

# Detailed Investigation of Velocity Distributions in Compound Channels for both Main Channel and Flood Plain

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**ABSTRACT:** Due to the drastic changes of bed condition and atmospheric pressure acting on the free surface the velocity distribution is not uniform along the channel. Several other geometrical factors such as bends and boundaries in the channel also cause the flow velocity vector to have components in every possible direction. On bend, the flow velocity increases enormously owing to centrifugal force forming a convex shape. The turbulence and velocity variation along the flow increases with the density of floodplain vegetation. This sudden change of velocity due to turbulence cause energy losses and increased resistance to flow in the channel. In this research, some laboratory experimental investigation has been conducted, established in a flume of compound channel geometry bounded with vegetated flood plains. Analysis was done in order to determine effect of channel roughness on the curvature of velocity distribution along the depths of both main channel and the floodplain. The results show that the velocity distribution parabolic curve along the floodplain reduces due to effect of riparian vegetation whereas the main channel velocity is widely increased.

**KEYWORDS:** Velocity distribution, compound channel, vegetation, flood plain.

## I. INTRODUCTION

Accurate facts of velocity distribution in channels are very significant for inundation analysis, afflux investigations for substructure design and estimation of depth discharge in natural channels. Frequently for simplicity in hydraulic engineering practice the flow velocity is believed uniform and study is carried out considering energy or momentum methodology. In natural channel, due to variation in the cross-sections, the state of the flow may be changed from uniform to non-uniform. Under such conditions, the hydraulic analysis will be complex compared to regular uniform flow. However in prospect of large variations in velocity distribution has also been known to be affected by various factors such as geometry, alignment, depth of flow, channel gradient and irregularity etc.

According to Chow (1973) the measured maximum velocity in ordinary channels generally appears to occur below free surface at a distance of 0.05 to 0.25 of depth. Chow further declared that in a wide, rapid and shallow atream, the maximum velocity may be found at the free surface. Balachandar et al. (2002) indicated that the stream wise mean velocity profiles follow the logarithmic principle for a smooth surface, and the appropriate downward shift, for a rough surface. Tachie et al. (2003) used Laser-Doppler Anemometer (LDA) to measure velocity on a smooth and two geometrically different types of rough surfaces in an open channel and showed that roughness effects on the velocity field. Nezu (2005) correlated quality ratio (b/h) with the formation of secondary current indicated the presence of secondary currents generated due to the effect of side wall. Afzal et al. (2009) studied the effect of Reynolds number on the velocity characteristics of smooth open-channel flows. Their mean velocity profile in inner scaling showed that the extent of overlap with the log region increased with increasing Reynolds number. M. Amel Sadeghi et al. (2010) focused on non-submerged vegetation covering all the width of the flood plain and 50% of its area in order to determine the impact of vegetation on the velocity and roughness variation quantitatively.

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## II. MATERIALS AND METHODS

The non-tilting glass-walled flume with length 6m and width 0.3m was designed as a symmetric compound channel of rectangular cross-section. The main channel width of 12 cm and flood plain of 18cm. The bed slope of the flume was fixed to 1:133 and the single wide flood plain was covered with some synthetic grass of height 45mm in submerged condition and was arranged in series fixed throughout the whole length of the flume and boulders were used along the main channel (see Fig.1). Using a pump of 2870 rpm and pipelines of diameter 60mm the flow was supplied. The main channel and vegetated flood plain section were divided into each separate 6 sub-sections. At each sub-section of main channel and vegetated flood plain the height of water for calculating velocity in particular were measured separately using a pitot tube. And all the water depths were measured with the help of point gauge of 0.1mm accuracy at free surface and at depth of 0.2Y and 0.8Y where ‘Y’ is the total water depth measured from the free surface.

Field measurement of velocity in natural channels shows that the average velocity occurs at 0.6Y from the free surface. However, the field engineers generally measure the average velocity as follows:

$$V_{av} = \frac{V_{0.2} + V_{0.8}}{2} \text{----- (1)}$$

Where,

- $V_{av}$ = average velocity in the compound channel (m/s).
- $V_{0.2}$ = velocity at depth 0.2Y from the free surface (m/s).
- $V_{0.8}$ = velocity at depth 0.8Y from the free surface (m/s).

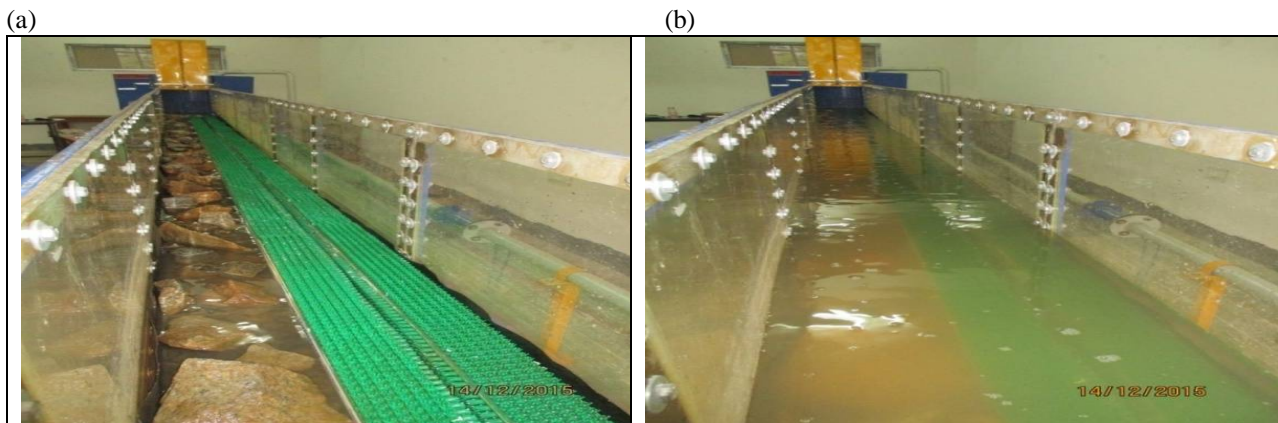


Fig. 1. (a) and (b) Cross-sections of the Flume.

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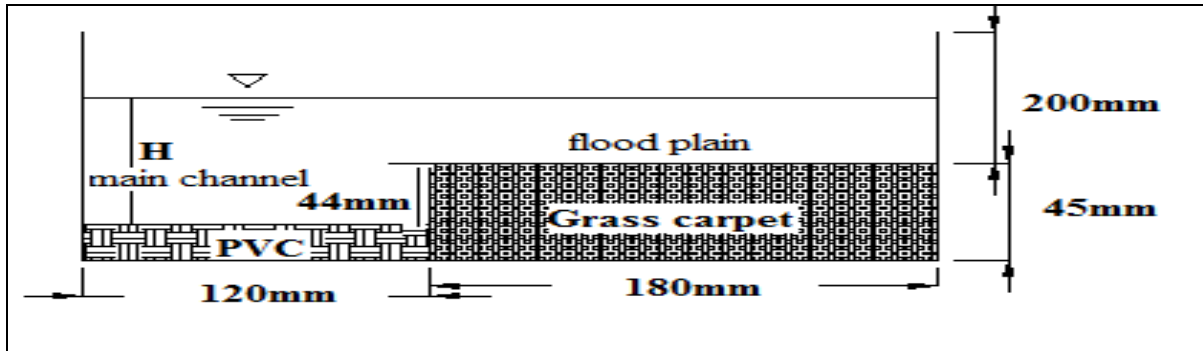


Fig. 2. Cross-section of Compound Channel of Hydraulics laboratory in Assam Downtown University.

On bend the flow velocity increases enormously owing to centrifugal force forming a convex shape. Shukry (1950) found that in short laboratory flumes, a small disturbance at the entry which is obvious to cause the region of peak water level to shift to one side giving rise to spiral motion. The sides of the channel have no influence on the velocity distribution in the central region.

The hydraulic parameters and variables obtained during the experiment are shown in Table 1.

Table 1. Hydraulic variables and parameters for each test case.

Distance from upstream (m)	Discharge ( $m^3/s$ )	Velocity Distribution (m/s)						Froude number	
		Main channel			Flood plain			Main channel	Flood plain
		Free surface	0.2 Y	0.8Y	Free surface	0.2 Y	0.8Y		
1.0 - 6.0	$2.21 \times 10^{-3} - 2.58 \times 10^{-3}$	3.8 - 7.0	3.0 - 4.7	1.0 - 2.7	2.0 - 3.5	1.6 - 2.4	1.1 - 1.7	0.5 - 0.77	1.21 - 3.10

### III. RESULTS

In this present study, the experimental analysis on impact of channel roughness on velocity distribution variation at different flow depths in a compound channel having a single wide floodplain is figured out. For a discharge ( $Q=2.21 \times 10^{-3} m^3/s$ ), variations in velocity distribution along consecutive sections of the flume at various depths are presented in figures below. As the flow depth increases along the channel length, the flow velocity along the surface has increased despite the existence of channel resistance as shown in fig. 4 and fig. 5. The influencing effect of resistance tends to retard as the flow depth increases.

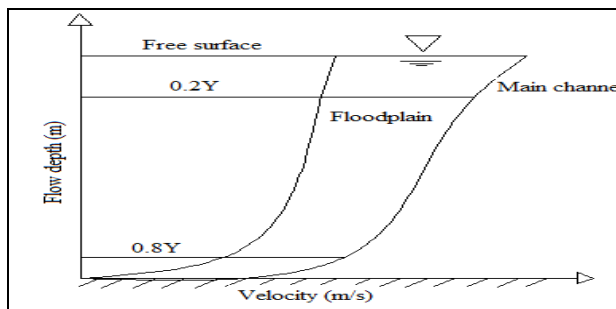


Fig. 3 Variation in velocity distribution in the channel (At Section 1m and  $Q=2.21 \times 10^{-3} m^3/s$ ).

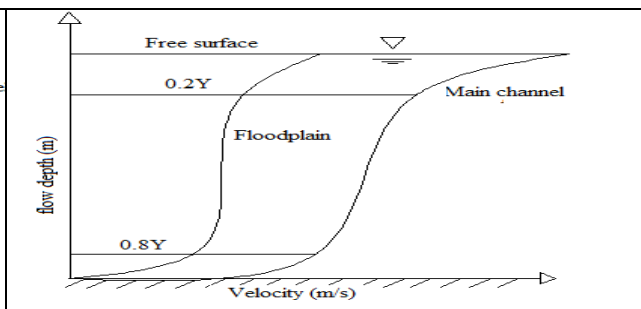


Fig. 4 Variation in velocity distribution in the channel (At Section 2m &  $Q=2.21 \times 10^{-3} m^3/s$ ).

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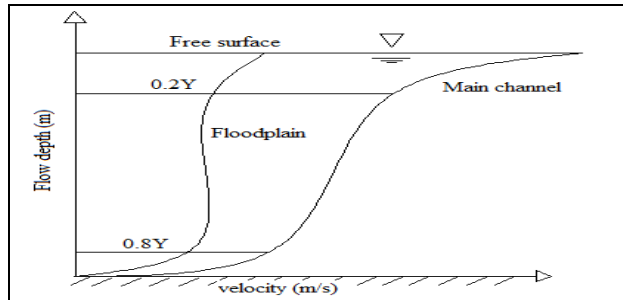


Fig. 5 Variation in velocity distribution in the channel (At Section 3m and  $Q=2.21 \times 10^{-3} \text{ m}^3/\text{s}$ )

The figures (fig. 3, 4 and 5) above show distinct difference in velocity distribution between the main channel and flood plain take at various relative depths because of the channel roughness. The velocity in the main channel is comparatively more than that of the floodplain velocity.

Similarly for discharge ( $Q=2.58 \times 10^{-3} \text{ m}^3/\text{s}$ ), variations in the velocity distribution along the consecutive sections of the flume at various depths are presented below (fig. 6, 7 and 8)

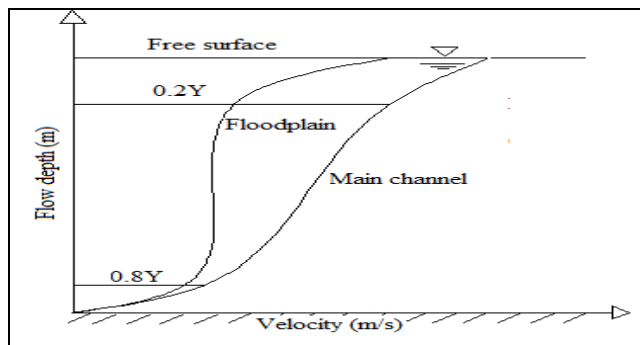


Fig. 6 Variation in velocity distribution in the channel (At Section 4m &  $Q=2.58 \times 10^{-3} \text{ m}^3/\text{s}$ ).

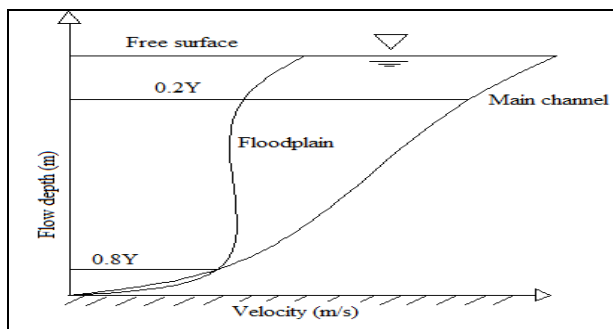


Fig. 7 Variation in velocity distribution in the channel (At Section 5m and  $Q=2.58 \times 10^{-3} \text{ m}^3/\text{s}$ ).

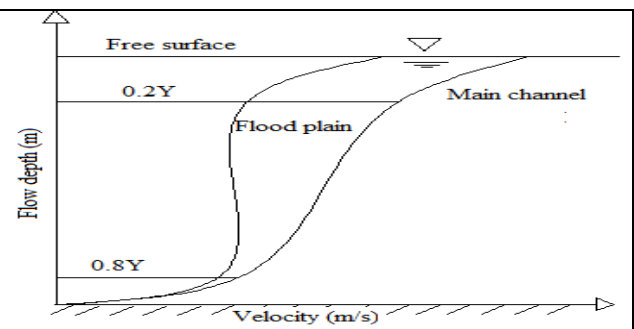


Fig. 8 Variation in velocity distribution in the channel (At Section 6m &  $Q=2.58 \times 10^{-3} \text{ m}^3/\text{s}$ ).

The velocity profile at sections 4m, 5m and 6m of the channel is more than that of the previous sections, this is due to the influencing end effect at channel end.

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The unevenness of the channel causes the curvature of the vertical velocity distribution curve to increase demonstrated in the above figures.

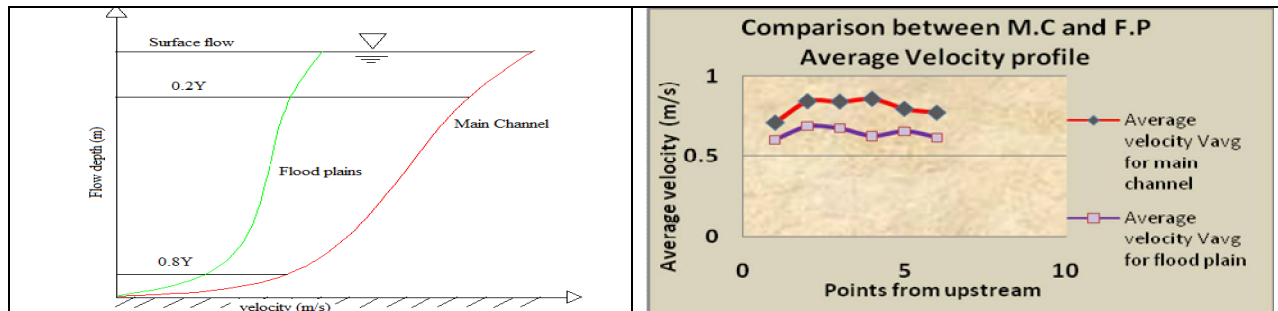


Fig. 9 Variation in average velocity distribution in the channel.

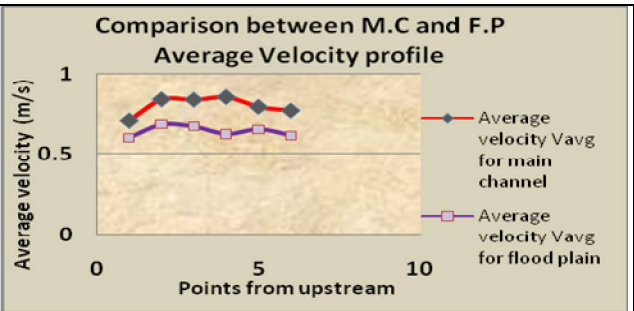


Fig. 10 Longitudinal average velocity variation in the channel

The above discussion shows non-uniform velocity distribution in the compound channel. This non-uniform pattern of velocity affects the computation of momentum in the channel. The results show that the velocity distribution parabolic curve along the floodplain reduces due to effect of riparian vegetation whereas the main channel velocity is widely increased.

## IV. CONCLUSION

This research was carried out to understand the extent of variation in flow velocity distribution in the compound channel due to the channel unevenness. Analysis was done in order to determine effect of channel roughness on the curvature of velocity distribution along the depths of both main channel and the floodplain.

## REFERENCES

- [1] Afzal, B., Faruque, M. A. A., and Balachandar, R.(2009). "Effect of Reynolds number, near-wall perturbation and turbulence on smooth open channel flows." *Journal of Hydraulic Research*, 47(1), 66-81.
- [2] Balachandar, R., and Patel, V. C. (2002). "Rough wall boundary layer on plates in open channels." *Journal of Hydraulic Engineering*, 128(10), 947-951.
- [3] Chow, Ven Te, *Open channel Hydraulics*, McGraw-Hill, New York, 1973.
- [4] M. Amel Sadeghi, M. Shafai Bajestan and M. Saneie "Experimental Investigation on Flow velocity variation in Compound Channel with Non-submerged Rigid Vegetation in Floodplain" *World Applied Sciences Journal* 9 (12): 1398-1402, 2010 ISSN 1818-4952
- [5] Nezu, I. (2005). "Open-channel flow turbulence and its research prospect in the 21st century." *Journal of Hydraulic Engineering*, 131(4), 229-246.
- [6] Shukry, A., *Flow Around Bends in an open channel*, Transaction, ASCE, vol. 115, pp. 751-779, 1950.
- [7] Tachie, M. F., Bergstrom, D. J., and Balachandar, R.(2003). "Roughness effects in low- $Re_{\tau}$  open-channel turbulent boundary layers." *Experiments in Fluids*, 35, 338-346.