COMPARISON OF CORRECTED N VALUES BETWEEN SNI 4153:2008 WITH OTHER METHODS IN STANDARD PENETRATION TEST

Kasmir Gon
Universitas Katolik Indonesia Santu Paulus Ruteng
Coresponding author: kasmirgon31@gmail.com

Abstract: The research aims to compare the $(N1)_{60}$ values between SNI 4153:2008 and other methods in the SPT for 3 sites for the Civil Engineering Laboratory Building at Unika Santu Paulus Ruteng. The depth of SPT Site 1 (S1) is 9 meters where N_{field} 5-66, S2 8.55 meters and N_{field} 6-52, and S3 8.10 meters with an N_{field} value of 4-51. N_{60} values at S1 6-79, S2 7-62, S3 5-66. Correction factors C_E = 1, C_R = 1, C_D = 1 and C_S = 1.2. γ_{sat} is obtained by correlating SPT data to calculate the C_N value based on the σ_v . $N1)_{60}$ S1 SNI 4153:2008 10.68-135.28; Liao and Whitman (1986) 31.84-271.32; Skempton (1986) 11.59-145.65; Tokimatsu and Yoshimi (1983) 13.87-171.13; Seed et al (1975) 16.87-184.83; Peck et al (1974) 12.71-144.33, Bazaraa (1967) 21.02-235.98. $(N1)_{60}$ S2 SNI 4153:2008 12.46-106.90; Liao and Whitman (1986) 37.15-224.89; Skempton (1986) 13.52-115.24; Tokimatsu and Yoshimi (1983) 16.18-135.82; Seed et al (1975) 19.68-148.73; Peck et al (1974) 14.83-115.54, and Bazaraa (1967) 24.52-190.18. $(N1)_{60}$ S3 SNI 4153:2008 8.90-114.64; Liao and Whitman Method (1986) 26.54-255.83; Skempton (1986) 9.66-123.76; Tokimatsu and Yoshimi (1983) 11.56-146.37; Seed et al (1975) 14.06-163.09; Peck et al (1974) 10.59-125.92, and Bazaraa (1967) 17.51-208.49. Comparison of $(N1)_{60}$ values are SNI 4153:2008 vs Skempton (1986) = 1:1.08; SNI 4153:2008 vs Peck et al (1974) = 1:1.13; SNI 4153:2008 vs Tokimatsu & Yoshimi (1983) = 1:1.29; SNI 4153:2008 vs Seed et al (1975) = 1:1.48; SNI 4153:2008 vs Bazaraa (1967) = 1:1.88; SNI 4153:2008 vs Liao & Whitman (1986) = 1:2.50.
Keywords: *SPT, effective overburden pressure, comparison C_N.*

INTRODUCTION

Civil engineering infrastructure design must begin with soil investigation work, both soil as construction material and soil as the final foundation. Soil as the final foundation of civil engineering buildings must have a reliable bearing capacity and subsidence that does not cause the building to collapse, such as buildings, highways, railways, bridges, dams, terminals, seaports, and airport runways (Das, 2016). The bearing capacity and settlement of the soil due to the construction of deep and shallow foundations must meet certain limit requirements so that the pressure that occurs does not exceed the allowable pressure of the soil at the base of the foundation (Pratama et al. 2021), Ruge et al. (2018), Sun et al. (2023), Sari et al. (2021), Haifani (2021), Ali (2023), Widiarso et al. (2025),

Soil data for designing deep and shallow foundations can be obtained through laboratory and field tests. Laboratory tests include soil physical properties, such as water content (w,%), specific gravity, Gs, grain size distribution, liquid limit, plastic limit, shrinkage limit, unit weight, and engineering properties, such as shear strength (c and φ), compressibility, such as void ratio (e) preconsolidation pressure, (pc), compaction (maximum dry density and w optimimum), abrasion, CBR, and UCT. In situ tests such as Standard Penetration Test (SPT), Cone Penetration Test (CPT), Pressuremeter Test (PMT), Vane Shear Test (VST), Dynamic Penetration Test (DCP), LWD (light Deflectometer Test), Plate Load Test (PLT) (Bowles, 1997). The field soil investigation method used depends on design needs, field conditions, and availability of testing equipment.

One of the most widely used field soil investigation methods is the Standard Penetration Test. Several reasons can be put forward, namely easy to mobilize, affordable costs, easy to operate, and more importantly, SPT test data can be used to meet various design needs (Verbrugge & Schroeder, 2018). Field data obtained through SPT includes the depth of the soil layer, the N-SPT value of the spade field at a depth of 45 centimeters for every 15 centimeters, disturbed soil samples for laboratory testing (BSN, 2008), Listanti et al. (2018), Ji et al. (2023), Arshid (2021).

The N-SPT field data obtained is not directly used for designing building foundations. The N-SPT value is first corrected for the hammer energy (C_E), rope length (C_R), borehole diameter (C_B), and split spoon sampler or split barrel sampler (C_S) so that the field N data becomes N60. Effective overburden pressure plays a major role in calculating the corrected N value (CN) to obtain the value $(N_1)_{60}$ (Yusof & Zabidi, 2018).The methods often used to calculate the correction factor (C_N) to obtain the value $(N_1)_{60}$, namely the Liao & Whitman (1986), Skempton (1986), Tokimatsu & Yoshimi (1983), Seed et al (1974), Peck et al (1975), Bazaraa (1967) method based on research by Manzur (2021) and SNI 4153:2008 (BSN, 2008), Yusof & Zabidi (2018), Tan & Ramli (2023).

This research was conducted with the aim of comparing the CN value of soil at the location of the Civil Engineering Laboratory Building Construction of the Catholic University of Indonesia, Santu Paulus Ruteng between SNI 4153:2008 and the Liao & Whitman (1986), Skempton (1986), Tokimatsu & Yoshimi (1983), Seed et al (1974), Peck et al (1975), Bazaraa (1967) methods based on SPT.

METHOD

This research was conducted at the location of the Civil Engineering Laboratory Building Construction of the Catholic University of Indonesia, Santu Paulus Ruteng, at 3 points as shown in Figure 1.

Figure 1. Site research (S: $8^0 36'49.56$ E: $120^0 28'13.356$)

Overview of SPT apparatus and testing procedures

The SPT equipment used is manual SPT, with equipment parts including a tripod, rod with a length of 12 meters, hammer weight 63.50 kg, split spoon sampler diameter 50 mm (60 mm borehole diameter), and anvil, as seen in Figure 2. The testing procedure is based on the provisions of ASTM D1586 and SNI 4153:2008, namely at every change in soil layers or at intervals of approximately 1.50 m to 2.00 m or as required. Pull the hammer strap until it reaches the mark that has been made (approximately 76 cm), then freely drop a load of 63.50 kg until it hits the load holder on the conductor rod. Repeat the pounding until the first 15 cm penetration (N1), the second 15 cm (N2), and the third 15 cm (N3) are achieved. The number of strokes counted is N2 + N3. The N1 value is not taken into account because it is still dirty from drilling; If the N value is greater than 50 strokes, stop the test and increase the test to a minimum of 6 meters.

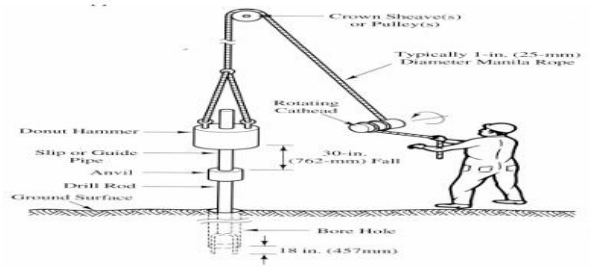

Figure 2. SPT equipment (ASTM D1586) & SNI 4153:2008

N-SPT Calculation

Calculation of field N value, N_{60}, soil unit weight, effective overburden pressure, N value correction factor (C_N) and soil profile depiction using Microsoft Excel 2010 media based on the following formulas (Sumanth et al. (2022), Miller (2022), Ibrahim et al. (2023), BSN (2008), Husain (2016), Dananjaya et al. (2020), Sophia et al. (2019):

$$N_{field} = N_M = N_2 + N_3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where:

NM : Measured N or N field

N2 : Nilai N untuk 15 cm kedua

N3 : Nilai N untuk 1 cm ketiga.

$$N_{60} = \frac{N_M . C_E . C_B . C_S . C_R}{60} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Where:

N_{60} : 60% N_{field} (N_M)

N_M : Measured N

C_E : Correction factor due to energy

C_B : Correction factor of borehole diametre

C_S : Correction factor of split spoon sampler

C_R : Correction factor of rod length

Saturated unit weight, γ_{sat} (kN/m³) (Verbrugge & Schroeder, 2018), Bowles (1997), Baban (2016):

$\gamma_{sat} = 16.8 + 0.15 N_{60}$ (kN/m³) ………………………………. (3) and:

$\gamma' = \gamma_{sat} - \gamma_w$

Where: γ_w=9.81 kN/m³ ……………………………………… (4)

The effecetive overburden pressure, σ'_v

$\sigma'_v = \gamma' .z$ ……………………………………………………….. (5)

Where z = 0.45 m.

$(N_1)_{60}$ and C_N

$(N_1)_{60} = N_{60}.C_N$ ……………………………………………….. (6)

SNI 4153:2008:

$$C_N = \frac{2.2}{\left(1.2 + \left(\frac{\sigma'_v}{p_a}\right)\right)} \quad \text{……………………………………………… (7)}$$

Where:

$(N_1)_{60}$: corrected SPT value about energy efficiency 60%

N_M : measured N value on site

C_N : correction factor due to effective overburden pressure

C_E : correction factor due to hammer weight (Table 1)

C_B : correction factor due to borehole diameter (Table 1)

C_R : correction factor due to rod length (Table 1)

C_S : correction factor due to split barrel sampler (Table 1)

σ'_v : effective overburden pressure (kPa)

p_a : athmospheric pressure 100 kPa

Skempton (1986):

$$C_N = \frac{2}{1 + \left(\frac{\sigma'_v}{p_a}\right)} \quad \text{(for normally consolidated sand) ………… (8)}$$

Peck et al (1974):

$$C_N = 0.77 \log\left(\frac{20}{\left(\frac{\sigma'_v}{p_a}\right)}\right) \quad \text{……………………………………….. (9)}$$

Tokimatsu & Yoshimi (1983):

$$C_N = \frac{1.7}{0.7 + \left(\frac{\sigma'_v}{p_a}\right)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(10)}$$

Seed et al (1975):

$$C_N = 1 - 1.25 \log\left(\frac{\sigma'_v}{p_a}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(11)}$$

Bazaraa (1967):

$$C_N = \frac{4}{1 + 4\left(\frac{\sigma'_v}{p_a}\right)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(12)}$$

Liao & Whitman (1986):

$$C_N = \left[\frac{1}{\left(\frac{\sigma'_v}{p_a}\right)}\right]^{0.5} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(13)}$$

Table 1: Correction Factor (Wenner, 1995)

	Correction factor			
Description	CE	CR	CS	CB
Hammer energy ratio correction	60%	-	-	-
Rod length correction	-	Length: '> 30 ft; CR = 1.00 20-30 ft; CR = 0.95 10-20 ft; CR = 0.85 0 – 10 FT; CR = 0.75	-	-
Sampler correction	-	-	Standard tube; CS = 1.00 With liner; CS = 0.80-0.90	-
Borehole correction	-	-	-	Hole diameter: 2.5″ – 5″; CB = 1.00 5″ – 6″; CB = 1.05

	6" – 8"; CB = 1.15

RESULT

Soil investigations using SPT were carried out at 3 points (sites), namely Site 1 (S1), Site 2 (S2), and Site 3 (S3). The N measurement data (N_{fielsd} = N_M) and the results of the correction to the hammer energy (N_{60}) based on Formula Number (2) are read in Table 2.

Table 2: N_M and N_{60}

`Depth (m)	N_M			N_{60}		
	S1	S2	S3	S1	S2	S3
0.00	0	0	0	0	0	0
0.45	5	6	4	6	7	5
0.90	10	7	6	12	7	7
1.35	15	8	5	18	10	6
1.80	14	12	7	17	14	8
2.25	15	15	9	18	18	11
2.70	18	20	15	22	24	18
3.15	25	28	26	30	34	31
3.60	32	30	33	38	36	40
4.05	24	34	37	29	41	44
4.50	33	30	36	40	36	43
4.95	32	38	38	39	46	46
5.40	22	37	34	26	44	41
5.85	25	29	44	30	35	53
6.30	28	31	45	34	37	54
6.75	35	33	47	42	40	56
7.20	42	36	45	50	43	54
7.65	41	40	47	49	48	56
8.10	43	41	51	52	49	61
8.55	55	52	-	66	62	-
9.00	66	-	-	79	-	-

SPT for 3 points as read in Table 1 shows that the depth of SPT S1 is 9 meters with a variation in N_M values of 5 - 66. S2 is 8.55 meters deep and NM 6-52 while the depth of S3 is 8.10 meters and N_M ranges between 5-51. The graph of the relationship between depth and NM is shown in Figure 3.

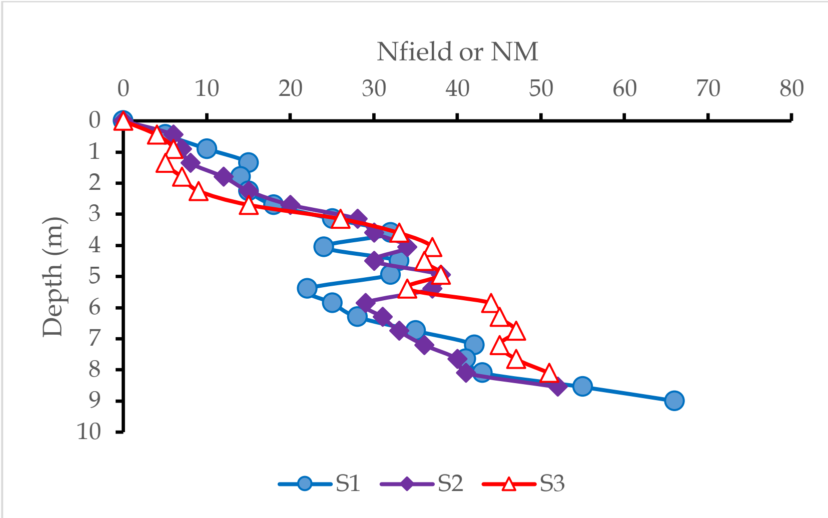

Figure 3. Nfield or NM values S1, S2, and S3

The highest N_M value at the end of the investigation was found in S1, followed by S2 and the lowest in S3. Based on the correction for energy efficiency, N60 was obtained to be greater than N_M. The graph of the relationship between depth and N_{60} can be seen in Figure 4.

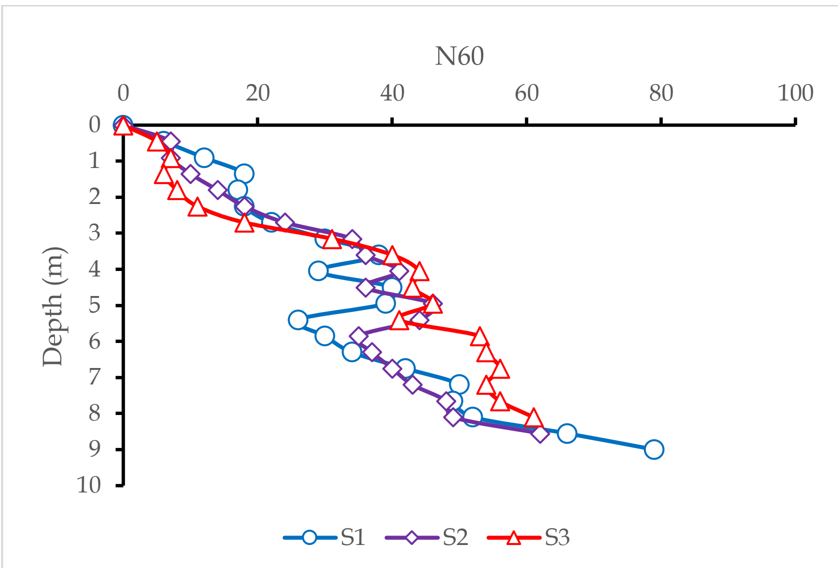

Figure 4. N_{60} values S1, S2, and S3

Based on Formula Number (3), the saturated unit weight and effective unit weight are obtained as shown in Table 2. The highest saturated unit weight value is found in S1, which is 28.65 kN/m^3 and the lowest in S3, which is 25.95 kN/m^3. The effective unit weight value consistently decreases from the saturated unit weight due to the water unit weight value of 9.81 kN/m^3.

Table 3: Saturated and Effective Unit Weight

Depth (m)	γ_{sat} (kN/m^3)			γ' (kN/m^3)		
	S1	S2	S3	S1	S2	S3
0.00	16.80	16.80	16.80	0	0	0
0.45	17.7	17.85	17.55	7.89	8.04	7.74
0.90	18.6	17.85	17.85	8.79	8.04	8.04
1.35	19.5	18.3	17.7	9.69	8.49	7.89
1.80	19.35	18.9	18	9.54	9.09	8.19
2.25	19.5	19.5	18.45	9.69	9.69	8.64
2.70	20.1	20.4	19.5	10.29	10.59	9.69
3.15	21.3	21.9	21.45	11.49	12.09	11.64
3.60	22.5	22.2	22.8	12.69	12.39	12.99
4.05	21.15	22.95	23.4	11.34	13.14	13.59
4.50	22.8	22.2	23.25	12.99	12.39	13.44
4.95	22.65	23.7	23.7	12.84	13.89	13.89
5.40	20.7	23.4	22.95	10.89	13.59	13.14
5.85	21.3	22.05	24.75	11.49	12.24	14.94
6.30	21.9	22.35	24.9	12.09	12.54	15.09
6.75	23.1	22.8	25.2	13.29	12.99	15.39
7.20	24.3	23.25	24.9	14.49	13.44	15.09
7.65	24.15	24	25.2	14.34	14.19	15.39
8.10	24.6	24.15	25.95	14.79	14.34	16.14
8.55	26.7	26.1		16.89	16.29	
9.00	28.65			18.84		

Table 3 shows the saturated unit weight and effective unit weight values which vary for each 45 cm depth interval according to the variation in N_M values. his is made clear in Figure 5.

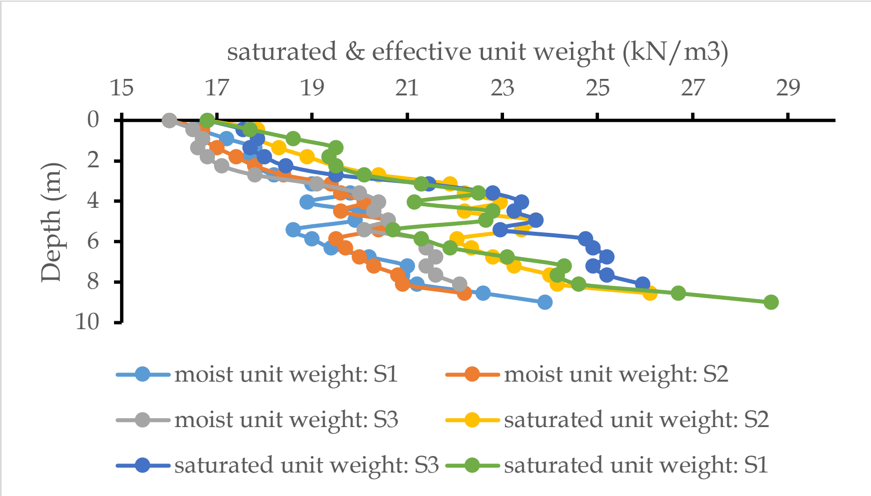

Figure 5. Saturated and effective unit weight vaues S1, S2, and S3

The effective overburden pressure is calculated according to Formula Number (5) and the results are shown in Table 4.

Table 4: Effective Overburden Pressure

	σ'_v (kPa)		
Depth (m)	1	2	3
0.00	0.00	0.00	0.00
0.45	3.55	3.62	3.48
0.90	3.96	3.62	3.62
1.35	4.36	3.82	3.55
1.80	4.29	4.09	3.69
2.25	4.36	4.36	3.89
2.70	4.63	4.77	4.36
3.15	5.17	5.44	5.24
3.60	5.71	5.58	5.85
4.05	5.10	5.91	6.12
4.50	5.85	5.58	6.05
4.95	5.78	6.25	6.25
5.40	4.90	6.12	5.91
5.85	5.17	5.51	6.72
6.30	5.44	5.64	6.79
6.75	5.98	5.85	6.93

7.20	6.52	6.05	6.79
7.65	6.45	6.39	6.93
8.10	6.66	6.45	7.26
8.55	7.60	7.33	-
9.00	8.48	-	-

In general, it can be said that the effective overburden pressure value from the ground surface to the final depth is getting bigger. This is a result of the sum of the effective overburden pressure of the soil layers above the point under review. The increasing value of effective overburden pressure is not always linear with its depth. This condition is caused by the level of soil consistency which is read through a number that indicates its penetration, namely the N value.

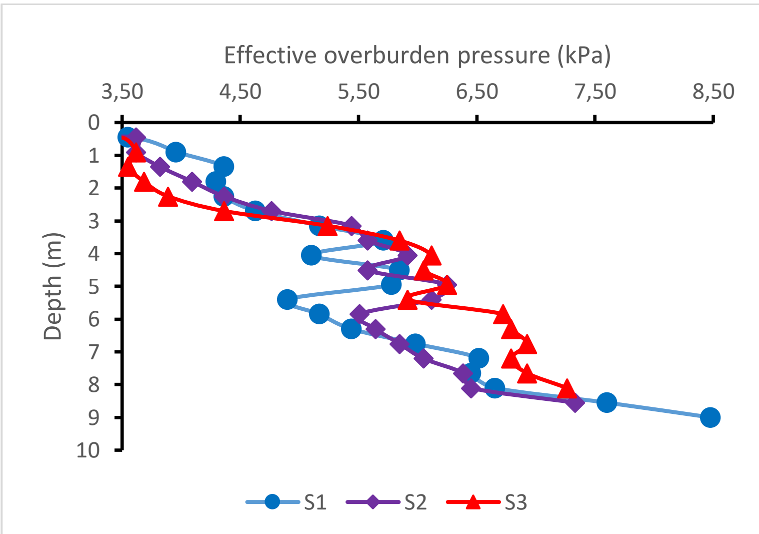

Figure 6. Effective overburden pressure values S1, S2, and S3

Figure 6 shows the variation of effective overburden values that are the basis for calculating the corrected N value (C_N). The C_N values S1, S2, and S3 are read in Tables 5, 6, and 7.

Table 5

Correction Factor (C_N) S1

Depth (m)	SNI 4153:2008	Skempton (1986)	Peck et al (1975)	Tokimatsu & Yoshimi (1983)	Seed et al (1975)	Bazaraa (1967)	Liao & Whitman (1986)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

0.45	1.78	1.93	2.12	2.31	2.81	3.50	5.31
0.90	1.77	1.92	2.08	2.30	2.75	3.45	5.03
1.35	1.77	1.92	2.05	2.29	2.70	3.41	4.79
1.80	1.77	1.92	2.05	2.29	2.71	3.41	4.83
2.25	1.77	1.92	2.05	2.29	2.70	3.41	4.79
2.70	1.77	1.91	2.03	2.28	2.67	3.37	4.65
3.15	1.76	1.90	1.99	2.26	2.61	3.31	4.40
3.60	1.75	1.89	1.96	2.25	2.55	3.26	4.18
4.05	1.76	1.90	2.00	2.26	2.62	3.32	4.43
4.50	1.75	1.89	1.95	2.24	2.54	3.24	4.14
4.95	1.75	1.89	1.96	2.24	2.55	3.25	4.16
5.40	1.76	1.91	2.01	2.27	2.64	3.34	4.52
5.85	1.76	1.90	1.99	2.26	2.61	3.31	4.40
6.30	1.75	1.90	1.98	2.25	2.58	3.29	4.29
6.75	1.75	1.89	1.94	2.24	2.53	3.23	4.09
7.20	1.74	1.88	1.91	2.22	2.48	3.17	3.92
7.65	1.74	1.88	1.92	2.22	2.49	3.18	3.94
8.10	1.74	1.88	1.91	2.22	2.47	3.16	3.88
8.55	1.72	1.86	1.86	2.19	2.40	3.07	3.63
9.00	1.71	1.84	1.83	2.17	2.34	2.99	3.43

The C_N value S1 shows varying values for each method. The SNI 4153:2008 method shows the lowest and highest values in the Liao & Whitman (1986) method. The fluctuation of C_N S1 is explained in Figure 7.

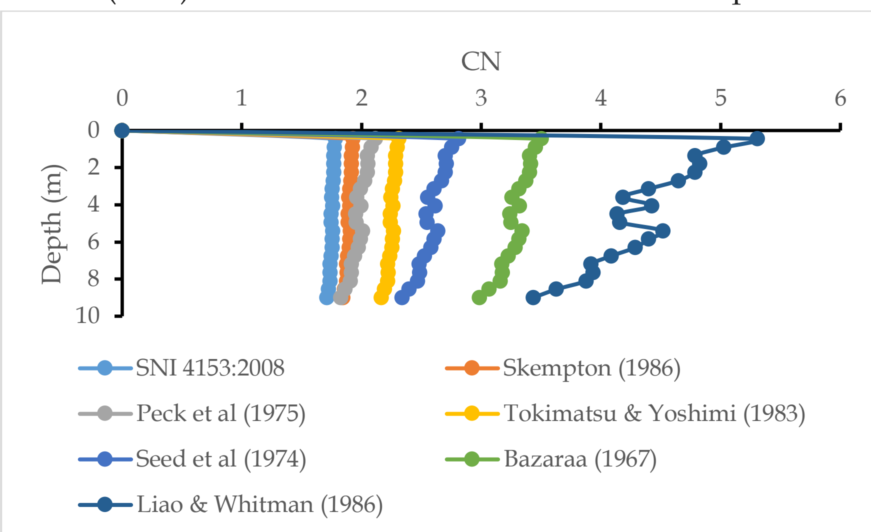

Figure 7. Corrected N (C_N) values SNI 4153:2008 and other methods S1

As in S1, the order of C_N values in S2 is also the same, starting from the lowest value of SNI 4153:2008 and the highest Liao & Whitman (1986).

Table 6: Correction Factor (C_N) S2

Depth (m)	SNI 4153:2008	Skempton (1986)	Peck et al (1975)	Tokimatsu & Yoshimi (1983)	Seed et al (1975)	Bazaraa (1967)	Liao & Whitman (1986)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.45	1.78	1.93	2.11	2.31	2.80	3.49	5.26
0.90	1.78	1.93	2.11	2.31	2.80	3.49	5.26
1.35	1.78	1.93	2.09	2.30	2.77	3.47	5.12
1.80	1.77	1.92	2.07	2.29	2.74	3.44	4.94
2.25	1.77	1.92	2.05	2.29	2.70	3.41	4.79
2.70	1.76	1.91	2.02	2.27	2.65	3.36	4.58
3.15	1.75	1.90	1.98	2.25	2.58	3.29	4.29
3.60	1.75	1.89	1.97	2.25	2.57	3.27	4.24
4.05	1.75	1.89	1.95	2.24	2.54	3.23	4.11
4.50	1.75	1.89	1.97	2.25	2.57	3.27	4.24
4.95	1.74	1.88	1.93	2.23	2.51	3.20	4.00
5.40	1.74	1.88	1.94	2.23	2.52	3.21	4.04
5.85	1.75	1.90	1.97	2.25	2.57	3.28	4.26
6.30	1.75	1.89	1.96	2.25	2.56	3.26	4.21
6.75	1.75	1.89	1.95	2.24	2.54	3.24	4.14
7.20	1.75	1.89	1.94	2.24	2.52	3.22	4.07
7.65	1.74	1.88	1.92	2.23	2.49	3.19	3.96
8.10	1.74	1.88	1.92	2.22	2.49	3.18	3.94
8.55	1.73	1.86	1.88	2.20	2.42	3.09	3.69

The C_N variation in S2 is read in Figure 8 and Figure 9 for S3.

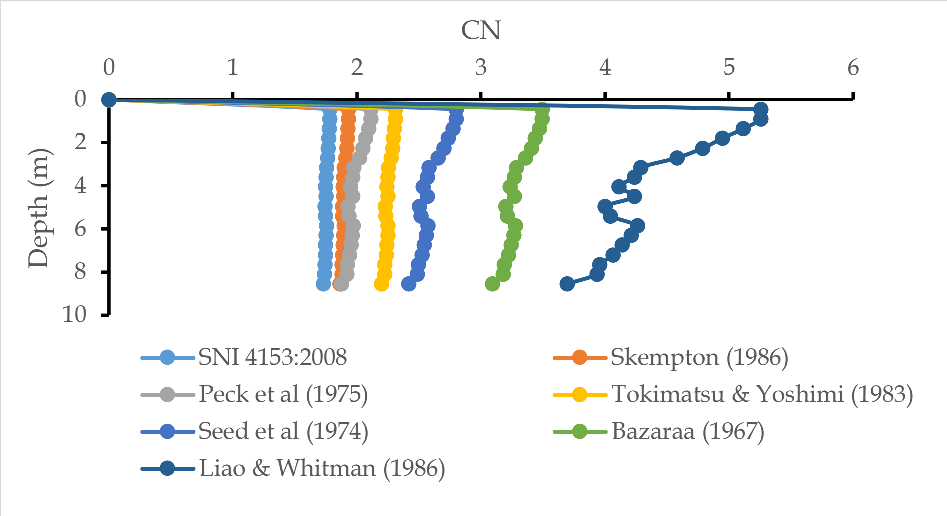

Figure 8. Corrected N (C_N) values SNI 4153:2008 and other methods S2

Table 7: Correction Factor (C_N) S3

Depth (m)	SNI 4153:2008	Skempton (1986)	Peck et al (1975)	Tokimatsu & Yoshimi (1983)	Seed et al (1975)	Bazaraa (1967)	Liao & Whitman (1986)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.45	1.78	1.93	2.11	2.31	2.80	3.49	5.36
0.90	1.78	1.93	2.11	2.31	2.80	3.49	5.26
1.35	1.78	1.93	2.09	2.30	2.77	3.47	5.31
1.80	1.77	1.92	2.07	2.29	2.74	3.44	5.21
2.25	1.77	1.92	2.05	2.29	2.70	3.41	5.07
2.70	1.76	1.91	2.02	2.27	2.65	3.36	4.79
3.15	1.75	1.90	1.98	2.25	2.58	3.29	4.37
3.60	1.75	1.89	1.97	2.25	2.57	3.27	4.14
4.05	1.75	1.89	1.95	2.24	2.54	3.23	4.04
4.50	1.75	1.89	1.97	2.25	2.57	3.27	4.07
4.95	1.74	1.88	1.93	2.23	2.51	3.20	4.00
5.40	1.74	1.88	1.94	2.23	2.52	3.21	4.11
5.85	1.75	1.90	1.97	2.25	2.57	3.28	3.86
6.30	1.75	1.89	1.96	2.25	2.56	3.26	3.84
6.75	1.75	1.89	1.95	2.24	2.54	3.24	3.80
7.20	1.75	1.89	1.94	2.24	2.52	3.22	3.84
7.65	1.74	1.88	1.92	2.23	2.49	3.19	3.80
8.10	1.74	1.88	1.92	2.22	2.49	3.18	3.71

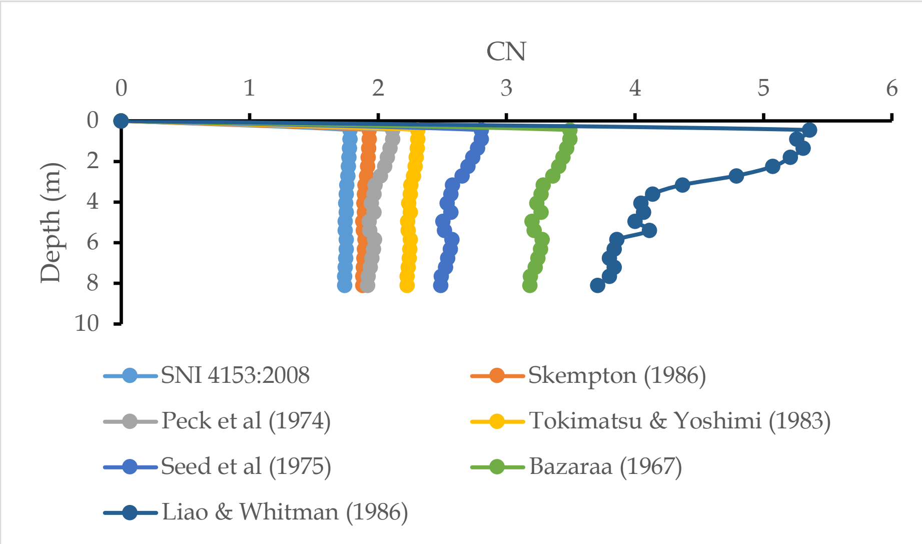

Figure 9. Corrected N (C_N) values SNI 4153:2008 and other methods S3

Average corrected N (CN) values

The corrected N (CN) values as listed in Tables 5, 6, 7, and Figures 7, 8, 9 are read in Table 8.

Table 8: Average Correction Factor (C_N) values

Site (S)	SNI 4153:2008	Skempton (1986)	Peck et al (1974)	Tokimatsu & Yoshimi (1983)	Seed et al (1975)	Bazaraa (1967)	Liao & Whitman (1986)
1	1.75	1.90	1.98	2.25	2.59	3.28	4.34
2	1.75	1.90	1.99	2.26	2.60	3.29	4.37
3	1.75	1.90	1.99	2.25	2.59	3.28	4.36
$\sum$	5.26	5.69	5.96	6.76	7.77	9.86	13.08
C_{Navg}	1.75	1.90	1.99	2.25	2.59	3.29	4.36
C_N Ratio	1.00	1.08	1.13	1.28	1.48	1.87	2.49

Average corrected N (C_N) is read in Figure 10.

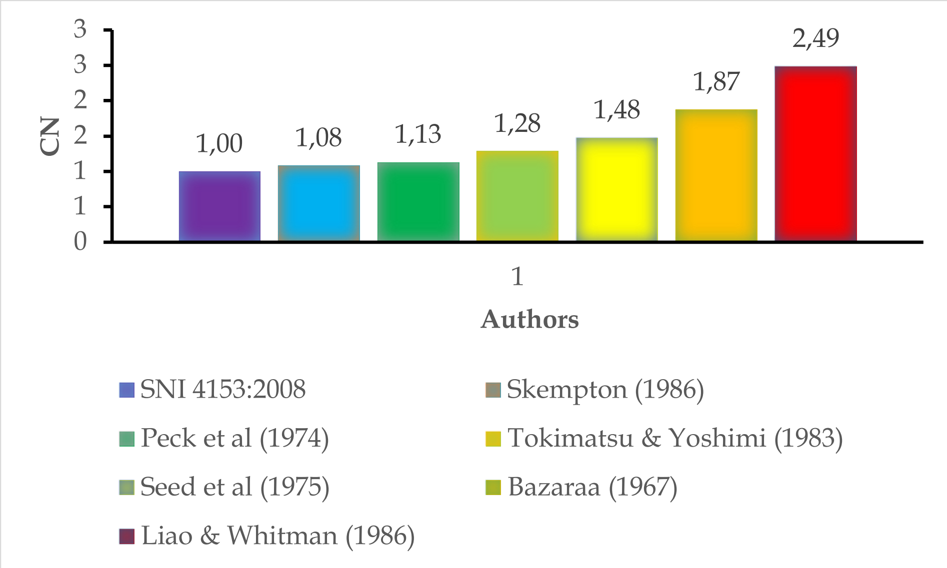

Figure 10. Average corrected N (C_N) values SNI 4153:2008 and other methods

DISCUSSION

Corrected N (C_N) values vary between SNI 4153:2008 and other methods, such as Skempton (1986), Peck et al. (1974), Tokimatsu & Yoshimi (1983), Seed et al. (1975), Bazaraa (1967), and Liao & Whitman (1986). The corrected N (C_N) values according to SNI 4153:2008 method are always at the lowest position and Liao & Whitman (1986) the highest. In fact, all methods are based on the same effective overburden and atmospheric pressure. The differences in question come from the formulas applied to each method, as can be seen in Formulas Numbers (7), (8), (9), (10), (11), (12), and (13).

The results of this study show clear differences in the calculated (N1)60 values when using SNI 4153:2008 compared with several widely used international correction methods. At Site 1 (S1), with an SPT depth of 9 m and Nfield values ranging from 5–66, the corrected N60 values ranged from 6–79 after applying correction factors CE = 1, CR = 1, CD = 1, and CS = 1.2. The resulting (N1)60 values for S1 varied significantly depending on the method used: SNI 4153:2008 produced values of 10.68–135.28, while Liao and Whitman (1986) yielded the highest range (31.84–271.32), followed by Bazaraa (1967) (21.02–235.98), Seed et al. (1975) (16.87–184.83), Tokimatsu and Yoshimi (1983) (13.87–171.13), Peck et al. (1974) (12.71–144.33), and Skempton (1986) (11.59–145.65). These differences highlight the sensitivity of overburden stress corrections and normalization approaches in SPT interpretation, as also emphasized in recent evaluations of SPT energy and correction variability (e.g., Youd et al., 2001; Idriss & Boulanger, 2008).

A similar trend was observed at Site 2 (S2), with an SPT depth of 8.55 m and Nfield values of 6–52, producing N60 values of 7–62. The (N1)60 values from SNI 4153:2008 ranged from 12.46–106.90. In comparison, Liao and Whitman (1986) again produced the highest range (37.15–224.89), followed by Bazaraa (1967) (24.52–190.18), Seed et al. (1975) (19.68–148.73), Tokimatsu and Yoshimi (1983) (16.18–135.82), Peck et al. (1974) (14.83–115.54), and Skempton (1986) (13.52–115.24). The consistency of this pattern across sites suggests that SNI 4153:2008 provides comparatively lower normalized blow counts than most international correlations, especially when compared with Liao and Whitman (1986) and Bazaraa (1967). This agrees with broader literature indicating that different CN formulations can significantly affect normalized SPT values and, consequently, soil classification and design parameters (Robertson & Cabal, 2015; Cetin et al., 2004).

At Site 3 (S3), with an SPT depth of 8.10 m and Nfield values of 4–51, the corrected N60 values ranged from 5–66. The (N1)60 results using SNI 4153:2008 were 8.90–114.64. Other methods again produced higher ranges: Liao and Whitman (1986) 26.54–255.83; Bazaraa (1967) 17.51–208.49; Seed et al. (1975) 14.06–163.09; Tokimatsu and Yoshimi (1983) 11.56–146.37; Peck et al. (1974) 10.59–125.92; and Skempton (1986) 9.66–123.76. The fact that Liao and Whitman (1986) consistently produced the highest (N1)60 values across S1, S2, and S3 indicates that its overburden correction factor leads to significantly greater amplification at lower effective stresses. This is consistent with discussions in the literature that emphasize how exponential or nonlinear CN formulations may produce higher normalized values in shallow or low-stress conditions (Idriss & Boulanger, 2008; Youd et al., 2001).

The comparative ratios further clarify the magnitude of differences between SNI 4153:2008 and other methods. The ratios are SNI vs Skempton (1986) = 1:1.08; SNI vs Peck et al. (1974) = 1:1.13; SNI vs Tokimatsu and Yoshimi (1983) = 1:1.29; SNI vs Seed et al. (1975) = 1:1.48; SNI vs Bazaraa (1967) = 1:1.88; and SNI vs Liao and Whitman (1986) = 1:2.50. These ratios indicate that Skempton (1986) and Peck et al. (1974) provide results most comparable to SNI 4153:2008, while Liao and Whitman (1986) produces values up to 2.5 times higher. Such variation has important implications for geotechnical design, particularly for liquefaction potential evaluation and settlement analysis, where (N1)60 is a key parameter (Youd et al., 2001; Cetin et al., 2004). Overestimation or underestimation of normalized blow counts can directly influence safety factors and foundation design recommendations.

Consequently, the findings demonstrate that although SNI 4153:2008 yields systematically lower (N1)60 values compared with most international methods, its results are closest to Skempton (1986) and Peck et al. (1974). Given that correction factors CE, CR, and CD were equal to 1 and CS was 1.2, the primary source of variation arises from differences in CN formulations rather than field energy corrections. Therefore, the selection of normalization method significantly affects the interpretation of SPT data for the Civil Engineering Laboratory Building at Unika Santu Paulus Ruteng. These results reinforce the importance of carefully selecting overburden correction correlations consistent with local standards and soil conditions, as emphasized in contemporary geotechnical engineering research (Robertson & Cabal, 2015; Idriss & Boulanger, 2008).

CONCLUSION

Correction factor of N value of Site 1 Method SNI 4153:2008 1.75; Skempton (1986) 1.90; Peck et al (1974) 1.98; Tokimatsu & Yoshimi (1983) 2.25; Seed et al (1975) 2.59; Bazaraa (1967) 3.28 and Liao and Whitman

(1986) 4.34. Site 2: SNI 4153:2008 1.75; Skempton (1986) 1.90; Peck et al (1974) 1.99; Tokimatsu & Yoshimi (1983) 2.26; Seed et al (1975) 2.60; Bazaraa (1967) 3.29; Liao and Whitman (1986) 4.37. Site 3: SNI 4153:2008 1.75; Skempton (1986) 1.90; Peck et al (1974) 1.99; Tokimatsu & Yoshimi (1983) 2.25; Seed et al (1975) 2.59; Bazaraa (1967) 3.28; Liao and Whitman (1986) 4.36. Average CN comparison: SNI 4153:2008: Skempton (1986) = 1:1.08; SNI 4153:2008: Peck et al (1974) = 1: 1.13: SNI 4153:2008: Tokimatsu & Yoshimi (1983) = 1:1.28; SNI 4153:2008: Seed et al (1975) = 1:1.48; SNI 4153:2008: Bazaraa (1967) = 1.87, and SNI 4153:2008: Liao and Whitman (1986) = 1:2.49.

REFERENCES

Ali, B. (2023). Contribution of the standard penetration test SPT to the design of pile foundations in sand–Practical recommendations. *Journal of Engineering Research (2307-1877)*, *11*(3). 55-68.

Arshid, M. U. (2021). Knowledge based prediction of standard penetration resistance of soil using geotechnical database. *Civ Eng J*, *7*, 1-2.

Baban, T. M. (2015). *SHALLOW FOUNDATION (Discussions and Problem Solving)*.

Bowles, J. E. (1997). Foundation Analysis and Design. In *Civil Engineering Materials*.

BSN. (2008). Cara Uji Penetrasi Lapangan dengan Alat Sondir. In *Badan Standardisasi Nasional*.

Cetin, K. O., Seed, R. B., Der Kiureghian, A., Tokimatsu, K., Harder, L. F., Kayen, R. E., & Moss, R. E. S. (2004). Standard penetration test-based probabilistic and deterministic assessment of seismic soil liquefaction potential. *Journal of Geotechnical and Geoenvironmental Engineering,130*(12),1314–1340. https://doi.org/10.1061/(ASCE)1090-0241(2004)130:12(1314)

Dananjaya, R. H., Djarwanti, N., & Rahma, H. A. (2020). Perhitungan Kapasitas Dukung Fondasi Tiang Tunggal Menggunakan Clustering Data Standard Penetration Test (SPT). *Matriks Teknik Sipil*, *8*(1). 28-38.

Das, B. M. (2004). Shallow Foundation (Bearing Capacity and Settlement). In *Geotextiles and Geomembranes* (Vol. 22, Issue c).

Das, B. M. (2019). Geotechnical Engineering Handbook. In *Library of Congress Cataloging-in-Publication Data Geotechnical* (Vol. 11, Issue 1).

Haifani, A. M. (2021). Developing New Relationship between Standard Penetration, Cone Penetration Test and Sleeve Friction in Various Soil Type. *Journal of Hunan University Natural Sciences*, *48*(4). 177-186.

Husain, R. S. (2016). *Standard Penetration Test in Predicting the Shear Strength and the Cyclic Mobility of Fine Grained Soils* (Master's thesis, Eastern Mediterranean University EMU-Doğu Akdeniz Üniversitesi (DAÜ)).

Ibrahim, M. O., Raheem, A. M., Naser, I. J., Omar, N. Q., & Najmadeen, K. T. (2023). Correlating standard penetration test (SPT) with various soil properties in different Kirkuk City Locations: A case study utilizing inverse distance weighted (IDW) for assessment and prediction. In *E3S Web of Conferences* (Vol. 427, p. 01005). EDP Sciences.

Idriss, I. M., & Boulanger, R. W. (2008). Soil liquefaction during earthquakes. *Earthquake Engineering Research Institute Monograph*. https://doi.org/10.1193/1.2981503

Ji, P., Yang, J., Zhang, N., Zhai, Q., Li, M., Wang, Y., ... & Satyanaga, A. (2023). Energy Measurement in Standard Penetration Tests. *Sustainability*, *15*(6), 4763.

Listanti, S. N. R., Darsono, D., & Purwana, Y. M. (2018). A Comparison between Drilling and Standard Penetration Test (SPT) Data to the Electrical Resistivity Sounding with Schlumberger Configuration in UNS Area. *Indones. J. Appl. Phys*, *8*(2), 67-74.

Miller, K. H. (2022). *An investigation of standard penetration test hammer efficiency through measurement of impact velocity and stress wave energy* (Doctoral dissertation, University of British Columbia).

Pratama, R. T., Sarie, F., & Hendri, O. (2021). Analisis Perbaikan Tanah Menggunakan Geotekstil Pada Lapisan Subgrade Proyek Pekerjaan Jalan (Studi Kasus: Peningkatan Jalan G. Obos XXIV Kota Palangka Raya). *Jurnal Teknika: Jurnal Teoritis Dan Terapan Bidang Keteknikan*, *4*(2), 148-154.

Robertson, P. K., & Cabal, K. L. (2015). Guide to cone penetration testing for geotechnical engineering. *Canadian Geotechnical Journal, 52*(11), 1713–1733. https://doi.org/10.1139/cgj-2014-0431

Ruge, J. C., Mendoza, C. C., Colmenares, J. E., Cunha, R. P., & Otalvaro, I. F. (2018). Analysis of the undrained shear strength through the standard penetration test with torque (SPT-T). *GEOMATE Journal*, *14*(41), 102-110.

Sari, U. C., Sholeh, M. N., Pratama, M. M. A., Aritonang, I. J., & Prasetya, F. D. (2021). Analisis Kapasitas Daya Dukung Pada Ragam Pondasi Beton Bulat Menggunakan Standard Penetration Test (SPT). *Pondasi*, *26*(1), 38-47.

Sophia Alta, E. P., Prakoso, J., Zakaria, Z., & Sophiaan, I. (2019). Daya Dukung Pondasi dalam Daerah Panyipatan, Tanah Laut, Kalimantan Selatan Berdasarkan Hasil Standard Penetration Test. *Geoscience Journal*, *3*(1), 1-8.

Sumanth, H. C., Parthasarathy, C. R., Nandhagopal, A. R., & Ramachandra, A. S. (2022, December). Significance of Energy Transfer Ratio in Standard Penetration Test and Its Influence on Foundation Design. In *Indian Geotechnical Conference* (pp. 269-282). Singapore: Springer Nature Singapore.

Sun, M., Zhang, Q., Sun, H., & Weng, Z. (2023). Experimental Study on Axial Stress and Hammer Impacting Energy of Offshore Standard Penetration Test. *Applied Sciences*, *13*(17), 9487.

Tan, J. J., & Ramli, H. (2023). Effect of standard penetration test corrections on the estimation of undrained shear strength. *Journal of Civil Engineering and Management*, *29*(6), 501-515.

Verbrugge, J. C., & Schroeder, C. (2018). *Geotechnical correlations for soils and rocks*. John Wiley & Sons.

Victoria, L. C., de Freitas Hermes, V., Vaz, J., Costi, J., Marques, W. C., Rocha, L. A. O., ... & Isoldi, L. A. (2020). Methodology allying standard penetration test and era-interim data set for numerical simulations of earth-air heat exchangers. *ADVANCED RESEARCH IN FLUID MECHANICS AND THERMAL SCIENCES*, *76*(2), 43-64.

Wener, C. R. (1995). *Standard penetration test correlations for Las Vegas soils*. University of Nevada, Las Vegas.

Widiarso, D. A., Qadaryati, N., & Winarno, T. (2025). The bearing capacity based on standard penetration test. In *E3S Web of Conferences* (Vol. 605, p. 03056). EDP Sciences.

Youd, T. L., Idriss, I. M., Andrus, R. D., Arango, I., Castro, G., Christian, J. T., ... & Stokoe, K. H. (2001). Liquefaction resistance of soils: Summary report from the 1996 NCEER and 1998 NCEER/NSF workshops. *Journal of Geotechnical and Geoenvironmental Engineering, 127*(10),817–833.https://doi.org/10.1061/(ASCE)1090-0241(2001)127:10(817)

Yusof, N. Q. A. M., & Zabidi, H. (2018), August). Reliability of using standard penetration test (SPT) in predicting properties of soil. In *Journal of Physics: Conference Series* (Vol. 1082, No. 1, p. 012094). IOP Publishing.