INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume6, Issue1)
Available online at: www.ijariit.com

Investigation of engineering properties of soils found in Arba Minch Zuria (Limat to Shara)

Saol Toyebo
soltoyebo@gmail.com
Wolaita Sodo University,
SNNP Region, Ethiopia

ABSTRACT

The objective of this thesis is to investigate the engineering properties of the soils found from Limat to Shara and understand the nature of the soils. Arba Minch town is located in Gamo Gofa Zone in SNNPRS at a distance of about 505km from the National Capital city, Addis Ababa, and 270km far from the Regional Capital city, Hawassa. Arba Minch town is one of the rapidly developing towns in Ethiopia and new construction activities were appearing in the town. Investigating the characteristic of the supporting soil is vital in order to have a safe and stable foundation. To achieve this objective, in order to determine the engineering properties of soils were accompanied on selected 24 soil samples, which were taken from Limat to Shara at not more than 500m interval, and the procedure used for analysis was done according to ASTM standard. This paper presents the field and laboratory test results of soils that were performed to determine the Engineering properties of soils from Limat to Shara. The test results showed that the field density ranges from 1.61 to 1.96g/cc. NMC ranges from 5.22 to 33.58%. LL ranges from 28.04 to 64.23%, PL ranges from 20.68 to 32.06%, and PI ranges from 4.16 to 33.21%. And from FSI results 12.5% are medium expansive soils were obtained. From plasticity characteristics of the study area falls in low to high plasticity characteristics are observed. The USCS classification soils are classified as CH, MH, CL, ML, SC, SC-SM, GC, and GC-GM. And AASHTO classification of soils is fallen in A-2-4, A-4, A-6, A-7-5, and A-7-6. The Compaction test result showed that maximum dry density (MDD) of the study area ranges from 1.57 to 1.93g/cm3 and the optimum moisture content (OMC) ranges 14.40 to 30.50%. The unconfined compressive strength test result ranges from 99.10 to157.17kPa. And direct shear test results, internal friction angle (Φ) and cohesion (C) falls for TP-11, C = 10.71kPa and Φ = 35.37°, for TP-12, C = 9.42kPa and Φ=36.80°C.Finally, from one-dimensional consolidation test results, Compression index, Cc ranges from 0.43 to 0.53, Swelling index, Cs ranges from 0.06 to 0.1, and Pc vary between 67 to 98kPa.

Keywords— *Natural soils, Index and Compressible characteristics, Shear strength parameters*

1. INTRODUCTION

The stability of the foundation of a building, a bridge, an embankment or any other structure built on soil depends on the strength and compressibility characteristics of the subsoil. The successes or failure of a foundation depends essentially on the reliability of the various soil parameters obtained from the field investigation and laboratory testing and used as an input into the design of a foundation [21].

Soil investigation program is necessary to provide information for design and construction and environmental assessment. The purposes of soil investigation are: to evaluate the general suitability of the site for the proposed project, to enable an adequate and economical design to be made and to disclose and make provisions for difficulties that may arise during construction due to ground and other local conditions. Investigations of the underground conditions at a site are prerequisite to the economical design of the substructure elements. It is also necessary to obtain sufficient information for feasibility and economic studies for a proposed project. An exploration program may be initiated on an existing structure where additions are contemplated [9].

1.1 OBJECTIVES

1.1.1 General objective

The objective of the study is to investigate the engineering properties of the soils found from Limat to Shara to understand the nature of the soils.

1.1.2 Specific objectives:

- To determine the range of values of index properties of soils in different parts of the area from Limat to Shara.
- To classify the soil based on ASHTOO and USCS soil classification system

- To determine the shear strength characteristics of the soils.
- To determine the one-dimensional consolidation characteristics.

2. LITERATURE REVIEW
2.1 SOIL FORMATION
Based on the method of formation, soils are sedimentary or residual. In sedimentary soil, the individual particles were created at one location, transported, and finally deposited at another location. Residual soil is one formed in place by the weathering of the rock, with little or no movement of the individual soil particles [18].

2.2 GENERAL TYPES OF SOILS
It has been discussed earlier that soil is formed by the process of physical and chemical weathering. The individual size of the constituent parts of even the weathered rock might range from the smallest state (colloidal) to the largest possible (boulders). This implies that all the weathered constituents of a parent rock cannot be termed soil. According to their grain size soil particles are classified as cobbles, gravel, sand, silt and clay. Grains having diameters in the range of 4.75 to 76.2mm are called gravel. If the grain is visible to the naked eye, but are less than about 4.75mm in size the soil is described as sand. The lower limit of visibility of grains for the naked eyes is about 0.075mm. Soil grains ranging from 0.075 to 0.002mm are termed as silt and those that are finer than 0.002mm as clay. This classification is purely based on size which does not indicate the properties of fine-grained materials [21].

3. RESEARCH METHODOLOGY
3.1 STUDY AREA
Arba Minch Zuria is one of the woredas in the Southern Nations, Nationalities, and Peoples' Region of Ethiopia. This woreda also includes portions of two lakes and their islands, Abaya and Chamo. Nechisar National Park is located between these lakes. The city of Arba Minch is surrounded by Arba Minch Zuria. Arba Minch town is located in Gamo Gofa zone of the SNNPRS at a distance of about 505km from the National Capital, Addis Ababa, and 270km far from the Regional Capital, Hawassa. The name "Arba Minch" derived from Amharic word "Arba"-means forty and "Minch"-means spring. Geographically, Arba Minch located at the floor of the southern part of the East African Rift valley between 5º51'0" N to 6º4'30" N latitude and 37º21'0" E to 37º34'30" E longitude and at an elevation of 1285 meters above sea level [20].

This study was aimed to investigate the engineering properties of finding in Arbaminch Zuria (Limat to Shara) on selected 24 disturbed and undisturbed soil samples taken at an average depth of 1.5m and 3m. In order to achieve the objectives of this work, the following methodologies were used.

- The literature of many journals, books and investigators are reviewed.
- Necessary information about the climatic condition and topography of the site are collected.
- Reconnaissance study of the area is done and the locations of test pits are selected.
- 12 sampling points are selected at an average depth of 1.5m and 3m and field GPS readings are taken to locate the ordinate of the sampling area.
- All the laboratory tests are performed according to ASTM standard.
- Classification of the subgrade soils based on the laboratory test results using AASHTO M 145 (2013) and Unified Soil Classification System.

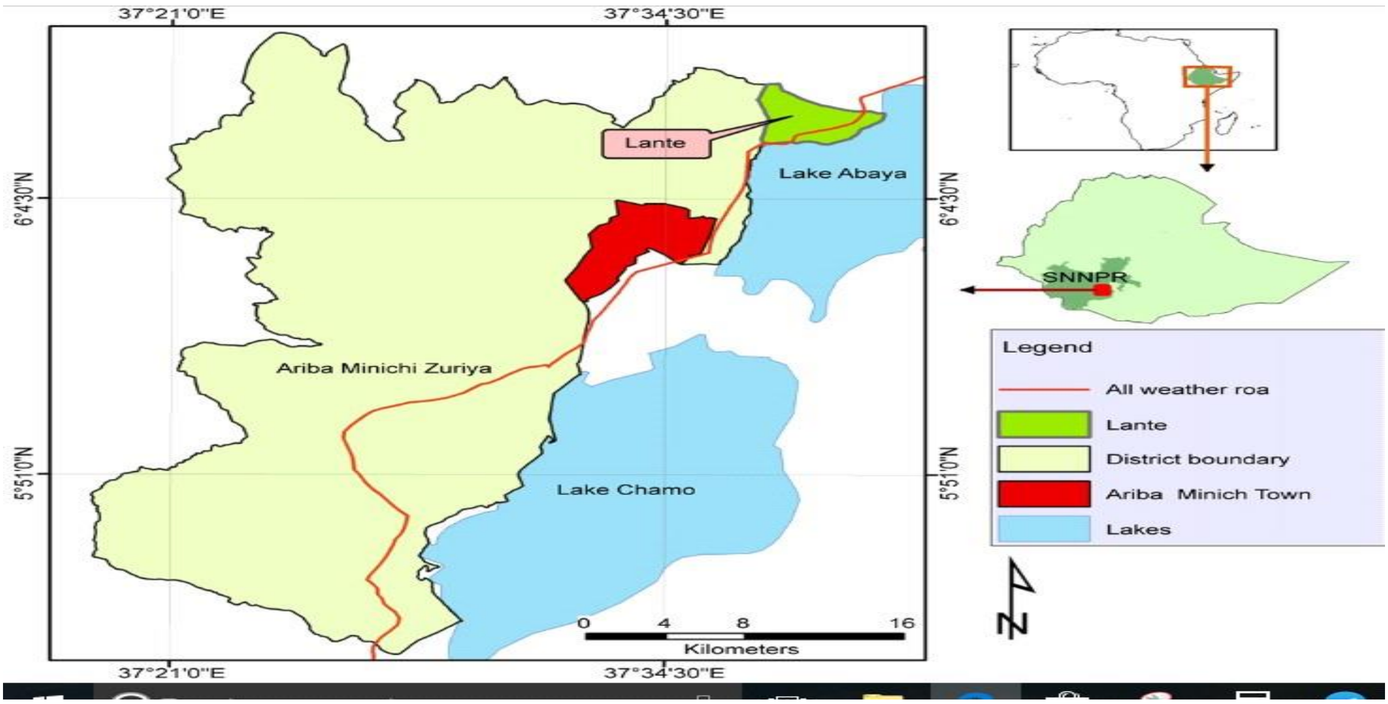

Fig. 3.1: Land use map

(Source: Arba Minch town structural plan)

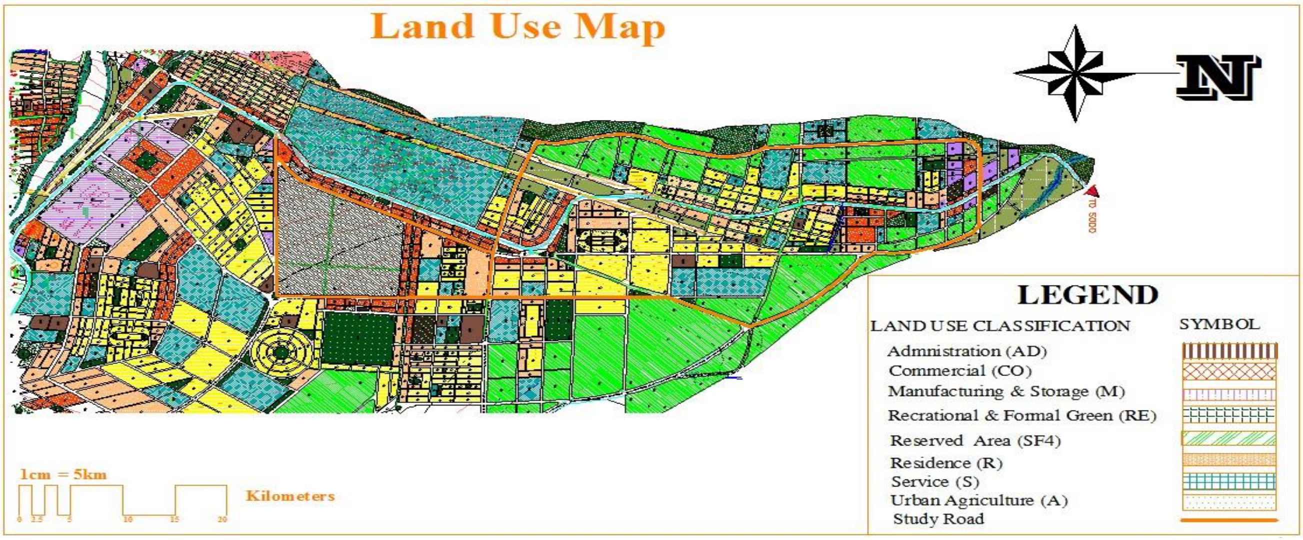

Fig. 3.2: Location of sample areas found in Limat to Shara

(Source: Arba Minch Municipality)

Fig. 3.3: Location of sample areas found in Limat to Shara

(Source: Arba Minch Municipality)

Table 3.1 Table 13 GPS coordinates of sampling areas

Ser. No	Location			Test pit designation
	Easting	Northing	Elevation(m)	
1	339145.3	668702.4	1230	TP-1-
2	339329.8	669214.9	1255	TP-2-
3	339916.8	669210.3	1224	TP-3-
4	340050.4	669689.2	1235	TP-4-
5	340368.3	668747.2	1209.5	TP-5-
6	340829.8	669415.5	1203	TP-6-
7	341364.5	670689.9	1191	TP-7-
8	342600	670606.5	1182.5	TP-8-
9	342036.4	669654.6	1189	TP-9-
10	341447.6	672635.8	1093	TP-10-
11	340634	672241.5	1246	TP-11-
12	340935.1	672885.6	1248	TP-12-

4. LABORATORY TEST RESULTS

The type of laboratory tests carried out includes, Atterberg limit, Grain size distribution, Moisture- density relationship, Specific gravity, UCS (Unconfined Compressive Strength Test), direct shear teat, In situ density, Free Swell (FS) Test and One-dimensional consolidation test. All tests are conducted based on ASTM standards.

Table 4.1: The laboratory test results

Test pit	Depth(m)	NMc (%)	Gs	LL (%)	PL (%)	PI (%)	FS (%)	OMC (%)	MDD(g/cc)
1	1.5	9.92	2.67	33	24.43	8.57	35.7	16.90	1.75
	3	19.21	2.65	34	27.31	6.69	35	15.75	1.86
2	1.5	5.22	2.62	28	20.68	7.36	32.5	15.00	1.93
	3	15.0	2.72	44.30	25.98	18.32	47.5	30.50	1.61
3	1.5	9.29	2.64	30.	21.42	8.58	35	19.00	1.80
	3	13.40	2.68	32.00	21.21	10.79	40	27.00	1.71
4	1.5	9.81	2.64	35.45	27.54	7.91	32.5	18.00	1.72
	3	11.64	2.68	43.85	27.14	16.71	42.5	27.20	1.58
5	1.5	30.74	2.71	58.13	28.92	29.21	48	25.00	1.61
	3	33.58	2.73	61.09	30.49	30.60	48	18.40	1.69
6	1.5	16.66	2.66	47.12	29.02	18.10	43	26.70	1.71
	3	21.39	2.68	60.50	39.51	20.99	48	23.00	1.77
7	1.5	31.57	2.72	62.30	30.85	31.45	60	23.70	1.59
	3	31.97	2.73	64.23	31.02	33.21	43	26.00	1.57
8	1.5	28.77	2.68	57.80	32.06	25.74	58	23.50	1.75
	3	30.27	2.71	58.46	28.13	30.33	48	22.30	1.76
9	1.5	27.62	2.67	47.85	29.82	18.03	58	16.67	1.91
	3	28.85	2.68	55.00	31.35	23.65	45	19.70	1.87
10	1.5	11.81	2.68	37.91	23.88	14.03	38	17.20	1.79
	3	13.73	2.66	53.00	29.84	23.16	48	16.90	1.75
11	1.5	8.60	2.64	32.00	24.08	7.92	30	14.40	1.87
	3	11.22	2.69	35.46	22.42	13.04	38	16.70	1.83
12	1.5	8.66	2.65	29.64	21.62	8.02	35	14.50	1.86
	3	9.57	2.66	30.58	20.78	9.80	38	14.55	1.85

Table 4.2: Summary of in-situ unit weight of soils in the study area

TP	Depth, m	Bulk Density, g/cm3	Bulk unit weight, kN/m3	Dry density, g/cm3	TP	Depth, m	Bulk Density, g/cm3	Bulk unit weight, kN/m3	Dry density, g/cm3
1	1.5	1.79	17.91	1.63	7	1.5	1.85	18.54	1.41
	3	1.81	18.1	1.52		3	1.86	18.59	1.41
2	1.5	1.61	16.08	1.53	8	1.5	1.86	18.57	1.44
	3	1.78	17.78	1.55		3	1.95	19.48	1.50
3	1.5	1.81	18.09	1.66	9	1.5	1.94	19.39	1.52
	3	1.91	19.08	1.68		3	1.96	19.57	1.52
4	1.5	1.8	18	1.64	10	1.5	1.87	18.72	1.67
	3	1.85	18.5	1.66		3	1.95	19.48	1.71
5	1.5	1.9	19	1.45	11	1.5	1.69	16.9	1.56
	3	1.94	19.36	1.45		3	1.75	17.52	1.57
6	1.5	1.67	16.67	1.43	12	1.5	1.81	18.07	1.67
	3	1.73	17.28	1.43		3	1.83	18.34	1.67

Table 4.3: Summary of grain size analysis results

Test pit	Depth (m)	Percent amount of particle size				Test pit	Depth (m)	Percent amount of particle size			
		Gravel	sand	silt	clay			Gravel	sand	Silt	clay
1	1.5	39.65	25.17	26.77	8.41	7	1.5	0.00	19.50	50.60	29.90
	3	15.19	50.30	26.34	8.18		3	0.00	19.64	46.05	34.32
2	1.5	23.00	46.00	23.55	7.45	8	1.5	0.00	21.33	48.11	30.56
	3	11.25	31.75	38.06	18.94		3	0.00	19.88	50.51	29.61
3	1.5	4.11	46.99	37.00	11.90	9	1.5	0.00	27.52	45.10	27.39
	3	2.91	40.00	43.28	13.80		3	0.00	19.55	50.01	30.44
4	1.5	9.97	53.37	28.30	8.36	10	1.5	12.45	23.92	48.42	15.21
	3	9.70	27.10	47.51	15.69		3	0.00	15.94	58.22	25.84
5	1.5	0.00	16.80	45.38	37.82	11	1.5	13.25	43.05	34.35	9.35
	3	0.00	2.40	56.44	41.16		3	4.25	19.60	60.19	15.96
6	1.5	9.90	27.30	44.82	17.98	12	1.5	28.15	29.05	33.16	9.64
	3	8.83	20.33	42.36	28.48		3	30.30	20.03	40.15	9.52

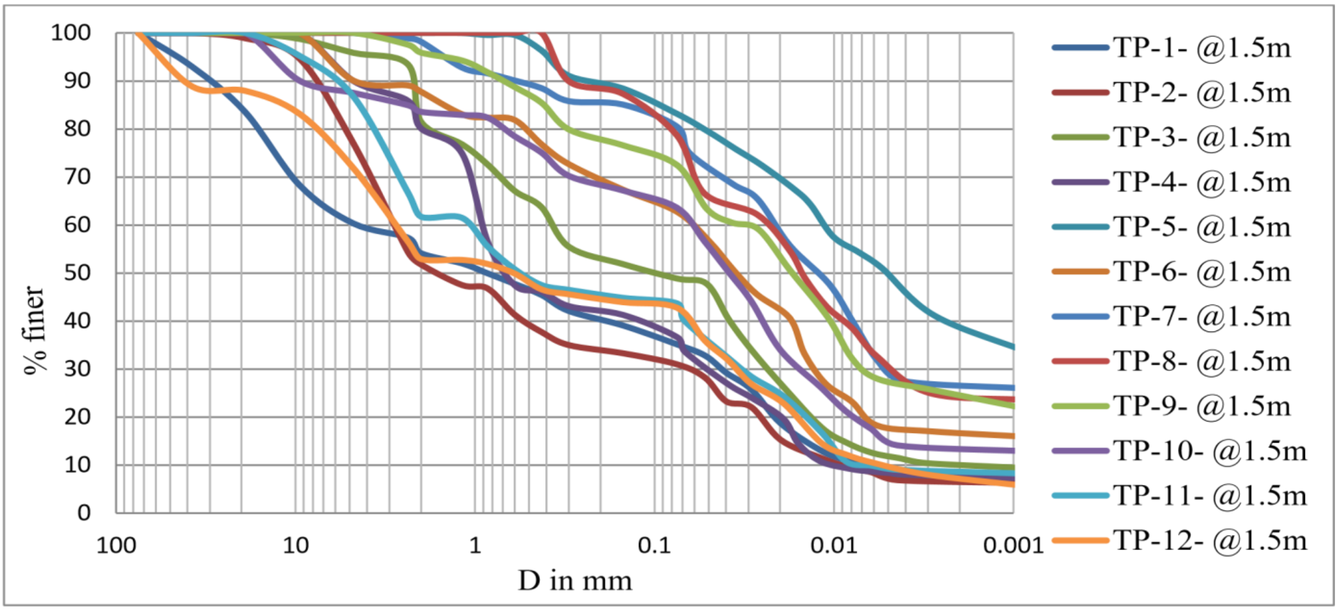

Fig. 4: Summary of combined grain size determination curves from sieve and hydrometer analysis at 1.5m depths

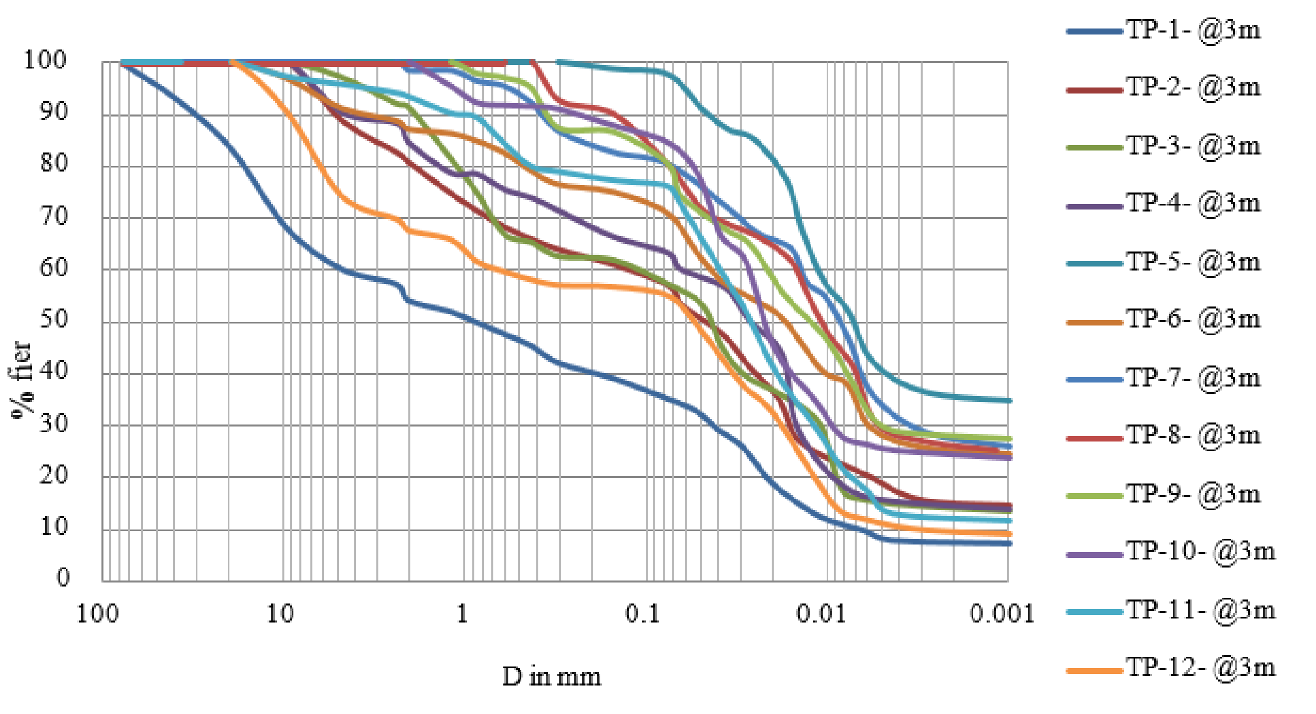

Fig. 4.4: Summary of combined grain size determination curves from sieve and hydrometer analysis at 3m depths

Table 4.4: Summary of maximum dry density and optimum moisture content

TP	Depth, m	Bulk Density, g/cm3	Bulk unit weight, kN/m3	Dry density, g/cm3
1	1.5	1.79	17.91	1.63
	3	1.81	18.1	1.52
2	1.5	1.61	16.08	1.53
	3	1.78	17.78	1.55
3	1.5	1.81	18.09	1.66
	3	1.91	19.08	1.68
4	1.5	1.8	18	1.64
	3	1.85	18.5	1.66
5	1.5	1.9	19	1.45
	3	1.94	19.36	1.45
6	1.5	1.67	16.67	1.43
	3	1.73	17.28	1.43

Table 4.5: Summary of direct shear test

TP	Depth(m)	Cohesion(C), Kpa	International Friction angle(ϕ), (deg.)
11	3	10.71	35.37
12	3	9.42	36.8

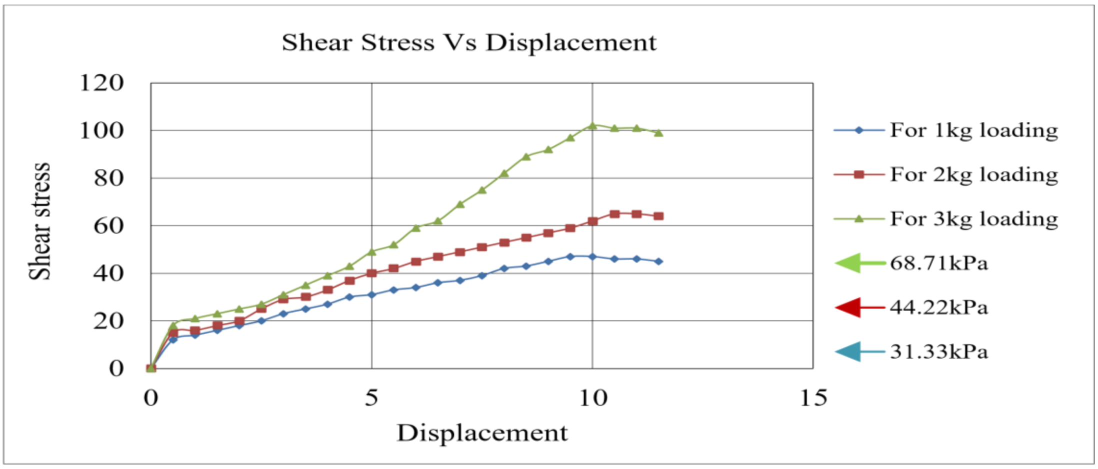

Fig. 4.5: Typical plot of shear stress and displacement for TP-11@3m

Table 4.6: Summary of UCS test in the study area

Test pits	Sampling Depth (m)	NMC, %	Unconfined compression strengths, Qu (kPa)	Untrained Shear strength, Cu (kPa)	Consistency
2	3	15.00	99.10	49.55	Medium
3	3	13.40	99.12	49.56	Medium
4	3	11.64	97.05	48.53	Medium
5	3	33.58	157.17	78.59	Stiff
6	3	21.39	129.8	64.9	Stiff
7	3	31.97	141.17	70.59	Stiff
8	3	30.27	136.76	68.38	Stiff
9	3	28.85	128.03	64.01	Stiff
10	3	13.73	113.3	56.66	Stiff

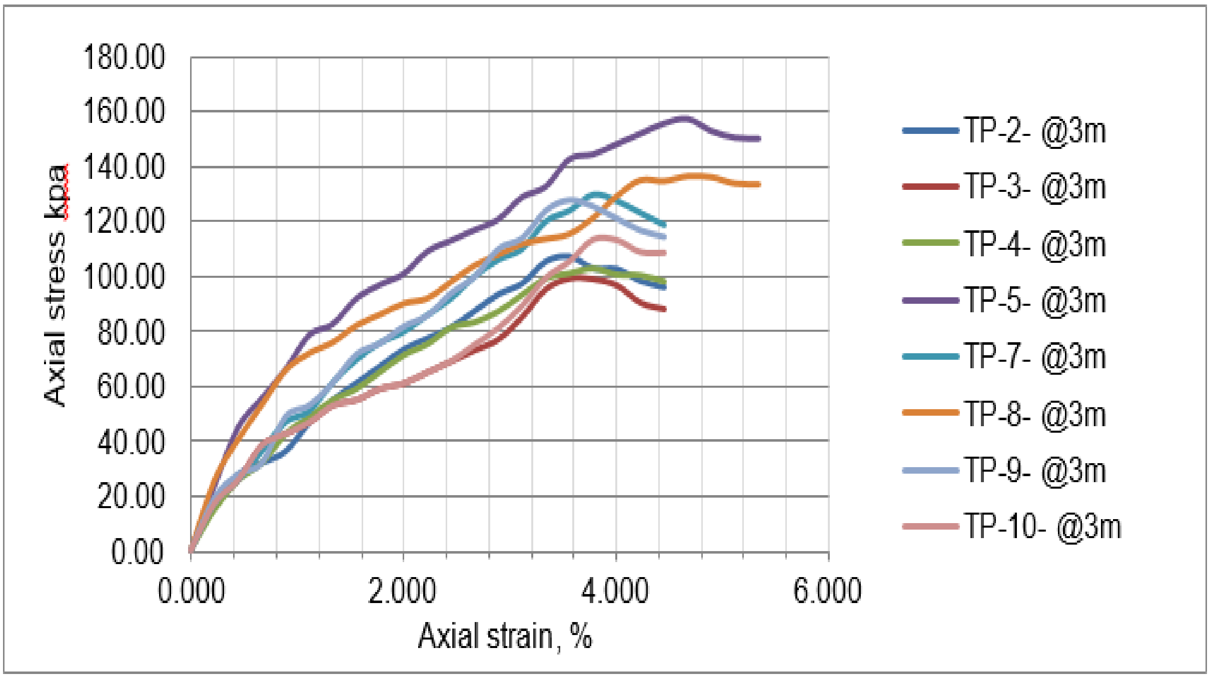

Fig. 4.6: Summary of the stress-strain curve of the UCS test from TP-2- to TP-10

Table 4.7: Summary of one-dimensional test results of the study area

Test Pit	Depth m	Natural moisture (%)	Unit weight(kN/m3)	Compression index, Cc	Recompression index, Cr	Pre-consolidation pressure, Pc(kPa)
5	3	33.33	19.36	0.43	0.06	67.00
6	3	21.40	17.30	0.46	0.07	98.00
7	3	32.65	18.60	0.45	0.10	94.00
8	3	28.90	19.50	0.53	0.07	95.00

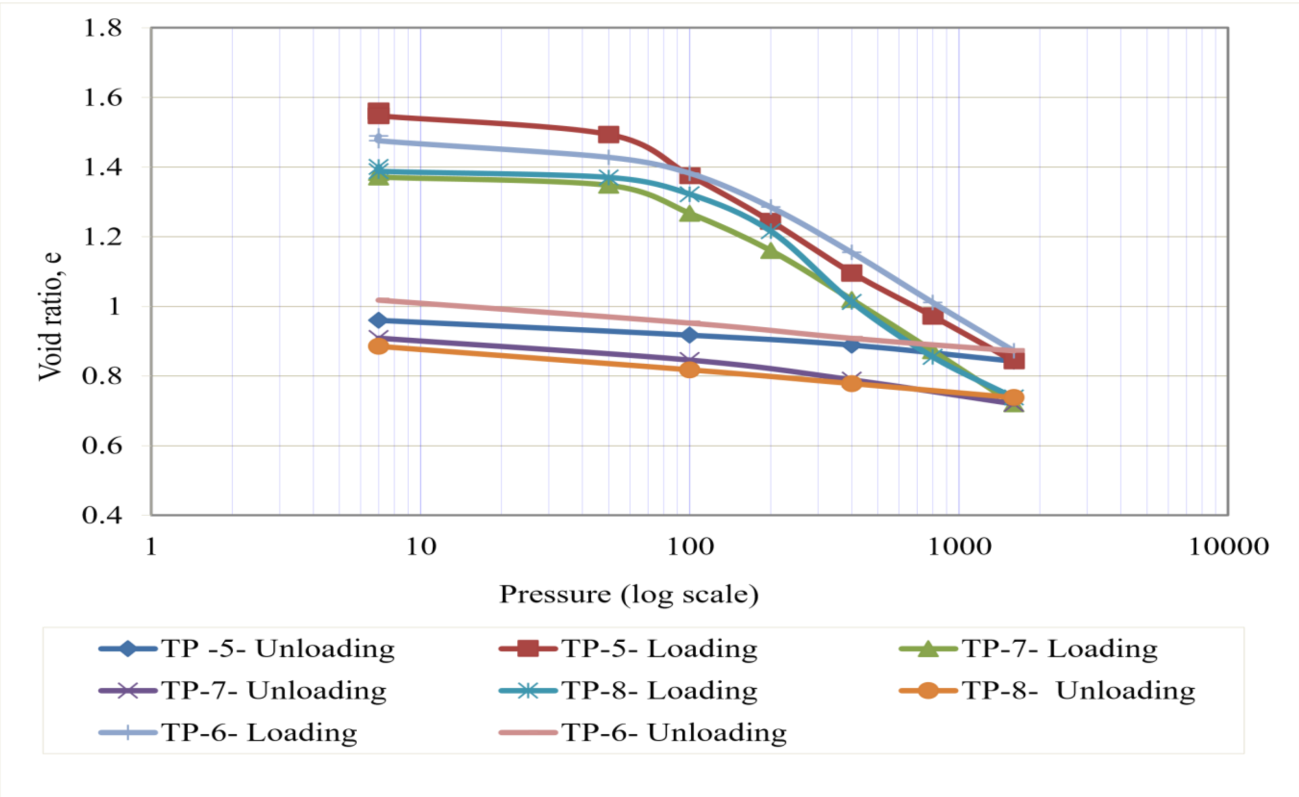

Fig. 4.7: Summary of P Vs e (Log scale) graphs of the study area

Table 4.8 Classification of soils according to USCS

Test pit	Depth(m)	Percent amount of particle size				Atterberg Limit		Group symbol
		Gravel	sand	silt	clay	LL, %	PI, %	
1	1.5	39.65	25.17	26.77	8.41	33.00	8.57	GM
	3	15.19	50.30	26.34	8.18	34.00	6.69	SM
2	1.5	23.00	46.00	23.55	7.45	28.04	7.36	CL
	3	11.25	31.75	38.06	18.99	44.30	18.32	CL
3	1.5	9.97	53.37	28.30	8.36	30.00	8.58	CL
	3	9.70	21.40	55.05	13.85	32.00	10.79	CL
4	1.5	9.97	53.37	28.30	8.36	35.45	7.91	SM
	3	9.70	27.10	47.51	15.69	43.85	16.71	ML
5	1.5	0.00	16.80	45.38	37.82	58.13	29.21	CH
	3	0.00	2.40	56.44	41.16	61.09	30.60	CH
6	1.5	9.90	27.30	44.82	17.98	47.12	18.10	ML
	3	8.83	20.33	42.36	28.48	60.50	20.99	CH
7	1.5	0.00	19.50	50.60	29.90	62.30	31.45	CH
	3	0.00	19.64	46.05	34.32	64.23	33.21	CH
8	1.5	0.00	21.33	48.11	30.56	57.80	25.74	MH
	3	0.00	19.88	50.51	29.61	58.46	30.33	CH
9	1.5	0.00	37.99	42.68	23.43	47.85	18.03	ML
	3	0.00	19.55	50.01	30.44	55.00	23.65	MH
10	1.5	12.45	23.92	48.42	15.21	37.91	14.03	CL
	3	0.00	15.94	58.22	25.84	53.00	23.16	CL
11	1.5	13.25	43.05	34.35	9.35	35.00	10.92	SM
	3	4.25	19.60	60.19	15.96	35.46	13.04	CL
12	1.5	28.15	29.05	33.16	9.64	29.64	8.02	CL
	3	30.30	20.03	40.15	9.52	30.58	8.44	GC

Table 4.9: Classification of soils using the AASHTO classification system

Test pit	Depth(m)	Sieve analysis, % passing			Atterberg Limit		Classification according to AASHTO
		No.10 (2.00mm)	No.40 (425µm)	No.200 (75µm)	LL	PI	
1	1.5	54.17	45.46	35.18	33.00	8.57	A-2-4
	3	72.73	45.39	34.51	34.00	6.69	A-2-4
2	1.5	51.80	37.70	31.00	28.04	7.36	A-2-4
	3	80.55	65.90	57.00	44.30	18.32	A-7-6(8)
3	1.5	81.56	63.73	48.90	30.00	8.58	A-6(1)
	3	91.20	65.30	57.30	32.00	10.79	A-6(6)
4	1.5	80.16	46.12	36.66	35.45	7.91	A-2-4(0)
	3	84.30	73.80	63.20	43.85	16.71	A-7-6(11)
5	1.5	100.00	96.36	83.20	58.13	29.21	A-7-6(27)
	3	100.00	100.00	97.60	61.09	30.60	A-7-6(36)
6	1.5	87.80	76.80	62.80	47.12	18.10	A-7-6(10)
	3	87.06	79.06	70.84	60.50	20.99	A-7-5(23)
7	1.5	98.20	88.50	80.50	62.30	31.45	A-7-5(28)
	3	98.38	92.10	80.36	64.23	33.21	A-7-5(32)
8	1.5	100.00	100.00	78.67	57.80	25.74	A-7-5(23)
	3	100.00	100.00	80.12	58.46	30.33	A-7-6(28)
9	1.5	95.89	85.42	72.48	47.85	18.03	A-7-6(14)
	3	100.00	95.00	80.45	55.00	23.65	A-7-5(20)
10	1.5	84.97	75.09	63.63	37.91	14.03	A-6(5)
	3	99.99	91.47	84.51	53.00	23.16	A-6(2)
11	1.5	61.75	47.50	43.70	35.00	10.92	A-6(2)
	3	93.35	79.95	76.15	35.46	13.04	A-6(9)
12	1.5	52.95	46.60	42.80	29.64	8.02	A-4(1)
	3	65.73	56.97	49.42	30.58	9.80	A-4(2)

5. CONCLUSION

From Atterberg limit tests the plasticity characteristics showed that 38 % of soils were high plasticity, 33% of soils were medium plasticity, and 29% of soils were low. The degrees of activity of the study area soil indicates that the soil the soils grouped under normal. The proportions of soil particles in study area contain clay fractions of 7.45 – 41.16 %, silt fraction of 23.55 – 60.19 %, sand fraction of 2.40 – 53.37%, and gravel fraction of 0.00 – 39.65%. This indicates that the dominant portion of soil found in the study area is silt. The free swell test result indicates that soils of the study area were 87.5% of non-expansive (which means the low degree of swell), and 12.5% was a medium degree of expansive soils are obtained. According to the AASHTO soil classification system most of the soils of the study area categorized in A2-4, A-4, A-6, A-7-5 and A-7-6. And USCS the soil in study area classified as 25% of CH, 21% of CL, 8% of MH, 8% of ML, 16% of SC, 9% of SM, 4% of GC, and 4% of GM. In TP-11, and 12 were conducted by direct shear strength so that the test results indicate the soils were compact state of packing. And the remaining TP (except PT 1 because dominated gravel with fine grain soils, so which is unsuitable for small shear box test) at 3m depth conducted by unconfined compressive strength test, and the test results showed that the consistency of the soils is naturally stiff soils. From the one-dimensional consolidation test results, the values of Cc and Cs are in the range from 0.43 to 0.53 and 0.06 to 0.1.

6. REFERENCES

[1] A.Aysen. Basic Concept and Engineering Application. 2002.
[2] A.Tefera. Soil mechanics. Addis Abeba: Faculity of Technology, 1999.
[3] Abel. Modification on engineering properties of expansive soils blending with non-expansive cohesive soils. Arba Minch, 2015.
[4] ASTMD122. Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass. Washington DC: Annual Book of ASTM Standards, 1998.
[5] ASTMD2166. Standard Test Method for Unconfined Compressive Strength of Cohesive Soil. Washington DC: Annual book of ASTM standard, 1998.
[6] ASTMD2435. Standard test method for Unconfined Compressive Strength of Cohesive Soil. Washington DC: Annual Book of ASTM standard, 1998.
[7] ASTMD4226. Standard Test Method for the Particle size of soils. Washington DC: Annual Book of ASTM Standards, 1998.
[8] ASTMD4318. Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index. Washington: Annual Book of ASTM standard, 1998.
[9] ASTMD698. Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (600 kN-m/m). Washington DC: Annual Book of ASTM Standards, 1998.

[10] ASTMD854. Standard Test Method for Specific Gravity of Soil Solids by Water. Washington DC: Annual Book of ASTM standard, 1998.
[11] C.Venkatramaiah. Geotechnical Engineering. New age international (p) ltd, 1993.
[12] Das. Principle of Geotechnical Engineering. California, 2006.
[13] Das, M.B. Principal of Foundation Engineering. USA: Global Engineering Chrisoper M.Short, 2007.
[14] J.Bowles. Foundation Analysis and Design. The Mc graw-Hill, 1996.
[15] K.R.Arora. Soil mechanics and Foundation Engineering. Delhi, 2004.
[16] keniraj, Shebaga R. Design Aids in Soil Mechanics And Foundation Engineering. Indian Institute of Technology: Delhi, 2008.
[17] M.Budhu. Foundation and Earth Retaining Structures. United States of America: John Wiley & Sons, Inc., 2008.
[18] M.budhu. Soil Mechanics and Foundation. United State of America: Hamilton printing company, 2010.
[19] P.Coduto, Donald. Foundation Design principles and practices. Practice-Hail.Inc, 2001.
[20] Prof.A.Balasubramaniam. Engineering properties of soils. University of Mysore, 2017. R.F.Craig. Creig's soil mechanics. Son press, 2004.
[21] R.K.Arora. Soil mechanics and foundation engineering. Delhi, 2004.
[22] R.kaniraj, Shenbagaga. Design Aids in Soil Mechanics and Foundation. 2008.
[23] R.W.day. Soil mechanics and foundations. Indian, 2006.
[24] T.W.Lambe. Soil mechanics. New York: John Wiley & Sons, 1969.
[25] Terzaghi. Soil Mechanics in Engineering Practice. 1996.
[26] Torora, Tekusha. Engineering properties of soils. University of Mysore, 2017.
[27] V.N.S.Murthy. Geotechnical Engineering: Principles and practices of soil mechanics and Foundation Engineering. New York: Mercel Dekker Inc., 2006

