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Geotechnical analysis of igneous rocks (Andesite) from west of Yazd for Engineering Uses

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Abstract

Andesite Rocks are highly distributed and available in huge quantities in west of Yazd in central Iran. The objective of this study is to determine the Evaluation of resistance and those relevant to engineering aims in central Iran., which is related to the Upper Eocene basaltic flows and to conduct a comparison of the results with the standard specifications. Ten random samples of west of Yazd, were collected representing five locations. The laboratory investigation included measurements of point load strength, splitting tensile strength (MPa), Los Angeles, abrasion value (%), slake durability, abrasion, porosity, and saturation degree. In addition, the chemical and mineralogical composition of the basalt was identified utilizing X-ray fluorescence (XRF), and X Ray Diffraction respectively.The laboratory investigation included measurements of point load strength, splitting tensile strength (MPa), Los Angeles,abrasion value (%), slake durability, abrasion, porosity, and saturation degree. In addition, the chemical and mineralogical composition of the basalt was identified.The results of properties related to engineering indicate that these rocks have mainly compressive strength values ranging from 40 to 130 Mpa. Los Angles Abrasion ranges between 3.66% and 4.83%, and splitting tensile strength (MPa) is between 1.954 and 3.331.The results show that the Andesiteof west of Yazd complies with the international standards, and the standards.used for classifying the decorative and building stones and some not recommended.

Keywords: Andesite, west of yazd, Geotechnical, Building stones, Engineering properties.

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Introduction

Andesite is relatively common, occurring in many tectonic settings. It is associated with andesite and rhyolite as part of the subalkaline tholeiitic and calc-alkaline magma series. Andesite consists mostly of plagioclase feldspar and biotite, hornblende, and pyroxene . The quartz appears as rounded, corroded phenocrysts, or as an element of the ground-mass. The plagioclase in Andesite ranges from oligoclase to andesine and labradorite. Sanidine occurs, although in small proportions, in some Andesite, and when abundant gives rise to rocks that form transitions to the rhyolites.

Andesite uses in construction and medical industry. Rocks are used for various purposes starting from construction of roads, bridges, buildings to pot in kitchen, as a gem stone or just for decorating your garden. However, some rocks have rare properties. uses in construction industry include as dimension stone, Construction aggregate, For road aggregate, Landscaping Andesite rock is not yet used in the medical industry. Some types of rocks have exceptional properties and can be used in medical industry (Goodman, 1993). The main objective of the present study is to assess the general suitability of the Andesite as a coarse aggregate for concrete mixes and/or as a cut stone for industrial uses.The quality properties of the basaltic rocks vary from place to another depending on their origin and weathering state and more significantly on the geological occurrence.

Materials and Methods

The study area is located in west of Yazd, and included Three locations as presented by the geological map in Figure 1.

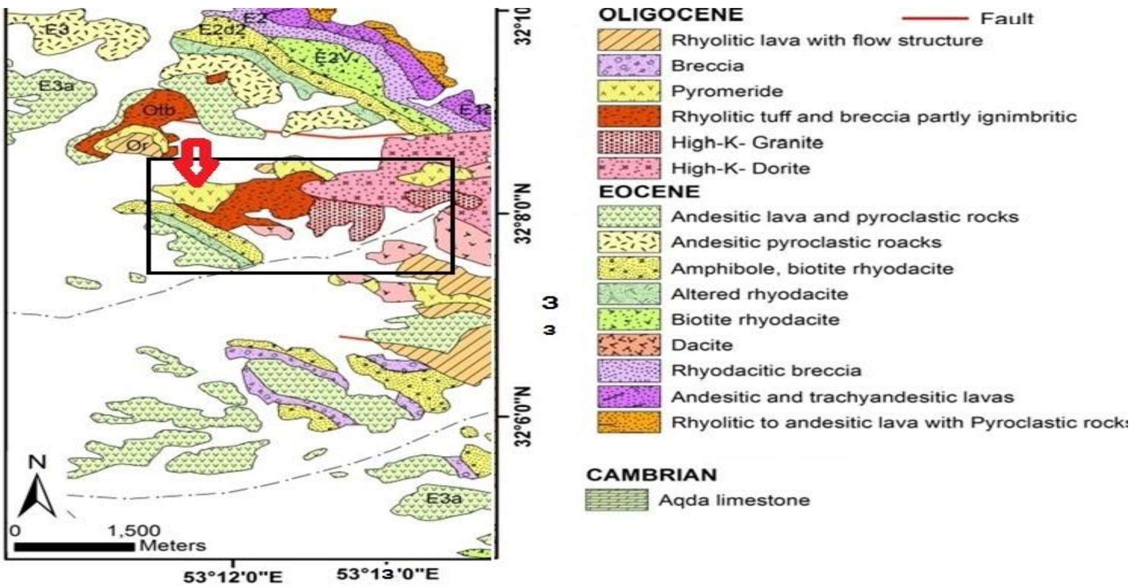

Figure 1.Geological map of studied area

Material Source

To carry out the research, ten Andesite samples were selected from west of Yasd. From each selected site, more than 60 kg fresh bulk samples have been collected; the coordinates of the sampling sites are given by figure 1.

The suitability for usage as materials for engineering purposes depends principally on the physical and mechanical properties of the Andesite; although for some applications, mineralogical or chemical properties are also required. The American Society for Testing and Materials (ASTM), and the

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International Society of Rock Mechanics, have devised a wide range of tests to assess materials and their value and potential and performance. These properties include specific gravity, density, water content, void ratio, absorption, degree of saturation, Los Angeles Abrasion, slake durability indices, point load index, and ultrasonic velocity. Following is a brief description of some of these properties tested in this study.

The mineralogy of andesite rocks, was identified using thin section according to Eberi, 2003, while the chemical composition of the rocks was determined using X - Ray Fluorescence (XRF) available at the laboratories. The physical characteristics of the rocks were determined in the laboratory. The rock specimens were prepared from rock block samples collected from the investigated representative sites. The mechanical characteristics include Point load test (PLT), splitting tensile strength, the Los Angeles Abrasion Test. Slake Durability tests were also carried out according to the ASTM or AASHTO standards. The physical characteristics of these rocks, including Void ratio (e), porosity (n), water content, and water saturation, were evaluated utilizing, Specific Gravity, and Bulk Density (Crawford, 2013).

To determine the mechanical strength of the rock, a point-load strength test was performed according to the recommendations of the ASTM, for blocks of irregular geometry. The value for Is (50) (Point load strength index for 50 mm diameter core) is determined with the

equivalent core diameter of the specimens. Early studies (Broch and Franklin, 1972), and Miller, 1965, were conducted on hard strong rocks, and found that the relationship between UCS and the point load strength could be expressed as follows.

Splitting Tensile Test was conducted according to ASTM standard, by extracted core samples, 50 mm diameter and 25mm length. The splitting tensile strength (σt) of each sample was calculated by equation 7 for each sample. Slake Durability Test (SDT): the test was performed in accordance with ASTM D4644; two cycle testes have been elaborated; each for ten minutes and at a speed of thirty revolutions/minute in a water bath. The percentage of dry mass, which remained in the drum of the original mass after one cycle, is reported as Id1, and the percentage of dry mass, which remained in the drum after two cycles, is reported as Id2. Los Angeles Abrasion test: the test was carried out according to AASHTO 96 T (Keaton et al., 2010, Eslami et al., 2014). For each basaltic source, the samples were prepared for A- grade, while considering the sample weight of 5kg. The prepared samples were subjected to 500 hundred revolutions at a speed of 30 revolutions/minute.

Materials and Methods

Mineralogical and Chemical Composition

The mineralogical investigation indicates that the studied basaltic rocks were mainly composed of clinopyroxene, plagioclase and feldspar; also sanidine is available in significant amounts (Figure 2).

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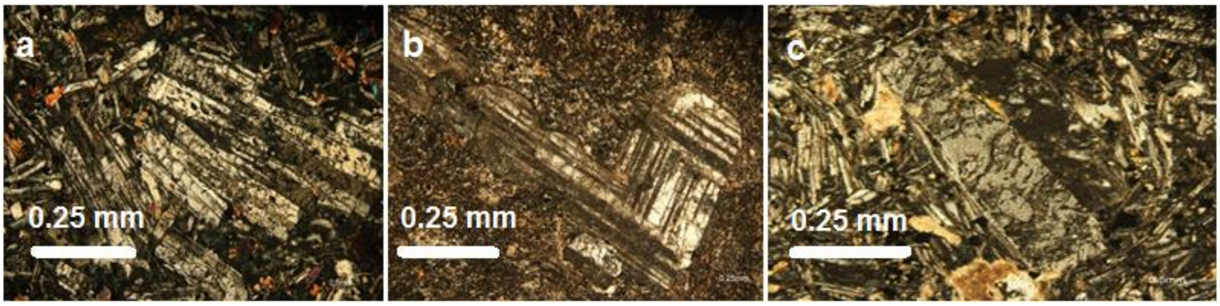

Figure2. Porphyritic texture with microlithic(a), Stretch separation in texture(b) and Sanidine(c) in texture.

Physical Characteristics

The results of geotechnical properties of the collected samples are listed in Table 3. The values reported in the tables are the averages of several replicate tests, compressive strength values Unconfined compressive strength (UCS) ranges from 115- (rarley70) to 154 Mpa, with an average of 125.6 Mpa, Using the classification system proposed by Deere and Miller (1966),the examined andesite rocks of the studied areas can be considered as a (C) classification having a medium strength rock (55-110) Mpa. Slake Durability was reported after the first cycle (Id1)

The analysis of the physical characteristics of the andesite samples shown in Table 4 revealed the following results:

Bulk density range was (2.73- 2.92) g/cm3, with an average of 2.82 g/cm. Based on the IAEG 1982 criteria, the andesite rock samples from two locations (SB-8 &SB-9) were classified as class -4, high density (2.5-2.75) g/cm. As for the

samples from the other locations, they are classified as class -4 very high density (Over 2.75) g/cm3.

Specific Gravity: The Specified gravity values reported for the samples were within the range (2.76-2.98) g/cm3, with an average of 2.86 g/cm.

Table1- geotechnical characteristics of the andesite samples

Unconfined compressive strength (MPa)	Splitting Tensile Strength (MPa)	Los Angeles Abrasion Value (%)*	Slake durability	
			I_{d1}	I_{d2}
143	2.3	3.73	96.25	99.42
135	3.127	3.68	99.28	99.17
115	2.81	3.84	99.30	99.23
136	2.919	3.97	99.19	99.05
122	3.15	4.2	99.14	99.11
154	3.291	4.27	99.16	99.10

Porosity (%) was found within the range of (1.1-2.8)%, with the average 1.6 %. According to the IAEG 1982 criteria, the basaltic rocks from ten locations were located within Class -4 (Low Porosity).

Water content (%) falls within the range of (0.15 to 0.37)%, with an average of 0.24% Saturation (%) was reported within the range of (26-58) %, with an average of 38%. Los Angeles Abrasion Value (%): The Los Angeles abrasion values (after 500 cycles) range between 3.6% and 4.8% with an average of 4.03%, which indicates a high resistance to abrasion According to IS: 2386 (Part 4), the aggregate impact value should not exceed 45% for aggregate used for concrete other than for wearing surface, while the aggregate impact value should not exceed 35% for concrete used for wearing surfaces such as runways, roads, pavements, floors etc.

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Splitting Tensile Strength (MPa): The results of Splitting Tensile Strength (MPa) range between 2.345 and 3.291 Mpa, with an average of 2.94 Mpa. Katayama et al. (1989) pointed out that where the silica content of bulk composition exceeds 63%, basalt may have a potential for alkali silica reaction.
The Porosity is mainly due to vesicles; however, the relatively high saturation may indicate some secondary porosity. Secondary porosity tends to connect parts of these vesicles, which is enabling water to move and fill the vesicles.

Table2-geotechnical characteristics of the andesite samples

Saturation	Specific Gravity	Bulk Density	Water content	Void ratio	Porosity (n)
%	(g/cm³)	(g/cm³)	%	(e)	%
34	2.98	2.92	0.22	0.017	1.67
36	2.86	2.83	0.17	0.0119	1.18
28	2.92	2.86	0.21	0.02	1.96
27	2.86	2.85	0.16	0.0145	1.43
50	2.87	2.82	0.32	0.0164	1.61
32	2.92	2.84	0.34	0.029	2.82

The Porosity is mainly due to vesicles; however, the relatively high saturation may indicate some secondary porosity. Secondary porosity tends to connect parts of these vesicles, which is enabling water to move and fill the vesicles.

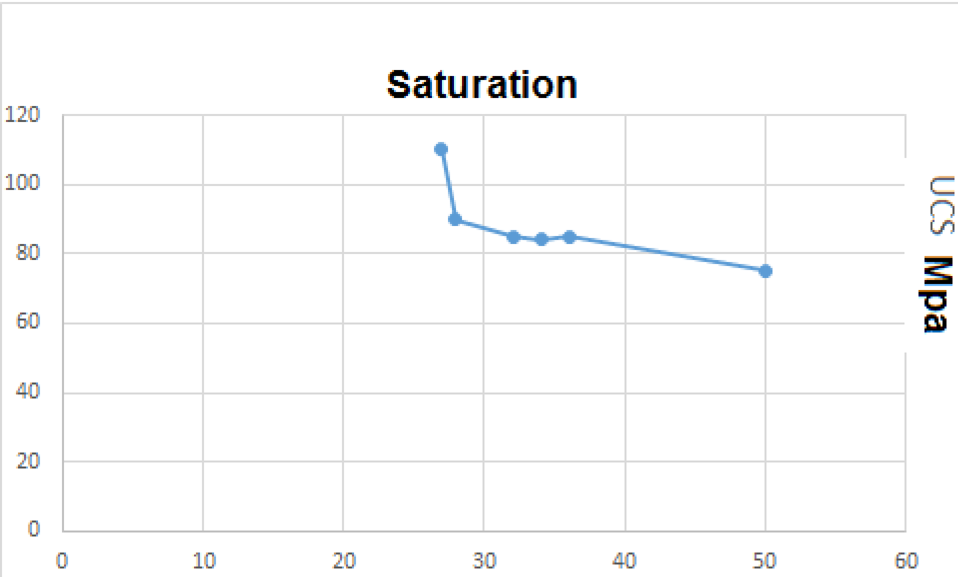

Figure 3. Relationship between the UCS and Saturation degree

Conclusion

This study presented detailed laboratory investigations on the andesitic rocks with very low weathering grades in west of Yazd. Based on the comprehensive analysis of the test results and the chemical analysis, very large supply of andesite rocks for material construction of west of Yazd was recognized. Moreover, based on the review of all the mechanical and physical tests of the samples from the some locations, the results show that the Yazd andesite meets the requirements and specifications of the ASTM or AASHTO standards specified for construction materials; accordingly, Yazd andesite can be used as a promising construction material.

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