Journal of Civil Engineering and Vocational Education

EISSN: 2622-6774
Vol 10 No.3 September 2023
http://cived.ppj.unp.ac.id/index.php/CIVED

The Influence of Ground Water Level Conditions on the Stability of Road Slopes with Retaining Walls

Eka Priadi[1], Murad[2*]
[1] Civil Engineering, University Tanjungpura Pontianak, Indonesia
[2] Mining Engineering, University Tanjungpura Pontianak, Indonesia
*Corresponding Author: murad@teknik.untan.ac.id

Received 19th August 2023; Revision 15th September 2023; Accepted 26th September 2023

ABSTRACT

This research was carried out using the P laxis 8.0 finite element method and manual calculations as well as by evaluating the safety factor value. Slope stability analysis using the P laxis program aims to determine the safe value of the slope before and after reinforcement using a cantilever - type retaining wall. Based on the analysis of the P laxis program before the installation of the cantilever retaining wall, in general the condition of the retaining wall on Jalan Ahmad Yani Gg. Batu Mas, Singkawang City experienced a landslide due to the condition of the soil which was classified as having low soil mechanical properties. Slopes with designed cantilever wall reinforcement are considered safer because they have the smallest displacement and settlement values, and meet all slope stability requirements, ie, shear stability is 1.251 > 1.5 (Safe), stability against overturning is 2.415 > 2 (Safe) , and bearing capacity is 0.555 < 0.583. The cantilever retaining wall structure uses D16-100 principal reinforcement and D10-100 shrinkage reinforcement, the base plate uses D16-150 principal reinforcement and D10-100 shrinkage reinforcement.

Keywords: *Cantilever Wall, Plaxis 8.0 Program, Safety factor*

INTRODUCTION

A slope is an open ground surface, forming a certain angle to the horizontal axis, or a ground surface that has two different elevations where the ground surface forms an angle [1][2].

A landslide is the collapse of a land mass located on a slope resulting in downward and outward movement of the land mass. Many influencing factors _ stability slope like layered soil conditions, anisotropic soil shear strength, water seepage in the soil and so on [3]. High rainfall conditions are one of the causes of landslides because an increase in the degree of soil saturation can result in an increase in soil pore water pressure so that the effective soil stress decreases and the soil shear strength also decreases.

The Singkawang City area is mostly an area with fairly flat topography, or around 80% with a slope of between 0-8% at an altitude of between 0-12 meters above sea level [4] . The problem that is often faced in Singkawang City is puddles during the rainy season.

The heavy rain in Singkawang City that occurred at the end of August 2022 not only caused flooding, but also landslides [5] . The soil on the slopes consists of clay, silt and sand, making the soil unstable and not very strong when it rains. Water that enters this type of soil will become unstable and weaken, causing dynamic loads on the slopes, causing landslides.

The results of field observations due to the high rainfall caused a number of roads in Singkawang City to be flooded, this has become a common experience for the community. Apart from that, the flood also submerged several main roads which provided access for the community. Not only flooding, due to the heavy rain that continues to cause a number of points in Singkawang City to be buried by landslides. Therefore, the high rainfall factor must be taken into account in every planning, implementation of development and maintenance of development results.

The location chosen for Singkawang City was the object of research because of the background of high rainfall which can cause the water level to rise and cause stress on the soil, such as pore water pressure which is one of the causes of landslides [6] . Therefore, the author tries to take a case study in this area to determine the influence of pore water pressure and the reinforcement that can be used.

Based on these problems it is necessary done research which aims to analyze the existing condition of retaining walls, designing the dimensions and stability of retaining walls against the risk of movement, overturning and subsidence manually as well as the value of the safety factor *(safety f actors)* on Jalan Ahmad Yani Gg. Batu Mas based on analysis using the Plaxis V.8.0 computer program.

MATERIALS AND METHODS

Type study This is type study applied from facet its use, where the concepts used tend to be operational And No draft Which abstract [7].

The data required in this research includes:
a. data N- C PT
b. Results photo/drawing location cliff landslide road _
c. Location map
d. Piece transverse road place happen landslide
e. Vehicle load and movement land .

Layer data land obtained from two locations point retrieval of results data drilling , point CPT.01 and point CPT . 0 2 Jalan Ahmad Yani Gg. Batu Mas, Singkawang City (figure 1).

CIVED Journal of Civil Engineering and Vocational Education

EISSN: 2622-6774
Vol 10 No.3 September 2023
http://cived.ppj.unp.ac.id/index.php/CIVED

Figure 1: Data Collection Locations CPT.01 and CPT 02

The data analysis techniques used in this research include field data and laboratory data to obtain:

1. Active Earth Pressure

   Rankine theory is used to calculate the active earth pressure value on lateral land, which is divided into the active earth pressure value on flat land and the active earth pressure value on sloping land. Use the formula below to calculate the active ground surface value and slope coefficient. Ka value on land flat is expressed in Equation 1 as follows:

$$Ka = \frac{1-sin\varphi}{1+sin\varphi} = tan^2.\left(45° - \frac{\varphi}{2}\right) \dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

   Information:
   φ = Soil friction angle (°)
   Ka = Active soil coefficient

2. Passive Earth Pressure

   Passive earth pressure for lateral soil is calculated in the same way as active earth pressure using Rankine theory, which is divided into passive earth pressure for flat soil and passive earth pressure for sloping soil. The calculation procedure uses the Rankine method

Journal of Civil Engineering and Vocational Education
EISSN: 2622-6774
Vol 10 No.3 September 2023
http://cived.ppj.unp.ac.id/index.php/CIVED

according to the formula below. The Kp value for flat land is expressed in Equation 2 as follows:

$$Kp = \frac{1+sin\varphi}{1-sin\varphi} = tan^2.\left(45° + \frac{\varphi}{2}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Information:
φ = Soil friction angle (°)
Kp = Passive soil coefficient

3. Stability of antilevered Earth Retaining Walls _ _ _ Against Rolling Force
   Rolling resistance is the stability that is considered when the soil is overturned due to the lateral pressure of the embankment behind the retaining wall. The value of structural stability against the possibility of overturning is calculated using the following equation 3:

$$FS\ guling = \frac{\Sigma Mw}{\Sigma Mguling} = \frac{W.b1}{\Sigma Pah.h1+\Sigma pav.B} \geq 2 \ldots\ldots\ldots (3)$$

   Information:
   ∑Mw = anti- rolling moment (kNm)
   ∑Mgl = magnitude of moment roll (kNm)
   W = weight of soil + weight of retaining wall (kN)
   B = width of retaining wall (m)
   ∑Pah = magnitude of horizontal force (kN)
   ∑Pav = magnitude of vertical force (kN)

4. Stability of antilevered Earth Retaining Walls _ _ _ Against Shear Force
   Shear resistance is the ratio between the retaining force and the compressive force of the retaining wall. The value of structural stability against shear potential is calculated using Equation 4-7 below:

$$FSgeser = \frac{\Sigma Rh}{\Sigma Pah} \geq 1.5 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

   For granular soil (c=0)

$$\sum Rh = WF$$
$$= W.\tan \delta h \text{ with } \delta h \leq \emptyset \ldots\ldots\ldots\ldots (5)$$

   For cohesive soil (∅ = 0)

$$\sum x\ Rh = Ca \,.\, B \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

   For soil $c = \emptyset$ ($\emptyset > ad$ 0 and $c = 0$)

$$\sum R_h = C \,.\, B + W.\tan \delta h \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

   Information:
   $\sum R_h$ = to shear resistance retaining wall
   W = total mass of soil above wall support and base plate
   δh = angle of friction between the soil and the foundation (1/3 to 2/3) ∅
   C = base layer cohesion
   B = width of retaining wall (m)
   ∑Pah = magnitude horizontal style
   f = tan δb = friction coefficient of soil and foundation

5. Stability Against Collapse of Soil Carrying Capacity
   The load equation for calculating the stability of retaining walls includes the Meyerhof method which is used to calculate inclined and eccentric loads. The following is the carrying capacity formulation from Meyerhof Theory [8]:

Journal of Civil Engineering and Vocational Education

EISSN: 2622-6774
Vol 10 No.3 September 2023
http://cived.ppj.unp.ac.id/index.php/CIVED

$$qu_{lt} = c.Nc\,(sc\,.dcic) + q'.Nq\,(sq\,.dq\,.iq) + ½\,\gamma.B.N\gamma(s\gamma\,.d\gamma\,.i\gamma) \quad ……(8)$$

with Nc, Nq, Nγ are non-dimensional Meyerhof bearing capacity factors which are obtained only from the value of the friction angle in the soil (φ). To calculate the shape factor (s= shape), depth (d= depth) and load angle (i= inclination) are displayed in Table 1 . The Kp value used by Meyerhof is the Rankine value.

$$Kp = tan^2(\frac{\pi}{4} + \frac{\varphi}{2}) \quad ……………………………………………….. (9)$$

Table 1. Shape factors, depth and load angle in Meyerhof theory

Faktor	Nilai ϕ	Rumus
s_c	semua nilai	$s_c = 1 + 0.2\,K_p\,(B'/L')$
$s_q = s_\gamma$	ϕ >10	$s_q = s_\gamma = 1 + 0.1\,K_p\,(B'/L')$
	ϕ = 0	$s_q = s_\gamma = 1$
d_c	semua nilai	$d_c = 1 + 0.2\,(K_p)^{0.5}\,(D/B)$
$d_q = d_\gamma$	ϕ >10	$d_q = d_\gamma = 1 + 0.1\,(K_p)^{0.5}\,(D/B)$
	ϕ = 0	$d_q = d_\gamma = 1$
$i_c = i_q$	semua nilai	$i_c = i_q = \left(1 - \frac{\theta°}{90°}\right)^2$
i_γ	ϕ >0	$i_\gamma = \left(1 - \frac{\theta°}{\phi°}\right)^2$
	ϕ = 0	$i_\gamma = 0$

The carrying capacity factor values Nc, Nq, Nγ from Meyerhof can then be calculated using the following equation:

$$Nc = [\,q - 1\,]\,cot\,\varphi \quad …………………………………….. (10)$$
$$Nq = e^{\pi\,tan\,\varphi}\,.\,K\,p \quad ……………………………………………... (11)$$
$$N\,\gamma = [\,q - 1\,]\,tan\,(1.\,4\,\varphi) \quad ………………………………. (12)$$

Safety factor against power failure subgrade support is calculated using The following equation.

$$SF = \frac{q_u}{q_{maks}} \geq 3 \quad ……………………………………..…… (13)$$

Description:
q_u = ultimate carrying capacity
q_{max} = structure load pressure

6. Element Method Until *Flaxis*

the numerical methods developed in numerical analysis is finite elements [8]. The Plaxis program is one of the finite element programs used to implement problems in research this.

RESULTS AND DISCUSSION

CIVED
Journal of Civil Engineering and Vocational Education

EISSN: 2622-6774
Vol 10 No.3 September 2023
http://cived.ppj.unp.ac.id/index.php/CIVED

Penetration Test Results Using the Sondir Tool (CPT. 01)

SNI 2827 :2008, Cara Uji Penetrasi Lapangan Dengan Alat Sondir

PENYELIDIKAN TANAH SUBSIDENCE PENAHAN TANAH
JLN. A. YANI, GG. BATU MAS, KOTA SINGKAWANG, KALIMANTAN BARAT

No CPT **01**

Cone Type/ID	Bi-cone	*Elevation (m)*	-	*Coordinate*	0.890942
Cone Diameter (cm)	3,535	*Stopped at depth (m)*	-6,8		108.973.125
Sleeve Diameter (cm)	3,584	*Ground water level (m)*	-0,50	*Field officer*	Shobari & Tim
Sleeve Length (cm)	10,395	*Testing Date*	5 Dec 2022	*Client*	

Depth (m)	qc (kg/cm^2)	qc+qf (kg/cm2)	qf (kg/cm2)	fs (kg/cm2)	Fd (kg/cm)	TFd (kg/cm)	Rf (%)	Est.Soil Type
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-
0,20	1,0	1,5	0,50	0,04	0,84	0,84	4,19	clay
0,40	1,5	2,5	1,00	0,08	1,68	2,52	5,59	clay
0,60	1,0	1,5	0,50	0,04	0,84	3,35	4,19	clay
0,80	1,0	1,5	0,50	0,04	0,84	4,19	4,19	clay
1,00	1,5	2,5	1,00	0,08	1,68	5,87	5,59	clay
1,20	2,0	3,0	1,00	0,08	1,68	7,55	4,19	clay
1,40	2,5	3,5	1,00	0,08	1,68	9,22	3,35	clay
1,60	2,0	3,0	1,00	0,08	1,68	10,90	4,19	clay
1,80	2,5	3,5	1,00	0,08	1,68	12,58	3,35	clay
2,00	2,5	3,5	1,00	0,08	1,68	14,26	3,35	clay
2,20	3,5	5,5	2,00	0,17	3,35	17,61	4,79	clay
2,40	3,0	5,0	2,00	0,17	3,35	20,96	5,59	clay
2,60	4,0	6,0	2,00	0,17	3,35	24,32	4,19	clay
2,80	5,0	7,0	2,00	0,17	3,35	27,67	3,35	clay
3,00	4,5	6,5	2,00	0,17	3,35	31,03	3,73	clay
3,20	6,0	8,0	2,00	0,17	3,35	34,38	2,80	sand
3,40	5,0	7,0	2,00	0,17	3,35	37,73	3,35	clay
3,60	4,5	6,5	2,00	0,17	3,35	41,09	3,73	clay
3,80	3,0	5,0	2,00	0,17	3,35	44,44	5,59	clay
4,00	3,0	5,0	2,00	0,17	3,35	47,80	5,59	clay
4,20	3,5	5,5	2,00	0,17	3,35	51,15	4,79	clay
4,40	6,0	9,0	3,00	0,25	5,03	56,18	4,19	clay
4,60	7,0	10,0	3,00	0,25	5,03	61,21	3,59	clay
4,80	9,0	13,0	4,00	0,34	6,71	67,92	3,73	clay
5,00	10,0	15,0	5,00	0,42	8,39	76,31	4,19	clay
5,20	15,0	20,0	5,00	0,42	8,39	84,69	2,80	sand
5,40	13,0	18,0	5,00	0,42	8,39	93,08	3,23	clay
5,60	12,0	17,0	5,00	0,42	8,39	101,46	3,49	clay
5,80	20,0	30,0	10,00	0,84	16,77	118,23	4,19	clay
6,00	25,0	36,0	11,00	0,92	18,45	136,68	3,69	clay
6,20	20,0	30,0	10,00	0,84	16,77	153,45	4,19	clay
6,40	85,0	120,0	35,00	2,93	58,70	212,15	3,45	clay
6,60	110,0	155,0	45,00	3,77	75,47	287,62	3,43	clay
6,80	155,0	250,0	95,00	7,97	159,32	446,94	5,14	clay

Penetration Test Results Using the Sondir Tool (CPT. 02)

SNI 2827 :2008, Cara Uji Penetrasi Lapangan Dengan Alat Sondir

PENYELIDIKAN TANAH SUBSIDENCE PENAHAN TANAH
JLN. A. YANI, GG. BATU MAS, KOTA SINGKAWANG, KALIMANTAN BARAT

No CPT **02**

Cone Type/ID	Bi-cone	*Elevation (m)*	-	*Coordinate*	0.891086
Cone Diameter (cm)	3,535	*Stopped at depth (m)*	-7,4		108.973.086
Sleeve Diameter (cm)	3,584	*Ground water level (m)*	-0,50	*Field officer*	Shobari & Tim
Sleeve Length (cm)	10,395	*Testing Date*	5 Dec 2022	*Client*	-

Depth (m)	qc (kg/cm^2)	qc+qf (kg/cm2)	qf (kg/cm2)	fs (kg/cm2)	Fd (kg/cm)	TFd (kg/cm)	Rf (%)	Est.Soil Type
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-
0,20	1,5	2,5	1,00	0,08	1,68	1,68	5,59	clay
0,40	1,5	2,5	1,00	0,08	1,68	3,35	5,59	clay
0,60	1,0	1,5	0,50	0,04	0,84	4,19	4,19	clay
0,80	1,0	1,5	0,50	0,04	0,84	5,03	4,19	clay
1,00	2,0	3,0	1,00	0,08	1,68	6,71	4,19	clay
1,20	2,0	3,0	1,00	0,08	1,68	8,39	4,19	clay
1,40	2,5	3,5	1,00	0,08	1,68	10,06	3,35	clay
1,60	2,0	3,0	1,00	0,08	1,68	11,74	4,19	clay
1,80	2,0	3,0	1,00	0,08	1,68	13,42	4,19	clay
2,00	2,5	3,5	1,00	0,08	1,68	15,09	3,35	clay
2,20	3,0	5,0	2,00	0,17	3,35	18,45	5,59	clay
2,40	3,5	5,5	2,00	0,17	3,35	21,80	4,79	clay
2,60	2,5	3,5	1,00	0,08	1,68	23,48	3,35	clay
2,80	4,0	6,0	2,00	0,17	3,35	26,83	4,19	clay
3,00	5,0	7,0	2,00	0,17	3,35	30,19	3,35	clay
3,20	5,5	7,5	2,00	0,17	3,35	33,54	3,05	clay
3,40	6,0	9,0	3,00	0,25	5,03	38,57	4,19	clay
3,60	8,0	12,0	4,00	0,34	6,71	45,28	4,19	clay
3,80	7,0	10,0	3,00	0,25	5,03	50,31	3,59	clay
4,00	6,5	10,0	3,50	0,29	5,87	56,18	4,52	clay
4,20	8,0	12,0	4,00	0,34	6,71	62,89	4,19	clay
4,40	10,0	15,0	5,00	0,42	8,39	71,28	4,19	clay
4,60	13,0	18,0	5,00	0,42	8,39	79,66	3,23	clay
4,80	11,0	16,0	5,00	0,42	8,39	88,05	3,81	clay
5,00	15,0	20,0	5,00	0,42	8,39	96,43	2,80	sand
5,20	20,0	30,0	10,00	0,84	16,77	113,20	4,19	clay
5,40	13,0	18,0	5,00	0,42	8,39	121,59	3,23	clay
5,60	15,0	20,0	5,00	0,42	8,39	129,97	2,80	sand
5,80	25,0	35,0	10,00	0,84	16,77	146,75	3,35	clay
6,00	20,0	30,0	10,00	0,84	16,77	163,52	4,19	clay
6,20	15,0	20,0	5,00	0,42	8,39	171,90	2,80	sand
6,40	15,0	20,0	5,00	0,42	8,39	180,29	2,80	sand
6,60	25,0	36,0	11,00	0,92	18,45	198,74	3,69	clay
6,80	30,0	42,0	12,00	1,01	20,13	218,86	3,35	clay
7,00	45,0	65,0	20,00	1,68	33,54	252,40	3,73	clay
7,20	120,0	165,0	45,00	3,77	75,47	327,87	3,14	clay
7,40	155,0	250,0	95,00	7,97	159,32	487,19	5,14	clay
7,60								
7,80								

Calculation Wall Cantilever Retaining *Wall*

Presentation of Land Data

Soil parameters results penetration test data correlation use tool sondir at locations CPT.01 and CPT.02 can be done seen in Table 2 below this.

Table 2. Soil Parameters Result of SPT Data Correlation

Depth (m)	N-SPT	c'	ϕ	γ
1-5	21	12.6	25	18
5-12	47	28.3	29	22

Note:
MAT = 0.5 m

Dimensions Wall Soil Retaining

a. Construction Design Wall Land Retaining (DPT)

H =	4.5	m	a =	0.5	m
H1 =	0.5	m	B =	3.5	m
H2 =	3,4	m	B1 =	1.0	m
H3 =	0.6	m	B2 =	1.1	m
D =	1.5	m	B3 =	1.4	m

b. Land and Construction Material Data

Layer 1:

γ1 =	18	kN /m³			
ϕ1 =	25	°			
c1 =	12.6	kN /m³			
γw =	9.81	kN /m³			
Bj Concrete =	24	kN /m³			
Even Load =	2	kN /m²			

Layer 2:

γ2 =	22	kN /m³			
ϕ2 =	29	°			
c2 =	28.3	kN /m³			
fc' =	30	Mpa	=	30,000	kN /m²
fy =	400	Mpa	=	400,000	kN /m²

3.3.3. Calculating Moments Due to Vertical Force

Calculation moment consequence vertical force can seen in Table 3 below this.

Table 3. Calculation of Moment Due to Vertical Force

No. Sections	Area (m²)	Weight/unit length (kN /m)	Arm moment from point O (m)	Moments (kN -m/m)
1	0.700	12,600	2,800	35,280
2	4,760	38,984	2,800	109,156
3	1,950	46,800	1,850	86,580

CIVED Journal of Civil Engineering and Vocational Education

EISSN: 2622-6774
Vol 10 No.3 September 2023
http://cived.ppj.unp.ac.id/index.php/CIVED

4	1,170	28,080	1,400	39,312
5	2,100	50,400	1,750	88,200
6	1,400	2,800	2,800	7,840
	Σv =	179,664	**ΣMv =**	366,368

Calculation Ground Pressure

a. Active Earth Pressure

Ka $= \boldsymbol{tan^2}(\mathbf{45} - \frac{\boldsymbol{\varphi}}{\mathbf{2}})$

= 0.334

Table 4. Active Soil Pressure

No. Sections	Pressure (kN)	Arm moment from point O (m)	Moment (kN -m/m)
Pa1	3,006	2,250	6,764
Pa2	0.752	4,167	3,131
Pa3	12,024	2,000	24,048
Pa4	21,884	1,333	29,178
Pa5	78,480	1,333	104,640
ΣPa =	116,145	**ΣMha =**	167,761

b. Passive Earth Pressure

Kp $= \boldsymbol{tan^2}(\mathbf{45} + \frac{\boldsymbol{\varphi}}{\mathbf{2}})$

= 1.583

Table 5. Passive Earth Pressure

No. Sections	Pressure (kN)	Arm moment from point O (m)	Moment (kN -m/m)
Pp	32,056	0.500	16,028
ΣPp =	32,056	**ΣMhp =**	16,028

ΣH = ΣPa - ΣPp
= 84,089 kNm
ΣMhtotal = Σmha - Σmhp
151,733 kNm

Analysis of Stability of External Forces

a. Overturning

FSroll = $\left(\frac{\sum M_V}{\sum Mhtotal}\right)$

= 2.415 > 2 (Safe)

b. Slide

FSsliding = $\frac{(\sum V)\tan\phi + B.c}{\sum H} > 1{,}5$

= 1.521 > 1.5 (Safe)

c. *Bearing Capacity*

e = $\frac{B}{2} - \frac{\sum M_V - \sum MH_{total}}{\sum V}$

= 0.555 < 583

$q_{heel}^{toe} = \frac{\sum V}{B}(1 \pm \frac{6e}{B})$

qtoe = 100.203 kN /m ^{2}

qheel = 2.462 kN /m ^{2}

Meyerhof Method:

CIVED Journal of Civil Engineering and Vocational Education

EISSN: 2622-6774
Vol 10 No.3 September 2023
http://cived.ppj.unp.ac.id/index.php/CIVED

qu $= c'_2 . Nc . Fcd . Fci + q . Nq . Fqd . Fqi + 0{,}5 . \gamma_2 . B' . N_\gamma . F\gamma d . F\gamma i$

q $= \gamma_2 . D$

= 33 kN /m ^{2}

B' = B – 2e

= 2,389 m

For ϕ_2 = 29°

So, Nc = 34.24

Nq = 19.98

Nγ _ = 16.18

Fqd $= 1 + 2\tan\phi'_2(1 - \sin\phi'_2)^2\left(\frac{D}{B'}\right)$

= 1.532

Fγd = 1

Fcd = $\frac{F_{qd}}{} - \frac{1 - F_{qd}}{}$

= 1.560

Fci = Fqi = $\left(1\right.$

ψ = $tan^{-1}\left(\frac{\sum H}{\sum V}\right)$

= 25,081

Fci = Fqi = 0.922

Fγi = $\left(1\right.$

= 0.018

qu = 2334.311 kN

$FS_{Bearing\ Capacity}$ $\frac{}{}$ q_u

= 23,296 ➢ *3 (Aman)*

Analysis of Stability of Internal Forces

Review Piece A-A' (Middle of Upright Wall)

Data:

H = 2.3 m H2 = 1.8 m b2 = 0.3 m

H1 = 0.5 m b1= 0.4 m B = 0.7 m

Count Active Earth Pressure

Ka= 0.334

Table 6. Active Soil Pressure Results

No. Sections	Pressure (kN)	Arm moment from point A (m)	Moment (kN - m/m)
Pa1	1,536	1,150	1,767
Pa2	0.752	1,967	1,478
Pa3	9,739	0.900	8,765

Pa4	4,431	0.600	2,659
Pa5	15,892	0.600	9,535
ΣPa =	32,351	**ΣMa =**	24,204

Calculating Construction Weight and Moment

Table 7. Calculation Results of Construction Weight and Moment

No. Sections	Area (m²)	Weight/unit length (kN /m)	Arm moment from point A (m)	Moment (kN -m/m)
1	0.920	22,080	0.480	10,598
2	0.322	7,728	0.187	1,443
Σv =		29,808	ΣMR =	12,041

Review Against Press

σ_{tekan}

$\sum V$. $\sum M$

= 201.667 kN /m ^{2}

σ_{tekan} > σ_{izin}

2,667 01> 13,500 (Safe)

Review Against Pull

σ_{tarik}

$\sum V$ $\sum M$

= -113.996 kN /m ^{2}

σ_{tarik} > σ_{izin}

-113,996 > 2,738,613 (Safe)

Review Against Shear

τ_{geser}

3 $\sum Pa$

= 31.027 kN /m ^{2}

τ_{geser} > τ_{izin}

31,027 > 497,930 (Safe)

Review B-B' Cut (Between Vertical Wall and Base Plate)

Data:

H = 3.9 m H2= 3.4 mb2= 0.6 m

H1 = 0.5 m b1= 0.5 mB2= 1.1 m

D = 1.5 m

Count Active Earth Pressure

Ka= 0.334

Table 8. Calculation Results Active Earth Pressure

No. Sections	Pressure (kN)	Arm moment from point B (m)	Moment (kN -m/m)
Pa1	2,605	1,950	5,080
Pa2	0.752	3,567	2,680
Pa3	34,749	1,700	59,074
Pa4	15,811	1,133	17,919
Pa5	56,702	1,133	64,262

ΣPa =	110,619	**ΣMa =**	149,016

Count Passive Earth Pressure
Kp = 1.583

Table 9. Passive Soil Calculation Results

No. Sections	Pressure (kN)	Arm moment from point B (m)	Moment (kN - m/m)
Pp	32,056	0.500	16,028
ΣPp =	32,056	**ΣMp =**	16,028

ΣMo = ΣMa - ΣMp
= 132,988
Calculating Construction Weight and Moment

Table 10. Calculation Results of Construction Weight and Moment

No. Sections	Area (m^2)	Weight/unit length (kN /m)	Arm moment from point B (m)	Moment (kN -m/m)
1	1,950	46,800	0.850	39,780
2	1,170	28,080	0.400	11,232
	Σv =	74,880	**ΣMR =**	51,012

Review Against Press

σ_{tekan} $\sum V$. $\sum M$ = 474.564 kN /m ^{2}

$\sigma_{tekan} > \sigma_{izin}$
474,564 > 13,500 (Safe)

Review Against Pull

σ_{tarik} $\sum V$ $\sum M$ = - 338.418

$\sigma_{tarik} > \sigma_{izin}$
-338,418 > 2,738,613 (Safe)

Review Against Shear

τ_{geser} 3 $\sum Pa$ = 38.678 kN /m ^{2}

$\tau_{geser} > \tau_{izin}$
38,678 > 497,930 (Safe)

Review Pieces C-C' and D-D' (Base Plate)
Data:
q_{max} = 100.203 kN /m ^{2}
q_{min} = 2.462 kN /m ^{2}
X3 = qmax – qmin = 97.741 kN /m ^{2}
X1 = (B3/B) x X 3 = 39.096 kN /m ^{2}
X2 = (B2 +B3/B) x X3 = 69.815 kN /m ^{2}

Journal of Civil Engineering and Vocational Education
EISSN: 2622-6774
Vol 10 No.3 September 2023
http://cived.ppj.unp.ac.id/index.php/CIVED

q1 = qmin + X1 = 41.559 kN /m ^{2}
q2 = qmin + X2 = 72.277 kN /m ^{2}
Wtoe = 41.4 kN /m ^{2}
Wheel = 51 kN /m ^{2}
Pressure Against Broken Toe and Heel
h1 = qmax – Wtoe = 58.803 kN /m ^{2}
h2 = q2 – Wtoe = 30.877 kN /m ^{2}

h3 = q1 - Wheel = -9.687 kN /m ^{2}
h4 = qmin – Wheel = - 48.784 kN /m ^{2}

Moment at Cross Section CC'
D = 1/2 (h1 + h2) B1 = 44,840 kN /m ^{2}
M = 24.747 kN /m ^{2}
W = 1/6.b.h² = 0.167 m ^{3}
Review Against Pull

σ_{Tarik} M = 148.484 kN /m ^{2}

$\sigma_{tarik} > \sigma_{izin}$
148,484 > 2,738,613 (Safe)
Review Against Shear

τ_{geser} 3 D = 67,260 kN /m ^{2}

$\bar{\tau}_{geser} \gtrless \tau_{izin}$
67,260 > 497,930 (Safe)

Latitudinal Force on Section DD'
D = 1/2 (h3 + h4) B13 = 40,930 kN /m ^{2}
Moment at Cross Section DD'
M = 35.037 kN /m ^{2}
W = 1/6.b.h² = 0.233 m ^{3}
Review Against Pull

σ_{Tarik} M = 150.157 kN /m ^{2}

$\sigma_{tarik} > \sigma_{izin}$
150,157 > 2,738,613 (Safe)
Review Against Shear

τ_{geser} 3 D = 43.854 kN /m ^{2}

$\bar{\tau}_{geser} \gtrless \tau_{izin}$
43,854 > 497,930 (Safe)

Reinforcement in Construction Soil Retaining Reinforcement Wall

Data:

fc' = 30 Mpa
fy = 400 MPa
b = 1000 mm
D principal = 16 mm
Shrinkage = 10 mm

Reviewed

CIVED
Journal of Civil Engineering and Vocational Education
EISSN: 2622-6774
Vol 10 No.3 September 2023
http://cived.ppj.unp.ac.id/index.php/CIVED

Reinforcement Tree
Minimum Wall Thickness (hmin) = 390 mm
Blanket Thickness (s) = 75 mm
Wall Thickness Effective (d) = 417 mm
Barrier Ratio Reinforcement
ρb = 0.033
ρmin = 0.0035
ρmax = 0.024
Moments On the Wall Vertical
Mmax = 149.016 kN /m
Mn= 186.269 kN /m
Rn= 1.071 kg/mm ^{2}
m= 15.686
Ratio Reinforcement (ρ) =0.0027
Ratio reinforcement used (ρ) = 0.0035
Reinforcement Area Necessary (As necessary)
As necessary = ρ.bd = 1,459.5 mm ^{2}
Reinforcement (n) = As/a = 8 pieces
Reinforcement Distance (S) = 125 mm = 100 mm

So use:
Reinforcement principal = 16 mm
Distance between reinforcement = 100 mm
Reinforcement Shrink
Reinforcement Area Necessary (As necessary)
As necessary = 0.002 x hmin xb = 780 mm ^{2}
Reinforcement (n) = As/a = 10 pieces
Reinforcement Distance (S) = 100mm = 100 mm
So use:
Reinforcement shrinkage = 10mm
Distance between reinforcement = 100 mm

Reinforcement Base Plate
Data:
fc' = 30 Mpa D principal = 16 mm
fy = 400 MPa Shrinkage = 10 mm
b = 1000 mm
Reviewed

Reinforcement Tree
Minimum Wall Thickness (hmin) = 350 mm
Blanket Thickness (s) = 75 mm
Wall Thickness Effective (d) = 517 mm
Barrier Ratio Reinforcement
ρb = 0.033
ρmin = 0.0035
ρmax = 0.024
Moment On Base Plate
Mmax = 35.037 kN /m
Mn= 42.796 kN /m

Rn= 1.164 kg/mm ^{2}
m= 15.686
Ratio Reinforcement (ρ) =0.000411
Ratio reinforcement used (ρ) = 0.0035
Reinforcement Area Necessary (As necessary)
As necessary = ρ.bd = 1,809.5 mm ^{2}
Reinforcement (n) = As/a = 9 pieces
Reinforcement Distance (S) = 111.111 mm = 100 mm
So use:
Reinforcement principal = 16 mm
Distance between reinforcement = 100 mm

Reinforcement Shrink
Reinforcement Area Necessary (As necessary)
As necessary = 0.002 x hmin xb = 700 mm ^{2}
Reinforcement (n) = As/a
= 9 pieces
Reinforcement Distance (S) = 111.111 mm = 100 mm
So use:
Reinforcement shrinkage = 10mm
Distance between reinforcement = 100 mm

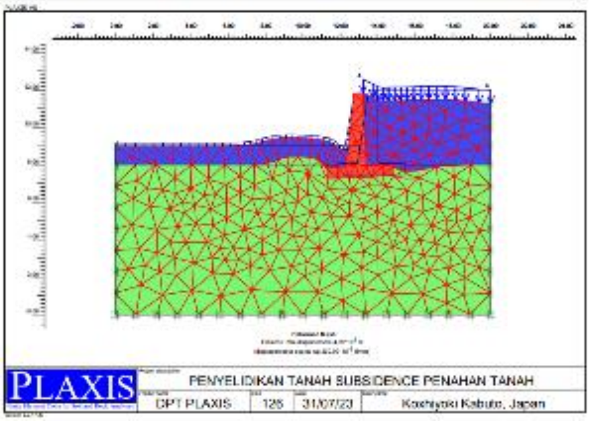
Analysis Wall Cantilever Retaining *Wall* _
The technical data of the cantilever wall that will be input to plaxis is as follows:

Table 11. Plaxis Input Data

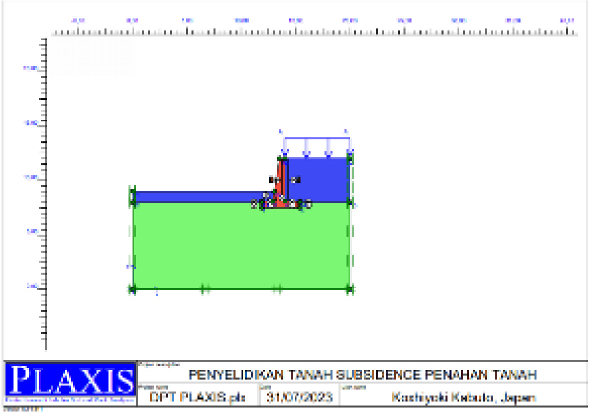
Parameter	Symbol	Layer 1	Layer 2	DPT	Unit
Material models	Model	Mohr Coulomb	Mohr Coulomb	Linear Elastic	-
Type behavior	Type	drained	drained	Non Porous	-
Soil weight dry	ϒunsat	11,405	12,337	24	kN /m3
Soil weight wet	ϒsat	16,305	17,185	-	kN /m3
Horizontal permeability	Kx	1x10^7	1x10^7	0	m/day
Permeability Vertical	Ky	1x10^7	1x10^7	0	m/day
Young's Modulus	Eref	30000	50000	2.524x10^7	kN /m2
Poisson numbers	v	0.4	0.4	0.15	-
Cohesion	c	12.6	28.3	-	kN /m2
Corner swipe	φ	25	29	-	°
Corner dilatancy	ψ	0	0	-	°

EISSN: 2622-6774
Vol 10 No.3 September 2023
http://cived.ppj.unp.ac.id/index.php/CIVED

1. Deformed Mesh



2. Existing Image



3. Calculate results

PLAXIS - Finite Element Code for Soil and Rock Analyses

Project description	: PENYELIDIKAN TANAH SUBSIDENCE PENAHAN TANAH	PLAXIS 8.0
User name	: Koshiyoki Kabuto, Japan	
Project name	: DPT PLAXIS	Date : 31/07/2023
Output	: Calculation information	Step : 126 Page : 1

Step Info

Step 126 of 126	Incremental Multipliers	2,000
PLASTIC STEP		0,000

Prescribed displacements	Mdisp:	0,000	Σ-Mdisp:	1,000
Load system A	MloadA:	0,000	Σ-MloadA:	1,000
Load system B	MloadB:	0,000	Σ-MloadB:	1,000
Soil weight	Mweight:	0,000	Σ-Mweight:	1,000
Acceleration	Maccel:	0,000	Σ-Maccel:	0,000
Strenght reduction factor	Msf:	-0,002	Σ-Msf:	6,662
Time	Increment:	0,000	End time:	150,000

Staged construction

Active proportion total area	Marea :	0,000	ΣMarea :	1,000
Active proportion of stage	Mstage :	0,000	ΣMstage :	0,000

PLAXIS - Finite Element Code for Soil and Rock Analyses

Project description	: PENYELIDIKAN TANAH SUBSIDENCE PENAHAN TANAH	PLAXIS 8.0
User name	: Koshiyoki Kabuto, Japan	
Project name	: DPT PLAXIS	Date : 31/07/2023
Output	: Calculation information	Step : 126 Page : 2

Tunnels

	Contraction tunnel A	Contraction tunnel B
Input value [%]	N/A	N/A
Realised value [%]	N/A	N/A

Forces

ForceX	0,000	kN/m
ForceY	0,000	kN/m

Consolidation

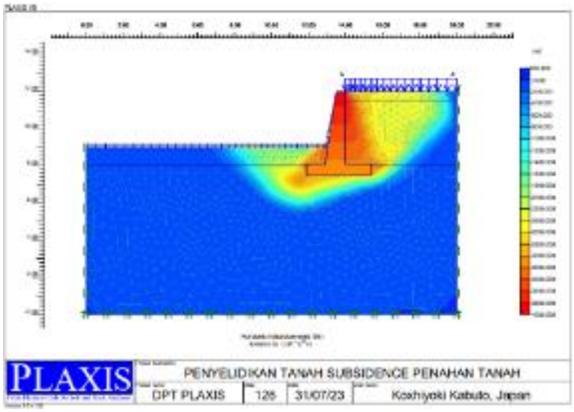
Realised Pmax : 27,846 kN/m2

PLASTIC STEP

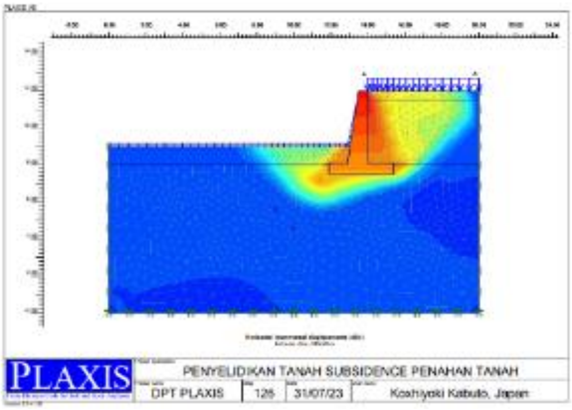
Iter. No.	Global Error	Plastic Points	Plastic Cap + Hard. points	Inacc. Pl. pts.	Plastic Intf. pts.	Inacc. Intf. pts.	Apex & Tension	Inacc. Apx. pts.
1	0,005	565	0	559	0	0	51	51
2	0,005	565	0	40	0	0	51	22

CIVED
Journal of Civil Engineering and Vocational Education
EISSN: 2622-6774
Vol 10 No.3 September 2023
http://cived.ppj.unp.ac.id/index.php/CIVED

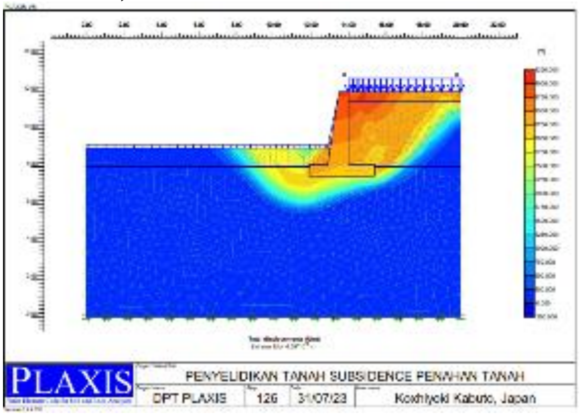
4. **Horizontal Displacements (Ux)**



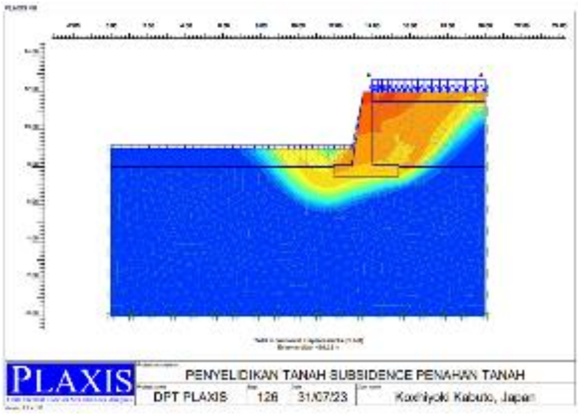
5. **Horizontal Incremental Displacements (dUx)**



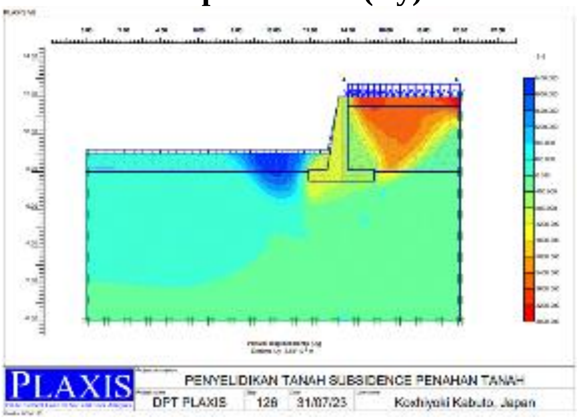
5. **Total Displacements (Utot)**



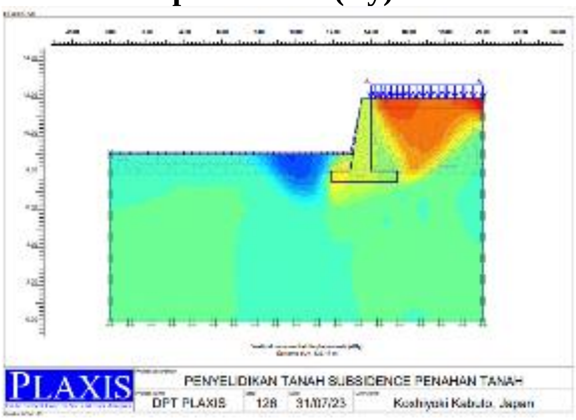
7. **Total Incremental Displacements (dUtot)**



8. **Vertical Displacements (Uy)**



9. **Vertical Displacements (Uy)**



CONCLUSION

Condition wall retainer land experienced landslides because the soil conditions were classified as having low mechanical properties. Realization of slopes with reinforced walls Cantilevers are considered safer because they have the lowest shear and *subsidence values and meet all slope stability requirements, namely shear resistance.* 1.251 > 1.5 (Safe), against rolling is 2, 415 > 2 (Safe) and *bearing capacity* 0.555 < 0.583. D16-100 main reinforcement and D10-100 shrinkage reinforcement are used in cantilever retaining wall structures, D16-150 main reinforcement and D10-100 shrinkage reinforcement are used in base plates.

REFERENCE

[1] Sundari, W., & Krisnasiwi, IF (2021). P influence Physical and Mechanical Properties Testing Clay For Analysis of Slope Safety Factors Using the M ohr Coulomb Method on the 40 P etuk Outer Ring Road Section 1 K subdistrict Kolhua Kupang City . _ *Journal of Technology*, *15* (2), 31-35.

[2] Hardiyatmo, HC (20 10). Soil mechanics II. Yogyakarta: Gadjah Mada University Press

[3] Fernandes, J.D. (2019). *Study _ Coastal Reclamation Slope Stability With Use Geotextiles _ As Soil Strengthening* (Doctoral dissertation, Narotama University).

[4] https://regional.kompas.com/read/2022/03/31/211603078/profil-kota-singkawang , accessed December 20, 2022.

[5] https://pontianak.tribunnews.com/2022/08/30/bencana-banjir-dan-longsor-di-singkawang- sutarmidji-buat-terkait-saluran-dan-permukiman-di-bukit , accessed December 20 , 2022.

[6] https://www.antaranews.com/foto/3084969/bencana-tanah-longsor-di-singkawang , accessed December 20, 2022.

[7] Irina, F. (2017). Applied Research Methods . _ Yogyakarta: Parama Ilmu

[8] Abdurrozak, MR (2017). The Influence of Ground Water Level Conditions on the Stability of Road Slopes with Retaining Walls (Case Study of the Banjarnegara-Karangkobar Road Kilometer 77, Banjarnegara Regency, Central Java Province).