Proceeding 6th International Conference on Sustainable Development (ICSD) 2023
"Collaborative Inovation on Research and Community Empowerment for Sustainable Development"
ISBN : 978-623-5839-12-7

Soil Investigation Analysis Using the Sondir Testing Method in The Jalan Pura Demak Area, Denpasar

Krisna Kurniari [1,b)], I Gede Angga Diputera [2,a)],
I Gusti Agung Ayu Istri Lestari[3,c)]

Author Affiliations
[123] *Civil Engineering Department of Universitas Mahasaraswati Denpasar, Bali, Indonesia*

Author Emails
[a)] *Corresponding author: anggadiputera@unmas.ac.id*
[b)] *krisnakurniari@unmas.ac.id*
[c)] *gekistri82@unmas.ac.id*

Abstract. The structure is calculated not only based on its own load bearing strength but must also take into account the soil bearing capacity. The soil bearing capacity is the maximum load per unit area where the land can still support the load without collapsing, taking into account safety factors (1). One way to find out the carrying capacity of land permits is by direct sondir testing in the field. In this research, sondir testing was carried out in the Jalan Pura Demak area, Denpasar. This location was chosen because of the rapid development in the area. Soil testing was carried out at three adjacent points. From the results of the sondir test, it was found that hard soil conditions began to be detected by the tip of the sondir cone at a depth of 2.8 meters (point 1), a depth of 3 meters (point 2) and a depth of 3.2 meters (point 3). Soil bearing capacity is analyzed using the Meyerhoff formula (2). The analysis results show that if the structural load is light, the use of reinforced concrete footings has provisions starting at a foundation depth of 1.6 meters from the ground surface and a soil bearing capacity of or 102 KN/m2.Meanwhile, for relatively heavy structural loads, it is recommended to use pile foundations with a depth of more than 3 meters from the ground surface, with a soil bearing capacity of 613 KN/m2.

Keyword. Denpasar, Soil Bearing Capacity, Sondir testing.

INTRODUCTION

Construction is a very complex field, consisting of parts that are interrelated with each other. Foundation is a part of the construction of the lower building (sub structure) that functions to continue the load of the upper construction (upper structure / super structure) which must be strong and safe to support the load of the upper construction (upper structure / super structure) and the weight of the foundation itself (3). In planning the foundation of building construction, a soil investigation is needed. Soil research aims to determine the soil parameters that will be used in calculating the carrying capacity of foundation soil. The carrying capacity of the soil greatly affects the shape and dimensions of the foundation in order to obtain optimal foundation planning. The carrying capacity of the soil is the maximum load of the unity of the area where the soil is able to support the load without collapsing, considering the safety factor. One way to determine the carrying capacity of the soil is by sondir testing or Cone Penetration test (CPT) in the field (4).

In this study, sondir testing was carried out in the area of Jalan Pura Demak, Denpasar. This location was chosen because of the rapid development in the area. It is hoped that with this test, the value of soil carrying capacity in the area can be known, as well as clear provisions related to development that requires soil carrying capacity value.

LITERATUR REVIEW

Soil Investigation

Soil investigation is one of the activities in the geotechnical field carried out to obtain soil properties and characteristics for the benefit of engineering design (engineering). There are 2 types of soil investigations namely,

ISBN : 978-623-5839-12-7

field investigations and laboratory investigations. (5). There are two types of field investigations, namely sondir and boring (6).

Sondir Test / CPT

In the design of foundation soil structures, stability analysis and calculation of building foundation design are often carried out using soil parameters, both total voltage and effective voltage. The parameter of penetrating resistance can be obtained in different ways. One of them is by doing a Sondir test or CPT (Cone Penetration Test) (4). The purpose of sondir testing or CPT is to obtain parameters of soil layer penetration resistance in the field (quasi-static penetration). These parameters are conus resistance (qc), shear resistance (fs), shear banding number (Rf), and total ground shear (Tf). The soil parameters of each layer can be easily obtained and analyzed by performing sondir or CPT testing. The values of static cone resistance or conus resistance (qc) obtained from testing can be directly correlated with the bearing capacity of the soil (4).

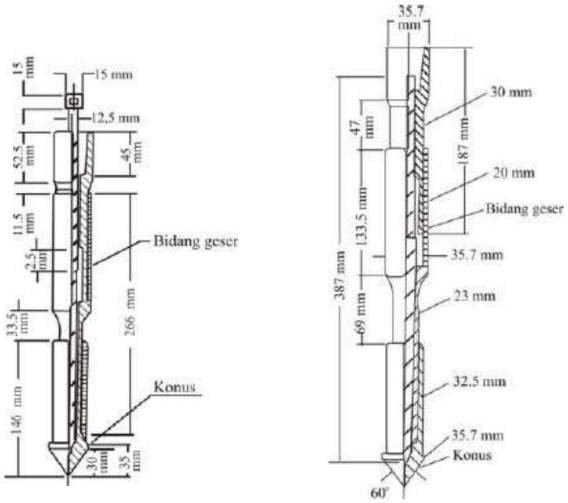

Figure 1. Sondir Tool

Soil Bearing Capacity

The Bearing capacity of the soil is the maximum load of the unity of the area where the soil is able to support the load without collapsing, considering the safety factor. The calculation of the carrying capacity of the soil uses the Meyerhof formula.. (1)

$\sigma_{Ijin} = \frac{qc}{30}$ ..... kPa/100 (kg/cm^2) (1)

Provided that B ≤ 1.2 meters,

$\sigma_{Ijin} = \frac{qc}{50(1+\frac{0,3}{B})^2}$.....kPa/100 (kg/cm^2) (2)

Provided that B >1,2 meter,

$\sigma_{Ijin} = \frac{qc}{40}$ .....kPa/100 (kg/cm^2) (3)

By not taking into account the width of the foundation.

Information :

σ_{ijin} : allowable soil bearing capacity on allowable foundation weaving of 1"

qc : The statistical mean value of the conus value pressure in the area of influence of the foundation is 0.5 meters above the palm to 1 meter below the palm

B : The size of the foundation width

ISBN : 978-623-5839-12-7

METHODS

Soil investigation is carried out by sondir testing. The implementation in the field is in the area of Jalan Pura Demak. Sondir testing was carried out as many as 3 points close together. The test used a sondir capacity of 2.5 tons. Testing is carried out until it reaches hard ground or until it reaches the maximum capacity of the rod sondir depth that can be reached, which is 20 meters. The readings on the manometer are then recorded and analyzed using the Meyerhoff formula so that the carrying capacity of the soil permit can be obtained.

RESULT AND DISCUSSION

Sondir Test Result

The data from the manometer reading on the sondir device is end resistance / conus (end resistance / cone resistance) with the symbol CR expressed in kg / cm 2 and total resistance (total resistance) expressed in kg / cm^2, then the calculation of the skin friction of the SF symbol is expressed in kg / cm and the number of sticky resistance (total skin friction) TSF symbol is expressed in kg / cm. Furthermore, it is depicted in the form of a graphic sondering test, namely the relationship of cone resistance with depth and the relationship between the amount of total skin friction and depth. Based on the results of sondir penetration testing, namely from conus resistance data (cone resistant = CR), the relative density level of the soil layer can be known, namely:

Table 1. Sondir Test Result Point 1

Depth (meters)	Cone Resistant Value Cw kPa/100	Average Cone resistant qc kPa/100	Total Resistant Tw kPa/100	Shear Friction	Local Friction Fs kPa/100	Skin Friction Fs x 20 cm	Total Skin Friction Tf kPa/100	Friction Ratio Rf (%)
0.00								
0.20	10	15.5	15	5	0.5	10	10	5.0
0.40	12	15.4	18	6	0.6	12	22	5.0
0.60	15	15.8	22	7	0.7	14	36	4.7
0.80	18	17.0	25	7	0.7	14	50	3.9
1.00	20	18.3	30	10	1	20	70	5.0
1.20	18	24.9	25	7	0.7	14	84	3.9
1.40	15	35.1	22	7	0.7	14	98	4.7
1.60	18	63.9	22	4	0.4	8	106	2.2
1.80	20	70.4	28	8	0.8	16	122	4.0
2.00	22	79.7	28	6	0.6	12	134	2.7
2.20	68	92.0	70	2	0.2	4	138	0.3
2.40	100	110.0	105	5	0.5	10	148	0.2
2.60	250	139.0	250	0	0	0	148	0.0
2.80		250.0						

ISBN : 978-623-5839-12-7

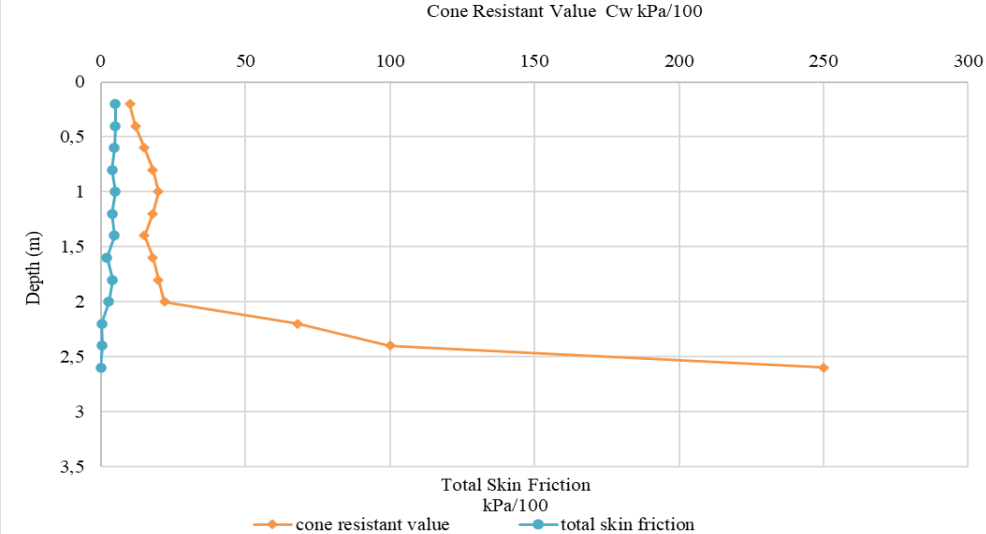

Figure 2. Graphic Sondering Test Point 1

Table 2. Sondir Test Result Point 2

Depth (meters)	Cone Resistant Value Cw kPa/100	Average Cone resistant qc kPa/100	Total Resistant Tw kPa/100	Shear Friction	Local Friction Fs kPa/100	Skin Friction Fs x 20 cm	Total Skin Friction Tf kPa/100	Friction Ratio Rf (%)
0.00								
0.20	10	10.0	15	5	0.5	10	10	5.0
0.40	8	11.1	12	4	0.4	8	18	5.0
0.60	5	12.3	7	2	0.2	4	22	4.0
0.80	10	13.3	15	5	0.5	10	32	5.0
1.00	12	14.1	18	6	0.6	12	44	5.0
1.20	15	17.0	20	5	0.5	10	54	3.3
1.40	18	28.0	25	7	0.7	14	68	3.9
1.60	20	41.5	28	8	0.8	16	84	4.0
1.80	18	70.9	25	7	0.7	14	98	3.9
2.00	15	78.4	22	7	0.7	14	112	4.7
2.20	28	88.2	36	8	0.8	16	128	2.9
2.40	98	102.2	100	2	0.2	4	132	0.2
2.60	120	124.0	122	2	0.2	4	136	0.2
2.80	250	156	250	0	0	0	136	0
3.00		250						

ISBN : 978-623-5839-12-7

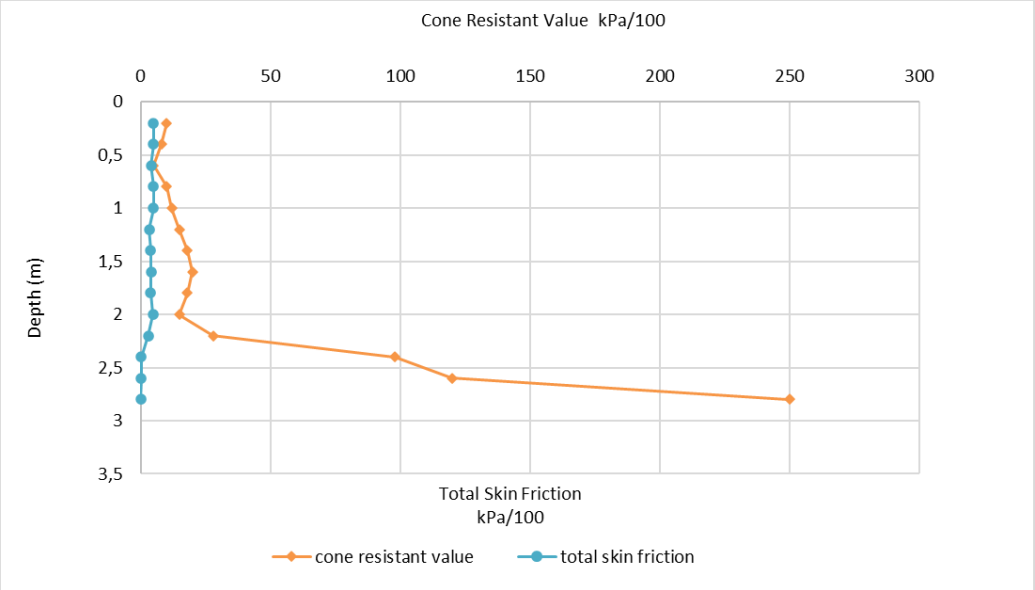

Figure 3. graphic sondering test point 2

Table 2. Sondir Test Result Point 3

Depth (meters)	Cone Resistant Value Cw kPa/100	Average Cone Resistant qc kPa/100	Total Resistant Tw kPa/100	Shear Friction	Local Friction Fs kPa/100	Skin Friction Fs x 20 cm	Total Skin Friction Tf kPa/100	Friction Ratio Rf (%)
0.00								
0.20	10	11.8	15	5	0.5	10	10	5.0
0.40	12	12.3	18	6	0.6	12	22	5.0
0.60	10	13	15	5	0.5	10	32	5.0
0.80	12	14.3	18	6	0.6	12	44	5.0
1.00	15	16.3	18	3	0.3	6	50	2.0
1.20	12	19.8	18	6	0.6	12	62	5.0
1.40	15	26.0	18	3	0.3	6	68	2.0
1.60	18	42.9	22	4	0.4	8	76	2.2
1.80	20	63.6	28	8	0.8	16	92	4.0
2.00	28	93.0	35	7	0.7	14	106	2.5
2.20	38	103.7	40	2	0.2	4	110	0.5
2.40	62	117.7	70	8	0.8	16	126	1.3
2.60	150	135.6	155	5	0.5	10	136	0.3
2.80	178	160.0	180	2	0.2	4	140	0.1
3.00	250	192.7	250	0		0	140	0.0
3.20		250						

ISBN : 978-623-5839-12-7

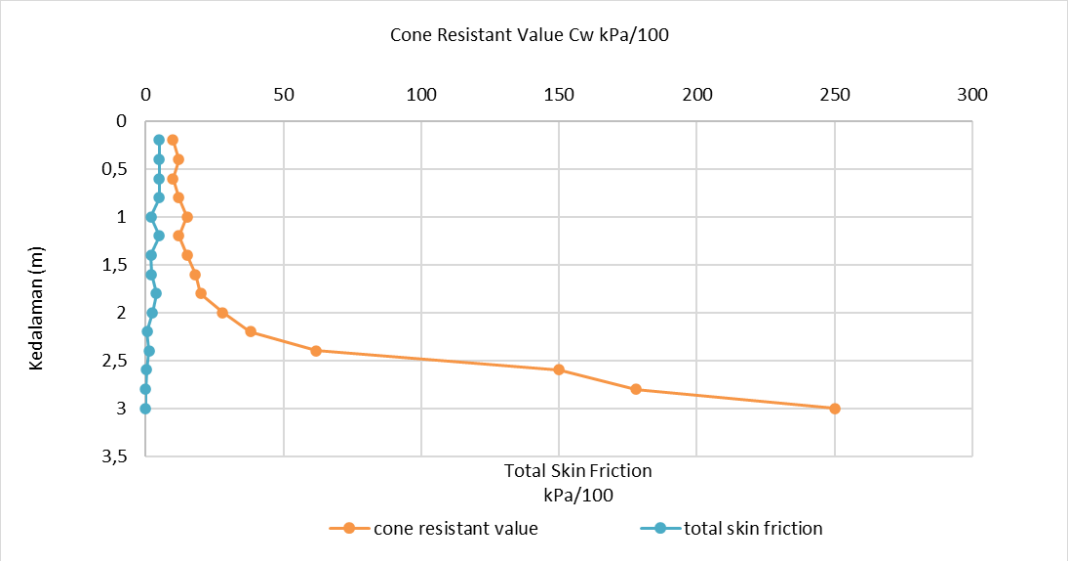

Figure 4. Graphic sondering test point 3

Based on tables 1, 2, 3 and figures 1, 2, 3 it can be seen that hard soil conditions began to be detected by the tip of the sondir cone at a depth of 2.8 meters (point 1), a depth of 3 meters (point 2) and a depth of 3.2 meters (point 3).

Soil Bearing Capacity

The earing capacity of the soil is analyzed using the Meyerhoff formula. The calculation results can be seen in the table below.

Table 3. Soil bearing capacity Point 1

Depth (meters)	average of cone resistant qc kPa/100	Allowable soil capacity for any foundation width (B)										allowable stress without considering the foundation width kPa/100
		B = 0.6 m	B = 0.8 m	B = 1.0 m	B = 1.2 m	B = 1.4 m	B = 1.6 m	B = 1.8 m	B = 2.0 m	B = 2.4m	B = 2.6 m	
0.20	15.5	0.52	0.52	0.52	0.52	0.46	0.44	0.42	0.41	0.39	0.39	0.39
0.40	15.4	0.51	0.51	0.51	0.51	0.45	0.44	0.42	0.41	0.39	0.38	0.39
0.60	15.8	0.53	0.53	0.53	0.53	0.46	0.44	0.43	0.42	0.4	0.39	0.39
0.80	17.0	0.57	0.57	0.57	0.57	0.50	0.48	0.46	0.45	0.43	0.42	0.43
1.00	18.3	0.61	0.61	0.61	0.61	0.54	0.52	0.50	0.48	0.46	0.45	0.46
1.20	24.9	0.83	0.83	0.83	0.83	0.73	0.70	0.68	0.66	0.63	0.62	0.62
1.40	35.1	1.17	1.17	1.17	1.17	1.04	0.99	0.96	0.93	0.89	0.87	0.88
1.60	63.9	2.13	2.13	2.13	2.13	1.88	1.80	1.74	1.69	1.62	1.59	1.60
1.80	70.4	2.35	2.35	2.35	2.35	2.08	1.99	1.92	1.86	1.78	1.75	1.76
2.00	79.7	2.66	2.66	2.66	2.66	1.35	2.25	2.17	2.11	2.02	1.98	1.99
2.20	92.0	3.07	3.07	3.07	3.07	2.71	2.60	2.50	2.43	2.33	2.29	2.30
2.40	110.0	3.67	3.67	3.67	3.67	3.24	3.11	2.99	2.91	2.78	2.74	2.75
2.60	139.0	4.64	4.64	4.64	4.64	4.11	3.93	3.79	3.69	3.53	3.47	3.48
2.80	250.0	8.33	8.33	8.33	8.33	7.37	7.06	6.81	6.61	6.33	6.22	6.25

ISBN : 978-623-5839-12-7

Tabel 4. Soil bearing capacity Point 2

Depth (meters)	average of cone resistant qc kPa/100	Allowable soil capacity for any foundation width (B)										allowable stress without considering the foundation width kPa/100
		B = 0.6 m	B = 0.8 m	B = 1.0 m	B = 1.2 m	B = 1.4 m	B = 1.6 m	B = 1.8 m	B = 2.0 m	B = 2.4m	B = 2.6 m	
0.20	10.0	0.33	0.33	0.33	0.33	0.29	0.28	0.27	0.26	0.25	0.25	0.25
0.40	11.1	0.37	0.37	0.37	0.37	0.33	0.31	0.30	0.29	0.28	0.28	0.28
0.60	12.3	0.41	0.41	0.41	0.41	0.36	0.35	0.33	0.32	0.31	0.30	0.31
0.80	13.3	0.44	0.44	0.44	0.44	0.39	0.37	0.36	0.35	0.34	0.33	0.33
1.00	14.1	0.47	0.47	0.47	0.47	0.42	0.40	0.38	0.37	0.36	0.35	0.35
1.20	17.0	0.57	0.57	0.57	0.57	0.50	0.48	0.46	0.45	0.43	0.42	0.43
1.40	28.0	0.93	0.93	0.93	0.93	0.83	0.79	0.76	0.74	0.71	0.70	0.70
1.60	41.5	1.38	1.38	1.38	1.38	1.22	1.17	1.13	1.10	1.05	1.03	1.04
1.80	70.9	2.36	2.36	2.36	2.36	2.09	2.00	1.93	1.87	1.79	1.76	1.77
2.00	78.4	2.61	2.61	2.61	2.61	2.31	2.21	2.13	2.07	1.99	1.95	1.96
2.20	88.2	2.94	2.94	2.94	2.94	2.60	2.49	2.40	2.33	2.23	2.19	2.20
2.40	102.2	3.41	3.41	3.41	3.41	3.01	2.89	2.78	2.70	2.59	2.54	2.56
2.60	124.0	4.13	4.13	4.13	4.13	3.66	3.50	3.38	3.28	3.14	3.09	3.10
2.80	156	5.20	5.20	5.20	5.20	4.60	4.40	4.25	4.13	3.95	3.88	3.90
3.00	250	8.33	8.33	8.33	8.33	7.37	7.06	6.81	6.61	6.33	6.22	6.25

Tabel 5. Soil bearing capacity Point 3

Depth (meters)	average of cone resistant qc kPa/100	Allowable soil capacity for any foundation width (B)										allowable stress without considering the foundation width kPa/100
		B = 0.6 m	B = 0.8 m	B = 1.0 m	B = 1.2 m	B = 1.4 m	B = 1.6 m	B = 1.8 m	B = 2.0 m	B = 2.4m	B = 2.6 m	
0.20	11.8	0.39	0.39	0.39	0.39	0.35	0.33	0.32	0.31	0.30	0.29	0.30
0.40	12.3	0.41	0.41	0.41	0.41	0.36	0.35	0.33	0.32	0.31	0.31	0.31
0.60	13.0	0.43	0.43	0.43	0.43	0.38	0.37	0.35	0.34	0.33	0.32	0.33
0.80	14.3	0.48	0.48	0.48	0.48	0.42	0.40	0.39	0.38	0.36	0.35	0.36
1.00	16.3	0.54	0.54	0.54	0.54	0.48	0.46	0.44	0.43	0.41	0.40	0.41
1.20	19.8	0.66	0.66	0.66	0.66	0.58	0.56	0.54	0.52	0.50	0.49	0.49
1.40	26.0	0.87	0.87	0.87	0.87	0.77	0.73	0.71	0.69	0.66	0.65	0.65
1.60	42.9	1.43	1.43	1.43	1.43	1.26	1.21	1.17	1.13	1.09	1.07	1.07
1.80	63.6	2.12	2.12	2.12	2.12	1.88	1.80	1.73	1.68	1.61	1.58	1.59
2.00	93.0	3.10	3.10	3.10	3.10	2.74	2.63	2.53	2.46	2.35	2.31	2.33
2.20	103.7	3.46	3.46	3.46	3.46	3.06	2.93	2.82	2.74	2.63	2.58	2.59
2.40	117.7	3.92	3.92	3.92	3.92	3.47	3.32	3.20	3.11	2.98	2.93	2.94
2.60	135.6	4.52	4.52	4.52	4.52	4.00	3.83	3.69	3.59	3.43	3.37	3.39
2.80	160.0	5.33	5.33	5.33	5.33	4.72	4.52	4.36	4.23	4.05	3.98	4.00
3.00	192.7	6.42	6.42	6.42	6.42	5.68	5.44	5.24	5.10	4.88	4.79	4.82
3.20	250	8.33	8.33	8.33	8.33	7.37	7.06	6.81	6.61	6.33	6.22	6.25

ISBN : 978-623-5839-12-7

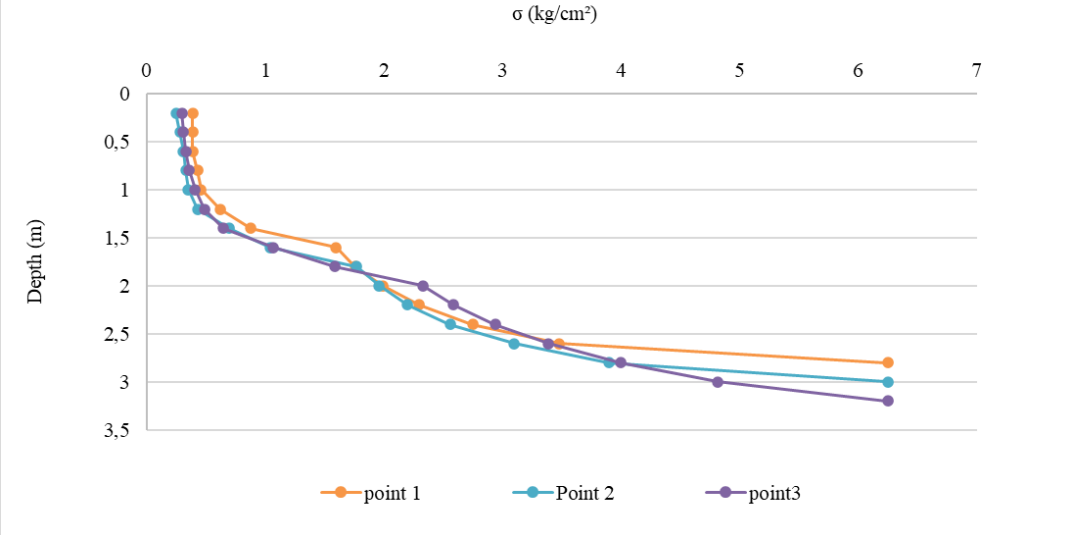

Figure 4. Graphic Soil Bearing Capacity

CONCLUSION

Soil testing was carried out at three adjacent points. From the results of the sondir test, it was found that hard soil conditions began to be detected by the tip of the sondir cone at a depth of 2.8 meters (point 1), a depth of 3 meters (point 2) and a depth of 3.2 meters (point 3). Soil bearing capacity is analyzed using the Meyerhof formula. The analysis results show that if the structural load is light, the use of reinforced concrete footings has provisions starting at a foundation depth of 1.6 meters from the ground surface and a soil bearing capacity of or 102 KN/m^2. Meanwhile, for relatively heavy structural loads, it is recommended to use pile foundations with a depth of more than 3 meters from the ground surface, with a soil bearing capacity of 613 KN/m^2.

ACKNOWLEDGMENTS

Thank you to the Head of Pemecutan Kelod Village who gave permission to conduct research in the area.

REFERENCES

1. Krisantos Ria Bela, Paulus Sianto, Waani JE, Ticoh JH, Mandagi AT, Supit CJ. PENYELIDIKAN TANAH MENGGUNAKAN METODE UJI SONDIR. Eternitas J Tek Sipil [Internet]. 2022;2(1):50–8. Available from: https://journal.unwira.ac.id/index.php/ETERNITAS/article/view/1755
2. Waani JE, Ticoh JH, Mandagi AT, Supit CJ. Studi Daya Dukung Ijin Tanah Berdasarkan Hasil Uji Sondir Di Lokasi Kel. Malalayang, Area Perum Aleandrew, Manado. 2022;20(April):139–46. Available from: https://ejournal.unsrat.ac.id/v3/index.php/tekno/article/view/43216
3. Daya Dukung Tanah Pada Perencanaan Proyek Gedung Dengan Metode Terzaghi A, Dan Vesic H, Analisis Kapasitas Saluran Pada Proyek Normalisasi Sungai di Desa Adat Peminge Banjar Sawangan Nusa Dua Bali P. Articles Analisis Riwayat Waktu Perilaku Struktur Gedung SMA Negeri 9 Denpasar. J Ilm Kurva Tek [Internet]. 2021;10(2). Available from: https://e-journal.unmas.ac.id/index.php/jikt/issue/view/176
4. Badan Standarisasi Nasional. SNI 2827-2008 Cara Uji Penetrasi Lapangan Dengan Alat Sondir. 2008.
5. "Badan Standardisasi Nasional Standar Nasional Indonesia Persyaratan perancangan geoteknik. 2017; Available from: www.bsn.go.id
6. BSNI. SNI 8460-2017 Persyaratan Perancangan Geoteknik. Vol. 8460. 2017. 2017 p.