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SURFACE FRICTION IN OPEN CHANNEL

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ABSTRACT

Roughness depends upon size of the roughness material. Since D_{50} are more for 2.5 inch roughness bed as compared to 2.0 inch roughness bed hence lesser value of $\frac{d}{D_{50}}$ and $\frac{d}{D_{84}}$ indicate more roughness. There is less size of 2.0 inch roughness bed which is not submerged as compared to 2.5 inch roughness bed and function of effective roughness concentration depends upon wetted frontal cross sectional area i.e. wetted frontal cross sectional area is more for 2.0 inch roughness bed hence function of effective roughness concentration is more for 2.0 inch roughness bed as compared to 2.5 inch roughness.

Subject Headings: Boulders, Channels, Drag, Flow resistance, Flumes

KEYWORDS: Friction Factor, Hydraulic Geometry, Roughness

INTRODUCTION

For large scale roughness $\frac{d}{D_{50}}$ <2 and $\frac{d}{D_{84}}$ <1.2 where d is the mean depth of flow and D_{50}= the size of the median axis which is bigger than or equal to 50% of median axis. Similarly D_{84} = The size of the median axis which is bigger than or equal to 84% of median axis. Similarly for Intermediate Scale roughness 2< $\frac{d}{D_{50}}$ <7.5 and 1.2 < $\frac{d}{D_{84}}$ <4. Hence both the roughness bed provide large scale roughness.

Experimental Set up and Procedures: Data were obtained for 2.0 inch and 2.5 inch roughness bed.

Flume: The flume is open and 1.168m wide and 9.54 m long. Each roughness bed was constructed by smearing masonite boards with fiberglass resin. The boards were then screwed to the bed of the flume.

Experimental Procedure: For each bed, five to seven flows were measured for three different slopes (2,5 and 8%). At each flow, depth was gaged at a single cross section, so that mean flow and channel properties could be calculated. In flow with large- scale roughness, the cross- sectional area of flow is significantly affected by the projections of the elements into the flow.

Table 1: Flume Data for 2.0 Inch Roughness Bed

Sl. No. (1)	Channel Slope (2)	Discharge in Cubic Meters per Second (3)	Mean Velocity in Meters per Second (4)	Mean Depth d in Meters (5)
1	0.02	0.00329	0.100	0.0282
2	0.02	0.00837	0.189	0.0378
3	0.02	0.01158	0.227	0.0436

Table 1: Contd.,

4	0.02	0.02541	0.377	0.0578
5	0.02	0.04047	0.519	0.0668
6	0.02	0.04949	0.601	0.0705
7	0.05	0.00329	0.132	0.0213
8	0.05	0.00713	0.214	0.0285
9	0.05	0.01413	0.337	0.0359
10	0.05	0.02068	0.431	0.0411
11	0.05	0.02941	0.542	0.0465
12	0.05	0.04368	0.643	0.0582
13	0.08	0.00247	0.162	0.0130
14	0.08	0.00565	0.205	0.0236
15	0.08	0.01077	0.313	0.0295
16	0.08	0.02187	0.515	0.0363
17	0.08	0.03249	0.637	0.0437
18	0.08	0.03724	0.712	0.0488

Table 2: Flume Data for 2.0 Inch Roughness Bed

Sl. No. (1)	Hydraulic Radius R= $\frac{Wd}{W+2d}$ (2)	Depth d' of Bed Datum in Meters (3)	Relative Roughness Area $\frac{Aw}{Wd'}$ (4)	Function of Effective Roughness Concentration (b) (5)
1	0.027	0.0505	0.4413	0.220
2	0.036	0.0611	0.3814	0.281
3	0.041	0.0665	0.3443	0.324
4	0.053	0.0795	0.2735	0.431
5	0.060	0.0892	0.2511	0.483
6	0.063	0.0947	0.2553	0.486
7	0.021	0.0442	0.5179	0.164
8	0.027	0.0513	0.4450	0.218
9	0.034	0.0575	0.3750	0.282
10	0.038	0.0633	0.3508	0.313
11	0.043	0.0688	0.3252	0.348
12	0.053	0.0788	0.2617	0.447
13	0.013	0.0411	0.6842	0.084
14	0.023	0.0505	0.5330	0.161
15	0.028	0.0551	0.4646	0.208
16	0.034	0.0659	0.4483	0231
17	0.041	0.0747	0.4155	0.267
18	0.041	0.0701	0.3615	0.312

Table 3: Flume Data for 2.0 Inch Roughness Bed. D_{50}=0.043m, D_{84}=0.047m

Sl. No. (1)	$\frac{d}{D_{50}}$ (2)	$\frac{d}{D_{84}}$ (3)	Manning's Roughness Coefficient n (4)	Darcy Weisbach Resistance Coefficient f (5)
1	0.656	0.600	0.186	4.463
2	0.879	0.804	0.120	1.654
3	1.014	0.928	0.109	1.323
4	1.344	1.230	0.078	0.639
5	1.553	1.421	0.061	0.390
6	1.640	1.500	0.055	0.307
7	0.495	0.453	0.190	4.796
8	0.663	0.606	0.139	2.437
9	0.835	0.764	0.103	1.245
10	0.956	0.874	0.087	0.870

Table 3: Contd.,

11	1.081	0.989	0.075	0.621
12	1.353	1.238	0.073	0.553
13	0.302	0.277	0.141	3.092
14	0.549	0.502	0.164	3.522
15	0.686	0.628	0.123	1.892
16	0.844	0.772	0.085	0.860
17	1.016	0.930	0.078	0.676
18	1.042	0.853	0.070	0.554

Table 4: Flume Data for 2.0 Inch Roughness Bed

Sl. No. (1)	Chezy's Resistance Factor c $C = \frac{V}{\sqrt{RS}}$ (2)
1	4.303
2	7.044
3	7.927
4	11.579
5	14.892
6	16.931
7	4.074
8	5.824
9	8.173
10	9.888
11	11.689
12	12.491
13	5.023
14	4.779
15	6.613
16	9.875
17	11.123
18	12.432

Table 5: Flume Data for 2.5 Inch Roughness Bed

Sl. No. (1)	Channel Slope (2)	Discharge in Cubic Meters per Second (3)	Mean Velocity in Meters per Second (4)	Mean Depth d in Meters (5)
1	0.02	0.00409	0.138	0.0254
2	0.02	0.00993	0.223	0.0381
3	0.02	0.01671	0.301	0.0475
4	0.02	0.02799	0.409	0.0586
5	0.02	0.04110	0.500	0.0703
6	0.02	0.04967	0.543	0.0782
7	0.05	0.00369	0.173	0.0183
8	0.05	0.00855	0.283	0.0259
9	0.05	0.01282	0.342	0.0321
10	0.05	0.02176	0.478	0.0390
11	0.05	0.03403	0.611	0.0477
12	0.05	0.04896	0.725	0.0578
13	0.08	0.00397	0.210	0.0162
14	0.08	0.00605	0.259	0.0200
15	0.08	0.01128	0.374	0.0258
16	0.08	0.01775	0.474	0.0321
17	0.08	0.02737	0.592	0.0396
18	0.08	0.03319	0.669	0.0425
19	0.08	0.04485	0.775	0.0495

Table 6: Flume Data for 2.5 Inch Roughness Bed

Sl. No. (1)	Manning's Roughness Coefficient n (2)	Hydraulic Radius R= $\frac{Wd}{W+2d}$ in Meters (3)	Darcy Weisbach Resistance Coefficient f (4)	Chezy's Resistance Factor C (5)
1	0.128	0.025	2.111	6.172
2	0.102	0.036	1.201	8.311
3	0.086	0.044	0.824	10.147
4	0.072	0.053	0.551	12.562
5	0.066	0.063	0.441	14.086
6	0.065	0.069	0.416	14.617
7	0.125	0.017	2.399	5.934
8	0.100	0.025	1.268	8.004
9	0.093	0.030	1.080	8.830
10	0.077	0.037	0.669	11.113
11	0.067	0.044	0.501	13.027
12	0.064	0.053	0.432	14.084
13	0.127	0.016	2.309	5.870
14	0.114	0.019	1.863	6.643
15	0.095	0.025	1.159	8.363
16	0.085	0.030	0.896	9.675
17	0.078	0.037	0.709	10.881
18	0.073	0.040	0.596	11.826
19	0.069	0.046	0.518	12.775

Table 7: Flume Data for 2.5 Inch Roughness Bed. D_{50}=0.05425m, D_{84}=0.058m

Sl. No. (1)	$\frac{d}{D_{50}}$ (2)	$\frac{d}{D_{84}}$ (3)	Depth of Bed Datum d' in Meters (4)	Relative Roughness Area $\frac{A_w}{Wd'}$ (5)
1	0.468	0.438	0.0567	0.5513
2	0.0702	0.657	0.0691	0.4489
3	0.876	0.819	0.0777	0.3879
4	1.080	1.010	0.0898	0.3469
5	1.296	1.212	0.1007	0.3021
6	1.441	1.348	0.1081	0.2761
7	0.337	0.316	0.0489	0.6266
8	0.477	0.477	0.0585	0.5575
9	0.592	0.553	0.0635	0.4942
10	0.719	0.672	0.0707	0.4490
11	0.879	0.822	0.0799	0.4034
12	1.065	0.977	0.0889	0.3497
13	0.299	0.279	0.0463	0.6503
14	0.369	0.345	0.0517	0.6141
15	0.476	0.445	0.0375	0.5512
16	0.592	0.553	0.0630	0.4911
17	0.730	0.683	0.0705	0.4383
18	0.783	0.733	0.0740	0.4265
19	0.912	0.853	0.0810	0.3587

Table 8: Flume Data for 2.5 Inch Roughness Bed

Sl. No. (1)	Function of Effective Roughness Concentration (b) (2)
1	0.156
2	0.234
3	0.295
4	0.354
5	0.426
6	0.476
7	0.112
8	0.154
9	0.196
10	0.236
11	0.284
12	0.349
13	0.101
14	0.120
15	0.156
16	0.198
17	0.244
18	0.257
19	0.299

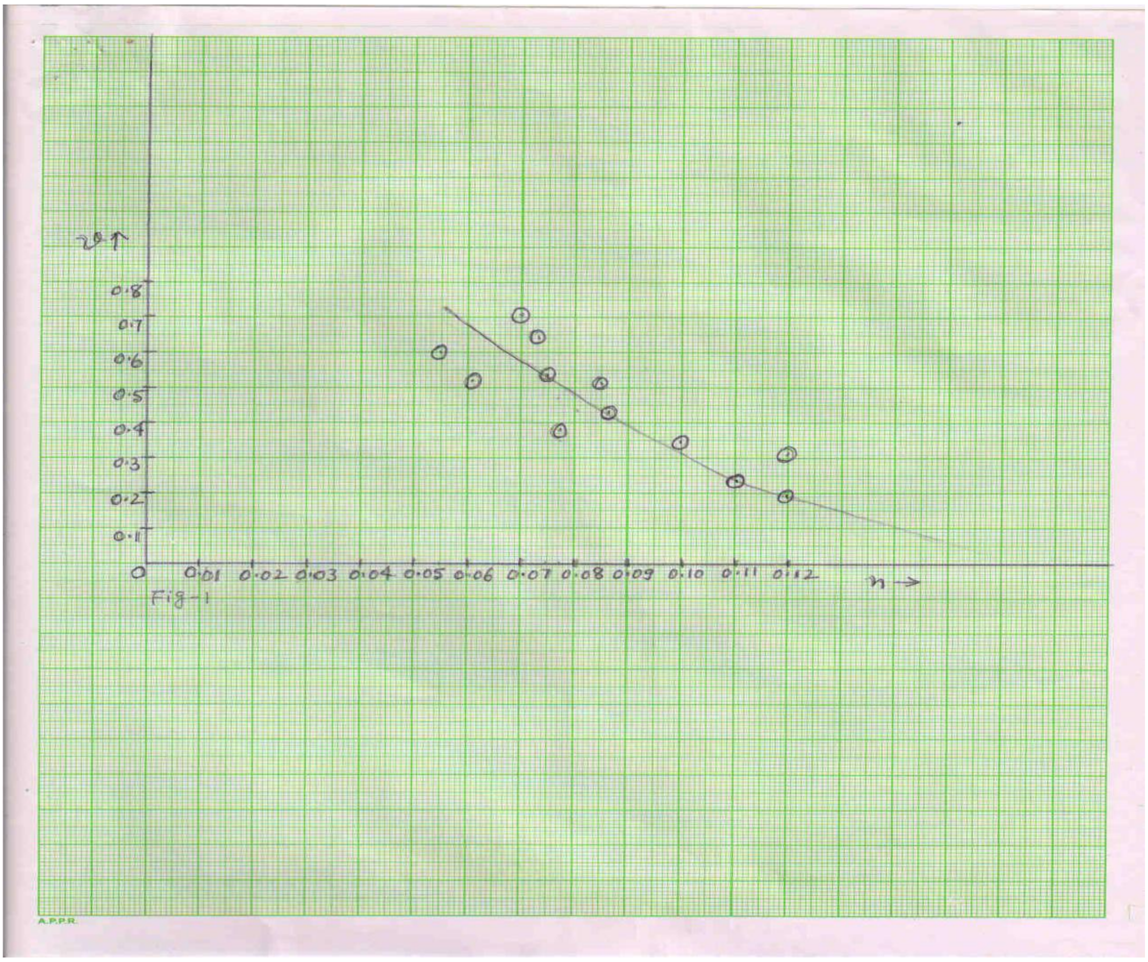

Figure 1: Variation of Parameter Mean Velocity of Flow (V) with Parameter Manning's Roughness Coefficient (n) for 2.0 Inch Roughness Bed

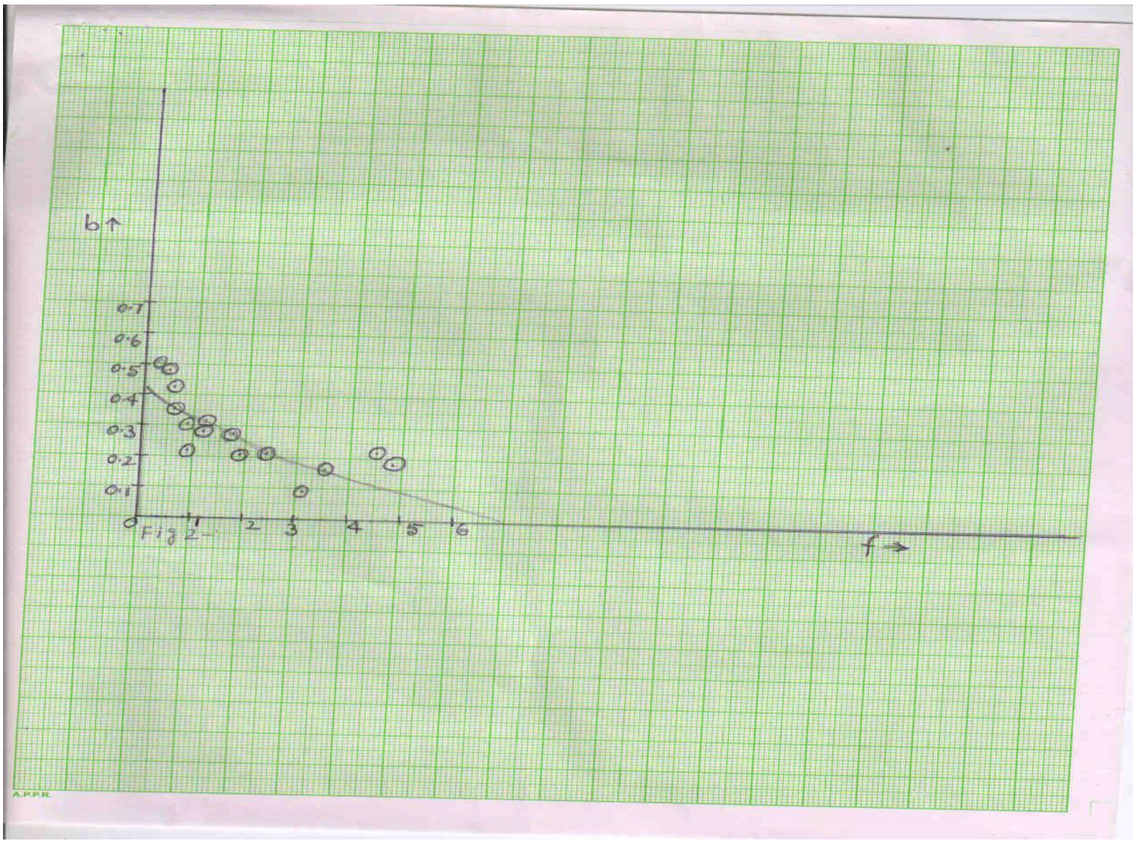

Figure 2: Variation of Parameter Function of Effective Roughness Concentration (b) with Parameter Darcy Weisbach Resistance Coefficient (f) for 2.0 Inch Roughness Bed

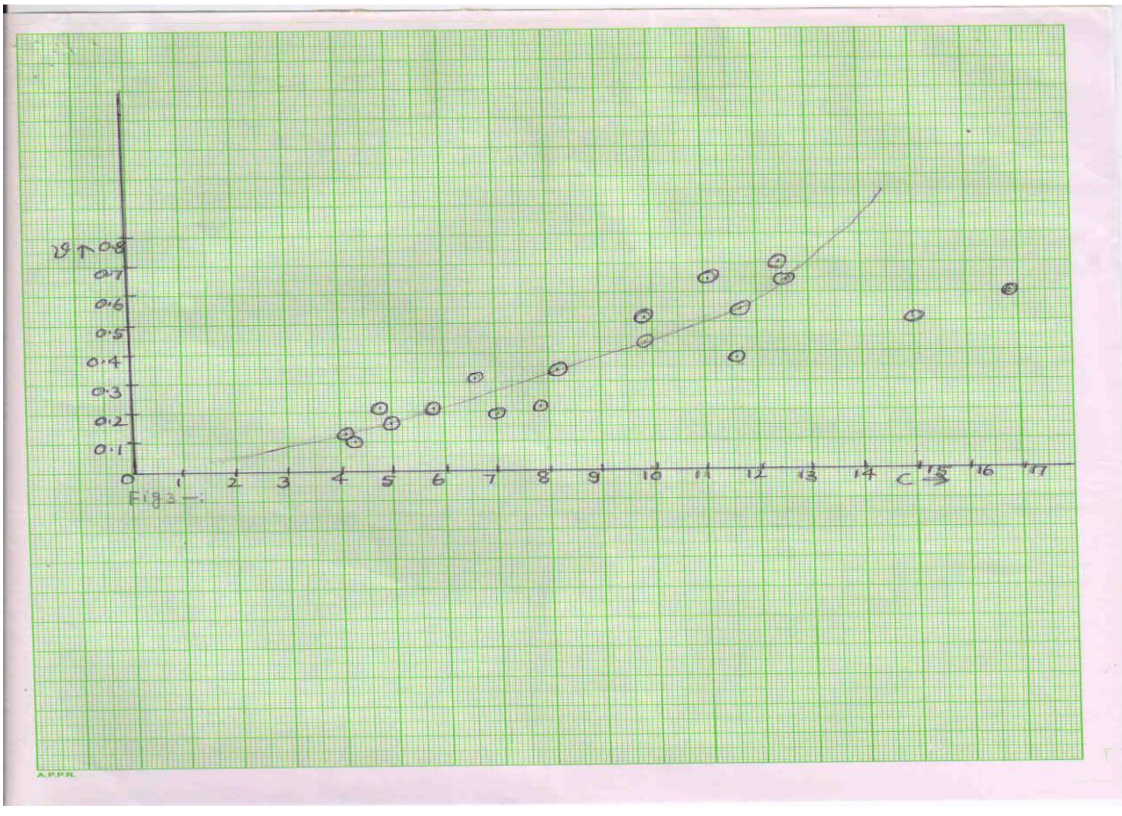

Figure 3: Variation of Parameter Mean Velocity of Flow (V) with Parameter Chezy's Roughness Coefficient (c) for 2.0 Inch Roughness Bed

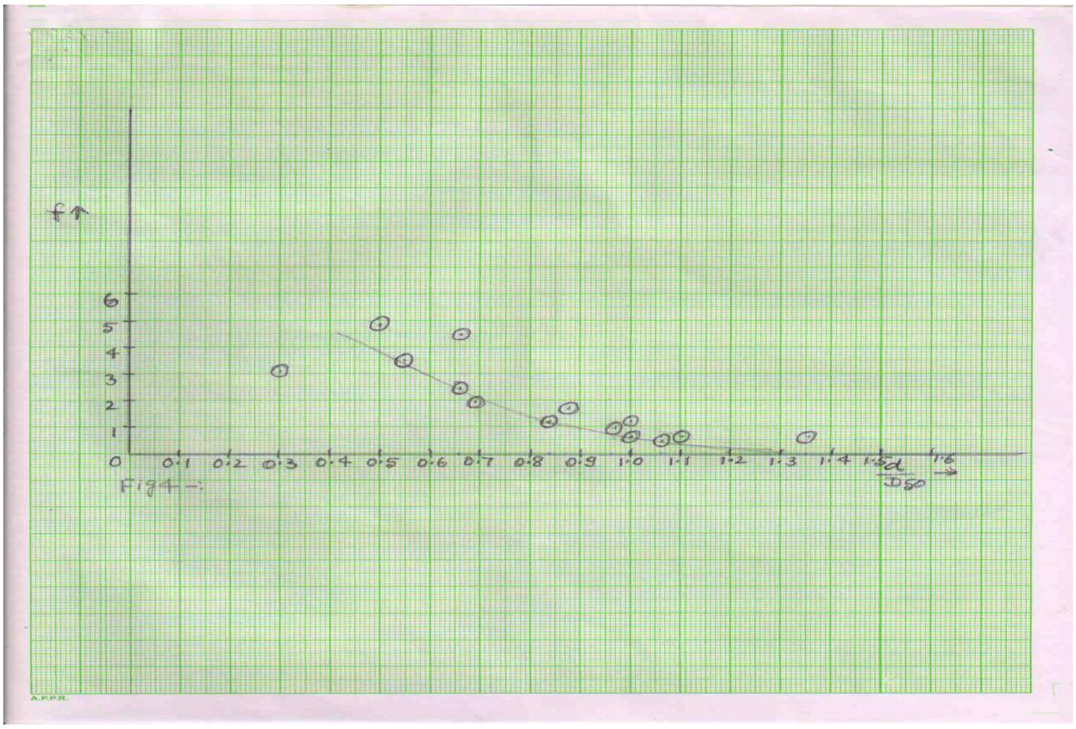

Figure 4: Variation of Parameter Darcy Weisbach Resistance Coefficient (f) with Parameter $\frac{d}{D_{50}}$ for 2.0 Inch Roughness Bed

2.0 INCH ROUGHNESS BED

i) Average $\frac{d}{D_{50}}$ = 0.939

ii) Average $\frac{d}{D_{84}}$ = 0.859

iii) Average discharge of flow = 0.0218m^3/sec.

D_{50} = 0.043 meter, D_{84} = 0.047 meter

2.5 INCH ROUGHNESS BED

i) Average $\frac{d}{D_{50}}$ = 0.742

ii) Average $\frac{d}{D_{84}}$ = 0.694

iii) Average discharge of flow = 0.0023m^3/sec.

D_{50} = 0.05425meter, D_{84} = 0.058 meter

Roughness depends upon size of the roughness material since D_{50} and D_{84} are more for 2.5 inch roughness bed as compared to 2.0 inch roughness bed hence lesser value of $\frac{d}{D_{50}}$ and $\frac{d}{D_{84}}$ indicate more roughness. There is 1.265 times more roughness for 2.5 inch roughness bed as compared to 2.0 inch roughness bed with respect to $\frac{d}{D_{50}}$. There is 1.238 times more roughness for 2.5 inch roughness bed as compared to 2.0 inch roughness bed with respect to $\frac{d}{D_{84}}$. Since size of the roughness material with respect to D_{50} is lesser than D_{84} hence roughness is more for 2.5 inch roughness bed with respect to $\frac{d}{D_{50}}$ as compared to $\frac{d}{D_{84}}$.

Roughness depends upon $\frac{d}{D_{50}}$ and $\frac{d}{D_{84}}$. For large scale roughness

$\frac{d}{D_{50}}<2$ and $\frac{d}{D_{84}}<1.2$ where d is the mean depth of flow and D_{50}= the size of the median axis which is bigger than or equal to 50% of median axis. Similarly D_{84} = The size of the median axis which is bigger than or equal to 84% of median axis. Similarly for Intermediate Scale roughness $2<\frac{d}{D_{50}}<7.5$ and $1.2<\frac{d}{D_{84}}<4$. Hence both the roughness bed provide large scale roughness.

There is 1.023 times more discharge of flow for 2.5 inch roughness bed as compared to 2.0 inch roughness bed hence capacity of the channel is more for large size of roughness material.

Average value of function of effective roughness concentration b for 2.0 inch roughness bed = 0.292 and average value of function of effective roughness concentration for 2.5 inch roughness bed = 0.245.

Since size of 2.5 inch roughness material is more as compared to 2.0 inch roughness bed hence it obstructs the flow more and wetted frontal cross sectional area is less due to more size of roughness material hence function of effective roughness concentration is lesser for 2.5 inch roughness bed hence more size of roughness material is more useful to resist more velocity of flow hence destruction is prevented.

As Manning’s roughness coefficient (n) increases the function of effective roughness concentration (b) decreases since due to increase in n the mean velocity of flow decreases and roughness is not dominant in lesser velocity of flow hence there is no much rise of water hence less wetted frontal cross sectional area hence b decreases.

Similarly as f increases the b decrease since due to increase in f the mean velocity of flow decrease and roughness is not dominant in lesser velocity of flow hence there is no much rise of water hence less wetted frontal cross sectional area hence b decreases.

We get d_{max} for the value of b = 0.486 in 2.0 inch roughness bed whereas at b = 0.476 we get d_{max} in 2.5 inch roughness bed. Also Q_{max} is obtained for these values of b for 2.0 inch roughness bed and 2.5 inch roughness bed. So these are the specific values of b to get d_{max} & Q_{max}. At lesser value of b we get d_{max} & Q_{max} for 2.5 inch roughness bed that is velocity of flow is much reduced due to larger size of roughness material and depth of flow is more and capacity of the channel is increased. So b = 0.476 will be effective value since we get more depth of flow & more discharge of flow.

As chezy's resistance factor increases it means velocity of flow increases because chezy's resistance factor (c) depends upon velocity of flow (V) since $V = C\sqrt{RS}$. As V increases the roughness is more effective hence there is increase in depth of flow hence more wetted frontal cross sectional area is obtained hence as C increases b increases.

As C increases V increases since C depends upon V. Since resistance factor is more effective in high velocity of flow hence as C increases V increases.

Since mean depth of flow is more for 2.0 inch roughness bed as compared to its size with respect to 2.5 inch roughness bed hence we get more wetted frontal cross sectional area for 2.0 inch roughness bed hence function of effective roughness concentration is more for 2.0 inch roughness bed as compared to 2.5 inch roughness bed. There is 1.192 times more function of effective roughness concentration for 2.0 inch roughness bed as compared to 2.5 inch roughness bed. There is 0.023m size of roughness material which is not submerged for 2.5 inch roughness material whereas there is 0.0104m size which is not submerged for 2.0 inch roughness material hence we get more function of effective roughness concentration for 2.0 inch roughness bed since 2.0 inch roughness material = 0.0508 m and mean depth of flow = 0.0404m whereas the size for 2.5 inch roughness material = 0.0635m and mean depth of flow= 0.0402 meter.

Average value of b = 0.292 for 2.0 inch roughness bed.

Average value of b = 0.245 for 2.5 inch roughness bed.

There is 1.192 times more function of effective roughness concentration (b) for 2.0 inch roughness bed as compared to 2.5 inch roughness be.

As $\frac{d}{D_{50}}$ increases it means roughness decreases since roughness $\frac{d}{D_{50}}$ depends upon size of the roughness material i.e. upon D_{50} and D_{84}. Due to increase in size of the roughness material i.e. due to increase in D_{50} & D_{84} roughness increases hence lesser value of $\frac{d}{D_{50}}$ indicates more roughness. Hence due to increase in $\frac{d}{D_{50}}$ value it indicates lesser roughness hence as $\frac{d}{D_{50}}$ increases the Darcy Weisbach resistance coefficient decreases.

2.0 INCH ROUGHNESS BED

Relationship between Q_{max} and b, n, f and c:-

$$Q_{max} = 1.110(C)^{0.541} - 1.664(b)^{0.601} - 0.509(n)^{1.964} - 0.185(f)^{5.410} + 2.426Q \quad (1)$$

Relationship between Q and b, f, n and c:-

$$Q = 0.228(C)^{0.926} - 1.072(b)^{0.933} - 0.524(f)^{1.909} - 0.806(n)^{1.241} + \frac{Q_{max}}{2.426} \quad (2)$$

Relationship between d with b, f, n and c:

$$d = 0.228(C)^{0.926} - 1.072\ (b)^{0.933} - 0.524(f)^{1.909} - 0.806(n)^{1.241} + \frac{d_{max}}{1.745} \quad (3)$$

Relationship for V with b, n, f and c:-

$$V = 0.902(C)^{0.385} - 1.476(b)^{0.677} - 0.722(n)^{1.385} - 0.385(f)^{2.599} + \frac{V_{max}}{1.869} \quad (4)$$

Relationship for V_{min} with b, f, n and c:

$$V_{min} = 0.035(C)^{2.127} - 0.753(b)^{1.327} - 2.687(f)^{0.372} - 1.722(n)^{0.581} + \frac{V_{max}}{7.120} \quad (5)$$

Relationship between Q_{max} with b, n and f:

$$Q_{max} = 0.051(f)^{5.410} - 0.509(n)^{1.964} - 1.664(b)^{0.601} + 2.426Q \quad (6)$$

Relationship between n and f:

$$n = 0.057(f)^{1.255} \quad (7)$$

Relationship between b and n:-

$$b = 21.627(n)^{0.900} \quad (8)$$

Relationship between b and c:

$$b = 0.016(c)^{1.299} \quad (9)$$

We know,

$$Q_{max} = 1.110(c)^{0.541} - 1.664(b)^{0.601} - 0.509(n)^{1.964} - 0.185(f)^{5.410} + 2.426\ Q \quad (1)$$

and

$$Q_{max} = 0.051(f)^{5.410} - 0.509(n)^{1.964} - 1.664(b)^{0.601} + 2.426\ Q \quad (2)$$

From 1 & 2,

$$1.110(c)^{0.541} - 1.664(b)^{0.601} - 0.509(n)^{1.964} - 0.185(f)^{5.410} \quad (3)$$

$$= \quad 0.051(f)^{5.410} - 0.509(n)^{1.964} - 1.664(b)^{0.601}$$

From (9),

$$(c)^{1.299} = \frac{6}{0.016} = \frac{1}{0.016} \times b = 62.5b \quad (4)$$

$$C = (62.5b)^{\frac{1}{1.299}} = (62.5b)^{0.770}$$

$$C = 24.145b^{0.770} \quad (5)$$

Now 1.110 $[24.145b^{0.770}]^{0.541}$

$1.110\ [24.145(21.627(n)^{0.900})^{0.770}]^{0.541}$

$= 1.110\ [24.145(10.665n^{0.7623})]^{0.541}$

$= 1.110\ [5.600(3.599n^{0.412})]$

$= 1.110[20.154n^{0.412}]$

$= 22.371n^{0.412}$

$1.664(b)^{0.601} = 1.664[21.627(n)^{0.900}]$

$= 1.662[6.344(n)^{0.541}]$

$= 10.556n^{0.541}$

$0.185(f)^{5.410} = 0.185[9.808n^{0.797}]^{5.410}$

$= 0.185[231446.32n^{4.312}]$

$= 42817.57n^{4.312}$

$0.051(f)^{5.410} = 0.051[9.809n^{0.797}]^{5.410}$

$= 0.051[231446.32n^{4.312}]$

$= 11803.76n^{4.312}$

$1.664(b)^{0.601} = 1.664[21.627(n)^{0.900}]^{0.601}$

$= 1.664[6.344n^{0.541}]$

$= 1.556n^{0.541}$

Now,

$22.371n^{0.412}-42817.57n^{4.312}$

$= 11.803.76n^{4.312}$

$22.371n^{0.412} = 11803.76n^{4.312}+42817.57n^{4.312}$

$= 54621.33n^{4.312}$

$$\frac{5421.33n^{4.312}}{22.371n^{0.412}} = 1$$

Or $2.42.34n^{4.312-0.412} = 1$

Or $n^{3.900} = \dfrac{1}{242.34} = 0.0041$

$\therefore n = (0.0041)^{\frac{1}{3.900}}$

$= (0.0041)^{0.256} = 0.245 \approx 0.108$

Mathematical Formulation for Q

$$Q_{max} = 1.110(c)^{0.541}-1.664(b)^{0.601}-0.509(n)^{1.964}-0.185(f)^{5.410}+2.426\,Q \quad (1)$$

$$Q = 0.228(c)^{0.926}-1.072(b)^{0.933}-0.524(f)^{1.909}-0.806(n)^{1.241}+\frac{Q_{max}}{2.426} \quad (2)$$

Substituting Q_{max} from 1 in 2

$$Q = 0.228(c)^{0.926}-1.072(b)^{0.933}-0.524(f)^{1.909}-0.806(n)^{1.241}+\frac{1}{2.426}[1.110(c)^{0.541}-1.664(b)^{0.601}-0.509(n)^{1.964}-0.185(f)^{5.410}+2.426\,Q]$$

$$= 0.228[24.145(b)^{0.770}]^{0.926}-1.072(b)^{0.933}-0.524(f)^{1.909}-0.806[0.057(f)^{1.255}]^{1.241}+\frac{1}{2.426}[1.110\,(24.145\,(b)^{0.770})^{0.541}]\,-1.664\,(b)^{0.601}\,-0.509\,(0.057(f)^{1.255})^{1.964}\,-0.185(f)^{5.410}+2.426\,Q\,]$$

Substituting the average value of b, f, and Q in the above equation we gat:

$$Q = 0.228[19.076(b)^{0.713}]-1.702x0.317-1.3804-0.806[0.0286(1.661)^{1.557}]+\frac{1}{2.426}[1.110(5.599(0.292)^{0.417})-0.794-0.509(0.0036(1.661)^{2.465})-2.880+2.426\,Q\,]$$

$$Q = 1.808-0.340-1.3804-0.0508+\frac{1}{2.426}[3.720-0.794-0.0064-2.880+0.04949]$$

$$= 0.0728+\frac{1}{2.426}[3.7695-3.6804]$$

$= 0.0728+0.0367 \qquad = 0.110 \approx 0.04949$

Mathematical formulation for V:

$$V = 0.902(\,C)^{0.385}-1.476(b)^{0.677}-0.722(n)^{1.385}-0.385(f)^{2.599}+\frac{V_{max}}{1.869} \quad (1)$$

$$V_{min} = 0.035(C)^{2.127}-0.753(b)^{1.327}-2.687(f)^{0.372}-1.722(n)^{0.581}+\frac{V_{max}}{7.120} \quad (2)$$

From (2)

$$\frac{V_{max}}{7.120} = V_{min}-0.035\,(C)^{2.127}+0.753(b)^{1.327}+2.687(f)^{0.372}+1.722n)^{0.581}$$

$$\therefore\ V_{max} = 7.120[V_{min}-0.035(C)^{2.127}+0.753(b)^{1.327}+2.687(f)^{0.372}+1.722(n)^{0.581}]$$

$$= 7.120\,V_{min}-0.2492(C)^{2.127}+5.361(b)^{1.327}+19.131(f)^{0.372}+12.261(n)^{0.581}$$

Substituting V_{max} in (1) we get:

$$V = 0.902(C)^{0.385}-1.476(b)^{0.677}-0.722(n)^{1.385}-0.385(f)^{2.599}+\frac{1}{1.869}$$

$$[7.120V_{min}-0.249(C)^{2.127}+5.361(b)^{1.327}+19.131(f)^{0.372}+12.261(n)^{0.581}]$$

Substituting the average values of c, b, n & f and V_{min} we get:-

$$V = 0.902(9.153)^{0.385}-1.476(0.292)^{0.677}-0.722(0.108)^{1.385}-0.385(1.661)^{2.599}+\frac{1}{1.869}$$

$$[7.120x0.100-0.2492(9.153)^{2.127}+ \quad 5.361(0.292)^{1.327}+19.131(1.661)^{0.372}+12.261(0.108)^{0.581}]$$

$$=2.115-0.641-0.033-1.438+\frac{1}{1.869}[0.712-27.656+1.047+23.105+3.365]$$

$$= 2.115-2.113+\frac{1}{1.869}[28.229-27.656]$$

= 0.002+0.307 = 0.309m/sec ≈0.381m/sec

Hence this is the required mathematical formulation for V.

CONCLUSIONS

There is 1.265 times more roughness for 2.5 inch roughness bed as compared to 2.0 inch roughness bed with respect to $\frac{d}{D_{50}}$. There is 1.238 times more roughness for 2.5 inch roughness bed as compared to 2.0 inch roughness bed with respect to $\frac{d}{D_{84}}$. As Manning's roughness coefficient (n) increases the function of effective roughness concentration (b) decreases because due to increase in n velocity of flow decreases and roughness is not so effective in low velocity of flow to raise more depth of flow. Hence wetted frontal cross sectional area is less hence function of effective roughness concentration decreases due to increase in n. As V increases the roughness is more effective hence chezy's resistance factor C & function of effective roughness concentration b both increase.

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APPENDICES: NOTATION

The following symbols are used in this paper:

$\frac{A_w}{Wd'}$ = Relative roughness area

A_w = Wetted cross sectional area

b = Function of effective roughness concentration

C = Chezy’s resistance factor

d = Mean depth of flow in meters

d’ = Depth of bed datum in meters.

D_{50} = The size of median axis which is bigger than or equal to 50% of median axis.

D_{84} = The size of median axis which is bigger than or equal to 84% of median axis.

f = Darcy Weisbach resistance coefficient

g = Acceleration due to gravity

n = Manning’s roughness coefficient

P = Wetted Perimeter

Q = Discharge in cubic meters per second

R = Hydraulic radius = $\frac{A}{p}$

A = Flow cross sectional area = Wd

P = Wetted Perimeter

S = Channel slope

V = Mean velocity of flow in meters per second.

W = Width of the channel = 1.168m

Formula Used

$$\frac{A_w}{Wd'} = \left(\frac{w}{d}\right)^{-b}$$

$$\left(\frac{8}{f}\right)^{1/2} = \frac{V}{(gRS)^{1/2}}$$

Hydraulic radius $R = \frac{Wd}{W+2d}$

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

$$V = C\sqrt{RS}$$

$$R = \frac{A}{P} = \frac{Wd}{W+2d}$$

$A + A_w$ = Wd'