Development of Mackintosh Probe Extractor

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Abstract. Dynamic probing is a continuous soil investigation technique, which is one of the simplest soil penetration test. It basically consist of repeatedly driving a metal tipped probe into the ground using a drop weight of fixed mass and travel. Testing was carried out continuously from ground level to the final penetration depth. Once the soil investigation work done, it is difficult to pull out the probe rod from the ground, due to strong soil structure grip against probe cone and prevent the probe rod out from the ground. Thus, in this case, a tool named Extracting Probe was created to assist in the process of retracting the probe rod from the ground. In addition, Extracting Probe also can reduce the time to extract the probe rod from the ground compare with the conventional method. At the same time, it also can reduce manpower cost because only one worker involve to handle this tool compare with conventional method used two or more workers. From experiment that have been done we found that the time difference between conventional tools and extracting probe is significant, average time difference is 155 minutes. In addition the extracting probe can reduce manpower usage, and also labour cost for operating the tool. With all these advantages makes this tool has the potential to be marketed.

1. Introduction
Soil investigation (SI) is a fundamental step which held prior to any construction activity on site. The main purpose of SI is to obtain all soil parameters that are needed in designing the foundation of any given loads on the building to be constructed. Parameters obtained will assist in designing phase so that the good quality, economic and safe structure can be built. Three main processes of SI frequently carried are boring, sampling and testing of soil on site. Standard Penetration Test (SPT) is the most popular method of SI that caters all the processes mentioned that recorded completely the soil profile at any chosen bore hole. Normally large scale project with high budget suits this method which produce detail information on soil profile and almost at any sensible depth for building construction. At normal circumstances, for smaller scale projects or any small construction within a huge project, there might be some need for the SI report at the particular vicinity. In handling this, Mackintosh Probe is the widely available, least costly and most practical method to use. The use of Mackintosh
probe is normally as complimentary to the SPT method and not to substitute it. The difference between Mackintosh probe and JKR probe is the angle of the cone, where the Mackintosh probe have 60° angle cone and the JKR probe, with 30° angle cone. According to [1], although this test is considered as a classic method, but it still used in soil investigation for the any construction. Base on [2], the Mackintosh Probe has been described, where it consist of a 27.94 mm diameter cone with a 30° angle; 12.7 mm diameter solid rods and a 4.5 kg dead weight with standard drop height of 300 mm, Figure 1. The cone is advanced into the soil by standard blows from the drop weight and the number of blows for 100 mm penetration is countered. Based on the principles by [3], the probe rod will be advanced into the soil to get the data to analyse. According to [2], Mackintosh probe was developed for the investigation of peat and has been used in a variety of soft soils.

![Figure 1. Assembly of Mackintosh Probe](image_url)

The method involve is hammering in rod connected to a cone both of which are in their standard sizes. Number of blows per 0.3m of rod will be counted and recorded [3], record sample is as shown in Table 1 and Figure 2 (a) and (b). Note : Depth no. correspond to the particular range of depth as shown

| Depth (m) | No. of Blows | Cumulative No. of Blows |
|-----------|--------------|------------------------|
| 0.0 - 0.3 | 262          | 262                    |
| 0.3 - 0.6 | 207          | 469                    |
| 0.6 - 0.9 | 146          | 615                    |
| 0.9 - 1.2 | 74           | 689                    |
| 1.2 - 1.5 | 60           | 749                    |
| 1.5 - 1.8 | 49           | 798                    |
| 1.8 - 2.1 | 57           | 855                    |
| 2.1 - 2.4 | 74           | 929                    |
| 2.4 - 2.7 | 92           | 1021                   |
| 2.7 - 3.0 | 142          | 1163                   |
| 3.0 - 3.3 | 274          | 1437                   |
| 3.3 - 3.6 | 316          | 1753                   |
| 3.6 - 3.9 | 400          | 2153                   |
Frequent problem faced by handling this method is the difficulty of extracting the rod after it reaches the following conditions: the maximum depth 14 rods or 400 number of blows per 0.3m. Hence, the main scope of this paper is to develop the portable and effective equipment that extract the rod after it reaches the two (2) conditions. It is normal that there is difficulty in the process of retracting the probe rod out from the ground. This is due to the horizontal pressure that the surrounding soil (Figure 3) which imposed on the rod and cone and this has to be overcome in order to successfully extract it out. Thus, in this study, we create a tool that able to overcome this horizontal pressure (Figure 3) thus be able to retract the probe rod easily from the ground. The tool named as Probe Extractor. After the completion of the Probe Extractor, its effectiveness in terms of time, labour and costs used are tested and analysed. Three different locations were selected to test the effectiveness of the Probe Extractor.

Figure 2: (a) Graph of no. of blows versus depth number (b) Graph of cumulative no. of blows versus depth number.

Figure 3: Pressure force on probe from the ground
2. Methodology and Materials

2.1 Probe Extractor Design
First class lever concept was chosen as the design criteria for the probe extractor [2]. This concept can reduce manpower usage to extract probe rod from the ground and make the extraction process easy and goes smoothly. In addition, this new invention design can against pressure force from the ground because at the end of the rod was penetrated and was clutched tightly by ground strengths. Analyization was done on this equipment to determine suitability materials used with using several formula. Calculation of minimum size of the tool base, minimum size of bolt and minimum size of the pusher were based on structure design concept. Comparison between total soils bearing capacity [6] with total human pressure force has shown that minimum size that suitable to use for the based tool is 15 times 10 inch. Meanwhile, for pusher tools, shear force diagram, shear force formula [5],[7], and first class lever formula [2] were used to obtain the suitable minimum size for the tools. From this formula, we obtained 30mm diameter and 31 inch long for the pusher minimum size. Minimum bolt size calculation was obtained using shear force diagram and shear formula for nut and the size was fixed with 6 inch long and 0.1mm diameter.

2.2 Probe Extractor Fabrication
Several processes were involved in fabricating the probe extractor including welding and cutting steel plate. There were four parts for this tools (a) based tool, (b) upholder, (c) pusher and (d) arm holder. Each parts were cut according to minimum size (Figure 4). Few nuts and bolts were used to connect between arm holder and pusher and also upholder. Once cutting processes were done, pusher part was welded with upholder using 6 inch nuts. Then, installation between grapper with arm holder was did using 50mm long and 10mm diameter nuts and bolts. After this two parts had fabricate it was combined with pusher using nuts and bolts to make it easy to be moved clearly. Tool based was added with 2 wheels as additional criteria of this design. The wheels will make the user feel free to bring it without holding it on their back compared to conventional tools.

2.3 Driving in the Probe
A tool to retract the probe rod from the ground will be created in order to assist in the process of retracting probe rod from the ground after the soil investigation was completed. The design for this tool was made up by using solid work. This tool was created using readily available materials and easy to set up. The material that has been used in producing this tool is steel. Extracting Probe has several components such as grippers, arms, press tool, straighteners and stand supported that will be joined together to make it perfect tool and can be functioning as planned. Figure 4 shows the design of a Probe Extractor.

(A) Pusher
(B) Upholder
(C) Based Tool
(D) Grappler
(E) Arm Holder
In process of retracting the probe rod from the ground, the press tool of the Probe Extractor will be pressed downward (Figure 5) and this will cause the arms to move upward and directly the grippers will grip strongly the probe rod and bring it out from the ground gradually. This step was repeated until all the probe rod out from the ground. After Probe Extractor was produced, it workability will be tested. Four different location will be chosen to test this tool. It on the Kolej Kediaman Perwira, RECESS UTHM, Pt. Rasipan, and one of it in Taman Manis, Parit Raja. After that, the data will be collected and analysed. The data will be collected by making comparison between Probe Extractor and conventional method in terms of time, labor and costs used in process of retracting the probe rod from the ground after soil investigation was finished. The expected result from this Probe Extractor is it can reduce the time spent to retract the probe rod from the ground compared to the conventional method because it will be reduce the cost to pay employee. Next, it also can reduce the labor used because Probe Extractor just only use one employee (Figure 5) compared to conventional method that use more than one employee.
3. Results and Discussions

Results that were collected is in term of time, labour and costs used in process of extracting the probe rod from the ground after soil investigation was finished. The discussions also was made up to improve this Extracting Probe in the future.

3.1 Graph of average time against the rod for three different places

Following were the graph of average time against the rod for the Extracting Probe and conventional method in process of extracting the probe rod from the ground for three different places, Kolej Kediaman Perwira, RECESS UTHM, Pt. Rasipan, and one of it in Taman Manis, Parit Raja.

Table 2: Average time to Extract probe Probe

| Location            | Depth (m) 400 blows | Existing Tool (min) | Probe Extractor (min) | Time Differences (min) |
|---------------------|---------------------|---------------------|-----------------------|------------------------|
| Kolej Kediaman Perwira | 11.4                | 180                 | 25                    | 155                   |
| RECESS UTHM         | 9.9                 | 160                 | 15                    | 145                   |
| Kg. Pt. Rasipan     | 10.2                | 170                 | 20                    | 150                   |
| Taman Manis         | 13.3                | 200                 | 30                    | 170                   |

Figure 6: Graph of average time against the rod

Table 2 shows the average time against the rod for Kolej Kediaman Perwira, RECESS UTHM, Pt. Rasipan and Taman Manis, Pt. Raja. From the all graph the time taken to retract the probe rod from the ground by using the Extracting Probe is more faster compare with conventional method with average time differences is 155 minutes. Overall average time taken for the all rod totally out from the ground is proved by Extracting Probe, where it faster compare with the conventional method. In Table 3, the different time taken to extract probe rod from the ground by using Extracting Probe and conventional.
Table 3: Time Comparison between the Existing Lift Rod and Probe Extractor

| Location       | Existing Tools (min) | Extracting Probe (min) | Time Difference (min) |
|----------------|----------------------|------------------------|-----------------------|
| Kolej Kediaman Perwira | 180                  | 25                     | 155                   |
| RECESS UTHM     | 160                  | 15                     | 145                   |
| Kg. Pt. Rasipan | 170                  | 20                     | 150                   |
| Taman Manis     | 200                  | 30                     | 170                   |

3.2 Cost and labour use
According to the respondents, the representatives of three companies, namely Chengal Jati Sdn.Bhd., Alur Bina and Gagasan Teguh Sdn.Bhd. who asked about the payment of salaries of workers to extract the probe rod out from the ground is about RM50 per person. It need two or more person if use the conventional method, where the cost will be double but by using the Extracting Probe, it just only need one person to handle this tool, so the cost to pay the employee will be decreased.

4. Conclusions
Invasion of Extracting Probe has proved it can reduce the problems in process extracting probe rod out from the ground after soil investigation work finishes. It can solve the problems in term of time, manpower usage and the payment for the employee. This was proved after the data of average time by using the Extracting Probe is faster compare with conventional method in the process of extracting the probe rod from the ground. Besides that, Extracting Probe only use one labour to handle this tool compare with conventional which need two or more labour to extract the probe rod from the ground and this will directly reduce the cost to pay the employee.

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