Penetrometer: Group 18

Team Number: 18

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Abstract

It has been established by the National Park Services and Southeast Archeological Center that there is a need for a much more efficient way to detect soil midden levels present on their testing sites. The objective of this project is to "design an instrument that can identify midden and differentiate soil types at various depths," which can be identified as Team 18's goal statement. It is the task of Team 18 to provide the instructors of this course with a Needs Assessment which will identify the basic needs, background research, goal statements and objectives, constraints, methodology and a conclusion which will summarize the entire scope of this year's project.

We have been provided with last year's prototype and it is in the best interest of both the sponsors and mentors to completely redesign and improve upon the penetrometer. Typically, penetrometers are used by farmers to detect compaction levels of the soil present. However, we want to take the standardized penetrometer design and refabricate it to read friction coefficients that will be used to determine the type of soil present. Many constraints have been provided by the sponsor. If these are not complied with, the design will not be considered by the National Park Services. It is our team's mission to comply and communicate with the sponsor and provide them with a prototype that will accomplish the goals and needs that they have provided.

1 Introduction

The objective of this project is to design and build an instrument that can identify midden in remote locations and differentiate soil types at various depths. The prototype must be relatively lightweight, have strength in compression, and be portable. The penetrometer was originally used as an agricultural tool to determine the soil compaction, which helped farmers decide if the soil could be used for crop production. Due to varied results from site to site, a standard design of the penetrometer was developed. Archeologists use penetrometers to locate soil midden levels as well as determine how deep it runs below the ground. This information can assists archeologists in verifying if there is organic material present at the test site. Team 18 will develop a prototype of a penetrometer that is portable, wireless, and easy to use in the field. This penetrometer prototype will determine the type of soil by calculating the friction coefficient of the soil. The prototype should produce reliable data that can be transmitted to a handheld device.

2 Project Definition

2.1 Background research

A penetrometer is a basic force instrument in design and simple in use. However, it cannot be effectively used by a novice for precise results. Originally, a penetrometer was used by agricultural personnel for penetration of the ground soil on several acres of land to determine the soil compaction and how viable the soil will be for crop production. Before a standardized penetrometer, results could vary from farm to farm and with different surveying teams. Depending on the varying level of experience by the surveying team, these results can either be interpreted as good or bad soil results. To account for this inexperience during surveying of the ground, calculations will be used to be unbiased in the testing of the soil composition and compaction before any ground comparisons need to be done via a computer.

The standard design of a penetrometer was adopted by the American Society of Agricultural Engineers in 1999 and with this standard design the comparison of data across a wide range of locations could be compared and used for soil compaction. This design calls for a 30 degree cone angle and the use of a ½ inch or ¾ inch base cone. These dimensions more closely resemble a root growing and penetrating the ground as it grows and with certain ground compaction can yield higher or lower crop turn out. [1]

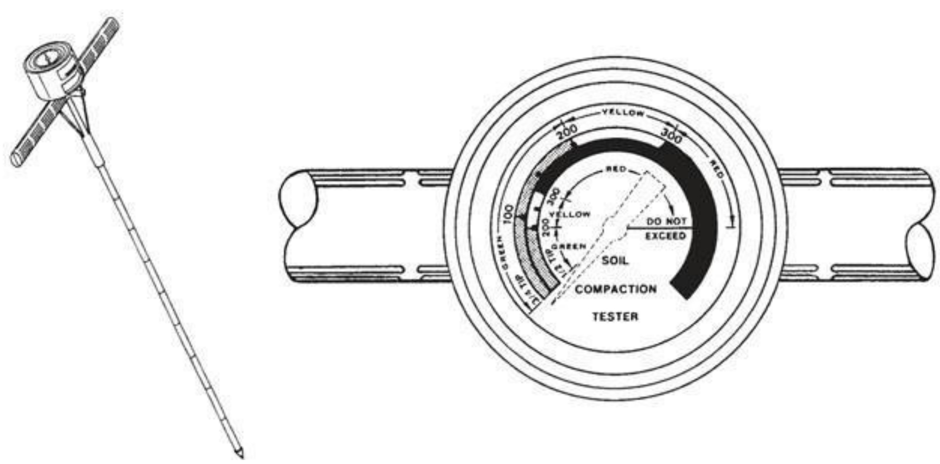

Figure 1. Standardized Penetrometer Design[2]

In the field of archeology, soil compaction and composition can save a lot of time and money from large excavation digging to uncover important soil types shallow or deep underneath the top soil. A penetrometer is being used to detect the location of midden, which is archeological soil type produced from decomposed artifacts that were tossed into the environment during the time of population in that certain location. The used method to determine the midden is a basic T-bar penetrometer that has several extendable rods that can allow for several meters of distance to map the location and depth of midden. When used by an experienced surveying team, the midden can be located based on the “feel” of the midden soil type as the compaction and compression is different than the surrounding soil types. This feel can be misinterpreted by an unexperienced surveyor and the data collected could be wrong. To account for this inexperience, load cells can be used along with a computer program to determine the depth and soil types.

One method closely related to our approach on the penetrometer is the cone penetrometer test (CPT) which incorporates an electronic friction cone and piezocone penetrometer. When used to test the soil composition and compaction, a computer logs the values from the cone and friction sleeve and uses the ratio to determine if the soil is suitable for use. Using this same concept of separating load cells to determine the friction ratio, archeological dirt can be determined several meters under the topsoil without digging several holes. The surveying team using the device with not need a high level of experience as the data collected will be based on calculated values to determine the actual soil that is being penetrated. [3]

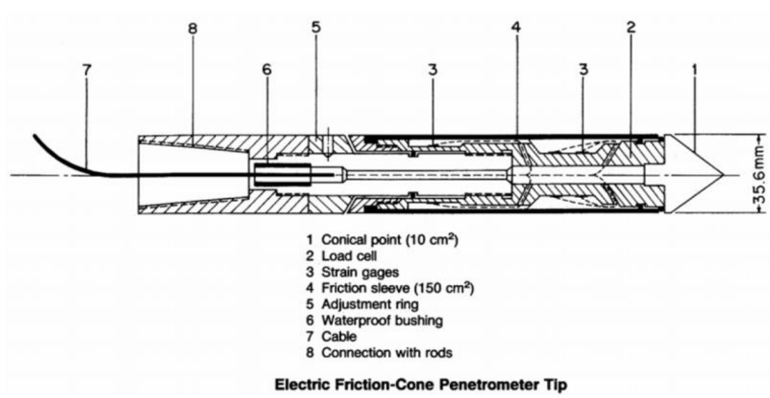

Figure 2. Electric Components of the Penetrometer Tip[3]

2.2 Need Statement

As an extension of the 2013-2014 senior design project, it is the object of Team 18 to redesign a penetrometer which will detect midden levels in the soil present at the Southeast Archeological Center & National Park Services' field testing site. This penetrometer will have portable and wireless capabilities in order to properly distinguish the type of soil present below the ground. It has been established that the sponsor is looking for a more reliable and easier-to-use system than the prototype designed by the previous senior design project. Currently, this year's project has been to redesign last year's design project. Team 18 has taken the prototype out into the field at the National Park Services' testing site. However, upon the first day of field testing, the epoxy failed and the tip of the penetrometer no longer took input readings. With the failed prototype as an example, Team 18 has gathered much information as what not to do with this year's design.

"It is difficult to distinguish soil midden levels apart from other organic and mineral soil levels when field testing on site."

2.3 Goal Statement & Objectives

Goal Statement: "Design an instrument that can identify midden and differentiate soil types at various depths."

Objectives:

- Must be able to identify midden levels in remote locations
- Must weigh less than 50 lbs.
- Must be able to reach depths past 2 meters
- Should wirelessly display results to a handheld device
- Device should be very portable
- Weight should be minimized

2.4 Constraints

Listed below are the constraints placed on the design. If a design does not meet the listed constraints, the design will not be considered.

- The prototype design must be easy to use.
- The prototype must be able to be used by one person in the field, without assistance.
- The diameter of the prototype must be small enough for the device to penetrate the ground easily.
- The material of the prototype must be strong enough for the device to penetrate the ground without fracturing.
- The prototype design must be able to determine the location of midden and how deep the midden runs.
- The prototype design must be wireless, allowing it to be portable.
- The weight of the prototype must not exceed 50 pounds.
- The data from the device must be reliable.
- The prototype design must allow for wireless data transmission to a handheld device.
- The total cost must not initially exceed $2,000.
    - The sponsor is able to expand the budget if it is deemed necessary by the team and the advisor.

2.5 Methodology

To begin the project, the team will research existing penetrometer designs that are relevant to the project. The team shall also review the progress made on the project by last year's team; this includes reviewing their reports and testing their prototype. The team will then determine the range of values that need to be read by the device, based upon the wants of the sponsor. The team shall also discuss with the sponsor what he would prefer in the design for performance, reliability, and portability. Simultaneously, the team will explore various wireless data acquisition components and charging methods that could possibly be used in the design. After extensive research has been done, the team will develop and evaluate multiple ideas. The cost of materials shall be estimated for each design. Then, the team will create a decision matrix in order to compare all designs without bias. A final design shall be chosen from this matrix.

After the design has been validated, the team will simulate the design using a computer program. Final decisions on the type and cost of materials will be made. This will all be discussed with the sponsor in order to obtain his approval. After obtaining approval, materials and equipment will be purchased and the prototype will be constructed. After the construction is complete, the prototype will be tested in the field, and the test data will be analyzed, with the assistance of the sponsor. After the test performance and results have been analyzed, the team will reevaluate the design and decide upon any necessary or desired changes to the prototype. This may include, but is not limited to, multiple improvements and partial redesign. After these changes have been decided upon, the final prototype shall then be built and test in the field, in the same manner as the previous prototype. Again, the team will discuss the performance and results with the sponsor. If the sponsor approves the prototype, the team will compose the final report of the project and present the final model to the sponsor and advisor, and at the open house event in April 2015.

3 Conclusion

In summary, Team 18 will be designing and fabricating a fully functioning penetrometer for use by the National Park Services. The device will successfully determine where midden is located in an archeological site and it will be very user friendly. In order to choose a design, the team will do extensive background research on several different existing designs and compare the information with what the sponsor requests. The new design will not focus on the compaction factors as current penetrometers do, but will instead determine the soil type and the friction coefficient of the environment the penetrometer is placed.

The sponsor will be kept involved throughout the entire design process to ensure the team’s design correctly accommodates each given constraint. The project process will involve researching past designs, brainstorming and communicating with the sponsor to create a new design, and further prototyping the finalized solution. After the prototype is created, there will be testing in the field with National Park Services, and changes will be made as needed. The goal of the project is as stated earlier to “Design an instrument that can identify midden and differentiate soil types at various depths.” Team 18 believes that following a strict schedule and working as a unit with the sponsor will result in an instrument that will successfully aide the work of archeologists in all future sites and meet the team’s stated goal.

4 References

[1]Fee, Rich. "Soil Penetrometers." Probing for Compaction (2005). Successful Farming. Web. 25 Sept. 2014. <http://www.specmeters.com/assets/1/7/soil_penetrometers.pdf>.

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[3] "NOTES on the CONE PENETROMETER TEST." Web.mst.edu. Advanced Engineering Geology & Geotechnics, 1 Jan. 2004. Web. 25 Sept. 2014. <http://web.mst.edu/~rogersda/umrcourses/ge441/Cone Penetrometer Test.pdf>.