Study of Plastic sand starting velocity

Yanhua WANG, Guosen LI

Tianjin Research Institute for Water Transport Engineering, Key Laboratory of EngineeringSediment of Ministry of Communications, Tianjin 300456, China

email: 630442375@qq.com

Keywords: Model test; Plastic sand; The starting velocity; Flume experiments

Abstract. Plastic sand has more widely used in bed load and suspended load sediment model tests in recent years, But the plastic basic limited to fine sediment simulation test, Size large granular sediments (gravel-shaped plastic sand) less test.This project through the Flume, Set up incipient velocity formula of agravel-like plastic sediment, and by contrast with the formula of plastic sediment have been proved that formula of incipient velocity of feasible, for the larger size of granularsediment (gravel-shaped plastic sand) starting velocity calculation basis.

Introduction

Starting velocity model sand is one of the important basis of model design, and starting velocity test is conducted in the early period of the movable bed model test is one of the pilot study. Styrene-divinylbenzene (plastic), it has in recent years is widely used in the bed load and suspended load sediment model tests[1]- [2]. Plastic sand density is smaller than natural sand, stable chemical performance, non-toxic, insoluble in water, not bibulous, non-viscous. But the plastic basic limited to fine sediment simulation test, particle size of large grain sediment (sand and gravel shape plastic) body simulation is less, this project intends to through flume experiments, to establish initial velocity of sand and gravel shape plastic.

Test conditions and test results

Figure 1 Experimental flume and sand

Test in the 83 m long, 1.0 m wide, 0.8 m high of the glass in the sink, sink gradient is 1 ‰. Model sand spread in the middle of the tank parts, laying length is 3 m, 10 cm thick (figure 1). Uneven thickness, the non-uniform sand mixed grain size, the starting situation was complex, coarse particle due to highlight the bed surface and the stress is larger, and have the masking effect

of fine particles, coarse particle starting velocity must have the corresponding homogeneous small sand, fine particle starting velocity is larger, so the testing and discriminant is difficult, so the test from the plastic sand in six kinds of different particle size of uniform sediment experiment respectively. Sediment diameter points as follows: 0.65 mm, 1.025 mm and 1.875 mm, 3.75 mm and 7.5 mm and 15 mm. Plastic sand bulk density are 1.42 t/m^3 and 1.30 t/m^3.

Test for 6 cm to 15 cm depth range, flow range from 11 to 115.3 l/s. Measure all kinds of particle size of sand in the state of all kinds of starting velocity values listed in table 1.

Table1 Plastic sand in a variety of different starting velocity

depth of water（cm)	Particle size（mm）	γ_s （t/m3）	velocity （m/s)		
			A single move	A small amount of movement	Generally move
15	15	1.42	0.667	0.685	0.769
10	15	1.42	0.611	0.653	0.722
8	15	1.42	0.556	0.590	0.712
6	15	1.42	0.556	0.602	0.694
12.5	7.5	1.42	0.522	0.567	0.622
15	7.5	1.42	0.565	0.583	0.639
10	7.5	1.42	0.528	0.556	0.597
8	7.5	1.42	0.503	0.538	0.573
6	7.5	1.42	0.417	0.486	0.532
15	3.75	1.42	0.407	0.444	0.500
12.5	3.75	1.42	0.422	0.456	0.489
10	3.75	1.42	0.389	0.431	0.472
8	3.75	1.42	0.365	0.382	0.434
6	3.75	1.42	0.347	0.370	0.417
15	1.875	1.42	0.333	0.352	0.389
12.5	1.875	1.42	0.289	0.333	0.378
10	1.875	1.42	0.278	0.306	0.361
8	1.875	1.42	0.278	0.313	0.347
6	1.875	1.42	0.231	0.278	0.324
15	1.025	1.42	0.287	0.315	0.333
12.5	1.025	1.42	0.267	0.289	0.322
10	1.025	1.42	0.250	0.278	0.306
8	1.025	1.42	0.226	0.260	0.295
6	1.025	1.42	0.185	0.231	0.278
15	7.5	1.30	0.426	0.463	0.524
12.5	7.5	1.30	0.422	0.453	0.507
10	7.5	1.30	0.408	0.444	0.500
8	7.5	1.30	0.382	0.424	0.476
6	7.5	1.30	0.347	0.370	0.431
15	3.75	1.30	0.343	0.380	0.426
12.5	3.75	1.30	0.338	0.367	0.411
10	3.75	1.30	0.333	0.361	0.403
8	3.75	1.30	0.313	0.340	0.382
6	3.75	1.30	0.278	0.301	0.347
15	1.875	1.30	0.270	0.296	0.333
12.5	1.875	1.30	0.267	0.289	0.324
10	1.875	1.30	0.253	0.289	0.317
8	1.875	1.30	0.243	0.264	0.299
6	1.875	1.30	0.245	0.269	0.301
15	1.025	1.30	0.219	0.246	0.278
12.5	1.025	1.30	0.216	0.233	0.262
10	1.025	1.30	0.208	0.231	0.258
8	1.025	1.30	0.191	0.219	0.243
6	1.025	1.30	0.176	0.208	0.227

Test result analysis

For coarser sediment starting velocity formula of sharmov [3] for starting velocity:

$$U_e = 1.14\sqrt{\frac{\rho_s - \rho}{\rho} gd}\left(\frac{h}{d}\right)^{1/6}$$

Sharmov formula using sand form, initial velocity according to the actual test measured sediment, fitting out plastic sand starting velocity formula (1) - (3), fitting chart shown in figure 2 to figure 4.

A single move $$U_e = 1.782\sqrt{\frac{\rho_s - \rho}{\rho} gd}\left(\frac{h}{d}\right)^{1/6} \quad (1)$$

A small amount of movement $$U_e = 1.931\sqrt{\frac{\rho_s - \rho}{\rho} gd}\left(\frac{h}{d}\right)^{1/6} \quad (2)$$

Generally move $$U_e = 2.159\sqrt{\frac{\rho_s - \rho}{\rho} gd}\left(\frac{h}{d}\right)^{1/6} \quad (3)$$

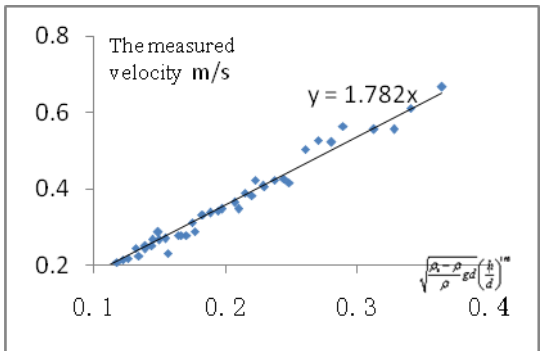

Figure 2 Fitting diagram of individual incipient velocity formula

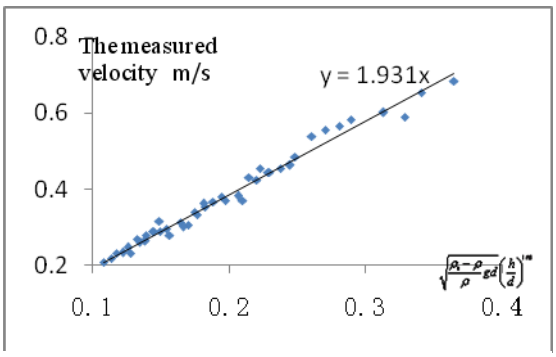

Figure 3 Fitting diagram of small amount incipient velocity formula

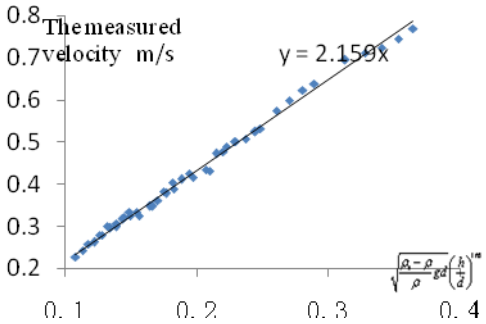

Figure 4 Fitting diagram of universal incipient velocity formul

Test results

Jiangxi province water conservancy science research institute of γ_s = 1.15 t/m^3, d_{50} = 0.063, 0.12, 0.21, 0.28, 0.41 mm yellow plastic sand [4] the starting velocity experiment, ministry of water resources of songliao water resources commission research on γ_s = 1.05 t/m^3, d_{50} = 0.2, 0.32, 0.45 mm plastic sand [5] the starting velocity experiment, initial velocity is obtained. With three formula to calculate the median particle size of 0.65 mm, 1.025 mm and 1.875 mm, 3.75 mm and 7.5 mm, 15 mm, 0.063 mm and 0.12 mm, 0.21 mm and 0.28 mm, 0.41 mm and 0.2 mm, 0.32 mm and 0.45 mm, bulk density of γ_s = 1.42 t/m^3 plastic sand, bulk density of γ_s = 1.15 t/m^3 plastic sand and bulk density of γ_s = 1.05 t/m^3, starting speed, the calculation results as shown in figure 5.

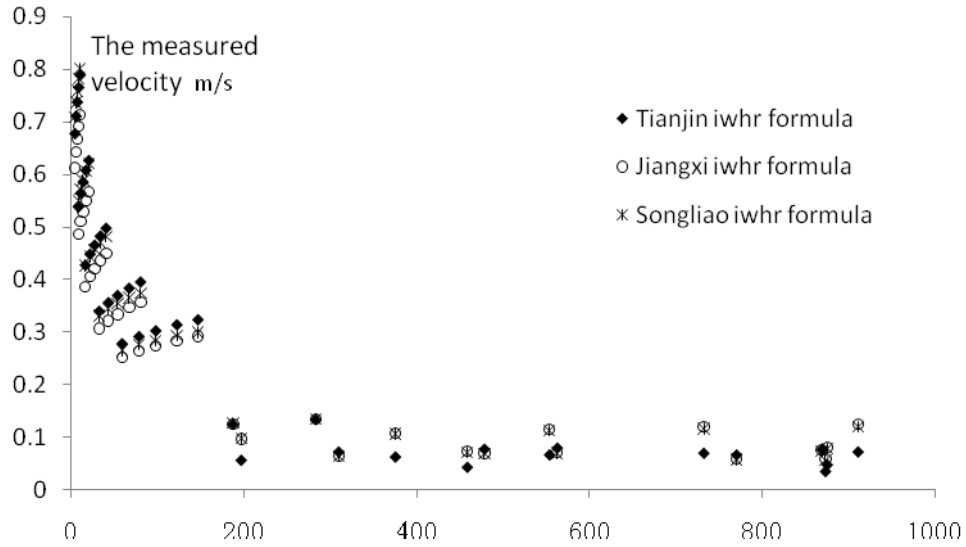

Figure 5 The starting velocity contrast

By comparing the figure can be seen that the three formulas of starting velocity were similar, more close to Tianjin iwhr formula and Songliao iwhr formula, Jiangxi iwhr formula small. In h/d is small, the songliao iwhr formula calculated value is larger, Tianjin iwhr formula in the middle and small iwhr formula of Jiangxi province; When h/d is larger, the Songliao iwhr formula and Tianjin iwhr formula, Jiangxi small iwhr formula. In conclusion, Tianjin iwhr formula is feasible.

Conclusion

(1) Plastic sandis widely used in bed load and suspended load sediment model test, but the plastic basic limited to fine sediment simulation test, particle size of large grain sediment (sand and gravel shape plastic) body simulation is less, this project intends to through flume experiments, to establish initial velocity of sand and gravel shape plastic.

(2) Based on the flume experiment of median size points than for: 0.65 mm, 1.025 mm and 1.875 mm, 3.75 mm and 7.5 mm and 15 mm, bulk density were γ_s = 1.42 t/m^3 and γ_s = 1.30 t/m^3 plastic sand the incipient motion velocity test, the plastic is obtained starting velocity of sand.

(3) By comparing with existing plastic starting velocity of sand, and proved the feasibility of starting velocity concluded. As the particle size of larger grain body sediment (sand and gravel shape plastic) provides the basis for starting velocity calculation.

References

[1] Dou Guoren. Incipient Motion of Coarse and Fine Sediment [J]. Journal of sediment research, June 1999

[2] Wang Yangui, Hu Chunhong, Zhu Bisheng. Study on formula of incipient velocity of sediment in model test [J]. Journal of Hydraulic Engineering, May 2007

[3] Zhang Ruijin. River sediment dynamics [M]. Beijing: China water conservancy and hydropower press, 1998

[4] Huang Zhiwen, Lu Bowen, Wu Nianhua. Starting velocity model sand experimental study [J]. Journal of jiangxi province water conservancy science and technology, March 2012

[5] Gao Shuhua, Zhou Youzhong. Starting velocity and sink rate of experimental study [J]. Journal of sediment research, June 1992