

Investigations on Index Properties and Maximum Dry Density of Soils Found in Kemise Town

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Abstract

The objective of this research is investigations on some of the index properties and maximum dry density of soils found in Kemise town. To find the necessary information from the sub soil, geotechnical investigation on engineering properties of soil is very essential and it is one of the most important parts of Foundation engineering. However, the engineering properties of soils in the area are not studied. To achieve the central aim of this research nineteen disturbed and undisturbed soil samples were collected from eleven test pits. Thereafter, tests for engineering properties were carried out in the laboratory. The dry densities of the soil are ranges from 1.37 to 1.61 g/cm^3 , while the optimum moisture content ranges from 20 to 31%. So the dry density of cohesion less soil has relatively higher dry density than cohesive soil. According to engineering properties test results, it is concluded that the type of soils found in Kemise town is clay, silt and silty sand. The tentative soil map is prepared according to the USCS soil classification.

Keywords: Investigation, Index property, Atterberg limit, Maximum dry density, Optimum moisture content, Unified Soil Classification System, Soil map.

1. Introduction

Kemise town is the administrative center of the Oromiya zone in Amhara region, north eastern part of Ethiopia, and 325km far from Addis Ababa.

A Field and laboratory soil properties investigation is required to obtain the essential information on the subsoil and is one of the most important parts of Foundation Engineering. In a country like Ethiopia which is developing at high growth rate and which needs many construction works in the future, geotechnical investigation on the Engineering property of soil is very essential. The growth of Kemise town has been rapid, since the town became the capital of the new zone of Oromiya and simultaneously became the woreda (sub-zonal administration) town of the Dewa Chefa woreda. However, the index properties of soils in the area are not studied.

1.1 Scope of the study

The scope of this study is focused on investigating the index properties, dry density, and optimum moisture content and prepares the tentative soil map of the study area. Nineteen Soil samples were collected from eleven test pits. Due to budget constraint, the depth of investigation in this research is limited to a maximum of three meters.

1.2 Materials and methods

1.2.1 Soil samples

Identification of sampling area has been done by collecting information from walk-over survey. Tests have been carried out samples collected from different sites. Accordingly eleven test pits have been selected within the town. Test pits were excavated up to depth of 3m. Disturbed and undisturbed soil samples were taken at 1.5m and 3m depths.

And then, index properties and dry densities of soils have been determined using laboratory equipment. The compaction test was conducted to find maximum dry density and optimum moisture content. The Standard Proctor Test [ASTM, 2004] was used for the compaction. Soil passing No.4 (4.75mm) sieve air-dried soil is prepared and compacted in three layers with each layer compacted by 25 blows. The compaction tests were conducted for samples TP1, TP2, TP4 and TP9 at depth of 1.5 and 3m. The latitude and longitude coordinates of test pits were located by using global positioning system (GPS). The soil map and location of test pits are done by using Global Mapper 11 software.

2. The study area

Kemise is a town and a separate woreda in northeastern Ethiopia, the administrative center of the Oromiya Zone of the Amhara Region. This town has a latitude and longitude of 10°43'N 39°52'E respectively with elevation of 1450 meters above sea level [Jonathan B., 2012].



Fig. 2.1 Location map of Kemise town in Oromiya zone [Jonathan B., 2012]

The area investigated is located between latitudes from 10°42'23"N to 10°43'17"N and longitudes from 39°51'44"E to 39°52'41"E. Eleven boreholes were drilled in the area to collect disturbed and undisturbed natural samples. The test pits locations are shown in [Fig.4].

3. Result and discussion

Information obtained from the results tested in laboratory is used to provide an indicator of general engineering behavior of soil in study area.

3.1 Properties of soil

For test pits TP6 and TP7, ground water is found at depths of 1.9m and 1.7m respectively. For test pit TP8, a bed rock is found at 1.6m. The study area soil is nearly dark and light gray.

Table 3.1: Test results which are determined in laboratory are tabulated below [ASTM,2004; Arora, K.R 2004; Agus Tugas S., M.Cakrawala, and Candra A,2012]:

S.no.	Depth (m)	Property	Value							
			Test Pits							
			TP1	TP2	TP3	TP4	TP5	TP9	TP10	TP11
1	1.5	Liquid limit (%)	53.8	53.3	36.8	61.2	58.9	37.4	81.4	52.7
		Plastic Limit (%)	26.2	30.4	24.7	32.4	31.2	27.4	33	30.9
		Plastic Index (%)	27.5	22.8	12.1	28.9	27.7	10	48.4	21.8
		Activity	0.75	0.62	0.47	0.8	0.85	0.6	0.91	0.7
		Free Swell (%)	55	40	35	35	40	15	95	30
		Specific gravity	2.63	2.63	2.72	2.69	2.69	2.7	2.73	2.67
		Optimum Moisture content (%)	27.5	27	-	20	-	22	-	-
		Maximum dry density (g/cm^3)	1.41	1.38	-	1.53	-	1.61	-	-
2	3	Liquid limit (%)	64.5	51.1	45.3	45.1	67.5	30.7	84.9	40
		Plastic Limit (%)	32.5	33.1	25.2	27.5	33.3	24.2	29.5	23.3
		Plastic Index (%)	32	18	20.1	17.6	34.2	6.5	55.4	16.7
		Activity	0.82	0.54	0.65	0.81	0.76	0.59	0.97	0.33
		Free Swell (%)	57.5	35	25	27.5	45	20	97.5	75
		Specific gravity	2.64	2.67	2.7	2.64	2.7	2.71	2.7	2.6
		Optimum Moisture content (%)	31	26	-	-	-	22.8	-	-
		Maximum dry density (g/cm^3)	1.37	1.47	-	-	-	1.59	-	-
3	TP6@1.9m, TP7@1.7m and TP8@1.6m		TP6	TP7	TP8					
		Liquid limit (%)	65.8	62.0	65.2					
		Plastic Limit (%)	31.1	33.1	31.8					
		Plastic Index (%)	34.7	28.9	33.5					
		Activity	0.86	0.82	0.72					
		Free Swell (%)	60	85	60					
		Specific gravity	2.67	2.74	2.68					

3.1.1 Atterberg limit

Atterberg Limits are integral parts of several engineering classification systems to characterize fine grained soil [Richard P. Weber, 2010]. The characteristics of a soil, especially a fine-grained soil, change to a marked degree with a variation of its water content [Arora, K.R 2004].

3.1.2 Specific gravity

For clayey and silty soils, the specific gravity varies from 2.6 to 2.9 [Braja M. Das, 2006]. The values of specific gravity of the tested soils range from 2.6-2.74, which is within this range.

3.1.3 Grain size analysis

For all test pits the grain size analysis is done according to ASTM D 422-63 and D1140-97 [Richard P. Weber, 2010]. The gradation curves are presented in Fig.3.1 and Fig.3.2. The grain size analysis result show that the dominant proportion of soil particles in study area is silt.

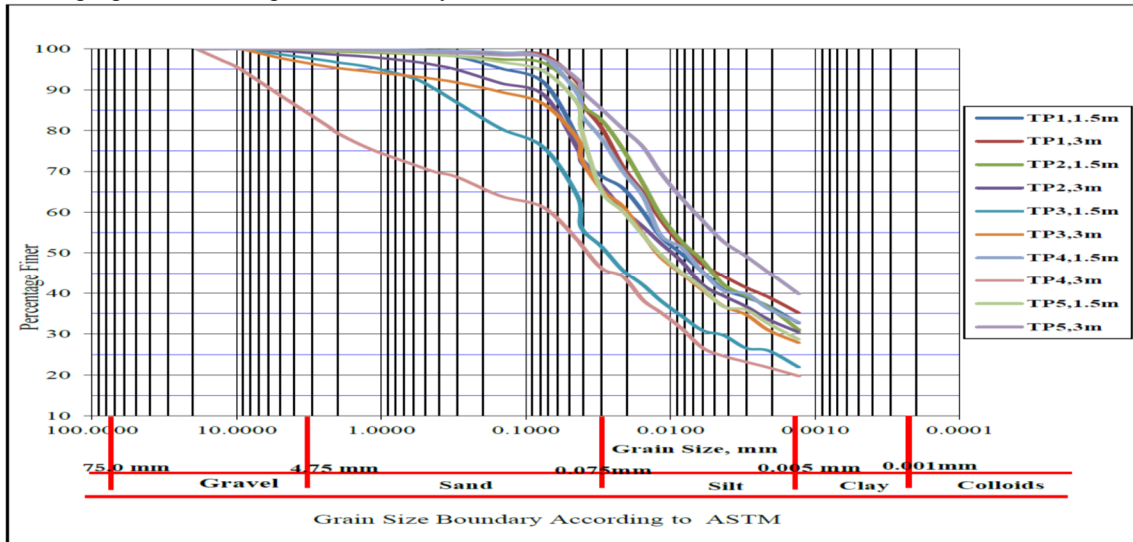


Fig.3.1 Grain size distribution curve for TP1 to TP5

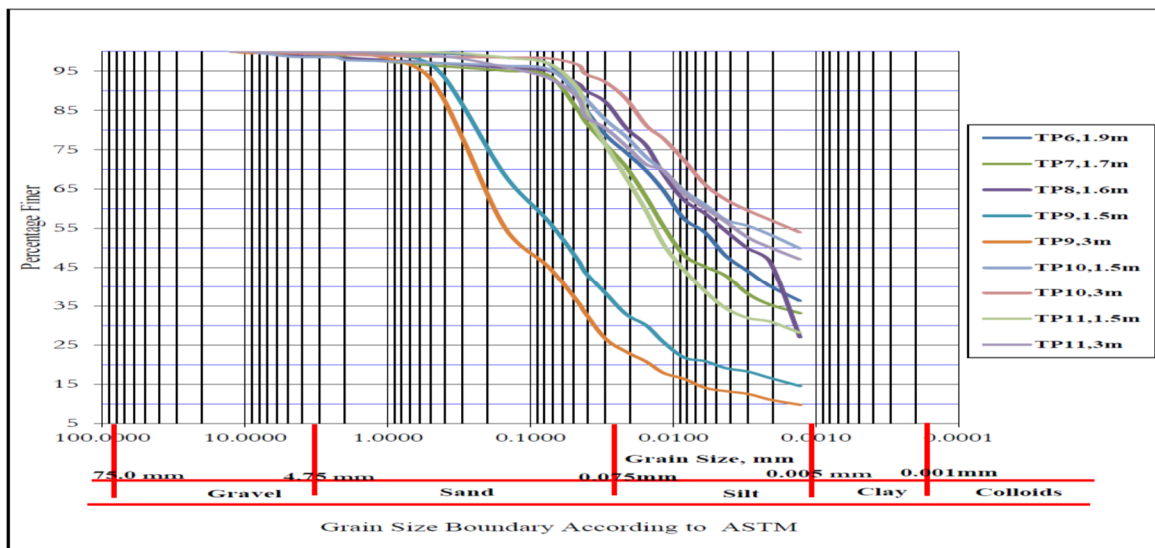


Fig.3.2 Grain size distribution curve for TP6 to TP11

Soil classification has done using Unified soil classification system (USCS), American Association of State Highway and Transportation officials (AASHTO) and activity number by combining the atterberg limit and grain size analysis result.

According to USCS [ASTM, 2004; Joseph E. Bowles, 1997], soils found in Kemise town are classified under CH, CL, MH, ML and SM with a plasticity range from low to high [Fig.1]. The values are tabulated in Table 1. According to AASHTO [Braja M. Das, 2006; AASHTO, 2004], the soils under the study area are categorized in A-4, A-6 and A-7-5/6 [Fig.2]. According to this classification system, the usual type of material is clayey soils except TP-9 which is silty soils. This classification indicates that the suitability of soils as sub grade material is not good. Based on activity number value most of the soils in the study area are moderate to in active

[Fig.3].

3.1.4 Compaction

In general cohesionless soils have a relatively higher maximum dry density and require less water than cohesive soils. Therefore, the optimum water content is less for cohesion less soils. Heavy clays of very high plasticity have very low dry density and very high optimum water content [ASTM, 2004; Braja M. Das, 2006].

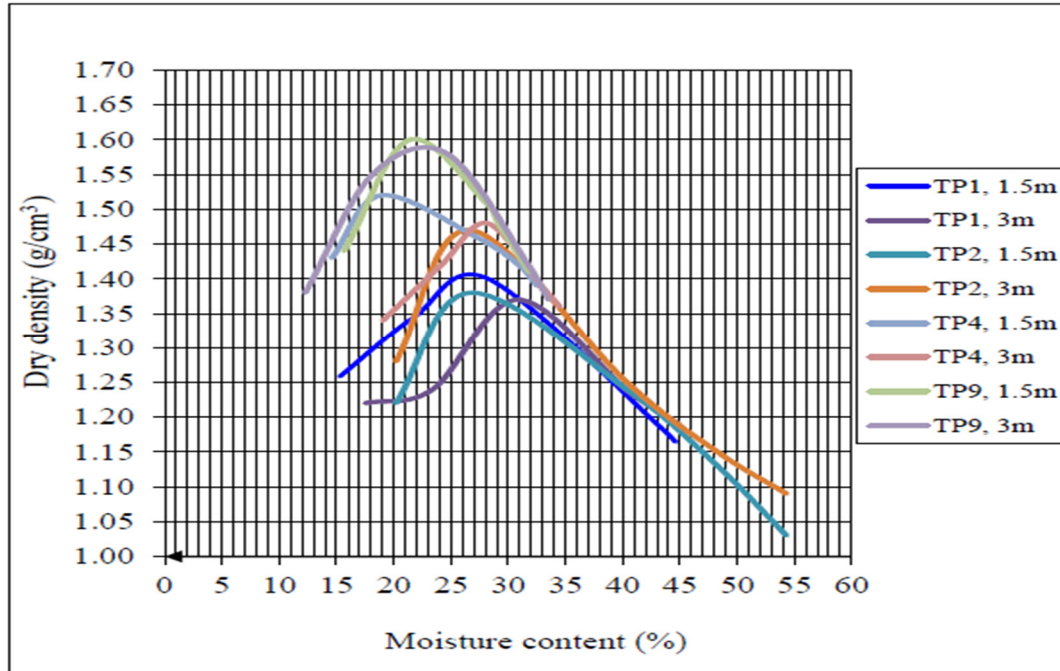


Fig.3.3 Dry density Vs Moisture content graph

3.2 Tentative soil map

In the study area soil samples were collected and tested from eleven test pits. The test pits are excavated up to a depth of 3m. The tentative soil map is prepared by assembling the laboratory analysis and field observation [Fig.5]. The delineation is done by interpolation between neighboring test pits.

4. Conclusion and Recommendation

The following conclusions and recommendations may be drawn based on the current study.

4.1 Conclusions

The types of soil found in Kemise town are clay, silt and silty sand. The test results for liquid limit ranges from 30.7 to 84.9%, plastic limit ranges from 23.3 to 34.7% and plastic index ranges from 6.5 to 55.4%. The soils have specific gravity ranges from 2.6 to 2.74. The free swell values ranges from 15 to 110%, indicates that the soils are non-expansive to moderate soil. The activity of the soil ranges from 0.33 to 0.97. The results obtained from grain size analysis the clay content ranges from 11.07 to 57.16%, silt ranges from 34.07-65.96%, sand ranges from 1.4 to 54.42% and gravel ranges from 0 to 11.87%.

4.2 Recommendations

Since the town became the capital of the new zone of Oromiya and simultaneously became the woreda (sub-zonal administration) town of the Dawa Chefa woreda; very recently, the boundaries of the town of Kemise are greatly extended, in terms of area and population. The tentative soil map of the study area should be modified by considering the newly incorporated surrounding areas.

Reference

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Table 1: Classifications of soils based on USCS Classification system [ASTM, 2004]

Test Pit	Depth (m)	Percent amount of particle size				LL (%)	PI (%)	Classification According to USCS
		Gravel	Sand	Silt	Clay			
TP1	1.5	0.11	8.18	54.93	36.78	53.8	27.5	CH
	3	0.1	1.4	59.5	39	64.5	32	MH
TP2	1.5	0.31	3.16	59.99	36.54	53.3	22.8	MH
	3	0.54	10.77	55.17	33.52	51.1	18.0	MH
TP3	1.5	1.43	22.78	49.88	25.91	36.8	12.1	ML
	3	2.4	11.16	55.33	30.91	45.3	20.1	CL
TP4	1.5	-	2.14	61.75	36.11	61.2	28.9	MH
	3	11.87	27.02	39.33	21.78	45.1	17.6	ML
TP5	1.5	0.07	5.44	61.98	32.51	58.9	27.7	MH
	3	-	2.06	52.77	45.17	67.5	34.2	MH
TP6	1.9	-	3.11	56.76	40.13	65.8	34.7	MH
TP7	1.7	0.26	5.82	58.56	35.36	62.0	28.9	MH
TP8	1.6	0.95	3.94	48.71	46.4	65.2	33.5	MH
TP9	1.5	-	43.22	40.18	16.6	37.4	10.0	SM
	3	0.44	54.42	34.07	11.07	30.7	6.5	SM
TP10	1.5	1.32	3.15	42.14	53.39	81.4	48.4	CH
	3	0.32	1.4	41.12	57.16	84.9	55.4	CH
TP11	1.5	-	3.06	65.96	30.98	52.7	21.8	MH
	3	0.06	6.71	43.11	50.12	40.0	16.7	CL

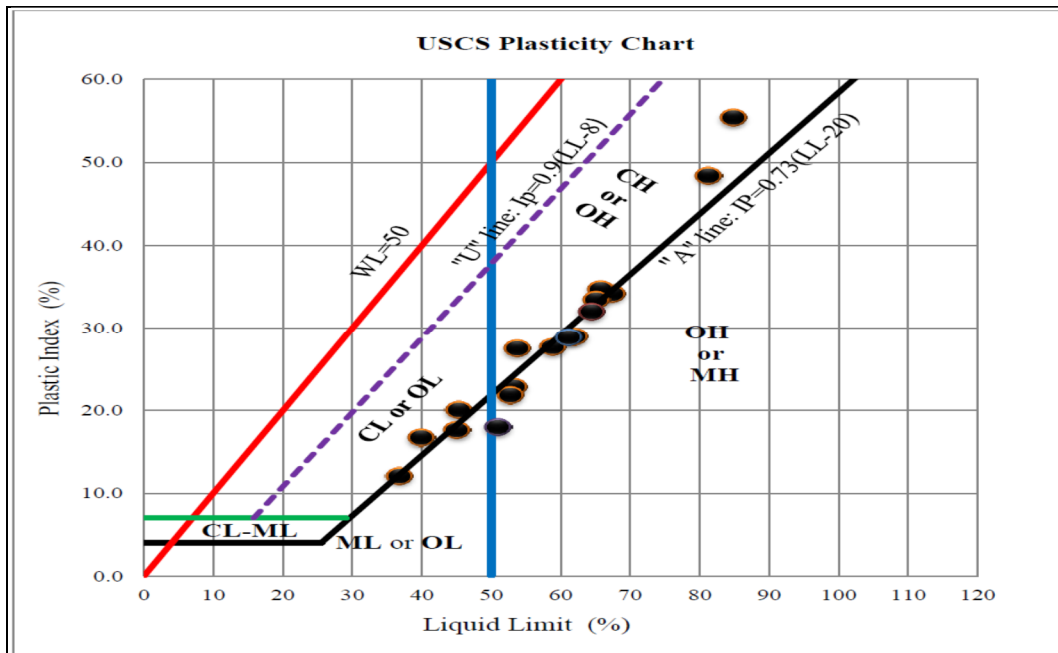


Fig.1 Plasticity chart for soil classification based USCS

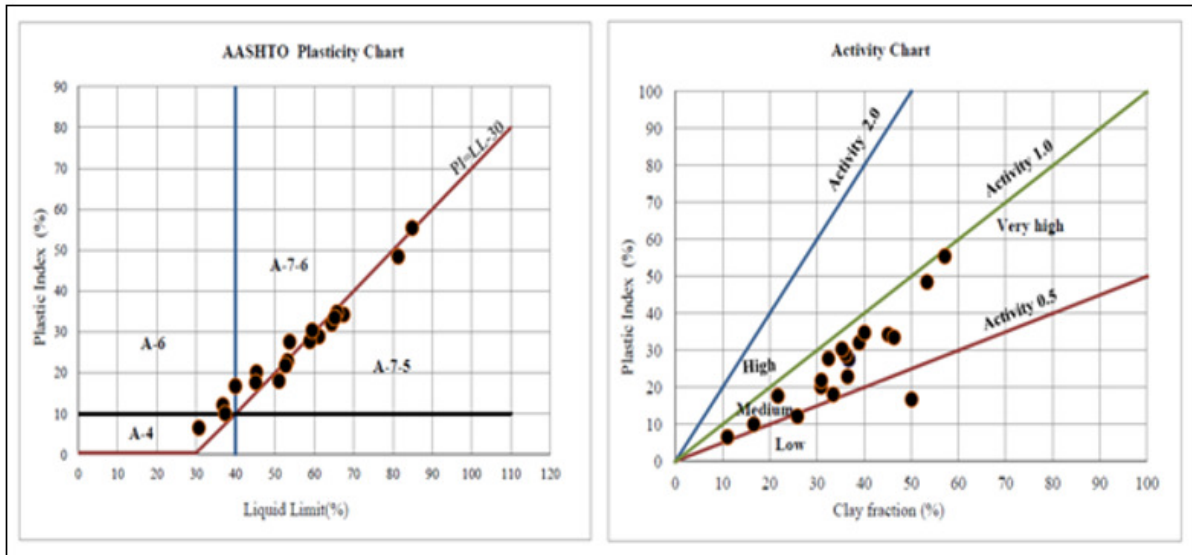


Fig.2 Plasticity chart for soil classification based on AASHTO.

Fig.3 Activity chart for soil classification.

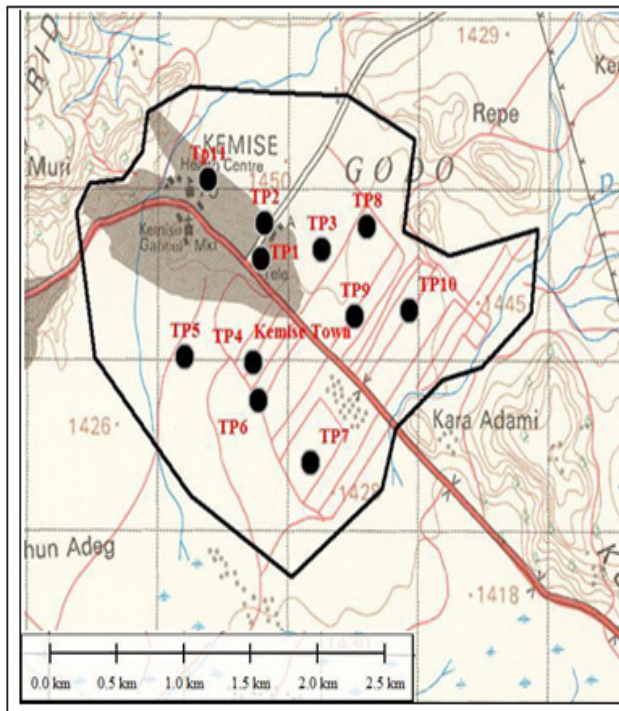


Fig.4 Test pits location for Kemise town.

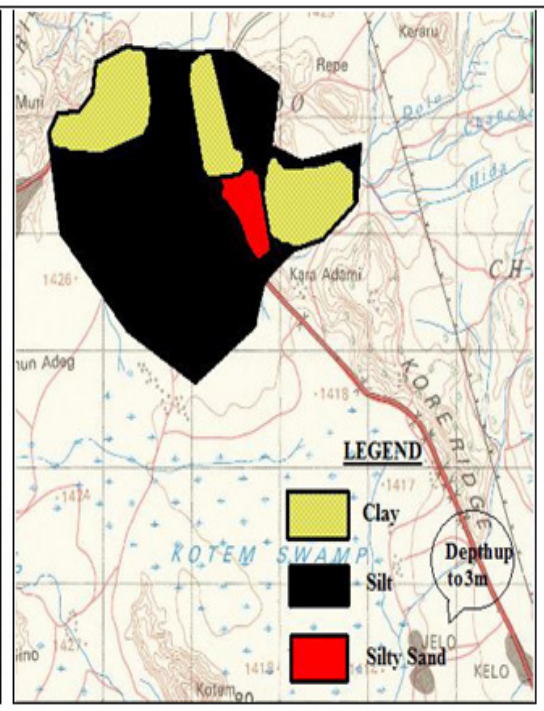


Fig.5 Tentative soil map for Kemise town.