

Analysis of Scour at the Komering River Bend Due to Secondary Flow

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Abstract

This research aims to determine the relationship between scour depth (dq) and sediment capacity (qs) at river or channel bends resulting from secondary flow.

Laboratory modeling is intended to calibrate or compare numerical calculation results against a fixed-bed baseline.

The study results show that there is a strong correlation between scour depth (qd) and sediment capacity (qs) at river or channel bends due to secondary currents. For discharge Q_5 , the coefficient of determination is $R^2 = 0.8699$; for Q_{10} , $R^2 = 0.8839$; and for Q_{25} , $R^2 = 0.9065$. The correlation coefficients (R) are 0.7567 for Q_5 , 0.7813 for Q_{10} , and 0.8217 for Q_{25} . This indicates that the model explains 86.99%–90.65% of the data variation, demonstrating a strong correlation between qd and qs .

Keywords: Scale model, scour depth, sediment capacity, coefficient of determination, correlation coefficients

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I. INTRODUCTION

Geographically, East Ogan Komering Ulu (OKU Timur) Regency is situated between 103°40'–104°33' East Longitude and 3°45'–4°55' South Latitude. In accordance with Law Number 37 of 2003, the regency covers an area of 3,370 km², the majority of which consists of lowlands and generally flat terrain, with the exception of the Martapura District and its surrounding areas, which tend to be hilly. (OKUT in Figures, 2017)

The Komering Sub-Watershed is one of the priority sub-watersheds that requires immediate treatment, because in line with the development of society in the Komering River Watershed (DAS) area, various living arrangements are changing rapidly following the various needs of the community.

The pressure of the Komering River's flow is causing progressive erosion of the riverbanks, specifically affecting the areas bordering residential settlements in Sabah Lioh Village, Bunga Mayang District, East OKU Regency, South Sumatra Province.

In Sabah Lioh Village, Bunga Mayang District, East OKU Regency, the land along the riverbanks has been continuously eroded by the water. This erosion threatens local settlements and a provincial road with landslides; homes in Hamlets 1, 3, and 4—situated near the Komering River—are at risk of collapsing and being swept away should the river overflow.

The East OKU Regional Disaster Management Agency (BPBD) is coordinating with irrigation authorities in the neighboring regency of South OKU to continuously monitor river discharge levels and determine the appropriate alert status. "This includes placing personnel on standby and establishing disaster response posts in flood-prone areas so that natural disasters can be addressed as early as possible," he said. He noted that several areas in East OKU Regency have been identified as flood-prone, including the villages of Tanjung Kemala Barat (Kampung Sawah) and Tanjung Aman in Martapura District, as well as Kurungan Nyawa Village in BP Bangsa Raja District.

Additionally, areas identified as flood-prone include Mendayun and Rasuan villages in Madang Suku I District; Kota Negara and Riang Bandung villages in Madang Suku II District; and Kangkung, Suka Negeri, and Minanga Besar villages in Semendawai Barat District; meanwhile, all villages in Cempaka District are mapped as flood-prone. "These areas are mapped as prone to flooding during heavy, prolonged rainfall due to their low-lying terrain and proximity to watersheds" (BPBD OKUT, 2023).

Flooding is a serious issue affecting various urban and rural areas in Indonesia. These floods are not caused solely by natural factors but result from uncontrolled changes in land use that disregard the sustainability of the watershed from its headwaters to its downstream reaches. According to Suripin (2004), flood control efforts must address not only surface flow but also runoff; the rate and volume of runoff are influenced by the distribution and intensity of rainfall across the entire watershed.

In hydrology, rainfall is a crucial input component of the hydrological process. Analyzing rainfall data within the context of hydrological planning serves as a method for estimating flood discharge magnitudes within a watershed. This estimation approach is employed when the watershed in question lacks an Automatic Water Level Recorder (AWLR). To determine a rainfall value that accurately represents the actual precipitation depth across the entire watershed, a sufficient number of rainfall stations are required to represent the rainfall characteristics of that area.

Physical modeling involves replicating the issues present in a prototype at a smaller scale, executed using appropriate methods. To conduct this modeling, researchers must possess sufficient knowledge to identify the phenomena inherent in the problem at hand. This ensures that the resulting model is useful and that the findings derived from the research can be effectively interpreted back to the prototype.

II. MATERIAL AND METHODS

This research will be conducted at the Hydraulics Laboratory of Bina Darma University, Palembang, using a model scale as shown in Figure 1.

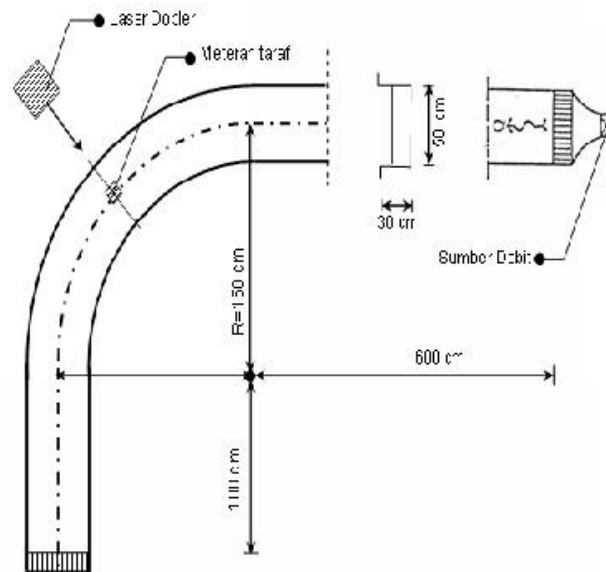


Figure 1: Flow scale model

2.1 Laboratory Modeling

Laboratory modeling is intended to calibrate or compare numerical calculation results against a fixed-bed baseline. The experimental equipment and procedures are as follows:

1. A rectangular channel (50 cm wide, 30 cm high) with a 90° bend; the straight sections are made of glass, while the bend section is made of fiberglass.
2. A point gauge for measuring water surface elevation. Water levels are measured during the simulation run across the transverse direction of the channel at the bend.
3. A stopwatch, used to measure the time required to collect the flow discharge at the channel outlet. For this purpose, the water discharge is collected, and both the collection time and volume are measured. Based on the time and volume data, the average flow velocity in the channel can be determined.
4. Laser Doppler (a laser-based flow velocity measuring instrument) and a current meter, used to measure flow velocity distribution (vertically and horizontally) in both the straight sections and the bend. These instruments are movable, allowing for the measurement of vertical velocity distribution, particularly at the channel bend.

5. Water source (pump). Water discharge is supplied by a previously calibrated pump. Simulation runs are conducted using various discharge rates.

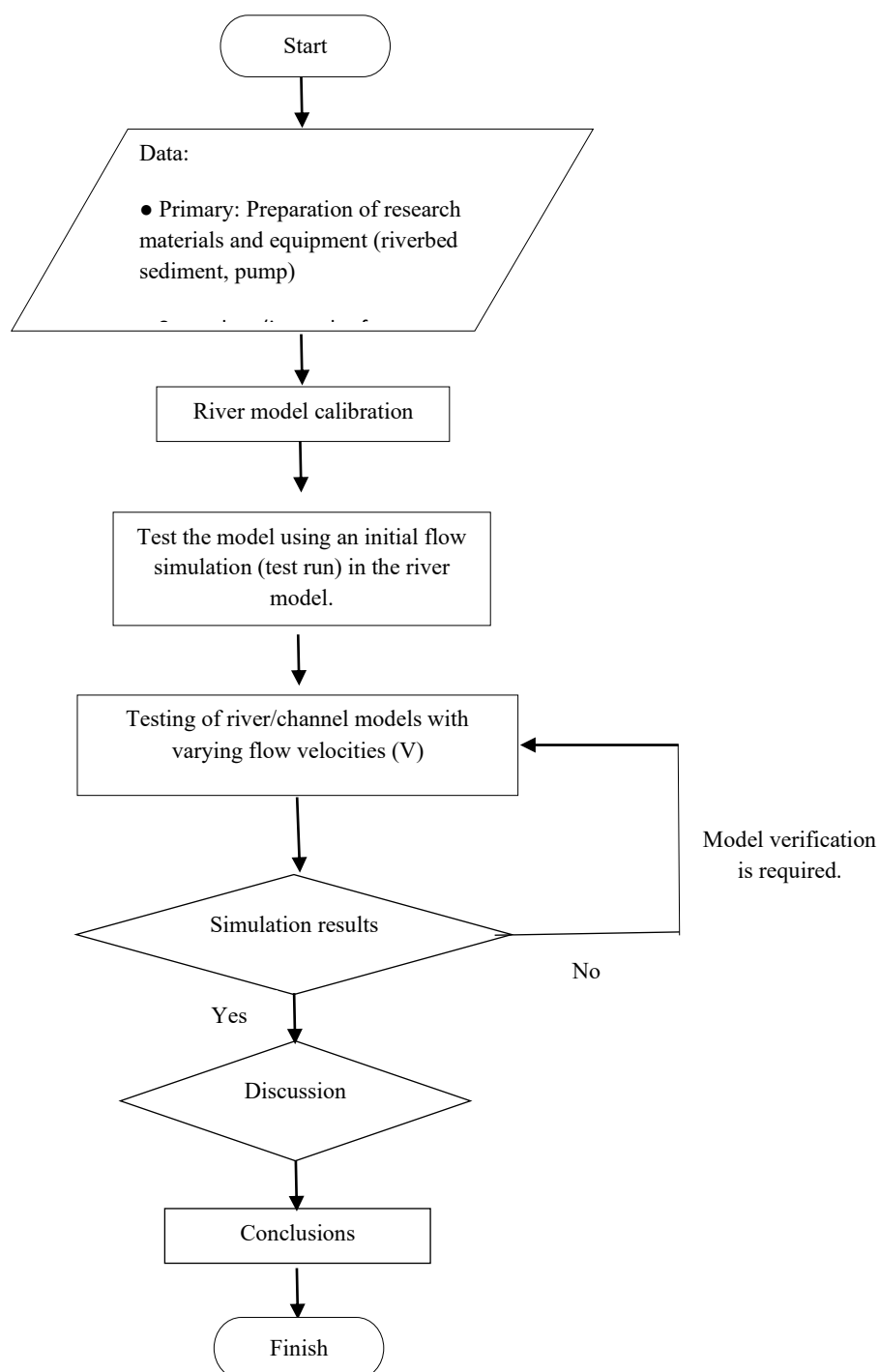


Figure 3.Flowchart

III. RESULTS AND DISCUSSION

3.1 Scale Model Analysis

The dimensional analysis in this study employs Langhaar's method; this approach is considered more suitable because it involves relatively few parameters and is typically used for relatively simple problems. Dimensionless numbers are derived directly from the relationships between the existing parameters. However, this method would encounter difficulties in complex problems involving a large number of parameters.

$$q_s = f(Q, v, h, \rho_w, g, t) \quad (1)$$

The steps for the dimensional analysis are as follows:

1. The problem formulation identifies the parameters influencing sedimentation (bedload) as follows: flow discharge (Q), flow distance (x), water depth (h), sediment capacity (qd), gravity (g), water density (ρ_w), and time (t).

2. These parameters are categorized as follows:

- Dependent parameter: q_s
- Parameters that vary during the experiment: Q, x, qd, h, and t
- Another parameter: g and ρ

3.2. Graph showing the effect of secondary current on the scour pattern

3.2.1. Graph of the relationship between (q_s/t) and (q_d/t) with $Q_5 = 0.134 \text{ m}^3/\text{s}$

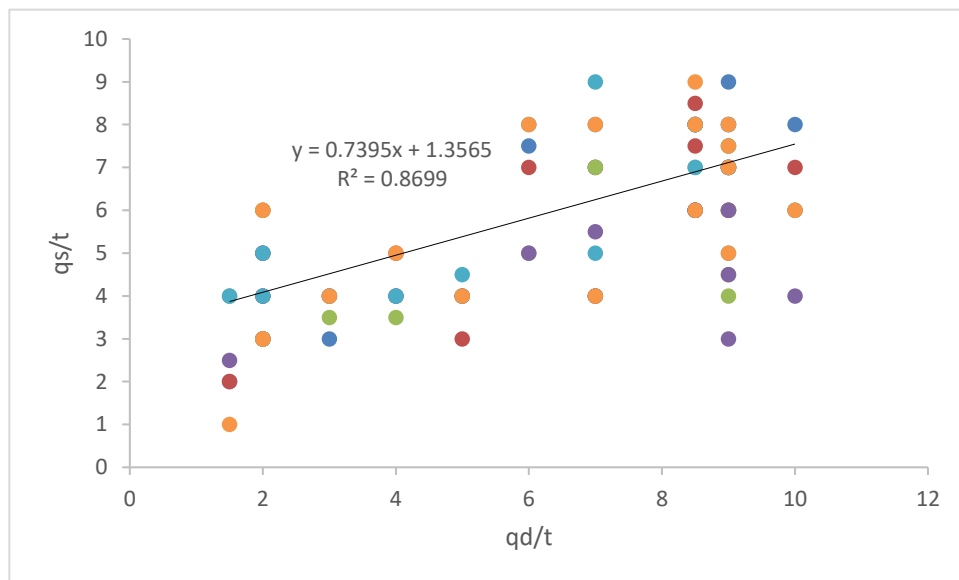


Figure 4: Sediment (bed load) movement pattern $Q_5 = 0.134 \text{ m}^3/\text{s}$

Figure 4. illustrates the sediment transport pattern associated with a 5-year return period discharge (Q_5). The model yields a coefficient of determination (R^2) of 0.8699—indicating that 86.99% of the data variation is explained by the model—and a correlation coefficient (R) of 0.75673 (75.67%). This signifies a strong relationship between bed load sediment transport (q_s) and the 5-year return period discharge (q_d)₅ at the river or channel bend.

3.2.2 Graph showing the relationship between (qs/t) and (qd/t) with $Q_{10} = 0.154 \text{ m}^3/\text{s}$.

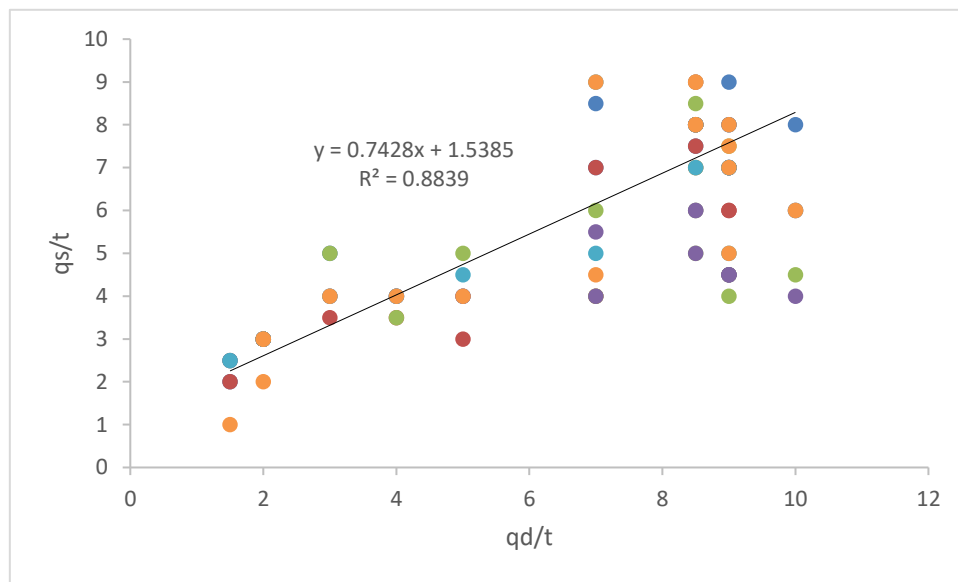


Figure 5: Sediment (bed load) movement pattern $Q_{10} = 0.154 \text{ m}^3/\text{s}$

For a discharge of $Q_{10} = 0.154 \text{ m}^3/\text{s}$ —as shown in Figure 5—the model of sediment movement for the 10-year return period (Q_{10}) yields a coefficient of determination (R^2) of 0.8839, meaning 88.39% of the data variation is explained by the model; additionally, the correlation coefficient (R) is 0.7813 (or 78.13%), indicating a strong relationship between bed load sediment movement (q_s) and the discharge (q_d)₁₀ at the river or channel bend.

3.2.3 Graph of the relationship between (qs/t) and (qd/t) with $Q_{25} = 0.180 \text{ m}^3/\text{sec}$

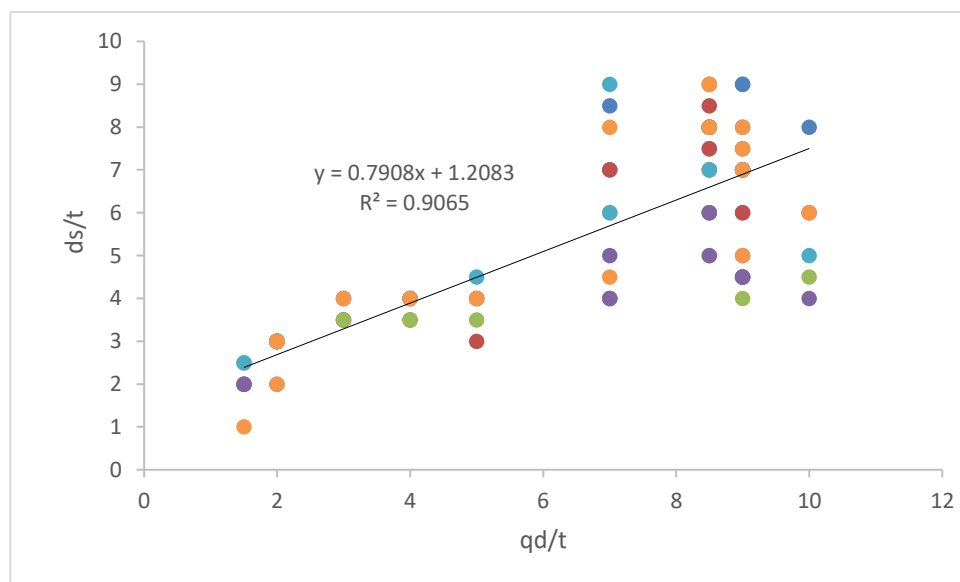


Figure 6: Graph of the relationship between (qs/t) and (qd/t) with $Q_{25} = 0.180 \text{ m}^3/\text{sec}$

Based on the analysis results shown in Figure 6—where a discharge of $Q_{25} = 0.180 \text{ m}^3/\text{sec}$ was used—the coefficient of determination (R^2) is 0.9065, meaning 90.65% of the data variation can be explained by the model; with a correlation coefficient (R) of 0.82174 (or 82.17%), there is a strong relationship between the sediment transport variable (q_s) and the flow discharge (q_d).

IV. CONCLUSION

Based on the data analysis and discussion, the conclusions of this study are there is a strong correlation between scour depth (qd) and sediment capacity (qs) at river or channel bends due to secondary currents. For discharge Q_5 , the coefficient of determination is $R^2 = 0.8699$; for Q_{10} , $R^2 = 0.8839$; and for Q_{25} , $R^2 = 0.9065$. The correlation coefficients (R) are 0.7567 for Q_5 , 0.7813 for Q_{10} , and 0.8217 for Q_{25} . This indicates that the model explains 86.99%–90.65% of the data variation, demonstrating a strong correlation between qd and qs.

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