1985 RIPRAP TESTS

IN FLOOD CONTROL CHANNELS

prepared for

U. S. Army Corps of Engineers
Waterways Experiment Station
Vicksburg, Mississippi

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FORWARD

This study was performed under a contract titled "Stability Tests of Riprap in Flood Control Channels" between the U. S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, and Colorado State University. This report includes the tabluated and mapped data collected during the study, as well as analysis of the major results. The study plan and program was coordinated between WES and CSU by Mr. Stephen T. Maynard of WES.

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CHAPTER I

INTRODUCTION

1.1 Background

This study is a continuation of the work to determine the point of incipient failure and other hydraulic characteristics of riprap for providing criteria for design of stable ripraps in flood control channels. The study initiated in 1981 at Colorado State University (CSU) by and in cooperation with the U. S. Army Corps of Engineers, Waterways Experiment Station (WES), Vicksburg, Mississippi. The previous work was presented in two reports. The first report entitled, "Stability Tests of Riprap in Flood Control Channels," was prepared by A. A. Fiuzat, Y. H. Chen and D. B. Simons in October, 1982, and is referred to as the "1982 Report" throughout this latest report (1985). The second report was entitled, "Supplemental Stability Tests of Riprap in Flood Control Channels" and was prepared by A. A. Fiuzat and E. V. Richardson in December, 1983. The second report similarly is referred to as the "1983 Report" throughout this new report (1985). The equipment, flume test procedures, and data collection methods are either identical or similar to those procedures described in the 1982 and 1983 Reports.

Two sizes riprap materials were tested. One material had a d_{so} = 1.0 in. and the other had a d_{so} = 2.0 in. Both riprap sizes had the ETL 1110-2-120 gradation recommended by WES. The design gradation of the riprap material is

shown in Figure 1.1. The design gradation of the riprap material of the 1982 and 1983 Reports is also shown in this Figure. Tests were performed for both size gradations with the thickness of the riprap set at $2d_{50}$ and then at $3d_{50}$. The failure criterion for both riprap thicknesses was the exposure of the underlying filter blanket observed after a run. Incipient failure was then defined as the run when the flume slope was set one increment lower than the failure run. In the following chapters the experimental program and analysis of data are presented.

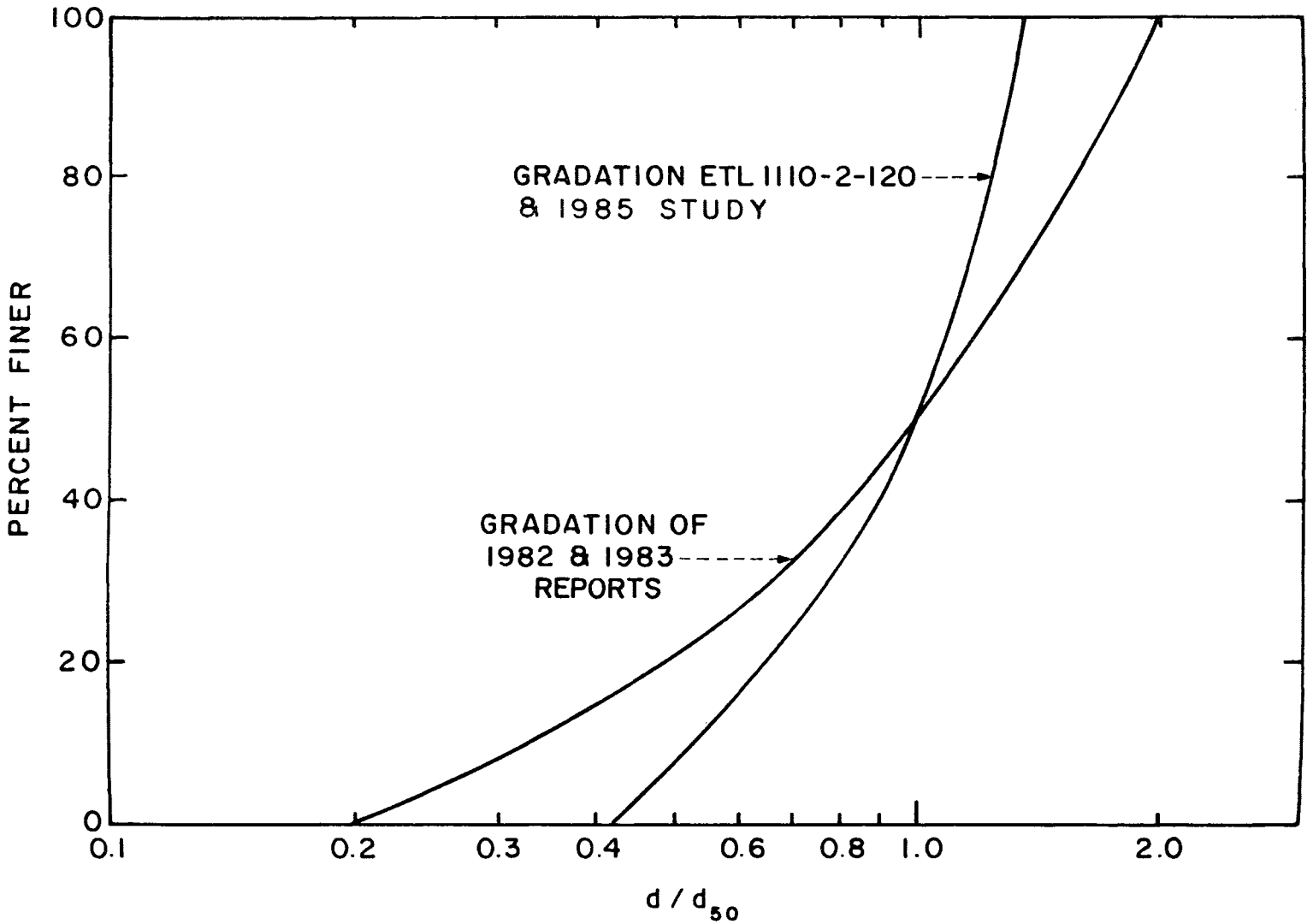


Figure 1.1 Gradation of riprap material of this study (1985) and the 1982 and 1983 Reports.

CHAPTER 2

EXPERIMENTAL PROGRAM

The experimental program conducted for this phase of the riprap study generally follows the procedures and methods described in the 1982 and 1983 Reports.

In this chapter the materials and methods that differ from those of the 1982 and 1983 Reports are explained. Those which are not explained are similar to the 1982 and 1983 Reports.

2.1 Experimental Setup

For the first 18 runs, the test section was 50 ft long with a transition section of 40 ft. From the upstream end of the flume (Station 0) to the beginning of the transition section (Station 60), rocks of 6 to 10 in. in diameter were cemented to the flume floor. The 40 ft transition section (from Station 60 to station 100) was made of 1 in. rocks cemented to the flume floor. For the remaining runs (from run #19 to 94), the test section was reduced to 40 ft and the transition section was constructed by placing rocks of similar size as the test section in the transition. These rocks in the transition section were not cemented to the flume floor; instead they were covered with a wire mesh (chicken wire) to hold them in place. The transition section was 40 ft long and started at Station 70. The test section started at Station 110. The rocks in the transition section were placed such that the top of the rocks in the test and transition sections were in the same plane for all riprap thicknesses. The first 70 ft of the flume was comprised of 6 to 10 in. rocks cemented on the floor.

2.2 Material

Crushed limestone was used as the riprap material. The specific gravity of the d_{50} = 1 in. rocks was 2.68 and the d_{50} = 2 in. rocks was 2.64. The gradations of the riprap material tested are shown in Figure 2.1. The gradation of d_{50} = 1 in. riprap was determined using a mechanical sieve shaker. The gradation of d_{50} = 2 in. riprap was established using flat sieves manufactured at CSU for this purpose. The values of d_{85}/d_{15} of the riprap material are presented in Table 2.1. In this Table the values of d_{85}/d_{15} of the riprap material of the 1982 Report (for d_{50} = 1 in) and the 1983 Report (for d_{50} = 2 in) are also presented.

Table 2.1 Values of the d_{85}/d_{15} of the riprap material of this (1985) Study and the 1982 and 1983 Reports.

	This Study (1985)		1982 Report	1983 Report
d_{50} (in)	1	2	1.87	1
d_{85}/d_{15} (in)	2.0	2.4	2.8	4.4

For the first series of tests (d_{50} = 1 in., runs # 1- 31) the riprap material consisted of about 10 percent (by weight) flat rocks. The flat rocks were removed after the first series of tests. For the rest of the runs, the riprap material met the shape criteria of the Army Corps of Engineers. These criteria (C.O.E. Report - Em 1110-2-1601, 1970) are:

1. The stone shall be predominately angular in shape.
2. No more than 25 percent of the stones reasonably well distributed throughout the gradation shall have a length more than 2.5 times the breadth or thickness.
3. No stone shall have a length exceeding 3.0 times its breadth or thickness.

2.3 Testing Procedure and Data Collection Program

The data collected included bed and water surface elevations, discharge, velocity profiles using either a pitot-static tube or an Ott meter, and the size and location of areas washed free of riprap down to the underlying filter cloth. Trials were performed with riprap thickness of $2d_{so}$ and $3d_{so}$.

A "general datum" for each rock thickness was established by the following procedures:

(1) The flume was set to the horizontal position.

(2) Water was added to the flume until about 90% of the rocks were covered with water.

(3) The elevation of the water surface was measured along the flume at 10 ft intervals; at the locations where flow depths were measured.

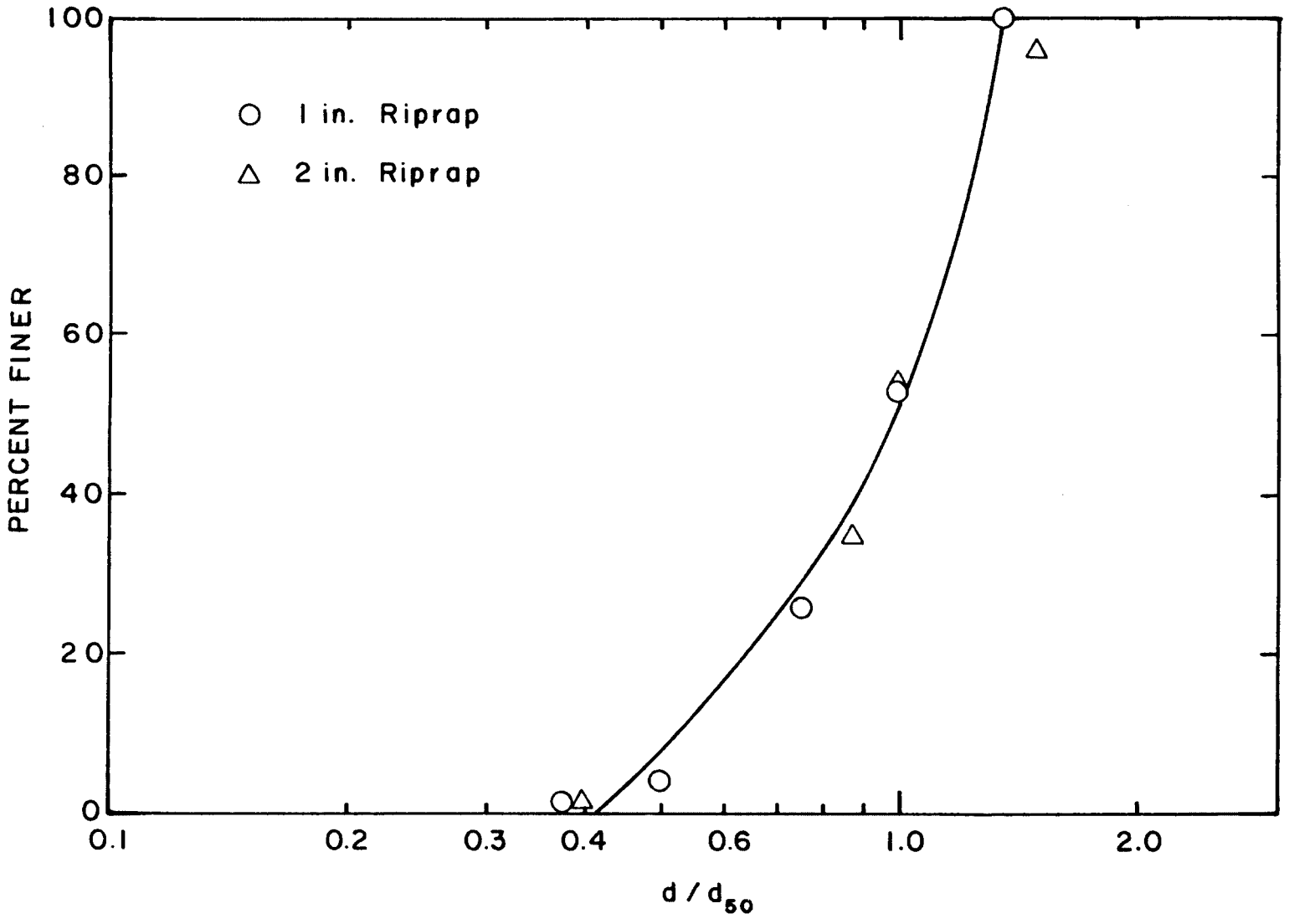
(4) These elevations were considered as the elevations of the bottom of channel (general datum) in measuring the flow depth.

Five series of tests with a total of 94 runs were performed. The methods of testing are summarized in Table 2.2. Other information such as bed slope, water temperature, area washed, and test duration for each run are presented in Appendix A.

Table 2.2 Methods of Testing

Test Series #	Run #	Median Size (in) (in)	Riprap Thickness	Velocity Data Collected By	Remarks
1	1-31	1	2	Ott Meter	Data collection was similar to the previous reports.
2	32-45	1	2	Ott Meter	Repeating the series #1 after removing flat rocks.
3	46-64	1	3	Pitot Tube	Flat rocks were removed.
4	65-78	2	4	Pitot Tube	Flat rocks were removed.
5	79-94	2	6	Pitot Tube	Flat rocks were removed.

As shown in Table 2.2, the test procedure for the riprap of d_{50} = 1 in. and thickness = 2 in. was similar to that of the 1982 and 1983 Reports. For test series No. 3 to 5, a pitot tube was used to measure the velocities. For these last series of tests the velocity data were collected at 0.05, 0.10, 0.15, 0.2, 0.3, 0.4, 0.5, 0.7, 0.9D above the "general datum." In addition, the pitot tube was set on the top of the rocks and velocities at these points also were measured. These points established by the pitot tube on top of the rocks will be referred as the "local datums." The elevations of these local datums in most cases were below the general datum. For the last 3 series of tests the comprehensive velocity data were collected for every test, and not only for the incipient failure conditions. Velocity profile traverses were taken at several locations in the cross sections throughout the test section. Specific locations are listed for each run in Appendix B.


100
80
60
40
20
0
PERCENT FINER
1 in. Riprap
2 in. Riprap
0.1
0.2
0.3
0.4
0.6
1.0
2.0
d / d50

CHAPTER 3

DATA ANALYSIS

The failure criterion for the riprap stability study was the exposure of the underlying filter blanket after a run. For a given discharge, the run at which the flume slope was one increment lower than the failure run was regarded as the incipient failure run. In this study the term "incipient failure" was used in place of "incipient motion" to avoid confusion. Incipient motion condition is considered to occur when the exerted force by flow just overcomes the resistance force of a particle to motion without moving the particle. However, at the incipient failure condition, a substantial amount of riprap material may move without exposing the underlying filter blanket. The latter condition can occur specially at greater thicknesses of ripraps.

In this study there were some exceptional cases where the above criterion was not met. These cases are explained in the following.

The transition section for the first 18 runs was made of 1 in. rocks cemented to the flume floor, as previously mentioned. The transition section was 40 ft. long; the elevation of upstream end was 8 in. above the elevation of downstream end with a slope of 1.7 percent relative to the flume floor. The flow accelerated down this slope and did not produce a smooth transition into the test section. Because of this transition section, it was not possible to reach uniform flow depth within the test reach at discharge greater than 25 cfs, and all riprap failure occurred at the beginning of the test section due to high velocity of flow. The test result was not considered to be representative of behavior of the riprap under uniform flow for flows greater than 25 cfs because of the problems caused by the transition section.

Therefore, the transition section was reconstructed and the tests were repeated. Since the above problems were not pronounced for the flow rate of 25 cfs, the tests were not repeated for the 25 cfs flow rate. The data for runs 8 to 18 were not used for analysis in this chapter, however, they are presented in Appendices.

In run numbers 27, 37, 41 and 45 the failure occured at the beginning of the test section and was believed to be the result of local disturbances at the junction between the transition and test section. These runs were not considered to be the failure runs but the incipient failure runs. The washed area for these runs was less than three square feet which occurred at the beginning of the test section.

For run #77 (d_{so} = 2 in, $2d_{so}$ thick riprap) failure was not observed when the flow rate was 25 cfs and flume was at its maximum slope (about 1.9 percent). When the riprap thickness was increased to $3d_{so}$, failure did not occur at flows equal to or less than 50 cfs and maximum flume slope (run #s 80 and 84). Run #84 was, however, considered to be the incipient failure run since some of the rocks were moved and several dips were observed on the riprap surface.

The following methods are used to calculate the bed Shields' coefficients from the collected data.

1) Using Manning's roughness factor for riprap surface
2) Using Darcy-Weisbach friction factor for riprap surface
3) Using velocity distribution equation

3.1 Calculation of Bed Shields' Coefficient Using Manning's Roughness Factor For Riprap Surface

The development of the equations to calculate the Manning's roughness factor for the riprap surface n_b is presented in the 1982 Report (p. 19). This method is a side-wall correction technique (Vanoni, 1975, P. 152) which can be used to calculate

the average shear stress on the bed, τ_b, and bed Shield's coefficient C_b. The assumptions in this technique are: a) the flow cross-sectional area can be divided into two parts, A_b and A_w where resistance to flow is caused by the bed and the walls respectively, and b) the mean velocity and energy gradient are the same for A_b and A_w and Manning's equation can be applied to each part of the cross-section as well as to the whole. The resulting equations (developed in the 1982 Report) for this technique are:

$$n = \frac{1.49}{V} R^{2/3} S^{1/2} \tag{3.1}$$

$$\frac{R}{n^{3/2}} = \frac{R_b}{n_b^{3/2}} = \frac{R_w}{n_w^{3/2}} \tag{3.2}$$

$$n_b = \left[\frac{n^{3/2} p - n_w^{3/2} p_w}{p_b}\right]^{2/3} \tag{3.3}$$

where

n, n_b, n_w = Manning's roughness factor for the flume (overall), bed, and wall respectively

V = average velocity of flow in fps
S = channel slope in ft/ft
p = wetted perimeter of channel = w + 2D, in ft
p_b = wetted perimeter for bed = w, in ft
p_w = wetted perimeter for walls = 2D, in ft
R = hydraulic radius of channel = A/p = wD/(w+2D), in ft
R_b = hydraulic radius for bed = A_b/p_b, in ft
R_w = hydraulic radius for walls = A_w/p_w, in ft
w = channel width = 8 ft
D = water depth in ft

Substituting the values of p_b = w = 8 ft, P_w = 2D, and n_w = 0.012 (for smooth painted wall and plexiglas, Chow, 1959, p. 110-111) in equation (3.3) results in

$$n_b = \left[\frac{n^{3/2} p - (0.012)^{3/2} (2D)}{8}\right]^{2/3} \qquad (3.4)$$

The value of n_b calculated from equation (3.4) can be used to calculate the vlaues of the average shear stress on bed and the bed Shields' coefficient. The calculation procedure is as follows:

1. Calculate n from equation (3.1) for known values of V, R, and S.
2. Calculate n_b from equation (3.4).
3. Calculate R_b from equations (3.2) for known values of R and n.
4. Calculate average shear stress on bed using the relationship

$$\tau_b = \gamma_w R_b S \qquad (3.5)$$

where γ_w is the unit weight of water.

5. Calculate C_b using the relaionship

$$C_b = \frac{\tau_b}{(\gamma_S - \gamma_w) d_{so}} = \frac{\gamma_w R_b S}{(\gamma_S - \gamma_w) d_{so}} = \frac{R_b S}{(s-1) d_{so}} \qquad (3.6)$$

where γ_S is the specific weight of rock, s is the specific gravity of rocks (γ_s/γ_w), and d_{so} is median size of the riprap in ft.

The values of n, n_b, and C_b are calculated by the above procedure and results are presented in Tables 3.1 to 3.5. The values of bed Shield's coefficient for incipient failure runs will be termed the bed critical Shields' coefficient; the bed critical Shields' coefficient calculated by this method (using Manning's roughness factor) will be denoted by C_{cn}.

In addition of the bed Shield's coefficient, the values of the overall Shields' coefficient C, are also calculated and presented in Table 3.1 to 3.5. The overall Shields' coefficient is defined as:

$$C = \frac{DS}{(s - 1) d_{50}} \tag{3.7}$$

The values of C for incipient failure runs will be termed the overall critical Shields' coefficient and will be denoted by C_c.

The range and average values of the bed Manning's roughness factor, for the five series of tests, are summarized in Table 3.6. This Table also contains the values of Manning's roughness factor calculated by the two following equations:

1. Anderson et al. (1970) equation

$$n = 0.0395\, d_{50}^{1/6} \tag{3.8}$$

where d_{50} is in feet, and

2. Strickler's equation (Simons and Senturk, 1977, p. 309)

$$n = d_{90}^{1/6} / 26$$

where d_{90} is in meters.

The results in Table 3.6 show that 1) the values of n obtained by Anderson et al. equation are in agreement with the values of n_b obtained experimentally; and 2) Strickler's equation underestimates the bed Manning's roughness factor.

The coefficient of Strickler's equation was modified in order to fit the data. The modified equation is:

$$n = d_{90}^{1/6} / 22.4 \quad (d_{90} \text{ in meters}) \tag{3.10}$$

The coefficient 1/22.4 was obtained by calculating the corresponding coefficient of Strickler's equation for each n_b value given in Tables 3.1 to 3.5 and then averaging all coefficients. The calculated values of n from equation (3.10) are also presented in Table 3.6.

Run #	Nominal discharge Q cfs	Flume slope S	Average velocity V ,fps	Average depth D , ft	Froude number F	Wetted premeter p=w+2D ft	Hydraulic radius R, ft	Overall Manning coef. n	Bed Manning coef. n_b	Bed Hydraulic radius R_b, ft	Bed Shields coef. C_b	Area washed sq. ft	Overall Shields coef. C
1	25	0.00367	2.57	1.273	0.40	10.55	0.966	0.034	0.040	1.209	0.032		0.033
2	25	0.00490	3.55	0.906	0.66	9.81	0.739	0.024	0.026	0.847	0.030		0.032
3	25	0.00617	3.87	0.846	0.74	9.69	0.698	0.024	0.026	0.793	0.035		0.037
4	25	0.00749	4.22	0.745	0.86	9.49	0.628	0.022	0.024	0.699	0.037		0.040
5	25	0.00872	4.45	0.714	0.93	9.43	0.606	0.022	0.024	0.672	0.042	2	0.044
f 6	25	0.01012	4.59	0.689	0.97	9.38	0.588	0.023	0.025	0.651	0.047	23	0.050
* 7	25	0.00869	4.77	0.714	0.99	9.43	0.606	0.021	0.022	0.667	0.041		0.044
28	50	0.00409	3.85	1.386	0.58	10.77	1.029	0.025	0.029	1.269	0.037		0.040
29	50	0.00490	4.30	1.262	0.67	10.52	0.959	0.024	0.027	1.152	0.040		0.044
30	50	0.00561	4.76	1.252	0.75	10.50	0.954	0.023	0.026	1.137	0.046	0.03	0.050
* 31	50	0.00561	5.06	1.262	0.79	10.52	0.959	0.021	0.024	1.135	0.045		0.051
20	75	0.00284	5.03	2.018	0.62	12.04	1.341	0.019	0.022	1.684	0.034		0.041
21	75	0.00333	5.14	1.886	0.66	11.77	1.282	0.020	0.023	1.600	0.038		0.045
f 22	75	0.00407	4.64	1.802	0.61	11.60	1.242	0.024	0.028	1.600	0.047	12	0.052
* 23	75	0.00343	5.02	1.885	0.64	11.77	1.281	0.021	0.024	1.615	0.040		0.046
24	100	0.00225	4.86	2.479	0.54	12.96	1.530	0.019	0.023	2.014	0.032		0.040
25	100	0.00266	4.62	2.397	0.53	12.79	1.499	0.022	0.027	2.030	0.039		0.046
26	100	0.00308	5.15	2.286	0.60	12.57	1.455	0.021	0.025	1.917	0.042	2	0.050
* 27	100	0.00318	5.06	2.337	0.58	12.67	1.475	0.022	0.026	1.978	0.045	0.7	0.053

f Failure conditions
* Incipient failure conditions

Table 3.1. Calculation of Manning's and Shields' Coefficients For Riprap of d_{so} = 1 in. and Thickness = 2 in.

Run #	Nominal discharge Q cfs	Flume slope S	Average velocity V ,fps	Average depth D , ft	Froude number F	Wetted premeter p=w+2D ft	Hydraulic radius R, ft	Overall Manning coef. n	Bed Manning coef. n_b	Bed hydraulic radius R_b, ft	Bed Shields coef. C_b	Area washed sq. ft	Overall Shields coef. C
33	25	0.00998	4.40	0.684	0.94	9.37	0.584	0.024	0.025	0.648	0.046		0.049
34	25	0.01088	4.51	0.703	0.95	9.41	0.598	0.024	0.026	0.667	0.052		0.055
35	25	0.01186	4.72	0.672	1.01	9.34	0.575	0.024	0.025	0.637	0.054		0.057
f 36	25	0.01337	4.95	0.618	1.11	9.24	0.535	0.023	0.024	0.587	0.056	7.2	0.059
* 37	25	0.01204	4.77	0.651	1.04	9.30	0.560	0.023	0.025	0.617	0.053	2.7	0.056
f 32	50	0.00558	4.90	1.300	0.76	10.60	0.981	0.022	0.025	1.175	0.047	10.8	0.052
* 41	50	0.00475	4.71	1.353	0.71	10.71	1.011	0.022	0.025	1.215	0.041	2.5	0.046
f 38	75	0.00402	5.02	1.832	0.65	11.66	1.257	0.022	0.026	1.599	0.046	0.4	0.053
f 39	75	0.00377	5.00	1.842	0.65	11.68	1.261	0.021	0.025	1.597	0.043	0.1	0.050
* 40	75	0.00345	4.84	1.918	0.62	11.84	1.296	0.021	0.025	1.659	0.041		0.047
42	100	0.00314	4.97	2.371	0.57	12.74	1.489	0.022	0.027	2.013	0.045		0.053
43	100	0.00403	4.90	2.415	0.56	12.83	1.506	0.025	0.032	2.119	0.061		0.070
f 44	100	0.00436	5.20	2.210	0.62	12.42	1.424	0.024	0.029	1.931	0.060	17.7	0.069
* 45	100	0.00354	5.09	2.332	0.59	12.66	1.473	0.023	0.028	1.999	0.051	2.5	0.059

f Failure conditions
* Incipient failure conditions

Table 3.2. Calculation of Manning's and Shields' Coefficients for Riprap of d_{50} = 1 in. and Thickness = 2 in. (after removing flat rocks).

Run #	Nominal discharge Q cfs	Flume slope S	Average velocity V ,fps	Average depth D , ft	Froude number F	Wetted premeter p=w+2D ft	Hydraulic radius R, ft	Overall Manning coef. n	Bed Manning coef. n_b	Bed Hydraulic radius R_b, ft	Bed Shields coef. C_b	Area washed sq. ft	Overall Shields coef. C
46	25	0.00880	4.37	0.720	0.91	9.44	0.610	0.023	0.025	0.679	0.043		0.045
47	25	0.01011	4.61	0.688	0.98	9.38	0.587	0.023	0.024	0.649	0.047		0.050
48	25	0.01313	5.02	0.640	1.11	9.28	0.552	0.023	0.024	0.606	0.057		0.060
* 57	25	0.01475	5.02	0.625	1.12	9.25	0.541	0.024	0.026	0.595	0.063		0.066
f 58	25	0.01626	5.52	0.568	1.29	9.14	0.497	0.022	0.023	0.539	0.063	23	0.066
49	50	0.00526	4.94	1.268	0.77	10.54	0.963	0.021	0.024	1.139	0.043		0.048
50	50	0.00636	5.36	1.169	0.87	10.34	0.905	0.021	0.023	1.053	0.048		0.053
52	50	0.00726	5.74	1.096	0.97	10.19	0.860	0.020	0.022	0.987	0.051		0.057
f 53	50	0.00802	5.66	1.095	0.95	10.19	0.860	0.021	0.024	0.996	0.057	37.4	0.063
f 54	50	0.00732	5.64	1.111	0.94	10.22	0.869	0.021	0.023	1.004	0.052	2.3	0.058
f 55	50	0.00732	5.03	1.245	0.79	10.49	0.949	0.024	0.028	1.144	0.060	3.7	0.065
* 56	50	0.00647	5.11	1.231	0.81	10.46	0.941	0.023	0.025	1.118	0.052		0.057
59	75	0.00423	4.90	1.907	0.63	11.81	1.291	0.023	0.028	1.682	0.051		0.058
* 60	75	0.00517	5.11	1.814	0.67	11.63	1.248	0.024	0.029	1.618	0.060		0.067
f 61	75	0.00621	5.50	1.714	0.74	11.43	1.200	0.024	0.028	1.533	0.068	49.5	0.076
62	100	0.00406	4.63	2.513	0.51	13.03	1.543	0.027	0.035	2.232	0.065		0.073
f 63	100	0.00457	5.25	2.210	0.62	12.42	1.424	0.024	0.030	1.937	0.063	2	0.072
* 64	100	0.00409	5.10	2.298	0.59	12.60	1.460	0.024	0.030	2.002	0.058		0.067

f Failure conditions
* Incipient failure conditions

Table 3.3. Calculation of Manning's and Shields' Coefficients for Riprap of d_{so} = 1 in. and Thickness = 3 in.

Run #	Nominal discharge Q cfs	Flume slope S	Average velocity V ,fps	Average depth D , ft	Froude number F	Wetted premeter p=w+2D ft	Hydraulic radius R, ft	Overall Manning coef. n	Bed Manning coef. n_b	Bed Hydraulic radius R_b, ft	Bed Shields coef. C_b	Area washed sq. ft	Overall Shields coef. C
76	24.8	0.01193	4.55	0.681	0.97	9.36	0.582	0.025	0.027	0.626	0.027		0.030
77	25.2	0.01858	5.27	0.598	1.20	9.20	0.520	0.025	0.027	0.554	0.038		0.041
65	50.1	0.00998	5.03	1.246	0.79	10.49	0.950	0.029	0.033	1.089	0.040		0.045
66	50.0	0.01378	6.13	1.019	1.07	10.04	0.812	0.025	0.028	0.901	0.045		0.051
* 67	50.2	0.01519	6.36	0.987	1.13	9.97	0.792	0.025	0.027	0.876	0.049		0.055
68	50.2	0.01796	6.71	0.935	1.22	9.87	0.758	0.025	0.027	0.834	0.055		0.061
f 69	50.3	0.01888	6.63	0.948	1.20	9.90	0.766	0.026	0.029	0.847	0.059	59.8	0.065
f 78	50.2	0.01579	6.14	1.022	1.07	10.04	0.814	0.027	0.030	0.908	0.052	5.5	0.059
f 70	75.0	0.01110	6.65	1.410	0.99	10.82	1.043	0.024	0.028	1.197	0.049	64.1	0.057
71	75.1	0.00781	6.33	1.483	0.92	10.97	1.082	0.022	0.025	1.236	0.035		0.042
* 72	77.5	0.00937	6.81	1.423	1.01	10.85	1.050	0.022	0.025	1.193	0.041		0.049
73	100.5	0.00731	6.43	1.954	0.81	11.91	1.313	0.024	0.028	1.574	0.042		0.052
* 74	100.2	0.00840	6.62	1.891	0.85	11.78	1.284	0.024	0.029	1.537	0.047		0.058
f 75	101.0	0.01066	7.00	1.804	0.92	11.61	1.243	0.025	0.030	1.484	0.058	27	0.070

f Failure condition
* Incipient failure conditions

Table 3.4. Calculation of Manning's and Shields' Coefficients for Riprap of d_{so} = 2 in. and Thickness = 4 in.

Run #	Nominal discharge Q cfs	Flume slope S	Average velocity V ,fps	Average depth D , ft	Froude number F	Wetted premeter p=w+2D ft	Hydraulic radius R, ft	Overall Manning coef. n	Bed Manning coef. n_b	Bed Hydraulic radius R_b, ft	Bed Shields coef. C_b	Area washed sq. ft	Overall Shields coef. C
79	25	0.01180	4.42	0.710	0.92	9.42	0.603	0.026	0.028	0.651	0.028		0.031
80	25	0.01870	5.17	0.607	1.17	9.21	0.527	0.026	0.027	0.563	0.039		0.042
81	50	0.01205	5.90	1.068	1.01	10.14	0.843	0.025	0.028	0.940	0.041		0.047
82	50	0.01544	6.47	0.966	1.16	9.93	0.778	0.024	0.027	0.858	0.048		0.055
83	50	0.01724	6.76	0.928	1.24	9.86	0.753	0.024	0.026	0.827	0.052		0.059
* 84	50	0.01879	6.61	0.970	1.18	9.94	0.781	0.026	0.029	0.866	0.059		0.067
85	75	0.00898	6.19	1.519	0.89	11.04	1.101	0.024	0.028	1.276	0.042		0.050
86	75	0.01095	6.58	1.414	0.98	10.83	1.045	0.024	0.028	1.200	0.048		0.057
87	75	0.01206	6.63	1.423	0.98	10.85	1.050	0.025	0.029	1.212	0.053		0.063
* 88	75	0.01359	6.88	1.372	1.04	10.74	1.022	0.026	0.029	1.175	0.058		0.068
f 89	75	0.01565	6.84	1.399	1.02	10.80	1.036	0.028	0.032	1.203	0.069	9.6	0.080
90	100	0.00866	6.97	1.808	0.91	11.62	1.245	0.023	0.027	1.469	0.047		0.057
91	100	0.00938	6.96	1.796	0.92	11.59	1.239	0.024	0.028	1.468	0.050		0.062
92	100	0.01084	7.39	1.711	1.00	11.42	1.198	0.024	0.028	1.408	0.056		0.068
* 93	100	0.01189	7.44	1.698	1.01	11.40	1.192	0.025	0.029	1.405	0.061		0.074
f 94	100	0.01300	8.02	1.572	1.13	11.14	1.128	0.023	0.027	1.306	0.062	15	0.075

f Failure conditions
* Incipient failure conditions

Table 3.5. Calculation of Manning's and Shields' Coefficients for Riprap of d_{so} = 2 in. and Thickness = 6 in.

Table 3.6 Values of Bed Manning's Roughness Factor Calculated From Experimental Data And Equations Listed

Test Series #	Riprap Size d_{50} in.	d_{90} in.	Experimental data n_b range	n_b average	Anderson et al. equation	Strickler equation	Modified Strickler equation
1	1	1.3	.022-.029	0.026			
2	1	1.3	.024-.032	0.026			
3	1	1.3	.022-.035	0.026			
1,2,3	1	1.3	.022-.035	0.026	0.026	0.022	0.025
4	2	1.3	.025-.033	0.028			
5	2	2.9	.026-.032	0.028			
4,5	2	2.9	.025-.033	0.028	0.029	0.025	0.029

3.2 Calculation of Bed Critical Shields' Coefficient Using Darcy-Weisbach Friction Factor For Riprap Surface

This method is similar to the method presented in Section 3.1, that is, a side-wall correction technique which results in average values of shear stress on bed and bed Shields' coefficient. The only difference between these two methods is that in section 3.1 the Manning's equation was used to describe the relationship between resistance to flow and hydraulic parameters while in this section the Darcy-Weisbach equation is used to describe such a relationship. The development of the equations for this method are presented in the 1982 Report (p. 22). The resulting equations are:

$$C_b = \frac{R_b S}{(s-1) d_{so}} \tag{3.11}$$

$C_{cf} = C_b$ for incipient failure runs

$$\frac{V^2}{8} = \frac{gSR}{f} = \frac{gSR_b}{f_b} \tag{3.12}$$

$$f_b = f + \frac{D}{4}(f - f_w) \tag{3.13}$$

$$\frac{R_w}{f_w} = \frac{R}{f} \tag{3.14}$$

where

C_b	=	bed Shields' coefficient
C_{cf}	=	bed critical Shield's coefficient
R_b	=	hydraulic radius for bed in ft
R	=	channel hydraulic radius in ft
f, f_b, f_w	=	Darcy-Weisbach friction factor for the flume, bed and wall respectively
R, R_w	=	Reynolds number for channel and wall respectively

The calculated values of the bed critical Shields' coefficient for incipient failure conditions (C_{cf}) are presented in Table 3.7.

Riprap median size in.	Riprap thickness in.	Nominal discharge Q cfs	Run #	Flume slope S	Average velocity V, fps	Average depth D, ft	Overall hydraulic radius R, ft	Reynolds number R	Overall friction factor f	R/f	Wall friction factor f_w	Bed friction factor f_b	Bed hydraulic radius R_b	Bed Shields coef. C_{cf}
1	2	25	7	0.00869	4.77	0.714	0.606	1.16E+06	0.060	1.94E+07	0.015	0.068	0.688	0.043
1	2	50	31	0.00561	5.06	1.262	0.959	1.94E+06	0.054	3.59E+07	0.013	0.067	1.188	0.048
1	2	75	23	0.00343	5.02	1.885	1.281	2.57E+06	0.045	5.73E+07	0.012	0.060	1.720	0.042
1	2	100	27	0.00318	5.06	2.337	1.475	2.99E+06	0.047	6.33E+07	0.012	0.068	2.116	0.048
1	2	25	37	0.01204	4.77	0.651	0.560	1.07E+06	0.076	1.40E+07	0.015	0.086	0.633	0.054
1	2	50	41	0.00475	4.71	1.353	1.011	1.90E+06	0.056	3.42E+07	0.013	0.070	1.271	0.043
1	2	75	40	0.00345	4.84	1.918	1.296	2.51E+06	0.049	5.10E+07	0.012	0.067	1.761	0.043
1	2	100	45	0.00354	5.09	2.332	1.473	3.00E+06	0.052	5.78E+07	0.012	0.075	2.128	0.054
1	3	25	57	0.01475	5.02	0.625	0.541	1.09E+06	0.082	1.33E+07	0.016	0.092	0.609	0.064
1	3	50	56	0.00647	5.11	1.231	0.941	1.92E+06	0.060	3.20E+07	0.014	0.074	1.166	0.054
1	3	75	60	0.00517	5.11	1.814	1.248	2.55E+06	0.064	4.01E+07	0.013	0.087	1.698	0.063
1	3	100	64	0.00409	5.10	2.298	1.460	2.98E+06	0.059	5.04E+07	0.013	0.086	2.121	0.062
2	4	50	67	0.01519	6.36	0.987	0.792	2.01E+06	0.077	2.63E+07	0.014	0.092	0.952	0.052
2	4	75	72	0.00937	6.81	1.423	1.050	2.86E+06	0.055	5.23E+07	0.012	0.070	1.338	0.045
2	4	100	74	0.00840	6.62	1.891	1.284	3.40E+06	0.063	5.36E+07	0.012	0.088	1.772	0.053
2	6	50	84	0.01879	6.61	0.970	0.781	2.06E+06	0.086	2.39E+07	0.014	0.104	0.939	0.063
2	6	75	88	0.01359	6.88	1.372	1.022	2.81E+06	0.076	3.72E+07	0.013	0.097	1.311	0.064
2	6	100	93	0.01189	7.44	1.698	1.192	3.55E+06	0.066	5.38E+07	0.012	0.089	1.603	0.068

Table 3.7 Calculation of Bed Critical Shields' Coefficient Using Darcy Weisbach Friction Factor

3.3 Calculation Of Bed Critical Shields Coefficient Using Velocity Distribution Equation

The Prandtl-Von Karman velocity distribution equation is used in this section to calculate the bed critical Shields' coefficient C_{cv}. The Prandtl-Von Karman equation is presented as (Chow, 1959, p. 202)

$$U = 5.75\, U_* \log \frac{30z}{k_s} \tag{3.15}$$

where

U = velocity at height z [L/T] in ft/sec
U_* = shear velocity [L/T] in ft/sec
z = vertical height above the "bed" [L] in ft
k_s = equivalent roughness height [L] in ft

Equation (3.15) can be written as

$$U = 5.75\, U_* \log z + 5.75\, U_* \log \frac{30}{k_s} \tag{3.16}$$

or

$$U = a \log z + b \tag{3.17}$$

where

$$a = 5.75\, U_* \tag{3.18}$$

$$b = 5.75\, U_* \log \frac{30}{k_s} \tag{3.19}$$

Equation (3.17) indicates that if velocities are plotted versus depth on semi-logarithmic paper the value of shear velocity, U_*, can be determined from the slope of the line passing through the data points. The value of "b" can be evaluated by using known points on the line. The magnitude of k_s then can be calculated from equation (3.19). For a known value of U_*, the critical bed shear stress, τ_c, and corresponding Shields' coefficient, C_{cv} can be determined as follows:

$\tau_c = \tau_b$ for incipient failure runs

$$\tau_c = \rho U_*^2 \tag{3.20}$$

$$C_{cv} = \frac{\tau_c}{(\gamma_s - \gamma_w)\, d_{so}} \tag{3.21}$$

where

γ_s = specific weight of rocks
γ_w = unit weight of water

The graphs of velocity distribution versus depth for incipient motion runs are presented in Appendix C (indicated by the run number). The calculated values of C_{cv} and k_s are presented Tables 3.8 and 3.9. The values of C_{cv} and k_s are obtained from the velocity profiles along the centerline of the flume (Y=4.0 ft) and across the middle section of the test reach (X=125 ft for run No. 7 and X=130 ft for the rest of the runs). When the velocity profile lines were drawn through the data points adjacent to the riprap surface low values for C_{cv} and k_s resulted. Examples are run No. 57 (Y=4.0 ft, line #2) and run No. 84 (Y=4.0 ft, line #3) where C_{cv} = 0.020.

To evaluate the effect of the bottom elevation on the logarithmic distribution of the velocity profile, a comparison was made between velocity profiles plotted using four different elevation datums. Two of these datums are the "general datum" (GD) and the "local datum" (LD) as defined in Chapter 2. The other two datums are selected to be a distance $d_{so}/2$ below the GD and LD (that is, GD - $d_{so}/2$ and LD - $d_{so}/2$). The velocity distribution for some selected runs (runs No. 67, 74, 76, 84, 88, and 93) are plotted using these four datums. The graphs of velocity distributions for these runs are presented in Appendix C. As shown in these graphs, the data points adjacent to the riprap surface did not coincide with the velocity distribution line drawn through the remainder of the data points when the "local datum" was used. The effect of using these four different datums to evaluate the

bed Shields' coefficient C_{cv} can be observed by referring to the values presented in Table 3.10. These values indicate that the magnitudes of C_{cv} are generally highest when the LD - $d_{so}/2$ datum is used, and lowest when "general datum" is used. In the next section, the values of C_{cv} that are obtained using the "general datum" will be compared with the values of Shields' coefficient obtained in sections 3.1 and 3.2.

RUN #	Riprap Thickness in.	Discharge Q cfs	Location of vel. profile	Line #	b	a	b/a	U* fps	Bed shear stress psf	Critical Shields coef.	Roughnes factor k_s,ft
7	2	25	Y=4.0'		6.03	3.00	2.010	0.522	0.528	0.060	0.293
			X=125'		6.17	3.27	1.887	0.569	0.627	0.072	0.389
31		50	Y=4.0'		5.77	3.07	1.879	0.534	0.552	0.063	0.396
			X=130'	1	5.67	2.97	1.909	0.517	0.517	0.059	0.370
				2	6.03	2.96	2.037	0.515	0.514	0.059	0.275
23		75	Y=4.0'		5.60	2.90	1.931	0.504	0.493	0.056	0.352
			X=130'		5.43	2.73	1.989	0.475	0.437	0.050	0.308
27		100	Y=4.0'		4.83	2.60	1.858	0.452	0.396	0.045	0.416
			X=130'	1	4.83	2.50	1.932	0.435	0.366	0.042	0.351
				2	5.57	3.07	1.814	0.534	0.552	0.063	0.460
									Average	0.057	0.361
37	2	25	Y=4.0'		6.53	3.16	2.066	0.550	0.585	0.067	0.257
			X=130'		6.70	3.37	1.988	0.586	0.666	0.076	0.308
41		50	Y=4.0'		5.33	3.10	1.719	0.539	0.563	0.064	0.572
			X=130'		5.40	2.67	2.022	0.464	0.418	0.048	0.285
40		75	Y=4.0'		5.27	2.40	2.196	0.417	0.338	0.039	0.191
			X=130'		5.33	2.36	2.258	0.410	0.326	0.037	0.165
45		100	Y=4.0'		4.83	2.13	2.268	0.370	0.266	0.030	0.162
			X=130'		5.23	2.43	2.152	0.423	0.346	0.040	0.211
									Average	0.050	0.269
57	3	25	Y=4.0'	1	6.40	3.33	1.922	0.579	0.650	0.074	0.359
				2	5.63	1.73	3.254	0.301	0.175	0.020	0.017
			X=130'	1	7.23	3.90	1.854	0.678	0.892	0.102	0.420
				2	6.83	2.90	2.353	0.504	0.493	0.029	0.132
56		50	Y=4.0'		5.90	3.10	1.903	0.539	0.563	0.064	0.375
			X=130'	1	5.73	2.60	2.204	0.452	0.396	0.045	0.188
				2	6.07	3.17	1.915	0.551	0.589	0.067	0.365
60		75	Y=4.0'		5.70	3.43	1.662	0.597	0.690	0.079	0.654
			X=130'		6.03	2.46	2.451	0.428	0.355	0.041	0.106
64		100	Y=4.0'		5.17	2.44	2.119	0.424	0.349	0.041	0.228
			X=130'		5.53	2.50	2.212	0.435	0.366	0.042	0.184
									Average	0.055	0.275

Table 3.8 Calculation of Bed Critical Shields' Coefficient Using Velocity Distribution Equation for d_{50} = 1 in. Riprap.

RUN #	Riprap thickness in.	Discharge Q cfs	Location of vel. profile	Location of origin (Z=0)	Line #	b	a	b/a	U_* fps	Bed shear stress psf	Critical shields coef.	Roughness factor k_s, ft
67	4	50	Y=4.0'	GD	1	8.00	4.13	1.937	0.718	1.000	0.059	0.347
					2	7.90	3.67	2.153	0.638	0.789	0.046	0.211
				GD-d50/2		6.70	3.70	1.811	0.643	0.802	0.047	0.464
				LD		7.87	4.67	1.685	0.812	1.278	0.075	0.619
				LD-d50/2		6.80	4.73	1.438	0.823	1.311	0.077	1.095
72		75	Y=4.0'	GD		7.56	3.83	1.974	0.666	0.860	0.050	0.319
			X=130'	GD	1	7.80	3.77	2.069	0.656	0.833	0.049	0.256
					2	7.87	2.97	2.650	0.517	0.517	0.030	0.067
74		100	Y=4.0'	GD	1	6.80	3.13	2.173	0.544	0.574	0.034	0.202
					2	7.40	3.13	2.364	0.544	0.574	0.034	0.130
			X=130'	GD		7.40	3.17	2.334	0.551	0.589	0.035	0.139
				GD-d50/2		7.20	3.69	1.951	0.642	0.798	0.047	0.336
				LD		7.33	3.83	1.914	0.666	0.860	0.050	0.366
				LD-d50/2		7.12	4.33	1.644	0.753	1.099	0.064	0.680
										Average	0.050	0.374
84	6	50	Y=4.0'	GD	1	8.27	3.77	2.194	0.656	0.833	0.049	0.192
					2	7.73	3.30	2.342	0.574	0.638	0.037	0.136
					3	7.93	2.43	3.263	0.423	0.346	0.020	0.016
				GD-d50/2	1	8.20	4.86	1.687	0.845	1.384	0.081	0.616
					2	7.93	4.85	1.635	0.843	1.379	0.081	0.695
					3	8.39	4.16	2.017	0.723	1.014	0.059	0.289
				LD	1	7.87	4.70	1.674	0.817	1.295	0.076	0.635
					2	8.03	3.03	2.650	0.527	0.538	0.032	0.067
				LD-d50/2	1	7.70	5.96	1.292	1.037	2.082	0.122	1.532
					2	8.50	4.89	1.738	0.850	1.402	0.082	0.548
88		75	Y=4.0'	GD		8.30	4.07	2.039	0.708	0.971	0.057	0.274
				GD-d50/2		8.16	5.04	1.619	0.877	1.489	0.087	0.721
				LD	1	8.10	4.87	1.663	0.847	1.390	0.082	0.651
					2	8.40	4.17	2.014	0.725	1.019	0.060	0.290
				LD-d50/2	1	7.80	5.47	1.426	0.951	1.754	0.103	1.125
					2	8.40	5.38	1.561	0.936	1.697	0.099	0.824
93		100	Y=4.0'	GD		8.36	4.86	1.720	0.845	1.384	0.081	0.571
				GD-d50/2		8.10	5.44	1.489	0.946	1.735	0.102	0.973
				LD		8.23	5.00	1.646	0.870	1.465	0.086	0.678
				LD-d50/2		7.93	5.80	1.367	1.009	1.972	0.116	1.288
										Average	0.076	0.606

GD = General Datum
LD = Local Datum

Table 3.9 Calculation of Bed Critical Shields' Coefficient Using Velocity Distribution Equation for d_{50} = 2 in. Riprap.

Table 3.10. Values of C_{CV} for Some Selected Runs Calculated Based on Four Different Datums

Run #	Discharge Q cfs	Location of vel. profile	Line #	Datums GD	GD-d_{50} /2	LD	LD-d_{50} /2
76	25	X=130'		0.020	0.039	0.028	0.056
67	50	Y=4.0'	1	0.059	0.047	0.075	0.077
	50		2	0.046			
74	100	X=130'		0.035	0.047	0.050	0.064
84	50	Y=4.0'	1	0.049	0.081	0.076	0.122
	50		2	0.037	0.081	0.032	0.082
	50		3	0.020	0.059		
88	75	Y=4.0'	1	0.057	0.087	0.082	0.103
	75		2			0.060	0.099
93	100	Y=4.0'		0.081	0.102	0.086	0.116

GD = General Datum
LD = Local Datum
Note: More than one value of C_{CV} for a given run resulted from different velocity distribution profiles along a section.

3.4 Comparison Of The Values Of Critical Shields' Coefficients Calculated By The Previous Three Methods

In Table 3.11 The calculated values of critical Shields' coefficient are presented for comparison. The results show that values of bed critical Shields' coefficient obtained using the Manning's friction factor (C_{cn}) have the lowest magnitudes and those obtained by Prandtl-Von Karman equation (C_{cv}) have generally (for 60% of the time) the highest magnitudes. However, some very low values of the Shields' coefficient were obtained using the Prandtl-Von Karman equation.

The values of C_{cv} that are presented in Table 3.11 were calculated based on the "general datum". As mentioned in the previous section, the values of C_{cv} that were calculated based on the other three datums are higher than the ones obtained using the "general datum" and, therefore, much higher than the values of C_{cn} and C_{cf}. Because of the wide range of values of C_{cv} (as shown in Tables 3.10 and 3.11), a general conclusion cannot be made as if the values of C_{cv} represent the actual values of bed critical Shields' coefficient or not. This raises the question of the validity of the Prandtl-von Karman equation in predicting the shear stress on the riprap surface, τ_b, and, therefore, bed Shields' coefficient.

3.5 Effect Of Flat Rocks

The 1 in. riprap contained about 10 percent flat rocks. To determine the influence of these flat rocks on the failure of the riprap, the flat rocks were removed after the first series of tests and the tests were repeated.

No significant changes in critical Shields' coefficient were observed after removal of flat rocks. The values of critical Shields' coefficient differ appreciably only for a flow rate of 25 cfs (see Table 3.11 - runs No. 7 and 37). This difference is probably due to the influence of the transition section of run No. 7 as mentioned earlier and not attributed to removal of the flat rocks.

Table 3.11. Values of Critical Shields Coefficients Calculated by Different Methods Listed

Run #	Riprap median size in.	Riprap thicknes in	Discharge Q cfs	Overall C_C	Manning C_{Cn}	Darcy Weisbach C_{Cf}	Velocitydistrib C_{CV} @Y=4.0'	Velocitydistrib C_{CV} @X=130
7	1	2	25	0.044	0.041	0.043	0.060	0.072
31			50	0.051	0.045	0.048	0.063	0.059
23			75	0.046	0.040	0.042	0.056	0.050
27			100	0.053	0.045	0.048	0.045	0.042
			100					0.063
37	1	2	25	0.056	0.053	0.054	0.067	0.076
41			50	0.046	0.041	0.043	0.064	0.048
40			75	0.047	0.041	0.043	0.039	0.037
45			100	0.059	0.051	0.054	0.030	0.040
57	1	3	25	0.066	0.063	0.064	0.074	0.102
			25				0.020	0.033
56			50	0.057	0.052	0.054	0.064	0.045
			50					0.067
60			75	0.067	0.060	0.063	0.079	0.041
64			100	0.067	0.058	0.062	0.041	0.042
67	2	4	50	0.055	0.049	0.052	0.059	
			50				0.046	
72			75	0.049	0.041	0.045	0.050	0.049
			75					0.030
74			100	0.058	0.047	0.053	0.034	0.035
84	2	6	50	0.067	0.059	0.063	0.049	
			50				0.037	
			50				0.020	
88			75	0.068	0.058	0.064	0.057	
93			100	0.074	0.061	0.068	0.081	

Note: More than one value of C_{CV} for a given run resulted from different velocity distribution profiles along a section.

3.6 Effect Of The Riprap Thickness On Critical Shields' Coefficient(C_c)

The failure criterion for riprap was the exposure of the filter blanket after a run. For a given discharge, the run at which the flume slope was one increment lower than the failure run was regarded as the incipient failure run from which the critical Shields' coefficient was calculated. Based on the above definition of the incipient failure run, it was expected that the riprap with greater thickness would have higher values of critical Shields' coefficient. This is because the Shields' coefficient is used to define a point that is the result of a significant amount of motion of the riprap even prior to what is defined as a failure.

The values of critical Shields' coefficient, C_c, are presented in Table 3.11. These values show that, on the average, the critical Shields' coefficient increased 22 percent for 1 in. rocks and 30 percent for 2 in. rocks when rock thickness increased from $2d_{so}$ to $3d_{so}$. The values of overall critical Shields' coefficient calculated from equation (3.7) (C_c) are plotted in Figure 3.1. The increase in the critical Shields' coefficient as shown in Figure 3.1 was relatively small when the rock size increased from 1 in. to 2 in. (4 percent on the average) and the thickness remained at $2d_{so}$. However, the critical Shields' coefficient increased about 30 percent when rock riprap thickness increased from $2d_{so}$ to $3d_{so}$.

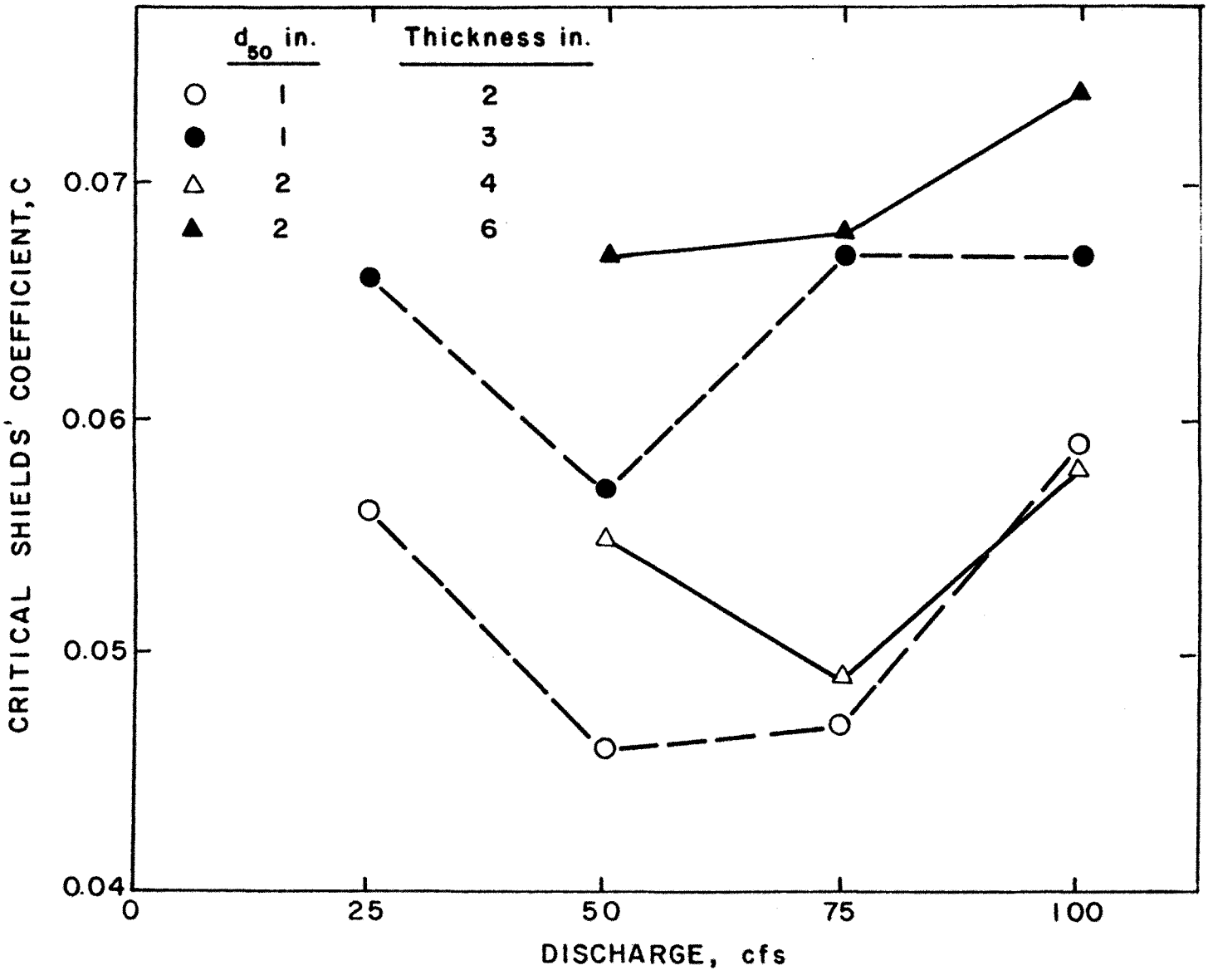


Figure 3.1 Values of overall critical Shields' coefficient for different rock sizes and thicknesses.

3.7 Effect of Riprap Gradation on Critical Shields' Coefficient (C_c)

To examine the effect of gradation, values of overall critical Shields' coefficients are plotted in Figure 3.2 for the riprap materials presented in Table 3.12. The values of d_{85}/d_{15} are used as the parameters to represent the gradation of riprap material. The values of d_{85}/d_{15} in Table 3.12 indicates that the riprap material of this 1985 Study and the 2 in. riprap of the 1982 Report had a more uniform gradation than the 1 in. riprap of the 1983 Report.

As shown in Figure 3.2, the range of values of the critical Shields' coefficients for 1 in. riprap of the 1983 Report was lower than the rest of data points. These results show that a riprap with more uniform gradation is more stable. Additional data are required to generalize the effect of gradation on riprap stability.

TABLE 3.12 Gradation of the Riprap Material

d_{50} in	Riprap Thickness	d_{85}/d_{15}	Year of Study
1	2	2.0	1985
1	2	4.4	1983
2	4	2.4	1985
1.87	4	2.8	1982

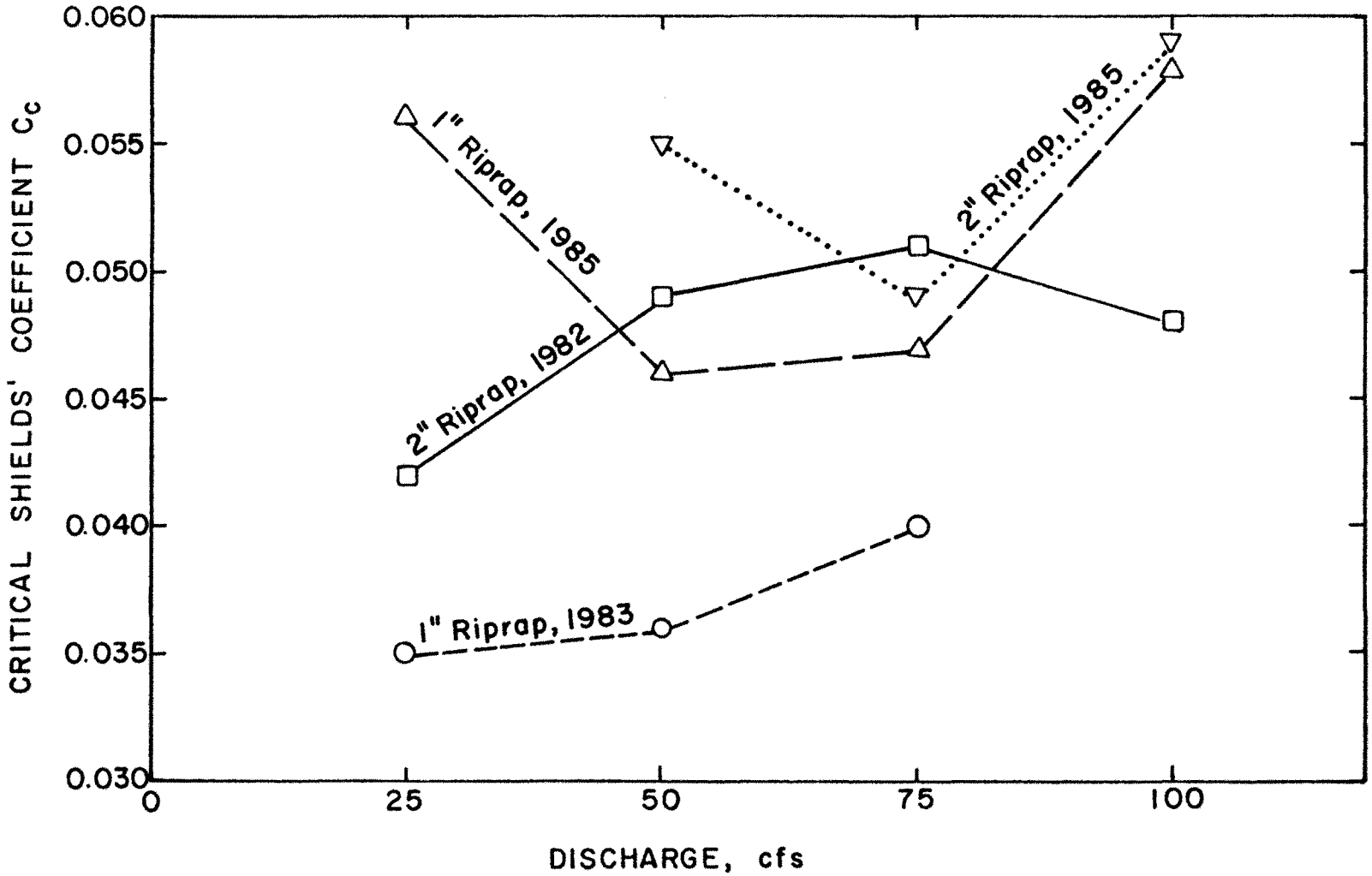


Figure 3.2 Variation of overall critical Shields' coefficient with riprap gradation.

3.8 Comparison With Shields' Diagram

Shields' diamgram is an experimental relationship between the values Shields' coefficient for incipient motion runs ($C_{ci} = \tau_c / (\gamma_w (s-1)d)$) and grain Reynolds number ($R_* = U_* d/\nu$) where U_* is shear velocity in fps, d is particle size in ft, and ν is kinematic viscosity in ft^2/sec. Shields assumed that for a flat bed of uniform particle size, C_{ci} is only a function of R_* (Rouse, 1950). Shields' diagram is shown in Figure 3.3. Shields determined this relationship by measuring the washed out mterial (bed load) at various values of $\tau/(\gamma_w (s-1) d)$ at least twice as large as the critical value (C_{ci}) and then extrapolating to the point of zero washed out material (Gessler, 1971). Gessler (1971) argued that some of Shields bed load measurements were under conditions where ripples and small duens prevailed, and therefore the shear stress on bed was resisted by both bed deformation and grain roughness. Gessler concluded that values of C_{ci} determined by Shields were up to 10 percent too high. Gessler modified the Shields' diagram as shown in Figure 3.3.

To compare the results of this riprap stability study with Shields' diagram, the values of overall critical Shields' coefficient (C_c) versus boundary Reynolds' number ($R_x = U_* d_{so} / \nu$) are presented in Table 3.13 and plotted in Figure 3.3. In this figure, the values of C_c from the 1982 and 1983 Reports are also plotted. Note that the original Shields' diagram was constructed using the values of Shields' coefficient for incipient motion runs but values of C_c are for the incipient failure runs. the scatter of data points in Figure 3.3 are most probably due to two reasons: 1) In incipient failure runs some of the riprap material may move without exposing the underlying filter blanket. this is more pronounced in riprraps with greater thicknesses. As shown in Figure 3.3, the values of C_c for $3d_{so}$ thickness riprap are greater than the Shields' coefficient of 0.06. 2) The riprap materials were not uniform in size. The data points in Figure 3.3 represent various riprap gradations.

The data points in Figure 3.3 indicate that the values C_c obtained from the recent study are generally higher than those of the previous reports. There is some overlap between the C_c values of the 2 in. riprap of 1982 Report and the recent data. Agreement does not exist for 1 in. rocks of the 1983 Report and the present study. There is a pronounced difference between the critical Shields' coefficient, C_c, based upon the riprap thickness of $2d_{so}$ and $3d_{so}$. The variations in C_c among various ripraps can be attributed to the differences in thicknesses and gradations of the riprap material. As discussed in section 3.6, it is expected that a riprap with greater thickness requires greater bed shear stress (or Shields' coefficient) to begin to fail. the influence of gradation was discussed in section 3.7. The difference in C_c values for 1 in. riprap ($2d_{so}$ thick) of the 1983 Report and the present study may be because of the differences in gradations of the ripraps. Some of these discrepancies are also because of the procedure to change the flume slope to reach the incipient failure run. The actual point of incipient failure could occur at a point where the slope was between that slope called failure and that slope set one increment lower than failure.

3.9 Maximum Stable Slopes At The Incipient Failure Runs

The slopes of the incipient failure runs versus flow rate are plotted in Figure 3.4. This figure also contains the information from the previous report. No general conclusion can be drawn from this plot.

Table 3.13. Values of C_C and R_*

Riprap median size in.	Riprap thickness in.	Discharge Q cfs	Run #	Overall Shields coef. C_C	Boundary Reynolds number R_*
1	2	25	7	0.044	3725
1	2	50	31	0.051	3979
1	2	75	23	0.046	3802
1	2	100	27	0.053	4077
1	2	25	37	0.056	4186
1	2	50	41	0.046	3791
1	2	75	40	0.047	3847
1	2	100	45	0.059	4296
1	3	25	57	0.066	4540
1	3	50	56	0.057	4220
1	3	75	60	0.067	4579
1	3	100	64	0.067	4584
2	4	50	67	0.055	11580
2	4	75	72	0.049	10921
2	4	100	74	0.058	11920
2	6	50	84	0.067	12768
2	6	75	88	0.068	12914
2	6	100	93	0.074	13438

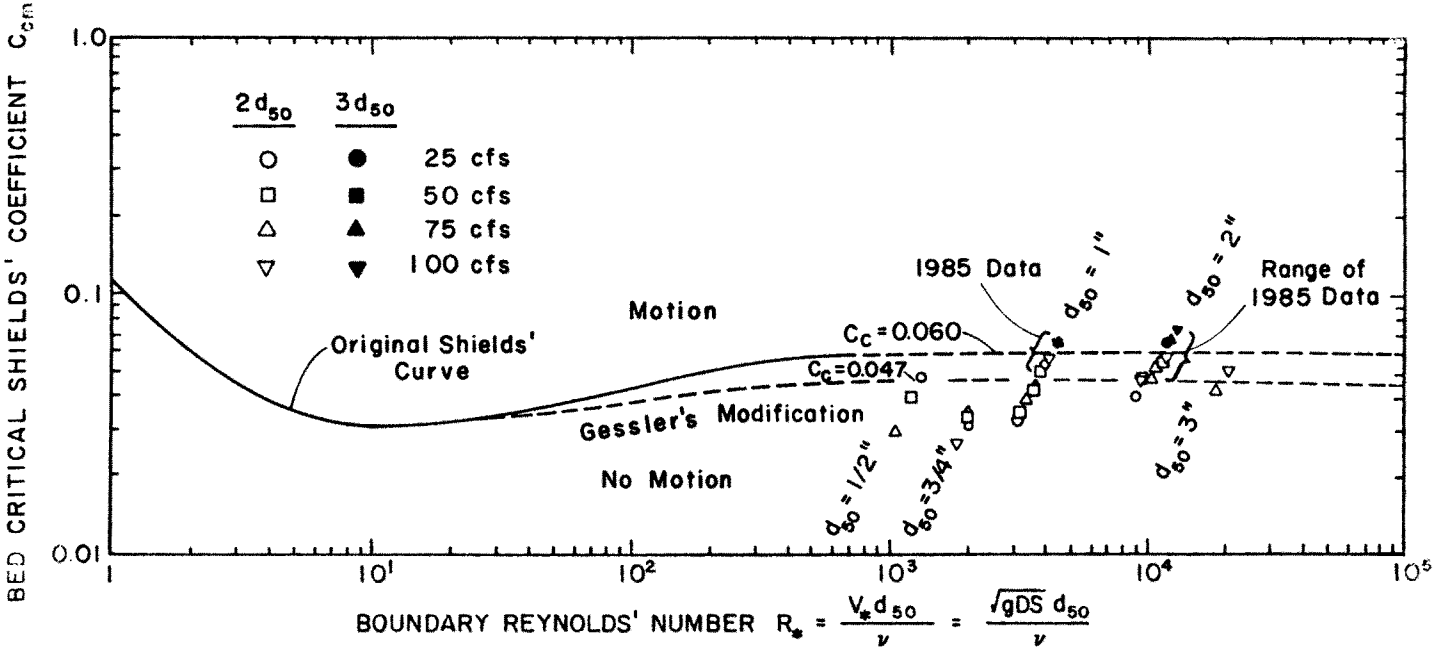


Figure 3.3 The Shields' Diagram

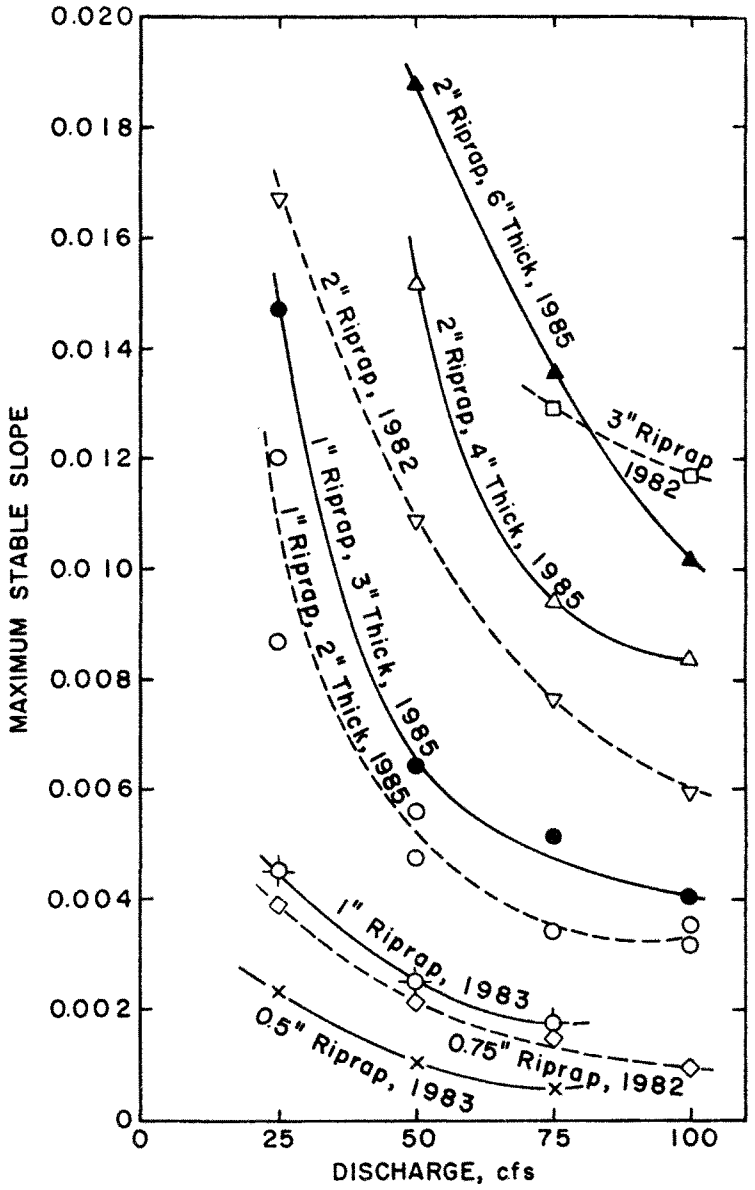


Figure 3.4 Maximum stable slope vs. discharge

CHAPTER 4

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A total of 94 tests were conducted on riprap with d_{so}=1 in. and d_{so}=2 in. and with thickness layers of $2d_{so}$ and $3d_{so}$. The flow rates tested were 25, 50, 75, and 100 cfs. The tests were conducted in the 8 ft tilting flume of the Hydraulics Laboratory, Engineering Research Center of Colorado State University. For each riprap and each flow rate the flume slope was increased by small increments until the failure of the riprap occurred. The exposure of the filter blanket underneath the riprap was the failure criterion. The run with the flume slope reduced one increment lower than the slope at failure was considered to be the incipient failure run. Velocity data were collected either by ott meter or pitot tube. The data are presented in the Appendices.

The following conclusions are made in this study.

1. The average values calculated for bed Manning's roughness, n_b, agree with the ones calculated by Anderson et al. equation. Strickler equation underestimates the bed Manning's roughness factor.
2. The values of bed Shields' coefficient at the incipient failure conditions range from 0.041 to 0.054 for riprap placed $2d_{so}$ thick and range from 0.052 to 0.068 for riprap placed $3d_{so}$ thick. The above values are obtained using the Manning's and Darcy-Weisbach friction factors.

Shields' coefficients calculated using velocity distribution equations, range from 0.020 to 0.102. These differences result from local flow patterns and velocity distributions.

3. No general relationship exists between maximum stable slope and rock size for a given flow rate. There is a trend of the maximum slope increasing with riprap size as shown in Figure 3.4.
4. Generally, The wide range of the results is most likely due to the wide variation in gradations and thicknesses of ripraps.

The recommendations are generally similar to the ones presented in the 1982 and 1983 Reports. It is suggested that a small portion of the riprap be painted and placed in a grid on the surface of the riprap. Displacement of a percentage of painted rocks, then can be used to define the incipient motion or incipient failure runs. Some means should be designed to observe the behavior of the painted rock during a test, for example, using a video camera and recorder.

REFERENCES

1. Anderson, A. G., A. S. Paintal, and J. T. Davenport, 1970. Tentative Design Procedure for Riprap-Lined Channels: National Cooperative Highway Research Program Report 108, Highway Research Board, National Research Council, National Academy of Science, 75 p.

2. Chow, V. T., 1959. Open Channel Hydraulics. McGraw-Hill Book Company, Inc. New York, New York.

3. Department of Army - Corps of Engineers. Hydraulic Design of Flood Control Channels. Manual EM1110-2-1601, July, 1970.

4. Fiuzat, A. A., Y. H. Chen, and D. B. Simons, 1982. Stability Tests of Riprap in Flood Control Channels. Report No. CER81-82AAF-YCH-DBS56, Dept. of Civil Engineering, Colorado State University, Fort Collins, Colorado, October.

5. Fiuzat, A.A. and E. V. Richardson, 1983. Supplemental Stability Tests of Riprap in Flood Control Channels. Draft Report CER83-84AAF-EVR18, Civil Engineering Department, Colorado State University, Fort Collins, Colorado, December.

6. Gessler, J., 1971. Beginning and Ceasing of Sediment Motion, River Mechanics edited by H. W. Shen, Chapter 7, Fort Collins, Colorado.

7. Rouse, H. (1950), Ed., Engineering Hydraulics, John Wiley & Sons, New York, p. 790.

8. Shields, A., 1936. "Anwendung der Aehnlichkeitsmechanik und Turbulenz Forschung auf die Geschiebebewegung," Mitteilung Preussiche Versuchanstalt Wasser, Erd, Schiffbau, Berlin, No. 26 (in German), cited in D. B. Simons and F. Senturk, 1977. Sediment Transport Technology, Water Resources Publications, Fort Collins, Colorado.

9. Simons, D. B. and F. Senturk, 1977. Sediment Transport Technology. Water Resources Publications, Fort Collins, Colorado.

10. Vanoni, V. A., ed. 1975. Sedimentation Engineering, ASCE, 345 East 47th St. New York, New York.

APPENDICES

The notations used in the appendices are as follows:

Q	=	nominal discharge, cfs
S	=	bed slope of the flume
D	=	depth of flow, ft
V	=	average velocity, fps
X	=	station along the flume, starting at the upstream end of the flume, ft
Y	=	distance across the flume from the west wall of the flume, ft
Z	=	depth at which velocity was measured (vertical distance above the "general" datum), ft
Rock Size	=	the median size or d_{50} of the riprap, in.
Thickness	=	thickness of the riprap, in.
Fraction of Depth	=	Z/D, measured above the "general" datum
Temp.	=	water temperature, °F

APPENDIX A

SUMMARY

Table A-1. Summary of the Tests Conducted for the 1 in. Riprap with 2 in. Thickness

Discharge Q cfs	Run #	Flume slope S	Average velocity V ,fps	Average depth D , ft	Froude number F	Water temp. F	Area washed sq. ft	Test duration hrs
25	$ 1	0.00367	2.57	1.273	0.40	74		3.5
	$ 2	0.00490	3.55	0.906	0.66	74		2.5
	$ 3	0.00617	3.87	0.846	0.74	72		3.0
	$ 4	0.00749	4.22	0.745	0.86	72		3.0
	$ 5	0.00872	4.45	0.714	0.93	74	2	2.5
	f$ 6	0.01012	4.59	0.689	0.97	74	23	2.5
	*$ 7	0.00869	4.77	0.714	0.99	74		4.0
50	$ 8	0.00220	3.76	1.703	0.51	74		2.5
	$ 9	0.00269	4.12	1.519	0.59	75		2.0
	$10	0.00334	Nc data collected because of power failure					1.7
	$11	0.00481	4.62	1.305	0.71	74	40	2.0
	$12	0.00317	4.22	1.432	0.62	74		4.0
	28	0.00409	3.85	1.386	0.58	71		2.0
	29	0.00490	4.30	1.262	0.67	71		2.0
	30	0.00561	4.76	1.252	0.75	72	0.03	2.3
	* 31	0.00561	5.06	1.262	0.79	72		4.0
75	$13	0.00239	Test was repeated because of low tailwater depth.					
	$14	0.00239	4.48	2.098	0.55	74		2.0
	$15	0.00288	4.70	2.009	0.58	68	0.7	2.0
	$16	0.00340	4.90	1.891	0.63	74	25	2.0
	$17	0.00281	4.64	1.970	0.58	70		3.5
	$18	0.00281	4.63	1.966	0.58	74	13	2.0
	19	0.00281	No data collected because of power failure					2.0
	20	0.00284	5.03	2.018	0.62	68		2.0
	21	0.00333	5.14	1.886	0.66	71		2.0
	f 22	0.00407	4.64	1.802	0.61	67	12	2.0
	* 23	0.00343	5.02	1.885	0.64	71		4.0
100	24	0.00225	4.86	2.479	0.54	68		2.0
	25	0.00266	4.62	2.397	0.53	70		2.0
	f 26	0.00308	5.15	2.286	0.60	72	2	2.0
	* 27	0.00318	5.06	2.337	0.58	70	0.7	3.5

f Failure of riprap
* Incipient failure conditions
$ The slope of the transition section was 1.75% more than that of the test section (see Chapter 3).

Table A-2. Summary of the Tests Conducted for the 1 in. Riprap with 2 in. Thickness (After removing flat rocks)

Discharge Q cfs		Run #	Flume slope S	Average velocity V ,fps	Average depth D , ft	Froude number F	Water temp. °F	Area washed sq. ft	Test duration hrs
25		33	0.00998	4.40	0.684	0.94	70		2.0
		34	0.01088	4.51	0.703	0.95	68		4.0
		35	0.01186	4.72	0.672	1.01	68		2.0
	f	36	0.01337	4.95	0.618	1.11	68	7.2	2.0
	*	37	0.01204	4.77	0.651	1.04	68	2.7	4.0
50	f	32	0.00558	4.90	1.300	0.76	70	10.8	5.0
	*	41	0.00475	4.71	1.353	0.71	62	2.5	2.5
75	f	38	0.00402	5.02	1.832	0.65	63	0.4	2.0
	f	39	0.00377	5.00	1.842	0.65	69	0.1	2.0
	*	40	0.00345	4.84	1.918	0.62	72		4.0
100		42	0.00314	4.97	2.371	0.57	68		2.5
		43	0.00403	4.90	2.415	0.56	66		1.8
	f	44	0.00436	5.20	2.210	0.62	63	17.7	2.0
	*	45	0.00354	5.09	2.332	0.59	72	2.5	4.0

* Incipient failure condition

f Failure Conditions

Table A-3. Summary of the Tests Conducted for the 1 in. Riprap with 3 in. Thickness

Discharge Q cfs	Run #	Flume slope S	Average velocity V ,fps	Average depth D , ft	Froude number F	Water temp. °F	Area washerd sq. ft	Test duration hrs
25	46	0.00880	4.37	0.720	0.91	66		2.0
	47	0.01011	4.61	0.688	0.98	69		2.0
	48	0.01313	5.02	0.640	1.11	68		2.0
	* 57	0.01475	5.02	0.625	1.12	64		4.5
	f 58	0.01626	5.52	0.568	1.29	67	23	3.0
50	49	0.00526	4.94	1.268	0.77	70		2.0
	50	0.00636	5.36	1.169	0.87	68		3.5
	51	0.00726	5.61	1.102	0.94	68	4.6	3.3
	52	0.00726	5.74	1.906	0.73	63		2.7
	f 53	0.00802	5.66	1.095	0.95	58	37.4	2.0
	f 54	0.00732	5.64	1.111	0.94	64	23	1.7
	f 55	0.00732	5.03	1.245	0.79	65	3.7	4.3
	* 56	0.00647	5.11	1.231	0.81	67		4.0
75	59	0.00423	4.90	1.907	0.63	68		3.0
	* 60	0.00517	5.11	1.814	0.67	72		3.0
	f 61	0.00621	5.50	1.714	0.74	73	49.5	2.0
100	62	0.00406	4.63	2.513	0.51	75		2.5
	f 63	0.00457	5.25	2.210	0.62	67	2	2.5
	* 64	0.00409	5.10	2.298	0.59	65		3.0

* Incipient failure conditions

f Failure conditions

Table A-4. Summary of the Tests Conducted for the 2 in. Riprap with 4 in. Thickness

Discharge Q cfs		Run #	Flume slope S	Average velocity V ,fps	Average depth D , ft	Froude number F	water temp. °F	Area washed sq. ft	Test duration hrs
25		76	0.01193	4.55	0.681	0.97	67		3.0
		77	0.01858	5.27	0.598	1.20	67		1.5
50		65	0.00998	5.03	1.246	0.79	68		2.8
		66	0.01378	6.13	1.019	1.07	75		2.0
	*	67	0.01519	6.36	0.987	1.13	72		1.7
		68	0.01796	6.71	0.935	1.22	72		3.3
	f	69	0.01888	6.63	0.948	1.20	68	59.8	1.7
	f	78	0.01579	6.14	1.022	1.07	68	5.5	1.7
75	f	70	0.01110	6.65	1.410	0.99	69	64.1	0.8
		71	0.00781	6.33	1.483	0.92	70		2.5
	*	72	0.00937	6.81	1.423	1.01	70		2.0
100		73	0.00731	6.43	1.954	0.81	72		2.5
	*	74	0.00840	6.62	1.891	0.85	71		3.0
	f	75	0.01066	7.00	1.804	0.92	70	27	2.3

* Incipient failure conditions
f Failure conditions

Table A-5. Summary of the Tests Conducted for the 2 in. Riprap with 6 in. Thickness

Discharge Q cfs	Run #	Flume slope S	Average velocity V ,fps	Average depth D , ft	Froude number F	water temp. °F	Area washed sq. ft	Test duration hrs
25	79	0.01180	4.42	0.710	0.92	68		2.0
	80	0.01870	5.17	0.607	1.17	69		2.0
50	81	0.01205	5.90	1.068	1.01	70		2.0
	82	0.01544	6.47	0.966	1.16	67		2.7
	83	0.01724	6.76	0.928	1.24	67		1.5
	* 84	0.01879	6.61	0.970	1.18	68		2.0
75	85	0.00898	6.19	1.519	0.89	72		1.7
	86	0.01095	6.58	1.414	0.98	72		1.5
	87	0.01206	6.63	1.423	0.98	73		1.5
	* 88	0.01359	6.88	1.372	1.04	73		2.0
	f 89	0.01565	6.84	1.399	1.02	75	9.6	2.3
100	90	0.00866	6.97	1.808	0.91	77		2.3
	91	0.00938	6.96	1.796	0.92	77		1.3
	92	0.01084	7.39	1.711	1.00	77		2.0
	* 93	0.01189	7.44	1.698	1.01	75		2.3
	f 94	0.01300	8.02	1.572	1.13	75	15	1.3

* Incipient failure conditions
f Failure conditions

APPENDIX B

VELOCITY DATA

CORPS OF ENGINEERS RIPRAP PROJECT

Q=25 cfs Rock size 1 in. Thickness 2 in.

	X (ft)	Y (ft)	D (ft)	Fraction of Depth	Velocity ft/sec
Run # 1 S=0.00872	110	4.0	1.25	0.80	3.09
				0.20	2.13
	125	4.0	1.26	0.80	2.91
				0.20	2.33
	140	4.0	1.32	0.80	3.04
				0.20	1.94
Run # 2 S=0.00490	110	4.0	0.89	0.80	4.20
				0.20	3.18
	125	4.0	0.89	0.80	4.23
				0.20	2.94
	140	4.0	0.94	0.80	4.06
				0.20	2.70
Run # 3 S=0.00617	110	4.0	0.82	0.80	4.50
				0.20	3.32
	125	4.0	0.84	0.80	4.54
				0.20	3.35
	140	4.0	0.89	0.80	4.33
				0.20	3.18
Run # 4 S=0.00749	110	4.0	0.75	0.80	4.81
				0.20	3.32
	125	4.0	0.78	0.80	4.88
				0.20	3.62
	140	4.0	0.86	0.80	4.98
				0.20	3.72
Run # 5 S=0.00872	110	4.0	0.71	0.80	5.18
				0.20	4.06
	125	4.0	0.71	0.80	5.29
				0.20	3.28
	140	4.0	0.72	0.80	5.29
				0.20	3.62
Run # 6 S=0.01012	110	4.0	0.72	0.80	5.15
				0.20	3.59
	125	4.0	0.65	0.80	5.59
				0.20	4.06
	140	4.0	0.69	0.80	5.46
				0.20	3.69

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 7 S=0.00845 Rock size 1 in.
Q=25 cfs Temp. 74 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=110'	0.90	0.64	4.57	5.46	5.15
D=0.715'	0.70	0.50	5.32	5.25	4.91
	0.50	0.36	5.15	4.64	4.40
	0.30	0.21	4.47	4.00	3.76
X=125'	0.90	0.63	5.66	5.46	4.98
D=0.703'	0.70	0.49	5.35	5.12	4.98
	0.50	0.35	4.67	4.64	4.57
	0.30	0.21	4.06	4.03	3.93
X=140'	0.90	0.65	5.35	5.42	5.32
D=0.724'	0.70	0.51	5.05	5.05	5.01
	0.50	0.36	4.64	4.67	4.50
	0.30	0.22	4.10	4.00	3.89

CORPS OF ENGINEERS RIPRAP PROJECT

Q=50 cfs Rock size 1 in. Thickness 2 in.

	X (ft)	Y (ft)	D (ft)	Fraction of Depth	Velocity ft/sec
Run # 8	110	4.00	1.70	0.80	4.44
S=0.00220				0.20	3.08
	125	4.00	1.70	0.80	4.30
				0.20	3.28
	140	4.00	1.71	0.08	4.40
				0.02	3.08
Run # 9	110	4.00	1.51	0.80	5.15
S=0.00269				0.20	3.25
	125	4.00	1.52	0.80	4.67
				0.20	3.55
	140	4.00	1.52	0.80	4.78
				0.20	3.32
Run # 10	110	4.00	1.42	0.80	5.05
S=0.00334				0.20	3.62
	125	4.00	1.46	0.80	4.61
				0.20	
Run # 11	110	4.00	1.37	0.80	5.05
S=0.00481				0.20	3.96
	125	4.00	1.26	0.80	4.71
				0.20	4.37
	140	4.00	1.29	0.80	5.25
				0.20	4.40

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 12 S=0.00317 Rock size 1 in.
Q=50 cfs Temp 74 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=110'	0.90	1.26	5.49	5.49	3.93
D=1.404'	0.70	0.98	5.35	4.91	4.20
	0.50	0.70	4.98	4.61	4.13
	0.30	0.42	4.37	3.79	3.83
	0.10	0.14	3.01	3.04	2.84
X=125'	0.90	1.29	5.14	5.01	4.06
D=1.435'	0.70	1.00	5.19	4.78	4.33
	0.50	0.72	4.95	4.57	4.13
	0.30	0.43	4.33	3.96	3.83
	0.10	0.14	3.04	2.87	2.81
X=140'	0.90	1.31	4.98	5.12	4.40
D=1.458'	0.70	1.02	5.12	4.78	4.64
	0.50	0.73	4.71	4.40	4.44
	0.30	0.44	4.06	3.93	3.72
	0.10	0.15	3.04	2.94	2.67

CORPS OF ENGINEERS RIPRAP PROJECT

Q=75 cfs Rock size 1 in. Thickness 2 in.

	X (ft)	Y (ft)	D (ft)	Fraction of Depth	Velocity ft/sec
Run # 13 S=0.00239	110	4.00	2.11	0.80	5.35
				0.20	3.49
	125	4.00	2.07	0.80	5.35
				0.20	3.93
	140	4.00	2.06	0.08	5.49
				0.02	4.23
Run # 14 S=0.00239	110	4.00	2.09	0.80	5.25
				0.20	3.79
	125	4.00	2.10	0.80	5.12
				0.20	3.76
	140	4.00	2.10	0.80	5.22
				0.20	3.76
Run # 15 S=0.00288	110	4.00	2.06	0.80	5.35
				0.20	3.50
	125	4.00	1.98	0.80	5.86
				0.20	4.00
	140	4.00	1.99	0.80	5.52
				0.20	3.96
Run # 16 S=0.00340	110	4.00	1.88	0.80	6.07
				0.20	3.69
	125	4.00	1.91	0.80	5.69
				0.20	4.13
	140	4.00	1.88	0.80	5.73
				0.20	4.10

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 17 S=0.00281 Rock size 1 in.
Q=75 cfs Temp. 70 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=110'	0.90	1.79	5.39	5.69	4.37
D=1.985'	0.70	1.39	5.49	5.25	5.05
	0.50	0.99	5.29	4.74	5.09
	0.30	0.60	4.47	4.06	4.61
	0.10	0.20	3.01	2.91	3.18
X=125'	0.90	1.74	5.52	6.00	4.60
D=1.930'	0.70	1.35	5.42	5.46	5.08
	0.50	0.97	5.01	5.01	4.95
	0.30	0.58	4.74	4.40	4.57
	0.10	0.19	3.66	2.98	3.42
X=140'	0.90	1.80	5.22	5.62	4.37
D=1.996	0.70	1.40	5.49	5.52	4.74
	0.50	1.00	5.15	4.95	4.78
	0.30	0.60	4.74	4.44	4.13
	0.10	0.20	3.69	3.32	3.15

CORPS OF ENGINEERS RIPRAP PROJECT

Q=75 cfs Rock size 1 in. Thickness 2 in.

	X (ft)	Y (ft)	D (ft)	Fraction of Depth	Velocity ft/sec
Run # 18	110	4.00	1.98	0.80	5.42
S=0.00281				0.20	3.38
	125	4.00	1.94	0.80	5.69
				0.20	3.69
	140	4.00	1.98	0.08	5.52
				0.02	3.79
Run # 20	120	4.00	2.01	0.80	5.93
S=0.00284				0.20	4.37
	130	4.00	2.02	0.80	5.76
				0.20	4.20
	140	4.00	2.02	0.80	5.86
				0.20	4.06
Run # 21	120	4.00	1.87	0.80	6.10
S=0.00333				0.20	3.86
	130	4.00	1.90	0.80	6.03
				0.20	4.30
	140	4.00	1.89	0.80	6.20
				0.20	4.30
Run # 22	120	4.00	1.81	0.80	5.79
S=0.00407				0.20	3.51
	130	4.00	1.79	0.80	5.56
				0.20	3.52
	140	4.00	1.81	0.80	5.74
				0.20	3.69

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 23 S=0.00343 Rock size 1 in.
Q=75 cfs Temp. 71 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=120'	0.90	1.69	5.39	6.44	5.49
D=1.880'	0.70	1.32	5.73	6.13	5.59
	0.50	0.94	5.39	5.49	5.42
	0.30	0.56	4.84	4.78	4.67
	0.10	0.19	3.21	3.59	3.52
X=130'	0.90	1.69	5.32	6.13	5.52
D=1.883'	0.70	1.32	5.57	5.73	5.42
	0.50	0.94	5.49	5.46	5.29
	0.30	0.56	4.57	4.91	4.74
	0.10	0.19	3.49	3.35	3.52
X=140'	0.90	1.70	5.42	6.17	5.59
D=1.892'	0.70	1.32	5.59	5.96	5.66
	0.50	0.95	5.39	5.66	5.49
	0.30	0.57	4.71	4.88	4.71
	0.10	0.19	3.49	3.59	3.38

CORPS OF ENGINEERS RIPRAP PROJECT

Q=100 cfs Rock size 1 in. Thickness 2in.

	X (ft)	Y (ft)	D (ft)	Fraction of Depth	Velocity ft/sec
Run # 24 S=0.00225	120	4.00	2.48	0.80	5.79
				0.20	3.93
	130	4.00	2.47	0.80	5.79
				0.20	3.83
	140	4.00	2.49	0.08	5.69
				0.02	4.13
Run # 25 S=0.00266	120	4.00	2.39	0.80	5.66
				0.20	3.69
	130	4.00	2.39	0.80	5.39
				0.20	3.72
	140	4.00	2.41	0.80	5.35
				0.20	3.93
Run # 26 S=0.00308	120	4.00	2.28	0.80	6.41
				0.20	4.13
	130	4.00	2.28	0.80	6.10
				0.20	4.06
	140	4.00	2.30	0.80	6.07
				0.20	4.13

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 27 S=0.00318 Rock size 1 in.
Q=100 cfs Temp 70 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=120'	0.90	2.10	5.46	5.93	5.66
D=2.328'	0.70	1.63	5.81	5.22	5.93
	0.50	1.16	5.62	4.84	5.81
	0.30	0.70	5.05	4.44	5.13
	0.10	0.23	3.66	3.15	3.66
X=130'	0.90	2.10	5.61	6.20	6.00
D=2.334'	0.70	1.63	5.90	5.81	6.17
	0.50	1.17	5.62	5.04	5.95
	0.30	0.70	4.85	4.44	5.09
	0.10	0.23	3.80	3.26	3.69
X=140'	0.90	2.11	5.48	5.69	5.84
D=2.348'	0.70	1.64	5.73	5.56	6.03
	0.50	1.17	5.62	4.95	5.62
	0.30	0.70	4.80	4.54	5.12
	0.10	0.23	3.50	3.10	3.07

CORPS OF ENGINEERS RIPRAP PROJECT

Q=50 cfs Rock size 1 in. Thickness 2 in.

	X (ft)	Y (ft)	D (ft)	Fraction of Depth	Velocity ft/sec
Run # 28	120	4.00	1.37	0.80	4.87
S=0.00409				0.20	2.73
	130	4.00	1.39	0.80	4.90
				0.20	3.00
	140	4.00	1.40	0.08	4.74
				0.02	2.77
Run # 29	120	4.00	1.26	0.80	5.25
S=0.00490				0.20	3.20
	130	4.00	1.25	0.80	5.32
				0.20	3.31
	140	4.00	1.27	0.80	5.52
				0.20	3.21
Run # 30	120	4.00	1.25	0.80	5.59
S=0.00561				0.20	4.06
	130	4.00	1.25	0.80	5.72
				0.20	3.72
	140	4.00	1.26	0.80	5.62
				0.20	3.76

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 31 S=0.00561 Rock size 1 in.
Q=50 cfs Temp. 72 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=120'	0.90	1.13	5.99	6.00	5.93
D=1.250'	0.70	0.88	6.07	5.46	5.90
	0.50	0.63	5.59	5.11	5.46
	0.30	0.38	4.91	4.44	4.50
	0.10	0.13	3.72	3.11	3.35
X=130'	0.90	1.14	6.10	5.96	5.90
D=1.269'	0.70	0.89	5.93	5.49	5.96
	0.50	0.63	5.52	5.05	5.46
	0.30	0.38	4.64	4.37	4.88
	0.10	0.13	3.55	3.04	3.35
X=140'	0.90	1.14	6.00	6.00	6.07
D=1.268	0.70	0.89	6.03	5.66	6.10
	0.50	0.63	5.62	5.05	5.66
	0.30	0.38	5.02	4.52	5.08
	0.10	0.13	3.45	3.23	3.42

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 32 S=0.005575 Rock size 1 in.
Q=50 cfs Temp. 70 F Thickness 2 in.

	Fraction of Depth	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=2.67'	Velocity ft/sec Y=4.00'	Velocity ft/sec Y=5.32'	Velocity ft/sec Y=6.67'
X=120'	0.90	5.76	6.10	5.85	6.30	5.88
D=1.302'	0.70	5.92	5.96	5.68	5.95	5.83
	0.50	5.59	5.39	5.12	5.63	5.39
	0.30	4.84	4.88	4.17	4.83	4.70
	0.10	3.11	3.63	3.25	3.58	3.42
X=125'	0.90	6.07		5.73		5.62
D=1.300'	0.70	5.93		5.46		5.73
	0.50	5.49		5.08		5.18
	0.30	4.74		4.23		4.47
	0.10	3.38		3.28		3.15
X=130'	0.90	5.73	5.76	5.86	6.06	5.66
D=1.267'	0.70	5.70	5.52	5.35	5.86	5.66
	0.50	5.25	5.25	4.84	5.42	5.12
	0.30	4.27	4.54	4.20	4.54	4.47
	0.10	3.25	3.28	3.18	3.32	3.25
The Following Data Collected After Readjustment of The Depth.						
X=125'	0.90			5.87		
D=1.292'	0.70			5.52		
	0.50			5.22		
	0.30			4.33		
	0.10			2.96		
X=130'	0.90		6.07	5.90		
D=1.281'	0.70		5.86	5.60		
	0.50		5.46	5.01		
	0.30		4.78	4.40		
	0.10		3.25	3.21		

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 33	S=0.00998	Rock size 1 in.
Q=25 cfs	Temp. 70 F	Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	0.55	5.18	5.25	5.52
D=0.692'	0.20	0.14	3.42	3.42	3.83
X=130'	0.80	0.54	5.35	5.32	5.83
D=0.680'	0.20	0.14	3.38	3.52	3.62
X=140'	0.80	0.54	4.98	5.29	5.22
D=0.678'	0.20	0.14	3.25	3.59	3.25

Run # 34	S=0.01088	Rock size 1 in.
Q=25 cfs	Temp. 68 F	Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	0.56	5.25	5.25	5.64
D=0.703'	0.20	0.14	3.38	3.72	3.69
X=130'	0.80	0.56	5.49	5.49	5.93
D=0.699'	0.20	0.14	3.52	3.65	3.60
X=140'	0.80	0.57	5.29	5.45	5.22
D=0.707'	0.20	0.14	3.38	3.35	3.59

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 35 S=0.01186 Rock size 1 in.
Q=25 cfs Temp. 68 F Thickness 2 in.

	Fraction of depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	0.53	5.42	5.59	6.03
D=0.665'	0.20	0.13	3.18	3.38	3.96
X=130'	0.80	0.54	5.59	5.76	6.02
D=0.679'	0.20	0.14	3.79	3.69	4.06
X=140'	0.80	0.54	5.35	5.73	5.86
D=0.673'	0.20	0.13	3.11	4.03	4.33

Run # 36 S=0.01337 Rock size 1 in.
Q=25 cfs Temp. 68 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	0.50	5.56	5.62	6.03
D=0.630'	0.20	0.13	3.59	3.76	3.96
X=130'	0.80	0.49	6.13	6.13	6.44
D=0.610'	0.20	0.12	4.17	4.47	4.33
X=140'	0.80	0.49	5.59	6.10	5.59
D=0.614'	0.20	0.12	3.72	4.10	3.79

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 37 S=0.01204 Rock size 1 in.
Q=25 cfs Temp. 68 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=120'	0.90	0.59	5.52	5.76	6.03
D=0.657'	0.70	0.46	5.18	5.46	5.57
	0.50	0.33	4.61	4.84	4.98
	0.30	0.20	3.76	4.20	4.37
	0.15	0.10	3.11	3.35	3.83
X=130'	0.90	0.58	5.56	5.90	5.93
D=0.645'	0.70	0.45	5.15	5.51	5.52
	0.50	0.32	4.57	4.91	5.05
	0.30	0.19	3.89	4.20	4.27
	0.22	0.14	3.49	3.79	3.89
X=140'	0.90	0.59	5.86	5.96	5.82
D=0.650'	0.70	0.46	5.25	5.21	5.15
	0.50	0.33	4.91	5.22	4.88
	0.30	0.20	4.33	4.44	4.23
	0.20	0.13	3.76	3.79	3.66

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 38 S=0.00402 Rock size 1 in.
Q=75 cfs Temp 63 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	1.47	5.56	6.07	5.56
D=1.841'	0.20	0.37	4.30	4.27	4.27
X=130'	0.80	1.45	5.59	6.17	5.79
D=1.815'	0.20	0.36	4.10	4.30	4.23
X=140'	0.80	1.47	5.59	6.10	5.73
D=1.840'	0.20	0.37	4.10	4.27	4.30

Run # 39 S=0.00377 Rock size 1 in.
Q=75 cfs Temp. 69 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	1.46	5.50	6.24	5.66
D=1.819'	0.20	0.36	4.13	4.54	4.13
X=130'	0.80	1.45	5.59	5.97	5.63
D=1.815'	0.20	0.36	4.27	4.20	4.98
X=140'	0.80	1.48	5.59	6.07	5.63
D=1.856'	0.20	0.37	4.13	4.34	5.01

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 40		S=0.00330		Rock size 1 in.	
Q=75 cfs		Temp 72 F		Thickness 2 in.	
	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=120'	0.90	1.72	5.25	6.17	5.25
D=1.907'	0.70	1.33	5.42	5.76	5.46
	0.50	0.95	5.22	5.15	5.15
	0.30	0.57	4.57	4.50	4.47
	0.10	0.19	3.49	3.49	3.38
X=130'	0.90	1.72	5.35	6.10	5.29
D=1.906'	0.70	1.33	5.52	5.76	5.39
	0.50	0.95	5.22	5.25	5.01
	0.30	0.57	4.61	4.74	4.37
	0.10	0.19	3.59	3.66	3.15
X=140'	0.90	1.75	5.21	6.07	5.18
D=1.942'	0.70	1.36	5.52	5.62	5.32
	0.50	0.97	5.05	5.29	4.95
	0.30	0.58	4.61	4.78	4.54
	0.10	0.19	3.11	3.55	3.45

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 41 S=0.00475 Rock size 1 in.
Q=50 cfs Temp. 62 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=120'	0.90	1.23	5.62	5.49	5.49
D=1.364'	0.70	0.95	5.56	5.18	5.56
	0.50	0.68	5.15	4.67	5.19
	0.30	0.41	4.50	3.96	4.57
	0.10	0.14	3.38	2.87	3.35
X=130'	0.90	1.20	5.66	5.56	5.46
D=1.338'	0.70	0.94	5.66	5.25	5.56
	0.50	0.67	5.18	4.74	5.18
	0.30	0.40	4.74	3.93	4.50
	0.10	0.13	3.21	3.11	3.04
X=140'	0.90	1.22	5.62	5.29	5.49
D=1.356'	0.70	0.95	5.66	5.32	5.56
	0.50	0.68	5.18	4.84	5.35
	0.30	0.41	4.44	4.17	4.57
	0.10	0.14	3.11	2.67	3.28

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 42 S=0.00314 Rock size 1 in.
Q=100 cfs Temp 68 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	1.94	5.59	5.52	6.02
D=2.424'	0.20	0.48	4.30	3.76	4.57
X=130'	0.80	1.85	5.76	5.32	6.00
D=2.308'	0.20	0.46	4.61	3.96	4.84
X=140'	0.80	1.90	5.59	5.52	6.03
D=2.380'	0.20	0.48	4.17	3.96	4.71

Run # 43 S=0.00403 Rock size 1 in.
Q=100 cfs Temp. 66 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	1.96	5.18	5.62	5.66
D=2.448'	0.20	0.49	4.27	4.00	4.23
X=130'	0.80	1.88	5.52	5.90	5.97
D=2.355'	0.20	0.47	4.13	4.03	4.47
X=140'	0.80	1.95	5.29	5.79	5.59
D=2.441'	0.20	0.49	4.30	3.85	4.44

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 44 S=0.00436 Rock size 1 in.
Q=100 cfs Temp. 63 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.00'	Velocity ft/sec Y=6.67'
X=120'	0.80	1.76	5.86	6.30	6.27
D=2.194'	0.20	0.44	4.23	4.27	4.54
X=130'	0.80	1.78	5.76	6.10	6.13
D=2.223'	0.20	0.44	4.03	3.89	4.27
X=140'	0.80	1.77	5.90	6.37	6.07
D=2.213'	0.20	0.44	4.54	4.37	4.64

Run # 45 S=0.00354 Rock size 1 in.
Q=100 cfs Temp 72 F Thickness 2 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=120'	0.90	2.10	5.69	5.73	6.00
D=2.337'	0.70	1.64	5.62	5.33	6.07
	0.50	1.17	5.52	4.91	6.00
	0.30	0.70	4.88	4.52	5.12
	0.10	0.23	3.66	3.38	3.92
X=130'	0.90	2.04	5.52	6.24	6.37
D=2.272'	0.70	1.59	5.76	5.59	6.20
	0.50	1.14	5.52	5.05	6.00
	0.30	0.68	4.71	4.47	5.12
	0.10	0.23	3.66	3.52	4.00
X=140'	0.90	2.15	5.29	5.56	5.73
D=2.387'	0.70	1.67	5.52	5.35	5.96
	0.50	1.19	5.46	4.82	5.83
	0.30	0.72	4.78	4.40	5.22
	0.10	0.24	3.52	3.66	3.76

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 46 S=0.00888 Rock size 1 in.
Q=25 cfs Temp. 66 F Thickness 3 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	0.57	5.46	5.25	5.46
D=0.712'	0.20	0.14	3.32	3.42	3.52
X=130'	0.80	0.56	5.35	5.29	5.35
D=0.702'	0.20	0.14	3.62	3.52	3.89
X=140'	0.80	0.60	5.35	5.22	5.29
D=0.746'	0.20	0.15	3.55	3.55	3.52

Run # 47 S=0.01011 Rock size 1 in.
Q=25 cfs Temp 69 F Thickness 3 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	0.55	5.69	5.49	5.83
D=0.682'	0.20	0.14	3.35	3.49	3.45
X=130'	0.80	0.53	5.46	5.59	5.42
D=0.664'	0.20	0.13	3.79	3.76	3.72
X=140'	0.80	0.58	5.56	5.56	5.39
D=0.719'	0.20	0.14	3.59	3.45	3.72

Run # 48 S=0.01313 Rock size 1 in.
Q=25 cfs Temp 68 F Thickness 3 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	0.50	6.27	6.04	6.14
D=0.622'	0.20	0.12	3.80	4.20	4.20
X=130'	0.80	0.49	5.87	6.13	5.70
D=0.618'	0.20	0.12	3.72	2.98	3.69
X=140'	0.80	0.54	5.97	6.14	5.77
D=0.679'	0.20	0.14	4.10	4.27	3.76

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 49		S=0.00526		Rock size 1 in.	
Q=50 cfs		Temp 70 F		Thickness 3 in.	
	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y=6.67'
X=120'	0.80	1.02	6.11	5.59	6.00
D=1.281'	0.20	0.26	4.49	3.76	4.27
X=130'	0.80	1.00	6.00	5.63	6.04
D=1.253'	0.20	0.25	4.58	4.03	4.20
X=140'	0.80	1.02	5.90	5.56	6.00
D=1.270	0.20	0.25	4.24	3.86	4.14

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 50 S=0.00636 Rock size 1 in.
Q=50 cfs Temp 68 F Thickness 3 in.

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.90	1.06		6.30	
D=1.178'	0.80	0.94	6.24		6.20
	0.70	0.82		5.93	
	0.50	0.59		5.39	
	0.40	0.47		4.98	
	0.30	0.35		4.47	
	0.20	0.24	4.03		4.00
	0.11	0.13		3.38	
X=130'	0.80	0.92	6.37	6.07	6.27
D=1.146'	0.20	0.23	4.37	4.00	4.23
X=140'	0.80	0.95	6.17	5.90	6.30
D=1.184'	0.20	0.24	4.44	4.13	4.10

The Folowing Velocity Data Collected Using a Pitot Tube

	Fraction of Depth	Velocity ft/sec X=120' D=1.178'	Velocity ft/sec X=130' D=1.146'	Velocity ft/sec X=140' D=1.184'
Y=4.0'	0.90	6.47	6.71	6.42
	0.70	6.34	6.30	6.04
	0.50	5.67	5.90	5.57
	0.40	5.38	5.53	5.43
	0.30	5.02	5.33	4.80
	0.20	4.69	4.51	4.45
	0.15	4.33	4.27	4.33
	0.10	3.95	4.01	3.66
	0.05	3.66	3.51	3.02

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 51 S=0.00726 Rock size 1 in.
Q=50 cfs Temp 68 F Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.637	0.90	0.93		6.80	
D=1.113'	71.458	0.70	0.75		6.30	
	71.244	0.50	0.54		5.90	
	71.137	0.40	0.43		5.60	
	71.030	0.30	0.32		5.20	
	70.922	0.20	0.21		4.90	
	70.869	0.15	0.16		4.60	
	70.815	0.10	0.11		4.10	
	70.762	0.05	0.05		3.10	
*		0.80	0.89	6.58	6.23	6.34
*		0.20	0.22	4.21	3.88	4.33
X=130'	71.67	0.90	0.97		6.50	
D=1.083'	71.46	0.70	0.76		6.00	
	71.24	0.50	0.54		5.60	
	71.13	0.40	0.43		5.10	
	71.02	0.30	0.33		4.80	
	70.91	0.20	0.22		4.10	
	70.86	0.15	0.16		3.60	
	70.81	0.10	0.11		2.80	
	70.75	0.05	0.05		2.50	
*		0.80	0.87	6.55	6.71	6.98
*		0.20	0.22	4.60	4.51	4.71
X=140'	71.70	0.90	1.00		6.50	
D=1.109'	71.48	0.70	0.78		6.10	
	71.26	0.50	0.56		5.50	
	71.15	0.40	0.44		5.10	
	71.03	0.30	0.33		4.90	
	70.92	0.20	0.22		4.50	
	70.87	0.15	0.17		4.10	
	70.81	0.10	0.11		3.70	
	70.76	0.05	0.06		3.30	
*		0.80	0.89	6.90	6.59	6.99
*		0.20	0.22	4.58	4.73	4.48

* Velocity Data Collected Using an Ott Meter

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 52	S=0.00726	Rock size 1 in.
Q=50 cfs	Temp 63 F	Thickness 3 in

	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	0.80	0.89	6.51	6.25	6.77
D=1.118'	0.20	0.22	4.36	5.36	4.47
X=130'	0.80	0.87	6.56	6.40	6.75
D=1.085'	0.20	0.22	4.29	4.33	4.89
X=140'	0.80	0.87	6.73	6.50	6.73
D=1.084'	0.20	0.22	4.81	4.01	4.65

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 54	S=0.00732	Rock size 1 in.
Q=50 cfs	Temp 63 F	Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.71	0.90	1.00	6.75	6.63	6.83
D=1.111'	71.49	0.70	0.78	6.34	6.22	6.55
	71.27	0.50	0.56	5.63	5.48	6.13
	71.16	0.40	0.44	5.28	4.97	5.67
	71.05	0.30	0.33	4.63	4.63	5.13
	70.93	0.20	0.22	4.21	4.33	4.80
	70.88	0.15	0.17	3.88	4.08	4.63
	70.82	0.10	0.11	3.51	3.74	4.33
	70.77	0.05	0.05	3.19	2.54	3.59

Test stop d due to power failure

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 55 S=0.00732 Rock size 1 in.
Q=50 cfs Temp 65 F Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.75	0.90	1.04	6.39	6.47	6.67
D=1.151'	71.52	0.70	0.81	6.04	5.95	6.39
	71.29	0.50	0.58	5.48	5.38	5.58
	71.17	0.40	0.46	5.18	5.02	5.33
	71.06	0.30	0.34	4.86	4.46	4.91
	70.94	0.20	0.23	4.01	4.01	4.14
	70.89	0.15	0.17	3.74	3.51	3.74
	70.83	0.10	0.11	3.28	2.93	3.28
	70.77	0.05	0.06	2.54	1.94	2.07
	70.66			1.27		
	70.69				1.79	
	70.67					1.27
X=130'	71.67	0.90	0.97	6.55	6.75	6.59
D=1.078'	71.46	0.70	0.75	6.30	6.22	6.43
	71.24	0.50	0.54	5.77	5.67	5.72
	71.13	0.40	0.43	5.43	5.18	5.38
	71.03	0.30	0.32	5.08	4.63	5.13
	70.92	0.20	0.22	4.52	4.01	4.52
	70.86	0.15	0.16	4.08	3.66	4.21
	70.81	0.10	0.11	3.81	2.93	3.95
	70.76	0.05	0.05	2.64	2.74	3.44
	70.66			1.26		
	70.74				2.54	
	70.62					1.79
X=140'	71.73	0.90	1.03	6.39	6.55	6.51
D=1.147'	71.50	0.70	0.80	6.13	6.00	6.39
	71.27	0.50	0.57	5.67	5.38	5.91
	71.16	0.40	0.46	5.18	5.26	5.43
	71.04	0.30	0.34	4.52	5.72	4.91
	70.93	0.20	0.23	4.21	4.08	4.27
	70.87	0.15	0.17	3.81	3.88	3.81
	70.81	0.10	0.11	3.28	3.59	3.19
	70.76	0.05	0.06	2.84	2.84	2.07
	70.70			2.32		
	70.68				2.64	
						2.07

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 56 S=0.00647 Rock size 1 in.
Q=50 cfs Temp 67 F Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y =1.33'	Velocity ft/sec @Y =4.00'	Velocity ft/sec @Y =6.67'
X=120'	71.86	0.90	1.11	6.47	6.04	6.28
D=1.236'	71.61	0.70	0.87	6.28	5.51	6.24
	71.36	0.50	0.62	5.74	5.21	5.60
	71.24	0.40	0.49	5.43	4.72	5.42
	71.12	0.30	0.37	4.97	4.36	5.05
	70.99	0.20	0.25	4.40	3.98	4.40
	70.93	0.15	0.19	4.08	3.23	4.11
	70.87	0.10	0.12	3.40	3.02	3.36
	70.81	0.05	0.06	2.26	2.79	1.79
	70.72			1.04		
	70.72				0.90	
	70.73					0.10
X=130'	71.82	0.90	1.08	5.97	6.39	6.17
D=1.206'	71.58	0.70	0.84	5.86	5.91	6.09
	71.34	0.50	0.60	5.58	5.15	5.77
	71.22	0.40	0.48	5.26	4.86	5.53
	71.10	0.30	0.36	5.10	4.60	5.20
	70.98	0.20	0.24	4.72	4.36	4.78
	70.92	0.15	0.18	4.40	3.67	4.36
	70.86	0.10	0.12	4.08	3.36	4.11
	70.80	0.05	0.06	3.51	2.98	3.32
	70.73			2.32		
	70.67				2.00	
	70.66					0.00
X=140'	71.86	0.90	1.12	6.00	5.91	5.86
D=1.247'	71.61	0.70	0.87	5.84	5.65	5.86
	71.36	0.50	0.62	5.53	5.23	5.60
	71.23	0.40	0.50	5.08	4.78	5.28
	71.11	0.30	0.37	4.80	4.52	4.75
	70.98	0.20	0.25	4.27	3.98	4.43
	70.92	0.15	0.19	4.01	3.40	
	70.86	0.10	0.12	3.59	3.15	
	70.80	0.05	0.06	3.11	2.93	
	70.73			2.64		
	70.75				2.48	

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 57 S=0.01475 Rock size 1 in.
Q=25 cfs Temp 64 F Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y =1.33'	Velocity ft/sec @Y =4.00'	Velocity ft/sec @Y =6.67'
X=120'	71.29	0.90	0.56	6.20	6.00	6.00
D=0.618'	71.17	0.70	0.43	5.80	5.20	5.30
	71.04	0.50	0.31	5.10	4.80	4.60
	70.98	0.40	0.25	4.50	4.30	4.10
	70.92	0.30	0.19	4.10	4.10	3.60
	70.86	0.20	0.12	3.90	3.30	3.40
	70.83	0.15	0.09	3.50	2.80	2.90
	70.80	0.10	0.06	3.30	2.40	2.70
	70.77	0.05	0.03	3.00	2.20	
	70.65			1.60		
	70.74				1.60	
	70.75					1.90
X=130'	71.28	0.90	0.56	6.10	6.20	6.30
D=0.625'	71.16	0.70	0.44	5.80	5.90	6.00
	71.03	0.50	0.31	5.40	5.50	5.30
	70.97	0.40	0.25	5.00	5.20	4.90
	70.91	0.30	0.19	4.80	4.70	4.50
	70.84	0.20	0.13	4.40	4.20	3.80
	70.81	0.15	0.09	3.80	3.80	3.10
	70.78	0.10	0.06	3.60	3.50	2.60
	70.75	0.05	0.03	3.40	3.10	2.20
	70.67			2.60		
	70.66				2.90	
	70.72					2.00
X=140'	71.28	0.90	0.57	6.08	6.26	6.13
D=0.632'	71.16	0.70	0.44	6.11	5.90	5.65
	71.03	0.50	0.32	5.70	5.40	5.12
	70.97	0.40	0.25	5.53	4.70	4.60
	70.91	0.30	0.19	5.02	4.30	4.30
	70.84	0.20	0.13	4.27	3.60	3.77
	70.81	0.15	0.09	3.88	3.10	3.36
	70.78	0.10	0.06	3.15	2.70	2.88
	70.75	0.05	0.03	3.11	2.30	
	70.69			2.43		
	70.74				2.43	
	70.69					0.89

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 58 S=0.01626 Rock size 1 in.
Q=25 cfs Temp 67 F Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.26	0.90	0.52	6.30	6.63	7.10
D=0.581'	71.14	0.70	0.41	6.04	6.17	6.41
	71.03	0.50	0.29	5.48	5.63	5.95
	70.97	0.40	0.23	5.28	5.28	5.28
	70.91	0.30	0.17	4.80	5.02	4.80
	70.85	0.20	0.12	4.33	4.57	4.21
	70.82	0.15	0.09	4.21	4.30	3.88
	70.79	0.10	0.06	3.88	3.95	3.59
	70.76	0.05	0.03	3.66	3.19	2.74
	70.74			3.11		
	70.68				0.00	
						1.55
X=130'	71.16	0.90	0.50	6.85	7.00	7.00
D=0.554'	71.05	0.70	0.39	6.50	6.80	6.60
	70.94	0.50	0.28	5.90	6.00	6.20
	70.89	0.40	0.22	5.70	5.70	6.00
	70.83	0.30	0.17	5.00	5.30	5.50
	70.78	0.20	0.11	4.10	4.70	5.30
	70.75	0.15	0.08	3.50	4.40	5.00
	70.72	0.10	0.06	3.20	3.90	4.90
	70.69	0.05	0.03	2.50	3.55	4.50
	70.66			2.60		
	70.66				2.88	
	70.58					2.80

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 59 S=0.00423 Rock size 1 in.
Q=75 cfs Temp 68 F Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	72.45	0.90	1.73		6.51	
D=1.919'	72.26	0.80	1.54	6.04		6.05
	72.07	0.70	1.34		6.19	
	71.68	0.50	0.96		5.53	
	71.49	0.40	0.77		5.33	
	71.30	0.30	0.58		4.94	
	71.11	0.20	0.38	4.46	4.52	4.97
	71.01	0.15	0.29		4.14	
	70.91	0.10	0.19		3.44	
	70.82	0.05	0.10		2.93	
	70.65				1.64	
X=130'	72.42	0.90	1.71		6.30	
D=1.900'	72.23	0.80	1.52	6.26		6.22
	72.04	0.70	1.33		6.22	
	71.66	0.50	0.95		5.48	
	71.47	0.40	0.76		5.33	
	71.28	0.30	0.57		4.97	
	71.09	0.20	0.38	4.40	4.52	4.91
	71.00	0.15	0.29		4.40	
	70.90	0.10	0.19		4.21	
	70.81	0.05	0.10		3.44	
	70.63				2.07	
X=140'	72.42	0.90	1.71		6.26	
D=1.902'	72.23	0.80	1.52	6.04		6.00
	72.04	0.70	1.33		6.22	
	71.66	0.50	0.95		6.00	
	71.47	0.40	0.76		5.43	
	71.28	0.30	0.57		5.02	
	71.09	0.20	0.38	4.57	4.57	4.63
	70.99	0.15	0.28		4.21	
	70.90	0.10	0.19		3.81	
	70.80	0.05	0.09		2.93	
	70.76				2.74	

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 60 S=0.00517 Rock size 1 in.
Q=75 cfs Temp 72 F Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y =1.33'	Velocity ft/sec @Y =4.00'	Velocity ft/sec @Y =6.67'
X=120'	72.38	0.90	1.66		6.44	
D=1.847'	72.20	0.80	1.48	6.59		6.63
	72.02	0.70	1.29		6.08	
	71.65	0.50	0.92		5.53	
	71.46	0.40	0.74		4.85	
	71.28	0.30	0.55		4.74	
	71.09	0.20	0.37	4.91	4.07	5.02
	71.00	0.15	0.28		3.84	
	70.91	0.10	0.19		3.66	
	70.81	0.05	0.09		3.02	
	70.78				2.42	
X=130'	72.34	0.90	1.63	6.59	6.34	6.59
D=1.812'	71.98	0.70	1.27	6.34	6.04	6.44
	71.62	0.50	0.91	5.99	5.57	6.04
	71.44	0.40	0.72	5.76	5.12	5.76
	71.26	0.30	0.54	5.43	4.74	5.53
	71.07	0.20	0.36	4.96	4.33	4.91
	70.98	0.15	0.27	4.63	4.01	4.80
	70.89	0.10	0.18	4.20	3.80	4.27
	70.80	0.05	0.09	3.43	3.19	3.51
	70.71			1.15		
	70.73				2.31	
	70.73					2.31
X=140'	72.31	0.90	1.60		6.59	
D=1.782'	72.14	0.80	1.43	6.51		6.55
	71.96	0.70	1.25		6.21	
	71.60	0.50	0.89		5.72	
	71.42	0.40	0.71		5.33	
	71.24	0.30	0.53		4.91	
	71.07	0.20	0.36	5.07	4.39	5.12
	70.98	0.15	0.27		3.84	
	70.89	0.10	0.18		3.51	
	70.80	0.05	0.09		2.53	

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 61 S=0.00621 Rock size 1 in.
Q=75 cfs Temp 73 F Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	72.25	0.90	1.51		7.84	
D=1.676'	72.08	0.80	1.34	7.05		7.25
	71.91	0.70	1.17		7.34	
	71.58	0.50	0.84		6.55	
	71.41	0.40	0.67		6.26	
	71.24	0.30	0.50		5.74	
	71.07	0.20	0.34	4.72	5.02	5.26
	70.99	0.15	0.25		4.80	
	70.91	0.10	0.17		4.63	
	70.82	0.05	0.08		3.84	
	70.75			2.01		
	70.75				3.06	
	70.76					3.44
X=130'	72.41	0.90	1.68		6.67	
D=1.870'	72.22	0.80	1.50	5.95		6.09
	72.04	0.70	1.31		6.39	
	71.66	0.50	0.94		6.13	
	71.48	0.40	0.75		5.63	
	71.29	0.30	0.56		5.23	
	71.10	0.20	0.37	4.75	4.75	4.69
	71.01	0.15	0.28		3.95	
	70.91	0.10	0.19		3.88	
	70.82	0.05	0.09		3.51	
	70.74			1.27		
	70.77				1.79	
	70.75					1.27
X=140'	72.16	0.90	1.44		7.47	
D=1.597'	72.00	0.80	1.28	6.87		7.72
	71.84	0.70	1.12		7.14	
	71.52	0.50	0.80		6.59	
	71.36	0.40	0.64		6.17	
	71.20	0.30	0.48		6.00	
	71.04	0.20	0.32	5.13	5.33	5.58
	70.96	0.15	0.24		4.69	
	70.88	0.10	0.16		4.40	
	70.80	0.05	0.08		3.51	
	70.74			3.19		
	70.74				2.07	
	70.68					1.64

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 62 S=0.00406 Rock size 1 in.
Q=100 cfs Temp 75 F Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	72.95	0.90	2.21		5.81	
D=2.457'	72.70	0.80	1.97	5.81		6.22
	72.46	0.70	1.72		5.33	
	71.47	0.50	0.73		4.86	
	71.72	0.40	0.98		4.40	
	71.47	0.30	0.74		3.95	
	71.23	0.20	0.49		3.74	
	71.11	0.15	0.37	4.57	3.66	4.80
	70.98	0.10	0.25		3.19	
	70.86	0.05	0.12		2.84	
	70.68				1.27	
X=130'	72.99	0.90	2.27	5.43	5.91	5.91
D=2.519'	72.49	0.70	1.76	5.23	5.13	5.91
	71.99	0.50	1.26	5.48	4.86	5.77
	71.74	0.40	1.01	5.33	4.27	5.53
	71.48	0.30	0.76	5.02	4.14	5.28
	71.23	0.20	0.50	4.52	3.95	4.52
	71.11	0.15	0.38	4.08	3.51	4.14
	70.98	0.10	0.25	3.88	3.28	4.01
	70.85	0.05	0.13	3.19	2.64	3.11
	70.69			1.27		
	70.71				1.27	
	70.67					1.64
X=140'	73.03	0.90	2.31		5.48	
D=2.562'	72.77	0.80	2.05	5.48		5.72
	72.52	0.70	1.79		5.02	
	72.01	0.50	1.28		5.02	
	71.75	0.40	1.02		4.46	
	71.49	0.30	0.77		4.01	
	71.24	0.20	0.51	4.52	3.74	4.80
	71.11	0.15	0.38		3.59	
	70.98	0.10	0.26		3.28	
	70.85	0.05	0.13		2.64	
	70.73				1.47	

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 63 S=0.00457 Rock size 1 in.
Q=100 cfs Temp 67 F Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	72.70	0.90	1.98		6.75	
D=2.201'	72.48	0.80	1.76	5.95		6.55
	72.26	0.70	1.54		6.13	
	71.82	0.50	1.10		5.53	
	71.60	0.40	0.88		5.18	
	71.38	0.30	0.66		4.69	
	71.16	0.20	0.44	4.40	4.33	4.91
	71.05	0.15	0.33		4.14	
	70.94	0.10	0.22		3.74	
	70.83	0.05	0.11		3.11	
	70.68			1.04		
	70.65				1.16	
	70.67					2.64
X=130'	72.67	0.90	1.97	6.08	7.05	6.53
D=2.184'	72.24	0.70	1.53	6.37	6.59	6.57
	71.80	0.50	1.09	6.16	5.77	6.19
	71.58	0.40	0.87	5.60	5.33	5.77
	71.36	0.30	0.66	5.31	4.94	5.48
	71.14	0.20	0.44	4.72	4.72	5.13
	71.04	0.15	0.33	4.49	4.57	4.52
	70.93	0.10	0.22	3.95	4.11	4.14
	70.82	0.05	0.11	3.51	3.47	3.55
	70.70			2.20		
	70.73				1.79	
	70.68					2.48
X=140'	72.72	0.90	2.02		6.47	
D=2.244'	72.50	0.80	1.80	5.95		6.22
	72.28	0.70	1.57		6.17	
	71.83	0.50	1.12		5.63	
	71.60	0.40	0.90		5.28	
	71.38	0.30	0.67		4.86	
	71.15	0.20	0.45	4.57	4.40	4.80
	71.04	0.15	0.34		4.08	
	70.93	0.10	0.22		3.74	
	70.82	0.05	0.11		3.20	
	70.69			2.43		
	70.70				1.04	
	70.70					0.73

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 64 S=0.00409 Rock size 1 in.
Q=100 cfs Temp 65 F Thickness 3 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.00'	Velocity ft/sec @Y=6.67'
X=120'	72.794	0.90	2.08	5.91	6.71	6.79
D=2.306'	72.333	0.70	1.61	6.17	6.04	6.75
	71.872	0.50	1.15	6.04	5.67	6.43
	71.641	0.40	0.92	5.63	5.18	5.95
	71.411	0.30	0.69	5.13	4.80	5.43
	71.180	0.20	0.46	4.52	4.46	4.91
	71.065	0.15	0.35	4.27	4.08	4.52
	70.950	0.10	0.23	3.81	3.66	4.14
	70.834	0.05	0.12	3.11	2.93	3.51
	70.632			1.04		
	70.648				1.04	
	70.695					2.20
X=130'	72.77	0.90	2.06	5.67	6.22	6.34
D=2.292'	72.31	0.70	1.60	5.95	6.04	6.61
	71.86	0.50	1.15	5.91	5.33	6.26
	71.63	0.40	0.92	5.63	5.02	5.99
	71.34	0.30	0.63	5.02	4.80	5.26
	71.17	0.20	0.46	4.63	4.33	4.86
	71.05	0.15	0.34	4.40	3.88	4.33
	70.94	0.10	0.23	4.14	3.66	3.98
	70.82	0.05	0.11	3.36	3.02	3.28
	70.72			2.20		
	70.72				2.20	
	70.71					0.00
X=140'	72.77	6.00	2.07	5.67	6.55	6.47
D=2.297'	72.31	0.70	1.61	5.95	5.97	6.24
	71.86	0.50	1.15	5.60	5.60	6.04
	71.63	0.40	0.92	5.51	5.15	5.72
	71.40	0.30	0.69	5.15	4.57	5.46
	71.17	0.20	0.46	4.75	4.39	4.80
	71.05	0.15	0.34	4.46	3.81	4.60
	70.94	0.10	0.23	4.05	3.55	3.98
	70.82	0.05	0.11	3.51	3.02	3.39
	70.74			2.07		
	70.74				2.14	
	70.64					2.07

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 65 S=0.00998 Rock size 2 in.
Q=50 cfs Temp 68 F Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.910	0.90	1.16		6.13	
D=1.292'	71.782	0.80	1.03	5.95		6.47
	71.652	0.70	0.91		5.43	
	71.394	0.50	0.65		4.80	
	71.265	0.40	0.52		4.63	
	71.136	0.30	0.39		4.33	
	71.006	0.20	0.26	3.88	4.01	4.14
	70.942	0.15	0.19		3.36	
	70.877	0.10	0.13		3.11	
	70.812	0.05			2.93	
				1.94	2.32	
	70.747				2.93	
X=130'	71.81	0.90	1.05		6.65	
D=1.170'	71.70	0.80	0.94	6.91		6.91
	71.58	0.70	0.82		6.26	
	71.35	0.50	0.58		5.67	
	71.23	0.40	0.47		5.53	
	71.11	0.30	0.35		5.13	
	70.99	0.20	0.23	4.80	4.46	4.33
	70.94	0.15	0.18		4.14	
	70.88	0.10	0.12		3.66	
	70.82	0.05	0.06		3.44	
	70.80			3.02		
	70.76				2.20	
	70.81					2.32
X=140'	71.91	0.90	1.15		6.43	
D=1.275'	71.78	0.80	1.03	6.43		6.34
	71.66	0.70	0.90		5.81	
	71.40	0.50	0.64		5.08	
	71.27	0.40	0.52		4.63	
	71.15	0.30	0.39		4.33	
	71.02	0.20	0.26	4.01	4.08	3.95
	70.95	0.15	0.20		3.28	
	70.89	0.10	0.13		2.93	
	70.83	0.05	0.07		2.54	
	70.77			1.64		
	70.76				2.07	
	70.77					1.47

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 66 S=0.01378 Rock size 2 in.
Q=50 cfs Temp 75 F Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.56	0.90	0.91		7.43	
D=1.012'	71.46	0.80	0.81	7.18		7.10
	71.36	0.70	0.71		6.95	
	71.15	0.50	0.51		6.17	
	71.05	0.40	0.41		5.67	
	70.95	0.30	0.30		5.28	
	70.85	0.20	0.20	4.08	4.86	4.63
	70.80	0.15	0.15		4.46	
	70.75	0.10	0.10		4.01	
	70.70	0.05	0.05		3.66	
	70.63			2.20		
	70.55				2.07	
	70.59					2.74
X=130'	71.56	0.90	0.90		7.49	
D=1.00'	71.46	0.80	0.80	7.42		7.49
	71.36	0.70	0.70		6.95	
	71.16	0.50	0.50		6.34	
	71.06	0.40	0.40		6.00	
	70.96	0.30	0.30		5.79	
	70.86	0.20	0.20	5.05	5.23	5.36
	70.81	0.15	0.15		5.00	
	70.76	0.10	0.10		4.63	
	70.71	0.05	0.05		4.08	
	70.65			2.59		
	70.61				2.93	
	70.66					2.48
X=140'	71.59	0.90	0.94		7.22	
D=1.046'	71.49	0.80	0.84	6.80		7.29
	71.38	0.70	0.73		6.51	
	71.17	0.50	0.52		6.09	
	71.07	0.40	0.42		5.48	
	70.96	0.30	0.31		5.18	
	70.86	0.20	0.21	4.57	4.21	4.14
	70.81	0.15	0.16		3.59	
	70.76	0.10	0.10		3.02	
	70.70	0.05	0.05		2.64	
	70.58			1.94		
	70.56				1.47	
	70.58					2.07

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 67 S=0.01519 Rock size 2 in.
Q=50 cfs Temp 72 F Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y =1.33'	Velocity ft/sec @Y =4.00'	Velocity ft/sec @Y =6.67'
X=120'	71.53	0.90	0.88		7.82	
D=0.980'	71.43	0.80	0.78	8.22		7.68
	71.33	0.70	0.69		7.36	
	71.14	0.50	0.49		6.67	
	71.04	0.40	0.39		6.34	
	70.94	0.30	0.29		5.86	
	70.84	0.20	0.20	4.57	5.38	5.58
	70.80	0.15	0.15		4.63	
	70.75	0.10	0.10		3.74	
	70.70	0.05	0.05		2.20	
	70.60			2.07		
	70.60				1.04	
	70.50					0.73
X=130'	71.56	0.90	0.90		7.40	
D=1.00'	71.46	0.80	0.80	7.96		7.96
	71.36	0.70	0.70		7.40	
	71.16	0.50	0.50		6.63	
	71.06	0.40	0.40		6.43	
	70.96	0.30	0.30		5.86	
	70.86	0.20	0.20	5.67	5.13	5.13
	70.81	0.15	0.15		4.80	
	70.76	0.10	0.10		4.33	
	70.71	0.05	0.05		3.51	
	70.64			2.20		
	70.62				2.20	
	70.60					1.27
X=140'	71.54	0.90	0.89		7.86	
D=0.982'	71.44	0.80	0.79	7.61		7.75
	71.34	0.70	0.69		7.10	
	71.14	0.50	0.49		6.55	
	71.04	0.40	0.39		6.13	
	70.95	0.30	0.29		5.58	
	70.85	0.20	0.20	5.08	5.18	4.91
	70.80	0.15	0.15		4.69	
	70.75	0.10	0.10		4.21	
	70.70	0.05	0.05		3.36	
	70.61			2.54		
	70.60				1.79	
	70.61					2.20

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 68 S=0.01796 Rock size 2 in.
Q=50 cfs Temp 72 F Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.52	0.90	0.87		8.57	
D=0.963'	71.42	0.80	0.77	8.04		8.90
	71.32	0.70	0.67		7.96	
	71.13	0.50	0.48		7.40	
	71.00	0.40	0.36		7.14	
	70.94	0.30	0.29		6.22	
	70.84	0.20	0.19	5.77	6.02	5.28
	70.79	0.15	0.14		5.88	
	70.74	0.10	0.10		5.18	
	70.70	0.05	0.05		4.80	
	70.59			2.07		
	70.67				4.63	
	70.51					0.00
X=130'	71.50	0.90	0.84		8.07	
D=0.930'	71.40	0.80	0.74	8.13		8.20
	71.31	0.70	0.65		7.70	
	71.12	0.50	0.47		7.16	
	71.03	0.40	0.37		6.87	
	70.94	0.30	0.28		6.45	
	70.84	0.20	0.19	5.63	5.84	5.91
	70.80	0.15	0.14		5.38	
	70.75	0.10	0.09		5.02	
	70.71	0.05	0.05		4.24	
	70.54			2.54		
	70.64				2.88	
	70.58					3.02
X=140'	71.47	0.90	0.82		8.19	
D=0.914'	71.38	0.80	0.73	7.92		8.02
	71.29	0.70	0.64		7.94	
	71.11	0.50	0.46		7.22	
	71.01	0.40	0.37		7.03	
	70.92	0.30	0.28		6.59	
	70.83	0.20	0.18	5.28	6.24	5.31
	70.76	0.15	0.11		5.86	
	70.74	0.10	0.09		5.79	
	70.69	0.05	0.05		4.57	
	70.71			2.84		
	70.62				0.73	
	70.64					1.27

CORPS OF ENGINEERS RIPRAP PROJECT

	Run # 69 Q=50 cfs		S=0.01888 Tepm 68 F		Rock size 2 in. Thickness 4 in.	
	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
=120'	71.50	0.90	0.85		8.50	
=0.948'	71.40	0.80	0.76	8.40		8.76
	71.31	0.70	0.66		8.00	
	71.12	0.50	0.47		7.22	
	71.03	0.40	0.38		6.70	
	70.93	0.30	0.28		6.77	
	70.84	0.20	0.19	5.31	6.26	5.79
	70.79	0.15	0.14		5.93	
	70.74	0.10	0.09		5.74	
	70.69	0.05	0.05		4.75	
	70.27			1.04		
	70.52				3.00	
	70.57					2.07

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 70 S=0.01110 Rock size 2 in.
Q=75 cfs Temp 69 F Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.92	0.90	1.27		8.54	
D=1.410'	71.78	0.80	1.13	8.35		8.26
	71.64	0.70	0.99		8.12	
	71.35	0.50	0.70		7.23	
	71.21	0.40	0.56		6.83	
	71.07	0.30	0.42		6.45	
	70.93	0.20	0.28	6.47	5.84	6.26
	70.85	0.15	0.20		5.31	
	70.79	0.10	0.14		5.08	
	70.72	0.05	0.07		4.57	
	70.72			4.30		
	70.57				3.36	
	70.57					2.20

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 71 S=0.00781 Rock size 2 in.
Q=75 cfs Temp 70 F Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	72.00	0.90	1.35	7.00	7.60	7.06
D=1.498'	71.70	0.70	1.05	7.08	6.95	7.27
	71.40	0.50	0.75	6.85	6.53	6.75
	71.25	0.40	0.60	6.34	6.13	6.70
	71.10	0.30	0.45	5.84	5.53	5.93
	70.95	0.20	0.30	5.36	5.05	5.10
	70.87	0.15	0.23	5.05	4.43	4.52
	70.80	0.10	0.15	4.46	3.66	3.59
	70.72	0.05	0.08	4.91	3.06	2.84
	70.63			2.84		
	70.65				2.69	
	70.58					1.87
X=130'	71.99	0.90	1.33	7.18	7.75	7.25
D=1.474'	71.69	0.70	1.03	7.29	7.47	7.22
	71.40	0.50	0.74	6.79	6.75	6.91
	71.25	0.40	0.59	6.51	6.17	6.63
	71.10	0.30	0.44	5.95	5.81	6.26
	70.95	0.20	0.30	5.43	5.33	5.67
	70.88	0.15	0.22	4.69	5.08	5.08
	70.81	0.10	0.15	4.14	7.75	4.63
	70.73	0.05	0.07	3.74	4.14	3.95
	70.58			3.11		
	70.60				4.52	
	70.51					3.19
X=140'	71.98	0.90		7.27	7.66	7.00
D=1.476'	71.68	0.70		7.03	7.05	7.23
	71.39	0.50		6.85	6.70	6.89
	71.24	0.40		6.63	6.09	6.55
	71.09	0.30		6.13	5.60	6.02
	70.95	0.20		5.58	5.38	5.60
	70.87	0.15		5.33	5.18	5.10
	70.80	0.10		4.55	4.49	4.49
	70.72	0.05		4.08	4.21	4.05
	70.65			4.05		
	70.60				4.18	
	70.61					2.00

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 72 S=0.00937 Rock size 2 in.
Q=75 cfs Temp 70 F Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.94	0.90	1.29		8.14	
D=1.432'	71.79	0.80	1.15	7.65		7.63
	71.65	0.70	1.00		7.49	
	71.36	0.50	0.72		6.93	
	71.22	0.40	0.57		6.43	
	71.08	0.30	0.43		5.97	
	70.93	0.20	0.29	5.72	5.65	5.41
	70.86	0.15	0.22		5.05	
	70.79	0.10	0.14		4.57	
	70.72	0.05	0.07		3.36	
	70.65			2.74		
	70.65				2.84	
	70.66					0.90
X=130'	71.95	0.90	1.29	7.68	8.19	7.54
D=1.431'	71.66	0.70	1.00	7.86	7.86	7.79
	71.37	0.50	0.71	7.47	7.25	7.44
	71.23	0.40	0.57	7.22	6.87	7.06
	71.08	0.30	0.42	6.75	6.34	6.67
	70.94	0.20	0.28	6.26	5.67	6.04
	70.87	0.15	0.21	5.77	5.28	5.53
	70.80	0.10	0.14	5.29	4.63	4.91
	70.73	0.05	0.07	4.40	2.84	2.54
	70.56			1.47		
	70.61				0.73	
	70.63					0.00
X=140'	71.92	0.90	1.27		7.92	
D=1.405'	71.78	0.80	1.13	7.66		7.58
	71.63	0.70	0.98		7.36	
	71.35	0.50	0.70		6.73	
	71.21	0.40	0.56		6.22	
	71.07	0.30	0.42		5.95	
	70.93	0.20	0.28	4.46	4.83	5.63
	70.86	0.15	0.21		4.66	
	70.79	0.10	0.14		4.05	
	70.72	0.05	0.07		3.02	
	70.56			1.55		
	70.63				1.27	
	70.56					2.14

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 73 S=0.00731 Rock size 2 in.
Q=100 cfs Temp 72 F Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	72.41	0.90	1.76		8.26	
D=1.960'	72.22	0.80	1.57	7.22		7.00
	72.02	0.70	1.37		7.61	
	71.63	0.50	0.98		7.14	
	71.43	0.40	0.78		6.51	
	71.24	0.30	0.59		6.00	
	71.04	0.20	0.39	5.67	5.72	5.81
	70.94	0.15	0.29		5.28	
	70.84	0.10	0.20		4.75	
	70.75	0.05	0.10		3.02	
	70.60			2.47		
	70.58				2.64	
	70.65					3.73
X=130'	72.39	0.90	1.73	7.05	8.12	6.81
D=1.923'	72.00	0.70	1.35	7.12	7.79	6.99
	71.62	0.50	0.96	7.00	6.81	6.93
	71.43	0.40	0.77	6.51	6.13	6.55
	71.24	0.30	0.58	6.13	5.84	5.95
	71.04	0.20	0.39	5.33	5.70	5.53
	70.95	0.15	0.29	4.94	5.02	5.13
	70.85	0.10	0.19	5.18	4.69	5.02
	70.75	0.05	0.10	4.66	4.01	4.57
	70.61			3.74		
	70.60				2.37	
	70.75					4.69
X=140'	72.43	0.90	1.78		8.02	
D=1.978'	72.23	0.80	1.58	6.80		6.95
	72.04	0.70	1.38		7.65	
	71.64	0.50	0.99		6.87	
	71.44	0.40	0.79		6.43	
	71.24	0.30	0.59		5.86	
	71.05	0.20	0.40	5.30	5.38	5.43
	70.95	0.15	0.30		5.00	
	70.85	0.10	0.20		4.27	
	70.75	0.05	0.10		3.74	
	70.60			3.44		
	70.62				2.07	
	70.59					3.11

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 74 S=0.00840 Rock size 2 in.
Q=100 cfs Temp 71 F Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y =1.33'	Velocity ft/sec @Y =4.00'	Velocity ft/sec @Y =6.67'
X=120'	72.39	0.90	1.74	7.08	8.40	7.54
D=1.932'	72.00	0.70	1.35	7.74	8.02	7.86
	71.61	0.50	0.97	7.33	7.03	7.45
	71.42	0.40	0.77	7.06	6.65	7.16
	71.23	0.30	0.58	6.61	5.88	6.51
	71.03	0.20	0.39	6.26	5.33	6.02
	70.94	0.15	0.29	5.65	5.00	5.18
	70.84	0.10	0.19	5.23	4.78	4.66
	70.74	0.05	0.10	3.73	4.40	4.27
	70.64			2.59		
	70.56				2.54	
	70.63					3.28
X=130'	72.30	0.90	1.65	7.22	8.59	7.45
D=1.831'	71.94	0.70	1.28	7.54	8.07	7.77
	71.57	0.50	0.92	7.14	7.23	7.40
	71.39	0.40	0.73	6.91	6.95	6.73
	71.21	0.30	0.55	6.45	6.67	6.55
	71.02	0.20	0.37	5.91	5.91	6.06
	70.93	0.15	0.27	5.36	5.61	5.51
	70.84	0.10	0.18	5.08	5.15	5.02
	70.75	0.05	0.09	4.46	3.98	4.63
	70.61			3.63		
	70.60				3.32	
	70.58					2.93
X=140'	72.37	0.90	1.72	7.54	8.48	7.10
D=1.909'	71.98	0.70	1.34	7.68	7.75	7.74
	71.60	0.50	0.95	7.22	7.14	7.20
	71.41	0.40	0.76	6.71	6.93	6.85
	71.22	0.30	0.57	6.32	6.24	6.26
	71.03	0.20	0.38	5.72	5.41	5.79
	70.93	0.15	0.29	5.41	5.08	5.67
	70.84	0.10	0.19	4.69	4.46	4.91
	70.74	0.05	0.09	4.05	3.84	4.08
	70.58			2.07		
	70.63				2.69	
	70.60					1.79

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 75 S=0.01066 Rock size 2 in.
Q=100 cfs Temp 70 F Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	72.27	0.90	1.62		8.91	
D=1.804'	72.09	0.80	1.44	8.02		8.09
	71.91	0.70	1.26		8.40	
	71.55	0.50	0.90		7.70	
	71.37	0.40	0.72		7.16	
	71.19	0.30	0.54		6.65	
	71.01	0.20	0.36	6.04	5.86	5.88
	70.92	0.15	0.27		5.72	
	70.83	0.10	0.18		5.53	
	70.74	0.05	0.09		4.86	
	70.59			1.47		
	70.56				0.73	
	70.65					3.23
X=130'	72.28	0.90	1.62		8.76	
D=1.800'	72.10	0.80	1.44	8.02		7.68
	71.92	0.70	1.26		8.16	
	71.56	0.50	0.90		7.40	
	71.38	0.40	0.72		7.25	
	71.20	0.30	0.54		6.51	
	71.02	0.20	0.36	5.86	6.13	5.81
	70.93	0.15	0.27		5.58	
	70.84	0.10	0.18		5.43	
	70.75	0.05	0.09		4.80	
	70.63			1.27		
	70.58				1.64	
	70.56					1.27
X=140'	72.28	0.90	1.63		8.73	
D=1.808'	72.10	0.80	1.45	7.92		7.51
	71.92	0.70	1.27		8.12	
	71.60	0.50	0.95		7.61	
	71.42	0.40	0.77		7.22	
	71.24	0.30	0.59		6.55	
	71.06	0.20	0.41	6.26	6.26	5.67
	70.97	0.15	0.32		5.53	
	70.88	0.10	0.23		4.75	
	70.79	0.05	0.14		3.81	
	70.71			4.21		
	70.66				1.64	
	70.56					0.00

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 76 S=0.01193 Rock size 2 in.
Q=25 cfs Temp 67 F Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y =1.33'	Velocity ft/sec @Y =4.00'	Velocity ft/sec @Y =6.67'
X=120'	71.25	0.90	0.60	5.23	5.81	5.58
D=0.666'	71.11	0.70	0.47	5.02	5.43	5.28
	70.98	0.50	0.33	4.46	4.97	4.69
	70.91	0.40	0.27	4.14	4.69	4.40
	70.85	0.30	0.20	3.88	4.40	4.08
	70.78	0.20	0.13	3.51	3.81	3.59
	70.75	0.15	0.10	3.28	2.93	3.44
	70.72	0.10	0.07	3.02	1.64	3.02
	70.68	0.05	0.03	1.64	0.73	2.54
	70.66			0.00		
	70.63				0.00	
	70.59					1.66
X=130'	71.26	0.90	0.60	5.23	5.51	5.70
D=0.668'	71.12	0.70	0.47	5.15	5.38	5.33
	70.99	0.50	0.33	4.83	4.97	4.89
	70.92	0.40	0.27	4.52	4.49	4.69
	70.86	0.30	0.20	3.81	4.33	4.40
	70.79	0.20	0.13	3.59	3.91	3.66
	70.76	0.15	0.10	3.44	3.59	3.66
	70.72	0.10	0.07	3.02	3.44	3.32
	70.69	0.05	0.03	2.64	3.28	2.88
	70.62			1.16		
	70.62				2.59	
	70.60					1.72
X=140'	71.29	0.90	0.64	5.28	5.75	5.28
D=0.708'	71.15	0.70	0.50	5.07	5.23	5.07
	71.00	0.50	0.35	4.52	4.91	4.57
	70.93	0.40	0.28	4.21	4.40	4.33
	70.86	0.30	0.21	3.81	4.21	3.88
	70.79	0.20	0.14	3.44	3.81	3.66
	70.76	0.15	0.11	3.19	3.66	3.51
	70.72	0.10	0.07	2.93	3.66	3.28
	70.69	0.05	0.03	2.84	3.19	3.02
	70.66			2.74		
	70.64				2.84	
	70.64					2.43

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 77 S=0.01858 Rock size 2 in.
Q=25 cfs Temp 67 F Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.20	0.90	0.55		6.26	
D=0.610'	71.14	0.80	0.49	5.95		5.91
	71.08	0.70	0.43		5.95	
	70.95	0.50	0.31		5.62	
	70.89	0.40	0.24		5.23	
	70.83	0.30	0.18		4.97	
	70.77	0.20	0.12	4.08	4.75	4.27
	70.74	0.15	0.09		4.57	
	70.71	0.10	0.06		4.33	
	70.68	0.05	0.03		3.74	
	70.63			2.43		
	70.62				3.51	
	70.68					3.88
X=130'	71.18	0.90	0.52		6.53	
D=0.577'	71.12	0.80	0.46	6.51		6.47
	71.06	0.70	0.40		6.17	
	70.95	0.50	0.29		5.81	
	70.89	0.40	0.23		5.51	
	70.83	0.30	0.17		5.08	
	70.77	0.20	0.11	4.27	4.78	4.40
	70.75	0.15	0.09		4.49	
	70.72	0.10	0.06		4.14	
	70.69	0.05	0.03		3.91	
	70.62			2.14		
	70.62				4.01	
	70.62					2.07
X=140'	71.20	0.90	0.55		6.59	
D=0.608'	71.14	0.80	0.49	6.00		6.39
	71.08	0.70	0.43		6.22	
	70.95	0.50	0.30		5.48	
	70.89	0.40	0.24		5.13	
	70.83	0.30	0.18		4.75	
	70.77	0.20	0.12	4.08	4.27	3.95
	70.74	0.15	0.09		4.01	
	70.71	0.10	0.06		3.36	
	70.68	0.05	0.03		3.02	
	70.66			3.66		
	70.65				2.93	
	70.63					2.32

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 78 S=0.01579 Rock size 2 in.
Q=50 cfs Temp 68 F Thickness 4 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y =1.33'	Velocity ft/sec Y =4.00'	Velocity ft/sec Y =6.67'
X=120'	71.59	0.90	0.95	7.86	7.23	8.46
D=1.050'	71.38	0.70	0.73	7.51	6.53	8.27
	71.17	0.50	0.53	6.53	5.72	7.47
	71.07	0.40	0.42	6.24	5.23	7.03
	70.96	0.30	0.31	5.56	4.30	6.63
	70.86	0.20	0.21	5.00	4.14	6.11
	70.81	0.15	0.16	4.66	3.63	5.97
	70.75	0.10	0.11	4.46	3.19	5.31
	70.70	0.05	0.05	3.84	3.51	5.13
	70.60			2.74		
	70.60				3.15	
	70.52					3.15
X=130'	71.52	0.90	0.86	7.99	8.12	7.96
D=0.961'	71.33	0.70	0.67	7.43	7.43	7.68
	71.14	0.50	0.48	6.75	6.83	7.03
	71.04	0.40	0.38	6.47	6.71	6.63
	70.95	0.30	0.29	5.95	6.13	6.17
	70.85	0.20	0.19	5.43	5.77	5.67
	70.80	0.15	0.14	4.97	5.28	5.08
	70.75	0.10	0.10	4.69	5.02	4.97
	70.71	0.05	0.05	3.95	4.21	4.46
	70.60			1.27		
	70.57				3.11	
	70.61					2.64
X=140'	71.60	0.90	0.95	7.87	7.67	7.58
D=1.056'	71.39	0.70	0.74	7.43	7.20	7.42
	71.18	0.50	0.53	6.49	6.63	6.57
	71.07	0.40	0.42	6.22	6.11	6.02
	70.97	0.30	0.32	5.67	5.53	5.33
	70.86	0.20	0.21	4.57	4.78	4.75
	70.81	0.15	0.16	3.77	4.49	4.30
	70.76	0.10	0.11	3.36	3.74	3.95
	70.70	0.05	0.05		3.28	
	70.72			3.11		
	70.70				3.44	
	70.73					0.00

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 79 S=0.01180 Rock size 2 in.
Q=25 cfs Temp. 68 F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.0'	Velocity ft/sec @Y=6.67'
X=120'	71.46	0.90	0.64	5.53	5.77	5.58
D=0.714'	71.32	0.70	0.50	5.13	5.28	5.13
	71.18	0.50	0.36	4.69	4.97	4.80
	71.11	0.40	0.29	4.33	4.57	4.52
	71.03	0.30	0.21	3.74	4.27	4.27
	70.96	0.20	0.14	3.44	3.95	3.95
	70.93	0.15	0.11	3.19	3.74	3.66
	70.89	0.10	0.07	2.84	3.59	3.44
	70.86	0.05	0.04	2.64	3.36	3.19
	70.72			1.47		
	70.80				2.64	
	70.77					2.84
X=130'	71.44	0.90	0.63	5.18	5.60	5.67
D=0.702'	71.30	0.70	0.49	4.69	5.48	5.33
	71.16	0.50	0.35	4.21	5.02	4.66
	71.09	0.40	0.28	4.18	4.78	4.49
	71.02	0.30	0.21	3.66	4.30	4.05
	70.95	0.20	0.14	3.47	3.74	3.32
	70.91	0.15	0.11	2.88	3.70	3.06
	70.88	0.10	0.07	2.93	3.59	2.93
	70.84	0.05	0.03	2.84	3.28	2.59
	70.72			2.00		
	70.71				1.37	
	70.74					0.90
X=140'	71.44	0.90	0.64	5.33	5.63	5.63
D=0.713'	71.30	0.70	0.50	5.13	5.46	5.18
	71.16	0.50	0.36	4.63	5.07	4.75
	71.08	0.40	0.28	4.27	4.52	4.33
	71.01	0.30	0.21	3.81	4.33	3.74
	70.94	0.20	0.14	3.44	3.66	3.02
	70.91	0.15	0.11	3.02	3.36	2.74
	70.87	0.10	0.07	2.74	3.19	2.43
	70.84	0.05	0.04	2.32	2.74	1.94
	70.79			1.94		
	70.75				1.94	
	70.81					1.79

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 80 S=0.01870 Rock zise 2 in.
Q=25 cfs Temp. 69 F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=120'	71.37	0.90	0.55	6.30	6.55	6.17
D=0.612'	71.25	0.70	0.43	6.00	6.22	5.86
	71.13	0.50	0.31	5.53	5.53	5.38
	71.07	0.40	0.25	5.33	5.13	5.18
	71.00	0.30	0.18	4.69	4.97	4.80
	71.94	0.20	1.12	4.00	4.33	4.46
	70.91	0.15	0.09	3.81	4.08	4.14
	70.88	0.10	0.06	3.36	3.81	3.88
	70.85	0.05	0.03	3.10	3.74	3.88
	70.73			2.07		
	70.85				3.81	
	70.75					0.73
X=130'	71.36	0.90	0.55	6.09	6.55	6.34
D=0.614'	71.24	0.70	0.43	5.67	6.39	6.00
	71.11	0.50	0.31	5.23	5.77	5.67
	71.05	0.40	0.25	4.75	5.43	5.28
	70.99	0.30	0.18	4.33	4.91	5.08
	70.93	0.20	0.12	4.08	4.52	4.63
	70.90	0.15	0.09	3.88	4.14	1.64
	70.87	0.10	0.06	3.81	3.81	0.00
	70.84	0.05	0.03	3.74	3.74	0.00
	70.84			0.00		
	70.72				2.54	
	70.77					
X=140'	71.33	0.90	0.53	6.26	6.63	6.67
D=0.594'	71.22	0.70	0.42	5.77	6.34	6.13
	71.10	0.50	0.30	5.38	5.63	5.72
	71.04	0.40	0.24	5.02	5.18	5.43
	70.98	0.30	0.18	4.52	4.69	4.63
	70.92	0.20	0.12	3.81	4.21	3.51
	70.89	0.15	0.09	3.51	3.81	2.93
	70.86	0.10	0.06	3.02	3.51	2.32
	70.83	0.05	0.03	2.74	3.11	1.64
	70.80			2.07		
	70.78				2.54	
	70.78					1.04

CORP OF ENGINEERS RIPRAP PROJECT

RUN # 81 S=0.01205 Rock size 2 in.
Q=50 cfs Twmp. 70 F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=120'	71.79	0.90	0.97		7.31	
D=1.078'	71.68	0.80	0.86	7.42		7.05
	71.58	0.70	0.76		6.81	
	71.36	0.50	0.54		6.41	
	71.25	0.40	0.43		6.00	
	71.14	0.30	0.32		5.43	
	71.04	0.20	0.22	5.21	4.89	5.26
	70.98	0.15	0.16		4.46	
	70.93	0.10	0.11		4.30	
	70.87	0.05	0.05		4.00	
	70.72			2.07		
	70.72				3.47	
	70.78					3.44
X=130'	71.76	0.90	0.95		7.03	
D=1.060'	71.85	0.80	1.05	7.12		6.97
	71.55	0.70	0.74		6.73	
	71.34	0.50	0.53		6.39	
	71.23	0.40	0.42		6.04	
	71.12	0.30	0.32		5.53	
	71.02	0.20	0.21	4.89	4.94	5.23
	70.97	0.15	0.16		4.52	
	70.91	0.10	0.11		4.36	
	70.86	0.05	0.05		3.95	
	70.78			2.97		
	70.69				2.84	
	70.81					1.87
X=140'	71.76	0.90	0.96		7.36	
D=1.065'	71.65	0.80	0.85	7.20		7.16
	71.55	0.70	0.75		6.95	
	71.33	0.50	0.53		6.43	
	71.23	0.40	0.43		6.11	
	71.12	0.30	0.32		5.48	
	71.01	0.20	0.21	4.63	4.97	5.18
	70.96	0.15	0.16		4.60	
	70.91	0.10	0.11		4.36	
	70.85	0.05	0.05		3.66	
	70.76			0.90		
	70.77				1.94	
	70.73					1.87

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 82 S=0.01544 Rock size 2 in.
Q=50 cfs Temp. 67 F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=120'	71.69	0.90	0.87	7.92	7.61	7.99
D=0.968'	71.50	0.70	0.68	7.82	7.33	7.54
	71.30	0.50	0.48	7.36	6.83	6.95
	71.21	0.40	0.39	6.71	6.34	6.47
	71.11	0.30	0.29	6.34	5.95	6.30
	71.01	0.20	0.19	5.48	5.48	5.67
	70.97	0.15	0.15	5.18	5.18	5.28
	70.92	0.10	0.10	4.86	4.86	4.97
	70.87	0.05	0.05	4.01	4.52	4.52
	70.75			1.27		
	70.82				4.33	
	70.78					3.19
X=130'	71.68	0.90	0.98	7.87	7.68	7.89
D=0.976'	71.49	0.70	0.78	7.38	7.36	7.61
	71.29	0.50	0.59	6.75	6.81	7.05
	71.20	0.40	0.49	6.37	6.13	6.97
	71.10	0.30	0.39	5.72	5.93	6.17
	71.00	0.20	0.30	5.10	5.53	5.43
	70.95	0.15	0.25	4.63	5.26	5.23
	70.90	0.10	0.20	4.33	4.60	4.69
	70.86	0.05	0.15	3.63	4.52	4.24
	70.79			2.48		
	70.76				3.84	
	70.81					3.47
X=140'	71.66	0.90	0.86	7.89	7.99	7.99
D=0.955'	71.47	0.70	0.67	7.36	7.40	7.61
	71.28	0.50	0.48	7.06	6.87	6.99
	71.18	0.40	0.38	6.63	6.63	6.67
	71.09	0.30	0.29	5.86	6.26	6.30
	70.99	0.20	0.19	5.28	5.58	5.77
	70.94	0.15	0.14	4.86	5.18	5.23
	70.90	0.10	0.10	4.40	4.27	4.33
	70.85	0.05	0.05	3.51	3.44	3.36
	70.80			3.44		
	70.77				1.79	
	70.82					2.54

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 83 S=0.01724 Rock size 2 in.
Q=50 cfs Temp. 67 F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=120'	71.64	0.90	0.82		8.09	
D=0.913'	71.55	0.80	0.73	8.32		8.19
	71.46	0.70	0.64		7.68	
	71.28	0.50	0.46		7.14	
	71.19	0.40	0.37		6.83	
	71.09	0.30	0.27		6.43	
	71.00	0.20	0.18	6.06	5.48	5.53
	70.96	0.15	0.14		5.08	
	70.91	0.10	0.09		4.75	
	70.87	0.05	0.05		4.08	
	70.74			2.59		
	70.81				4.01	
	70.75					2.84
X=130'	71.66	0.90	0.85		7.96	
D=0.943'	71.56	0.80	0.76	8.11		8.17
	71.47	0.70	0.66		7.65	
	71.28	0.50	0.47		7.03	
	71.18	0.40	0.38		6.63	
	71.09	0.30	0.28		6.08	
	71.00	0.20	0.19	5.74	5.53	5.91
	70.95	0.15	0.14		5.23	
	70.90	0.10	0.09		4.86	
	70.85	0.05	0.05		4.57	
	70.76			2.48		
	70.75				1.04	
	70.79					1.47
X=140'	71.63	0.90	0.83		8.19	
D=0.928'	71.54	0.80	0.74	7.94		8.32
	71.45	0.70	0.65		7.65	
	71.26	0.50	0.46		7.10	
	71.17	0.40	0.37		6.67	
	71.08	0.30	0.28		6.13	
	70.99	0.20	0.19	5.31	5.38	5.81
	70.94	0.15	0.14		4.63	
	70.89	0.10	0.09		4.27	
	70.85	0.05	0.05		3.51	
	70.84			1.72		
	70.76				1.67	
	70.83					4.30

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 84 S=0.01879 Rock size 2 in.
Q=50 cfs Temp. 68F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=120'	71.64	0.90	0.82		8.48	
D=0.916'	71.55	0.80	0.73	8.64		8.42
	71.46	0.70	0.64		7.89	
	71.28	0.50	0.46		7.47	
	71.19	0.40	0.37		6.69	
	71.10	0.30	0.28		6.00	
	71.00	0.20	0.18	5.58	5.51	6.13
	70.96	0.15	0.14		5.18	
	70.91	0.10	0.09		4.55	
	70.87	0.05	0.05		3.40	
	70.76			2.32		
	70.85				3.40	
	70.72					2.07
X=130'	71.70	0.90	0.90		8.04	
D=0.995'	71.60	0.80	0.80	8.29		8.79
	71.50	0.70	0.70		7.38	
	71.30	0.50	0.50		6.67	
	71.20	0.40	0.40		6.43	
	71.11	0.30	0.30		5.63	
	71.01	0.20	0.20	5.91	5.41	6.34
	70.96	0.15	0.15		4.78	
	70.91	0.10	0.10		4.40	
	70.86	0.05	0.05		3.95	
	70.80			0.00		
	70.73				0.90	
	70.74					1.79
X=140'	71.70	0.90	0.90		8.34	
D=0.998'	71.60	0.80	0.80	8.61		8.45
	71.50	0.70	0.70		8.16	
	71.30	0.50	0.50		7.36	
	71.20	0.40	0.40		7.18	
	71.10	0.30	0.30		6.75	
	71.00	0.20	0.20	5.18	6.13	5.86
	70.95	0.15	0.15		5.81	
	70.90	0.10	0.10		5.48	
	70.85	0.05	0.05		4.80	
	70.80			3.66		
	70.77				4.46	
	70.81					3.11

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 85 S=0.00898 Rock size 2 in.
Q=75 cfs Temp. 72 F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=120'	72.16	0.90	1.34	7.36	7.99	7.33
D=1.492'	71.86	0.70	1.04	7.47	7.29	7.29
	71.57	0.50	0.75	7.03	6.47	6.99
	71.42	0.40	0.60	6.34	6.00	6.63
	71.27	0.30	0.45	5.86	5.63	6.04
	71.12	0.20	0.30	5.38	5.07	5.63
	71.04	0.15	0.22	5.38	4.75	4.80
	70.97	0.10	0.15	4.80	4.21	4.69
	70.90	0.05	0.08	3.81	3.66	4.14
	70.70			1.27		
	70.74				1.94	
	70.77					3.19
X=130'	72.19	0.90	1.38	7.22	7.60	7.14
D=1.537'	71.88	0.70	1.08	7.42	6.65	7.23
	71.58	0.50	0.77	6.95	6.17	6.99
	71.42	0.40	0.62	6.63	5.93	6.45
	71.27	0.30	0.46	6.19	5.31	6.02
	71.11	0.20	0.31	5.79	4.69	5.72
	71.04	0.15	0.23	5.05	4.46	5.21
	70.96	0.10	0.15	4.66	4.01	4.89
	70.88	0.05	0.08	3.36	3.36	4.24
	70.87			2.98		
	70.87				2.54	
	70.70					2.37
X=140'	72.17	0.90	1.38	7.29	7.42	6.97
D=1.528'	71.87	0.70	1.07	7.14	7.23	7.12
	71.56	0.50	0.76	6.73	6.34	6.53
	71.41	0.40	0.61	6.65	5.93	6.45
	71.26	0.30	0.46	6.02	5.46	5.77
	71.11	0.20	0.31	5.41	4.60	4.72
	71.03	0.15	0.23	5.10	4.21	4.30
	70.95	0.10	0.15	4.46	3.88	3.59
	70.88	0.05	0.08	3.77	1.79	2.20
	70.73			0.00		
	70.75				1.27	
	70.81					1.64

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 86 S=0.01095 Rock size 2 in.
Q=75 cfs Temp. 72 F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=120'	72.09	0.90	1.27		8.24	
D=1.406'	71.95	0.80	1.13	7.91		7.86
	71.80	0.70	0.98		7.45	
	71.52	0.50	0.70		7.10	
	71.38	0.40	0.56		6.55	
	71.24	0.30	0.42		6.22	
	71.10	0.20	0.28	5.33	5.48	5.79
	71.03	0.15	0.21		4.91	
	70.96	0.10	0.14		4.55	
	70.89	0.05	0.07		3.81	
	70.72			0.00		
	70.67				1.72	
	70.73					1.27
X=130'	72.08	0.90	1.28		7.70	
D=1.418'	71.94	0.80	1.13	7.60		7.65
	71.80	0.70	0.99		7.56	
	71.52	0.50	0.71		6.75	
	71.37	0.40	0.57		6.28	
	71.23	0.30	0.42		5.86	
	71.09	0.20	0.28	5.77	5.18	5.91
	71.02	0.15	0.21		5.02	
	70.95	0.10	0.14		4.72	
	70.88	0.05	0.07		4.01	
	70.83			2.32		
	70.75				1.16	
	70.79					3.06
X=140'	72.08	0.90	1.28		8.19	
D=1.419'	71.93	0.80	1.13	7.65		7.68
	71.79	0.70	0.99		7.80	
	71.51	0.50	0.71		7.06	
	71.37	0.40	0.57		6.77	
	71.23	0.30	0.43		6.02	
	71.08	0.20	0.28	5.86	5.36	6.02
	71.01	0.15	0.21		5.13	
	70.94	0.10	0.14		4.49	
	70.87	0.05	0.07		3.95	
	70.73			2.59		
	70.80				3.11	
	70.79					0.00

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 87 S=0.01206 Rock size 2 in.
Q=75 cfs Temp. 73 F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67
X=120'	72.09	0.90	1.27		8.57	
D=1.410'	71.95	0.80	1.13	8.35		8.17
	71.81	0.70	0.99		7.61	
	71.53	0.50	0.71		6.79	
	71.38	0.40	0.56		6.39	
	71.24	0.30	0.42		6.00	
	71.10	0.20	0.28	5.77	5.33	6.06
	71.03	0.15	0.21		5.18	
	70.96	0.10	0.14		4.52	
	70.89	0.05	0.07		3.74	
	70.79			3.98		
	70.79				3.11	
	70.71					2.48
X=130'	72.11	0.90	1.31		8.38	
D=1.445'	71.96	0.80	1.16	7.99		8.01
	71.82	0.70	1.02		7.89	
	71.53	0.50	0.73		6.95	
	71.38	0.40	0.58		6.71	
	71.24	0.30	0.44		6.26	
	71.10	0.20	0.30	5.91	5.58	6.11
	71.02	0.15	0.22		5.08	
	70.95	0.10	0.15		4.52	
	70.88	0.05	0.08		4.08	
	70.70			3.66		
	10.82				2.54	
	70.74					3.11
X=140'	72.07	0.90	1.27		8.67	
D=1.415'	71.93	0.80	1.13	8.12		8.22
	71.79	0.70	0.99		7.89	
	71.51	0.50	0.71		7.29	
	71.37	0.40	0.57		7.03	
	71.22	0.30	0.42		6.39	
	71.08	0.20	0.28	6.28	5.72	5.91
	71.01	0.15	0.21		5.43	
	70.94	0.10	0.14		4.69	
	70.87	0.05	0.07		4.14	
	70.72			0.73		
	70.76				2.20	
	70.84					1.16

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 88 S=0.01359 Rock size 2 in.
Q=75 cfs Temp. 73 F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.0'	Velocity ft/sec @Y=6.67'
X=120'	72.06	0.90	1.24		8.70	
D=1.382'	71.93	0.80	1.11	8.45		8.45
	71.79	0.70	0.97		8.19	
	71.51	0.50	0.69		7.68	
	71.37	0.40	0.55		6.95	
	71.24	0.30	0.42		6.51	
	71.10	0.20	0.28	5.91	5.86	6.00
	71.03	0.15	0.21		5.33	
	70.96	0.10	0.14		4.80	
	70.89	0.05	0.07		4.46	
	70.75			1.04		
	70.77				2.64	
	70.75					0.00
X=130'	72.05	0.90	1.24		8.82	
D=1.377'	71.91	0.80	1.10	8.54		8.19
	71.77	0.70	0.96		7.96	
	71.50	0.50	0.69		7.58	
	71.36	0.40	0.55		7.29	
	71.22	0.30	0.41		6.55	
	71.08	0.20	0.28	6.26	6.00	
	71.01	0.15	0.21		5.43	6.26
	70.94	0.10	0.14		4.75	
	70.88	0.05	0.07		4.33	
	70.59			0.73		
	70.75				3.28	
	70.73					4.27
X=140'	72.02	0.90	1.22		8.88	
D=1.356'	71.88	0.80	1.08	8.22		8.38
	71.75	0.70	0.95		8.35	
	71.48	0.50	0.68		7.58	
	71.34	0.40	0.54		7.29	
	71.21	0.30	0.41		6.95	
	71.07	0.20	0.27	6.17	6.09	5.23
	71.00	0.15	0.20		5.58	
	70.94	0.10	0.14		5.08	
	70.87	0.05	0.07		4.27	
	70.75			1.64		
	70.76				3.36	
	70.81					2.83

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 89 S=0.01565 Rock size 2 in.
Q=75 cfs Temp. 75 F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=130'	72.07	0.90	1.26		9.06	
D=1.399'	71.93	0.80	1.12	8.95		9.03
	71.79	0.70	0.98		8.37	
	71.51	0.50	0.70		7.72	
	71.37	0.40	0.56		7.00	
	71.23	0.30	0.42		6.71	
	71.09	0.20	0.28	6.22	5.48	5.67
	71.02	0.15	0.21		4.91	
	70.95	0.10	0.14		4.55	
	70.88	0.05	0.07		2.64	
	70.75			2.54		
	70.80				1.27	
	70.72					3.02

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 90 S=0.00866 Rock size 2 in.
Q=100 cfs Temp. 77 F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec Y=1.33'	Velocity ft/sec Y=4.0'	Velocity ft/sec Y=6.67'
X=120'	72.45	0.90	1.63	8.67	8.75	7.68
D=1.805'	72.08	0.70	1.26	8.53	8.01	7.91
	71.72	0.50	0.90	7.99	7.67	7.36
	71.54	0.40	0.72	7.27	7.05	7.05
	71.36	0.30	0.54	6.73	6.63	6.59
	71.18	0.20	0.36	6.30	6.08	6.02
	71.09	0.15	0.27	6.24		5.41
	71.00	0.10	0.18	5.70	5.18	5.02
	70.91	0.05	0.09	5.05	3.74	4.01
	70.75			2.84		0.00
	70.82				2.74	
	70.77					1.37
X=130'	72.44	0.90	1.63	7.36	8.82	7.68
D=1.816'	72.08	0.70	1.27	7.47	8.22	7.82
	71.71	0.50	0.91	6.99	7.43	7.51
	71.53	0.40	0.73	6.51	7.03	7.06
	71.35	0.30	0.55	5.81	6.55	6.39
	71.17	0.20	0.36	5.48	5.86	5.67
	71.08	0.15	0.27	5.13	5.48	5.18
	70.99	0.10	0.18	4.63	4.86	4.91
	70.90	0.05	0.09	2.93	4.21	3.44
	70.73			0.00		
	70.75				2.64	
	70.72					1.47
X=140'	72.43	0.90	1.62	7.68	8.82	7.60
D=1.803'	72.06	0.70	1.26	7.68	8.27	7.96
	71.70	0.50	0.90	7.23	7.33	7.68
	71.52	0.40	0.72	7.10	6.95	7.14
	71.34	0.30	0.54	6.73	6.61	6.53
	71.16	0.20	0.36	5.60	5.58	5.97
	71.07	0.15	0.27	5.00	5.13	5.26
	70.98	0.10	0.18	4.77	4.91	4.63
	70.89	0.05	0.09	4.14	3.15	3.28
	70.77			3.28		
	70.74				0.00	
	70.78					1.16

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 91 S=0.00938 Rock size 2 in.
Q=100 cfs Temp. 77 F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=.133'	Velocity ft/sec @Y=4.0'	Velocity ft/sec @Y=6.67'
X=120'	72.43	0.90	1.61	7.86	8.61	7.96
D=1.786'	72.07	0.70	1.25	7.82	8.32	7.99
	71.71	0.50	0.89	7.51	7.58	7.43
	71.53	0.40	0.71	6.83	7.06	6.91
	71.36	0.30	0.54	6.47	6.34	6.39
	71.18	0.20	0.36	5.63	5.91	5.86
	71.09	0.15	0.27	5.38	5.77	5.48
	71.00	0.10	0.18	4.52	5.23	5.12
	70.91	0.05	0.09	3.59	4.33	4.08
	70.81			1.04		
	70.82				4.14	
	70.79					1.27
X=130'	72.43	0.90	1.63	7.79	8.82	7.82
D=1.806'	72.07	0.70	1.26	7.89	8.16	8.16
	71.71	0.50	0.90	7.51	7.68	7.61
	71.53	0.40	0.72	7.29	7.47	7.18
	71.35	0.30	0.54	6.83	6.60	6.51
	71.17	0.20	(ft)	6.00	5.72	5.90
	71.08	0.15	0.27	5.28	5.23	5.58
	70.99	0.10	0.18	4.91	4.91	4.57
	70.90	0.05	0.09	4.33	4.52	3.80
	70.85			3.73		
	70.70				1.04	
	70.73					2.07

CORPS OF ENGINEERS RIPRAP PROJECT

RUN # 92 S=0.01084 Rock size 2 in.
Q=100 cfs Temp. 77 F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=.133'	Velocity ft/sec @Y=4.0'	Velocity ft/sec @Y=6.67'
X=120'	72.36	0.90	1.54		9.18	
D=1.714'	72.19	0.80	1.37	8.48	8.45	8.51
	72.02	0.70	1.20		7.96	
	71.68	0.50	0.86		7.03	
	71.51	0.40	0.69		6.75	
	71.33	0.30	0.51		6.08	
	71.16	0.20	0.34	5.95	5.72	6.26
	71.08	0.15	0.26		5.08	
	70.99	0.10	0.17		4.52	
	70.91	0.05		0.00		
	70.71				4.01	
	70.84					1.04
	70.72					
X=130'	72.37	0.90	1.56		8.97	
D=1.733'	72.19	0.80	1.39	8.26	8.35	8.51
	72.02	0.70	1.21		7.92	
	71.67	0.50	0.87		7.14	
	71.49	0.40	0.69		6.59	
	71.33	0.30	0.52		5.81	
	71.15	0.20	0.35	6.22	5.38	6.87
	71.07	0.15	0.26		5.02	
	70.98	0.10	0.17		4.46	
	70.89	0.05		3.74		
	70.82				0.00	
	70.74					3.28
	70.78					
X=140'	72.32	0.90	1.52		9.41	
D=1.685'	72.15	0.80	1.35	8.48		8.70
	71.98	0.70	1.18		8.91	
	71.64	0.50	0.84		8.19	
	71.47	0.40	0.67		7.68	
	71.31	0.30	0.51		7.06	
	71.14	0.20	0.34	6.22	5.86	6.43
	71.05	0.15	0.25		5.53	
	70.97	0.10	0.17		4.63	
	70.88	0.05	0.08		3.88	
	70.73			2.20		
	70.76				3.36	
	70.73					3.11

CORPS OF ENGINEERS RIPRAP PROJECT

Run # 93 S=0.01189 Rock size 2 in.
Q=100 cfs Temp. 75 F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.0'	Velocity ft/sec @Y=6.67'
X=120'	72.32	0.90	1.50		9.55	
D=1.663'	72.15	0.80	1.33	8.32		8.50
	71.98	0.70	1.16		8.97	
	71.65	0.50	0.83		8.29	
	71.49	0.40	0.67		7.54	
	71.32	0.30	0.50		6.91	
	71.15	0.20	0.33	6.02	6.22	5.60
	71.07	0.15	0.25		5.72	
	70.99	0.10	0.17		5.43	
	70.90	0.05	0.08		4.91	
	70.75			2.59		
	70.75				3.80	
	70.76					2.48
X=130'	72.35	0.90	1.54		9.15	
D=1.714'	72.18	0.80	1.37	8.32		8.61
	72.01	0.70	1.20		8.57	
	71.60	0.50	0.80		7.86	
	71.49	0.40	0.69		7.25	
	71.32	0.30	0.51		6.71	
	71.15	0.20	0.34	5.97	6.22	6.22
	71.06	0.15	0.26		5.58	
	70.98	0.10	0.17		5.28	
	70.89	0.05	0.09		4.21	
	70.82			1.55		
	70.80				3.66	
	70.76					1.79
X=140'	72.34	0.90	1.55		9.21	
D=1.716'	72.17	0.80	1.38	8.51		8.73
	72.00	0.70	1.21		8.61	
	71.66	0.50	0.86		8.02	
	71.49	0.40	0.69		7.43	
	71.31	0.30	0.52		6.71	
	71.14	0.20	0.35	6.06	5.91	6.24
	71.06	0.15	0.26		5.43	
	70.97	0.10	0.18		4.75	
	70.89	0.05	0.09		4.08	
	70.98			4.33		
	70.76				2.54	
	70.81					1.16

CORPS OF ENGINEERS RIPRAP PROJECT

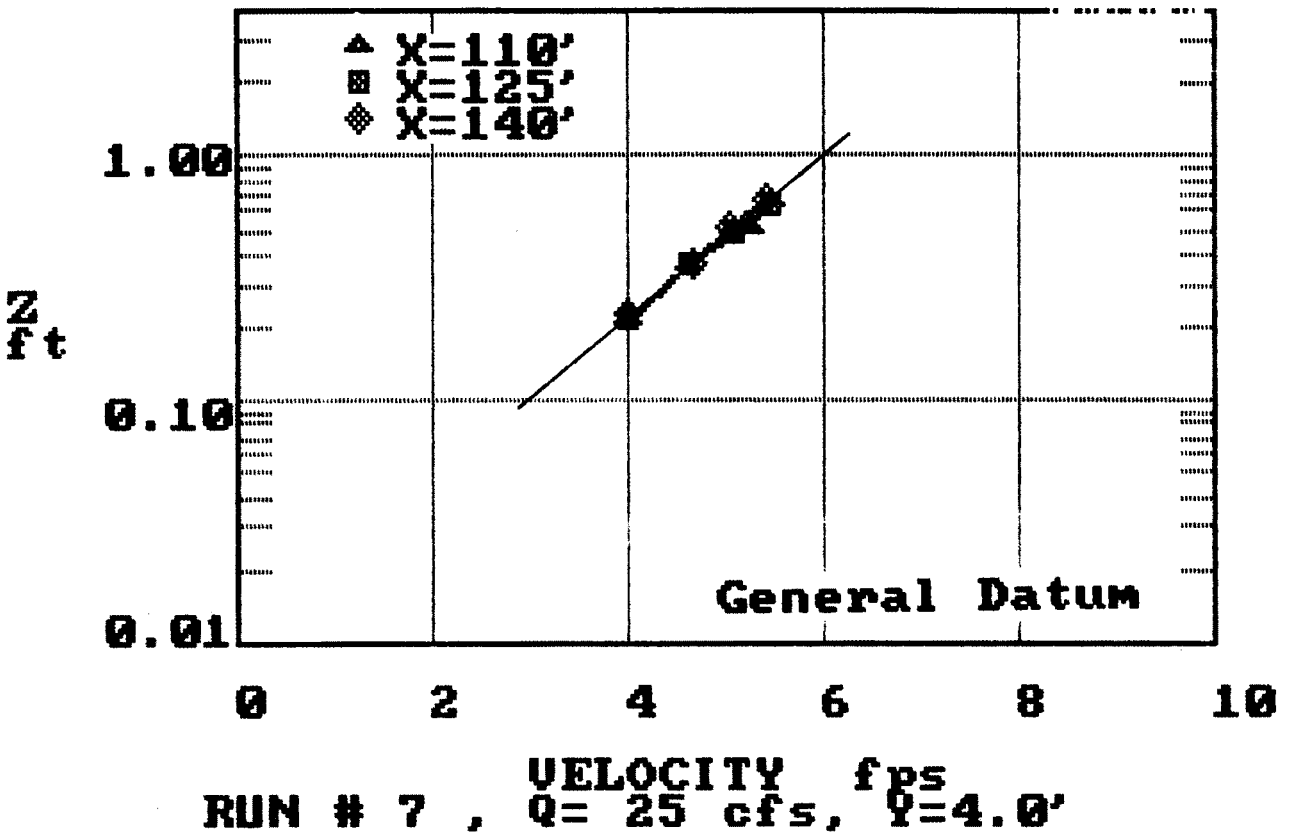
Run # 94 S=0.01300 Rock size 2 in.
Q=100 cfs Temp. 75 F Thickness 6 in.

	Elevation (ft)	Fraction of Depth	Depth Z (ft)	Velocity ft/sec @Y=1.33'	Velocity ft/sec @Y=4.0'	Velocity ft/sec @Y=6.67'
X=120'	72.24	0.90	1.42		10.00	
D=1.572'	72.08	0.80	1.26	9.21		9.27
	71.92	0.70	1.10		9.21	
	71.61	0.50	0.79		8.67	
	71.45	0.40	0.63		8.29	
	71.29	0.30	0.47		7.33	
	71.13	0.20	0.31	6.63	6.34	6.55
	71.06	0.15	0.24		6.22	
	70.98	0.10	0.16		5.72	
	70.90	0.05	0.08		5.13	
	70.73			2.32		
	70.76				2.93	
	70.63					0.00

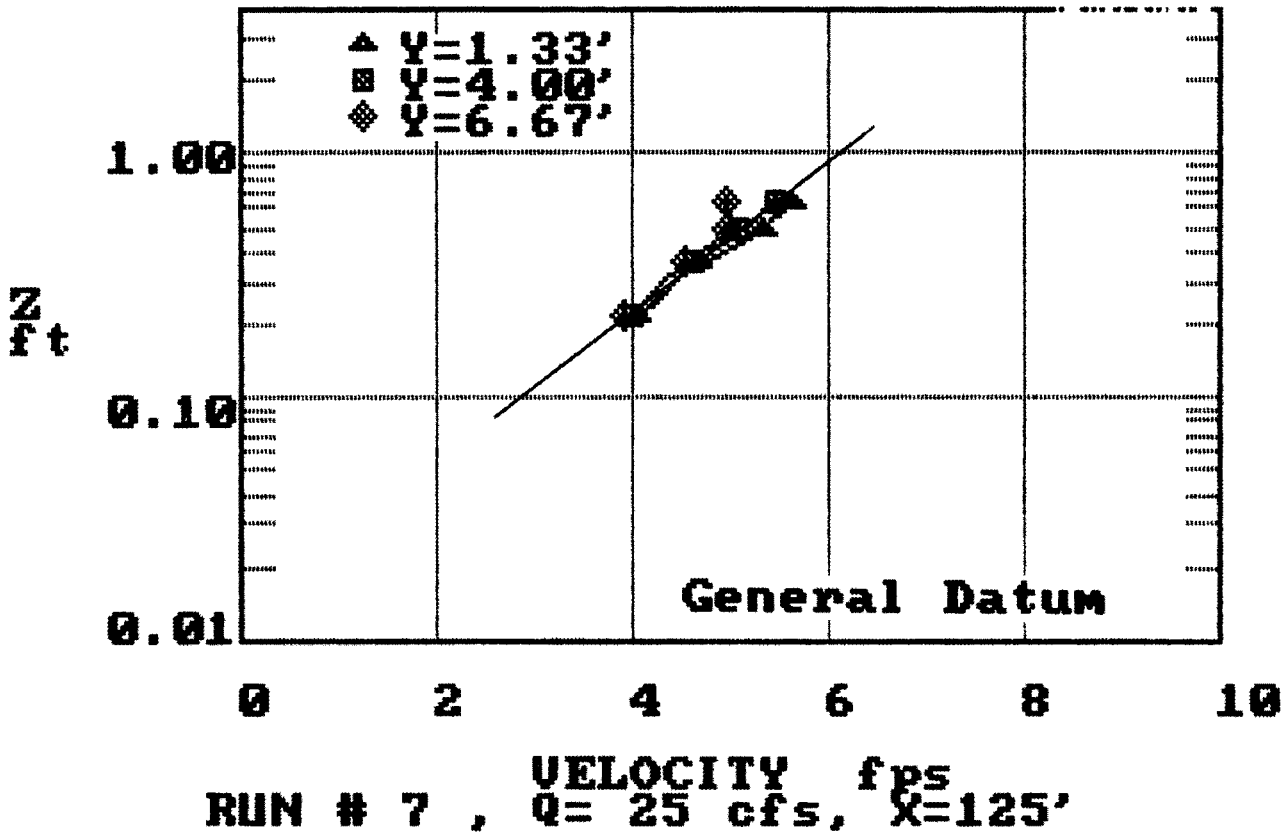
APPENDIX C

VELOCITY PROFILES

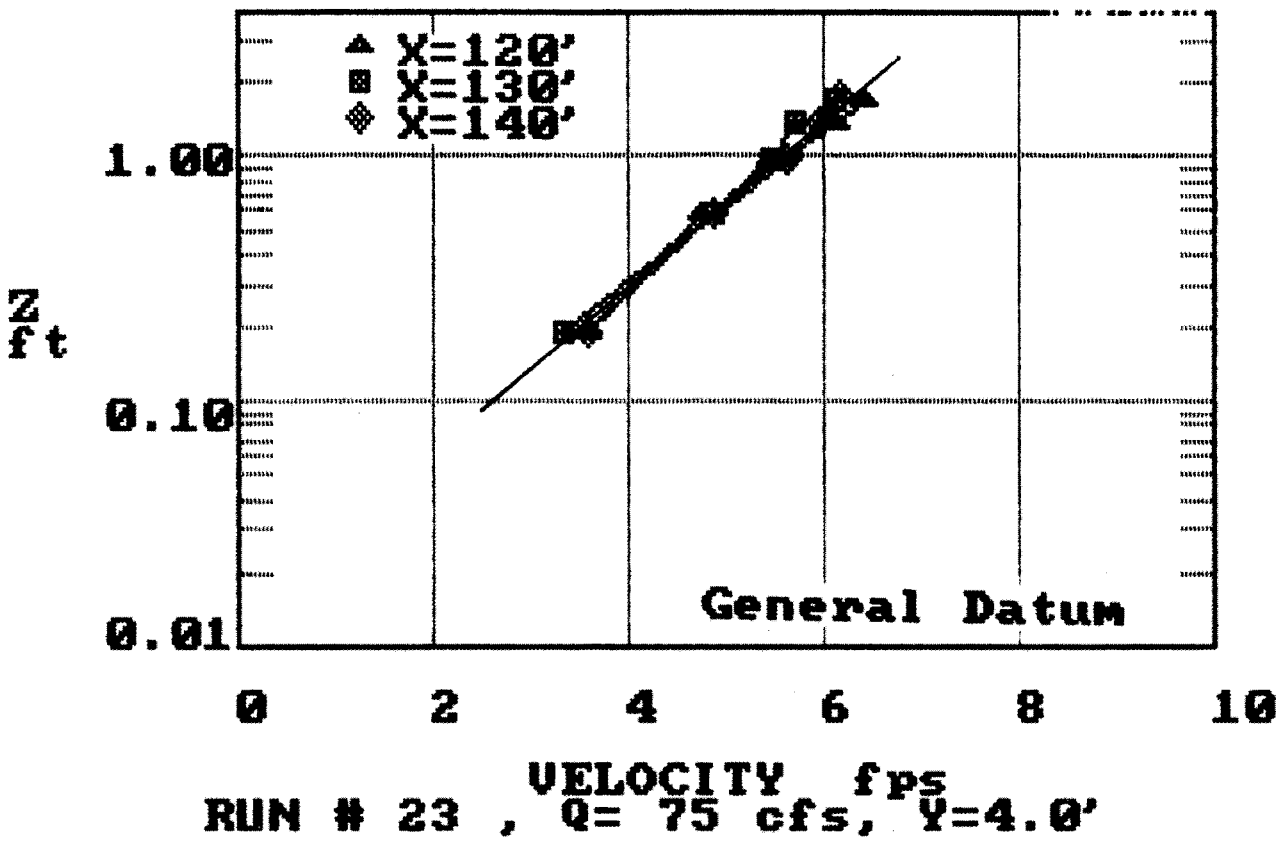
Test Series #	Riprap Size in.	Riprap Thickness in.	Run Numbers
1	1	2	7, 23, 27, 31
2	1	2	37, 40, 41, 45
3	1	3	56, 57, 60, 64
4	2	4	67, 72, 74, 76
5	2	6	84, 88, 93



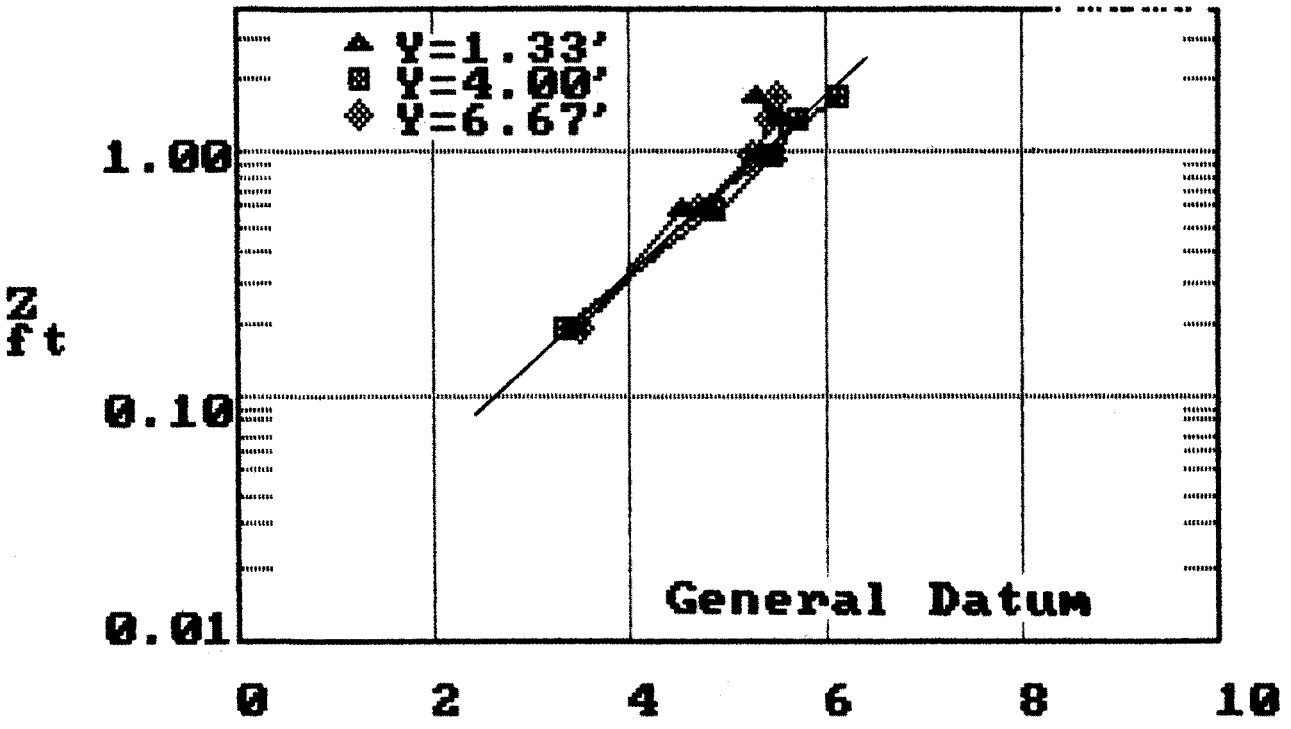
RUN # 7 , Q= 25 cfs, Y=4.0'



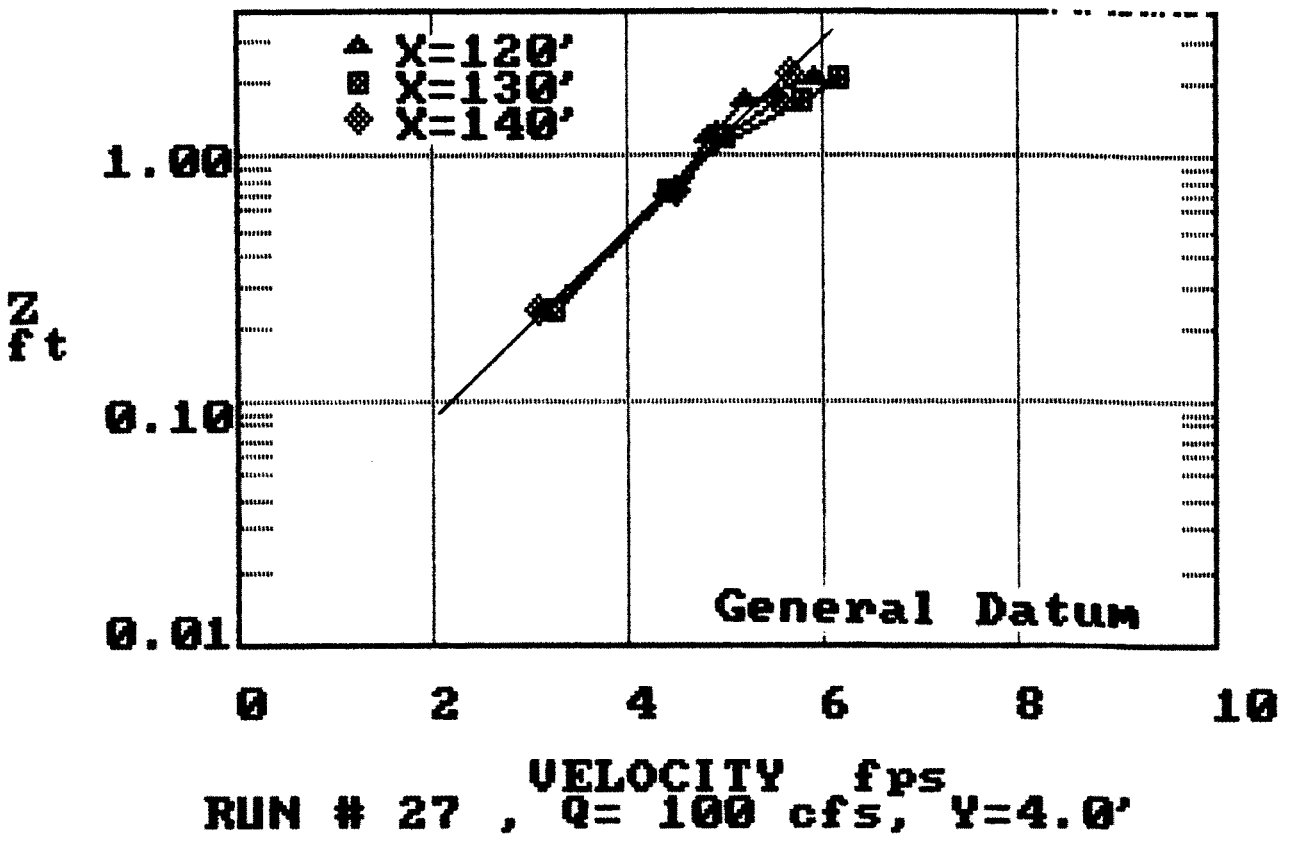
RUN # 7 , Q= 25 cfs, X=125'



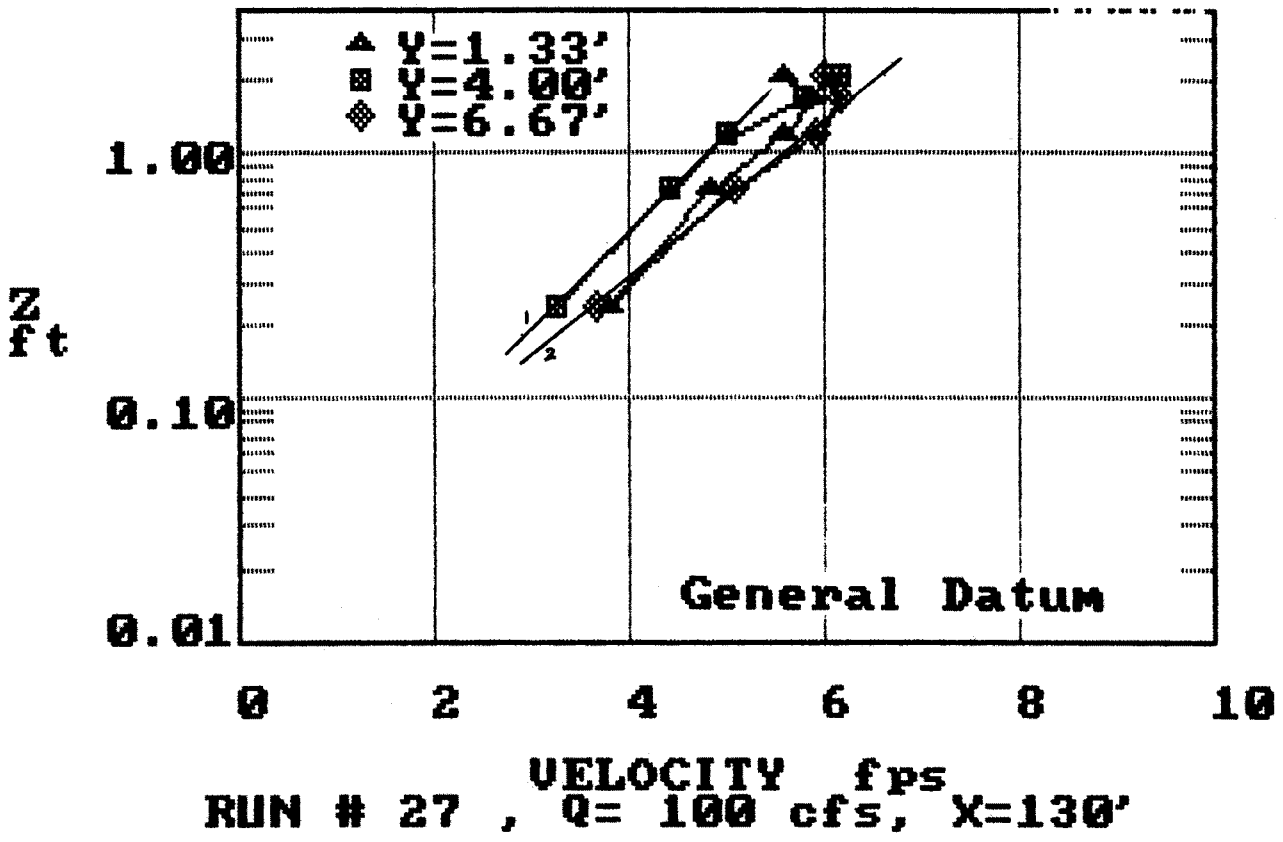
RUN # 23 , Q= 75 cfs, Y=4.0'



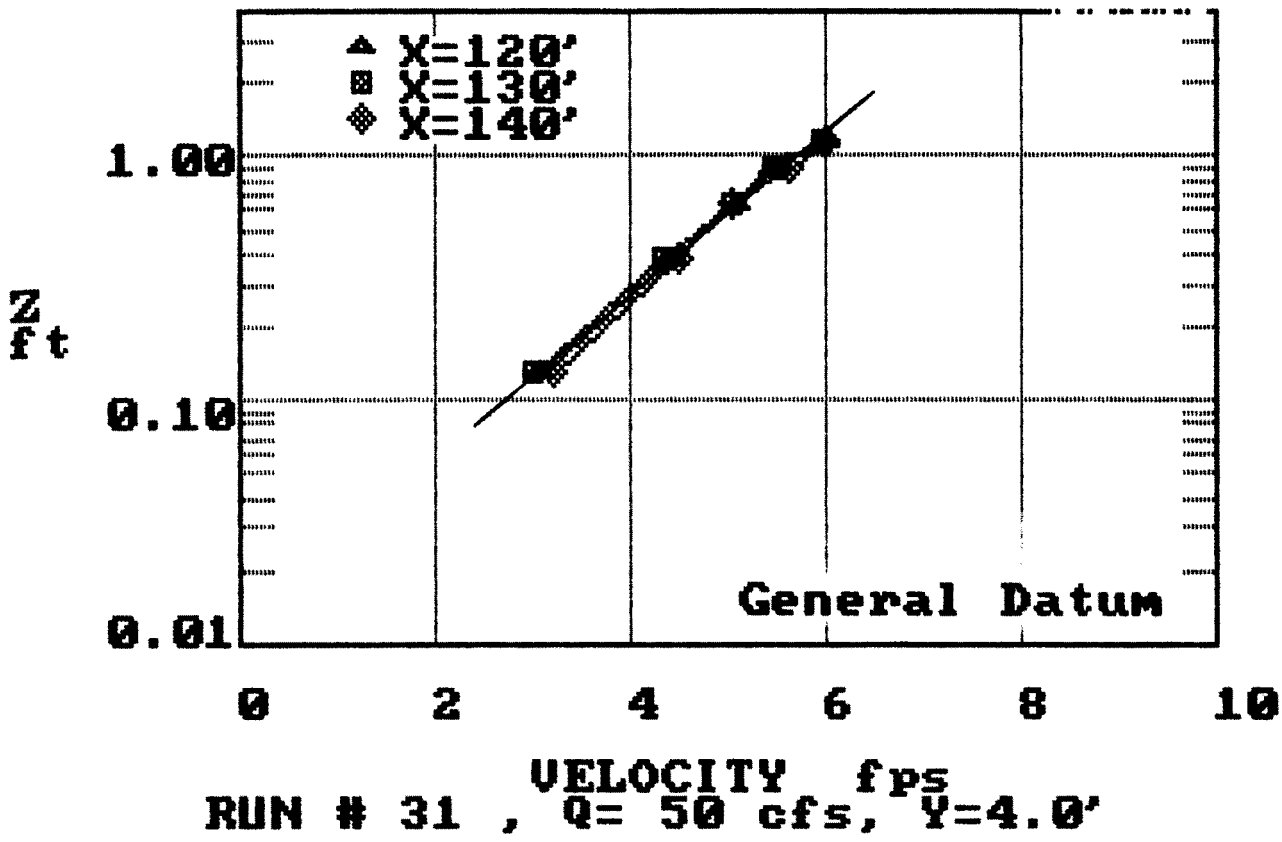
RUN # 23 , Q= 75 cfs, X=130'



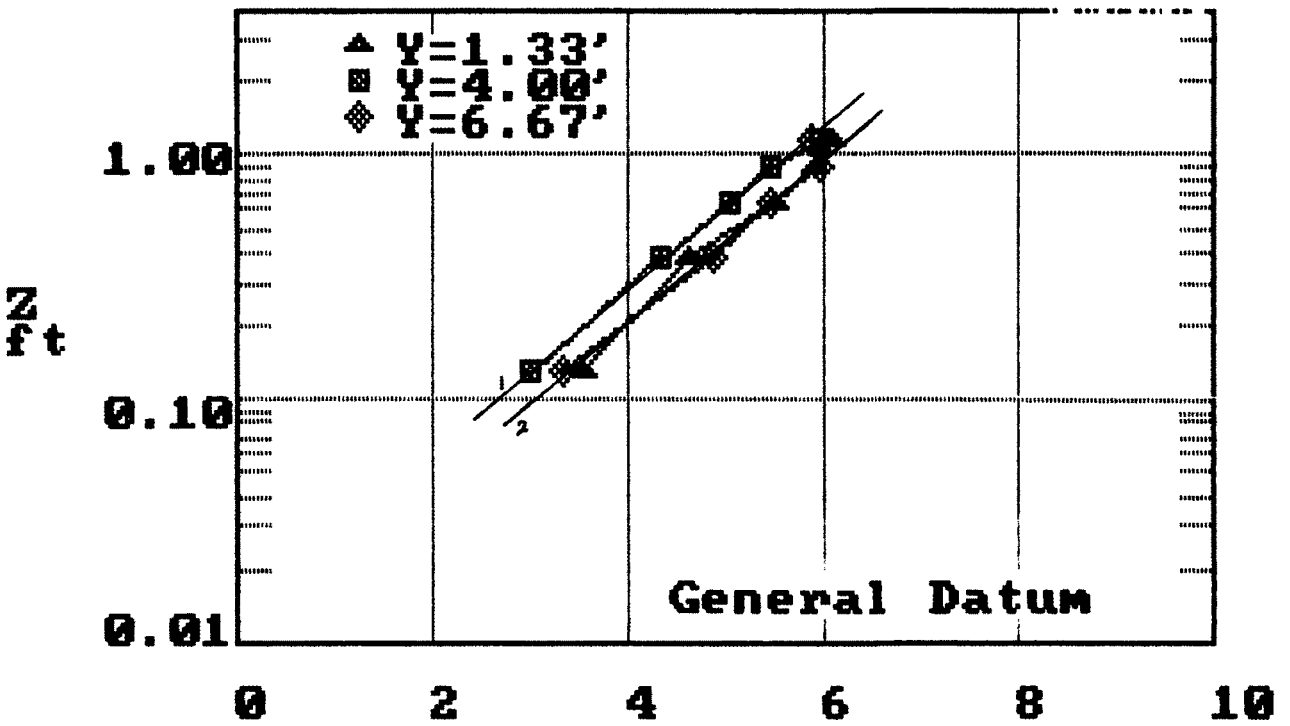
RUN # 27 , Q= 100 cfs, Y=4.0'



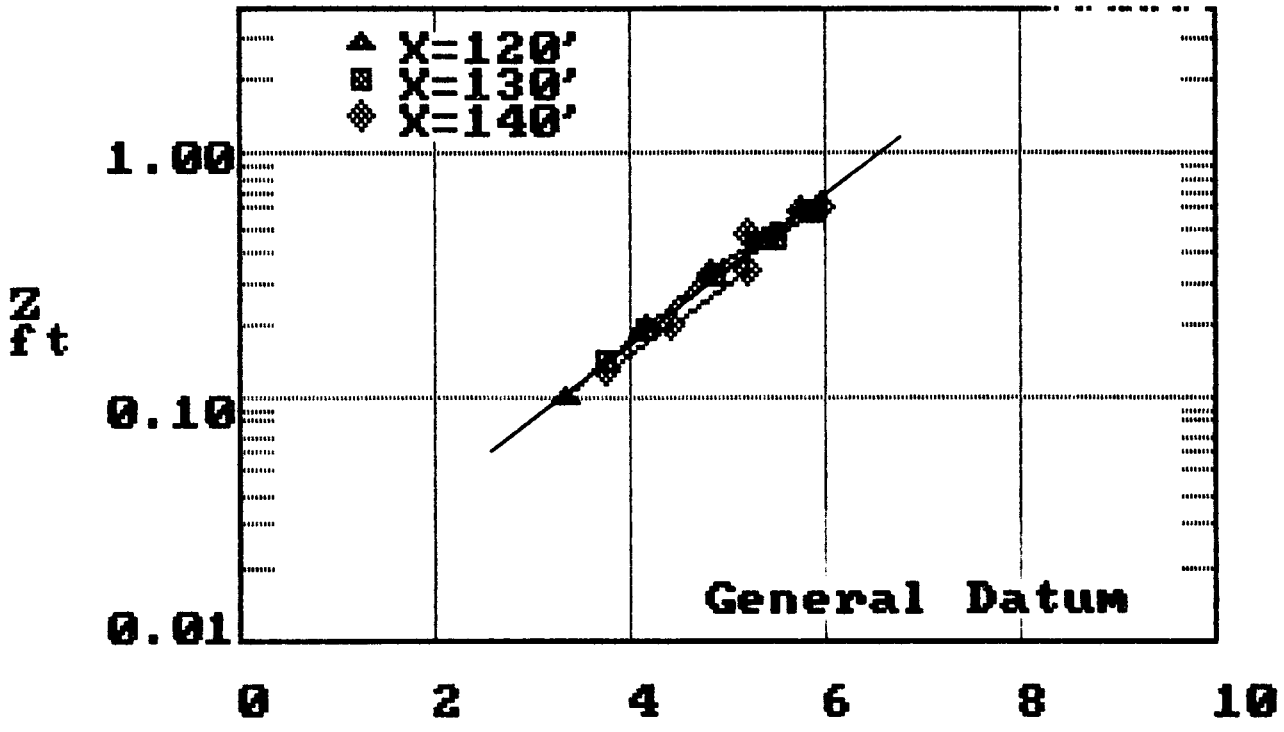
RUN # 27 , Q= 100 cfs, X=130'



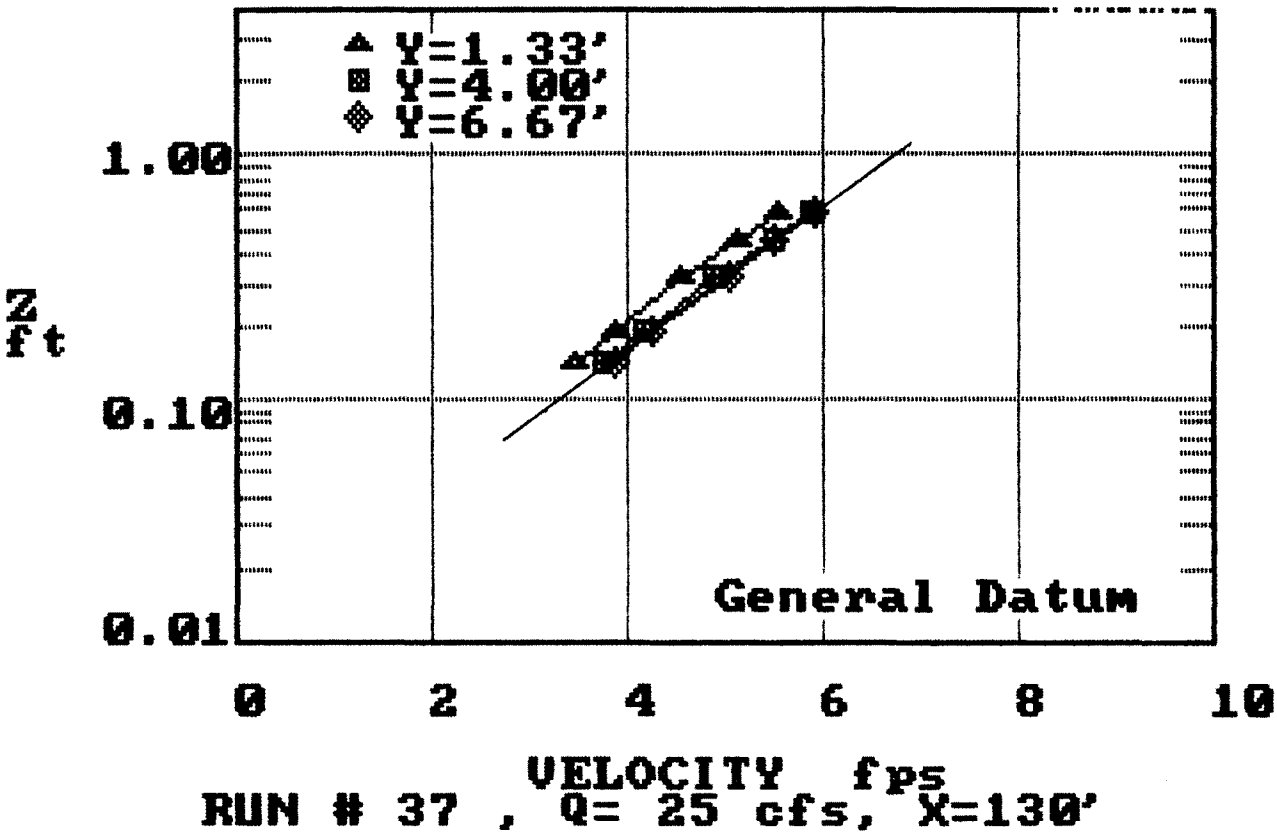
RUN # 31 , Q= 50 cfs, Y=4.0'



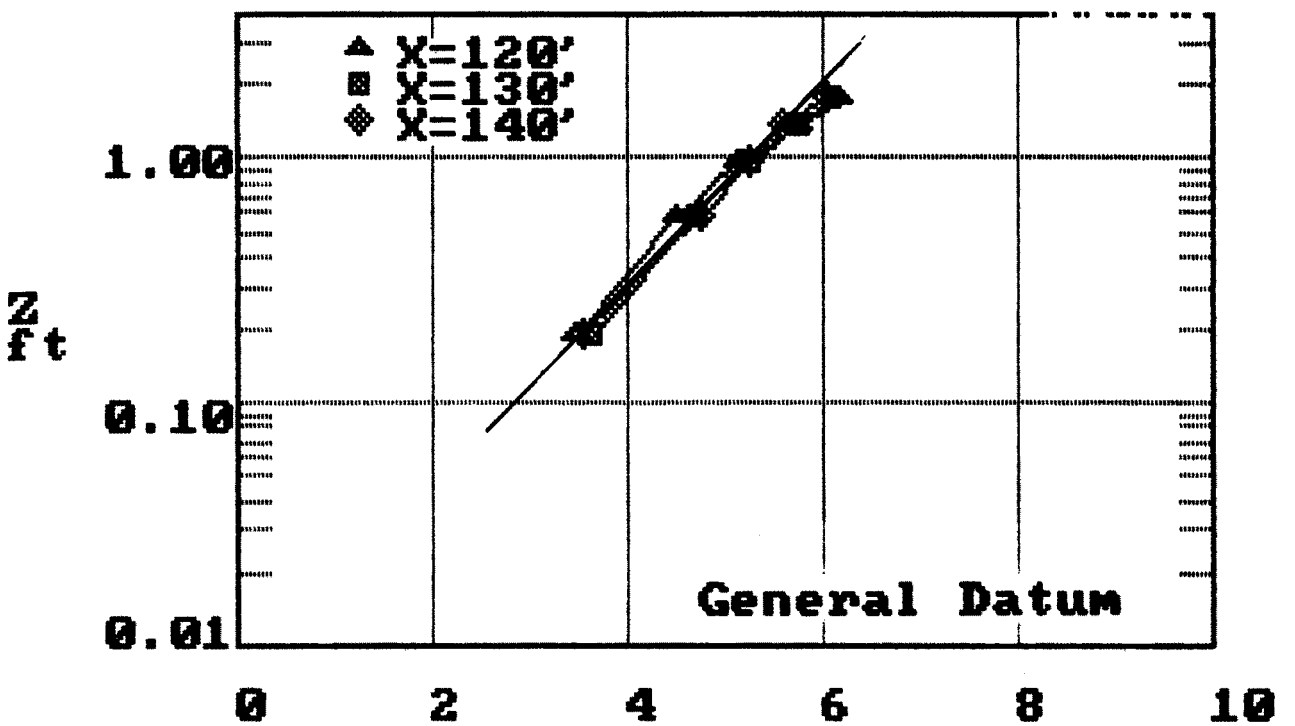
RUN # 31 , Q= 50 cfs, X=130'



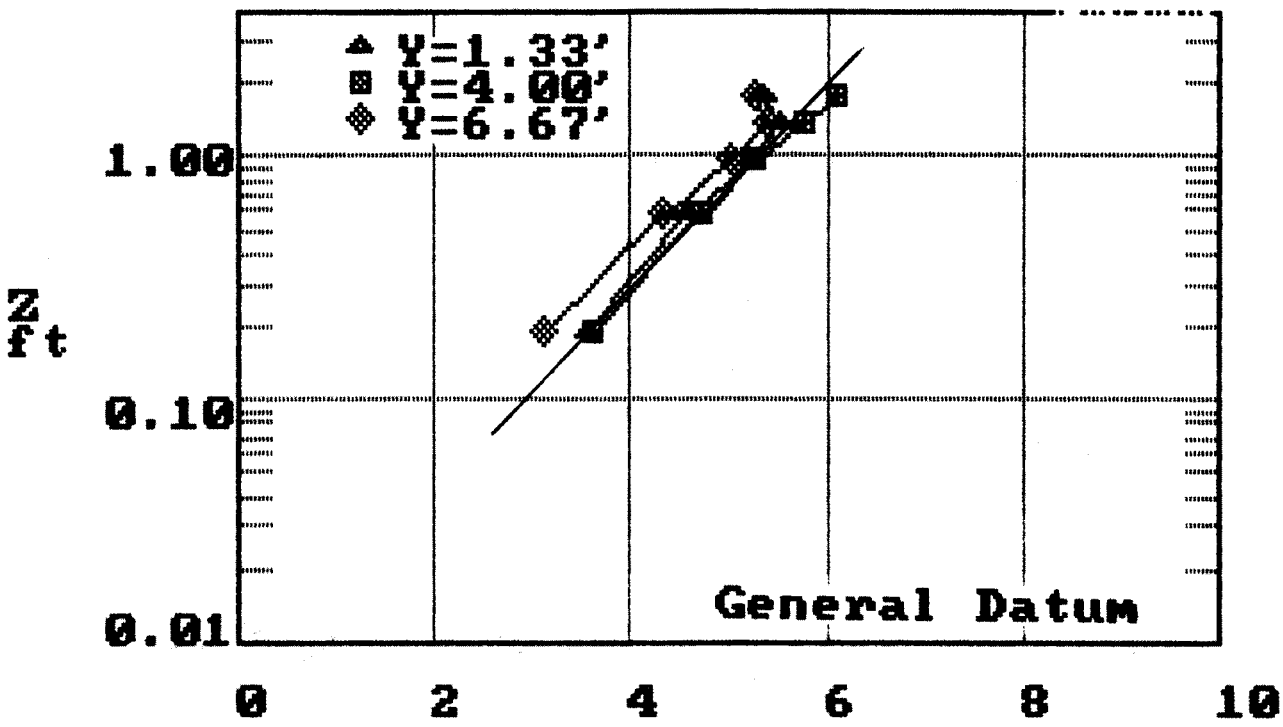
RUN # 37 , Q= 25 cfs, Y=4.0'



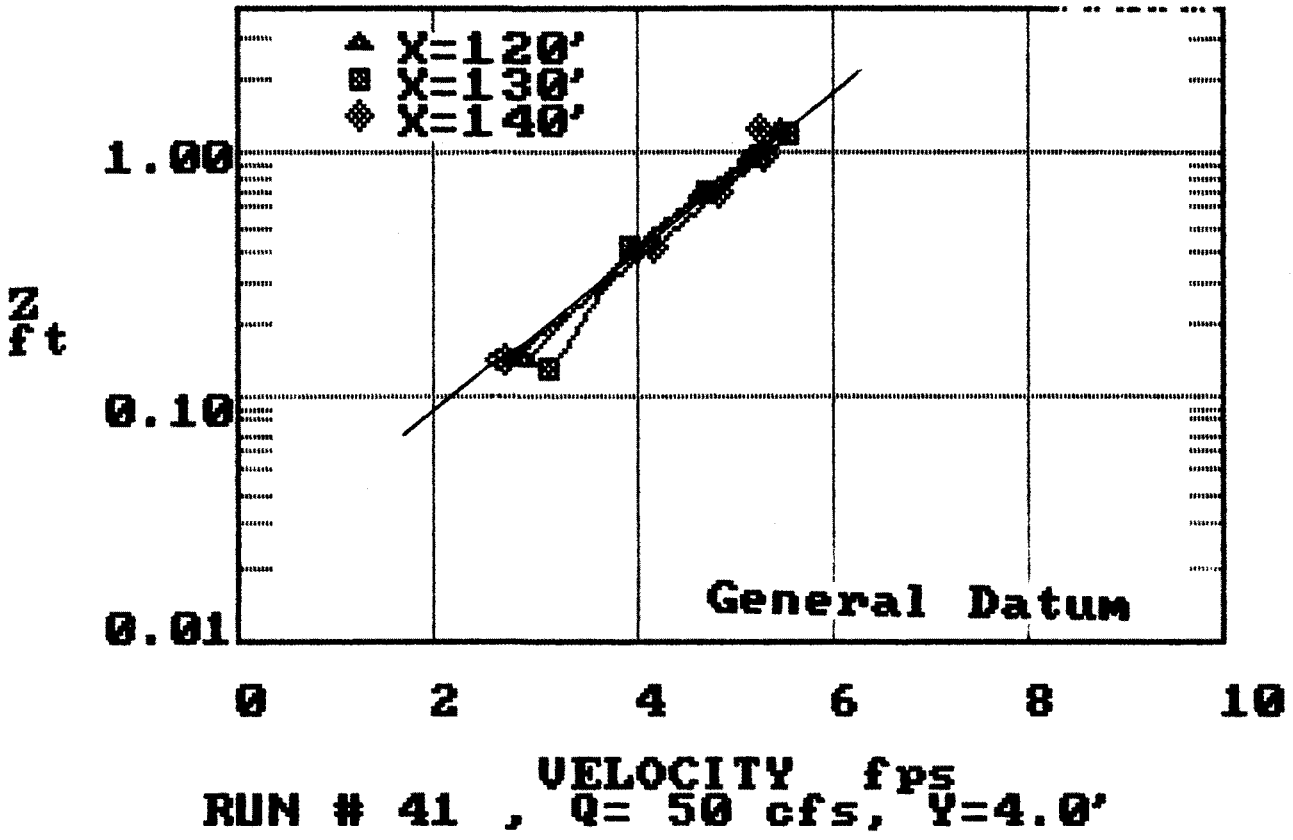
RUN # 37 , Q= 25 cfs, X=130'



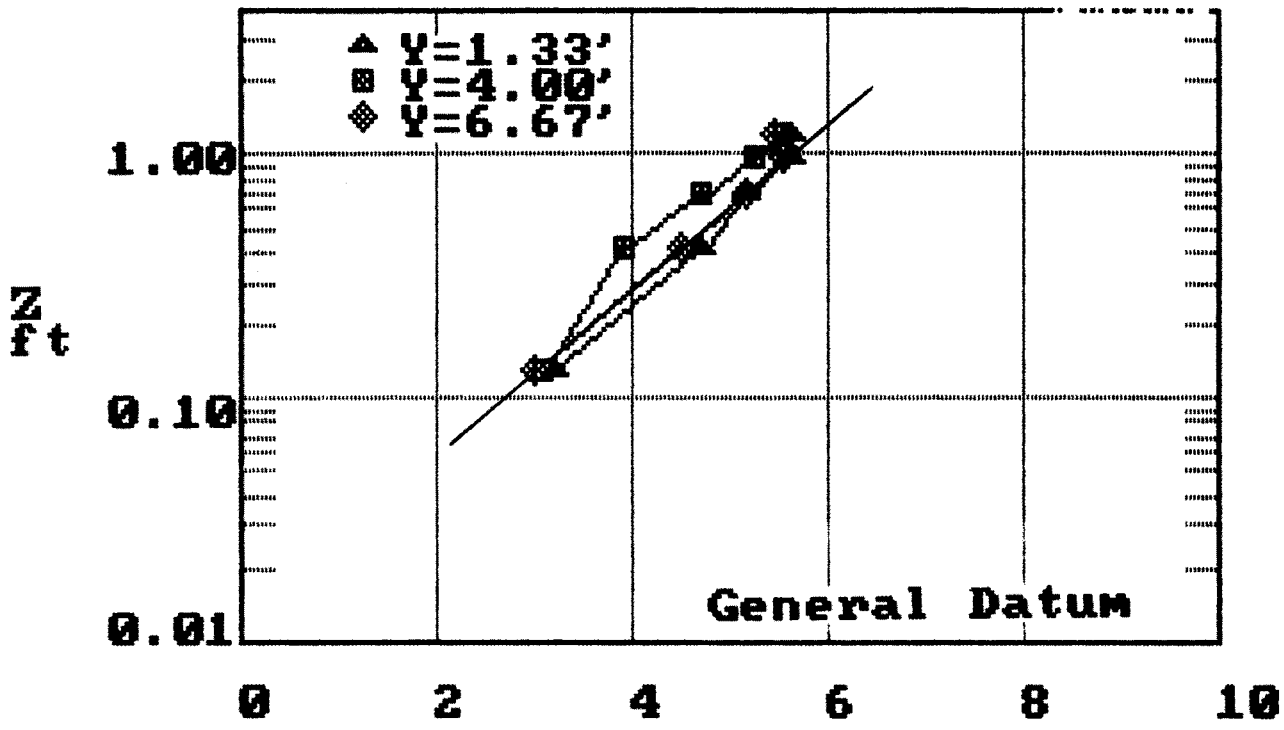
RUN # 40 , Q= 75 cfs, Y=4.0'



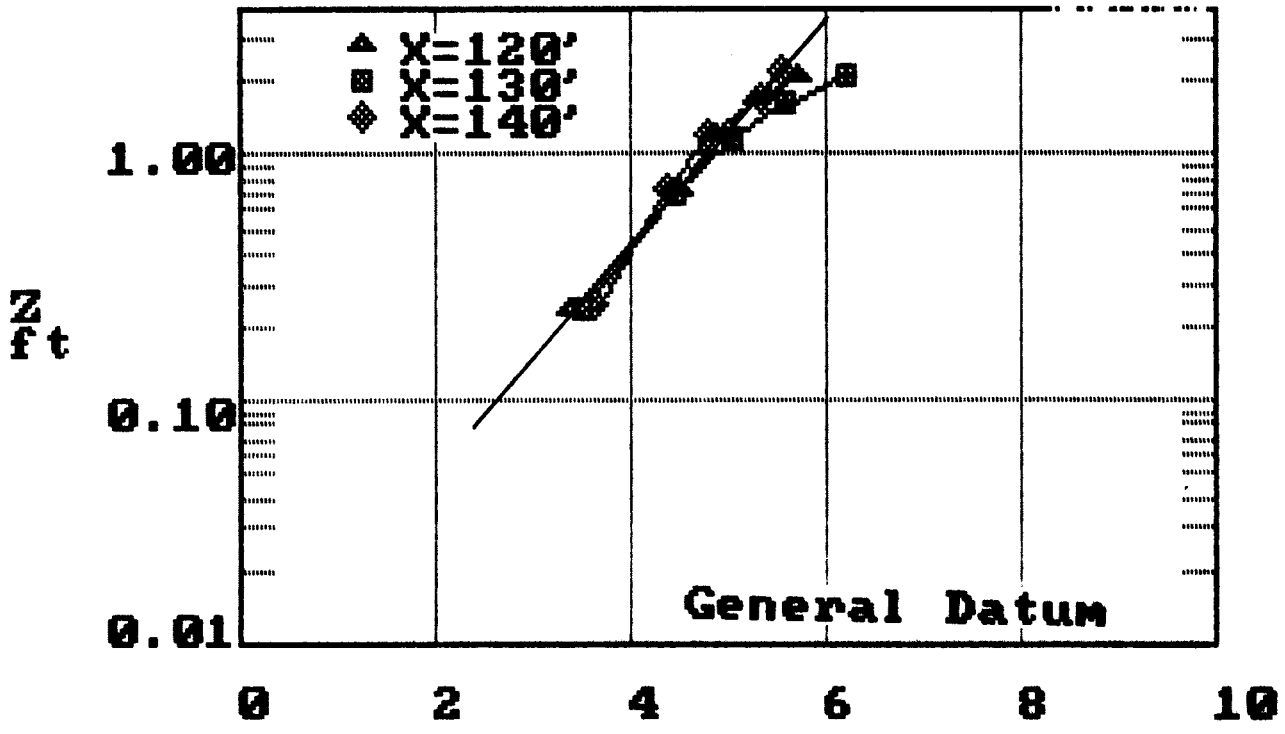
RUN # 40 , Q= 75 cfs, X=130'



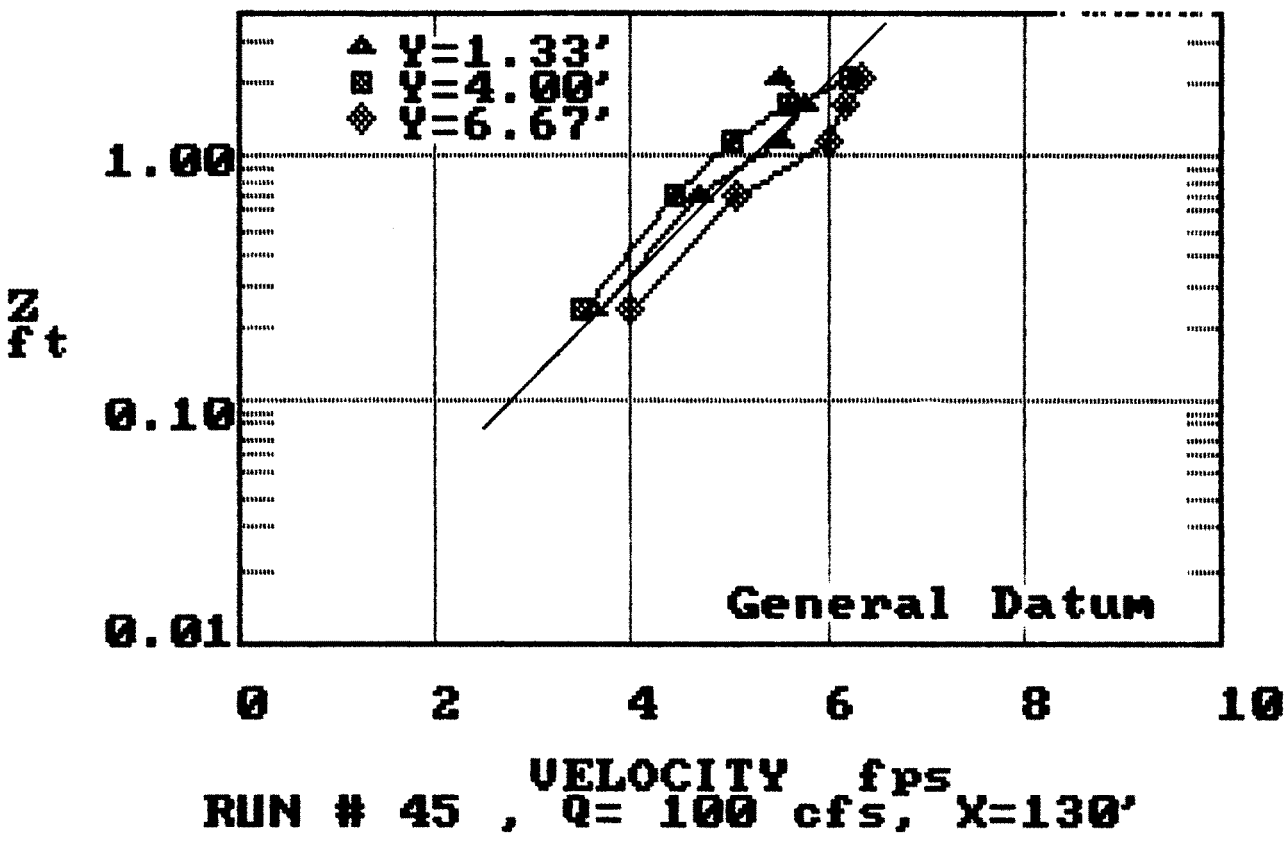
RUN # 41 , Q= 50 cfs, Y=4.0'



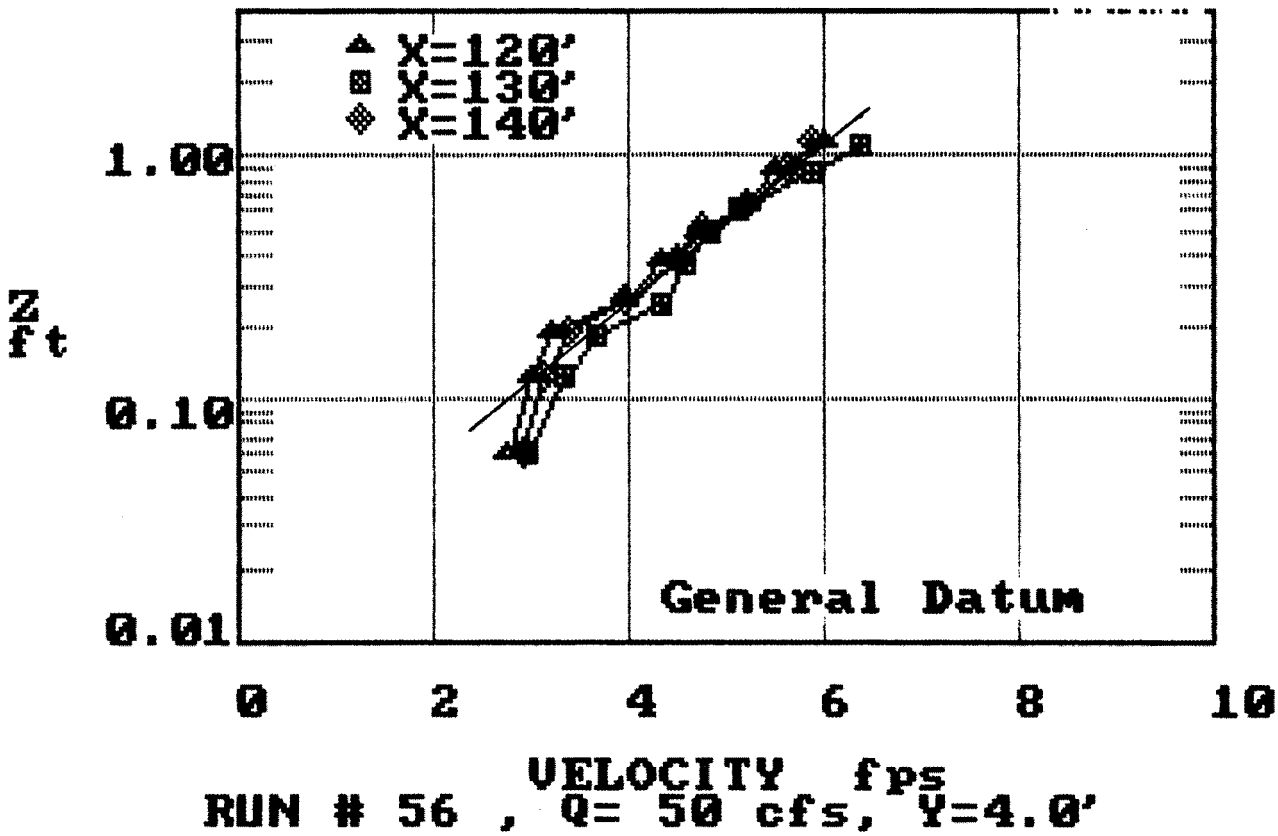
RUN # 41 , Q= 50 cfs, X=130'



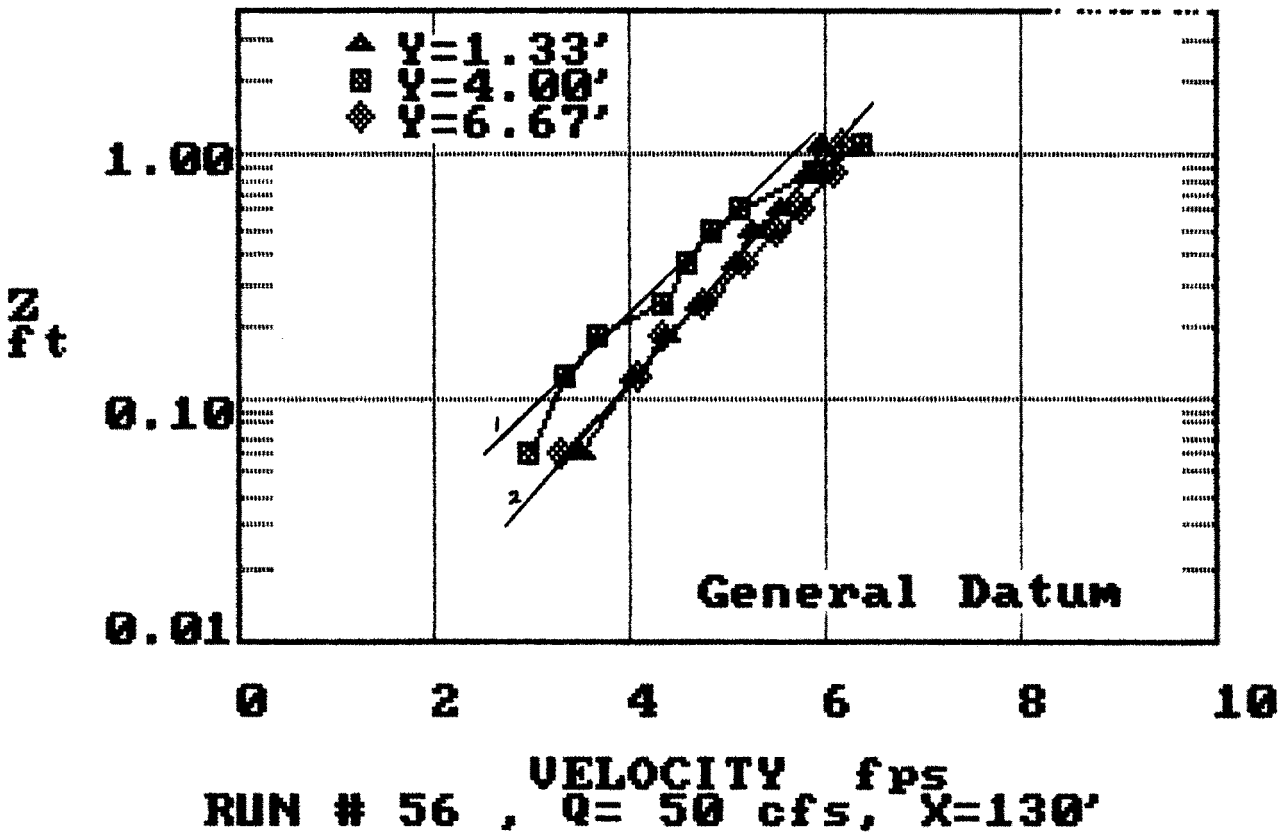
RUN # 45 , Q= 100 cfs, Y=4.0'



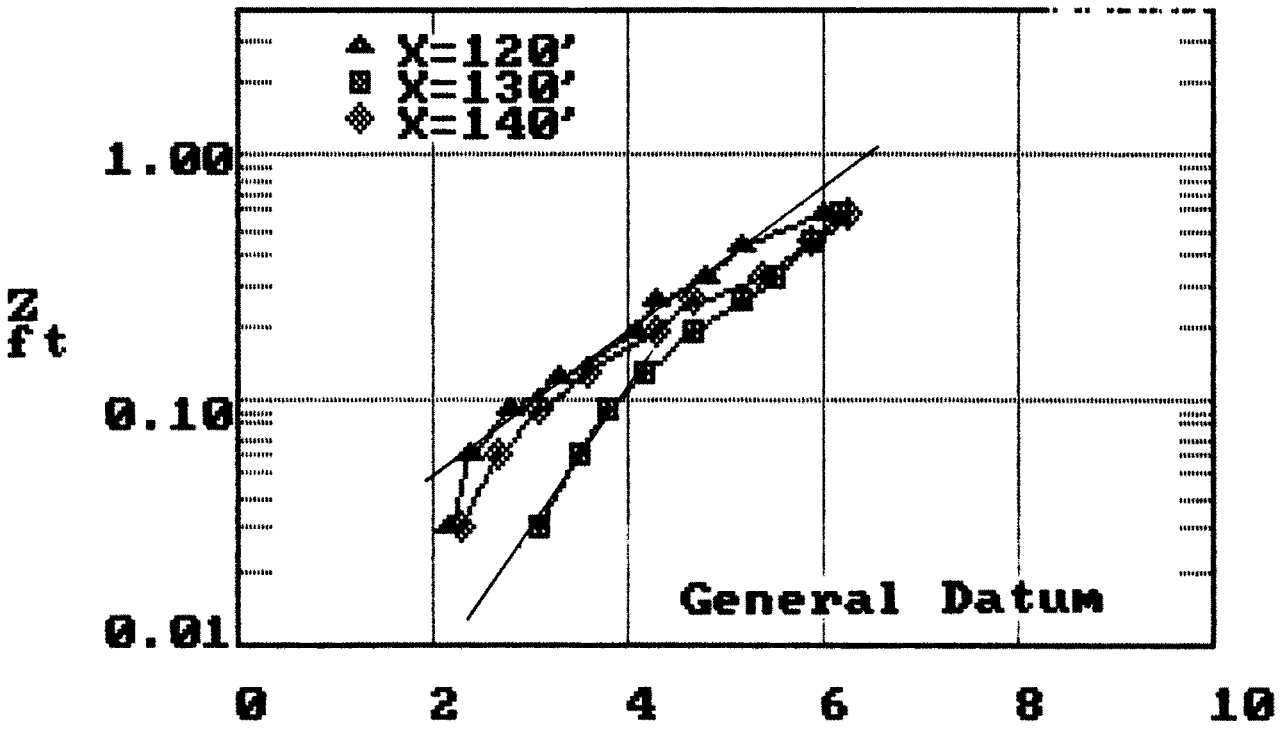
RUN # 45 , Q= 100 cfs, X=130'



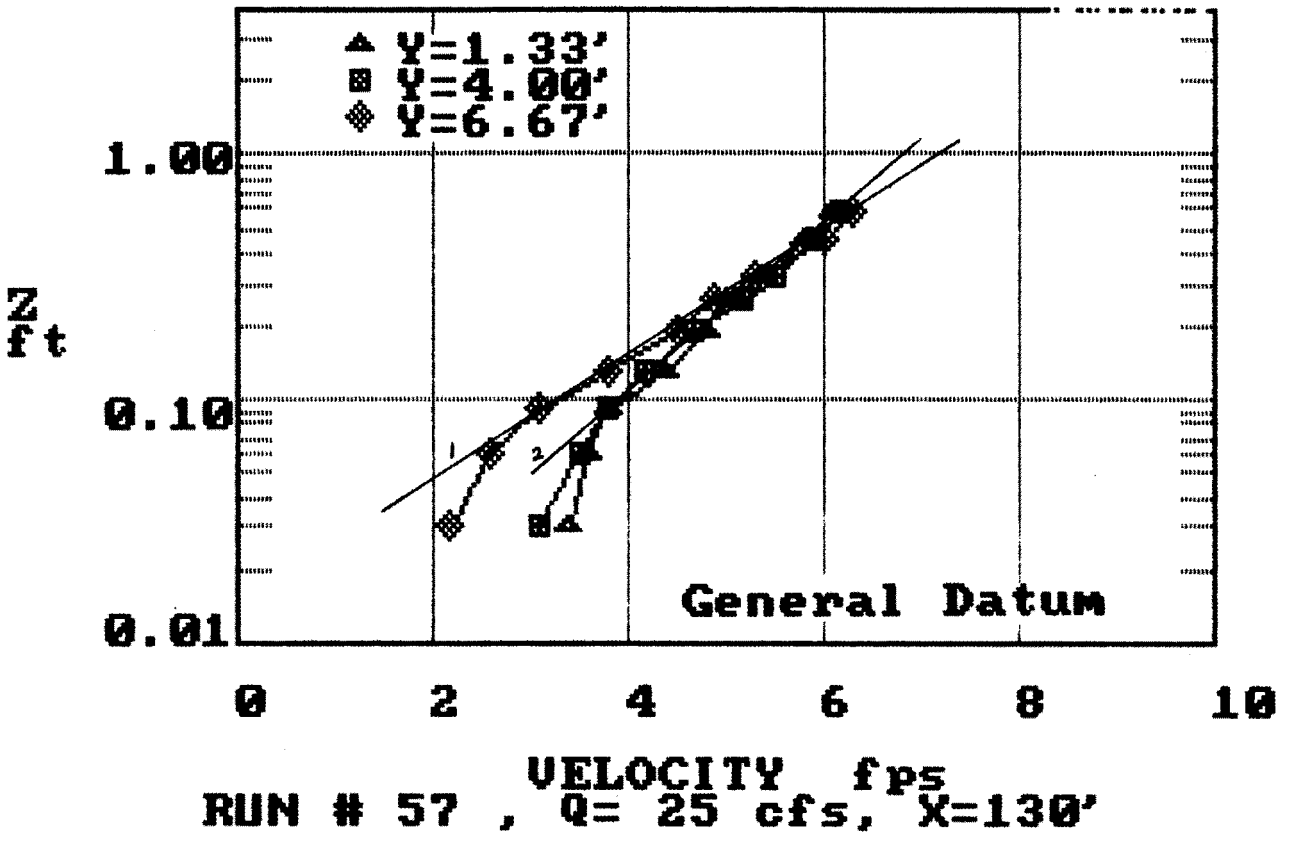
RUN # 56 , Q= 50 cfs, Y=4.0'



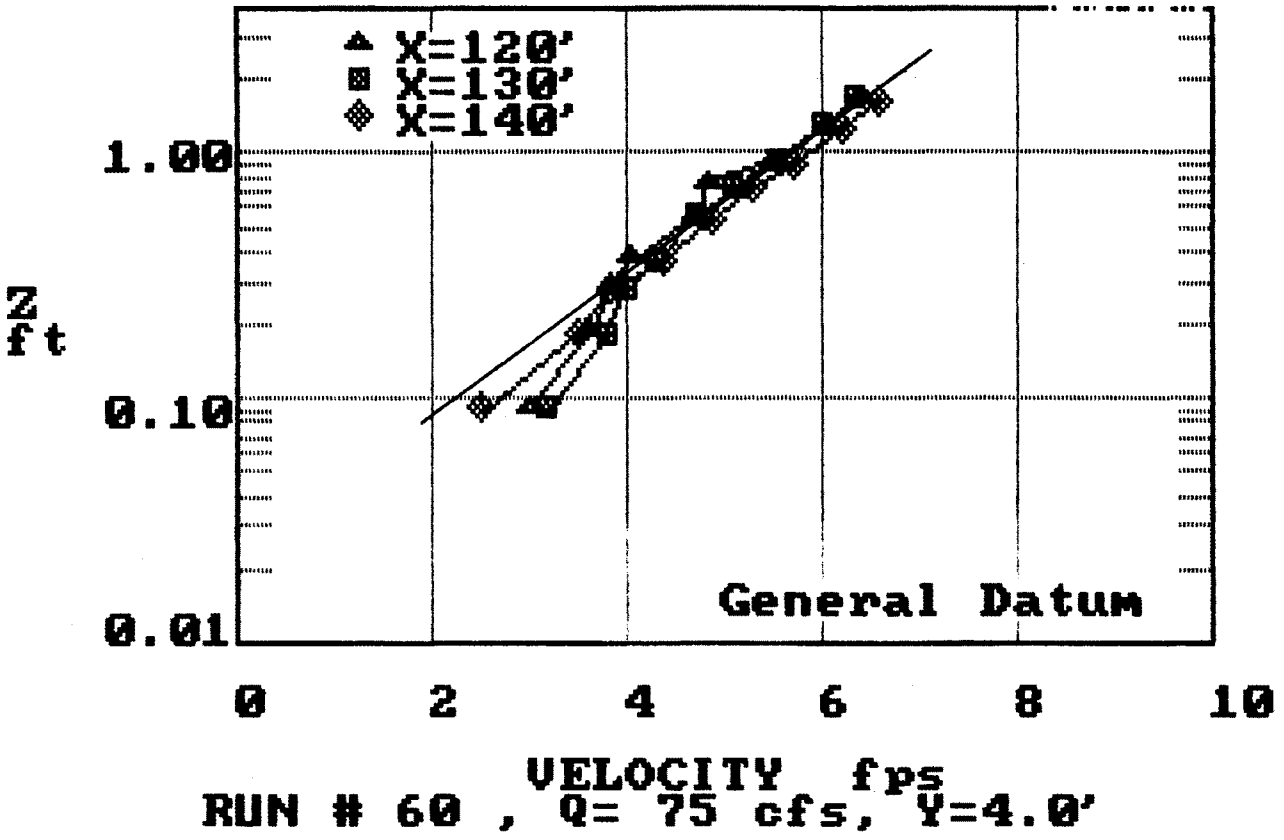
RUN # 56 , Q= 50 cfs, X=130'



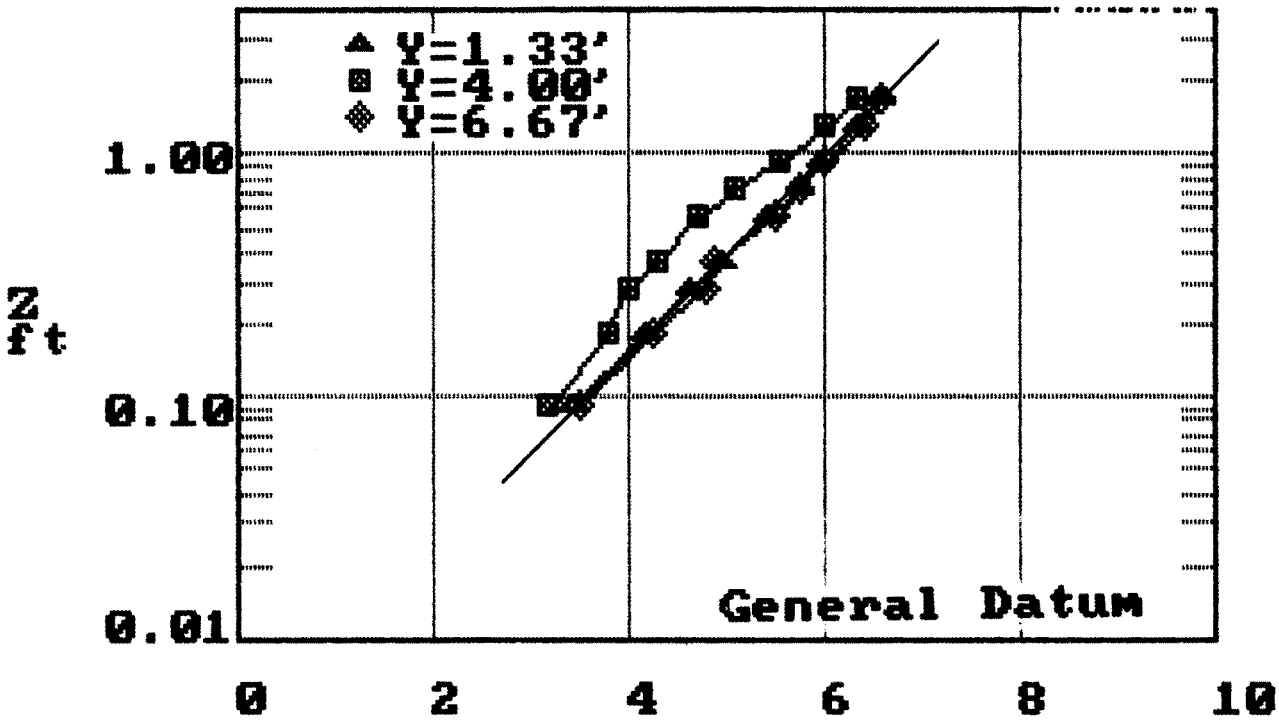
RUN # 57 , Q= 25 cfs, Y=4.0'



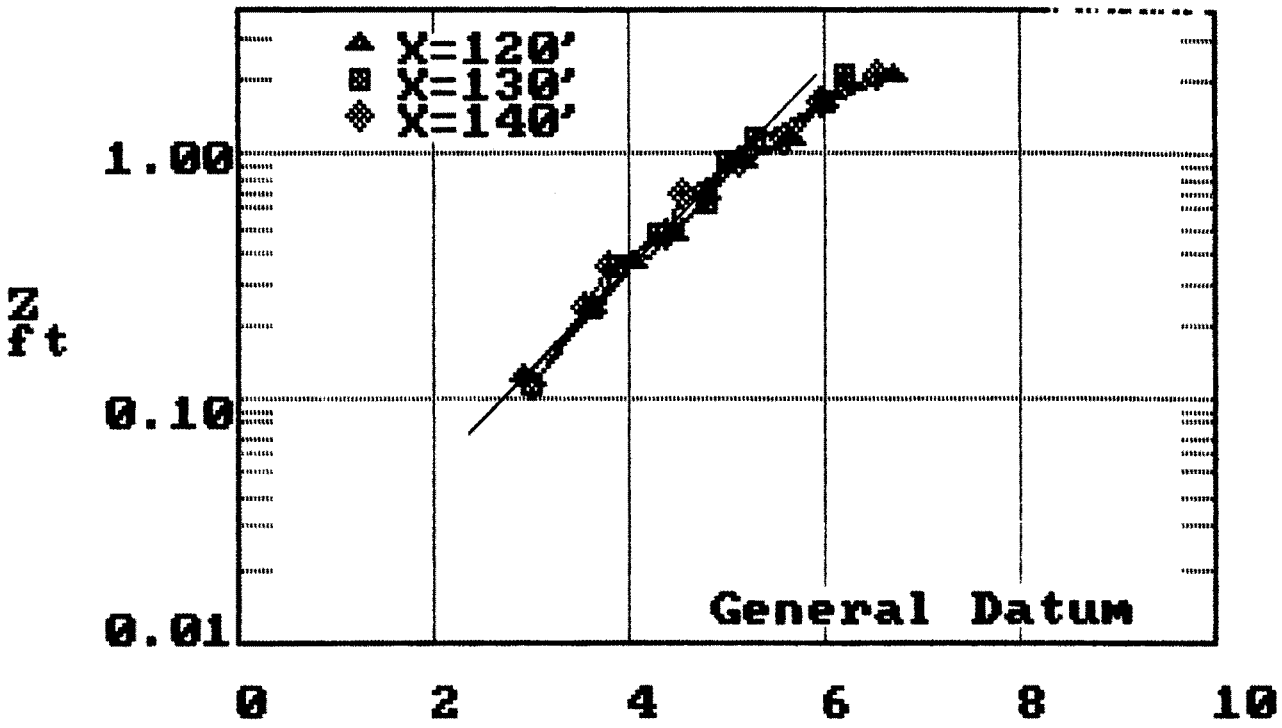
RUN # 57 , Q= 25 cfs, X=130'



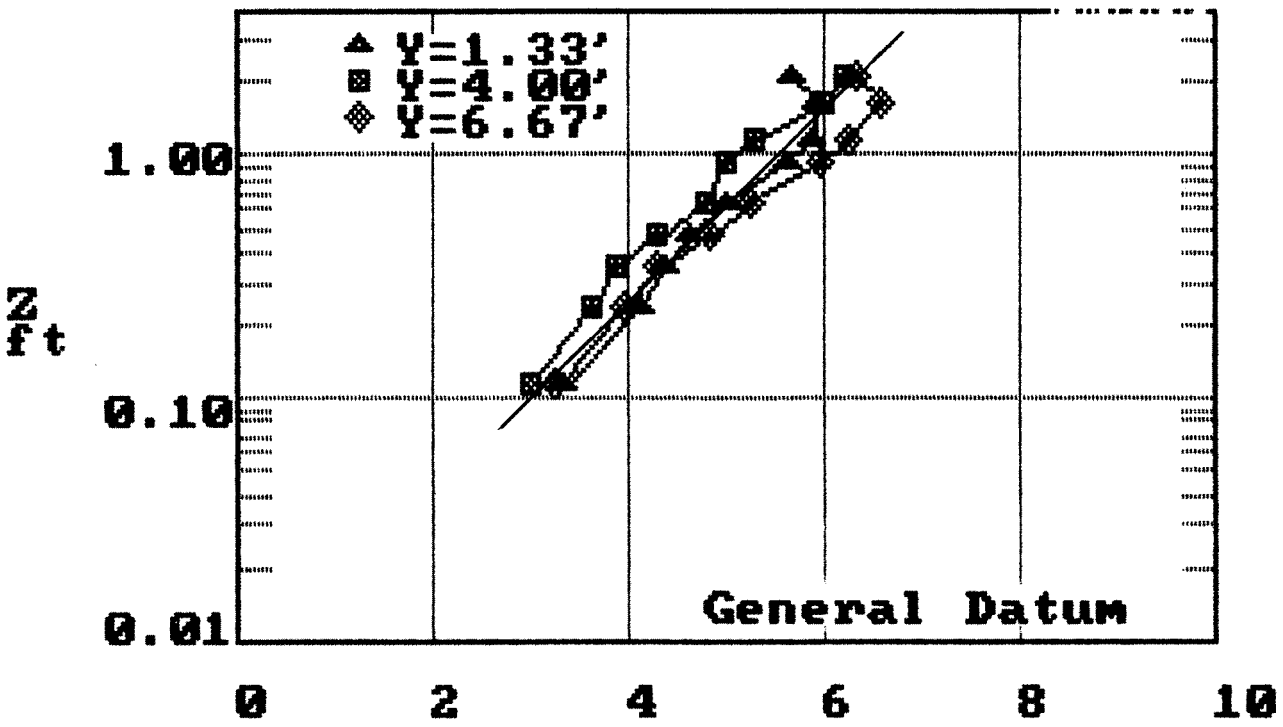
RUN # 60 , Q= 75 cfs, Y=4.0'



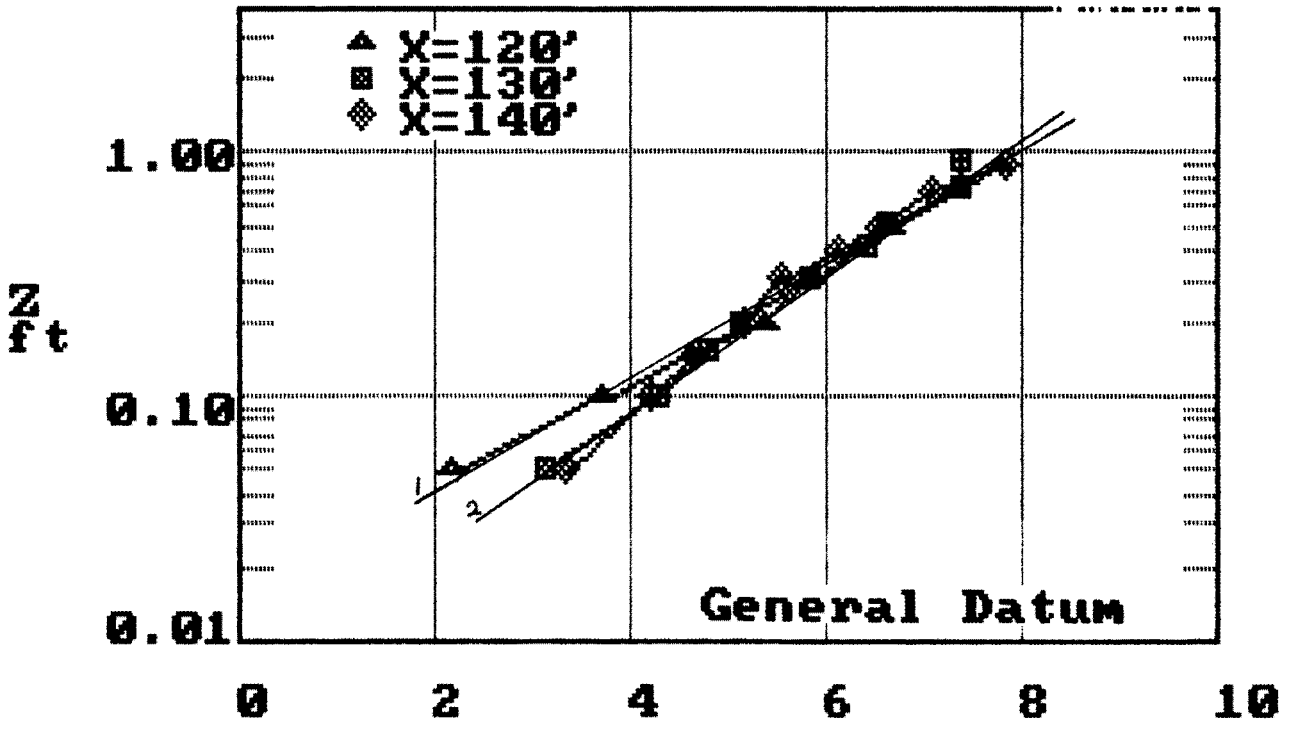
RUN # 60 , Q= 75 cfs, X=130'



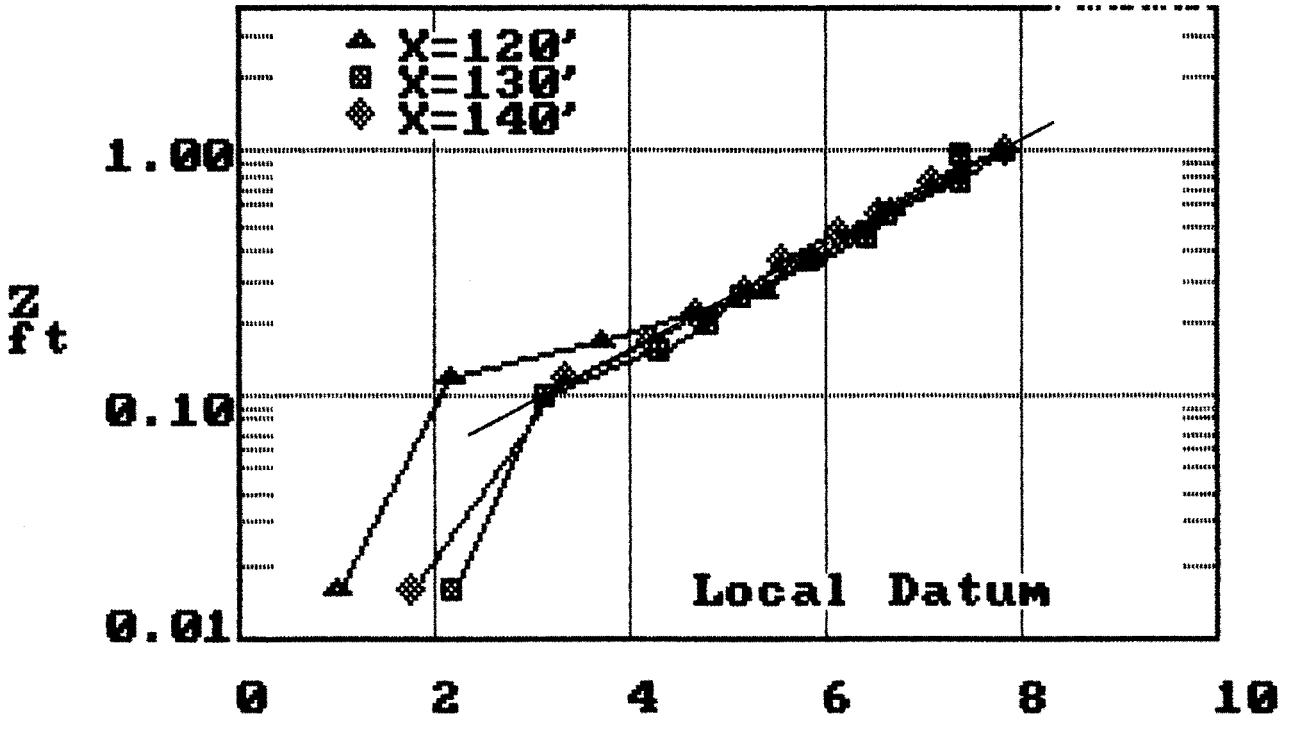
RUN # 64 , Q= 100 cfs, 4.0'



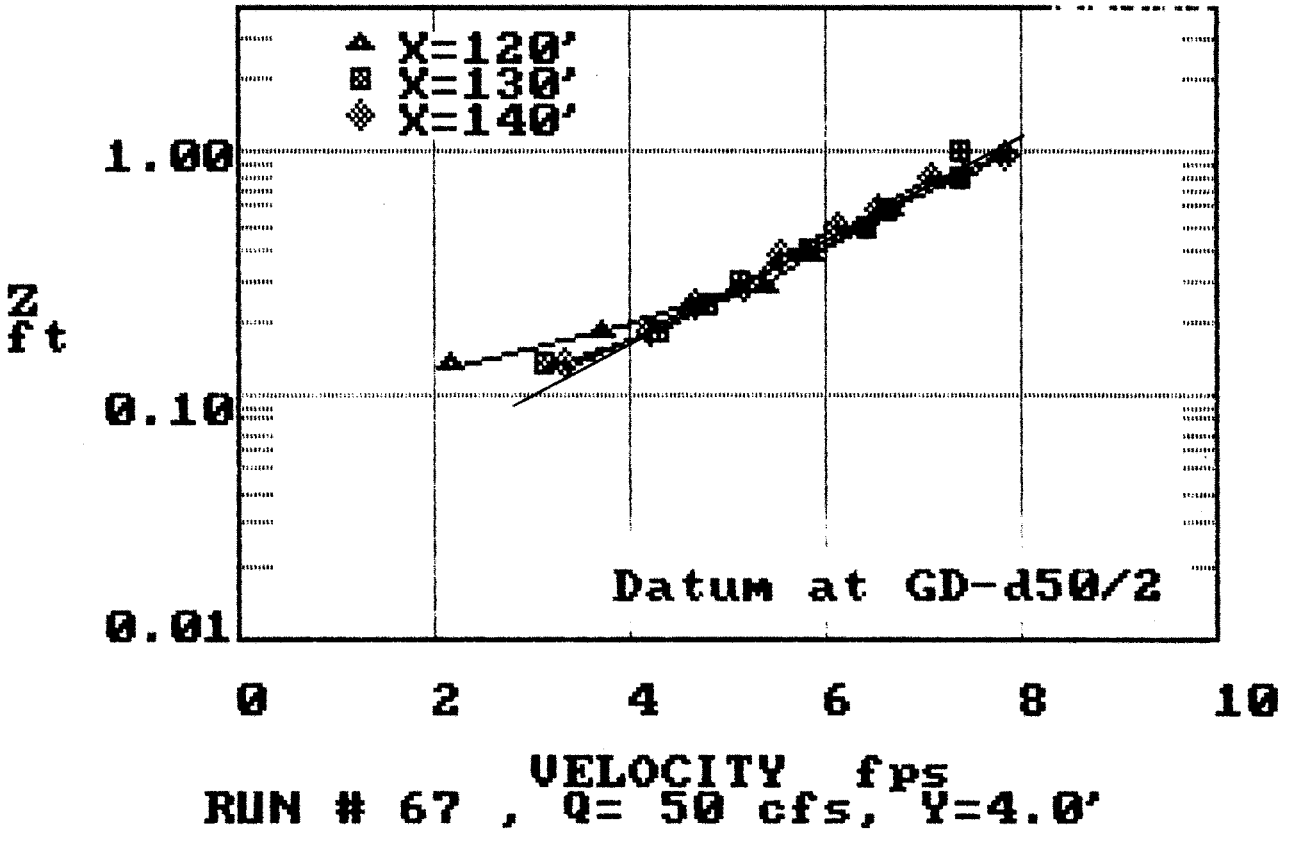
RUN # 64 , Q= 100 cfs, X=130'



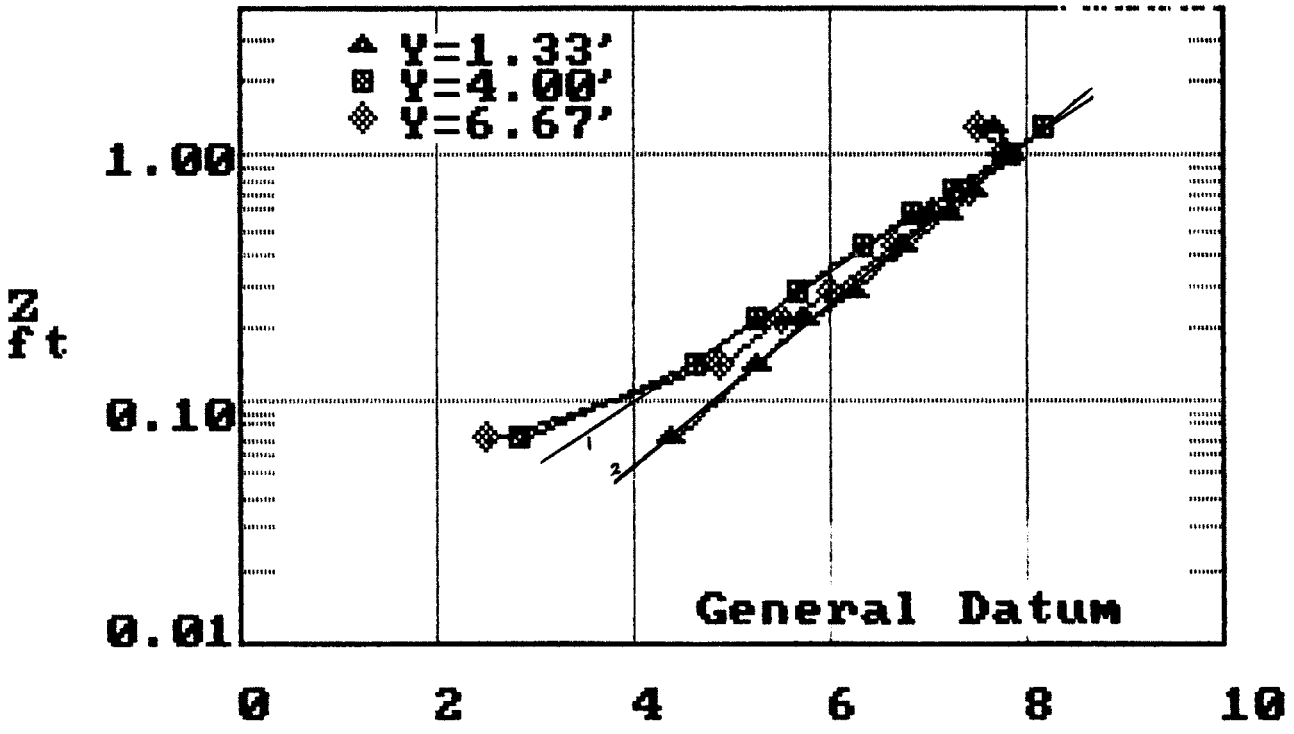
RUN # 67 , Q= 50 cfs, Y=4.0'



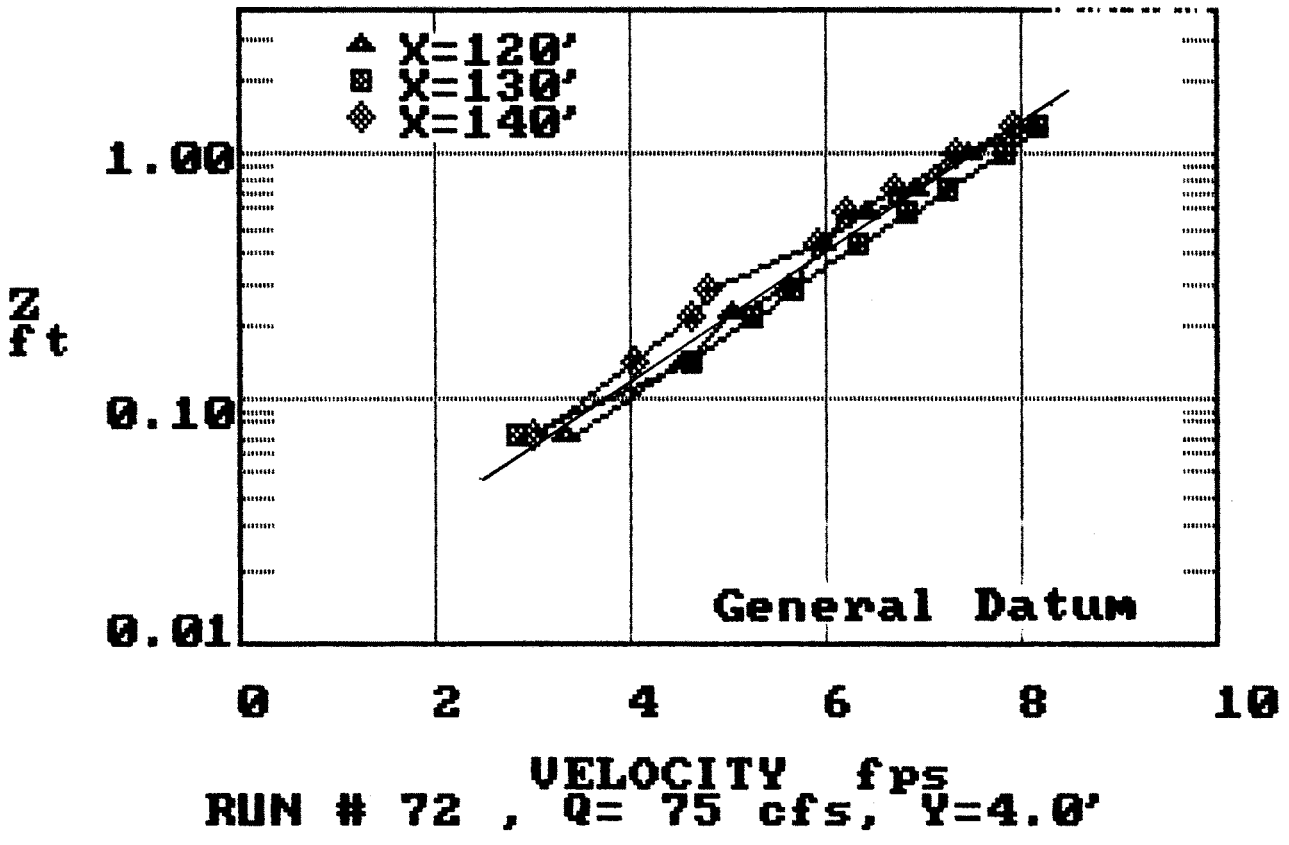
RUN # 67 , Q= 50 cfs, Y=4.0'



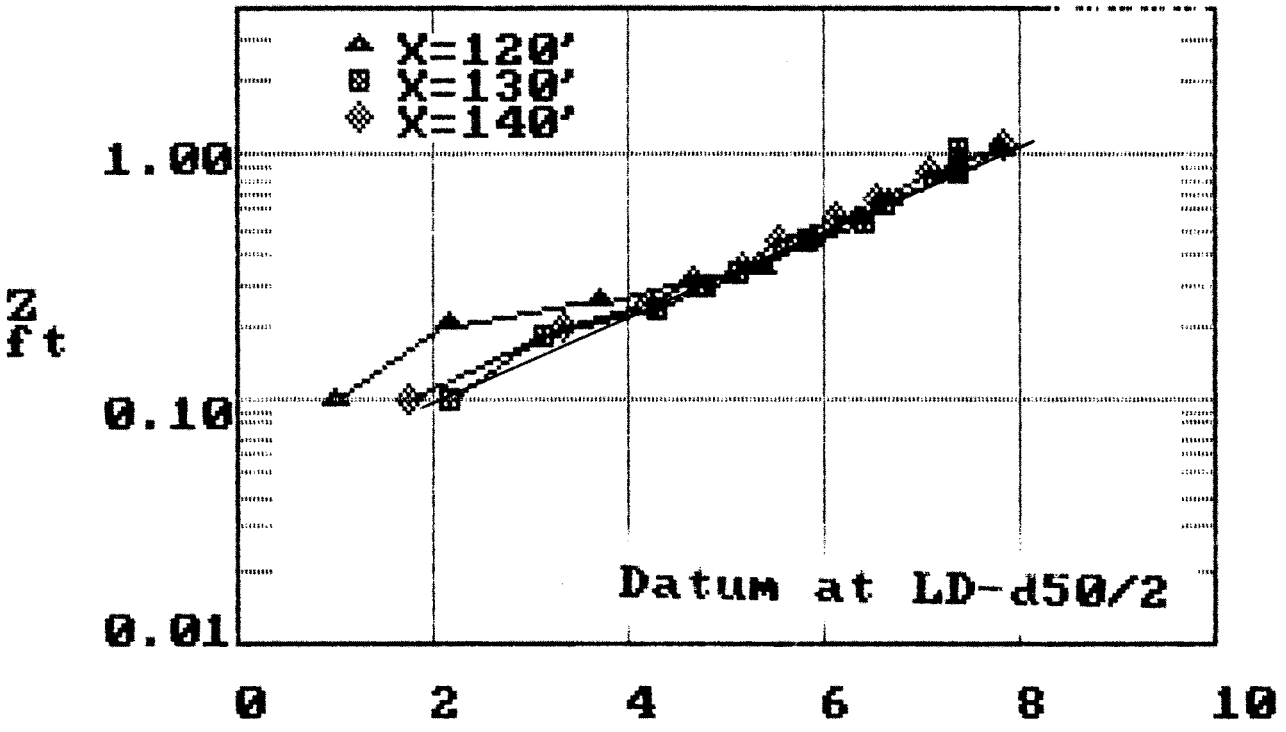
RUN # 67 , Q= 50 cfs, Y=4.0'



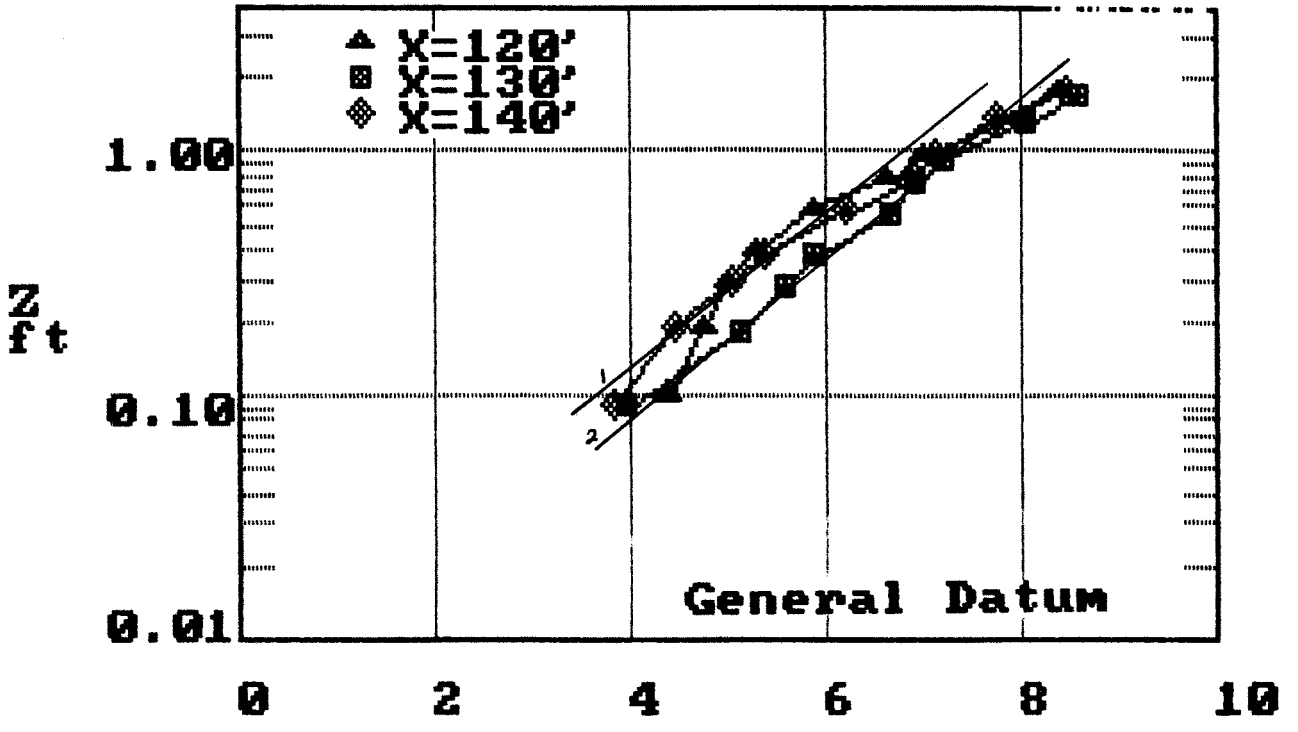
RUN # 72 , Q= 75 cfs, X=130'



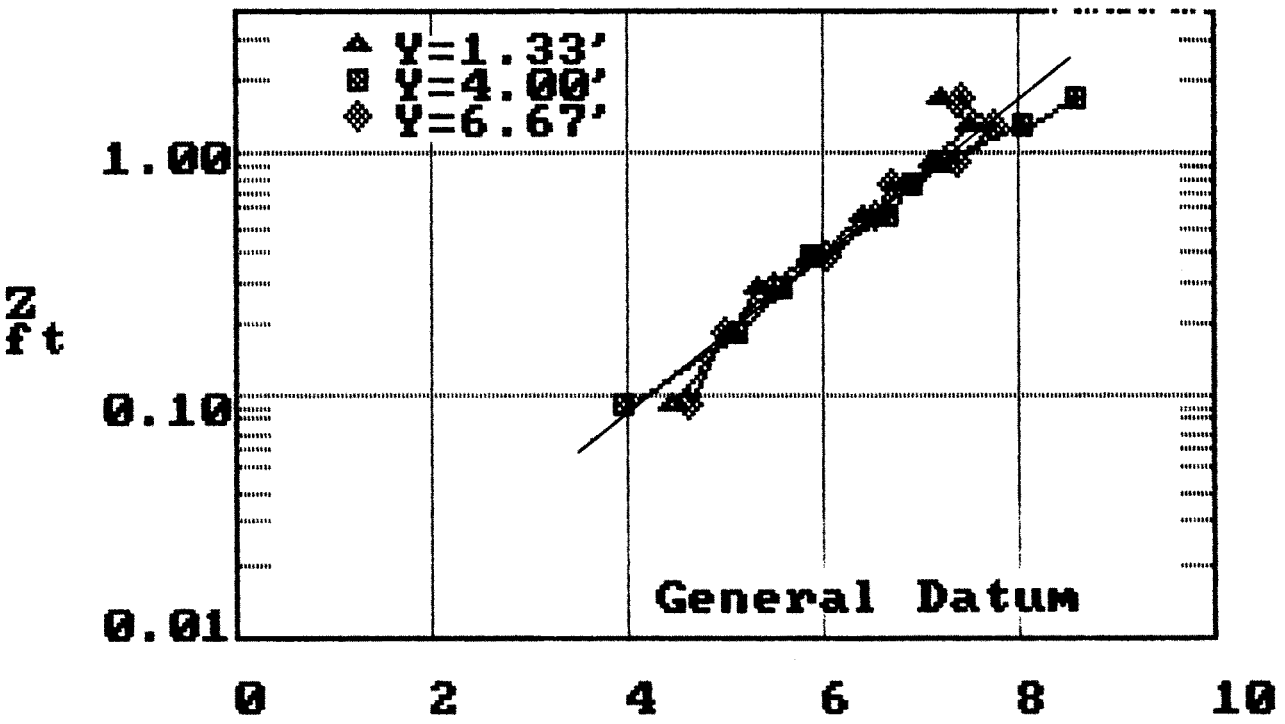
RUN # 72 , Q= 75 cfs, Y=4.0'



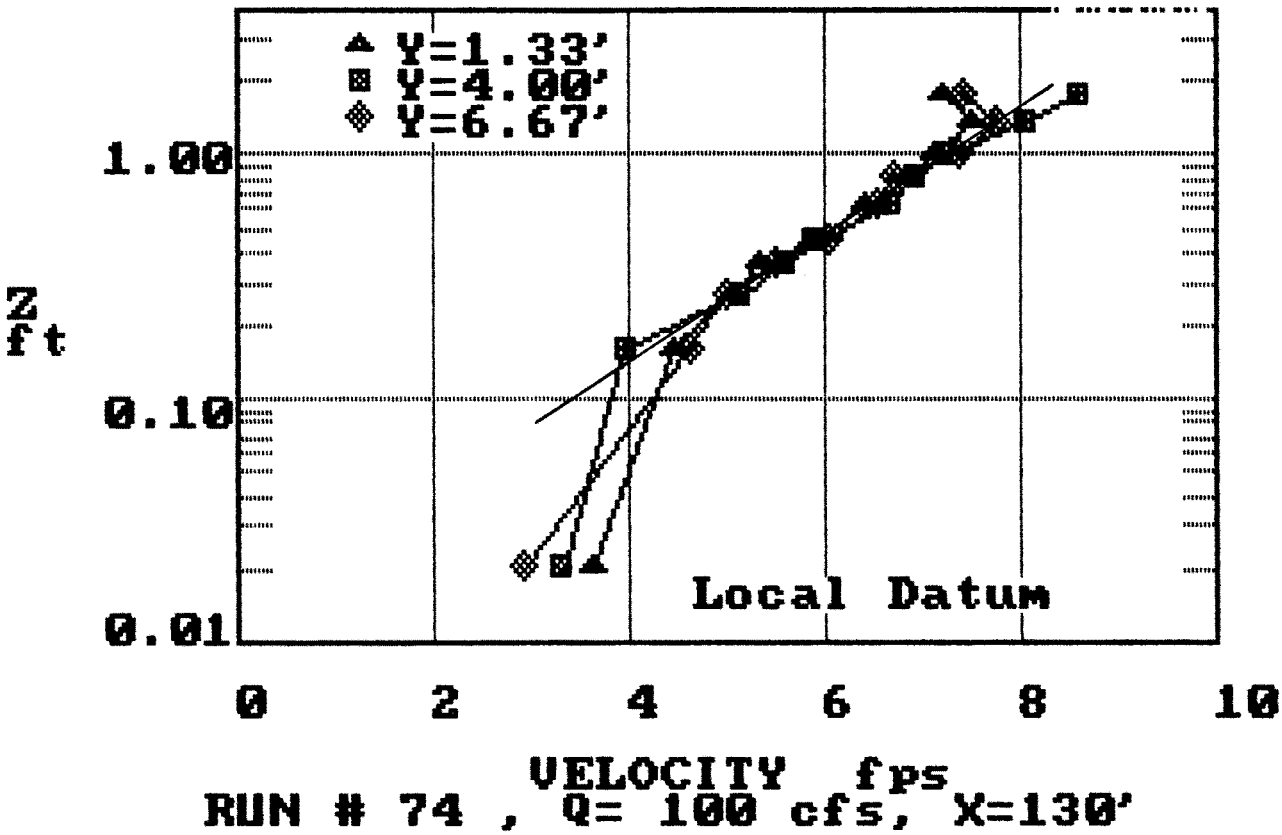
RUN # 67 , Q= 50 cfs, Y=4.0' LD



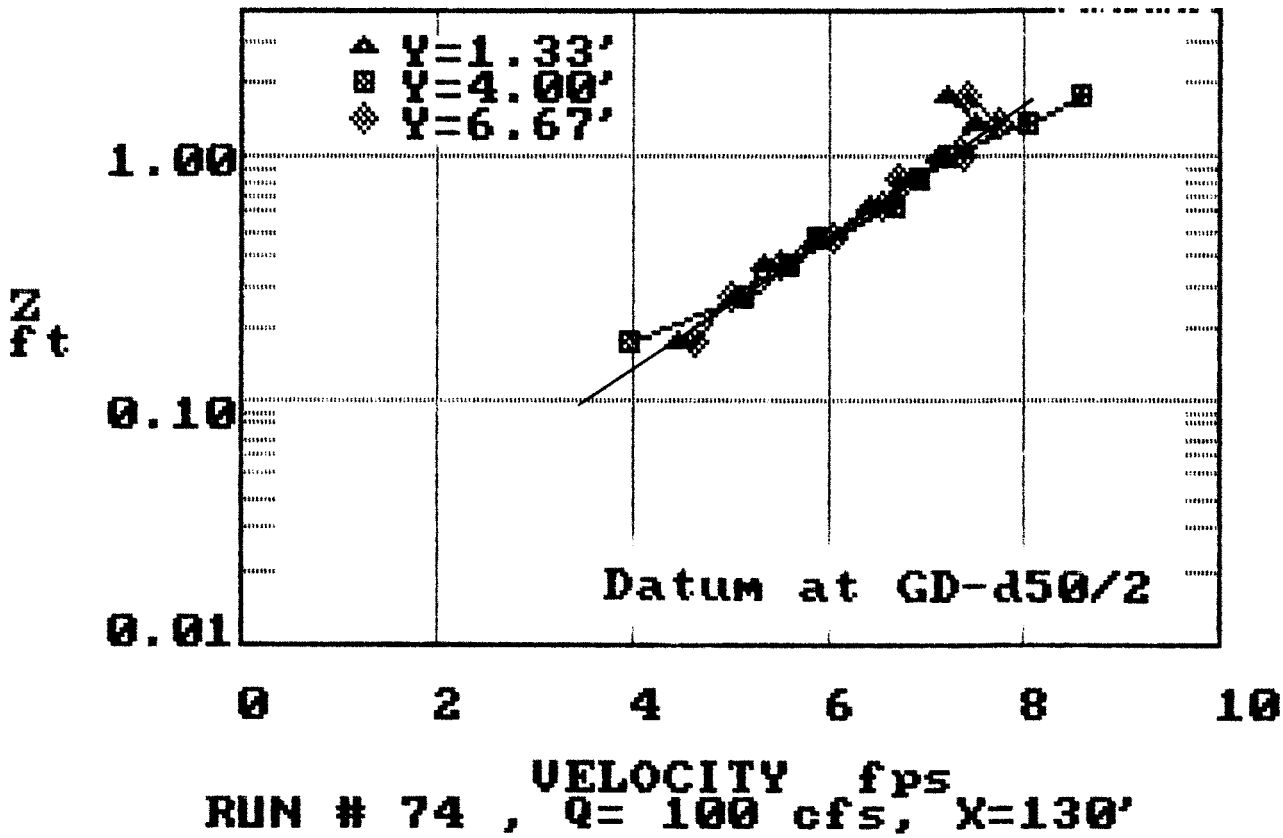
RUN # 74 , Q= 100 cfs, Y=4.0'



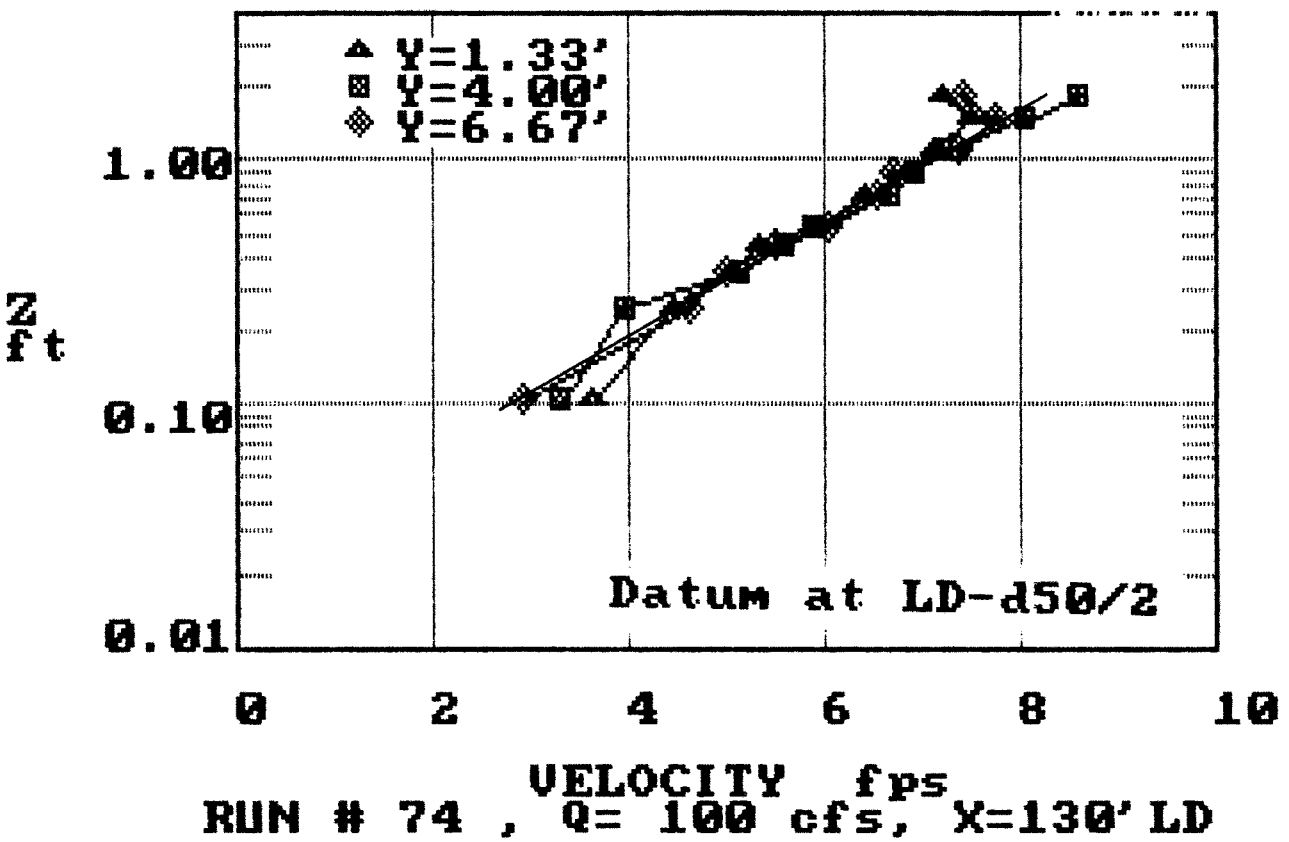
RUN # 74 , Q= 100 cfs, X=130'



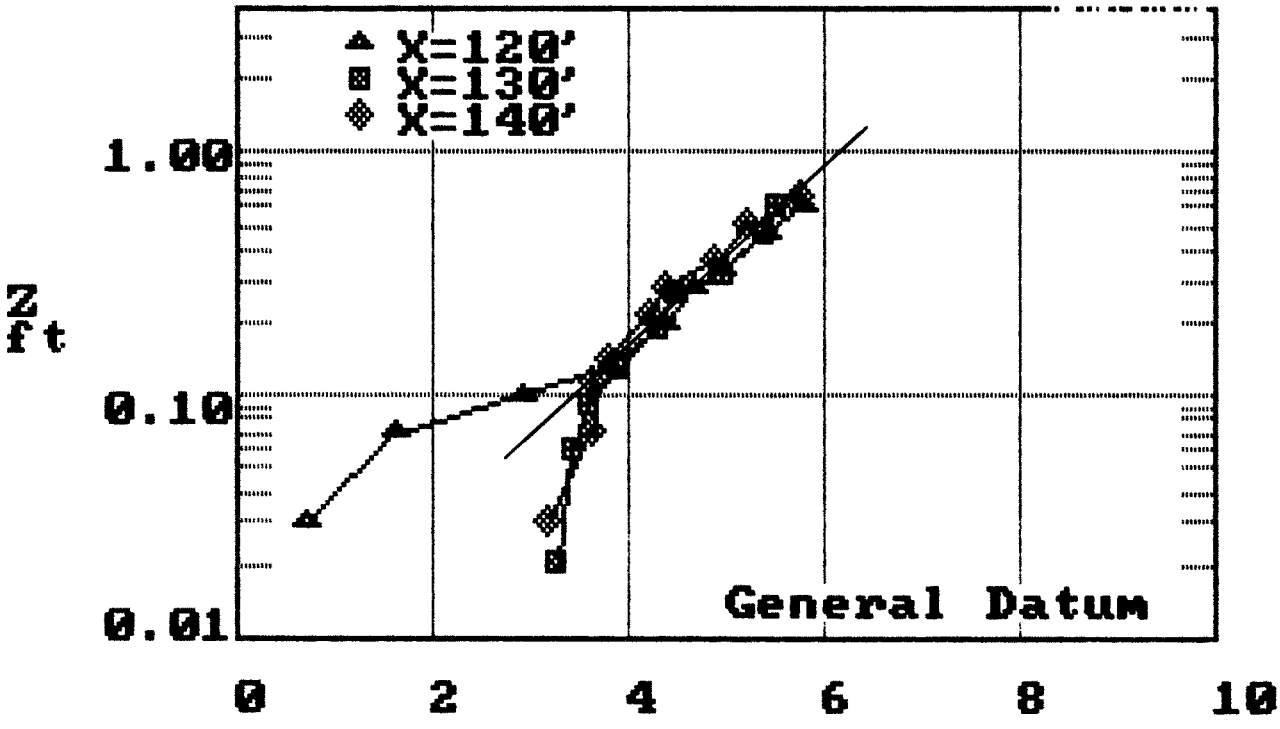
RUN # 74 , Q= 100 cfs, X=130'



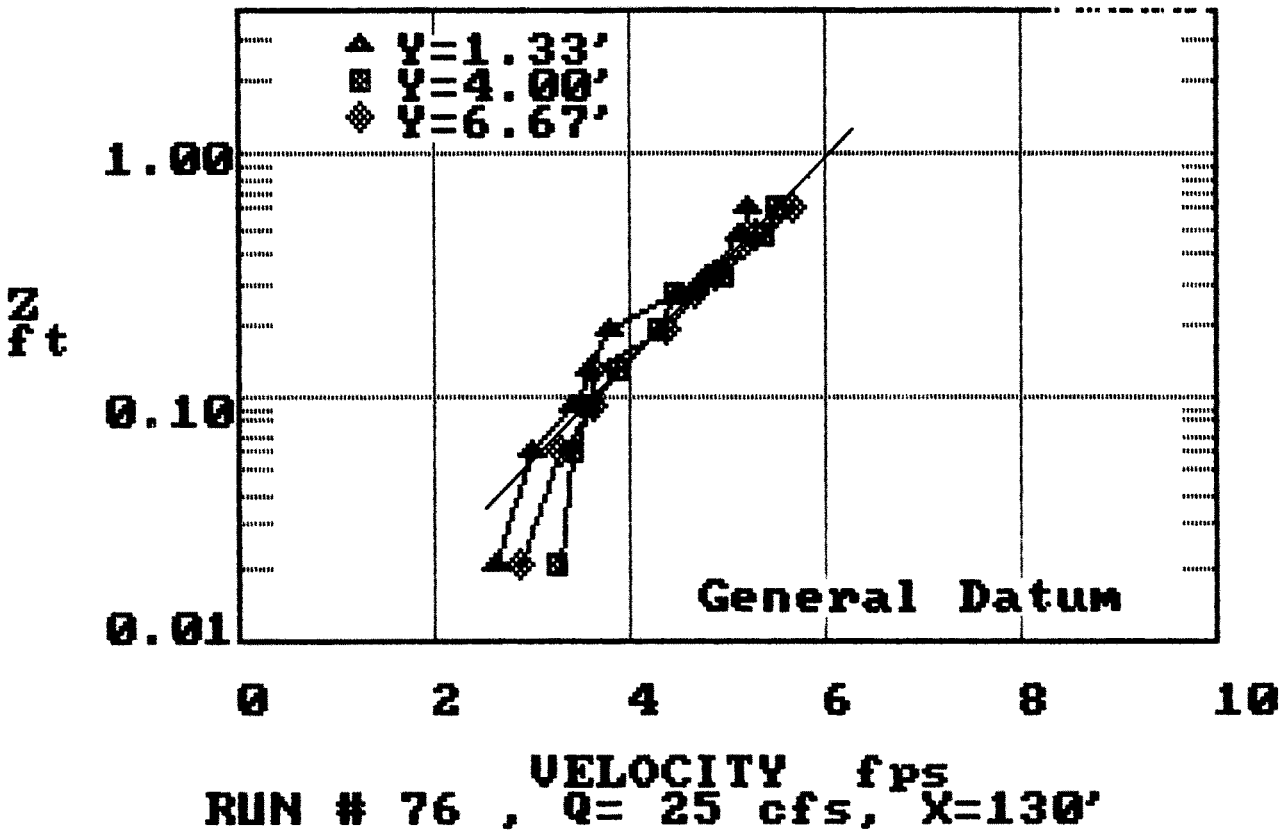
RUN # 74 , Q= 100 cfs, X=130'



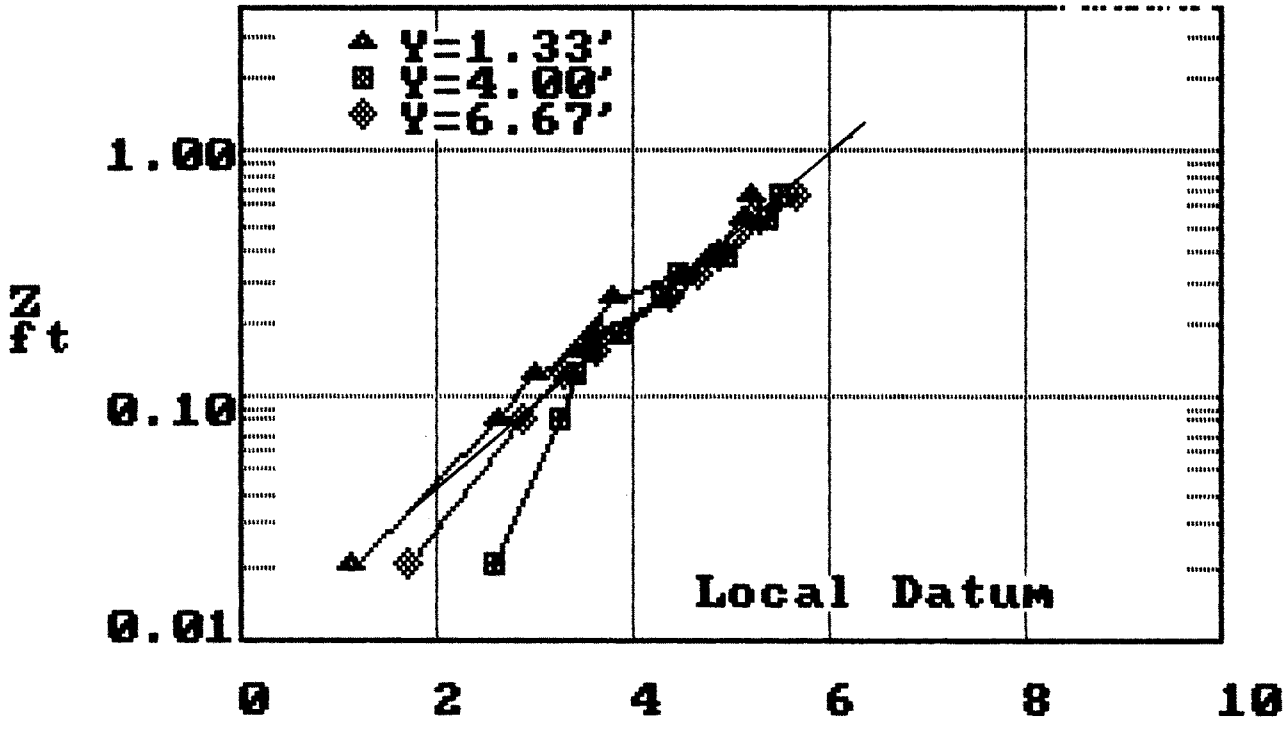
RUN # 74 , Q= 100 cfs, X=130' LD



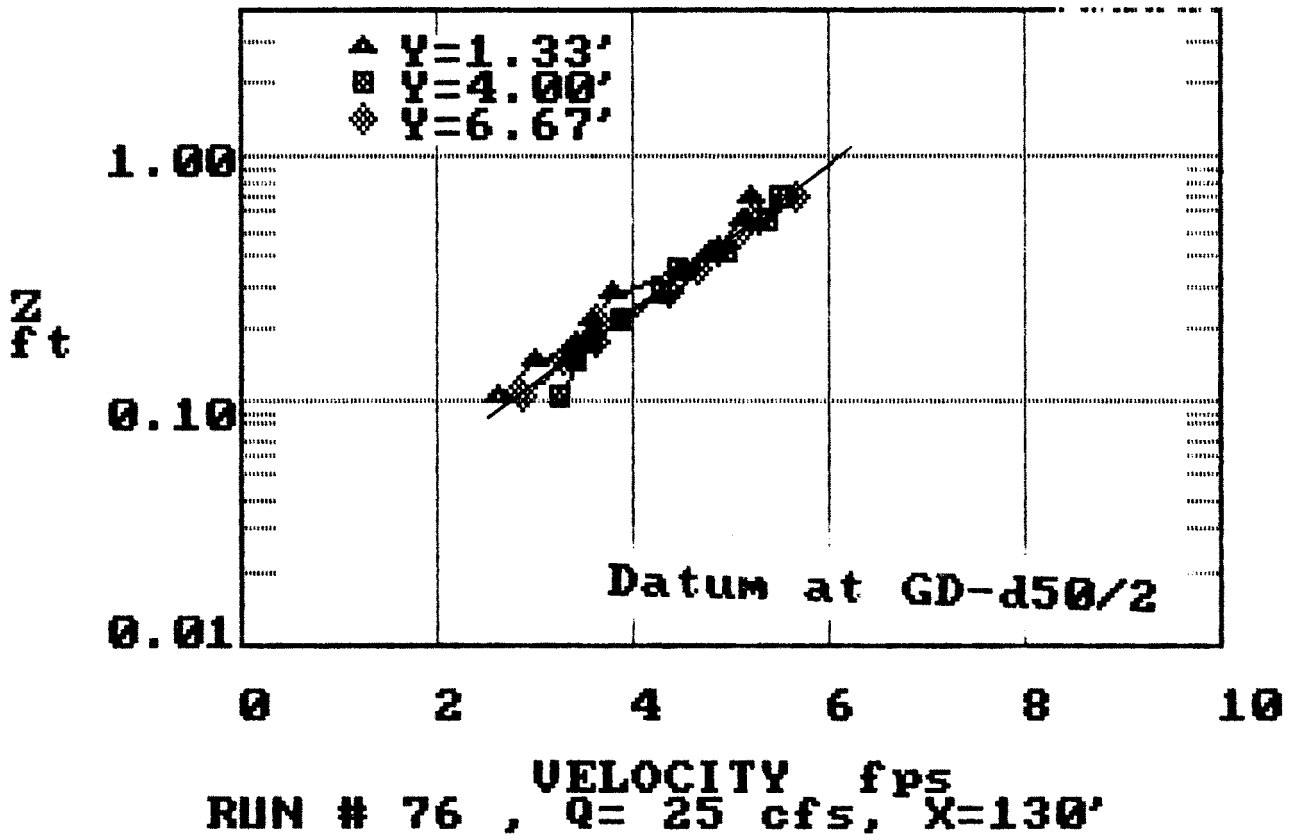
RUN # 76 , Q= 25 cfs, Y=4.0'



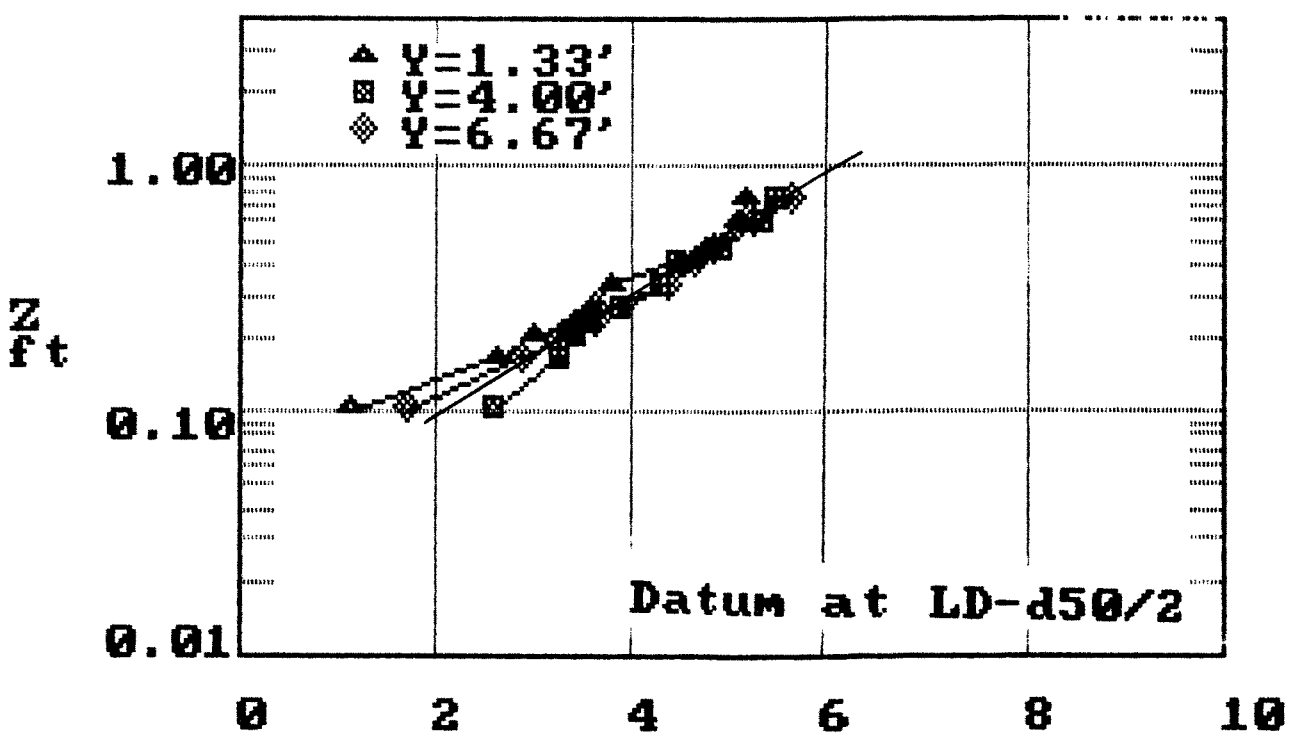
RUN # 76 , Q= 25 cfs, X=130'



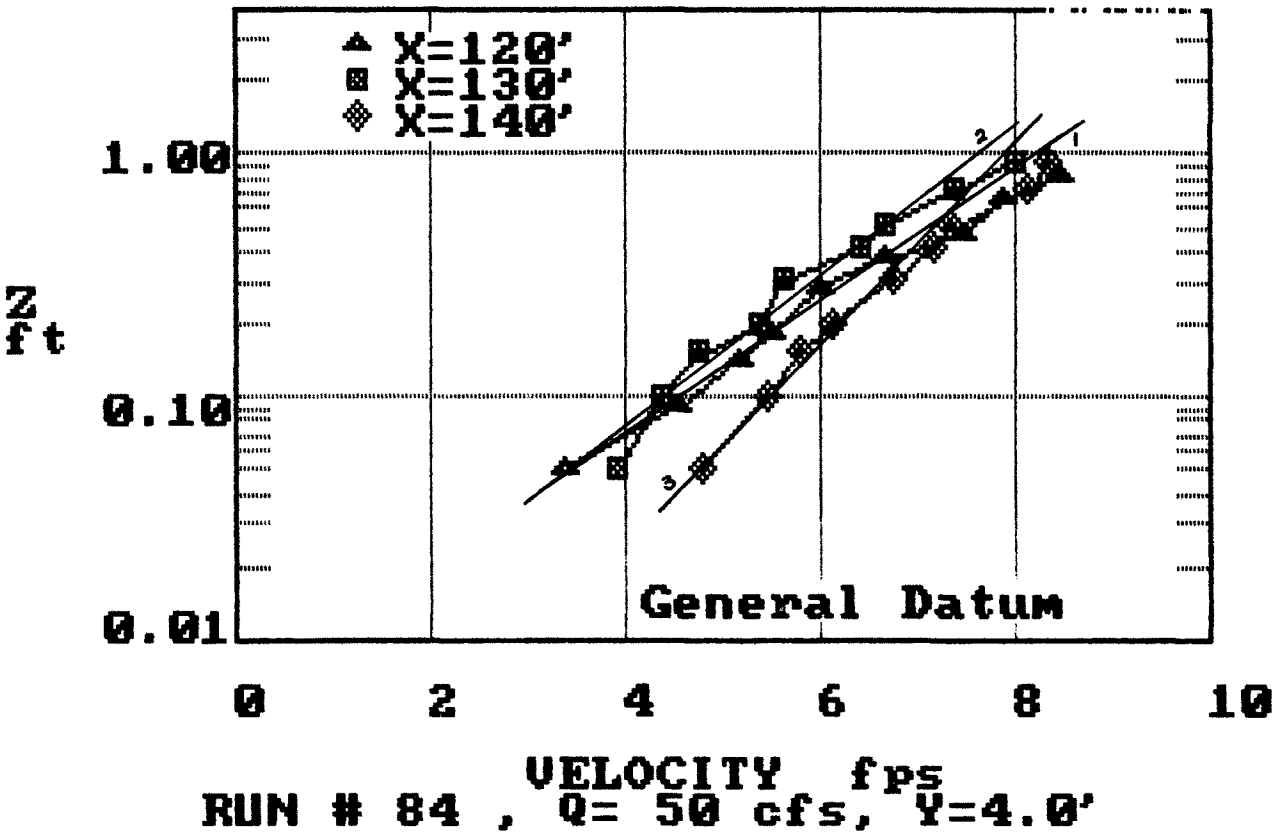
RUN # 76 , Q= 25 cfs, X=130'



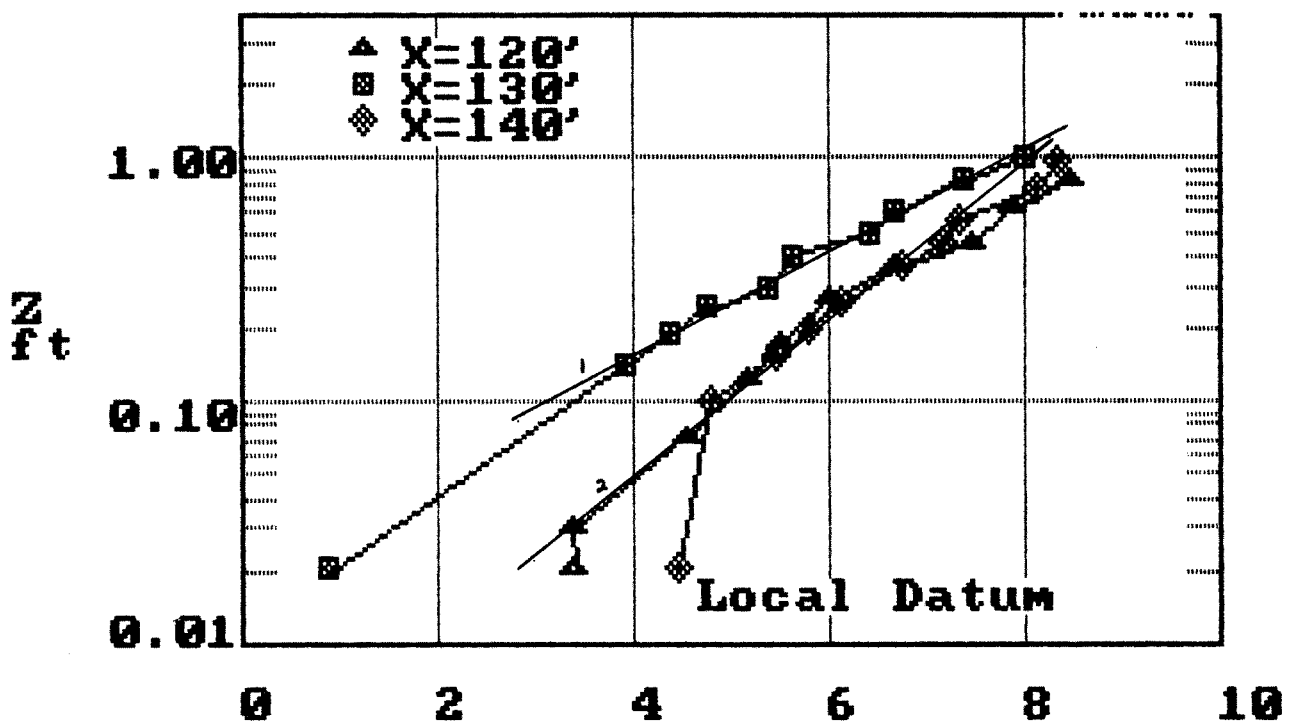
RUN # 76 , Q= 25 cfs, X=130'



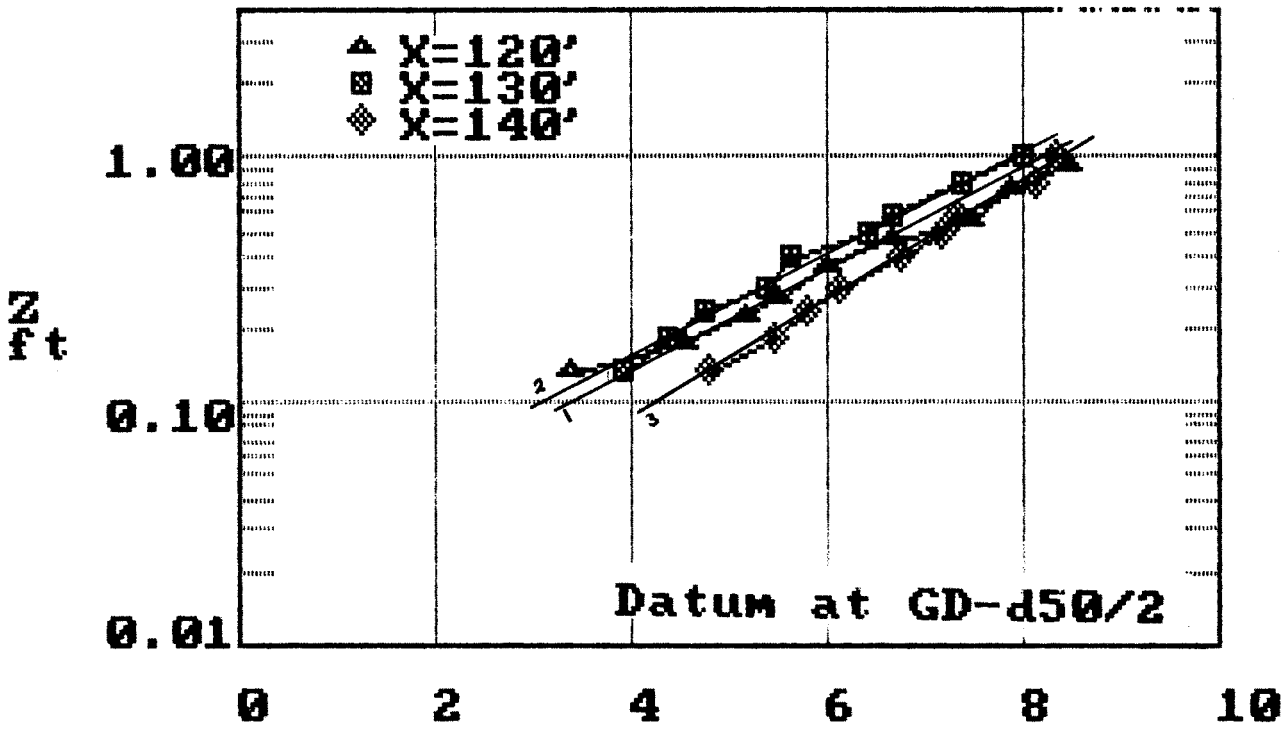
RUN # 76 , Q= 25 cfs, X=130' LD



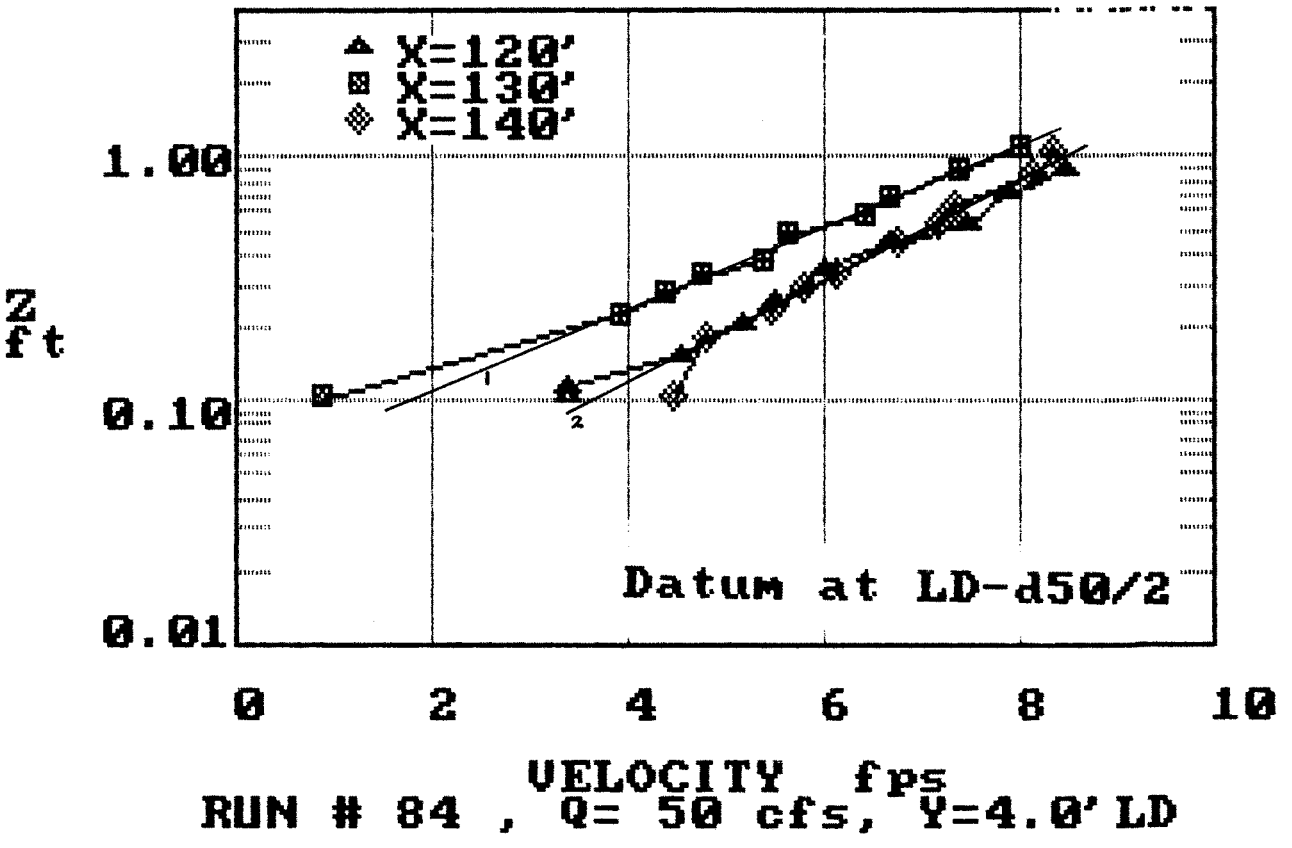
RUN # 84 , Q= 50 cfs, Y=4.0'



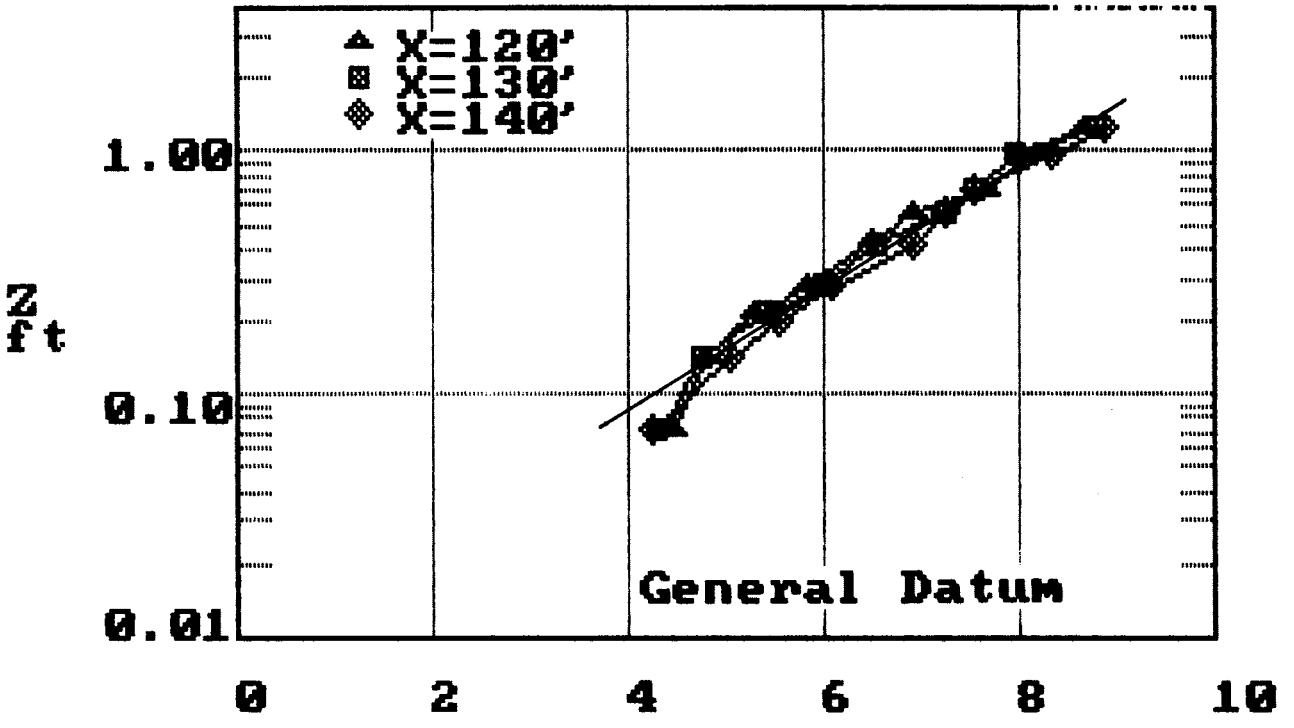
RUN # 84 , Q= 50 cfs, Y=4.0'



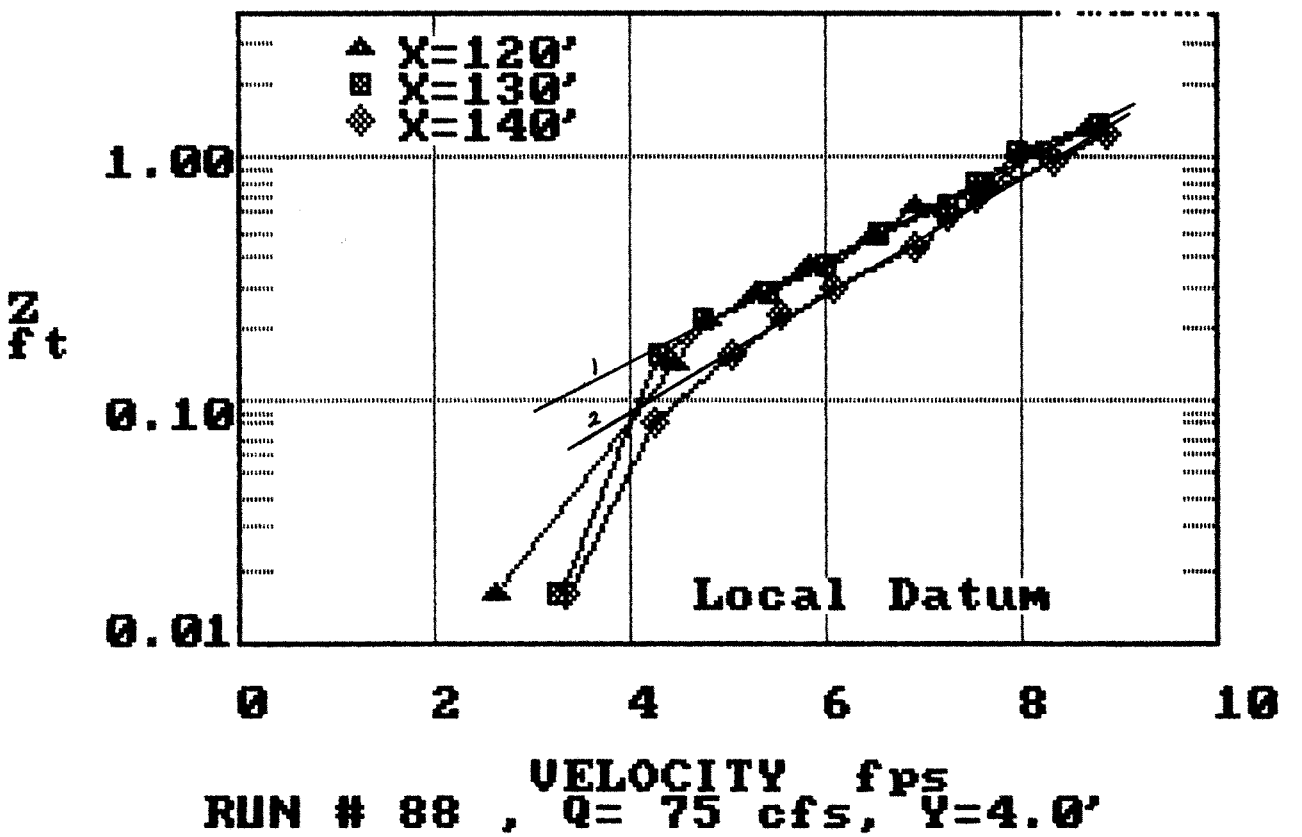
RUN # 84 , Q= 50 cfs, Y=4.0'



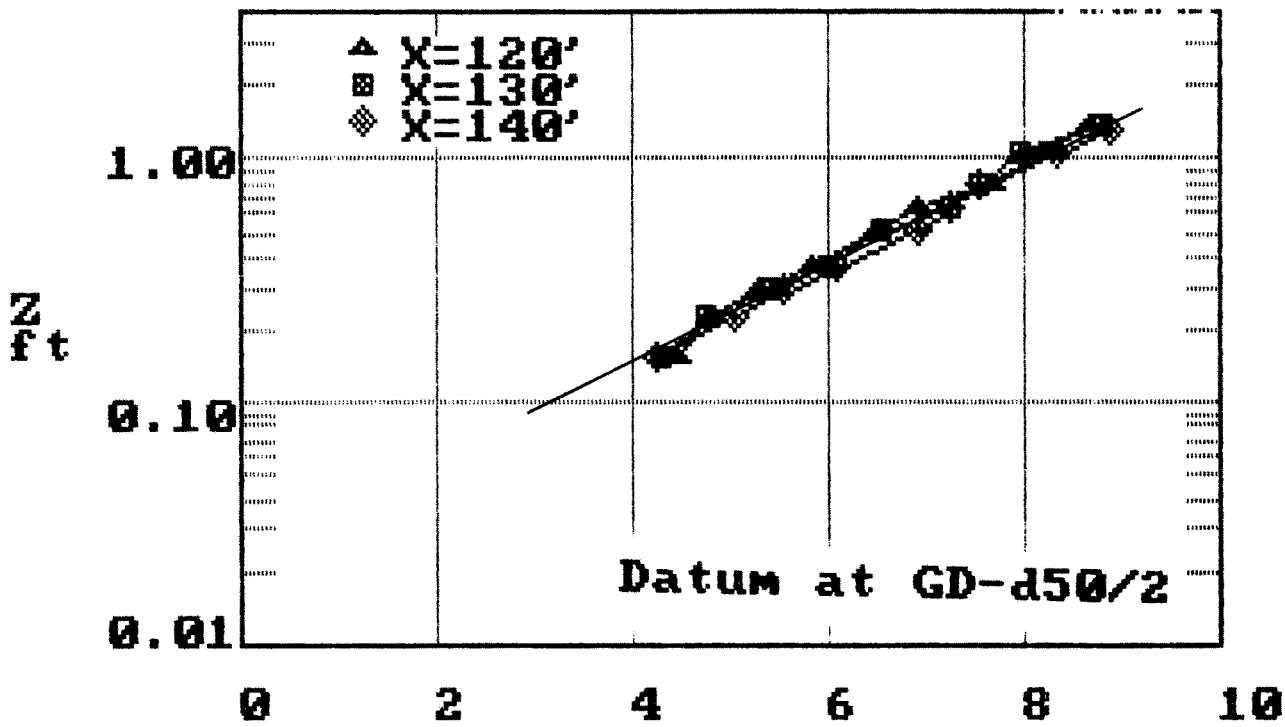
RUN # 84 , Q= 50 cfs, Y=4.0' LD



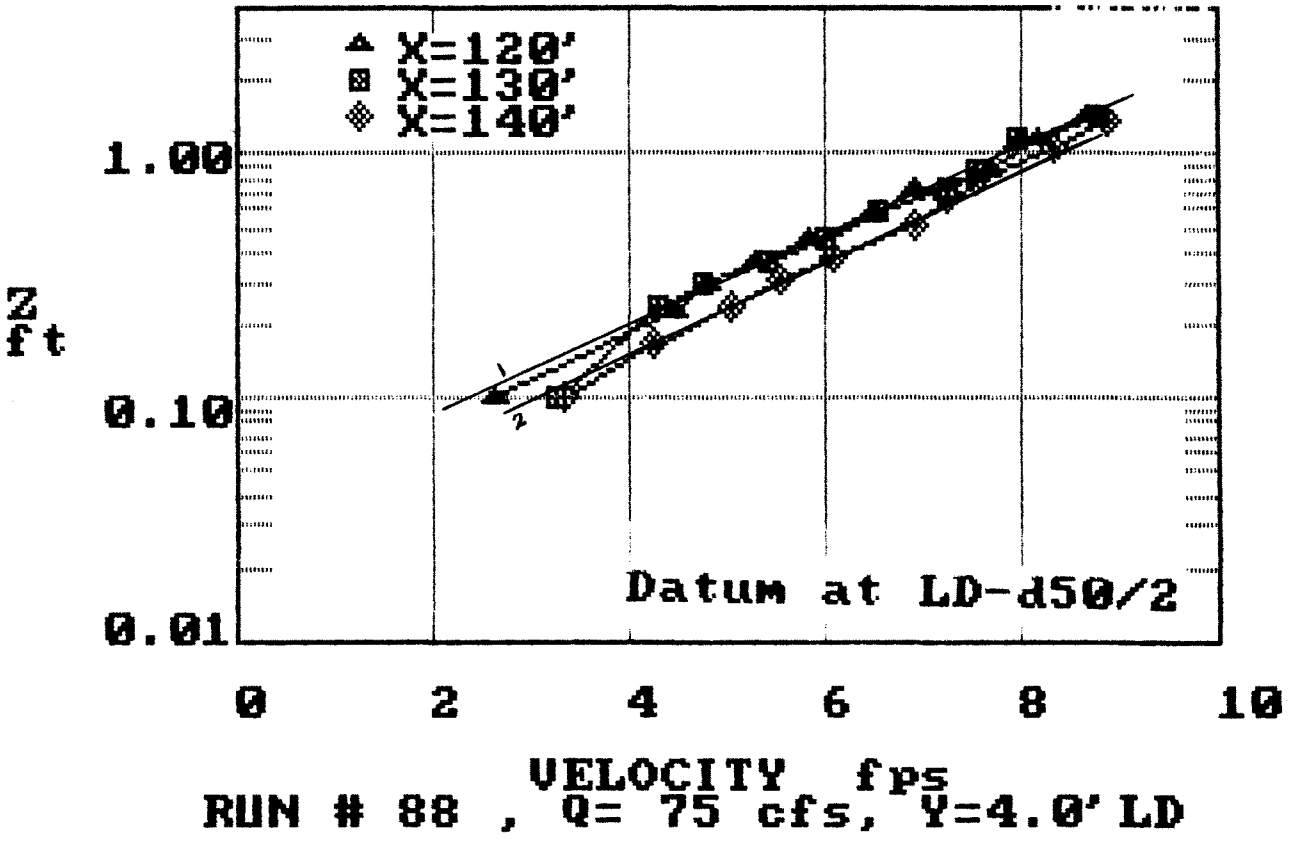
RUN # 88 , Q= 75 cfs, Y=4.0'



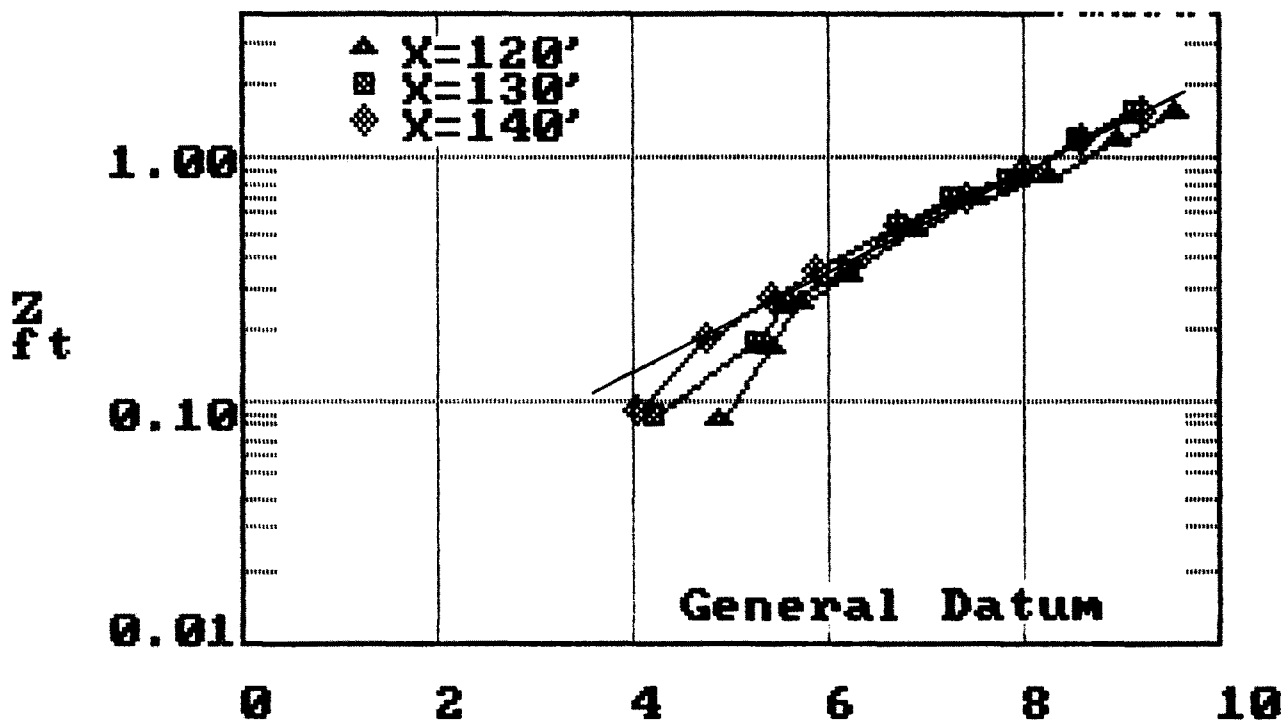
RUN # 88 , Q= 75 cfs, Y=4.0'



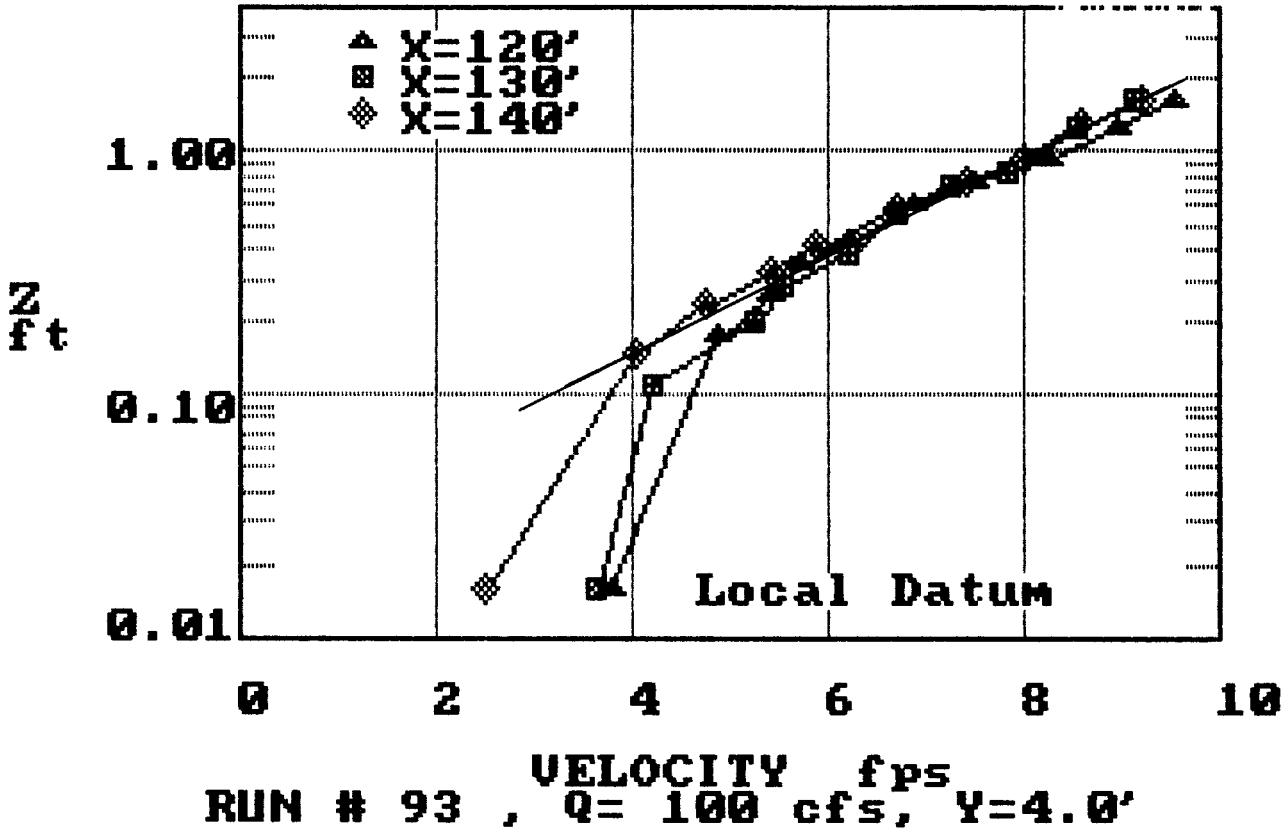
RUN # 88 , Q= 75 cfs, Y=4.0'



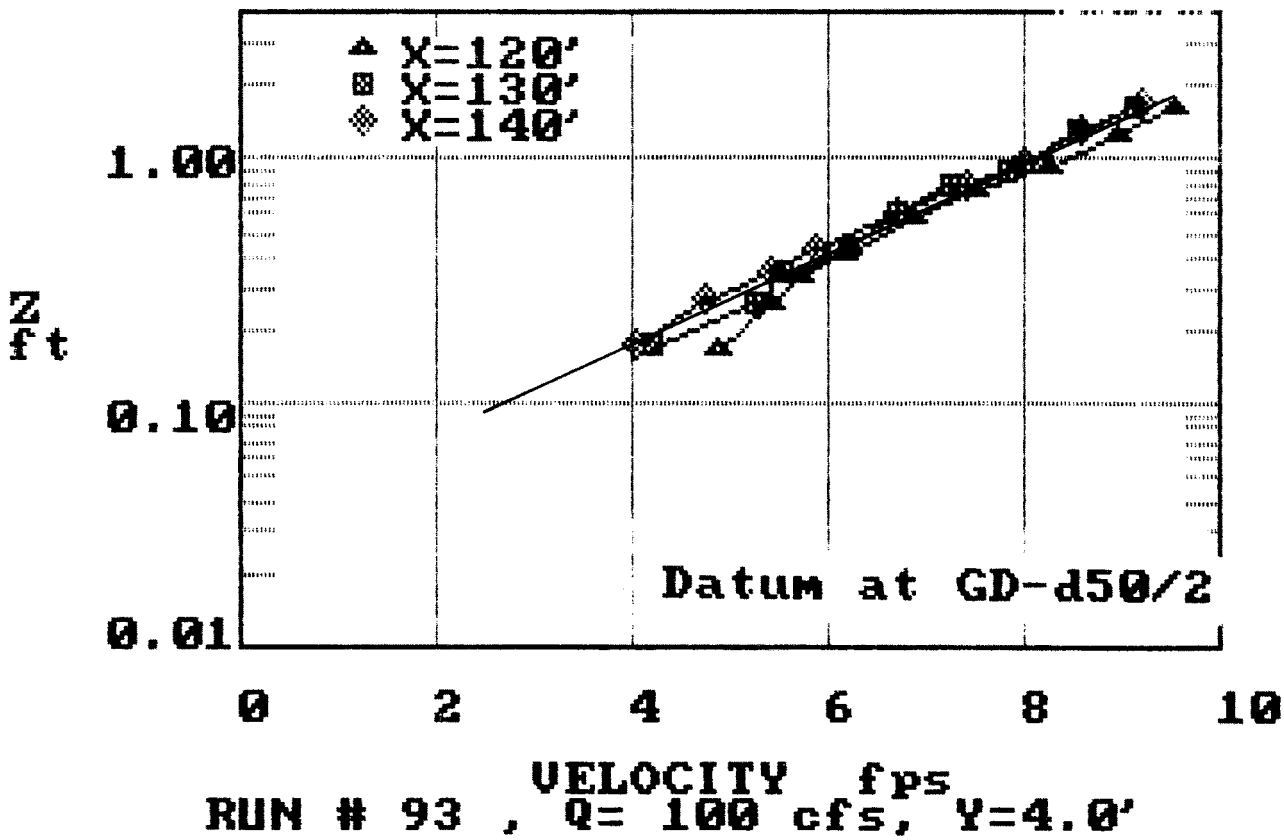
RUN # 88 , Q= 75 cfs, Y=4.0' LD



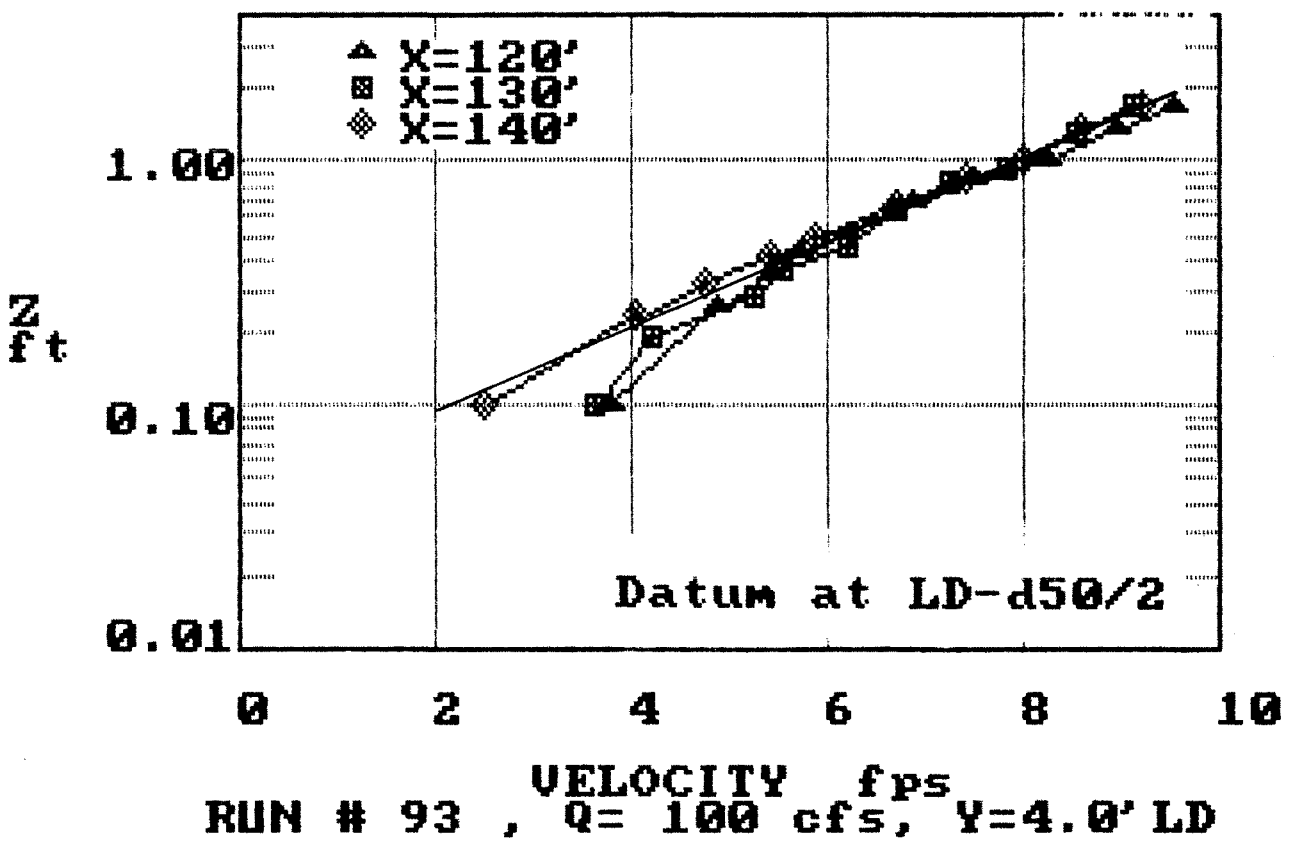
RUN # 93 , Q= 100 cfs, Y=4.0'



RUN # 93 , Q= 100 cfs, Y=4.0'



RUN # 93 , Q= 100 cfs, Y=4.0'



RUN # 93 , Q= 100 cfs, Y=4.0' LD