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Research Article

Rock Slope Stability Assessment Using Slope Mass Rating (SMR) Method: Gunung Lang Ipoh Malaysia

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Abstract: Limestone hill are natural beauty due to their unique landscape and features of karst terrain. However, the hill may also pose danger to properties and human due to the instability of slope. Thus, the main objective of this study was to assess the stability of three slopes (GL1, GL2 and GL3) at Gunung Lang, Ipoh, Perak based on rock mass classification system of Slope Mass Rating. The slopes of GL1 and GL2 were identified as class II slopes. The GL3 slopes was categorized as class III to IV slope. The assessment revealed that the slope GL1 and GL2 were stable with the probability of failure of 0.2. The stabilities of GL3 slope were from partially stable to unstable with the probability of failure of 0.4 to 0.6. The outcomes of the study are used for development consideration in the near future.
Keywords: Limestone, slope mass rating, slope stability.

INTRODUCTION

Limestone hill in Kinta Valley, Ipoh are natural beauty due to their unique landscape and features of karst terrain. However, the hill may also pose danger to properties and human due to the instability of slope [1]. Reported that a massive rock falled from Gunung Cheroh, Ipoh, and Perak caused the demise of 40 people in October, 1973[2]. Also reported rock fall from Gunumg Pondok, Perak. The limestone hill in Gunung Lang, Ipoh, and Perak attracted development and tourist [3] and [4] warned the danger of rock fall at Gunung Lang, Ipoh, and Perak. Thus, this research was conducted to assess the stability of three slopes of this location as exhibited in Figure 1, based on Slope Mass Rating [5]. The outcomes of the study are used for development consideration in the near future.

MATERIALS AND METHODOLOGY

Geology of Study Area

The main lithology (Figure 2) in Gunung Lang, Ipoh is massive limestone bodies that are heavily jointed and fractured. The schist found was at the bottom of a massive limestone body. Joints and fractures are common features in the limestone bodies with two to four joint sets [6-7]. Named this limestone bodies as Kinta Limestone Formation with the age of Silur to Permian.

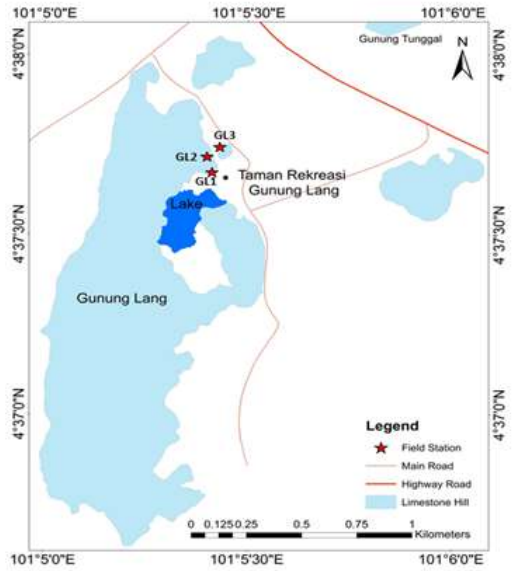

Fig-1: Location of 3 study slopes (GL1, GL2 and GL3) at Gunung Lang, Ipoh, Perak, Malaysia

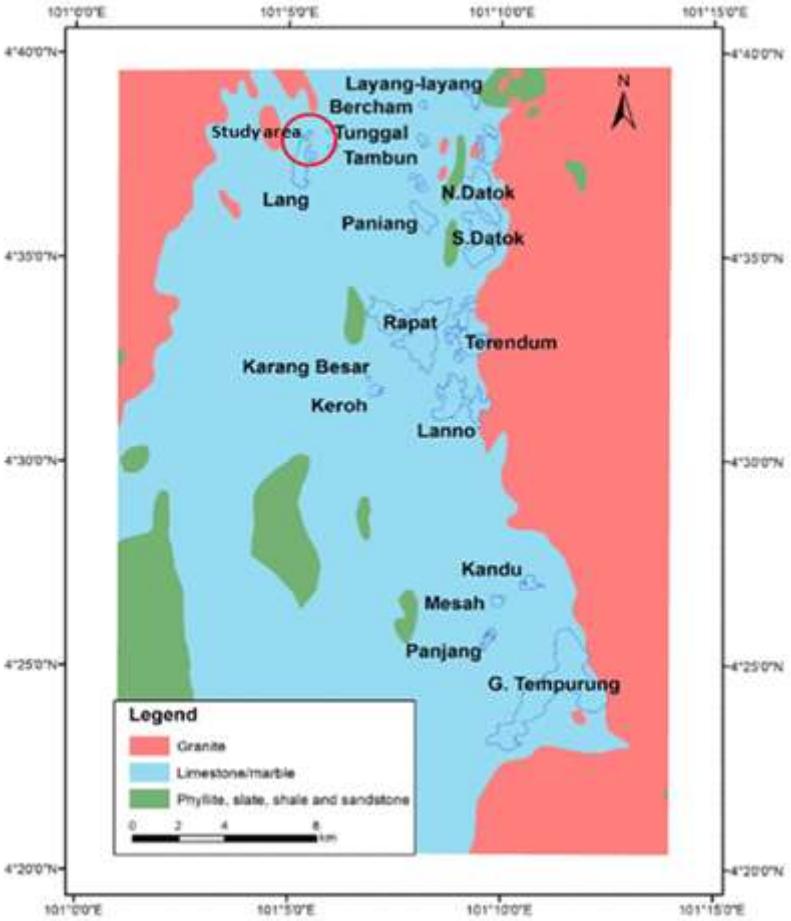

Fig-2: Lithology map of study area. Modified from [6]

Slope Mass Rating (SMR) Method

The slope mass rating method was proposed by [5] and used to assess the stability of rock slope. This method comprised of the following components:

(a) Uniaxial compressive strength (UCS)
(b) Rock quality designation (RQD)
(c) Discontinuities spacing

(d) Conditions of discontinuities
(e) Ground water condition
(f) Adjusting factors for joints (F1, F2, F3)
(g) Adjusting factor for excavation (F4)

The uniaxial compressive strength (UCS) of rock material was determined based on the recommendations of the [8]. The valúes of respectivecomponentes of (b), (c), (d) and (d) were determined froms can line discontinuities survey, following suggestion of [8]. F1 was the rating of in considering the difference of dip direction between joints and slope face. F2 was the rating of dip angle of the respective joint. F3 was the rating of considering the difference of dip angle between joints and slope face. The values of respective component of (a), (b), (c), (d) and (e) will be rated based on[5] suggestion. The total rating, RMR_b was determined as:

RMR_b = Rating (a) + Rating (b) + Rating (c) + Rating (d) + Rating (e) (1)

The rating for SMR was determined based on following equation suggested by [5]:

$SMR = RMR_b + (F1 \times F2 \times F3) + F4$ (2)

RESULTS AND DISCUSSION

A total of 3 slopes at Gunung Lang hill were assessed and were labeled as GL1, GL2 and GL3 as shown in Figure 3, Figure 4 and Figure 5. The locations of respective slopes were exhibited in Figure 1.The stereograf of respective slope are shown in Figure 6, Figure 7 and Figure 8. Slope of GL1, GL2, and GL3 composed of 4 to 5 major joint sets. The orientation of major joint sets and slope face of respective slope are exhibited in Table 1.

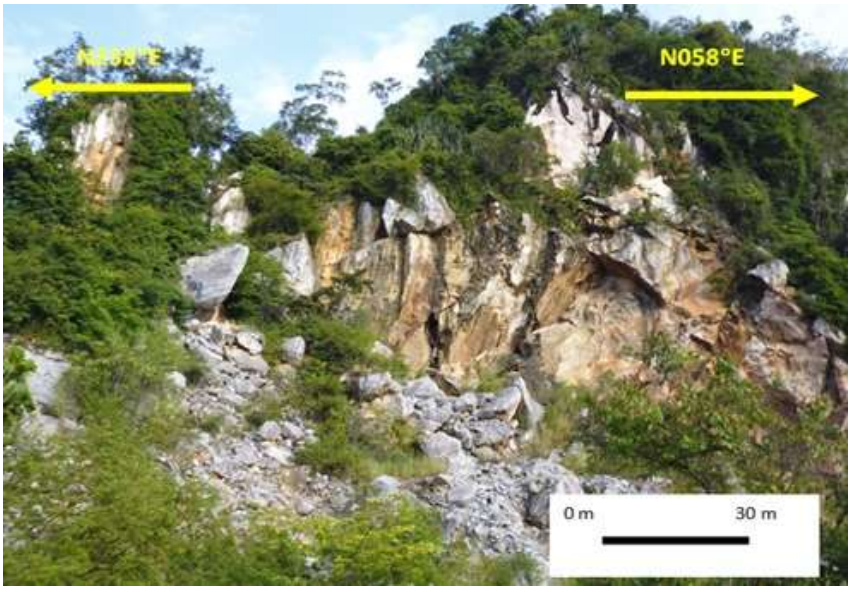

Fig-3: Slope of GL1, Gunung Lang, Ipoh, Perak

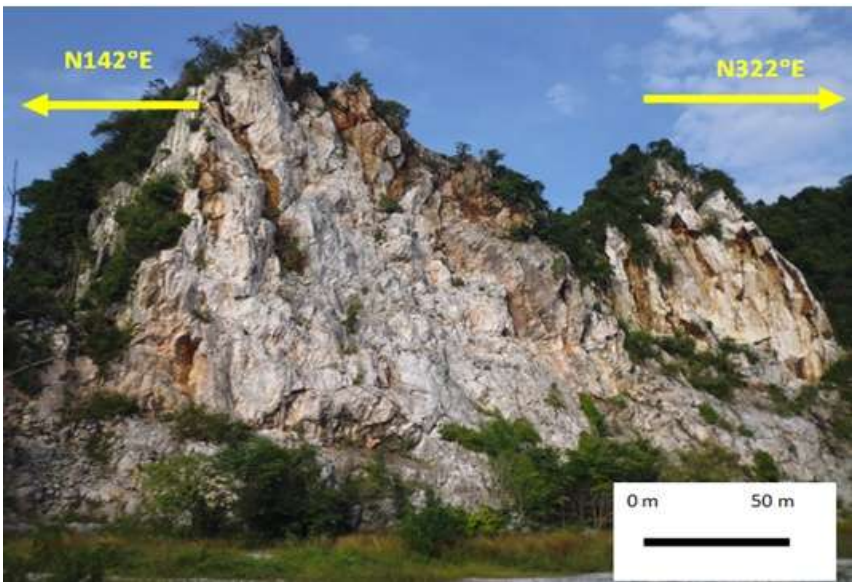

Fig-4: Slope of GL2, Gunung Lang, Ipoh, Perak

Fig-5: Slope of GL3, Gunung Lang, Ipoh, Perak

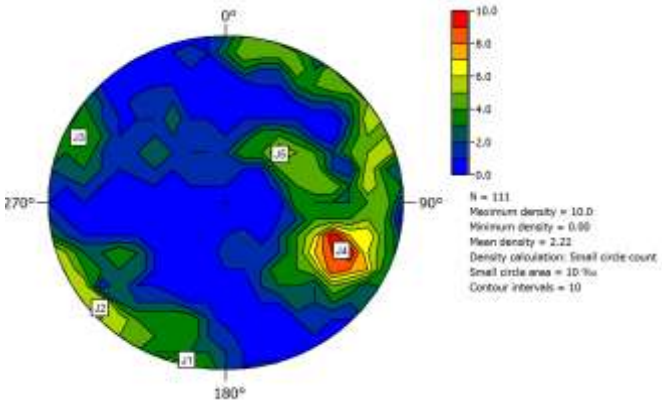

Fig-6: Stereograf for slope of GL1, Gunung Lang, Ipoh, Malaysia

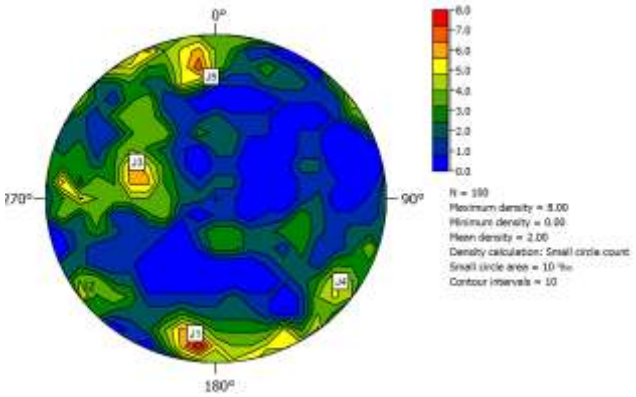

Fig-7: Stereograf for slope of GL2, Gunung Lang, Ipoh, Malaysia

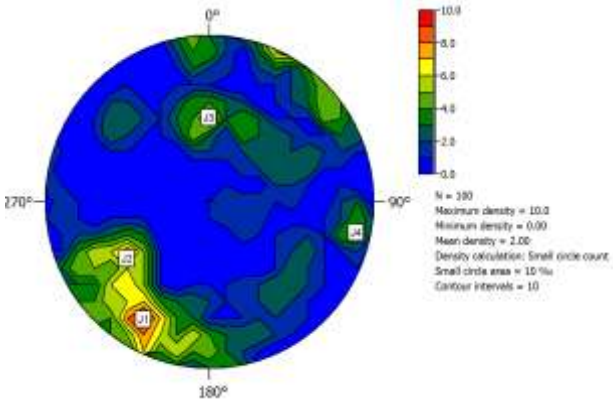

Fig-8: Stereograf for slope of GL3, Gunung Lang, Ipoh, Malaysia

Table 1: Orientation of major joint set and slope face for slopes of GL1, GL2 and GL3, Gunung Lang, Ipoh, Malaysia

Slope	Major Joint set/Slope Face	Dip Direction (°)	Dip Angle (°)
GL1	Slope face (SF)	148	82
	J1	013	84
	J2	050	83
	J3	115	81
	J4	293	59
	J5	229	36
GL2	Slope face (SF)	052	78
	J1	007	80
	J2	055	84
	J3	106	39
	J4	309	77
	J5	174	70
GL3	Slope face (SF)	270	82
	J1	030	71
	J2	054	51
	J3	179	42
	J4	280	79

The peak friction angles for respective slopes in kinematic analysis were determined based on the tilt testing method, suggested by [9]. The peak friction angle of 43° was used in the kinematic analysis for respective slope of GL, GL2 and GL3. Figure 9, Figure 10 and Figure 11 show the results of kinematic analysis for respective slopes. No mode of failure was identified in slope of GL1 and GL2. A planar failure and a wedge failure were identified in slope of GL3. The dip direction/dip angle for respective wedge and planar failure were 345°/65° and 280°/79°.

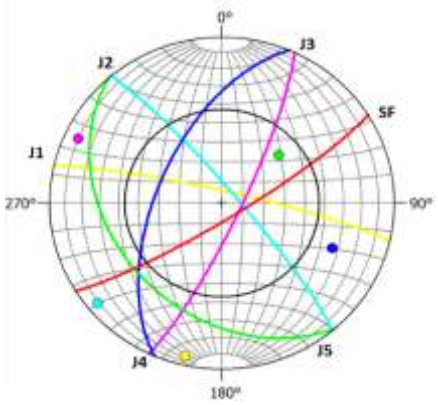

Fig-9: Kinematic analysis for slope of GL1 using friction angle of 43°. No mode of failure at this slope

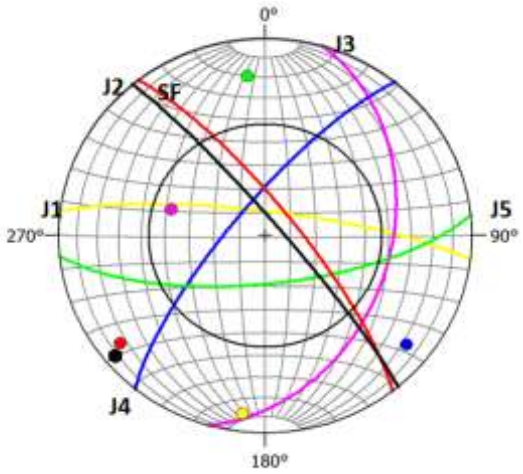

Fig-10: Kinematic analysis for slope of GL2 using friction angle of 43°. No mode of failure at this slope

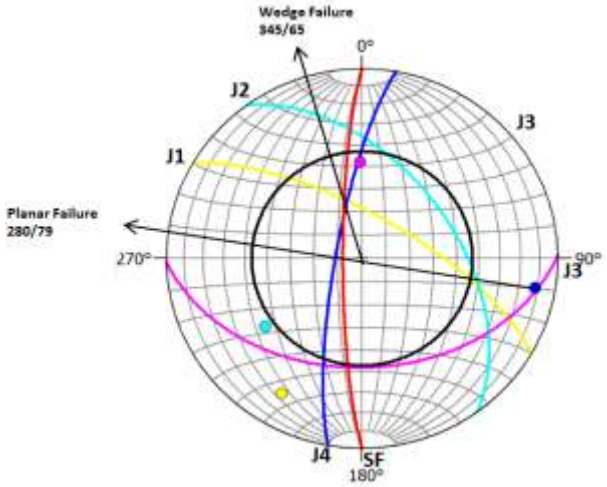

Fig-11: Kinematic analysis for slope of GL3 using friction angle of 43°. From the kinematic analysis, a planar and a wedge failure were identified. The dip direction/dip angle for respective wedge and planar failure were 345°/65° and 280°/79°

Table 2, Table 3 and Table 4 shows the results of assessment of RMR_b for respective slope of GL1, GL2, GL3, Gunung Lang, Ipoh, Perak. The respective total rating RMR_b for slope of GL1, GL2 and GL3 were 77, 77 and 82.

Table 2: Result of assessment of RMR_b for slope of GL1, Gunung Lang, Ipoh, Perak, Malaysia

Parameter	Value	Rating
Uniaxial compressive strength, UCS	53.6 -83.4 MPa	7
Rock Quality designation, RQD	97 %	20
Spacing of discontinuities	0.34 m	10
Condition of discontinuities	Discontinuities length 1-3 m, separation 0.1 - 1.0 mm, rough, no infilling, unweathered	25
Ground water condition	Completely dry	15
RMR_b		77

Table 3: Result of assessment of RMR_b for slope of GL2, Gunung Lang, Ipoh, Perak, Malaysia

Parameter	Value	Rating
Uniaxial compressive strength, UCS	53.6 -83.4 MPa	7
Rock Quality designation, RQD	98 %	20
Spacing of discontinuities	0.47 m	10
Condition of discontinuities	Discontinuities length 1-3 m, separation 0.1 -1.0 mm, rough, no infilling, unweathered	25
Ground water condition	Completely dry	15
RMR_b		77

Table 4: Result of assessment of RMR_b for slope of GL3, Gunung Lang, Ipoh, Perak, Malaysia

Parameter	Value	Rating
Uniaxial compressive strength, UCS	53.6 -83.4 MPa	7
Rock Quality designation, RQD	99 %	20
Spacing of discontinuities	0.62 m	15
Condition of discontinuities	Discontinuities length 1-3 m, separation 0.1 - 1.0 mm, rough, no infilling, unweathered	25
Ground water condition	Completely dry	15
RMR_b		82

Based on the [5] recommendation, the results of assessment on slope of GL1, GL2 and GL3 are exhibited in Table 5. The respective SMR rating for GL1, GL2 and GL3 were 77, 77 and 31.5 - 65. The classes of respective slopes were from class II to IV. The assessment revealed that the slope of GL1 and GL2 are stable with the probability of failure of 0.2. The stabilities of GL3 slope are from partially stable to unstable with the probability of failure of 0.4 to 0.6.

Table 5: Results of assessment based on SMR method

Slope	Mode of failure	RMR_b	F1	F2	F3	F4	SMR	Class	Stability	Probability of failure
GL1	No failure	77	-	-	-	-	77	II, Good	Stable	0.2
GL2	No failure	77	-	-	-	-	77	II, Good	Stable	0.2
GL3	Wedge 345°/65°	82	0.15	1	-60	-8	65	III, Fair	Partially stable	0.4
	Planar 280°/79°	82	0.85	1	-50	-8	31.5	IV, Bad	Unstable	0.6

CONCLUSION

The assessment revealed that the slope of GL1 and GL2 are stable with the probability of failure of 0.2. The stabilities of GL3 slope are from partially stable to unstable with the probability of failure of 0.4 to 0.6. According to [5] recommendation, the suggested support methods for GL3 slope are installation of surface drainage, shotcrete, dental concrete and toe walls.

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REFERENCES

1. Shu YK, Lai KH; Rockfall at Gunung Cheroh, Ipoh. Geological Survey Report. Ipoh: Minerals & Geoscience Department, Malaysia, 1974.
2. Shu YK, Razak YA; Rockfall at Gunung Pondok Padang Rengas, Perak. Geological Survey Report. Ipoh: Minerals & Geoscience Department, Malaysia, 1984.
3. Wong TW; Rockfall Danger at Project Area of Mini Disneyland in GunungLang, Ipoh. Geological Survey Report. Ipoh: Minerals & Geoscience Department, Malaysia, 1979.
4. Shu YK, Lai KH; Rockfall Danger at Gunung Lang Rifle Range Road, Ipoh. Geological Survey Report.Ipoh: Minerals & Geoscience Department, Malaysia, 1973.
5. Romana M; New adjustment ratings for application of Bieniawski classification to slopes.Int. Symp. on the Role of Rock Mech. ISRM, Zacatecas, 1985; 49-53.
6. Simon N, Ghani MFA, Lai GT, Rafek AG, Hussin A, Roslee R, Ern LK; Assessment of rockfall potential of limestone hills in the Kinta Valley. Journal of Sustainability Science and Management, 2015; 10(2):24-34.
7. Foo KY;The Paleozoic Sedimentary Rocks of Peninsular Malaysia-Stratigraphy and Correlation. Proceeding of the Workshop on Stratigraphic Correlation of Thailand and Malaysia, 1983; 1: 1-19.

8. International Society for Rock Mechanics; Rock characterization, testing and monitoring. In Brown, E.T. (Editor), ISRM suggested Methods. Pergamon Press, Oxfored, U.K, 1981.
9. Abdul Ghani Rafek, Goh Thian Lai. Correlation of joint roughness coefficient (JRC) and peak friction angles of discontinuities of Malaysian Schists. Earth Science Research, 2012; 1(1):57-63