Discharge Fluctuation Effect on Meandering River Bed Evolution

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Abstract. This research was based on some considerations: first discharge fluctuation argued that none rivers with constant discharge and second meandering river bed evolution with considering none of rivers in steady state without bed change. This research developed to get formulation the relationship between fluctuations discharge with the evolution of the bottom of a river considering discharge, parameter rivers and parameter sediment. In the span of daily discharge data 1997-2011 and cross section monitoring annual results 1997-2011 evolution of bottom of a river subjects obtained: Formula 1 is the relationship between discharge fluctuations with rate of sedimentation ($S$) and Formula 2 is the relationship between discharge fluctuations with rate of erosion ($E$). Thus formula have higher prediction accuracy than other published formulas and it is applicable to predict Brantas River bed evolution approximate with the real conditions. Further analysis from the output KUN-QArSHOV formula produces: Erosion equation $\Delta S = 25.167 \times e^{0.0034 \Delta Q}$, on constant discharge, sedimentation value occur is $25.167 \times 10^{-5}$ meter. Sedimentation equation $\Delta E = 8.3455 \times e^{0.0075 \Delta Q}$, on constant discharge, erosion value occur is $8.3455 \times 10^{-5}$ meter. Critical point between sedimentation and erosion happened on discharge between $269 \text{ m}^3/\text{second}$ and $270 \text{ m}^3/\text{second}$.

1. Introduction

No constant discharge in the real river conditions. In the notes of discharge rivers resulting from automatic water level recorder (AWLR), river discharge is always changing. It means there are always fluctuations in discharge in all the time. Erosion and sedimentation in the river depend on the discharge in the river. Thus discharge fluctuations will have an influence to the formation and change the bottom of a river.
erosion and sedimentation quantities analysed based on the discharge quantity $Q$ that happen all the time. Thus obtained change of bottom vertical ($\Delta V$) and horizontal ($\Delta H$) in any change of discharge ($\Delta Q$).

$$\Delta V = \Delta Q \cdot T$$

Where:
- $y =$ river depth (feet)
- $x =$ abscise (feet)
- $D =$ hydraulic depth (feet)
- $r_o =$ outer arc radius (feet)
- $K = 17.52$ (Chow, 1959)

Figure 1. The form of river cross section in arch condition.

3. Meandering River Evolution and Method for Predicting Scouring and Sedimentation in Meandering River

3.1. Meandering River Evolution

Meander evolution depends on initial geometric condition and upstream meanders that was reviewed. Thus can be estimated the movement of meanders evolution direction [4], some possible direction of meander evolution as shown in Figure 2. [6],[7],[9].

Type A describe evolution meanders with low amplitude with the rate of evolution of sluggish. Type B is meander evolution that occurs along flood plains in the narrow flow of river. Type C is meander evolution that occurs in unstable levee of the river. Type D occurs in highly meandering stream, when the meandering bend becomes too large, secondary meanders were created along the existing loop. Type E is quite similar to Mode D, but cut off is expected in this type. Type F and G were occurred along locally braided sinuous or meandering stream. [8],[10].
3.2. Predicting Scouring and Sedimentation in Meandering River

Erosion in toe of bank of the river cause sliding and other process in the river [17], these can be harmful to the river bank and hydraulic structure near closely with the river. Figure 2 shows the type of meander loop evolution [3].

Figure 3. Meandering River bed evolution [12].

3.2. Predicting Scouring and Sedimentation in Meandering River

Erosion and sedimentation in meandering river position are illustrated in Figure 3. Then predicted by Kun-Qarshov equation [14], [15], [16].

4. Study Area and Data Collection

4.1. Meandering and Geometry of Brantas River

Plan form of Brantas River look from Google Earth shown in Figure 4. And cross section in two points of observation show in Figure 5 and Figure 6.
Figure 4. Two points of observation in Meandering of Brantas River.

[Image of the river with research stations labeled]

Figure 5. Cross Section of the river in Research Point 1.
4.2. River Meander parameter

River meander parameter on research point 1 and point 2 were explained in Table 1.

| Research Station | River Meander Parameter |  |
|-----------------|-------------------------|---|
|                 | $r_c$ (m) | $\lambda$ (m) | $a$ (m) | $\theta$ ($^\circ$) | $\phi$ | $W$ (m) |
| 1               | 490       | 1900           | 395     | 41          | 120     | 292     |
| 2               | 1462      | 1809           | 261     | 8           | 61      | 179     |

4.3. Discharge Fluctuation of Brantas River

Discharge fluctuation in Brantas River from automatic water level recorded nearby research station 1 is arranged in Figure 7 to Figure 10.
Figure 8. Discharge fluctuation 1997-2001.

Figure 9. Discharge fluctuation 2002-2006.
5. Result of river bed evolution from KUN-QArSHOV simulation methods

The result of river bed evolution by KUN-QArSHOV simulation in research station 1 output from KUN-QArSHOV simulation is the relationship chart between $\delta Q$ with $\Delta H$ and $\Delta V$. The relationship chart between $\Delta Q$ with $\Delta H$ and $\Delta V$ for research station 1 can be examined in Figure 11 to Figure 15.

Figure 10. Discharge fluctuation 2002-2010.

Figure 11. Discharge Fluctuation Effect on the Meandering River Bed Evolution in Research station 1 along 1992 to 1996.
Figure 12. Discharge Fluctuation Effect on the Meandering River Bed Evolution in Research station 1 along 1997-2001.

Figure 13. Discharge Fluctuation Effect on the Meandering River Bed Evolution in Research station 1 along 2002-2005.
5.2. The results of river bed evolution by KUN-QARSHOV simulation in research station 2

The relationship curve between $\Delta Q$ with $\Delta h$ and $\Delta v$ for research station 2 can be examined in Figure 15 to 19.
Figure 16. Discharge fluctuation effect on the meandering river bed evolution in research station 2 along 1992 to 1996.

Figure 17. Discharge fluctuation effect on the meandering river bed evolution in research station 2 along 1997-2001.
Figure 18. Discharge fluctuation effect on the meandering river bed evolution in Research station 2 along 2002-2007.

Figure 19. Discharge fluctuation effect on the meandering river bed evolution in Research station 2 along 2008 to 2011.
6. Discharge fluctuation and meandering river evolution relationship

6.1 River bed sedimentation in river evolution

The analysis results are shown in Figure 20.

Relationship between ∆Q with ∆S.

6.2 River bed erosion in river evolution

The analysis results are shown in Figure 20.

Relationship between ∆Q with ∆E.
### 6.3 Simultaneous Erosion and Sedimentation in River Meandering Evolution

Evolution of the bottom of meandering river is the difference between sedimentation value and erosion value in the same discharge and the right time.

**Table 2.** Simultaneous Erosion and Sedimentation in River Meandering Evolution

| AQ (m³/second) | Sedimentation (10⁻⁵ m) | Erosion (10⁻⁵ m) |
|----------------|------------------------|------------------|
| 267            | 62.39                  | 61.82            |
| 268            | 62.60                  | 62.29            |
| 269            | 62.81                  | 62.75            |
| 270            | 63.03                  | 63.23            |
| 271            | 63.24                  | 63.70            |
| 272            | 63.46                  | 64.18            |
| 273            | 63.67                  | 64.67            |
6.4 Result of river bed evolution in research station 1

6.5 Result of river bed evolution in research station 2
7. Conclusions

- Critical point between sedimentation and erosion happened on discharge between 269 m$^3$/second and 270 m$^3$/second.

- Erosion equation \[
\Delta S = 25,167e^{0.0034\Delta Q}\]
- On constant discharge, sedimentation value was $25.167 \times 10^{-5}$ meter.

- Sedimentation equation \[
\Delta E = 8,345.5e^{0.0075\Delta Q}\]
- On constant discharge, erosion value was $8.3455 \times 10^{-5}$ meter.

8. Advice

- Needed annual cross section measurement in similar points to synchronize data from Perum Jasa Tirta I measurements to measurement data that will be input in next research.

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10. References

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