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SPT-CPT CORRELATION IN SOUTHEAST QUEENSLAND, AUSTRALIA

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ABSTRACT: Among the most popular *in situ* investigation techniques for identifying subsurface strata, cone penetrometer testing (CPT) and standard penetrometer testing (SPT) are employed in geotechnical engineering. In fact, both tests are adopted to correlate a wide range of geotechnical parameters in various design applications. The cost associated with conducting both in situ tests at the same locations often results in one method being chosen over the other. Hence, engineers have to corelate one of the tests' parameters into the other test using empirical correlation in translating SPT blow counts (*SPT-N*) into CPT cone tip resistance (*CPT-*q_c). However, disadvantages of this in situ test are that it does not directly quantify geotechnical parameters but uses correlations which are significantly influenced by soil properties. Also, many of correlations do not provide sufficient background on the statistical approach. This study investigates the conformity of the empirical correlations against local SPT-CPT correlation for different soil occurrences in Southeast Queensland (SEQ), adopting a linear regression model to validate the degree of the relationship. Seven soil groups were classified in SEQ, comprising cohesionless and cohesive soil. The results of the SEQ samples showed a strong liner relationship (r = 0.69 – 0.89) with at least 50% of data points coinciding with the regression line (R^2 = 0.48 – 0.80). It follows that for some soil groups, the published correlation agrees well with the SEQ study, while others did not.

INTRODUCTION

In the engineering and geotechnical industry, identifying geotechnical parameters is critical and typically, geotechnical engineers would retrieve soil samples from site and send them for laboratory testing. However, because of the long waiting period for laboratory results and associated costs, in situ site tests tend to be more effective and economical.

In Australia, static cone penetration tests (CPT) and Standard Penetration Tests (SPT) are the most popular geotechnical in situ tests. SPT is a dynamic test method (disturbed technique) while CPT is a quasi-static (undisturbed technique), and both methods have proven to be accurate and reliable. Prior to the introduction of CPT, SPT was widely used. There are various geotechnical design parameters that are related to SPT, but CPT is becoming more popular today. Financial implications often make it impossible to conduct both *in situ* tests at the same location. Thus, engineers have been able to interpret one of the tests' parameters into the other using empirical correlation in translating SPT (blow counts – *SPT-N*) into CPT (cone tip resistance – *CPT-*q_c) values. In the last sixty years, many studies have been published on correlations between the two parameters for different types of soil occurrence. The most common ratio is the linear relationship known as the *n-value* (**Error! Reference source not found.**).

However, these correlations are greatly influenced by soil properties, which are established from previous records collected from different studies around the world. Similarly, the geological formation and stratigraphy are heterogeneous and non-uniform in nature and would vary from one location to another. Therefore, applying these correlations to another area may not reflect the actual soil

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characteristics. In addition, the statistical approach was not clearly demonstrated in the assignment of the n-values.

$$n = \frac{q_c}{N} \text{ (MPa)} \tag{1}$$

- n is the n-value
- q_c is the cone tip resistance
- N is the *SPT-N* blows

BACKGROUND

Historical Studies

According to Meyerhof (1956) the *n-value* was assigned a general value of 0.4 MPa for all material but later it was found that the effect of grain size (sand and gravel) influenced this ratio. The *n-value* was corrected back then as 0.2 MPa for coarse sand and 0.3 – 0.4 MPa for gravelly sand (Meigh and Nixon, 1961). At this point in time, researchers realised that further work was required to accurately and precisely assign an indicative correlation factor for different types of material.

De Alencar Velloso (1959) published one of the first papers which suggested different *n-value* for different types of soil. In fact, numerous other published linear relationships were identified. The assigned *n-value* for different types of soil is summarised in **Table 1**. In these published studies, the comparison of material descriptions was unclear, but can be used to assess interpreted correlations in general. In fact, these earlier studies indicate that the *n-values* increases for the transition from fine and cohesive material to more granular and cohesionless material. Yet during the following years, extensive research papers were published without any formal standards that were not adopted until the mid-1980s. Roberson PK, Campanella, R.G., Wightman, A (1983) stated that while improvement would be made on local experience and field observation, a more reliable SPT-CPT correlation would be necessary for CPT data to be incorporated into the current SPT-based approach.

Table 1: Summary of historical works for *n-value (n = (qc / N))*

Reference	Soil Types	Correlation
(De Alencar Velloso, 1959)	Clay and silty clay	0.35
	Sandy clay and silty sand	0.2
	Sandy silt	0.35
	Fine sand	0.6
	Sand	1.0
(P. Robertson, Campanella, and Wightman, 1983)	Silty Fine Sand	0.3 – 0.4
	Fine Sand	0.5 – 0.6
	Fine Sand with Silt	0.3
	Clayey Fine Sand	0.2
(Mayerhoff, 1956)	Clayey sand	0.6
	Silty Sand	0.5
	Sandy Clay	0.4
	Silty Clay	0.3
	Clay	0.2
Franki Piles 1960, from (Akca, 2003)	Sand	1.0
	Clayey Sand	0.6
	Silty Sand	0.5
	Sandy Clay	0.4
	Silty Clay	0.3
	Clays	0.2
(Akca, 2003)	Sand	0.77
	Silty Sand	0.70
	Sandy Silt	0.58
(Schmertmann, 1970)	Silty Fine Sand	0.3 – 0.4
	Fine Sand	0.3 – 0.6
	Silty Clayey Fine Sand	0.2
(Danziger, Politano, and Danziger, 1998)	Silty Fine Sand	0.5 – 0.64
	Fine Sand	0.57
	Clayey Fine Sand	0.46 – 0.53
	Silty Clayey Fine Sand	0.1 – 0.35

Other publishers identified that other variables could affect the SPT-CPT relationship. In fact, the amount of energy distributed to the drill rods from the hammer was a significant variable parameter that affected the *n-value* (Schmertmann, 1970; Skempton, 1986). Consequently, some published works corrected their *SPT N-value* to an estimated rod energy ratio of 60% (N_{60}).

Current Studies

Many researchers have tried to determine if the empirical SPT-CPT correlations were relevant to respective local soil profiles. According to a study carried out by Akca (2003), it was identified that there was a lack of geological consideration, as well as any acknowledgement of the statistical procedures engaged for analysis in previous empirical correlations. Consequently, the author adopted several statistical techniques and correlation functions (arithmetic average method, linear and power correlation) to correlate the SPT-CPT data acquired from the United Arab Emirates' (UAE) coastline area. The results showed that the *n-value* of the UAE soils were higher than literature values.

In the early twenty-first century, the geotechnical industry recognised two sources of uncertainty while conducting *in situ* testing: the changing character of natural materials (subsurface conditions) and measurement error (test repeatability). The analysis of soil property variability necessitated a complicated mathematical technique that included data filtering, data de-trending, and derivation of statistical parameters. A study was carried out to correlate *SPT-N* and *CPT*-q_c parameters for three soft organic clay layers in a Southern Brazilian port site. The statistical parameters effectively identified that the variability of SPT was greater than that of CPT and that each layer had a distinct distribution even though they were of the same material.

METHODOLOGY

Study Area

The empirical correlation between SPT and CPT was studied in the south-eastern part of the State of Queensland, Australia – SEQ. The region covers approximately 35,248 km2 with 12 local administration area including – Noosa, Sunshine Coast, Moreton Bay, Brisbane, Redland, Logan, Gold Coast, Scenic Rim, Ipswich, Lockyer Valley, Toowoomba and Somerset (Council of Mayors, 2022). **Figure 2** illustrates the SEQ subdistricts with respect to the Australian mainland. A variety of physical features exist in SEQ, including alluvial valleys, volcanic hills, coastal sand masses, and coastal dune systems. In fact, the topography varied from flat and slightly sloping terrain to high depressions along the coastal line. As a result of the numerous surface waterways that are found in the SEQ region - such as creeks, wetlands, lakes, rivers, and bays – most of the region's soil has alluvial characteristics.

Geology of SEQ

SEQ have a very complex geological formation with various areas influenced by volcanic activity and tectonic periods. In general, uniform Palaeozoic rocks are the oldest rocks in the region and occur as weathered greywackes, limestone, siltstones, and shales. These massive Palaeozoic rocks have been interposed by Permo-Triassic coarse-grained igneous rocks such as diorite, adamellite, granite, and granodiorite. These occur as outcrops and batholiths.

Traces of basaltic and rhyolitic flows and tuffs are found in the south section of SEQ due to a period of complex Tertiary volcanic activity. The Great Dividing Range was formed by these Tertiary lavas. This has led to the occurrence of Tertiary sediments such as sandstones, lignite, soft mudstones, and coarse agglomerates. Related with the natural inland drainage systems, during the Quaternary period, transported materials were deposited as coastal sand plains and dunes, and as alluvium (Holocene and Pleistocene). Similarly, near-surface sedimentary rocks – such as mudstone, conglomerate, sandstone, shale and siltstone – were formed under regional conditions (Commonwealth Queensland Regional Forest Agreement Steering Committee, 1999).

It is of importance to understand that SPT and CPT techniques are mostly relevant to the geotechnical parameters of soil rather than rock. In fact, most of the investigation in the past have been carried out in the alluvium deposit. These techniques are usually disregarded wherever shallow outcrop is observed. Consequently, it is common to see SPT and CPT being carried out along the coastal plains.

Data collection and strategy

The strategy of data collection is outlined below:

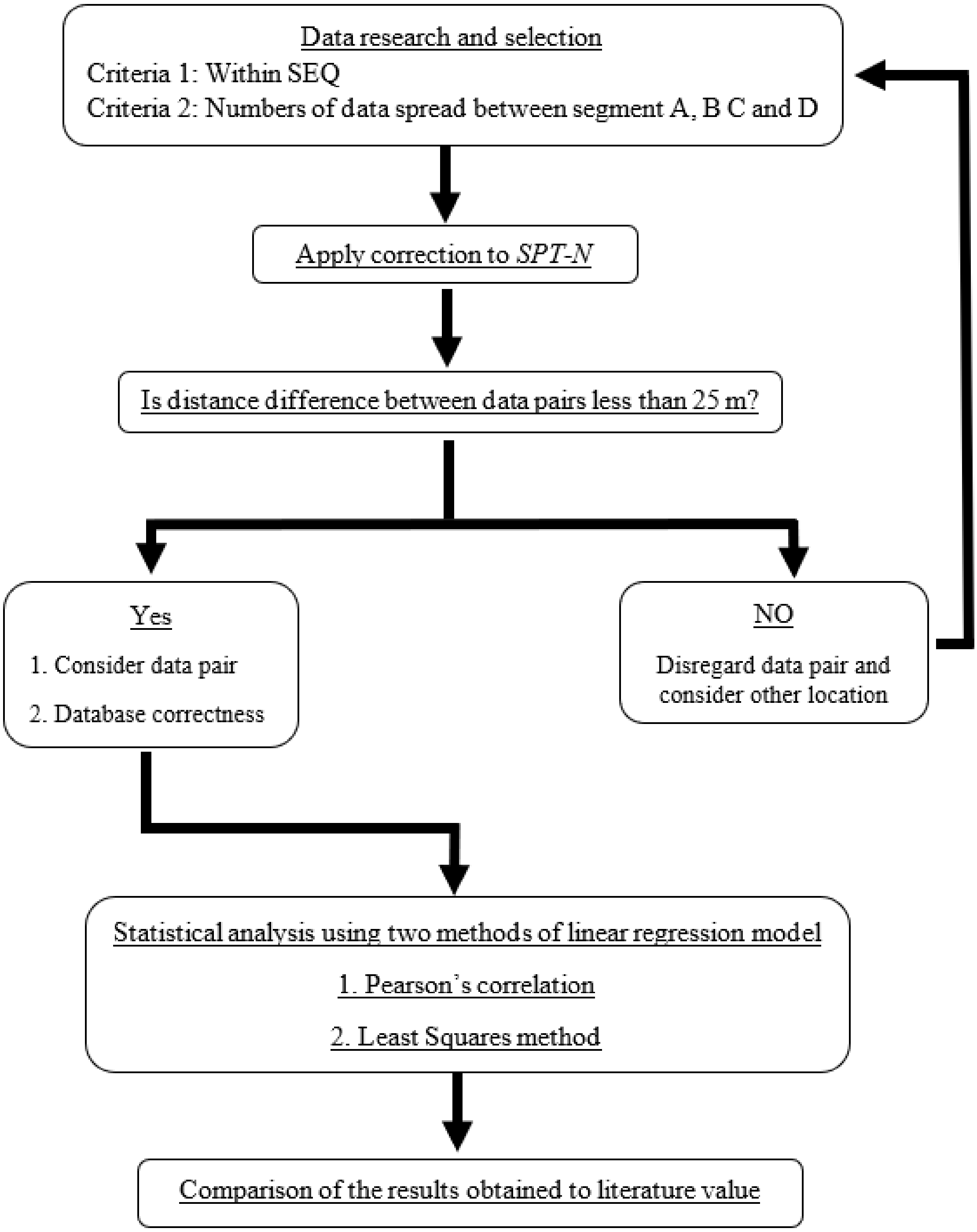

Figure 1: Process for correlation and analysis of SPT and CPT data

Sample population

Stratification of the data was done relative to the geographical location and geology of SEQ. The study also had the objective of having enough data to capture the different variability in soil formation. Consequently, the region was delineated into four segments (strata), namely:

- Segment A – north of SEQ (Noosa, Sunshine Coast and Moreton)
- Segment B – east of SEQ (Somerset, Toowoomba, and Lockyer Valley)
- Segment C – west of SEQ (Brisbane, Ipswich, and Redland)
- Segment D – south of SEQ (Scenic Rim, Logan, and Gold Coast)

Figure 2 illustrates the demarcation of the different segments.

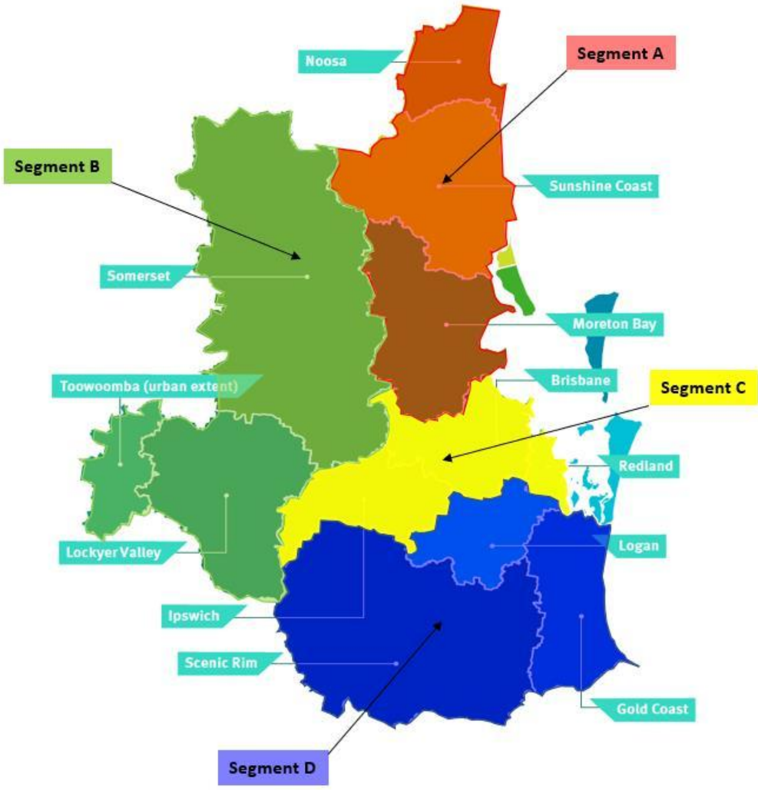

Figure 2: Segmentation and distribution of regions for data sampling

Table 2: Summary of total number of data pairs for SEQ

Segment ID	Number of data pairs (*SPT-N* and *CPT-q_c*)
Segment A	24
Segment B	Nill (1)
Segment C	245
Segment D	35
Total	304

Note: (1) No relevant CPT and SPT data was recovered from the same site in these regions. Thus, data collected was inconclusive.

Data acquisition

Both SPT and CPT data had been acquired from past geotechnical investigations (reports) and relevant desktop studies. Data were readily available on geotechnical database platforms – such as the Queensland Geotechnical Database (QGD). However, most of the SPT and CPT data was made available by the study collaborator's – namely WSP Golder Pty Ltd – under some confidentiality, that the supplied data would not be shared other than for research purposes. The paired SPT tests and CPT investigation data are summarised in **Table 2**. The different encountered material within the different stratigraphy was – SAND, Clayey SAND, Silty SAND, Sandy CLAY, Silty CLAY, Clayey SILT and CLAY.

Correction of *SPT N-Values*

The normalisation or correction of the *SPT N-value* due to field procedures was discussed earlier. However, the energy ratio values vary from one study to another and as a result of the lack of standardisation of these correlation factors, the values of these variables may vary from country to country, making it unreliable in adopting a range. In fact, the Australian Standards do not recommend any conditions for its application and thus, no information is available about local energy measurement on our rigs (ASTM, 1984).

Due to the lack of information about the rig procedures to carry out the SPT testing for each sample, this study adopted a more conservative approach – with the Energy ratio being taken as 1.0 where N_{60} would be equal to the raw SPT *N-value*. Consequently, no change was resulted as N_{60} = N.

Data screening

It is of common practice to keep the spacing between successive geotechnical investigations at least 25 m apart whenever carrying out geotechnical investigation, since the material variation is assumed constant (unless there is an area of interest for the investigation). In engineering it is often beneficial and practical to carry out simple-minded checks to validate certain data groups based on logic and common sense. Thus, the application of an engineering judgement on the SPT-CPT data pair for different materials were adopted on the basis that the SPT-CPT data pairs were:

i. either greater or smaller than the general population of the trend.
ii. uncertain data pairs between transition of two stratigraphy layer and
iii. geological formation differentiation between nearby SPT and CPT investigations.

A total number of 304 data pairs of SPT-CPT was captured from the factual reports. In fact, these data were representative of different types of materials and consequently, these data pairs were sorted out as original and filtered data, respectively as summarised in **Table 3**. It was observed that only 262 data pairs were validated for the analysis process, which represent 86% of the original data. For completeness of this paper, both the filtered and original data were displayed in the results section.

Table 3: Summary of database correctness due to engineering judgement

Soil	Original data No.	Filtered data No.	No. of data omitted
1. SAND	83	79	4
2. Clayey SAND	63	51	12
3. Silty SAND	37	30	7
4. Sandy CLAY	42	31	11
5. Silty CLAY	54	50	4
6. Clayey SILT	15	15	Nill
7. CLAY	10	6	4
Total	**304**	**262**	**42**

Statistical analysis

In statistics, a regression line is used to predict the value of (y) based on a straight line for any given value of (x) based on Equation 2. In this study, (y) was adopted as *CPT*-q_c while (x) was taken as the *SPT N-value* since q_c is the variable that we mostly like to predict using the *SPT N-value*. The application of these correlations was validated using linear regression models in this study namely, coefficient of correlation (r) and coefficient of determination (R^2).

$$y = mx + c \tag{2}$$

m is the slope of the line and c is the y-intercept

The coefficient of correlation was validated using Pearson's correlation as per Equation 3. According to Ramsey's rule of thumb (2010), **Table 4** is used:

$$r = \frac{1}{n-1} \cdot \sum_{i=1}^{n} \frac{x_i - \bar{x}}{s_x} \cdot \quad \frac{y_i - \bar{y}}{s_y} \tag{3}$$

- r is the correlation between (x) and (y).
- s_x and s_y is the standard deviations of x-values and y-values, respectively.
- n is the number of data points.
- $\bar{x}$ and $\bar{y}$ is the average of all x and y-coordinates, respectively.

Table 4: Pearson's Correlation value and interpretation

Correlation, *r*	Description and interpretation
-1	Perfect downhill (negative) linear relationship
-0.7	Strong downhill (negative) linear relationship
-0.5	Moderate downhill (negative) relationship
-0.3	Weak downhill (negative) linear relationship
0	No linear relationship
0.3	Weak uphill (positive) linear relationship
0.5	Moderate uphill (positive) relationship
0.7	Strong uphill (positive) linear relationship
1.0	Perfect uphill (positive) linear relationship

The coefficient of determination (R^2) is the square of the correlation coefficient *(r)*; thus, they are similar. R^2 would identify the percentage variation between the parameters and the range will be 0 to 1 (0% to 100%). In fact, the coefficient of determination is the percentage of the number of points that coincide with the results of the linear equation formed by the regression method. A higher percentage of R^2 indicates a better fit as more data points pass through the line and the coefficient of determination cannot be negative.

RESULTS AND DISCUSSIONS

General

The current study consisted of 262 filtered SPT-CPT data pairs for different types of cohesive and cohesionless soil across SEQ. The statistical and graphical SPT-CPT results are presented in **Figure 3** for the different soils. In fact, linear equations were developed based on the SPT-CPT correlation data output in the form of a scatter plot and linear regression analysis was carried out as summarised in **Table 5**. Statistical control has been adopted to predict the probability of occurrence and to test if the correlation used were within the expected limits – indicating if perfect, strong, moderate, weak, or no linear relationship was achieved. The arithmetic mean *n-values* (q_c / *SPT N*) were calculated for the sample population size of data captured for each soil group.

Table 5: Correlation function between SPT and CPT for all soil types

Soil Type	Sample Size	Correlation equations	*(r)*	(R^2)
1. SAND	79	$q_c = 0.36(N) + 2.58$	0.84	0.70
2. Clayey SAND	51	$q_c = 0.40(N) – 0.48$	0.72	0.52
3. Silty SAND	30	$q_c = 0.21(N) + 1.15$	0.75	0.56
4. Sandy CLAY	31	$q_c = 0.16(N) + 0.74$	0.81	0.66
5. Silty CLAY	50	$q_c = 0.20(N) + 0.18$	0.74	0.55
6. Clayey SILT	15	$q_c = 0.32(N) – 0.21$	0.89	0.80
7. CLAY	6	$q_c = 0.11(N) + 0.48$	0.69	0.48

(r = Pearson's correlation and R^2 = coefficient of determination)

Statistical Correlation Results

In general, both correlation coefficient *(r)* and the coefficient of determination (R^2) are satisfactory. In particular, the mathematical functions indicate a strong to perfect positive linear relationship (*r* = 0.69 – 0.89) and approximately an average 50% of data points coincide with the regression line (R^2 = 0.48 – 0.80) for all soil groups. All correlations show a strong to perfectly upward (uphill) linear relationship between the SPT and CPT which validates the theory against other published empirical research. This states that as *SPT-N* blow counts increase, *CPT-*q_c's would increase. However, omitting the data pair that was outside of the general sample population, greatly influenced the output of the improved correlation coefficient over that from the original database.

In the case of *SPT-N* close to zero (*N = 0),* it is practically impossible to correlate it to *CPT-*q_c's. For instance, for silty sand with a correlation equation of $q_c = 0.21(N) + 1.15$ when $N = 0$, then q_c = 1.15 MPa. If no SPT is carried out, then no tip resistance should be recorded. Consequently, no validation of correlation when $N = 0$ for all equations of the different soil groups.

The correlations could be classified only valid for the highest range of *SPT-N* used in this paper for development of the linear relationship for each material. According to Sanglerat (1972), it is proposed that the values of q_c should not exceed 20 MPa. In fact, the highest *SPT-N* recorded in sand was 45 blows per 300 mm for sand. Similarly, as a rule of thumb for the application of the equations, no correlations virtually exist or should be avoided for very high *SPT-N* (75 - 100 blows per 300 mm) for any soil groups (Akca, 2003).

The correlations found for both clayey sand and clayey silt have a negative y-intercept as the equation given as $q_c = 0.40(N) – 0.48$ and $q_c = 0.32(N) – 0.21$, respectively. Due to the regression trendline, it is not practically possible when *CPT-*q_c equals zero, as the trendline will be negative. Similarly, for validation of the linear equation for clayey sand, the *SPT-N* value should be kept to a minimum value of 2 blows per 300 mm while clayey sand should be kept to a minimum of 1 blow per 300 mm.

The filtered sample size for clayey silt and clay are 15 and 6, respectively. There are some uncertainties on those correlation due to the limited number of historical reports available. Even though a linear regression relationship has been established, it should be viewed with consideration given to the small sample size. One of the main reasons of the scarcity of data pairs for these two materials is due to fact that these materials are considered highly cohesive and SPT testing are not favourably practical.

N-Value Comparison to Published Values

The *n-value* of this study was calculated using the arithmetic average for each of the soil types. **Table 6** represents the local *n-value* (presented as SEQ data) along with the published literature for different types of materials encountered in SEQ. While some publishers suggested a range of *n-value* to be adopted for different soil groups, others had given a specific *n-value*. In fact, it might be assumed that the range scale was chosen rather than a specific value due to the conservative approach taken in interpretating different types of materials, thus provided an upper and lower bound.

Table 6: SEQ n-values comparison against Empirical values

Soil Type				*Published Literature n-values*				
	SEQ Data	***De Alencar Velloso***	***Robertson, PK et al***	***Mayerhoff***	***Franki Piles***	***Acka***	***Schmertman***	***Danziger and Velloso***
Years	***2022***	***1959***	***1986***	***1956***	***1960***	***2003***	***1970***	***1995***
Location	***AUS***	***unknown***	***Canada***	***Canada***	***unknown***	***UAE***	***USA***	***Brazil***
1. SAND	0.74	0.6 – 1.0	0.5 – 0.6	-	1.0	0.77	0.3 – 0.6	0.57
2. Clayey SAND	0.57	-	0.2	0.6	0.6	-	0.2	0.46 – 0.53
3. Silty SAND	0.39	0.2	0.3 – 0.4	0.5	0.5	0.70	0.3 – 0.4	0.5 – 0.64

It can be concluded that the results (highlighted in red) from this paper states that some of the published *n-values* (highlighted in blue) are quite consistent with the SEQ study for some soil groups, while others are not. Correspondingly, some of the values have a higher factor and others had lower. There has been extensive debate other the years, as mentioned in the literature review section, about the discrepancy of one result to the others and which one to adopt. In agreement to Robertson et al. (1983), one characteristic applicable to all published correlations is that the *n-values* ratio increases from fine (clay) to coarse (sand) grain sizes. Thus, *n-values* are a function of mean grain sizes. The discrepancy in the results between these papers results to the published literature could certainly be a combination or merely one of the following conditions:

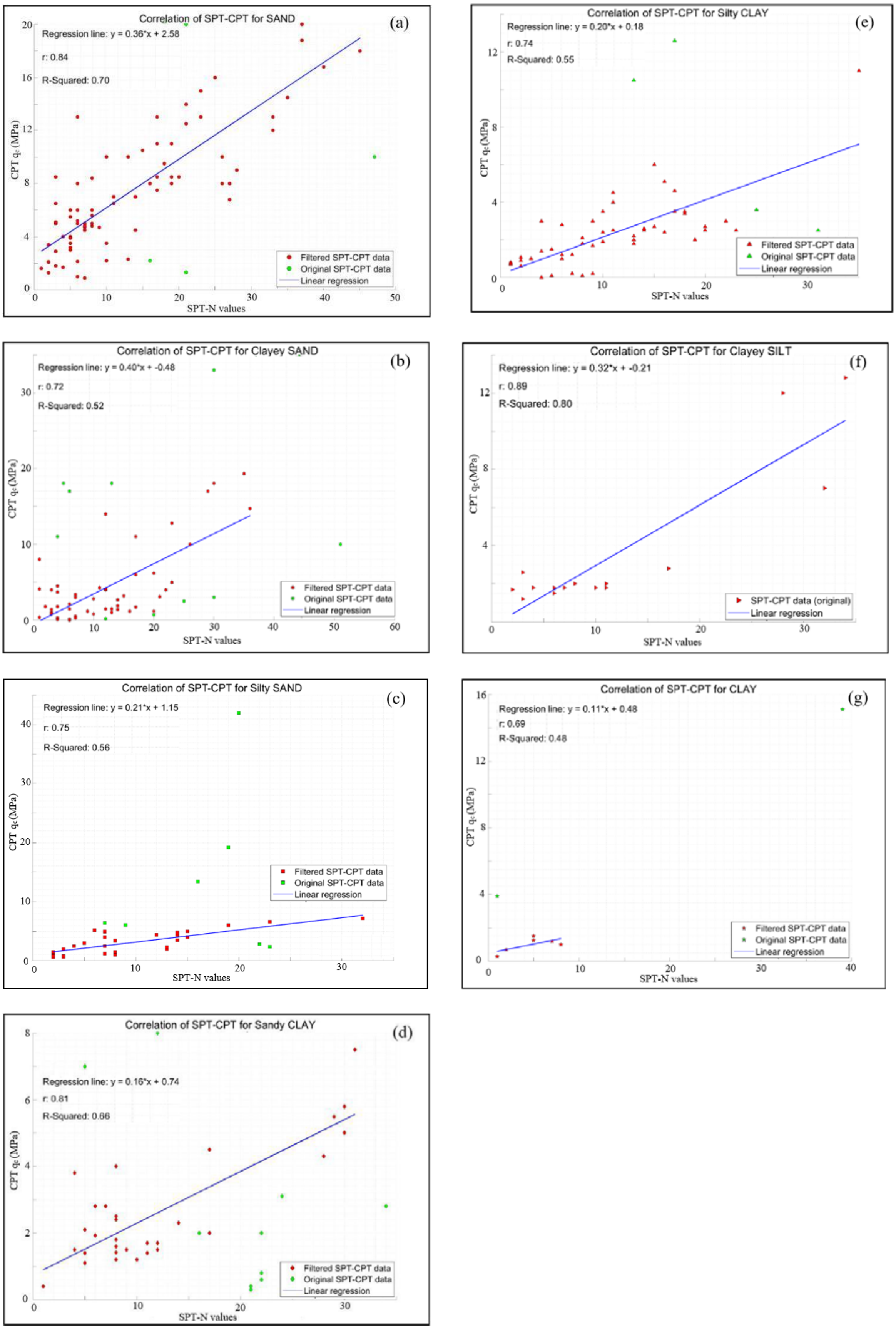

Figure 3: Relationship between SEQ SPT-CPT: (a) SAND, (b) Clayey SAND, (c) Silty SAND, (d) Sandy CLAY, (e) Silty CLAY, (f) Clayey SILT and (g) CLAY

- Correction of *SPT-N* due to field procedures

It is standard practice to correct the *SPT-N* blows to an equivalent 60% hammer energy efficiency (N_{60}) due to the equipment and methodology of carrying out the investigation. Due to the lack of information for each borehole – the types of hammers utilised, borehole diameter, sampler types and rod length – no correction to the raw *SPT-N* blows was carried out. Similarly, due to the number of different SPT rigs in Australia, it is challenging to establish an equivalent correction factor that could be applied locally. In fact, it is typical to have variation between one country and another, with respect to the equipment availability and application of its correction. Consequently, the *n-values* reported in the published literature have a wide range of variability of in-field measures with respect to *SPT-N*. In other words, it is highly plausible that part of the published work might have used corrected *SPT-N* (N_{60}) while others used the uncorrected raw *SPT-N* (Akca, 2003).

- Difference of CPT cone types

According to Kulhawy and Mayne (1990), the differences in the various types of cones lead to inconsistency in the results for same soil groups. In fact, penetrometer tests which are carried by the mechanical tip (CPTm) in sands, resulted in less tip resistance than for the electrical or piezometric tip (CPTu). CPT tests on granular or cohesionless materials (sand) will be more affected by what kind of cone is used. Based on the published literature, it could be assumed that CPT testing was conducted with several cone types without much consideration to this effect. This could explain the variation of the wide range of *n-values* correlation (0.3 -1.0) that have been obtained throughout the years, for sand.

- Screening of data pairs

Most of the previous published work does not present the raw *SPT-N* and *CPT-*q_c for their respective correlations. Instead, equations, and *n-values* are presented. Consequently, it is not cleared if the data pairs were screened based an engineering judgement or some sort of selection criteria. As a result, the arithmetic average *n-value* and correlation would certainly differ between the data pairs with and without filtering. In this study, data were screened when the y differed from the general sample populations.

- Soil classifications

SPT-N or *CPT-*q_c is frequently obtained through factual reports or raw data. In fact, most of the time, the soil is already described from the logs. In other words, the *SPT-N* is classified as such based on the descriptions provided by another person and with the assumption that the description is accurate. Therefore, there is a limitation in being one hundred percent confident that the soil types described through other published work compares to this current study and are the same.

- Statistical methodology

Modern correlation methodology relies extensively on statistical and mathematical analysis. In the last decades, there have been some concerns with respect to the numerical methodology adopted by recognised published work in relation to SPT-CPT correlations. In fact, it is not clear as to whether their respective mathematical approach in assessing if the correlation was reliable was good enough. Similarly, none, or very little indication is given for the number of samples taken from each type of soil type. Accordingly, the published study's statistical technique raises questions.

- Data pair size

The correlation of different soil types is directly a function of the sample size. Generally, the larger the sample size, the greater the level of confidence. In fact, these previous empirical correlations do not specify a sample size to verify their reliability. While most soil types in this study have a generally acceptable sample size, clayey silt's is 15 while for clay's it is 6. Due to the small sample size of the two types of material (clayey silt and clay), the correlation should be adopted with some limitations.

- Proximity of SPT an CPT data

Modern SPT-CPT correlation clearly indicates how the impact that the distance between each of the tests can influence the quality of the correlation (Akca, 2003). Due to the heterogenous characteristics of soil formation, it should be expected that the soil geology might differs from one location to another. Therefore, it is critical that the SPT and CPT test are in the same proximity. Again, it is unsure if the data from the published literature uses a proximity criterion in selection of their data pair. In this study, SPT and CPT tests were correlated only if these were within a 25 m distance.

- Geological factors

The published literature has been developed in different countries around the world – including Canada, USA, UAE, Brazil, and other undisclosed countries. The geological formation for each of these countries could be expected to vary due to the heterogenous nature of rock and soil. Past research has been conducted on quarzitic soils most often. Recent studies have suggested that a cohesionless soil type would exhibit the same morphological and physical characteristics as the parental rock. Higher *n-values* were identified for UAE due to the cementation and shelly features – calcareous particles – when compared to previous empirical correlations (Akca, 2003). As a result, regional geological subsurface features can contribute to variation in SPT-CPT correlation values. SEQ have a very complex geology including several types of residual soil occurrences composed mostly of carbonate, quartzite, rhyolitic and basaltic rocks and thus the equation developed within this study can be assumed applicable to the range of rock types.

CONCLUSIONS

This study has successfully investigated the SPT-CPT correlation for the different soil occurrence in SEQ. In fact, the two main variables – *the SPT N-value* (N) of the SPT and the cone tip resistance (q_c) of the CPT – followed a linear relationship similar to the most common empirical formula. For determining the strength of the correlation and whether it could be used as a predictor of future events, a linear regression model was created.

The typical soil groups encountered within the SEQ geological formation were – SAND, Clayey SAND, Silty SAND, Sandy CLAY, Silty CLAY, Clayey SILT and CLAY. Thus, the range of cohesive and cohesionless soils were of varying consistency and composition. In addition, no published work was formerly recorded for Clayey SILT which is presented in this study. In fact, this soil group is encountered frequently in SEQ, mostly along the dune and coastal areas. However, further work is required – in increasing the database to confidently validate the application of the correlation equations.

According to the mathematical functions, most soil groups showed a strong to positive perfect linear relationship (r = 0.69 – 0.89), and approximately 50% on average of data points coincide with the regression line (R^2 = 0.48 – 0.80) for all soil groups. This stated that the data filtration process in the methodology (database correctness due to the large distance between tests and due to engineering judgement) enhances the correlation strength. Results from this study reveal that some of the empirical published *n-values* are quite similar to the SEQ study for some soil groups, while others disagree. This hypothesis conclusively identified that there is potentially some variability between these worldwide correlations due mainly to the geological characteristics of the samples. Further, there may be other sub-factors contributing to this variance as well, such as different equipment, methods, and interpretations.

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