

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	x
	LIST OF FIGURES	xi
	LIST OF SYMBOLS	xiii
I	INTRODUCTION	1
	1.1 Background Of The Problem	1
	1.2 Problem Statement	3
	1.3 Objective Of Study	4
	1.4 Scope Of Study	4
	1.5 Site Location	5

II	LITERATURE REVIEW	7
2.1	Introduction	7
2.2	Clay	8
2.2.1	Clay Minerals	9
2.2.2	The importance Of Clay Fraction	12
2.2.3	Cation Exchange	14
2.2.4	Specific Gravity (Gs)	16
2.3	Electro-osmosis	16
2.3.1	Theories of Electro-osmosis	20
2.3.1.1	The Helmholtz Smoluchowski Theory	20
2.3.1.2	The Schmid Theory	23
2.3.1.3	Spieglers Theory	25
2.3.2	Electro-osmosis as a Method of Consolidation and Dewatering	28
2.3.3	Electro-osmosis as a Method of Introducing Chemicals into Fine-grained Soils	32
2.4	Electrochemical	34
III	RESEARCH METHODOLOGY	40
3.1	Introduction	40
3.2	Literature Review	40
3.3	Laboratory Experiments	41
3.4	Sample Preparation for Electro Kinetic Processing	43
3.5	Preparation of Samples For Laboratory Experiments	46
3.6	Geonor Vane Shear Test	49
3.7	Soil Testing	50
3.7.1	Grained Size Distribution	50
3.7.1.1	Hydrometer (Sedimentation)	51
3.7.2	Atterberg Limit	53
3.7.2.1	Plastic Limit	54
3.7.2.2	Liquid Limit	54

	3.7.2.3 Plasticity Index	56
	3.7.3 Specific Gravity	57
	3.7.4 pH	58
	3.7.5 Atomic Absorption Spectroscopy (AAS)	59
IV	RESULT AND DISCUSSION	63
	4.1 Introduction	63
	4.2 Characteristic of Kahang Clay	64
	4.2.1 Atterberg Limit	64
	4.2.2 Particle Size Distribution (Hydrometer)	66
	4.2.3 Specific Gravity	72
	4.2.4 Atomic Absorption Spectroscopy (AAS)	73
	4.2.5 pH Value	74
	4.3 Laboratory Result	76
	4.3.1 Dewatering of Kahang Clay	76
	4.3.2 Shear Strength of Kahang Clay	79
	4.4 Calculation of Co-efficient of Electro-osmotic Permeability	83
	4.5 Electrochemical Reaction	84
V	CONCLUSIONS AND RECOMMENDATIONS	89
	5.1 Introduction	89
	5.2 Conclusions	90
	5.3 Recommendations	92
	REFERENCES	94
Appendix A	Vane Shear Test Guide	97
Appendix B	Atomic Absorption Spectroscopy Result	107

LIST OF TABLES

NO	TITLE	PAGE
2.1	Size and properties of soil particles	9
2.2	Cation exchange capacity of organic matter and clays	15
2.3	Specific gravity of common minerals	16
3.1	Hydrometer reading	52
4.1	Plastic limit result	64
4.2	Liquid limit result	65
4.3	Typical liquid and plastic limit result for some clay types	66
4.4	Hydrometer result	67
4.5	Hydrometer calibration for serial No.3286	69
4.6	Particle density of Kahang Clay result	72
4.7	Atomic Absorption Spectroscopy result	74
4.8	Shear strength due to electro-osmosis on Kahang Clay	80
4.9	Electro-osmosis permeability coefficient	84

LIST OF FIGURES

NO	TITLE	PAGE
1.1	Location of Johor state in Malaysia	5
1.2	Site location of where the samples were collected	6
2.1	(a) Silica tetrahedron; (b) Silica Sheet; (c) alumina octahedron; (d) octahedral (gibbsite) sheet; (e) element silica-gibbsite sheet	10
2.2	Atomic structure of kaolinite	11
2.3	Diagram of the structures of (a) kaolinite; (b) illite; (c) montmorillonite	11
2.4	Scanning electron micrograph of a kaolinite specimen	12
2.5	Diffuse double layer	13
2.6	Dipolar character of water	13
2.7	Attraction of dipolar molecules in diffuse double layer	14
2.8	Helmholtz-Smoluchowski model for electrokinetic phenomena	21
2.9	Schmid model for electro-osmosis	23
3.1	Flow chart of research methodology	42
3.2	Schematic diagram of the electro kinetic experiment	44
3.3	Escalated shape of the electrode	45
3.4	Coil shape of the electrode	45
3.5	Three types of electrodes (i.e.; cuprum, aluminium and ferum)	47
3.6	Sample preparation	47
3.7	Placing slurry into mould	48

3.8	5 set up of the sample during experiment	48
3.9	Multimeter and D.C power with 5 experiments running	49
3.10	Geonor vane shear test H-6	49
3.11	Sample preparation	51
3.12	Mechanical shaker testing	52
3.13	Hydrometer testing	52
3.14	Soil hydrometer	52
3.15	Parameters of atterberg limit	53
3.16	Plastic limit test	54
3.17	Mixing water into soil	55
3.18	Liquid limit test	56
3.19	Specific gravity vacuum	57
3.20	Weight of pyknometer with soil and without soil	57
3.21	pH meter	58
3.22	Flow chart for digestion of solid sample	60
3.23	Atomic Absorption Spectroscopy	62
4.1	Cone penetration test on Kahang Clay	65
4.2	Calibration for hydrometer	69
4.3	Grading curve from hydrometer test	70
4.4	Plasticity chart	71
4.5	Triangular classification chart	71
4.6	Geological map of Johor area	75
4.7	Major soil types in Johor	75
4.8	Cumulative of Dewatering Water due to Various Electrode Types	76
4.9	Dewatering due to electro-osmosis versus electrode types	78
4.10	Cumulative water to days of experiment	79
4.11	Shear Strength of Ferum 1	80
4.12	Shear Strength of Ferum 2	81
4.13	Shear Strength of Aluminium	81
4.14	Shear Strength of Cuprum	82
4.15	Ferum electrode after electro-osmosis	85
4.16	Cuprum electrode after electro-osmosis	86
4.17	Aluminium electrode after electro-osmosis	88

LIST OF SYMBOLS

A	-	Area
A_o	-	Concentration of wall charges in ionic equivalent per unit volume
AAS	-	Atomic Absorption Spectroscopy
AEC	-	Anion exchange capacity
Al	-	Aluminium
Am	-	Amp meter
AASHTO	-	American Association of State Highway and Transportation Official
ASTM	-	American Society for Testing and Materials
BS	-	British Standard
C	-	Coarse (Pg.70)
Ca^{2+}	-	Calcium
CEC	-	Cation exchange capacity
CH	-	Clay high plasticity
cm	-	Centimeter
Cm	-	Meniscus correction
Cu	-	Cuprum
c_1	-	Concentration of mobile cations
c_3	-	Concentration of free water
D	-	Dielectric constant
D.C	-	Direct current
DDDW	-	Double distill de-ionized water
E	-	Electric potential
EO	-	Electro-osmosis
F	-	Fines (Pg.70)
f_a	-	Faraday constant

Fe	-	Electrical force per unit length (Pg.24)
Fe	-	Ferum
F_n	-	Hydraulic force
g	-	Gram
G_s	-	Specific gravity
i_e	-	Hydraulic gradient (Pg.18)
i_h	-	Hydraulic gradient (Pg.23)
kPa	-	Kilo Pascal
K^+	-	Potassium
K_e	-	Electro-osmosis permeability
l	-	Length measured along the capillary
LL	-	Liquid limit
M	-	Medium (Pg.70)
mL	-	Mililiter
mm	-	Milimeter
Mg^{2+}	-	Magnesium
Mn	-	Manganese
m_s	-	Mass of sample
MIT	-	Massachusetts Institute of Technology
NH^{4+}	-	Ammonium
n	-	Porosity of the soil
Pa	-	Pascal
PI	-	Plasticity index
PL	-	Plastic limit
Q_T	-	Total flow
q_e	-	Hydraulic flow (Pg. 27)
R	-	Radius of capillary
s	-	Second
USCS	-	Unified Soil Classification System
USDA	-	U.S. Department of Agriculture
v	-	Velocity
V	-	Volt (Pg. 34)

V_m	-	Volt meter
V_s	-	Volume of sample
x_{13}	-	Friction coefficient between cation and water
x_{34}	-	Friction coefficient between water and the pore wall
Z	-	Zeta potential
Zn	-	Zinc
μm	-	micrometer
η	-	Kinematic viscosity of electrolyte
σ	-	Surface charge density
ζ	-	Potential across a condenser
$\frac{\Delta E}{\Delta L}$	-	Voltage gradient
γ_w	-	Density of water
Ω	-	True electro-osmotic plug
ρ_s	-	Particle density