



The Effect of Slope Angle on the Stability of Course Subbase Employed Soil on Toll Road Project Construction Binjai – Pangkalan Brandan

Lis Ayu Widari¹, Yovi Chandra², Nanda Savira Ersa^{3*}, Abdul Jalil⁴, T. Mudi Hafli⁵ and Ikmal Fasha Lubis⁶

^{1,2,3,4,5,6}Departement of Civil Engineering, Universitas Malikussaleh, Aceh, Indonesia

nanda.savira@unimal.ac.id

Abstract. The construction of the Binjai - Pangkalan Brandan toll road has a variety of embankments with different heights and slope angles. The slope angle is one of the things that has an influence on the failure of a slope (Budhu, 2011). The study aims to determine how much influence the slope angle has on the stability of embankment slopes with angle variations of 15°, 25°, 45° and 60° before and after loading. The analysis was conducted using manual bishop method and geostudio program. The results of manual bishop and geostudio stability analysis before loading obtained safety factor (SF) values of 1.80 and 1.79, while the SF value of the slope after loading is 1.46 and 1.52. In the analysis using the geostudio program with variations in embankment 15°, 25°, 45° and 60° before loading obtained SF values of 3.16, 2.16, 1.43 and 1.09, while the SF value after loading is 2.60, 1.79, 1.15 and 0.89. From the results of the study it can be concluded that the variation of slope angle affects the SF value. The stability of a slope decreases with the greater the angle. The more gentle a slope, the greater the stability value. Conversely, the steeper the slope, the less the stability value under the same soil parameter conditions.

Keywords: Bishop, Geostudio, Safety Factor, Slope Stability, Slope Angle.

1 Introduction

Toll roads are traffic pavement structures with high level services. According to Law No. 38 of 2004 the toll road is part of the road network system and as a national road whose users are required to pay when crossing it. Toll roads have a strategic role to increase the mobility of people, goods and services to support economic growth, increase equitable development results and development of an area.

In a toll road construction plan requires a pile work in an area that has uneven contour or in poor soil conditions. Soil Layer The pile of course subbase is a layer of soil that holds the entire pavement layer on it. Good pile work planning affects the strength and durability of the pavement layer

Slope is a tilted ground surface and forms a certain angle to a horizontal plane [7]. In an area where there are two different height surfaces, there will be a force that works to push so that higher soils tend to move towards the bottom called the gravitational

potential force that causes landslides. The slope angle is one of the things that has an influence on the failure of a slope [3]. The stability of the slope depends on the driving force and the resistance force that works in the lake plane, where the soil can be said to be stable if the retaining force on the slope is greater than the driving force [17].

The study was conducted on the construction of the Binjai-Pangkalan Brandan STA 29+375 toll road with the aim of finding out the stability rate of the pile on the Binjai-Pangkalan Brandan toll road planning and to find out how much the influence of the slope angle on the stability of the pile slope with a variation of 15°, 25°, 45° and 60° before and after loading using two analyzes, namely manual calculations and element programs up to

In [10], it was concluded that the height of the pile and the slope of the subgrade affect the value of safety factors, especially in high piles and steep subgrade slopes. The rock fill used as a reinforcement of piles has proven to have an effect in increasing safety factors. The earthquake greatly affects the stability of the pile, which value of the safety factor will decrease[15].

According to [1] in his research stated that if the higher the pile, the reduced the value of the safety rate. The high pile results in the safety factor of the subgrade decreasing, so that methods are needed to strengthen the subgrade. In the 2018 Geostudio Program calculation, a safety factor was obtained of: 2,608 on a pile with a slope of 30 ° and 1,962 in 55° slope.

In the study of [14], concluded that on the slopes of the pile 3, 6 and 9 meters of the original land, the value of a safe number was obtained by 1,4307, 1,1987 and 1,0784, while at post -construction at 1,3345, 1 , 1712 and 1,0589. On the illegal slopes of 12 meters of the original soil, a secure number of 1,0154 is obtained, whereas at post -construction the slope of the pile has experienced collapse.

Similar slope stability case studies in mining and infrastructure projects, such as the Ferari Block area of PT. Vale Indonesia, further confirm the significant role of slope geometry and soil parameters on the resulting safety factor [9].

2 Literature Review

2.1 Land

In the view of civil engineering, the soil is a set of minerals, organic matter, and loose deposits, which are located above the base rock [12]. In soil mechanics, soil is all natural deposits related to civil engineering. The bond between a relatively weak grain can be caused by carbonate. organic substances, or oxides that settle between particles. The space between particles can contain water, air or both. The process of weathering rocks or other geological processes that occur near the surface of the earth form the soil. Soil formation from its parent rock, can be in the form of physical and chemical processes[6]. The soil classification system commonly used in road techniques is two, namely the USCS (Unified Soil Classification System) soil classification system and the AASHTO (American Association of State Highway and Transportation Officials

Classification system the same is to analyze particle size and the characteristics of plasticity[5] [11].

2.2 Slope

The slope is a tilted earth surface that is more prominent due to differences in height between two places. The formation of slopes is caused by erosion, weathering, and soil movement. The slope angle can be seen from the contour of the soil which is a line that connects one point to another point. The slope angle must be monitored to detect the potential for landslides. The collapse of the slope can occur at any time, either in the case of natural slopes or artificial slopes slowly or suddenly with or without previous signs. The collapse of the slope is often caused by a process that increases or decreases shear stress and shear strength in the soil mass. A load that is done on a soil mass will always produce a voltage with different intensity in the lamp bulb (bulb) zone under the load.

2.3 Analysis Of Slope Stability

Soil stability is a method used to improve the carrying capacity of a soil layer, by giving treatment to the soil layer, the stability of the slope depends on the driving force and the resistance force that works in the plane of the break, where Soil can be said to be stable if the retaining force on the slope is greater than the drive force [17]. Based on the quote from the soil mechanics book written by [13], the safe factor is defined as the appeal value between the force that holds and the force that moves, the value of the safety factor and the slope conditions can be seen in the following table[8].

2.4 Bishop Method (Simplified Bishop Method)

Analysis of soil stability will use simplified bishop method. This method assumes that the force between horizontal slices (normal to the side) and ignores the shear force between the slices. The normal and sliding force at the bottom is obtained by adding the force in the vertical direction ($\sigma_{fy} = 0$) and using the Mohr-Coulomb shear strength relationship. The equation for the safety factor is determined by the equilibrium of the moment ($\sum MY = 0$) around the center of the circle of the slope. Compared to other limit equilibrium methods such as the Janbu method, the simplified Bishop method has been shown to provide comparable and reliable safety factor results in slope stability studies [2].

2.5 Geostudio Program

Geostudio is an integrated geotechnical analysis software series used to analyze slope stability, groundwater flow, and heat and mass transfer in the soil and rocks. Because of its integrated nature that allows geostudio to use the results of one product into another product.

3 Materials and Methods

In this study an analysis will be carried out on two slope conditions, namely the original slope conditions according to planning and slope with a specified slope variation and each slope will be analyzed by taking into account the addition of external loads of piles after the addition of structural and traffic loads. Analysis of stability using the simplified manual calculation of the simplified bishop and geostudio software program.

4 Research Data

The study was conducted on the construction of the Binjai - Brandan STA 29 + 375 Toll Road and the data used was secondary data at STA 29 + 375 obtained from PT Hutama Karya Infrastructure as the Implementing Contractor in the Binjai - Pangkalan Brandan Toll Road Construction. The data used in this study are as follows.

4.1 Soil parameter data

The pile material used is a material in the form of clay soil that has passed the laboratory test before the start of the overflowing process in the field and is certain to meet the planning requirements [16].

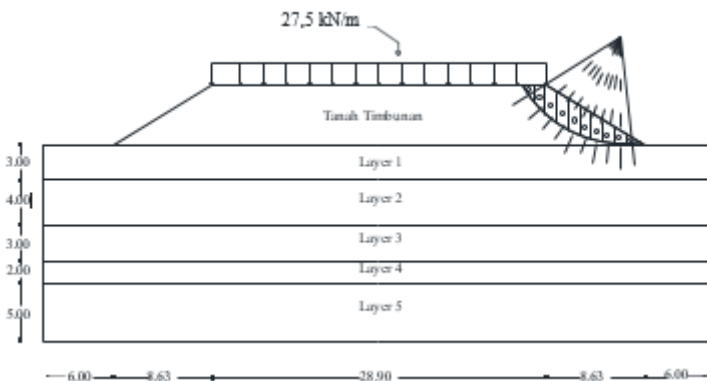


Fig. 1. Transverse Pieces Sta 29+375

Soil parameter data obtained from geotechnical report data with triaxial testing in the field and presented in Tabel 1 below

Table 1. Land Parameter Data

	Unit	Pile	Layer1	Layer2	Layer3	Layer4	Layer5
		Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
γ	kN/m ³	15,31	12	12	13	13	13
C	kN/m ³	8	25	11	0	20	25
Φ	(°)	23	30	19	42	22	23
E	kN/m ³	-	5000	1400	30000	3000	6000
v	-	-	0,3	0,3	0,25	0,3	0,3
depth	m	-	0 – 3	3 - 7	7 - 10	10 - 12	>12

4.2 Pavement and traffic expense data

Structure or pavement loads affect the stability of the pile of land because the pile of land will hold the entire dead load or living load on it. Structure loads are calculated based on the specific gravity of each pavement layer multiplied by the thickness of the road layer.

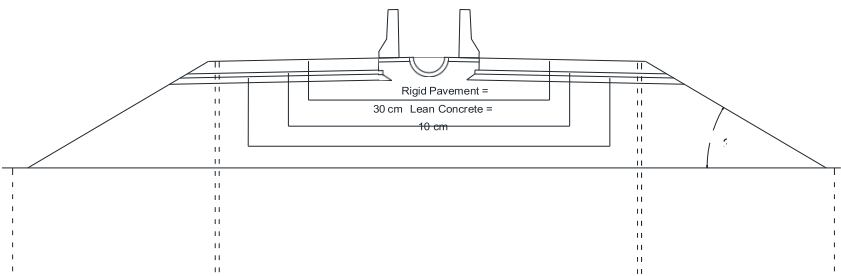


Fig. 2. road cross section

Calculation of road pavement load

$$\begin{aligned} &= \gamma_1 h_1 + \gamma_2 h_2 + \gamma_3 h_3 \\ &= (24 \times 0,30) + (23 \times 0,10) + (20 \times 0,15) \\ &= 12,50 \text{ kN/m}^2 \end{aligned}$$

Table 2. Traffic Load Data

Function	Network System	Daily Traffic Average (LHR)	traffic burden (kN/m ²)
Primer	Arteri	All	15
		>10.000	15
	Kolektor	<10.000	12
		>20.000	15
Sekunder	Arteri	<20.000	12
		>6.000	12
		<6.000	10
	Kolektor	>500	10
		<500	10
		<500	10

As for the traffic expense data that works on toll roads, it can be seen in Table 2 Traffic expenses based on the function and system of road and toll road networks in the primary arterial category with a traffic load of 15 kN/m². Then the vertical load (surcharge loads) received by the landfill and will be input into the geostudio is:

$$\begin{aligned}
 &= \text{pavement load} + \text{traffic load} \\
 &= 12.5 \text{ kN/m}^2 + 15 \text{ kN/m}^2. \\
 &= 27.5 \text{ kN/m}^2.
 \end{aligned}$$

4.3 Bishop Method (Simplified Bishop Method)

The simplified bishop method is an analytical method that uses the principle of slices. In determining the safety factor of a slope, bishop assumes a circle-shaped landslide plane then the landslide plane is broken down into several slices and then calculated in each sliced method of the bishop method ignoring the frictional force between the slices and assumes that Normal force is enough to define the force between slices. The Bishop method is simplified assuming that the forces acting on the sides of the slices have zero results (Hardiyatmo, 2014). The stages of calculation analysis using the Bishop method are as follows:

1. Collecting soil parameter data needed for the calculation of the bishop method
2. Sketch slope then determine the center point of the landslide
3. Determine the slip surface by making a circle
4. For the landslide area into several slices/sections

5. Determine the width, weight and angle of each slice to the center of the landslide center
6. Calculate the area and weight of each slice/part that has been predetermined
7. Calculate safety factors using the Bishop equation
8. Evaluate the safety factor number

Based on the quote from the soil mechanics book written by Hardiyatmo (2014), the safe factor is defined as the appeal value between the force that holds and the force that moves the equation formula in the manual calculation using the simplified bishop method as follows:

$$SF = \frac{\sum_{i=1}^n [c b_i + w w_i \tan \phi'] \left(\frac{1}{m \theta_i} \right)}{\sum_{i=1}^n \frac{w w_i \sin \theta_i}{l}} \quad (1)$$

With

$$m \theta \theta_i = \cos \theta \theta_i + \frac{\tan \phi \sin \theta \theta_i}{SF} \quad (2)$$

Where :

SF = safety factor

c = Effective soil cohesion (KN/m²)

b_i = width of the i th slice (m)

w_i = weight of the thills of i (KN)

$\theta \theta_i$ = angle of each slice (°)

ϕ = Inner friction angle (°)

4.4 Geostudio Program

Geostudio is an integrated geotechnical analysis software series used to analyze slope stability, groundwater flow, and heat and mass transfer in the soil and rocks. Because of its nature Integrated so that it allows geostudio to use the results of one product into another.

Slope / W is one of the features of the geostudio that is useful for analyzing the safety factor of a slope. Geostudio makes it easy for us to solve complicated problems such as for example, a layer of soil 19 complex, very irregular water pressure conditions, some of the strength of the soil sliding, strength shear parameters in unsaturated conditions, approaches to the shape of the plane of the lake with or without tension crack, evenly distributed load, and earthquake load, and strengthening with structure in general the stages for the analysis of the stability of the pile of slopes using the Geostudio program are as follows:

a. Modeling stage

At this stage the components and settings are appropriate to the modeling that we want and need. Modeling is done by entering the soil geometry model in the form of soil coating, structural elements, soil parameters, loading and other boundary conditions that can be done in detail.

b. Calculation stage

After going through the modeling stage as above will be followed by sketching the landslide sector then running analyses on the Solve Manager menu.

c. The output stage

The output stage is the result of the calculation stage. The resulting output is a safety factor for the modeled slope. But this stage must be done repeatedly several times until the smallest safety factor value results or critical slopes.

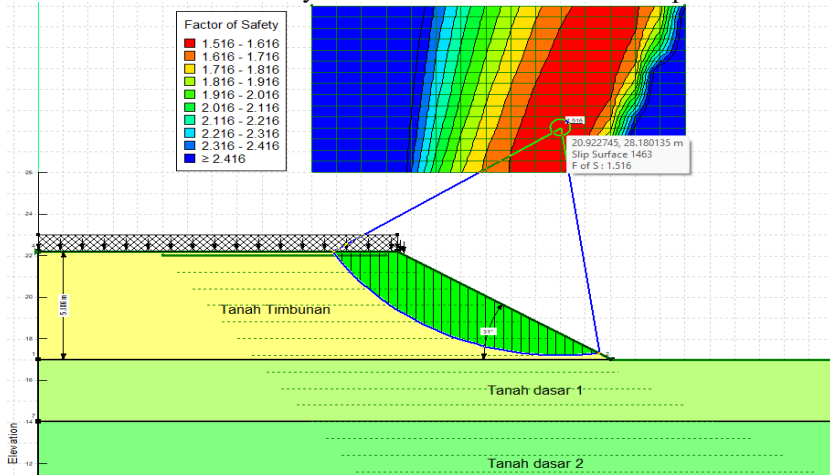


Fig. 3. Output run analysis geostudio 2018

The picture above is an example of the results of the analysis of the stability of the pile slope using the Geostudio program with the addition of the pavement structure load above. Geostudio can also display a safety zone map that shows a landslide -prone area on the slope like Figure 4 below

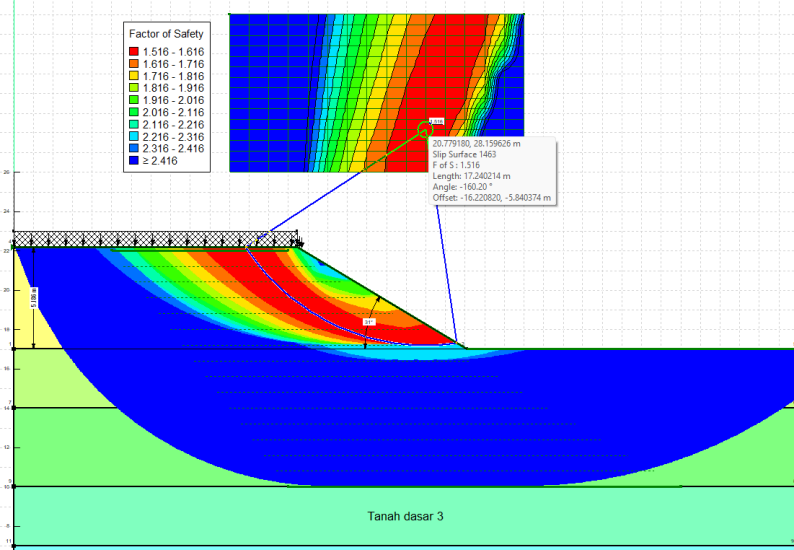


Fig. 4. Display safety map zone

The results of the analysis will be in the form of a security number that will show stability and slope. The reference for determining the state of the slope is the following safety factor value classification table.

Table 3. Safety Factor is reviewed based on the state of the slope

Safety Factor (F)	Slope
$F < 1,00$	Slopes in non -stable conditions (unstable slopes)
$1,00 < F < 1,20$	The slope in a doubtful state of stability
$1,30 < F < 1,40$	Slope in satisfying condition
$1,50 < F < 1,70$	Slope in a great condition (stable slope)

Table 4. Safety Factor in terms of the intensity of the landslide

Safety factor value	Possible landslides
$F < 1,07$	Landslides occur normal/ frequent (unstable slopes)
$1,07 < F < 1,25$	Landslides have occurred (critical slopes)
$F > 1,25$	Landslides are rare (slopes relatively stable)

5 Results and Discussion

5.1 Analysis of Bishop Method Slope Stability

The simplified manual calculation of the simplified bishop method is used to analyze the stability of the slope in the original condition in the field in STA 29 + 375 under conditions before loading and after loading with calculation evenly distributed load due to the addition of pavement structure loads and traffic loads above the pile. The bishop method assumes a circle -shaped landslide plane and then broken down into several slices like Figure 5 above, then the calculation is done on each slice.

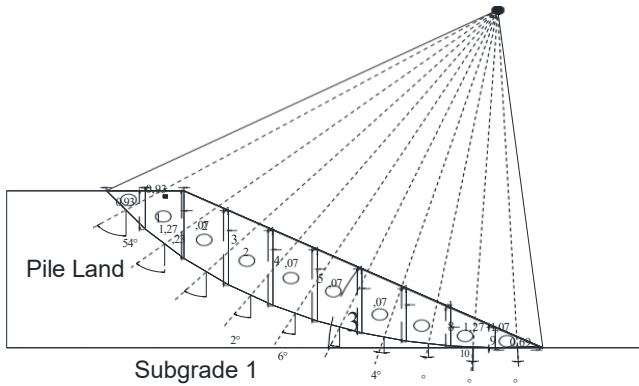


Fig. 5. critical slip area at Sta 29+375

Calculation of the force acting in each slice before loading can be seen in the following table.

Table 5. Calculation of the gravity of each slice before loading

No slice	b_n	Slice Area	W_n	α_n	$m\alpha_n$	$W_n \tan \phi$	$W_n \sin \alpha_n$	$(c \cdot b_n + W_n \tan \phi)^* / m\alpha_n$
	(m)	(m ²)	(kN)	(°)		(kN)	(kN)	
1	0.93	0.5906	9.0413	54	0.7786	3.8378	7.3146	12.111
2	0.93	1.6275	24.9170	46	0.8643	10.5766	17.9238	18.017
3	1.07	2.5092	38.4151	39	0.9256	16.3062	24.1754	23.812
4	1.07	2.6536	40.6266	32	0.9730	17.2450	21.5288	24.050
5	1.07	2.6108	39.9713	26	1.0022	16.9668	17.5223	23.530
6	1.07	2.4075	36.8588	20	1.0203	15.6456	12.6065	22.312
7	1.07	2.0705	31.6986	14	1.0273	13.4553	7.6686	20.518
8	1.07	1.6157	24.7364	9	1.0246	10.5000	3.8696	18.082
9	1.07	1.0486	16.0541	3	1.0110	6.8145	0.8402	15.061
10	1.07	0.3692	5.6517	-2	0.9912	2.3990	-0.1972	11.131
Total							113.2525	188.622

In the formula equation with the Bishop method, the SF value appears on both sides of the equation, therefore it takes a trial and error way to obtain safety factor numbers. The SF value on the right segment is the temporary value assumed in advance, then it will be changed to follow the value approaching the SF number of the left segment until

the same value is found in both sides. Trial error done with the help of the Excel program.

Table 6. trial of the right safety factor value before loading

Trial	F(kanan)	$\frac{\Sigma (c.b_n+Wn.tan\Phi)}{1/m\alpha_n}$	$\Sigma Wn.Sin \alpha_n$	Safety factor
1	1	188.622	113.2525	1,67
2	1,67	202,531		1,79
3	1,79	204.087		1,80
4	1,80	204,209		1,80

The safety factor value on the original slopes before the loading of construction and traffic loads was successfully obtained in the fourth trial after the SF numbers in the two similar equations were 1.80. There is no significant difference between the calculation before and after loading, which is only the addition of loads to the slices affected by the load on the calculation of the weight of the slices. The calculation of the force acting in each slice after loading can be seen in the following table.

Table 7. Calculation of the gravity of each slice after loading

No Slice	bn	Slice Area	Wn	α_n	$m\alpha_n$	Wn.tan Φ	Wn . Sin α_n	$\frac{(c.b_n+Wn.tan\Phi)^*}{1/m\alpha_n}$
	(m)	(m ²)	(kN)	(°)		(kN)	(kN)	
1	1.31	1.074	52.471	52	0.8448	22.2726	41.3477	38.771
2	1.32	2.937	81.265	41	0.9454	34.4951	53.3149	47.655
3	1.01	2.868	43.915	34	0.9916	18.6409	24.5571	26.947
4	1.01	2.858	43.761	27	1.0230	18.5753	19.8669	26.056
5	1.01	2.712	41.518	22	1.0361	17.6235	15.5531	24.808
6	1.01	2.444	37.421	16	1.0414	15.8841	10.3145	23.011
7	1.01	2.071	31.699	10	1.0353	13.4556	5.5045	20.801
8	1.01	1.596	24.432	5	1.0215	10.3706	2.1294	18.062
9	1.01	1.025	15.695	0	1.0000	6.6622	0.0000	14.742
10	1.01	0.359	5.489	-6	0.9641	2.3301	-0.5738	10.797
			Total				172.0143	237.522

Table 7 shows the forces acting on each slice of the landslide by assuming the right SF value of 1. In the condition after loading the structure and traffic, the analysis will take into account the addition of loads in the affected area, namely the first and second slices.

From the calculation of each type The layer and guide of traffic load data obtained pavement and traffic loads are 27.5 kN/m².

Table 8. trial of the right safety factor value after loading

trial	F(kanan)	$\Sigma (c.b_n + Wn.tan\Phi)$ $1/m\alpha_n$	$\Sigma Wn.Sin \alpha_n$	Safety factor
1	1	237.522	172.0143	1,38
2	1,38	249.736		1,45
3	1,45	251.421		1,46
4	1,46	251.651		1,46

The safety factor value on the original slopes with pavement and traffic loads was successfully obtained in the fourth trial after the SF numbers in both similar equations were 1.46. The results of the security number of manual analysis with the simplified bishop method can be seen in the following table.

Table 9. Results of Safety Factor Value Bishop Manual Calculation

Method	Simplified Bishop Manual	
Slope Conditions	Before Loading	After Loading
Safety Factor	1.80	1.46

5.2 Results of Analysis of Calculation of Original Conditions Slope

Analysis of stability in the condition of the pile of slopes with the original slope, namely the slopes of the Binjai-Pangkalan Brandan STA 29+375 toll road construction project will be carried out with two stages of the analysis, namely using the simplified manual calculation of the simplified bishop method and with the help of the 2018 geostudio program. Recapitulation of the calculation results. The security rate of the original slope using the manual method and the 2018 Geostudio program can be seen in the following table 10

Table 10. Results of Analysis of Calculation of Original Conditions Slope Calculation (31°)

Method	Bishop manual Simplified	Software Geostudio 2018
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Slope conditions	Before Loading	After Loading	Before Loading	After Loading
Safety Factor	1.80	1.46	1.79	1.52
Slope (Sosrodarsono, 2003)	Safe	satisfying	Safe	Safe
Landslide Intensity (Bowles, 1991)	stable	stable	stable	stable

The table above is the condition of the pile slope if it is associated with the Safety Factor Classification Table according to the slope (Sosrodarsono, 2003) and the intensity of the landslide (Bowles, 1991). After an analysis of the calculation manual and geostudio program found there is a slight difference in results. The difference in results between manual calculations and using geostudio can be caused by the complexity of the analysis method, numerical algorithms, and assumptions used in geostudio. The comparison of manual and geostudio calculation results is also displayed in the following graphics.

Based on the results of the analysis using the simplified bishop method, it was obtained that the results of the original slope safety factor value with a slope angle of 31° before loading 1.80 and under conditions after loading the value of the original slope's safety factor dropped to 1.46 due to the increase in load received by the pile . In the results of the run analysis using the geostudio program obtained a safety factor value of 1.79 before loading and the safety factor value of 1.52 after loading.

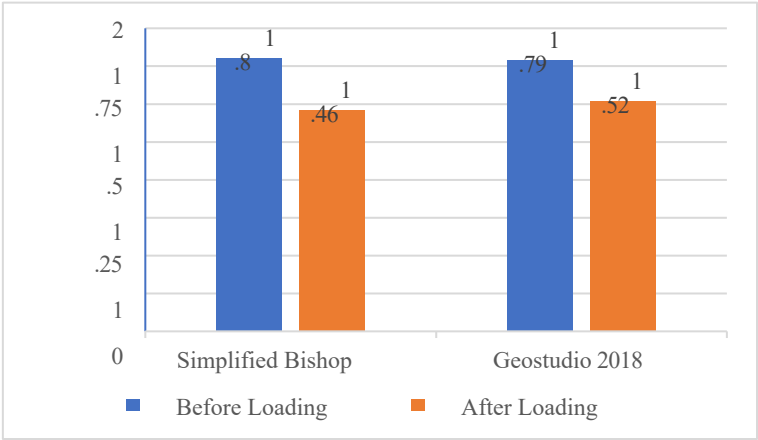


Fig. 6. comparison of the original slope safety factor results

The state of the pile slope refers to Table 3 Safety Factor Value is reviewed based on the slope conditions obtained that the slope is in a stable and safe state except on the results of the simplified manual bishop calculation that is simplified after loading which

according to Table 3 is in a satisfying state. While the slope conditions are reviewed, the intensity of the landslide is concluded in Table 4.

5.3 Results of Slope Variation Analysis with Geostudio Software

Slope stability analysis with slope angle variations is carried out to determine how much influence the changes in slope angle variations have on the stability of the embankment slope so that later it can be concluded what slope conditions are safer for the stability of the embankment slope. At this stage, the analysis will only be carried out using geostudio software.

Based on the output of the geostudio program run analyses on the stability analysis with embankment variations of 15°, 25°, 45° and 60° before loading, the safety factor values were 3.16, 2.16, 1.43 and 1.09 respectively, while the slope safety factor values after loading were 2.60, 1.79, 1.15 and 0.89 respectively. The results of the SF value and its relationship to the slope condition and intensity landslides according to the SF Sosrodarsono and Bowles classification table are shown in table 11 below.

Table 11. Results of the Geostudio program analysis of slope angle variations

Slope Conditions	Slope Original	Variasi kemiringan			
		15°	25°	45°	60°
Before Loading	1,79	3,16	2,16	1,43	1,09
After Loading	1,52	2,60	1,79	1,15	0,89
Slope Conditions (Sosrodarsono, 2003)	Safe	Safe	Safe	Satisfying	Doubtful
	Safe	Safe	Safe	Doubtful	Not safe
Landslide Intensity (Bowles, 1991)	Stable	Stable	Stable	Stable	Critical Slope
	Stable	Stable	Stable	Critical Slope	Unstable

After obtaining the safety factor value for each slope variation, a slope condition review will be carried out referring to the Sosrodarsono and Bowles classification table, from the classification table value, the slope condition for each slope angle is concluded as follows:

1. Safety factor value based on slope conditions (Sosrodarsono, 2003)

A. Original Slope 31°

SF values on the original slope before and after loading are 1.79 and 1.52 which are in the range of slopes in steady and stable conditions

B. Slope 15°

At a slope of 15°, the SF values before and after loading are 3.16 and 2.60, it can be concluded that the slope is in a steady and stable condition

C. Slope 25°

The geostudio output results at a slope of 25° obtain SF values before and after loading of 2.16 and 1.79 which according to the slope condition classification table are stable and in steady condition

D. Slope 45°

Based on the slope condition classification table before loading with an SF value of 1.43 in a satisfactory condition and after loading in a doubtful condition with an SF value of 1.15. Additional reinforcement is needed on the slope

E. Slope 60°

At a slope of 60° before loading with an SF value of 1.09, the slope is included in the category of doubtful stability conditions, but after receiving additional loads the SF value drops to 0.89 which indicates the slope is in an unstable condition or unstable slope and re-planning is needed on the slope geometry in this condition.

2. Safety factor value based on landslide intensity (Bowles, 1991)

A. Original Slope 31°

The SF value on the original slope before and after loading is 1.79 and 1.52 which defines that in this condition the slope is relatively stable and the possibility of landslides is rare.

B. Slope 15°

At a slope of 15°, the SF values before and after loading are 3.16 and 2.60, indicating a stable slope and the possibility of landslides rarely occurs

C. Slope 25°

At a slope of 25°, the SF values before and after loading are 2.16 and 1.79, which according to the slope classification table are stable and landslides rarely occur

D. Slope 45°

Based on the slope condition classification table before loading with an SF value of 1.43, the slope is in a stable condition and after loading SF 1.15, the slope is in a critical condition and the possibility of landslides has occurred

E. Slope 60°

At a slope of 60° before loading with an SF value of 1.09, the slope is in the critical category with landslides having occurred, but after loading the SF value drops to 0.89 which indicates an unstable slope and the possibility of landslides occurring frequently.

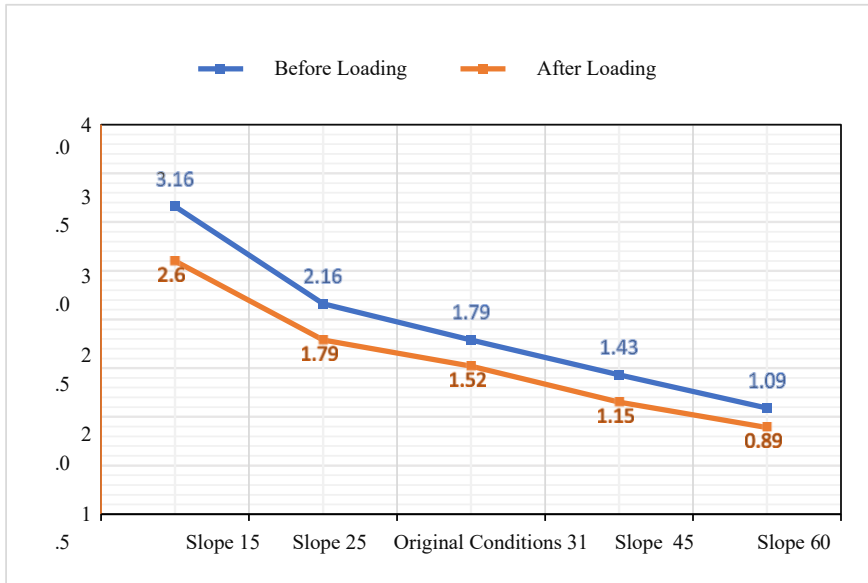


Fig. 7. comparison of SF values of geostudio program analysis

Figure 7 shows a comparison of the safety factor values before and after loading. Based on the overall analysis results with the geostudio 2018 program, it can be concluded that variations in the slope angle affect the stability of a slope.

6 Conclusion

In the stability analysis of the pile with the original slope of the Bishop Manual Method and the 2018 Geostudio Program before loading the Safety Factor results are 1.80 and 1.79, while the slopes safety factor value after the loading is 1.46 and 1.52. Then in the stability analysis with a pile variation of 15°, 25°, 45° and 60° before the loading of each safety factor is 3.16, 2.16, 1.43 and 1.09, while the safety factor value of the slope after loading of 2.60, 1.79, 1.15 and 0.89. From the safety factor value the results of geostudio analysis can be concluded that the slope angle affects the stability of a slope. The stability of a slope decreases along with the greater the angle. The more sloping a slope, the greater the stability value. Conversely, the steeper of a slope, the decrease in stability value in the same soil parameter conditions.

From the overall research results that have been conducted, it is recommended to conduct further research by analyzing or modeling the slope with the addition of reinforcement, such as geotextile reinforcement analyzed using the Plaxis program [4], calculating costs on each slope model that is made and pay attention to the value of sf

wet soil to determine the decrease in slope stability in The rainy season for anticipation of landslides, especially on natural slopes located on the side of the road.

7 Acknowledgement

This research was funded by the AKSI-ADB Unimal Project through the Research Grant for Young Researchers Scheme. The author would like to thank PT. Hutama Karya Infrastruktur (HKI) Jalan Tol Binjai – Pangkalan Brandan for granting permission to collect data for this study. And also thanks to the Research Team for providing support so that this study can be carried out.

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