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Site Response Analysis of the Sub-Soil of Ganakbari, Dhaka, Bangladesh

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Abstract: *The Subsurface soil condition of a site has great influence on earthquake hazard and shows a specific seismic response. To ensure site safety against probable earthquake hazard, proper and accurate analysis of soil response of that site is essential. . This paper deals with the site response analysis of sub soil of Ganakbari, Dhaka. SPT N values of nine boreholes were collected from Standard Penetration Test. Shear wave velocity was determined by using universal correlation of Shear wave velocity and Standard penetration Test values. The site response analysis was performed using DEEPSOIL (Hashash et al., 2011) V5.1. Equivalent linear analysis was performed and the response spectrum, the PGA, maximum strain, maximum stress ratio and the amplification factor was determined and represented in this paper.*

Keywords: *SPT N; Shear Wave Velocity; DEEPSOIL; PSA; PGA, Amplification Factor; Stress-Strain.*

I. Introduction

In the past several earthquakes like Mexico earthquake (1985), San Francisco earthquake (1989), Los Angeles earthquake (1995) have established the fact that, local site conditions has significant role in the amplification of ground motion. In case of Bangladesh he 1897 Great Indian Earthquake with a magnitude of 8.7, which is one of the strongest earthquake in the world killed 1542 and affected almost the whole of Bangladesh (Oldham, 1899). For this reason accurate and proper soil investigation of a site has become an essential concern to grasp precise knowledge about site response and as well as seismic hazard. A geotechnical investigation was carried out at Ganakbari, Savar, Dhaka by the detailed subsurface investigation program which includes nine (9) borings, execution of standard penetration test (SPT). Using the SPT N value, shear wave velocity was determined from empirical correlation equation and Equivalent linear site response analysis of the investigated area under a given earthquake motion was performed.

II. Information of Study Area

The study area comprises the northern extremity of Dhaka District and located within longitude **91° 35′ E** to **91° 17′ E** and latitude **23° 54′ N** to **23° 58′ N** (Figure 1). The Madhupur Clay soil of Ganakbari composed predominantly of silt size particles with small amount sand and clay. The layer of the cohesive clay soil was extended to the depth of 0-28 feet, further below the non-cohesive silty and sandy layers extended to the depth of about 28-65 feet.

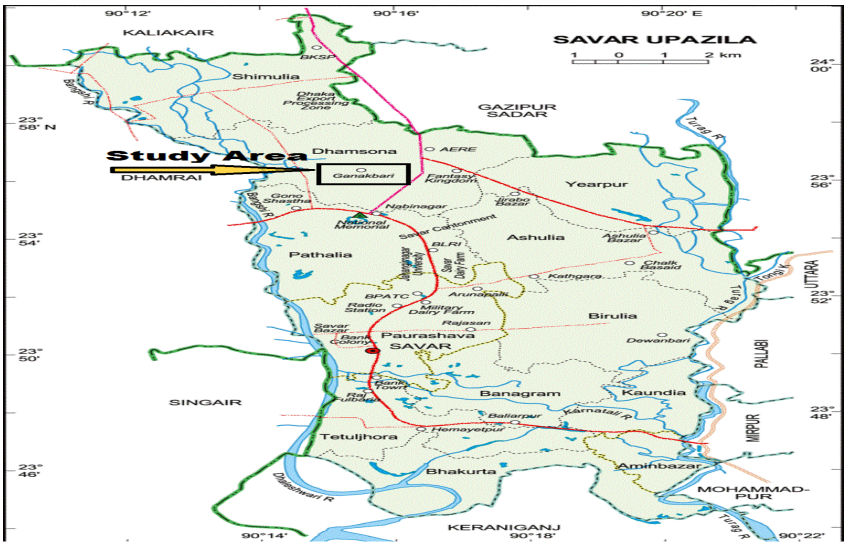


Figure 1 Location map of the study area (After Banglapedia)

III. Methodology

1. The standard penetration test (SPT) was performed during the advancement of a soil boring to obtain an approximate measure of the dynamic soil resistance and remains today as the most common in-situ test worldwide. The procedures for the SPT are detailed in ASTM 1974. To collect SPT data nine (9) borings, each extending 65 feet depth, have been executedin the studied area.The SPT value of study area ranges from 4 to 60 in the area and shows that the values are high at greater depth and low at the near surface.
2. The field SPT N values were corrected using the overburden correction by the following equation

$$C_N = 0.77 \log_{10} \frac{20}{P}$$

Where, **P**is the effective vertical overburden pressure in tons / sq ft at the elevation of the penetration test. The equation is valid for **P**≥ 0.25 ton / sq ft

3. Shear wave velocity V_S was calculated from the corrected SPT-N value using the following universal correlation equation (Marto et al, 2013)

$$V_S = 77.13\ N^{0.377}$$

The equation was selected because the values of corrected field SPT value, N_C has lays between 6 to 34 and from Figure 2we can see that the Percentage of VS Error (PVE) is less than 2% for the aforesaid SPT-N value.

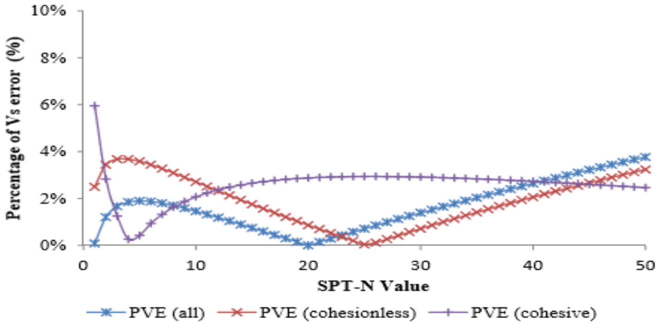


Figure2 Percentage of error (PVE) for all proposed correlation

4. Equivalent Linear Site amplification was performed using the DEEPSOIL (Hashash, Y.M.A. et al., 2011). The Kobe Earthquake in south-central Japan on January 17, 1995 (Mb-7.2) was selected as input motion for ground response analysis. All input motionswere converted to Site class A, to be imposed on the bottom of the bed rock. The time history of the input ground motion is shown in figure 3.

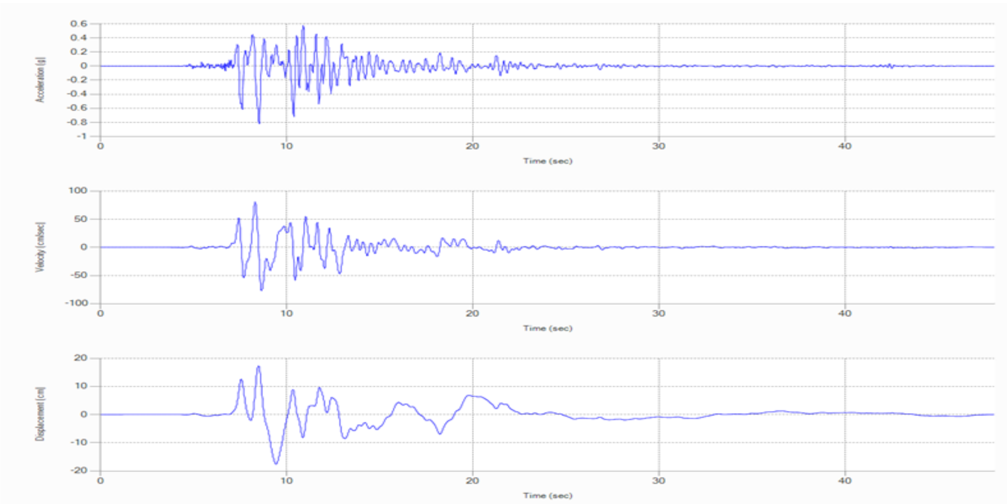


Figure3 Time history of Kobe earthquake

IV. Site Data

From the standard penetration Test of the selected locations,The N values with respect to depth in different boreholes are given in Table1. The corrected SPT N values and calculated shear wave velocities along with depth of nine locations are shown as graphical form in figure 4.

Table 1 SPT N values of different boreholes with respect to depth

Depth (ft)	SPT N Values								
	BH-1	BH-2	BH-3	BH-4	BH-5	BH-6	BH-7	BH-8	BH-9
5	7	6	4	4	6	4	6	7	4
10	8	9	6	5	9	10	8	8	11
15	9	9	9	11	11	11	12	10	12
20	9	12	9	11	10	9	11	9	11
25	11	9	11	12	10	8	12	10	11
30	23	19	17	12	12	16	17	14	15
35	26	33	23	28	24	30	30	29	30
40	41	46	29	33	33	35	38	37	37
45	46	43	44	47	33	46	41	40	41
50	51	44	46	48	36	55	36	38	47
55	53	42	49	51	41	54	44	37	47
60	57	41	46	56	46	50	58	40	55
65	56	43	59	60	49	51	56	45	54

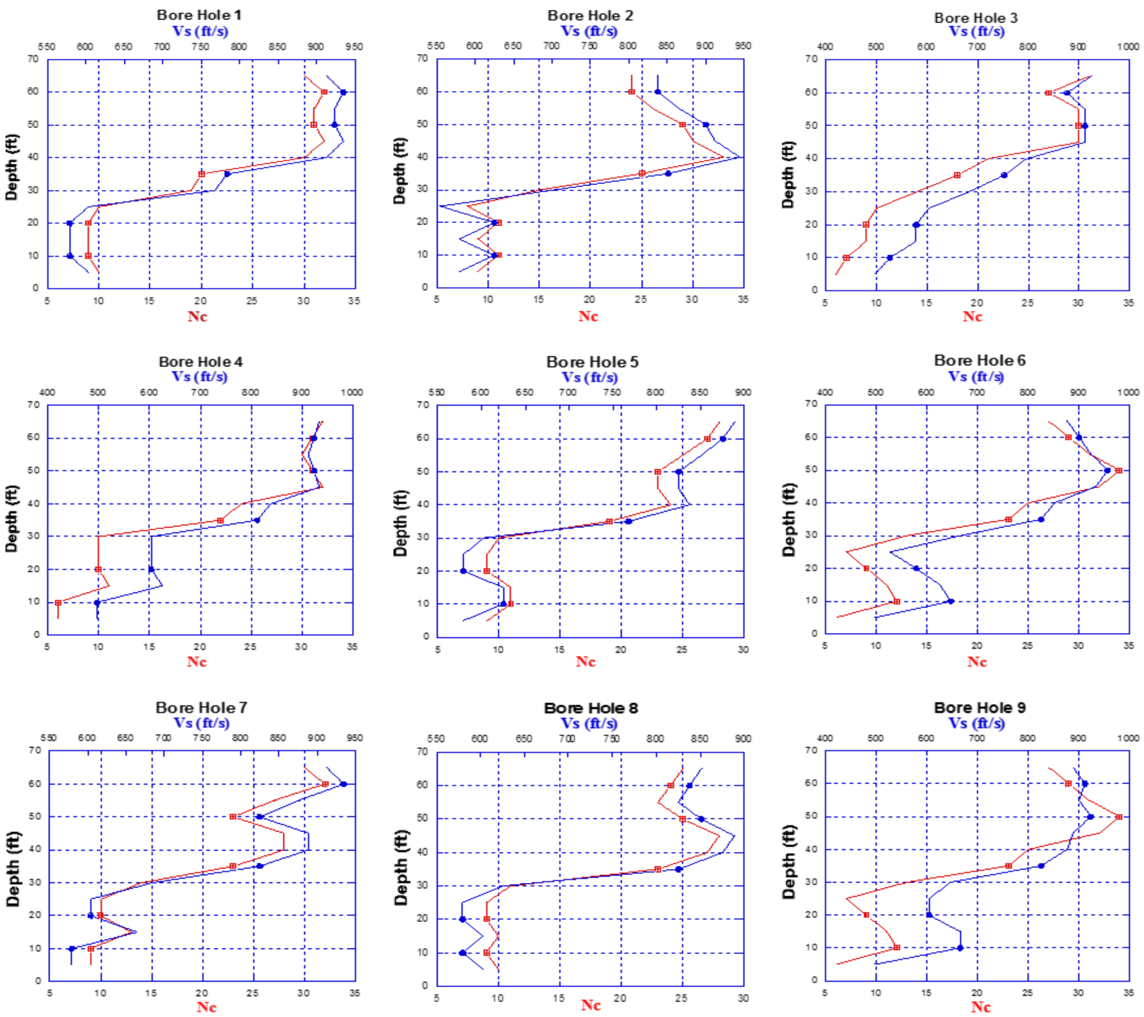


Figure 4 Corrected SPT NValue and Shear Wave Velocity with respect to depth

V. Ground Response Analysis Result

Response Spectrum

Response Spectrum of input motion and 9 bore holes are shown in figure 5. Among the 9 bore holes Bore hole-2 produces highest (3.107g) peak spectral acceleration (PSA) for this site and Bore hole-5 produces lowest (2.379g) peak spectral acceleration (PSA). It was observed that surface response of maximum locations were more than the response of Kobe.

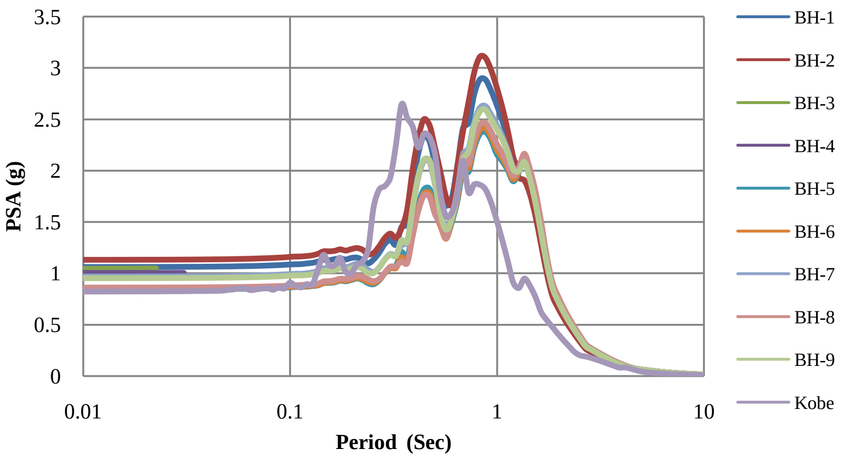


Figure 5 Response Spectrum of different locations

Maximum Peak Ground Acceleration (PGA)

Maximum Peak Ground Acceleration (PGA) at different depths of 9 locationsare shown in figure 6. PGA at surface and that at bedrock is obtained from the analysis. The peak ground acceleration values at surface are observed to be in the range of 0.843g (Bore Hole-5) to 1.130g (Bore Hole-2) and that of the bed rock were observed to vary from 0.688g (Bore Hole-2) to 0.812g (Bore Hole-4).

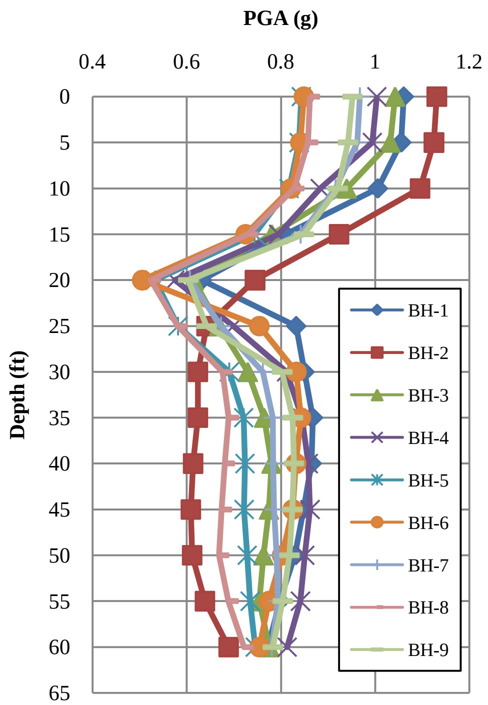
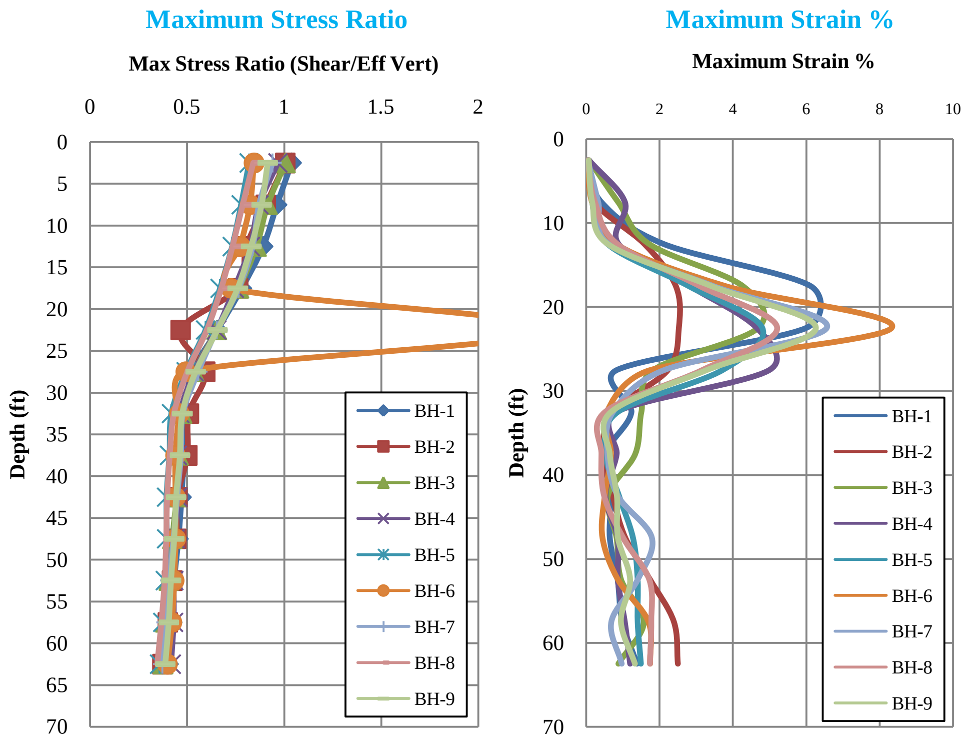


Figure 6 Peak Ground Acceleration of different locations

Maximum Stress ratio and Maximum Strain

The maximum stress ratios of different locations at different depths are shown in figure 7 (a). The stress ratio ranges from 0.345 (BH-8) to 2.421 (BH-6). The strains values of different locations at different depths are shown in figure7 (b). The strainvalues ranges from 0.031 (BH-8) to 8.324 (BH-6).



(a) (b)

Figure 7(a) Maximum Stress Ratio of different locations along with depth. (b) Maximum Strain of different locations along with depth.

Site Amplification Factor

Site amplification factors at sub surface layers are often used as one of the parameters for estimation of ground response. The amplification factor is the ratio of peak ground acceleration at surface to that of acceleration at hard rock.

Amplification Factor = PGA recorded at ground surface / PGA recorded at hard rock
Amplification Factor (For Bore hole-1) = 1.216
Amplification Factor (For Bore hole-2) = 1.642
Amplification Factor (For Bore hole-3) = 1.344
Amplification Factor (For Bore hole-4) = 1.235
Amplification Factor (For Bore hole-5) = 1.131
Amplification Factor (For Bore hole-6) = 1.124
Amplification Factor (For Bore hole-7) = 1.239
Amplification Factor (For Bore hole-8) = 1.194
Amplification Factor (For Bore hole-9) = 1.216

It has been identified that the maximum amplification factor is 1.642 (Bore Hole-2) and the minimum is 1.194 (Bore Hole-8). The amplification factors of different locations are shown as bar chart in figure 8.

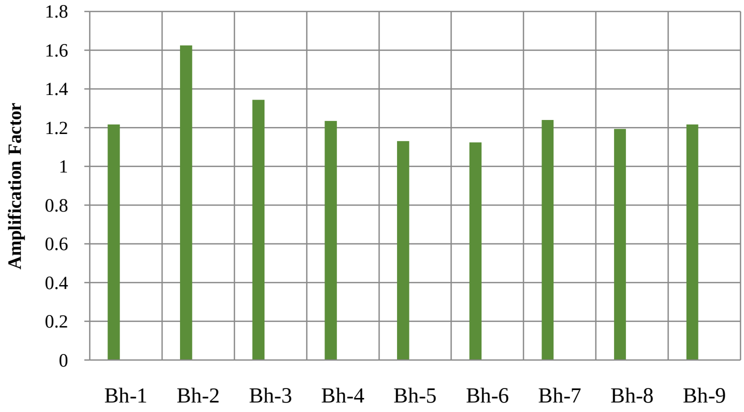


Figure 8 Amplification Factor of different locations

VI. Conclusion

Gankabari is a very much important place in Dhaka and familiar to the people because of rapid urbanization and huge population and also for The Export Processing Zone (EPZ) which is beside the area. So that ground response analysis was performed for the area. The surface soil response was more than the input motion in some part of the area. The PGA values were also very high. The amplification factor of all locations wasmore than one. So the surface soil is very much vulnerable for earthquake like Kobe. The perceived shaking will be violent and damage potential is heavy for this site. So that site response analysis of this area in deeper level is needed. Shear wave velocity should be measured using geophysical tests and using the values, site response analysis should be estimated.

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