International Journal of Applied Engineering Research.
ISSN 0973-4562, Volume 9, Number 2 (2014) pp. 133-138

http://www.ripublication.com/ijaer.htm

Flow Analysis for a Converging Compound Channel

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Abstract

In overbank flow, due to interaction mechanism between the main channel and floodplain, the flow properties of the compound sections are greatly affected. The complexity raises more when dealing with a compound channel with converging floodplains. In converging compound channels, due to change in floodplain geometry, there is either severe change of momentum exchanges if the geometry of transition is contraction or expansion. Many investigators have studied and explained the complexity of such compound geometry in predicting the flow variable. In this paper, some experimental results in compound channels with converging floodplains are described and compared. The variations of flow properties for both prismatic and non-prismatic floodplains of different convergence angles are studied and analysed.

Keywords: compound channel, converging angle, water surface profile, flow depth, velocity.

1. Introduction

Open Channels are classified either Prismatic open channels or non-prismatic channels. The open channels in which shape, size of cross section and slope of the bed remain constant are said to be as the prismatic channels otherwise said to be non-prismatic channels. In non-prismatic compound channels with converging/diverging floodplains, due to continuous change in floodplain geometry along the flow path, the resulting interactions and momentum exchanges is increased. This extra momentum exchange is very important parameter and should be taken into account in the overall flow modelling of a river.As natural river data during flood are very difficult to obtain, research on such a topic is generally done in laboratory flumes. The present study focuses on converging compound channels. In a converging compound channel if the flood plain is contracted, the flow is forced to leave the flood plains and enter to the main channel because of change in cross section area. New experiments have been conducted at the Hydraulics and Fluid mechanics Laboratory of Civil Engineering Department of NIT, Rourkela to analyse the behaviour of flow effect due to change in flood plain geometry in terms of converging angle.

2. Experimental Work

2.1 Experimental Setup

Experiments have been conducted in non-prismatic compound channels with varying cross section built inside a concrete flume measuring 15m long ×.95m width × 0.55m depth. The width ratio of the channel is α>1.72 and the aspect ratio is δ>5.78.The converging angle of the channel is taken as 12.38°.Converging length of the channel is found to be 0.84m. The channel is made up of cement concrete. Water was supplied through a Centrifugal pumps (a 15 hp) discharging into a RCC overhead tank. In the downstream end there lies a measuring tank followed by a sump which feed the water to the overhead tank through pumping.. 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 compound channel and a downstream volumetric tank fitted with closure valves for calibration purpose. 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 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 compound converging channel could be accessed for taking measurements.

Water surface measurements were measured directly with point. The measurements were made each 5mm and 10mm in converging flume of 840 mm length. Point velocities were measured along verticals spread across the main channel and flood plain so as to cover the width of entire cross section. Also at a no. of horizontal layers in each vertical, point velocities were measured. Measurements were thus taken from mid-point of main channel to the left edge of floodplain. The lateral spacing of grid points over which measurements were taken was kept5cm inside the main channel and the flood plain. Velocity measurements were taken by pitot static tube (outside diameter 4.77mm) and two piezometers fitted inside a transparent fibre 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 ends.. Steady uniform discharge was maintained the run of the experiment and several runs were conducted for overbank flow with relative depth varying between 0.05-0.51. The discharge varied between 39259.768cm^3/s to 146672.3cm^3/s. Point depth average velocity were made at a depth of 0.4H from the bed in the main channel and 0.4(H-h) on the flood plains.

Table 1: Hydraulic parameters for the experimental runs.

Sl. No. of Runs	Discharge Q in cm3/s	Overbank depth H in cm	Relative depth $D_{r=(H-h)/H}$	Froude no.(Fr)	Reynolds no.(R)
1	39259.36	10	0.05	0.677465	34138.57
2	51338.78	11.7	0.19	0.537911	43360.45
3	62014.92	14.02	0.32	0.353251	50402.24
4	92108.59	15.83	0.4	0.259969	72721.13
5	146672.3	19.4	0.51	0.205241	109620.5

After obtaining the point velocities at various grid points representing the whole compound channel flow cross section, velocity contours were drawn. The velocity contours were drawn by normalizing the point velocities with the cross sectional means velocities for the respective overbank depth of flow

3. Result and Discussion

The new experimental results from non-prismatic compound channels are presented in this section. Velocity contour of prismatic non prismatic section are shown in **Fig1(a,b)**The stage discharge curve at experimental section-1&2 was plotted and shown in **Fig 2(a&b) .** The water surface profile of different relative depth are shown in **Fig 3(a)**.The depth average velocity of different converging part of relative depth of 0.5 are shown in the **Fig 4(a,b,c).**. The boundary shear stress of different converging part of relative depth of 0.5 are shown in the **Fig 5(a,b,c)**.

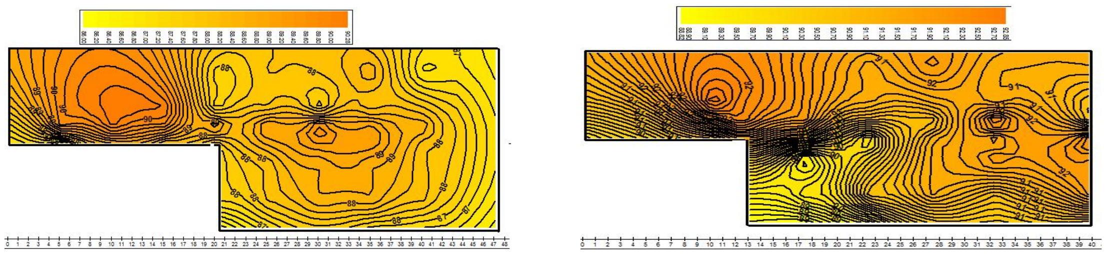


Fig. 1: (a)Velocity contour of sec-1 (b)Velocity contour of sec-2

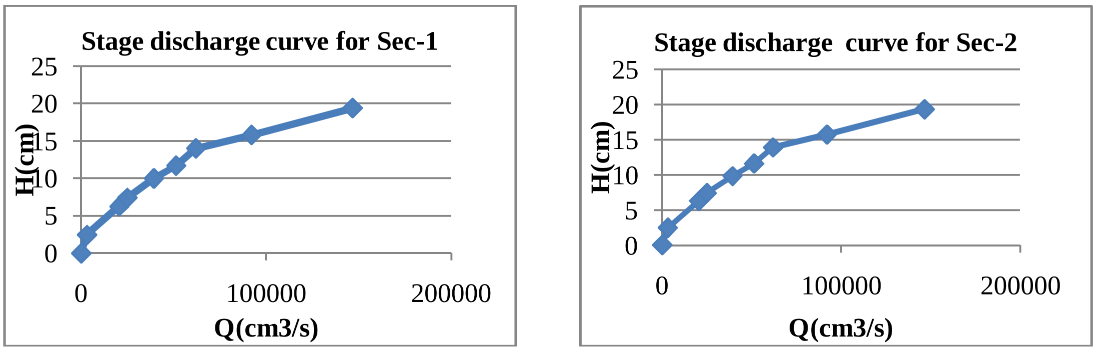


Fig. 2: (a,b)Stage discharge curve for Prismatic and Non prismatic section.

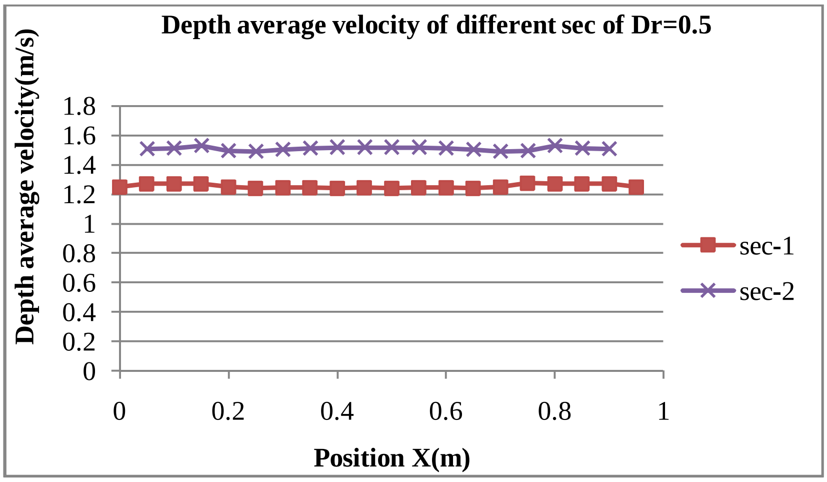
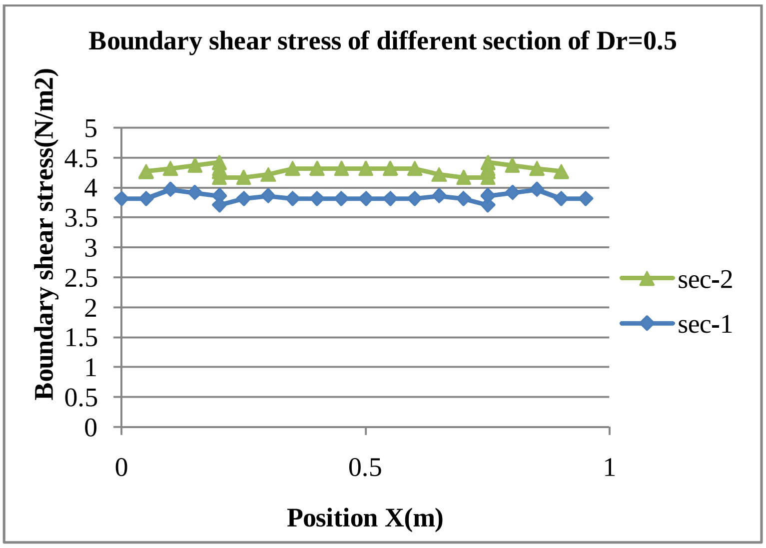


Fig. 3: (a) shows the Depth average velocity.



(b) shows the boundary shear of Prismatic and Non prismatic section

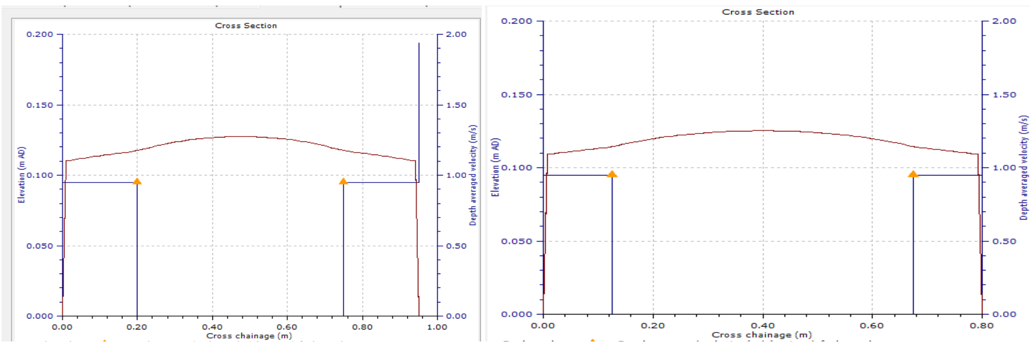


Fig. 4: (a) Depth average velocity of sec-1 (b) Depth average velocity of sec-2 by CES

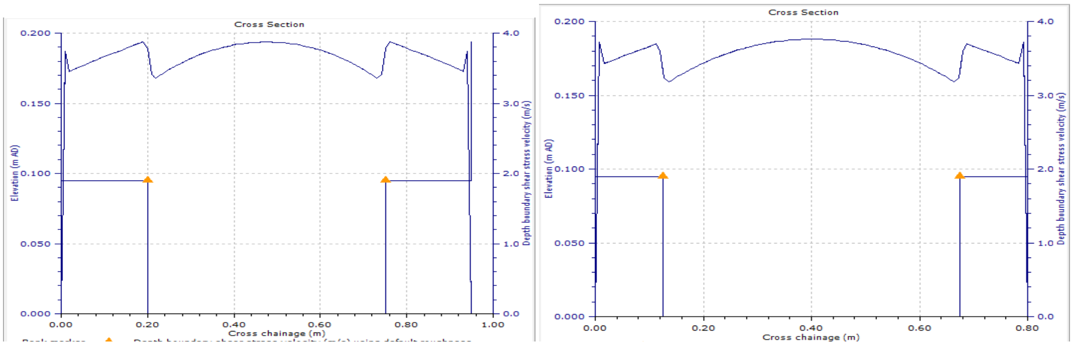


Fig. 5: (a) Boundary shear stress of sec-1 (b) Boundary shear stress of sec-2 by CES

4. Conclusions

1. Experiments are conducted to study the effect of flow variables for converging and non-converging compound channels.
2. From the Velocity contours of the expetrimental channels, it is seen that at section 1 the higher velocity contours occur both at the middle of flood plain and interface of main channel. At section 2 the occurrence of higher magnitude velocity contours happens same for floodplain however in the main channel region it is again at central region.
3. From the stage discharge curve it is seen that non of the methods is good agreement with the actual stage discharge.
4. From the water surface profile curve it is seen that the depth of flow start decreases from mid section of the converging part. It is clearly distinguish at higher relative depth
5. From the depth average velocity curve and boundary shear stress curve it is seen that both increses along the narrowing part of the flume.
6. In CES also the depth average velocity and boundary shear stress increase along the narrow part of the flume.

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