NAUTICA GAUGE MACKINTOSH PROBE

By

Syahril Azim Bin Saiful Bahri

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Universiti Teknologi PETRONAS

Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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(CIVIL)

Approved by,

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( )

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

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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.

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(SYAHRIL AZIM BIN SAIFUL BAHRI)

ABSTARCT

A Mackintosh probe is a lightweight portable penetrometer that is designed to be a tool to investigate the soil bearing capacity. The tool consist of high yield steel rods, each of length approximately 120cm that are connected each other by 25mm outer diameter couplings with a 27.9mm diameter of a 30^{o} –apex angle; 12.7 mm diameter solid rods and a 4.5 kg dead weight with standard drop height of 300mm. The applications of the Mackintosh probe are by assembling the equipment, marked on each 0.3m on the rods, set up the equipment on the ground, pulled up the hammer until maximum height, dropped freely to driven the rod and cone into the soil, continued until the blow reach more than 400 blows per 0.3m penetration or the depth reached 15m. Under any circumstances of the soil conditions, the rate of driven must be from 15 to 30 blows per minute and the deviation from the vertical of the first extension rod shall not be greater than 2%. The result from the Mackintosh probe test shall be recorded for every blows per 0.3m. Thus, the value of the bearing capacity will be referred to the standard bearing capacity graph. Mackintosh probe have lots of disadvantages that can lead to misleading test result that are contributed mostly from human error. To overcome this problem, this study will mainly focusing on developing a mechanism that will improve the present Mackintosh probe. The mechanism is called the Nautical Gauge Mackintosh Probe (NGMP). From the progress test result of this study, it shows the number of blows per 0.3m is exceed the limitation of the standard bearing capacity graph. The recommendation for the problem is to change the location of study to a more adequate location.

ACKNOWLEDGEMENT

My deepest gratitude to Allah The Most Gracious and Merciful, for the guidance and blessings, for granting me strength when all hope seems lost. The author would like to thanks AP IR Dr Ibrahim Kamaruddin for being very proactive helping and supporting throughout the Final Year Project 1 and 2 period. It has been a precious experience researching under his supervision because he gave the best opportunity in handling and experiencing real life problems.

A Special thanks to Muhammad Fairus bin Abdullah (welding specialist for Arjafi Resources Sdn. Bhd) for coaching and helping the author in making the NGMP a reality by contributing in manufacturing the NGMP without any hassle and miscommunications. By this experience, it helps the author practicing to be a competent engineer during the designing process of the NGMP. My most sincere appreciation is also dedicated to Muhammad Hafiz bin Mustafa for his helps and opinions in the process of delivering the NGMP to the site.

The author would like to give his deepest thanks to the workforce Universiti Teknologi Petronas staffs for being very helpful along the Final Year Project 1 and 2 period. All ambiguity during the research period was explained thoroughly without hesitation. Their openness in sharing experience in handling a real life research had made my internship period worth a priceless knowledge.

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CHAPTER 1

INTRODUCTION

1. INTRODUCTION

A thoroughly soil investigation is required before any construction building or project begins. This is important due to the assurance of the safety of a structure. Mackintosh Probe is a tool used for research purposes especially for soil investigation. Mackintosh Probe test is carried out to determine the bearing capacity which is the strength of the soil.

The result obtain from the test provides a rough estimation of the soil layer at a point. It is a tool that is light and easy to operate by a group of people consisting of a technician with one or two workers who do not required any skills in handling the tool. Fakher et. al (2005), who quoted this statement from Sabtan and Shehata (1994) that the Mackintosh Probe is a lightweight dynamic penetrometer and a considerably faster and cheaper tool than boring, particularly when the depth of exploration is moderate and the soils being investigated are soft or loose.

The apparatus for the Mackintosh Probe consists of high yield steel rod each of length approximately 120cm. The rods are connected to each other by 25mm outer diameter couplings. The cone's diameter is 27.94mm with a 30^{o} –apex angle; 12.7 mm diameter solid rods and a 4.5kg dead weight with standard drop height of 300mm as illustrated in Figure 1

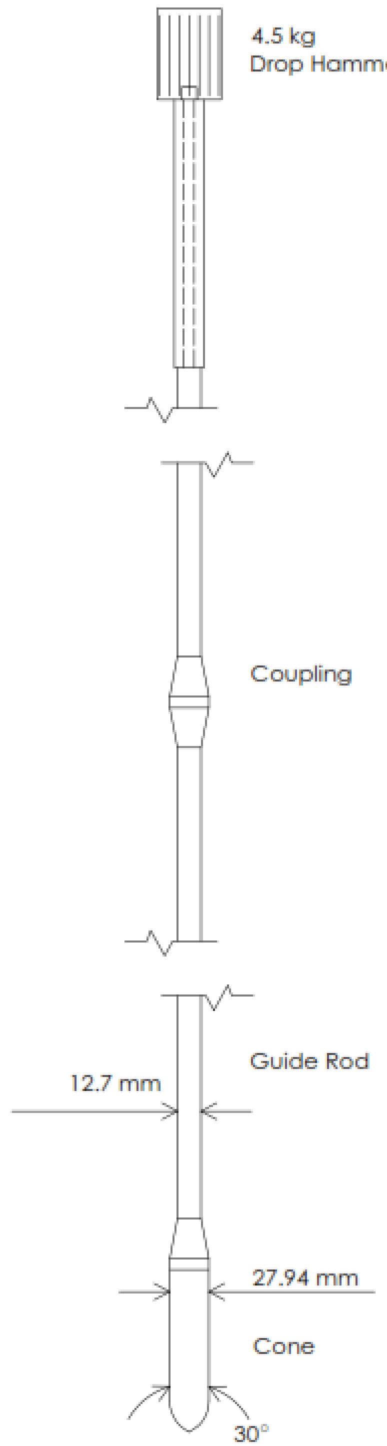

FIGURE 1. Mackintosh Probe

1.1 Advantages of Mackintosh Probe

Fakher et al. (2005) briefly report the main advantages of the Mackintosh Probe that are :

i. Speed of operation;
ii. Use in difficult terrain where access is poor;
iii. Minimal equipment and personnel are required;
iv. Equipment is very low cost;
v. Simplicity of operation and data recording/analysis;
vi. Use in the interpolation of soil strata and properties between trial pits and boreholes;
vii. Reduces the number of boreholes required.

1.2 Disadvantages of Mackintosh Probe

Despite of the many advantages of the Mackintosh Probe, there are also many disadvantages to this tool. The disadvantages are as follows:

i. Contribute to human error.
   a. Wrong counting
   b. Non-consistent drop height
   c. Not accurately vertical when using of the tool
ii. This tool can only be used in shallow soil
iii. Unable to penetrate into medium strength.
iv. Depending on human strength limitation
v. Might injured the user.

1.3 Problem Statement

As reported by Fakher at al. (2005), in the introduction section, there are many advantages of the Mackintosh Probe, but there are also some error and disadvantages of Mackintosh Probe. According to Sew et. al (2000), human errors are also prone in this method such as wrong counting, non-consistent drop height or exerting force to the drop hammer giving misleading results. Therefore, many error might occur during this process due to human error that cannot be prevented and this will affect the results of the investigation.

The application of the Mackintosh Probe must be followed thoroughly as it might affect the end result of the soil investigation. Sew at al. (2000) briefly wrote in their research that the usage of the Mackintosh Probe, some of precautionary measures to prevent errors in testing which are as follows :

i. Drop of hammer should be a free fall and consistent drop height.
ii. Components and apparatus properly washed and oiled.

Even though the Mackintosh Probe is said to be a light tool as cited by Fakher at al.(2005), but the limitation of human strength will eventually become a factor of human error because this tool tend to use a big portion of human energy in a long term usage.

1.4 Objectives of study

The main objectives of this study are as follows:

i. Designing and introducing the Nautical Gauge Mackintosh Probe (NGMP).
ii. Improving the usage of Mackintosh Probe in order to reduce errors.
iii. Comparing the results between the present Mackintosh Probe with the NGMP.

1.5 Scope of study

The scope of this study concentrate on the comparisons between results on the present Mackintosh Probe with the NGMP. This study relies on data that is obtain in the study area at Universiti Teknologi Petronas (UTP) region.

1.6 Mechanism of soil strength determination using Mackintosh Probe

To determine the soil strength using the Mackintosh Probe, the user must get the data that is plot on a table according to the number of blows per 0.3m and depth. Figure 2 shows example of data table. From this data, the user have to form the graph of 100mm penetration that is counted for (M) versus the depth, m. Figure 3 shows the graph that is taken from Fakher et al. (2005). This graph is to obtain a rough estimation of the soil layer at a point.

TABLE 1. Example of data table

PROJEK : RUMAH KEDAI EMPAT TINGKAT *PROJECT : FOUR STOREY SHOP HOUSE* LOKASI : LOT 110, PT 275 , ALOR STAR *LOCATION :*	
Kedalaman (m) *Depth (m)*	Bil. Hentaman/0.3m *Number of Blows / 0.3m*
0.0 – 0.3	15
0.3 – 0.6	10
0.6 – 0.9	8
0.9 – 1.2	16
1.2 – 1.5	42
1.5 – 1.8	50
1.8 – 2.1	52
2.1 – 2.4	48
2.4 – 2.7	56
2.7 – 3.0	54
3.0 – 3.3	90
3.3 – 3.6	95
3.6 – 3.9	105
3.9 – 4.0	400

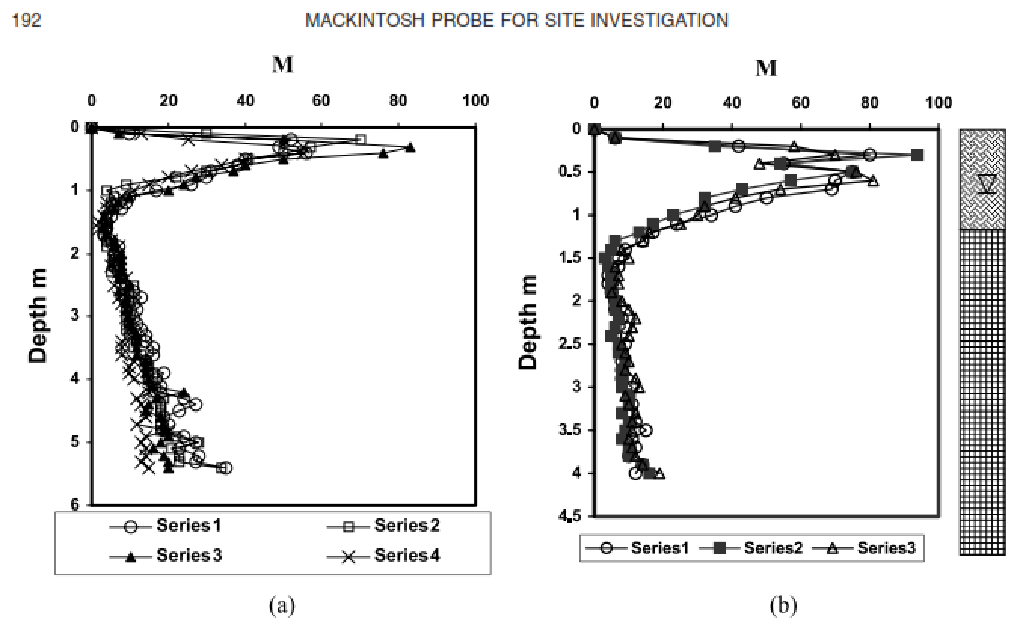

FIGURE 2. Graph M versus depth.

From the data that have been analyse, the cumulative number of blows according to their respective depth will be divided by the total gap. The answer will give us the number of blows per 0.3m. From here, we need to use the standard graph (JKR standard) for bearing capacity (as in Figure 4) to determine the Bearing Capacity (kN/m^2)

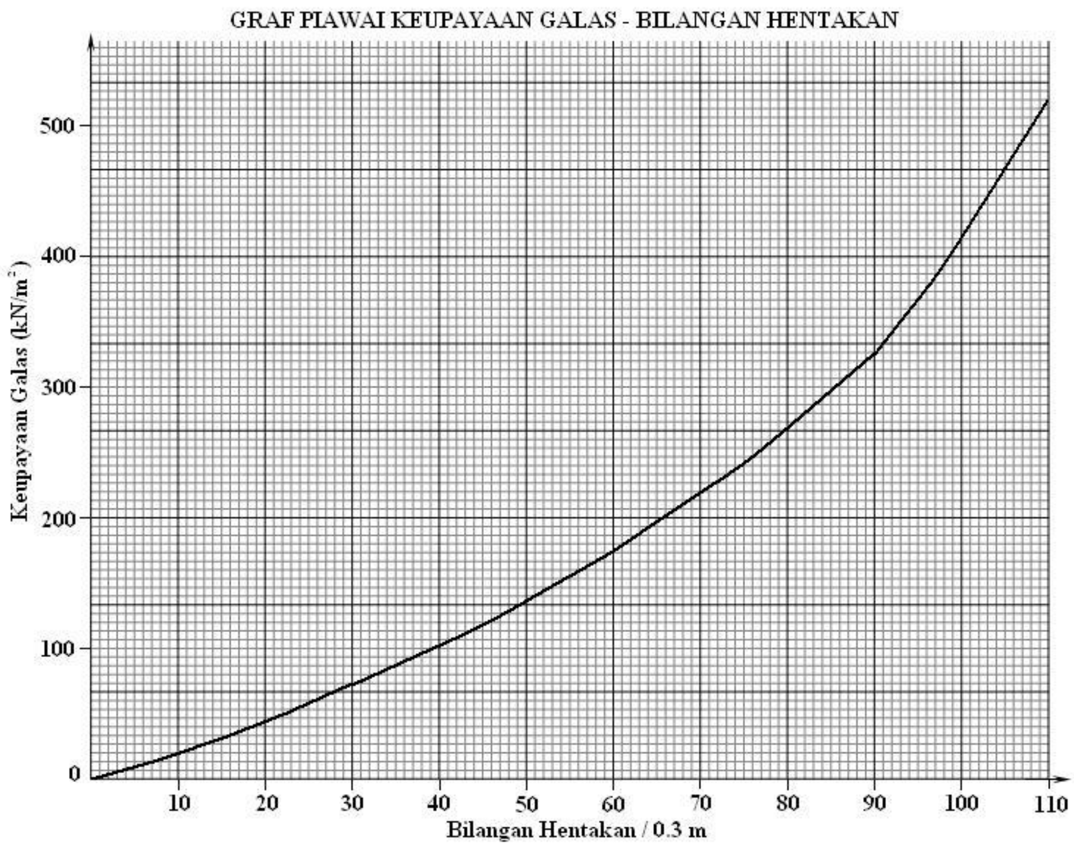

FIGURE 3. Standard Bearing Capacity Graph

According to ISI904-1978, the recommendations for the safe bearing capacity should be calculated on the basis of the soil test data. But, in absence of such data, the values of safe bearing capacity can be taken equal to the presumptive bearing capacity values given in the Table 1.0, for different types of soils and rocks. It is further recommended that for non-cohesive soils, the value should be reduced by 50% if the water table is above or near base of footing.

TABLE 2 Safe/allowable bearing capacity for various type of soil/rock

Type of soil/rock	Safe/allowable bearing capacity (KN/m^2)
Rock	3240
Soft rock	440
Coarse sand	440
Medium sand	245
Fine sand	440
Soft shell / stiff clay	100
Soft clay	100
Very soft clay	50

CHAPTER 2

LITERATURE REVIEW

2.0 LITERATURE REVIEW

Mackintosh Probe is usually used in preliminary soil investigation to acquire the undrained shear strength (directly through correlations) and consistency of the subsoil layering for very soft soils, Sew et. al (2000). Therefore, the application of this tool is very important to the construction world as it affect the whole construction of structure.

There are many shape and model of Mackintosh Probe but this research will be using the same model as Fakher et. al (2005) that consists of a 27.94 mm diameter cone with a 30^{o} –apex angle; 12.7 mm diameter solid rods and a 4.5kg dead weight with standard drop height of 300mm as illustrated in Figure 1.

The usage of the Mackintosh Probe is very easy and the tools itself is light in weight but it is also a boring tool to be used. As quote by Fakher et al.(2006), it is a tool that is much faster and cheaper but boring, especially when the depth of exploration is moderate and below ground is soft or loose investigation. In a human nature perspective, the user tend to make error along the process of the investigation because of the tireless feeling.

CHAPTER 3

METHODOLOGY

3.0 Methodology

The design methodology was structured in stages which has been illustrated in Figure3.

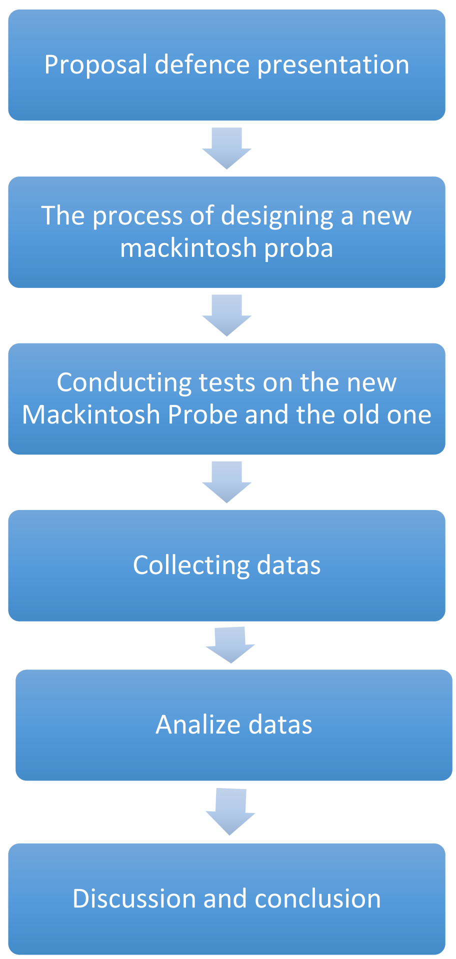

FIGURE 4. Steps of project implementation.

There are two results which will determine whether this project is successful or the opposite. The results will based on the result's differences between the old Mackintosh Probe and the new Mackintosh Probe. If the results from the new Mackintosh Probe are almost the same with the results from the old Mackintosh Probe, then the objective of this studies is a success and vice versa. The results will be obtain from the procedure of the Mackintosh Probe. The procedure of the old Mackintosh Probe are as follows:

i. Equipment for the test are assembled. The cone diameter is measured in SI unit.
ii. The boring rods and hammer are joint using the rod coupling. Grease is sweep up for an easy dissembles later.
iii. Distance of 0.3 m is measured and marked on the rod start from the tip of the cone.
iv. The equipment is set up on the ground.
v. The hammer is pulled up until it reached the maximum. The hammer is dropped freely to driven the cone into the soils.
vi. The sum of the number of blows for each 0.3m penetration is recorded in the data sheet.
vii. The rod will continuously joint until :
    a. The blow is more than 400 for 0.3m penetration.
    b. The depth reached 15m
viii. Pull the rods using lifting tools after the penetration reached the requirement.
ix. The equipment are dissembled and cleaned before storing

3.1 Process on producing the new Mackintosh Probe

i. Designing the new Mackintosh Probe
ii. Collecting information of materials to be used for the new Mackintosh Probe.
iii. Works with companies that can construct the new Mackintosh Probe

3.2 Steps in collecting the results

i. Do the soil investigation by using the old Mackintosh Probe and the new Mackintosh Probe at Universiti Teknologi Petronas.
ii. Collecting data obtained from the investigation.
iii. Check the differences between the old Mackintosh Probe's results with the new Mackintosh Probe's results.
iv. Make conclusion and discussion.

3.3 Approval from Jabatan Kerja Raya(JKR)

i. To support this studies, the new Mackintosh Probe must be shown to the JKR whether they approved the usage of it.
ii. To support and proven to its application.
iii. JKR themselves will try the new Mackintosh Probe

3.4 Project Timeline/Key Project Milestone

Table 3: Gantt chart of the project time line and key project milestone

ACTIVITIES	WEEKS																											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Selection of Project Topic	■	■																										
Preliminary Research Work		■	■	■	■																							
Submission of Extended Proposal						●																						
Proposal Defence								■	■																			
Designing and Developing the NGMP								■	■	■	■	■	■	■	■	■	■	■	■	■	■							
Project work continues										■	■	■																
Submission of Interim Draft Report													●															
Submission of Interim Report														●														
Project work continues															■	■	■	■	■	■	■							
Submission of Progress Report																					●							
Project work continues																						■	■	■	■	■		
Pre-SEDEX																								●				
Submission of Draft Final Report																									●			
Submission of Dessertation (soft bound)																										●		
Submission of Technical Paper																										●		
Viva																											●	
Submission of Project Dissertation (hard bound)																												●

● Milestone

■ Process

3.5 Designing the Nautica Gauge Mackintosh Probe

3.5.1 Agreement with Arjafi Resources Sdn. Bhd

As a result from the discussion with Arjafi Resources Sdn. Bhd., an expert welding company, they had agreed to jointly help the designing and building process of the Nautica Gauge Mackintosh Probe.

RM Dagang Sdn. Bhd. had agreed to give their full services which compromise of :-

i. Welding work expertise
ii. Consulting on the design
iii. Manpower and machineries

It is necessary to let the highly expertise companies, which is in the field of welding, to produce the Nautica Gauge Mackintosh Probe. This is because the welding process requires experience, qualified and expert workers in handling such dangerous tools.

3.5.2 Designing Process of the NGMP

Further discussions and meetings had been arrange with Arjafi Resources Sdn. Bhd to design the Nautical Gauge Mackintosh Probe. All of the designs had been illustrate in Autodesk AutoCAD which gives the study a clearer view of any negligence. Combining ideas and descriptions of the problems that have been identified from the preliminary study had help RM Dagang to understand the necessarily of their expertise skills.

Some rough ideas and sketches have been made to get an overview of the Nautical Gauge Mackintosh Probe. All of the point of the problems had been identify from further sketches before the final drawings were made. These sketches was adapted using Autodesk AutoCAD to produce the blueprint of the design.

All of the layout needs to take account the capacity factor of the materials that will be used for the production of the Nautical Gauge Mackintosh Probe. In Figure 5 Figure 6 and Figure 7 illustrate some of the initial and final design of the Nautical Gauge Mackintosh Probe.

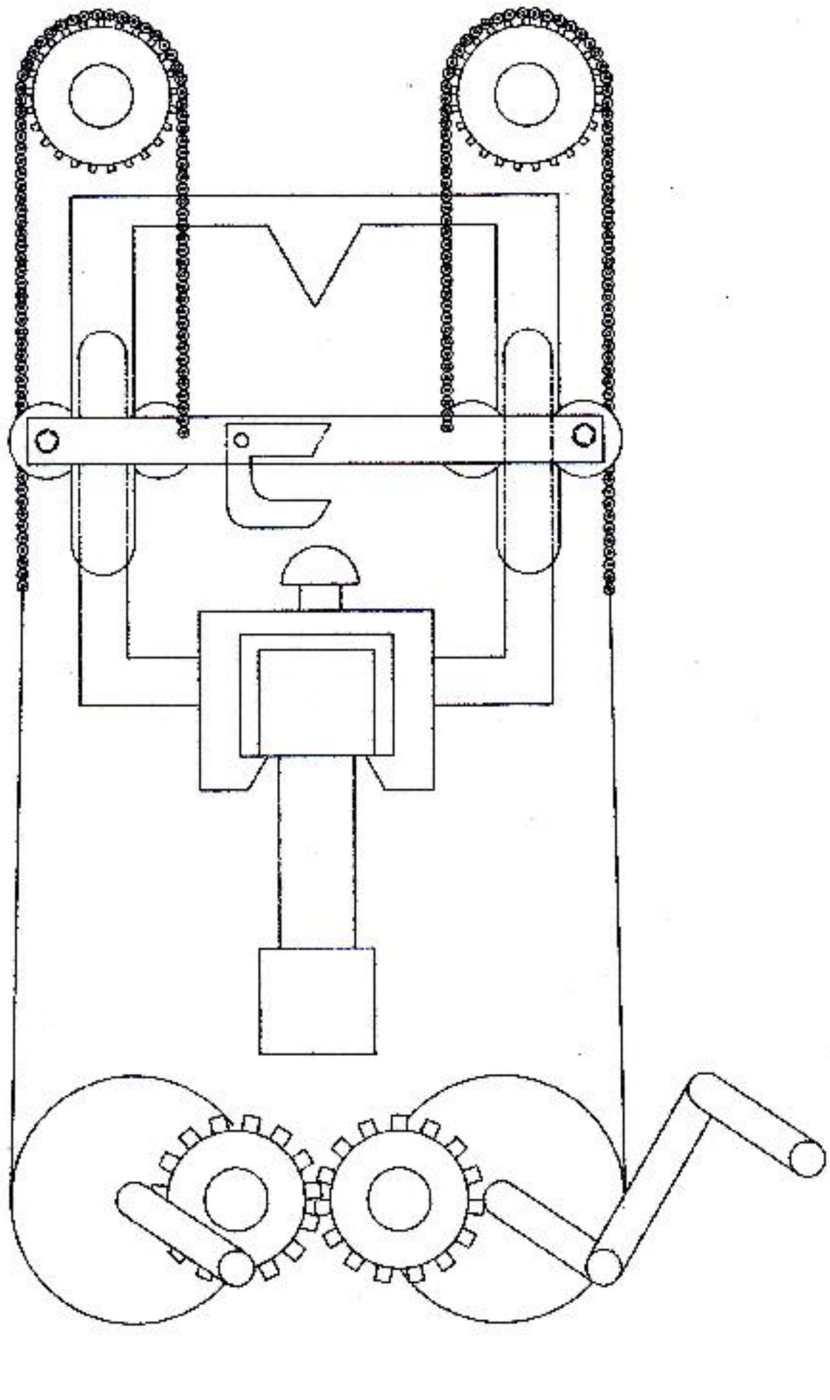

FIGURE 5. Illustration of the first initial design of the Nautical Gauge Mackintosh

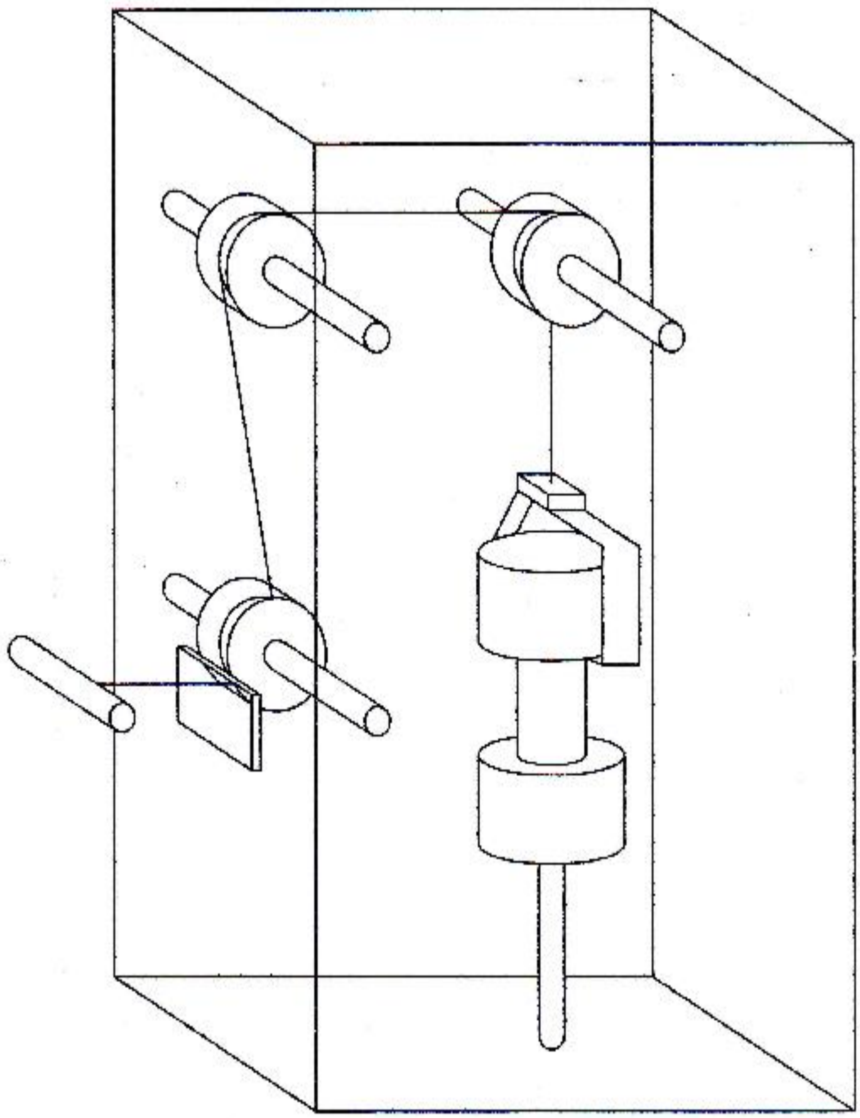

FIGURE 6. Illustration of the second initial design of the Nautical Gauge Mackintosh Probe

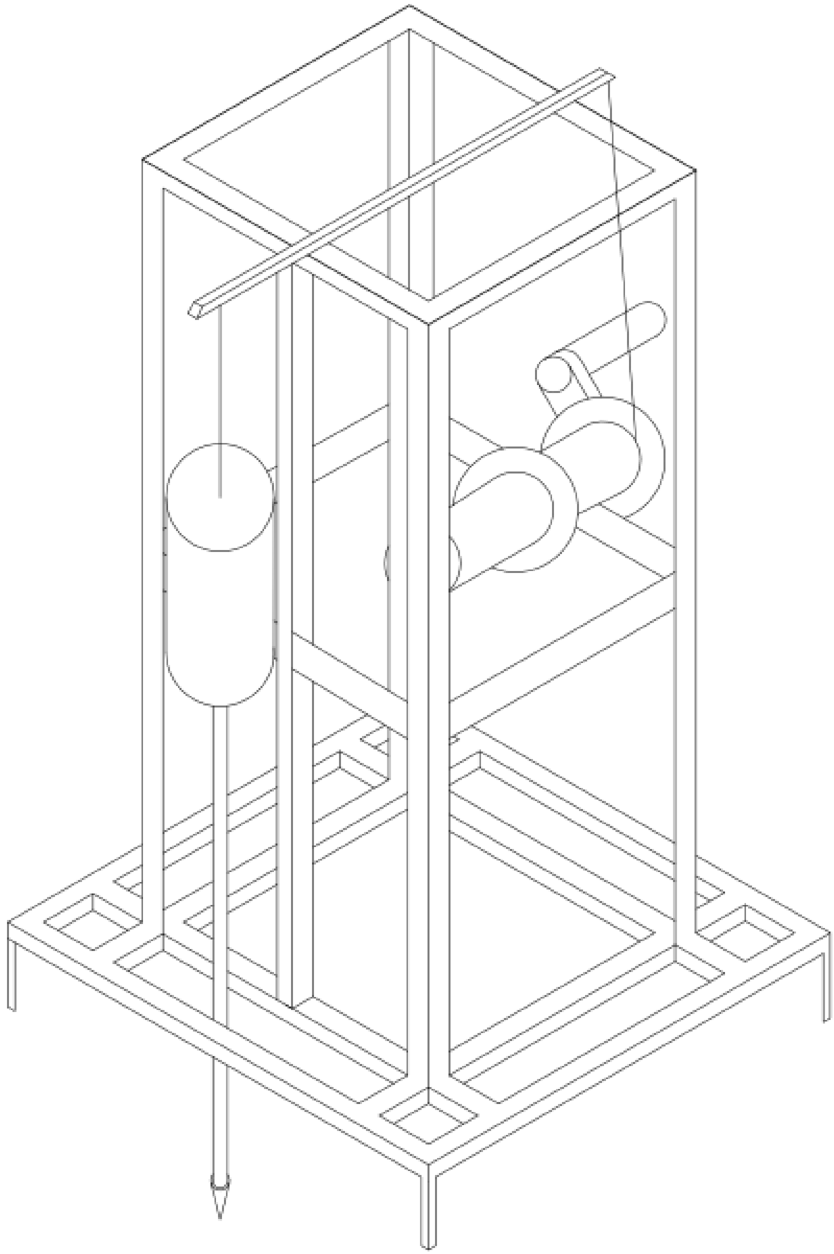

FIGURE 7. Illustration of the final design of the Nautical Gauge Mackintosh Probe

3.6 Manufacturing process of the NGMP

Meeting

- Meeting with the welding specialist
- Discuss upon the status of the agreement on manufacturing the NGMP and the design

Finalize

- Some problems occur on the measurement of the NGMP
- Finalize on the measurement and the price

Add on

- There are some addition feature in the NGMP
- Material :
  1) Steel
  2) Automatic countable gauge
  3) Steel plate
  4) Cable

FIGURE 8. Welding process of the NGMP

FIGURE 9. Automatic countable gauge

3.7 Testing process of the NGMP

The process of manufacturing of the Nautica Gauge Mackintosh Probe took 3 month. Thus, along the process of it, there are some verification and adjustment that had been done. Once the NGMP had been transported to UTP, the author had tested it.

In this research, the result to determine whether this research is a success is determine thoroughly on the comparison between the result of the present Mackintosh Probe and the result of the NGMP.

All of tests had been carried out inside of UTP ground and the result had been collected and analysed which to ensure whether the objective had been achieved or not.

CHAPTER 4

RESULT AND DISCUSSION

4. RESULT AND DISCUSSION

4.1 Preliminary test

The preliminary present Mackintosh probe test had been done at Block 14, Universiti Teknologi Petronas. The results are as follows:-

TABLE 4. Result from the preliminary test.

Depth	Number of blows	Cumulative number of blows
0 – 0.3	140	140
0.3 – 0.6	115	255
0.6 – 0.9	79	334
0.9 – 1.2	96	430
1.2 – 1.5	200	630
1.5 – 1.8	267	797
1.8 – 2.1	321	1118
2.1 – 2.4	400	1518

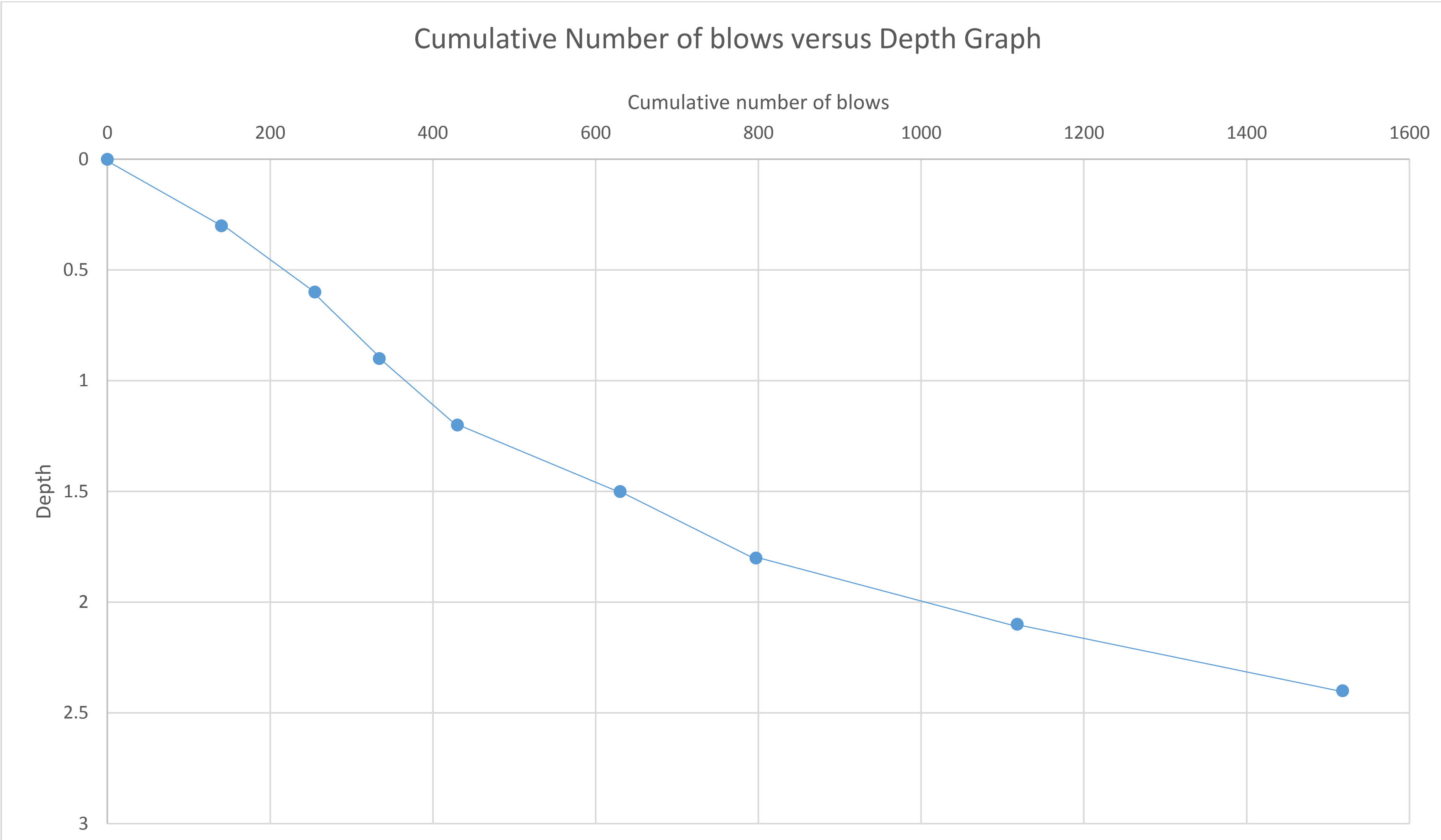

FIGURE 10. Cumulative Number of Blows versus Depth Graph

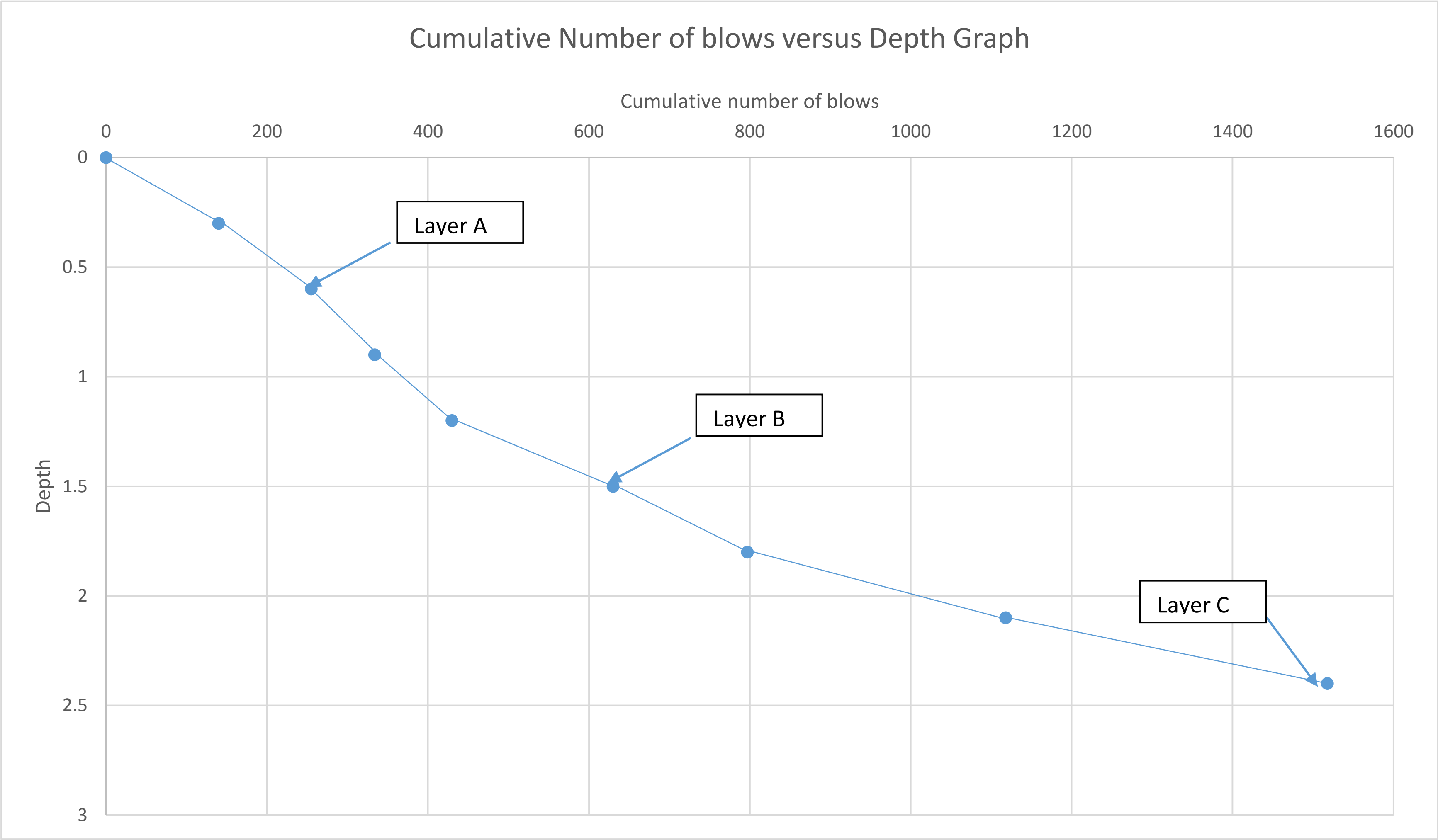

FIGURE 11. Rough estimation of layer of soil

4.1.1 Soil bearing capacity

From the calculation that have been calculated for the number of blows per 0.3m, Layer A accumulate a total number of 110 blows per 0.3m to reach to the Layer B. Layer B gives a total number of 148 blows per 0.3m to reach to the Layer C. The layer C give a total number of 296 blows.

All of this result have exceeding the limitation of the standard bearing capacity graph which only limited to 110 blows per 0.3m. Figure 4 shows the standard bearing capacity graph.

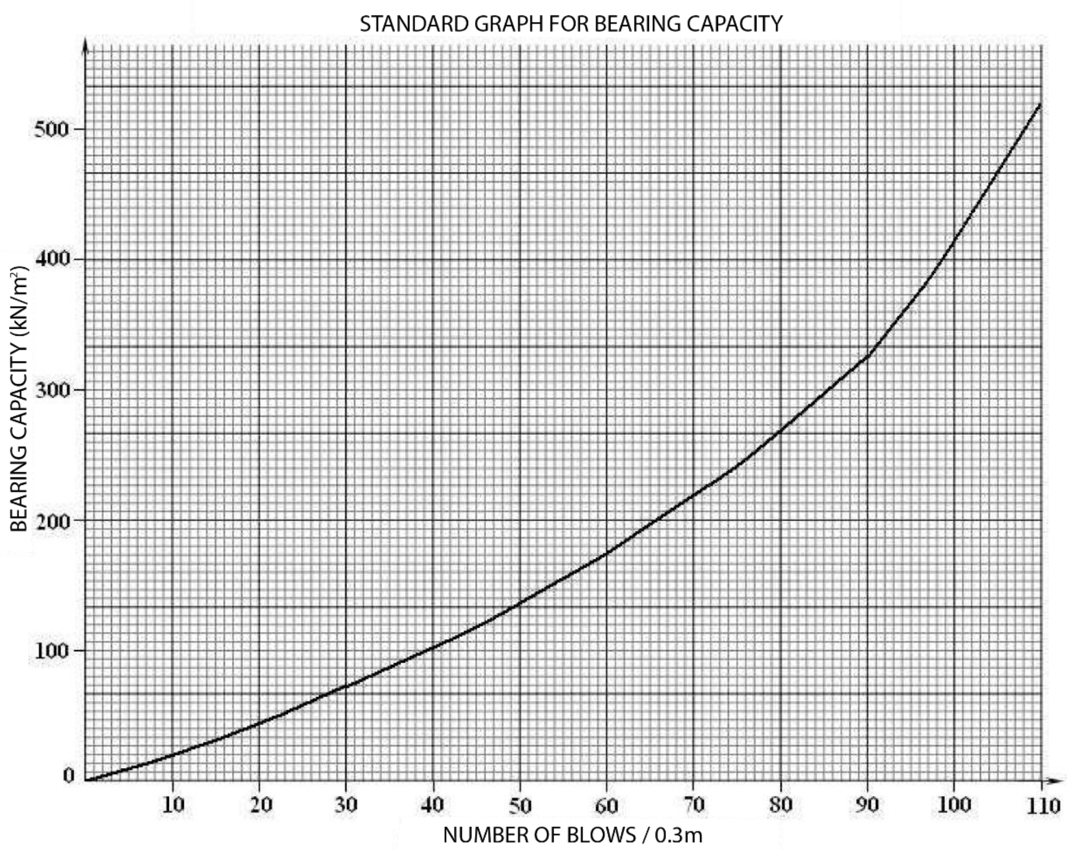

Figure 12. The standard bearing capacity graph.

4.2 Progress test

4.2.1 Test 1

The progress present Mackintosh probe test had been done at Oval Park, Universiti Teknologi Petronas. The results are as follows:-

TABLE 5. Result from the progress test 1.

Depth	Number of blows	Cumulative number of blows
0 – 0.3	313	313
0.3 – 0.6	400	713

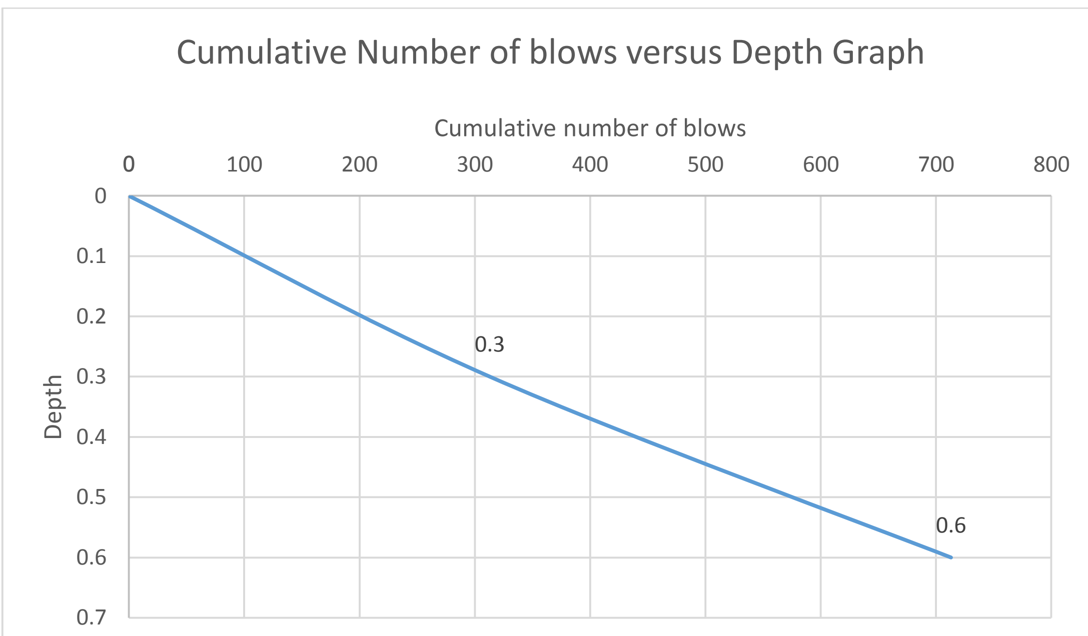

Figure 13 Cumulative Number of Blows versus Depth Graph for Test 1

4.2.2 Test 2

The progress present Mackintosh probe test had been done at Oval Park, Universiti Teknologi Petronas. The results are as follows:-

TABLE 6. Result from the progress test 2.

Depth	Number of blows	Cumulative number of blows
0 – 0.3	298	298
0.3 – 0.6	400	698

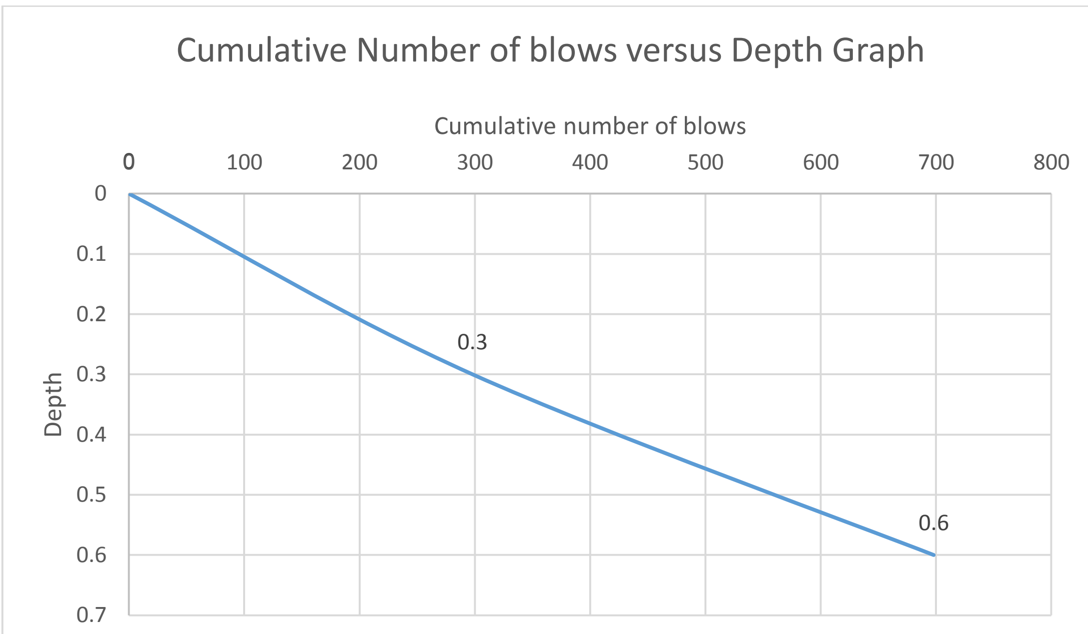

Figure 14 Cumulative Number of Blows versus Depth Graph for Test 2

4.2.3 Test 3

The progress present Mackintosh probe test had been done at Oval Park, Universiti Teknologi Petronas. The results are as follows:-

TABLE 7. Result from the progress test 3.

Depth	**Number of blows**	**Cumulative number of blows**
0 – 0.3	400	400

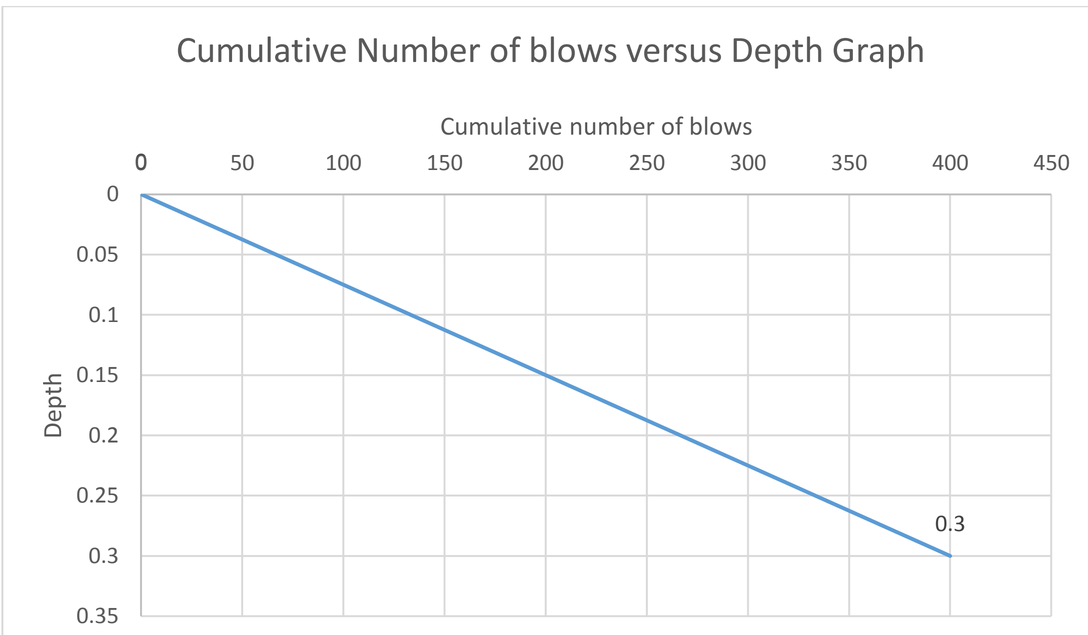

Figure 15 Cumulative Number of Blows versus Depth Graph for Test 3

4.2.4 Test 4

The progress present Mackintosh probe test had been done at Oval Park, Universiti Teknologi Petronas. The results are as follows:-

TABLE 8. Result from the progress test 4.

Depth	Number of blows	Cumulative number of blows
0 – 0.3	149	149
0.3 – 0.6	285	434
0.6 – 0.9	400	834

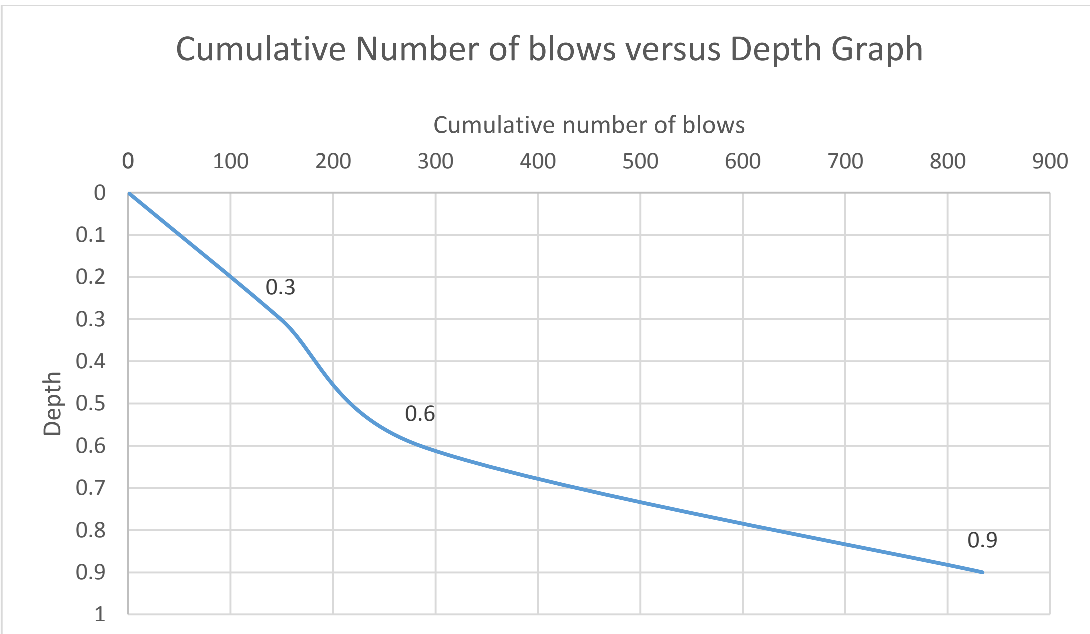

Figure 16 Cumulative Number of Blows versus Depth Graph for Test 4

4.2.5 Test 5

The progress present Mackintosh probe test had been done at Block 14 parking area, Universiti Teknologi Petronas. The results are as follows:-

TABLE 9.0. Result from the progress test 5 without NGMP.

Depth	Number of blows	Cumulative number of blows
0 – 0.3	107	107
0.3 – 0.6	89	196
0.6 – 0.9	45	241
0.9 – 1.2	30	271
1.2 – 1.5	32	303
1.5 – 1.8	28	331
1.8 – 2.1	46	377
2.1 – 2.4	102	479
2.4 – 2.7	260	739
2.7 – 3.0	249	988
3.0 – 3.3	400	1388

TABLE 9.1. Result from the progress test 5 with NGMP.

Depth	Number of blows	Cumulative number of blows
0 – 0.3	100	100
0.3 – 0.6	83	183
0.6 – 0.9	43	226
0.9 – 1.2	33	259
1.2 – 1.5	30	289
1.5 – 1.8	25	314
1.8 – 2.1	50	364
2.1 – 2.4	96	460
2.4 – 2.7	249	709
2.7 – 3.0	255	964
3.0 – 3.3	400	1364

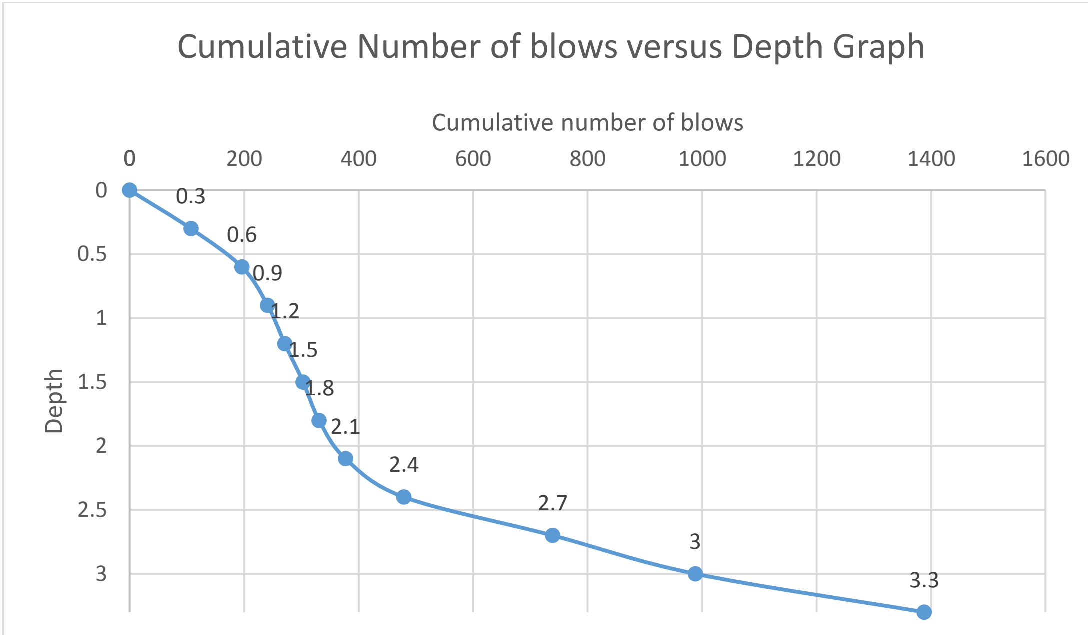

Figure 17 Cumulative Number of Blows versus Depth Graph for Test 5 without NGMP

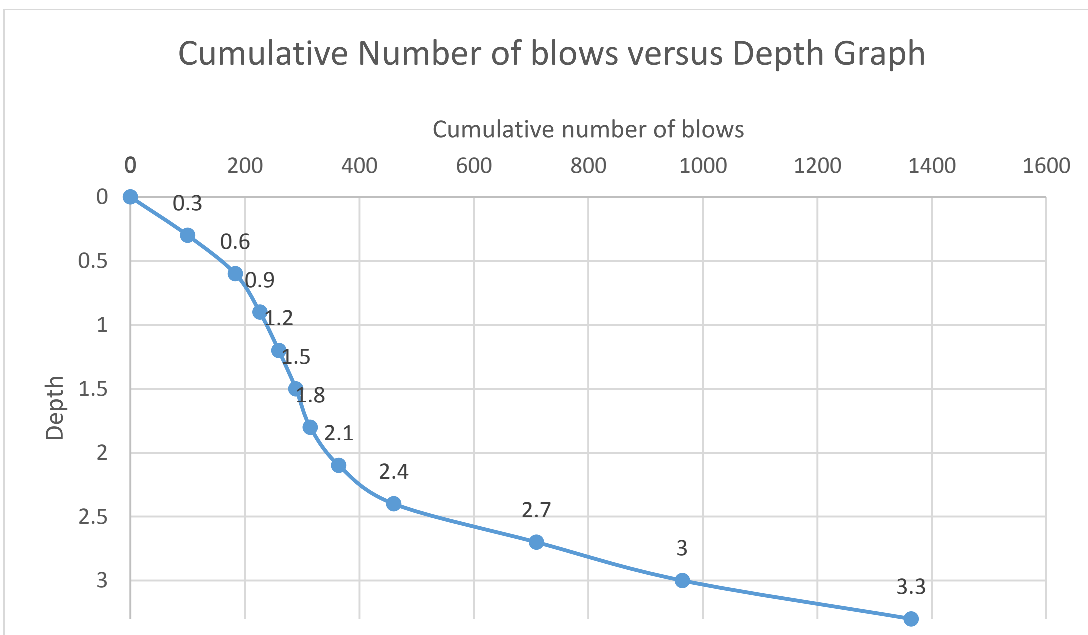

Figure 18 Cumulative Number of Blows versus Depth Graph for Test 5 with NGMP

4.2.6 Test 6

The progress present Mackintosh probe test had been done at Block 14 parking area, Universiti Teknologi Petronas. The results are as follows:-

TABLE 10.0. Result from the progress test 6 without NGMP.

Depth	Number of blows	Cumulative number of blows
0 – 0.3	110	110
0.3 – 0.6	103	213
0.6 – 0.9	89	302
0.9 – 1.2	65	367
1.2 – 1.5	74	441
1.5 – 1.8	43	484
1.8 – 2.1	91	575
2.1 – 2.4	156	731
2.4 – 2.7	212	943
2.7 – 3.0	400	1343

TABLE 10.1. Result from the progress test 6 with NGMP.

Depth	Number of blows	Cumulative number of blows
0 – 0.3	105	105
0.3 – 0.6	97	202
0.6 – 0.9	71	273
0.9 – 1.2	64	337
1.2 – 1.5	83	420
1.5 – 1.8	50	470
1.8 – 2.1	84	554
2.1 – 2.4	120	674
2.4 – 2.7	199	873
2.7 – 3.0	400	1273

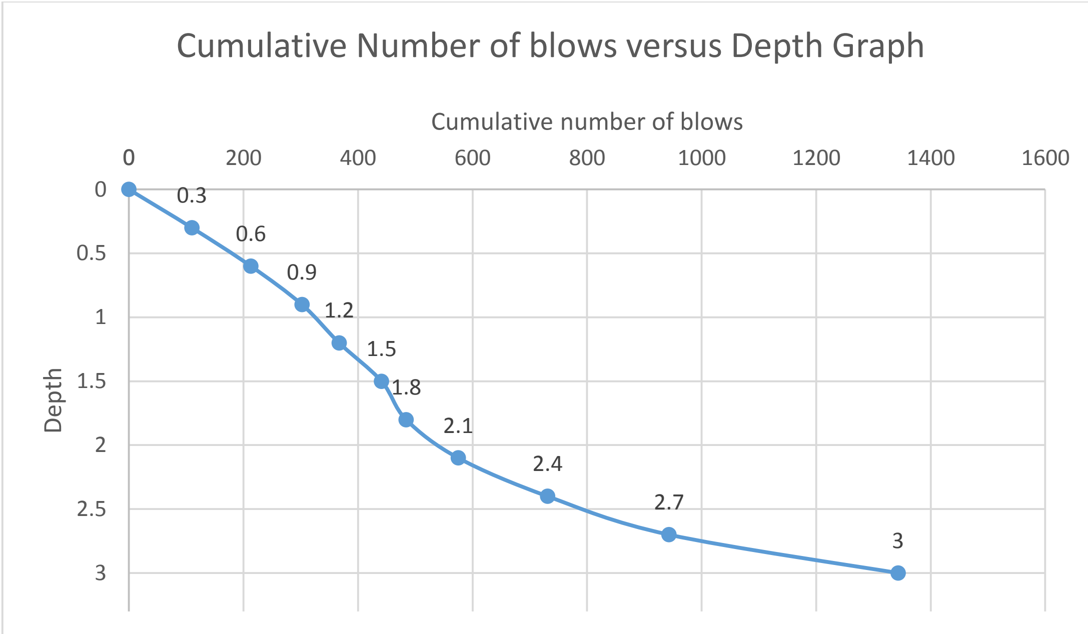

Figure 19: Cumulative Number of Blows versus Depth Graph for Test 6 without NGMP

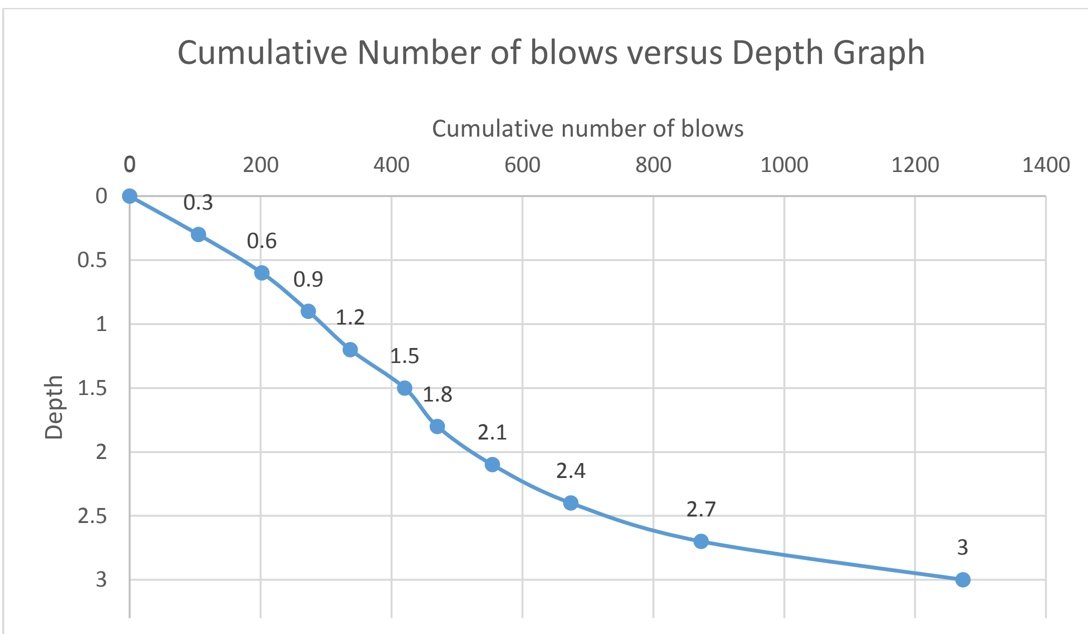

Figure 20: Cumulative Number of Blows versus Depth Graph for Test 6 with NGMP

4.2.7 Test 7

The progress present Mackintosh probe test had been done at Block 14 parking area, Universiti Teknologi Petronas. The results are as follows:-

TABLE 11.0. Result from the progress test 7 without NGMP.

Depth	Number of blows	Cumulative number of blows
0 – 0.3	45	45
0.3 – 0.6	39	84
0.6 – 0.9	42	126
0.9 – 1.2	56	182
1.2 – 1.5	94	276
1.5 – 1.8	86	362
1.8 – 2.1	115	477
2.1 – 2.4	400	877

TABLE 11.1. Result from the progress test 7 with NGMP.

Depth	Number of blows	Cumulative number of blows
0 – 0.3	50	50
0.3 – 0.6	33	83
0.6 – 0.9	44	127
0.9 – 1.2	51	178
1.2 – 1.5	84	262
1.5 – 1.8	84	346
1.8 – 2.1	121	467
2.1 – 2.4	357	824
2.4 – 2.7	400	1224

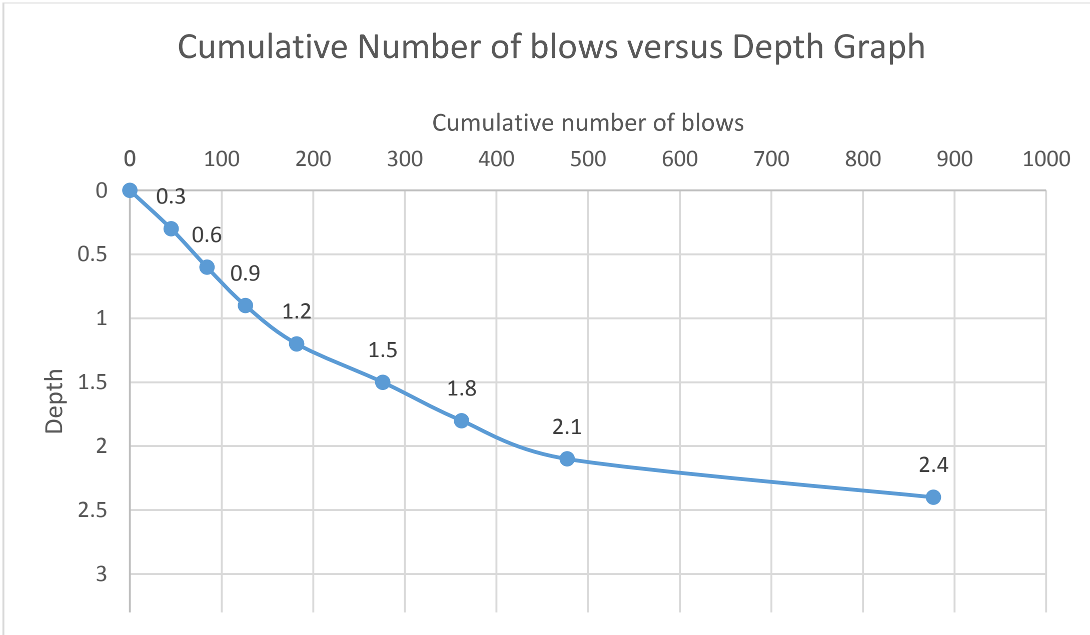

Figure 21: Cumulative Number of Blows versus Depth Graph for Test 7 without NGMP

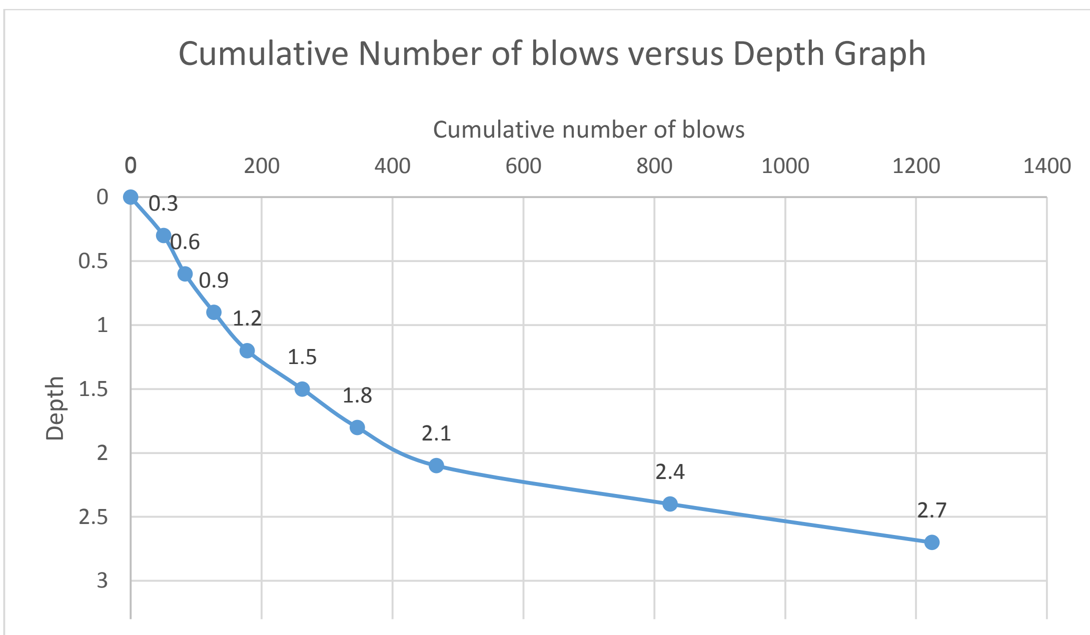

Figure 22: Cumulative Number of Blows versus Depth Graph for Test 7 with NGMP

4.3 Discussion

4.3.1 Preliminary results

From the preliminary results obtained, it is safe to say that the soil in Block 14 are too hard for the present Mackintosh probe to operate. The result shows that the number of blows per 0.3m are far greater than the limitation of the standard bearing capacity graph.

With this limitation problem, the suggestion to overcome this problem is by changing the location of the study from Block 14 to the construction site behind the Universiti Teknology Petronas. This is due to the expected soft layer that have been excavate at the construction site. From here onwards, the study can flow nicely without any obstacle to obtain more data to be analyse.

Furthermore, the factor that might lead to the lack of force to driven the rod into the soil, excluding the hard layer factor, are probably caused by the followings:-

i. Limitation energy of the user
ii. The verticality of the tool itself is inaccurate
iii. The drop of the 4.5 kg dead weight is not from the maximum height of 300mm.

4.3.2 Progress results

From the results obtained, it is safe to say that the soil at Oval Park for Test 1 is well compacted as it is too hard for the present Mackintosh probe to operate. The result shows that the number of blows between the depth of 0.3m and 0.6m are far greater than the limitation of the standard bearing capacity graph.

For test 1, it shows that the present Macintosh probe can only penetrate at the depth of 0.3m and 0.6m. At the depth of 0m to 0.3m, the number of blows are 313. The test is stop at the 400th time number of blows which end at the depth of 0.6m. This result cannot determine the strength or the bearing capacity of the soil as the result is far greater than the limitation of the standard bearing capacity graph. This can be caused by the well compacted process when the Oval Park is construct a long time ago.

For test 2, it shows almost the same result as test 1 because this study have made the test just around the area of the first test. At the depth of 0m to 0.3m, the number of blows are 298. The test is stop at the 400th time number of blows which end at the depth of 0.6m too. This result also cannot determine the strength or the bearing capacity of the soil as the result is far greater than the limitation of the standard bearing capacity graph.

For test 3, the soil here is the hardest part of the test location. It took 400 blows of the Mackintosh probe for the depth of 0.3m. On the 4th test, the Mackintosh probe manage to penetrate up to 0.9m. The first 0.3m, it takes 149 blows. On the depth of 0.6m, the blows were 285 and stop at the depth of 0.9m which took 400 blows.

Therefore, for test 1 until test 4, the soil is too hard for the Mackintosh Probe to be tested. The researcher had to change the location of the test site.

4.3.3 Progress results (present Mackintosh Probe)

For test 5 until 7, the test of the present Mackintosh Probe and the NGMP had been changed to Block 14 parking area, Universiti Teknologi Petronas. From the 5th test, present Mackintosh Probe test give a rough estimation of 3 layer. The soil bearing capacity of the first layer is 160 kn/m^2. The soil bearing capacity of the second and third layer is more than 500 kn/m$^{2.}$

On the 6th test, present Mackintosh Probe test had given a rough estimation of 3 layer also. The soil bearing capacity of the first layer is 340 kn/m^2. The soil bearing capacity of the second layer is 173 kn/m^2 and third layer is more than 500 kn/m^2.

For the 7th test, present Mackintosh Probe test had given a rough estimation of 3 layer also. The soil bearing capacity of the first layer is 120 kn/m^2. The soil bearing capacity of the second layer is 327 kn/m^2 and third layer is more than 500 kn/m^2.

4.3.4 Progress results (Nautical Gauge Mackintosh Probe)

For test 5 until 7, the test of the NGMP had been done right beside of the respective present Mackintosh Probe test location. From the 5th test, the NGMP result shows a rough estimation of 3 layer. The soil bearing capacity of the first layer is 147 kn/m^2. The soil bearing capacity of the second and third layer is more than 500 kn/m$^{2.}$

On the 6th test, the NGMP result shows a rough estimation of 3 layer also. The soil bearing capacity of the first layer is 293 kn/m^2. The soil bearing capacity of the second layer is 207 kn/m^2 and third layer is more than 500 kn/m^2.

For the 7th test, the NGMP results shows a rough estimation of 4 layer. The soil bearing capacity of the first layer is 103 kn/m^2. The soil bearing capacity of the second layer is 127 kn/m^{2,} the third layer is 293, and fourth layer is more than 500 kn/m^2.

TABLE 12.0. Result for the present Mackintosh Probe test

Present Mackintosh Probe Test		
Test	Layer	Bearing Capacity (kn/m$^{2)}$
5	1 (0 – 1.8m)	165
	2 (1.8 – 2.7m)	>500
	3 (2.7 – 3.3m)	>500
6	1 (0 – 1.2m)	340
	2 (1.2 – 1.8m)	173
	3 (1.8 – 3.0m)	>500
7	1 (0 – 1.2m)	120
	2 (1.2 – 1.8m)	327
	3 (1.8 – 2.4m)	>500

TABLE 12.1. Result for the NGMP

NGMP Test		
Test	Layer	Bearing Capacity (kn/m$^{2)}$
5	1 (0 – 1.8m)	147
	2 (1.8 – 2.7m)	>500
	3 (2.7 – 3.3m)	>500
6	1 (0 – 1.2m)	293
	2 (1.2 – 1.8m)	207
	3 (1.8 – 3.0m)	>500
7	1 (0 – 0.6m)	103
	2 (0.6 – 1.2m)	127
	3 (1.2 – 1.8m)	293
	4(1.8 – 2.7m)	>500

From the result, it shows that by using the NGMP, the soil bearing of the site location is not as high as the present Mackintosh Probe. This is due to the inconsistency of the drop of free fall height for the present Mackintosh Probe. Even though for Test 5 and 6, the rough estimation of the layer of the soil is three layer, but the present Mackintosh Probe test shows that the soil has a higher soil bearing capacity, where else the NGMP shows otherwise. For the test 7, it shows that the NGMP manage to penetrate deeper into the soil which conclude a rough estimation of four layer.

This is really important as this result might be used in the real life Soil Investigation process which the engineer will use this data as their foundation design. Furthermore, the design will be lower in term of strength than the actual strength of the soil which meant that the soil will not compatible with the design that had been calculated.

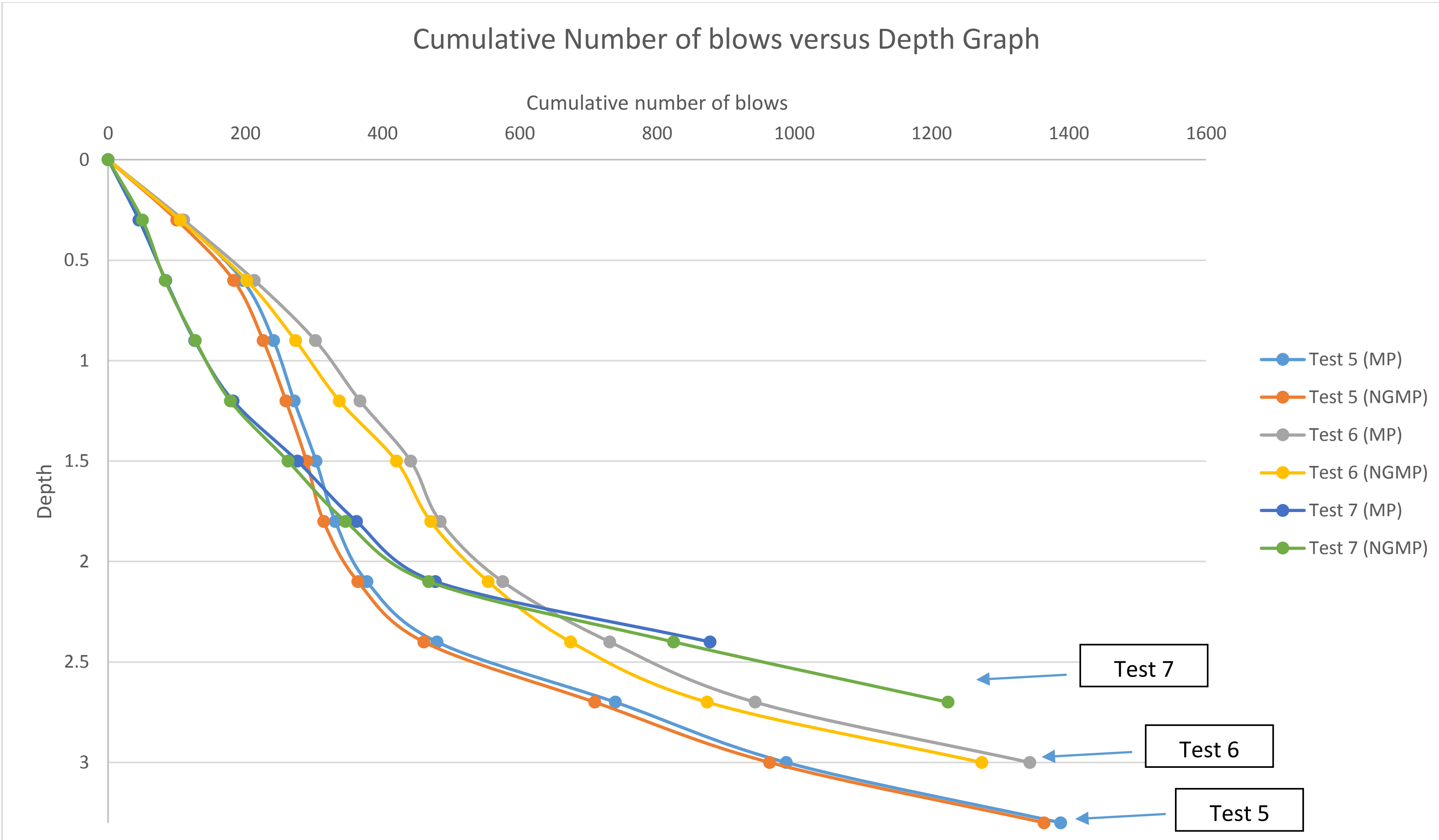

Figure 23: Cumulative Number of Blows versus Depth Graph for Test 5 until 7

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The conclusion of this study is that the present Mackintosh probe do have limitation on its application. The user required enormous amount of energy due to the weightage of the 4.5 kg dead weight and the condition of the usage of the tool must be in a condition which is very tedious just to get an accurate result. Therefore, the outcome from developing the Nautical Gauge Mackintosh Probe (NGMP) are:

i. Eliminating the burden of the user.
ii. Set up the Mackintosh Probe accurately vertical.
iii. Precisely drop the 4.5 kg dead weight at the maximum height of 0.3m.
iv. Eliminating the miscount of the blows.
v. The comparisons of the results between the usage of NGMP and without shows that by using NGMP, it gives a much accurate result because the rod can penetrate much deeper into the soil.

It is safe to conclude that the objective of this study is achieved with the existence of the NGMP which can improved the present Mackintosh Probe in terms of the results accuracy. Without an accuracy result in any investigation study, the work is useless and can devote a huge catastrophe that may leads to death and destruction.

5.2 Recommendation

Some additional thought and ideas were given to this study that can give confidence and versatility to this product development status. The recommendations are as follows:-

i. Design the NGMP that can use other soil investigation's tools besides Mackintosh Probe.
ii. Design a mechanism that can pull out the rods from the soil.
iii. Insert a small motor engine to the NGMP to make the application work automatically.
iv. Using a light weight but strong enough material for the fabrication of the NGMP to easily transport into the site.
v. Change the location of the Automatic Countable gauge from below part of the NGMP to the top part of it as it seems that the gauge cannot withstand the force of the Mackintosh 5 kg blows.

REFERENCE

Fakher, A., Khodaparast, M., & Jones, C. J. F. P. (2005). The use of the Mackintosh Probe for Site Investigation in Soft Soils.

Sew, I. D. G. S., Gue, I. T. Y. C., & Bhd, P. S. (2000). Subsurface Investigation and Interpretation of Test Results for Foundation Design in Soft Clay.

APPENDICES

Preliminary Test

1. Total number of blows from layer A to B

= 255 – 0

= 255 blows

Total depth gap from layer A to B

= (0.6 – 0) / 0.3

= 2

Total blows per 0.3m

= 255 / 2

= 128 blows/0.3m

2. Total number of blows from layer B to C

= 630 – 255

= 375 blows

Total depth gap from layer B to C

= (1.5 – 0.6) / 0.3

= 3

Total blows per 0.3m

= 375 / 3

= 125 blows/0.3m

3. Total number of blows from layer C to D

= 1518 – 630

= 888 blows

Total depth gap from layer C to D

$$= \frac{2.4 - 1.5}{0.3}$$

= 3

Total blows per 0.3m

$$= \frac{888}{3}$$

= 296 blows/0.3m

From the Standard Graph Bearing Capacity

Layer	Blows/0.3m	Bearing Capacity (kN/m^2)
1	128	<500
2	125	<500
3	296	<500

Test 1

1. Total number of blows from layer A to B

= 713 – 0

= 713 blows

Total depth gap from layer A to B

= (0.6 – 0) / 0.3

= 2

Total blows per 0.3m

= 713 / 2

= 357 blows/0.3m

From the Standard Graph Bearing Capacity

Layer	Blows/0.3m	Bearing Capacity (kN/m^2)
1	357	<500

Test 2

1. Total number of blows from layer A to B

= 698 – 0

= 698 blows

Total depth gap from layer B to C

= (0.6 – 0) / 0.3

= 2

Total blows per 0.3m

= 698 / 2

= 349 blows/0.3m

From the Standard Graph Bearing Capacity

Layer	Blows/0.3m	Bearing Capacity (kN/m^2)
1	349	<500

Test 3

1. Total number of blows from layer A to B

= 400 – 0

= 400 blows

Total depth gap from layer A to B

= (0.3 – 0) / 0.3

= 1

Total blows per 0.3m

= 400 / 1

= 400 blows/0.3m

From the Standard Graph Bearing Capacity

Layer	Blows/0.3m	Bearing Capacity (kN/m^2)
1	400	<500

Test 4

1. Total number of blows from layer A to B

= 434 – 0

= 434 blows

Total depth gap from layer B to C

= (0.6 – 0) / 0.3

= 2

Total blows per 0.3m

= 434 / 2

= 217 blows/0.3m

2. Total number of blows from layer B to C

= 834 – 434

= 400 blows

Total depth gap from layer B to C

= (0.9 – 0.6) / 0.3

= 1

Total blows per 0.3m

= 400 / 1

= 400 blows/0.3m

From the Standard Graph Bearing Capacity

Layer	Blows/0.3m	Bearing Capacity (kN/m^2)
1	217	<500
2	400	<500

Test 5 (Present Mackintosh Probe)

1. Total number of blows from layer A to B

= 331 – 0

= 331 blows

Total depth gap from layer A to B

= (1.8 – 0) / 0.3

= 6

Total blows per 0.3m

= 331 / 6

= 56 blows/0.3m

2. Total number of blows from layer B to C

= 739 – 331

= 408 blows

Total depth gap from layer A to B

= (2.7 – 1.8) / 0.3

= 3

Total blows per 0.3m

= 408 / 3

= 136 blows/0.3m

3. Total number of blows from layer C to D

= 1388 – 739

= 649 blows

Total depth gap from layer A to B

= (3.3 – 2.7) / 0.3

= 2

Total blows per 0.3m

= 649 / 2

= 325 blows/0.3m

From the Standard Graph Bearing Capacity

Layer	Blows/0.3m	Bearing Capacity (kN/m^2)
1	56	161
2	135	<500
3	325	<500

Test 5 (NGMP)

1. Total number of blows from layer A to B

= 314 – 0

= 314 blows

Total depth gap from layer A to B

= (1.8 – 0) / 0.3

= 6

Total blows per 0.3m

= 314 / 6

= 53 blows/0.3m

2. Total number of blows from layer B to C

= 709 – 314

= 395 blows

Total depth gap from layer A to B

= (2.7 – 1.8) / 0.3

= 3

Total blows per 0.3m

= 395 / 3

= 132 blows/0.3m

3. Total number of blows from layer C to D

= 1364 – 709

= 655 blows

Total depth gap from layer A to B

= (3.3 – 2.7) / 0.3

= 2

Total blows per 0.3m

= 655 / 2

= 328 blows/0.3m

From the Standard Graph Bearing Capacity

Layer	Blows/0.3m	Bearing Capacity (kN/m^2)
1	53	147
2	132	<500
3	328	<500

Test 6 (Present Mackintosh Probe)

1. Total number of blows from layer A to B

= 367 – 0

= 367 blows

Total depth gap from layer A to B

= (1.2 – 0) / 0.3

= 4

Total blows per 0.3m

= 367 / 4

= 92 blows/0.3m

2. Total number of blows from layer B to C

= 484 – 367

= 117 blows

Total depth gap from layer A to B

= (1.8 – 1.2) / 0.3

= 2

Total blows per 0.3m

= 117 / 2

= 59 blows/0.3m

3. Total number of blows from layer C to D

= 1343 – 484

= 859 blows

Total depth gap from layer A to B

= (3.0 – 1.8) / 0.3

= 4

Total blows per 0.3m

= 859 / 4

= 215 blows/0.3m

From the Standard Graph Bearing Capacity

Layer	Blows/0.3m	Bearing Capacity (kN/m^2)
1	92	340
2	59	173
3	215	<500

Test 6 (NGMP)

1. Total number of blows from layer A to B

= 337 – 0

= 337 blows

Total depth gap from layer A to B

= (1.2 – 0) / 0.3

= 4

Total blows per 0.3m

= 337 / 4

= 85 blows/0.3m

2. Total number of blows from layer B to C

= 470 – 337

= 133 blows

Total depth gap from layer A to B

= (1.8 – 1.2) / 0.3

= 2

Total blows per 0.3m

= 133 / 2

= 67 blows/0.3m

3. Total number of blows from layer C to D

= 1273 – 470

= 803 blows

Total depth gap from layer A to B

= (3.0 – 1.8) / 0.3

= 4

Total blows per 0.3m

= 803 / 4

= 201 blows/0.3m

From the Standard Graph Bearing Capacity

Layer	Blows/0.3m	Bearing Capacity (kN/m^2)
1	85	293
2	67	207
3	201	<500

Test 7 (Present Mackintosh Probe)

1. Total number of blows from layer A to B

= 182 – 0

= 182 blows

Total depth gap from layer A to B

= (1.2 – 0) / 0.3

= 4

Total blows per 0.3m

= 182 / 4

= 46 blows/0.3m

2. Total number of blows from layer B to C

= 362 – 182

= 180 blows

Total depth gap from layer A to B

= (1.8 – 1.2) / 0.3

= 2

Total blows per 0.3m

= 180 / 2

= 90 blows/0.3m

3. Total number of blows from layer C to D

= 877 – 362

= 515 blows

Total depth gap from layer A to B

= (2.4 – 1.8) / 0.3

= 2

Total blows per 0.3m

= 515 / 2

= 258 blows/0.3m

From the Standard Graph Bearing Capacity

Layer	Blows/0.3m	Bearing Capacity (kN/m^2)
1	46	120
2	90	327
3	258	<500

Test 7 (NGMP)

1. Total number of blows from layer A to B

= 83 – 0

= 83 blows

Total depth gap from layer A to B

= (0.6 – 0) / 0.3

= 2

Total blows per 0.3m

= 83 / 2

= 42 blows/0.3m

2. Total number of blows from layer B to C

= 178 – 83

= 95 blows

Total depth gap from layer A to B

= (1.2 – 0.6) / 0.3

= 2

Total blows per 0.3m

= 95 / 2

= 48 blows/0.3m

3. Total number of blows from layer C to D

= 346 – 178

= 168 blows

Total depth gap from layer A to B

= (1.8 – 1.2) / 0.3

= 2

Total blows per 0.3m

= 168 / 2

= 84 blows/0.3m

4. Total number of blows from layer D to E

= 1224 – 346

= 878 blows

Total depth gap from layer A to B

= (2.7 – 1.8) / 0.3

= 3

Total blows per 0.3m

= 878 / 3

= 293 blows/0.3m

From the Standard Graph Bearing Capacity

Layer	Blows/0.3m	Bearing Capacity (kN/m^2)
1	42	103
2	48	127
3	84	293
4	293	<500