Estimation of Strong Ground Motion Parameters in Amarapura Township, Mandalay Region

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Abstract

Amarapura Township, Mandalay Region is located very closed to the most active dextral Sagaing Fault in Myanmar. In the historical record, several earthquakes happened in and around Mandalay, Amarapura, Innwa, Sagaing region from the beginning of the year of 1400. Even a moderately strong earthquake may cause great loss of lives and property damage. An evaluation of the seismic risk of urban areas cannot neglect the variability of the ground vibration due to site amplification and the induced effects, such as soil liquefaction etc. We conducted 21-sites of microtremor measurement to gain a representative determination of the underground structures and predominant frequency in Amarapura Township. These parameters are required for seismic resistant design of structures. The very highest potential zone of seismic hazard mainly locates the western marginal part of Amarapura Township, in the proximal portion to the dextral Sagaing Fault.

Keywords: seismic risk of urban areas, site amplification, microtremor, Sagaing Fault

Introduction

In recent years, several guidelines for rational approaches aimed at seismic microzonation have been proposed. In particular, the scientific community agrees that the zonation detail is linked to the dimension of the area, while the scale of the maps is related to the availability of data, as well as to the degree of accuracy and complexity of the method adopted for the analysis [1]. Nowadays, a well-established approach is the multi-level methodology currently shared by international and national guidelines: it is based on the adoption of mapping criteria with an increasing level of detail, as directly proportional to the completeness of the underground database, to the degree of definition of the reference seismic hazard, and to the complexity of the approach followed to describe the mechanical behavior of the soil. It follows that the reliability of the predictions is proportional to the accuracy of seismological, geological and geotechnical models and therefore, a multidisciplinary approach is required in order to correctly assess the seismic performance of buildings and infrastructures.

Location and Size

The study area is located about 7 miles SW of Mandalay Region on the UTM map of No (2196-01). It lies between North Latitude to 21˚ 54' and East Longitude to 96˚ 03'. It extends is about 5 km from north to south and about 5 km from east to west, covering about 25 sq.km. It sits at 64 meters above the mean sea level. Amarapura Township, Mandalay Region lies

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near the dextral Sagaing Fault [2],[3] and [4] (Figure (1.1)), a tectonic plate boundary between the India and Sunda plates. Figure 1.2 represents the location of Amarapura Township where the present study of strong ground motion analysis is carried out.

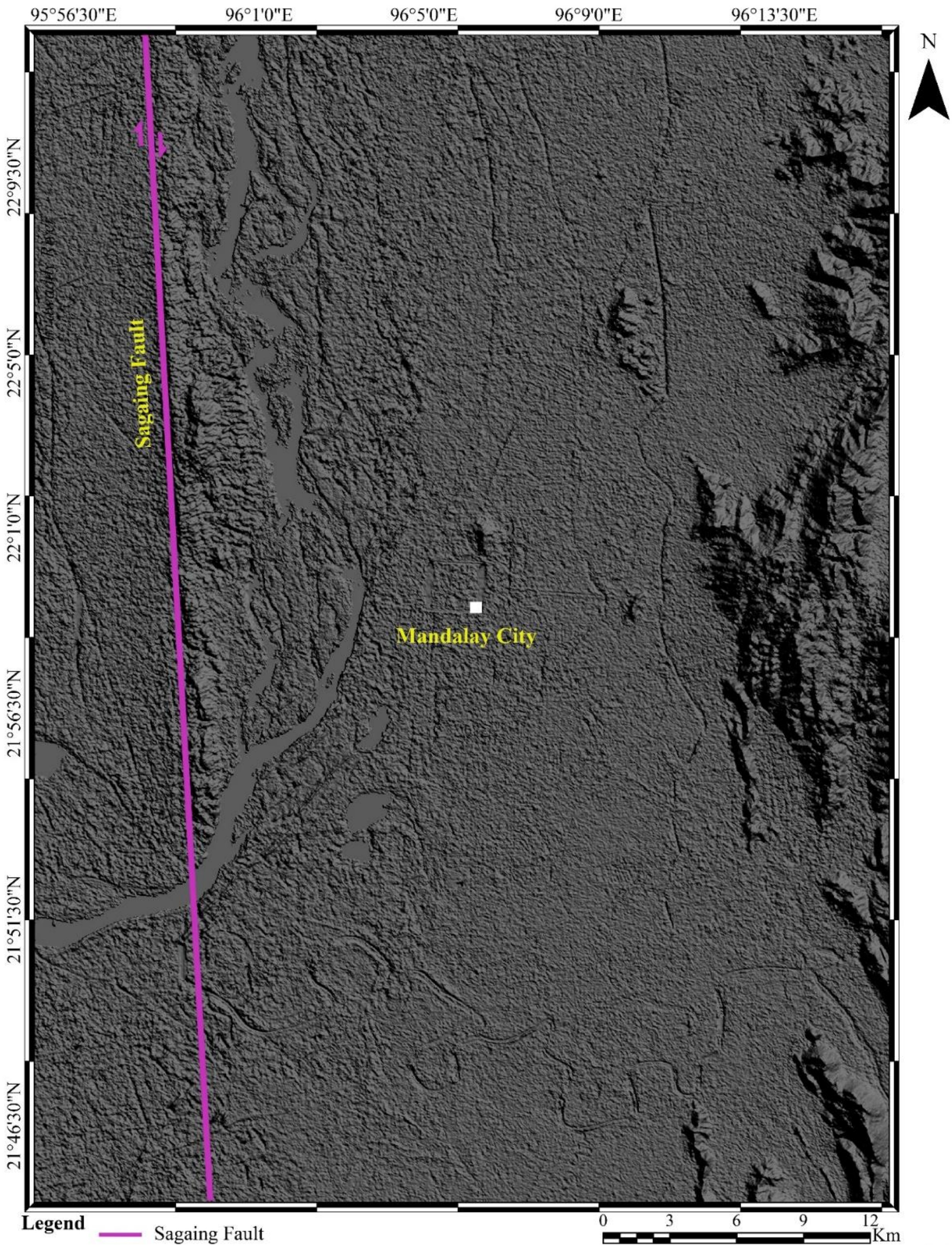

Figure 1.1 ASTER GDEM image showing topographic feature of the Mandalay Region.

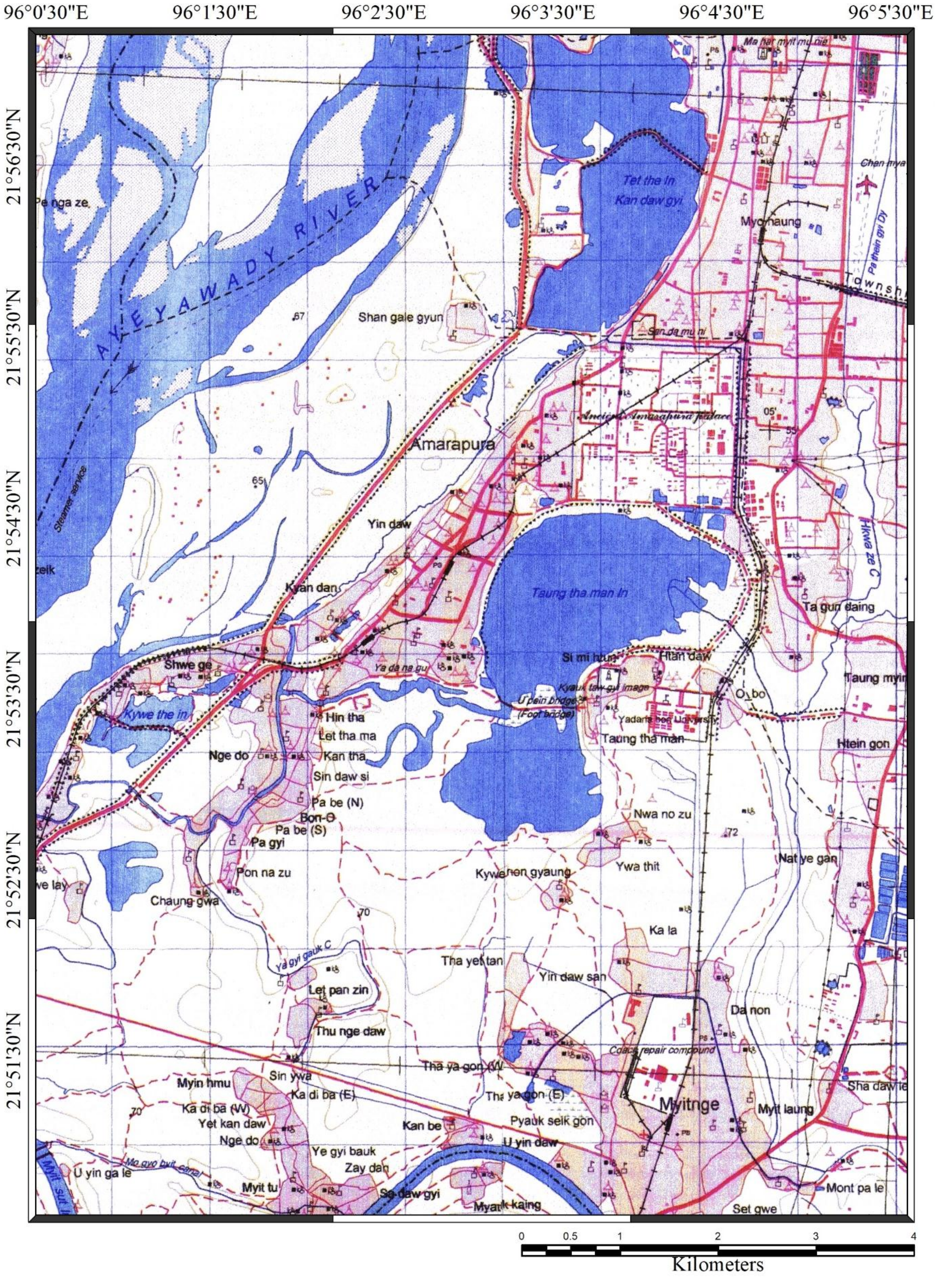

Figure 1.2 Location map of the study area.

Objectives

The objectives of the Survey were as follows:

1. To determine the status of strong ground motion parameters and their use in the socio-economic planning of the Amarapura Township.
2. To determine critical success factors, gaps and best practices in the preparation and use of seismic microzonation maps and vulnerability assessment studies in the Amarapura Township.
3. To compile a database of hazard parameters, and digital maps available in the Amarapura Township.

Methodology

The methodology is divided into three major parts: (i) Soil modeling and Engineering Bed Layer establishment (ii) Estimation of the ground motion (iii) Estimation of ground motion at the surface by ground response analysis using the stochastic green function. The EBL is a prominent subsurface soil layer with shear wave velocity of 350 m/s to 750 m/s. The detail of methodology in the form of a flow chart is given in Figure. 1.3.

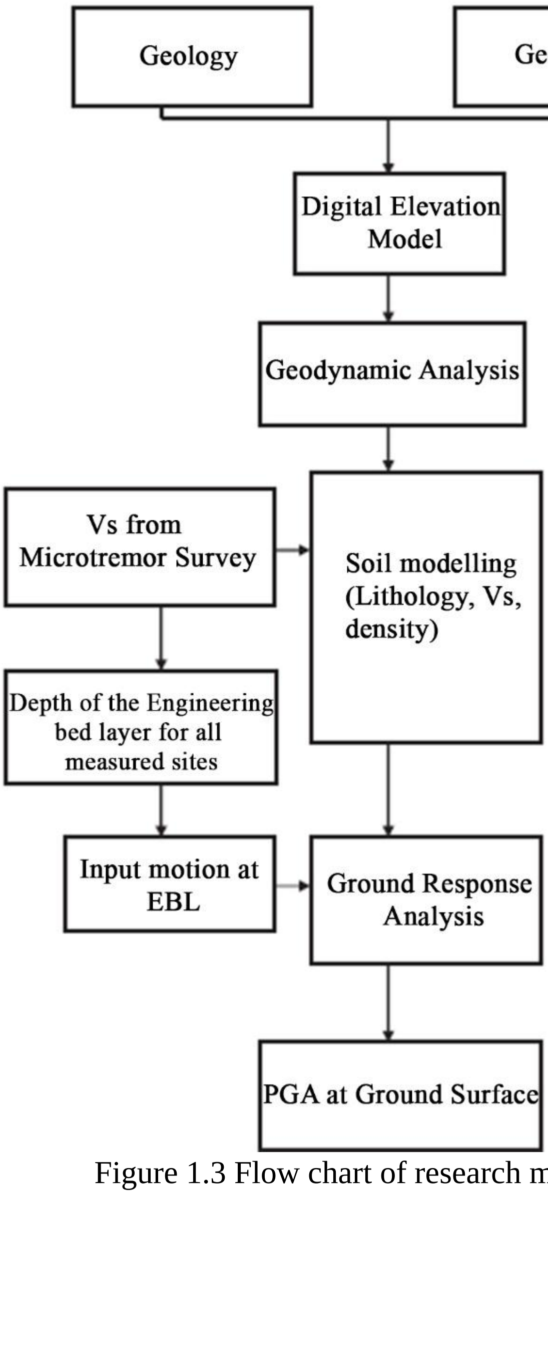

Figure 1.3 Flow chart of research methodology.

Microtremor Survey

Amarapura Township, a three-component accelerometer with data logger, GPL-6A3P, produced by the Mitsutoyo Co. Ltd., was used for disaster mitigation. Amarapura Township had been applied for evaluation of fundamental frequency and spectral ratio between horizontal and vertical components (H/V Ratio). The number of single microtremor survey was 21 (Figure 1.4 and 1.5). The sampling frequencies were 100 Hz or 500 Hz and the observation times were 15 to 20 minutes [5].

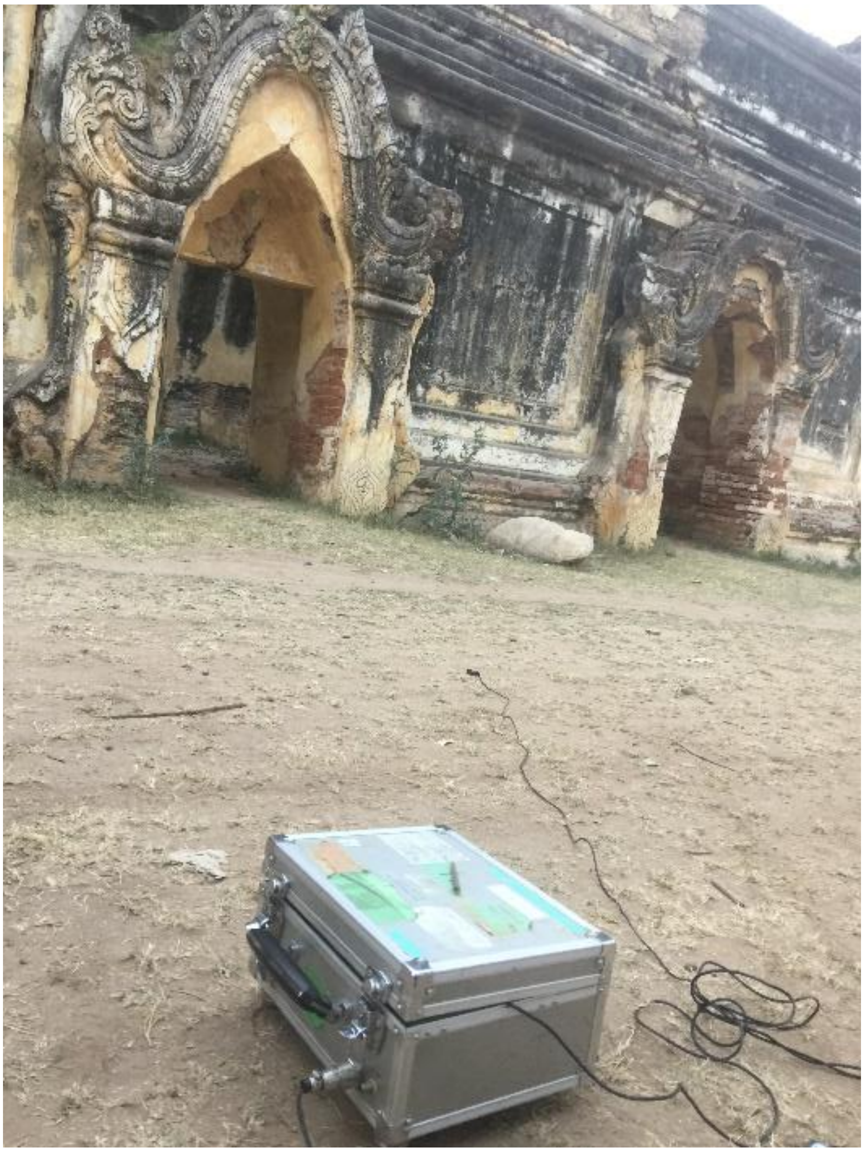

Figure 1.4 Microtremor survey at site no 7.

Figure 1.5 Location map of microtremor sites around Amarapura Township.

Modeling of Subsurface Structure

We could obtain subsurface structure at microtremor observation, however, the ground profiles are not uniquely determined. In this study, we proposed three layer model in Amapura Township by averaging the first two layers of all observation sites. By combining with the first peak of H/V data, we could obtain the thickness of the sediment layer (Figure 1.6). The technique used was the 1/4 wavelength principle, which can approximately be extended to multi layered media.

$$T = 4H / VS \qquad (1)$$

where, H is a thickness of a layer, Vs shear wave velocity and T predominant period.

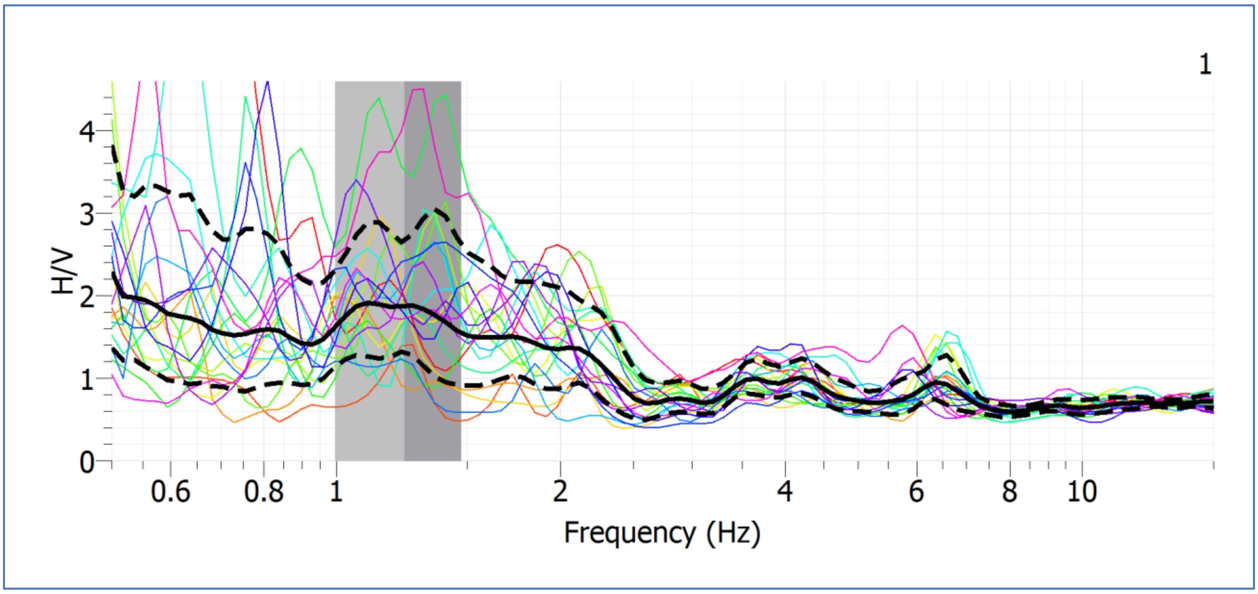

Figure.1.6 Subsurface structure at microtreor survey site no.1

Seismic Microzonation

Seismic microzonation models are being updated by modifying some of the seismic sources in Myanmar. In this research, the input motions were selected based on the geophysical data and engineering bedrock condition [6], [7] and [8]. The ground response analyses were conducted by using the assumption of vertical propagation of shear waves from the engineering bedrock to the ground surface. The surface ground motion is estimated by passing ground motion simulated at EBL through prepared soil models of each site using the stochastic green function (Table 1).

Table 1. Results of Geophysical and Geological data.

Location Site	**PGA (g)**	**Geology** [9]	**Vs^{30} (m/s)**
Amarapura palace	0.35 - 0.40	Holocene	300
Yadanabon University	0.35 - 0.40	Holocene	260
The western marginal part of Amarapura Township area	0.50 - 0.55	Holocene	200

Conclusions

This study shows the preliminary results of geophysical and geological data, which deals with the seismic microzonation of the Amarapura Township. The selected case study is a challenging choice, as the seismic microzonation is affected by both tectonic and seismicity, which in historical time differently affected the urban setting. Seismic microzonation is the process of estimating the seismic hazard parameters such as peak ground acceleration (PGA), peak ground velocity (PGV), peak ground displacement (PGD) and spectral acceleration at different periods. These seismic hazard parameters are the essential components in any earthquake resistant design. The Kriging method can be used for the interpolation of subsurface information such as shear wave velocity and depth of irregular boundary [10]. There are very high acceleration areas appears along the dextral Sagaing Fault, especially near the epicenter. Peak acceleration becomes more than 0.5 g in some areas, which causes severe damage for buildings in high probability. In this framework, the seismic microzonation certainly represent the most adequate tool to account for this element in the seismic risk and for urban planning mitigation strategies.

Acknowledgements

The author would like to express deep gratitude to all of the researchers who provided advice regarding the writing of this research paper.

References

[1] Kramer, S. L. 1996. Geotechnical Earthquake Engineering, Prentice-Hall International Series in Civil Engineering and Engineering Mechanics, 653 pp.

[2] Win Swe, 1970, Rift-features at the Sagaing-Tagaung Ridge. Abstract, Burma Research Congr., Rangoon, 101.

[3] Hla Maung, 1987. Transcurrent movements in the Burma-Andaman Sea region. Geology 15, 911-912.

[4] Myint Thein, Kyaw Tint and Aye, Ko Aung, 1991. On the lateral displacement of the Sagaing fault. Georeports 1, 23–34.

[5] Ohta, Y. and Goto, N. 1976. Estimation of s-wave velocity in terms of characteristic indices of soil, Butsuri-Tanko, 29(4): 34-41

[6] Maung Thein and Tint Lwin Swe, 2006. Explanatory Account for Seismic Zone Map of Myanmar (Revised Version, 2005) February (Prepared under the auspices of Myanmar Earthquake Committee), 4 p.

[7] Myo Thant, Nwai Le' Ngal, Soe Thura Tun, Maung Thein, Win Swe, Than Myint 2012. Seismic Hazard Assessment For Myanmar, Report to Myanmar Earthquake Committee and Myanmar Geoscience Socity, P58.

[8] Pyi Soe Thein, Junji Kiyono, Tun Tun Win, Than Than Nu, Day Wa Aung (2015). Seismic Microzonation of Mandalay City, Myanmar. Journal of Geological Resources and Engineering, David Puiblishing.

[9] Myanmar Geoscience Society, 2014. Geological map of Burma, Partly based on Geological Map of the Socialist Republic of the Union of Burma (1977((Scale 1:1,000,000).

[10] Kiyono, J. and Suzuki, M. 1996. Conditional Simulation of Stochastic Waves by Using Kalman Filter and Kriging Techniques, Proc. of the 11th World Conference on Earthquake Engineering, Acapulco, Mexico, Paper No.1620.