CUSTOMER SUPPORT NOTE

Calculation of spring constants for use as spring supports in LUSAS piling analyses

Note Number:	**CSN/LUSAS/1001**

This support note is issued as a guideline only.

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1. Introduction

This support note describes how lateral spring constants should be derived from Standard Penetration Test (SPT) "N" values for use in LUSAS piling analyses where the soil is not modelled explicitly and no information is known regarding the soil stiffness. SPT "N" values are used in the calculation of stress-strain modulus, E_s which in turn is then transformed into a lateral modulus of subgrade reaction, k_s. Once a k_s profile has been determined spring constants can be calculated based on nodal spring spacing within the finite element mesh.

2. Description

When calculating spring constants to be used as lateral restraints in piling analyses the initial step is to calculate a soil profile for the lateral modulus of subgrade reaction, k_s. This itself can be derived from the stress-strain modulus of the soil, Es (Glick, 1948).

$$k_s' = \frac{22.4 E_s (1-\mu)}{(1+\mu)(3-4\mu)[2\ln(2L_p/B) - 0.433]}$$

where:

	E_s	= stress-strain modulus
	μ	= Poisson's ratio
	L_p	= pile length, m
	B	= pile width, m

Then $$k_s = \frac{k_s'}{B}$$

An approximate value of stress-strain modulus, E_s, can be derived from results of Standard Penetration Test "N" values or "blow-counts".

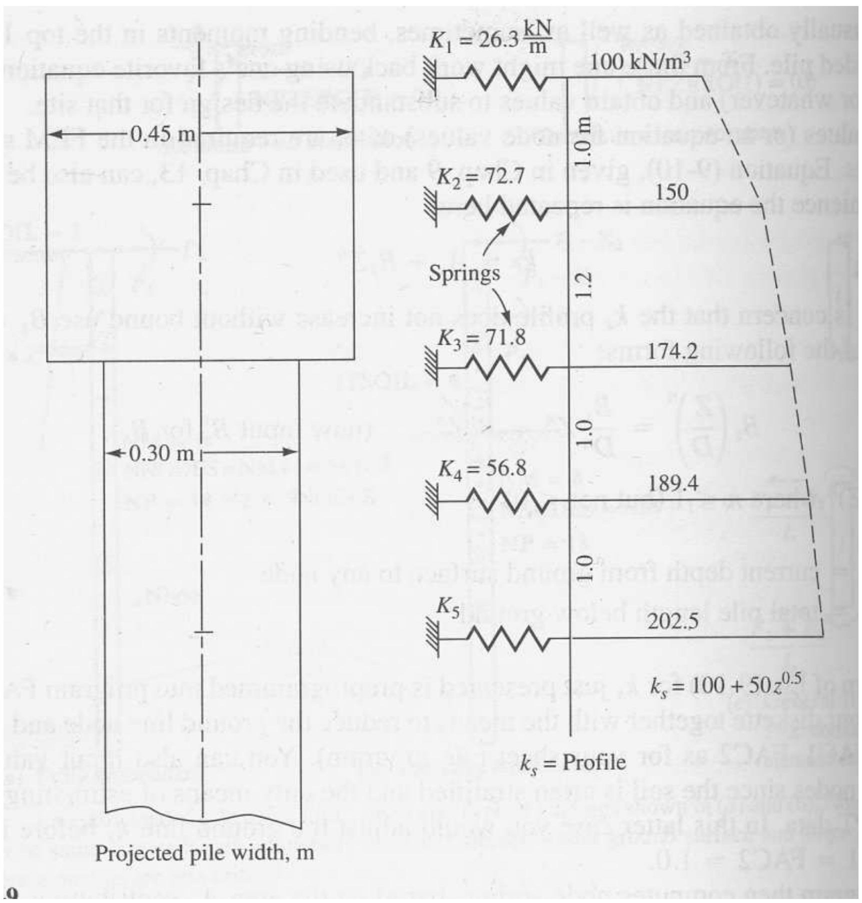
The following table provides the empirical relationship to be used depending on the soil type under consideration (Bowles, 1996).

Soil type	E_s (kPa)
Sand (normally consolidated)	500 (N + 15)
Sand (saturated)	250 (N + 15)
Gravelly sand	1200 (N + 6)
Clayey sand	320 (N + 15)
Silts, sandy silt, clayey silt	300 (N + 6)

A check on the values of lateral modulus of subgrade reaction obtained can be quickly made by comparing the values against typical values such as those found in the following table for various soil types.

Soil type	k_s (MN/m3)
Dense sandy gravel	220 – 400
Medium dense coarse sand	157 - 300
Medium sand	110 - 280
Fine or silty, fine sand	80 - 200
Stiff clay (wet)	60 – 220
Stiff clay (saturated)	30 - 110
Medium clay (wet)	39 - 140
Medium clay (saturated)	10 - 80
Soft clay	2 - 40

Actual spring constants to be used in the analysis are derived from the lateral modulus of subgrade reaction and nodal spacing down the length of the pile as shown in the following example.



Example 16-9. Compute the first four node springs for the pile shown in Fig. E16-9. The soil modulus is $k_s = 100 + 50Z^{0.5}$. From the k_s profile and using the average end area formula:

$$K_i = \frac{BL}{6}(2k_{s,i} + k_{s,i-1}) \quad \text{or} \quad \frac{BL}{6}(2k_{s,i} + k_{s,i+1})$$

$$K_1 = H(1) \times B(1)(2k_{s,1} + k_{s,2})/6 = 1.0 \times 0.45(2 \times 100 + 150)/6 = 26.3$$

$$K_2 = H(1) \times B(1)(2k_{s,2} + k_{s,1})/6 = 1.0 \times 0.45(2 \times 150 + 100)/6 = 30.0$$

$$K_2' = H(2) \times B(2)(2k_{s,2} + k_{s,3})/6 = 1.0 \times 0.45(2 \times 150 + 174.2)/6 = 42.7$$

$$K_3 = H(3) \times B(3)(2k_{s,3} + k_{s,2})/6 = 1.0 \times 0.45(2 \times 174.2 + 150)/6 = 44.9$$

$$K_3' = 1.0 \times 0.30(2 \times 174.2 + 189.4)/6 = 26.9$$

$$K_4 = 1.0 \times 0.30(2 \times 189.4 + 174.2)/6 = 27.7$$

Summary.

K_1 = **26.3** kN/m

$K_2 = K_2 + K_2' = 30.0 + 42.7 =$ **72.7** kN/m

$K_3 = K_3 + K_3' = 44.9 + 26.9 =$ **71.8** kN/m

$K_4 = 27.7 + 29.1 =$ **56.8** kN/m, . . . , etc.

3. References

GLICK, G. W. (1948). "Influence of Soft Ground in the Design of Long Piles". 2nd ICSMFE, vol. 4, pp. 84-88.

BOWLES, J. E. (1996). "Foundation Analysis and Design". 5th Edition, McGraw-Hill, Singapore.