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FACTORS INFLUENCING THE PREDICTION OF RESISTANCE IN A MEANDERING CHANNEL

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Abstract— Flow in a meandering channel is a complex mechanism which is very crucial for its analysis for different investigators in the field of river hydraulics. Accurate scientific analysis helps to predict different flow variables of a meandering channel. In a meandering channel the flow properties are found to be affected by different geometric, surface and flow parameters. In the present work, an experimental investigation has been done to analyse the important parameters affecting the flow behavior in a meandering channel. Emphasis has been made to analyse the dependency of flow resistance in term of Manning' *n* of a meandering channel. The factors influencing for predicting the roughness coefficient of a meandering channel are non-dimensionlised and its dependency with different parameters are presented.

Index Terms— Meandering channel, Manning's *n*, Sinuosity, Longitudinal Slope, Reynolds' number, Froude's number, Aspect Ratio

1 INTRODUCTION

A meandering channel is author of its own geometry. In case of meandering channel there is a huge scope in scientific investigation because of these morphological parameters and its major governing factors is of fundamental importance in river control and regulation. Meandering river exhibits complex plan form pattern in meander bend. In order to describe the effect of morphological features on a high sinous meandering river evolution, it is of great importance to describe the parameter effects on the hydro dynamics of the flow. For a straight channel, it is assume that the mean velocity across along the centre line of the channel where as for a meandering channel the maximum velocity occur the inner bank and occurance of the mean velocity deviates from its centre line. These factors are all influenced by discharge, sediment load and valley slope. The flow resistance in river channel is a complex phenomenon for a meandering channel. The degree of complexity arises from a large no. of parameters. There parameters to gain resistance affect the flow structure and flow variable of meandering channel ([1] and [2]). Estimate of the energy dissipation due to all sources, such as bed friction, planform/bend losses, expansion/contraction losses and other interaction losses is the one of the method of solution for meandering channel. Such a hydromechanics approach has been attempted by [3], [4], [5], [6], [7], and [8].
From the literature it is found that at least five major parameters which include geometric conditions, roughness conditions and flow conditions etc. influence the prediction of the flow behavior, conveyance and roughness for a meandering channel. The non-dimensional parameters can be summarised as:

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1. Sinuosity of meandering channel
2. Aspect ratio
3. Froude's number
4. Reynolds' number
5. Longitudinal slope

These parameters are investigated in the context of their influence on roughness on meandering channel. In the present study, a step has been taken to investigate the influence of different parameters affecting the prediction of roughness of a meandering channel. High quality data are also obtained involving velocity, discharge observation, employing three meandering channel geometries. The influence of these conditions on prediction of roughness is presented and also com-parision has been made to find the affect of these parameters with increasing and decreasing of values.

2 EXPERIMENTAL STUDIES

For carrying out investigation in meandering channels, experimental setup was built in Fluid mechanics and Hydraulics Laboratory of NIT, Rourkela. A meandering channel having trapezoidal main channel (bottom width 0.33m,depth 0.065m and side slope 1:1) Pl. see Fig1 was fabricated inside a steel tilting flume of around 15m length. The main channel is a sine generated curve of one and half wave length and is preceded and followed by a straight portion jointed with a transitional curved portion in order to have proper flow field developed in the test reach which is at the second bend apex of the central curve .Water was supplied to the flume from an underground sump via an overhead tank by centrifugal pump (15 hp) and recirculated to the sump after flowing through the meandering channel and a downstream volumetric tank fitted with closure valves for calibration purpose. Water entered the channel bell mouth section via an upstream rectangular notch specifically built to measure discharge in such a wide laboratory channel. An adjustable vertical gate along with flow straighteners was provided in upstream section sufficiently ahead of rectangular notch to reduce turbulence and velocity of approach in the flow near the notch section.

At the downstream end another adjustable tail gate was provided to control the flow depth and maintain a quasi-uniform flow in the channel. A movable bridge was provided across the flume for both span wise and stream wise movements over the channel area so that each location on the plan of meandering channel could be accessed for taking measurements.

Point velocities were measured along verticals spread across the main channel and also at a no. of horizontal layers in each vertical, point velocities were measured. Measurements were taken from left edge to the right edge of the main channel bed and side slope. The lateral spacing of grid points over which measurements were taken was kept 4cm inside the main channel. Velocity measurements were taken by pitot static tube (outside diameter 4.77mm) and two piezometers fitted inside a transparent fiber block fixed to a wooden board and hung vertically at the edge of flume the ends of which were open to atmosphere at one end and connected to total pressure hole and static hole of pitot tube by long transparent PVC tubes at other nds. Before taking the readings the pitot tube along with the long tubes measuring about 5m were properly immersed in water and caution was exercised for complete expulsion of any air bubble present inside the Pitot tube or the PVC tube. This was done to prevent the presence of a small air bubble inside the static limb or total pressure limb as same could give erroneous readings in piezometers used for recording the pressure. Steady uniform discharge was maintained in each run of the experiment.

Fig. 1. Geometrical setup of pitot tube and structure of Meandering channel

Table.1 shows the hydraulic parameters considered in the experimental runs

TABLE 1

HYDRAULIC PARAMETERS OF EXPERIMENTAL SETUP

	Item Description	Experiment channels
1	Channel type	Meandering
2	Flume type	4.0m×15m×0.5m long
3	Geometry	Trapezoidal (side-slope1:1)
4	Nature of surface bed	Smooth & rigid bed
5	Channel Width	33cm at bottom and 46 cm at top
6	Bank full depth of channel	6.5cm
7	Bed slope of the channel	0.0011,0.00165
8	Sinuosity	1,1.11,1.31

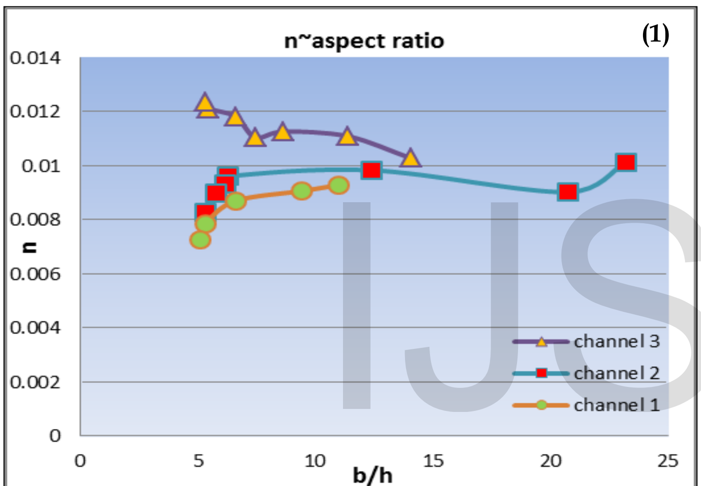
3 RESULTS

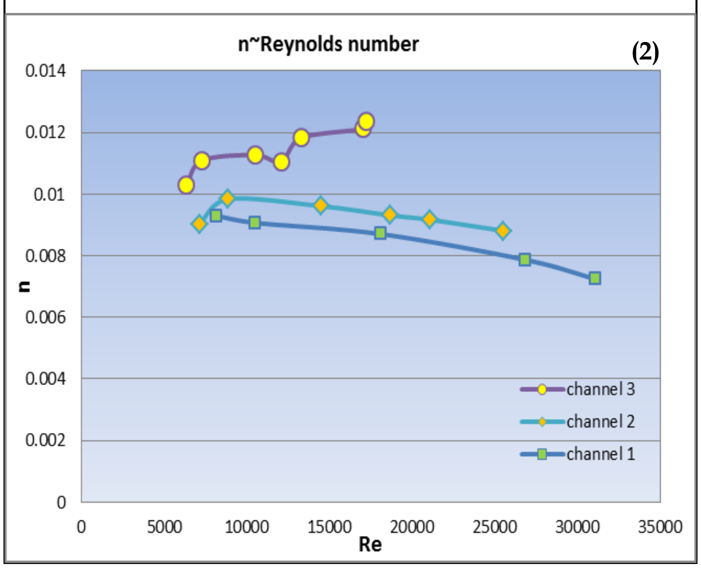
The variation of roughness co-efficient has been found out for three meandering channels of different sinuosity. The variation of roughness co-efficient in terms of Manning's n are plotted for different aspect ratio in fig 2-(1). It is seen that, as sinuosity increased, Manning's n also increased for the low sinuosity channel and straight channel (channels- 1 &2) the Manning's n isfound to be decreased with flow depth but for meandering channel of higher sinuosity, the flow resistance are found tobe increase in aspect ratio. Further it is seen that for high sinuosity channel, Manning's n is found to remain constant. This may be due to the reason that at lower depth the meandering channel exhibits the higher energy loss due to bend affect but in higher depth of flow, the effect of bend loss diminishes.Next, the mean velocities of the meandering channels are calculated for each depth of flow. Then the Reynolds no vs. Manning's n are plotted for all the channels and presented in fig 2-(2). From the fig 2-(2) it is seen that Manning's n decreases with Reynolds no for lower sinuosity channel but for higher sinuous channel Manning's increase with Reynolds number. Because for straight channel and low sinuous channel the loss of energy is less for higher depth of flow but higher sinuous channel, Manning's n increase with Reynolds number. The reason of the results may be considered as similar to the results of figure 1 i.e. Manning's vs. Aspect ratio.

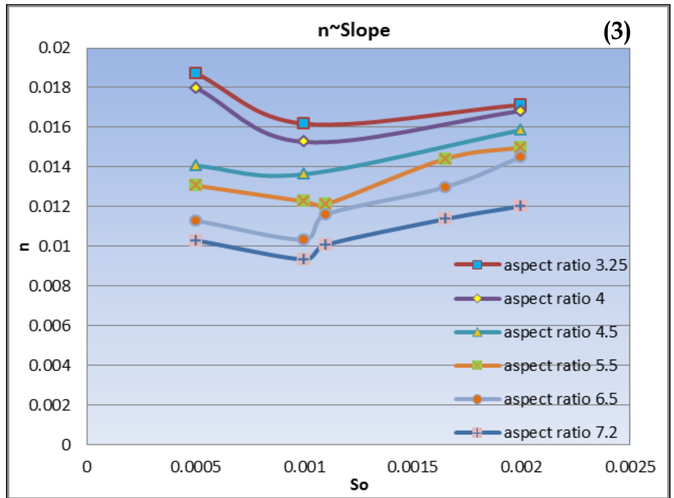
In the third case, we tried to find the effect of gravity on evaluation of resistance of a meandering channel. Therefore, Mannings, n values are plotted with different Froudes no. Here in this fig Froude's no vs. Manning's n are plotted for all the flow channels. From fig 2-(3) it is seen than Manning's n decreases with Froude's no for both lower sinuous channel as well as higher sinuous channel. This may be due to that Froude's number is directly proportional to mean velocity and at the same time Manning's n is inversely proportional to mean velocity. Due to this reason Manning's n decreases with successive increment of Froude's number.

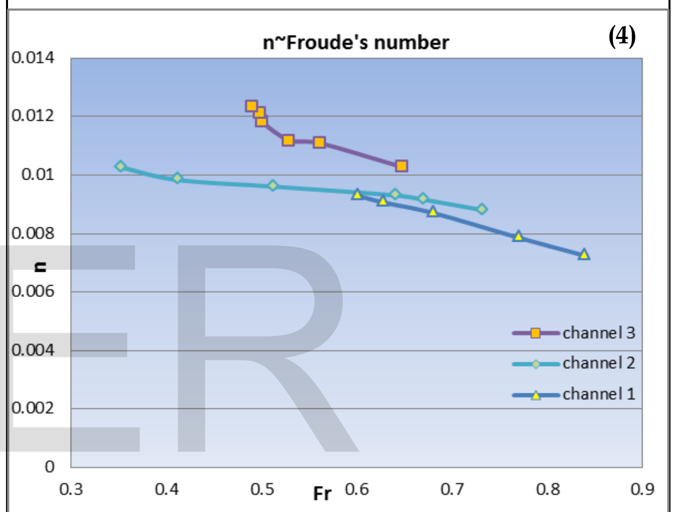
Similar to the previous cases, the variation of Manning's n is tested for channels of different sinuosities. Therefore in fig 2-(4) the relationships between Manning's n and sinuosity for different aspect ratios is plotted. In this case, it is clearly seen that when sinuosity increases, Manning's n substantially increases for a constant aspect ratio. The reason may be that velocity of the flow gradually decreased with increased sinuosity. It can be stated that, increase of sinuosity is found to have direct effects to decrease the values of Manning's n, for a constant geometry of a meandering channel.

Finally we have tested the variation of Manning's n with longitudinal slope in fig 2-(5). It is a well known fact that the conveyance is mainly affected by longitudinal slope. Attempt has been made now to see the variation of roughness coefficient with respect to the longitudinal slope. Due to absence of different slope data, in the present work data of [7] has been analysed with our experimental data. From experimental data, it was clearly noticed that when slope increase s the gravity component increase, so during force increase which subsequentlty reduces the roughness coefficient, therefore the Manning's n found to bed decrease, but in higher slope means greater than 0.001 it is found from fig 2-(5) it is clearly show that roughness value in-creases. This reason may be that the higher value of slope, the formation of turbulence, eddies, starts producing more loss of energy, so increasing the value of Manning's n.









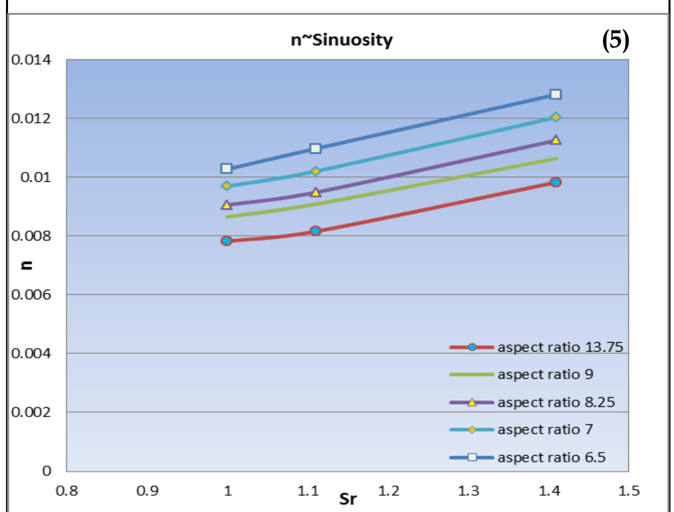


Fig. 2-(1-5). Comparision of Manning's n with different subsequent flow parameters.

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4 Summary And Conclusion

a) From the literature study, it is seen that the roughness coefficient of a meandering channel varies from channel to channel and flow depth to flow depths. They are found to be function of geometric parameter and flow parameter.

b) Experiments were conducted in meandering channels (Sinuosity range, (1-4.11) to study the effects of different parameters to predict the roughness of a meandering channel.

c) The variation of Manning's *n* is found to be mostly dependent upon the non dimensional parameters such as (i) geometric parameters like aspect ratio,slope and sinuosity (ii) flow parameters like Reynolds no, Froude's no.

d) Manning's *n* is found to increase with aspect ratio for higher sinuos channel but decrease for low sinuous channel.

e) It increases with Reynold no, Frouds no and sinuosity but decreases with aspect ratio. A peculiliar behavior regarding the variation of Manning's n with slope is noticed. It decreses for lower value of slope than increases with increase of slope.

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