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Assessment of Slopes Stability For Conglomerate In Tikrit City -Salahaddine Governorate- Iraq

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Abstract

This research represents outcrops of rocks at Cliffs of Tigris river (Terraces), most are Conglomerate, Sandstone, Siltstone and Clay stone. The research covers several aspects ; it includes a collection of field information from unstable rock slopes at (6) stations representing all the rock failure types that happened or likely to happen . In each station rock slopes are completely surveyed ; also the rocks are described in an engineering way and a complete discontinuity survey is carried out according to Anon (1972,1977) and their relationship with the rock failure is established. The field study shows that rock failures include toppling (mostly in secondary type), rock fall. Point load test shows that Compressive Strength of the rock,(very weak – strong, $\sigma_c = 0.450 - 51.480$)Mpa.

Keywords: Slope Mode, Diagram, Stereoscopic projection, Compressive strength.

تقييم استقراريه منحدرات المدملكات في مدينة تكريت - محافظة صلاح الدين - العراق

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الخلاصة

يمثل هذا البحث مكاشف صخرية تقع على الجرف الصخري لنهر دجلة (مصاطب)، معظمها تتكون من المدملكات ، الحجر الرملي، الحجر الجيري والحجر الطيني . يغطي البحث مظاهر مختلفة : شملت جمع معلومات المنحدرات الصخرية غير المستقرة ، ل (6) محطات . تمثل كل انواع الانهيارات الحاصلة والمحملة الحدوث . تم اجراء مسح شامل لاستقراريه المنحدرات ولكل محطة ، كذلك تم وصف الانقطاعات الصخرية هندسيا، وفق (1972,1977) Anon وعلاقتها مع انهياره الصخرة ، اظهرت الدراسة الحقلية ان الانهيارات الصخرية كانت معظمها من نوع السقوط الصخري وبعضها من انواع الانقلاب والدرجة. اظهرت نتائج فحص حمل النقطة ان المقاومة الانضغاطية للصخور تراوحت (ضعيفة جدا - قوية = 0.450 - 51.480) ميكا باسكال .

Introduction

The study area comprised outcrops of rocks, laying out at the right side of Tigris river, within east part of Tikrit City (170 km North Baghdad), it is extending between longitudes (43°38'10" - 43°41'00" E) and latitudes (34°37'00" - 34°40'50" N), Figure-1,[1], generally the sitting geology, research area represented Mesopotamian plain Figure-2,[2], high of cliff is about (7-11) meter above ground surface, and represented by Pleistocene alluvial fans. In addition to the cliff, the research area showed NW-SE valleys that transport the rain fall to the river. The research area includes bedding planes. Which its attitude is horizontal and inclined to the southwest ward (less than 5°). The beds included fractures as vertical tension joints or cracks, some surfaces of these joints are parallel to the surface slope while the others are perpendicular to it.

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The climate of the research area is arid to semiarid. Where the rain fall average about 160 mm manually, the heat degree in Summer is 49 ° and becomes about 3 ° in Winter. Mostly, the climate used as indication to the influence on the rock weathering, slope, failure happened and probably happened according conditions of weathering, as well as another factors. Occurrence and history. Many Previous studied were done in Tikrit area they deals with, Geophysics[3], Engineering geology[4]. hydrogeology [5], Geomorphology[6], and Sedimentology[7-9].

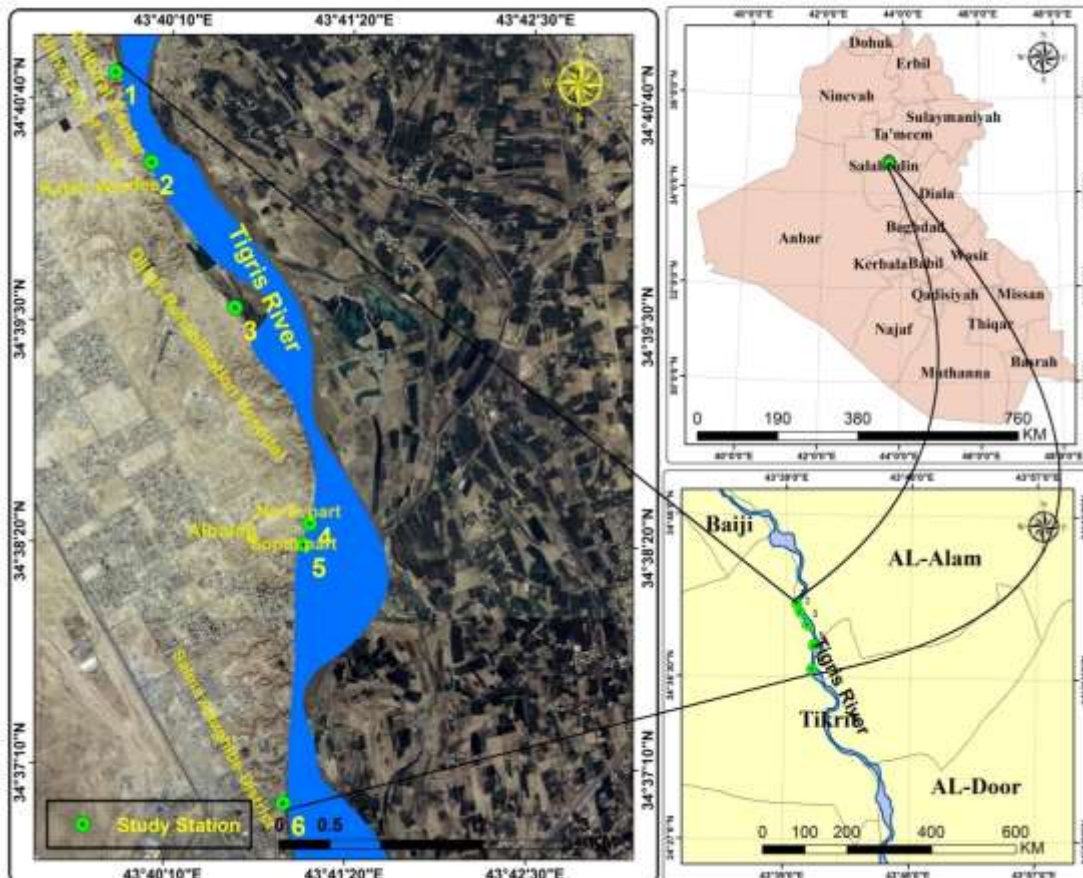


Figure 1-Location map of the research area [1]

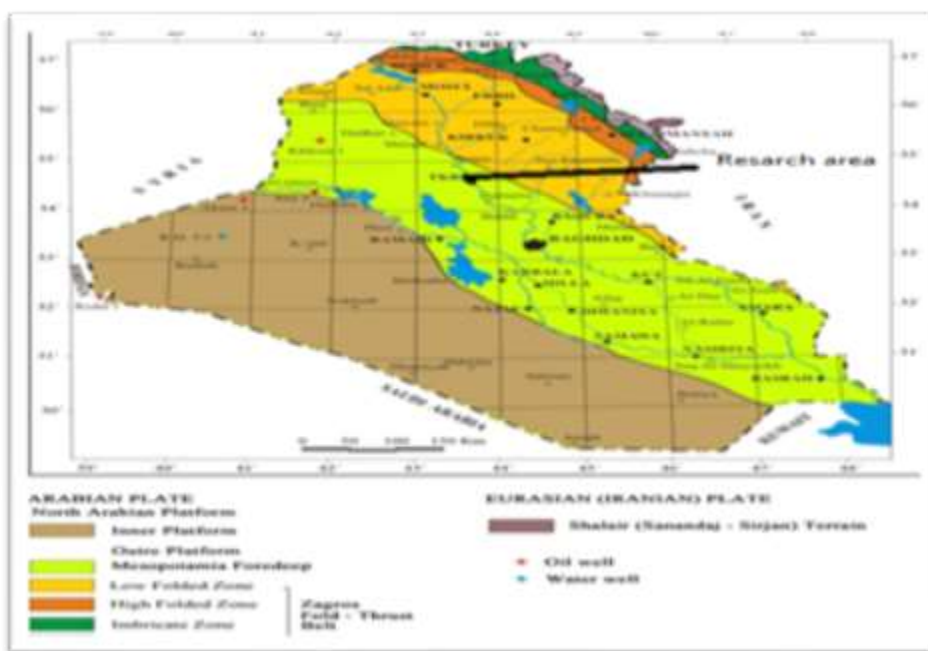


Figure 2-Iraq Geological Map[2]

Materials and Methods

In order to draw diagrams according to [10] table(1) ,and describe the rocks in all selected stations in the research area in terms of Engineering Geology, the description is based on the report suggested by the working party of the Engineering Group of the Geological Society of London [11,12]

Table1-Symbols of the stereographic projection and plates after [10]

Symbol	Description	Failure		Failure Type
		Probable	Happened	
o	Pole of average dip bedding plane			Toppling
●	Pole of Discontinuities Plane			Rock fall
	Cyclo graphic trace of a general slope (g.s)			Rolling
	Cyclo graphic trace of side slope (s.s)			
Rock Mass	Cyclographic trace of vertical slope or overhanging (OH)			Wedge Sliding
Symbols used in plates				
	Cyclographic trace of a general slope of soil (g.s.s)	Up.s	Upper Slope	
		(r.r.1- r.r.2-)	Fractures	
	Cyclographic trace of lower slope (L.s)	T.C	Tension crack	
		T.C.b.	T.C. in building	
		s.s	Side slope	
	Photograph direction (position)	h.s	Height of slope	
		A, B, C...	Failed rock mass	

Engineering Geological Description of rocks

Six Stations were selected to study according to[11,12] as follow.

- 1."Color" Rock color described in terms of three parameters, basic color or a mixture to basic colors, and the value or the lightness of color, [11].
- 2."Grain Size" The same descriptive terms for grain size ranges should be applicable to all rocks , and the size ranges used for soils would appear to be suitable for this purpose [11].

3. "**Bedding Planes**" Based on [11], and according to their thickness, rocks strata are described, scale should be used.

4. "**Joints**" The description of joints according to [11] includes the orientation of joints, dip and their characteristics such as spacing, their persistence on bedding plane, opened or closed.

5. "**Weathering**" Weathered state described according to the effect of weathering on the resistance of rocks and other characteristics such as loss of strength, opening in joints and discoloration. There are six grades of weathering based on [11]

6. "**Strength**" Determination of the mechanical strength of the rock sample, indirectly measured compressive strength from point load test for rock samples for measuring stations, showing the terms and a scale of strength, [11]

7. "**Rock Name**" Should be written in capital letters. Then, rock name followed by suffixes which include, the compressive strength.

8. "**Permeability**" based on discontinuity spacing. provides generalized values for jointed rocks [11], and modified after [13]

Station 1: This station lies at latitude ($34^{\circ}40'48''N$) and longitude ($43^{\circ}39'47''E$), within Form, Figure-1, plate1. located within Tikrit University area, below the Cultural center. The slope is 11m high, 15m long along its trend, and its direction is (90°). The bedding plane is faint and horizontal to sub horizontal. The rock mass layers consist of 6m thick layers which are exposed. They are light Brown, medium grained, very thickly bedded, widely jointed, moderately weathered, Conglomerate. Compressive Strength ($\sigma_c=44.322MPa$) moderately strong (table2)[8], and moderately permeable. The rock mass layers are cut by one set of joints in (S1), Diagram2.dip direction/ average dip of S1 ($41^{\circ}/88.33^{\circ}$). The spacing of joints in (S1) ranges between (60-200mm) closely spaced, their persistence reaches 2.8 m. Plate1.Failure type. Happened& Probable Rock fall Dig2

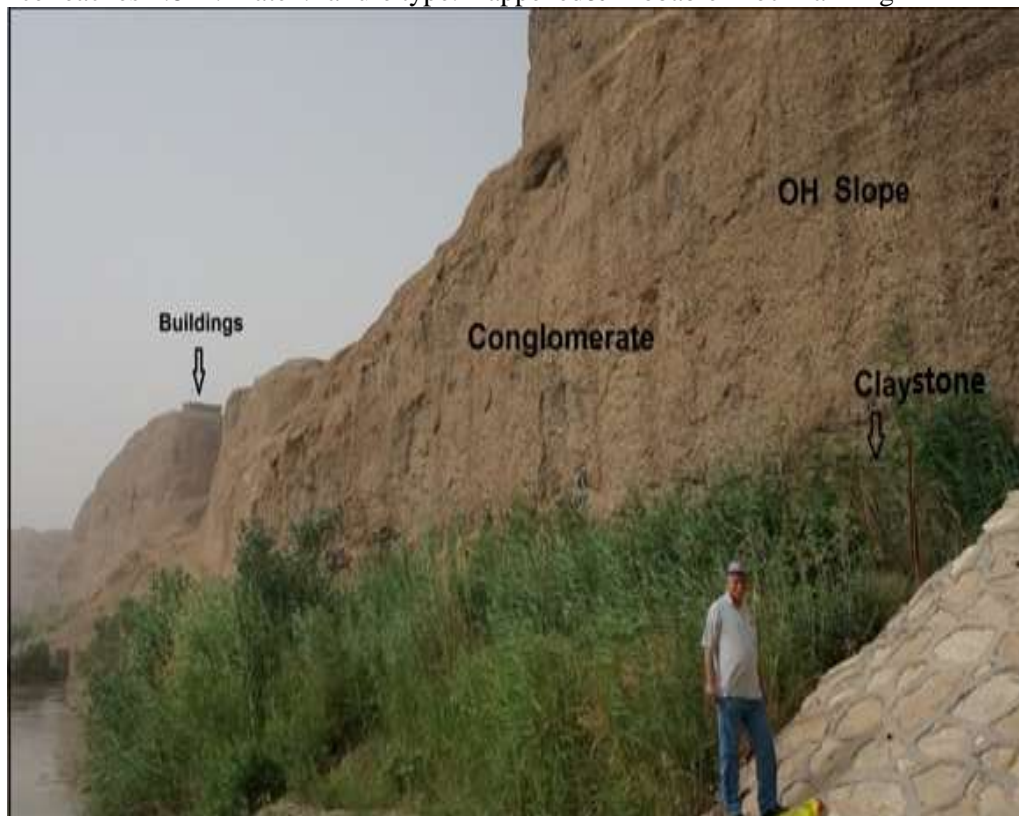


Plate 1-Lithology and slope mode of station 1

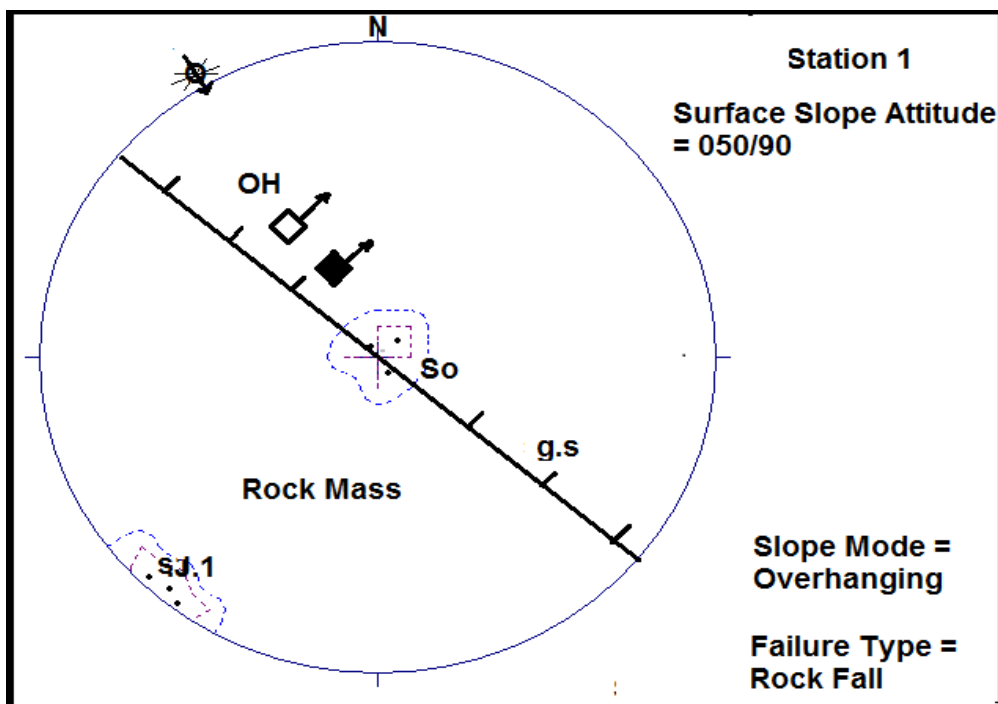


Diagram 1-Stereographic projection with failure type in station 1

Station2: located in Qala Wardi area lies, at latitude (34°39'56" N) longitude (43°40'37" E), within Form, Figure1, plate2. The slope is 11m high, 150 m long along its trend and its direction is 90°. The bedding plane is faint and horizontal to sub horizontal. The rock mass layers consist of thick layers which are exposed. They are light brown to grey color, coarse - fine grained(conglomerate), with lenses of sandstone, widely jointed, moderately weathered, Conglomerate, compressive strength ($\sigma_c=51.480\text{MPa}$) strong, and Moderately permeable . The rock mass layers are cut by one set of joints in (S1), Diagram2.Dip direction/ Average dip is (50°/88°).The spacing of joints in (S1) ranges between (60-200mm),their persistence reaches (2.8m) Plate2 .Failure type. Rock fall Happened and probable.Diagram2

Table 2-Results of Compressive Strength terms for research stations

Station No. / Samples No. Lithology	Dia. m.	Dia. ² m ²	Load P	= P/D ² Is	σ_c K*Is 50 MPa.	σ_c average MPa
Station1 /1	0.07	0.0049	9.77	1.993	44.840	42.322 MPa Moderately Strong
/2	0.06	0.0036	10.76	2.988	67.230	
3 / Conglomerate.	0.04	0.0016	1.06	0.662	14.895	
Station2 /1	0.08	0.0064	17.03	2.660	44.840	51.480 MPa. Strong
/2	0.06	0.0036	12.46	3.461	67.230	
/3	0.04	0.0016	1.19	0.743	14.895	
Station3 /1	0.08	0.0064	2.24	0.350	59.850	34.406 MPa Moderately strong
/2	0.07	0.0049	16.45	3.357	77.872	
/3	0.05	0.0025	2.20	0.880	16.718	
Conglomerate						
Station4 /1	0.09	0.0081	18.86	2.257	50.783	43.373 MPa Moderately strong
/2	0.08	0.0064	10.05	1.570	35.325	
/3	0.04	0.0016	3.13	1.956	44.010	
Conglomerate						
/4 Silt stone	0.05	0.0025	0.05	0.020	0.450	0.450 MPa Very Weak

Station5/1	0.115	0.0133	36.05	2.731	61.448	48.900 MPa Moderately strong
/2	0.075	0.0563	9.32	1.664	37.440	
/3	0.040	0.0016	3.40	2.125	47.813	
Conglomerate	0.050	0.0025	0.70	0.280	6.300	
Clay stone	0.050	0.0025	0.70	0.280	6.300	6.300 MPa Weak
Station6/1	0.075	0.0563	5.77	1.030	23.175	31.693 MPa Moderately strong
/2	0.055	0.0033	0.83	0.276	06.210	
/3	0.045	0.0023	5.84	2.920	65.700	
Conglomerate						



Plate 2-Lithology and slope mode of station 2

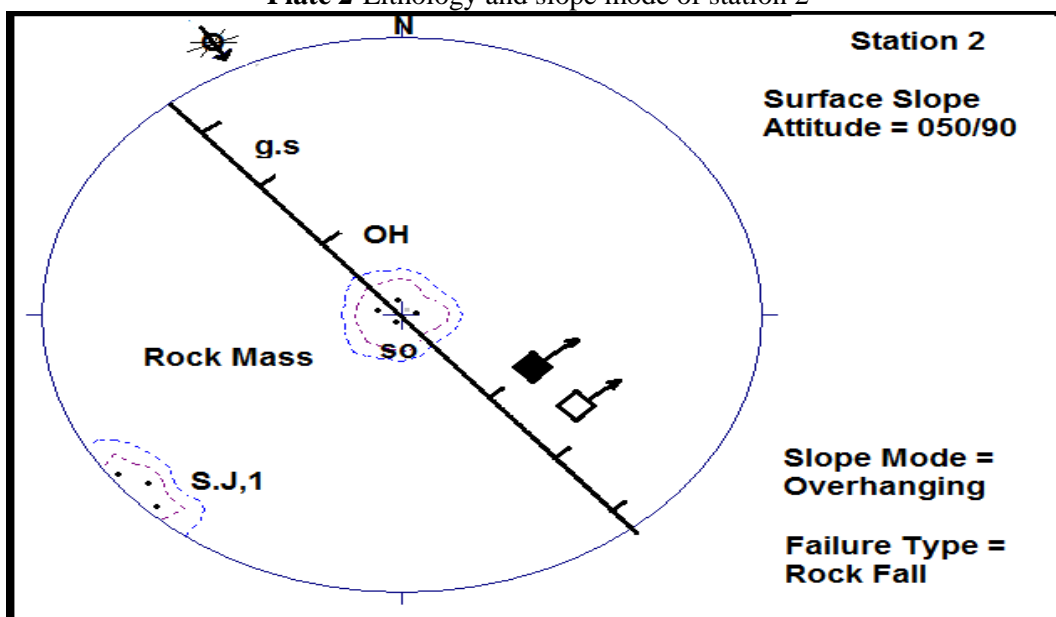


Diagram 2: Stereographic projection with failure type in station 2

Station3: located near Dijlah rehabilitation Hospital. This station lies at latitude (34°39'23" N) and longitude (43°40'13"E), within Form. Figure-1, Plate-3. The slope is 11m high, 40m long along its trend , and its direction is 90°. The bedding plane is faint and horizontal to sub horizontal . The layers consist of thick layers which are exposed. They are light brown, coarse - outcrops of , thickly bedded, widely jointed, moderately weathered, Conglomerate. Compressive Strength ($\sigma_c=34.406\text{MPa}$)Moderately strong and moderately permeable . The layers are cut by two sets of joints in (S1&S2), Diagram 4.The Dip direction/ average dip of S1 is (32°/ 88.33°) , and that dip direction /average dip of S2 is (120°/ 88.33°). The spacing of joints between (60-200mm), their persistence reaches (2.8m). Plate3. Joints in (S1) set acted as back release surfaces (BRS) block. Failure type Toppling Happened and probable. Diagram3.

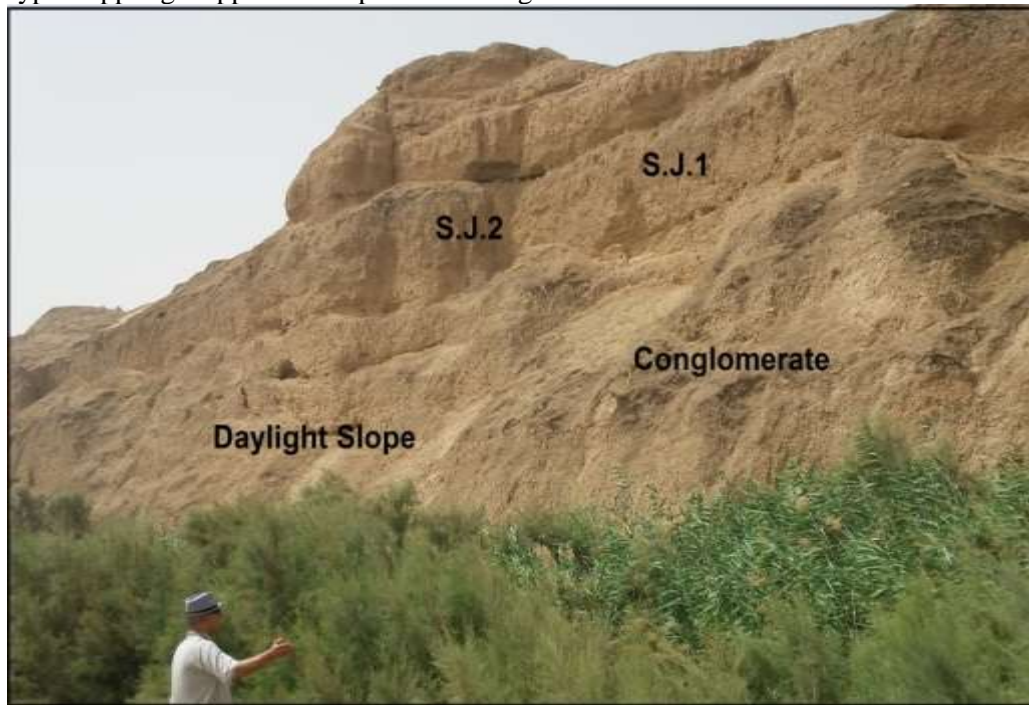


Plate3-Lithology and slope mode of station 3

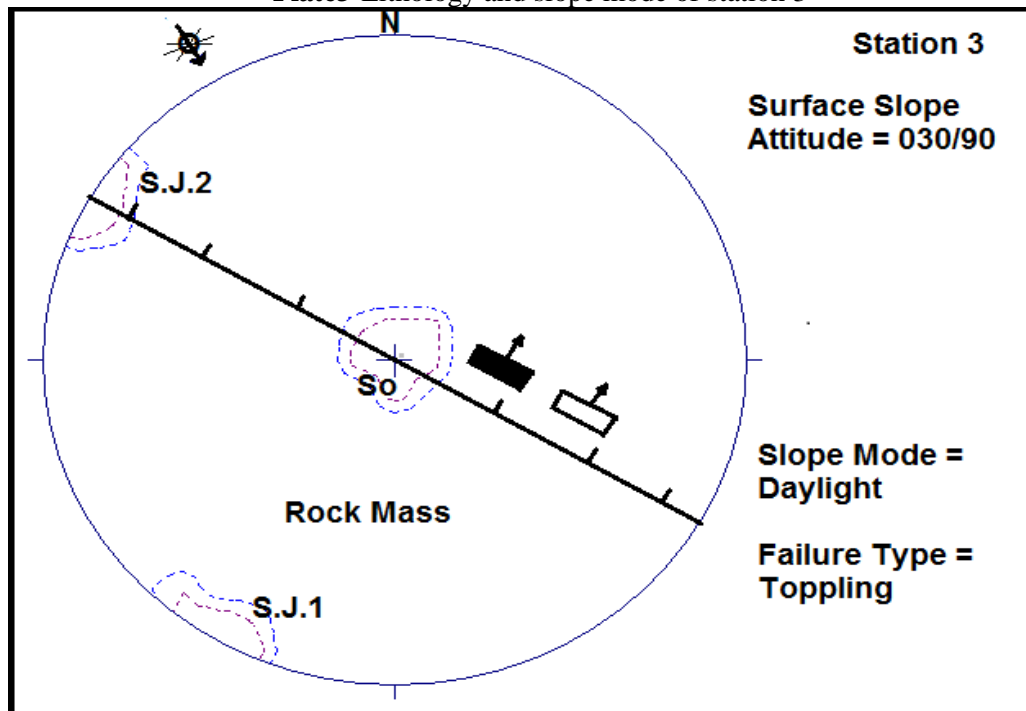


Diagram 3-Stereographic projection with failure type in station 3

Station 4: located within Al-Bilaj area south of Tikrit University. This station lies at latitude (34°38'16" N) and longitude (43°40'07"E), within Form, Figure-1, plate4. The slope is 11m high, 30m long along its trend , and its direction is 90° The bedding plane is faint and horizontal to sub horizontal. The rock mass layers consist of 3m of light brown sandstone, overlaid by 8m thick layers which are exposed. They are light gray, Fine –Coarsen grained, very thickly bedded, widely jointed, moderately weathered, Conglomerate. Compressive Strength($\sigma_c=43.373\text{MPa}$)Moderately strong, and Moderately permeable. The rock mass layers are cut by one set of joints in (S1). Diag.4.The Dip direction/ average dip of S1 (99°/ 88.66°) .The spacing of joints in (S1)) ranges between (60-200 mm), their persistence reaches 2.8 m. Plate4,failure type happened and probable. Rock fall. Diag.4.

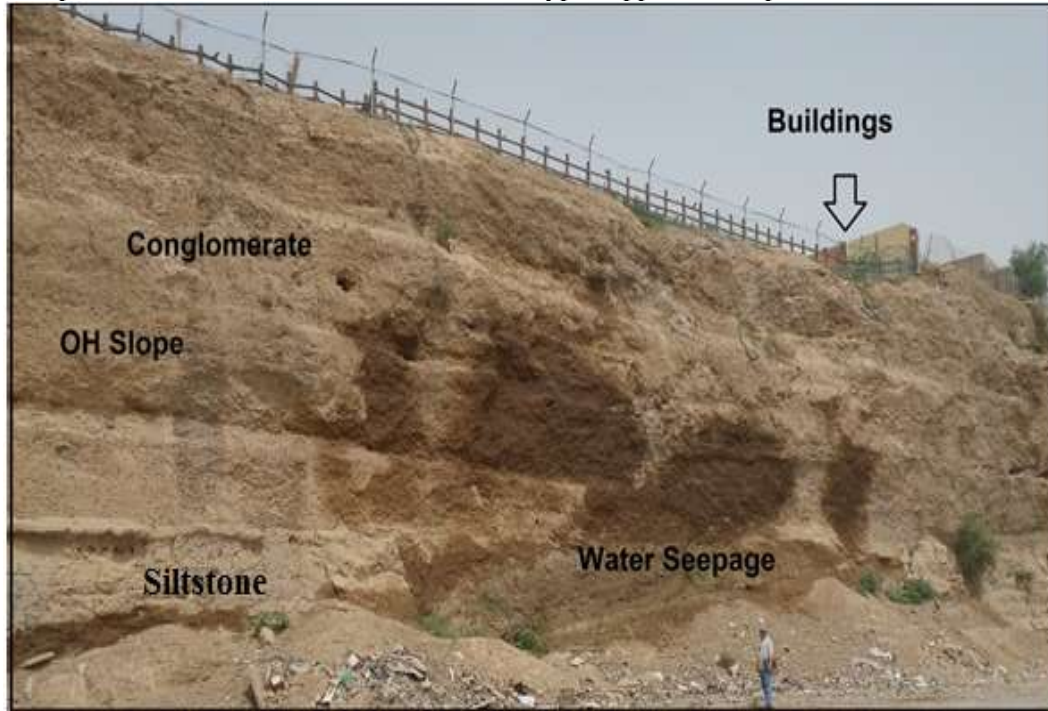


Plate 4-Lithology and slope mode of station 4

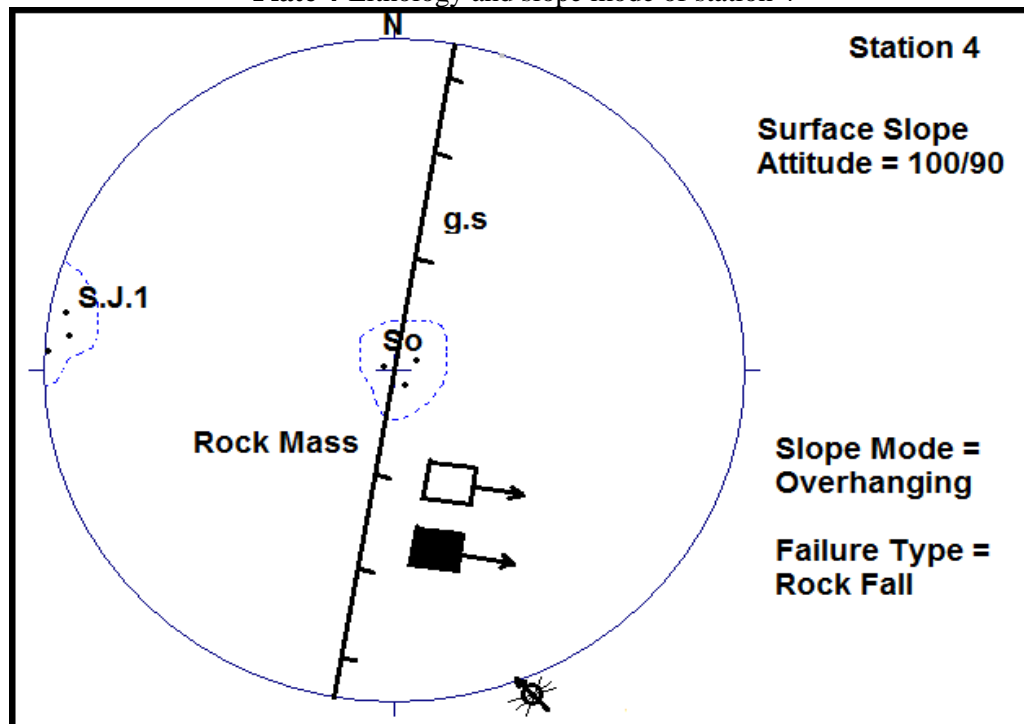


Diagram 4-Stereographic projection with failure type in station 4

Station5: located within Al-Bilaj area (about 100 meter south of station 4). This station lies at latitude (34°38'13" N) and longitude (43°40'05"E), within Form, Figure-1, plate5. The slope is (7m) high, (11m) long along its trend , and its direction is (90°). The bedding plane is faint and horizontal to sub horizontal . The rock mass layers consist of 4m of brown Sandstone and Claystone. overlaid by 3meter of fine - medium grained. Conglomerate brown color, very thickly bedded, widely jointed, moderately weathered, Compressive Strength($\sigma_c=48.9\text{MPa}$)moderately Strong and moderately permeable. The rock mass layers are cut by two sets of joints in (S1&S2), Diagram6. The dip direction/ average dip of S1 is (107°/88.66°) , and that dip direction /dip of S2 is (21°/88°). The spacing of joints in (S1)) ranges between (60-200mm), their persistence reaches 2m. The spacing ranges in joints (S2) between (60-200mm), their persistence reaches 2m, Plate5. Failure types, happened and probable toppling, and happened rolling, Diagram5.

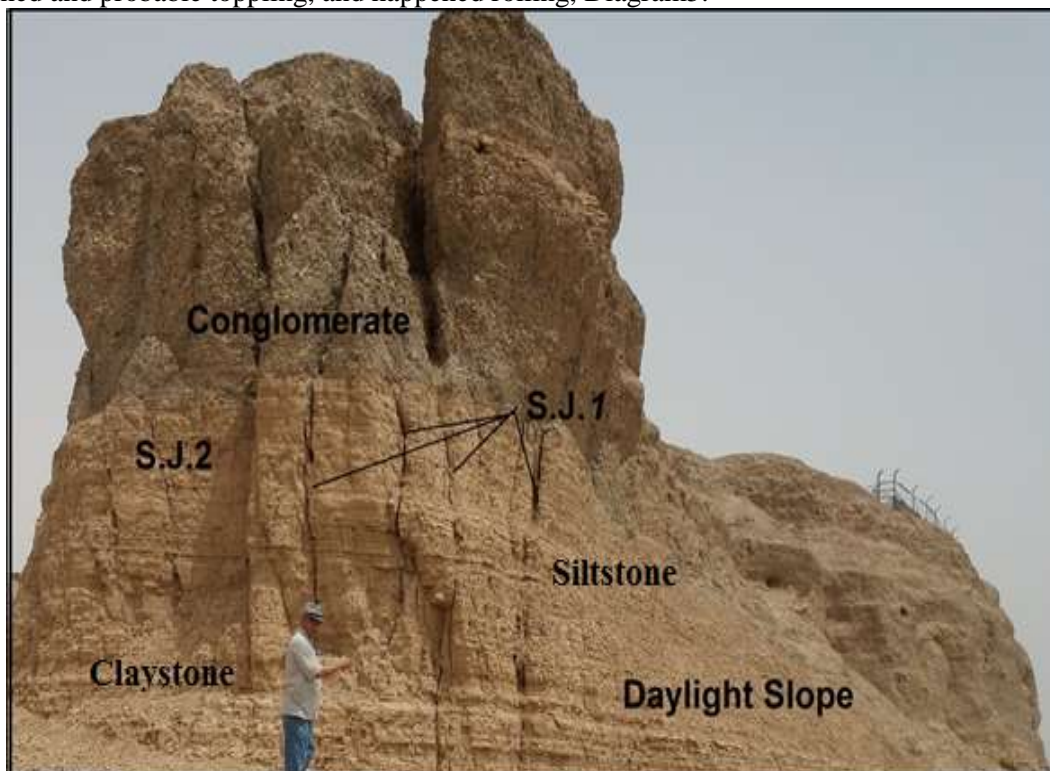


Plate 5-Lithology and slope mode of station 5

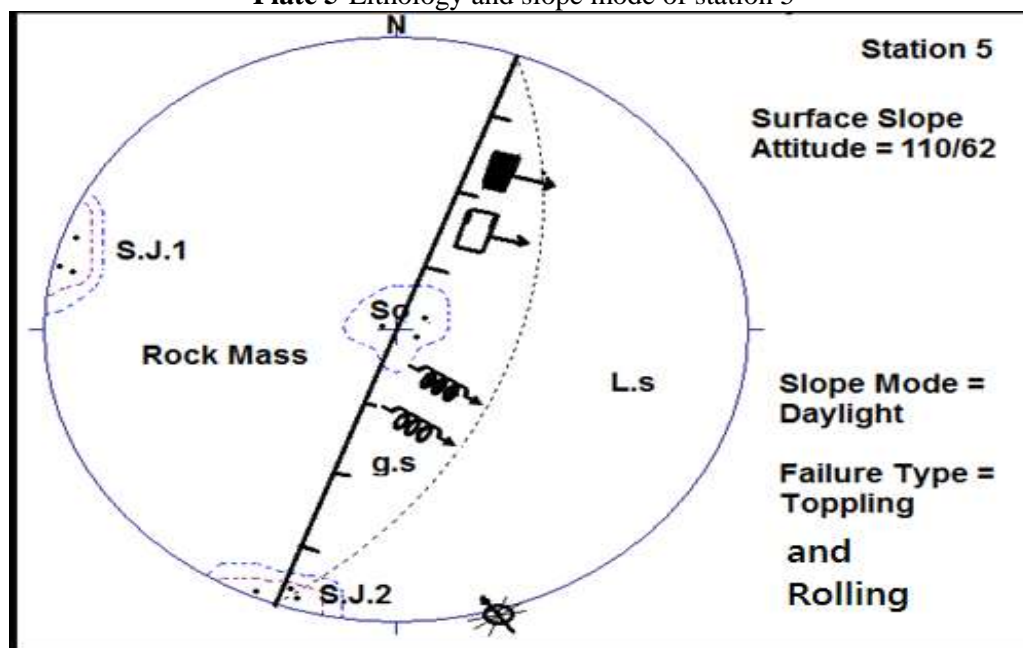


Diagram 5-Stereographic projection with failure type in station 5

Station6: located within Salma AL taghlbe district - Tikrit City, This station lies at latitude (34°36'59" N) and longitude (43°40'02"E), within Form, Figure-1, plate6. The slope is 9m high, 50m long along its trend , and its direction is (70°). The bedding plane is faint and horizontal to sub horizontal .The rock mass layers consist of 6m thick layers which are exposed. They are light Brown, Coarse –fine grained ,very thickly bedded, widely jointed, moderately weathered, Conglomerate. Compressive Strength($\sigma_c=31.693\text{MPa}$)moderately strong and moderately permeable .The rock mass layers are cut by one set of joints in (S1), Diagram7.The dip direction/ average dip of S1 is (81°/88°). The spacing of joints in (S1) ranges between (60-200mm), their persistence reaches (2.8m) Plate6.Failure types, happened and probable toppling and rock fall Dig.6

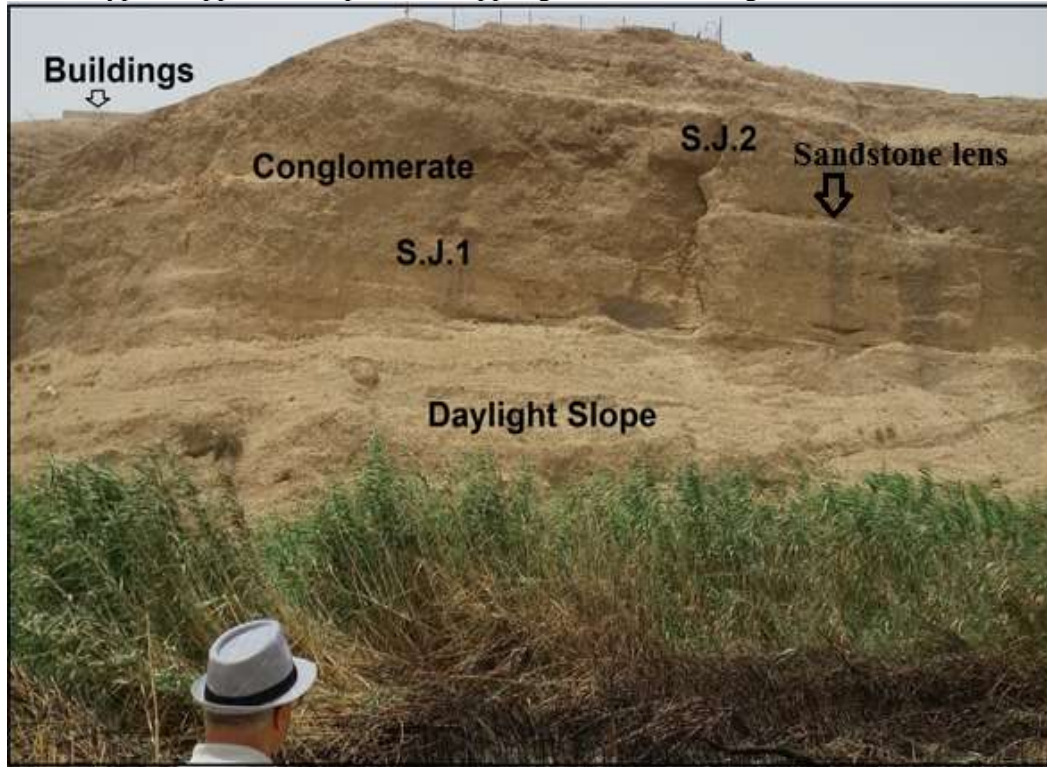


Plate 6-Lithology and slope mode of station 6

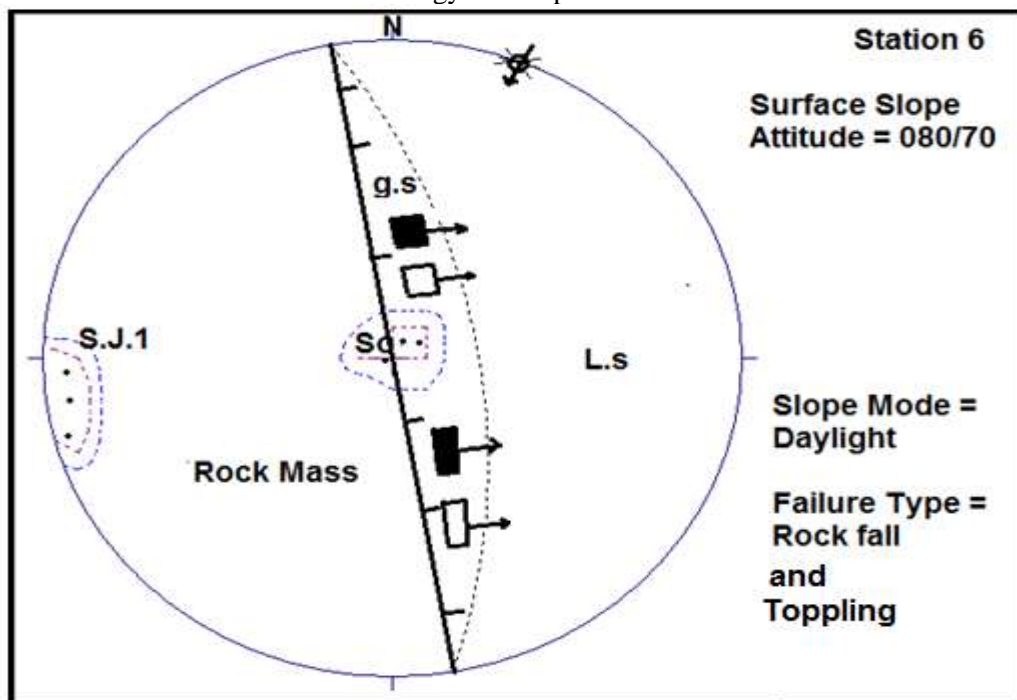
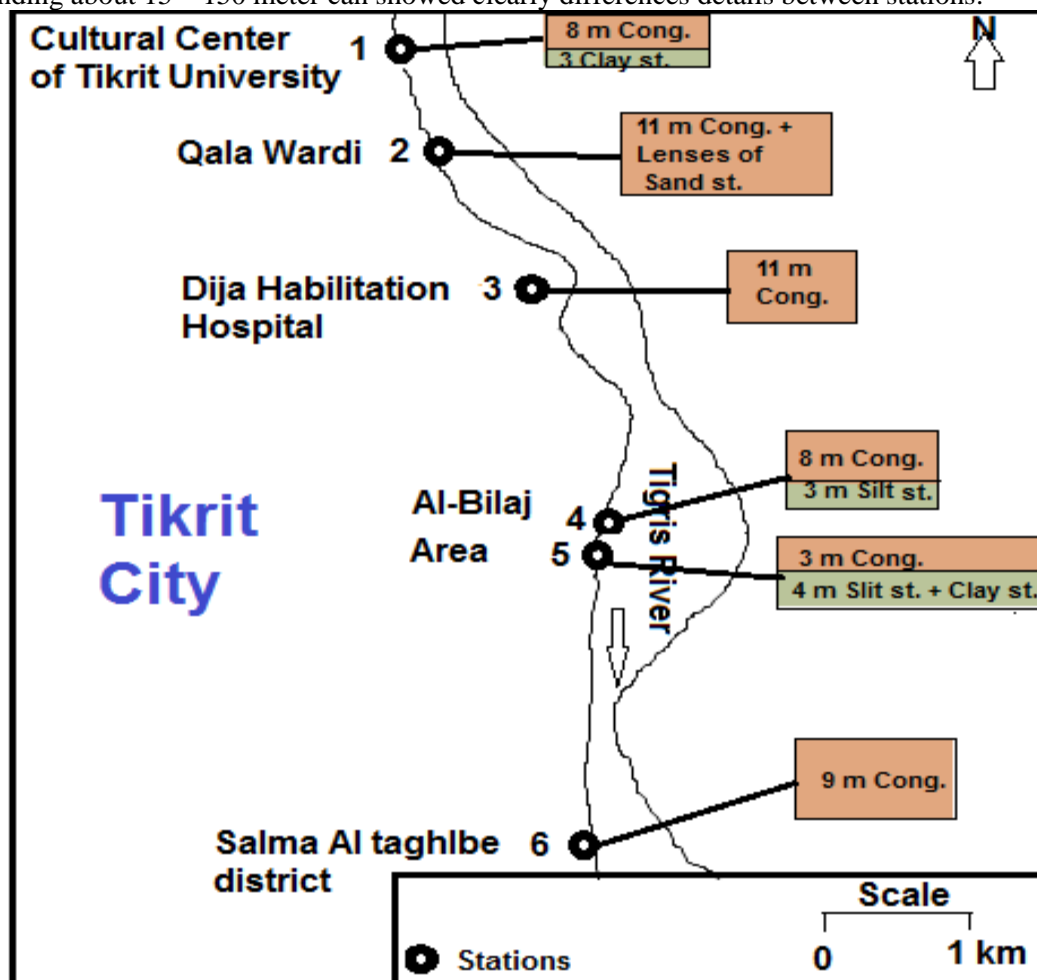


Diagram 6-Stereographic projection with failure type in station6

Discussion:

Six stations selected, represented research area (Cliff of right side Tigris river), Sketch 1 many works were done, some results indicated consented with standards, while another results Height of the slopes (stations) about 7 – 11 meter. Conglomerate formed it only, or the great part and the another parts (Sandstone lenses) Siltstone, Clay stone or mixed from all. Length of slop surfaces expanding about 15 – 150 meter can showed clearly differences details between stations:



Sketch 1 research area stations Far from bank river about 3 – 350 meter, mostly covered with natural vegetation, raised about 2.5 – 3.5 meter, and recent sediments. Rocks Failures products, floor river (Boulder, Gravels, Sand, Silt, Clay).

Three stations 1, 2, 4 Slope mode over hanging slope (dip amount = 90°), failure type and probable failure rock fall, no tension joints, which doing as side and back released surfaces. Water flow and sea page, above slopes surfaces noticed clearly. Compressive strength about 42.322 – 51.480 Mega Pascal (M.pa). and 0.450 M.pa., for Conglomerate and very weak Siltstone respectively. Stations 3, 5, 6 Slope mode daylight, dip amount variation between (62° – 90°), failure types. Toppling and probable Toppling in station 3, due to back release surfaces (B.R.S.) and Varity of dip amount. Failure types and probable type in station 5 (Toppling and Rolling) because of the difference of dip amount and two sets of tensions joints, which doing as side and back realized surfaces, in addition to Weak Clay stone (6.3)M.pa. Overlaid Moderately Strong Conglomerate (43.373)Mpa. While station 6 has Rock fall, Toppling failures and probable failures for same formerly reasons, Conglomerate only 31.693 Mpa., in addition to inclusion, weak Sandstone lenses. The most building above apex of slopes directly. its sites, very dangerous (caused hazard) and accreted the failures as, a result of increasing moisture sediments, in addition to human activities.

Conclusions

The exposed sediments of the research area is attributed to Quaternary (Conglomerate), Sandstone, Siltstone, and Clay stone, and recent sediments, which covered the river bank. The Pleistocene

alluvial fans formed the sequence of horizontal beds and showed fractures vertical inclined or parallel tension joints (discontinuities), and cracks, which did as a side, and back release surfaces. In addition to the vertical tension joints, the Pleistocene alluvial fans showed water seepage as an indication to increasing porosity and permeability. So caused moisture of the surfaces, which it considers one of the weakness factors.

In all stations, the layers of Pleistocene alluvial fans showed surface joints parallel the surface slope, these joints doing as back released surfaces, caused with overhanging slope mode, r of the layers is variable frock fall, probably rock fall failure type in mostly. The compressive strength is very weak to strong, according to its sediments, in addition to weathering and water

Table 3-Abbreviations

Abbrev.&Symbols	Description
σ_c	Compressive strength
B.R.S.	Back release surface
Clay st.	Claystone
Cong.	Conglomerate
Dia.	Diameter
K*Is	Correct coefficient*Point load index
Km	Kilometer
Is	Point load index
mm	Millimeter
Mpa	Mega Pascal
Sandst.	Sandstone
Silt st.	Siltstone
S1&S2	Joint set one and Joint set two

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