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Preliminary Analysis of Slope Stability in Kuok and Surrounding Areas

Dewandra Bagus Eka Putra[1,]*, Tiggi Choanji[1,]*
[1] *Universitas Islam Riau, Jl. Kaharuddin Nasution, Pekanbaru 28284, Riau, Indonesia*

* Corresponding Author's: dewandra.bagus@eng.uir.ac.id and tiggich@eng.uir.ac.id
Tel.: +6281959543306 /+6282110740659
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Abstract

The level of slope influenced by the condition of the rocks beneath the surface. On high level of slopes, amount of surface runoff and water transport energy is also enlarged. This caused by greater gravity, in line with the surface tilt from the horizontal plane. In other words, topsoil eroded more and more. When the slope becomes twice as steep, then the amount of erosion per unit area be 2.0 - 2.5 times more. Kuok and surrounding area is the road access between the West Sumatra and Riau which plays an important role economies of both provinces. The purpose of this study is to map the locations that have fairly steep slopes and potential mode of landslides. Based on SRTM data obtained, the roads in Kuok area has a minimum elevation of + 33 m and a maximum + 217.329 m. Rugged road conditions with slope ranging from 24.08 ° to 44.68 ° causing this area having frequent landslides. The result of slope stability analysis in a slope near the Water Power Plant Koto Panjang, indicated that mode of active failure is toppling failure or rock fall and the potential zone of failure is in the center part of the slope.

Keywords: Kuok, Landslide, Slope Stability Analysis, Toppling Failure, Rock Fall.

1. Introduction

Kuok and the surrounding area have quite diverse of slope, so there are a several locations which have range from gentle slope to steep. Based on the surface conditions, the level of slope affects from the condition of the rock beneath the surface. On the high level of slopes, the amount of surface runoff and water transport energy are also enlarged. This is caused by greater gravity, in line with the ground surface tilt from horizontal plane. Therefore, topsoil will be eroded more and more. When the slope of the land surface becomes twice steep, then the amount of erosion become 2.0 - 2.5 times more per unit area [1]. So, our research will conduct on area that predicted to become dangerous based on slope stability analysis.

2. Data and Method

Data obtained from Digital Elevation Models using SRTM data with raster grid format of pixels that value of the pixels must be counted vicinity to all directions. In calculating the value of the slope of a single pixel, involving a 3x3 pixel as illustrated in Figure 1 and calculations of formula quoted from [3] below.

$$\left[\frac{Slope\ (h)}{Distance\ (r)}\right] = \sqrt{\left[\frac{dz}{dx}\right]^2 + \left[\frac{dz}{dy}\right]^2} \quad \text{.....(1)}$$

$$\left[\frac{dz}{dx}\right] = \left[\frac{((c+2f+i)-(a+2+g))}{8\ x\ grid\ width}\right] \quad \text{.....(2)}$$

$$\left[\frac{dz}{dy}\right] = \left[\frac{((g+2h+i)-(a+2b+c))}{8\ x\ grid\ width}\right] \quad \text{.....(3)}$$

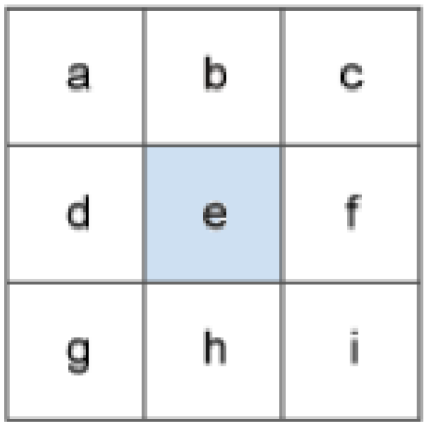

Fig 1. Illustration of pixels that are taken in the calculation of the slope value pixel on DEM / DTM grid raster format (Burrough, 1998).

Kinematic analysis had been conduct to determine the possibility of mode of failures in a jointed rock slope [15]. Angular relationship between discontinuities and slope surface are also be applied to identify the potential and mode of failures [7].

3. Geology Regional

Kuok and the surrounding area are composed by several formations and geological structures which formed the topography at recent time (Figure 2). Based on the Geological Map of Pekanbaru [12] suggested that formation on the research area consist of Bohorok Formation (Pub) consist of Wacke, conglomeratic wacke and turbidite deposit; then also at the same age deposited Member of Tanjung Pauh (Pukt) of the Tapanuli Group that consist of muscovit chlorit cabonate schist with strong lineation. Then an intrusion of Granite Pulaugadang triad (MPipg), consist of strong foliation of granite gneiss. On the northeast side, Pematang Formation was deposited containing red and mottled mudstone, breccio-conglomerates and conglomeratic sandstones. After that Sihapas Formations (Tms) deposited on miocene which contains the conglomerate sandstone, and siltstone. The youngest formation on research area is Petani Formation (Tup) consisting of mudstone, carbonaceous, lignite, slightly siltstone and sandstone. (Fig 3).

Fig 2. Topography map of research area

Structural geology conditions of the research area was formed by collision of india-australian plate to Eurasian plate which resulting basement highs trending northwest - southeast (Metcalfe, 2012), the structural pattern formed such as folds anticline and syncline also trending from northwest - southeast, accompanied with some fault lineaments in the western area of research that also has a direction parallel to the fold, along with the establishment cleavage-slates and slate cleavage [12].

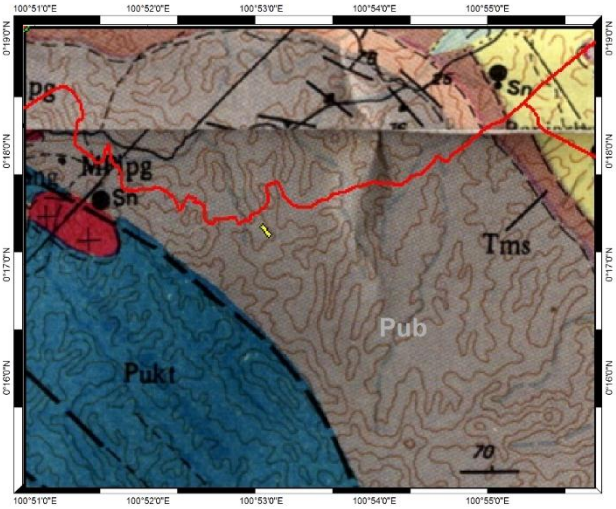

Fig 3. Geological map of research area

4. Result and Discussion

Research area located near the Water Power Plant Koto Panjang which become sorce electicity for Riau Province. Based on slope analysis in Kuok and Surrounding area, there are five type related with degree of slope in research area, from nearly level to very steep slope. First, nearly level class of slope having 30% on coverage area, this class distibute on NE research area as a habitation and some part in SW are lake of Koto Panjang. Second are moderately sloping that cover 30 % of the area, and then steep area that cover 20 % on kuok area, and class of very steep cover about 20 % in all area. Some of the steep area are located near the road, used as rock mining site for local villagers, this is the potential risk that can become dangerous if landslide happens on that area.

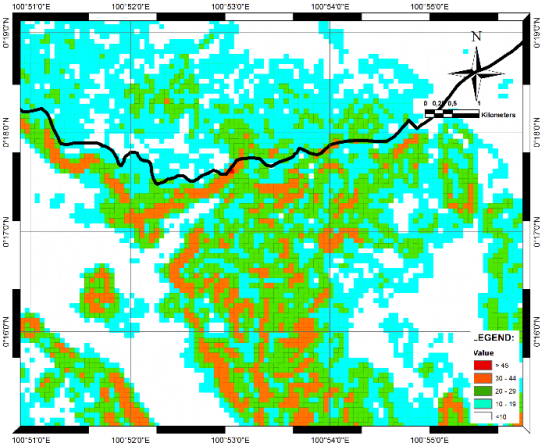

Fig 4. Slope map of Kuok Area and Surroundings

A slope stability analysis had been assessed to the cut slope. The slope was considered as heavily jointed slope due to a fault system that developed in the site (Fig 5).

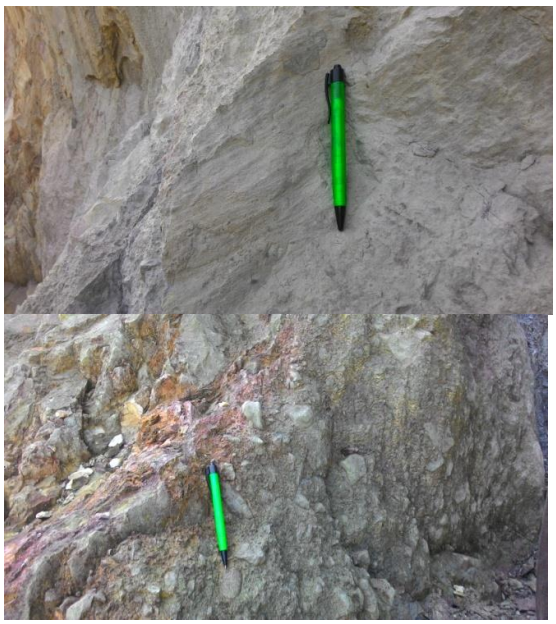

Fig 5. Fault breccias and slicken side feature indicating the slope was affected by a fault system.

The analysis had been conducted using Stereonet software to identify the mode of active failure and the potential failure zone of the slope. The slope face direction is N295E and 85o dip. Overall, 193 joint sets had been plot into the Stereonet and 2 sets of joint considered as major sets based on the 1% area contour analysis (Fig 6). The mode of failure had been analyzed based on the relationship between slope face and major joint sets plane. The mode of failure is toppling failure or rock fall and the potential zone of failure is in the center part of slope (Fig 7).

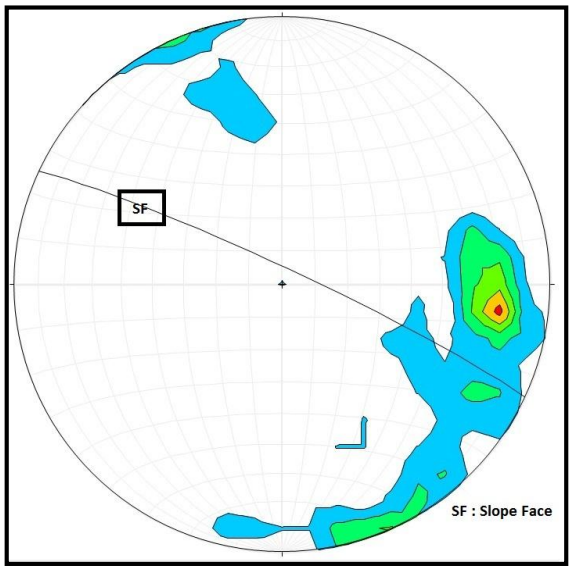

Fig 6. 1% area contour analysis to determine the major sets of joint.

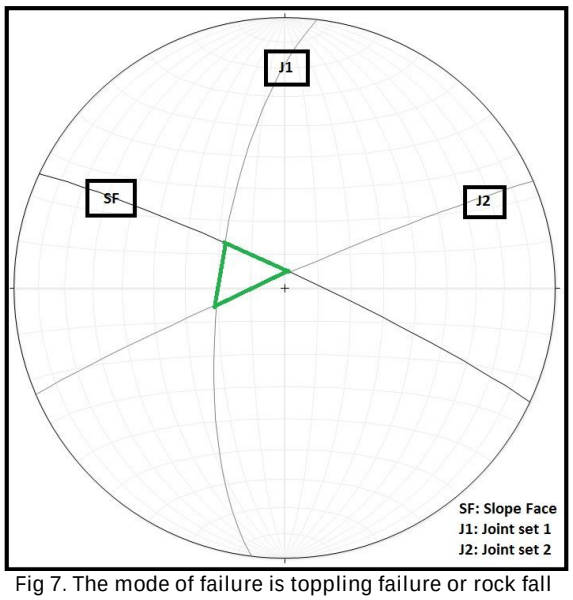

Fig 7. The mode of failure is toppling failure or rock fall (indicating by green triangle) and the potential zone of failure is in the center part of the slope.

5. Conclusion

Kuok and surrounding areas are potentially endangered for the road user because of the existence of cut slopes. Some of the cut slopes are used as rock mining by local villagers and could be the trigger for landslide. The major factor of landslide occurrence is the geological structure, as the cut slopes in Kuok and surrounding areas considered as heavily jointed rock slope, the possibility of slope failure is higher.

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