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Case Study of Site Investigation for a Proposed Construction of Double-Storey Houses in Sibaya Portion

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Abstract: The heterogeneous nature of soils causes them to behave differently under different environmental conditions. If only the soil was a completely homogenous and isotropic material, structures built on them would not suffer the consequences of differential settlement. However, a homogenous and isotropic soil is merely imaginative.

I. INTRODUCTION

Geotechnical engineers play a crucial role in the construction industry. Site investigation carried by geotechnical engineers is a very important precursor to construction because it is where the groundwater and geological conditions and engineering parameters are determined. Site investigation is usually carried prior to construction, but in some cases, it is done to assess the safety of an existing structure or were failure has occurred

II. OBJECTIVES

1) Collect representative samples on the proposed site.
2) Undertake in situ tests and soil profiling.
3) Carry laboratory tests to determine index as well as mechanical properties of the soil.

III. LITERATURE REVIEW

Site investigation as defined by Craig (2004) is a precursor to the execution of civil engineering projects. It involves a thorough ground investigation from which soil parameters are determined for a safe and economic design of an engineering project. Geological, geotechnical, and other relevant information which might affect construction is acquired through site investigation (Clayton et al., 1992). It is crucial to note that site investigation is an essential prerequisite element to a sound and safe engineering structure. Recent studies based on old case studies have proven numerous times that a job poorly done during site investigation often results in time and financial setbacks that could be avoided if site investigation is carried thoroughly. The first step in site investigation is the desk study and preliminary reconnaissance. Most of the work done in stage one of site investigation involves office work, where old literature, maps, and surveys related to the area of interest are reviewed in search of valuable information. Clayton et al. (1992) mentions that from desk study and preliminary reconnaissance, probable ground conditions may be defined. This is particularly important because it is regarded as time and cost efficient. The permissible load that the soil can support without undergoing shear failure and destructive settlement is defined as the soil's bearing capacity (Bell, 1980). To predict the performance of an engineering structure, Parsons and Frost (2002) states that two values need to be determined, the actual value inherent in the soil (capacity) and the value required for acceptable performance (demand). Failure can only occur if the demand exceeds the capacity. Deep foundations are adopted if the soil near ground surface is incapable of supporting the structural loads imposed. With deep foundations, the structural loads are transmitted to suitable soil/rock at greater depth (Craig, 2004). Curtin et al (2006) states that piles are used to transmit loads through unsuitable bearing strata either by skin friction and end-bearing or end-bearing alone into a firm layer at great depth.

IV. PROPOSED METHODOLOGY

Site investigation will be largely based on sample testing in a soils laboratory in the University of KwaZulu-Natal (UKZN) Westville campus. Representative samples, both disturbed and undisturbed will be taken from inspection pits and sent to the laboratory immediately for testing. Undisturbed samples can be obtained either by a cylindrical sample tube, or by taking a block sample from an excavation such as an inspection pit and covering it with wax or cling wrap to conserve its natural moisture content.

Disturbed samples are collected in bulk bags by a shovel, and they are relatively easy to obtain. The first step will be to identify and adequately describe the soil samples, this is often done on site. As it is the case with most site investigations, the kind of tests done are governed by the nature of the proposed construction. In situ testing will be carried out in the form of penetration tests, from which consistency values may be derived.

Once the samples are nicely prepared, described and classified, testing may commence after the unit weight and moisture content of the samples are determined. Geophysical methods (i.e. electromagnetic surveys), drilling, and aerial photography are expensive techniques of acquiring geotechnical data, and as a result, relatively cheaper method such as the Dynamic Cone Penetrometer (DCP) will be adopted instead to acquire consistency data.

A. Field Tests

Two field tests carried out in in February 2018 include the dynamic cone penetrometer and soil profiling (soil profiling is not necessarily a test but a method of acquiring field data). Soil profiling could only be done in inspections pits which were excavated using the Tractor-Loader Backhoe (TLB).

B. Laboratory Tests

1) Particle size analysis: Particle size analysis can be done in various ways to determine particle size distribution of a soil. Particle size distribution helps classify the soil in terms of grain size.
2) The hydrometer test procedure: The test was done with reference to the British Standard, BS 1377: Part 2: 1990. A disturbed sample of 100 g is placed in a ‘wide-mouthed’ conical flask. 100 ml of dispersive agent, hexametaphosphate, is added to the soil and mixed thoroughly for about 5 minutes until the soil is broken down to individual particles. The mixture is passed through a 75 µm sieve placed on a receiver, and the soil is washed with distilled water not exceeding 500 mL the soil suspension that passes through the 75 µm sieve is transferred to a 1 L measuring cylinder. The total amount of material required for the sedimentation analysis ranges from 40 – 50 g. The material retained on the 75 µm sieve is transferred to an evaporation dish and oven-dried at 105 – 110 o C, then it is re-sieved on relevant sieves down to 75 µm. Any material passing through the 75 µm sieve is added to the soil suspension in the 1 L measuring cylinder. The soil suspension in the measuring cylinder (up to 1 L mark) is mixed vigorously for 2 minutes. After 2 minutes of mixing, the cylinder is placed quickly on the table and the timer is started immediately. The hydrometer is immersed in the soil suspension and allowed to float freely. At time intervals ½ minutes, 2 minutes, 4 minutes, the hydrometer readings are recorded at the upper ring of the meniscus without removing the hydrometer from suspension. After approximately 8 minutes, 15 minutes, 30 minutes, 1 hour, 2 hours, 4 hours, and 24 hours from the start of the sedimentation the hydrometer is inserted and removed from the soil suspension after each 27 recorded reading. Lastly, the temperature of the soil suspension is recorded once during the first 15 minutes and then recorded after each subsequent reading.
3) Atterberg Limit Tests: Atterberg limits are water contents which define the transition between the liquid, plastic, semi solid, and solid states of fine-grained soils (Craig, 2004). All the Atterberg limits in this report are determined in accordance with BS 1377: Part 2: 1990.
4) Compaction Test: Water and air exist in the voids that are inherent between the solid soil particles. Compaction is often carried to minimize the potential for settlement and to increase the shear strength of the soil (Smith & Smith, 1998). Since air is highly compressible, the need for compaction before construction is, therefore, essential to assuring a safe and improved ground to lay foundations on. Before compaction can be performed on site, a laboratory compaction test must be done. A Light compaction (Standard Proctor – 1 litre mould) test was undertaken in accordance with BS 1377: Part 4: 1990.
5) California Bearing Ratio (CBR) Test: The CBR is a value (%) which indicates the strength of a sub grade, sub base and base course materials. The CBR can also be used to assess the load-bearing capacity of soils. The method for the determination of the CBR involves the use of soil dynamically compacted by metal rammers. The choice of a rammer depends on the required degree of compaction. The soil in this test is compacted to 100% of its maximum dry density.

V. RESULTS AND DISCUSSIONS

A. Particle Size Analysis

The particle size analysis enables for the determination of the particle size distribution. As can be seen in Figure 5.3, all the particle size distribution curves are continuous.

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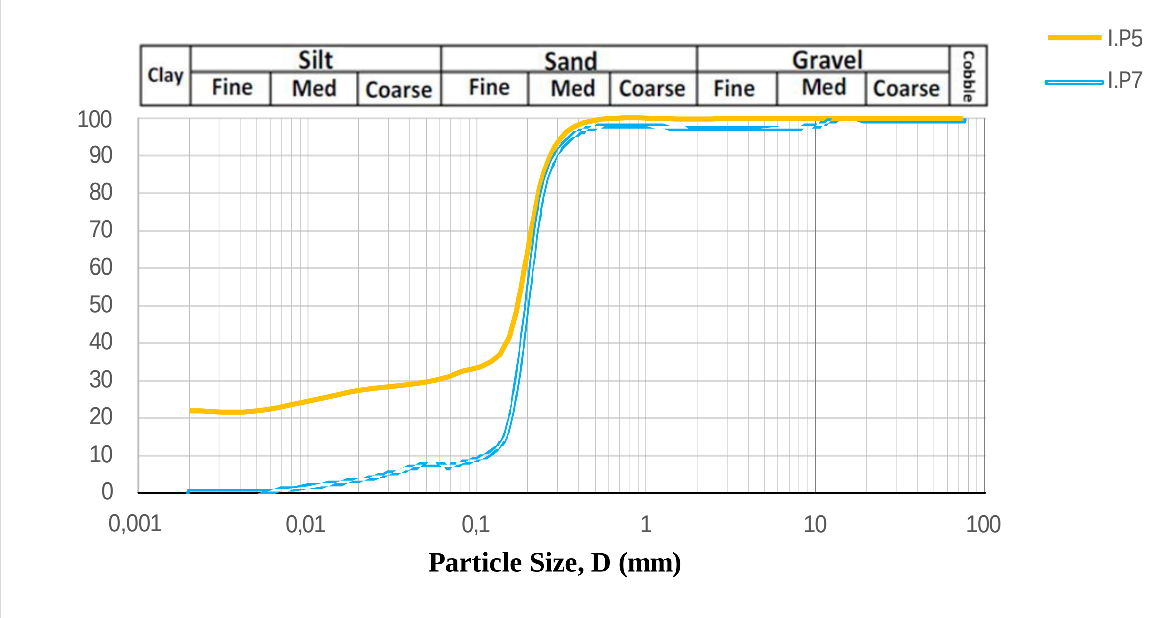

Figure 5.3 Particle size distribution curves

As can be seen in Table 5.2, the soil samples from all six inspection pits are classified according to the M.I.T system, the Technical Recommendations for Highways (TRH14) system, and the USCS systems which makes use of the M.I.T size classification and the D-values.

Table5.2. Particle size analysis summary and corresponding soil classification.

Index		IP.5	IP.7	IP.9	IP.11	IP.18	IP.23
M.I.T Size Classification	Gravel %	0.2	2.4	0.0	0.0	0.0	0.0
	Sand%	69.3	89.7	57.4	92.2	59.7	76.0
	Silt%	8.5	7.3	11.7	7.2	10.1	12.3
	Clay%	21.9	0.6	30.9	0.6	30.2	11.7
D10Size(mm)		<0.002	0.089	<0.002	0.081	<0.002	<0.002
Grading Modulus		0.70	0.97	0.59	0.93	0.59	0.76
TRH14(1985)		G10	G10	>G10	G9	G10	G10
USCS Classification		SM-SC	SP-SM	SC	SP-SM	SC	SM

B. Atterberg Limits

The results of the Atterberg limits are presented in Figure 5.6 and Table 5.3 gives a summary of the results with corresponding classification mark the transition between the liquid, plastic, semi-solid, and solid state of the soil.

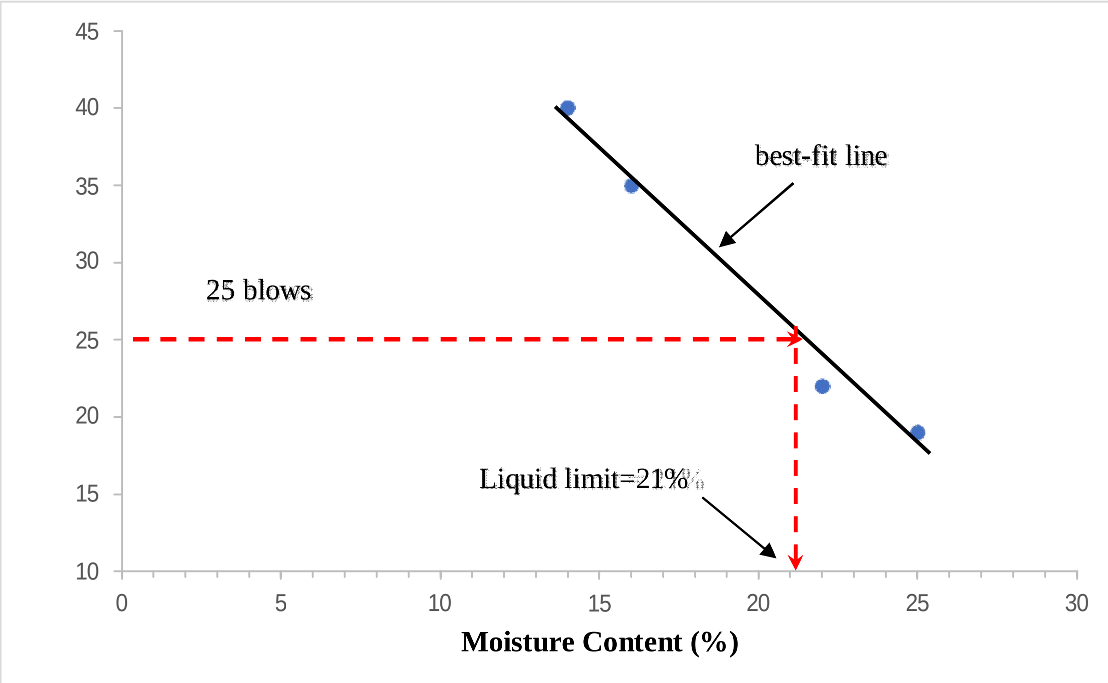

Figure5.6. Liquid limit determination

Table5.3. A summary of the Atterberg limits and soil classification.

Test		IP.5	IP.7	IP.9	IP.11	IP.18	IP.23
Atterberg Limits	Liquid Limit%	21	30.3	27.5	22.3	27.3	17.7
	Plastic Limit%	15.9	-	19.6	-	17.9	-
	Linear Shrinkage%	2.7	0	2	0	4.5	0
	Plasticity Index%	5.1	0	7.9	0	9.4	0
AASHTO Classification		A–2–4 (0)	A– 3 (0)	A–4 (0)	A– 3 (0)	A–4 (1)	A–2–4 (0)
Major constituent materials		Clayey gravel sand	Fine sand	Silty soils	Fine sand	Silty soils	Clayey gravel sand
General Rating as Sub grade		Excellent to good	Excellent to good	Fair to poor	Excellent good	Fair to poor	Excellent to good

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C. Compaction Test

The compaction test results are presented in Figure 5.14 and the rest is summarised in Table 5.4. Compaction is very important as it helps increase the shear strength and reduces the potential for settlement by increasing the density of the soil.

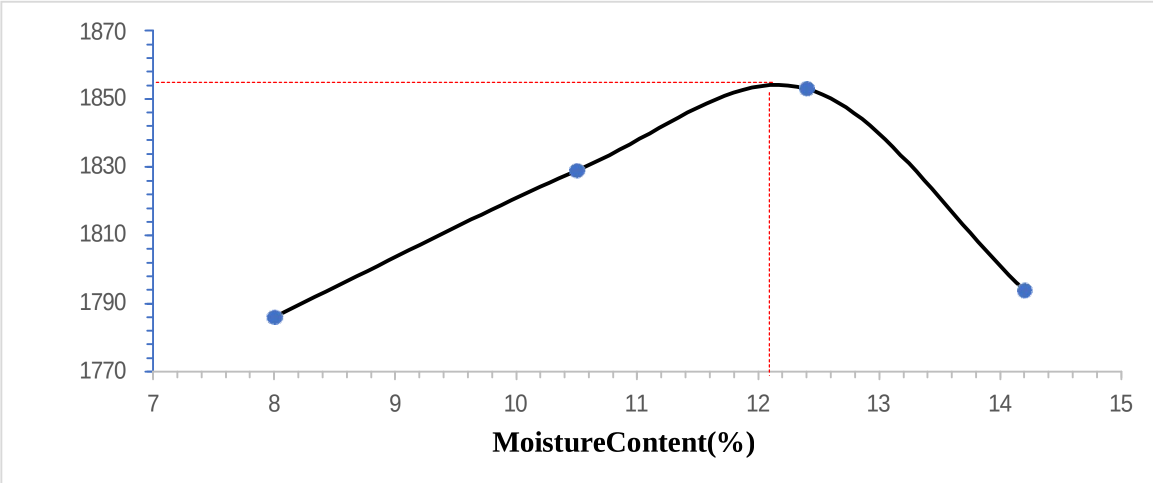

Figure 5.14 Determination of the maximum dry density

Table5.4. Compaction test summary.

Position & Depth (m)	Maximum Dry Density (kg/m^3)	Optimum Moisture Content (%)
IP.5at 0.5 -2.4	1854	12.1
IP.7at 0.4 -2.9	1609	13.9
IP.9at 2.0 -3.0	1804	13.9
IP.11at 0.5 -2.7	1651	13.5
IP.18at 1.7 -3.0	1871	11.1
IP.23at 0.6 -1.8	1799	7.8

VI. CONCLUSION AND RECOMMENDATIONS

Geotechnical site investigations are a necessity when it comes to civil engineering projects. Of course, the magnitude of the investigation is governed by the size of the proposed project. For the double-storey houses proposed to be built in Sibaya portion 24, the aims and objectives of the investigation were straightforward. However, this is not to rule out the fact that there were some complexities involved along the way. Is the site, Sibaya portion 24, suitable or not suitable for the proposed construction? Yes, the site is suitable for the proposed construction of double-storey houses since there are no disastrous geological flaws that exist. However, the recommendations provided in this section should be strictly adhered to.

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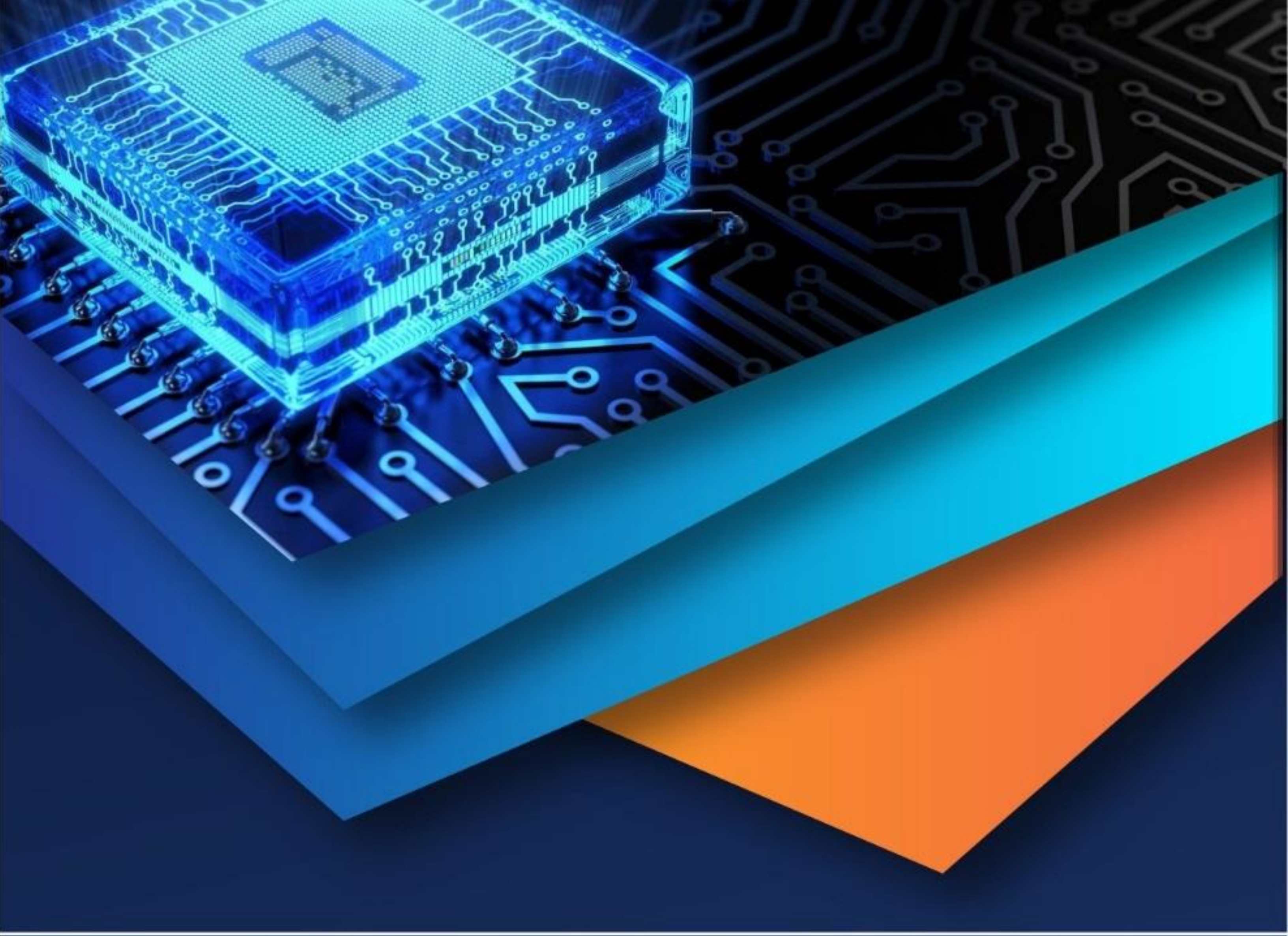

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