



Study of Some Physical, Mechanical and Chemical Properties of Basalt Rock in Sukna Area

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Abstract: Volcanic rocks may arise on the surface of the earth or under the surface and form different rocks with a distinctive chemical composition in addition to the distinctive mineral composition of each rock. Basalt rocks are considered one of the natural resources spread in the form of basalt fields in different parts of our country, such as Haruj Al-Aswad, Al-Sawda Mountains in Sukna, the heights of the Western Mountain and other places.

Basalt rocks have many uses in several fields, so it was necessary to study their properties. In this research, the physical properties were studied in order to determine the absorption ratio and specific gravity, as well as the mechanical properties to measure the compressive strength and fracture resistance of cubic samples with different dimensions (30x30x30) mm³ and (50x50x50).mm³ Also, the fine particles of the stone were studied to determine the percentages of the composition of elements and oxides using XRF spectroscopy on powdered samples taken from the study area. The test results proved that the basalt rock in the study area has high resistance strength after comparing it with the resistance strength of other basalt rocks in previous studies conducted in different regions of Libya. On the other hand, the results of the absorption rate and specific gravity tests of the basalt rock in the study area are very close to the values of the standard specifications for basalt. As for the analysis of oxides and elements (XRF chemical analysis), the results were that it contained iron(III) oxides and a high percentage of calcium oxides, reaching about three times. In contrast, it contained lower percentages of aluminum oxide than a previous study on basalt rocks north of Gharyan.

Keywords: Basalt Rock, Properties, XRF, Sukna, Haruj Region

I. INTRODUCTION

Petrology is the science that studies rocks and their properties, characteristics, and cycle of formation, and the minerals that make up each rock. This science deals with the origin of rocks, the state in which they exist, and their relationships to geological processes. It is an essential part of geology. It is an application of the principles of physical chemistry to the study of naturally occurring terrestrial materials [1, 5]. The history of rock formation on Earth dates back to about 4.6 billion years. Rocks began to form since the beginning of the formation of the Earth itself, and were formed due to various geological processes such as heat, pressure, oxidation, and chemical tolerance. By studying rocks and minerals, scientists can better understand the evolution and history of the Earth [2].

Igneous rocks, especially basalt rocks, are the main and basic component of the aggregate industry used in many construction and building works and providing them at lower prices than imported outside the city, and the additional economic value is the Al-Jufra region in general and the city of Sokna in particular.

Aljufra, specifically the Sokna region, contains a large amount of volcanic rocks, which are considered the primary source for the production of aggregates used in all construction works. Due to the lack of sufficient information, it was assumed to discover and know the different properties of these rocks in order to contribute to creating a reference for the values obtained from conducting various tests to benefit from them when dealing with these rocks [3, 4]. This information will also contribute to helping researchers and engineers determine the costs and required designs.

Knowing the compressive strength of rocks in geotechnical engineering is of utmost importance in the analysis and design of geotechnical problems. Laboratory testing is the most likely method for estimating the compressive strength of rocks [13].

Al-Siddiq Muhammad Al-Zandah and others at 2020 explained in a study that igneous rock raw materials represent a good alternative to clay, especially in areas that suffer from a shortage of such raw materials. "This is with the aim of obtaining the best percentage of the main cement phases directly related to the physical properties of cement, and then comparing these results with other mixtures of igneous rocks with a clay substitution rate of up to 100% and approaching the reflection of this on the percentages of the cement phases obtained." That is, it is possible to design any mixture of igneous rocks to provide the necessary requirements of cement phases as an alternative to clay and with a complete substitution rate for this raw material. The results of the tests showed

that it is possible to design a cement mixture containing basalt and providing the necessary requirements of cement phases. It was shown from the calculation results of the mixtures that there is a good possibility of obtaining cement containing basalt whose conditions comply with Libyan and international standard specifications [9].

II. PLACES WHERE BASALT IS FOUND IN LIBYA

The heart of southern Libya contains Precambrian basement blocks, represented by the Tibesti Block, Jebel Uyant, and the Tihambuka Arch, which are parts of the eastern Sahara, the Nile River, and the remobilized Pan-African Belt [6]. The Haruj area is not characterized by mountain ranges, but rather a large plateau. Most of the volcanoes are basaltic lava flows. The central part of the Haruj Mountains represents the central eruption center for most of these lava flows. The areas adjacent to or close to this volcanic crater appear as one continuous layer or rock, containing some cracks and faults. In contrast, in the Sukna area (the study area), the volcanic rocks are present in the form of scattered stones and are about 250 km away from the center of these lava flows [8].

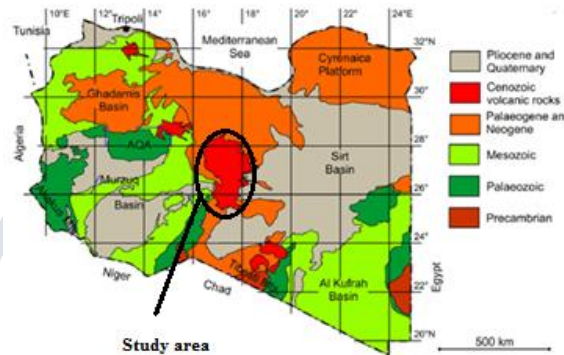


Fig 1: Basalt Rocks in the Haruj Region

Basalt rocks are found in the Haruj region, which extends about 45,000 Km², and are also abundant between the Sukna region and the Fuqaha region [2, 3].



Fig 2: Lava flow center in Al-Harouj area in Al-Fuqaha



Fig 3: Some faults and cracks in the lava of Harouge



Fig 4: Rocky mountains near the sampling sites



Fig 5: Volcanic rocks are present as scattered rocks in the sampling area.



Fig 6: Basalt rocks taken from the Sukna area before the cutting process

III. PRACTICAL FRAMEWORK

A. Method of Taking the Sample

The site was visited and a group of samples were taken from the study area. They were located on the surface of the earth and were cut into cubes with dimensions (30x30x30) mm³ and (50x50x50).mm³. Then they were taken to the laboratory to conduct experiments on them.

B. Mechanical Tests

- Compression Resistance

It is the ability of the material to withstand external pressure without collapsing or deforming. The compressive strength was measured in pascal pressure units. To calculate the sample's compressive stress resistance, the following equation was used:

$$\text{The Load at which a sample breaks} = \text{Stress (KN)/Area (m}^2\text{)} \dots\dots\dots (1)$$

Some devices and equipment were used to cut, slice and level the samples. One of these devices was a rock cutting machine to prepare them for testing. Special devices were also used for testing them, such as a pressure resistance device for samples.



Fig7: Pressure resistance measuring device



Fig 8: Sample cutting device with required dimensions



Fig 9: Final sample shape ready for testing

The dimensions of the specimen depend on several factors, including the type of material to be tested, the types of measurements required, the available testing machine, etc. In general, the specimens used in compression tests are usually circular in cross-section, and sometimes square or rectangular cross-section specimens are used for these tests. The ratio between the height of the specimen h and its diameter d is also very important to avoid some undesirable situations, as increasing the height increases the tendency for the specimen to buckle and the accompanying irregular distribution of stress across the specimen section. The specimens used in this test are cubic specimens.

❖ Test steps

After preparing the sample with the specified dimensions, the sample was carefully cleaned to remove dirt and dust because it is required that the samples be pure and free of large impurities and prominent cracks before conducting the test. After that, the sample was placed in a pressure testing machine and an equal pressure was applied to the sample until it broke. This was done taking into account that the pressure application speed was uniform and pre-determined.

After the sample failed, the pressure testing machine gives the value of the sample's resistance pressure in Pascals. Then the data collected during the test was recorded and analyzed and then these measured values of pressure resistance were compared between different samples.

- Fracture load

It is a procedure used to determine the resistance of rocks to cracking and fracturing under axial compression.

- Steps for performing a fracture load test for samples

Before testing, the specimens must be properly prepared. This includes cleaning the specimens from dust and impurities and drying them carefully. The specimen is then placed in a compression testing machine. An axial force is slowly applied to the specimen until fracture occurs. During the test, the applied force and optical or acoustic emissions (if available) are measured to monitor the specimen's response to compression. The applied force value is recorded when fracture occurs. After the test is completed, the recorded data is analyzed to determine the fracture resistance of the rock specimens. The following equation was used to determine the fracture resistance of the specimens:

$$\text{Fracture strength} = \text{Load at break} / \text{Cross-sectional area of specimen} \dots\dots\dots (2)$$

Where:

Load at Break: is the maximum load that the specimen can withstand before it fails.

Cross-sectional area: is the cross-sectional area of the specimen being tested.

C. Physical Tests

- Specific Gravity Test

Specific gravity is a measure of the relative mass of a rock compared to the weight of an equivalent volume of water. The specific gravity of a rock is calculated by dividing its mass by its volume and reflects its density and internal composition. Rocks with a higher specific gravity are denser and contain more material per unit volume. The units for the specific gravity of rocks are often g/cm³ or kg/m³.

To calculate the specific weight, you must obtain the values of mass and volume, and then use the following equation:

$$SG = W_1 / W_w \dots\dots\dots (3)$$

Where:

SG: specific gravity.

W₁: dry weight of the sample.

W_w: weight of the same volume of water.

- Absorption Rate Test

Absorption ratio is a measure of the ability of rocks to absorb water or other liquids. Absorption ratio refers to the percentage of empty volume within a rock that can be filled with water or other liquids. Absorption ratio is an important parameter in many geological and engineering applications. For example, it is used to determine the ability of rocks to store water in groundwater reservoirs, to determine the ability of rocks to absorb oils and gases in oil and gas fields, and to evaluate rock properties in engineering projects such as dam construction, foundations, etc. The volume of water absorbed and the total volume of the rock are usually measured in appropriate volume units such as cubic centimeters or cubic meters.

To calculate the absorption rate, the following equation is used:

$$\text{Absorption ratio} = (\text{absorbed water volume} / \text{total sample volume}) \times 100 \dots\dots\dots (4)$$

Where:

Volume of absorbed water: The volume of water or liquid that is absorbed by the rock.

Total sample volume: The entire volume of the rock including pores and internal voids.

D. Chemical Tests

- X-ray Fluorescence (XRF) Testing

It is a non-destructive chemical analysis technique used to determine the chemical composition of a variety of samples. This technique relies on the interaction of X-rays with the analyte and produces signals related to the chemical elements present in the sample. XRF technology works by directing a beam of X-rays at the sample to be analyzed. When the X-rays interact with the sample, the X-rays are scattered and absorbed by the chemical elements present in the sample. Signals are generated that are detected and measured to determine the chemical elements and their concentrations in the sample. X-ray diffraction is characterized by being a rapid and non-destructive technique, as the test does not require the destruction of the sample or complex re-preparation. It can also be used to analyze samples in their solid, liquid, or gaseous state.



Fig 10: XRF testing device

❖ Test steps

- Sample preparation: This is done by grinding the rock sample into a powder to obtain small and homogeneous grains, so that the sample must be dry, clean and free of dirt and impurities.



Fig 11: Sample preparation before starting the test

- Device preparation: This is done by operating the XRF device and following the accompanying instructions to prepare and adjust the device, which is to calibrate it according to the specific requirements of the rock and the desired analysis.
- Sample placement: The ground sample is placed in a container designated for measurement by the XRF device, taking care to ensure that the sample is distributed homogeneously inside the container.
- Measurement: The XRF device is turned on and the measurement process begins. X-rays are directed at the ground sample and signals related to the chemical elements present in the rock are generated.
- Data analysis: After the measurement, data is obtained indicating the chemical composition of the ground rock. This may require data analysis using special programs or the assistance of experts in interpreting the results.

IV. RESULTS

Table 1: Results of the Compression test

NO of Sample	MPa
1	138.4
2	168.0
3	159.5
4	146.8
5	153.9
Average	153.32

Table 2: Results of the fracture load test

NO of Sample	KN
1	324
2	290
3	347
4	299
5	355
Average	323

Table 5: Results of the Specific gravity

NO of Sample	gm/cm ³
1	2.99
2	2.86
3	2.97
4	2.89
5	2.97
Average	2.94

Table 6: Results of the Absorption ratio test

NO of Sample	%
1	0.6
2	0.55
3	0.53
4	0.57
5	0.58
Average	0.57

Table 7: Chemical analysis of oxides for a sample of basalt from the Sukna area

Component	Fe ₂ O ₃	CaO	SiO ₂	Al ₂ O ₃	TiO ₂	K ₂ O	Cl	BaO	CuO
%	33.9	22.0	20.5	5.48	4.65	1.96	1.69	1.46	1.38

Table 8: Chemical analysis of oxides for a sample of basalt from the Al-Hira, north of Gharyan area

Component	Fe ₂ O ₃	CaO	SiO ₂	Al ₂ O ₃	TiO ₂	MnO	P ₂ O ₅	Na ₂ O	MgO
%	10.3	8.90	38.4	14.0	2.88	0.16	0.55	0.61	4.01

Using X-ray spectroscopy technique, the analysis of the basalt rock sample in the study area was conducted in the Chemistry Department Laboratory - Faculty of Science - at Sabha University. Referring to the chemical specifications for the use of basalt rock, it became clear from the results of the X-ray spectroscopy analysis that the highest percentage is iron (III) oxide 33.9%, the second highest percentage is calcium oxide 22.0%, and the third highest percentage is silicon dioxide 20.5%. By comparing the chemical analysis of basalt rocks in the Al-Hira area in northern Gharyan, where the percentage of silicon dioxide 38.4% was the highest percentage in the sample, then the percentage of aluminum oxide was 14.0%, and the percentage of iron (III) oxide was 10.3%. Can be note from the results that the sample in the study area (Sokna) is rich in iron (III) oxide, while the percentage of aluminum oxide was the highest in the samples in the Al-Hira area [2].

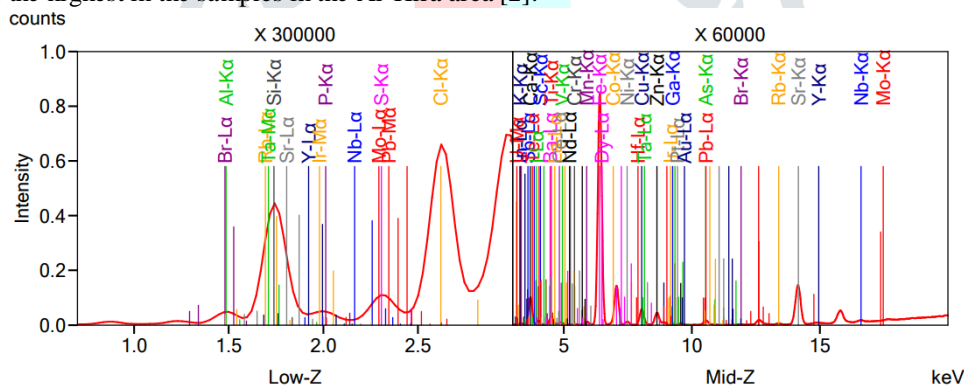


Fig 12: Chemical analysis diagram of oxides of basalt rock in the Sukna area using XRF

V. CONCLUSIONS

1. The physical properties represented by the specific gravity and absorption ratio of the basalt available in the Al-Jufra-Sukna area are consistent with the standard values for basalt, while the absorption ratio was slightly increased by 0.1%.
2. The compressive strength of the basalt available in the Al-Jufra-Sukna area gave higher values than the compressive strength of the basalt rock in the (Al-Hira, north of Gharyan) area.
3. Elements and oxides According to the chemical test (XRF), the percentage of iron (III) oxides in the basalt rocks located in the Sukna area was three times higher than the value obtained for the basalt rock in the Al-Hira area, while the percentage of calcium oxides was higher by 2.5% and aluminum oxide was lower by 2.4% on the rocks of the Al-Hira area, north of Gharyan.

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