EVALUATION OF CONE FACTOR FOR SRI LANKAN SOFT SOILS
Case Study of Southern Transport Development Project in Sri Lanka

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1. Introduction
This paper is written based on the results obtain from geotechnical investigations conducted for the ADB section of the Southern Transport Development Project (STDP) in Sri Lanka. A large number of Static Cone Penetration Tests (SCPT) was carried out using an electrical cone. Being that this was the first time that an electric cone SCPT was used in Sri Lanka, there was no reference value for the cone factor N_k. To overcome this problem, soil parameters, such as the cone factor (N_k) for peat, clay and organic silt, were determined by correlating values obtained from both the SCPT and the insitu vane shear results.

2. Southern Transport Development Project
Southern Transport Development Project consists of an expressway linking the capital city, Colombo, to the southernmost city, Matara approximately 130km away. This project is funded by two agencies, namely JBIC and ADB. The northern section funded by the former is 69km long while the southern section funded by the latter is 61km in length. The project summary for ADB section is summarised under Table 1.

Table 1 – Project Summary

Project Name	Southern Transport Development Project- Kurundugahahethekma to Matara
Period	3rd January 2003 to 25th April 2006 (40 month)
Employer	Road Development Authority
Engineer	Halcrow Group Ltd.,UK
Designer	Wilber Smith (USA), PCI (JP), BECA (NZ), RDC
Contractor	KUMAGAI GUMI Co., Ltd., Japan
Source of Funding	Asian Development Bank (ADB)

3. Problematic Soil Encountered Along STDP
The highway traverses predominantly over series of hillsides and low laying areas, which are in the flood plains of main rivers and lakes. A prominent feature of these low laying areas is the presence of subsoil, which are predominantly organic. Geotechnical investigations indicate that these low laying areas consist of either, or a combination of, highly compressible peat or soft inorganic clays and silts of thickness varying from 1m to 9m. The design requires the construction of 8 to 10m high embankments over these soft ground areas. Consequently, the introduction of soft ground treatment is required.
To identify these problematic areas and design appropriate ground treatment methods the Employer required the use of an economic and practicable ground investigation method. Among other conventional insitu laboratory tests, 270numbers of SCPT with electric cone and piezocone were carried out. As this consisted of the first use of electric cone SCPT in Sri Lanka, there was an absence of necessary soil parameters, such as the cone factor N_k to use the SCPT results effectively. Therefore SCPT results and insitu vane shear results were used here to evaluate cone factor (N_k) for cohesive soils such as peat, clays and silty soils. Basic properties of the problematic soils encountered are presents under the Table 2.

Key words: Peat, Cone factor, cone tip Resistance, Statistical, Soft Soil, Sri Lanka
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Table 2 - Basic Soil Properties for the Problematic Soil

Soil Type	Natural Moisture Content (%)	Specific Gravity	Wet Density (kN/m^3)	Initial Void Ratio (e_0)
Peat	498	1.8	11.2	6.1
Clay	184	2.6	16.6	1.4
Organic Silts	87	2.4	13.7	2.6

4. Evaluating a Cone Factor, N_k Using Field Measured Data

Over the years a large number of studies have been performed to determine applicable values for cone factors, N_k, relative to soft soils specific to regions in the world. For instance, in UK the resulting N_k factor ranges between 15-20 (ref. 1 & 2), while in Japan factor ranges between 8-16 (ref. 3).

One correlation between the cone tip resistance q_c, undrained shear strength s_u and overburden pressure σ_{v0} based on the bearing capacity equation is as follows:

$$q_c = N_k S_u + p_0$$

Solving for the cone factor N_k ,

$$N_k = (q_c - \sigma_{v0}) / S_U$$

Using measured values of q_c from SCPT and s_u from vane shear test, N_k was evaluated. Statistical analysis was done to obtain reasonable value for the N_k for each soil type using the results from 54 numbers of SCPT's and vane shear tests conducted side by side over the same soils. Results are tabulated under the Table 3.

Table 3 - Statistical Results for Initial and Evaluated Soil Parameters

Soil Type	Item	Measured Values		Evaluated Value
		ConeTip Resistance (Mpa)	Undrained Shear Strength (kN/m^2)	Cone Factor (N_k)
Peat	n	27	27	27
	X	0.12	5.98	**18**
	σ	0.03	2.14	7.81
Clay	n	20	20	20
	X	0.13	5.63	**22**
	σ	0.06	1.81	12.12
Organic Silts	n	7	7	7
	X	0.071	8.74	**11**
	σ	0.029	7.15	8.99

Where, n=number of samples, X= mean value, σ = Standard deviation

5. Conclusion

According to the available geotechnical investigation results, cone factors for peat, clay and organic silt were determined as 18, 22 and 11, respectively. A cone factor of 18 for peat is found to lie within the typical range included in reference literature. Notwithstanding, the cone factors of 22 for clay and 11 for organic silt have small variations relative to those found in literature for similar soils. It is believed that increasing the number of tests on other soil samples and including the results in the study will aid in determining appropriate cone factors for clay and organic silts. Authors will update these results following further information to come from results of ongoing investigations.

References

1) Lunne, T.,Robertson, P.K. & Powell, J.J.M. (1997). Cone Penetration Testing in Geotechnical Practice.(First edition). Blackie Acadamic &Professional, London.
2) Bowels, J.E. (1997). Foundation Analysis and Design. (Fifth edition). Mc Graw-Hill International, New York.
3) Site Investigation Methods–The Japan Geotechnical Society (Sep 1995).