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Investigation on some of the engineering properties of soils found in Shanto town

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ABSTRACT

Investigations of the underground conditions at a site are prerequisite to the economical design of the substructural elements. The objectives of this paper are to investigate some of the engineering properties of soils found in shanto town. In order to achieve objectives this study, 20 soil samples were taken at an average depth of 1.5m and 3m from different kebeles based on future expansion of the town and different laboratory tests were accompanied on the collected soil samples. The test results showed that the NMC ranges 18.07% to 45.22%, Y ranges from15.28 to 19.17 KN/m^3, Gs ranges from 2.66 to 2.75, LL ranges from 55 to 87%, PL ranges from 29.4 to 42.2%, PI from 25 to 45%, Q_u ranges from 112.6 -206.7kN/m^2, Su ranges from 56.31-103.33 KN/m^2, over consolidation ratio greater than 1 and compression index ranges from 0.110 to 0.246. Based on the laboratory test results, the study area soil was characterized as highly inorganic clay with soil class of A-7-5 and A-7-6 according to AASHTO soil classification scheme and inorganic clay of high plasticity (CH) according to Unified Soil Classification System. One-dimensional consolidation test shows that the area under investigation is overconsolidated in its natural state with over consolidation ratio greater than 1 and have compression index ranges from 0.110 to 0.246.

Keywords— *Investigation, Soil, Engineering properties*

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 [18].

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. The current safety of an existing structure may require investigation if excessive settlements or cracks have occurred. The required remedial measures may be undertaken based on new-found information or on the damage evidence and a reinterpretation of the original data [5]. 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 [16].

1.1 OBJECTIVE

1.1.1 General Objective: The general objectives of this study is to investigate some of the engineering properties of soils found in Shanto town.

1.1.2 Specific Objective:

- To investigate the index properties of the soil
- To classify the soil based on ASHTOO and USCS soil classification system
- To determine the shear strength characteristics of the soil.
- To determine the one-dimensional consolidation characteristics of soils in Shanto town.

2. LITERATURE REVIEW

In engineering, soils are considered to include all organic and inorganic earth materials occurring in the zone overlying the rock crust. They are usually non-homogenous porous material whose engineering behavior is greatly affected by changes in moisture content and density [1]. Soils may be separated into three very broad categories i.e. cohesionless, cohesive, and organic soils. Cohesive soils are characterized by very small particle size where surface chemical effects predominate. The particles do tend to stick together as the result of water particle interaction and attractive forces between particles. therefore, both sticky and Cohesive soils are plastic. Cohesive soils (mostly clays, but also silty clays and clay-sand mixtures with clay being predominant) exhibit generally undesirable engineering properties compared with those of granular soils [14].

A bulk soil, as it exists in nature, is more or less randomly assembled of soil particles, water and air. The properties of soils are complex and variable. Every civil engineering work involves the determination of soil type and its associated engineering application; certain properties are more significant than others. The common problems faced by civil engineers are related to bearing capacity and compressibility of soil and seepage through the soil. The possible solution to these problems is arrived at based on the study of the physical and index properties of the soil [9].

Index properties are the properties of soil that help in identification and classification of soil. Water content, Specific gravity, Particle size distribution, in situ density (Bulk Unit weight of soil), Consistency Limits and relative density are the index properties of soil. These properties are generally determined in the laboratory [10].

2.1 SOIL FORMATION

Soil is defined as a natural aggregate of mineral grains, with or without organic constituents that can be separated by gentle mechanical means such as agitation in water. By contrast, rock is considered to be a natural aggregate of mineral grains connected by strong and permanent cohesive force. The process of weathering of rock decreases the cohesive force binding the mineral grains and leads to the disintegration of bigger masses to smaller and smaller particles. Soils are formed by the process of weathering of the parent rock [17].

Soils are formed from the physical and chemical weathering of rocks. Physical weathering involves a reduction of size without any change in the original composition of the parent rock. The main agent responsible for these processes is exfoliation, unloading, erosion, freezing and thawing. Chemical weathering causes both reductions in size and chemical alteration of the original parent rock. The main agents responsible for chemical weathering are hydration, carbonation and oxidation. Often chemical and physical weathering take place in concert [16].

Chemical weathering is much more important than physical weathering in soil formation. Soils at a particular site can be residual (that is weathered in place) or transported (moved by water, wind, glacier, etc.) and the geologic history of a particular deposit significantly affects its engineering behavior. Natural soils generally are mixtures of several different particle sizes and may even contain organic matter. Some soils such as peat may be almost entirely organic. Furthermore, because soils are a particulate material, they have voids and the voids are usually filled with water and air [11].

3. RESEARCH METHODOLOGY

This study was aimed to investigate some of the engineering properties of finding in Shanto town on selected 20 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.
- 10 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.

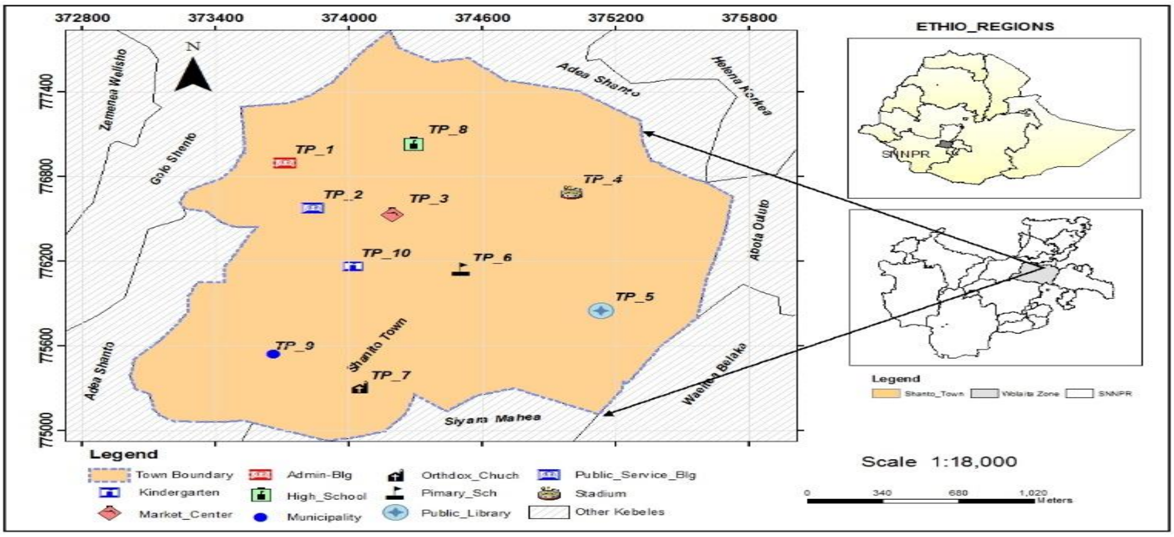

Fig. 3.1: Location map of the study area

Table 3.1: GPS coordinates of sampling areas

Test Pit designation	GPS Data		
	Northing	**Easting**	**Elevation (m)**
TP$_1$	037^{0}37’79.0’’	077^{0}65’69.00’’	1958.
TP$_2$	037^{0}94’79.0’’	077^{0}64’48.60’’	1948.5`
TP$_3$	037^{0}41’82.05’’	077^{0}64’45.19’’	1953
TP$_4$	037^{0}48’92.05’’	077^{0}63’44.19’’	1954.5
TP$_5$	037^{0}48’72.05’’	077^{0}63’46.17’’	1956
TP$_6$	037^{0}46’71.00’’	077^{0}64’44.22’’	1957
TP$_7$	037^{0}48’.00’	077^{0}64’48.55’’	1959.5
TP$_8$	037^{0}47’.75’’	077^{0}63’49.5’’	1958
TP9	037^{0}57’’.65’’	077^{0}66’48.5’’	1957.45
TP10	037^{0}58’.60’’	077^{0}61’46.8’’	1958

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), In situ density Free Swell Test and One-dimensional consolidation test. All tests are conducted based on ASTM standards.

Table 4.1: Laboratory test results

Depth(m)	NMC (%)	Gs	LL (%)	PL (%)	PI (%)	YKN/m^3	OMC (%)	MDD(g/cc)	Fs (%)
1.5	27.7	2.7	63	31.2	32	16.4	24.5	1.32	60
3.0	23.66	2.72	71	30.7	40	15.3	27.8	1.17	71
1.5	36.39	2.68	77	34.8	42.2	17.20	24.8	1.37	81
3.0	31.77	2.70	87	42.2	45	16.4	27.4	1.18	91
1.5	45.22	2.75	86	41.9	44	16.4	24.2	1.33	90
3.0	43.63	2.74	69	29.4	39.6	17	28.7	1.20	82
1.5	43.60	2.67	65	31	34	16.89	24.5	1.31	68
3.0	41.69	2.69	64	31	33	16.3	28.7	1.16	65
1.5	35.40	2.69	59	30.5	28	16	24.3	1.46	63
3.0	33.11	2.71	55	30.2	25	16.3	27.9	1.23	60
1.5	28.49	2.66	57	29.7	27	18.3	28.6	1.28	62
3.0	23.45	2.70	61	32.3	29	19.2	28.7	1.16	60
1.5	34.25	2.67	62	30.8	31	17.3	26.8	1.60	68
3.0	31.41	2.71	63	30.6	32	18.0	27.9	1.23	70
1.5	40.59	2.66	66	31.2	34.6	18.3	28.3	1.30	73
3.0	34.75	2.68	63	31.4	32	16.0	28.7	1.19	67
1.5	20.36	2.68	64	31.2	33	17.3	28.6	1.28	75
3.0	21.41	2.70	67	31.5	35.7	18.2	28.7	1.22	78
1.5	20.98	2.72	65	31.3	34	18.2	24.2	1.34	69
3.0	18.07	2.67	64	31.7	33	18.5	28.1	1.20	65

Table 4.2: Unconfined compression test result

Test pit code	Depth(m)	Moisture content (%)	Unconfined compressive strength, Qu (kN/m2)	Un-drained shear strength(kN/m2)	Consistency
Tp1	1.5	46.7	109	54.5	medium
	3	47.7	106.2	53.1	medium
Tp2	1.5	45.5	123.4	61.7	medium
	3	46	116.5	58.24	medium
Tp7	1.5	42.9	202	101	Stiff
	3	44.5	123	61.48	medium
Tp9	1.5	41.1	206.7	103.33	stiff
	3	42.4	133.33	66.65	medium

Table 4.3: one-dimensional consolidation test results

Test pit and depth	Bulk unit weight (kN/m^3)	Pressure (KPa)	Coefficient of consolidation Cv ($10^{-3} cm^2/min$)	Compression index Cc	Recompression index, Cr	Pre-consolidation pressure (KPa)	Over-consolidation ratio (OCR)
Tp_1@3m	15.3	50	0.063	0.135	0.08	250	5.45
		100	0.12				
		200	0.35				
		400	0.38				
		800	0.62				
		1600	0.50				
Tp_2@3m	16.4	50	0.185	0.346	0.094	180	3.65
		100	0.245				
		200	0.168				
		400	0.426				
Tp_5@3m	16.3	50	0.481	0.201	0.086	280	5.74
		100	1.058				
		200	0.885				
		400	0.858				
Tp_6@3m	19.2	50	1.470	0.182	0.012	160	2.78
		100	2.53				
		200	2.67				
		400	1.510				

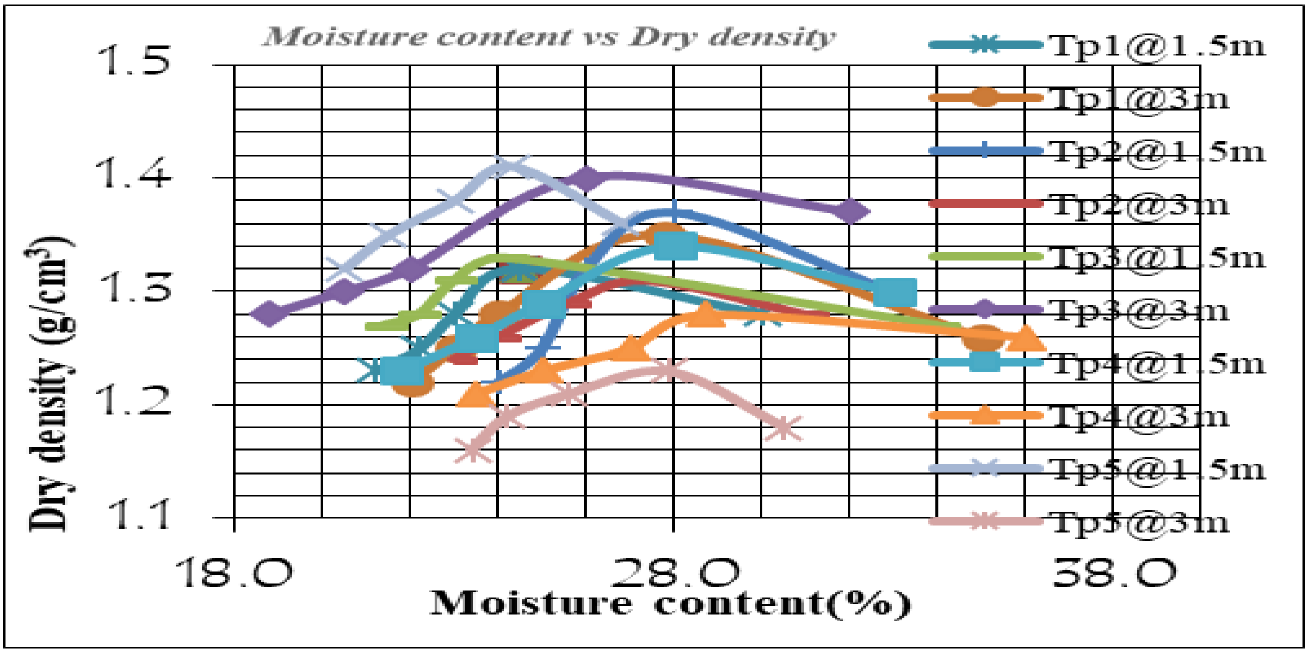

Fig. 4.1: Compaction test result graph

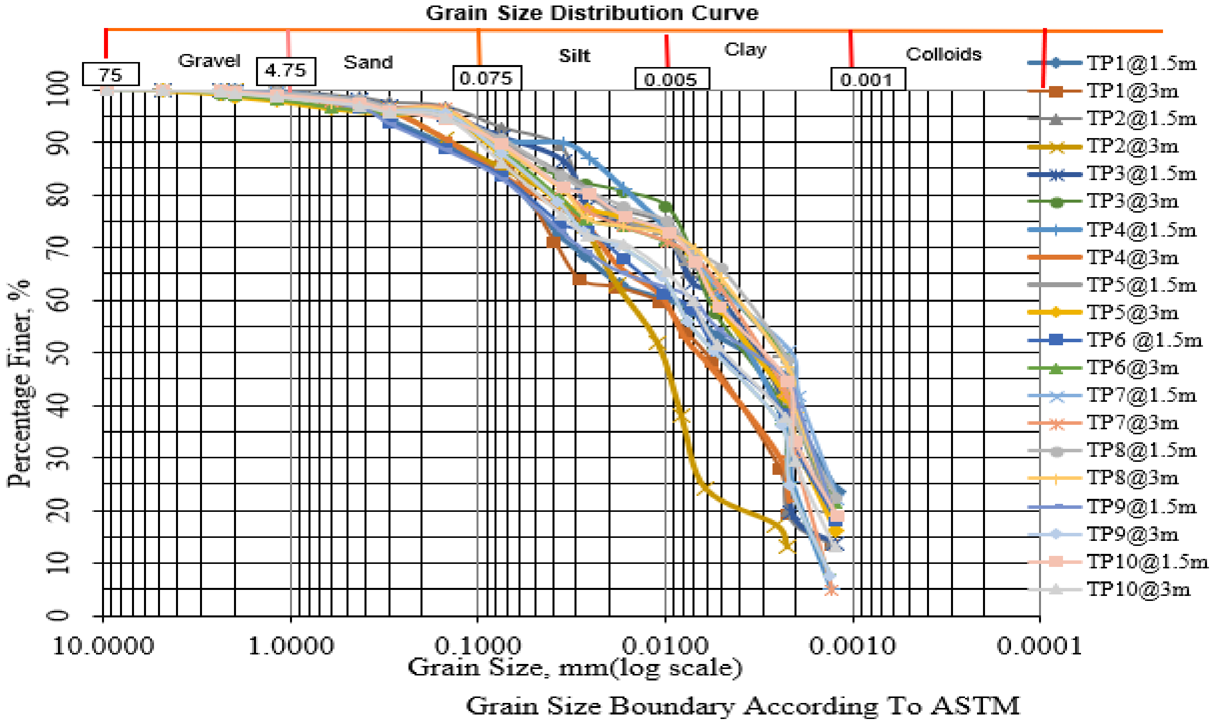

Fig. 4.2: Particle size distribution chart

Table 4.4: USCS Classification of Study area soil

Test pit code	Depth(m)	Particle size passing sieve size 200 (%)	Liquid Limit (%)	Plastic Index (%)	USCS Classification
TP1	1.5	84.15	63	32	CH
	3	87.5	71	40	CH
TP2	1.5	91.06	77	42.2	CH
	3	88.25	87	45	CH
TP3	1.5	92.9	86	44	CH
	3	85.15	69	39.6	CH
TP4	1.5	90.25	65	34	CH
	3	83.85	64	33	CH
TP5	1.5	89.92	59	28	CH
	3	87.75	55	25	CH
TP6	1.5	83.55	57	27	CH
	3	88.55	61	29	CH
TP7	1.5	88.90	62	31	CH
	3	89	63	32	CH
TP8	1.5	90.65	66	34.6	CH
	3	89	63	32	CH
TP9	1.5	82.95	64	33	CH
	3	87.85	67	35.7	CH
TP10	1.5	89.75	65	34	CH
	3	86.15	64	32	CH

Table 4.5: Activity of Study area soils

Test pit designation	Clay Fraction (%)	PI	Activity (A)	Soil description
Tp1@1.5m	53.32	32	0.60	Inactive
Tp1@3m	48.06	40	0.83	Normal
Tp2@1.5m	62.2	42.2	0.68	Inactive
Tp2@3m	24.08	45	1.87	Active
Tp3@1.5m	60.27	44	0.73	Inactive
Tp3@3m	57.35	39.6	0.69	Inactive
Tp4@1.5m	60.57	34	0.56	Inactive
Tp4@3m	46	33	0.7	Inactive
Tp5@1.5m	63.75	28	0.4	Inactive
Tp5@3m	58.75	25	0.43	Inactive

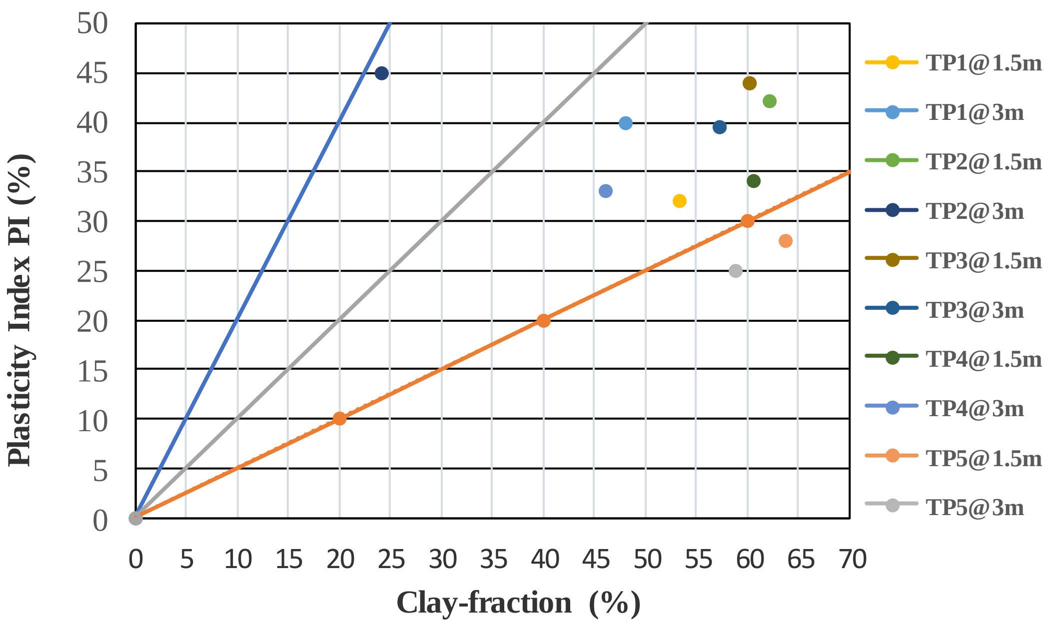

Fig. 4.3: Plasticity chart of study area Soil according to USCS [18]

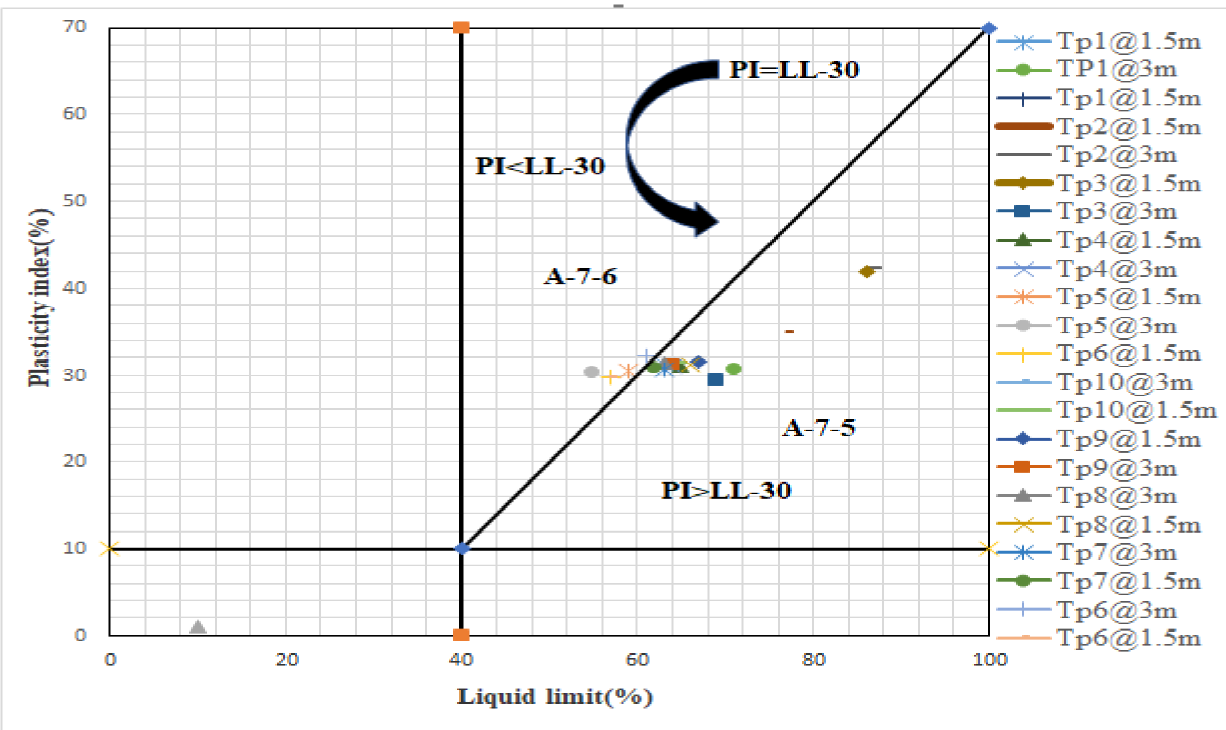

Fig. 4.4: Plasticity chart of soils of the study area according to AASHTO classification [2]

Table 4.6: Shows AASHTO soil classification of the study area

S.No	Depth(m)	Sieve Analysis percent passing			LL (%)	PI (%)	GI	Group Classification	Significant Constituent of materials	General Ratings as subgrade	AASHTO Classification
		No. 10	NO.40	No.200							
TP1	1.5	100	92.13	84.25	63	32	22	A-7-5	Clayey soil	poor	A-7-5(22)
	3	99.9	93.7	87.5	71	40	28	A-7-5	Clayey soil	poor	A-7-5(28)
TP2	1.5	99.7	95.38	91.06	77	42.2	33	A-7-5	Clayey soil	poor	A-7-5(33)
	3	99.8	94	88.25	87	45	31	A-7-5	Clayey soil	poor	A-7-5(31)
TP3	1.5	100	96.5	92.9	86	44	38	A-7-5	Clayey soil	poor	A-7-5(38)
	3	99.9	92.53	85.15	69	39.6	26	A-7-5	Clayey soil	poor	A-7-5(26)
TP4	1.5	99.6	94.3	90.25	65	34	26	A-7-5	Clayey soil	poor	A-7-5(26)
	3	99.8	91.83	83.85	64	33	22	A-7-5	Clayey soil	poor	A-7-5(22)
TP5	1.5	99.5	94.71	89.92	59	28	22	A-7-6	Clayey soil	poor	A-7-5(22)
	3	98.8	92.28	87.75	55	25	19	A-7-6	Clayey soil	poor	A-7-6(19)
TP6	1.5	99.5	91.53	83.55	57	27	19	A-7-6	Clayey soil	poor	A-7-6(19)
	3	98.9	93.58	88.55	61	29	23	A-7-6	Clayey soil	poor	A-7-6(23)
TP7	1.5	99.8	94.4	88.9	62	31	24	A-7-5	Clayey soil	poor	A-7-5(24)
	3	99.5	94.25	89	63	32	24	A-7-5	Clayey soil	poor	A-7-5(24)
TP8	1.5	99.8	95.23	90.65	66	34.6	27	A-7-5	Clayey soil	poor	A-7-5(27)
	3	99.2	94.1	89	63	32	30	A-7-5	Clayey soil	poor	A-7-5(30)
TP9	1.5	99.6	91.28	82.95	64	33	31	A-7-5	Clayey soil	poor	A-7-5(31)
	3	99.3	93.53	87.85	67	35.7	33	A-7-5	Clayey soil	poor	A-7-5(33)
TP10	1.5	99.2	94.46	89.75	65	34	31	A-7-5	Clayey soil	poor	A-7-5(31)
	3	99.3	92.73	86.15	64	33	31	A-7-5	Clayey soil	poor	A-7-5(31)

3. CONCLUSIONS

According to this study, the dominant type of soil found in Shanto town is clay. The specific gravity of soils in the study area ranges from 2.66- 2.75 and this shows that the investigated soil is within range. Mechanical grain size analysis shows that more than 85% of the total masses pass through sieve size of 0.075mm. This indicates that almost all soils can be taken as fine-grained soils. From hydrometer analysis, for most of the samples, more than 60% of their grain sizes are less than 0.005mm (clay size range as per ASTM boundaries criteria). This shows that the soil in the study area is categorized under the marginal degree of expansion. The liquid limit of soil the study area ranges from55 – 87%, plastic limit ranges from 29.4 – 42.2% and plasticity index range from 25–45%.%. This high value of consistency limits indicates the presence of high clay content. Based on the Unified Soil Classification System, the soils investigated in the research area are classified under CH. According to soil classification on plasticity index values stated in [18], the soil samples investigated under this thesis is categorized as very high plasticity. According to the AASHTO soil classification system, soil investigated in Shanto town is classified under A-7-5 and A-7-6. This reveals that the investigated soil has poor quality when used as subgrade material and needs stabilization or other techniques if recommended for using as subgrade material. The unconfined compressive strength of the soils in the study area range from 75 to 260kN/m^2 and undrained shear strength value range from 37.5 to 130kN/m^2. Based on unconfined compressive strength the approximate consistency of the soil ranges from soft to stiff. As determined from the one-dimensional consolidation test conducted on undisturbed soil samples, the ratio of Preconsolidation pressure with respect to overburden pressure shows the soils are over-consolidated with OCR greater than 1.

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