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Experimental Study of Discharge Characteristics in a Compound Meandering River

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Abstract : - Most of the river flow in the world can be characterized as compound meandering channel in which the discharge distributions are very intricate. Now-a-days engineers, planners as well as researchers are highly interested in predicting precisely and reliably the quantitative estimates of discharge in a compound meandering river. A Laboratory experiment has been performed in a compound meandering channel with symmetric cross-sections having floodplain width ratio of 1, 1.67, 2.33, 3 and depth ratio of 0.20, 0.30, 0.35, 0.40 using the large-scale open air facility in the Department of Water Resources Engineering, Bangladesh University of Engineering and Technology (BUET), Dhaka. Point velocity data have been collected using an ADV (Acoustic Doppler Velocity Meter) for different depth and width ratio at different locations of a compound meandering channel. Cross-sectional discharge is computed by area velocity method from observed velocity profile. The laboratory experiment shows that the discharge always increases with the increase of depth ratio for all the above mentioned cases. At low depth ratio, discharge decreases with the increase of width ratio but for higher depth ratio, discharge increases with the increase of width ratio.

Keywords : - *Acoustic Doppler Velocity meter, Compound Meandering River, Depth Ratio, Discharge Characteristics, Flood Plains, Width Ratio.*

I. INTRODUCTION

Most of the river flow can be characterized as compound meandering channel flow i.e. consisting of a meandering main channel flanked by one or two side flood plains. In fact, Bangladesh is one of the biggest Deltas in the world which is composed of three major compound river systems in the world, namely the Ganges, the Brahmaputra-Jamuna and the Megna. Proper quantification of the flow parameters for the main channel and flood plain flow of such rivers still has been a subject of considerable research. A systematic study is of utmost importance from the view point of better understanding of the flow phenomena in a compound meandering river. Though Bangladesh is criss-crossed by so many rivers having meandering mechanism i.e. erosion in the outer bend and deposition in the inner bend but unfortunately research documents related to this are hard to come by. Considering the importance and scope for research, the present study is undertaken. Stage-discharge curve in a compound meandering channel plays an important role in controlling floods, solving a variety of river hydraulics and engineering problems, designing stable channels, revetments and artificial waterways. There are limited reports concerning the stage-discharge relationship in a compound meandering channel. Most of the efforts of [1], [2], [3], [4], [5], [6], [7], [8], [9] and [10] were concentrated on the energy loss, different methods for stage-discharge assessment in the compound meandering sections. This study is aimed at understanding the phenomenon of discharge characteristics in a compound meandering channel.

Generally, natural rivers, streams and manmade surface drainage channels often overflow their banks during episodes of high flooding resulting in a huge potential damage to life and property as well as erosion and depositions of sediments. Many rivers have meandering compound channels possessing a main channel, which always carries flow and one or two floodplains, which only carry flow at above bankful stages. It has been established that a strong interaction between the faster moving main channel flow and slower moving floodplain flow takes place in a compound channel. This interaction results in a lateral transfer of a significant amount of longitudinal momentum which affects the discharge distribution in a channel flow. Discharge in a compound meandering channel is strongly governed by interaction between flow in the main channel and that in the floodplain and are different due to prevailing of different hydraulic conditions in the main channel and floodplain flow.

II. EXPERIMENTAL SETUP AND PROCEDURE

The experimental study has been conducted in the open air facility of Water Resources Engineering Department, Bangladesh University of Engineering and Technology (BUET), Dhaka. The experimental setup is shown in the Fig.1 which consists of two parts, the permanent part and the temporary part. The permanent part is the experimental facility necessary for the storage and regulation of water circulating through the experimental reach. The temporary part is mainly brick walls which are used to vary the floodplain width for different setups. The experimental reach consists of a 670 cm long symmetric compound meandering channel, set at constant bed slope (S_o) 0.001845 with fixed bed and banks and sinuosity ratio (S_r) of 1.20.Water is drawn by the centrifugal pump of discharge capacity 80 l/s from the storage reservoir then it discharges into the u/s reservoir and coveys water to the experimental reach through approach channel of 30m in length and 3.1m in width. To ensure a more smooth flow towards the approach channel guide vanes and tubes are placed between the upstream reservoir and the approach channel which are at right angle to each other. In order to prevent turbulence in the approach channel, PVC pipes (Diffuser) are used. The water regulating function of the downstream end is provided by tail gate. The tail gate rotates around a horizontal axis. It is operated to maintain desired water level in the experimental reach. At the end of the experimental channel, water is allowed to flow freely so that backwater has no effect in the experimental reach. Behind the tail gate, the water falls into the stilling basin and passes through a transition flume which allows water for recirculation. Experiments were performed for four cases i.e. width ratio 1, 1.67, 2.33,3 at four runs i.e. depth ratio Dr =0.2, 0.3, 0.35, 0.4.

Case1: It represents no floodplain condition having width ratio Wr =1 and cross-sectional dimension of the Channel is 45.7cmx42cm.
Case2: It indicates symmetric floodplain width 15.3 cm having width ratio Wr =1.67. The cross-sectional dimension of the main channel is 45.7cmx24.5cm, left floodplain 15.3cm x18 cm and right floodplain 15.3cm x18 cm.
Case3: It indicates symmetric floodplain width 30.5 cm having width ratio Wr=2.33. The cross-sectional dimension of the main channel is 45.7cmx24.5cm, left floodplain 30.5cm x18 cm and right floodplain 30.5cm x18 cm.
Case4: It indicates symmetric floodplain width 45.70 cm having width ratio Wr=3. The cross-sectional dimension of the main channel is 45.7cmx24.5cm, left floodplain 45.7cm x18 cm and right floodplain 45.7cm x18 cm.

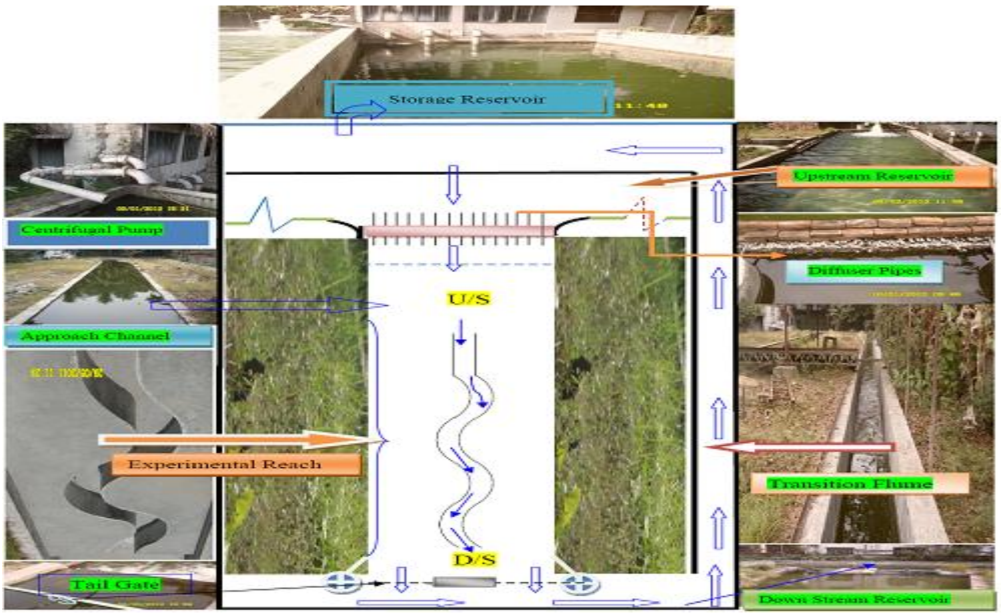

Figure 1: A Schematic Diagram of the Experimental Setup

Point velocities data have been collected by ADV (Acoustic Doppler Velocity meter) at different locations (u/s clockwise bend, u/s crossover, u/s anticlockwise bend etc) of a compound meandering channel. Each location is divided into 19zones starting from left floodplain to right floodplain. The main channel is equally divided into nine zones (zone 1 to zone9), the left floodplain is equally divided into 5zones (zone1 to zone5) and right floodplain is divided into 5 zones (zone1 to zone5). The definition sketch of compound meandering channel is shown in Fig. 2.

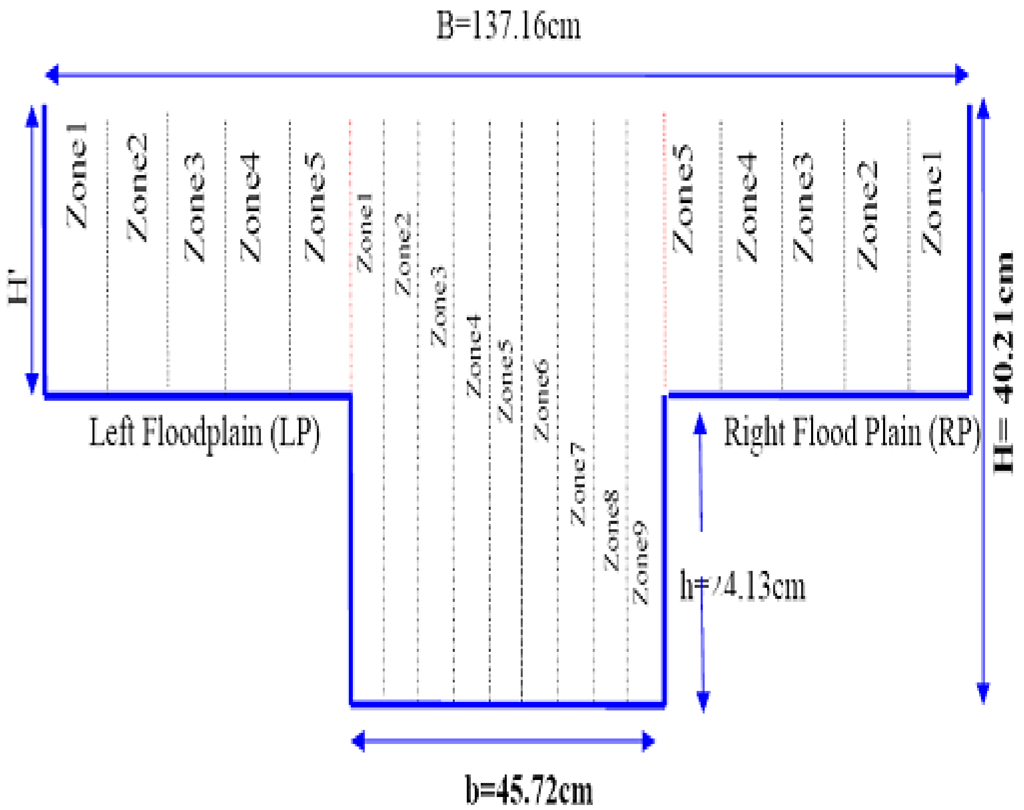

Figure 2: The definition sketch of the compound meandering flow section

In each zone 3D point velocity readings are taken by ADV at five vertical points i.e. 0.1H, 0.2H, 0.4H, 0.6H, 0.8H for main channel and 0.1H',0.2H', 0.4H', 0.6H', 0.8H' for floodplain. Sample of data collection by ADV is shown in the figure 3. In each vertical point 60 seconds point velocity readings are taken and average velocity of 60 seconds point velocity is used for plotting the velocity profile. Cross-sectional discharge is calculated by area velocity method from observed velocity profile. In this method a channel section is subdivided into a number of segments by a number of successive intervals. For all the cross-sections, discharge are calculated separately for the main channel, right and left flood plain; and then total discharge is obtained. The discharge of the segment is calculated as follows

$$\Delta Q_i = \Delta A_i . U_i \quad \textbf{(1)}$$

Where ΔQ_i the discharge in the ith segment, ΔA_i is the cross-sectional area of the ith segment and U_i is the average velocity at the ith vertical.

The total discharge is computed as

$$Q = \Sigma \Delta Q_i$$

III. RESULTS AND DISCUSSIONS

Stage discharge curves with varying width ratios at u/s clockwise bend section, cross-over section and u/s anticlockwise bend section are shown in the Fig. 3, Fig. 4 and Fig. 5. In all cases, the discharge increases with the increase of width ratio for the discharge just above the bank level of the main channel. For the discharges just above the bank level, the retarding influence of the flood plain takes its toll on the overall discharge of the channel. As the depth ratio increases, the retarding effect of the floodplain is counter balanced by the increase in greater flow area provided by the floodplain. So for the higher water level (depth ratio), the discharge increases with the increase in depth of flow.

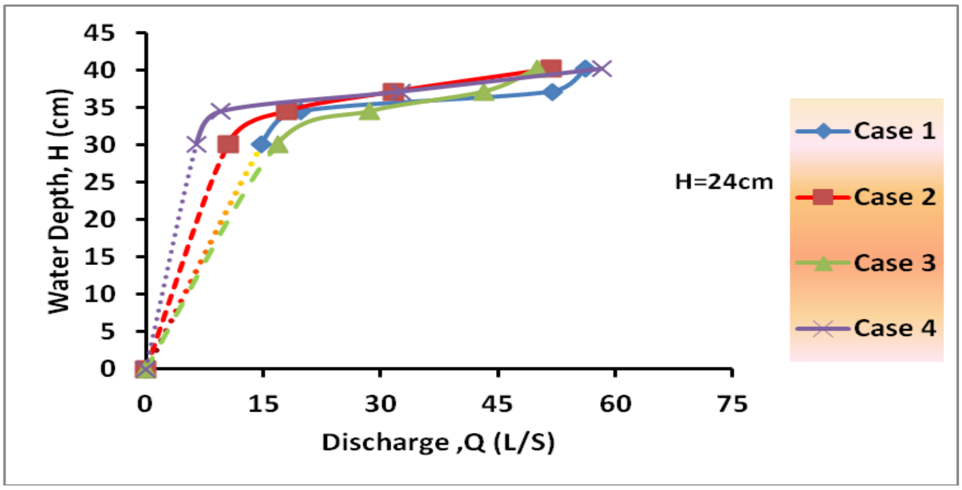

Figure 3: Stage Discharge Curve at U/S Clockwise Bend Section

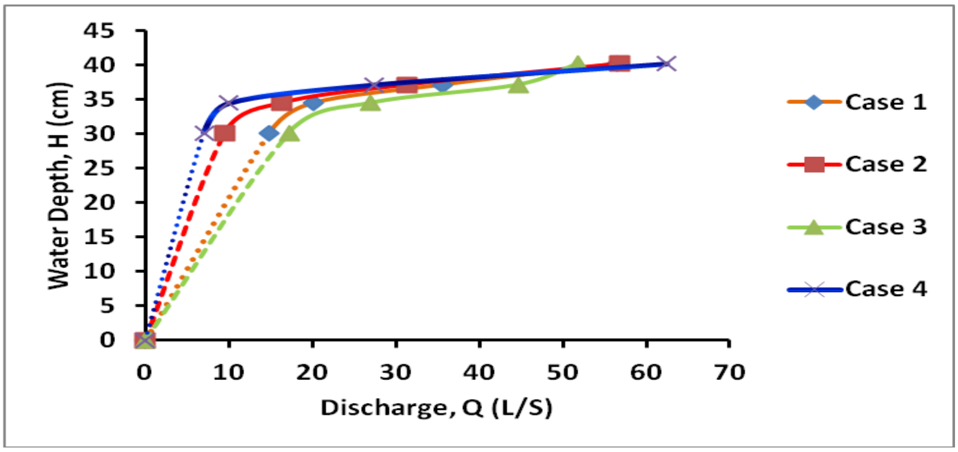

Figure 4: Stage Discharge Curve at U/S Cross-over Section

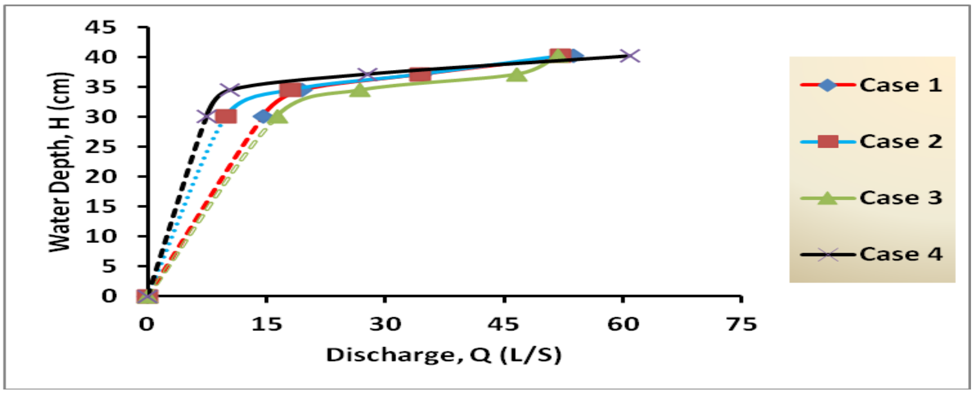

Figure 5: Stage Discharge Curve at U/S Anti-clockwise Bend Section

IV. CONCLUSIONS

On the basis of this research concerning the discharge characteristics in a compound meandering river with different floodplain width the following conclusions are drawn:

- In a compound meandering river, discharge increases with the increase of depth ratio and increasing rate of discharge is more at high water depth ratio. Because at low water depth ratio, the slow moving flow in the floodplain interact with the fast moving main channel flow strongly and considerable momentum exchange takes place. But the intensity of interaction diminishes considerably with the increase of depth ratio.
- In a compound meandering river, stage-discharge curve represents straight curve up to in bank flow and curvature nature in the out bank flow.

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Notations

The following symbols are used in this paper ΔAi = Cross-sectional area of the ith segment B= top width of compound meandering channel b= width of main channel Dr=depth ratio (H-h)/h H= total water depth H'= depth of water above floodplain bed h= height of the main channel ΔQi = discharge in the ith segment Q= total discharge S_o= bed slope S_r = sinuosity ratio Ui = average velocity at the ith vertical. Wr = width ratio [B/b]

REFERENCES

[1] Al-Romaih, J. S. (1996). "Stage discharge assessment in meandering channels," PhD thesis, Univ. of Bradford, U.K.

[2] Groenhill, R. K., and Sellin, R. H. J. (1993). ''Development of a simple method to predict discharge in compound meandering channels.'' *Proc. Institute Civil Engineers, Water, Merit and Energy*, 101, Water Board, (March), 37–44.

[3] Muto, Y. (1995). ''Turbulent flow in two stage meander chanenls.'' PhD thesis, Univ. of Bradford, U.K. Patra, K.C., and Kar, S.K., Bhattacharya.A.K. (2004). "Flow and Velocity Distribution in Meandering Compound Channels." Journal of Hydraulic Engineering, ASCE, Vol. 130, No. 5. 398-411.

[4] Sellin, R. H. J., Ervine, D. A., and Willetts, B. B. (1993). ''Behavior of meandering two stage channels.'' *Proc. of Institute Civil Engineers Water Maritime and Energy*, 101, (June), *Paper No. 10106*, 99–111.

[5] Shiono, K., and Muto, Y. (1993). ''Secondary flow structure for inbank and overbank flows in trapezoidal meandering channels.'' *Proc., 5th Int. Symp. of Refined Flow Modl. and Turb. Measu.*, Paris (September), 645–652.

[6] Shiono, K., Muto, Y., Knight, D. W., and Hyde, A. F. L. (1999a). ''Energy losses due to secondary flow and turbulence in meandering channels with over bank flow.'' *J. Hydraul. Res.*, 37(5), 641–664.

[7] Toebes, G. H., and Sooky, A. A. (1967). ''Hydraulics of meandering rivers with flood plains.'' *J. Waterw. Harbors Div., Am. Soc. Civ. Eng.*, 93(2), 213–236.

[8] Wark, J. B., and James, C. S. (1994). ''An application of new procedure for estimating discharge in meandering overbank flows to field data.'' *2nd Int. Conf. on River Flood Hydraulics*, March 22–25, Wiley, NewYork, 405–414.

[9] Willetts, B. B., and Hardwick, R. I. (1993). ''Stage dependency for over bank flow in meandering channels.'' *Proc., Institute of Civil Engineers Water Maritime and Energy*, 101, 45–54.