

## EARTHQUAKE GROUND RESPONSE ANALYSIS OF BANASREE RESIDENTIAL AREA USING SHAKE 2000.

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### ABSTRACT

The study attempted in performing one dimensional ground response analysis by the use of program SHAKE 2000 for assessing the potential amplification of earthquake ground motions with respect to different characteristic parameters in different types of soil conditions in Banasree residential area, Dhaka. A definite earthquake motion from the earthquake record database was taken as input motion for the soil profiles. Simplified relations relating only to the SPT-N value was used for determining maximum shear modulus and damping of 5% was considered for all the locations. From the database of dynamic material properties, G/Gmax and Damping curves were adopted for the layers. Characteristic graphs of Strain Compatible Damping, Strain Compatible Shear Modulus, Maximum Shear Strain & Stress, Peak Acceleration, Acceleration Time History, Amplification Ratio, etc. were obtained for each location. From the seismic response analysis, relatively dense stratum range of the shear modulus was much lower with a gradual rise within the sandy layers. The range of shear modulus was relatively low within the sand layers in dense soil. In hard soils within the sand layers the range of shear strains were low but with the densification of layers the shear strain gradually increased. Again peak ground acceleration was high in soft soil areas indicating site amplification in soft soil. The highest acceleration occurred at 22 seconds and at 31 seconds about 0.19g for the input motion acceleration of 0.051g at 21 seconds. Cyclic stress ratio decreased with depth for all types of soil. Spectral acceleration and Fourier amplitude spectrum was found highest.

**Keywords:** Shake 2000, Ground Response, Shear waves, Peak acceleration, Damping

### 1. INTRODUCTION

Earthquake is such a natural disaster that mankind has been combating with since its origin. The intensity of earthquake threat is not uniform in all the regions of the world. So, regions within the earthquake threat demands their careful consideration in the design of structures and facilities. But on the context of Bangladesh, in spite of being a region of high seismic activity, earthquake resistant design considerations are given least importance. But over the years few of the major earthquakes as, The Great Indian earthquake with magnitude of 8.7 on surface wave magnitude scale, one of the world's strongest, had its epicentre only about 230 km from the capital city Dhaka (Ali and Chowdhury, 1992) and most recently the earthquake. Past studies, such as by Ansary et al. (2004), Ashford et al. (2005), Ranjan (2005) and Abe et al. (1996) have demonstrated the role played by the surface geology in altering the observed seismic motion. Most of the methods are based on the assumption that the main response in a soil deposit is caused by the upward propagation of shear waves from the underlying rock formation. Determining the characteristics of the motions likely to develop in the rock formation underlying the site, and selecting an accelerogram with these characteristics is used in the analysis. The maximum acceleration, predominant period, and effective duration are the most important parameters of an earthquake motion. Empirical relationships between these parameters and the distance from the causative fault to the site have been established for different magnitude earthquakes (Gutenberg and Richter, 1956;

Seed et. al., 1969; Schnabel and Seed, 1972). A design motion with the desired characteristics can be selected from the strong motion accelerograms that have been recorded during previous earthquakes (Seed and Idriss,1969) or from artificially generated accelerograms (Housner and Jennings,1964).Average relationships between the dynamic shear moduli and damping ratios of soils, as functions of shear strain and static properties; have been established for various soil types (Hardin and Drnevich,1970; Seed and Idriss,1970).A one dimensional method of analysis can be used if the soil structure is essentially horizontal (Kanai, 1951; Matthiesen et al., 1964; Roesset and Whitman,1969; Lysmer et al.,1971). In this study, As a method of assessment the one dimensional analysis by the program SHAKE 2000 is followed for the local soil conditions at five locations of Banasree residential area to know about the amplification effects on the structures made at that locations based on the soil testing information for a particular damping and a generalized earthquake data .

## 2. STUDY AREA

Here, study area as Block A, B , D, E, F; shown in the Figure 1, is referred as site 1, site2, site 3, site 4 and site 5 .



Figure 1: Working map locations.

## 3. METHODOLOGY

The program models the nonlinear variation of the soil Shear Module and Damping as a function of shear strain. The hysteretic stress-strain behavior of soils under symmetrical cyclic loading is represented by an equivalent modulus,  $G$  corresponding to the secant modulus through the end points of the hysteresis loop and equivalent linear damping ratio,  $\beta$  which is proportional to the energy loss from a single cycle of shear deformation. For a given soil layer,  $G$  and  $\beta$  are assumed to be constant with time during the earthquake shaking. The soil types present on the actual bore log data were made to match the default soil profiles present within the program to get the Shear Modulus and Damping values considering the

soil type anvarious strata. The Maximum Shear Modulus for Sandy Soil and Clayey Soil was determined following the simplified formulae (Imai and Tonuchi,1982; Seed and Idriss 1970; Egan and Ebeling, 1985) which consider the SPT value only. They are shown in the Table1.

Table 1: Equations for Maximum Shear Modulus

Soil Type	Formulae	Variables	Unit	References
Sand	$G_{max}= 325N_{60}^{0.68}$	$N_{60}$ = SPT value	Kip/ft <sup>2</sup>	(Imai and Tonuchi,1982) Table A. 2
Clay	$G_{max}= 2000S_u$ $S_u = 6 N_f$	$S_u$ = Undrained Shear Strength, $N_f$ = Field SPT Value	KN/m <sup>2</sup>	(Seed,H.B and Idriss, I.M 1970); Egan, J.A and Ebeling R.M ,1985)

The shear wave velocity at the bottom of the bedrock was considered to be of 700 m/s. for all types of soil profiles. A default earthquake source was considered for the analysis for knowing the change in the characteristic curves in the soil profiles.

### 2.1 Damping Provided

It is a common practice to specify a design spectrum for a 5% damping ratio. So 5% damping was taken for the analysis. However, depending on the structural material behavior and the level of ground motion excitation, a design spectrum for other damping values may be needed.

### 2.2 Input Motion Provided

Due to unavailability of an earthquake source that influenced a significant amplification in the cities of Bangladesh; the earthquake at Southeastern, Alaska, 1979 - M: 7.3 R: 166 km - N279E Component - Yakutat Station shown in Figure 2, was taken for input motion for the analysis for all types of soil profiles.

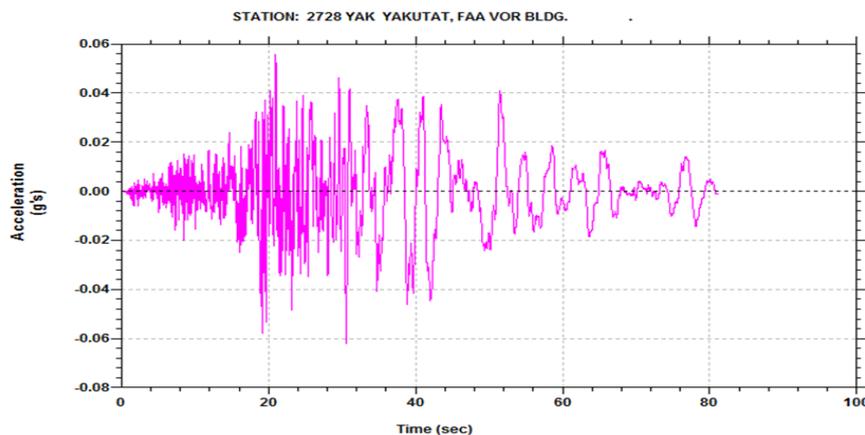
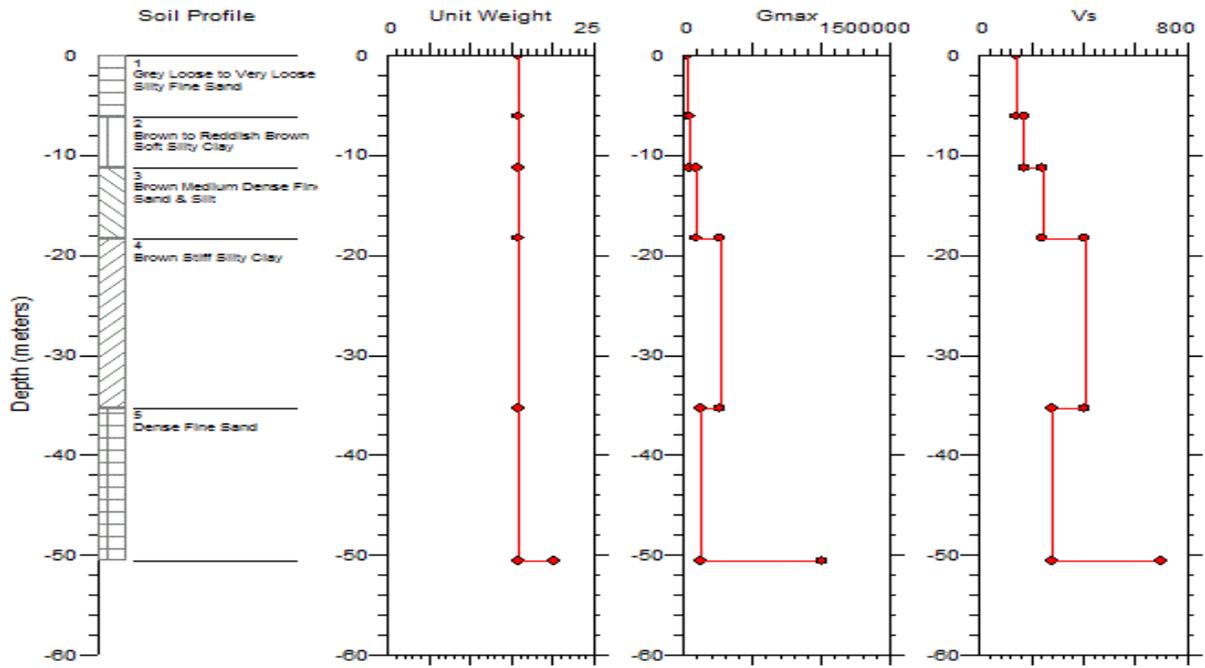


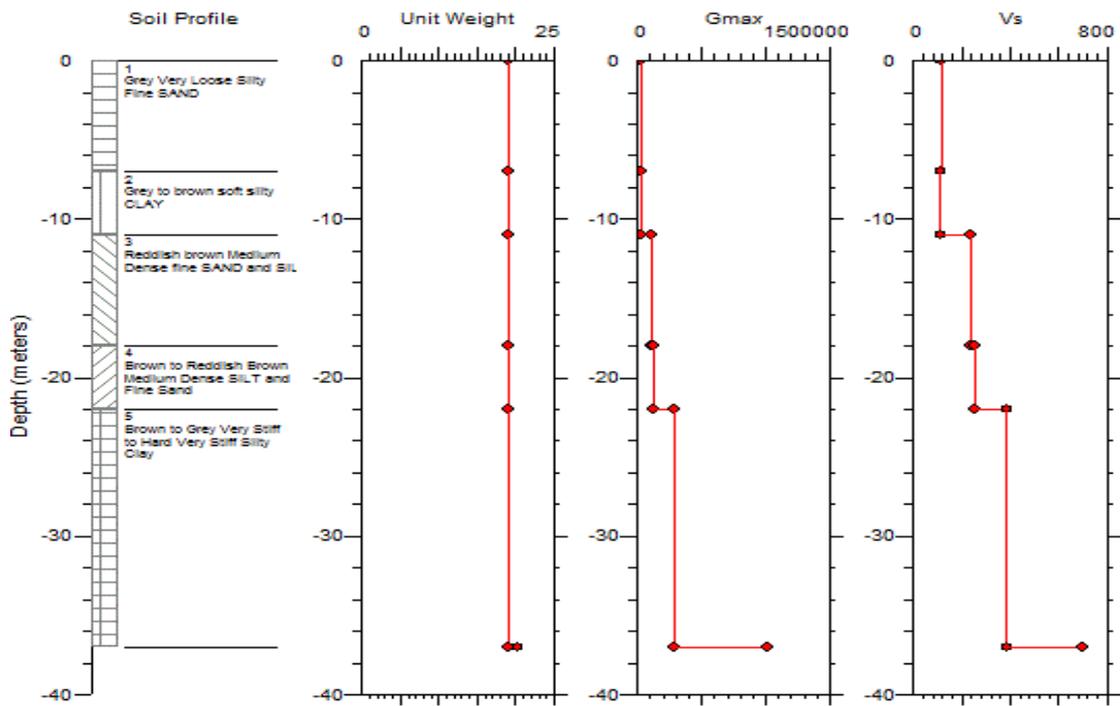
Figure 2: Acceleration Time History Recorded at Yakutat Station For South Eastern Alaskan Earthquake, 1979

### 3. OUTCOMES OF ANALYSES

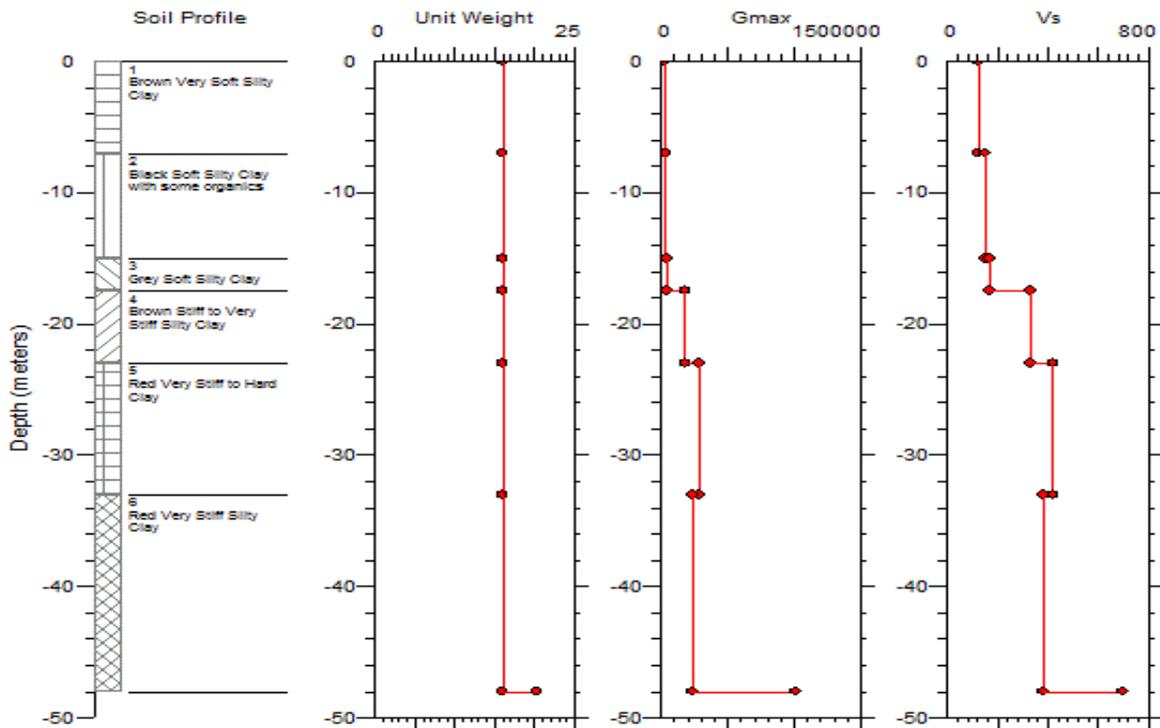
The results of analyses are obtained by the program SHAKE 2000 in the form of characteristic curves. The curve induces the following important defining parameters based on which relative discussions on response analysis over the soil profile are provided.



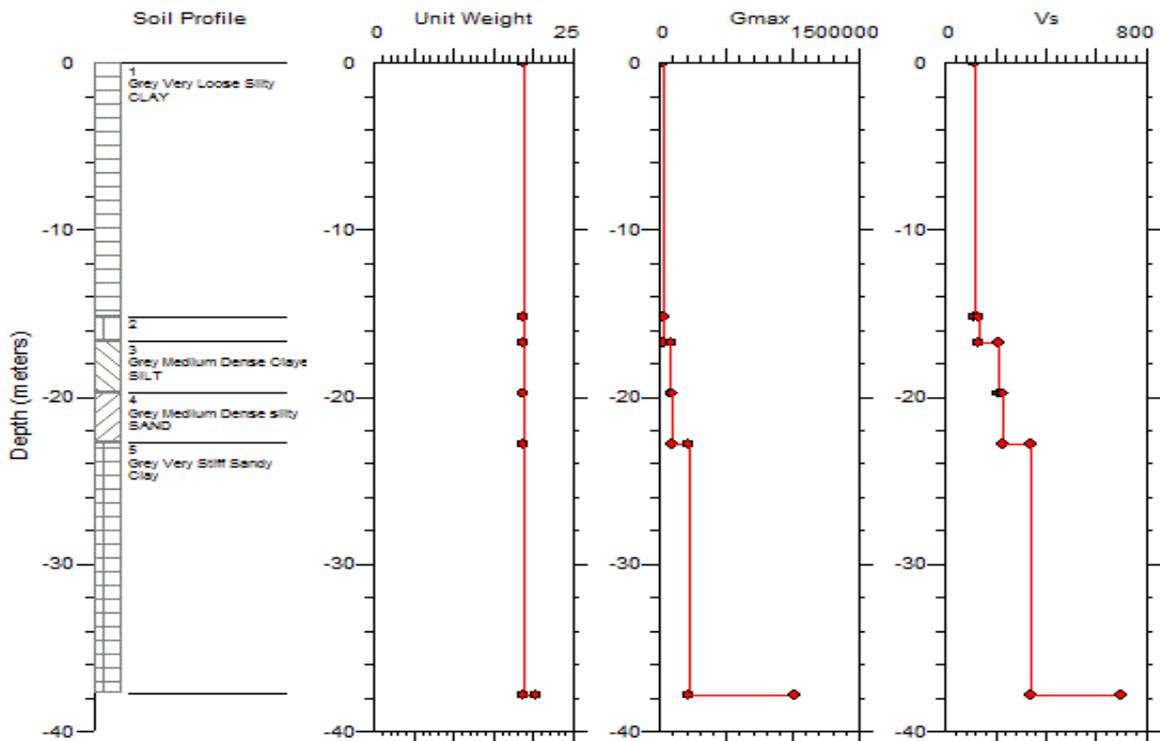
( a ) Site-1



( b ) Site-2



(c) Site-3



(d) Site-4

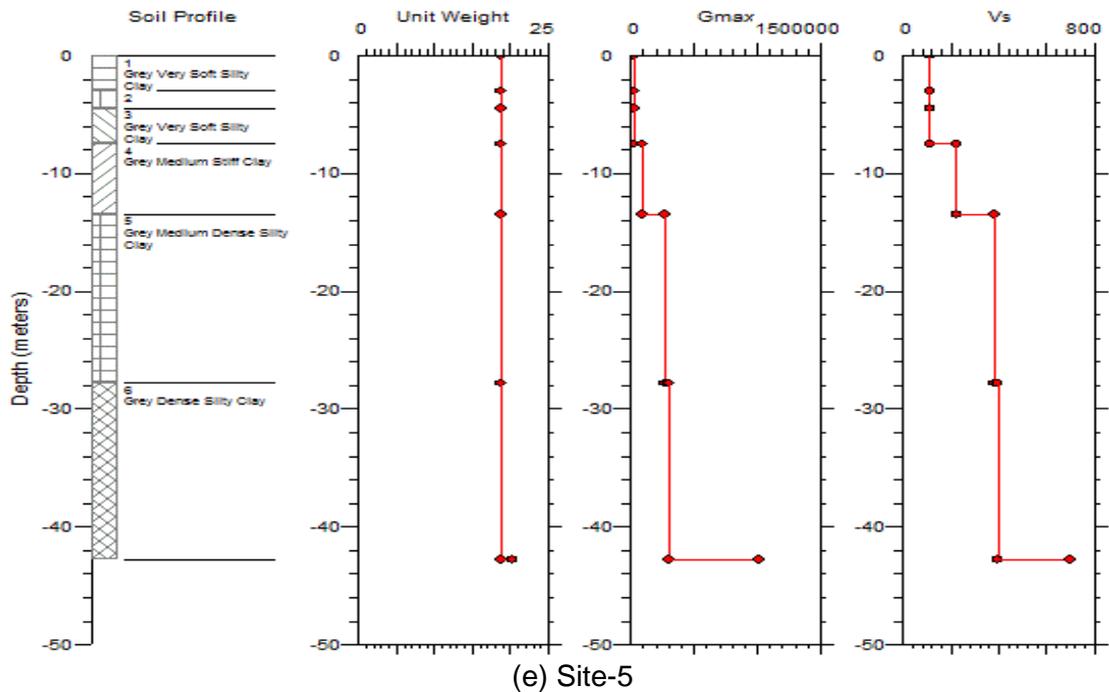
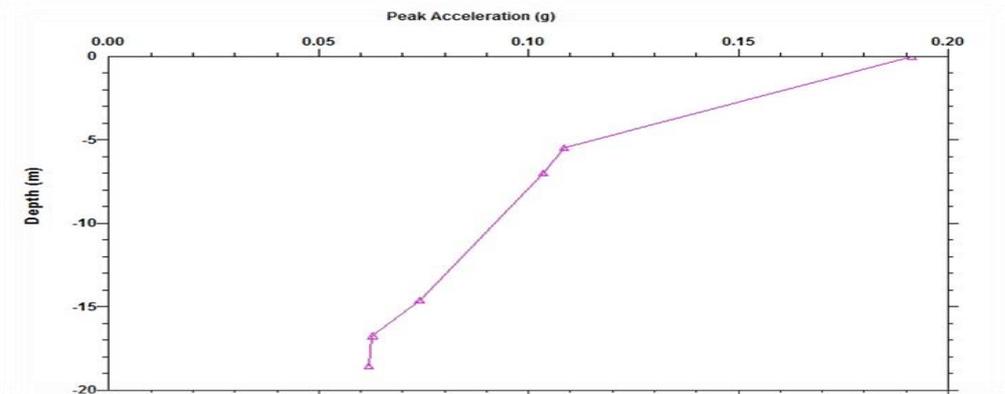


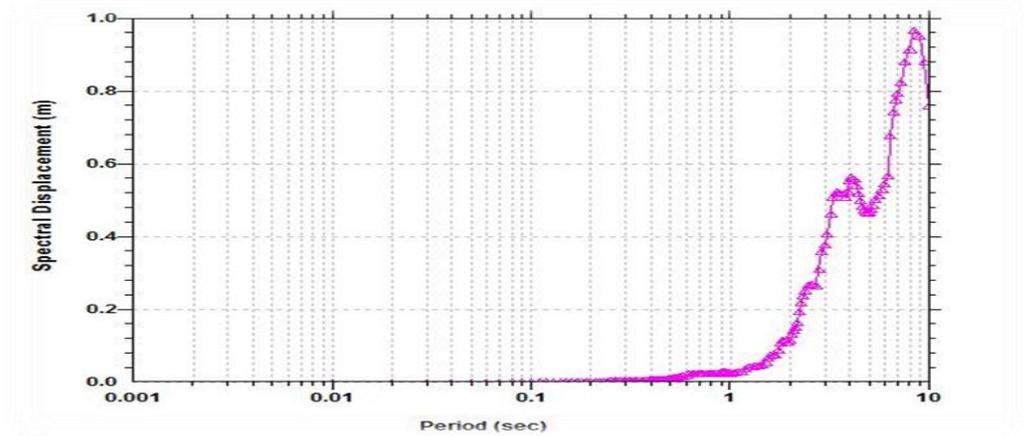
Figure 3: Soil profile of study locations depicting variation of Unit Weight ( $\text{KN/m}^3$ ),  $G_{\text{max}}$  ( $\text{KN/m}^2$ ), Velocity (m/s) with depth.

### 3.1 Peak Acceleration

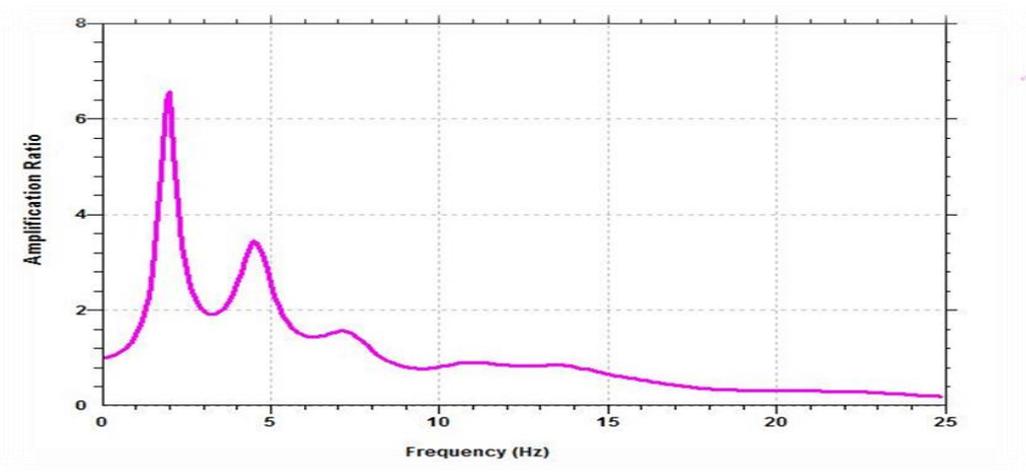
Peak ground acceleration (PGA) is equal to the maximum ground acceleration that occurred during earthquake shaking at a location. PGA is equal to the amplitude of the largest absolute acceleration recorded on an accelerogram at a site during a particular earthquake. Earthquake shaking generally occurs in all three directions. Therefore, PGA is often split into the horizontal and vertical components. Horizontal PGAs are generally larger than those in the vertical direction but this is not always true, especially close to large earthquakes. Peak acceleration is highest at the top surface but relatively less in hard stratum compared to loose stratum shown in Figure 3. Among all the locations the highest acceleration occurs in Site-2 at 22 seconds and at 31 seconds about 0.19g for the input motion acceleration of 0.051g at 21 seconds. Peak spectral velocity is almost constant at 1.1 m/s over all the five locations. Figure 3 represents the outputs from the several parameters.



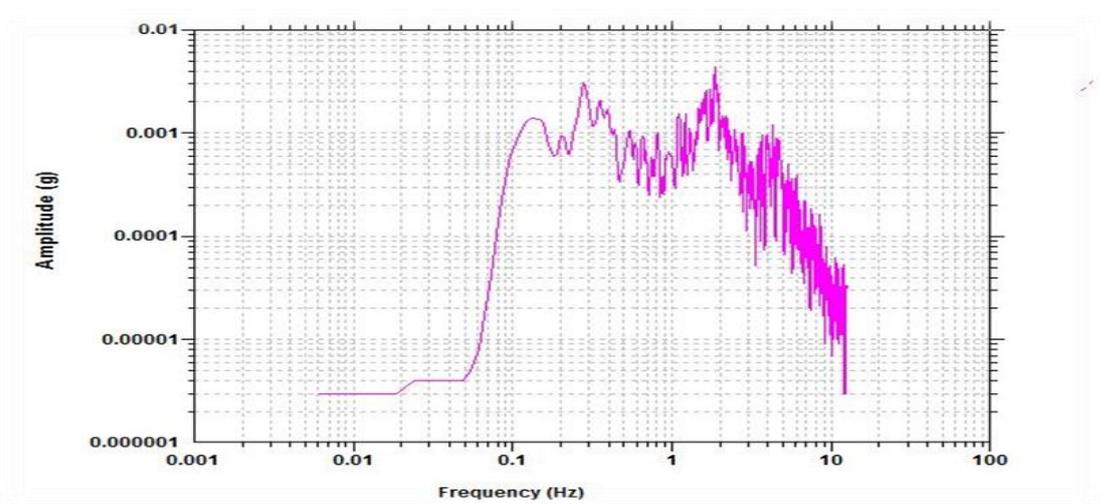
(a) Depth vs Peak Acceleration



(b) Spectral Displacement Vs Period



(c) Amplification Ratio Vs Frequency

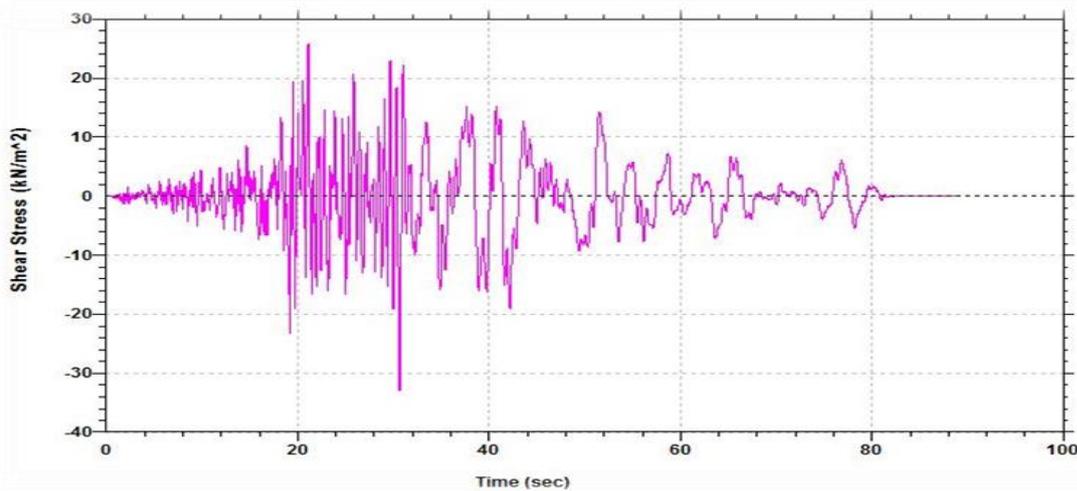


(d) Amplitude vs frequency

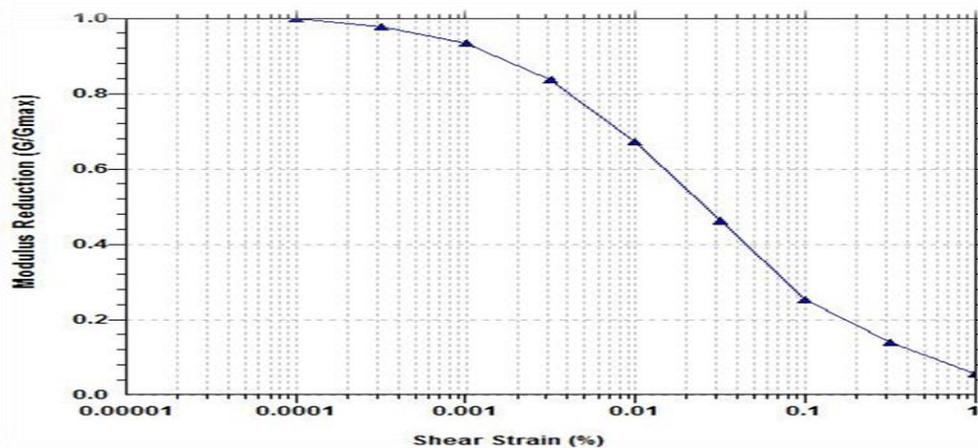
Figure 4: Analysis result of Site-

### 3.2 Shear Modulus

The strain compatible shear modulus curve, it can be concluded that within the loose stratum where both clay and sandy layers are present, shear modulus increases from sand to clay layers, where organic material was present shear modulus was low at that layers and when a hard clay layer is present between the soft clay layers an increase in shear modulus occurs in those layers. In case of relatively dense stratum range of the shear modulus was much lower with a gradual rise within the sandy layers. The range of shear modulus was relatively low within the sand layers in dense soil. In hard soils within the sand layers the range of shear strains are low but with the densification of layers the shear strain gradual increases. With the increase in depth of bedrock from ground surface higher shear stress was obtained in the adjacent layer of soil. The shear wave velocity was low within the hard stratum of soil and with the densification of soil the shear wave velocity increases. Shear stress was comparatively high in Site-2 locations shown in Figure 5.



(a) Shear Stress vs Time



(b) Modulus Reduction vs Shear Strain

Figure 5: Analysis result of Site-2

### 4. CONCLUSIONS

The ground response analysis by the program SHAKE 2000 was done on the five study locations in Banasree where the soil testing data of a particular site in that location was used to determine the characteristics of response analysis parameters. The study focused on locally available dry sand. The range of damping and shear modulus was relatively low within the sand layers in dense soils. Shear wave velocity was considerably low within the

hard stratum of soil and with the densification of soil the shear wave velocity increases. Shear stress and Peak spectral acceleration was comparatively high in Site-2 locations. Peak acceleration is highest at the top surface but relatively less in hard stratum compared to loose stratum. Peak spectral velocity was almost constant at 1.1 m/s over all the five locations. Gradual decrease in CSR occurs with depth in all of the locations but the variation of CSR with top and the underlying layers is less in hard stratum. For the case of simplicity, number of assumptions and simplified relations was used for the analysis. The results may vary with the change in the earthquake intensity and with the attenuation relations used in the analysis for the program. So, further research can be focused on attenuation relations for peak ground acceleration, peak ground velocity, acceleration spectrum and the velocity spectrum both in the horizontal and vertical direction.

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