

STUDY OF SEDIMENT TRANSPORT DISCHARGES OF CITARUM RIVER, WEST JAVA IN LABORATORY

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STUDY OF SEDIMENT TRANSPORT DISCHARGES OF CITARUM RIVER, WEST JAVA IN LABORATORY

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Abstract. Citarum River is one of the longest and largest rivers in Indonesia located in West Java with a length of 300 km. The Citarum River carries the sediment in the water stream from the erosion. This study focused on bed load sediment transport. The study of sediment transport is still a few, but some experts have proposed the formula to calculate the amount of sediment transport such as Einstein, Shields, and Schoklitsch. A research in Hydraulics Laboratory and Soil Mechanics Laboratory is conducted to examine the bed load transport from the Citarum River. The purpose of this study is to analyze and compare the result of discharge obtained from the laboratory with the Einstein, Shields, and Schoklitsch approach.

Keywords : bedload sediment transport, Citarum River, discharge

1. BACKGROUND

Citarum River is one of the rivers in Indonesia. With a length of 300 km, the Citarum river is the largest and longest river in West Java Province. This river crosses the Regency / City, starting from a spring located in Mount Wayang (Bandung Regency) and then ending in the Muara Gembong area by passing Bandung / West Bandung District, Cianjur Regency, Purwakarta Regency, and Karawang / Bekasi Regency.

This Citarum River has been around since the Kingdom of Taruma. The Citarum river has long been navigated by small boats. Many people use the Citarum River for fisheries (fishing, fishing, fish farming) and for drinking water supplies for a portion of Jakarta's population.

The water that flows in the Citarum River besides carrying water, this river also carries various kinds of particles. The particles carried by the water flow are caused by erosion that occurs in this river. After that these particles can settle in several parts of the river because of the sedimentation process.

In the process of sedimentation, there are many factors that affect sediment transport. Besides being influenced by flow velocity, bed load transport is also influenced by the length of the river, the slope of the river bed, river cross section, and various other parameters that affect the sedimentation process.





Figure 1. Sample Taken Location

2. THEORY

Many approaches are used by experts to research and develop studies on bed load transport. The study was conducted to compare the results in the laboratory with the results of the approach proposed by several experts, as follow :

- Einstein

Einstein was the first expert to proposed the bed load sediment transport equations with the theoretical approach, namely statistical theory.

$$\Phi = \frac{q_b}{\gamma_s} \left(\frac{\gamma}{\gamma_s - \gamma} \times \frac{1}{g D^3} \right)^{1/2} \quad (1)$$

Where :

Φ = instensity parameter bed load

Q_b = bed load sediment transport (N/m.s)

γ dan γ_s = specific weight of water and specific weight of sediment (kg/m^3)

g = gravity (m/s^2)

D = diameter of sediment (mm)

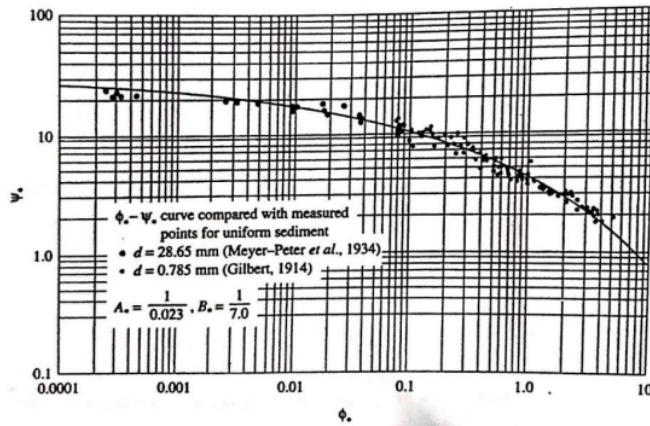


Figure 2. Relationship between Ψ and Φ for Einstein's bed load function (Einstein, 1950)

- Shields
 Shields (1936) measured flow conditions with sediment transport greater than zero, and then extended the relationship to obtain the flow condition corresponding to incipient motion. Thus, a semiempirical equation for bed load is obtained, namely

$$\frac{q_b \gamma_s}{q S \gamma} = \frac{10 (\tau - \tau_c)}{(\gamma_s - \gamma) d_{50}} \quad (2)$$

$$\tau_c = c (\gamma_s - \gamma) d \quad (3)$$

$$U_* = (gDS)^{\frac{1}{2}} \quad (4)$$

$$R_e = \frac{U_* d}{\nu} \quad (5)$$

Where :

- Q_b = bed load sediment transport discharge ((ft³/s)/ft)
- q = water discharge ((ft³/s)/ft)
- d_{50} = diameter of sediment (mm)
- $\tau = \gamma S$ (lb/ft²)
- D = depth of water (ft)
- γ = specific weight of water (lb/ft³)
- S = channel slope (assumption 0.5%)
- τ_c = critical tractive force along the bed (lb/ft²)
- U_* = shear velocity (ft/s)
- ν = kinematic viscosity of water
- R_e = Reynold constants
- C = dimensionless shear stress (Figure 3)

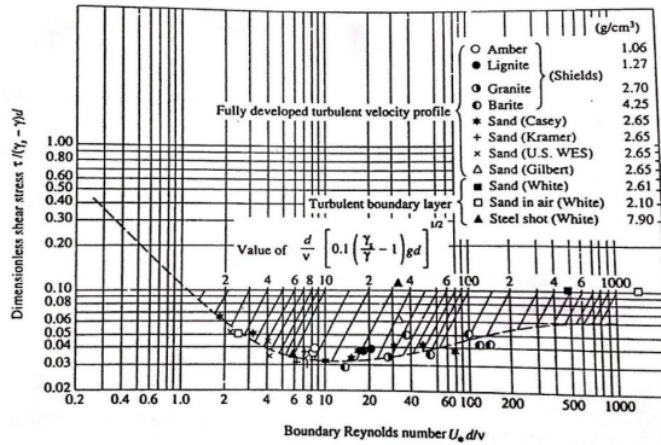


Figure 3. Shields Diagram (Dake, M. K. Jones, 1985)

- Schoklitsch

Schoklitsch (1934) is an expert who suggests the influence of water discharge that occurs to determine the amount of bed load sediment transport, as follows:

$$Q_b = 7000 \frac{s^{3/2}}{d^{1/2}} (q - q_c) \quad (6)$$

$$q_c = \frac{0.00001944 d}{s^{4/3}} \quad (7)$$

Where:

Q_b = bed load sediment transport ((kg/s)/m)

d = diameter of sediment (mm)

q = water discharge ((m³/s)/m)

q_c = critical water discharge ((m³/s)/m)

3. RESEARCH METHODOLOGY

the steps taken in this study are as follows:

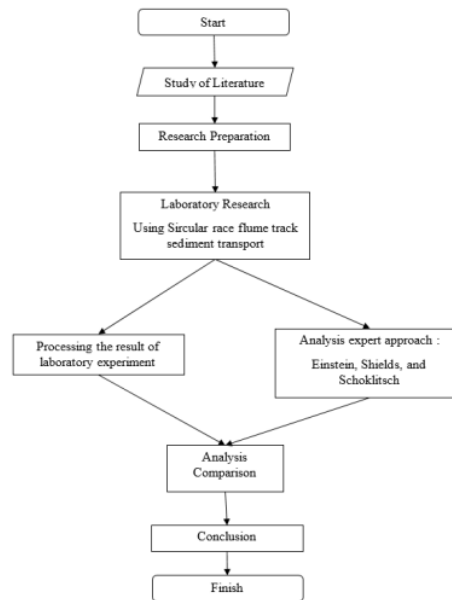


Figure 4. Research Flowchart

4. RESULT

The sediment that is use for the research must be analyzed for the dominant sand size gradations in the soil using sieve analysis. The result is as follow :

Table 1. Sieve Analysis Data

Sieve No	Diam. (mm)	Wt. retained	% retained	% passing
4	4.75	0.4	0.08	99.92
10	2	6.7	1.34	98.58
20	0.85	21.6	4.32	94.26
40	0.425	110.7	22.14	72.12
60	0.25	229.7	45.94	26.18
140	0.106	40.5	8.1	18.08
200	0.075	0.2	0.04	18.04
pan	-	0.3	0.06	
sum		410.1		

After determine the diameter particle sediment, compare the water discharge and the bed load sediment transport discharge between the research results and the 3 approach (Einstein, Shields, and Schoklitsch).

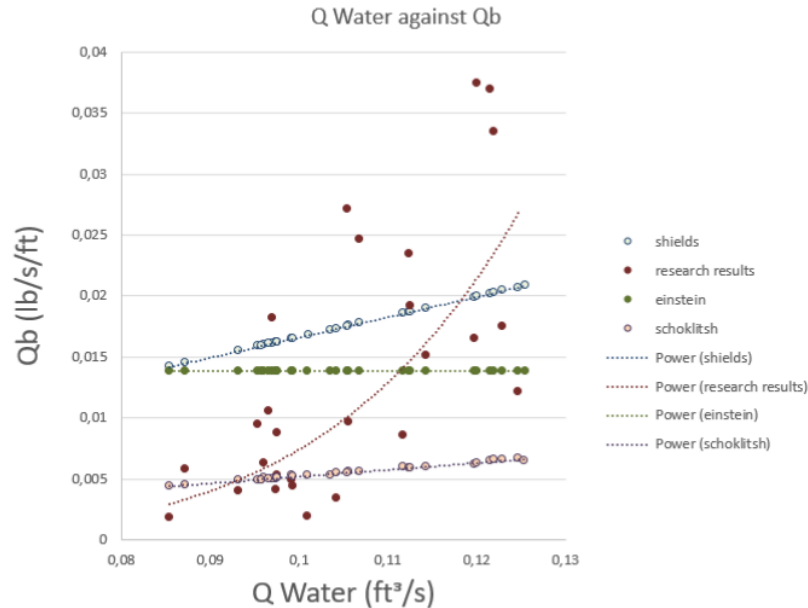


Figure 5. Q water against Qb from 3 approach

From **Figure 5.** we can conclude that the sediment discharge in Citarum river obtained in the research is not in accordance with the discharge obtained from 3 approaches (Einstein, Shields, and Schoklitsch). This can happen because the Einstein approach did not pay attention to the speed and only focused with the diameter of the sediment. Whilst the Schoklitsch approach is only applicable from the velocity range of 0.004 to 0.007 and Shields approach is more variegated, hence is more suitable is for multifarious elements.

To get the equation that is more suitable for the condition of the Citarum River, more research and deep learning is required to obtain specific equations for the Citarum River. Also for the soil type and chemical properties.

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