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Kampung Mesilou landslide: The controlling factors

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ABSTRACT

This landslide study was conducted in Kampung Mesilou, Kundasang. Desk study, field study and data analysis used were based on recorded slides occurred in 2008, July 2013, November 2013 and June 2015. These episodic landslides have significant impact on road, concrete bridge, vegetable gardens and killed a farmer. Factors that control the slides are natural and anthropogenic activities. The natural factors include geological characteristics, weathering, excessive precipitation and natural river phenomena. Human activity is represented by unguided cutting slope for development purposes. The geological factor consists of unconsolidated Pinosuk Gravel rock unit, topography and occurrence of active northeast-southwest fault zone crossing this area. High weathering rate has weakening the underlying rock unit as well as heavy precipitation. Intermittently high energy during storm of the main river channel of Mesilou River has been increasing the rate of erosion at slope base since few decades. Natural slope was steepened during road construction and become less stable. Slope stability analysis has confirmed the slope is unstable with FOS < 1, especially during rainy session.

1. INTRODUCTION

Landslide is a general term for variety of earth processes by which large masses and/or earth materials spontaneously move downward, either slowly or quickly by gravitation (Montgomery, 1996). Such earth processes become geologic hazards and disasters when their interaction with the material environment is capable of causing significant negative impact on structures and human's well-being, respectively.

Engineering structures damages by landslide in Kundasang area has cost trillion of Ringgit Malaysia for reconstruction and repairs as well as loss of three (3) lives include an elderly woman behind a farm in Kampung Mesilou on 16 July 2013 (Photograph 1). Landslides in Kampung Mesilou are repeated and happened for fifth times i.e before 2008 (?), 2008, July 2013 and November 2013 as well as triggered by Kinabalu earthquake on June 2015 (Photograph 2 & Figure 1).

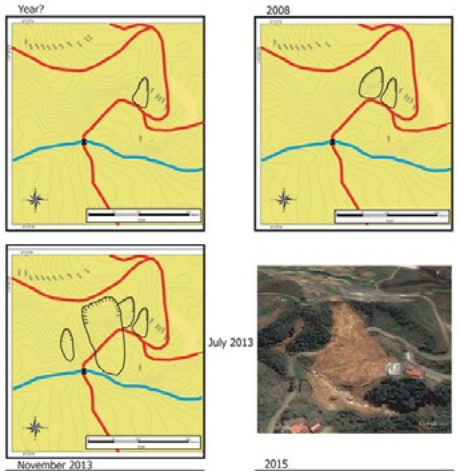
Photograph 1 Victims of 16 July 2013 landslide (New Straits Times, 2013).

This study had been conducted to identify the controlling factors for the repeated and disastrous Kampung Mesilou's landslides.

ROCK UNIT

The Kampung Mesilau landslide is located at 6o00' 49"N and 116o36'5"E. This area is underlain by the poorly consolidated tilloid deposit that known as Pinosuk Gravel rock unit of Upper Pleistocene to Holocene in ages and consists of variety of gravel and sizes such as granodiorite, monzodiorite, adamelite, peridotite, slate, metasandstone (metaquartzite), sandstone and shale in argillaceous groundmass (Figure 2 and Photograph 3). Maximum thickness of this rock unit is 150 meter (Hutchison, 2005).

Photograph 2 Landslides in 2008, 16 July 2013, 15 Nov 2013 and 5 June 2015.



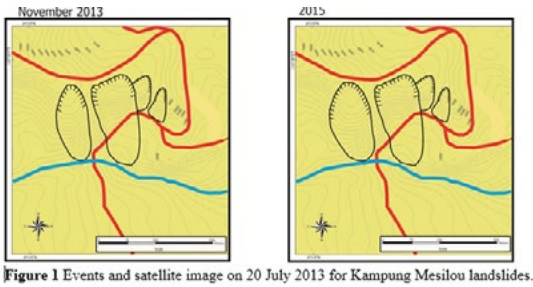


Figure 1 Events and satellite image on 20 July 2013 for Kampung Mesilou landslides.

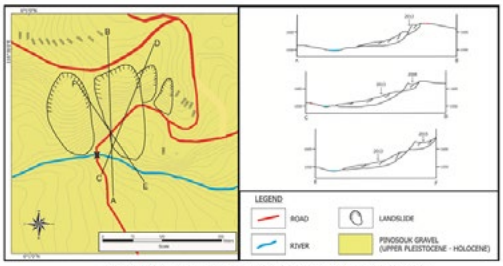


Figure 2 Geological map and Kampung Mesilou landslide zones.

METHODOLOGY

This study has been conducted by desk study, field study and data analysis. Desk study includes literature review, aerial photograph interpretation, satellite image interpretation, field data sheet preparation and base map preparation. Field study was conducted by geological mapping and slope failure survey and mapping.

Data analysis has been conducted for slope stability analysis. Field observation has found that the mode of failure is circular than limit equilibrium analysis of Bishop method were used in this analysis. To perform this analysis, SLIDES software (Rocscience Inc., 2012) was used. In this analysis, physical and shear properties of rock mass are needed.

The value of physical and shear properties of tilloid deposit in United State of America (Koloski et. al., 1989; Linell & Shea 1960) were used due to the limitation and difficulty in determining these properties (Table 1).

Table 1 Rock mass properties (adapted from Koloski et. al., 1989; Linell & Shea 1960).

Min unit weight (kN/m³)	Min Cohesion (MPa)	Min Friction (degree)	Max unit weight (kN/m³)	max cohesion (MPa)	max friction (degree)
18.85	0.05	35	22	0.19	45
18.85	0.05	35	22	0.19	45
18.85	0.05	35	22	0.19	45

LANDSLIDE FACTORS

Studies by South East Asia Disaster Program Research Institute (SEADPRI) and the Department of Mineral and Geoscience Malaysia in Borneo Post (2011) stats that the average of movement or displacement in Kundasang area is 0.5 meters / year. Before that, in order to provide physical meaning to GPS displacements, correlation between hydro-geological and geotechnical characteristics of the area and its surrounding should be studied (Abidin et al,. 2004).

The factors that control landslides in Kampung Mesilou are natural and anthropogenic activities. The natural factors include geological characteristics, topographic, weathering, excessive precipitation and natural river phenomena. Human activity is represented by unguided slope cutting for development purposes.

The geological factor consists of unconsolidated Pinosuk Gravel rock unit. topography and active fault zones crossing this area. The Pinosuk Gravel that underlain this area is incompletely litified due to space and time then become loose rock mass unit. These unconsolidated loose rock units are behaving very porous, easy to weathered, saturated and behave very week.

Topographic factor for landslides are reported by many researches such as Majeed et al. (1999), Gerard (1994) and Lewis (2008). Altitude of more than 1500 meter from sea level is lees stable compare to near sea level.

Aerial photograph, satellite images and field studies are also found that the kg Mesilou landslide is located in intersection of active thrust Mesilou fault zone of Tongkul and Shariff (2009) (Figure 3). Fault zone is a crush and very week zone. Material that crossed this zone will be move easily especially in hilly or sloping areas.

High weathering rate has changing the underlying rock unit into grade IV and V. This is also reducing and weakening the strength of Pinosuk Gravel as well as stability of the slope. Weathering has been causing the rock unit behave as soil characteristics.

All of the Kampung Mesilou landslides was happened during the heavy rain as state by Giannecchini et al. (2012), Polimeo and Petrucci (2000) & Majeed et al. (1999). The data from Meteorological Department show that the rain is more than 2000mm per day. The slide will occur when the rock unit are saturated where the rock unit strength are decreased. Pinosuk Gravel is a porous rock mass and easily entered by rain water. During raining even, water will entering pore space and reducing inter-grain bonding of rock unit as well as saturating them. Low inter-grain bonding and saturation will decreasing shear strength and increasing weight of rock mass. This will contribute to rock mass movement or failure.

The Kampung Mesilou landslide is also caused by a natural Mesilou river flow. High energy during storm of the main river channel of Mesilou River has been increasing the rate of erosion at slope base since few decades. Erosion at slope base has been decreasing the resistence force for the slope to slide.

Figure 3 Mesilou and northwest-southeast fault lines.

For the sake of accessibility, the natural slope was cute for road construction. Generally, the normal slopes will erode or change to achieve equilibrium. But road construction has been steepened the natural slope and become less stable.

Slope stability analysis has been conducted for the slopes with their geometries as shown in Table 2. The results are shown in Table 2 and Figure 4. Landslide in 2008, July 2013 and Nov 2013 show that all of the slopes is stable for normal condition but during the rainy session or saturated condition, all the slopes are unstable with FOS < 1

Table 2 Slope geometry and FOS values.

Year	H (meter)	W (meter)	β (degree)	Min FOS	max FOS	Min Saturated FOS	Max Saturated FOS
2008	80	70	68	0.76	1.664	0.071	0.544
16-7-2013	100	120	43	1.104	2.307	0.709	1.153
15-11-2013	120	80	48	1.005	1.981	0.368	0.861

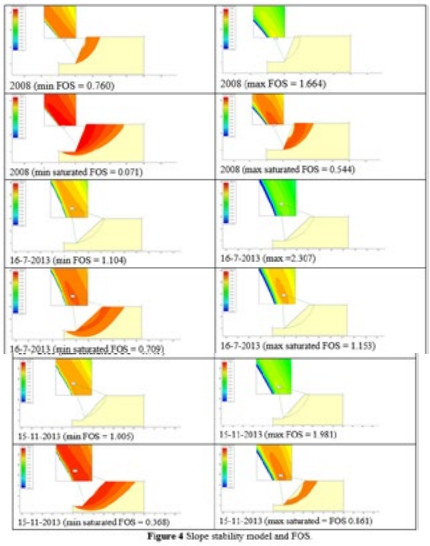


Figure 4 Slope stability model and FOS.

CONCLUSION

Factors that control the slides are natural and anthropogenic activities. The natural factors include geological characteristics, weathering, excessive precipitation and natural river. Anthropogenic activity is represented by unguided cutting slope for development purposes

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