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Time and Cost Efficiency of Kedunglarangan River Normalization Using Channel Design Optimization

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Abstract— *Flood often occurs in the downstream of Kedunglarangan River as a result of river's capacity reducing. Some efforts were conducted by normalization in a form of dredging, widening, and the making of river embankments. Physical activity in the field is still running now, but in this study simulation is conducted as scientific study to get design alternative which saves more in time and cost in the implementation. Specifically, the aims of this study are 1) doing hydraulic simulation to get alternative of normalization design with 2 year return periodic plan (Q2) of flood debit to know the river's condition. 2) determining work's volume after applying the design alternative, 3) determining the comparison between cost and time of the implementation based on the volume of normalization work before and after design alternative applied. The result of analysis of the water level profile using HEC-Ras shows that: 1) Alternative design is able to flow the debit with 2 year return period, 2) work volume after normalization design alternative applied for soil excavation using Ponton Excavator at the previous design is 922.402.19 m^3, meanwhile at the alternative design gest 826.577,32 m^3, 3) the amount of time and cost comparison for the implementation of previous normalization design with cost IDR 178,717,842,203.45 can be done in 21 months as the schedule in the contract plan, while using alternative design using cost IDR 163,335,103,433.64 can be done in 19 months.*

Keywords— *Optimization, river normalization, time and cost, HEC-Ras.*

I. INTRODUCTION

Kedungralangan River is passing through Sidoarjo Regency and Pasuruan Regency and empties into Madura strait, East Java. Naturally, the main function of river is to flow water and to lift the sediment as a result of erosion in the watershed and its furrows. Both happens together and affects each other (Masdugi et.al, 2009). The area of Kedunglarangan is 282,67 km2 with the length of the river for 23,7 km. Kedunglarangan river's furrows on its mainstream got big sedimentation because the river's current was blocked by the tide, and it caused flood in every year. Flood control is part of more specific water resource management to control flood debit that is generally through flood control embankment, or to improve carrier system (river, drainage), and to prevent things that potentially can damage by managing the usability and flood area (Kodoatie, 2008).

The effort of flood control conducted was river normalization in the downstream. This normalization was done in the form of: widening and channel excavation, and the embankment making. The length of river furrows normalized was about 7 km. The effect of the tide was quite significant, therefore in the designing of normalization must conduct hydraulic analysis with downstream sea level elevation.

In the existing design, whether it is cross section or long section, river seems still less optimal although it is safe enough from flood. Below is the design's result of long section with HEC-Ras program.

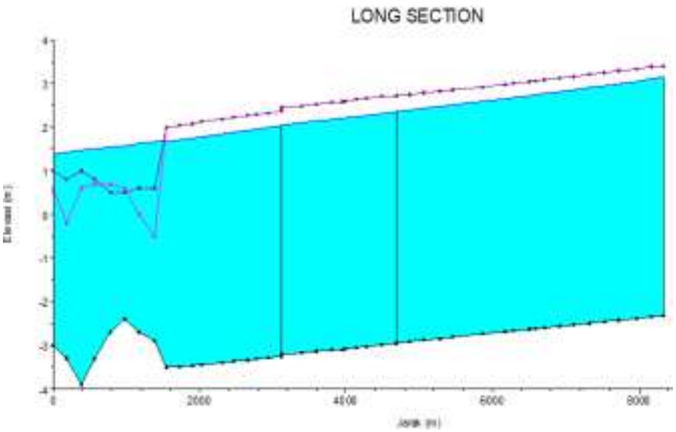

Figure 1.1 Previous Design of Kedunglarangan Long Section

From the picture above, it can be seen that if the data of previous design is applied, it can create hollow or stagnant. In the riverbed of the downstream, base channel elevation was -2.40 m. The impact is the work is done not optimally because it is like temporary pool. Moreover, the condition in which the work is near the sea can cause the river affected by the tide. This condition leads flood plan to significantly rising although the river has a deep bottom.

In this study, redesigning will be done as an alternative by making condition of base river elevation higher to reduce created sedimentation and expected to reduce cost from the implementation of normalization. Both previous design and alternative design are using 2 year return period plan (Q2) of flood debit because the flood intensity is very high. To get the most economic design, this study is using long section simulation using HEC-Ras application. The best design was

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chosen based on economic view and to fill design safety criteria.

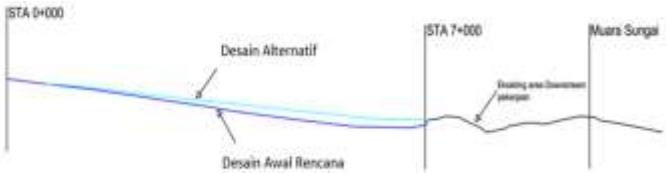

Figure 1.2 Scheme of Riverbed Elevation

This study aims to do hydraulic simulation to get an alternative design of normalization with 2 year return period plan (Q2) of flood debit in order to know the safety condition of the alternative design towards the river. Other than that, the application of this alternative design is expected to reduce the volume of soil excavation work, so the cost and time of normalization can be more optimal and efficient.

II. Literature Review

A. River

A river is a place and container as well as a water flowing network from a spring to an estuary, bounded by a border line (Government Regulation Number 35 Year 1991). The water flow is usually bordered by channels with the bottom and cliffs on the left and right. The river flows continuously from upstream to downstream. From upstream in steep sloping land conditions successively become rather steep, slightly sloping, and relatively flat. Flow is relatively fast in the upstream area and moves slower and slower downstream. Areas around rivers that supply water to rivers are known as catchments or buffer zones. The condition of water supply from buffer zones is influenced by the activities and behavior of its inhabitants (Wardhana, 2001). River as a source of water is one of the natural resources that has a versatile function for life and human life. According to Masduqi, et al (2009) there are two main functions of rivers that are naturally flowing water and lifting eroded sediments in the River Basin and its flow (Self Purification). These two functions occur together and influence each other. Water flow in the open channel that passes through the channel has several conditions, namely free flow, transition flow, and pressure flow. Free flow occurs if the entire length of the channel has not been filled with water or the upstream end of the channel has not sunk. Transition flow, on the other hand, occurs when the upstream water level reaches the upper end of the inlet, where this condition will last until it reaches the maximum water discharge in the channel with a uniform flow state and does not work under pressure (Wulandari, 2019)

B. Flood

Flood is a condition where water is not accommodated in the drainage channel (river) or obstructed the flow of water in the drainage channel (Suripin, 2004). Flood control is part of the management of more specific water resources to control flood discharges generally through flood control dams, or enhancing carrier systems (rivers, drainage) and prevention of potentially damaging things by managing land use and flood areas (Kodoatie , 2008). Flood events in Indonesia are getting more frequent. According to hydrological and hydraulic reviews, the causes of floods include high rainfall falling in the catchment area, drainage clogging, dam bursting or due to the lack of water catchment areas. Besides that, it can also be caused by the high profile of the river water level that exceeds the elevation of the drainage channel, so that the rainwater that should go out through the channel returns and causes inundation in residential areas. A flood can be defined or described as the result of run-off from rainfall quantities that are too enormous. Furthermore flooding in urban areas is a matter that should be avoided because it will cause disruption to public activity (S.Azis, 2016)

C. Hydraulics Analysis

Hydraulics analysis aims to determine the ability of a drainage channel to accommodate the discharge plan. In the design dimensions of the channel of trapezium-shaped must be cultivated to obtain economical To plan the dimensions of the channel, then use the manning formula.

$$Q = \frac{1}{n} R^{2/3} S^{1/2} . A$$

Where : n = hardness coefficient of wall (Manning)
R = hydraulic radius (m)
S = channel bottom slope
Q = discharge (m^3 / sec)
A = sectional area of the channel (m^2)

D. Project Evaluatiaon Stage

Project plans that have been implemented and are still being worked on within a certain time will be evaluated to find out progress, and make the necessary improvements. Evaluation can involve several things including:

- Duration of Work
- Occupation
- Start Date
- Cost

Variations in each of these fields help the contractor to compare and evaluate the progress of the following information:

- Plan
- Schedule
- Actual conditions
- The remaining resources

So the contractor can evaluate whether the budgeted costs can still be adjusted or need to communicate with the capital owner if there are changes that are already outside the budgeted.

III. Research Method

This study is using trials on design alternative; therefore it can get a result that fulfills design safety criteria. It is expected that the chosen design alternative can fulfill the main aim of river normalization that is flood control. It is also expected that cost and time efficiency on the normalization can be gained. From the method used, this study belongs to descriptive research.

The result of this study is expected can be used as a

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reference in a design plan of river normalization that is affected by the tide because the work location is near with estuary. Data analysis will be processed using computer software HEC-Ras.

A. Research Location

This study is conducted in the location between Wrati River and Kedunglarangan River confluence as the first point of normalization work until along 7km to the downstream where this river is flowing through Pasuruan Regency and Sidoarjo Regency. The location of this study can be seen on the picture below.

Figure 3.1 Map of Research Location

B. Data Collection

The collection of primary data on this study was obtained from the previous design, those are: Design Picture, work implementation method, and other supporting data. Meanwhile the secondary data collection was obtained from: rainfall data in Kedunglarangan watershed, work's location characteristics based on local people information, and other supporting secondary data.

C. Data Process and Data Analysis

Based on the process of data collection, the validity of the data obtained is conducted to improve the accuracy from the result of this study later.

After conducting data processing, many trials will be conducted to get a design data that is closest to the aim of this study. Then, it will be compared with the previous design so that the comparison of previous cost and time can be known in detailed about the saving of normalization work using the correct design alternative. The software used in this data analysis is HEC-Ras.

IV. ANALYSIS AND DISCUSSION

A. General Overview of Research

This study got topography survey data with an alternative design that is applied as input data geometry and rainfall data of Kedunglarangan watershed that has been processed to be debit data as input flow data in HEC-Ras application. After getting safety criteria, next it will be analyzed from work's volume, time, and cost.

B. Hydraulic Analysis Using HEC-Ras Application

After conducting data sorting and processing, next is conducting hydraulic analysis using HEC-Ras application as a trial to get the right design alternative.

In this HEC-Ras application, it needs topography data input of normalization work in a form of design coordinates of cross section and long section in one table.

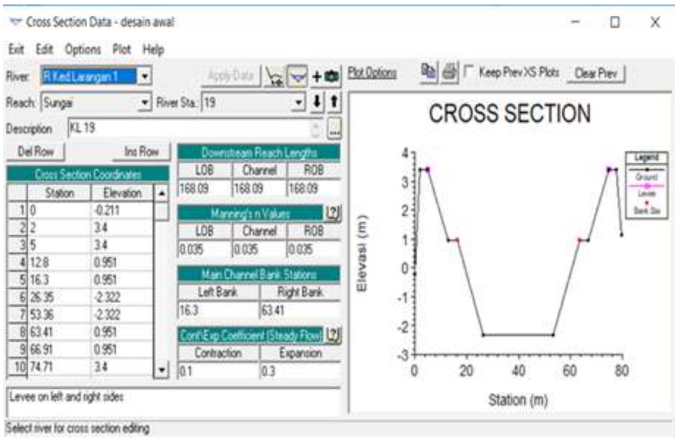

Figure 4.1 Geometry Data Input in HEC-Ras Application

The data of rainfall from all Kedunglarangan watershed system that has been analyzed will be used as debit data as input data and flow data of HEC Ras. In accordance with the aim of this study, it will use 2 year return periodic plan of flood debit (Q2)

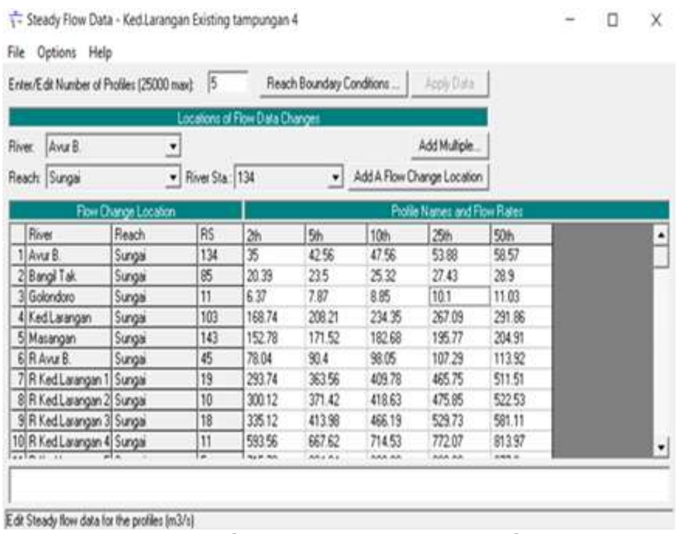

Figure 4.2 Flow Data Input on HEC Ras Application

From overall hydraulic analysis using HEC Ras application, it obtains hydraulic simulation with alternative design as its base. The following is the result of the running program of HEC Ras

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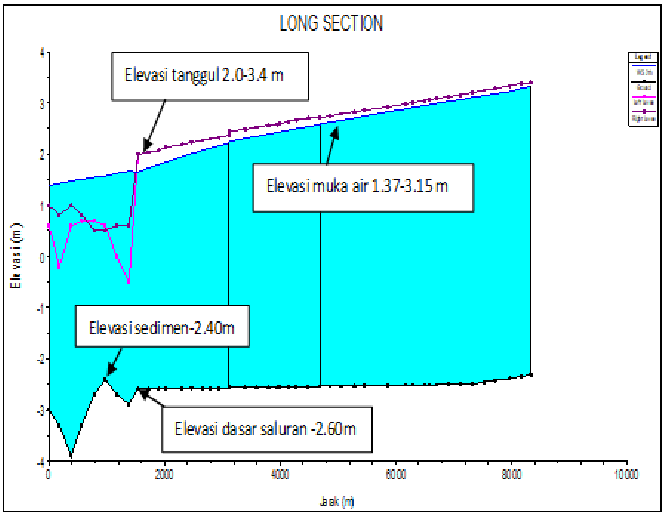

Figure 4.3 Simulation of Hydraulic Alternative Design
The Result of running of HEC-Ras Application

In the previous design in the downstream of channel base elevation, it gets -3.51 m with sediment elevation for -2.40 m in length, with the difference in elevation for 1.1 m, it will have effect on the cross section of the river, and therefore the debit going to flow will be decreased. Meanwhile, in the alternative design in the downstream of the channel base elevation, it gets -2.60 m with the same sediment elevation that is -2.40m, with the different elevation for 0.2 m, the effect of debit decreasing caused by the increasing of the cross section of the river caused by the sediment can be solved, so that the water rise that might be happen in the work field can be solved.

From the second flood handling, the design is safe from the flood and even can solve it. In the first design, the Q2 debit is still under the plan embankment where the water level elevation with Q2 debit is 1.37-3.15 m high, it is lower than the embankment elevation 2.0-3.4 m, and it is the same as in the alternative design of Q2 debit which is also still under the plan embankment where the water level elevation with Q2 debit for 1.37 - 3.15 m high and the embankment elevation is the same for 2,0 - 3.4 m because the design of the embankment is the same, the different between both designs are on their channel base elevations. So, it can be concluded that design alternative is fulfilling the criteria of flood control, so that the design has fulfilled the target of normalization.

C. *Analysis of Volume, Cost and Time of Work*

Based on the result of hydraulic analysis using HEC Ras application, it is stated that the alternative design is fulfilling the safety criteria of a design and the main purpose of normalization, therefore the work's volume, time, and cost can be analyzed by applying that alternative design.

In this study, the major item of the normalization work is soil excavation of the river. The total volume of this soil excavation obtained is 826.577,324 m³. While the total cost of the soil work is IDR 101.802.916.378, 49. This cost is obtained from multiplication between soil work total volumes with the unit price for IDR 123.162,00 per m³.

With the information of the total volume and total cost of soil excavation work, the total time of the soil work can be determined. Based on the result of total time needed, soil excavation volume for 826.577,324 m³ is 19 months.

Based on the work's volume analysis, time and cost, the comparison between the previous design and the alternative one can be matrixed as follows.

TABLE 4.1. The Comparison between the Previous Design and the Alternative Design

No	Comparison	Previous Design (before)	Alternative Design (after)
1	Volume of Soil Excavation Work	922.402,19 m³	826.577,32 m³
2	Cost of Soil Excavation	Rp 113.604.898.154,29	Rp 101.802.916.378,49
3	Cost of All Works	Rp 178.717.842.203,45	Rp 163.335.103.433,64
4	Time of Works	21 months out of 26 months	19 months out of 26 months

Source: Analysis, 2019

V. CONCLUSIONS AND SUGGESTIONS

A. *Conclusions*

In the data processing that has been conducted, it can be concluded that:

a. The condition of Kedunglarangan River as the result of alternative design of normalization simulation with flood debit of 2 year return periodical plan (Q2), it can be stated that it is safe/ fulfilling the aim of flood control that is not overtopping yet above embankment's alternative design.
b. After applying normalization alternative design with flood debit of 2 year return periodical plan (Q2) for soil excavation work with Ponton excavator in the alternative design, the work's volume is obtained 922.402,19 m³.
c. The amount of the work implementation's cost and time comparison based on the normalization work's volume with flood debit of 2 year return periodical plan (Q2) before and after implementing the alternative; the cost needed in the previous design is IDR 113.604.898.154,29 for total cost IDR 178.717.842.203,45, and the processing time is 21 months out of 26 months in total, while the alternative design needs cost of IDR 101.802.916.378,49 from IDR 163.335.103.433,64 in tota, and processing time is 19 months out of 26 months in total.

Based on the comparison above, it can be concluded that the alternative design is effective and efficient because it is faster and cheaper in time and cost compared with the previous design, and the main purpose of the work is fulfilled that is flood control.

B. *Suggestions*

Based on the results of the analysis of this study, it is suggested to the parties involved (policy makers) to:

a. Considering that the normalization of Kedunglarangan River is an effort of channel widening, the boundary of

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land ownership must be considered to expedite the work.

b. Every design can be applied, but it needs to conduct feasibility study and proper study because it supports the process and the result of the river's normalization work a lot.

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