# Section Factor with Respect to Surface Roughness

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*Abstract:-* **The relationship for section factor $AR^{2/3}$ with different roughness coefficient are established and the section factor is determined with respect to the derived equations with respect to maximum mean depth of flow and minimum velocity of flow. We find that the value of section factor is more with respect to maximum depth of flow as compared to minimum depth of flow because section factor depends upon mean depth of flow. As we have more mean depth of flow, it indicates more discharge of flow. Hence, section factor is more but we get less mean depth of flow with respect to minimum velocity of flow.**

*Keywords:* **Section factor; Manning's roughness constant; Conveyance; Darcy Weisbach resistance coefficient; Constant varying with bed material properties; Flow cross sectional area; Hydraulic radius.**

## I. INTRODUCTION

The section factor obtained with respect to Darcy Weisbach resistance coefficient gives more value of section factor as compared to Manning's roughness coefficient because power of mean velocity of flow is two which is in denominator and power of mean velocity of flow is unity

since $f = \frac{8gRs}{V^2}$ and $n = \frac{1.49R^{2/3}S^{1/2}}{V}$. Hence there is more reduction in mean velocity of flow due to Darcy Weisbach resistance coefficient as compared to Manning's roughness coefficient. And there will be more increase in mean depth of flow for Darcy Weisbach resistance coefficient as compared to Manning's roughness coefficient. F =Darcy Weisbach resistance coefficient. n= Manning's roughness coefficient. g=Acceleration due to gravity in m/sec$^2$. R=Hydraulic radius in metre. V=Mean velocity of flow in m/sec. S=Channel slope.

The relationship between hydraulic radius and mean depth of flow is established with coefficient and power. And it is seen that as hydraulic radius increases, power which is constant, decreases.

Hence power i.e. constant which acts like surface roughness. The relationship with section factor and constant and conveyance is established and analysis is made with respect to maximum mean depth of flow and minimum velocity of flow. And it is found the value of section factor obtained with this constant gives more value as compared to Manning's roughness coefficient and Darcy Weisbach resistance coefficient. And the value of section factor obtained with respect to $V_{min}$ for Darcy Weisbach resistance coefficient gives more value as compared to the section factor obtained with respect to $V_{min}$ for this constant.

## II. EXPERIMENTAL SETUP & PROCEDURES

Data were obtained for 0.75-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

*(Refer Appendix 1 – Observation Tables for data)*

The relationship for section factor with Manning's roughness coefficient and conveyance is given by:-

$$AR^{2/3} = \frac{nK}{1.49} \quad - \quad (1)$$

Where $AR^{2/3}$ = Section factor in m$^3$/sec

n= Manning's roughness coefficient

K= Conveyance in m$^3$/sec.

As Manning's roughness coefficient increases, the velocity of flow decreases. As a result, depth of flow increases and section factor and conveyance depend upon depth of flow. Hence, section factor $\left(AR^{2/3}\right)$ and conveyance (K) increase with increase in Manning's roughness coefficient.

Similarly, as Darcy Weisbach resistance coefficient increases, the velocity of flow decreases and depth of flow increases. Hence, section factor and conveyance increase and the relationship of section factor with Darcy Weisbach resistance coefficient and conveyance is given by:

$$AR^{2/3} = \frac{fK}{1.412} \quad - \quad (2)$$

where f= Darcy Weisbach resistance coefficient.

With respect to advantage of roughness point of view i.e. with respect to maximum mean depth of flow $d_{max}$=0.0698m (S.

No. 5) of 0.75-inch roughness bed flume data- corresponding values of: -

Manning's roughness coefficient n = 0.050

Discharge of flow Q = 0.05348$m^3$/sec

Channel slope S = 0.02

Hence using conveyance K = $\frac{Q}{\sqrt{S}} = \frac{0.05348}{\sqrt{0.02}} = 0.378$

Hence, from equation (1), section factor $AR^{2/3}$ = 0.0127$m^3$/sec

Where A = Flow cross sectional area in $m^2$

R=Hydraulic radius in metre

Similarly, corresponding to $d_{max}$=0.0698m, f=0.255

Hence from equation (2), section factor $AR^{2/3}$ =0.0683 $m^3$/sec.

Velocity is much reduced in Darcy Weisbach resistance coefficient since $f = \frac{8gRs}{V^2}$ where

f= Darcy Weisbach resistance coefficient

g=Acceleration due to gravity in m/$sec^2$

R= Hydraulic radius in metre

S= Channel slope

V=Mean velocity of flow in m/sec

And $n = \frac{1.49R^{2/3}S^{1/2}}{V}$ .Here power of V which is in denominator is unity whereas power of V is two for Darcy Weisbach resistance coefficient. Hence velocity is much reduced for Darcy Weisbach resistance coefficient and there is more increase in depth of flow. And section factor depends upon depth of flow hence section factor is more for equation (2) as compared to equation (1).

With respect to minimum value of velocity of flow i.e. $V_{min}$= 0.186m/sec (S. No. 12) of 0.75-inch roughness bed flume data. Corresponding value of n=0.096, f=1.731, Q=0.00207$m^3$/sec and S=0.08. Hence from equation (1) using K=conveyance $\frac{Q}{\sqrt{S}}$ we get section factor $AR^{2/3}$ =0.00047$m^3$/sec whereas from equation (2) section factor $AR^{2/3}$ =0.00894$m^3$/sec. Here comparison is made with respect to $V_{min}$ i.e. for less depth of flow and section factor depends upon depth of flow hence section factor is lesser as compared to $d_{max}$. But increase in depth of flow is more for Darcy Weisbach resistance coefficient hence section factor is more for f as compared to n.

The relationship between hydraulic radius and mean depth of flow is given by R=0.658$(d)^{a}{}_2$ where $a_2$= constant varying with bed material properties and it is seen that as hydraulic radius increases depth of flow increases and constant $a_2$ decreases like n & f.

The relationship between section factor with constant $a_2$ and conveyance is given by: -

$$AR^{2/3} = \frac{a_2 K}{1.031} \qquad (3)$$

With respect to $d_{max}$= 0.0698 m (S.No. 5) of 0.75 inch roughness bed flume data, corresponding value of R= 0.063m, Q=0.05348 $m^3$/sec & S=0.02 Hence K= $\frac{Q}{\sqrt{S}}$ =0.378 and we know that R=0.658(d)$a_2$

Hence $a_2$=0.881.

Hence, section factor from equation (3) is $AR^{2/3}$ =0.323 $m^3$/sec with respect to $V_{min}$=0.186m/sec (S. No. 12) of 0.75 inch roughness bed corresponding value of hydraulic radius

R= 0.009m

Q=0.00207$m^3$/sec

d=0.0095m

S=0.08

Hence using R = 0.658(d)$a_2$

$a_2$=0.921

and section factor from equation (3) is $AR^{2/3}$ =0.0065$m^3$/sec. Hence, with respect to $d_{max}$= 0.0698m (S. No. 5) of 0.75-inch roughness bed flume data we get more value of section factor using constant $a_2$ as compared to Manning's roughness coefficient and Darcy Weisbach resistance coefficient.

## IV. CONCLUSION

The section factor obtained from constant $a_{2,}$ which is varying with bed material properties, is more effective with respect to depth of flow as compared to Manning's roughness coefficient and Darcy Weisbach resistance coefficient to provide more section factor. The Darcy Weisbach resistance coefficient is more effective than Manning's roughness coefficient and constant $a_2$ with respect to minimum velocity of flow to raise more depth of flow in case of Darcy Weisbach resistance coefficient and to give more section factor as compared to Manning's roughness coefficient and constant $a_2$ which is varying with bed material properties.

## V. APPENDIX 1: OBSERVATION TABLES

Table 1: 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 2: Flume data for 0.75 inch roughness bed

| Sl. No. (1) | Hydraulic radius R (2) | Manning's roughness coefficient n (3) | Darcy Weisbach resistance co-efficient f (4) |
|---|---|---|---|
| 1. | 0.021 | 0.071 | 0.708 |
| 2. | 0.028 | 0.055 | 0.375 |
| 3. | 0.040 | 0.050 | 0.294 |
| 4. | 0.054 | 0.051 | 0.270 |
| 5. | 0.063 | 0.050 | 0.255 |
| 6. | 0.013 | 0.078 | 1.046 |
| 7. | 0.019 | 0.065 | 0.591 |
| 8. | 0.029 | 0.053 | 0.345 |
| 9. | 0.035 | 0.045 | 0.234 |
| 10. | 0.041 | 0.043 | 0.209 |
| 11. | 0.044 | 0.042 | 0.195 |
| 12. | 0.009 | 0.096 | 1.731 |
| 13. | 0.014 | 0.063 | 0.617 |
| 14. | 0.019 | 0.069 | 0.680 |
| 15. | 0.029 | 0.049 | 0.289 |
| 16. | 0.035 | 0.043 | 0.221 |
| 17. | 0.037 | 0.043 | 0.218 |

## VI. APPENDIX 2 - NOTATIONS

The following symbols are used in this paper: -

A = Flow cross sectional area = Wd.

$AR^{2/3}$ = Section factor in $m^3$/sec

$a_2$ = Constant Varying with bed material properties

d = Mean depth of flow in meters.

f = Darcy Weisbach Resistance Coefficient

g = Acceleration due to gravity in metre/$sec^2$

k = Conveyance in $m^3$/sec

n = Manning's roughness coefficient

P = Wetted Perimeter.

Q = Discharge in cubic meters per second.

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

S = Channel slope.

V = Mean velocity of flow in meters per second.

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