GEOTECHNICAL INVESTIGATION REPORT

ADVANCE REPORT

for the

Proposed Philippine General Hospital Expansion

OETS, Taft Avenue, Ermita, Manila

as prepared for

PHILIPPINE GENERAL HOSPITAL
UNIVERSITY OF THE PHILIPPINES
Taft Avenue, Ermita, Manila

BY:

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GEOTECHNICAL INVESTIGATION ADVANCED REPORT

1.0 INTRODUCTION

The **Active Geoanchor, Inc. (AGI**) conducted subsurface soil investigation at the site of the **PROPOSED PHILIPPINE GENERAL HOSPITAL BUILDING B** located in OETS, Taft Avenue, Ermita, Manila. The objective of the investigation is to determine the nature of subsurface deposits and analyze the strength and deformation characteristics of the subsoil to allow selection of an appropriate foundation scheme to support the proposed structure. This report is an advanced copy requested by the Client to be used for schematic design reference only and for planning of construction methodology. The final design of foundation shall be based on the final evaluation report. The information provided herein is based on published references regarding seismology and geology in the vicinity of the site and the field soil test results.

2.0 SITE DESCRIPTION

Project description is still not available from the client at the time this factual report was being written by the undersigned.

3.0 SCOPE OF WORK

Three (3) boreholes were advanced in the site by using Concore drilling machines. The length of boreholes are 42.0m, 30.0m, and 43.50m for BH-1, BH-2, and BH-3 respectively. Standard Penetration Test (SPT) was conducted by obtaining disturbed soil samples taken from the borehole with the use of a 2.0-inch outside diameter and 1-3/8-inch inside diameter split spoon sampler driven with the help of 140-lb hammer free-falling from a height of 30 inches. In between sampling sections, the hole was advanced using the rotary wash method. The obtained N values represent the number of blows required to drive the sampler to at least 300 mm of penetration distance. SPT was also conducted in between coring layers where the recovery is very poor. After the sample and tube are brought to the surface and separated, the sample is removed from the tube and properly preserved and sealed using a moisture tight plastic bag for further testing in the laboratory. For reference purposes, **Tables 1 and 2** show the correlation between SPT N-values and shear strength parameters for cohesionless and cohesive soils respectively. Site drilling works were conducted from October 06 to October 13, 2018.

Source: Kulhawy and Maine, 1990

SPT N-Value	Consistency	Unit Wt. (kN/m)	Relative Density, Dr (%)	Angle of Internal Friction, ø (Peck)	Angle of Internal Friction, ø (Meyerhof)
0 – 4	Very Loose	16	0 – 20	< 28.5	< 30.0
4 – 10	Loose	17	20 – 40	28.5 – 30	30 - 35
10 – 30	M. Dense	18	40 – 60	30 – 36	35 - 40
30 – 50	Dense	19	60 – 80	36 - 41.0	40 - 45
> 50	Very Dense	20	80 – 100	> 41	> 45

Table 1. Correlations Between SPT Results and Friction Angle of Cohesionless Soils

Source: Bowles, 1988

SPT N-Value	Consistency	Unit Wt. (kN/m)	Undrained Strength, s_u (kPa)
0 – 2	Very Soft	11 – 13	< 12
3 – 5	Soft	14 – 16	12 - 24
6 – 9	M. Stiff	16 – 17	24 - 48
10 – 16	Stiff	17 – 18	48 - 96
17 – 30	Very Stiff	18 – 19	96 - 192
> 30	Hard	19 -20	< 192

Table 2. Correlations Bet. SPT N-Values and Undrained Shear Strength of Cohesive Soils

4.0 FIELD TEST

The depth of boreholes extended deeper than the originally intended depth of 30 meters in order to reach a hard strata. The recorded SPT N-values may be correlated to determine the soil strength parameters. Certain correction factors are used to account for Hammer Efficiency, Sampler Type, Rod Diameter, and Rod Length. The corrected SPT N-value is then called N60. The N60 values are given in **Figure 1**. These values may be used in correlating the strength parameters given in Table 1 and Table 2. The average N60 value across three boreholes generally increases with depth with an average of 20.

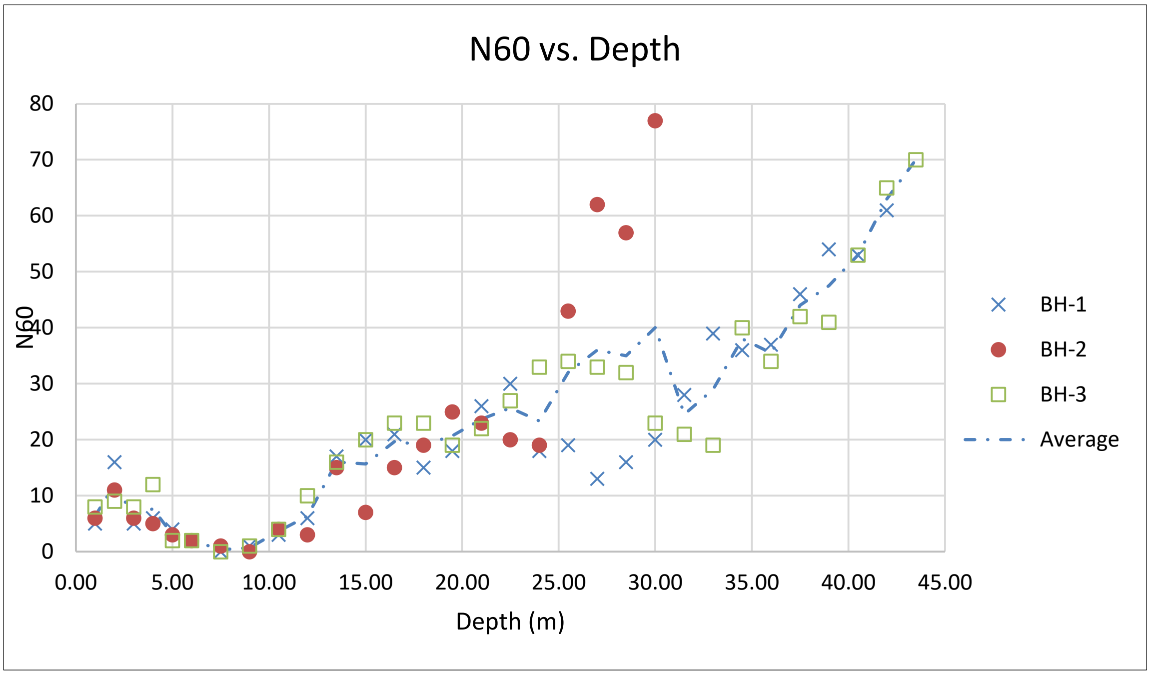

Figure 1. N60 vs. Depth Chart

5.0 WATER LEVEL OBSERVATION

The groundwater level was recorded for each borehole as shown in **Table 3**. This measurement may be affected by many factors including weather, seasonal tide, and through the introduction of drilling water. However, the consistent groundwater depth recorded and the proximity of the site to nearby Manila Bay suggests that the permanent groundwater elevation may be present at a shallow depth.

Borehole No.	Groundwater Elevation from EGL (m)
BH-1	3.35
BH-2	1.20
BH-3	2.20

Table 3. Groundwater Elevation

6.0 FOUNDATION DESIGN RECOMMENDATIONS

The underlying soils are composed mostly of silty clay and sandy clay with traces of gravel and seashells. The top soil up to 12.00 meters from the EGL is very weak with an average N60 value of 3. From this information, we infer that a shallow foundation system for most mid-rise and high-rise buildings will not be viable.

Meanwhile, the hard clay is encountered between 27 to 40 meters below the EGL. The N60 of ≥30 is attained at 39.0m for BH-1, 27.0m for BH-2, and 40.0m for BH-3. At this zone between 27 to 40 meters below the EGL, it is highly likely that refusal shall be attained by most pile driving operations. Therefore, this advanced report shall focus on pile load capacities that will possibly be attained at these depths under dynamic or static driving techniques. In choosing the pile driving technique, surrounding structures should be considered and vibration should be minimized. Splicing of piles should be avoided; otherwise, splicing shall not be done on more than one location.

The results of the effective stress method of analysis using both end bearing resistance at the pile tip and skin friction are given in **Table 4** using a safety factor equivalent to 3.0. To optimize the capacity of piles and avoid uniform and differential settlement, it is required for piles be driven to practical refusal level. Probe piles may be installed to confirm the achievable penetrations and to exactly determine the refusal level. Preferrably, a two-phase pile testing program is employed wherein the first phase involves verifying the calculated pile capacities, and secondly, verifying the quality of the installed piles. The static or instrumented dynamic tests is suggested to be conducted early on proble piles so that any necessary changes or adjustments can be made on the rest of the piles to avoid over or underdesign.

SAFE PILE CAPACITY PER BOREHOLE (KN) IN COMPRESSION			
PILE SIZE	**BH-1 39.0M LENGTH**	**BH-2 27.0M LENGTH**	**BH-3 40.0M LENGTH**
0.30m x 0.30m	598	376	679
0.35m x 0.35m	711	454	805
0.40m x 0.40m	827	537	935
0.45m x 0.45m	947	624	1068
0.50m x 0.50m	1071	715	1205

Figure 4a. Safe Pile Capacity under Compression

SAFE PILE CAPACITY PER BOREHOLE (KN) IN TENSION			
PILE SIZE	**BH-1 39.0M LENGTH**	**BH-2 27.0M LENGTH**	**BH-3 40.0M LENGTH**
0.30m x 0.30m	532	297	612

0.35m x 0.35m	620	347	714
0.40m x 0.40m	709	397	816
0.45m x 0.45m	798	446	919
0.50m x 0.50m	886	496	1021

Figure 4b. Safe Pile Capacity under Tension

The calculation of soil spring coefficient or lateral subgrade reaction (kh) was based on the paper of Uchida, A. and Tokimatsu, K., Comparison of current Japanese Design Specifications for Pile Foundations in Liquefiable and Laterally Spreading Ground, Seismic Performance and Simulation of Pile Foundations in Liquefied and Laterally Spreading Ground. ASCE Geotechnical Special Publication No. 145.

The soil spring coefficient is given by:

$$\boldsymbol{k_h = 56000 N_{60} D^{-3/4}}$$

where: k_h *= soil spring coefficient,*
N_{60} *= SPT N-value for the soil layer, and*
D *= pile diameter in cm.*

The nearest known active fault based on data from the Philippine Institute of Volcanology and Seismology (PHIVOLCS) is the West Valley Fault (WVF) located about 9.0 kilometers east of the subject site. The WVF, based on historical information, is expected to have the capacity to produce a magnitude 7.0 earthquake or more. The subject site is within *Seismic Zone 4* with *Seismic Source Type A* as defined in the National Structural Code of the Philippines 2015 edition (NSCP). Soil type S_D is applicable for seismic load analysis. The Near-Source Factor values of Na = 1.1 and Nv = 1.3 may be adopted.

7.0 EXCAVATION AND SLOPE PROTECTION

Any excavation work must make use of a suitable slope protection system to protect the adjacent roads and properties from damage due any lateral soil movement along the excavation face. In this case, since the water table is considerably shallow, a water tight excavation system is recommended with the sheet pile system being one of the more economical choices. If sheet piles are used, it must consider the upward transition of water. The slope protection design is beyond the scope of this evaluation and is usually delegated to the excavation contractor.

8.0 OTHER COMMENTS

The analysis and design of foundation for the proposed structure are beyond the scope of this report. The foregoing analyses, conclusions and recommendations were based on the subsoil investigation data from three (3) boreholes.

Underlying soil conditions may vary from borehole location to another and thus, may not be taken by-fact as the entire site's actual subsoil condition. Should any difference in the subsoil condition be observed during excavation or construction works, the undersigned should be informed immediately by the Project Manager so that necessary actions can be made.

Prepared by:
October 22, 2018

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