Classification of grain size distribution curves of bed material and the porosity

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1. Introduction

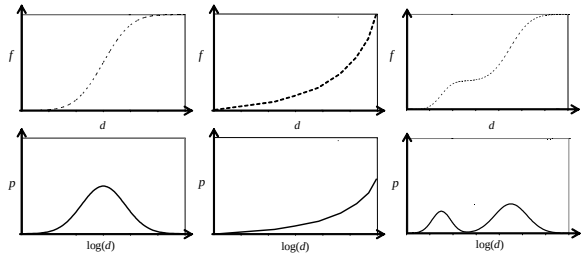
Assessing the change in porosity of riverbed material is very important for an ecological issue in rivers. Therefore, we have already developed a framework of the bed variation model available for the analysis of the change of porosity of bed material as well as the bed variation. In this framework, the porosity is assumed to be dependent only on the grain size distribution. Thus, it is necessary to relate the porosity of sediment mixture with the grain size distribution in the model. Actual sediment mixtures have various types of grain size distribution. Therefore, it is necessary to obtain the porosity for each grain size distribution one by one in calculation of bed variation. However, it is not practical. It is better to install some relationships between porosity and typical grain size distribution in the bed variation model in advance. For that modeling, classification and identification of the grain size distribution type are necessary. The purpose of this study is to develop a method for classifying the type of grain size distribution curves and obtaining the porosity for the different type of grain size distribution.

2. Classification

A type of the distribution can be determined by the shape of size distribution, the shape of density distribution, and the values of two indices β and γ that designate the relative locations of d_{50} and d_{peak} between d_{min} and d_{max}.

$$\beta = \frac{\log d_{max} - \log d_{peak}}{\log d_{max} - \log d_{min}} \quad ; \quad \gamma = \frac{\log d_{max} - \log d_{50}}{\log d_{max} - \log d_{min}} \qquad (1)$$

The grain size distributions are roughly classified into three types of grain size distribution, namely, log-normal distribution, Talbot distribution and bimodal distribution. Based on the shape of size distribution and density distribution, the grain size distributions were classified into log-normal distribution if the trend of the size distribution curves similar to log-normal curve and the density distribution has a single peak. If the density distribution is skewed towards a high-end tail of distribution, the grain size distribution is classified into Talbot distribution. If the density distribution has two peaks, the grain size distribution classified into bimodal distribution. Based on the visual identification and the relation between β and γ, the critical value of these indices for each type distribution can be determined. Grain size distributions are classified into Talbot type if $\beta \leq 0.3$ and $\gamma \leq 0.3$, log-normal type if $0.3 < \beta < 0.7$ and $0.3 < \gamma < 0.7$ and anti-Talbot type if $\beta > 0.7$ and $\gamma > 0.7$.



(a) Log-normal type (b) Talbot type (c) Bimodal type

Fig.1 Typical of grain size distribution of sediment mixture and the density function of grain size

3. Porosity measurement

A laboratory experiment was conducted to obtain the porosity of the sediment mixtures. Twelve different kinds of particle size distribution were prepared; consist of five lognormal distributions, two Talbot distributions and five bimodal distributions. Porosities were measured by the difference of the volume of water that displaces the sediment. The results show that the porosity of log-normal distributions decreased with an increasing standard deviation. The porosity of Talbot distributions increased with an increasing of the Talbot number n_T . The porosity of bimodal distribution depends on the percentage of each fraction in the mixture and a porosity minimum is observed.

4. Conclusion

Grain size distribution of actual sediment mixture can be roughly classified into three types of distribution, namely, log-normal distribution, Talbot distribution and bimodal distribution, based on the mode of density distribution and indices β and γ. The porosity could be reasonably estimated by means of the presented method.