Sediment Problems: Strategies for Monitoring, Prediction and Control (Proceedings of the Yokohama Symposium, July 1993). IAHS Publ. no. 217, 1993.

Reservoir sedimentation for different size particles

RYOEI ITO
Faculty of Bioresources, Mie University, Tsu city, Mie, Japan

Abstract Reservoir sedimentation for different size particles was investigated by detailed laboratory experiments. Theses experiments showed that the sand particle size affected the formation of deposited sediment profiles and the rate with which the delta's shoulder advanced forward in reservoir. Especially, the latter varied much for different size sand particles. And the concentration distribution did not agree with equilibrium distribution near the bed surface. It may be thought that in this near bed region, less flow disturbance exists than near the water surface.

INTRODUCTION

It is very important to predict how the sediment will be deposited in a reservoir for a given discharge. But the formation of reservoir sediment is affected by many factors, for example, water discharge, properties of sand grain particles, shape of reservoir lake, and so on. In this study, reservoir sedimentation for different size sand particles were investigated by laboratory experiments.

EXPERIMENTS

Experiments were performed in a rectangular flume, 40 cm wide and 10 m long, equipped 35 cm high weir at the downstream-end. The upper part of the flume (2 m long) was set level and the lower part (8 m long) was set 1/27 slope. Well-mixed sand and water were fed at the upstream-end, keeping their discharges constant through the experiments. And eight sets of tubes with enlarged nozzle (3-5 nozzles at one station) were installed every 1 m in the direction of the flow, with which vertical concentration distributions of suspended sediment were measured.

Two different kinds of sand were used, which were mainly consisted of quartz particles having a real specific gravity almost 2.7 for both sands. And mean fall diameters (d_{50}) were 0.054 mm, 0.16 mm for each sands. Sand and water discharge was adjusted to keep constant volume concentration (about 1%) all through the experiments. Detail data of the experimental conditions are listed in Table 1.

Bed-profiles of deposited sediment were measured at 10 cm intervals in the direction of the flow every 30 min. Mixture of sand and water was extracted from the nozzles every 1 hour after 30 min from the start of experiments. Concentration distributions were measured using these samples. In the case of RUN-2, grain size distributions in the reservoir were also measured.

Table 1 Experimental conditions.

RUN	Mean fall diameter (mm)	Real specific gravity	Discharge of sand ($g\ s^{-1}$)	Discharge of water ($g\ s^{-1}$)	Volume concentration (%)
1	0.029	2.73	64.8	2.51	0.946
2	0.16	2.68	56.1	2.40	0.872

RESULTS

The symbols and the coordinate system used in the following discussion are shown in Fig. 1. Bed-profiles of deposited sediment in the case of RUN-1 (d_{50} = 0.054 mm) is shown in Fig. 2(a). It is seen from Fig. 2(a) that the gradient of the frontset slope was a little steeper at the delta's shoulder and varied to a more gentle slope in the direction of the flow. Figure 2(a) also shows that the delta's shoulder advanced at almost constant rate.

Bed profiles of deposited sediment in the case of RUN-2 (d_{50} = 0.16 mm) is shown in Fig. 2(b). Figure 2(b) shows that the gradient of the frontset slope was steeper, compared to the case of RUN-1, and it was almost constant from the delta's shoulder to near the original bed. It is also evident from Fig. 2(b) that the delta's shoulder advanced faster than in the case of RUN-1.

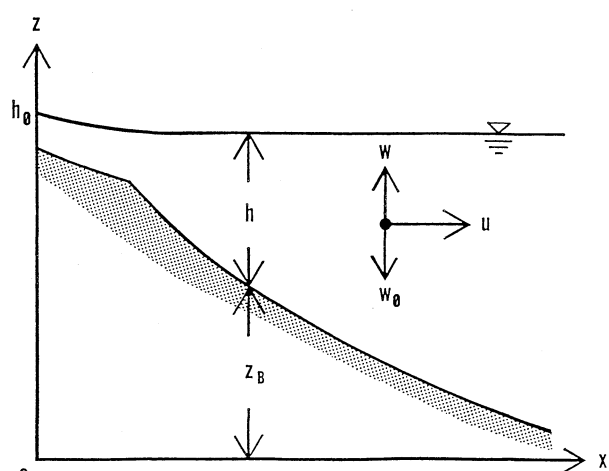

Fig. 1 Definition sketch.

DISCUSSION

It is said that, in equilibrium condition, the vertical concentration distribution has a good agreement with one which is described as equation (1) (which is often called as Rouse (1937) distribution).

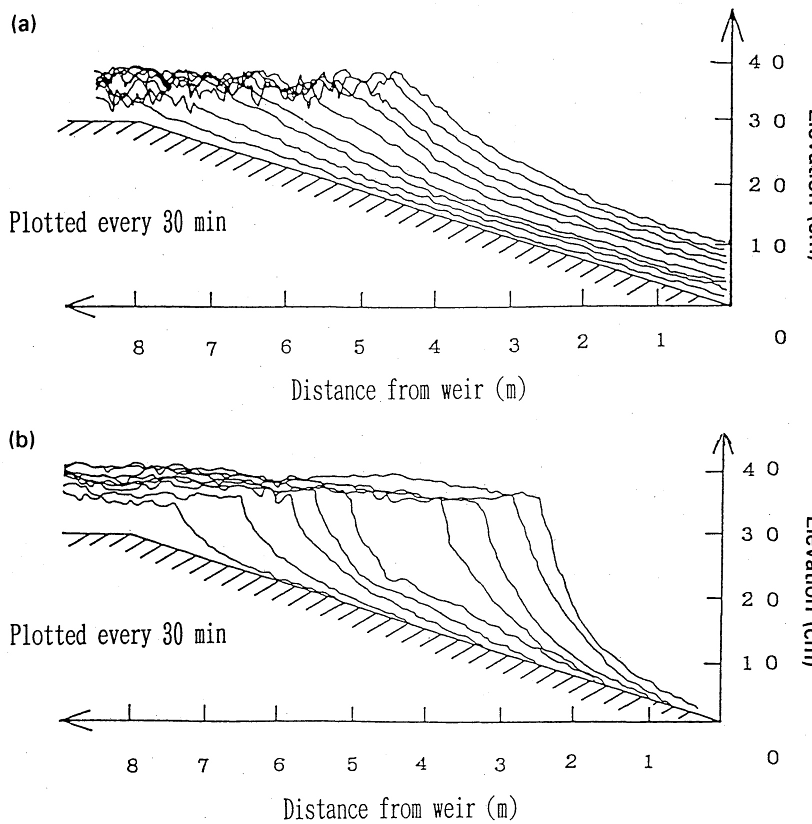

Fig. 2 Bed-profiles of deposited sediment: (a) (RUN-1), (b) (RUN-2).

$$\frac{c}{c_a} = \left\{ \left(\frac{h}{z - z_B} - 1 \right) \left(\frac{z_a - z_B}{h - z_a + z_B} \right) \right\}^{\frac{w_0}{k u_*}} \tag{1}$$

in which c = volume concentration; c_a = volume concentration at the standard point; h = water depth; z = elevation from the datum line; z_B = elevation of the bed surface; z_a = elevation of the standard point; w_0 = falling velocity of suspended sediment; k = Karmann's constant = 0.4; and u_* = shear velocity.

But some experimental data show that the vertical concentration distribution does not agree with equilibrium distribution in the sediment processes in reservoirs (Yano & Ashida *et al.*, 1964). So measured values of concentration were plotted against $h/(z - z_B)$ in Fig. 3(a),(b). It is seen that the concentration values near the bed surface become smaller compared from the equilibrium ones. This implies that at near the bed surface, the flow disturbs less than at near the water surface.

Figure 4 shows the accumulation curves of suspended sediment at different vertical points in the case of RUN-1. It is evident from this figure that the rate of larger sand becomes smaller according to the elevation from the bed. This means that the sand is sorted in the vertical direction.

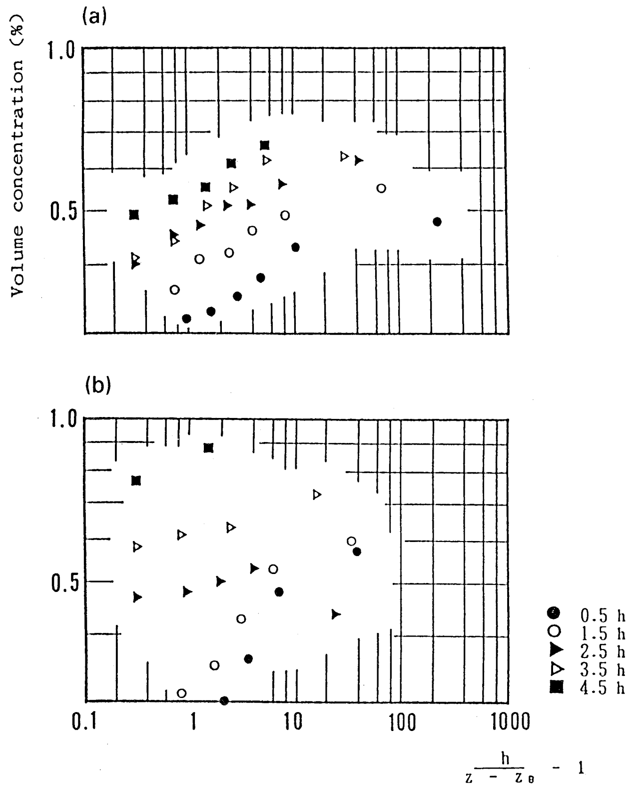

Fig. 3 Vertical distributions of volume concentration: (a) RUN-2, 3.5 m upstream from weir, (b) RUN-2, 4.5 m upstream from weir.

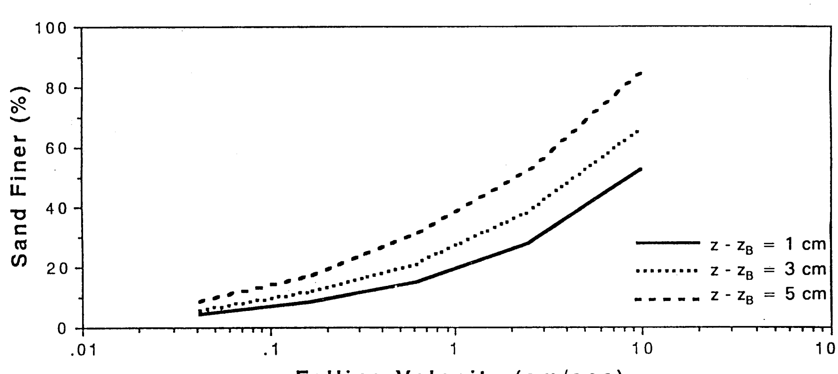

Fig. 4 Accumulation curves of suspended sediment (RUN-2, 1.5 hour, 6.5 m upstream from weir).

CONCLUSION

Laboratory flume experiments showed that the sand particle size affected the formation of deposited sediment profiles and the rate with which the delta's shoulder advanced forward in reservoir. Especially, the latter varied much for different size particles. And the concentration distribution did not agree with the equilibrium distribution near the bed surface. It may be thought that in this near bed region, less flow disturbance exists than near the water surface.

Acknowledgements The author would like to thank Mr Kamide for his great efforts to the experiments.

REFERENCES

Rouse, H. (1937) Modern conception of the mechanism of turbulence. *Trans. ASCE.* **102**, 463-543.

Yano, K., Ashida, K., Daido, A. & Maeda, T. (1964) Study on the sedimentation of suspended sediment in reservoirs. *Disaster Prevention Research Institute Annuals, Kyoto Univ.* 7, 348-364. (in Japanese)