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FLOW RESISTANCE IN OPEN CHANNEL

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ABSTRACT

Rivers with large-scale roughness have steep slopes and depths of the same order of magnitude as the bed material size. Flow resistance depends on the form drag of the roughness elements and their disposition in the channel. Theoretical processes considerations show resistance to be a function of Reynolds number, Frande number, roughness geometry and channel geometry. These processes are examined using the results of flume experiments based on different roughness beds and a wide range of flows.

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

KEYWORDS: Friction Factor, Hydraulic Geometry, Roughness

INTRODUCTION

Boulder bed channels provide large scale roughness because roughness material affects the free surface of flow. The size of the bed material is of the same order of magnitude as the depth of flow.

Flow Characteristics: The relative submergence or ratio of depth d to mean element height be less than about four for large scale roughness because we know that roughness is of large scale if it affects free surface of flow hence mean element height will be of the same order of magnitude as the depth of flow. The roughness is intermediate-scale if the relative submergence lies between about four and 15. If the relative submergence is 15 it shows small-scale roughness because mean element height is less that is channels consists of finer bed materials. Element height is given by short axis because for example of large scale roughness the roughness element affect free surface of flow more. However for typical bed materials the median axis is taken in account. More percentage of shorter axis is not taken into account because if more percentage of shorter axis is taken into account it effects more the free surface of flow in large scale roughness. Hence the size of short axis which is bigger than or equal to n% of short axis. Ratio of depth of flow d to median axis is lesser than the ratio of depth d to short axis because median axis is more than shorter axis.

Flow Resistance Theory: Large scale roughness is related mainly to the form drag of the elements and their disposition in the channel. The resistance to the flow is more in boulder bed channel and also if the concentration of roughness material is more it provides more resistance to the flow.

Experimental Setup & Procedures: Data were obtained for 0.5”and 0.75” roughness bed.

Flume: The flume is open and 1.168m wide and 9.54m 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 Flows 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 0.5 Inch Roughness Bed

Sl. No.	Channel Slope (1)	Discharge in Cubic Meters per Second (2)	Mean Velocity in Meters per Second (3)	Mean Depth d in Meters (4)	Froude No. $\frac{V}{\sqrt{gd}}$
1	0.02	0.00241	0.146	0.0141	0.392
2	0.02	0.01274	0.391	0.0279	0.748
3	0.02	0.03046	0.584	0.0446	0.883
4	0.02	0.05746	0.785	0.0627	1.001
5	0.02	0.07197	0.877	0.0702	1.056
6	0.05	0.00143	0.161	0.0076	0.590
7	0.05	0.00522	0.296	0.0151	0.768
8	0.05	0.01737	0.619	0.0240	1.275
10	0.05	0.03249	0.823	0.0338	1.429
11	0.05	0.04896	1.017	0.0412	1.600
12	0.08	0.00196	0.201	0.0084	0.701
13	0.08	0.00610	0.392	0.0133	1.083
14	0.08	0.01355	0.563	0.0206	1.252
15	0.08	0.03576	0.965	0.0317	1.731
16	0.08	0.06061	1.225	0.0424	1.900
17	0.08	0.07065	1.301	0.0465	1.927

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 $\frac{d}{D_{50}}$ = 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.

Table 2: Flume Date for 0.5 Inch Roughness D_{50}=0-0088m, D_{84}=0-0115m

Sl. No.	Mean Depth d in Meters	$\frac{d}{D_{50}}$	$\frac{d}{D_{84}}$
1	0.0141	1.602	1.226
2	0.0279	3.170	2.426
3	0.0446	5.068	3.878
4	0.0627	7.125	5.452
5	0.0702	7.977	6.104
6	0.0076	0.864	0.661
7	0.0151	1.716	1.313
8	0.0240	2.727	2.087
9	0.0338	3.841	2.939
10	0.0412	4.682	3.583
11	0.0084	0.955	0.730
12	0.0133	1.511	1.157
13	0.0206	2.341	1.791
14	0.0317	3.602	2.757
15	0.0424	4.818	3.687
16	0.0465	5.284	4.043

Table 3: Flume Data for 0.75 Inch Roughness Bed

Sl. No	Channel Slope (1)	Discharge in Cubic Meters per Second (2)	Mean Velocity in Meters per Second (3)	Mean Depth d in Meters (4)	Froude No. $\frac{V}{\sqrt{gd}}$
1	0.02	0.00580	0.222	0.0223	0.475
2	0.02	0.01181	0.348	0.0290	0.653
3	0.02	0.02482	0.484	0.0439	0.738
4	0.02	0.04047	0.586	0.0591	0.770
5	0.02	0.05348	0.656	0.0698	0.792
6	0.05	0.00381	0.230	0.0141	0.619
7	0.05	0.00843	0.363	0.0199	0.822
8	0.05	0.02037	0.583	0.0299	1.077
9	0.05	0.03333	0.782	0.0365	1.308
10	0.05	0.04586	0.904	0.0434	1.385
11	0.05	0.05460	0.979	0.0477	1.432
12	0.08	0.00207	0.186	0.0095	0.608
13	0.08	0.00631	0.380	0.0142	1.018
14	0.08	0.01007	0.430	0.0200	0.970
15	0.08	0.02825	0.807	0.0299	1.489
16	0.08	0.04518	1.032	0.0375	1.703
17	0.08	0.04879	1.064	0.0392	1.175

Table 4: Flume Data for 0.75 Inch Roughness Bed D_{50}=0-013m, D_{84}=0-0193m

Sl. No.	Mean Depth d in Meters	$\frac{d}{D_{50}}$	$\frac{d}{D_{84}}$
1	0.0223	1.715	1.155
2	0.0290	2.231	1.503
3	0.0439	3.377	2.275
4	0.0591	4.546	3.062
5	0.0698	5.369	3.617
6	0.0141	1.085	0.731
7	0.0199	1.531	1.031
8	0.0299	2.300	1.549
9	0.0365	2.808	1.891
10	0.0434	3.338	2.249
11	0.0477	3.669	2.472
12	0.0095	0.731	0.492
13	0.0142	1.092	0.736
14	0.0200	1.538	1.036
15	0.0299	2.300	1.549
16	0.0375	2.885	1.943
17	0.0392	3.015	2.031

RESULTS AND ANALYSIS

For large-scale roughness $\frac{d}{D_{50}}$<2 and $\frac{d}{D_{84}}$<1.2 we can say that size of the median axis of roughness material for D_{84} is more than D_{50} hence $\frac{d}{D_{84}}$ is less than $\frac{d}{D_{50}}$

Since D_{50} and D_{84} are constant for the particular roughness bed hence due to increase in depth of flow the value of $\frac{d}{D_{50}}$ and $\frac{d}{D_{84}}$ increase because $\frac{d}{D_{50}}$ and $\frac{d}{D_{84}}$. depend on the mean depth of flow. For large scale roughness the size of the roughness material is of same order as the depth of flow or roughness materials affect the free surface. As roughness increases the depth of flow increases.

We know that roughness is dominant in high velocity of flow. Hence depth of flow increases for large scale roughness as compared to intermediate scale roughness. Hence large size of roughness materials are useful for water distribution and irrigation purposes because we get more depth of water for larger size of roughness material. Also erosion of channel bed is prevented even in steep slope for larger size of roughness material because it obstructs the flow of water as compared to smaller size of roughness material. The large scale roughness is obtained by larger size of roughness material and the size of roughness material is less for intermediate scale roughness. Hence the depth of flow and discharge of flow are more for large-scale roughness as compared to intermediate-scale roughness.

The 0.75 inch roughness bed 0.5 inch roughness bed both provide intermediate scale roughness. The average increase in depth of flow is 1.64 times for 0.75 inch roughness bed as compared to 0.5 inch roughness bed. The average increase in discharge of flow for is 1.91 times for 0.75 inch roughness bed as compared to 0.5 inch roughness bed. Since depth of flow increases and velocity of flow is dominant in more roughness to increase the depth of flow hence there is much increase in discharge of flow as compared to depth of flow. Discharge is directly proportional to mean velocity of flow hence discharge increases much for more roughness because velocity of flow is dominant for more roughness.

The 0.75 inch roughness bed has average increase in roughness of 1.37 times as compared to 0.5 inch roughness bed as compared to roughness $\frac{d}{D_{50}}$ and the 0.75 inch roughness bed has average increase in roughness of 1.55 times as compared to 0.5 inch roughness bed as compared to roughness $\frac{d}{D_{84}}$There is nearly double difference in size for 0.5 inch and 0.75 inch roughness bed with respect to $\frac{d}{D_{84}}$ as compared to $\frac{d}{D_{50}}$ hence there is more increase in roughness for 0.75 inch roughness bed as compared to $\frac{d}{D_{84}}$ because we are comparing the roughness with respect to same discharge of flow and same bed slope i.e nearly equal depth of flow hence size of the roughness material is dominant to determine roughness. More size will give more amount of roughness hence roughness is more for 0.75 inch compared with $\frac{d}{D_{84}}$.

The size of the roughness material is fixed for a particular roughness bed hence value of d/D84 or d/D50 depends upon depth of flow. Hence as $\frac{d}{D_{84}}$ increases $\frac{d}{D_{50}}$ increases because both the roughness depend upon mean depth of flow.

As depth of flow increases $\frac{d}{D_{84}}$ increases and $\frac{d}{D_{50}}$ increases.

Variation of parameter depth of flow with $\frac{d}{D_{50}}$and $\frac{d}{D_{84}}$ -: As $\frac{d}{D_{50}}$ or $\frac{d}{D_{84}}$ increases means depth of flow increases because size of the roughness material is fixed for each roughness bed hence $\frac{d}{D_{50}}$and $\frac{d}{D_{84}}$and d/D84 depend upon depth of flow.

Roughness is useful in steep slope where it is desirable to keep flow velocities from becoming excessively high.

If size of roughness material is more then $\frac{d}{D_{50}}$and $\frac{d}{D_{84}}$will be lesser hence lesser value of $\frac{d}{D_{50}}$and $\frac{d}{D_{84}}$ indicate more roughness. Here size of the roughness material is dominant factor i.e. value of $\frac{d}{D_{50}}$and $\frac{d}{D_{84}}$ depend upon size of the roughness material for equal discharge of flow or nearly equal depth of flow.

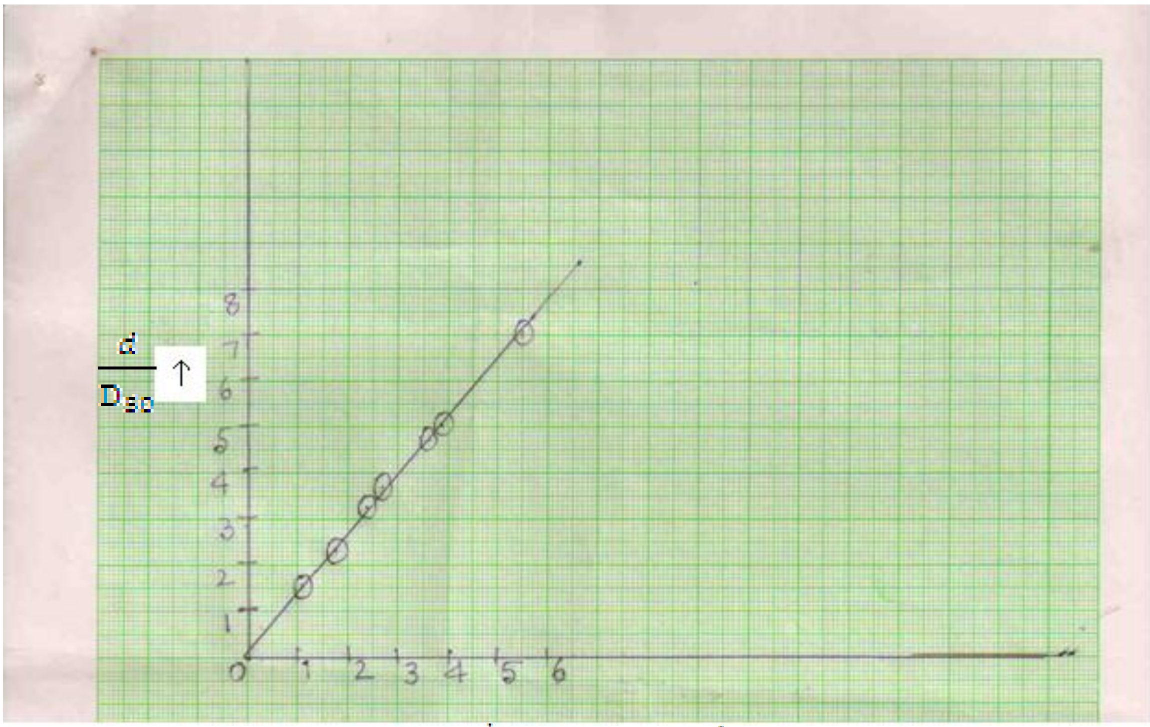

Figure 1: Variation of Parameter $\frac{d}{D_{50}}$ with Parameter $\frac{d}{D_{84}}$ for 0.5 Inch Roughness Bed

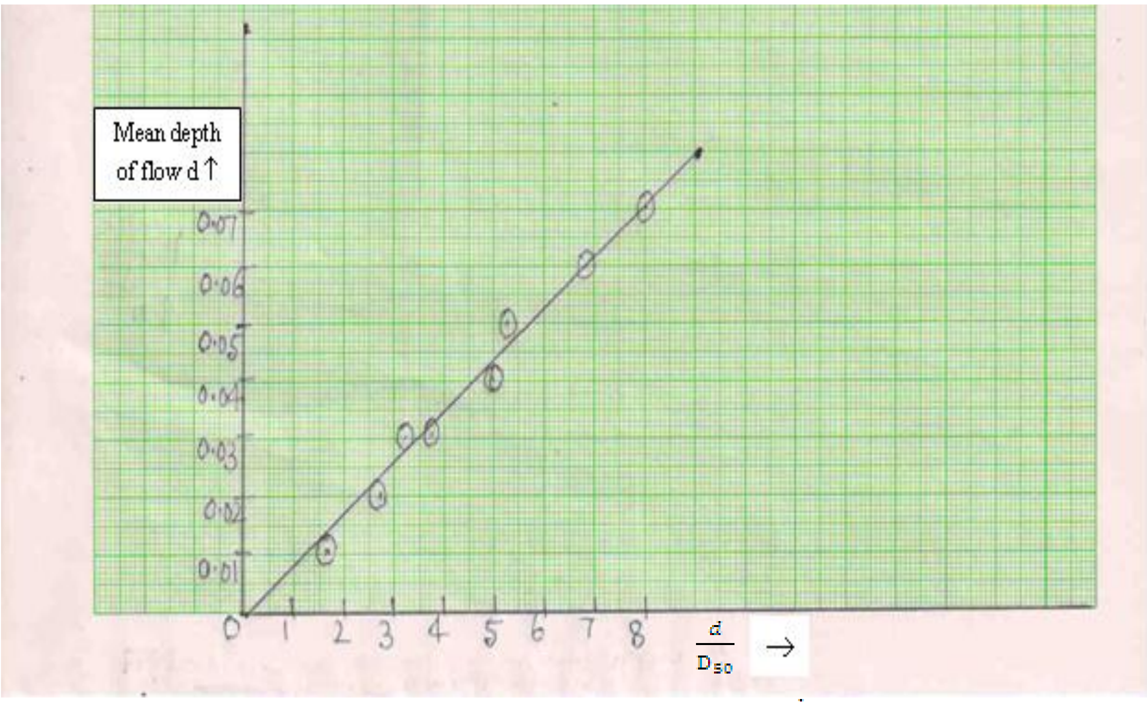

Figure 2: Variation of Parameter Mean Depth of Flow with for $\frac{d}{D_{50}}$ 0.5 Inch Roughness Bed

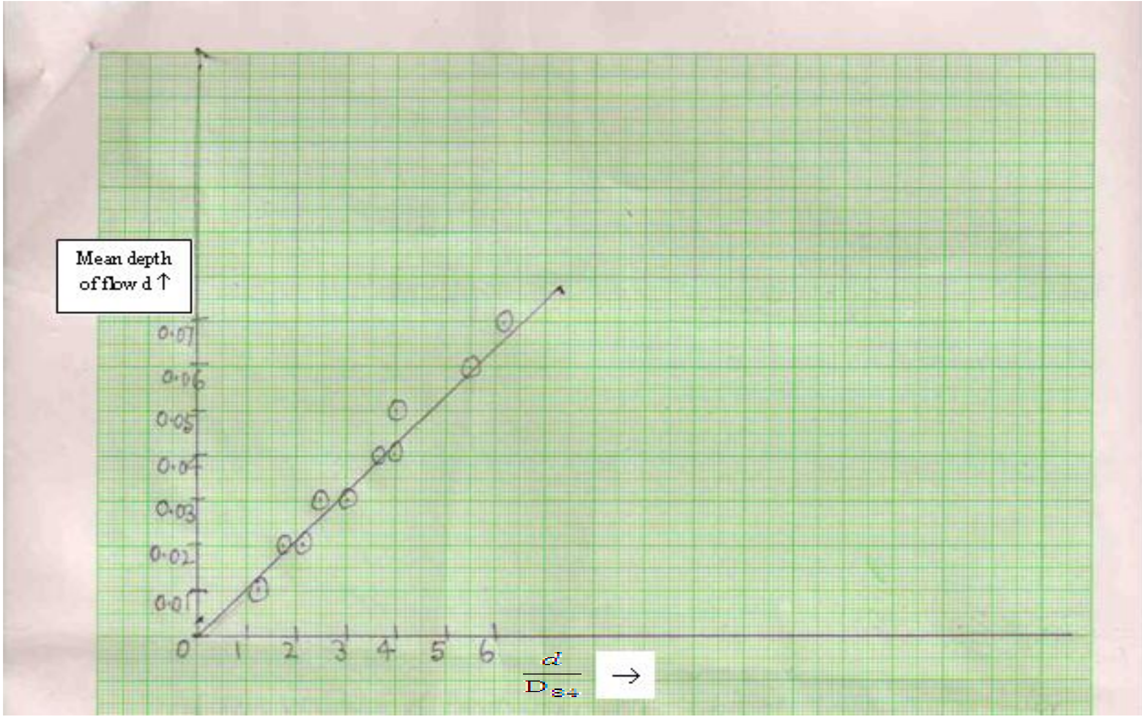

Figure 3: Variation of Parameter Mean Depth of Flow with Parameter $\frac{d}{D_{50}}$ for 0.5 Inch Roughness Bed for 0.5 Inch Roughness Bed

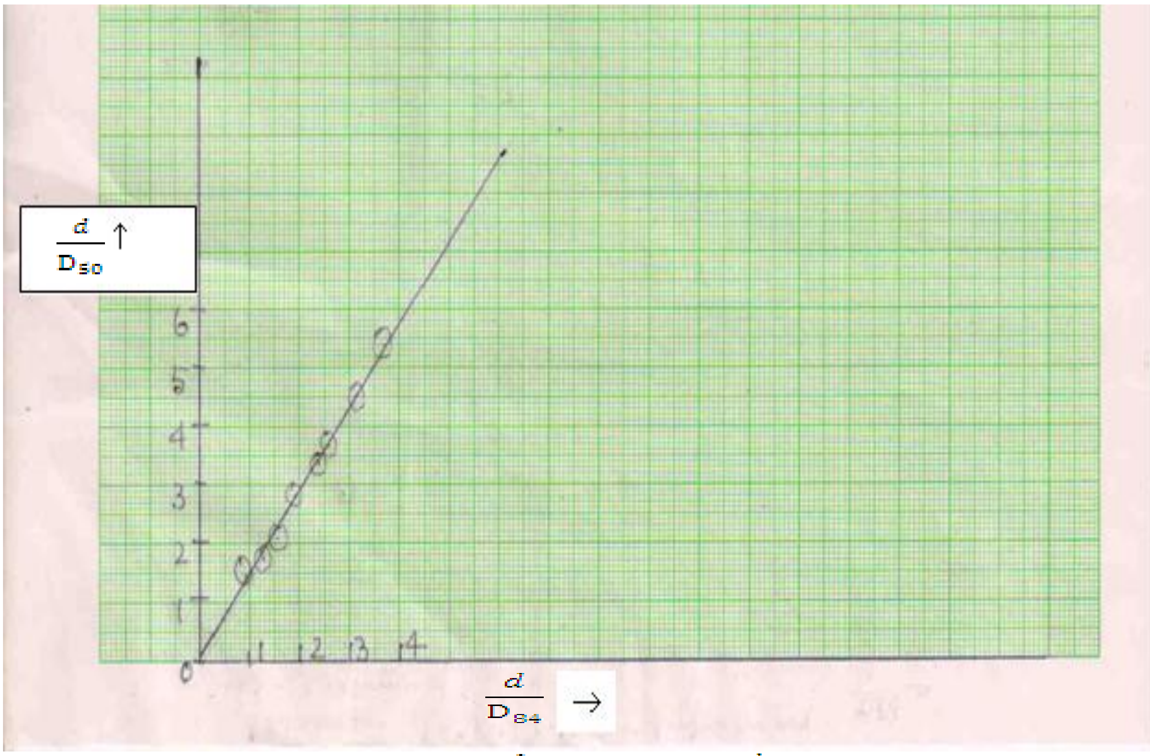

Figure 4: Variation of Parameter $\frac{d}{D_{50}}$ with Parameter $\frac{d}{D_{84}}$ for 0.75 Inch Roughness Bed for 0.5 Inch Roughness Bed

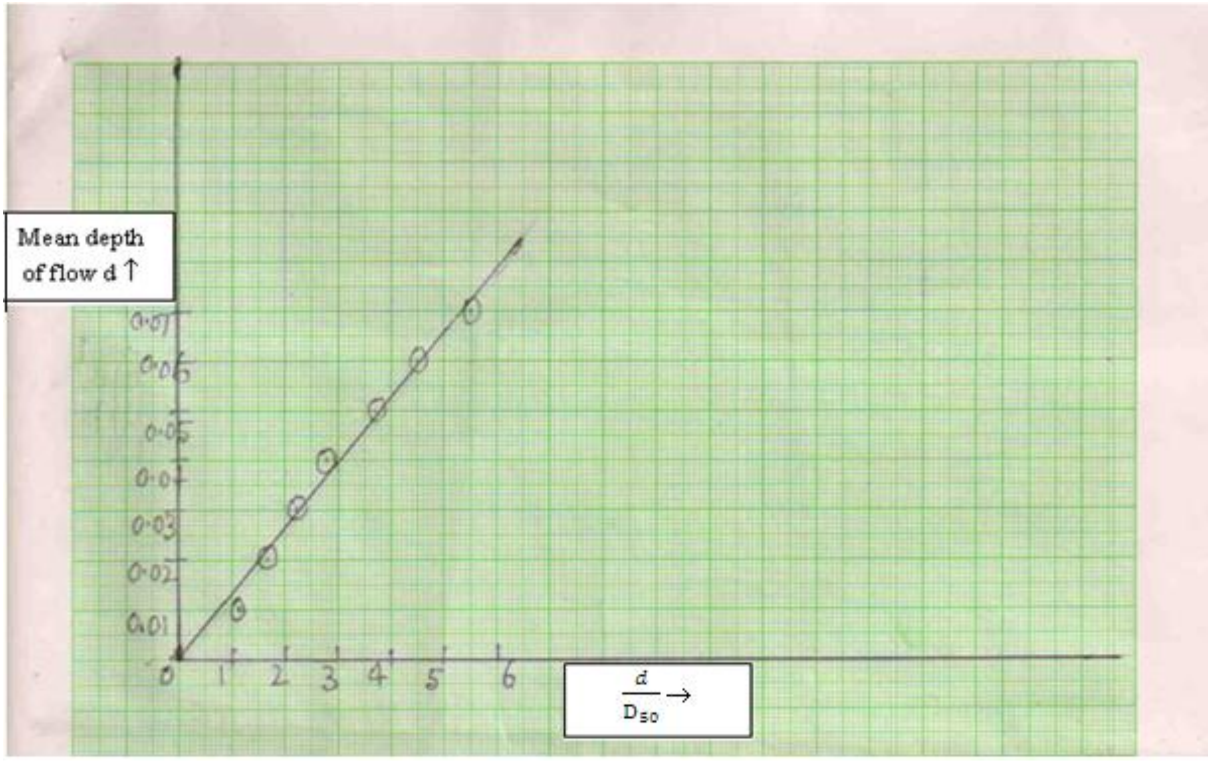

Figure 5: Variation of Parameter Mean Depth of Flow with $\frac{d}{D_{50}}$ for 0.75 Inch Roughness Bed for 0.5 Inch Roughness Bed

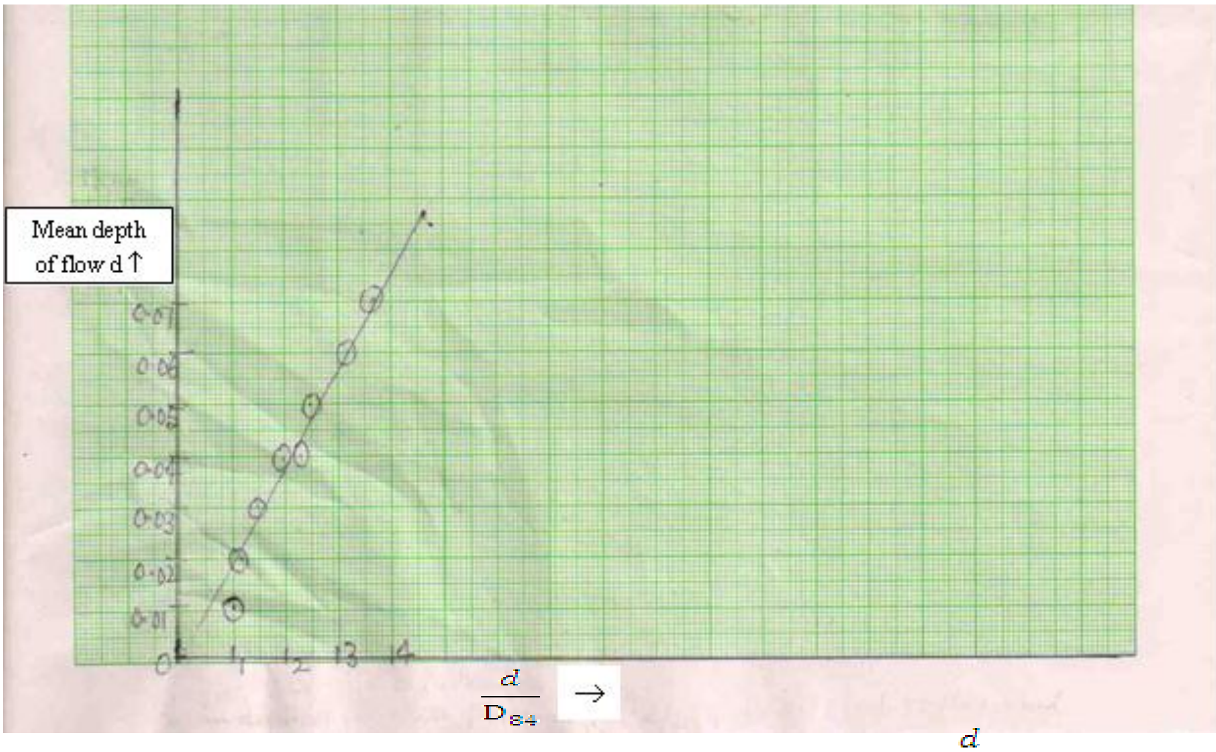

Figure 6: Variation of Parameter Mean Depth of Flow with Parameter $\frac{d}{D_{84}}$ for 0.75 Inch Roughness Bed for 0.5 Inch Roughness Bed

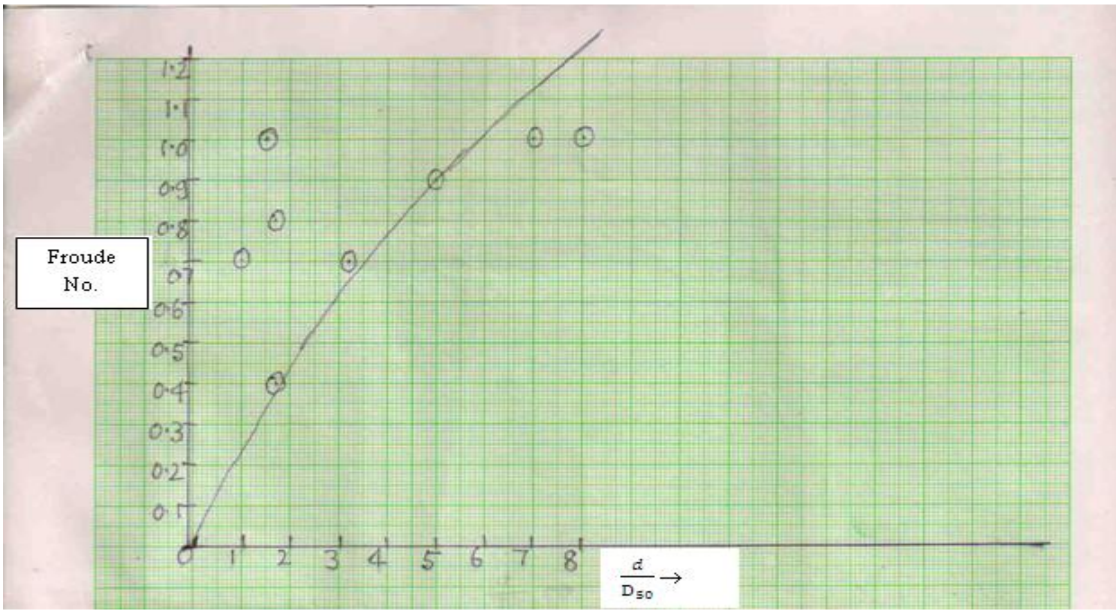

Figure 7: Variation of Parameter Froude No with Parameter $\frac{d}{D_{50}}$ for 0.5 Inch Roughness Bed for 0.5 inch Roughness Bed

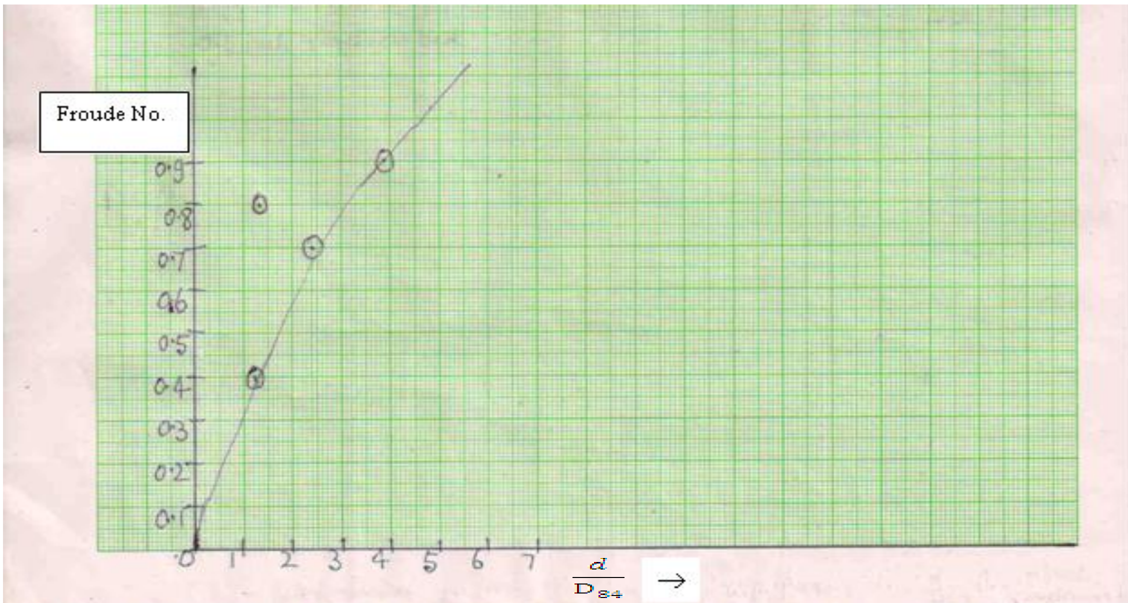

Figure 8: Variation of Parameter Froude No with Parameter $\frac{d}{D_{84}}$ for 0.5 Inch Roughness Bed for 0.5 Inch Roughness Bed

Figure 1: For a particular roughness bed the size of the roughness material is fixed hence value of $\frac{d}{D_{84}}$ or $\frac{d}{D_{50}}$ depends upon depth of flow hence as $\frac{d}{D_{84}}$ increases $\frac{d}{D_{50}}$ increases because both the roughness depend upon depth of flow. As depth of flow increases both then $\frac{d}{D_{50}}$and $\frac{d}{D_{84}}$increase.

Figure 2: As $\frac{d}{D_{50}}$ increases mean depth of flow increases because size of roughness material is fixed hence as $\frac{d}{D_{50}}$ increases mean depth of flow increases.

Figure 3: As $\frac{d}{D_{84}}$ increases mean depth of flow increases because then $\frac{d}{D_{84}}$ depends upon mean depth of flow.

Figure 7: As $\frac{d}{D_{50}}$ increases it means roughness decreases because more value of $\frac{d}{D_{50}}$ *and* $\frac{d}{D_{84}}$ indicates less roughness since roughness depends upon size and size is more for larger size of roughness material. Hence D50 & D84 will be more for larger size of roughness material or for more roughness hence value of $\frac{d}{D_{50}}$ *and* $\frac{d}{D_{84}}$ will be lesser for more roughness. Since increase in $\frac{d}{D_{50}}$ *and* $\frac{d}{D_{84}}$ indicates less roughness hence the velocity of flow increases and Froude no. depends upon velocity of low hence as $\frac{d}{D_{50}}$ *or* $\frac{d}{D_{84}}$ increase the Froude no. increases.

There is average decrease in Froude no. of 1.17 times for 0.75 inch roughness bed as compared to 0.5 inch roughness bed. Since velocity of flow is less for 0.75 inch roughness bed and Froude no depends upon velocity of flow hence Froude no is lesser for 0.75 inch roughness bed as compared to 0.5 inch roughness bed.

0.5 Inch Roughness Bed

$$Q = 1.415 \left(\frac{d}{D_{50}}\right)^{0.707} - 1.712 \left(\frac{d}{D_{84}}\right)^{0.707} + \frac{Qmax}{2.482} \tag{A}$$

$$Q_{max} = 2.227 \left(\frac{d}{D_{50}}\right)^{0.449} - 2.511 \left(\frac{d}{D_{84}}\right)^{0.449} + 2.482Q \tag{B}$$

$$d = 1.01 \left(\frac{d}{D_{50}}\right)^{0.994} - 1.318 \left(\frac{d}{D_{84}}\right)^{0.994} + \frac{dmax}{2.208} \tag{C}$$

$$d_{max} = 2.227 \left(\frac{d}{D_{50}}\right)^{0.449} - 2.513 \left(\frac{d}{D_{84}}\right)^{0.448} + 2.208d \tag{D}$$

$$V = 0.761 \left(\frac{d}{D_{50}}\right)^{1.314} - 1.084 \left(\frac{d}{D_{84}}\right)^{1.312} + \frac{Vmax}{2.00} \tag{E}$$

$$V_{max} = 1.475 \left(\frac{d}{D_{50}}\right)^{0.678} - 1.768 \left(\frac{d}{D_{84}}\right)^{0.678} + 2.00V \tag{F}$$

$$\frac{d}{D_{50}} = 1.307 \left(\frac{d}{D_{84}}\right) \tag{G}$$

$$\left(\frac{d}{D_{50}}\right)_{max} = 5.068 \left(\frac{d}{D_{84}}\right)^{0.450} \tag{H}$$

0.75 Inch Roughness Bed

- Relationship between $\frac{d}{D_{50}}$ *and* $\frac{d}{D_{84}}$ - :

$$\frac{d}{D_{50}} = 1.557\left(\frac{d}{D_{84}}\right)^{0.912} \tag{1}$$

- Relationship between $\left(\frac{d}{D_{50}}\right)\max\ with\ \frac{d}{D_{84}}$ - :

$$\left(\frac{d}{D_{50}}\right)\max\ = 4.139\left(\frac{d}{D_{84}}\right) \tag{2}$$

- Relationship between Froude No F, $\frac{d}{D_{50}}\ and\ \frac{d}{D_{84}}$ - :

$$F = 0.426\left(\frac{d}{D_{50}}\right)^{2.345} - 0.789\left(\frac{d}{D_{84}}\right)^{2.344} \tag{3}$$

- Relationship between Q and F, $\frac{d}{D_{50}}, \frac{d}{D_{84}}$: -

$$Q = 0.898\left(\frac{d}{D_{84}}\right)^{1.114} + 1.440(F)^{0.694}$$

$$-1.10\left(\frac{d}{D_{50}}\right)^{1.113} + \frac{Q_{max}}{2.092} \tag{4}$$

- Relationship between Q_{max} with $\frac{d}{D_{50}}, \frac{d}{D_{84}}$ and Froude no. F - :

$$Q_{max} = 1.433\left(\frac{d}{D_{84}}\right)^{0.698} + 1.385(F)^{0.722} - 1.824\left(\frac{d}{D_{50}}\right)^{0.698} + 2.092Q \tag{5}$$

- Relationship between d with $\frac{d}{D_{50}}, \frac{d}{D_{84}}\ and\ F -:$

$$d = 0.898\left(\frac{d}{D_{84}}\right)^{1.114} + 1.44(F)^{0.694} - 1.096\left(\frac{d}{D_{50}}\right)^{1.113} + \frac{d_{max}}{2.096} \tag{6}$$

- Relationship between d_{max} with $\frac{d}{D_{50}}, \frac{d}{D_{84}}\ and\ F -:$

$$d_{max} = 2.097\left(\frac{d}{D_{84}}\right)^{0.477} + 0.766(F)^{1.306} - 2.248\left(\frac{d}{D_{50}}\right)^{0.477} + 2.096d \tag{7}$$

- Relationship for $v\ with \frac{d}{D_{50}}, \frac{d}{D_{84}}$ and Froude no. F - :

$$V = 1.775\left(\frac{d}{D_{84}}\right)^{0.563} + 0.745(F)^{0.745} - 1.871\left(\frac{d}{D_{50}}\right)^{0.563} + \frac{V_{max}}{1.803} \tag{8}$$

- Relationship between V_{max} with $with \frac{d}{D_{50}}, \frac{d}{D_{84}}$ and Froude no. F - :

$$V_{max} = 1.177\left(\frac{d}{D_{84}}\right)^{0.849} + 1.659(F)^{0.603} - 1.604\left(\frac{d}{D_{50}}\right)^{0.849} + 1.803v \tag{9}$$

0.75 Inch Roughness Bed

$$\frac{d}{D_{50}} = 1.557\left(\frac{d}{D_{84}}\right)^{0.912} \tag{1}$$

Froude no. $F = 0.426\left(\frac{d}{D_{50}}\right)^{2.345} - 0.789\left(\frac{d}{D_{84}}\right)^{2.344}$ (2)

$$Q_{max} = 1.433\left(\frac{d}{D_{84}}\right)^{0.698} + 1.385(F)^{0.722} - 1.824\left(\frac{d}{D_{50}}\right)^{0.698} + 2.092Q \tag{3}$$

Using equation (1) and (2) in equation (3) we get - :

$$Q_{max} = 1.433\left(\frac{d}{D_{84}}\right)^{0.698} + 1.385\left[0.426\left\{1.557\left(\frac{d}{D_{84}}\right)^{0.912}\right\}^{2.345} - 0.789\left(\frac{d}{D_{84}}\right)^{2.344}\right]^{0.722}$$

$$-1.824\left(\frac{d}{D_{50}}\right)^{0.698} + 2.092Q$$

$$Hence\ Q_{max} = 1.433\ (1.725)^{0.698}$$

$$+1.385\left[0.426\left\{1.557(1.725)^{0.912}\right\}^{2.345} - 0.789(1.725)^{2.344}\right]^{0.722}$$

$$-1.824\ (2.561)^{0.698} + 2.092 \times 0.0261$$

Taking $\frac{d}{D_{84}} = 1.725, \frac{d}{D_{50}} = 2.561$ and $Q = 0.0261\, m^3 / Sec$

Hence after Simplication we get Q_{max} = 0.053 m^3/Sec ≈ 0.054 m^3/Sec hence we get same value of Q_{max} from 0.75 inch roughness bed. Hence equation (1), (2) and (3) are taken into account for Mathematical formulation of Q_{max}.

$$d_{max} = 2.097\left(\frac{d}{D_{84}}\right)^{0.477} + 0.766(F)^{1.306} - 2.248\left(\frac{d}{D_{50}}\right)^{0.477} + 2.096d \quad (1)$$

and $$d = 0.898\left(\frac{d}{D_{84}}\right)^{1.114} + 1.44(F)^{0.694} - 1.096\left(\frac{d}{D_{50}}\right)^{1.113} + \frac{d_{max}}{2.096} \quad (2)$$

Substituting equation (2) in (1) we get - :

$$d_{max} = 2.097\left(\frac{d}{D_{84}}\right)^{0.477} + 0.766(F)^{1.306}$$

$$-2.248\left(\frac{d}{D_{50}}\right)^{0.477} + 2.096\left[0.898\left(\frac{d}{D_{84}}\right)^{1.114} + 1.44(F)^{0.694} - 1.096\left(\frac{d}{D_{50}}\right)^{1.113} + 0.0333\right]$$

Substituting the average value of $\frac{d}{D_{84}} = 1.725$

Froude no. F $= 1.034$, $\frac{d}{D_{50}} = 2.561$

and d_{max} = 0.0698m

We get d_{max} from equation (1) = 0.0698m

Hence equation (1) and equation (2) are taken into account to determine the value of d_{max}

Mathematical formulation to get mean value of Q

$$Q = 0.898\left(\frac{d}{D_{84}}\right)^{1.114} + 1.440(F)^{0.694} - 1.10\left(\frac{d}{D_{50}}\right)^{1.113} + \frac{Q_{max}}{2.092} \quad (1)$$

Again -:

$$Q_{max} = 1.433\left(\frac{d}{D_{84}}\right)^{0.698} + 1.385(F)^{0.722} - 1.824\left(\frac{d}{D_{50}}\right)^{0.698} + 2.092Q \quad (2)$$

Substituting Q_{max} from (2) in (1) we get -:

$$Q = 0.898\left(\frac{d}{D_{84}}\right)^{1.114} + 1.440(F)^{0.694} - 1.10\left(\frac{d}{D_{50}}\right)^{1.113}$$

$$+\frac{1}{2.092}\left[1.433\left(\frac{d}{D_{84}}\right)^{0.698} + 1.385(F)^{0.722} - 1.824\left(\frac{d}{D_{50}}\right)^{0.698} + 0.05460\right]$$

Substituting the average value of $\frac{d}{D_{84}}, F, \frac{d}{D_{50}}$ *and* $2.092\,Q = 0.05460\ \ m^3/Sec$

Hence we get

$Q = 0.0165$ m^3/Sec

≈ = 00261 m^3/Sec

Hence this is the required mathematical formulation for determination of average value of Q.

Mathematical formulation for average value of ν -:

$$v = 1.775\left(\frac{d}{D_{84}}\right)^{0.563} + 0.745(F)^{0.745} - 1.871\left(\frac{d}{D_{50}}\right)^{0.563} + \frac{v_{\max}}{1.803} \tag{1}$$

$$v_{\max} = 1.177\left(\frac{d}{D_{84}}\right)^{0.849} + 1.659(F)^{0.603} - 1.604\left(\frac{d}{D_{50}}\right)^{0.849} + 1.803v \tag{2}$$

Substituting ν_{max} from equation (2) in equation (1) we get -:

$$v\ = 1.775\left(\frac{d}{D_{84}}\right)^{0.563} + 0.745(F)^{0.745} - 1.871\left(\frac{d}{D_{50}}\right)^{0.563}$$

$$+\frac{1}{1.803}\left[1.177\left(\frac{d}{D_{84}}\right)^{0.849} + 1.659(F)^{0.603} - 1.604\left(\frac{d}{D_{50}}\right)^{0.849} + 1.803v\right]$$

Substituting the average value of $\frac{d}{D_{84}}, F, \frac{d}{D_{50}}$ *and* $1.803\,v = 1.064\ m/\sec$

We get ν = 0.590 m/Sec which is equal to mean velocity of flow for 0.75 inch roughness bed. hence this is the mathematical formulation to get mean velocity of flow V.

Average Values

(i)	$\frac{d}{D_{50}} = 2.561$	(ii)	$\frac{d}{D_{84}} = 1.725$
(iii)	Froude no F = 1.034	(iv)	$Q = 0.0261\ \ m^3/Sec$
(v)	d = 0.0333m	(vi)	ν = 0.590 m/Sec

CONCLUSIONS

Roughness provides large capacity of the channel because velocity of flow is reduced and depth of flow increases. Roughness prevents erosion in steep channels, underlying soil is completely protected since velocity of flow is reduced due to roughness. Roughness is useful in steep slope where it is desirable to keep flew velocities from becoming excessively high.

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APPENDICES

Appendix –I-: Notation

The following symbols are used in this paper-:

D = Mean depth of flow in meters

q = Discharge in cubic meters per second

v = Mean velocity of flow in meters per second.

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

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