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Developing New Relationship between Standard Penetration, Cone Penetration Test and Sleeve Friction in Various Soil Type

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Abstract: The Standard Penetration Test (NSPT) and Cone Penetration Test (CPT) is the most implemented standard procedures in the in-situ site investigations to characterize geotechnical foundation designs and determine soil properties. The purpose of this analysis is to review some of the correlations between existing CPT and NSPT and propose new associations based on eight types of soil, namely silty sand, sand, gravelly sand, clay, sandy silt, silt, clayey sand, and sandy clay by considering suitability geotechnical design and its potential against soil liquefaction by using a phased statistical approach. The statistical analysis called a statistical gradation approach is applied using Linear Regression to produce new equations between NSPT and CPT and Power Regression for further comparisons between NSPT and sleeve friction (fs). The purpose of this paper is to develop a robust correlation between NSPT with Qc and fs for five soil types, namely Gravelly Sand, Sand, Sandy Silt, Silty Sand, Clay-based on SPT data, CPT, and sieve test. The correlation between NSPT to Qc and fs shows that the RMSE value is lower than the value referenced from the literature.

Keywords: Standard Penetration Test, Cone Penetration Test, sleeve friction, gradation approach, RMSE.

发展各种土壤类型的标准贯入度，圆锥贯入度试验和套筒摩擦之间的新关系

摘要：标准渗透试验和锥孔渗透试验是原位现场调查中最常用的标准程序，用于表征岩土基础设计并确定土壤特性。该分析的目的是回顾现有圆锥渗透测试和标准渗透测试之间的一些相关性，并根据粉土，砂，砾石，粘土，沙质粉砂，粉砂，黏土砂和砂质土的八种类型的土壤提出新的关联。通过采用分阶段统计方法来考虑岩土工程设计的适宜性及其对土壤液化的潜力。使用线性回归的统计分析称为统计渐变方法，可以在标准渗透测试和圆锥渗透测试和功率回归之间产生新的方程式，以进一步比较标准渗透测试和套筒摩擦。本文的目的是基于标准渗透测试数据，圆锥渗透测试和筛分试验，开发砾石，砂，沙质粉砂，粉质砂，粘土等五种土壤类型的标准渗透测试与锥头阻力和套筒摩擦之间的稳健相关性。标准渗透测试与锥头阻力和套筒摩擦之间的相关性表明，根均方误差值低于文献参考的值。

关键词：标准渗透测试，圆锥渗透测试，套筒摩擦，渐进方法，RMSE。

1. Introduction

Standard Penetration Test – NSPT and Cone Penetration Test- CPT is the most standard geotechnical procedure currently implemented in the in-situ site investigations to characterize geotechnical foundation designs and determine soil properties. SPT is used to obtain continuous soil profiles for depth, soil properties, identification of soil sequences and their spread laterally, and see unsustainable soil profiles caused by liquefaction and landslides [1], [2]. SPT is widely applied to determine soil parameters using correlation [3]. SPT reflects the effects of historical

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stress and strain, soil fabric, effective horizontal stress, and also a combination of relative and vertical pressures. NSPT offers confirmed the in-situ soil characteristics under stress conditions at the time of the earthquake, challenging to simulate under laboratory tests and predict natural liquefaction soil for future earthquakes. Besides, undisturbed samples pushed into tubes are mostly different from their natural conditions in the area of original stress at a certain depth, which must be considered. CPT is very reliable for conducting site investigations and conducting geotechnical designs. CPT testing is useful for describing soil stratigraphy and recording fast and continuous parameters such as cone end resistance (Qc) and sleeve friction (fs) [1]. CPT's benefits are repetition, continuous measurement, and ease to do (Robertson et al., 1983a). The CPT investigation provides information about bearing capacity, pore water pressure, and sleeve friction [4], [1], [5].

Geotechnical investigation in construction work is carried out by combining NSPTand CPT data, where penetration data serves as an initial design based on soil parameters. In contrast, the final construction or design quality controls are based on static conus penetration tests [6] and [7]. The Standard Penetration Test (SPT) has many shortcomings and influencing factors affecting the results, including the application misinterpretation, undisturbed sample pushed into the tube essentially different from its natural conditions in the original stress area a certain depth, which must note 3. SPT is relatively more expensive because it requires sample data processing [8], [9]. For the effective use of available field data, it is crucial to correlate the CPT and the SPT so that if only the NSPT data is available. At the same time, the engineer understands the CPT data interpretation, then converting NSPT data is the right solution. The CPT approach as a form of field penetration testing with a sonder instrument is used to obtain parameters of soil penetration resistance in the field, including cone resistance (Qc) for measure end bearing resistance penetration and sleeve friction for measuring site friction (fs) which can be used for the interpretation of soil layers. Sleeve friction helps to assess the friction of the horizon being penetrated. The purpose of this paper is to assess some of the correlations between existing CPT and SPT and propose a robust formulation based on five types of soil, Gravelly Sand, Sand, Sandy Silt, Silty Sand, Clay, by considering the suitable geotechnical design and its potential against soil liquefaction. This paper is a novel determination that is referred to as the Statistical Gradation Approach (SGA).

2. Methodology

The SGA is an iterative operation that builds mathematical models from measured data. It covers the cleaning of duplicate data sets, removing outliers by adjusting the database, filtering data with the equal width distance bin, and processing filtered data with the appropriate regression method. Comparisons are then made with previously developed relationships from other studies to evaluate the results of this work.

3. Data Collection

Geologically, Bantul Regency is located on a plain, namely Terban Bantul, a Quaternary Terban Bantul. The soil has a lithological composition dominated by unconsolidated sand material that is quaternary, composed of the Mount Merapi and Alluvium Volcanoes [10]. The deposit is a pyroclastic collapse material, spread over 85% of the Bantul region, and alluvium material is covered in a limited manner in the Progo River, Opak-Oyo River South Coast. SPT and CPT data located in the same location have almost no significant distance between these two types of investigations (see Figures 1 and 2).

SPT data are taken to analyze soil carrying capacity, using a split tube dropped from a height of 75 cm with a weight of 63.5 kg hammer to push a split tube to a depth of 45 cm. The evaluation of NSPT does not apply in the first 15 cm because of an initial position, and the second and third 15 cm shows the importance of N (ASTM D1586-99,2003). Every split tube reaches a depth of 15 cm calculation is carried out with a blow count not exceeding 50 times, every 15 cm. Calculation of SPT is carried out at 1.5 m intervals to a maximum depth of 20 m. The recording process starts when the CPT reaches 20 cm intervals to a depth of 20 m. SPT data is recorded at each 45 cm depth interval while the CPT data is recorded at an interval depth of 20 cm so that the NSPT is adjusted according to emission at each 20 cm depth interval to equal the CPT depth [11].

Statistical analysis is needed before the regression process starts. It is crucial to anticipate data like outliers, namely information with very extreme values with other observational data in a data set that will result in a final analysis error or miss interpretation. This status can occur because of measurement errors or sampling of damaged data and data. For this reason, the implementation of a gradual statistical analysis is needed to eliminate the outlier data before the regression analysis is carried out.

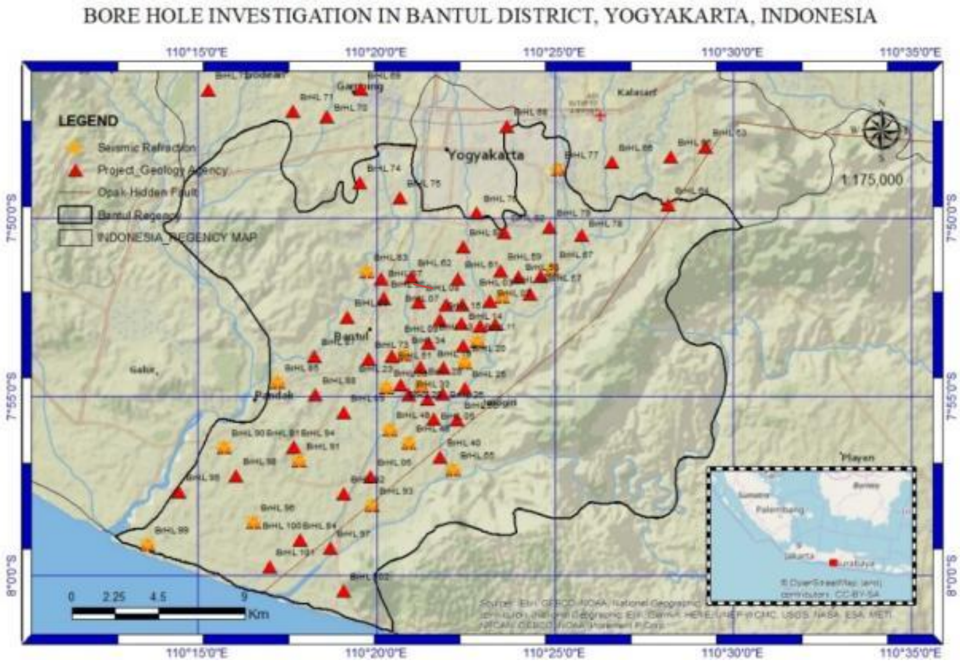

Fig. 1 The boreholes, NSPT, CPT, and seismic measurements in the vicinity of the study area

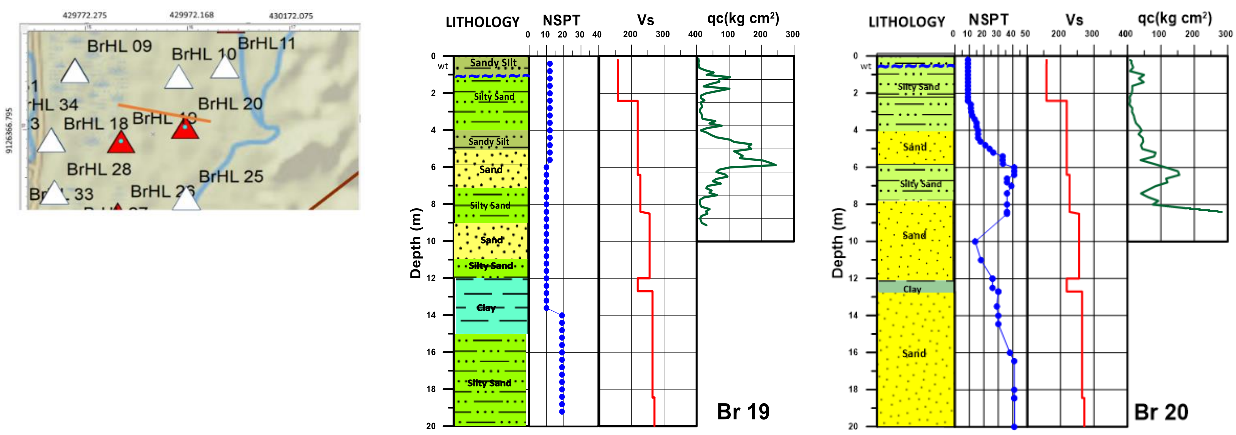

Fig. 2 The position of the boreholes, NSPT, CPT, and seismic measurements between borehole 19 and borehole 20 representing one shear wave velocity

4. Data Processing and Analysis

The statistical analysis with a progressive approach using Power Regression is applied to produce new equations between NSPT and CPT and Linear Regression for further comparisons between NSPT and sleeve friction (fs). The regression concept determines the relationship between the parameter of a function that causes the service to best suit a series of data observations. Power regression is used by looking at typical non-linear data distributions. The choice of regression type depends on the regression coefficient produced; the closer to 1, the more accurate the model proposed when used for prediction. This study's data variables are penetration test data and cone tip (CPT) test data. Field data is processed using a Statistical Gradation Approach.

4.1. Cleaning Duplicate Data Sets

Cleaning duplicate data will involve removing those pairs from the data set with the same values, leaving only one pair. Compiling data from various sources, and therefore with potentially varying degrees of reliability, can affect the accuracy of the analysis compared to using only one data source. The duplicate data removal process considers two factors that can identify the outliers, such as data errors due to human error or mal equipment functions (causing significant problems with the reliability and validity of the results). Another reason for removing data is duplicate data requires a longer time to process.

4.2. Removing Outliers by Adjusting the Database

The second step is adjusting the database to make standardized data before the regression process. This process is the first step in eliminating outliers. Outliers are the observational data with an abnormal distance to the other data in a population [11]. This process is done by using a Z-score or standard score approach [12]. The Z-score's underlying assumption is to explain the standard deviation of the average amount of data. Soil class data is then standardized to know the distance between soil data and the mean in the unit standard deviation. The approach, also known as the Standard normal distribution (Z-score), describes the relationship between the mean population and the standard data deviation population. Z-score can be negative, which means that the data has a standard deviation below the mean, and Zscore is positive, which means the standard deviation is higher than the mean. The Z score calculates how much the standard deviation is from soil distribution data. The mathematical equation used in the analysis of the Z score is

$$Z_{sc} = x - \mu / \sigma \tag{1}$$

where Zsc is Zscore, x is the observation data, μ is the data mean, and σ is the standard deviation. Detecting the presence of outliers can be seen in the calculation of normal standard distribution if the z is greater than 3 or the z is smaller than -3 [11]. There are also those who use the maximum 2.5 and minimum -2.5 as the limit for determining outliers [13].

4.3. Filtering Data with Equal Width Distance Binning Approach

The third step is to refine filtered data. Adjustment of the detected data still contains outliers, and the data must discard. This process removes data that has a position far from neighboring data by using the Equal Width Distance binning approach. At this step, the aim is to obtain smooth evidence by considering compatibility with adjacent data. The data then classified into three-bin classes: low, middle, and higher grades [14]. The purpose of this classification is to eliminate the effect of outliers, where data can have abnormal distances from other values in a random population sample. Processing filtering data includes define; the boundary limit condition, the range classes bin, the processing filtering data.

4.3.1. Define the Boundary Limit Condition of Bin Class

Applied three-class bins are a simplification process in evaluating statistical data. Partition into three class bins assuming the class bin 1 as an assessment of the lowest grade data that is still acceptable and the class bin 3 limit as the highest-grade data value as the controller is the class bin 2, preserved as an average value of the data. In other words, the first- and third-class bin are the value of the data distribution limit that exceeds the average value that is still acceptable.

4.3.2. Define the Range Class Bin

This study determines the range of data values used as boundary values between data levels by defining the difference between the maximum NSPT and CPT against the minimum NSPT and CPT; then, the data range is divided by the number of the class bin. For bin one SPT and CPT classes, data taken by adding the minimum value of bin one level in the data range with one-third of the data range. For class bin two, it is derived from the number of class bin one plus one-third of the data range and class bin three. It can be seen through Eq. (2) – Eq. (6). The path of the formulation to determine can be followed as:

$$X_{class\ bin\ 1} = X_{min} + X_{range} \tag{2}$$

$$X_{class\ bin\ 2} = X_{class\ bin\ 1} + X_{range} \tag{3}$$

$$X_{class\ bin\ 3} = X_{class\ bin\ 2} + X_{range} \tag{4}$$

where X_{range} is Vs or NSPT data range and can be obtained from:

$$X_{range} = \frac{X_{max} - X_{min}}{3} \tag{5}$$

where $X_{class\ bin\ 1}$, $X_{class\ bin\ 2}$, $X_{class\ bin\ 2}$ are the class bin series for NSPT and CPT, X_{max} and X_{min} are maximum and minimum data series (NSPT and CPT), the value of 3 is a number of X class bin.

4.3.3. Filtering Data

The filtering process places the data according to the data bin class value. Deleting bin CPT class data can be done by removing CPT data positioned above the CPT class bin one.

This process is also applied to class CPT bin two and three. CPT will use in regression analysis must be smaller than the boundary class bin CPT. The bin class system is also applied to delete SPT data, which is considered an outlier using the same procedure. The process of removing outlier data will also apply to eight soil types, and it can follow in Eq. (6):

$$X_{data} = X_i - X_{class\ bin\ 1};\quad if\ X_{data} \le 0\ insert\ or\ X_{data} \ge 0\ delete \tag{6}$$

where X_{data} is data series will be used in the power regression process, X_i standardized data from the previous step. The X_{data} is positive they will be deleted; otherwise, they will be used in both linear regression and power regression.

4.4. Processing Linear and Power Regression

The statistical analysis is applied using Linear Regression to produce new equations between NSPT and CPT and Power Regression for further comparisons between NSPT and sleeve friction (fs).

5. Proposing a New Function of NSPT–CPT and Sleeve Friction (Fs) – CPT

Many previous researchers emphasized the importance of the correlation between SPT and CPT; this shows that the need for a positive relationship in further CPT data can be used in a design approach based on SPT. The type of hammer influences the NSPT because it will be affected by energy travel transferred through the stem. During SPT investigation, the energy delivered to the rod can vary from 30 % - 80 % of the theoretical maximum. On the other hand, CPT is influenced by the type of penetrometer type and the procedure for pressing cones into the soil [15]. Many Qc/N ratios are determined by the mean grain size [16], hammer type SPT, and soil density make the Qc/N change. For certain soil types, the comparison between NSPT and CPT depends on several factors, including void ration, effective overburden pressure, shape and distribution of grain size, groundwater pressure, and soil structure. However, it is not easy to quantify it with penetration test data.

The correlation between CPT and SPT proposed by Robertson, 1983 is then upgraded by considering discontinuity values [17]. Other relationships developed using the grain size approaches D50 [14] show that D50 will increase the Xp assuming that the amount of fines content is a proper parameter for determining Xp [16] and [18]. CPT and NSPT correlations for soil sand types in Florida showed that the NSPT and Qc relationships produced better relationships than fs and NSPT [19]. Empirical equations for SPT-CPT and dynamic probing light (DPL)-CPT correlations for sandy soils have been proposed. The use of the arithmetic average method and linear regression is used to show the close relationship between several types of soil such as Silty Sand, Sandy, Silt Clay, and Lean Clay with the results of the investigation of the good agreement for fine grants while showing a little variation for coarse-grained soils [7]. The correlation between SPT and CPT produces the equation Xp = Qc/N = 0.4. The grain size factor also affects the Xp. The larger the grain size, the higher the Xp produced. The study shows the correlation between NSPTs and Qc is applied to 5 types of soil: Silty Sand, Sand, Gravelly Sand, Sandy Silt, and Clay. The study is conducted using SPT and CPT field data. It is supported by laboratory analysis of filter tests to obtain the optimal value of the soil's size that passes on a mesh scale of 200. The four soil types, namely, Clayey Sand, Silt, and Sandy Clay, were not applied to this correlation, taking into account the absence of CPT data and grain size analysis (see Fig. 3). Summary of types of lithology that are spread in the Bantul area, Yogyakarta Province.

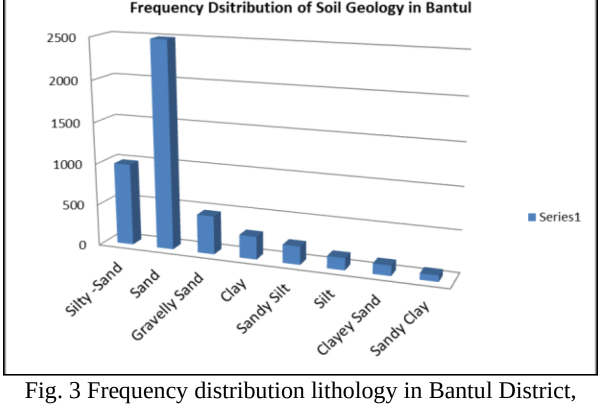

Fig. 3 Frequency distribution lithology in Bantul District, Yogyakarta Province

The type of sandy soil characterized by an average grain size of 20.64%, passing the 200 (μm) sieve test found at the study site represents a particle size with low gradation and a unique flow pattern, making it susceptible to liquefaction. Sandy soil has excellent characteristic drainage, good shear stress, and low compression levels. The correlation between the NSPT and Cone Tip Penetration parameters uses 152 pairs of data from 29 observation points with a range of NSPTs 4 - 40 and a Qc between 0.35 - 24.5 MPa. The correlation produces a strong relationship between Qc and NSPT with a correlation coefficient of 0.756 (Figure 4a).

Gravelly sand is characterized by grain size passing the average of 22.02% using a 200 (μm) sieve filter size. The study used nine field data for various depths, combined with laboratory analysis in a filter test resulting in 51 data pairs Qc and NSPT, which described the NSPT distribution as the lowest 4 and the highest 33. While the Qc distribution with the lowest is 0.07 and the highest 19.11, the proposed equation (Figure 4b) produces a strong correlation with the correlation coefficient (R) of 0.758. For Silty Sand, the proposed equation is generated from field data of 14 observation points with 66 pairs of Qc and NSPT data at various depth ranges. The sieve test results showed that the grain size characterizes the Silty Sand passed an average of 36.3% using a sizing of 200 (μm) sieves. The built coefficient produces 0.679, while the Qc distribution with the lowest is 0.86 and the highest 24.157.

For the Sandy Silt, the data used are from 5 observation points with 22 pairs of Qc and NSPT (Figure 4d). The distribution of the NSPT for the lowest is 5, and the highest is 50, while for Qc, the lowest is 0.27 and the highest is 5.82. The correlation results show a coefficient of 0.734. The Clay Correlation is developed using 18 pairs of data from 7 locations. The correlation is produced with an average composition of granules size passing the 200 mesh by 36.43%. The NSPT data range with the lowest of 15 and the highest of 34, while the lowest Qc of 4.69 and the highest of 14.34 MPa produces a correlation coefficient (R) 0. 865 (Fig. 4).

The statistical approach, the Z score [20] and [21], is also implemented to produce a correlation between NSPT and sleeve friction (fs) as standardized data formulations. The process is needed as data preparation before the linear regression process is carried out to form an equation that describes the correlation between NSPT and fs. The steps are taken to dispose of outliers in the NSPT, and fs correlations are used. The same approach is applied to the NSPT and Qc correlation analysis so that the correlation results can be described optimally. In detail, it can refer to section 3, Data Processing and Analysis. Modeling using a linear regression statistical approach is used to obtain a correlation between two variables. The modeling consists of independent variables (x) and dependent variables (y), explained in the general form of the equation as follows:

$$y = ax + b + ei \quad (7)$$

where *y* is the dependent variable, *a* is an independent variable, *b* is intercepted, and *ei* is the residual representing the deviation of the observation value and the Y value's predicted value. The correlation between SPT and CPT only uses the *y* variable and *ax* [22], [23], and [24]. For that format, the coefficients that will be proposed which explain the relationship between NSPT and CPT are as follows:

$$Xp = \frac{Qc}{N} \quad (8)$$

where Qc is of the Cone Resistance test while N is the NSPT. The CPT and NSPT equations are proposed using a mathematical form approach based on Median soil and fines content [16] and [22].

The publication of the equation between NSPT and CPT submitted by previous researchers uses several different approaches. Some researchers used mechanical cones with NSPT that are not corrected, but some use an electrical cone penetration test approach with a combination of NSPT corrected for hammer efficiency. Previous researchers' statistical method also looks still vague. Hence the potential for an outlier is biased. The combination of gradual statistics proposed in the paper is essential to be implemented.

Figure 5a – b shows the relationship between NSPT and fs, indicating a positive trend where the greater NSPT, the greater the fs produced. Meaningly, the rougher the grain size found in each penetration activity, the greater the penetration obtained. The sleeve friction shows that the distribution of sandy soil types is relatively homogenous. The correlation coefficient produced is 0.648, which shows a reasonably good correlation between NSPT and fs (Figure 5a), with the lowest NSPT 1 and the highest is 19.8 while the lowest of fs is 0.76775 and the highest is 188.16. For Gravelly Sand, the distribution pattern spread with the lowest NSPT limit is 3, and the highest is 33, while the lowest fs is 22.5718 and the highest is 225,694 (Figure 5b). The resulting correlation coefficient (R) is 0.77084. Silty sand has the lowest limit of NSPT 3 and the highest 35, while the fs distribution is 23.52, and the highest of 76,775 produces a correlation coefficient (R) of 0.776 (Figure 5c). The correlation is relatively diffuse but shows a uniform pattern with the more considerable NSPT, contributing to the more excellent tip resistance value.

The overall association of the 5 soil types proposed in this research shows the correlation between NSPT between CPT and fs has a positive trend, and those relationships can be seen in Table 1 and Table 2 as follow:

Table 1 Proposed correlation for NSPT and Qc

No.	Soil Type	Correlation Equation	Coefficient Corr. (R)
1	Gravelly Sand	Qc = 0.4602 N – 0.295	0.759
2	Sand	Qc = 0.4037 N + 0.4879	0.756
3	Silty Sand	Qc = 0.7201 N - 2.0387	0.679
4	Sandy Silt	Qc = 0.2376 N – 0.5761	0.734
5	Clay	Qc = 0.2994 N + 2.4232	0.863

Table 2 Proposed correlation for NSPT and sleeve friction (fs)

No.	Soil Type	Correlation Equation	Coefficient Corr. (R)
1	Gravelly Sand	fs = 4.9064 N +15.642	0.771
2	Sand	fs = 6.7098 N + 22.797	0.648
3	Silty Sand	fs = 1.7701 N + 23.274	0.776
4	Sandy Silt	fs = 0.2985 N + 20.192	0.858
5	Clay	fs = 1.4622 N + 62.345	0.904

Based on the equation of the regression results between NSPT to Qc, a pattern of comparison of the Qc/N gets smaller with the increasing importance of fines content. The coefficient correlation also has a linear relationship between NSPT and Qc which tends to be higher than Gravelly Sand to Clay (Table 3). The a is due to the uniform and homogeneous nature of the soil under investigation. NSPT correlation to Vs. Shows a high fs distribution for Gravel and sand; the homogeneity of sand soil is dominant as a factor contributing significantly to high fs (Figures 5a and 5b). The correlation coefficient also shows a significant relationship. Coefficient values generally show that Gravelly Sand to Clay shows a pattern that tends to rise. The higher the fines content indicates, the greater the correlation coefficient.

6. Comparison and Validation

The research's final stage of developing the new formulation is to conduct a comparative study of several formulations that previous researchers have proposed. The aim is to validate the proposed equation and make the confidence that the formulation results better reflect the optimal correlation between NSPT and CPT. The RMSE approach perceives the smallest error factor from the equation assumed due to the calculation approaching the field investigation data. RMSE close to zero indicates that the proposed correlation is valid. Overall, it can be seen in Table 3 for the NSPT correlation against CPT and Table 3 for the NSPT correlation to the following sleeve friction (fs). Table 5 shows that the equation proposed to explain the relationship between NSPT and fs produces the smallest error factor. It can be assumed that the better the soil grain fragmentation will reflect, the smaller the error factor generated.

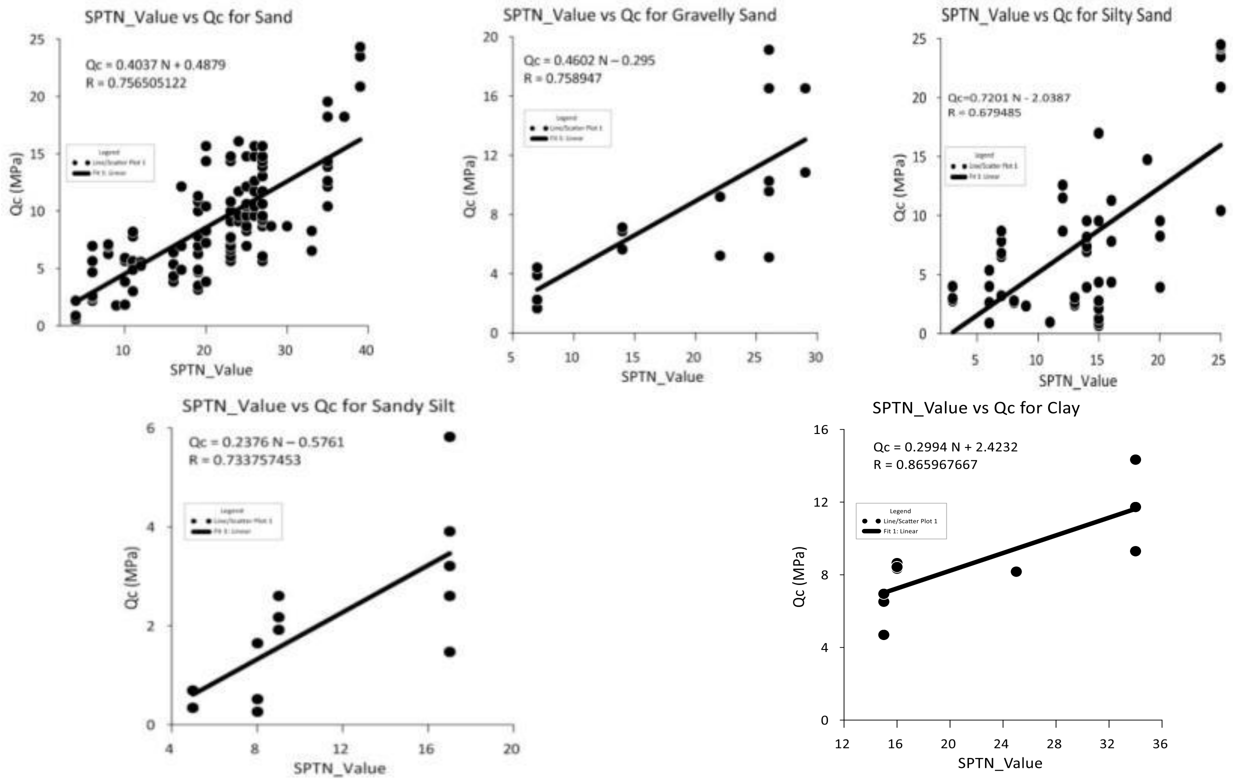

Fig. 4 Correlation between NSPT and Qc: a) sandy soil, b) gravelly sand, c) silty sand, d) sandy silt, e) clay soil

Table 3 The RMSE that results from the equations proposed against the existing equation for sand, gravelly sand, silty sand, sandy silt, and clay for NSPT vs. Qc

No	Formula	RMSE
	Formulation for Silty Sand	
1	This work (proposed)	4.67
2	[25]	6.09
3	[26]	7.09
4	[27]	63.84
5	[5]	5.51
6	[19]	7.99
	Proposed for Gravelly Sand	
1	This work (proposed)	4.45
2	[28]	6.21
	Formulation for Sand	
1	This work (proposed)	58.41
2	[27]	86.03
3	[22]	88.76
4	[29]	87.31
5	[19]	95.82
6	[21]	95.82
	Formulation for Sandy Silt	
1	This work (proposed)	1.08
2	[30]	2.18
3	[29]	3.89
4	[19]	0.77
	Formulation for Clay	
1	This work (proposed)	2.68
2	[30]	2.06
3	[31]	23.09
4	[27]	57.076
5	[5]	2.06

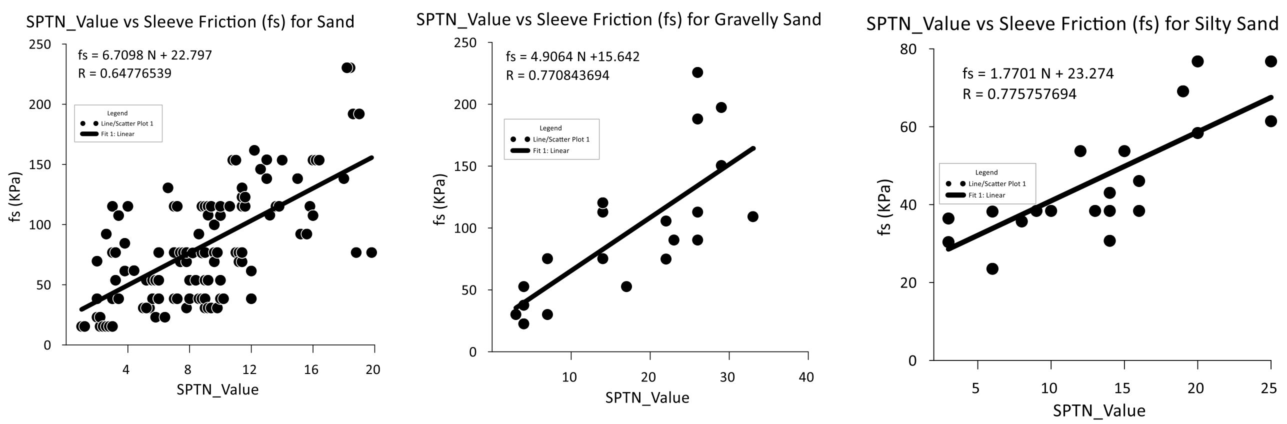

Fig. 5 Correlation between NSPT and sleeve friction (fs): a) sandy soil, b) gravelly sand, c) silty sand, d) sandy silt, and e) clay soil

Based on the results of this comparison, the error obtained from the proposed equation has an error factor with the smallest amount compared to the equation proposed by previous researchers. This judgment shows that a new model is close to the variation in its observations. Otherwise, it will be slightly different for clay, where the proposed equation has a slightly higher error value than the equation proposed by De Alencar Velloso and Lingwanda [5]. Interesting things related to the RMSE for the type of sandy soil. Table 4 shows that sand soil has a more significant error factor than clay because of the assumption that the influence of the amount of the shear-type of sand soil on the type of clay has a finer particle size. The accuracy of the new equation proposed to predict the fs of the data collected is also compared with the previous equation suggested using the RMSE approach. The formula proposed with RMSE 3,123 for sand and 2,396 for clay showed better performance in predicting the fs than other equations (Table 4).

Table 4 The RMSE that results from the equations proposed against the existing equation for sand and clay for NSPT vs. sleeve fraction (fs) only for sand and clay

No	Formula	RMSE
	Formulation for Sand	
1	This work (proposed)	3.12
2	[19]	4.35
	Formulation for Clay	
1	This work (proposed)	2.39
2	[32]	3.71
3	[33]	80.29

7. Conclusion

The benefits of implementing investigations with the CPT method are identifying soil stratigraphy and identifying soil types. The availability of SPT and CPT data is a significant thing in the geotechnical investigation; consequently, the two results of the survey will complement each other. A stepwise statistical approach for identifying outliner potentials will result in the bias of the regression results being an alternative approach that can be used to find correlations between NSPT and CPT and fs. The combination of geotechnical data used in the form of NSPT data, Cone Type Resistance, and laboratory analysis of sieve test are used to explain NSPT Correlation to both Qc and fs, which showed a definite linear pattern, which means an increase in NSPT increased Qc and fs. The correlation formed between Qc/N generally indicates that the higher the Fines Content, the smaller the Qc/N ratio indicates that the more uniform the grain size, the lower the difference between SPT and CPT. The correlation coefficient generally shows that the more consistent the grain size, the higher the correlation coefficient indicates that the higher the Fines Content will show the better the correlation relationship. Overall, the correlation between NSPT and Qc shows that the type of Sand soil produces a correlation coefficient of 0.75651. The association between fs and NSPT shows a positive linear relationship. The kind of sand soil with exceptionally high content shows an upper sleeve fraction, which will result in a high intercept value. That proves that the higher the fines content, the more significant the amount of fs.

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