Surface Geology Characteristic and Its Influence to Landslide Potential in Cisokan Drainage Pattern, West Bandung, Indonesia

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***Abstract*—Study area is located around Cisokan Drainage Pattern, West Bandung, Indonesia. Topography characteristic around the study area is hilly landform with steep – very steep slope. Study of slope stability become necessary to prevent and to minimize the effect of landslide. The aim of this research is to analyze the slope characteristic that may cause landslide. Several methods used in this study such as desk studies and fieldwork. Desk studies consist of geomorphology analysis and using geological software. Fieldwork consist of geological surface mapping, outcrop analysis, rock sampling, and joint density mapping. Result of this study shows that the average orientation of strike and dip is NE-SW. Joint density analysis shows that the average orientation of major stress is relative to NW-SE. Fault Plane analysis shows that there are two major faults in this study area, there are oblique strike-slip dominated fault and normal fault which has major stress relatively oriented to NW-SE and NE-SW. The conclusion of this research is that the study area is highly prone to landslide due to steep – very steep slopes, the presence of soft sedimentary rocks, tectonic influence, rock weakening due to the presence of intensive joint, high erosion activity, weather influence and land clearing in several area, located in shear zone which has high tectonic influence and become highly potential to reactivate and affect the durability of slope and may cause landslide.**

***Index Terms*—landslides, cisokan drainage pattern, west bandung**

I. Introduction

A. Landslide & Study Area

Ref. [1] Landslide is a mass displacement of block of soil, rocks or soil mixture that have low stability. Several factor such as topography, geology, weather and seismic activity can be used as variable in determining slope stability (Hunt, 2007).

Ref. [2] A landslide can be typed by a term describing the natural materials before they were displaced and a second term describing the movement. Materials are rock, debris or earth; earth may be sand, silt or clay. Movements may be falls, flows, slides, spreads or topples (Cruden and Lan, 2014).

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Study area is located in Rongga and its vicinity, West of Bandung, Indonesia (Fig. 1). Topography of study area is hilly landform with steep – very steep slope with elevation between 400 – 1000m, lithology consist of sandstone and alternation of strata claystone and sandstone, some overlaid by volcanic sediment.

Since Java Island, Indonesia located along active subduction zone, the probability of earthquake happens is higher. Ref. [3] Factors contributing to susceptibility of a certain area to earthquake-induced landslides are distance from seismic fault, slope profile types, slope angle and elevation (Huang, 2014).

B. Background

Landslide is a natural hazard that happen commonly in hilly and mountain landform with steep slope. Landslide can become a disaster when its effect cause damage to human. This study is done because study area have interesting characteristic such as the existence of geological structure, steep – very steep slope, and there are some village around. These character may become factors that dispose the occurrence of landslide that may damaging the village around.

C. Objectives

The purpose of this study is to analyze slope characteristic and the influence of surface geology characteristic toward the occurrence of landslide. The result of this study is expected to be reference in geohazard mitigation especially landslide, and to provide knowledge about landslide and several factors that affect its occurence.

II. Material

A. Regional Geology

Ref. [4] Study area located in Bandung Zone, this zone outstretched from gulf of West Pelabuhan Ratu pass through Cimandiri valley to Sukabumi, Cianjur, Bandung, Garut, Citanduy valley, ended in the Segara Anakan at South coast of Central Java. It is structurally the top part of Geanticline of Java, which has broken down after of during its arching up at the end of the Tertiary (Bemmelen, 1949).

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Ref. [5] Study area is located in Rongga and its vicinity, West Bandung. This area consist of sandstone belongs to Citarum Formation and alternation of strata claystone and sandstone, some overlaid by volcanic sediment. Average strike-dip is West-East. There are two major shear trending relatively North-South and NW-SE (Sudjatmiko, 2003). (See Fig. 2)

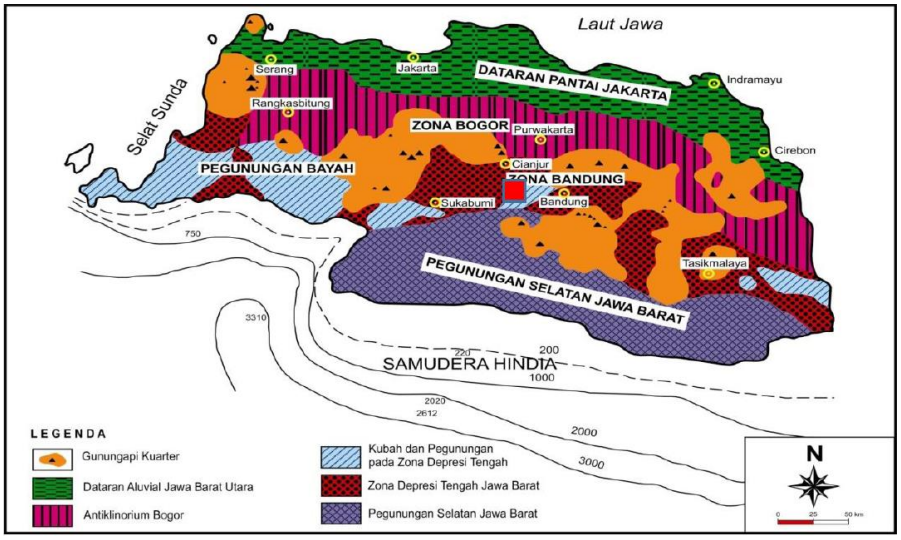

Figure 1. Study area.

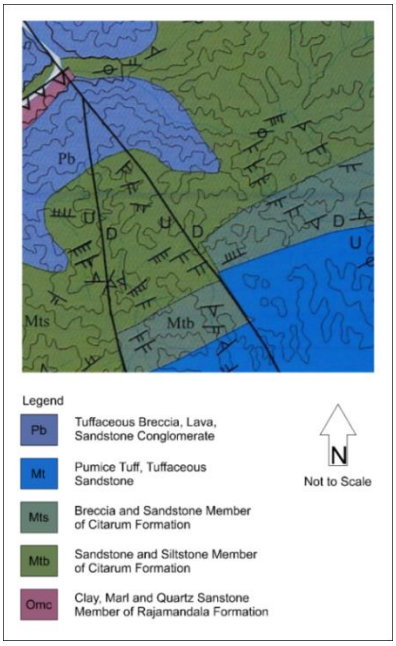

Figure 2. Regional geology map of study area, modification from Sudjatmiko (2003).

B. *Topography*

Ref. [6] Topography included in morfometrical aspect of geomorphology that consist geomorphological value such as slope, elevation point, length of slope, and hardness of relief (Zuidam, 1985). Slope classification is calculated with equation and contouring method based on Zuidam (1985).

III. Methodology

A. *Desk Study*

Desk study consist of DEM analysis, geomorphology analysis, regional map analysis, and slope calculation using GIS software. DEM (Digital Elevation Model) is satellite imagery that represent variation in terrain elevation. Lineament can be drawn and become reference to interpret geological structure, drainage pattern and slope.

Geomorphology analysis consist of morfometric analysis. Morfometric analysis used to classify and determine slope using equation (Zuidam, 1985) and contouring method with GIS software. (See Table I for Classification)

TABLE I. Slope Classification, Modification from Zuidam (1985).

Classification	Slope		Elevation Difference (m)
	Percent (%)	Degreet (°)	
Flat	0-2	0-2	<5
Gently Slope	2-7	2-4	5-25
Sloping	7-15	4-8	25-75
Moderately Steep	15-30	8-16	75-200
Steep	30-70	16-35	200-500
Very Steep	70-140	35-55	500-1000
Extremely Steep	>140	>55	>1000

Regional map analysis is early study of topographic map analysis and regional geological map analysis. Regional study consist of lithologic study, structural geology and making a plan for traversing route.

Slope calculation done using contouring method, the study area approximately 5x5 km shaded by colours that represents it's slope.

B. *Field Work*

Fieldwork consist of geological surface mapping, outcrop analysis, rock sampling, and joint density mapping. Surface mapping is the basic field work required to collect data such as lithology, outcrop data

and geological structure data. Outcrop analysis done to identify the characteristic of lithology. Joint Density mapping is done from 14 stopsite, the data processed using DIPS Software to determine major stress direction.

IV. Result and Discussion

A. Topography

Topography of study area is hilly landform with steep – very steep slope with elevation between 400 – 1000m. Calculation and result of GIS processing shows that study area has variation of slope ranging from flat to very steep slope shown in color from green to red. Center, North and Westward of study area are dominated by steep slope with slope about 30-70 in percent and 16-35 in degree, very steep slope with slope about 70-140 in percent and 35-55 in degree (Fig. 3). The area which has steep and very steep slope are predicted to become landslide potential area.

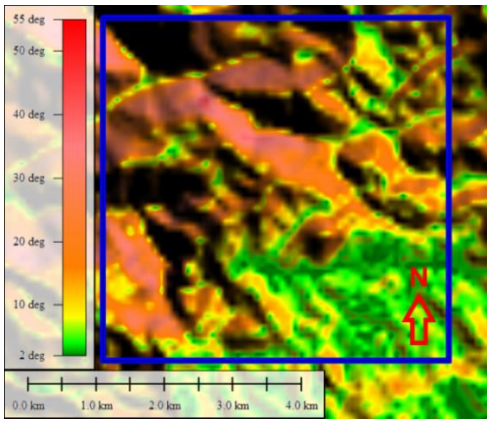

Figure 3. Slope classification based on contouring method processing using GIS software.

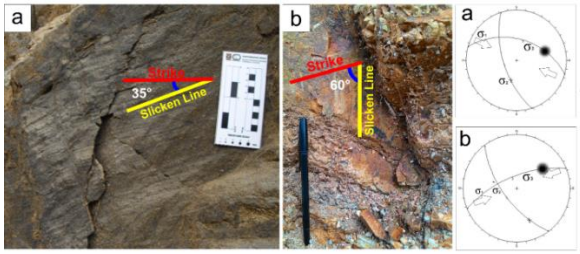

Figure 4. Fault plane and stereographic projection: a1. Fault plane with strike N162 °E/61 °pitch 35 °, stopsite C16; a2. Stereonet diagram from fault plane a1 showing major stress trending relatively NW – SE; b1. Fault plane with strike N143 °E/62 °pitch 60 °, stopsite B9; b2. Stereonet diagram from fault plane B sowing major stress trending relatively NE – SW.

B. Geology

Surface mapping data shows the lithology on the North of study area is dominantly sandstone, and alternation of strata claystone and sandstone on the South of study area overlaid by volcanic sediment. Ref. [7] Fault plane found at Buana Waterfall showing the characteristic of oblique fault – strike slip dominated (Angelier, 1994; Fossen, 2010), fault plane strike-dip N162 °E/61 ° pitch 35 ° trending relatively North – South with major stress direction relatively NW – SE meanwhile fault plane found at Cikadu showing the characteristic of normal fault, fault plane strike-dip N143 °E/62 ° pitch 60 ° trending relatively NW – SE with major stress direction relatively NE – SW (Fig. 4). Joint mapping from 14 outcrop shows major stress direction is NW – SE.

C. Landslide Issue

There are some issue in study area. Data taken on October 2014. Minor landslide reported to be happened at several area. Land clearing done to be used as agricultural land regardless of the characteristic aspect of the slope. Land clearing on the steep slope can be a potential factor that may cause landslide and damaging human life (Fig. 5). The update of data has been taken on May 2015. Landslide happens on steep – very steep area and damaging infrastructure especially road and damaging rice field and farm field. Landslide reported to be happen on January – February 2015 where rainy days occurs. High rain intensity decrease slope stability that cannot restrain its load so slide occurs everywhere especially in Langkob, Cilimus and north Cikadu (Fig. 6).

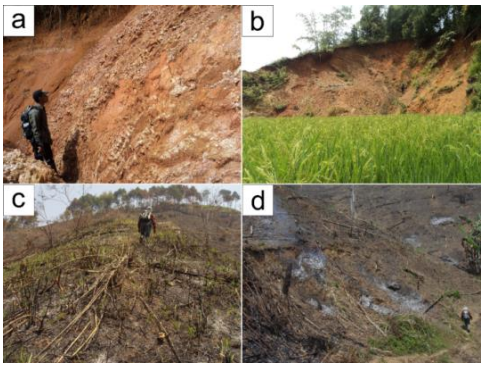

Figure 5. Landslide occurrence at soft sedimentary rocks. a. Very steep slope; b. Landslide occur at agricultural zone; c. Land clearing at very steep slope; d. Land clearing at steep slope.

From the update data, we concluded that landslides happen in study area is affected by topography (steep – very steep slope), lithology (consists of soft sedimentary rocks), and is more affected by high rain intensity than structural or tectonic activity.

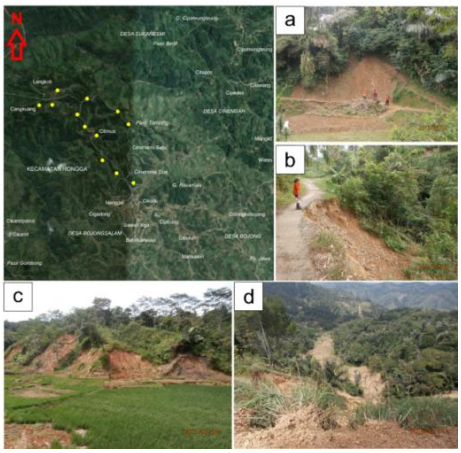

Figure 6. Map of observed landslide; a. Lanslide occurred at Cilimus; b. Landslide occurred at north Cikadu; c. Landslide occurred at south Langkob; d. Landslide occured at Pasir Tamiang.

V. Conclusion

Study area is located in hilly landform with elevation 400 – 1000m, high relief topography with steep – very steep slope. The region is highly prone to landslide due to steep – very steep slopes, the presence of soft sedimentary rocks, tectonic influence, rock weakening due to the presence of intensive joint, high erosion activity, weather influence and land clearing in several area. However, this study is only preliminary study and there are other parameters that need to be considered to decide landslide zonation. Geotechnical parameter for example slope stability which depended on several factors such as geological condition, topography, seismic activity, weather and another technical parameters need to be considered.

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