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Slope Stability Evaluation of Euphrates Out Crops at Najaf Governorate-Center of Iraq: Analysis Study

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تقييم استقراريه المنحدرات الصخرية لمكاشف الفرات محافظة النجف الاشرف-وسط العراق: دراسة تحليلية

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ABSTRACT

In this study the stability of the rock has been evaluated to determine the most relevant factors affecting instability of slope . The discontinuity data collected from the field surveys was analyzed using stereograph projection. Sub horizontal-layer slopes of limestone rocks in Euphrates formation at Al-Najaf governorate, center of Iraq, presence of failures in slopes , Its from most to least rock fall, secondary toppling, and rolling. The degree and nature of hazard risk depend on properties of the rock discontinuity. This study recommends that rock instability is enhanced by fences barrier and building concrete walls and remove weak rocks.

Key words: stability of rock, failures types, stabilization of rocks , Euphrates outcrops.

INTRODUCTION

failure of slope is a process geologic that movement down of rock masses in slope caused by gravity. When the rock mass has full strength, it can maintain the stability of the slope. Anything that disturbs the rock mass from time to time causes it to failure and then move down the slope [1] [2] [3]). [4]. Rockslides are a form of landslides, as well as rock falls It was updated by [5] classification systems, The type of material or rock is the first term. Either fall or slip refers to the type of movement, which is the second term and that any comprehensive information about geology and engineering geology is what evaluates the stability of rock slopes, the most important of which is the discontinuity characteristics of rock masses and cuts in the face of the slope. The degree and nature of the risks depend, and they determine some of the engineering characteristics of the rock masses are the height of the rock slope, the weathering method of the rocks, the characteristics of the rock discontinuities, the adequacy of the water reservoir pit and the presence of water.[6][7][8][9][10].

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Objectives

The assessment of the instability of the cut faces of limestone rocks is one of the main objectives of this research according to the field work. The term rock fall is a general term for rock segments and rocks of all types. Field trips were conducted to determine the engineering and geological characteristics of the limestone rock of the Euphrates outcrops, and then evaluate the factors that lead to the lack of The stability of the rock slopes, the most important of these aims are:

1-Study and description of the factors that lead to the instability of the rock slopes of the Euphrates Formation outcrops.

2-Collect data from outcrops and determine the direction and dip angle of the discontuities and types of failures.

Location of the study area

The outcrops of Euphrates rocks away about (26 Km) west of Najaf city, central Iraq as shown in figure (1). This area is located between latitudes (N 32° 21′ 44.4″); (N 32° 24′ 18.1″)- (E 42° 42′ 22.1″), (E 42° 63′ 05.1″).Fig (1) a located map of the study area. Quaternary deposits cover more than 25% of the study area, and the rest of the tertiary sediments. The outcrops of the Euphrates out crops are shown in limited parts on the surface to the west and northwest of the city of Najaf and in the form of a strip parallel to the Euphrates River. The properties of the Euphrates rocks colors are gray, or sometimes yellowish, yellowish and strong. The thickness of the layer varies from thick to very thick [11]. The typical section of Euphrates is located in Wadi al-Fahimi near the western region of Anha, divided into five units, from bottom to top, dolomite with dark yellow color with basal conglomerate, dolomite, soft white limestone, rich in fossils, limestone and chalk stone, dolomite with brown color [12].

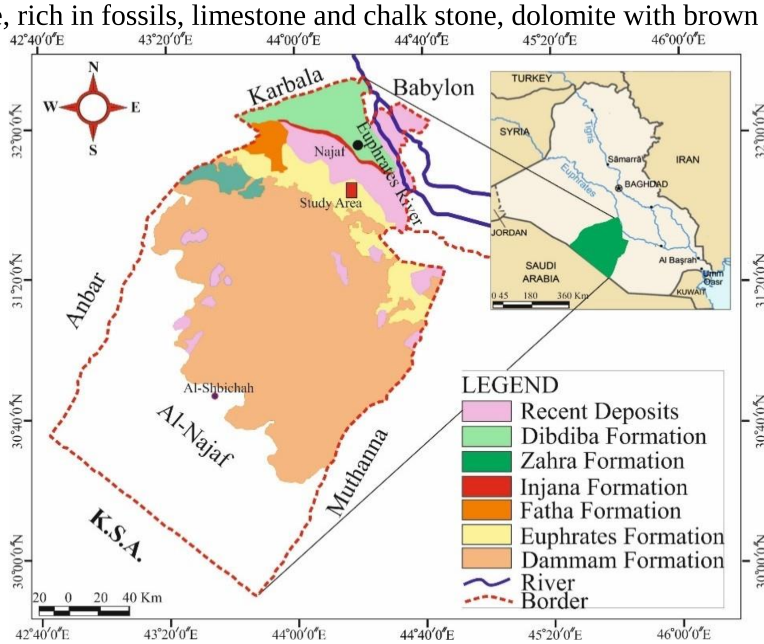

Figure (1)located map of study area modified after [13]

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Previous studies

Despite the many geological studies that have taken place in the study area in general, there are some studies that include points to other aspects, including:
[14]presented geological study of selected areas of Tar-Al-Najaf in central Iraq. The study included two studies: stability of rock slopes and geotechnical assessment of the soil of the study area. [15] conducted an Evaluation of dolomite rocks for the Euphrates Formation of the (Lower Miocene) in the west and north west of Najaf city for industrial applications and extraction of some magnesium compounds[16] assessed the quantity, quality and radiation of the clay layer in the Euphrates formation used in the cement industry in Kufa cement plant in Najaf Governorate. conducted a geotechnical assessment of limestone used in Kufa cement plant in Najaf Governorate and their validity for the purposes of the portland cement industry.

Geology of the Study Area:

Euphrates Formation:

The typical section of the Euphrates Formation located Wadi Al-Fahimi near Anah city on the Stable Shelf. The thickness of the Formation in typical section is 8 m, may expanded arrange to 100 m, and the average thickness between is between 60-70 m, showing change in its rock contents especially in the Western Desert area. It consists of limestone, well-bedded recrystallized limestone , marly and marly limestone shells. The age of this formation is Early Miocene. The environment of the Euphrates Formation is a shallow marine environment interferes with reefs and lagoonal.

. **Quaternary sediments:**

which are present in the study area, and can be studied as follows

Valley Sediments:

This type of sediment is consist of poorly sorted of, gravel ,sand and silt

Colluvial Sediments:

These sediments only presence at the lower slope of Tar- Al-Najaf site.

Tectonic and Structural Setting:

The tectonic setting of the study area is that it is a subsurface structure with a clear effect on the rocks of the basement. Previous studies have pointed to the existence of two major faults, namely, the Abu Jir fault, which belong to the Hijaz movement that took place in the pre-Cambrian period. It is due to the Nejd movement that occurred in the lower Cambrian as well as the existence of a set of different directions faults . The region is structurally characterized as sub horizontal the average dip of strata range to (4 – 6°); therefore, most of slopes in study area as sub horizontal layer [17]. Vertical and semi-vertical joints constitute two important groups in the study area, trending (NE – SW and NW – SE).

Climate of study area:

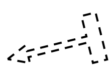
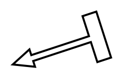
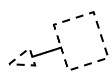
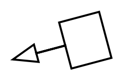
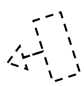
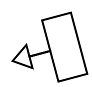
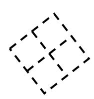
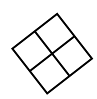
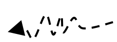
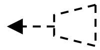
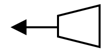
The long hot dry summer and the short cold winter with a wide range of temperature fluctuations from day to night and limited rainfall are the prevailing characteristics of the study area climate. The different elements of climate are greatly affect on the natural resources and the nature of their exploitation. That's the reason for different environmental characteristics for the area to be influenced, as the climate governs in the dispersion and distribution of vegetation and the abundance of water resources including their physical and chemical properties. Besides climate parameters influence on soil and sediments formation, and governs on their depth, properties and transportation of mineral deposits due to erosion processes

Precipitation sometimes occurs in the form of intermittent and intense flashes, which leads to the formation of surface patterns with temporary valleys and excused valleys, but its climate is considered desert.These wadies, like Hassab, Al Ewier, Al Saba'a and Al Maleh are running from western and southern parts toward the depression of Bahr Al-Najaf at the eastern side, generally. The variation of direction of these wadies at sometimes follow the direct effects of large occurrence of faults and lineaments features in this area [18]

Rock Slope Stability Analysis:

Four stations representing the slopes and outcrops of the Euphrates Formation were studied in order to determine the stability of the rock slopes and their engineering analysis, where the unconfined compressive strength was estimated by the geological hammer by means of the relationship between the number of blows and the manual pressure with the geological hammer [19]. Field observation showed that Euphrates Formation slopes have many failures, particularly rock fall, toppling, and local disintegration followed almost by rolling. [20] [21] [22] [23] [24] . To represent field data, the following symbols are used in Tables 1

Table 1: Types of failure and photo direction to analysis of slope,

Failures type	**Symbol**	
	Possible	**Present**
Toppling		
Rock fall		
Plane sliding		
Granular disintegration		
Rolling		
Slumping		
Photo direction		

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Field Tests

To obtain data including engineering properties of rock masses and intact rocks . Tests that use geological hammer pressure are a simple term. It was used to determine the strength of intact rocks as shown in the table 2. The geological hammer of limestone rocks was used to test ten samples, materials weathered extend the discontinuities. Multiple estimates of rock strength for exposure in many cases were made; often more than 3 values were averaged.

Table 2. Estimation the strength of intact rock [25]

Intact rock strength	Description	Rock type
MPa < 1.25	Crumbles in hand	Very weak
MPa 1.25 – 5	Thin slabs easily break in the hand	Weak
MPa 5 - 12.5	Thin slabs break by heavy hand pressure	Moderately weak
MPa 12.5 – 50	Lumps broken by blows light hammer	Moderately Strong
MPa 50 – 100	Lumps broken by blows heavy hammer	Strong
MPa 100 – 200	Lumps only chip by blows heavy hammer	Very strong
MPa > 200	Rocks ring on hammer blows. Sparks fly.	Extremely strong

Station .1: This station lies at latitude latitude (31° 49' 58" N) and longitude (44° 14' 14" E) Euphrates outcrops (picture 1). The heighof slope is 5 m, long 10 m long and inclined is 260/88°. Average dip layer is (240/04°); As a result, the layer slope is subhorizontal. A 1 m thick stratum is exposed at the top of the slope. They are LIMESTONE, strong (c = 32 MPa), pale gray, massive bedded, broadly jointed.The underlying rock layers in the bottom of the slope are 4 m thick. They are MARLY LIMESTONE, which is light grayish, thickly bedded, widely jointed, and highly weathered. They are moderately strong (c = 1.25 MPa).

The limestone layers were cut by two sets of discontinuities (S1 and S2) (Fig.2). S1 has a discontinuity spacing of 1.5–2.5 m, 4 m persistence on the bedding plane, and opens up to 4 m. (0.15 m). The discontinuity spacing in S2 ranges between 1 – 1.6 m; reaches 3 m persistence and open up to 0.2 m.

failure Rock fall or toppling, particularly multidirectional toppling, has caused rock block.

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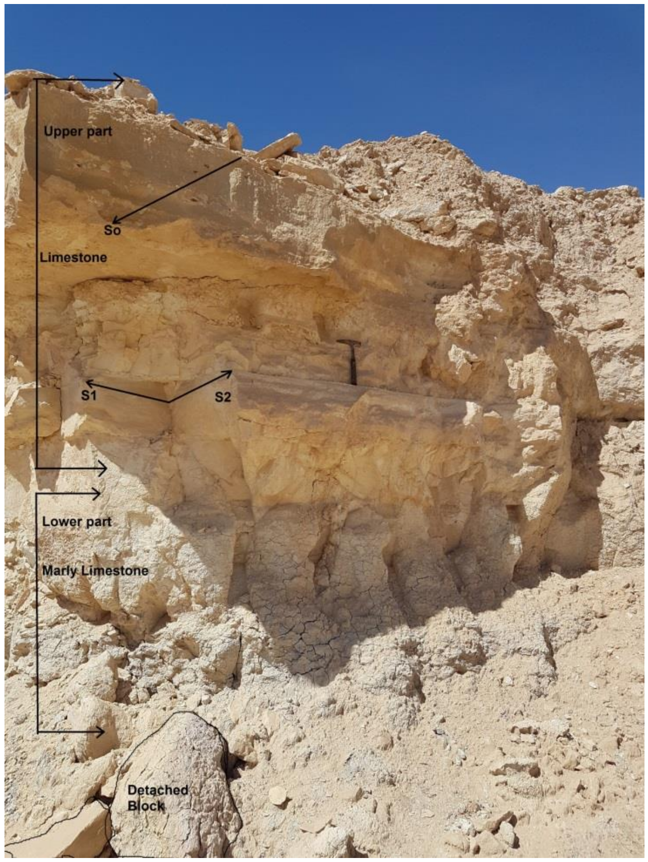

Picture1: The slope and discontinuities of S(1), photo direction SW

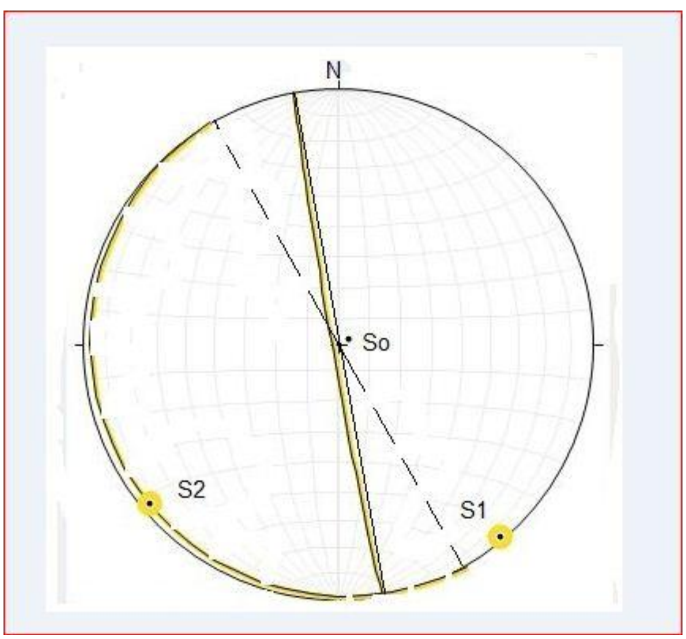

Fig.2: discontinuities, The slope and failure Stereogram for S(.1)

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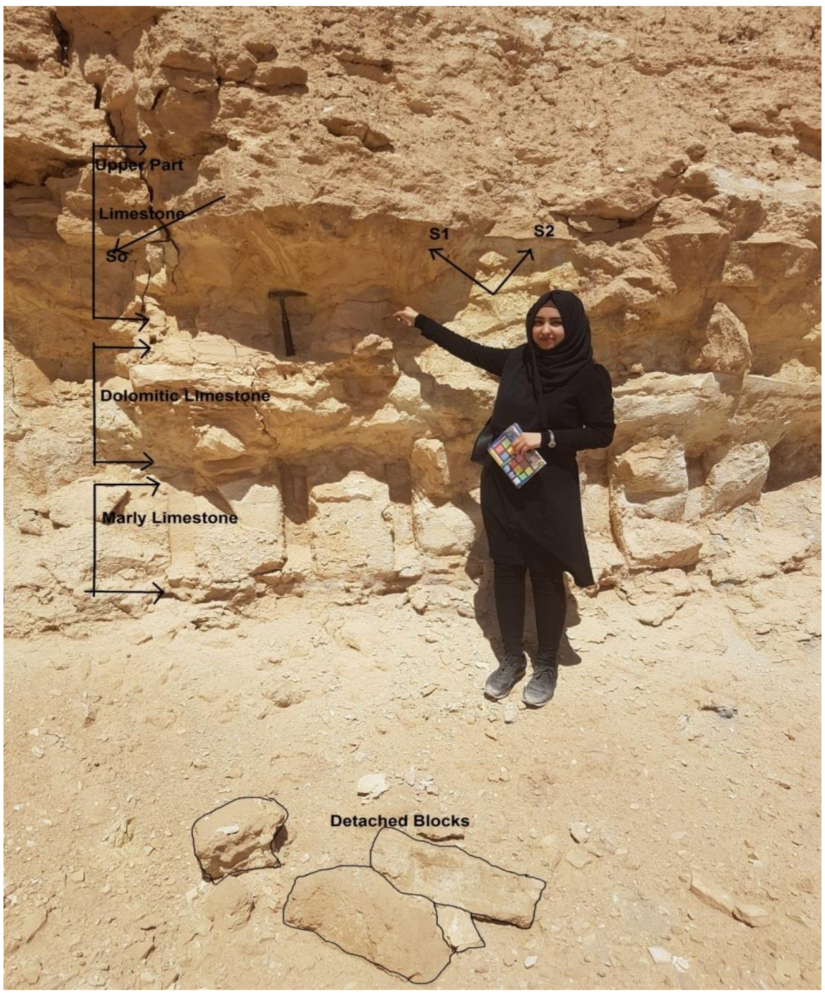
S.2: The Euphrates outcrops are located at latitude (31° 50' 3.248" N) and longitude (44° 14' 14.771" E) (picture 2). The slope is 6 meters high, 15 meters long, and 320 degrees inclined. Because the average dip layer is 170/04°, it has a subhorizontal – layer slope. A 3 m thick stratum is exposed at the top of the hill. They are LIMESTONE (c = 38 MPa), pale green, thick bedded, and moderately strong

The underlying rock layers in the lowest of the slope are 2.5 meters thick. They are MARLY LIMESTONE (c = 34 MPa), light greenish, with 0.5 m thick, pale grayish, moderately weathered DOLOMITIC LIMESTONE (c = 34 MPa). The limestone layers were cut by two sets of discontinuities in S1 and S2, (Fig.3)

were failureg through the limestone layers .The spacing of discontinuities in S1 ranges from 0.7 to 1.3 m, their persistence on the bedding plane reaches 2.5 m, and they are nearly open up to 0.13 m. S2 has a discontinuity spacing of 1–2 m, 2.5 m persistence on the bedding plane, and can expand up to 0.13 m. failure Rock block has occurred through rock fall or toppling.



picture 2: slope and discontinuities of S(2), photo direction NE

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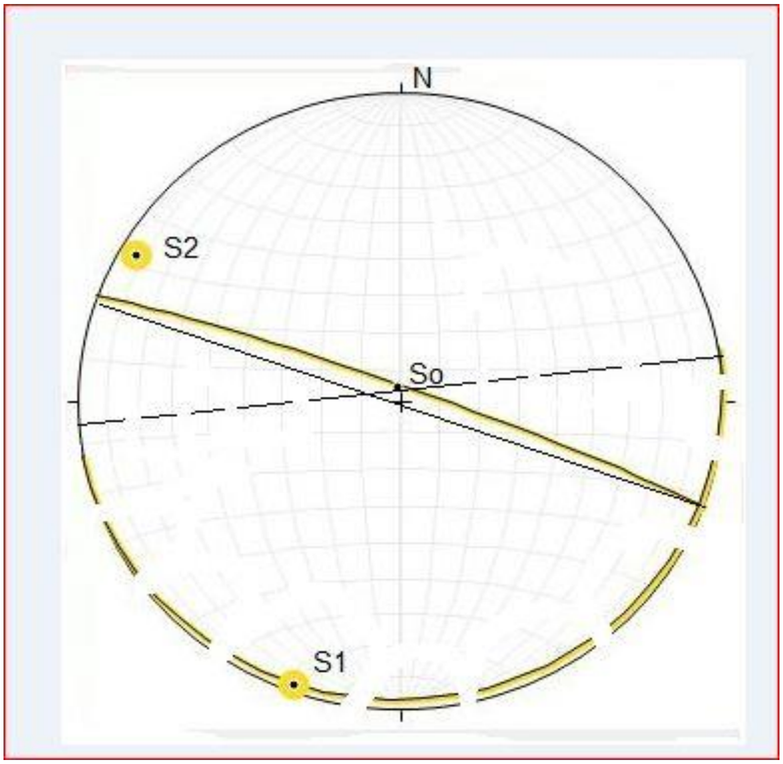

Fig.3: discontinuities, types of failure for slope and Stereogram for (S2)

S.3: This station is located on the Euphrates outcrops at latitude (31° 50' 6" N) and longitude (44° 14' 16" E) (picture 3). The slope is 3 meters high, 10 meters long, and 170/4 inclined. Because the average dip layer is 070/02, it has a subhorizontal – layer slope. A 1 m thick stratum is exposed at the top of the slope. They are LIMESTONE relatively strong (c = 30 MPa), pale green, medium strong.

The slope lower is 2 meters thick. MARLY LIMESTONE is light grayish, very thinly bedded, and. S1 and S2 were two sets of discontinuities that were cutting limestone layers. S1 has a discontinuity spacing of 1.9–2.2 m, 0.5 m persistence on the bedding plane, and opens out to 0.1 m. S2 has discontinuity spacing ranging from 0.6 to 1.4 m, 1.2 m persistence on the bedding plane, and opens up to 0.01 m. Rock fall failure due to differential erosion at the slope toe, overhanging slope in some areas, and contributing to the inclined soil slope can enable rolling of rock block detached.

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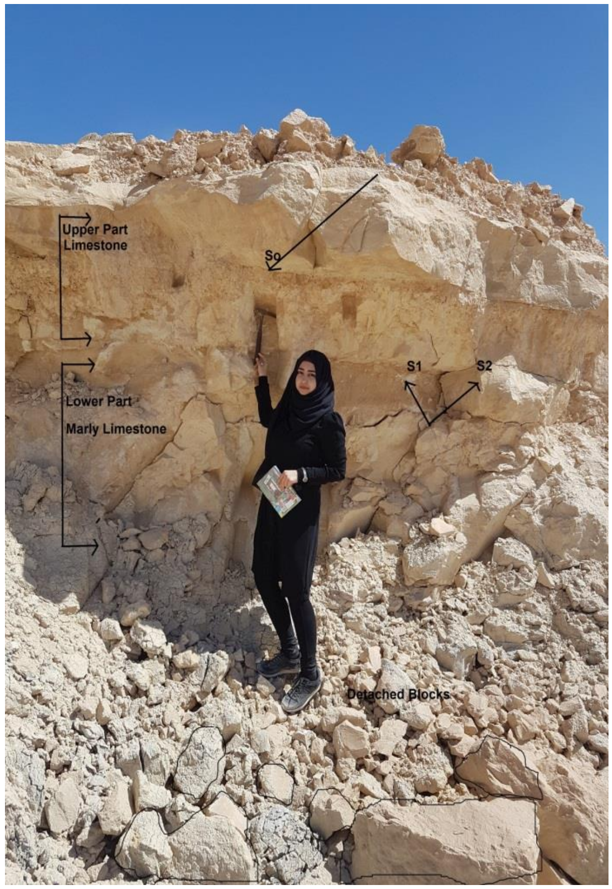

picture3: slope and discontinuities of station No.3, photo direction NE

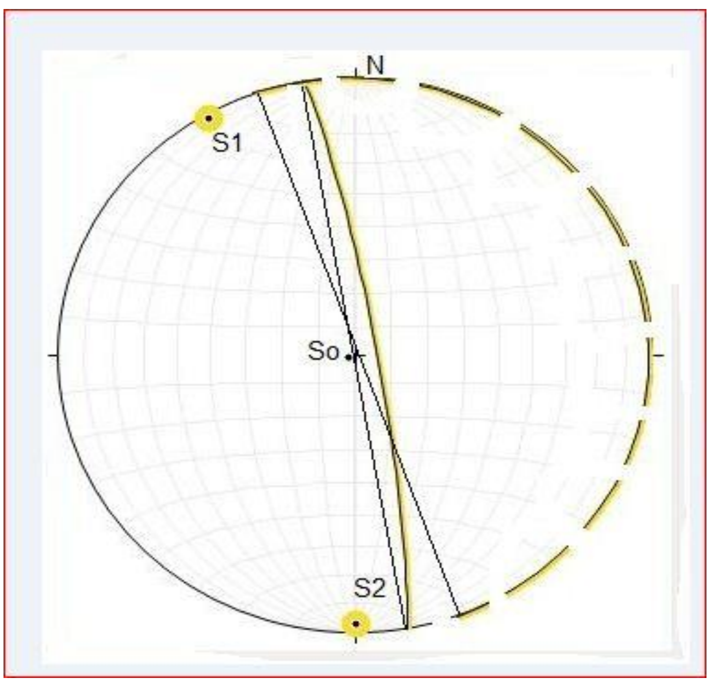

Fig.4:: discontinuities, types of failure for slope and Stereogram for (S3)

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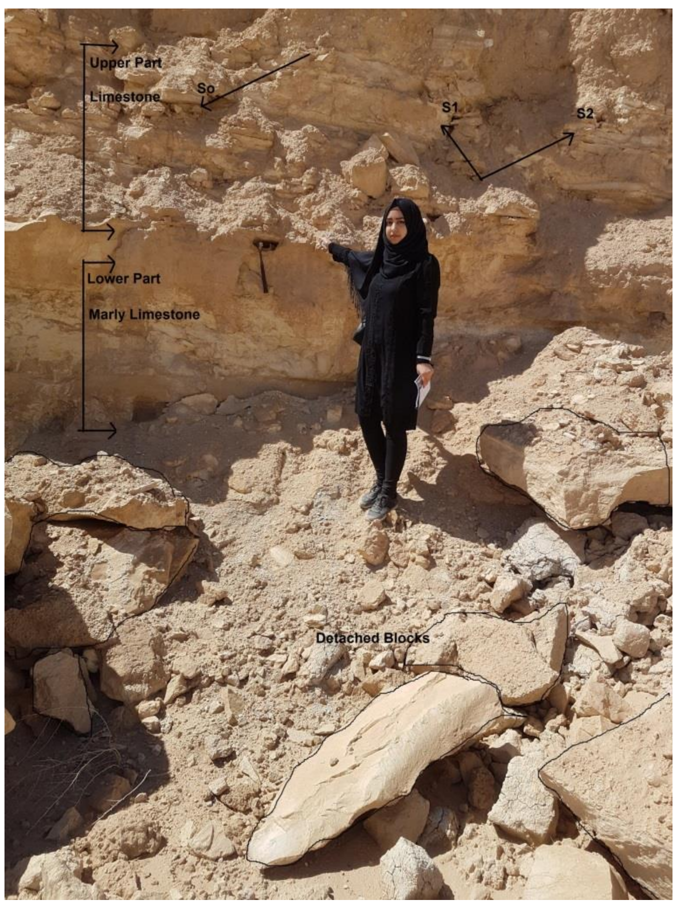
S.4: The Euphrates outcrops are located at latitude (31° 51' 4" N) and longitude (44° 15' 15" E) (picture 4). The slope is 5 meters high, 20 meters long, and sloped at 260/84 degrees. The average dip layer slope is 250/02, making it a subhorizontal − layer slope. A 2 m thick stratum is exposed at the top of the slope. They are LIMESTONE medium strong (c = 32 MPa), pale green, deeply bedded, and severely worn. The underlying rock strata in the lowest of the slope .are 3 meters thick. MARLY LIMESTONE is light grayish, deeply bedded.

S1 and S2 were two sets of discontinuities that were cutting limestone layers. S1 has a discontinuity spacing of 1–2.2 m, 0.7 m persistence on the bedding plane, and opens out to 0.1 m. S2 has discontinuity spacing ranging from 0.4 to 1.2 m, 1.0 m persistence on the bedding plane, and opens up to 0.02 m. Rock fall failure due to differential erosion at the slope toe, overhanging slope in some areas, and contributing to the inclined soil slope can enable rolling of rock block detached.



picture 4: The discontinuities and the slope of (S4), direction photo SW

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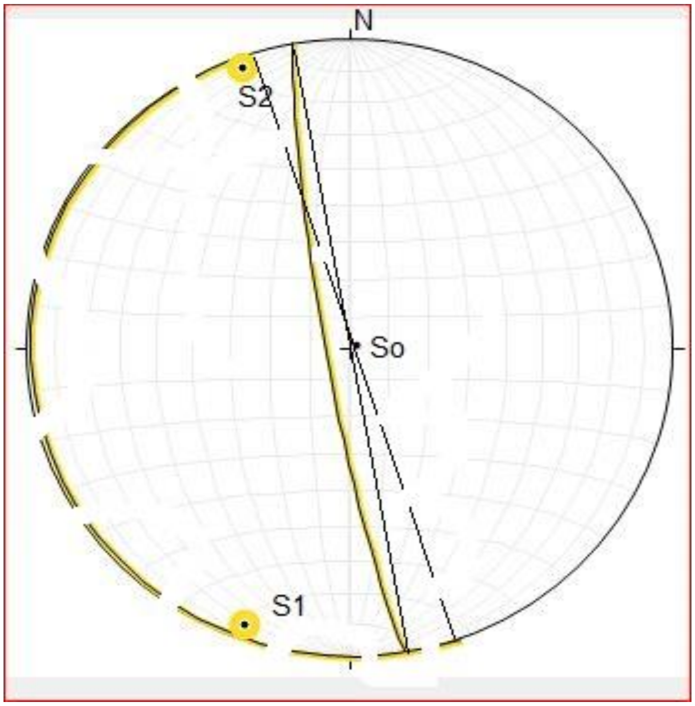

Fig.5:: discontinuities, types of failure for slope and Stereogram for (S4)

CONCLUSIONS

1- Nature and degree of the slope failure risk in the study area depends in most part on the properties of discontinuities rock, slope height and weathering of rock behavior.

2- Discontinuities of rock mass for the structural position controlled failures as well as the phenomena of the cut faces rock for the type raveling failures.

3- Intact strength of the limestone rocks, range from 5-50 MPa while Intact strength of marly limestone in study area less than 1.25 MPa.

RECOMMENDATIONS

1.Lifting unstable rock masses that are affected to toppling and rock fall in critical cases.

2. Filling the lower parts of the slope toe with binders such as cement, rock bolts and chemical sodium silicates.

.

3. Continuous monitoring of cracks and joints in those areas, especially during the rainy season, to see the extent of these cracks and the emergence of new cracks .

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Conflict of interests.

There are non-conflicts of interest.

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الخلاصة

في هذه الدراسة تم تقييم ثبات الصخور لتحديد أكثر العوامل ذات الصلة التي تؤثر على عدم استقرار المنحدر. تم تحليل بيانات عدم الاستمرارية التي تم جمعها من المسوحات الميدانية باستخدام الإسقاط المجسم. منحدرات الطبقة الفرعية الأفقية للصخور الجيرية في تكوين الفرات في محافظة النجف وسط العراق، وجود أعطال في المنحدرات، سقوط من معظم الصخور إلى أقلها، انقلاب ثانوي، وتدحرج. تعتمد درجة وطبيعة مخاطر الخطر على خصائص عدم استمرارية الصخور. توصي هذه الدراسة بتعزيز عدم استقرار الصخور عن طريق الأسوار وبناء الجدران الخرسانية وإزالة الصخور الضعيفة.

الكلمات المفتاحية: استقرار الصخور، أنواع الانهيارات، استقرار الصخور، نتوءات نهر الفرات.

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