

Characterization and Mapping of Subgrade Soils on Future Expansion Roads Between Kulfo and Hare Rivers

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Abstract - Subgrade soil characterization plays a vital role for examining the suitability of the subgrade soils for proposed project work. This paper presents the laboratory test results of subgrade soils that were performed to characterize and mapping the subgrade soils of Arba Minch town on future lateral expansion roads between Kulfo and Hare River. In order to characterize subgrade soils laboratory tests were accompanied on selected 16 soil samples which are taken from the road section at not more than 1km interval. The test results showed that the NMC ranges from 8.33% to 16.8%, LL ranges from 35.3% to 60.5%, PI ranges from 8.10% to 28.2%, OMC ranges from 10.6% to 18.7%, MDD ranges from 1.8g/cc to 1.95g/cc, CBR ranges from 3.89% to 7.95% and CBR swell ranges from 0.95% to 2.92%. Based on the laboratory test result the study area was characterized as silty clay with soil class of A-4, A-5 and A-7-5 according to AASHTO soil classification scheme. From which soil classes A-4 and A-5 are categorized as subgrade strength class of S3 and A-7-5 are categorized as subgrade strength class of S2 according to ERA pavement design manual. The data (laboratory test results of the study area) were input into a Geographical Information System (GIS) frame work to provide interactive maps that show the spatial distribution of the variables and identify their characteristics. This maps are then used to easily identify the properties of subgrade soils at various locations of study area.

Index Terms - Subgrade soil, Characterization, Mapping

I. INTRODUCTION

Soils possess different characteristics in nature. Soil characteristics are a measure of a soil's suitability to provide a proposed purpose. Strength of the pavement structures depends on the characteristics of the subgrade soil on which they built. Subgrade soil characterization is important components for the design and construction of road projects.

There are a number of laboratory tests which are useful in identifying and characterizing various soil types. According to ERA, pavement design manual, characterization of subgrade soils are determined using Grain Size Analysis (AASHTO T88), Atterberg Limits (AASHTO T89, T90), Moisture Content (AASHTO T265), Compaction Test (AASHTO T180), CBR and CBR Swell (AASHTO T193) (ERA, 2013). Whereas, According to AASHTO soil classification system characterization of soils are based on Grain size distribution and consistency (AASHTO, 2013).

For characterization purpose properties of subgrade soils are commonly grouped in to index properties (Natural Moisture Content, Grain-Size Analysis, Atterberg Limits, Specific Gravity) and engineering properties (Moisture-Density Relations, California Bearing Ratio (CBR))

II. LITERATURE REVIEW

2.1 Characterization of subgrade soil

AASHTO soil classification system introduced soil classification for subgrade characterization and accordingly, the AASHTO soils classification includes seven major groups; A-1 through A-7 and twelve subgroups; soils classified under groups A-1, A-2 and A-3 are granular materials of which 35% or less of the particles pass through the No.200 sieve. Soils of which more than 35% pass through the No.200 sieve are classified under groups A-4, A-5, A-6, and A-7. This soils are mostly silt and clay type materials (AASHTO, 2013).

2.2 Geotechnical Soil Mapping

The objective of the geotechnical soil mapping is to provide information about soils physical and engineering properties. Geotechnical soil mapping requires identification, classification and characterization of geotechnical soil units and analyzing these units to identify problematic soils and then determine the condition of foundation.

The GIS based soil mapping enables evaluating numerous soil properties dependent scenarios easily and quickly. This soil mapping can be used by different researchers. Libab M., et al' (2012) used GIS based mapping in order to map expansive soils in Toshka region. They used Geographic Information System (GIS) framework to provide interactive maps that show the results of a subsurface site investigation that was performed to characterize different soil and rock formations along Sheikh Zayed canal with particular emphasis on the swelling characteristics of the clays in that area (Libab, M. and Nashed, A., 2012). Chung (2007) used accepted Geographic Information System (ArcGIS) to prepare single Virtual Geotechnical Database map which can be used to retrieve subsurface data and perform an array of spatial analyses at St. Louis Metropolitan area (Chung, 2007).

III. RESEARCH METHODOLOGY

This study aimed to characterize and mapping subgrade soils of Arba Minch town on selected 16 soil samples taken from the proposed future expansion roads between kulfo and Hare River. In order to achieve the objectives of this work the following methodologies were used.

- 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.
- 16 sampling points are selected at less than 1km interval and field GPS readings are taken to locate the ordinate of sampling area.
- Soil samples are taken from selected 16 sampling areas.
- All the laboratory tests are performed according ASTM standard.
- Classification of the subgrade soils based on the laboratory test results using AASHTO M 145 (2013) Standard was held.
- Characterizing the subgrade soil by comparing and relating different parameters of engineering properties of soil was held.
- Finally data processing, presenting and preparation of maps was done using ArcGIS software.

IV. LABORATORY TEST RESULTS AND DISCUSSION

The type of laboratory tests carried out includes, Atterberg limit, Grain size distribution, Moisture- density relationship, Specific gravity, California Bearing Ratio (CBR), and CBR swell test. All testes are based on ASTM standards. The test results are as shown in Table 1.

Table 1; Laboratory test results

Test Pit	NMC (%)	Gs	LL (%)	PL (%)	PI (%)	OMC (%)	MDD (g/cc)	CBR (%)	CBR swell (%)
1	11.39	2.68	42.30	33.40	8.90	12.90	1.88	6.14	1.46
2	13.57	2.74	47.20	37.60	9.60	15.40	1.84	5.33	1.80
3	14.49	2.77	48.10	37.59	10.51	15.50	1.83	5.84	1.80
4	13.77	2.79	56.00	32.00	24.00	16.30	1.82	4.94	2.49
5	15.51	2.82	52.30	31.20	21.10	17.10	1.82	4.49	2.58
6	16.80	2.85	60.50	32.30	28.20	18.60	1.80	3.89	2.92
7	15.03	2.84	60.20	33.30	26.90	18.70	1.81	4.38	2.83
8	11.33	2.67	41.20	31.40	9.80	12.10	1.89	7.12	1.37
9	10.48	2.71	38.40	29.40	9.00	11.70	1.92	6.52	1.12
10	8.33	2.68	35.30	28.10	7.20	10.60	1.95	7.95	0.95
11	8.96	2.69	36.30	28.20	8.10	10.80	1.94	7.71	1.00
12	9.68	2.70	37.80	29.30	8.50	11.40	1.93	7.49	1.12
13	10.29	2.72	39.20	30.20	9.00	12.50	1.90	6.82	1.29
14	12.50	2.73	45.30	35.60	9.70	14.40	1.86	6.21	1.63
15	13.92	2.74	46.80	37.50	9.30	14.70	1.85	5.88	1.72
16	12.35	2.73	44.20	36.10	8.10	13.00	1.87	6.22	1.54

Atterberg limits are used to characterize the interaction of the fines with moisture. Liquid and plastic limits tests determine the plasticity of fines particles and thereby allow them to be defined as either silt or clay soils. The word “silty” is applied to a fine material having a plasticity index of 10 or less, and the term clayey is applied to fine material having a PI of more than 10, (AASHTO M 145). Based on this 25% of the study subgrade soils are classified as clay and 75% are silt.

Based on wet sieve analysis all the subgrade soils in the study area were found to have fine (clay & silt) fraction of above 35% by weight and the percent of fine content shows increasing slightly as the elevation reduced. Accordingly, the study area subgrade soils are classified as A-4, A-5, and A-7-5, from which soil classes A-4 and A-5 are categorized as subgrade strength class S3 and soil class A-7-5 are categorized as subgrade strength class S2.

Geotechnical Soil Mapping

Based on the results obtained from laboratory test GIS geo-database was designed to include the properties of 16 subgrade soil samples obtained from study area. This properties are stored in the geo-database using ArcGIS software. In order to visualize the soil properties of the collected samples, GIS layouts were generated to display the required properties. As an example, the gradation, and strength class and atterberg limits are given in Figure 1, 2 and 3 respectively. These layouts relate the soil properties of the samples to their geographic locations along study route, and the structural plan of the area is used as a base map. Moreover, the Geographic Information System (GIS), designed in this research provides a tool to select a particular soil sample and retrieve all its properties, as shown in Figure 4. This data are retrievable and can be easily reviewed and updated periodically in light of any future variation or observation which is difficult to put in tabular form. Accordingly, numerous tasks can be handled using the developed system depending on the purpose of information needed and the scenario under evaluation.

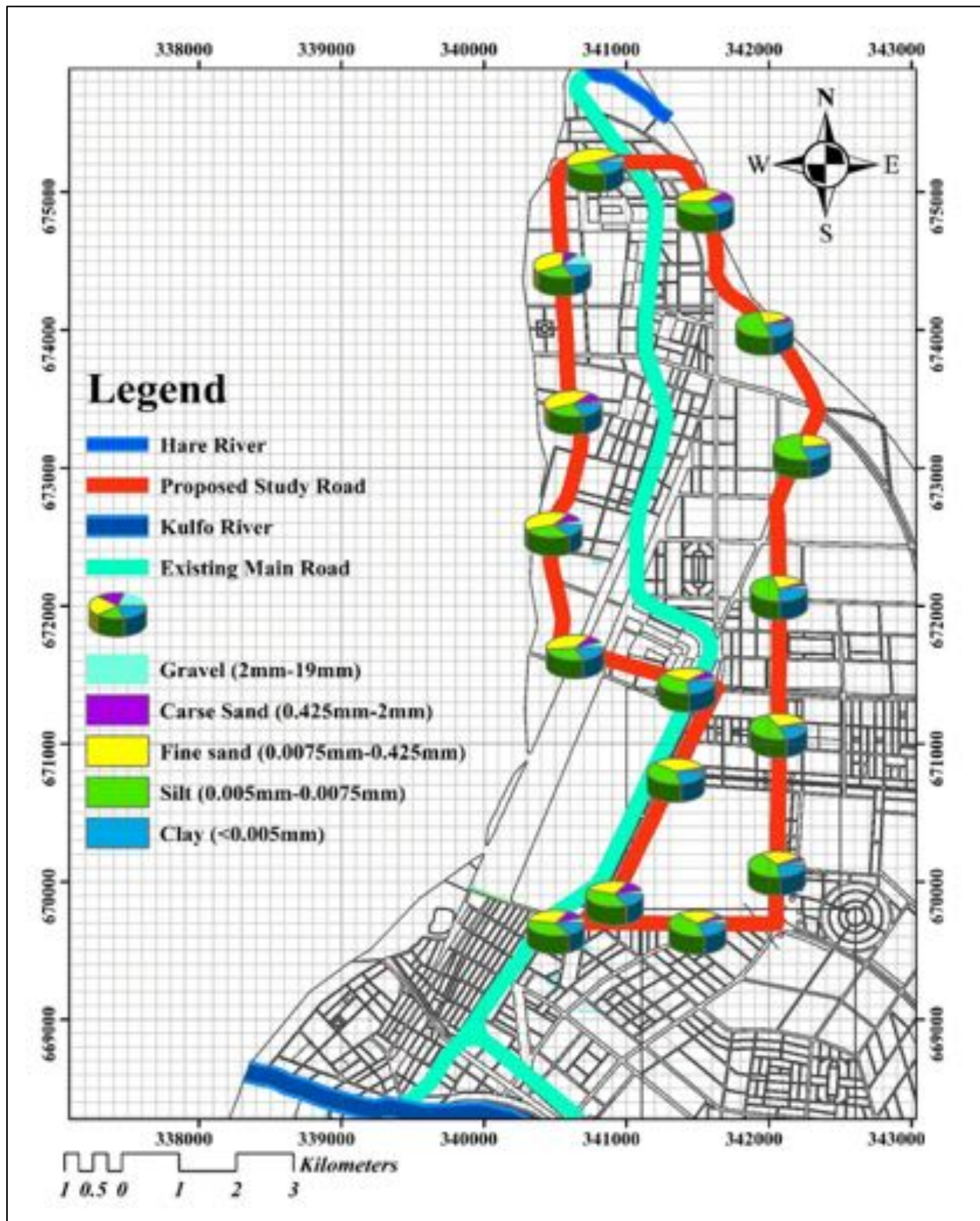


Figure 1; Subgrade Soil Gradation Map of Study Area

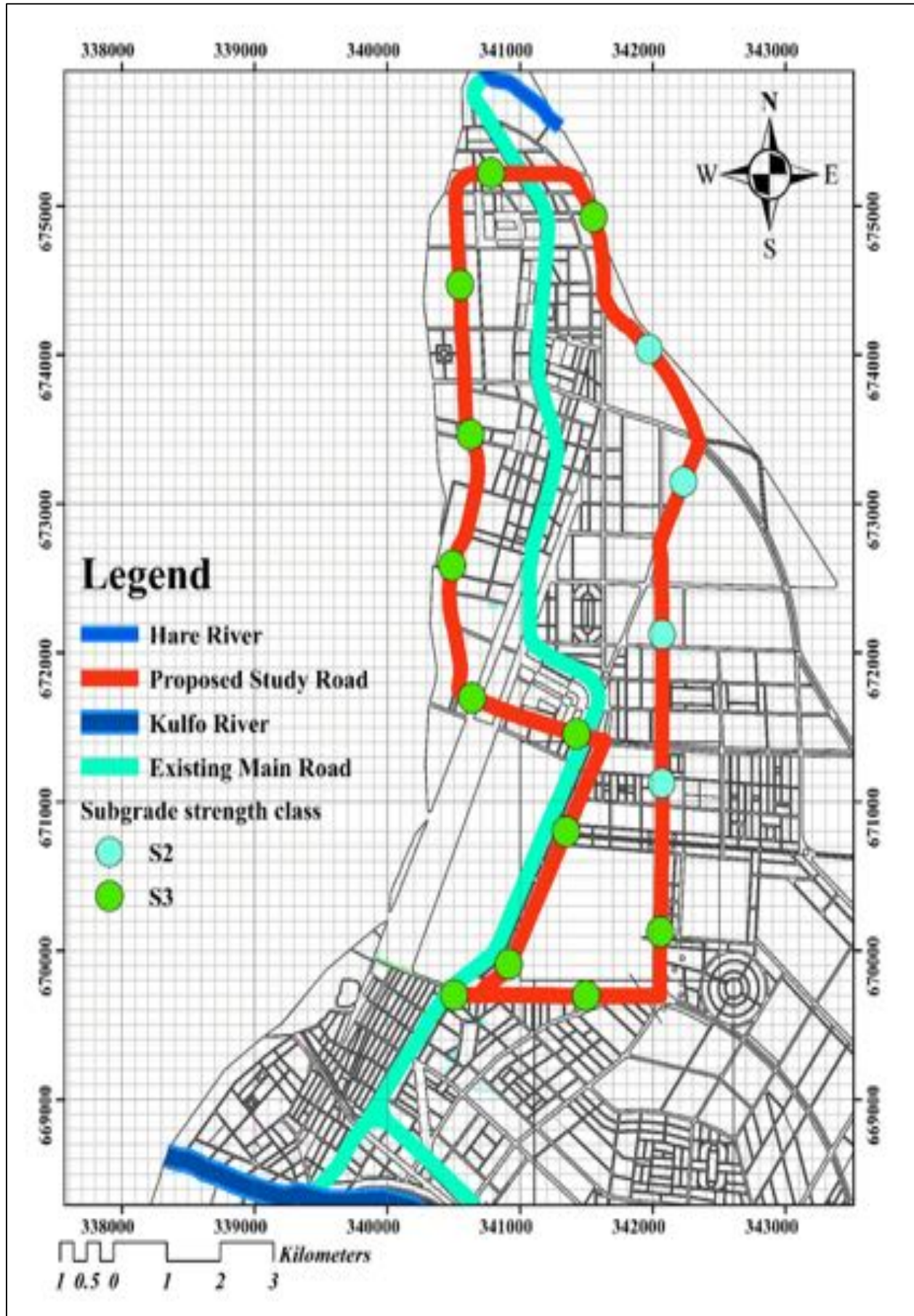


Figure 2; Subgrade Strength Class Map of Study Area.

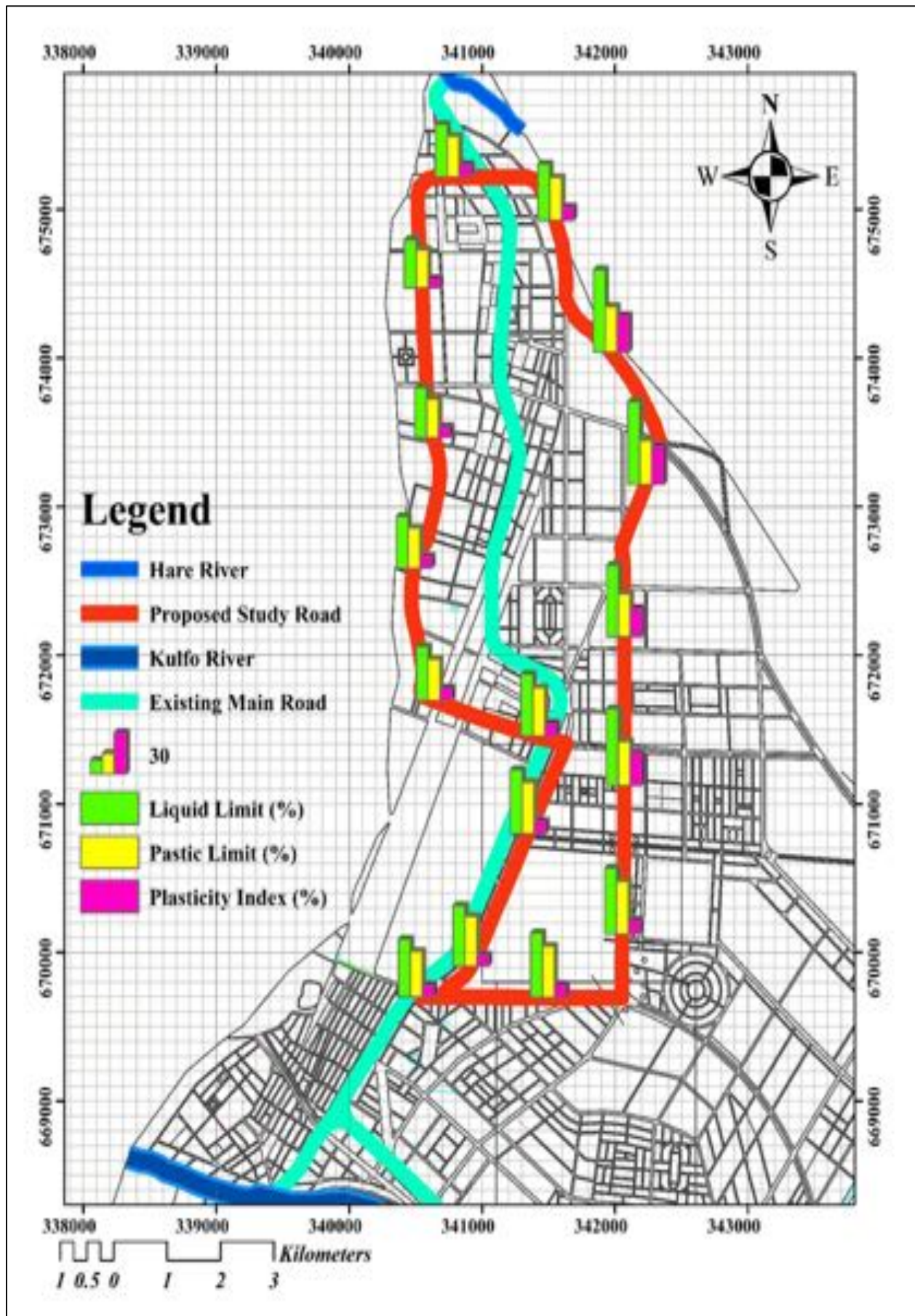


Figure 3, Atterberg Limits Map of Study Area

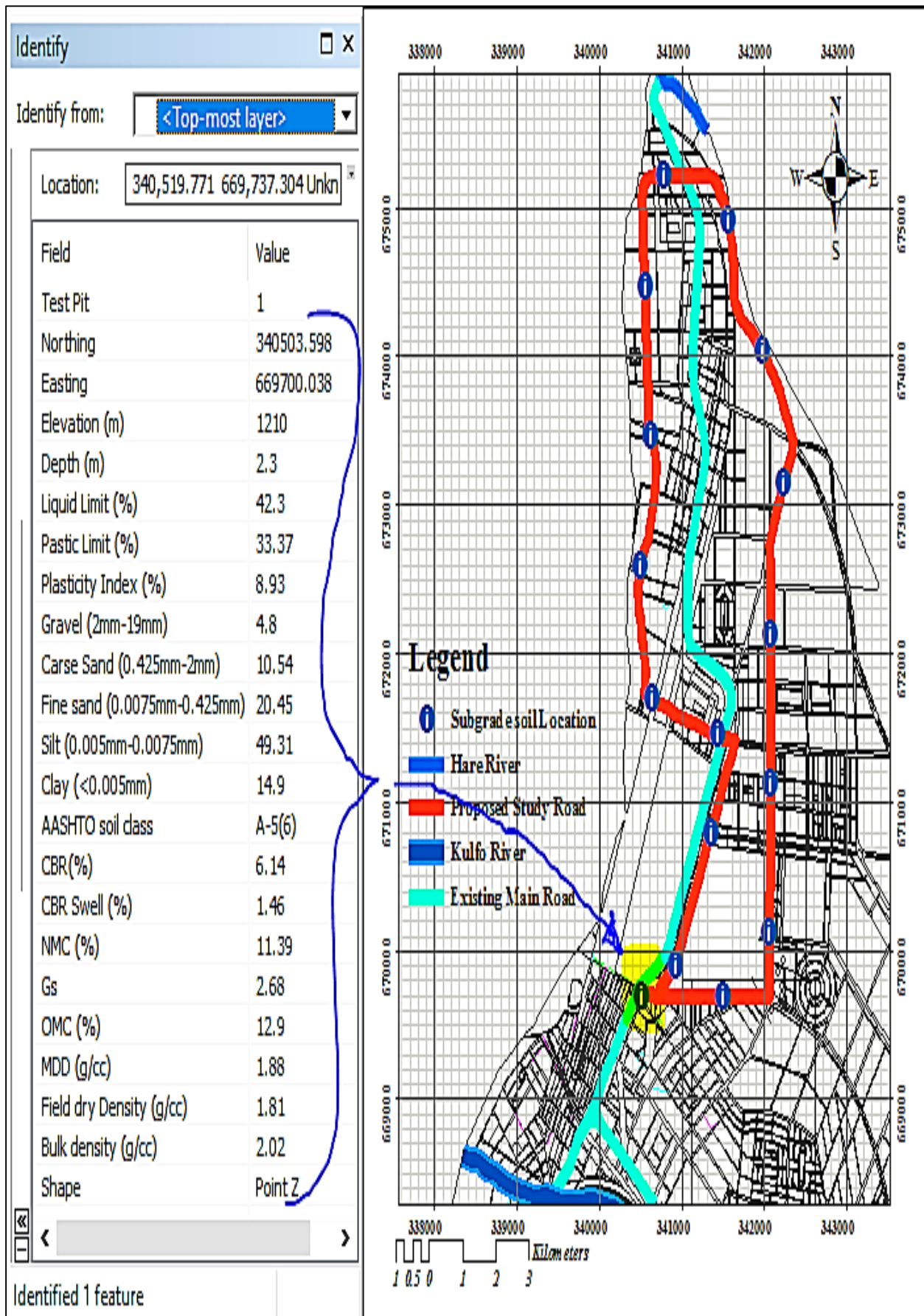


Figure 4; Subgrade soil Property of Selected Location

V. CONCLUSIONS

The present paper emphasized on characterizing and mapping of subgrade soils of Arba Minch town on future expansion roads between Kulfo and Hare River, and the following conclusions are drawn based on the field and laboratory test results.

The subgrade soils of the study area are characterized as silty clay soil, poor to fair bearing capacity and low to medium swelling potential with soil class of A-4, A-5, A-7-5, and subgrade strength classes of S2 and S3.

The GIS based map on the field and laboratory test results provides all the necessary information associated with each soil sample and enables evaluating numerous soil property dependent scenarios easily in an efficient and time saving way and combines them with its spatial location in a clear and organized form.

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