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Variation of Roughness Coefficient in Compound Channel

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Abstract : *Generally a meander is a bend in a sinuous watercourse or river. Rivers generally meanders due to many factors like environmental condition and roughness. In an open channel flow the resistance is dependent on factors like number of flows and several geometric parameters. Discharge estimation are necessary flood prediction, flood protection measure and water management too. For the actual carrying capacity of a channel it is quite indispensable to understand the accurate value of roughness coefficient. . The usual practise in flow analysis is to select a value of n to determine the carrying capacity of a channel. The excessive value and lowest value can underrate and overrate respectively. Rivers generally change their flow of pattern minimizing the "energy loss". All the different parameters are correlated the single value of manning's n. The value of 'n' is directly proportional with the loss of energy. Recently discharge estimation methods used in river modelling software are originated from the hand calculation formulae such as chezy's, manning's and Darcy-Weisbach equation. The factors influence the roughness coefficient is dimensionless. The different geometric, flow parameters and surface always affect the flow properties. In this paper the variation of coefficient roughness manning's n, chezy's c and Darcy's weisbach coefficient f are estimated in both meandering and straight channel.*

Keywords: *Aspect ratio, Compound channel, energy loss, Meander, manning's n, Relative depth, Sinuosity.*

I. Introduction

It is so ubiquitous curves in rivers and therefore smooth meander forms so that they attracted the investigators of many field. The condition varied from one meandering loop to another meandering loop. Different meandering shows the different geometric characteristic and grain size distribution too. Water is the most obligatory things for mankind. Life can't be imaginable without water. River may return all the water to sea but in the occurrence of high rainfall, the river may overflow with possible danger to life. Rivers are the integral part of water cycle and due to this cycle the water available in landscape. Sometimes due to overbank flow in river it causes serious damage to the living beings. Therefore its very much necessary the accurate estimate the design capacity of meandering channel due to the flood protection, flood plain management, protection of bank, to understand the mechanism of sediment transport etc.Regarding the nature of flow distribution in both meandering and straight compound channel need to be understand though discharge through both type channel are totally different from each other[1,2]. In order to parameter basis the flow through straight channel are quite simple than a meandering channel. The flow is very much complicated in meandering channel. So flow distribution and velocity plays a vital role in it. As meander is formed when the moving water widens the valley by erodes the outer banks in a stream. Roughness coefficient is a vital facet that also needs to understand properly in a channel. The influence of roughness is quite significant as it can overestimate and underestimate the discharge. For the calculation of channel discharge sinuosity and slope is an important aspect. Recently discharge calculation method deployed in meandering channel which is based on the hand calculation formulae such as chezy's, manning's and Darcy-weisbach equation. Usually these equations are used to calculate the velocity distribution in an open channel. Already many researchers work in this to provide improvement mainly in straight channel. The velocity distribution, flow resistance in compound cross section has been discussed earlier by many of the investigators. Mostly the roughness coefficient and the parameters assumed to be no change in flow distribution formula of over topping channel. But in meandering channel the shear stress distribution and geometry varies point to point. Therefore it's very significant to address properly these parameters which can predict the accurate discharge during flood control. Many field engineers use manning's equation due to its popularity to estimate the velocity distribution. In meandering channel the values of "n" can be calculated by considering both geometry factors and sinuosity effects. The value of roughness coefficient varies a lot in meandering channel as compared to straight channel. In manning's equation ,the values of 'n' is most important in all as it is the only parameter which can proper estimate the velocity in straight and meandering channel. When the flows interacts, more energy consumed in high meandering section, the resistance coefficient recognised in the form of variation of resistance coefficients of the channel[3,4]. Such resistance is characterised by parameters like manning's roughness coefficient (n), Darcy-weisbach fraction factor (f) and chezy's resistance factor(c).

II. Experimental Details

The results are obtained by taking the help of experimental data obtained from channel facility of Hydraulics lab of civil engineering department at NIT Rourkela. The geometrical parameters of experimental channels are given in Table-II-1. For the two types of experimental channels the flow aspect ratio "α" between flow depth "h" and main channel base width "b" and relative depth "β" between difference in depth of flood plain and main channel "(H-h)" and flood plain depth "H". The experimental channels are fabricated using 6mm thick Perspex sheet inside a tilting flume. The tilting flume is 12m long and 0.6m wide. The meandering channel model thus fabricated having wavelength L = 40cm, double amplitude 2A'= 32.3cm, 12cm×12 cm main channel and flood plain width B = 45.7cm.The meandering channel is having sinuosity = 1.44.The 2nd set up constitutes a straight compound channel with all surfaces made up of Perspex sheets (same material as the meandering compound channel). The model for straight symmetrical compound channel thus fabricated has 12cm×12cm main channel and the flood plain width of 32 cm. The iron framed flume has the overall dimension of 12 m long and 0.50 m wide and 0.5 m depth. The discharge is measured by the time rise method using piezometer connected with rectangular volumetric tank having dimension 198.5 cm long and 190 cm wide for meandering compound channel and 169 cm long and 103 cm wide for straight compound channel.

III. Results And Discussion

The discharge for both channel is calculated by the conventional formula manning's, Chezy's or Darcy-Weischbach equation. Manning's roughness coefficient denoted as also energy. Under steady and uniform flow conditions, we use the equations proposed by Chezy, Darcy-Weisbach (1857), or Manning (1891) to compute the section mean velocity carried by a channel section proposed as

$$(1) \quad U = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

$$(2) \quad U = C\sqrt{RS}$$

$$(3) \quad U = \sqrt{\frac{8gRS}{f}}$$

The variation of roughness coefficients are plotted below.

IV. Straight Channel

4.1 Variation of manning's n with depth of flow.

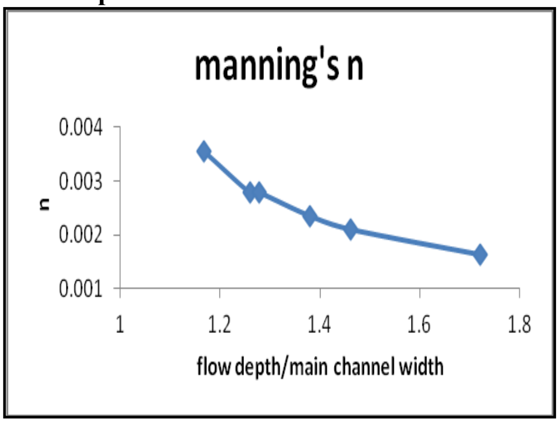

Fig.1. Variation of manning's n with depth of flow.

The variation of roughness coefficient in terms of mannings 'n' with depth of flow are plotted. As shown in Fig.1. the behaviour trend of manning's n is found to be decrease with increase of flow depth.It shownclearlythat straight channel require more energy as the depth of flow increases.manning's n also varies for different depth.

4.2. Variation of manning's n with relative depth.

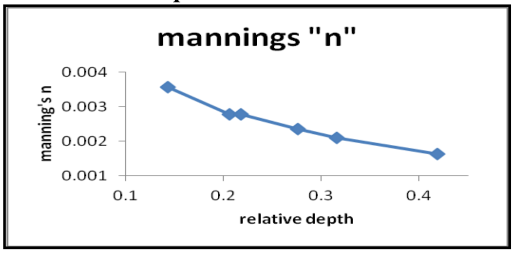

Fig.2. Variation of manning's n with relative depth.

As shown in Fig.2. the variation of roughness coefficient in terms of mannings n shows a steady decrease in the value of 'n' with increasing the relative depth of flow in straight channel.

4.3. Variation of chezy's c with depth of flow

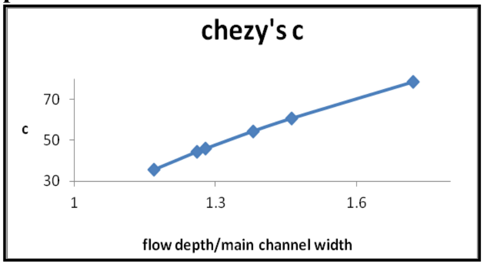

Fig.3. Variation of chezy's c with depth of flow

The variation of chezy's with depth of flow for the straight channel investigated for different flow depth is given in the as shown in Fig.3. It can be seen that in straight channel the variation of 'c' is increases when the flow depth is increases. It means chezy's c is directly proportional to depth of flow.

4.4 Variation of chezy's c with relative depth

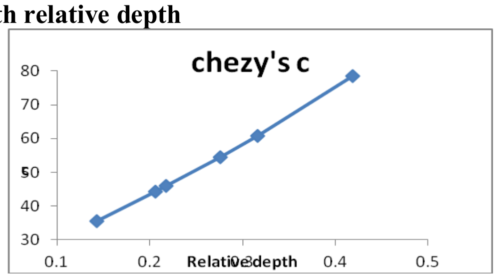

Fig.4. Variation of chezy's c with relative depth

The variation of chezy's c with depth of flow for the straight channel is shown in above fig.4. The behavioral trend of chezy's c is also increasing with increasing of relative depth. It is seen that the roughness coefficient 'n' and 'c' are behaving different with relative depth.

4.5. Variation of friction factor f with depth of flow

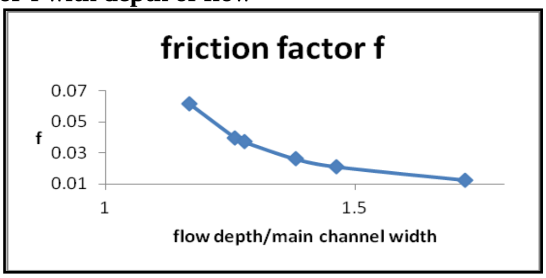

Fig.5. Variation of friction factor f with depth of flow

It can be suggested that the Darcy-weisbach formula can also be applicable to predict the discharge n to see the variance of friction factor f with depth of flow.here the graph plotted in above fig.5.The variation of f gradually decreases with increase the value of depth.It is clearly seen f is inversly propertional to depth of flow.

4.6. Variation of friction factor f with relative depth of flow

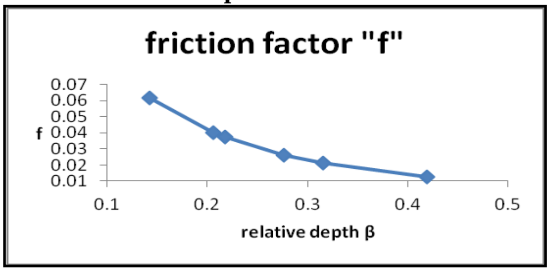

Fig.6. Variation of friction factor f with relative depth of flow

The variation of friction factor in terms of f is plotted with the variation of depth of flow the above fig.6. It is also quite similar with the friction factor with depth of flow. The value of depth is decreasing gradually with the increasing of relative depth of flow of straight channel.

V. Meandering Channel

5.1. Variation of manning's n with depth of flow

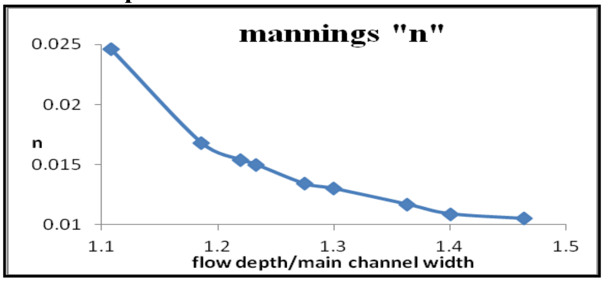

Fig.7. Variation of manning's n with depth of flow

The variation of manning's n with depth of flow for highly meandering channel investigated for different flow depth shown in the above fig.7. It can be seen from the meandering channels, exhibit a steady decrease in the value of roughness coefficient 'n' with increase in the depth of flow. It is quite similar if we compare it with the straight channel. It shows constant value increasing the depth but in straight channel is not constant.

5.2. Variation of manning's n with relative depth.

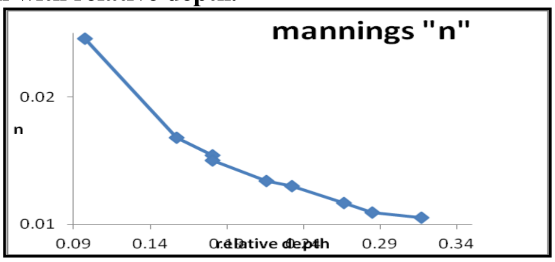

Fig.8. Variation of manning's n with relative depth.

The variation of manning's n are plotted with relative depth of flow. Here it can be from the fig.8.that in the meandering channel the variation of manning's n is steadily decreasing and is found to be constant at higher depth of flow. It is not quite similar with the straight channel. The coefficient n is found to be constant at greater depth.

5.3. Variation of chezy's c with depth of flow.

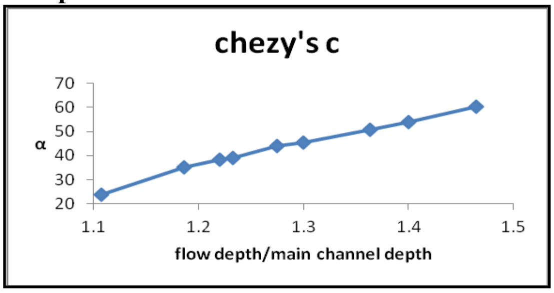

Fig.9. Variation of chezy's c with depth of flow.

The variation of chezy's constant c with depth of flow for highly meandering channels investigated for different depth of flow is shown in above fig.9. It can be seen that there is a steady increase in the value of c with increase depth of flow. It can be suggested that chezy's formula can be applicable more correctly compared with the other formulas. It is quite similar with the straight channel.

5.4. Variation of chezy's c with relative depth.

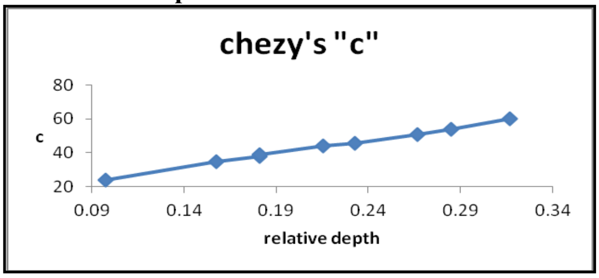

Fig.10. Variation of chezy's c with relative depth.

The variation of chezy's c with relative depth of flow for the present meandering channels are shown in above fig.10. The behaviour trend of chezy's consstant c is also increasing with relative depth of flow. The behaviour of c and n are quite simillar.It is nt simillar with the straight channel.

5.5. Variation of friction factor f with depth of flow

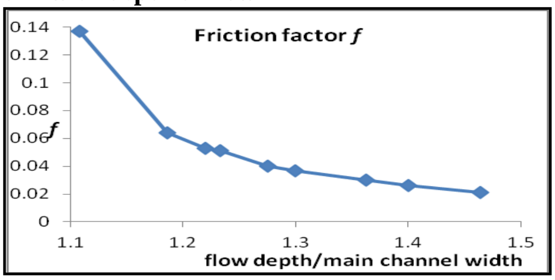

Fig.11. Variation of friction factor f with depth of flow

The variation friction factor f with depth of flow for highly meandering channel are shown in above fig.11. It has been seen the behavioural trend of f is decreasing with the flow depth. It is also investigated that the roughness coefficient n and f are presenting in a simillar manner as the relationship between the coefficients and hydralic radius(R) is mentioned as f=$\frac{8g}{R^{\frac{1}{3}}}n^2$.

5.6. Variation of friction factor f with relative depth of flow

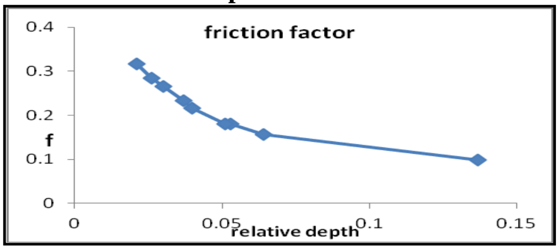

Fig.12. Variation of friction factor f with relative depth of flow

The variation of roughness coefficient f with relative depth are shown in the above fig.12. Here in the graph the behavioral trend of weisbach factor f is decreasing gradually with the increasing relative depth. The value of friction factor f found to be constant at higher depth.It is somewhat similar with straight channel.

VI. Conclusions

6.1.The roughness coefficients in terms of manning's n,chezy's c and Darcy-Weisbach friction factor f varies significantly with flow depth.The variation of manning's n is continuously decreasing with the increasing depth of flow where as the chesy's constant c is inverse to n .It is increasing the value of c with increasing depth of flow.The variation of friction factor f is quite simillar with the n and shows the constant flow at higher deptof flow.

6.2.The degree of roughness depends upon many factors such as surface roughness,cross section geometry,degree of channel meandering too.It indicates from the above discussions that the simple meandering channel consumes more energy as the depth increases.the chezy's constant c decrease continously with depth of flow.The roughness coefficients manning's n,chezy's c and weisbach factor f varies with flow depth for meandering channel.

6.3.The resistance coefficients is known as both roughness characterstics and energy loss of the flow.The variation of manning's n is found to be more as compared with both chezy's c and Darcy's friction factor f for the present highly sinous meandering channel.

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