Proceeding International Conference on Green Agro-Industry
Volume 4, 2020 | Pages : 333-338

Slope Reinforcement Method With Green Construction Concept To Reduce Risk of Landslides

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Abstract.

Landslides are common events that occur on a slope structure, this event can occur on land slopes or rock slopes. Landslide events may occur on natural slopes or man made slopes. Improvement of the slope stability, aims to reduce the forces that move the landslide mass, and increase the shear resistance of land itslef. Methods for improving slope stability that are recommended for being environmentally friendly are geometric slope improvements, improvement and addition of horizontal drainage systems, and slopes strengthening with vegetation (soil bioengineering**).**

1. Introduction

Landslides are common events that occur on a slope structure, this event can occur on land slopes or rock slopes. Landslide events may occur on natural slopes or man made slopes. The occurrence of landslides is caused by the movement of soil or rock mass due to the collapse of the shear strength of the soil or rock mass along its potential landslide field. Hardiyatmo (2012) states that mass movements that trigger landslides are generally caused by gravitational forces, and / or vibrations caused by earthquake events or by other sources of vibration.

The number of landslide events that occurred in Indonesia, encourages us to take anticipatory steps to prevent or reduce the occurrence of landslides, so that it can reduce the losses that occur due to landslides and of course also reduce fatalities due to landslides. One of the anticipatory steps taken to prevent landslides is to improve slope stability. The improvement of the stability of the slope aims to reduce the forces that move the landslide mass, and increase the soil shear resistance (Hardiyatmo, 2012). Recommended methods for improving slope stability because they are environmentally friendly are geometric improvements to slopes, repair and addition of horizontal drainage systems, and strengthening slopes with vegetation (soil bioengineering). The purpose of this study is to examine several slope reinforcement methods that have the concept of environmentally friendly structures (green construction)

Green construction is a structural concept which is a sustainable movement that aspires to create construction from the planning, implementation that use environmentally friendly construction products. (Harimurti, 2012).

2. Material and Methods

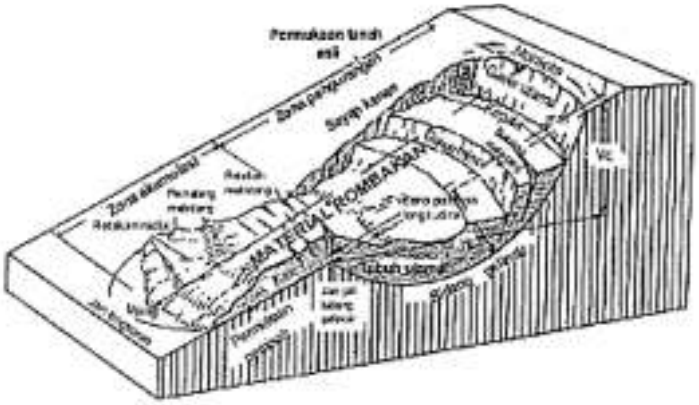
This research is a library/ literature research namely by taking data and information sourced from reference books, encyclopedias, and scientific journals. Data taken from scientific journals from the identification studies, investigative studies, and detailed design studies. With the limitation of qualifying scientific articles that are used as references, it is expected that the method of library research conducted will present the latest literature.

3. Result

3.1. Triggering Factors of Landslides

The initial occurrence of landslides is marked by the presence of cracks at the top of the slope which are relatively perpendicular to the direction of movement. In the rainy season, if the cracks have not been closed or not immediately closed, they will be filled with rain water which will then make the soil soft and will also add horizontal forces that encourage landslides. Landslide sections are shown in Figure 1.

Figure 1. Landslide cross section



Gambar 1. Penampang Longsoran
(Cruden dan Varnes, 1996 dalam Hardiyatmo, 2012)

Landslide events occur because of some causal factor, where these factors will become active if there are trigger factors that activate them. Factors causing landslides are defined as factors that make slopes vulnerable to collapse at certain locations and times. In general, the factors causing landslides are caused by geological factors, morphological factors, and human activity factors. While the trigger factor is a single event that drives the cause of a landslide, these trigger factors include: rain, earthquake, and volcanic activity. Table 1 below describes the factors that cause landslides.

Table 1. Causing Factors of Landslides (Muntohar, 2012)

Group Factors	Source Cause
Geological Factors	1. Weak and sensitive rock layers
	2. Weathering of rocks
	3. Shifting rocks
	4. Cracks or confluence of rock layers
	5. Difference in permeability of soil layers
	6. Difference in rock strength
Morphological Factors	1. Tectonic or volcanic removal
	2. Ice layers
	3. Erosion

	4. Change the location of the load on the slope
	5. Plants on the slope
Human	1. Slopes excavation
Factors	2. Deforestation
	3. Mining
	4. Artificial vibration due to explosion

According to Vernes (in Muntohar, 2012) slope will experience a collapse or landslide mechanically caused by two components, namely increased shear stress and reduced shear strength. The increasing value of the shear stress on the slope is influenced by:

a. Adding loads to the slope, for example, the addition of building structures and embankments at the top of the slope

b. Eliminating reinforcement structures due to cutting and moving of the foot section of the slope, or collapse of the retained slope

c. Changes in groundwater levels very quickly on the slope

d. The force from an earthquake which causes an increase in force that pushes a block of mass in the horizontal direction

Another factor that causes mechanical landslides is reduced shear strength, according to Ralph and Peck (in Hardiyatmo, 2012) is caused by:

a. Increased pore water pressure due to infiltration of water into the slope, uncontrolled water discharge in the drainage channel, or earthquakes which results in increased pore water pressure.

b. Soil on slopes contains clay minerals that expand so that it is easy to absorb water but can eliminate soil adhesiveness.

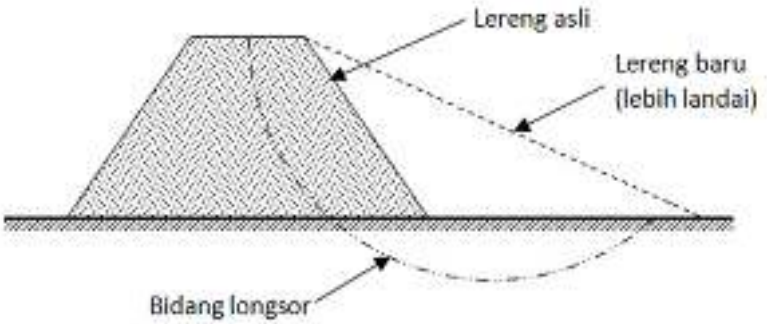
c. Weathering and physical-chemical degradation due to ion exchange, hydrolysis, and salting.

d. Gradual collapse due to strengthening of shear strain softening

1. Improve Slope Geometry

Improving the geometry of the slope aims to reduce the force or moment of movement by changing the shape of the slope. Improvement of the geometry of the slope is done by making the slope more gentle or reducing the slope angle, and or reducing the height of the slope.

Figure 2. the concept of inclining the slope



Gambar 2. Konsep melandaikan lereng (FHWA, 1988)

Figure 2 is the concept of improving the slope geometry by reducing the slope degrees, where the important thing to consider in changing the geometry is the sloping marking work must cover the foot of the landslide area. Sloping the slope that does not cover the foot of the landslide area will only add to the forces that cause the slope movement.

Figure 3. concept of traps / benches for the improvement of the slope geometry

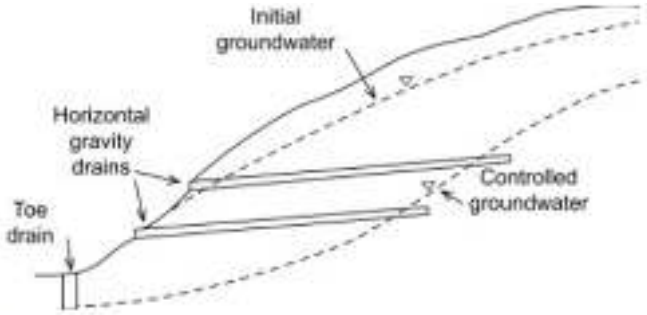
Gambar 3. Konsep trap/bangku untuk perbaikan geometri lereng (FHWA, 1988)

Trapping or bench-shaped excavations as in Figure 3. are carried out on steep slopes, where repairs by this method are carried out if the slope is not possible to be sloped.

2. Controlling Drainage and Seepage

The main purpose of using drainage to support slope stability naturally is to drain groundwater out of the slope so that the soil remains dry. The study of slope collapse due to the water infiltration process conducted by Muntohar (2006) concludes that changes in water content due to water infiltration into the soil will immediately increase water content and reduce shear strength in the soil. Water flow in the soil will accelerate the process of slope collapse, this is because water can reduce the level of viscosity of soil grains. Increasingly the water that enters the pores of the soil or stagnant on the surface of the soil will accelerate the collapse of the soil.

Figure 4. the concept of horizontal slope drainageimprovement of the slope geometry



Gambar 4. Konsep drainase horisontal lereng (Nicholson, 2015)

4. Vegetative Strengthening Methods

Sittadewi (2017) explains that soil bioengineering or slope strengthening methods using vegetation or plants, has an important role, especially in reducing the surface flow velocity which can wash away soil particles that are not dense. For the application of soil bioengineering, vegetation is needed that meets the criteria, including fast growing, has a deep root penetration system and the ability to bind the soil well and can live on various types of soil. The type of root fibers can form natural nets that serve to strengthen the soil so it is not easily carried by surface water flow.

The main advantage of having a plant on the stability of the slope is its roots which mechanically strengthen the slope-forming soil. Tall and strong plant stems have a function like anchors that work as a barrier to the downward slope movement, even if under certain conditions due to the load of wind that moves the stems of the plant will also make these plants as dynamic loads that disturb the stability of the slope. One alternative to the vegetative strengthening method is to choose plants that are small but have deep roots and have a high density.

Akar Wangi (vetiviera grass) is one of the plants that can be used as a slope strengthening vegetation. Agustina (2012) in her research on the effect of vetivarias on slope stability, concluded that the use of vetivarias as a stabilization method can improve the stability of the slope, from the results of tests on soils planted with vetivary grass. show increased shear strength. Hamdhan (2018) in his research on Akar wangi (vetiviera grass) recommends that the role of Akar Wangi (vetiviera grass) in supporting slope stability is effective if planted in regular patterns and distances.

5. Conclusion

Landslide is a common event that occurs on a slope structure, this is caused by the movement of soil or rock mass due to the collapse of the shear strength of the soil or rock mass along the field of potential landslides. Green construction is a structural concept which is a sustainable movement that aspires to create construction from the planning, implementation and use of environmentally friendly construction products. The right methods to improve slope stability in accordance with environmentally friendly concepts are geometric improvement of slopes, repair and addition of horizontal drainage systems, and slopes strengthening with vegetation (soil bioengineering).

Acknowledgments

Thanks to the Lembaga Penelitian dan Pengabdian Masyarakat (LP2M) Universitas Pembangunan Nasional Veteran (UPNV) Yogyakarta for funding this research through the 2019 Cluster Research Scheme.

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