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Geotechnical Properties of Soil in Ranya and Arbat Area, Sulaimaniya, Kurdistan Region, Iraq

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Abstract

This study deals with the determination of some geotechnical properties of soil in Ranya district and Arbat sub-district area. These two areas are located in Sulaymaniya Governorate, Kurdistan region of Iraq. The soil in nature is changing from one place to another. This is because of the mineral composition of rocks and climate change, so, studying the properties of soil is important for various purposes especially for engineering structures. In this paper, some geotechnical soil were studied, like particle size distribution, specific gravity and Atterberg limits. The study of particle size distribution indicated that the soil comprises mostly of silt and sand with some clay. This means that the soil consists of coarse and fine mixture. The Atterberg limits results are indicating that both areas are characterized by low to medium plasticity index. Specific gravity test results are indicating that the soil in both areas is free from iron and mica minerals. A good matching of the geotechnical soil properties between Ranya and Arbat area is indicated.

Keywords: Geotechnical properties, particle size, Atterberg limits, specific gravity of soil, Ranya, Arbat.

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1. Introduction

Soil exploration is a must in the present age for the design of foundations of any project. The extent of the exploration depends upon the magnitude and importance of the project. Projects such as buildings, power plants, fertilizer plants, bridges, etc. are localized in an area extend. The area occupied by such projects may vary from a few square meters to many square kilometers (Murthy, 2007). Before a field investigation is started, available technical data including topographic maps, aerial photographs, agricultural soil maps, ground water resources documents, geological maps, detailed information from adjacent or similar sites, local residents, and sub-surface explorations should be reviewed (Fratta et al., 2007). Soils are used as construction materials; in other words the civil engineering structures are found in or on the surface of the earth. Geotechnical properties of soil influence the stability of civil engineering structures. The choice of particular methods of particle size distribution should be governed by the details required and specific characteristics of the materials to be analyzed (Olawuyi1 and Asante1, 2016). Experimental characterization of the size of individual particles are achieved by a combination of two procedures: sieving and sedimentation (Jury, 1991). The sedimentation analysis is based on Stokes' law, according to which terminal velocity of sinking a spherical particle in a still liquid medium is dependent upon density and viscosity of the liquid (Das, 2002). Ranya District and Arbat Sub- District area are located in Sulaimaniya Governorate, within the Kurdistan Region of Iraq. Both areas (Arbat and Ranya) are approximately 34 and 104 km far from the Sulaymaniyah city center. Ranya is located from the north west while the Arbat is from south east of the Sulaymaniyah city (see Figure 1). Structurally, both areas are located at the boundary between highly folded zone and imbricated zone (Jassim and Goff, 2006). Alluvial sediments cover Ranya area, which consists of clay, silt, sand, and gravel (Sissakian, 2000), see Figure 2; while Arbat area is located on Shiranish and Kometan Formations. Shiranish Formation consists of bluish grey marl with marly limestone, while Kometan Formation consists of well bedded white limestone.

2. Materials and Methods

Sixteen boreholes were dug from the two areas with different depth approximately ranged from 5.5m to 6.0 m. Disturbed soil samples were collected from the boreholes in order to perform classification of the soil. Classification tests were conducted on disturbed samples. The soil samples were separated into coarse - grain soils and fine-grained soils according to ASTM D 422. Coarse-grained soils include those particle sizes diameter larger than 0.075 mm (retained on sieve number 200) such as boulders, cobbles, gravel and sand; while fine – grained soils consist of particle sizes smaller than 0.075mm (passing through sieve number 200) such as silts and clays (Allen, 1997). Sieve analysis was performed for coarse grain soil particles and sedimentation analysis (Hydrometer test) for fine grain soil particles. In the sedimentation analysis, the density of the suspension is measured by taking hydrometer reading at different times (Gee and Bauder, 1986). It gives a percentage of clay and silt fractions which is used as a construction material for earth structures or as supporting strata for building structures (Roy and Bhalla, 2017). Specific gravity test was conducted to the samples according to ASTM D 854.

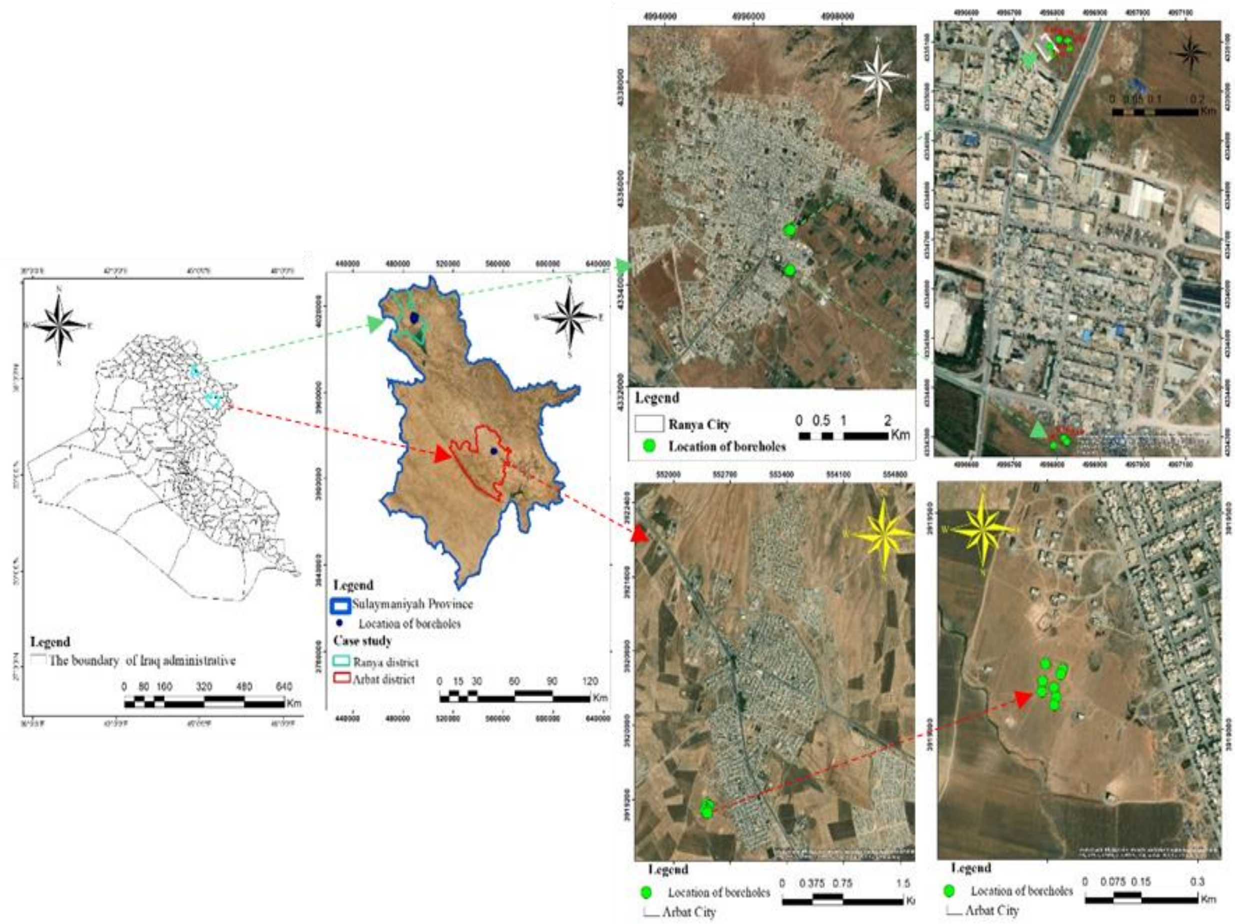

Figure 1: Location Map of Ranya and Arbat area.

Soil specific gravity refers to the mass of solid matter of a given soil sample as compared to an equal volume of water (Gofar, 2007). The value of specific gravity obtained for at least 2 h time period by using partially vacuum and shaking method for particle size smaller than 4.75 mm, was the nearest to the value of specific gravity obtained by using the pycnometer method (Rashid et al, 2017). Atterberg limits test have been done for the same sixteen samples according to ASTM D 4318. Atterberg limits are defined as the water content of soil (as a percentage) of various consistency stages for fine grained soils.

These tests include determination of liquid limit and plastic limit. For the liquid limit test, the Casagrande method was used with 250gr. of soil sample passing through sieve number 40, then distilled water added to form a soil paste and then leaved to soak. A part of the soaked soil paste was placed in a Casagrande cup using groove tools to cut the soil in the cup, then the cup is given blows, the number of blows required to close the groove for a distance of 13 mm is noted down. A number of trials was repeated with different percentage of water content, then a flow curve chart was drawn between water content and number of blows. The liquid limit is obtained as the water content corresponding to 25 blows. Plastic limit can be defined as the lowest water content in which the soil can be rolled into threads of 3.2mm in diameter without breaking into pieces. Plasticity Index is the difference between liquid limit and plastic limit (Burns et al., 2005).

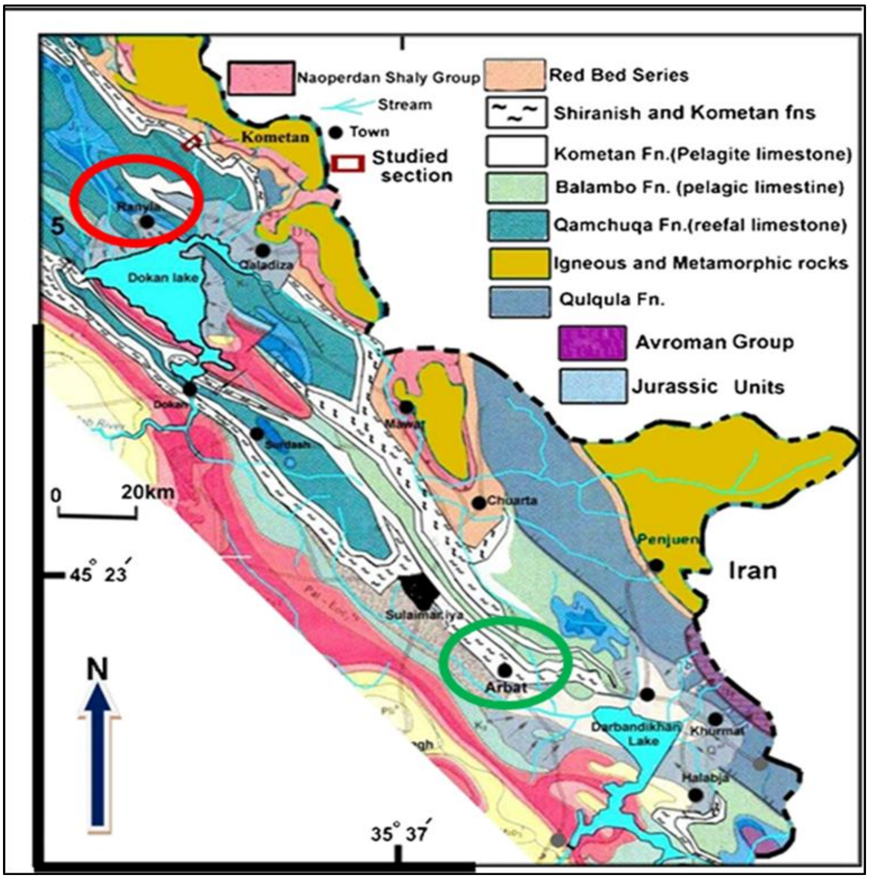

Figure 2: Geological map of the studied area (modified from Sissakian, 2000).

3. Results and Discussion

The results that were obtained from the laboratory tests are as follows:

1. The particle size distribution curves suggest that the soil in Ranya Area is of sand-silt mixture, with clay which is present in borehole No.1. Whereas, the soil in the Arbat area is of sand-silt mixture without clay. This means that the soil in both areas is a mixture between coarse and fine grain texture. (refer Figure 3 and Tables 1, 2).
2. The specific gravity classification is based on the typical values presented in Bowles (Bowles, 2012). The test results indicate that the soil specific gravity in Ranya area ranges between 2.5 and 2.61, whereas in Arbat area ranges between 2.51 and 2.61. According to Bowles, soil in both areas is free from mica and iron (refer Tables 1, 2 and 3).
3. The liquid limit, plastic limit and plasticity index values in the studied samples, according to Casagrande test method, are shown in Tables 1 and 2. Plasticity index classification, based on plasticity index chart prepared by Das (Das, 2002) refer Table 4, indicate that the plasticity index in Ranya area ranges between 7 and 17. This means that the soil in this area is characterized by low to medium plasticity. The plasticity index in Arbat area ranges between 6 and 18. This means that the soil in the Arbat area is characterized by low to medium plasticity as well.

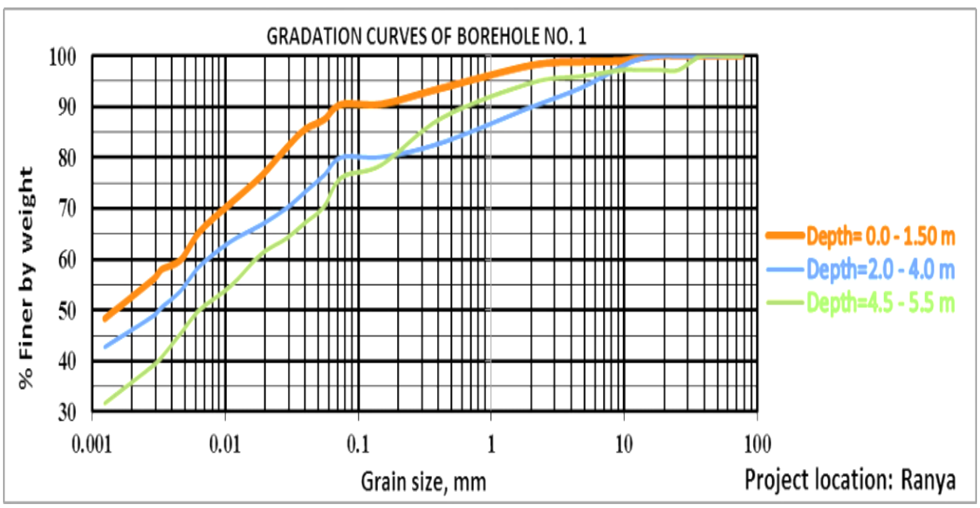

Figure 3: Gradation curve of borehole (No.1) Ranya area.

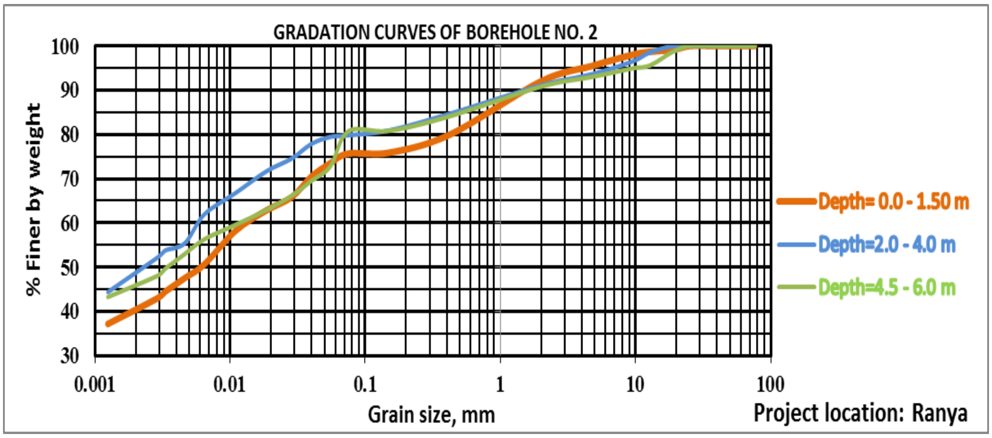

Figure 4: Gradation curve of borehole (No.2) Ranya area.

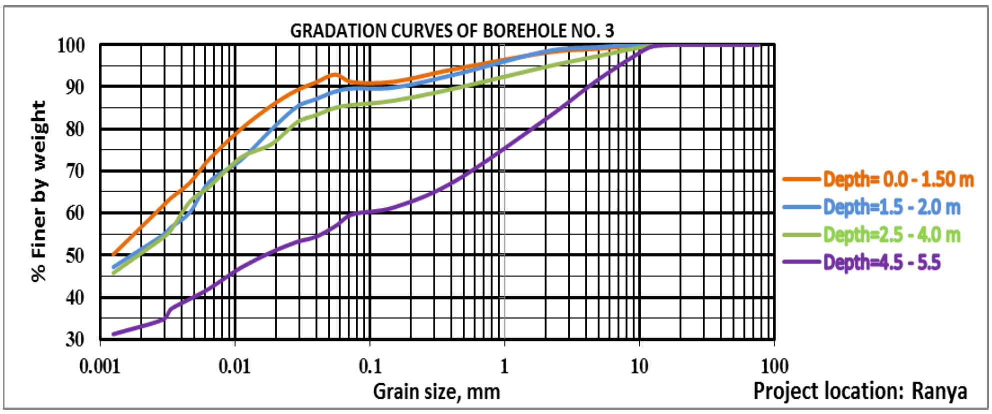

Figure 5: Gradation curve of borehole (No.3) Ranya area.

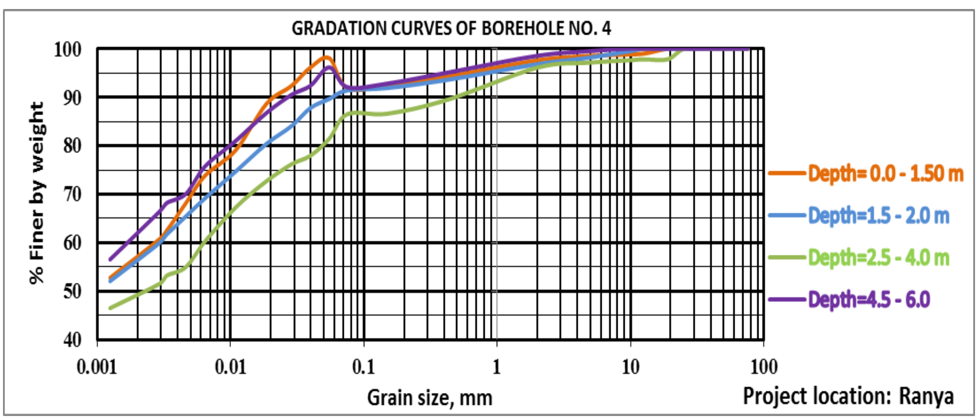

Figure 6: Gradation curve of borehole (No.4) Ranya area.

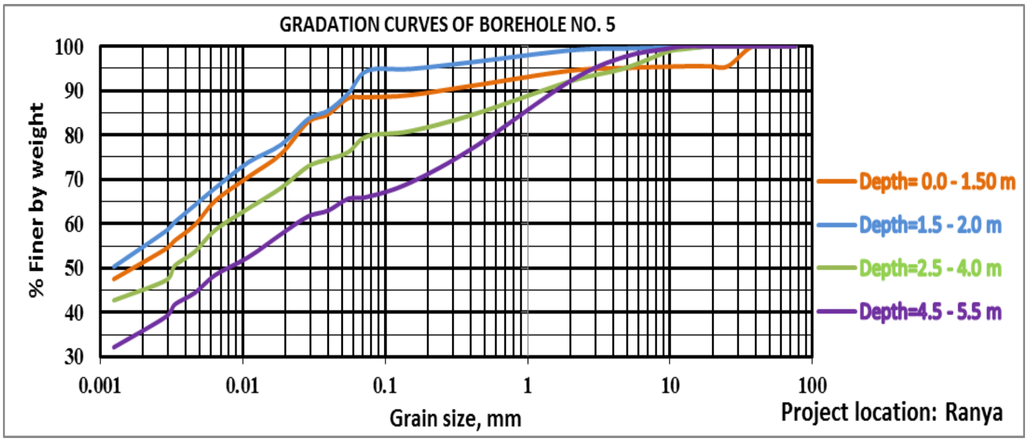

Figure 7: Gradation curve of borehole (No.5) Ranya area.

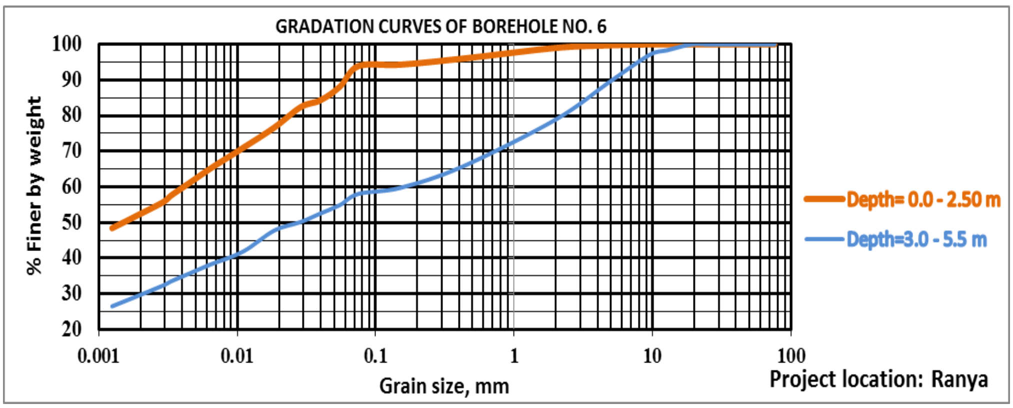

Figure 8: Gradation curve of borehole (No.6) Ranya area.

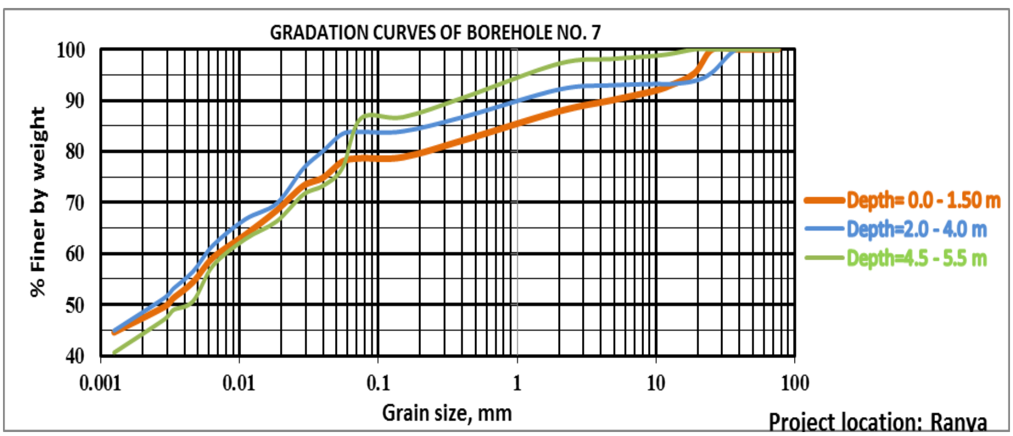

Figure 9: Gradation curve of borehole (No.7) Ranya area.

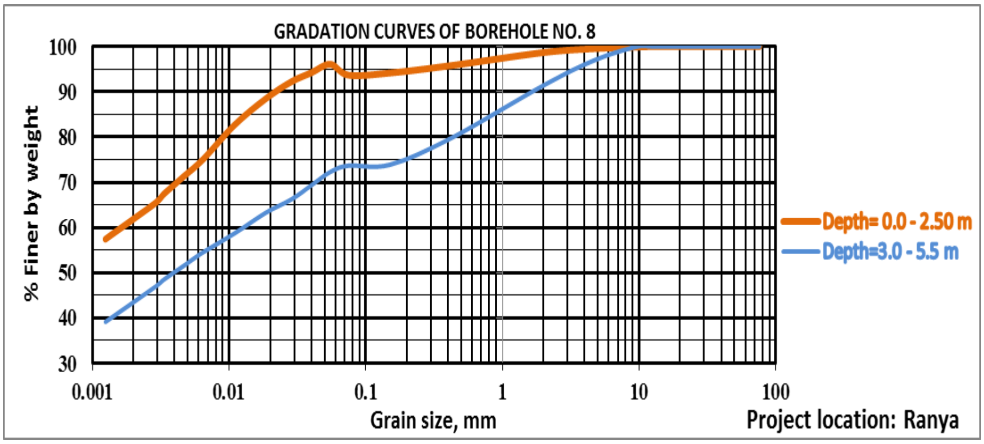

Figure 10: Gradation curve of borehole (No.8) Ranya area.

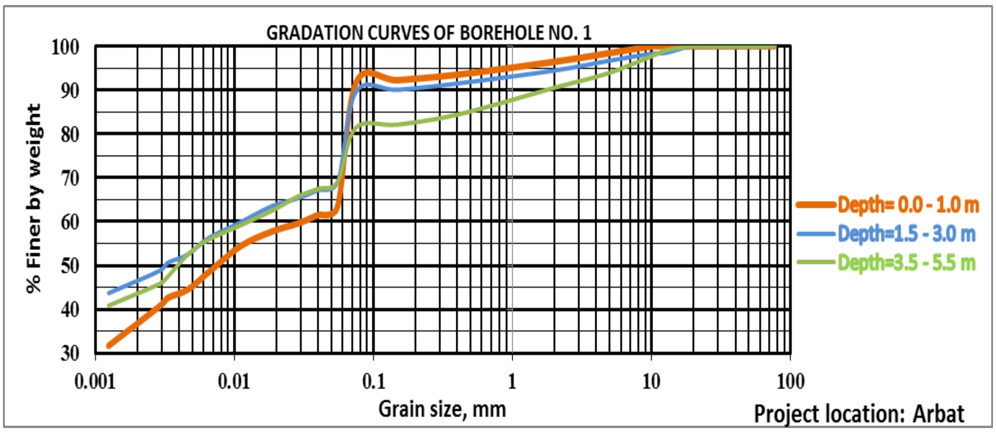

Figure 11: Gradation curve of borehole (No.1) Arbat area.

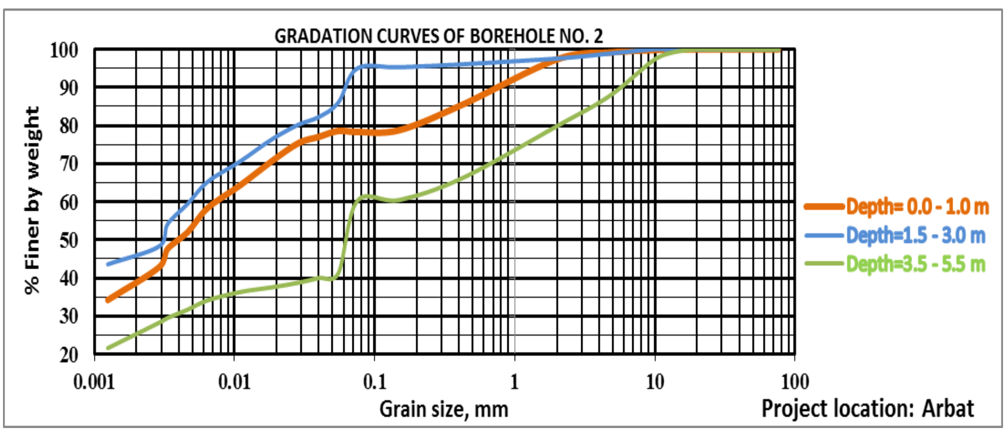

Figure 12: Gradation curve of borehole (No.2) Arbat area.

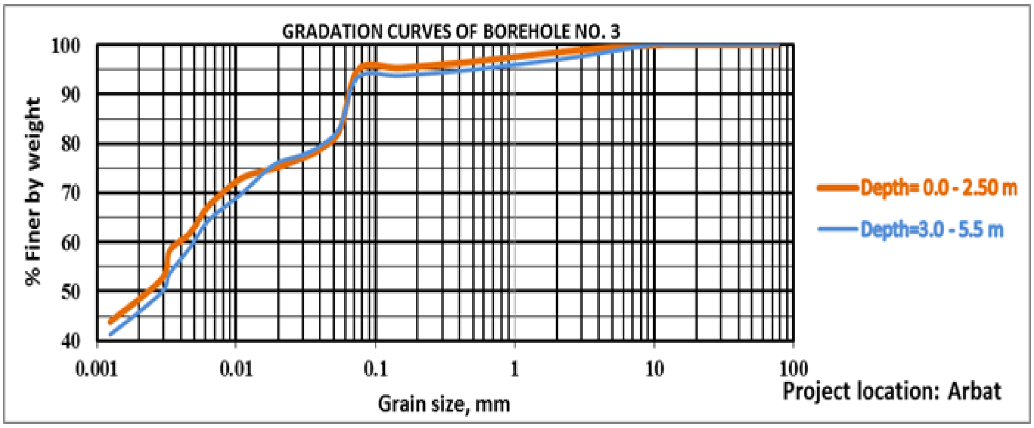

Figure 13: Gradation curve of borehole (No.3) Arbat area.

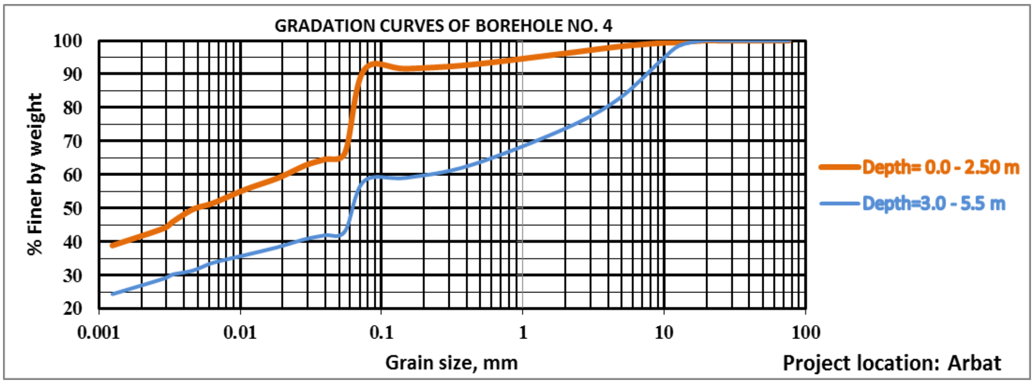

Figure 14: Gradation curve of borehole (No.4) Arbat area.

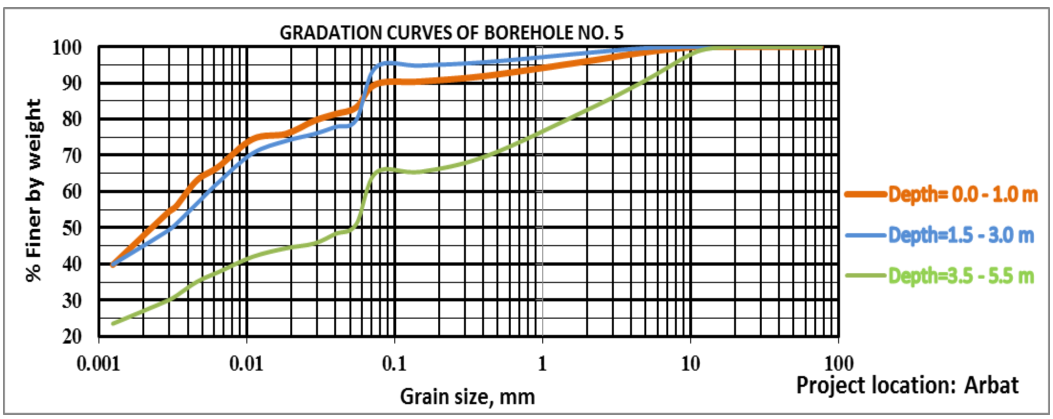

Figure 15: Gradation curve of borehole (No.5) Arbat area.

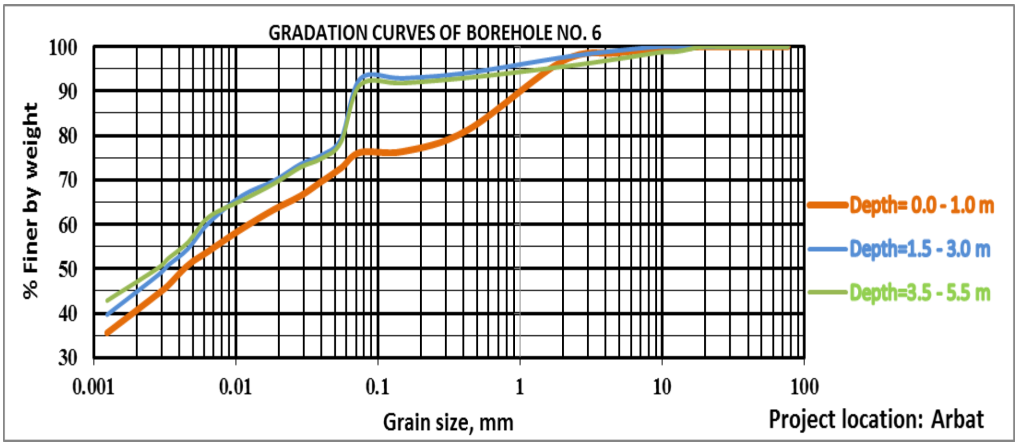

Figure 16: Gradation curve of borehole (No.6) Arbat area.

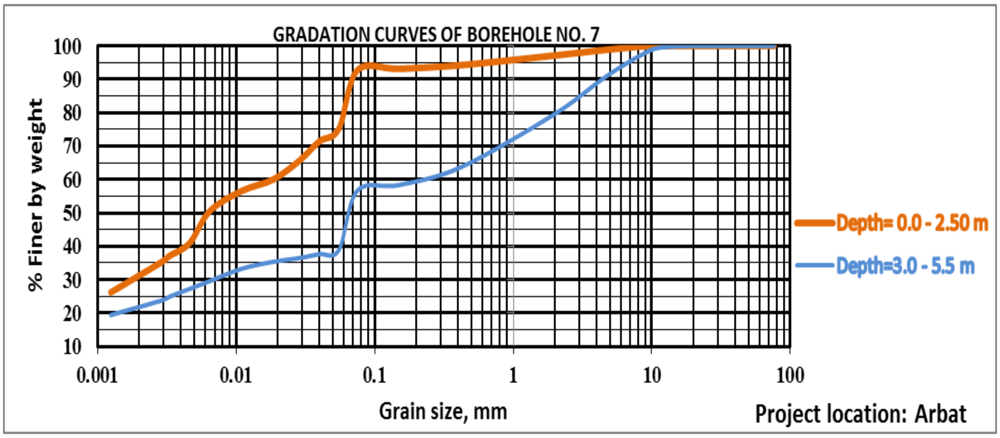

Figure 17: Gradation curve of borehole (No.7) Arbat area.

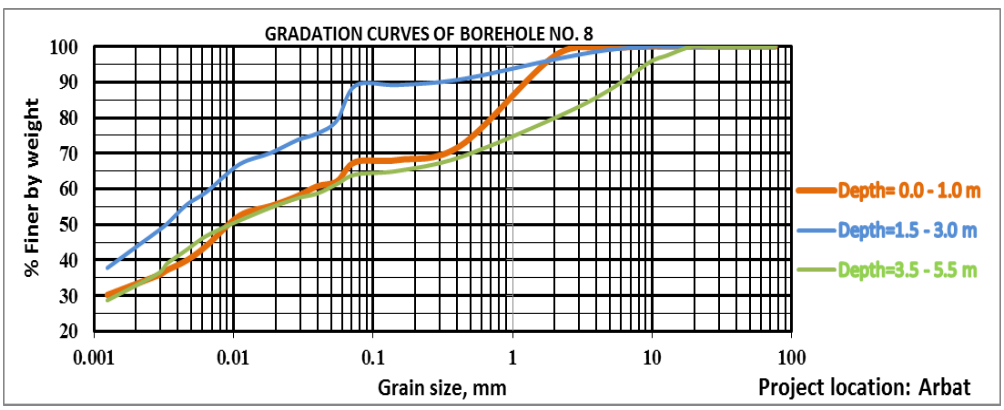

Figure 18: Gradation curve of borehole (No.8) Arbat area.

Table 1: Some Geotechnical Properties of Ranya Area .

Location	B.H no.	Boring depth (m)	Specific gravity	Atterberg limits			Classification tests of soil				
				Liquid limit	Plastic limit	Plasticity index	By Sieving		By hydrometer		Unified Soil Classification System
							% Gravel	% Sand	% Silt	% Clay	
Ranya	1	0.00 -1.50	2.51	43	33	10	1.2	8.33	30.61	59.86	ML-Silt
		2.00 -4.00	2.59	40	27	13	6.27	13.67	26.3	53.77	ML-Silt with sand
		4.50 -5.50	2.54	32	23	9	4	19.9	30.71	45.39	CL-Lean clay with sand
	2	0.00 -1.50	2.61	36	27	9	4.53	19.8	30.1	45.57	ML-Silt with sand
		2.00 -4.00	2.57	38	28	10	6.4	13.8	24.37	55.43	ML-Silt with sand
		4.50 -6.00	2.55	38	28	10	7	12.27	27.73	53	ML-Silt with sand
	3	0.00 -1.50	2.55	41	31	10	1	7.93	23.85	67.22	ML-Silt
		1.50 -2.00	2.59	47	34	13	0.6	9.8	38.89	50.71	ML-Silt
		2.50 -4.00	2.59	42	32	10	2.8	11.5	21.89	63.81	SM-Silty sand
		4.50 -5.50	2.5	35	28	7	8.67	31.6	20.13	39.6	ML-Sandy silt
	4	0.00 -1.50	2.52	42	32	10	1.53	6.6	23.66	68.21	ML-Silt
		1.50 -2.00	2.56	45	32	13	1.9	6.7	25.93	65.47	ML-Silt
		2.50 -4.00	2.55	45	34	11	2.9	10.6	31.48	55.02	ML-Silt
		4.50 -6.00	2.53	49	32	17	0.53	7.4	21.96	70.11	ML-Silt
	5	0.00 -1.50	2.56	42	34	8	4.9	6.6	28.71	59.79	ML-Silt
		1.50 -2.00	2.53	45	30	15	0.5	5	30.28	64.22	ML-Silt
		2.50 -4.00	2.57	36	26	10	5	15.27	25.97	53.76	ML-Silt with sand
		4.50 -5.50	2.58	34	25	9	2.4	31.53	21.61	44.46	ML-Sandy silt
	6	0.00 -2.50	2.57	39	29	10	0.3	5.8	32.49	61.41	ML-Silt
		3.00 -5.50	2.53	34	26	8	10.87	31.07	22.18	35.89	ML-Sandy silt
	7	0.00 -1.50	2.59	39	30	9	10	11.33	24.24	54.43	ML-Silt with sand
		2.00 -4.00	2.57	44	34	10	7.07	9.13	27.3	56.5	ML-Silt with sand
		4.50 -5.50	2.63	43	32	11	1.9	11.6	35.81	50.69	ML-Silt
	8	0.00 -2.50	2.54	46	34	12	0.47	5.87	22.48	71.19	ML-Silt
		3.00 -5.50	2.54	42	31	11	3	23.33	22.2	51.47	ML-Silt with sand

Table 2: Some Geotechnical Properties of Arbat area.

Location	B.H no.	Boring depth (m)	Specific gravity	Atterberg limits			Classification tests of soil				
				Liquid limit	Plastic limit	Plasticity index	By Sieving		By hydrometer		Unified Soil Classification System
							% Gravel	% Sand	% Silt	% Clay	
Arbat	1	0.00 – 1.0	2.51	43	33	10	1.67	6.53	47.29	44.51	ML-Silt
		1.50 –3.00	2.53	44	32	12	3.4	6.93	37.18	52.49	ML-Silt
		3.50 –5.50	2.55	52	35	17	6.27	12.27	28.98	52.49	MH-Elastic silt with sand
	2	0.00 – 1.0	2.59	35	29	6	0.8	20.87	24.25	54.08	ML-Silt with sand
		1.50 –3.00	2.57	48	35	13	1.1	3.9	35.54	59.46	ML-Silt
		3.50 –5.50	2.55	39	30	9	12.2	27.6	28.52	31.68	ML-Sandy silt
	3	0.00 –2.50	2.54	37	31	6	0.53	4.47	33.25	61.75	ML-Silt
		3.00 –5.50	2.54	44	33	11	1.4	5.1	34.64	58.86	ML-Silt
	4	0.00 –2.50	2.53	45	32	13	1.8	7	41.55	49.65	ML-Silt
		3.00 –5.50	2.61	45	28	17	17.4	24.53	26.7	31.37	ML-Sandy silt with gravel
	5	0.00 – 1.0	2.56	42	31	11	1.6	8.7	25.46	64.24	ML-Silt
		1.50 –3.00	2.57	43	32	11	0.4	5.2	37.65	56.75	ML-Silt
		3.50 –5.50	2.59	42	31	11	9.73	25	30.15	35.12	ML-Sandy silt
	6	0.00 – 1.0	2.53	39	32	7	1.4	22.4	25.35	50.85	ML-Silt with sand
		1.50 –3.00	2.51	47	34	13	0.9	6.3	38.26	54.54	ML-Silt
		3.50 –5.50	2.51	46	32	14	2.8	5.8	35.4	56	ML-Silt
	7	0.00 –2.50	2.53	42	31	11	1.13	6.13	51.74	40.99	ML-Silt
		3.00 –5.50	2.55	36	26	10	8.93	34.4	29.41	27.26	ML-Sandy silt
	8	0.00 – 1.0	2.52	34	27	7	0.53	31.87	27.65	39.95	ML-Sandy silt
		1.50 –3.00	2.55	44	33	11	1	9.9	33.51	55.59	ML-Silt
		3.50 –5.50	2.51	38	30	8	12.6	23.33	21.15	42.92	ML-Sandy silt

Table 3: Typical values of specific gravity (Bowles, 2012 in Roy & Bhalla, 2017).

Type of soil	Specific gravity
Sand	2.65 – 2.67
Silty sand	2.67 – 2.70
Inorganic clay	2.70 – 2.80
Soil with mica or iron	2.75 – 3.00
Organic Soil	1.00 – 2.60

Table 4: Plasticity Index Chart (Das, 2002).

Plasticity Index (PI)	Description
0	No Plasticity
1-5	Slight Plasticity
5-10	Low Plasticity
10-20	Medium Plasticity
20-40	High Plasticity
>40	Very High Plasticity

4. Conclusions and Recommendations

Based on the laboratory test results, the following are concluded.

1. Ranya area is covered by alluvial sediments which consists of clay, silt and gravel.
2. Arbat area is covered by Shranish and Kometan Formations.
3. The study of particle sizes distribution indicate that the soil is mostly silt and sand with some clay.
4. The Atterberg results indicate that both areas are characterized by low to medium plasticity.
5. A good matching is indicated between the assessed geotechnical properties of Ranya and Arbat soil.

Acknowledgments

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