
GEOTECHNICAL SITE INVESTIGATION OF FEDERAL UNIVERSITY DUTSIN-MA KATSINA STATE

By

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ABSTRACT

This study is a geotechnical investigation of the Permanent site of Federal University of Technology, Dutsin-Ma located in Katsina State. The soil sample was obtained from 10 trial pits and 10 SPT boreholes at 0.6, 2.1 and 3.6 m depths and all laboratory tests were conducted in accordance with BS 1377 (1990). The study is aimed at investigating the subsoil conditions based on geotechnical site exploration methodologies of soil samples and site data obtainment in order to take precise engineering decisions on the type of foundations suitable for the proposed structures, to determine the best depth of foundation embedment and best locations for different utilities. Plasticity indices values indicated presence of high content of fines and values of cohesion and angle of internal friction show that the shearing resistance and bearing capacity of soils will be relatively low. Allowable bearing capacity values in the range of 80 – 150 kN/m² were found adequate for use in the study area with embedment depth between 1 – 3 m and raft or deep footings was recommended for story buildings in this study area.

KEYWORDS: Geotechnics, Site investigation, Subsoil exploration, Atterberg limits, Shear strength parameters, bearing capacity

INTRODUCTION

The Federal University of Technology Dutsin-Ma, Katsina state, was one of the nine (9) federal universities approved by the Federal Government on 22nd December, 2010. The University is expected to take off at the Temporary site located along Katsina-Kankara highway in Dutsin-ma during the 2011/2012 session. The permanent site which is about twelve minutes' drive from the temporary site along the same road covers a land area of about 1120.29 ha. This site is expected to accommodate the University structures and facilities which are intended to grow into full maturity over a period of 10 to 15 years. As a pre-requisite for the development of the site, a physical

development master plan for the site is required which include the topographical and boundary survey of the site, geotechnical and groundwater profiling, environmental impact assessment and development of the master plan of the site.

This study is based on the geotechnical investigation of the site. Standard penetration test (SPT) was conducted in the study area (Permanent site of Federal University, Dutsin-Ma located in Katsina State) to obtain direct field data and soil samples at various depths for laboratory tests. This aimed at investigating the subsoil conditions based on geotechnical site exploration methodologies of soil samples and site data obtainment in order to take

precise engineering decisions on the type of foundations suitable for the proposed structures, to determine the best depth of foundation embedment and best locations for different utilities.

Site investigation is the process by which geological, geotechnical, and other relevant information which might affect the construction or performance of a civil engineering or building project is acquired. Soil and rock are created by many processes out of a wide variety of materials. Because deposition is irregular, soils and rocks are notoriously variable, and often have properties which are undesirable from the point of view of a proposed structure. Unfortunately, the decision to develop a particular site cannot often be made on the basis of its complete suitability from the engineering viewpoint; geotechnical problems therefore occur and require geotechnical parameters for their solution (Clayton et al., 2004).

According to BS 5930 (1981), site investigation determine all the information relevant to site usage, including meteorological, hydrological and environmental information. Ground investigation only determine the ground and groundwater conditions at and around the site; this is normally achieved by boring and drilling exploratory holes, and carrying out soil and rock testing. In common engineering parlance, however, the terms site investigation and ground investigation are used interchangeably. Site investigation should be an integral part of the construction process. Unfortunately it is often seen as a necessary evil. This is an unfortunate by-product of the way in which site investigation is often carried out, and it can hardly be surprising that if no effort is put into targeting the investigation to precise issues, then little of value emerges (Salahudeen, Ijimdiya, Eberemu, & Osinubi, 2016a).

MATERIALS AND METHODS

Materials

Soil: The soil sample used for this study was obtained by both trial pit and SPT methods from the study area. Trial pit sampling was conducted using the method of disturbed sampling. The samples were taken from 10 trial pits and 10 SPT boreholes at 0.6, 2.1 and 3.6 m depths.

Index properties: Laboratory tests were performed to determine the index properties of the soil samples. All laboratory tests were conducted in accordance with BS 1377 (1990).

Strength tests: Direct shear test was performed to determine the strength properties (cohesion and angle of internal friction) of the soil samples. These parameters were used to determine the allowable bearing capacities for square footings based on safety factor of 3 using the Terzaghi's method.

Standard penetration test: The standard penetration test (SPT) consists of driving a standard split barrel sampler a distance of 460 mm into the soil at the bottom of the boring, counting the number of blows to drive the sampler the last two 150 mm distances (to obtain the N number) using a 63.5 kg driving hammer falling free from a height of 760 mm (Bowles, 1996). The boring log shows refusal if 50 blows are required for any 150 mm penetration, 100 blows are obtained for a 300 mm penetration or 10 successive drops of the hammer produce no advance in penetration.

The SPT was conducted in accordance with ASTM D-1586-99 (2001). The standard split tube sampler has an inside diameter of 34.93 mm and an outside diameter of 50.8 mm. The numbers of blows required for a spoon penetration of three 150 mm intervals are recorded. The number of blows required for the last two intervals are added to give the standard penetration number, N, at that depth. This number is generally referred to as the N-value which

was a correction to an average energy ratio of 60% (N_{60}) because of the greater confinement caused by the increasing overburden pressure Bezgin (2010) and Al-Jabban (2013). The correction factors used in this study are those proposed by Das (2011) to standardize the field penetration number as a function of the input driving energy and its dissipation around the sampler into the surrounding soil. The sampler is then withdrawn, and the shoe and coupling are removed. Finally, the soil sample recovered from the tube is placed in polythene bag and transported to the soil laboratory of the Department of Civil Engineering, Ahmadu Bello University (ABU) Zaria. Samples are generally taken at intervals of 1.5 m.

LOCATION AND GEOLOGY OF THE STUDY AREA

The study area, which is the permanent site of the Federal University, Dutsin-Ma is about 25Km south of the temporary site along Katsina-Kankara highway. The land, which is about 1120.29 hectares, is used as grazing reserve. It is bordered by the Katsina-Kankara highway on the east and by footpath on the north and south ends while to the west it shares

border with land used for farming by the villagers. The land is generally flat in topography with rock outcrops dotted around the centre and to the north of the area. The geology of the soils in the study area is generally crystalline from the basement complex (Ola, 1983).

RESULTS AND DISCUSSION

Sieve Analysis

Particle size distribution curves of soils obtained from ten boreholes at three different depths of 0.6, 2.1 and 3.6 m respectively are shown in Figures 2 – 4. Generally, the percentage fines decreased with increase in boring depth and the curves are closely packed indicating homogeneity. This could be as a result of overburden that has subjected the soil below to compression overtime thereby forming larger particles with stronger bonds. With increase in boring depth, the quantity of free silt and clay progressively reduced and coarser materials were formed. This observation is in agreement with Salahudeen and Akijje (2014) Salahudeen et al. (2014), Sadeeq et al. (2014; 2015) and Sadeeq et al. (2016).

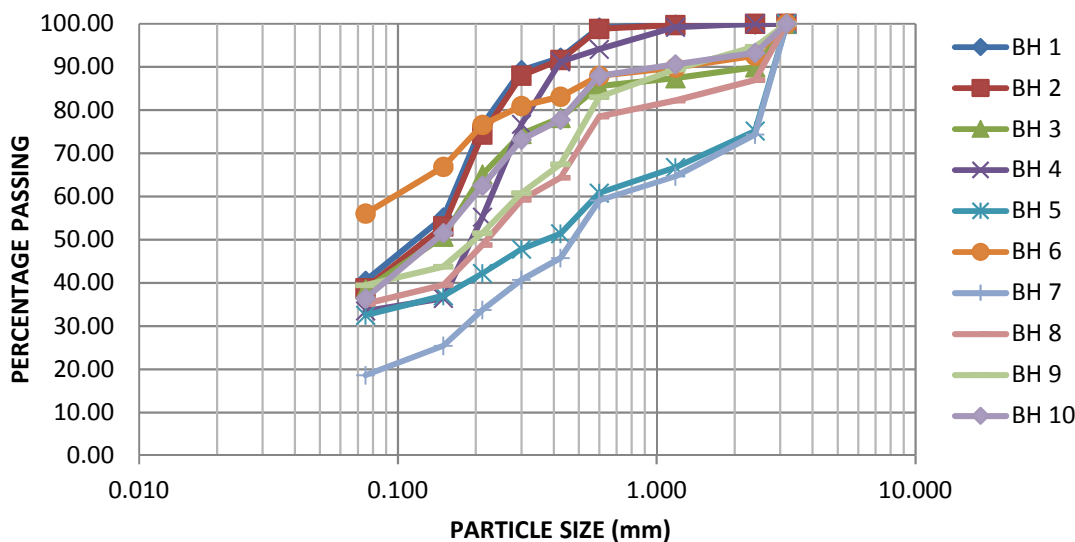


Figure 1: Particle size distribution curve for soil at 0.6 m boring depth

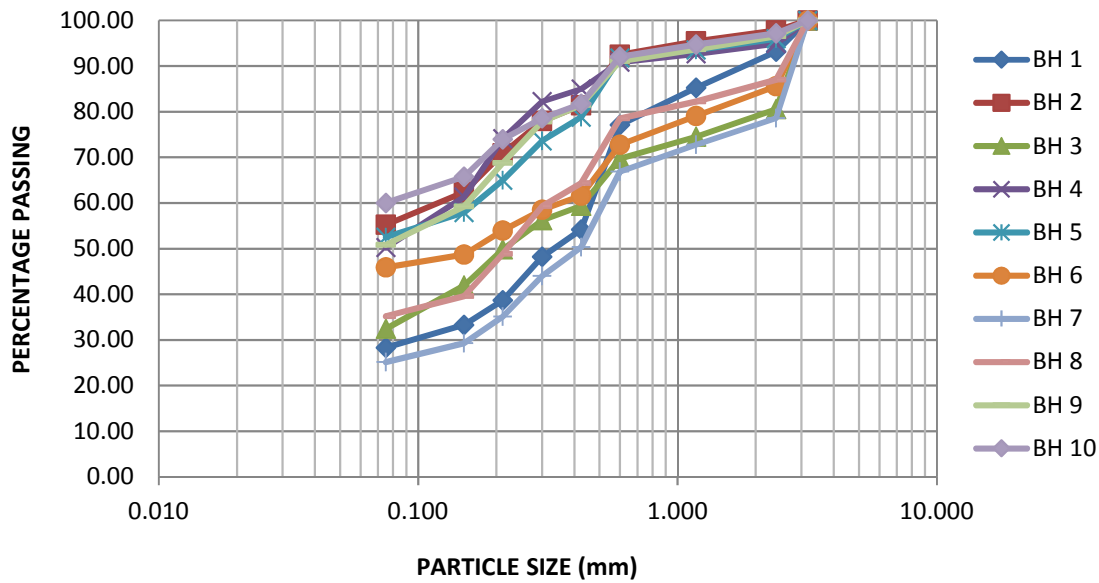


Figure 2: Particle size distribution curve for soil at 2.1 m boring depth

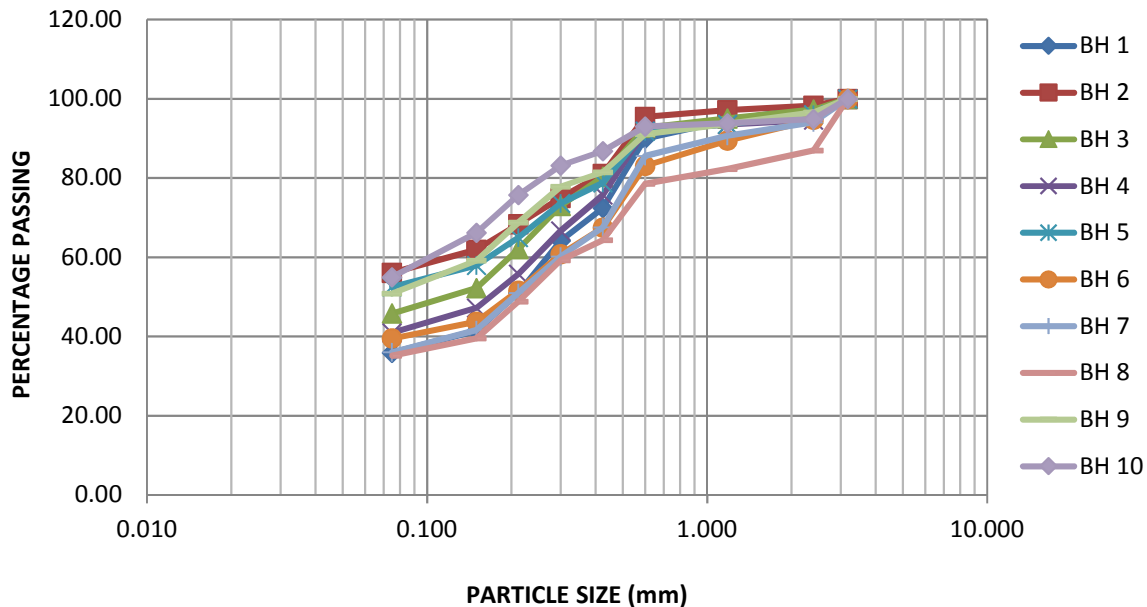


Figure 3: Particle size distribution curve for soil at 3.6 m boring depth

Atterberg Limits

The variations of liquid limit, plastic limit and plasticity indices are shown in Figures 5 - 7 respectively. It was observed that the liquid limit generally increased with increase in boring depth and the plasticity indices values are on the high side. Soils with high values of plasticity indices are normally associated with high content of fines which are in turn

associable with high compressibility, consolidation settlement and sometimes, low values of bearing capacity. Structural footings that are to be founded on such soils should be carefully designed taking into serious consideration, the ground water profile, compressibility characteristics and possible bearing capacity failure.

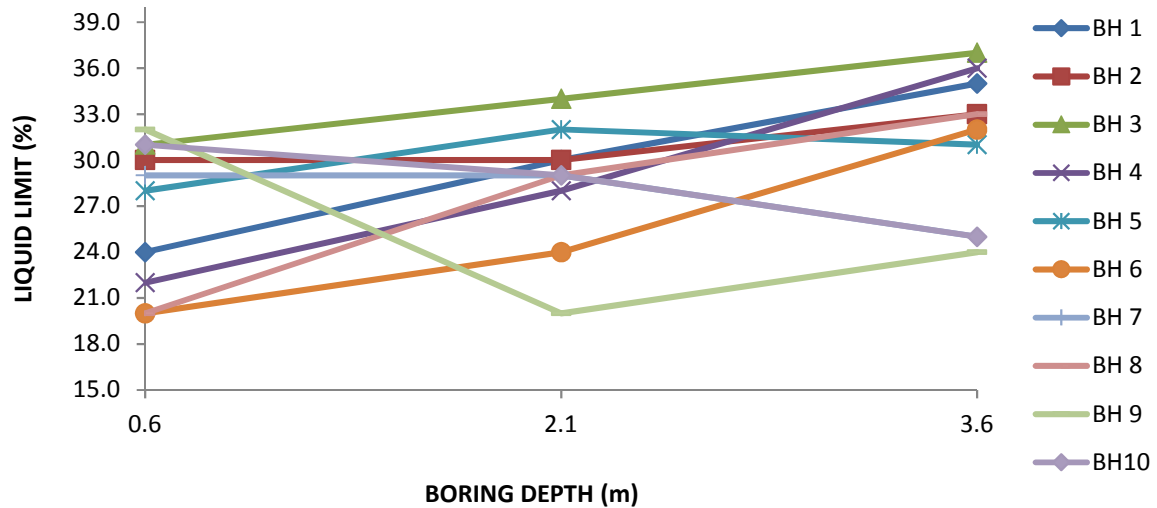


Figure 4: Variation of liquid limit with boring depth

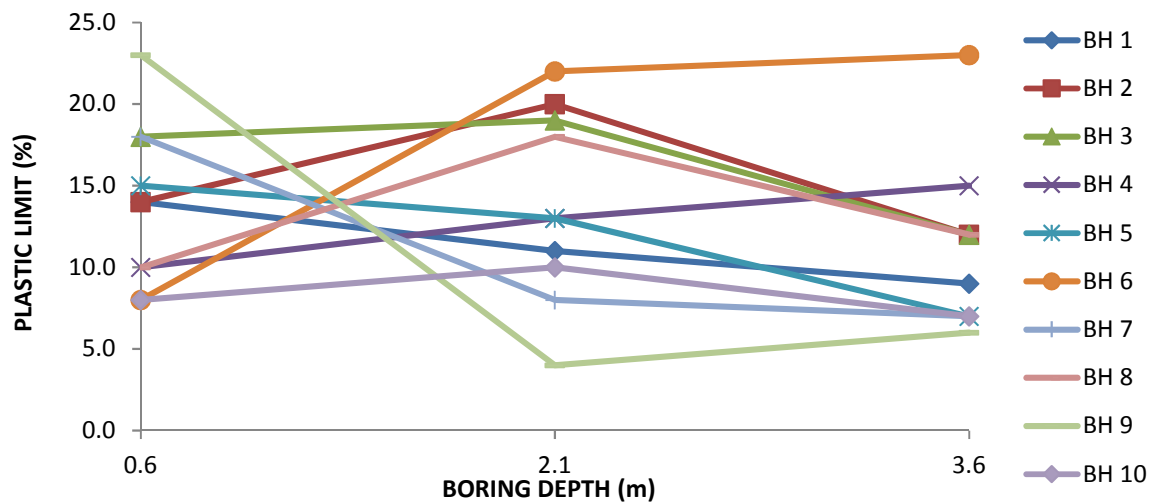


Figure 5: Variation of plastic limit with boring depth

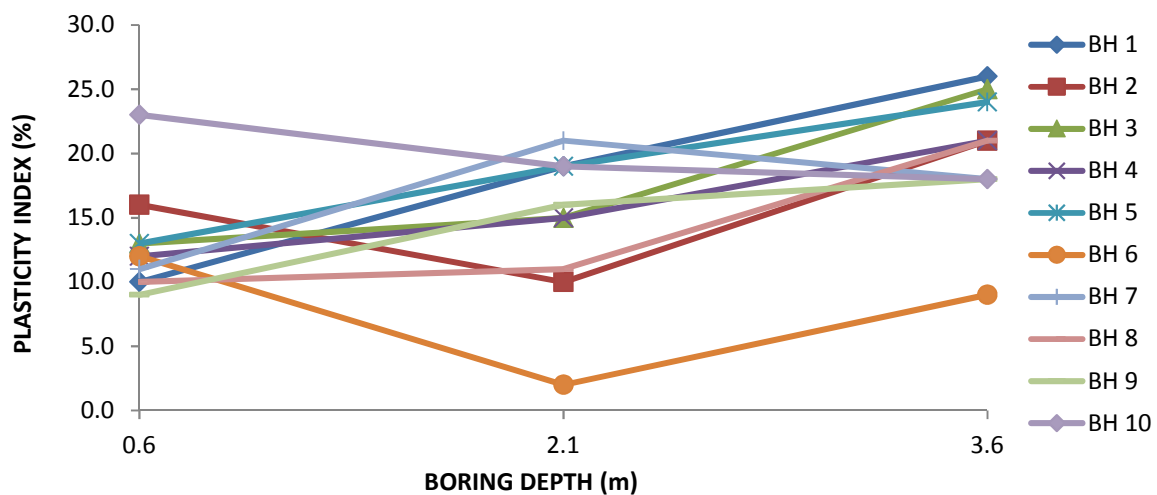


Figure 6: Variation of plasticity index with boring depth

SHEAR STRENGTH PARAMETERS

Cohesion and angle of internal friction

Variations of the cohesion and angle of internal friction with boring depth are shown in Figures 8 and 9. The shear strength of a soil mass is the internal resistance per unit area that the soil mass can offer to resist failure along any plane inside it. When this resistance is exceeded failure occurs. Shear strength within a soil matrix is due to cohesive and frictional forces between adjacent particles (Adunoye, 2014). Therefore, cohesion and angle of internal

friction are the most important parameters of soil strength. Angle of internal friction could be described as a measure of the ability of a unit of soil to withstand a shear stress. Cohesion, which is the mutual attraction among the soil particles without the application of any external force, is used to measure the shearing resistance and bearing capacity of soils. The two parameters are found in this study to be relatively low. This is an indication that the bearing capacity of the soils will be averagely low.

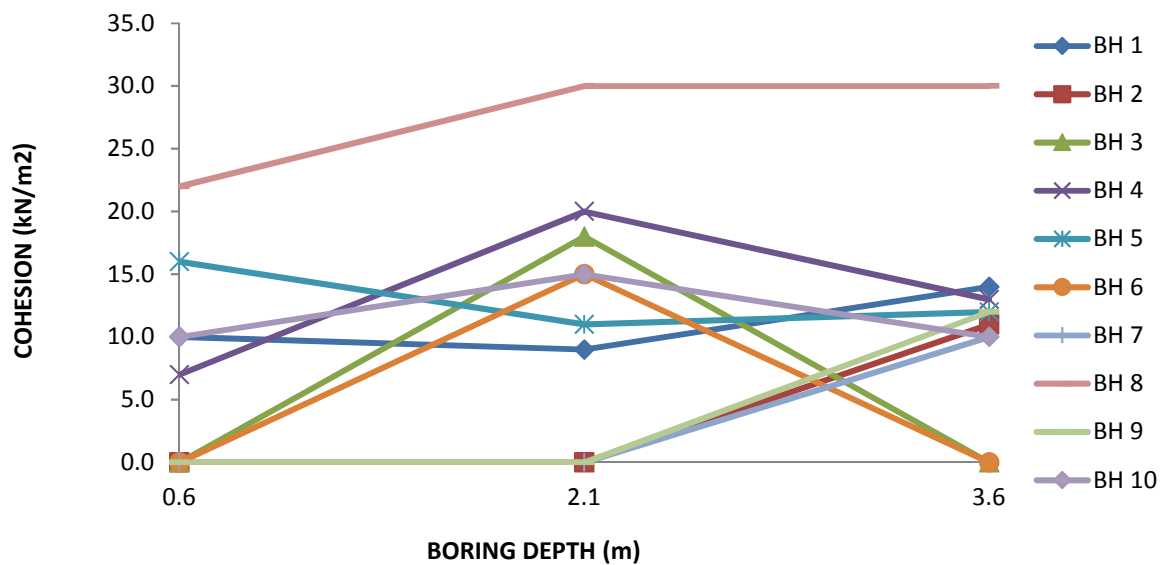


Figure 7: Variation of cohesion with boring depth

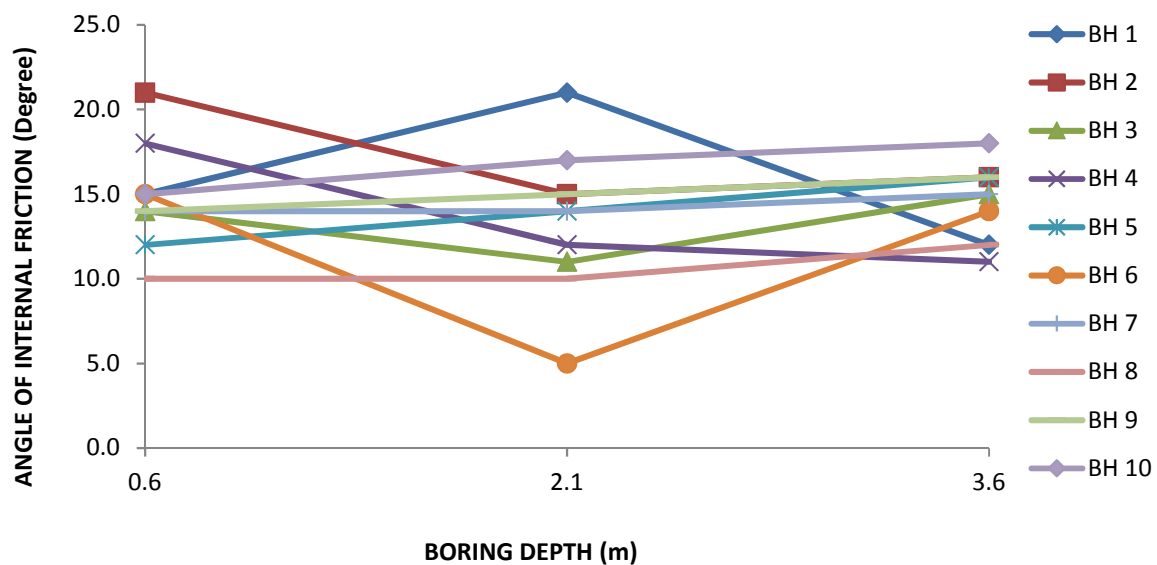


Figure 8: Variation of angle of internal friction with boring depth

Allowable Bearing Capacity

Based on field test results, the bearing capacities of shallow foundations are determined in terms of the allowable bearing pressures while those of deep foundations are given in terms of the ultimate bearing capacity. This is because settlement (service limit) controls the allowable bearing capacity in design of shallow foundations while the ultimate limit (shear failure) usually controls the allowable bearing capacity in deep foundations design (Salahudeen *et al.*, 2016b).

For the allowable bearing pressures of shallow foundations, footing plan dimensions of 2 m by 2 m by 0.5 m for length, breadth and depth, respectively were assumed with safety factor of 3. Variation of allowable bearing capacity with boring depth is shown in Figures 10. Based on the method proposed by Meyerhof (1974) allowable bearing capacity values in the range of 80 – 150 kN/m² were proposed for use in the study area within the depths considered.

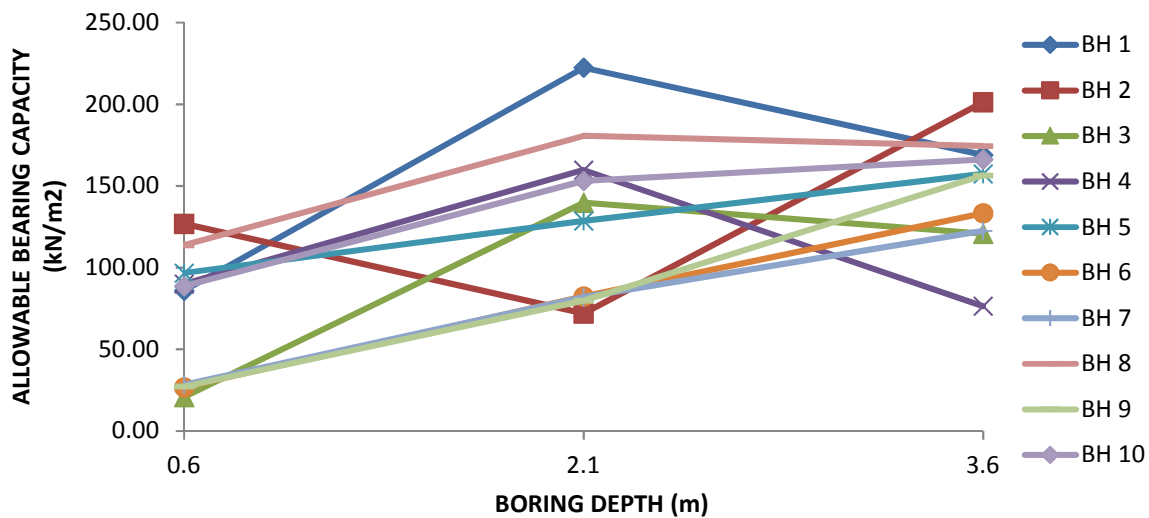


Figure 9: Variation of allowable bearing capacity with boring depth

CONCLUSION

Based on the results of this investigation, the following conclusions were made:

1. It was observed that the plasticity indices values are high indicating high content of fines, high compressibility and low bearing capacity.
2. Values of cohesion and angle of internal friction show that the shearing resistance and bearing capacity of soils will be relatively low.
3. Allowable bearing capacity values in the range of 80 – 150 kN/m² were found adequate for use in the study area with embedment depth between 1 – 3 m.

RECOMMENDATIONS

Based on the results of this study, we recommend that:

1. The structural footings that are to be founded on soils of this study area should be carefully designed taking into serious consideration, the ground water profile, compressibility characteristics and possible bearing capacity failure.
2. Raft or deep footings should be considered for story buildings in this study area.

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