Manual on Estimating Soil Properties for Foundation Design

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Prepared by

CORNELL UNIVERSITY
Geotechnical Engineering Group
Hollister Hall
Ithaca, New York 14853-3501

Authors
F. H. Kulhawy
P. W. Mayne

Principal Investigator
F. H. Kulhawy

Prepared for

Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, California 94304

EPRI Project Manager
V. J. Longo

Overhead Transmission Lines Program
Electrical Systems Division

strength of OC clays using the VST. Earlier it was shown that, for laboratory tests, the strength increased with increasing OCR^{Λ}. Typical Λ values ranged from about 0.7 to 0.8. However, with the VST in the field, Λ basically is equal to unity. This point has been demonstrated effectively by several authors (e.g., <u>23</u>, <u>32</u>, <u>67</u>).

Subsequent examination by Mesri (<u>68</u>) of Bjerrum's correction factor (Figure 4-48) and $s_u(VST)/\bar{\sigma}_p$ relationship (Figure 4-49) suggested the following:

$$s_u(\text{field})/\bar{\sigma}_p \approx \mu \; s_u(VST)/\bar{\sigma}_p \approx 0.22 \qquad (4\text{-}57)$$

in which s_u(field) represents the average mobilized undrained strength in the field for stability problems such as embankments on soft clay and foundation bearing capacity. This relationship has been corroborated in independent studies by Trak, et al. (<u>69</u>) and Larsson (<u>70</u>). Recent studies by Mesri (<u>36</u>) have reconfirmed this relationship and have noted further that:

$$s_u(\text{field})/\bar{\sigma}_p \approx [s_u(CK_oUC)/\bar{\sigma}_p + s_u(DSS)/\bar{\sigma}_p + s_u(CK_oUE)/\bar{\sigma}_p]/3 \qquad (4\text{-}58)$$

These last two equations link the direct field and laboratory shear tests and provide a general basis for evaluating the actual field value of s_u for design. As noted previously, caution is warranted in unusual clays.

<u>Correlations with SPT N Value</u>

Correlations have been attempted for estimating s_u from SPT N values, even though it is known that these correlations are weak. The most common of these is shown in Table 4-10, which was developed primarily using unconfined compression tests. From the results of this table, s_u can be approximated as follows:

$$s_u/p_a \approx 0.06 \; N \qquad (4\text{-}59)$$

pa ≈ 100 kPa

Many other relationships have been proposed as well, and several of these are shown in Figure 4-50. It is clear that these relationships represent a wide variety of interpretations of soil types and testing conditions and that a universal relationship between s_u and N is unlikely. Several other serious problems exist with Figure 4-50. First, the SPT N values have not all been standardized to the same energy level. Second, there is no indication of the reference strength used to determine s_u. The mixing of different undrained strength data is inconsistent, and it increases the scatter in the reported trends. Third, the sensitivity of the

Table 4-10

APPROXIMATE s_u VERSUS N RELATIONSHIP

N Value (blows/ft or 305 mm)	Consistency	Approximate s_u/p_a
0 to 2	very soft	< 1/8 0.125
2 to 4	soft	1/8 to 1/4 0.125 ~ 0.25
4 to 8	medium	1/4 to 1/2 0.25 - 0.5
8 to 15	stiff	1/2 to 1 0.5 - 1
15 to 30	very stiff	1 to 2 1 - 2
> 30	hard	> 2

Source: Terzaghi and Peck (4), p. 347.

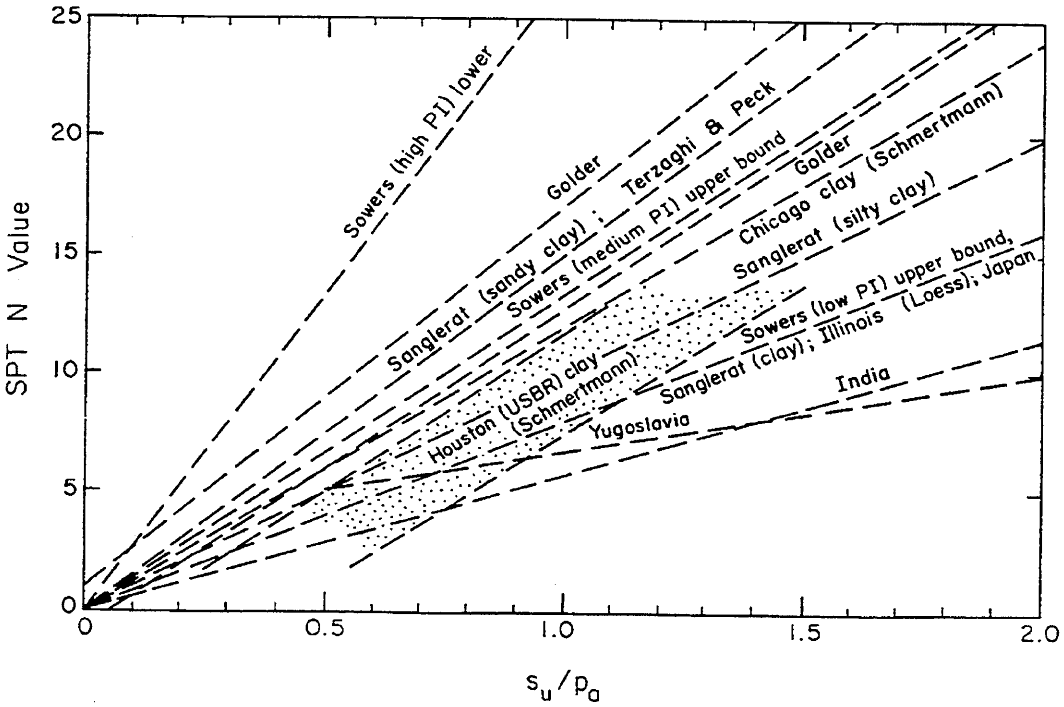

Figure 4-50. Selected Relationships Between N and s_u

Source: Djoenaidi (71), p. 5-93.

clay can affect the N value greatly, as shown in Figure 4-51. Apparently, the penetration process causes temporary excess pore water stresses which reduce the effective stresses in the vicinity of the sampler, thereby resulting in an apparently lower N value.

However, for clays within a given geology, a reasonable correlation might be expected between s_u and N. Figure 4-52 indicates this behavior over a wide range of N values where the same drilling equipment, SPT procedure, and consistent reference strength (UU triaxial) were employed. For these data, the reported regression is given by:

$$s_u/p_a = 0.29\ N^{0.72} \qquad (4\text{-}60)$$

This equation tends to predict s_u/p_a on the high side of the relationships shown in Figure 4-50.

<u>Correlations with CPT q_c Value</u>

The theoretical relationship for the cone tip resistance in clay is given by:

$$q_c = N_k\ s_u + \sigma_{vo} \qquad (4\text{-}61)$$

in which q_c = cone tip resistance, σ_{vo} = total overburden stress, and N_k = cone bearing factor. The application of classical plasticity theory to this bearing capacity problem suggests N_k on the order of 9 for a general shear model. Cavity

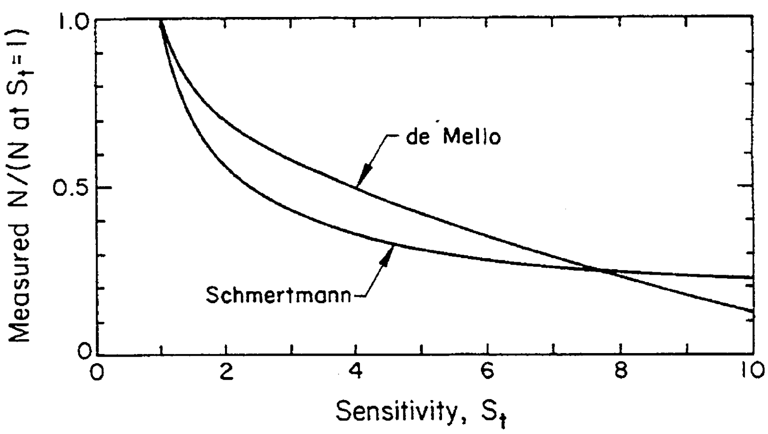

Figure 4-51. Apparent Decrease of N with Increasing Sensitivity

Source: Schmertmann (<u>14</u>), p. 66.