The Steel Construction Institute

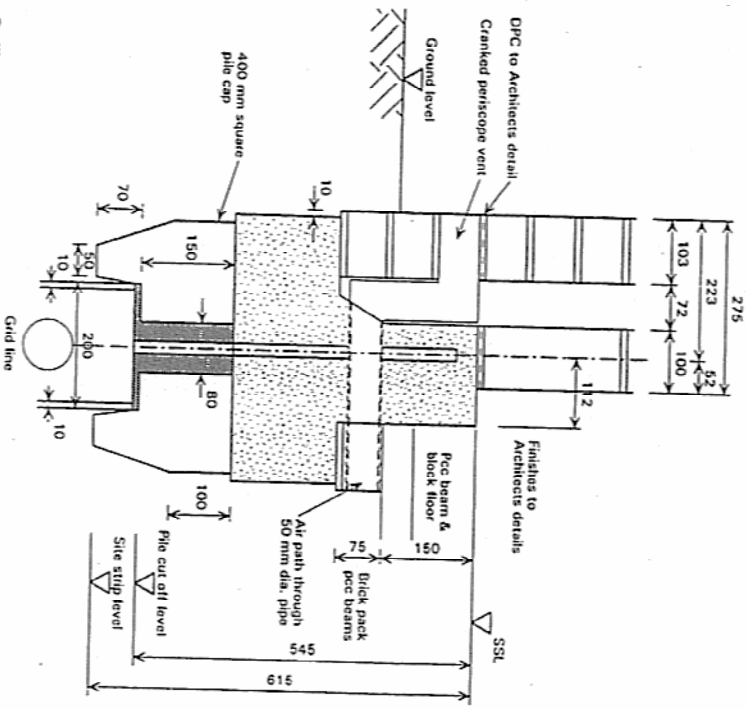
Composite Ground Floors and Minipiles for Housing Project

Mini pile load test database interpretation

A R Biddle
Manager of Civil Engineering

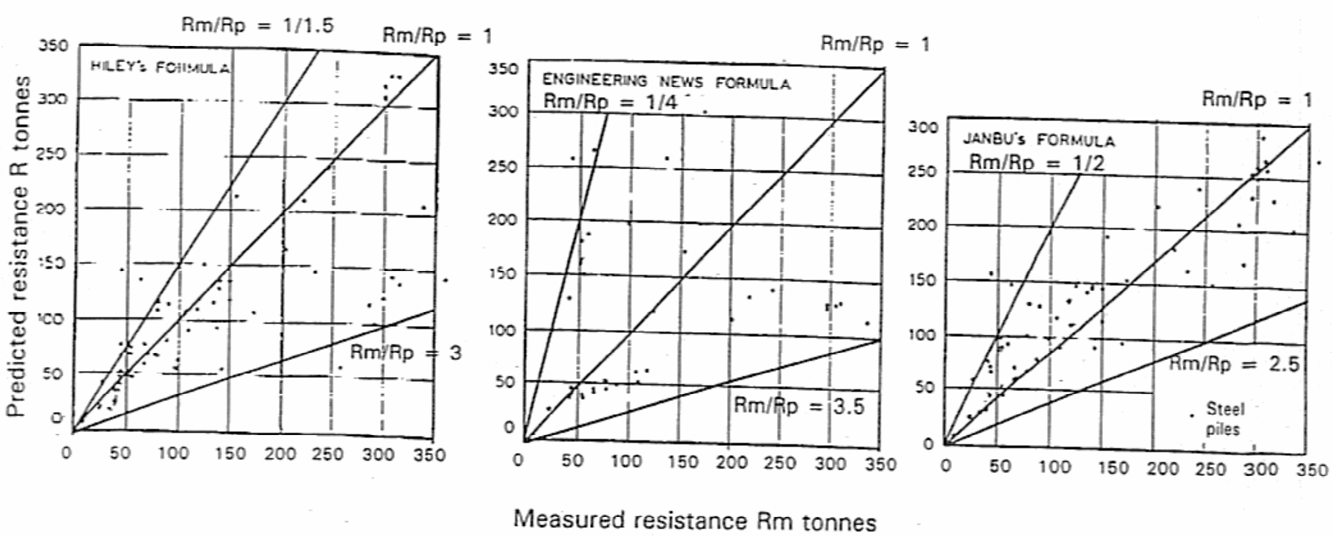
Technical Report RT 751
DRAFT 03
Version 03

The Steel Construction Institute, Silwood Park, Ascot, Berks, SL5 7QN Tel: 01344 623345 Fax: 01344 622944



Roger Bullivant's concrete floor edge beam showing details of dpc, groundlevels, subfloor venting and the beam and block floor construction

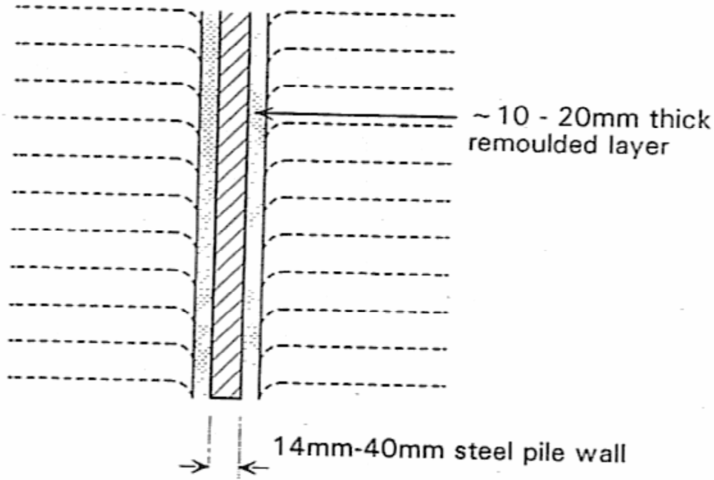
Comparison of pile driving formulae - Reliability of Resistance Predictions



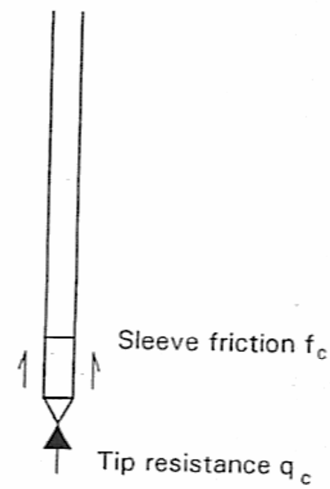
Comparison of pile driving formulae for steel piles by Flaate, 1964

Driving resistance from research tests

Cohesive soils



Granular soils

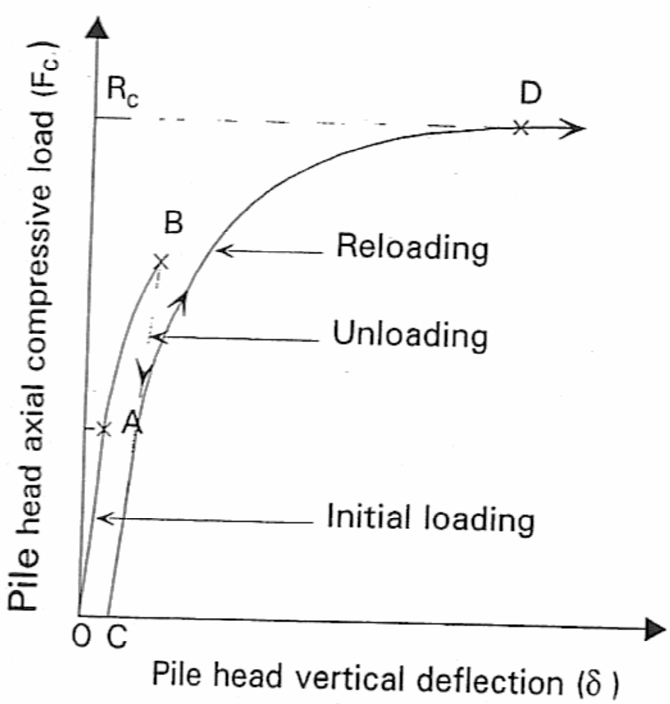


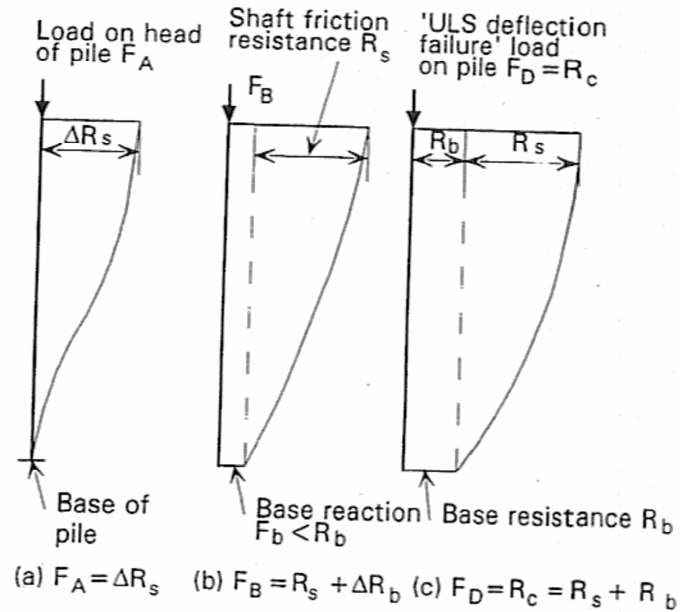
Cone penetration test

$$R_b \approx 0.25 c_u \cdot A_s$$

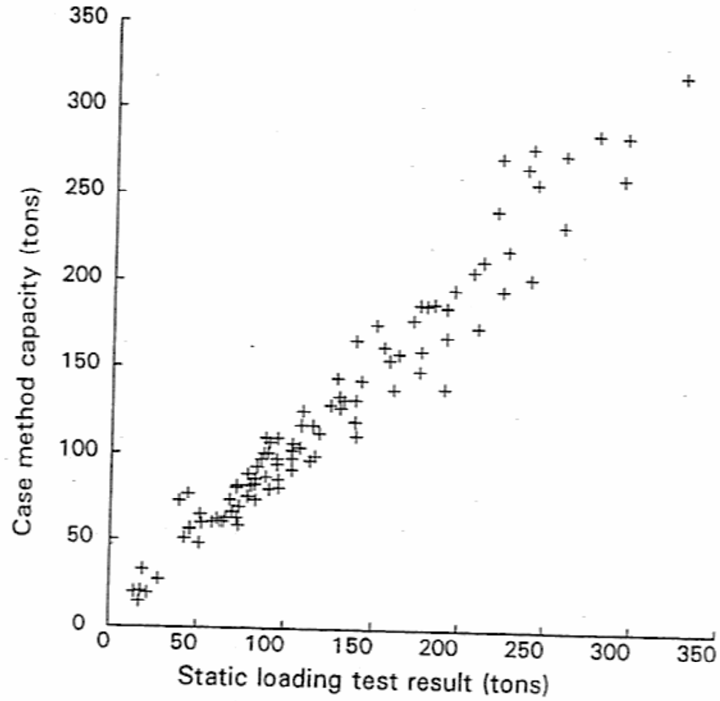
$$R_b \approx q_c \cdot A_b = q_c \cdot A_c$$

Steel Piles - Axial Load Transfer friction piles

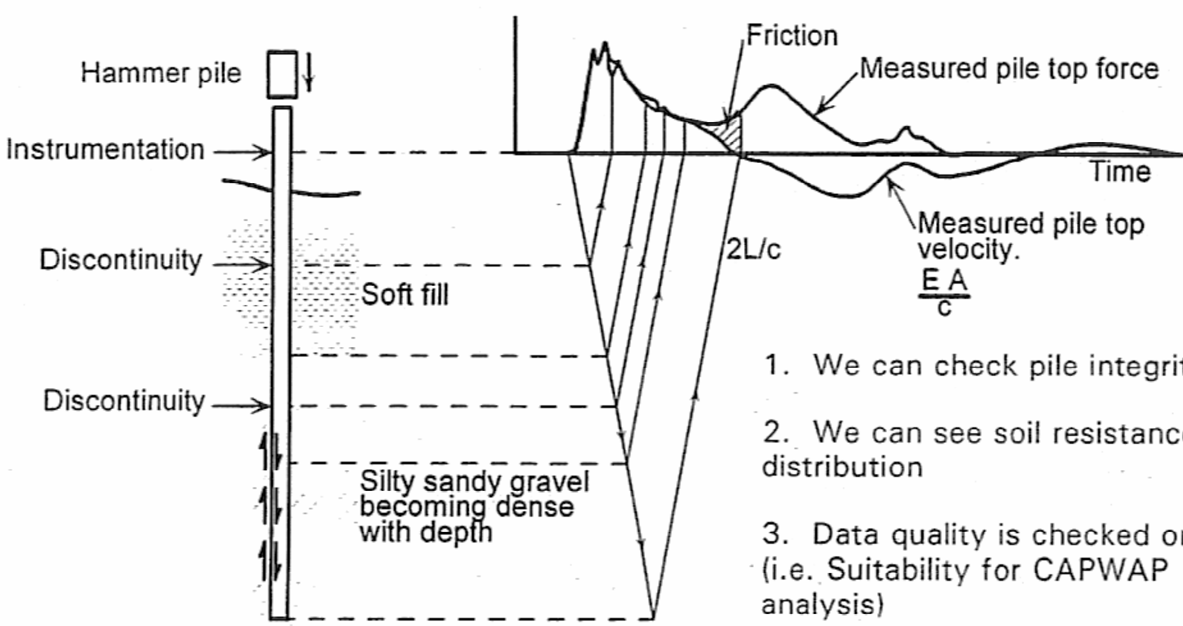




Dynamic pile testing .v. static load tests
Capwap .v. static measurement



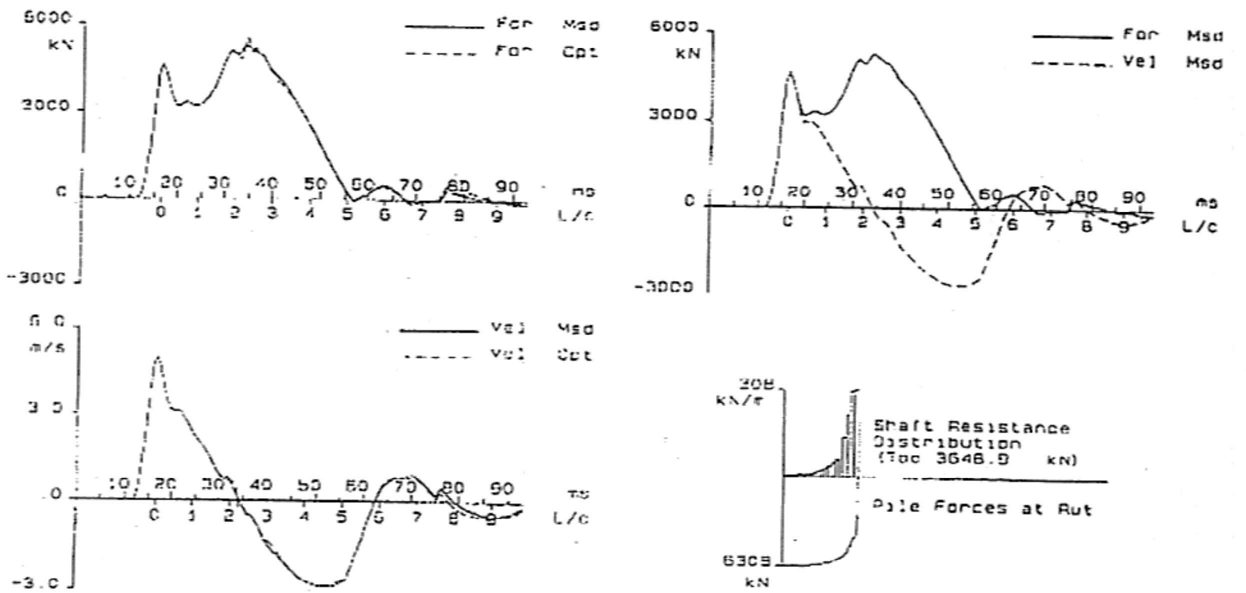
Force - Velocity Data Interpretation



1. We can check pile integrity
2. We can see soil resistance and distribution
3. Data quality is checked on site (i.e. Suitability for CAPWAP analysis)

c = constant m/s (Velocity of stress wave in pile)

CAPWAP Matching of Force/Time Plots



2 INTERPRETATION OF RESULTS

For the additional industry pile load tests, shaft and base capacity were estimated from the load-displacement curves using the procedure described by Fleming (1992) ('Cemsolve'). The data required for input to the Cemsolve procedure were predominantly obtained by estimating values from the site investigation data; in particular, initial estimates of base stiffness were obtained from the relationships based on SPT and given by Stroud (1989). The key information from the pile load tests is tabulated in Annex 1 [in preparation].

The sections that follow look at the industry data superimposed on the research data reported previously; the results are presented in a similar format. As before, methods relating unit shaft friction, f, and unit end-bearing, q, to S_U and SPT N-value are examined against the database for cohesive and granular soils respectively.

2.1 Cohesive soils

2.1.1 Shaft capacity

The simplest methods of estimating a pile's shaft capacity in cohesive soils relate f to S_u by an empirical coefficient, α, so that

$$f = \alpha S_u \quad (1)$$

Data from load tests on bored piles presented by Skempton (1959) suggest that α is in the range 0.3 to 0.6; Skempton recommended using a mean value of $\alpha = 0.45$ for estimating load carrying capacity[1]. Current UK design practice is to use α values of between 0.4 and 0.6 for bored piles in overconsolidated sedimentary clays (Findlay et al, 1997), while slightly higher values might be used for driven piles.

Other values of α have been suggested elsewhere. For the design of offshore steel piles, the American Petroleum Institute (API) Design Code RP2A suggest using α=1 for S_U<24kPa and α=0.5 for S_U>72kPa, with a transitional zone between. Biddle (1997) suggests that for steel H-piles, α=0.25 is a suitable general design rule for predicting the capacity available within two weeks of driving for small displacement steel piles.

Figure 1 shows calculated values of f plotted against S_U for all of the relevant piles in the research database, together with the additional results obtained from the industrial database. The figure also shows lines corresponding to α=0.3, 0.45, 0.6 and 1.0.

The lowest value of f obtained from the industrial piles was obtained from a tension test that was not taken to failure; therefore, this result is an absolute lower-bound

[1] These values of α were intended to apply to 'quick' unconsolidated undrained strength determinations on 38mm diameter test specimens and not necessarily to larger diameter specimens or other test techniques.

value. Consequently, the four relevant piles from the industrial database tend to be towards the higher values of α.

On the basis of the research results, the earlier report suggested that it would be reasonable to use an α value of 0.3 for prediction of a lower bound shaft resistance with a 90% confidence level. This is a lower value than might be used for larger cross-section piles under similar circumstances. It was suggested by members of the Steering Group for this project that, even though α=0.3 might provide a more cautious value than current practice, checking authorities would be unlikely to accept factors of safety or partial factors significantly different to those currently used. This suggestion has prompted a comparison of data obtained for small cross-section piles with two data sets for which 'normal' α values might be considered to apply:

- the data on driven piles given in Fleming et al (1992); and
- the data for bored piles in London Clay given by Skempton (1959) which formed the basis of the commonly used α=0.45.

Figures 2 (all data) and 3 (S_U < 300kPa) show the small cross-section pile data plotted alongside these two additional data sets. The scatter of the small cross-section pile data appears similar to that of the two other data sets combined. Testing these data sets against an assumption of α=0.45, allows the comparison of the range of values of Q_{SC}/Q_{SM} from each data set, where Q_{SC} and Q_{SM} are the calculated and measured shaft capacity respectively. Table 1 shows values of mean (μ), standard deviation (s), coefficient of variation (COV = μ/s), Ranking Index (RI) as defined by Briaud & Tucker (1988)[2], minimum and maximum of the distributions of values of Q_{SC}/Q_{SM} for each data set.

Table 1. Comparison of reliability measures for shaft friction assessment using α=0.45 tested on three data sets.

	Variation in Q_{sc}/Q_{sm}, calculated using α=0.45		
	Small cross-section pile data	**Fleming et al data**	**Skempton data**
Mean, μ	0.84	0.77	1.16
Standard deviation, s	0.39	0.31	0.32
Coefficient of variation, COV	0.46	0.40	0.27
Ranking Index, RI	0.70	0.77	0.39
Maximum	2.00	1.37	1.89
Minimum	0.26	0.32	0.73

[2] The Ranking Index, RI, described by Briaud & Tucker (1988), provides a means of ranking pile capacity predictions which gets over the problem of the distribution of Q_{SC}/Q_{SM} not being normal. In this case

$$RI = \left|\mu\left(\ln(Q_{SC}/Q_{SM})\right)\right| + s\left(\ln(Q_{SC}/Q_{SM})\right)$$

The lower the RI, the better the performance of the method.

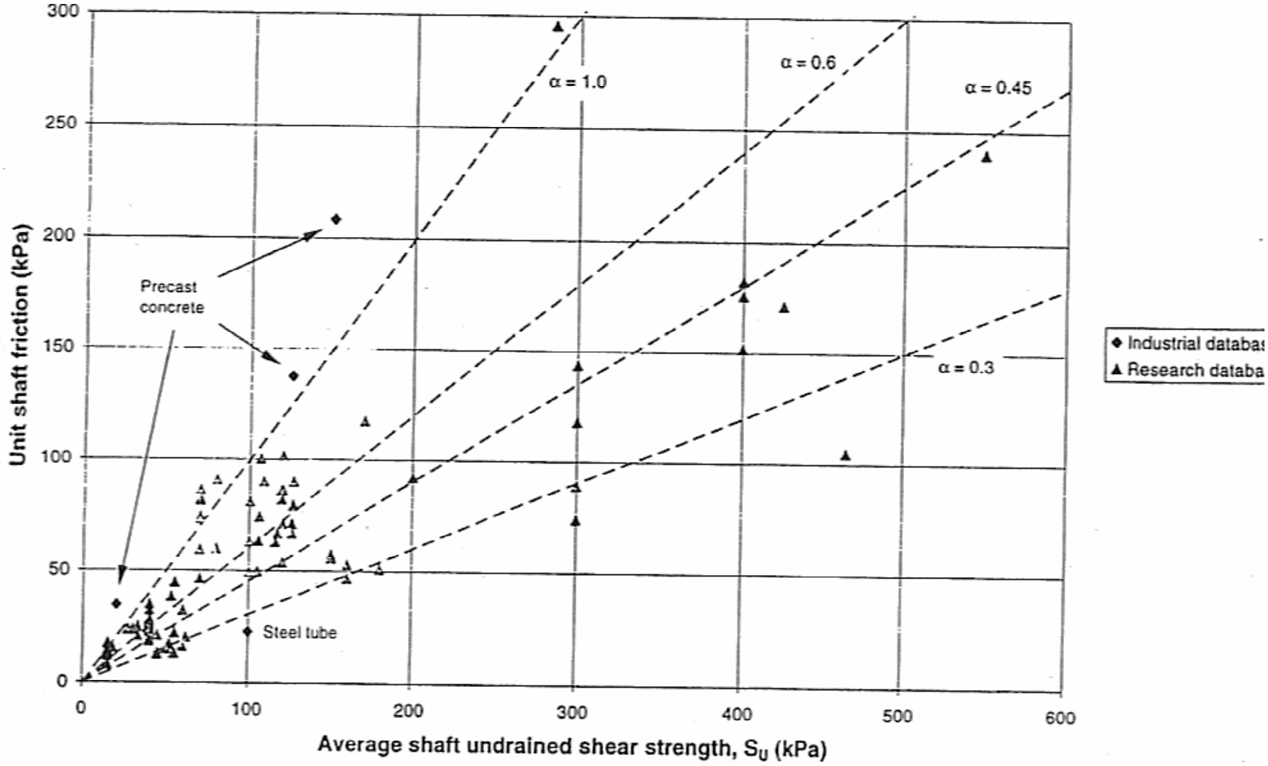
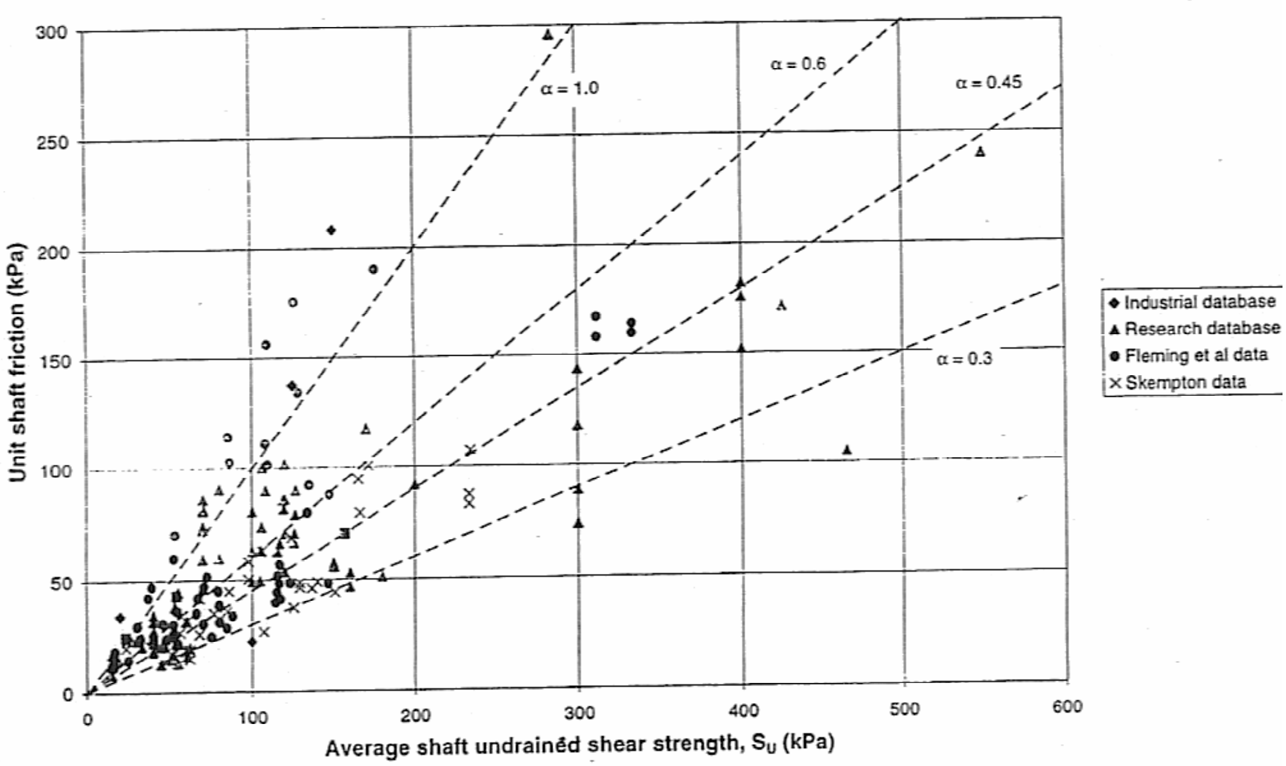


Figure 1. Relationship between shaft friction and undrained shear strength.



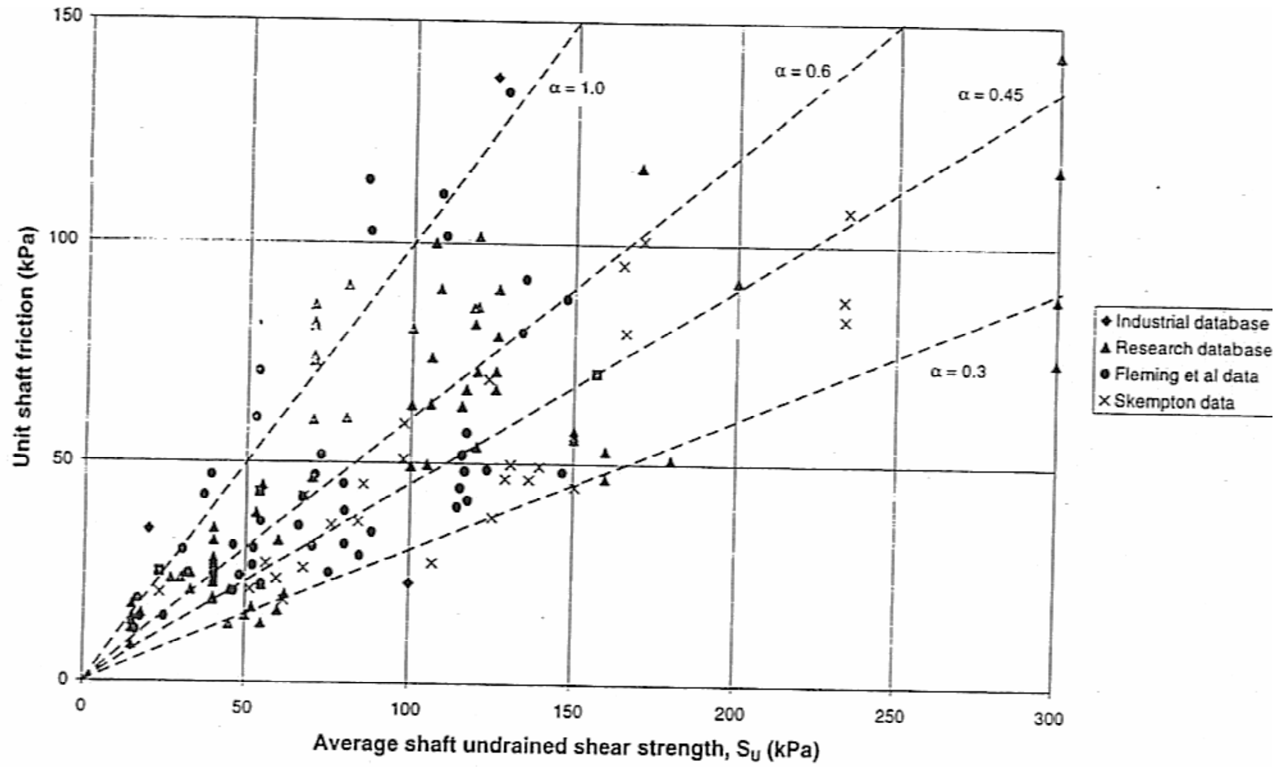
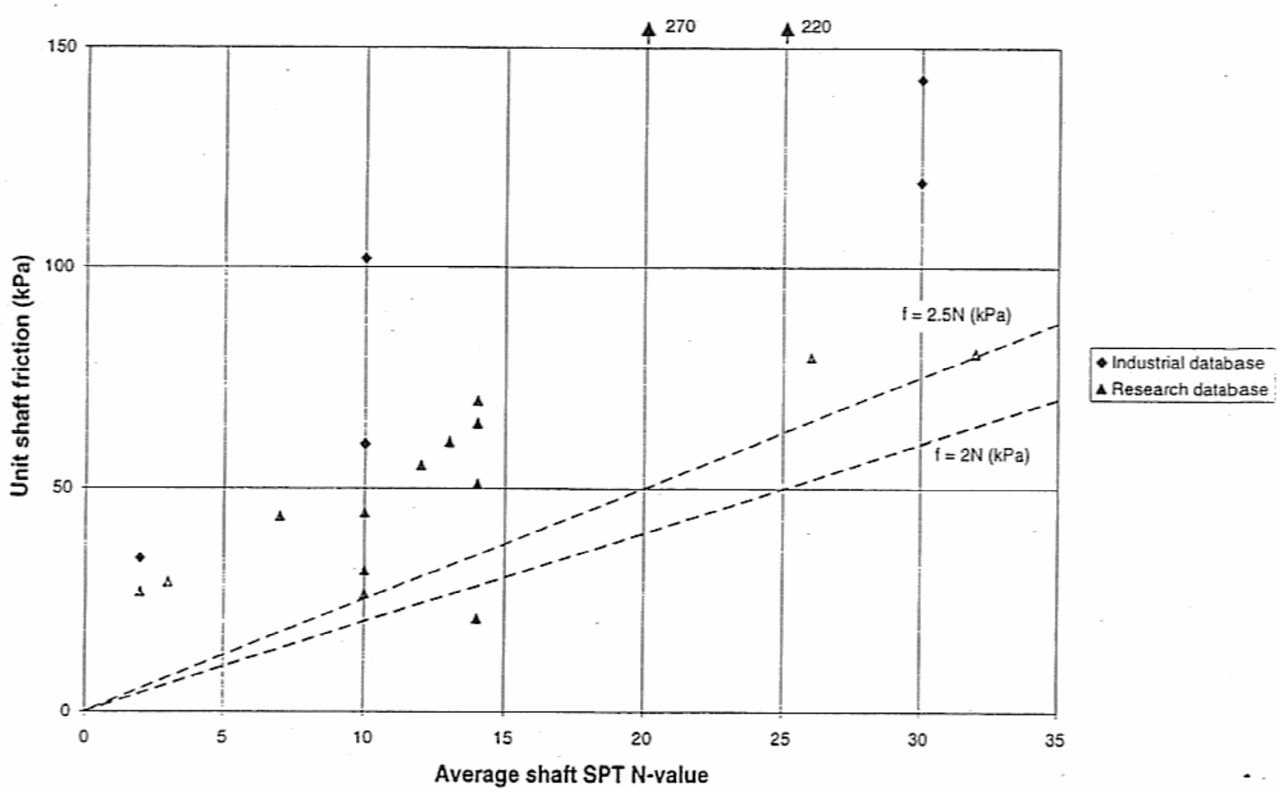


Figure 3. Relationship between shaft friction and undrained shear strength - additional datasets (S_U < 300kPa).



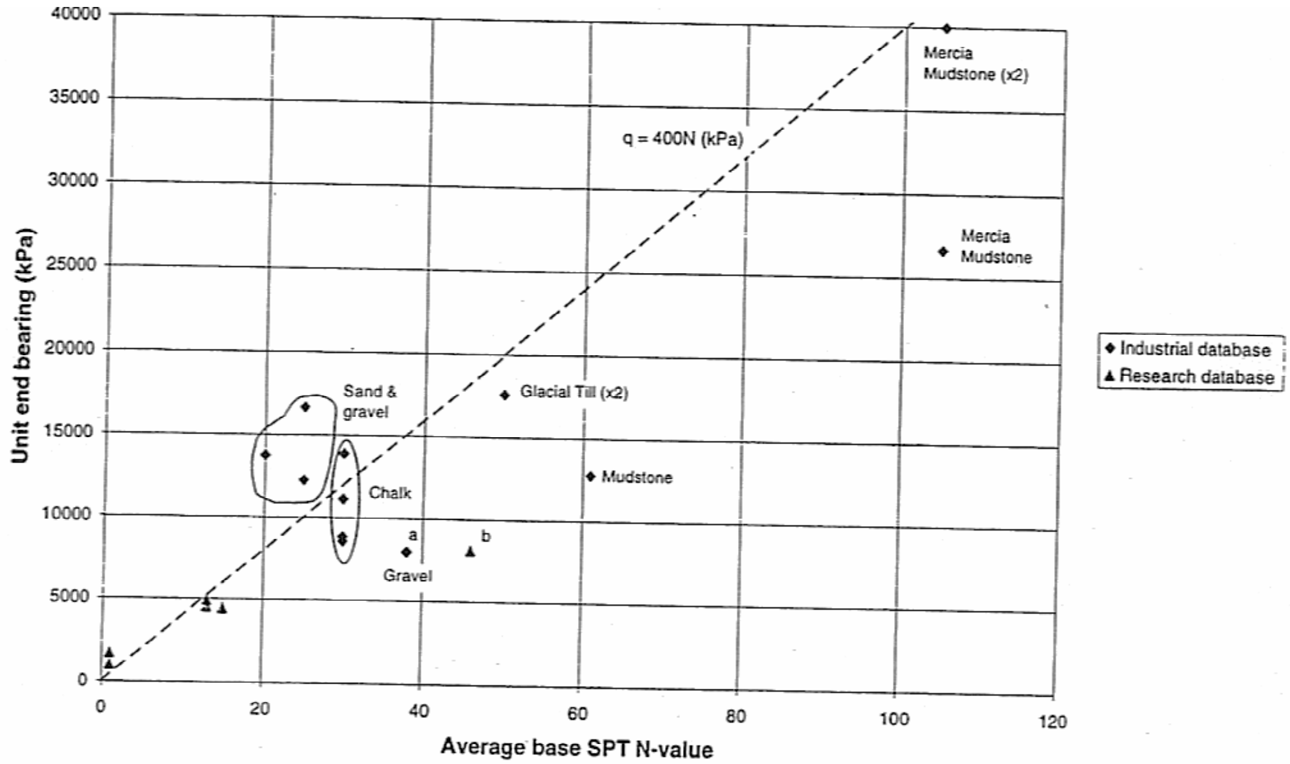


Figure 5. Relationship between unit end-bearing and SPT N-value.

Rock shear strengths from NGI testing database