IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684, p-ISSN: 2320-334X.
PP 38-43
www.iosrjournals.org

Transverse Distribution of Shear Stress in Compound Meandering Channel

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Abstract : *The present work is to study the shear stress distribution which is essential to deal with the hydraulic problem such as channel design, channel migration and interaction losses. Bed shear stress is useful for the study of bed load transfer where as wall shear stress presents a general view of channel migration pattern. , it is important to understand the behaviour of flows within compound channels for designing of flood control, hydraulic structure, sedimentation, water management. Distribution of boundary shear which is a better indicator of secondary flows than velocity, on different parameters like aspect ratio, sinuosity, and hydraulic parameter such as relative depth. Experimental data collected from laboratory under different discharge to obtain shear stress distribution at the walls and on the bed of compound channels and the geometry, slope and sinuosity of the channel maintained by relative depths. Preston-tube technique is used to collect velocity heads at various intervals along the wetted perimeter and distributions of boundary shear stress along the wetted perimeter are plotted.*

Keywords *- Aspect ratio, Compound channel , In-bank flow, Interaction loss, Preston-tube , Sinuosity.*

I. Introduction

This resistive force is manifested in the form of boundary shear force. Otherwise stated, tractive force, or boundary shear stress acting along the channel bed. Distribution of boundary shear force along the wetted perimeter directly affects the flow structure in an open channel. To define velocity profile and fluid field required knowledge on distribution of boundary shear. by bearing the idea of boundary shear stress distribution the computation related to bed form resistance, sediment transport, side wall correction, cavitations, channel migration, conveyance estimation, and dispersion all the hydraulic problem can be solved easily. Also the idea regarding boundary shear stress distribution provides solution in open channel. Einstein (1942) developed the first method to estimate the shear stresses at the bed and wall. Taylor (1961)[1] concluded that Einstein s method was appropriate to evaluate friction with an aspect ratio smaller than 0.5. Johnson (1942)[2] admitted the convenience of using the friction logarithmic law with Einstein method. Different researches considered the shear distribution problem by local shear stress as a function of the total shear stress and as function of aspect ratio B/y where B is channel width and y is the depth.(Rajaratnam and muralidhar 1969 ,Ghosh and roy 1971 ,Knight and Macdonald 1979,knight & Demetriou 1984, knight & knight & patel1985 . In this paper intended to verify that experimental data related to shear stress, knight & sterling (2000) [3,4,5,6,7].This mainly to determine the contribution of wall and bed shear stress on total boundary .and also this represent the separation analysis for inner and outer wall. Compound channel consist of main channel and flood plain. When the flow in the natural or main made channel exceeds the channel section, flow of water take place in the flood plain. These compound channels are extremely complex[8]. Geometrical and physical parameters and hence have attracted the attention of researchers in last half century. Hence the main channel flow are usually much faster as compared to the floodplain flow compound channels used for investigating flow characteristics are often varied with respect to different geometric and hydraulic parameters[9,10].

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[11]. The experimental channels are fabricated using 6mm thick perspex sheet inside a tilting flume. The tilting flume is 15m long and 4m wide & 0.5m deep made up of metal .

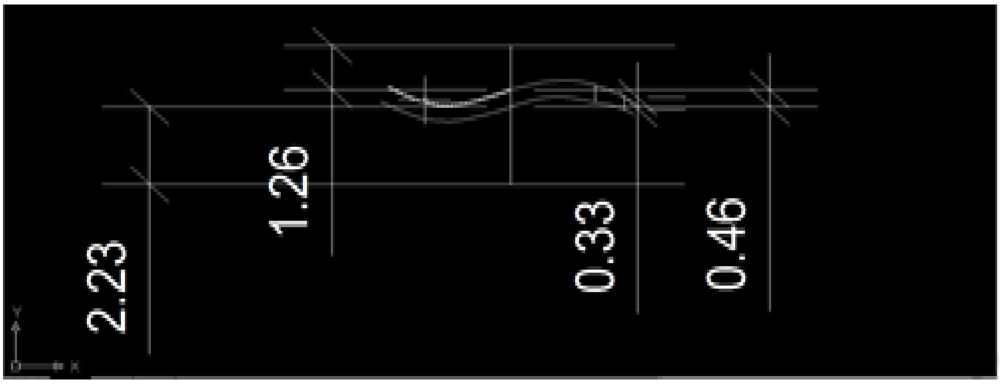

Fig.1. Plan View of Meandering Channel

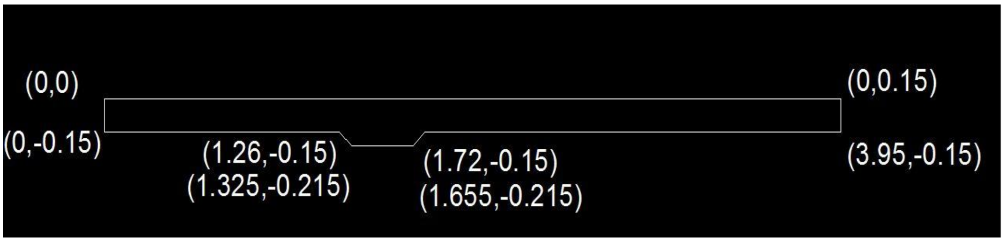

Fig.2. Cross Section of Straight Compound Section

The preston–tube method is used to estimate of shear stress measurement and is widely used for laboratory channels. To evaluate the boundary shear stress a Preston micro-pitot is used .The the Dynamic & Static pressures are recorded manually at different intervals. The definitive calibration curve presented by Patel (1965) for the preston tube define in terms of two non-dimensional parameter are used to convert the pressure reading to boundary shear stress.

$$x^* = \log 10(\Delta p d^2/4\rho v^2) \quad (1)$$
$$y^* = \log 10(\tau_o d^2/4\rho v^2) \quad (2)$$
$$y^* = 050\, x^* + 0.037, \qquad 0 \leq y^* \leq 1.50 \quad \text{or} \quad 0 \leq x^* \leq 2.9 \quad (3)$$
$$y^* = -0.0060\, x^{*3} + 0.1437\, x^{*2} - 0.1381\, x^* + 0.8287, \qquad 1.50 < y^* < 3.50 \quad \text{or} \quad 2.9 \leq x^* \leq 5.6 \quad (4)$$
$$x^* = y^* + 2 \log 10(1.95\, y^* + 4.02), \qquad 3.50 < y^* < 5.30 \quad \text{or} \quad 5.6 \leq x^* \leq 7 \quad (5)$$

The calibration of x* & y* for different regions of the velocity distribution is expressed by three different formulae.

III. Results And Discussion

The shear stress distribution is measured with the help of Preston tube technique. Shear stress distribution in open channel flow depends on various factors such as channel cross- section, roughness, depth of flow and the presence of bends in the channel alignment. Pitot tube is used to record the pressure difference along the flow of river. This differential dynamic pressure head is used to calculate the shear stress. Graphs between shear stress (τ) vs transverse distance was drawn with the help of Excel.

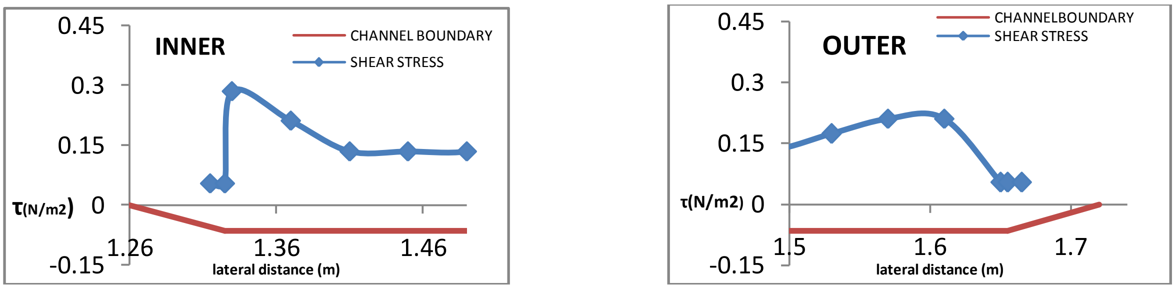

Fig.3. Distribution of shear stress for 2.8cm depth of flow

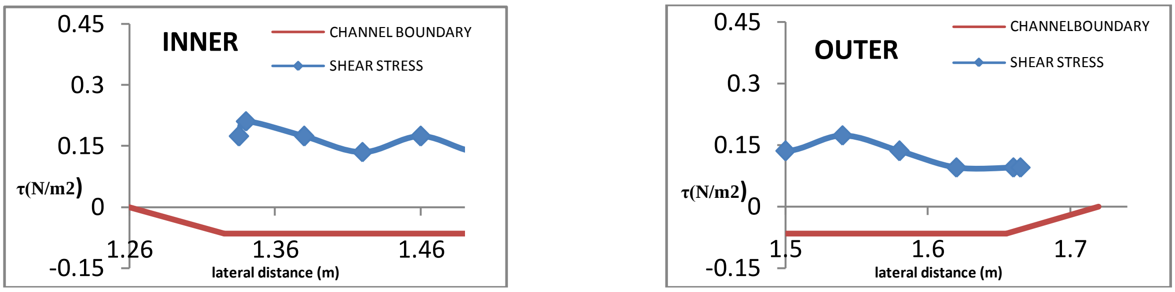

Fig.4. Distribution of shear stress for 3.27cm depth of flow

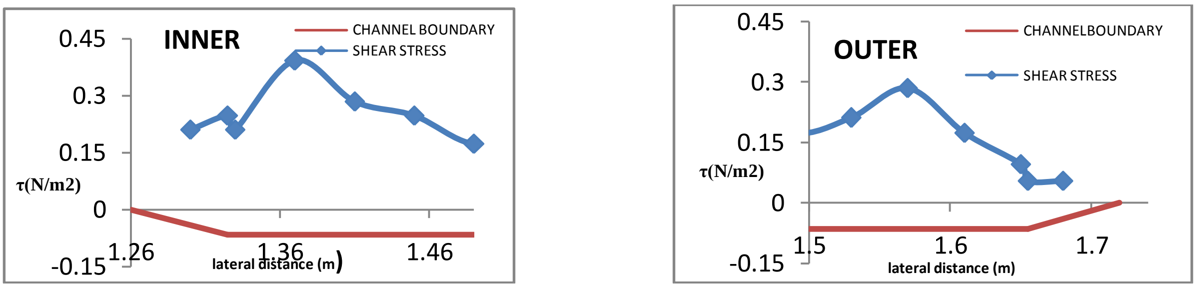

Fig.5. Distribution of shear stress for 3.28cm depth of flow

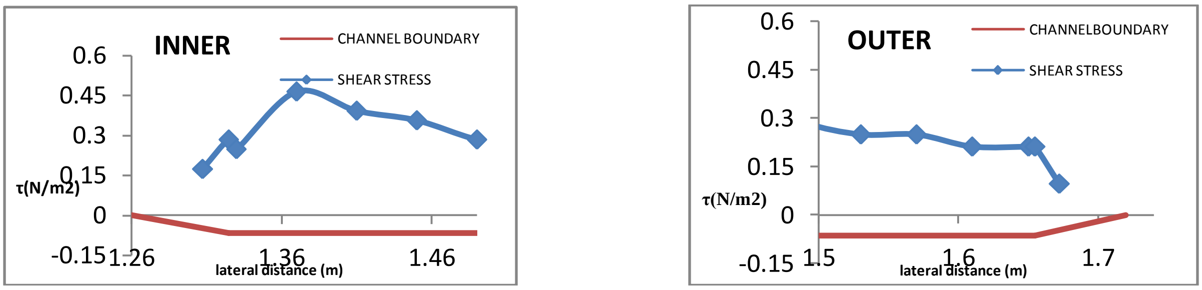

Fig.6. Distribution of shear stress for 4.4cm depth of flow(at depth 0.6*4.4=2.64cm)

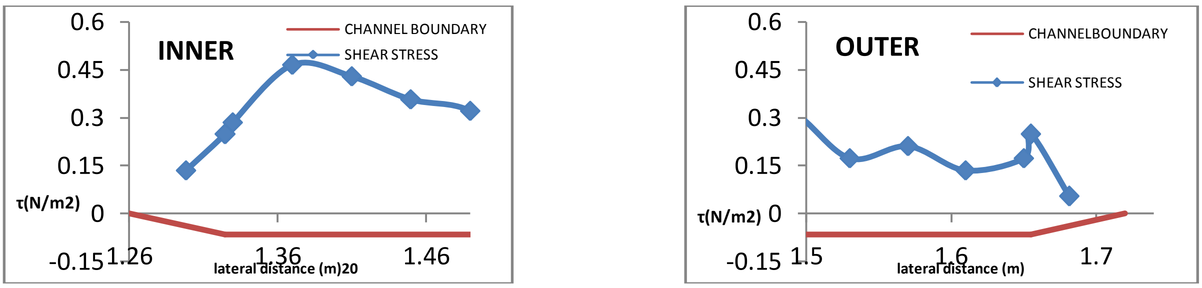

Fig.7. Distribution of shear stress for 4.4cm depth of flow (at depth 0.4*4.4=1.76cm)

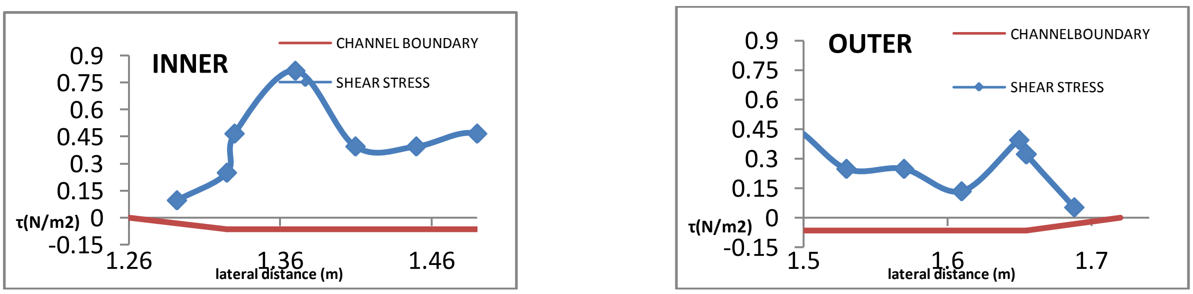

Fig.8. Distribution of shear stress for 4.4cm depth of flow (at depth 0.2*4.4=0.88cm)

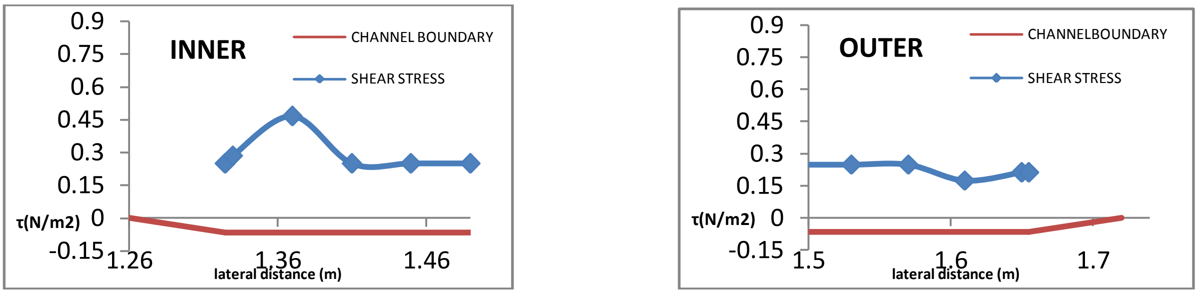

Fig.9. Distribution of shear stress for 5cm depth of flow(at depth 0.6*5=3cm)

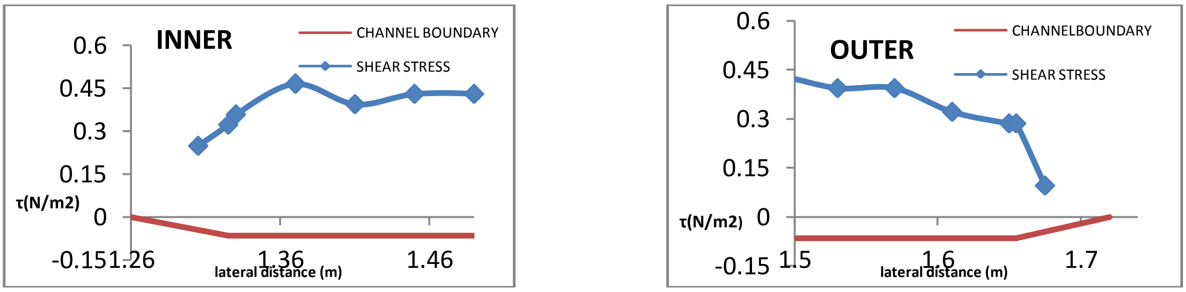

Fig.10. Distribution of shear stress for 5cm depth of flow (at depth 0.4*5=2cm)

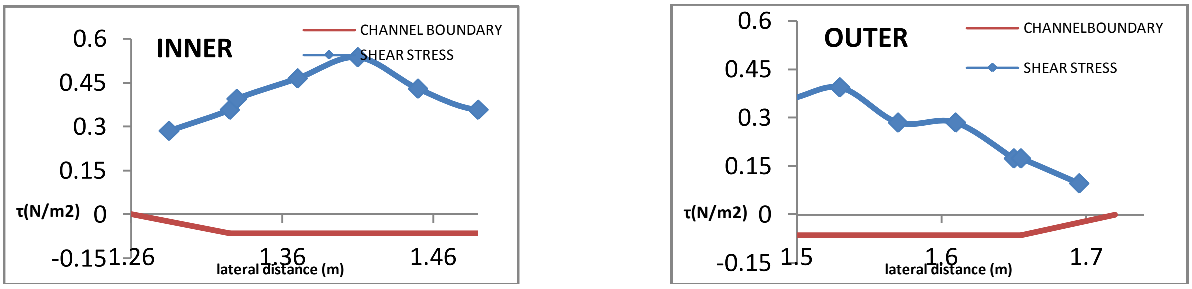

Fig.11. Distribution of shear stress for 5cm depth of flow (at depth 0.2*5=1cm)

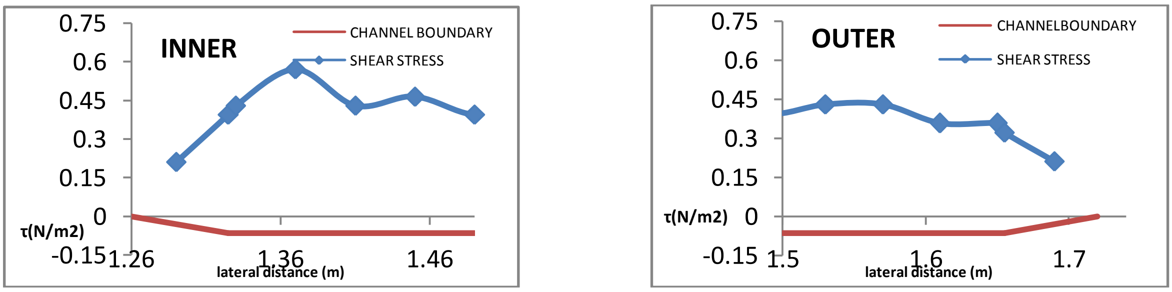

Fig.12. Distribution of shear stress for 5.5cm depth of flow (at depth 0.6*5.5=3.3cm)

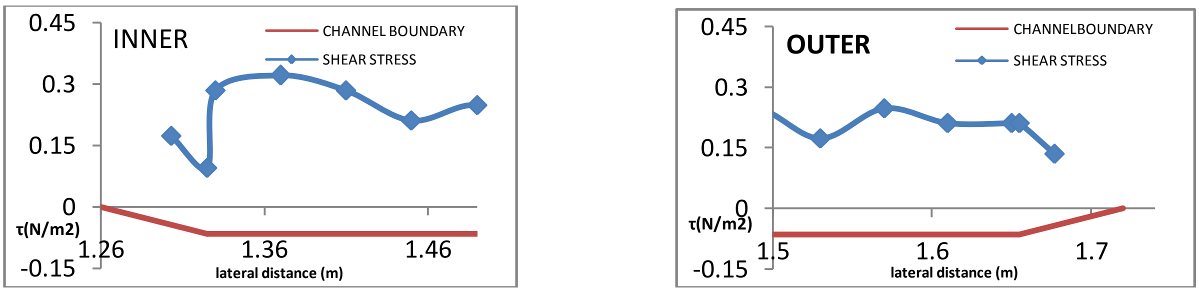

Fig.13. Distribution of shear stress for 7.28cm depth of flow (at depth 0.4*7.28=2.912cm)

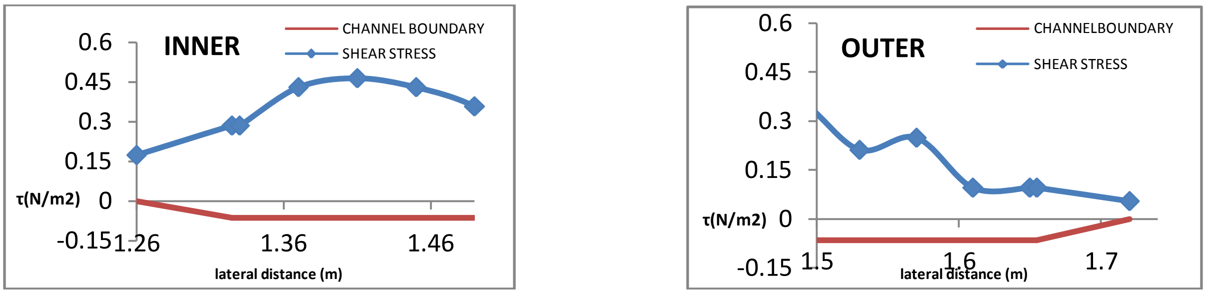

Fig.14. Distribution of shear stress for 7.28cm depth of flow (at depth 0.2*7.28=1.456cm)

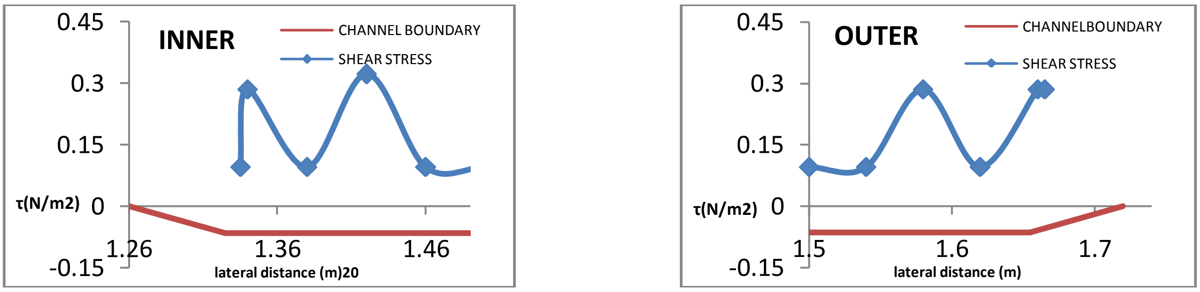

Fig.15. Distribution of shear stress for 9.395cm depth of flow (at depth 0.6*9.395=5.637cm)

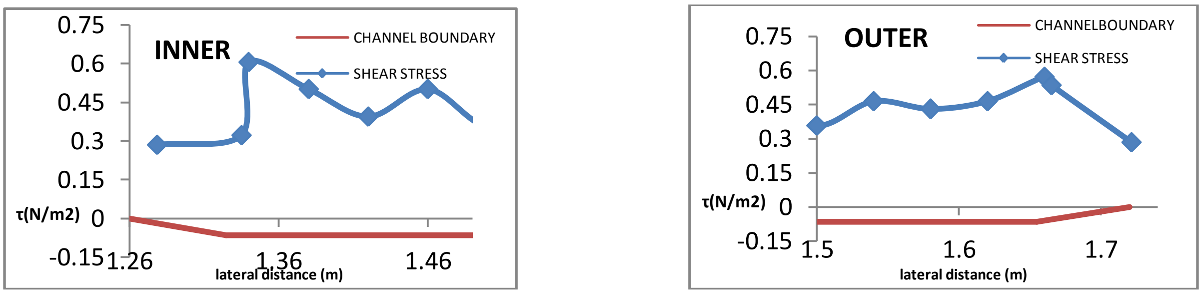

Fig 16. Distribution of shear stress for 9.395cm depth of flow (at depth 0.4*9.395=3.758cm)

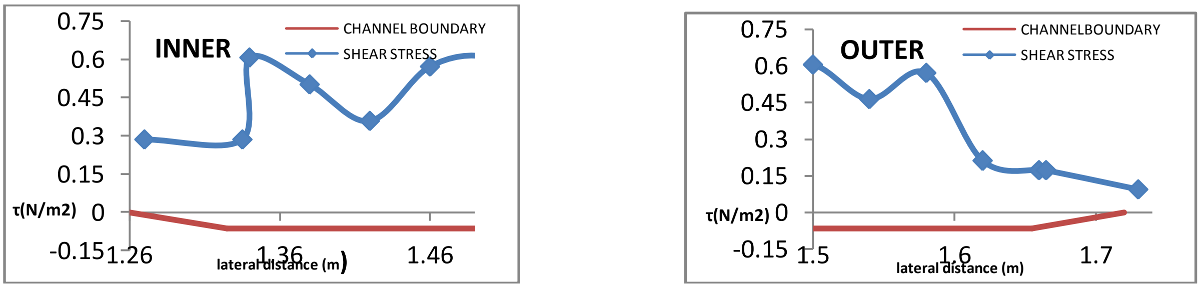

Fig.17. Distribution of shear stress for 9.395cm depth of flow (at depth 0.2*9.395=1.879cm)

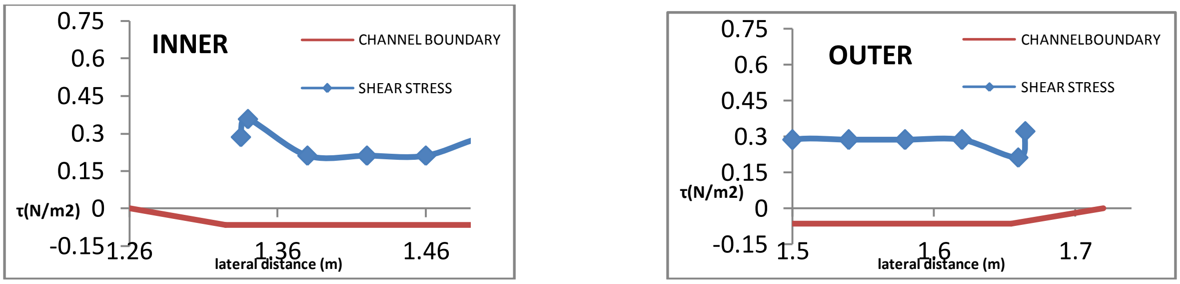

Fig.18. Distribution of shear stress for 9.9cm depth of flow

IV. Conclusion

1. The results show that shear stress more at the inner wall than outer wall.
2. It can be seen that the bed and wall shear increases with depth of flow in main channel.
3. With the decreases of the aspect ratio the shear stress increases.
4. Sinusoidal distribution of boundary shear stress along the wetted perimeter confirms the presence of secondary currents in meandering inbank flows

Acknowledgements

The authors thankfully acknowledge the Department of Science and Technology (DST), Government of India for providing financial support for creating the research facilities in Fluid Mechanics and Hydraulics laboratory at the National Institute of Technology, Rourkela, India. The paper is part of the experimental outcomes created by DST support at the Institute.

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