TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Bauingenieurwesen
Institut für Geotechnik
Professur für Bodenmechanik und Grundbau

Determination of Soil Types from Cone Penetration Tests

Bestimmung des Bodentyps aus Drucksondierungen

Omar Al-Sharif

Introduction

The CPT has been used for many decades now to give a quick, relatively accurate view of the subsurface layers. It functions on the principle of measuring both cone resistance and sleeve friction, although pore water pressure can also be measured. The measured values can then be used to classify the soil layers that the cone passes through. An example of a soil classification chart that uses CPT data is shown in figure 1.

The objectives of this project were threefold. Firstly, to review and display the work done up to now in the field of CPT classification methods and gather it in one location. Secondly, to overlay similar classification charts and compare them directly. Lastly, a program was written that classifies real-world data based on selected charts and comparing their output to a borehole.

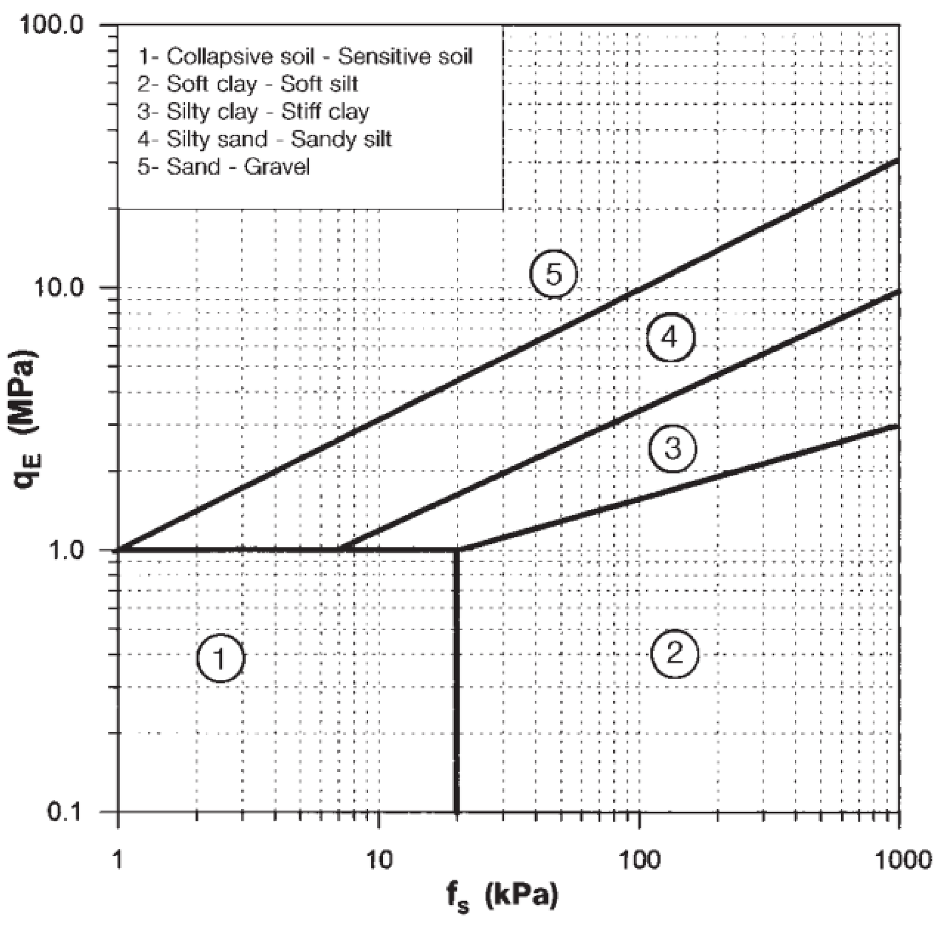

Fig. 1: A typical CPT Soil classification chart. [1]

Direct Comparison: Chart Overlaying

After digitalizing the images, the charts could be directly compared to each other. Each group of charts with the same (or similar) axes was overlaid and the overlapping zones were noted. What was of interest here is where the authors disagree on the classification for a certain area, since this is where the categorization is most unclear.

Although the overlaying is useful, it does not give the reader an immediate impression of the extent of agreement (or lack thereof) between the authors. To improve readability and simplify analysis, a color coded system was devised to sort the overlapping regions, as seen in figure 2.

An analysis of the resulting red zones of disagreement showed that mixed soils tend to be the most difficult to classify, with silty sand and loam being the usual classifications for these soils.

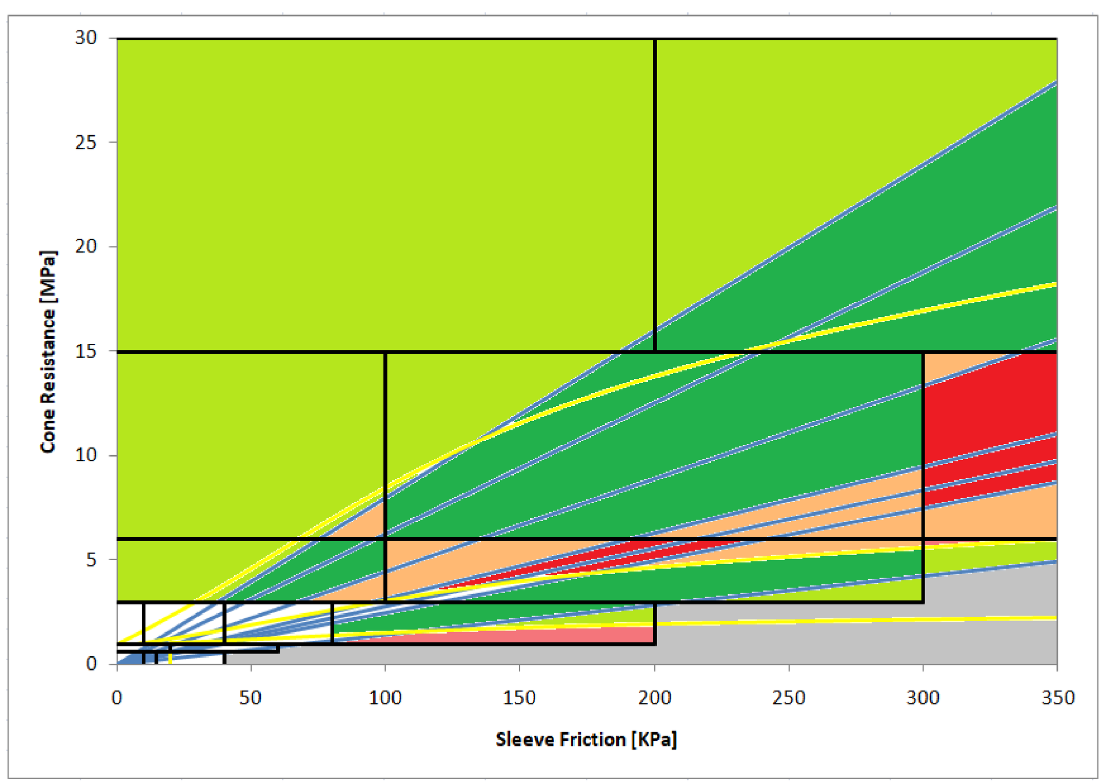

Fig. 2: Overlaying the charts of Eslami [1], Begemann [2], & Sanglerat [3]. Green & red colors indicate agreement & disagreement respectively.

Programming

A program was written to automate the classification procedure for 4 charts, namely those of Eslami, Fugro [4], Searle [5], and the Swedish National Report [6]. The program runs according to the steps outlined in figure 3.

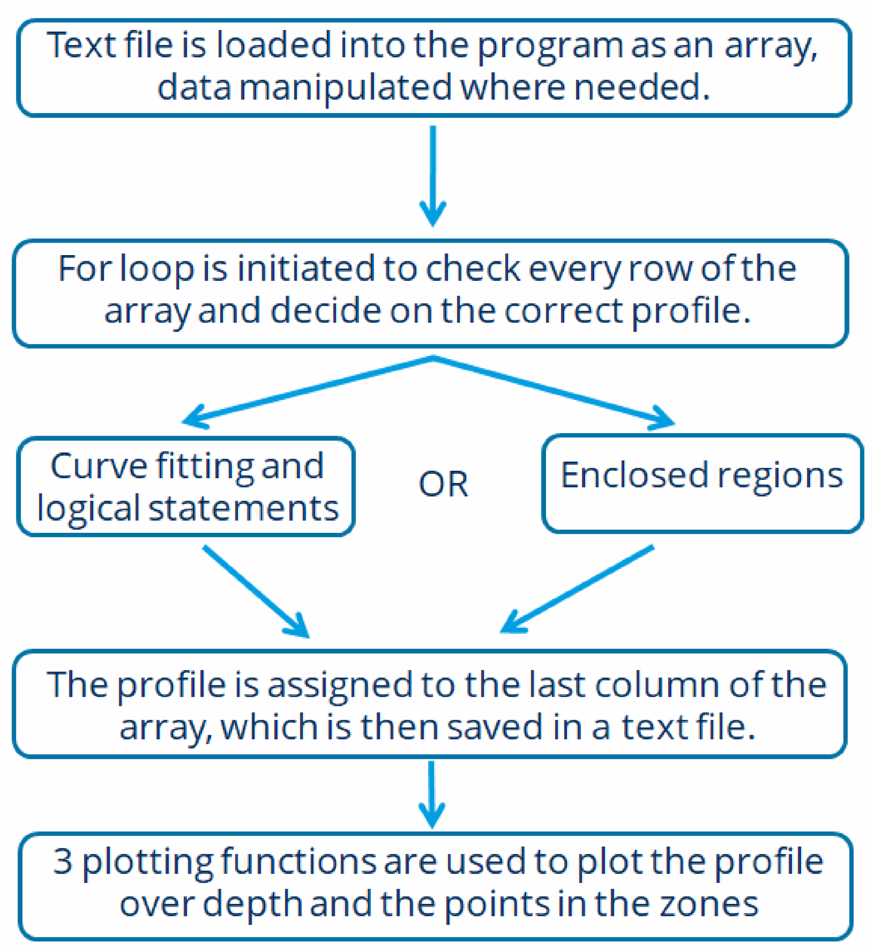

Fig. 3: Flow chart of the classification program

Chart Suitability Determination

The data was classified using the four charts and the results were compared in figure 4. It must be kept in mind that these conclusions are valid only for this particular CPT and this particular soil. That said, the Eslami chart works very well for this type of soil, giving accurate classifications without any severe issues except for the last 5 meters. FUGRO performs much the same. Figure 5 shows the FUGRO results graphically. The Swedish chart gave the best results, especially at high depths due to the normalization. The Searle chart had many issues with the classification, especially in the middle layer.

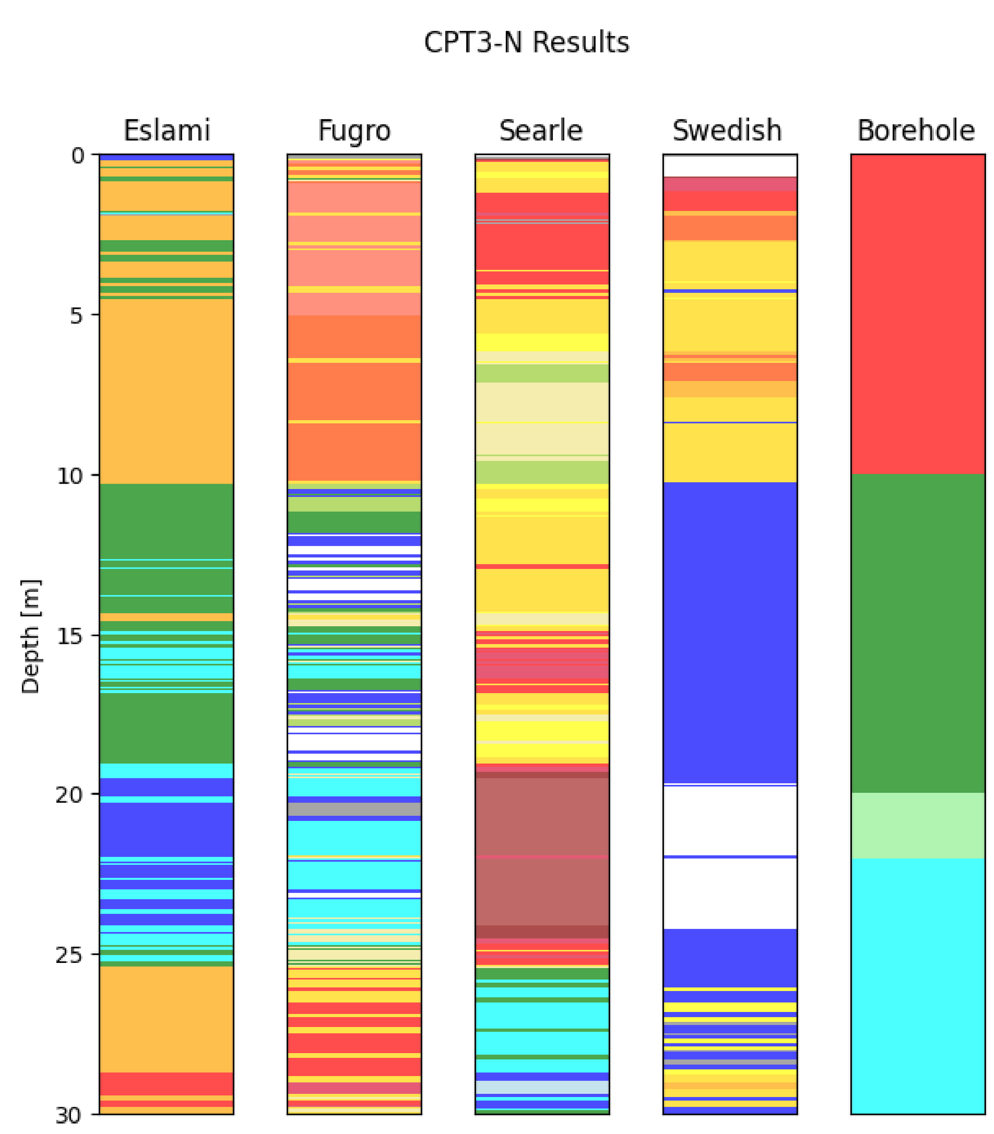

Fig. 4: Colored profiles of the CPT log arranged with the borehole. See figure 6 for the color legend.

Field Data: Hambach Open-pit Mine

The data used for the program was taken from a report done on the Hambach coal mine in western Germany. [7] The goal of the report was to analyze the dumped material extracted during the mining process. Two test sites were examined, and at each site one borehole and three CPTs were taken. The logs were taken approximately 1m from the borehole.

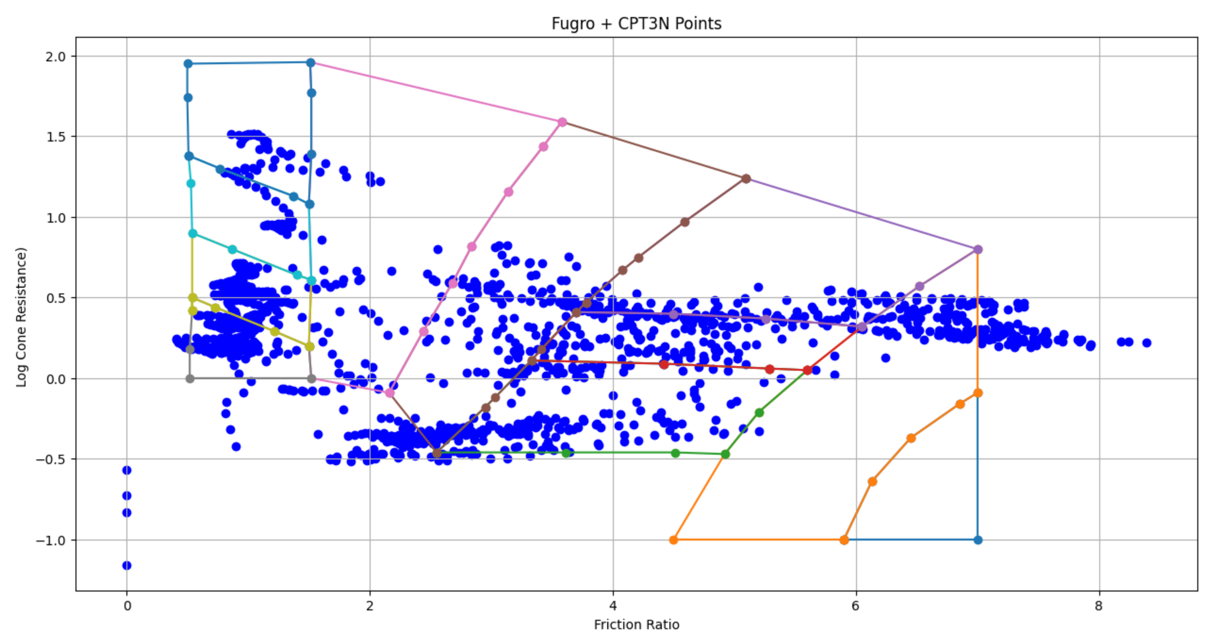

Fig. 5: CPT North sounding points shown on the FUGRO chart

Summary

The main theme of this project was to review and analyze the available CPT classification charts in the literature and to check their efficacy against real world data. 20 different charts from various authors spanning decades of research were listed, categorized, and compared. Four of these charts were selected for programming to allow the analysis of a full sounding log. From the results of the comparison, it can be stated that a chart that incorporates normalization, such as the Swedish chart, is preferable over other unnormalized charts, especially at high depths.

In summary, the project was able to show the abilities and limitations of the CPT soil classification charts currently in use. Further research is needed in order to determine which chart would be most suitable for a given soil type or mixture.

Colour	Eslami	Fugro	Searle	Swedish
	Collapsive soil - Sensitive soil	Peat	Peat	Clay & organic soil
		Organic Clay	Peaty Clay	
	Soft clay - Soft silt	Soft Clay	Heavy clay	
	Silty clay - Stiff clay	Stiff Clay	Silty clay	
		Very Stiff Clay	Clayey silt	
	Silty sand - Sandy silt	Sandy Clay	Clayey sandy silt	
		Loose silt	Clayey silty sand	Loose silt
		Silty Sand	Silty sand	Medium silt
				Dense silt
				Very dense silt
	Sand - Gravel	Very loose Sand		
		Loose Sand		Loose sand
		Medium sand	Medium sand	Medium dense sand
		Dense Sand	Gravelly sand	Dense sand
			Sandy Gravel	Very dense sand
			Gravel	

Fig. 6: Legend for the color scheme adopted for the CPT profile comparison.

Literature

[1] Eslami, A., & Fellenius, B. H. (1997). Canadian Geotechnical Journal , 886-904.

[2] Begemann, H. (1965). 6th International Conference on Soil Mechanics and Foundation Engineering, Canada.

[3] Sanglerat, G. (1972). Amsterdam: Elsevier Publishing Company.

[4] Neidhart, T. (2008). Regensburg: FH Regensburg - UAS.

[5] Searle, I. (1979). Brighton, U.K.

[6] Swedish National Report (1995) CPT '95. Linkoping, Sweden.

[7] Herle, I., & Uhlig, M. (2015). Dresden: Technische Universität Dresden.

Project
Project Work

Professor
Univ.-Prof. Dr.-Ing. habil. Ivo Herle, TU Dresden

Supervisor
Dr.-Ing. Markus Uhlig, TU Dresden

Submission Date
03.2024