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The study of rock slop stability along the road adjacent to the flood plain of Tigris River in Al-Hajjaj District/ Salah Addin Governorate

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Abstract
This work aims to conduct a study of the stability of the rocky slopes on the road adjacent to the floodplain in Al-Hajjaj district in Salah Al-Din Governorate. The study involves (6) stations within the formation of Injana, which unfolds in the region in the form of horizontal layers, in addition to the sediments of the Quaternary age. Many Failures were diagnosed, including what happened as rock falls due to the presence of vertical and overhanging slopes and differential erosion, as the mud layers in the formation of Injana are more affected by erosion than the sand layers, which led to the occurrence of overhanging slopes and when the cohesion between the discontinuities became zero, the rock blocks fall due to their weight and there is a possibility of occurrence toppling failure due to differential weathering between sandstone rocks and mudstone rocks and the presence of vertical slopes. Outside the base of reference shows kinetic analysis using softwareDips-v6-008 that it gives a preliminary assessment of the types of failures, as well as it is short in time and its results facilitate the assessment of stability by means of the rock mass rating system of slope (SMR). It showed the probability of a plane sliding in the following stations (1,2,5,6), a wedge sliding in the following stations (1,3), and Toppling in the following stations (2,4,5,6). Using the SMR Tool-v205 program, the classification values of discrete and continuous SMR show that the value of the discrete SMR and the value of the continuous CSMR in the worst case (the lowest value of the SMR) for wedge sliding and plane sliding at stations (1,5) and their value ranges from (28)- (22) This means that the rock mass falls within the fourth category (IV), meaning that the slope is unstable, as for the flexural toppling, its value ranges from (68) – (77) in stations (1,2,4,5,6), which means that the rock masses fall into the second category (II), meaning that the slope is in a stable condition.

Keywords: slope stability, RMR, SMR, low folded zone

Introduction

Landslides occur in various regions of the world. Rock slopes are formed in places of folding as well as in places where there are geological activities and operations of cutting rock layers, especially in mountainous areas in order to cut roads or for engineering purposes (Al-Obaidi, 2005) [1]. There are many failures that occur on rocky slopes and the most common types are (sliding, rockfall, toppling). failures occurs when the resistive force is less than the force causing the failures. filures are the basic of all terrestrial features.(Small & clark, 1982) [13]. Slope stability is defined as: the resistance shown by the inclined surface exposed to failures by falling or slipping (Kliche, 1999) [10], and the main and important factor in the failures of rocky slopes is the presence of breaks, faults, and surfaces that are applied within the surfaces of cuts of rock blocks. And discontinuities are classified into types that include (sliding, toppling, rockfall). The study area is geographically located in central Iraq within the borders of Salah Al-Din Governorate, specifically in the Al-Hajjaj district of Baiji District North Salah al-Din Governorate, fig (1).

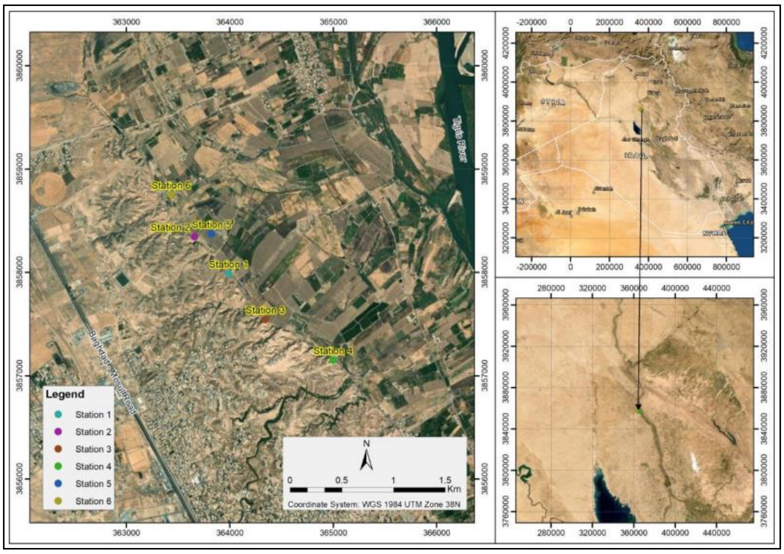

Fig 1: Location map of the study area

Materials and Methods

1. Field Work and Sample Collection

A detailed survey was conducted for three days (6-October-2021) (13-December-2021) (8-Feb-2022), where (6) stations were selected in the studied area and the coordinates of each station location were taken using a device(GPS), and a comprehensive field survey was also conducted for each slope, including (the attitude of the slope and bedding plan, discontinuities, height and width of the slope, rocky description, condition of discontinuites determining the probability or occurrence of failure) according to (Hoek and Bray, s 1995) [7], as well as taking photographs and collecting representative samples for each station.

2. Laboratory Testing and Office Work

The laboratory work includes conducting some geotechnical tests, including the load test according to ISMR (1985) to calculate the unconfined compressive strength (UCS), Table (1), as well as to determine the internal friction angle using the tilt method of Bruce *et al*, (1989) [5], which is an important factor for the study of the failure case, (Zarraq 2021) [15]. The office work included the representation of the obtained data and the results of the field rock in Table (2). The Dips v6.008 kinetic analysis program was used to assess the stability of the rocky slopes, and the rock mass classification system (RMRb) was used to classify rock masses, and it was also used to classify the slope mass (SMR) by SMR Tool (Riqeelme et. al., 2016) [11].

Table 1: The results of Unconfined Compressive Strength Test

Stations	L mm))	W mm))	D Mm))	F KN))	F MN))	A (mm^2)	A $((m^2$	De2={(4A)/π} m^2))	IS=F/De^2 Mpa))	f=(D/50)0.45	Is(50)=Is* f	UCS=21*IS(50) Mpa))
1	75	63	55	0.94	0.00094	3465	0.00346	0.00440	0.21363	1.0438	0.2229	4.6809
2	73	66	52	1.24	0.00124	3432	0.00343	0.00436	0.28440	1.0178	0.2894	6.0774
3	57	50	51\\\	0.99	0.00099	2550	0.00255	0.00324	0.30555	1.0089	0.3082	6.4722
4	52	54	49	1.50	0.0015	2646	0.00264	0.00336	0.4464	0.9909	0.4423	9.2883
5	56	63	51	0.89	0.00089	3213	0.00321	0.00408	0.2181	1.0089	0.2200	4.62
6	55	59.1	52	1.08	0.00108	3073.3	0.00307	0.00391	0.3517	1.0178	0.3579	7.5159

Table 2: The attitude of slopes, beds and sets

Station number	Slope direction/slope value	Attitude of bedding plan/ attitude of slope	Tilt direction of spacer assembly)1) / attitude of Set.1	Tilt direction of spacer assembly)2) / attitude of Set.2	internal friction angle ϕ
1	040°/88°	308°/02°	042°/87°	300°/87°	320
2	040°/88°	308°/02°	320°/88°	630°/88°	320
3	020°/88°	308°/02°	294°/87°	630°/87°	320
4	030°/88°	308°/02°	333°/89°	630°/89°	320
5	030°/88°	308°/02°	298°/87°	300°/87°	320
6	054°/88°	308°/02°	333°/87°	630°/87°	320

Objectives and Justifications of the Study

The aim of this study is:-

1. Finding some geotechnical properties related to the stability of rocky slopes.
2. Conducting an engineering geological survey for the stations of the study area.
3. Classification of slopes and failures and assessment of the risks and stability of rocky slopes

It requires a detailed and comprehensive study of the study area, as the road that has been constructed and is located in the area to be studied and surrounded by many rocky slopes that may be more prone to failures as a result of its influence by various geological factors. Where the occurrence of any kind of failures, which poses many risks, leads to the occurrence of many material and human losses, or it may also lead to the closure of the road completely or partially, as well as traffic congestion and accidents, so it must be fully studied and the problems resulting from the failures should be determined.

Tectonic and Structural of Study Area

The study area is located within the (low folded zone) in the unstable shelf in the Makhul_ Hemrin subzone. According to the division (Jassim and Goff, 2006) [9], the structural in the region is due to the influence of the second phase of alpine movement. As the layers are horizontal meaning that their effect is the second phase of the alpine movement and it contains fractures of the type of breaks and cracks, Fig. (2).

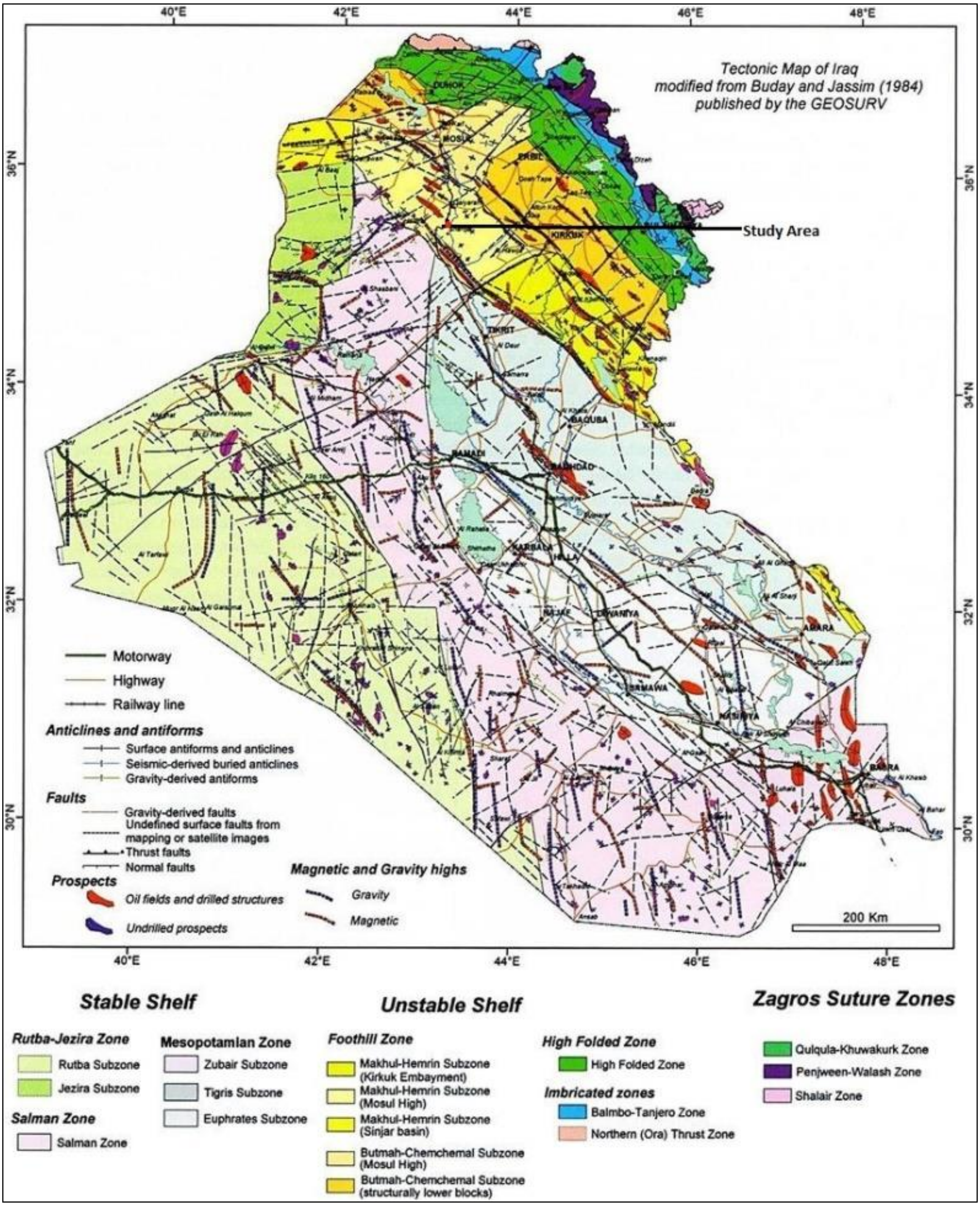

Fig 2: shows a map of the tectonic divisions of Iraq according to (Jassim and Goff, 2006) [9] indicating the study area.

Stratigraphy of Study Area

In the study area, the formation of Anjana (Fig. 3) is revealed, in addition to the sediments of the Quaternary age. The following is a description of this formation:

1. Injana Formation (Late Miocene)

This formation was described in the Faris region of southwestern Iran for the first time by (Busk & Mayo, 1918) and according to what was stated in (Jassim & Goff, 2006) [9], and this formation dates back to the age of the Upper Miocene (Bellen *et al*., 1959) [4]. As for (Adeeb, 2006) [2] this formation is described comprehensively in the Agha Gary oil field, where The formation was called the upper fars, and then this name was replaced by the name of the Injana formation by choosing an ideal section in the Injana area within the southern Hamrin fold south of Al-Tuz, according to (AL-Rawi, IK, 1981) [3]. The age of this composition dates back to (Late Miocene).

It spreads in the form of sediments at the beginning of the alpine molasses and widely in the north of Iraq and in the south of Iraq these sediments disappear and the formation of al-Dibdba replaces them, as this formation consists of perfect sequences of sandy, alluvial rocks and ends with mud (Jassim & Goff, 2006) [9], which belong to the coastal environment. As the detectors of this formation are spread along the eastern edge of Lake Tharthar and are also spread in the form of cliffs in areas north of Tikrit, the height of these cliffs may reach 10 m. As this formation is exposed on the southwestern edge of the Makhoul fold between the Baiji refinery and the fertilizer plant, and it is believed to be a source Clay and sand deposits in some parts of the study area.

2. Quaternary Sediments

These sediments are located in the study area and include recent sediments towards the center of the district AL Hijaj and also in the flood plain and cover large areas of different thickness as they contain clay, alluvial, sand and gravel deposits.

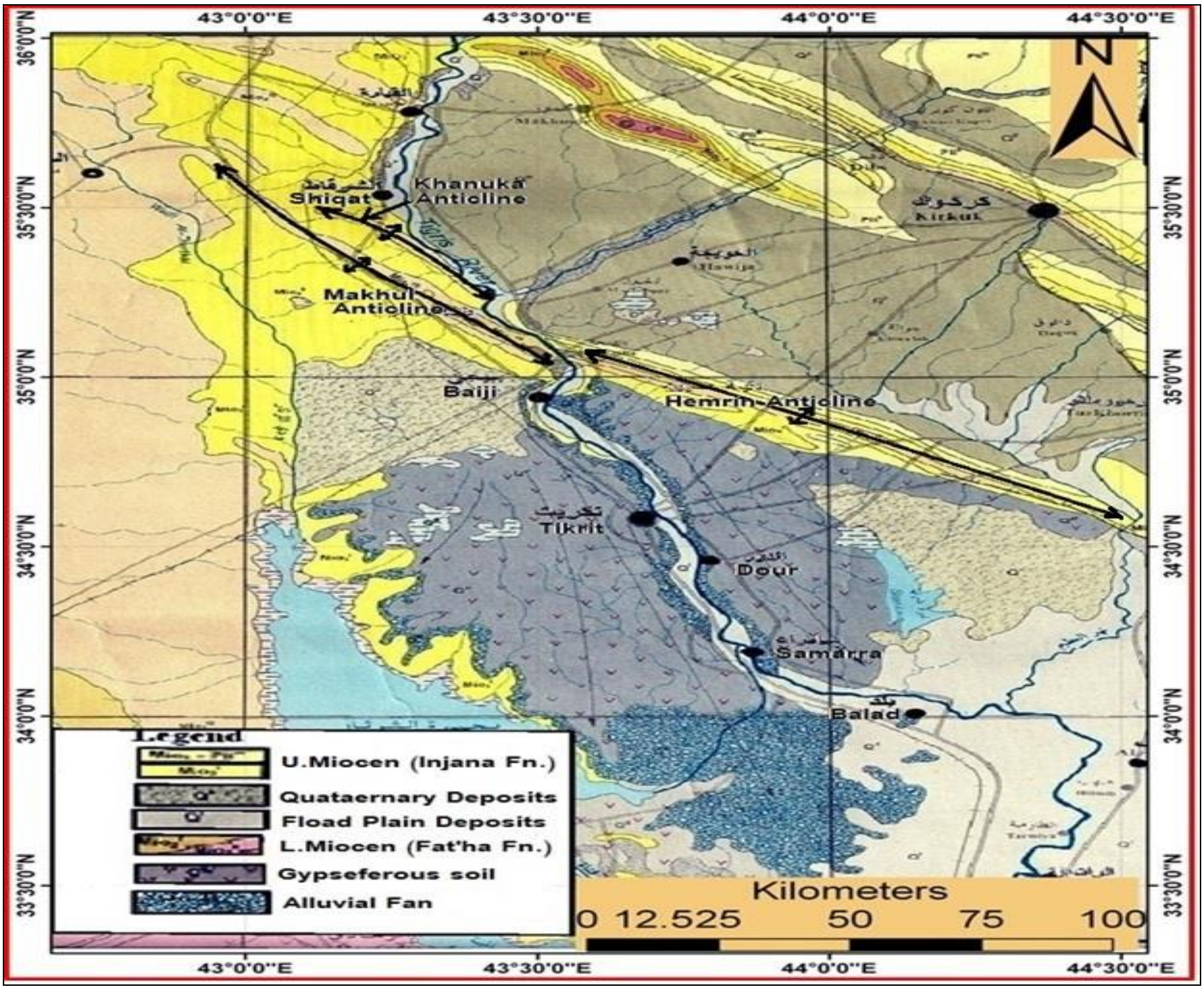

Fig 3: shows the geological map of the study area modified from the geological map of Iraq (General Organization for Geological Survey and Mining, 2000)

Geomorphology Study Area

There are geomorphological features within the study area, where layers appear in the formation of Injana horizontally. The area is somewhat flat, with some valleys of the branching type, and their direction is towards the Tigris River, and some of them are transversely, and covered with sediments of the Quaternary age.

Results and Discussion

The stability of the rocky slopes was evaluated at all stations, and the slope mass classification system was applied SMR of (Romana, 1985) [12] and continuous slope mass classification of (Tomas *et al*., 2007) [14] using SMRTool-v205 (Riquelme *et al*., 2016) [11]. It includes discrete SMR and continuous SMR. The RMRb found from the rock mass determinants classification was used in calculating the SMR for all stations. F1, F2 and F3 were calculated by SMRTool-v205 software based on the relative orientation of the joints relative to the slope. As for F4, it was zero (0) in all stations, where the excavation method was mechanical means to pave the road. The program SMRTool-v205 showed that the discrete (SMR) value and the continuous (SMR) value is in its worst case (the lowest value of the SMR) (for wedge sliding, plane sliding) at stations (1,5) ranging from (22)_ (28 This means that the rock mass falls within the fourth category (IV), meaning that it has a bad slope and its condition is unstable. And that (extrusion and wedge sliding) their values range from (62)_(77) in stations (1,2,3,5). This means that the rock mass falls within the fourth category (IV), meaning that it has a bad slope and its condition is unstable. And that (the inversion and wedge slip) their values range from (62)_(77) in the stations (1,2,3,5,6), and this means that the rock masses fall within the second category (II), that is, they have a good slope and their stable condition, Tables (3) and (4). This study showed that the slopes that are formed as a result of the road construction, as well as the vertical slopes, have greatly affected the stability of the slopes, as it is possible that other failures will occur in the parts that are unstable in the future. Therefore, some slopes need to be observed regularly, and some of them need to be monitored from time to time, and some of them may need treatments.

Table 3: The results of discrete – SMR system using SMRTool-v205

station number	Slope attitude	RMRb	failures type	failures direction	F1	F2	F3	F4	F1.F2.F3	Values SM	SMR class / stabilization
1	040°/88°	72	a) ps. b) ws. c)	a) 42 b) 132 c) 42	1 1 0.15	1 1 1	-50 --50 0	0 0 0	-50 -50 0	22 22 72	IV/Unsta. IV/Unsta. II/Sta.
2	040°/88°	72	a) ps. c) ft.	a) 59 b) 63	0.4 0.15	1 1	-25 0	0 0	-10 0	62 72	II/Sta. II/Sta.
3	020°/88°	77	b) ws.	b) 355	0.15	0.15	-60	0	-1.35	75	II/Sta.
4	030°/88°	72	c)	c) 60	-	-	-	-	-	-	-
5	030°/88°	72	a) ps. c)	a) 30 c) 32	1 0.15	1 1	-50 -25	0 0	-50 -3.75	22 68	IV/Unsta. II/Sta.
6	054°/88°	77	a) ps. c)	a) 58 b) 63	0.15 0.15	1 1	-50 0	0 0	-7.5 0	69 77	II/Sta. II/Sta.

Whereas (PS) plane sliding, (WS) wedge sliding, (FT) flexural toppling, (F1,F2,F3 & F4) sliding correction coefficients for (SMR, (Sta.) stable, (Pa.Sta.) stable Partially, (Unsta.) is unstable, the letters (a, b, c & d) represent (plane sliding, wedge sliding, inversion flexural toppling and direct toppling respectively).

Table 4: The results of continuous – SMR system using SMRTool-v205

station number	Slope attitude	RMRb	failures type	failures direction	F1	F2	F3	F4	F1.F2.F3	Values SM	SMR class / stabilization
1	040°/88°	72	a) ps. b) ws. c)	a)42 b)132 c) 42	0.97786 0.97786 0.1481	0.99413 0.99413 1	-45 -45 -0.41559	0 0 0	-43.7454 -43.7454 -0.06155	28 28 71	**IV/Unsta.** **IV/Unsta.** **II/Sta.**
2	040°/88°	72	a) ps. c)	a) 59 b) 63	0.45422 0.15248	0.99464 1	-30 -0.41559	0 0	-13.5534 -0.06336	58 71	**II/Pa.Sta.** **II/Sta.**
3	020°/88°	77	b) ws.	b) 355	0.16183	0.16307	-59.7779	0	-1.5775	75	**II/Sta.**
4	030°/88°	72	c)	c) 60	-	-	-	-	-	-	-
5	030°/88°	72	a) ps. c)	a) 30 c)32	0.99721 0.1481	0.99413 1	-45 -25.7083	0 0	-44.6109 -3.8075	27 68	**IV/Unsta.** **II/Sta.**
6	054°/88°	74	a) ps. c)	a)58 b) 63	0.15328 0.1597	0.99413 1	-45 -0.41559	0 0	-6.8573 -0.06637	70 76	**II/Sta.** **II/Sta.**

Conclusions

1. The failures of the type of rockfall occurred in the study area due to the presence of over hanging slopes and due to the erosion of the mudstone layers, and the cohesion through the discontiniuties became zero.
2. The possibility of toppling type failures due to differential weathering, as the clay layers are more affected by weathering and their resistance to bear the weight of the sand layers above them, and when the cohesion through the discontinuties equal to zero and the center of mass of mass exits outside the base of its support, the toppling of the rock mass occurs.
3. The analysis program (Dips-v6.008) stated the probability of a plane sliding in the following stations (1, 2, 5, 6), a wedge sliding in the following stations (1, 3) and an flexural toppling in the following stations (2, 4, 5, 6).
4. Through the application of the program SMR Tool.v205 shows that the value of (SMR)) and the continuous CSMR value in the worst case (the lowest value of the SMR) for wedge sliding and plane sliding in stations (1.5), and its value ranges from (22)- (28) and this means that the rock mass falls within the fourth category (IV). That is, the slope is unstable, whereas, flexural toppling has value ranges from (68) - (77) in stations (1, 2, 4, 5, 6), and this means that the rock masses fall within the second category (II), meaning that the slope is in the case of Stable and with good slope.

Recommendations

1. Conducting an integrated geotechnical study of the rocks of the study area to establish some tourist facilities in that area as it overlooks the flood plain of the Tigris River.
2. Carry out some treatments for unstable slopes according to their type to avoid their dangers on the road.

References

1. Al-Obaidi, Louay Daoud Yousef. A geological-engineering study of the stability of the rocky slopes of the Shiranish-Kolush-Girks and Blasby formations surrounding the Shaqlawa region in northeastern Iraq, unpublished master's thesis, College of Science - University of Baghdad, Department of Earth Sciences, 2005, 127.

2. Adeeb, Hadeer Ghazi. The Tectonic Structure of the Alpine Molasses Basin - Northern Iraq, unpublished Ph.D. thesis, Department of Earth Sciences, College of Science, University of Mosul, 2006.
3. AL-Rawi IK. Sedementology and petrology of the Tanjero clastic formation North and Northeastern Iraq. Unpub. Ph.D. thesis, Baghdad University, 1981.
4. Bellen, Van RC, Dunnington HV, Wetzel RD. Lexique Stratigraphique Internal, 0310 Asie (Iraq), Reprinted electronically and on paper by Gulf Petrolink in 2005, by permission of CNRS Editions, France, 1959, 333.
5. Bieniawski ZT. Engineering rock mass classification, John Wiley, New York. 1989.
6. Busk HG, Mayo HT. some notes on the geology of the persian oil welds", Journal Institute petroleum Technology, 1918.
7. Hoek E, Bray JW. Rock Slope Engineering, 3rd. ed., Institution of Mining and Metallurgy, London, 1981, 358.
8. ISRM. Suggested method for determining point load strength. ISRM Commission on Testing Methods, Working Group on Revision of the Point Load Test Method. Int. J. Rock Mech. Min. Sci. & Geomech. Abstr,1985:22:51-60.
9. Jassim SZ, Goff JC. Geology of Iraq. First edation. printed in the Czech Republic, 2006.
10. Kliche CA. Rock Slope Stability: Society for Mining, Metallurgy, and Exploration, Colorado, USA, 1999, 253.
11. Riquelme A, Tomás R, Antonio Abellán F. "SMR Tool (MATLAB)". rua.ua.es. Retrieved 2016.
12. Romana, M. New adjustment ratings for application of Bieniawski classification to slopes, in: Proceedings of the International Symposium on the Role of Rock Mechanics in Excavations for Mining and Civil Works. International Society of Rock Mechanics, Zacatecas, 1985, 49-53.
13. Small RJ, Clarck Mj. Slope and Weathering, Cambridge University, Great Britain, 1982, 112.
14. Tomas R, Delgadob J, Seron JB. Modification of slope mass rating (SMR) by continuous functions. International Journal of Rock Mechanics & Mining Sciences,2007:44(7):1062-1069.
15. Zarraq, Gh A. Slope Stability Analysis of the Southwestern Limb of Kosret Anticline in Dokan, Northeastern Iraq, Iraqi Geological Journal, 2021, 34-48.