ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Vol. 2, Issue 6, June 2015

A Mathematical Approach to Transverse Distribution of Shear Stress

A.Sahu[1], L.Mohanty[2], K.C.Patra[3]

M Tech Scholar, Department of Civil Engg., VSSUT, Sambalpur, India [1]

Assistant Professor, Department of Civil Engg., VSSUT, Sambalpur, India [2]

Professor, Department of Civil Engg, NIT Rourkela,Rourkela , India [3]

Abstract: This research paper demonstrates the distribution of shear stress along the bed of wide open meandering main channel. As a complementary study to experimental investigation the mathematical tool like MATLAB is used. With the aim of obtaining shear stress distribution at the bed, experimental data are analysed with the help of MATLAB. The results of some experimental study are reported concerning the distribution of shear stress in compound meandering channel which is influenced by the secondary flow. The estimation of boundary shear stress distribution is essential to deal with the hydraulic problem such as channel migration, channel design & interaction losses. It is important to understand the behaviour of flows within compound channels for designing the flood control. Preston-tube technique is used to collect velocity heads at various intervals along the wetted perimeter and distributions of boundary shear stress are computed through MATLAB coding.

Keywords: Boundary shear stress, Compound channel, Interaction losses, Preston-tube, Secondary flow, Matlab.

I. INTRODUCTION

The scenario analysis for knowledge of the shear stress distribution is necessary for the visualization of complete flow mechanism along with the extent of turbulence. Shear stress plays a key role for prediction of bank erosion and migration pattern. According to the laboratory data analysis, shear stress from a preston tube is the most felicitous shear stress calculation method. 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 is highly essential. By bearing the idea of boundary shear stress distribution the computation related to bed form resistance, sediment transport, side wall correction, cavitation, 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) concluded that Einstein s method was appropriate to evaluate friction with an aspect ratio smaller than 0.5. Johnson (1942) admitted the convenience of using the friction logarithmic law with Einstein method.

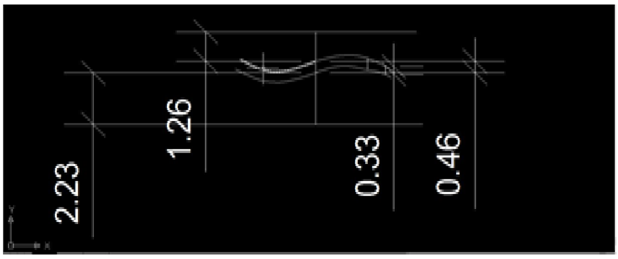
Different researches considered the shear distribution problem by local shear stress as a function of the total shear stress and as function of aspect ratio B/y where B is channel width and y is the depth.(Rajaratnam and Muralidhar 1969, Ghosh and Roy 1971 ,Knight and Macdonald 1979, Knight & Demetriou 1984, knight & knight & patel1985. In this paper intended to verify that experimental data related to shear stress, knight & sterling (2000) .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 manmade channel exceeds the channel section, flow of water takes place in the flood plain. These compound channels are extremely complex in behavior. Geometrical and physical parameters and hence have attracted the attention of researchers in last half century.

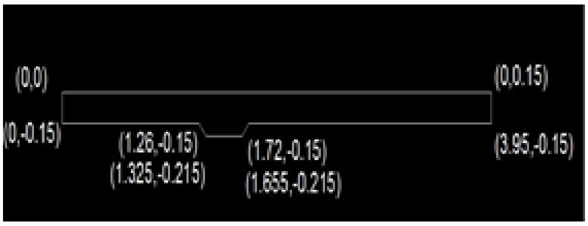
Hence the main channel flow are usually much faster as compared to the floodplain flow compound channels used for investigating flow characteristics are often varied with respect to different geometric and hydraulic parameters.

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. 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



“Figure 1. Plan View of Meandering Channel”



"Figure 2.cross section of 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 Dynamic & Static pressure 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.

$$x^* = \log10(\Delta p d^2/4\rho v^2) \qquad (2.1)$$

$$y^* = \log10(\tau_o d^2/4\rho v^2) \qquad (2.2)$$

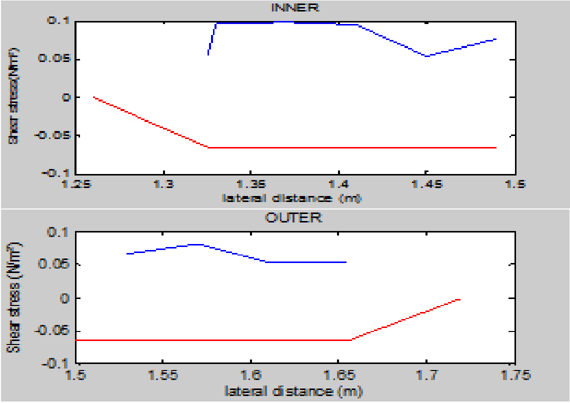
$$y^* = 050\, x^* + 0.037,$$
$$0 \leqslant y^* \leqslant 1.50 \ \text{or} \ 0 \leqslant x^* \leqslant 2.9 \qquad (2.3)$$

$$y^* = -0.0060\, x^{*3} + 0.1437\, x^{*2} - 0.1381\, x^* + 0.8287,$$
$$50 < y^* < 3.50 \ \text{or} \ 2.9 \leqslant x^* \leqslant 5.6 \qquad (2.4)$$

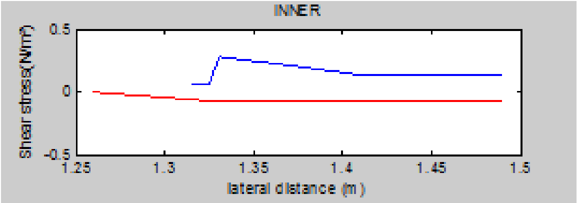
$$x^* = y^* + 2\log10(1.95\, y^* + 4.02),$$
$$3.50 < y^* < 5.30 \ \text{or} \ 5.6 \leqslant x^* \leqslant 7 \qquad (2.5)$$

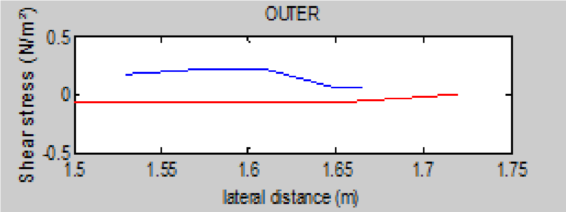
III. RESULTS AND DISCUSSION

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 MATLAB Codeing.

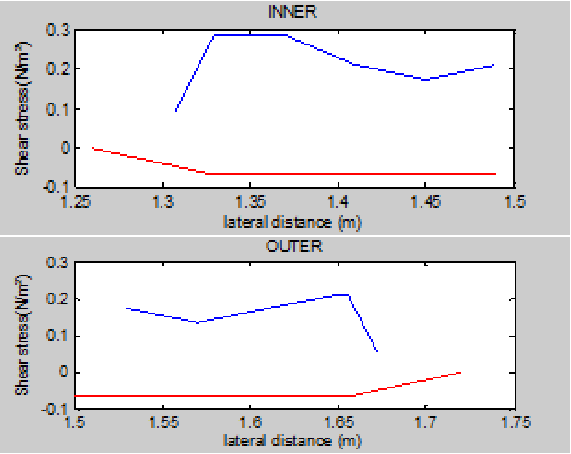


"Figure 3. Distribution of shear stress for 2.8cm of flow"

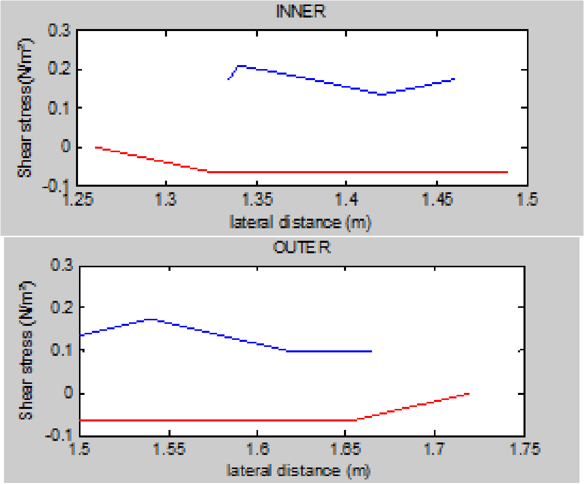




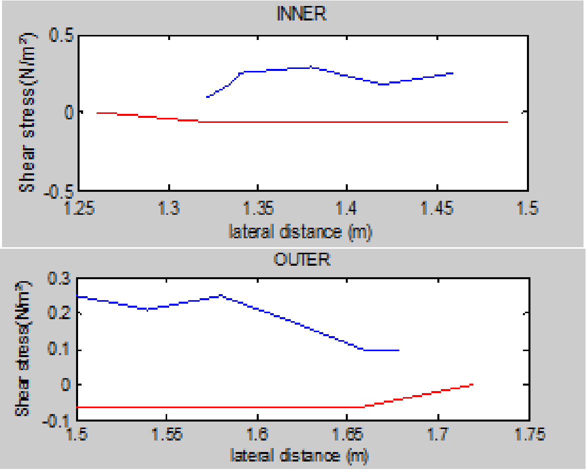
"Figure 4. Distribution of shear stress for 2.8cm depth of flow"



"Figure 5. Distribution of shear stress for 2.8cm depth of flow"

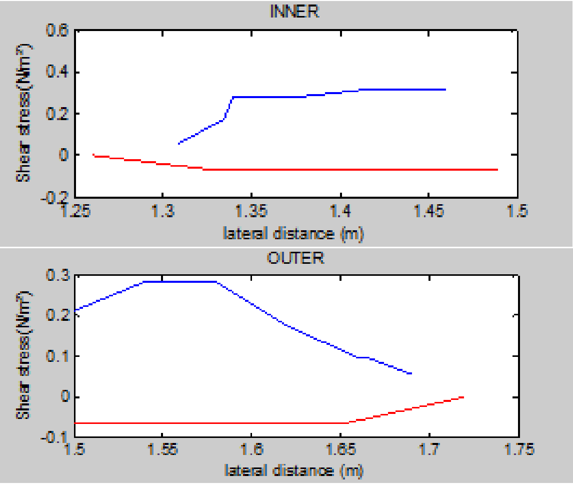


"Figure 6. Distribution of shear stress for3.27cm depth of flow"

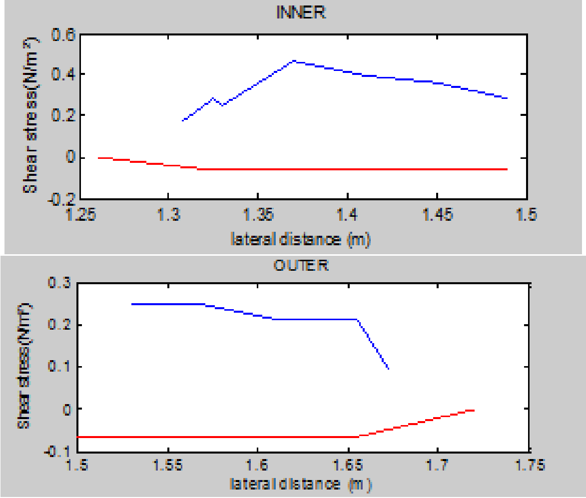


"Figure 7. Distribution of shear stress for3.27cm depth of flow"

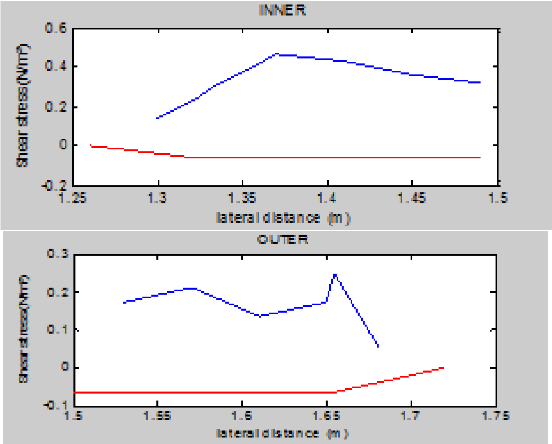
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Vol. 2, Issue 6, June 2015



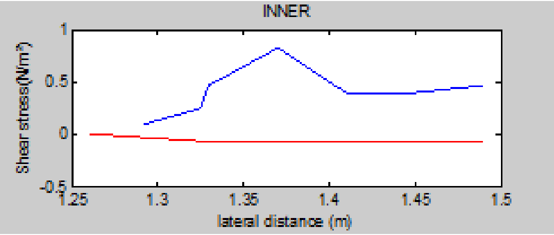
“Figure 8. Distribution of shear stress for3.27cm depth of flow”

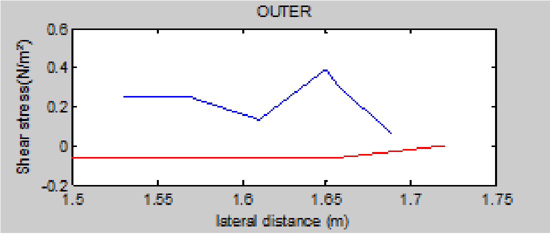


“Figure 9. Distribution of shear stress for4.4cm depth of flow”

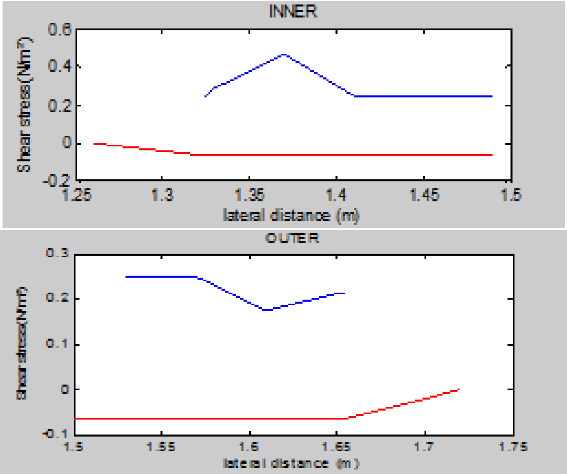


“Figure10.Distribution of shear stress for4.4cm depth of flow”

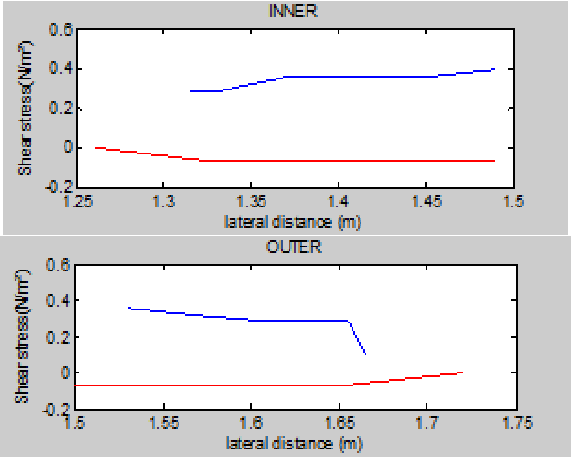




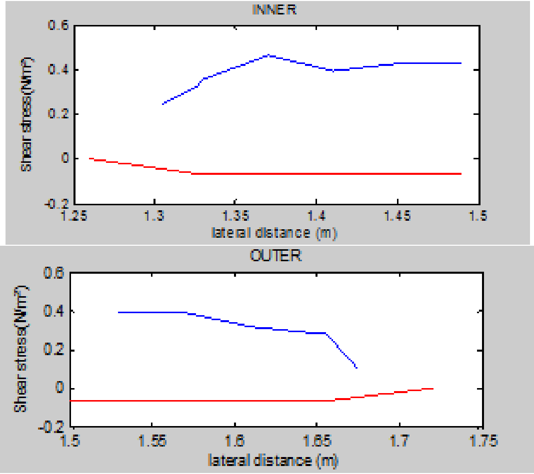
“Figure11.Distribution of shear stress for4.4cm depth of flow”



“Figure12.Distribution of shear stress for5cm depth of flow”

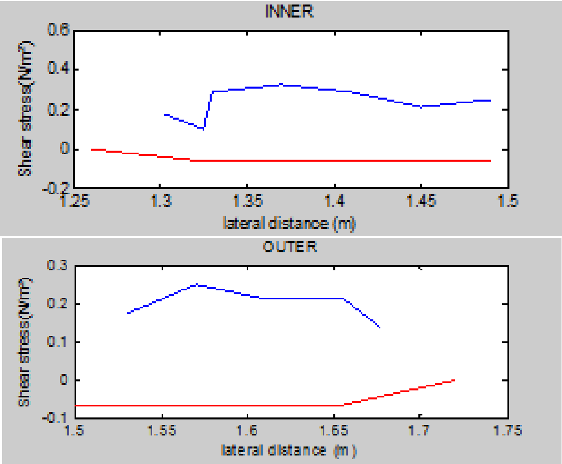


“Figure13.Distribution of shear stress for5cm depth of flow”

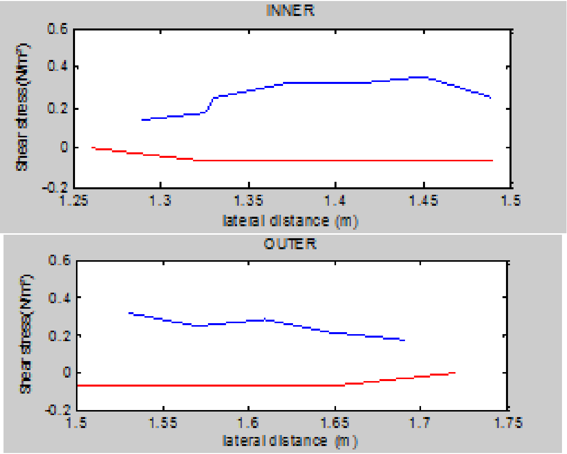


“Figure14.Distribution of shear stress for 5cm depth of flow”

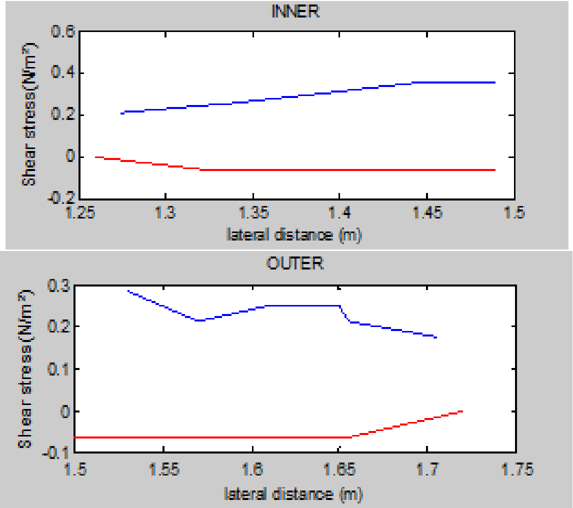
DOI 10.17148/IARJSET.2015.2617

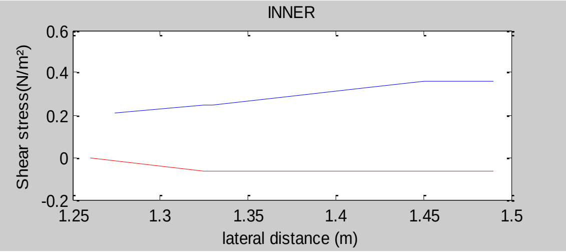


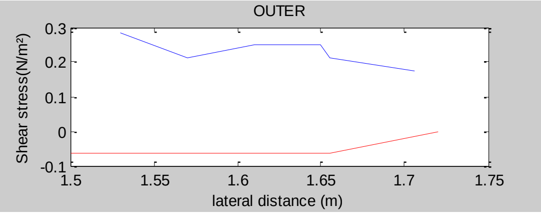
“Figure15.Distribution of shear stress for7.28cm depth of flow”



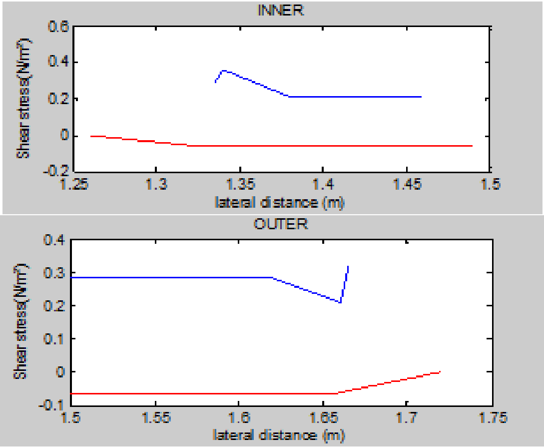
“Figure16.Distribution of shear stress for7.28cm depth of flow



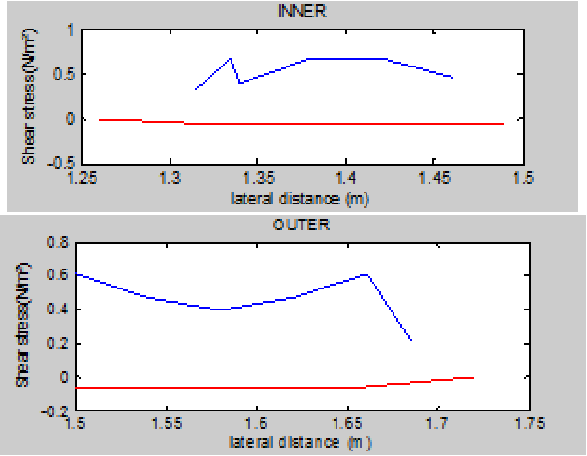




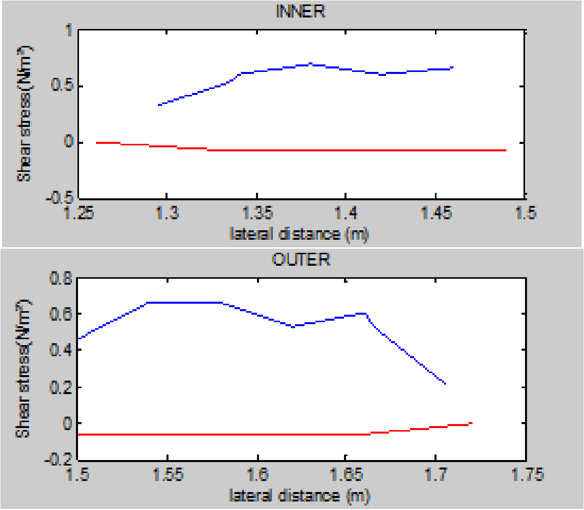
“Figure17.Distribution of shear stress for7.28cm depth of flow”



“Figure18.Distribution of shear stress for9.9cm depth of flow”



“Figure19.Distribution of shear stress for9.9cm depth of flow”



“Figure20.Distribution of shear stress for9.9cm depth of flow”

DOI 10.17148/IARJSET.2015.2617

IV. CONCLUSION

- From the above experiment it conform that shear stress more at the inner wall than outer wall in meandering channel.
- It can be seen that the bed and wall shear increases with depth of flow in main channel.
- The aspect ratio decreases with the increases of shear stress
- Sinusoidal distribution of boundary shear stress gives the conformation of 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.

REFERENCES

[1] Maria Olivero N.,Julian Aguirre-pe and Alix Moncada , "Shear stress distribution in rectangular channels",Centro de investigations Hydraulics y de Mecanica de los Fluidos – Chidra,

[2] Junke Guo and Pierre Y.Julien , "Shear stress in Smooth Rectangular Open Channel Flows",10.1061/(ASCE)0733-9429(2005)131:1(30).

[3] Donald W.knight and Harish S.Patel,"Boundary Shear in Smooth Rectangular Ducts",(ASCEJ).Hydraul.Eng.1985.1111: [29-47].

[4] David G. Rhodes and Donald W. knight ,"Distribution of shear force on boundary of smooth rectangular duct",(ASCE) J.Hydraul.Engg. 1994 .120:[787-807].

[5] Cheng, N.S. and L.H.C. Chua, (2005). " Comparisons of sidewall correction of bed shear stress in open-channel flows". J. Hydr. Eng., vol. 131, pp. [605-609]

[6] Ghosh, S.N. and Roy, N. (1970) "Boundary shear distribution in open channel flow". J. Hvdr. Div. ASCE vol.96 (HY4), pp.[967-994].

[7] Knight, D.W. (1981) "Boundary shear in smooth and rough channels." J. Hydr. Div ASCE vol.107 (HY7).

[8] Knight, D.W., Demetriou, J.D. and Hamed, ME. (1984) "Boundary shear in smooth rectangular channels." J. Hydr. Engin. ASCE vol.110, pp. [405-422].

[9] Lashkar A.B and Fathi M.M, 2010. "Wall and Bed Shear Forces in Open Channels". Research Journal of Physics, vol. 4, pp.1-10

DOI 10.17148/IARJSET.2015.2617