

**HIGHER TECHNICAL INSTITUTE
CIVIL ENGINEERING DEPARTMENT**

DIPLOMA PROJECT

**CORRELATION OF THE CASSAGRANDE AND CONE
PENETROMETER TESTS FOR THE DETERMINATION OF
THE LIQUID LIMIT OF SOILS**

**by
NICANDROU APPOHODITE
THEOPHANOUS THEOPHANIS
CS/815**

1988

**CORRELATION OF THE CASSAGRANDE AND CONE
PENETROMETER TESTS FOR THE DETERMINATION OF THE
LIQUID LIMIT OF SOILS
C/815**

**BY:
NICANDROU APRHODITE
AND
THEOPHANOUS THEOPHANIS**

Project Report

**Submitted to:
The Department of Civil Engineering
of the Higher Technical Institute
Nicosia, Cyprus
in partial fulfillment of the requirements
for the diploma of
TECHNICIAN ENGINEER
in
CIVIL ENGINEERING**

21671081001

June 1997

**Project Supervisor: M. Poullaides
Senior Lecturer
In Civil Engineering
H.T.I**

External Assessor: K. Kyrou

Type of Project: Group

Date of submission: 10, June 1997

| | |
|----------------------------------|-----------------|
| HIGHER TECHNICAL INSTITUTE | PROJECT 2776 |
|----------------------------------|-----------------|

This study is dedicated to our Families

ACKNOWLEDGEMENTS

The authors are grateful to Mr M. Poullaides Senior Lecturer of the H.T.I., to Dr P. Michaelide of the GSD (Cyprus) and the K. Kyrou of the W.D.D for many helpful discussions during the preparation of this project.

CONTENTS

| | <u>PAGES</u> |
|---|--------------|
| ACKNOWLEDGEMENTS | |
| LIST OF CONTENTS | |
| LIST OF FIGURES | |
| LIST OF TABLES | |
| LIST OF PHOTOGRAPHS | |
| SUMMARY | |
| INTRODUCTION | 1 |
| OBJECTIVES | 2 |
| <u>CHAPTER 1: AN INTRODUCTION TO CLAYS</u> | |
| 1.1 What is clay | 3 |
| 1.2 Engineering properties of clays | 3 |
| 1.3 Limits of consistency of clay soils | 4 |
| 1.4 Cyprus clays | 5 |
| 1.4.1 Division of Cyprus clays | 5 |
| 1.4.1.1 Nicosia Marl | 5 |
| 1.4.1.2 Bentonite | 6 |
| 1.4.1.3 Red clay | 6 |
| <u>CHAPTER 2: CLASSIFICATION OF SOILS</u> | |
| 2.1 General | 12 |
| 2.2 Limits of consistency | 12 |
| 2.2.1 Particle size analysis | 13 |
| 2.2.1.2 Particle classification by size | 13 |
| 2.2.2 Atterberg limit tests | 14 |
| <u>CHAPTER 3: LIQUID LIMIT</u> | |
| 3.1 General | 15 |
| 3.2 Definition - Purpose | 15 |
| 3.3 Methods of determining Liquid Limit | 15 |

CHAPTER 4: CASSAGRANDE TEST

| | | |
|--------|-------------------------------------|----|
| 4.1 | General | 16 |
| 4.2 | Historical background of test | 16 |
| 4.3 | Apparatus | 16 |
| 4.4 | Procedure | 17 |
| 4.4.1 | Selection and preparation of sample | 18 |
| 4.4.2 | Mixing with water | 18 |
| 4.4.3 | Maturing | 19 |
| 4.4.4 | Adjustment of apparatus | 19 |
| 4.4.5 | Remixing | 19 |
| 4.4.6 | Placing in bowl | 20 |
| 4.4.7 | Cutting groove | 20 |
| 4.4.8 | Application of blows | 20 |
| 4.4.9 | Repeat run measurements | 21 |
| 4.4.10 | Moisture content | 21 |
| 4.4.11 | Repeat tests | 21 |
| 4.4.12 | Calculations | 22 |
| 4.4.13 | Results | 22 |
| 4.4.14 | Typical results | 23 |

CHAPTER 5: CONE PENETROMETER TEST

| | | |
|-------|-------------------------------------|----|
| 5.1 | General | 26 |
| 5.2 | Historical background of test | 26 |
| 5.3 | Apparatus | 26 |
| 5.4 | Procedure | 27 |
| 5.4.1 | Selection and preparation of sample | 28 |
| 5.4.2 | Mixing with water | 28 |
| 5.4.3 | Maturing | 28 |
| 5.4.4 | Checking apparatus | 28 |
| 5.4.5 | Remixing | 29 |
| 5.4.6 | Placing in cup | 29 |
| 5.4.7 | Adjustment of cone | 29 |
| 5.4.8 | Measuring cone penetration | 29 |

| | | |
|--------|------------------------------|----|
| 5.4.9 | Repeat penetration | 30 |
| 5.4.10 | Moisture content measurement | 30 |
| 5.4.11 | Remixing | 30 |
| 5.4.12 | Calculation and plotting | 31 |
| 5.4.13 | Results | 31 |
| 5.4.14 | Typical results | 32 |

CHAPTER 6: THE SURVEY

| | | |
|-------|--------------------------|----|
| 6.1 | Introduction | 34 |
| 6.2 | Methodology & Techniques | 34 |
| 6.2.1 | Methodology & Techniques | 34 |
| 6.2.2 | Sampling | 35 |
| 6.2.3 | Test performed | 35 |
| 6.2.4 | Presentation of results | 35 |

CHAPTER 7: DISCUSSION OF EXPERIMENTAL FINDINGS 36

**CHAPTER 8: CORRELATION OF THE CASSARANDE
AND CONE PENETROMETER TEST** 41

CHAPTER 9: GENERAL CONCLUSIONS ON THE PROJECT 44

REFERENCES 49

APPENDIX A: LABORATORY TEST RESULTS

APPENDIX B: PHOTOS

LIST OF FIGURES

| <u>Figure No</u> | <u>Page No.</u> |
|--|-----------------|
| 1.1 Consolidation of clay | 4 |
| 1.2 Characteristics of clays | 8 |
| 1.3 Geological map of Cyprus | 9 |
| 1.4 Grading of marl in accordance with the CaCO ₃ and clay content | 10 |
| | |
| 2.1 Limits of consistency of soils | 12 |
| 2.2 Index tests | 13 |
| 2.3 Atterberg limits | 14 |
| 2.4 Consistency states of soil | 14 |
| | |
| 4.1 Casagrande liquid limit apparatus | 25 |
| 4.2 Grooving tool and height gauge | 25 |
| 4.3 Casagrande liquid limits apparatus and tools | 18 |
| 4.4 Principle of Casagrande apparatus | 17 |
| 4.5 Grooving tool for casagrande apparatus (dimensions in mm) (from BS 1377:1975) | 24 |
| 4.6 Soil placed in Casagrande bowl, and use of grooving tool | 24 |
| 4.7 Groove before applying bumps | 24 |
| 4.8 Groove after applying bumps | 24 |
| 4.9 Liquid limit (cassagrande test) results and graph | 23 |
| | |
| 5.1 Transferring moisture sample to container | 31 |
| 5.2 Liquid limit (cone test) results and graph | 32 |
| 5.3 Cone Penetrometer Apparatus | 33 |
| 5.4 Details of cone for liquid limit test. | 33 |
| | |
| 7.1 Representations of categories of water surrounding clay particles | 37 |
| | |
| 8.1 Correlation of liquid limit results from two test methods (from BS 1377:1975) | 43 |
| 8.2 LL against LLu | 42 |

LIST OF TABLES

| | <u>Page</u> |
|---|-------------|
| 1.1 Field identification and classification of fine grained soils | 11 |
| 7.1 Liquid limit results determined with Casagrande and cone penetrometer tests | 37 |
| 7.2 Differences in LL values found by Cassagrande and Cone Penetrometer test. | 40 |
| 8.1 Liquid limit values | 42 |
| 9.1 Characteristic of cone | 48 |

LIST OF PHOTOGRAPHS

- 4.1 Cassagrande apparatus
- 5.1 Cone penetrometer apparatus
- 1. General view of bentonite in Pentakomo (cutting slope)
- 2. Pliocene marl of Nicosia
- 3. Stratified Mamonía mudstones
- 4. Superficial Melagne overlying folded and sheared stratified
- 5. Kannaviou Clay
- 6. Striated, Slickensided Melagne Shear Surface at base of Slipped Chalk debris
- 7. Recent shallow rotational slip in Kannaviou

SUMMARY

The main purpose of the project was to correlate experimentally the cassagrande and the cone penetrometer tests. To fulfil this purpose, different type of clay samples were tested using the before said tests and liquid limit values were found.

The approach followed was based on ten elements:

Chapter 1, which constitutes the first element, was entirely devoted on giving information about clays such as engineering properties and to give a brief reference of the Cyprus clays and its division.

Chapter 2, which is the second element is a general report about soils classification.

Chapter 3, the third element, is based on the engineering meaning of liquid limit.

Chapters 4 and 5, briefly describe the two methods used for the determination of liquid limit; cassagnade and cone tests.

The sixth chapter, state the preliminaries for the project.

Chapters 7, 8, 9 are composed of the discussion of experimental findings, the correlation of two test and lastly general conclusions on the project.

Finally, the references which form the final element state the different hints which helped for the completion of this project.

1. INTRODUCTION

This report, occupies with the engineering importance of the liquid limit in civil engineering projects. In fact this is studied indirect as the main aim centralises on the Cassagrande and Cone Penetrometer test and the question: "Which is the most reliable and accurate test for the determination of liquid limit".

Since the central objects were the experiments, hence a laboratory work was "imposed". The laboratory work was carried out in the Higher Technical Institute Soil's laboratory from a variety of samples taken from different areas of Cyprus, during the academic year 1996-1997.

The samples taken, consisted of clays of the variable groups of Cyprus clays.

After the tests have been conducted, a desk study followed for working out the results.

This study born the relationship between Cassagrande and Cone Penetrometer tests together with the answer of the question made on the beginning of the introduction.

2. OBJECTIVES

The main objectives of the present study were:

- (a) To correlate experimentally the Cassagrande and Cone Penetrometer tests.
- (b) To explain in depth the results of the experimental findings.
- (c) To give a brief account of the usefulness of the Liquid Limits in soils with special emphasis to the Cyprus practices.

It was intended to perform the two tests on as many samples of fine-grained soils as possible. The samples were taken from different areas of Cyprus so as to include low, intermediate and high compressibility soils. It was also intended to cover as much as possible of the large variety of Cyprus clays so as to establish a relationship of between the two experiments. and to reveal the most suitable and reliable test for the determination of L.L Emphasis was also given to the usefulness of the L.L of soils for the different engineering projects.