Relationships for Flow Discharge-Sediment Load in Small and Medium River Systems

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1. Introduction

Erosion and transportation and deposition in the catchment which is one of the important and the difficult problems in practical applications of the hydraulic engineers. The study of analytical and experimental and numerical on the sediment transport which has been carried out by a number of scholar and hydraulic engineers from the times past to the present time in the world. Sedimentation Engineering proposed from the ASCE which one of these study has compiled many references published on 1975 ago and also this is presented by the containing with the researched results during thereafter 30 years as the same title put up another subtitle on 2008 by the editor Garcia[1]. Lee et al. [5] and Lee[4] was studied suspended load during normal and dry seasons in small-medium rivers, and project of measurements on flow discharge-sediment with river master planes in Nonsan River, Gankyeong River, Noseong River, and Wangduck Stream, respectively.

The field measured data are obtained from analyzed by the dry or the filtration method and the modified Einstein's method using the samplers at the depth-averaged of the suspended concentration (DH-48, D-74) and the bed load (BLH-84, BL-84), respectively. The data had been collected from August 2012 to August 2013 at the seven measuring stations of the national river and the local stream in the four rivers of small and medium rivers. As a results, the relationships of flow discharge-total load are derived as a function of power law and it will be used as a useful tool for the small and medium river systems in hydraulic engineering.

2. Theoretical Consideration

Suspended load is calculated by integrating the product of suspension concentration and velocity at each flow depth according to the Rouse number which is proportional to terminal fall velocity and inversely proportional to shear velocity when the von Karman's universal parameter is constant. Volume-averaged concentration as the field measured data are obtained either from sieve or dry analysis after being sampled by a DH-48 (or D-74) sampler at the free surface.

Governing equation of the suspended concentration profile in this study is used diffusion equation derived in equilibrium the rate of mass transport per unit area between fall downward due to gravity and upward particle due to eddy motion of turbulent as following[2,3];

$$\omega C + \varepsilon_m \frac{\partial C}{\partial z} = 0 \tag{1}$$

where w=fall velocity of sediment particle, C=volume-averaged sediment concentration inside the infinitesimal control volume, $\varepsilon_{\rm m}$=transpiration coefficient due to eddy viscosity in vertical direction mass transport, respectively.

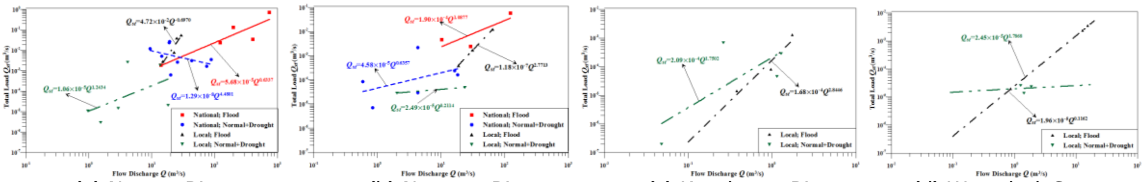
Solution of the Equation (1) is derived from the relationships in connection with the eddy viscosity which is associated with the unit tractive force in fluid and the logarithmic velocity profile of the Karman-Prandtl equation. [2,3];

$$\frac{C_z}{C_a} = [(\frac{h-z}{z})(\frac{a}{h-a})]^{R_0} \tag{2}$$

where R_0=the Rouse number, it is used to predict the suspended concentration with a relative concentration=C_z/C_a.

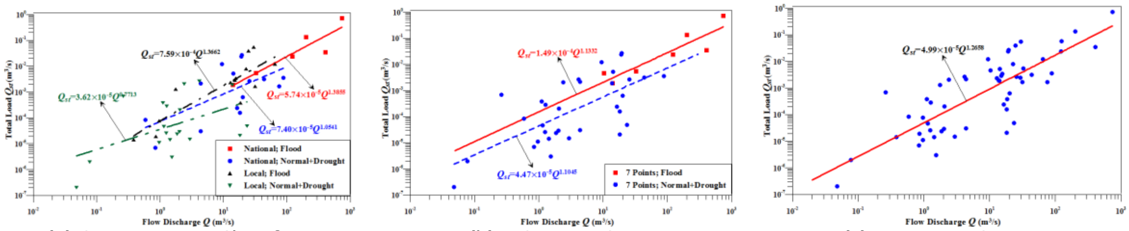
3. Relationships Derivation and Analysis

Field measured data of flow discharge and total load in this study are analyzed by the Box-Whisker method with the sum 56 data set of flood 22, normal 24, drought 10 at 7 stations of the national river and the local stream in small and medium river systems[4]. Flow discharge-total load relationships are derived as a function of power law from the national river and the local stream at 7 stations of 4 rivers in small and medium river systems and the results is shown as in Figures 1 and 2, respectively.



(a) Nonsan River (b) Noseung River (c) Kangkyong River (d) Wangduck Stream

Figure 1. Relationships for Discharge-Sediment Rating Curve in Small and Medium River Systems.



(a) Seasons-River Classification (b) 7 Stations-Seasons (c) 4 Rivers-7 Stations

Figure 2. Relationships for Discharge-Sediment Rating Curve with Measured Seasons and Stations.

Flow discharge-total load relationships for the national river and the local stream in the flood that are recommended as the Equation (3a) (R^2=0.85) and the Equation (3b) (R^2=0.79), respectively.

$$Q_{stN} = 5.74\times10^{-5} Q^{1.3855} \quad (3a) \qquad Q_{stL} = 7.59\times10^{-4} Q^{1.3662} \quad (3b)$$

Flow discharge-total load relationships for the national river and the local stream of the flood season in this study that are recommended as the Equation (4a) (R^2=0.82) and the Equation (4b) (R^2=0.65), respectively derived at 7 stations of 4 rivers in small and medium river systems.

$$Q_{stF} = 1.49\times10^{-4} Q^{1.1332} \quad (4a) \qquad Q_{stNL} = 4.49\times10^{-5} Q^{1.2658} \quad (4b)$$

Flow discharge-total load relationships in this study are recommended as the Equations (3) and (4) derived at seven stations of four rivers in small and medium river systems and it can be used for flow discharge-total load rating curve analysis in the catchments.

4. Conclusions

Flow discharge-total sediment rating curve in this study are measured during flood, normal and drought at seven stations of four rivers in small and medium and the analyzed result is shown as following.

(1) The flow discharge is shown 0.381m^3/s (min.)～744.029m^3/s (max.) (mean; 87.256m^3/s) in flood and 0.263m^3/s (min.)～88.479m^3/s (max.) (mean; 17.573m^3/s), 0.048m^3/s(min.)～14.412m^3/s (max.) (mean; 3.300m^3/s) in normal and drought, respectively.

(2) Flow discharge-total load relationships are recommended as the Equation (3a) and the Equation (3b) in flood at the national river and the local stream, and the seven stations in four rivers are recommended as the Equation (4a) and the Equation (4b) in flood season, respectively.

(3) Discharge-sediment rating curve in this study are recommended as the Equations (3) and (4) derived at seven stations of four rivers in small and medium river systems and it can be used for hydraulic engineering in small and medium river systems.

5. References

[1] Garcia, M.H., ed., Sedimentation engineering, processes, measurement, modeling, and practice, ASCE Manual and Reports on Engineering Practice No. 110, pp. 107-123, 2008.

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