SITE EXPLORATION, SAMPLING AND LABORATORY TESTING

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Site Exploration,Sampling and Laboratory Testing

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@JABATAN PENGAJIAN POLITEKNIK DAN KOLEJ KOMUNITI

KEMENTERIAN PENDIDIKAN TINGGI

SITE EXPLORATION, SAMPLING AND LABORATORY TESTING

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PREFACE

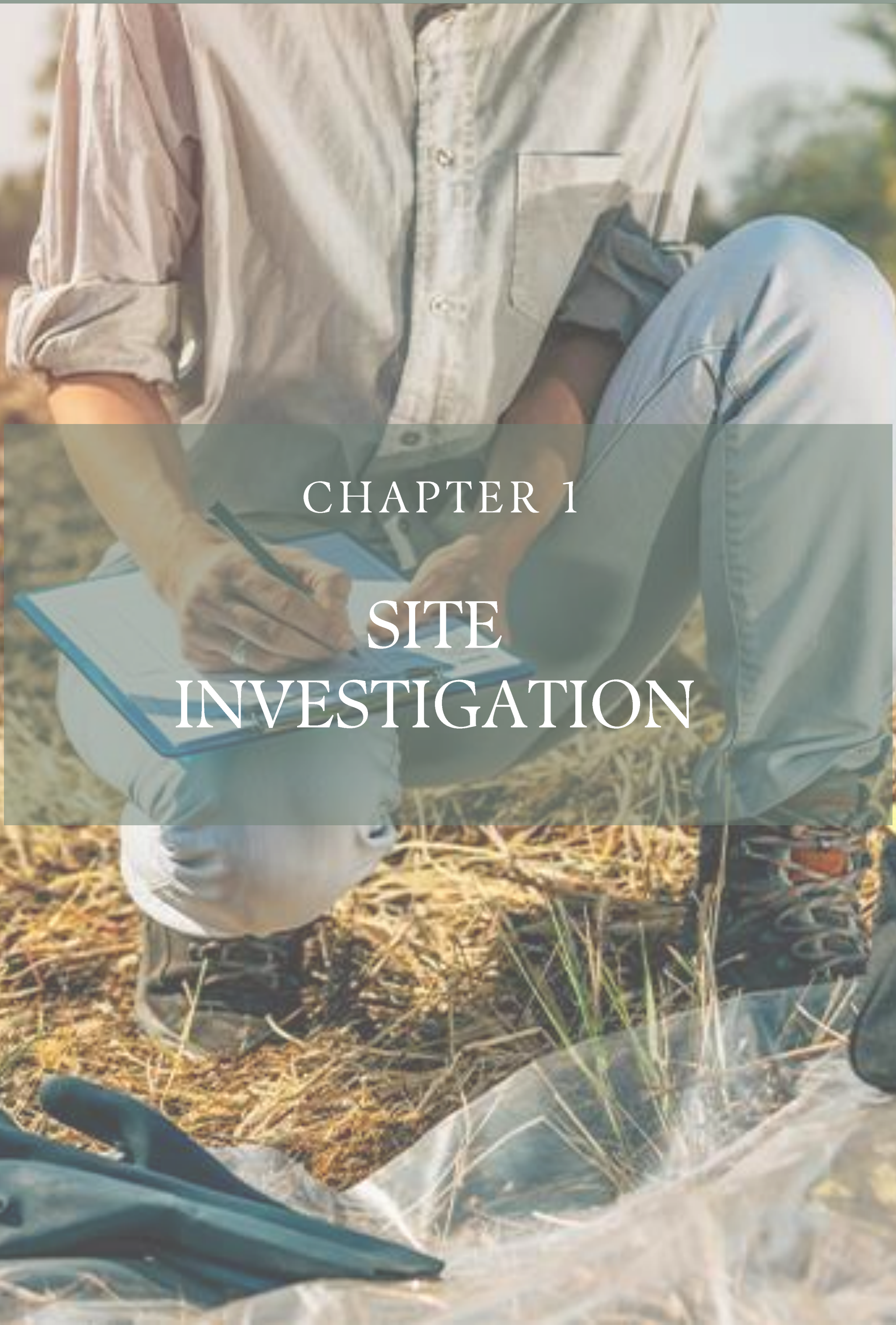
Structures of all types such as buildings, bridge, highway, etc. rest directly on, in or against soil; hence, proper analysis of soil and design foundation are necessary to ensure that these structures remain safe and free of undue settling and collapse. The main purpose of the site investigation is to collect all the necessary ground information and data to prepare a safe, practical and economical geotechnical or foundation design.
As such, the goal of this eBook is to help readers' comprehension of the basic site investigation.

Any suggestions, comments or feedbacks for further improvement are most welcome.

Table of Contents

INTRODUCTION

Structures of all types such as buildings, bridge, highway, etc. rest directly on, in or against soil; hence, proper analysis of soil and design foundation are necessary to ensure that these structures remain safe and free of undue settling and collapse. The main purpose of the site investigation is to collect all the necessary ground information and data to prepare a safe, practical and economical geotechnical or foundation design. The implementation phase of site investigation usually includes three important aspect : boring, sampling and testing.



CHAPTER 1

SITE INVESTIGATION

1.1 DEFINITION OF SITE INVESTIGATION

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Site investigation refers to the process of determining the surface and subsurface conditions in the area of the proposed construction.

Site investigation is a process of site exploration consisting of boring, sampling and testing so as to obtain geotechnical information for a safe, practical and economical geotechnical evaluation design.

The site exploration, testing of materials, evaluation of results and general evaluation of the site are referred to as site investigation.

1.2 OBJECTIVE OF SITE INVESTIGATION

i. To assess the general suitability of the site and neighbour -hood for the proposed works, from a geological and geotechnical point of view.

ii. To provide suitable geotechnical data for all aspects of an economic, safe and reliable design of foundations, earthworks and temporary works, including assessment of the effects of any previous uses of the site.

iii. To assess the problems and constraints associated with the construction of the works arising from the soil or groundwater conditions and to plan the best method of construction.

iv. To assess the quantity, quality and ease of extraction of construction materials suitable for the works.

v. To determine the changes in the stability, drainage and other geotechnical aspects of the site and the surrounding ground and buildings, which might be initiated by the construction works.

vi. To make comparison on the construction works by alternative methods or at alternative sites.

1.3 MAIN PURPOSE OF SITE INVESTIGATION

I. Obtaining information on strata and ground water table

ii. Collecting soil samples to identify and classify the soil

iii. To determine the safety of existing structures e.g nearby buildings

iv. To determine the suitability of the site

v. To have economy of design

1.4 STAGE OF SITE INVESTIGATION

i. Preliminary and Site Exploration/ Site Reconnaissance

This is essentially the collection of a variety of information about the site, e.g., maps, drawings, details of existing or historic development, local authority information, geological maps, records, memoirs, details of utilities, services, restrictions, rights of way, ownership of adjacent property, aerial photographs.

ii. Programme planning and scope of site investigation

Site investigation are performed to obtain information about subsurface conditions at the site proposed for construction. Soil exploration includes determining the profile of the natural soil deposits at the site, taking soil samples, and determining the engineering properties of the soils using laboratory tests and in-situ testing methods.

iii. Soil investigation, sampling and lab test

Investigation of detailed geology and sub-surface soil conditions using surface surveys, trial pits, headings, boreholes, sounding, geophysical methods, as appropriate; survey of groundwater conditions over a signification period of time. The implementation phase of site investigation usually includes three important aspect: boring, sampling and testing.

1.4 STAGE OF SITE INVESTIGATION

iv. Boring

Boring is the process of enlarging a hole that has already been drilled or cast by means of a single point cutting tools. Examples: Trial pits are shallow excavation (backhoe), boreholes may be excavated by auger boring.

v. Sampling

Sampling is the process of extracting a small volume of soil for subsequent analysis at a lab. Examples: soil samples (disturbed and undisturbed) and rock sample(rock cores).
Testing: in-situ test and laboratory test. Figure 1 depicts the general process of traditional drilling, sampling, and laboratory testing of collected samples

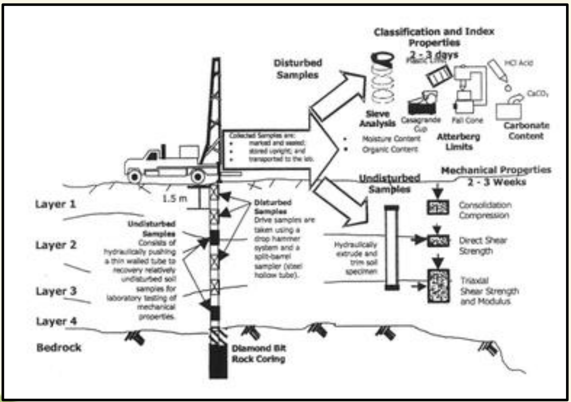


Figure 1 : Traditional drilling, sampling and laboratory testing of collected samples

1.4 STAGE OF SITE INVESTIGATION

vi. Preparation of the site investigation report

After the completion of all field and laboratory works, a site investigation report is prepared. The report is also called soil exploration report or geotechnical factual report. Site investigation report included details of geological study, including structures, results of boring, including log, references for samples and stratigraphy interpretations as requested, comments and recommendations relating to the design. The Site Investigation report is important for the use of the design office and for reference during future construction works.

vii. Design and review during construction and monitoring

A design review is a milestone within a product development process whereby a design is evaluated against its requirements in order to verify the outcomes of previous activities and identify issues before committing to - and if need to be re-priorities - further work.

" I find the harder i work, the more luck i seem to have "

-Thomas Jefferson-

CHAPTER 2

IN SITU TESTING

2.1 MACKINTOSH PROBE

The Mackintosh Probe is lightweight and portable penetrometer. Provide a profile penetration resistance with depth, in order to give an assessment of the variability of in-situ materials on site. It produces simple results, in terms of blow per unit depth of penetration that can be used to determine thickness of unsuitable material to be removed and also for preliminary design of embankments. Limited to about 15 m.

Figure 2 : Mackintosh Probe

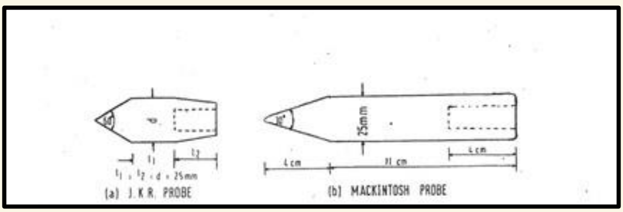


Figure 3 : Pointer geometry of light dynamic cone penetrometer

2.2 CONE PENETRATION TEST

The static cone penetration test (CPT), also known as the Dutch cone penetration test. Is a static penetration test in which the device is pushed, rather than being driven by blows, into the soil. The cone, which has an angle of 60 and a diameter of 35.7 mm is attached to the road. The ratio of force required to the end area is called the cone penetration resistance

2.3 STANDARD PENETRATION TEST

The standard penetration test is used to determine the relative density of granular soils. Before starting the test, the bottom of borehole must be carefully cleaned out to remove any disturbed materials. Figure 4 shows the standard penetration test .

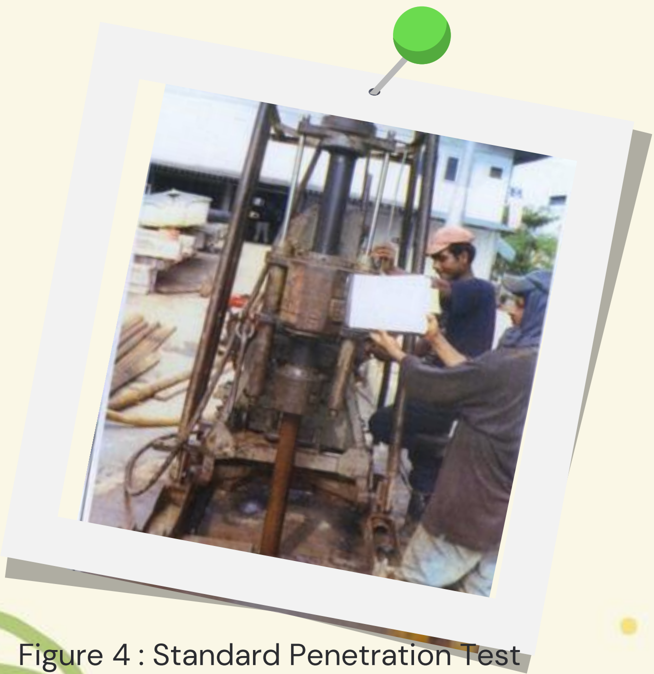


Figure 4 : Standard Penetration Test

Figure 5 : Standard Penetration Test for Bridge Project

Figure 6 : Standard Penetration Test for Jetty Project

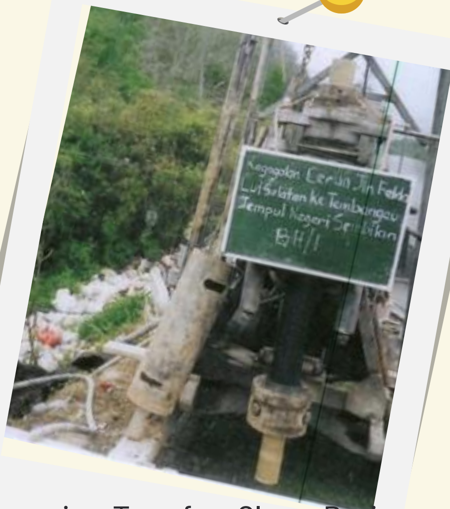


Figure 7 : Standard Penetration Test for Slope Project

Figure 8 : Movement of boring machine Using Mobile Crane

2.4 CONE PENETRATION TEST

The static cone penetration test (CPT), also known as the Dutch cone penetration test. Is a static penetration test in which the device is pushed, rather than being driven by blows, into the soil. The cone, which has an angle of 60 and a diameter of 35.7 mm is attached to the road. The ratio of force required to the end area is called the cone penetration resistance

Figure 10 : Cone Penetration Test

2.5 PACKER TEST

Single or double packer test is sometimes carried out in rock strata to assess the amount of grout that rock will accept to check the effectiveness of grouting, to obtain a measure of fracturing of rock to give an approximate permeability of rock.

What is Packer test?

Packer test is done in borewells, which isolates a portion of boreholes to take samples of fluid in it and thus allows to test its. Packer test is used to find out the hydraulic conductivity and Injection value which will be used as parameters which will then be used as an analysis for water seepage and estimates of injection type selection to reduce the graduation coefficient of rock-water or to increase rock shear strength.

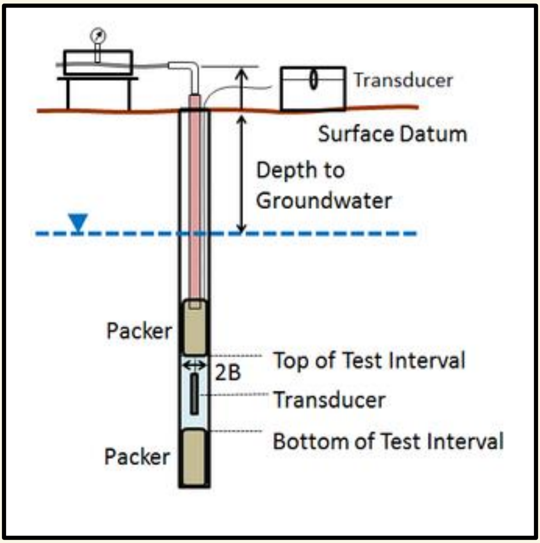


Figure 10 : Packer Test Cross section

2.6 VANE SHEAR TEST

The vane shear test (VST) or field vane (FV), is used to evaluate the in place undrained shear strength (Suv) of soft to stiff clays and silts at regular depth of 1 meter (3.28 feet). Very suitable for very soft to stiff clay to obtain undrained strength. The field vane shear test, shown schematically in Figure 10.25, is commonly used for determining the in situ undrained shear strength of saturated clays, especially of soft to medium consistency.

The test is most suitable for sensitive saturated cohesive soil deposits which are highly susceptible to sampling disturbance. The vane used in the test consists of two rectangular blades that are perpendicular to each other, as seen in Figure 10.25. The blades are as thin as possible, consistent with the strength requirements, so that the vane causes as little remolding and disturbance as possible to the soil when inserted into it.

Figure 10 : Vane shear test apparatus

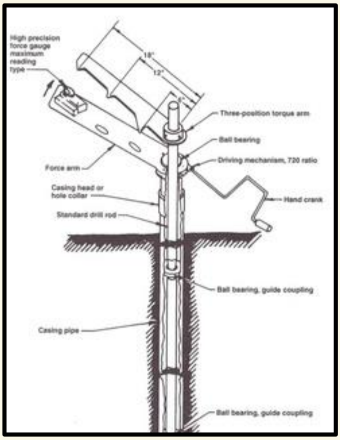


Figure 11 : Diagram illustration the field vane shear test

Figure 12 illustrates the general Vane Shear Test procedures. In Very soft clays, a special protective housing that encases the vane is also available where no borehole is required and the vane can be installed by pushing the encasement to the desired test depth to deploy the vane.

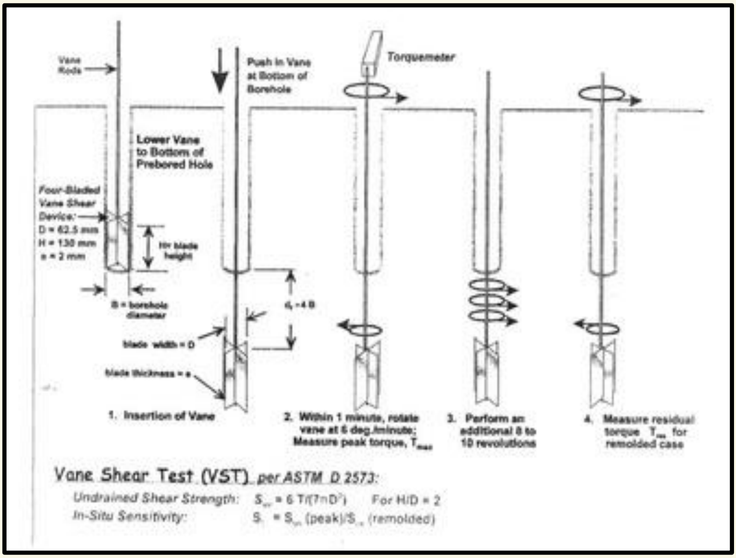
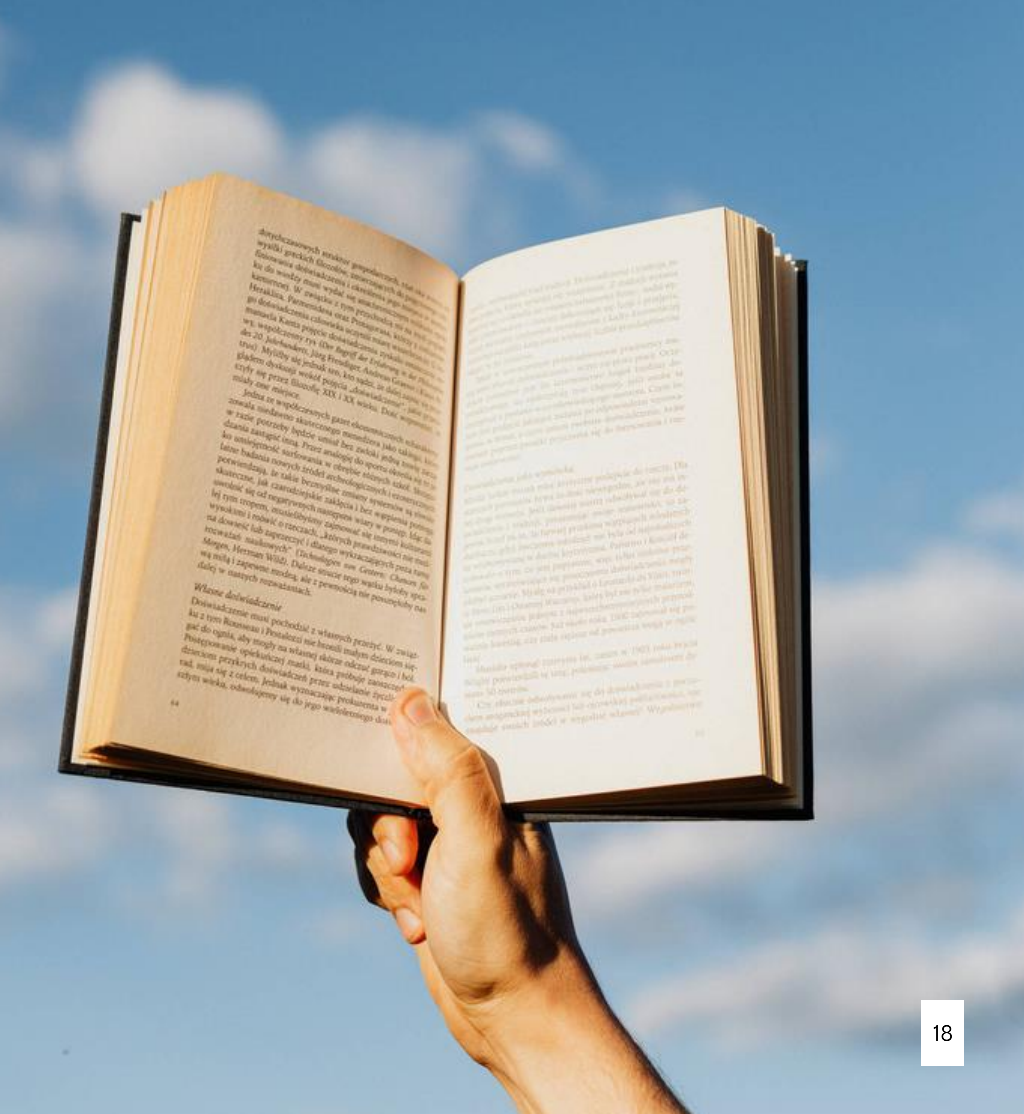


Figure 12 : General Test Procedures for the Field vane in Fine-Grained Soils

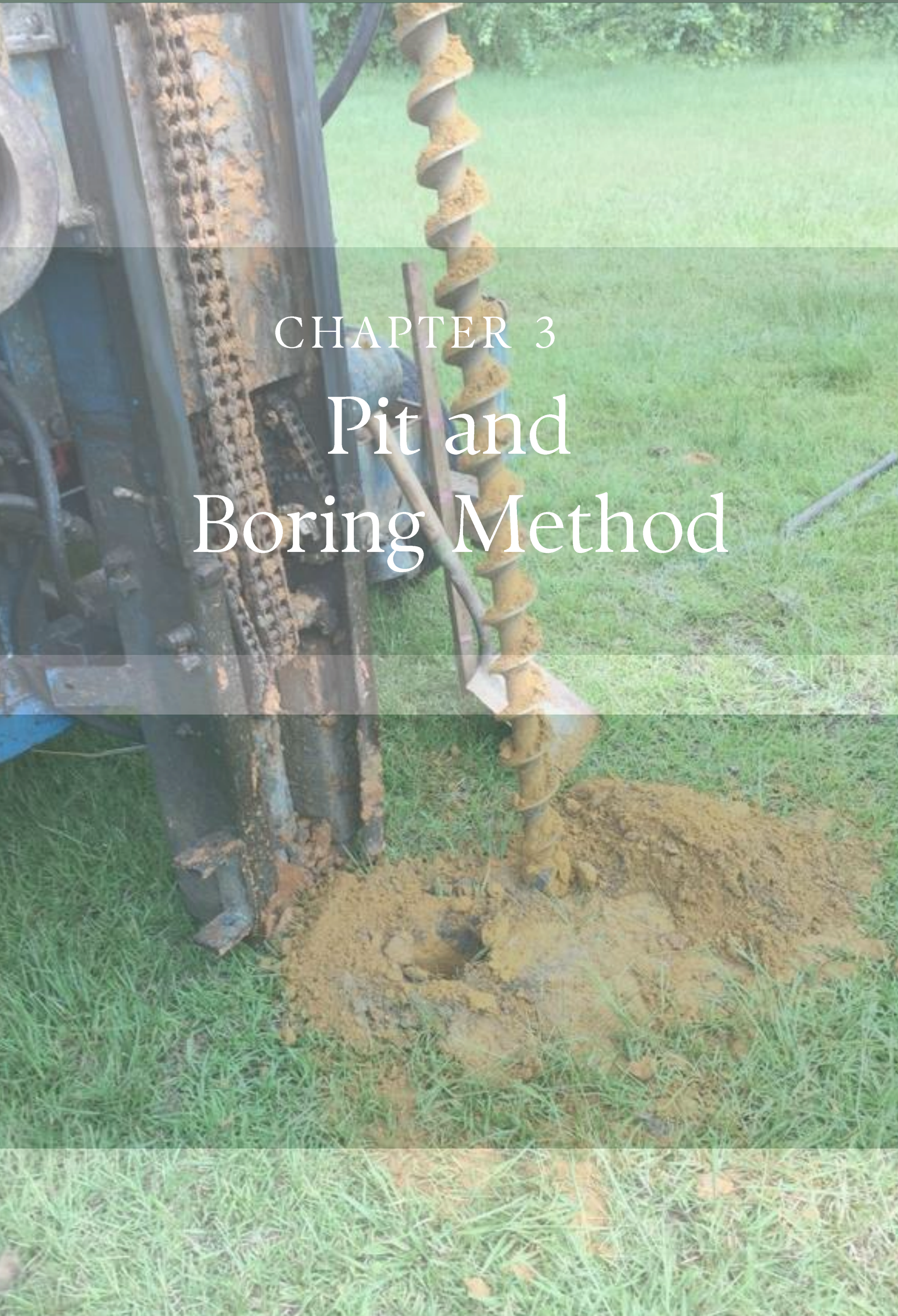
" READING IS ESSENTIAL FOR THOSE WHO SEEK TO RISE ABOVE ORDINARY "

-Jim Rohn-



CHAPTER 3

Pit and Boring Method



3.1 TRIAL PITS

Generally, provide the cheapest method of exploration and give the clearest picture of soil conditions but can be dug only to about 5m depth, at most. Pits may be dug by hand or mechanical excavator; no special equipment is required, but care must be taken to ensure that the sides are stable and shoring may be required before it is safe to enter the bit. Disturbed, undisturbed and hand-cut samples can be taken and the side can be photographed for permanent record.

Test pits are suitable for quick and shallow investigations and inspections, especially for foundations of shallow footing as well as for services installations such as sub-surface water, sewer, gas, electricity and telecommunications lines. Test pitting allows logging of the soil profile, observing seepage and groundwater sampling.

Figure 13 : Trial Pits

3.2 SHELL AND AUGER BORING

This technique can be used in all types of soil above and below the water table. Boreholes are usually 150 – 200 mm diameter and steel casing are generally required throughout most or all of the depth.

Figure 14 : Auger boring

3.3 ROTARY DRILLING

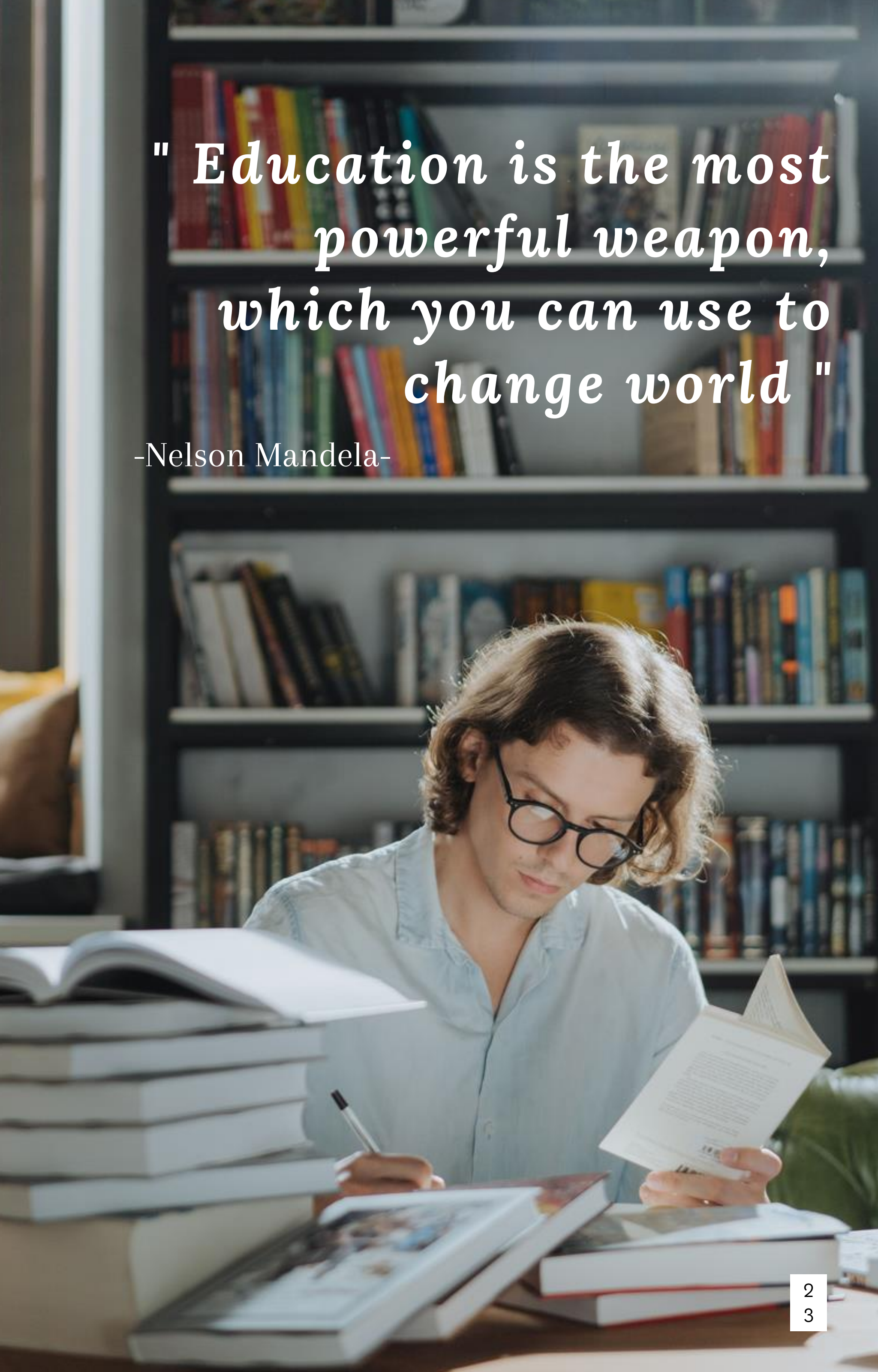
This is used in rocks and granular soils where it is adequate to rely on wash water samples and standard penetration test results. Various types of pit are used., depending on ground conditions, to produce a 35 – 60 diameter hole which is usually cased. This method can be to produce very deep holes; the maximum depth obtainable depends on the equipment and ground conditions.

Figure 15 : Rotary Drilling

3.4 ROTARY CORING

Coring is essentially the same operation as rotary drilling but is carried out in rocks or hard clays and the drilling bits is a diamond-tipped core bit connected to a core barrel, so that rock cores may be obtained. As with rotary drilling, cutting are flushed out the hole using water or air.

Figure 16 : Rotary Coring


" Education is the most powerful weapon, which you can use to change world "
-Nelson Mandela-

CHAPTER 4

SAMPLE COLLECTION

4.1 UNDISTURBED SAMPLE

In which the structure and water content is preserved, as far as possible, to truly represent site conditions. Undisturbed soil samples retain the structural integrity of the in-situ soil. These are usually obtained by a suitable coring method. Undisturbed samples are often defined as those samples obtained by slowly pushing thin-wall tubes, having sharp cutting ends and tip relief, into the soil. Undisturbed samples are required for test of shear strength, consolidation and permeability, compressibility and fracture patterns among others. Results of these analyses are helpful in design of a new building because structure and moisture content are preserved as far as possible to truly represent site conditions. It should be recognized that no soil sample can be taken from the ground in a perfectly undisturbed state.

For undisturbed soil sample, a sample made of steel is usually used to obtain such sample. The sample tube is sealed with wax at both ends once the sampling process is done to prevent loss of moisture. This process will help preserve the soil samples as in its original conditions.

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Figure 17: Block sample

Figure 18 : Sample From Split Spoon Sampler

Figure 19 shows the process applying melted paraffin to seal soil sample to prevent the loss of moisture content.

Figure 19 : Applying Melted Paraffin to seal soil sample

A standard split-spoon sampler, shown in figure 20, is driven 450 mm into the soil by repeated blow.

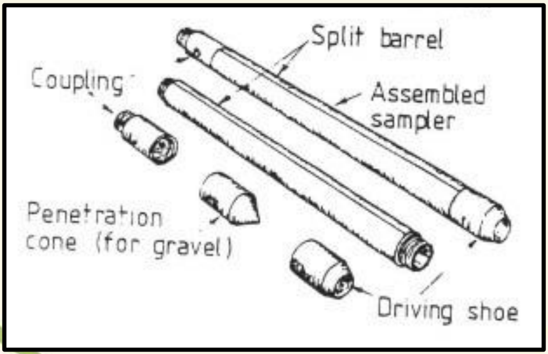

Figure 20 : Split spoon sampler

4.2 DISTURBED SAMPLE

The structure of the soil has been changing sufficiently that test of structural properties of the soil will not representative of in-situ conditions and only properties of the soil grains. Disturbed samples are easier to collect as drilling or digs proceed. They are used when the precision necessary for collecting an undisturbed sample is not required for soil test. Disturbed soil samples do not retain the in-situ properties of the soil during the collection process, but attempt is made to preserve in-situ moisture content.

Example test: Grains size distribution, Atterberg Limits, water content Test and contaminant analysis. Hand auger are commonly used for obtaining disturbed soil samples at or near the surface and for boring to depths where samples may be obtained with a soil sampler or soil core sampler.

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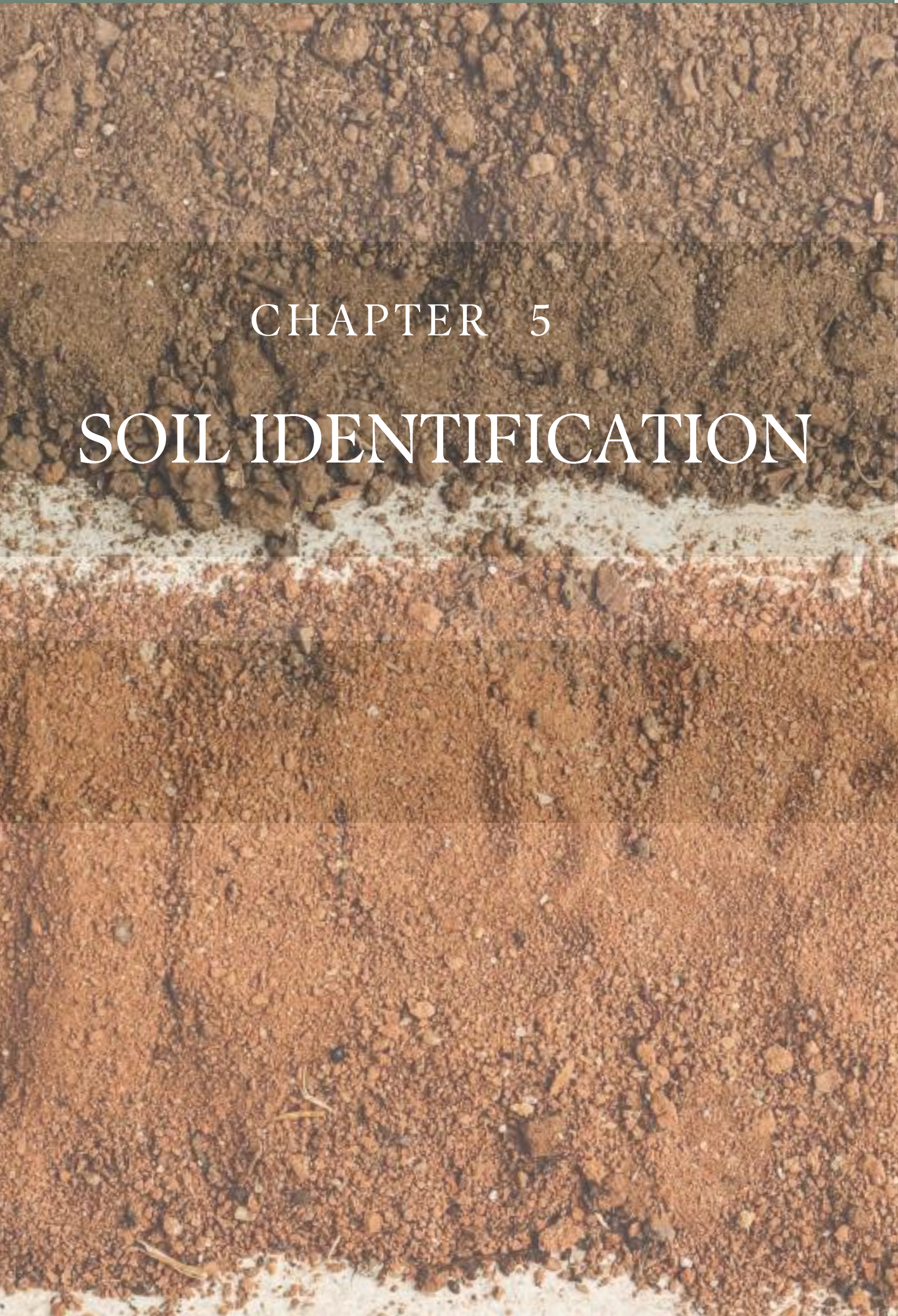
Figure 21 : Disturbed samples

“However difficult life may seem, there is always something you can do and succeed at.”

— STEPHEN HAWKING



CHAPTER 5

SOIL IDENTIFICATION

5.1 GRADING AND PRACTICLE SHAPE

The Unified Soil Classification System (USCS) separates soil into two main group: coarse-grained soil and fine-grained soils.

- Coarse-grained soils : Defined as having more than 50 %(by dry mass) of soil particles retained on the No. 200 sieve. Coarse granular materials, such as sand and gravels have particles of sufficient size to allow a visual assessment of their shape, angularity and grading.

- Fine-grained soils : Defined as having 50% or more (by dry mass0 of soil particles passing the No. 200 sieve

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5.2 DENSITY AND STRENGTH

The relative density of granular soils is assessed on the basis of field testing. Its field tests are not carried out, then the density description should not be used. Simple field tests, suitable for application in trial pits, are given in BS 5930:1981

5.3 COLOR

Color changes may indicate the extent of weathering or changes of strata. The absolute color of a soil is rarely of enormous importance, which is perhaps fortunate as many people are color-blind and also because color is highly subjective. The color seen by one person will depend on the type of light source, the background, the size of the object and the color that have been seen immediately before.

Usually the standard primary color (red, orange, yellow, etc.) of the soil is listed. Color can be very important in identifying different types of soil.

Figure 22 : Colour of soil

CHAPTER 6

Soil Types

The distribution of particle sizes larger than 0.075 mm (No. 200 sieve is determined by sieving, while the distribution of particle size smaller than 0.075 mm is determined by a sedimentation process (hydrometer). For the USCS, the rock fragments or soil particles versus size are defined as follows (from largest to smallest particles size):

- Boulders. Rocks that have an average diameter greater than 300 mm (12in.)

- Cobbles. Rock that are smaller than 300 mm (12 in.) and are retained On the 75-mm (3 in) U.S. standard sieve

- Gravel-size particles. Rock fragments or soil particles that will pass a 75-mm93-in) sieve and be retained on a No.4 (4.75-mm) U.S. standard sieve. Gravel-size particles are subdivided into coarse gravel size and fine gravel sizes.

- Sand-size particles. Soil particles that will pass a No. 4 (4.75-mm) sieve and retained on a No. 200 (0.075-mm) U.S. standard sieve. Sand-size particles are subdivided into coarse sand size, medium sand size, and fine sand size.

- Silt-size particles. Fine soil particles that pass the No. 200 (0.075-mm) U.S. standard sieve and are larger than 0.002 mm

- Clay-size particles. Fine soil particles that are smaller than 0.002 mm.

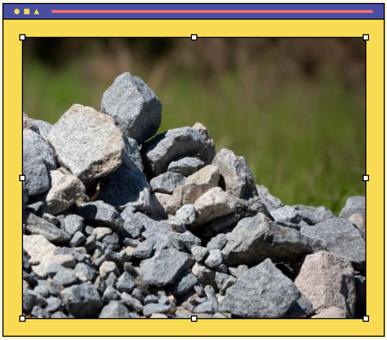


Figure 23: Gravel

Figure 24 : Sand

Figure 25 : Clay

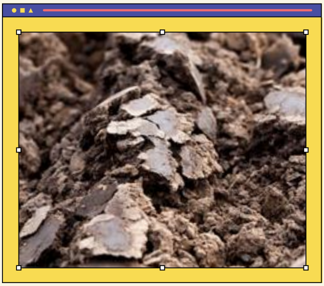


Figure 26 : Clay

The precise boundaries between different soil types are somewhat arbitrary, but the following scale is now in use worldwide.

Gravel			Sand			Silt			Clay		
C	M	F	C	M	F	C	M	F	C	M	F
60	20	6	2	0.6	0.2	0.06	0.02	0.006	0.002	0.0006	0.0002

Where: C, M F stands for coarse, medium and fine respectively and particle sizes are in millimetres.

Most soils will be composed of a variety of different particle sizes, some of which may be cohesive.

Boulders- particles of rock that will pass a 12-in (300 mm) square opening.

Cobbles – particles of rock that will pass a 12-in. (300 mm) square opening and be retained on a 3-in. (75 mm) sieve

Gravel – particles of rock that will pass a 3-in. (75 mm) and retained

Sand – particle of rock that will pass a no. 4 (4.75 mm) sieve and be retained on a No. 200(75 um) sieve with the following sub-division:

Coarse- pass a No. 4 (4.75 mm) and is retained on a No.10 (200 mm) sieve

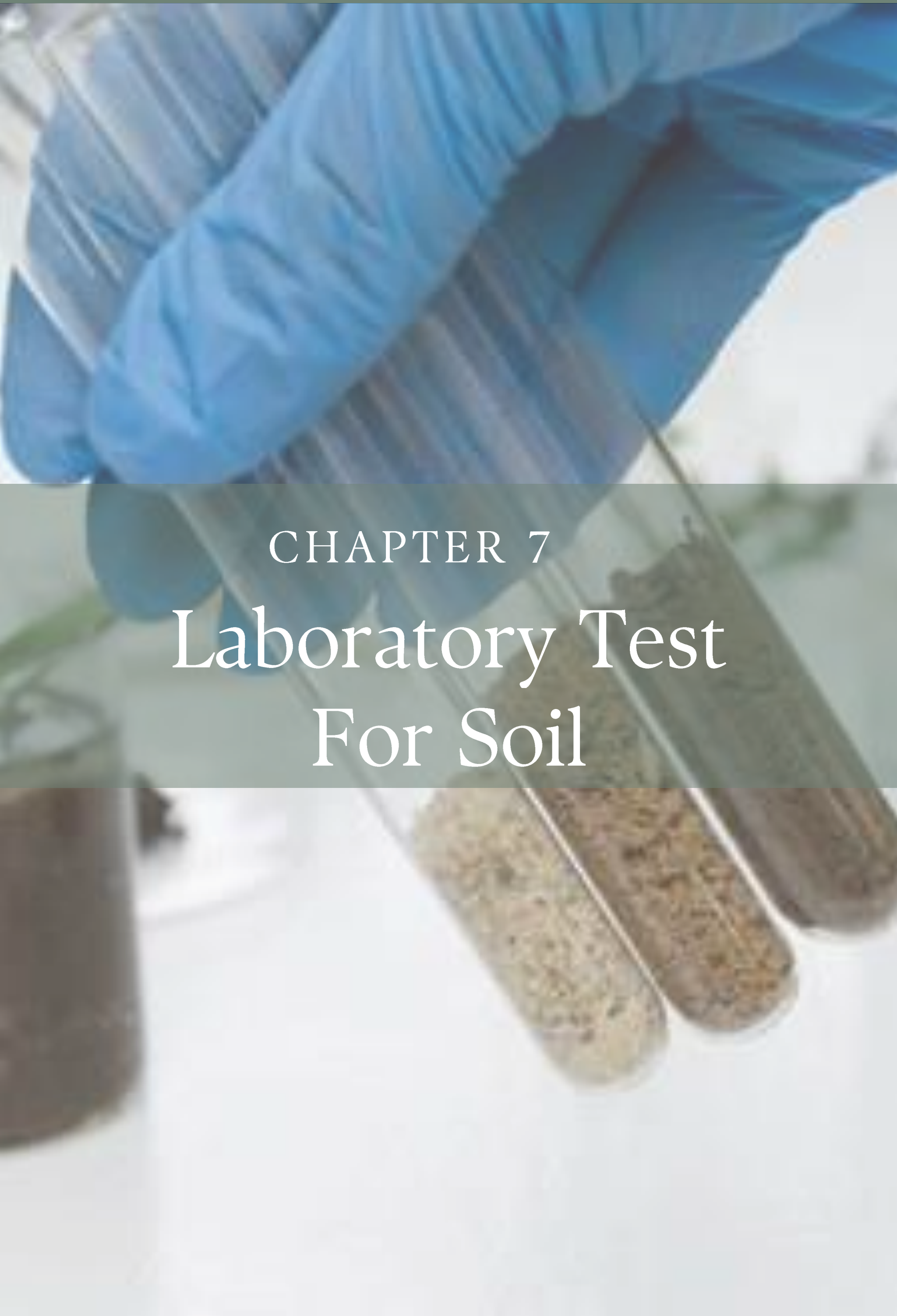
Medium – passes a No. 10(2.00 mm) sieve and is retained on a No. 40 (425 um) sieve.

Fine – pass a No. 40 (425 um) sieve and is retained on a No. 200(75um) sieve.

Silt –soil passing a No. 200 (75 um) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry.

Clay – soil passing a No. 200 (75 um) sieve a No. 200 (75 mm) sieve that can be made to exhibit plasticity within a range of water contents and that exhibits considerable strength when air dry.

Peat – a soil comprised primarily of vegetable tissue in various stages of decomposition, usually with an organic odor. A dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.



CHAPTER 7

Laboratory Test For Soil

6.1 Introduction

The sample from the field tests are brought to the laboratory to carry out the laboratory test. All preparation, testing and reporting shall be where applicable in accordance with the relevant British standard. Soil testing shall be carried out and reported in accordance with BS 1377 unless otherwise specified. They include:

i. Basic properties (colour, natural moisture content, specific gravity, porosity, void, reactivity etc) for soil description, classification and correlations

ii. Index properties (Liquid limit, Plastic limit, plastic index, SL, particle size distribution, organic content etc) for soil description, classification and correlations with engineering properties

iii. Chemical properties (total dissolved salts, sulphate and chloride contents; pH value etc) for corrosion and durability assessment of foundations.

iv. Engineering properties (shear strength, stiffness, compressibility, compaction or California bearing ratio, permeability etc.) for analysis and design. Engineering properties can be obtained from in-situ testing and laboratory test on undisturbed samples. The results from the in-situ and laboratory testing should be viewed as complimentary and the compared with the recommended data from the published literatures before adopting as design parameters.

6.2 Size analysis Test

Soil consists of individual particles, or grains. Grain size refers to the size of an opening in a square mesh through which a grain will pass. Since all of the grains in a mass of soils are not the same size, it is convenient to quantify grain size terms of a gradation curve. A gradation curves contains points corresponding to a particular grain size and a corresponding percent (by weight) of the soil grains that are smaller than that of grain size.

The objective of sieve analysis test is to determine the percentage of grain size distribution (silt, fine sand, medium sand and coarse sand) by plotting the percentage grain passing versus grain size on semi log graph.

Figure 27 :

Moisture content

The moisture (or water) content test is one of the simplest and least expensive laboratory tests to perform. Moisture content is defined as the ratio of the mass of the water in a soil specimen to the dry mass of the specimen.

Typical ranges of degree of saturation versus soil condition are follows (Terzaghi and Peck 1967):

- Dry: S = 0%
- Humid: S = 1-25 %
- Damp : S = 26 - 50 %
- Moist : S = 51 - 75%
- Wet : S = 76 - 99 %
- Saturated S = 100 %

Figure 28 : Moisture Content apparatus

i. Atterberg limits

The Atterberg Limits of a fine grained (i.e., clayey or silty) soil represent the moisture content at which the behavior of the soil changes. Test for the Atterberg limits are referred to as index test because the serve as an indication of several physical properties of the soil, including strength, permeability, compressibility, and shrink or swell potential.

The limits also provide a relative indication of the plasticity of the soil, where plasticity refers to the ability of a silt or clay to retain water without changing state from a semi-solid to a viscous liquid. To determine the liquid limit, use the Casagrande method or the cone penetrometer method.

The procedure for determining the plastic limit is quite simple. The soil sample is rolled between the fingers and the rolling surface until a 3.2 mm (1/8 in) diameter thread is obtained.

ii. Compaction Test

In soil mechanics, it means to press soil particles tightly together by expelling air from void spaces between the particles. Compaction is normally done deliberately, often by heavy compactions rollers, and proceeds rapidly during construction. A common compaction test is known as Standard Proctor Test. The basic premise of the test is that a soil sample is compacted in 5 or 6 in, (101.6 or 152.2 mm) diameter mould by dropping a 5.5-ib (24.4 N(\) hammer onto the sample from height of . An alternative test, known as the modified Proctor Test, uses a 10lb (44.5 N) hammer that is dropped 18 in. (457 mm). Therefore, the modified Proctor test may be use when greater soil unit weight is required.

Figure 29 : Compaction Apparatus

Direct Shear Test

The test is to determine shear strength of soil sample on predetermined shear plane. In the test, a number of soil samples are tested by applying different normal stress. Soil strength parameters are expressed in term of apparent cohesion, C and angle of friction, θ.

Figure 30 : Direct Shear Apparatus

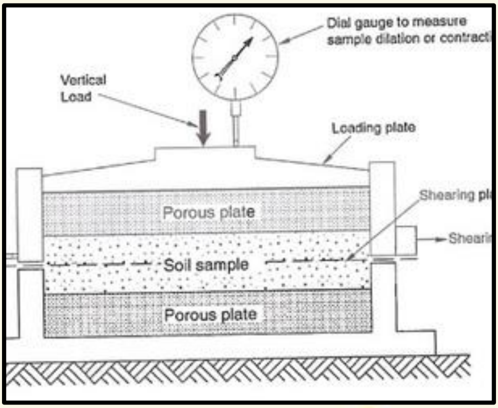


Figure 31 : Cross section direct shear

Falling Head Test

The objective of Falling Head Test is to determine the coefficient of permeability or hydraulic conductivity of fine-grained soils with intermediate and low permeability such as silts and clays.

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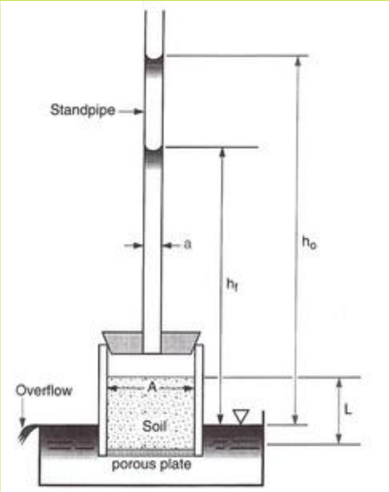


Figure 32: Falling Head Diagram

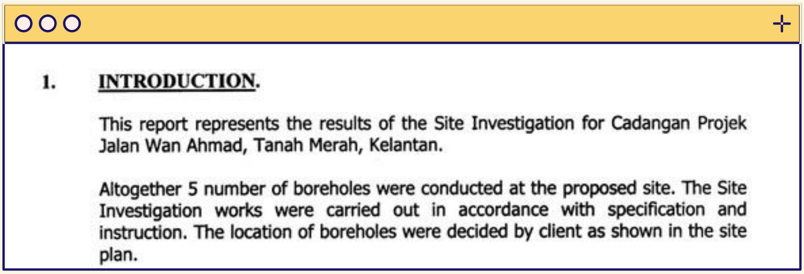
Figure 33 : Falling Head Test Apparatus

CHAPTER 8

Site Investigation Report

After carrying out any geotechnical investigation involving drilling, sampling, insitu testing, laboratory testing the report have be done. The Site Investigation report submitted by the SI contractor registered with CIDB should be checked to ensure the following items are included: The factual SO report should be prepared, checked and certified by a suitably qualified geotechnical engineer or engineering geologist. Is should include but not limited to the following details:

a) Introduction – State for whom the SI works was done, the nature and scope of SI, purpose of SI and period on time over which AI was done.



1. **INTRODUCTION.**

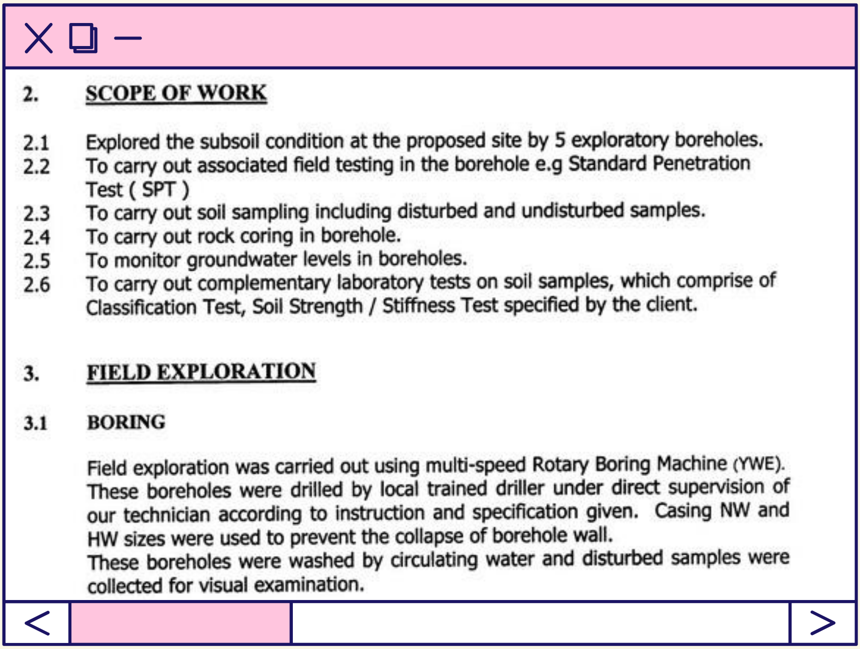
This report represents the results of the Site Investigation for Cadangan Projek Jalan Wan Ahmad, Tanah Merah, Kelantan.

Altogether 5 number of boreholes were conducted at the proposed site. The Site Investigation works were carried out in accordance with specification and instruction. The location of boreholes were decided by client as shown in the site plan.

Figure 33: Example of introduction

b) Site Description – Describe access, terrain, vegetation, land use, geological information etc. about the site.

c) Field work – account for SI method, testing, procedures, types and models of equipment used (quote standards use). Problems encountered in testing and sampling; date and time of SI. Weather conditions. Photo showing site and testing process or conditions. Plan showing site and boreholes or testing locations



2. **SCOPE OF WORK**

2.1 Explored the subsoil condition at the proposed site by 5 exploratory boreholes.
2.2 To carry out associated field testing in the borehole e.g Standard Penetration Test (SPT)
2.3 To carry out soil sampling including disturbed and undisturbed samples.
2.4 To carry out rock coring in borehole.
2.5 To monitor groundwater levels in boreholes.
2.6 To carry out complementary laboratory tests on soil samples, which comprise of Classification Test, Soil Strength / Stiffness Test specified by the client.

3. **FIELD EXPLORATION**

3.1 **BORING**

Field exploration was carried out using multi-speed Rotary Boring Machine (YWE). These boreholes were drilled by local trained driller under direct supervision of our technician according to instruction and specification given. Casing NW and HW sizes were used to prevent the collapse of borehole wall.
These boreholes were washed by circulating water and disturbed samples were collected for visual examination.

Figure 35: Example of field work

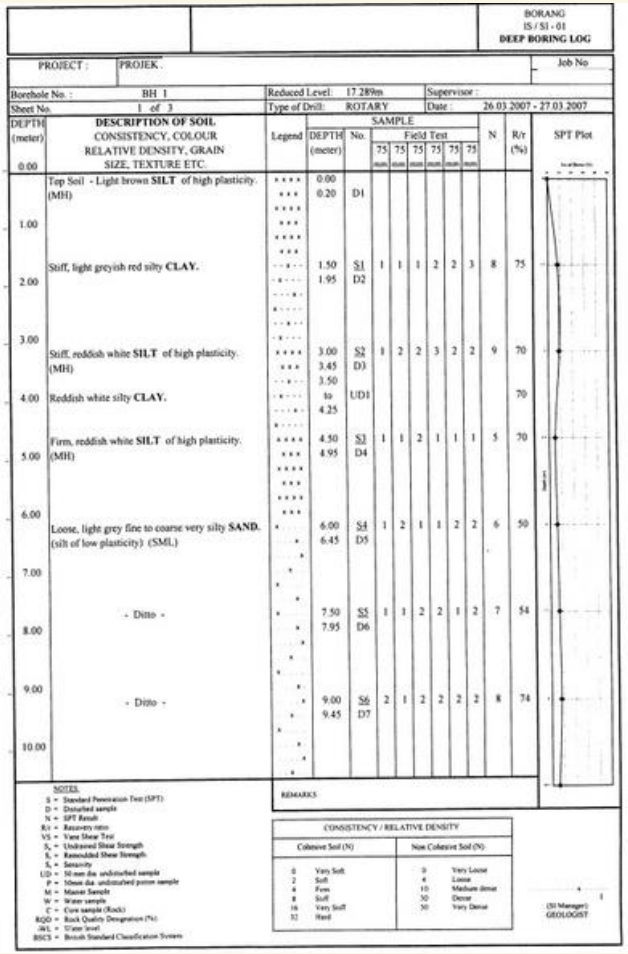
d) Bore log (fields bore logs should be corrected and checked) – Title of investigation or report. Location reference or borehole number and sheet number. Name of supervisor Or driller. Date of boring, types of boring, make of plants or tools. GL/RL; depth to ground water and raising or lowering of level including dates and time measured.

Type, size and depth of casing, drilling fluid/ Size, type and design of core bits, core barrel and reaming shell used. Types of in-situ testing, sampling and rock coring details (R/r, RQD, types of sampler). Depth, date and time of boring disruptions and determination of boreholes.

Any change to drilling fluid or drilling fluid return. Legends and symbols for subsoil profile. Soil or rock description of each stratum and thickness or levels shall be made in accordance to BS 5930.

Borings represent a considerable part of the cost of a site investigation. The total cost of an investigation project may be calculated simply on the basis of the number of boreholes and their depths.

Figure 36 shows a typical boring log. The log also include project name, bore hole no, supervisor name, date and etc.



BORANG
IS / SI - 01
DEEP BORING LOG

PROJECT : PROJEK . | Job No

Borehole No. : BH 1	Reduced Level: 17.289m	Supervisor :	
Sheet No. 1 of 3	Type of Drill: ROTARY	Date : 26.03.2007 - 27.03.2007	

DEPTH (meter)	DESCRIPTION OF SOIL CONSISTENCY, COLOUR RELATIVE DENSITY, GRAIN SIZE, TEXTURE ETC.	Legend	SAMPLE DEPTH (meter)	SAMPLE No.	Field Test 75 mm	75 mm	75 mm	75 mm	75 mm	75 mm	N	R/r (%)	SPT Plot
0.00	Top Soil - Light brown **SILT** of high plasticity. (MH)		0.00 0.20	D1									
1.00													
2.00	Stiff, light greyish red silty **CLAY.**		1.50 1.95	S1 D2	1	1	1	2	2	3	8	75	
3.00	Stiff, reddish white **SILT** of high plasticity. (MH)		3.00 3.45	S2 D3	1	2	2	3	2	2	9	70	
4.00	Reddish white silty **CLAY.**		3.50 to 4.25	UD1								70	
5.00	Firm, reddish white **SILT** of high plasticity. (MH)		4.50 4.95	S3 D4	1	1	2	1	1	1	5	70	
6.00	Loose, light grey fine to coarse very silty **SAND.** (silt of low plasticity) (SML)		6.00 6.45	S4 D5	1	2	1	1	2	2	6	50	
7.00													
8.00	- Ditto -		7.50 7.95	S5 D6	1	1	2	2	1	2	7	54	
9.00	- Ditto -		9.00 9.45	S6 D7	2	1	2	2	2	2	8	74	
10.00													

NOTES.
S = Standard Penetration Test (SPT)
D = Disturbed sample
N = SPT Result
R/r = Recovery ratio
VS = Vane Shear Test
S_u = Undrained Shear Strength
S_r = Remoulded Shear Strength
S_t = Sensitivity
UD = 50 mm dia. undisturbed sample
P = 50mm dia. undisturbed piston sample
M = Mazier Sample
W = Water sample
C = Core sample (Rock)
RQD = Rock Quality Designation (%)
WL = Water level
BSCS = British Standard Classification System

REMARKS

CONSISTENCY / RELATIVE DENSITY			
Cohesive Soil (N)		Non Cohesive Soil (N)	
0	Very Soft	0	Very Loose
2	Soft	4	Loose
4	Firm	10	Medium dense
8	Stiff	30	Dense
16	Very Stiff	50	Very Dense
32	Hard		

(SI Manager)
GEOLOGIST

Figure 36: Sample of bore log

e) Summary of all-important lab, test results for each .

GEOTECHNICAL LABORATORY

Summary Of Laboratory Test Results - BS 1377 : 1990

PROJECT : CAD. MEMBINA JAMBATAN

Your Ref :
Our Ref : IL
Job No : 23/06
Report No :
Date : 24.7.2006

BH No	Sample No	Depth (m)	MC %	Bulk Density Mg/m³	SG	1-D Consol Test: Pc kN/m²	1-D Consol Test: Cc	1-D Consol Test: Initial Void	UCT Test: c kN/m²	UU Test: c kN/m²	UU Test: φ Degree	CU Test: c' kN/m²	CU Test: φ' Degree	OM %	SO_3 %	SSO_4 mg/kg	pH	Cl %	SCl mg/kg	LL %	PL %	PI %	LS %	CLAY %	SILT %	SAND %	GRAVEL %
BH/1	S1D1	1.50 - 1.95	32		2.7101											151.5	3.80		ND(<2.0)	N.E.S	N.E.S	38	18	64	34	2	0
BH/1	UD 1	3.0-3.50	27		2.6349	80	0.163	0.77												54	33	21					
BH/1	S3D2	4.50 - 4.95	33		2.6480															N.E.S	N.E.S	47	22	61	36	3	0
BH/1	UD 2	6.0-6.50	30		2.7041				40											64	38	26		42	53	5	0
BH/1	S4D3	7.50 - 7.95	27		2.6697															N.E.S	N.E.S	38	18	36	60	4	0
BH/1	S7D6	12.00 - 12.45	23		2.6894															50	27	23		29	47	23	1
BH/2	S1D1	1.50 - 1.95	34		2.6768															46	28	18		49	42	9	0
BH/2	S6D6	9.00 - 9.45	26		2.7022									0.03						N.A	N.A	11	5	28	44	28	0
BH/3	S1D1	1.50 - 1.95	21		2.6862															46	28	18		21	49	30	0
BH/3	UD 1	3.00 - 3.50	33		2.6075	150	0.302	1.121	19.2	N.E.S						147.9			ND(<2.00)	N.E.S	N.E.S	11	5				
BH/3	UD 2	6.00 - 6.50	34		2.67							6	32			9.36			13.45	51	27	24					
BH/3	S5D5	10.50 - 10.95	30		2.6808									0.94		215.2			[illegible]	N.E.S	N.E.S	11	5	12	40	47	1
BH/4	S3D3	4.50 - 4.95	40		2.6165									1.23		91.1			<1.48	N.E.S	N.E.S	17	8	16	55	28	1
BH/4	S8D8	12.00 - 12.45	12		2.6639											223.5	3.70		ND(<2.00)	N.A	N.A	0	0	1		99	0
BH/5	S1D1	6.00 - 6.45	6		2.7821											N.E.S	N.E.S	-	N.E.S					4		96	0
BH/5	S7D7	15.00 - 15.45	13		2.6573											3003.9	7.61		[illegible]	N.A	N.A	0	0	4		96	0
BH/6	S2D2	6.00 - 6.070	6		2.7901											N.E.S	N.E.S		N.E.S	N.A	N.A	0	0	4		22	74
BH/7	S1D2	1.50 - 1.95	28		2.6155											ND(<4.0)	4.98		[illegible]	N.E.S	N.E.S	13	8	8	39	38	15
BH/8	S2D3	3.00 - 3.380	17		2.5469											ND(<4.0)			[illegible]	N.A	N.A	13	4	13	48	39	0
BH/8	S4D5	6.00 - 6.290	12											0.68		ND(<4.0)			ND(<2.00)	N.E.S	N.E.S	28	13	11	54	18	7
C-V9	S1D2	1.50 - 1.95	8		2.5316									0.18		ND(<4.0)			[illegible]	N.A	N.A	0	0	7	19	51	23
BH/10	S1D2	1.50 - 1.95	28													ND(<4.0)			[illegible]	N.E.S	N.E.S	28	13	45	36	19	0

NOTE : N.E.S = NOT ENOUGH SAMPLE N.A = NOT APPLICABLE N.D = NOT DETECTED

Laporan Disediakan Oleh	Disahkan Oleh

Figure 37: Summary test result

f) Generalized subsoil profile – drawing

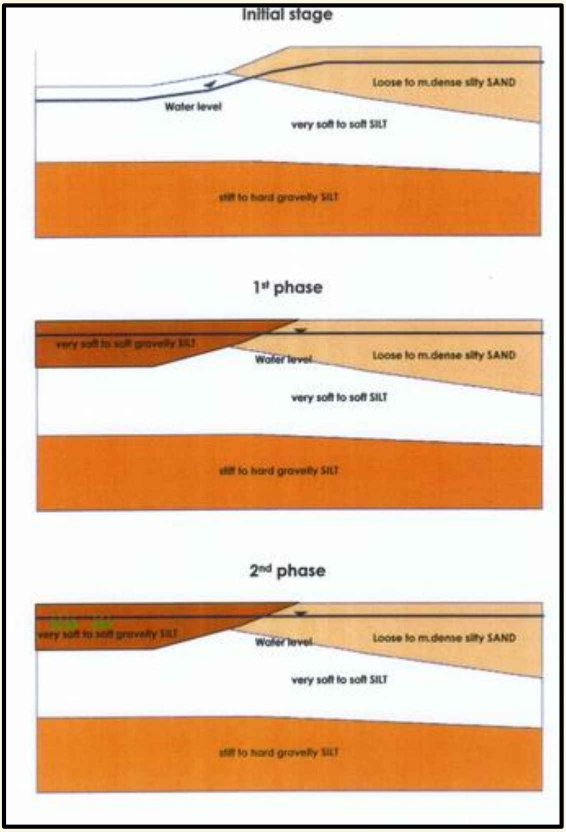


Figure 38: Sample of Subsoil profile

iii.Appendix – plan/ drawing; photo for site conditions, plant or machine set up, typical rock samples, typical soil samples etc.

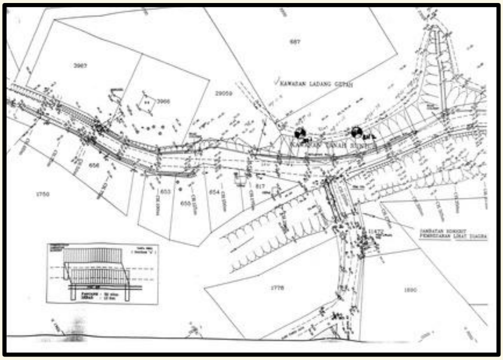


Figure 39: Location plan

Conclusion

This book that this guideline for site investigation works is useful and helpful to assist lecturer and students to plan and execute a proper site investigation works. The results of the investigation are interpreted in terms of the actual findings, and recommendations for design parameters should be made by experienced geotechnical engineers who are familiar with the purpose, conditions, and requirements of the site investigation study.

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Assessment

a) Define Site Investigation in accordance with BS 5930.

b) State **FOUR (4)** objectives of Site Investigation.

c) Describe the important of soil investigation in civil engineering project.

d) Site investigation is an important component of any development project. Explain clearly FIVE (5) main purpose of site investigation.

e) Explain briefly the following stages of Site Investigation

f) There are FIVE (5) stages of Site Investigation. Explain briefly the following stages of Site Investigation

g) Identify the work procedure in Site Investigation.

h) List FOUR (4) information that can be gathered during site reconnaissance

i) List down FOUR (4) information that can be gathered from a subsurface exploration of a site investigation.

j) Soil Investigation is one of the phases in Site Investigation which consist of sampling and lab testing. State FOUR (4) common test in site investigation

k) Give FOUR (4) advantages and FOUR (4) common errors in conducting the Probe Mackintosh Test.

l) Differentiate the advantages and disadvantage of Standard Penetration Test (SPT)

m) Explain the functions of Hand Auger.

n) Explain disturbed sample and undisturbed sample.

o) There are two types of soil samples you need to prepare during site exploration. Explain the types of soil sample you need to prepare to determine the distribution of grain particle and plasticity index.

p) Explain the important of laboratory test

q) Explain the contents of Site Investigation Report.

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