ISSN: 0067-2904
GIF: 0.851

Engineering Geological Assessment for Rock Slope Stability of Chosen Areas from SW of Haibat Sultan Mountain, Kalkasmak-Koisanjaq Road / Iraq

Thair Thamer Al-Samarrai*
Department of Geology, College of Science, University of Baghdad, Baghdad, Iraq

Abstract

Engineering geological study of rock slope stability in two stations lying in the SW of Haibat Sultan mountain, along the Kalksmaq - Koisanjaq road was carried out. At each station, rock slopes and discontinuities were comprehensively surveyed and the relationships with failures were determined. The limestone rock was described in engineering terms, the types of failures recorded during field study were rock roll and toppling whiles the probable failures were sliding, toppling, and rock roll. The study also revealed that the factors affecting slope stability in the study area were slope angle, height, dip of strata, and discontinuities (which are almost perpendicular to the bedding plane). The laboratory test, of the rock samples (point-load test) showed that the average value of compressive strength of the rock for the study area is about 192 M.Pa. Landslide possibility index (LPI) classification of Bejerman (1998) is applied to the study area, it shows that slopes of both stations lie in the category IV of moderate (LPI). The hazards related to the (LPI) are also moderated (LPI). Some remedial measures were suggested to slopes, such as remove of unstable blocks, to avoid further failure problems and safeguard the slopes in the future.

Keywords: slope stability, landslide possibility index

التقييم الجيولوجي الهندسي لاستقرارية المنحدرات الصخرية لمناطق مختارة من الجزء الجنوبي الغربي لجبل هيبت سلطان على طريق كلكسماك–كويسنجق/ العراق

ثائر ثامر السامرائي*

قسم علم الارض، كلية العلوم، جامعة بغداد، بغداد، العراق

الخلاصة

اجريت دراسة جيولوجية هندسية لاستقرارية المنحدرات الصخرية لمحطتين واقعتين في الطرف الجنوبي الغربي من جبل هيبت سلطان وعلى الطريق الذي يربط بين كالكسماك–كويسنجق. في كل محطة اجري مسح شامل للمنحدرات والانقطاعات الصخرية وتحديد علاقتها بالانهيار ووصف الصخور (الجيرية) هندسيا وتحديد انواع الانهيار وتحليل استقرارية المنحدرات بواسطه طريقة الاسقاط الفراغي المجسم. انواع الانهيارات التي سجلت في هذه الدراسة هي الدحرجة الصخرية والانقلاب، اما المحتملة فهي الانزلاق والانقلاب والدحرجة الصخرية واظهرت الدراسة ان العوامل المؤثرة في استقرارية المنحدرات هي ارتفاع المنحدر، ميل الطبقات الصخرية،الانقطاعات الصخرية (اغلبها عمودية على اسطح التطبق). اظهرت نتائج الفحوصات المختبرية للنماذج الصخرية (فحص حمل النقطة) ان معدل قيم المقاومة الانضغاطية لصخور منطقة الدراسة كانت δ=192 Mpa. تم تطبيق تصنيف Bejerman, 1998 المتعلق بأمكانية الانهيار(LPI) على منطقة الدراسة وظهر بأن منحدري المحطتين تقعان ضمن المجموعة (4) وهي متوسط امكانية الانزلاق (LPI) كذلك فأن

*Email: alsamarri_thair@yahoo.com

المخاطر المتعلقة ب(LPI) هي متوسطة ايضا. تم اقتراح بعض المعالجات لحماية الطريق من الانهيارات الصخرية مثل ازالة الكتل غير المستقرة لضمان سلامة الطريق في المستقبل.

Introduction

The study area lies in SW of Haibat Sultan mountain, along the Kalksmaq - Koisanjaq road, about 50km north west of Dokan city in sulaimaniyah government as shown in Figure-1. This area is very important because of firstly its contains the road that connects between two important cities, Kalksmaq & Koisanjaq, and secondly the slopes alongside the roads is consists of the limestone that use as cement industry and building materials. These slopes in some parts are unstable. The climate of the area is characterized by the annual rainfall (700.2) mm. The temperature shows annual average (16-20 ºC), which varies from minimum (50 ºC) in August to minimum (3.1 ºC) in January, and below (zero) in some period. These variations in climatic conditions effect on mechanical and chemical weathering of the rocks exposed in the area, and effect on the slope stability.

The aim of this paper is to study and analyze the unstable slopes, the acts of joints and bedding planes, and mode of failure. Therefore, two sites have been selected they are characterized by occurrence of failures in the rock slopes; this instable slope makes hazards on land. In this paper the attitude (inclination or dip) of slopes or layers are referred to by two numbers representing the direction to the left and the angle to the right. The stations were studied in detail; the study covered the slope. Descriptions of slope and underlying layers from the structural, lithological and engineering points of view are depending on the reports of [1-5] giving the nature of failure, the infusing factors, and naming the mode of failure.

Geology of the study area

The formation exposed in the studied area is Pila Spi ranging in age from Mid-Late Eocene [6].The resistant Pila Spi Formation from South a conspicuous ridge between the recessive weathering Gercus and pars formation throughout the High Folded Zone. The Pila Spi Formation is 100-200m thick. The upper part of the formation comprises well bedded, bituminous, chalky, and crystalline limestones, with bands of white, chalky marl and with chert nodules towards the top. The lower part comprises well bedded hard, porous or vitreous, bituminous, white, poorly fossiliferous, limestones, with algal or shell section. In the supplementary type section, it consists of dolomitic and chalky limestone with chert nodules. The formation was deposited in a shallow lagoon. Fossils are abundant and indicate a late Eocene age. In N Iraq formation may be party of Middle Eocene age to the NE the Pila Spi formation oversteps the Gercus Formation: small outliers of Pila Spi Formation (containing beds of red shale) unconformable overlie older tertiary sediment in the Zubair area [7]. The upper boundary is unconformable throughout. The overlying sediments are mostly of Miocene age. Structurally, there are money geological structures in this studied area Haibat Sultan mountain. The length of Haibat Sultan mountain is about 1609m and its high is 1230m it is axial trend N50W.the dip of its beds in SW part about 28-30º.

Different types of fault exist within the study area; all are associated with anticline. The first is the thrusts are believed to be developed simultaneously with the folding [8] and there are two types of faults in the studied area, and the second is transversal-strike slip system. The geomorphology of studied area is controlled by structure and lithology. The lithological variation of the stratigraphic units helps to increase the differential weathering and erosion [9].

Figure 1- location of study area (by Bing map)

Laboratory work

The point load test [10], [11] and [5] was carried out on limestone (in which slope failure has occurred) to find their unconfined compressive strength (δc) by indirect method. It was found that (δc) values is about 192Mpa and that means it is very strong.

Slope stability analyses

There are many failures accrued along the Kalksmaq - Koisanjaq road in SW part of Haibat Sultan mountain. Near Al Fatha area therefore two stations (sites) have been chosen in that area to analyses the slopes

- **Station No.1**

The station lies on the SW part of Haibet Sultan mountain within Pila Spi Formation, along the Kalksmaq - Koisanjaq road Figure-1. The length of the slope is about 20m, and (6m) average of height, its oriented (265/62) and the average dip of beds (194/25) Figures-2,3. The exposed rocks in slope face are light creamy to yellowish brown, fine grained, thinly to medium bedded, containing some facility (lamination 1-5cm) very closely to moderately widely spaced joints, slightly to moderately weathered, LIMESTONE, very strong with average δc=192 MPa, and slightly to highly permeability, Figure-2. The rock mass is cut by two main sets of sub-vertical joints, in addition to the bedding plane Figures-2,3.The first set [sj1(bc)], is with an average dip (080/88), with length range, between (0.1-8.6)m, open with range between (2-30)mm, empty to filling with limestone sediments, very closely to moderately widely spaced joint. (0.05-0.58)m. Figures-2,3.The second set.sj2(ac), it average dip is (338/86), with length average between (0.3-0.7)m, open with ranges between (2-25)mm, filling with limestone sediments, very closely to moderately widely spaced joints (0.04-0.06)m. There are some of facility and disintegration in rock mass Figure-2.

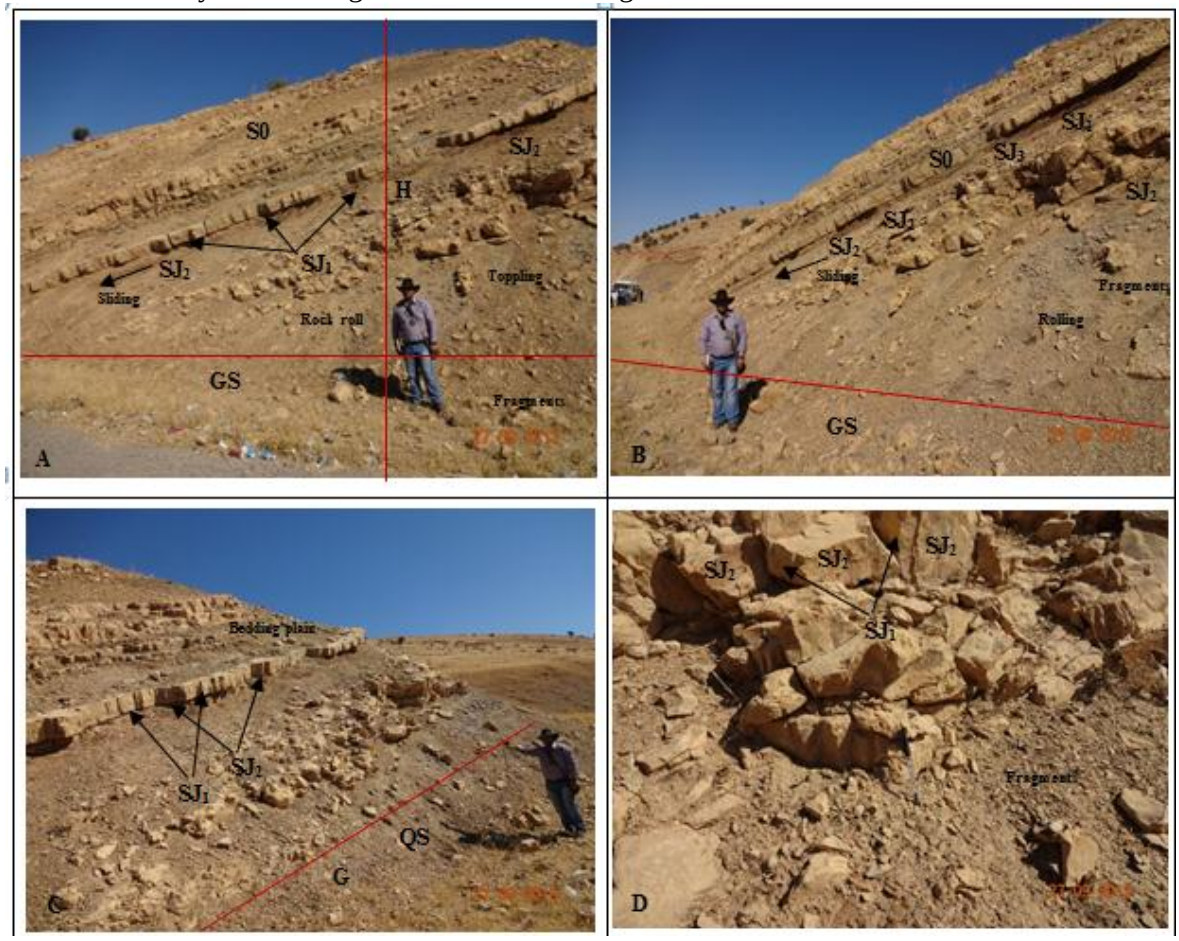

Figure 2- Slope of station No.1 at SW of Haibat Sultan Mountain. Kalksmaq - Koisanjaq road. A- General front view showing the high and inclination of slope, bedding plane, SJ1, SJ2, toppling and rock roll, and some of separated rock fragments. B- Side view of the slope showing the SJ1, SJ2, so trapping, rock roll, and probably of sliding and separated fragments. C-Side view of slope showing the SJ1, SJ2, toppling and rock roll, and some separated rock fragments. D- Close views showing SJ1, SJ2, fractures, disintegration in rock mass.

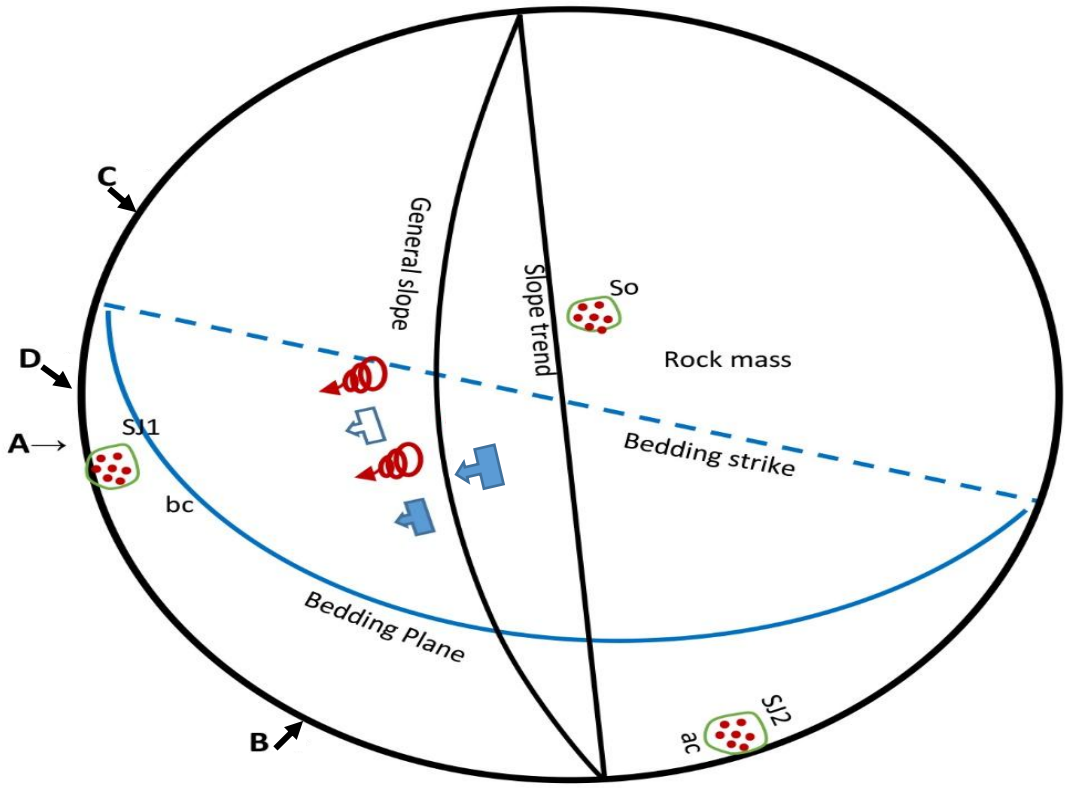

Figure 3- Showing the relationships among slope, bedding planes, discontinuities, and models of occur and probable failure at station No.1 in SW of Haibt Sultan mountain Kalkasmag-Koysinjaq.

The main mode failures that occurred in the rock mass in this station are rock roll, toppling, and disintegration of rock fragments in which bedding plane acts as basal surfaces (B.S), SJ1, acts as back release surface (B.R.S), and SJ2 acts as lateral release surface (L.R.S). Figure-2,3. The probable types of failures in future in this station are sliding, toppling, and rock roll. In sliding, the daylighting slope at this station is favorable geometrically for plane sliding Figure-2a, b, c, the bedding acts as sliding surface while SJ1 act as (B.R.S) and SJ2 acts as (L.R.S).

- **Station (site) No.2.**

The station lies on the SW part of Haibat Sultan mountain within Pila Spi Formation, along the Kalksmaq - Koisanjaq road, it is located about (5)m, NW of station No.1 Figure-1.

The length of the slope is about (15) m, and (6)m average of height, its oriented (256/60),average dip of bed is (205/28), Figure-4, 5.

The exposed rocks in slope face are light creamy to yellowish brown, fine graind, thinly to medium bedded, very closely to moderately widely spaced joints, slightly to moderately weathered, limestone, very strong with average δc=192 MPa, and slightly to highly permeable, Figure-4.

The rock mass is cut by two main sets of sub-vertical joints, in addition to the bedding plane, Figure-2,3. The first set is SJ1(bc), its average dip (065,84), with length ranges between (0.1-0.6)m, open with ranges between (2-30)m, empty to fill with limestone sediments, very closely to moderately widely spaced joint,(0.07-0.6)m. The second set is SJ2(ac), its average dip (318/88), with length average between (0.4-0.8) m, open with ranges between 3-27 mm, filling with limestone sediments, very close to moderate wide joints (0.05-0.7)m. This station is very hazardous (danger) because the Conditions of sliding are available, Figure-4. Where the daylighting slope at this station is favorable geometrically for plane sliding. During the sliding the bedding planes act as sliding surfaces, while SJ1 acts (B.R.S) and SJ2 acts as (L.R.S), also the rock roll is probable to occur in this slope of the station Figure-4,5.

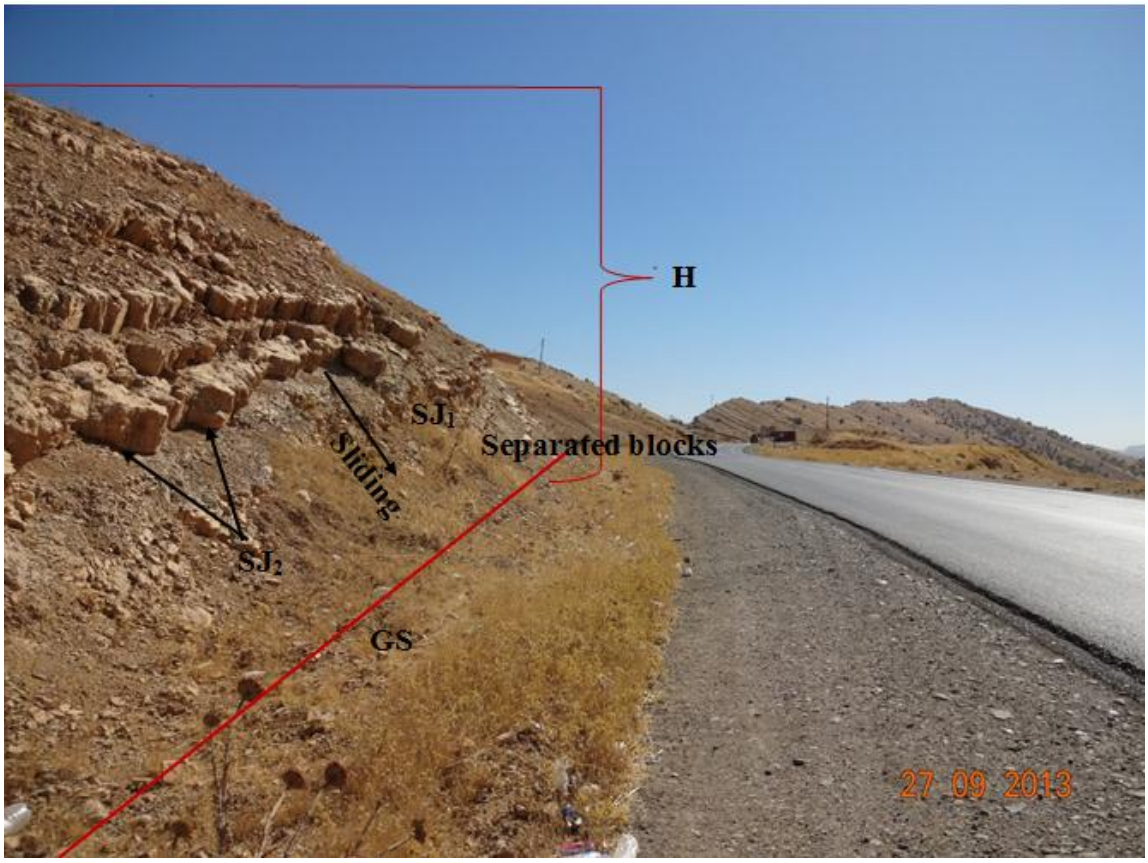

Figure 4- Side view of the slope in station No.2 in Kalkasmag-Koysinjaq road shows height of slope SJ1, SJ2, bedding plane, and separated blocks.

Landslide Possibility Index (LPI) in the studied area

The landslide possibility index (LPI) of [12] and Hazard category that corresponding to (LPI) also of [10] are applied to the slopes of the two stations that have been selected. This estimation system considers characteristic features for the slope estimation in the field and depending on ten factors.

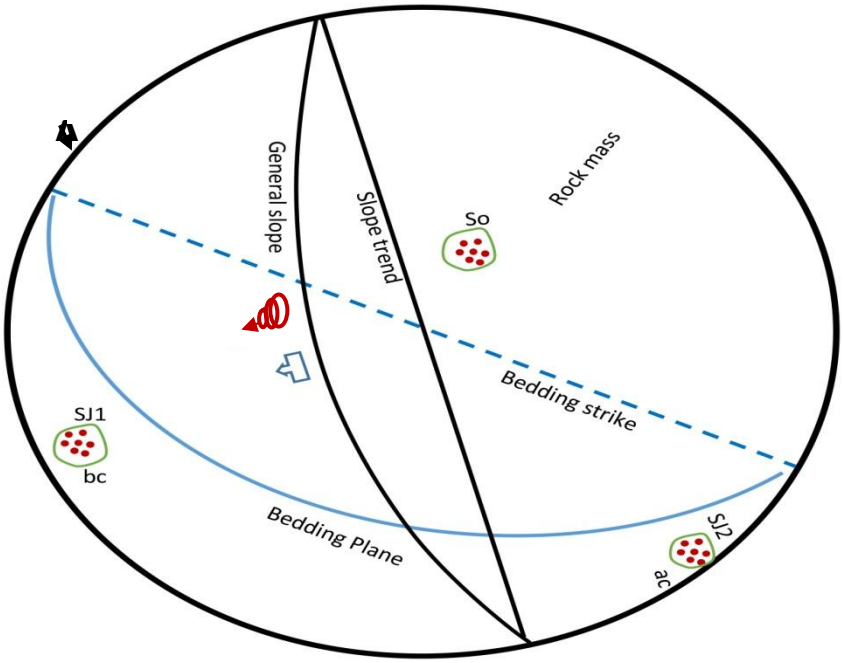

Figure 5- Shows the relationship among slope, bedding planes, discontinuities, and models of occur and probable failurs at station No.2 in SW Haibt Sultan mountain Kalkasmag-Koysinjaq.

The ten parameter of [12] classification are calculated for each station in Table-1.

Table 1- The calculated LPI parameter in studied station

LPI parameter		LPI for st. No.1	LPI for st. No.2
1-	Slope hight	1	1
2-	Slope angle	3	3
3-	Grade of fracture	1	1
4-	Grad of weathering	2	2
5-	Grade of discontinuities	1	1
6-	Spacing of the continuities	2	3
7-	Orientation of the discount.	4	4
8-	Vegetation cover	1	1
9-	Water infiltration	1	1
10-	Previous land sliding	1	1
Total		17	18

The results of the (LPI) calculation of ten parameters for the slopes in two stations in table (1), and according to the hazard categories, shown in Table-2.

Table 2- The results of (LPI) calculation and category (LPI) and Hazard

St. No	LPI	(LPI) category	Hazard category
1	17	(IV) moderate (LPI=16-20)	moderate (LPI=III-IV)
2	18	(IV) moderate (LPI=16-20)	moderate (LPI=III-IV)

From the results it appears that there is moderate landslide possibility at the two studied stations, and the landslide hazard of the category of (LPI) is also moderate.

Conclusions

1. The slopes of studied stations are daylight slopes which are geometrically favorable for plane sliding
2. The main failure modes are rock roll, toppling, in addition to disintegration of rock fragment of various sizes (few centimeters up to 20 cm), probable types of failure in future are planer sliding, toppling, and rock roll.
3. Two sets of joints are present SJ1 (bc) and SJ2 (ac) in addition to the bedding planes, where SJ1 (bc) acts as back release surface, SJ2 (ac) act as lateral reals' surface, and bedding planes act as basal surface for rock roll and toppling.
4. the compressive strength of the rock is very strong with average δc = 129 MPa.
5. The slopes in both stations are moderate landslide possibility and moderate landslide hazard, when the landslide possibility index (LPI)and hazard category corresponding to (LPI), according to Bejerman classification (1998) (LPI)values (category of LPI=16-20), this requires treatment.

References

1. Anon. **1972.**The preparation of maps and plans in terms of engineering geology, *Quarterly Journal of Engineering Geology*, 45, pp:293–382.
2. Anon. **1977**. The description of rock masses for engineering purposes. *Quarterly Journal of Engineering Geology*.701. 150(4), pp:355-388.
3. Anon. **1999**. Geotechnical considerations in open pit mines guideline, Moshab, Western Australia, upa.
4. Anon. **2003**. Engineering rock mass classification workshop, *Australian Center for Geomechanics*, Victoria, pp:39-60.
5. Hawkins, A. B. **1986**. Rock descriptions, geological Society. *Engineering geology*. Special publication, (2), pp:59-72
6. Jassim. S. Z. and Goff, J.C. **2006**. *Geology of Iraq*. Published by Dolin, Praght and Moravian Museum, Brno. p: 34.
7. Hall, P. K. **1958**. Geological map Kurdistan Reconnaissance Series, Scale 1:100.000, Sheet K2., Amadiya. Manuscript report. Geosurv, Baghdad.
8. Sissakian, K. **1993**. The geology of Kirkuk quadrangle. Sheet NI- 38-2 (GM9) Scale 1: 250000, GEOSURV, Iraq, p:48.

9. Ma'ala, K. A., Hassan, K. M. and Galib, A. A. **2004**. Semi - details geological survey for Azmur Mountain-Chworta area in sulaimaniya Governorate. State Company of geological survey and mining. Rep. No. 2885, p:114 . (In Arabic).
10. ISRM. **1973**. Suggested method for determining point-load Strength inde. Int., Workshop on landslide risk assessment, Honolulu, In Lerouail, S. and Locat, J. pp:215-226.
11. Hoek. E. and Bray, J. W. **1981**. *Rock slope engineering*. Institution of mining and metallurgy, Third Edition, London, p:358.
12. Bejerman, N. J. **1998**. Evaluation of Landslide Susceptibility Along State Road 5, Cordoba, Argentina Proceedings, 8th Inter. IAEG Cong., Balkema, Rotterdam, 2, pp:1175-1178.