Assessment of Soil Strength Using Cone Penetrometer

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INTRODUCTION

Dynamic cone penetrometer (DCP) testing, a popular method for determining soil strength in the geotechnical engineering field, is physically taxing, requires an additional operator to determine and record penetration depth, and is noisy. A newly developed push-type static cone penetrometer (SCP), on the other hand, requires one person to operate, is quiet, simultaneously measures soil strength and penetration depth continuously, and records the data electronically in real time.

OBJECTIVES

- Compare the DCP and SCP at three sites with different soils and water content conditions.
- Develop a direct relationship between the applied force and the strength of the tested soils using a DCP and SCP.

MATERIALS AND METHODS

Using disposable 60° cones, soil penetration resistance was measured within a 5-m by 5-m area at three sites at the NC State University-NC Department of Agriculture Field Laboratory in Clayton, NC. We used the DCP (Humboldt Mfg. Co., Elgin, IL), and a SCP developed in-house at NCSU (Fig. 1).

At Site 1 five measurements were made by each penetrometer, while at Sites 2 and 3 six measurements were made. Penetration depth was measured manually for each blow for the DCP and the penetration depth and force for the SCP were recorded using a data-logger (Campbell Scientific, Logan, UT) (Fig. 1).

Soil samples from different depths were collected for water content, bulk density and particle size distribution analyses.

Using the procedure described by Minasny[1], the DCP penetration distance for each blow was converted to penetration resistance by

$$PR = (Mgh/A\Delta x)[M/(M + m)]$$

where M is the mass of the sliding hammer (4.6 kg), m is the mass of the DCP shaft (4.31 kg), g is the acceleration due to gravity, h is the height of the hammer drop (0.57 m), A is the basal area of the cone (3.14x10^-4 m^2), and Δx is the penetration depth per blow.

Fig. 1. Photographs of SCP and DCP (left), and the data collection system for the SCP (right).

RESULTS AND DISCUSSION

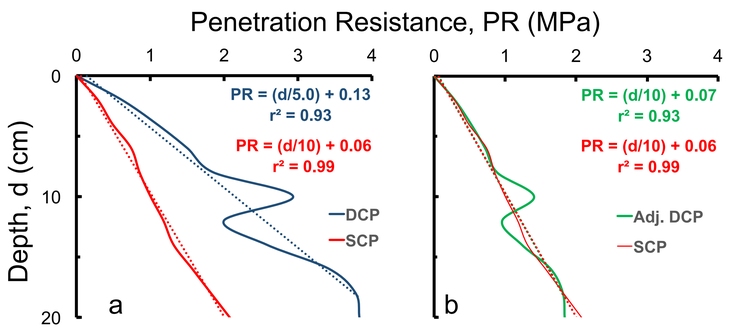

Fig. 2. Average penetration resistance values determined by DCP and SCP within Site 1 with a loamy sand soil (a) and adjusted DCP values using a factor of 0.48 (b). The mean water content was 0.1 g/g.

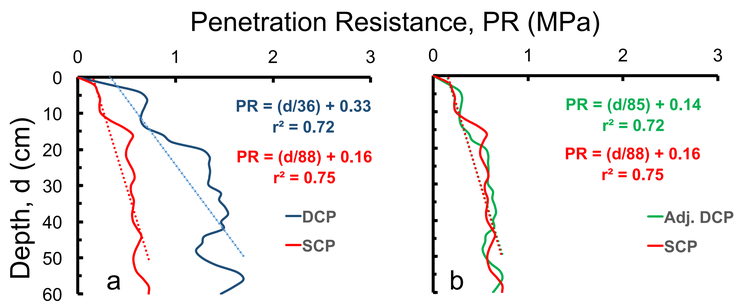

Fig. 3. Average penetration resistance values determined by DCP and SCP within Site 2 with a sandy clay soil (a) and adjusted DCP values using a factor of 0.43 (b). The mean water content was 0.23 g/g.

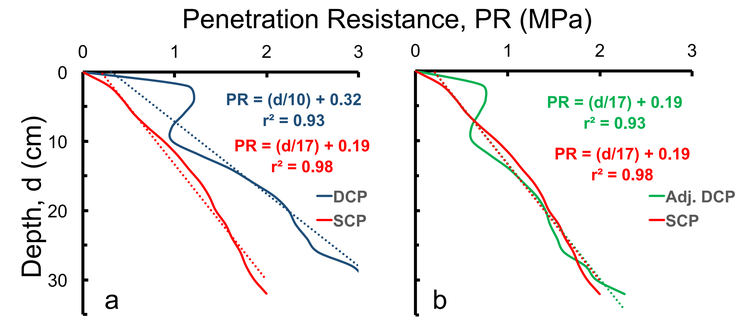

Fig. 4. Average penetration resistance values determined by DCP and SCP within Site 3 with a loamy sand soil (a) and adjusted DCP values using a factor of 0.63 (b). The mean water content was 0.1 g/g.

CONCLUSION

The push-type SCP and DCP showed similar trends in assessing the soil strength over the same depth. Similar to the study by Minasny[1] and Sun et al.[2], the calculated DCP values overestimated the soil strength compared to the measured SCP values. A multiplication factor to scale the calculated DCP values to the measured SCP values was found to range from 0.43-0.63. The push-type SCP has the potential to replace the DCP in assessing soil strength, but more research will have to be conducted to find a more definitive relationship between the two.

REFERENCES

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