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Slope Reinforcement Due to Landslide in Cipakancilan River, Sukaresmi Village, Bogor City

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ABSTRACT

In October 2022, there was a landslide in Tanah Sareal Subdistrict at Cipakancilan River, Sukaresmi Village, Bogor City. The location of the landslide occurred on the edge of the road adjacent to the Cipakancilan river, the road is an access road that connects the Regency area and the Bogor City area. The length of the landslide that occurred was 30 meters and 11.5 meters high from the Cipakancilan river water level. The construction of a retaining wall (DPT) is the right solution to maintain slope stability, namely rolling stability, shear stability and soil bearing capacity stability to restore stable slope conditions to hold the road body which can be reused as an access road for residents. This research started with an initial stage in the form of a field survey, then continued with a geotechnical investigation to determine the characteristics of the soil that experienced landslides. Based on the results of the research, it was found that the design of retaining walls of gravity type and cantilever type was analyzed using the Coulomb method for calculating lateral soil pressure and Mayerhof for calculating the stability of soil bearing capacity. For construction costs from the calculation of the cost budget plan, the results obtained for the gravity type retaining wall amounted to Rp. 1,229,923,600 (one billion two hundred twenty-nine million nine hundred twenty-three thousand rupiah), while the cantilever type retaining wall amounted to Rp. 1,620,913,000. 1,620,913,000 (one billion six hundred twenty million nine hundred thirteen thousand rupiah), the time of the planned implementation of gravity retaining wall work for 2.5 months or 75 calendar days, the time of the planned implementation of cantilever retaining wall work for 3 months or 90 calendar days.

Keywords: retaining wall; DPT; landslide; cost; time.

INTRODUCTION

Bogor City is known as a rainy city, having an average monthly rainfall of around 267.9 - 385.3 mm. The slope of Bogor City is quite high and the soil type in Bogor City is reddish brown lotosil with fine soil texture and is somewhat sensitive to erosion. Landslides in Bogor City often occur in landslide-prone areas, namely on slopes with dense settlements and river slopes that intersect with highway access, In October 2022 a landslide occurred in the Tanah Sareal District area, namely in Cipakancilan River, Sukaresmi Village, Bogor City. The location of the landslide occurred on the edge of the road adjacent to the Cipakancilan river, the road is an access road that connects the Regency area and the Bogor City area. The length of the landslide that occurred was 30 meters and as high as 11.5 meters from the Cipakancilan river water level. The construction of retaining walls is the right solution to repair slopes or landslides to restore slope stability, choosing the right retaining wall design as well as the cost and time of implementation is a consideration as the right decision maker.

Figure 1. Existing condition of landslide site

Retaining Wall

According to [1], retaining walls are structural buildings that are generally made to withstand road bodies in the form of high enough embankments, both in rolling areas (highlands) and in lowland areas that have a difference in normal water level and water level large enough. Retaining wall buildings are used to withstand lateral soil pressures generated by backfilled soil or unstable native soil due to topographical conditions. Types of retaining walls include:

1. Gravity retaining wall
   This retaining wall is usually made of pure concrete (without reinforcement) or from river stone masonry, its stability lies in the construction's own weight [1], [2].
2. Cantilever retaining wall
   Cantilevered retaining walls are made of reinforced concrete, hence the stem and base slab dimensions are relatively thin. In addition to its own weight, the cantilever retaining wall relies on the mass weight of the soil above the base slab, to maintain its stability. This retaining wall is suitable for retaining high ground, up to 8 m [3].
3. Counterfort Retaining Wall with Ribs
   To withstand high ground while maintaining a thin vertical wall, the stem of the cantilever retaining wall needs to be reinforced with concrete ribs installed at certain distances. The ribs are behind the wall (will be covered with soil) the stiffener is called counterfort [3].

Retaining Wall Stability

In the planning of retaining wall construction, it is necessary to pay attention to several factors so that the construction remains safe. Based on [3], retaining walls must be designed to remain safe against, stability against sliding, stability against overturning, and stability against collapse of soil bearing capacity. The stability analysis of the retaining wall is reviewed on the following matters:

1. Safety factors against sliding, overturning and bearing capacity must be sufficient.
2. The pressure occurring in the subgrade of the foundation shall not exceed the allowable capacity.
3. The overall slope stability must be qualified.

Stability Against Shifting

The safety factor against sliding (F_{gs}) is defined as:

$$F_{gs} = \frac{\sum R_h}{\sum P_h} \geq 1.5$$

With:
$\sum R_h$ = Retaining Wall Resistance to sliding (kN/m^2),
$\sum P_h$ = Sum of horizontal forces (kN).

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The minimum safe factor against foundation base displacement (F_{gs}) is taken as 1.5 [4]-[9], suggests:
$F_{gs} \geq 1.5$ for granular subgrade
$F_{gs} \geq 2$ for cohesive subgrade

Stability Against Roll

The safety factor against overturning (F_{gl}), is defined as:

$$F_{gl} = \frac{\sum M_w}{\sum M_{gl}} \geq 1.5$$

With:
$\sum M_w$= Moment against overturning (kN.m),
$\sum M_{gl}$= Moment resulting in overturning (kN.m).
The safety factor against overturning (F_{gl}) depends on the soil type, i.e. :
$F_{gl} \geq 1.5$ for granular subgrade
$F_{gl} \geq 2$ for cohesive subgrade

Stability of Soil Support Capacity

Suggested the bearing capacity equation considering the foundation shape, load slope and shear strength of the soil above the foundation, as follows [5], [10]-[11]:

$$q_u = s_c\, d_c\, i_c\, c\, N_c + s_q\, d_q\, i_q\, p_o\, N_q + s_\gamma\, d_\gamma\, i_\gamma\, 0.5\, B'\gamma' N_\gamma$$

With:
d_c, d_q, and d_γ= Depth factor,
i_c, i_q, and i_γ= Load slope factor,
N_c, N_q, and N_γ= Bearing capacity factors,
B'= Effective foundation width (m),
Po= $Df \times g$ = Overburden pressure at the base of the foundation (kN/m^2),
Df= Depth of foundation (m), and
= Volume weight of soil (kN/m^3).

Stability of Group Foundation Support

The ultimate capacity of *a bored pile* foundation is expressed by the equation [5]:

$$Q_g = 2D\,(B + L)\,c + 1.3\,c_b\,N_c\,BL$$

Where:
Q_g = Group ultimate capacity (kN),
c = Soil cohesion around the pile group (kN/m^2),
c_b = Soil cohesion under the base of the pile group (kN/m^2),
B = Pole group width, calculated from the edge of the pole (m),
L = Pole group length (m),
D = Pile depth (m), and
N_c = Bearing capacity factor.

A retaining wall is a structure that functions to resist lateral soil pressure to prevent landslides or shifts in soil mass, especially in areas with differences in elevation. The effectiveness of a retaining wall is determined by planning that takes into account structural stability, soil conditions, and drainage. Common types of retaining walls include gravity walls, cantilever walls, counterfort walls, and sheet piles, which are selected based on embankment height, soil properties, and material availability [16].

Maintaining an effective retaining wall encompasses several aspects. First, planning must take into account active and passive forces, as well as pore water pressure, to ensure overturning, shear, and bearing stability of the soil. Second, a drainage system behind the wall is crucial to reduce water pressure, for example by installing drain pipes or gravel filters. Without proper drainage, the wall is at risk of collapse. Third, the selection of construction materials must be appropriate to the site conditions, whether reinforced concrete, masonry, or steel [17], [18]. Periodic maintenance is necessary to detect cracks, erosion, or subsidence around the structure. With proper design, effective drainage, and regular maintenance, retaining walls can function optimally in preventing landslides and maintaining slope stability [19].

RESEARCH METHODS

The research location for the field survey was carried out at the landslide location on Jalan Raya Cilebut adjacent to the Cipakancilan riverbank, Sukaresmi Village, Tanah Sareal District, Bogor City. X = 6°.33'.16.43 "S and Y = 106°.48'0.42 "T. The research time was carried out starting on May 5, 2023, the time included the preliminary survey activities to the location. The research location map is shown in Figure 2 below.

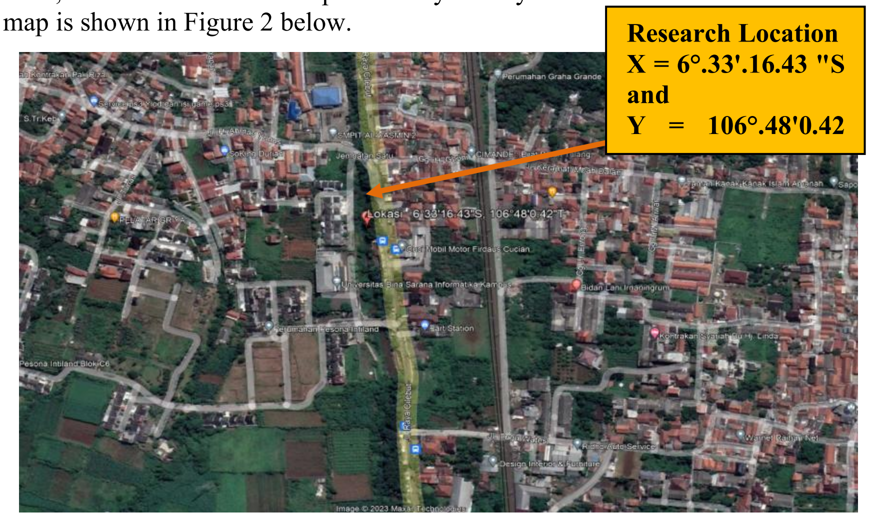

Figure 2. Research Location

The stages of this research began with the collection of necessary data in the form of geotechnical data (soil parameters) and landslide sketches that occurred on the slope. Soil parameter data was obtained from the survey results at the research location which was then tested at the Soil Mechanics Laboratory of the Civil Engineering Study Program, Faculty of Engineering and Science, Ibn Khaldun University of Bogor. Sketch data of the landslide that occurred on the slope was obtained from the survey results to the landslide location. After obtaining these data, a retaining wall can be planned in accordance with the landslide conditions that occur in the slope area. The flow of this research activity is depicted in the research flow diagram shown in Figure 3.

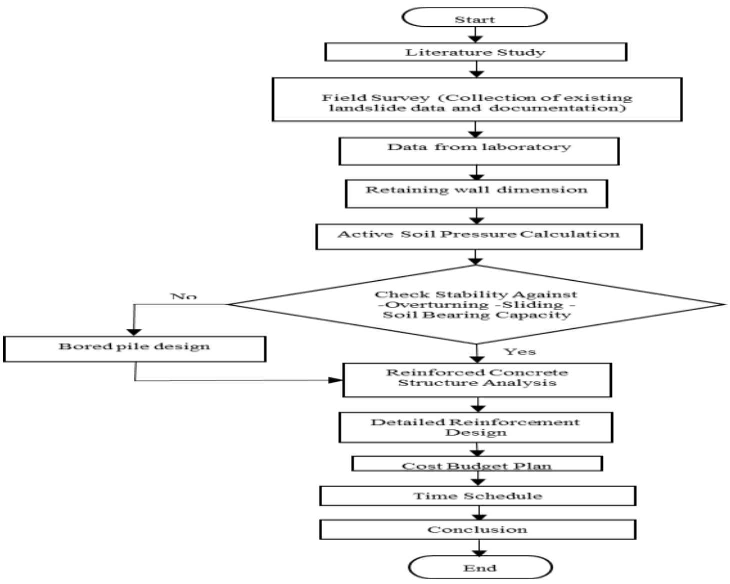

Figure 3. Research flow chart

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RESULTS AND DISCUSSION

Soil Parameter Data

Soil parameter data obtained from laboratory tests are shown in Table 1.

Table 1. Soil Parameter Data [12]-[15]

No.	Parameter Data	Notation	Value	Sat
1	Groundwater table	MAT	0	m
2	Land surface slope angle	i	0	°
3	Friction angle between wall and ground	d	33,8	°
4	Slope angle of soil collapse	a	90	°
5	The angle of inclination of the wall to the ground	b	85,77	°
6	Soil cohesion	c	0	kN/m^2
7	Dry soil volume weight	g_{dry}	18,2	kN/m^3
8	Saturated soil volume weight	g_{sat}	19,9	kN/m^3
9	Effective soil volume weight	g'	0	kN/m^3
10	Water content weight	g_w	9,81	kN/m^3
11	Friction angle in soil		35	°

(Source: Laboratory test results)

Existing Condition of Landslide Site

The existing condition of the landslide that occurred on the Cipakancilan riverbank is shown in Figure 4.

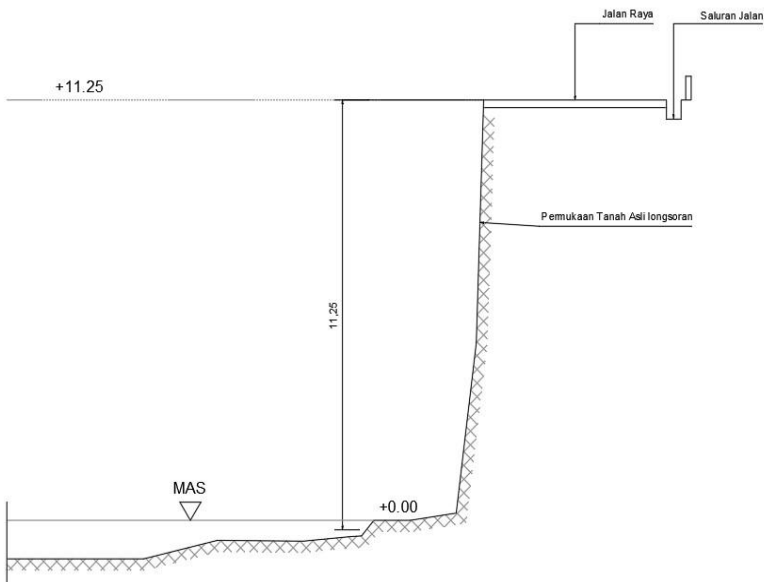

Figure 4. Sketch of landslide existing condition

The landslide that occurred on the bank of the Cipakancilan River was directly adjacent to the Cilebut Highway and stretched 30 meters long with a height of 11.25 meters.

Retaining Wall Plan Design

Based on the results of the field survey, the type of retaining wall that will be used in this study is the cantilever type retaining wall shown in Figure 5.

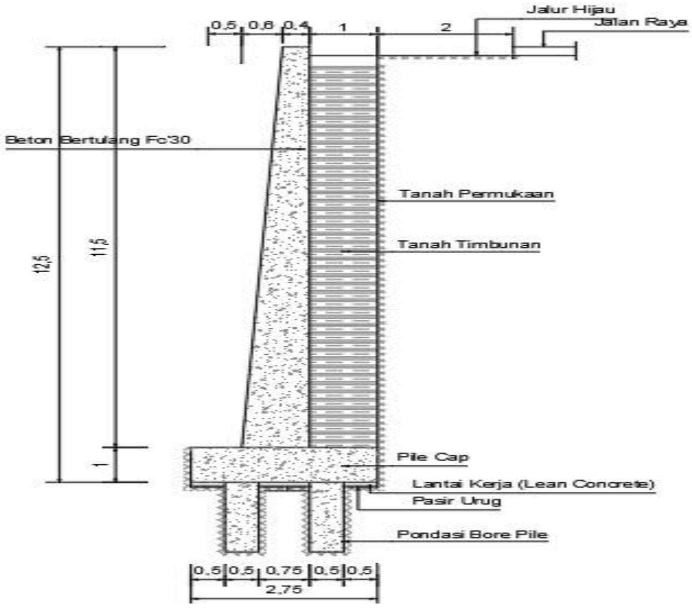

Figure 5. Retaining wall plan design

The cantilever type retaining wall above is planned using reinforced concrete masonry with additional *bored piles* as a lateral force resistor.

Active Ground Pressure Analysis

Active earth pressure analysis was conducted using the Mononobe-Okabe method which takes into account earthquake loads.

Active earth pressure coefficien

$$KAE = \frac{\cos^2(\varphi - \theta - \boldsymbol{\beta})}{\cos\theta \cos^2\boldsymbol{\beta} \, \boldsymbol{cos}\, (\delta+\boldsymbol{\beta}+\theta)\left\{1+\left[\sqrt{\frac{\sin(\delta+\varphi)\sin(\varphi-\theta-\boldsymbol{i})}{\cos(\delta+\boldsymbol{\beta}+\theta)\cos(\boldsymbol{i}-\boldsymbol{\beta})}}\right]^{\frac{1}{2}}\right\}^2}$$

$$KAE = \frac{1}{0{,}603 \times 2{,}635} = 0{,}511$$

Active ground pressure

Components of force: Force:
Ground Pressure on: Ground pressure:

P_{A1} = $g_t \times H_1 \times K_A$
= 18× 12,5 × 0,297
= 66.90 kN/m^2

P_{A1} = 0.50 ×g_t × K_A × H^2
= 0,50 × 18 × 0,297 × 12,5^2
= 418.10 kN/m

Earth Pressure on Earthquake Load: Ground pressure:

P_A1 = $g_t \times H_1 \times (K_{AE}-K_A) \times (1 - K_{(V)})$
= 18× 12,5 × 0,110
= 24.68 kN/m^2

$P_{A(1}$ = 0.50 × 2/3 × P_{A1} × $H_{(1)}$
= 0,50 × 2/3 × 89,74 × 12,5
= 107.99 kN/m

Total active earth pressure
ΣP_A= 418,10 + 107,99
= 526.09 kN

Table 2: Total active earth pressure [12]-[15]

Ground Pressure	Force (KN)	Distance from O (m)	Moment to O (kN.m)
P_{A1}	418,10	4,2	1742,07

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Ground Pressure	Force (KN)	Distance from O (m)	Moment to O (kN.m)
P_{AE}	107,99	8,33	899,95
	ΣP_{AE} = 526.09		ΣM = 2642.02

Analysis of Vertical Force and Moment on Wall

The vertical moment is determined based on the division of the plane using Autocad software. The plane division of the retaining wall is shown in Figure 6.

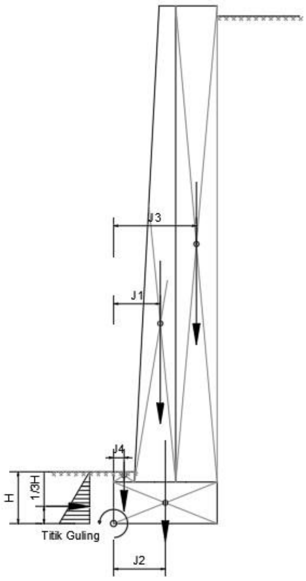

Figure 6. Construction self-weight overview

The results of the vertical moment on the cantilever type retaining wall are shown in Table 3.

Table 3. Vertical moment [12]-[15]

Section	Weight (W) (kN)	Arm (X) (m)	Moment (M_w) (kNm)
W1	193,20	1,379	266,30
W2	66,00	1,375	90,75
W3	207,00	2,250	465,75
W4	3,76	0,378	1,424
	ΣW = 469.96		ΣMw = 824.26

Stability to shear

Shear stability is obtained:

$$F_{gs} = \frac{\sum R_h}{\sum P_h} \geq 1{,}5$$

$$F_{gs} = \frac{1865{,}18}{418{,}09}$$

$$F_{gs} = 4{,}46$$

Since F_{gs} = 4.46 > SF = 1.5, the stability against shear is safe.

Stability Against Roll

In the calculation of overturning stability, it is obtained:

$$F_{gl} = \frac{\sum M_w}{\sum M_{gl}} \geq 1{,}5$$

$F_{gl} = \dfrac{1629{,}50}{1.742{,}07}$

$F_{gl} = 0{,}503$

Because F_{gl} = 0.503 < SF = 1.5, the stability against overturning is not safe. So that overturning stability is determined by the strength of the pile in resisting the load (My), namely with *bored pile*. The moment that bored pile still has to withstand is as follows

M_{active} = 1.742,07 - 875,42
= 866,65

Bored Pile = $\frac{1531{,}344}{866{,}65}$
= 1,76

Because the Fgl≥ value is 1.5, the stability against overturning of the retaining wall is met

Stability to soil bearing capacity

The calculation analysis of soil bearing capacity stability [5] method, the longitudinal foundation factor $s_c = s_q = s_g = 1$, the bearing capacity factor N_c = 46.12, N_q = 33.30, N_g = 37.15, and the foundation width B = B' = 2.75 meters.

Overbuden pressure on the foundation base:

$$\text{Po} = Df \times \gamma_b$$

$\text{Po} = 1{,}00 \times 19{,}90$

$\text{Po} = 19{,}90\ kN/m^2$

The angle of inclination of the resultant load in the vertical direction:

$\delta = arc\ tg\ \dfrac{H}{V}$

$\delta = arc\ tg\ \dfrac{469{,}96}{403{,}33} = 49{,}36°$

Load slope factor:

$$i_c = i_q = \left(1 - \frac{\delta}{90°}\right)2 = \left(1 - \frac{49{,}36°}{90°}\right) = 0{,}203$$

$i_\gamma = \left(1 - \dfrac{\delta}{\varphi}\right)2 = \left(1 - \dfrac{68{,}70°}{31°}\right) = 0{,}168$

Depth factor:

$d_c = 1 + 0{,}2 \times \dfrac{D}{B} \times tg(45° + \dfrac{\varphi}{2})$

$d_c = 1 + 0{,}2 \times \dfrac{1{,}25}{2} \times tg\left(45° + \dfrac{35°}{2}\right) = 1{,}17$

$d_q = d_\gamma = 1 + 0{,}1 \times \dfrac{D}{B} \times tg(45° + \dfrac{\varphi}{2})$

$d_q = d_\gamma = 1 + 0{,}1 \times \dfrac{1{,}25}{2} \times tg\left(45° + \dfrac{35°}{2}\right) = 1{,}08$

Ultimate bearing capacity:

$q_u = s_c\, d_c\, i_c\, c\, N_c + s_q\, d_q\, i_q\, p_o\, N_q + s_\gamma\, d_\gamma\, i_\gamma\, 0.5\, B'\gamma' N_\gamma$

$q_u = (1 \times 1{,}17 \times 0{,}203 \times 46{,}12)$

$= +(1 \times 1{,}08 \times 0{,}203 \times 19{,}90 \times 33{,}3)$

$= +(1 \times 1{,}08 \times 0{,}168 \times 0{,}5 \times 2{,}75 \times 6{,}62 \times 37{,}56)$

$= 289{,}04\ kN/m^2$

Net ultimate bearing capacity:

$q_{un} = 264{,}167 - 19{,}90$

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$q_{un} = 195{,}30\ kN/m^2$

Ultimate bearing capacity is safe:

$q_s = \frac{q_{un}}{F} \times Po$

$q_s = \frac{195{,}30}{2} \times 19{,}90$

$q_s = 1943{,}235\ kN/m^2$

Maximum total vertical load on the foundation base per meter length:

$q_s \times luas\ per\ meter\ panjang$

$= 1943{,}325 \times (2{,}75 \times 1)$

$= 5343{,}93\ kN/m^2$

Since, $q_s = 5343.89$ kN/m[(2)] > V = 2085.19 kN/m^2, the collapse of soil bearing capacity is safe.

Bored Pile Foundation Analysis

The planning dimensions of the bored pile foundation intended for cantilever retaining wall construction are shown in Table 4.

Table 4. Bored pile foundation planning data [12]-[15]

No.	Planning data	Notation	Value	Sat
1	Diameter/width of *bored pile* foundation	DM/B	0,5	m
2	Depth of *bored pile* foundation	D	1,5	m
3	Pole group length	L	30	m
4	Concrete quality	-	30	MPa
5	Steel grade	-	300	MPa

Bearing capacity stability of *bored pile* foundations Meyerhoff Method

Calculation of the bearing capacity of the pile tip of the bored pile foundation

$Q_p = qc \text{ x } Ap/3 =$
= 53,33 x 5024/3
= 89310 kg
= 875.83 kN

Calculation of bearing capacity of bored pile foundation blanket

Qs = JHL x Ka/5
= 155,25 x 251,2
= 38998.8 kg
= 382.44 kN

Calculation of ultimate bearing capacity of bored pile foundation

Qijin = Qp + Qs
= 89310 + 38998
= 128308 kg
= 1258.27 kN

The calculation analysis of the bearing capacity stabilization of *bored pile* foundations is reviewed at the pile group:

$$Q_g = 2D\ (B + L)\ c + 1.3\ c_b\ N_c\ BL$$

$Q_g = 2 \times 1{,}00 \times (0{,}8 + 30) + 1{,}30 \times 46{,}12 \times 0{,}8 \times 30$

$Q_g = 1531{,}344\ kN$

Permitted capacity of pile group $= \frac{1531{,}344}{2} = 765{,}672\ kN$

Table 5. Recapitulation of Cantilever and Bored Pile Retaining Wall Reinforcement [12]-[15]

Section	Overview	Vertical Tensile Reinforcement	Horizontal Tensile Reinforcement	Horizontal compressive reinforcement	Vertical compressive reinforcement	Shear Reinforcement (Sengkang)
Vertical Wall	I - I	D32-120mm	D16-100		D22-200	D13-300
Horizontal Wall	II-II		D19-200 D19-200			D13-300
Horizontal Wall	III-III		D19-200 D19-200			D16-200
Bored Pile		7-D22				Dia 10-200

The reinforcement used in the retaining wall and bored pile can be seen in Figure 7.

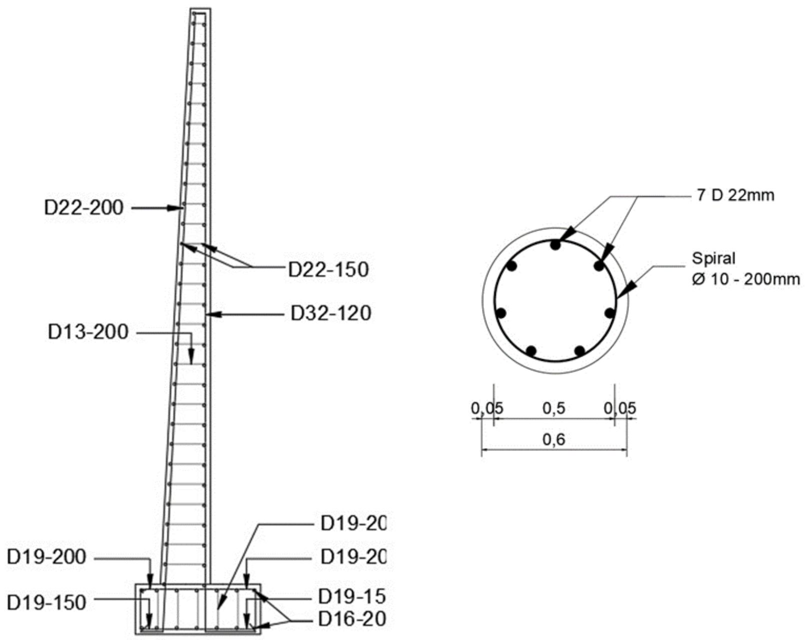

Figure 7: Reinforcement Drawings of Retaining Walls and *Bored Piles*

Cost Budget Plan

As a reference for the calculation, the coefficient is taken from the Regulation of the Minister of Public Works and Public Housing No.1 of 2022, concerning Guidelines for the Analysis of Unit Prices for Public Works.

Table 5. Cost Budget Plan [12]-[15]

No.	Job Description	Volume	Source	Unit Price (Rp)	Price Amount (Rp)
I	**Preparatory Work**				
1	Activity signboard	1	BH	457.800	457.800
2	Directors' quarters, warehouse & workstations	6	M2	818.400	4.910.400
3	Site Measurement	81	M2	6.400	518.400
4	Bouwplank	30	M1	95.700	2.871.000
5	Land Clearing	30	M1	33.700	1.011.000
6	Traffic Management and Safety	1	LS	26.218.500	26.218.500

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No.	Job Description	Volume	Source	Unit Price (Rp)	Price Amount (Rp)
7	Construction Occupational Safety and Health	1	LS	59.260.900	59.260.900
	Sub Total I				**95.248.000**
II	**Excavation And Embankment Work**				
1	Work. Excavation of soil structure Bored Pile Foundation (1.5m) and pilecap	109,47	M3	344.500	37.713009,26
2	50 Concrete Buis for Borepile foundation	16,5	M1	505.800	8.345.700
3	Ordinary excavation	101,25	M3	95.700	9.689.625
4	Ordinary backfill from excavation source & compacted	345	M3	504.040	173.893.800
	Sub Total II				**229.642.134,26**
III	**Retaining Wall Work**				
1	Sand 5 cm below the foot of TPT	3,731	M3	407.700	1.521.128,70
2	Plan. Working floor 1:3:5, t = 5 cm TPT Leg holder	3,731	M3	1.454.100	5.425.247,10
3	Bored Pile Foundation D50, fc' 30 Mpa	6,34	M3	1.236.700	7.848.994,81
4	Bored Pile Foundation Reinforcement D50	219,69	KG	17.500	3.844.627,50
5	Reinforced Concrete Fc' 30 Mpa	324	M3	1.236.700	400.690.800,00
6	Concrete Reinforcement	37990,45	KG	17.500	664.902.871,50
7	Scaffolding/support for TPT wall formwork	274,70	M2	111.900	30.738.
8	Distillator	30	M1	16.800	504.168
9	Column Relling G. Rail 15/20, fc' 15 Mpa SM	0,832	M3	1574.600	1.310.067,20
10	Specification. Reinforcement of Guard Rail Column 15.20, U32	185,10	KG	17.600	3.257.837.,44
11	Railling Backrest Installation	30	M1	475.400	14.262.000
12	Guard Rail Surface Painting	19,14	M2	56.700	1.085.238
Sub Total III					**1.135.391.910,25**

Rab Recapitulation

No.	Job Description	Price Amount
I	Preparatory Work	95.248.000
II	Excavation And Embankment Work	229.642.134,26
III	Retaining Wall Work	1.135.391.910,25
Amount		1.460.282.044,51
11% Vat		160.631.024,90
Amount		1.620.913.069,41
Final Amount		**1.620.913.000,00**

TIME SCHEDULE

Pekerjaan : Construction of the Cipakancilan River Cantilever Retaining Wall
Lokasi : Cilebut Highway, Cibadak Village, Tanah Sarael District, Bogor City

NO	Job Description	Progress %	WORK IMPLEMENTATION TIME = 3 months (90 calendar days)											
			1st month				2nd month				3rd month			
			1	2	3	4	5	6	7	8	9	10	11	12
I	**Preparatory Work**													
1	Activity signboard	0,03	0,03											
2	Directors' quarters, warehouse & workstations	0,34	0,34											
3	Site Measurement	0,04	0,04											
4	Bouwplank	0,20	0,20											
5	Land Clearing	0,07	0,07											
6	Traffic Management and Safety	1,79	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15
7	Construction Occupational Safety and Health	4,05	0,34	0,34	0,34	0,34	0,34	0,34	0,34	0,34	0,34	0,34	0,34	0,34
II	**Excavation And Embankment Work**													
1	Work. Excavation of soil structure Bored Pile Foundation (1.5m) and pilecap	2,58		0,86	0,86	0,86								
2	50 Concrete Buis for Borepile foundation	0,57		0,19	0,19	0,19								
3	Ordinary excavation	0,66		0,22	0,22	0,22								
4	Ordinary backfill from excavation source & compac	11,88								3,96	3,96	3,96		
III	**Retaining Wall Work**													
1	Sand Urug 5 cm below the foot of TPT	0,10			0,03	0,03	0,03							
2	Plan. Working floor 1:3:5, t = 5 cm TPT Leg holder	0,37			0,12	0,12	0,12							
3	Bored Pile Foundation D50, fc' 30 Mpa	0,54			0,18	0,18	0,18							
4	Bored Pile Foundation Reinforcement D50	0,26		0,09	0,09	0,09								
5	Reinforced Concrete Fc' 30 Mpa	27,37					6,84	6,84	6,84	6,84				
6	Concrete Reinforcement	45,42		6,49	6,49	6,49	6,49	6,49	6,49	6,49				
7	Scaffolding/support for TPT wall formwork	2,10			0,35	0,35	0,35	0,35	0,35	0,35				
8	Distillator	0,03					0,01	0,01	0,01	0,01				
9	Column Relling G. Rail 15/20, fc' 15 Mpa SM	0,09											0,09	
10	TSpecification. Reinforcement of Guard Rail Columr	0,22											0,22	
11	Pemasangan Sandaran Railling	0,97											0,97	
12	Guard Rail Surface Painting	0,07												0,07
	progress amount %	**100,00**												
	WEEKLY PROGRESS PLAN (%) =		1,15	8,33	9,02	9,02	14,51	14,18	14,18	18,14	4,45	4,45	2,01	0,56
	CUMULATIVE PROGRESS PLAN (%) =		1,15	9,49	18,51	27,53	42,04	56,22	70,40	88,54	92,98	97,43	99,44	100,00
	WEEKLY PROGRESS REALIZATION (%) =													
	CUMULATIVE PROGRESS REALIZATION (%) =													
	WEEKLY DEVIATION (%) =													
	CUMULATIVE REALIZATION DEVIATION (%) =													

Figure 8. Time Schedule

CONCLUSION

Based on the analysis of cost and time calculations on the design of retaining walls, namely gravity type and cantilever retainingwall type in the Cipakancilan River, Sukaresmi Village, Bogor City, it can be concluded as follows: 1) construction design of gravity tive retaining wall is obtained 11.5 meters high made in 2 levels, namely level 1 5.5 meters high, foundation foot width 2.75 meters, foundation foot height 0.7 meters, the top thickness of the retaining wall is 0.4 meters. Level 2 is 6 meters high, foundation foot width is 3 meters, foundation foot height is 1 meter, the top of the retaining wall is 0.5 meters thick, 2) the cantilever type retaining wall construction design obtained a height of 11.5 meters, a foot plate width of 2.75 meters, a foot plate height of 1.00 meters, and a retaining wall top thickness of 0.40 meters, Reinforced bored pile diameter 0.5 meters with a depth of 1.5 meters, 3) for construction costs from the calculation of the cost budget plan on the type of gravity retaining wall, the cost is obtained at Rp. 1,229,923,600 (One Billion Two Hundred Twenty-Nine Million Nine Hundred Twenty-Three Thousand Six Hundred Rupiah) while the cost budget plan on the type of cantilever retaining wall is obtained at Rp. 1,620,913,000 (One Billion Six Hundred Twenty Million Nine Hundred Thirteen Thousand Rupiah). The execution time of works on gravity-type retaining walls can be planned within 2.5 months or 75 calendar days, while the

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execution time of works on cantilever-type retaining walls is planned for 3 months or 90 calendar days displayed in the Bar Chart and S Curve.

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