LABORATORY MEASUREMENTS

OF BEDLOAD PARTICLE VELOCITIES

BY

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I. INTRODUCTION

Experimental research on particle segregation and stratification has been on-going at Colorado State University for several years. According to earlier reports by Julien and Chen (1989a,b), and Julien and Lan (1989, 1990), the mechanics of particle segregation depends largely on heterogeneous particle interaction, as opposed to external forces such as lift, drag and turbulence. A new concept of particle kinetic energy lost through impact with a rough boundary is examined. Conservation of angular momentum of heterogeneous particles implies that the fine fractions of a mixture lose most of their kinetic energy through impact with the stationary boundary while the coarse fractions of the mixture maintain most of their kinetic energy. This concept implies that a mixture in lateral motion in the bed layer should form a layer of fines covered with coarse fractions rolling on top of the smooth surface. This concept has been qualitatively observed in Julien et al. (1993) and filmed by Julien and Berthault (1993).

The primary interest in this research program has been to quantitatively examine the velocity of individual particles moving as bedload on both smooth and rough surfaces. The influence of particle size on particle velocity under submerged conditions is examined. If the aforementioned kinetic energy concept is applicable, then under identical flow and boundary roughness conditions, coarse particles should be expected to move faster than fine particles.

We intend to report herewith the experimental observations from this extensive laboratory investigation. A complete data set is presented in Appendix A with a limited analysis at this time. The primary expectation of this program is to determine whether particles that are rolling on a rough plane-bed surface move at different velocities for different grain sizes. If so, how does particle velocity increase with size?

II. EXPERIMENTAL SETUP

2.1 The Flume

A 9.77 m long plexiglass tiltable flume with trapezoidal cross-section was used for the experiment. The bed slope has a range of approximately 0% to 4%, although 1% was the largest slope used (runs 18, 20, 28 and 37). The side walls of the flume are adjustable, allowing for channel cross-section to be varied. In these experiments the side walls were kept fixed at a 3 H

to 1 V ratio, in order to minimize their influence on the flow. A 2 m long test reach near the downstream end of the flume was used to measure particle velocities. The location of the test reach was chosen by visual inspection as that portion of the flume with best uniform flow conditions. An adjustable weir located at the downstream end of the flume was used in some of the runs to control the test reach water levels. Many runs with higher flow rates were performed with the weir removed. The system recirculated; after flowing down the flume, water was collected at the downstream end in a stilling tank and recirculated with a pump driven by an electric motor. The motor has three-speed settings (slow, medium, fast) and the return pipe has a valve for fine adjustment of the flowrate. Three point gages were used to measure flow depths. Two gages were located at the beginning and end of the test section, the third was used to record flow depth over the weir (see Fig. 1). Flowrates were measured using an orifice plate located in the water return pipe. Pressure taps on each side of the construction are connected to two manometers in parallel, with water and mercury as manometric fluids. The mercury manometer was needed for the higher flowrates.

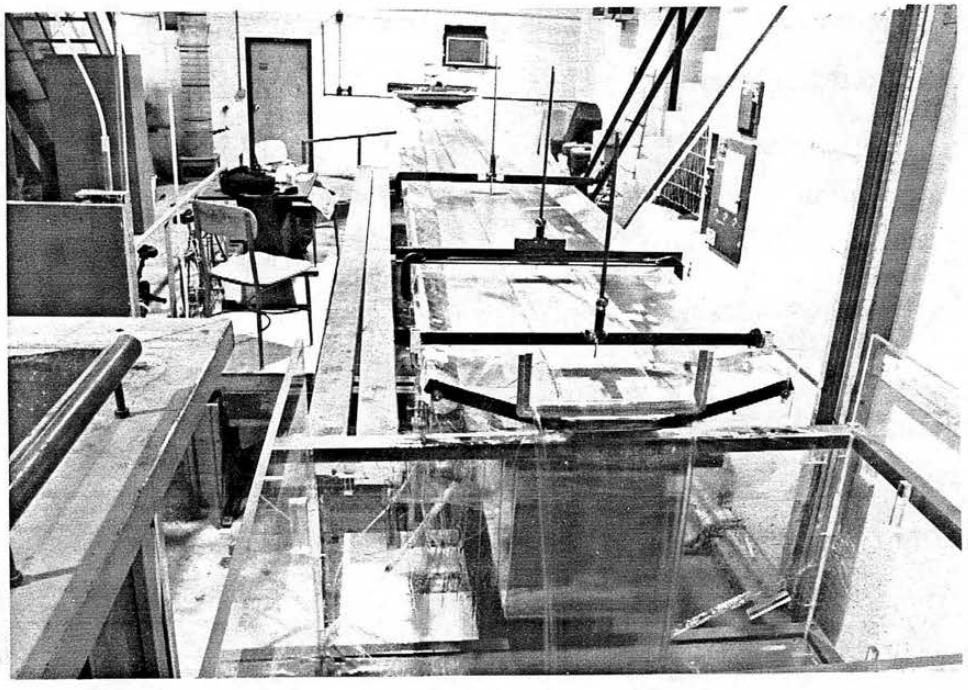


Figure 1. Three point gages used to measure water depth.

2.2 The Plates

Sand or gravel was glued to aluminum plates to achieve various bed roughnesses. Four sets of plates with rounded sand for gravel were used, one set with angular gravel and one smooth aluminum plate (bed roughness k=0). Grain sizes used as bed roughness are shown in Table 1. Two 12-ft long plates were used for each bed roughness condition. The upstream plate used the same roughness as the downstream plate in order to establish the velocity profile of the stream.The test reach was located in the downstream plate.

Table 1. Gravel Gradations for Roughened Plane Surfaces

Sieve Retained (mm)	Sieve Passed (mm)	Bed Roughness (mm)
No Gravel		0 mm
1.00	1.40	1.2
1.40	2.00	1.7
2.00	2.80	2.4
2.00	2.80	2.4 (angular)
2.80	4.00	3.4

Various adhesives were used to bond the sand and gravel to the plates. The first set of plates was produced using a spray lacquer made by Krylon to glue 2.4 mm (angular) gravel particles. This attempt failed as the gravel did not stick to the plates well. A varnish substitute called "EnviroTex Lite pour-on" made by Environmental Technology, Inc. was then used; the particles of gravel adhered much better. A contact cement from DAP was also used; it performed as well as the EnviroTex. One problem with the EnviroTex and the contact cement was the difficulty in producing a uniform layer of gravel without having "clumps" on the plates. For the 1.2 mm sand, a waterproof paint was used (Tile Clad II from Sherwin Williams). This held the sand in place very well, although clumping was difficult to prevent with this paint as well.

In the early runs, particles had a tendency to roll off the sides of the plates. To solve this problem extra sand/gravel was glued to the sides, creating small ridges that acted as "guard rails" to keep the particles on the plate. The roughened plates are shown in Figure 2.

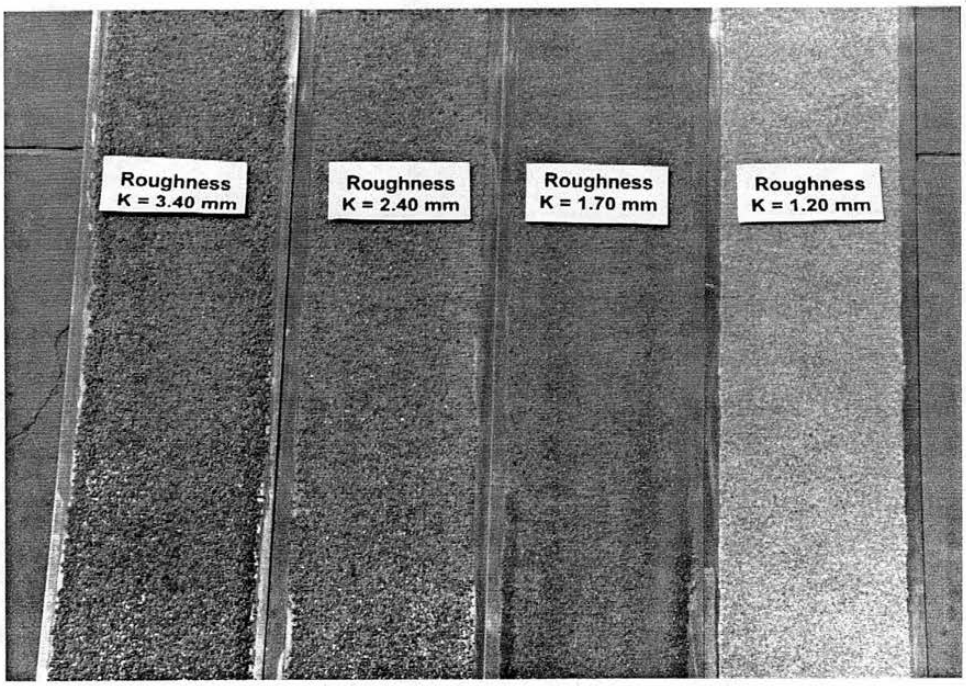


Figure 2a. From roughened plates.

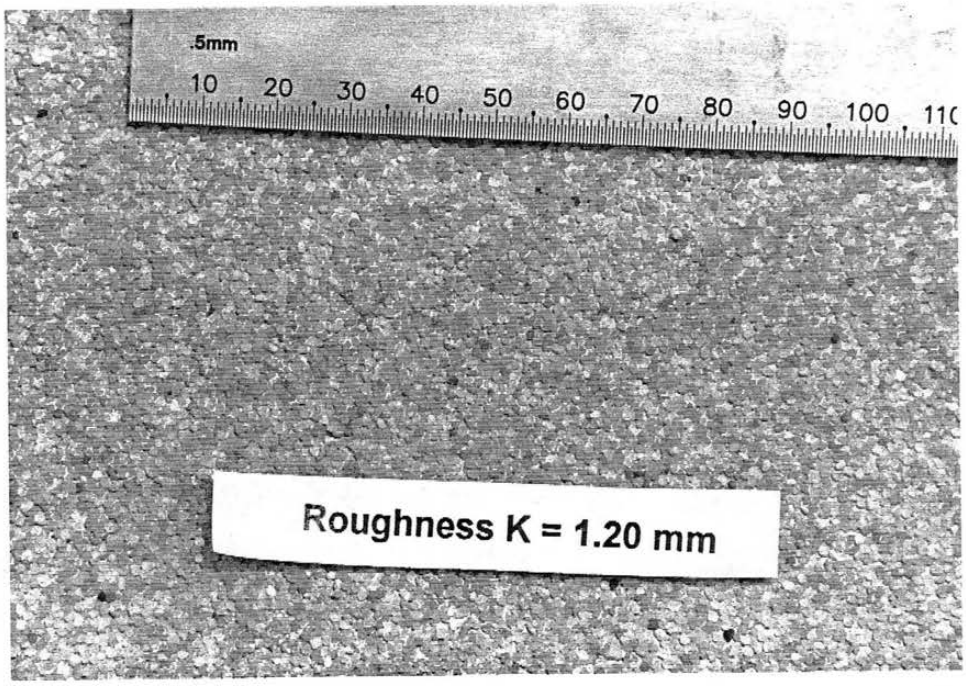


Figure 2b. Plate at roughness K=1.20 mm

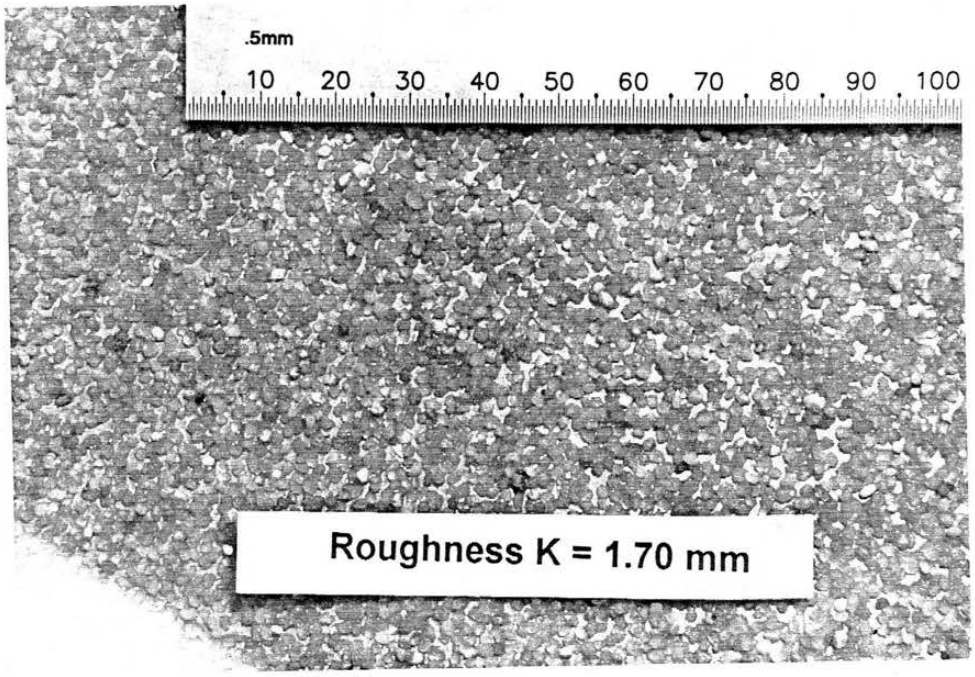


Figure 2c. Plate at roughness K=1.70 mm

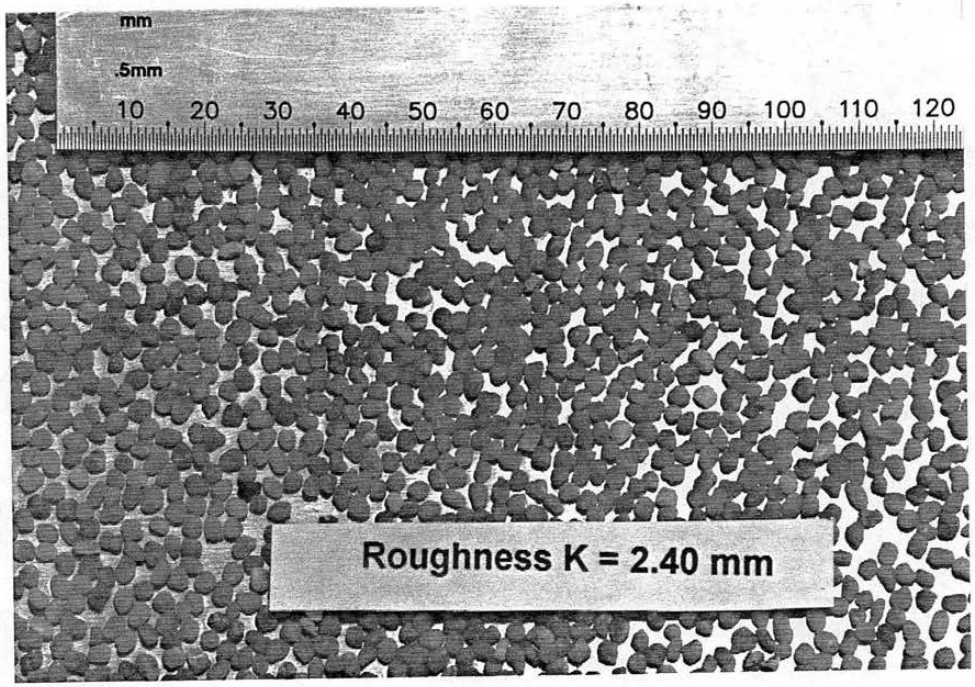


Figure 2d. Plate at roughness K=2.40 mm

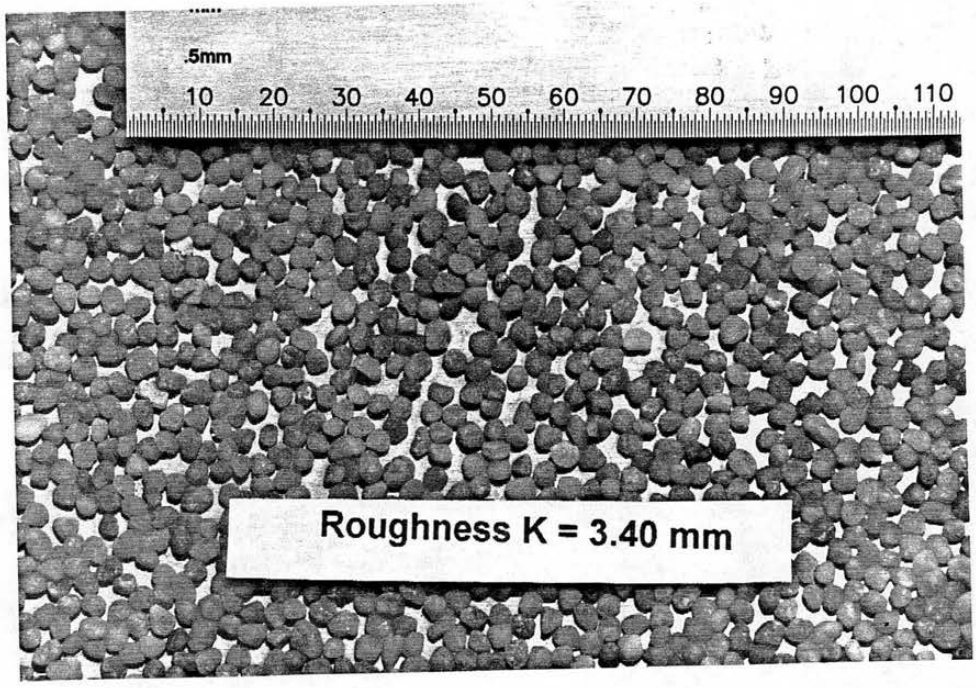


Figure 2e. Plate at roughness K=3.40 mm

2.3. The Particles

Three types of particles were run in the experiment: stainless steel ball bearings, glass marbles and natural quartz particles. The steel ball bearings and glass marbles were used because of their precise spherical shape. Using steel and glass also gave results for particles of two different densities. The quartz particles were used to emulate conditions closer to natural in what relates to slope and density, and also to examine the effects of particle angularity.

As can be seen from Figure 3 and Table 2, a large number of particle types and diameters were tested. Not all of them moved in every run. For the lower transport rates, most steel particles didn't move at all, or did so only for short distances before halting, because of their high density. The natural particles also rolled very little at low transport stages, tending to sit on their flatter sides. For the higher transport stages the smaller steel and natural particles simply disappeared when dropped in the water, presumably whisked away in suspension. The glass marbles were the most consistent across all transport stages. Almost every run used all five marbles. Many different particles were used for each size. The particles were sieved and categorized accordingly. For example, the 3.4 mm diameter "particle" was in fact a set of particles, all passing through the 4.00 mm sieve and retained in the 2.80 mm sieve.

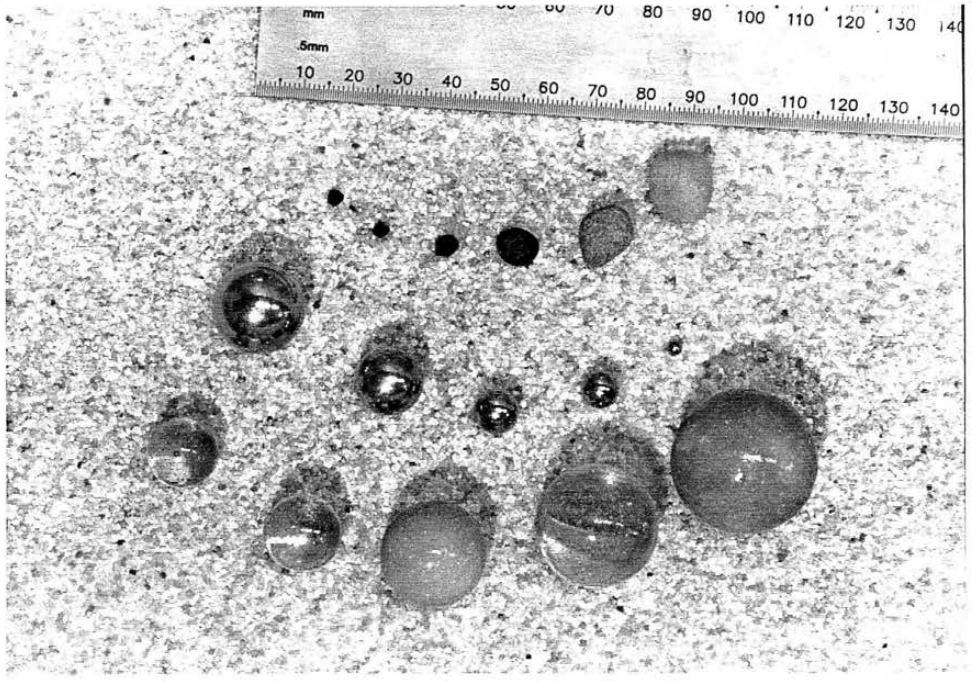


Figure 3. Particles used in the experiment

Table 2. Particle Sizes used in the Experiments

Type	Specific gravity	Diameter (mm)	Sieve Retained (mm)	Sieve Passed (mm)
Steel	8.02	19.04		
		15.88		
		14.28		
		9.50		
		7.90		
		6.34		
		4.75		
		3.14		
		1.57		
Glass	2.60	29.30		
		25.17		
		21.70		
		15.97		
		14.48		
Natural	2.65	13.60	11.2	16.0
		9.60	8.0	11.2
		6.80	5.6	8.0
		4.80	4.0	5.6
		3.40	2.8	4.0
		2.40	2.0	2.8
		1.70	1.4	2.0
		1.20	1.0	1.4

2.4 The Set-Up

Establishing the desired hydraulic conditions for each run involved setting the bed slope, pump, valve and (optionally) adjusting the weir in order to reach a predetermined value of shear velocity U_*. In general, a bed slope and pump setting were selected, then the valve and weir adjusted until the two point gages in the test section indicated approximately the same flow depth. If the flow depth was too shallow (<50 mm), or if the value of U* undesirable, bed slope and/or pump setting were changed and the process started over. Adjustments were made until the difference in flow depths between point gages was smaller than 15% of the drop in bed elevation between the point gages (due to the bed slope).

2.5 Experiments

After the hydraulic conditions were set (and recorded) for a given run, the particles were released upstream and their times measured over the 2 m test section. Notes were taken on any non-uniform particle motion, such as surging of particles, suspension or halting. If a particle ran off the plate, that measurement was discarded and repeated. Each particle was run at least 15 times. When the variance in the run times appeared to be large, the particle was run 18 or 21 times. Hydraulic conditions were measured and recorded at the middle and end of each run allowing an average over three readings for flow depths, top flow widths, and manometer readings.

A total of 49 runs have been completed on plates with six different roughnesses. For each roughness, a range of values of shear velocity $U_* = \sqrt{\frac{\tau_o}{\rho}}$ has been experimented in the range where the particles are expected to be in motion in contact with the bed. A summary of the runs is presented in Tables 3 and 4. One set of plates had no roughness and the experiments for the 2.4 mm gravel were repeated using rounded versus angular material to identify possible differences owing to the angularity of the surface material.

Table 3. Classification of Experimental Runs by Roughness

Plate Roughness	U*	Run #
0	0.0097	12
	0.0111	1
	0.0119	4
	0.0141	5
	0.0152	6
	0.0160	3
	0.0176	2
	0.0176	10
	0.0194	7
	0.0249	8
	0.0299	9
	0.0356	11
	0.0424	19
1.2 (rounded)	0.019	45
	0.027	46
	0.036	47
	0.044	48
	0.051	49
1.7 (rounded)	0.0186	36
	0.0242	34
	0.0285	35
	0.0359	33
	0.0419	32
	0.0480	31
	0.0516	30
	0.0593	29
	0.0625	28
2.4 (rounded)	0.0190	43
	0.0248	44
	0.0317	42
	0.0378	41
	0.0467	40
	0.0514	39
	0.0558	38
	0.0616	37

Plate Roughness	U*	Run #
2.4 (angular)	0.0250	15
	0.0301	13
	0.0339	16
	0.0386	14
	0.0506	17
	0.0641	18
3.4 (rounded)	0.0231	22 (no movement)
	0.0240	21
	0.0298	23
	0.0362	24
	0.0438	25
	0.0501	26
	0.0550	27
	0.0623	20

Table 4. Classification of Experimental Runs

Run #	U_*	Plate Roughness
1	0.0111	0
2	0.0176	0
3	0.016	0
4	0.0119	0
5	0.0141	0
6	0.0152	0
7	0.0194	0
8	0.0249	0
9	0.0299	0
10	0.0176	0
11	0.0356	0
12	0.0097	0
13	0.0301	2.4 (angular)
14	0.0386	2.4 (angular)
15	0.025	2.4 (angular)
16	0.0339	2.4 (angular)
17	0.0506	2.4 (angular)
18	0.0641	2.4
19	0.0424	0
20	0.0623	3.4 (rounded)
21	0.024	3.4 (rounded)
22	0.0231	3.4 (rounded)
23	0.0298	3.4 (rounded)
24	0.0362	3.4 (rounded)
25	0.0438	3.4 (rounded)
26	0.0501	3.4 (rounded)
27	0.055	3.4 (rounded)
28	0.0625	1.7 (rounded)
29	0.0593	1.7 (rounded)
30	0.0516	1.7 (rounded)
31	0.048	1.7 (rounded)
32	0.0419	1.7 (rounded)
33	0.0359	1.7 (rounded)
34	0.0242	1.7 (rounded)
35	0.0285	1.7 (rounded)
36	0.0186	1.7 (rounded)
37	0.0616	2.4 (rounded)

Run #	U_*	Plate Roughness
38	0.0558	2.4 (rounded)
39	0.0514	2.4 (rounded)
40	0.0467	2.4 (rounded)
41	0.0378	2.4 (rounded)
42	0.0317	2.4 (rounded)
43	0.019	2.4 (rounded)
44	0.0248	2.4 (rounded)
45	0.019	1.2 (rounded)
46	0.027	1.2 (rounded)
47	0.036	1.2 (rounded)
48	0.044	1.2 (rounded)
49	0.051	1.2 (rounded)

The voluminous data set in Appendix A provides a substantial compilation of particle velocity information for each size fraction for plane surfaces of different roughnesses and particles of different size, density and angularity.

III PRELIMINARY RESULTS

The data set shows the following overall characteristics:

1) under given hydraulic and surface roughness conditions, coarse particles generally roll faster than fine particles;

2) exceptions to 1) were observed either when smaller particles were partly in saltation, or when the standard deviation of repeated particle velocity measurements were large compared to the mean velocity;

3) the most convincing results are found on runs 3 and 5 for a smooth plate, and runs 34, 36 and 44 for rough plates;

4) at a given roughness size, particles roll slightly faster on a plane boundary of rounded particles as opposed to angular particles; and

5) as shear velocity U* increases, the smaller particles enter saltation and tend to move faster then coarser particles.

A detailed analysis of this substantial data set is forthcoming with the intent of finding quantitative relationships between fluid forces and particle velocities in the bed layer. This will contribute to better understanding of the mechanics of sediment transport in boundary layers for the formation of stratified deposits.

APPENDIX A

LABORATORY DATA SET ON PARTICLE VELOCITY

Data Sheet Legend

Bed roughness k	the average diameter of the particles of gravel glued to the plates (see Table 1), in mm;
Pump setting	for major adjustment of the flow (slow, medium, fast);
Valve setting	for fine adjustment of the flow;
Reach length	length of test section (2000 mm);
Slope reading	reading of vertical displacement (in mm) of a ruler attached to the flume near the upstream end, the ruler is 7145 mm upstream of the pivot point of at flume support;
Bed slope S_o	slope (in m/m);
T_{avg}	average water temperature in °C (measured at start and end of each run);
Manometer readings	manometer heights in inches of water to compute flow rates;
Flow depths	depth of the water in mm, measured at each point gage;
Top widths	top width of the trapezoidal cross-section of the stream in mm, measured at each point gage along the flume;
d	diameter of the rolling particles, in mm;
n	number of trials for each particles (between 15 and 21 trials per particle type and size);
G	specific gravity of the particles;
V_p	average velocity over n trials for each particle in mm/s;
y	flow depth in mm (measured at three locations with point gages);
y/k	relative submergence, ratio of average stream depth to bed roughness;
Q	flow rate in liters/s, $Q = 6.45632\ (\text{manometer reading} / 12)^{0.503}$;
u.s.	upstream -- generally referring to the position of the upstream point gage in the test section;
d.s.	downstream -- generally referring to the position of the downstream point gage in the test section;

B_w width of the plate, which also defined the bottom width of the channel (in mm);

T_w top width of the channel (in mm);

A area of the stream cross-section (in m^2), $A = \frac{1}{2} (T_w + B_w)\, y$;

P wetted perimeter of the stream cross-section (in mm), $P = B_w + 2\sqrt{y^2 + \left(\frac{1}{2}\left(T_w - B_w\right)\right)^2}$;

Rh hydraulic radius of the stream cross-section (in m), $Rh = A/P$;

V average stream flow velocity (in m/s)

$V = Q/A$

$V_{u.s.}$ = average flow velocity at the upstream point gage

$V_{d.s.}$ = average flow velocity at the downstream point gage;

Δ_x distance between the two point gages in the test section (1.62 m);

H energy grade line (in m) at the two point gages

$H_{u.s.} = y_{u.s.} + (S_o\, \Delta_x) + (V_{u.s.})^2/2g$

$H_{d.s.} = y_{d.s.} + (V_{d.s.})^2/2g$;

Δ_H energy loss or head loss (in m) between the two point gages

$H_{u.s.} - H_{d.s.}$;

S_f friction slope Δ_H / Δ_x;

U* shear velocity in m/s, $U* = \sqrt{g\, Rh\, S_f}$;

T_{avg} average temperature reading in °C (taken at the beginning and at the end of each run);

ν kinematic viscosity in mm^2/s or $m^2/s \times 10^{-6}$,

$\nu = 0.0003625\, (T_{avg})^2 - 0.038775\, (T_{avg}) + 1.6345$;

V_p mean particle velocity in m/s

δ laminar sub-layer thickness (in m), $\delta = 11.6\, \nu/U* \times 10^{-6}$ if ν in mm^2/s;

σ standard deviation of particle velocities (in m/s);

d* dimensionless particle diameter, $d* = d\, [(G - 1)\, g/\nu^2]^{1/3}$;

w settling velocity of the rolling particles (in m/s)

$$w = \left(8\,\frac{\nu}{d}\right)\left[\sqrt{1 + 0.0139\,(d*)^3} - 1\right];$$

τ^*	Shields parameter, $\tau^* = \frac{(U^*)^2}{(G-1)gd}$;
delta	delta = δ;
k/δ	ratio of surface roughness to laminar sublayer thickness; and
d/δ	ratio of particle diameter to laminar sublayer thickness.

Run#	1	Bed Roughness k:	0	mm	Streamflow	9.1400	L/s
Date	5-17-95	Pump Setting	low		Valve Setting	1/2 open	
Reach Length	2000 mm	Slope Reading	0	mm	Bed Slope	0	

		Initial		Intermediate		Final	
Temperature		18	°C			18.5	°C
Manometer in. of water	Hi	34.28		34.39		34.4	
	Lo	10.32		10.45		10.45	
	Hi - Lo	23.96		23.94		23.95	
Flow Depth:	u.s.	73	mm	72.5	mm	72.7	mm
	d.s.	72.1	mm	71.4	mm	71	mm
	u.s. - d.s.	0.9	mm	1.1	mm	1.7	mm
Top Width:	u.s.	694	mm	695	mm	696	mm
	d.s.	627	mm	628	mm	629	mm

Velocities (mm/s)

type	steel	72.5163	77.8210	72.8863	71.2251	77.5494	74.8223	73.9372
d (mm)	1.57	71.4541	76.0746	72.3327	73.6106			
n	11							
G	8.02			Std Dev	2.2964		Avg	74.0209

Velocities (mm/s)

type	steel	123.6858	116.6861	119.6888	120.0480	120.5546	121.3592	116.4144
d (mm)	3.14	123.9157	120.6273	115.0748				
n	10							
G	8.02			Std Dev	2.9680		Avg	119.8055

Velocities (mm/s)

type	steel	142.6534	152.7884	143.6782	130.0390	134.9528	136.0544	151.8603
d (mm)	4.75	139.9580	148.5884	137.8360				
n	10							
G	8.02			Std Dev	7.5248		Avg	141.8409

Velocities (mm/s)

type	steel	162.9992	142.1464	153.6098	154.0832	158.6043	144.7178	150.7159
d (mm)	6.34	152.9052	155.7632	150.3759				
n	10							
G	8.02			Std Dev	6.1230		Avg	152.5921

		Velocities (mm/s)						
type	steel	153.9646	159.4896	155.7632	155.8846	159.7444	165.5629	155.1591
d (mm)	7.9	172.2653	162.2060	145.9854				
n	10							
G	8.02			Std Dev	7.1352		Avg	158.6025

		Velocities (mm/s)						
type	steel	166.8057	169.2047	167.6446	177.1479	177.9359	171.3796	177.4623
d (mm)	9.5	170.5030	161.8123	167.9261				
n	10							
G	8.02			Std Dev	5.3074		Avg	170.7822

		Velocities (mm/s)						
type	steel	191.7546	191.3876	191.2046	196.0784	187.2659	194.3635	182.4818
d (mm)	14.28	185.7010	180.1802	176.5225	177.1479			
n	11							
G	8.02			Std Dev	6.8624		Avg	186.7353

		Velocities (mm/s)						
type	steel	197.6285	189.2148	189.3939	200.8032	193.7984	193.6108	190.2950
d (mm)	15.88	188.5014	188.6792	190.1141	197.8239			
n	11							
G	8.02			Std Dev	4.3311		Avg	192.7148

		Velocities (mm/s)						
type	steel	203.2520	187.2659	211.6402	192.8640	206.8252	201.4099	192.4928
d (mm)	19.04	201.0050	196.6568	203.8736				
n	10							
G	8.02			Std Dev	7.3827		Avg	199.7285

		Velocities (mm/s)						
type	tin	132.8904	130.1236	150.8296	135.1351	124.6883	134.2282	132.1877
d (mm)	4.375	126.8231	134.1382	137.7410	133.7793			
n	11							
G	7.31			Std Dev	6.7543		Avg	133.8695

		Velocities (mm/s)						
type	glass	230.1496	224.4669	227.0148	225.2252	227.0148	228.5714	222.2222
d (mm)	24.835	223.7136	232.5581	227.0148				
n	10							
G	2.6			Std Dev	3.0922		Avg	226.7951

		Velocities (mm/s)						
type	glass	207.6843	208.5506	226.2443	196.0784	220.0220	215.7497	210.0840
d (mm)	16.365	204.0816	212.7660	208.9864	200.0000	200.0000		
n	12							
G	2.6			Std Dev	8.7096		Avg	209.1873

Run# 1 Bed
Date: 5-17-95 Roughness k: 0 mm y/k:

Slope: 0 Q: 9.140028 L/s U*: 0.0111 m/s

	u.s.	d.s.	avg
y (mm)	72.7333333	71.5	72.11667
Tw (mm)	695	628	661.5
A (m^2)	0.033821	0.030852	0.032326
P (m)	0.71745264	0.653208	0.685228
Rh (m)	0.04714039	0.047232	0.047176
V (m/s)	0.27024714	0.296252	0.283249
H (m)	0.07645701	0.075975	0.076216

delta H: 0.0004822 m delta x: 1.824 m

Sf: 0.00026438

Tavg: 18.25 °C

ν: 1.0476E-06 m^2/s

δ: 0.00109878 m

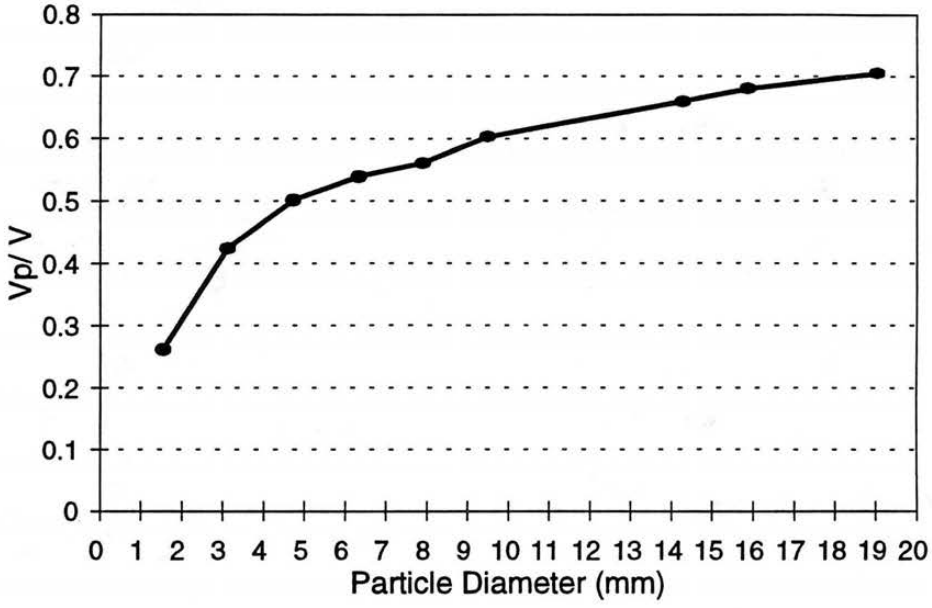
Run# 1

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	1.57	8.02	11	0.0740	0.0023	0.3048	62.3818	0.001132
steel	3.14	8.02	10	0.1198	0.0030	0.4359	124.7635	0.000566
steel	4.75	8.02	10	0.1418	0.0075	0.5376	188.7346	0.000374
steel	6.34	8.02	10	0.1526	0.0061	0.6218	251.9111	0.000280
steel	7.9	8.02	10	0.1586	0.0071	0.6945	313.8955	0.000225
steel	9.5	8.02	10	0.1708	0.0053	0.7619	377.4693	0.000187
steel	14.28	8.02	11	0.1867	0.0069	0.9346	567.3959	0.000124
steel	15.88	8.02	11	0.1927	0.0043	0.9856	630.9697	0.000112
steel	19.04	8.02	10	0.1997	0.0074	1.0794	756.5279	0.000093
tin	4.375	7.31	11	0.1339	0.0068	0.4888	167.7645	0.000452
glass	24.835	2.6	10	0.2268	0.0031	0.5884	602.7674	0.000314
glass	16.365	2.6	12	0.2092	0.0087	0.4774	397.1930	0.000476

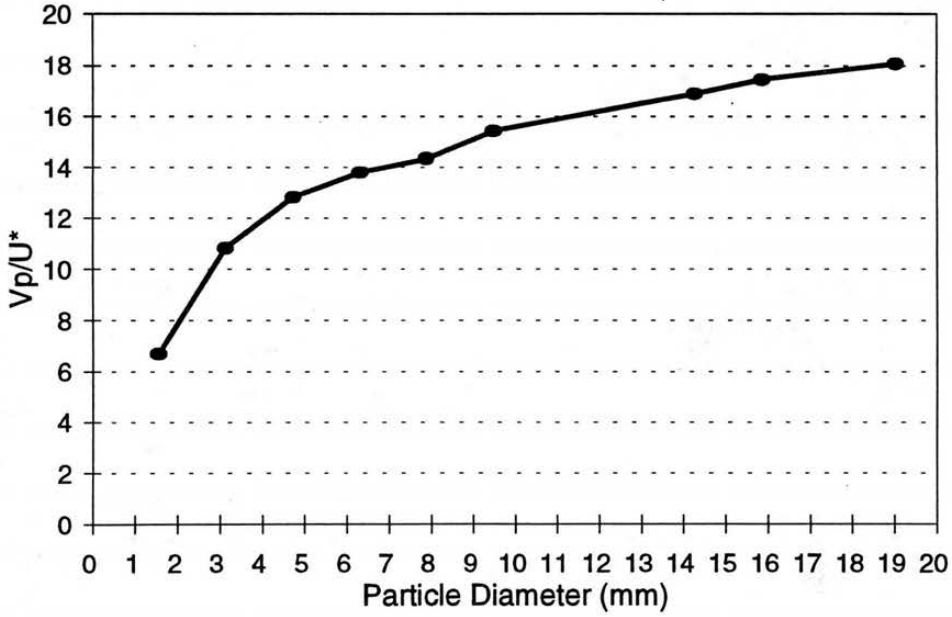
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.2613	6.6929	0.2429	0.0363	ERR	0.0000	1.4289	45.9342
steel	0.4230	10.8327	0.2749	0.0254	ERR	0.0000	2.8577	22.9671
steel	0.5008	12.8252	0.2638	0.0206	ERR	0.0000	4.3230	15.1825
steel	0.5387	13.7973	0.2454	0.0178	ERR	0.0000	5.7700	11.3749
steel	0.5599	14.3408	0.2284	0.0159	ERR	0.0000	7.1898	9.1287
steel	0.6029	15.4420	0.2242	0.0145	ERR	0.0000	8.6459	7.5912
steel	0.6593	16.8845	0.1998	0.0118	ERR	0.0000	12.9962	5.0502
steel	0.6804	17.4252	0.1955	0.0112	ERR	0.0000	14.4524	4.5414
steel	0.7051	18.0593	0.1850	0.0102	ERR	0.0000	17.3283	3.7876
tin	0.4726	12.1044	0.2739	0.0226	ERR	0.0000	3.9817	16.4838
glass	0.8007	20.5067	0.3854	0.0188	ERR	0.0000	22.6023	2.9038
glass	0.7385	18.9146	0.4382	0.0232	ERR	0.0000	14.8938	4.4068

Run 1
U* = 0.0111 m/s

Vp/V vs. d
(steel)



Vp/U* vs. d
(steel)



Run#	2		Bed Roughness k:	0	mm	Streamflow	9.1195 L/s
Date	5-25-95		Pump Setting	slow		Valve Setting	1/2 open
Reach Length	2000	mm	Slope Reading	0	mm	Bed Slope	0

		Initial		Intermediate		Final	
Temperature		18	°C			18	°C
Manometer in. of water	Hi	37.13		37.3		37.18	
	Lo	13.3		13.43		13.35	
	Hi - Lo	23.83		23.87		23.83	
Flow Depth:	u.s.	72.9	mm	73	mm	72.9	mm
	d.s.	71.5	mm	71.6	mm	71.6	mm
	u.s. - d.s.	1.4	mm	1.4	mm	1.3	mm
Top Width:	u.s.	689	mm	691	mm	697	mm
	d.s.	671	mm	676	mm	681	mm

Velocities (mm/s)

type	glass	220.7506	216.2162	222.2222	210.5263	200.6018	ERR	ERR
d (mm)	14.48	217.6279	219.7802	214.1328	217.6279	214.1328	ERR	ERR
n	15	222.2222	221.4839	220.0220	222.9654	215.5172	ERR	ERR
G	2.6			Std Dev	5.8062		Avg	217.0553

Velocities (mm/s)

type	glass	216.2162	223.7136	218.5792	222.2222	213.2196	ERR	ERR
d (mm)	15.97	215.5172	209.2050	206.3983	216.2162	213.9037	ERR	ERR
n	15	225.4791	220.5072	215.5172	215.5172	214.8228	ERR	ERR
G	2.6			Std Dev	5.1019		Avg	216.4690

Velocities (mm/s)

type	glass	246.9136	241.5459	241.5459	240.3846	229.3578	ERR	ERR
d (mm)	21.7	242.4242	227.7904	223.7136	215.5172	235.2941	ERR	ERR
n	15	235.2941	238.6635	239.8082	237.2479	232.8289	ERR	ERR
G	2.6			Std Dev	8.2300		Avg	235.2220

Velocities (mm/s)

type	glass	260.0780	238.6635	242.4242	229.3578	237.2479	ERR	ERR
d (mm)	25.17	234.4666	223.9642	246.3054	239.8082	245.3988	ERR	ERR
n	15	232.5581	238.0952	243.3090	230.1496	220.7506	ERR	ERR
G	2.6			Std Dev	9.7559		Avg	237.5051

		Velocities (mm/s)						
type	glass	232.0186	237.2479	236.1275	232.0186	243.3090	ERR	ERR
d (mm)	29.30	241.2545	243.3090	243.3090	233.6449	238.0952	ERR	ERR
n	15	254.1296	237.8121	226.2443	254.1296	251.8892	ERR	ERR
G	2.6			Std Dev	8.2881		Avg	240.3026

Run# 2 Bed
Date: 5-25-95 Roughness k: 0 mm y/k:

Slope: 0 Q: 9.11953 L/s U*: 0.0176 m/s

	u.s.	d.s.	avg
y (mm)	72.9333333	71.56667	72.25
Tw (mm)	692.333333	676	684.1667
A (m^2)	0.03381676	0.032599	0.033205
P (m)	0.71503215	0.698647	0.706838
Rh (m)	0.04729404	0.04666	0.046977
V (m/s)	0.26967488	0.279752	0.274713
H (m)	0.07664125	0.075557	0.076099

delta H: 0.0010844 m delta x: 1.62 m

Sf: 0.00066937

Tavg: 18 °C

ν: 1.054E-06 m^2/s

δ: 0.00069625 m

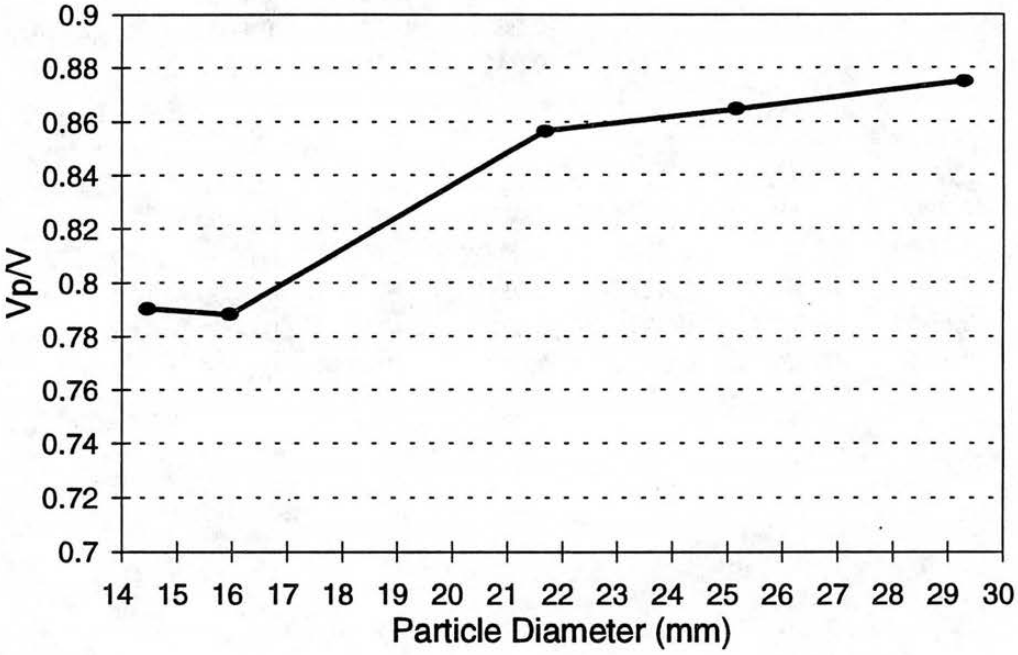
Run# 2

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	14.48	2.6	15	0.2171	0.0058	0.4490	350.0164	0.001357
glass	15.97	2.6	15	0.2165	0.0051	0.4716	386.0333	0.001231
glass	21.7	2.6	15	0.2352	0.0082	0.5500	524.5411	0.000906
glass	25.17	2.6	15	0.2375	0.0098	0.5924	608.4194	0.000781
glass	29.3	2.6	15	0.2403	0.0083	0.6392	708.2514	0.000671

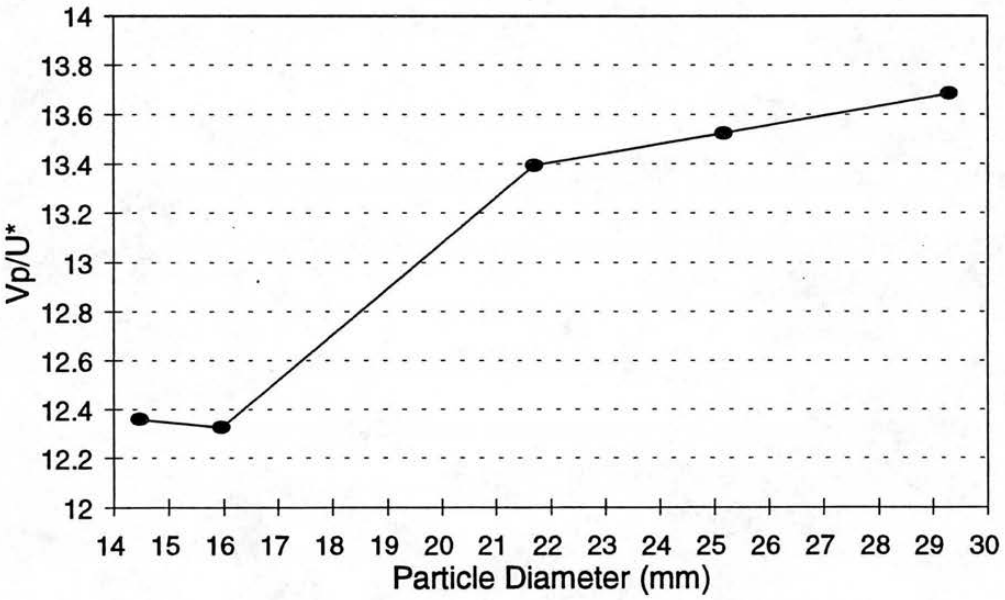
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.7901	12.3605	0.4834	0.0391	ERR	0.0000	20.7971	4.9896
glass	0.7880	12.3271	0.4590	0.0372	ERR	0.0000	22.9372	4.5241
glass	0.8562	13.3950	0.4277	0.0319	ERR	0.0000	31.1670	3.3295
glass	0.8646	13.5251	0.4009	0.0296	ERR	0.0000	36.1508	2.8705
glass	0.8747	13.6844	0.3759	0.0275	ERR	0.0000	42.0826	2.4659

Run 2
U* = 0.0176 m/s

Vp/V vs. d
(glass)



Vp/U* vs. d
(glass)



Run#	3		Bed Roughness k:	0	mm	Streamflow	6.5584 L/s
Date	6-17-95		Pump Setting	slow		Valve Setting	3/8 open
Reach Length	2000	mm	Slope Reading	103.6	mm	Bed Slope	0.0005

		Initial		Intermediate		Final	
Temperature		19	°C			19.5	°C
Manometer in. of water	Hi	12.87		13.01		13.09	
	Lo	0.45		0.67		0.71	
	Hi - Lo	12.42		12.34		12.38	
Flow Depth:	u.s.	60.9	mm	61.2	mm	61.1	mm
	d.s.	60.1	mm	61.1	mm	61	mm
	u.s. - d.s.	0.8	mm	0.1	mm	0.1	mm
	at weir	59.7	mm	59.6	mm	59.3	mm
Top Width:	u.s.	622	mm	623	mm	622	mm
	d.s.	613	mm	614	mm	614	mm
	at weir	6233	mm	625	mm	626	mm

Velocities (mm/s)

type	steel	199.6008	212.9925	201.4099	201.0050	195.3125	ERR	ERR
d (mm)	19.04	189.2148	205.9732	197.8239	206.6116	191.9386	ERR	ERR
n	15	201.8163	198.0198	200.8032	199.2032	195.3125	ERR	ERR
G	8.02			Std Dev	5.9116		Avg	199.8025

Velocities (mm/s)

type	steel	197.0443	189.9335	197.6285	183.9926	183.9926	ERR	ERR
d (mm)	15.88	186.0465	191.0220	186.0465	189.9335	189.9335	ERR	ERR
n	15	189.9335	185.5288	191.0220	193.2367	191.0220	ERR	ERR
G	8.02			Std Dev	4.1745		Avg	189.7544

Velocities (mm/s)

type	steel	182.3154	168.7764	183.3181	183.9926	192.6782	ERR	ERR
d (mm)	14.28	177.3050	187.7934	193.2367	180.8318	195.1220	ERR	ERR
n	15	181.3237	182.4818	183.1502	186.7414	192.6782	ERR	ERR
G	8.02			Std Dev	6.9306		Avg	184.7830

Velocities (mm/s)

type	steel	164.0689	163.6661	160.7717	161.5509	162.8664	ERR	ERR
d (mm)	9.5	161.0306	161.9433	160.7717	163.2653	167.9261	ERR	ERR
n	15	164.8805	167.9261	165.0165	174.3679	165.8375	ERR	ERR
G	8.02			Std Dev	3.6157		Avg	164.3926

Velocities (mm/s)

type	steel	153.8462	150.9434	145.7726	151.4005	148.5884	ERR	ERR
d (mm)	7.9	156.8627	160.0000	153.7279	152.7884	153.2567	ERR	ERR
n	15	162.4695	160.3849	162.0746	150.6024	180.1802	ERR	ERR
G	8.02			Std Dev	8.2889		Avg	156.1932

Velocities (mm/s)

type	steel	136.4256	139.6648	132.8021	146.5201	152.4390	ERR	ERR
d (mm)	6.34	141.5428	136.9863	153.4919	140.9443	158.8562	ERR	ERR
n	15	142.5517	150.4891	148.1481	142.5517	148.0385	ERR	ERR
G	8.02			Std Dev	7.1991		Avg	144.7635

Velocities (mm/s)

type	steel	125.9446	117.2333	110.0110	121.6545	123.5330	ERR	ERR
d (mm)	4.75	123.5330	136.4256	133.8688	125.5493	131.9261	ERR	ERR
n	15	128.2874	133.5113	150.4891	136.1470	128.0410	ERR	ERR
G	8.02			Std Dev	9.4523		Avg	128.4103

Velocities (mm/s)

type	steel	104.0583	109.0513	100.1502	104.2209	103.5733	ERR	ERR
d (mm)	3.14	105.7641	105.8201	104.9318	107.4114	95.9233	ERR	ERR
n	15	107.0091	111.0494	111.2966	110.3753	105.5966	ERR	ERR
G	8.02			Std Dev	4.0887		Avg	105.7488

Velocities (mm/s)

type	steel	71.9166	73.5565	71.3521	74.5990	72.1501	ERR	ERR
d (mm)	1.57	69.8568	72.6480	69.9545	67.1592	72.4638	ERR	ERR
n	15	72.6216	71.1997	68.8231	72.8067	69.0608	ERR	ERR
G	8.02			Std Dev	2.0078		Avg	71.3446

Velocities (mm/s)

type	glass	222.9654	228.5714	235.2941	220.7506	219.2982	ERR	ERR
d (mm)	29.3	223.2143	220.0220	229.3578	225.9887	229.3578	ERR	ERR
n	15	221.4839	220.7506	234.4666	222.9654	238.9486	ERR	ERR
G	2.6			Std Dev	6.1901		Avg	226.2290

Velocities (mm/s)

type	glass	219.2982	230.9469	222.9654	216.9197	222.2222	ERR	ERR
d (mm)	25.17	224.4669	217.1553	234.4666	224.4669	217.6279	ERR	ERR
n	15	220.0220	220.7506	220.7506	214.5923	211.8644	ERR	ERR
G	2.6			Std Dev	5.8564		Avg	221.2344

Velocities (mm/s)

type	glass	207.6843	195.1220	220.0220	203.8736	220.7506	ERR	ERR
d (mm)	21.7	201.0050	225.4791	200.0000	208.9864	211.1932	ERR	ERR
n	15	227.7904	218.5792	213.2196	202.0202	212.5399	ERR	ERR
G	2.6			Std Dev	9.8256		Avg	211.2177

Velocities (mm/s)

type	glass	207.2539	204.7083	197.6285	190.6578	199.6008	ERR	ERR
d (mm)	15.97	195.1220	199.0050	200.2002	209.4241	204.7083	ERR	ERR
n	15	198.2161	195.3125	204.7083	192.8640	216.2162	ERR	ERR
G	2.6			Std Dev	6.8064		Avg	201.0417

Velocities (mm/s)

type	glass	199.8002	203.4588	186.3933	187.4414	191.9386	ERR	ERR
d (mm)	14.48	187.4414	189.2148	208.3333	190.2950	194.9318	ERR	ERR
n	15	202.4291	192.1230	192.8640	189.7533	195.1220	ERR	ERR
G	2.6			Std Dev	6.5965		Avg	194.1027

Velocities (mm/s)

type	natural	153.6098	133.0672	162.3377	140.1542	128.7830	146.8429	147.0588
d (mm)	13.6	129.3661	152.3229	146.8429	147.6015	145.3488	155.0388	139.4700
n	21	151.9757	143.8849	145.7726	131.9261	152.9052	142.2475	144.5087
G	2.65			Std Dev	8.7804		Avg	144.8126

Velocities (mm/s)

type	natural	155.4002	160.7717	137.0802	139.3728	149.3652	161.6815	148.1481
d (mm)	9.6	144.0922	148.8095	137.1742	159.1090	159.2357	152.5553	143.3692
n	21	146.4129	142.9593	138.9854	156.1280	137.0802	140.8451	156.4945
G	2.65			Std Dev	8.4884		Avg	148.3367

Run# 3 Bed
Date: 6-17-95 Roughness k: 0 mm y/k:

Slope: 0.0005 Q: 6.558356 L/s U*: 0.016 m/s

	u.s.	d.s.	avg
y (mm)	61.0666667	60.73333	60.9
Tw (mm)	622.333333	613.6667	618
A (m^2)	0.02617724	0.025771	0.025974
P (m)	0.64113257	0.632671	0.636901
Rh (m)	0.04082969	0.040734	0.040782
V (m/s)	0.25053653	0.254484	0.25251
H (m)	0.06507697	0.064035	0.064556

delta H: 0.0010417 m delta x: 1.62 m

Sf: 0.00064302

Tavg: 19.25 °C

ν: 1.0224E-06 m^2/s

δ: 0.00073957 m

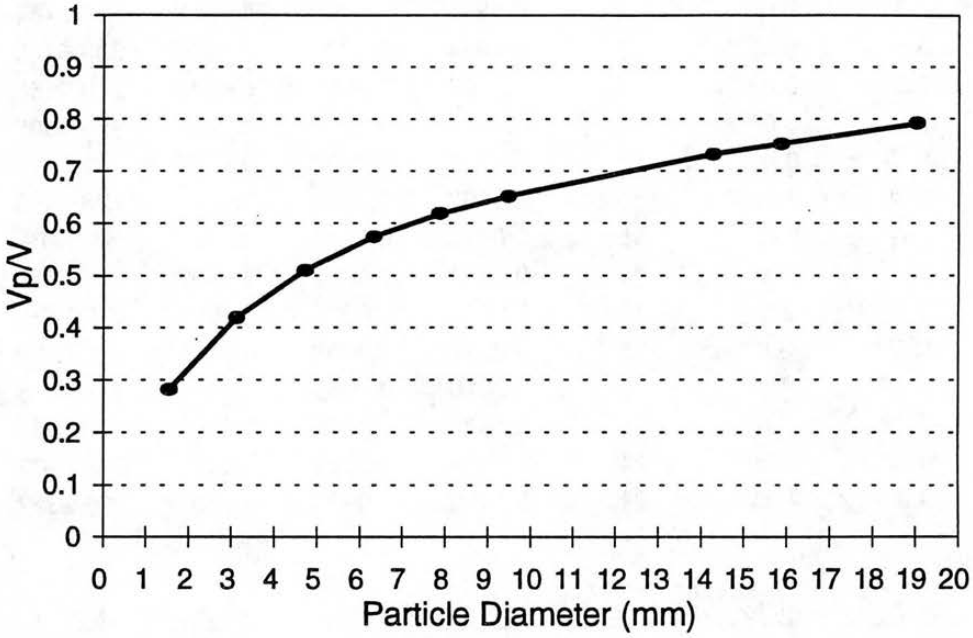
Run# 3

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	15	0.1998	0.0059	1.0794	768.8992	0.0001962
steel	15.88	8.02	15	0.1898	0.0042	0.9857	641.2878	0.0002352
steel	14.28	8.02	15	0.1848	0.0069	0.9346	576.6744	0.0002616
steel	9.5	8.02	15	0.1644	0.0036	0.7619	383.6420	0.0003932
steel	7.9	8.02	15	0.1562	0.0083	0.6945	319.0286	0.0004728
steel	6.34	8.02	15	0.1448	0.0072	0.6218	256.0305	0.0005892
steel	4.75	8.02	15	0.1284	0.0095	0.5376	191.8210	0.0007864
steel	3.14	8.02	15	0.1057	0.0041	0.4359	126.8038	0.0011897
steel	1.57	8.02	15	0.0713	0.0020	0.3049	63.4019	0.0023793
glass	29.3	2.6	15	0.2262	0.0062	0.6392	722.7660	0.0005594
glass	25.17	2.6	15	0.2212	0.0059	0.5924	620.8881	0.0006512
glass	21.7	2.6	15	0.2112	0.0098	0.5500	535.2909	0.0007553
glass	15.97	2.6	15	0.2010	0.0068	0.4716	393.9445	0.0010263
glass	14.48	2.6	15	0.1941	0.0066	0.4490	357.1895	0.0011319
natural	13.6	2.65	21	0.1448	0.0088	0.4419	338.9407	0.0011686
natural	9.6	2.65	21	0.1483	0.0085	0.3709	239.2522	0.0016555

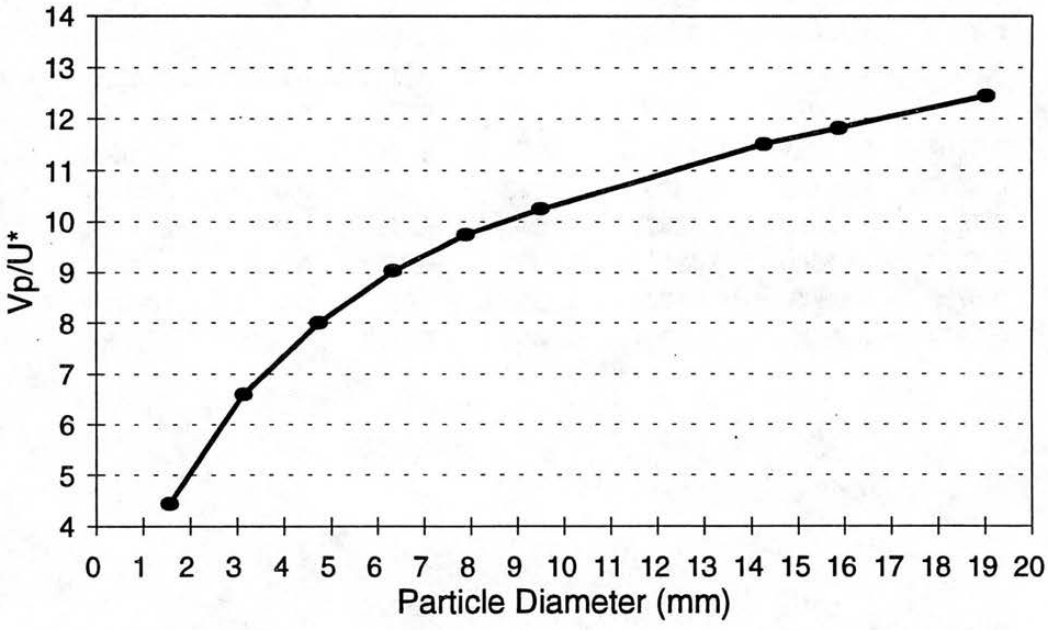
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.7913	12.4594	0.1851	0.0149	ERR	0.0000	25.7447	3.1985
steel	0.7515	11.8328	0.1925	0.0163	ERR	0.0000	21.4719	3.8350
steel	0.7318	11.5228	0.1977	0.0172	ERR	0.0000	19.3085	4.2647
steel	0.6510	10.2513	0.2158	0.0210	ERR	0.0000	12.8453	6.4105
steel	0.6186	9.7400	0.2249	0.0231	ERR	0.0000	10.6819	7.7089
steel	0.5733	9.0272	0.2328	0.0258	ERR	0.0000	8.5725	9.6057
steel	0.5085	8.0075	0.2388	0.0298	ERR	0.0000	6.4226	12.8211
steel	0.4188	6.5943	0.2426	0.0368	ERR	0.0000	4.2457	19.3949
steel	0.2825	4.4489	0.2340	0.0526	ERR	0.0000	2.1229	38.7898
glass	0.8959	14.1073	0.3539	0.0251	ERR	0.0000	39.6176	2.0785
glass	0.8761	13.7959	0.3734	0.0271	ERR	0.0000	34.0333	2.4195
glass	0.8365	13.1712	0.3840	0.0292	ERR	0.0000	29.3414	2.8065
glass	0.7962	12.5367	0.4263	0.0340	ERR	0.0000	21.5936	3.8134
glass	0.7687	12.1040	0.4323	0.0357	ERR	0.0000	19.5789	4.2058
natural	0.5735	9.0303	0.3277	0.0363	ERR	0.0000	18.3891	4.4779
natural	0.5874	9.2501	0.4000	0.0432	ERR	0.0000	12.9805	6.3438

Run 3
U* = 0.016 m/s

Vp/V vs. d
(steel)

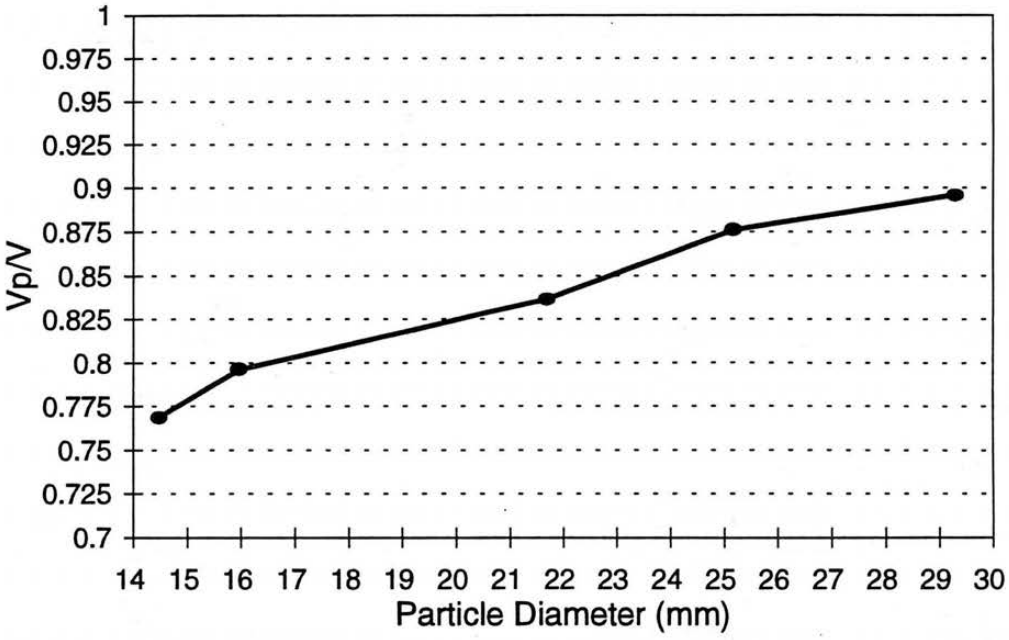


Vp/U* vs. d
(steel)

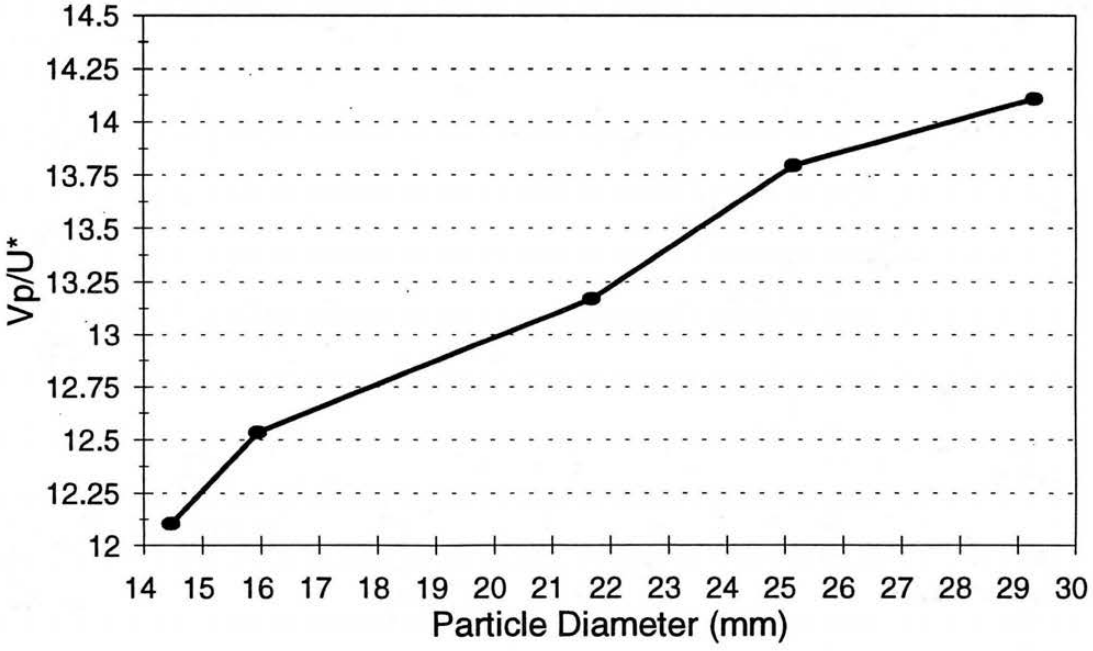


Run 3
U* = 0.016 m/s

Vp/V vs. d
(glass)



Vp/U* vs. d
(glass)



Run#	4	Bed Roughness k:	0	mm	Streamflow	3.1985	L/s
Date	6-20-95	Pump Setting	slow		Valve Setting	1/4 open	
Reach Length	2000	mm	Slope Reading	103.6	mm	Bed Slope	0.0005

		Initial		Intermediate		Final	
Temperature		19	°C			20	°C
Manometer in. of water	Hi	13.05		13.04		13.05	
	Lo	10.06		10.07		10.1	
	Hi - Lo	2.99		2.97		2.95	
Flow Depth:	u.s.	42.1	mm	41.8	mm	41.8	mm
	d.s.	42.1	mm	41.7	mm	41.9	mm
	u.s. - d.s.	0	mm	0.1	mm	-0.1	mm
	at weir	41.3	mm	41.15	mm	41.15	mm
Top Width:	u.s.	518	mm	514	mm	513	mm
	d.s.	518	mm	507	mm	509	mm
	at weir	514	mm	507	mm	509	mm

Velocities (mm/s)

type	steel	163.3987	169.3480	161.5509	166.9449	163.2653	ERR	ERR
d (mm)	19.04	161.4205	158.2278	163.6661	162.9992	165.0165	ERR	ERR
n	15	162.8664	161.9433	167.5042	159.2357	168.3502	ERR	ERR
G	8.02			Std Dev	3.2127		Avg	163.7159

Velocities (mm/s)

type	steel	154.5595	158.3531	160.3849	152.7884	160.3849	ERR	ERR
d (mm)	15.88	149.1424	154.6790	156.8627	150.9434	156.1280	ERR	ERR
n	15	162.4695	157.2327	159.4896	153.8462	151.9757	ERR	ERR
G	8.02			Std Dev	3.8529		Avg	155.9493

Velocities (mm/s)

type	steel	153.4919	153.9646	154.9187	144.4043	153.0222	ERR	ERR
d (mm)	14.28	148.6989	148.3680	147.0588	147.4926	154.5595	ERR	ERR
n	15	154.5595	152.2070	150.9434	151.2859	151.6300	ERR	ERR
G	8.02			Std Dev	3.2195		Avg	151.1070

Velocities (mm/s)

type	steel	135.8696	133.8688	138.7925	127.6324	127.1456	ERR	ERR
d (mm)	9.5	138.8889	135.5932	129.5337	127.7139	132.2751	ERR	ERR
n	15	129.0323	132.1004	140.0560	137.3626	134.2282	ERR	ERR
G	8.02			Std Dev	4.4132		Avg	133.3395

		Velocities (mm/s)						
type	steel	130.0390	125.7862	123.7624	123.6858	129.5337	ERR	ERR
d (mm)	7.9	123.1527	123.0769	127.7955	127.5510	125.7862	ERR	ERR
n	15	127.4697	125.3918	128.2874	131.4924	124.6883	ERR	ERR
G	8.02			Std Dev	2.6381		Avg	126.4999

		Velocities (mm/s)						
type	steel	112.2965	115.7407	116.4822	116.5501	115.2074	ERR	ERR
d (mm)	6.34	109.5890	113.8952	110.8647	115.3403	116.1440	ERR	ERR
n	15	111.2966	111.9821	110.5583	109.2299	112.9944	ERR	ERR
G	8.02			Std Dev	2.5830		Avg	113.2114

		Velocities (mm/s)						
type	steel	91.5332	100.5025	96.1076	98.3768	91.4077	ERR	ERR
d (mm)	4.75	101.0611	95.4198	106.4963	101.7294	102.8278	ERR	ERR
n	15	102.7221	106.7806	99.2063	101.9368	96.8523	ERR	ERR
G	8.02			Std Dev	4.6539		Avg	99.5307

		Velocities (mm/s)						
type	steel	84.9979	83.7872	84.1043	82.0681	79.0514	ERR	ERR
d (mm)	3.14	78.2167	75.2729	78.4314	80.0000	84.1043	ERR	ERR
n	15	75.3864	81.5661	81.3339	82.9876	77.0713	ERR	ERR
G	8.02			Std Dev	3.2129		Avg	80.5586

		Velocities (mm/s)						
type	steel	51.0725	50.1253	56.7054	52.1241	53.7346	54.6001	ERR
d (mm)	1.57	58.2581	56.7376	56.5131	52.9942	54.5554	52.3013	ERR
n	18	52.3560	55.3250	51.5597	51.6662	55.4477	52.2466	ERR
G	8.02			Std Dev	2.3172		Avg	53.7957

		Velocities (mm/s)						
type	glass	198.2161	200.0000	198.0198	192.1230	201.8163	ERR	ERR
d (mm)	29.3	192.1230	192.1230	196.2709	207.0393	193.9864	ERR	ERR
n	15	200.0000	195.1220	191.5709	199.4018	200.0000	ERR	ERR
G	2.6			Std Dev	4.4136		Avg	197.1875

		Velocities (mm/s)						
type	glass	191.7546	189.2148	197.0443	185.1852	183.4862	ERR	ERR
d (mm)	25.17	189.5735	186.2197	194.9318	188.8574	196.6568	ERR	ERR
n	15	187.6173	187.0907	183.8235	192.8640	193.4236	ERR	ERR
G	2.6			Std Dev	4.4338		Avg	189.8496

		Velocities (mm/s)						
type	glass	183.8235	186.7414	187.6173	187.6173	183.8235	ERR	ERR
d (mm)	21.7	189.3939	186.5672	190.4762	176.8347	178.2531	ERR	ERR
n	15	187.0907	172.5626	186.0465	183.4862	182.3154	ERR	ERR
G	2.6			Std Dev	4.9493		Avg	184.1766

Velocities (mm/s)

type	glass	174.2160	168.2086	167.0844	167.0844	167.7852	ERR	ERR
d (mm)	15.97	167.5042	165.9751	167.6446	174.5201	171.5266	ERR	ERR
n	15	177.6199	168.4920	177.4623	165.2893	167.0844	ERR	ERR
G	2.6			Std Dev	4.1398		Avg	169.8331

Velocities (mm/s)

type	glass	152.9052	169.2047	164.4737	166.6667	174.9781	ERR	ERR
d (mm)	14.48	163.6661	158.8562	161.2903	174.9781	172.4138	ERR	ERR
n	15	165.4260	169.7793	168.7764	163.6661	167.5042	ERR	ERR
G	2.6			Std Dev	5.9411		Avg	166.3057

Run#	4	Bed					
Date:	6-20-95	Roughness k:	0	mm		y/k:	
Slope:	0.0005		Q: 3.19854	L/s		U*: 0.0119	m/s

	u.s.	d.s.	avg
y (mm)	41.9	41.9	41.9
Tw (mm)	515	511.3333	513.1667
A (m^2)	0.0157125	0.015636	0.015674
P (m)	0.52727118	0.52376	0.525515
Rh (m)	0.02979966	0.029853	0.029826
V (m/s)	0.20356656	0.204567	0.204067
H (m)	0.04482282	0.044034	0.044428

delta H:	0.0007892	m	delta x:	1.62	m
Sf:	0.00048715				
Tavg:	19.5	°C			
ν:	1.0162E-06	m^2/s			
δ:	0.00098755	m			

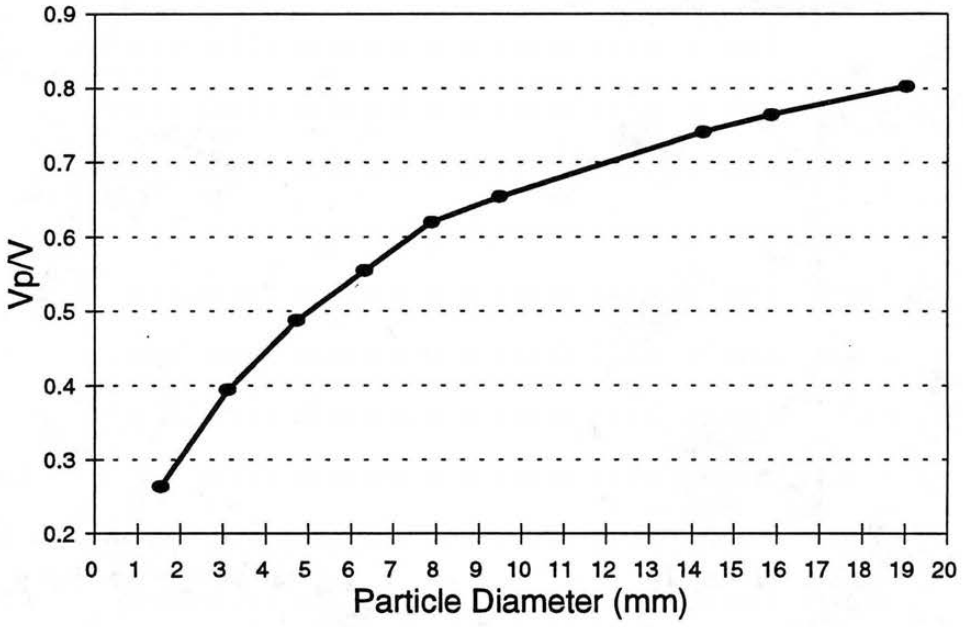
Run# 4

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	15	0.1637	0.0032	1.0794	772.0144	0.000109
steel	15.88	8.02	15	0.1559	0.0039	0.9857	643.8860	0.000130
steel	14.28	8.02	15	0.1511	0.0032	0.9346	579.0108	0.000145
steel	9.5	8.02	15	0.1333	0.0044	0.7619	385.1963	0.000218
steel	7.9	8.02	15	0.1265	0.0026	0.6945	320.3211	0.000262
steel	6.34	8.02	15	0.1132	0.0026	0.6218	257.0678	0.000326
steel	4.75	8.02	15	0.0995	0.0047	0.5376	192.5981	0.000436
steel	3.14	8.02	15	0.0806	0.0032	0.4359	127.3175	0.000659
steel	1.57	8.02	18	0.0538	0.0023	0.3049	63.6588	0.001318
glass	29.3	2.6	15	0.1972	0.0044	0.6392	725.6943	0.000310
glass	25.17	2.6	15	0.1898	0.0044	0.5924	623.4036	0.000361
glass	21.7	2.6	15	0.1842	0.0049	0.5500	537.4596	0.000418
glass	15.97	2.6	15	0.1698	0.0041	0.4716	395.5405	0.000569
glass	14.48	2.6	15	0.1663	0.0059	0.4490	358.6366	0.000627

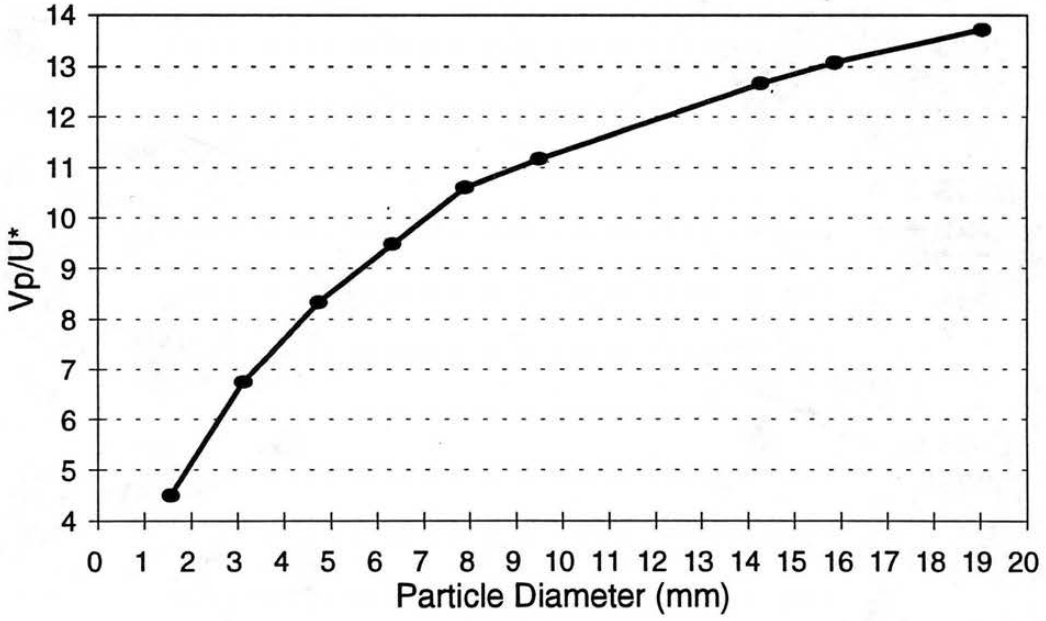
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.8023	13.7151	0.1517	0.0111	ERR	0.0000	19.2801	2.2006
steel	0.7642	13.0645	0.1582	0.0121	ERR	0.0000	16.0803	2.6385
steel	0.7405	12.6588	0.1617	0.0128	ERR	0.0000	14.4601	2.9342
steel	0.6534	11.1704	0.1750	0.0157	ERR	0.0000	9.6198	4.4105
steel	0.6199	10.5974	0.1821	0.0172	ERR	0.0000	7.9996	5.3038
steel	0.5548	9.4842	0.1821	0.0192	ERR	0.0000	6.4200	6.6088
steel	0.4877	8.3381	0.1851	0.0222	ERR	0.0000	4.8099	8.8211
steel	0.3948	6.7487	0.1848	0.0274	ERR	0.0000	3.1796	13.3439
steel	0.2636	4.5067	0.1764	0.0391	ERR	0.0000	1.5898	26.6879
glass	0.9663	16.5191	0.3085	0.0187	ERR	0.0000	29.6695	1.4300
glass	0.9303	15.9044	0.3205	0.0201	ERR	0.0000	25.4874	1.6647
glass	0.9025	15.4292	0.3349	0.0217	ERR	0.0000	21.9737	1.9309
glass	0.8322	14.2276	0.3601	0.0253	ERR	0.0000	16.1714	2.6237
glass	0.8150	13.9321	0.3704	0.0266	ERR	0.0000	14.6626	2.8936

Run 4
U* = 0.0119 m/s

Vp/V vs. d
(steel)

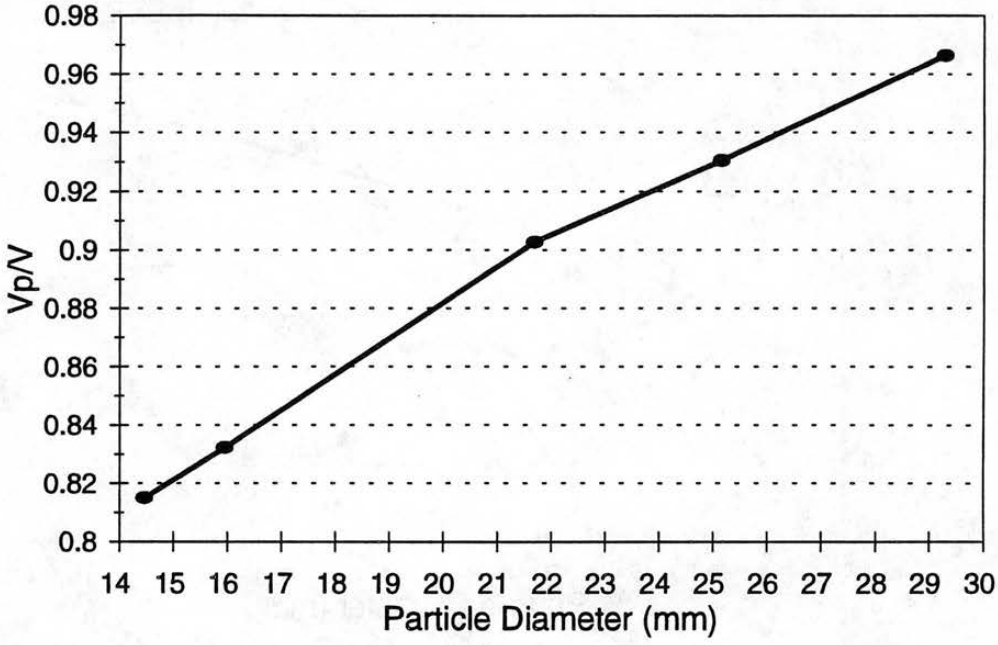


Vp/U* vs. d
(steel)

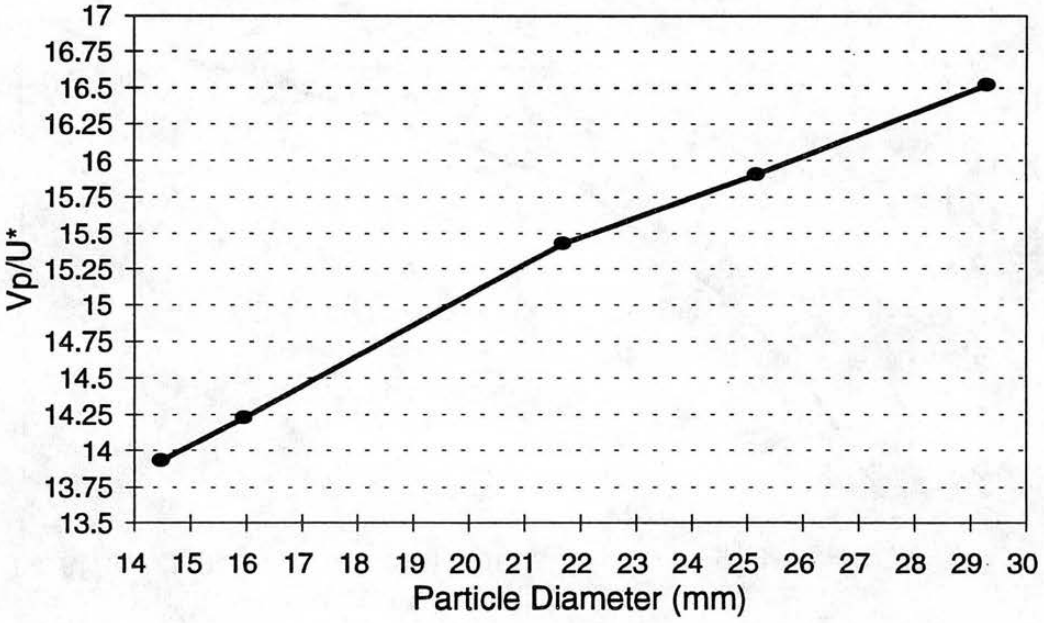


Run 4
U* = 0.0119 m/s

Vp/V vs. d
(glass)



Vp/U* vs. d
(glass)



Run#	5		Bed Roughness k:	0	mm	Streamflow	8.7157 L/s
Date	6-20-95		Pump Setting	slow		Valve Setting	1/2 open
Reach Length	2000	mm	Slope Reading	103.6	mm	Bed Slope	0.0005

		Initial		Intermediate		Final	
Temperature		19	°C			19.5	°C
Manometer in. of water	Hi	43.07		43		43.05	
	Lo	21.2		21.25		21.3	
	Hi - Lo	21.87		21.75		21.75	
Flow Depth:	u.s.	69.4	mm	69.4	mm	69.1	mm
	d.s.	69.5	mm	69.4	mm	69.1	mm
	u.s. - d.s.	-0.1	mm	0	mm	0	mm
	at weir	68.3	mm	68.9	mm	68.58	mm
Top Width:	u.s.	673	mm	673	mm	670	mm
	d.s.	667	mm	664	mm	665	mm
	at weir	674	mm	676	mm	677	mm

Velocities (mm/s)

type	steel	193.2367	195.5034	188.1468	209.8636	193.4236	ERR	ERR
d (mm)	19.04	189.7533	207.2539	199.4018	209.8636	197.2387	ERR	ERR
n	15	209.2050	214.5923	216.9197	199.4018	196.8504	ERR	ERR
G	8.02			Std Dev	9.1639		Avg	201.3770

Velocities (mm/s)

type	steel	192.3077	184.6722	192.1230	200.2002	190.4762	ERR	ERR
d (mm)	15.88	192.1230	200.6018	195.8864	200.0000	185.3568	ERR	ERR
n	15	189.9335	200.0000	195.1220	191.7546	192.1230	ERR	ERR
G	8.02			Std Dev	5.1019		Avg	193.5120

Velocities (mm/s)

type	steel	192.6782	190.4762	191.2046	186.3933	195.8864	ERR	ERR
d (mm)	14.28	203.2520	185.5288	191.0220	194.3635	193.4236	ERR	ERR
n	15	189.3939	189.0359	186.5672	193.0502	197.4334	ERR	ERR
G	8.02			Std Dev	4.6500		Avg	191.9806

Velocities (mm/s)

type	steel	178.4121	168.4920	185.0139	177.6199	167.0844	165.5629	ERR
d (mm)	9.5	171.5266	159.6169	174.3679	167.5042	166.6667	163.1321	ERR
n	18	167.9261	173.6111	173.0104	182.3154	167.0844	178.5714	ERR
G	8.02			Std Dev	6.8445		Avg	171.5288

Velocities (mm/s)

type	steel	168.7764	153.3742	166.6667	155.0388	156.3722	165.4260	ERR
d (mm)	7.9	157.6044	163.5323	167.0844	159.1090	162.4695	164.7446	ERR
n	18	158.3531	163.6661	160.0000	159.7444	164.6091	151.5152	ERR
G	8.02			Std Dev	4.9804		Avg	161.0048

Velocities (mm/s)

type	steel	153.8462	150.3759	144.8226	157.8532	152.0913	149.2537	ERR
d (mm)	6.34	148.8095	167.7852	151.2859	157.7287	144.0922	156.8627	ERR
n	18	151.7451	162.9992	154.5595	144.1961	162.0746	152.0913	ERR
G	8.02			Std Dev	6.5498		Avg	153.4707

Velocities (mm/s)

type	steel	162.6016	144.5087	144.0922	145.4545	136.6120	127.7955	141.0437
d (mm)	4.75	140.6470	140.0560	134.0483	137.6462	133.9585	141.8440	128.5347
n	21	132.5381	132.2751	134.7709	139.9580	148.1481	139.4700	127.7955
G	8.02			Std Dev	7.9923		Avg	138.7523

Velocities (mm/s)

type	steel	119.4030	120.7729	127.7955	120.6273	125.0000	121.6545	ERR
d (mm)	3.14	120.2646	115.3403	130.8901	120.3369	117.8550	109.7093	ERR
n	18	132.5381	122.8501	122.1001	111.7318	124.4555	114.3511	ERR
G	8.02			Std Dev	6.0066		Avg	120.9820

Velocities (mm/s)

type	steel	86.0215	79.8722	80.1282	79.5229	81.5328	76.3942	74.9344
d (mm)	1.57	79.9041	75.9013	76.8640	75.2729	76.3650	79.3336	73.7191
n	21	79.3336	75.5572	78.3085	85.3242	77.2798	82.4063	79.3021
G	8.02			Std Dev	3.2457		Avg	78.7275

Velocities (mm/s)

type	glass	234.4666	229.3578	251.8892	236.9668	245.0980	259.0674	ERR
d (mm)	29.3	227.7904	263.5046	234.4666	232.8289	243.6054	254.7771	ERR
n	18	249.0660	248.1390	247.8315	238.0952	234.4666	235.2941	ERR
G	2.6			Std Dev	10.4145		Avg	242.5951

Velocities (mm/s)

type	glass	239.8082	253.8071	225.2252	230.4147	238.0952	240.0960	ERR
d (mm)	25.17	232.5581	226.2443	242.7184	233.9181	222.2222	233.6449	ERR
n	18	228.8330	214.3623	238.6635	234.7418	218.8184	249.0660	ERR
G	2.6			Std Dev	10.1017		Avg	233.5132

Velocities (mm/s)

type	glass	220.5072	222.9654	231.2139	216.9197	224.4669	216.9197	ERR
d (mm)	21.7	232.8289	218.5792	222.9654	213.9037	225.9887	227.7904	ERR
n	18	224.7191	225.2252	219.2982	220.7506	231.7497	228.5714	ERR
G	2.6			Std Dev	5.4645		Avg	223.6313

		Velocities (mm/s)						
type	glass	224.7191	214.3623	218.8184	199.4018	193.6108	217.3913	ERR
d (mm)	15.97	219.5390	216.6847	212.9925	202.8398	215.7497	210.9705	ERR
n	18	218.1025	211.1932	202.0202	204.7083	219.7802	215.2853	ERR
G	2.6			Std Dev	8.3325		Avg	212.1205

		Velocities (mm/s)						
type	glass	204.2901	195.3125	213.9037	220.0220	195.8864	186.0465	ERR
d (mm)	14.48	189.9335	201.4099	193.9864	207.9002	205.7613	207.2539	ERR
n	18	212.0891	216.2162	202.6342	204.4990	203.2520	215.5172	ERR
G	2.6			Std Dev	9.3977		Avg	204.2175

Run# 5 Bed
Date: 6-20-95 Roughness k: 0 mm y/k: ERR

Slope: 0.0005 Q: 8.715652 L/s U*: 0.0141 m/s

	u.s.	d.s.	avg
y (mm)	69.3	69.33333	69.31667
Tw (mm)	672	665.3333	668.6667
A (m^2)	0.03142755	0.031212	0.03132
P (m)	0.69345279	0.687123	0.690287
Rh (m)	0.04532039	0.045424	0.045372
V (m/s)	0.27732523	0.279244	0.278285
H (m)	0.07403128	0.073309	0.07367

delta H: 0.0007222 m delta x: 1.62 m

Sf: 0.00044581

Tavg: 19.25 °C

ν: 1.0224E-06 m^2/s

δ: 0.00084209 m

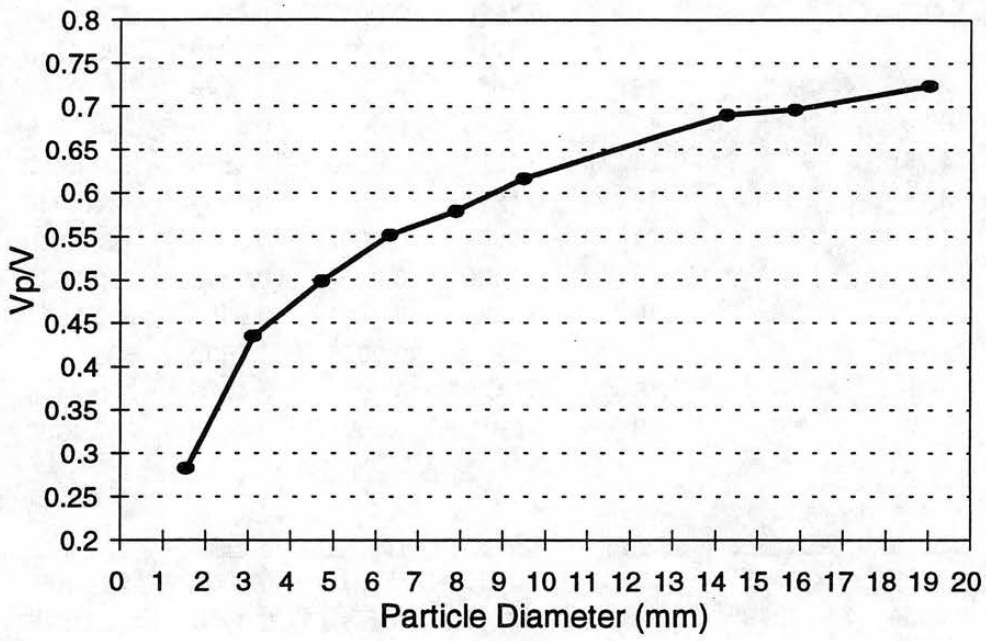
Run# 5

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	15	0.2014	0.0092	1.0794	768.8992	0.000151
steel	15.88	8.02	15	0.1935	0.0051	0.9857	641.2878	0.000181
steel	14.28	8.02	15	0.1920	0.0047	0.9346	576.6744	0.000202
steel	9.5	8.02	18	0.1715	0.0068	0.7619	383.6420	0.000303
steel	7.9	8.02	18	0.1610	0.0050	0.6945	319.0286	0.000365
steel	6.34	8.02	18	0.1535	0.0065	0.6218	256.0305	0.000454
steel	4.75	8.02	21	0.1388	0.0080	0.5376	191.8210	0.000607
steel	3.14	8.02	18	0.1210	0.0060	0.4359	126.8038	0.000918
steel	1.57	8.02	21	0.0787	0.0032	0.3049	63.4019	0.001835
glass	29.3	2.6	18	0.2426	0.0104	0.6392	722.7660	0.000431
glass	25.17	2.6	18	0.2335	0.0101	0.5924	620.8881	0.000502
glass	21.7	2.6	18	0.2236	0.0055	0.5500	535.2909	0.000583
glass	15.97	2.6	18	0.2121	0.0083	0.4716	393.9445	0.000792
glass	14.48	2.6	18	0.2042	0.0094	0.4490	357.1895	0.000873

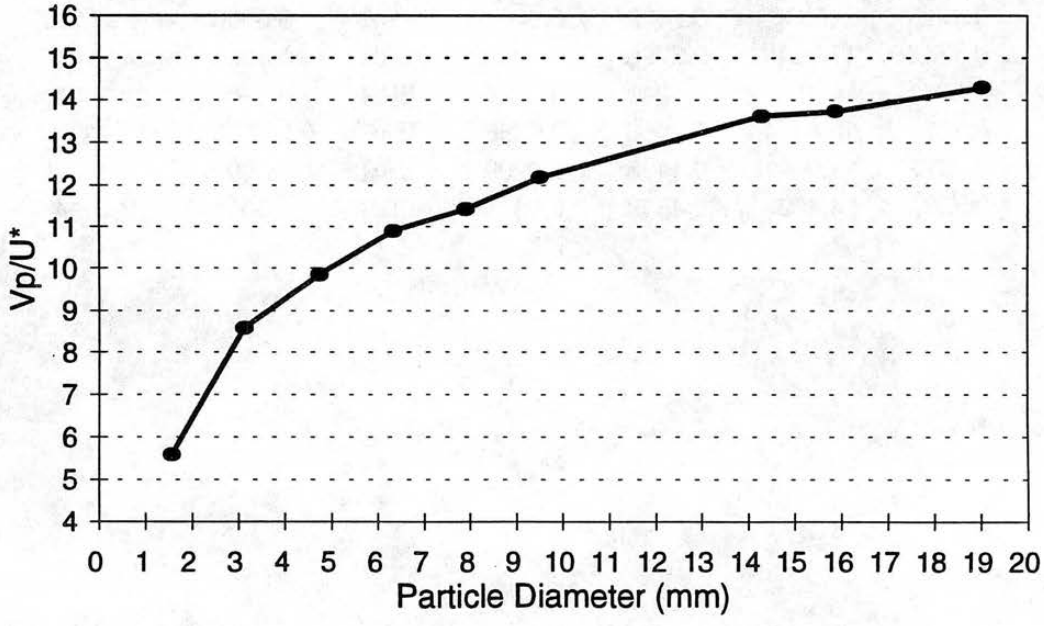
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.7236	14.2983	0.1866	0.0130	ERR	0.0000	22.6105	3.6406
steel	0.6954	13.7398	0.1963	0.0143	ERR	0.0000	18.8579	4.3650
steel	0.6899	13.6311	0.2054	0.0151	ERR	0.0000	16.9579	4.8541
steel	0.6164	12.1790	0.2251	0.0185	ERR	0.0000	11.2815	7.2965
steel	0.5786	11.4317	0.2318	0.0203	ERR	0.0000	9.3815	8.7743
steel	0.5515	10.8968	0.2468	0.0226	ERR	0.0000	7.5289	10.9332
steel	0.4986	9.8518	0.2581	0.0262	ERR	0.0000	5.6408	14.5930
steel	0.4347	8.5900	0.2775	0.0323	ERR	0.0000	3.7288	22.0754
steel	0.2829	5.5898	0.2582	0.0462	ERR	0.0000	1.8644	44.1507
glass	0.8718	17.2249	0.3795	0.0220	ERR	0.0000	34.7945	2.3658
glass	0.8391	16.5800	0.3942	0.0238	ERR	0.0000	29.8900	2.7539
glass	0.8036	15.8784	0.4066	0.0256	ERR	0.0000	25.7693	3.1943
glass	0.7622	15.0611	0.4498	0.0299	ERR	0.0000	18.9648	4.3404
glass	0.7338	14.4999	0.4548	0.0314	ERR	0.0000	17.1954	4.7871

Run 5
U* = 0.0141 m/s

Vp/V vs. d
(steel)

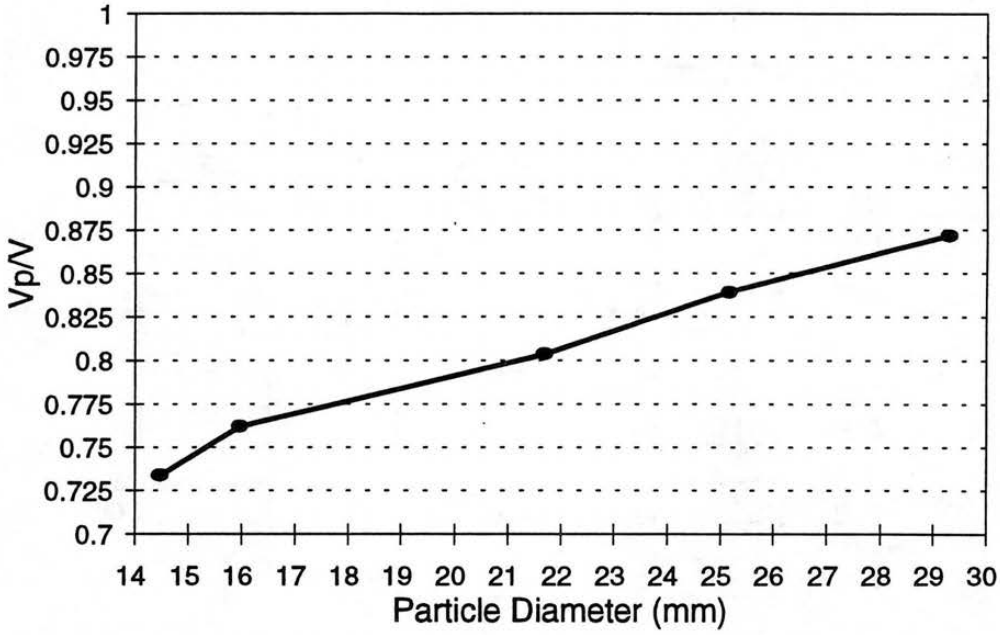


Vp/U* vs. d
(steel)

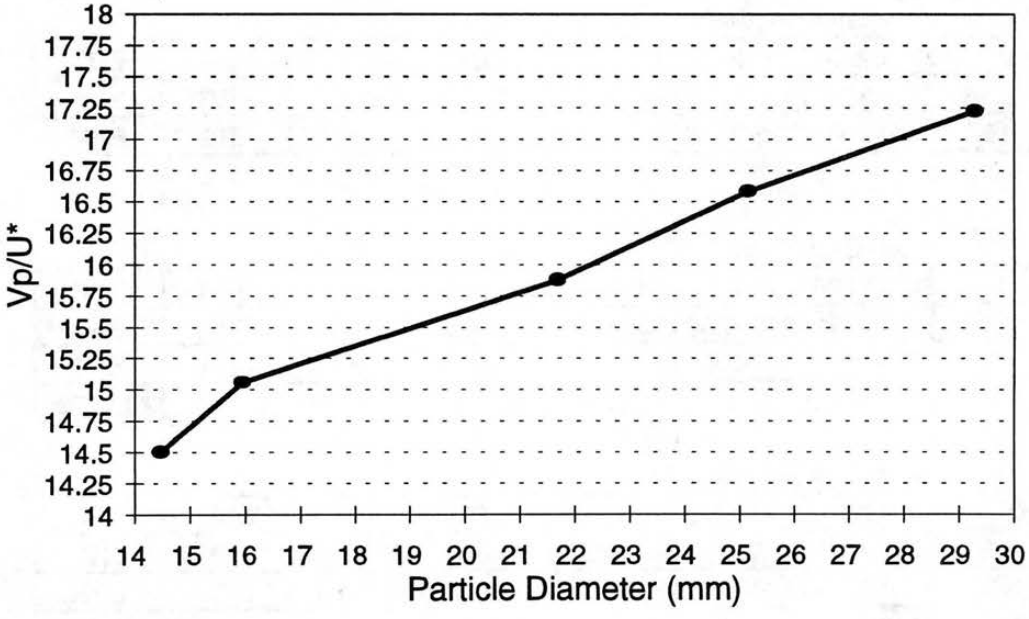


Run 5
U* = 0.0141 m/s

Vp/V vs. d
(glass)



Vp/U* vs. d
(glass)



Run#	6		Bed Roughness k:	0	mm	Streamflow	5.6083 L/s
Date	6-21-95		Pump Setting	slow		Valve Setting	3/8 open
Reach Length	2000	mm	Slope Reading	105	mm	Bed Slope	0.0007

		Initial		Intermediate		Final	
Temperature		19	°C			19.5	°C
Manometer in. of water	Hi	35.28		35.3		35.2	
	Lo	26.22		26.2		26.15	
	Hi - Lo	9.06		9.1		9.05	
Flow Depth:	u.s.	52.4	mm	52.3	mm	52	mm
	d.s.	52.4	mm	52.2	mm	52.1	mm
	u.s. - d.s.	0	mm	0.1	mm	-0.1	mm
	at weir	51.8	mm	51.7	mm	51.5	mm
Top Width:	u.s.	579	mm	577	mm	577	mm
	d.s.	572	mm	570	mm	566	mm
	at weir	577	mm	574	mm	571	mm

Velocities (mm/s)

type	steel	220.0220	223.7136	211.1932	208.7683	208.9864	ERR	ERR
d (mm)	19.04	207.9002	206.1856	220.7506	216.2162	215.0538	ERR	ERR
n	15	210.0840	221.2389	222.2222	216.9197	212.5399	ERR	ERR
G	8.02			Std Dev	5.8407		Avg	214.7863

Velocities (mm/s)

type	steel	204.2901	197.2387	200.0000	214.3623	201.4099	ERR	ERR
d (mm)	15.88	207.2539	196.8504	211.1932	217.6279	200.2002	ERR	ERR
n	15	200.0000	223.7136	207.0393	204.4990	208.1165	ERR	ERR
G	8.02			Std Dev	7.7663		Avg	206.2530

Velocities (mm/s)

type	steel	195.1220	212.7660	195.6947	200.0000	202.8398	ERR	ERR
d (mm)	14.28	202.4291	206.8252	203.6660	196.8504	200.6018	ERR	ERR
n	15	198.2161	200.0000	200.4008	191.7546	195.5034	ERR	ERR
G	8.02			Std Dev	5.2143		Avg	200.1780

Velocities (mm/s)

type	steel	178.7310	175.4386	171.9690	180.8318	178.4121	ERR	ERR
d (mm)	9.5	175.4386	175.9015	181.1594	176.3668	179.0510	ERR	ERR
n	15	174.3679	183.4862	173.9130	175.4386	170.0680	ERR	ERR
G	8.02			Std Dev	3.5925		Avg	176.7049

		Velocities (mm/s)						
type	steel	158.8562	160.3849	172.1170	165.0165	156.1280	ERR	ERR
d (mm)	7.9	166.9449	166.2510	177.4623	159.2357	173.4605	ERR	ERR
n	15	160.3849	169.6353	173.0104	162.9992	167.2241	ERR	ERR
G	8.02			Std Dev	6.3048		Avg	165.9407

		Velocities (mm/s)						
type	steel	164.7446	159.7444	154.5595	148.1481	155.6420	ERR	ERR
d (mm)	6.34	161.1604	153.4919	155.0388	155.7632	152.6718	ERR	ERR
n	15	161.2903	159.8721	160.9010	159.2357	162.6016	ERR	ERR
G	8.02			Std Dev	4.4654		Avg	157.6577

		Velocities (mm/s)						
type	steel	144.8226	140.4494	140.0560	135.8696	150.2630	135.3180	ERR
d (mm)	4.75	142.8571	142.3488	129.5337	128.2051	141.1433	140.9443	ERR
n	18	141.3428	133.7793	137.6462	131.9261	135.3180	139.5673	ERR
G	8.02			Std Dev	5.5316		Avg	138.4106

		Velocities (mm/s)						
type	steel	130.1236	127.8772	123.7624	122.3990	117.2333	123.7624	ERR
d (mm)	3.14	131.9261	120.7729	116.1440	119.4743	122.1747	114.4820	ERR
n	18	119.5457	121.8769	121.5805	114.4820	116.0093	125.2348	ERR
G	8.02			Std Dev	5.0477		Avg	121.6034

		Velocities (mm/s)						
type	steel	84.7458	86.6551	79.4281	86.6176	79.2079	86.9565	ERR
d (mm)	1.57	78.8955	85.8001	79.3021	76.8344	82.9876	85.9476	ERR
n	18	75.8438	81.3008	73.7463	83.2639	74.0741	77.2201	ERR
G	8.02			Std Dev	4.4820		Avg	81.0460

		Velocities (mm/s)						
type	glass	249.0660	262.1232	246.0025	250.9410	257.0694	ERR	ERR
d (mm)	29.3	251.8892	267.7376	254.7771	249.0660	257.0694	ERR	ERR
n	15	249.0660	259.0674	257.0694	243.3090	256.0819	ERR	ERR
G	2.6			Std Dev	6.4292		Avg	254.0223

		Velocities (mm/s)						
type	glass	244.2002	246.0025	250.0000	251.5723	242.1308	ERR	ERR
d (mm)	25.17	236.9668	240.6739	247.8315	250.9410	250.9410	ERR	ERR
n	15	236.1275	232.8289	236.6864	229.3578	250.0000	ERR	ERR
G	2.6			Std Dev	7.3218		Avg	243.0840

		Velocities (mm/s)						
type	glass	240.6739	233.6449	247.2188	259.0674	236.1275	ERR	ERR
d (mm)	21.7	240.6739	242.4242	232.8289	235.2941	239.8082	ERR	ERR
n	15	243.3090	231.7497	245.3988	244.4988	236.1275	ERR	ERR
G	2.6			Std Dev	7.0185		Avg	240.5897

Velocities (mm/s)

type	glass	215.0538	212.7660	225.9887	215.7497	218.1025	ERR	ERR
d (mm)	15.97	215.7497	214.8228	215.9827	227.5313	217.1553	ERR	ERR
n	15	218.5792	229.6211	210.7482	239.8082	224.4669	ERR	ERR
G	2.6			Std Dev	7.8027		Avg	220.1417

Velocities (mm/s)

type	glass	212.5399	208.7683	207.6843	220.9945	205.1282	ERR	ERR
d (mm)	14.48	210.5263	213.6752	209.6436	208.3333	218.1025	ERR	ERR
n	15	220.7506	211.8644	202.6342	220.0220	216.9197	ERR	ERR
G	2.6			Std Dev	5.7800		Avg	212.5058

Run# 6 Bed
Date: 6-21-95 Roughness k: 0 mm y/k: ERR

Slope: 0.0007 Q: 5.608323 L/s U*: 0.0152 m/s

	u.s.	d.s.	avg
y (mm)	52.2333333	52.23333	52.23333
Tw (mm)	577.666667	569.3333	573.5
A (m^2)	0.02122414	0.021007	0.021115
P (m)	0.59323697	0.585274	0.589253
Rh (m)	0.03577684	0.035892	0.035834
V (m/s)	0.26424261	0.26698	0.265611
H (m)	0.05692737	0.055868	0.056397

delta H: 0.0010598 m delta x: 1.62 m

Sf: 0.00065423

Tavg: 19.25 °C

ν: 1.0224E-06 m^2/s

δ: 0.00078219 m

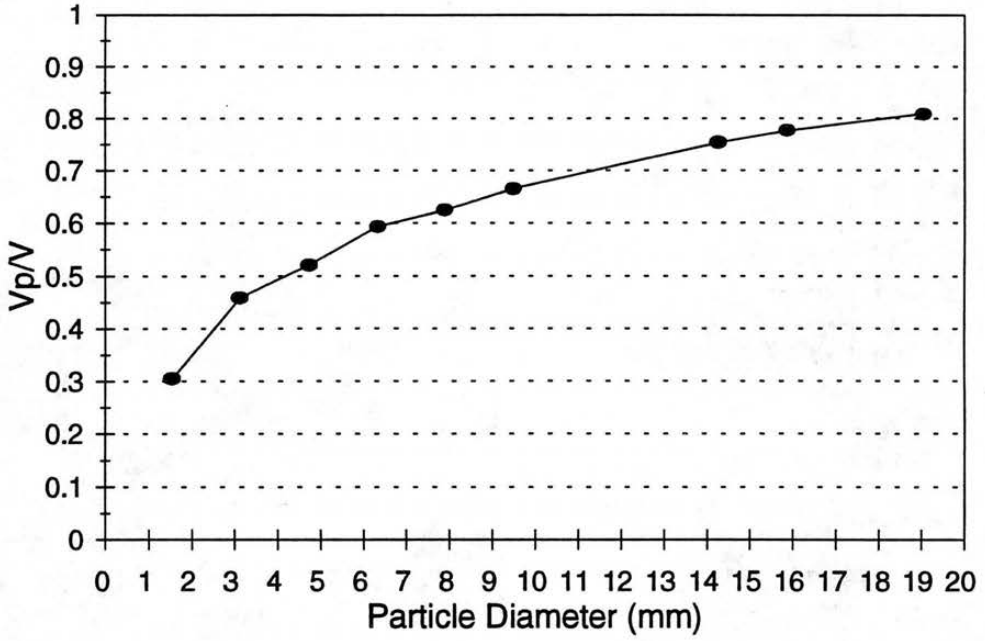
Run# 6

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	15	0.2148	0.0058	1.0794	768.8992	0.000175
steel	15.88	8.02	15	0.2063	0.0078	0.9857	641.2878	0.000210
steel	14.28	8.02	15	0.2002	0.0052	0.9346	576.6744	0.000234
steel	9.5	8.02	15	0.1767	0.0036	0.7619	383.6420	0.000352
steel	7.9	8.02	15	0.1659	0.0063	0.6945	319.0286	0.000423
steel	6.34	8.02	15	0.1577	0.0045	0.6218	256.0305	0.000527
steel	4.75	8.02	18	0.1384	0.0055	0.5376	191.8210	0.000703
steel	3.14	8.02	18	0.1216	0.0050	0.4359	126.8038	0.001064
steel	1.57	8.02	18	0.0810	0.0045	0.3049	63.4019	0.002127
glass	29.3	2.6	15	0.2540	0.0064	0.6392	722.7660	0.000500
glass	25.17	2.6	15	0.2431	0.0073	0.5924	620.8881	0.000582
glass	21.7	2.6	15	0.2406	0.0070	0.5500	535.2909	0.000675
glass	15.97	2.6	15	0.2201	0.0078	0.4716	393.9445	0.000917
glass	14.48	2.6	15	0.2125	0.0058	0.4490	357.1895	0.001012

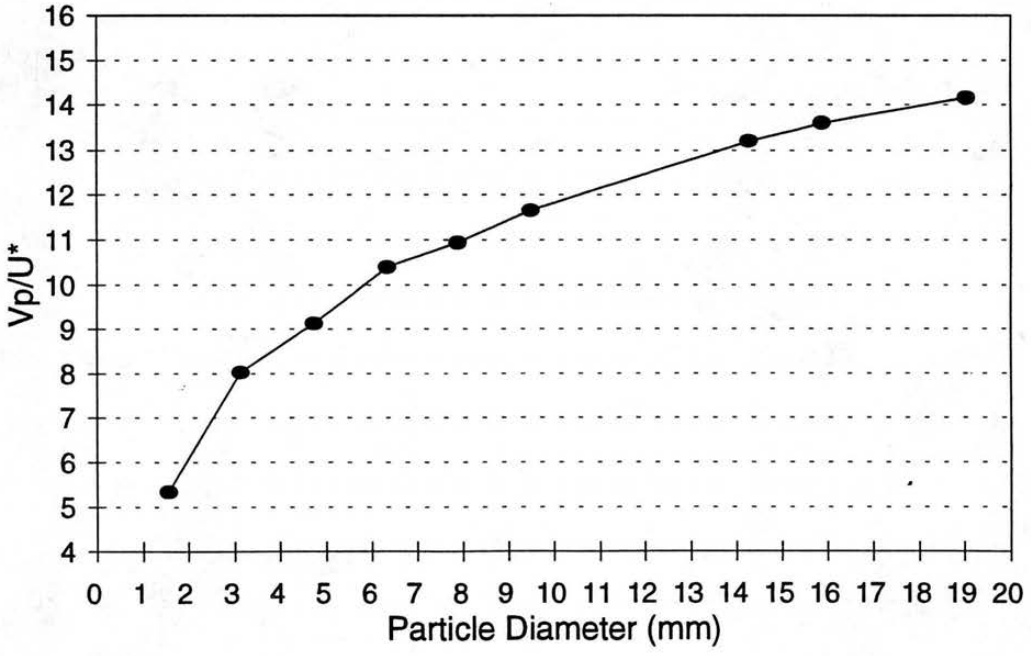
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.8086	14.1656	0.1990	0.0140	ERR	0.0000	24.3420	2.7433
steel	0.7765	13.6028	0.2093	0.0154	ERR	0.0000	20.3021	3.2893
steel	0.7536	13.2021	0.2142	0.0162	ERR	0.0000	18.2565	3.6578
steel	0.6653	11.6540	0.2319	0.0199	ERR	0.0000	12.1454	5.4982
steel	0.6247	10.9441	0.2389	0.0218	ERR	0.0000	10.0999	6.6118
steel	0.5936	10.3978	0.2535	0.0244	ERR	0.0000	8.1055	8.2387
steel	0.5211	9.1284	0.2574	0.0282	ERR	0.0000	6.0727	10.9965
steel	0.4578	8.0200	0.2790	0.0348	ERR	0.0000	4.0144	16.6348
steel	0.3051	5.3451	0.2658	0.0497	ERR	0.0000	2.0072	33.2696
glass	0.9564	16.7533	0.3974	0.0237	ERR	0.0000	37.4591	1.7827
glass	0.9152	16.0318	0.4103	0.0256	ERR	0.0000	32.1790	2.0752
glass	0.9058	15.8673	0.4374	0.0276	ERR	0.0000	27.7427	2.4071
glass	0.8288	14.5188	0.4668	0.0321	ERR	0.0000	20.4171	3.2707
glass	0.8001	14.0152	0.4733	0.0338	ERR	0.0000	18.5122	3.6073

Run 6
U* = 0.0152

Vp/V vs. d
(steel)

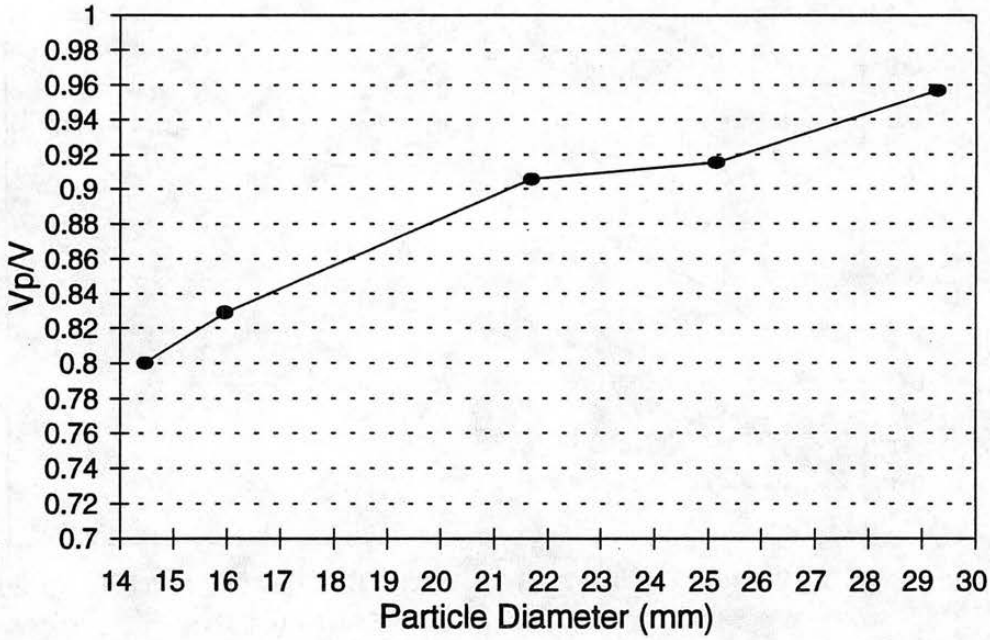


Vp/U* vs. d
(steel)

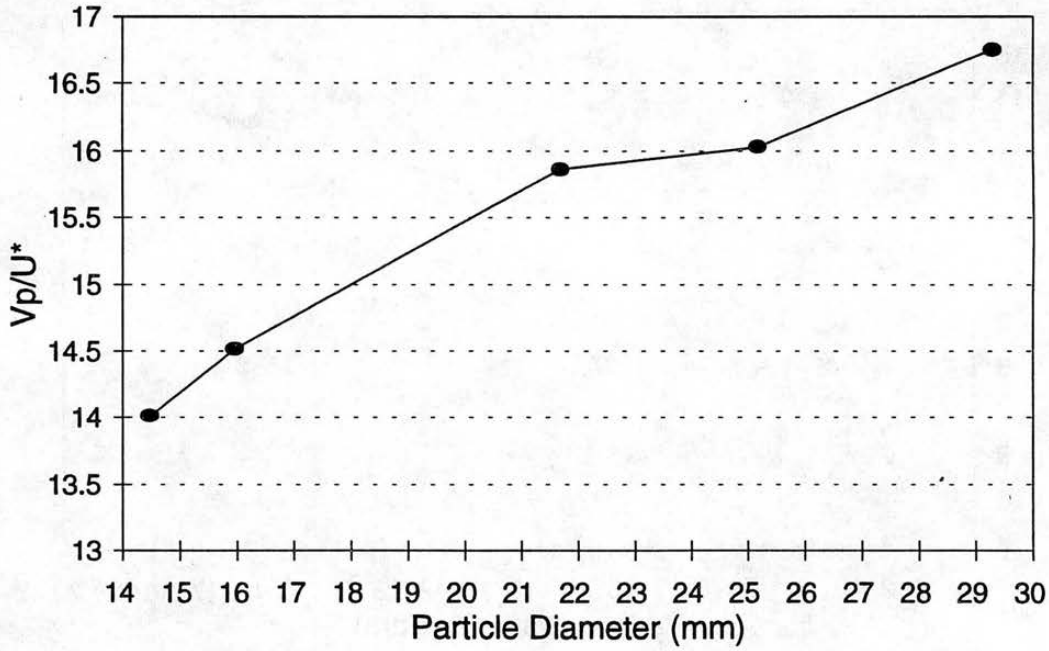


Run 6
U* = 0.0152

Vp/V vs. d
(glass)



Vp/U* vs. d
(glass)



Run#	7	Bed Roughness k:	0	mm	Streamflow	7.8242	L/s
Date	6-22-95	Pump Setting	medium		Valve Setting	5/16 open	
Reach Length	2000	mm	Slope Reading	107.3	mm	Bed Slope	0.001

		Initial		Intermediate		Final	
Temperature		19	°C			19	°C
Manometer in. of water	Hi	33.45		33.5		33.5	
	Lo	15.9		15.9		15.9	
	Hi - Lo	17.55		17.6		17.6	
Flow Depth:	u.s.	60.5	mm	60.4	mm	60.6	mm
	d.s.	60.5	mm	60.5	mm	60.7	mm
	u.s. - d.s.	0	mm	-0.1	mm	-0.1	mm
	at weir	60.4	mm	60.4	mm	60.4	mm
Top Width:	u.s.	611	mm	616	mm	616	mm
	d.s.	612	mm	614	mm	610	mm
	at weir	619	mm	622	mm	623	mm

Velocities (mm/s)

type	steel	222.9654	237.8121	220.5072	244.2002	239.8082	ERR	ERR
d (mm)	19.04	244.2002	246.0025	239.5210	223.7136	238.6635	ERR	ERR
n	15	227.7904	236.6864	244.2002	236.1275	243.0134	ERR	ERR
G	8.02			Std Dev	8.5155		Avg	236.3475

Velocities (mm/s)

type	steel	224.7191	220.5072	227.7904	226.5006	227.0148	213.6752	ERR
d (mm)	15.88	215.5172	233.3722	222.2222	234.4666	236.9668	237.8121	ERR
n	18	227.0148	251.8892	214.8228	221.4839	223.9642	243.9024	ERR
G	8.02			Std Dev	10.2005		Avg	227.9801

Velocities (mm/s)

type	steel	218.5792	222.9654	219.2982	215.7497	225.9887	ERR	ERR
d (mm)	14.28	223.7136	205.1282	227.7904	220.7506	228.5714	ERR	ERR
n	15	227.2727	217.6279	204.0816	209.8636	217.3913	ERR	ERR
G	8.02			Std Dev	7.7502		Avg	218.9848

Velocities (mm/s)

type	steel	189.9335	202.2245	193.9864	192.1230	192.8640	198.8072	193.4236
d (mm)	9.5	208.9864	207.2539	181.3237	216.4502	181.8182	202.2245	193.2367
n	21	203.2520	200.0000	196.8504	209.8636	209.2050	203.8736	208.5506
G	8.02			Std Dev	9.2622		Avg	199.3453

Velocities (mm/s)

type	steel	185.5288	192.8640	207.6843	203.0457	223.7136	200.6018	193.6108
d (mm)	7.9	211.8644	205.7613	194.5525	191.5709	204.0816	197.8239	193.7984
n	21	200.0000	196.6568	181.4882	187.6173	187.7934	202.4291	185.5288
G	8.02			Std Dev	10.0238		Avg	197.5246

Velocities (mm/s)

type	steel	171.2329	178.5714	182.8154	203.4588	186.5672	179.6945	ERR
d (mm)	6.34	186.0465	194.1748	188.1468	198.0198	203.2520	196.4637	ERR
n	18	188.3239	199.6008	188.3239	174.3679	178.0944	192.8640	ERR
G	8.02			Std Dev	9.6830		Avg	188.3344

Velocities (mm/s)

type	steel	182.3154	177.6199	171.0864	178.7310	162.4695	164.3385	ERR
d (mm)	4.75	165.9751	173.7619	167.5042	172.8608	175.2848	174.2160	ERR
n	18	162.0746	184.6722	176.8347	170.5030	169.7793	165.2893	ERR
G	8.02			Std Dev	6.6171		Avg	171.9620

Velocities (mm/s)

type	steel	147.4926	143.1639	139.7624	148.9203	157.9779	ERR	ERR
d (mm)	3.14	149.8127	144.8226	150.3759	153.8462	148.8095	ERR	ERR
n	15	155.0388	159.3625	158.1028	146.3058	145.6664	ERR	ERR
G	8.02			Std Dev	5.8367		Avg	149.9640

Velocities (mm/s)

type	steel	104.6025	96.3855	105.7641	98.1836	102.0929	107.7006	ERR
d (mm)	1.57	102.6694	112.4859	114.6789	106.3264	100.2506	109.8901	ERR
n	18	99.1572	106.8376	107.2386	103.5197	102.3018	110.3753	ERR
G	8.02			Std Dev	4.9789		Avg	105.0256

Velocities (mm/s)

type	glass	281.6901	284.4950	279.7203	280.8989	294.9853	ERR	ERR
d (mm)	29.3	280.5049	280.1120	286.9440	268.0965	290.6977	ERR	ERR
n	15	282.8854	275.8621	289.4356	273.5978	290.6977	ERR	ERR
G	2.6			Std Dev	7.1365		Avg	282.7082

Velocities (mm/s)

type	glass	275.4821	279.7203	256.4103	272.1088	260.7562	ERR	ERR
d (mm)	25.17	261.7801	265.6042	267.3797	264.2008	263.1579	ERR	ERR
n	15	265.2520	280.1120	282.0874	280.1120	262.4672	ERR	ERR
G	2.6			Std Dev	8.4147		Avg	269.1087

Velocities (mm/s)

type	glass	266.6667	248.7562	259.0674	267.7376	261.0966	ERR	ERR
d (mm)	21.7	263.5046	257.0694	253.1646	264.5503	255.7545	ERR	ERR
n	15	249.0660	254.1296	268.8172	250.0000	252.8445	ERR	ERR
G	2.6			Std Dev	6.9213		Avg	258.1483

		Velocities (mm/s)						
type	glass	241.8380	240.0960	216.9197	228.8330	229.8851	259.0674	245.3988
d (mm)	15.97	243.6054	234.1920	226.7574	242.7184	261.7801	236.9668	252.8445
n	21	246.6091	253.4854	235.8491	237.5297	227.7904	250.6266	235.8491
G	2.6			Std Dev	11.3102		Avg	240.4115

		Velocities (mm/s)						
type	glass	219.2982	240.6739	250.0000	247.2188	224.7191	232.8289	ERR
d (mm)	14.48	248.1390	236.1275	241.5459	247.8315	239.5210	238.6635	ERR
n	18	231.7497	231.2139	250.9410	246.6091	245.0980	228.5714	ERR
G	2.6			Std Dev	9.2600		Avg	238.9306

Run# 7 Bed
Date: 6-22-95 Roughness k: 0 mm y/k: ERR

Slope: 0.001 Q: 7.82425 L/s U*: 0.0194 m/s

	u.s.	d.s.	avg
y (mm)	60.5	60.56667	60.53333
Tw (mm)	614.333333	612	613.1667
A (m²)	0.02569233	0.02565	0.025671
P (m)	0.63316426	0.630983	0.632073
Rh (m)	0.04057767	0.040651	0.040614
V (m/s)	0.30453635	0.305039	0.304788
H (m)	0.06684855	0.065311	0.06608

delta H: 0.0015377 m delta x: 1.62 m

Sf: 0.0009492

Tavg: 19 °C

ν: 1.0286E-06 m²/s

δ: 0.00061368 m

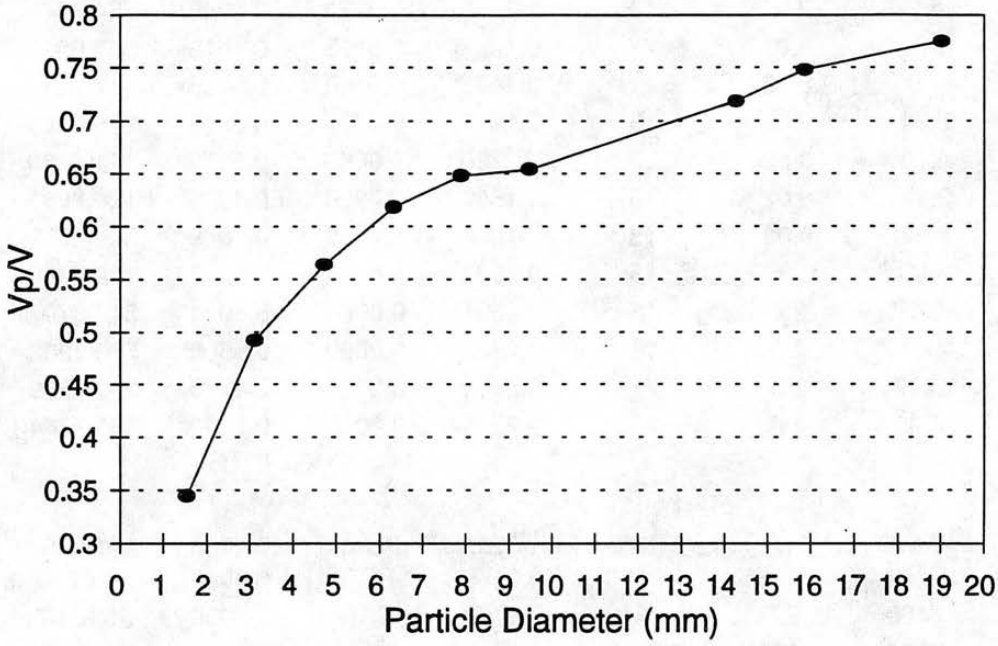
Run# 7

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	15	0.2363	0.0085	1.0794	765.7928	0.000288
steel	15.88	8.02	18	0.2280	0.0102	0.9857	638.6970	0.000346
steel	14.28	8.02	15	0.2190	0.0078	0.9346	574.3446	0.000385
steel	9.5	8.02	21	0.1993	0.0093	0.7619	382.0920	0.000578
steel	7.9	8.02	21	0.1975	0.0100	0.6945	317.7397	0.000695
steel	6.34	8.02	18	0.1883	0.0097	0.6218	254.9961	0.000866
steel	4.75	8.02	18	0.1720	0.0066	0.5376	191.0460	0.001156
steel	3.14	8.02	15	0.1500	0.0058	0.4359	126.2915	0.001749
steel	1.57	8.02	18	0.1050	0.0050	0.3049	63.1457	0.003498
glass	29.3	2.6	15	0.2827	0.0071	0.6392	719.8460	0.000822
glass	25.17	2.6	15	0.2691	0.0084	0.5924	618.3797	0.000957
glass	21.7	2.6	15	0.2581	0.0069	0.5500	533.1283	0.001110
glass	15.97	2.6	21	0.2404	0.0113	0.4716	392.3529	0.001509
glass	14.48	2.6	18	0.2389	0.0093	0.4490	355.7464	0.001664

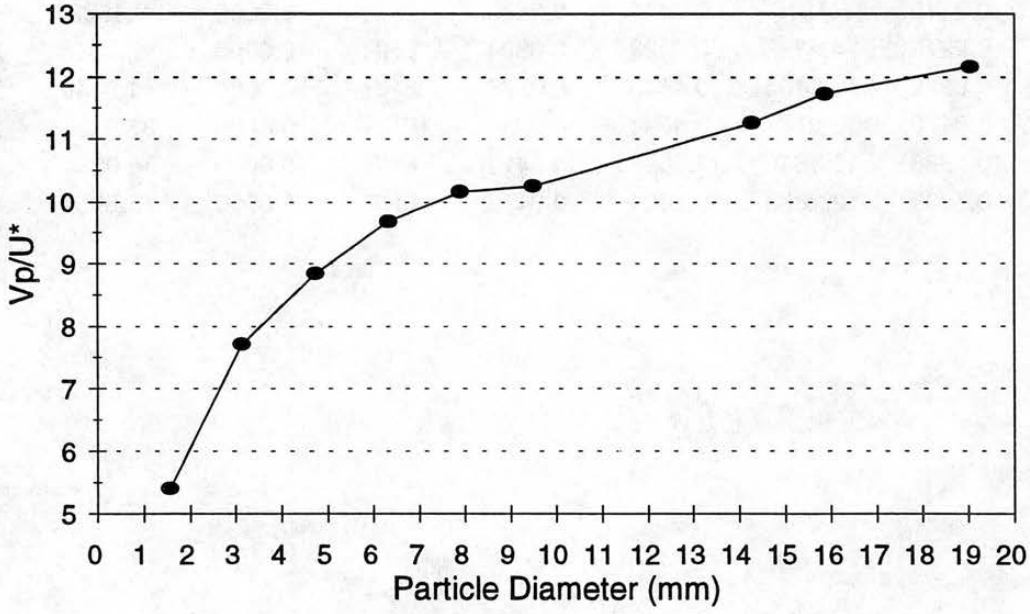
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.7754	12.1555	0.2190	0.0180	ERR	0.0000	31.0260	3.1793
steel	0.7480	11.7251	0.2313	0.0197	ERR	0.0000	25.8767	3.8119
steel	0.7185	11.2625	0.2343	0.0208	ERR	0.0000	23.2695	4.2390
steel	0.6540	10.2524	0.2616	0.0255	ERR	0.0000	15.4804	6.3719
steel	0.6481	10.1588	0.2844	0.0280	ERR	0.0000	12.8732	7.6624
steel	0.6179	9.6861	0.3029	0.0313	ERR	0.0000	10.3311	9.5478
steel	0.5642	8.8441	0.3199	0.0362	ERR	0.0000	7.7402	12.7439
steel	0.4920	7.7127	0.3440	0.0446	ERR	0.0000	5.1167	19.2781
steel	0.3446	5.4015	0.3445	0.0638	ERR	0.0000	2.5583	38.5563
glass	0.9276	14.5398	0.4423	0.0304	ERR	0.0000	47.7448	2.0660
glass	0.8829	13.8404	0.4543	0.0328	ERR	0.0000	41.0149	2.4050
glass	0.8470	13.2767	0.4694	0.0354	ERR	0.0000	35.3605	2.7896
glass	0.7888	12.3645	0.5098	0.0412	ERR	0.0000	26.0234	3.7904
glass	0.7839	12.2883	0.5321	0.0433	ERR	0.0000	23.5954	4.1805

Run 7
U* = 0.0194 m/s

Vp/V vs. d
(steel)

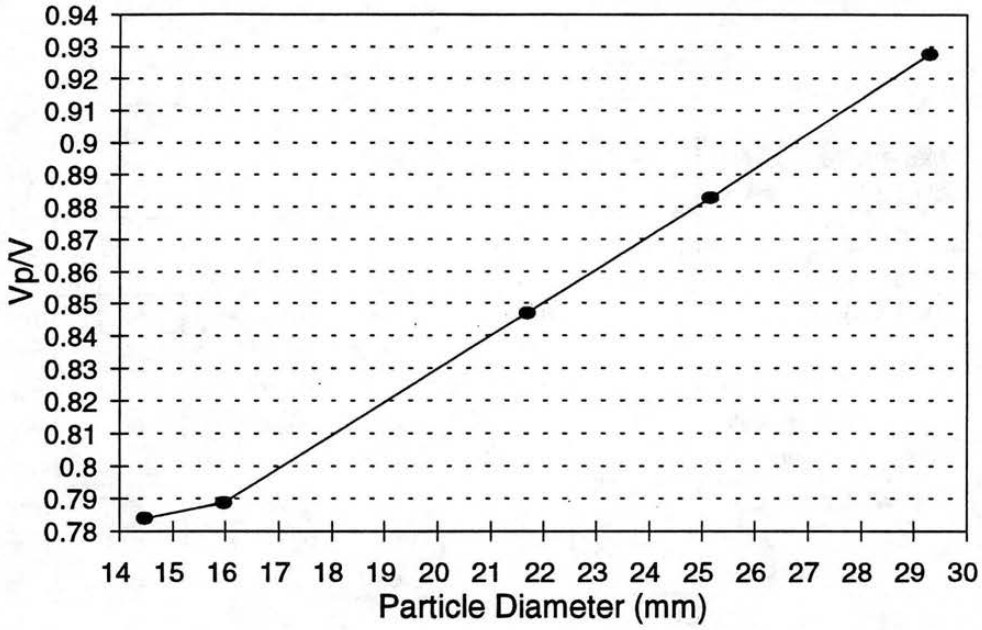


Vp/U* vs. d
(steel)

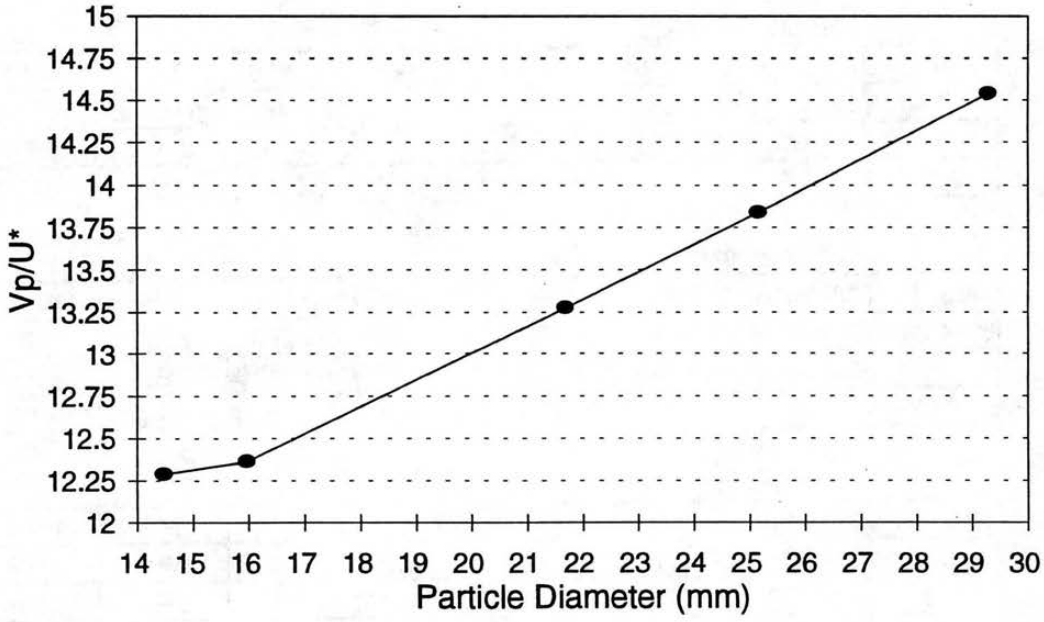


Run 7
U* = 0.0194 m/s

Vp/V vs. d
(glass)



Vp/U* vs. d
(glass)



Run#	8	Bed Roughness k:	0	mm	Streamflow	12.8276	L/s
Date	6-22-95	Pump Setting	medium		Valve Setting	1/2 open	
Reach Length	2000	mm	Slope Reading	110	mm	Bed Slope	0.0014

		Initial		Intermediate		Final	
Temperature		19	°C			20	°C
Manometer in. of water	Hi	49.5		49.85		49.9	
	Lo	2.5		2.9		2.9	
	Hi - Lo	47		46.95		47	
Flow Depth:	u.s.	69.2	mm	69.1	mm	69.1	mm
	d.s.	69.2	mm	69.3	mm	69	mm
	u.s. - d.s.	0	mm	-0.2	mm	0.1	mm
	at weir	69	mm	68.9	mm	68.9	mm
Top Width:	u.s.	667	mm	669	mm	667	mm
	d.s.	668	mm	669	mm	669	mm
	at weir	685	mm	690	mm	689	mm

Velocities (mm/s)

type	steel	304.4140	325.2033	320.5128	300.7519	312.9890	309.1190	297.1768
d (mm)	19.04	305.8104	309.1190	305.8104	318.4713	308.1664	291.5452	293.2551
n	21	294.9853	316.9572	288.1844	304.4140	320.5128	296.2963	312.9890
G	8.02			Std Dev	10.4804		Avg	306.5088

Velocities (mm/s)

type	steel	283.2861	317.9650	284.4950	291.5452	327.8689	289.4356	ERR
d (mm)	15.88	299.4012	321.5434	316.9572	291.9708	294.9853	291.9708	ERR
n	18	298.9537	293.2551	318.4713	289.8551	310.5590	308.6420	ERR
G	8.02			Std Dev	13.9985		Avg	301.7311

Velocities (mm/s)

type	steel	304.8780	297.6190	283.6879	298.9537	280.5049	ERR	ERR
d (mm)	14.28	300.3003	285.7143	301.2048	282.0874	283.2861	ERR	ERR
n	15	293.6858	303.0303	293.6858	293.2551	294.1176	ERR	ERR
G	8.02			Std Dev	8.1532		Avg	293.0674

Velocities (mm/s)

type	steel	267.7376	263.5046	259.7403	267.7376	263.5046	ERR	ERR
d (mm)	9.5	249.6879	262.8121	248.1390	275.8621	263.5046	ERR	ERR
n	15	267.7376	264.9007	262.1232	259.0674	260.4167	ERR	ERR
G	8.02			Std Dev	6.8865		Avg	262.4317

		Velocities (mm/s)						
type	steel	244.4988	255.1020	256.0819	266.6667	278.1641	260.7562	ERR
d (mm)	7.9	252.8445	254.1296	255.1020	257.7320	263.1579	251.2563	ERR
n	18	264.2008	269.9055	260.7562	258.0645	250.9410	250.0000	ERR
G	8.02			Std Dev	8.0652		Avg	258.2978

		Velocities (mm/s)						
type	steel	236.1275	244.7980	241.5459	238.0952	233.6449	247.8315	ERR
d (mm)	6.34	258.0645	242.4242	232.0186	238.0952	245.0980	225.4791	ERR
n	18	233.3722	248.4472	241.5459	243.9024	224.4669	232.8289	ERR
G	8.02			Std Dev	8.3998		Avg	239.3215

		Velocities (mm/s)						
type	steel	220.7506	228.8330	245.3988	224.4669	242.4242	223.7136	ERR
d (mm)	4.75	220.7506	226.2443	232.0186	217.8649	220.0220	208.1165	ERR
n	18	222.9654	229.8851	236.1275	236.9668	231.2139	233.6449	ERR
G	8.02			Std Dev	9.2214		Avg	227.8560

		Velocities (mm/s)						
type	steel	199.4018	224.4669	195.6947	199.2032	209.8636	205.1282	198.2161
d (mm)	3.14	203.6660	188.1468	191.0220	208.5506	205.7613	209.2050	187.7934
n	21	202.0202	185.5288	195.6947	212.7660	195.8864	201.4099	203.0457
G	8.02			Std Dev	9.2700		Avg	201.0701

		Velocities (mm/s)						
type	steel	146.0920	140.9443	138.2170	144.1961	152.3229	150.6024	144.4043
d (mm)	1.57	161.2903	163.6661	153.4919	152.4390	164.2036	158.4786	142.7552
n	21	160.3849	151.9757	142.5517	157.2327	151.9757	147.3839	158.4786
G	8.02			Std Dev	7.7955		Avg	151.5756

		Velocities (mm/s)						
type	glass	365.6307	355.8719	351.4938	372.4395	368.3241	361.6637	ERR
d (mm)	29.3	333.3333	349.6503	376.6478	349.0401	337.8378	363.6364	ERR
n	18	349.6503	357.7818	359.7122	383.1418	363.6364	365.6307	ERR
G	2.6			Std Dev	12.7142		Avg	359.1735

		Velocities (mm/s)						
type	glass	344.2341	329.4893	324.1491	337.8378	344.2341	322.5806	ERR
d (mm)	25.17	338.9831	344.8276	335.0084	327.3322	350.8772	343.0532	ERR
n	18	338.9831	336.7003	365.6307	328.4072	333.8898	341.8803	ERR
G	2.6			Std Dev	10.3771		Avg	338.2277

		Velocities (mm/s)						
type	glass	349.6503	327.8689	331.6750	327.8689	349.6503	ERR	ERR
d (mm)	21.7	331.6750	326.7974	338.9831	354.6099	326.7974	ERR	ERR
n	15	338.4095	332.7787	346.0208	330.0330	334.4482	ERR	ERR
G	2.6			Std Dev	9.3274		Avg	336.4844

		Velocities (mm/s)						
type	glass	312.0125	309.1190	316.9572	315.4574	316.9572	ERR	ERR
d (mm)	15.97	316.9572	302.1148	318.4713	309.5975	298.0626	ERR	ERR
n	15	317.4603	306.7485	312.0125	323.6246	300.7519	ERR	ERR
G	2.6			Std Dev	7.3277		Avg	311.7536

		Velocities (mm/s)						
type	glass	294.9853	318.4713	305.8104	314.4654	307.2197	ERR	ERR
d (mm)	14.48	317.4603	316.9572	306.7485	317.9650	293.2551	ERR	ERR
n	15	304.4140	298.5075	304.8780	316.9572	303.0303	ERR	ERR
G	2.6			Std Dev	8.5849		Avg	308.0750

Run# 8 Bed
Date: 6-22-95 Roughness k: 0 mm y/k: ERR

Slope: 0.0014 Q: 12.82758 L/s U*: 0.0249 m/s

	u.s.	d.s.	avg
y (mm)	69.1333333	69.16667	69.15
Tw (mm)	667.666667	668.6667	668.1667
A (m^2)	0.03120218	0.031252	0.031227
P (m)	0.68922254	0.690195	0.689709
Rh (m)	0.04527156	0.04528	0.045276
V (m/s)	0.41111157	0.410459	0.410785
H (m)	0.08001858	0.077757	0.078888

delta H: 0.0022620 m delta x: 1.62 m

Sf: 0.0013963

Tavg: 19.5 °C

ν: 1.0162E-06 m^2/s

δ: 0.00047344 m

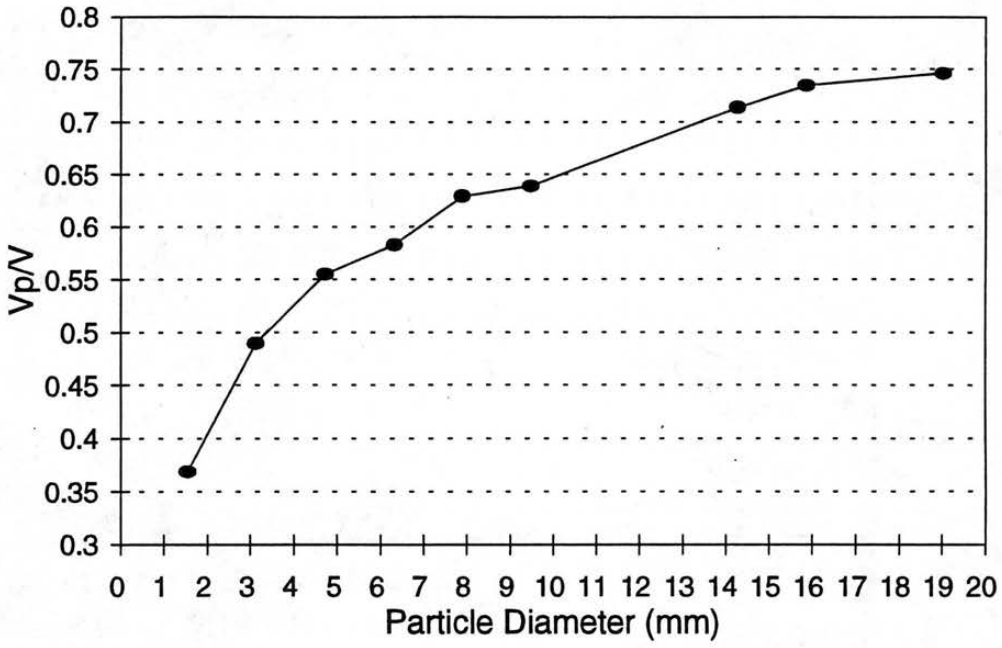
Run# 8

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	21	0.3065	0.0105	1.0794	772.0144	0.000473
steel	15.88	8.02	18	0.3017	0.0140	0.9857	643.8860	0.000567
steel	14.28	8.02	15	0.2931	0.0082	0.9346	579.0108	0.000631
steel	9.5	8.02	15	0.2624	0.0069	0.7619	385.1963	0.000948
steel	7.9	8.02	18	0.2583	0.0081	0.6945	320.3211	0.001140
steel	6.34	8.02	18	0.2393	0.0084	0.6218	257.0678	0.001420
steel	4.75	8.02	18	0.2279	0.0092	0.5376	192.5981	0.001896
steel	3.14	8.02	21	0.2011	0.0093	0.4359	127.3175	0.002868
steel	1.57	8.02	21	0.1516	0.0078	0.3049	63.6588	0.005736
glass	29.3	2.6	18	0.3592	0.0127	0.6392	725.6943	0.001349
glass	25.17	2.6	18	0.3382	0.0104	0.5924	623.4036	0.001570
glass	21.7	2.6	15	0.3365	0.0093	0.5500	537.4596	0.001821
glass	15.97	2.6	15	0.3118	0.0073	0.4716	395.5405	0.002474
glass	14.48	2.6	15	0.3081	0.0086	0.4490	358.6366	0.002729

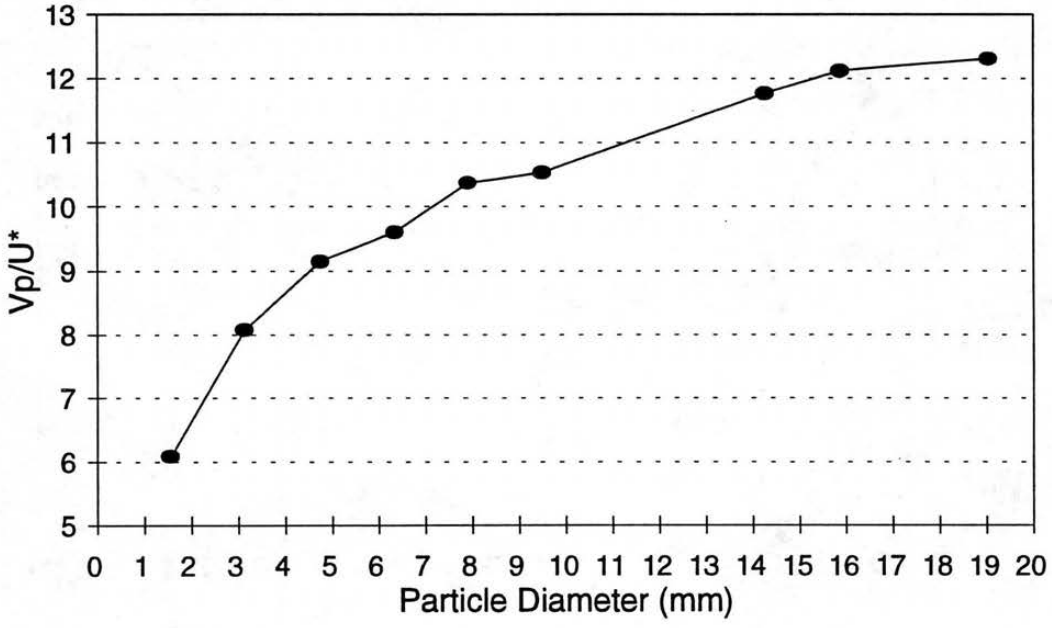
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.7462	12.3101	0.2840	0.0231	ERR	0.0000	40.2161	3.6318
steel	0.7345	12.1182	0.3061	0.0253	ERR	0.0000	33.5416	4.3545
steel	0.7134	11.7702	0.3136	0.0266	ERR	0.0000	30.1621	4.8424
steel	0.6389	10.5398	0.3444	0.0327	ERR	0.0000	20.0658	7.2789
steel	0.6288	10.3738	0.3719	0.0358	ERR	0.0000	16.6863	8.7532
steel	0.5826	9.6117	0.3849	0.0400	ERR	0.0000	13.3913	10.9069
steel	0.5547	9.1512	0.4238	0.0463	ERR	0.0000	10.0329	14.5579
steel	0.4895	8.0754	0.4612	0.0571	ERR	0.0000	6.6323	22.0223
steel	0.3690	6.0876	0.4971	0.0817	ERR	0.0000	3.3161	44.0446
glass	0.8744	14.4252	0.5619	0.0390	ERR	0.0000	61.8872	2.3601
glass	0.8234	13.5840	0.5709	0.0420	ERR	0.0000	53.1639	2.7473
glass	0.8191	13.5140	0.6118	0.0453	ERR	0.0000	45.8346	3.1866
glass	0.7589	12.5207	0.6610	0.0528	ERR	0.0000	33.7317	4.3300
glass	0.7500	12.3730	0.6861	0.0555	ERR	0.0000	30.5845	4.7756

Run 8
U* = 0.0249 m/s

Vp/V vs. d
(steel)

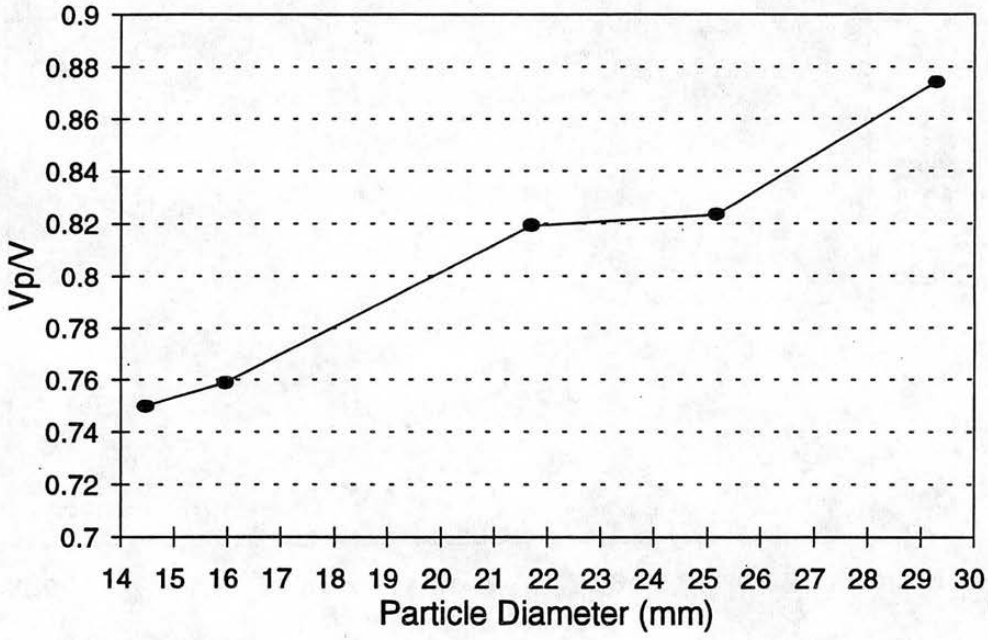


Vp/U* vs. d
(steel)

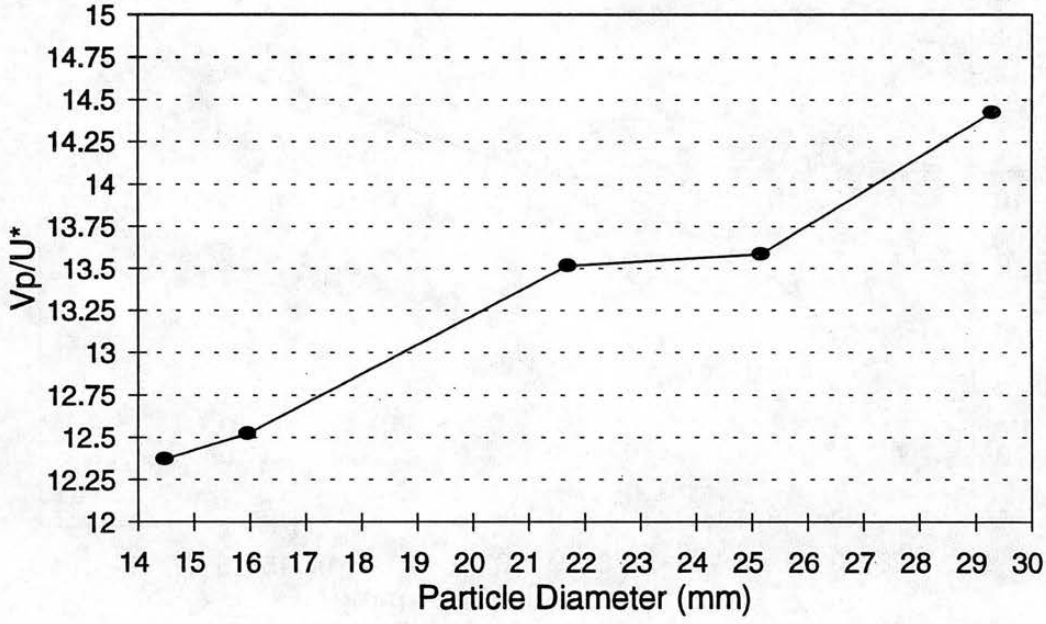


Run 8
U* = 0.0249 m/s

Vp/V vs. d
(glass)



Vp/U* vs. d
(glass)



Run#	9		Bed Roughness k:	0	mm	Streamflow	16.8752 L/s
Date	6-23-95		Pump Setting	fast		Valve Setting	7/16 open
Reach Length	2000	mm	Slope Reading	114.3	mm	Bed Slope	0.002

		Initial		Intermediate		Final	
Temperature		19	°C			20	°C
Manometer in. of water	Hi	39.28		39.28		38.61	
	Lo	-41.99		-41.99		-41.99	
	Hi - Lo	81.27		81.27		80.6	
Flow Depth:	u.s.	69.9	mm	69.8	mm	69.9	mm
	d.s.	69.9	mm	70	mm	70	mm
	u.s. - d.s.	0	mm	-0.2	mm	-0.1	mm
	at weir	69.5	mm	69.6	mm	69.6	mm
Top Width:	u.s.	675	mm	678	mm	678	mm
	d.s.	679	mm	678	mm	679	mm
	at weir	715	mm	714	mm	720	mm

Velocities (mm/s)

type	steel	438.5965	447.4273	448.4305	439.5604	445.4343	ERR	ERR
d (mm)	19.04	443.4590	435.7298	446.4286	438.5965	450.4505	ERR	ERR
n	15	456.6210	445.4343	453.5147	443.4590	466.2005	ERR	ERR
G	8.02			Std Dev	7.8811		Avg	446.6229

Velocities (mm/s)

type	steel	447.4273	423.7288	447.4273	441.5011	445.4343	ERR	ERR
d (mm)	15.88	438.5965	441.5011	430.1075	434.7826	447.4273	ERR	ERR
n	15	440.5286	434.7826	431.9654	442.4779	446.4286	ERR	ERR
G	8.02			Std Dev	7.2138		Avg	439.6078

Velocities (mm/s)

type	steel	470.5882	434.7826	418.4100	397.6143	434.7826	444.4444	ERR
d (mm)	14.28	451.4673	435.7298	434.7826	441.5011	426.4392	467.2897	ERR
n	18	448.4305	444.4444	459.7701	447.4273	467.2897	464.0371	ERR
G	8.02			Std Dev	18.7451		Avg	443.8462

Velocities (mm/s)

type	steel	392.9273	408.1633	397.6143	404.8583	365.6307	ERR	ERR
d (mm)	9.5	386.1004	399.2016	378.7879	392.9273	386.1004	ERR	ERR
n	15	405.6795	389.8635	399.2016	390.6250	383.1418	ERR	ERR
G	8.02			Std Dev	11.2601		Avg	392.0549

		Velocities (mm/s)						
type	steel	372.4395	361.6637	367.6471	357.1429	376.6478	363.6364	ERR
d (mm)	7.9	364.9635	362.9764	363.6364	373.8318	349.6503	383.1418	ERR
n	18	376.6478	394.4773	385.3565	371.7472	367.6471	376.6478	ERR
G	8.02			Std Dev	10.7762		Avg	370.5501

		Velocities (mm/s)						
type	steel	333.3333	353.3569	336.7003	342.4658	349.6503	ERR	ERR
d (mm)	6.34	336.7003	355.2398	349.6503	355.2398	361.6637	ERR	ERR
n	15	351.4938	343.6426	350.2627	339.5586	353.9823	ERR	ERR
G	8.02			Std Dev	8.3101		Avg	347.5294

		Velocities (mm/s)						
type	steel	329.4893	328.4072	330.0330	336.7003	332.7787	334.4482	ERR
d (mm)	4.75	337.2681	323.6246	325.2033	297.6190	336.1345	322.0612	ERR
n	18	325.7329	333.8898	326.2643	320.5128	336.1345	324.6753	ERR
G	8.02			Std Dev	9.2658		Avg	327.8321

		Velocities (mm/s)						
type	steel	294.9853	284.4950	304.8780	303.9514	322.0612	284.9003	ERR
d (mm)	3.14	284.4950	318.4713	287.7698	307.6923	309.1190	293.6858	ERR
n	18	289.8551	310.5590	305.8104	300.3003	291.9708	304.8780	ERR
G	8.02			Std Dev	11.5544		Avg	299.9932

		Velocities (mm/s)						
type	steel	238.6635	254.1296	242.7184	252.8445	249.6879	ERR	ERR
d (mm)	1.57	247.2188	253.1646	247.8315	258.0645	251.8892	ERR	ERR
n	15	250.9410	254.7771	245.0980	256.4103	249.3766	ERR	ERR
G	8.02			Std Dev	5.2544		Avg	250.1877

		Velocities (mm/s)						
type	glass	516.7959	546.4481	543.4783	511.5090	516.7959	ERR	ERR
d (mm)	29.3	537.6344	523.5602	527.7045	512.8205	524.9344	ERR	ERR
n	15	512.8205	529.1005	537.6344	529.1005	524.9344	ERR	ERR
G	2.6			Std Dev	11.1792		Avg	526.3514

		Velocities (mm/s)						
type	glass	500.0000	520.8333	516.7959	520.8333	505.0505	ERR	ERR
d (mm)	25.17	519.4805	500.0000	495.0495	507.6142	503.7783	ERR	ERR
n	15	512.8205	523.5602	516.7959	503.7783	498.7531	ERR	ERR
G	2.6			Std Dev	9.5051		Avg	509.6762

		Velocities (mm/s)						
type	glass	464.0371	470.5882	473.9336	524.9344	481.9277	459.7701	ERR
d (mm)	21.7	511.5090	516.7959	485.4369	488.9976	481.9277	465.1163	ERR
n	18	477.3270	500.0000	527.7045	467.2897	502.5126	492.6108	ERR
G	2.6			Std Dev	21.3023		Avg	488.4677

		Velocities (mm/s)						
type	glass	467.2897	441.5011	432.9004	444.4444	467.2897	ERR	ERR
d (mm)	15.97	450.4505	467.2897	432.9004	434.7826	444.4444	ERR	ERR
n	15	430.1075	464.0371	472.8132	419.2872	473.9336	ERR	ERR
G	2.6			Std Dev	17.8761		Avg	449.5648

		Velocities (mm/s)						
type	glass	430.1075	421.0526	438.5965	460.8295	453.5147	418.4100	ERR
d (mm)	14.48	450.4505	432.9004	458.7156	421.0526	412.3711	444.4444	ERR
n	18	404.8583	444.4444	426.4392	434.7826	423.7288	438.5965	ERR
G	2.6			Std Dev	15.9354		Avg	434.1831

Run# 9 Bed
Date: 6-23-95 Roughness k: 0 mm y/k: ERR

Slope: 0.002 Q: 16.87524 L/s U*: 0.0299 m/s

	u.s.	d.s.	avg
y (mm)	69.8666667	69.96667	69.91667
Tw (mm)	677	678.6667	677.8333
A (m²)	0.0318592	0.031963	0.031911
P (m)	0.69856165	0.700211	0.699386
Rh (m)	0.04560686	0.045648	0.045627
V (m/s)	0.52968171	0.52796	0.528821
H (m)	0.08741138	0.084179	0.085795

delta H: 0.0032329 m delta x: 1.62 m

Sf: 0.00199559

Tavg: 19.5 °C

ν: 1.0162E-06 m²/s

δ: 0.00039449 m

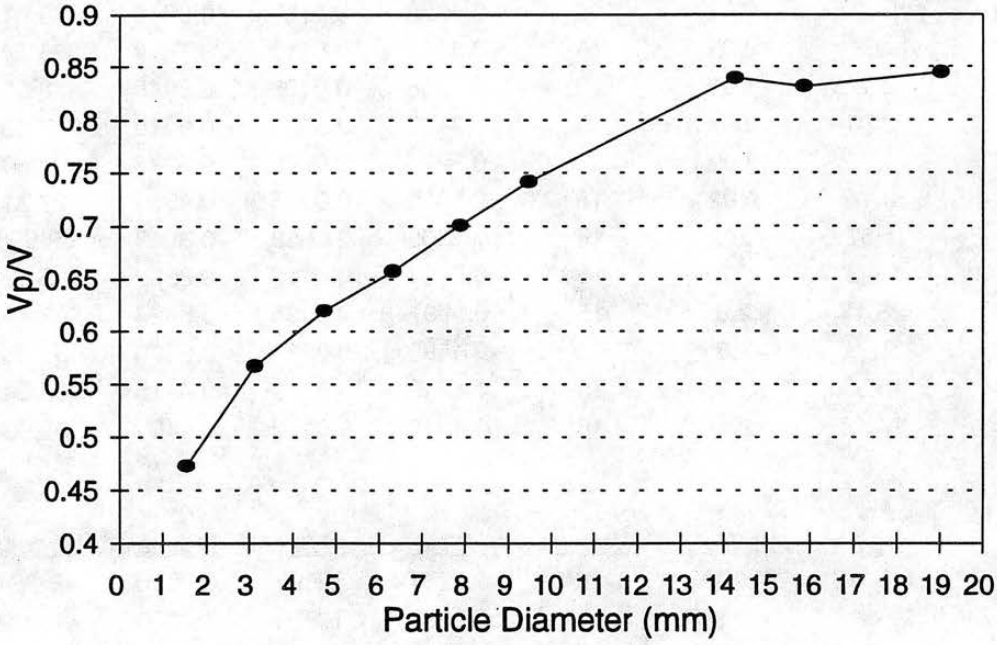
Run# 9

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	15	0.4466	0.0079	1.0794	772.0144	0.000681
steel	15.88	8.02	15	0.4396	0.0072	0.9857	643.8860	0.000817
steel	14.28	8.02	18	0.4438	0.0187	0.9346	579.0108	0.000908
steel	9.5	8.02	15	0.3921	0.0113	0.7619	385.1963	0.001365
steel	7.9	8.02	18	0.3706	0.0108	0.6945	320.3211	0.001642
steel	6.34	8.02	15	0.3475	0.0083	0.6218	257.0678	0.002046
steel	4.75	8.02	18	0.3278	0.0093	0.5376	192.5981	0.002731
steel	3.14	8.02	18	0.3000	0.0116	0.4359	127.3175	0.004131
steel	1.57	8.02	15	0.2502	0.0053	0.3049	63.6588	0.008262
glass	29.3	2.6	15	0.5264	0.0112	0.6392	725.6943	0.001942
glass	25.17	2.6	15	0.5097	0.0095	0.5924	623.4036	0.002261
glass	21.7	2.6	18	0.4885	0.0213	0.5500	537.4596	0.002623
glass	15.97	2.6	15	0.4496	0.0179	0.4716	395.5405	0.003563
glass	14.48	2.6	18	0.4342	0.0159	0.4490	358.6366	0.003930

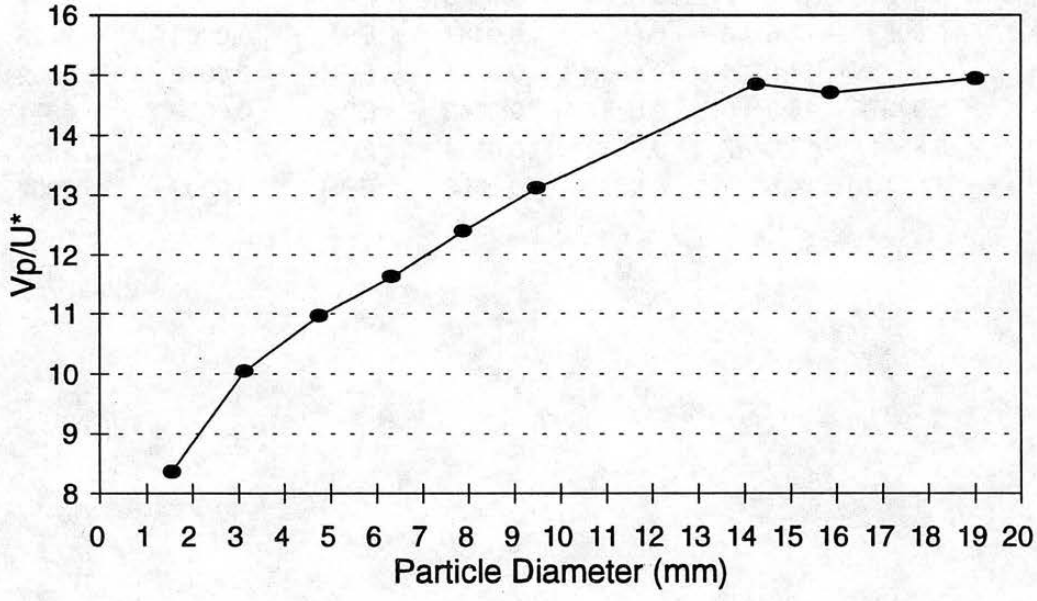
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.8446	14.9463	0.4138	0.0277	ERR	0.0000	48.2643	3.6721
steel	0.8313	14.7115	0.4460	0.0303	ERR	0.0000	40.2540	4.4028
steel	0.8393	14.8533	0.4749	0.0320	ERR	0.0000	36.1982	4.8961
steel	0.7414	13.1201	0.5146	0.0392	ERR	0.0000	24.0815	7.3596
steel	0.7007	12.4005	0.5335	0.0430	ERR	0.0000	20.0256	8.8502
steel	0.6572	11.6301	0.5589	0.0481	ERR	0.0000	16.0712	11.0279
steel	0.6199	10.9709	0.6098	0.0556	ERR	0.0000	12.0407	14.7193
steel	0.5673	10.0393	0.6882	0.0685	ERR	0.0000	7.9596	22.2665
steel	0.4731	8.3725	0.8204	0.0980	ERR	0.0000	3.9798	44.5329
glass	0.9953	17.6144	0.8234	0.0467	ERR	0.0000	74.2723	2.3862
glass	0.9638	17.0564	0.8603	0.0504	ERR	0.0000	63.8032	2.7778
glass	0.9237	16.3466	0.8881	0.0543	ERR	0.0000	55.0071	3.2220
glass	0.8501	15.0447	0.9532	0.0634	ERR	0.0000	40.4822	4.3780
glass	0.8210	14.5300	0.9670	0.0666	ERR	0.0000	36.7052	4.8285

Run 9
U* = 0.0299 m/s

Vp/V vs. d
(steel)

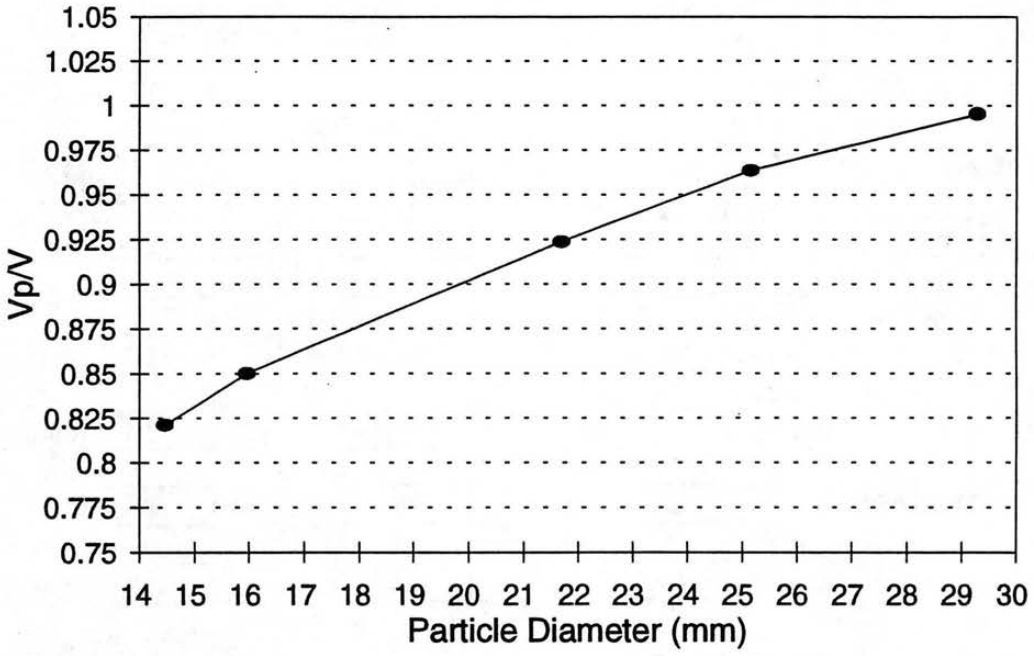


Vp/U* vs. d
(steel)

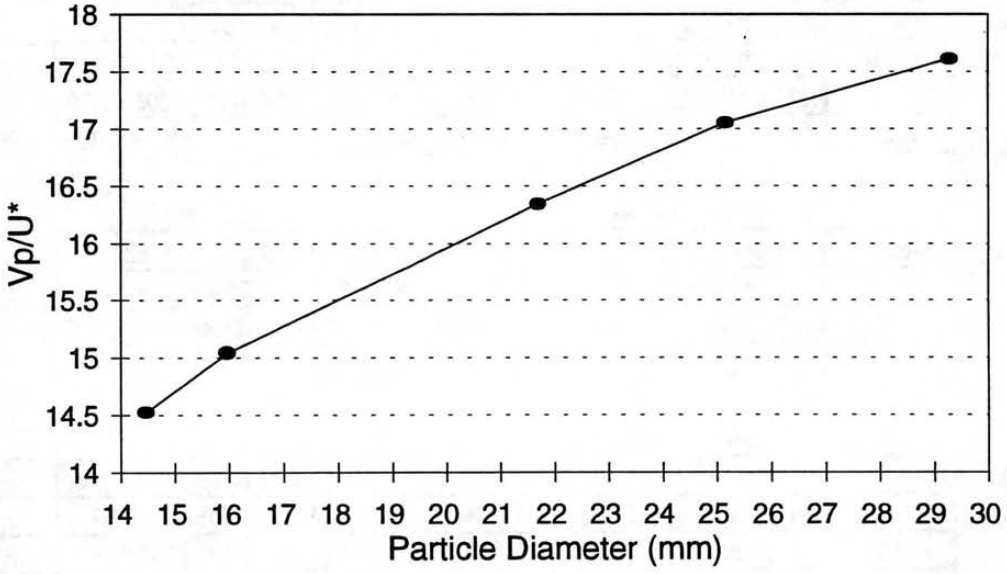


Run 9
U* = 0.0299 m/s

Vp/V vs. d
(glass)



Vp/U* vs. d
(glass)



Run#	10	Bed Roughness k:	0	mm	Streamflow	9.4608	L/s
Date	6-23-95	Pump Setting	medium		Valve Setting	3/8 open	
Reach Length	2000	mm	Slope Reading	105	mm	Bed Slope	0.0007

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer in. of water	Hi	40.15		40.15		40.15	
	Lo	14.55		14.5		14.45	
	Hi - Lo	25.6		25.65		25.7	
Flow Depth:	u.s.	72.3	mm	72.2	mm	72.3	mm
	d.s.	72.3	mm	72.3	mm	72.3	mm
	u.s. - d.s.	0	mm	-0.1	mm	0	mm
	at weir	72.2	mm	72.2	mm	72.1	mm
Top Width:	u.s.	685	mm	686	mm	686	mm
	d.s.	682	mm	684	mm	685	mm
	at weir	697	mm	699	mm	696	mm

Velocities (mm/s)

type	steel	217.6279	221.2389	216.9197	222.2222	224.9719	ERR	ERR
d (mm)	19.04	208.3333	212.7660	221.4839	216.4502	213.2196	ERR	ERR
n	15	221.9756	216.9197	207.9002	211.8644	214.8228	ERR	ERR
G	8.02			Std Dev	5.1615		Avg	216.5811

Velocities (mm/s)

type	steel	203.2520	201.8163	203.6660	216.4502	212.7660	199.2032	ERR
d (mm)	15.88	204.4990	201.0050	198.8072	200.8032	202.0202	188.1468	ERR
n	18	201.6129	200.6018	199.2032	201.2072	214.1328	205.1282	ERR
G	8.02			Std Dev	6.4012		Avg	203.0178

Velocities (mm/s)

type	steel	196.8504	197.2387	198.0198	197.6285	199.8002	ERR	ERR
d (mm)	14.28	195.5034	202.2245	194.7420	196.6568	193.0502	ERR	ERR
n	15	190.1141	195.1220	200.0000	192.6782	191.0220	ERR	ERR
G	8.02			Std Dev	3.3842		Avg	196.0434

Velocities (mm/s)

type	steel	188.8574	195.6947	176.8347	179.8561	170.6485	ERR	ERR
d (mm)	9.5	181.3237	170.7942	173.9130	182.9826	173.4605	ERR	ERR
n	15	177.3050	172.4138	186.7414	179.3722	176.5225	ERR	ERR
G	8.02			Std Dev	7.1137		Avg	179.1147

		Velocities (mm/s)						
type	steel	165.4260	162.8664	168.7764	168.4920	160.7717	ERR	ERR
d (mm)	7.9	173.0104	176.3668	171.8213	161.1604	173.1602	ERR	ERR
n	15	172.2653	166.1130	164.2036	165.4260	163.6661	ERR	ERR
G	8.02			Std Dev	4.8401		Avg	167.5684

		Velocities (mm/s)						
type	steel	171.5266	165.2893	151.1716	151.9757	153.4919	154.2020	ERR
d (mm)	6.34	159.2357	155.4002	154.5595	164.7446	146.7351	148.0385	ERR
n	18	156.8627	151.5152	166.9449	157.7287	147.4926	150.9434	ERR
G	8.02			Std Dev	7.0984		Avg	155.9921

		Velocities (mm/s)						
type	steel	152.4390	156.2500	152.6718	146.8429	142.8571	ERR	ERR
d (mm)	4.75	146.9508	146.3058	148.1481	153.9646	144.1961	ERR	ERR
n	15	151.4005	145.9854	144.5087	146.3058	148.8095	ERR	ERR
G	8.02			Std Dev	3.9539		Avg	148.5091

		Velocities (mm/s)						
type	steel	129.5337	131.3198	126.0239	123.8390	127.5510	124.6106	125.0782
d (mm)	3.14	123.6094	117.8550	124.1465	122.1747	124.4555	122.7747	121.9512
n	21	118.7648	130.3781	119.9041	129.7859	125.7862	117.9941	123.0012
G	8.02			Std Dev	3.9128		Avg	124.3113

		Velocities (mm/s)						
type	steel	88.2613	86.8432	79.5862	81.3670	76.4526	85.1789	ERR
d (mm)	1.57	84.4238	81.0373	80.0961	82.4063	83.3681	82.7815	ERR
n	18	79.9680	79.3021	81.6327	82.2707	81.1688	79.7766	ERR
G	8.02			Std Dev	2.8706		Avg	81.9956

		Velocities (mm/s)						
type	glass	255.7545	265.2520	248.1390	251.8892	256.0819	ERR	ERR
d (mm)	29.3	256.7394	243.3090	270.2703	254.7771	250.9410	ERR	ERR
n	15	246.3054	249.0660	252.8445	250.9410	262.1232	ERR	ERR
G	2.6			Std Dev	7.2122		Avg	254.2956

		Velocities (mm/s)						
type	glass	249.0660	231.2139	249.3766	242.7184	236.1275	229.8851	ERR
d (mm)	25.17	224.7191	255.1020	236.4066	244.2002	244.7980	230.1496	ERR
n	18	247.5248	243.3090	229.3578	258.7322	245.0980	238.9486	ERR
G	2.6			Std Dev	9.4789		Avg	240.9296

		Velocities (mm/s)						
type	glass	232.8289	228.5714	230.4147	234.1920	230.1496	ERR	ERR
d (mm)	21.7	244.4988	228.5714	230.9469	234.7418	236.1275	ERR	ERR
n	15	230.1496	248.1390	244.2002	247.8315	231.7497	ERR	ERR
G	2.6			Std Dev	7.0315		Avg	235.5409

		Velocities (mm/s)						
type	glass	244.4988	220.9945	215.7497	218.8184	215.5172	219.7802	ERR
d (mm)	15.97	210.5263	226.2443	211.1932	225.4791	236.9668	228.8330	ERR
n	18	229.0951	206.6116	229.8851	222.9654	224.9719	220.2643	ERR
G	2.6			Std Dev	9.4126		Avg	222.6886

		Velocities (mm/s)						
type	glass	217.6279	212.7660	217.6279	208.9864	213.2196	ERR	ERR
d (mm)	14.48	213.9037	214.1328	212.5399	215.9827	215.0538	ERR	ERR
n	15	214.5923	215.5172	216.6847	215.5172	213.4472	ERR	ERR
G	2.6			Std Dev	2.2266		Avg	214.5066

Run# 10 Bed
Date: 6-23-95 Roughness k: 0 mm y/k: ERR

Slope: 0.0007 Q: 9.460796 L/s U*: 0.0176 m/s

	u.s.	d.s.	avg
y (mm)	72.2666667	72.3	72.28333
Tw (mm)	685.666667	683.6667	684.6667
A (m^2)	0.03326676	0.03321	0.033238
P (m)	0.70827617	0.706393	0.707334
Rh (m)	0.04696862	0.047013	0.046991
V (m/s)	0.28439191	0.28488	0.284636
H (m)	0.07752434	0.076438	0.076981

delta H: 0.0010865 m delta x: 1.62 m

Sf: 0.00067069

Tavg: 20 °C

ν: 1.004E-06 m^2/s

δ: 0.00066247 m

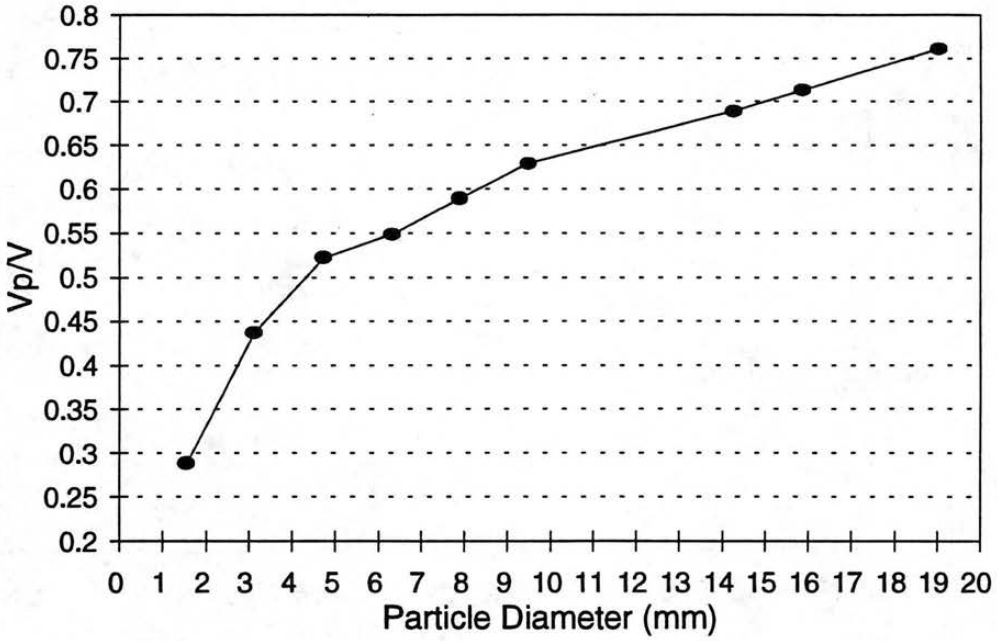
Run# 10

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	15	0.2166	0.0052	1.0794	778.2702	0.000236
steel	15.88	8.02	18	0.2030	0.0064	0.9857	649.1035	0.000283
steel	14.28	8.02	15	0.1960	0.0034	0.9346	583.7026	0.000314
steel	9.5	8.02	15	0.1791	0.0071	0.7619	388.3176	0.000473
steel	7.9	8.02	15	0.1676	0.0048	0.6946	322.9167	0.000568
steel	6.34	8.02	18	0.1560	0.0071	0.6219	259.1509	0.000708
steel	4.75	8.02	15	0.1485	0.0040	0.5377	194.1588	0.000945
steel	3.14	8.02	21	0.1243	0.0039	0.4360	128.3492	0.001430
steel	1.57	8.02	18	0.0820	0.0029	0.3050	64.1746	0.002860
glass	29.3	2.6	15	0.2543	0.0072	0.6392	731.5747	0.000672
glass	25.17	2.6	18	0.2409	0.0095	0.5924	628.4552	0.000783
glass	21.7	2.6	15	0.2355	0.0070	0.5500	541.8147	0.000908
glass	15.97	2.6	18	0.2227	0.0094	0.4716	398.7457	0.001233
glass	14.48	2.6	15	0.2145	0.0022	0.4490	361.5427	0.001360

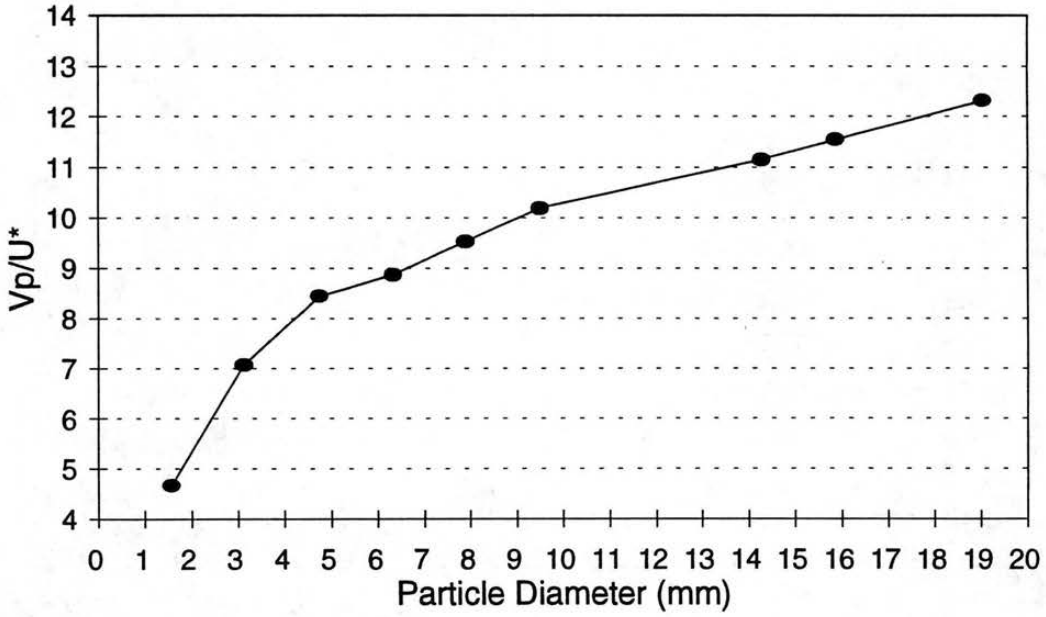
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.7609	12.3195	0.2006	0.0163	ERR	0.0000	28.7410	3.7964
steel	0.7133	11.5480	0.2060	0.0178	ERR	0.0000	23.9710	4.5518
steel	0.6888	11.1513	0.2098	0.0188	ERR	0.0000	21.5558	5.0619
steel	0.6293	10.1884	0.2351	0.0231	ERR	0.0000	14.3403	7.6088
steel	0.5887	9.5316	0.2413	0.0253	ERR	0.0000	11.9251	9.1498
steel	0.5480	8.8731	0.2509	0.0283	ERR	0.0000	9.5703	11.4012
steel	0.5218	8.4475	0.2762	0.0327	ERR	0.0000	7.1702	15.2175
steel	0.4367	7.0711	0.2851	0.0403	ERR	0.0000	4.7399	23.0202
steel	0.2881	4.6641	0.2688	0.0576	ERR	0.0000	2.3699	46.0403
glass	0.8934	14.4648	0.3978	0.0275	ERR	0.0000	44.2285	2.4670
glass	0.8464	13.7045	0.4067	0.0297	ERR	0.0000	37.9943	2.8718
glass	0.8275	13.3980	0.4283	0.0320	ERR	0.0000	32.7563	3.3310
glass	0.7824	12.6669	0.4722	0.0373	ERR	0.0000	24.1068	4.5262
glass	0.7536	12.2015	0.4777	0.0392	ERR	0.0000	21.8577	4.9919

Run 10
U* = 0.0176 m/s

Vp/V vs. d
(steel)

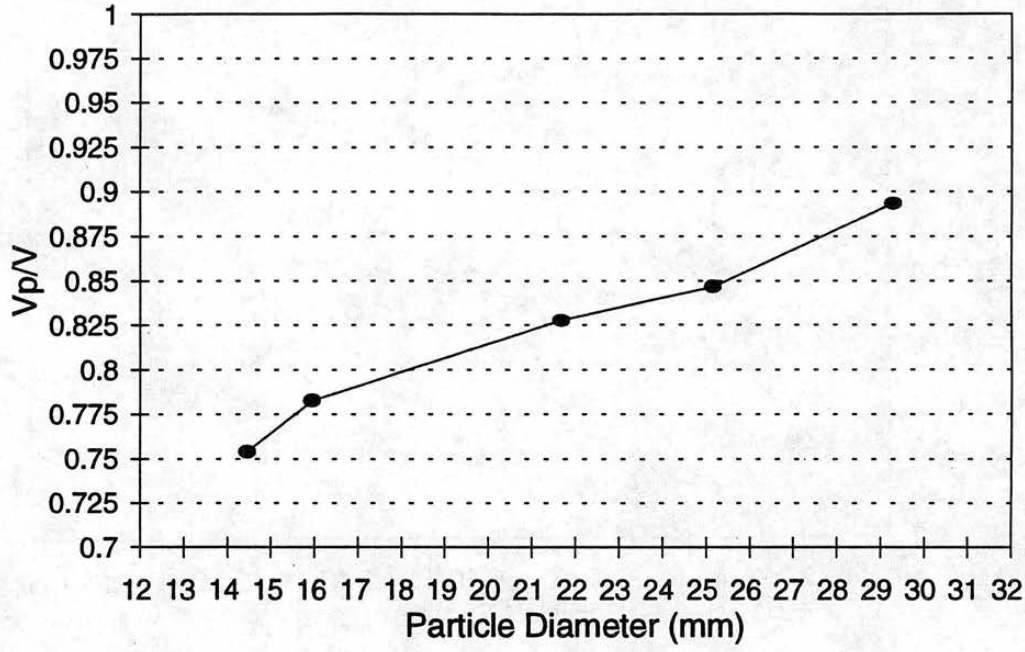


Vp/U* vs. d
(steel)

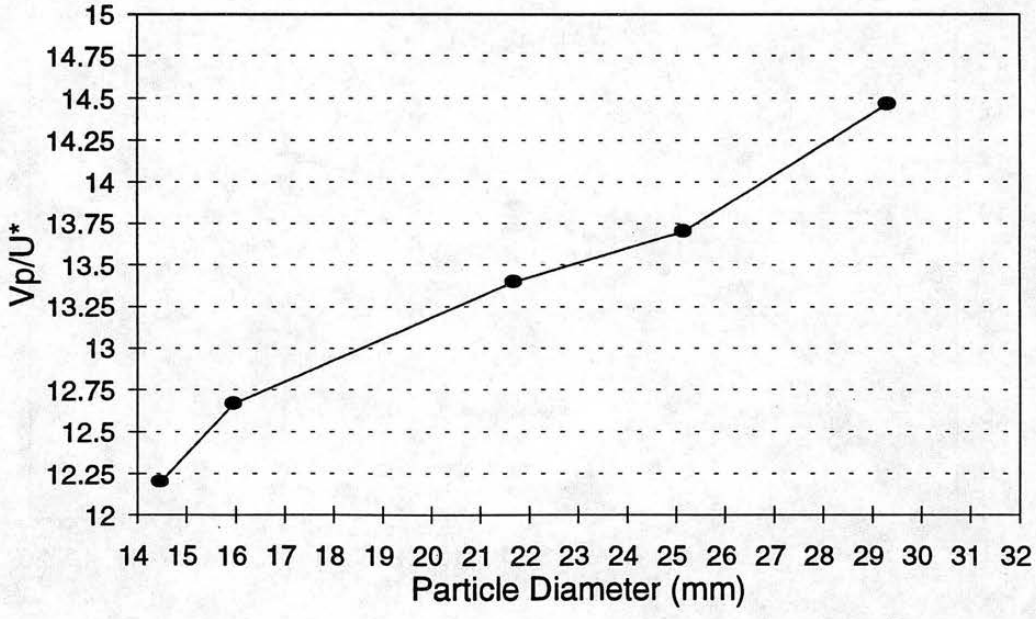


Run 10
U* = 0.0176 m/s

Vp/V vs. d
(glass)



Vp/U* vs. d
(glass)



Run#	11		Bed Roughness k:	0	mm	Streamflow	11.4881 L/s
Date	6-23-95		Pump Setting	medium		Valve Setting	3/16 open
Reach Length	2000	mm	Slope Reading	128.6	mm	Bed Slope	0.004

		Initial		Intermediate		Final	
Temperature		19	°C			19	°C
Manometer in. of water	Hi	41.85		41.85		41.85	
	Lo	4.05		4.1		4.2	
	Hi - Lo	37.8		37.75		37.65	
Flow Depth:	u.s.	43.6	mm	43.6	mm	43.7	mm
	d.s.	43.9	mm	43.9	mm	43.9	mm
	u.s. - d.s.	-0.3	mm	-0.3	mm	-0.2	mm
	at weir	44.2	mm	44.4	mm	44.3	mm
Top Width:	u.s.	523	mm	522	mm	523	mm
	d.s.	528	mm	526	mm	526	mm
	at weir	530	mm	532	mm	530	mm

Velocities (mm/s)

type	steel	598.8024	609.7561	638.9776	604.2296	647.2492	ERR	ERR
d (mm)	19.04	615.3846	638.9776	621.1180	615.3846	641.0256	ERR	ERR
n	15	606.0606	621.1180	607.9027	632.9114	626.9592	ERR	ERR
G	8.02			Std Dev	15.2695		Avg	621.7238

Velocities (mm/s)

type	steel	626.9592	604.2296	586.5103	619.1950	588.2353	ERR	ERR
d (mm)	15.88	632.9114	602.4096	625.0000	609.7561	604.2296	ERR	ERR
n	15	586.5103	615.3846	595.2381	626.9592	588.2353	ERR	ERR
G	8.02			Std Dev	16.3322		Avg	607.4509

Velocities (mm/s)

type	steel	542.0054	571.4286	547.9452	604.2296	645.1613	571.4286	ERR
d (mm)	14.28	626.9592	550.9642	604.2296	588.2353	546.4481	571.4286	ERR
n	18	653.5948	566.5722	581.3953	555.5556	576.3689	550.9642	ERR
G	8.02			Std Dev	33.7755		Avg	580.8286

Velocities (mm/s)

type	steel	566.5722	505.0505	598.8024	520.8333	527.7045	ERR	ERR
d (mm)	9.5	537.6344	533.3333	539.0836	544.9591	555.5556	ERR	ERR
n	15	514.1388	540.5405	558.6592	536.1930	546.4481	ERR	ERR
G	8.02			Std Dev	22.7584		Avg	541.7006

Velocities (mm/s)

type	steel	490.1961	500.0000	496.2779	493.8272	488.9976	ERR	ERR
d (mm)	7.9	495.0495	498.7531	496.2779	502.5126	500.0000	ERR	ERR
n	15	496.2779	484.2615	485.4369	506.3291	480.7692	ERR	ERR
G	8.02			Std Dev	7.1556		Avg	494.3311

Velocities (mm/s)

type	steel	470.5882	492.6108	524.9344	516.7959	473.9336	476.1905	ERR
d (mm)	6.34	491.4005	518.1347	502.5126	487.8049	514.1388	491.4005	ERR
n	18	523.5602	502.5126	473.9336	505.0505	498.7531	515.4639	ERR
G	8.02			Std Dev	17.7991		Avg	498.8733

Velocities (mm/s)

type	steel	470.5882	436.6812	457.6659	426.4392	448.4305	485.4369	ERR
d (mm)	4.75	454.5455	460.8295	421.0526	453.5147	462.9630	411.5226	ERR
n	18	464.0371	444.4444	426.4392	448.4305	456.6210	438.5965	ERR
G	8.02			Std Dev	18.8078		Avg	448.2355

Velocities (mm/s)

type	steel	457.6659	456.6210	414.9378	390.6250	438.5965	454.5455	432.9004
d (mm)	3.14	423.7288	435.7298	409.8361	457.6659	447.4273	435.7298	430.1075
n	21	410.6776	441.5011	383.1418	394.4773	406.5041	399.2016	418.4100
G	8.02			Std Dev	23.1619		Avg	425.7158

Velocities (mm/s)

type	steel	374.5318	340.1361	373.8318	338.9831	333.3333	325.2033	371.7472
d (mm)	1.57	335.5705	389.1051	336.1345	325.7329	366.9725	366.3004	363.6364
n	21	321.0273	343.0532	346.0208	353.3569	338.9831	373.1343	375.2345
G	8.02			Std Dev	20.1697		Avg	352.0014

Velocities (mm/s)

type	glass	735.2941	701.7544	727.2727	701.7544	746.2687	ERR	ERR
d (mm)	29.3	696.8641	743.4944	727.2727	719.4245	711.7438	ERR	ERR
n	15	722.0217	709.2199	724.6377	716.8459	738.0074	ERR	ERR
G	2.6			Std Dev	15.3423		Avg	721.4584

Velocities (mm/s)

type	glass	704.2254	666.6667	735.2941	696.8641	680.2721	ERR	ERR
d (mm)	25.17	694.4444	711.7438	689.6552	716.8459	694.4444	ERR	ERR
n	15	682.5939	668.8963	727.2727	664.4518	704.2254	ERR	ERR
G	2.6			Std Dev	21.3854		Avg	695.8597

Velocities (mm/s)

type	glass	680.2721	664.4518	660.0660	673.4007	647.2492	ERR	ERR
d (mm)	21.7	634.9206	671.1409	626.9592	687.2852	660.0660	ERR	ERR
n	15	673.4007	634.9206	675.6757	609.7561	680.2721	ERR	ERR
G	2.6			Std Dev	22.8736		Avg	658.6558

		Velocities (mm/s)						
type	glass	626.9592	638.9776	598.8024	623.0530	576.3689	ERR	ERR
d (mm)	15.97	595.2381	576.3689	609.7561	604.2296	634.9206	ERR	ERR
n	15	581.3953	609.7561	586.5103	606.0606	619.1950	ERR	ERR
G	2.6			Std Dev	20.2977		Avg	605.8395

		Velocities (mm/s)						
type	glass	609.7561	588.2353	593.4718	626.9592	591.7160	ERR	ERR
d (mm)	14.48	645.1613	598.8024	626.9592	613.4969	583.0904	ERR	ERR
n	15	578.0347	621.1180	630.9148	615.3846	621.1180	ERR	ERR
G	2.6			Std Dev	19.7985		Avg	609.6146

Run# 11 Bed
Date: 6-23-95 Roughness k: 0 mm y/k: ERR

Slope: 0.004 Q: 11.48813 L/s U*: 0.0356 m/s

	u.s.	d.s.	avg
y (mm)	43.6333333	43.9	43.76667
Tw (mm)	522.666667	526.6667	524.6667
A (m^2)	0.01652976	0.016719	0.016624
P (m)	0.53561201	0.539595	0.537603
Rh (m)	0.03086145	0.030984	0.030922
V (m/s)	0.69499698	0.687148	0.691072
H (m)	0.07474054	0.067974	0.071357

delta H: 0.0067665 m delta x: 1.62 m

Sf: 0.00417684

Tavg: 19 °C

ν: 1.0286E-06 m^2/s

δ: 0.00033527 m

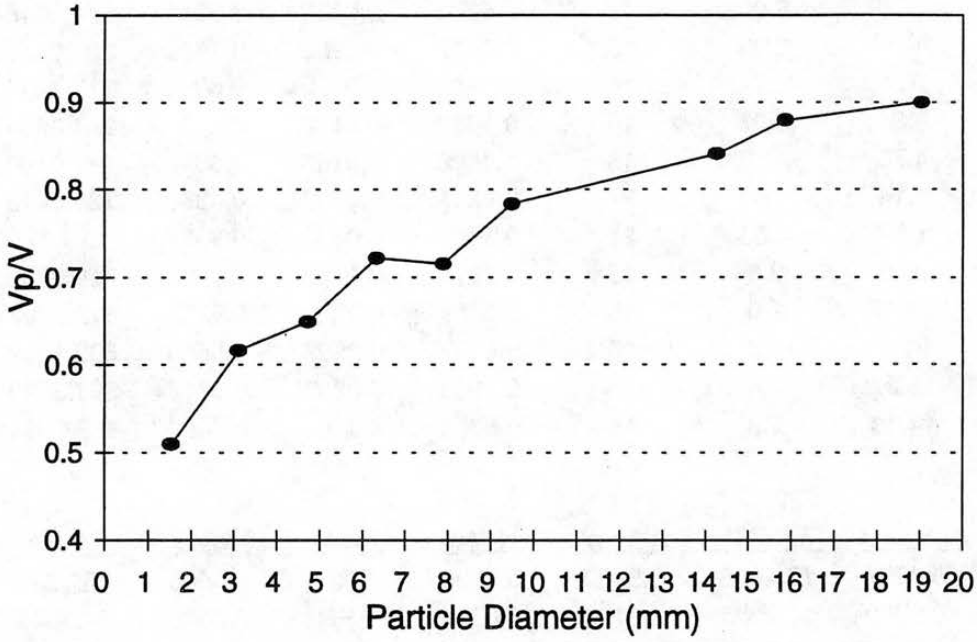
Run# 11

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	15	0.6217	0.0153	1.0794	765.7928	0.000966
steel	15.88	8.02	15	0.6075	0.0163	0.9857	638.6970	0.001159
steel	14.28	8.02	18	0.5808	0.0338	0.9346	574.3446	0.001288
steel	9.5	8.02	15	0.5417	0.0228	0.7619	382.0920	0.001937
steel	7.9	8.02	15	0.4943	0.0072	0.6945	317.7397	0.002329
steel	6.34	8.02	18	0.4989	0.0178	0.6218	254.9961	0.002902
steel	4.75	8.02	18	0.4482	0.0188	0.5376	191.0460	0.003873
steel	3.14	8.02	21	0.4257	0.0232	0.4359	126.2915	0.005859
steel	1.57	8.02	21	0.3520	0.0202	0.3049	63.1457	0.011719
glass	29.3	2.6	15	0.7215	0.0153	0.6392	719.8460	0.002755
glass	25.17	2.6	15	0.6959	0.0214	0.5924	618.3797	0.003207
glass	21.7	2.6	15	0.6587	0.0229	0.5500	533.1283	0.003720
glass	15.97	2.6	15	0.6058	0.0203	0.4716	392.3529	0.005055
glass	14.48	2.6	15	0.6096	0.0198	0.4490	355.7464	0.005575

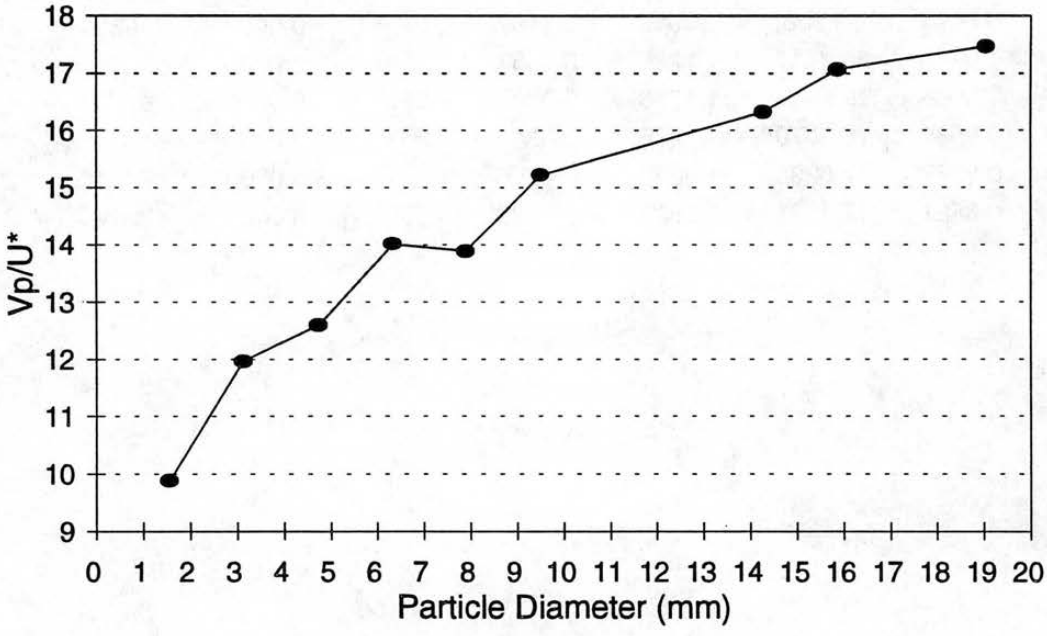
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.8997	17.4693	0.5760	0.0330	ERR	0.0000	56.7895	2.2987
steel	0.8790	17.0683	0.6163	0.0361	ERR	0.0000	47.3644	2.7561
steel	0.8405	16.3202	0.6215	0.0381	ERR	0.0000	42.5921	3.0649
steel	0.7839	15.2208	0.7110	0.0467	ERR	0.0000	28.3351	4.6070
steel	0.7153	13.8898	0.7118	0.0512	ERR	0.0000	23.5629	5.5401
steel	0.7219	14.0174	0.8023	0.0572	ERR	0.0000	18.9099	6.9033
steel	0.6486	12.5946	0.8337	0.0662	ERR	0.0000	14.1675	9.2140
steel	0.6160	11.9618	0.9766	0.0816	ERR	0.0000	9.3655	13.9384
steel	0.5094	9.8906	1.1545	0.1167	ERR	0.0000	4.6827	27.8769
glass	1.0440	20.2717	1.1286	0.0557	ERR	0.0000	87.3914	1.4937
glass	1.0069	19.5524	1.1746	0.0601	ERR	0.0000	75.0731	1.7388
glass	0.9531	18.5070	1.1976	0.0647	ERR	0.0000	64.7233	2.0169
glass	0.8767	17.0230	1.2846	0.0755	ERR	0.0000	47.6328	2.7406
glass	0.8821	17.1291	1.3577	0.0793	ERR	0.0000	43.1887	3.0226

Run 11
U* = 0.0356 m/s

Vp/V vs. d
(steel)

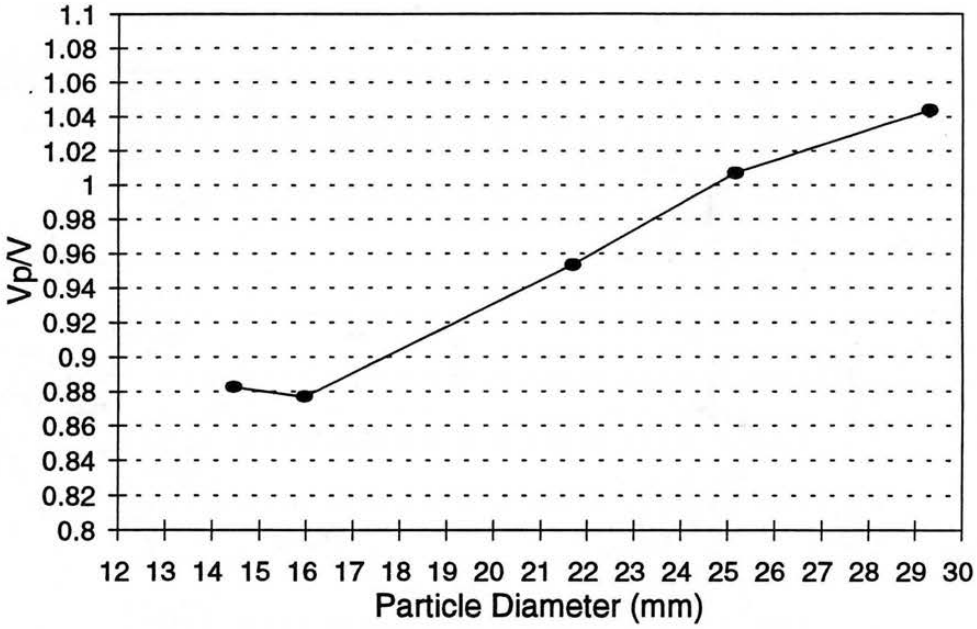


Vp/U* vs. d
(steel)

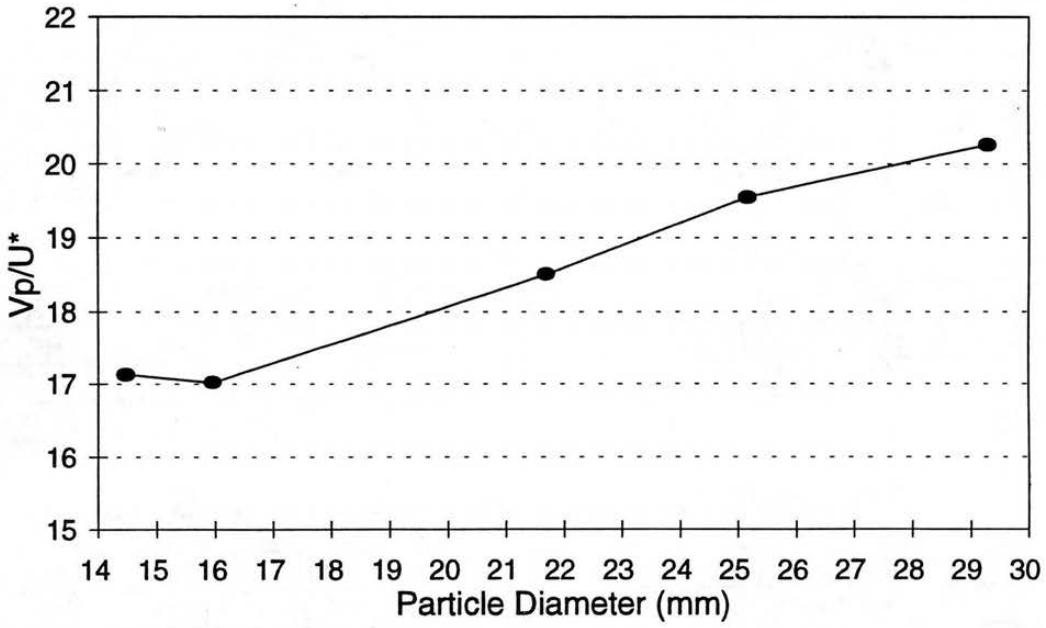


Run 11
U* = 0.0356 m/s

Vp/V vs. d
(glass)



Vp/U* vs. d
(glass)



Run#	12	Bed Roughness k:	0	mm	Streamflow	4.4528	L/s
Date	6-24-95	Pump Setting	slow		Valve Setting	5/16 open	
Reach Length	2000	mm	Slope Reading	102	mm	Bed Slope	0.00028

		Initial		Intermediate		Final	
Temperature		19	°C			19	°C
Manometer in. of water	Hi	27.35		27.3		27.2	
	Lo	21.6		21.55		21.5	
	Hi - Lo	5.75		5.75		5.7	
Flow Depth:	u.s.	52.6	mm	53.1	mm	52.8	mm
	d.s.	52.6	mm	52.9	mm	52.9	mm
	u.s. - d.s.	0	mm	0.2	mm	-0.1	mm
	at weir	52	mm	52.3	mm	52.2	mm
Top Width:	u.s.	570	mm	583	mm	575	mm
	d.s.	562	mm	569	mm	565	mm
	at weir	568	mm	576	mm	571	mm

Velocities (mm/s)

type	steel	161.0306	154.6790	162.4695	161.1604	164.8805	160.9010	ERR
d (mm)	19.04	152.6718	170.6485	160.7717	148.2580	162.0746	158.1028	ERR
n	18	156.9859	154.7988	165.4260	155.0388	161.6815	158.2278	ERR
G	8.02			Std Dev	5.2317		Avg	159.4337

Velocities (mm/s)

type	steel	156.6171	155.6420	155.4002	153.7279	148.2580	ERR	ERR
d (mm)	15.88	152.5553	157.3564	152.7884	157.8532	159.7444	ERR	ERR
n	15	149.0313	155.1590	147.3839	149.2537	145.3488	ERR	ERR
G	8.02			Std Dev	4.3223		Avg	153.0746

Velocities (mm/s)

type	steel	151.1716	153.6098	158.3531	150.3759	151.6300	ERR	ERR
d (mm)	14.28	143.3692	149.0313	150.7159	148.6989	147.3839	ERR	ERR
n	15	155.1590	146.0920	150.1502	144.3001	150.7159	ERR	ERR
G	8.02			Std Dev	3.9261		Avg	150.0505

Velocities (mm/s)

type	steel	138.3126	131.9261	135.9619	135.7773	128.8660	ERR	ERR
d (mm)	9.5	133.7793	135.5932	133.4223	135.5014	138.6001	ERR	ERR
n	15	133.9585	132.6260	127.7139	134.2282	137.0802	ERR	ERR
G	8.02			Std Dev	3.0799		Avg	134.2231

		Velocities (mm/s)						
type	steel	127.2265	129.7859	131.9261	123.7624	130.2083	116.4822	ERR
d (mm)	7.9	130.7190	124.2236	127.8772	125.8653	130.9758	128.3697	ERR
n	18	124.3781	114.4165	120.7729	130.2083	122.9256	121.2121	ERR
G	8.02			Std Dev	5.0605		Avg	125.6298

		Velocities (mm/s)						
type	steel	125.5493	122.1747	125.5493	115.6069	116.6181	113.3144	ERR
d (mm)	6.34	116.6861	121.7285	113.3144	120.5546	116.7542	120.9921	ERR
n	18	117.2333	115.3403	115.8749	116.2791	120.3369	110.1928	ERR
G	8.02			Std Dev	4.1810		Avg	118.0056

		Velocities (mm/s)						
type	steel	113.0582	112.6761	104.1124	103.1992	109.8298	112.9944	ERR
d (mm)	4.75	113.4430	106.3264	110.4362	111.2966	102.8807	108.1081	ERR
n	18	102.8807	104.3841	102.8807	102.9336	99.2063	101.2658	ERR
G	8.02			Std Dev	4.7035		Avg	106.7729

		Velocities (mm/s)						
type	steel	81.9336	84.6740	79.1139	79.3336	79.1139	79.6813	ERR
d (mm)	3.14	85.2878	88.1834	84.9257	79.4597	85.5798	89.0076	ERR
n	18	83.9278	82.4402	85.9107	81.1688	81.0701	85.2152	ERR
G	8.02			Std Dev	3.1724		Avg	83.1126

		Velocities (mm/s)						
type	steel	53.0926	52.0291	54.3774	53.7346	51.9615	ERR	ERR
d (mm)	1.57	51.2426	50.5178	51.1640	51.3347	51.2821	ERR	ERR
n	15	50.1253	50.3525	51.1509	50.5178	51.2952	ERR	ERR
G	8.02			Std Dev	1.2441		Avg	51.6119

		Velocities (mm/s)						
type	glass	185.5288	186.7414	191.5709	193.9864	191.7546	ERR	ERR
d (mm)	29.3	195.6947	192.3077	187.6173	189.9335	190.8397	ERR	ERR
n	15	187.7934	190.2950	190.8397	187.0907	186.5672	ERR	ERR
G	2.6			Std Dev	2.9515		Avg	189.9041

		Velocities (mm/s)						
type	glass	177.6199	183.4862	189.3939	186.2197	194.3635	ERR	ERR
d (mm)	25.17	182.3154	178.4121	178.5714	179.0510	177.9359	ERR	ERR
n	15	184.1621	180.0180	181.3237	177.7778	180.1802	ERR	ERR
G	2.6			Std Dev	4.8316		Avg	182.0554

		Velocities (mm/s)						
type	glass	188.1468	169.3480	174.3679	176.8347	184.5018	175.9015	ERR
d (mm)	21.7	175.4386	173.4605	168.3502	168.4920	182.8154	176.8347	ERR
n	18	178.2531	182.9826	174.5201	176.9912	171.6738	183.8235	ERR
G	2.6			Std Dev	5.7451		Avg	176.8187

		Velocities (mm/s)						
type	glass	162.7339	160.7717	165.0165	163.1321	164.7446	ERR	ERR
d (mm)	15.97	163.1321	162.3377	162.0746	158.1028	163.1321	ERR	ERR
n	15	161.2903	158.4786	165.0165	158.7302	161.2903	ERR	ERR
G	2.6			Std Dev	2.2525		Avg	161.9989

		Velocities (mm/s)						
type	glass	161.1604	159.2357	160.9010	161.1604	158.8562	ERR	ERR
d (mm)	14.48	159.8721	163.8002	162.8664	166.2510	157.6044	ERR	ERR
n	15	162.0746	158.3531	160.7717	164.8805	160.6426	ERR	ERR
G	2.6			Std Dev	2.4214		Avg	161.2287

Run# 12 Bed
Date: 6-24-95 Roughness k: 0 mm y/k: ERR

Slope: 0.00028 Q: 4.452816 L/s U*: 0.0097 m/s

	u.s.	d.s.	avg
y (mm)	52.8333333	52.8	52.81667
Tw (mm)	576	565.3333	570.6667
A (m^2)	0.02142392	0.021129	0.021276
P (m)	0.59199642	0.581802	0.586896
Rh (m)	0.03618927	0.036316	0.036252
V (m/s)	0.20784324	0.210746	0.209295
H (m)	0.05548946	0.055064	0.055277

delta H: 0.0004250 m delta x: 1.62 m

Sf: 0.00026233

Tavg: 19 °C

ν: 1.0286E-06 m^2/s

δ: 0.00123557 m

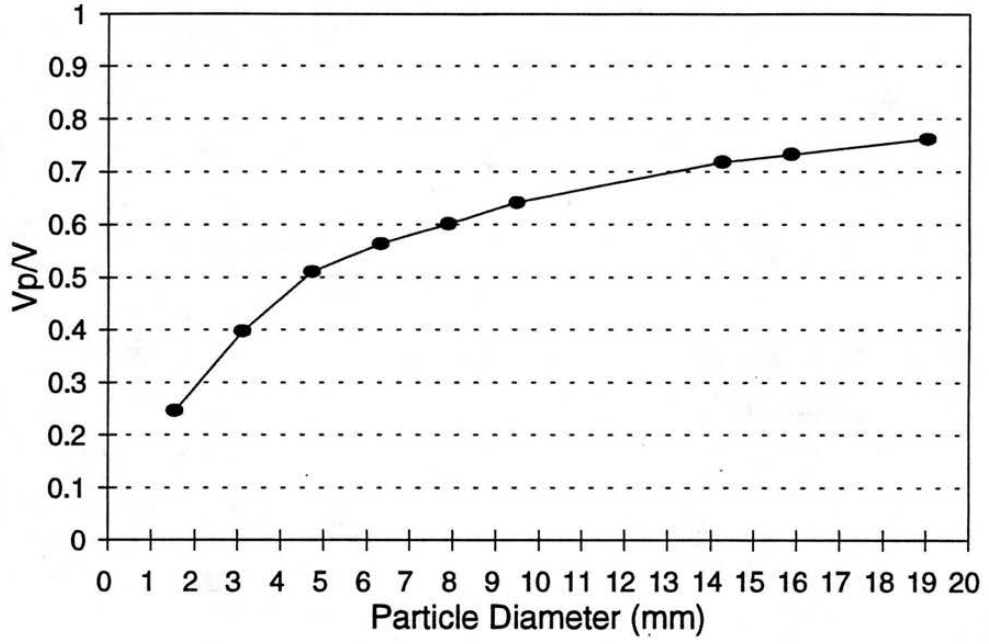
Run# 12

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	18	0.1594	0.0052	1.0794	765.7928	0.000071
steel	15.88	8.02	15	0.1531	0.0043	0.9857	638.6970	0.000085
steel	14.28	8.02	15	0.1501	0.0039	0.9346	574.3446	0.000095
steel	9.5	8.02	15	0.1342	0.0031	0.7619	382.0920	0.000143
steel	7.9	8.02	18	0.1256	0.0051	0.6945	317.7397	0.000171
steel	6.34	8.02	18	0.1180	0.0042	0.6218	254.9961	0.000214
steel	4.75	8.02	18	0.1068	0.0047	0.5376	191.0460	0.000285
steel	3.14	8.02	18	0.0831	0.0032	0.4359	126.2915	0.000431
steel	1.57	8.02	15	0.0516	0.0012	0.3049	63.1457	0.000863
glass	29.3	2.6	15	0.1899	0.0030	0.6392	719.8460	0.000203
glass	25.17	2.6	15	0.1821	0.0048	0.5924	618.3797	0.000236
glass	21.7	2.6	18	0.1768	0.0057	0.5500	533.1283	0.000274
glass	15.97	2.6	15	0.1620	0.0023	0.4716	392.3529	0.000372
glass	14.48	2.6	15	0.1612	0.0024	0.4490	355.7464	0.000410

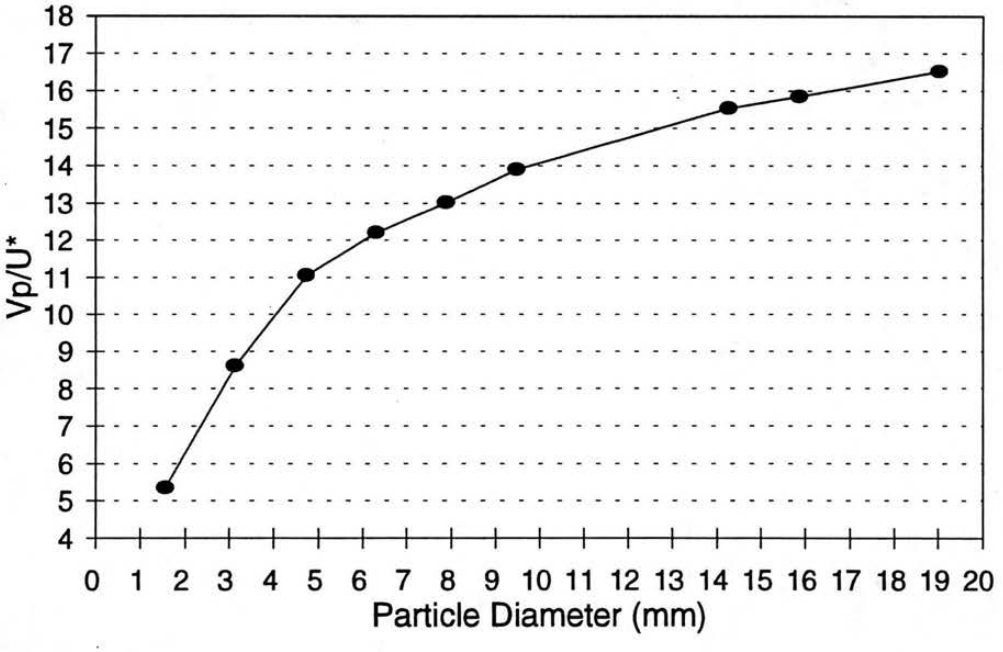
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.7618	16.5093	0.1477	0.0089	ERR	0.0000	15.4099	2.7740
steel	0.7314	15.8508	0.1553	0.0098	ERR	0.0000	12.8524	3.3260
steel	0.7169	15.5376	0.1606	0.0103	ERR	0.0000	11.5574	3.6986
steel	0.6413	13.8987	0.1762	0.0127	ERR	0.0000	7.6888	5.5596
steel	0.6003	13.0089	0.1809	0.0139	ERR	0.0000	6.3938	6.6857
steel	0.5638	12.2194	0.1898	0.0155	ERR	0.0000	5.1312	8.3307
steel	0.5102	11.0563	0.1986	0.0180	ERR	0.0000	3.8444	11.1193
steel	0.3971	8.6063	0.1907	0.0222	ERR	0.0000	2.5413	16.8206
steel	0.2466	5.3444	0.1693	0.0317	ERR	0.0000	1.2707	33.6412
glass	0.9074	19.6644	0.2971	0.0151	ERR	0.0000	23.7137	1.8026
glass	0.8699	18.8517	0.3073	0.0163	ERR	0.0000	20.3712	2.0984
glass	0.8448	18.3095	0.3215	0.0176	ERR	0.0000	17.5627	2.4339
glass	0.7740	16.7749	0.3435	0.0205	ERR	0.0000	12.9252	3.3072
glass	0.7703	16.6951	0.3591	0.0215	ERR	0.0000	11.7193	3.6476

Run 12
U* = 0.0097 m/s

Vp/V vs. d
(steel)

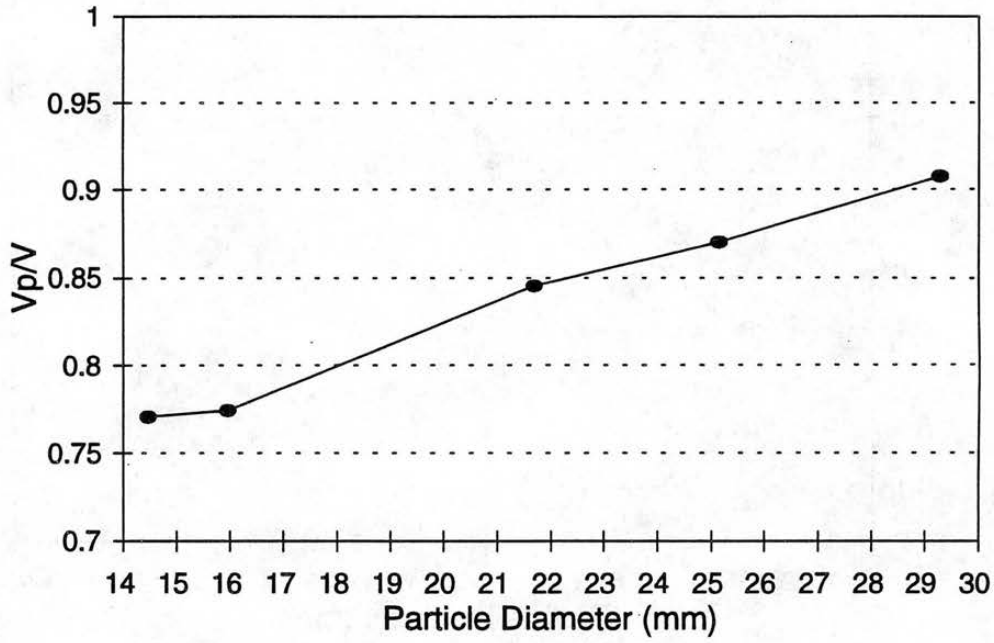


Vp/U* vs. d
(steel)

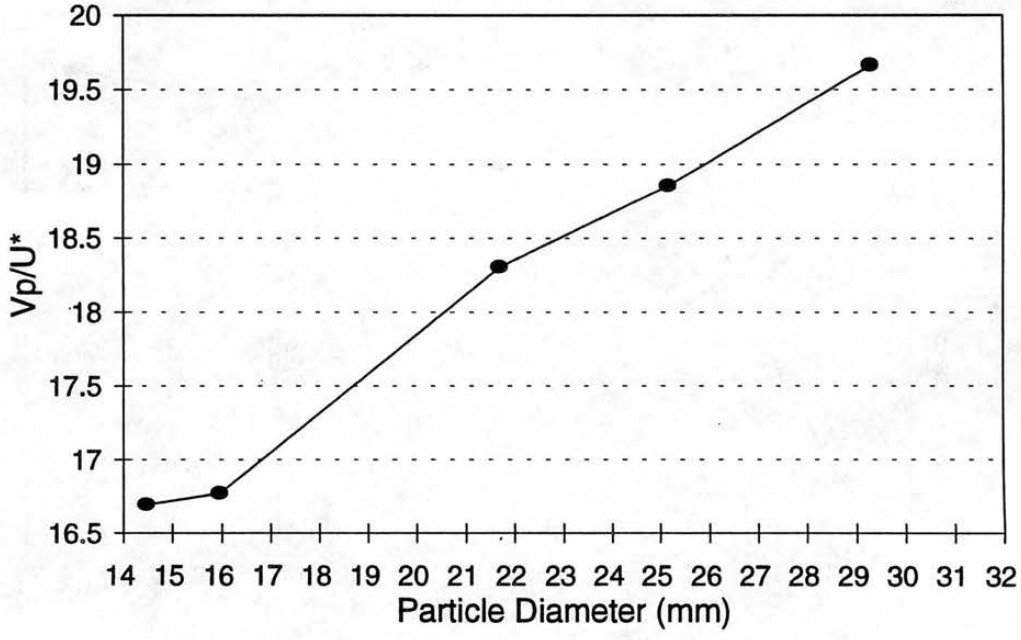


Run 12
U* = 0.0097 m/s

Vp/V vs. d
(glass)



Vp/U* vs. d
(glass)



Run#	13		Bed Roughness k:	2.4	mm	Streamflow	11.5467 L/s
Date	6-29-95		Pump Setting	slow		Valve Setting	
Reach Length	2000	mm	Slope Reading	114.3	mm	Bed Slope	0.002

		Initial		Intermediate		Final	
Temperature		18	°C			18	°C
Manometer	Hi	44.25		44.3		44.25	
in. of	Lo	6.05		6.1		6.3	
water	Hi - Lo	38.2		38.2		37.95	
Flow Depth:	u.s.	69.8	mm	68.6	mm	68.9	mm
	d.s.	69.8	mm	68.5	mm	68.9	mm
	u.s. - d.s.	0	mm	0.1	mm	0	mm
	at weir	69	mm	68.7	mm	68.4	mm
Top Width:	u.s.	682	mm	678	mm	675	mm
	d.s.	683	mm	682	mm	680	mm
	at weir	704	mm	705	mm	704	mm

Velocities (mm/s)

type	glass	118.5536	126.1830	118.9061	135.2265	131.1475	127.7139	ERR
d (mm)	29.3	124.2236	133.8688	132.5381	124.5330	131.9261	125.7071	ERR
n	18	128.0410	129.7859	127.5510	117.0275	138.5042	133.8688	ERR
G	2.6			Std Dev	5.9799		Avg	128.0725

Velocities (mm/s)

type	glass	112.0448	108.6366	124.0695	116.9591	115.7407	120.4819	ERR
d (mm)	25.17	121.4329	119.4030	109.9505	121.8769	123.6094	122.6242	ERR
n	18	115.9420	126.9841	119.6172	120.9921	118.7648	118.9061	ERR
G	2.6			Std Dev	4.8853		Avg	118.7798

Velocities (mm/s)

type	glass	115.1410	102.8807	105.4296	106.4963	107.7586	103.3592	ERR
d (mm)	21.7	104.9318	103.3592	109.2299	113.2503	113.8952	109.4092	ERR
n	18	107.2386	105.4852	94.8317	107.5847	112.2965	109.9505	ERR
G	2.6			Std Dev	4.8499		Avg	107.3627

Velocities (mm/s)

type	glass	100.5025	81.6327	91.0332	93.8086	ERR	ERR	ERR
d (mm)	15.97	100.3009	93.4143	91.9540	93.4143	ERR	ERR	ERR
n	8	ERR	ERR	ERR	ERR	ERR	ERR	ERR
G	2.6			Std Dev	5.9069		Avg	93.2576

		Velocities (mm/s)						
type	glass	90.0090	99.8502	ERR	ERR	ERR	ERR	ERR
d (mm)	14.48	ERR	ERR	ERR	ERR	ERR	ERR	ERR
n	2	ERR	ERR	ERR	ERR	ERR	ERR	ERR
G	2.6			Std Dev	6.9588		Avg	94.9296

The glass particles exhibited meandering motion with varying velocities.

Most trials for the glass particles with diameters 15.97mm and 14.48mm halted before finishing their run.

No motion for the steel particles.

Natural particles moved only a few centimeters before halting.

Run# 13 Bed
Date: 6-29-95 Roughness k: 2.4 mm y/k: 28.785

Slope: 0.002 Q: 11.54668 L/s U*: 0.0301 m/s

	u.s.	d.s.	avg
y (mm)	69.1	69.06667	69.08333
Tw (mm)	678.333333	681.6667	680
A (m^2)	0.03309314	0.033192	0.031606
P (m)	0.70159865	0.704728	0.700956
Rh (m)	0.04716819	0.047099	0.045089
V (m/s)	0.34891462	0.347872	0.348394
H (m)	0.07854708	0.075237	0.076892

delta H: 0.0033104 m delta x: 1.62 m

Sf: 0.00204343

Tavg: 18 °C

ν: 1.054E-06 m^2/s

δ: 0.00040674 m

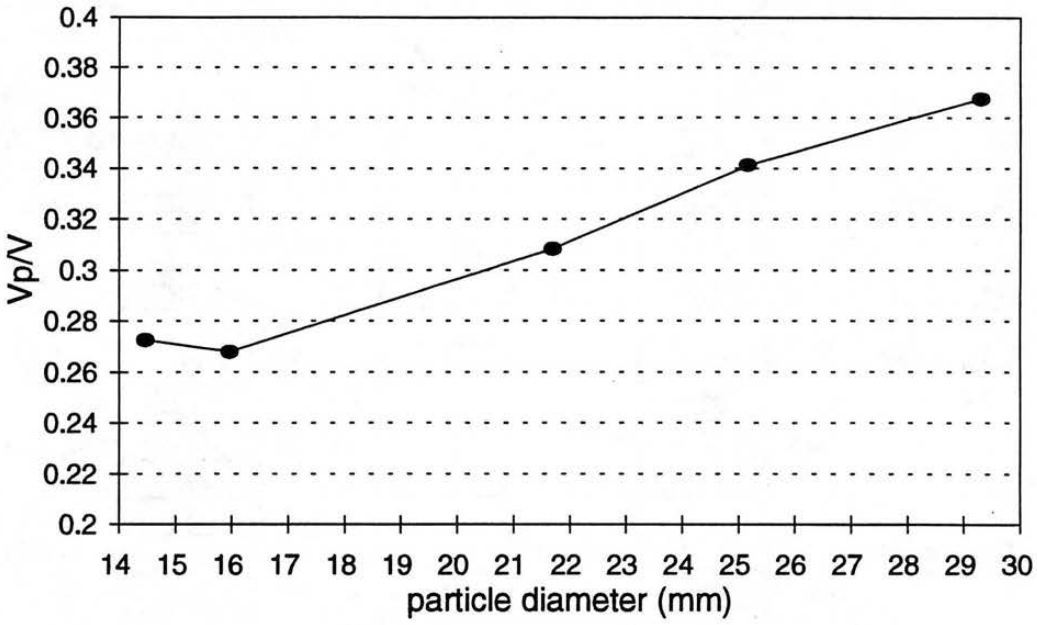
Run# 13

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	29.3	2.6	18	0.1281	0.0060	0.6392	708.2514	0.001965
glass	25.17	2.6	18	0.1188	0.0049	0.5924	608.4194	0.002288
glass	21.7	2.6	18	0.1074	0.0048	0.5500	524.5411	0.002654
glass	15.97	2.6	8	0.0933	0.0059	0.4716	386.0333	0.003606
glass	14.48	2.6	2	0.0949	0.0070	0.4490	350.0164	0.003977

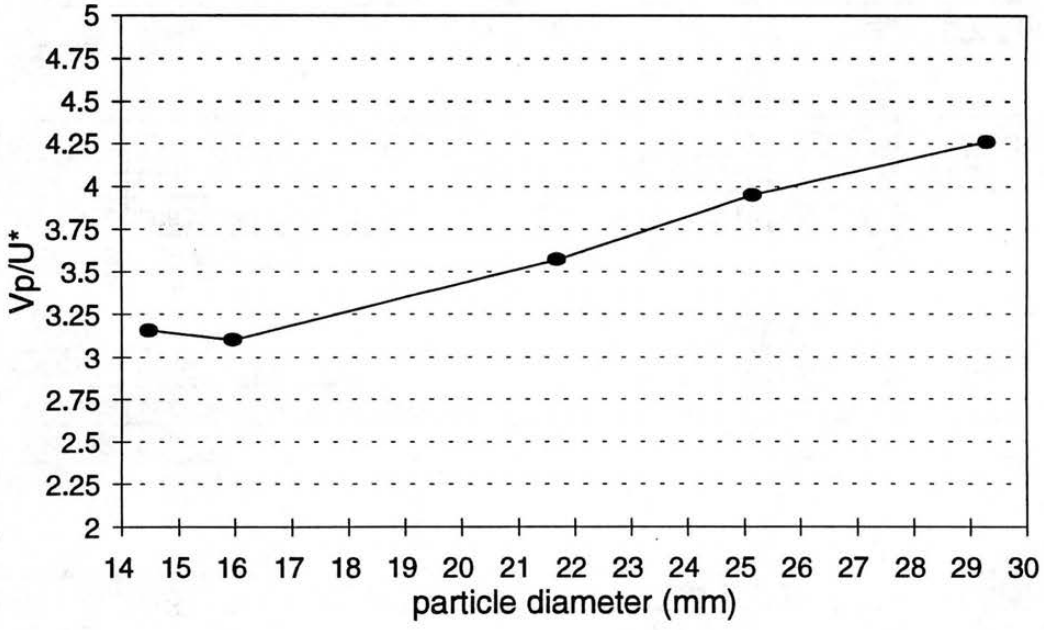
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.3676	4.2607	0.2004	0.0470	12.2083	5900.5144	72.0354	2.3578
glass	0.3409	3.9515	0.2005	0.0507	10.4875	5900.5144	61.8816	2.7447
glass	0.3082	3.5717	0.1952	0.0547	9.0417	5900.5144	53.3505	3.1836
glass	0.2677	3.1025	0.1977	0.0637	6.6542	5900.5144	39.2630	4.3258
glass	0.2725	3.1581	0.2114	0.0669	6.0333	5900.5144	35.5998	4.7709

Run 13
U* = 0.0301 m/s

Vp/V vs. d
(glass)



Vp/U* vs. d
(glass)



Run#	14		Bed Roughness k:	2.4	mm	Streamflow	16.8986 L/s
Date	6-29-95		Pump Setting	medium		Valve Setting	full open
Reach Length	2000	mm	Slope Reading	128.5	mm	Bed Slope	0.004

		Initial		Intermediate		Final	
Temperature		17.5	°C			17	°C
Manometer in. of water	Hi	39.28		39.28		39.28	
	Lo	-41.99		-41.99		-41.99	
	Hi - Lo	81.27		81.27		81.27	
Flow Depth:	u.s.	58.9	mm	59.1	mm	59	mm
	d.s.	62.7	mm	62.9	mm	62.8	mm
	u.s. - d.s.	-3.8	mm	-3.8	mm	-3.8	mm
	at weir	58.4	mm	57.3	mm	59.1	mm
Top Width:	u.s.	617	mm	617	mm	621	mm
	d.s.	640	mm	642	mm	645	mm
	at weir	637	mm	638	mm	640	mm

Velocities (mm/s)

type	glass	344.2341	283.2861	316.4557	281.6901	258.0645	292.3977	274.7253
d (mm)	29.3	296.2963	331.6750	292.3977	320.0000	303.4901	263.5046	282.0874
n	21	284.4950	271.3704	282.4859	289.4356	273.5978	298.9537	273.9726
G	2.6			Std Dev	21.9710		Avg	291.1722

Velocities (mm/s)

type	glass	302.1148	285.7143	408.1633	297.6190	313.4796	333.3333	311.0420
d (mm)	25.17	323.1018	318.4713	293.6858	298.9537	293.6858	318.4713	284.4950
n	21	290.6977	317.9650	328.4072	282.8854	307.6923	296.2963	325.2033
G	2.6			Std Dev	26.9549		Avg	311.0228

Velocities (mm/s)

type	glass	268.8172	312.0125	274.7253	261.0966	260.0780	353.3569	313.4796
d (mm)	21.7	335.5705	333.3333	283.2861	294.9853	365.6307	344.2341	321.5434
n	21	300.3003	268.0965	264.2008	323.6246	316.4557	307.6923	297.6190
G	2.6			Std Dev	31.6355		Avg	304.7685

Velocities (mm/s)

type	glass	267.3797	315.4574	240.3846	324.6753	270.2703	280.5049	309.1190
d (mm)	15.97	280.8989	296.2963	292.3977	274.7253	309.1190	260.4167	247.2188
n	21	335.0084	327.8689	299.4012	234.4666	345.4231	275.8621	288.1844
G	2.6			Std Dev	30.8202		Avg	289.2895

		Velocities (mm/s)						
type	glass	231.2139	359.7122	273.5978	335.0084	274.7253	279.7203	289.8551
d (mm)	14.48	297.6190	306.2787	296.2963	316.4557	247.2188	272.4796	286.9440
n	21	306.2787	323.1018	245.3988	288.1844	320.0000	335.0084	300.7519
G	2.6			Std Dev	31.7141		Avg	294.5642

		Velocities (mm/s)						
type	natural	229.6211	221.4839	223.7136	218.5792	239.8082	286.9440	312.0125
d (mm)	13.6	239.8082	229.3578	235.0176	231.2139	235.2941	201.8163	285.7143
n	21	277.0083	230.9469	236.1275	230.1496	235.2941	287.3563	277.0083
G	2.65			Std Dev	28.9931		Avg	245.9179

		Velocities (mm/s)						
type	natural	248.1390	203.6660	250.9410	288.6003	264.5503	239.5210	280.8989
d (mm)	9.6	307.2197	245.3988	221.9756	220.7506	247.8315	237.8121	238.6635
n	21	224.2152	254.4529	280.5049	237.5297	253.1646	231.2139	246.3054
G	2.65			Std Dev	24.7476		Avg	248.7312

		Velocities (mm/s)						
type	natural	198.2161	202.0202	216.9197	176.6784	233.6449	189.3939	200.0000
d (mm)	6.8	240.6739	281.6901	225.7336	204.0816	309.1190	233.6449	220.7506
n	21	165.2893	272.1088	246.0025	220.9945	238.6635	224.4669	247.8315
G	2.65			Std Dev	34.3545		Avg	226.0916

		Velocities (mm/s)						
type	natural	260.0780	208.5506	220.0220	173.4605	188.3239	242.4242	181.3237
d (mm)	4.8	236.9668	209.8636	208.3333	207.9002	227.7904	189.9335	204.9180
n	21	216.2162	205.1282	199.4018	215.5172	205.9732	200.0000	221.2389
G	2.65			Std Dev	20.2578		Avg	210.6364

All particles that moved meandered and exhibited varying velocities.

Smaller natural particles stopped before completing the run.

Steel particles moved only a few centimeters before halting.

Run# 14 Bed
Date: 6-29-95 Roughness k: 2.4 mm y/k: 25.375

Slope: 0.004 Q: 16.89864 L/s U*: 0.0386 m/s

	u.s.	d.s.	avg
y (mm)	59	62.8	60.9
Tw (mm)	618.333333	642.3333	630.3333
A (m^2)	0.02648608	0.028946	0.026349
P (m)	0.63829246	0.663458	0.648671
Rh (m)	0.04149522	0.043628	0.040621
V (m/s)	0.63801966	0.583808	0.610914
H (m)	0.08623475	0.080178	0.083206

delta H: 0.0060572 m delta x: 1.62 m

Sf: 0.003739

Tavg: 17.25 °C

ν: 1.0735E-06 m^2/s

δ: 0.00032266 m

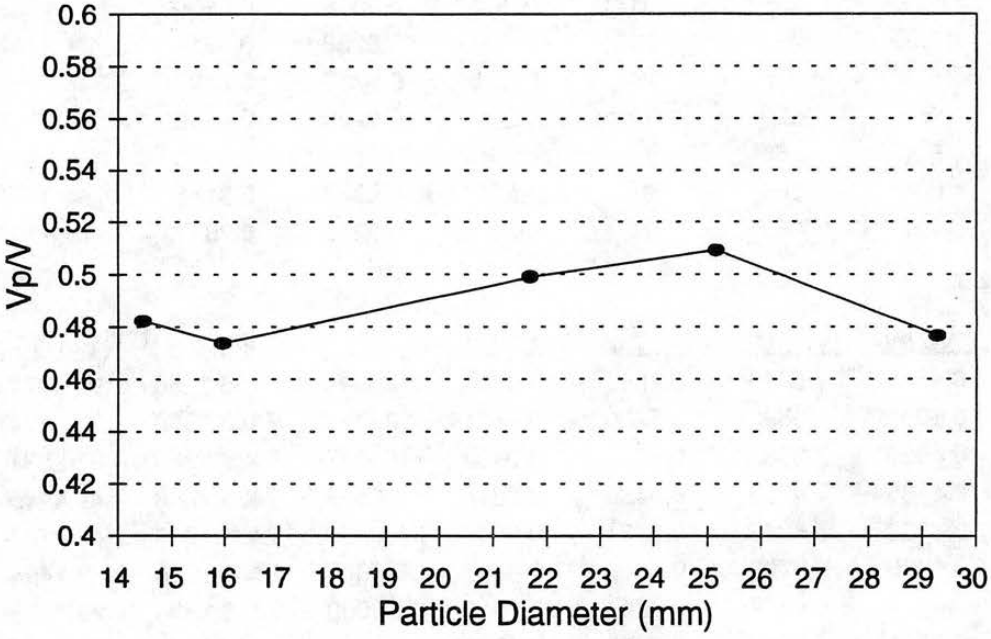
Run# 14

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	29.3	2.6	21	0.2912	0.0220	0.6392	699.6494	0.003240
glass	25.17	2.6	21	0.3110	0.0270	0.5924	601.0298	0.003771
glass	21.7	2.6	21	0.3048	0.0316	0.5500	518.1703	0.004374
glass	15.97	2.6	21	0.2893	0.0308	0.4716	381.3447	0.005944
glass	14.48	2.6	21	0.2946	0.0317	0.4490	345.7653	0.006556
natural	13.6	2.65	21	0.2459	0.0290	0.4418	328.1001	0.006768
natural	9.6	2.65	21	0.2487	0.0247	0.3708	231.6001	0.009588
natural	6.8	2.65	21	0.2261	0.0344	0.3116	164.0501	0.013537
natural	4.8	2.65	21	0.2106	0.0203	0.2611	115.8000	0.019177

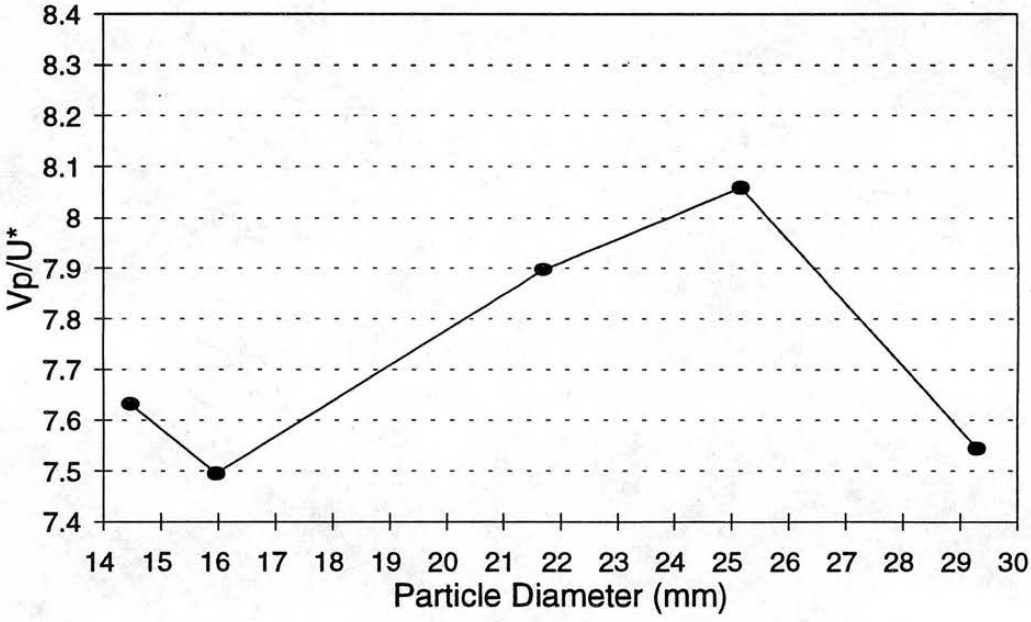
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.4766	7.5446	0.4555	0.0604	12.2083	7438.1268	90.8071	2.0785
glass	0.5091	8.0590	0.5250	0.0651	10.4875	7438.1268	78.0074	2.4195
glass	0.4989	7.8969	0.5542	0.0702	9.0417	7438.1268	67.2531	2.8065
glass	0.4735	7.4959	0.6134	0.0818	6.6542	7438.1268	49.4945	3.8134
glass	0.4822	7.6325	0.6561	0.0860	6.0333	7438.1268	44.8767	4.2058
natural	0.4025	6.3720	0.5566	0.0873	5.6667	7438.1268	42.1494	4.4779
natural	0.4071	6.4449	0.6707	0.1041	4.0000	7438.1268	29.7525	6.3438
natural	0.3701	5.8583	0.7256	0.1239	2.8333	7438.1268	21.0747	8.9559
natural	0.3448	5.4579	0.8068	0.1478	2.0000	7438.1268	14.8763	12.6875

Run 14
U* = 0.0386 m/s

Vp/V vs. d
(glass)

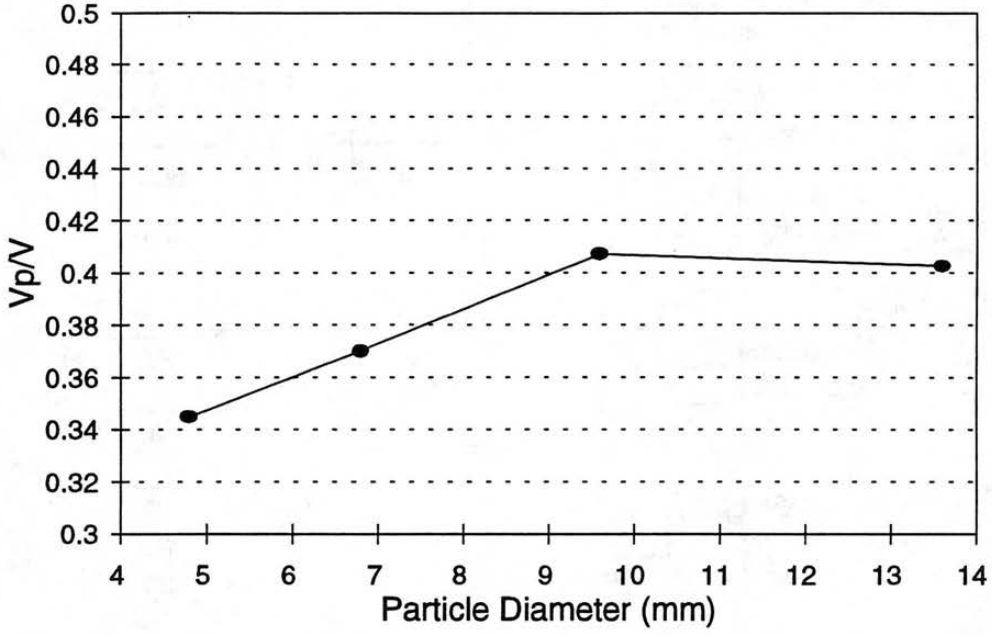


Vp/U* vs. d
(glass)

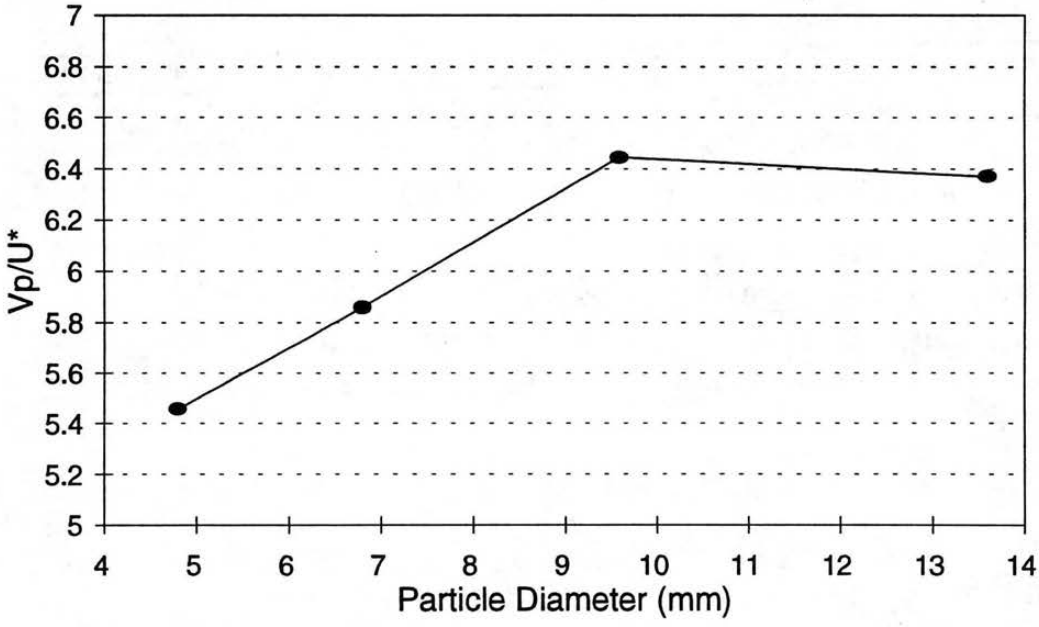


Run 14
U* = 0.0386 m/s

Vp/V vs. d
(natural)



Vp/U* vs. d
(natural)



Run#	15	Bed Roughness k:	2.4	mm	Streamflow	9.9551	L/s
Date	7-4-95	Pump Setting	slow		Valve Setting	1/2 open	
Reach Length	2000 mm	Slope Reading	110	mm	Bed Slope	0.0014	

		Initial		Intermediate		Final	
Temperature		17	°C			17	°C
Manometer in. of water	Hi	38.8		38.85		38.8	
	Lo	10.4		10.45		10.45	
	Hi - Lo	28.4		28.4		28.35	
Flow Depth:	u.s.	69.2	mm	69.1	mm	69.1	mm
	d.s.	69.2	mm	69	mm	69.1	mm
	u.s. - d.s.	0	mm	0.1	mm	0	mm
	at weir	69	mm	69.1	mm	69	mm
Top Width:	u.s.	677	mm	682	mm	681	mm
	d.s.	679	mm	681	mm	680	mm
	at weir	698	mm	699	mm	700	mm

Velocities (mm/s)

type	glass	104.9318	106.8376	107.7006	109.5890	100.6036	ERR	ERR
d (mm)	29.3	107.2386	101.5744	107.9331	104.6025	106.6667	ERR	ERR
n	15	108.6957	108.8139	112.6761	109.5890	107.4114	ERR	ERR
G	2.6			Std Dev	3.0925		Avg	106.9909

Velocities (mm/s)

type	glass	93.2836	91.2825	112.0448	98.4737	104.4386	99.4036	95.7854
d (mm)	25.17	102.0408	100.0000	100.1502	99.0589	106.4963	104.7120	91.9540
n	21	102.8807	93.2836	107.7586	95.5110	100.0000	102.5641	89.6459
G	2.6			Std Dev	5.8482		Avg	99.5604

Velocities (mm/s)

type	glass	78.7402	90.0090	91.2825	ERR	ERR	ERR	ERR
d (mm)	21.7	97.7040	78.8333	87.9121	ERR	ERR	ERR	ERR
n	9	91.5332	85.7633	93.5891	ERR	ERR	ERR	ERR
G	2.6			Std Dev	6.3858		Avg	88.3741

Natural and steel particles showed little or no motion.

The glass particles with diameters 29.30mm, 25.17mm, and 21.70mm had many failed trials due to halting or leaving the plates.

Glass particles with diameters 15.97mm and 14.48mm moved only short distances before halting.

Run#	15	Bed					
Date:	7-4-95	Roughness k:	2.4	mm		y/k:	28.799
Slope:	0.0014	Q:	9.955148	L/s	U*:	0.025	m/s

	u.s.	d.s.	avg
y (mm)	69.1333333	69.1	69.11667
Tw (mm)	680	680	680
A (m^2)	0.03316672	0.033151	0.031621
P (m)	0.70319555	0.703174	0.700976
Rh (m)	0.04716571	0.047144	0.04511
V (m/s)	0.30015477	0.3003	0.300227
H (m)	0.07599479	0.073698	0.074846

delta H:	0.0022969	m	delta x:	1.62	m
Sf:	0.00141784				
Tavg:	17	°C			
ν:	1.0801E-06	m^2/s			
δ:	0.00050027	m			

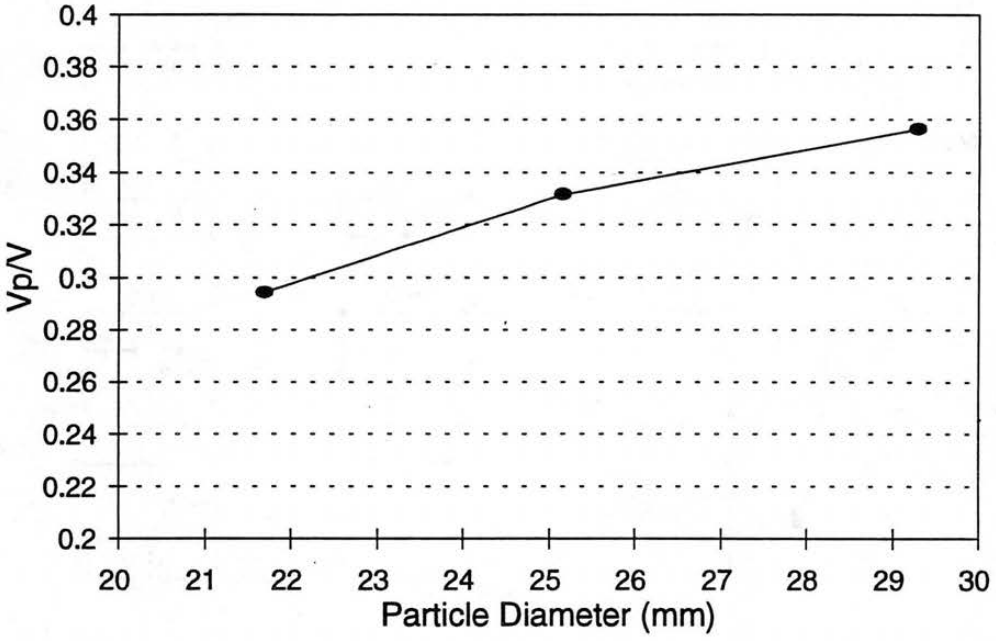
Run# 15

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	29.3	2.6	15	0.1070	0.0031	0.6392	696.8006	0.001364
glass	25.17	2.6	21	0.0996	0.0058	0.5924	598.5827	0.001588
glass	21.7	2.6	9	0.0884	0.0064	0.5500	516.0605	0.001842

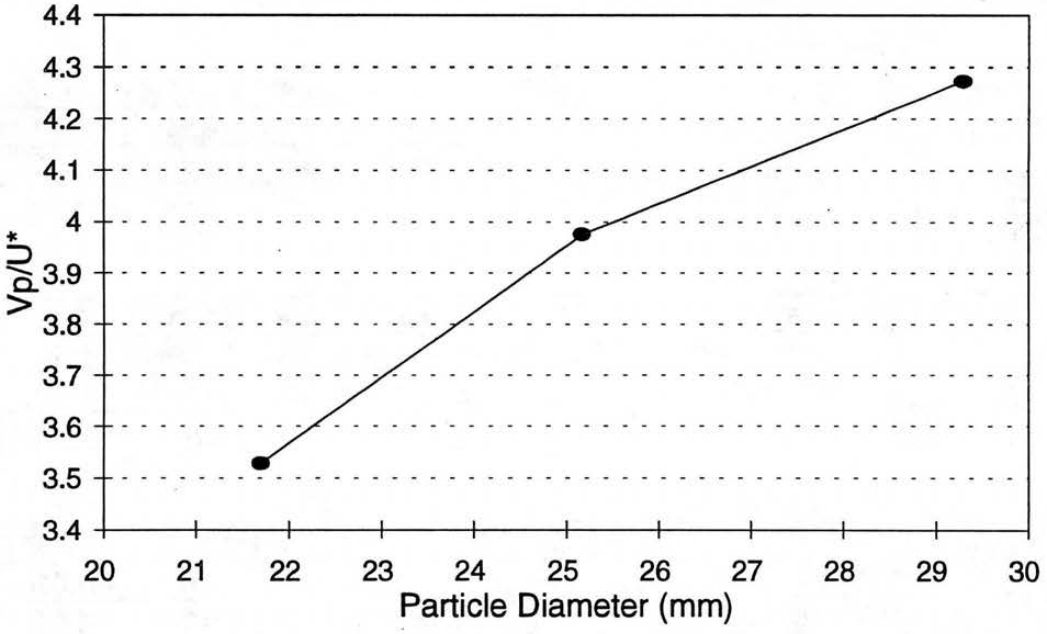
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.3564	4.2721	0.1674	0.0392	12.2083	4797.3750	58.5680	2.3589
glass	0.3316	3.9754	0.1681	0.0423	10.4875	4797.3750	50.3125	2.7460
glass	0.2944	3.5287	0.1607	0.0455	9.0417	4797.3750	43.3763	3.1851

Run 15
U* = 0.025 m/s

Vp/V vs. d
(glass)



Vp/U* vs. d
(glass)



Run#	16		Bed Roughness k:	2.4	mm	Streamflow	14.2923 L/s
Date	7-6-95		Pump Setting	medium		Valve Setting	1/2 open
Reach Length	2000	mm	Slope Reading	121.5	mm	Bed Slope	0.003

		Initial		Intermediate		Final	
Temperature		17	°C			17.5	°C
Manometer in. of water	Hi	28.45		28.45		28.45	
	Lo	-29.8		-29.8		-29.8	
	Hi - Lo	58.25		58.25		58.25	
Flow Depth:	u.s.	62	mm	62	mm	61.9	mm
	d.s.	62	mm	61.9	mm	62	mm
	u.s. - d.s.	0	mm	0.1	mm	-0.1	mm
	at weir	63.1	mm	63.1	mm	63.1	mm
Top Width:	u.s.	645	mm	648	mm	651	mm
	d.s.	636	mm	641	mm	640	mm
	at weir	675	mm	676	mm	670	mm

Velocities (mm/s)

type	glass	195.1220	206.6116	198.8072	207.6843	204.4990	ERR	ERR
d (mm)	29.3	190.4762	198.8072	186.5672	193.9864	192.1230	ERR	ERR
n	15	195.1220	182.9826	201.2072	197.4334	189.3939	ERR	ERR
G	2.6			Std Dev	7.1687		Avg	196.0549

Velocities (mm/s)

type	glass	178.4121	185.0139	180.3427	192.1230	200.6018	220.0220	ERR
d (mm)	25.17	201.2072	186.5672	204.4990	203.8736	199.4018	178.2531	ERR
n	18	186.5672	186.0465	183.8235	209.8636	180.3427	192.8640	ERR
G	2.6			Std Dev	12.0313		Avg	192.7680

Velocities (mm/s)

type	glass	172.5626	183.9926	191.5709	186.0465	188.8574	181.8182	ERR
d (mm)	21.7	171.2329	173.0104	167.5042	182.4818	182.8154	176.3668	ERR
n	18	162.8664	179.2115	170.2128	178.4121	191.0220	175.2848	ERR
G	2.6			Std Dev	8.1704		Avg	178.6261

Velocities (mm/s)

type	glass	180.6685	163.6661	192.8640	157.6044	158.3531	143.4720	169.6353
d (mm)	15.97	171.5266	169.7793	162.8664	175.2848	180.8318	186.0465	164.0689
n	21	168.9189	175.9015	169.7793	166.6667	156.1280	160.0000	161.9433
G	2.6			Std Dev	11.2039		Avg	168.3812

		Velocities (mm/s)						
type	glass	154.9187	186.5672	146.1988	154.6790	151.9757	175.9015	172.1170
d (mm)	14.48	170.6485	157.6044	181.8182	150.4891	173.4605	156.8627	167.9261
n	21	177.7778	158.8562	174.9781	191.0220	149.0313	185.5288	175.2848
G	2.6			Std Dev	13.6739		Avg	167.3165

		Velocities (mm/s)						
type	natural	166.6667	154.2020	161.9433	144.1961	150.9434	157.7287	135.3180
d (mm)	13.6	153.0222	156.4945	191.0220	168.0672	162.8664	161.9433	133.0672
n	21	166.6667	145.1379	165.4260	172.5626	128.2874	160.0000	146.7351
G	2.65			Std Dev	14.4922		Avg	156.2998

		Velocities (mm/s)						
type	natural	152.4390	168.3502	136.7054	157.9779	154.2020	139.1788	187.0907
d (mm)	9.6	178.2531	163.6661	135.3180	150.2630	198.0198	174.3679	113.1222
n	21	168.3502	137.6462	150.9434	130.8901	127.9591	152.7884	174.3679
G	2.65			Std Dev	21.2158		Avg	154.8524

		Velocities (mm/s)						
type	natural	168.3502	151.2859	127.4697	ERR	ERR	ERR	ERR
d (mm)	6.8	148.5884	205.7613	127.9591	ERR	ERR	ERR	ERR
n	9	177.3050	126.2626	156.4945	ERR	ERR	ERR	ERR
G	2.65			Std Dev	26.5075		Avg	154.3863

Very little movement of smaller natural particles.
The natural particles that did travel, meandered considerably and their velocities varied noticably.
The 6.8 mm natural particle stopped without restart 30 times in addition to the 9 "successful" trials .

The steel particles showed little or no motion.

The glass particles rolled with uniform velocity and very little meanderin

Run#	16	Bed					
Date:	7-6-95	Roughness k:	2.4	mm		y/k:	25.819
Slope:	0.003	Q:	14.29225	L/s	U*:	0.0339	m/s

	u.s.	d.s.	avg
y (mm)	61.9666667	61.96667	61.96667
Tw (mm)	648	639	643.5
A (m^2)	0.02873704	0.028458	0.027219
P (m)	0.66828236	0.659763	0.661886
Rh (m)	0.04300135	0.043134	0.041123
V (m/s)	0.49734605	0.502219	0.499783
H (m)	0.07943816	0.074827	0.077132

delta H:	0.0046116	m	delta x:	1.62	m
Sf:	0.00284669				
Tavg:	17.25	°C			
ν:	1.0735E-06	m^2/s			
δ:	0.00036752	m			

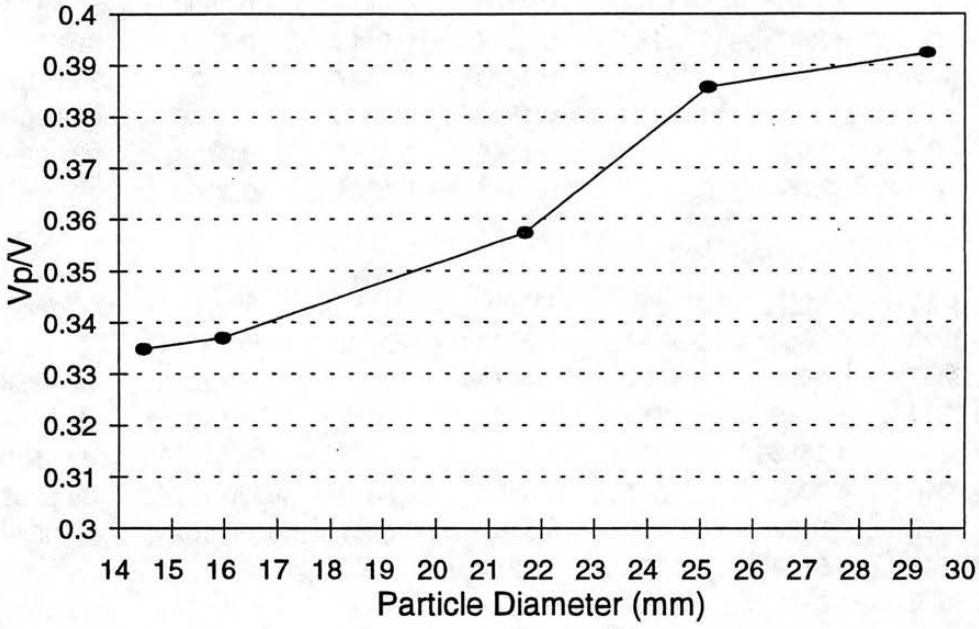
Run# 16

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	29.3	2.6	15	0.1961	0.0072	0.6392	699.6494	0.002497
glass	25.17	2.6	18	0.1928	0.0120	0.5924	601.0298	0.002907
glass	21.7	2.6	18	0.1786	0.0082	0.5500	518.1703	0.003372
glass	15.97	2.6	21	0.1684	0.0112	0.4716	381.3447	0.004581
glass	14.48	2.6	21	0.1673	0.0137	0.4490	345.7653	0.005053
natural	13.6	2.65	21	0.1563	0.0145	0.4418	328.1001	0.005217
natural	9.6	2.65	21	0.1549	0.0212	0.3708	231.6001	0.007390
natural	6.8	2.65	9	0.1544	0.0265	0.3116	164.0501	0.010434

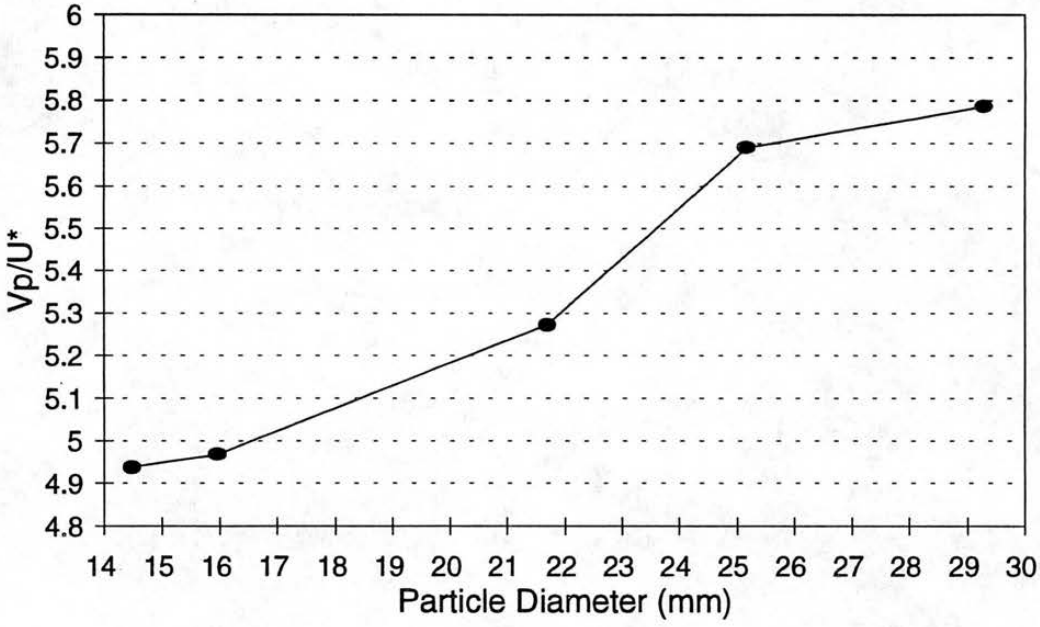
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.3923	5.7863	0.3067	0.0530	12.2083	6530.1925	79.7228	2.1149
glass	0.3857	5.6893	0.3254	0.0572	10.4875	6530.1925	68.4854	2.4619
glass	0.3574	5.2719	0.3248	0.0616	9.0417	6530.1925	59.0438	2.8556
glass	0.3369	4.9696	0.3570	0.0718	6.6542	6530.1925	43.4530	3.8802
glass	0.3348	4.9382	0.3727	0.0755	6.0333	6530.1925	39.3988	4.2795
natural	0.3127	4.6130	0.3538	0.0767	5.6667	6530.1925	37.0044	4.5564
natural	0.3098	4.5703	0.4176	0.0914	4.0000	6530.1925	26.1208	6.4549
natural	0.3089	4.5565	0.4955	0.1087	2.8333	6530.1925	18.5022	9.1127

Run 16
U* = 0.0339 m/s

Vp/V vs. d
(glass)

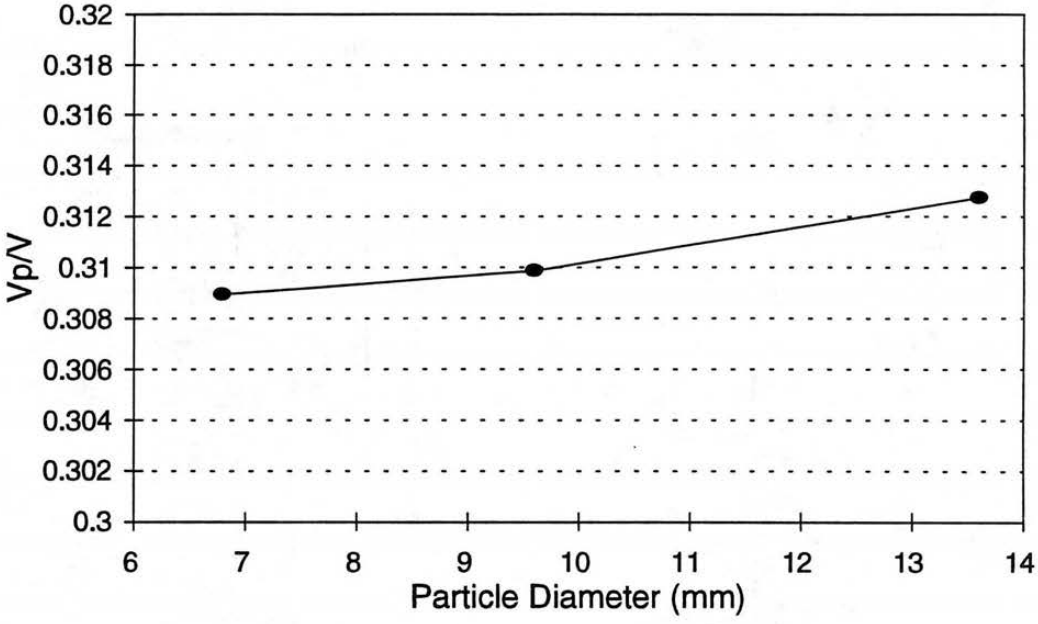


Vp/U* vs. d
(glass)

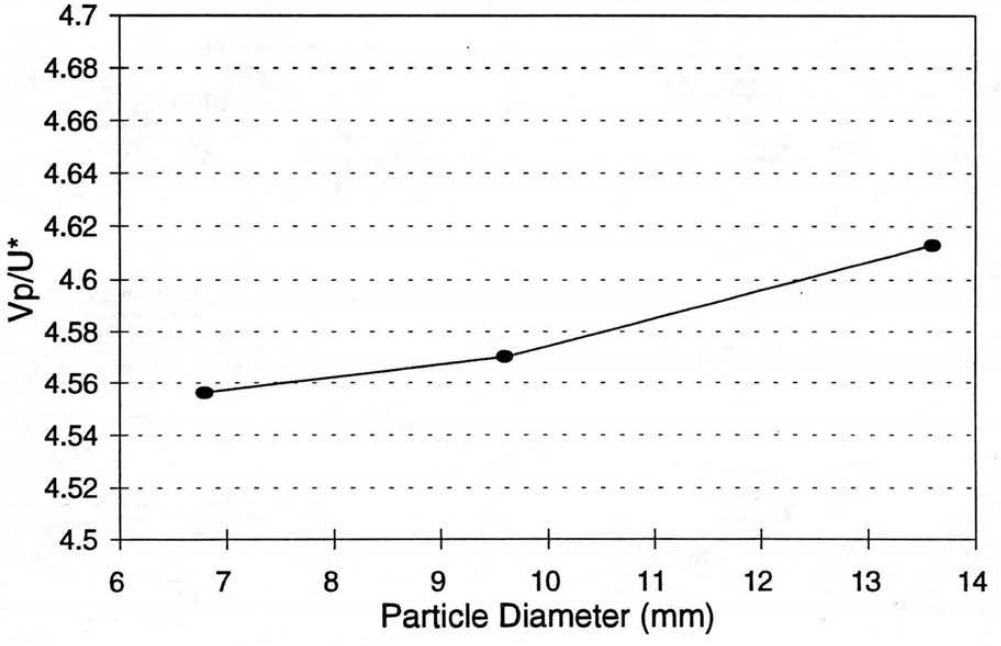


Run 16
U* = 0.0339 m/s

Vp/V vs. d
(natural)



Vp/U* vs. d
(natural)



Run#	17	Bed Roughness k:	2.4	mm	Streamflow	19.1789	L/s
Date	7-10-95	Pump Setting	fast		Valve Setting	1/2 open	
Reach Length	. 2000	mm Slope Reading	143	mm	Bed Slope	0.006	

		Initial		Intermediate		Final	
Temperature		17	°C			18	°C
Manometer in. of water	Hi	51.47		51.47		50.8	
	Lo	-54.18		-52.83		-52.83	
	Hi - Lo	105.65		104.3		103.63	
Flow Depth:	u.s.	59.8	mm	58.8	mm	59.6	mm
	d.s.	61.3	mm	61.1	mm	61.2	mm
	u.s. - d.s.	-1.5	mm	-2.3	mm	-1.6	mm
	at weir	57.2	mm	57.9	mm	57.3	mm
Top Width:	u.s.	614	mm	617	mm	620	mm
	d.s.	636	mm	635	mm	638	mm
	at weir	630	mm	627	mm	630	mm

Velocities (mm/s)

type	steel	136.4256	142.8571	151.2859	144.8226	137.0802	135.8696	137.9310
d (mm)	19.04	145.1379	142.2475	137.3626	146.4129	125.7071	139.7624	138.5042
n	21	142.8571	143.4720	133.3333	141.8440	142.8571	133.3333	136.9863
G	8.02			Std Dev	5.5523		Avg	139.8138

Velocities (mm/s)

type	glass	426.4392	447.4273	555.5556	485.4369	469.4836	477.3270	502.5126
d (mm)	29.3	477.3270	444.4444	467.2897	524.9344	464.0371	477.3270	422.8330
n	21	484.2615	511.5090	512.8205	453.5147	487.8049	473.9336	454.5455
G	2.6			Std Dev	32.1269		Avg	477.1793

Velocities (mm/s)

type	glass	470.5882	459.7701	524.9344	478.4689	476.1905	511.5090	467.2897
d (mm)	25.17	459.7701	546.4481	457.6659	511.5090	477.3270	496.2779	511.5090
n	21	404.8583	495.0495	507.6142	434.7826	530.5040	460.8295	546.4481
G	2.6			Std Dev	36.2082		Avg	487.1116

Velocities (mm/s)

type	glass	487.8049	437.6368	487.8049	496.2779	500.0000	512.8205	456.6210
d (mm)	21.7	500.0000	480.7692	456.6210	512.8205	453.5147	487.8049	495.0495
n	21	400.0000	491.4005	488.9976	516.7959	451.4673	512.8205	447.4273
G	2.6			Std Dev	30.1116		Avg	479.7359

		Velocities (mm/s)						
type	glass	473.9336	444.4444	514.1388	464.0371	395.2569	421.0526	511.5090
d (mm)	15.97	478.4689	470.5882	454.5455	418.4100	529.1005	492.6108	507.6142
n	21	409.8361	430.1075	415.8004	454.5455	450.4505	503.7783	473.9336
G	2.6			Std Dev	38.4180		Avg	462.5792

		Velocities (mm/s)						
type	glass	481.9277	432.9004	477.3270	423.7288	460.8295	507.6142	448.4305
d (mm)	14.48	395.2569	477.3270	460.8295	473.9336	444.4444	495.0495	473.9336
n	21	395.2569	441.5011	438.5965	520.8333	426.4392	473.9336	470.5882
G	2.6			Std Dev	32.8905		Avg	458.1277

		Velocities (mm/s)						
type	natural	396.8254	340.1361	341.8803	361.6637	392.1569	349.6503	366.3004
d (mm)	13.6	365.6307	349.6503	407.3320	371.7472	403.2258	408.1633	361.6637
n	21	413.2231	395.2569	357.7818	386.1004	367.6471	404.8583	380.9524
G	2.65			Std Dev	23.4601		Avg	377.2308

		Velocities (mm/s)						
type	natural	421.0526	395.2569	424.6285	385.3565	363.6364	359.7122	298.9537
d (mm)	9.6	363.6364	426.4392	293.6858	438.5965	423.7288	366.3004	353.3569
n	21	392.9273	346.0208	430.1075	467.2897	448.4305	389.8635	404.8583
G	2.65			Std Dev	45.8130		Avg	390.1828

		Velocities (mm/s)						
type	natural	418.4100	390.6250	324.6753	347.8261	397.6143	394.4773	361.6637
d (mm)	6.8	404.8583	349.6503	399.2016	340.1361	343.6426	448.4305	466.2005
n	21	413.2231	330.0330	491.4005	336.7003	355.8719	402.4145	387.5969
G	2.65			Std Dev	45.6947		Avg	385.9358

		Velocities (mm/s)						
type	natural	353.3569	333.3333	318.4713	335.0084	273.5978	361.6637	306.2787
d (mm)	4.8	340.1361	305.8104	395.2569	320.0000	307.6923	321.5434	370.3704
n	21	328.4072	312.0125	303.4901	353.9823	349.6503	346.0208	286.9440
G	2.65			Std Dev	28.9868		Avg	329.6679

Natural particles smaller than 4.8 mm were impossible to follow in the flow. Some were later found in the net, others were trapped between particles on the plate.

Steel particles smaller than 19.04 mm rarely finished a trial without stopping.

Run#	17	Bed					
Date:	7-10-95	Roughness k:	2.4	mm		y/k:	25.125
Slope:	0.006	Q:	19.17894	L/s	U*:	0.0506	m/s

	u.s.	d.s.	avg
y (mm)	59.4	61.2	60.3
Tw (mm)	617	636.3333	626.6667
A (m^2)	0.02662605	0.028025	0.025979
P (m)	0.63729839	0.656742	0.644814
Rh (m)	0.04177957	0.042672	0.04029
V (m/s)	0.72030739	0.684363	0.702335
H (m)	0.09557362	0.085079	0.090326

delta H:	0.0104943	m	delta x:	1.62	m
Sf:	0.00647793				
Tavg:	17.5	°C			
ν:	1.067E-06	m^2/s			
δ:	0.00024464	m			

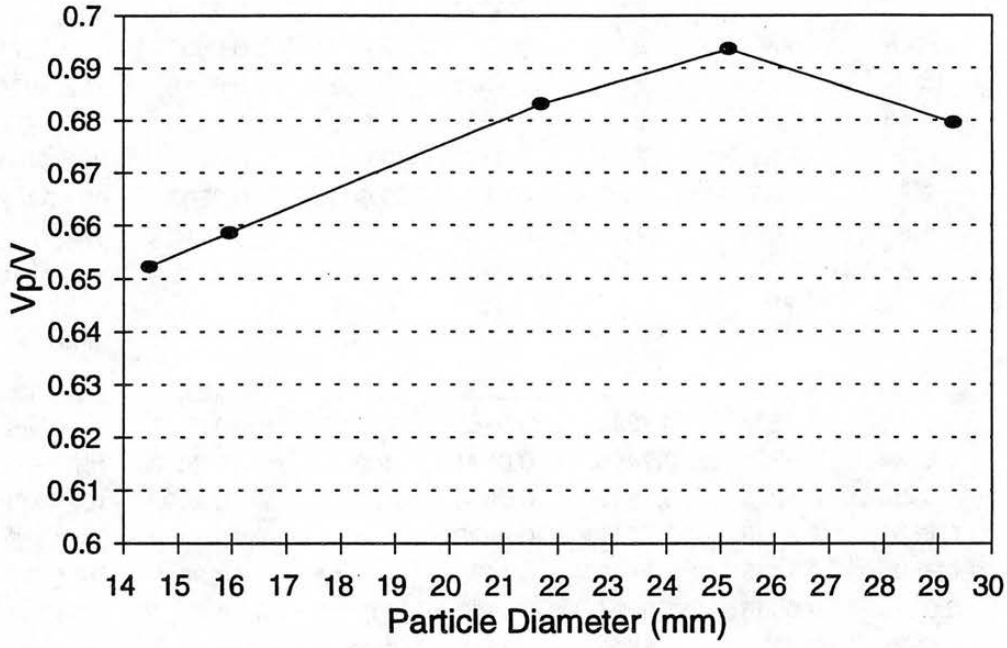
Run# 17

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	21	0.1398	0.0056	1.0794	747.3476	0.001953
glass	29.3	2.6	21	0.4772	0.0321	0.6392	702.5075	0.005567
glass	25.17	2.6	21	0.4871	0.0362	0.5924	603.4851	0.006481
glass	21.7	2.6	21	0.4797	0.0301	0.5500	520.2871	0.007517
glass	15.97	2.6	21	0.4626	0.0384	0.4716	382.9025	0.010214
glass	14.48	2.6	21	0.4581	0.0329	0.4490	347.1778	0.011265
natural	13.6	2.65	21	0.3772	0.0235	0.4418	329.4404	0.011631
natural	9.6	2.65	21	0.3902	0.0458	0.3708	232.5462	0.016477
natural	6.8	2.65	21	0.3859	0.0457	0.3116	164.7202	0.023261
natural	4.8	2.65	21	0.3297	0.0290	0.2611	116.2731	0.032954

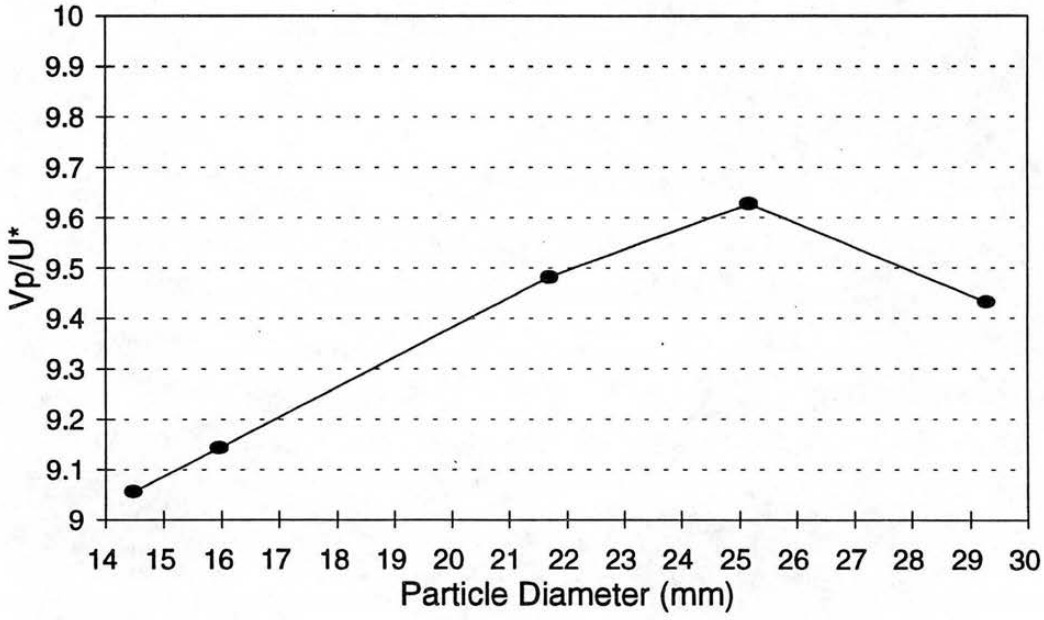
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.1991	2.7636	0.1295	0.0469	7.9333	9810.3090	77.8285	3.1670
glass	0.6794	9.4321	0.7465	0.0791	12.2083	9810.3090	119.7675	2.0580
glass	0.6936	9.6284	0.8223	0.0854	10.4875	9810.3090	102.8856	2.3957
glass	0.6831	9.4826	0.8723	0.0920	9.0417	9810.3090	88.7015	2.7788
glass	0.6586	9.1435	0.9809	0.1073	6.6542	9810.3090	65.2794	3.7758
glass	0.6523	9.0555	1.0204	0.1127	6.0333	9810.3090	59.1889	4.1644
natural	0.5371	7.4565	0.8538	0.1145	5.6667	9810.3090	55.5918	4.4338
natural	0.5556	7.7125	1.0521	0.1364	4.0000	9810.3090	39.2412	6.2813
natural	0.5495	7.6285	1.2385	0.1624	2.8333	9810.3090	27.7959	8.8676
natural	0.4694	6.5163	1.2627	0.1938	2.0000	9810.3090	19.6206	12.5625

Run 17
U*=0.0506

Vp/V vs. d
(glass)

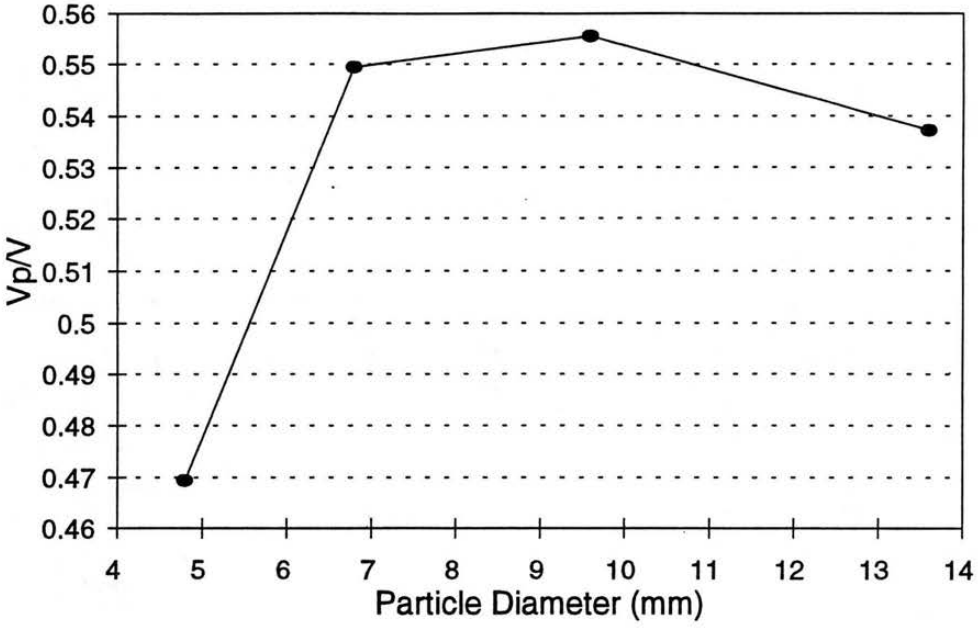


Vp/U* vs. d
(glass)

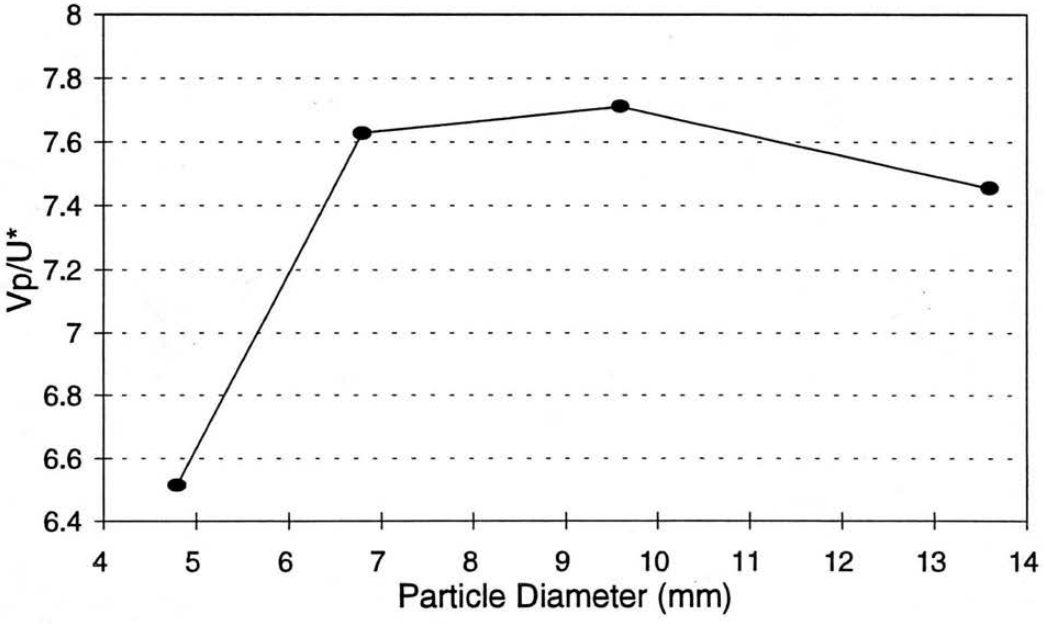


Run 17
U*=0.0506

Vp/V vs. d
(natural)



Vp/U* vs. d
(natural)



Run#	18	Bed Roughness k:	2.4	mm	Streamflow	21.8134	L/s
Date	7-11-95	Pump Setting	fast		Valve Setting	1/2 open	
Reach Length	2000	mm	Slope Reading	171.5	mm	Bed Slope	0.01

		Initial		Intermediate		Final	
Temperature		18	°C			20	°C
Manometer in. of water	Hi	66.38		65.02		65.02	
	Lo	-69.08		-70.44		-69.08	
	Hi - Lo	135.46		135.46		134.1	
Flow Depth:	u.s.	56.5	mm	56.3	mm	56.8	mm
	d.s.	56.5	mm	56.5	mm	55.6	mm
	u.s. - d.s.	0	mm	-0.2	mm	1.2	mm
	at weir	54.6	mm	54.4	mm	54.4	mm
Top Width:	u.s.	617	mm	613	mm	615	mm
	d.s.	637	mm	638	mm	639	mm
	at weir	628	mm	630	mm	628	mm

Velocities (mm/s)

type	steel	180.3427	184.5018	177.7778	185.0139	180.3427	176.2115	169.3480
d (mm)	19.04	199.4018	173.9130	175.2848	189.3939	157.2327	171.0864	182.4818
n	21	193.7984	184.8429	191.5709	189.7533	178.8909	181.3237	183.3181
G	8.02			Std Dev	9.3043		Avg	181.2300

Velocities (mm/s)

type	steel	180.6685	177.7778	153.0222	154.9187	169.3480	189.9335	172.4138
d (mm)	15.88	178.8909	160.7717	158.8562	167.6446	159.2357	170.2128	173.9130
n	21	167.0844	166.2510	170.6485	198.6097	151.7451	171.5266	163.2653
G	8.02			Std Dev	11.6893		Avg	169.3685

Velocities (mm/s)

type	steel	163.2653	160.7717	158.7302	173.3102	ERR	ERR	ERR
d (mm)	14.28	162.8664	140.6470	156.4945	163.6661	ERR	ERR	ERR
n	21	140.0560	159.2357	186.5672	165.4260	ERR	ERR	ERR
G	8.02			Std Dev	12.5117		Avg	160.9197

Velocities (mm/s)

type	glass	694.4444	709.2199	694.4444	653.5948	634.9206	638.9776	735.2941
d (mm)	29.3	751.8797	673.4007	738.0074	694.4444	743.4944	711.7438	660.0660
n	21	638.9776	666.6667	696.8641	647.2492	701.7544	727.2727	743.4944
G	2.6			Std Dev	38.2657		Avg	693.1529

		Velocities (mm/s)						
type	glass	719.4245	632.9114	673.4007	666.6667	743.4944	763.3588	701.7544
d (mm)	25.17	660.0660	701.7544	743.4944	716.8459	696.8641	727.2727	660.0660
n	21	704.2254	735.2941	673.4007	666.6667	673.4007	727.2727	657.8947
G	2.6			Std Dev	35.2794		Avg	697.4062

		Velocities (mm/s)						
type	glass	653.5948	673.4007	660.0660	653.5948	694.4444	687.2852	641.0256
d (mm)	21.7	687.2852	632.9114	687.2852	660.0660	666.6667	673.4007	653.5948
n	21	687.2852	660.0660	675.6757	628.9308	645.1613	673.4007	647.2492
G	2.6			Std Dev	19.0197		Avg	663.9234

		Velocities (mm/s)						
type	glass	666.6667	680.2721	632.9114	666.6667	609.7561	666.6667	615.3846
d (mm)	15.97	645.1613	593.4718	604.2296	680.2721	628.9308	621.1180	653.5948
n	21	581.3953	632.9114	711.7438	680.2721	586.5103	593.4718	647.2492
G	2.6			Std Dev	36.2862		Avg	638.0313

		Velocities (mm/s)						
type	glass	680.2721	593.4718	647.2492	701.7544	638.9776	709.2199	727.2727
d (mm)	14.48	647.2492	754.7170	719.4245	615.3846	645.1613	621.1180	626.9592
n	21	666.6667	660.0660	607.9027	641.0256	727.2727	701.7544	687.2852
G	2.6			Std Dev	45.0125		Avg	667.6288

		Velocities (mm/s)						
type	natural	588.2353	484.2615	647.2492	571.4286	537.6344	561.7978	588.2353
d (mm)	13.6	533.3333	511.5090	651.4658	520.8333	571.4286	492.6108	560.2241
n	21	586.5103	653.5948	543.4783	511.5090	604.2296	512.8205	566.5722
G	2.65			Std Dev	49.7252		Avg	561.8553

type	natural	571.4286	647.2492	533.3333	543.4783	560.2241	634.9206	673.4007
d (mm)	9.6	647.2492	571.4286	598.8024	597.0149	743.4944	586.5103	673.4007
n	21	581.3953	621.1180	716.8459	581.3953	571.4286	561.7978	576.3689
G	2.65			Std Dev	56.5515		Avg	609.1564

type	natural	511.5090	500.0000	488.9976	546.4481	576.3689	500.0000	527.7045
d (mm)	6.8	609.7561	598.8024	473.9336	615.3846	515.4639	537.6344	657.8947
n	21	454.5455	533.3333	516.7959	581.3953	566.5722	507.6142	566.5722
G	2.65			Std Dev	51.4599		Avg	542.2251

type	natural	426.4392	347.8261	470.5882	491.4005	527.7045	507.6142	456.6210
d (mm)	4.8	520.8333	524.9344	500.0000	542.0054	524.9344	415.8004	480.7692
n	21	537.6344	432.9004	426.4392	561.7978	473.9336	496.2779	394.4773
G	2.65			Std Dev	55.1873		Avg	479.0920

Smaller natural particles were impossible to see below the water surface.

Steel particles with diameters 9.5mm and smaller halted before finishing their runs.

Run#	18	Bed					
Date:	7-11-95	Roughness k:	2.4	mm		y/k:	23.486
Slope:	0.01	Q:	21.81345	L/s	U*:	0.0641	m/s

	u.s.	d.s.	avg
y (mm)	56.5333333	56.2	56.36667
Tw (mm)	615	638	626.5
A (m^2)	0.02528453	0.025782	0.02428
P (m)	0.63354	0.655207	0.642408
Rh (m)	0.03990992	0.039349	0.037795
V (m/s)	0.86271904	0.846081	0.8544
H (m)	0.11068126	0.092698	0.10169

delta H:	0.0179829	m	delta x:	1.62	m
Sf:	0.01110057				
Tavg:	19	°C			
ν:	1.0286E-06	m^2/s			
δ:	0.00018602	m			

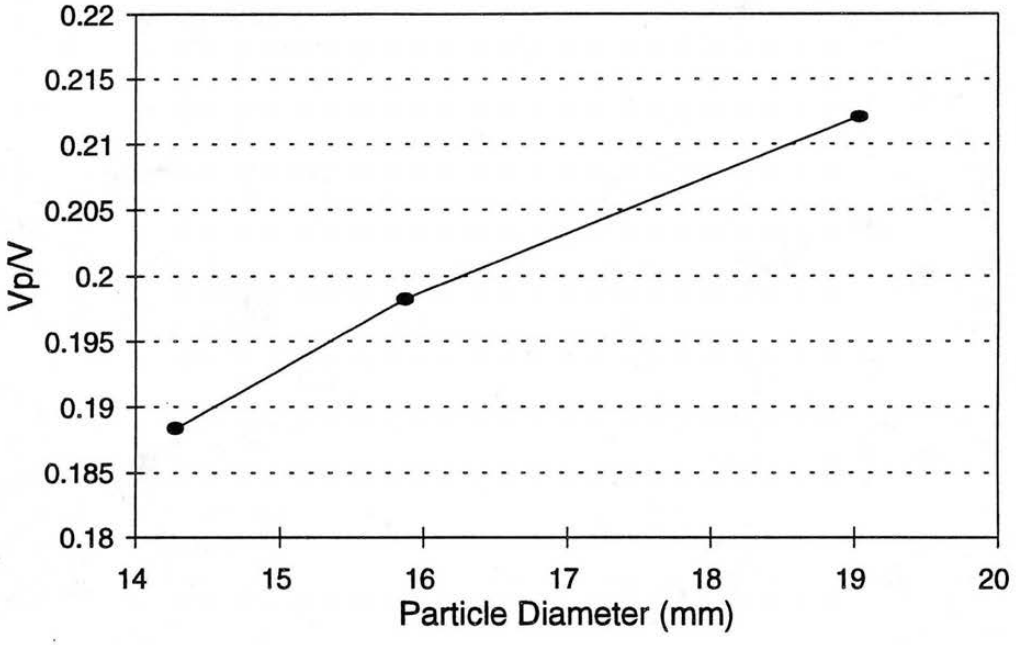
Run# 18

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	21	0.1812	0.0093	1.0794	765.7928	0.003139
steel	15.88	8.02	21	0.1694	0.0117	0.9857	638.6970	0.003764
steel	14.28	8.02	21	0.1609	0.0125	0.9346	574.3446	0.004185
glass	29.3	2.6	21	0.6932	0.0383	0.6392	719.8460	0.008949
glass	25.17	2.6	21	0.6974	0.0353	0.5924	618.3797	0.010418
glass	21.7	2.6	21	0.6639	0.0190	0.5500	533.1283	0.012084
glass	15.97	2.6	21	0.6380	0.0363	0.4716	392.3529	0.016419
glass	14.48	2.6	21	0.6676	0.0450	0.4490	355.7464	0.018109
natural	13.6	2.65	21	0.5619	0.0497	0.4419	337.5713	0.018696
natural	9.6	2.65	21	0.6092	0.0566	0.3709	238.2856	0.026487
natural	6.8	2.65	21	0.5422	0.0515	0.3117	168.7857	0.037393
natural	4.8	2.65	21	0.4791	0.0552	0.2611	119.1428	0.052973

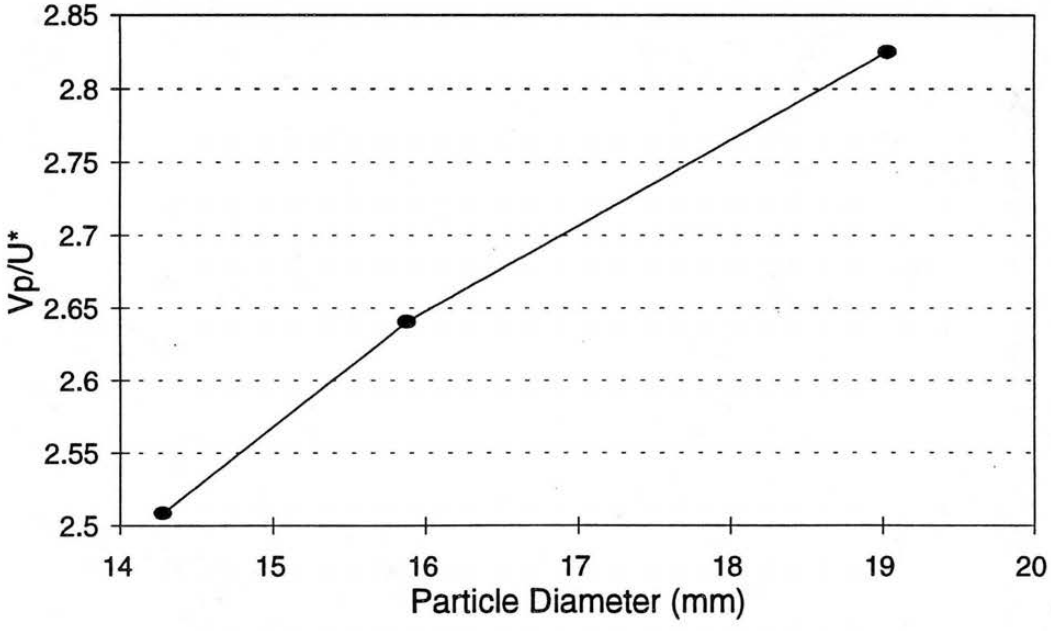
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.2121	2.8254	0.1679	0.0594	7.9333	12901.5604	102.3524	2.9604
steel	0.1982	2.6405	0.1718	0.0651	6.6167	12901.5604	85.3653	3.5495
steel	0.1883	2.5088	0.1722	0.0686	5.9500	12901.5604	76.7643	3.9472
glass	0.8113	10.8063	1.0843	0.1003	12.2083	12901.5604	157.5066	1.9238
glass	0.8163	10.8726	1.1772	0.1083	10.4875	12901.5604	135.3051	2.2394
glass	0.7771	10.3506	1.2072	0.1166	9.0417	12901.5604	116.6516	2.5975
glass	0.7468	9.9470	1.3528	0.1360	6.6542	12901.5604	85.8491	3.5295
glass	0.7814	10.4084	1.4869	0.1429	6.0333	12901.5604	77.8394	3.8927
natural	0.6576	8.7594	1.2716	0.1452	5.6667	12901.5604	73.1088	4.1446
natural	0.7130	9.4968	1.6425	0.1729	4.0000	12901.5604	51.6062	5.8715
natural	0.6346	8.4533	1.7398	0.2058	2.8333	12901.5604	36.5544	8.2892
natural	0.5607	7.4691	1.8346	0.2456	2.0000	12901.5604	25.8031	11.7431

Run 18
U* = .0641 m/s

Vp/V vs. d
(steel)

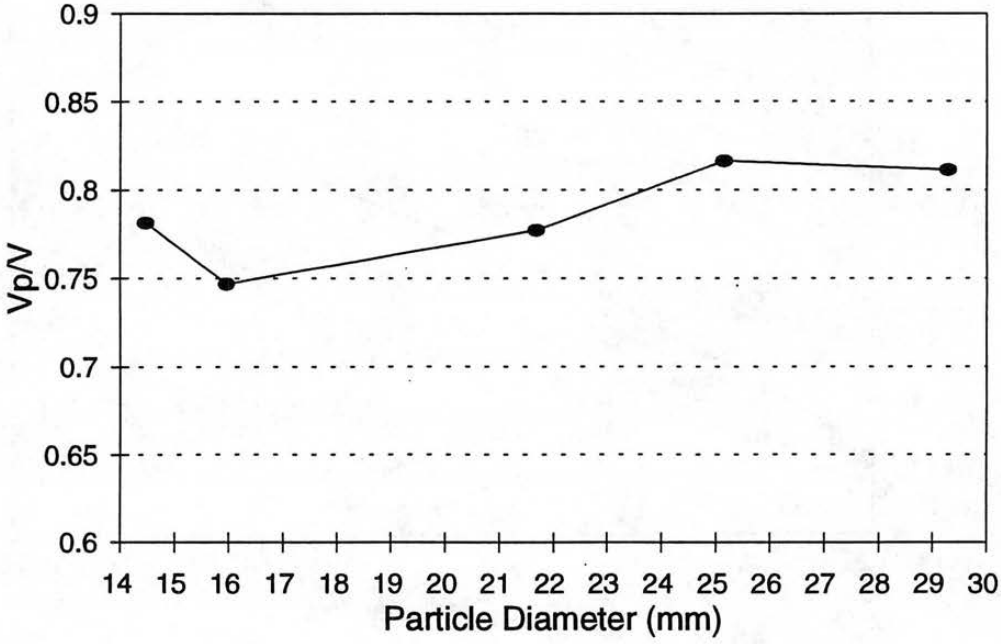


Vp/U* vs. d
(steel)

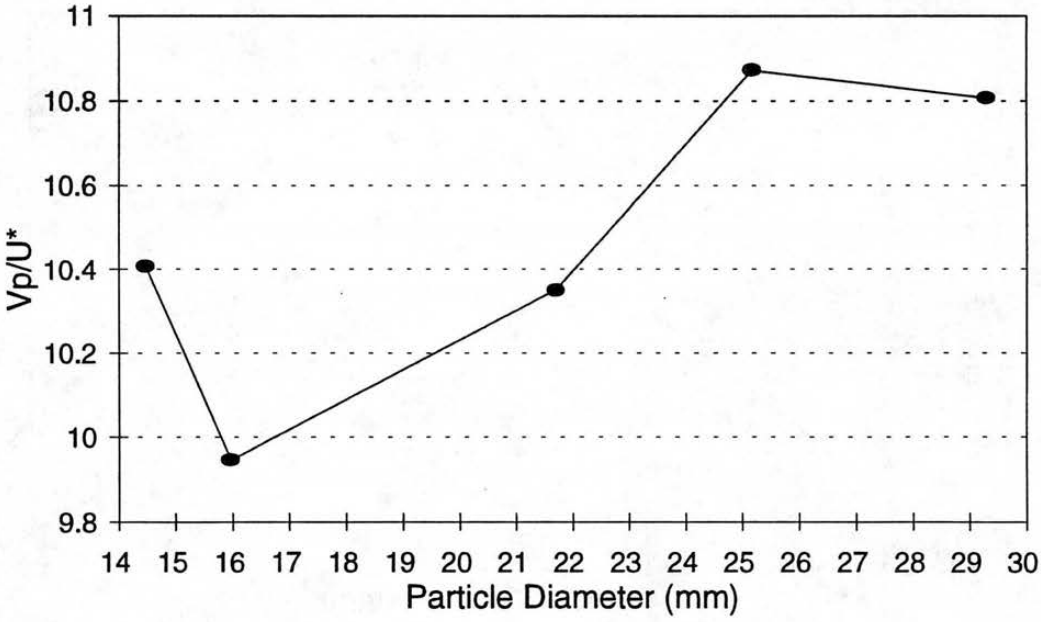


Run 18
U* = .0641 m/s

Vp/V vs. d
(glass)

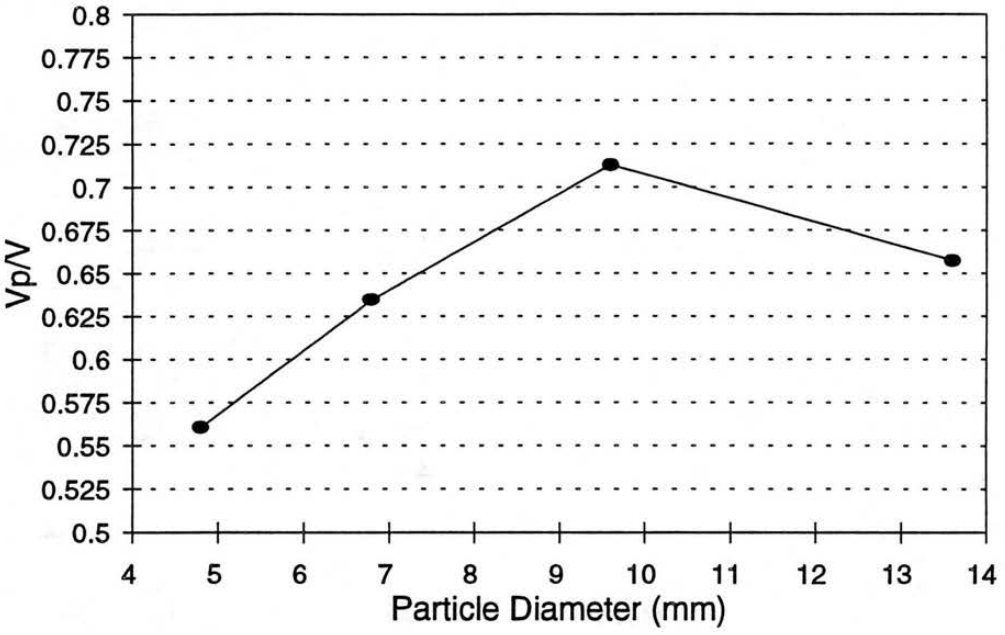


Vp/U* vs. d
(glass)

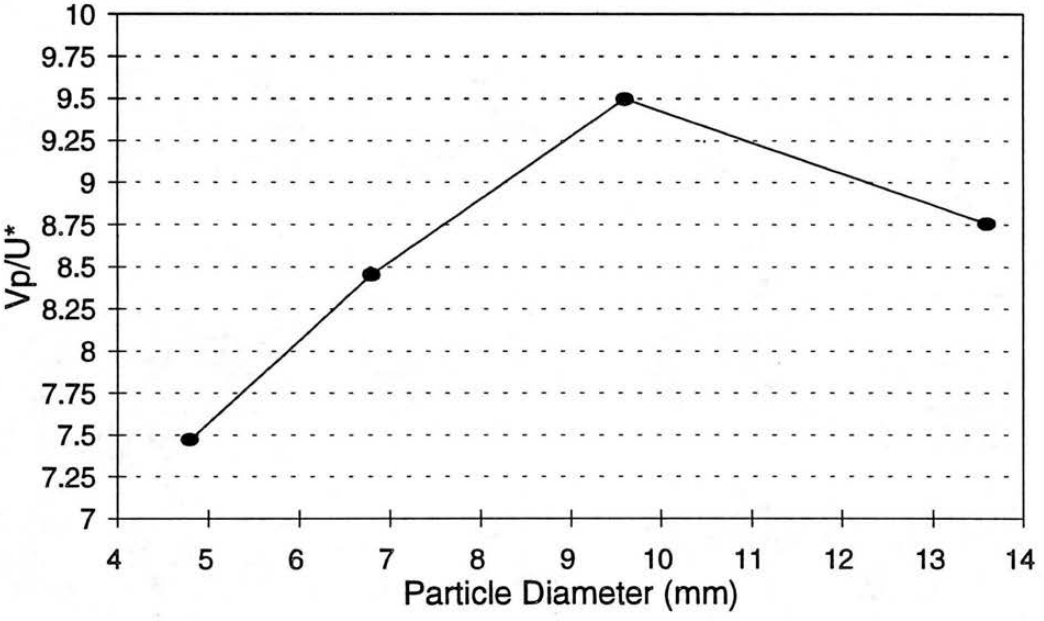


Run 18
U* = .0641 m/s

Vp/V vs. d
(natural)



Vp/U* vs. d
(natural)



Run#	19	Bed Roughness k:	0	mm	Streamflow	18.3922	L/s
Date	7-12-95	Pump Setting	fast		Valve Setting	7/16	
Reach Length	2000	mm	Slope Reading	132	mm	Bed Slope	0.00448

		Initial		Intermediate		Final	
Temperature		19	°C			20	°C
Manometer in. of water	Hi	46.73		46.06		47.41	
	Lo	-49.44		-48.77		-50.12	
	Hi - Lo	96.17		94.83		97.53	
Flow Depth:	u.s.	54.8	mm	54.6	mm	54.6	mm
	d.s.	55.1	mm	55.3	mm	55.2	mm
	u.s. - d.s.	-0.3	mm	-0.7	mm	-0.6	mm
	at weir	53.6	mm	53.3	mm	53.5	mm
Top Width:	u.s.	588	mm	584	mm	587	mm
	d.s.	591	mm	590	mm	588	mm
	at weir	580	mm	580	mm	581	mm

Velocities (mm/s)

type	steel	666.6667	711.7438	653.5948	727.2727	711.7438	727.2727	ERR
d (mm)	19.04	687.2852	719.4245	751.8797	727.2727	735.2941	751.8797	ERR
n	18	763.3588	763.3588	743.4944	746.2687	727.2727	711.7438	ERR
G	8.02			Std Dev	30.4488		Avg	723.7126

Velocities (mm/s)

type	steel	735.2941	719.4245	711.7438	751.8797	735.2941	727.2727	ERR
d (mm)	15.88	735.2941	711.7438	743.4944	666.6667	716.8459	719.4245	ERR
n	18	735.2941	666.6667	680.2721	696.8641	719.4245	694.4444	ERR
G	8.02			Std Dev	25.0678		Avg	714.8525

Velocities (mm/s)

type	steel	680.2721	711.7438	760.4563	709.2199	647.2492	704.2254	ERR
d (mm)	14.28	694.4444	727.2727	727.2727	680.2721	660.0660	673.4007	ERR
n	18	660.0660	704.2254	687.2852	673.4007	735.2941	680.2721	ERR
G	8.02			Std Dev	29.7106		Avg	695.3577

Velocities (mm/s)

type	steel	560.2241	615.3846	576.3689	604.2296	641.0256	604.2296	ERR
d (mm)	9.5	638.9776	615.3846	591.7160	641.0256	638.9776	615.3846	ERR
n	18	591.7160	680.2721	651.4658	571.4286	647.2492	645.1613	ERR
G	8.02			Std Dev	32.1311		Avg	618.3456

		Velocities (mm/s)						
type	steel	566.5722	609.7561	626.9592	591.7160	615.3846	687.2852	ERR
d (mm)	7.9	615.3846	597.0149	628.9308	641.0256	598.8024	621.1180	ERR
n	18	626.9592	666.6667	615.3846	593.4718	632.9114	598.8024	ERR
G	8.02			Std Dev	28.0846		Avg	618.5637

		Velocities (mm/s)						
type	steel	571.4286	555.5556	586.5103	626.9592	632.9114	566.5722	ERR
d (mm)	6.34	604.2296	609.7561	571.4286	593.4718	537.6344	593.4718	ERR
n	18	598.8024	529.1005	621.1180	581.3953	571.4286	602.4096	ERR
G	8.02			Std Dev	28.7898		Avg	586.3436

		Velocities (mm/s)						
type	steel	566.5722	503.7783	555.5556	552.4862	576.3689	566.5722	ERR
d (mm)	4.75	537.6344	542.0054	520.8333	546.4481	537.6344	546.4481	ERR
n	18	552.4862	537.6344	529.1005	546.4481	503.7783	555.5556	ERR
G	8.02			Std Dev	19.7092		Avg	543.1856

		Velocities (mm/s)						
type	steel	547.9452	491.4005	484.2615	500.0000	462.9630	516.7959	ERR
d (mm)	3.14	500.0000	524.9344	492.6108	500.0000	505.0505	542.0054	ERR
n	18	500.0000	496.2779	492.6108	512.8205	488.9976	485.4369	ERR
G	8.02			Std Dev	20.5775		Avg	502.4506

		Velocities (mm/s)						
type	steel	438.5965	447.4273	410.6776	441.5011	390.6250	441.5011	ERR
d (mm)	1.57	421.0526	403.2258	455.5809	447.4273	441.5011	430.1075	ERR
n	18	421.0526	437.6368	402.4145	437.6368	423.7288	378.7879	ERR
G	8.02			Std Dev	21.4262		Avg	426.1378

		Velocities (mm/s)						
type	glass	751.8797	790.5138	735.2941	781.2500	746.2687	781.2500	ERR
d (mm)	29.3	772.2008	809.7166	829.8755	763.3588	800.0000	829.8755	ERR
n	18	862.0690	800.0000	751.8797	800.0000	746.2687	809.7166	ERR
G	2.6			Std Dev	34.4407		Avg	786.7454

		Velocities (mm/s)						
type	glass	829.8755	754.7170	769.2308	763.3588	823.0453	751.8797	ERR
d (mm)	25.17	769.2308	727.2727	809.7166	769.2308	823.0453	840.3361	ERR
n	18	751.8797	809.7166	772.2008	790.5138	800.0000	781.2500	ERR
G	2.6			Std Dev	31.8833		Avg	785.3611

		Velocities (mm/s)						
type	glass	743.4944	735.2941	769.2308	727.2727	760.4563	754.7170	ERR
d (mm)	21.7	735.2941	743.4944	760.4563	819.6721	781.2500	800.0000	ERR
n	18	743.4944	809.7166	696.8641	800.0000	735.2941	754.7170	ERR
G	2.6			Std Dev	32.1086		Avg	759.4844

		Velocities (mm/s)						
type	glass	660.0660	735.2941	711.7438	754.7170	704.2254	680.2721	ERR
d (mm)	15.97	743.4944	800.0000	701.7544	709.2199	666.6667	711.7438	ERR
n	18	704.2254	687.2852	711.7438	694.4444	704.2254	711.7438	ERR
G	2.6			Std Dev	32.5809		Avg	710.7147

		Velocities (mm/s)						
type	glass	719.4245	711.7438	696.8641	657.8947	781.2500	645.1613	ERR
d (mm)	14.48	653.5948	719.4245	781.2500	680.2721	704.2254	709.2199	ERR
n	18	735.2941	641.0256	704.2254	719.4245	719.4245	704.2254	ERR
G	2.6			Std Dev	39.5962		Avg	704.6636

Run# 19 Bed
Date: 7-12-95 Roughness k: 0 mm y/k: ERR

Slope: 0.00448 Q: 18.39221 L/s U*: 0.0424 m/s

	u.s.	d.s.	avg
y (mm)	54.6666667	55.2	54.93333
Tw (mm)	586.333333	589.6667	588
A (m^2)	0.02366611	0.023989	0.023827
P (m)	0.60523067	0.608729	0.60698
Rh (m)	0.03910263	0.039408	0.039256
V (m/s)	0.7771537	0.766693	0.771924
H (m)	0.09271806	0.08517	0.088944

delta H: 0.0075476 m delta x: 1.62 m

Sf: 0.00465904

Tavg: 19.5 °C

ν: 1.0162E-06 m^2/s

δ: 0.00027835 m

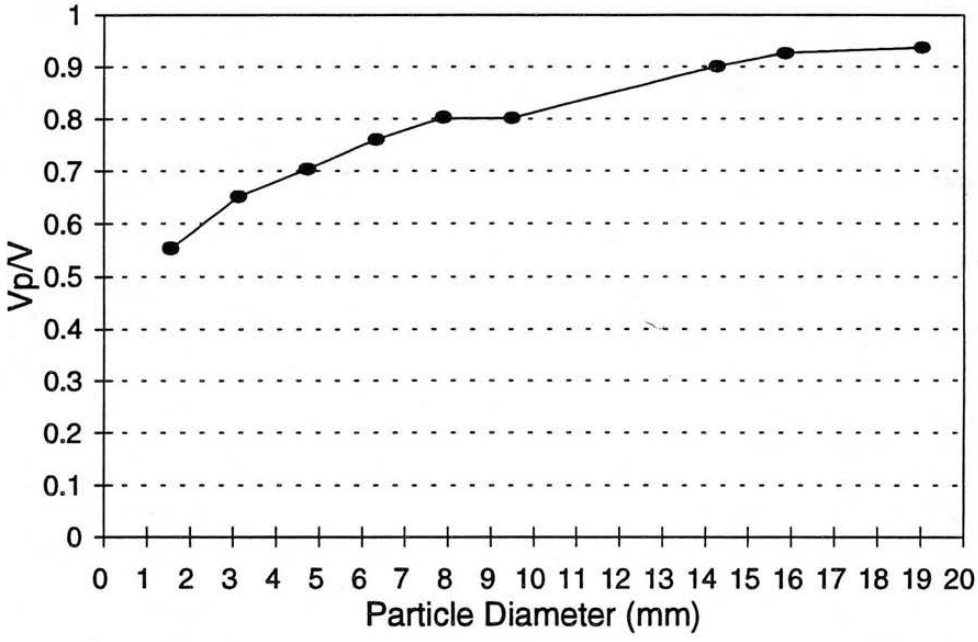
Run# 19

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	18	0.7237	0.0304	1.0794	772.0144	0.0014
steel	15.88	8.02	18	0.7149	0.0251	0.9857	643.8860	0.0016
steel	14.28	8.02	18	0.6954	0.0297	0.9346	579.0108	0.0018
steel	9.5	8.02	18	0.6183	0.0321	0.7619	385.1963	0.0027
steel	7.9	8.02	18	0.6186	0.0281	0.6945	320.3211	0.0033
steel	6.34	8.02	18	0.5863	0.0288	0.6218	257.0678	0.0041
steel	4.75	8.02	18	0.5432	0.0197	0.5376	192.5981	0.0055
steel	3.14	8.02	18	0.5025	0.0206	0.4359	127.3175	0.0083
steel	1.57	8.02	18	0.4261	0.0214	0.3049	63.6588	0.0166
glass	29.3	2.6	18	0.7867	0.0344	0.6392	725.6943	0.0039
glass	25.17	2.6	18	0.7854	0.0319	0.5924	623.4036	0.0045
glass	21.7	2.6	18	0.7595	0.0321	0.5500	537.4596	0.0053
glass	15.97	2.6	18	0.7107	0.0326	0.4716	395.5405	0.0072
glass	14.48	2.6	18	0.7047	0.0396	0.4490	358.6366	0.0079

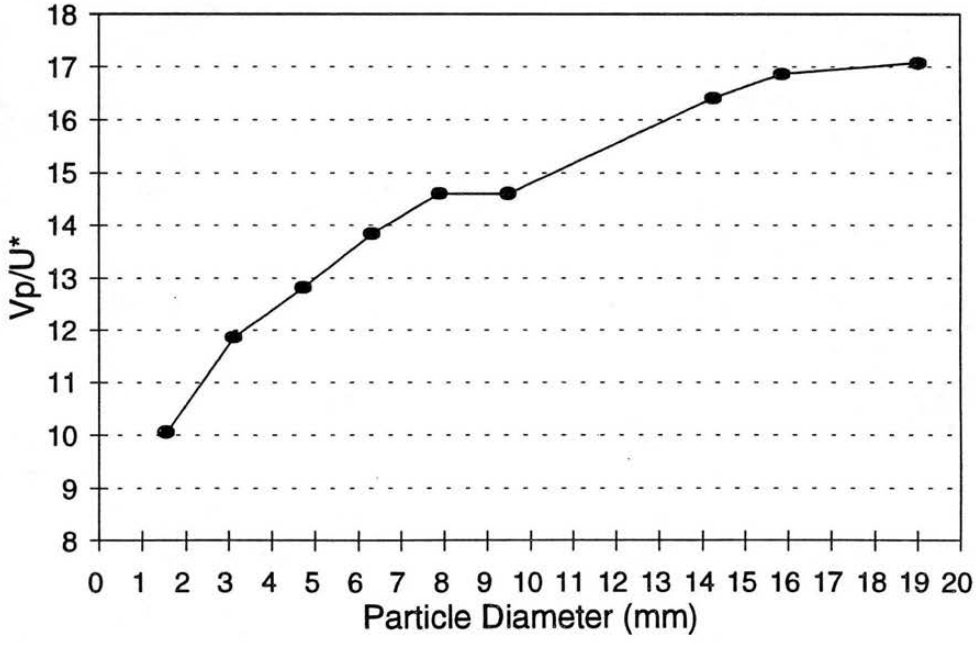
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.9375	17.0886	0.6705	0.0392	ERR	0.0000	68.4033	2.8852
steel	0.9261	16.8794	0.7253	0.0430	ERR	0.0000	57.0507	3.4593
steel	0.9008	16.4191	0.7440	0.0453	ERR	0.0000	51.3025	3.8469
steel	0.8010	14.6006	0.8116	0.0556	ERR	0.0000	34.1298	5.7825
steel	0.8013	14.6058	0.8906	0.0610	ERR	0.0000	28.3816	6.9536
steel	0.7596	13.8450	0.9429	0.0681	ERR	0.0000	22.7771	8.6646
steel	0.7037	12.8259	1.0103	0.0788	ERR	0.0000	17.0649	11.5649
steel	0.6509	11.8641	1.1526	0.0971	ERR	0.0000	11.2808	17.4947
steel	0.5520	10.0621	1.3974	0.1389	ERR	0.0000	5.6404	34.9894
glass	1.0192	18.5770	1.2308	0.0663	ERR	0.0000	105.2635	1.8749
glass	1.0174	18.5443	1.3257	0.0715	ERR	0.0000	90.4260	2.1825
glass	0.9839	17.9333	1.3809	0.0770	ERR	0.0000	77.9596	2.5315
glass	0.9207	16.7817	1.5069	0.0898	ERR	0.0000	57.3740	3.4398
glass	0.9129	16.6388	1.5694	0.0943	ERR	0.0000	52.0210	3.7937

Run 19
U* = 0.0423 m/s

Vp/V vs. d
(steel)

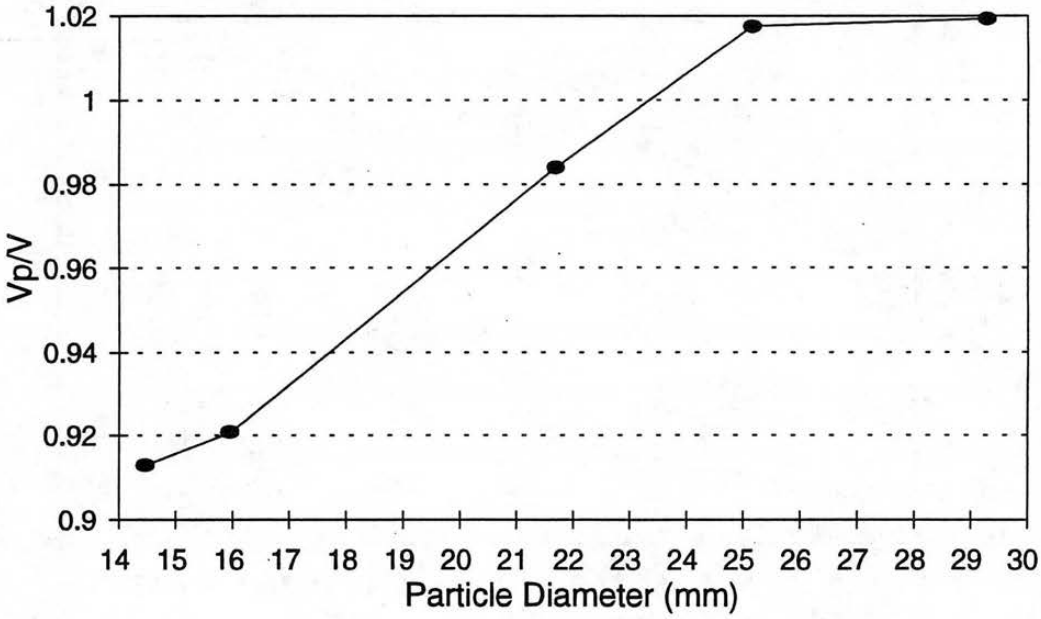


Vp/U* vs. d
(steel)

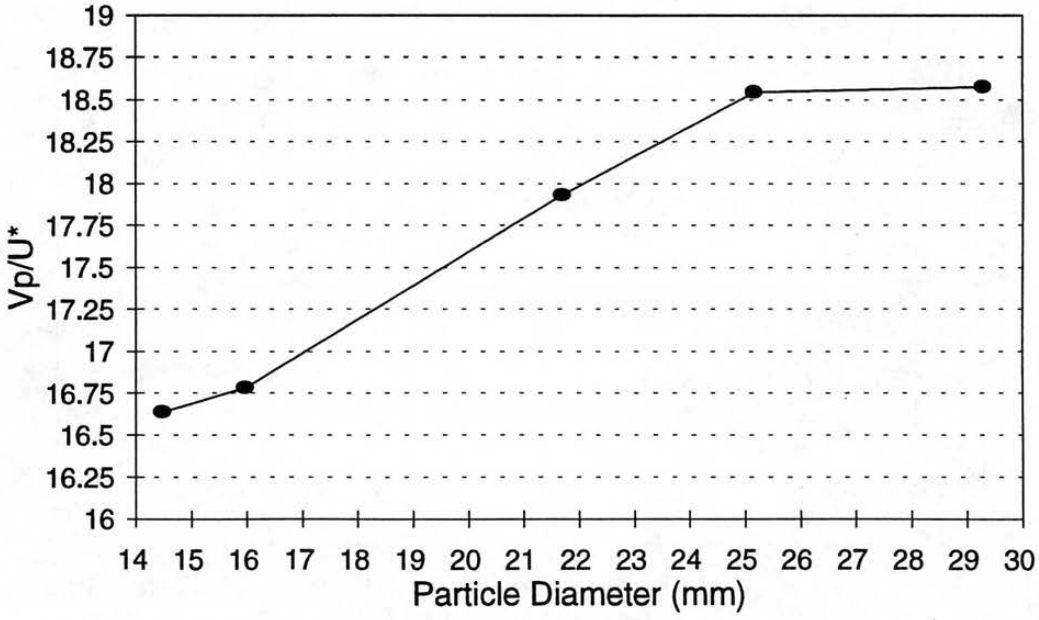


Run 19
U* = 0.0423 m/s

Vp/V vs. d
(glass)



Vp/U* vs. d
(glass)



Run #	20	Bed Roughness k:	3.4	mm	Streamflow	20.1749	L/s
Date	7-13-95	Pump Setting	fast		Valve Setting	1/2 open	
Reach Length	2000	mm	Slope Reading	171.5	mm	Bed Slope	0.01

		Initial		Intermediate		Final	
Temperature		20	°C			21	°C
Manometer in. of water	Hi	56.89		55.54		56.22	
	Lo	-59.6		-59.6		-58.93	
	Hi - Lo	116.49		115.14		115.15	
Flow Depth:	u.s.	55.1	mm	54.2	mm	54.5	mm
	d.s.	56	mm	55.6	mm	56.5	mm
	u.s. - d.s.	-0.9	mm	-1.4	mm	-2	mm
	at weir	54.3	mm	53.8	mm	53.9	mm
Top Width:	u.s.	604	mm	608	mm	608	mm
	d.s.	602	mm	603	mm	606	mm
	at weir	602	mm	598	mm	604	mm

Velocities (mm/s)

type	steel	191.0220	201.8163	194.5525	203.0457	193.4236	184.3318	ERR
d (mm)	19.04	200.6018	201.2072	197.4334	195.1220	203.2520	202.4291	ERR
n	18	200.0000	195.1220	192.8640	198.8072	198.2161	199.4018	ERR
G	8.02			Std Dev	4.9432		Avg	197.3694

Velocities (mm/s)

type	steel	175.4386	204.4990	159.6169	198.8072	196.4637	189.3939	208.9864
d (mm)	15.88	179.2115	188.8574	182.3154	201.2072	171.9690	173.9130	185.0139
n	21	188.3239	199.4018	196.2709	177.3050	157.2327	197.0443	185.5288
G	8.02			Std Dev	13.9938		Avg	186.5143

Velocities (mm/s)

type	steel	196.8504	182.9826	162.8664	176.3668	183.9926	189.3939	189.9335
d (mm)	14.28	176.2115	158.3531	196.8504	215.5172	189.9335	206.6116	173.9130
n	21	179.6945	164.6091	206.6116	168.9189	177.7778	205.7613	198.0198
G	8.02			Std Dev	15.8695		Avg	185.7700

Velocities (mm/s)

type	glass	657.8947	673.4007	666.6667	696.8641	760.4563	604.2296	704.2254
d (mm)	29.3	682.5939	694.4444	666.6667	604.2296	673.4007	687.2852	621.1180
n	21	704.2254	694.4444	609.7561	711.7438	735.2941	746.2687	666.6667
G	2.6			Std Dev	43.4983		Avg	679.1369

		Velocities (mm/s)						
type	glass	647.2492	701.7544	727.2727	666.6667	701.7544	694.4444	711.7438
d (mm)	25.17	727.2727	653.5948	696.8641	694.4444	711.7438	634.9206	711.7438
n	21	660.0660	643.0868	657.8947	673.4007	711.7438	680.2721	680.2721
G	2.6			Std Dev	28.1627		Avg	685.1527

		Velocities (mm/s)						
type	glass	666.6667	638.9776	621.1180	657.8947	626.9592	660.0660	621.1180
d (mm)	21.7	651.4658	609.7561	653.5948	615.3846	638.9776	704.2254	666.6667
n	21	621.1180	666.6667	711.7438	593.4718	621.1180	666.6667	634.9206
G	2.6			Std Dev	29.9198		Avg	645.1703

		Velocities (mm/s)						
type	glass	632.9114	711.7438	571.4286	636.9427	581.3953	689.6552	645.1613
d (mm)	15.97	694.4444	615.3846	687.2852	591.7160	704.2254	666.6667	609.7561
n	21	727.2727	634.9206	746.2687	660.0660	727.2727	666.6667	701.7544
G	2.6			Std Dev	50.4963		Avg	662.0447

		Velocities (mm/s)						
type	glass	660.0660	602.4096	581.3953	598.8024	680.2721	632.9114	653.5948
d (mm)	14.48	604.2296	704.2254	680.2721	647.2492	666.6667	628.9308	680.2721
n	21	694.4444	647.2492	660.0660	653.5948	704.2254	660.0660	604.2296
G	2.6			Std Dev	35.8785		Avg	649.7701

		Velocities (mm/s)						
type	natural	719.4245	576.3689	581.3953	598.8024	632.9114	641.0256	555.5556
d (mm)	13.6	529.1005	503.7783	480.7692	546.4481	581.3953	523.5602	604.2296
n	21	557.1031	576.3689	597.0149	576.3689	550.9642	547.9452	552.4862
G	2.65			Std Dev	51.2423		Avg	573.0008

		Velocities (mm/s)						
type	natural	571.4286	593.4718	557.1031	634.9206	571.4286	557.1031	537.6344
d (mm)	9.6	615.3846	578.0347	560.2241	641.0256	660.0660	566.5722	626.9592
n	21	597.0149	473.9336	651.4658	588.2353	641.0256	651.4658	641.0256
G	2.65			Std Dev	47.0451		Avg	595.9773

		Velocities (mm/s)						
type	natural	626.9592	523.5602	566.5722	597.0149	571.4286	593.4718	586.5103
d (mm)	6.8	576.3689	630.9148	623.0530	666.6667	511.5090	503.7783	632.9114
n	21	597.0149	542.0054	609.7561	460.8295	507.6142	488.9976	542.0054
G	2.65			Std Dev	55.1753		Avg	569.4734

		Velocities (mm/s)						
type	natural	581.3953	480.7692	597.0149	473.9336	591.7160	647.2492	503.7783
d (mm)	4.8	597.0149	533.3333	431.9654	571.4286	511.5090	583.0904	434.7826
n	21	621.1180	467.2897	537.6344	537.6344	496.2779	424.6285	505.0505
G	2.65			Std Dev	64.8898		Avg	529.9340

All of the glass and natural particles exhibited unsteady motion with suspension. Many trials resulted in the particles leaving the track over the top of the "guardrails".

Steel particles smaller than 14.28 mm all halted before completing their runs.

Smaller natural particles just seem to disappear when dropped into the water.

Run# 20 Bed
Date: 7-13-95 Roughness k: 3.4 mm y/k: 16.27

Slope: 0.01 Q: 20.17486 L/s U*: 0.0623 m/s

	u.s.	d.s.	avg
y (mm)	54.6	56.03333	55.31667
Tw (mm)	606.666667	603.6667	605.1667
A (m²)	0.02419235	0.024743	0.024468
P (m)	0.62440965	0.622491	0.623446
Rh (m)	0.03874436	0.039749	0.039247
V (m/s)	0.83393535	0.815364	0.824649
H (m)	0.10625799	0.08993	0.098094

delta H: 0.0163284 m delta x: 1.62 m

Sf: 0.01007925

Tavg: 20.5 °C

ν: 9.9195E-07 m²/s

δ: 0.00018474 m

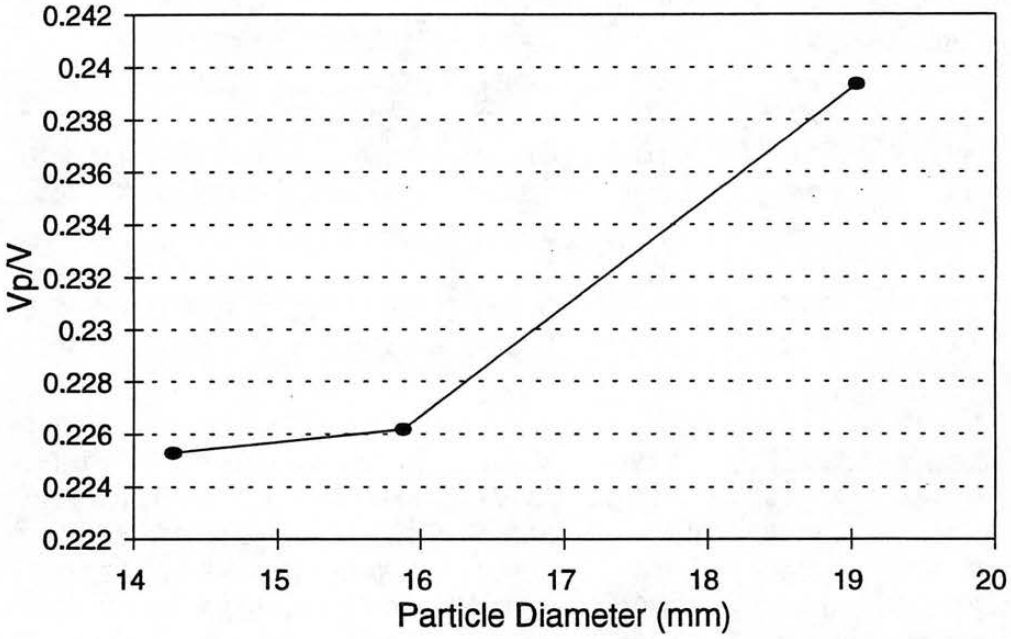
Run# 20

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	18	0.1974	0.0049	1.0794	784.5587	0.0030
steel	15.88	8.02	21	0.1865	0.0140	0.9857	654.3483	0.0035
steel	14.28	8.02	21	0.1858	0.0159	0.9346	588.4190	0.0039
glass	29.3	2.6	21	0.6791	0.0435	0.6392	737.4859	0.0084
glass	25.17	2.6	21	0.6852	0.0282	0.5924	633.5331	0.0098
glass	21.7	2.6	21	0.6452	0.0299	0.5500	546.1927	0.0114
glass	15.97	2.6	21	0.6620	0.0505	0.4716	401.9676	0.0155
glass	14.48	2.6	21	0.6498	0.0359	0.4490	364.4640	0.0171
natural	13.6	2.65	21	0.5730	0.0512	0.4419	345.8436	0.0176
natural	9.6	2.65	21	0.5960	0.0470	0.3709	244.1249	0.0250
natural	6.8	2.65	21	0.5695	0.0552	0.3117	172.9218	0.0353
natural	4.8	2.65	21	0.5299	0.0649	0.2612	122.0624	0.0499

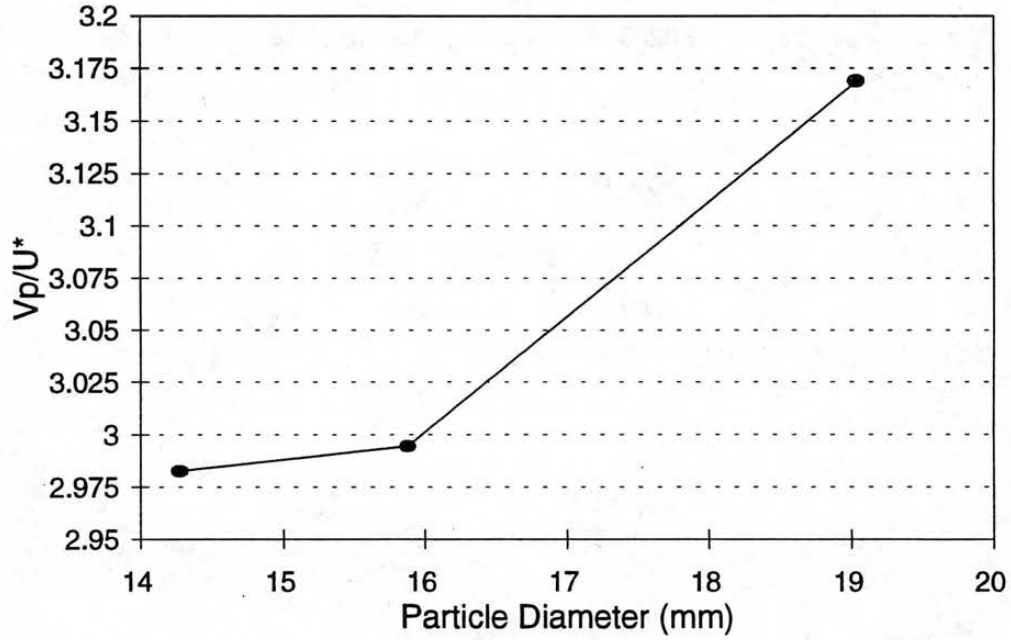
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.2393	3.1689	0.1828	0.0577	5.6000	18403.8115	103.0613	2.9053
steel	0.2262	2.9946	0.1892	0.0632	4.6706	18403.8115	85.9566	3.4834
steel	0.2253	2.9826	0.1988	0.0666	4.2000	18403.8115	77.2960	3.8737
glass	0.8235	10.9038	1.0624	0.0974	8.6176	18403.8115	158.5976	1.8879
glass	0.8308	11.0004	1.1565	0.1051	7.4029	18403.8115	136.2423	2.1977
glass	0.7824	10.3585	1.1730	0.1132	6.3824	18403.8115	117.4596	2.5492
glass	0.8028	10.6294	1.4037	0.1321	4.6971	18403.8115	86.4438	3.4638
glass	0.7879	10.4323	1.4471	0.1387	4.2588	18403.8115	78.3786	3.8202
natural	0.6948	9.1998	1.2968	0.1410	4.0000	18403.8115	73.6152	4.0674
natural	0.7227	9.5687	1.6068	0.1679	2.8235	18403.8115	51.9637	5.7622
natural	0.6906	9.1431	1.8270	0.1998	2.0000	18403.8115	36.8076	8.1348
natural	0.6426	8.5083	2.0288	0.2384	1.4118	18403.8115	25.9819	11.5243

Run 20
U* = 0.0623 m/s

Vp/V vs. d
(steel)

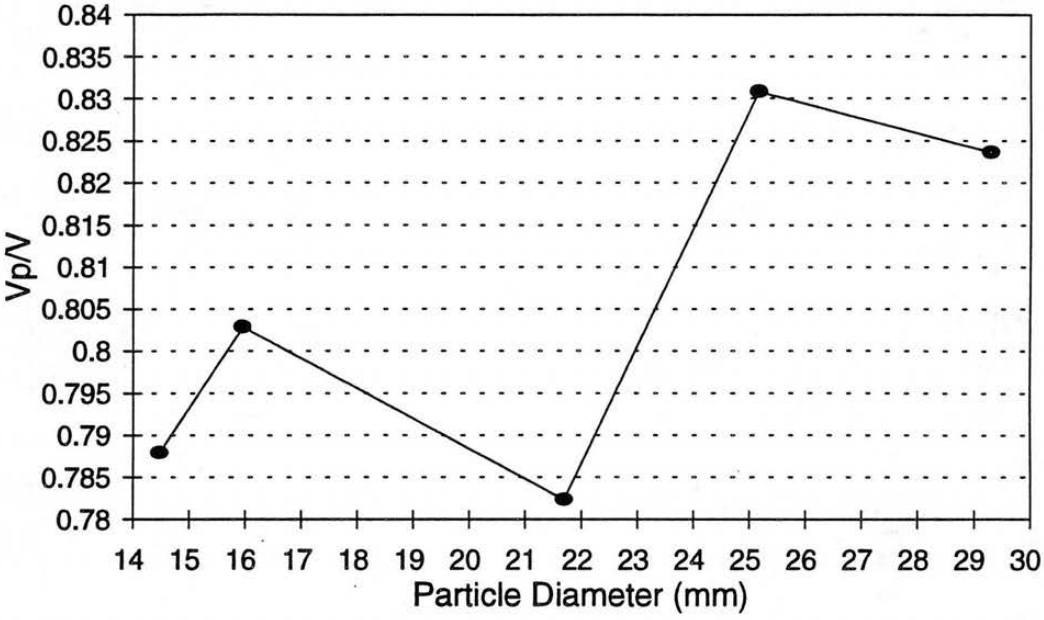


Vp/U* vs. d
(steel)

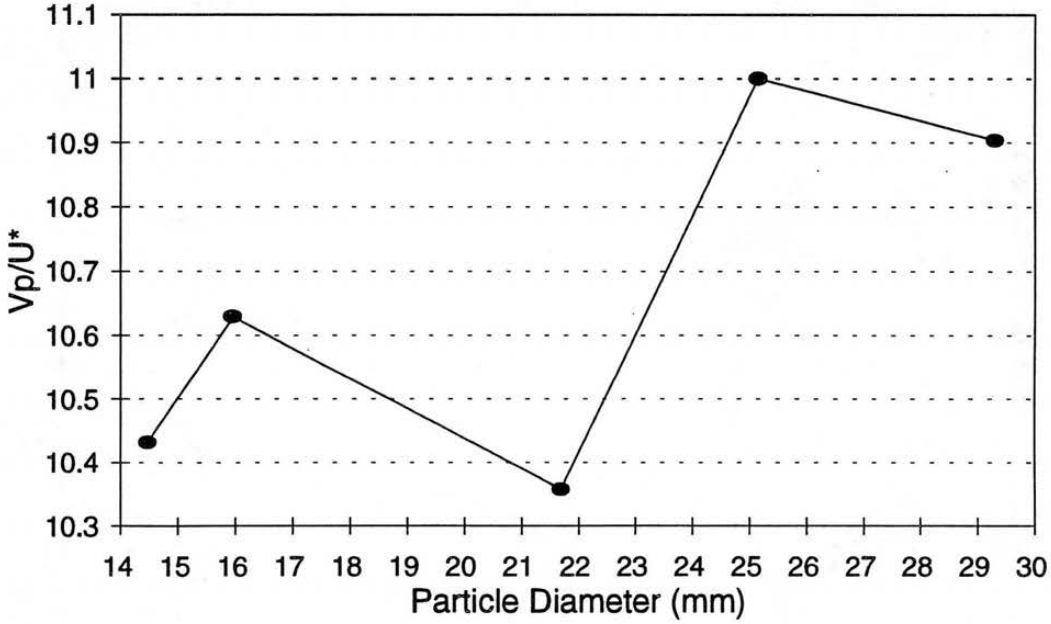


Run 20
U* = 0.0623 m/s

Vp/V vs. d
(glass)

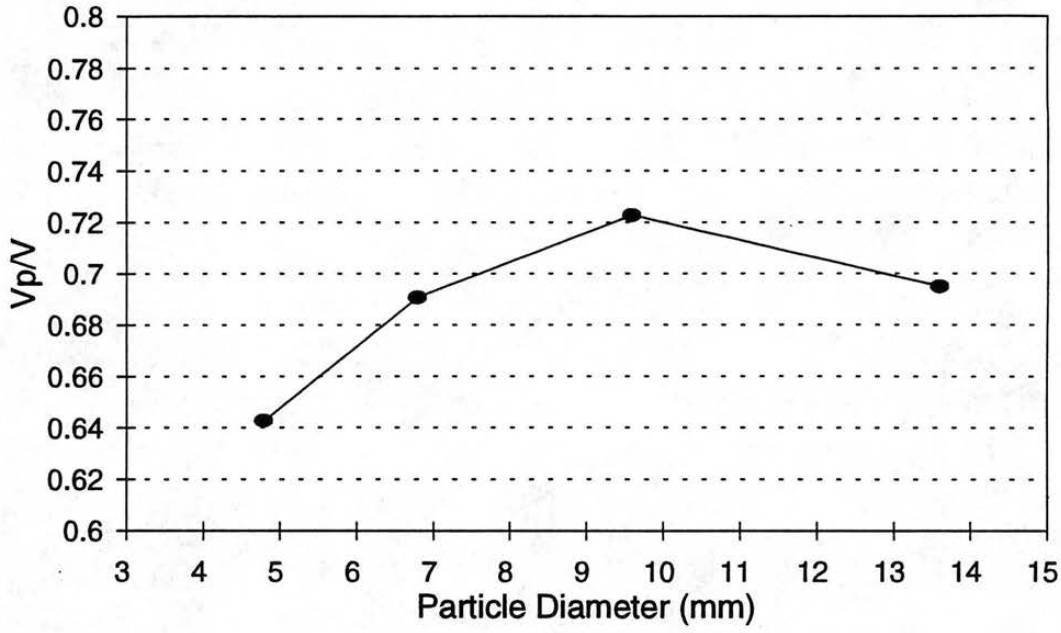


Vp/U* vs. d
(glass)

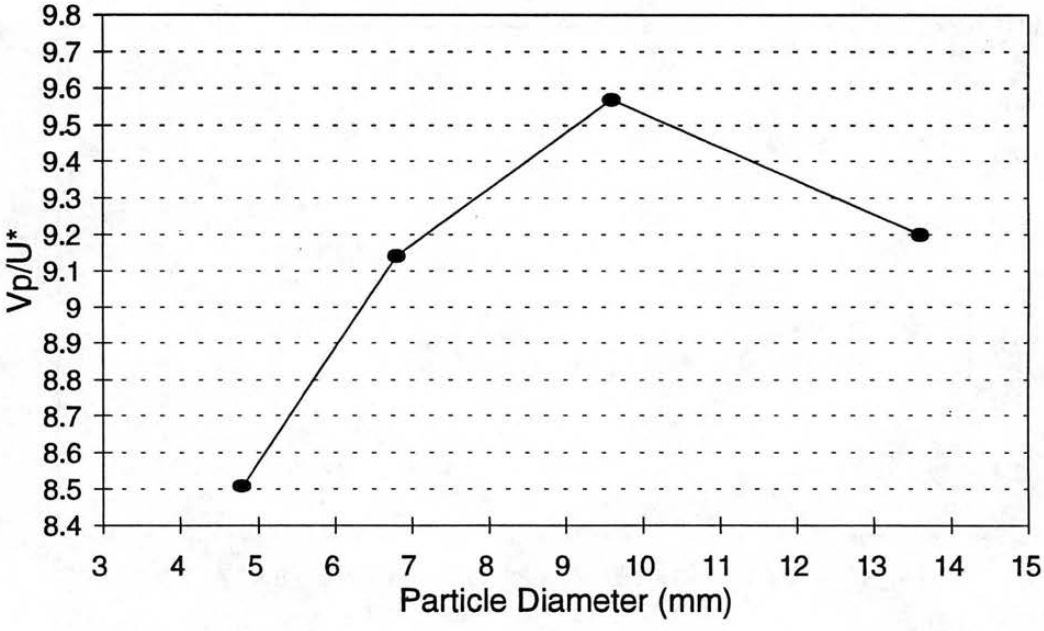


Run 20
U* = 0.0623 m/s

Vp/V vs. d
(natural)



Vp/U* vs. d
(natural)



Run#	21		Bed Roughness k:	3.4	mm	Streamflow	9.9228 L/s
Date	7-15-95		Pump Setting	slow		Valve Setting	1/2 open
Reach Length	2000	mm	Slope Reading	110	mm	Bed Slope	0.0014

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer in. of water	Hi	38.9		38.9		38.9	
	Lo	10.7		10.7		10.7	
	Hi - Lo	28.2		28.2		28.2	
Flow Depth:	u.s.	69	mm	68.7	mm	68.9	mm
	d.s.	69.2	mm	69.1	mm	69.1	mm
	u.s. - d.s.	-0.2	mm	-0.4	mm	-0.2	mm
	at weir	68.6	mm	68.6	mm	68.6	mm
Top Width:	u.s.	674	mm	680	mm	679	mm
	d.s.	676	mm	675	mm	675	mm
	at weir	697	mm	696	mm	698	mm

Velocities (mm/s)

type	glass	105.0972	105.7641	110.3144	104.5478	102.4066	100.0000	106.2699
d (mm)	29.3	105.0972	110.3753	99.5520	115.1410	108.6366	97.1345	106.8376
n	21	102.5641	98.6193	96.5251	116.3467	114.0901	117.6471	111.6695
G	2.6			Std Dev	6.3037		Avg	106.4113

Velocities (mm/s)

type	glass	103.6807	99.8502	100.4520	102.2495	91.9540	96.5251	107.4114
d (mm)	25.17	96.6651	104.0583	100.4520	106.3264	96.8523	99.0589	99.2556
n	21	111.1111	96.3855	95.7854	99.4036	107.1811	106.3264	99.7009
G	2.6			Std Dev	4.7733		Avg	100.9850

Smaller glass particles never finished the trials without stopping.

No motion for the natural or steel particles.

Run# 21 Bed
Date: 7-15-95 Roughness k: 3.4 mm y/k: 20.294

Slope: 0.0014 Q: 9.922753 L/s U*: 0.024 m/s

	u.s.	d.s.	avg
y (mm)	68.8666667	69.13333	69
Tw (mm)	677.666667	675.3333	676.5
A (m²)	0.03295844	0.033005	0.032982
P (m)	0.70081599	0.698787	0.699801
Rh (m)	0.04702866	0.047232	0.047131
V (m/s)	0.30106866	0.30064	0.300854
H (m)	0.07575614	0.073742	0.074749

delta H: 0.0020145 m delta x: 1.62 m

Sf: 0.0012435

Tavg: 20 °C

ν: 1.004E-06 m²/s

δ: 0.0004858 m

Run# 21

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	29.3	2.6	21	0.1064	0.0063	0.6392	731.5747	0.0013
glass	25.17	2.6	21	0.1010	0.0048	0.5924	628.4552	0.0015

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.3537	4.4387	0.1665	0.0375	8.6176	6998.7802	60.3130	2.3549
glass	0.3357	4.2123	0.1705	0.0405	7.4029	6998.7802	51.8116	2.7414

Run#	22		Bed Roughness k:	3.4	mm	Streamflow	6.2501 L/s
Date	7-15-95		Pump Setting	slow		Valve Setting	3/8 open
Reach Length	2000	mm	Slope Reading	110	mm	Bed Slope	0.0014

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer in. of water	Hi	30.05		30.05		30.05	
	Lo	18.8		18.8		18.8	
	Hi - Lo	11.25		11.25		11.25	
Flow Depth:	u.s.	52.9	mm	52.9	mm	52.9	mm
	d.s.	52.7	mm	52.7	mm	52.7	mm
	u.s. - d.s.	0.2	mm	0.2	mm	0.2	mm
	at weir	52.1	mm	52.1	mm	52.1	mm
Top Width:	u.s.	588	mm	588	mm	588	mm
	d.s.	576	mm	576	mm	576	mm
	at weir	590	mm	590	mm	590	mm

The largest two glass particles rolled with many stops and starts, rarely finishing the trial. None of the other particles showed any desire to move at all.

Run# 22 Bed
Date: 7-15-95 Roughness k: 3.4 mm y/k: 15.529

Slope: 0.0014 Q: 6.250095 L/s U*: 0.0231 m/s

	u.s.	d.s.	avg
y (mm)	52.9	52.7	52.8
Tw (mm)	588	576	582
A (m^2)	0.02294538	0.022542	0.022744
P (m)	0.60563784	0.594177	0.599902
Rh (m)	0.0378863	0.037939	0.037912
V (m/s)	0.27239018	0.277259	0.274825
H (m)	0.05895096	0.056619	0.057785

delta H: 0.0023315 m delta x: 1.62 m

Sf: 0.00143923

Tavg: 20 °C

ν: 1.004E-06 m^2/s

δ: 0.00050347 m

Run#	23		Bed Roughness k:	3.4	mm	Streamflow	11.4421 L/s
Date	7-16-95		Pump Setting	slow		Valve Setting	1/2 open
Reach Length	2000	mm	Slope Reading	114.5	mm	Bed Slope	0.002

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer in. of water	Hi	42.85		42.8		42.8	
	Lo	5.35		5.4		5.4	
	Hi - Lo	37.5		37.4		37.4	
Flow Depth:	u.s.	64.6	mm	65	mm	66	mm
	d.s.	64.6	mm	65.5	mm	64.9	mm
	u.s. - d.s.	0	mm	-0.5	mm	1.1	mm
	at weir	64	mm	64.2	mm	63.9	mm
Top Width:	u.s.	654	mm	655	mm	657	mm
	d.s.	646	mm	647	mm	649	mm
	at weir	670	mm	673	mm	672	mm

Velocities (mm/s)

type	glass	154.6790	147.4926	153.4919	160.0000	147.8197	140.6470	150.2630
d (mm)	29.3	153.0222	155.7632	158.1028	158.1028	150.6024	156.4945	147.8197
n	21	149.1424	159.6169	139.7624	143.1639	159.6169	142.5517	151.4005
G	2.6			Std Dev	6.3511		Avg	151.4074

Velocities (mm/s)

type	glass	141.0437	147.8197	137.3626	148.1481	148.1481	144.8226	142.2475
d (mm)	25.17	129.2825	132.1877	147.8197	155.4002	141.5428	132.7140	149.5886
n	21	143.7815	144.1961	148.1481	145.7726	142.5517	149.2537	130.0390
G	2.6			Std Dev	7.0449		Avg	142.9462

Velocities (mm/s)

type	glass	127.9591	137.3626	137.9310	123.0769	132.8021	126.5022	129.0323
d (mm)	21.7	121.6545	125.2348	133.6005	131.4060	134.4990	121.4329	129.5337
n	21	115.4734	133.6005	128.0410	125.4705	131.4060	140.6470	140.0560
G	2.6			Std Dev	6.5409		Avg	129.8439

Velocities (mm/s)

type	glass	110.1322	117.6471	126.4223	118.0638	120.4819	117.0275	123.9926
d (mm)	15.97	125.7071	125.0000	113.8952	122.3242	101.1122	107.4114	118.2732
n	21	127.7139	114.8765	118.9768	125.4705	122.1001	115.2738	121.7285
G	2.6			Std Dev	6.7257		Avg	118.7443

		Velocities (mm/s)						
type	glass	113.0582	107.9331	115.0748	120.0480	103.5733	98.7654	119.6172
d (mm)	14.48	110.0110	110.3144	104.3841	115.9420	113.7010	122.8501	110.3144
n	21	102.0408	116.1440	120.3369	109.0513	111.1111	117.9245	121.2121
G	2.6			Std Dev	6.7416		Avg	112.5432

Steel particles showed no motion.

Natural particles rolled only a few centimeters before halting.

15 trials for the glass particle with diameter 14.48mm resulted in halting

Run# 23 Bed
Date: 7-16-95 Roughness k: 3.4 mm y/k: 19.147

Slope: 0.002 Q: 11.4421 L/s U*: 0.0298 m/s

	u.s.	d.s.	avg
y (mm)	65.2	65	65.1
Tw (mm)	655.333333	647.3333	651.3333
A (m^2)	0.03047557	0.030122	0.030299
P (m)	0.67731259	0.66963	0.67347
Rh (m)	0.04499483	0.044983	0.044989
V (m/s)	0.37545166	0.379858	0.377655
H (m)	0.07562716	0.072357	0.073992

delta H: 0.0032703 m delta x: 1.62 m

Sf: 0.00201872

Tavg: 20 °C

ν: 1.004E-06 m^2/s

δ: 0.00039025 m

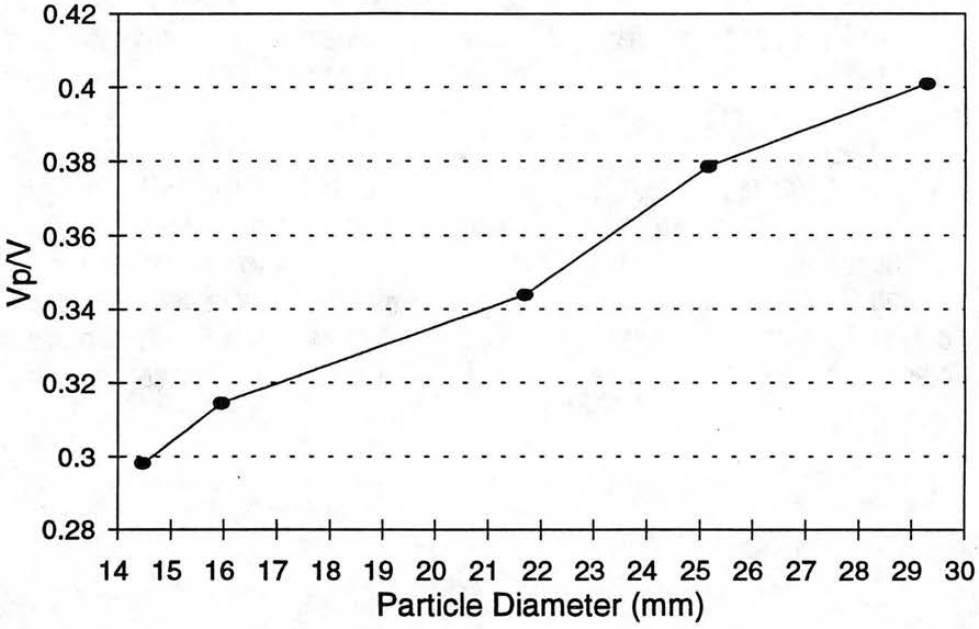
Run# 23

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	29.3	2.6	21	0.1514	0.0064	0.6392	731.5747	0.0019
glass	25.17	2.6	21	0.1429	0.0070	0.5924	628.4552	0.0023
glass	21.7	2.6	21	0.1298	0.0065	0.5500	541.8147	0.0026
glass	15.97	2.6	21	0.1187	0.0067	0.4716	398.7457	0.0036
glass	14.48	2.6	21	0.1125	0.0067	0.4490	361.5427	0.0039

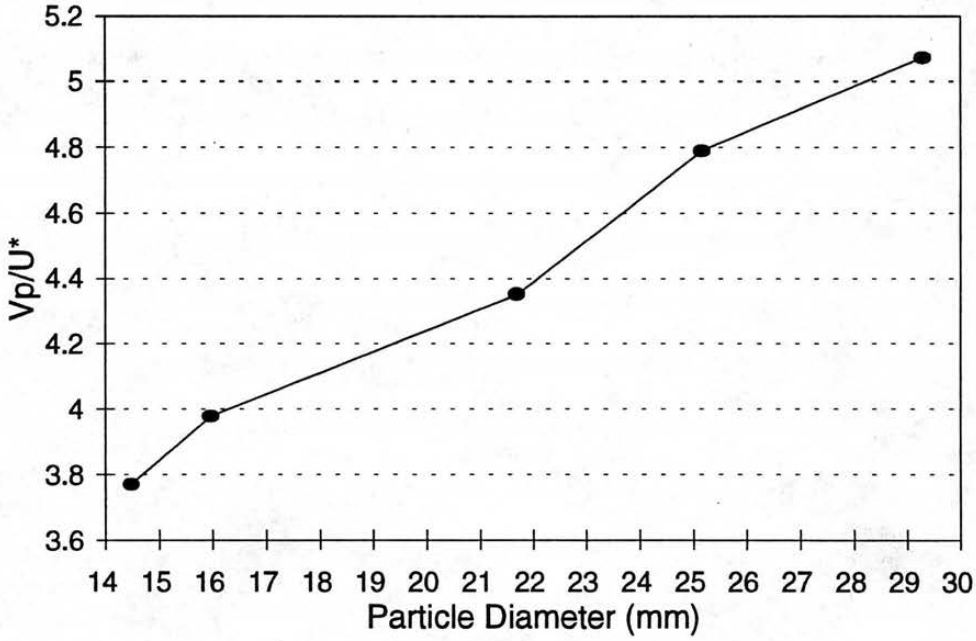
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.4009	5.0734	0.2369	0.0467	8.6176	8712.4060	75.0804	2.2218
glass	0.3785	4.7898	0.2413	0.0504	7.4029	8712.4060	64.4974	2.5864
glass	0.3438	4.3508	0.2361	0.0543	6.3824	8712.4060	55.6056	3.0000
glass	0.3144	3.9789	0.2518	0.0633	4.6971	8712.4060	40.9227	4.0764
glass	0.2980	3.7711	0.2506	0.0665	4.2588	8712.4060	37.1046	4.4959

Run 23
U* = 0.0298 m/s

Vp/V vs. d
(glass)



Vp/U* vs. d
(glass)



Run#	24		Bed Roughness k:	3.4	mm	Streamflow	16.0510 L/s
Date	7-17-95		Pump Setting	med		Valve Setting	3/4 open
Reach Length	2000	mm	Slope Reading	121.5	mm	Bed Slope	0.003

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer in. of water	Hi	-------		-------		-------	
	Lo	-------		-------		-------	
	Hi - Lo	73.3		73.5		73.3	
Flow Depth:	u.s.	66.9	mm	67.2	mm	66.7	mm
	d.s.	66.5	mm	66.3	mm	66.4	mm
	u.s. - d.s.	0.4	mm	0.9	mm	0.3	mm
	at weir	66.4	mm	66	mm	66.8	mm
Top Width:	u.s.	665	mm	667	mm	670	mm
	d.s.	651	mm	652	mm	650	mm
	at weir	690	mm	692	mm	705	mm

Velocities (mm/s)

type	glass	240.6739	238.9486	259.0674	220.7506	232.0186	251.8892	232.8289
d (mm)	29.3	217.8649	235.2941	232.8289	236.9668	240.3846	248.1390	223.9642
n	21	267.7376	243.3090	254.1296	234.4666	213.4472	228.5714	229.3578
G	2.6			Std Dev	13.5854		Avg	237.2685

Velocities (mm/s)

type	glass	219.2982	232.8289	232.5581	211.8644	273.5978	223.7136	247.2188
d (mm)	25.17	215.5172	252.8445	211.8644	218.3406	229.3578	241.5459	233.6449
n	21	250.9410	221.4839	234.4666	242.4242	234.4666	252.2068	236.9668
G	2.6			Std Dev	15.6900		Avg	234.1501

Velocities (mm/s)

type	glass	214.8228	209.2050	233.6449	211.8644	215.5172	208.3333	227.7904
d (mm)	21.7	260.4167	226.2443	232.8289	218.5792	250.0000	224.7191	222.2222
n	21	212.7660	211.1932	200.0000	198.8072	248.1390	201.2072	216.9197
G	2.6			Std Dev	16.5561		Avg	221.2010

Velocities (mm/s)

type	glass	216.2162	210.5263	216.9197	216.2162	209.6436	189.9335	223.9642
d (mm)	15.97	180.6685	257.0694	210.5263	206.3983	212.5399	227.0148	203.8736
n	21	220.0220	242.4242	225.9887	219.2982	203.2520	211.1932	226.2443
G	2.6			Std Dev	16.2259		Avg	215.7111

		Velocities (mm/s)						
type	glass	202.6342	202.0202	224.7191	219.7802	209.8636	195.6947	195.1220
d (mm)	14.48	247.2188	225.9887	203.0457	214.1328	203.6660	254.7771	191.0220
n	21	216.9197	205.1282	210.5263	218.5792	197.6285	205.7613	223.9642
G	2.6			Std Dev	16.3066		Avg	212.7711

		Velocities (mm/s)						
type	natural	160.0000	146.8429	157.3564	203.8736	221.4839	148.1481	171.0864
d (mm)	13.6	169.7793	206.3983	196.8504	216.9197	183.3181	225.4791	208.5506
n	21	217.8649	216.2162	181.3237	188.8574	207.0393	173.9130	167.5042
G	2.65			Std Dev	25.2905		Avg	188.9907

		Velocities (mm/s)						
type	natural	174.3679	251.8892	198.2161	201.2072	207.0393	231.2139	180.8318
d (mm)	9.6	191.0220	192.8640	179.8561	171.5266	165.2893	255.1020	236.9668
n	21	203.6660	221.4839	220.7506	168.7764	236.9668	192.8640	152.6718
G	2.65			Std Dev	29.3105		Avg	201.6463

		Velocities (mm/s)						
type	natural	192.1230	243.3090	184.5018	153.1394	164.4737	182.8154	198.8072
d (mm)	6.8	202.4291	182.8154	205.7613	188.1468	200.0000	165.2893	205.1282
n	21	177.7778	252.2068	195.1220	196.2709	198.0198	219.2982	176.6784
G	2.65			Std Dev	23.6395		Avg	194.4816

Steel particles moved only a few centimeters before halting.

Run#	24	Bed					
Date:	7-17-95	Roughness k:	3.4	mm		y/k:	19.608
Slope:	0.003	Q:	16.05102	L/s	U*:	0.0362	m/s

	u.s.	d.s.	avg
y (mm)	66.9333333	66.4	66.66667
Tw (mm)	667.333333	651	659.1667
A (m^2)	0.03168736	0.030893	0.031289
P (m)	0.68978646	0.674023	0.681899
Rh (m)	0.04593792	0.045833	0.045885
V (m/s)	0.50654343	0.519575	0.513059
H (m)	0.08487559	0.080164	0.08252

delta H:	0.0047116	m	delta x:	1.62	m
Sf:	0.00290837				
Tavg:	20	°C			
ν:	1.004E-06	m^2/s			
δ:	0.00032194	m			

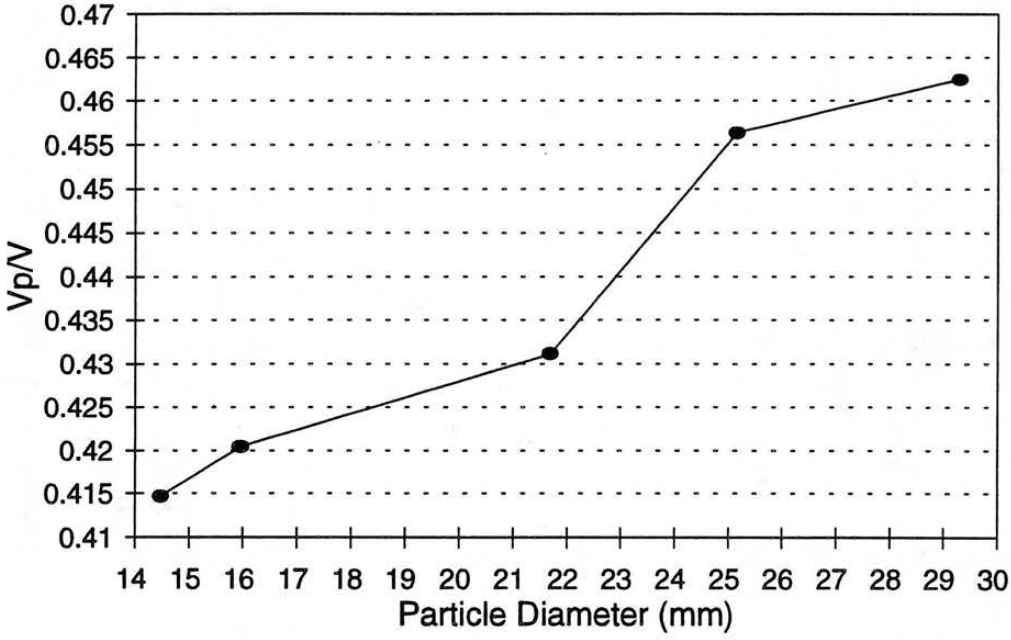
Run# 24

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	29.3	2.6	21	0.2373	0.0136	0.6392	731.5747	0.0028
glass	25.17	2.6	21	0.2342	0.0157	0.5924	628.4552	0.0033
glass	21.7	2.6	21	0.2212	0.0166	0.5500	541.8147	0.0038
glass	15.97	2.6	21	0.2157	0.0162	0.4716	398.7457	0.0052
glass	14.48	2.6	21	0.2128	0.0163	0.4490	361.5427	0.0058
natural	13.6	2.65	21	0.1890	0.0253	0.4419	343.0715	0.0059
natural	9.6	2.65	21	0.2016	0.0293	0.3709	242.1681	0.0084
natural	6.8	2.65	21	0.1945	0.0236	0.3117	171.5357	0.0119

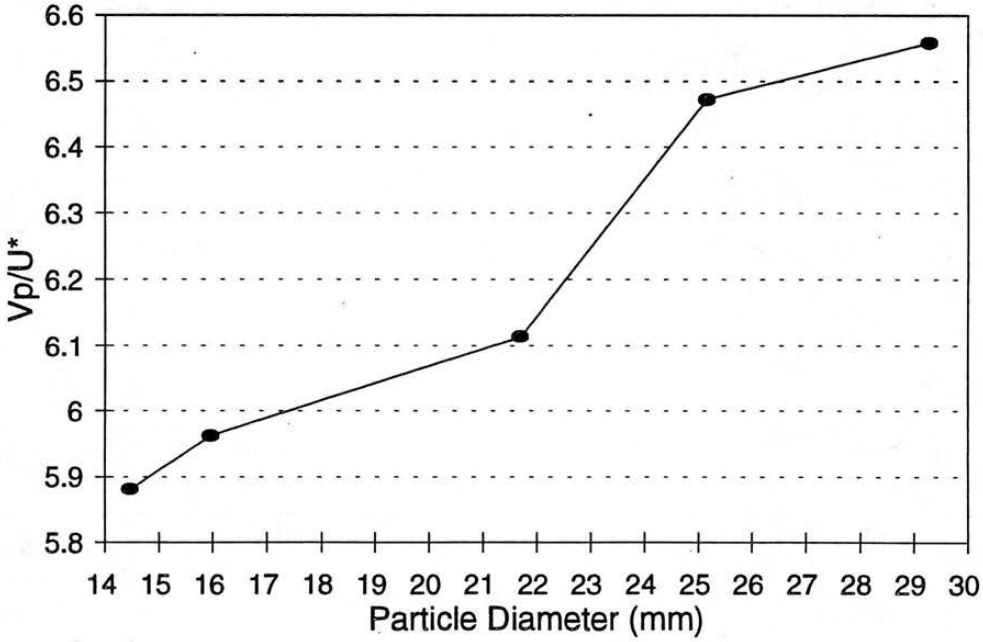
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.4625	6.5587	0.3712	0.0566	8.6176	10561.0579	91.0115	2.2753
glass	0.4564	6.4725	0.3952	0.0611	7.4029	10561.0579	78.1829	2.6487
glass	0.4311	6.1146	0.4022	0.0658	6.3824	10561.0579	67.4044	3.0722
glass	0.4204	5.9628	0.4574	0.0767	4.6971	10561.0579	49.6059	4.1745
glass	0.4147	5.8816	0.4739	0.0806	4.2588	10561.0579	44.9777	4.6041
natural	0.3684	5.2242	0.4277	0.0819	4.0000	10561.0579	42.2442	4.9020
natural	0.3930	5.5740	0.5437	0.0975	2.8235	10561.0579	29.8195	6.9444
natural	0.3791	5.3760	0.6240	0.1161	2.0000	10561.0579	21.1221	9.8039

Run 24
U* = 0.036 m/s

Vp/V vs. d
(glass)

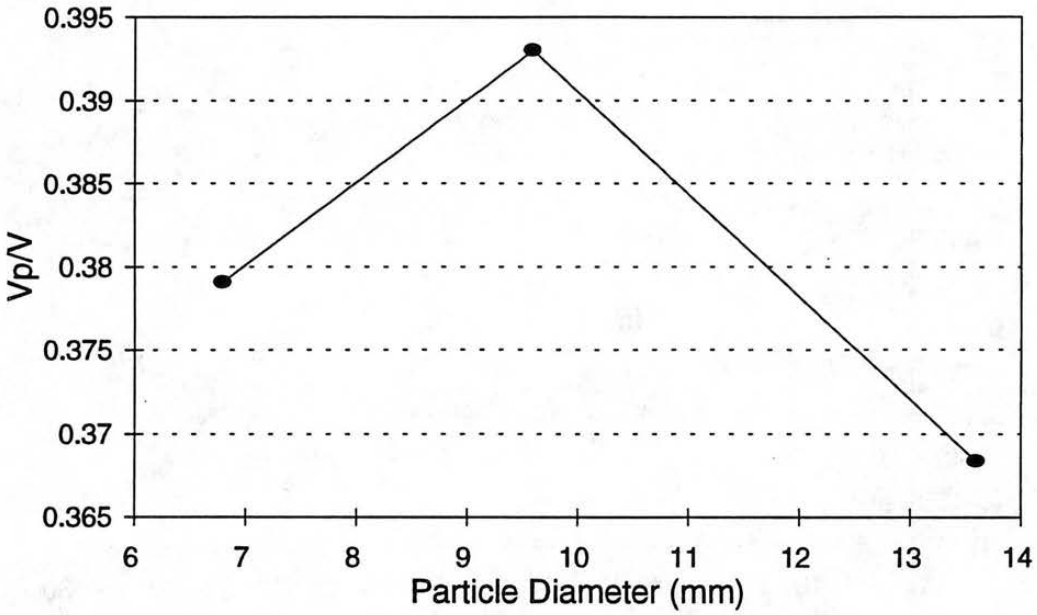


Vp/U* vs. d
(glass)

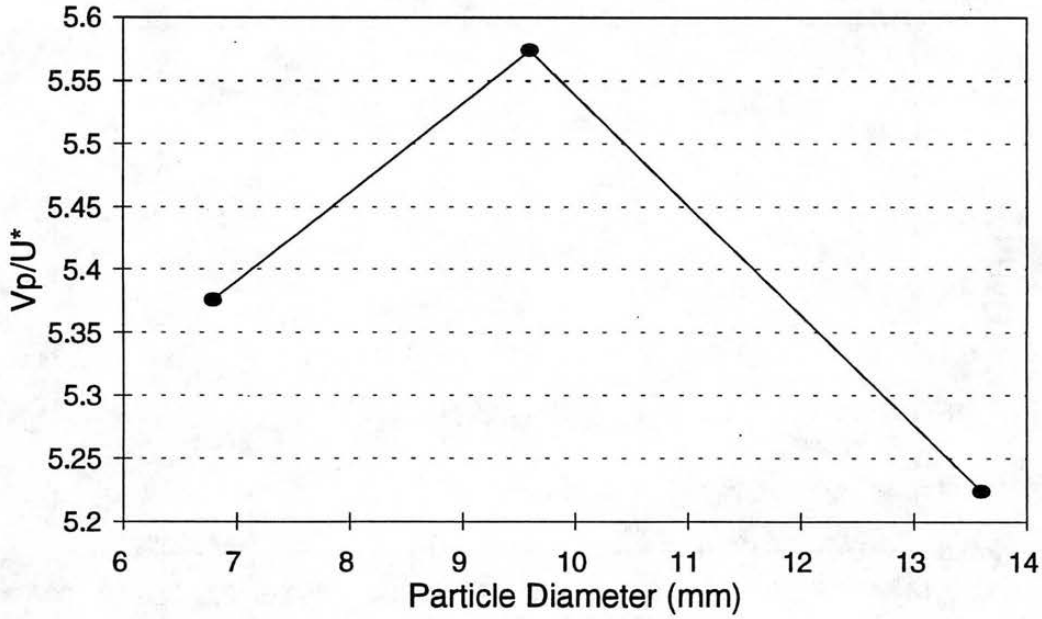


Run 24
U* = 0.036 m/s

Vp/V vs. d
(natural)



Vp/U* vs. d
(natural)



Run#	25		Bed Roughness k:	3.4	mm	Streamflow	19.3243 L/s
Date	7-17-95		Pump Setting	fast		Valve Setting	1/2 open
Reach Length	2000	mm	Slope Reading	129.5	mm	Bed Slope	0.00413

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer in. of water	Hi	51.47		51.47		50.12	
	Lo	-55.54		-54.18		-55.54	
	Hi - Lo	107.01		105.65		105.66	
Flow Depth:	u.s.	64.6	mm	64	mm	64.5	mm
	d.s.	65.8	mm	65.7	mm	65.6	mm
	u.s. - d.s.	-1.2	mm	-1.7	mm	-1.1	mm
	at weir	61.3	mm	61	mm	60.4	mm
Top Width:	u.s.	639	mm	640	mm	642	mm
	d.s.	658	mm	658	mm	660	mm
	at weir	658	mm	657	mm	655	mm

Velocities (mm/s)

type	glass	374.5318	361.6637	389.8635	338.4095	395.2569	350.2627	373.8318
d (mm)	29.3	338.9831	389.8635	403.2258	349.6503	386.1004	396.8254	374.5318
n	21	349.6503	336.7003	371.7472	359.7122	335.5705	349.6503	301.6591
G	2.6			Std Dev	25.8227		Avg	363.2233

Velocities (mm/s)

type	glass	340.7155	390.6250	338.4095	383.1418	344.8276	325.2033	360.3604
d (mm)	25.17	403.2258	379.5066	395.2569	346.0208	357.1429	353.3569	346.0208
n	21	378.0718	323.1018	355.2398	344.2341	357.7818	321.5434	418.4100
G	2.6			Std Dev	26.9652		Avg	360.1046

Velocities (mm/s)

type	glass	289.4356	321.5434	369.6858	324.6753	331.6750	357.1429	285.7143
d (mm)	21.7	363.6364	400.0000	285.7143	289.4356	324.6753	383.1418	330.0330
n	21	374.5318	390.6250	326.2643	315.4574	395.2569	327.8689	361.0108
G	2.6			Std Dev	36.9912		Avg	340.3583

Velocities (mm/s)

type	glass	342.4658	316.9572	307.6923	344.2341	316.9572	378.0718	376.6478
d (mm)	15.97	312.5000	316.9572	340.7155	320.0000	344.2341	375.9398	320.0000
n	21	341.8803	329.4893	308.1664	364.2987	410.6776	313.4796	357.7818
G	2.6			Std Dev	28.3304		Avg	339.9594

		Velocities (mm/s)						
type	glass	353.3569	333.3333	380.9524	314.9606	383.1418	352.7337	285.7143
d (mm)	14.48	312.0125	333.8898	330.0330	357.7818	313.4796	341.2969	338.9831
n	21	314.9606	361.6637	313.4796	347.8261	374.5318	378.7879	338.4095
G	2.6			Std Dev	26.4368		Avg	341.0157

		Velocities (mm/s)						
type	natural	329.4893	257.0694	277.3925	304.8780	267.7376	282.0874	342.4658
d (mm)	13.6	267.7376	298.9537	275.8621	282.0874	289.8551	267.7376	301.6591
n	21	286.9440	301.6591	318.4713	361.6637	275.8621	341.8803	320.0000
G	2.65			Std Dev	28.6757		Avg	297.6902

		Velocities (mm/s)						
type	natural	321.5434	273.5978	333.3333	355.8719	277.0083	315.4574	320.0000
d (mm)	9.6	199.4018	314.9606	321.5434	316.9572	313.4796	232.8289	275.8621
n	21	351.4938	259.0674	373.8318	273.5978	297.6190	258.0645	335.0084
G	2.65			Std Dev	42.6488		Avg	300.9775

		Velocities (mm/s)						
type	natural	236.1275	263.1579	230.4147	284.4950	228.5714	233.3722	309.1190
d (mm)	6.8	243.3090	288.1844	278.5515	296.2963	246.9136	303.4901	241.5459
n	21	307.6923	326.7974	301.6591	243.3090	336.7003	304.8780	311.0420
G	2.65			Std Dev	35.0234		Avg	276.9346

		Velocities (mm/s)						
type	natural	275.1032	284.4950	254.7771	202.0202	296.2963	260.0780	318.9793
d (mm)	4.8	236.1275	250.9410	244.2002	279.3296	250.0000	267.7376	307.6923
n	21	280.5049	282.0874	326.7974	242.1308	275.8621	344.2341	286.9440
G	2.65			Std Dev	33.1786		Avg	274.5875

		Velocities (mm/s)						
type	natural	258.0645	269.9055	275.8621	302.1148	257.0694	286.9440	252.8445
d (mm)	3.4	235.2941	331.6750	259.0674	310.5590	249.0660	297.6190	294.9853
n	21	272.4796	254.7771	215.5172	236.9668	315.4574	279.7203	268.8172
G	2.65			Std Dev	29.0445		Avg	272.6098

Very little motion for the steel particles.

Run# 25 Bed
Date: 7-17-95 Roughness k: 3.4 mm y/k: 19.127

Slope: 0.00413 Q: 19.32429 L/s U*: 0.0438 m/s

	u.s.	d.s.	avg
y (mm)	64.3666667	65.7	65.03333
Tw (mm)	640.333333	658.6667	649.5
A (m^2)	0.0296033	0.030819	0.030208
P (m)	0.6626096	0.68079	0.671696
Rh (m)	0.04467684	0.045269	0.044973
V (m/s)	0.6527747	0.62703	0.639902
H (m)	0.09278308	0.085746	0.089264

delta H: 0.0070372 m delta x: 1.62 m

Sf: 0.00434394

Tavg: 20 °C

ν: 1.004E-06 m^2/s

δ: 0.00026608 m

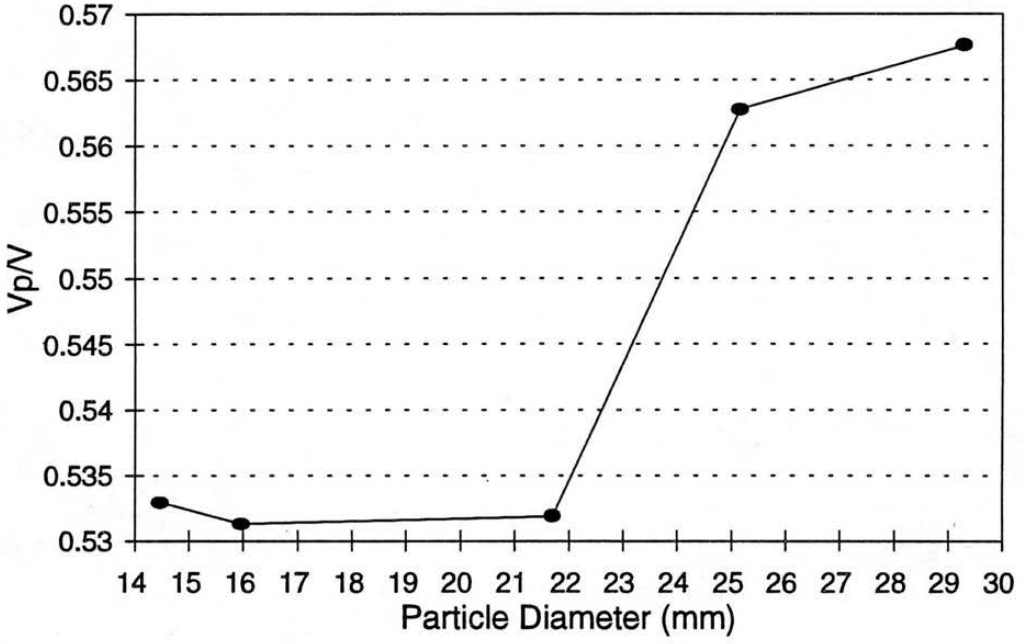
Run# 25

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	29.3	2.6	21	0.3632	0.0258	0.6392	731.5747	0.0042
glass	25.17	2.6	21	0.3601	0.0270	0.5924	628.4552	0.0049
glass	21.7	2.6	21	0.3404	0.0370	0.5500	541.8147	0.0056
glass	15.97	2.6	21	0.3400	0.0283	0.4716	398.7457	0.0076
glass	14.48	2.6	21	0.3410	0.0264	0.4490	361.5427	0.0084
natural	13.6	2.65	21	0.2977	0.0287	0.4419	343.0715	0.0087
natural	9.6	2.65	21	0.3010	0.0426	0.3709	242.1681	0.0123
natural	6.8	2.65	21	0.2769	0.0350	0.3117	171.5357	0.0174
natural	4.8	2.65	21	0.2746	0.0332	0.2612	121.0841	0.0247
natural	3.4	2.65	21	0.2726	0.0290	0.2189	85.7679	0.0348

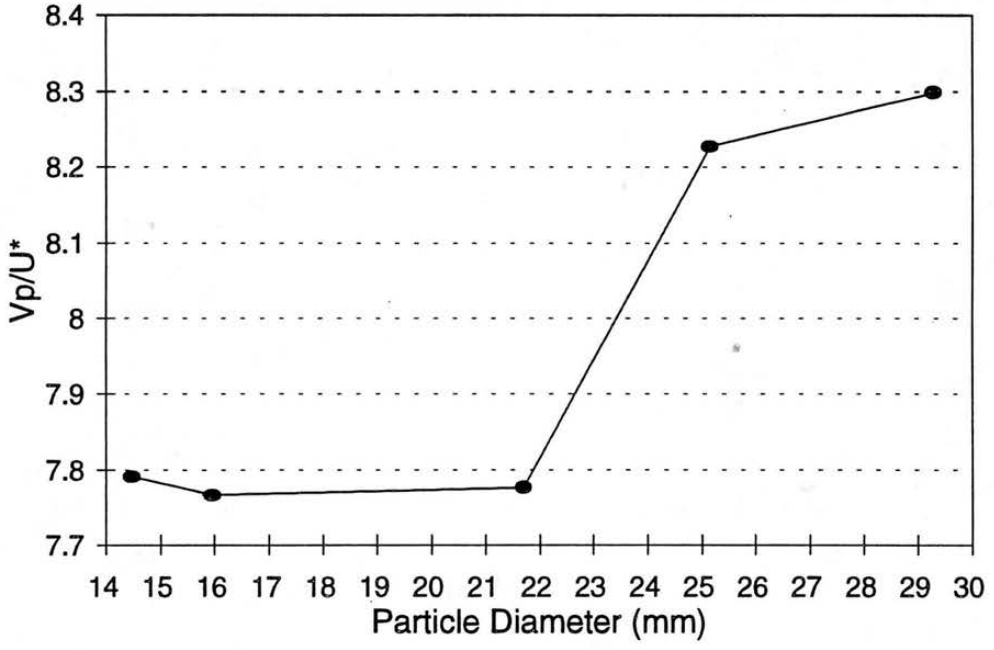
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.5676	8.2985	0.5682	0.0685	8.6176	12778.0298	110.1166	2.2196
glass	0.5627	8.2272	0.6079	0.0739	7.4029	12778.0298	94.5950	2.5838
glass	0.5319	7.7761	0.6188	0.0796	6.3824	12778.0298	81.5539	2.9969
glass	0.5313	7.7669	0.7208	0.0928	4.6971	12778.0298	60.0192	4.0722
glass	0.5329	7.7911	0.7595	0.0975	4.2588	12778.0298	54.4194	4.4913
natural	0.4652	6.8012	0.6737	0.0991	4.0000	12778.0298	51.1121	4.7819
natural	0.4703	6.8763	0.8115	0.1180	2.8235	12778.0298	36.0791	6.7743
natural	0.4328	6.3270	0.8885	0.1404	2.0000	12778.0298	25.5561	9.5637
natural	0.4291	6.2734	1.0513	0.1676	1.4118	12778.0298	18.0396	13.5486
natural	0.4260	6.2282	1.2455	0.2000	1.0000	12778.0298	12.7780	19.1275

Run 25
U* = 0.04377 m/s

Vp/V vs. d
(glass)

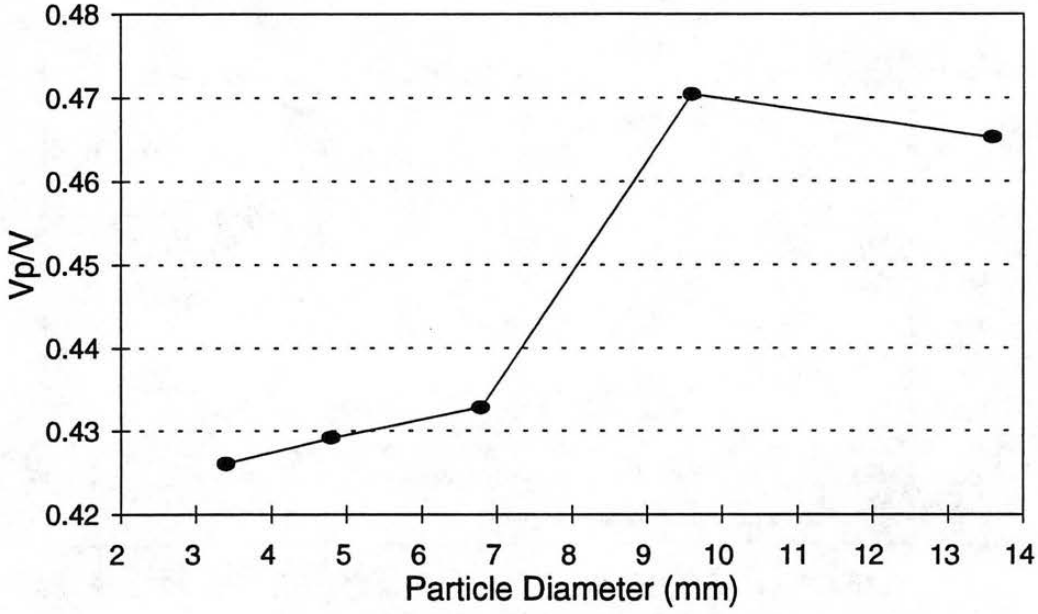


Vp/U* vs. d
(glass)

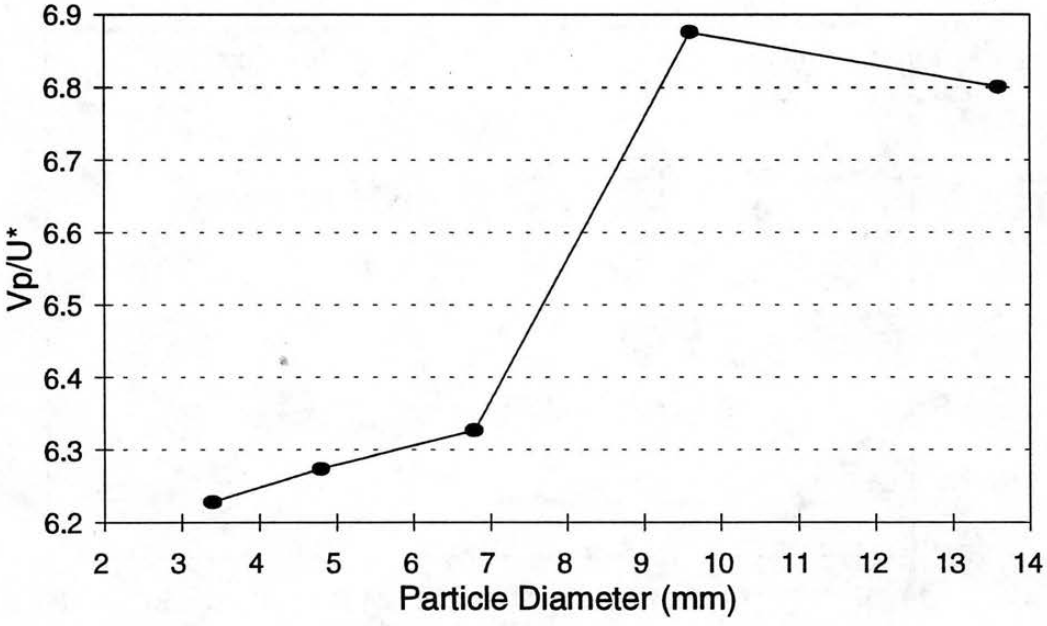


Run 25
U* = 0.04377 m/s

Vp/V vs. d
(natural)



Vp/U* vs. d
(natural)



Run#	26	Bed Roughness k:	3.4	mm	Streamflow	14.0104	L/s
Date	7-19-95	Pump Setting	fast		Valve Setting	3/8 open	
Reach Length	2000	mm	Slope Reading	147.5	mm	Bed Slope	0.00665

		Initial		Intermediate		Final	
Temperature		20	°C			21	°C
Manometer in. of water	Hi	27.09		27.09		27.09	
	Lo	-29.8		-28.45		-28.45	
	Hi - Lo	56.89		55.54		55.54	
Flow Depth:	u.s.	50.8	mm	51.4	mm	50.7	mm
	d.s.	49.6	mm	49.6	mm	49.8	mm
	u.s. - d.s.	1.2	mm	1.8	mm	0.9	mm
	at weir	48.9	mm	49.1	mm	48.8	mm
Top Width:	u.s.	563	mm	564	mm	567	mm
	d.s.	572	mm	572	mm	576	mm
	at weir	574	mm	577	mm	580	mm

Velocities (mm/s)

type	steel	137.3626	136.0544	ERR	ERR	ERR	ERR	ERR
d (mm)	19.04	141.6431	135.3180	ERR	ERR	ERR	ERR	ERR
n	6	135.8696	137.6462	ERR	ERR	ERR	ERR	ERR
G	8.02			Std Dev	2.3026		Avg	137.3157

Velocities (mm/s)

type	glass	503.7783	546.4481	477.3270	457.6659	515.4639	453.5147	447.4273
d (mm)	29.3	426.4392	473.9336	464.0371	480.7692	453.5147	578.0347	408.1633
n	21	421.0526	460.8295	444.4444	496.2779	453.5147	496.2779	454.5455
G	2.6			Std Dev	40.5004		Avg	472.0695

Velocities (mm/s)

type	glass	412.3711	424.6285	512.8205	464.0371	496.2779	467.2897	464.0371
d (mm)	25.17	444.4444	453.5147	515.4639	464.0371	441.5011	453.5147	470.5882
n	21	503.7783	488.9976	481.9277	444.4444	441.5011	454.5455	450.4505
G	2.6			Std Dev	27.5142		Avg	464.2939

Velocities (mm/s)

type	glass	470.5882	413.2231	487.8049	376.6478	426.4392	438.5965	496.2779
d (mm)	21.7	450.4505	409.8361	429.1845	473.9336	441.5011	402.4145	421.0526
n	21	450.4505	447.4273	409.8361	410.6776	448.4305	496.2779	457.6659
G	2.6			Std Dev	32.2751		Avg	440.8913

		Velocities (mm/s)						
type	glass	460.8295	444.4444	412.3711	427.3504	444.4444	484.2615	450.4505
d (mm)	15.97	444.4444	470.5882	438.5965	440.5286	415.8004	432.9004	438.5965
n	21	459.7701	415.8004	421.0526	473.9336	426.4392	437.6368	413.2231
G	2.6			Std Dev	20.5493		Avg	440.6411

		Velocities (mm/s)						
type	glass	400.0000	413.2231	447.4273	441.5011	392.9273	450.4505	453.5147
d (mm)	14.48	481.9277	450.4505	466.2005	500.0000	450.4505	387.5969	438.5965
n	21	400.0000	418.4100	438.5965	470.5882	418.4100	438.5965	430.1075
G	2.6			Std Dev	29.4438		Avg	437.5703

		Velocities (mm/s)						
type	natural	326.2643	355.2398	323.6246	383.1418	386.1004	300.7519	338.9831
d (mm)	13.6	330.0330	331.6750	355.8719	359.0664	333.3333	357.7818	374.5318
n	21	361.6637	312.0125	330.0330	380.9524	367.6471	385.3565	367.6471
G	2.65			Std Dev	25.3263		Avg	350.5577

		Velocities (mm/s)						
type	natural	423.7288	394.4773	423.7288	418.4100	387.5969	460.8295	357.7818
d (mm)	9.6	395.2569	326.2643	369.6858	353.3569	316.9572	408.1633	415.8004
n	21	434.7826	395.2569	363.6364	392.1569	297.6190	256.7394	312.0125
G	2.65			Std Dev	51.2631		Avg	376.3925

		Velocities (mm/s)						
type	natural	347.8261	335.0084	397.6143	353.9823	317.9650	310.5590	340.1361
d (mm)	6.8	349.6503	383.1418	306.2787	336.7003	329.4893	383.1418	373.8318
n	21	303.4901	278.1641	274.7253	304.8780	400.0000	418.4100	355.8719
G	2.65			Std Dev	39.7786		Avg	342.8983

		Velocities (mm/s)						
type	natural	312.0125	333.3333	342.4658	355.8719	297.6190	326.7974	376.6478
d (mm)	4.8	313.9717	330.5785	303.9514	361.0108	353.9823	299.4012	327.8689
n	21	324.6753	344.2341	328.9474	402.4145	357.7818	306.2787	336.7003
G	2.65			Std Dev	26.5729		Avg	335.0736

		Velocities (mm/s)						
type	natural	333.8898	289.8551	331.6750	295.8580	310.5590	335.5705	318.9793
d (mm)	3.4	313.4796	333.3333	355.2398	333.8898	346.0208	307.6923	314.9606
n	21	320.0000	383.1418	264.5503	387.5969	331.6750	342.4658	288.6003
G	2.65			Std Dev	29.3646		Avg	325.6682

Steel particles smaller than 19.04 mm never finished a trial.
Those with 15.58 mm diameters rolled as much as a meter before halting.
Smaller particles moved only a few centimeters.
20 trials for the 19.04mm steel particle resulted in early halting.

Run# 26 Bed
Date: 7-19-95 Roughness k: 3.4 mm y/k: 14.799

Slope: 0.00665 Q: 14.01037 L/s U*: 0.0501 m/s

	u.s.	d.s.	avg
y (mm)	50.9666667	49.66667	50.31667
Tw (mm)	564.666667	573.3333	569
A (m^2)	0.02151218	0.021179	0.021347
P (m)	0.5823373	0.58967	0.585992
Rh (m)	0.0369411	0.035916	0.036429
V (m/s)	0.65127593	0.661531	0.656404
H (m)	0.08336583	0.071979	0.077673

delta H: 0.0113866 m delta x: 1.62 m

Sf: 0.00702875

Tavg: 20.5 °C

ν: 9.9195E-07 m^2/s

δ: 0.00022963 m

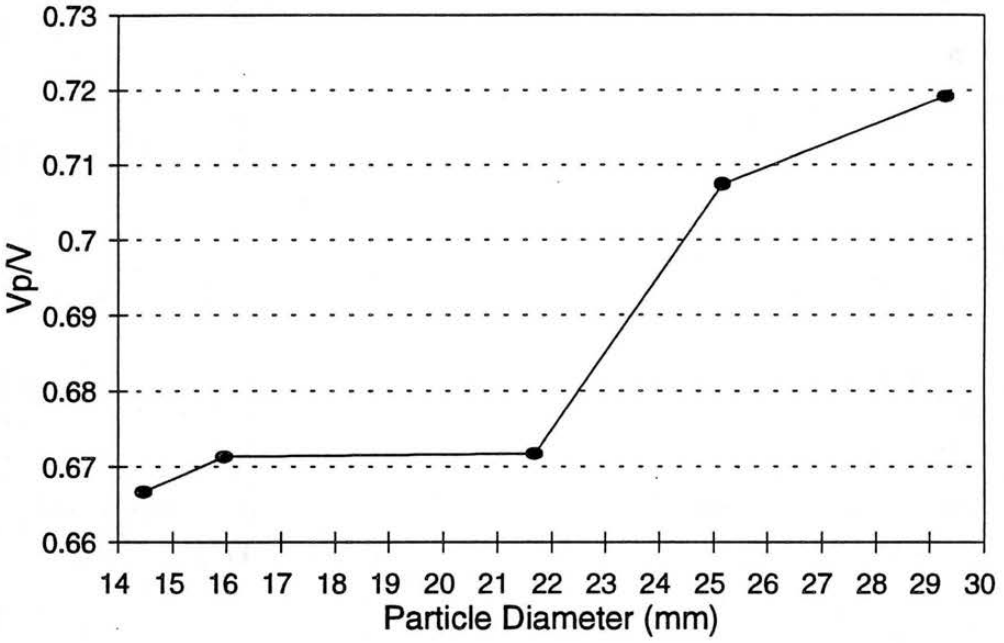
Run# 26

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	29.3	2.6	21	0.4721	0.0405	0.6392	737.4859	0.0055
glass	25.17	2.6	21	0.4643	0.0275	0.5924	633.5331	0.0064
glass	21.7	2.6	21	0.4409	0.0323	0.5500	546.1927	0.0074
glass	15.97	2.6	21	0.4406	0.0205	0.4716	401.9676	0.0100
glass	14.48	2.6	21	0.4376	0.0294	0.4490	364.4640	0.0111
natural	13.6	2.65	21	0.3506	0.0253	0.4419	345.8436	0.0114
natural	9.6	2.65	21	0.3764	0.0513	0.3709	244.1249	0.0162
natural	6.8	2.65	21	0.3429	0.0398	0.3117	172.9218	0.0228
natural	4.8	2.65	21	0.3351	0.0266	0.2612	122.0624	0.0323
natural	3.4	2.65	21	0.3257	0.0294	0.2189	86.4609	0.0456

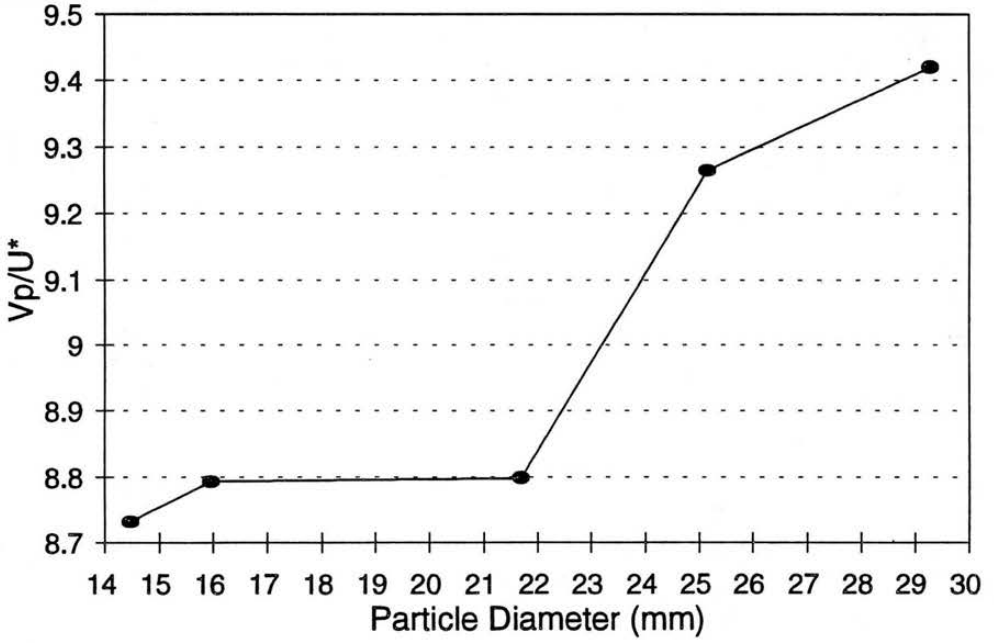
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.7192	9.4208	0.7385	0.0784	8.6176	14806.4237	127.5965	1.7173
glass	0.7073	9.2656	0.7837	0.0846	7.4029	14806.4237	109.6111	1.9991
glass	0.6717	8.7985	0.8016	0.0911	6.3824	14806.4237	94.4998	2.3187
glass	0.6713	8.7936	0.9343	0.1062	4.6971	14806.4237	69.5466	3.1507
glass	0.6666	8.7323	0.9745	0.1116	4.2588	14806.4237	63.0579	3.4749
natural	0.5341	6.9958	0.7933	0.1134	4.0000	14806.4237	59.2257	3.6998
natural	0.5734	7.5114	1.0148	0.1351	2.8235	14806.4237	41.8064	5.2413
natural	0.5224	6.8430	1.1001	0.1608	2.0000	14806.4237	29.6128	7.3995
natural	0.5105	6.6868	1.2828	0.1918	1.4118	14806.4237	20.9032	10.4826
natural	0.4961	6.4991	1.4877	0.2289	1.0000	14806.4237	14.8064	14.7990

Run 26
U* = 0.050 m/s

Vp/V vs. d
(glass)

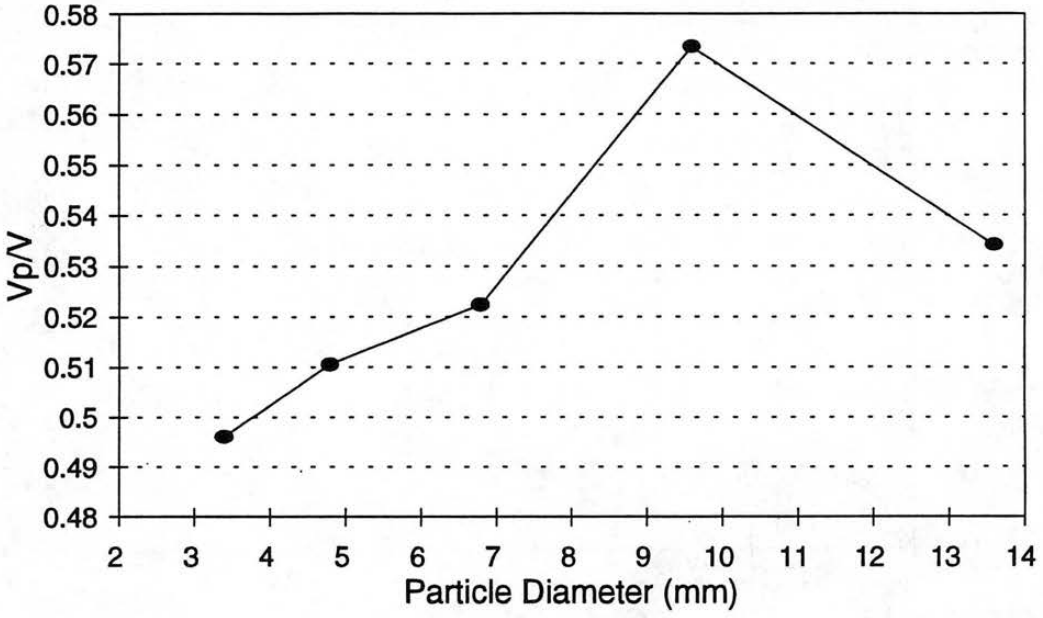


Vp/U* vs. d
(glass)

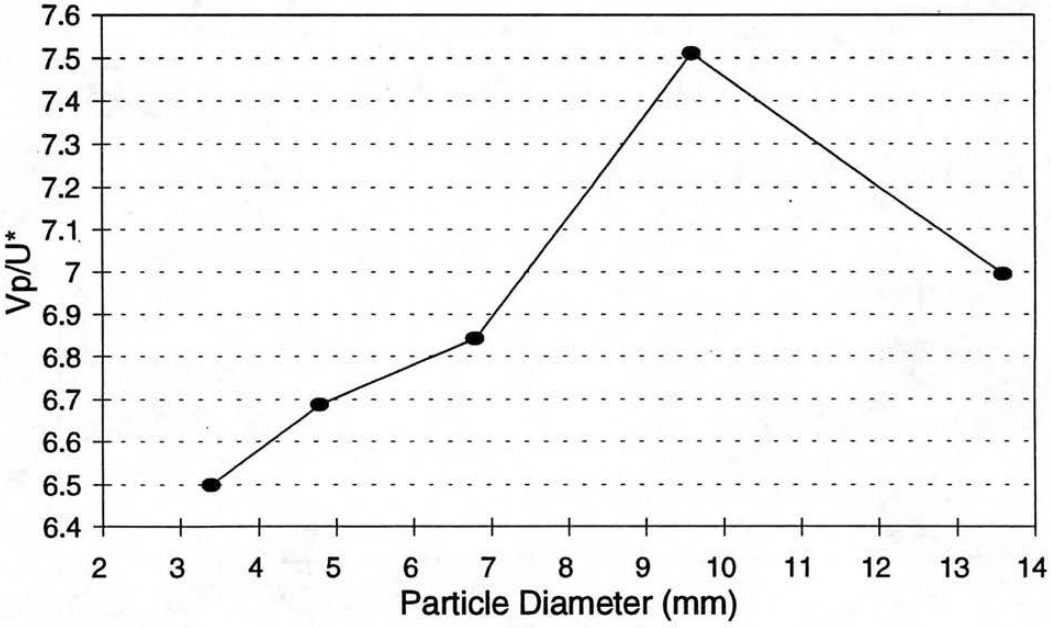


Run 26
U* = 0.050 m/s

Vp/V vs. d
(natural)



Vp/U* vs. d
(natural)



Run#	27	Bed Roughness k:	3.4	mm	Streamflow	17.9961	L/s
Date	7-20-95	Pump Setting	fast		Valve Setting	7/16 open	
Reach Length	2000	mm	Slope Reading	160	mm	Bed Slope	0.0084

		Initial		Intermediate		Final	
Temperature		20	°C			21	°C
Manometer in. of water	Hi	44.7		44.7		44.7	
	Lo	-47.4		-47.4		-47.4	
	Hi - Lo	92.1		92.1		92.1	
Flow Depth:	u.s.	53.7	mm	53.7	mm	53.3	mm
	d.s.	52.7	mm	52.5	mm	52.7	mm
	u.s. - d.s.	1	mm	1.2	mm	0.6	mm
	at weir	53	mm	52.7	mm	53.34	mm
Top Width:	u.s.	596	mm	598	mm	599	mm
	d.s.	590	mm	595	mm	596	mm
	at weir	595	mm	595	mm	595	mm

Velocities (mm/s)

type	steel	162.4695	164.6091	181.3237	176.2115	162.8664	174.8252	177.1479
d (mm)	19.04	174.8252	196.2709	179.2115	178.7310	178.7310	165.8375	170.7942
n	21	162.0746	194.5525	165.8375	177.1479	170.2128	171.9690	180.6685
G	8.02			Std Dev	9.3717		Avg	174.5865

Velocities (mm/s)

type	steel	144.5087	153.8462	157.6044	158.8562	144.0922	153.8462	159.6169
d (mm)	15.88	156.4945	154.6790	167.6446	159.2357	148.4781	168.4920	151.9757
n	21	163.6661	153.1394	157.6044	157.2327	153.0222	155.4002	164.6091
G	8.02			Std Dev	6.4619		Avg	156.3831

Velocities (mm/s)

type	steel	141.6431	141.9446	157.2327	155.7632	163.8002	149.4768	135.8696
d (mm)	14.28	150.2630	155.7632	161.1604	143.5750	152.3229	146.7351	155.7632
n	21	160.3849	154.5595	144.8226	146.0920	160.9010	155.4002	144.5087
G	8.02			Std Dev	7.6505		Avg	151.3325

Velocities (mm/s)

type	glass	576.3689	673.4007	628.9308	593.4718	632.9114	621.1180	591.7160
d (mm)	29.3	581.3953	576.3689	638.9776	653.5948	593.4718	583.0904	591.7160
n	21	533.3333	557.1031	609.7561	591.7160	615.3846	576.3689	615.3846
G	2.6			Std Dev	32.8152		Avg	601.6942

Velocities (mm/s)

type	glass	609.7561	581.3953	615.3846	529.1005	581.3953	537.6344	588.2353
d (mm)	25.17	604.2296	574.7126	641.0256	561.7978	591.7160	626.9592	571.4286
n	21	653.5948	598.8024	615.3846	566.5722	647.2492	632.9114	638.9776
G	2.6			Std Dev	35.0037		Avg	598.4887

Velocities (mm/s)

type	glass	555.5556	566.5722	588.2353	621.1180	550.9642	626.9592	609.7561
d (mm)	21.7	571.4286	628.9308	566.5722	604.2296	660.0660	653.5948	586.5103
n	21	576.3689	597.0149	586.5103	529.1005	586.5103	597.0149	591.7160
G	2.6			Std Dev	32.6995		Avg	593.0823

Velocities (mm/s)

type	glass	602.4096	555.5556	598.8024	552.4862	581.3953	626.9592	598.8024
d (mm)	15.97	571.4286	542.0054	564.9718	566.5722	598.8024	604.2296	651.4658
n	21	581.3953	597.0149	515.4639	588.2353	524.9344	523.5602	566.5722
G	2.6			Std Dev	34.2424		Avg	576.8125

Velocities (mm/s)

type	glass	557.1031	615.3846	566.5722	533.3333	576.3689	591.7160	586.5103
d (mm)	14.48	598.8024	586.5103	576.3689	547.9452	581.3953	561.7978	588.2353
n	21	576.3689	634.9206	615.3846	615.3846	480.7692	634.9206	537.6344
G	2.6			Std Dev	36.2928		Avg	579.2108

Velocities (mm/s)

type	natural	480.7692	467.2897	462.9630	432.9004	467.2897	488.9976	524.9344
d (mm)	13.6	473.9336	503.7783	488.9976	477.3270	507.6142	492.6108	456.6210
n	21	529.1005	533.3333	547.9452	477.3270	550.9642	491.4005	492.6108
G	2.65			Std Dev	30.7054		Avg	492.7956

Velocities (mm/s)

type	natural	481.9277	555.5556	520.8333	485.4369	524.9344	660.0660	405.6795
d (mm)	9.6	473.9336	500.0000	537.6344	430.1075	520.8333	477.3270	516.7959
n	21	481.9277	537.6344	488.9976	505.0505	557.1031	488.9976	431.9654
G	2.65			Std Dev	53.3776		Avg	503.9401

Velocities (mm/s)

type	natural	511.5090	561.7978	477.3270	520.8333	488.9976	524.9344	477.3270
d (mm)	6.8	496.2779	456.6210	500.0000	591.7160	542.0054	473.9336	402.4145
n	21	453.5147	555.5556	418.4100	490.1961	508.9059	467.2897	533.3333
G	2.65			Std Dev	46.1442		Avg	497.7571

Velocities (mm/s)

type	natural	390.6250	470.5882	500.0000	465.1163	390.6250	435.7298	467.2897
d (mm)	4.8	478.4689	423.7288	392.1569	485.4369	402.4145	408.1633	421.0526
n	21	429.1845	227.2727	435.7298	488.9976	438.5965	456.6210	478.4689
G	2.65			Std Dev	58.3567		Avg	432.6794

		Velocities (mm/s)						
type	natural	438.5965	459.7701	453.5147	444.4444	552.4862	426.4392	500.0000
d (mm)	3.4	460.8295	441.5011	409.8361	418.4100	423.7288	397.6143	454.5455
n	21	423.7288	450.4505	447.4273	367.6471	415.8004	418.4100	487.8049
G	2.65			Std Dev	38.7199		Avg	442.5231

Run# 27 Bed
Date: 7-20-95 Roughness k: 3.4 mm y/k: 15.618

Slope: 0.0084 Q: 17.99614 L/s U*: 0.055 m/s

	u.s.	d.s.	avg
y (mm)	53.5666667	52.63333	53.1
Tw (mm)	597.666667	593.6667	595.6667
A (m^2)	0.02349345	0.022979	0.023236
P (m)	0.61521949	0.610833	0.613026
Rh (m)	0.0381871	0.037619	0.037903
V (m/s)	0.76600698	0.783162	0.774584
H (m)	0.09709144	0.083905	0.090498

delta H: 0.0131864 m delta x: 1.62 m

Sf: 0.00813973

Tavg: 20.5 °C

ν: 9.9195E-07 m^2/s

δ: 0.00020919 m

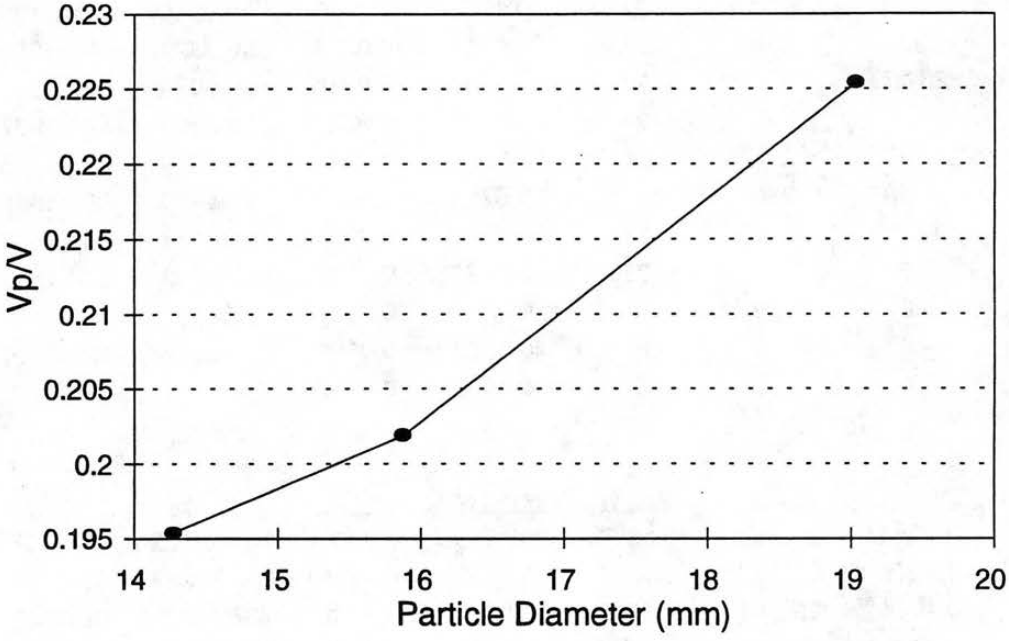
Run# 27

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	21	0.1746	0.0094	1.0794	784.5587	0.0023
steel	15.88	8.02	21	0.1564	0.0065	0.9857	654.3483	0.0028
steel	14.28	8.02	21	0.1513	0.0077	0.9346	588.4190	0.0031
glass	29.3	2.6	21	0.6017	0.0328	0.6392	737.4859	0.0066
glass	25.17	2.6	21	0.5985	0.0350	0.5924	633.5331	0.0077
glass	21.7	2.6	21	0.5931	0.0327	0.5500	546.1927	0.0089
glass	15.97	2.6	21	0.5768	0.0342	0.4716	401.9676	0.0121
glass	14.48	2.6	21	0.5792	0.0363	0.4490	364.4640	0.0133
natural	13.6	2.65	21	0.4928	0.0307	0.4419	345.8436	0.0137
natural	9.6	2.65	21	0.5039	0.0534	0.3709	244.1249	0.0195
natural	6.8	2.65	21	0.4978	0.0461	0.3117	172.9218	0.0275
natural	4.8	2.65	21	0.4327	0.0584	0.2612	122.0624	0.0390
natural	3.4	2.65	21	0.4425	0.0387	0.2189	86.4609	0.0550

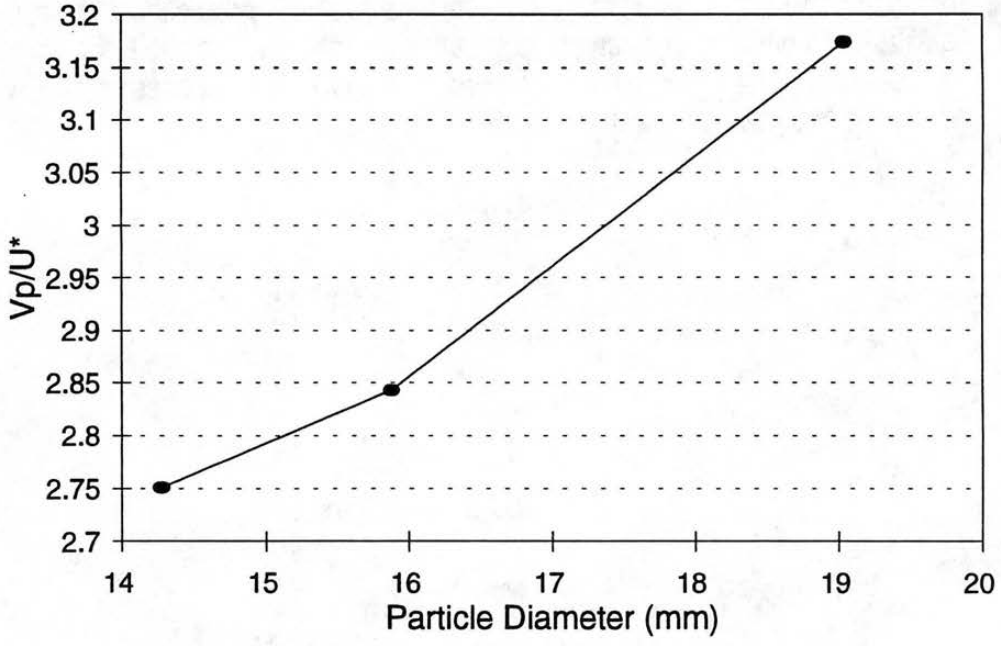
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.2254	3.1740	0.1617	0.0510	5.6000	16252.9838	91.0167	2.7889
steel	0.2019	2.8431	0.1587	0.0558	4.6706	16252.9838	75.9110	3.3438
steel	0.1954	2.7512	0.1619	0.0589	4.2000	16252.9838	68.2625	3.7185
glass	0.7768	10.9389	0.9413	0.0860	8.6176	16252.9838	140.0625	1.8123
glass	0.7727	10.8806	1.0102	0.0928	7.4029	16252.9838	120.3199	2.1097
glass	0.7657	10.7823	1.0783	0.1000	6.3824	16252.9838	103.7323	2.4470
glass	0.7447	10.4865	1.2230	0.1166	4.6971	16252.9838	76.3412	3.3250
glass	0.7478	10.5301	1.2899	0.1225	4.2588	16252.9838	69.2186	3.6671
natural	0.6362	8.9591	1.1152	0.1245	4.0000	16252.9838	65.0119	3.9044
natural	0.6506	9.1617	1.3587	0.1483	2.8235	16252.9838	45.8908	5.5313
natural	0.6426	9.0493	1.5969	0.1765	2.0000	16252.9838	32.5060	7.8088
natural	0.5586	7.8662	1.6564	0.2106	1.4118	16252.9838	22.9454	11.0625
natural	0.5713	8.0451	2.0215	0.2513	1.0000	16252.9838	16.2530	15.6176

Run 27
U* = 0.055 m/s

Vp/V vs. d
(steel)

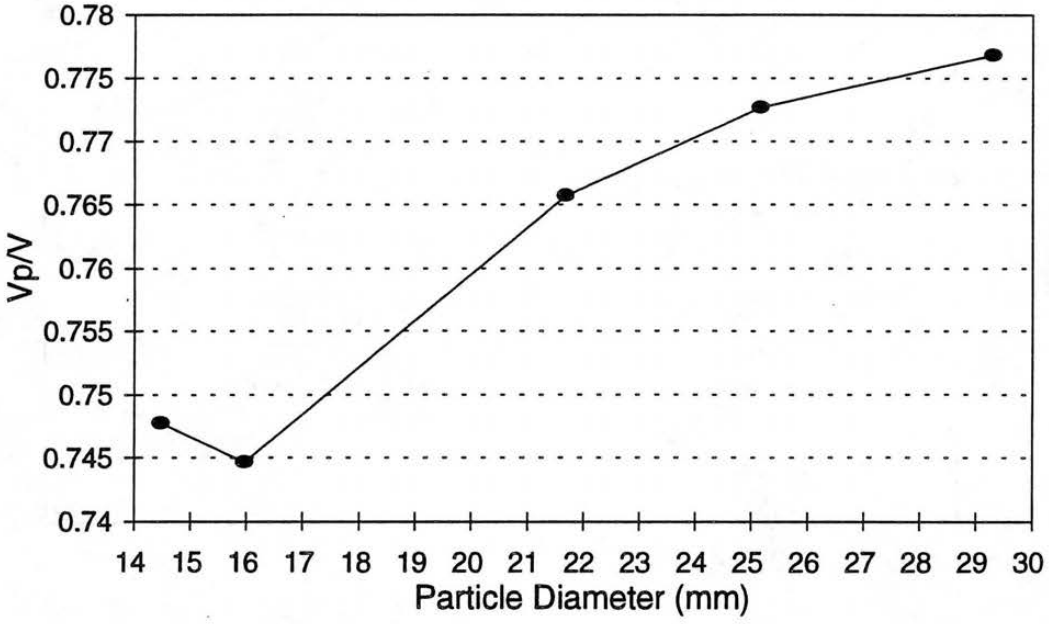


Vp/U* vs. d
(steel)

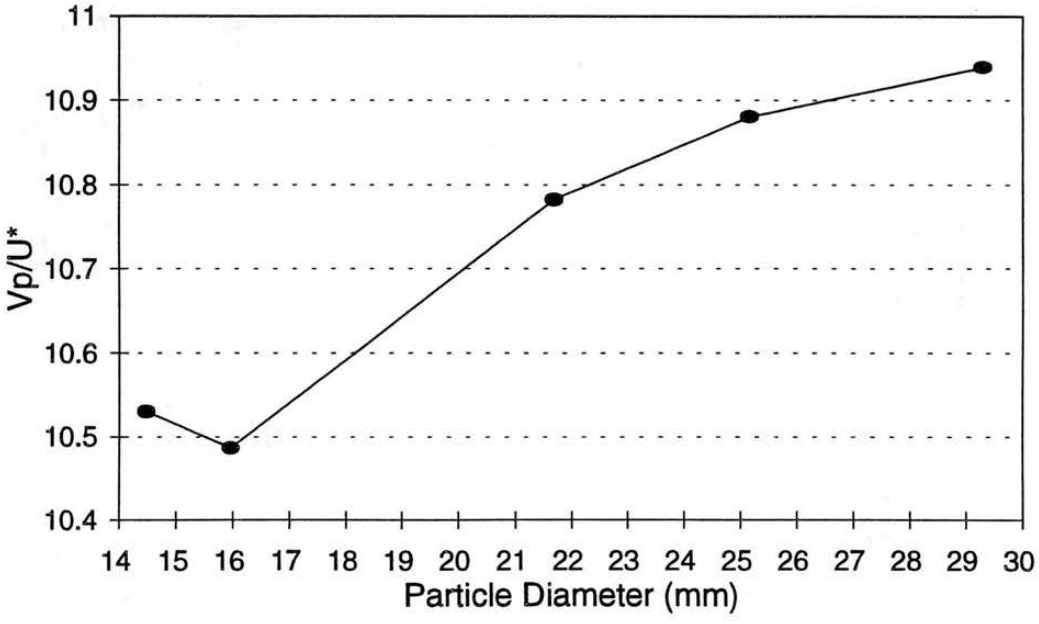


Run 27
U* = 0.055 m/s

Vp/V vs. d
(glass)

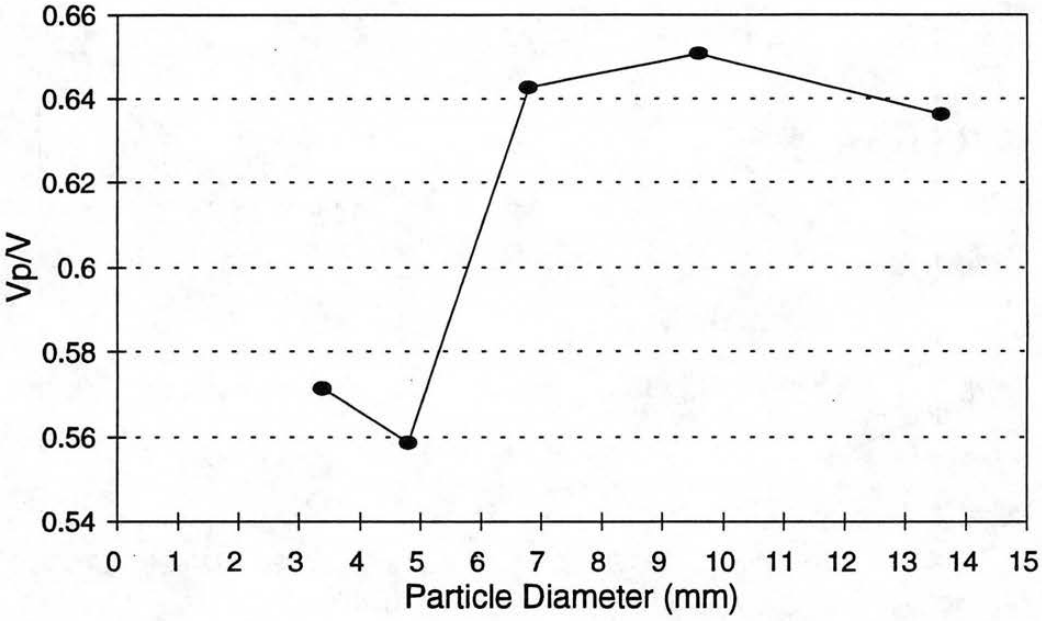


Vp/U* vs. d
(glass)

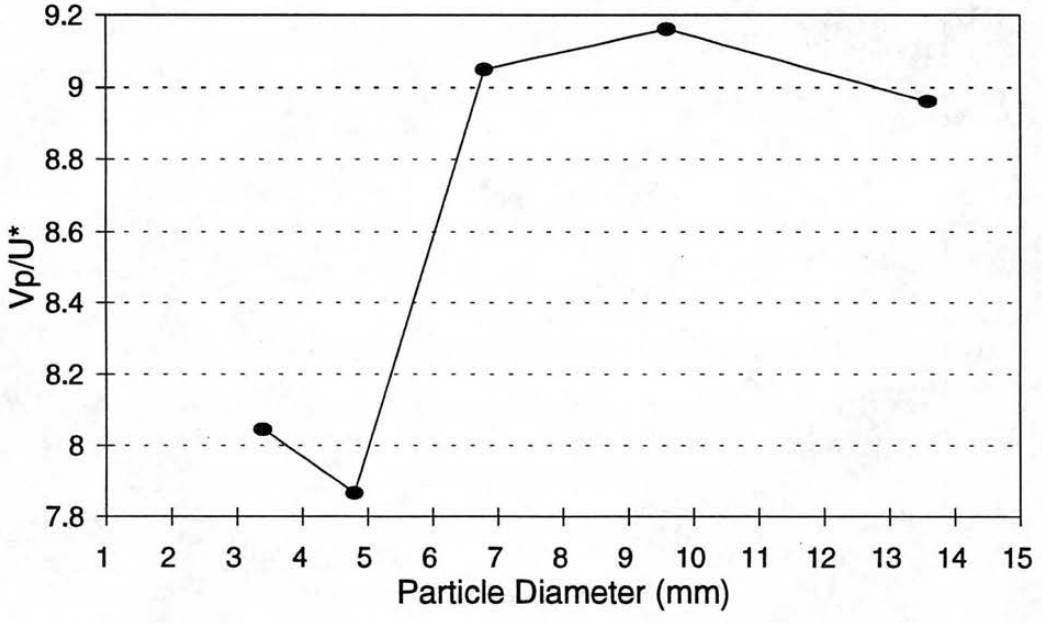


Run 27
U* = 0.055 m/s

Vp/V vs. d
(natural)



Vp/U* vs. d
(natural)



Run#	28		Bed Roughness k:	1.7	mm	Streamflow	22.3930 L/s
Date	7-25 95		Pump Setting	fast		Valve Setting	1/2 open
Reach Length	2000	mm	Slope Reading	171.5	mm	Bed Slope	0.01

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer in. of water	Hi	69.08		69.08		69.08	
	Lo	-73.15		-73.15		-73.15	
	Hi - Lo	142.23		142.23		142.23	
Flow Depth:	u.s.	55.9	mm	55.5	mm	55.5	mm
	d.s.	57.2	mm	57.1	mm	57.3	mm
	u.s. - d.s.	-1.3	mm	-1.6	mm	-1.8	mm
	at weir	54.3	mm	54.6	mm	54.4	mm
Top Width:	u.s.	612	mm	620	mm	615	mm
	d.s.	605	mm	608	mm	610	mm
	at weir	615	mm	620	mm	620	mm

Velocities (mm/s)

type	steel	397.6143	310.5590	326.2643	304.8780	323.1018	312.0125	366.3004
d (mm)	19.04	284.4950	363.6364	347.8261	340.7155	336.7003	330.0330	322.0612
n	21	291.1208	318.4713	300.7519	303.4901	309.1190	300.7519	400.0000
G	8.02			Std Dev	31.8934		Avg	328.0906

Velocities (mm/s)

type	steel	272.4796	370.3704	346.0208	271.3704	300.7519	357.1429	301.6591
d (mm)	15.88	316.4557	302.1148	291.9708	309.1190	325.2033	340.7155	335.5705
n	21	275.8621	346.0208	312.5000	321.5434	324.6753	315.4574	320.0000
G	8.02			Std Dev	26.8293		Avg	317.0002

Velocities (mm/s)

type	steel	295.4210	298.9537	303.4901	289.8551	395.2569	287.3563	304.8780
d (mm)	14.28	400.0000	304.8780	304.8780	280.8989	300.3003	323.1018	359.7122
n	21	353.3569	351.4938	355.8719	312.0125	353.3569	323.6246	297.6190
G	8.02			Std Dev	34.8940		Avg	323.6341

Velocities (mm/s)

type	steel	372.4395	336.7003	309.1190	378.0718	336.7003	316.4557	357.1429
d (mm)	9.5	357.7818	374.5318	342.4658	369.6858	352.1127	275.8621	330.0330
n	21	341.8803	309.1190	323.6246	383.1418	318.4713	303.4901	357.7818
G	8.02			Std Dev	28.5291		Avg	340.3148

		Velocities (mm/s)						
type	steel	397.6143	388.3495	318.4713	342.4658	378.7879	333.3333	330.0330
d (mm)	7.9	353.3569	383.1418	321.5434	346.0208	385.3565	337.2681	340.1361
n	21	333.3333	335.0084	371.7472	380.9524	289.8551	383.1418	376.6478
G	8.02			Std Dev	28.9990		Avg	353.6459

		Velocities (mm/s)						
type	glass	809.7166	809.7166	772.2008	754.7170	751.8797	ERR	ERR
d (mm)	29.3	790.5138	763.3588	727.2727	800.0000	809.7166	ERR	ERR
n	15	772.2008	781.2500	809.7166	751.8797	800.0000	ERR	ERR
G	2.6			Std Dev	26.5152		Avg	780.2760

		Velocities (mm/s)						
type	glass	760.4563	735.2941	757.5758	829.8755	809.7166	816.3265	800.0000
d (mm)	25.17	711.7438	687.2852	735.2941	751.8797	800.0000	727.2727	840.3361
n	21	769.2308	722.0217	687.2852	716.8459	829.8755	781.2500	778.2101
G	2.6			Std Dev	46.9771		Avg	764.1798

		Velocities (mm/s)						
type	glass	775.1938	772.2008	781.2500	751.8797	709.2199	ERR	ERR
d (mm)	21.7	729.9270	778.2101	743.4944	751.8797	769.2308	ERR	ERR
n	15	704.2254	787.4016	763.3588	743.4944	738.0074	ERR	ERR
G	2.6			Std Dev	25.4727		Avg	753.2649

		Velocities (mm/s)						
type	glass	790.5138	719.4245	704.2254	719.4245	843.8819	781.2500	ERR
d (mm)	15.97	760.4563	687.2852	711.7438	716.8459	727.2727	711.7438	ERR
n	18	743.4944	763.3588	696.8641	704.2254	778.2101	711.7438	ERR
G	2.6			Std Dev	40.9390		Avg	737.3313

		Velocities (mm/s)						
type	glass	704.2254	754.7170	704.2254	800.0000	778.2101	704.2254	689.6552
d (mm)	14.48	763.3588	760.4563	694.4444	641.0256	743.4944	727.2727	701.7544
n	21	653.5948	696.8641	743.4944	735.2941	704.2254	746.2687	781.2500
G	2.6			Std Dev	41.1526		Avg	725.1455

		Velocities (mm/s)						
type	natural	680.2721	666.6667	630.9148	617.2840	790.5138	704.2254	657.8947
d (mm)	13.6	709.2199	687.2852	625.0000	673.4007	649.3506	727.2727	638.9776
n	21	854.7009	711.7438	628.9308	682.5939	666.6667	660.0660	682.5939
G	2.65			Std Dev	56.1968		Avg	683.1226

		Velocities (mm/s)						
type	natural	591.7160	778.2101	657.8947	682.5939	694.4444	735.2941	673.4007
d (mm)	9.6	751.8797	701.7544	615.3846	754.7170	763.3588	687.2852	664.4518
n	21	696.8641	638.9776	719.4245	793.6508	689.6552	735.2941	704.2254
G	2.65			Std Dev	52.1525		Avg	701.4513

		Velocities (mm/s)						
type	natural	621.1180	666.6667	694.4444	743.4944	689.6552	673.4007	ERR
d (mm)	6.8	651.4658	632.9114	719.4245	634.9206	743.4944	694.4444	ERR
n	18	709.2199	687.2852	709.2199	680.2721	706.7138	682.5939	ERR
G	2.65			Std Dev	34.9766		Avg	685.5970

		Velocities (mm/s)						
type	natural	628.9308	581.3953	588.2353	653.5948	588.2353	552.4862	589.9705
d (mm)	4.8	632.9114	772.2008	727.2727	600.6006	576.3689	772.2008	557.1031
n	21	673.4007	617.2840	660.0660	682.5939	576.3689	743.4944	626.9592
G	2.65			Std Dev	68.2148		Avg	638.1749

		Velocities (mm/s)						
type	natural	634.9206	673.4007	593.4718	632.9114	581.3953	626.9592	533.3333
d (mm)	3.4	579.7101	598.8024	606.0606	604.2296	595.2381	613.4969	588.2353
n	21	621.1180	602.4096	554.0166	625.0000	619.1950	597.0149	615.3846
G	2.65			Std Dev	29.5169		Avg	604.5859

Run#	28	Bed					
Date:	7-25 95	Roughness k:	1.7	mm		y/k:	33.186
Slope:	0.01	Q:	22.39296	L/s		U*:	0.0625 m/s

	u.s.	d.s.	avg
y (mm)	55.6333333	57.2	56.41667
Tw (mm)	615.666667	607.6667	611.6667
A (m^2)	0.02490055	0.025373	0.025138
P (m)	0.6336021	0.627035	0.630308
Rh (m)	0.03929998	0.040465	0.039883
V (m/s)	0.89929561	0.882552	0.890924
H (m)	0.11306722	0.096913	0.10499

delta H:	0.0161545	m	delta x:	1.62	m
Sf:	0.00997191				
Tavg:	20	°C			
ν:	1.004E-06	m^2/s			
δ:	0.00018649	m			

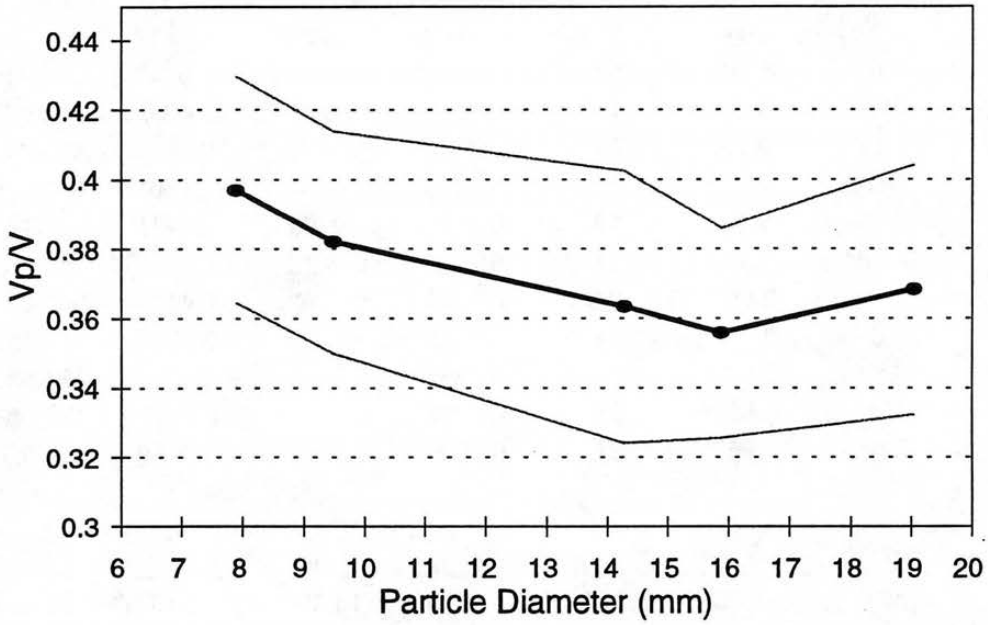
Run# 28

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	21	0.3281	0.0319	1.0794	778.2702	0.0030
steel	15.88	8.02	21	0.3170	0.0268	0.9857	649.1035	0.0036
steel	14.28	8.02	21	0.3236	0.0349	0.9346	583.7026	0.0040
steel	9.5	8.02	21	0.3403	0.0285	0.7619	388.3176	0.0060
steel	7.9	8.02	21	0.3536	0.0290	0.6946	322.9167	0.0072
glass	29.3	2.6	15	0.7803	0.0265	0.6392	731.5747	0.0085
glass	25.17	2.6	21	0.7642	0.0470	0.5924	628.4552	0.0099
glass	21.7	2.6	15	0.7533	0.0255	0.5500	541.8147	0.0115
glass	15.97	2.6	18	0.7373	0.0409	0.4716	398.7457	0.0156
glass	14.48	2.6	21	0.7251	0.0412	0.4490	361.5427	0.0172
natural	13.6	2.65	21	0.6831	0.0562	0.4419	343.0715	0.0177
natural	9.6	2.65	21	0.7015	0.0522	0.3709	242.1681	0.0251
natural	6.8	2.65	18	0.6856	0.0350	0.3117	171.5357	0.0354
natural	4.8	2.65	21	0.6382	0.0682	0.2612	121.0841	0.0502
natural	3.4	2.65	21	0.6046	0.0295	0.2189	85.7679	0.0709

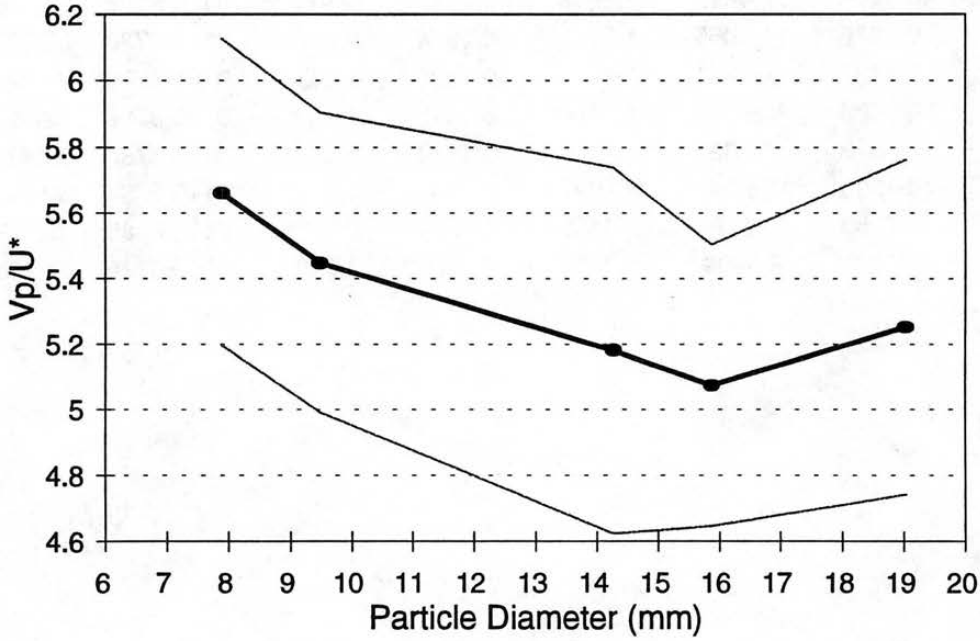
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.3683	5.2535	0.3040	0.0579	11.2000	9115.8786	102.0978	2.9631
steel	0.3558	5.0760	0.3216	0.0634	9.3412	9115.8786	85.1530	3.5527
steel	0.3633	5.1822	0.3463	0.0668	8.4000	9115.8786	76.5734	3.9507
steel	0.3820	5.4493	0.4467	0.0820	5.5882	9115.8786	50.9417	5.9386
steel	0.3969	5.6627	0.5092	0.0899	4.6471	9115.8786	42.3620	7.1414
glass	0.8758	12.4942	1.2206	0.0977	17.2353	9115.8786	157.1148	1.9255
glass	0.8577	12.2364	1.2899	0.1054	14.8059	9115.8786	134.9686	2.2414
glass	0.8455	12.0616	1.3696	0.1135	12.7647	9115.8786	116.3615	2.5998
glass	0.8276	11.8065	1.5633	0.1324	9.3941	9115.8786	85.6356	3.5327
glass	0.8139	11.6114	1.6149	0.1391	8.5176	9115.8786	77.6458	3.8962
natural	0.7668	10.9385	1.5460	0.1413	8.0000	9115.8786	72.9270	4.1483
natural	0.7873	11.2320	1.8912	0.1684	5.6471	9115.8786	51.4779	5.8767
natural	0.7695	10.9781	2.1997	0.2004	4.0000	9115.8786	36.4635	8.2966
natural	0.7163	10.2188	2.4433	0.2391	2.8235	9115.8786	25.7390	11.7535
natural	0.6786	9.6809	2.7622	0.2853	2.0000	9115.8786	18.2318	16.5931

Run 28
U* = 0.062 m/s

Vp/V vs. d
(steel)

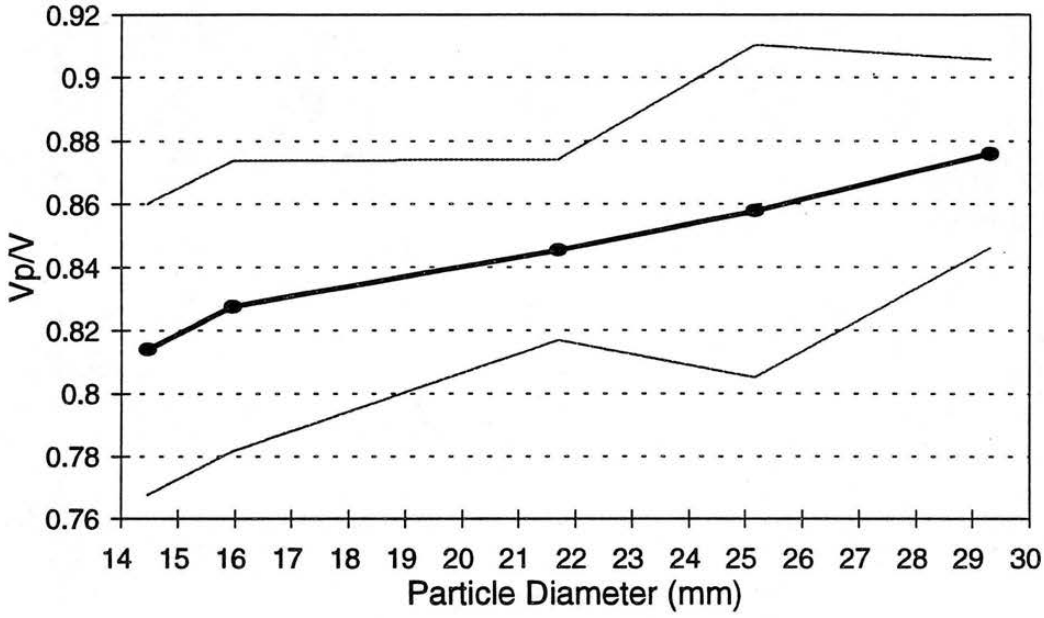


Vp/U* vs. d
(steel)

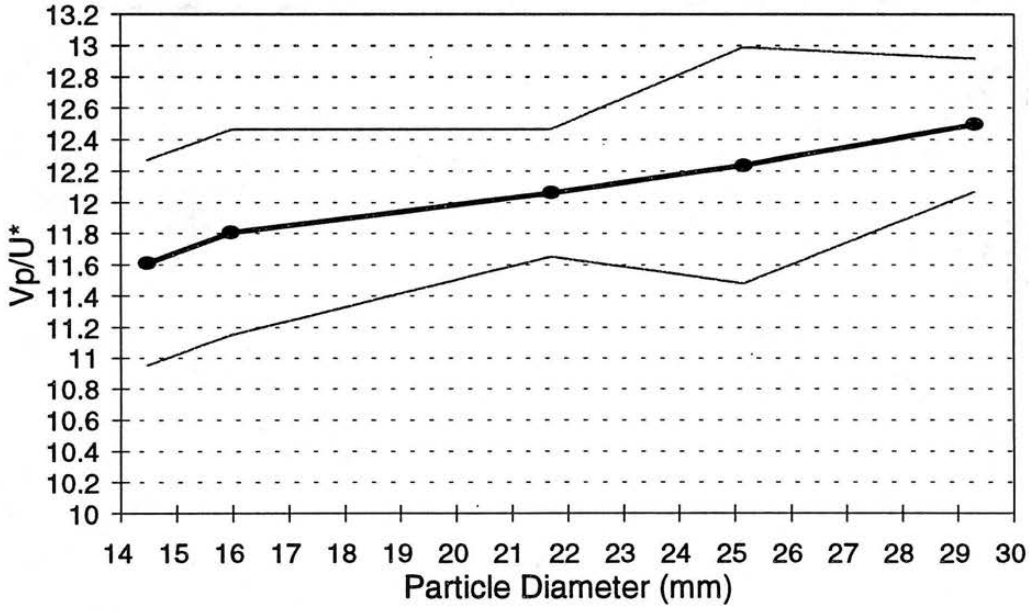


Run 28
U* = 0.062 m/s

Vp/V vs. d
(glass)

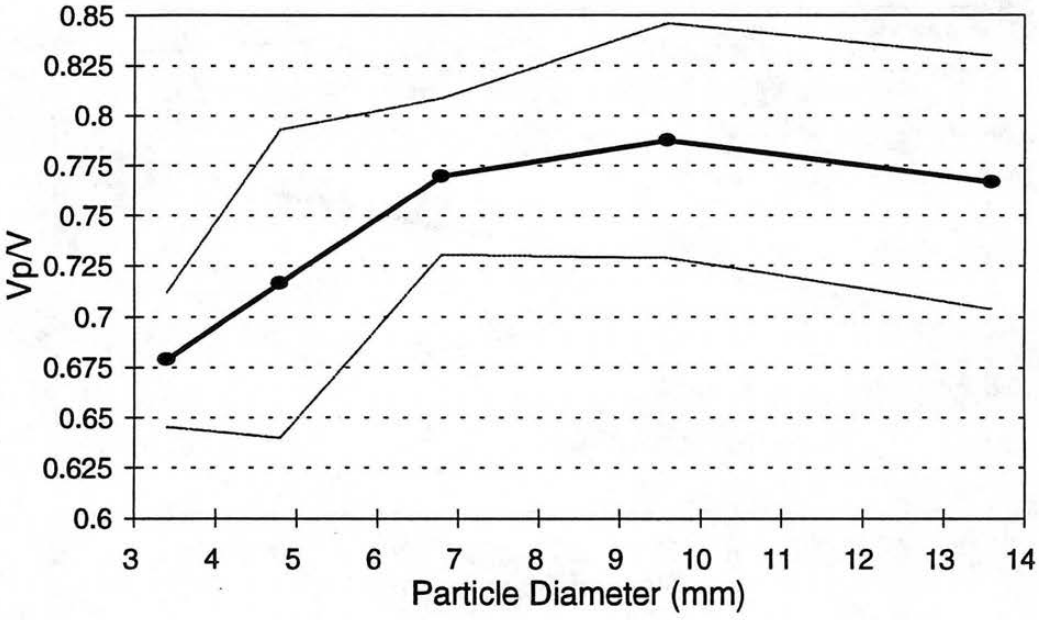


Vp/U* vs. d
(glass)

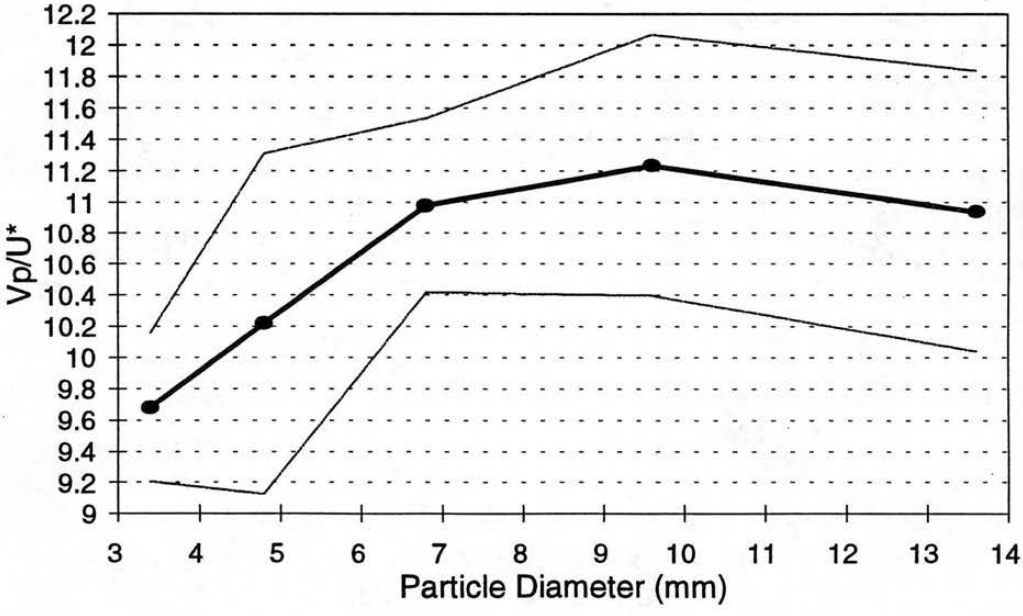


Run 28
U* = 0.062 m/s

Vp/V vs. d
(natural)



Vp/U* vs. d
(natural)



Run#	29		Bed Roughness k:	1.7	mm	Streamflow	21.7029 L/s
Date	7-26-95		Pump Setting	fast		Valve Setting	1/2 open
Reach Length	2000 mm		Slope Reading	161.5	mm	Bed Slope	0.00861

		Initial		Intermediate		Final	
Temperature		20	°C			21	°C
Manometer in. of water	Hi	65.02		65.02		65.02	
	Lo	-67.73		-69.08		-69.08	
	Hi - Lo	132.75		134.1		134.1	
Flow Depth:	u.s.	56.4	mm	57.1	mm	56.2	mm
	d.s.	57.1	mm	56.4	mm	57.6	mm
	u.s. - d.s.	-0.7	mm	0.7	mm	-1.4	mm
	at weir	56.1	mm	56.2	mm	56.1	mm
Top Width:	u.s.	621	mm	612	mm	625	mm
	d.s.	622	mm	623	mm	630	mm
	at weir	615	mm	620	mm	610	mm

Velocities (mm/s)

type	steel	263.5046	291.9708	252.2068	260.0780	265.6042	263.1579	259.0674
d (mm)	19.04	246.3054	257.0694	275.8621	290.6977	250.9410	275.8621	251.2563
n	21	266.6667	252.8445	280.8989	261.0966	289.4356	255.1020	271.3704
G	8.02			Std Dev	13.7728		Avg	265.7618

Velocities (mm/s)

type	steel	255.1020	271.3704	256.0819	264.5503	267.7376	312.0125	248.1390
d (mm)	15.88	272.4796	239.5210	233.9181	258.0645	296.2963	253.1646	268.8172
n	21	260.0780	267.7376	234.4666	254.1296	252.8445	277.0083	257.0694
G	8.02			Std Dev	18.4569		Avg	261.9328

Velocities (mm/s)

type	steel	243.0134	257.0694	236.1275	296.2963	280.5049	279.3296	279.7203
d (mm)	14.28	289.4356	265.6042	260.0780	280.5049	244.2002	265.2520	261.4379
n	21	231.2139	258.7322	253.1646	284.4950	303.0303	254.1296	233.6449
G	8.02			Std Dev	20.7060		Avg	264.6183

Velocities (mm/s)

type	steel	258.3979	278.1641	282.0874	312.0125	278.1641	293.2551	233.6449
d (mm)	9.5	264.5503	252.8445	263.1579	255.1020	242.4242	300.7519	243.9024
n	21	248.1390	275.1032	323.6246	271.0027	282.0874	263.5046	310.5590
G	8.02			Std Dev	24.5454		Avg	272.9752

		Velocities (mm/s)						
type	steel	267.0227	372.4395	320.0000	349.6503	291.9708	283.2861	281.6901
d (mm)	7.9	279.3296	283.2861	274.7253	297.6190	313.4796	231.2139	284.4950
n	21	280.8989	271.3704	397.6143	242.4242	294.1176	280.5049	306.2787
G	8.02			Std Dev	39.0012		Avg	295.4008

		Velocities (mm/s)						
type	steel	330.0330	318.4713	271.3704	269.1790	264.2008	322.0612	316.9572
d (mm)	6.34	342.4658	289.0173	378.7879	294.1176	327.8689	331.6750	280.8989
n	21	284.4950	291.9708	257.0694	346.0208	293.6858	342.4658	286.9440
G	8.02			Std Dev	32.1939		Avg	306.6550

		Velocities (mm/s)						
type	glass	751.8797	738.0074	735.2941	680.2721	727.2727	743.4944	727.2727
d (mm)	29.3	689.6552	743.4944	719.4245	735.2941	751.8797	727.2727	746.2687
n	21	784.3137	657.8947	666.6667	696.8641	781.2500	716.8459	735.2941
G	2.6			Std Dev	32.9892		Avg	726.4720

		Velocities (mm/s)						
type	glass	722.0217	735.2941	743.4944	694.4444	704.2254	680.2721	682.5939
d (mm)	25.17	769.2308	743.4944	746.2687	716.8459	809.7166	657.8947	701.7544
n	21	716.8459	732.6007	719.4245	760.4563	687.2852	687.2852	719.4245
G	2.6			Std Dev	35.0179		Avg	720.5178

		Velocities (mm/s)						
type	glass	757.5758	696.8641	763.3588	735.2941	763.3588	636.9427	701.7544
d (mm)	21.7	711.7438	680.2721	727.2727	719.4245	645.1613	657.8947	680.2721
n	21	727.2727	645.1613	660.0660	673.4007	694.4444	660.0660	662.2517
G	2.6			Std Dev	40.0139		Avg	695.2311

		Velocities (mm/s)						
type	glass	692.0415	719.4245	666.6667	682.5939	615.3846	735.2941	727.2727
d (mm)	15.97	673.4007	719.4245	645.1613	621.1180	653.5948	719.4245	647.2492
n	21	727.2727	673.4007	719.4245	651.4658	621.1180	682.5939	696.8641
G	2.6			Std Dev	38.3105		Avg	680.4853

		Velocities (mm/s)						
type	glass	641.0256	711.7438	666.6667	680.2721	586.5103	781.2500	576.3689
d (mm)	14.48	673.4007	704.2254	675.6757	787.4016	673.4007	673.4007	666.6667
n	21	735.2941	653.5948	662.2517	673.4007	738.0074	653.5948	809.7166
G	2.6			Std Dev	58.6946		Avg	686.8509

		Velocities (mm/s)						
type	natural	666.6667	604.2296	609.7561	615.3846	593.4718	613.4969	533.3333
d (mm)	13.6	609.7561	666.6667	560.2241	598.8024	660.0660	593.4718	588.2353
n	21	714.2857	604.2296	666.6667	660.0660	609.7561	552.4862	680.2721
G	2.65			Std Dev	45.6256		Avg	619.1107

Velocities (mm/s)

type	natural	595.2381	561.7978	615.3846	666.6667	607.9027	666.6667	621.1180
d (mm)	9.6	689.6552	647.2492	543.4783	628.9308	576.3689	591.7160	557.1031
n	21	615.3846	576.3689	586.5103	581.3953	660.0660	595.2381	634.9206
G	2.65			Std Dev	39.8570		Avg	610.4362

Velocities (mm/s)

type	natural	526.3158	566.5722	533.3333	598.8024	576.3689	645.1613	645.1613
d (mm)	6.8	653.5948	607.9027	557.1031	625.0000	609.7561	660.0660	680.2721
n	21	519.4805	520.8333	621.1180	552.4862	615.3846	675.6757	546.4481
G	2.65			Std Dev	52.5702		Avg	596.9922

Velocities (mm/s)

type	natural	609.7561	529.1005	645.1613	460.8295	503.7783	588.2353	508.9059
d (mm)	4.8	546.4481	485.4369	583.0904	476.1905	647.2492	571.4286	591.7160
n	21	520.8333	593.4718	621.1180	520.8333	488.9976	571.4286	591.7160
G	2.65			Std Dev	55.9999		Avg	555.0345

Velocities (mm/s)

type	natural	606.0606	552.4862	537.6344	571.4286	641.0256	581.3953	492.6108
d (mm)	3.4	557.1031	651.4658	533.3333	561.7978	480.7692	503.7783	516.7959
n	21	453.5147	569.8006	516.7959	537.6344	602.4096	660.0660	512.8205
G	2.65			Std Dev	55.6458		Avg	554.3203

Velocities (mm/s)

type	natural	549.4505	602.4096	503.7783	447.4273	576.3689	539.0836	645.1613
d (mm)	2.4	496.2779	552.4862	566.5722	549.4505	557.1031	542.0054	533.3333
n	21	524.9344	544.9591	456.6210	527.7045	447.4273	515.4639	476.1905
G	2.65			Std Dev	49.1969		Avg	531.1528

Notes: Steel paricles with diameters 7.90 mm and 6.34 mm moved in surges, very irregularly. No doubt this caused significant variation.

Steel particles smaller than 6.34 mm diameter darted about the plate, leaving the plates frequently. It was difficult to get data, in fact two particles were lost completely.

The smallest two glass particles (15.97 mm and 14.48 mm diameters) were in suspension much of the time.

Noticable suspension for the natural particles, particularly the smaller ones.

Natural particles smaller than 2.4 mm would simply disappear when dropped in the water.

Run# 29 Bed
Date: 7-26-95 Roughness k: 1.7 mm y/k: 33.412

Slope: 0.00861 Q: 21.70291 L/s U*: 0.0593 m/s

	u.s.	d.s.	avg
y (mm)	56.5666667	57.03333	56.8
Tw (mm)	619.333333	625	622.1667
A (m^2)	0.025422	0.025793	0.025607
P (m)	0.63767013	0.643343	0.640506
Rh (m)	0.03986701	0.040093	0.03998
V (m/s)	0.85370588	0.841416	0.847561
H (m)	0.10767403	0.09313	0.100402

delta H: 0.0145437 m delta x: 1.62 m

Sf: 0.00897761

Tavg: 20.5 °C

ν: 9.9195E-07 m^2/s

δ: 0.00019395 m

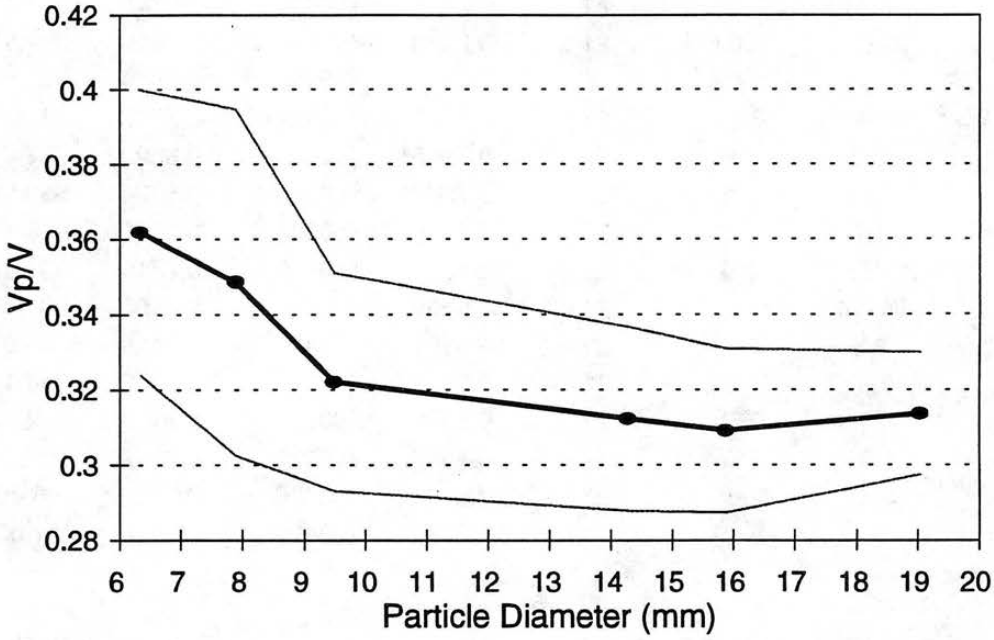
Run# 29

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	21	0.2658	0.0138	1.0794	784.5587	0.0027
steel	15.88	8.02	21	0.2619	0.0185	0.9857	654.3483	0.0032
steel	14.28	8.02	21	0.2646	0.0207	0.9346	588.4190	0.0036
steel	9.5	8.02	21	0.2730	0.0245	0.7619	391.4552	0.0054
steel	7.9	8.02	21	0.2954	0.0390	0.6946	325.5259	0.0065
steel	6.34	8.02	21	0.3067	0.0322	0.6219	261.2449	0.0081
glass	29.3	2.6	21	0.7265	0.0330	0.6392	737.4859	0.0077
glass	25.17	2.6	21	0.7205	0.0350	0.5924	633.5331	0.0089
glass	21.7	2.6	21	0.6952	0.0400	0.5500	546.1927	0.0103
glass	15.97	2.6	21	0.6805	0.0383	0.4716	401.9676	0.0140
glass	14.48	2.6	21	0.6869	0.0587	0.4490	364.4640	0.0155
natural	13.6	2.65	21	0.6191	0.0456	0.4419	345.8436	0.0160
natural	9.6	2.65	21	0.6104	0.0399	0.3709	244.1249	0.0227
natural	6.8	2.65	21	0.5970	0.0526	0.3117	172.9218	0.0320
natural	4.8	2.65	21	0.5550	0.0560	0.2612	122.0624	0.0453
natural	3.4	2.65	21	0.5543	0.0556	0.2189	86.4609	0.0640
natural	2.4	2.65	21	0.5312	0.0492	0.1826	61.0312	0.0906

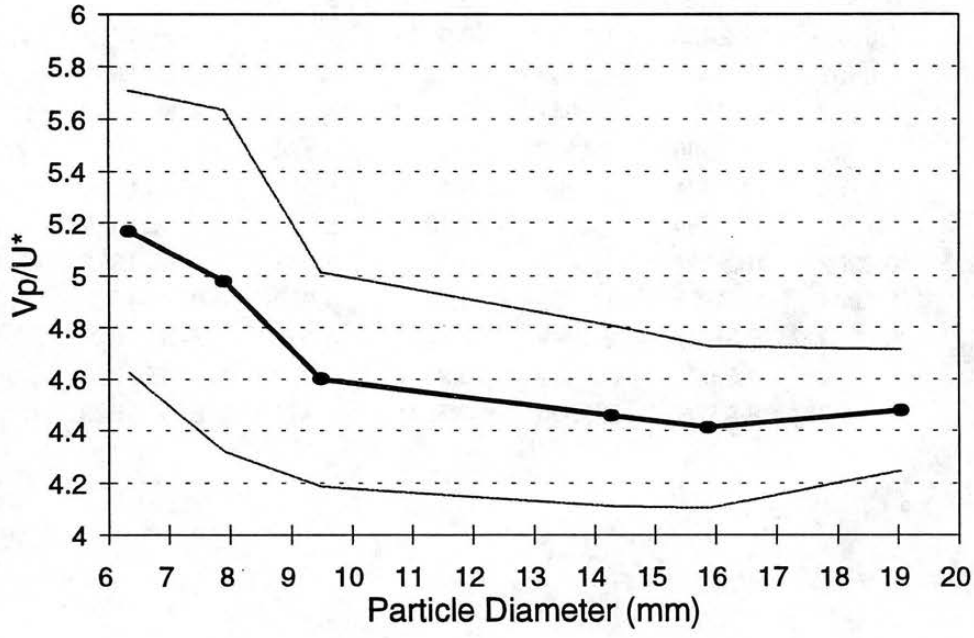
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.3136	4.4795	0.2462	0.0550	11.2000	8765.1823	98.1700	2.9832
steel	0.3090	4.4150	0.2657	0.0602	9.3412	8765.1823	81.8771	3.5768
steel	0.3122	4.4602	0.2831	0.0635	8.4000	8765.1823	73.6275	3.9776
steel	0.3221	4.6011	0.3583	0.0779	5.5882	8765.1823	48.9819	5.9789
steel	0.3485	4.9791	0.4253	0.0854	4.6471	8765.1823	40.7323	7.1899
steel	0.3618	5.1688	0.4931	0.0954	3.7294	8765.1823	32.6890	8.9590
glass	0.8571	12.2450	1.1365	0.0928	17.2353	8765.1823	151.0705	1.9386
glass	0.8501	12.1446	1.2162	0.1001	14.8059	8765.1823	129.7763	2.2567
glass	0.8203	11.7184	1.2641	0.1079	12.7647	8765.1823	111.8850	2.6175
glass	0.8029	11.4698	1.4428	0.1258	9.3941	8765.1823	82.3412	3.5567
glass	0.8104	11.5771	1.5296	0.1321	8.5176	8765.1823	74.6587	3.9227
natural	0.7305	10.4354	1.4011	0.1343	8.0000	8765.1823	70.1215	4.1765
natural	0.7202	10.2891	1.6458	0.1600	5.6471	8765.1823	49.4975	5.9167
natural	0.7044	10.0625	1.9153	0.1903	4.0000	8765.1823	35.0607	8.3529
natural	0.6549	9.3553	2.1249	0.2271	2.8235	8765.1823	24.7488	11.8333
natural	0.6540	9.3433	2.5322	0.2710	2.0000	8765.1823	17.5304	16.7059
natural	0.6267	8.9528	2.9090	0.3249	1.4118	8765.1823	12.3744	23.6667

Run 29
U* = 0.059 m/s

Vp/V vs. d
(steel)

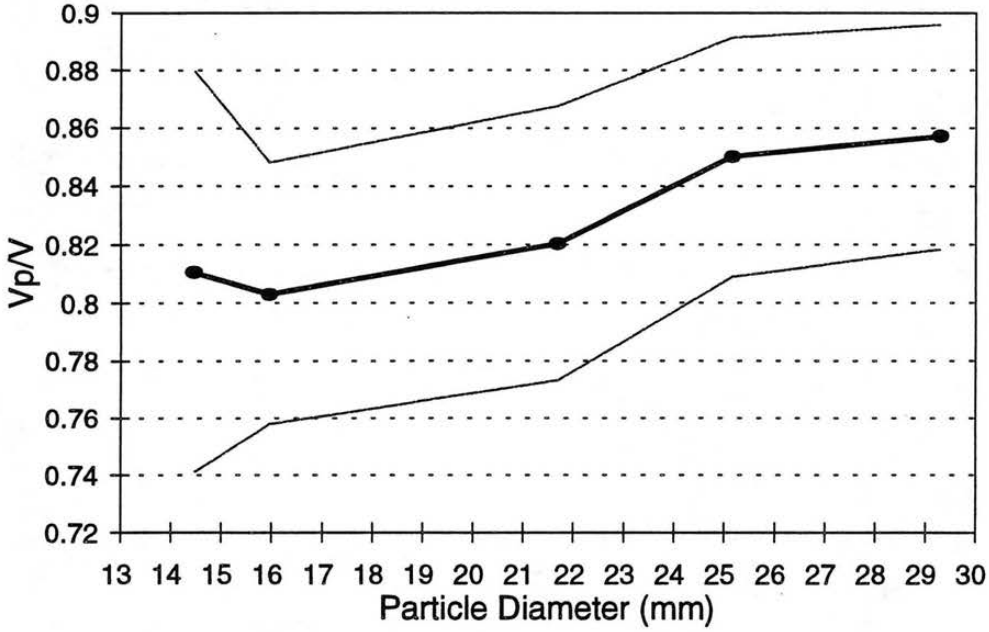


Vp/U* vs. d
(steel)

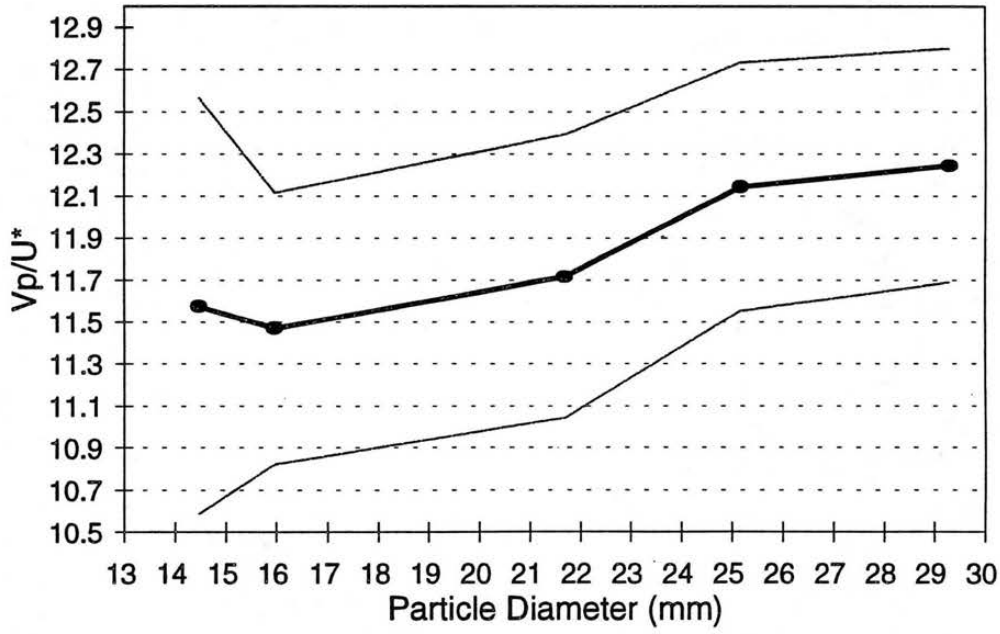


Run 29
U* = 0.059 m/s

Vp/V vs. d
(glass)

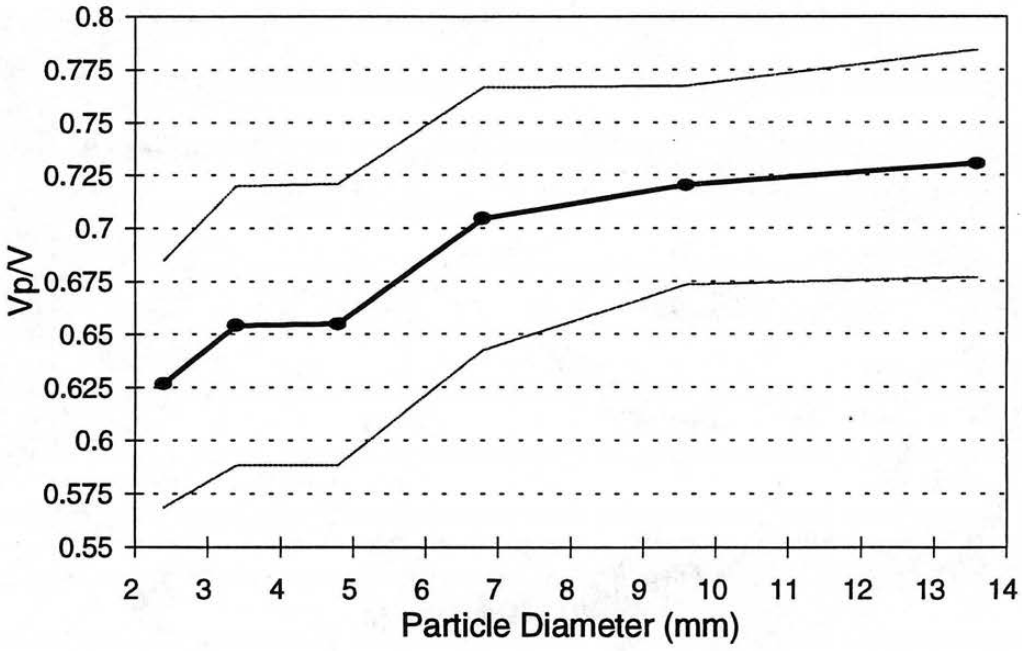


Vp/U* vs. d
(glass)

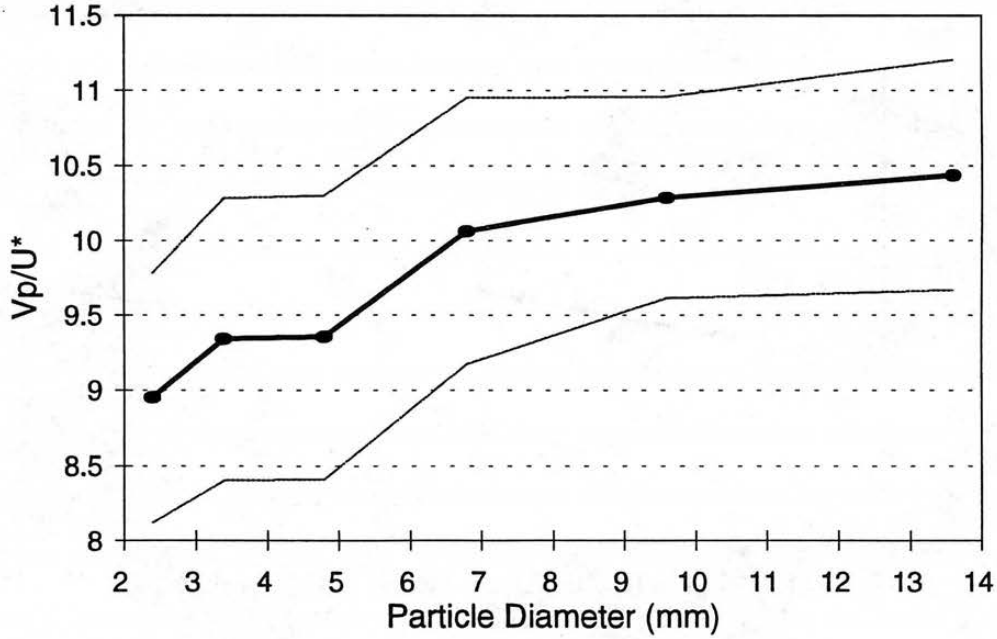


Run 29
U* = 0.059 m/s

Vp/V vs. d
(natural)



Vp/U* vs. d
(natural)



Run#	30		Bed Roughness k:	1.7	mm	Streamflow	16.7569 L/s
Date	7-27-95		Pump Setting	medium		Valve Setting	7/8 open
Reach Length	2000	mm	Slope Reading	150	mm	Bed Slope	0.007

		Initial		Intermediate		Final	
Temperature		21	°C			21	°C
Manometer in. of water	Hi	39.28		39.28		39.28	
	Lo	-40.64		-40.64		-40.64	
	Hi - Lo	79.92		79.92		79.92	
Flow Depth:	u.s.	52.8	mm	52.8	mm	52.6	mm
	d.s.	54	mm	54.3	mm	54.4	mm
	u.s. - d.s.	-1.2	mm	-1.5	mm	-1.8	mm
	at weir	51.8	mm	51.8	mm	51.8	mm
Top Width:	u.s.	583	mm	584	mm	585	mm
	d.s.	585	mm	585	mm	588	mm
	at weir	589	mm	588	mm	585	mm

Velocities (mm/s)

type	steel	191.0220	203.6660	207.9002	200.6018	201.2072	ERR	ERR
d (mm)	19.04	190.4762	209.2050	197.6285	192.6782	216.2162	ERR	ERR
n	15	209.8636	197.4334	200.0000	208.5506	198.8072	ERR	ERR
G	8.02			Std Dev	7.5204		Avg	201.6837

Velocities (mm/s)

type	steel	189.3939	202.6342	176.3668	190.4762	216.2162	182.8154	197.4334
d (mm)	15.88	203.0457	183.8235	190.4762	183.9926	198.6097	193.4236	197.0443
n	21	205.7613	192.6782	191.0220	190.4762	193.4236	188.3239	198.2161
G	8.02			Std Dev	8.9071		Avg	193.6025

Velocities (mm/s)

type	steel	193.4236	192.6782	194.5525	190.4762	193.2367	174.3679	ERR
d (mm)	14.28	187.2659	194.5525	189.3939	180.1802	180.8318	178.8909	ERR
n	18	187.0907	191.5709	202.6342	188.1468	180.6685	193.4236	ERR
G	8.02			Std Dev	7.1150		Avg	188.5214

Velocities (mm/s)

type	steel	171.0864	164.2036	190.4762	189.3939	160.9010	182.3154	167.0844
d (mm)	9.5	170.6485	178.7310	179.3722	207.0393	185.5288	212.5399	183.4862
n	21	173.9130	189.9335	173.9130	165.4260	206.3983	177.7778	191.5709
G	8.02			Std Dev	14.3596		Avg	181.9876

		Velocities (mm/s)						
type	steel	183.4862	164.0689	163.2653	158.1028	193.4236	179.8561	167.0844
d (mm)	7.9	182.8154	167.0844	185.5288	188.6792	209.6436	212.7660	170.2128
n	21	205.7613	176.8347	165.2893	202.6342	187.6173	171.5266	154.2020
G	8.02			Std Dev	17.1674		Avg	180.4706

		Velocities (mm/s)						
type	glass	628.9308	547.9452	617.2840	615.3846	651.4658	607.9027	623.0530
d (mm)	29.3	666.6667	621.1180	571.4286	609.7561	586.5103	581.3953	593.4718
n	21	609.7561	598.8024	604.2296	615.3846	597.0149	615.3846	626.9592
G	2.6			Std Dev	25.7922		Avg	609.0402

		Velocities (mm/s)						
type	glass	617.2840	581.3953	615.3846	609.7561	615.3846	602.4096	609.7561
d (mm)	25.17	604.2296	560.2241	581.3953	564.9718	638.9776	588.2353	561.7978
n	21	626.9592	573.0659	647.2492	581.3953	571.4286	597.0149	615.3846
G	2.6			Std Dev	25.1343		Avg	598.2714

		Velocities (mm/s)						
type	glass	583.0904	512.8205	546.4481	557.1031	621.1180	571.4286	597.0149
d (mm)	21.7	609.7561	566.5722	571.4286	571.4286	524.9344	571.4286	571.4286
n	21	586.5103	576.3689	533.3333	621.1180	546.4481	571.4286	533.3333
G	2.6			Std Dev	29.3931		Avg	568.7877

		Velocities (mm/s)						
type	glass	549.4505	571.4286	533.3333	628.9308	581.3953	664.4518	604.2296
d (mm)	15.97	657.8947	581.3953	546.4481	566.5722	591.7160	604.2296	566.5722
n	21	542.0054	527.7045	542.0054	561.7978	586.5103	547.9452	578.0347
G	2.6			Std Dev	37.7536		Avg	577.8120

		Velocities (mm/s)						
type	glass	520.8333	554.0166	561.7978	598.8024	557.1031	571.4286	546.4481
d (mm)	14.48	491.4005	515.4639	634.9206	581.3953	615.3846	598.8024	537.6344
n	21	547.9452	537.6344	480.7692	621.1180	588.2353	447.4273	546.4481
G	2.6			Std Dev	47.4457		Avg	555.0004

		Velocities (mm/s)						
type	natural	496.2779	507.6142	470.5882	438.5965	473.9336	524.9344	478.4689
d (mm)	13.6	477.3270	547.9452	488.9976	446.4286	464.0371	505.0505	485.4369
n	21	434.7826	549.4505	496.2779	457.6659	481.9277	488.9976	480.7692
G	2.65			Std Dev	30.5891		Avg	485.5004

		Velocities (mm/s)						
type	natural	503.7783	547.9452	503.7783	566.5722	477.3270	557.1031	488.9976
d (mm)	9.6	579.7101	421.0526	533.3333	557.1031	462.9630	481.9277	478.4689
n	21	542.0054	477.3270	533.3333	459.7701	550.9642	555.5556	505.0505
G	2.65			Std Dev	42.8077		Avg	513.5270

		Velocities (mm/s)						
type	natural	476.1905	533.3333	571.4286	418.4100	431.9654	435.7298	444.4444
d (mm)	6.8	500.0000	447.4273	475.0594	480.7692	448.4305	450.4505	481.9277
n	21	547.9452	537.6344	456.6210	437.6368	508.9059	429.1845	479.6163
G	2.65			Std Dev	43.1510		Avg	475.8624

		Velocities (mm/s)						
type	natural	444.4444	395.2569	426.4392	560.2241	412.3711	444.4444	450.4505
d (mm)	4.8	387.5969	444.4444	452.4887	459.7701	561.7978	450.4505	421.0526
n	21	404.8583	447.4273	404.8583	480.7692	558.6592	500.0000	456.6210
G	2.65			Std Dev	51.6230		Avg	455.4488

		Velocities (mm/s)						
type	natural	395.2569	467.2897	464.0371	432.9004	412.3711	544.9591	447.4273
d (mm)	3.4	464.0371	421.0526	492.6108	476.1905	414.9378	444.4444	415.8004
n	21	402.4145	400.0000	453.5147	450.4505	427.3504	464.0371	400.0000
G	2.65			Std Dev	36.7259		Avg	442.4325

		Velocities (mm/s)						
type	natural	429.1845	440.5286	355.8719	359.7122	516.7959	351.4938	430.1075
d (mm)	2.4	365.6307	431.9654	380.9524	381.6794	456.6210	418.4100	503.7783
n	21	434.7826	383.1418	400.0000	488.9976	470.5882	437.6368	390.6250
G	2.65			Std Dev	48.6517		Avg	420.4049

Notes: Steel particles meandered considerably.
For the steel particles with diameters 9.5 mm and 7.9 mm there was highly irregular motion (very nonconstant velocity).
Steel particles smaller than 7.9 mm exhibited start/stop motion, generally rolling off the plates or halting.

The natural particles with diameters smaller than 9.6 mm showed considerable suspension, it increased with decreasing particle size.
Natural particles smaller than 2.4 mm diameter simply disappeared when dropped into the water.

Run# 30 Bed
Date: 7-27-95 Roughness k: 1.7 mm y/k: 31.461

Slope: 0.007 Q: 16.75686 L/s U*: 0.0516 m/s

	u.s.	d.s.	avg
y (mm)	52.7333333	54.23333	53.48333
Tw (mm)	584	586	585
A (m^2)	0.02276762	0.023469	0.023118
P (m)	0.60174753	0.604627	0.603185
Rh (m)	0.03783583	0.038816	0.038327
V (m/s)	0.73599525	0.713985	0.72499
H (m)	0.09169179	0.080225	0.085958

delta H: 0.0114672 m delta x: 1.62 m

Sf: 0.0070785

Tavg: 21 °C

ν: 9.8009E-07 m^2/s

δ: 0.00022041 m

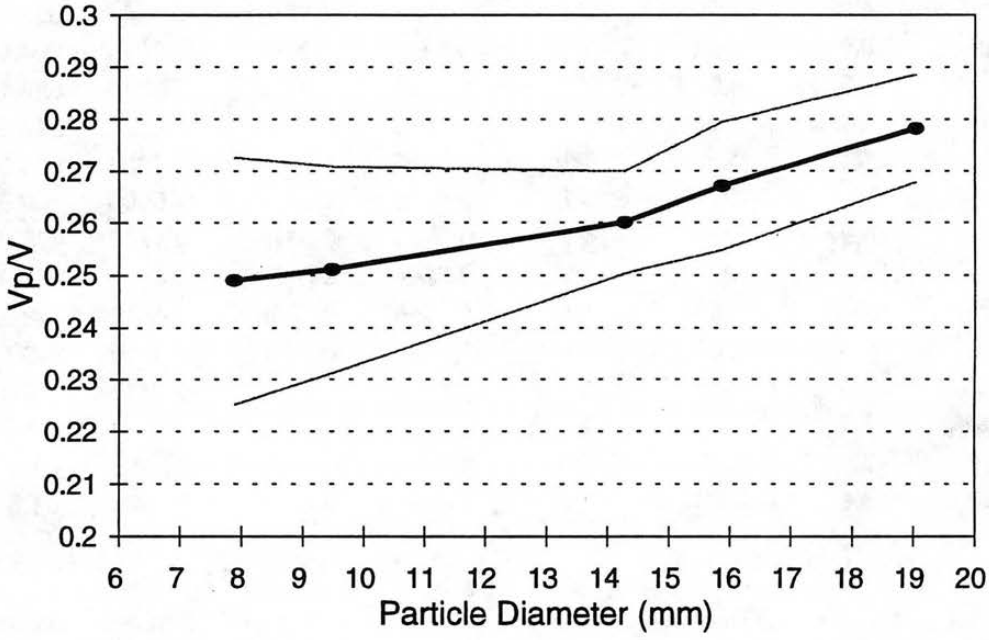
Run# 30

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	15	0.2017	0.0075	1.0794	790.8783	0.0020
steel	15.88	8.02	21	0.1936	0.0089	0.9857	659.6191	0.0024
steel	14.28	8.02	18	0.1885	0.0071	0.9346	593.1587	0.0027
steel	9.5	8.02	21	0.1820	0.0144	0.7619	394.6084	0.0041
steel	7.9	8.02	21	0.1805	0.0172	0.6946	328.1480	0.0049
glass	29.3	2.6	21	0.6090	0.0258	0.6392	743.4263	0.0058
glass	25.17	2.6	21	0.5983	0.0251	0.5924	638.6362	0.0067
glass	21.7	2.6	21	0.5688	0.0294	0.5500	550.5922	0.0078
glass	15.97	2.6	21	0.5778	0.0378	0.4716	405.2054	0.0106
glass	14.48	2.6	21	0.5550	0.0474	0.4490	367.3998	0.0117
natural	13.6	2.65	21	0.4855	0.0306	0.4419	348.6293	0.0121
natural	9.6	2.65	21	0.5135	0.0428	0.3709	246.0913	0.0171
natural	6.8	2.65	21	0.4759	0.0432	0.3117	174.3146	0.0242
natural	4.8	2.65	21	0.4554	0.0516	0.2612	123.0456	0.0343
natural	3.4	2.65	21	0.4424	0.0367	0.2189	87.1573	0.0484
natural	2.4	2.65	21	0.4204	0.0487	0.1826	61.5228	0.0685

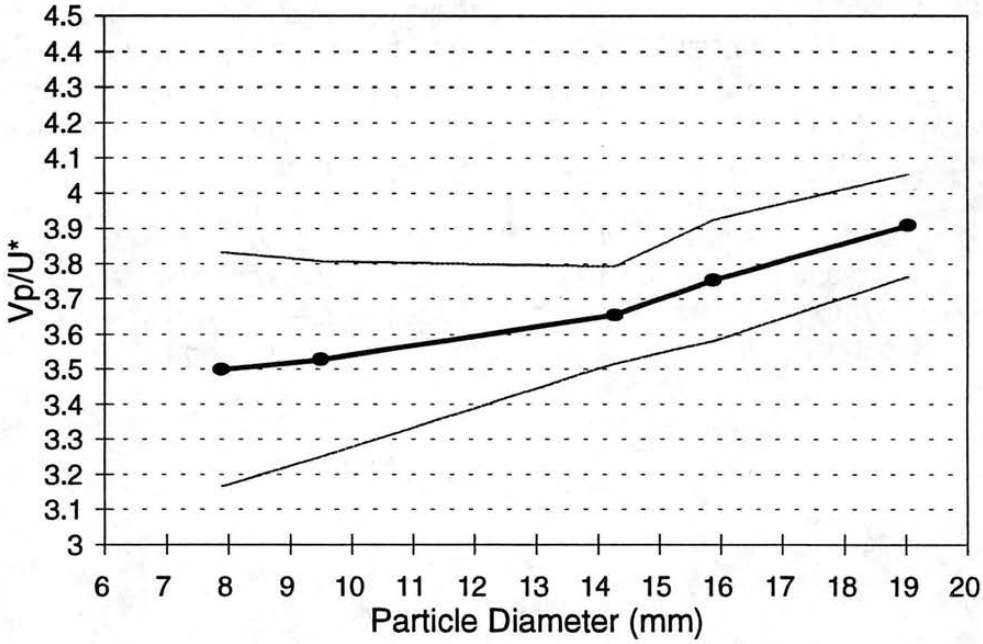
Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.2782	3.9101	0.1868	0.0478	11.2000	7712.7349	86.3826	2.8090
steel	0.2670	3.7534	0.1964	0.0523	9.3412	7712.7349	72.0460	3.3680
steel	0.2600	3.6549	0.2017	0.0552	8.4000	7712.7349	64.7870	3.7453
steel	0.2510	3.5283	0.2388	0.0677	5.5882	7712.7349	43.1006	5.6298
steel	0.2489	3.4988	0.2598	0.0743	4.6471	7712.7349	35.8415	6.7700
glass	0.8401	11.8077	0.9527	0.0807	17.2353	7712.7349	132.9313	1.8254
glass	0.8252	11.5989	1.0099	0.0871	14.8059	7712.7349	114.1938	2.1249
glass	0.7845	11.0273	1.0342	0.0938	12.7647	7712.7349	98.4508	2.4647
glass	0.7970	11.2022	1.2251	0.1094	9.3941	7712.7349	72.4543	3.3490
glass	0.7655	10.7600	1.2360	0.1149	8.5176	7712.7349	65.6944	3.6936
natural	0.6697	9.4125	1.0987	0.1167	8.0000	7712.7349	61.7019	3.9326
natural	0.7083	9.9559	1.3845	0.1391	5.6471	7712.7349	43.5543	5.5712
natural	0.6564	9.2257	1.5266	0.1655	4.0000	7712.7349	30.8509	7.8652
natural	0.6282	8.8299	1.7435	0.1975	2.8235	7712.7349	21.7771	11.1424
natural	0.6103	8.5776	2.0209	0.2356	2.0000	7712.7349	15.4255	15.7304
natural	0.5799	8.1505	2.3019	0.2824	1.4118	7712.7349	10.8886	22.2847

Run 30
U* = 0.0516 m/s

Vp/V vs. d
(steel)

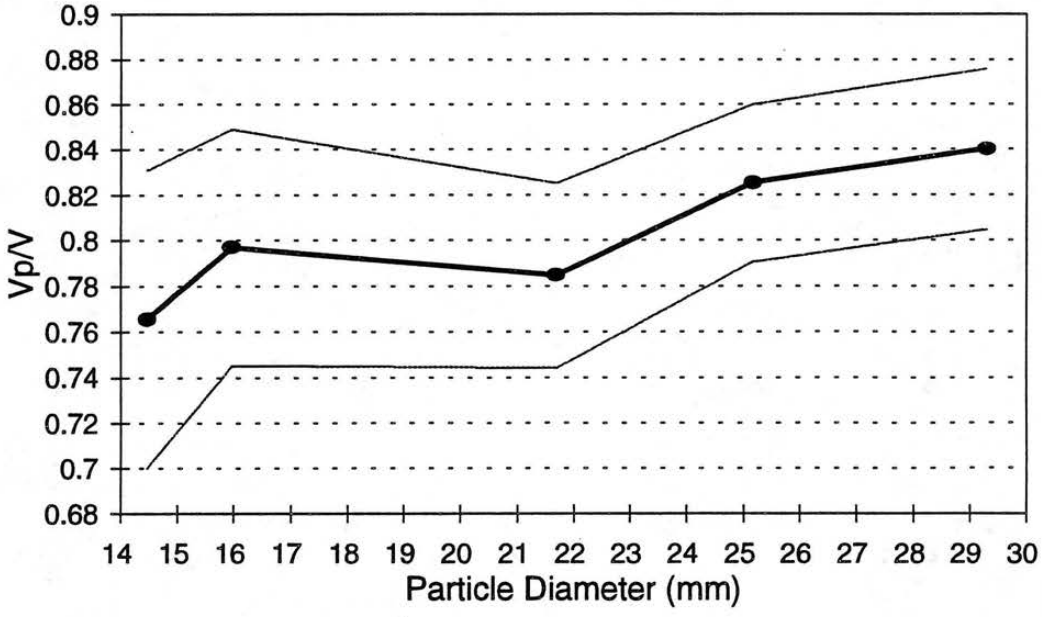


Vp/U* vs. d
(steel)

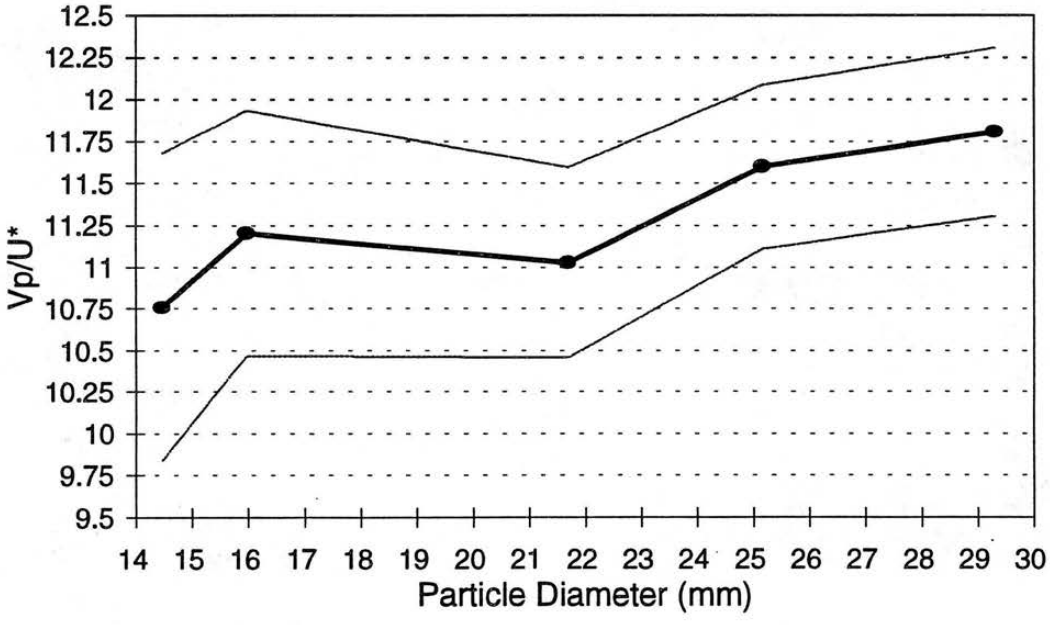


Run 30
U* = 0.0516 m/s

Vp/V vs. d
(glass)

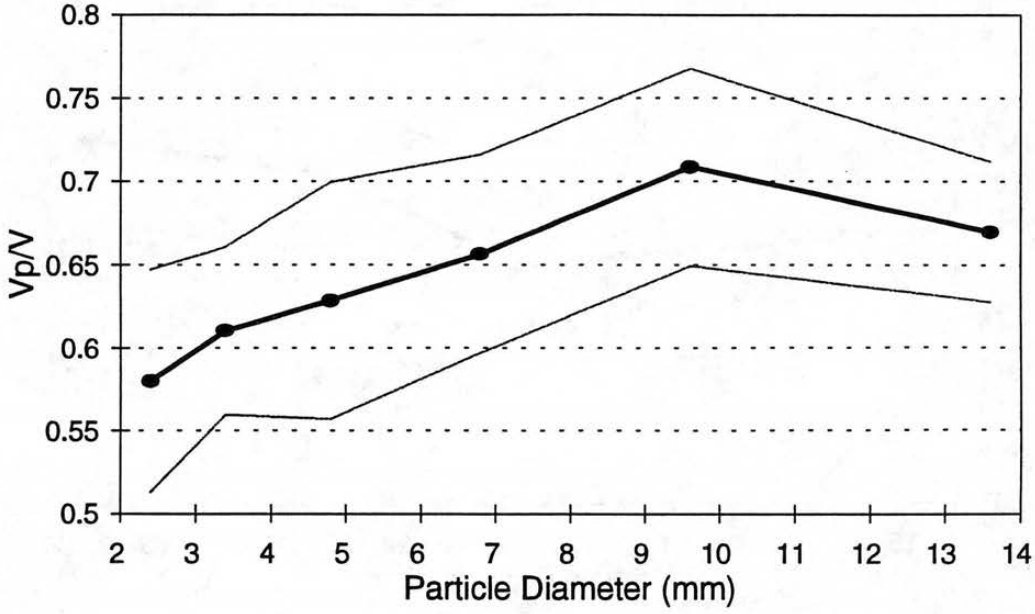


Vp/U* vs. d
(glass)

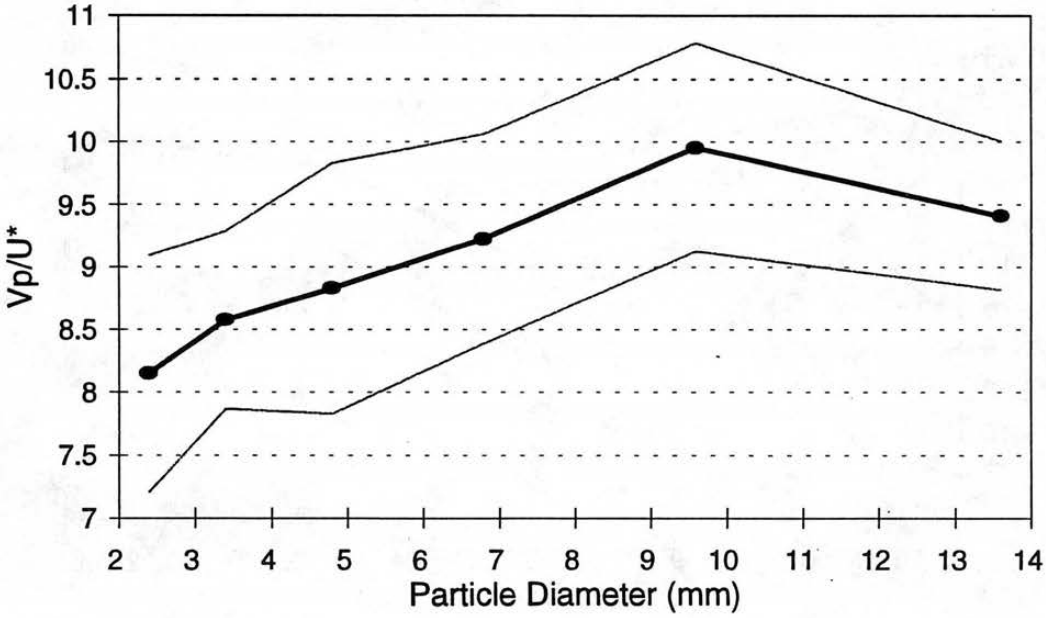


Run 30
U* = 0.0516 m/s

Vp/V vs. d
(natural)



Vp/U* vs. d
(natural)



Run#	31		Bed Roughness k:	1.7	mm	Streamflow	16.4193 L/s
Date	7-29-95		Pump Setting	medium		Valve Setting	5/8 open
Reach Length	2000	mm	Slope Reading	140.5	mm	Bed Slope	0.00567

		Initial		Intermediate		Final	
Temperature		21	°C			21	°C
Manometer in. of water	Hi	36.57		36.57		37.93	
	Lo	-39.28		-39.28		-40.64	
	Hi - Lo	75.85		75.85		78.57	
Flow Depth:	u.s.	55.5	mm	55	mm	55.2	mm
	d.s.	56.5	mm	56.4	mm	55.9	mm
	u.s. - d.s.	-1	mm	-1.4	mm	-0.7	mm
	at weir	53.6	mm	53.2	mm	53.2	mm
Top Width:	u.s.	590	mm	588	mm	590	mm
	d.s.	600	mm	600	mm	600	mm
	at weir	602	mm	605	mm	605	mm

Velocities (mm/s)

type	steel	188.8574	180.3427	192.8640	180.8318	176.8347	ERR	ERR
d (mm)	19.04	179.6945	192.1230	185.5288	191.2046	187.0907	ERR	ERR
n	15	188.8574	177.7778	178.7310	183.8235	178.8909	ERR	ERR
G	8.02			Std Dev	5.6103		Avg	184.2302

Velocities (mm/s)

type	steel	170.6485	167.5042	168.3502	170.6485	168.9189	ERR	ERR
d (mm)	15.88	166.2510	167.0844	165.8375	164.8805	162.4695	ERR	ERR
n	15	169.3480	179.3722	168.4920	160.0000	175.2848	ERR	ERR
G	8.02			Std Dev	4.7121		Avg	168.3393

Velocities (mm/s)

type	steel	165.0165	169.3480	148.1481	172.4138	161.6815	ERR	ERR
d (mm)	14.28	168.9189	163.6661	174.3679	157.9779	162.8664	ERR	ERR
n	15	156.1280	159.4896	158.3531	156.4945	156.8627	ERR	ERR
G	8.02			Std Dev	7.0439		Avg	162.1156

Velocities (mm/s)

type	steel	127.2265	149.5886	121.4329	135.5932	137.6462	132.5381	137.3626
d (mm)	9.5	151.4005	155.4002	145.1379	130.6336	131.8392	134.1382	133.6005
n	21	150.2630	139.6648	141.6431	147.4926	140.9443	143.8849	126.5022
G	8.02			Std Dev	9.0573		Avg	138.7587

		Velocities (mm/s)						
type	glass	505.0505	537.6344	542.0054	557.1031	546.4481	520.8333	ERR
d (mm)	29.3	561.7978	516.7959	537.6344	552.4862	537.6344	511.5090	ERR
n	18	507.6142	546.4481	519.4805	576.3689	583.0904	547.9452	ERR
G	2.6			Std Dev	22.5843		Avg	539.3266

		Velocities (mm/s)						
type	glass	537.6344	546.4481	524.9344	543.4783	533.3333	542.0054	ERR
d (mm)	25.17	566.5722	533.3333	566.5722	503.7783	515.4639	503.7783	ERR
n	18	524.9344	488.9976	500.0000	552.4862	520.8333	555.5556	ERR
G	2.6			Std Dev	22.7403		Avg	531.1189

		Velocities (mm/s)						
type	glass	524.9344	516.7959	524.9344	496.2779	470.5882	500.0000	ERR
d (mm)	21.7	503.7783	524.9344	507.6142	515.4639	496.2779	488.9976	ERR
n	18	492.6108	542.0054	470.5882	492.6108	524.9344	488.9976	ERR
G	2.6			Std Dev	19.6697		Avg	504.5747

		Velocities (mm/s)						
type	glass	410.6776	477.3270	529.1005	511.5090	488.9976	515.4639	546.4481
d (mm)	15.97	477.3270	441.5011	454.5455	464.0371	524.9344	464.0371	507.6142
n	21	467.2897	524.9344	488.9976	478.4689	475.0594	470.5882	444.4444
G	2.6			Std Dev	33.6969		Avg	483.9668

		Velocities (mm/s)						
type	glass	560.2241	520.8333	453.5147	511.5090	444.4444	426.4392	473.9336
d (mm)	14.48	487.8049	477.3270	555.5556	454.5455	503.7783	487.8049	500.0000
n	21	488.9976	426.4392	432.9004	453.5147	529.1005	484.2615	464.0371
G	2.6			Std Dev	38.6116		Avg	482.7126

		Velocities (mm/s)						
type	natural	467.2897	437.6368	444.4444	415.8004	421.0526	438.5965	367.6471
d (mm)	13.6	409.8361	441.5011	421.0526	464.0371	404.8583	435.7298	404.8583
n	21	397.6143	447.4273	396.8254	421.0526	426.4392	376.6478	432.9004
G	2.65			Std Dev	25.6964		Avg	422.5356

		Velocities (mm/s)						
type	natural	441.5011	434.7826	484.2615	421.0526	380.9524	410.6776	418.4100
d (mm)	9.6	404.8583	410.6776	376.6478	404.8583	405.6795	352.1127	492.6108
n	21	438.5965	353.9823	456.6210	408.1633	349.6503	434.7826	460.8295
G	2.65			Std Dev	39.7899		Avg	416.2718

		Velocities (mm/s)						
type	natural	438.5965	388.3495	421.0526	331.6750	457.8755	361.6637	338.9831
d (mm)	6.8	387.5969	441.5011	426.4392	400.0000	441.5011	488.9976	413.2231
n	21	375.2345	392.1569	415.8004	385.3565	346.0208	369.6858	378.7879
G	2.65			Std Dev	40.6779		Avg	400.0237

		Velocities (mm/s)						
type	natural	378.7879	447.4273	397.6143	389.1051	369.6858	459.7701	404.8583
d (mm)	4.8	408.1633	404.8583	429.1845	412.3711	490.1961	378.7879	392.9273
n	21	431.0345	413.2231	453.5147	380.9524	369.6858	363.6364	361.6637
G	2.65			Std Dev	34.8174		Avg	406.5451

		Velocities (mm/s)						
type	natural	385.3565	407.3320	335.5705	332.2259	380.9524	385.3565	389.1051
d (mm)	3.4	357.1429	434.7826	378.0718	392.1569	447.4273	401.6064	397.6143
n	21	402.4145	338.4095	369.6858	367.6471	400.0000	353.3569	386.1004
G	2.65			Std Dev	29.6619		Avg	382.9674

		Velocities (mm/s)						
type	natural	377.3585	346.0208	329.4893	345.4231	389.1051	390.6250	454.5455
d (mm)	2.4	400.0000	440.5286	353.3569	400.0000	378.7879	374.5318	365.6307
n	21	335.0084	376.6478	344.2341	351.4938	378.7879	376.6478	427.3504
G	2.65			Std Dev	33.4371		Avg	377.8844

Motion of the 9.5mm steel particle becoming noticably irregular. Smaller steel particles exhibited highly irregular motion with surging, meandering and halting.

Natural particles smaller than 9.6mm showed considerable suspension, more so with smaller perticles. The natural particles smaller than 6.8mm moved with surges.

Run# 31 Bed
Date: 7-29-95 Roughness k: 1.7 mm y/k: 32.794

Slope: 0.00567 Q: 16.41932 L/s U*: 0.048 m/s

	u.s.	d.s.	avg
y (mm)	55.2333333	56.26667	55.75
Tw (mm)	589.333333	600	594.6667
A (m²)	0.02399428	0.024743	0.024367
P (m)	0.60843704	0.619182	0.613809
Rh (m)	0.03943593	0.039961	0.039699
V (m/s)	0.68430149	0.663587	0.673944
H (m)	0.08829378	0.078718	0.083506

delta H: 0.0095756 m delta x: 1.62 m

Sf: 0.00591086

Tavg: 21 °C

ν: 9.8009E-07 m²/s

δ: 0.000237 m

Run# 31

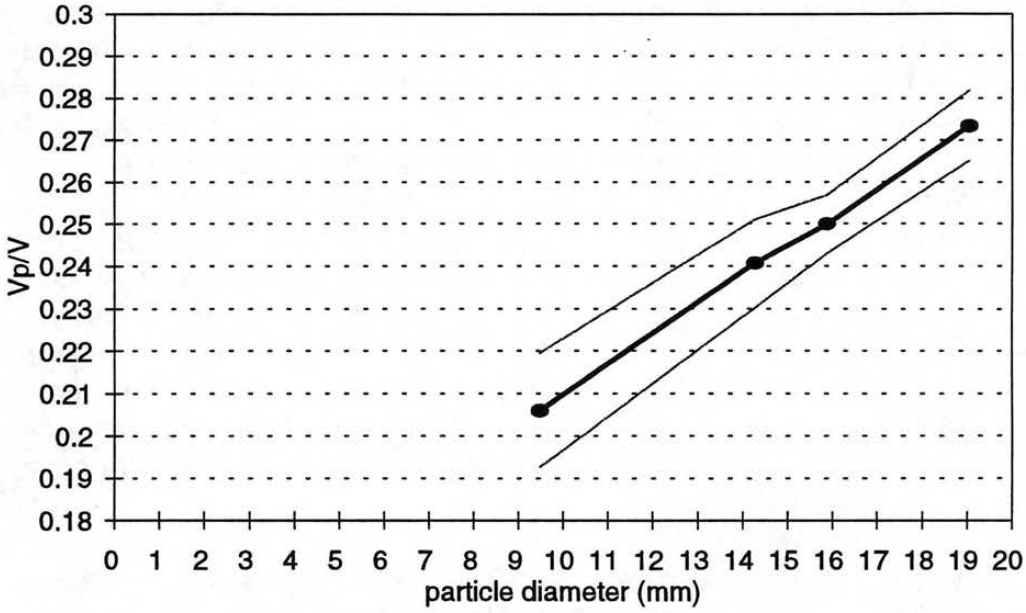
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	15	0.1842	0.0056	1.0794	790.8783	0.0018
steel	15.88	8.02	15	0.1683	0.0047	0.9857	659.6191	0.0021
steel	14.28	8.02	15	0.1621	0.0070	0.9346	593.1587	0.0023
steel	9.5	8.02	21	0.1388	0.0091	0.7619	394.6084	0.0035
glass	29.3	2.6	18	0.5393	0.0226	0.6392	743.4263	0.0050
glass	25.17	2.6	18	0.5311	0.0227	0.5924	638.6362	0.0058
glass	21.7	2.6	18	0.5046	0.0197	0.5500	550.5922	0.0068
glass	15.97	2.6	21	0.4840	0.0337	0.4716	405.2054	0.0092
glass	14.48	2.6	21	0.4827	0.0386	0.4490	367.3998	0.0101
natural	13.6	2.65	21	0.4225	0.0257	0.4419	348.6293	0.0105
natural	9.6	2.65	21	0.4163	0.0398	0.3709	246.0913	0.0148
natural	6.8	2.65	21	0.4000	0.0407	0.3117	174.3146	0.0209
natural	4.8	2.65	21	0.4065	0.0348	0.2612	123.0456	0.0296
natural	3.4	2.65	21	0.3830	0.0297	0.2189	87.1573	0.0418
natural	2.4	2.65	21	0.3779	0.0334	0.1826	61.5228	0.0593

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.2734	3.8405	0.1707	0.0444	11.2000	7172.9857	80.3374	2.9280
steel	0.2498	3.5092	0.1708	0.0487	9.3412	7172.9857	67.0041	3.5107
steel	0.2405	3.3795	0.1735	0.0513	8.4000	7172.9857	60.2531	3.9041
steel	0.2059	2.8926	0.1821	0.0630	5.5882	7172.9857	40.0843	5.8684
glass	0.8003	11.2429	0.8437	0.0750	17.2353	7172.9857	123.6285	1.9027
glass	0.7881	11.0718	0.8965	0.0810	14.8059	7172.9857	106.2024	2.2149
glass	0.7487	10.5184	0.9174	0.0872	12.7647	7172.9857	91.5611	2.5691
glass	0.7181	10.0889	1.0261	0.1017	9.3941	7172.9857	67.3839	3.4909
glass	0.7162	10.0627	1.0750	0.1068	8.5176	7172.9857	61.0970	3.8501
natural	0.6270	8.8082	0.9562	0.1086	8.0000	7172.9857	57.3839	4.0993
natural	0.6177	8.6777	1.1223	0.1293	5.6471	7172.9857	40.5063	5.8073
natural	0.5936	8.3390	1.2833	0.1539	4.0000	7172.9857	28.6919	8.1985
natural	0.6032	8.4749	1.5563	0.1836	2.8235	7172.9857	20.2531	11.6146
natural	0.5682	7.9834	1.7492	0.2191	2.0000	7172.9857	14.3460	16.3971
natural	0.5607	7.8774	2.0691	0.2627	1.4118	7172.9857	10.1266	23.2292

Run # 31
U* = 0.048 (m/s)

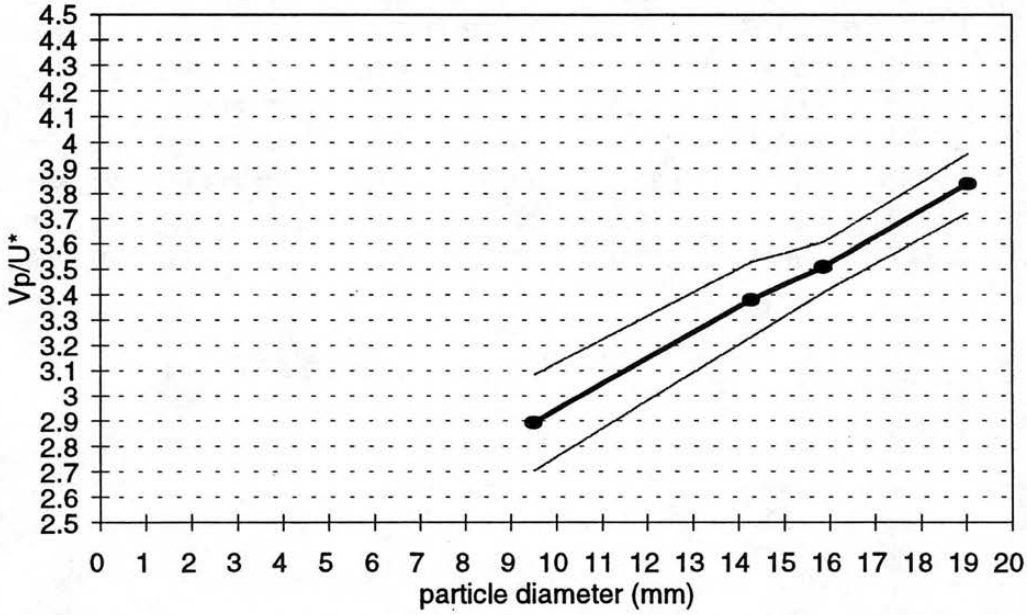
Vp/V vs. d

(steel)



Vp/U* vs. d

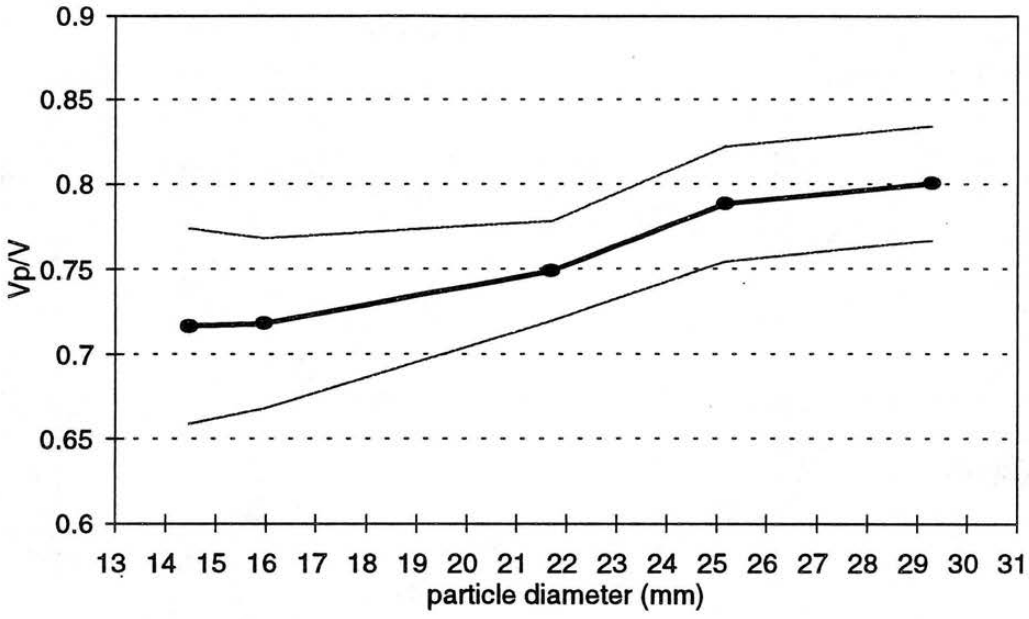
(steel)



Run # 31
U* = 0.048 (m/s)

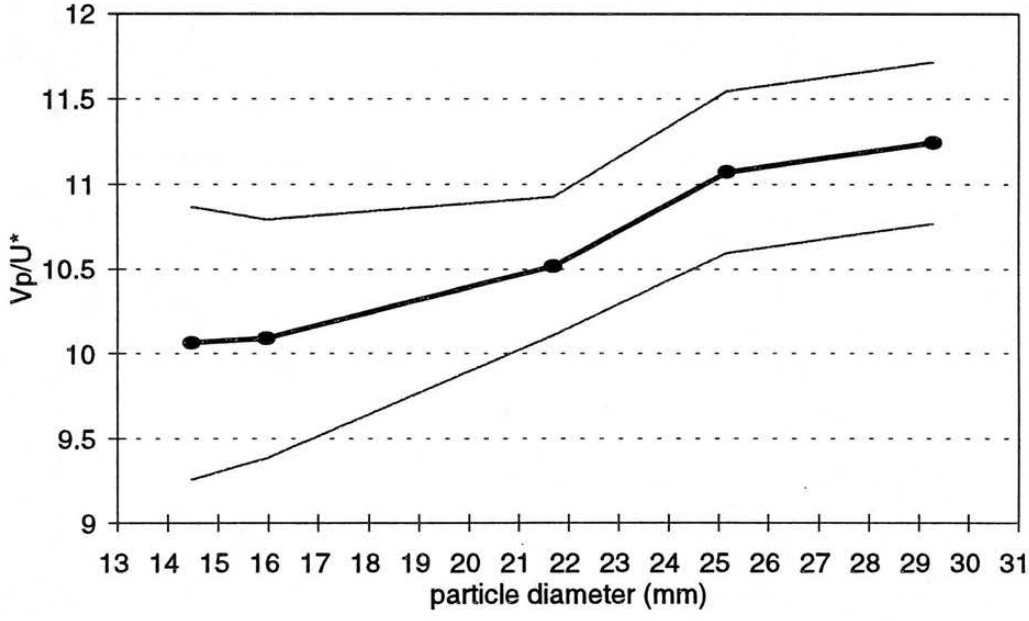
Vp/V vs. d

(glass)



Vp/U* vs. d

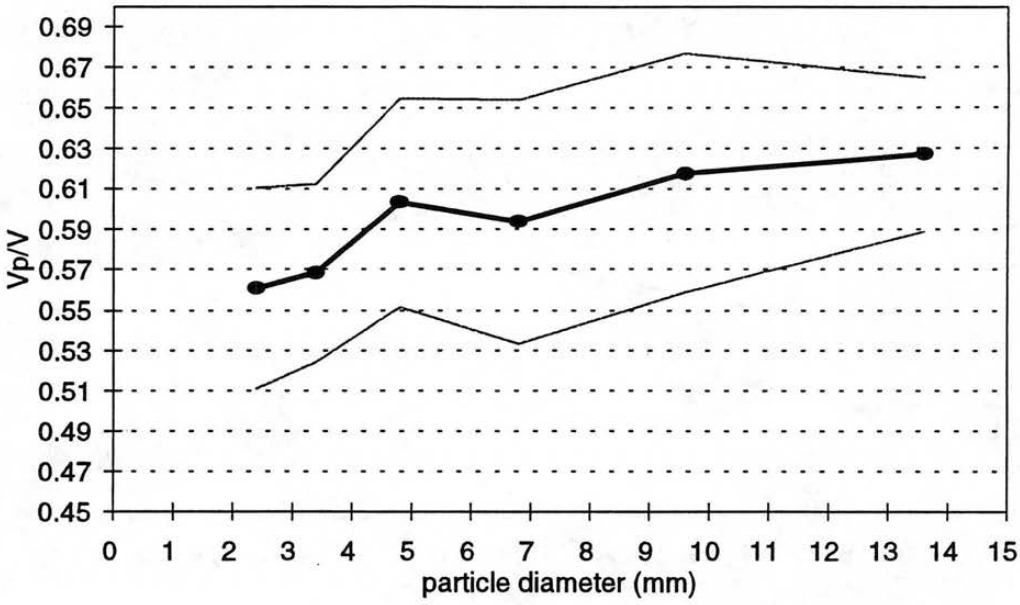
(glass)



Run # 31
U* = 0.048 (m/s)

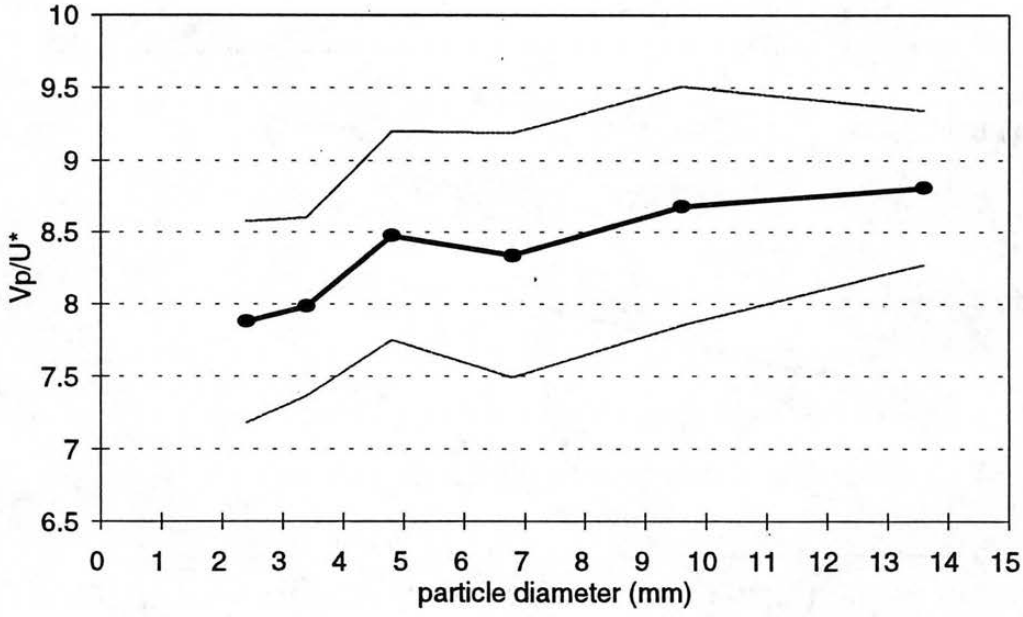
Vp/V vs. d

(natural)



Vp/U* vs. d

(natural)



Run#	32		Bed Roughness k:	1.7	mm	Streamflow	15.5990 L/s
Date	7-30-95		Pump Setting	medium		Valve Setting	9/16 open
Reach Length	2000	mm	Slope Reading	130.5	mm	Bed Slope	0.00427

		Initial		Intermediate		Final	
Temperature		21	°C			22	°C
Manometer in. of water	Hi	33.87		33.87		33.87	
	Lo	-35.22		-35.22		-35.9	
	Hi - Lo	69.09		69.09		69.77	
Flow Depth:	u.s.	55.7	mm	55.5	mm	55.6	mm
	d.s.	56.3	mm	56.7	mm	56.7	mm
	u.s. - d.s.	-0.6	mm	-1.2	mm	-1.1	mm
	at weir	53.6	mm	53.8	mm	53.6	mm
Top Width:	u.s.	595	mm	598	mm	600	mm
	d.s.	610	mm	614	mm	612	mm
	at weir	615	mm	615	mm	617	mm

Velocities (mm/s)

type	steel	159.2357	164.8805	157.7287	153.1394	158.3531	171.6738	162.3377
d (mm)	19.04	163.2653	152.4390	163.6661	155.0388	169.3480	159.6169	154.5595
n	21	162.0746	156.8627	161.9433	156.1280	156.1280	153.4919	164.0689
G	8.02			Std Dev	5.2448		Avg	159.8086

Velocities (mm/s)

type	steel	141.3428	151.6300	143.4720	150.1502	149.8127	143.1639	152.0913
d (mm)	15.88	148.9203	147.0588	139.4700	146.8429	148.1481	144.4043	139.4700
n	21	149.5886	148.1481	147.8197	144.7178	143.4720	149.1424	145.4545
G	8.02			Std Dev	3.7095		Avg	146.3962

Velocities (mm/s)

type	steel	141.9446	141.0437	142.8571	124.2236	138.7925	139.6648	136.9863
d (mm)	14.28	130.8901	132.1877	137.2684	136.9863	146.0920	149.2537	127.4697
n	21	136.7054	135.8696	136.7989	139.7624	139.4700	137.6462	137.9310
G	8.02			Std Dev	5.6632		Avg	137.6116

Velocities (mm/s)

type	glass	477.3270	456.6210	450.4505	421.0526	396.8254	457.6659	485.4369
d (mm)	29.3	450.4505	435.7298	430.1075	457.6659	470.5882	470.5882	410.6776
n	21	464.0371	444.4444	426.4392	470.5882	418.4100	467.2897	460.8295
G	2.6			Std Dev	23.8852		Avg	448.7250

		Velocities (mm/s)						
type	glass	470.5882	447.4273	435.7298	473.9336	423.7288	435.7298	412.3711
d (mm)	25.17	407.3320	438.5965	457.6659	421.0526	450.4505	423.7288	402.4145
n	21	441.5011	454.5455	402.4145	441.5011	475.0594	481.9277	423.7288
G	2.6			Std Dev	24.0810		Avg	439.1156

		Velocities (mm/s)						
type	glass	402.4145	421.0526	423.7288	387.5969	396.8254	407.3320	441.5011
d (mm)	21.7	448.4305	444.4444	470.5882	423.7288	408.1633	400.0000	421.0526
n	21	427.3504	417.5365	460.8295	464.0371	421.0526	437.6368	423.7288
G	2.6			Std Dev	22.6427		Avg	426.1443

		Velocities (mm/s)						
type	glass	369.6858	440.5286	397.6143	369.6858	388.3495	396.8254	450.4505
d (mm)	15.97	429.1845	380.9524	421.0526	423.7288	378.7879	363.6364	371.7472
n	21	353.3569	371.7472	371.7472	355.2398	451.4673	435.7298	392.1569
G	2.6			Std Dev	31.9188		Avg	395.8893

		Velocities (mm/s)						
type	glass	390.6250	365.6307	412.3711	359.0664	415.8004	357.7818	415.8004
d (mm)	14.48	394.4773	441.5011	415.8004	415.8004	395.2569	388.3495	417.5365
n	21	390.6250	429.1845	380.9524	429.1845	429.1845	454.5455	426.4392
G	2.6			Std Dev	26.4788		Avg	405.9959

		Velocities (mm/s)						
type	natural	351.4938	365.6307	380.9524	316.9572	320.0000	336.7003	335.0084
d (mm)	13.6	333.3333	363.6364	315.4574	304.4140	397.6143	359.0664	357.7818
n	21	336.7003	361.6637	313.4796	318.9793	357.7818	349.6503	340.7155
G	2.65			Std Dev	24.1419		Avg	343.6675

		Velocities (mm/s)						
type	natural	357.7818	378.7879	355.2398	365.6307	342.4658	353.3569	373.8318
d (mm)	9.6	318.4713	266.6667	395.2569	323.1018	387.5969	351.4938	347.8261
n	21	344.2341	335.5705	397.6143	307.6923	363.6364	328.4072	315.4574
G	2.65			Std Dev	31.6196		Avg	348.1010

		Velocities (mm/s)						
type	natural	349.6503	357.7818	301.6591	327.8689	274.7253	330.0330	312.0125
d (mm)	6.8	367.6471	344.2341	349.6503	286.9440	347.8261	257.0694	335.5705
n	21	343.6426	400.0000	300.3003	347.8261	385.3565	310.5590	340.7155
G	2.65			Std Dev	35.0962		Avg	331.9558

		Velocities (mm/s)						
type	natural	346.0208	303.0303	314.9606	346.0208	310.5590	321.5434	301.6591
d (mm)	4.8	294.9853	331.6750	338.4095	321.5434	314.9606	385.3565	284.4950
n	21	313.4796	280.8989	315.4574	389.8635	363.6364	331.6750	345.4231
G	2.65			Std Dev	29.1888		Avg	326.4597

		Velocities (mm/s)						
type	natural	351.4938	268.8172	349.6503	317.9650	318.4713	353.3569	288.1844
d (mm)	3.4	264.5503	294.9853	326.7974	365.6307	273.2240	288.1844	359.0664
n	21	302.1148	274.7253	292.3977	301.6591	324.6753	318.4713	314.9606
G	2.65			Std Dev	31.0714		Avg	311.8753

Steel particles smaller than 14.28mm showed start/stop motion with considerable meander and surges. Completed runs were impossible.

The natural particles smaller than 6.8mm were in suspension much of the time and moved in surges.
Natural particles smaller than 3.4mm surged, stopped, restarted repeatedly.

Run# 32 Bed
Date: 7-30-95 Roughness k: 1.7 mm y/k: 32.99

Slope: 0.00427 Q: 15.59901 L/s U*: 0.0419 m/s

	u.s.	d.s.	avg
y (mm)	55.6	56.56667	56.08333
Tw (mm)	597.666667	612	604.8333
A (m²)	0.02438523	0.025215	0.024798
P (m)	0.61653927	0.63072	0.623627
Rh (m)	0.03955179	0.039977	0.039764
V (m/s)	0.63969087	0.61865	0.629171
H (m)	0.08338102	0.07608	0.079731

delta H: 0.0073007 m delta x: 1.62 m

Sf: 0.00450658

Tavg: 21.5 °C

ν: 9.684E-07 m²/s

δ: 0.00026797 m

Run# 32

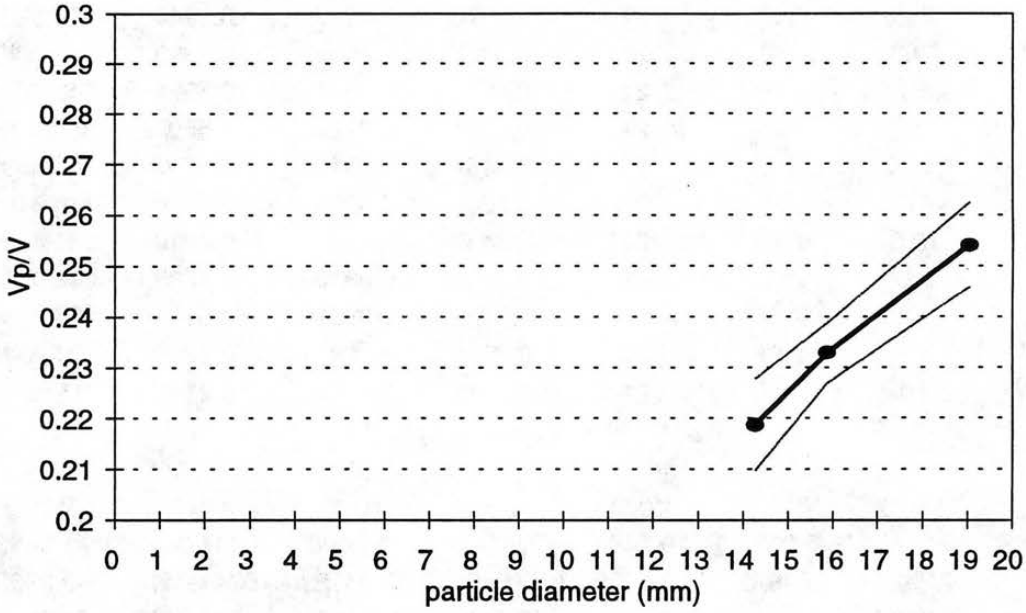
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	21	0.1598	0.0052	1.0794	797.2272	0.0013
steel	15.88	8.02	21	0.1464	0.0037	0.9857	664.9142	0.0016
steel	14.28	8.02	21	0.1376	0.0057	0.9346	597.9204	0.0018
glass	29.3	2.6	21	0.4487	0.0239	0.6393	749.3943	0.0038
glass	25.17	2.6	21	0.4391	0.0241	0.5924	643.7630	0.0044
glass	21.7	2.6	21	0.4261	0.0226	0.5500	555.0122	0.0052
glass	15.97	2.6	21	0.3959	0.0319	0.4717	408.4583	0.0070
glass	14.48	2.6	21	0.4060	0.0265	0.4490	370.3491	0.0077
natural	13.6	2.65	21	0.3437	0.0241	0.4419	351.4280	0.0080
natural	9.6	2.65	21	0.3481	0.0316	0.3709	248.0668	0.0113
natural	6.8	2.65	21	0.3320	0.0351	0.3117	175.7140	0.0160
natural	4.8	2.65	21	0.3265	0.0292	0.2612	124.0334	0.0226
natural	3.4	2.65	21	0.3119	0.0311	0.2190	87.8570	0.0319

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.2540	3.8121	0.1480	0.0388	11.2000	6344.0418	71.0533	2.9456
steel	0.2327	3.4922	0.1485	0.0425	9.3412	6344.0418	59.2608	3.5317
steel	0.2187	3.2826	0.1472	0.0449	8.4000	6344.0418	53.2900	3.9274
glass	0.7132	10.7041	0.7020	0.0656	17.2353	6344.0418	109.3414	1.9141
glass	0.6979	10.4748	0.7412	0.0708	14.8059	6344.0418	93.9291	2.2282
glass	0.6773	10.1654	0.7748	0.0762	12.7647	6344.0418	80.9798	2.5845
glass	0.6292	9.4437	0.8394	0.0889	9.3941	6344.0418	59.5967	3.5118
glass	0.6453	9.6848	0.9041	0.0934	8.5176	6344.0418	54.0363	3.8732
natural	0.5462	8.1980	0.7777	0.0949	8.0000	6344.0418	50.7523	4.1238
natural	0.5533	8.3037	0.9385	0.1130	5.6471	6344.0418	35.8252	5.8420
natural	0.5276	7.9186	1.0649	0.1345	4.0000	6344.0418	25.3762	8.2475
natural	0.5189	7.7875	1.2496	0.1605	2.8235	6344.0418	17.9126	11.6840
natural	0.4957	7.4396	1.4243	0.1915	2.0000	6344.0418	12.6881	16.4951

Run # 32
U* = 0.0419 (m/s)

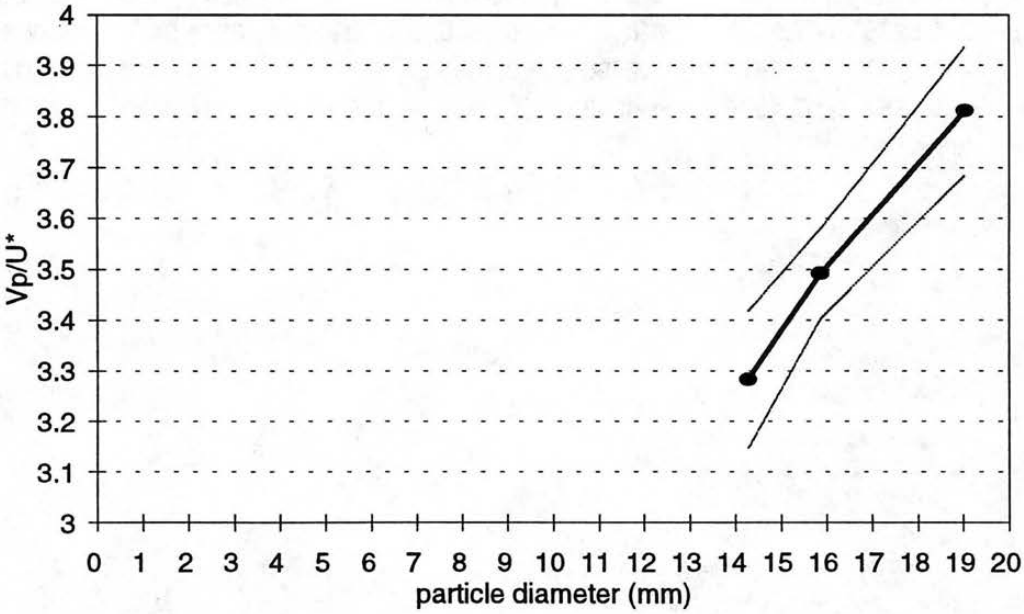
Vp/V vs. d

(steel)



Vp/U* vs. d

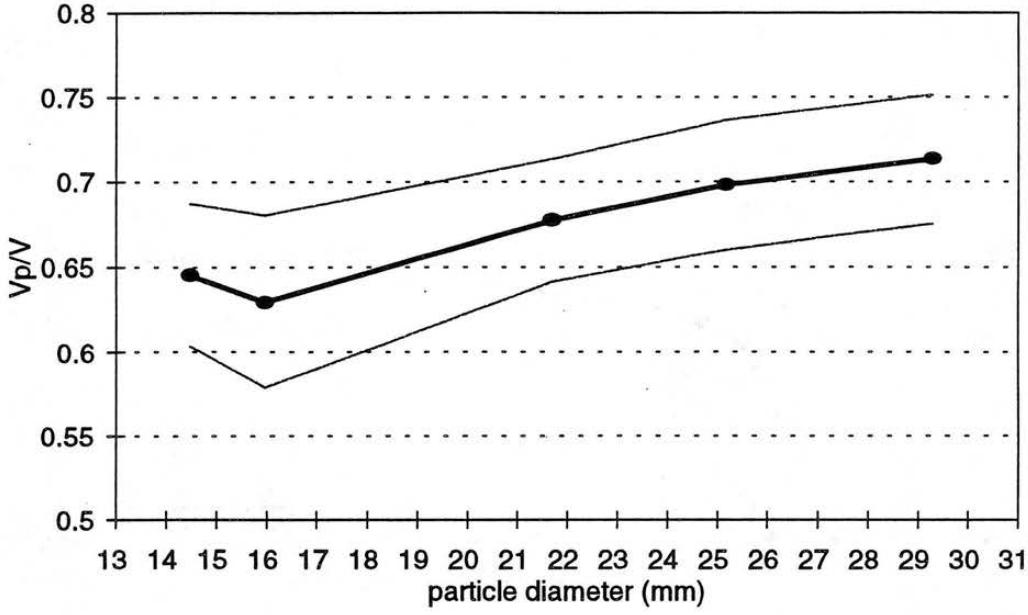
(steel)



Run # 32
U* = 0.0419 (m/s)

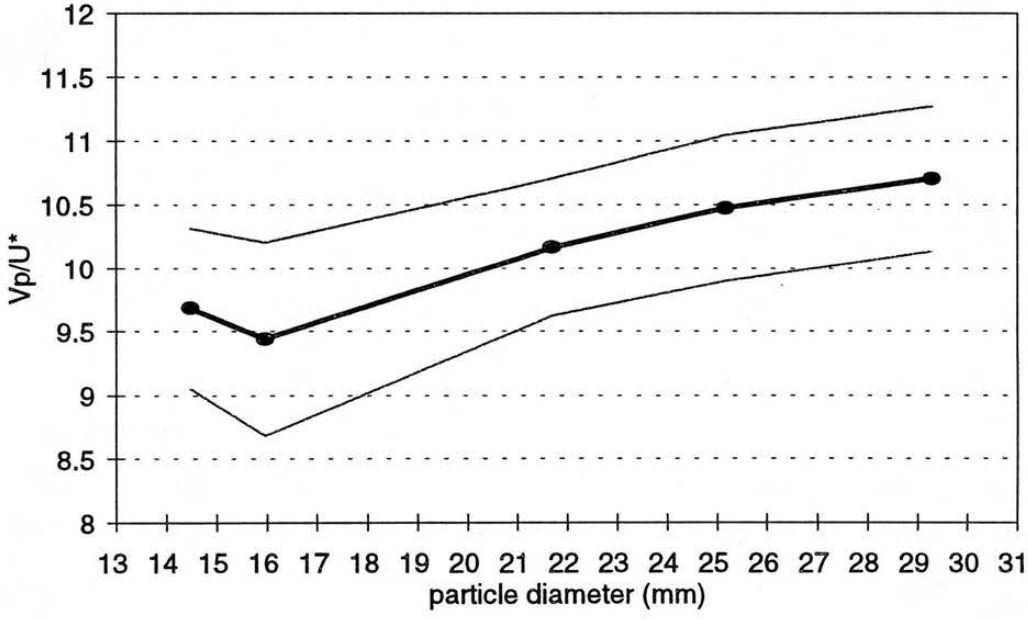
Vp/V vs. d

(glass)



Vp/U* vs. d

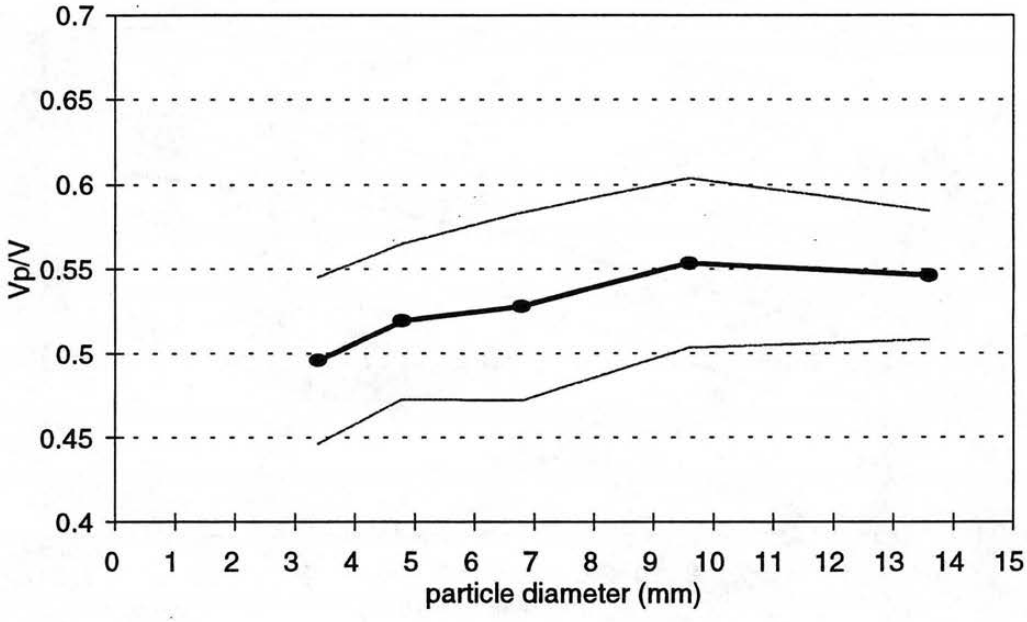
(glass)



Run # 32
U* = 0.0419 (m/s)

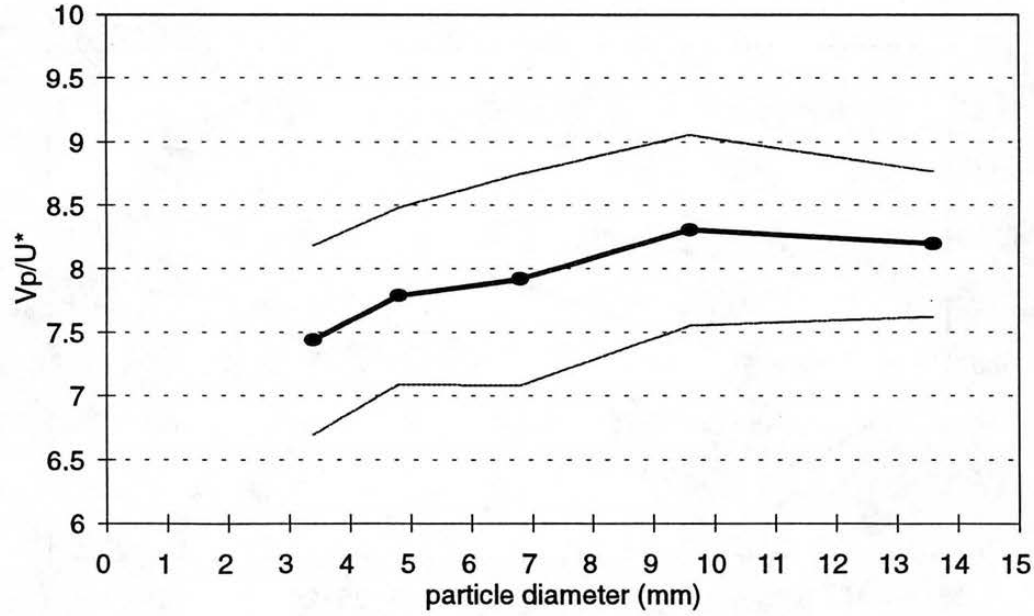
Vp/V vs. d

(natural)



Vp/U* vs. d

(natural)



Run#	33		Bed Roughness k:	1.7	mm	Streamflow	15.1260 L/s
Date	8-1-95		Pump Setting	medium		Valve Setting	9/16 open
Reach Length	2000	mm	Slope Reading	121	mm	Bed Slope	0.00294

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer in. of water	Hi	-----		-----		-----	
	Lo	-----		-----		-----	
	Hi - Lo	65.1		65.4		65.1	
Flow Depth:	u.s.	63.3	mm	63.2	mm	63.5	mm
	d.s.	62.9	mm	62.7	mm	62.2	mm
	u.s. - d.s.	0.4	mm	0.5	mm	1.3	mm
	at weir	64.3	mm	63.1	mm	63.4	mm
Top Width:	u.s.	646	mm	646	mm	639	mm
	d.s.	633	mm	633	mm	635	mm
	at weir	672	mm	673	mm	675	mm

Velocities (mm/s)

type	steel	123.5330	125.2348	131.1475	130.8901	134.2282	131.1475	128.2874
d (mm)	19.04	133.9585	130.1236	117.0275	132.0132	130.8901	129.7859	134.4990
n	21	140.3509	125.2348	131.6656	125.7862	130.6336	123.9926	127.5510
G	8.02			Std Dev	4.9186		Avg	129.4277

Velocities (mm/s)

type	steel	113.8304	114.4820	114.4820	121.2121	122.8501	106.6667	117.4398
d (mm)	15.88	115.3403	107.7006	113.0582	121.4329	111.7318	108.1666	120.7729
n	21	110.7420	118.7648	121.8769	123.5330	117.8550	112.9305	119.1895
G	8.02			Std Dev	5.1569		Avg	115.9075

Velocities (mm/s)

type	steel	103.4126	105.9322	103.7344	112.9305	110.9262	107.0091	102.5641
d (mm)	14.28	101.9368	104.7669	112.1076	103.5733	119.1185	108.4599	114.2857
n	21	100.0000	89.0076	101.5744	103.6807	101.4199	110.5583	107.6426
G	8.02			Std Dev	6.3208		Avg	105.9353

Velocities (mm/s)

type	glass	304.8780	313.9717	316.4557	314.9606	327.8689	309.5975	306.2787
d (mm)	29.3	324.6753	307.6923	323.6246	329.4893	323.6246	353.9823	300.7519
n	21	326.7974	301.6591	313.4796	309.1190	340.7155	298.9537	297.6190
G	2.6			Std Dev	14.3761		Avg	316.4855

		Velocities (mm/s)						
type	glass	357.7818	298.9537	278.1641	346.0208	316.9572	340.1361	320.0000
d (mm)	25.17	335.0084	328.4072	340.1361	323.1018	311.0420	285.7143	301.6591
n	21	307.6923	312.5000	323.1018	275.8621	340.1361	289.4356	346.0208
G	2.6			Std Dev	23.5724		Avg	317.9920

		Velocities (mm/s)						
type	glass	306.2787	307.6923	282.0874	282.8854	278.1641	320.0000	285.7143
d (mm)	21.7	315.4574	328.4072	330.0330	307.6923	298.9537	312.0125	270.2703
n	21	288.6003	283.2861	330.0330	327.8689	273.5978	278.5515	294.9853
G	2.6			Std Dev	20.1239		Avg	300.1225

		Velocities (mm/s)						
type	glass	320.0000	309.1190	300.3003	324.6753	310.5590	283.2861	288.1844
d (mm)	15.97	293.2551	304.8780	300.7519	280.8989	264.2008	264.5503	307.6923
n	21	324.6753	303.4901	298.9537	279.7203	330.0330	277.3925	314.9606
G	2.6			Std Dev	19.1166		Avg	299.1227

		Velocities (mm/s)						
type	glass	331.6750	298.9537	307.6923	312.0125	297.6190	274.7253	265.6042
d (mm)	14.48	266.6667	291.9708	272.4796	274.7253	277.0083	310.5590	300.7519
n	21	288.1844	265.6042	261.0966	279.7203	304.8780	265.6042	300.7519
G	2.6			Std Dev	19.6029		Avg	288.0135

		Velocities (mm/s)						
type	natural	219.7802	271.3704	254.7771	188.1468	274.7253	255.1020	210.5263
d (mm)	13.6	268.8172	244.2002	237.2479	204.4990	232.5581	225.2252	236.1275
n	21	219.0581	241.5459	207.9002	277.3925	285.7143	248.1390	210.5263
G	2.65			Std Dev	27.2652		Avg	238.7324

		Velocities (mm/s)						
type	natural	245.3988	236.1275	260.0780	288.1844	236.1275	304.8780	253.8071
d (mm)	9.6	264.2008	246.9136	250.0000	271.3704	241.2545	271.0027	239.8082
n	21	215.5172	260.0780	304.8780	282.0874	220.7506	263.5046	238.9486
G	2.65			Std Dev	24.2621		Avg	256.9008

		Velocities (mm/s)						
type	natural	236.1275	212.5399	213.2196	213.4472	233.6449	282.0874	219.7802
d (mm)	6.8	229.3578	253.8071	273.5978	209.2050	231.7497	214.8228	250.9410
n	21	241.5459	222.9654	202.0202	233.6449	262.1232	232.0186	274.7253
G	2.65			Std Dev	23.1348		Avg	235.3986

		Velocities (mm/s)						
type	natural	244.2002	250.9410	253.8071	219.0581	249.0660	263.5046	291.1208
d (mm)	4.8	218.3406	265.6042	198.8072	278.1641	262.1232	208.3333	261.0966
n	21	222.9654	242.4242	247.2188	222.9654	282.4859	254.1296	210.5263
G	2.65			Std Dev	25.6881		Avg	245.0897

		Velocities (mm/s)						
type	natural	246.9136	237.8121	220.0220	225.4791	251.8892	230.9469	231.2139
d (mm)	3.4	248.1390	240.6739	241.5459	218.5792	166.2510	258.0645	201.2072
n	21	233.6449	231.7497	227.0148	238.9486	279.3296	249.0660	227.7904
G	2.65			Std Dev	22.3225		Avg	233.6325

The natural particles smaller than 6.8mm showed highly irregular motion with suspension and surging.

The steel particles of diameter 14.28 moved with highly irregular motion. Steel particles smaller than 14.28mm moved with surges and start/stop motion, rarely able to finish a run.

Run# 33 Bed
Date: 8-1-95 Roughness k: 1.7 mm y/k: 37.039

Slope: 0.00294 Q: 15.12597 L/s U*: 0.0359 m/s

	u.s.	d.s.	avg
y (mm)	63.3333333	62.6	62.96667
Tw (mm)	643.666667	633.6667	638.6667
A (m^2)	0.02923361	0.028582	0.028907
P (m)	0.66506686	0.655145	0.660105
Rh (m)	0.0439559	0.043627	0.043791
V (m/s)	0.51741701	0.529211	0.523314
H (m)	0.08174607	0.076879	0.079313

delta H: 0.0048668 m delta x: 1.62 m

Sf: 0.00300418

Tavg: 20 °C

ν: 1.004E-06 m^2/s

δ: 0.00032425 m

Run# 33

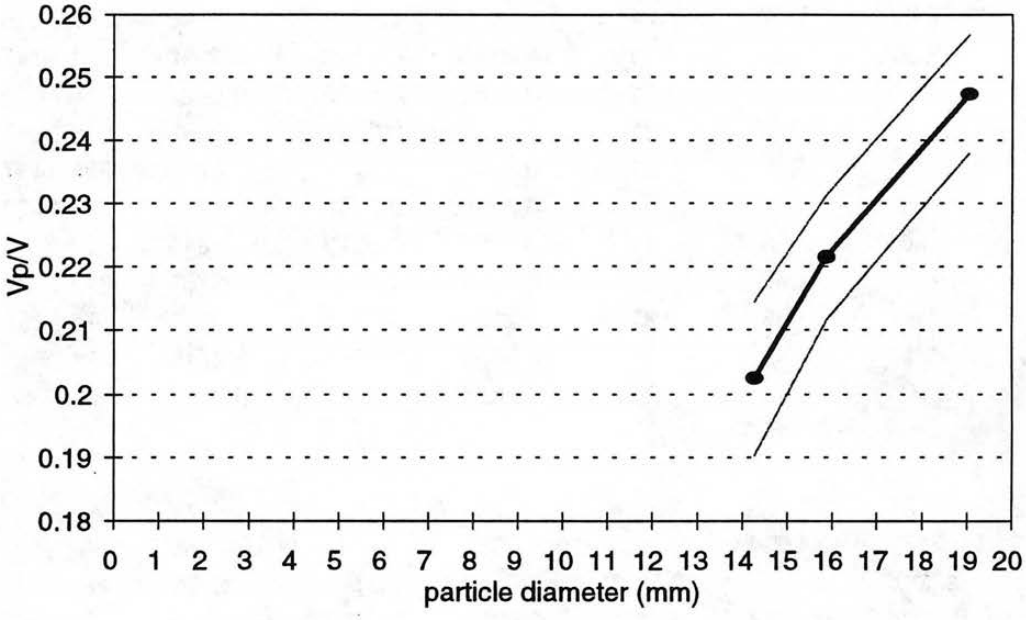
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	21	0.1294	0.0049	1.0794	778.2702	0.0010
steel	15.88	8.02	21	0.1159	0.0052	0.9857	649.1035	0.0012
steel	14.28	8.02	21	0.1059	0.0063	0.9346	583.7026	0.0013
glass	29.3	2.6	21	0.3165	0.0144	0.6392	731.5747	0.0028
glass	25.17	2.6	21	0.3180	0.0236	0.5924	628.4552	0.0033
glass	21.7	2.6	21	0.3001	0.0201	0.5500	541.8147	0.0038
glass	15.97	2.6	21	0.2991	0.0191	0.4716	398.7457	0.0051
glass	14.48	2.6	21	0.2880	0.0196	0.4490	361.5427	0.0057
natural	13.6	2.65	21	0.2387	0.0273	0.4419	343.0715	0.0059
natural	9.6	2.65	21	0.2569	0.0243	0.3709	242.1681	0.0083
natural	6.8	2.65	21	0.2354	0.0231	0.3117	171.5357	0.0117
natural	4.8	2.65	21	0.2451	0.0257	0.2612	121.0841	0.0166
natural	3.4	2.65	21	0.2336	0.0223	0.2189	85.7679	0.0235

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.2473	3.6034	0.1199	0.0333	11.2000	5242.9457	58.7210	3.3071
steel	0.2215	3.2270	0.1176	0.0364	9.3412	5242.9457	48.9753	3.9652
steel	0.2024	2.9493	0.1133	0.0384	8.4000	5242.9457	44.0407	4.4094
glass	0.6048	8.8112	0.4951	0.0562	17.2353	5242.9457	90.3637	2.1490
glass	0.6077	8.8532	0.5368	0.0606	14.8059	5242.9457	77.6264	2.5017
glass	0.5735	8.3557	0.5457	0.0653	12.7647	5242.9457	66.9247	2.9017
glass	0.5716	8.3278	0.6342	0.0762	9.3941	5242.9457	49.2528	3.9428
glass	0.5504	8.0185	0.6414	0.0800	8.5176	5242.9457	44.6576	4.3485
natural	0.4562	6.6465	0.5403	0.0813	8.0000	5242.9457	41.9436	4.6299
natural	0.4909	7.1523	0.6926	0.0968	5.6471	5242.9457	29.6072	6.5590
natural	0.4498	6.5537	0.7552	0.1152	4.0000	5242.9457	20.9718	9.2598
natural	0.4683	6.8235	0.9384	0.1375	2.8235	5242.9457	14.8036	13.1181
natural	0.4464	6.5045	1.0674	0.1641	2.0000	5242.9457	10.4859	18.5196

Run # 33
U* = 0.0359 (m/s)

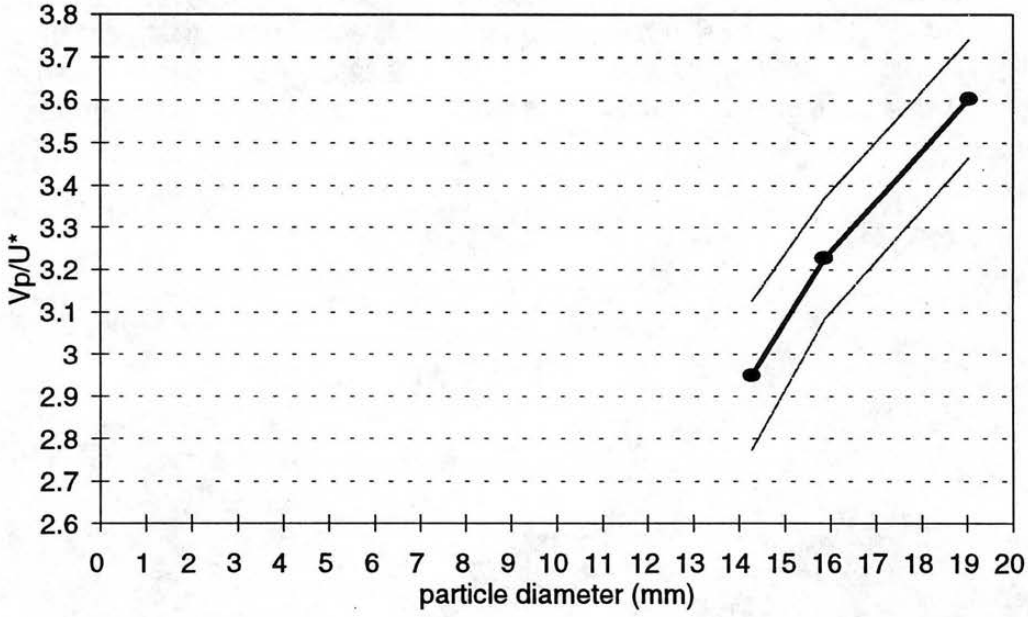
Vp/V vs. d

(steel)



Vp/U* vs. d

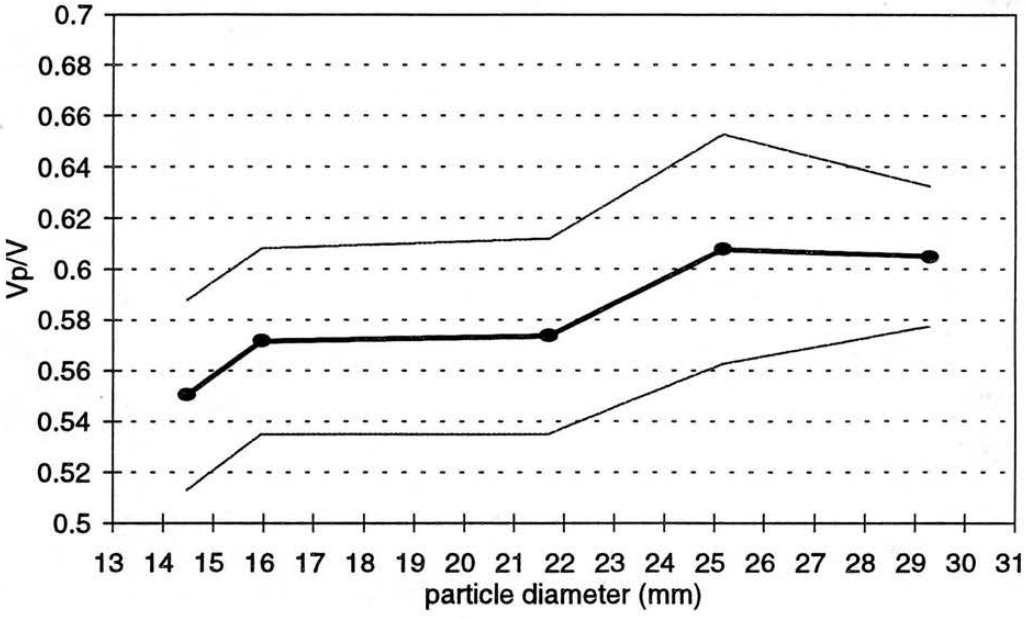
(steel)



Run # 33
U* = 0.0359 (m/s)

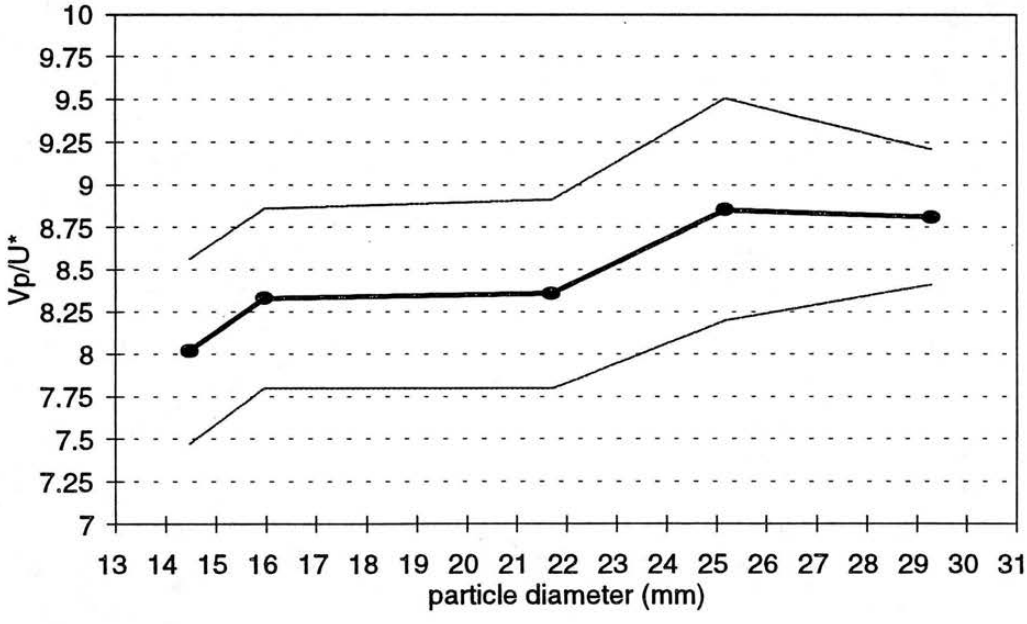
Vp/V vs. d

(glass)



Vp/U* vs. d

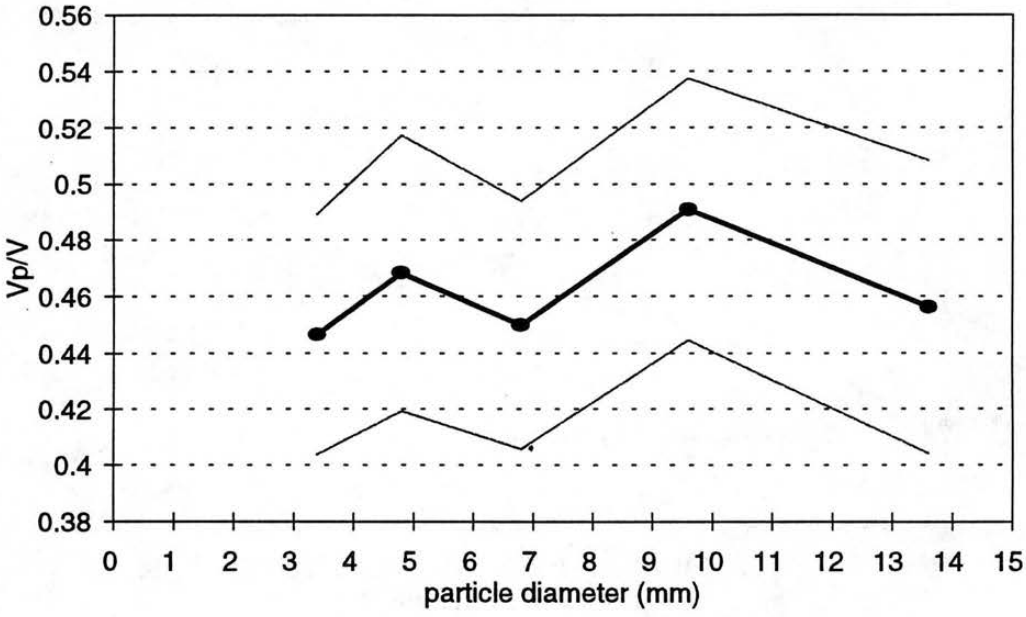
(glass)



Run # 33
U* = 0.0359 (m/s)

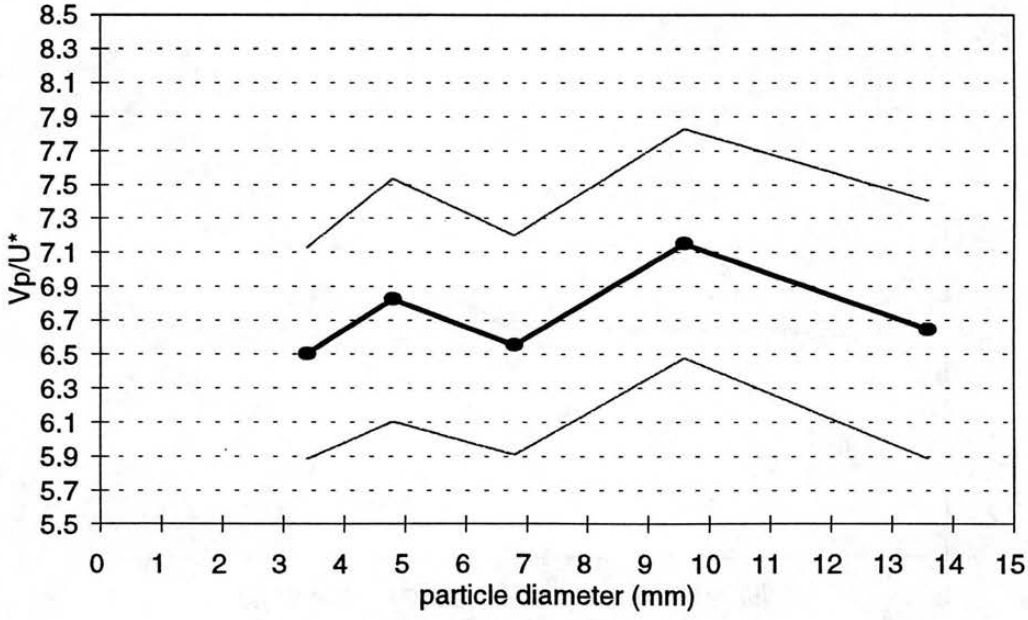
Vp/V vs. d

(natural)



Vp/U* vs. d

(natural)



Run#	34		Bed Roughness k:	1.7	mm	Streamflow	11.5746 L/s
Date	8-2-95		Pump Setting	slow		Valve Setting	full open
Reach Length	2000	mm	Slope Reading	111.5	mm	Bed Slope	0.00161

		Initial		Intermediate		Final	
Temperature		20	°C			19	°C
Manometer in. of water	Hi	53.9		53.7		53.8	
	Lo	15.5		15.5		15.5	
	Hi - Lo	38.4		38.2		38.3	
Flow Depth:	u.s.	68.6	mm	68.1	mm	68	mm
	d.s.	68.8	mm	68.7	mm	68.9	mm
	u.s. - d.s.	-0.2	mm	-0.6	mm	-0.9	mm
	at weir	68.1	mm	68.6	mm	67.8	mm
Top Width:	u.s.	675	mm	680	mm	684	mm
	d.s.	670	mm	673	mm	678	mm
	at weir	692	mm	702	mm	696	mm

Velocities (mm/s)

type	glass	160.0000	173.4605	181.3237	180.6685	167.9261	165.2893	167.0844
d (mm)	29.3	180.3427	163.6661	169.7793	166.6667	166.6667	167.0844	169.7793
n	21	165.8375	170.2128	178.8909	164.0689	162.8664	167.9261	167.9261
G	2.6			Std Dev	6.1259		Avg	169.4032

Velocities (mm/s)

type	glass	150.9434	166.2510	152.3229	156.3722	161.6815	153.8462	156.8627
d (mm)	25.17	156.1280	163.2653	160.0000	155.6420	159.4896	157.6044	156.8627
n	21	158.7302	164.8805	154.9187	164.3385	153.8462	157.9779	161.6815
G	2.6			Std Dev	4.2199		Avg	158.2688

Velocities (mm/s)

type	glass	149.5886	144.8226	150.6024	142.8571	142.5517	144.8226	148.1481
d (mm)	21.7	149.5886	149.9250	151.2859	147.0588	143.4720	145.7726	159.6169
n	21	154.2020	146.7351	132.0132	145.7726	146.7351	156.4945	155.0388
G	2.6			Std Dev	5.8645		Avg	147.9574

Velocities (mm/s)

type	glass	134.6801	139.1788	137.6462	145.7726	144.7178	130.0390	135.8696
d (mm)	15.97	132.5381	137.9310	135.0439	150.2630	127.4697	143.4720	136.1470
n	21	136.7054	135.5932	131.1475	129.2825	136.1470	130.2932	136.7054
G	2.6			Std Dev	5.7763		Avg	136.5068

		Velocities (mm/s)						
type	glass	130.8901	140.3509	135.5932	127.2265	133.3333	131.4060	131.1475
d (mm)	14.48	148.8095	151.6300	127.9591	135.3180	127.4697	132.1877	132.4503
n	21	130.6336	119.1895	152.7884	134.9528	137.9310	139.7624	135.8696
G	2.6			Std Dev	8.1921		Avg	135.0904

Steel particles moved only a few centimeters.

Natural particles exhibited start/stop motion rarely ever finishing a run.

Run# 34 Bed
Date: 8-2-95 Roughness k: 1.7 mm y/k: 40.304

Slope: 0.00161 Q: 11.57459 L/s U*: 0.0242 m/s

	u.s.	d.s.	avg
y (mm)	68.2333333	68.8	68.51667
Tw (mm)	679.666667	673.6667	676.6667
A (m^2)	0.03272357	0.032789	0.032757
P (m)	0.70229606	0.696994	0.699642
Rh (m)	0.04659512	0.047043	0.046819
V (m/s)	0.35370805	0.353003	0.353355
H (m)	0.07722034	0.075153	0.076187

delta H: 0.0020669 m delta x: 1.62 m

Sf: 0.00127589

Tavg: 19.5 °C

ν: 1.0162E-06 m^2/s

δ: 0.00048705 m

Run# 34

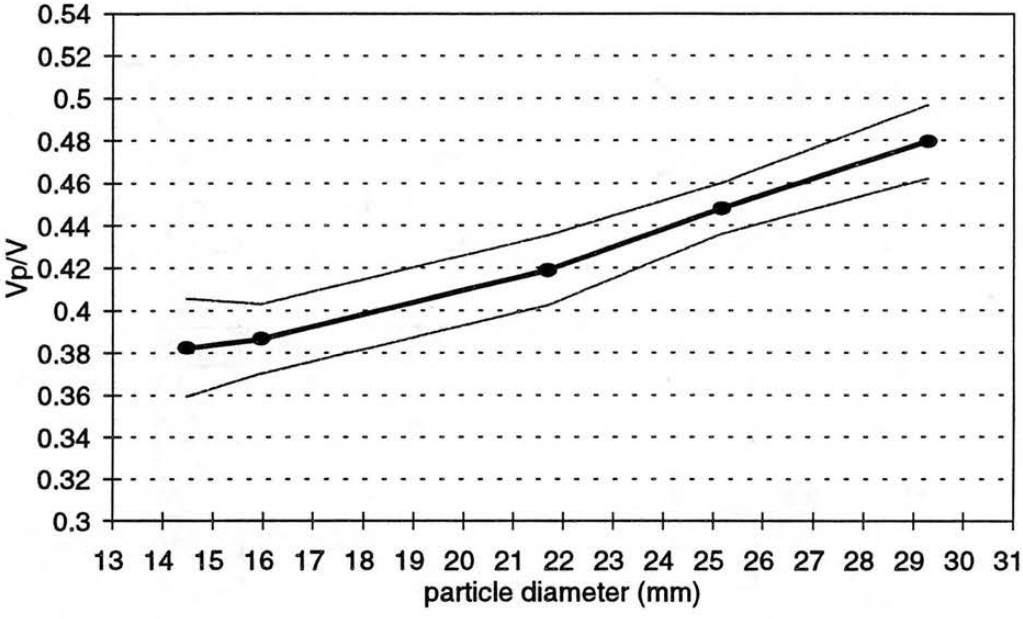
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	29.3	2.6	21	0.1694	0.0061	0.6392	725.6943	0.0013
glass	25.17	2.6	21	0.1583	0.0042	0.5924	623.4036	0.0015
glass	21.7	2.6	21	0.1480	0.0059	0.5500	537.4596	0.0017
glass	15.97	2.6	21	0.1365	0.0058	0.4716	395.5405	0.0023
glass	14.48	2.6	21	0.1351	0.0082	0.4490	358.6366	0.0026

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.4794	6.9991	0.2650	0.0379	17.2353	3490.4256	60.1585	2.3385
glass	0.4479	6.5391	0.2672	0.0409	14.8059	3490.4256	51.6788	2.7222
glass	0.4187	6.1130	0.2690	0.0440	12.7647	3490.4256	44.5543	3.1575
glass	0.3863	5.6400	0.2894	0.0513	9.3941	3490.4256	32.7895	4.2903
glass	0.3823	5.5814	0.3009	0.0539	8.5176	3490.4256	29.7302	4.7318

Run # 34
U* = 0.0242 (m/s)

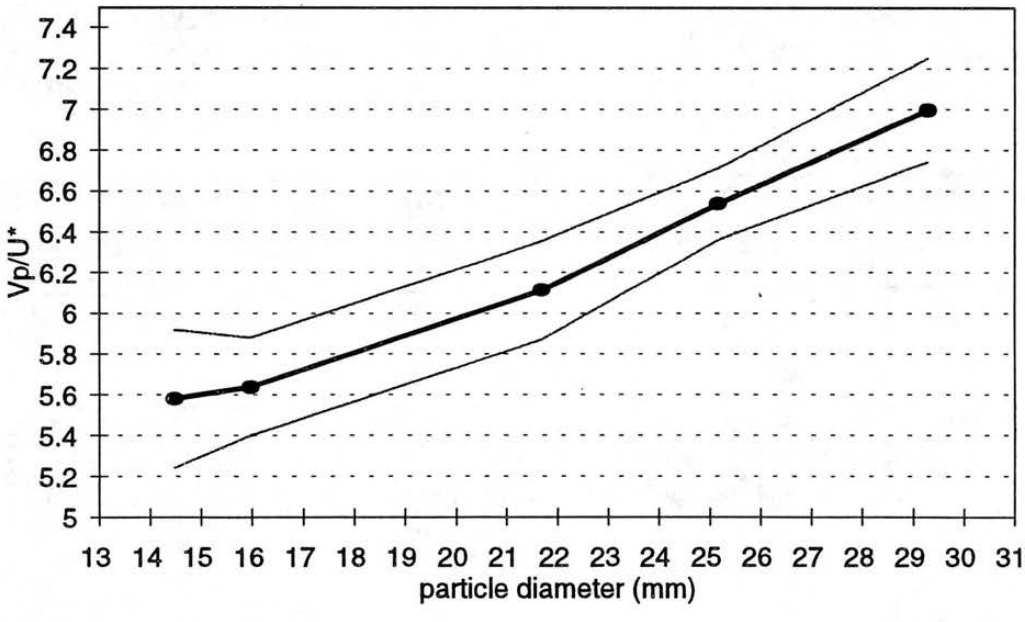
Vp/V vs. d

(glass)



Vp/U* vs. d

(glass)



Run#	35	Bed Roughness k:	1.7	mm	Streamflow	11.7226	L/s
Date	8-3-95	Pump Setting	medium		Valve Setting	7/16 open	
Reach Length	2000	mm	Slope Reading	116	mm	Bed Slope	0.00224

		Initial		Intermediate		Final	
Temperature		19.5	°C			19	°C
Manometer in. of water	Hi	18.96		18.96		18.96	
	Lo	-20.32		-20.32		-20.32	
	Hi - Lo	39.28		39.28		39.28	
Flow Depth:	u.s.	60.6	mm	60.4	mm	61	mm
	d.s.	60.8	mm	60.7	mm	61.1	mm
	u.s. - d.s.	-0.2	mm	-0.3	mm	-0.1	mm
	at weir	59.7	mm	60.4	mm	61.1	mm
Top Width:	u.s.	649	mm	632	mm	636	mm
	d.s.	618	mm	622	mm	627	mm
	at weir	635	mm	649	mm	660	mm

Velocities (mm/s)

type	glass	209.6436	197.4334	204.4990	213.2196	215.5172	217.8649	209.8636
d (mm)	29.3	211.1932	206.3983	202.4291	201.8163	198.8072	188.6792	212.7660
n	21	210.5263	200.8032	203.2520	207.6843	210.5263	207.6843	214.1328
G	2.6			Std Dev	6.9744		Avg	206.8924

Velocities (mm/s)

type	glass	182.3154	209.2050	199.4018	196.8504	217.6279	191.7546	197.0443
d (mm)	25.17	205.7613	201.8163	189.2148	191.5709	207.0393	198.0198	195.1220
n	21	191.7546	211.8644	200.0000	202.6342	195.6947	200.0000	209.2050
G	2.6			Std Dev	8.4070		Avg	199.7094

Velocities (mm/s)

type	glass	193.9864	195.1220	192.1230	181.8182	203.0457	218.5792	197.0443
d (mm)	21.7	195.1220	183.8235	186.0465	193.2367	183.9926	185.3568	207.2539
n	21	191.0220	176.8347	196.8504	222.9654	189.3939	197.6285	189.9335
G	2.6			Std Dev	11.3285		Avg	194.3419

Velocities (mm/s)

type	glass	171.9690	193.7984	179.2115	192.8640	176.2115	188.3239	186.7414
d (mm)	15.97	168.7764	200.0000	183.8235	174.8252	182.9826	185.0139	191.0220
n	21	180.8318	183.9926	191.7546	210.5263	192.1230	205.7613	209.2050
G	2.6			Std Dev	11.5128		Avg	188.0837

		Velocities (mm/s)						
type	glass	203.0457	171.5266	181.8182	165.0165	174.3679	183.9926	181.8182
d (mm)	14.48	179.8561	196.4637	174.8252	202.6342	186.0465	160.3849	176.3668
n	21	195.6947	171.6738	180.3427	172.4138	182.4818	180.3427	195.1220
G	2.6			Std Dev	11.5588		Avg	181.7255

		Velocities (mm/s)						
type	natural	130.8901	156.3722	154.2020	176.6784	142.5517	153.8462	146.8429
d (mm)	13.6	154.2020	156.1280	173.9130	171.0864	156.4945	153.0222	171.5266
n	21	147.1670	161.5509	156.1280	160.7717	164.0689	151.2859	169.7793
G	2.65			Std Dev	11.8266		Avg	157.4803

		Velocities (mm/s)						
type	natural	148.4781	181.8182	143.4720	141.2429	167.6446	146.7351	147.8197
d (mm)	9.6	143.1639	134.7709	175.2848	149.5886	160.7717	127.2265	148.8095
n	21	149.2537	142.2475	155.4002	149.8127	198.8072	177.7778	146.4129
G	2.65			Std Dev	17.7084		Avg	156.1171

The natural particles were moving in surges. Those smaller than 9.6mm rarely finished a run.

The steel particles rolled only a short distance before stopping.

Run# 35 Bed
Date: 8-3-95 Roughness k: 1.7 mm y/k: 35.745

Slope: 0.00224 Q: 11.72263 L/s U*: 0.0285 m/s

	u.s.	d.s.	avg
y (mm)	60.6666667	60.86667	60.76667
Tw (mm)	639	622.3333	630.6667
A (m²)	0.02786117	0.027446	0.027654
P (m)	0.65892328	0.643304	0.651102
Rh (m)	0.04228287	0.042664	0.042472
V (m/s)	0.42075166	0.427119	0.423936
H (m)	0.07332158	0.070168	0.071745

delta H: 0.0031535 m delta x: 1.62 m

Sf: 0.00194662

Tavg: 19.25 °C

ν: 1.0224E-06 m²/s

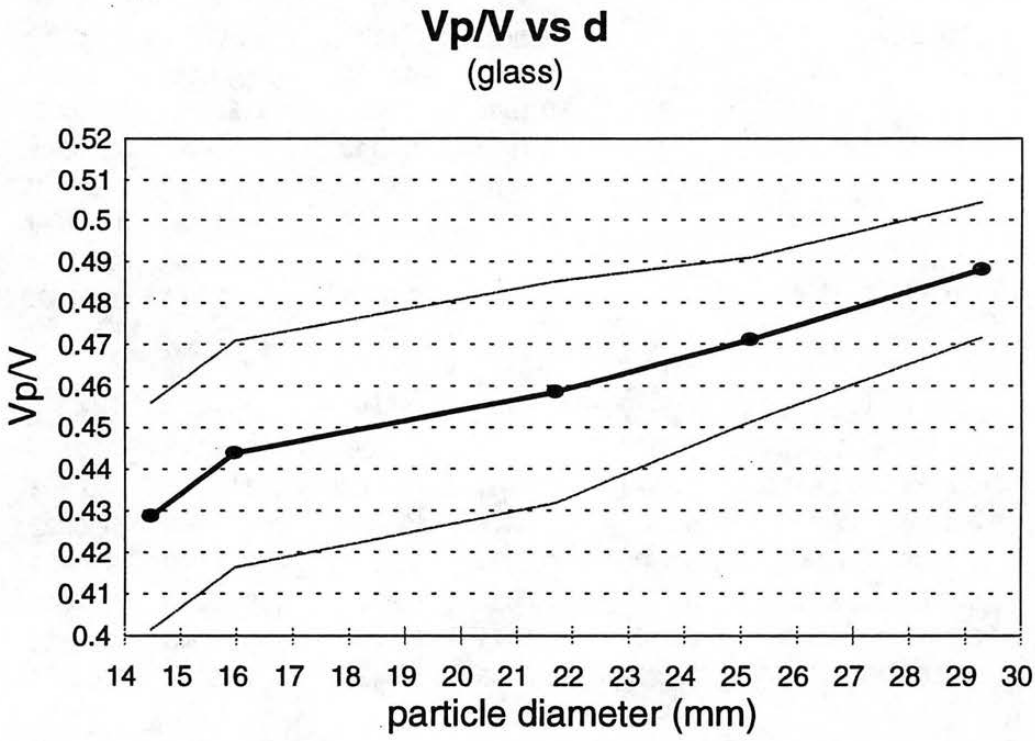
δ: 0.00041651 m

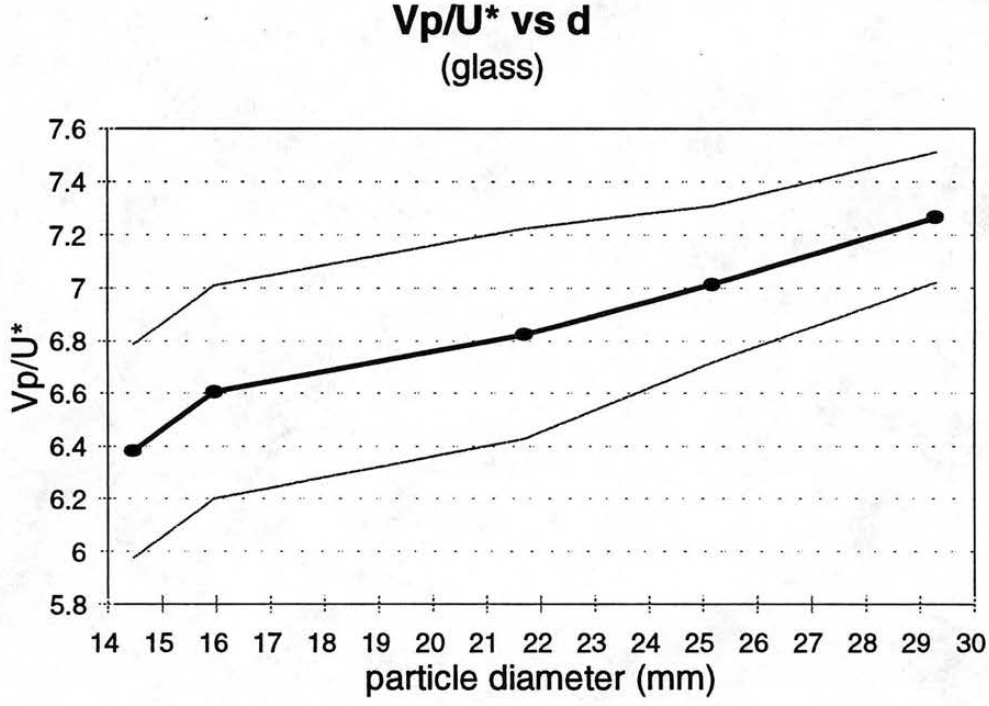
Run# 35

Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	29.3	2.6	21	0.2069	0.0070	0.6392	722.7660	0.0018
glass	25.17	2.6	21	0.1997	0.0084	0.5924	620.8881	0.0021
glass	21.7	2.6	21	0.1943	0.0113	0.5500	535.2909	0.0024
glass	15.97	2.6	21	0.1881	0.0115	0.4716	393.9445	0.0032
glass	14.48	2.6	21	0.1817	0.0116	0.4490	357.1895	0.0036
natural	13.6	2.65	21	0.1575	0.0118	0.4419	338.9407	0.0037
natural	9.6	2.65	21	0.1561	0.0177	0.3709	239.2522	0.0052

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.4880	7.2659	0.3237	0.0445	17.2353	4081.5043	70.3459	2.0739
glass	0.4711	7.0136	0.3371	0.0481	14.8059	4081.5043	60.4303	2.4142
glass	0.4584	6.8251	0.3534	0.0518	12.7647	4081.5043	52.0992	2.8003
glass	0.4437	6.6054	0.3988	0.0604	9.3941	4081.5043	38.3421	3.8051
glass	0.4287	6.3821	0.4047	0.0634	8.5176	4081.5043	34.7648	4.1966
natural	0.3715	5.5306	0.3564	0.0644	8.0000	4081.5043	32.6520	4.4681
natural	0.3683	5.4827	0.4209	0.0768	5.6471	4081.5043	23.0485	6.3299

Run 35
U* = 0.0285 m/s





Run#	36		Bed Roughness k:	1.7	mm	Streamflow	9.2545 L/s
Date	8-4-95		Pump Setting	slow		Valve Setting	1/2 open
Reach Length	2000	mm	Slope Reading	105	mm	Bed Slope	0.0007

		Initial		Intermediate		Final	
Temperature		19.5	°C			19.5	°C
Manometer in. of wasser	Hi	45.95		46		46	
	Lo	21.5		21.4		21.4	
	Hi - Lo	24.45		24.6		24.6	
Flow Depth:	u.s.	71.2	mm	71.2	mm	71.2	mm
	d.s.	71.1	mm	71.1	mm	71.1	mm
	u.s. - d.s.	0.1	mm	0.1	mm	0.1	mm
	at weir	70	mm	69.8	mm	69.8	mm
Top Width:	u.s.	688	mm	691	mm	691	mm
	d.s.	683	mm	685	mm	685	mm
	at weir	699	mm	700	mm	700	mm

Velocities (mm/s)

type	glass	132.5381	120.5546	125.9446	123.9926	120.9921	119.4030	119.1895
d (mm)	29.3	124.7661	124.5330	123.7624	117.0275	122.8501	123.5330	122.7747
n	21	122.8501	119.9041	120.0480	123.8390	117.0275	130.3781	128.2874
G	2.6			Std Dev	3.9825		Avg	123.0569

Velocities (mm/s)

type	glass	120.3369	117.4398	115.3403	109.4092	118.1335	117.4398	115.7407
d (mm)	25.17	111.8568	122.8501	122.1747	114.8765	117.8550	113.0582	112.4859
n	21	115.9420	119.6172	112.6761	112.6761	121.4329	116.3467	111.6695
G	2.6			Std Dev	3.7577		Avg	116.1599

Velocities (mm/s)

type	glass	107.3537	111.1111	103.8961	108.6366	114.6789	110.7420	107.4114
d (mm)	21.7	112.2334	114.4820	109.5890	118.4834	109.1703	110.9262	105.4296
n	21	103.8961	109.9505	109.0513	111.4827	102.1972	107.5847	110.3144
G	2.6			Std Dev	3.8546		Avg	109.4581

Velocities (mm/s)

type	glass	96.2464	96.5251	95.8313	98.6193	92.0810	93.1532	91.4495
d (mm)	15.97	96.0615	88.8889	95.7854	88.6525	90.9091	93.6768	93.2836
n	21	93.9408	92.8505	95.2381	88.4173	89.5255	97.8474	92.7644
G	2.6			Std Dev	3.0214		Avg	93.4166

		Velocities (mm/s)						
type	glass	81.3339	89.6459	93.1532	87.6808	89.2459	97.7040	96.1076
d (mm)	14.48	85.6898	89.5656	84.6740	87.5274	92.4642	95.1022	86.3931
n	21	84.1043	90.6618	98.2801	91.1577	87.9121	88.4173	90.2935
G	2.6			Std Dev	4.4597		Avg	89.8626

No motion for the steel and natural particles.

Smaller glass particles meandered noticably.

Run# 36 Bed
Date: 8-4-95 Roughness k: 1.7 mm y/k: 41.853

Slope: 0.0007 Q: 9.254487 L/s U*: 0.0186 m/s

	u.s.	d.s.	avg
y (mm)	71.2	71.1	71.15
Tw (mm)	690	684.3333	687.1667
A (m²)	0.0345142	0.034264	0.034389
P (m)	0.71399742	0.708581	0.711289
Rh (m)	0.04833939	0.048356	0.048348
V (m/s)	0.26813563	0.270091	0.269114
H (m)	0.07599971	0.074819	0.07541

delta H: 0.0011803 m delta x: 1.62 m

Sf: 0.0007286

Tavg: 19.5 °C

ν: 1.0162E-06 m²/s

δ: 0.00063424 m

Run# 36

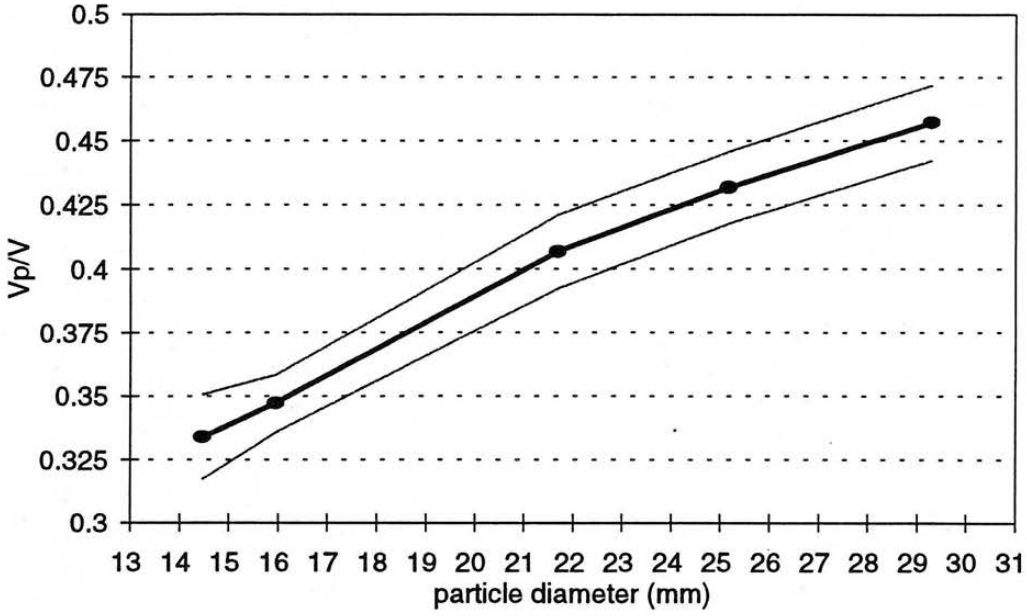
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	29.3	2.6	21	0.1231	0.0040	0.6392	725.6943	0.0008
glass	25.17	2.6	21	0.1162	0.0038	0.5924	623.4036	0.0009
glass	21.7	2.6	21	0.1095	0.0039	0.5500	537.4596	0.0010
glass	15.97	2.6	21	0.0934	0.0030	0.4716	395.5405	0.0014
glass	14.48	2.6	21	0.0899	0.0045	0.4490	358.6366	0.0015

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.4573	6.6208	0.1925	0.0291	17.2353	2680.3533	46.1967	2.4283
glass	0.4316	6.2498	0.1961	0.0314	14.8059	2680.3533	39.6850	2.8268
glass	0.4067	5.8892	0.1990	0.0338	12.7647	2680.3533	34.2139	3.2788
glass	0.3471	5.0261	0.1981	0.0394	9.3941	2680.3533	25.1796	4.4552
glass	0.3339	4.8349	0.2001	0.0414	8.5176	2680.3533	22.8303	4.9137

Run # 36
U* = 0.0186 (m/s)

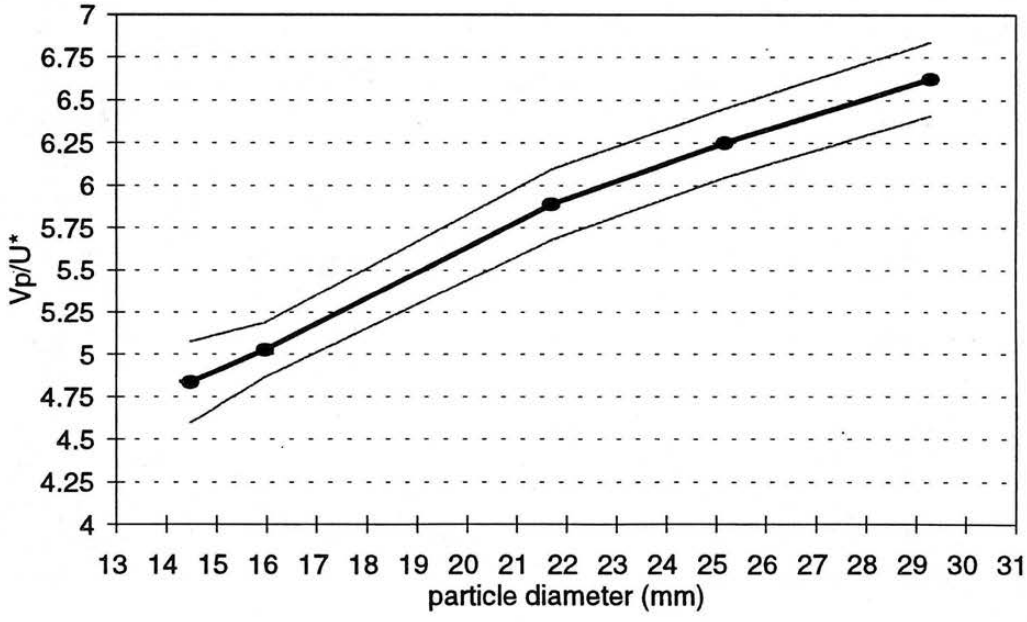
Vp/V vs. d

(glass)



Vp/U* vs. d

(glass)



Run#	37		Bed Roughness k:	2.4	mm	Streamflow	19.2825 L/s
Date	8-5-95		Pump Setting	fast		Valve Setting	7/16 open
Reach Length	2000	mm	Slope Reading	171.5	mm	Bed Slope	0.01

		Initial		Intermediate		Final	
Temperature		19.5	°C			21	°C
Manometer in. of water	Hi	51.47		51.47		51.47	
	Lo	-54.18		-54.18		-54.18	
	Hi - Lo	105.65		105.65		105.65	
Flow Depth:	u.s.	52.4	mm	53.1	mm	53.1	mm
	d.s.	52.9	mm	53.7	mm	54.1	mm
	u.s. - d.s.	-0.5	mm	-0.6	mm	-1	mm
	at weir	50.7	mm	52.1	mm	52.1	mm
Top Width:	u.s.	592	mm	597	mm	600	mm
	d.s.	592	mm	598	mm	602	mm
	at weir	593	mm	595	mm	595	mm

Velocities (mm/s)

type	steel	243.3090	273.2240	268.8172	243.3090	249.0660	285.7143	263.5046
d (mm)	19.04	282.8854	234.4666	291.1208	264.5503	268.8172	288.1844	266.6667
n	21	246.0025	248.1390	231.7497	285.7143	263.1579	288.6003	260.0780
G	8.02			Std Dev	18.6375		Avg	264.1465

Velocities (mm/s)

type	steel	274.7253	251.8892	264.5503	228.5714	243.3090	240.6739	268.0965
d (mm)	15.88	266.6667	231.7497	264.2008	244.2002	250.0000	231.2139	284.4950
n	21	280.5049	288.1844	236.1275	255.1020	294.9853	252.2068	235.2941
G	8.02			Std Dev	20.1189		Avg	256.5118

Velocities (mm/s)

type	steel	257.0694	300.3003	238.6635	233.6449	254.7771	276.6252	254.1296
d (mm)	14.28	275.8621	237.2479	244.4988	285.7143	297.6190	239.8082	251.8892
n	21	236.9668	274.7253	255.7545	239.5210	312.5000	247.8315	269.9055
G	8.02			Std Dev	23.2782		Avg	261.1930

Velocities (mm/s)

type	steel	274.7253	294.9853	290.6977	331.6750	264.5503	331.1258	257.0694
d (mm)	9.5	283.2861	258.7322	268.8172	330.0330	296.2963	244.2002	286.9440
n	21	293.6858	261.4379	278.1641	251.8892	316.4557	297.6190	289.4356
G	8.02			Std Dev	25.9322		Avg	285.8012

Velocities (mm/s)

type	steel	260.7562	260.0780	340.7155	320.0000	283.2861	253.8071	312.5000
d (mm)	7.9	288.1844	284.4950	293.2551	324.6753	392.9273	311.0420	353.9823
n	21	306.2787	307.6923	361.6637	301.6591	302.1148	301.6591	284.4950
G	8.02			Std Dev	34.3608		Avg	306.9175

Velocities (mm/s)

type	steel	338.4095	282.8854	297.6190	365.6307	324.6753	343.6426	321.5434
d (mm)	6.34	281.6901	372.4395	331.1258	365.6307	315.4574	263.8522	323.6246
n	21	323.6246	271.3704	324.6753	253.8071	293.6858	312.5000	327.8689
G	8.02			Std Dev	32.9746		Avg	315.9885

Velocities (mm/s)

type	glass	704.2254	781.2500	727.2727	778.2101	727.2727	790.5138	775.1938
d (mm)	29.3	727.2727	694.4444	751.8797	763.3588	704.2254	790.5138	775.1938
n	21	749.0637	727.2727	790.5138	781.2500	751.8797	696.8641	727.2727
G	2.6			Std Dev	32.9799		Avg	748.3307

Velocities (mm/s)

type	glass	727.2727	704.2254	709.2199	696.8641	673.4007	760.4563	701.7544
d (mm)	25.17	769.2308	743.4944	778.2101	735.2941	696.8641	749.0637	790.5138
n	21	735.2941	727.2727	729.9270	769.2308	727.2727	772.2008	800.0000
G	2.6			Std Dev	34.1035		Avg	737.9554

Velocities (mm/s)

type	glass	760.4563	696.8641	738.0074	680.2721	709.2199	796.8127	790.5138
d (mm)	21.7	696.8641	711.7438	719.4245	677.9661	687.2852	727.2727	754.7170
n	21	735.2941	823.0453	709.2199	711.7438	701.7544	696.8641	666.6667
G	2.6			Std Dev	41.3911		Avg	723.4289

Velocities (mm/s)

type	glass	735.2941	751.8797	694.4444	696.8641	704.2254	628.9308	757.5758
d (mm)	15.97	653.5948	735.2941	666.6667	689.6552	735.2941	689.6552	696.8641
n	21	666.6667	746.2687	754.7170	666.6667	647.2492	711.7438	687.2852
G	2.6			Std Dev	37.9256		Avg	700.8017

Velocities (mm/s)

type	glass	607.9027	660.0660	727.2727	743.4944	800.0000	787.4016	593.4718
d (mm)	14.48	645.1613	719.4245	743.4944	694.4444	680.2721	687.2852	727.2727
n	21	694.4444	660.0660	673.4007	709.2199	701.7544	711.7438	719.4245
G	2.6			Std Dev	50.6111		Avg	699.3818

Velocities (mm/s)

type	natural	533.3333	625.0000	586.5103	598.8024	604.2296	662.2517	576.3689
d (mm)	13.6	647.2492	684.9315	576.3689	628.9308	638.9776	619.1950	626.9592
n	21	604.2296	680.2721	660.0660	566.5722	680.2721	699.3007	638.9776
G	2.65			Std Dev	43.7873		Avg	625.6571

		Velocities (mm/s)						
type	natural	634.9206	581.3953	673.4007	634.9206	641.0256	523.5602	673.4007
d (mm)	9.6	680.2721	666.6667	537.6344	643.0868	666.6667	696.8641	581.3953
n	21	634.9206	597.0149	628.9308	666.6667	576.3689	668.8963	653.5948
G	2.65			Std Dev	47.8212		Avg	631.5049

		Velocities (mm/s)						
type	natural	680.2721	621.1180	636.9427	604.2296	680.2721	709.2199	645.1613
d (mm)	6.8	470.5882	615.3846	738.0074	481.9277	546.4481	621.1180	546.4481
n	21	809.7166	563.3803	623.0530	606.0606	641.0256	694.4444	547.9452
G	2.65			Std Dev	81.5297		Avg	622.9887

		Velocities (mm/s)						
type	natural	566.5722	609.7561	626.9592	550.9642	641.0256	581.3953	630.9148
d (mm)	4.8	602.4096	533.3333	615.3846	549.4505	576.3689	638.9776	542.0054
n	21	571.4286	579.7101	557.1031	578.0347	520.8333	496.2779	529.1005
G	2.65			Std Dev	40.9971		Avg	576.0955

		Velocities (mm/s)						
type	natural	588.2353	446.4286	547.9452	470.5882	524.9344	680.2721	487.8049
d (mm)	3.4	555.5556	465.1163	534.7594	496.2779	512.8205	566.5722	537.6344
n	21	464.0371	571.4286	473.9336	586.5103	552.4862	550.9642	560.2241
G	2.65			Std Dev	54.9988		Avg	532.1204

Steel particles smaller than 14.28mm moved with surges and suspension, smaller particles were worse than the larger.

There was considerable suspension in the glass particles smaller than 21.7mm.

All the natural particles showed suspension, it increased noticably with a decrease in particle size.

Run# 37 Bed
Date: 8-5-95 Roughness k: 2.4 mm y/k: 22.174

Slope: 0.01 Q: 19.2825 L/s U*: 0.0616 m/s

	u.s.	d.s.	avg
y (mm)	52.8666667	53.56667	53.21667
Tw (mm)	596.333333	597.3333	596.8333
A (m^2)	0.02315119	0.023485	0.023318
P (m)	0.61351033	0.614904	0.614207
Rh (m)	0.03773562	0.038192	0.037964
V (m/s)	0.8328942	0.821073	0.826983
H (m)	0.10443617	0.087939	0.096188

delta H: 0.0164969 m delta x: 1.62 m

Sf: 0.01018327

Tavg: 20.25 °C

ν: 9.9795E-07 m^2/s

δ: 0.00018801 m

Run# 37

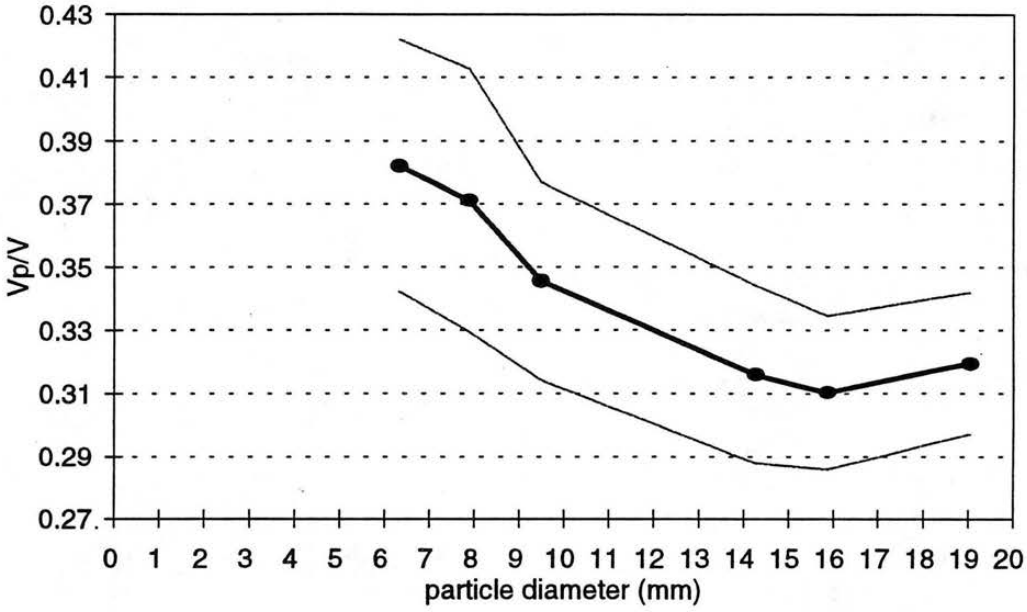
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	21	0.2641	0.0186	1.0794	781.4105	0.0029
steel	15.88	8.02	21	0.2565	0.0201	0.9857	651.7226	0.0035
steel	14.28	8.02	21	0.2612	0.0233	0.9346	586.0578	0.0039
steel	9.5	8.02	21	0.2858	0.0259	0.7619	389.8844	0.0058
steel	7.9	8.02	21	0.3069	0.0344	0.6946	324.2197	0.0070
steel	6.34	8.02	21	0.3160	0.0330	0.6219	260.1965	0.0087
glass	29.3	2.6	21	0.7483	0.0330	0.6392	734.5266	0.0082
glass	25.17	2.6	21	0.7380	0.0341	0.5924	630.9909	0.0096
glass	21.7	2.6	21	0.7234	0.0414	0.5500	544.0009	0.0111
glass	15.97	2.6	21	0.7008	0.0379	0.4716	400.3546	0.0151
glass	14.48	2.6	21	0.6994	0.0506	0.4490	363.0015	0.0167
natural	13.6	2.65	21	0.6257	0.0438	0.4419	344.4558	0.0172
natural	9.6	2.65	21	0.6315	0.0478	0.3709	243.1452	0.0244
natural	6.8	2.65	21	0.6230	0.0815	0.3117	172.2279	0.0345
natural	4.8	2.65	21	0.5761	0.0410	0.2612	121.5726	0.0488
natural	3.4	2.65	21	0.5321	0.0550	0.2189	86.1139	0.0689

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.3194	4.2900	0.2447	0.0570	7.9333	12765.3597	101.2719	2.7950
steel	0.3102	4.1660	0.2602	0.0625	6.6167	12765.3597	84.4641	3.3512
steel	0.3158	4.2420	0.2795	0.0659	5.9500	12765.3597	75.9539	3.7267
steel	0.3456	4.6417	0.3751	0.0808	3.9583	12765.3597	50.5295	5.6018
steel	0.3711	4.9846	0.4419	0.0887	3.2917	12765.3597	42.0193	6.7363
steel	0.3821	5.1319	0.5081	0.0990	2.6417	12765.3597	33.7218	8.3938
glass	0.9049	12.1536	1.1706	0.0963	12.2083	12765.3597	155.8438	1.8163
glass	0.8923	11.9850	1.2457	0.1039	10.4875	12765.3597	133.8767	2.1143
glass	0.8748	11.7491	1.3153	0.1120	9.0417	12765.3597	115.4201	2.4524
glass	0.8474	11.3816	1.4859	0.1306	6.6542	12765.3597	84.9428	3.3323
glass	0.8457	11.3586	1.5576	0.1371	6.0333	12765.3597	77.0177	3.6752
natural	0.7566	10.1612	1.4159	0.1393	5.6667	12765.3597	72.3370	3.9130
natural	0.7636	10.2562	1.7026	0.1660	4.0000	12765.3597	51.0614	5.5434
natural	0.7533	10.1179	1.9987	0.1975	2.8333	12765.3597	36.1685	7.8260
natural	0.6966	9.3563	2.2056	0.2357	2.0000	12765.3597	25.5307	11.0868
natural	0.6434	8.6421	2.4310	0.2813	1.4167	12765.3597	18.0843	15.6520

Run # 37
U* = 0.0616 (m/s)

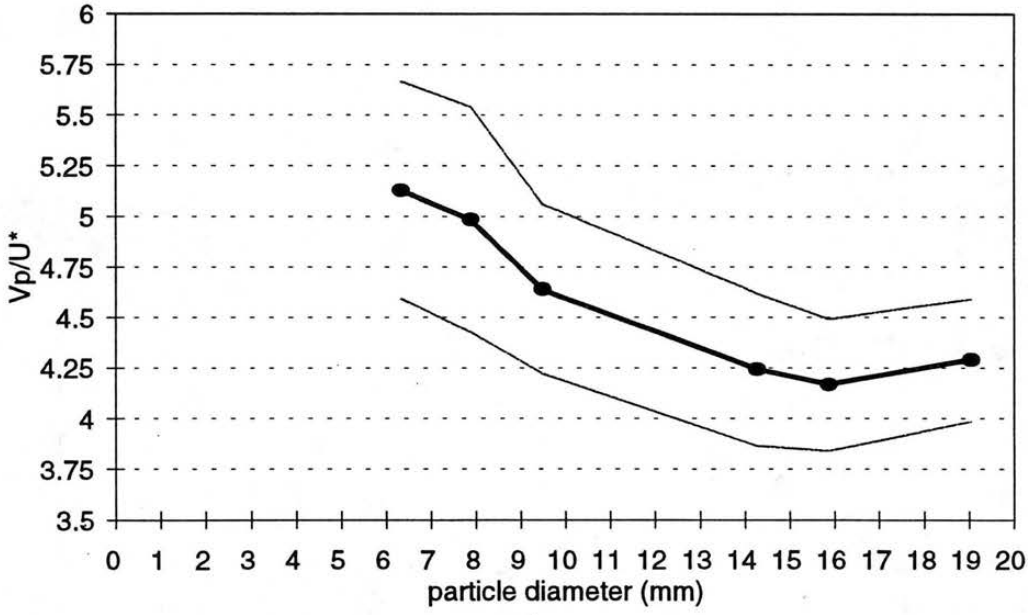
Vp/V vs. d

(steel)



Vp/U* vs. d

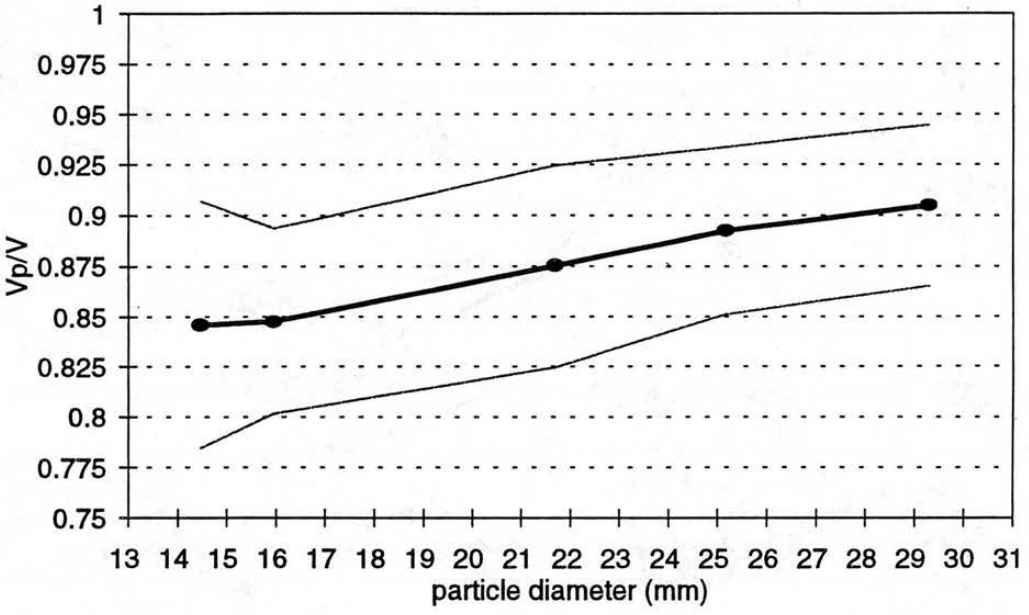
(steel)



Run # 37
U* = 0.0616 (m/s)

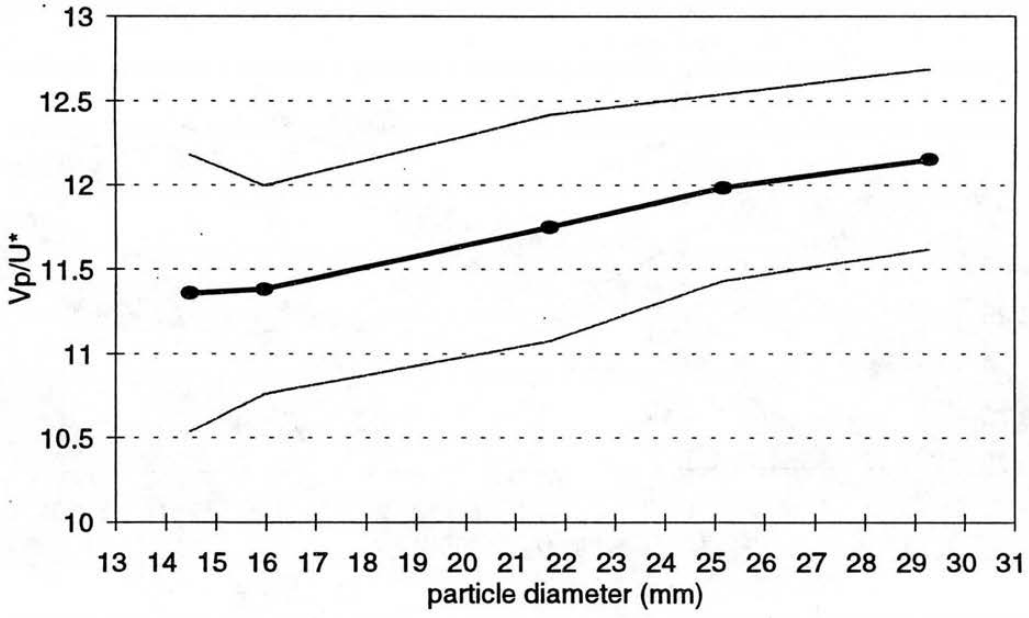
Vp/V vs. d

(glass)



Vp/U* vs. d

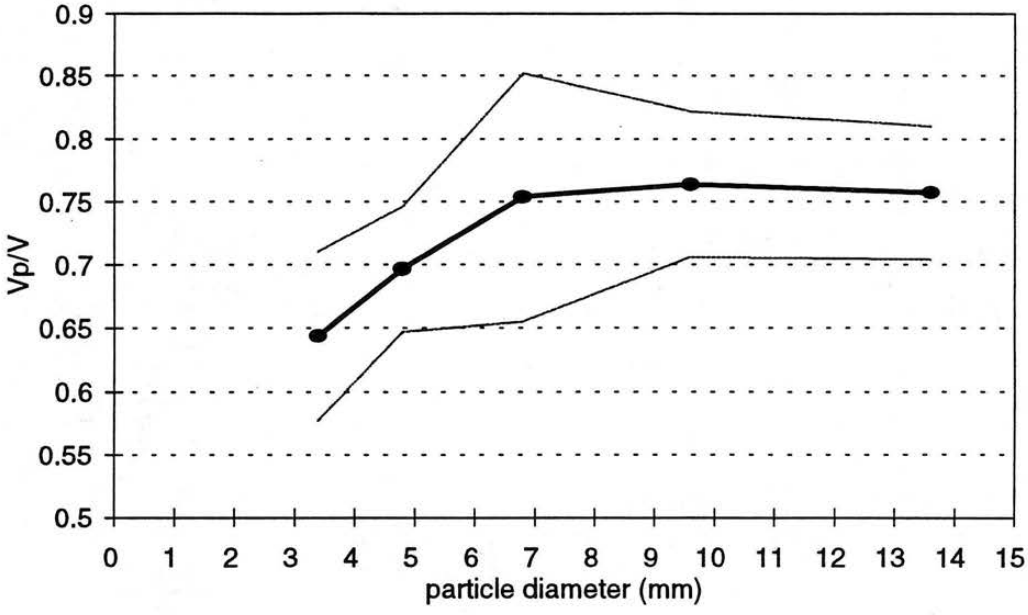
(glass)



Run # 37
U* = 0.0616 (m/s)

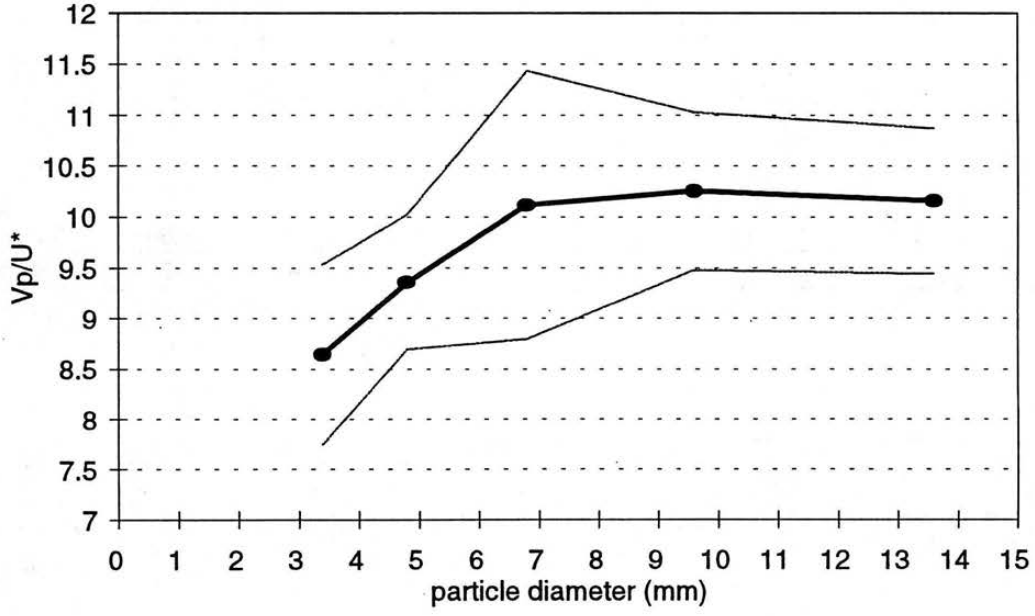
Vp/V vs. d

(natural)



Vp/U* vs. d

(natural)



Run #	38		Bed Roughness k:	2.4	mm	Streamflow	17.7298 L/s
Date	8-7-95		Pump Setting	fast		Valve Setting	7/16 open
Reach Length	2000	mm	Slope Reading	160	mm	Bed Slope	0.0084

		Initial		Intermediate		Final	
Temperature		20	°C			21	°C
Manometer in. of water	Hi	43.35		43.35		43.35	
	Lo	-46.06		-46.06		-46.06	
	Hi - Lo	89.41		89.41		89.41	
Flow Depth:	u.s.	52.4	mm	52.1	mm	52.1	mm
	d.s.	53.9	mm	54.1	mm	53.2	mm
	u.s. - d.s.	-1.5	mm	-2	mm	-1.1	mm
	at weir	52.4	mm	52.4	mm	52.7	mm
Top Width:	u.s.	597	mm	593	mm	595	mm
	d.s.	590	mm	590	mm	595	mm
	at weir	584	mm	578	mm	586	mm

Velocities (mm/s)

type	steel	215.5172	224.7191	199.4018	210.5263	210.5263	221.4839	207.0393
d (mm)	19.04	204.4990	209.8636	201.8163	227.0148	214.1328	210.5263	217.8649
n	21	202.4291	207.0393	203.6660	229.6211	227.7904	206.3983	212.7660
G	8.02			Std Dev	9.0904		Avg	212.6020

Velocities (mm/s)

type	steel	215.5172	204.4990	211.8644	212.7660	236.1275	176.6784	191.5709
d (mm)	15.88	194.3635	215.5172	205.1282	202.6342	198.0198	202.6342	220.0220
n	21	216.9197	231.7497	219.2982	230.4147	202.6342	214.8228	221.4839
G	8.02			Std Dev	14.2809		Avg	210.6984

Velocities (mm/s)

type	steel	206.6116	216.2162	202.4291	204.4990	221.4839	208.9864	220.7506
d (mm)	14.28	188.1468	208.9864	186.0465	215.5172	215.5172	220.7506	230.9469
n	21	208.3333	192.1230	191.0220	192.1230	222.9654	214.5923	204.4990
G	8.02			Std Dev	12.6660		Avg	208.2165

Velocities (mm/s)

type	steel	250.9410	256.7394	213.9037	218.3406	251.8892	222.9654	203.2520
d (mm)	9.5	197.4334	213.2196	242.4242	221.4839	222.4694	189.7533	222.2222
n	21	216.9197	193.9864	172.5626	199.4018	214.8228	212.5399	196.2709
G	8.02			Std Dev	21.5520		Avg	215.8829

		Velocities (mm/s)						
type	steel	250.9410	200.6018	187.0907	213.4472	223.7136	222.2222	236.9668
d (mm)	7.9	233.6449	192.6782	220.7506	222.2222	266.6667	197.4334	200.6018
n	21	215.5172	222.9654	208.3333	298.0626	201.2072	202.4291	311.0420
G	8.02			Std Dev	32.7231		Avg	225.1685

		Velocities (mm/s)						
type	glass	626.9592	666.6667	638.9776	673.4007	649.3506	651.4658	673.4007
d (mm)	29.3	647.2492	621.1180	621.1180	641.0256	591.7160	673.4007	632.9114
n	21	696.8641	666.6667	666.6667	704.2254	626.9592	638.9776	660.0660
G	2.6			Std Dev	26.8787		Avg	650.9136

		Velocities (mm/s)						
type	glass	666.6667	660.0660	634.9206	653.5948	647.2492	660.0660	687.2852
d (mm)	25.17	641.0256	653.5948	645.1613	641.0256	626.9592	647.2492	673.4007
n	21	653.5948	660.0660	647.2492	604.2296	666.6667	602.4096	638.9776
G	2.6			Std Dev	20.2633		Avg	648.1647

		Velocities (mm/s)						
type	glass	609.7561	660.0660	597.0149	647.2492	632.9114	660.0660	647.2492
d (mm)	21.7	666.6667	638.9776	634.9206	615.3846	666.6667	653.5948	634.9206
n	21	660.0660	632.9114	628.9308	604.2296	632.9114	660.0660	615.3846
G	2.6			Std Dev	21.0071		Avg	638.0926

		Velocities (mm/s)						
type	glass	609.7561	621.1180	609.7561	591.7160	621.1180	647.2492	615.3846
d (mm)	15.97	626.9592	621.1180	647.2492	597.0149	666.6667	704.2254	598.8024
n	21	609.7561	581.3953	673.4007	666.6667	687.2852	576.3689	621.1180
G	2.6			Std Dev	34.9506		Avg	628.2917

		Velocities (mm/s)						
type	glass	561.7978	647.2492	626.9592	632.9114	660.0660	647.2492	581.3953
d (mm)	14.48	588.2353	571.4286	645.1613	581.3953	641.0256	607.9027	588.2353
n	21	593.4718	597.0149	566.5722	680.2721	615.3846	519.4805	547.9452
G	2.6			Std Dev	40.9071		Avg	604.8168

		Velocities (mm/s)						
type	natural	468.3841	529.1005	534.7594	500.0000	491.4005	609.7561	558.6592
d (mm)	13.6	546.4481	503.7783	550.9642	488.9976	523.5602	487.8049	542.0054
n	21	533.3333	598.8024	571.4286	546.4481	593.4718	533.3333	571.4286
G	2.65			Std Dev	38.5990		Avg	537.3269

		Velocities (mm/s)						
type	natural	435.7298	597.0149	591.7160	561.7978	623.0530	503.7783	520.8333
d (mm)	9.6	505.0505	581.3953	561.7978	581.3953	537.6344	546.4481	591.7160
n	21	611.6208	515.4639	561.7978	434.7826	473.9336	539.0836	477.3270
G	2.65			Std Dev	54.4324		Avg	540.6367

		Velocities (mm/s)						
type	natural	441.5011	500.0000	546.4481	485.4369	480.7692	450.4505	550.9642
d (mm)	6.8	546.4481	581.3953	507.6142	487.8049	542.0054	581.3953	533.3333
n	21	515.4639	438.5965	488.9976	576.3689	519.4805	480.7692	547.9452
G	2.65			Std Dev	43.7822		Avg	514.4375

		Velocities (mm/s)						
type	natural	554.0166	505.0505	557.1031	561.7978	460.8295	500.0000	500.0000
d (mm)	4.8	527.7045	477.3270	516.7959	464.0371	450.4505	500.0000	566.5722
n	21	492.6108	630.9148	626.9592	547.9452	454.5455	512.8205	447.4273
G	2.65			Std Dev	52.8717		Avg	516.9004

		Velocities (mm/s)						
type	natural	395.2569	542.0054	488.9976	475.0594	455.5809	505.0505	426.4392
d (mm)	3.4	466.2005	447.4273	424.6285	495.0495	475.0594	507.6142	497.5124
n	21	467.2897	459.7701	395.2569	480.7692	446.4286	533.3333	588.2353
G	2.65			Std Dev	46.7735		Avg	474.9031

The steel particles with 7.90mm diameter showed noticable surging. Smaller steel particles did not move much.

All natural particles showed suspension, the smaller ones more than the larger ones.
The natural particles of diameter 3.4mm also moved with significant surging.

Run# 38 Bed
Date: 8-7-95 Roughness k: 2.4 mm y/k: 22.069

Slope: 0.0084 Q: 17.72981 L/s U*: 0.0558 m/s

	u.s.	d.s.	avg
y (mm)	52.2	53.73333	52.96667
Tw (mm)	595	591.6667	593.3333
A (m²)	0.02282445	0.023405	0.023116
P (m)	0.61182456	0.609647	0.61073
Rh (m)	0.03730555	0.038392	0.037849
V (m/s)	0.77679025	0.757511	0.767151
H (m)	0.096573	0.08299	0.089782

delta H: 0.0135828 m delta x: 1.62 m

Sf: 0.00838446

Tavg: 20.5 °C

ν: 9.9195E-07 m²/s

δ: 0.00020626 m

Run# 38

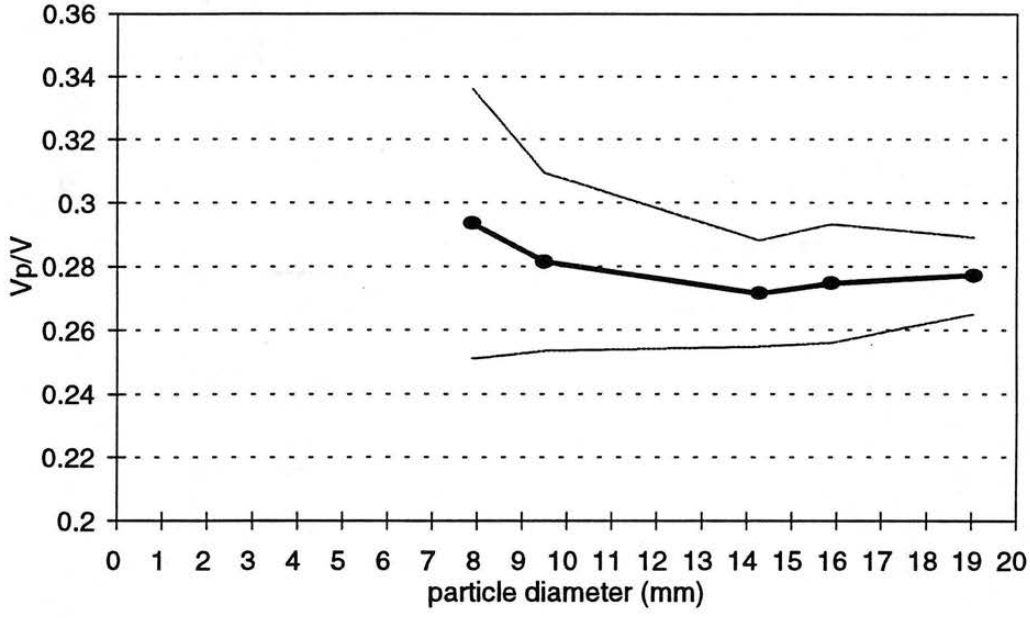
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	21	0.2126	0.0091	1.0794	784.5587	0.0024
steel	15.88	8.02	21	0.2107	0.0143	0.9857	654.3483	0.0028
steel	14.28	8.02	21	0.2082	0.0127	0.9346	588.4190	0.0032
steel	9.5	8.02	21	0.2159	0.0216	0.7619	391.4552	0.0048
steel	7.9	8.02	21	0.2252	0.0327	0.6946	325.5259	0.0057
glass	29.3	2.6	21	0.6509	0.0269	0.6392	737.4859	0.0068
glass	25.17	2.6	21	0.6482	0.0203	0.5924	633.5331	0.0079
glass	21.7	2.6	21	0.6381	0.0210	0.5500	546.1927	0.0091
glass	15.97	2.6	21	0.6283	0.0350	0.4716	401.9676	0.0124
glass	14.48	2.6	21	0.6048	0.0409	0.4490	364.4640	0.0137
natural	13.6	2.65	21	0.5373	0.0386	0.4419	345.8436	0.0141
natural	9.6	2.65	21	0.5406	0.0544	0.3709	244.1249	0.0200
natural	6.8	2.65	21	0.5144	0.0438	0.3117	172.9218	0.0283
natural	4.8	2.65	21	0.5169	0.0529	0.2612	122.0624	0.0401
natural	3.4	2.65	21	0.4749	0.0468	0.2189	86.4609	0.0566

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.2771	3.8110	0.1970	0.0517	7.9333	11635.5612	92.3088	2.7819
steel	0.2747	3.7769	0.2138	0.0566	6.6167	11635.5612	76.9886	3.3354
steel	0.2714	3.7324	0.2228	0.0597	5.9500	11635.5612	69.2316	3.7092
steel	0.2814	3.8698	0.2833	0.0732	3.9583	11635.5612	46.0574	5.5754
steel	0.2935	4.0363	0.3242	0.0803	3.2917	11635.5612	38.3004	6.7046
glass	0.8485	11.6680	1.0183	0.0873	12.2083	11635.5612	142.0508	1.8077
glass	0.8449	11.6188	1.0941	0.0942	10.4875	11635.5612	122.0279	2.1044
glass	0.8318	11.4382	1.1602	0.1014	9.0417	11635.5612	105.2049	2.4409
glass	0.8190	11.2625	1.3321	0.1183	6.6542	11635.5612	77.4250	3.3166
glass	0.7884	10.8417	1.3469	0.1242	6.0333	11635.5612	70.2012	3.6579
natural	0.7004	9.6319	1.2160	0.1262	5.6667	11635.5612	65.9348	3.8946
natural	0.7047	9.6913	1.4576	0.1504	4.0000	11635.5612	46.5422	5.5174
natural	0.6706	9.2216	1.6504	0.1790	2.8333	11635.5612	32.9674	7.7892
natural	0.6738	9.2658	1.9789	0.2136	2.0000	11635.5612	23.2711	11.0347
natural	0.6190	8.5129	2.1694	0.2548	1.4167	11635.5612	16.4837	15.5784

Run # 38
U* = 0.0558 (m/s)

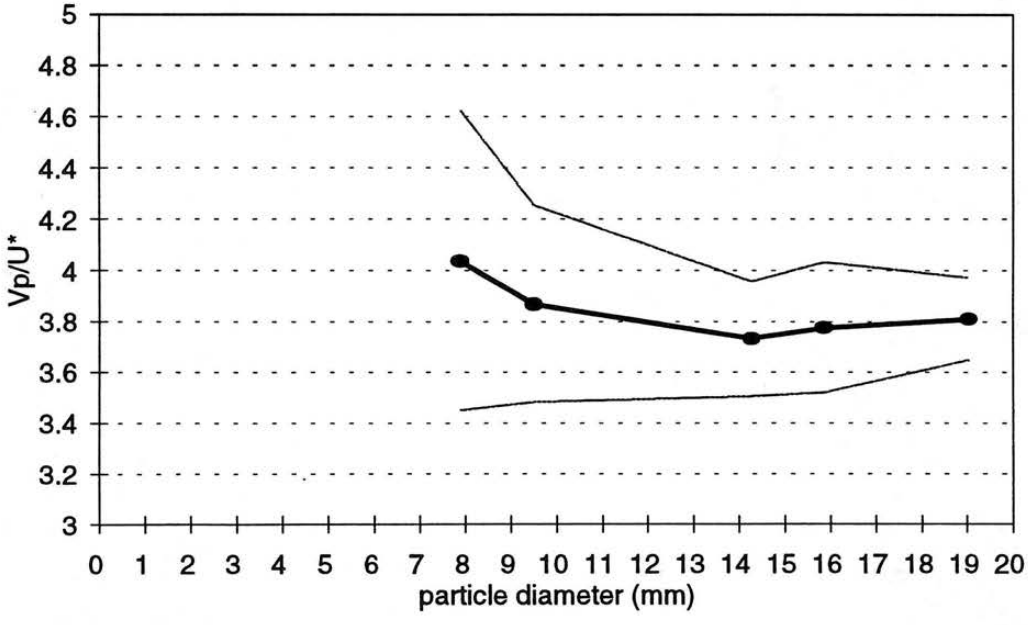
Vp/V vs. d

(steel)



Vp/U* vs. d

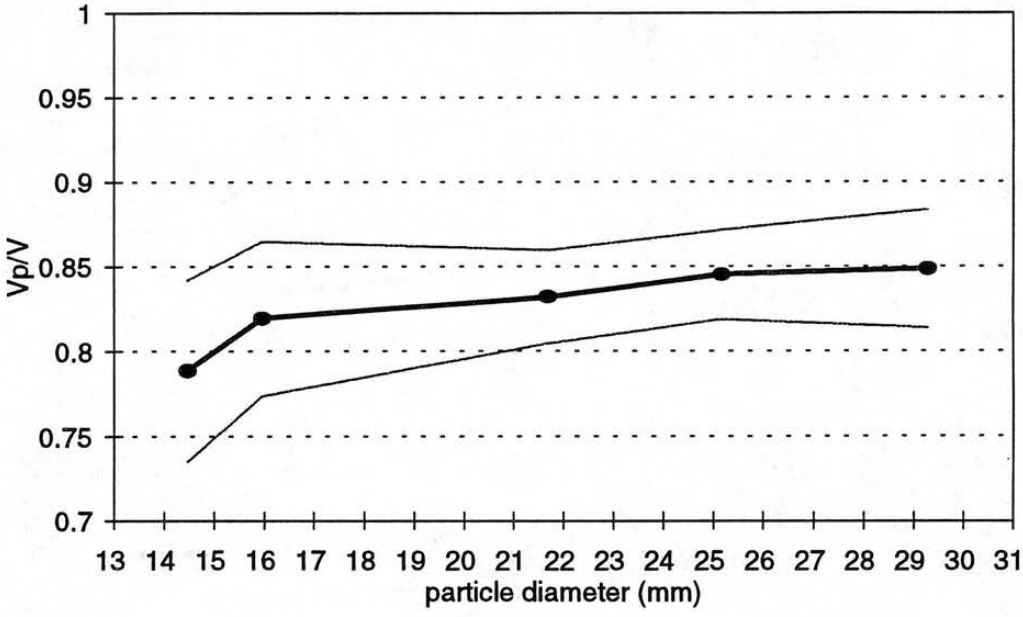
(steel)



Run # 38
U* = 0.0558 (m/s)

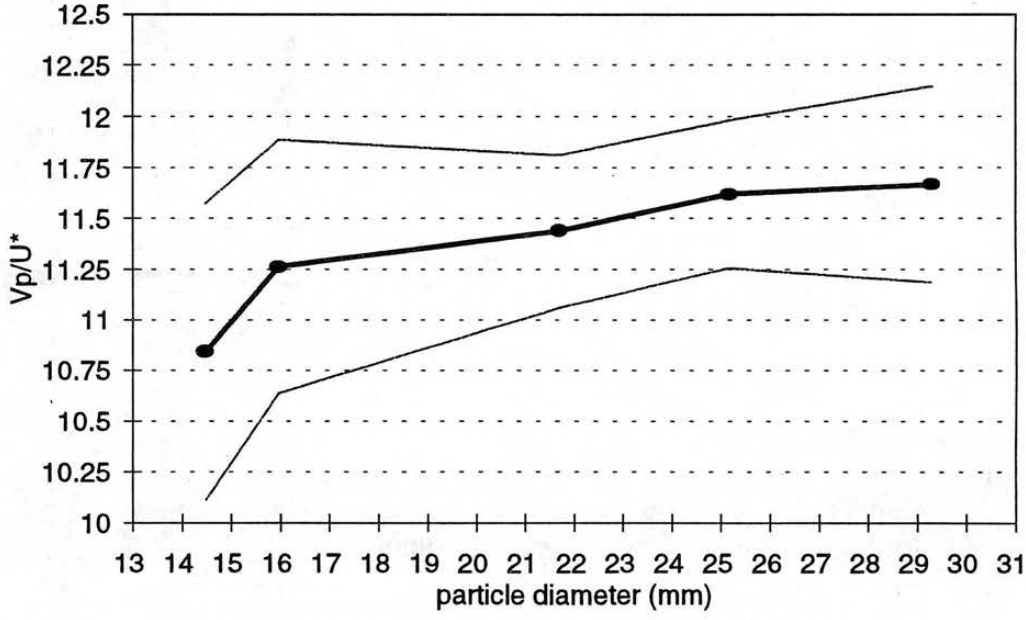
Vp/V vs. d

(glass)



Vp/U* vs. d

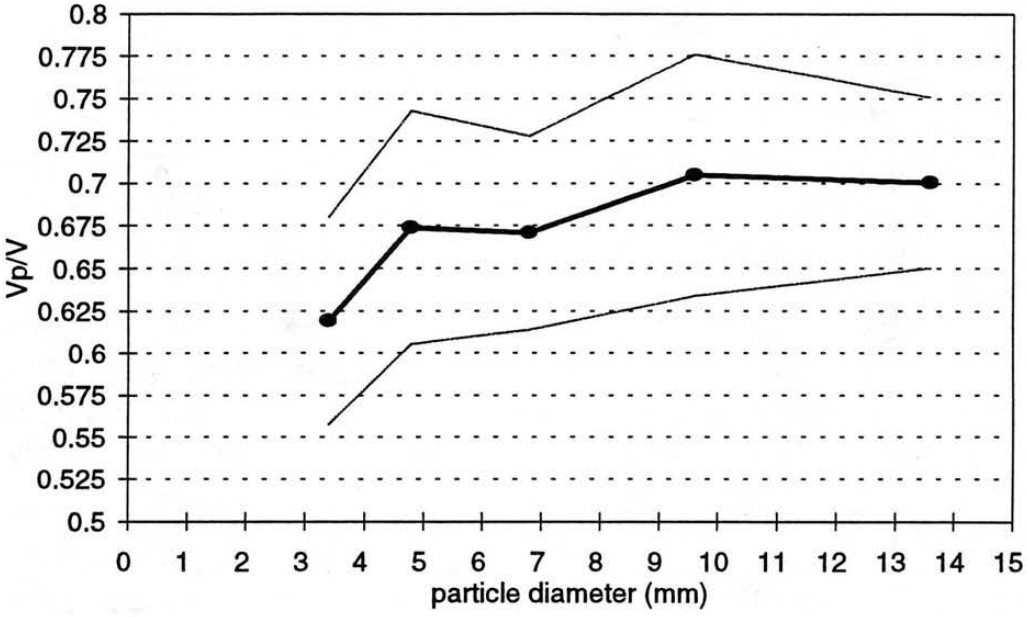
(glass)



Run # 38
U* = 0.0558 (m/s)

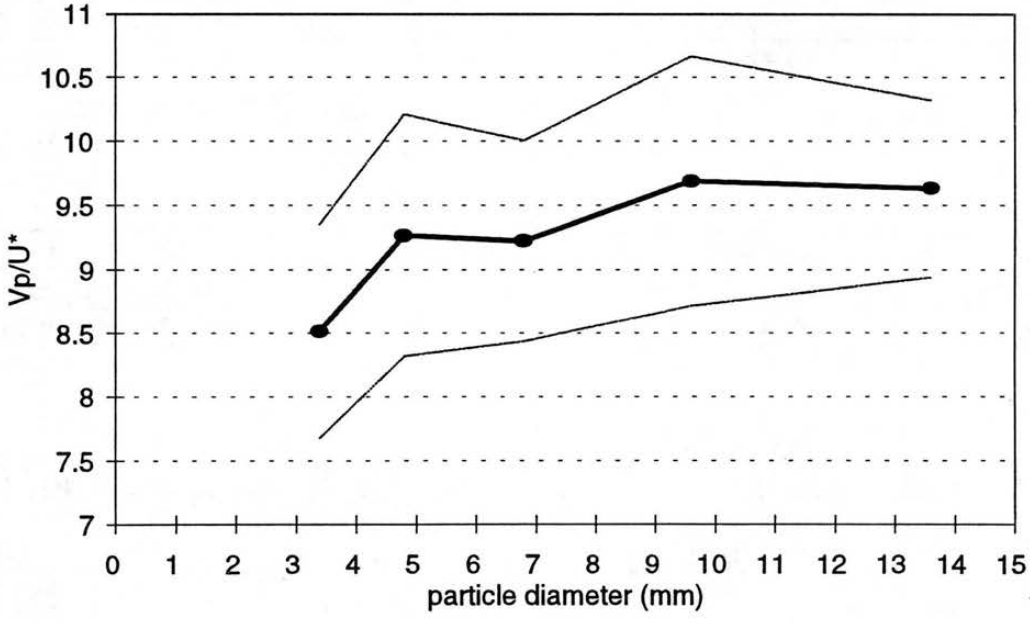
Vp/V vs. d

(natural)



Vp/U* vs. d

(natural)



Run#	39	Bed Roughness k:	2.4	mm	Streamflow	15.8263	L/s
Date	8-8-95	Pump Setting	medium		Valve Setting	5/8 open	
Reach Length	2000	mm	Slope Reading	150	mm	Bed Slope	0.007

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer	Hi	33.87		35.22		35.22	
in. of	Lo	-36.57		-36.57		-36.57	
water	Hi - Lo	70.44		71.79		71.79	
Flow Depth:	u.s.	52.6	mm	52	mm	52	mm
	d.s.	53.3	mm	53.1	mm	53.1	mm
	u.s. - d.s.	-0.7	mm	-1.1	mm	-1.1	mm
	at weir	49.7	mm	49.7	mm	50	mm
Top Width:	u.s.	578	mm	575	mm	578	mm
	d.s.	579	mm	583	mm	580	mm
	at weir	589	mm	588	mm	589	mm

Velocities (mm/s)

type	steel	182.9826	176.2115	192.1230	195.6947	194.3635	184.3318	182.3154
d (mm)	19.04	193.4236	180.3427	176.2115	191.5709	192.3077	186.0465	180.8318
n	21	188.8574	190.4762	193.4236	188.8574	199.4018	185.0139	195.6947
G	8.02			Std Dev	6.6143		Avg	188.1182

Velocities (mm/s)

type	steel	173.4605	188.3239	178.2531	180.1802	172.5626	176.3668	182.3154
d (mm)	15.88	170.6485	168.4920	176.2115	179.2115	171.9690	175.9015	198.8072
n	21	180.1802	171.6738	191.5709	172.1170	173.9130	165.4260	180.6685
G	8.02			Std Dev	7.8951		Avg	177.5359

Velocities (mm/s)

type	steel	165.4260	182.8154	167.0844	169.7793	158.8562	176.3668	174.3679
d (mm)	14.28	164.4737	189.3939	168.3502	180.1802	181.3237	170.2128	163.2653
n	21	169.3480	187.6173	183.3181	182.3154	194.5525	178.7310	152.0913
G	8.02			Std Dev	10.7684		Avg	174.2795

Velocities (mm/s)

type	steel	162.8664	162.4695	139.4700	ERR	ERR	ERR	ERR
d (mm)	9.5	143.3692	150.9434	182.8154	ERR	ERR	ERR	ERR
n	9	161.5509	148.4781	145.1379	ERR	ERR	ERR	ERR
G	8.02			Std Dev	13.5393		Avg	155.2334

Velocities (mm/s)

type	glass	609.7561	571.4286	621.1180	609.7561	546.4481	566.5722	571.4286
d (mm)	29.3	552.4862	542.0054	561.7978	581.3953	561.7978	566.5722	571.4286
n	21	588.2353	626.9592	609.7561	586.5103	560.2241	609.7561	566.5722
G	2.6			Std Dev	25.1902		Avg	580.0954

Velocities (mm/s)

type	glass	571.4286	571.4286	598.8024	588.2353	571.4286	508.9059	555.5556
d (mm)	25.17	598.8024	552.4862	566.5722	626.9592	529.1005	523.5602	571.4286
n	21	529.1005	537.6344	560.2241	557.1031	602.4096	533.3333	571.4286
G	2.6			Std Dev	29.7690		Avg	563.1394

Velocities (mm/s)

type	glass	529.1005	492.6108	566.5722	529.1005	566.5722	581.3953	561.7978
d (mm)	21.7	598.8024	537.6344	533.3333	557.1031	524.9344	454.5455	552.4862
n	21	533.3333	576.3689	516.7959	552.4862	591.7160	500.0000	546.4481
G	2.6			Std Dev	34.4657		Avg	543.0065

Velocities (mm/s)

type	glass	547.9452	557.1031	533.3333	477.3270	527.7045	542.0054	520.8333
d (mm)	15.97	566.5722	537.6344	529.1005	519.4805	550.9642	566.5722	529.1005
n	21	561.7978	537.6344	529.1005	533.3333	516.7959	507.6142	604.2296
G	2.6			Std Dev	25.7997		Avg	537.9134

Velocities (mm/s)

type	glass	571.4286	555.5556	561.7978	581.3953	487.8049	576.3689	563.3803
d (mm)	14.48	604.2296	586.5103	566.5722	564.9718	552.4862	542.0054	552.4862
n	21	555.5556	547.9452	583.0904	542.0054	576.3689	604.2296	529.1005
G	2.6			Std Dev	25.8553		Avg	562.1566

Velocities (mm/s)

type	natural	444.4444	478.4689	516.7959	477.3270	560.2241	434.7826	444.4444
d (mm)	13.6	507.6142	447.4273	423.7288	467.2897	437.6368	444.4444	435.7298
n	21	473.9336	487.8049	496.2779	529.1005	447.4273	533.3333	429.1845
G	2.65			Std Dev	39.0801		Avg	472.2581

Velocities (mm/s)

type	natural	450.4505	500.0000	552.4862	464.0371	477.3270	477.3270	492.6108
d (mm)	9.6	529.1005	464.0371	412.3711	392.9273	470.5882	459.7701	496.2779
n	21	456.6210	473.9336	537.6344	557.1031	480.7692	450.4505	431.9654
G	2.65			Std Dev	42.0955		Avg	477.5137

Velocities (mm/s)

type	natural	456.6210	421.0526	432.9004	507.6142	347.8261	496.2779	438.5965
d (mm)	6.8	380.9524	438.5965	453.5147	485.4369	511.5090	426.4392	441.5011
n	21	403.2258	450.4505	537.6344	363.6364	511.5090	438.5965	454.5455
G	2.65			Std Dev	49.4546		Avg	447.5446

		Velocities (mm/s)						
type	natural	459.7701	389.8635	475.0594	431.9654	491.4005	424.6285	404.8583
d (mm)	4.8	336.7003	438.5965	400.0000	604.2296	441.5011	414.9378	453.5147
n	21	444.4444	376.6478	418.4100	432.9004	397.6143	470.5882	496.2779
G	2.65			Std Dev	54.2014		Avg	438.2814

		Velocities (mm/s)						
type	natural	394.4773	395.2569	409.8361	397.6143	441.5011	357.7818	496.2779
d (mm)	3.4	444.4444	355.2398	367.6471	392.9273	389.8635	464.0371	415.8004
n	21	357.7818	310.5590	441.5011	434.7826	454.5455	447.4273	312.5000
G	2.65			Std Dev	48.8542		Avg	403.8953

		Velocities (mm/s)						
type	natural	480.7692	421.0526	367.6471	421.0526	376.6478	373.8318	383.1418
d (mm)	2.4	410.6776	447.4273	441.5011	402.4145	376.6478	359.7122	347.8261
n	21	421.0526	500.0000	392.9273	418.4100	392.1569	415.8004	404.8583
G	2.65			Std Dev	38.0578		Avg	407.4074

The smallest two glass particles showed noticable suspension.

All of the natural particles showed surging and suspension. The smaller ones showed considerably more than the larger ones.

Run# 39 Bed
Date: 8-8-95 Roughness k: 2.4 mm y/k: 21.951

Slope: 0.007 Q: 15.82629 L/s U*: 0.0514 m/s

	u.s.	d.s.	avg
y (mm)	52.2	53.16667	52.68333
Tw (mm)	577	580.6667	578.8333
A (m^2)	0.02235465	0.022866	0.02261
P (m)	0.59478655	0.598887	0.596837
Rh (m)	0.03758432	0.038181	0.037883
V (m/s)	0.70796408	0.692129	0.700047
H (m)	0.08909476	0.077591	0.083343

delta H: 0.0115037 m delta x: 1.62 m

Sf: 0.00710106

Tavg: 20 °C

ν: 1.004E-06 m^2/s

δ: 0.00022675 m

Run# 39

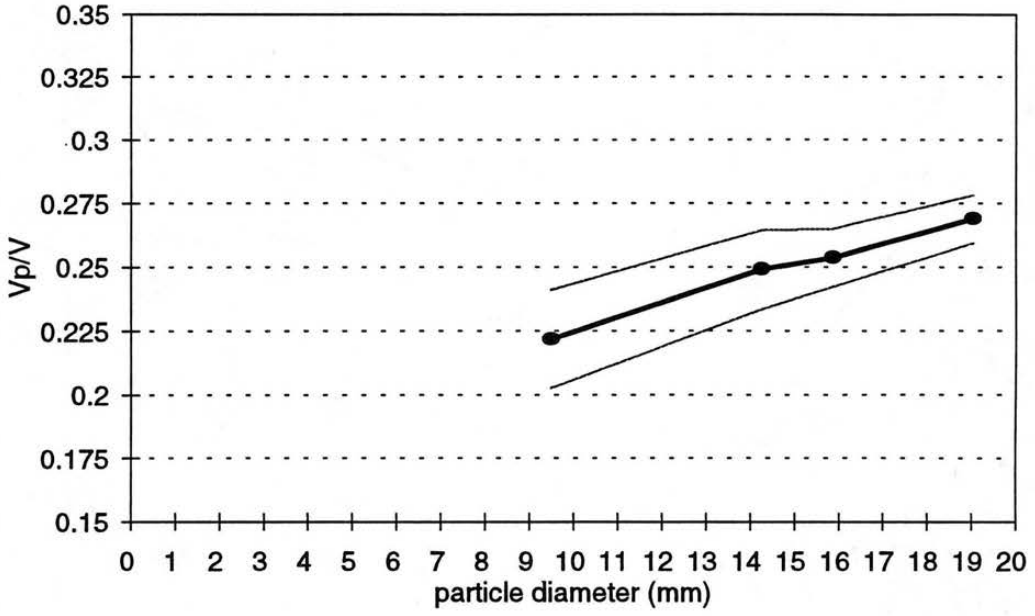
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	21	0.1881	0.0066	1.0794	778.2702	0.0020
steel	15.88	8.02	21	0.1775	0.0079	0.9857	649.1035	0.0024
steel	14.28	8.02	21	0.1743	0.0108	0.9346	583.7026	0.0027
steel	9.5	8.02	9	0.1552	0.0135	0.7619	388.3176	0.0040
glass	29.3	2.6	21	0.5801	0.0252	0.6392	731.5747	0.0057
glass	25.17	2.6	21	0.5631	0.0298	0.5924	628.4552	0.0067
glass	21.7	2.6	21	0.5430	0.0345	0.5500	541.8147	0.0077
glass	15.97	2.6	21	0.5379	0.0258	0.4716	398.7457	0.0105
glass	14.48	2.6	21	0.5622	0.0259	0.4490	361.5427	0.0116
natural	13.6	2.65	21	0.4723	0.0391	0.4419	343.0715	0.0120
natural	9.6	2.65	21	0.4775	0.0421	0.3709	242.1681	0.0170
natural	6.8	2.65	21	0.4475	0.0495	0.3117	171.5357	0.0240
natural	4.8	2.65	21	0.4383	0.0542	0.2612	121.0841	0.0340
natural	3.4	2.65	21	0.4039	0.0489	0.2189	85.7679	0.0480
natural	2.4	2.65	21	0.4074	0.0381	ERR	ERR	0.0679

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.2687	3.6626	0.1743	0.0476	7.9333	10584.3292	83.9690	2.7670
steel	0.2536	3.4565	0.1801	0.0521	6.6167	10584.3292	70.0330	3.3176
steel	0.2490	3.3931	0.1865	0.0550	5.9500	10584.3292	62.9768	3.6893
steel	0.2217	3.0223	0.2037	0.0674	3.9583	10584.3292	41.8963	5.5456
glass	0.8287	11.2942	0.9075	0.0803	12.2083	10584.3292	129.2170	1.7981
glass	0.8044	10.9641	0.9506	0.0867	10.4875	10584.3292	111.0032	2.0931
glass	0.7757	10.5721	0.9873	0.0934	9.0417	10584.3292	95.7000	2.4278
glass	0.7684	10.4729	1.1405	0.1089	6.6542	10584.3292	70.4299	3.2989
glass	0.8030	10.9449	1.2520	0.1144	6.0333	10584.3292	63.8588	3.6384
natural	0.6746	9.1947	1.0688	0.1162	5.6667	10584.3292	59.9779	3.8738
natural	0.6821	9.2970	1.2874	0.1385	4.0000	10584.3292	42.3373	5.4878
natural	0.6393	8.7135	1.4359	0.1648	2.8333	10584.3292	29.9889	7.7475
natural	0.6261	8.5331	1.6780	0.1966	2.0000	10584.3292	21.1687	10.9757
natural	0.5770	7.8637	1.8453	0.2347	1.4167	10584.3292	14.9945	15.4951
natural	0.5820	7.9320	ERR	ERR	1.0000	10584.3292	10.5843	21.9514

Run # 39
U* = 0.0514 (m/s)

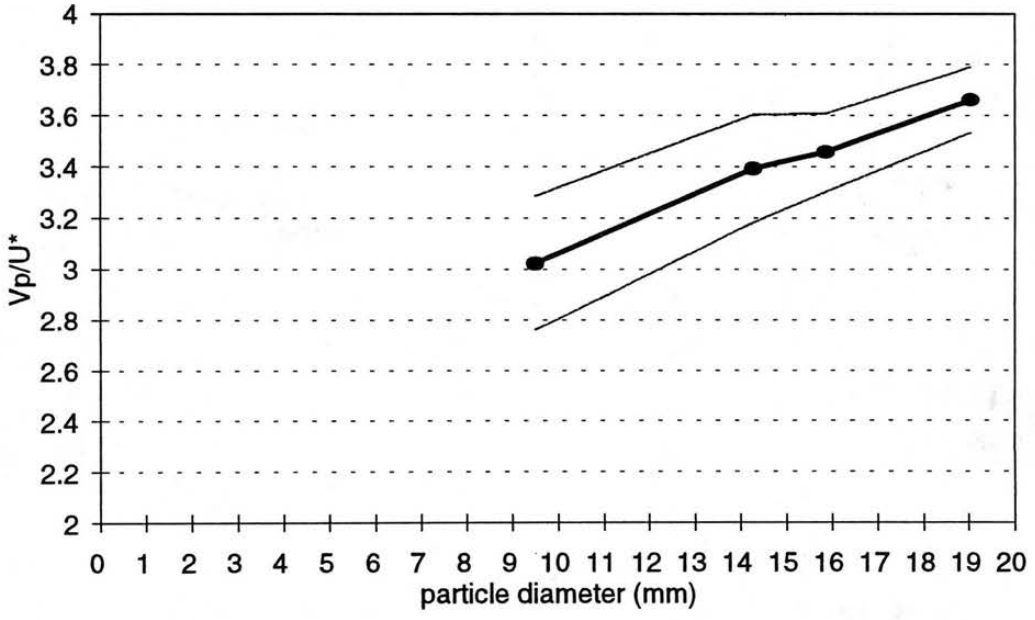
Vp/V vs. d

(steel)



Vp/U* vs. d

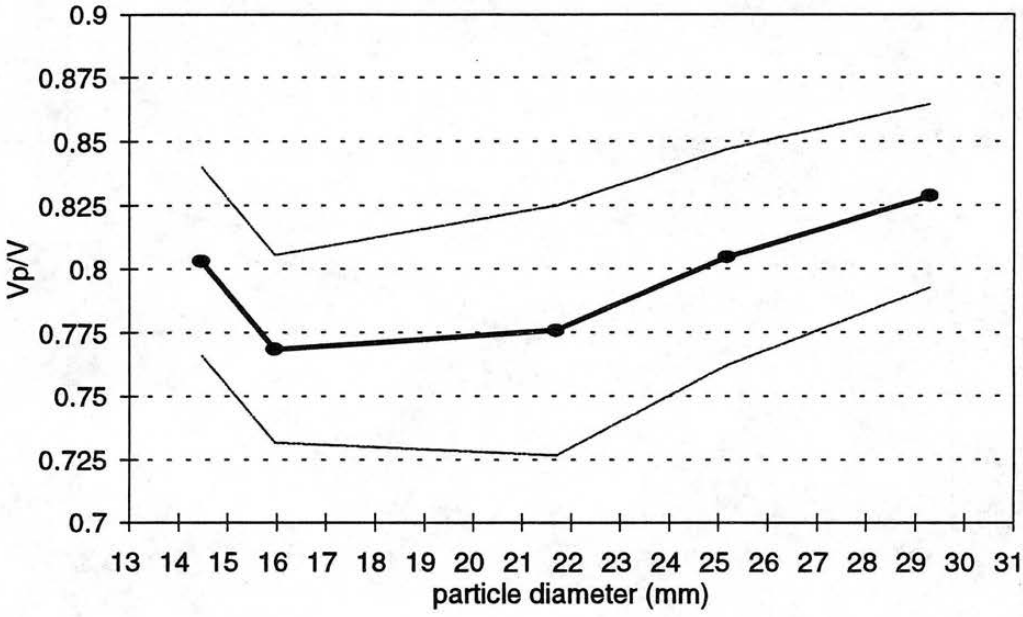
(steel)



Run # 39
U* = 0.0514 (m/s)

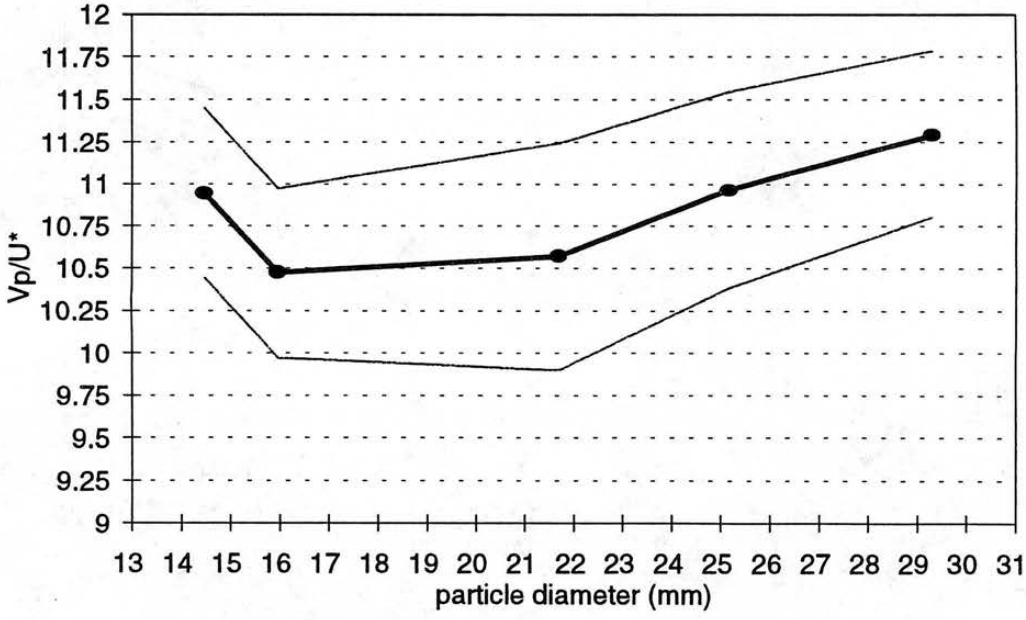
Vp/V vs. d

(glass)



Vp/U* vs. d

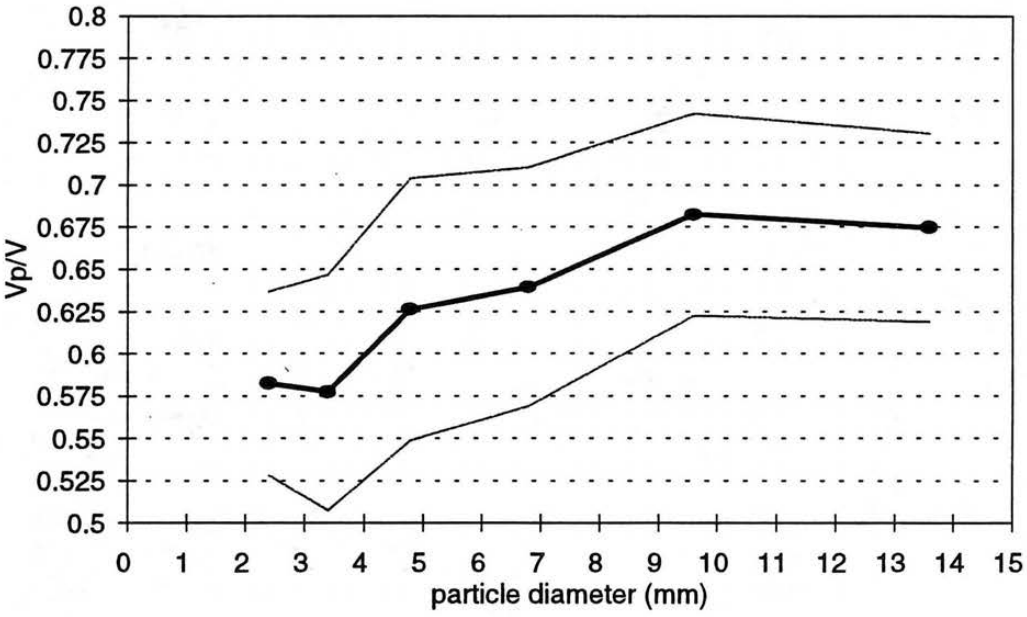
(glass)



Run # 39
U* = 0.0514 (m/s)

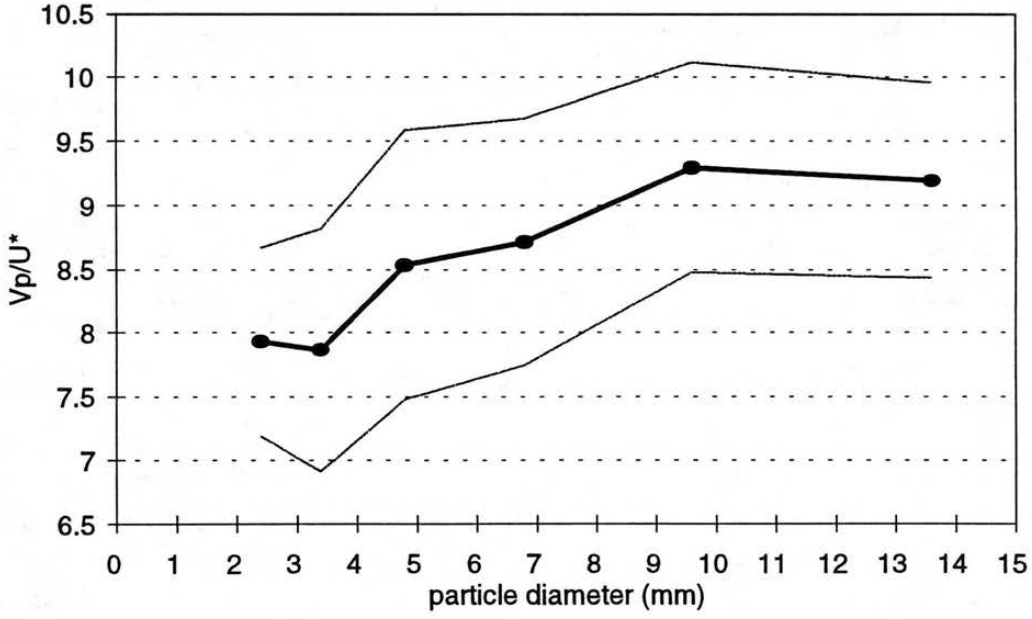
Vp/V vs. d

(natural)



Vp/U* vs. d

(natural)



Run#	40	Bed Roughness k:	2.4	mm	Streamflow	13.3459	L/s
Date	8-9-95	Pump Setting	medium		Valve Setting	1/2 open	
Reach Length	2000	mm	Slope Reading	140	mm	Bed Slope	0.0056

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer in. of water	Hi	-----		-----		-----	
	Lo	-----		-----		-----	
	Hi - Lo	51.2		50.6		50.7	
Flow Depth:	u.s.	52.5	mm	52.7	mm	52.7	mm
	d.s.	52	mm	52	mm	52.7	mm
	u.s. - d.s.	0.5	mm	0.7	mm	0	mm
	at weir	54.7	mm	53.3	mm	53	mm
Top Width:	u.s.	566	mm	566	mm	563	mm
	d.s.	572	mm	575	mm	571	mm
	at weir	625	mm	620	mm	610	mm

Velocities (mm/s)

type	steel	168.9189	164.4737	165.0165	165.7001	174.3679	171.0864	158.7302
d (mm)	19.04	167.0844	162.4695	160.3849	165.4260	168.0672	160.0000	153.8462
n	21	167.9261	159.2357	162.0746	160.9010	168.3502	162.0746	162.8664
G	8.02			Std Dev	4.7465		Avg	164.2381

Velocities (mm/s)

type	steel	150.6024	151.2859	143.4720	150.9434	145.4545	141.6431	146.7351
d (mm)	15.88	151.2859	143.1639	160.0000	156.4945	146.1988	131.6656	152.7884
n	21	157.6044	150.6024	157.6044	158.7302	157.6044	154.5595	152.7884
G	8.02			Std Dev	6.9579		Avg	150.5346

Velocities (mm/s)

type	steel	139.3728	148.1481	148.4781	150.4891	149.9250	135.0439	138.5042
d (mm)	14.28	137.2684	151.6300	147.1670	149.5886	147.0588	129.7859	139.0821
n	21	133.8688	138.6001	145.1379	139.3728	134.4086	153.3742	135.3180
G	8.02			Std Dev	7.0232		Avg	142.4582

Velocities (mm/s)

type	glass	484.2615	477.3270	444.4444	475.0594	488.9976	485.4369	447.4273
d (mm)	29.3	492.6108	460.8295	500.0000	484.2615	485.4369	460.8295	503.7783
n	21	464.0371	473.9336	423.7288	473.9336	470.5882	467.2897	424.6285
G	2.6			Std Dev	21.7526		Avg	470.8972

Velocities (mm/s)

type	glass	456.6210	435.7298	470.5882	441.5011	450.4505	480.7692	503.7783
d (mm)	25.17	503.7783	467.2897	462.9630	444.4444	516.7959	500.0000	492.6108
n	21	485.4369	481.9277	456.6210	434.7826	434.7826	473.9336	484.2615
G	2.6			Std Dev	25.0122		Avg	470.4317

Velocities (mm/s)

type	glass	507.6142	456.6210	441.5011	421.0526	456.6210	470.5882	437.6368
d (mm)	21.7	441.5011	437.6368	492.6108	478.4689	435.7298	453.5147	426.4392
n	21	447.4273	460.8295	500.0000	464.0371	470.5882	444.4444	432.9004
G	2.6			Std Dev	23.7772		Avg	456.0840

Velocities (mm/s)

type	glass	444.4444	447.4273	470.5882	451.4673	413.2231	383.1418	427.3504
d (mm)	15.97	418.4100	438.5965	421.0526	387.5969	414.9378	464.0371	412.3711
n	21	380.9524	409.8361	430.1075	423.7288	400.0000	400.0000	409.8361
G	2.6			Std Dev	24.8869		Avg	421.3860

Velocities (mm/s)

type	glass	470.5882	467.2897	429.1845	507.6142	400.0000	423.7288	409.8361
d (mm)	14.48	432.9004	457.6659	404.8583	432.9004	402.4145	450.4505	440.5286
n	21	432.9004	441.5011	389.8635	447.4273	410.6776	404.8583	394.4773
G	2.6			Std Dev	29.5069		Avg	431.0317

Velocities (mm/s)

type	natural	399.2016	418.4100	380.9524	432.9004	395.2569	366.3004	361.6637
d (mm)	13.6	388.3495	340.1361	370.3704	326.7974	397.6143	375.9398	417.5365
n	21	404.8583	342.4658	378.7879	338.4095	380.9524	408.1633	355.8719
G	2.65			Std Dev	29.0277		Avg	380.0447

Velocities (mm/s)

type	natural	404.8583	349.6503	346.0208	359.7122	329.4893	409.8361	376.6478
d (mm)	9.6	408.1633	365.6307	383.1418	400.0000	353.3569	402.4145	309.1190
n	21	357.7818	352.1127	353.3569	347.8261	335.0084	378.0718	351.4938
G	2.65			Std Dev	27.9222		Avg	365.4139

Velocities (mm/s)

type	natural	355.8719	301.6591	346.0208	397.6143	390.6250	418.4100	407.3320
d (mm)	6.8	409.8361	340.7155	388.3495	323.1018	376.6478	304.8780	351.4938
n	21	378.7879	324.6753	402.4145	429.1845	373.8318	347.8261	365.6307
G	2.65			Std Dev	36.8309		Avg	368.3289

Velocities (mm/s)

type	natural	370.3704	329.4893	365.6307	400.0000	349.6503	397.6143	326.7974
d (mm)	4.8	353.3569	293.6858	353.9823	338.9831	326.7974	426.4392	400.0000
n	21	347.8261	363.6364	306.2787	355.2398	301.6591	336.7003	349.6503
G	2.65			Std Dev	34.0139		Avg	352.0851

		Velocities (mm/s)						
type	natural	330.0330	320.0000	301.6591	363.6364	306.2787	301.6591	309.1190
d (mm)	3.4	294.9853	278.5515	306.2787	344.2341	323.1018	306.2787	326.7974
n	21	361.0108	343.6426	283.2861	292.3977	267.7376	353.3569	344.2341
G	2.65			Std Dev	27.3388		Avg	317.0609

		Velocities (mm/s)						
type	natural	357.7818	326.7974	275.8621	288.1844	303.4901	355.2398	340.1361
d (mm)	2.4	267.7376	321.5434	313.4796	361.6637	280.5049	351.4938	351.4938
n	21	357.7818	330.0330	342.4658	357.7818	347.8261	310.5590	303.4901
G	2.65			Std Dev	30.2140		Avg	325.9689

Steel particles smaller than 14.28mm diameter halted before finishing their runs.

Run# 40 Bed
Date: 8-9-95 Roughness k: 2.4 mm y/k: 21.847

Slope: 0.0056 Q: 13.34591 L/s U*: 0.0467 m/s

	u.s.	d.s.	avg
y (mm)	52.6333333	52.23333	52.43333
Tw (mm)	565	572.6667	568.8333
A (m^2)	0.02222443	0.022256	0.02224
P (m)	0.58378822	0.590723	0.587251
Rh (m)	0.03806933	0.037675	0.037872
V (m/s)	0.6005064	0.599661	0.600084
H (m)	0.08009122	0.070567	0.075329

delta H: 0.0095237 m delta x: 1.62 m

Sf: 0.00587884

Tavg: 20 °C

ν: 1.004E-06 m^2/s

δ: 0.00024924 m

Run# 40

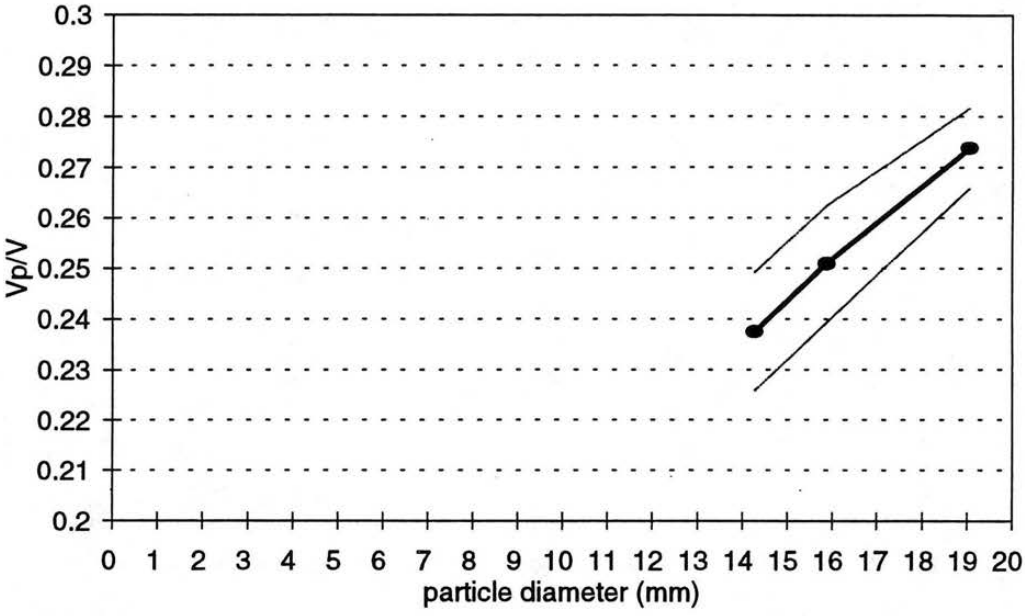
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	21	0.1642	0.0047	1.0794	778.2702	0.0017
steel	15.88	8.02	21	0.1505	0.0070	0.9857	649.1035	0.0020
steel	14.28	8.02	21	0.1425	0.0070	0.9346	583.7026	0.0022
glass	29.3	2.6	21	0.4709	0.0218	0.6392	731.5747	0.0047
glass	25.17	2.6	21	0.4704	0.0250	0.5924	628.4552	0.0055
glass	21.7	2.6	21	0.4561	0.0238	0.5500	541.8147	0.0064
glass	15.97	2.6	21	0.4214	0.0249	0.4716	398.7457	0.0087
glass	14.48	2.6	21	0.4310	0.0295	0.4490	361.5427	0.0096
natural	13.6	2.65	21	0.3800	0.0290	0.4419	343.0715	0.0099
natural	9.6	2.65	21	0.3654	0.0279	0.3709	242.1681	0.0141
natural	6.8	2.65	21	0.3683	0.0368	0.3117	171.5357	0.0198
natural	4.8	2.65	21	0.3521	0.0340	0.2612	121.0841	0.0281
natural	3.4	2.65	21	0.3171	0.0273	0.2189	85.7679	0.0397
natural	2.4	2.65	21	0.3260	0.0302	0.1826	60.5420	0.0562

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.2737	3.5149	0.1522	0.0433	7.9333	9629.1030	76.3909	2.7539
steel	0.2509	3.2216	0.1527	0.0474	6.6167	9629.1030	63.7126	3.3018
steel	0.2374	3.0487	0.1524	0.0500	5.9500	9629.1030	57.2932	3.6718
glass	0.7847	10.0777	0.7366	0.0731	12.2083	9629.1030	117.5553	1.7895
glass	0.7839	10.0677	0.7941	0.0789	10.4875	9629.1030	100.9852	2.0832
glass	0.7600	9.7606	0.8293	0.0850	9.0417	9629.1030	87.0631	2.4163
glass	0.7022	9.0181	0.8935	0.0991	6.6542	9629.1030	64.0737	3.2832
glass	0.7183	9.2245	0.9599	0.1041	6.0333	9629.1030	58.0956	3.6211
natural	0.6333	8.1333	0.8601	0.1057	5.6667	9629.1030	54.5649	3.8554
natural	0.6089	7.8202	0.9852	0.1260	4.0000	9629.1030	38.5164	5.4618
natural	0.6138	7.8826	1.1817	0.1499	2.8333	9629.1030	27.2825	7.7108
natural	0.5867	7.5350	1.3480	0.1789	2.0000	9629.1030	19.2582	10.9236
natural	0.5284	6.7854	1.4486	0.2135	1.4167	9629.1030	13.6412	15.4216
natural	0.5432	6.9761	1.7856	0.2560	1.0000	9629.1030	9.6291	21.8472

Run # 40
U* = 0.0467 (m/s)

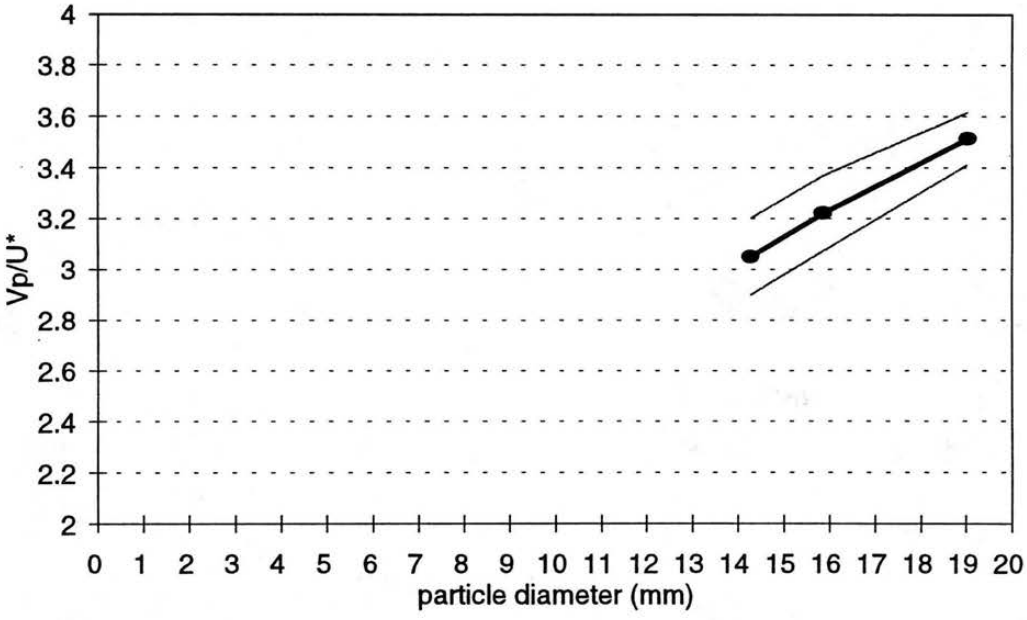
Vp/V vs. d

(steel)



Vp/U* vs. d

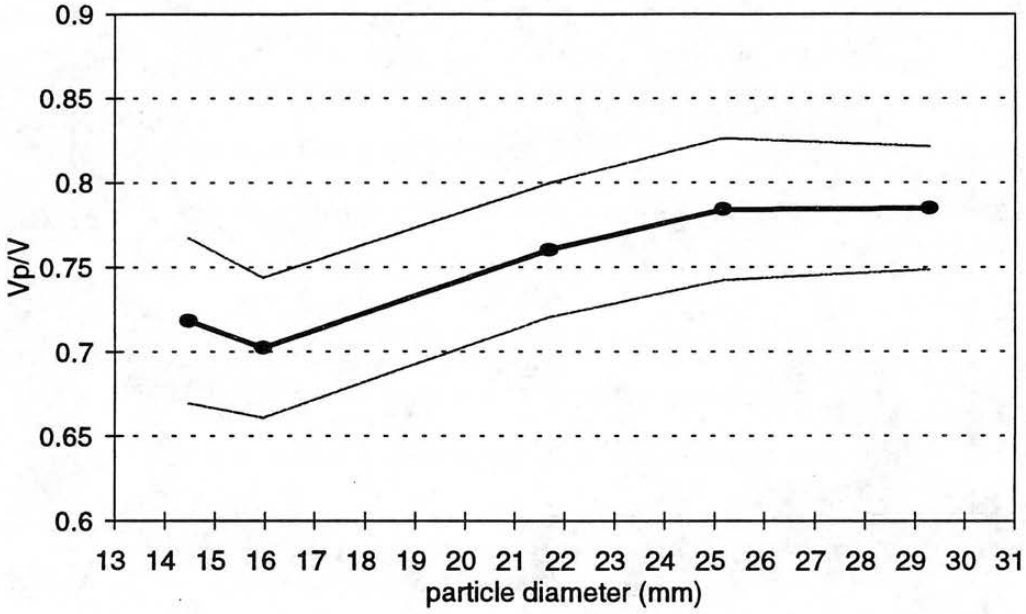
(steel)



Run # 40
U* = 0.0467 (m/s)

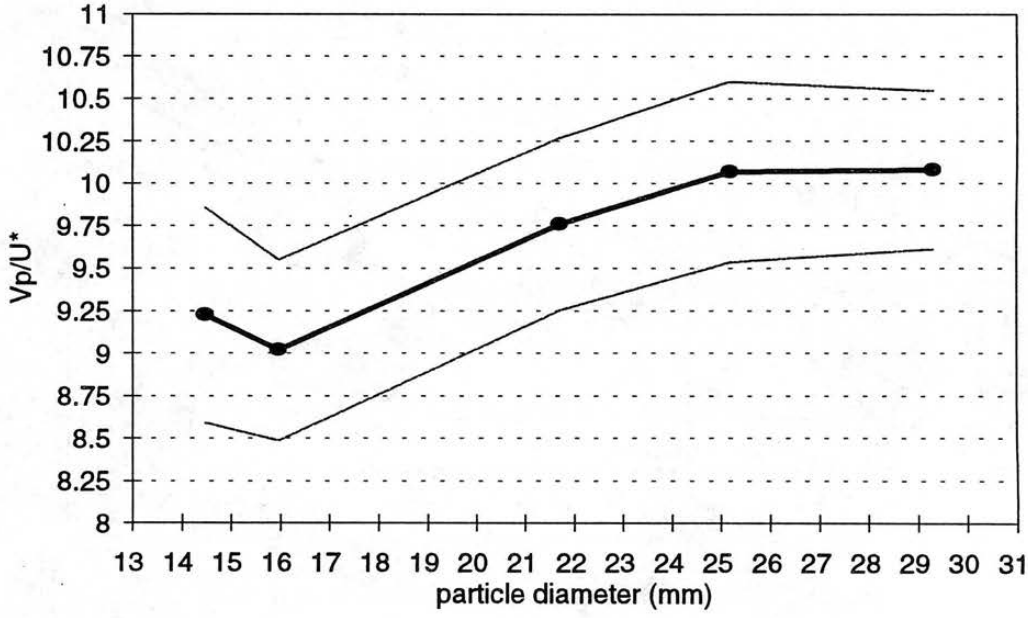
Vp/V vs. d

(glass)



Vp/U* vs. d

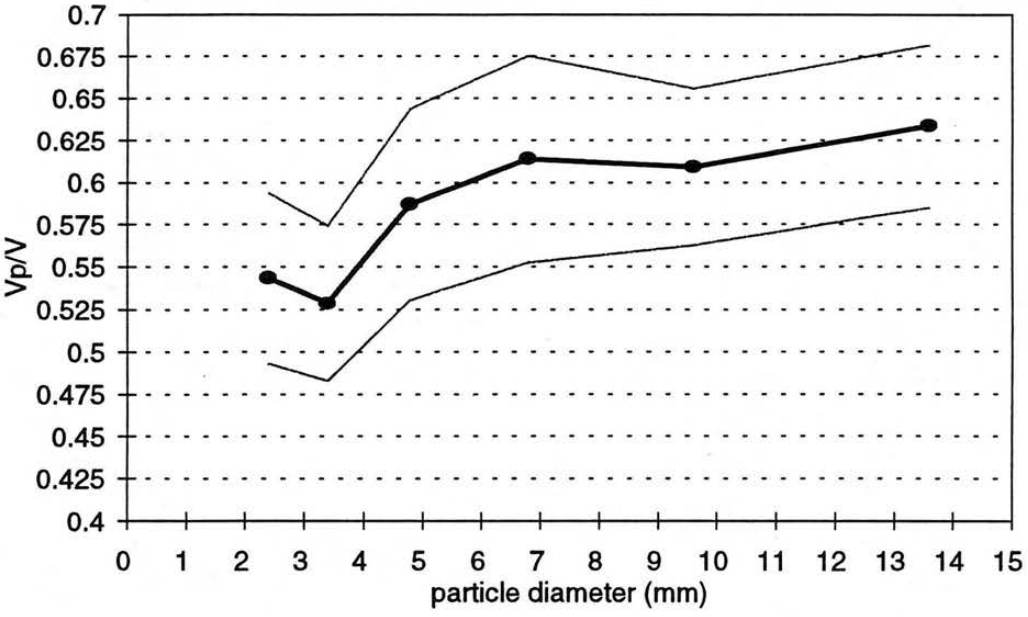
(glass)



Run # 40
U* = 0.0467 (m/s)

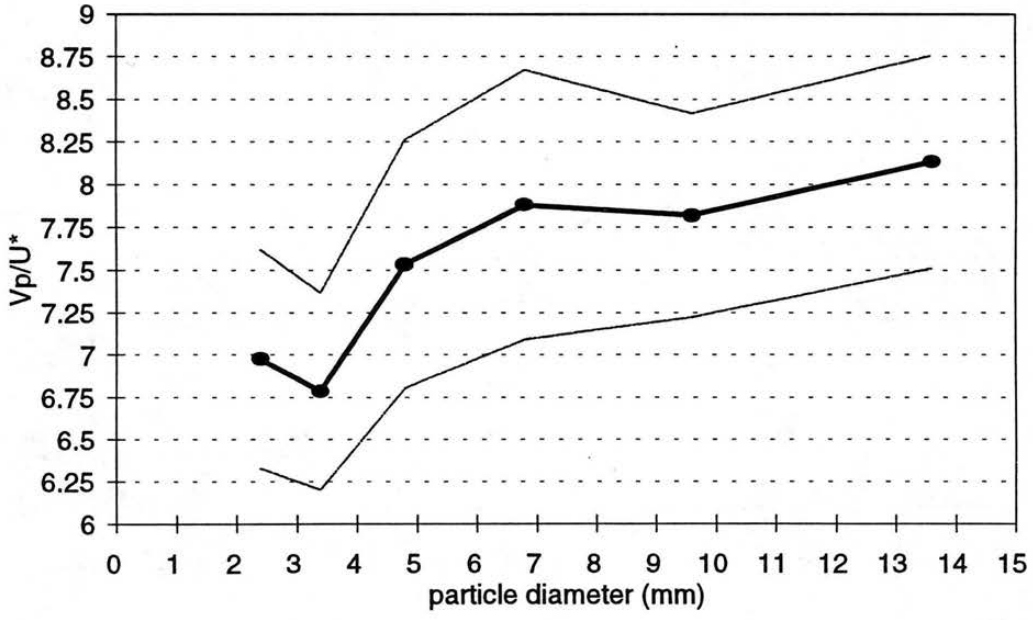
Vp/V vs. d

(natural)



Vp/U* vs. d

(natural)



Run#	41	Bed Roughness k:	2.4	mm	Streamflow	13.1865	L/s
Date	8-10-95	Pump Setting	medium		Valve Setting	1/2 open	
Reach Length	2000	mm	Slope Reading	126.5	mm	Bed Slope	0.00371

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer in. of water	Hi	46.8		46.7		46.6	
	Lo	-3		-2.8		-3	
	Hi - Lo	49.8		49.5		49.6	
Flow Depth:	u.s.	56.2	mm	56.1	mm	56.1	mm
	d.s.	56.1	mm	56.1	mm	56	mm
	u.s. - d.s.	0.1	mm	0	mm	0.1	mm
	at weir	63.6	mm	64	mm	64	mm
Top Width:	u.s.	605	mm	610	mm	604	mm
	d.s.	602	mm	605	mm	603	mm
	at weir	675	mm	680	mm	680	mm

Velocities (mm/s)

type	steel	125.7862	130.3781	134.9528	138.2170	124.0695	126.7427	126.2626
d (mm)	19.04	121.6545	128.7830	121.4329	126.9841	131.4060	122.1001	126.7427
n	21	129.0323	133.3333	132.5381	139.1788	128.7830	136.1470	125.0000
G	8.02			Std Dev	5.2219		Avg	129.0250

Velocities (mm/s)

type	glass	323.1018	329.4893	316.9572	338.4095	309.1190	320.0000	320.0000
d (mm)	29.3	302.1148	316.9572	328.4072	349.6503	323.1018	323.1018	342.4658
n	21	338.4095	347.8261	335.0084	320.0000	307.6923	341.8803	331.6750
G	2.6			Std Dev	13.1679		Avg	326.9222

Velocities (mm/s)

type	glass	312.0125	336.7003	325.2033	333.3333	318.4713	351.4938	318.4713
d (mm)	25.17	320.0000	333.3333	298.9537	338.4095	306.2787	328.4072	303.4901
n	21	320.0000	342.4658	304.8780	284.4950	378.7879	321.5434	315.4574
G	2.6			Std Dev	20.3226		Avg	323.4374

Velocities (mm/s)

type	glass	342.4658	316.9572	293.6858	309.1190	313.4796	296.2963	293.2551
d (mm)	21.7	303.0303	321.5434	286.9440	321.5434	313.4796	302.1148	293.6858
n	21	307.6923	331.6750	271.3704	347.8261	316.9572	333.3333	316.4557
G	2.6			Std Dev	18.7676		Avg	311.0910

		Velocities (mm/s)						
type	glass	304.8780	344.2341	347.8261	361.6637	324.6753	316.9572	321.5434
d (mm)	15.97	306.2787	326.7974	320.0000	300.3003	306.2787	297.6190	318.4713
n	21	307.6923	315.4574	324.6753	320.0000	326.7974	312.0125	280.5049
G	2.6			Std Dev	17.9973		Avg	318.3173

		Velocities (mm/s)						
type	glass	265.6042	304.8780	297.6190	303.4901	307.6923	328.4072	291.9708
d (mm)	14.48	300.3003	315.4574	285.7143	365.6307	310.5590	320.0000	340.1361
n	21	323.1018	321.5434	310.5590	285.7143	365.6307	272.1088	307.6923
G	2.6			Std Dev	25.5937		Avg	310.6576

		Velocities (mm/s)						
type	natural	281.6901	274.7253	288.1844	233.6449	192.8640	280.8989	256.7394
d (mm)	13.6	244.2002	280.8989	279.7203	237.8121	210.5263	278.1641	261.0966
n	21	233.6449	265.6042	236.4066	231.2139	264.5503	214.1328	244.4988
G	2.65			Std Dev	27.0155		Avg	251.9627

		Velocities (mm/s)						
type	natural	293.2551	302.1148	283.2861	271.3704	290.6977	258.0645	254.7771
d (mm)	9.6	252.8445	285.7143	245.3988	250.0000	236.9668	265.6042	242.4242
n	21	299.4012	247.2188	297.6190	278.5515	253.1646	231.2139	296.2963
G	2.65			Std Dev	23.0370		Avg	268.3802

		Velocities (mm/s)						
type	natural	279.7203	251.8892	231.2139	251.8892	222.9654	229.3578	252.8445
d (mm)	6.8	227.0148	229.3578	267.7376	255.7545	284.4950	280.8989	244.2002
n	21	264.5503	214.8228	254.1296	287.3563	294.9853	278.1641	255.1020
G	2.65			Std Dev	23.4877		Avg	255.1643

		Velocities (mm/s)						
type	natural	267.7376	249.0660	232.8289	ERR	ERR	ERR	ERR
d (mm)	4.8	246.3054	228.5714	225.2252	ERR	ERR	ERR	ERR
n	9	277.3925	259.0674	278.1641	ERR	ERR	ERR	ERR
G	2.65			Std Dev	20.3096		Avg	251.5954

The steel particles of diameter 19.04mm meandered considerably. Steel particles smaller than 19.04mm showed stop/start motion and wouldn't complete the trials.

There was a small amount of surging seen for the natural particles with diameters 13.6mm and 9.6mm.
The natural particle with diameter 6.8mm showed more surging and some suspension.
The 4.8mm natural particle exhibited start/stop motion with significant suspension and surging.

Run# 41 Bed
Date: 8-10-95 Roughness k: 2.4 mm y/k: 23.375

Slope: 0.00371 Q: 13.18653 L/s U*: 0.0378 m/s

	u.s.	d.s.	avg
y (mm)	56.1333333	56.06667	56.1
Tw (mm)	606.333333	603.3333	604.8333
A (m^2)	0.02486239	0.024749	0.024806
P (m)	0.62507753	0.622198	0.623637
Rh (m)	0.03977489	0.039776	0.039776
V (m/s)	0.53038072	0.532816	0.531598
H (m)	0.07648603	0.070541	0.073514

delta H: 0.0059449 m delta x: 1.62 m

Sf: 0.00366967

Tavg: 20 °C

ν: 1.004E-06 m^2/s

δ: 0.00030783 m

Run# 41

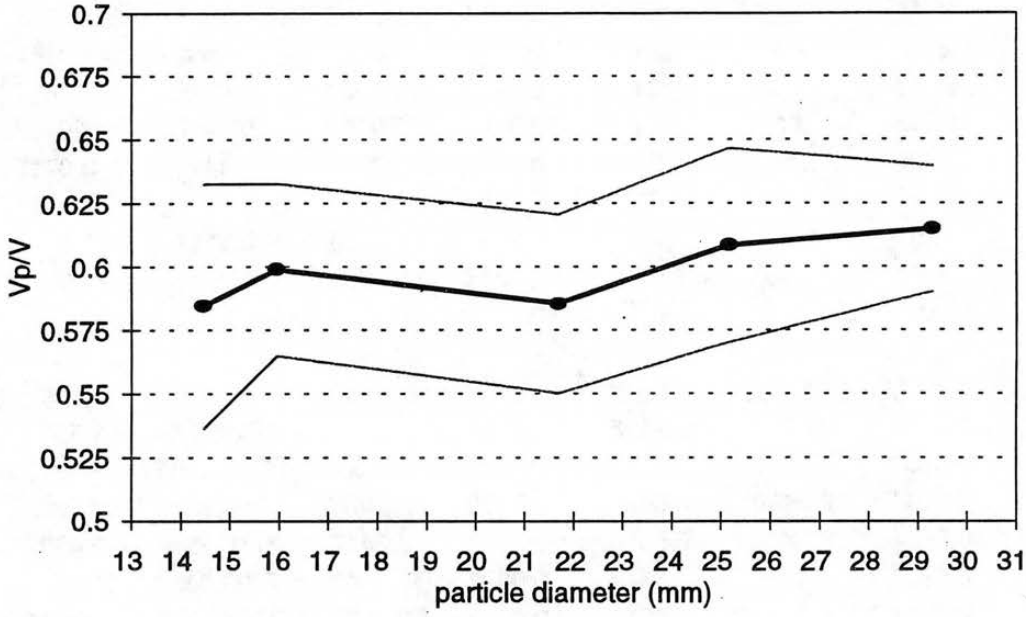
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	21	0.1290	0.0052	1.0794	778.2702	0.0011
glass	29.3	2.6	21	0.3269	0.0132	0.6392	731.5747	0.0031
glass	25.17	2.6	21	0.3234	0.0203	0.5924	628.4552	0.0036
glass	21.7	2.6	21	0.3111	0.0188	0.5500	541.8147	0.0042
glass	15.97	2.6	21	0.3183	0.0180	0.4716	398.7457	0.0057
glass	14.48	2.6	21	0.3107	0.0256	0.4490	361.5427	0.0063
natural	13.6	2.65	21	0.2520	0.0270	0.4419	343.0715	0.0065
natural	9.6	2.65	21	0.2684	0.0230	0.3709	242.1681	0.0092
natural	6.8	2.65	21	0.2552	0.0235	0.3117	171.5357	0.0130
natural	4.8	2.65	9	0.2516	0.0203	0.2612	121.0841	0.0184

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.2427	3.4103	0.1195	0.0351	7.9333	7796.5356	61.8525	2.9464
glass	0.6150	8.6410	0.5114	0.0592	12.2083	7796.5356	95.1827	1.9147
glass	0.6084	8.5489	0.5460	0.0639	10.4875	7796.5356	81.7662	2.2288
glass	0.5852	8.2225	0.5656	0.0688	9.0417	7796.5356	70.4937	2.5853
glass	0.5988	8.4135	0.6749	0.0802	6.6542	7796.5356	51.8794	3.5128
glass	0.5844	8.2111	0.6919	0.0843	6.0333	7796.5356	47.0391	3.8743
natural	0.4740	6.6597	0.5702	0.0856	5.6667	7796.5356	44.1804	4.1250
natural	0.5049	7.0936	0.7236	0.1020	4.0000	7796.5356	31.1861	5.8438
natural	0.4800	6.7443	0.8187	0.1214	2.8333	7796.5356	22.0902	8.2500
natural	0.4733	6.6500	0.9633	0.1449	2.0000	7796.5356	15.5931	11.6875

Run # 41
U* = 0.0378 (m/s)

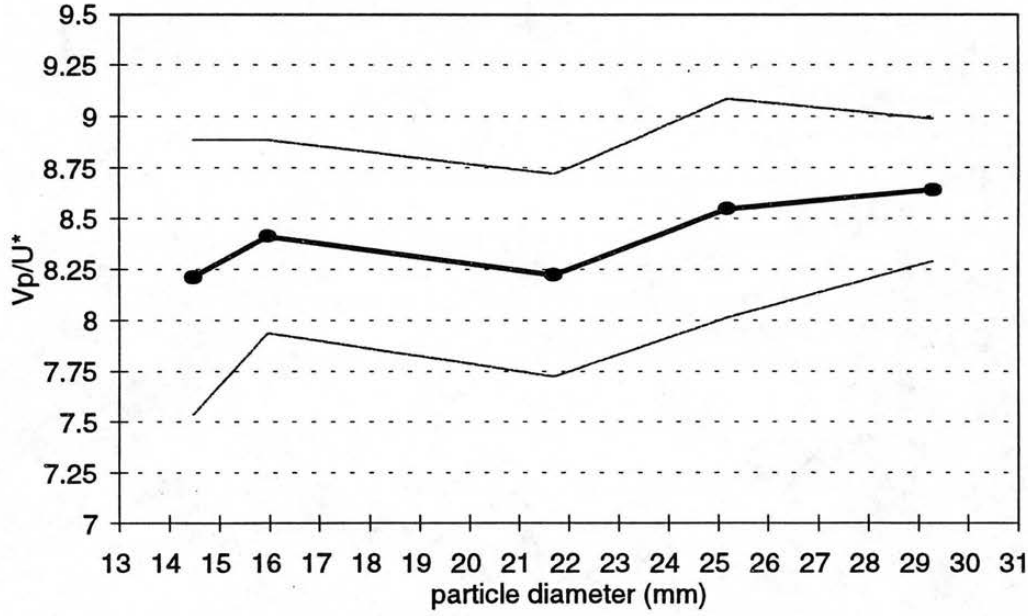
Vp/V vs. d

(glass)



Vp/U* vs. d

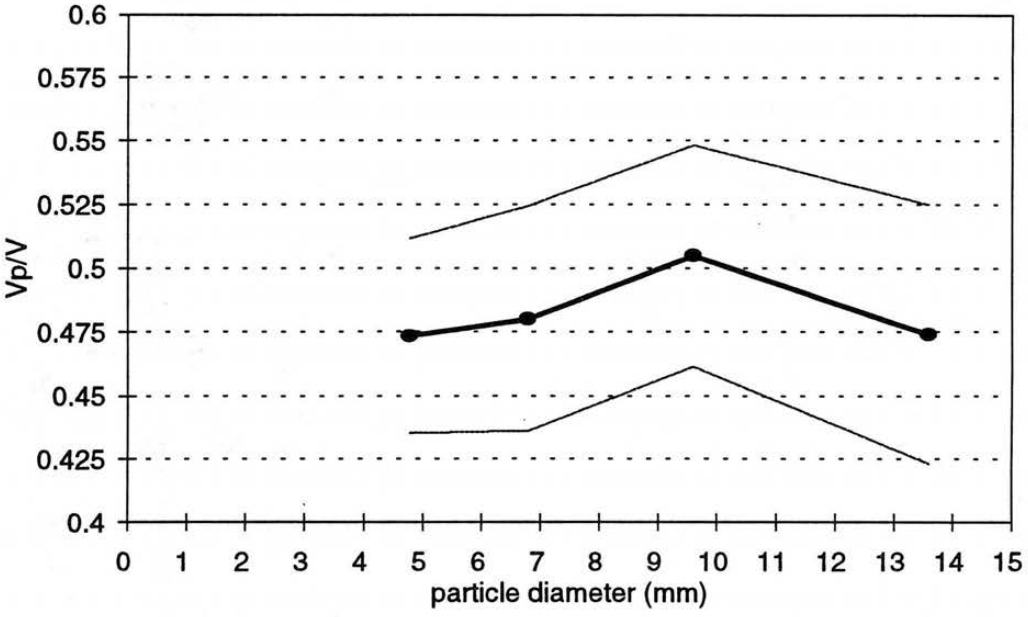
(glass)



Run # 41
U* = 0.0378 (m/s)

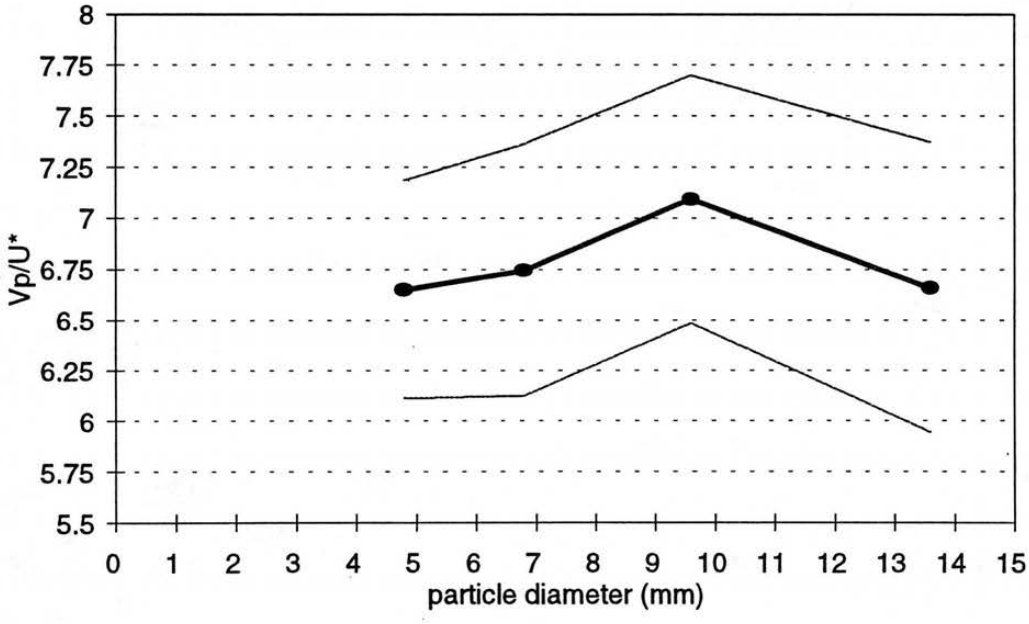
Vp/V vs. d

(natural)



Vp/U* vs. d

(natural)



Run#	42		Bed Roughness k:	2.4	mm	Streamflow	11.5442 L/s
Date	8-11-95		Pump Setting	slow		Valve Setting	full open
Reach Length	2000	mm	Slope Reading	115	mm	Bed Slope	0.0021

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer	Hi	-----		-----		-----	
in. of	Lo	-----		-----		-----	
water	Hi - Lo	38.1		38.1		38.1	
Flow Depth:	u.s.	62.7	mm	62.5	mm	62.5	mm
	d.s.	61.8	mm	62	mm	62	mm
	u.s. - d.s.	0.9	mm	0.5	mm	0.5	mm
	at weir	62.9	mm	62.2	mm	62.2	mm
Top Width:	u.s.	633	mm	634	mm	634	mm
	d.s.	630	mm	633	mm	633	mm
	at weir	677	mm	678	mm	678	mm

Velocities (mm/s)

type	glass	196.2709	200.6018	202.0202	205.7613	192.6782	184.5018	202.0202
d (mm)	29.3	199.4018	190.4762	195.1220	192.1230	195.8864	197.0443	197.4334
n	21	213.2196	190.4762	196.4637	193.4236	195.6947	193.4236	188.8574
G	2.6			Std Dev	6.2557		Avg	196.3286

Velocities (mm/s)

type	glass	186.5672	195.1220	196.4637	180.8318	194.5525	208.5506	194.5525
d (mm)	25.17	181.8182	198.0198	185.3568	180.1802	188.8574	188.1468	187.2659
n	21	197.4334	182.3154	205.1282	178.7310	188.1468	191.5709	194.5525
G	2.6			Std Dev	8.0564		Avg	190.6744

Velocities (mm/s)

type	glass	183.3181	192.8640	181.8182	164.4737	187.0907	198.2161	205.7613
d (mm)	21.7	179.3722	192.1230	179.8561	178.7310	187.2659	180.3427	176.3668
n	21	193.9864	172.5626	184.5018	173.4605	183.3181	216.2162	192.6782
G	2.6			Std Dev	11.7112		Avg	185.9202

Velocities (mm/s)

type	glass	179.8561	183.9926	168.0672	162.4695	181.3237	186.0465	163.8002
d (mm)	15.97	171.0864	187.0907	177.7778	169.7793	182.9826	170.2128	186.0465
n	21	170.2128	156.8627	188.3239	165.8375	168.7764	192.3077	187.0907
G	2.6			Std Dev	10.1743		Avg	176.1878

		Velocities (mm/s)						
type	glass	171.5266	175.2848	166.6667	161.6815	180.8318	185.5288	163.6661
d (mm)	14.48	170.6485	175.9015	173.4605	168.9189	176.3668	179.6945	176.2115
n	21	170.2128	155.7632	202.6342	161.5509	181.8182	193.9864	191.7546
G	2.6			Std Dev	11.4848		Avg	175.4338

		Velocities (mm/s)						
type	natural	141.2429	138.2170	149.4768	ERR	ERR	ERR	ERR
d (mm)	13.6	164.4737	143.7815	149.5886	ERR	ERR	ERR	ERR
n	9	125.9446	145.7726	174.9781	ERR	ERR	ERR	ERR
G	2.65			Std Dev	14.3798		Avg	148.1640

		Velocities (mm/s)						
type	natural	137.0802	152.6718	129.5337	ERR	ERR	ERR	ERR
d (mm)	9.6	155.4002	213.9037	164.4737	ERR	ERR	ERR	ERR
n	9	151.2859	133.6005	164.4737	ERR	ERR	ERR	ERR
G	2.65			Std Dev	25.2240		Avg	155.8248

		Velocities (mm/s)						
type	natural	165.0165	142.5517	171.0864	ERR	ERR	ERR	ERR
d (mm)	6.8	170.6485	127.7955	131.6656	ERR	ERR	ERR	ERR
n	9	168.0672	135.0439	182.3154	ERR	ERR	ERR	ERR
G	2.65			Std Dev	20.4896		Avg	154.9101

Steel particles moved only a few centimeters before halting.

The natural particles exhibited stop/start motion with highly varying velocity. Most trials resulted in halting.

Run# 42 Bed
Date: 8-11-95 Roughness k: 2.4 mm y/k: 25.938

Slope: 0.0021 Q: 11.54415 L/s U*: 0.0317 m/s

	u.s.	d.s.	avg
y (mm)	62.5666667	61.93333	62.25
Tw (mm)	633.666667	632	632.8333
A (m^2)	0.0285669	0.028226	0.028396
P (m)	0.65512265	0.65313	0.654126
Rh (m)	0.04360542	0.043217	0.043411
V (m/s)	0.40410951	0.408988	0.406549
H (m)	0.07429488	0.070462	0.072378

delta H: 0.0038331 m delta x: 1.62 m

Sf: 0.00236609

Tavg: 20 °C

ν: 1.004E-06 m^2/s

δ: 0.00036696 m

Run# 42

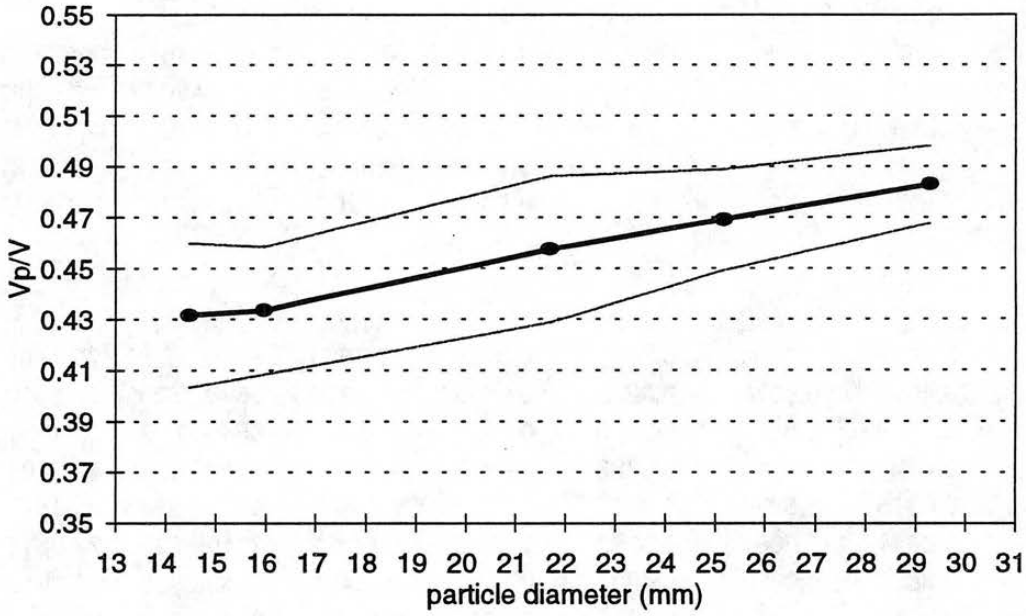
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	29.3	2.6	21	0.1963	0.0063	0.6392	731.5747	0.0022
glass	25.17	2.6	21	0.1907	0.0081	0.5924	628.4552	0.0026
glass	21.7	2.6	21	0.1859	0.0117	0.5500	541.8147	0.0030
glass	15.97	2.6	21	0.1762	0.0102	0.4716	398.7457	0.0040
glass	14.48	2.6	21	0.1754	0.0115	0.4490	361.5427	0.0044
natural	13.6	2.65	9	0.1482	0.0144	0.4419	343.0715	0.0046
natural	9.6	2.65	9	0.1558	0.0252	0.3709	242.1681	0.0065
natural	6.8	2.65	9	0.1549	0.0205	0.3117	171.5357	0.0092

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.4829	6.1860	0.3071	0.0496	12.2083	6540.2828	79.8460	2.1246
glass	0.4690	6.0078	0.3219	0.0536	10.4875	6540.2828	68.5912	2.4732
glass	0.4573	5.8580	0.3380	0.0577	9.0417	6540.2828	59.1351	2.8687
glass	0.4334	5.5514	0.3736	0.0673	6.6542	6540.2828	43.5201	3.8979
glass	0.4315	5.5276	0.3907	0.0707	6.0333	6540.2828	39.4597	4.2990
natural	0.3644	4.6684	0.3353	0.0718	5.6667	6540.2828	37.0616	4.5772
natural	0.3833	4.9098	0.4201	0.0856	4.0000	6540.2828	26.1611	6.4844
natural	0.3810	4.8809	0.4970	0.1018	2.8333	6540.2828	18.5308	9.1544

Run # 42
U* = 0.0317 (m/s)

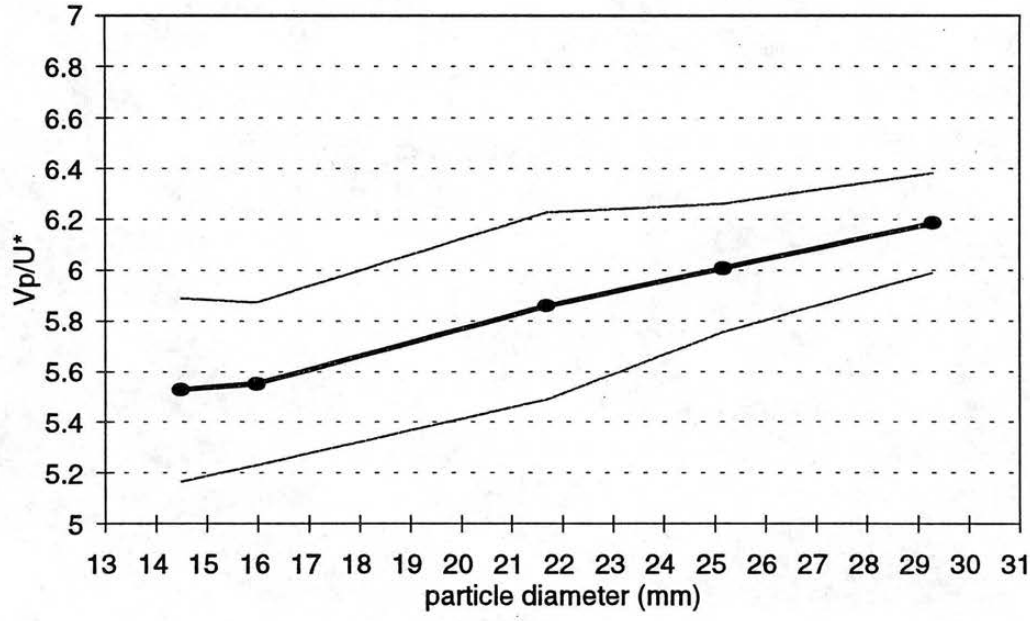
Vp/V vs. d

(glass)



Vp/U* vs. d

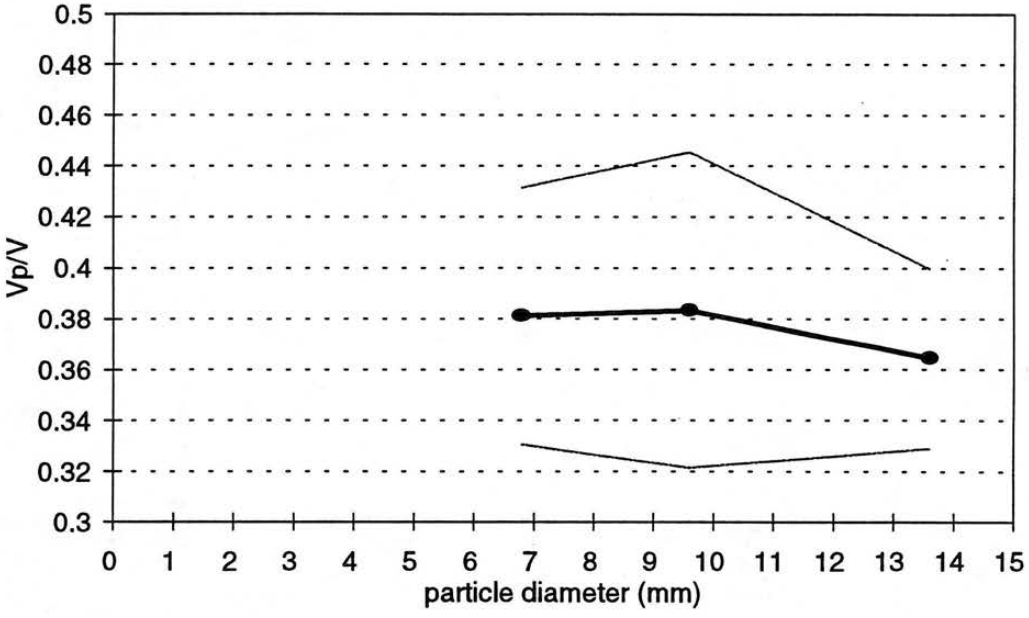
(glass)



Run # 42
U* = 0.0317 (m/s)

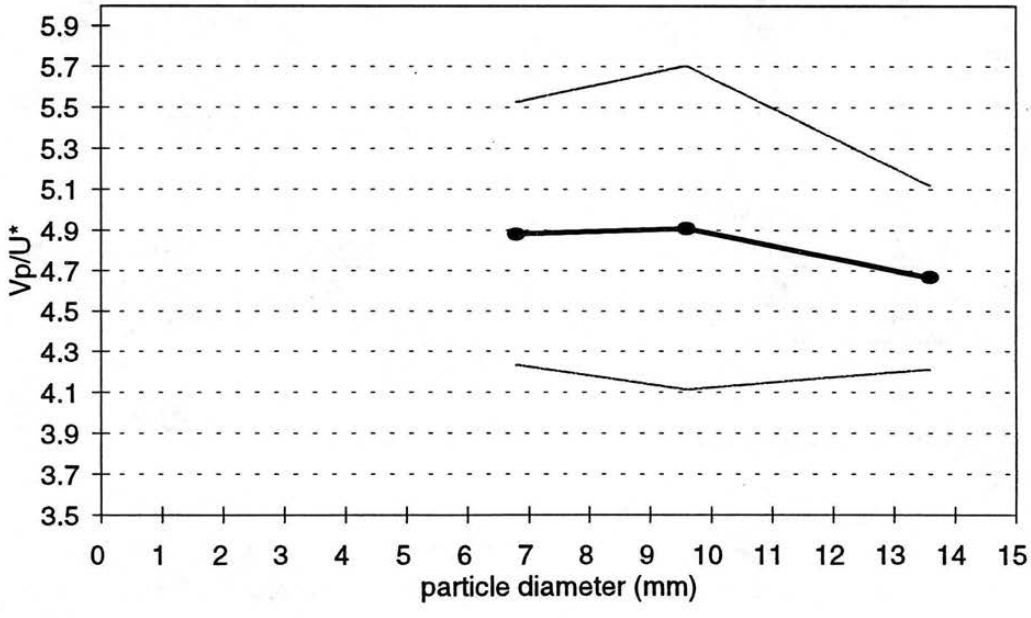
Vp/V vs. d

(natural)



Vp/U* vs. d

(natural)



Run#	43		Bed Roughness k:	2.4	mm	Streamflow	8.5245 L/s
Date	8-12-95		Pump Setting	slow		Valve Setting	7/16 open
Reach Length	2000	mm	Slope Reading	106.5	mm	Bed Slope	0.00091

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer in. of water	Hi	43.4		43.3		43.3	
	Lo	22.5		22.45		22.5	
	Hi - Lo	20.9		20.85		20.8	
Flow Depth:	u.s.	68.3	mm	68.1	mm	68.3	mm
	d.s.	68.5	mm	68.5	mm	68.4	mm
	u.s. - d.s.	-0.2	mm	-0.4	mm	-0.1	mm
	at weir	68	mm	68	mm	68	mm
Top Width:	u.s.	672	mm	673	mm	674	mm
	d.s.	675	mm	675	mm	673	mm
	at weir	707	mm	706	mm	707	mm

Velocities (mm/s)

type	glass	128.2051	125.0000	111.1111	115.3403	107.8749	129.7859	121.7285
d (mm)	29.3	105.9883	120.3369	113.5074	106.8376	123.3046	115.3403	113.8952
n	21	121.2121	106.4963	118.9061	115.1410	119.1895	118.0638	120.7729
G	2.6			Std Dev	6.8970		Avg	117.0494

Velocities (mm/s)

type	glass	113.8952	116.1440	108.1081	115.7407	110.0110	112.1076	106.1008
d (mm)	25.17	116.3467	115.9420	112.8668	107.4114	115.4734	108.4599	115.0748
n	21	117.6471	113.2503	122.8501	112.8668	117.0275	112.6761	105.8201
G	2.6			Std Dev	4.2883		Avg	113.1343

Velocities (mm/s)

type	glass	99.8502	107.1811	107.4114	99.5520	101.8849	101.5744	100.3009
d (mm)	21.7	100.0000	105.0972	100.0000	103.5197	105.0972	97.8953	101.5744
n	21	109.7695	98.3284	94.9217	105.2632	100.1502	100.0000	91.5332
G	2.6			Std Dev	4.2547		Avg	101.4717

Steel and natural particles showed little or no motion.

All of the glass particles meandered considerably.
Many trials for the 21.7mm glass particles resulted in halting.
Glass particles smaller than 21.7mm were not able to finish their trials due to halting.

Run# 43 Bed
Date: 8-12-95 Roughness k: 2.4 mm y/k: 28.479

Slope: 0.00091 Q: 8.524463 L/s U*: 0.019 m/s

	u.s.	d.s.	avg
y (mm)	68.2333333	68.46667	68.35
Tw (mm)	673	674.3333	673.6667
A (m²)	0.03249613	0.032653	0.032574
P (m)	0.69599178	0.697404	0.696698
Rh (m)	0.04669039	0.046821	0.046756
V (m/s)	0.26232244	0.261063	0.261693
H (m)	0.07321602	0.071942	0.072579

delta H: 0.0012745 m delta x: 1.62 m

Sf: 0.00078671

Tavg: 20 °C

ν: 1.004E-06 m²/s

δ: 0.00061321 m

Run# 43

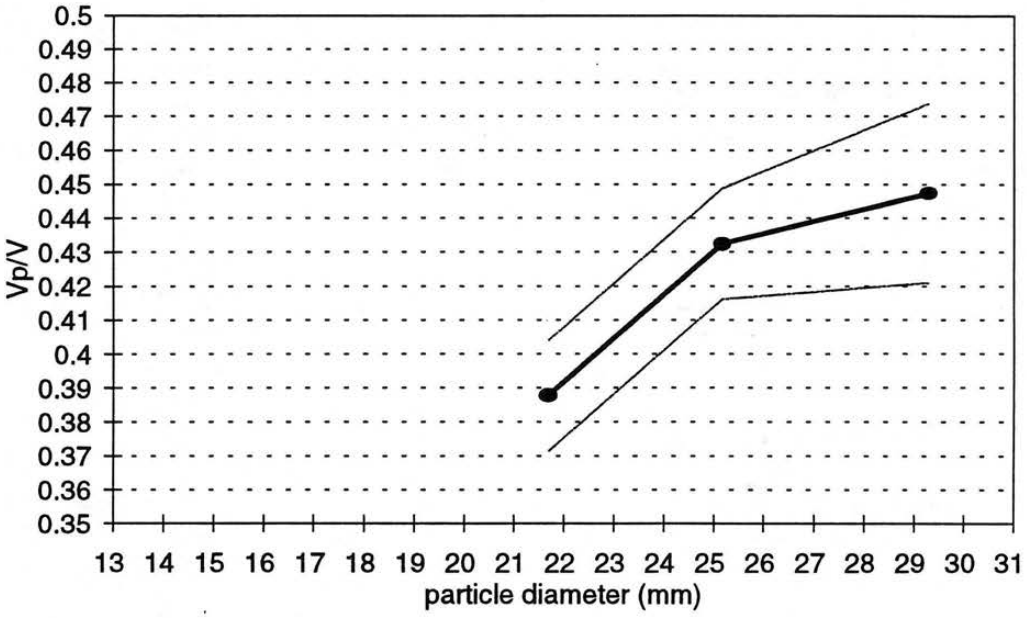
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	29.3	2.6	21	0.1170	0.0069	0.6392	731.5747	0.0008
glass	25.17	2.6	21	0.1131	0.0043	0.5924	628.4552	0.0009
glass	21.7	2.6	21	0.1015	0.0043	0.5500	541.8147	0.0011

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.4473	6.1629	0.1831	0.0297	12.2083	3913.8519	47.7816	2.3328
glass	0.4323	5.9568	0.1910	0.0321	10.4875	3913.8519	41.0465	2.7155
glass	0.3878	5.3427	0.1845	0.0345	9.0417	3913.8519	35.3877	3.1498

Run # 43
U* = 0.019 (m/s)

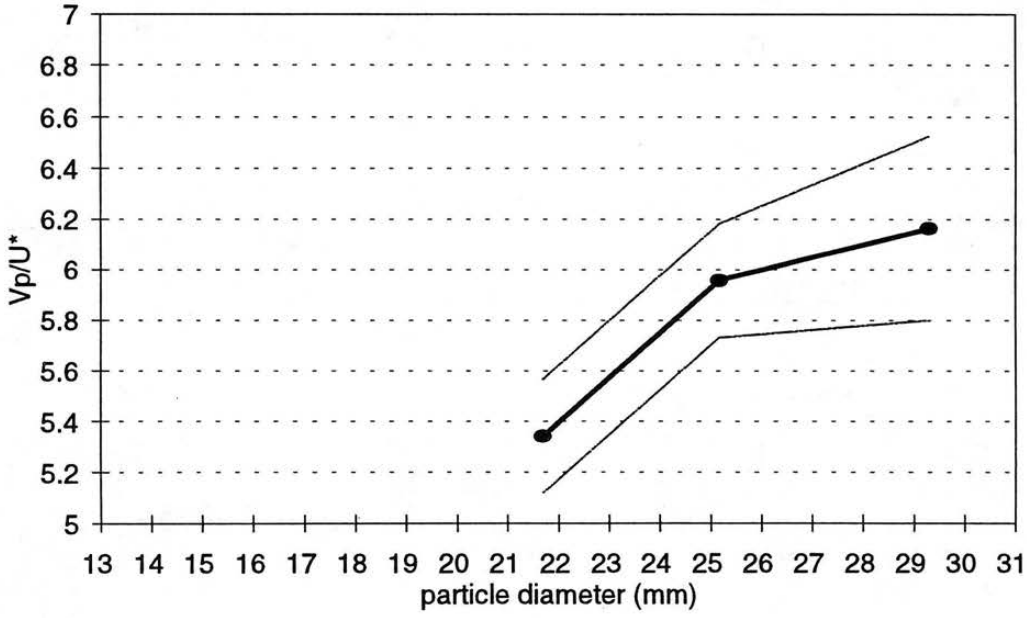
Vp/V vs. d

(glass)



Vp/U* vs. d

(glass)



Run#	44		Bed Roughness k:	2.4	mm	Streamflow	8.0631 L/s
Date	8-12-95		Pump Setting	slow		Valve Setting	7/16 open
Reach Length	2000	mm	Slope Reading	111	mm	Bed Slope	0.00154

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer in. of water	Hi	42.05		42		42	
	Lo	23.4		23.25		23.4	
	Hi - Lo	18.65		18.75		18.6	
Flow Depth:	u.s.	57.7	mm	57.7	mm	57.8	mm
	d.s.	57.7	mm	57.8	mm	57.6	mm
	u.s. - d.s.	0	mm	-0.1	mm	0.2	mm
	at weir	56.1	mm	56.2	mm	56.2	mm
Top Width:	u.s.	618	mm	614	mm	618	mm
	d.s.	615	mm	615	mm	615	mm
	at weir	648	mm	650	mm	643	mm

Velocities (mm/s)

type	glass	154.9187	151.2859	154.6790	151.2859	144.5087	149.5886	148.8095
d (mm)	29.3	149.9250	154.3210	156.1280	150.1502	149.2537	152.0913	144.0922
n	21	145.7726	150.2630	153.4919	155.7632	150.6024	145.7726	155.6420
G	2.6			Std Dev	3.7055		Avg	150.8736

Velocities (mm/s)

type	glass	138.7925	135.8696	145.1379	142.4501	147.8197	140.0560	145.1379
d (mm)	25.17	142.8571	135.8696	140.6470	139.7624	146.5201	140.9443	138.7925
n	21	148.9203	139.4700	143.4720	142.5517	148.1481	146.0920	141.2429
G	2.6			Std Dev	3.8131		Avg	142.4073

Velocities (mm/s)

type	glass	127.9591	128.5347	131.6656	135.3180	139.4700	126.7427	132.7140
d (mm)	21.7	135.3180	133.3333	130.2932	138.2170	133.3333	129.6176	135.3180
n	21	134.4990	128.4522	133.8688	136.7989	140.0560	137.0802	136.7054
G	2.6			Std Dev	3.8835		Avg	133.5855

Velocities (mm/s)

type	glass	121.2121	118.7648	122.3990	110.5583	125.5493	114.8765	120.1201
d (mm)	15.97	116.3467	121.4329	120.9921	114.8765	108.2837	121.2121	114.8765
n	21	112.0448	115.9420	119.8322	113.0582	119.6172	113.2503	115.5402
G	2.6			Std Dev	4.4112		Avg	117.1803

		Velocities (mm/s)						
type	glass	113.8952	115.9420	110.7420	112.6761	111.9194	106.4963	116.5501
d (mm)	14.48	109.5890	115.3403	103.8961	117.8550	107.8749	112.2965	118.0638
n	21	113.8952	109.7695	115.7407	111.7318	112.2965	117.0275	108.4011
G	2.6			Std Dev	3.8675		Avg	112.4761

Little or no motion for the steel particles.

The natural particles exhibited stop/start motion, rarely ever able to finish a trial.

Run# 44 Bed
Date: 8-12-95 Roughness k: 2.4 mm y/k: 24.049

Slope: 0.00154 Q: 8.063115 L/s U*: 0.0248 m/s

	u.s.	d.s.	avg
y (mm)	57.7333333	57.7	57.71667
Tw (mm)	616.666667	615	615.8333
A (m²)	0.02586934	0.025806	0.025838
P (m)	0.63589011	0.634292	0.635091
Rh (m)	0.0406821	0.040685	0.040684
V (m/s)	0.3116861	0.312447	0.312067
H (m)	0.06518131	0.062677	0.063929

delta H: 0.0025039 m delta x: 1.62 m

Sf: 0.00154562

Tavg: 20 °C

ν: 1.004E-06 m²/s

δ: 0.000469 m

Run# 44

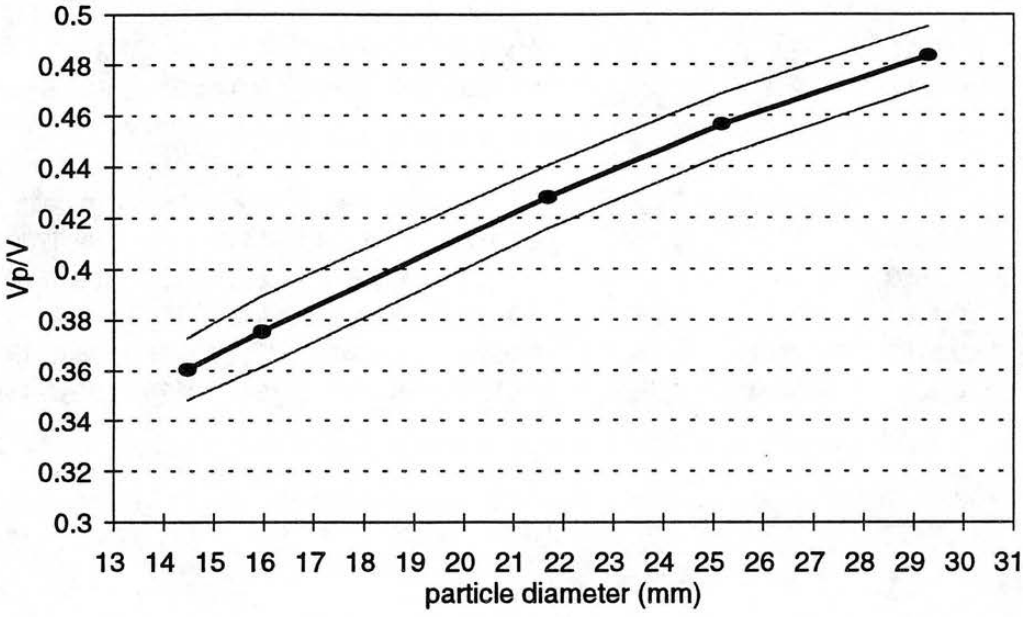
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	29.3	2.6	21	0.1509	0.0037	0.6392	731.5747	0.0013
glass	25.17	2.6	21	0.1424	0.0038	0.5924	628.4552	0.0016
glass	21.7	2.6	21	0.1336	0.0039	0.5500	541.8147	0.0018
glass	15.97	2.6	21	0.1172	0.0044	0.4716	398.7457	0.0025
glass	14.48	2.6	21	0.1125	0.0039	0.4490	361.5427	0.0027

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.4835	6.0756	0.2360	0.0388	12.2083	5117.3126	62.4739	1.9699
glass	0.4563	5.7347	0.2404	0.0419	10.4875	5117.3126	53.6678	2.2931
glass	0.4281	5.3794	0.2429	0.0452	9.0417	5117.3126	46.2690	2.6598
glass	0.3755	4.7188	0.2485	0.0527	6.6542	5117.3126	34.0515	3.6141
glass	0.3604	4.5294	0.2505	0.0553	6.0333	5117.3126	30.8745	3.9860

Run # 44
U* = 0.0248 (m/s)

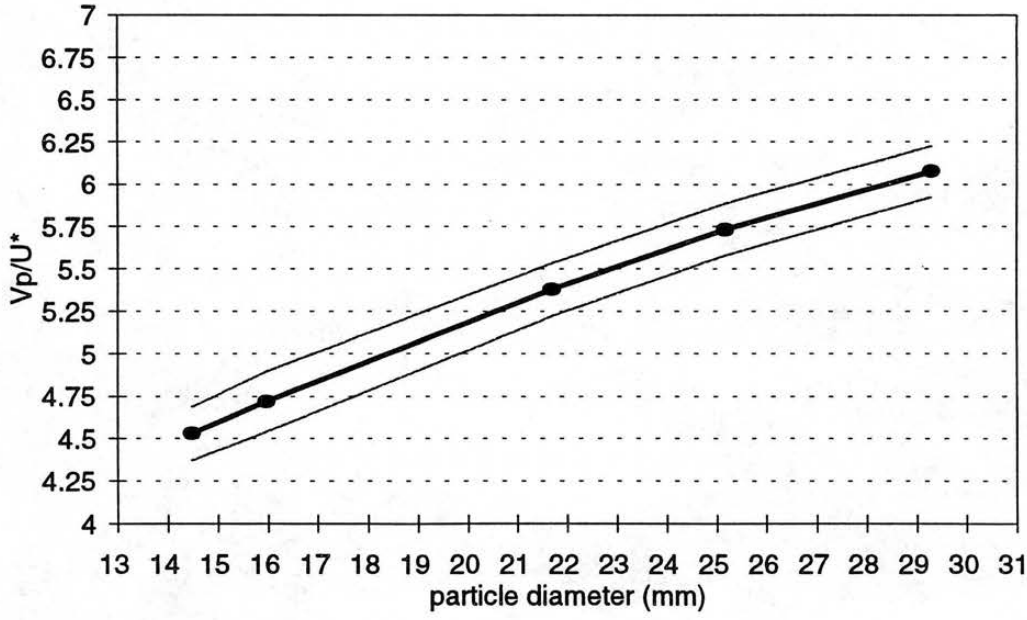
Vp/V vs. d

(glass)



Vp/U* vs. d

(glass)



Run#	45		Bed Roughness k:	1.2	mm	Streamflow	6.9012 L/s
Date	8-14-95		Pump Setting	slow		Valve Setting	3/8 open
Reach Length	2000	mm	Slope Reading	106.5	mm	Bed Slope	0.00091

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer in. of water	Hi	38.55		38.6		38.6	
	Lo	24.85		24.9		24.9	
	Hi - Lo	13.7		13.7		13.7	
Flow Depth:	u.s.	59.5	mm	59.9	mm	60	mm
	d.s.	59.8	mm	59.9	mm	59.9	mm
	u.s. - d.s.	-0.3	mm	0	mm	0.1	mm
	at weir	59.6	mm	59.7	mm	59.6	mm
Top Width:	u.s.	625	mm	634	mm	630	mm
	d.s.	627	mm	632	mm	631	mm
	at weir	657	mm	665	mm	660	mm

Velocities (mm/s)

type	glass	121.8769	117.6471	118.6944	118.6944	124.0695	ERR	ERR
d (mm)	29.3	132.8021	129.2825	133.0672	114.0901	115.0748	ERR	ERR
n	15	123.5330	120.3369	123.8390	114.5475	117.6471	ERR	ERR
G	2.6			Std Dev	6.1486		Avg	121.6802

Velocities (mm/s)

type	glass	110.6807	106.1571	112.1076	116.7542	118.9768	ERR	ERR
d (mm)	25.17	121.2121	115.9420	109.2299	112.1076	108.6366	ERR	ERR
n	15	109.9505	110.1322	107.7006	106.8376	118.4834	ERR	ERR
G	2.6			Std Dev	4.7796		Avg	112.3273

Velocities (mm/s)

type	glass	105.8201	106.4963	103.5733	112.8668	103.8961	ERR	ERR
d (mm)	21.7	104.3841	100.0000	112.8668	108.4599	105.0972	ERR	ERR
n	15	114.0901	106.4963	101.7812	104.0583	113.5074	ERR	ERR
G	2.6			Std Dev	4.4884		Avg	106.8929

Velocities (mm/s)

type	glass	97.1345	88.5347	90.2527	93.6768	97.1345	ERR	ERR
d (mm)	15.97	101.2658	86.9565	92.5069	91.5751	93.8086	ERR	ERR
n	15	89.0076	98.2801	96.9932	100.7557	88.9284	ERR	ERR
G	2.6			Std Dev	4.6067		Avg	93.7874

		Velocities (mm/s)						
type	glass	88.4173	93.0233	96.1076	88.1834	88.1834	ERR	ERR
d (mm)	14.48	87.6424	89.4855	97.5610	89.6459	86.1326	ERR	ERR
n	15	91.0332	84.3170	86.9565	89.1266	86.9565	ERR	ERR
G	2.6			Std Dev	3.6134		Avg	89.5182

Steel particles showed no desire to move.

Natural particles moved only a few centimeters before halting.

The glass particles with diameters 15.97mm and 14.48mm moved with severe meandering motion.

Run# 45 Bed
Date: 8-14-95 Roughness k: 1.2 mm y/k: 49.861

Slope: 0.00091 Q: 6.901243 L/s U*: 0.019 m/s

	u.s.	d.s.	avg
y (mm)	59.8	59.86667	59.83333
Tw (mm)	629.666667	630	629.8333
A (m^2)	0.02718408	0.027224	0.027204
P (m)	0.64952818	0.649887	0.649707
Rh (m)	0.04185205	0.041891	0.041871
V (m/s)	0.25387073	0.253495	0.253683
H (m)	0.06456025	0.063143	0.063852

delta H: 0.0014173 m delta x: 1.62 m

Sf: 0.00087485

Tavg: 20 °C

ν: 1.004E-06 m^2/s

δ: 0.00061448 m

Run# 45

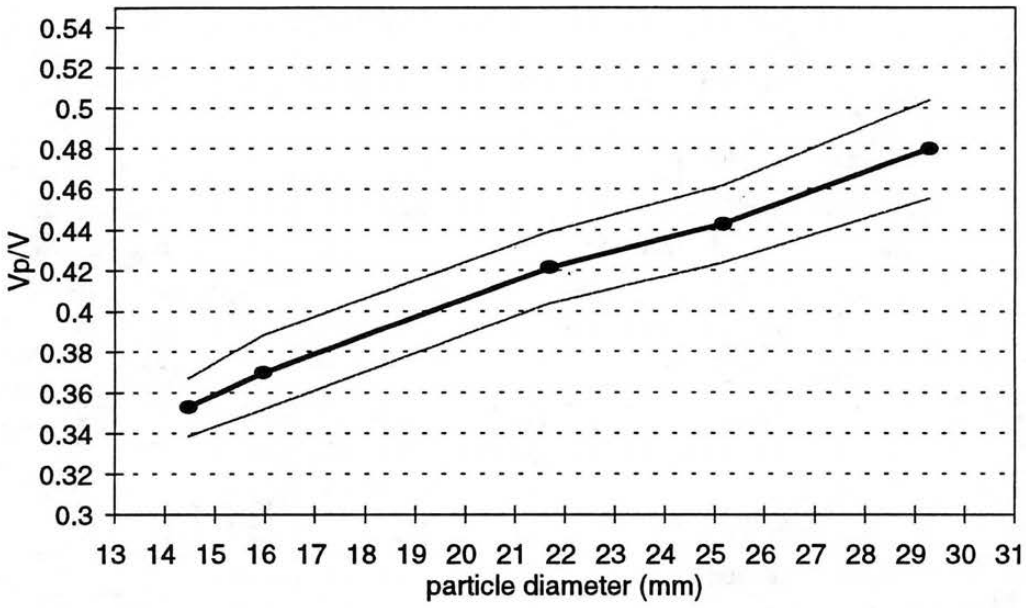
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	29.3	2.6	15	0.1217	0.0061	0.6392	731.5747	0.0008
glass	25.17	2.6	15	0.1123	0.0048	0.5924	628.4552	0.0009
glass	21.7	2.6	15	0.1069	0.0045	0.5500	541.8147	0.0011
glass	15.97	2.6	15	0.0938	0.0046	0.4716	398.7457	0.0014
glass	14.48	2.6	15	0.0895	0.0036	0.4490	361.5427	0.0016

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.4797	6.4200	0.1904	0.0296	24.4167	1952.8773	47.6828	2.0421
glass	0.4428	5.9265	0.1896	0.0320	20.9750	1952.8773	40.9616	2.3772
glass	0.4214	5.6398	0.1944	0.0345	18.0833	1952.8773	35.3145	2.7573
glass	0.3697	4.9483	0.1989	0.0402	13.3083	1952.8773	25.9895	3.7466
glass	0.3529	4.7231	0.1994	0.0422	12.0667	1952.8773	23.5647	4.1321

Run # 45
U* = 0.019 (m/s)

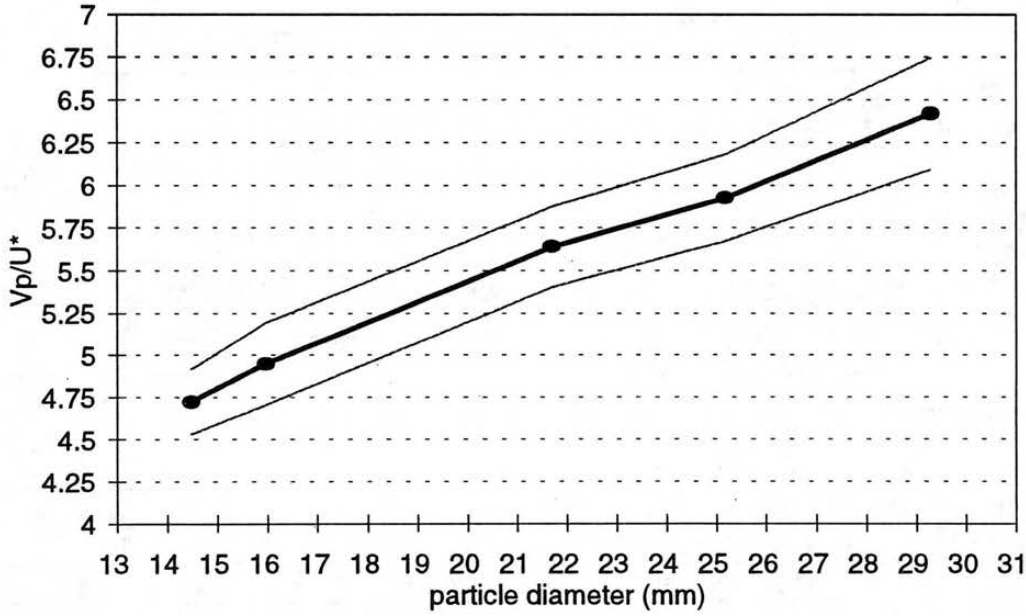
Vp/V vs. d

(glass)



Vp/U* vs. d

(glass)



Run#	46	Bed Roughness k:	1.2	mm	Streamflow	8.0086	L/s
Date	8-15-95	Pump Setting	slow		Valve Setting	7/16 open	
Reach Length	2000	mm	Slope Reading	115	mm	Bed Slope	0.0021

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer in. of water	Hi	42.05		42.1		42.05	
	Lo	23.65		23.7		23.6	
	Hi - Lo	18.4		18.4		18.45	
Flow Depth:	u.s.	52.7	mm	52.5	mm	52.5	mm
	d.s.	52.7	mm	52.7	mm	52.8	mm
	u.s. - d.s.	0	mm	-0.2	mm	-0.3	mm
	at weir	54.3	mm	54.4	mm	54.3	mm
Top Width:	u.s.	586	mm	590	mm	590	mm
	d.s.	582	mm	583	mm	582	mm
	at weir	622	mm	620	mm	625	mm

Velocities (mm/s)

type	glass	188.3239	194.5525	186.5672	191.5709	190.4762	ERR	ERR
d (mm)	29.3	186.0465	186.0465	183.4862	186.0465	187.0907	ERR	ERR
n	15	183.4862	185.3568	189.3939	176.8347	178.4121	ERR	ERR
G	2.6			Std Dev	4.6011		Avg	186.2461

Velocities (mm/s)

type	glass	170.2128	188.6792	175.7469	174.8252	176.6784	ERR	ERR
d (mm)	25.17	183.3181	187.0907	185.5288	180.1802	173.4605	ERR	ERR
n	15	175.7469	175.2848	193.2367	193.4236	169.3480	ERR	ERR
G	2.6			Std Dev	7.8847		Avg	180.1841

Velocities (mm/s)

type	glass	166.6667	158.3531	167.0844	179.8561	167.0844	ERR	ERR
d (mm)	21.7	167.0844	160.3849	165.4260	177.7778	168.3502	ERR	ERR
n	15	172.1170	168.9189	167.9261	174.8252	172.4138	ERR	ERR
G	2.6			Std Dev	5.7852		Avg	168.9513

Velocities (mm/s)

type	glass	160.3849	183.8235	167.5042	182.8154	160.0000	ERR	ERR
d (mm)	15.97	167.2241	172.8608	160.0000	156.4945	157.2327	ERR	ERR
n	15	156.1280	163.2653	149.5886	166.2510	185.0139	ERR	ERR
G	2.6			Std Dev	10.8816		Avg	165.9058

		Velocities (mm/s)						
type	glass	154.2020	158.7302	160.0000	168.3502	154.5595	ERR	ERR
d (mm)	14.48	157.7287	156.4945	156.4945	156.1280	163.9344	ERR	ERR
n	15	157.2327	169.7793	173.9130	153.8462	167.9261	ERR	ERR
G	2.6			Std Dev	6.4726		Avg	160.6213

		Velocities (mm/s)						
type	natural	125.0000	123.7624	139.6648	131.9261	117.3709	ERR	ERR
d (mm)	13.6	130.6336	125.4705	125.0000	116.3467	144.5087	ERR	ERR
n	15	132.8021	136.1470	137.6462	142.5517	132.2751	ERR	ERR
G	2.65			Std Dev	8.5438		Avg	130.7404

		Velocities (mm/s)						
type	natural	147.8197	146.0920	151.6300	129.0323	122.1001	ERR	ERR
d (mm)	9.6	126.4223	147.1670	166.2510	116.8224	119.6172	ERR	ERR
n	15	118.6944	157.3564	119.1185	132.7140	135.0439	ERR	ERR
G	2.65			Std Dev	15.9161		Avg	135.7254

Steel particles moved only a few centimeters before stopping.

A few trials of natural particles with 13.6mm diameters resulted in halting. Many trials of the natural particles with 9.6mm diameters resulted in halting. Natural particles with diameters smaller than 9.6mm exhibited stop/start motion with some surging, most trials resulted in halting.

Run# 46 Bed
Date: 8-15-95 Roughness k: 1.2 mm y/k: 43.875

Slope: 0.0021 Q: 8.008625 L/s U*: 0.027 m/s

	u.s.	d.s.	avg
y (mm)	52.5666667	52.73333	52.65
Tw (mm)	588.666667	582.3333	585.5
A (m²)	0.02281831	0.022724	0.022771
P (m)	0.60605328	0.600173	0.603111
Rh (m)	0.03765067	0.037862	0.037756
V (m/s)	0.35097355	0.352435	0.351704
H (m)	0.06224922	0.059066	0.060658

delta H: 0.0031829 m delta x: 1.62 m

Sf: 0.00196476

Tavg: 20 °C

ν: 1.004E-06 m²/s

δ: 0.0004318 m

Run# 46

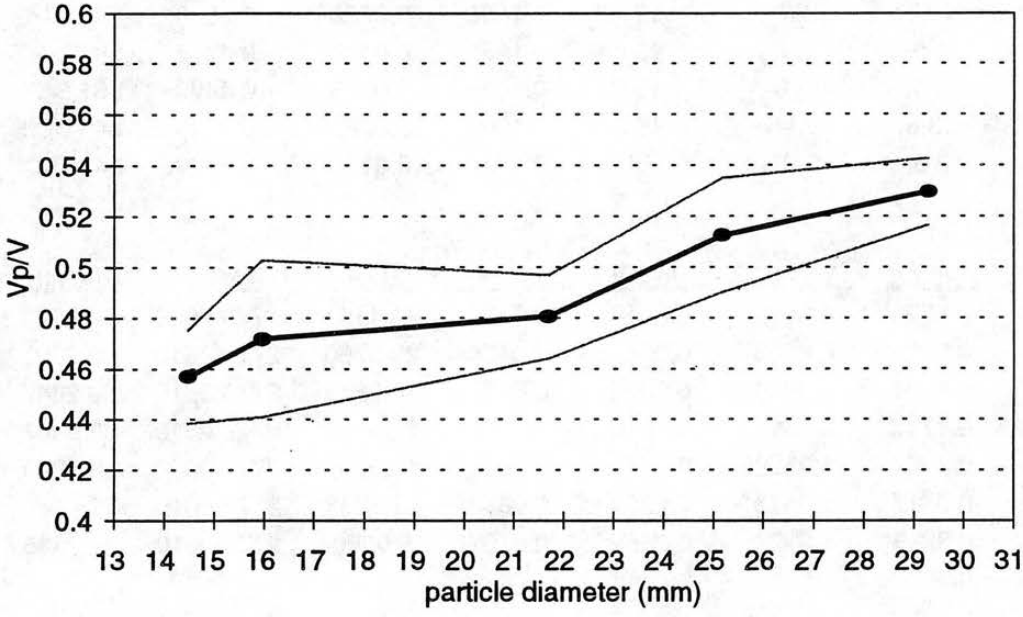
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
glass	29.3	2.6	15	0.1862	0.0046	0.6392	731.5747	0.0016
glass	25.17	2.6	15	0.1802	0.0079	0.5924	628.4552	0.0018
glass	21.7	2.6	15	0.1690	0.0058	0.5500	541.8147	0.0021
glass	15.97	2.6	15	0.1659	0.0109	0.4716	398.7457	0.0029
glass	14.48	2.6	15	0.1606	0.0065	0.4490	361.5427	0.0032
natural	13.6	2.65	15	0.1307	0.0085	0.4419	343.0715	0.0033
natural	9.6	2.65	15	0.1357	0.0159	0.3709	242.1681	0.0047

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
glass	0.5296	6.9052	0.2914	0.0422	24.4167	2779.0610	67.8554	1.7969
glass	0.5123	6.6805	0.3042	0.0455	20.9750	2779.0610	58.2908	2.0918
glass	0.4804	6.2640	0.3072	0.0490	18.0833	2779.0610	50.2547	2.4263
glass	0.4717	6.1511	0.3518	0.0572	13.3083	2779.0610	36.9847	3.2968
glass	0.4567	5.9552	0.3577	0.0601	12.0667	2779.0610	33.5340	3.6360
natural	0.3717	4.8473	0.2959	0.0610	11.3333	2779.0610	31.4960	3.8713
natural	0.3859	5.0321	0.3659	0.0727	8.0000	2779.0610	22.2325	5.4844

Run # 46
U* = 0.027 (m/s)

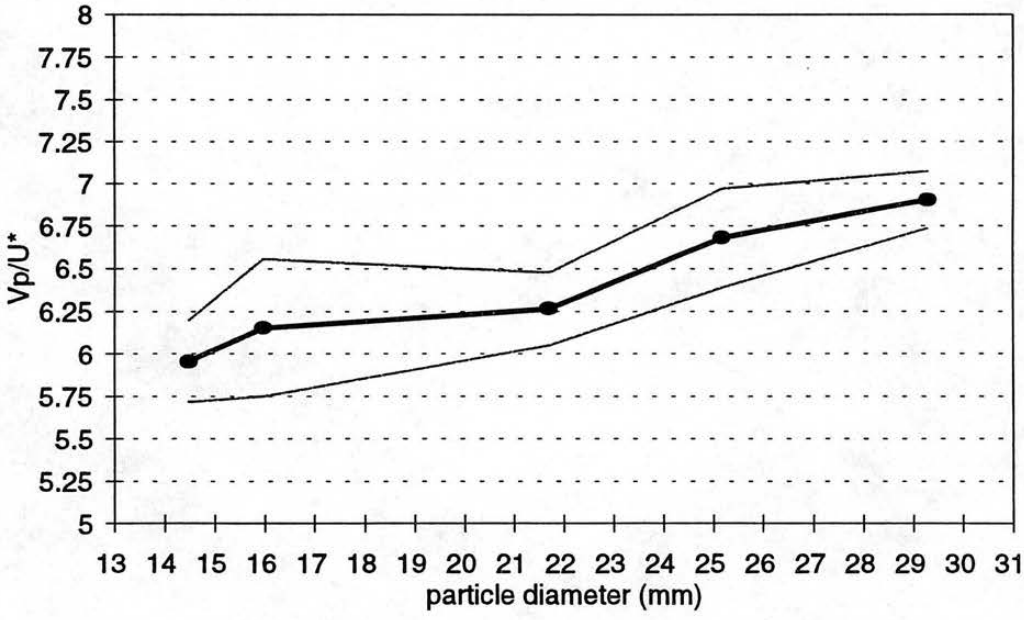
Vp/V vs. d

(glass)



Vp/U* vs. d

(glass)



Run#	47	Bed Roughness k:	1.2	mm	Streamflow	11.4575	L/s
Date	8-16-95	Pump Setting	slow		Valve Setting	3/4 open	
Reach Length	2000	mm	Slope Reading	123.5	mm	Bed Slope	0.00329

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer in. of water	Hi	54.6		54.5		54.6	
	Lo	17		17		17.1	
	Hi - Lo	37.6		37.5		37.5	
Flow Depth:	u.s.	55.7	mm	55.4	mm	55.5	mm
	d.s.	55.7	mm	55.7	mm	55.4	mm
	u.s. - d.s.	0	mm	-0.3	mm	0.1	mm
	at weir	60.5	mm	60.4	mm	60.5	mm
Top Width:	u.s.	600	mm	601	mm	597	mm
	d.s.	603	mm	605	mm	598	mm
	at weir	670	mm	668	mm	680	mm

Velocities (mm/s)

type	steel	126.6624	130.8901	136.4256	136.1470	135.5932	ERR	ERR
d (mm)	19.04	138.8889	134.6801	129.7859	129.6176	137.0802	ERR	ERR
n	15	139.7624	129.5337	132.8021	131.6656	134.7709	ERR	ERR
G	8.02			Std Dev	3.8343		Avg	133.6204

Velocities (mm/s)

type	steel	131.1475	119.4030	122.6242	124.5330	115.1410	ERR	ERR
d (mm)	15.88	106.4963	116.5501	123.7624	118.7648	123.5330	ERR	ERR
n	15	116.4144	124.7661	124.7661	126.7427	125.2348	ERR	ERR
G	8.02			Std Dev	5.9934		Avg	121.3253

Velocities (mm/s)

type	steel	105.2632	114.8765	105.4296	117.4398	117.2333	ERR	ERR
d (mm)	14.28	114.0251	114.2857	112.6761	113.0582	109.7695	ERR	ERR
n	15	117.2333	113.0582	113.8952	112.0448	117.2333	ERR	ERR
G	8.02			Std Dev	3.8610		Avg	113.1681

Velocities (mm/s)

type	glass	338.9831	349.6503	316.9572	361.6637	336.7003	ERR	ERR
d (mm)	29.3	351.4938	312.5000	361.6637	324.6753	349.6503	ERR	ERR
n	15	369.6858	351.4938	335.0084	347.8261	355.2398	ERR	ERR
G	2.6			Std Dev	16.5972		Avg	344.2128

Velocities (mm/s)

type	glass	340.1361	323.1018	304.8780	342.4658	318.4713	ERR	ERR
d (mm)	25.17	335.0084	324.6753	357.7818	338.9831	340.7155	ERR	ERR
n	15	349.6503	335.0084	312.5000	357.7818	353.3569	ERR	ERR
G	2.6			Std Dev	16.1448		Avg	335.6343

Velocities (mm/s)

type	glass	304.8780	329.4893	333.3333	304.8780	347.8261	ERR	ERR
d (mm)	21.7	311.0420	320.0000	335.0084	321.5434	344.2341	ERR	ERR
n	15	336.7003	325.2033	341.8803	338.9831	324.6753	ERR	ERR
G	2.6			Std Dev	13.6454		Avg	327.9783

Velocities (mm/s)

type	glass	312.0125	297.6190	321.5434	320.0000	333.3333	ERR	ERR
d (mm)	15.97	301.6591	310.5590	320.0000	312.5000	313.4796	ERR	ERR
n	15	323.1018	323.1018	303.4901	313.4796	307.6923	ERR	ERR
G	2.6			Std Dev	9.4754		Avg	314.2381

Velocities (mm/s)

type	glass	301.6591	316.4557	285.7143	280.5049	336.7003	ERR	ERR
d (mm)	14.48	321.5434	294.9853	293.2551	353.3569	298.9537	ERR	ERR
n	15	303.4901	279.7203	346.0208	316.9572	307.6923	ERR	ERR
G	2.6			Std Dev	22.7157		Avg	309.1340

Velocities (mm/s)

type	natural	244.4988	227.7904	191.0220	222.9654	223.7136	ERR	ERR
d (mm)	13.6	236.1275	239.8082	232.8289	249.0660	192.8640	ERR	ERR
n	15	218.3406	216.9197	222.2222	217.8649	228.5714	ERR	ERR
G	2.65			Std Dev	16.3410		Avg	224.3069

Velocities (mm/s)

type	natural	226.7574	206.6116	260.0780	219.0581	250.0000	ERR	ERR
d (mm)	9.6	241.5459	239.8082	236.9668	243.6054	212.5399	ERR	ERR
n	15	194.5525	282.8854	265.6042	205.7613	265.6042	ERR	ERR
G	2.65			Std Dev	25.6919		Avg	236.7586

Velocities (mm/s)

type	natural	224.7191	220.7506	198.6097	226.2443	282.0874	ERR	ERR
d (mm)	6.8	250.0000	266.6667	258.0645	215.5172	263.5046	ERR	ERR
n	15	285.7143	225.2252	281.6901	230.9469	271.0027	ERR	ERR
G	2.65			Std Dev	28.0048		Avg	246.7162

Velocities (mm/s)

type	natural	278.1641	331.1258	266.6667	248.1390	283.2861	ERR	ERR
d (mm)	4.8	255.1020	267.7376	285.7143	251.8892	250.0000	ERR	ERR
n	15	293.2551	273.9726	287.7698	256.4103	262.8121	ERR	ERR
G	2.65			Std Dev	21.8132		Avg	272.8030

The steel particle with diameter 14.28mm halted without restart on 8 trials.
The steel particle with diameter 9.5mm was run 10 times, all resulted in halting without restart.
Steel particles smaller than 9.5mm moved only short distances before stopping.

The natural particles with diameters 9.6mm and 6.8mm showed a small amount of suspension.
The natural particles with diameter 4.8mm moved with considerable suspension and noticable surging.
Natural particles smaller than 4.8mm showed surging, suspension, stop/start motion, rolled off the plates, etc.

Run# 47 Bed
Date: 8-16-95 Roughness k: 1.2 mm y/k: 46.306

Slope: 0.00329 Q: 11.45747 L/s U*: 0.0358 m/s

	u.s.	d.s.	avg
y (mm)	55.5333333	55.6	55.56667
Tw (mm)	599.333333	602	600.6667
A (m^2)	0.02440227	0.024506	0.024454
P (m)	0.61806929	0.620633	0.619351
Rh (m)	0.03948145	0.039485	0.039483
V (m/s)	0.4695246	0.467543	0.468534
H (m)	0.07210313	0.066745	0.069424

delta H: 0.0053578 m delta x: 1.62 m

Sf: 0.00330729

Tavg: 20 °C

ν: 1.004E-06 m^2/s

δ: 0.00032545 m

Run# 47

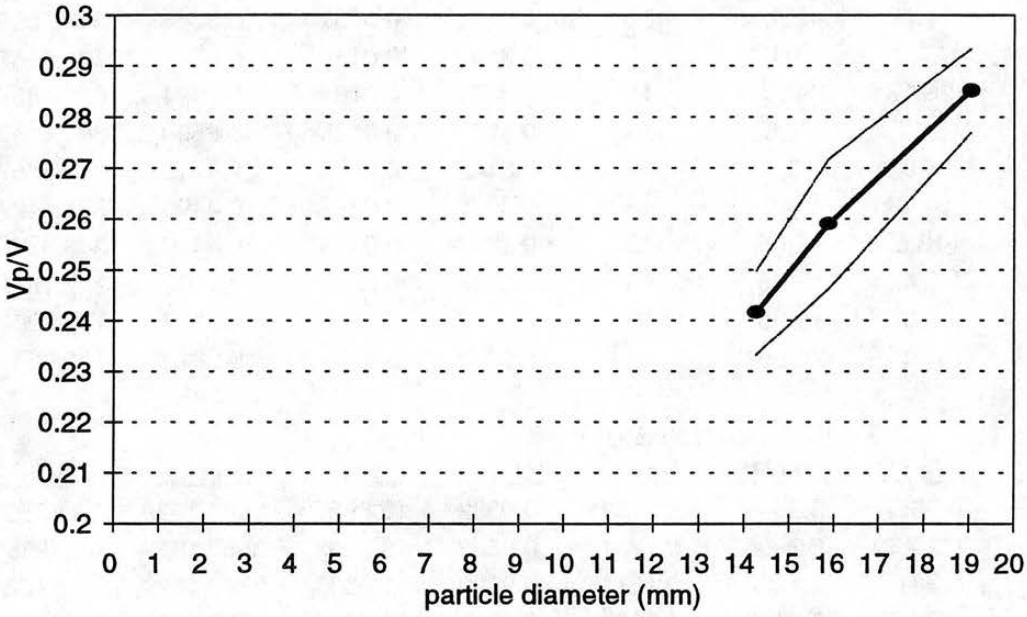
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	15	0.1336	0.0038	1.0794	778.2702	0.0010
steel	15.88	8.02	15	0.1213	0.0060	0.9857	649.1035	0.0012
steel	14.28	8.02	15	0.1132	0.0039	0.9346	583.7026	0.0013
glass	29.3	2.6	15	0.3442	0.0166	0.6392	731.5747	0.0028
glass	25.17	2.6	15	0.3356	0.0161	0.5924	628.4552	0.0032
glass	21.7	2.6	15	0.3280	0.0136	0.5500	541.8147	0.0038
glass	15.97	2.6	15	0.3142	0.0095	0.4716	398.7457	0.0051
glass	14.48	2.6	15	0.3091	0.0227	0.4490	361.5427	0.0056
natural	13.6	2.65	15	0.2243	0.0163	0.4419	343.0715	0.0058
natural	9.6	2.65	15	0.2368	0.0257	0.3709	242.1681	0.0082
natural	6.8	2.65	15	0.2467	0.0280	0.3117	171.5357	0.0116
natural	4.8	2.65	15	0.2728	0.0218	0.2612	121.0841	0.0165

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.2852	3.7340	0.1238	0.0332	15.8667	3687.1629	58.5030	2.9184
steel	0.2589	3.3904	0.1231	0.0363	13.2333	3687.1629	48.7935	3.4992
steel	0.2415	3.1624	0.1211	0.0383	11.9000	3687.1629	43.8772	3.8912
glass	0.7347	9.6189	0.5385	0.0560	24.4167	3687.1629	90.0282	1.8965
glass	0.7164	9.3792	0.5666	0.0604	20.9750	3687.1629	77.3382	2.2077
glass	0.7000	9.1652	0.5963	0.0651	18.0833	3687.1629	66.6762	2.5607
glass	0.6707	8.7812	0.6663	0.0759	13.3083	3687.1629	49.0700	3.4794
glass	0.6598	8.6386	0.6885	0.0797	12.0667	3687.1629	44.4918	3.8375
natural	0.4787	6.2682	0.5076	0.0810	11.3333	3687.1629	41.7878	4.0858
natural	0.5053	6.6161	0.6383	0.0965	8.0000	3687.1629	29.4973	5.7882
natural	0.5266	6.8944	0.7916	0.1148	5.6667	3687.1629	20.8939	8.1716
natural	0.5822	7.6234	1.0445	0.1370	4.0000	3687.1629	14.7487	11.5764

Run # 47
U* = 0.0358 (m/s)

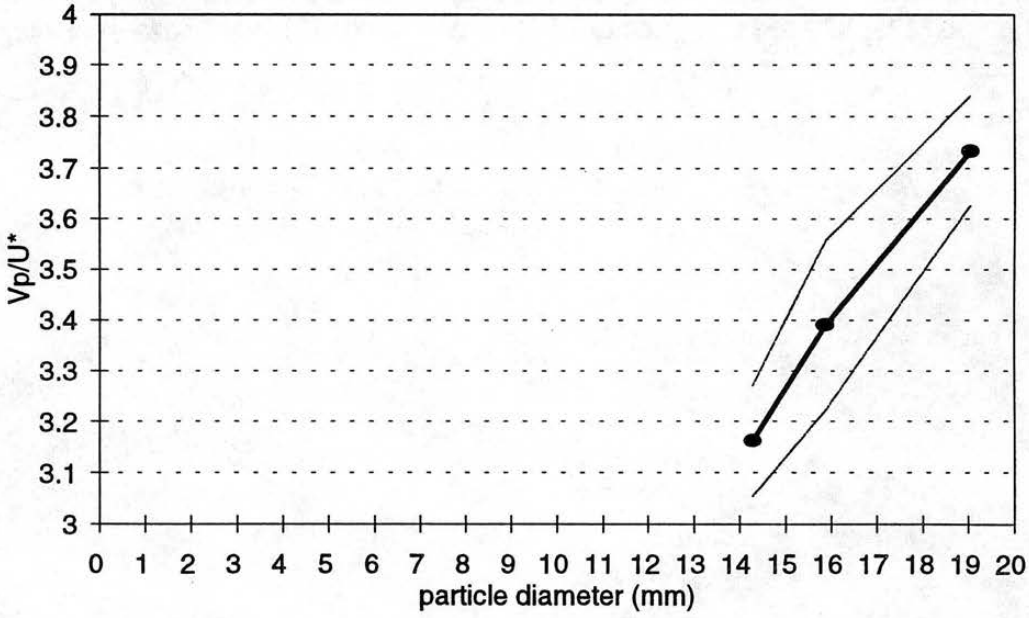
Vp/V vs. d

(steel)



Vp/U* vs. d

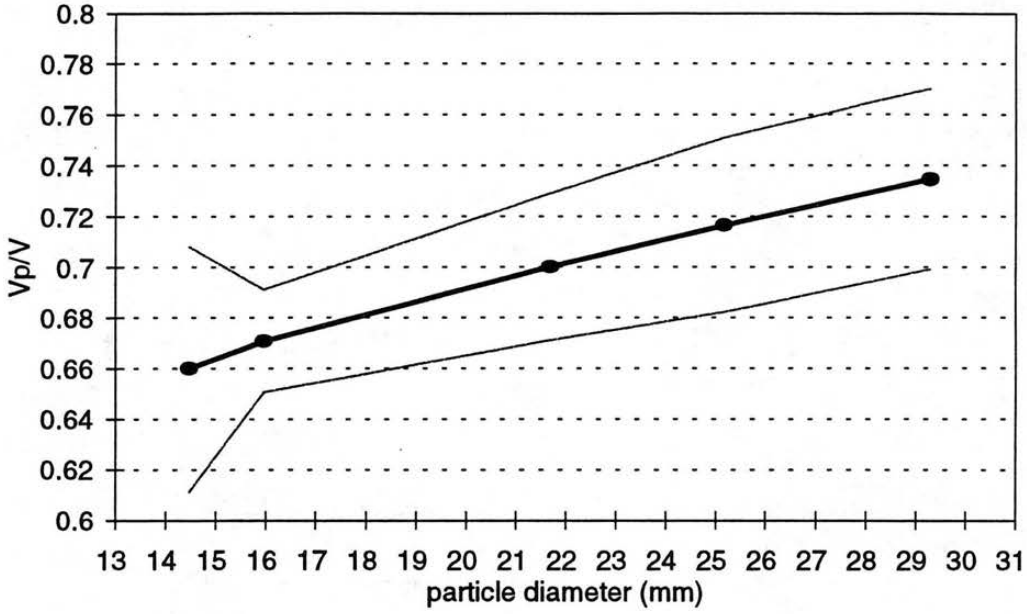
(steel)



Run # 47
U* = 0.0358 (m/s)

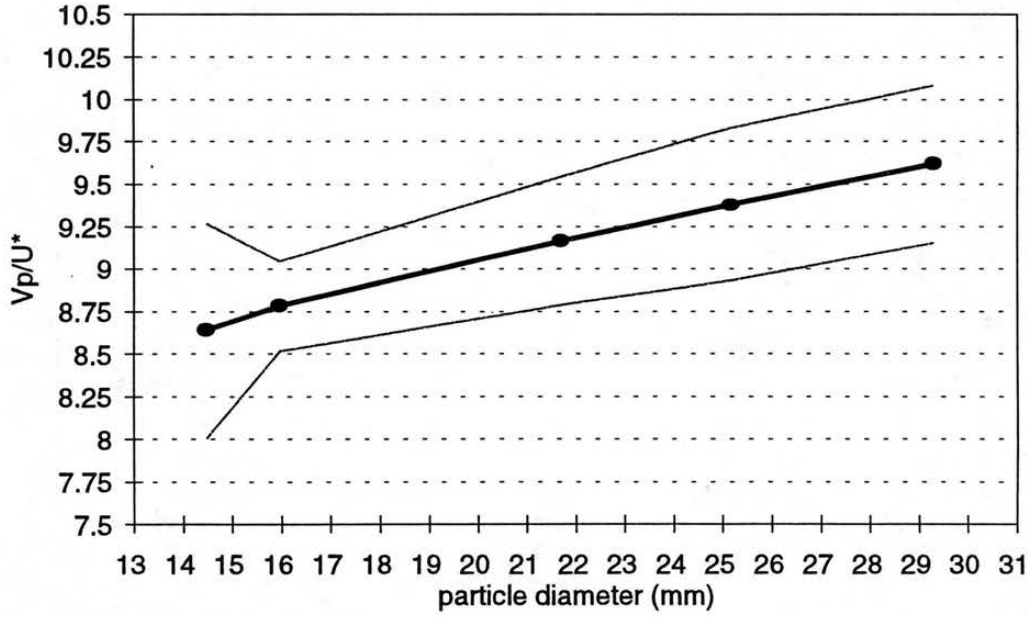
Vp/V vs. d

(glass)



Vp/U* vs. d

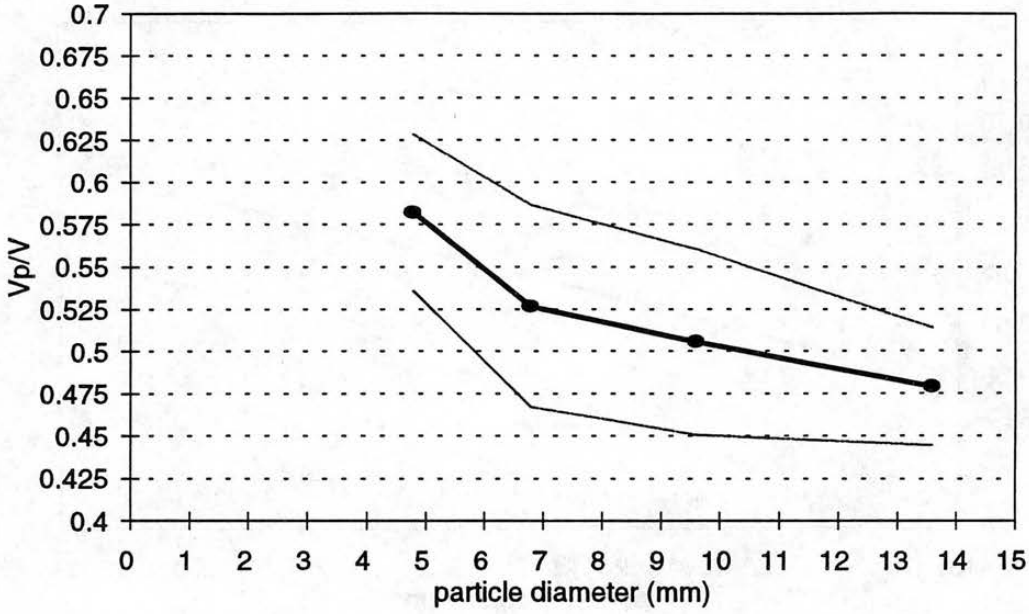
(glass)



Run # 47
U* = 0.0358 (m/s)

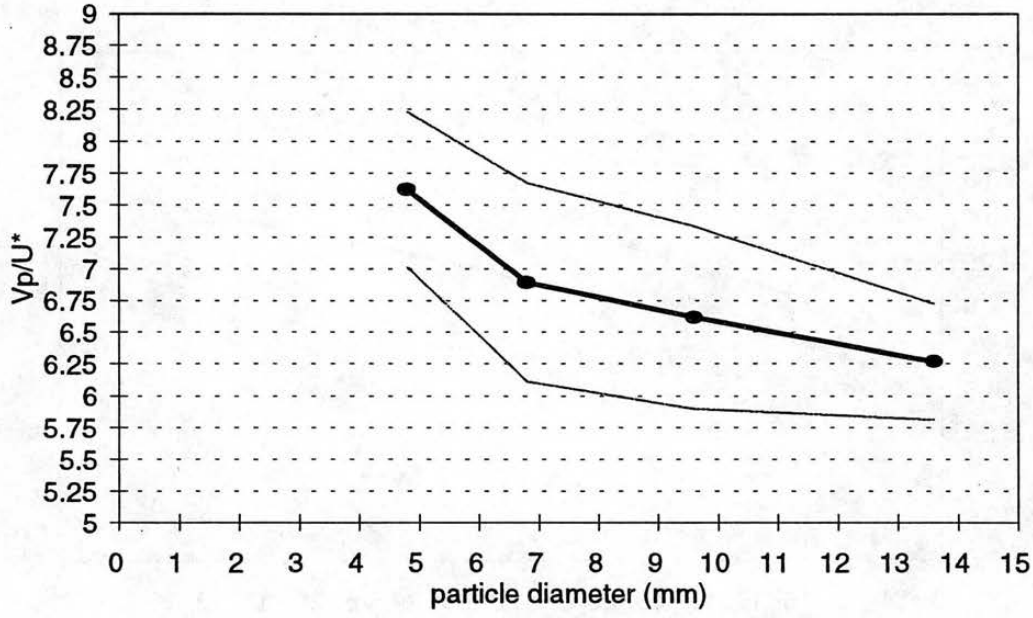
Vp/V vs. d

(natural)



Vp/U* vs. d

(natural)



Run#	48	Bed Roughness k:	1.2	mm	Streamflow	18.7850	L/s
Date	8-17-95	Pump Setting	fast		Valve Setting	7/16 open	
Reach Length	2000	mm	Slope Reading	131.5	mm	Bed Slope	0.00441

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer in. of water	Hi	48.8		48.8		48.8	
	Lo	-51.5		-51.5		-51.5	
	Hi - Lo	100.3		100.3		100.3	
Flow Depth:	u.s.	60.8	mm	60.1	mm	60.4	mm
	d.s.	61.3	mm	60.7	mm	60.6	mm
	u.s. - d.s.	-0.5	mm	-0.6	mm	-0.2	mm
	at weir	66.8	mm	67.1	mm	66.1	mm
Top Width:	u.s.	627	mm	622	mm	623	mm
	d.s.	630	mm	633	mm	638	mm
	at weir	710	mm	715	mm	720	mm

Velocities (mm/s)

type	steel	181.8182	188.6792	186.5672	196.2709	190.4762	ERR	ERR
d (mm)	19.04	175.4386	184.8429	185.5288	187.7934	188.3239	ERR	ERR
n	15	185.0139	183.3181	191.5709	188.3239	203.2520	ERR	ERR
G	8.02			Std Dev	6.3532		Avg	187.8145

Velocities (mm/s)

type	steel	174.8252	179.3722	179.2115	173.4605	171.5266	ERR	ERR
d (mm)	15.88	162.8664	175.4386	179.8561	175.2848	171.0864	ERR	ERR
n	15	177.3050	185.0139	182.3154	164.6091	171.9690	ERR	ERR
G	8.02			Std Dev	6.0588		Avg	174.9427

Velocities (mm/s)

type	steel	156.8627	166.2510	166.6667	173.9130	172.5626	ERR	ERR
d (mm)	14.28	171.5266	164.0689	167.9261	181.8182	169.3480	ERR	ERR
n	15	162.8664	159.2357	162.0746	165.0165	169.7793	ERR	ERR
G	8.02			Std Dev	6.2614		Avg	167.3278

Velocities (mm/s)

type	steel	155.2795	158.8562	155.4002	145.4545	146.8429	ERR	ERR
d (mm)	9.5	151.9757	149.5886	173.4605	148.8095	159.2357	ERR	ERR
n	15	162.8664	150.6024	160.0000	157.9779	179.8561	ERR	ERR
G	8.02			Std Dev	9.5478		Avg	157.0804

Velocities (mm/s)

type	steel	162.4695	149.9250	149.4768	172.4138	157.2327	ERR	ERR
d (mm)	7.9	169.2047	213.4472	168.0672	151.2859	158.1028	ERR	ERR
n	15	162.8664	171.6738	177.7778	151.6300	176.2115	ERR	ERR
G	8.02			Std Dev	16.2521		Avg	166.1190

Velocities (mm/s)

type	steel	198.8072	152.7884	185.0139	152.6718	145.7726	ERR	ERR
d (mm)	6.34	143.4720	195.1220	162.8664	157.2327	155.7632	ERR	ERR
n	15	147.1670	184.5018	204.4990	158.4786	160.0000	ERR	ERR
G	8.02			Std Dev	20.7099		Avg	166.9438

Velocities (mm/s)

type	steel	154.5595	148.1481	216.2162	177.7778	191.5709	ERR	ERR
d (mm)	4.75	186.5672	252.2068	204.4990	187.0907	181.8182	ERR	ERR
n	15	203.6660	183.4862	192.8640	178.2531	192.1230	ERR	ERR
G	8.02			Std Dev	24.4857		Avg	190.0564

Velocities (mm/s)

type	glass	511.5090	487.8049	496.2779	473.9336	447.4273	ERR	ERR
d (mm)	29.3	516.7959	464.0371	500.0000	508.9059	527.7045	ERR	ERR
n	15	503.7783	480.7692	547.9452	503.7783	508.9059	ERR	ERR
G	2.6			Std Dev	25.2265		Avg	498.6382

Velocities (mm/s)

type	glass	473.9336	480.7692	516.7959	492.6108	481.9277	ERR	ERR
d (mm)	25.17	557.1031	529.1005	487.8049	533.3333	507.6142	ERR	ERR
n	15	473.9336	516.7959	537.6344	519.4805	542.0054	ERR	ERR
G	2.6			Std Dev	26.9165		Avg	510.0562

Velocities (mm/s)

type	glass	507.6142	464.0371	447.4273	477.3270	487.8049	ERR	ERR
d (mm)	21.7	450.4505	441.5011	485.4369	480.7692	467.2897	ERR	ERR
n	15	507.6142	508.9059	459.7701	529.1005	475.0594	ERR	ERR
G	2.6			Std Dev	25.5364		Avg	479.3405

Velocities (mm/s)

type	glass	464.0371	473.9336	434.7826	484.2615	387.5969	ERR	ERR
d (mm)	15.97	438.5965	441.5011	505.0505	477.3270	507.6142	ERR	ERR
n	15	447.4273	480.7692	500.0000	470.5882	496.2779	ERR	ERR
G	2.6			Std Dev	32.6112		Avg	467.3176

Velocities (mm/s)

type	glass	515.4639	467.2897	423.7288	429.1845	470.5882	ERR	ERR
d (mm)	14.48	441.5011	500.0000	467.2897	503.7783	451.4673	ERR	ERR
n	15	410.6776	450.4505	413.2231	500.0000	457.6659	ERR	ERR
G	2.6			Std Dev	33.6032		Avg	460.1539

		Velocities (mm/s)						
type	natural	353.9823	390.6250	320.0000	431.9654	464.0371	ERR	ERR
d (mm)	13.6	437.6368	457.6659	397.6143	378.7879	378.7879	ERR	ERR
n	15	365.6307	395.2569	390.6250	496.2779	380.9524	ERR	ERR
G	2.65			Std Dev	46.4401		Avg	402.6564

		Velocities (mm/s)						
type	natural	365.6307	376.6478	385.3565	392.9273	357.7818	ERR	ERR
d (mm)	9.6	402.4145	459.7701	404.8583	375.9398	418.4100	ERR	ERR
n	15	435.7298	378.7879	365.6307	397.6143	395.2569	ERR	ERR
G	2.65			Std Dev	27.6738		Avg	394.1838

		Velocities (mm/s)						
type	natural	335.0084	462.9630	353.3569	363.6364	336.7003	ERR	ERR
d (mm)	6.8	372.4395	336.7003	397.6143	353.3569	351.4938	ERR	ERR
n	15	456.6210	347.8261	326.2643	342.4658	380.9524	ERR	ERR
G	2.65			Std Dev	41.8370		Avg	367.8266

		Velocities (mm/s)						
type	natural	359.7122	365.6307	389.8635	402.4145	365.6307	ERR	ERR
d (mm)	4.8	412.3711	387.5969	376.6478	459.7701	431.9654	ERR	ERR
n	15	365.6307	404.8583	438.5965	412.3711	371.0575	ERR	ERR
G	2.65			Std Dev	30.4932		Avg	396.2745

		Velocities (mm/s)						
type	natural	318.4713	320.0000	380.9524	352.1127	423.7288	ERR	ERR
d (mm)	3.4	441.5011	371.7472	394.4773	316.9572	346.0208	ERR	ERR
n	15	335.0084	400.0000	380.9524	387.5969	415.8004	ERR	ERR
G	2.65			Std Dev	39.7793		Avg	372.3551

The steel particles with diameters 6.34mm and 4.75mm exhibited noticable surging and meandering motion. Many trials resulted in particle halting before finishing the run.

The natural particles with 6.8mm diameter started to show suspension and surging. The 4.8mm and 3.4mm diameter particles showed significant surging and suspension.

Run# 48 Bed
Date: 8-17-95 Roughness k: 1.2 mm y/k: 50.542

Slope: 0.00441 Q: 18.785 L/s U*: 0.044 m/s

	u.s.	d.s.	avg
y (mm)	60.4333333	60.86667	60.65
Tw (mm)	624	633.6667	628.8333
A (m²)	0.02730076	0.027791	0.027545
P (m)	0.64458766	0.654004	0.649294
Rh (m)	0.04235383	0.042493	0.042423
V (m/s)	0.68807621	0.675945	0.682011
H (m)	0.09171671	0.084162	0.087939

delta H: 0.0075545 m delta x: 1.62 m

Sf: 0.00466328

Tavg: 20 °C

ν: 1.004E-06 m²/s

δ: 0.00026441 m

Run# 48

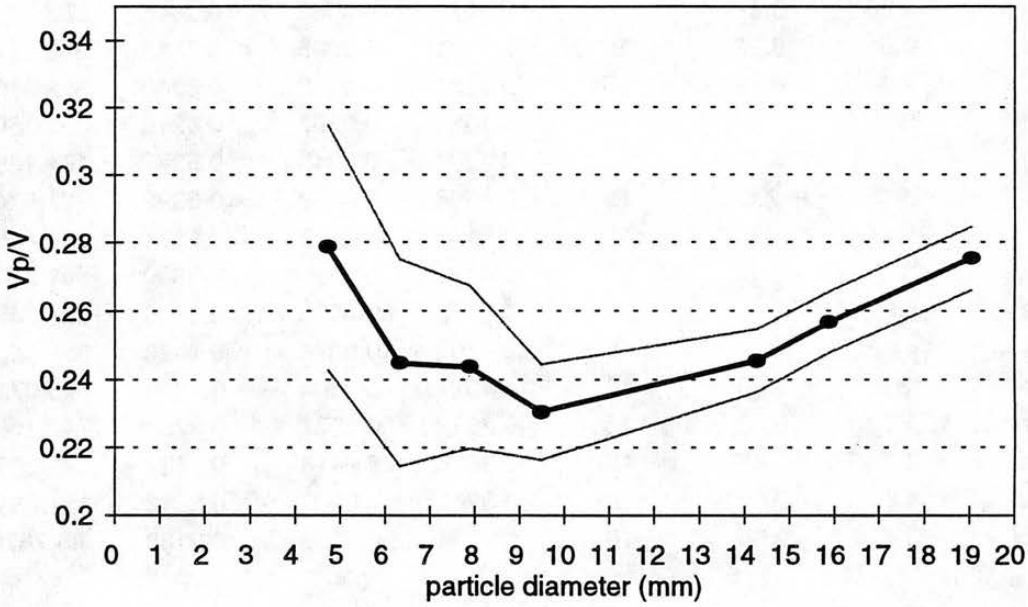
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	15	0.1878	0.0064	1.0794	778.2702	0.0015
steel	15.88	8.02	15	0.1749	0.0061	0.9857	649.1035	0.0018
steel	14.28	8.02	15	0.1673	0.0063	0.9346	583.7026	0.0020
steel	9.5	8.02	15	0.1571	0.0095	0.7619	388.3176	0.0030
steel	7.9	8.02	15	0.1661	0.0163	0.6946	322.9167	0.0036
steel	6.34	8.02	15	0.1669	0.0207	0.6219	259.1509	0.0044
steel	4.75	8.02	15	0.1901	0.0245	0.5377	194.1588	0.0059
glass	29.3	2.6	15	0.4986	0.0252	0.6392	731.5747	0.0042
glass	25.17	2.6	15	0.5101	0.0269	0.5924	628.4552	0.0049
glass	21.7	2.6	15	0.4793	0.0255	0.5500	541.8147	0.0057
glass	15.97	2.6	15	0.4673	0.0326	0.4716	398.7457	0.0077
glass	14.48	2.6	15	0.4602	0.0336	0.4490	361.5427	0.0085
natural	13.6	2.65	15	0.4027	0.0464	0.4419	343.0715	0.0088
natural	9.6	2.65	15	0.3942	0.0277	0.3709	242.1681	0.0125
natural	6.8	2.65	15	0.3678	0.0418	0.3117	171.5357	0.0176
natural	4.8	2.65	15	0.3963	0.0305	0.2612	121.0841	0.0250
natural	3.4	2.65	15	0.3724	0.0398	0.2189	85.7679	0.0353

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.2754	4.2640	0.1740	0.0408	15.8667	4538.3482	72.0085	3.1854
steel	0.2565	3.9718	0.1775	0.0447	13.2333	4538.3482	60.0575	3.8193
steel	0.2453	3.7989	0.1790	0.0471	11.9000	4538.3482	54.0063	4.2472
steel	0.2303	3.5663	0.2062	0.0578	7.9167	4538.3482	35.9286	6.3842
steel	0.2436	3.7715	0.2392	0.0634	6.5833	4538.3482	29.8775	7.6772
steel	0.2448	3.7902	0.2685	0.0708	5.2833	4538.3482	23.9776	9.5662
steel	0.2787	4.3149	0.3535	0.0819	3.9583	4538.3482	17.9643	12.7684
glass	0.7311	11.3208	0.7800	0.0689	24.4167	4538.3482	110.8113	2.0700
glass	0.7479	11.5800	0.8610	0.0744	20.9750	4538.3482	95.1919	2.4096
glass	0.7028	10.8827	0.8715	0.0801	18.0833	4538.3482	82.0685	2.7949
glass	0.6852	10.6097	0.9908	0.0934	13.3083	4538.3482	60.3979	3.7977
glass	0.6747	10.4471	1.0248	0.0981	12.0667	4538.3482	54.7627	4.1885
natural	0.5904	9.1417	0.9113	0.0997	11.3333	4538.3482	51.4346	4.4596
natural	0.5780	8.9493	1.0628	0.1188	8.0000	4538.3482	36.3068	6.3177
natural	0.5393	8.3509	1.1801	0.1413	5.6667	4538.3482	25.7173	8.9191
natural	0.5810	8.9968	1.5172	0.1686	4.0000	4538.3482	18.1534	12.6354
natural	0.5460	8.4537	1.7012	0.2012	2.8333	4538.3482	12.8587	17.8382

Run # 48
U* = 0.044 (m/s)

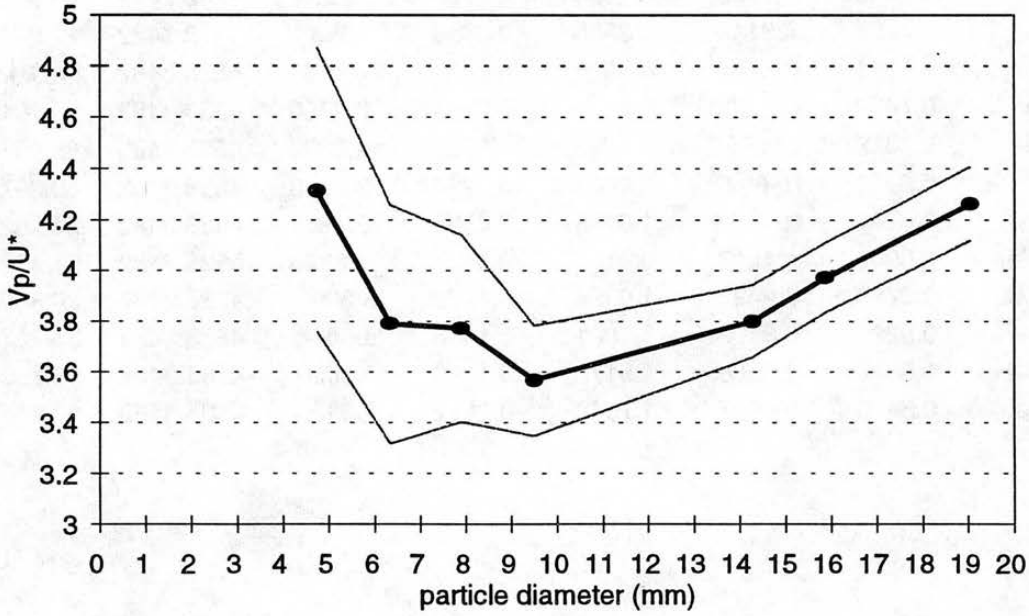
Vp/V vs. d

(steel)



Vp/U* vs. d

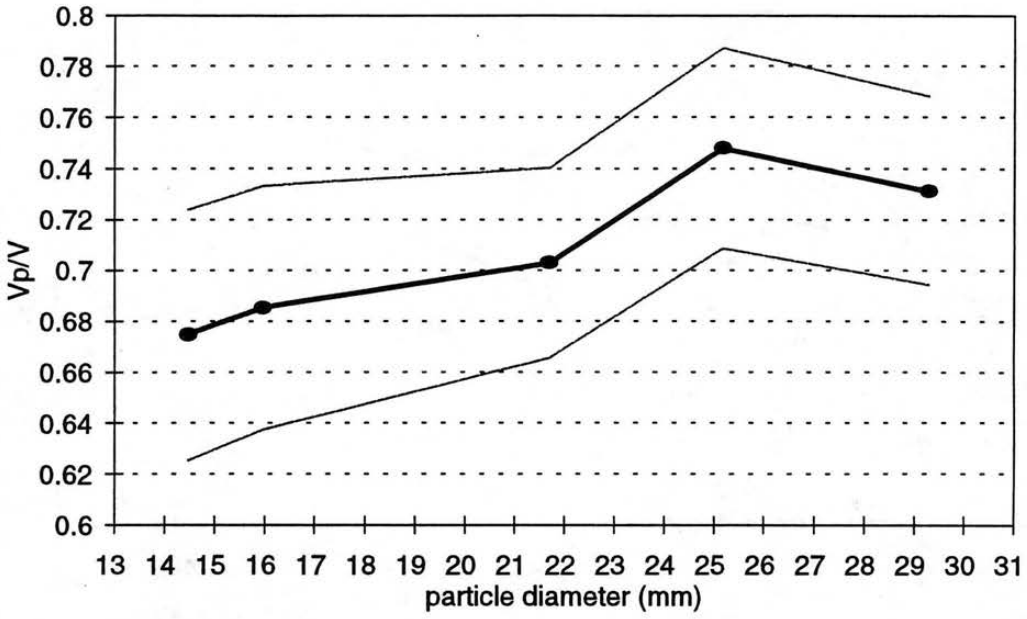
(steel)



Run # 48
U* = 0.044 (m/s)

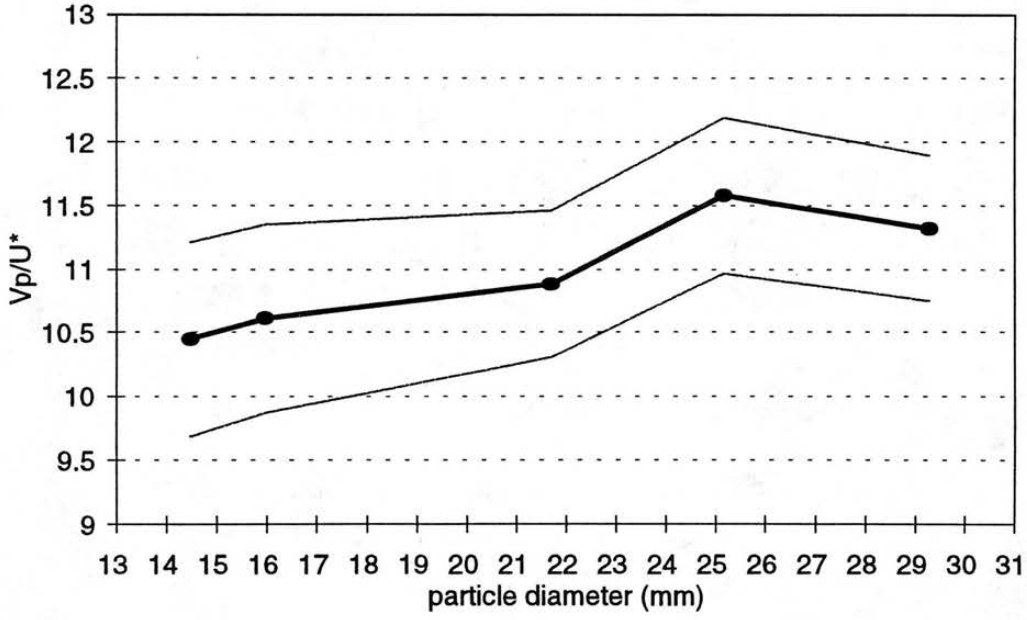
Vp/V vs. d

(glass)



Vp/U* vs. d

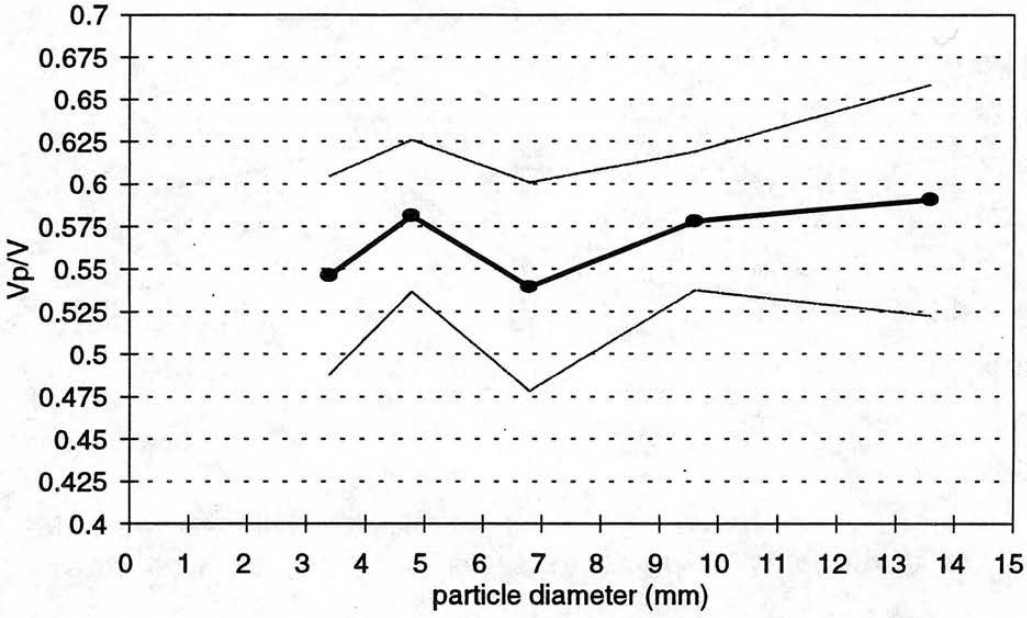
(glass)



Run # 48
U* = 0.044 (m/s)

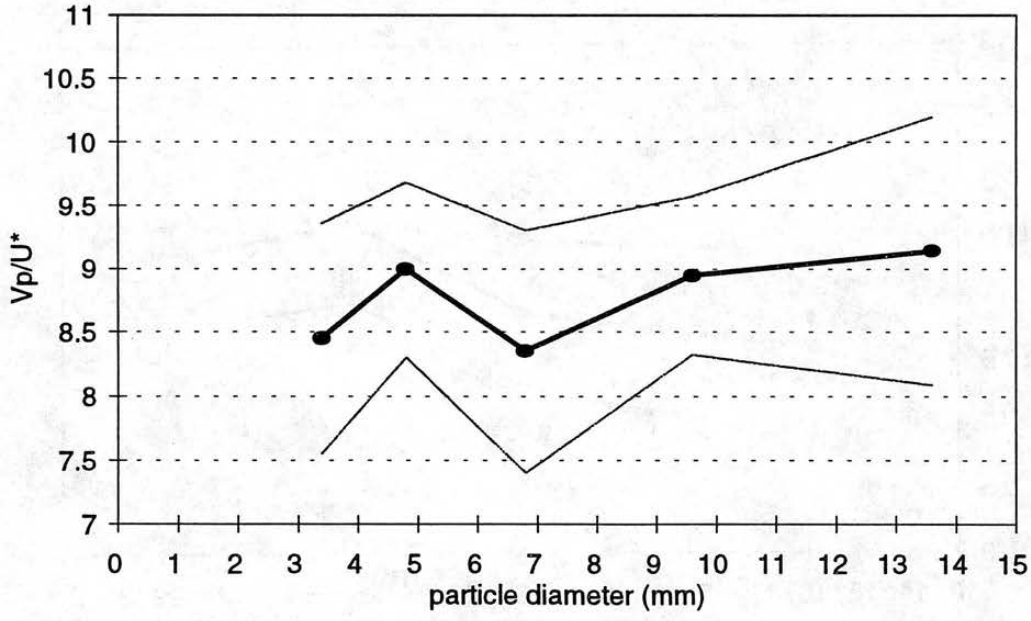
Vp/V vs. d

(natural)



Vp/U* vs. d

(natural)



Run#	49	Bed Roughness k:	1.2	mm	Streamflow	23.8830	L/s
Date	8-18-95	Pump Setting	fast		Valve Setting	9/16 open	
Reach Length	2000	mm	Slope Reading	140	mm	Bed Slope	0.0056

		Initial		Intermediate		Final	
Temperature		20	°C			20	°C
Manometer in. of water	Hi	78.6		78.6		77.2	
	Lo	-84		-84		-82.6	
	Hi - Lo	162.6		162.6		159.8	
Flow Depth:	u.s.	64.4	mm	64.1	mm	64	mm
	d.s.	64.4	mm	64	mm	63.8	mm
	u.s. - d.s.	0	mm	0.1	mm	0.2	mm
	at weir	59.7	mm	59.7	mm	59.7	mm
Top Width:	u.s.	656	mm	652	mm	656	mm
	d.s.	662	mm	662	mm	663	mm
	at weir	663	mm	663	mm	665	mm

Velocities (mm/s)

type	steel	233.6449	251.8892	232.8289	257.0694	226.2443	ERR	ERR
d (mm)	19.04	234.1920	237.8121	226.7574	236.9668	225.4791	ERR	ERR
n	15	237.8121	229.3578	245.3988	214.1328	225.4791	ERR	ERR
G	8.02			Std Dev	10.9997		Avg	234.3377

Velocities (mm/s)

type	steel	213.2196	230.9469	236.9668	259.7403	261.0966	ERR	ERR
d (mm)	15.88	274.7253	217.8649	233.6449	204.4990	220.5072	ERR	ERR
n	15	223.7136	251.8892	224.7191	261.0966	246.9136	ERR	ERR
G	8.02			Std Dev	20.7948		Avg	237.4362

Velocities (mm/s)

type	steel	220.0220	232.8289	250.9410	268.8172	251.8892	ERR	ERR
d (mm)	14.28	227.7904	244.2002	280.8989	241.8380	261.4379	ERR	ERR
n	15	225.2252	220.0220	209.8636	251.8892	260.0780	ERR	ERR
G	8.02			Std Dev	20.2882		Avg	243.1828

Velocities (mm/s)

type	steel	237.2479	255.1020	208.9864	224.4669	216.9197	ERR	ERR
d (mm)	9.5	203.0457	251.8892	249.0660	225.2252	230.1496	ERR	ERR
n	15	228.5714	239.5210	219.7802	260.0780	212.0891	ERR	ERR
G	8.02			Std Dev	17.5880		Avg	230.8092

		Velocities (mm/s)						
type	steel	250.0000	244.4988	246.0025	270.2703	274.7253	ERR	ERR
d (mm)	7.9	304.8780	242.4242	258.0645	236.9668	244.2002	ERR	ERR
n	15	238.6635	235.2941	222.2222	246.9136	213.2196	ERR	ERR
G	8.02			Std Dev	22.1254		Avg	248.5562

		Velocities (mm/s)						
type	glass	645.1613	581.3953	597.0149	606.0606	597.0149	ERR	ERR
d (mm)	29.3	621.1180	626.9592	621.1180	689.6552	615.3846	ERR	ERR
n	15	694.4444	660.0660	586.5103	638.9776	604.2296	ERR	ERR
G	2.6			Std Dev	34.5307		Avg	625.6740

		Velocities (mm/s)						
type	glass	653.5948	593.4718	566.5722	673.4007	597.0149	ERR	ERR
d (mm)	25.17	604.2296	647.2492	571.4286	677.9661	583.0904	ERR	ERR
n	15	609.7561	657.8947	638.9776	586.5103	615.3846	ERR	ERR
G	2.6			Std Dev	36.9816		Avg	618.4361

		Velocities (mm/s)						
type	glass	591.7160	576.3689	615.3846	623.0530	619.1950	ERR	ERR
d (mm)	21.7	609.7561	609.7561	607.9027	593.4718	632.9114	ERR	ERR
n	15	598.8024	609.7561	591.7160	607.9027	621.1180	ERR	ERR
G	2.6			Std Dev	14.7032		Avg	607.2541

		Velocities (mm/s)						
type	glass	660.0660	566.5722	586.5103	537.6344	598.8024	ERR	ERR
d (mm)	15.97	615.3846	571.4286	719.4245	621.1180	641.0256	ERR	ERR
n	15	537.6344	625.0000	696.8641	578.0347	566.5722	ERR	ERR
G	2.6			Std Dev	53.9484		Avg	608.1381

		Velocities (mm/s)						
type	glass	615.3846	492.6108	537.6344	478.4689	593.4718	ERR	ERR
d (mm)	14.48	609.7561	598.8024	547.9452	609.7561	529.1005	ERR	ERR
n	15	626.9592	576.3689	527.7045	586.5103	573.0659	ERR	ERR
G	2.6			Std Dev	45.8156		Avg	566.9026

		Velocities (mm/s)						
type	natural	604.2296	430.1075	444.4444	434.7826	542.0054	ERR	ERR
d (mm)	13.6	524.9344	520.8333	529.1005	498.7531	555.5556	ERR	ERR
n	15	495.0495	470.5882	557.1031	460.8295	520.8333	ERR	ERR
G	2.65			Std Dev	50.3079		Avg	505.9433

		Velocities (mm/s)						
type	natural	561.7978	571.4286	464.0371	487.8049	496.2779	ERR	ERR
d (mm)	9.6	473.9336	459.7701	527.7045	512.8205	547.9452	ERR	ERR
n	15	492.6108	550.9642	447.4273	576.3689	508.9059	ERR	ERR
G	2.65			Std Dev	42.3233		Avg	511.9865

		Velocities (mm/s)						
type	natural	432.9004	507.6142	519.4805	432.9004	460.8295	ERR	ERR
d (mm)	6.8	450.4505	520.8333	543.4783	375.2345	447.4273	ERR	ERR
n	15	519.4805	488.9976	421.0526	522.1932	450.4505	ERR	ERR
G	2.65			Std Dev	48.3599		Avg	472.8882

		Velocities (mm/s)						
type	natural	507.6142	516.7959	462.9630	492.6108	503.7783	ERR	ERR
d (mm)	4.8	431.9654	451.4673	491.4005	500.0000	491.4005	ERR	ERR
n	15	554.0166	447.4273	487.8049	496.2779	542.0054	ERR	ERR
G	2.65			Std Dev	33.2968		Avg	491.8352

		Velocities (mm/s)						
type	natural	434.7826	484.2615	511.5090	454.5455	478.4689	ERR	ERR
d (mm)	3.4	516.7959	491.4005	459.7701	543.4783	459.7701	ERR	ERR
n	15	444.4444	429.1845	533.3333	495.0495	456.6210	ERR	ERR
G	2.65			Std Dev	35.3541		Avg	479.5610

		Velocities (mm/s)						
type	natural	438.5965	413.2231	456.6210	492.6108	477.3270	ERR	ERR
d (mm)	2.4	450.4505	466.2005	515.4639	423.7288	520.8333	ERR	ERR
n	15	520.8333	478.4689	515.4639	473.9336	447.4273	ERR	ERR
G	2.65			Std Dev	35.1294		Avg	472.7455

The steel particles with diameter 7.90mm showed noticable surging.
Steel particles smaller than 7.90mm are getting lost in the flow.

For the natural particles surging and suspension started with the 6.8mm diameter particles and increased with decreasing particle diameter.

Run# 49 Bed
Date: 8-18-95 Roughness k: 1.2 mm y/k: 53.431

Slope: 0.0056 Q: 23.88303 L/s U*: 0.0507 m/s

	u.s.	d.s.	avg
y (mm)	64.1666667	64.06667	64.11667
Tw (mm)	654.666667	662.3333	658.5
A (m^2)	0.02997118	0.03017	0.030071
P (m)	0.67600911	0.683207	0.679606
Rh (m)	0.04433547	0.044159	0.044247
V (m/s)	0.79686638	0.791613	0.79424
H (m)	0.10561445	0.096017	0.100816

delta H: 0.0095974 m delta x: 1.62 m

Sf: 0.00592434

Tavg: 20 °C

ν: 1.004E-06 m^2/s

δ: 0.0002297 m

Run# 49

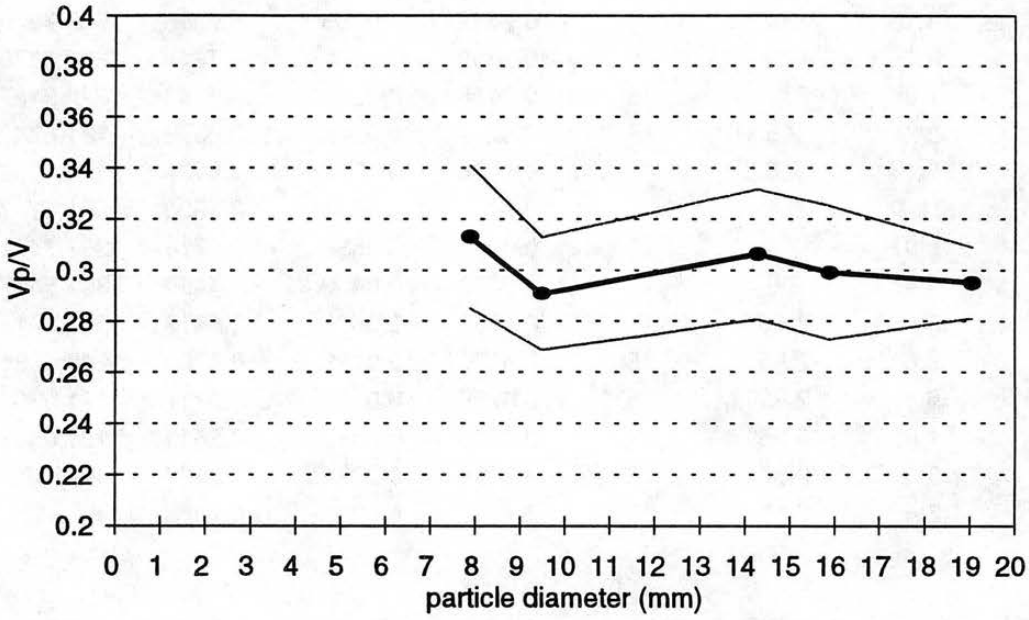
Type	d (mm)	G	n	Vp (m/s)	σ (m/s)	w (m/s)	d*	τ*
steel	19.04	8.02	15	0.2343	0.0110	1.0794	778.2702	0.0020
steel	15.88	8.02	15	0.2374	0.0208	0.9857	649.1035	0.0024
steel	14.28	8.02	15	0.2432	0.0203	0.9346	583.7026	0.0026
steel	9.5	8.02	15	0.2308	0.0176	0.7619	388.3176	0.0039
steel	7.9	8.02	15	0.2486	0.0221	0.6946	322.9167	0.0047
glass	29.3	2.6	15	0.6257	0.0345	0.6392	731.5747	0.0056
glass	25.17	2.6	15	0.6184	0.0370	0.5924	628.4552	0.0065
glass	21.7	2.6	15	0.6073	0.0147	0.5500	541.8147	0.0076
glass	15.97	2.6	15	0.6081	0.0539	0.4716	398.7457	0.0103
glass	14.48	2.6	15	0.5669	0.0458	0.4490	361.5427	0.0113
natural	13.6	2.65	15	0.5059	0.0503	0.4419	343.0715	0.0117
natural	9.6	2.65	15	0.5120	0.0423	0.3709	242.1681	0.0165
natural	6.8	2.65	15	0.4729	0.0484	0.3117	171.5357	0.0234
natural	4.8	2.65	15	0.4918	0.0333	0.2612	121.0841	0.0331
natural	3.4	2.65	15	0.4796	0.0354	0.2189	85.7679	0.0467
natural	2.4	2.65	15	0.4727	0.0351	0.1826	60.5420	0.0662

Type	Vp / V	Vp / U*	Vp / w	U* / w	d / k	k/delta	d/delta	y/d
steel	0.2950	4.6219	0.2171	0.0470	15.8667	5224.1213	82.8894	3.3675
steel	0.2989	4.6830	0.2409	0.0514	13.2333	5224.1213	69.1325	4.0376
steel	0.3062	4.7963	0.2602	0.0542	11.9000	5224.1213	62.1670	4.4900
steel	0.2906	4.5523	0.3029	0.0665	7.9167	5224.1213	41.3576	6.7491
steel	0.3129	4.9023	0.3579	0.0730	6.5833	5224.1213	34.3921	8.1160
glass	0.7878	12.3403	0.9788	0.0793	24.4167	5224.1213	127.5556	2.1883
glass	0.7787	12.1975	1.0439	0.0856	20.9750	5224.1213	109.5759	2.5473
glass	0.7646	11.9770	1.1041	0.0922	18.0833	5224.1213	94.4695	2.9547
glass	0.7657	11.9944	1.2894	0.1075	13.3083	5224.1213	69.5243	4.0148
glass	0.7138	11.1811	1.2625	0.1129	12.0667	5224.1213	63.0377	4.4279
natural	0.6370	9.9788	1.1450	0.1147	11.3333	5224.1213	59.2067	4.7145
natural	0.6446	10.0980	1.3804	0.1367	8.0000	5224.1213	41.7930	6.6788
natural	0.5954	9.3268	1.5172	0.1627	5.6667	5224.1213	29.6034	9.4289
natural	0.6193	9.7005	1.8831	0.1941	4.0000	5224.1213	20.8965	13.3576
natural	0.6038	9.4585	2.1910	0.2316	2.8333	5224.1213	14.8017	18.8578
natural	0.5952	9.3240	2.5897	0.2777	2.0000	5224.1213	10.4482	26.7153

Run # 49
U* = 0.0507 (m/s)

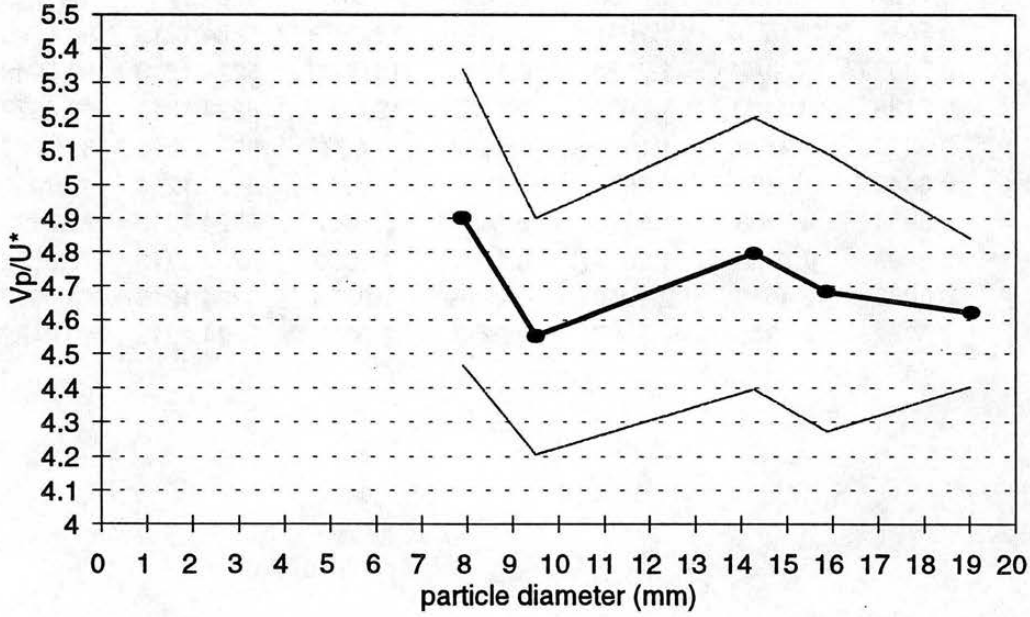
Vp/V vs. d

(steel)



Vp/U* vs. d

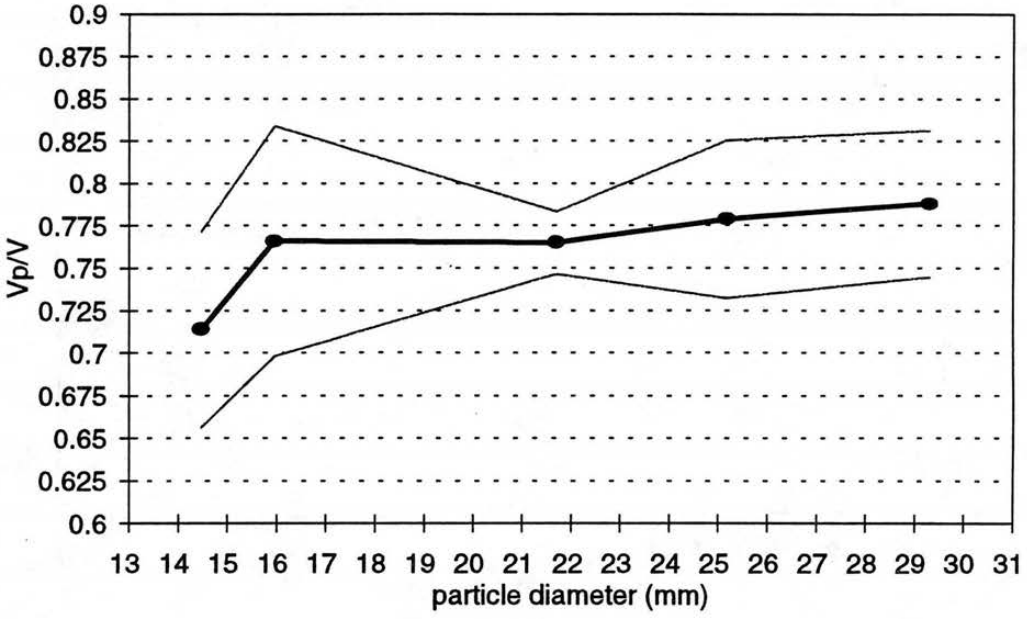
(steel)



Run # 49
U* = 0.0507 (m/s)

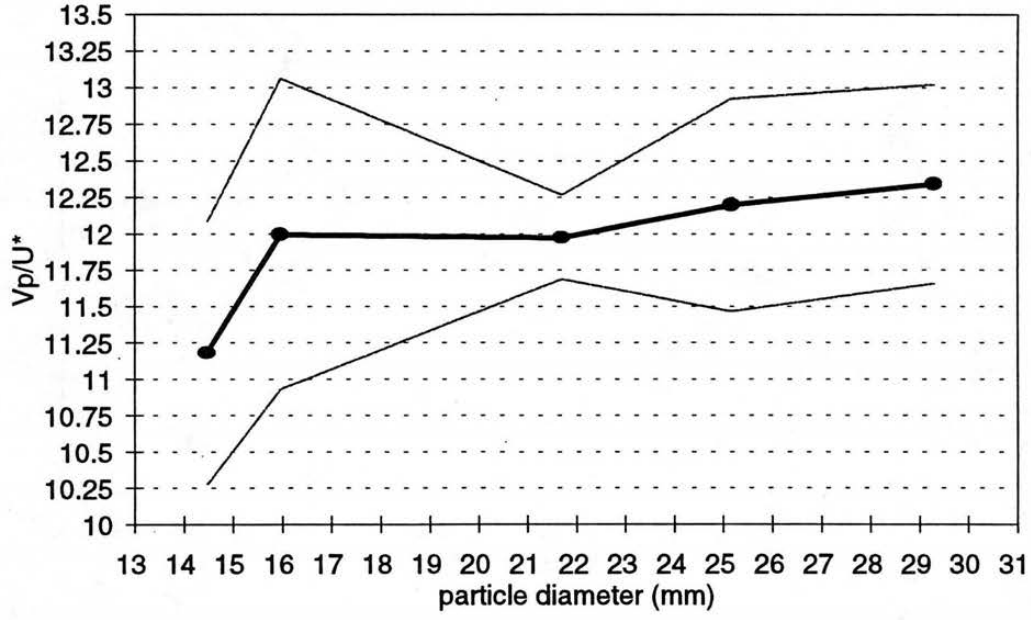
Vp/V vs. d

(glass)



Vp/U* vs. d

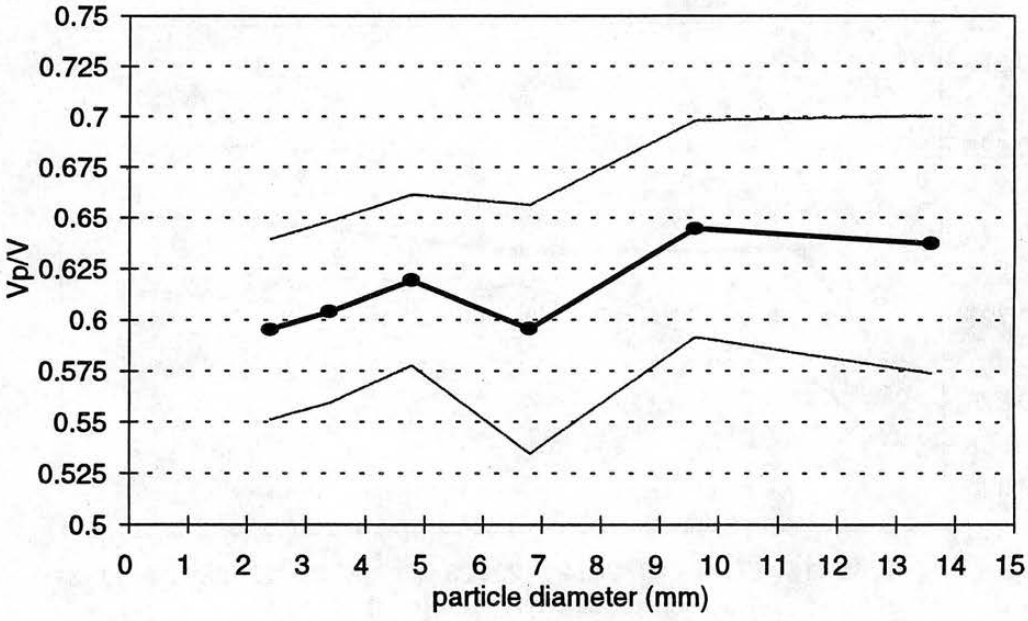
(glass)



Run # 49
U* = 0.0507 (m/s)

Vp/V vs. d

(natural)



Vp/U* vs. d

(natural)