

HIGHER TECHNICAL INSTITUTE

NICOSIA - CYPRUS

CIVIL ENGINEERING COURSE

DIPLOMA PROJECT

SITE INVESTIGATION

C/834

LESTAS A. CHARALAMBOS

JUNE 1998

**HIGHER TECHNICAL INSTITUTE**

**NICOSIA - CYPRUS**

**CIVIL ENGINEERING COURSE**

**DIPLOMA PROJECT**

**SITE INVESTIGATION**

**C/ 834**

**LESTAS A. CHARALAMBOS**

**JUNE 1998**

HIGHER TECHNICAL INSTITUTE	PROJECT NO.  2816
----------------------------------	-------------------------

# **SITE INVESTIGATION**

**By:**

**LESTAS A. CHARALAMBOS**

**Project Report**

**Submitted to**

**The Department of Civil Engineering**

**of The Higher Technical Institute**

**Nicosia - Cyprus**

**In partial fulfilment of the requirements**

**for the diploma of**

**TECHNICIAN ENGINEER**

**in**

**CIVIL ENGINEERING**

**JUNE 1998**

HIGHER TECHNICAL INSTITUTE	PROJECT NO. 2816
----------------------------------	---------------------

<b>ACKNOWLEDGEMENTS</b>	
<b>SUMMARY</b>	
<b>Chapter One: INTRODUCTION</b>	<b>1</b>
1.0 Introduction	1
1.1 Objectives of Site Investigation	2
1.2 Site Investigation related with Civil Engineering	4
1.3 Types of Ground Investigation	6
<b>Chapter Two: FORMATION OF SOILS</b>	<b>8</b>
2.0 General	8
<b>Chapter Three: PLANNING OF SITE INVESTIGATION</b>	<b>11</b>
3.0 Introduction	11
3.1 Stages of a Site Investigation	13
3.2 Points to be considered	17
<b>Chapter Four: METHODS &amp; EQUIPMENT OF GROUND INVESTIGATION</b>	<b>19</b>
4.0 Introduction	19
4.1 Points to be considered	19
4.2 Methods of sub-surface exploration	20
4.2.1 EXPLORATION IN SOILS	22
4.2.1.1 Trial Pits	23
4.2.1.2 Large bored shafts	24
4.2.1.3 TV and borehole cameras	24
4.2.1.4 Hand or portable augers	27
4.2.1.5 Percussion Boring	28
4.2.1.6 Mechanical Augering	31
4.2.1.7 Probing	34
4.2.1.8 Wash Boring	36
4.2.1.9 Rotary Drilling	38
4.2.2 ROCK EXPLORATION	40
4.2.2.1 Rotary Coring	41
4.2.2.2 Drilled Shafts	41
4.2.2.3 Test pits	41
4.2.3 EXPLORATION IN WATER	43
4.2.4 GEOPHYSICAL METHODS OF SITE INVESTIGATION	48
4.2.4.1 Electrical resistivity	50
4.2.4.2 Gravitational methods	51
4.2.4.3 Seismic methods	52
4.2.4.4 Magnetic methods	52
4.2.4.5 Borehole logging	52
4.2.5 IN SITU TESTING	53

<b>Chapter Five: IN SITU TESTING &amp; SAMPLING</b>	<b>54</b>
<b>5.1 IN SITU TESTING</b>	<b>54</b>
5.1.1 Vane test	55
5.1.2 Penetration tests	58
5.1.3 Permeability tests	60
5.1.4 Plate tests	63
5.1.5 Pressuremeter tests	67
<b>5.2 SAMPLING</b>	<b>69</b>
5.2.1 DRIVE SAMPLERS	72
5.2.1.1 Open-drive samplers	72
5.2.1.2 Split-barrel samplers	73
5.2.1.3 Thin-walled tube samplers	73
5.2.1.4 Stationary piston samplers	75
5.2.1.5 Continuous soil sampling	75
5.2.2 ROTARY SAMPLING	76
5.2.3 SAND SAMPLERS	78
5.2.4 BLOCK SAMPLERS	80
<b>Chapter Six: LABORATORY TESTING OF SAMPLES</b>	<b>81</b>
6.0 Introduction	81
6.1 Classification of soils	82
6.2 Shear strength tests	89
6.3 Consolidation Tests	92
6.4 Permeability Tests	95
6.5 Compaction Tests	95
6.6 Chemical Tests	98
<b>Chapter Seven: SITE INVESTIGATION REPORTS</b>	<b>101</b>
7.0 General	101
7.1 The factual report	101
7.2 The Interpretive report	104
<b>Chapter Eight: SITE INVESTIGATION IN CYPRUS</b>	<b>106</b>
8.0 General	106
8.1 Boring and Drilling / Sampling	107
8.2 Testing: In Situ / Laboratory	109
8.3 Kind Of Reports	112
<b>CONCLUSION</b>	
<b>APPENDICES</b>	
<b>BIBLIOGRAPHY</b>	

<i>Fig. 1. 1 Works related with Civil Engineering construction and site investigation</i>	5
<i>Fig. 3. 1 Construction of piles for a proposed bridge</i>	12
<i>Fig. 3. 2 Stages of a Site Investigation</i>	15
<i>Fig. 4. 1 Borehole Layout</i>	21
<b>Table 4. 1 Application of the methods of soil exploration</b>	22
<i>Fig. 4. 2 Mechanical Excavator</i>	23
<i>Fig. 4. 3 Borehole Camera</i>	26
<i>Fig. 4. 4 Hand-operated Augers</i>	29
<i>Fig. 4. 5 (a) Percussion boring rig (b) Shell (c) Clay cutter (d) Chisel</i>	30
<i>Fig. 4. 6 Mechanical Augering</i>	32
<i>Fig. 4. 7 Classification of Mechanical Augers</i>	33
<i>Fig. 4. 8 A Mackintosh Probe</i>	35
<i>Fig. 4. 9 Wash Boring rig</i>	37
<i>Fig. 4. 10 Rotary Drilling</i>	39
<i>Fig. 4. 11 Destructive Drilling</i>	40
<i>Fig. 4. 12 Rotary Core Drilling</i>	42
<i>Fig. 4. 13 Standpipe and Standpipe piezometer installations</i>	44
<i>Fig. 4. 14 Hydraulic Piezometer</i>	46
<i>Fig. 4. 15 Pneumatic Piezometer</i>	47
<i>Fig. 4. 16 Sea-water investigations</i>	49
<i>Fig. 4. 17 Arrangement for a resistivity survey</i>	51
<b>Table 5. 1 Uses of in situ tests</b>	55
<i>Fig. 5. 1 Shear Vane test</i>	56
<b>Table 5. 2 Values of clay's hardness</b>	57
<b>Table 5. 3 N-values related to relative density</b>	59
<i>Fig. 5. 2 Standard Penetration Test (SPT) equipment</i>	59
<i>Fig. 5. 3 Dutch cone penetrometer</i>	61
<i>Fig. 5. 4 Packer permeability tests</i>	64
<i>Fig. 5. 5 Plate bearing test</i>	66
<i>Fig. 5. 6 Menard pressuremeter</i>	68
<b>Table 5. 4 Usage of sample quality related to type of soil</b>	71
<i>Fig. 5. 7 (a) Open drive sampler (b) Thin-walled sampler</i>	74
<i>(c) Split-barrel Sampler (d) Stationary piston sampler</i>	74
<i>Fig. 5. 8 Continuous sampler</i>	77
<i>Fig. 5. 9 Bishop sand sampler</i>	79
<i>Fig 6. 1 Grading soil chart with grading curves</i>	83
<i>Fig 6. 2 Water Content determination</i>	84
<i>Fig 6. 3 Graphical presentation of Atterberg Limits</i>	85
<i>Fig 6. 4 Cassagrande Plasticity chart</i>	87
<b>Table 6.1 British Classification System for Engineering Purposes</b>	88
<i>Fig 6. 5 Shear box test</i>	90
<i>Fig 6. 6 The unconfined compression test</i>	91
<i>Fig 6. 7 Triaxial test</i>	93
<i>Fig 6. 8 Consolidation test</i>	94
<i>Fig 6. 9 Constant head permeability test</i>	96
<i>Fig 6. 10 Falling head permeability test</i>	97
<i>Fig 6. 11 California Bearing Ratio test</i>	99
<i>Fig. 7. 1 Typical borehole record</i>	103
<i>Fig. 7. 2 Typical soil section</i>	105
<i>Fig. 8.1 Rotary Core Drilling in Cyprus)</i>	108
<i>Fig. 8.2 Geophysical and in situ tests carried out in Cyprus</i>	110

---

## ACKNOWLEDGEMENT

---

I would like to express my appreciation to all persons that have in any way contributed to the completion of this project. Thinking of acknowledgements, the greatest thanks must go to my project supervisor, Mr I. Economides, with whom I have discussed the different steps for the completion of this study.

I would also like to thank Mr A. Shiathas, geotechnical engineer of the GEOINVEST LTD, for his guidance and advise, especially concerning the information about Cyprus. Thanks are also expressed to the Land Survey Department and Mr A. Spyrou, site engineer of the Dhekelia Famagusta road.

Finally, I would like to thank all my lecturers of Civil Engineering Department, who though their lectures at the H.T.I., have helped me gain interest in Site Investigation, which resulted in this study.

---

## SUMMARY

---

Site Investigation is an essential part of the civil engineering process and can be thought of as a process of discovery. The procedure followed is outlined in the following steps: boreholes are drilled to vast depths; samples are recorded (in situ tests are also performed); and laboratory tests are carried out on the obtained samples. Thus, a picture of the ground and its properties is built up. Using this picture, the engineer can meet the challenge of determining how structures will interact with the ground so that a practical, safe and economic design can be produced.

This project is mainly intended to analyse the objectives of Site Investigation and to discuss its importance, in conjunction with the main procedures, equipment and plant used in the Site Investigation of civil engineering works. A survey about procedures and extent of Site Investigation in Cyprus is also made.

Chapter One, introduces Site Investigation; its types and objectives. It also gives its relationship with Civil Engineering Construction.

Chapter Two, describes the formation of soils in a general manner. An understanding of the geology of the site is a fundamental requirement in the planning and interpretation of ground investigation.

Chapter Three, deals with the planning of Site Investigation. The stages followed are: desk study; reconnaissance; and detailed investigation.

Chapter Four, describes the methods and equipment of ground investigation in soils, rocks and water. A description on the Geophysical methods used is also given.

Chapter Five, deals with the different kinds and procedures of in situ tests, as well as sampling. A description on the different kind of samplers used, as well as information on disturbed and undisturbed samples is also given.

Chapter Six, deals with laboratory testing. The different kinds of laboratory tests are outlined concerning the soil's classification, shear strength, consolidation, permeability, compaction and chemical composition.

Chapter Seven gives the importance of Site Investigation reports. The factual and the interpretive kinds of report are described.

Chapter Eight, describes the present day practise in Cyprus with reference to two projects (the Dhekelia Famagusta road and the Nice Day Tower).

Photographs, tables and graphs are used whenever possible, to give a clear explanation of plant and techniques in all aspects of this project. Four Appendices are provided for further reference.