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Study of suspended sediment transport discharge of Serayu River, Central Java, Indonesia in laboratory

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Abstract. Sedimentation is a natural phenomena that occurs in rivers in Indonesia, including Serayu River in Central of Java, Indonesia. The sedimentation will result in siltation on the riverbed that reducing river function. Suspended load is one of the main factor that cause of sedimentation, therefore research is needed to to determine the amount of sedimentation. knowledge about suspended sediment transport has been developed by several experts in the water sector. This research is done by creating a simulation of the flow of water so that made a susoended load drift. This research was done by using the sediment that pass sieve No.200. The result from the research is knowing the correlation between water discharge and suspended sediment discharge. The result from laboratory then will be compared with Enstein's; Chang, Simon and Richardson's; and Lane and Kalinske's approach.

1. Background

River is one part of public waters and is a natural channel that carries water from upstream to downstream. Indonesia itself has 5,590 main rivers, one of which is Serayu River. Serayu River is one of the largest rivers in Java Island which is located in Central Java Province which crosses several districts, such as Wonosobo, Banjarnegara, Purbalingga, Banyumas and Cilacap Regencies. The length of the main river reaches 180km with 11 tributaries.

Because the flow rate is large, of course, the Serayu River not only flows water, but the flow also carries various particles with water flow. The particles carried by the flow of water are the result of eroded soil and then undergo sedimentation in several parts of the Serayu River. Most of the results of erosion will settle in the estuary area in the form of mud and sand.

In the process of transporting sediment due to the flow of the river will be divided into two types of sediment transport, basic sediment transport (bed load transport) and transport of floating sediments (suspended load transport). The amount of sediment transported due to river water flow is determined by flow velocity. Apart from being influenced by flow velocity, the transport of floating sediments (Suspended Load Transport) is also influenced by the length of the river, the slope of the riverbed, the cross-sectional area, the depth of the river and several other parameters that influence the transport process of sedimentation.

Suspended load is a particle that moves in a vortex of flow that tends to continue to float along the flow. Loads of flying sediments move along with river water flow, consisting of fine sand which is

always supported by water, and has very little interaction with the river bed because it has been pushed up by flow turbulence.

The material used in the study was taken from the Serayu River estuary :

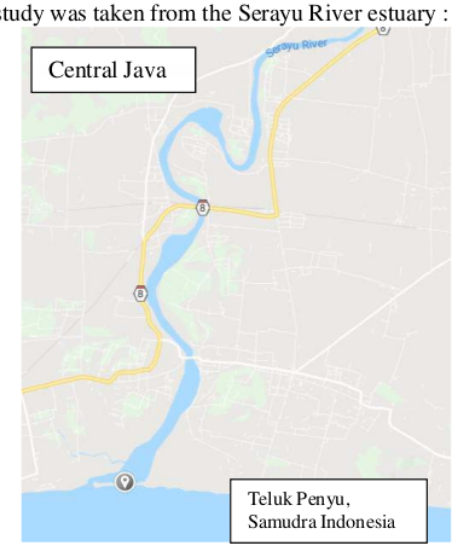

Figure 1. Sample Taken Location

2. Theory

There are several factors that can influence the sedimentation process, namely, the size and shape of sediment-forming materials, sediment loads, and changes in the speed of water flow. These things will greatly affect the sedimentation process itself. If there is a change from several factors above, it is normal to change from the channel channel shape which will adjust from slope, depth, thickness, pattern, layer composition and vegetation around the channel.

There are several general techniques for determining grain size gradations, namely (I) direct measurement with macros or microscopes, (II) using sieve analysis, and (III) with Hydrometer. Filter analysis is used to determine the size of the grain from a rather large to fine sand. To determine the diameter of granules such as silt and clay, the Hydrometer method must be used to determine the diameter size of the dominating sample.

The result of the research will be compared with three expert approach that develop studies in suspended load transport, as follow :

- Einstein's (1950)

  Einstein is assumed that β = 1 and k = 0.4. Einstein approach is based by shear velocitu and grain roughness or grain zise of the suspended load. The equation of Einstein approach :

$$q_{sw} = 11.6\, U^{*} C_a a \left\{ \left[2.303 \log \frac{3.02D}{\Delta} \right] I_1 + I_2 \right\} \quad (1)$$

where:

q_{sw} = Suspended load transport discharge
U* = U'* = Shear velocity
Ca = Concentration by dry weight
a = Thickness of bedload in the riverbed
D = Depth of water
I_1, I_2= Numeric Intregrity from **Figure 3.** and **Figure 4.**

Δ = Sediment size x (correction factor on **Figure 2.**)

$Z = \frac{\omega}{0.4\, U'^*}$

ω = Fall velocity

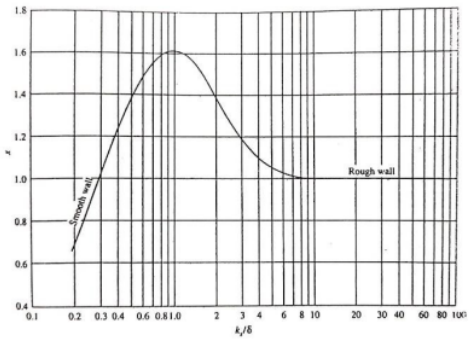

Figure 2. Correction Factor (Yang, 1996)

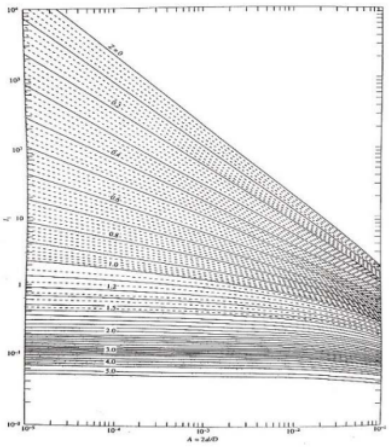

Figure 3. I_1 (Yang, 1996)

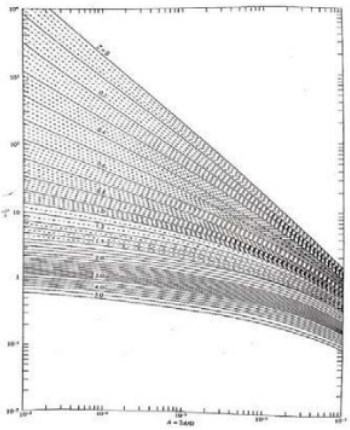

Figure 4. I_2 (Yang, 1996)

- Lane and Kalinske's (1941)
  Lane and Kalinske assumed that $\beta = 1$ and $\varepsilon_s = \varepsilon_m$, and the Lane and Kalinske approach is as follow as :

$$q_{sw}=q\,C_a\,P_L\exp\left(\frac{15\,\omega a}{U^*D}\right) \quad (2)$$

Where :

qsw = Suspended load transport discharge
Ca = Concentration by dry weight
PL = Coefficient Relative With ω and U* from **Figure 5.**
= Fall velocity according by dominant sediment size
U* = Shear velocity
D = Depth of water

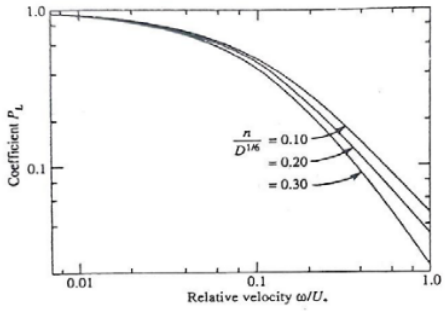

Figure 5. PL Coefficient Relative With ω and U*(Yang, 1996)

- Chang, Simon and Richardson's (1965)
The Chang, Simon and Richardson approach is based by measured in weight per unit volume of water-sedimen mixture. The Chang, Simon, and Richardson approach is follow as:

$$q_{sw}=DC_a\left(V\,I_1-\frac{2\,U^*}{k}I_2\right) \quad (3)$$

Where :
D = Depth of water
Ca = Concentration by dry weight
V = Water velocity
I_1 & I_2 = From **Figure 6.** And **Figure 7.**
U* = Shear velocity
k = konstanta Von Karman (0,4)
Z_2 $=\frac{2\omega}{\beta U^*k}$
ξa $=\frac{a}{D}$

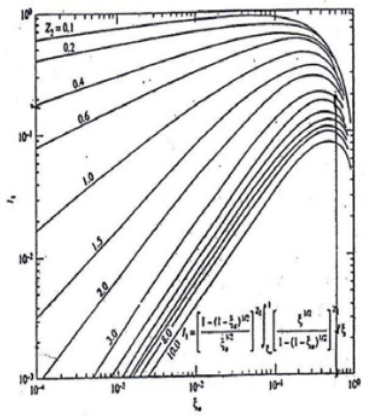

Figure 6. I_1 Base on ξa and Z_2 (Yang, 1996)

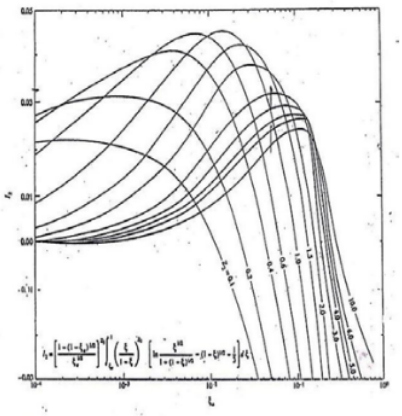

Figure 7. I_2 Base on ξa and Z_2 (Yang, 1996)

3. Research Methodology

The step taken in this research is as follow :

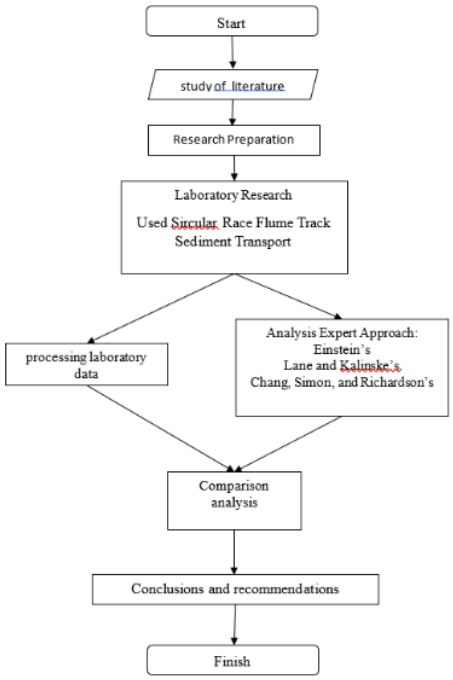

Figure 8. Research Flowchart

4. Results

This research was done by using the sediment that pass sieve No.200. The specific sediment size is used determine with Hydrometer test. From hydrometer test ,the most particle size is the most dominance is ⌀ = 0,0321 mm with percent retained is 17,66%. Hydrometer test result is as follow :

Table 1. Hydrometer Test

Particle Diameter (mm)	Percent Retained (%)
0.0321	17.66
0.0254	10.88
0.0221	7.25
0.0201	7.25
0.0155	12.69
0.0118	7.25
0.0087	7.25
0.0062	3.63
0.0050	1.26
0.0045	0.55
0.0032	1.81
0.0023	1.81
0.0013	1.81

After determine the particle size, the research will Compared the water discharge with suspended sediment transport discharge between Laboratory result and expert approach (Enstein's; Chang, Simon and Richardson's; and Lane and Kalinske's approach).

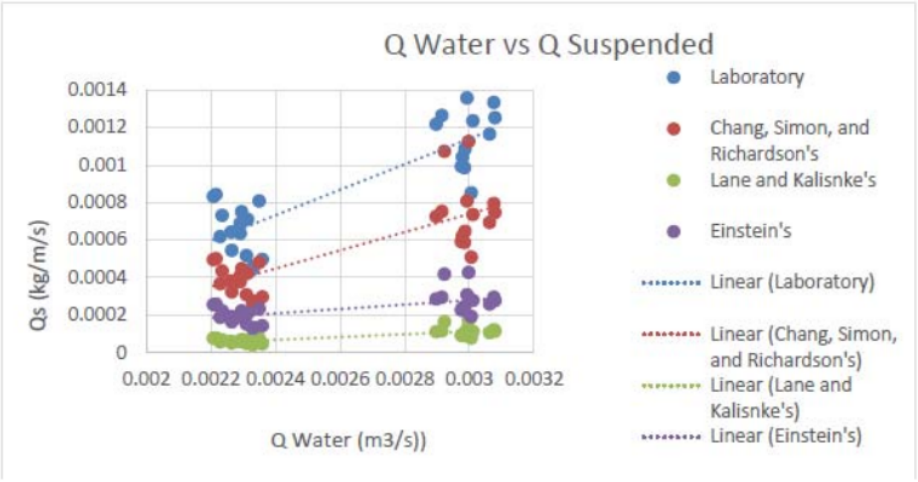

Figure 9. Q Water Against Q Suspended Load Transport

From the Figure 9. the bigger Q water, the bigger too Q suspended load transport from the result of Laboratory research and from the equation approach. the biggest results are the results of laboratory research and the lowest is from Lane and Kalinske's equation. the results closest to the lab results are the results from Chang, Simon and Richardson's approach. The main factor of all result is the water

velocity, because the bigger water velocity it will bring more the particle of suspended sediment. The result of Chang, Simon and Richardson's equation approach is the closest to Laboratory research result, so it more suitable to used compared with another equation approach.

To get the equation that is more suitable for the condition of the Serayu river, more research is needed to obtain the specific equations for the river Serayu and also requires deep learning of sedimentary material, both from soil type and chemical properties.

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