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Development and Calibration of Empirical and Statistical Models for SPT-N Prediction in Fine Grained Soils

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Abstract

This study aims to develop and calibrate predictive models for the Standard Penetration Test number (N-SPT) in cohesive soils with a Liquid Limit between 20% and 60%. The objectives were to evaluate and compare empirical estimations based on the Consistency Index (CI) against statistical models derived from Multiple Linear Regression (MLR). Methods involved the analysis of a comprehensive dataset containing 469 samples obtained from the Thailand-China High-Speed Railway project and established literature, utilizing soil index properties (Liquid Limit (LL), Plastic Limit (PL), and water content (w_n)) alongside unit weight (γ) as independent variables. Findings demonstrate that the MLR model provides significantly higher predictive reliability with a coefficient of determination (R^2) of 0.982, compared to the empirical method (R^2 = 0.667). To enhance practical application, both models were calibrated using a 90% confidence level modification factor. Novelty/Improvement: This research identifies unit weight as a critical parameter that, when integrated with index properties, substantially improves the accuracy of N-SPT estimations. The resulting framework provides geotechnical engineers with a validated, high-precision tool for soil strength estimation, effectively accelerating soil investigation processes while maintaining high reliability in design parameters.

Keywords: Standard Penetration Number; Index Properties; Soil Investigations; Empirical Method; Multiple Regression Analysis.

1. Introduction

The standard penetration number (N_{SPT}) is the value obtained from Standard Penetration Test (SPT) and defines whether the cohesive soil is hard or soft soil and whether the soil is dense or loose. This N_{SPT} is a significant value in the field of geotechnical engineering and can be transformed to soil strength parameters using the empirical relationships required for soil foundation design and soil engineering property test such as the correlation between standard penetration numbers (N_{60}) and a number of parameters such as friction angle (ϕ) [1-2], shear strength [2-4], Cone Penetration Test (CPT) [5-7], resistance to Dynamic Cone Penetration Test (DCPT) [8-9], soil bearing capacity [10], Shear Modulus [11], Pressure meter test (PMT) [12-13], and light weight penetration (N_{KPT}) [14].

In the large-scale construction (e.g. roadwork or railway) requires a number of boring along the construction site so it is quite difficult to collect the data throughout the depth of each boring pit. To make the drilling process faster, instead

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of testing every 1.0-1.5 meters a standard penetration test is employed when the soil layer changes. Accordingly, the standard penetration number at a particular depth is estimated without testing the basic parameters, the result is quite accurate and reliable. However, a critical review of existing literature reveals a significant gap. Most traditional models rely solely on consistency limits (Liquid Limit, Plastic Limit) and neglect the influence of in-situ unit weight (γ), which is a key factor governing the structural behavior and overburden stress of cohesive soils. Recent studies in 2025 have addressed similar complexities using advanced data-driven approaches. For instance, Iskandar et al. [15] utilized big data to correlate SPT with shear parameters for soft clays, while Tran et al. [16] applied machine learning techniques to enhance cohesive soil classification accuracy. Chate & Bhamare [17] demonstrated the efficacy of deep learning in classifying soil types based on image texture features. Furthermore, Almarzooqi et al. [18] benchmarked various machine learning models for predicting dynamic soil properties, highlighting the superior performance of regression-based algorithms. Shin et al. [19] provided a comprehensive review on integrating machine learning with spectral data to estimate soil properties efficiently. Despite these advancements, a simplified predictive model specifically calibrated for the fine-grained soil deposits of the Thailand-China High-Speed Railway—integrating unit weight with index properties—remains unavailable.

To address this gap and establish the study's novelty, this research develops a robust predictive framework that distinguishes itself from existing empirical correlations by explicitly integrating unit weight (γ) as a core variable. Unlike traditional methods that depend solely on consistency limits, the inclusion of unit weight allows the model to capture the effects of in-situ density and overburden stress, which are physically fundamental to soil strength. This study utilizes a comprehensive dataset from the Thailand-China High-Speed Railway project to calibrate this relationship specifically for cohesive soils with a Liquid Limit of 20–60%. By employing Multiple Linear Regression (MLR), the proposed approach aims to provide a statistically superior tool compared to conventional index-based methods, ensuring higher reliability for geotechnical investigations in this specific geological region.

The outcome of this study should provide a clearer insight toward the basic parameters that control the soil strength property, and types of cohesive soil. It was able to estimate the standard penetration number from the parameters obtained from the disturbed samples collected from the boring pits. In addition, the relationships obtained in this study could be used for the estimation of strength parameters, shear strength, and settlements in different forms of soil layers.

2. Research Methodology

2.1. Soil Boring

All data sets used in this study were taken from the boring logs on the construction site of the Thailand-China High Speed Railway Project (Phase 2) in the northeast of Thailand stretching from Nakhon Ratchasima Province to Nong Khai Province passing Khon Kaen Province and Udon Thani Province covering a total distance of 355 Kilometers from Sta. 253+030 to Sta. 488+222 with 296 boring pits as illustrated in Figure 1.

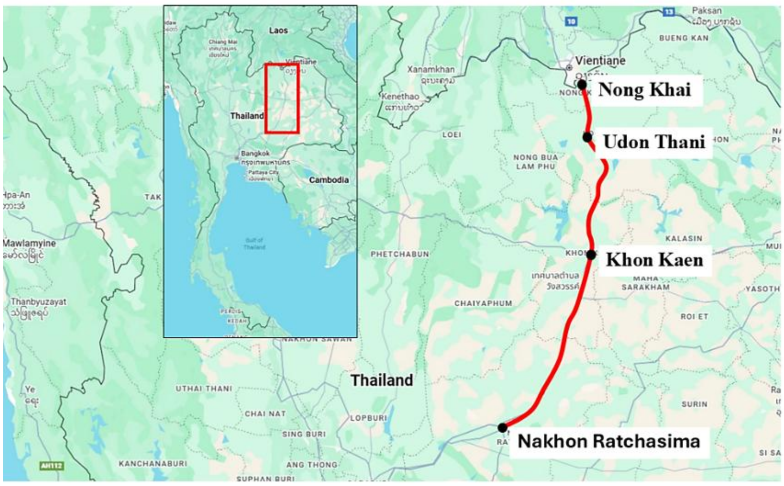

Figure 1. Location of the study area for the Thailand-China High-Speed Railway Project (Phase 2). The map illustrates the alignment stretching 355 km from Nakhon Ratchasima to Nong Khai, covering major stations in Northeast Thailand. The inset map shows the project location relative to Thailand [20].

2.1.1. Standard Penetration Test

Standard Penetration Test (SPT) is a field test based on the Railway Engineering Geology (TB10018-2018) equivalent to the ASTM D 1586 in which, the standard penetration test is performed during the boring process. The SPT value is then used for the spot where the penetration was done with split spoon.

The test started with drilling through the first 15 centimeters of the soil layer. After this, the SPT's were performed in 3 steps with 10 cm deep for each step. The sum of the blow counts from the three steps is called the "Blow Count/ 30 cm". For hard soil, the penetration was stopped after 50 SPTs and the result was recorded as "Blow Count/Penetration Depth".

Note on Energy Correction: The N-values utilized in this study represent field resistance (N_{field}) obtained using standardized drilling rigs consistent with the project's technical specifications. No specific energy correction to 60% efficiency (N_{60}) was applied to the raw data. Given the uniformity of the equipment used, the relative consistency of the dataset is preserved. However, for design applications requiring N_{60}, engineers should apply an appropriate energy correction factor (C_E) based on the specific hammer efficiency of the drilling equipment employed.

2.1.2. Disturbed Sample Collection

Disturbed sample of the soil layer was collected from the split spoon after the standard penetration test (SPT). Both the disturbed sample collection and standard penetration test (SPT) were performed every 2.0 m depth. The collected sample gave the characters of each soil layer which are used for the determination of the basic property viz., density, particle gradation, soil moisture, Liquid Limit, and Plastic Limit. The engineering properties of the disturbed sample are described in Table A1.

2.1.3. Soil Sample

The soil sample was classified into 2 sets of data. The first set was used to create an equation to predict the standard penetration number, and the second set was used to verify the predicted results compared with the results from other studies. Particularly, the first data of 266 samples were collected from the boring pits from Sta 253+930.00 to Sta 287+552.00 as presented in Table A2. The second set of 123 samples were taken from the boring pits from Sta 289+152.00 to Sta 345+475.00. Additionally, another 80 data sets from other studies were presented in Tables A3 and A4. A total of 469 data sets were used in this study. The soil samples from all boring pits were classified following the Unified Soil Classification Systems (USCS). The Liquid Limits of the samples were between 20%-60% and thus could be classified as cohesive soil. Using Casagrande Chart, the samples could be divided into Low swelling clay (CL) and High swelling clay (CH) (on an A-Line) as illustrated in Figure 2.

Note on Data Uniformity: It should be noted that the dataset contains several entries with identical values. These correspond to distinct samples collected from different depths within thick, homogeneous soil layers where geological properties remain constant. These data points represent independent in-situ tests and are included to preserve the statistical weight of uniform soil deposits in the analysis.

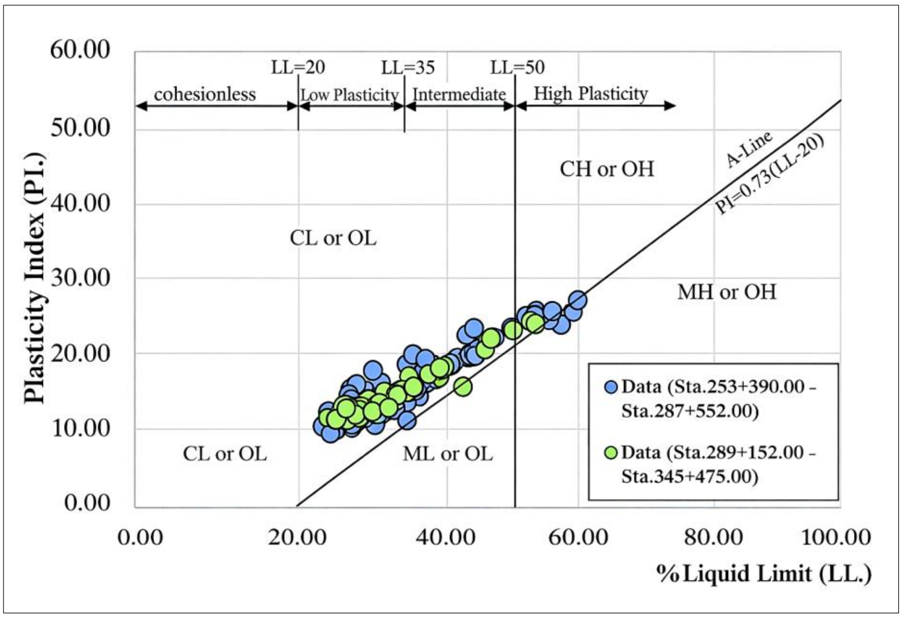

Figure 2. Casagrande chart classification of soil

2.2. Standard Penetration Number Estimation

In this study, the standard penetration number was estimated based on the basic parameters using 2 methods viz., 1) Empirical estimation and 2) Multiple Linear Regression for statistic estimation. The procedures of those two methods are described in Figure. 3.

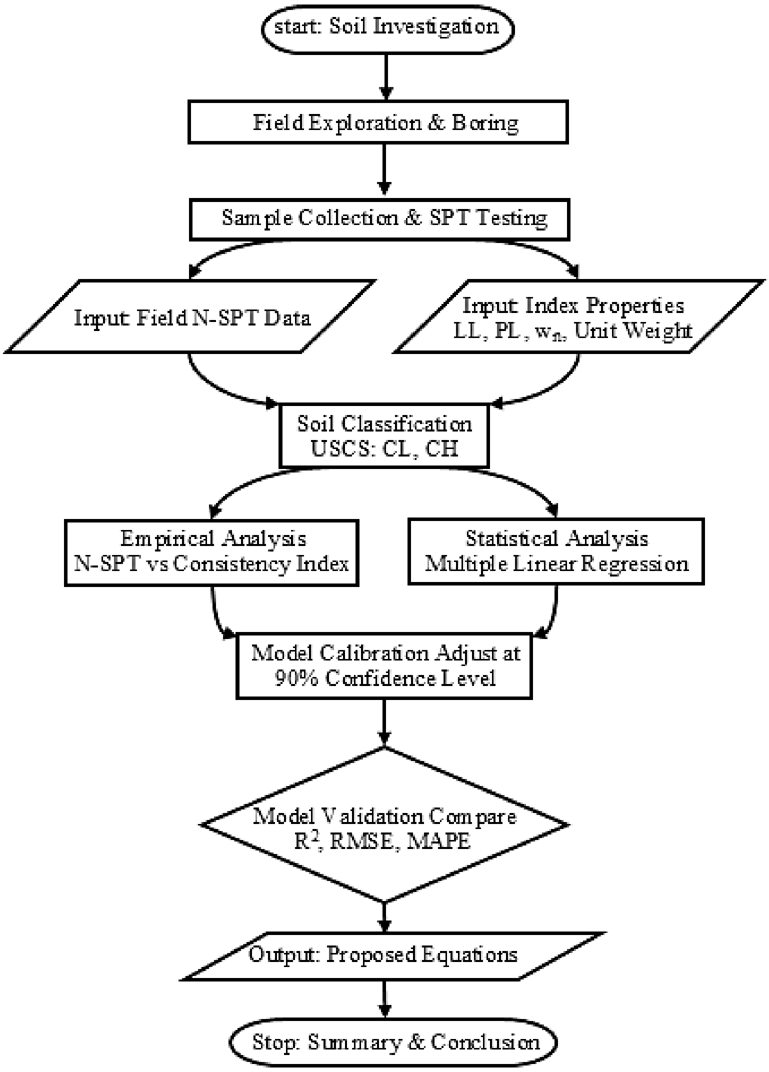

Figure 3. Flow chart of standard penetration number estimation based on basic soil properties

2.2.1. Empirical Estimation

Basic parameters for the estimation of standard penetration number (NSPT) comprises soil moisture, Liquid Limit, and Plastic Limit. The three parameters could be grouped as Consistency Index (CI). The relationship between NSPT and CI is a power function as depicted in Equation 1.

$$N_{SPT} = \mathrm{k}(\mathrm{CI})^{\mathrm{a}} \tag{1}$$

where, NSPT = standard penetration number, CI is the ratio of the difference between Liquid Limit (LL) and natural water content (w_n) to the Plasticity Index (PI).

2.2.2. Multiple Linear Regression

Multiple regression analysis (MLR) is one of statistical techniques that simulates a relationship between independent variable and dependent variable. A MLR linear equation could be described as follows (Equation 2):

$$y_i = b_0 + b_1(x_{i,1}) + b_2(x_{i,2}) + \ldots . + b_k(x_{i,k}) + e_i \tag{2}$$

where, y_i = Independent Variable, $x_{i,1}$ = Dependent Variable, b_k = vector of regression coefficients, e_i = Random Error, and b_0 = Regression Equation Constant.

Standard penetration number (N_{SPT}) could be assumed from the basic parameters viz., unit weight, Plastic Limit, Liquid Limit, and soil moisture content as described in Equation 3.

MLR model was based on minimizing statistical redundancy and maximizing physical representativeness. Specifically, the Plasticity Index (PI) was excluded from the regression equation to avoid multicollinearity, as PI is mathematically derived from the Liquid Limit (LL) and Plastic Limit (PL) (PI = LL - PL). Including all three would compromise the stability of the regression coefficients. Furthermore, Unit Weight (γ) was prioritized over calculated overburden stress. Unit weight serves as a direct, measurable proxy for the soil's in-situ density and consolidation state, allowing the model to predict N-values based solely on laboratory-tested physical properties without requiring additional stratigraphic depth calculations.

$$N_{SPT} = \beta_i + \beta_i(\gamma) + \beta_i(\text{PL}) + \beta_i(\text{LL}) + \beta_i(W_n) \tag{3}$$

where, N_{SPT} = standard penetration number, γ = Unit Weight, PL = Plastic Limit, LL = Liquid Limit, Soil Moisture Content (w_n)/ Plasticity Index (PI), β_i = Regression Equation Constant.

2.3. Performance Evaluation Using Statistical Method

The equation derived from the data analysis was tested for its performance using a statistical method with the required parameters consisting of Coefficient of Determination (R^2), Root Mean Square Error (RMSE), and Mean Absolute Percentage Error (MAPE). These parameters could be obtained from Equations 4 – 6.

$$\text{R}^2 = 1 - \frac{\sum_{i=1}^{N}(t_i - td_i)^2}{\sum_{i=1}^{N}(t_i - t)^2} \tag{4}$$

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(t_i - td_i)^2} \tag{5}$$

$$\text{MAPE} = \frac{1}{N}\sum_{i=1}^{N}\left[\frac{t_i - td_i}{t_i}\right] \times 100 \tag{6}$$

where t_i = Experimental standard penetration number, td_i = Predicted standard penetration number, N = Total data set, t = Average Predicted Result, and SD = Standard Deviation

3. Results

3.1. Relationship between Standard Penetration Number with Consistency Index and Basic Properties

Figure 4 describes the relationship between the standard penetration number with consistency index and basic properties and indicates that the standard penetration number increased with the increasing consistency index. The relationship between the standard penetration number and consistency index was in the form of power function as described in Equation 7 where the coefficient of determination or R-Squared (R^2) was 0.769.

$$N_{SPT} = 15.36(CI)^{1.77} \tag{7}$$

where, N_{SPT} = Standard Penetration Number and CI = Consistency Index from (LL-W_n/PI).

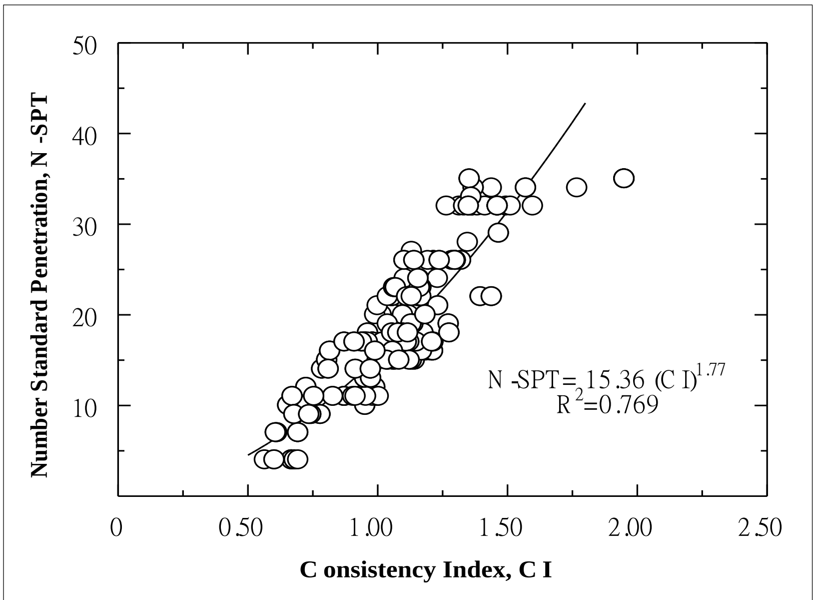

Figure 4. Relationship between Standard Penetration Number (N-SPT) and Consistency Index (CI)

Table 5 explains the standard penetration number analysis using a multiple linear regression model. The standard penetration number had a linear relationship with the following dependent variables: Liquid Limit, Plastic Limit, soil moisture content, and unit weight. The relationship could be described by P-Value which in this case was lower than 0.05, while the coefficient of determination (R^2) was 0.945 indicating that these dependent variables had the statistical significance with the independent variables [21-22].

$$N_{SPT} = 5.96(\gamma) + 0.37(\text{PL}) + 0.12(\text{LL}) + 0.20(W_n) - 97.00 \tag{8}$$

where, N_{SPT} = Standard Penetration Number, LL = Liquid Limit (%), PL = Plastic Limit (%), w_n = Soil Moisture Content (%), and γ = Unit Weight (kN/m^3).

Table 5. Standard penetration number analysis using multiple linear regression model

No.	β_i	Variable	Unit	T-statistic	P-value< 0.05
1	-97.00	-	-	-31.024	1.53×10^{-89}
2	-0.12	LL	%	-3.026	0.0027
3	0.37	PL	%	4.380	1.72×10^{-5}
4	-0.20	W_n	%	-4.815	2.50×10^{-6}
5	5.96	γ	kN/m^3	37.039	6.50×10^{-106}

R^2=0.945, *Adj.* R^2= 0.944, F- statistics = 1131.83.

Figure 5 presents the comparison between the predicted N-SPT and the experimental N-SPT between an empirical analysis and regression analysis. The standard penetration obtained from the empirical method was statistically lower than the number from the regression method. The coefficient of determination (R^2) from the empirical method was 0.723; whereas the coefficient of determination (R^2) from the regression method was 0.996. Verification of Statistical Assumptions To ensure the reliability of the proposed MLR model, the underlying statistical assumptions were rigorously verified. The Variance Inflation Factor (VIF) for all independent variables (LL, PL, w_n, γ) was calculated to be less than 5.0, indicating that multicollinearity is not a critical issue. Furthermore, the analysis of residuals demonstrated a normal distribution, and the scatter plot of residuals versus predicted values showed no distinct pattern, confirming that the assumption of homoscedasticity is satisfied. These checks validate the robustness of the regression coefficients presented in Equation 8.

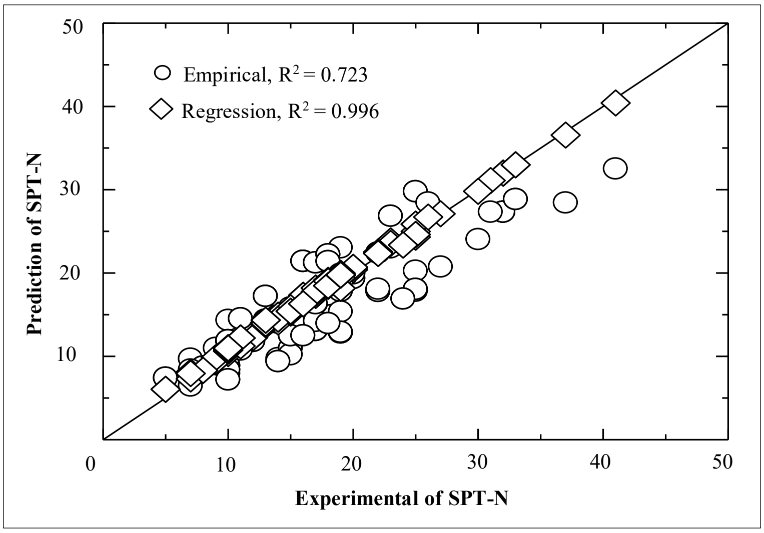

Figure 5. Relationship between predicted N-SPT and experimental N-SPT using empirical analysis and multiple regression analysis

3.2. Section Headings

3.2.1. Modified Equation for Relationship between Standard Penetration Number and Consistency Index

Figure 6(a) depicts the ratio of the relationship between experimental penetration number and predicted number (N_{Exp}/N_{Pre}) from the empirical analysis based on the consistency index as described in Equation 7 compared with 123 data set from the construction field between Sta. 289+152.00 to Sta. 345+475.00. The data set was used for the equation calibration, and it was discovered that the ratio between the experimental number and the predicted number from the equation was less than 1 by 44%, indicating that the predicted number was significantly higher than the experimental number. Therefore, the equation was modified by using a percentile rank at 90% (Confidence level = 90%) and the constant was 0.77%. This constant was then used to multiply Equation 7 and the result as shown in Equation 9 was obtained. Comparing the experimental number and predicted number from Equation 9, the minimum residual was lower than 1 (risk) by approx. 10% and the maximum was higher than 1 (over estimation) by almost 200% as illustrated in Figure 6(b).

$$N_{SPT} = 11.83(\mathrm{CI})^{1.77} \tag{9}$$

where, N_{SPT} = Standard Penetration Number and CI = Consistency Index from ($LL-W_n/PI$).

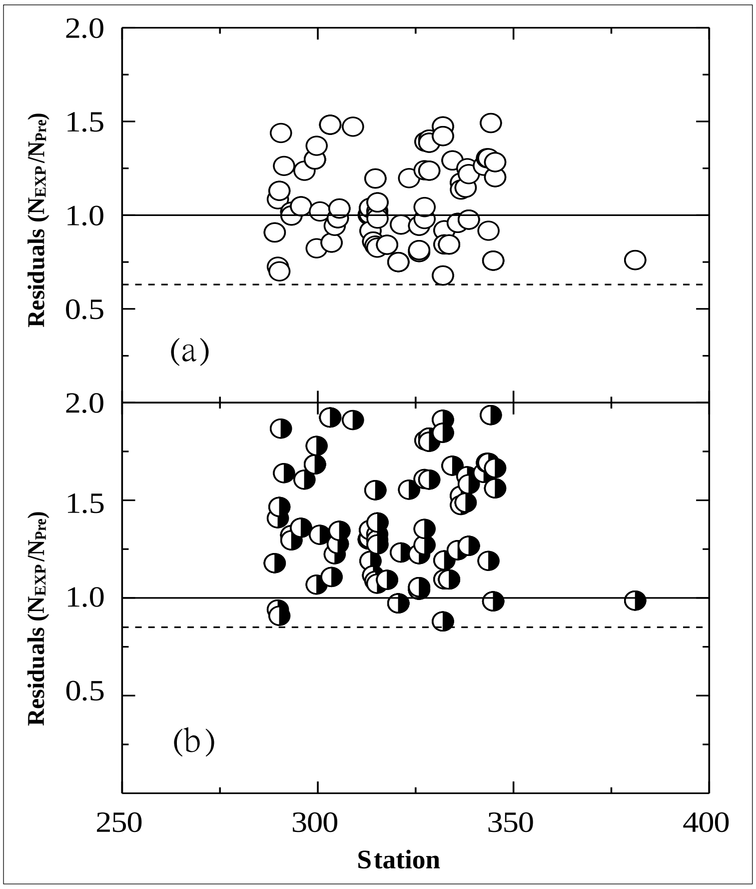

Figure 6. Distribution of Residuals (N_{Exp}/N_{Pre}) and Station (a) before modifying the equation (b) after modifying the equation

3.2.2. Modified Equation for Standard Penetration Number and Soil Basic Properties

Figure 7(a) presents the ratio of the relationship between the experimental penetration number and the predicted penetration number (N_{Exp}/N_{Pre}) assumed from the soil basic parameters using the multiple regression analysis (Equation 8) compared with 123 data set from Sta. 289+152.00 to Sta. 345+475.00.

These data sets were used in the equation calibration, and it found that the ratio between the experimental number and the predicted number from the equation was lower than 1 by 15% (Figure 7a) describing that the predicted number derived from the multiple regression analysis was notably higher than the experimental value with the confidence level = 85%. For a higher level of confidence, the equation was modified by using a percentile rank at 90% (confidence level = 90%) and the constant was 0.92%. This 0.92% was later multiplied to Equation 8 and Equation 10 was obtained. Comparing the experimental number and the predicted number from Equation 9, the minimum result was lower than 1 (risk) by approx. 10% and the maximum was higher than 1 (over estimation) by approx. 12.5% as illustrated in Figure 7(b).

$$N_{SPT} = 5.48(\gamma) + 0.34(\mathrm{PL}) + 0.11(\mathrm{LL}) + 0.18(W_n) - 89.24 \tag{10}$$

where, N_{SPT} = Standard Penetration Number, LL = Liquid Limit (%), PL = Plastic Limit (%), w_n = Soil Moisture Content (%), and γ = Unit Weight (kN/m^3).

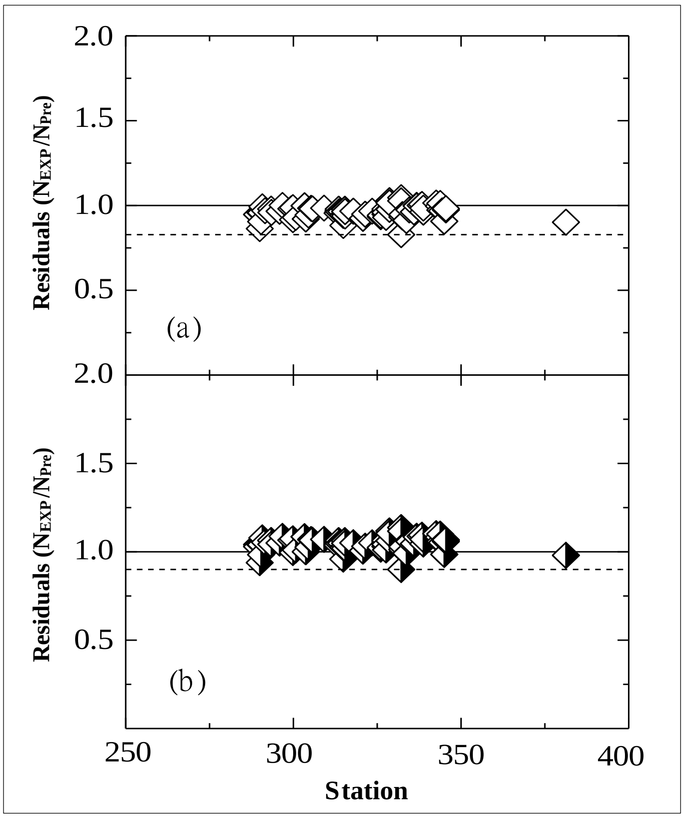

Figure 7. Relationship between residuals (N_{Exp}/N_{Pre}) and station (a) before modifying the equation (b) after modifying the equation

Figure 8 shows the comparison between the predicted N-SPT and the experimental N-SPT of the disturbed samples using both empirical analysis and multiple linear regression analysis. The standard penetration number from the empirical method was lower than the penetration number from the multiple regression method. The empirical method gave R^2=0.723, RMSE = 51.08 and MAPE = 0.22; whereas the multiple regression method gave R^2 =0.996, RMSE = 5.89 and MAPE = 0.025.

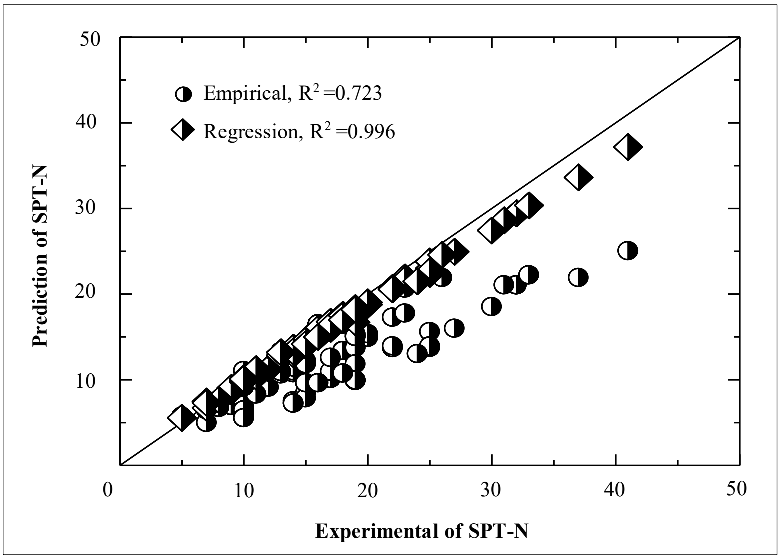

Figure 8. Relationship between predicted N-SPT and experimental N-SPT using empirical method and multiple regression analysis

4. Discussion

The disturbed sample used in this study was fine-grained soil consisting of silt and clay and the test result indicated that the sample contained 20-60% Liquid Limit, so it was considered cohesive soil. The engineering property of this fine-grained soil depended on the pore fluid and surface area based on clay minerals inside the soil [23]. A type of soil with tiny and thin grain normally has a large surface so it also has the status and properties of fine-grained soil and is greatly influenced by water or moisture content.

In general, the basic property that defines fine-grained soil based on soil moisture content is called soil consistency limit [18-25]. According to this property, the standard penetration number directly correlates to the engineering property of soil and depends on the consistency index viz., Liquid Limit, (LL), Plastic Limit, (PL), plasticity index, (PI) and moisture content (w_n) as presented in Equations 7 and 9. This has been reported by a number of researchers [26-30].

Nevertheless, the particle of clay mutually attracts and binds as a cluster and thus the engineering property of clay also depends on the soil structure and fabric [31]. The cohesive soil structure is based on the process of soil formation consisting of 3 steps: 1) non-settling process where soil particles are bound together to form a larger group; 2) flocculation; and 3) consolidation by soil weight. After the formation, soil is subjected to change by stress, time, and surrounding environment. At this point, the clay is referred to as "Structured clay" composed of 1) Flocculation, and 2) Dispersion structures [32].

Accordingly, the estimation on the standard penetration number using the multiple regression analysis where the unit weight of the sample was added in the equation demonstrated the estimated penetration number with higher level of confidence than that of the empirical method. Figures 9 and 10 illustrate the relationship between the predicted N-SPT and experimental N-SPT from the empirical equation and the multiple regression equation compared to the previous studies [33-38]; and Design Excellence [39]. Hence, the basic properties of the sample have some limits; namely, Liquid Limit around 19-56% and the unit weight of 17.3 – 22.9 kN/m^3

From the figures, the estimation on standard penetration number via the empirical method based on the consistency index alone has the coefficient of determination (R^2) = 0.667. Whereas the estimation on standard penetration number using the multiple regression analysis assumed from the consistency index together with the unit weight of soil has the coefficient of determination (R^2) = 0.982. Consequently, the index properties of soil (Liquid Limit, Plastic limit, and moisture content) are merely parameters within the process of standard penetration number estimation. Therefore, the unit weight should be another key parameter to create an equation with the accurate result and to be able to stimulate the most suitable soil properties.

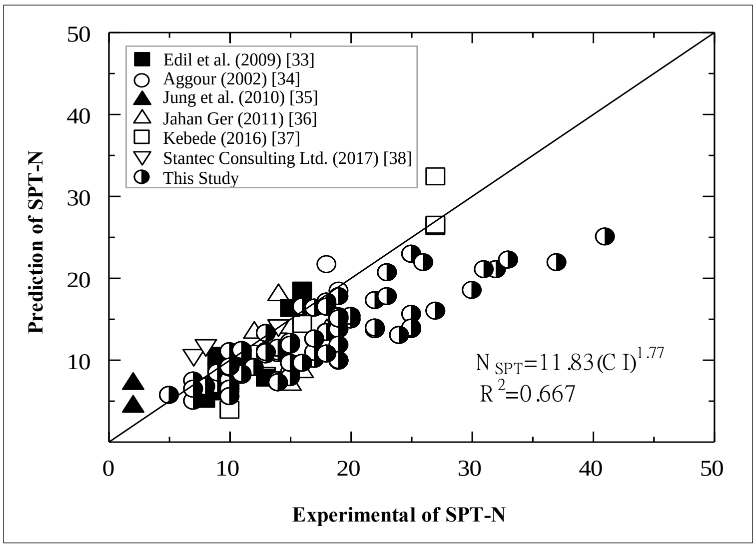

Figure 9. Relationship between predicted N-SPT and experimental N-SPT using empirical method

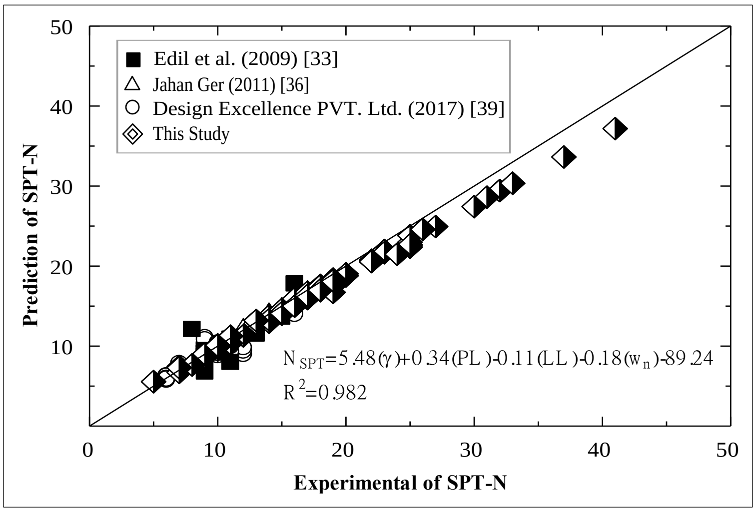

Figure 10. Relationship between predicted N-SPT and experimental N-SPT using multiple regression analysis

Interpretation and Comparison

The superior accuracy of the MLR model (R^2=0.982) compared to the empirical method (R^2=0.667) and previous studies (e.g., Aggour [34]; Edil et al. [33], which typically report R2 between 0.60–0.85) is primarily attributed to the inclusion of unit weight (γ). Physically, unit weight reflects the in-situ density and particle packing, which directly influences shearing resistance and SPT-N values. Traditional models relying solely on consistency limits (LL, PL) fail to capture this structural densification effect. By explicitly integrating unit weight, the proposed model provides a more robust representation of soil strength behavior than simplified correlations.

To provide a complete analysis of the proposed model's performance relative to existing literature, the results were quantitatively compared with established correlations for fine-grained soils. Previous studies, such as those by Aggour [34] and Edil et al. [33], developed empirical equations relying primarily on consistency limits (LL, PL) or unconfined compressive strength. These earlier models typically reported coefficient of determination (R^2) values ranging from 0.60 to 0.85, indicating a moderate predictive capability limited by the variability of natural soil deposits.

In contrast, the Multiple Linear Regression (MLR) model developed in this study achieved a significantly higher R^2 of 0.982. This substantial improvement is attributed to the integration of unit weight (γ) as an independent variable. The analysis reveals that while consistency limits effectively categorize soil plasticity, they fail to account for the in-situ state of compactness. By incorporating unit weight, the proposed model successfully captures the influence of soil density and overburden stress—factors that were often neglected in previous index-based correlations. Additionally, the high coefficient of determination (R^2) is supported by the high data-to-variable ratio (266 samples for 4 predictors), which minimizes the risk of statistical overfitting compared to smaller datasets commonly used in previous studies. Consequently, the MLR model provides a more complete and accurate prediction for cohesive soils in the studied region.

Limitations of the Study It is strictly recommended to apply the proposed equations only within the calibrated Liquid Limit range of 20% to 60%. Extrapolation beyond these limits involves significant uncertainty. Soils with a Liquid Limit exceeding 60% are typically high-plasticity clays (CH) or organic soils that exhibit high swelling potential and complex mineralogical interactions not captured by this model. Conversely, soils with a Liquid Limit below 20% often transition toward cohesionless behavior (silty sands), where frictional resistance becomes dominant rather than cohesion. Therefore, using these equations outside the specified range may lead to erroneous N-SPT predictions.

5. Conclusions

The standard penetration number of cohesive soils was tested using soil with 20-60 % Liquid Limit. From the test results, the following conclusions could be drawn:

- The standard penetration number could be estimated from the index properties of cohesive soil viz., Liquid Limit, Plastic Limit, Moisture Content, and Unit Weight. The estimation could be employed using either the empirical estimation or multiple linear regression analysis (MLR).
- The multiple linear regression gave a more precise estimation compared with the empirical estimation. Specifically, the empirical estimation provided the coefficient of determination (R^2) of 0.667, and the multiple regression analysis (MLR) provided the coefficient of determination (R^2) of 0.982.
- To adjust the empirical estimation, a confidence limit of 90% was used and the multiplying factor was found to be 0.92%. This number was used to adjust the empirical estimation by multiplying the factor to the standard penetration number equation.
- The study shows that the multiple linear regression analysis and the modified empirical estimation could be used to estimate the standard penetration number of cohesive soils with Liquid Limit in the range of 20-60 %.

6. Declarations

6.1. Author Contributions

Conceptualization, P.A., Y.S., A.K., and A.B.; methodology, P.A., Y.S., A.K., and A.B.; software, A.K., A.B., and T.T.; validation, Y.S., P.A., A.K., and A.B.; formal analysis, P.A., Y.S., A.B., and A.K.; investigation, A.K., A.B., T.T., and N.K.; resources, P.A., Y.S., and A.B.; data curation, A.K., A.A., P.A., Y.S., and A.B.; writing—original draft preparation, P.A., Y.S., and A.B.; writing—review and editing, A.K. and A.B.; visualization, P.A., Y.S., and A.B.; supervision, A.K. and A.B.; project administration, P.A., Y.S., and A.B.; funding acquisition, P.A., Y.S., and A.B. All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement

The data presented in this study are available in the article.

6.3. Funding

This research was contributed with financial support from Rajamangala University of Technology Isan. The last author would also like to acknowledge the "Support by Research and Graduate Studies" Khon Kaen University.

6.4. Conflicts of Interest

The authors declare no conflict of interest.

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Appendix I

Table A1. Engineering property test of disturbed sample

Basic Test	Standard
Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils	ASTM D1586 / D1586M-18e1
Total Unit Weight	ASTMD 4253-93
Grain size distribution	ASTM C 117 / ASTM D 422
Standard Test Method for Determination of Water (Moisture) Content	ASTM D 4959-89
Liquid Limit / Plastic Limit	ASTM D 4318-98

Table A2. Basic properties of boring pits from sta. 253+930.00 to sta. 287+552.00

Station	BH	Liquid Limit, LL (%)	Plastic Limit, PL (%)	Water content (%)	Unit weight (kN/m³)	N_{SPT} (Blow/ft)
Sta 253+930.00 to Sta 287+552.00 (266 data)	BH2	33	21.1	19.2	20.40	24
	BH3	35.9	22.4	21.3	19.35	17
	BH3	35.9	22.4	21.3	19.35	17
	BH3	35.9	22.4	21.3	20.10	22
	BH3	29.4	16.1	14.5	19.80	20
	BH3	29.4	16.1	15.9	19.80	20
	BH3	29.4	17.1	15.9	19.80	20
	BH3	56.9	33.7	31.8	20.10	22
	BH3	56.9	33.7	23.5	21.90	34
	BH3	55.0	31.2	12.9	21.90	34
	BH3	37.1	21.7	12.9	21.90	34
	BH3	37.1	21.7	12.9	21.90	34
	BH4	24.7	14.1	13.2	18.20	16
	BH4	24.7	14.1	13.2	18.20	16
	BH4	30.7	18.9	18.1	18.20	16
	BH4	30.7	18.9	16.7	18.20	16
	BH4	29.6	18.4	16.7	18.20	16
	BH4	29.6	18.4	16.1	18.20	16
	BH4	27.3	16.6	16.1	18.20	16
	BH4	27.3	16.6	15.1	18.20	16
	BH4	26.9	16.1	15.1	18.20	16
	BH4	35.1	20.7	19.2	20.40	24
	BH5	23.3	13.0	13.1	19.80	20
	BH5	33.0	19.5	20.0	19.50	18
	BH5	33.0	19.5	20.0	19.50	18
	BH5	30.7	19.6	18.6	19.50	18
	BH5	30.7	19.6	18.6	19.50	18
	BH5	23.5	13.1	11.6	19.50	18
	BH5	23.5	13.1	11.6	19.50	18
	BH5	23.4	13.2	11.4	19.50	18
	BH5	23.4	13.2	11.4	19.50	18
	BH5	58.7	33.7	30.4	20.85	27
	BH6	32.4	20.7	23.2	18.90	14
	BH6	32.4	20.7	23.2	18.90	14
	BH6	41.5	22.9	20.0	20.10	22
	BH6	41.5	22.9	20.0	20.10	22
	BH6	43.9	23.2	21.5	20.10	22
	BH6	43.9	23.2	21.5	20.10	22
	BH6	43.9	23.2	18.4	20.40	24
	BH7	23.4	14.5	13.9	19.05	15
	BH7	23.4	14.5	13.9	19.05	15
	BH7	34.1	21.5	19.7	19.05	15
	BH7	34.1	21.5	19.7	19.05	15
	BH7	27.1	16.8	18.8	19.05	15

Station	BH	Liquid Limit, LL (%)	Plastic Limit, PL (%)	Water content (%)	Unit weight (kN/m³)	N_{SPT} (Blow/ft)
	BH7	27.1	16.8	18.8	19.05	15
	BH7	27.1	15.6	15.6	19.05	15
	BH7	27.1	15.6	15.6	19.95	21
	BH7	44.9	24.7	21.3	20.25	23
	BH7	44.9	24.7	21.3	20.25	23
	BH8	21.9	11.5	12.0	18.75	13
	BH8	21.9	11.5	12.0	18.75	13
	BH8	36.0	20.7	21.4	18.75	13
	BH8	36.0	20.7	21.4	18.75	13
	BH8	26.1	15.7	16.1	18.75	13
	BH8	26.1	15.7	16.1	18.75	13
	BH8	28.9	17.2	16.5	19.05	15
	BH8	28.9	17.2	16.5	19.05	15
	BH8	34.5	20.1	18.2	19.05	15
	BH8	34.5	20.1	18.2	19.05	15
	BH9	26.1	15.5	14.1	19.35	17
	BH9	28.5	17.6	16.1	19.65	19
	BH9	28.5	17.6	16.1	19.65	19
	BH9	26.5	15.0	13.5	19.65	19
	BH9	26.5	15.0	13.5	19.65	19
	BH10	22.4	12.0	13.9	19.20	16
	BH10	22.4	12.0	13.9	19.20	16
	BH10	25.6	15.0	13.7	19.20	16
	BH10	25.6	15.0	13.7	19.20	16
	BH10	25.6	15.3	13.1	19.20	16
	BH10	25.6	15.3	13.1	19.20	16
	BH10	31.5	19.2	17.1	19.20	16
	BH10	31.5	19.2	17.1	19.20	16
	BH10	34.1	19.2	16.7	20.10	22
	BH10	34.1	19.2	16.7	20.10	22
	BH10	27.7	16.8	13.3	20.70	26
	BH10	27.7	16.8	13.3	20.70	26
	BH10	24.2	13.9	10.8	20.70	26
	BH10	24.2	13.9	10.8	20.70	26
	BH10	26.2	15.1	12.7	20.70	26
	BH10	26.2	15.1	12.7	20.70	26
	BH10	27.6	16.5	13.3	20.70	26
	BH10	27.6	16.5	13.3	20.70	26
	BH10	29.2	17.4	13.3	21.00	28
	BH10	33.1	19.1	14.0	21.60	32
	BH10	33.1	19.1	14.0	21.60	32
	BH11	53.0	28.0	29.2	19.35	17
	BH11	53.0	28.0	29.2	19.35	17
	BH11	53.0	28.0	29.2	19.35	17
	BH11	25.6	15.1	14.7	19.35	17
	BH11	25.6	15.1	14.7	19.35	17
	BH11	25.4	14.7	13.1	19.35	17
	BH11	25.4	14.7	13.1	19.35	17
	BH11	29.6	17.5	14.9	19.35	17
	BH11	29.6	17.5	14.9	19.35	17
	BH11	32.7	21.1	19.9	20.70	26
	BH11	32.7	21.1	19.9	20.70	26
	BH11	24.5	14.1	11.0	20.70	26
	BH11	24.5	14.1	11.0	20.70	26
	BH11	25.6	15.3	13.3	20.70	26
	BH12	26.9	16.2	15.8	19.20	16
	BH12	26.9	16.2	15.8	19.20	16

Station	BH	Liquid Limit, LL (%)	Plastic Limit, PL (%)	Water content (%)	Unit weight (kN/m³)	N_{SPT} (Blow/ft)
	BH12	26.7	15.2	14.4	19.20	16
	BH12	26.7	15.2	14.4	19.20	16
	BH12	33.7	19.0	18.8	19.20	16
	BH12	33.7	19.0	18.8	19.20	16
	BH12	28.2	16.6	12.0	20.10	22
	BH12	28.2	16.6	12.0	20.10	22
	BH12	38.5	22.1	21.2	20.10	22
	BH12	38.5	22.1	21.2	20.10	22
	BH12	24.6	14.1	13.5	20.10	22
	BH12	24.6	14.1	13.5	20.10	22
	BH13	25.5	14.7	14.9	19.35	17
	BH13	25.5	14.7	14.9	19.35	17
	BH13	25.5	14.7	14.9	19.35	17
	BH13	25.4	15.1	14.9	19.35	17
	BH13	25.4	15.1	14.9	19.35	17
	BH13	27.1	16.5	15.6	19.35	17
	BH13	27.1	16.5	15.6	19.35	17
	BH13	30.4	18.1	16.6	19.35	17
	BH13	30.4	18.1	16.6	19.35	17
	BH13	26.6	16.0	16.4	19.35	17
	BH13	25.3	15.1	14.7	19.65	19
	BH13	25.3	15.1	14.7	20.10	22
	BH14	27.6	16.9	16.3	19.50	18
	BH14	27.6	16.9	16.3	19.50	18
	BH1	30.6	18.5	17.5	19.50	18
	BH14	30.6	18.5	17.5	19.50	18
	BH14	35.4	21.1	19.7	19.50	18
	BH14	35.4	21.1	19.7	19.50	18
	BH15	24.1	13.9	15.2	18.45	11
	BH15	24.1	13.9	15.2	18.45	11
	BH15	24.1	13.9	15.2	19.35	17
	BH15	24.1	13.9	15.2	19.35	17
	BH15	40.5	22.9	19.2	19.35	17
	BH15	40.5	22.9	19.2	19.35	17
	BH15	43.2	24.5	22.4	19.35	17
	BH15	43.2	24.5	22.4	19.35	17
	BH15	29.4	17.1	15.1	20.25	23
	BH16	25.4	14.8	16.8	18.90	14
	BH16	25.4	14.8	16.8	18.90	14
	BH16	27.7	16.7	16.0	20.25	23
	BH16	27.7	16.7	16.0	20.25	23
	BH17	25.7	15.1	15.2	18.60	12
	BH17	25.7	15.1	15.2	18.60	12
	BH17	22.7	12.5	15.3	18.60	12
	BH17	22.7	12.5	15.3	18.60	12
	BH17	53.7	29.4	27.7	20.25	23
	BH17	53.7	29.4	27.7	20.25	23
	BH18	42.9	24.1	26.5	18.00	11
	BH18	42.9	24.1	26.5	18.00	11
	BH18	42.9	24.1	26.5	18.00	11
	BH18	33.0	19.0	21.4	18.00	11
	BH18	33.0	19.0	21.4	18.00	11
	BH18	27.3	15.9	15.9	18.00	11
	BH18	27.3	15.9	15.9	18.00	11
	BH18	26.4	16.2	16.9	18.00	11
	BH18	26.4	16.2	16.9	18.00	11
	BH19	37.7	20.0	26.1	18.3	10

Station	BH	Liquid Limit, LL (%)	Plastic Limit, PL (%)	Water content (%)	Unit weight (kN/m³)	N_{SPT} (Blow/ft)
	BH19	37.7	20.0	26.1	18.30	10
	BH19	28.7	16.1	16.7	18.30	10
	BH19	28.7	16.1	16.7	18.30	10
	BH23	29.9	17.8	21.8	17.40	4
	BH23	29.9	17.8	21.8	17.40	4
	BH23	29.9	17.8	21.8	17.40	4
	BH23	29.6	19.9	23.0	17.40	4
	BH23	29.6	19.9	23.0	17.40	4
	BH23	28.3	17.7	22.3	17.40	4
	BH23	38.6	22.7	23.0	18.45	11
	BH23	46.7	25.4	27.4	18.45	11
	BH23	51.4	27.1	27.0	18.45	11
	BH23	52.7	28.1	29.2	18.45	11
	BH23	43.3	24.5	26.1	18.45	11
	BH23	49.3	26.6	18.2	21.90	34
	BH23	49.3	26.6	18.2	21.90	34
	BH24	35.0	20.9	26.5	17.40	4
	BH24	35.0	20.9	26.5	17.40	4
	BH24	43.7	24.1	30.1	17.40	4
	BH24	43.7	24.1	30.1	17.85	7
	BH24	43.7	24.1	30.1	17.85	7
	BH24	43.7	24.1	30.1	17.85	7
	BH24	55.5	30.5	28.5	19.50	18
	BH24	55.5	30.5	28.5	19.50	18
	BH24	59.5	32.7	23.2	22.05	35
	BH24	59.5	32.7	23.2	22.05	35
	BH24	52.7	28.4	5.3	22.05	35
	BH24	52.7	28.4	5.3	22.05	35
	BH24	52.7	28.4	5.3	22.05	35
	BH24	52.7	28.4	5.3	22.05	35
	BH25	40.4	22.7	28.5	18.45	11
	BH25	40.4	22.7	28.5	18.45	11
	BH27	44.2	25.5	31.5	18.15	9
	BH27	44.2	25.5	31.5	18.15	9
	BH29	31.4	19.1	17.7	20.10	22
	BH29	31.4	19.1	17.7	20.10	22
	BH29	28.1	16.7	15.2	20.10	22
	BH30	27.6	16.5	13.0	20.60	32
	BH30	29.2	17.5	13.0	20.60	32
	BH30	27.1	16.2	13.3	20.60	32
	BH30	29.3	17.3	13.3	20.60	32
	BH30	28.8	17.1	10.1	20.60	32
	BH30	26.7	15.6	10.1	20.60	32
	BH30	26.7	15.6	11.0	20.60	32
	BH30	29.0	17.1	11.0	20.60	32
	BH30	29.0	17.1	11.6	20.60	32
	BH30	29.0	17.1	11.6	20.60	32
	BH30	29.0	17.1	11.6	20.60	32
	BH33	27.2	15.2	13.5	20.70	26
	BH33	27.2	15.2	13.5	20.70	26
	BH41	25.1	10.6	11.3	18.75	13
	BH41	25.1	10.6	11.3	18.75	13
	BH41	23.1	14.3	12.2	20.70	26
	BH41	23.1	14.3	12.2	20.70	26

Station	BH	Liquid Limit, LL (%)	Plastic Limit, PL (%)	Water content (%)	Unit weight (kN/m³)	N_{SPT} (Blow/ft)
	BH44	24.0	12.2	12.5	18.75	13
	BH44	24.0	12.2	12.5	18.75	13
	BH47	21.2	11.7	9.1	19.65	19
	BH47	21.2	11.7	9.1	19.65	19
	BH49	27.5	13.4	7.2	20.10	22
	BH49	27.5	13.4	7.2	20.10	22
	BH50	26.0	16.6	14.0	19.50	18
	BH50	26.0	16.6	14.0	19.50	18
	BH52	26.0	11.0	14.3	18.15	9
	BH52	26.0	11.0	14.3	18.15	9
	BH55	28.5	15.2	12.1	19.95	21
	BH55	28.5	15.2	12.1	19.95	21
	BH57	35.2	19.0	17.1	19.50	18
	BH57	35.2	19.0	17.1	19.50	18
	BH57	32.3	19.3	17.7	19.05	15
	BH57	32.3	19.3	17.7	19.05	15
	BH57	31.5	19.0	16.7	19.80	20
	BH57	31.5	19.0	16.7	19.80	20
	BH58	33.7	15.9	17.4	18.90	14
	BH58	33.7	15.9	17.4	18.90	14
	BH62	26.9	16.7	15.1	20.40	24
	BH62	26.9	16.7	15.1	20.40	24
	BH63	36.5	19.6	18.9	19.05	15
	BH63	36.5	19.6	18.9	19.05	15
	BH64	26.0	16.3	12.8	21.75	33
	BH64	26.0	16.3	12.8	21.75	33
	BH66	24.9	11.3	10.5	19.20	16
	BH66	24.9	11.3	10.5	19.20	16
	BH69	21.7	10.4	10.0	19.05	15
	BH69	21.7	10.4	10.0	19.05	15
	BH71	22.3	13.9	13.2	19.05	15
	BH71	22.3	13.9	13.2	19.05	15
	BH72	42.5	20.9	22.2	19.35	17
	BH72	42.5	20.9	22.2	19.35	17
	BH73	34.7	24.6	25.5	19.35	17
	BH73	34.7	24.6	25.5	19.35	17
	BH75	26.0	14.2	14.3	19.20	16
	BH75	26.0	14.2	14.3	19.20	16
	BH75	30.0	18.9	15.0	21.60	32
	BH75	30.0	18.9	15.0	21.60	32
	BH75	30.0	14.8	7.7	21.15	29
	BH75	30.0	14.8	7.7	21.15	29
	BH76	28.5	11.7	18.2	17.85	7
	BH76	28.5	11.7	18.2	17.85	7
	BH76	34.5	15.5	16.0	18.90	14
	BH76	34.5	15.5	16.0	18.90	14
	BH84	25.3	12.3	17.4	17.85	7
	BH84	25.3	12.3	17.4	17.85	7
	BH95	36.5	18.1	22.8	18.15	9
	BH95	36.5	18.1	22.8	18.15	9
	BH95	30.1	16.6	19.9	18.45	11
	BH95	30.1	16.6	19.9	18.45	11
	BH97	43.5	21.1	27.0	18.15	9
	BH97	43.5	21.1	27.0	18.15	9

Table A3. Basic properties of boring pits from sta. 253+930.00 to sta. 287+552.00

Station	BH	Liquid Limit, LL (%)	Plastic Limit, PL (%)	Water content (%)	Unit weight (kN/m³)	N_{SPT} (Blow/ft)
Sta 289+152.00 to Sta 345+475.00 (123 data)	BH2	33.0	21.1	19.2	20.40	24
	BH3	35.9	22.4	21.3	19.35	17
	BH3	35.9	22.4	21.3	19.35	17
	BH3	35.9	22.4	21.3	20.10	22
	BH3	29.4	16.1	14.5	19.80	20
	BH3	29.4	16.1	15.9	19.80	20
	BH3	29.4	17.1	15.9	19.80	20
	BH3	56.9	33.7	31.8	20.10	22
	BH3	56.9	33.7	23.5	21.90	34
	BH3	55.0	31.2	12.9	21.90	34
	BH3	37.1	21.7	12.9	21.90	34
	BH3	37.1	21.7	12.9	21.90	34
	BH4	24.7	14.1	13.2	18.20	16
	BH4	24.7	14.1	13.2	18.20	16
	BH4	30.7	18.9	18.1	18.20	16
	BH4	30.7	18.9	16.7	18.20	16
	BH4	29.6	18.4	16.7	18.20	16
	BH4	29.6	18.4	16.1	18.20	16
	BH4	27.3	16.6	16.1	18.20	16
	BH4	27.3	16.6	15.1	18.20	16
	BH4	26.9	16.1	15.1	18.20	16
	BH4	35.1	20.7	19.2	20.40	24
	BH5	23.3	13.0	13.1	19.80	20
	BH5	33.0	19.5	20.0	19.50	18
	BH5	33.0	19.5	20.0	19.50	18
	BH5	30.7	19.6	18.6	19.50	18
	BH5	30.7	19.6	18.6	19.50	18
	BH5	23.5	13.1	11.6	19.50	18
	BH5	23.5	13.1	11.6	19.50	18
	BH5	23.4	13.2	11.4	19.50	18
	BH5	23.4	13.2	11.4	19.50	18
	BH5	58.7	33.7	30.4	20.85	27
	BH6	32.4	20.7	23.2	18.90	14
	BH6	32.4	20.7	23.2	18.90	14
	BH6	41.5	22.9	20.0	20.10	22
	BH6	41.5	22.9	20.0	20.10	22
	BH6	43.9	23.2	21.5	20.10	22
	BH6	43.9	23.2	21.5	20.10	22
	BH6	43.9	23.2	18.4	20.40	24
	BH7	23.4	14.5	13.9	19.05	15
	BH7	23.4	14.5	13.9	19.05	15
	BH7	34.1	21.5	19.7	19.05	15
	BH7	34.1	21.5	19.7	19.05	15
	BH7	27.1	16.8	18.8	19.05	15
	BH7	27.1	16.8	18.8	19.05	15
	BH7	27.1	15.6	15.6	19.05	15
	BH7	27.1	15.6	15.6	19.95	21
	BH7	44.9	24.7	21.3	20.25	23
	BH7	44.9	24.7	21.3	20.25	23
	BH8	21.9	11.5	12.0	18.75	13
	BH8	21.9	11.5	12.0	18.75	13
	BH8	36.0	20.7	21.4	18.75	13
	BH8	36.0	20.7	21.4	18.75	13
	BH8	26.1	15.7	16.1	18.75	13
	BH8	26.1	15.7	16.1	18.75	13
	BH8	28.9	17.2	16.5	19.05	15
	BH8	28.9	17.2	16.5	19.05	15
	BH8	34.5	20.1	18.2	19.05	15
	BH8	34.5	20.1	18.2	19.05	15

Station	BH	Liquid Limit, LL (%)	Plastic Limit, PL (%)	Water content (%)	Unit weight (kN/m^3)	N_{SPT} (Blow/ft)
	BH9	26.1	15.5	14.1	19.35	17
	BH9	28.5	17.6	16.1	19.65	19
	BH9	28.5	17.6	16.1	19.65	19
	BH9	26.5	15.0	13.5	19.65	19
	BH9	26.5	15.0	13.5	19.65	19
	BH10	22.4	12.0	13.9	19.20	16
	BH10	22.4	12.0	13.9	19.20	16
	BH10	25.6	15.0	13.7	19.20	16
	BH10	25.6	15.0	13.7	19.20	16
	BH10	25.6	15.3	13.1	19.20	16
	BH10	25.6	15.3	13.1	19.20	16
	BH10	31.5	19.2	17.1	19.20	16
	BH10	31.5	19.2	17.1	19.20	16
	BH10	34.1	19.2	16.7	20.10	22
	BH10	34.1	19.2	16.7	20.10	22
	BH10	27.7	16.8	13.3	20.70	26
	BH10	27.7	16.8	13.3	20.70	26
	BH10	24.2	13.9	10.8	20.70	26
	BH10	24.2	13.9	10.8	20.70	26
	BH10	26.2	15.1	12.7	20.70	26
	BH10	26.2	15.1	12.7	20.70	26
	BH10	27.6	16.5	13.3	20.70	26
	BH10	27.6	16.5	13.3	20.70	26
	BH10	29.2	17.4	13.3	21.00	28
	BH10	33.1	19.1	14.0	21.60	32
	BH10	33.1	19.1	14.0	21.60	32
	BH11	53.0	28.0	29.2	19.35	17
	BH11	53.0	28.0	29.2	19.35	17
	BH11	53.0	28.0	29.2	19.35	17
	BH11	25.6	15.1	14.7	19.35	17
	BH11	25.6	15.1	14.7	19.35	17
	BH11	25.4	14.7	13.1	19.35	17
	BH11	25.4	14.7	13.1	19.35	17
	BH11	29.6	17.5	14.9	19.35	17
	BH11	29.6	17.5	14.9	19.35	17
	BH11	32.7	21.1	19.9	20.70	26
	BH11	32.7	21.1	19.9	20.70	26
	BH11	24.5	14.1	11.0	20.70	26
	BH11	24.5	14.1	11.0	20.70	26
	BH11	25.6	15.3	13.3	20.70	26
	BH12	26.9	16.2	15.8	19.20	16
	BH12	26.9	16.2	15.8	19.20	16
	BH12	26.7	15.2	14.4	19.20	16
	BH12	26.7	15.2	14.4	19.20	16
	BH12	33.7	19.0	18.8	19.20	16
	BH12	33.7	19.0	18.8	19.20	16
	BH12	28.2	16.6	12.0	20.10	22
	BH12	28.2	16.6	12.0	20.10	22
	BH12	38.5	22.1	21.2	20.10	22
	BH12	38.5	22.1	21.2	20.10	22
	BH12	24.6	14.1	13.5	20.10	22
	BH12	24.6	14.1	13.5	20.10	22
	BH13	25.5	14.7	14.9	19.35	17
	BH13	25.5	14.7	14.9	19.35	17
	BH13	25.5	14.7	14.9	19.35	17
	BH13	25.4	15.1	14.9	19.35	17
	BH13	25.4	15.1	14.9	19.35	17
	BH13	27.1	16.5	15.6	19.35	17
	BH13	27.1	16.5	15.6	19.35	17
	BH13	30.4	18.1	16.6	19.35	17
	BH13	30.4	18.1	16.6	19.35	17
	BH13	26.6	16.0	16.4	19.35	17
	BH13	25.3	15.1	14.7	19.65	19
	BH13	25.3	15.1	14.7	20.10	9

Table A4. Basic properties from other studies

Research	Liquid Limit, LL (%)	Plastic Limit, PL (%)	Water content (%)	CI	USCE	Unit weight (kN/m³)	N_{SPT} (Blow/ft)
Aggour (2002) [34] (5 data)	39.00	22.00	26.00	0.76	CL	-	9
	54.00	33.00	27.00	1.28	CL	-	19
	45.00	24.00	28.00	0.81	CL	-	11
	38.00	19.00	20.00	0.94	CL	-	12
	56.00	34.00	25.00	1.40	CL	-	18
Jung et al. (2010) [35] (2 data)	55.40	31.58	37.54	0.75	CH	21.18	2
	47.05	25.80	35.02	0.56	CH	21.20	2
Stantec Consulting Ltd. (2017) [38] (4 data)	38.00	20.00	18.00	1.11	CL	-	14
	45.00	20.00	26.00	0.76	CL	-	9
	37.00	20.00	21.00	0.94	CL	-	7
	40.00	20.00	20.00	1.00	CL	-	8
Design Execelence (India) PVT. LTD. (2017) [39] (29 data)	17.97	45.10	22.10	14.20	CI	17.97	9
	17.97	45.60	21.20	14.20	CI	17.97	9
	18.17	44.80	22.90	14.36	CI	18.17	9
	18.17	40.60	20.10	14.36	CI	18.17	9
	18.17	42.90	19.20	14.36	CI	18.17	9
	18.22	52.60	22.10	14.31	CH	18.22	9
	18.22	40.80	22.60	14.31	CI	18.22	9
	18.22	43.50	21.10	14.31	CI	18.22	9
	18.22	42.60	22.40	14.31	CI	18.22	9
	18.04	49.00	23.70	14.52	CI	18.04	12
	18.04	44.20	20.60	14.52	CI	18.04	12
	18.04	44.80	20.80	14.52	CI	18.04	12
	18.08	45.40	21.40	14.20	CI	18.08	12
	18.08	43.70	22.10	14.20	CI	18.08	12
	17.99	48.00	22.10	14.29	CI	17.99	10
	17.99	49.50	26.10	14.29	CI	17.99	10
	18.21	47.60	21.90	13.89	CI	18.21	10
	18.21	46.10	22.40	13.89	CI	18.21	10
	17.55	38.90	18.60	13.99	CI	17.55	6
	17.55	36.40	17.60	13.99	CI	17.55	6
	17.32	35.90	19.40	13.99	CI	17.32	6
	17.41	37.60	19.20	13.45	CI	17.41	6
	17.41	35.10	18.50	13.45	CI	17.41	6
	18.01	48.20	23.10	14.23	CI	18.01	11
	18.05	44.00	23.10	14.15	CI	18.05	11
	19.26	39.60	18.50	14.20	CI	19.26	16
	17.88	43.90	22.60	22.60	CI	17.88	7
	18.42	43.40	19.90	19.90	CI	18.42	10
	18.63	35.60	17.60	17.60	CI	18.63	10
Edil et al. (2009) [33] (11 data)	18.21	31.00	16.00	18.30	CL-ML	18.21	10
	18.39	24.00	14.00	14.80	CL-ML	18.39	11
	18.24	29.00	14.00	15.00	CL-ML	18.24	9
	17.85	21.00	12.00	12.60	CL-ML	17.85	11
	18.12	26.00	15.00	16.80	CL-ML	18.12	9
	19.51	19.00	12.00	10.00	CL-ML	19.51	16
	18.83	23.00	12.00	9.80	CL-ML	18.83	15
	18.10	22.00	13.00	13.60	CL-ML	18.10	10
	18.83	38.00	17.00	21.40	CL-ML	18.83	13
	17.96	33.00	15.00	20.60	CL	17.96	9
	18.90	36.00	19.00	25.30	CL	18.90	8
Jahan Ger (2011) [36] (5 data)	18.90	40.00	22.00	17.20	CL	18.90	14
	19.72	55.00	27.00	24.60	CH	19.72	18
	19.68	48.00	23.00	27.20	CL	19.68	16
	18.71	44.00	23.00	21.50	CL	18.71	12
	19.50	43.00	20.00	25.90	CL	19.50	15