Engineering Geological Assessment at Grandview Heights, Paya Terubong, Pulau Pinang, Malaysia

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Abstract. Grandview Heights, Paya Terubong is an old apartment building situated on a coarse-grained biotite granitic bedrock hillside. Paya Terubong is a landslide prone area where various landslides have been reported since 1998. The granitic hill has been disturbed during construction of the apartment. Due to the possibility of future landslides, an engineering geological study was conducted to assess the stability of this rock hill beneath this apartment. The scopes of study included discontinuity surveys, geomechanical characterization of the rock mass and slope stability analysis. Based on the results of discontinuity surveys, four major joints sets were identified and labelled as J1 (195°/62°), J2 (248°/65°), J3 (304°/63°) and J4 (230°/39°). One (1) potential planar failure J2 (248°/65°) and one (1) potential wedge failure J1-J2 intersection (213°/60°) were identified based on kinematic analysis. Dry rock density was from 2.56 g/cm^3 to 2.61g/cm^3. The water content was from 0.14 % to 0.15% with low porosity values from 0.50% to 0.54%. The point load strength index, $I_{s(50)}$ was 6.63 MPa. The

Slope Mass Rating (SMR) for was 64 to 79 and classified as class II with the probability of failure of 0.2.

1. Introduction

Engineering geology is an applied science dealing with the application of geology methods in civil engineering works. Among the earlier research on engineering geological mapping was prepared by [1] and [2]. Apart from that, a few researchers also found have discussed the similar matter might be referred worldwide for examples the geotechnical properties [3-7], slope instability [8-13], engineering seismology [14-17] and geological risk [18-21].

This paper discusses the roles or applications of engineering geology in construction works. Basically, engineering geology applied in this study encompasses three fundamental studies or issues, which is the lithology or rock type, geological structures, weathering grades and discontinuity survey. Fundamentals of engineering geology are discussed in detail, followed by the applications of Slope Mass Rating (SMR) technique to assess the stability of the rock hill beneath to the study area.

2. Study Area

Grandview Heights, (Figure 1), Paya Terubong is an old apartment building situated on a coarse-grained biotite granitic bedrock hillside and is located in the south eastern part of the state of Penang. Paya Terubong is a landslide prone area where various landslides have been reported in this area since 1998.

The slope (Figure 2) with the length of 80 m and height of 10 m is located at coordinates of 5°22’19.0”N dan 100°16’49.0”E (Figure 3). The granitic rock hill was disturbed during construction of the apartment. In view of possible future landslides an engineering geological study was conducted to assess the stability of the rock hill beneath this apartment.

Figure 1. Grandview Heights, Paya Terubong, Pulau Pinang

Figure 2. The outcrop of study area is beneath Grandview Heights. The scanline method was conducted to quantify the discontinuities of the rock mass forming the slope.

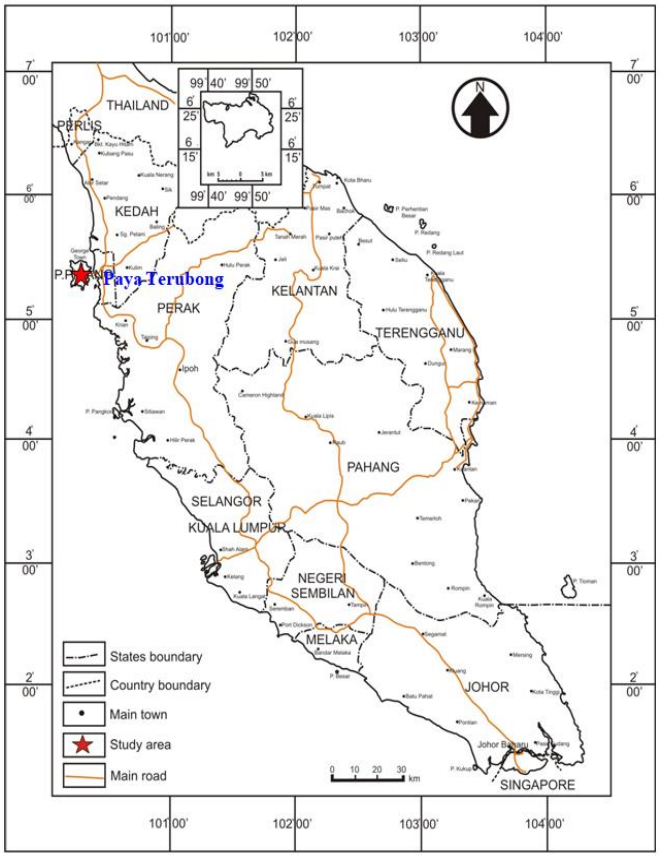

Figure 3. Location of study area-Paya Terubong, Pulau Pinang.

3. Geological Setting of the Study Area

The granite at Paya Terubong has been named as the South Penang Pluton (SPP) by [22] and was described as coarse-grained biotite granite [23]. [24] suggested that the age of this granite is from Late Triassic to Early Jurassic.

4. Material and Methods

This study encompasses field discontinuity surveys, physical and geomechanical laboratory testing, kinematic analysis and Slope Mass Rating (SMR) determination.

4.1. Discontinuities Survey

Scanline method [25] was conducted to measure the orientation and properties of discontinuities at this study slope. Parameters of a discontinuity include spacing, orientation, length and surface roughness.

4.2. Slope Mass Rating

The determination of Slope Mass Rating (SMR) [26] was calculated based on equation (1).

$$\boldsymbol{SMR = RMR_{basic} + (F_1 \text{ x } F_2 \text{ x} F_3) + F_4} \quad (1)$$

RMR_{basic} is the total rating of Rock Mass Rating [27] for the 5 basic parameters such as strength of intact rock material, rock quality designation (RQD), spacing of discontinuities, condition of discontinuities and as well as ground water. F1 is the rating adjustment for the difference of dip direction between joints and slope face. F2 is the rating adjustment for the dip angle of the respective joints. F3 is the rating adjustment for the difference of dip angle between joints and slope face. F4 is the adjusting factor for excavation method.

5. Results and Discussion

Discontinuities survey results revealed that the slope beneath Grandview Heights, Paya Terubong is composed of four sets of major joints (Figure 4) and labelled as J1, J2, J3 and J4. The dip direction and dip angle for J1, J2, J3 and J4 are 195°/62°, 248°/65°, 304°/63° and 230°/39° respectively. The 3D slope was produced by using photogrammetry method for geological interpretation. The joint set were identified and verified at field as shown in Figure 5. The results of slope kinematic analysis (Figure 6) showed the potential of one planar failure J2 (248°/65°) and one wedge failure J1-J2 (213°/60°). The orientation (dip direction/dip angle) of slope face is 240°/65°. The peak friction angles (50°) for this slopes in kinematic analysis were determined based on the tilt testing method, suggested by [28] and [29].

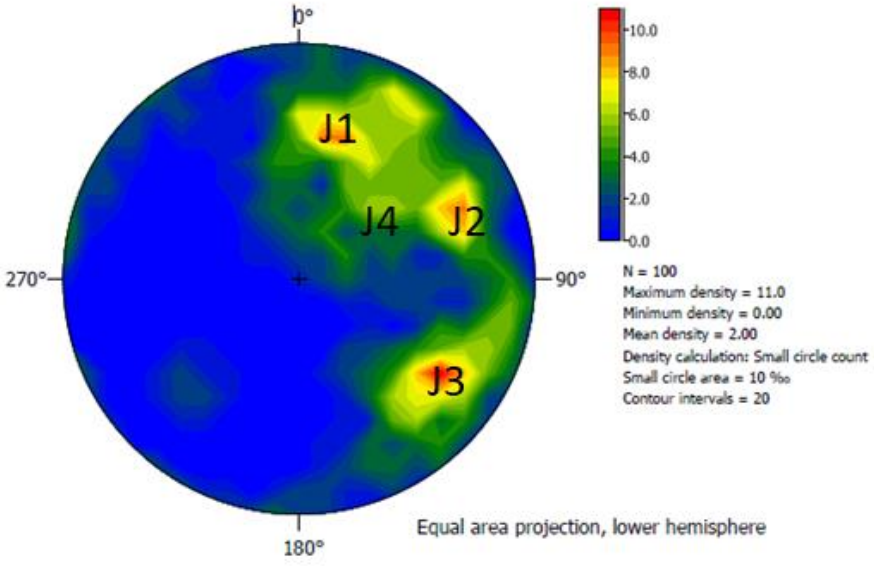

Figure 4. Stereoplot for slope beneath Grandview Heights, Paya Terubong. Four sets of major joints were identified and labelled as J1 (195°/62°), J2 (248°/65°), J3 (304°/63°) and J4 (230°/39°).

The physical and geomechanical laboratory tests on the rock samples revealed that the dry density of the rock samples were from 2.56 g/cm^3 to 2.61g/cm^3. The water content were from 0.14 % to 0.15% with low porosity values from 0.50% to 0.54%. The point load strength index, $I_{s(50)}$ was 6.63 MPa.

Table 1 and Table 2 show the result of assessment of RMR_{basic} and Slope Mass Rating. The rating of RMR_{basic} for this slope was 84. The respective SMR for potential planar J2 (248^o/65^o) and wedge failure J1-J2 (213^o/60^o) were 79 and 64 with class of II and probability failure of 0.2.

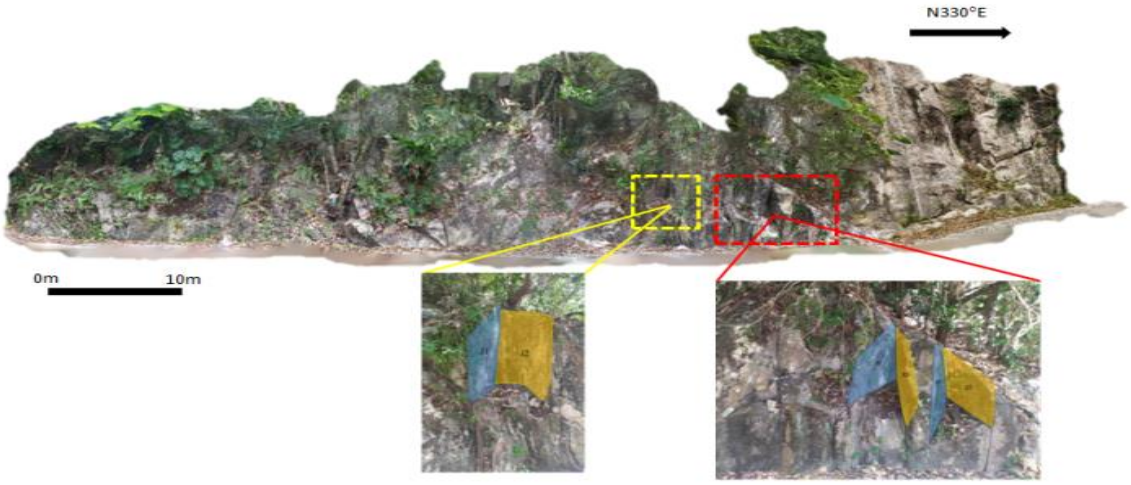

Figure 5. Joint sets J1 and J2 were verified at outcrop. The 3D slope was produced using photogrammetry method for better geological interpretation.

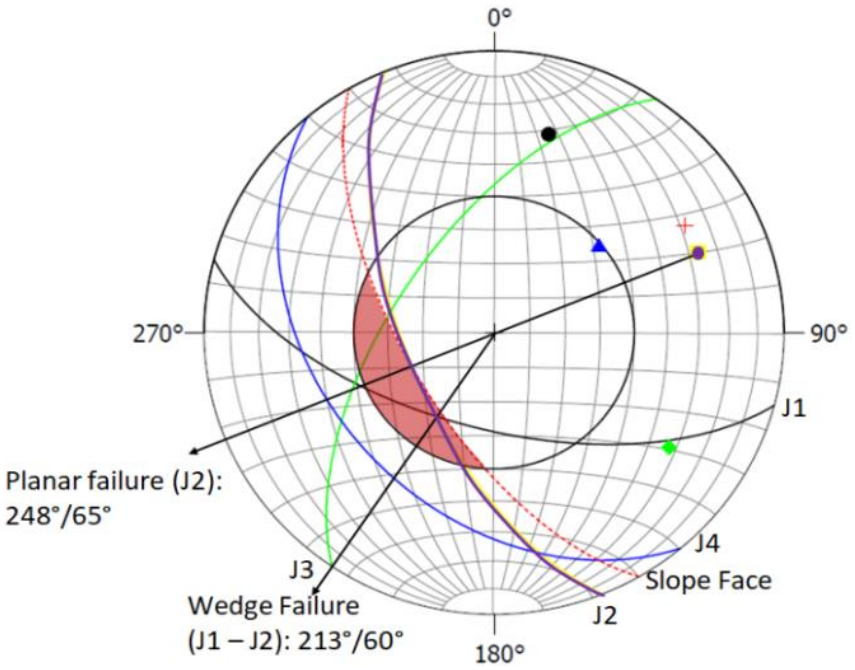

Figure 6. Kinematic analysis for slope beneath Grandview Heights, Paya Terubong. One potential planar failure J2 (248^o/65^o) and one potential wedge failure J1-J2 (213^o/60^o) were identified.

Table 1. RMR_{basic} rating based on Bieniawski (1989).

Parameter	Value	Rating
Point load index strength, (MPa)	6.3	12
Rock Quality Designation (RQD), %	97	20
Spacing (m)	0.25	10
Condition of discontinuities		
Discontinuities length (m)	1.42	4
Separation (mm)	None	6
Roughness	Rough	5
Infilling	None	6
Weathering	Unweathered	6
Ground Water	Dry	15
RMR_{basic}		84

Table 2. Results of assessment based on SMR method

Mode of failure	RMR_{basic}	F1	F2	F3	F4	SMR	Class	Stability	Probability of failure
Planar 248°/64°	84	0.85	1	-6	0	79	II	Stable	0.2
Wedge 213°/60°	84	0.40	1	-50	0	64	II	Stable	0.2

6. Conclusions

One potential planar failure J2 (248°/65°) and one potential wedge failure J1-J2 (213°/60°) were identified on the slope beneath Grandview Heights, Paya Terubong. The Slope Mass Rating for this slope was 64 to 79 and classified as class II. The engineering geological assessment revealed that this slope is stable with the probability of failure of 0.2.

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