
Analysis of Groundsill Design in Cimanuk River, Jatitujuh, Majalengka

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Abstract:

This study analyzes the groundsill design in the Cimanuk River at the Jatitujuh area, Majalengka, with the goal of addressing riverbed degradation and enhancing flood control. The research aims to provide a sustainable solution by stabilizing the riverbed and preventing further erosion, which threatens the river's hydraulic structures. The study utilizes a combination of hydrological analysis, including discharge frequency analysis, and morphological analysis to calculate the design of the groundsill structure. The hydrological analysis employs several methods, with the Log Pearson III method identified as the most suitable for calculating the 100-year return period flood discharge of 1,444.28 m³/s. The structure's design includes a main dam height of 3.83 meters and a sub-dam height of 1.10 meters, with stability analysis confirming its safety against overturning and shear forces. The findings indicate that the groundsill will reduce water velocity, prevent further riverbed degradation, and maintain the structural integrity of the Rentang Weir. The study highlights the need for community participation in maintaining the groundsill and calls for further environmental impact assessments and climate change considerations. This research contributes to the development of effective river management strategies and provides recommendations for future studies, including optimization of the groundsill design under varying conditions and exploring the effects of climate change on river discharge.

Keywords: River; Discharge; Groundsill; Hydrology; Stability

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INTRODUCTION

A river is a natural or man-made water channel that serves as a conduit for water flow from upstream to downstream, bordered on both sides by defined boundaries. It functions to store, contain, and channel rainwater that accumulates within its cross-section naturally (Ananta et al., 2023b). A watershed is an area that includes water flow regions and river channels, including riverbanks, levees, and areas designated as a watershed as stated in the law (Yuliman Ziliwu, 2015). A Watershed is often used as a basis for natural resource planning and management. Within the watershed ecosystem, living organisms and their environment interact dynamically, and there is interdependence among its constituent components (Kusbiantoro et al., 2015). Rivers often face several issues, one of the most common being riverbed degradation, which refers to the lowering of the riverbed elevation. This can disrupt hydrological functions, ecological balance, and the stability of river structures (Anderson et al., 2023).

The Cimanuk River, one of the main rivers in West Java, plays a vital role in irrigation, raw water supply, and flood control (SAIHUL ANWAR, 2015) (Darmawan & Saihul Anwar, 2016). The Cimanuk River is a river located in the eastern part of West Java Province, Indonesia. It originates in the

Mandalagiri Mountains in Garut Regency at an altitude of approximately 1,700 meters above sea level (masl), flowing northeast for 180 km before emptying into the Java Sea in Indramayu Regency. The Cimanuk River has two estuaries: Cimanuk Lawas ("Old Cimanuk") and Cimanuk Anyar ("New Cimanuk") (Ernas et al., 2023). However, in recent years, the Cimanuk River has faced various hydrological and morphological issues, such as riverbed erosion, channel degradation, and sedimentation, which threaten its function and stability. The Jatitujuh area in Majalengka has been significantly affected by worsening degradation due to changes in land use patterns and deforestation in the upstream region.

To address this issue, the construction of a groundsill has become a crucial solution. A groundsill is a type of weir structure built across the river flow to reduce the water velocity and accelerate the sedimentation process upstream of the structure. A groundsill functions as a measure to maintain the stability of other hydraulic structures in the river and reduce the issue of scouring. Its construction also aims to stabilize the elevation of sediment layers, ensuring the durability of upstream hydraulic structures and preventing excessive riverbed degradation (Ananta et al., 2023a). This study aims to analyze the design of the groundsill to ensure its effectiveness in addressing riverbed degradation without disrupting the ecosystem. The analysis considers technical, environmental, and social aspects to develop a sustainable solution for the Cimanuk River in the Jatitujuh area, Majalengka.

The research provides a comprehensive analysis of the groundsill design in the Cimanuk River at the Jatitujuh area, Majalengka, with a primary focus on addressing the hydrological and morphological issues, including riverbed degradation. The novelty of this research lies in its combination of hydrological and morphological analyses with practical, structural design considerations for riverbed stabilization. While previous studies, such as those by Ananta et al. (2023) and Bravikawati and Fatimah (2021), have explored similar topics, the current research introduces more detailed methods for calculating the discharge frequency, including a thorough statistical approach using the Log Pearson III method, which outperforms other methods like Gumbel and Normal distributions in this particular case. The study also stands out by incorporating stability analysis, focusing on the safety factors against overturning and shear forces, which further ensures the effectiveness of the groundsill structure. Additionally, this research places significant emphasis on environmental and social sustainability by recommending community involvement in river management, thus adding value beyond technical design alone.

RESEARCH METHODOLOGY

The method used in this study is the quantitative method. According to Sugiyono (2009) in (M. Noor Ali, 2017), "the quantitative method is a scientific method because it adheres to scientific principles, namely being concrete, objective, measurable, rational, and systematic. Additionally, it is called a quantitative method because the research data consists of numerical values, and the analysis employs statistics and models".

This study is conducted through the analysis of primary and secondary data. Primary data is obtained from field measurements using RTK GNSS equipment, while secondary data is collected from river discharge records over the past ten years (2014–2023) at the Rentang Weir, as well as other technical data from BBWS Cimanuk–Cisanggarung. According to Soewarno in (Bravikawati & Fatimah, 2021), "discharge data is a time-series data set with monthly increments that cannot be considered as independent variables. For example, the discharge in the current month is highly dependent on the discharge from the previous month and possibly even earlier months. Therefore, to generate artificial time-series data, the Markov process should be used for monthly data".

Before conducting the design calculations for the groundsill structure, this study first analyzes calculations using two methods: morphological analysis and hydrological analysis. "River morphology is defined as the study of river shapes, types, characteristics, and behaviors in all aspects of their changes across spatial and temporal dimensions" (Azwarman, 1999) in (Hari Wibowo, 2015). Hydrological analysis is an essential initial step in the planning of hydraulic structures. It plays a crucial role as it significantly influences subsequent analyses (Karya & Sipil, 2015). The hydrological analysis in this study consists of weir discharge frequency analysis and design flood discharge analysis. The hydrological analysis is conducted using several methods, including normal distribution, log-normal, Gumbel, and Log Pearson Type III, with return periods of 2 years, 5 years, 10 years, 25 years, 50 years, and 100 years (Ika Sari Damayanthi Sebayang, 2019). The design flood discharge analysis is conducted using the rational method with a 100-year return period. Based on the results of the morphological and hydrological analyses, the next step involves calculating the structural dimensions of the groundsill, following the guidelines for construction materials and civil engineering design of groundsills (riverbed control dams) as stated in SE/Menteri of PUPR/2019.

The groundsill dimension design includes a stability analysis against overturning and sliding forces, with safety factors of 17.55 and 2.43, respectively, meeting the required planning standards. The design process also considers aspects such as spillway height, protective floor length, foundation depth, and slope angle, ensuring the structure's stability against various acting forces. Through this method, the study successfully designs a safe and effective groundsill to mitigate riverbed degradation in the Cimanuk River at the Jatitujuh area, Majalengka.

- **Cross-sectional River Measurement Data Collection**

The field measurement data was collected from one segment of the Cimanuk River, located in Panongan Village, Jatitujuh Subdistrict, Majalengka Regency.



Figure 1 Cross Plan Map And Review Location



Figure 2 Bathymetric Measurement Data

Weir Discharge Frequency Analysis

The purpose of analyzing frequency distribution is to predict the magnitude of a specific random variable (Nurzanah et al., 2022).

Statistical Parameter Distribution Test

Table 1 Formulas for Distribution Test Parameters

Parameter Statistic	Sample	Population
Average	$x = \frac{1}{n} \sum_{i=1}^n x_i$	$\mu = E(X) = \int_{-\infty}^{\infty} xf(x)dx$
Standard Deviation	$s = \left[\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2 \right]^{\frac{1}{2}}$	$\sigma = \{E[(x - \mu)^2]\}^{\frac{1}{2}}$
Coefficient Of Variation	$CV = \frac{s}{\bar{x}}$	$CV = \frac{\sigma}{\mu}$
Coefficient Skewness	$G = \frac{n \sum_{i=1}^n (x_i - \bar{x})^3}{(n-1)(n-2)s^3}$	$\gamma = \frac{E[(x - \mu)^3]}{\sigma^3}$
Kurtosis (Ck)	$K = \alpha_4 = \frac{1 \sum_{i=1}^n (X_i - \bar{X})^4}{s^4}$	$K = \alpha_4 = \frac{1 \sum_{i=1}^n (X_i - \mu)^4}{\sigma^4}$

Source: SE Mentri PUPR no 03/SE/M/2019 (SE Menteri PUPR, 2019)

Selection of Distribution Type

Normal

$$SR = \sqrt{\frac{\sum_{i=1}^n (R_i - \bar{R})}{n-1}} \quad (1)$$

R_i = The design discharge value with a return period of T_r years (mm).

\bar{R} = Average discharge value (mm).

SR = Standard Deviation.

K_{T_r} = Frequency Factor for a Specific Return Period.

Log Normal

$$\text{Log } R = \frac{\sum_{i=1}^n \log R_i}{n} \text{KTr} \quad (2)$$

Log R_t = Logarithm value of the design discharge with a return period of T (mm).

Log \bar{R}_i = Logarithm Value of Average Rainfall (mm).

K_{Tr} = Frequency Factor for a Specific Return Period.

Gumbel

$$RT_r = R + K_{T_r} \cdot SR \quad (3)$$

R_i = The design discharge value with a return period of T_r years (mm).

\bar{R} = Average discharge value (mm).

SR = Standard Deviation.

K_{T_r} = Frequency Factor for a Specific Return Period.

Log Pearson III

$$Cs = \frac{n^2 \times \sum_{i=1}^n (Ri - \bar{R})^2}{(n-1)(n-2)(SR^2)} \quad (4)$$

- n = Logarithm of the design discharge value with a return period of T (mm).
- Log \bar{R} = Logarithm of the average discharge value (mm).
- SR = Standard Deviation.
- KTr = Frequency Factor for a Specific Return Period.
- Cs = Coefficient Stewness.

Distribution Fit Test

The goodness-of-fit test uses the chi-square method with the X^2 value, which can be calculated using the following equation.

$$X^2 = \sum_{i=1}^n \frac{(Ri - Ei)^2}{Ei} \quad (5)$$

In which,

- X^2 = Calculated chi-square parameter.
- Ri = Measurement data.
- Ei = Calculated data from the theoretical frequency curve (graph).
- Dk = $K - (p + 1)$.
- Dk = Degrees of freedom.

Flood Discharge Analysis (Rational Method)

Calculating Flow Velocity (V)

$$V = 72 \times (s)^{0.6} \quad (6)$$

Time (t)

$$t = \frac{L}{V} \quad (7)$$

Mononobe Intensity (Rt)

$$Rt = \frac{R24}{24} \times \left(\frac{24}{t}\right)^{0.6667} \quad (8)$$

Runoff Coefficient

Table 2 The relationship between the runoff coefficient and the watershed area

Watershed Condition	Runoff Coefficient
Mountainous and Steep	0.75 – 0.90
Tertiary Mountains	0.70 – 0.80
River with Forested Upper and Lower Sections	0.50 – 0.75
Flat Land with Crops	0.45 – 0.60

Watershed Condition	Runoff Coefficient
Rice Field During Irrigation	0.70 – 0.80
Mountainous River	0.75 – 0.85
Lowland River	0.45 – 0.75

Planned Peak Flood Discharge (Q_p) 100th

$$Q_p = 0,45 \times R_t \times \frac{A}{3,6} \quad (9)$$

Groundsill Dimension Analysis**Spillway Dimensions****Determination of Design Discharge**

$$Q_d = \frac{c}{c-c_d} Q_o \quad (10)$$

Explanation :

C = Sediment Concentration at the Riverbed

C_d = Sediment Concentration in the Flow.Q_o = Maximum Water Discharge (Flood Discharge) (m³/s)Q_d = Design Discharge or Peak Debris Flow Discharge (m³/s)**Determining Flow Depth Over the Weir Crest**

$$Q_d = \frac{2}{15} \cdot C_p \cdot \sqrt{2 \cdot g} \cdot (3 \cdot B + 2 \cdot T) H_1^{\frac{1}{3}} \quad (11)$$

Explanation:

C_p = Weir Coefficient (0,60 – 0,66).g = Acceleration due to Gravity (9.80 m/s²).

B = Width of the Lower Spillway (m).

T = Flow Face Width at Depth h₁ Above the Spillway Crest (m).h₁ = Flow Depth Above the Spillway Crest of the Main Dam (m).Δh₁ = Freeboard Height (m).m_s = Slope of the Spillway Embankment.**Determination of Spillway Crest Thickness**

The thickness of the spillway crest can be practically determined using the table below.

Table 3. Determination of Spillway Crest Thickness

Crest Thickness of Spillway (b)	1,50 – 2,00 m	3,00 – 4,00 m	> 4,00 m
b_1 : For the Main Dam b_2 : For the Sub Dam			
Longitudinal Slope of the Riverbed	< 1/50	> 1/20	If Equipped with an Approach Ramp as an Evacuation Road/Bridge
Sediment	Sand and Gravel or Gravel and Cobble	Large Rocks	
Hydraulic Characteristics of Flow	Independent Movement	Mass Movement	

Source : SE Mentri PUPR no 03/SE/M/2019 (SE Menteri PUPR, 2019)

Main Dam Dimensions

Determination of the Upstream Slope of the Main Dam Body

For the groundsill design with a maximum effective height of 4.00 m, the upstream slope of the main dam body (m) is determined using the following equation.

$$(1 + \alpha)m^2 + \{4\alpha(n + \beta) + n(2 + \delta) + 2\beta\}m = 1 + 3\alpha - \delta(3n\beta + \beta^2 + n^2)$$

$$\alpha = \frac{h_1}{H_m} \quad \beta = \frac{b_1}{H_m} \quad \delta = \frac{\rho_c}{\rho_w} \tag{12}$$

Explanation :

n = The downstream slope of the main dam body (set at 0.20).

m = The upstream slope of the main dam body.

H_m = Total height of the main dam (m).

LW = Jump distance (distance from the downstream edge of the spillway crest) (m).

B1 = Main dam base thickness (m).

b_1 = Main dam spillway crest thickness (m).

ρ_w = Mass density of debris flow (water + sediment) (taken as 1000 - 1200 kg/m³).

ρ_c = Mass density of concrete (taken as 2300 kg/m³).

Protective Floor Dimensions

Determination of Protective Floor Thickness

> Empirical Equation

For the protective floor without a sub-dam:

$$d \geq 0,2 (0,6H + 3h_1 - 1) \tag{13}$$

For the protective floor with a sub-dam:

$$d \geq 0,1 (0,6H + 3h_1 - 1)$$

Determination of the Length of the Protective Floor

> Mathematical Equation

$$L = L_w + X_w + b_2 \quad (14)$$

$$L_w = V_0 \left[\frac{2(H + \frac{1}{2}h_1)}{g} \right]^{0,5} \quad (15)$$

$$q_0 = \frac{Q_d}{B} \quad (16)$$

$$V_0 = \frac{q_0}{h_1} \quad (17)$$

$$X_w = B_j \cdot h_j \quad (18)$$

$$h_j = \frac{h_3}{2} \cdot \left\{ \sqrt{1 + 8 \cdot F_{r3}^2} - 1 \right\} \quad (19)$$

$$h_3 = \frac{q'}{V_3} \quad (20)$$

$$q' = \frac{Q_d}{B'} \quad (21)$$

$$V_3 = \sqrt{2 \cdot g \cdot (H + h_1)} \quad (22)$$

$$F_{r3} = \frac{V_3}{\sqrt{g \cdot h_3}} \quad (23)$$

Explanation :

L = The length of the protective floor (m)

L_w = The drop distance (the distance from the point of drop to the downstream edge of the spillway) (m).

X_w = The length of the water jump (m).

b₂ = The thickness of the spillway crest of the subdam (m).

q₀ = The specific discharge per meter of spillway crest width (m³/s/m) or (m²/s).

q' = The specific discharge per meter of river span at the planned groundsill location (m³/s/m) or (m²/s).

H_s = Height of the subdam (m).

h₂ = The depth of flow above the subdam spillway (m).

h₃ = The flow depth above the protective floor due to velocity V₃ (m).

B' = The average river span between the main dam and subdam (m).

B_j = The plunge coefficient (4.0 – 5.0).

h_j = The hydraulic jump height above the surface of the protection floor (m).

V₀ = The flow velocity above the spillway of the main dam (m/s).

V_3 = The velocity of fall at the waterfall (m/second).

Fr_3 = The Froude number at the flow depth (h_3).

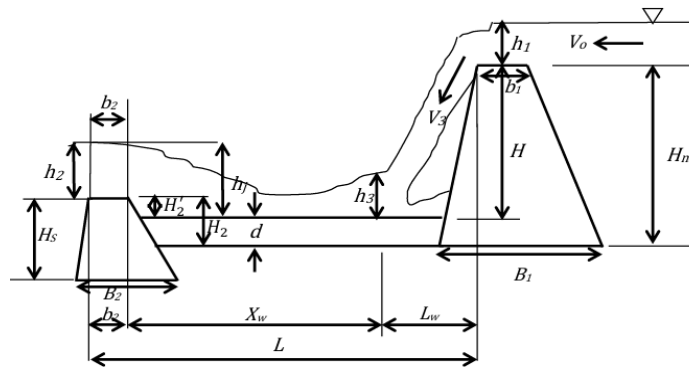


Figure 3 Groundsill Dimensional

Source : JDIH Kementrian PUPR

Sub Dam Dimensions

Determining the Downstream Slope of the Sub Dam

From an aesthetic perspective, the slope of the downstream body of the subdam is determined to be the same as the slope of the downstream body of the main dam, which is $n = 0.20$. This is also intended to prevent large rocks transported by the debris flow and falling from the subdam spillway from directly hitting the downstream body of the subdam and causing abrasion on its surface.

Determining the Sub Dam height

The height of the subdam spillway from the surface of the protective floor can be determined using mathematical equations or empirical equations, as shown in the formula below.

> Mathematical Equation

$$H'_2 = 0,33 (hm - t) \quad (24)$$

Explanation:

hm = Main Dam Height.

t = Thickness of Protective Floor.

> Empirical Equation

$$H'_2 = C_h (H_m - d) \quad (25)$$

or

$$H'_2 = C_H \cdot H \quad (26)$$

Explanation:

$$C_H = \text{The coefficient of the subdam height. } \left[\frac{1}{4} \frac{s}{d} \frac{1}{3} \right] \quad (27)$$

Determining the Foundation Depth

The calculation of foundation depth can be determined using the following formula:

$$h_p = \frac{1}{3}(h_3 + H) \quad (28)$$

Explanation:

h_p = Foundation depth (m).

h_3 = Water height above the crest (m).

H = Weir height (m).

Groundsill stability analysis

Stability Against Rolling

$$SF_{\text{against Overturning}} = \frac{\sum M_v}{\sum M_H} \quad (30)$$

Explanation :

$SF_{\text{against Overturning}}$ = Factor of safety against Overturning.

Shear Stability

$$SF_{\text{Shear}} = \frac{f \sum PV}{\sum PH} \quad (31)$$

$$f = \tan \phi$$

Explanation :

SF_{shear} = Adjusted factor of safety against shear.

f = Adjusted shear coefficient between the foundation of the main dam body and the underlying soil.

ϕ = Shear angle in soil.

RESULTS AND DISCUSSION

Riverbed Morphology Analysis

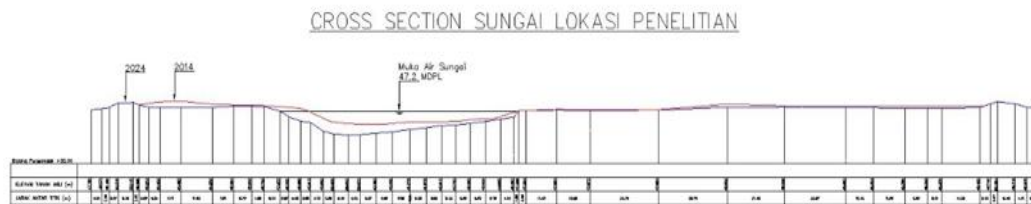


Figure 4 River Cross-Section Data Overlay

At the study site, changes in the riverbed cross-section (riverbed degradation) have occurred due to various factors, one of which is the hydrological behavior of the river and illegal sand mining activities by irresponsible individuals. The changes in the river cross-section were identified by conducting transverse river measurements, combining two research methods: the bathymetric method and the RTK GNSS method. The measurement results from 2024 were then compared with those from 2014.

Barrage Discharge Frequency Analysis

The annual maximum barrage discharge data from Bendung Rentang is processed to determine the discharge frequency for various return periods. The methods used include Normal distribution, Log Normal, Gumbel, and Log Pearson III. Based on distribution tests and statistical parameters, the Log Pearson III method is found to be the most representative for rainfall data in the Cimanuk River Basin.

Table 4 Calculation Results of the Gumbel Method and Normal Method

Data Size (n)	10
Average	116.82
Standard Deviation	2.574164205
Coefficient Stewness (Cs)	-0.660671788
Coefficient Kurtosis (Ck)	3.072021493
Coefficient of Varians (Cv)	0.022035883
3Cv	0.06610765

Table 5 Calculation Results of the Log Normal Method and Log Pearson III Method

Data Size (n)	10
Average	116.8169
Standard Deviation	0.719156506
Coefficient Stewness (Cs)	-20.9453562
Coefficient Kurtosis (Ck)	10.55703152
Coefficient Varians (Cv)	0.00615627
3Cv	0.018468809

Table 6 Distribution Test Requirement Table

No	Method Name	Requlrements	Outcome	Explanation
1	Gumbel	Cs = 1.14	1.14 Cs	-0.66067 Does Not Refresent
		Ck = 5.4	5.4 Ck	3.072021 Does Not Refresent
2	Normal	Cs = 0	0 Cs	-0.66067 Does Not Refresent
		Ck = 3	3 Ck	10.55703 Does Not Refresent
3	Log Pearson	Cs ≠ 0	Cs	-20.9454 Refresent
4	Log Normal	Cs = Cv ³ + 3Cv	2 Cs	0.018469 Does Not Refresent
		Ck = Cv ⁸ + 6Cv ⁶ + 15Cv ⁴ + 16Cv ² + 3	4 Ck	3.000606 Does Not Refresent

Table 7 Calculation of Log Pearson III

No	Year	Rmax (mm)	Ri (mm)	Log Ri	Log (Ri-Rt)	Log (Ri-Rt) ²	Log (Ri-Rt) ³
1	2014	118	119.92538	2.0789111	0.01150	0.000132273	0.000001521
2	2015	112	119.08333	2.075851	0.00844	0.000071248	0.000000601
3	2016	116	119	2.0742842	0.00687	0.000047253	0.000000325
4	2017	118	118.46846	2.0736028	0.00619	0.000038349	0.000000237
5	2018	119	118.10479	2.0722675	0.00486	0.000023594	0.000000115
6	2019	114	117.543	2.0701968	0.00279	0.000007765	0.000000022
7	2020	120	116.01139	2.0645006	-0.00291	0.000008465	-0.000000025
8	2021	119	114.23789	2.0578102	-0.00960	0.000092159	-0.000000885
9	2022	118	113.83597	2.0562795	-0.01113	0.000123890	-0.000001379
10	2023	114	112.30457	2.0503974	-0.01701	0.000289431	-0.000004924
Total				20.67	0.00	0.00	0.000834429
Data Size	n					10	
Average (Rt)	\bar{R}	116.817		2.0674101			
Standard Deviation	Sr	2.574		S log R	0.0096		
Coef. Stewness (Cs)	Cs	-0.661			-0.6832		

Table 8 Analysis Results of the Discharge Frequency Distribution at Bendung Rentang

Planned Weir Discharg				
Frequency Distribution Analysis				
Tr (Year)	Normal	Gumbel	Log Normal	Log Pearson III
100	123	128	123	122.9923
50	122	126	122	122.2615
25	121	124	121	121.4510
10	120	122	120	120.1851
5	119	120	119	118.9603
2	117	116	117	116.5765

Table 9 Distribution Fit Test Results

Distribution Fit Test				
Chi-Square Test				
Calculated χ^2	3.6000	6.8000	6.80000	1.18182
Critical χ^2	3.841	3.841	3.841	3.841
Conclusion	Refresent	Does Not Refresent	Does Not Refresent	Refresent
Smirnov-Kolmograv Test				
Calculated D	0.173066126	0.173066126	0.174204901	0.174204901
Critical D	0.41	0.41	0.41	0.41
Conclusion	Refresent	Refresent	Refresent	Refresent

Flood Discharge Analysis (Rational Method)

R24 (100)	= 122.9923246 mm
Watershed Area (A)	= 3584 km ²
River Length (L)	= 180 km
Difference in Elevation Between Upstream and Study Site	= 1303 m
Average Slope (s)	= 0.007238889 m

The calculation results, based on the river data above, indicate that the flow velocity (V) is 3.74 m/s, the time of concentration (t) is 48.1 hours, the Mononobe intensity (Rt) is 3.22 mm/hour, the runoff coefficient is 0.45, and the highest peak discharge occurs at a 100-year return period with a value of 1,444.28 m³/s.

Groundsill Structure Dimension Planning

Based on hydrological analysis, the researcher recommends the minimum design dimensions for the groundsill structure in accordance with the Circular Letter of the Minister of Public Works and Public Housing Number 03/SE/M/2019 dated January 23, 2019, as follows:

Freeboard Height	= 1,5 m
Main Dam Thickness	= 3 m
Sub Dam Thickness	= 2 m
Main Dam Height	= 3,83 m
Upstream Slope of Main Dam	= 2,51 m
Downstream Slope	= 0,53 m
Protective Floor Thickness	= 0,48 m
Protective Floor Length	= 10,93 m
Sub Dam Height	= 1,10 m
Main Dam Foundation	= 1,66 m
Sub Dam Foundation	= 2,65 m

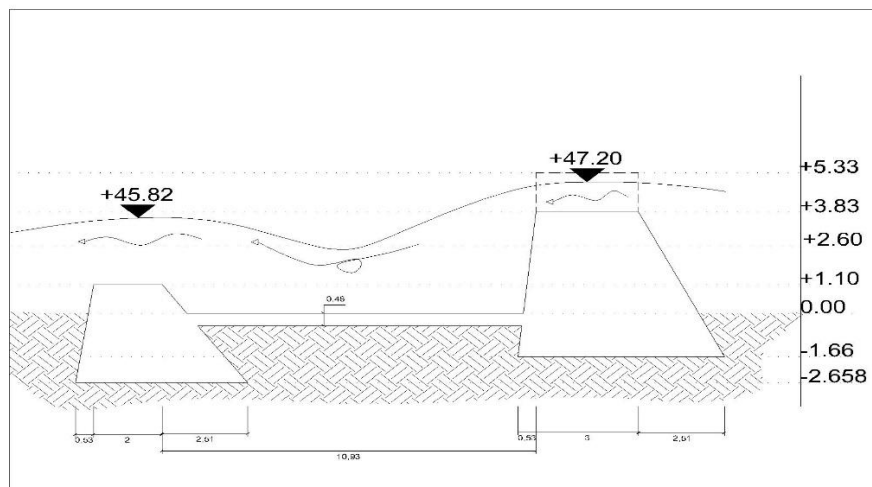


Figure 5 Dimensional Analysis of Grounsill Structure

Analisis Stability Analysis of Groundsill Structure Dimensions

Table 10 Analysis of Acting Forces

		Force (Newton) per m'			Arm (m)	Moment (kNm)
Types Of Forces		Symbol	Force Vaule (kn)			
		1	2	3	4	5
Hydrostatic Force on Vertical Component	Vertical Force Due to the Self-Weight of the Main Dam	W1		96.69	7.91	765.10
		W2		231.37	3.53	816.67
		W3		23.34	1.35	31.59
	Vertical Force Due to Water Pressure	PV1		57.67	11.44	659.54
		PV2		134.54	9.84	1323.26
		PV3		51.66	3.53	182.33
Total Force and Moment Due to Hydrostatic Force on the Vertical Component		ΣPV		595.26	ΣMV	3783.50
Hydrostatic Force on the Vertical Component	Horizontal Force Due to Water Pressure	PH1		88.16	1.27769921	-112.64
		PH2		53.66	1.91654881	-102.84
Total Force and Moment Due to Hydrostatic Force on the Horizontal Component		ΣPH		141.81	ΣMH	-215.47

$$SF_{\text{against Overturning}} = \frac{\Sigma M_v}{\Sigma M_H} = \frac{3783,496}{-215,474} = 17,558 \geq 1,5 \quad OK$$

$$SF_{\text{Shear}} = \frac{f \Sigma PV}{\Sigma PH} = \frac{0,5 \times 595,261}{141,813} = 2,434 \geq 1,5 \quad OK$$

CONCLUSION

The research concluded that the Log Pearson III method is the most suitable for representing river discharge data, with a 100-year return period flood discharge of 1,444.28 m³/s. The designed groundsill, with a main dam height of 3.83 meters and sub dam height of 1.10 meters, meets stability requirements and aims to reduce water flow velocity, prevent riverbed degradation, and maintain structural stability in the Cimanuk River's Rentang Weir area. The study highlights the importance of community involvement in maintaining the groundsill and emphasizes the need for further environmental impact assessments and flow changes analysis. It recommends routine monitoring of the river's condition, adjustment of the groundsill design for climate change scenarios, and active community participation in river management. Future research could focus on the impact of climate change on river discharge, long-term environmental assessments, optimization of the groundsill under

various conditions, economic evaluations, and comparative studies of different riverbed stabilization techniques to improve sustainability and resilience in river management.

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