Engineering Geologcal Assessment of Alvand Granitic Rocks

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Abstract

The purpose of this paper is to demonstrate the influence of lithology and weathering on the physico-mechanical properties of the Alvand granitic rocks. It also presents the results of engineering geology investigations carried out on the Alvand granitic rocks in southwest part of Hamedan, Iran. Studies were carried out both in the field and laboratory. Petrological studies have shown that there are different types of granite in Alvand granitic rocks including: porphyry granite, monzo-granite, holo-leucogranite and diorite. From laboratory testing it was concluded that the physical and mechanical characteristics of garnitic rocks are depend on their weathering degree. These results reflect the effect of the mineralogy on the engineering properties of granitic rocks.

Keywords: *engineering geology, granitic rocks, engineering properties, lithology, mineralogy*

Introduction

The Alvand granitic rocks are the most abundant intrusive plutonic rocks in Iran. From a structural geological point of view, it is a very complicated igneous rock mass, because it was affected by several tectonic phases. Alvand granitic rocks methamorphed the adjacent Jurassic schists to hornfels. Throughout the history, granite has been used as a building stone and also shaped into rock reliefs, rock statues, bathing-tub, stone pavements and some famous monuments such as the inscriptions of Darius in Persepolis, Shiraz, and Ganjnameh in Hamedan, Iran respectively. Figure 1 shows one of the most important of the Persepolis memorials from the Alvand granitic rocks in Hamedan, Iran.

Different parameters such as environmental (external) and inherent (internal) factors affect the engineering properties of rocks. One of the most important environmental factors affecting the engineering behaviour of rocks is weathering. Rock masses, on the other hand, are addressed in terms of rock strength and discontinuity characteristics (e.g., joints, faults, bedding and foliation) (Ehlen, 1991).

Therefore, when we are using granitic rocks as a construction material, we have to study their engineering properties in order to understand their engineering behaviors under the loads and the surrounding factors.

Geological Setting

The study region contains a very complicated arrangement of igneous and metamorphic rocks with ages from Liassic to Late Cretaceous (Valizade *et al*, 1974). The Alvand granitic rocks are part of the Sanadaj-Sirjan zone which belongs to the main thrust of the Zagros in the western part of Iran. The petrology of the Alvand granite consists of five different types of granite (Sepahigreo, 1999). From an engineering geology point of view, these granitic rocks were divided into three main categories by Khanlari *et al* (2003).

Figures 2 to 5 show some geological structures within the Alvand granites.

General Characteristics of the Alvand Granitic Rocks

The Alvand granitic rocks are usually light grey to white color and fine to coarse grained (2-5 mm in diameter). Petrographical study of the Alvand granitic rocks indicates that the main minerals are plagioclase feldspar (25%), orthoclase feldspar (30%) and quartz (25%), biotite (15%). The remaining 5% contains hornblende accompanied by lesser amounts of apatite, titanite, zircon, epidote and other opaque minerals.

Weathering Characteristics

The weathering state and weatherability of rocks are very important for engineering geology projects and to assess the useability of these rocks as building stones. The weathering state of rocks can be described by various chemical and petrographical indices. To determine the weathering state of a rock, a considerable amount of chemical analysis is required.

In this research, the samples are subjected to chemical and petrographical analyses and also physical and mechanical properties testing. Weathering profiles were studied in a number of excavated sections in the study area. The weathering of the Alvand granitic rockds has been described by Gholizadeh, (2006) following the six stage classification schemes proposed by GSL (1995) as shown in Table1. Definitions of the grades of the weathering are classified by following the procedure suggested by The ISRM (1981).

The Alvand granitic rocks exhibits a complete weathering profile from fresh rock to completely weathered rock and locally residual soil.Figures 6 to 8 show different photomicrographs of the mineralogy and textural characteristics of the Alvand granitic rocks (fresh and weathered samples).

Description of Engineering Properties of Alvand Granitic Rocks

The main objective of this research work was an assessment of the engineering properties of rock sample from the Alvand granitic rocks based on site investigations and laboratory testing. Variations in measured rock properties are due not only to the physical dimensions of the specimens used, but also to the testing equipment, test techniques, rate of loading and rate of displacement (Khanlari *et al,* 2005).

Laboratory tests were carried out on different samples of rock from the Alvand granitic rocks to acquire data on the engineering properties of the intact rock. Many samples were prepared from the block rocks according to the ISRM, (1981).

The most important physical and mechanical properties of intact rock granite (unweathered samples) obtained from the laboratory tests are presented in Table 2. For the whole rock analyses, the X-ray fluorescence (XRF) has been used to obtain the oxide content of the samples having different degree of weathering (Table 3).

Conclusions

The following results are achieved from this research:

1- Physical and mechanical properties of granitic rocks can be used as weathering indices and these are cheaper to perform the chemical indices.

2- Three different types of granitic rocks (holo-leucogranite, porphyritic granite and granodiorite) were recognized based on texture and fabric

characteristics of granitic rocks as important factors with respect to their engineering geological properties.

3 – Physical and mechanical properties of weathered granitic rocks are varied extremely depending upon the degree of weathering.

4- Because of climate conditions in the study area (around 70 degrees changes between the highest and lowest temprature), there is a predominance of physical rather that chemical processes operating on the rocks, as indicated by the mineralogical and chemical analyses.

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Table 1: Weathering classification for rock materials (GSL, 1995)

Grade	Description	Typical characteristics
I	Fresh	Unchanged from original state
II	Slightly weathered	Slight discoloration, slight weathering
III	Moderately weathered	Considerably weakened, penetrative discoloration Large pieces cannot be broken by hand
IV	Highly weathered	Large pieces can be broken by hand Does not readily disaggregate (slake) when dry sample immersed in water
V	Completely weathered	Considerably weakened Slakes in water Original texture apparent
VI	Residual soil	Soil derived by in-situ weathering but retaining none of the original texture or fabric

Table 2 Physical and mechanical properties of Alvand granitic rocks (Khanlari *et al*, 2003)

Name of the sample	UCS (MPa)	$I_S(50)$ (MPa)	σ_t (MPa)	Dry density ($gr.cm^3$)	Porosity %	Water absorption% (I_V)	Moisture content%
Hololeuco granite	72.38	3.29	2.26	2.55	1.46	1.09	0.32
Monzogranite	136.49	6.20	7.41	2.65	0.94	0.5	0.05
Diorite	203.28	9.24	9.74	2.86	0.76	0.27	0.21

Table 3: Elemental composion obtained by XRF from the Alvand Granitic rocks samples

Weathering grade of samples	SiO_2	Al_2O_3	Na_2O	MgO	K_2O	TiO_2	MnO	CaO	Fe_2O_3	P2O5	LOI
D1	63.67	14.63	2.62	2.29	5.42	0.7	0.11	2.26	7.32	0.15	0.84
D2	63.42	14.82	2.45	2.08	5.20	1.05	0.12	2.17	7.48	0.12	1.18
D3	63.15	15.23	2.42	1.70	4.88	1.13	0.90	2.15	7.50	0.16	1.39
D4	63.31	16.65	2.34	1.63	4.81	1.25	0.11	2.13	7.51	0.15	1.62
D5	63.02	16.70	2.12	1.52	4.40	1.26	0.16	1.98	7.53	0.11	1.68
D6	62.68	16.76	2.01	1.51	4.15	1.30	0.19	1.73	7.54	0.13	2.00
H1	62.14	19.99	7.19	0.42	0.44	0.64	0.01	8.56	0.63	0.23	0.34
H2	62.12	20.14	7.13	0.38	0.34	0.69	0.01	7.74	0.68	0.32	0.42
H3	62.11	20.23	7.06	0.33	0.31	0.70	0.03	7.54	0.87	0.26	0.52
H4	61.46	21.01	6.94	0.25	0.28	0.72	0.01	7.52	0.96	0.03	0.67
H5	61.36	21.11	6.37	0.23	0.27	0.74	0.01	7.44	1.14	0.03	1.21
H6	61.26	21.32	6.22	0.17	0.22	0.84	0.02	6.89	1.12	0.07	1.55
G1	68.07	13.21	2.04	1.55	6.00	0.69	0.08	0.88	5.78	0.13	0.53
G2	01.68	27.13	98.1	5.1	6.5	71.0	1.0	83.1	23.6	17.0	63.0
G3	01.67	52.13	94.1	46.1	2.5	94.0	12.0	55.1	55.6	11.0	61.1
G4	66.57	13.72	1.87	1.36	5.05	1.00	0.09	1.55	6.65	0.09	2.05
G5	66.49	13.98	1.80	1.35	2.78	1.22	0.18	0.56	7.00	0.11	3.53
G6	66.08	14.08	1.76	1.31	2.51	1.85	0.10	1.49	6.98	0.19	3.65

D = Porphyry granite H = Holo-leucogranite G = Granodiorite 0 = Fresh 1 = Slightly weathered 2 = Moderately weathered 3 = Highly weathered 4 = Completely weathered 6 = Residual soil LOI = Oxid content and loss on ignition

Figure 1. A very famous inscriptions of Darius in Ganjnameh, Hamedan,Iran (2550 years ago).

Figure 2. Illustration of the porphyry granite (G2) with an aplitic dyke.

Figure 3. Illustration of holo-leucogranite (G3) with oriented enclaves

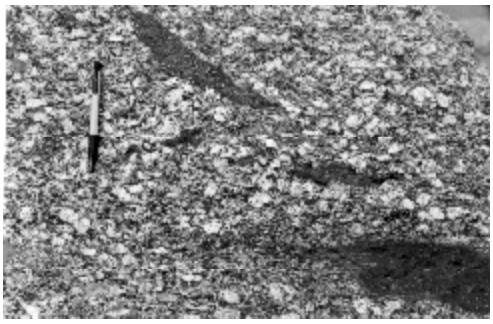

Figure 4. Illustration of porphyry granite with oriented feldspars and enclaves.

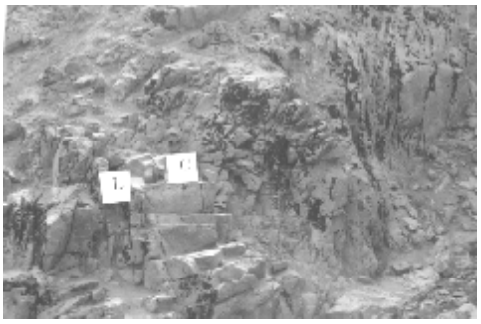

Figure 5. Illustration of two orthogonal joints system in the Alvand granitic rocks. The C joints are horizontal and formed later than the L joints which are vertical.

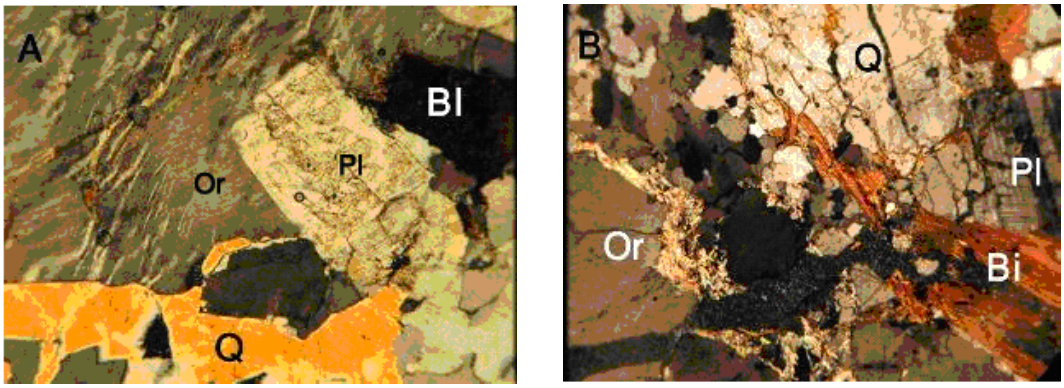

Figure 6.a) Photomicrograph of fresh Porphyrtic granit , b) Photomicrograph of weathered porphyritic granite

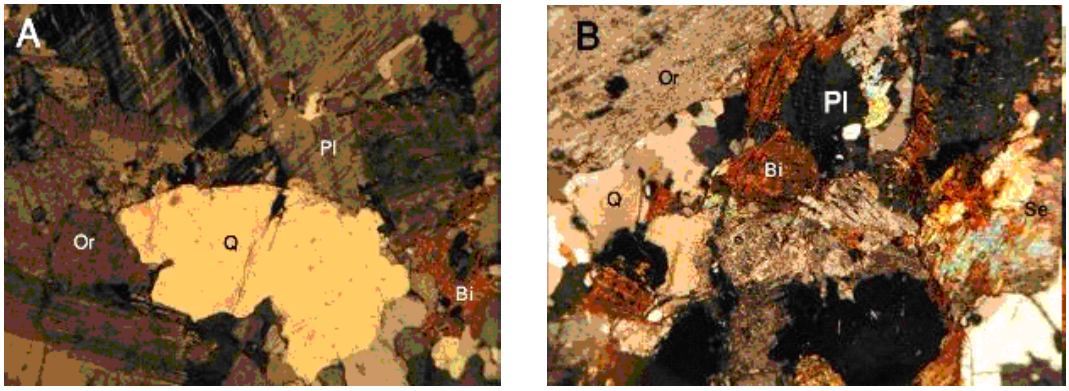

Figure 7.a) Photomicrograph of fresh granodiorite, b) Photomicrograph of weathered granodiorite

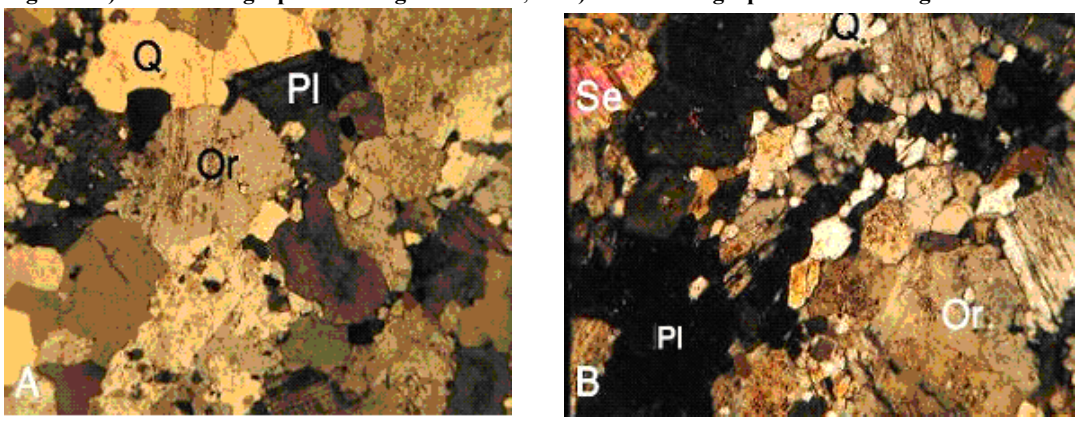

Figure 8.a) Photomicrograph of fresh holo-leucogranite, b) Photomicrograph of weathered holo-leucogranite

In these photomicrographs, minerals are illustrated with: Pl = plagioclase, Or = orthoclase, Q = quartz, Bi = biotite, and Se = sericite.