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RETAINING WALL PLANNING IN WASTE MANAGEMENT

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Waste management, TPSA, Heavy equipment productivity, Retaining walls, Operational costs

ABSTRACT
This study aims to analyze the performance and productivity of heavy equipment as well as the volume of waste produced in a waste disposal area (TPSA) located in Kuningan Regency. The research was carried out at the Ciniru TPSA located in Jalaksana District, Kuningang Regency, with the aim of finding out the data on the volumes of waste, transport trucks, and excavator heavy equipment. The results show that the amount of existing waste in the area reaches 630 m3 with an average amount of irritation of 71 times per day. In addition, the production of heavy machinery for garbage trucks, excavators, and bulldozers reaches 128.07 m3/hour, which is a working time of 8 hours and operational costs of Rp 244,957/hour, respectively. The findings of this study offer valuable information on the effectiveness of retaining walls in mitigating environmental impact, protecting agricultural areas, and improving waste handling practices. Moreover, investigating methods to extend landfill lifespan through improved spatial planning and capacity forecasting will be crucial, especially for regions facing waste overflow challenges in the near future.

INTRODUCTION

The problem of waste is constantly being discussed, because it is related to the lifestyle and culture of the community itself. The increase in waste production without a proper treatment system is the reason for not creating a clean environment. According to the World Health Organization (WHO) waste is something that is not used, not used, disliked or something that is thrown away that comes from human activities and does not occur by itself (Mardiani, 2019; Rizal, 2011).

In general, garbage can be interpreted as all objects that are no longer used by living things, so that their nature becomes discarded. So waste objects produced by humans, animals, and even plants all have the potential to be considered as waste as long as they are no longer used (SNI 19-2454-2002 Tentang Tata Cara Teknik Operasional Pengelolaan Sampah, 2002; Utami & Gischa, 2021). Waste is categorized into three groups: organic, inorganic, and hazardous waste (Sucipto, 2009). Organic or wet waste, such as leaves, kitchen scraps, and fruit, comes from living organisms and can naturally decompose. Inorganic or dry waste, like metal, plastic, and glass, cannot degrade naturally and persists in the environment. Hazardous waste, including batteries, syringes, and toxic chemicals, poses dangers to humans and requires special handling for disposal.

The increase in waste production without proper processing is the reason for not creating a clean environment (Abdel-Shafy & Mansour, 2018; Mostaghimi & Behnamian, 2023). Most of the waste processing in Indonesia is carried out by open dumping, where waste is only disposed of without being closed with soil. So that it causes disturbances to the surrounding environment (Handoko, 2009; Sahil et al., 2016). Therefore, waste must be managed properly to the smallest possible extent so as not to disturb or threaten the balance of the environment and public health.

The concept of integrated waste management consists of several stages, namely prevent or reduce (prevent or minimize its use), reuse (extend the use period or reuse), recycle (recycle waste into new goods), energy recovery (capture energy in waste or make waste an alternative energy source) (SNI 19-2454-2002 Tentang Tata Cara Teknik Operasional Pengelolaan Sampah, 2002; Sucipto, 2009). Waste management directed at the 3R concept (Reduce, Reuse, Recycle) aims to reduce waste from the source, reduce environmental pollution, and provide benefits to the community. Management with this 3R concept is expected to reduce the burden on landfills (Final Processing Sites) in receiving waste (Nurfitria et al., 2024).

In Kuningan, the problem arising from the TPSA located in Ciniru Village, Jalaksana District, Kuningan Regency is the community's concern about the existence of the volume of waste in the Ciniru TPSA which is increasing and even exceeding the limit (Mahrudin, 2024). It should be noted that Kuningan Regency consists of 32 sub-districts which are subdivided into a total of 361 sub-districts and 15 sub-districts. The center of government in Kuningan and the total area of Kuningan Regency is 1,178.56 km^2 (Kuningan, 2023).

TPSA Ciniru has an area of 5.5 hectares with 14 sub-districts, 90 villages and sub-districts served. From the beginning of operation until now, only 15% of the remaining land is left and of course it is very worrying considering that the waste produced reaches 480 tons/day, while until now the Ciniru TPSA can only serve around >200 tons/day (Rohman, 2024). With the remaining land, action is needed to make the remaining land effective. One of them is by making a retaining wall.

This study aims to analyze the performance and productivity of heavy equipment as well as the volume of waste produced. The retaining wall in this study was used as a waste barrier and a barrier between the disposal zone and the residents' plantation land. This is necessary considering the height of the pile which has reached 4 m. The research contributes by providing insights into the performance and productivity of heavy equipment in waste management, specifically in relation to the construction and use of retaining walls as waste barriers. This study addresses a practical challenge—separating waste disposal zones from nearby agricultural land—as the height of the waste pile has reached 4 meters. The findings offer valuable information on the effectiveness of such barriers in mitigating environmental impact, protecting agricultural areas, and improving waste handling practices.

METHODS

The research was conducted at the Ciniru TPSA, Kuningan Regency with the aim of finding out the data on the volume of existing waste and the operational costs of heavy equipment. The data needed in this study are in the form of primary and secondary data. The primary data collection technique is in the form of direct interviews in the field which are carried out to obtain data in the form of waste volume per day, the intensity of the garbage truck fleet per day, heavy equipment or existing inventory, what infrastructure facilities exist at the TPSA, and direct observation of the work process in the field, as well as questionnaire questions to the surrounding community to compare and as completeness of data. Meanwhile, secondary data collection is taken from documents and literature in the service (DLH) as information that supports this research.

The survey object was carried out on the volume of waste, transport trucks and excavator heavy equipment to find out an overview of the operational time of waste transportation. The data on the weight of the garbage entering the TPSA is obtained from the result of the reduction between the total weight of the truck and the empty weight of the truck, where this result can be obtained from the weighing operator's room.

The data analysis that will be carried out in the research is in the form of quantitative analysis using the following formulas (Ramadhani, K.M. Aminuddin, 2021):

1) Volume of garbage: The volume of waste entering the landfill can be calculated by:

$$\frac{Garbage\ volume\ 1\ truck}{(body\ capacity\ x\ Fp)}$$

Where:
Body capacity = 8 m3
Compaction factor (Fp) = 1.2

2) Machine productivity: Heavy equipment productivity is the amount of work that can be produced in a unit of time. The volume of work intended in heavy equipment at TPSA is the volume of incoming waste (coming from garbage trucks) so that it is formulated:

$$\frac{Volume\ of\ incoming\ waste\ (from\ 1\ truck)}{Tool\ uptime}$$

The number of equipment needs in accordance with the volume of waste entering the landfill can be calculated by:

$$\frac{Garbage\ volume}{Tool\ productivity\ x\ working\ hours}$$

3) Dump truck cycle calculation: In this study, one unit of dump truck transporting waste was taken to identify the transport time, distance, and amount of waste transported, the transport time in question was:
   a) Time required for garbage trucks from the pool to the first TPS (T1)
   b) It is the amount of time it takes for a dump truck to start from the first TPS to the last TPS waste (T2)
   c) Time required from the last polling station to the polling station (T3)
   d) The queue time before weighing is the time it takes for the garbage truck to get to the weighing device (T4)
   e) Weighing time is the time for the garbage truck to find out the amount of waste disposed of at the landfill (T5)
   f) Travel time of garbage trucks from the scale to the TPSA cell to dispose of garbage (T6)
   g) Time used by garbage trucks to unload / empty trucks on landfill land (T7)
   So, cycle times can be known by:
   (T1 + T2 +T3 + T4 + T5 + T6 + T7)

Calculation of heavy equipment needs (Firda et al., 2024):

$$\frac{Garbage\ volume\ per\ day}{Excavator\ productivity\ per\ hour}$$

RESULTS

The research was conducted in Ciniru Village, Jalaksana District, this TPSA has a total area of 5.5 Ha, divided into two areas, namely 4.5 Ha as a waste disposal zone as well as a place for processing and 1 Ha for road infrastructure, offices and garages for heavy equipment. The source of waste comes from housing or shops where waste is collected and transported to the landfill.(Ferdiansyah, 2024)

Based on the results of identification, the disposal system is divided into two, namely: (1) Collection at the TPS (temporary disposal site) is then transported by a fleet of dump trucks owned by DLH. (2) The collection at each polling station is then transported by a fleet from the village itself (independent disposal).

Table 1. Waste Volume Data

No	Month	Types of Activities	Location	Vol
1	January	Irritation and Volume of Waste	TPSA	6069
2	February	Irritation and Volume of Waste	TPSA	5715
3	March	Irritation and Volume of Waste	TPSA	6066
4	April	Irritation and Volume of Waste	TPSA	6070
5	May	Irritation and Volume of Waste	TPSA	6075
6	June	Irritation and Volume of Waste	TPSA	6070
7	July	Irritation and Volume of Waste	TPSA	6070
8	August	Irritation and Volume of Waste	TPSA	6768
9	September	Irritation and Volume of Waste	TPSA	6828
10	October	Irritation and Volume of Waste	TPSA	6841
11	November	Irritation and Volume of Waste	TPSA	6841
12	December	Irritation and Volume of Waste	TPSA	6841
		Total (ton)		76254

Source: Kuningan Regency Environmental Agency

From the waste volume data in 2023 above, the volume of waste for 1 year was 76254 tons or around 231072.71 m3 and the following data can be known:

- Volume of garbage transported by dump truck (E 8016 Z)

Body capacity x Fp = 8 x 1.2
= 9.6 m3

Where:

Body capacity = 8 m3

Compaction factor (Fp) = 1.2

- So the amount of irritation in 1 week

= 497 ritus

- Average incoming garbage

= 630 m3/hari

- If multiplied per year, the tonnage is:

= Amount of waste per day x 365 days

= 630 x 365

= 231072.73 m3/year

The volume of waste has increased from the previous year with a total waste of 76,124 tons or 230,678,788 m3/year in 2022.

Figure 1. Waste volume data per month

The figure above is the result of a survey in waste management in the Kuningan Regency area where the heavy equipment used is in the form of Amroll trucks and Dump Trucks.

The number of Dump Trucks used is 15 units and Amroll Trucks are 7 units. The entire fleet is used as a waste management activity that serves waste transportation in Kuningan Regency.

Table 2. Friday's garbage volume data

No	License Plate	Ride	Flight (m3)	Garbage (m3)
1	E 8049 Z	3	9	27
2	E 8005 Z	2	9	18
3	E 8007 Z	3	9	27
4	E 8035 Z	3	9	27
5	E 8014 Z	2	9	18
6	E 8015 Z	2	9	18
7	E 8016 Z	2	9	18
8	E 8017 Z	4	9	36
9	E 8018 Z	3	9	27
10	E 8019 Z	3	9	27
11	E 8022 Z	4	9	36
12	E 8062 Z	3	9	27

13	E 8137 Z	2	9	18
14	E 8006 Z	3	9	27
15	E 8131 Y	3	9	27
16	E 8124 Z	4	9	36
17	E 8063 Z	4	10	40
18	E 8040 Z	4	10	40
19	E 8328 Y	4	8	32
20	E 8125 Z	4	8	32
21	E 8037 Y	4	6	24
22	E 8064 Z	5	10	50
	TOTAL	**71**	**196**	**632.0**

Source: Kuningan Regency Environmental Agency

Each unit of heavy equipment dump trucks and amrolls serves a different number of TPS. For dump trucks, it serves an area of 6-8 while amrolls only serve container-type TPS by serving 4-5 per day.

The productivity of waste management heavy equipment can be determined by identifying the amount of irritation per day, the amount of waste disposed of at the landfill and the time of entry to the landfill where each waste transportation has different performance. The dump truck used focuses on picking up garbage at TPS with concrete tubs or garbage cans in roadside shops while Amroll only picks up garbage at TPS with container tubs and does not serve TPS with concrete tubs.

Based on the observation results of table 1, it shows that the amount of waste produced in the Kuningan Regency area reaches 630 m3 with an average amount of irritation of 71 times per day. The productivity of heavy equipment in waste management can be determined by calculating how much waste is transported by garbage trucks to the landfill. In addition to heavy equipment for garbage trucks, there is also a role of heavy equipment in TPSA, namely in the form of excavator heavy equipment. Each of these tools works when there is a garbage disposal from a garbage truck heading to the disposal site. This means that the productivity of heavy equipment also depends on the number of garbage trucks with a certain volume of waste.

Based on this, it is necessary to identify the calculation of heavy equipment productivity. To find out the productivity of heavy equipment and its operational price can be calculated in the following way:

Dump truck productivity calculation:

- Dump truck productivity

$= \frac{Garbage\ volume}{Cycle\ time}$

$= \frac{9,6}{2,53}$

= 3,794 m3/jam

- Maintenance costs

Purchase price = IDR 360,000,000

Residual value = IDR 36,000,000

Useful life = Rp. 10,000 / hour

$= \frac{Purchase\ price - Remaining\ value}{Usage\ life}$

$= \frac{360.000.000 - 36.000.000}{10.000}$

= Rp. 32,400 / hour

Depreciation $= \frac{360.000.000}{10.000}$

= IDR 36,000

Maintenance cost = 32,400 + 36,000

= IDR 68,400 / hour

- Fuel costs

In a day's operation, 3.8 liters of fuel are needed with a diesel dexlite price of Rp. 14,550 / liter and 8 hours of work in a day, then the total fuel cost needed: = Rp. 55,326 / hour$\frac{3,8}{8}\ x\ 14.550$

- Lubrication costs

Table 3. Dump Truck Lubrication Cost

LUBRICATION COST				
Type	***Requirement(liters)***	***Unit price***	***Replacement Period(hours)***	***Cost***
Machine	8,7	IDR 65,000	250	Rp 2,762.00
Transmission	1,2	IDR 65,000	1000	IDR 78
Axle	2	IDR 65,000	1000	IDR 130.00
Hydraulic	15	IDR 65,000	1000	IDR 975.00
Total Lubrication Cost				**IDR 3,445.00**

- Filter fees

Table 4. Dump Truck filter cost

FILTER COST				
Type	***Requirement (liters)***	***Unit price***	***Spare Time (hours)***	***Cost***
Solar	1	IDR 76,000	500	IDR 152.00
Transmission	1	IDR 58,000	500	IDR 116.00
Hydraulic	1	IDR 89,000	2000	IDR 44.50
Air	1	IDR 175,000	2000	IDR 87.50
Engine oil	1	IDR 58,000	200	IDR 58.00
Total Lubrication Cost				**IDR 458.00**

- Dump truck operating costs

1. Maintenance = IDR 68,400
2. Management
   - Lubrication = IDR 4,011
   - Filter change = Rp 581
   - Fuel = IDR 3,232
3. Others = IDR 127
4. Total = IDR 76,441
5. Unexpected fee = IDR 7,644

Dump truck operating costs
= IDR 84,085 / hour
= IDR 672,678 / day
Excavator productivity calculation
Bucket capacity = 0.92 m3
Work efficiency = 0,81
Bucket factor = 0,90
Excavation time = 10 seconds
Disposal time = 5 seconds
Rotation time = 5 seconds

- Cycle time

(Cm) = w. dig + (2 x w.turn) + w. dispose
= 10 + (2 x 5) + 5
= 25 seconds

- Production per cycle

q = q1 x k
= 0.92 x 0.90
= 0.828 m3

- Productivity (m3/h) for native soils

$Q = \frac{q \; x \; 360 \; x \; E}{Cm}$

$= x \; 1\frac{0{,}928 \; x \; 360 \; x \; 0{,}81}{25}$

= 96,576 m3/hr

- Productivity (m3/h) for loose soils

Q = $\frac{q \times 360 \times E}{Cm}$

= x 0.8$\frac{0{,}928 \times 3600 \times 0{,}81}{25}$

= 77,262 m3/hr

- Excavator capacity (m3/h)

Q = 96,576 x1

= 96,576 m3/hr

- Actual working production per hour x 8 hours

= 96,576 x 8

= 772,624 m3/hr

- Maintenance costs

Purchase price = IDR 500,000,000

Busy value = IDR 50,000,000

Useful life = Rp. 10,000 / hour

= $\frac{Purchase\ price - Remaining\ value}{Usage\ life}$

= $\frac{500.000.000 - 50.000.000}{10.000}$

= IDR 45,000 / hour

- Depreciation

= $\frac{500.000.000}{10.000}$

= IDR 50,000

- Maintenance costs

= Useful life + Depreciation

= 45.000 + 50.000

= Rp. 95,000 / hour

- Fuel costs

In one day's operation, 58,913 liters of fuel are needed with a diesel dexlite price of Rp. 14,550 / liter and 8 hours of work a day, so the total fuel cost needed:

= IDR 127,313 / hour$\frac{3{,}8}{8}$ x 14.550

- Lubrication costs

Table 5. Excavator lubrication cost

LUBRICATION COST				
Type	***Requirement (liters)***	***Unit price***	***Spare Time (hours)***	***Cost***
Machine	12	IDR 65,000	250	IDR 3,120.00
Transmission	23	IDR 65,000	1000	IDR 1,495.00
Axle	20	IDR 65,000	1000	IDR 1,300.00
Hydraulic	30	IDR 65,000	1000	IDR 1,950.00
Total Lubrication Cost				**IDR 7,865.00**

- Filter fees

Table 6. Excavaor Filter Cost

FILTER COST				
Type	***Requirement (liters)***	***Unit price***	***Spare Time (hours)***	***Cost***
Solar	3	IDR 230,000	1000	IDR 690.00
Transmission	1	IDR 115,000	1000	IDR 115.00
Hydraulic	1	IDR 60,000	2000	IDR 30.00
Air	1	IDR 125,000	2000	IDR 107.50
Engine oil	1	IDR 215,000	500	IDR 250.00
Total Lubrication Cost				**IDR 1,192.50**

- Excavator operating costs

1. Maintenance = IDR 95,000
2. Management

- Lubrication = IDR 7,865
- Filter change = IDR 1,192
- Fuel = IDR 127,313

3. Others = IDR 11,482
4. Total = IDR 242,852
5. Unexpected fee = IDR 24,285

Excavator operating costs
= IDR 267,138 / hour
= IDR 2,137,101/ day
Waste management operational costs / m3

Table 7. Operational costs of the tool

Tool Name	Hourly Fee	Per Day Fee	Monthly Fee	Cost Per Year
DUMP TRUCK	IDR 3,564,985	IDR 28,519,876.90	IDR 867,479,589.10	IDR 10,409,755,069.23
EXCAVATOR	IDR 244,957	IDR 1,959,653.40	IDR 59,606,124.22	IDR 715,273,490.64
TOTAL	**IDR 3,809,941**	**IDR 30,479,530**	**IDR 927,085,713**	**IDR 11,125,028,560**

Table 8. Volume of garbage

Items	Garbage Per Hour (m3)	Waste Per Day (m3)	Waste Per Month (m3)	Waste Per Year (m3)
Garbage	**79.13**	**633.08**	**19256.06**	**231072.73**

From the table above, it can be seen that the total operational costs of the equipment and the volume of waste at the Citiru TPSA can be known. Thus, the cost of waste / m3 is:

$= \frac{total\ equipment\ operating\ costs\ per\ year}{total\ of\ waste\ per\ year\ (m3)}$

$= \frac{Rp.11.189.796.847}{231.072,73\ m3}$

= IDR 48,245.43 / m3

Calculation of TPSA volume and capacity
Location Area = 5.5 Ha = 55000 m2
Pile height = 10 m
Specific gravity of waste = 0.6 tons/m3
Average tonnage = 231,072.73 m3/year

- Volume of waste per year

$= \frac{average\ tonnage}{specific\ gravity\ of\ waste}$

$= \frac{231,.072,73}{0,6}$

= 385.121 m3

- Annual garbage height

$= \frac{waste\ volume\ per\ year}{area\ width}$

$= \frac{382.121}{55000}$

= 7,002 m

Calculation of pile height over the life of the plan
High clay pile = 0.15 m
Solid rotten garbage height = 0.2 m
So the increase in the height of the pile per year
= 0.2 + 0.15 + 0.2
= 0.55 m / per year

Assuming that no settlement occurred in the previous stockpile, then the total height of the stockpile over the planned lifetime:
= 15 years x 0.55 = 8.25 m

From all the calculations that have been made, measurements were obtained for the tamping capacity during the planned life, which is 15 years, which is 8.25m. It should be enough to accommodate waste for the life of the plan, but real data on the ground shows the opposite.

633.08 m3 x 365 days

= 231,072.73 m3/year
231,072.73 x 15 years
= 3,466,090.95 m3

Meanwhile, the situation in the field that can accommodate waste is only 15% or around 519,913.64 m3. It can be said that the landfill can no longer accommodate waste for the next 2 years.

To increase the capacity and life of the plan with the remaining existing land, retaining walls can be added to critical locations with the following planning:

Figure 2. Location of the Retaining Wall

Planning for the Retaining Wall

- Planning data

Garbage pile height = 4 m
Friction angle in the ground (c) = 1 T/m2
Ground cohesives (φ) = 15 ∘
Soil volume weight = 2.58 T/m3
Therefore, from this data, the Retaining Wall is planned to hold the soil as follows:

Plan wall height (H) = 5 m
Palm height (D) = 0.5 m
Palm width (B) = 5.5 m
Top palm width (B') = 0.5 m

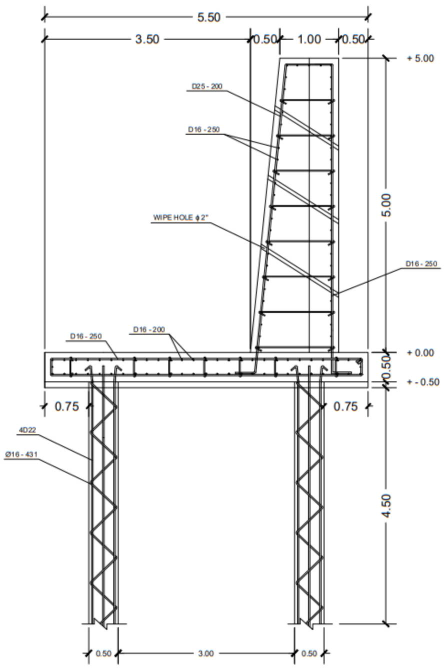

Figure 2. Retaining Wall Pieces Details

- Load calculation

Table 8. Vertical Load

No.	Description							W	X	W x X
1	0.5	x	3.5	x	2.4			4.200	3.750	5.75
2	0.5	x	1.5	x	2.4			1.800	1.250	2.25
3	0.5	x	0.5	x	2.4			0.600	0.250	0.15
4	0.5	x	0	x	3.5	x	2.4	0.000	3.167	0.00
5	0.5	x	0	x	0.5	x	2.4	0.000	0.167	0.00
6	0.5	x	5	x	0.5	x	2.4	3.000	1.833	5.50
7	5	x	1	x	2.4			12.000	1.000	12.00
8	0.5	x	5	x	0	x	2.4	0.000	0.500	0.00
9	0.5	x	5	x	0.5	x	1.8	2.250	1.833	4.13
10	3.5	x	5	x	1.8			31.500	3.750	118.13
11	3.5	x	0	x	1.8			0.000	3.750	0.00
12	0.5	x	3.5	x	0	x	2.8	0.000	4.333	0.00
q	0.5	x	4					2.000	3.500	7.00
	Total (1 to q)							**57.350**		**164.91**

Horizontal load

$$Ka = \frac{\text{Cos}2(\phi-\alpha)}{\text{Cos}2\alpha \text{ x } \text{Cos}(\alpha+\delta) x \left(1+\sqrt{\frac{Sin(\phi+\delta) x\, Sin\phi}{\text{Cos}(\alpha+\delta)\, x\, \text{Cos}\alpha}}\right)2}$$

0.589

Passive compressive strength of the soil

$$Kp = \frac{\text{Cos}2(\phi+\alpha)}{\text{Cos}2\alpha \text{ x } \text{Cos}(\alpha-\delta) x \left(1+\sqrt{\frac{Sin(\phi+\delta) x\, Sin\ \phi}{\text{Cos}(\alpha-\delta)\, x\, \text{Cos}\ \alpha}}\right)2}$$

Kp = 1.699

Table 9. Horizontal Load

No.	Description					H	Y	H x Y
Pa1	0.294	x	5.00			1.472	3.000	4.41
Pa2	5.298	x	5.00	x	0.50	13.244	2.167	28.69

Pa3	5.592	x	0.50			2.796	0.250	0.70
Pa4	0.530	x	0.50	x	0.50	0.132	0.167	0.02
Pw1	0.500	x	0.50	x	0.50	0.125	0.167	0.02
Pw2	-0.500	x	0.50	x	0.50	-0.125	0.167	-0.02
Pp1	-1.529	x	0.50	x	0.50	-0.382	0.167	-0.06
		Total				**17.261**		**33.77**

- Stability calculation

a. Stability against overturning

Without uplift

B = 5.50 m

X = = $\frac{\sum W \times X - \sum H \times Y}{\sum W}$ $\frac{164.91-33.77}{57.350}$

= 2.287 m

e = − X = − 2.287 = 0.463 m$\frac{B}{2}$ $\frac{5.50}{2}$

0.463 m < B/6 = 0.917 m **OK !**

With uplift

B = 5.50 m

X = $\frac{\sum W \times X - \sum H \times Y}{\sum W}$

= = 2.263 m$\frac{157.35-33.77}{54.600}$

E = − X $\frac{B}{2}$

= − 2.263 = 0.487 m$\frac{5.50}{2}$

0.487 m < B/6 = 0.917 m **OK !**

b. stability against sliding

without uplift

Sliding force : ∑H = 17.261 ton

Resistance : HR= μ X ∑ W

= 0.50 x 57.350

= 28,675 tonnes

Fs = $\frac{HR}{\sum H}$

= = 1.661 > 1.50 OK !$\frac{28.675}{17.261}$

with uplift

Sliding force : ∑H = 17.261 ton

Resistance : HR = μ X ∑ W

= 0.50 x 54.600

= 27,300 tonnes

Fs = $\frac{HR}{\sum H}$

= = 1.582 > 1.50 OK !$\frac{27.300}{17.261}$

c. Reaction of foundation soil

q1,2 = x $\frac{\sum W}{B}$ $\frac{6\,x\,e}{(1+B)}$

q1 = x $\frac{57.350}{5.50}$ $\frac{6\,x\,0.463}{(1+5.50)}$

= 15.694 t/m2 < qa

= 51.900 t/m2 OK !

q1 = x $\frac{57.350}{5.50}$ $\frac{6\,x\,0.463}{(1-5.50)}$

= 5.161 t/m2 < qa

= 51.900 t/m2 OK !

d. Returns

Table 10. Returns

	Section A-A	Section B-B	Section C-C	Section D-D
	Back	***Back***	***Lower***	***Upper***
Bending moment	2,402,906	2,402,906	177,185	2,046,158
Shearing force (joint)	13,731	13,731	7,008	7,657
Axial force	0	0	0	0
Height of member	150.0	150.0	50.0	50.0
Covering depth	7.0	7.0	7.0	7.0
Effective height	143.0	143.0	43.0	43.0
Effective width	100.0	100.0	100.0	100.0
Young's modulus ratio	24	24	24	24
Required R-bar	9.90	10.21	2.44	31.06
R-bar arrangement	**25~200**	**25~100**	**16~250**	**25~100**
Reinforcement	24.54	49.09	8.04	49.09
Perimeter of R-bar	39.27	78.54	20.11	78.54
Dist. from neutral axis	35.57	47.45	11.10	22.16
Compressive stress	10.3	8.0	8.1	51.9
Allowable stress	60.0	60.0	60.0	60.0
	ok	ok	ok	ok
Tensile stress	747	385	561	1,170
Allowable stress	1,850	1,850	1,850	1,850
	ok	ok	ok	ok
Shearing stress at joint	0.96	0.96	1.63	1.78
Allowable stress	5.50	5.50	5.50	5.50
	ok	ok	ok	ok
Resisting Moment	5,234,703	13,748,467	720,792	6,330,614
Mr for compression	6,558,506	14,771,164	1,363,934	6,330,614
x for Mrc	27	44	11	32
ss for Mrc	3,316	2,693	4,201	1,969
Mr for tensile	5,234,703	13,748,467	720,792	6,876,920
x for Mrs	32	55	13	42
sc for Mrs	44	59	32	96
Distribution bar (>As/6 and >Asmin)	4.09	8.18	1.34	8.18
	16~250	**16~125**	16~200	**16~200**
Reinforcement	8.04	16.08	10.05	10.05
	ok	ok	ok	ok

Pile Foundation Calculation

- Pile dimension planning data:

Mast depth (D) = 4 m
Pile diameter (d) = 50 cm
Pile circumference (USA)
= л x d x D
= 3.14 x 50
= 628 cm = 6.28 m

Pile area (Ap)
= 1/2 x л x d2
= ½ x 3.14 x 502
= 3925 cm2
= 0.3925 m

- Finding Cu values

With = N-SPT x 2/3 x 10
= 3 x 2/3 x 10
= 20 Kn/m2
= 0.2000 t/m2
Cu2 = N-SPT x 2/3 x 10
= 267 kN/m2
= 2.6667 t/m2

- Calculation of the force in

Table 11. Value of the Force Inside

Foundation	Deep Style				
	P(Kn)	*E.g. (kn)*	*Fy (kn)*	*Mx (Knm)*	*My (Knm)*
P1	600.46	126.268	121.901	33.783	14.529

Mxo = Mx + Fy + t
= 91.25 + 17.261 + 0.5
= 109.011 kNm
Myo = My + Fx + t
= 33.77 + 32.677 + 0.5
= 66.947 kNm
Pmax = 522.6372 kN
Poer's own weight calculation
= 94.5 x 5.5 x 0.5 x 24
= 6237 kN
Axial load of column P = 522.6372 kN
SP = 6759.6372 kN

- Single pole axial bearing capacity

Capacity of pile ends based on Mayerhoff method
Qp = (40 x Nb x Ap)
= 40 x 63.087 x 0.3925
= 990.463615 kN

- Ultimate pile carrying capacity

Qu = Qp + Qs
=990.463615 + 3.5325
= 993.996115
Bearing capacity of pile permits
P Permission = Qu/Fs
= 993.996115/3
= 331.3320383

- Calculating the pressure on each pole

$$pi = + + \frac{\Sigma p}{n} \frac{Mxu\ x\ yi}{\Sigma y2} \frac{Myo\ x\ xi}{\Sigma x2}$$

$$= + + \frac{6759.6372}{14} \frac{109.011\ x\ 1.2}{6.25} \frac{66.947\ x\ 0.75}{2.25}$$

= 541.150 kN

$$pi = - - \frac{\Sigma p}{n} \frac{Mxu\ x\ yi}{\Sigma y2} \frac{Myo\ x\ xi}{\Sigma x2}$$

$$= - - \frac{6759.6372}{14} \frac{109.011\ x\ 1.2}{6.25} \frac{66.947\ x\ 0.75}{2.25}$$

= 514,337 kN
Then the maximum pressure of one pole is = 541,150 kN

Check the maximum pressure with the strength value of the material and soil

Pi > P

541.150 > 3247.99 OK !

So Q group permission

= Ek x Q permission 1 pile x n

= 0.628 x 3247.99 x 13

= 26108.631 kN

Q checking group permissions with Pu

26108.631 > 522.6372 OK !

Axial bearing capacity of pile group

Qg = Ek x n x Qu

= 0.628 x 13 x 993.603615

= 7986.97753 kN

- Pile group pile calculation

Qg = Ek x n x Qu

= 0.628 x 13 x 993.603615

= 7986.97753 kN

Info:

I = efficiency of pile group

n = number of poles in a group

Qg = Axial Bearing Capacity of Pole

Qu = Ultimate Bearing Capacity of Pole

- Bearing capacity due to lateral forces

The critical length of the soil clamp against the foundation pile according to the philhonographic method where the minimum depth of the soil to the foundation pile is obtained from the following forces:

Monolayer = 3 meters or 6 times D

Multilayer = 1.5 meters or 3 times D

Account:

The = clamping length

= 6 x D

= 6 x 0.5

= 3 m

Y direction

My $= \frac{Le\ x\ h\ x\ X}{n}$

$= \frac{3\ x\ 0.5\ x\ 0.75}{13}$

= 0.088

Check against pile bending crack

Y direction < bending crack

0.088 < 17 OK!

Direction x

Mx $= \frac{Le\ x\ h\ x\ X}{n}$

$= \frac{3\ x\ 0.5\ x\ 1.25}{13}$

= 0.146

Check against pile bending crack

Direction x < bending crack

0.146 < 17 OK !

CONCLUSION

The research on Retaining Wall Planning in Waste Management has been completed, revealing the volume of waste and productivity of heavy equipment in the area. The current heavy equipment includes 1 unit of excavator, 15 dump trucks, and 7 units of truck amrolls, each with a different waste service area. The TPSA Ciniru can accommodate 633.08 m3/day or 231,072.73 m3/year at a cost of Rp. 48,245.43/m3. To increase waste management effectiveness and extend landfill life, it is recommended to add heavy equipment and plan a retaining wall along the critical point, which is 94.5 m long and 5 m high using a pile foundation. The safety factor (SF) for the retaining wall design was calculated to be 0.52 (Safe) and 1.90 (Safe), with bearing capacity per pile = 269.78 Kn and carrying capacity of the pile group = 173.13516 Kn. Future studies could explore optimizing waste management operations by investigating advanced technologies and equipment for heavy-duty waste handling, evaluating the environmental and economic impacts of using alternative materials or innovative designs for retaining walls, and comparing landfill designs to improve waste management practices.

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