CERUCUK
Volume 7 No. 6 2023 (304-311)

STUDY OF PLANT ROOTS ON INCREASING THE SHEAR STRENGTH TO PREVENT SCOURING ON SOIL SLOPE SURFACES OR SHALLOW SLIDES

Innocentia Eka Aulia, Rusdiansyah
Civil Engineering Study Program, Faculty of Engineering, University of Lambung Mangkurat
Jl. A. Yani KM. 36 Banjarbaru, South Kalimantan, Indonesia
Tel. (0511)47738568-4781730 Fax (0511)4781730
e-mail: innocentia413@gmail.com, rusdiansyah74@ulm.ac.id

ABSTRACT

The phenomenon of soil scour is influenced by several factors, namely, continuous rainfall, slope, and soil movement. This causes landslides, especially on slope surfaces. The use of vegetation can be used as an effort to overcome shallow landslides on a slope.

This study aims to determine the characteristics of the soil, the effect of plant roots on the shear strength of the soil by using a direct shear test tool and to determine the safety value on the slopes by using Geo5 application analysis. The types of plant roots used in this study were Paitan grassroots, Teki grassroots, Setaria grassroots, Gajah grassroots and Alang-Alang grassroots.

From the results of the direct shear test, the shear strength value of the soil and Paitan grassroots was 101.433 kg/cm^2, the soil with Teki grassroots was 99.392 kg/cm^2, the soil with Setaria grassroots^2, Alang-Alang grass is 123,730 kg/cm^2 and the highest value is found in the soil and Gajah grassroots which is 105,7039 kg/cm^2. With the characteristic form of fibrous roots and able to grow to very deep depths, the roots of these plants can have a great impact on soil shear resistance. The greater the diameter and root content in the soil, the greater the shear resistance. The presence of plant roots has proven to be helpful in increasing the holding moment even after erosion has occurred. It can be said that the presence of plant roots on slopes is one of the potential solutions as an effective, economical, and environmentally friendly method.

Keywords*:* shear strength, retaining moment, safety value, plant roots, erosion

1. INTRODUCTION

Soil movement due to changes in the shape of the soil structure is a very common thing. With various causes, the occurrence of this movement is commonly referred to as the landslide phenomenon. Rainfall with high intensity and long time is often the reason for landslides, especially on the surface of a slope. Many efforts have been made to overcome these landslides, one of which is *soil bioengineering, namely* the use of parts of a plant to strengthen shear strength and soil resistance. In this study, the use of plant roots was carried out as an effort to deal with landslides. With the characteristics of the roots gripping the soil, it is expected to be able to provide additional strength to the soil. Research by Santiawan et al (2017, pp 11-23) proves that the addition of Gajah grassroots can increase the safety factor on soil slopes. In addition, in a study conducted by Nugraha et al (2016), *switchgrass was able* to increase the safety factor value of 16.24% compared to slopes without plant roots. Apart from these two types of plants, Vetiver grassroots still be favorite in slope stabilization. However, the difficulty of finding vetiver grass outside of Java and the less adaptive characteristics of Vetiver underlie other studies to find plant species that are more effective, economical, and easy to find anywhere.

2. LITERATURE REVIEW

Theory and Mechanism of Slope Collapse

A landslide is evidence that a soil structure has changed shape so that it is no longer able to withstand the load and water pressure on it (Priyono, 2014-2015). Based on the depth of landslide events can be distinguished as follows.

Table 1. Landslide Depth Classification

NO	Landslide Type	Depth (m)
1.	Surface Slide	<1,5
2.	Shallow Slides	1,5-5,0
3.	Deep Slides	5,0-20
4.	Very Deep Slides	>20

The failure that occurs when the deformation occurs indicates that the shear stress applied to the soil has reached its critical value. This theory is known as the Mohr Coulomb theory (Das, Endah & Mocthar, 1995). This theory states that the shear stress in the soil has a functional relationship with cohesion and friction between soil particles, so that:

$$\boldsymbol{\tau = c + \sigma \tan\phi}$$

Description:

τ = soil shear stress

c = cohesion

= normal stress

= shear angle in

SOIL BIOENGINEERING

This method utilizes parts of a plant as living material. In handling slope failure, this method is a conservation measure by covering the slope surface with plants, with the aim of reducing infiltration that occurs in the soil (Nugraha, Yudistira, Hamdhan & Noer, 2016). The influence given by plants consists of hydrological mechanisms in the form of evaporation and absorption by leaves and absorption by roots so that the transpiration process occurs and can reduce positive pore water tension. And a mechanical mechanism in which the ability of roots to add strength to the soil, the ability of roots to grip or anchor roots into the soil layer and the ability of roots to bind soil particles thereby reducing erosion.

RAIN EROSIVITY

Rainfall is the most common factor for erosion, rainwater that falls on the soil surface forms water flows so that particles of the soil surface are lifted and move to lower places (Karyati, 2006). The factors that control the process of the erosion system are the erosivity of rain, soil erodibility, length and slope of the slope, planting and conservation practices carried out on the surface of the soil slope. Formula *Universal Soil Loss Equation* (USLE)Thus, based on the USLE method, the erosion rate is determined by the following equation:

$$E = R\ .K.LS\ .C\ .P$$

:

E = Annual soil erosion (tons/ha)

R = Rain erosion (MJ.cm/ha.hour)

K = Soil erodibility (sensitivity) (ton.ha.ha/ha.mj.cm)

LS = Length Factor and slope

P = Conservation Action

C = Plant management factor

3 RESEARCH METHODOLOGY

The stages carried out in this research are as follows.

1. Preparation of materials and tools needed in research

2. Soil extraction with 5 types of plants in five locations namely 1) Setaria grassroots come from Jln. Soeratno Guntung Payung Banjar Baru Utara, South Kalimantan, 2) Gajah grassroots Jln. Sidodadi I Guntung Payung BanjarBaru North, South

Kalimantan, 3) Grassroots Alang-Alang Jln Rosela Ujung, Kemuning, Banjarbaru South Kalimantan, 4) Grassroots Teki Jln. HM Sanusi Bereng Kalingu Village, Central Kalimantan and 5) Paitan grassroots Jln. HM Sanusi, Bereng Kalingu Village, Central Kalimantan.

3. The initial test was carried out by physical testing to determine the nature and characteristics of the soil in the presence of plant roots. The water content, volume weight, grain analysis (sieve analysis and hydrometer analysis) and Atterberg limits were tested. The mechanical test was continued, namely the direct shear test.
4. Analysis of the results of physical and mechanical testing of soil samples and 5 types of plants.

4 RESULTS AND DISCUSSION

Results of Testing the Physical Properties of Soil with 5 Types of Plant Roots

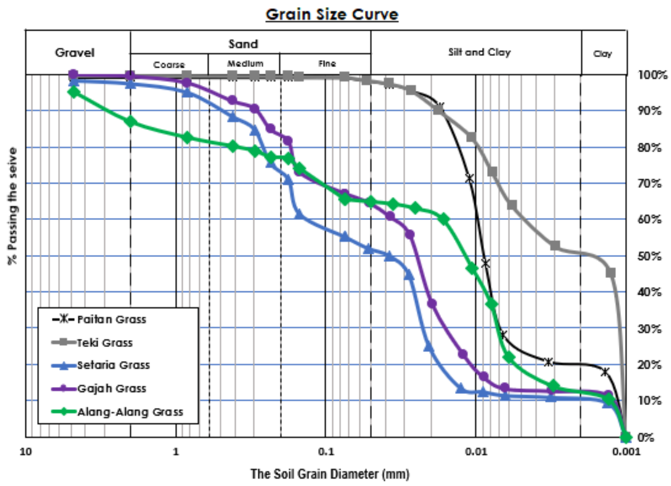

Figure 1. Graph of Grain Distribution of Soil with 5 Types of Plant Roots

Table 2. Results of Testing Soil Physical Properties with Teki Grassroots, Paitan Grassroots, Setaria Grassroots, Gajah Grassroots, and Alang-Alang Grassroots

Type of Grass				Paitan Grass	Teki Grass	Setaria Grass	Gajah Grass	Alang-Alang Grass
Depth				**0,00-1,00 m**	**0,00-1,00 m**	**0,00-1,00 m**	**0,00-1,00 m**	**0,00-1,00 m**
The Physical Characteristic of Soil	*Soil Properties*	Specific Gravity (Gs)		2.371	2.428	2.545	2.577	2.580
		Water Content (W)	%	65.690	54.500	20.690	32.680	10.080
		Volume Weight (g)	gr/cm³	1.570	1.589	1.857	1.836	2.079
	Grain Size Distribution	Gravel (>2mm)	%	0.71	0.25	2.47	0.47	13.05
		Coarse Sand (0.6-2.00mm)	%	0.03	0.09	5.68	4.30	5.50
		Medium Sand (0.2-0.6mm)	%	0.01	0.10	18.45	11.97	4.36
		Fine Sand (0.05-0.2mm)	%	1.39	1.60	22.34	20.57	12.49
		Silt and Clay (0.002-0.05mm)	%	78.47	49.21	40.90	50.67	52.35
		Clay (<0.002mm)		19.39	48.75	10.16	12.03	12.25
		No. 10 (2.00mm)	%	99.29	99.75	97.53	97.73	86.95
		No. 40 (0.425mm)	%	99.25	99.63	88.53	92.73	80.25
		No. 200 (0.0075mm)	%	99.21	99.37	55.23	67.13	65.51
	Atterberg Limits	Liquid Limits (LL)	%	66.11	81.82	27.38	40.93	34.21
		Plastic Limit (PL)	%	38.64	64.58	21.51	23.98	20.43
		Plasticity Index (PI)	%	27.48	17.23	5.88	16.95	13.78
		USCS Classification	USCS	OH	MH	ML	CL	CL

Based on the above test results, the highest water content was on soil with Gajah grassroots of 32.68% and the lowest was on soil with Alang-Alang grassroots of 10.08%.

Based on the results of the Atterberg limits test, it shows that the soil and roots of Paitan grass with a liquid limit of 66.11% and a plastic limit of 38.64%, which is based on the USCS classification system, the soil with Paitan grass plants is classified as *Organic clay* (OH). Teki soil and grassroots have a liquid limit of 81.82% and a plasticity limit of 64.58%, so that according to the USCS classification system, they are classified as *Inorganic Silt* (MH) soil types. Setaria soil and grass have a liquid limit of 27.38% and a plasticity limit of 21.51%, so according to the USCS classification they are classified as *Silty or clayey fine sand* (ML). Gajah soil and grassroots have a liquid limit of 40.93% and a plasticity limit of 23.98%, so that according to the USCS classification the soil is classified as an *Inorganic clay low* (CL) soil type. Also, Alang-Alang soil and grassroots have a liquid limit of 34.2% and a plasticity limit of 20.43% so that according to the USCS classification the soil is classified as an *Inorganic clay low* (CL) soil type.

Results of Mechanical Properties Testing

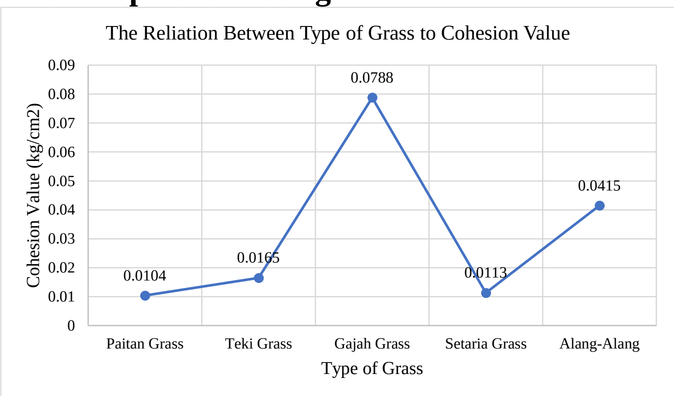

Figure 2. Graph of Relationship of Grass Root Types with Cohesion Value

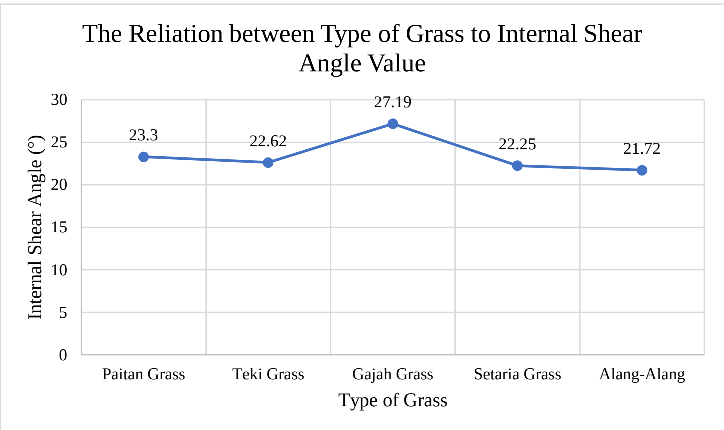

Figure 3. Graph of Relationship of Internal Friction Angle with Grass Root Types

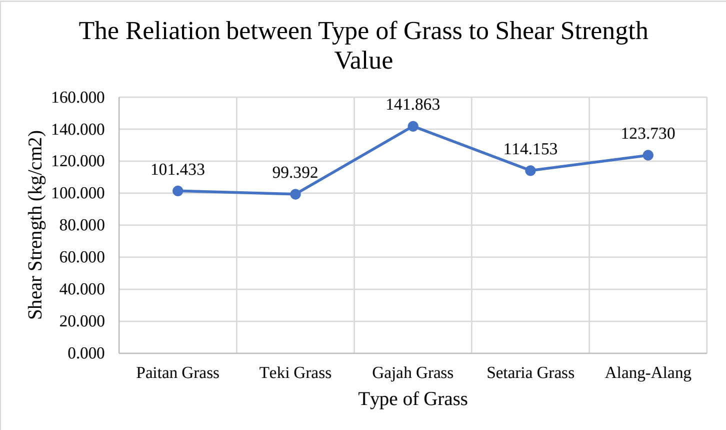

Figure 4. Graph of Relationship of Soil Shear Strength with Plant Root Types

Based on the results of testing mechanical properties, soil with Gajah grassroots has the highest friction and cohesion angle values are 27.19° and cohesion is 0.788 kg/cm^2 so that the highest shear strength is 141.863 kg/cm^2. The value of the internal friction angle on the Teki grass is 22.62° and the cohesion is 0.016 making the Teki grass have the lowest shear strength value of 99.392 kg/cm^2.

5 CONCLUSIONS

1) The existence of roots in the soil through mechanical mechanisms can help increase the shear strength of the soil which has a positive impact on increasing slope stability, so that it can help prevent shallow landslides or erosion on the surface of the soil slope.
2) The root of the plant that has the highest value of shear strength with a value of 141,863 kg/cm^2 is the root of the Gajah grass plant. Followed by the roots of the Alang-Alang grass plant with a value of 123.730 kg/cm^2. Setaria grassroots have the third largest shear strength value with a value of 114.153 kg/cm^2. The Paitan grass root has a shear strength value of 101.433 kg/cm^2. And the smallest is Teki grass root with a shear strength value of 99.392 kg/cm^2.
3) Gajah grass root is a type of plant root that has a high potential value that can withstand slope stability as evidenced by the results of the highest retaining moment after the erosion factor, which is 4366.51 tons/ha.
4) The use of vegetation in helping to maintain soil stability has potential value as an effective, economical, and environmentally friendly way.

REFERENCES

Agrotek. (2020). *Agrotek.id*. Retrieved Agustus 26, 2021, from https://agrotek.id/klasifikasi-dan-morfologi-tanaman-jukut-pahit/

Agrotek. (2020). *Agrotek.Id*. Retrieved Agustus 25, 2021, from https://agrotek.id/klasifikasi-dan-morfologi-tanaman-rumput-teki/

Andiyarto, H. T., & Purnomo, M. (2012). Efektifitas Pemanfaatan Rumput Akar Wangi untuk Pengendalian Longsoran Permukaan pada Lereng Jalan Ditinjau dari Aspek Respon Pertumbuhan Akar. *Jurnal Teknik Sipil, 14*(2), 151-164.

Badan Standarasisasi Nasional. (2016). *SNI 3420 Metode Uji Kuat Geser Langsung Tanah Tidak Terkonsolidasi dan Tidak Terdrainase.* Jakarta, Indonesia: Badan Standarisasi Nasional.

Blanco, H., & Lal, R. (2008). Principles of Soil Conservation and Management. *Springer*.

Chirico, G. B., Borga, M., Tarolli, P., Rigon, R., & Preti, F. (2013). Role of Vegetation on Slope Stability Under Transient Unsatured Conditions. *Procedia Environmental Sciences, 19*, 932-941.

Das, B. M., Endah, N., & Mochtar, I. B. (1995). *Mekanika Tanah (Prinsip-Prinsip Rekayasa Geoteknis)* (1 ed.). Jakarta: Erlangga.

Das, B. M., Endah, N., & Mochtar, I. B. (1995). *Mekanika Tanah (Prinsip-Prinsip Rekayasa Geoteknis)* (2 ed.). Jakarta: Erlangga.

Hairiah, K., Widianto, & Suprayogo, D. (2008). Adaptasi dan Mitigasi Pemanasan Global: Bisakah Agroforestri Mengurangi Resiko Longdro dan Emisi Gas Rumah Kaca? *Kumpulan Makalah (bunga rampai) INAFE*, 42-62.

Hairiah, K., Widianto, & Suprayogo, D. (2008). Adaptasi dan Mitigasi Pemanasan Global: Bisakah Agroforestri Mengurangi Resiko Longsor dan Emisi Gas Rumah Kaca? *Kumpulan Makalah INAFE*, 42-62.

Hakim, R. N., Santoso, E., & Prihatino, G. T. (2020). STUDI PENGARUH KADAR AIR TERHADAP KUAT GESER TANAH PADA AREA BEKAS TAMBANG DI KOTA BANJARBARU. *Jurnal GEOSAPTA, 6 No. 1*, 19-21.

Hardyatmo, H. C. (2002). *Mekanika Tanah I* (3 ed.). Yogyakarta: Gadjah Mada University Press.

Karyati. (2016). Penaksiran Indeks Erisivitas Hujan di Kuching, Sarawak. *Jurnal Gerbang Etam, 10*(2), 38-45.

Krisnaindra. (2017, April 14). *Klasifikasi Dan Morfologi Alang-alang (Imperata cylindrica)*. Retrieved Januari 19, 2022, from Kumpulan Materi Pengetahuan Umum: https://www.teorieno.com/2017/04/klasifikasi-dan-morfologi-alang-alang.html

Li, Y., Wang, Y., Ma, C., Zhang, H., Wang, Y., Song, S., & Zhu, J. (2016). Influence of the Spatial Layout of Plant Roots on Slope Stability. *Ecological Engineering*, 477-486.

Moteleone, S., & Sabatino, M. (2014). Hydrogeological hazards and weather events: Triggering and evolution of shallow landslides. *International Soil and Water Conservation Research, 2*(2), pp. 23-39.

Muntohar, A. S., Jotisankasa, A., & Mukhlisin, M. (2016). Contribution of Vetiver Roots on Stability of A Residual Soil Slope. *International Technical Conference*, 355-362.

Nugraha, Yudhistira, F., Hamdhan, & Noer, I. (2016). Analisa Stabilitas Lereng Menggunakan Perkuatan Tanaman Switchgrass. *Reka Rencana Jurnal Online Institut Teknologi Nasional, 2*(2), 71-82.

Nurdian, S., Setyanto, & Afriani, L. (2015). Korelasi Parameter Kekuatan Geser Tanah dengan Menggunakan Uji Triaksial dan Uji Geser Langsung pada Tanah Lempung Subtitusi Pasir. *JRSDD, 3*(1), 13-26.

Priyono. (2014-2015). Hubungan Klasifikasi Tanah Longsor, Klasifikasi Tanah Rawan Longsor dan Klasifikasi Tanah Pertanian Rawan Longsor. *GEMA, 49*(XXVII), 1602-1617.

Rahmawati W., D. (2009). Hubungan Jumlah Akar dan Kekuatan Akar Pohon dengan Ketahanan Geser Tanah (Soil Shear Strength). 40-62.

Santiawan, I. G., Wardana, I. N., & Redana, I. (2007). Penggunaan Vegetasi (Rumput Gajah) dalam Menjaga Kestabilan Tanah Terhadap Kelongsoran. *Jurnal Ilmiah Teknik Sipil, 11*(1), 11-23.

Santiawan, I. G., Wardana, I. N., & Redana, I. W. (2007). Penggunaan Vegetasi (Rumput Gajah) dalam Menjaga Kestabilan Tanah terhadap Kelongsoran. *Jurnal Ilmiah Teknik Sipil, 11*(1), 11-24.

Suharni, S. (2004). *Evaluasi Morfologi, Anatomi, Fisiologi dan Sitologi Tanaman Rumput Pakan yang MEndapat Perilaku Kolkisin.* Semarang.

Suryolelono, K. B. (2002). Bencana Alam Tanah Longsor Perspektif Ilmu Geoteknik. Yogyakarta: Fakultas Teknik UGM