Comparison of Minimum and Maximum Permissible Velocity of Flow with Respect to Advantage of Roughness

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***Abstract:-*The comparison of minimum permissible velocity and maximum permissible velocity is done with respect to mean depth of flow. We find that the minimum permissible velocity of flow or non silting velocity is more advantageous as compared to maximum permissible velocity of flow or non erodible velocity of flow from mean depth of flow point of view. Also, we get more conveyance with respect to minimum permissible velocity. Hence, minimum permissible velocity of flow or non silting velocity is more advantageous as compared to maximum permissible velocity or non erodible velocity from advantage of roughness point of view.**

Keywords: **Minimum permissible velocity; Maximum permissible velocity; Advantage of roughness; Mean depth of flow; Conveyance**

I. INTRODUCTION

The values of non-silting velocity of flow or minimum permissible velocity, maximum permissible velocity or non erodible velocity are calculated with respect to mean depth of flow, conveyance and hydraulic radius. The Analysis of the results derived is done to suggest that the minimum permissible velocity of flow or non silting velocity is more advantageous as compared to maximum permissible velocity of flow or non erodible velocity of flow from mean depth of flow point of view.

II. EXPERIMENTAL SETUP & PROCEDURES

Data was obtained for 0.5, 0.75 & 2.0 inch roughness bed.

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

Experimental Procedure - 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.

III. RESULTS AND ANALYSIS

The equation for non silting velocity of flow and depth of flow is given by:-

$$V_s = 0.239(Y_p)^{0.698} \quad - \quad (1)$$

Where V_s = Maximum permissible velocity or non silting velocity of flow in m/sec, Y_p= Depth of flow of prototype in meters. Non silting velocity = 0.762 m/sec

$$V_o = 0.84(Y_p)^{0.64} \quad - \quad (2)$$

Where V_o= Maximum permissible velocity of flow in m/sec.

For average value of depth of flow taken from 0.75 inch roughness bed flume data, we have Y_m=0.0333m where Y_m= Depth of flow for model or laboratory channel.

Now $\frac{Y_m}{Y_p} = \frac{1}{n} = \frac{1}{130}$ where n = 130= scale factor for prototype. Hence, Y_p = 4.329 metre

Now from the equation Vo= 0.84 $(Y_p)^{0.64}$

V_o=1.5 m/sec. Hence, Y_p = 2.476 metre.

From non silting velocity point of view,

$$V_s = 0.239(Y_p)^{0.698}$$

V_s=0.762 m/sec

Hence, Y_p=5.267 metre

Hence, non silting velocity of flow or minimum permissible velocity of flow is more advantageous as compared to maximum permissible velocity or non erodible velocity of flow from more depth of flow point of view i.e. with respect to roughness point of view. With respect to non silting velocity, the velocity of flow reduces to displace silt. Hence, mean depth of flow increases hence conveyance also increases.

We know conveyance

$$K = \frac{1.49}{n} AR^{2/3}$$

Where K = Conveyence

n= Manning’s roughness coefficient

A= Flow cross ectional area = $2Y_p^2$ for best hydraulic section

$$V_o = 0.84(Y_p)^{0.64}$$

V_o=1.5m/sec hence Y_p=2.476 metre.

Hence, flow cross sectional area for rectangular channel = 2 $(2.476)^2$ =12.262m^2

Now $\frac{Y_m}{Y_p} = \frac{1}{130}$

$\therefore$ Y_m=0.0190 metre.

Hence, flow cross sectional area for laboratory channel = 2 Y_m^2=0.0008m^2.

For best hydraulic section :-

Hydraulic radius = $\frac{1}{2}Y_m$ = 0.0095 metre.

Corresponding to hydraulic radius =0.0095 m from 0.75 inch roughness bed flume data, the value of Manning's roughness coefficient n=0.065

Hence conveyance

$$K = \frac{1.49}{0.065}\, x\, 0.0008\, x\, (0.0095)^{2/3}$$

= 0.0008 m^3/sec

Now $\frac{K_m}{K_p} = \frac{1}{n^{2.5}}$

Where K_m= conveyance for model or laboratory channel in m^3/sec

K_p = Conveyance for prototype or river

n=130 = scale factor for river

Hence $\frac{0.0008}{K_p} = \frac{1}{192690}$

$\therefore$ K_p=154.2m^3/sec.

With respect to minimum permissible velocity :-

Conveyance $K = \frac{1.49}{n} = AR^{2/3}$

K = 0.0017 m^3/sec

Now $\frac{K_m}{K_p} = \frac{1}{n^{2.5}}$

K_p=328 m^3/sec

Hence with respect to minimum permissible velocity or non silting velocity the conveyance is more as compared to maximum permissible velocity.

Since $V_s=0.239(Y_p)^{0.698}$

$0.762 = 0.239(Y_p)^{0.698}$

Y_p=5.267 mtre

$\frac{Y_m}{Y_p} = \frac{1}{130}$

$\therefore$ Y_m=0.0405 metre

Flow cross sectional area from best hydraulic section $2Y_m^2$ =0.0032 metre.

Hydraulic radius = $\frac{1}{2}Y_m$ = 0.0016 metre

Corresponding to Y_m =0.0405 metre S.No.(10) of 0.5 inch roughness bed flume data

n = 0.037

Hence, $K = \frac{1.49}{0.037}\, x\, 0.0032\, x\, (0.0016)^{2/3}$ =0.0017 m^3/sec

Now $\frac{K_m}{K_p} = \frac{1}{n^{2.5}} = \frac{1}{(130)^{2.5}}$

$\therefore$ K_p= 328m^3/sec

With respect to no silting velocity:-

$0.762 = V_s=0.239(Y_p)^{0.698}$

$\therefore$ Y_p=5.267metre

$\frac{Y_m}{Y_p} = \frac{1}{130}$

$\therefore$ Y_m= 0.0405 metre.

Width of channel = 1.168 metre = W

Hence, hydraulic radius,

$$R = \frac{1.168\, x\, 0.0405}{1.168 + 2\, x\, 0.0405}$$

=0.0379 metre

With respect to maximum permissible velocity hydraulic radius = R =0.0184m. Hence with respect to non silting velocity, we get more hydraulic radius i.e. with respect to advantage of roughness point of view hence non silting velocity is useful from advantage of roughness point of view.

IV. CONCLUSIONS

Non silting velocity of flow or minimum permissible velocity is advantageous as compared to maximum permissible velocity or non erodible velocity with respect to mean depth of flow, conveyance and hydraulic radius i.e. we get more mean depth of flow, conveyance and hydraulic radius for minimum permissible velocity as compared to maximum permissible velocity of flow.

APPENDIX 1: OBSERVATION TABLES

Table 1: Flume Data for 0.5 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)	Hydraulic radius $R=\frac{A}{P}=\frac{Wd}{W+2d}$ (6)	Manning's Roughness Coefficient $n=\frac{1.49}{V}R^{2/3}S^{1/2}$ (7)
1.	0.02	0.00241	0.146	0.0141	0.014	0.083
2.	0.02	0.01274	0.391	0.0279	0.027	0.048
3.	0.02	0.03046	0.584	0.0446	0.041	0.043
4.	0.02	0.05746	0.785	0.0627	0.056	0.038
5.	0.02	0.07197	0.877	0.0702	0.063	0.038
6.	0.05	0.00143	0.161	0.0076	0.008	0.081
7.	0.05	0.00522	0.296	0.0151	0.015	0.068
8.	0.05	0.01737	0.619	0.0240	0.023	0.043
9.	0.05	0.03249	0.823	0.0338	0.032	0.041
10.	0.05	0.04896	1.017	0.0412	0.038	0.037
11.	0.08	0.00196	0.201	0.0084	0.008	0.080
12.	0.08	0.00610	0.392	0.0133	0.013	0.059
13.	0.08	0.01355	0.563	0.0206	0.020	0.055
14.	0.08	0.03576	0.965	0.0317	0.030	0.041
15.	0.08	0.06061	1.225	0.0424	0.040	0.040
16.	0.08	0.07065	1.301	0.0465	0.043	0.039

Table 2: Flume data for 0.75 inch roughness bed

Sl. No. (1)	Channel Slope (2)	Discharge in cubic meters per second (3)	Mean depth d in meters (4)	Mean velocity in meters per second (5)
1.	0.02	0.00580	0.0223	0.222
2.	0.02	0.01181	0.0290	0.348
3.	0.02	0.02482	0.0439	0.484
4.	0.02	0.04047	0.0591	0.586
5.	0.02	0.05348	0.0698	0.656
6.	0.05	0.00381	0.0141	0.230
7.	0.05	0.00843	0.0199	0.363
8.	0.05	0.02037	0.0299	0.583
9.	0.05	0.03333	0.0365	0.782
10.	0.05	0.04586	0.0434	0.904
11.	0.05	0.05460	0.0477	0.979

12.	0.08	0.00207	0.0095	0.186
13.	0.08	0.00631	0.0142	0.380
14.	0.08	0.01007	0.0200	0.430
15.	0.08	0.02825	0.0299	0.807
16.	0.08	0.04518	0.0375	1.032
17.	0.08	0.04879	0.0392	1.064

Table 3: Flume data for 0.75 inch roughness bed

Sl. No. (1)	Hydraulic radius $R=\frac{A}{P} = \frac{Wd}{W+2d}$ (2)	Manning's roughness coefficient n (3)
1.	0.021	0.071
2.	0.028	0.055
3.	0.040	0.050
4.	0.054	0.051
5.	0.063	0.050
6.	0.013	0.078
7.	0.019	0.065
8.	0.029	0.053
9.	0.035	0.045
10.	0.041	0.043
11.	0.044	0.042
12.	0.009	0.096
13.	0.014	0.063
14.	0.019	0.069
15.	0.029	0.049
16.	0.035	0.043
17.	0.037	0.043

Table 4 : Flume data for 2.0 inch roughness bed.

Sl. No. (1)	Channel Slope (2)	Discharge in cubic meters per second (3)	Mean depth d in meters (4)	Mean velocity in meters per second (5)
1.	0.02	0.00329	0.0282	0.100
2.	0.02	0.00837	0.0378	0.189
3.	0.02	0.01158	0.0436	0.227
4.	0.02	0.02541	0.0578	0.377
5.	0.02	0.04047	0.0668	0.519
6.	0.02	0.04949	0.0705	0.601
7.	0.05	0.00329	0.0213	0.132
8.	0.05	0.00713	0.0285	0.214
9.	0.05	0.01413	0.0359	0.337
10.	0.05	0.02068	0.0411	0.431
11.	0.05	0.02941	0.0465	0.542

12.	0.05	0.04368	0.0582	0.643
13.	0.08	0.00247	0.0130	0.162
14.	0.08	0.00565	0.0236	0.205
15.	0.08	0.01077	0.0295	0.313
16.	0.08	0.02187	0.0363	0.515
17.	0.08	0.03249	0.0437	0.637
18.	0.08	0.03724	0.0488	0.712

Table 5 : Flume data for 2.0 inch roughness bed.

Sl. No. (1)	Hydraulic radius R= $\frac{A}{P} = \frac{Wd}{W+2d}$ (2)	Manning's roughness coefficient n (3)
1.	0.027	0.186
2.	0.036	0.120
3.	0.041	0.109
4.	0.053	0.078
5.	0.060	0.061
6.	0.063	0.055
7.	0.021	0.190
8.	0.027	0.139
9.	0.034	0.103
10.	0.038	0.087
11.	0.043	0.075
12.	0.053	0.073
13.	0.013	0.141
14.	0.023	0.164
15.	0.028	0.123
16.	0.034	0.085
17.	0.041	0.078
18.	0.041	0.070

APPENDIX 2: NOTATIONS

The following symbols are used in this paper:-

A	=	Flow cross sectional area = Wd.
$AR^{2/3}$	=	Section factor
b	=	Function of effective roughness concentration.
d	=	Mean depth of flow in meters.
k	=	Conveyance in m^3/sec
n	=	Manning's roughness coefficient
P	=	Wetted Perimeter.
R	=	Hydraulic radius $= \frac{A}{p} = \frac{Wd}{W+2d}$
S	=	Channel slope.
Q	=	Discharge in cubic meters per second.
V	=	Mean velocity of flow in meters per second.
W	=	Width of the channel = 1.168m

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