Possibility of Stabilizing Peat Soil Using Electroosmotic Method

By

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CERTIFICATION OF APPROVAL

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Civil Engineering Programme
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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

HASLIN IDAYU AMARUDDIN

TABLE OF CONTENT

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Background Study

Major construction problems related to structure on soft soil such as peat are low shear strength and large compressibility. Peat soil normally, very high in water content and has low dry density. Thus, it has low shear strength. Any construction on this type of soil is usually avoided. It is because any construction on peat soil requires soil modification to increase the strength of the soil and to avoid long term consolidation. Therefore, it will raise the overall cost of the construction.

However, it was reported by Duraisamy (2007) in his journal that about three million hectares of land in Malaysia is covered with peat. The construction on peat soil area sometimes cannot be avoided. Then, several innovation techniques are developed to overcome the problem of peat land area.

Electrokinetic stabilization is a new method of ground improvement where direct current (DC) is applied through a wet soil mass via a pair of electrodes to promote the migration of stabilizing agents into the soil. This technique has been approved effective in treating soft soils such as clay as published in some journal.

This type of stabilization method has an advantage of not disturbing site activities. It is suitable for construction works that requires soil improvement without any excavation. In addition, it is possible to use this method to improve the low strength soil exists in the place where other methods cannot access the soil directly such as radio active waste facilities or volcanic areas. However, the processes of electrokinetic method are complex and difficult to predict (Otsuki *et al.*, 2006).

1.4 Scope of Study

This study will be using the electroosmotic method to treat peat soil. The undisturbed peat soil sample is collected and the basic physical properties testing will be carried out. The tests are Atterberg limit, particle size distribution, particle density, pH, conductivity, XRD, shear strength, moisture content and hydraulic test.

The peat soil will be stabilized using electroosmotic equipment under the influence of direct current. The stabilization process will be carried out at different current voltages and surcharge loads.

The basic soil properties testing are conducted again after the treatment process. Then, the results obtained will be compared to the initial basic testing results to see the effect of the treatment in improving the peat soil in term of strength and basic engineering properties.

The equipments used in this research are electroosmotic cell, LVDT measurement, connection wire, computer software, power supply, multimeter, vane shear, oven, pH meter and conductivity meter. The figures of the equipments are provided in appendix (Figure 2).

The selected peat soil is obtained from Tasik Bera, Pahang which located in the south east of Pahang. The location of the Tasek Bera is shown in appendix. Electrochemical stabilization is not applied in the experiment; therefore the improvement might be very small. Further study must be done to observe the effects of chemical solution to the soil specimen.

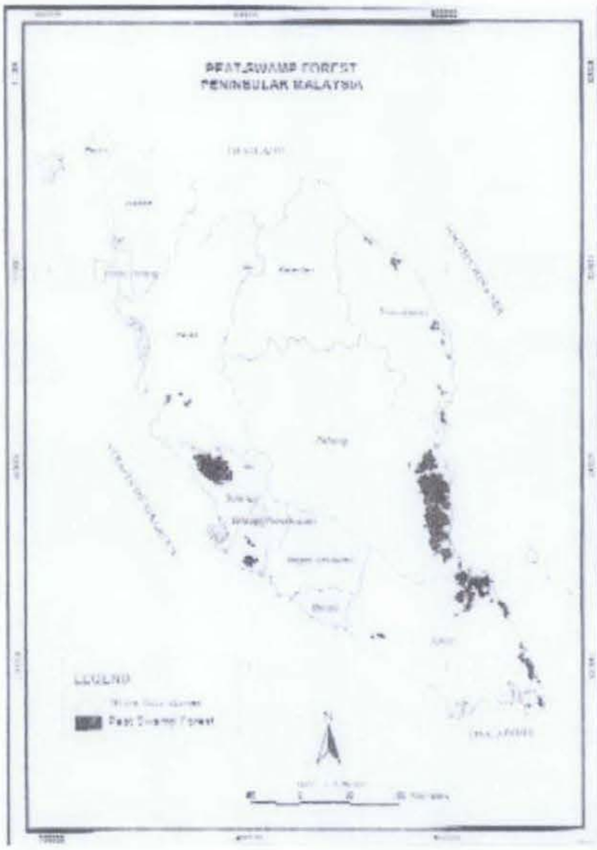

Figure 2-1: Peat Swamp Forest in Peninsular Malaysia (Peat-Portal)

2.2 Peat Soil Engineering Properties

Peat actually represents an accumulation of disintegrated plant remains, which have been preserved under condition of incomplete aeration and high water content (Huat, 2005). Peat is generally found in thick layers in limited areas, has low shear strength and high compressive deformation which often results in difficulties when construction work is undertaken on the deposit.

Peat is organic soil that consists more than 70% of organic matters. Peat at different locations will have different fiber content and organic content due to some factors such as fiber origin, temperature and humidity.

2.3 Electroosmosis Method of Soil Improvement

The construction of structures on areas with soft and incapable soils requires some improvement of the soil conditions. The choice of the appropriate technique has to be made depending on the type of soil, the load applied and the time available for the improvement process.

The improvement of ground by the application of electric current is a technique that has been employed successfully throughout the world. Electric current was applied to ground improvement since 1930s (Casagrande, 1949). In the five decades since its first application, electro-osmosis has been used in applications such as (1) improving stability of excavations, (2) increasing pile strength, (3) stabilization of fine-grained soils, (4) dewatering of foams, sludges, and dredgings, (5) groundwater lowering and barrier systems, (6) chemical grout injection, (7) removal of metallic objects from the ocean sea bottom, (8) decreasing pile penetration resistance, (9) increasing petroleum production, (10) determination of volume change and consolidation characteristics of soils, (11) removal of easily water-soluble salts from agricultural soils, and (12) separation and filtration of certain materials in soils and solutions (Acar and Gale, 1997).

The electroosmosis term is defined as a method of reducing the water content of the selected soil and thus increasing the shear strength. Electroosmosis basically is one of the processes occur during electrokinetic stabilization. Electrokinetic stabilization generates three basic electrokinetic processes as elaborated as follows (Syed, 2007):

1. Electrophoresis – the migration of charged colloids, not small ions, in solid-liquid mixture under electric potential gradient, where discrete particles are transported through water.
2. Electromigration – the movement of charged ions towards the oppositely charged electrodes relative to solution. In a dilute system or a porous medium with moderately concentrated aqueous solution of electrolytes, electromigration of ions is the major cause of current conduction. With regard to contaminated soils, electromigration is the primary mechanism of electroremediation when the contaminants are ionic or surface charged.

3. Electroosmosis- involves water transport through a continuous soil particle network, where the movement is primarily generated in the diffuse double layer or soil moisture film. The principle mechanism in electroosmosis is the migration of ions, where the cations migrate to the cathode and the anions move toward the anode.

Electroosmosis provides uniform pore water movement when properly applied. The movement of water from anode to cathode results in the consolidation between electrodes proportional to the quantity of water removed. Transportation of water away from anode results in the development of negative pore water pressure, which results in increases in effective stress hence increase the shear strength.

Electroosmotic method has been proven to be effective in stabilizing and consolidating soils both in laboratory and in the field (Mitchell and Wan, 1977). Electroosmotic consolidation induced the reduction of moisture content and increase shear strength (Shang and Dunlap, 1996). It was indicated from Casagrande's work that small reduction in moisture content by electroosmosis could produce significant increase in soil strength.

Electroosmotic treatment however in some cases is not always effective. The relative contribution of electroosmosis and ion migration to the total transportation of water varies according to soil type, water content, and type of ion species, pore fluid concentration ions and processing conditions. Electroosmosis treatment is only applicable in fine grained soils which include silts, clayey silt and fine clayey-silty sands and will be of no advantage to a coarse grain material such as sand with hydraulic conductivity of $k_h \geq 50 \times 10^{-4}$ cms^{-1} (Casagrande, 1952).

Beside the movement of water between electrodes, the effectiveness of electoosmotic process is influenced by oxidation and reduction of water molecules as the electrons are transferred in and out the system. The oxidation and reduction of water molecules trigger the formation of other sequential effects such as ion diffusion, ion exchange, mineral decomposition, precipitation of salts, electrolysis, hydrolysis, physical and chemical absorption and fabric changes (Mitchell, 1993).

2.3.1 Electrolysis

Electrolysis at the electrodes causes hydrogen (H^+) and hydroxide (OH^-) ions to be released from anode and cathode respectively. Application of direct current via electrodes immersed in water results in oxidation at anode and reduction at the cathode by following reactions (Acar and Alshawabkeh, 1993):

At the anode:

$$2H_2O - 4e^- \rightarrow O_2\uparrow + 4\,H^+ \tag{1}$$

At the cathode:

$$2H_2O + 2e^- \rightarrow H_2\uparrow + 2\,OH^- \tag{2}$$

Reduction of water molecules at the cathode doubles the amount of water molecules undergoing oxidation at anode. If the resulting ions are not removed or neutralized, an acid front (that is, an area of decreased pH) will develop at the anode, while a base front (that is, an area of increased pH) develops at the cathode. When these two fronts meet, they form a neutralized zone of very low conductivity (Barker, 2004).

2.3.2 Electrode reactions

The reactions that occur between the electrodes and the pore water depend on the characteristics of the pore and the material properties of the electrodes. From corrosion theory it is known that oxidation of the hydroxide forming oxygen occurs at the anode owing to the loss of electrons, while reduction of hydrogen from water occurs at the cathode (Owen and Knowles, 1994). Both reactions at the anode and cathode are as follows:

At cathode:

$$2H_2O \rightarrow H_3O^+ + OH^- \tag{3}$$

$$H_3O^+ + e + M \rightarrow MH + H_2O \tag{4}$$

$$MH + H_3O^+ + e \rightarrow H_2\uparrow + 2H_2O + M \tag{5}$$

Or

$$2\,H_3O^+ + 2e \rightarrow H_2\uparrow + 2H_2O \tag{6}$$

Or

$$4H_2O + 4e \rightarrow 2H_2\uparrow + 4OH^- \quad (7)$$

As shown above, the principle reaction at cathode is the reduction of hydrogen from water (Potter, 1956), where M is the metal used as the electrode. This process results in increase in concentration of hydroxide ions, enhances the precipitation of metallic hydroxide and the liberation of hydrogen gas. The increase in hydroxide ion is indicated by an increase in the pH value in the vicinity of the cathode. Similar observation have been made by Eykholt and Daniel (1994) and Alshawabkeh and Acar (1996).

At anode, metal corrodes into its oxide and the oxidation of hydroxide ions from oxygen. The following equation described the chemical reaction;

$$2H_2O \rightarrow H_3O^+ + OH^- \quad (8)$$

$$OH^- + M \rightarrow MHO + e \quad (9)$$

$$MHO + OH^- \rightarrow MO + H_2O + e$$

(10)

Or

$$4OH^- \rightarrow O_2\uparrow + 2H_2O + 4e \quad (11)$$

Or

$$2H_2O - 4e \rightarrow O_2\uparrow + 4H^+ \quad (12)$$

The reactions at anode result in the liberation of oxygen and the production of hydrogen ions. The increase in the hydrogen ions lowers the pH at the anode. The chemical reaction above depends on the type of metal used as electrodes. If copper is used as the anode, copper oxide is formed at the anode with a little or no liberation of oxygen.

Barker (2004) described the ability of applied electric current in promoting the migration of pore water and chemical solutions through the region of soil between electrodes. He found that there was migration of pore water from anode to cathode. The pH was found to reduce up to 2m from the anode, whereas small increases in pH were observed within around 0.7m from cathode. The increases observed may be attributed to the reduction of water near cathode; the decreases may be due to electrode corrosion and the oxidation of water near anode.

2.3.3 Electroosmotic consolidation

Consolidation or pre-compression of soils through electroosmosis is based on extraction of pore fluid in the soil with an electric potential applied between an anode and a cathode. Suction generated by the electroosmotic transport of the pore fluid decreases the void ratio of the soil, and can thereby cause settlement of the deposit. This higher density improves the soil characteristics, and reduces further settlement of structures placed in such deposits. This flow of pore fluid can also be used to stabilize slopes.

One of the method in which soil could be consolidated is applying a vertical load on the soil's surface. The applied vertical loads or pressure can be due to the self weight of the soil structure or surcharge load. When this load applied to the soil, there will be a build up in the pore water pressure and the process of consolidation can be used to induce an additional effective pressure or to accelerate the dissipation of positive pore pressure. After the positive pore water pressure induced by the direct loading had dissipated, the electroosmosis continues to induce negative pore water, causing further consolidation. Thus, if electroosmotic action is required to stabilize the soil, the process could go on after all the excess positive water pressure has dissipated (Hamir, 1997).

The theory combining these two methods of consolidation was presented by Wan and Mitchell (1976) indicating that applying electroosmotic consolidation on top of vertical loading or surcharge results in a more rapid dissipation of excess pore water pressure. Basically, the desired effect of electroosmosis is the removal of water from soil mass which results in the consolidation and stabilization of the treated soil. Therefore, the consolidation aspect of the process is also special interest to many researchers.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The research was carried out in two semesters. Therefore, it has conducted in two phases. In the first phase, it involved the basic testing on peat soil samples. Then, the actual test was carried out on the second phase in the second semester. This research basically focused on laboratory tests on the soil sample. Literature review was carried out to understand the natural behavior or properties of the peat soil and the problems related to it. Literature review was also done to understand the aspect of electrokinetic treatment and process on soils.

3.2 Research Methodology

3.2.1 Literature Review

Further information research had been carried out to find more related articles. Literature Review is the analytical, critical and objective review of written materials on the chosen topic and area. It provides the background information on the research question and to identify what others have said and/or discovered about the question. It contains all relevant theories, hypotheses, facts and data which are relevant to the objective and the findings of the project.

3.2.2 Basic Physical and Chemical Tests on Soil

The peat soil was obtained from Tasek Bera, Pahang. This swamp is a natural swamp that has been formed hundred thousand of years ago and has about 10 m deep of peat soil in the bed of the swamp. The undisturbed samples were collected using hand auger.

Figure 3-1: Soil Sampling Location in Tasek Bera

In the first phase, all the basic testing was carried out to obtain the engineering properties of the peat soil such as shear strength, moisture content, Atterberg limits and others. Some of the tests are listed below:

i. **Vane Shear Tests:**

These tests were carried out on the undisturbed samples brought from site and on the remolded sample after every treatment using electroosmosis. All procedures in these tests were in accordance to BS1337: Part7: 1990.

ii. **Permeability Test (Falling Head Test)**

This test was performed to determine the coefficient of permeability of a soil using falling head method. Coefficient of permeability, k is the rate of flow under laminar flow conditions

viii. **X-Ray Diffraction (XRD) and X-Ray Fluorescence (XRF) Analysis**

This test was done to compare the mineralogical pattern of the soil. From these tests, the mineralogical content of the soil was presented in a graph.

ix. **pH Tests**

pH value of the treated and untreated soil samples were taken using digital pH meter. These tests were conducted in accordance to BS1337: Part 3:1990.

x. **Conductivity Tests**

The electrical conductivity of the soil was measured using conductivity meter. The soil specimens prepared for measurement of pH were also used for measurement of conductivity.

xi. **Loss of Ignition**

This experiment was done to find the organic content of the soil sample. The test was conducted in accordance to ASTM D 2974.

3.2.3 Actual Electroosmotic Test

In the second phase of the research, the actual electroosmotic were carried out. The tests took about eight weeks to complete, if no distraction such as equipment failure occurs during the testing period.

The tests were divided into two categories, test using 10Kpa surcharge load and 20Kpa surcharge load. For each category, 0, 10, 30 and 60 volt of current voltage as shown in table 1 was applied. The soil sample was dried out for 24 hours before started the test. Then, it was mixed with distilled water and leaved it for 24 hours, so that it became homogenous. The percentage of water added approximately to the liquid limit of the peat. After a day, the sample was placed in the electroosmotic cell equipment and the test was started. The cell then was monitored daily for seven days. The figures of the processes are provided in appendix (Figure 3).

3.3 Hazard Analysis

Hazard is anything that can cause harm to the user in the workplace area. It must be identified as preventive measure before some accidents occur. Hazards analysis includes physical and chemical hazards. Since there are potential hazards in the workplace, therefore safety precaution must be taken seriously into consideration.

Table 3-2: Hazard Analysis

AREA	ACTIVITY	HAZARD	EFFECTS	PRECAUTION
Geotechnical Lab	Sieve analysis Plastic and Liquid limit test	Dust	Respiration problems	Wear nose protection (mask)
Geotechnical Lab	Oven Dry Process	Heat	Injuries	Wear glove
Geotechnical Lab	Electroosmosis	Electricity	Short circuiting	Avoid contact with wet hand

RESEARCH METHODOLOGY FLOW CHART

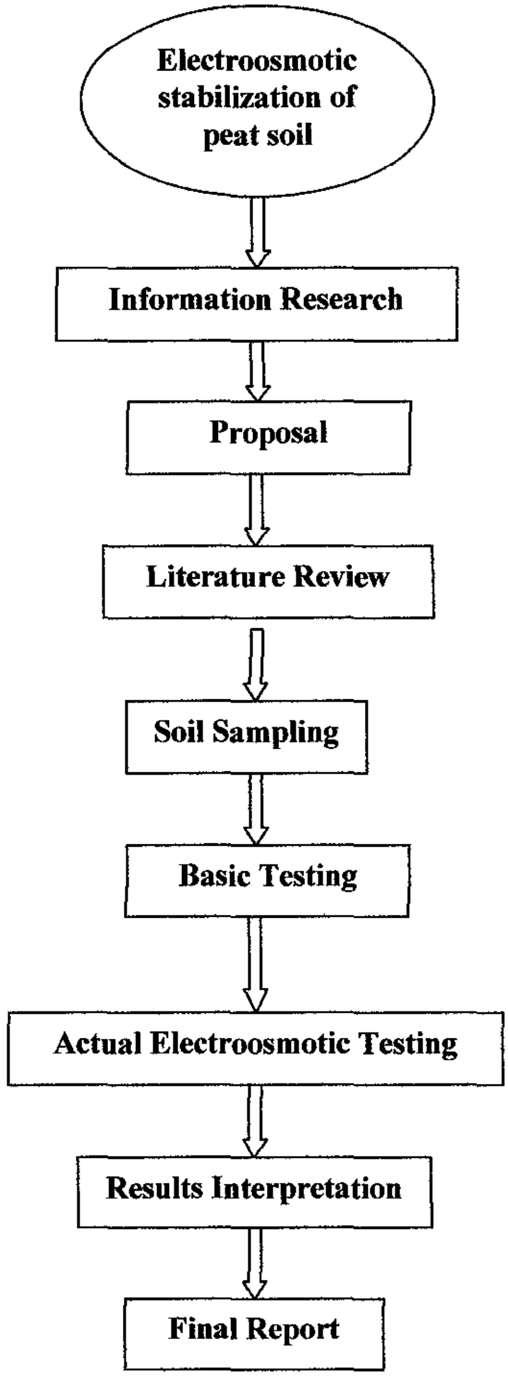

Figure 3-3: Research Methodology's Flow chart

Table 3-3: Gantt chart

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	First Semester (Phase 1)														
1	Selection of Project Topic	■													
2	Preliminary Research Work		■	■											
3	- Literature Review				■	■	■	■	■						
	- Methodology							■	■						
4	Collection of Soil Sample									■					
5	Basic Engineering Properties Tests										■	■	■	■	
6	Final Report													■	■
	Second Semester (Phase 2)														
7	Actual Testing														
	- Electroosmosis Method	■	■	■	■	■	■	■	■	■					
8	Engineering Properties Tests		■	■	■	■	■	■	■	■	■				
9	Final Report											■	■	■	
10	Oral Presentation														■

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Peat Soil Basic Properties Testing

Results of the various tests on the basic properties of peat soil as mentioned in section 3.2.2 are given in Table 4.1. Supplementary results are included in Appendix A.

Table 4-1 : Basic properties results

No	Basic Engineering Properties	Values
1	Moisture content	277 %
2	Liquid limit	112 %
3	Plastic limit	59.85 %
4	Plasticity index	52.05 %.
5	Specific gravity	1.58
6	Permeability	6.1 x 10^{-5} cm/sec
7	Particle size analysis	
	Silt	4.8 %
	Sand	94.1 %
	Gravel	1.1 %
8	Vane shear strength	11.13 KN/m^2
9	pH	3.9
10	Conductivity	640 micro Siemens/cm
11	Organic content	30 %
12	Mineralogical content from XRD	Carbon, Kaolin mineral.

The soil sample was taken from Tasek Bera, Pahang. Tasek Bera is a natural peat swamp that is located in the Southeast region of Pahang. The major remaining areas of peat swamp in Malaysia are the North Selangor Peat Swamp, Kuala Langat (South Selangor) and Southeast Pahang Peat Swamp (from Kuantan to Endau along the east coast). The map of Tasek Bera location is provided in the appendix (Figure 1). Peat soil generally has very high natural water content due to its natural water-holding capacity. Huat (2004) as cited by Duraisamy (2007) stated that the average natural water content of peat in Malaysia ranges from 200% to 700%.

Therefore, the obtained values of moisture content fulfill this statement since the average natural water content is 277 %. The high moisture content obtained indicates that the selected soil has natural water-holding capacity. On the other hand, the liquid limit 112% was not in the range 200% to 500% as reported by Huat. The specific gravity 1.58 falls in the range of 1.07-1.7. Specific gravity of peat depends greatly on its composition and percentage of the organic content. The lower specific gravity indicates a lower degree of decomposition and low mineral content. The hydraulic permeability, k was 6.1 x 10^{-5} cm/sec which is lower than 50 x 10^{-5} cm/sec, the maximum value of permeability considered to be suitable and advantageous for electroosmotic treatment, Casagrande (1952).

The 30% organic content for peat soil obtained from loss of ignition experiment indicates that the soil had low organic content. The organic content for peat soil is about 75% in average. There may be some error during experiment such as the ash was not fully burned that will affect the end results. The ignition period may vary with type of soil and size of sample. Visual identification of the soil shows that the soil was slightly decomposed peat which, when squeezed, it releases very muddy brown water, but from which no peat passes between fingers. According to von post classification published by Huat (2004), the soil was classified as H3. Referring to Figure 4 in appendix, XRD test indicate that the sample contains kaolinite minerals and carbon. Particle size distribution analysis has been conducted and was found that the soil falls under sandy soil category according to British Soil Classification System. The percentage soil passing 63μm was 4.8%. The soil is predominantly sand. For a soil such peat which has high moisture content, the soil particles intend to stick together when dried form bigger particles. That may be the reason why high sand particles present in the soil. Wet sieving can be conducted to improve the distribution of the soil.

In its natural state, the selected soil sample was acidic with average pH value 3.9. Peat in Peninsular Malaysia is known to have very low pH values ranging from 3.0 to 4.5, the acidity tends to decrease with depth, and the decrease may be large near the bottom layer depending on the type of the underlying soil (Muttalib et al. 1991). Undrained shear strength of 11.13 Kpa obtained from vane shear test falls under very soft soil category.

4.2 Actual Electroosmotic Tests

The results of the actual electroosmosis testing are summarized in Table 4.2. The tests were divided into two categories as mentioned in section 3.2.3 and were using copper as the electrodes.

Table 4-2: Summary of electroosmotic test results

Surcharges (kPa)	10	10	10	10	20	20	20	20
Voltage (V)	0	10	30	60	0	10	30	60
Settlement (mm)	14.21	15.55	16.18	17.51	16.37	17.62	19.89	22.81
Moisture content (%)	100	89	87	81	91	88	82	76
Reduction of moisture content (%)	10	21	23	29	19	22	28	34
Strength (kPa)	0.0	6.2	16.0	18.6	4.0	16.0	19.0	26.4

From Table 4.2, the settlement shows an increasing trend ranging from 14.2 mm to 22.8 mm for increases value of current voltage and surcharge load. For 10kpa surcharge, the settlements increase as the current voltage increases. The settlement is higher when subjected to 20kpa loads compared to the settlement using 10kpa loads at similar current voltage. When the loads applied to the soil, there will be a build up in the pore water pressure and dissipation of the positive pore pressure. After the positive pore water pressure induced by the direct loading had dissipated, the electroosmosis continues to induce negative pore water, causing further consolidation. From the graph in Figure 4.1, the settlements occur rapidly on the first 50 minutes of the test. By comparing all the tests, it could be observed that the rate of consolidation was about the same for all. The major difference was the variation of the magnitude of consolidation. Beyond the point of the major settlement, the rate of settlement decreased. This phenomenon is in accordance with findings by Gray and Mitchell (1967) who indicated that electroosmotic efficiency decreases with a decrease in moisture content.

Figure 4-1: Settlement vs Time Graph

By referring to Figure 4.2, it is observed that the results for the moisture content conformed to the magnitude of consolidation. For 20 kPa surcharge loads, the moisture content reduction was greater by applying only 10 volt of voltage compared to without any voltage. The lowest moisture content was achieved in 60V-20kPa test with moisture content value of 76% which was about 34 % reduction from the initial moisture content. Higher decreases in moisture content would generally indicate higher consolidation and strength gain in electrosmotic treatment.

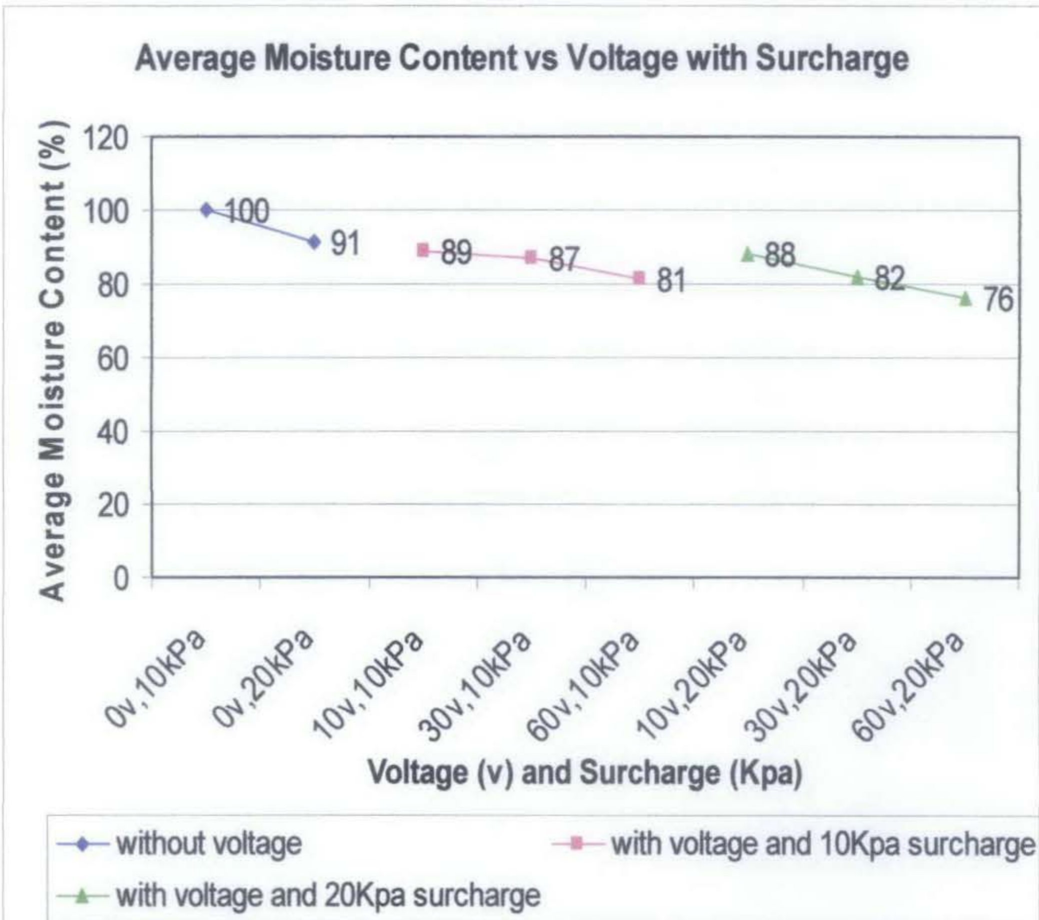

Figure 4-2: Average Moisture Content vs Voltage and Surcharge

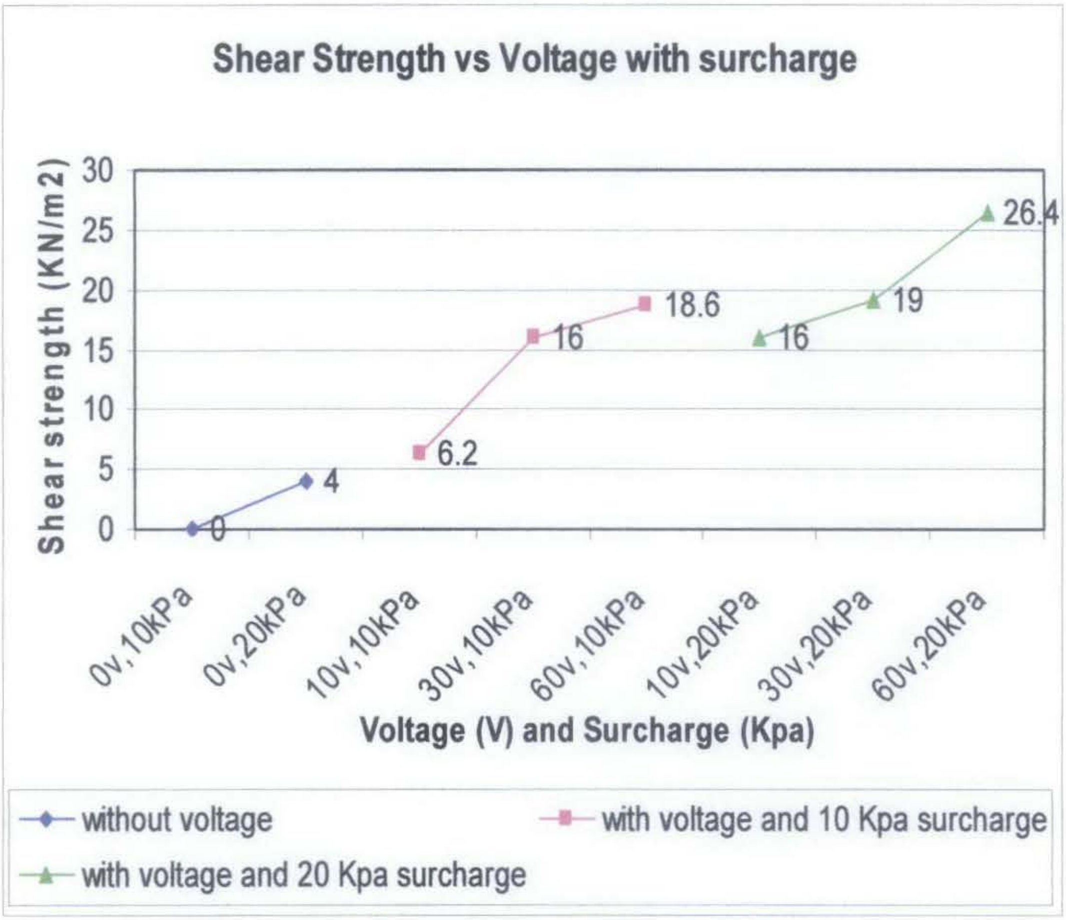

Figure 4-3: Shear Strength vs Voltage and Surcharge

Figure 4.3 shows the value of shear strength after the treatment using electroosmotic method. The treatment using 60V-20kPa generated the highest strength value of 26.4kPa which was about 84% increases compared to the strength obtained using 0V-20kPa treatment. The corresponding moisture content for the same test was 76% and about 34% reduction. It has been confirmed that electroosmotic consolidation induced the reduction of moisture content and increased shear strength (Shang and Dunlap, 1996).

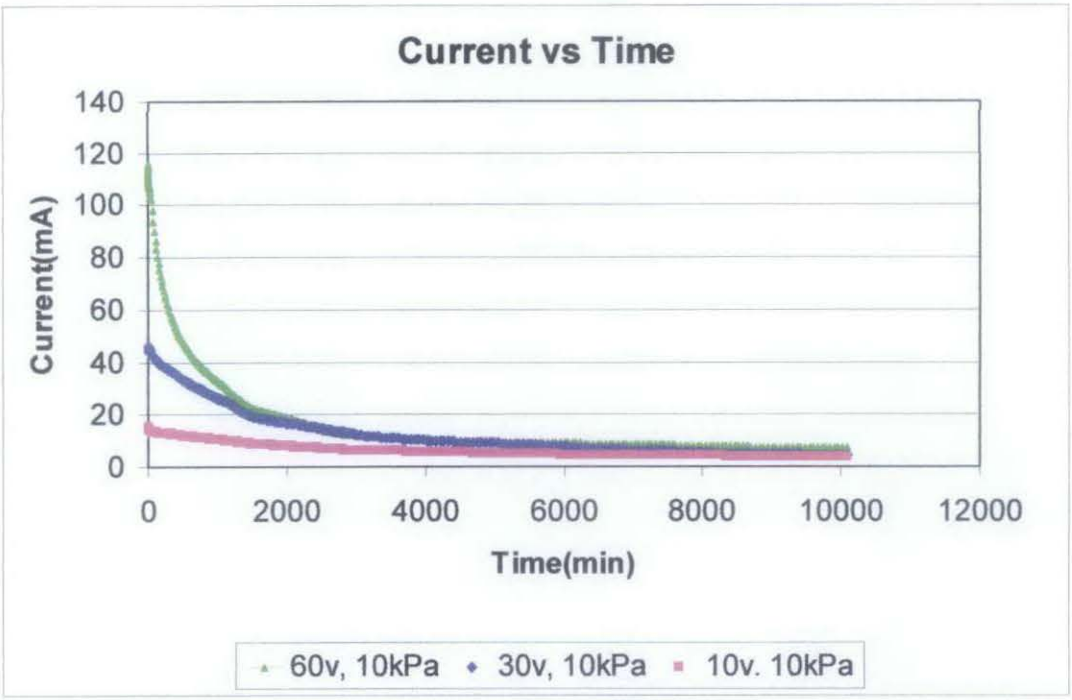

Figure 4-4: Current vs Time for 10 kPa Surcharge

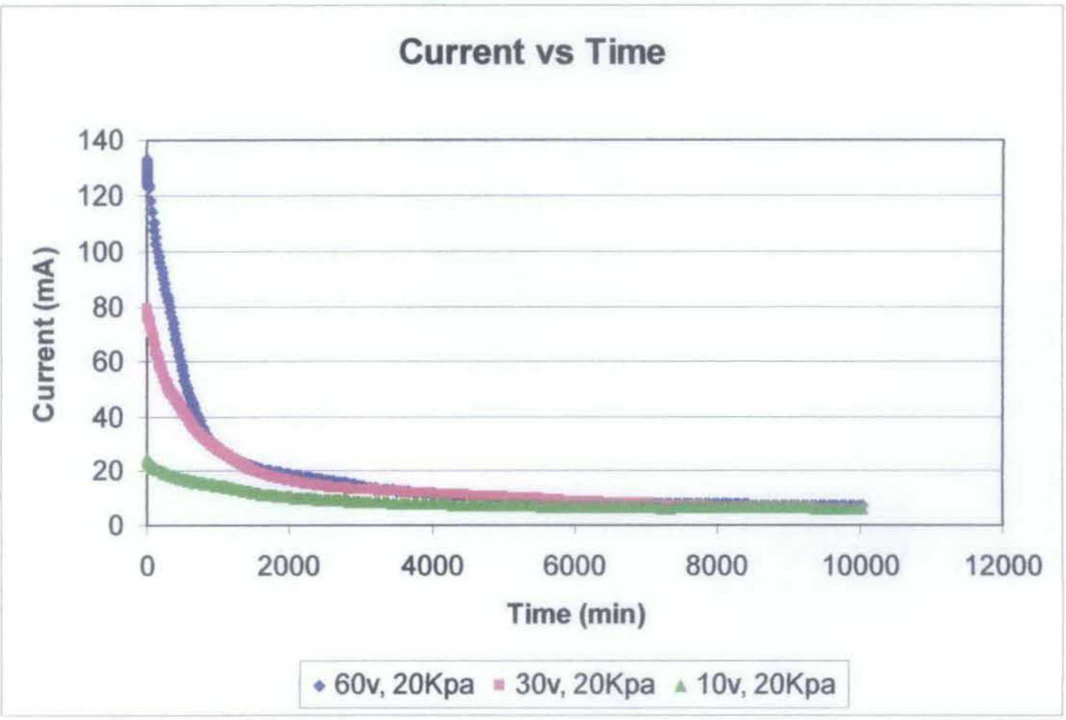

Figure 4-5: Current vs Time for 20kPa Surcharge

The current variation with time is shown in Figure 4.4 and 4.5. They show a typical characteristic of current variation in the sense that in electroosmotic treatment, current or current density will gradually reduce from the initial maximum value.

The reductions of current that are shown in the figures above indicate the concurrent decrease in pore water. A clear reduction in the magnitude of current could be seen from the plot for 60V-10kPa and 60V-20kpa tests having reduction of about 108 mA and 126 mA respectively. The period of major reduction in current is similar to the period of major settlement of 60V-20kpa. Both figures show major reduction in magnitude of current and magnitude of consolidation within a period approximately 0 - 500 minutes. As the electroosmotic process continued, pore water was reduced and caused a decrease in the conductivity of the soil water system reducing the magnitude of current.

The reduction in moisture content was the result of electrolysis process during electroosmotic treatment. The application of direct current via electrodes immersed in water resulted in oxidation at anode and reduction at the cathode. The oxidation and reduction process caused decreased in the pH value at anode and increased the pH at cathode. The pH and conductivity results are summarized in Table 4.3.

Table 4-3: pH and conductivity results

Test	pH		Conductivity, μSiemens/cm	
	anode	cathode	anode	cathode
0volt,10Kpa	4.1	4.1	500	480
0volt, 20Kpa	3.9	3.9	700	680
10volt,10Kpa	3.8	4.6	850	350
30volt,10Kpa	3.7	5.3	800	1000
60volt, 10Kpa	3.7	5.4	1300	1000
10volt, 20Kpa	3.8	4.9	1500	1350
30volt, 20Kpa	3.7	5.3	1500	1000
60volt, 20Kpa	3.6	5.6	1300	1200

Table 4.3 shows that there were reduction in the pH at anode and some increased in pH at the cathode when current voltage was applied. It indicated that electrolysis was take place in the treatment. Corrosion of cooper electrode occurred at anode during the treatment. The reactions at anode result in the liberation of oxygen and the production of hydrogen ions. Increasing in the hydrogen ions would lower the pH at the anode. The conductivity of the soil indicated the movement of the anions and cations in the soil mass during the treatment. Higher the conductivity values, higher the movement of electrons.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From the tests that had been conducted, the results show that:

i. The settlement increase with increases of surcharge loads and current voltages.
ii. There were reductions in current voltages after the treatment shows that the reduction in moisture content took place.
iii. The reductions of current and moisture content were greater as the voltages and surcharge loads increases.
iv. The rate of settlement and current reductions were higher at first day of the treatment.
v. Increasing in strength was obtained after the treatment which depending on the current voltages and the surcharge loads applied.

Therefore, it is possible from the results to stabilize peat soil that contains 30% organic content. Further research is required to ensure the effectiveness of this method in stabilizing peat with higher organic content.

5.2 Recommendation

For future works, it is recommended that:

i. The treatment is using pure peat soil with at least 75% organic content to see the real effect of electroosmotic method.
ii. Electrochemical method of treatment is used by introducing some chemicals to improve the treatment effect.

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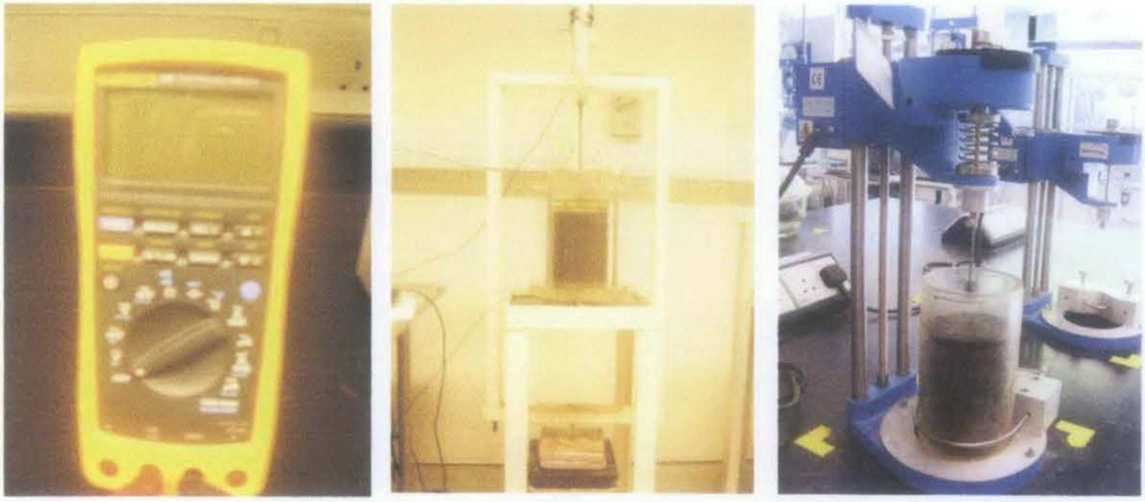
APPENDIX

APPENDIX

1. Tasek Bera Map

Figure 1: Tasek Bera Location

2. Equipments



(a) **(b)** **(c)**

Figure 2: (a) multimeter; (b) electrosmotic cell and LVDT; (c) vane shear

3. Electroosmotic Treatment Process

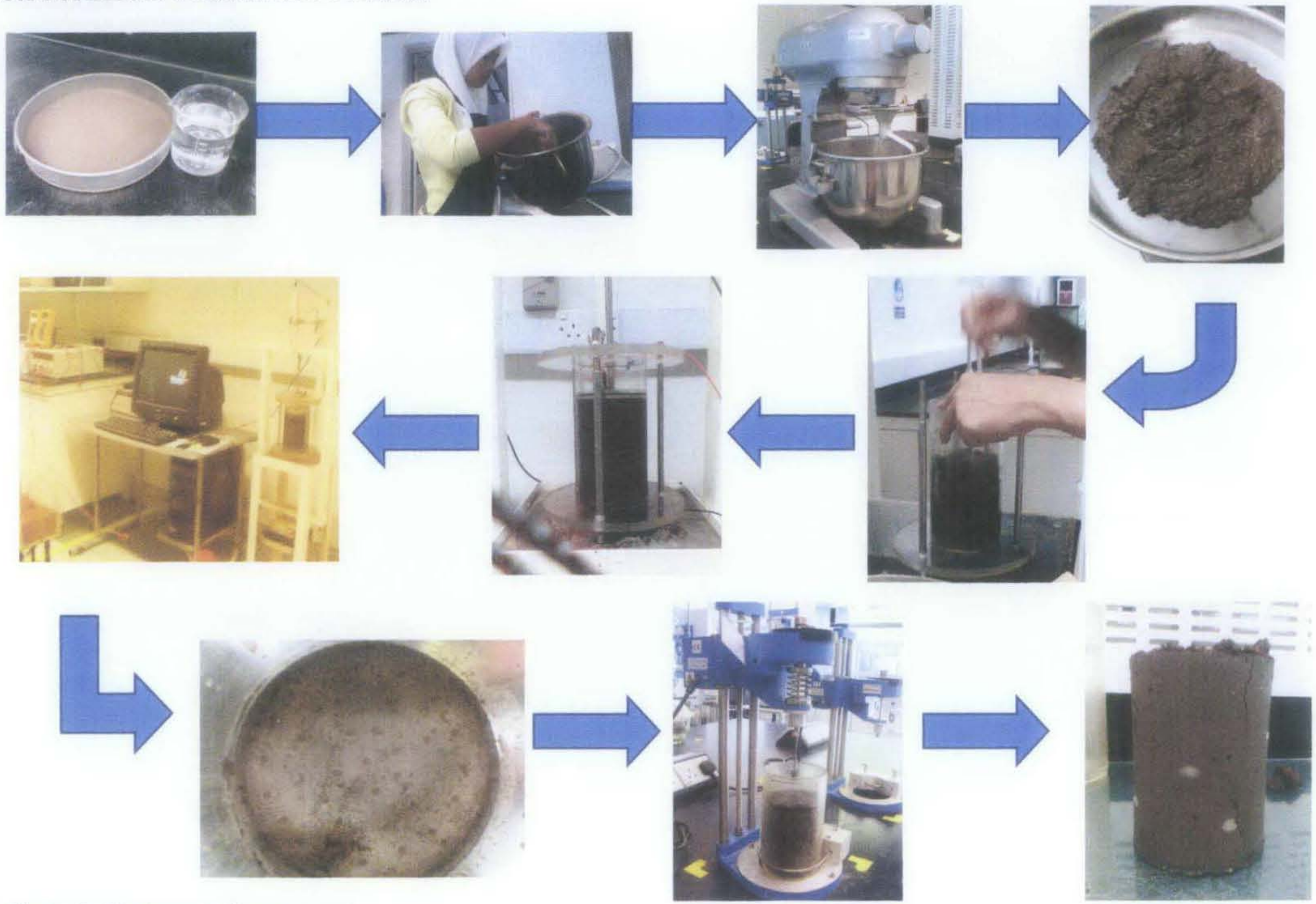


Figure 3: Electroosmotic processes

3. Vane Shear Test Calculation

Calculation:

Vane shear data for original soil.

Deflection of spring (inner) = 40 °

Rotation of vane (outer) = 5 °

Spring rotation = 46 °

Calibration factor (inner – outer) = 35 °

The torque, M (KN/m^2) was obtained from calibration chart.

Table 1: Calibration chart

Torque		Spring No.			
Kg.cm	Nm	1	2	3	4
0.25	0.025	8	10	14	21
0.50	0.049	16	19	27	39
0.75	0.074	23	29	41	58
1.00	0.098	31	39	55	78
1.25	0.123	40	49	69	98
1.50	0.147	48	60	82	118
1.75	0.172	56	69	95	139
2.00	0.196	65	79	108	160
2.25	0.221	72	90	122	179
2.50	0.245	81	100	135	199
2.75	0.270	89	110	150	
3.00	0.295	98	120	161	
3.25	0.319	105	129	175	

By interpolation, the torque, M for 68 ° for spring 3 was obtained.

$$(41 - 35) / (74 - M) = (41 - 27) / (74 - 49)$$

$$M = 63.29 \text{ KN.m}$$

Therefore, the vane shear strength was calculated as,

$$Tv = M / k \qquad (KN/m^2)$$

Where

$$K = \Pi D^2 [(H/2) + (D/6)]$$

K value is 6008 mm^3 for vane with H=19.00mm and D=12.82mm.

By taking the vane K= 6.008 m^3, therefore

$$Tv = (63.29) / 6.008$$
$$= 10.53 KN/ m^2$$

The calculation for sample 2 was similar as calculated above. Then, the average value of sample 1 and 2 was defined.

$$Tv_{ave} = (10.53 + 11.72) / 2$$
$$= 11.13 Kpa$$

Base on table 2, therefore the soil was classified as very soft soil. The visual identification was exudes between fingers.

Table 2: Typical Value.

Term	Undrained Shear strength (Kpa)	Visual identification
Very soft	<12.5	Exudes between fingers
Soft	12.5 – 25	Easily molded with fingers and indented considerably with thumb.
Firm	25 – 50	Can be molded with moderate pressure of fingers and indented with moderate pressure.
Stiff	50 – 100	Molded with difficulty by fingers, can be indented by strong pressure of the thumb only a small mount
Very stiff	100 - 200	Can be indented to little more then a fingerprint with strong pressure of the thumb.

4. Particles Size Distribution Calculation

Table 3: Seive Analysis

BS test sieve	Mass retained (g)	Percentage retained (m/m_1) x 100%	Cumulative Percentage Retained (%)	Percentage Passing (%)
2 mm	8.26	1.12	1.12	98.88
1.18 mm	12.38	1.67	2.79	97.21
600 um	32.77	4.43	7.22	92.78
425 um	125.81	17.00	24.22	75.78
300 um	115.66	15.63	39.85	60.15
212 um	121.99	16.48	56.33	43.67
150 um	137.05	18.52	74.85	25.15
63 um	150.94	20.38	95.23	4.77
Passing 63um	35.30	4.76	99.99	0
Total	740.16	99.99 %		

Calculation:

From table 4.4, the result obtained was expressed on a semi-logarithmic chart. From the plotted graph, the uniformity coefficient (Cu) and coefficient of gradation (Cz) was calculated.

Uniformity coefficient (Cu) is given as $Cu = D_{60} / D_{10}$ and the coefficient of gradation (Cz) is $Cz = D^2_{30} / (D_{60} \times D_{10})$. Therefore

$$Cu = D60 / D10$$
$$= 0.29mm / 0.08mm$$
$$= 3.625$$

And

$$Cz = D30^2 / D60 \times D10$$
$$= 0.11^2 mm / 0.29mm \times 0.08mm$$
$$= 0.52$$

The percentages of gravel, sand and silt particles present in the soil can be obtained from the particle size distribution curve. The percentage was calculated as below. From the calculation, the soil was classified as sandy soil. However, the soil has no sand. It is because when high moisture soil was dried, it tend to stick together to form large solid particles.

Size (mm)	% finer	
60	100	100 – 98.88 = 1.12 % Gravel
2	98.88	98.88 - 4.77 = 94.11 % Sand
0.063	4.77	4.77 -0.0 = 4.77 % Silt
	0.0	

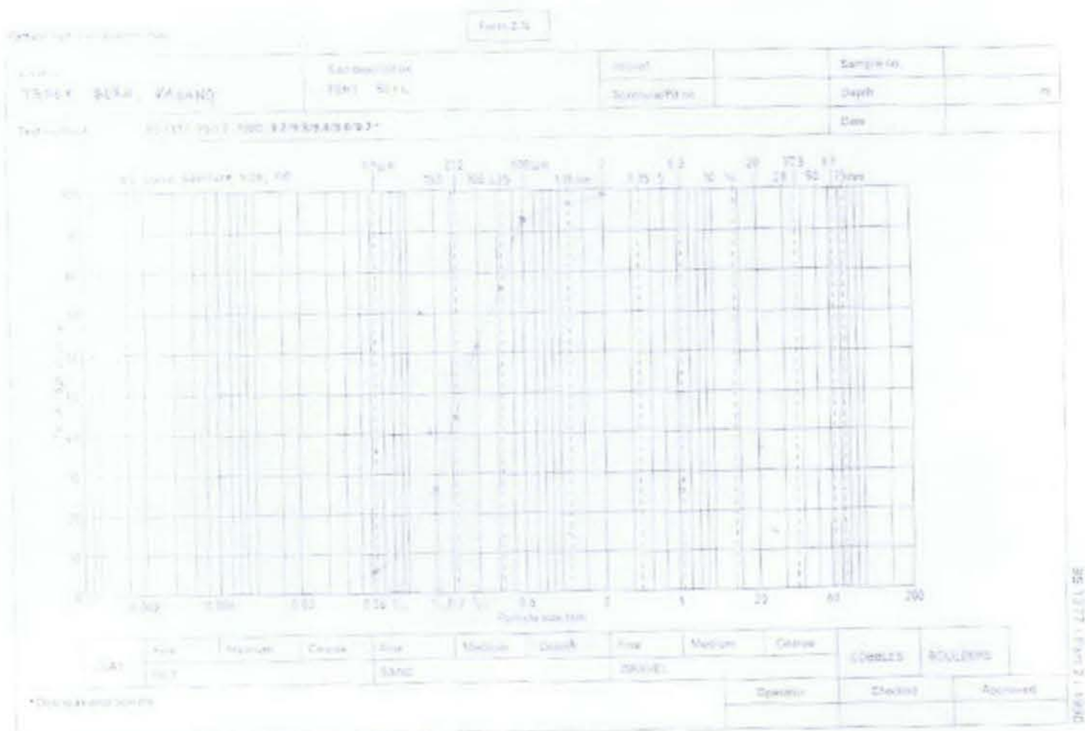


Figure 4: Particle Distribution Curve

5. Liquid Limit

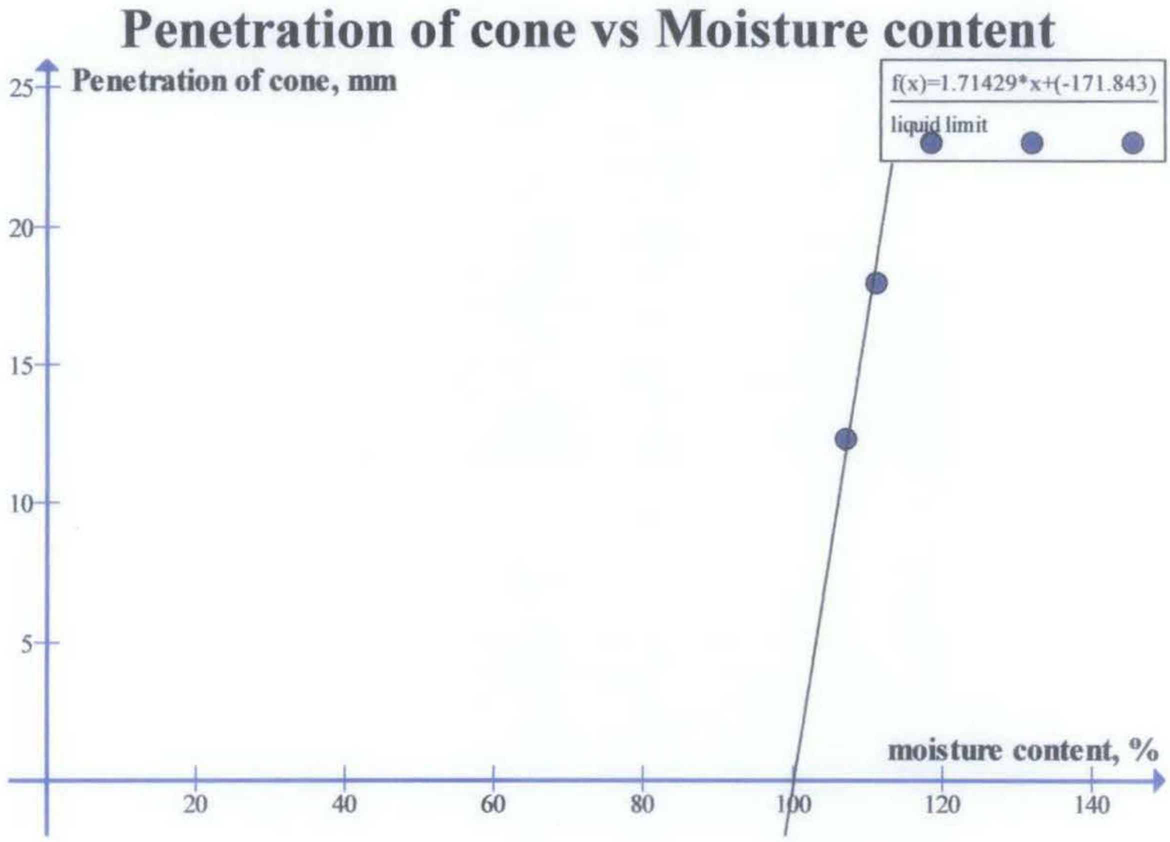


Figure 5: liquid limit

Calculation:

The liquid limit of the soil occur at penetration 20mm.From the graph, at y = 20 mm

$$y = 1.71429\,x - 171.843$$

$$x = \frac{20 + 171.843}{1.71429}$$

$$x = 111.9\ \%$$

Therefore, the liquid limit was 111.9 %.

6. Plastic Limit and Plasticity Index

Calculation:

The plastic limit is the state when the soil is to dry to be plastic. The plastic limit was 27.38 % as obtained from table 4.4. The plasticity index was given by:

$$I_p = LL - PL$$
$$= 111.9 - 59.85$$
$$= 52.05$$

From the plasticity chart for the classification of fines soils as shown in figure 1, the soil was classified as ML (M = Silt, E = extremely high plasticity) since the liquid limit was 111.9 % and plasticity index was 52.05 %.

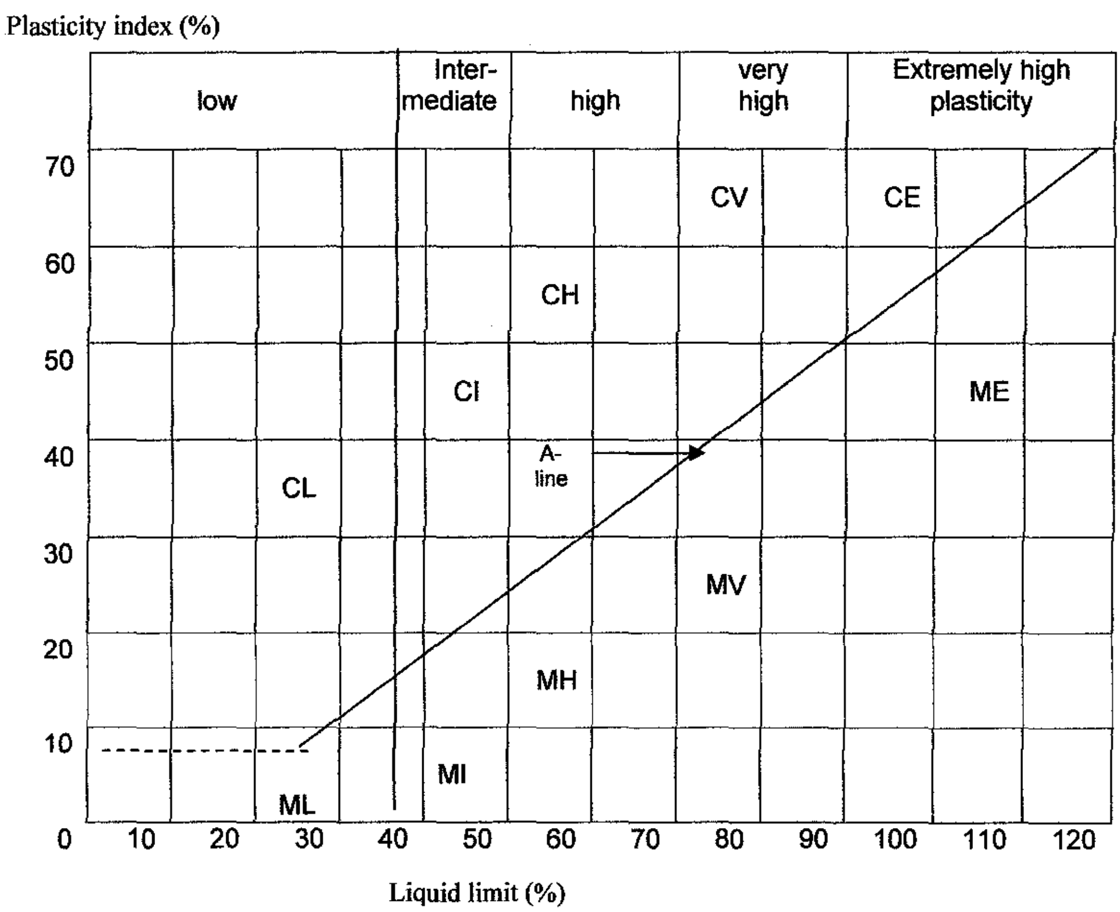


Figure 6: Plasticity Chart for the Classification of Fine Soils

7. X-Ray Diffraction (XRD)

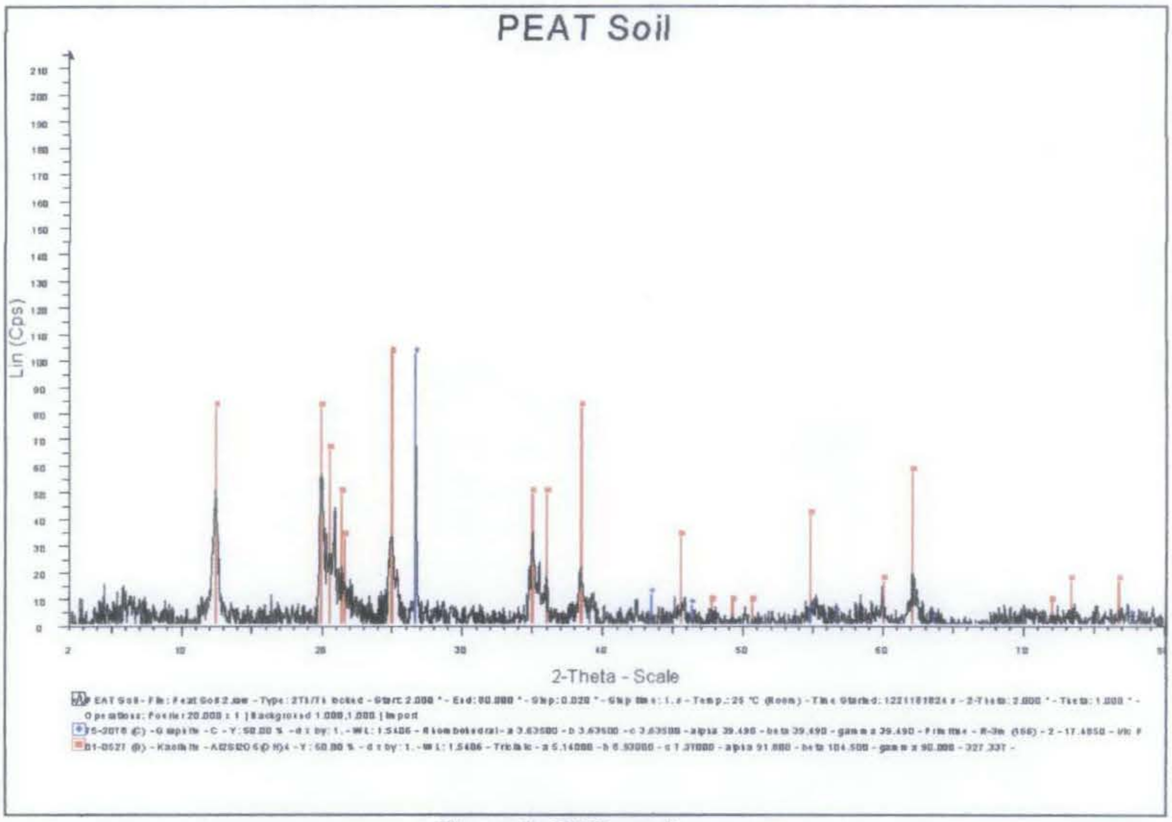


Figure 7: XRD result

REDUCTION OF CURRENT (mA)

TEST 2: 30V,10kPa

15.01	12.884	10.457	7.96	5.733	4.367	3.845
14.876	12.902	10.42	7.9	5.692	4.329	3.82
14.826	12.792	10.379	7.842	5.65	4.269	3.794
14.79	12.75	10.334	7.785	5.607	4.212	3.768
14.78	12.677	10.284	7.73	5.566	4.155	3.748
14.751	12.448	10.234	7.677	5.527	4.103	3.731
14.724	12.598	10.182	7.624	5.489	4.078	3.736
14.72	12.582	10.131	7.571	5.456	4.055	3.736
14.709	12.525	10.08	7.52	5.425	4.049	
14.69	12.45	10.029	7.472	5.391	4.035	
14.676	12.374	9.979	7.427	5.36	4.035	
14.662	12.3	9.932	7.382	5.328	4.041	
14.646	12.232	9.887	7.335	5.291	4.044	
14.636	12.165	9.843	7.293	5.255	4.046	
14.622	12.101	9.8	7.25	5.216	4.058	
14.611	12.037	9.758	7.208	5.177	4.072	
14.6	11.975	9.712	7.164	5.137	4.071	
14.58	11.913	9.662	7.093	5.099	4.07	
14.565	11.853	9.608	7.017	5.061	4.069	
14.539	11.796	9.555	6.942	5.024	4.073	
14.523	11.738	9.502	6.87	4.989	4.07	
14.488	11.681	9.448	6.802	4.954	4.067	
14.462	11.627	9.394	6.736	4.92	4.062	
14.437	11.573	9.34	6.676	4.888	4.057	
14.435	11.52	9.287	6.621	4.856	4.048	
14.411	11.468	9.234	6.582	4.824	4.037	
14.389	11.418	9.183	6.548	4.795	4.004	
14.366	11.366	9.133	6.512	4.769	3.973	
14.322	11.315	9.086	6.473	4.746	3.939	
14.322	11.264	9.039	6.432	4.725	3.919	
14.303	11.214	8.993	6.395	4.709	3.901	
14.263	11.166	8.949	6.361	4.692	3.881	
14.221	11.12	8.906	6.34	4.683	3.869	
14.186	11.075	8.864	6.338	4.675	3.864	
14.118	11.031	8.823	6.321	4.667	3.863	
14.03	10.988	8.782	6.297	4.617	3.868	
13.79	10.946	8.703	6.278	4.521	3.874	
13.586	10.862	8.641	6.246	4.464	3.878	
13.474	10.855	8.6	6.212	4.452	3.881	
13.377	10.825	8.556	6.177	4.447	3.883	
13.302	10.786	8.508	6.138	4.444	3.883	
13.23	10.748	8.455	6.095	4.441	3.882	
13.161	10.71	8.398	6.051	4.437	3.88	
13.093	10.673	8.338	6.007	4.429	3.878	
13.015	10.636	8.278	5.968	4.421	3.874	
12.929	10.6	8.22	5.911	4.413	3.87	
12.875	10.564	8.155	5.867	4.403	3.866	
13.05	10.529	8.088	5.829	4.391	3.862	
12.887	10.494	8.023	5.776	4.38	3.857	

REDUCTION OF CURRENT (mA)						
TEST 3:	30V,10kPa					
46.15	38.199	26.59	17.129	10.57	6.577	4.523
45.81	37.914	26.418	17.007	10.462	6.53	4.502
45.69	37.645	26.248	16.888	10.354	6.482	4.483
45.62	37.38	26.082	16.773	10.246	6.431	4.465
45.54	37.122	25.92	16.662	10.143	6.376	4.447
45.45	36.867	25.766	16.554	10.047	6.325	4.428
45.36	36.618	25.617	16.446	9.953	6.279	4.41
45.29	36.374	25.475	16.338	9.862	6.236	4.392
45.21	36.13	25.338	16.235	9.772	6.195	
45.12	35.888	25.207	16.086	9.686	6.154	
45.05	35.65	25.08	15.944	9.604	6.114	
44.98	35.322	24.84	15.807	9.524	6.073	
44.9	35.003	24.601	15.676	9.445	6.031	
44.83	34.694	24.347	15.549	9.375	5.99	
44.74	34.393	24.083	15.427	9.314	5.915	
44.64	34.092	23.81	15.308	9.257	5.822	
44.59	33.801	23.539	15.193	9.207	5.724	
44.52	33.516	23.273	15.082	9.155	5.63	
44.46	33.247	23.005	14.912	9.101	5.546	
44.64	32.982	22.737	14.746	9.046	5.476	
44.99	32.724	22.471	14.584	8.991	5.413	
45.03	32.469	22.21	14.43	8.938	5.353	
45	32.22	21.954	14.281	8.886	5.294	
44.9	31.976	21.703	14.139	8.837	5.237	
44.76	31.732	21.457	14.002	8.791	5.208	
44.88	31.49	21.217	13.871	8.747	5.183	
44.87	31.252	20.984	13.744	8.676	5.157	
44.78	31.03	20.762	13.622	8.605	5.128	
44.65	30.82	20.552	13.503	8.532	5.095	
44.59	30.618	20.35	13.388	8.457	5.065	
44.48	30.422	20.154	13.277	8.379	5.038	
44.29	30.238	19.97	13.169	8.297	5.012	
44.56	30.06	19.792	13.061	8.216	4.987	
44.6	29.885	19.617	12.891	8.135	4.962	
44.44	29.724	19.456	12.718	8.054	4.936	
44.3	29.569	19.301	12.547	7.974	4.91	
43.57	29.421	19.153	12.375	7.895	4.885	
42.9	29.133	18.983	12.205	7.817	4.86	
42.48	28.854	18.81	12.039	7.745	4.835	
42.176	28.581	18.639	11.877	7.618	4.803	
41.705	28.323	18.467	11.723	7.455	4.77	
41.169	28.076	18.297	11.574	7.293	4.737	
40.648	27.828	18.131	11.432	7.17	4.704	
40.048	27.618	17.969	11.295	7.062	4.674	
39.72	27.436	17.815	11.164	6.969	4.646	
39.401	27.269	17.666	11.037	6.888	4.62	
39.092	27.104	17.524	10.915	6.797	4.596	
38.791	26.934	17.387	10.796	6.707	4.571	
38.49	26.761	17.256	10.681	6.627	4.547	

REDUCTION OF CURRENT (mA)

TEST 4: 60V,10kPa

115.41	67.16	33.519	19.614	11.012	8.704	7.579
114.71	65.51	33.198	19.361	10.936	8.69	7.574
114.43	63.97	32.881	19.089	10.872	8.678	7.568
114.2	62.51	32.573	18.82	10.817	8.666	7.564
113.72	61.11	32.273	18.553	10.762	8.636	7.552
113.23	59.81	31.977	18.293	10.707	8.574	7.498
113.21	58.56	31.689	18.039	10.634	8.499	7.445
113.03	57.38	31.408	17.805	10.548	8.44	7.389
112.76	56.25	31.132	17.583	10.466	8.394	
112.23	55.18	30.862	17.375	10.344	8.344	
113.02	54.16	30.602	17.168	10.219	8.306	
112.68	53.17	30.104	16.967	10.107	8.281	
112.25	52.21	29.647	16.575	10.011	8.261	
112	51.28	29.206	16.232	9.924	8.268	
111.81	50.39	28.776	15.894	9.844	8.268	
111.5	49.53	28.358	15.557	9.758	8.256	
111.04	48.71	27.952	15.263	9.67	8.23	
110.6	48.16	27.581	14.968	9.586	8.196	
110.84	47.771	27.224	14.671	9.508	8.156	
110.63	47.153	26.872	14.369	9.436	8.126	
110.37	46.418	26.552	14.085	9.39	8.11	
110.38	45.726	26.264	13.838	9.382	8.107	
110.71	45.055	25.975	13.637	9.387	8.104	
109.86	44.418	25.678	13.466	9.391	8.103	
110.06	43.81	25.375	13.312	9.394	8.099	
109.25	43.227	25.077	13.171	9.394	8.096	
108.7	42.666	24.779	13.043	9.388	8.092	
108	42.124	24.484	12.917	9.38	8.088	
108.2	41.606	24.191	12.799	9.368	8.062	
109.01	41.108	23.908	12.69	9.338	7.978	
108.45	40.623	23.639	12.586	9.273	7.899	
107.28	40.147	23.382	12.487	9.202	7.839	
107.06	39.698	23.137	12.396	9.139	7.743	
106.56	39.259	22.912	12.314	9.092	7.688	
105.41	38.836	22.7	12.239	9.052	7.638	
104.27	38.435	22.494	12.146	9.034	7.6	
103.6	38.051	22.294	12.046	9.022	7.582	
102.03	37.683	22.094	11.949	9.023	7.579	
97.75	37.324	21.894	11.863	8.995	7.572	
93.61	36.974	21.686	11.786	8.986	7.573	
89.83	36.638	21.494	11.703	8.96	7.583	
86.42	36.304	21.292	11.614	8.921	7.589	
83.27	35.945	21.088	11.514	8.877	7.591	
80.36	35.579	20.884	11.423	8.828	7.591	
77.67	35.217	20.671	11.334	8.781	7.586	
75.21	34.86	20.46	11.262	8.753	7.585	
72.93	34.516	20.251	11.199	8.738	7.584	
70.85	34.177	20.04	11.141	8.726	7.583	
68.93	33.844	19.828	11.077	8.715	7.581	

REDUCTION OF CURRENT (mA)

TEST 6: 10V,20kPa

24.81	19.46	14.562	10.441	7.846	6.28	6.11
24.76	19.283	14.504	10.354	7.802	6.274	6.106
24.69	19.103	14.441	10.281	7.762	6.268	6.102
24.61	18.933	14.377	10.211	7.722	6.263	6.1
24.55	18.767	14.316	10.141	7.684	6.257	6.096
24.43	18.598	14.253	10.07	7.647	6.251	6.092
24.35	18.437	14.191	9.997	7.61	6.244	6.089
24.28	18.283	14.126	9.927	7.572	6.238	6.082
24.19	18.137	14.057	9.861	7.533	6.225	
24.11	17.995	13.98	9.795	7.493	6.185	
23.97	17.855	13.898	9.73	7.452	6.138	
23.9	17.719	13.811	9.668	7.413	6.096	
23.83	17.588	13.732	9.611	7.376	6.08	
23.75	17.455	13.645	9.554	7.341	6.184	
23.67	17.32	13.558	9.51	7.306	6.247	
23.59	17.197	13.474	9.461	7.276	6.255	
23.51	17.087	13.39	9.408	7.245	6.246	
23.46	16.985	13.308	9.357	7.214	6.234	
23.4	16.887	13.228	9.307	7.18	6.242	
23.396	16.794	13.156	9.259	7.148	6.257	
23.39	16.706	13.087	9.213	7.116	6.271	
23.387	16.619	13.011	9.167	7.084	6.282	
23.342	16.534	12.936	9.122	7.054	6.292	
23.32	16.45	12.859	9.078	7.022	6.3	
23.285	16.365	12.785	9.036	6.992	6.307	
23.255	16.281	12.706	8.993	6.963	6.312	
23.228	16.197	12.625	8.957	6.934	6.315	
23.2	16.114	12.547	8.915	6.905	6.317	
23.167	16.033	12.46	8.873	6.875	6.32	
23.146	15.951	12.374	8.834	6.846	6.322	
23.128	15.871	12.284	8.794	6.82	6.323	
23.062	15.792	12.191	8.754	6.796	6.325	
23.016	15.714	12.101	8.715	6.772	6.322	
22.965	15.636	12.013	8.678	6.74	6.294	
22.915	15.559	11.928	8.635	6.671	6.252	
22.875	15.484	11.849	8.591	6.601	6.219	
22.669	15.409	11.769	8.549	6.545	6.217	
22.552	15.336	11.695	8.507	6.503	6.231	
22.009	15.263	11.566	8.468	6.465	6.239	
21.612	15.193	11.442	8.395	6.426	6.243	
21.299	15.124	11.325	8.332	6.398	6.233	
21.041	15.056	11.216	8.275	6.372	6.22	
20.82	14.989	11.106	8.224	6.34	6.214	
20.606	14.925	11.004	8.176	6.322	6.204	
20.4	14.862	10.903	8.124	6.318	6.188	
20.202	14.799	10.803	8.067	6.314	6.167	
20.009	14.738	10.708	8.006	6.308	6.146	
19.823	14.679	10.618	7.947	6.299	6.127	
19.639	14.62	10.531	7.892	6.288	6.115	

REDUCTION OF CURRENT (mA)						
TEST 7:	30V,20kPa					
78.8	55.57	28.557	16.952	11.885	7.92	6.098
78.64	54.51	28.256	16.779	11.787	7.879	6.08
78.58	53.48	27.965	16.608	11.691	7.839	6.061
78.5	52.49	27.68	16.436	11.598	7.798	6.044
78.43	51.56	27.411	16.266	11.505	7.756	6.028
78.37	50.71	27.146	16.1	11.411	7.715	5.971
78.31	49.93	26.888	15.938	11.318	7.64	5.899
78.28	49.2	26.633	15.784	11.225	7.547	5.898
78.26	48.53	26.384	15.635	11.136	7.449	
78.25	48.11	26.14	15.493	11.05	7.355	
78.23	47.806	25.896	15.356	10.969	7.271	
78.12	47.335	25.654	15.225	10.891	7.201	
78.05	46.799	25.416	15.098	10.817	7.138	
77.99	46.278	25.177	14.976	10.747	7.078	
77.94	45.678	24.923	14.857	10.678	7.019	
77.88	44.97	24.659	14.742	10.609	6.962	
77.87	44.271	24.386	14.631	10.541	6.933	
77.82	43.632	24.115	14.523	10.472	6.908	
77.71	43.042	23.849	14.415	10.401	6.882	
77.62	42.413	23.581	14.307	10.33	6.853	
77.48	41.796	23.313	14.204	10.257	6.82	
77.3	41.154	23.047	14.108	10.182	6.79	
77.22	40.523	22.786	14.014	10.104	6.763	
77.05	39.932	22.53	13.923	10.022	6.737	
76.97	39.405	22.279	13.833	9.941	6.712	
76.93	38.923	22.033	13.747	9.86	6.687	
76.77	38.359	21.793	13.665	9.779	6.661	
76.62	37.772	21.56	13.585	9.699	6.635	
76.57	37.188	21.338	13.506	9.62	6.61	
76.5	36.619	21.128	13.436	9.542	6.585	
76.46	36.076	20.926	13.375	9.47	6.56	
76.27	35.549	20.73	13.318	9.343	6.528	
76.11	35.04	20.546	13.268	9.18	6.495	
75.95	34.553	20.368	13.216	9.018	6.462	
75.76	34.085	20.193	13.162	8.895	6.429	
75.61	33.633	20.032	13.107	8.787	6.399	
75.31	33.199	19.877	13.052	8.694	6.371	
74.84	32.779	19.729	12.999	8.613	6.345	
72.67	32.371	19.439	12.947	8.522	6.321	
70.77	31.977	19.151	12.845	8.432	6.296	
68.97	31.592	18.872	12.755	8.352	6.272	
67.2	31.216	18.599	12.669	8.302	6.248	
65.43	30.85	18.341	12.583	8.255	6.227	
63.71	30.495	18.094	12.49	8.207	6.208	
62.11	30.15	17.846	12.395	8.156	6.19	
60.64	29.814	17.636	12.292	8.101	6.172	
59.23	29.486	17.454	12.187	8.05	6.153	
57.98	29.167	17.287	12.083	8.004	6.135	
56.7	28.858	17.122	11.984	7.961	6.117	

REDUCTION OF CURRENT (mA)						
TEST 8:	60V,20kPa					
133.07	89.9	29.353	19.13	12.093	8.046	7.36
131.62	88.04	28.974	19.008	11.887	8.026	7.357
131.2	86.19	28.612	18.867	11.737	8.006	7.35
130.74	84.48	28.263	18.722	11.592	7.986	7.345
130.52	82.89	27.928	18.579	11.449	7.969	7.33
130.1	81.36	27.611	18.431	11.312	7.944	7.273
130.06	79.8	27.315	18.286	11.178	7.876	7.213
129.97	78.07	27.029	18.148	11.046	7.8	7.154
129.95	76.15	26.755	18.008	10.922	7.743	7.101
129.53	74.15	26.497	17.871	10.803	7.688	
129.9	72.14	26.246	17.737	10.691	7.638	
129.72	70.16	26.006	17.604	10.586	7.6	
129.33	68.13	25.775	17.473	10.487	7.582	
129.13	66.14	25.543	17.343	10.394	7.579	
128.87	64.19	25.315	17.216	10.307	7.572	
128.54	62.24	25.089	17.091	10.225	7.573	
128.14	60.38	24.856	16.968	10.143	7.583	
127.71	58.57	24.622	16.844	10.066	7.589	
127.31	56.74	24.388	16.72	9.991	7.591	
127	55	24.151	16.593	9.917	7.591	
126.77	53.37	23.923	16.463	9.844	7.586	
126.34	51.86	23.701	16.342	9.771	7.585	
125.47	50.45	23.489	16.222	9.699	7.584	
124.89	49.14	23.287	16.104	9.627	7.583	
124.53	48.26	23.091	15.987	9.556	7.581	
124.41	47.654	22.899	15.873	9.487	7.579	
123.94	46.71	22.715	15.759	9.42	7.574	
123.38	45.575	22.54	15.643	9.354	7.568	
124	44.483	22.371	15.519	9.286	7.564	
126	43.43	22.213	15.38	9.225	7.552	
125.52	42.415	22.065	15.245	9.168	7.498	
124.49	41.425	21.925	15.111	9.059	7.445	
124.67	40.446	21.788	14.97	8.934	7.389	
123.51	39.496	21.653	14.83	8.809	7.341	
122.94	38.577	21.519	14.691	8.693	7.305	
122.8	37.704	21.391	14.552	8.595	7.266	
122.69	36.869	21.267	14.418	8.509	7.228	
117.7	36.078	21.147	14.286	8.431	7.205	
117.96	35.328	20.917	14.157	8.354	7.192	
114.24	34.614	20.7	13.905	8.276	7.21	
110.38	33.936	20.495	13.653	8.229	7.292	
107.58	33.294	20.32	13.418	8.208	7.283	
105.21	32.692	20.151	13.215	8.19	7.301	
102.19	32.122	19.973	13.029	8.17	7.319	
99.69	31.586	19.803	12.852	8.146	7.333	
97.72	31.085	19.66	12.682	8.122	7.343	
95.65	30.611	19.525	12.518	8.101	7.35	
93.67	30.166	19.393	12.354	8.083	7.355	
91.76	29.748	19.263	12.195	8.064	7.358	

SETTLEMENT (mm)					
TEST 1:	0V,10kPa				
0	-9.66	-13.64	-14.09	-14.16	-14.2
-2.73	-9.8	-13.65	-14.1	-14.17	-14.22
-2.96	-10.26	-13.64	-14.1	-14.16	-14.2
-3.38	-10.28	-13.65	-14.11	-14.14	-14.19
-3.4	-10.29	-13.68	-14.1	-14.13	-14.21
-3.45	-10.33	-13.67	-14.11	-14.14	-14.23
-3.61	-10.38	-13.66	-14.1	-14.15	-14.22
-3.66	-10.66	-13.68	-14.12	-14.15	-14.24
-3.84	-10.67	-13.68	-14.13	-14.22	-14.21
-3.94	-10.71	-13.69	-14.15	-14.19	
-4.15	-10.91	-13.73	-14.14	-14.2	
-4.21	-11.4	-13.73	-14.16	-14.17	
-4.33	-11.97	-13.77	-14.13	-14.21	
-4.4	-12.4	-13.79	-14.14	-14.21	
-4.47	-12.43	-13.76	-14.16	-14.21	
-4.76	-12.65	-13.79	-14.16	-14.19	
-4.81	-12.75	-14.08	-14.15	-14.18	
-5.13	-12.81	-14.06	-14.15	-14.2	
-5.16	-12.83	-14.07	-14.16	-14.18	
-5.34	-12.87	-14.08	-14.15	-14.2	
-5.37	-12.91	-14.1	-14.14	-14.22	
-5.46	-13.27	-14.09	-14.16	-14.18	
-5.45	-13.29	-14.07	-14.15	-14.21	
-5.59	-13.29	-14.07	-14.15	-14.2	
-5.62	-13.32	-14.07	-14.14	-14.18	
-5.62	-13.35	-14.06	-14.16	-14.2	
-5.59	-13.36	-14.08	-14.16	-14.2	
-5.63	-13.5	-14.08	-14.15	-14.2	
-5.62	-13.49	-14.07	-14.15	-14.21	
-5.59	-13.51	-14.09	-14.16	-14.21	
-5.6	-13.51	-14.09	-14.14	-14.2	
-5.62	-13.51	-14.08	-14.17	-14.18	
-5.6	-13.53	-14.06	-14.13	-14.21	
-5.62	-13.52	-14.06	-14.15	-14.19	
-5.6	-13.54	-14.09	-14.17	-14.18	
-5.59	-13.51	-14.11	-14.15	-14.21	
-5.62	-13.55	-14.1	-14.14	-14.19	
-5.62	-13.53	-14.11	-14.15	-14.22	
-5.59	-13.54	-14.11	-14.14	-14.22	
-6.32	-13.57	-14.12	-14.16	-14.19	
-7.13	-13.64	-14.1	-14.15	-14.2	
-7.1	-13.62	-14.12	-14.14	-14.18	
-7.13	-13.63	-14.13	-14.13	-14.22	
-7.13	-13.65	-14.12	-14.14	-14.2	
-7.52	-13.65	-14.1	-14.16	-14.22	
-7.55	-13.62	-14.12	-14.14	-14.21	
-7.62	-13.62	-14.12	-14.16	-14.21	
-8.24	-13.66	-14.1	-14.14	-14.19	
-9.4	-13.66	-14.11	-14.15	-14.21	

SETTLEMENT (mm)					
TEST 2:	10V,10kPa				
0	-2.78	-2.77	-15.33	-15.44	-15.53
-1.81	-2.81	-2.8	-15.35	-15.45	-15.54
-1.81	-2.79	-2.8	-15.39	-15.45	-15.54
-1.88	-2.78	-2.77	-15.36	-15.46	-15.54
-1.88	-2.77	-2.8	-15.39	-15.46	-15.53
-1.9	-2.81	-2.76	-15.39	-15.46	-15.53
-1.9	-2.77	-2.77	-15.39	-15.46	-15.55
-1.92	-2.77	-2.77	-15.42	-15.47	-15.55
-1.93	-2.77	-2.77	-15.39	-15.5	-15.55
-1.91	-2.8	-2.81	-15.42	-15.48	-15.54
-1.94	-2.81	-11.97	-15.41	-15.47	-15.52
-1.93	-2.78	-13.64	-15.44	-15.51	-15.55
-1.94	-2.81	-14.53	-15.44	-15.48	
-1.93	-2.81	-14.81	-15.44	-15.47	
-1.98	-2.81	-14.86	-15.41	-15.52	
-1.96	-2.78	-14.82	-15.44	-15.48	
-2	-2.78	-14.85	-15.45	-15.48	
-2.01	-2.77	-14.84	-15.43	-15.47	
-1.97	-2.8	-14.84	-15.42	-15.48	
-2.02	-2.77	-15.31	-15.44	-15.47	
-2.01	-2.77	-15.29	-15.46	-15.5	
-1.98	-2.78	-15.33	-15.42	-15.49	
-1.99	-2.78	-15.3	-15.44	-15.5	
-2	-2.78	-15.3	-15.41	-15.5	
-1.99	-2.81	-15.33	-15.46	-15.49	
-2.03	-2.8	-15.3	-15.46	-15.49	
-2	-2.8	-15.29	-15.43	-15.51	
-1.99	-2.8	-15.31	-15.43	-15.48	
-2	-2.79	-15.29	-15.44	-15.51	
-2.03	-2.77	-15.3	-15.46	-15.51	
-2.01	-2.77	-15.3	-15.43	-15.49	
-2.02	-2.8	-15.29	-15.45	-15.51	
-2.01	-2.78	-15.31	-15.47	-15.52	
-2.03	-2.78	-15.3	-15.43	-15.5	
-2.02	-2.8	-15.34	-15.44	-15.51	
-2.01	-2.81	-15.36	-15.45	-15.51	
-2	-2.79	-15.34	-15.45	-15.5	
-2.05	-2.77	-15.31	-15.44	-15.54	
-2.01	-2.77	-15.32	-15.46	-15.51	
-2.01	-2.79	-15.33	-15.47	-15.51	
-2.05	-2.77	-15.34	-15.46	-15.54	
-2.02	-2.81	-15.35	-15.48	-15.52	
-2.06	-2.8	-15.35	-15.45	-15.5	
-2.02	-2.78	-15.34	-15.44	-15.53	
-2.07	-2.8	-15.34	-15.46	-15.5	
-2.07	-2.78	-15.34	-15.45	-15.53	
-2.03	-2.77	-15.34	-15.48	-15.53	
-2.8	-2.79	-15.33	-15.46	-15.54	
-2.78	-2.77	-15.32	-15.48	-15.51	

SETTLEMENT (mm)					
TEST 3:	30V,10kPa				
0	-7.21	-14.15	-15.62	-15.95	-16.16
-3.55	-7.36	-14.16	-15.62	-15.95	-16.17
-3.67	-7.42	-14.18	-15.65	-15.96	-16.17
-3.79	-7.45	-14.22	-15.69	-15.96	-16.18
-3.87	-9.65	-14.27	-15.75	-15.98	-16.16
-4.01	-9.92	-14.32	-15.77	-16.01	-16.17
-4.05	-10.24	-14.48	-15.78	-16.06	-16.17
-4.08	-10.38	-14.5	-15.81	-16.12	-16.17
-4.38	-10.44	-14.53	-15.84	-16.12	-16.18
-4.4	-10.72	-14.66	-15.85	-16.13	-16.18
-4.43	-10.86	-14.86	-15.86	-16.13	-16.18
-4.44	-11.09	-14.93	-15.87	-16.13	-16.18
-4.46	-11.28	-15.03	-15.87	-16.13	
-4.8	-11.32	-15.06	-15.87	-16.13	
-4.83	-11.57	-15.08	-15.87	-16.13	
-4.86	-11.63	-15.08	-15.87	-16.13	
-4.91	-11.71	-15.1	-15.86	-16.14	
-4.95	-11.93	-15.1	-15.87	-16.13	
-5.02	-11.95	-15.12	-15.87	-16.13	
-5.05	-12.09	-15.12	-15.87	-16.14	
-5.09	-12.14	-15.14	-15.88	-16.13	
-5.11	-12.37	-15.15	-15.87	-16.13	
-5.13	-12.38	-15.16	-15.87	-16.13	
-5.24	-12.42	-15.19	-15.88	-16.14	
-5.29	-12.51	-15.25	-15.89	-16.13	
-5.32	-12.53	-15.31	-15.89	-16.12	
-5.34	-12.61	-15.32	-15.89	-16.13	
-5.71	-12.71	-15.33	-15.89	-16.15	
-5.72	-12.77	-15.35	-15.88	-16.13	
-5.72	-12.86	-15.36	-15.89	-16.13	
-5.73	-12.97	-15.37	-15.9	-16.14	
-5.74	-13.01	-15.39	-15.9	-16.14	
-5.75	-13.09	-15.49	-15.91	-16.15	
-5.77	-13.19	-15.5	-15.91	-16.15	
-5.78	-13.24	-15.51	-15.9	-16.15	
-5.79	-13.39	-15.51	-15.91	-16.15	
-6.14	-13.41	-15.51	-15.9	-16.17	
-6.15	-13.45	-15.51	-15.91	-16.17	
-6.14	-13.56	-15.51	-15.92	-16.16	
-6.16	-13.58	-15.52	-15.92	-16.17	
-6.15	-13.63	-15.52	-15.92	-16.16	
-6.18	-13.78	-15.53	-15.93	-16.17	
-6.19	-13.83	-15.54	-15.93	-16.17	
-6.39	-13.85	-15.54	-15.94	-16.17	
-6.39	-13.89	-15.54	-15.93	-16.16	
-6.41	-13.94	-15.55	-15.92	-16.16	
-6.43	-14.07	-15.57	-15.93	-16.16	
-6.77	-14.09	-15.58	-15.94	-16.16	
-7.03	-14.12	-15.58	-15.94	-16.16	

SETTLEMENT (mm)					
TEST 4:	60V,10kPa				
0	-9.56	-14.54	-16.84	-17.23	-17.48
-2.55	-10.22	-14.55	-16.86	-17.25	-17.49
-2.72	-10.86	-14.56	-16.88	-17.24	-17.48
-2.96	-11.32	-14.54	-16.87	-17.26	-17.5
-3.21	-11.69	-14.57	-16.89	-17.26	-17.48
-3.35	-12.2	-14.55	-16.88	-17.26	-17.48
-3.46	-12.49	-14.55	-16.89	-17.27	-17.5
-3.56	-12.84	-14.56	-16.91	-17.29	-17.5
-3.67	-13.03	-14.57	-16.89	-17.31	-17.49
-3.78	-13.21	-14.59	-16.91	-17.32	-17.5
-4.03	-13.43	-14.6	-16.91	-17.32	-17.5
-4.06	-13.47	-14.61	-16.93	-17.37	-17.51
-4.13	-13.7	-14.62	-16.93	-17.36	
-4.34	-13.75	-14.66	-17.01	-17.39	
-4.42	-13.9	-14.85	-17	-17.42	
-4.51	-13.91	-15.01	-17.03	-17.44	
-4.7	-13.94	-15.15	-17.04	-17.45	
-4.84	-13.95	-15.2	-17.02	-17.43	
-4.91	-14.1	-15.43	-17.03	-17.45	
-4.97	-14.09	-15.57	-17.04	-17.44	
-5.1	-14.11	-15.72	-17.06	-17.45	
-5.2	-14.13	-15.77	-17.05	-17.45	
-5.27	-14.15	-15.78	-17.06	-17.46	
-5.31	-14.17	-15.8	-17.04	-17.45	
-5.4	-14.2	-16.04	-17.07	-17.44	
-5.59	-14.22	-16.04	-17.08	-17.45	
-5.71	-14.26	-16.04	-17.07	-17.46	
-5.74	-14.27	-16.09	-17.07	-17.44	
-5.8	-14.28	-16.24	-17.07	-17.46	
-5.89	-14.28	-16.3	-17.1	-17.45	
-5.93	-14.28	-16.35	-17.12	-17.44	
-6	-14.31	-16.37	-17.16	-17.45	
-6.14	-14.31	-16.39	-17.17	-17.47	
-6.19	-14.33	-16.4	-17.16	-17.47	
-6.22	-14.35	-16.42	-17.16	-17.47	
-6.42	-14.36	-16.43	-17.18	-17.48	
-6.46	-14.35	-16.42	-17.18	-17.48	
-6.55	-14.51	-16.42	-17.17	-17.51	
-6.6	-14.5	-16.44	-17.18	-17.48	
-6.64	-14.53	-16.46	-17.19	-17.47	
-6.74	-14.52	-16.58	-17.19	-17.5	
-6.8	-14.54	-16.62	-17.21	-17.48	
-6.88	-14.54	-16.62	-17.23	-17.47	
-6.95	-14.53	-16.63	-17.23	-17.48	
-7.05	-14.54	-16.64	-17.23	-17.47	
-7.06	-14.52	-16.65	-17.22	-17.49	
-7.16	-14.52	-16.66	-17.24	-17.49	
-8.14	-14.54	-16.67	-17.24	-17.5	
-8.74	-14.54	-16.86	-17.25	-17.48	

SETTLEMENT (mm)					
TEST 5:	0V,20kPa				
0	-14.55	-15.46	-15.8	-16.29	-16.32
-4.55	-14.87	-15.46	-15.83	-16.29	-16.32
-5.01	-14.88	-15.46	-15.82	-16.27	-16.32
-5.59	-14.89	-15.5	-16.25	-16.29	-16.33
-5.96	-14.92	-15.48	-16.24	-16.3	-16.33
-6.45	-14.91	-15.52	-16.23	-16.31	-16.35
-6.92	-14.92	-15.51	-16.22	-16.31	-16.37
-7.33	-14.97	-15.5	-16.22	-16.28	-16.35
-7.6	-14.95	-15.52	-16.23	-16.31	-16.36
-8.05	-14.97	-15.51	-16.24	-16.3	-16.35
-8.39	-15.37	-15.53	-16.22	-16.28	-16.36
-8.85	-15.38	-15.51	-16.23	-16.28	-16.37
-8.88	-15.39	-15.54	-16.21	-16.3	
-9.39	-15.36	-15.53	-16.24	-16.31	
-9.45	-15.38	-15.55	-16.23	-16.28	
-9.69	-15.38	-15.55	-16.21	-16.31	
-9.83	-15.39	-15.52	-16.22	-16.31	
-10.25	-15.38	-15.53	-16.23	-16.3	
-10.29	-15.39	-15.54	-16.24	-16.28	
-10.7	-15.39	-15.53	-16.26	-16.31	
-11.01	-15.39	-15.54	-16.24	-16.3	
-11.04	-15.39	-15.55	-16.27	-16.28	
-11.12	-15.38	-15.57	-16.27	-16.3	
-11.5	-15.4	-15.58	-16.28	-16.3	
-11.53	-15.42	-15.56	-16.26	-16.3	
-11.86	-15.41	-15.59	-16.28	-16.32	
-11.93	-15.42	-15.57	-16.27	-16.31	
-12.3	-15.43	-15.61	-16.26	-16.32	
-12.33	-15.41	-15.6	-16.29	-16.3	
-12.39	-15.41	-15.57	-16.3	-16.33	
-12.64	-15.41	-15.58	-16.26	-16.34	
-12.68	-15.42	-15.62	-16.28	-16.3	
-12.75	-15.42	-15.66	-16.27	-16.32	
-12.78	-15.42	-15.69	-16.27	-16.35	
-12.9	-15.43	-15.68	-16.29	-16.33	
-13.02	-15.44	-15.68	-16.3	-16.33	
-13.27	-15.42	-15.67	-16.3	-16.34	
-13.27	-15.41	-15.7	-16.29	-16.33	
-13.27	-15.42	-15.68	-16.31	-16.33	
-13.31	-15.42	-15.67	-16.31	-16.32	
-13.63	-15.44	-15.68	-16.28	-16.32	
-13.62	-15.44	-15.67	-16.29	-16.34	
-13.64	-15.42	-15.68	-16.26	-16.31	
-13.68	-15.43	-15.71	-16.29	-16.33	
-13.72	-15.44	-15.71	-16.3	-16.33	
-14	-15.43	-15.71	-16.27	-16.31	
-14.03	-15.44	-15.72	-16.29	-16.33	
-14.02	-15.42	-15.74	-16.29	-16.35	
-14.45	-15.42	-15.74	-16.3	-16.31	

SETTLEMENT (mm)					
TEST 6:	10V,20kPa				
0	-12.63	-15.74	-17.32	-17.47	-17.5
-2.7	-13.18	-15.73	-17.33	-17.46	-17.52
-3.12	-13.58	-15.74	-17.33	-17.47	-17.51
-3.6	-13.72	-15.76	-17.33	-17.47	-17.51
-4.04	-13.87	-15.75	-17.33	-17.46	-17.51
-4.46	-13.91	-15.75	-17.33	-17.47	-17.5
-4.79	-14.08	-15.77	-17.32	-17.46	-17.51
-5.09	-14.41	-15.77	-17.35	-17.46	-17.52
-5.33	-14.75	-15.76	-17.34	-17.46	-17.53
-5.65	-14.86	-15.77	-17.35	-17.46	-17.55
-5.95	-14.9	-15.77	-17.36	-17.46	-17.6
-6.14	-15.02	-15.88	-17.36	-17.46	-17.62
-6.53	-15.11	-15.93	-17.37	-17.47	
-6.64	-15.15	-16.1	-17.38	-17.47	
-6.85	-15.26	-16.18	-17.39	-17.46	
-7.04	-15.3	-16.5	-17.39	-17.46	
-7.28	-15.32	-16.55	-17.39	-17.46	
-7.44	-15.33	-16.57	-17.41	-17.47	
-7.44	-15.35	-16.67	-17.4	-17.48	
-7.64	-15.36	-16.8	-17.41	-17.46	
-7.86	-15.36	-16.83	-17.42	-17.47	
-8.03	-15.36	-16.85	-17.42	-17.47	
-8.23	-15.38	-16.87	-17.43	-17.46	
-8.33	-15.39	-16.88	-17.42	-17.47	
-8.57	-15.39	-16.89	-17.43	-17.48	
-8.69	-15.39	-16.9	-17.43	-17.47	
-8.94	-15.42	-16.93	-17.44	-17.48	
-9.09	-15.41	-16.96	-17.45	-17.46	
-9.15	-15.42	-16.97	-17.43	-17.47	
-9.39	-15.47	-16.98	-17.46	-17.46	
-9.53	-15.59	-16.99	-17.46	-17.47	
-9.64	-15.6	-17	-17.46	-17.47	
-9.81	-15.61	-17	-17.45	-17.47	
-9.95	-15.62	-17.03	-17.46	-17.47	
-10.02	-15.63	-17.06	-17.46	-17.45	
-10.24	-15.65	-17.07	-17.47	-17.47	
-10.36	-15.65	-17.08	-17.47	-17.47	
-10.45	-15.66	-17.13	-17.46	-17.47	
-10.62	-15.71	-17.22	-17.47	-17.49	
-10.67	-15.71	-17.23	-17.48	-17.48	
-10.83	-15.7	-17.25	-17.46	-17.49	
-10.87	-15.7	-17.28	-17.47	-17.48	
-11.05	-15.72	-17.29	-17.48	-17.48	
-11.15	-15.71	-17.29	-17.47	-17.48	
-11.25	-15.7	-17.29	-17.48	-17.51	
-11.33	-15.73	-17.29	-17.47	-17.51	
-11.39	-15.72	-17.28	-17.46	-17.5	
-11.47	-15.74	-17.3	-17.47	-17.51	
-11.67	-15.73	-17.32	-17.47	-17.51	

SETTLEMENT (mm)					
TEST 7:	30V,20kPa				
0	-13.34	-18.88	-19.63	-19.72	-19.71
-0.56	-14.09	-18.9	-19.65	-19.7	-19.7
-5.7	-14.66	-18.91	-19.63	-19.71	-19.71
-6.13	-15	-18.95	-19.66	-19.72	-19.73
-6.28	-15.39	-19.17	-19.68	-19.72	-19.77
-6.65	-15.5	-19.19	-19.67	-19.72	-19.76
-6.98	-15.57	-19.19	-19.66	-19.72	-19.82
-7.01	-15.55	-19.19	-19.65	-19.69	-19.85
-7.15	-15.67	-19.24	-19.67	-19.7	-19.88
-7.28	-15.72	-19.24	-19.65	-19.73	-19.85
-7.71	-15.81	-19.27	-19.68	-19.71	-19.89
-7.76	-15.84	-19.28	-19.69	-19.71	-19.89
-7.75	-15.87	-19.29	-19.67	-19.72	
-8.17	-15.91	-19.31	-19.67	-19.71	
-8.17	-15.93	-19.31	-19.69	-19.7	
-8.19	-15.95	-19.35	-19.68	-19.73	
-8.24	-16.23	-19.32	-19.68	-19.73	
-8.56	-16.21	-19.34	-19.68	-19.73	
-8.57	-16.23	-19.35	-19.67	-19.71	
-8.62	-16.22	-19.35	-19.67	-19.74	
-8.75	-16.23	-19.33	-19.69	-19.73	
-8.82	-16.25	-19.36	-19.68	-19.71	
-9.03	-16.27	-19.34	-19.69	-19.71	
-9.06	-16.31	-19.35	-19.69	-19.72	
-9.45	-16.7	-19.36	-19.69	-19.72	
-9.44	-16.72	-19.37	-19.68	-19.73	
-9.49	-16.77	-19.38	-19.7	-19.73	
-9.51	-16.93	-19.38	-19.72	-19.7	
-9.58	-16.98	-19.38	-19.69	-19.7	
-9.84	-17.12	-19.43	-19.69	-19.7	
-9.87	-17.19	-19.5	-19.71	-19.72	
-9.97	-17.54	-19.49	-19.72	-19.73	
-10.06	-17.86	-19.5	-19.72	-19.73	
-10.13	-18	-19.51	-19.73	-19.72	
-10.24	-18.04	-19.51	-19.71	-19.73	
-10.24	-18.2	-19.51	-19.71	-19.71	
-10.27	-18.24	-19.53	-19.72	-19.71	
-10.33	-18.49	-19.53	-19.71	-19.7	
-10.77	-18.5	-19.53	-19.7	-19.7	
-10.76	-18.52	-19.54	-19.7	-19.73	
-10.78	-18.56	-19.55	-19.72	-19.72	
-10.88	-18.55	-19.54	-19.72	-19.71	
-10.93	-18.84	-19.55	-19.72	-19.72	
-10.99	-18.82	-19.6	-19.72	-19.72	
-11.06	-18.82	-19.59	-19.73	-19.73	
-11.19	-18.86	-19.61	-19.72	-19.72	
-11.23	-18.87	-19.63	-19.73	-19.73	
-11.28	-18.88	-19.59	-19.73	-19.72	
-12.43	-18.89	-19.64	-19.74	-19.7	

SETTLEMENT (mm)					
TEST 8:	60V,20kPa				
0	-13.41	-22.37	-22.58	-22.83	-22.83
-4.19	-14.97	-22.38	-22.59	-22.84	-22.85
-4.29	-16.22	-22.36	-22.59	-22.82	-22.83
-4.29	-17.05	-22.36	-22.59	-22.83	-22.84
-4.46	-17.57	-22.37	-22.59	-22.82	-22.84
-4.71	-17.83	-22.38	-22.6	-22.84	-22.82
-4.77	-18.15	-22.37	-22.6	-22.84	-22.84
-4.78	-18.41	-22.37	-22.6	-22.84	-22.82
-5.21	-18.48	-22.37	-22.62	-22.83	-22.83
-5.24	-18.56	-22.38	-22.6	-22.84	-22.84
-5.31	-18.86	-22.38	-22.6	-22.82	-22.82
-5.54	-18.93	-22.38	-22.62	-22.83	-22.81
-6.57	-18.99	-22.39	-22.63	-22.84	
-6.58	-19.2	-22.38	-22.61	-22.84	
-6.8	-19.28	-22.38	-22.62	-22.83	
-6.83	-19.31	-22.38	-22.6	-22.82	
-6.86	-19.61	-22.39	-22.63	-22.81	
-6.87	-19.96	-22.4	-22.63	-22.81	
-6.92	-20.19	-22.39	-22.63	-22.83	
-6.94	-20.68	-22.38	-22.64	-22.82	
-6.95	-20.82	-22.52	-22.64	-22.83	
-6.99	-21.03	-22.53	-22.62	-22.83	
-6.98	-21.15	-22.52	-22.64	-22.83	
-7.37	-21.3	-22.54	-22.64	-22.84	
-7.37	-21.34	-22.55	-22.62	-22.84	
-7.39	-21.5	-22.53	-22.82	-22.84	
-7.39	-21.56	-22.55	-22.82	-22.83	
-7.41	-21.57	-22.54	-22.82	-22.83	
-7.42	-21.64	-22.54	-22.82	-22.84	
-7.41	-21.98	-22.54	-22.82	-22.84	
-7.48	-21.96	-22.54	-22.82	-22.84	
-7.8	-22.01	-22.55	-22.82	-22.83	
-7.79	-22	-22.55	-22.83	-22.84	
-7.8	-22.07	-22.56	-22.83	-22.84	
-7.78	-22.09	-22.55	-22.82	-22.84	
-7.8	-22.11	-22.58	-22.82	-22.84	
-7.83	-22.3	-22.58	-22.82	-22.81	
-7.87	-22.29	-22.57	-22.84	-22.81	
-8.2	-22.31	-22.6	-22.8	-22.83	
-8.17	-22.33	-22.59	-22.8	-22.84	
-8.19	-22.33	-22.59	-22.83	-22.81	
-8.2	-22.34	-22.59	-22.83	-22.82	
-8.21	-22.34	-22.59	-22.82	-22.84	
-8.24	-22.35	-22.59	-22.81	-22.81	
-8.58	-22.36	-22.6	-22.83	-22.84	
-11.51	-22.35	-22.58	-22.82	-22.84	
-11.51	-22.36	-22.59	-22.82	-22.84	
-11.54	-22.35	-22.59	-22.84	-22.85	
-11.6	-22.36	-22.59	-22.83	-22.83	