INTERNATIONAL JOURNAL ON ADVANCED TECHNOLOGY, ENGINEERING, AND INFORMATION SYSTEM
(IJATEIS)

CAPACITY ANALYSIS OF DRAINAGE CHANNELS ON PUBLIC ROADS IN FRONT OF THE SIDOARJO CLASS 1A RELIGIOUS COURT OFFICE: A REVIEW OF MAINTENANCE COSTS

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Abstract

Flooding in front of the Sidoarjo Class 1A Religious Court Office road happens frequently during the rainy season. It disrupts traffic and damages the roads. Flooding is caused by the condition of the drainage channels, which are not performing efficiently due to sediment barriers such as garbage, and some channels appear to be damaged. The existing channels can no longer accommodate the water discharge caused by the rain, thus water overflows from the drainage channels, flooding the main road. These conditions show the importance of handling drainage problems. One of the ways that can be taken is to evaluate the capacity of existing drainage channels. In this study, the evaluation of drainage channel capacity was carried out using the Hydrological and Hydraulics Analysis method. The purpose of this study to assess the suitability of the magnitude of the 5-year return period flood discharge with the capacity of the existing drainage channel, and to find a solution if the drainage system can no longer accommodate the magnitude of the proposed flood discharge. The chosen alternative was alternative 2 drainage channel rehabilitation with increased channel dimensions. Based on the calculated results, a channel dimension plan with a width of 0.6 m and a height of 0.80 m was necessary. The cost required for drainage channel rehabilitation was 750,605,179.00 rupiahs.

Keywords: *Drainage, Flood, Hydrological, Hydraulic*

1. INTRODUCTION

The Sidoarjo Class 1A Religious Court Office is a legal institution that plays a central role in the resolution of civil and family cases in the region. Located in a strategic location, the office is an important law enforcement center for the community. Wijaya Kusuma Sidoarjo Road in front of the office is not only a public traffic route, but also the main access for local residents to carry out various daily activities, including access to legal services, government and other social activities. Good connectivity through public roads supports the smooth and effective movement of visitors, judges, employees and other stakeholders who need smooth and safe access to the Sidoarjo Class 1A Religious Court Office. As such, the smooth running of public roads around the office has a direct impact on the efficiency of overall community activities.

Floods in front of the Sidoarjo Religious Court Class 1A often occur when the rainy season comes. This condition causes traffic disruptions and damages to the road surface. The impact of floods on road performance includes significant traffic disruptions due to water puddles, resulting in traffic congestion and travel delays for road users. In addition, floods can also cause damage to road infrastructure, such as damaged roads and clogged drainage channels, all of which have an impact on the deterioration of road quality and the comfort of road users. This infrastructure damage can also affect accessibility, limiting the movement of the community and increasing the risk of accidents on the highway due to dangerous road conditions (Yulius, 2018).

The flood that occurred in the public road area in front of the Sidoarjo Class 1A Religious Court Office was caused by the ineffective condition of the drainage system, due to the presence of sediment blockages in the channels including trash, and some channels appeared to be damaged. The existing channels were no longer able to accommodate the water flow due to the rain, causing the water to overflow from the drainage channels, resulting in the main road being flooded.

The condition highlights the importance of addressing drainage issues in the public road area in front of the Sidoarjo Class 1A Religious Court Office. One approach that can be taken is to conduct a capacity evaluation for each existing drainage channel. The flooding and puddling problems that occur in the public road area in front of the Sidoarjo Class 1A Religious Court Office can be overcome by redesigning the drainage channels according to the flood capacity in each segment of the channels (Guntoro et al., 2017).

In this study, the evaluation of drainage capacity was carried out using the Hydrological and Hydraulics Analysis method. The purpose of this study is to determine the amount of storage capacity of the drainage channel, so that flooding can be resolved, analyze the suitability of the magnitude of the 5-year return period flood discharge with the capacity of the existing drainage channel and get a solution if the drainage system cannot accommodate the magnitude of the plan flood discharge.

2. LITERATURE REVIEW

Drainage or also originates from the English word *drainage*, which means draining, disposing, or diverting. In the field of civil engineering, drainage is generally used to reduce excess water such as rainwater, seepage water, or excess irrigation water from an area/land, so that the function of the area/land is not disrupted (Juliana, 2019). In general, a drainage system can be defined as a collection of water structures designed to reduce and/or divert excess water from an area/land so that land utilization can be optimized. The drainage system can be defined as a series of water structures that function to reduce and/or dispose of excess water from a region/land, allowing the land to be optimally utilized. The sequential water structures of the drainage system, starting from the upstream, consist of interceptor drains, collector drains, conveyor drains, main drains, and receiving waters. Commonly encountered drainage structures include culverts, bridges, gutters, and sloping channels (Andana et al., 2016). Sediment in a river commonly mentioned as increasing the risk of flooding due (Patriadi et al., 2022).

2.1. Hydrological Analysis

Hydrological analysis is an initial analysis related to the design of flood management systems and drainage system planning, determining the amount of runoff that will be carried so that the dimensions of the drainage channel can be determined (Linsley Jr et al., 1975). The flow rate used as a basic criterion in drainage planning, especially flood management, is the design flow rate, which is the amount of rain runoff planned for a certain return period and wastewater discharge from an area (Krisnayanti et al., 2017). The analysis is carried out by calculating the average rainfall of the flow area using the Thiessen Polygon method. To calculate the annual rainfall plan can use the Normal Method, Log Normal, Gumbel, Log Pearson III Distribution (Asmorowati et al., 2021).

a. Calculation of Flow Coefficient (C)

Surface runoff time is the time it takes to runoff rainwater from the farthest point to the nearest channel, often referred to as inlet time, overflow time (t_0) in minutes. The formula for calculating t_0 is:

$$t_0 = \left(\frac{2}{3}.3{,}28.L_o\frac{n_d}{\sqrt{S}}\right)^{0.167}$$

Flow time is the time required to drain water in the channel, from one point of entry of runoff water to the review point. The amount of flow time according to SNI on Planning Procedures for Road Surface Drainage: 1994, is:

$$t_d = \frac{Ld}{60.Vsal}$$

The velocity of water in the channel depends on the material of which the channel is made. Concentration time or flood arrival time is the time required by rainwater to flow from the most distant point to a certain review point (e.g. point at the mouth of the drainage) in a drainage area (Rachman et al., 2014).

$$T_c = t_0 + t_d$$

b. Calculation of Rain Intensity (I)

Meanwhile, if only daily rainfall data is available, the rainfall intensity can be calculated using the Mononobe formula. Calculation of design rainfall intensity is done based on the Mononobe Method:

$$I = \frac{R24}{24}\ X\ \left(\frac{24}{t}\right)^{2/3}$$

c. Flood Discharge Calculation (Q)

A commonly used method for urban drainage, estimating peak flow rates (plan discharge), is the Rational Method. The rational method is developed based on the assumption that rainfall that occurs has a uniform intensity and is evenly distributed throughout the drainage area for at least equal to the time of concentration (tc). Channel dimensions are planned based on the amount of rainwater discharge that will be flowed using the Rational Method The mathematical equation of the Rational Method is as follows:

$$Q = 0{,}278\ .\ C\ .\ I\ .\ A$$

2.2. Hydraulics Analysis

Hydraulics analysis is intended to find the hydraulic dimensions of the drainage channel and its complementary buildings. In determining the dimensions of the drainage channel, it is necessary to take into account the planning criteria based on the rules of hydraulics. Channel Capacity in the early stages of the analysis it is assumed that what occurs is uniform flow (Mahendra et al., 2023). Analysis to calculate channel capacity, the continuity equation and Manning's formula are used, namely:

$$R = \frac{A}{P}$$

Where the values of A and P are obtained from the following equations:

A = (B + mh) H (for trapezoidal section channels)
A = B x H (for square section channel)
P = B + 2H + $\sqrt{1}$+m^2 (for trapezoidal section channel)
P = B + 2H (for square section channel)

Where the value of m is obtained from:

$$m = \frac{B - b}{2\ X\ H}$$

Then calculate the channel capacity discharge with the following equation:

$$Q = V \cdot A$$

Where the value of V is obtained from the following equation:

$$V = \frac{1}{n}\ x\ R^{2/3}\ x\ S^{1/2}$$

$$S = \left(\frac{v\ x\ n}{R^{2/3}}\right)^2$$

3. RESEARCH METHODS

This research was conducted on a public road in front of the Sidoarjo Class 1A Religious Court Office, namely Wijaya Kusuma Street. The stages carried out in this research were presented in a flowchart according to Figure 1.

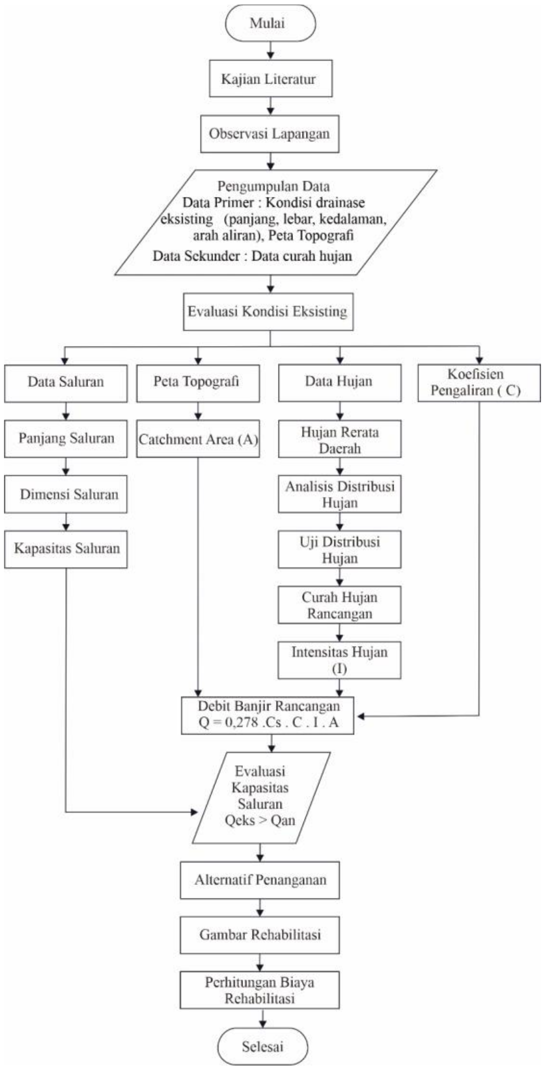

Figure 1. Research Stages

3.1. Research Data

a. Primary data

Survey of existing channel conditions in the form of measuring channel dimensions, length, width, depth and flow direction contained in the channel. To measure the height of sediment in the channel manually, namely using wood, then plugged until it touches the bottom of the channel, then the value of the sediment height can be known (Agustyawan & Arif, 2020). Making topographic maps with Google Earth Pro and ArcMap software according to the delineation of the area to be studied (Yu & Gong, 2012).

b. Secondary data

Obtained through literature studies and collecting data and information from various sources. The secondary data in this study are rainfall data from 2011-2023 (13 years).

3.2. Data Analysis Technique

Data analysis activities are carried out using Hydrological analysis and Hydraulics analysis methods. The stages of data analysis carried out from the basic data include:

a. Analyze hydrological data, to obtain planned rainfall and design discharge for existing and planning evaluation (Azhari, 2021).
b. Analyzing hydraulics data, such as analyzing channel capacity after obtaining existing channel discharge
c. Evaluation of channel capacity (Widiastomo et al., 2022).
d. Calculating the rehabilitation cost budget plan.

4. RESULTS AND DISCUSSION

From the results of the hydraulics analysis, it is known that the T1 channel cannot accommodate the design flood discharge due to sedimentation in the channel, therefore it is necessary to rehabilitate the channel. The alternative handling strategy plan is channel normalization and the second is an increase in channel dimensions.

Figure 2. Existing Channel Rehabilitation

4.1. Alternative 1

In alternative 1, channel normalization is planned by cleaning and excavating sedimentation in the channel so that the width and depth of the channel match the initial construction of the channel.

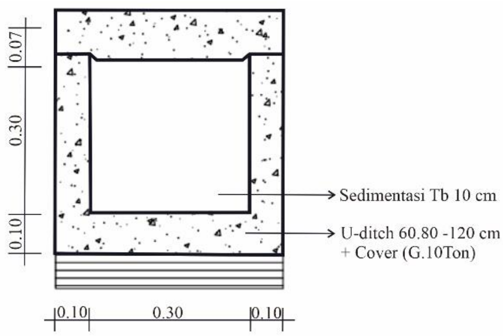

Figure 3. Sediment Details

Table 1. Alternative 1 dimensions

Point	d	S original	Cross-Section of Channel		n	B	H	A	P	R	V	Qhydraulic
	m		Shape	Material		(m)	(m)	(m2)	(m)	(m)	(m/s)	(m^3/s)
J1-J2	295	0,02%	Rectangular	Concrete	0,019	0,3	0,30	0,090	0,090	0,100	0,175	0,016

From the table 1, it is known that the capacity that can be accommodated by the channel after normalization is 0.016 m3 / sec. The indicator that the channel can accommodate flood discharge is if the Qhydraulic channel is equal to or greater than the planned flood discharge, the comparison of the existing channel discharge (Qhydraulic) with the design flood discharge (Q5). Qhydraulic < Q5 is obtained, it is known that the Q hydraulics of the channel cannot accommodate the channel design flood discharge with a return period of 5 years. It is known that in alternative 1 channel normalization, the channel capacity cannot accommodate the design flood discharge (Q5) and there is still a runoff of 0.698 m3 / second. So, it is necessary to plan other alternatives, namely increasing channel dimensions.

Table 2. Alternative 1 Result

Q5 (m^3/s)	Qhydraulic (m^3/s)	Qrunoff (m^3/s)	Conclusion
0,717	0,016	0,702	The channel cannot accommodate Qplanning

4.2. Alternative 2

Alternative 2 involves the planned rehabilitation of the channel by increasing its dimensions and enhancing the slope of the channel bed to achieve a flow velocity within the permissible range of greater than 0.6 to 3 m/s. The required channel dimensions are calculated in the following table: In Alternative 2, the rehabilitation plan includes increasing the channel dimensions and enhancing the channel bed slope to achieve the permissible flow velocity of 1.5 m/s. The required channel dimensions are determined through a trial-and-error process. In Change 1, both the width and depth of the channel are planned to be modified. In Change 2, the existing width and depth dimensions are maintained. In Change 3, the channel width is planned to be modified while maintaining the existing channel depth.

Table 3. Change 1 dimensions

Point	Ld	n	V	S	B	H	A	P	R	Q
	m		(m/s)	plan	(m)	(m)	(m^2)	(m)	(m)	(m^3/s)
J1-J2	295	0,013	1,50	0,003	0,60	0,797	0,478	2,193	0,218	0,717

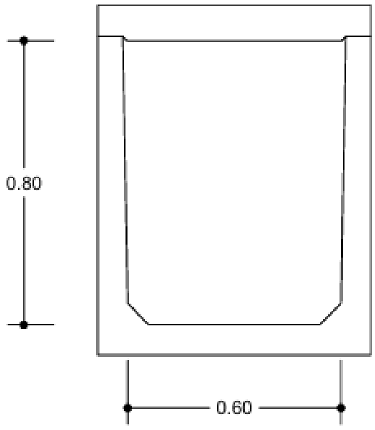

Figure 4. figure of Change 1 dimensions

Table 3. Change 2 dimensions

Poi nt	Ld m	n	V (m/s)	S plan	B (m)	H (m)	A (m^2)	P (m)	R (m)	Q (m^3/s)
J1-J2	295	0,013	1,50	0,003	0,300	1,593	0,478	3,487	0,137	0,717

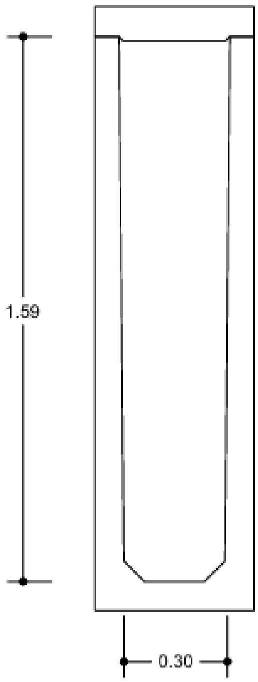

Figure 5. figure of Change 2 dimensions

Table x. Change 3 dimensions

Poi nt	Ld m	n	V (m/s)	S plan	B (m)	H (m)	A (m^2)	P (m)	R (m)	Q (m^3/s)
J1-J2	295	0,013	1,50	0,003	1,593	0,300	0,478	2,193	0,218	0,717

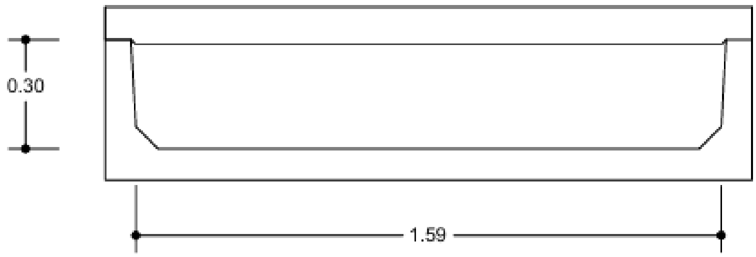

Figure 6. figure of Change 3 dimensions

From the table above, the dimensional change required to accommodate the design flood discharge indicates a width of 0.6 m and a height of 0.797 m. However, for the second scenario, if the width remains constant at 0.3 m, the channel depth needed would be 1.593 m. This dimension is considered neither proportional nor efficient and would be challenging to implement. In the third scenario, if the depth remains constant at 0.3 m and the width changes, the required width would be 1.593 m. This dimension is also deemed neither proportional nor efficient, and there would be insufficient space. From the three scenarios, it is determined that the most efficient dimension is the first scenario, with dimensions of 0.6 x 0.797 m. Since the specified item for precast U-Ditch channels with dimensions of 0.6 x 0.797 m is not available, the U-Ditch dimensions used will correspond to the fabricated U-Ditch dimensions of 0.6 x 0.8 m.

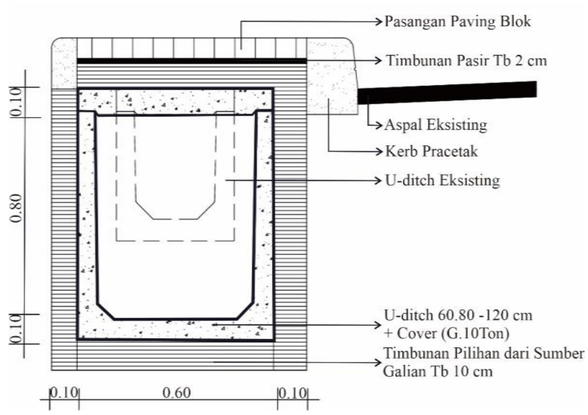

Figure 7. Alternative 2 Plan Details

4.3. Rehabilitation Image

From the results of the Hydrology and Hydraulics analysis above, the existing channel cannot accommodate the design flood discharge with a return period of 5 years, therefore it is necessary to rehabilitate the drainage channel according to the calculation.

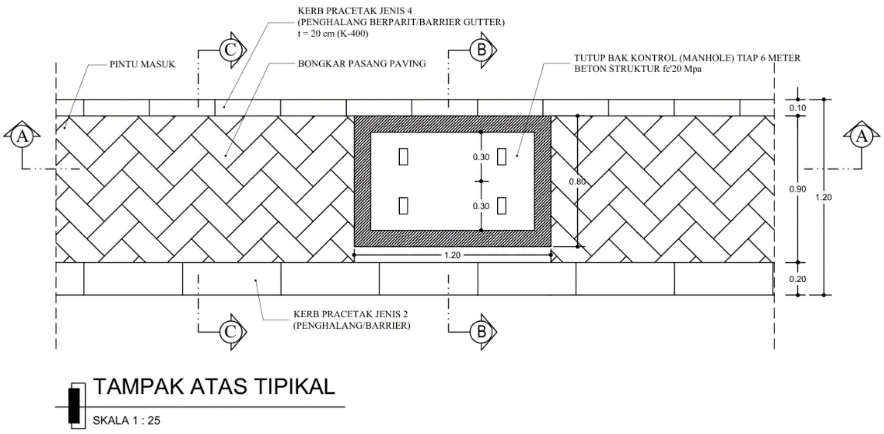

Figure 8. Typical top view

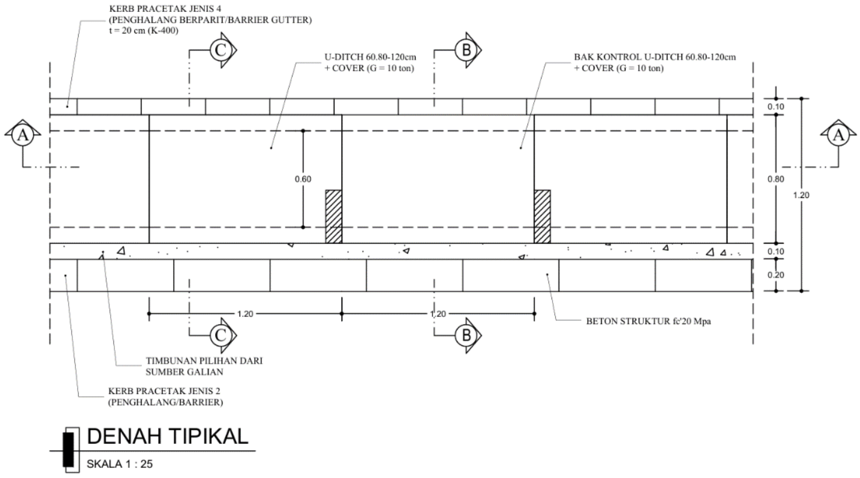

Figure 9. Typical layout

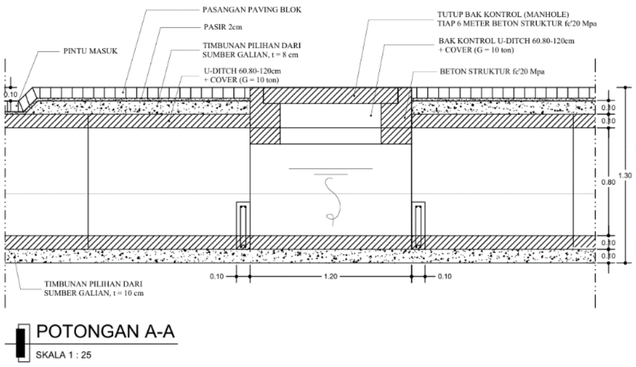

Figure 10. A-A Section

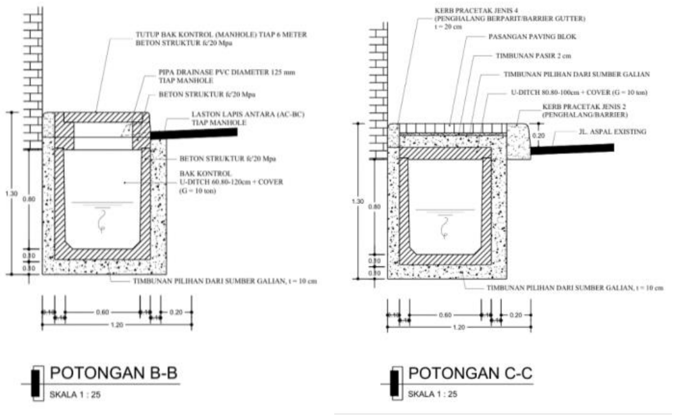

Figure 11. B-B Section

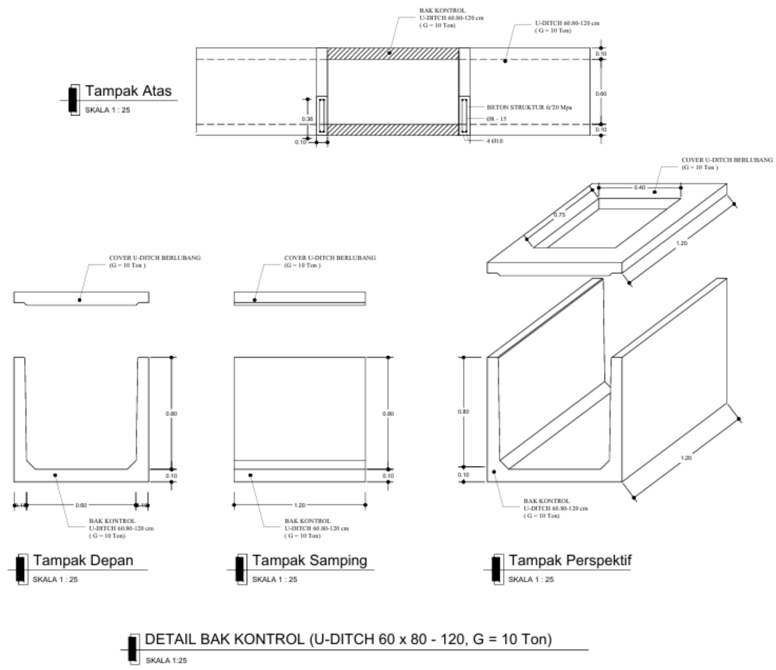

Figure 12. Detail of Control Structure

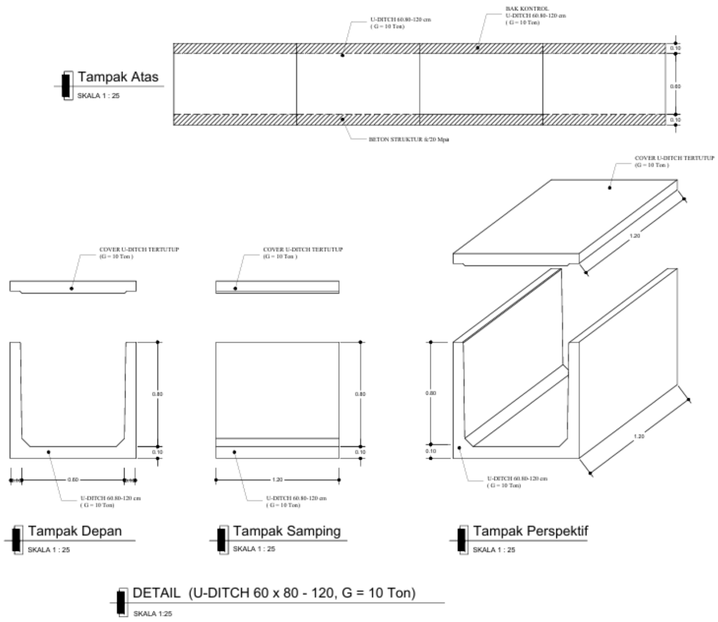

Figure 13. Front, side and perspective views details

4.4. Rehabilitation Planning Budget Plan

a. RAB (Cost Budget Plan) of Drainage Rehabilitation Planning

Table 4. Project Cost of Each Division

No	Job Description	Total Price
1	2	3
A	General Division	Rp. 25.184.600,00
B	Drainage Division	Rp. 656.051.811,00
C	Earthwork and Geosynthetics Division	Rp. 27.574.217,86
D	Structure Division	Rp. 41.794.550,00
	Total Amount	Rp. 750.605.178,86
	Rounded	Rp. 750.605.179,00
AMOUNTED: Seven Hundred Fifty Six Hundred Five Thousand One Hundred Seventy Nine Rupiahs		

Table 5. Description of Project Cost in each division

No	Desc.	Unit	Estimated Quantity	Unit Price	Project Cost
a	b	c	d	e	f = (d x e)
A	General Division	Ls	1,00	Rp. 8.000.000,00	Rp. 8.000.000,00
1	Mobilization				
	SMKK document preparation				
	Preparation of RKK, RMPK, RKPPL, and RMLLP documents	Set	1,00	Rp. 3.000.000,00	Rp. 3.000.000,00

No	Desc.	Unit	Estimated Quantity	Unit Price	Project Cost
	Socialization, promotion and training				
	Construction Safety Briefing	People	4,00	Rp. 50.000,00	Rp. 200.000,00
	Safety meeting (Safety Talk and/or Tool Box Meeting)	People	4,00	Rp. 50.000,00	Rp. 200.000,00
	Banner				
	Poster/ leafet	Pcs	1,00	Rp. 100.000,00	Rp. 100.000,00
	Construction Safety Information Board	Sheet	2,00	Rp.100.000,00	Rp. 200.000,00
	Occupational Protective Equipment and Personal Protective Equipment	Sheet	2,00	Rp. 250.000,00	Rp. 500.000,00
2	PPE				
	Safety Helmet	Pcs	4,00	Rp. 80.000,00	Rp. 320.000,00
	Goggles, Spectacles	Pcs	4,00	Rp.45.000,00	Rp. 180.000,00
	Safety Gloves	Pairs	4,00	Rp.20.900,00	Rp. 83.600,00
	Safety cover (Safety Shoes, rubber safety shoes and toe cap)	Pairs	4,00	Rp.150.000,00	Rp. 600.000,00
	Safety Vest	Pcs	4,00	Rp.35.000,00	Rp. 140.000,00
3	Construction Safety Personnel				
	First Aid Officer	People	1,00	Rp. 4.000.000,00	Rp. 4.000.000,00
	Traffic control officer	People	1,00	Rp. 4.800.000,00	Rp. 4.800.000,00
4	Medical facilities, infrastructure, and equipment				
	First Aid Equipment	Set	1,00	Rp. 600.000,00	Rp. 600.000,00
5	Required traffic signs and equipment				
	Guidance signs	Pcs	2,00	Rp. 285.000,00	Rp. 570.000,00
	Prohibition sign	Pcs	1,00	Rp. 285.000,00	Rp. 285.000,00
	Warning signs	Pcs	1,00	Rp. 285.000,00	Rp. 285.000,00
	Information signs	Pcs	1,00	Rp. 285.000,00	Rp. 285.000,00
	traffic cone	Pcs	2,00	Rp. 98.000,00	Rp. 196.000,00
	Warning Lights Stick	Pcs	1,00	Rp. 450.000,00	Rp. 450.000,00
	Temporary lamp/lighting device	Pcs	1,00	Rp. 140.000,00	Rp. 140.000,00
6	Consultation with related experts				
	K3 Flag	Pcs	1,00	Rp. 50.000,00	Rp. 50.000,00
	Total Cost of Work A				Rp. 25.184.600,00

No	Desc.	Unit	Estimated Quantity	Unit Price	Project Cost
B	Drainage Division				
	Procurement and installation of U-ditch 60.80-120cm+cover (G.10Ton)	Pcs	227,00	Rp. 1.935.681,00	Rp. 439.399.587,00
	Procurement and installation of BC 100.100.120.12.5cm 9G.10Ton)	Pcs	18,00	Rp. 3.135.982,00	Rp. 56.447.676,00
	Total Cost of Work B				Rp. 656.051.811,00
C	Earthworks and Geosynthetics Division				
	Regular excavation	M^3	249,81	Rp. 32.774,00	Rp. 8.187.272,94
	Selected backfill from excavation sources	M^3	92,54	Rp. 209.498,00	Rp. 19.386.944,92
	Total Cost of Work C				Rp. 27.574.217,86
D	Structure Division				
	U-ditch dismantling	M^3	245,00	Rp. 170.590,00	Rp. 41.794.550,00
	Total Cost of Work D				Rp. 41.794.550,00
	Total A+B+C+D				Rp. 750.605.178,86

5. CONCLUSION

Based on the calculation results, it can be concluded that the chosen alternative is Alternative 2, which involves rehabilitating the drainage channel by increasing its dimensions to 0.6 m in width and 0.8 m in height, with an estimated cost of Rp. 750,605,179.00.

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