CHAPTER II

LITERATURE REVIEW

2.1. Sediment Movement

Sediment movement is a natural activity due to the movement of material as impact of the characteristic of its material, slope and water contain influence of the force which dominates the material itself. There are two type of sediment movement. The first is the individual movement that basic material transported by water flow around the sediment particles, in this case water pressure dominate the force that cause the movement. The second is mass movement in this case the gravity force dominate the movement. Because Mass balance of sediment disturbed by the additional supply of water or land masses that move by force of gravity due to external forces (Mizuyama, 1977). However, both of individual movement and mass movement influenced by condition of the river and the different of material characteristics.

In reality the sediment both individual movements and mass movement in a river basin give us benefit as well as natural disasters. Mass movement often caused destructive impact for human being as a short term event. In the other hand the deposit of suspended material in the river basin potentially become benefit. In this aspect the sediment resources from volcanic material is good for a concrete material because the sediment contains the silica fume. Considering of those two aspect together the sediment movement should be maintained well.

2.2. Debris Flow

Debris flow is formed in the upper catchment area of the river sometimes the location is isolated. Assumptions flood with the return period of 25 years based on the intensity of rainfall that cause the occurrence of debris flow is equal to 50 mm/hour (Mukhlisin, 1998). Debris flow formed when the collection of material such as sand, gravel, boulder, and another material come from the catchment area combined with water get the gravity force cause the slope flows to the downstream area (T Takahashi, 2007). However, debris is a mixture of fine materials (clay, silt, sand) and coarse materials (gravel, cobbles, boulders). Often coarse material predominates (Hutchinson, 1988). Beside that debris flow may be described as being analogous to "wet concrete" (Hutchinson, 1988). Debris flows are potentially very destructive as they cause significant erosion of the substrates over which they flow, thereby increasing their sediment charge and further increasing their erosive capabilities. The density and rapid movement of debris flow materials yield a mass with significant energy.

Voight et al, (2000) mentioned during or just after an eruption, a huge amount of volcanic material is deposited on the slope of the volcano. Loose sediment and high intensity of rainfall cause a debris flow disaster. A debris flow is water-saturated debris flowing down on slopes under the gravity force. Debris flows commonly occur after or during heavy rainfall. Debris flows consist of material from clay to rock with a size of several meters. In Mount Merapi basin, debris flows start on the upper slope at the elevations of 1,000 to 2,000 m. Debris flows have frequently happened just after eruptions because pyroclastic flows piled up a huge quantity of loose sediments and ashes in the river basin of the volcano.

2.3. Sediment Control Structure

Several facilities of sediment control structure or Sabo structure that constructed to control debris flow either in volcanic area or non-volcanic area basically have the same function. First to catch the debris flow to reduce the discharge flow rate. Beside that to reduce the velocity of debris flow. Then to outing the debris flow as well as to provide the capacity to store debris flow. Another reason is to limiting the spread of debris flow. Beside that to reducing the possibilities of debris flow to occur.

Compare with the other river structure, the sediment control dam or Sabo dam have different characteristics, such as; Foundation of Sabo dam is a floating foundation, therefore in the deciding the location of the dam, the function of the dam itself became the main consideration instead of placement of the dam. the slope in the downstream part of main Sabo dam is very small (almost vertical) compared with the upper stream part, with the objective of preventing the crushing impact of a big stones carried by the flood. Beside that water holes are constructed in the body of the dam to flow the water during the construction of dam. After it is finished, the function of water holes became the one who route the sediment when the small scale flood occurs.

2.4. Sediment Analysis Principle

2.4.1. Area

To determine the area of Gendol river, analyzing and observing using topographic map is need to be done.

2.4.2. Sediment Estimation on Control Point

Theoretically estimating amount of sediment that can be transported based on planning Sabo Dam to debris flow using the formula below. Based on the formula below empirical formula of Takahashi (1991) and Mizuyama (1977) shows on the eguation (2.1 and 2.2):

$$V_{ec} = \frac{10^3.R_{24}.A}{1-\lambda}\left(\frac{C_d}{1-C_d}\right)fr \;=\; m^3 \qquad (2.1)$$

V_{ec} : Volume of sediment (m ^{3})

C_d : the concentration of sediment in the debris flow

and

$$C_d = \frac{\rho_w . \tan\theta}{(\rho_d - \rho_w)(\tan\varphi - \tan\theta)} = \qquad (2.2)$$

where:

R_{24} = *Maximum rainfall in the return period*

A = *Catchment area*

λ = *Coefficient void ratio (0,4)*

fr = *coefficient run off (based on graph)*

ρ_d = *density of sediment*

θ = *slope*

φ = *sliding angle in the sediment (30°)*

This formula applies on the slope 10°-20°, but it also suitable for the slope more than 20° if C_d calculated more than 0,9. So use C_d = 0,9. If calculated C_d less than 0,3 so use C_d = 0,3.

To obtain the runoff coefficient using the graphic correction factor below. See Figure 2.1 Correction Factor of Runoff Coefficient.

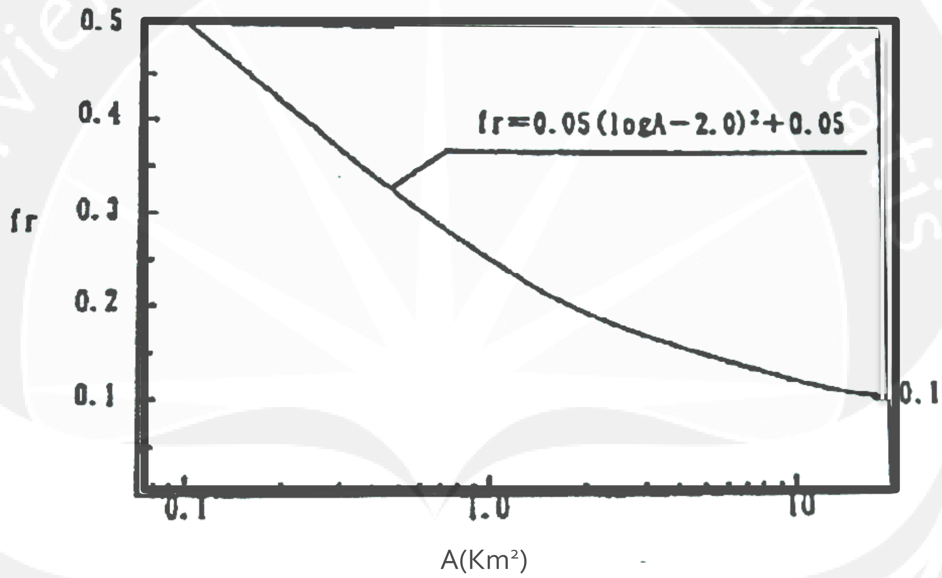

Figure 2.1 Correction Factor of Runoff coefficient

2.5. <u>Storage Capacity of Sediment Control Structure</u>

To calculate the volume of sediment storage should be based on the topography and high effective sediment control structure (manual planning Sabo, 2006: 26).

Where:

lo = slope of the river.

I2 = slope of the balanced kinetic.

I1 = slope of the balanced static.

Storage occurs when the slope of the balanced static already formed and occur in a great flood. The amount of tilt I1 and I2 are as follows.

I1 = 2/3 Io ↔ I2 = 3/4 Io

To calculate the volume of storage capacity of the sediment control structure uses the formula below on formula (2.3 and 2.4).

1. Static sediment volume

$$VS = \frac{1}{2}\left[\frac{H.B}{I_0 - I_1}\right] \quad (2.3)$$

2. Dynamic sediment volume

$$VD = \frac{1}{2}\left[\frac{H.B}{I_0 - I_2}\right] \quad (2.4)$$

For the detail information see the figure below Figure 2.2 Cross Section of Sabo and Figure 2.3 Dimension Detail.

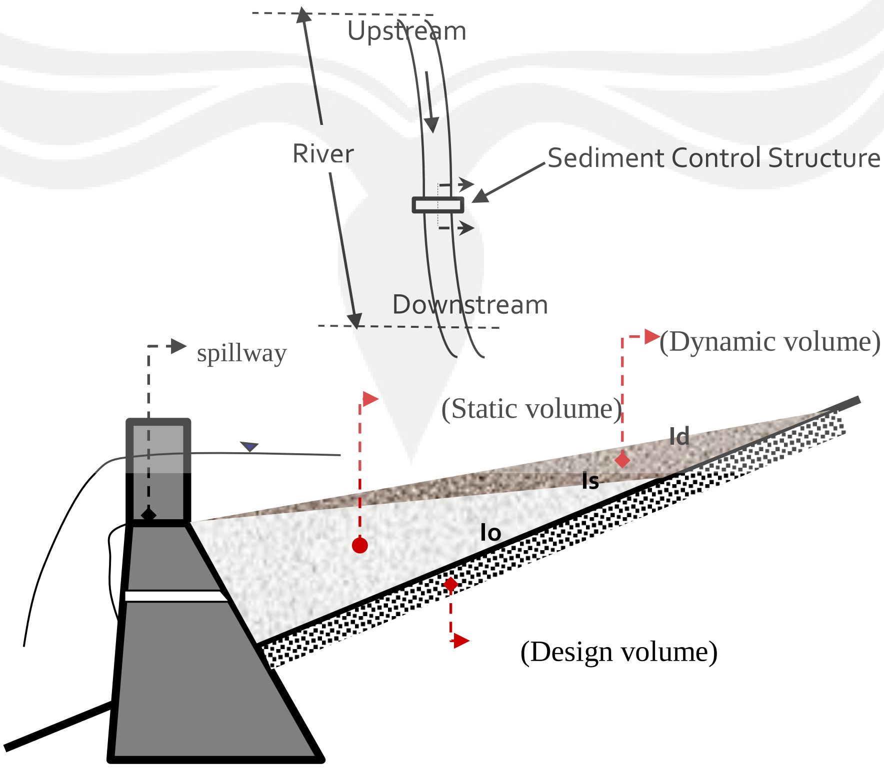

Figure 2.2 Cross Section of Sabo

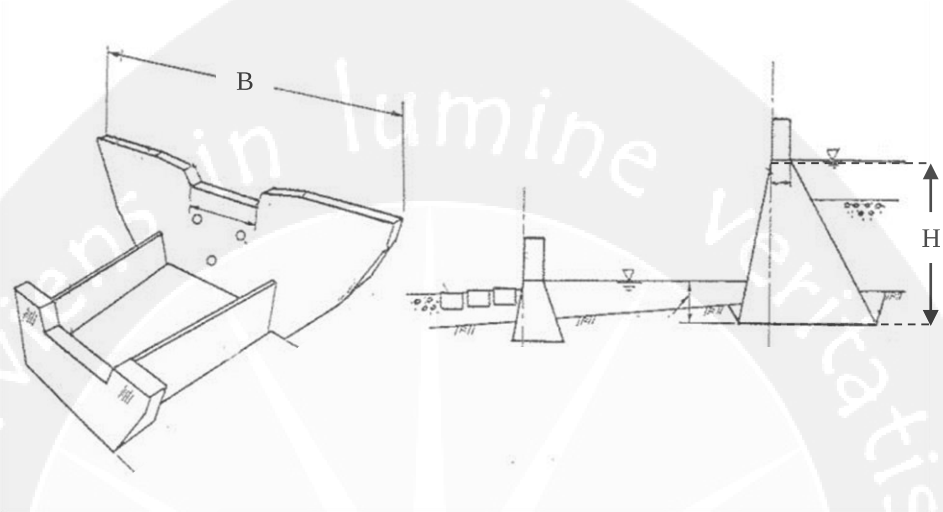

Figure 2.3 Dimension Detail

Where:

V = the storage capacity of sediment (m^3)

H = High of Dam (m)

B = The width of the river where the position of the building (m)

2.6. <u>Peak Discharge of the debris</u>

Peak discharge of debris Q_{sp} (m^3 ldt) obtained from related calculation of discharge only, Q_p (m^3 ldt) explain below on equation (2.6 and 2.7).

$$Q_{sp} = \alpha . Q_p \tag{2.5}$$

$$Q_{sp} = \frac{C}{C.C_d} Q_p \tag{2.6}$$

Where:

C = volumetric concentration of sediments (around 0,6)

C_d *= the concentration of sediment in the debris flow*

2.7. <u>Building Capacity for Controlling Debris Flow</u>

Sediment control planning is prepared for fulfil the equation below that contain five elements using the equation below on equation (2.7).

$$Q - E - (C + D + B) = 0 \qquad (2.7)$$

Where:

Q = sediment discharge.

E = allowable sediment discharge.

C = sediment retained.

D = sediment deposit.

B = controlled sediment.