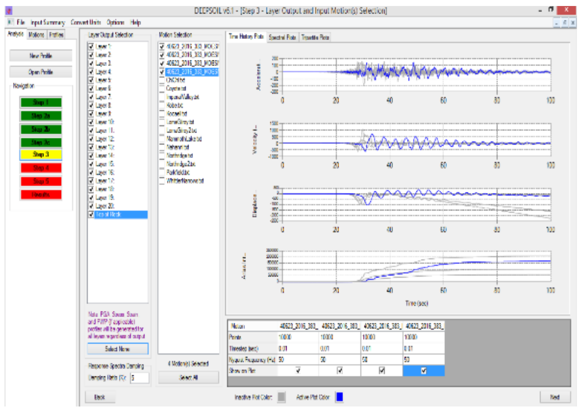

Fig. 4. Time Plots

## III. RESULT AND DISCUSSION

For the input motion recorded at Tribhuvan university instrument the psa of three places are shown

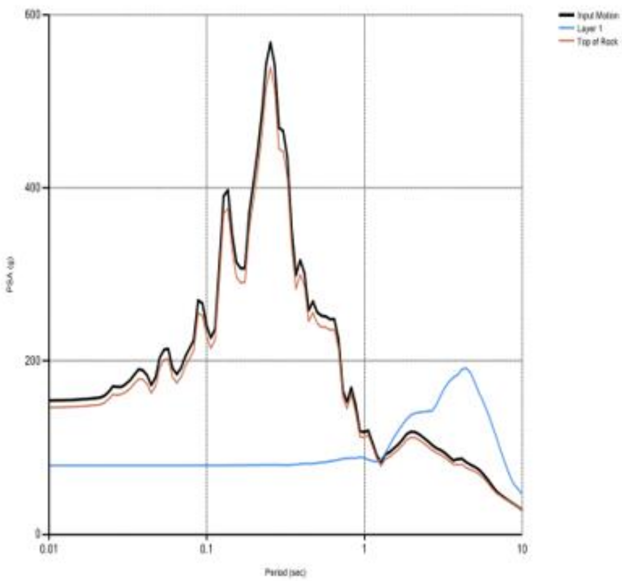


Fig. 5. PSA plot of Balkumari Area

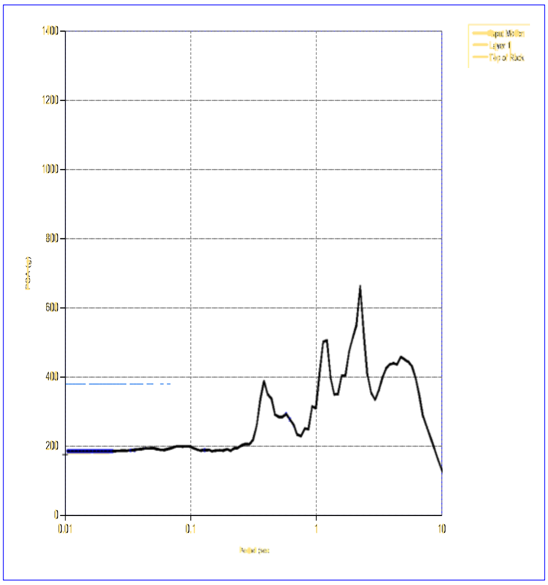


Fig. 6. PSA plot of Balaju Area

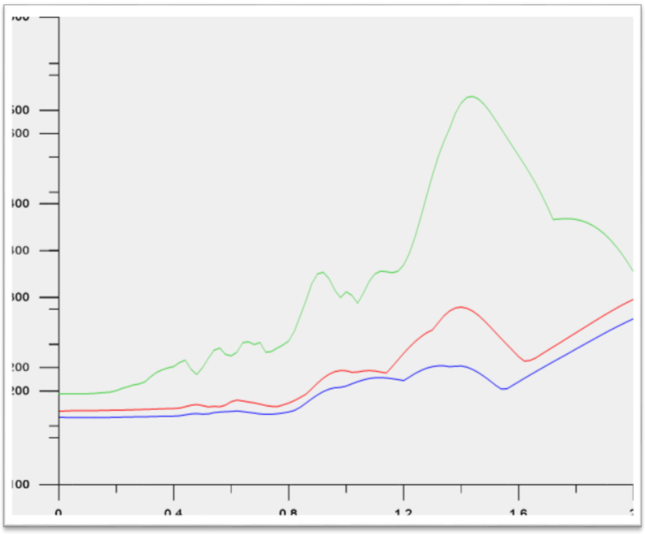

Fig. 7. Application plot of 3 area

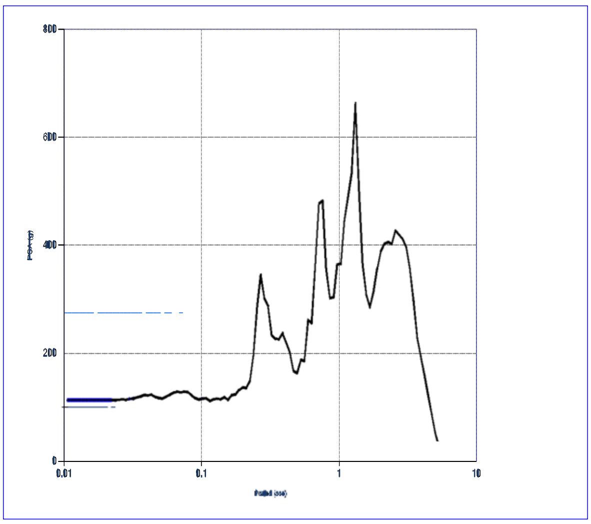


Fig. 8. PSA plot of Gongabu Area

We can compare from graph for a same input motion response spectrum of three place is very different in magnitude and nature that is the effect of soil nature which can be termed as site effect.

As in a small area valley soil is showing different nature of response to the earthquake waves, from this what can be put in note that soil of Gongabu and Balaju comparative to Balkumari are amplifying the shear waves as their soil is gray loose sand soil which can add amplification to waves in mainly three way first is impedance contrast effect which can be simplified as seismic wave travel faster in hard rocks than in soft soil and sediments as the seismic wave passes from hard medium to soft medium their celerity decreases,so they must get bigger in amplitude to carry the same amount of energy and next, it traps the waves and wave goes under multiple reflection and finally undergoes in total internal reflection which will make vibration in resonate condition and maximum vibration occurs and another way which add local amplification is soil particle which will accelerate due to earthquake and add energy to the waves in the direction of propagation and data are showing that Balaju is tentatively triple to Balkumari PSA(peak surface acceleration) which have stiff clay in which it is hard to accelerate the soil particle and reflect the earthquake waves for same motion the amplitude of shaking can be more than 10 times stronger than surrounding rocks.

## IV. CONCLUSION

Being a lacustrine basin with a complex depositional environment, the Kathmandu Valley has a wide range of sediment layers. As a result, there are in-homogeneities in the sediments, and their responses to seismic waves are different and so the destruction pattern is non-uniform so the design codes are to be reformed by taking consideration of local site effect which can be properly managed by doing micro zonation of the valley. Proper soil bearing capacity strengthening techniques is to be applied in Balaju and Gongabu area. Therefore, the behavior of the surface layer as well as the layer underneath should be taken into consideration for seismic risk studies in the valley

## V. RECOMMENDATION

Dynamic soil analysis must be done to find exact behavior making design of structure and choice of foundation and Compaction techniques like dynamo compaction Vibro compaction, compaction grouting, surcharging with prefabricated with vertical drain Reinforcement techniques like stone column, vibro concreting column, soil nailing, micro piles, fracture grouting, fiber and biotechnical fixation technique like grouting, soil mixing and freezing and virtification rammed aggregate piers and many more.

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