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STUDY ON THE SIMILARITY BETWEEN SWEDISH WEIGHT SOUNDING AND UNCONFINED COMPRESSIVE STRENGTH OF SOIL FOR CONSTRUCTIONAL PURPOSES (A CASE STUDY OF CLAY SOILS OF ORO TOWN IN IREPODUN LOCAL GOVERNMENT AREA, KWARA STATE

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ABSTRACT

This study attempt to correlate the Swedish weight sounding test results with that of unconfined comprehensive strength of clay soils of Oro Town in Irepodun Local Government area in Kwara State at different consistency field locations field and Laboratory testing programs were carried out at different sites that comprises common soil types in Oro town. Undisturbed and disturbed soil sample were obtained from different depths. Laboratory test were conducted on soil samples in order to determine the unconfined compressive strength; and soils physical properties. The results of both the field and laboratory tests were finally analyzed and correlated. The developed correlation showed that there is a linear relationship between Swedish weight sounding and unconfined compressive strength| test results. The relationship can be used to estimate the natural undrained shear strength of the soil under investigation from the Swedish weight sounding test results obtained.

Keywords:- *Analysis, Assessment, correlation, weight sounding equipment, unconfined compressive strength of soils, Oro Town.*

INTRODUCTION

The Swedish weight sounding equipment is generally known to be one of the penetration equipments that is used to determine the relative resistance that is offered by the different soil strata. The equipment is portable and generally tests can be conducted by operators with minimum training efforts. The test results obtained by using the equipment are usually recorded by the number of half – turns required to penetrate a given distance. The application of this method is generally known to be fast, Economical and it has also been proved in other countries of the world that the results obtained from this equipment successfully correlated with the standard Laboratory test result. The developed correlation in this study showed that there is a linear relationship between Swedish weight sounding and unconfined compressive strength test results of clay soils in Oro Town, in Irepodun Local Area of kwara State. This relationship can be used to estimate the natural untrained shear strength of the soil under Investigation from the same Swedish weight sounding test result.

MATERIALS AND METHODS

Laboratory and Field Test

I. **Test pit locations:** In order developed representatives, sample (disturbed and undisturbed) were taken from various sites tests were conducted. Red clay soil samples were also obtained from different areas and also used for the test

II. **Laboratory Tests:** Most of the Laboratory tests were carried out in accordance with the ASTM procedures for soil testing. The Laboratory conducted includes the following

I. **Index property test**
   Grain size analysis
   Atterberg limit test
   Natural Moisture content

II. **Unconfined compression strength test**

Grain size analysis

In this test, each sample collected from test pits was dried and pulverized before allowing it to pass through a series of sieves. The portion of soil passing the number of 10 sieves was subjected to a hydrometer analysis. The result of the analysis is presented on table 1 below.

Table 1

Sample No	Descriptions	Sample Depth (M)	Percentage of different size		
			Sand (%)	Silt (%)	Clay (%)
9	Along Iludun Oro Road (1)	1:50	14	34	52
10	Along Iludun Oro Road (2)	2:00	15	30	55
11	Along Iludun Oro Road (3)	2:00	13	34	53
12	Along Iludun Oro Road (4)	1:10	13	36	51
13	Along Iludun Oro Road (5)	1:10	9	31	60
14	Along Iludun Oro Road (6)	2:30	15	28	57
15	Along Iludun Oro Road (7)	2:10	13	34	53
16	Along Iludun Oro Road (8)	1:50	15	33	52
17	Along Iludun Oro Road (9)	3:00	11	32	57
18	Along Iludun Oro Road	2:00	11	30	59
19	Along Iludun Oro Road (10)	1:70	11	29	60
20	Along Iludun Oro Road (11)	2:00	12	26	62

The Grain size analysis Test results revealed that the soil under investigation were fine grained soil in which the percentage of clay ranges from 51-62%, silt from 26-36%, and sand from 9-15%.

Atterberg Limit Test

The cohesive soil was tested in order to determine the liquid and plastic limits, which are the moisture contends that define boundaries between material consistency states,

Table 2 shows the summary of atterberg limit test results together with the natural moisture investigation.

Take 2:- Result of Atterberg limit test

Sample No	Description	Depth of Sample	Natural moist cont	Natural Density	Liquid Limit %	Plastic limit %	Plastic Index %
1.	Along Ijomu-Oro road (1)	1.3	21.4	1.82	55	21.5	33.5
2.	Along Ijomu-Oro road (2)	1.5	42.45	Nil	86	24.5	61.5
3.	Along Ijomu-Oro road (3)	1.65	23.6	Nil	54	19.85	34.15
4.	Along Ijomu-Oro road (4)	1.65	23.05	Nil	49.4	19.2	30.2
5.	Along Ijomu-Oro road (5)	1.5	35.1	Nil	118	33	85
6.	Along Ijomu-Oro road (6)	2	41.62	Nil	118	33	85
7.	Along Ijomu-Oro road (7)	1.5	49	Nil	86	24.5	61.5
8.	Along Ijomu-Oro road (8)	1.2	50.34	Nil	85	25	60
9.	Along Ijomu-Oro road (9)	1.5	48.9	Nil	56	31.55	24.45
10.	Along Ijomu-Oro road (10)	2	23.5	Nil	53	25.05	27.95
11.	Along Ijomu-Oro road (11)	2	25.77	1.95	57	24.7	32.3
12.	Along Ijomu-Oro road (12)	1.10	26	2.08	48	24.65	23.35
13.	Along Ijomu-Oro road (13)	1.10	25	1.92	51	25.3	25.7
14.	Along Ijomu-Oro road (14)	2.3	24.09	2.03	51.5	27.85	23.65
15.	Along Ijomu-Oro road (15)	2.0	30.4	2.01	47.3	22	25.3
16.	Along Ijomu-Oro road (16)	2.25	38.15	1.81	58.5	31.37	27.13
17.	Along Ijomu-Oro road (17)	1.5	28.3	1.95	67	33	34
18.	Along Ijomu-Oro road (18)	3	29.95	1.97	63	24.55	38.45
19.	Along Ijomu-Oro road (19)	2	28.5	1.92	71	31.65	9.35
20.	Along Ijomu-Oro road (20)	1.7	31.7	1.97	59.3	22.15	37.35
21.	Along Ijomu-Oro road (21)	2.0	29	1.98	74	39.5	34.5

22.	Along Ijomu-Oro road (22)	2.4	33.1	1.95	75	30.51	44.5
23.	Along Ijomu-Oro road (23)	2	34.2	1.84	97.9	41.09	56.81
24.	Along Ijomu-Oro road (24)	2	34.69	1.83	92.2	39.5	52.70
25.	Along Ijomu-Oro road (24)	2	34.69	1.64	97.9	41.9	56
26.	Along Ijomu-Oro road (26)	1.5	46.15	2.32	64.3	27.15	37.15

The range of values for liquid limit, plastic limit and plastic index of the tested samples are summarized in table

Table 3

	Red clay soil	Black clay soil			
Liquid Limit %	47.3 – 82	54 – 81	56 – 75	85 – 118	79 – 12.1
Plastic Limit %	19.2 – 39.5	21 – 30	25 – 34	24.5 – 41.9	25 – 50
Plastic Index %	23.35 – 55.5	28 – 58	29 – 47	52.7 – 85	38 - 84

CONSISTENCY INDEX

The consistency index of any soil is a term used to describe the degree of firmness of any fine grained soils. Consistency is conventionally described as very soft, medium (firm), stiff and very stiff (hard). The value of consistency firmness of the tested samples is summarized in Table 5.

Table 5

Sample No	Location	Natural moist Cont %	Consistency Index (%)	Firmness
1.	Esie-Iludun Road (1)	21.4	100.3	Very Stiff (hard)
2.	Esie-Iludun Road (2)	42.45	70.9	Medium (firm)
3.	Esie-Iludun Road (3)	23.6	89	Stiff
4.	Esie-Iludun Road (4)	23.05	87.3	Stiff
5.	Esie-Iludun Road (5)	35.1	97.3	Stiff
6.	Esie-Iludun Road (6)	44.62	89.8	Stiff
7.	Esie-Iludun Road (7)	49.0	60.2	Medium (firm)
8.	Esie-Iludun Road (8)	50.34	57.8	Medium (firm)
9.	Esie-Iludun Road (9)	48.9	29.0	Stiff
10.	Esie-Iludun Road (10)	23.5	105.4	Very Stiff hard
11.	Esie-Iludun Road (11)	25.77	96.7	Stiff
12.	Esie-Iludun Road (12)	26.0	94.2	Stiff
13.	Esie-Iludun Road (13)	25.0	100.16	Very Stiff (hard)
14.	Esie-Iludun Road (14)	24.09	115.9	Very Stiff (hard)
15.	Esie-Iludun Road (15)	30.4	66.8	Medium (firm)
16.	Esie-Iludun Road (16)	38.15	76.4	Stiff
17.	Esie-Iludun Road (17)	28.3	113.82	Very Stiff (herd)
18.	Esie-Iludun Road (18)	29.95	85.96	Stiff

19.	Esie-Iludun Road (19)	28.5	108	Very Stiff (hard)
20.	Esie-Iludun Road (20)	31.7	74.8	Medium (Firm)
21.	Esie-Iludun Road (21)	29	130	Very Stiff (hard)
22.	Esie-Iludun Road (22)	33.1	94.2	Stiff
23.	Esie-Iludun Road (23)	34.2	111.27	Very Stiff (hard)
24.	Esie-Iludun Road (24)	34.69	109.2	Very Stiff (hard)
25.	Esie-Iludun Road (25)	14.69	111.37	Very Stiff (hard)
26.	Esie-Iludun Road (26)	46.15	48.9	Stiff

As presented in the above table, out of the total 26 tested samples, 10 samples fall in the very stiff (hard) group, 9 groups in the medium (firm) group, and 2 samples in the soft group based on their consistency index values.

Unconfined compression test results

Unconfined compressive strength test is one of the most common shear test that is usually used to measure the untrained shear strength of cohesive soils. in this study, a series of unconfined compressive strength test were carried out on undisturbed samples collected from different test pits, and tested in the laboratory with excel loads applied at as train rate of 0.8mm per minute. After the completion of the test, samples were collected to determine their water content. Mode of failure of the sample are shown in figures 2,3 and 4. figure 2 shows very stiff sample. The corresponding stress – strain curve in figure 5 shows small deformation before failure.

Fig 2 Typical Mode of failure of Very Stiff Clay Sample
Clay Sample

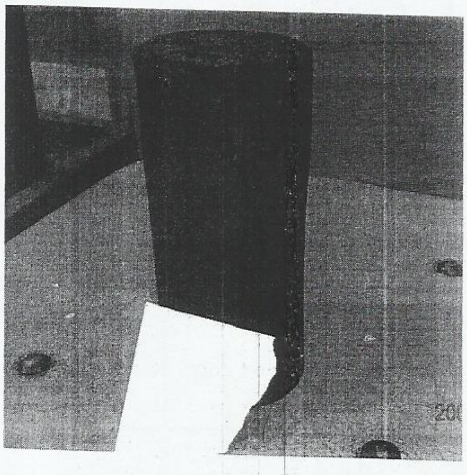

Fig 3 Typical Mode of failure of Stiff Clay Sample

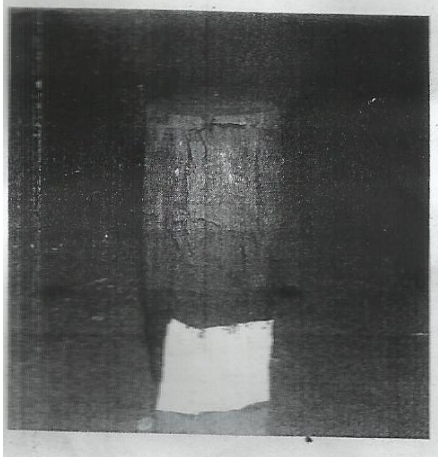

Fig 4 Typical Mode of failure of Medium (Firm) Clay Sample

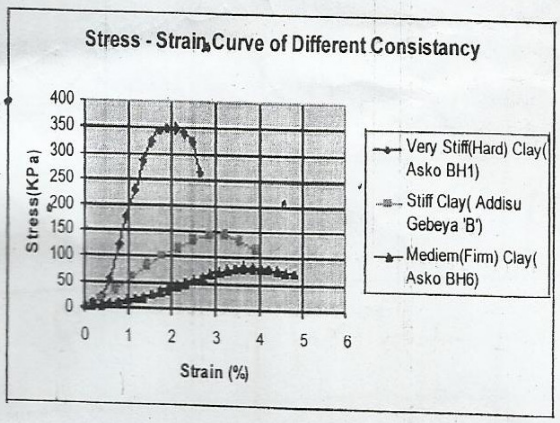

Fig 5 Typical Stress – Strain Curve for different consistencies

The stress – strain curves for the sample sheared in unconfined compression are plotted and the maximum value obtained from these curves are presented in table 6.

Table: Summary of use test results

S/N	Location	Sample Number	Depth of Sample (m)	UCS
1	Oro Grammar Sch Road (1)	1	1.30	305
2	Oro Grammar Sch Road (2)	2	1.50	68.8
3	Oro Grammar Sch Road (3)	3	1.65	189.5
4	Oro Grammar Sch Road (4)	4	1.65	148.8
5	Oro Grammar Sch Road (5)	5	1.50	160.7
6	Oro Grammar Sch Road (6)	6	2.00	105
7	Oro Grammar Sch Road (7)	7	1.50	105.7
8	Oro Grammar Sch Road (8)	8	1.20	81.7
9	Oro Grammar Sch Road (9)	9	1.50	22.3
10	Oro Grammar Sch Road (10)	10	2.00	350
11	Oro Grammar Sch Road (11)	11	2.00	196.2
12	Oro Grammar Sch Road (12)	12	1.10	182
13	Oro Grammar Sch Road (13)	13	1.10	293.9
14	Oro Grammar Sch Road (14)	14	2.30	341.4
15	Oro Grammar Sch Road (15)	15	2.00	83.8
16	Oro Grammar Sch Road (16)	16	2.25	125.1
17	Oro Grammar Sch Road (17)	17	1.50	352.8
18	Oro Grammar Sch Road (18)	18	3.00	196.1
19	Oro Grammar Sch Road (19)	19	2.00	270.18
20	Oro Grammar Sch Road (20)	20	1.70	127.3
21	Oro Grammar Sch Road (21)	21	2.00	317
22	Oro Grammar Sch Road (22)	22	2.40	163.3
23	Oro Grammar Sch Road (23)	23	2.00	157.82
24	Oro Grammar Sch Road (24)	24	2.00	216
25	Oro Grammar Sch Road (25)	25	1.5	73.09

Field Test (Swedish Weight Sounding Results)

Swedish weight sounding test is one of the static penetration test, which usually measures the resistance of the soil by considering the number of half turns required for 20 on penetration. During this test, the apparatus was positioned just adjusted till it reached more depth away from sampling out at two or more points at each test taken. The summary of the filed Test results is as shown in Table of below.

Table7:- Summary of Swedish Sounding Test Results

Location	Sample Number	Dept of Sample (M)	Swedish weight sounding Test (20cm) Penetration
College of Edu Oro road (1)	1	1.30	63.0
College of Edu Oro road (2)	2	1.50	13.0
College of Edu Oro road (3)	3	1.65	36.0
College of Edu Oro road (4)	4	1.65	21.7
College of Edu Oro road (5)	5	1.50	27.0

College of Edu Oro road (6)	6	2.00	13.0
College of Edu Oro road (7)	7	1.50	19.0
College of Edu Oro road (8)	8	1.20	3.0
College of Edu Oro road (9)	9	2.00	94.0
College of Edu Oro road (10)	10		
College of Edu Oro road (11)	11	1.00	41.0
College of Edu Oro road (12)	12	1.10	39.0
College of Edu Oro road (13)	13	2.30	79.7
College of Edu Oro road (14)	14	2.00	61.0
College of Edu Oro road (15)	15	2.25	9.7
College of Edu Oro road (16)	16	1.50	27.0
College of Edu Oro road (17)	17	3.00	79.3
College of Edu Oro road (18)	18	2.00	33.3
College of Edu Oro road (19)	19	1.70	40.2
College of Edu Oro road (20)	20	2.00	24.0
College of Edu Oro road (21)	21	2.40	56.2
College of Edu Oro road (22)	22	2.00	29.3
College of Edu Oro road (23)	23	2.00	45.3
College of Edu Oro road (24)	24	2.00	44.0
College of Edu Oro road (25)	25	2.00	40.7
College of Edu Oro road (26)	26	1.5	3

Result obtained from Swedish weight sounding test; consistency Index, and unconfined compressive strength test were compared. The data from atterberg limit test and natural moisture content were used to calculate the consistency Index of the soils. By using ic, are can determine the firmness of the soil as soft, medium (firm), stiff and very stiff. Out of the total twenty six samples, ten samples were very stiff (hard), nine samples were stiff, five samples were medium (firm), and two samples were soft soil, for each range of firmness; the corresponding ranges of UCS and SWS were determined and tabulated for red and expansive soils separated as shown in Table 9 and 10

Table 9 Correlation between SWS and UCS

Firmness	Lc (%)	SWS (NHT/20cm)	UCS (KPa)	Range of UCS from previous Works (Kpa) [2][4][6]
soft	25-50	2-3	22-73	25-50
medium (firm)	50-24	10-24	84-127	50-100
stiff	75-100	22-41	125-196	100-200
very stiff (Hard)	>100	40-94	270-352	200-400

Table 10 Correlation between SWS and UCS of Addis Ababa Black clay soil

Firmness	Lc (%)	SWS (NHT/20cm)	UCS (KPa)	Range of UCS from previous Works (Kpa) [2][4][6]
soft	25-50	2-3	22-73	25-50
medium (firm)	50-24	10-24	84-127	50-100
stiff	75-100	22-41	125-196	100-200
very stiff (Hard)	>100	40-94	270-352	200-400

As it can be seen from Table 9 and 10 the range of values of UCS for each consistency range are comparable with the previous UCS values suggested by different researchers. Using the available data, it is possible to show how the natural water content alone cannot be an adequate index property of soil. At the same water content, one soil relatively software as another soil may be hard. However, the soils with the same consistency limits behave somewhat in a similar manner. This is clearly seen in fig 7 and fig 8. For evaluation of the stiffness of the soil, what matter is the relative position of the natural moisture content with respect to its plastic limit. Even though, almost all available data of grain size distribution of tested samples looks identical, their sheer strength behavior differs due to their change in consistency limit. That is why clay soil strength classification based on consistency index, instead of grain size. In proceeding with the comparison of results of the field and laboratory tests, there is a linear relationship between UCS and SWS in each firmness ranges. UCS will increase together with SWS but the rate of increasing reduces as the natural moisture content gets smaller and smaller. This can be seen clearly in fig 9. Form the plot of UCS verses SWS (fig 9), it is possible to assume a linear relation between the two variable within each firmness typ. So that one can determine the value of UCS by caring out only simple insitu test, SWS. But if the value of SWS is falls in the range of overlap, it is necessary to determine the natural moisture content and atterberg limits to determine the consistency index. The consistency index value helps to judge the firmness type.

CONCLUSION

Based on the tests result the following conclusions were reached.

1. Grain size analysis tests revealed that the soils under investigation were fine grained soils in which the percentage of clay ranges from 51-62% silt from 26-36% and sand from 9-15%.
2. 2. The general index properties with respect to Atterberg limit show that the red clay soils had Liquid Limit 47.3-82%, Plastic 19.2-39.5% and Plastic index

23.35-55.5%, but expansive clay soils had Liquid limit 85-118%, Plastic limit 24.5-41.9%, and Plastic index 52.7-85%

3. There is a linear relation between UCS and SWS in each firmness range. So that it is possible to determine the value of UCS by carrying out only simple insitu test of SWS.
4. There is a large strength difference between the Red and Black clay soils within same consistency index. In this research the strength (UCS) of red clay soil for the same consistency. Hence two different correlations were developed for the soils.
5. As the natural moisture content gets closer and closer to the plastic limit, the penetration resistant as well as the UCS value increases but the rate of increasing gets reduces.

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APPENDIX

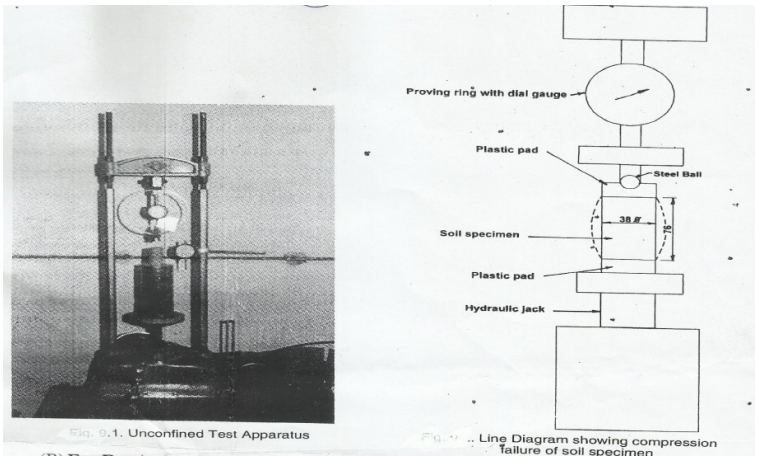

Figure i
Unconfined clay compression Machine
(ASTM d 2166-BS 1377)

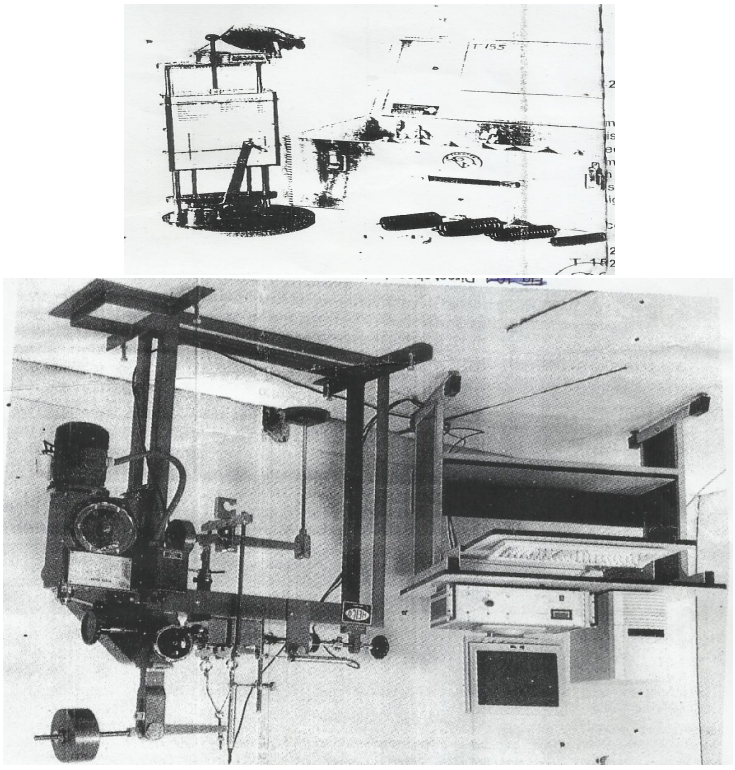

Figure ii