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The Effect of Soil Cracks on Cohesion and Internal Friction Angle at Landslide

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ABSTRACT

In most cases of landslide in Indonesia and elsewhere in the world there is the fact that landslide occurred during heavy rains, landslide may occur anytime in the rainy season, landslide occurs on rocky slopes or on the stiff silty or clayey soilwith a hard layer, landslide occurs on relatively gentle slopes, landslide does not occur on all part of the slopes even though the condition of rocks and soil along the side of the road is relatively same and the intensity of rainfall are practically the same. In areas with frequent landslide, the data surveyed from some field drill results on the ground outside the landslide area showed that the layers of soil on the slopes of the mountains was not saturated, and the ground water level is quite deep. A preliminary investigation showed that the soil cracks has occurred on the slope. The cracks occur due to soil movement or weathering by plant. Cracks in the soil can be short or long and even form a potential areas of landslides on the slopes. The cracks area is then filled by rainwater. This rainwater that fills the cracksarea causes the independent pore water pressure on the slopes. The purpose of this research is to analyze the influence of cracks on the shear strength parameters of cohesion (c ') and the internal friction angle (ϕ). A series of laboratory activities carried out by varying the cracks in the test specimen ranging from 0% to 75% then testing using the direct shear test tool that has been modified. The results showed that the cracks in the soil greatly affects the decrease in cohesion but did not significantly affect to the internal friction angle.
KEYWORDS: Slopes, landslides, rain, cracks, cohesion, internal friction angle

INTRODUCTION

Until recent time, calculation of slope stability is based on the assumption that the shear field is a circle, shaped logarithmic-spiral or in form of trapezium and triangle. The slope safety factor are calculated on the basis of slice principle, for example the most famous are Bishop's methods [1], also by the stability of triangular or trapezoidal ground blocks methods. The basic assumptions of soil shear strength used in the above methods are as follows:

a) Before collapse when experiencing a slide, the soil is intact and does not crack. The shear field occurs after the driving forces in the ground exceed the shear forces of the soil.
b) Soil shear strengths are assessed on the basis of the shear strength of the original soil obtained from the Triaxial Test as well as from the Direct Shear Test performed on the ground specimen which is intact and not cracked.
c) Soil testing can be done in saturated and unsaturated conditions, and soil shear strength is also highly dependent on pore-water pressure occurring on saturated soils, and from pore-air pressure occurring on unsaturated soils; which occurs in the sliding plane when the soil is in ruins.
d) Soil shear strength and pore-water pressureare also highly dependent on the original soil conditions (granular/coarse grained or fine-grained soil), speed of rupture (fast or slow), and stress history of soil in the past (consolidated or unconsolidated) from the soil that collapsed.

Many researchers were in agreement that heavy rainfalls were related directly to the failure of many slope [2] [3] [4] [5], but the mechanisms of how the heavy rainfalls may cause the slope to slide are not yet understood [6]. In most cases of landslide in Indonesia and elsewhere in the world, the landslide generally occurwithin the following conditions [7]:

a) Sliding occurs during heavy rainfall to very heavy rainfall. Almost no land slide occur during the dry season.
b) Sliding may occur at any time during the rainy season, either at the beginning, in the middle, or at the end of the rainy season. So the sliding is not a function of the duration of the rainy season.The important factor is the intensity of the rain, heavy or not.
c) Many long-standing slopes in the field - many years, even decades - are in stable condition, but suddenly rupture and slides during heavy rainfall, especially if the rain continues for days with high intensity.
d) Many landslidehappen on rocky cliffs or from dominant land of rigid clay and contains stifflayer of soil, which if investigated on the soil there will be a stable slope stability (safe). In reality, the landslide is still

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occur. This is due to soil conditions on rocky slopes, it is very difficult on the ground to drill or to do CPT test because the drill and the end of the CPT cone cannot penetrate the stones. Based on these facts, the slope can be considered stable.

e) In some part of the slope, the movement of the slope still occurs although the slope is not relatively steep. So, if this slope evaluated the stability of the slope based on the original soil data, will obtained the eligible slope safety factor (>> 1.0). Generally also in these conditions, the movement of sliding always happens during or after heavy rain.

f) In areas that are often slides, drill results from the field on the ground outside the field of landslide indicate that the soil layers on the slopes of the mountains are unsaturated, and the ground water level is quite deep. So slope or landslide is not affected by the saturation of the soil.

g) The movement of landslides on the slopes along the sides of a highway in the mountains usually occurs in certain places only. Landslides do not occur on all part of the slopes along the road, although the rock and soil conditions along the side of the highway are relativeequal. Landslides does not occur simultaneously along the slopes, but alternately from one place to the other, whereas for the entire length of the road in question it turns out that rainfall and intensity are practically the same.

Based on this field incidents that are not in accordance with the assumptions that have been used, it is necessary to found a new way to analyze slope slides in accordance with the field incidents conditions.
The observations result in the field found that the most likely assumption for the occurrence of field slump phenomenon as described above, is that in the soil layer within the slope there has been previous cracks as shown in Figure 1. Initially, small and shallow cracks has occur in soil on the slope. The cracks propagate deeper when the rainfall is heavy. If the rain intensity is high and the rainfall occurs in many hours, the cracks in soil become deeper and the crack will become a sliding plane. The cracks determine the stability of the slope.

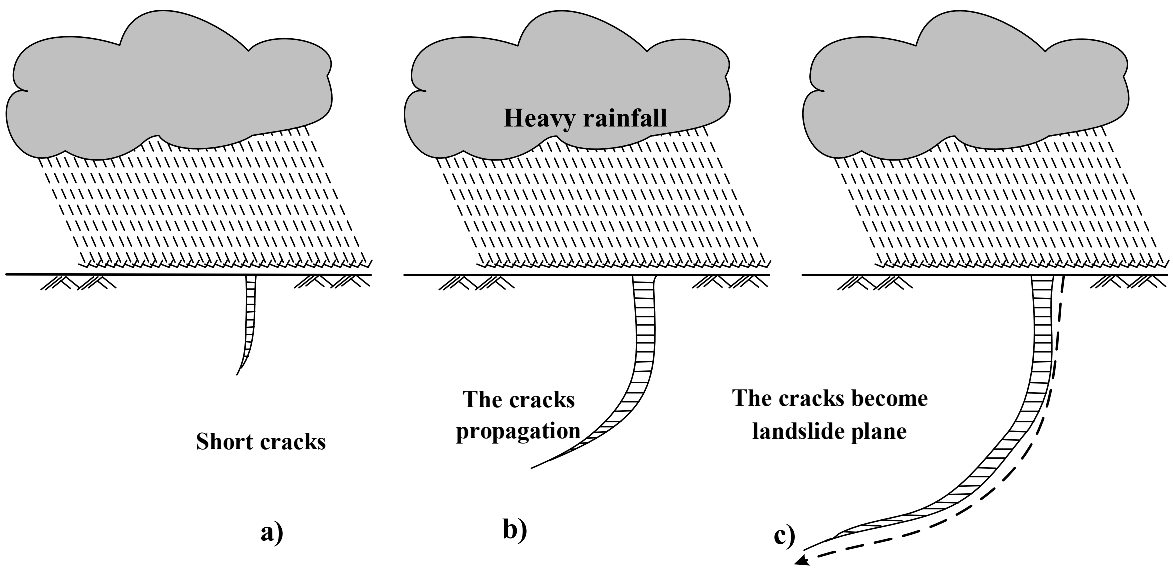

Figure 1.The cracks propagation on landslide

The short crack may occur due to the movement of soil, different types of soil layers, or the presence of rotting plant roots [8]. The cracks change depending on soil conditions. As long as the crack length is relatively short, the slope is still in stable condition. As the ground moves and the water pressure that fills the crack field go up, the crack will propagate to become longer. The assumption of a cliff occurrence is thought to be caused by a cracking crack as described in Figure 1. In Figure 1 illustrates that the crack plane is gradual and propagates in such a way as the potential landslide plane, so that at one time the cliff landslides during heavy rains. At a time of heavy rain, water fills a small cracked field (Fig. 1.a). Due to the high rainfall intensity, rainwater makes the crack plane radiate deeper on the cliff (Figure 1. b). Along with the high rainfall intensity and long rain, the crack field gradually creeps deeper and forms a landslide field on the cliff (Fig. 1.c) so there is a slide on the slopes or cliff. Based on Figure 1 can be answered why the slopes that have been stable for years suddenly experienced a slidingwithin the heavy rainfall.

MATERIALS AND METHODS

The laboratory test is conduct using a modified direct shear test apparatus to test the soil according to the assumptions above, as shown in Figure 2.Laboratory investigations were carried out by testing the specimens in the intact soil and crack conditions. The soil that is used as specimen is clay soil that has physical properties of soil volume wieght (γm) = 1,82 - 1,93 kg/cm3, natural water content (w_n) = 33,19% - 37,53%. Clay dominates the volume of the soil but there is also a bit of gravel and sand. Fine grains percentage is 60% - 80%, and coarse grains percentage is 20% - 40%. The result of soil classification test based on Atterberg Consistency Test shows that the soil is clay with plasticity index16.63.In laboratory testing, the crack conditions were varied from 25% to 75% to diameter of specimen.

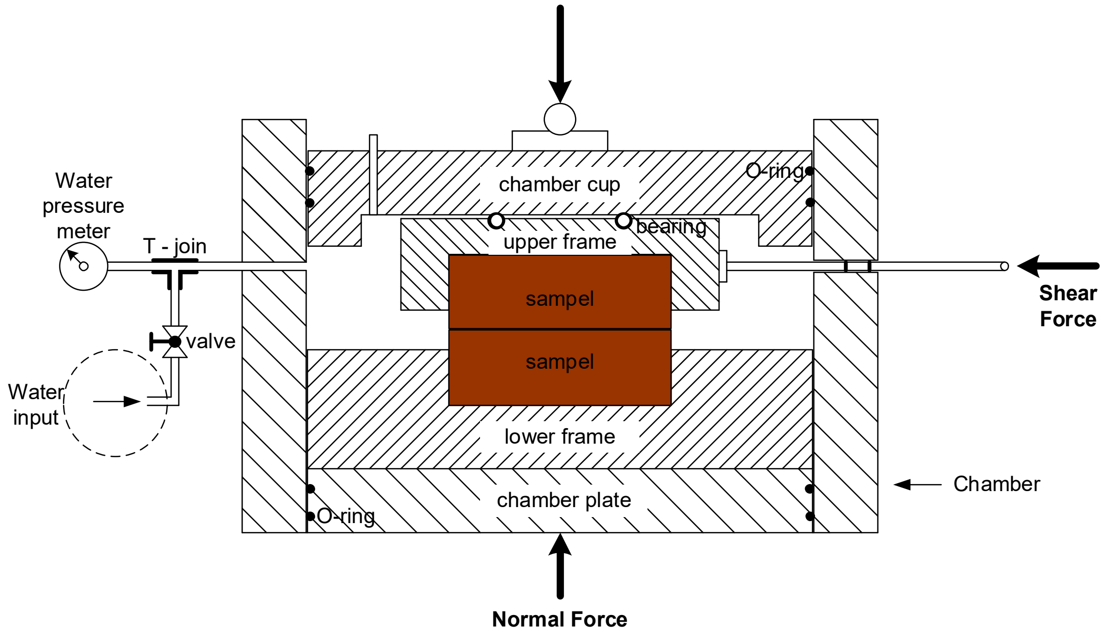

Figure 2. Modified direct shear test apparatus

RESULTS AND DISCUSSION

The results of the laboratory investigation are shown in Figure 3 and Figure 4. Figure 3 shows the effect of the length percentage of cracks on the change in soil cohesion values. Based on Figure 3 it can be seen that the soil that originally had cohesion before cracking was 0.3281 kg/cm^2, after cracking up to 75% will decrease to 0.1472 kg/cm^2. After correction of the cross-sectional area, the apparent cohesion value for the soil at 75% crack is 0.0642 kg/cm^2.

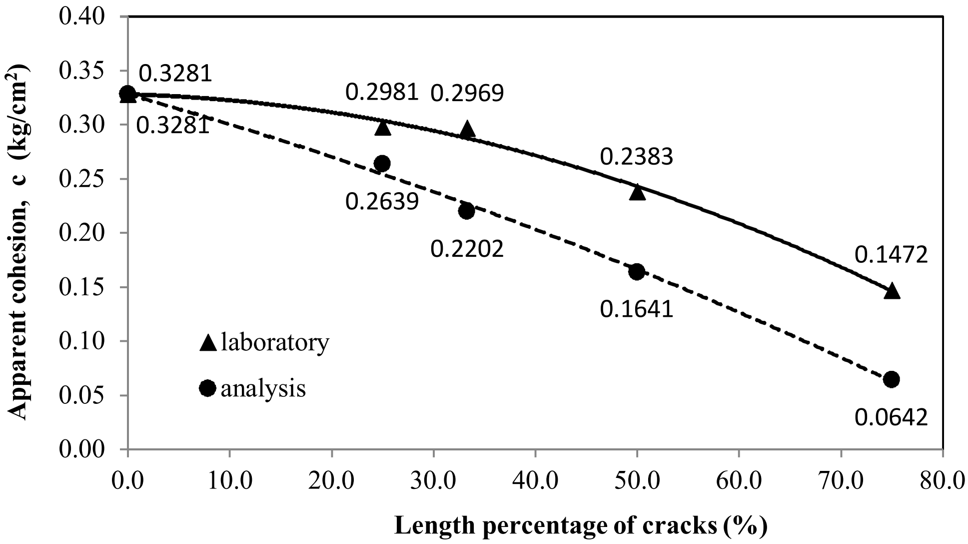

Figure 3.The effect of cracks propagation on cohesion

The test results of crack propagation effects on the internal friction angle of the soil are shown in Figure 4. Based on Figure 4 it can be seen that the internal friction angle has not changed due to cracks in the soil. Internal friction angle before crack is 17,43° and after crack and corrected to cross section area become 17,42°.This results are very much in agreement with the drained strength behavior of shearing strength alongside of model pile in Kaolinite Clay [9].

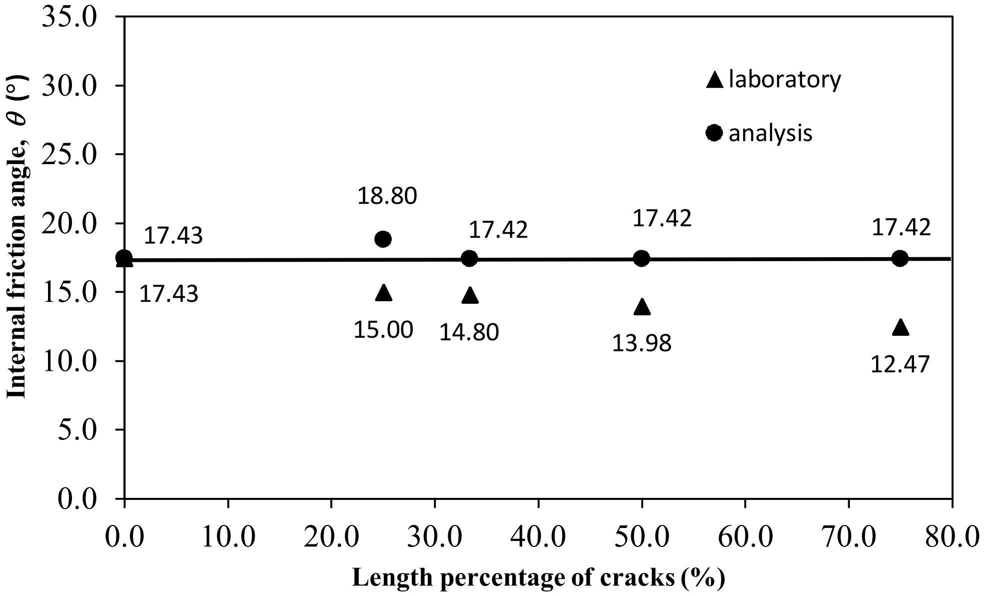

Figure 4.The effect of cracks propagation on internal friction angle

From the test results in Figs. 3 and 4, it can be seen that the former soil is clay soil that has a cohesion value of 0.3281 kg/cm^2 and internal friction angle of 17.43°, after cracking up to 75%, the soil has cohesion value 0.0642 kg/cm^{2}only and internal friction angle 17,42°. The results of this study indicate that the original soil condition which is clay with some internal cohesion and friction angle, when cracked into clay soil, becomes a soil that has the value of internal friction angle only.

CONCLUSIONS

1. Cracks in the soil have been found in a series of laboratory tests. The crack is the main factor of slope sliding during heavy rainfall.
2. Cracks in the soil resulting the soil that having the value of internal cohesion and friction angle, into the soil that only have internal friction angle values. It shows that crack will result in soil condition having behaving like sand.
3. Crack propagation greatly affects the value of soil cohesion.
4. Crack propagation does not affect the internal friction angle.

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