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Comparison of Manning and Chezy Discharge Analysis Methods on the Primary Irrigation Channel of Lanangga Reservoir, Dompu Regency

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A B S T R A C T

Irrigation is the addition of artificial soil water deficiencies by channeling water needed for plant growth to cultivated land and distributing it systematically. Therefore, it is important to conduct a comparative analysis between the Manning and Chezy methods in the context of the Lanangga primary irrigation channel to determine the most appropriate method. The results of the second analysis showed differences in flow rate (Q) and velocity (V) for Manning Q = 0.572 m3/s and velocity V = 0.487 m/s while Chezy flow rate Q = 0.546 m3/s and velocity V = 0.465 m/s. Factors that cause differences in results where Manning's main parameter is the roughness coefficient (n) while Chezy's main parameter (C) is calculated from n. Roughness Coefficient n and C where Manning's formula directly uses the value of n which is very sensitive to channel surface conditions, vegetation, and shape, while Chezy's formula uses the coefficient C which also depends on R and n, but the form of the relationship is more indirect

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INTRODUCTION

Irrigation is one of the important components in the agricultural system, especially in tropical areas such as Indonesia which have unpredictable seasonal patterns. In the irrigation system, primary channels play a vital role because they function as the main distribution route for water from the source to the secondary and tertiary networks. Therefore, the design and hydraulic analysis of primary channels must be carried out with accurate calculations so that water distribution to agricultural land can run optimally and efficiently.

The Lanangga irrigation channel, located in the Pajo District, Dompu Regency, is one of the primary channels that supports the irrigation system in the area. Problems that often occur in this channel include the discrepancy between the planned discharge and the actual discharge in the field. This can be caused by various factors, including inaccuracy in the method of calculating the channel flow rate. In the study of open channel hydraulics, there are several methods that are commonly used to calculate flow rate, including the Manning method and the Chezy method.

Both of these methods have characteristics and accuracy that depend on channel conditions such as cross-sectional shape, channel wall roughness, and bottom slope. Therefore, it is important to conduct a comparative analysis between the Manning and Chezy methods in the context of the Lanangga primary irrigation canals to determine the most appropriate and representative method for actual conditions in the field.

Water discharge in irrigation channels is very important to increase agricultural productivity. Manning and Chezy methods are two methods commonly used to calculate water discharge. This study aims to analyze water discharge in irrigation channels with both methods; analyzing water discharge in irrigation channels with Manning and Chezy methods, identifying factors that influence differences in water discharge calculation results and determining which is more accurate between the Manning and Chezy methods. So that in planning it can help related parties for the right analysis method.

LITERATURE REVIEW

Flow Rate

Open channels are those used to channel water with the surface cross-section of the flow in contact with atmospheric pressure. These channels can be natural channels such as rivers and ditches, or artificial channels such as irrigation channels, drainage, and canals (Chow, 1959). Several types of open channel cross-sections such as square, trapezoidal, circular and others. Calculation of flow discharge (Q) in the channel cross-section can be calculated using the formula: $Q = V * A$ With: Q = flow discharge (m^3 / s) A = flow cross-sectional area (m^2) V = flow velocity (m / s) Flow velocity can be calculated using various methods, one of which is through empirical formulas such as Manning and Chezy. The hydraulic radius (R) is an important parameter in hydraulics that is used to describe the hydraulic efficiency of the flow cross-section as: Where: A = flow cross-sectional area (m^2) P = wet circumference (m).

Manning's Formula

Manning's formula is used to estimate the velocity of water flow based on various factors, including channel slope, channel surface roughness, and channel geometry. The basic formula for calculating discharge (Q) in an open channel using Manning's equation is:

$Q = 1/n*A*R^{(2/3)}* I^{(1/2)}$

$A = (Bb+m*h)*h$

$P = (Bb+2*h)* \sqrt{(1+m^2)}$

$R = A/P$

$Q = V * A$

Where:

Q = Flow rate (m^3/s)

A = Channel cross-sectional area (m^2)

R = Hydraulic radius (m)

I = Channel slope (mm)

n = Manning's roughness coefficient

This n coefficient is selected based on channel conditions, such as the type of soil or material at the bottom of the channel. The rougher the channel surface, the greater the nnn value, which means the water will flow slower. This formula is useful in the planning and design of open channels, as it allows engineers to estimate the capacity of the channel to handle water flow. The value of the roughness coefficient n is highly dependent on the condition of the channel surface (smooth, rough, rocky, vegetated, etc.).

Chezy's Formula

The basic theory behind Chezy's formula is that the velocity of water flow in an open channel is affected by the roughness of the channel surface and the geometry of the channel itself. This formula is very useful in designing open channels because of its ability to provide accurate estimates of flow velocity and discharge. This formula is very useful in designing open channels because of its ability to provide accurate estimates of flow velocity and discharge.

$V = C*A* \sqrt{(R*S)}$

Where:

V = Water flow velocity (m/s)

C = Chezy coefficient (m/s)

R = Hydraulic radius (m)

S = Channel slope (mm)

A = Channel cross-sectional area (m^2)

METHODOLOGY

This study uses a quantitative approach with a comparative study method to compare the discharge values between the Manning method and the Chezy method based on field data from the Lanangga primary irrigation channel. The steps taken to solve a problem are through the process of data collection and data processing. In order to obtain research certainty, minimize possible errors and obtain research results in accordance with the stated objectives, a research methodology needs to be created. These research stages are steps that must be taken by researchers in carrying out their research. The data and parameters required in this study are, channel base slope (S), roughness coefficient (n) for Manning / (C) for Chezy, Flow cross-sectional area (A), Wet circumference (P).

Research Variables

Independent Variable; channel slope (S), can affect flow discharge, roughness coefficient (n or C), can affect flow discharge, channel width (b), can affect flow discharge, channel depth (h), can affect flow discharge Dependent Variable; Flow rate (Q), flow rate is the variable to be measured or predicted. Control Variables; the type of channel material can affect the roughness coefficient and flow rate, environmental conditions, such as weather and vegetation can affect flow rate

Data Analysis

Calculating the velocity and flow rate using the Manning method is as follows: Calculation Steps

- ✓ Calculating the Cross-Section Area (A)

  A = (Bb+m*h)*h m^2
- ✓ Calculating the Wet Circumference (P)

  P = (Bb+2*h)* √(1+m^2) m
- ✓ Calculating the Hydraulic Radius

  R=A/(P) m
- ✓ Calculating the Velocity (V)

  V=1/n* R^(2/3)* S^(1/2) m/sec
- ✓ Calculating the Flow Rate

  Q=A*V m^3/sec m^3/sec

Determining the coefficient C from the Manning equation

C=1/n*R^(1/6)

- ✓ Calculating the Velocity (V)

  V=C* √(R*S) m/sec
- ✓ Calculating the Flow Rate using the Chezy Equation

  Q = A*V m^3/sec

RESEARCH RESULT

Manning Flow Discharge Calculation

Given the following measurement data in the field:

Bottom width of channel (Bb) = 1.2 m
Top width of channel (Ba) = 3.5 m
Flow depth (h) = 0.5 m
Channel type: Stone masonry
Channel bottom slope (S) = we assume 0.001
Roughness coefficient (n) for stone masonry = 0.030
Channel side slope (m): = 2,3

Because Ba and Bb are known, we can calculate:

$$m = \frac{Ba - Bb}{2 * h} = \frac{3{,}5 - 1{,}2}{2 * 0{,}5} = 2{,}3$$

Calculation Steps

1. Calculating Cross-sectional Area (A)

$A = (Bb + m * h) * h$
$= (1{,}2 + 2{,}3 * 0{,}5)0{,}5$
$= 1{,}175\ m\hat{}2$

2. Calculating Wet Perimeter (P)

$P = (Bb + 2 * h) * \sqrt{1 + m^2}$
$= (1{,}2 + 2 * 0{,}5) * \sqrt{1 + (2{,}3)^2}$
$= (1{,}2 + 1) * \sqrt{1 + 6{,}29}$
$= 1{,}2 + 2{,}51 = 3{,}71\ m$

3. Calculating Hydraulic Radius

$R = \frac{A}{P} = \frac{1{,}175}{3{,}71} = 0{,}317\ m$

4. Calculating Speed (V)

$V = \frac{1}{n} * R^{\frac{2}{3}} * S^{\frac{1}{2}}$
$= \frac{1}{0{,}030} * 0{,}317^{\frac{2}{3}} * 0{,}001^{\frac{1}{2}}$
$= \frac{1}{0{,}030} * 0{,}317^{\frac{2}{3}} * 0{,}001^{\frac{1}{2}}$
$= 33{,}33 * 0{,}464 * 0{,}0316$
$= 0{,}487\ m/det$

5. Calculating the Primary Channel Flow Discharge of Lanangga Reservoir

$Q = A * V\ m^3/det$
$= 1{,}175 * 0{,}487\ m^3/det$
$= 0{,}572\ m^3/det$

Calculating Flow Discharge with Chezy's Formula

Determining the coefficient C from the Manning equation

1. $C = \frac{1}{n} * R^{\frac{1}{6}}$

$= 33{,}33 * 0{,}317^{\frac{1}{6}}$
= 33.33*0.783
= 26.1

2. Calculating Speed (V)

V= C* √(R*S)
= 26.1* √(0.317*0.001)
= 26.1* 0.0178
= 0.465 m/sec

3. Calculating Flow Discharge with Chezy's Equation

Q = A*V m^3/sec
= 1.175 *0.465
= 0.546 m^3/sec

Comparison of Manning and Chezy Methods

Table 1 Comparison of Manning and Chezy Methods

Method	Velocity (V) m/sec	Discharge m3/sec
Manning	0,487	0,572
Chezy	0,465	0,546

Source: Analysis Results

Factors Causing Differences in Manning and Chezy Method Results

Table 2 Differences in Manning and Chezy Method Results

Aspects	Manning Formula Chezy Formula	Chezy Formula
Basic formula	Empirical (based on field observations)	Semi-theoretical (combination of theory and experiment)
Formula	$V = \frac{1}{n} * R^{\frac{2}{3}} * S^{\frac{1}{2}}$	$V = C * \sqrt{R * S}$
Main Parameters	Manning roughness coefficient (n)	) Chezy coefficient (C) (which can be calculated from n)
Roughness Coefficient n and C	Manning's formula directly uses the value of n which is very sensitive to channel surface conditions, vegetation, and shape	Chezy's formula uses the coefficient C which also depends on R and n, but the form of the relationship is more indirect
	Has an exponent value of 2/3	Chezy only uses the root (1/2) of the product of R·S

Source: Analysis Results

Although the coefficient of C value can be calculated from n, the difference in approach makes the discharge (Q) and velocity (V) results can be slightly different. Both formulas use R, but the sensitivity of the formula to the value of R is different. Manning's formula is more suitable for channels with real roughness (eg earth channels, river stone channels). Chezy's formula is often considered more suitable for flow in uniform artificial channels, eg smooth concrete, or used for theoretical approaches.

DISCUSSION

Although the coefficient of C value can be calculated from n, the difference in approach makes the discharge (Q) and velocity (V) results can be slightly different. Both formulas use R, but the sensitivity of the formula to the value of R is different. Manning's formula is more suitable for channels with real roughness (eg earth channels, river stone channels). Chezy's formula is often considered more suitable for flow in uniform artificial channels, eg smooth concrete, or used for theoretical approaches.

CONCLUSIONS AND RECOMMENDATIONS

The results of the analysis of the two methods as in table 1 do show differences in flow rate (Q) and velocity (V) where for Manning Q = 0.572 m3/s and velocity V = 0.487 m/s while Chezy flow rate Q = 0.546 m3/s and velocity V = 0.465 m/s. The factors that cause differences in results where Manning's main parameter is the roughness coefficient (n) while Chezy's main parameter (C) is calculated from n. The Roughness Coefficient n and C are where the Manning formula directly uses the value of n which is very sensitive to channel surface conditions, vegetation, and shape, while the Chezy formula uses the C coefficient which also depends on R and n, but the form of the relationship is more indirect. Further research suggestions in data collection are to carry out direct measurements, related to flow velocity parameters and determining the Chesy coefficient based on channel conditions, not depending on the Manning coefficient.

ADVANCED RESEARCH

This research is certainly not perfect and still has many shortcomings, this is because at the time of measurement, a small flow discharge was carried out affecting the velocity analysis on the channel cross-section, so that future research can analyze the rainfall that enters and is accommodated by the Lanangga Reservoir so that an analysis of the discharge that comes out of the gate can be carried out so that the analysis results are more optimal, for research to continue and improve.

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