International Journal of Engineering Research and Development
e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 11, Issue 01 (January 2015), PP.67-72

Evaluation of Structural Geology of Jabal Omar

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Abstract:-The proposed Jabal Omar Development project includes several multi-storey buildings, roads, bridges and below ground structures. Dykes and joints are the most common geological features in the area; they vary in thickness and orientation. The spacing between adjacent discontinuities largely control the size of individual blocks of rock masses which govern the stability of rock structures. The shearing and faulting system normally associated with tectonic movement making the area very weak, highly weathered and unstable. All Structural geological units analyzed using stereographic projection.

Keywords:- Jabal Omar, Dykes, Joints, Discontinuities, shear and faults.

I. INTRODUCTION

The structure in the area (Fig. 1) is related to the Red Sea rifting. According to Nebert et al. (1974), it has a very complicated history. It passes through a Precambrian jointing and folding, early to late Tertiary faulting with tilting and finally to Quaternary wrenches faulting, with other primary structural features due to both volcanic and intrusive activity (Basahel, 2008).

II. METHODOLOGY

The studied area has been divided into 8 different locations depending on the designed roads. In each location, the rock type, state of weathering, nature and characteristics of discontinuity surfaces were identified. Some of in-situ tests were conducted such as the joint wall hardness (compressive strength) by using the Schmidt hammer of L-type. Rock samples were collected from the petrography analysis and weathering evaluation.

For a rock slope design, the most important characteristic of a discontinuity is its orientation which is defined by two parameters; dip and strike. These values are determined by compass measurements on rock outcrops after the excavation or blasting works. The discontinuity data were then analyzed statistically by plotting them onto lower hemisphere stereographic projections (pole plot and contour plot) to visualize and to identify the sets of major discontinuities and their average orientations. This was done by using a rocsience, DIPS application software.

Interpretation of these geological structural data requires the use of stereographic projections that allow the three-dimensional orientation data to be represented and analyzed in two dimensions. The stereographic projection analysis consider only angular relationships between lines, planes and both line and planes. Based on this stereographic analysis, the potential mode of rock slope failures can be determined and assisting the engineer to design or planning the suitable stabilization works.

All site practice works and principles of rock slope kinematics stability analysis carried out in this review is referred to the works by Hoek and bray (1981), Hoek and brown (1980) and goodman (1976).

III. RESULTS

a. Dykes:

Dykes are one of the most common geological features in the area of Jabal Omar. They vary in thickness and orientation. Their trend and dip direction are associated with the joint systems. Two types of dykes were identified at Jabal Omar. The first one is the basaltic dyke. It is found at north part of road A in the diorite rocks. The second type is the andesite dyke which is common in and found in the most of the area. The general orientations of the dykes are summarized in Table 1. From the results in Table1 and from the field observation it was concluded that, the Jabal Omar is intruded by many andesitic and basaltic dykes of different thickness and different orientation. These dykes made the rock mass weak, highly deformed and very sensitive to weathering.

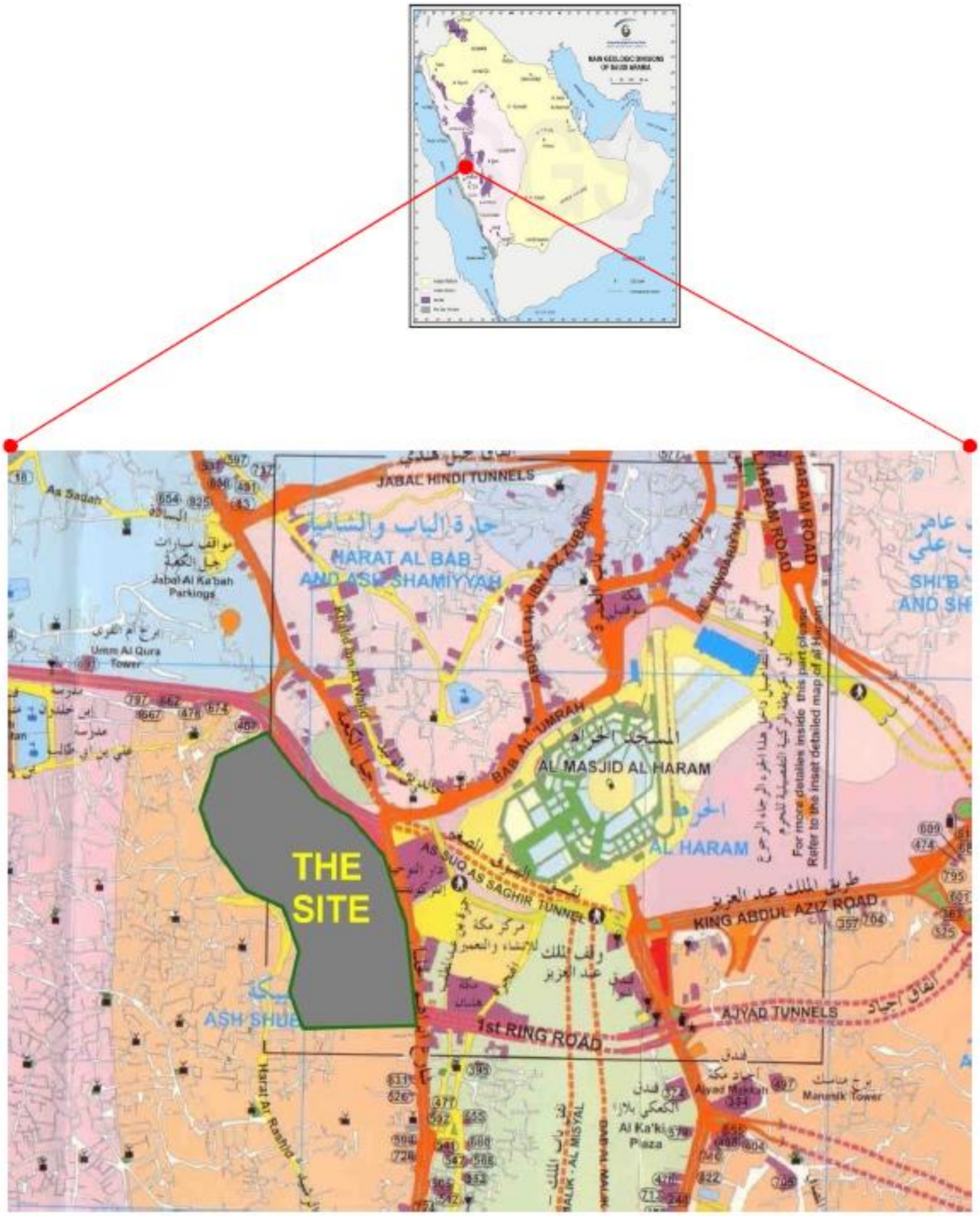

Fig. 1: Location Map of Jabal Omar

b. Joint systems:

Joints are the second most common structural discontinuities in the Jabal Omar after dykes. They are defined as those fractures along which there has been little or no movement. A series of parallel joints is called joint set. While, two or more intersecting sets are called joint system.

The Jabal Omar has been classified into a number of locations according to the lithology and the degree of weathering. Generally, more than 20 to 50 readings of discontinuities attitude were taken at each location. The readings were plotted on the Schmidt equal area projection net (lower hemispherical projection) by using DIPS package software.

Table 1: The general orientations of basalt and andesite dykes in the study area.

Rock type	Location	Strike	Dip	Dip direction
Basalt	Road A North	075	75	NW
Basalt	Road A North	48	81	NW
Andesite	Road A North	165	85	NE
Andesite	Road A North	160	85	SW
Andesite	Road A North	140	85	SW
Andesite	Road B North	140	85	SW
Andesite	Road B North	140	75	SW
Andesite	Road B North	130	85	NE
Andesite	Road B North	120	65	NE
Andesite	Road B North	130	75	NE
Andesite	Road M North	260	85	SE
Andesite	Road M North	265	85	SE
Andesite	Road M North	265	75	NE
Andesite	Road M North	310	75	SW
Andesite	Road M North	310	75	SW
Andesite	Road N North	200	70	NW
Andesite	Road N North	210	63	NW
Andesite	Road N North	205	54	NW
Andesite	Road N North	220	75	NW
Andesite	Road N North	215	70	NW
Andesite	Road P	005	85	SE
Andesite	Road P	015	60	SE
Andesite	Road P	010	65	SE
Andesite	Road P	015	65	SE
Andesite	Road P	020	55	SE
Andesite	Road Q	195	85	SE
Andesite	Road Q	195	60	SE
Andesite	Road Q	190	65	SE
Andesite	Road Q	195	65	SE
Andesite	Road Q	200	55	SE

The presence of joints and fractures in the area make the rock blocks small and weak. The Jabal Omar is full of jointing systems as measured for different types of rocks as illustrated and presented in fig. 2.

From the above mentioned, it was observed that, the northern side of the Jabal Omar consists of 3 to 4 jointing systems with 2 random fractures associated with dykes. The southern part of the Jabal Omar is affected by 2 to 3 jointing systems with minor fault and shearing zones.

These jointing and fracturing systems made the block size at Jabal Omar small and very deformed and the rock cut face will be unstable after drilling and blasting.

The orientation of the discontinuities determines the shape of the individual blocks or beds comprising the rock mass.

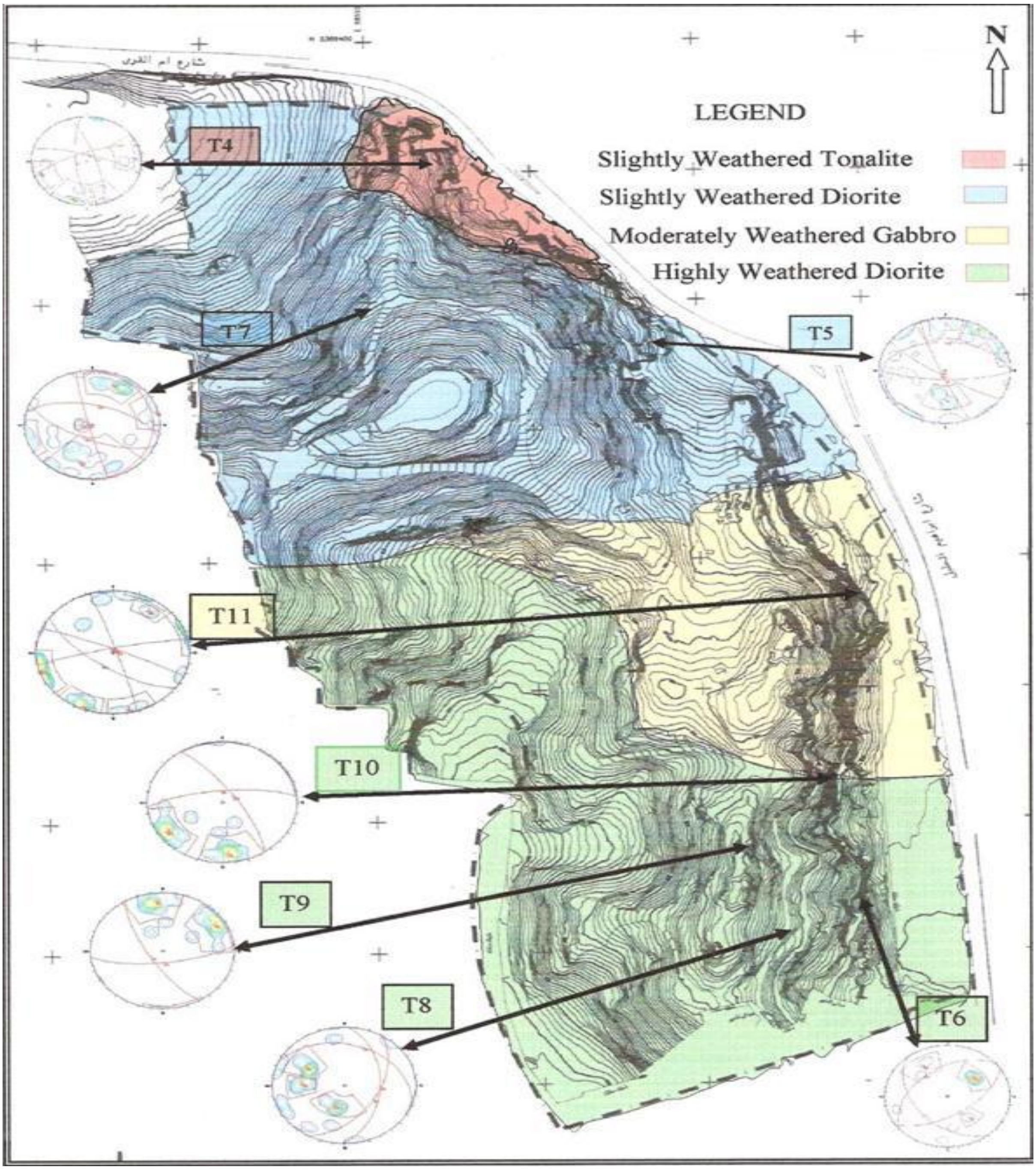

Fig. 2: Structural geological map of Jabal Omar

IV. CHARACTERISTICS OF DISCONTINUITY SURFACES

a. Joint spacing:

The spacing between adjacent discontinuities largely control the size of individual blocks of rock masses which govern the stability of rock structures. The closely spaced joints change the mode of failure completely than the widely spaced joints which results different interlocking conditions.

The fracture spacing of a set is given by the average distance between adjacent pair of joints in that set. Intersect a line of known length, and expressed as a mean joints spacing. Table (2) illustrate the descriptive terms for joint spacing according to their intervals.

Table 2: Descriptive terms for joint spacing (Geological Society of London, 1977).

Descriptive Terms	Intervals (cm)	Symbols
Extremely widely spaced	200	F1
Widely spaced	60 - 200	F2
Moderately widely spaced	20 - 60	F3
Closely spaced	6 - 20	F4
Very closely spaced	2 – 6	F5
Extremely closely spaced	<2	F6

It was found that the joint spacing values at the study area are ranging from 7 cm (F4) to 100 cm (F2), with an average of 54 cm (F3) (moderately wide spaced).

b. Aperture (separation):

Aperture is defined as the degree to which a discontinuity is open or to which the faces of discontinuity have been separated. It is measured as the perpendicular distance separating the adjacent wall of an open discontinuity. The apertures have an indirect significant effect in changing normal stress and shear strength along the discontinuities. The large apertures could be as a result of tensile opening, out wash, solution and shear displacement of discontinuities having appreciable roughness. The descriptive terms that shown the degree to which a discontinuity is open are given in Table (3). In general; the aperture of the different joint sets in the studied area are ranging from 2 mm to 17 mm, and described very narrow to narrow.

Table 3: Aperture of discontinuity surfaces (Geological Society of London, 1977).

Term	Aperture (Discontinuities) Thickness (Veins, faults)
Wide	**> 200 mm**
Moderately wide	**60 – 200 mm**
Moderately narrow	**20 – 60 mm**
Narrow	**6 – 20 mm**
Very narrow	**2 – 6 mm**
Extremely narrow	**0 – 2 mm**
Tight	**Zero**

c. Infilling Material:

The infilling is defined as that materials which fill the opening between discontinuity surfaces. It may consist of sand, silt, clay, and calcite or gouge or breccia in the case of faults. It has a significant effect on the shear strength of these discontinuities, in addition to the deformability and permeability of rock masses.
The infilling materials in the studied area are composed of crushed rock and soil, such as sand and clay.

d. Shear and faulting systems:

A shear zone is a planar feature of few centimeters to a few meters wide along which the rock is slickenside, cleavage, or crushed. The shearing system normally associated with tectonic movement making the area very weak, highly weathered and unstable.

Shearing zones in Jabal Omar are associated with faulting and movements. The Red Sea fault system has affected most of the rocks in the studied area. According to Nebert et al. (1974) and Al-Shanti (1966) the faults can be defined by two major sets (1) the older set trending NE-SW is a block faulting related to the Red Sea tectonic movements, and (2) the younger set trending NNW-SSE, which is running rectangular to wadi Fatima.

V. SUMMARY

From the field measurements and observations, it was concluded that, the Jabal Omar intruded by andesitic and basaltic dykes of different thickness and orientation. These dykes made the outcrop weak, highly deformed and made the rock masses sensitive to weathering.

The presence of joints and fractures in the area made the rock blocks small and weak. The Jabal Omar is full of jointing systems as measured for different types of rocks. It was observed that, the northern side of the Jabal Omar consists of 3 to 4 jointing systems with 2 random fractures associated with dykes. The southern part of the Jabal Omar is affected by 2 to 3 jointing systems with minor fault and shear zones.

The jointing and shearing systems at Jabal Omar were associated with tectonic movement making the area very weak, highly weathered and unstable.

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