(e)ISSN 2656-8896 (p)ISSN 2656-890X
Journal of Infrastructure and Facility Asset Management – Vol. 6, Special Issue 2, January 2024

Excavation Slopes Stability Analysis with Cracked Soil in the Construction of the Serang – Panimbang Toll Road (STA 54+625) Under Maximum Rainfall Condition

Wahyu Purnamayoga[1,a)], **Trihanyndio Rendy Satrya**[2,b)], **Mahendra Andiek Maulana**[2,c)], **Wahyu Supriyo Winurseto**[3,d)]

[1)] *Magister Student, Civil Engineering Department, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia*
[2)] *Civil Engineering Department, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia*
[3)] *Head of BPJN Banten, Ministry of Public Works and Housing, Indonesia*

Correspondent : [a)]wahyu.purnamayoga@gmail.com, [b)]trendysatrya@its.ac.id, [c)]mahendrasipil@its.ac.id, & [d)]winurseto@pu.go.id

ABSTRACT

Construction of the Serang-Panimbang toll road requires deep excavation in several places finishing grade which then forms a roadside slope. Slope stability analysis is very critical in slope design so that infrastructure assets can be managed and maintained. The surrounding infrastructure may sustain damage if the slope is unstable. Rainfall is one of the most important triggers for landslide occurrence. In general, the effects of precipitation infiltration on slopes can cause changes in soil suction and positive pore water pressure, increase soil unit weight, and decrease soil shear strength. If cracked soil is found, the process of rain infiltration will be accelerated. It starts with small cracks and then turns into deep cracks, indicating the possibility of landslides, and the longer the landslide surface becomes, the more the slope will slide. This research discusses the effects of cracked soil and precipitation on slope stability. A slope stability analysis was performed using the Finite Element Method (FEM) and the cracked soil was modelled as a thin weak layer. The results showed that the safety factor decreased from 1,891 in the initial condition to 1,471 (before rain) and 1,441 (after rain) in the worst conditions.

Keywords : slope stability, cracked soil, precipitation, infrastructure asset management

INTRODUCTION

Infrastructure development is one of Indonesia's national priority agendas. According to Infrastructure Asset Management (IAM), all phases of the life cycle of infrastructure, including designing, building, operating, maintaining, and disposing of it when it is no longer required, require careful management (Suprayitno & Soemitro, 2018). Road infrastructure plays an important role in the development of a country. The construction of roads is generally aimed at improving accessibility to public facilities and services, connecting regions, and building transportation systems and networks to support ease of mobility and logistics, thus enhancing the potential for national economic growth.

The Serang-Panimbang Toll Road is one of the National Strategic Projects (PSN) based on Perpres No. 56/2018, which is the Second Amendment to Perpres No. 3/2016 concerning the Acceleration of National Strategic Project Implementation. This toll road section is connected to the Jakarta-Merak Toll Road and serves as a supporting facility connecting the city of Serang to the Ujung Kulon National Park. This toll road construction is divided into three sections **(**Error! Reference source not found.): Section I (Serang-Rangkasbitung),

(e)ISSN 2656-8896 (p)ISSN 2656-890X
Journal of Infrastructure and Facility Asset Management – Vol. 6, Special Issue 2, January 2024

Section II (Rangkasbitung-Cileles), and Section III (Cileles-Panimbang), with a total length of 83,6 kilometers. Currently, the construction is entering the section III phase which has a length of 33 kilometers starting from STA 50+677 - STA 83+677.

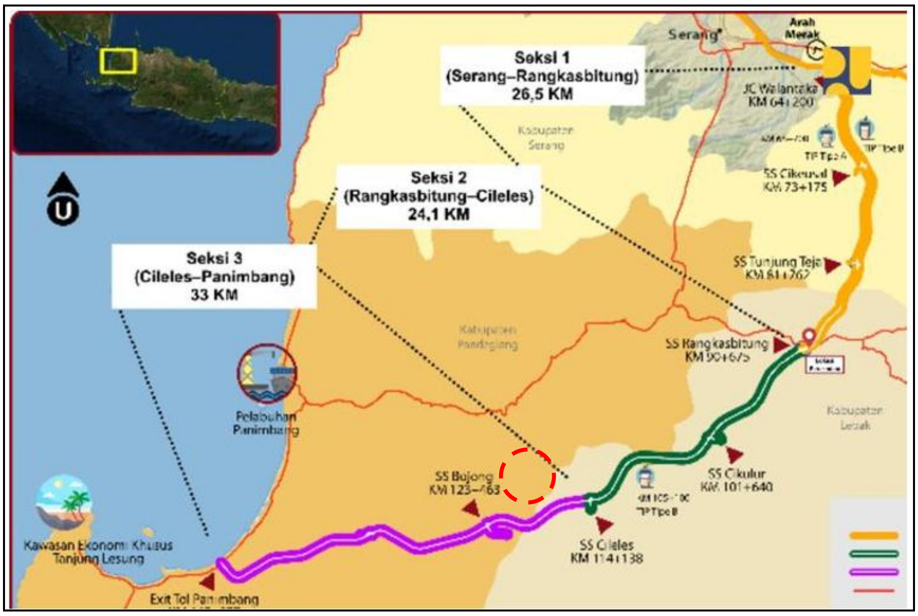

Figure 1. Serang-Panimbang toll road construction site

The early segment of the Serang - Panimbang toll road construction is located on hilly areas that require excavation work for the road finishing grade design. A frequent problem in excavation works is slope stability. During the period of rapid excavation, the shear stress increases, while the shear strength remains fixed, resulting in a reduced factor of safety. Furthermore, at the end of the excavation work, although the shear stress remains, the reduction in shear strength also results in a reduced factor of safety (Hardiyatmo, 2002). The excavation work planned has various depths. At STA 54+625, the excavation work will form a 25,2-meter-high slope with a slope angle between 26^0 - 63^0. The designed slope reinforcements are soil nailing and ground anchors. A typical cross-section at STA 54+625 can be seen in **Figure 2**.

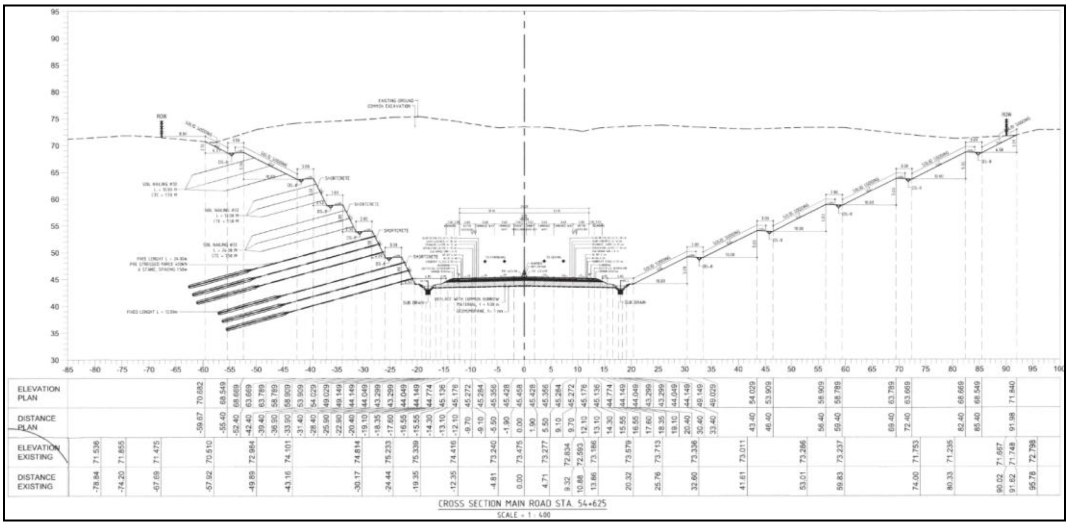

Figure 2. Cross Section at STA 54+625

Slope stability is influenced by many factors, one of which is rainfall infiltration. The effect of rainfall infiltration on slope stability has been widely discussed by researchers (Hengxing, et. al, 2003; Kristo et. al, 2017; Hidayat, 2020). Rainfall infiltration causes water to seep into the slope resulting in an increase in the parameters of water content, degree of soil saturation and void ratio. The longer the rain lasts, the more these parameters will increase. Increased moisture content due to rain, will reduce soil suction and increase soil weight. The infiltration process will accelerate when cracked soil is found. The cracks will ease the flow of water into the soil layers and erode the material in the soil so that the bond between soil particles is weaker. In cracked soils, the presence of water flow paths increases rainfall infiltration and affects pore pressure because of rainfall intensity and soil properties (Galeandro et. al, 2013). Research on landslides caused by rainfall infiltration that considers the influence of cracks plane has not been widely conducted. In reality, cracked soil is a common phenomenon. Therefore, consideration of the cracked soil approach to slope stability calculations is necessary.

LITERATURE REVIEW

Empirical correlation of soils data

The main methods for defining design parameters in geotechnical engineering are in-situ and laboratory testing from samples collected during site investigation. However, when testing is limited, empirical correlation becomes more valuable. In the geotechnical engineering field, empiricism plays a major role. Besides providing initial estimates, correlations can also be utilized to compare values defined by laboratory tests and field tests. There are numerous empirical correlations accessible from many sources that have been collected and covered by researchers (Terzaghi & Peck, 1996; Look, 2007; Ameratunga, et. al., 2016), which are often used in designs around the world. These are inferred from laboratory or field data, experiences, and engineering judgment. The use of empirical correlation is an attempt to maximize the test results from the laboratory and the limited availability of field investigation data (Ameratunga et al., 2016).

Rainfall-induce Landslides

Most of the slope instability is due to rainfall. Landslides retrieved by rainfall are generally geohazard worldwide, especially in tropical regions such as Indonesia. Various studies have clearly shown that this hazard is very destructive to property and lives. Precipitation is one of the foremost critical retrieving factors for the occurrence of slope failures. Studying the mechanism of rainfall-induced landslides is one of the most important and difficult topics in landslide research (Hengxing, et. al., 2003). Rainfall-induced landslides are known to be caused by increased pore water pressure and infiltration during or immediately after periods of heavy rainfall. Increased pore water pressure reduces the effective load on the soil, thus reducing soil strength and potentially causing slope failure. Increased pore water pressure is generally caused by precipitation intrusion (Muntahor & Liao, 2010).

Cracked Soil Approach

According to Mochtar (2020), the cracked soil approach is an approach with the assumption that a slope has cracks so that the slope is vulnerable to landslides. **Figure 3** shows the cracked area filled with water during heavy rainfall. Because the infiltration flow into the cracks is greater than the infiltration flow out of the cliff from the other side, the pore-water pressure is concentrated in the cracks in the slope. Due to the water pressure on the cracks, the crack plane can gradually expand, making the slope more critical than before. Hutagamissufardal and Mochtar (2018) in their research showed that there was a decrease in the cohesion value along with the increase in the spread of soil cracks. As seen in the **Error! Reference source not found.**, the crack plane, which is initially short, will gradually lengthen. This happens because the soil around the crack dissolves so that the soil has no cohesion value. Because the soil has no cohesion, the soil will behave like sand. If the cracks extend to the bottom of the slope, landslides will occur due to the absence of cohesion in the cracked area so that the soil cannot withstand its weight and other external loads.

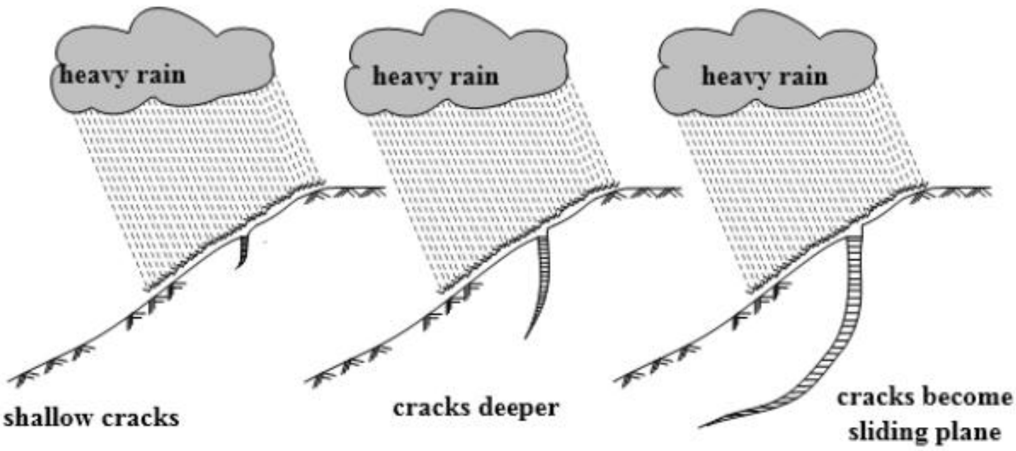

Figure 3. Cracks propagation on heavy rain

There are different approaches to evaluate, analyse and modelling slope stability and predict landslides by considering cracked soil. In this study, cracked soil will be modeled by creating a thin weak layer on the slope geometry. This layer is located on the slide plane and represents a weaker layer due to loss of cohesion. Numerous researchers have investigated the impact of a weak layer on the stability of slopes, analysing different angles and thicknesses of the weak layer (Crusoe Jr., et. al., 2016) or crack depth (Jiang, et. al., 2023).

Research carried out by Jiang, et., al. (2023) studied the impact of cracks on loess soil. The cracks model applied involves analysing the depth and thickness of cracks using software that uses finite elements analysis (FEA). The impact of the depth of crack on the stability of collapse was easily noticeable. As the crack depth increases, the influence of the soil at the back edge on the collapse body's stability decreases gradually. This leads to a decrease in the counteracting force against rolling and an increase in the hydrostatic pressure within the crack. Consequently, the overturning force acting on the collapse body increases. The stability of the collapsing structure is influenced by the crack width, but its impact is not significant (see **Figure 4**). As the crack width increases, the centre of gravity of the collapse gradually shifts outward. The distance between the foot of the slope (acting as the moment centre) and the gravity arm reduces slowly, which leads to a gradual decrease in the resistance against toppling of the collapsed structure.

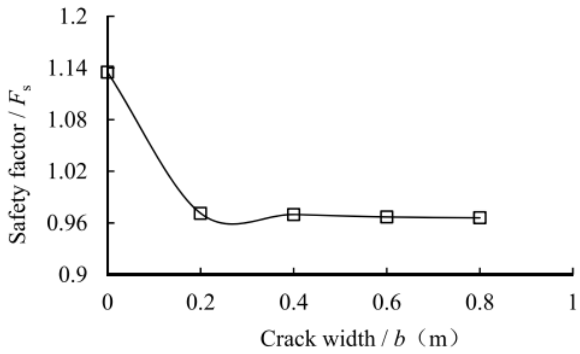

Figure 4. The relationship curve between safety factor and crack width

RESEARCH METHOD

Data Collection

The research data used is secondary data collected from BPJN Banten. The data included plan drawings (long section and cross section), soil investigation and laboratory testing, and rainfall data for the last 15 years to determine the maximum rainfall condition.

Slope Stability Modelling Tools

Plaxis is an application program based on the finite element method that is widely used in geotechnical analysis including analysing soil deformation and slope stability. Plaxis analysis has many soil behaviour modelling options. One that is commonly used for slope stability analysis is the Hardening Soil (HS)-model. HS-models are commonly used to simulate in-situ soils for excavation and reinforcement structure applications. HS-model can be considered as an advanced soil model that can estimate complex soil behaviour precisely. In HS-model, a more precise representation of soil deformation can be achieved by incorporating three stiffness parameters, specially related to triaxial loading stiffness (E_{50}), triaxial unloading stiffness (E_{ur}), and oedometer loading modulus (E_{oed}) (Obzurd & Truty, 2020).

Precipitation Model

In this study, rainfall in Plaxis is modelled as precipitation. The rainfall model in this study was performed by adding a phase after the final phase of excavation work and slope reinforcement. In the rainfall phase, the calculation type selected is fully coupled flow-deformation. The model applied was 1-day rainfall with the amount of rainfall used being the highest maximum rainfall from known rainfall data, which is q = 0.33 mm/day.

Thin-weak Layer Model

In this study, the thin weak layer is modelled with thickness variations: 0.5, 1, 1.5, and 2 meters. The weakening of this thin layer is applied by decreasing the cohesion value in the layer. To see the effect of the behaviour of the thin weak layer, the cohesion value is decreased gradually. With the initial cohesion value being Cu_1, the cohesion in the thin layer is called cu_2. The cu_2/cu_1 ratios are 0.8, 0.6, 0.4, 0.2, and 0.0 modelled the gradual weakening of the thin layer.

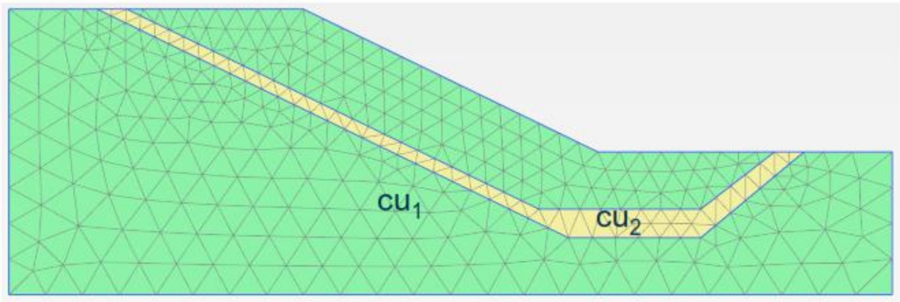

Figure 5. Thin-weak layer typical model

ANALYSIS

Soil Parameter

Soil parameter values were determined from boring tests and standard penetration tests (SPT). Boring tests were carried out to a depth of 80,24 meters. SPT tests were performed at every 2-meter depth interval. Laboratory tests revealed that silty clay is the main soil type up to a depth of 62 meters, and clayey sand is the main soil type from 62 to 80 meters deep. Based on the analysis results, the soil types are grouped into four layers based on their classification and consistency. Soil parameter values were determined from laboratory test results of undisturbed samples. However, due to the limitations of undisturbed samples, some parameters require empirical correlation of parameter values. See **Error! Reference source not found.** and **Error! Reference source not found.** for details on determining soil parameters which will be used in modelling in Plaxis.

Table 1. Soil layer identification

Depth (m)	Soil Description	NSPT	Consistency	Layer Names
0 - 4	Clayey Silt	6	Medium	Layer 1
4 - 16	Silty Clay	15	Stiff	Layer 2
16 - 62	Silty Clay	34	Hard	Layer 3
62 - 80	Sand	60	Very Dense	Layer 4

Table 2. Soil parameters

Layer Names	γ_{sat} kN/m^2	c kN/m^2	φ (^{o})	E_{50} kN/m^2	ν
Layer 1	17,18	9,33	16,57	3600	0,3
Layer 2	16,83	21,33	17,3	6300	0,3
Layer 3	17,90	46,67	18,9	12000	0,3
Layer 4	20	5	38,97	24000	0,35

Shop drawings shows soil nailing and ground anchors being used as part of the slope reinforcement scheme. Soil nailing used is 32 mm diameter nail and 100 mm diameter grout with an installation distance of 1,5 m, and in Plaxis modeling, the soil nails are modelled using a geogrid material. Ground anchors consist of two parts: free length and fixed length. The free length part is a 6-strand steel wire with a strand diameter of 12.7 mm, while the fixed length part is a grout body with a diameter of 200 mm using concrete with a compressive strength (fc') of 30 Mpa. Free-length modeling uses an anchor material (Anchor) between nodes, and fixed-length sections are modelled with a geogrid (Grout Body). The required parameter is the axial stiffness (EA). The value of EA can be determined based on the material specifications used. The following **Error! Reference source not found.** shows the reinforcement parameter values to input the modeling.

Table 3. Slope reinforcement parameters

Material Names	Material Model	EA (kN/m)
Soil Nailing	Geogrid	210522,3
Ground Anchor (Free Length)	Node-to-node anchor	151935,2
Ground Anchor (Fixed Length)	Geogrid	808329,0

Initial Model of Slope

The first step of modeling in Plaxis is to draw the initial geometry and its reinforcement based on the geometry in the design drawings. The shop drawing provides coordinates details for each point of geometry change. After the geometry is created, the soil type assignment (set material) is applied to each layer according to the layers that have been made in the previous discussion. After the cross-section geometry is formed, the next step is to perform stability analysis through stage construction. At this stage, phases are created in order to model the excavation work from the initial elevation to the planned elevation and the installation of slope reinforcement. The excavation work is modelled into several phases with an excavation depth of about two meters in each phase. Between the excavation phases, a phase of slope reinforcement installation work was also inserted in the exposed slope area. This approach was taken to match the actual work conditions in the field. The subdivision of the phases also made it possible to see if the reinforcement model that had been created could work properly.

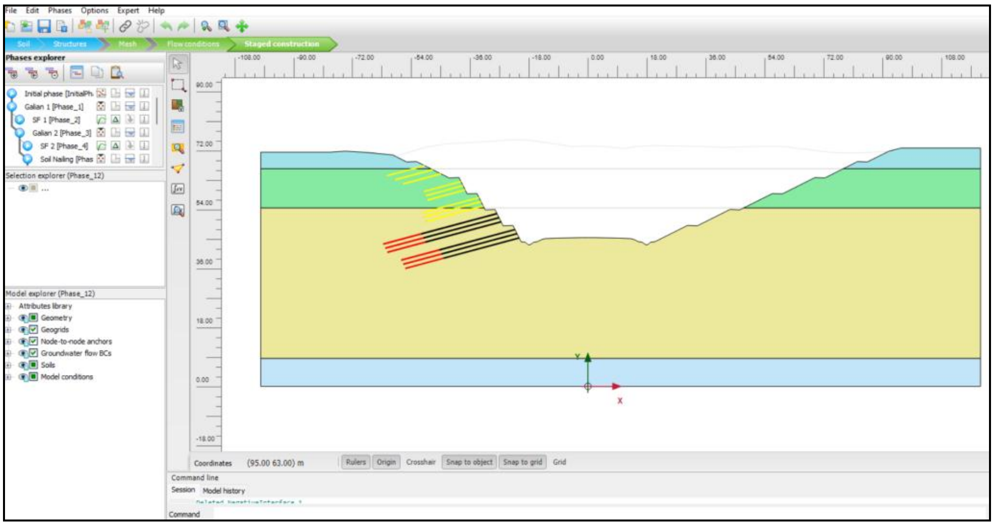

Figure 6. STA 54+625 cross section model

After all phases have been established, the last step is to run the calculation. But before that, the selection of '*nodes*' is needed as a representation of the observed location points. In this study, the point selected to observe the deformation value is at the toe of the slope and the top of the slope. To see the results of the initial slope stability analysis, look at **Error! Reference source not found.** below.

Table 4. Initial slope SF and deformation

STA	SF	Deformation |u| (m)	
54+625	1,891	Top	0,118
		Toe	0,126

Thin Weak Layer Model

Cracked soil is modelled by creating a thin weak layer on the slope geometry. The location of this thin layer is in the sliding plane formed from the calculation results that have been carried out in the existing modeling. **Figure 6** shows the method for modelling the thin weak layer geometry. The combination of cohesion reduction applications is then applied to each thin weak layer thickness (t) model.

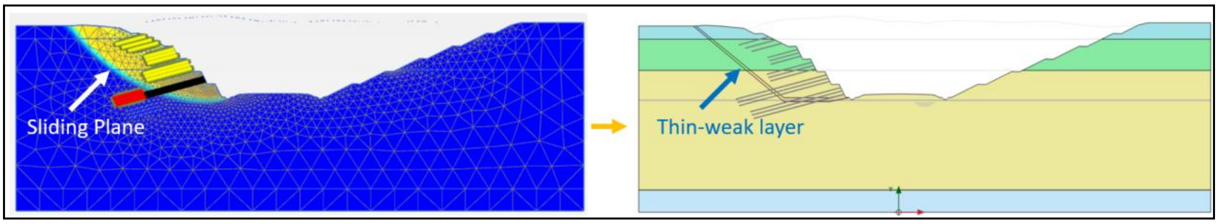

Figure 7. Thin-weak layer model at STA 54+625

Based on the variations applied to the model, the analysis is divided into two parts. One is the effect of decreasing cohesion ratio, and the other is the difference in the thickness of the weak layer. To see the effect of decreasing cohesion values, look at the graph in **Figure 7**. The pattern of decreasing safety factor for each variation in weak layer thickness is similar. For example, if the thickness of the thin layer is 1 meter, the value of the safety factor gradually decreases from the initial state of 1,891 due to the weakening of the cohesive force of the thin layer until the thin layer loses cohesion the factor of safety declines to 1,537. The decline in the safety factor follows a linear pattern, but the initial decrease in cohesive losses is less steep. This condition is still within the safe boundaries of the excavated slope. The planned reinforcement cuts the sliding plane and maintains the safety of the excavation slope even if the cohesive strength of the thin layer is lost.

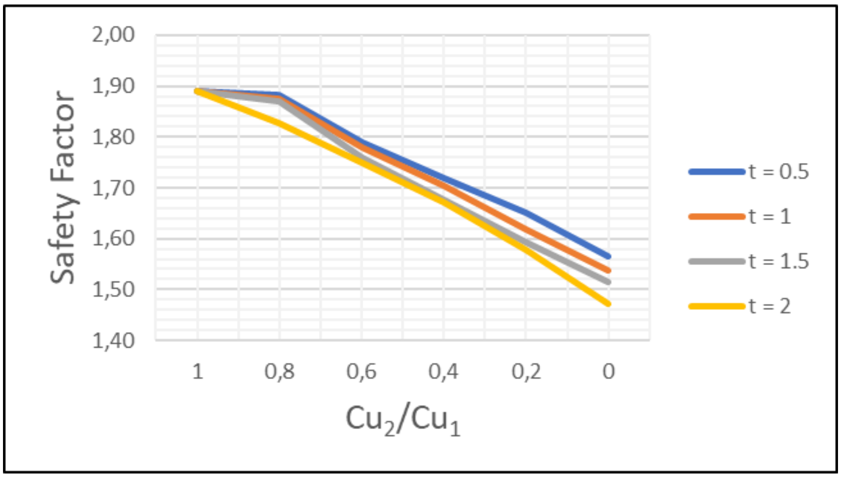

Figure 8. Safety factor vs cohesion ratio for various weak layer thicknesses

The graph in **Figure 8** shows the relationship between the thickness of the weak layer and the factor of safety under the condition of a thin cohesionless layer. As can be seen from the graph, the increase in weak layer thickness is directly proportional to the decrease in safety factor value. A decrease in the cohesion value will decrease the shear strength of the soil. By increasing the thickness of weak layer, the area of the weakened plane expands so that the safety factors continue to decline. The linear regression has a value of R^2 = 0.97 which states that the linear regression can represent the modelling behaviour well. In addition, when compared to the research conducted by Jiang, et. al. (2023), although using two different methods and software, the results obtained are typically the same. This shows the consistency of the influence of weak layer thickness modelling on slope stability. It is also an input for planners to consider the presence of cracked soil in modelling, especially if it is found in the field, in order to obtain a more reliable design.

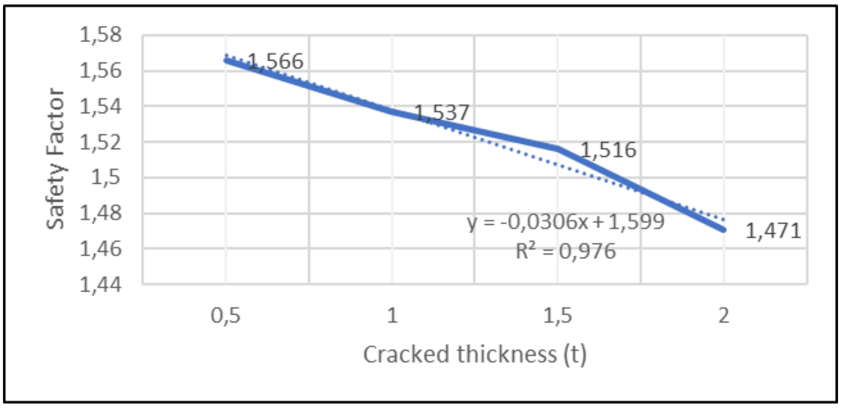

Figure 9. Graph of the relationship between weak layer thickness and safety factor

The deformation output for each variation of the weak layer thickness model and cohesion ratio was examined to determine the influence of cracked soil. Based on the data acquired, modelling the thin weak layer does not affect the deformation that occurs. The resultant deformation in the initial condition and each model variation is also the same |u| = 0.118 m. To see more details, vertical and horizontal deformations at the top and toe of the slope were observed. The difference in deformation that occurred with the initial model did not reach 1 cm. **Table 5** shows a recapitulation of the deformation rates of each model.

(e)ISSN 2656-8896 (p)ISSN 2656-890X
Journal of Infrastructure and Facility Asset Management – Vol. 6, Special Issue 2, January 2024

Table 5. recapitulation of the deformation rate of each weak layer model

Deformation	Cohesion Ratio	t = 0,5 m		t = 1 m		t = 1,5 m		t = 2 m	
		U_x	U_y	U_x	U_y	U_x	U_y	U_x	U_y
	Cu_2/Cu_1	10^{-3} m	10^{-3} m	10^{-3} m	10^{-3} m	10^{-3} m	10^{-3} m	10^{-3} m	10^{-3} m
Top	0,8	118,316	-3,039	118,411	-3,478	118,400	-3,643	118,318	-3,822
	0,6	118,280	-3,249	118,376	-3,388	118,374	-3,530	118,288	-3,667
	0,4	118,248	-3,185	118,287	-3,318	118,194	-3,434	118,076	-3,549
	0,2	118,204	-3,125	117,895	-3,370	117,786	-3,531	117,612	-3,623
	0,0	114,679	-3,642	113,409	-3,438	113,408	-3,324	115,513	-4,006
Toe	0,8	72,145	104,147	72,111	104,313	71,779	104,007	72,115	103,983
	0,6	72,369	104,148	72,342	104,302	71,948	103,905	72,238	103,875
	0,4	72,650	104,140	72,617	104,271	72,124	103,802	72,383	103,782
	0,2	73,088	104,146	72,939	104,232	72,383	103,568	72,561	103,538
	0,0	71,487	100,982	70,544	100,198	69,869	99,113	71,753	101,630

Rainfall Condition

The output of the 1-day rain simulation at maximum rainfall conditions carried out on each variation of slope height, weak layer thickness and cohesion ratio generally shows the behaviour of a decrease in the value of the slope safety factor. The average decrease in the factor of safety value due to rain is 1,54%. This shows that the effect of rain is not very significant on the slope safety factor. This condition is caused by several factors, first, the amount of maximum rainfall is already high but not extreme enough to have a greater influence. Then, this excavated slope model has a layer of fine-grained soil material (clay and silt) that has low permeability, making it difficult for rainfall to infiltrate into the soil. Finally, the presence of the thin weak layer also does not significantly reduce the slope safety factor because the geometry line of the thin layer is likely a barrier to the entry of water into the thin layer of soil model.

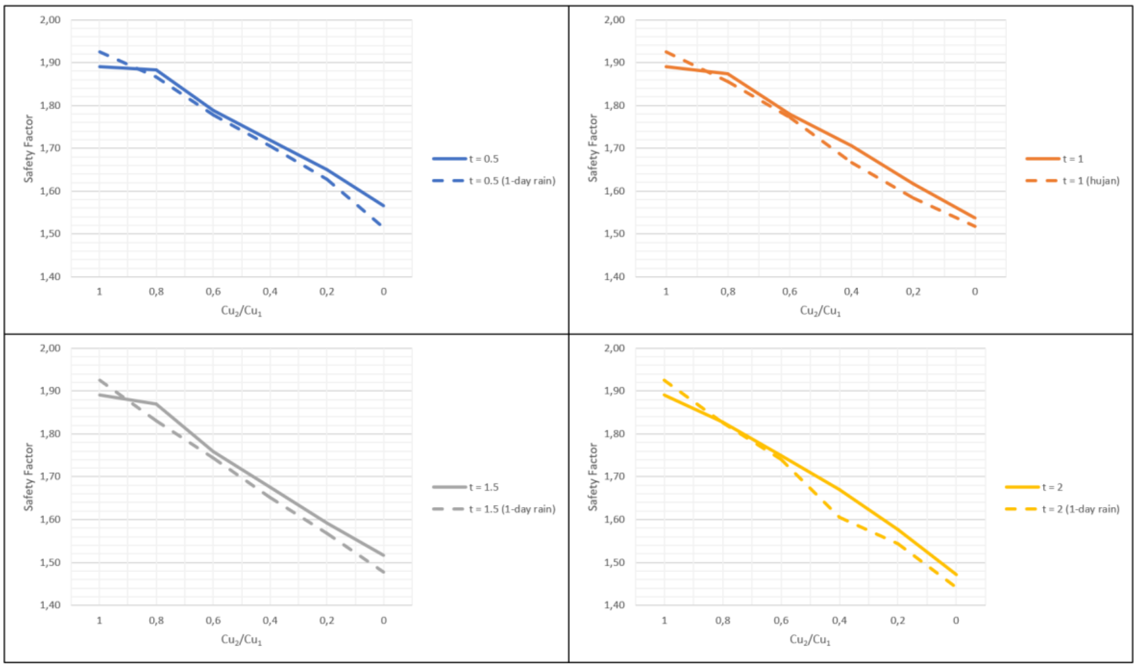

Figure 10. Effect of rainfall on FS in each variation of the thin weak model

Figure 10 shows the distribution of excess pore water pressure on the slope. Although the pore water pressure increases slightly with increasing weak layer thickness, the results show almost no difference. The only slight difference lies in the activity of increasing pore water pressure in the upper layer of the slope, especially in the crack plane. The behaviour of pore water pressure within the thin weak layer is generally similar to that outside the thin weak layer, and no concentration of pore water pressure activity within the layer is indicated. The reduction in the safety factor is not caused by a particularly thin weak layer but is an interaction between precipitation and the entire slope.

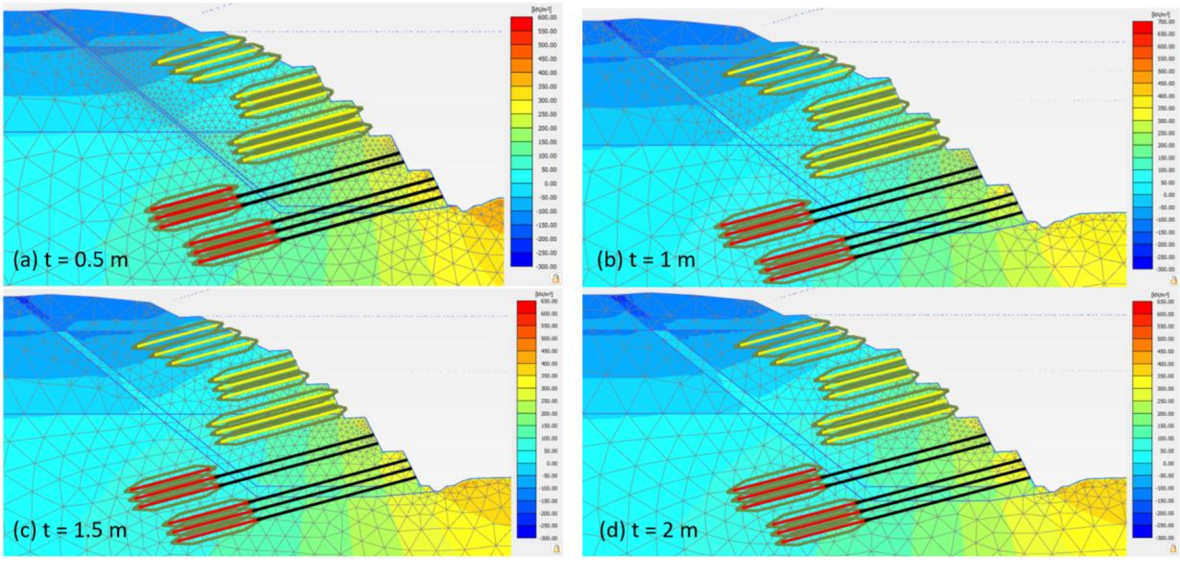

Figure 11. Excess pore water pressure of thin weak model

CONCLUSIONS

As a result of analysis, the slope's factor of safety and deformation are influenced by cracked soil approach and the effects of precipitation, the following results were obtained:

1. Decreasing the cohesion value has the greatest impact on reducing the safety factor. In the initial state, the slope factor of safety is 1,891 and gradually decreases in direct proportion to the weakening of the cohesion of the thin weak layer. In the cohesionless condition, the safety factor drops to 1,471. Furthermore, adding 0.5 m to the weak layer thickness only reduces the safety factor by 1,3% on average.
2. Modelling of thin weak layers does not affect the deformation rate occurring in each modelling variations.
3. The average decrease in safety factor value due to rain is 1,54%. Soil layers consisting mainly of fine-grained materials (clays and silts) have low permeability, making it difficult for precipitation to infiltrate the soil and having little effect on slope stability. Moreover, the thin weak model is not effective enough to explain the infiltration process within the crack plane.

REFERENCES

[1] Ameratunga, J., Sivakugan, N., & Das, B. M. (2016). *Correlations of Soil and Rock Properties in Geotechnical Engineering.* Springer. India.

[2] GarmondyuJr, E. C., Qing-xiang, C., Ji-sen, S., Liu, H., & Barvor, Y. J. (2016, June). "Effects of Weak Layer Angle and Thickness on the Stability of Rock Slopes". *Int. J. Min. & Geo-Eng. (IJMGE), Vol.50*(No.1), 97-110.

[3] Hardiyatmo, H. C. (2002). *Mekanika Tanah II.* Gadjah Mada University Press. Yogyakarta.

[4] Hengxing, L., Chenghu, Z., Lee, C. F., Sijing, W., & Faquan, W. (2003). "Rainfall-induced Landslide Stability Analysis in Response to Transient Pore Pressure". *Science in China Ser. E Technological Sciences, Vol.46,* Supp. 52-68.

[5] Hidayat, R. (2020). "Analisis Pengaruh Infiltrasi Hujan Terhadap Stabilitas Lereng di Pangkalan, Sumatera Barat". *Jurnal Teknik Hidraulik, Vol. 11, No. 1*. doi:https://doi.org/10.32679/jth.v11i1.630

[6] Hutagamissufardal, Mochtar, I. B., & Mochtar, N. E. (2018a). "The Effect of Soil Cracks on Cohesion and Internal Friction Angle at Landslide". *Journal of Applied Environmental and Biological Sciences*.

[7] Hutagamissufardal, Mochtar, I. B., & Mochtar, N. E. (2018b). "The Effect of Cracks Propagation on Cohesion and Internal Friction Angle for High Plasticity Clay". *International Journal of Applied Engineering Research, Volume 3, Number 5*, pp. 2504-2507.

[8] Jiang, X. D., Hou, T. S., Guo, S. L., & Chen, Y. (2023). "Influence of Cracks on Loess Collapse Under Heavy Rainfall. *Catena"*. doi:https://doi.org/10.1016/j.catena.2023.106959

[9] Kristo, C., Rahardjo, H., & Satyanaga, A. (2017)."Effect of Variations in Rainfall Intensity on Slope Stability in Singapore". *International Soil and Water Conservation Research*. doi:http://dx.doi.org/10.1015/j.iswcr.2017.07.001

[10] Look, B. G. (2007). *Handbook of Geotechnical Investigation and Design Tables.* Taylor & Francis Group.

[11] Obzurd, R., & Truty, A. (2020). *The Hardening Soil Model (A Practical Guidebook).* GeoDev. Switzerland.

[12] Soemitro, R. A., & Suprayitno, H. (2020). "Preliminary Reflection on Basic Principle of Operation Management for Public Work Infrastructure Asset Management". *Journal of Infrastructure and Facility Asset Management, Vol. 2, Supplemet 1, December 2020*.

[13] Suprayitno, H., Soemitro, R. A., Maulana, M. A., & Hesna, Y. (2020). "Preliminary Reflection on Performance Indicator and Performance Factor for Infrastructure Asset Management". *Journal of Infrastructure and Facility Asset Management, Vol. 2, Issue 1, March 2020*.

[14] Terzaghi, K., Peck, R. B., & Mesri, G. (1996). *Soil Mechanics in Engineering Practice.* A Wiley-Interscience Publication.

[15] Yudianto, A. M., Lastiasih, Y., Taufik, R., & Ismawanto, I. (2022, Februari). Analisis Deformasi Lereng dengan Perkuatan Soil Nailing pada Proyek Pembangunan Jalan Baru Batas Kota Singaraja-Mengwitani. *Jurnal Aplikasi Teknik Sipil, Volume 20*(Nomor 1), hal. 59-68.

EDITING CHECK TABLE

General		
	Reason	
	Material	
	Logic	
	Reference	
	Acceptance	
	Revision	

Format - Basic			**Format - Formula, Table, Figue, Space**			
	Paper Size A4	OK		Formula		OK
	Portrait	OK		Table		OK
	Margin U = 3, B = 2, L = 3, R = 2	OK		Figure		OK
	Header	OK		Space		OK
	Page Number	OK			author, institution, corresp.	
					abstract, keywords	
					chapter, sub-chapter	
					Acknowledgment	

Formating - Reference			**Format - Other**		
	Number of References	OK		Enumeration	
	Format Reference	OK			
	Ref. Indexng in Text	OK			

Content		
	Title	
	Abstract	
	Keywords	
	Introduction	
	Method	
	Literatur Study	
	Data Collection	
	Analyse	
	Conclusion	
	Acknowledgment	