IOP Conf. Series: Earth and Environmental Science **106** (2018) 012002 doi:10.1088/1755-1315/106/1/012002

Analysis of slope stabillity and controlling factor on residual soil of folded breccia formation

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Abstract. This research aims to obtain a potential landslide zonation.Theresearch area is located in Depok Village and surroundings, Jatigede District, Sumedang regency, West Java province. Geographically located at the point of coordinates 06°50'33 "- 06°51'00" South Latitude and 108°05'37 "- 108°06'17" East Longitude. This research is intended to mapping the identification of landslide and soil properties data. The mapping and soil sampling were conducted only in the research area. The methodology used was mapping and finding the safety factor with Bishop Analysis. The morphological condition of the study area indicates moderate conditions undulating hilly area with slopes between15° - 40°, with a tick soil layer was covering the slope. This condition is greatly affected by rainfall. This research is to know the type of ground movement along with the value of the safety factor of the slope so that can provide suggestions for overcoming instability in the study area.
Keywords: bishop, landslide, safety factor

1. Introduction

The process of moving large material from one place to another lower due to the influence of gravity both fast and slow [1]. The slope material may consist of soil or rocks [2].

Slope stability is one of factor in occupation that related with mining and human activities of construction. Anthropogenic activity such as excavation and ground levelling, can modify the existing environmental condition, including soil composition [3].

This stability of slope is related with availability of various works, i.e. at construction site, dam construction, road making process and irrigation flow etc. In doing the activities it was necessary to make anticipation about the slope problem. Each slopes have differ stability, so it is necessary to get some information related to slope stability. The information about the zoning of landslide potential areas is very important to be used as a basis for consideration of regional development. This matter is done to reduce victim that caused by landslide. This research is intended to mapping the identification of landslide and soil properties data [4]. This research aims to obtain a potential landslide zonation in a downstream of Dam. These natural phenomena included in one of most economic-destructive disaster, either wealth loss or victim especially if it occurred in crowded area where people do daily activities. Even though land slide cannot be prevented, however there is a possibility to reduce the cause of this disaster.

2. Research Method

In this research, the method is using basic geological mapping, lab analysis and studio analysis, therefore in this research can be divided into several steps (Figure 1).

2.1. Geological setting and analysis of slope stability

2.1.1. Geomorphology of Area

According to researchers [5] in the study area is divided into 3 forms of morphology based on relief, i.e. :

1) Geomorphological Unit of Fluvial Plain
2) Geomorphological Unit of Wavy Hills
3) Geomorphological Unit of Very Steep Hill.

2.1.2. Geomorphological Unit of Fluvial Plain

This fluvial plain geomorphological unit is located in the southern and south western of research area. The spread of this morphological unit occupies about 20% of the total research area. In this plain fluvial area, there are river stream. In this unit also found a high erosion river.

This geomorphological unit is located in southwestern and eastern researched area. Distribution of this unit cover in about 50% of the total researched area. With the percentage of degree of slope 14%-20%, and has a difference elevation of 180 m -27 m, with parallel contour pattern and corrugated contour pattern.

This very steep hill geomorphological unit is located alongside the western area. Distributions from this geomorphological unit cover about 30% from the total of researched area. With percentage of slope degree 21% – 50%, and have altitude 210 m – 300 m, with rounded contour pattern and wavy contour pattern. Lithology in this unit is claystone and breccia tuff.

2.1.3. Stratigraphy of Area

According to researchers [5], researched area can be categorized in Bogor Zone. And based on Physiographic Zone, this area has age comparison according to researcher [6]. Stratigraphy of researched area is described as from older age to the younger one: Volcanic Breccia Unit, Claystone Unit, Breccia Tuff Unit and Alluvial.

2.1.4. Volcanic Breccia Unit

Outcrops are clearly visible to be observed as they appear along the cliff. However, at some place this unit quite weathered. This breccia has characteristic like fragmentation with pebble size and categorized as andesitic. The andesitic categorized due to its dark grey colored outcrop with sandstone matrix.

2.1.5. Claystone Unit

Outcrop looks quite fresh as exposed in the cliff. This unit has properties that are easily expandable and in the field will look like inserted with volcanic breccia and breccia tuff. This unit consists of claystone that have clayey property. The appearance of this unit has gray color, soft and cracked.

2.1.6. Alluvial

This unit named with river deposition because in this area, occurred river depositions formed pebble and cobble stone. Deposition type that visible looks vary from fresh cobble to weathered cobble. This unit consists of river deposition from clay size, sand size, to cobble deposited mainly in river base and at the base of a cliff.

2.1.7. Rainfall

In research area, rainfall is effected by topographical of surrounding area, and weather condition of research area. The rainfall intensity on this area is about 2500 – 3000 mm/year. Rainfall condition on this area as one factor of landslide occurrence, if those areas have high intensity of rainfall and poor-resistant lithology so it is possible to occur a landslide.

2.1.8. Land Use

The land use of research area divided into 5 (five) cover of land use

1) Paddy field
   This land use cover about 10% from the total of land use. The paddy field located at eastern of research area with wavy hill-shaped geomorphology.
2) Bushes
   This area covers about 40% from area the total of research area. The bushy area located in northern and southwestern area with steep hill-shaped geomorphology.
3) Settlements
   The settlement area covers about 20% area from the total of researched area. This settlement located in eastern and southeastern of research area with wavy hill-shaped geomorphology.
4) Field
   The field of this area covers about 10% area from the total of research area. The field is located in eastern of researched area with very steep hill-shaped geomorphology.
5) Farm
   Farm in this area cover about 20% area from the total of research area. The farm area is located in northern and southwestern of researched area with steep hill morphology.

2.2. Slope stability analisys

The research area divided to a several segment with some section. This division purposed to acquire the Safety Factor Score (SF Score) to know a land movement on that cell area (Figure 1).

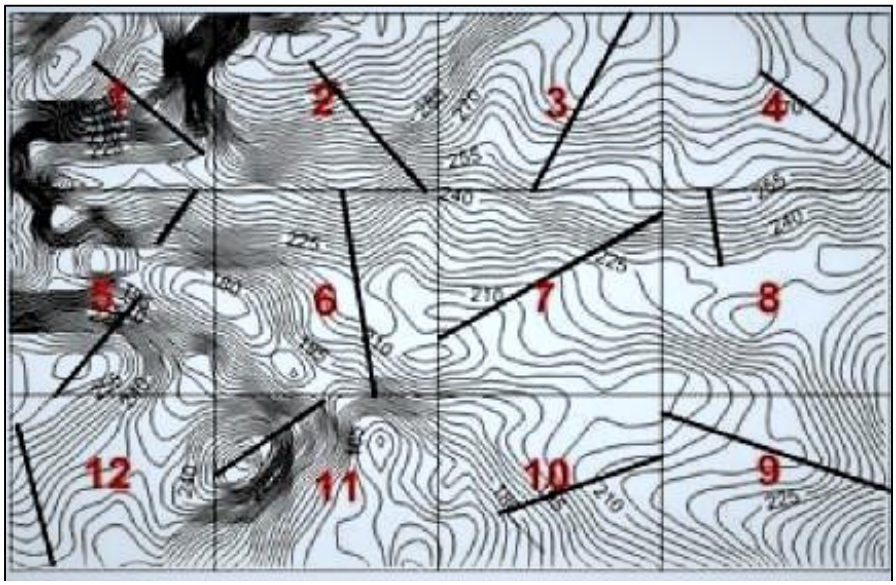

Figure 1. Safety Factor Score (SF Score) to know a ground movement on that CELL area.

Table 1. Safety factor analisys in the Cell area.

No	Cell	Slope angle (degree)	Safety factor	Remark
1	2	22	1.520	Stable
2	3	16	1.337	Stable
3	10	18	1.397	Stable
4	9	19	1.347	Stable
5	12	19	1.388	Stable
6	6	26	1.820	Stable
7	7	19	0.540	Landslidealreadyoccurredbefore

No	Cell	Slope angle (degree)	Safety factor	Remark
8	4	12	1.047	Critical
9	8	19	1.156	Critical
10	11	-	-	Rock
11	1	-	-	Rock
12	5	-	-	Rock

Based on safety analysis factor in the cell area, slopestability and also relatively unstable slope with sometime or frequent chance of landslide occurrences was obtained (table.1).

3. Results and Discussion

3.1. Geomorphological Effect

Geomorphological effect to ground movement is caused by some factors that caused landslide; morphology shape, slope tilt, rock condition of an area, rainfall intensity and land use [7]. In research are a geomorphological unit divided into low tilted geomorphological unit, wavy hill geomorphological unit, and steep hill geomorphological unit. Indication of landslide occurrence caused in very steep geomorphological unit where the slope on that area is quite steep.

3.2. Rainfall Effect

Rainfall can trigger a landslide trough accumulation of slope weighting and increasing pore in land or rock. Rainfall is a main factor of a landslide occurrence if the intensity of rainfall is very high so that speed up the erosion and weathering process in rock. Also in this area, the rainfall is categorized as a normal one 2500 – 3000 mm/year.

3.3. Land Use Effect

In research area, land use including paddy fields, bushes, settlements, field, and farm. The vulnerable area from a landslide are located in paddy field and field area. Paddy field area are more vulnerable than bushes, settlements, field, and farm area. This is happen because water is saturated in paddy field area so that creating a sliding plane especially in steep slope. If the intensity of rainfall in research area is high, it will cause a water accumulation so that potentially to occur a landslide

3.4. Lithological Effect

In the research area, lithological unit is divided by 3 (three) units [2]. Breccia tuff unit, claystone unit, and volcanic breccia unit. From that three unit, breccia tuff are very vulnerable of landslide because the physical properties of this unit is very easily weathered.

3.5. Vulnerable Zone of Ground Movement

Vulnerable Zone of Low Ground Movement

1) Cover plain fluvial geomorphological unit (0 – 2 %)
2) Lithology: breccia tuff
3) Land use: farm, bushes
4) Have safety factor score (SF) between 1,397 – 2,190 and included in relatively stable slope with rare chance of landslide

Vulnerable Zone of Middle Ground Movement

1) Cover steep hills geomorphological unit (14 –20%)
2) Lithology: breccia tuff, claystone, and volcanic breccia
3) Land use: bushes and farm
4) Have safety factor score (SF) between 1,330 – 1,049 and included in critical slope with single chance of landslide

Vulnerable Zone of High Ground Movement

1) Cover very steep hills geomorphological unit (21–55%)
2) Lithology: breccia tuff, volcanic breccia
3) Land use: bushes
4) Have safety factor score (SF) between 0.540 – 0.525 and included in slightly unstable slope with normal or frequent chance of landslide

3.6. Landslide Mitigation

There are several ways to overcome a disaster especially landslide. There are reducing water intake on the surface, big-root tree planting to reduce water flow on the surface, make a steep slope to a more plain, reducing pore pressure on slope, installing wall like *'bronjong'*.

4. Conclusion

Morphology of research area according to geomorphological analysis can be divided by 3 (three) geomorphological unit there are, plain fluvial geomorphological unit 0 – 2 %, and very steep hills geomorphological unit 21–55%. River flow pattern in research area are dendritic with adult stage. Lithological unit in researched area divided into 4 (four) units from old to young there are. Volcanicbreccia unit, claystone unit, brecciatuff unit, andalluvial. Rainfall intensity at researched area is about 2500 – 3000 mm/year. Land use of researched area divided into 5 (five), there are rice fields, bushes, settlement, field, and farm. From slope stability analysis of research area, slope stability divided into 3 (three) there are vulnerable zone of low ground movement, vulnerable zone of middle ground movement, and vulnerable zone of high ground movement. The mitigation of the area which have a moderate to high ground movement should make a plain slope, and also make some drainage control, make a holding wall and installment of wall like *'bronjong'*.

Acknowledgment

Acknowledgments to the Dirjen DIKTI for grant competed with the organization. And support in geology engineering programs.

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