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Study of Deformation Behavior of Retaining Walls at Sepakat Ii Parallel Road Project in Pontianak City

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Abstract

The development of urban planning and infrastructure such as roads, buildings, bridges, ports has increased in recent years in Pontianak City. One of them is the construction of Jalan Parallel Sepakat II which was carried out in early 2022, connecting Jalan Sepakat II to the Tanjungpura University Campus Complex. In the case in the field, the previously compacted embankment has decreased, so backfilling is carried out to adjust the planned elevation. Due to the unsafe existing condition factor, improvements were made that were supported by retaining wall modeling. In addition to the retaining wall modeling, the current planning in the field is also stabilized by using a pile and geotextile, in order to increase the bearing capacity of the soil and can minimize the decrease or deformation that occurs at the research location. In the process of analyzing the retaining wall, analysis is also carried out with the Plaxis Proffesional 8.6 program. The results obtained in the form of deformation numbers and safety factor results. From the conclusion, the factor of safety is obtained which is not safe so that it is feasible to be reinforced. However, some adjustments are needed to the design plan so that it can function properly in accordance with the intent and purpose of the reinforcement.

Key words: retaining wall, deformation, Plaxis Proffesional 8.6, factor of safety.

1. Introduction

Sepakat II road is one of the roads in Pontianak City with a fairly high density of vehicles and the expansion of residential areas along the road.

The construction of the Sepakat II Parallel Road is being carried out in early 2022 which connects Jalan Sepakat II to the Tanjungpura University Campus Complex. In the embankment soil there is a decrease so that backfilling must be done to adjust the planned elevation. Due to the influence of the existing conditions of the road built near the ditch, it can allow the collapse of the embankment. Due to the unsafe existing condition factor, improvements are made which are supported by retaining wall modeling.

In addition to retaining wall modeling, the current planning in the field is also carried out stability by using geotextile and geotextile, to increase the bearing capacity of the soil and minimize the decline that occurs.

2. Materials and Method

2.1 Lateral Earth Pressure

According to Hardiyatmo (2010), factors that affect the value of lateral soil pressure are changes in the location (displacement) of the retaining wall. Lateral ground pressure calculation variables, namely:

1. Active Earth Pressure

To calculate the value of the active soil coefficient on the surface of the flat dredged soil is defined:

$$ka = \tan^2\left(45° - \frac{\varphi}{2}\right) \quad (1)$$

where φ is the soil shear Angle (°)

2. Passive Earth Pressure

The value of the passive soil coefficient on the horizontal buried soil surface is defined:

$$kp = \tan^2\left(45° + \frac{\varphi}{2}\right) \quad (2)$$

where φ is the soil shear Angle (°)

3. Cohesive Soil

Based on Rankine's theory, in order to calculate the pressure value of the buried soil that has a cohesion value (c) with an inner friction angle (φ), it is defined:

Active Soil

$$Pa = 0,5\ H\ 2\gamma\ Ka - 2\ c\ H\sqrt{Ka} \quad (3)$$

Passive Soil

$$Pp = 0,5\ H\ 2\gamma\ Kp - 2\ c\ H\sqrt{Kp} \quad (4)$$

where is γ is volume weight of backfill soil (kN/m^3); Ka is active soil permeability coefficient; Kp is Passive soil permeability coefficient; H is uplift soil height (m); c is cohesion of backfill soil (kN/m^2)

2.2 *Slope Stability*

In this research 2 methods are used to find slope stability, namely:

1. Fellinius Method

The Fellinius method factor of safety is defined:

$$F = \frac{\sum_{i=1}^{i=n} c\ a_i + (W_i \cos\theta_i - u_i a_i) tg\ \varphi}{\sum_{i=1}^{i=n} W_i \sin\theta_i} \quad (5)$$

where is c is cohesion (kN/m^2); θ is Angle of friction in soil (°); a_i is size of the curved circle of the-I slice (m); Wi is Weight of Ith soil slice (kN); Ui is Pore water pressure in the-I slice (kN/m^2); θ_i is Angle of inclination (°)

2. Bishop Method

The safety factor of the Bishop method is defined:

$$F = \frac{[c'l + (P - ul)\tan\emptyset']}{W \sin\alpha} \quad (6)$$

where is W is total weight on the slice; EL, ER is force between wedges horizontally at left and right cross sections; XL, XR is force between slices vertically at left and right cross-sections; P is normal force on the wedge; T is base shear force of the wedge; b is Wedge width (m); l is wedge length (m); α is slope inclination angle (°)

2.3 *Cantilever Type Retaining Wall*

Important factors that are taken into account in planning the construction of retaining walls include:

1. Retaining Wall Stability Against Rolling

The factor of safety in rolling can be defined as:

$$Fgl = \frac{\sum Mw}{\sum Mgl} \quad (7)$$

where is Σ Mw is overturning resisting moment (kNm); Σ Mgl is overturning moment (kNm). Based on SNI 8460: 2017 it is said to be safe against rolling forces having a value of SF ≥ 2. (BSN, 2017).

2. Retaining Wall Stability Against Shifting

The factor of safety against sliding can be defined as:

$$Fgs = \frac{\sum Rh}{\sum Ph} \quad (8)$$

where is Σ Rh is retaining wall resistance to displacement; Σ Ph is horizontal force (kN). Based on SNI 8460: 2017 is said to be safe against shear forces if it has an SF value ≥ 1.5. (BSN, 2017).

3. Retaining Wall Stability against Soil Support Capacity

The factor of safety for soil bearing capacity is defined as:

$$SF = \frac{qu}{q'} \quad (9)$$

Based on SNI 8460: 2017 is said to be safe against soil bearing capacity if it has a SF value ≥ 3. (BSN, 2017).

2.4 *Settlement*

This settlement can be defined as follows:

- Settlement against consolidated normal clay

$$Sc = C_c \frac{H}{1+e_0} \log\frac{p_1'}{p_0} \quad (10)$$

- Settlement of over-consolidated clay

If $p_1' < p_c'$

$$Sc = C_r \frac{H}{1+e_0} \log\frac{p_1'}{p_0} \quad (11)$$

If $p_1' > p_c'$

$$Sc = C_r \frac{H}{1+e_0} \log\frac{p'}{p_0} + C_c \frac{H}{1+e_0} \log\frac{p_1'}{p_c'} \quad (12)$$

where is p_1' is $p_0 + \Delta p$ (kN/m^2); C_c is compression index; C_r is back compression index; His thickness of each soil layer; p_c' is preconsolidation pressure (kN/m^2); e_o is initial pore number; p_o is effective overburden pressure before loading.

The location of this research is on street Sepakat II, Southeast Pontianak.

Figure 1.Research location
(Source: Google Earth)

2.5 *Soil Properties*

Soil parameter data obtained at the retaining wall location, then handbored to a depth of 4 meters. Furthermore, soil samples were tested with direct shear tests conducted at the Soil Mechanics' Laboratory of Tanjungpura University.

2.6 *Structure Modeling*

In structural modeling, data will be taken in the form of dimensions and types of construction materials used. It is seen that the conditions in the

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field where the retaining wall is located on soft soil are then given embankment to adjust the planned elevation.

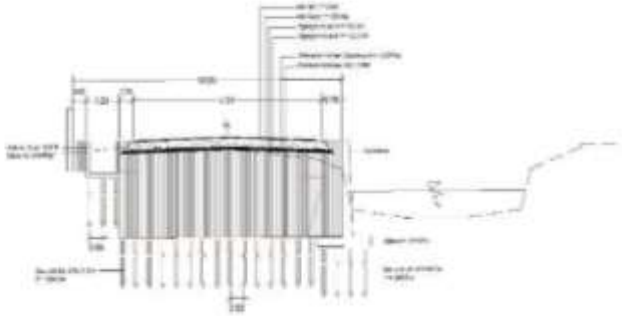

Figure 2. Illustration of conditions in the field
(Source: Pontianak City Public Works and Spatial Planning Office)

2.7 Analysis Procedure of Plaxis Professional 8.6 Program

In this Plaxis program analysis procedure, there are several steps that need to be done, namely:

Data input process

Table 1.Data inputted in plaxis

No.	Parameters	Symbol	Backfill	Clay	Retaining wall
1	Material model	Model	MC	MC	Linear elastic
2	Type of behavior	Tipe	drained	drained	Non porous
3	Dry weight	Ɣdry	16,139	9,173	24
4	Wet weight	Ɣsat	26,281	14,646	-
5	Horizontal permeability	K_x	1.10^{-4}	1.10^{-7}	-
6	Vertical permeability	K_y	1.10^{-4}	1.10^{-7}	-
7	Modulus young	E_{ref}	500	1380	2350.10^4
8	Poisson number	v	0,4	0,4	0,15
9	Cohesion	c	6,5116	3,854	-
10	Friction angle	φ	34,625	3,177	-
11	Dilatancy angle	ψ	4,625	0	-

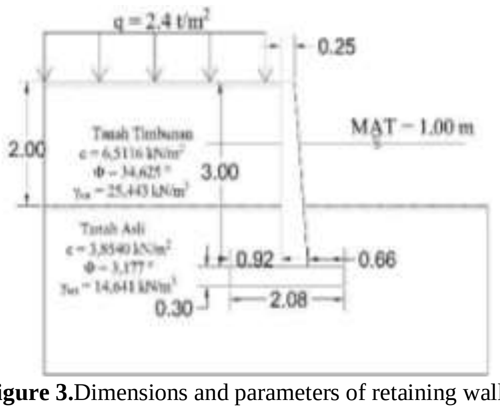

Figure 3. Dimensions and parameters of retaining walls

Table 2.Woodchip and geotextile parameter data

Name	Type	EA (kN/m)	EI (kNm²/m	w (kN/m/m)	v	Mp
Funnel	Elastic	78500	49,0625	0,00471	0,37	4906,25
Geotextile	Elastic	346				

Calculation Process

The steps of the calculation process consist of several stages, namely:

1. Analyze the deformation that occurs
2. Analyze the safety factor
3. Analyze the deformation that occurs due to the original consolidation and embankment, and then added with the construction of retaining walls and reinforcement of slugs and geotextile.
4. Analyze the factor of safety of the consolidation results of native soil and embankment soil, then added with retaining wall construction and reinforced with geotextile and geotextile.

Data Output Process

After going through the calculation process of the inputted data, the ground displacement value and the safety factor value will be obtained.

3. Result and Discussion

3.1 Loading

The total working load can be found

Qtotal = vehicle load + road construction load
= 150 +86,455
= 236.455 gr/cm2

3.2 Original Slope Analysis

The analysis includes stability analysis of the original slope at STA 0+834 with a slope height of 3 meters and a slope width of 11.5 meters. With a water level of 1.00 meters.

1. Fellinius method

Table 3.Recapitulation of Fellinius method slope stability modeling calculations

Modeling 1	Modeling 2	Modeling 3	Average	Cek
0,100 < 1,5	0,110 < 1,5	0,135 < 1,5	0,115 < 1,5	Not okay

2. Bishop's method

Table 4.Recapitulation of Bishop method slope stability modeling calculations

Modeling 1	Modeling 2	Modeling 3	Average	Cek
0,289 < 1,5	0,515 < 1,5	1,111 < 1,5	0,638 < 1,5	Not okay

The results of the calculation of the two methods obtained SF which is close to each other, namely in modeling 2, which is 0.110-0.515. Because SF does not meet the requirements of slope stability, then the next treatment is reinforced using retaining walls.

3.3 Analysis of Concrete Retaining Walls

Based on the retaining wall parameters and soil parameters obtained, the active and passive pressure coefficients are:

Ka_1 = 0,275 Kp_1 = 3,632
Ka_2 = 0,895 Kp_2 = 1,117

Furthermore, the calculation of stability:

1. Stability against shear

Fgs = 0,072

2. Stability against rolling
   Fgl = 2,035

3. Bearing capacity of collapsed soil
   SF = 0,026

Because the SF does not meet the stability requirements, the next analysis is carried out with the reinforcement of slugs and geotextile.

3.4 Bearing Capacity Analysis on Subgrade

1. Calculation of bearing capacity before soil improvement
   The calculation results are:
   qu = 82,615 t/m^2
   qa = 27,538 kg/cm^2
   from the calculation results obtained bearing capacity is not able to support the existing load. Therefore, it is necessary to improve the soil.
2. Calculation of bearing capacity after soil improvement
   Analysis of reinforcement using slugs
   Single pile bearing capacity value
   Qa = 135,805 kg
   Group pile bearing capacity values
   Qall = 15677,58 kg
   Analysis of reinforcement using geotextile
   $T_{ijin} \geq T_{perlu}$
   173 kN ≥ 87,468 kN

3.5 Settlement Analysis

1. Working load
   Qtotal = vehicle load + road construction load + retaining wall load
   = 266,455 + 129,708
   = 366,163 gr/cm^2
2. Calculation of settlement before reinforcing the slab

Table 5.Recapitulation of settlement of each layer

No	H (cm)	Cc	e0	P0' (kg/cm^2)	Δp (kg/cm^2)	Sc (cm)
1	1680	0,3831	1,547	1,044	3,2955	156,3149
2	340	0,2487	1,099	2,266	2,5631	13,2398
3	40	0,3093	1,301	2,455	1,8308	1,3011
Total decrease that occurred						170,8558

3. Calculation of settlement after reinforcing the slab

Table 6.Recapitulation of settlement of each layer

No	H (cm)	Cc	e0	P0' (kg/cm^2)	Δp (kg/cm^2)	Sc (cm)
1	1200	0,3831	1,547	0,772	3,6616	137,032
2	340	0,2487	1,099	2,266	2,5631	13,2398
3	40	0,3093	1,301	2,455	1,8308	1,3011
Total decrease that occurred						151,573

4. Overall stability with reinforced retaining wall, pile and geotextile

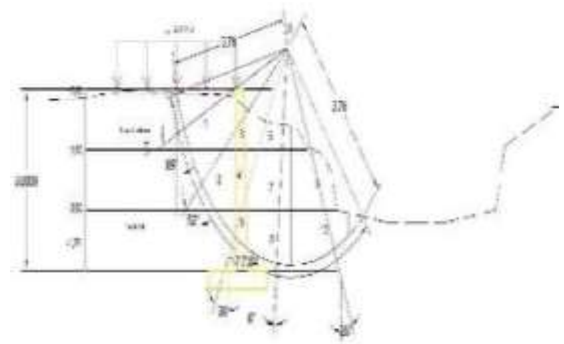

Figure 4.Slope soil collapse area slices

Table 7.Recapitulation of manual SF calculation on slope stability with reinforcement

Fellenius method	Bishop method
0,099	0,490

3.6 Analysis of Slope Stability with Reinforced Retaining Walls, Geotextile, and Culverts Using Plaxis Proffesional Program 8.6

1. Input stage

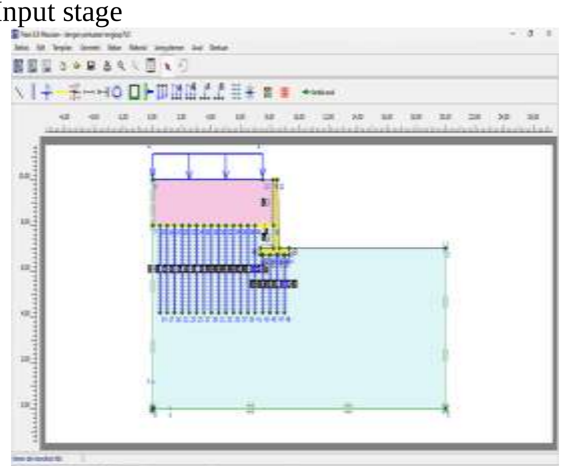

Figure 5.Modeling of slopes reinforced with retaining walls, cisterns and geotextile.

Next do the meshing drawing

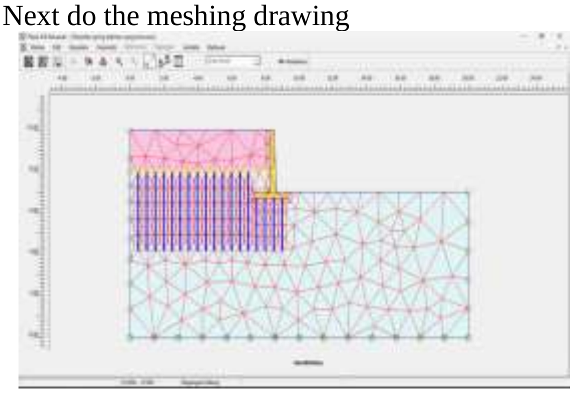

Figure 6.General Meshing of the slope

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2. Calculation stage

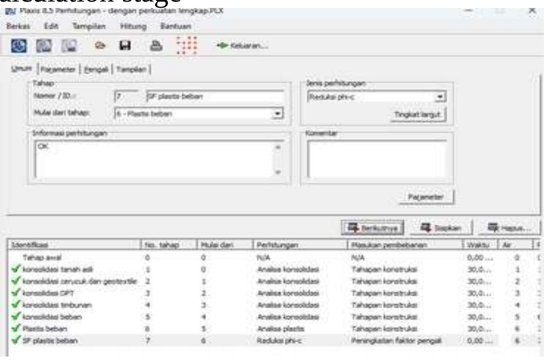

Figure 7.Calculation stages on slopes using retaining walls, cribs and geotextiles

3. Output stage

   On the original slope using normal reinforcement, the factor of safety obtained in the analysis of the original slope without reinforcement is 1.22 < 1.5, indicating that the slope is in critical condition but will not collapse immediately.

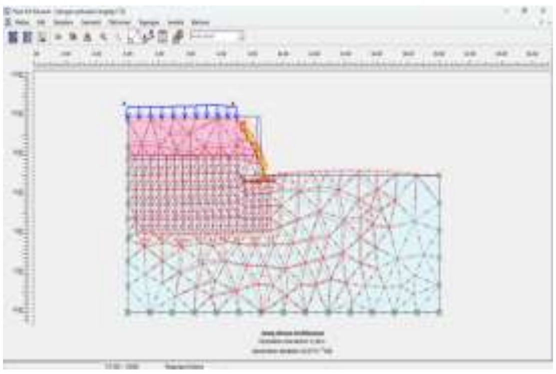

Figure 8. Landslide plane of the slope using retaining wall reinforcement

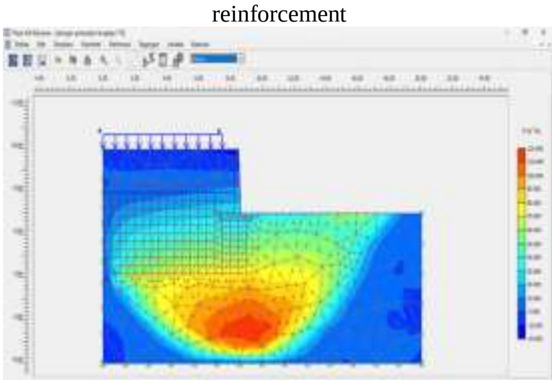

Figure 9. Total displacement on the slope using retaining wall reinforcement

The decrease in soil that occurs due to consolidation on slopes using reinforcement is 0.89 meters which occurs within 30 days.

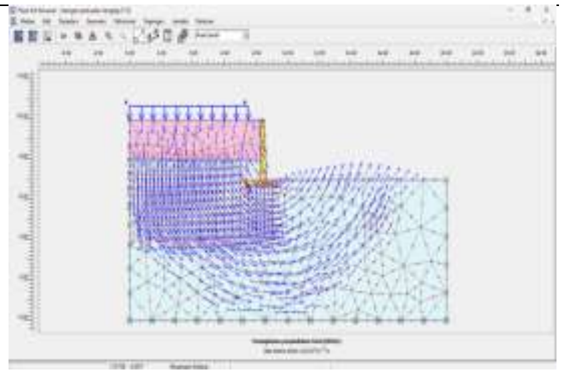

Figure 10 Consolidation and direction of ground settlement

4. Conclusion

Based on the results of the analysis conducted in this study, the following conclusions are obtained:

1. Based on manual calculations, the stability of the retaining wall is obtained with an unsafe failure factor. Analysis with the Plaxis Proffesional 8.6 application when compared to manual analysis obtained a decrease of 1.515 meters, while with the Plaxis Proffesional 8.6 program of 0.89 meters.
2. The value of the safety factor of the retaining wall plus the reinforcement of the pile and geotextile against landslides at each level is as follows:
   a. With the Fellenius method the most critical safety factor was found to be 0.099.
   b. With the Bishop method the most critical safety factor is found to be 0.490.
   c. With Plaxis Proffesional 8.6 software the most critical safety factor is found to be 1.22.

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