BOUNDARY SHEAR STRESS IN COMPOUND CHANNEL

A Project Submitted
In Partial Fulfilment of the Requirements
For the Degree of

Bachelor of Technology
In Civil Engineering
By

Parbesh Minz
Roll no.-10401021
&
Bhabani Bara
Roll No.-10401023

DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA
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Under the guidance of

Prof. K.C. Patra

&

Prof. K.K.Khatua

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NATIONAL INSTITUTE OF TECHNOLOGY
ROURKELA
CERTIFICATE

This is to certify that the project entitled "**boundary shear stress in compound channel**" submitted by Parbesh Minz [Roll no. 10401021] and Bhabani Bara [Roll no. 10401023] in partial fulfilment of the requirements for the award of Bachelor of Technology degree in Civil engineering at the National Institute of Technology Rourkela is an authentic work carried out by them under my supervision and guidance.

To the best of my knowledge the matter embodied in the project has not been submitted to any other university/institute for the award of any degree or diploma.

Date: 12.05.08

Prof K.K.khatua
Department of Civil Engineering
National Institute of Technology
Rourkela - 769008

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Date: 12.05.2008

Parbesh Minz

Bhabani Bara

ABSTRACT

Magnitude of flood prediction is the fundamental for flood warning, determining the development for the present flood-risk areas and the long-term management of rivers. Discharge estimation methods currently employed in river modeling software are based on historic hand calculation formulae such as Chezy's, Darcy-Weisbatch or Manning's equation. More recent work has provided significant improvements in understanding and calculation of channel discharge. This ranges from the gaining knowledge to interpretation of the complex flow mechanisms to the advent of computing tools that enable more sophisticated solution techniques.

When the flows in natural or man made channel sections exceed the main channel depth, the adjoining floodplains become inundated and carry part of the river discharge. Due to different hydraulic conditions prevailing in the river and floodplain, the mean velocity in the main channel and in the floodplain are different. Just above the bank-full stage, the velocity in main channel is much higher than the floodplain. Therefore the flow in the main channel exerts a pulling or accelerating force on the flow over floodplains, which naturally generates a dragging or retarding force on the flow through the main channel. This leads to the transfer of momentum between the main channel water and that of the floodplain. The interaction effect is very strong at just above bank full stage and decreases with increase in depth of flow over floodplain. The relative "pull" and "drag" of the flow between faster and slower moving sections of a compound section complicates the momentum transfer between them. Failure to understand this process leads to either overestimate or underestimate the discharge leading to the faulty design of channel section. This causes frequent flooding at its lower reaches.

Due to transfer of momentum between the subsections of the meandering compound channel, the shear distribution is largely affected. For such compound channels, the apparent shear force at the assumed interface plane gives an insight into the magnitude of flow interaction. The results of some experiments concerning the velocity distribution and the flow distribution in a smooth and rough compound meandering channel of rectangular cross section are presented. The influence of the geometry on velocity and flow distribution and different functional relationships are obtained.

Dimensionless parameters are used to form equations representing the velocity distribution and flow distribution between main channel and flood plain subsections. Once these equations get formed one can judge the exact flow in main channel and flood channel sections which could possibly guide in flood prediction.

The experiments concerning the flow in simple meander channels and meander channel - floodplain geometry have been conducted at the Fluid Mechanics and Water Resources Engineering Laboratory of the Department Civil Engineering, National Institute of Technology, Rourkela, India. Channels of different shapes and sizes have been fabricated in the laboratory with different equipments installed in them. Water is allowed to flow through these channels and the flow is maintained smooth. The Acoustics Doppler Velocitimeter (ADV**)** installed in the lab is worth mentioning. Taking the aid of a laptop terminal, this equipment helps in determining the three-dimensional velocities (Vx, Vy, Vz) at any point in the water channel.

All the velocity readings obtained are recorded and finally velocity contours (i.e. isovels) are plotted with a software 3D-Field. Depending on the flow pattern and shape of the channel, contours are obtained. Now with this software discharge through a channel cross-section is generated which when compared to the actual flow discharge gives a very less percentage of error. Finally equations related to the flow distribution are formed based on the given datas. These formed equations are validated with datas collected from IIT Kharagpur **(**Bhattacharya, A. K. (1995) and those from Knight and Demetriou**(** Knight, D.W., and Demetriou, J.D., (1983) which satisfies them as well.

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CHAPTER 1

INTRODUCTION

INTRODUCTION

Investigators have studied meanders and straight compound channels flows for a fairly long time. The name meander, which probably originated from the river Meanders in Turkey is so frequent in river that it has attracted the interest of investigators from many disciplines. Thomson (1876), was probably the first to point out the existence of spiral motion in curved open channel. Since then, a lot of laboratory and theoretical studies have been reported, more so, in the last decade or two. It may be worthwhile to know the developments in the field of constant curvature bends, simple meander channel flows and straight compound channels before knowing about the meander channel-floodplain geometry as limited studies concerning the meander plan form of the compound sections are available till date.

Information regarding the nature of flow distribution in a flowing simple and compound channel is needed to solve a variety of river hydraulics and engineering problems such as to give a basic understanding of resistance relationship, to understand the mechanism of sediment transport, to design stable channels, revetments. The flow distribution, velocity distribution and flow resistance in compound cross section channels have been investigated by many authors. Most of the flow distribution formulae assume that the roughness coefficient and the other geometrical parameters of natural river channel do not change when the flow starts overtopping the main channel.

For meandering channels the flood plain geometry, the wide variation in local shear stress distribution from point to point in the wetted perimeter varies. Therefore there is need for taking into account these parameters and developing one rock solid model which would predict the discharge accurately during flood forecasting.

CHAPTER 2

LITERATURE REVIEW

2.1 SIMPLE MEANDER CHANNELS

The Meandering channel flow is considerably more complex than constant curvature bend flow. The flow geometry in meander channel due to continuous stream wise variation of radius of curvature is in the state of either development or decay or both. The following important studies are reported concerning the flow in meandering channels.

Hook (1974) measured the bed elevation contours in a meandering laboratory flume with movable sand bed for various discharges. For each discharge he measured the bed shear stress, distribution of sediment in transport and the secondary flow and found that with increasing discharge, the secondary current increased in strength.

Chang (1984 a) analyzed the meander curvature and other geometric features of the channel using energy approach. It established the maximum curvature for which the river did the last work in turning, using the relations for flow continuity, sediment load, resistance to flow, bank stability and transverse circulation in channel bends. The analysis demonstrated how uniform utilization of energy and continuity of sediment load was maintained through meanders.

2.2 COMPOUND CHANNELS IN STRAIGHT REACHES

While simple channel sections have been studied extensively, compound channels consisting of a deep main channel and one or more floodplains have received relatively little attention. Analysis of these channels is more complicated due to flow interaction taking place between the deep main channel and shallow floodplains. Laboratory channels provide the most effective alternative to investigate the flow processes in compound channels as it is difficult to obtain field data during over bank flow situations in natural channels. Therefore, most of the works reported are experimental in nature.

2.3 MEANDERING COMPOUND CHANNELS

There are limited reports concerning the characteristics of flow in meandering compound sections.

A study by United States water ways experimental station (1956) related the channel and floodplain conveyance to geometry and flow depth, concerning, in particular, the significance of the ratios of channel width to floodplain width and meander belt width to floodplain width in the meandering two stage channel.

Toebes and Sooky (1967) were probably the first to investigate under laboratory conditions the hydraulics of meandering rivers with floodplains. They attempted to relate the energy loss of the observed internal flow structure associated with interaction between channel and floodplain flows. The significance of helicoidal channel flow and shear at the horizontal interface between main channel and floodplain flows were investigated. The energy loss per unit length for meandering channel was up to 2.5 times as large as those for a uniform channel of same width and for the same hydraulic radius and discharge. It was also found that energy loss in the compound meandering channel was more than the sum of simple meandering channel and uniform channel carrying the same total discharge and same wetted perimeter. The interaction loss increased with decreasing mean velocities and exhibited a maximum when the depth of flow over the floodplain was less. For the purpose of analysis, a horizontal fluid boundary located at the level of main channel bank full stage was proposed as the best alternative to divide the compound channel into hydraulic homogeneous sections. Hellicoidal currents in meander floodplain geometry were observed to be different and more pronounced than those occurring in a meander channel carrying in bank flow. Reynold's number (R) and Froude number (F) had significant influence on the meandering channel flow.

Ghosh and Kar (1975) reported the evaluation of interaction effect and the distribution of boundary shear stress in meander channel with floodplain. Using the relationship proposed by Toebes and Sooky (1967) they evaluated the interaction effect by a parameter (W). The interaction loss increased up to a certain floodplain depth and there after it decreased. They concluded that channel geometry and roughness distribution did not have any influence on the interaction loss.

Ervine, Willetts, Sellin and Lorena (1993) reported the influence of parameters like sinuosity, boundary roughness, main channel aspect ratio, and width of meander belt, flow depth above bank full level and cross sectional shape of main channel affecting the conveyance in the meandering channel. They quantified the effect of each parameter through a non-dimensional discharge coefficient F^* and reported the possible scale effects in modeling such flows.

Patra and Kar (2000) reported the test results concerning the boundary shear stress, shear force, and discharge characteristics of compound meandering river sections composed of a rectangular main channel and one or two floodplains disposed off to its sides. They used five dimensionless channel parameters to form equations representing the total shear force percentage carried by floodplains. A set of smooth and rough sections is studiedwith an aspect ratio varying from 2 to 5. Apparent shear forces on the assumed vertical, diagonal, and horizontal interface plains are found to be different from zero at low depths of flow and change sign with an increase in depth over the floodplain. A variable-inclined interface is proposed for which apparent shear force is calculated as zero. Equations are presented giving proportion of discharge carried by the main channel and floodplain. The equations agreed well with experimental and river discharge data.

Patra and Kar (2004) reported the test results concerning the velocity distribution of compound meandering river sections composed of a rectangular main channel and one or two floodplains disposed off to its sides. They used dimensionless channel parameters to form equations representing the percentage of flow carried by floodplains and main channel sub sections.

Shiono, Romaih &Knight (2004) carried out discharge measurements for over bank flow in a two-stage meandering channel with various bed slopes, sinuosities, and water depths. The effect of bed slope and sinuosity on discharge was found to be significant. A simple design equation for the conveyance capacity based on dimensional analysis is proposed. This equation may be used to estimate the stage-discharge curve in a meandering channel with over bank flow. Predictions of discharge using existing methods and the proposed method are compared and tested against the new measured discharge data and other available over bank data. The strengths and weaknesses of the various methods are discussed.

CHAPTER 3

EXPERIMENTAL SET-UP

3.1 EXPERIMENTAL SETUP

The experiments concerning the flow in meander channel- floodplain were conducted at the Fluid Mechanics and Hydraulics Engineering Laboratory of the Civil Engineering, National Institute of Technology, Rourkela, India. The compound meandering consisting of a meandering main channel with equal flood plains on both sides is fabricated (Figs. 3.1). A photo graphs of the experimental channel with measuring equipments taken from the up stream side end is shown in (photo 3.1).A photo graphs of the same channel with measuring equipments taken from the down stream side end is shown in photo (3.2). The channel surfaces formed out of Perspex sheets represents smooth boundary (Figs. 3.2). The channels are placed inside a rectangular masonry flume. The masonry flume has the overall dimension of 13 m long and 0.90 m wide. To facilitate fabrication, the whole channel length has been made in blocks of 1.20 m length. Meandering compound channel configurations were molded out of 50-mm-thick Perspex, which were cut to the dimensions of the appropriate configuration. These were then glued and sealed to the base of the flume. The model thus fabricated has a wavelength L = 40cm, double amplitude 2A'= 32.3cm,the trapezoidal main channel has10cm as the base width and 28cm as the top width and flood plain width B =46cm.The centerline of the meandering channel is taken as sinusoidal having sinuosity = 0.9

All measurements were carried out under uniform flow conditions by setting the water surface slope, using the downstream tailgate, parallel to the valley slope for straight channel and parallel to the valley bed slope at each meander wavelength. Points 2 m from both the inlet and outlet of the flume were eliminated from this slope estimation. The flume is adequately supported on suitable masonry at its bottom. The geometrical parameters of the experimental channels are given in Table-1.

A schematic diagram of the experimental setup for the channels is shown in Fig. 3.3. A re circulating water supply was present. A pumps pumped water from underground sump to an overhead tank. Water is supplied to the experimental channel from that overhead tank**.** A glass tube indicator with a scale arrangement in the overhead tank enables to draw water with constant flow head. The stilling tank located at the upstream of the channel has a baffle wall to reduce turbulence of the incoming water. An arrangement for the smooth transition of water from the stilling tank to the experimental channel is made. At the end of the experimental channel, water is allowed to flow over a tailgate and into a sump. From the sump water is pumped back to the overhead tank, thus setting a complete re-circulating system of water supply for the experimental channel. The tailgate helps to establish uniform flow in the channel. When the deviation of the pseudo water surface slope from the bed slope became less than 2%, it was accepted as attaining the quasi-uniform flow condition. It should be noted that the establishment of a flow that has its water surface parallel to the valley slope (where the energy losses are equal to potential energy input) may become a standard whereby the conveyance capacity of a meandering channel configuration can be assessed. The water surface slope measurement was carried out using a pointer gauge, operated manually, and reading to the nearest 0.1 mm at the center of the crossover sections. A hand-operated tailgate weir was constructed at the downstream end of the channel to regulate and maintain the desired depth of flow in the flume. From the stilling tank water is led to the experimental channel through a baffle wall and a transition zone helped to reduce turbulence of the flowing water. Water from the channel is collected in a masonry volumetric tank from where it is allowed to flow back to the underground sump. An adjustable tail gate at the downstream end of the flume helps to achieve uniform flow over the central test region. Point velocities were measured with 16-MHz Micro ADV (Acoustic Doppler Velocity meter) at different location across the channel section are made. Three types of ADV were used to measure the point velocities. They are up looking probe, down looking probe and side looking probe.

The discharge is measured by the time rise method. The water flowing out of the exit end of the experimental channel is diverted to a rectangular measuring tank of 198.5 cm long and 190 cm wide for meandering compound channel. The change in the depth of water with time is measured by a glass tube indicator system with a scale of accuracy 0.01cm. A traveling steel bridge spans the width of the composite channel and can be moved along the length of the channel on guide rails provided at the top of the flume. The bridges either supports either of a point gauge or the micro-ADV which can be moved in the transverse as well as in the longitudinal direction. As the down looking probe ADV is unable to read the upper layer(up to 5cm from free surface),the up looking probe is unable to read the down layer(up to 5cm from the base) and the side looking probe is unable to read the side surface(up to 5cm from the side of the channel) so a micro -pitot tube of (4mm external diameter) with a flow direction finder arrangements are used to measure some point velocity and its direction with in that locations of the flow-grid points.

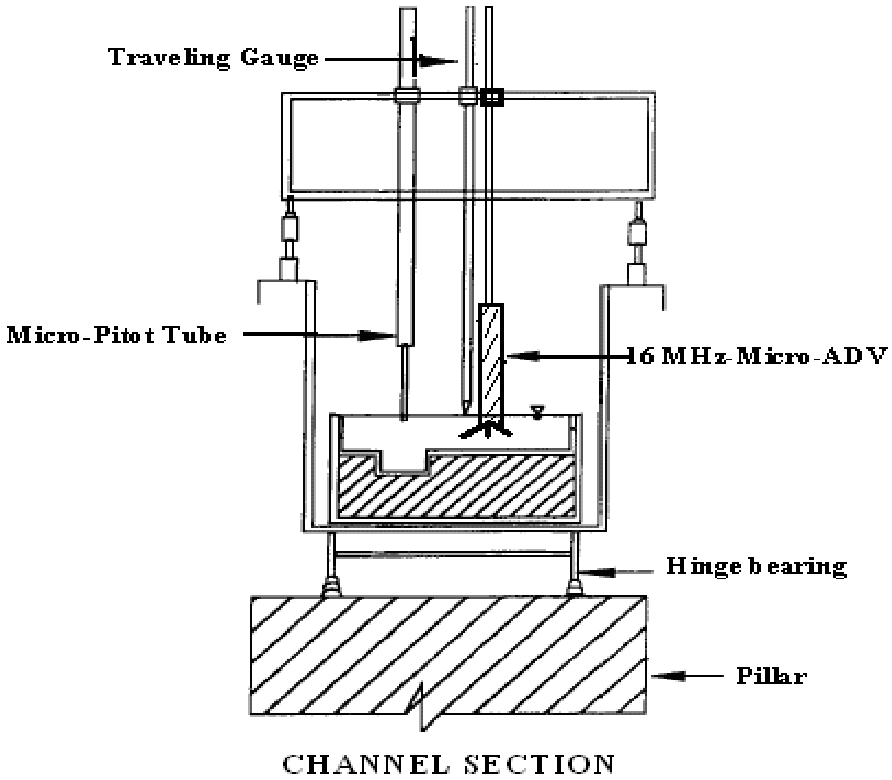

Fig 3.1. Channel section shown along with ADV positioning operation

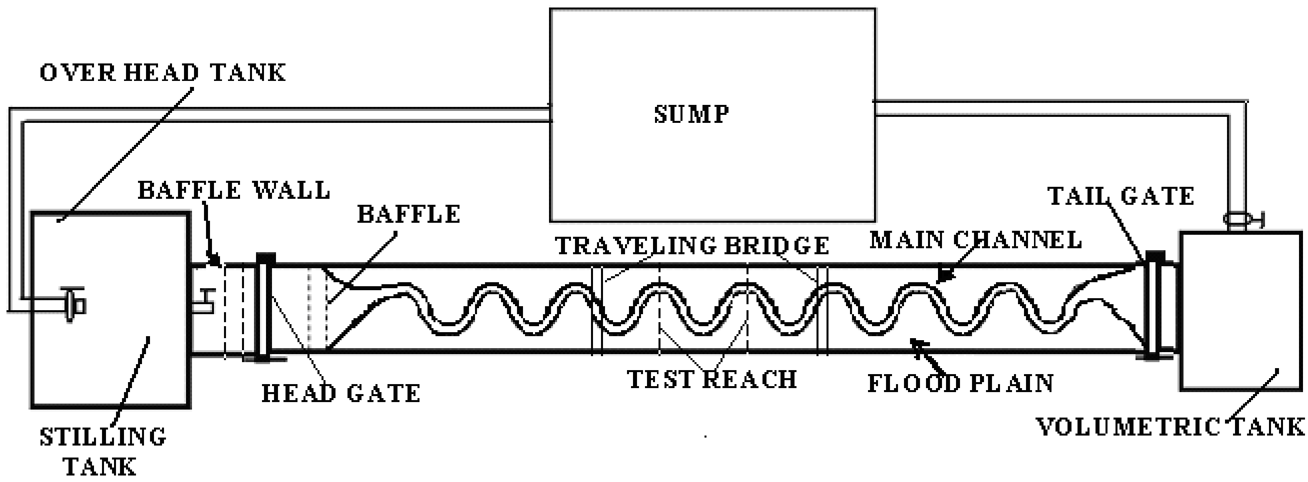

Fig3.2 Experimental set up with plan form of the meandering channel with floodplain

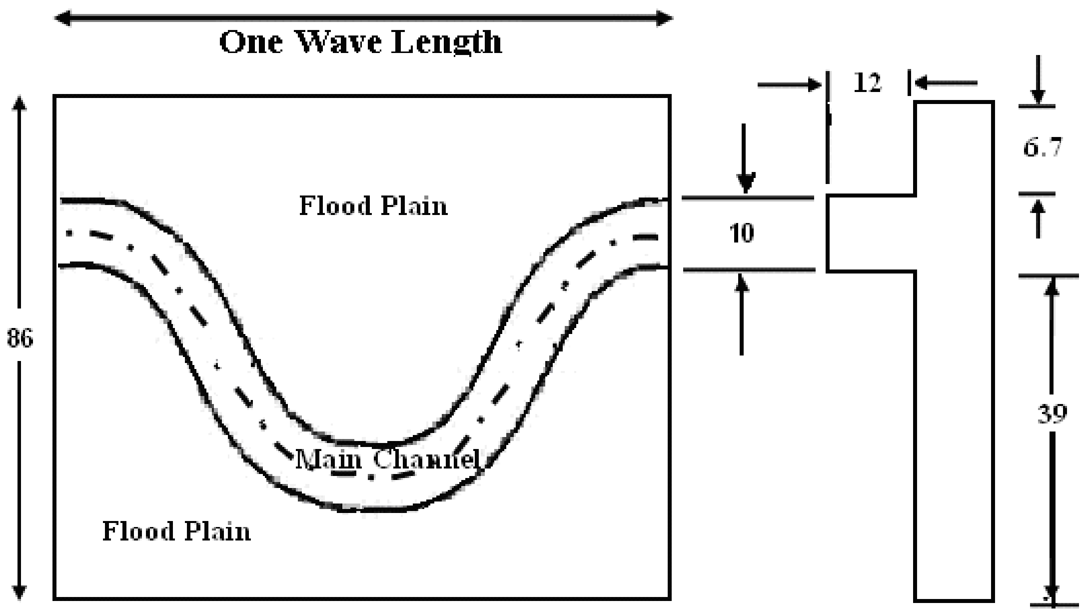

Fig.3.3 One wave length of meandering compound channel

3.3 EXPERIMENTAL PROCEDURE

3.3.1 Determination of Channel Slope

By blocking the tail end, the impounded water in the channel is allowed to remain standstill. The levels of channel bed and water surface are recorded at a distance of one wavelength along its centerline. The mean slope for each type of channel is obtained by dividing the level difference between these two points by the length of meander wave along the centerline. The valley slope for meandering compound channels is equal to 0.0054.

3.3.2 Measurement of Discharge and water surface elevation

A point gauge with a least count of 0.01cm was used to measure the water surface elevation above the bed of main channel or flood plain. As mentioned before, a measuring tank located at the end of test channel receives water flowing through the channels Depending on the flow rate the time of collection of water in the measuring tank varies between 50 to 240 seconds, lower one for higher discharge. The change in the mean water level in the tank for the time interval is recorded. From the knowledge of the volume of water collected in the measuring tank and the corresponding time of collection, the discharge flowing in the experimental channel is obtained.

3.3.3 Measurement of Velocity and its Direction

16-MHz Micro ADV (Acoustic Doppler Velocity meter) from the original Son-Tek, San Diego, Canada, is the most significant breakthrough in 3-axis (3D) Velocity meter technology. The higher acoustical frequency of 16 MHz makes the Micro-ADV the optimal instrument for laboratory study. After setup of the Micro ADV with the software package it is used for taking high-quality three dimensional Velocity data at different points of the flow area are received to the ADV-processor. Computer shows the raw data after compiling the software package of the processor. At every point the instrument is recording a number of velocity data for a minute. With the statistical analysis using the installed software, the mean value of the point velocities (three dimensional) were recorded for each flow depths. The Micro -ADV uses the Doppler shift principle to measure the velocity of small particles, assuming to be moving at velocities similar to the fluid. Velocity is resolved into three orthogonal components(Tangential, radial and vertical), and measured in a volume 5 cm below the sensor head, minimizing interference of the flow field, and allowing measurements to be made close to the bed.

The Micro ADV has the Features like

- Three-axis velocity measurement
- High sampling rates -- up to 50 Hz
- Small sampling volume -- less than 0.1 cm^3
- Small optimal scatterer -- excellent for low flows
- High accuracy: 1% of measured range
- Large velocity range: 1 mm/s to 2.5 m/s
- Excellent low-flow performance
- No recalibration needed
- Comprehensive software

As the down looking ADV is unable to read the upper layer velocity i.e. up to 5cm from free surface,the side looking probe is unable read 5cm from the side surface and the up looking probe is unable to read 5cm from the base of the flume, so A standard Prandtl type micro-pitot tube in conjunction with a water manometer of accuracy of 0.012 cm is also used for the measurement of point velocity readings at some specified location for the upper 5cm region from free surface across the channel. The results have been discussed in the next chapter.

3.3.4 Measurement of Boundary Shear Stress

Information regarding the nature of boundary shear stress distribution in flowing simple and compound channels is needed to solve a variety of river hydraulics and engineering problems such as to give a basic understanding of the resistance relationship, to understand the mechanism of sediment transport and to design stable channels etc. The most commonly used methods for boundary shear are based on the measurement of the near-wall velocity variation or wall or near-wall pressure differences

It is well established that for a regular prismatic channel under uniform flow conditions the sum of retarding boundary shear forces acting on the wetted perimeter must be equal to the resolved weight force along the direction of flow. Assuming the shear stress t(τ_0), o be constant over the entire boundary of the channel (τ_0), is given as.

$$\tau_0 = \rho g R S \qquad (1)$$

Where g = gravitational acceleration, ρ= density of flowing fluid, S = slope of the energy line, R= hydraulic radius of the channel cross section (A/P), A= area of channel cross section, P= wetted perimeter of the channel section.

The local shear velocity $u_* = (\tau_0 /\rho)^{0.5}$ is used as the velocity scale in the study of velocity distribution close to the walls in open channels. From the mixing length theory, the shear stress for the turbulent flow is given by

$$\tau_0 = \rho k^2 h \left(\frac{du}{dh} \right)^2 \qquad (2)$$

In which u= the velocity at location h from the wall, k= Von Karmans constant which has a value of approximately 0.40 for most of the flows. The shear stress (τ_0), close to the boundary can be assumed to be equal to that at the boundary (τ_0), as is indeed shown to be reasonably true by measurements. Substituting $u_* = (\tau_0 /\rho)^{0.5}$ in equation**(1)** integrating and taking u= 0 at h= h' (that is h' is the distance from the channel bottom at which logarithmic law indicates zero velocity) the equation results.

$$\frac{u}{u_*} = \frac{1}{k} \ln\left(\frac{h}{h'} \right) = \frac{2.3}{k} \log\left(\frac{h}{h'} \right) = 5.75 \log\left(\frac{h}{h'} \right) \qquad (3)$$

The equation is called Prandtl-Karman law of velocity distribution and is generally found applicable over the entire depth of flow.

In a curved channel, there is variation of the retarding shear force in the longitudinal and transverse direction and the variation is dependent on the location at the bend and the radius of curvature. For meander flood plain geometry, there is almost reversal of of the flow process from first wave length to the next half. Therefore, it is quite sufficient to know the parameters for half of the wave length of the meander path. Shear stress measurement carried out in the experimental channels helps to derive information's on the possible erosion and depositional patterns in the natural alluvial channels.

3.3.5 SMOOTH AND ROUGH BOUNDARY

Very close to the wall the viscous layer completely dominates the velocities. A boundary is designated as hydraulically smooth when $k_s/\delta' \leq 0.25$, where k_s= the equivalent sand grain roughness of the surface, δ'= the thickness of laminar sub-layer defined as $\delta'=11.6\nu/u_*$,ν= the kinematics viscosity. In this case the roughness projections are well covered by the laminar sub layer **(Fig.3.5a),** there by preventing the turbulent eddies from coming in contact with the roughness projections. The laminar sub-layer acts as a cushion and neither the absolute nor the relative height has any influence on the velocity distribution or resistance in such flows. Hydraulically rough surface **(Fig. 3.5b)** is obtained when $k_s/\delta' \geq 0.60$. In this case the roughness projections are much larger than the computed thickness of laminar sub-layer. The laminar sub-layer is destroyed and the turbulent eddies are in direct contact with roughness projections. The relative roughness is the governing parameter on the velocity distribution and resistance in such flows. The roughness projections at the values of k_s/δ' between 0.25 and 0.60 may come in contact with turbulent eddies and ta the same time the laminar sub-layer is not also completely destroyed. Such a boundary is also known as boundary in transition.

Nikurade's experiment has enabled the evaluation h' for different types of boundaries. For smooth bondary h'= $\delta'/107$, where as for rough boundary h'=$k_s/30$. Combining with the equation **(3.59)** for smooth boundary Results.

$$\frac{u}{u_*} = 5.75 \log\left(\frac{hu_*}{\nu}\right) + 5.5 \qquad (5)$$

and for rough boundary Results.

$$\frac{u}{u_*} = 5.75\log\left(\frac{30h}{k_s}\right) = 5.75\log\left(\frac{h}{k_s}\right) + 8.5 \quad (6)$$

Apart from this, flow in meandering channel is subjected to transverse pressure gradient. The combined effect of curvature ridden redistribution of velocity in the meandering channel, roughness on bed and walls, pressure variation and fluid viscosity gives rise to variation in shear stress distribution at the channel beds and walls, two indirect methods of estimation of boundary shear stress are generally used in open channel experiments. These methods are discussed in the following sections.

3.3.6 VELOCITY PROFILE METHOD

One indirect method uses the graphical plotting of velocity distribution based on the work of Karman and Prandtl. From the closely spaced velocity distribution obsercved at the vicinity of the channel bed and the wall and taking $u_* = (\tau/\rho)^{0.5}$, in equation **(3.59)** the relation between the boundary shear stress (τ_0) and the slope of the logarithmic velocity distribution close to the wall is written as

$$\sqrt{\frac{\tau_0}{\rho}} = u_* = \frac{1}{5.75}\frac{u_2 - u_1}{\log_{10}(h_2/h_1)} = \frac{M}{5.75} \quad (6)$$

In which u_1 and u_2 are the time averaged velocities measured at h_1 and h_2 heights respectively. Using **equation (1)**, the local shear stress at the boundary is determined. The vertical distribution of longitudinal local shear velocity is governed by the boundary shear turbulence. The distance from the boundary where the universal log- velocity distribution of Karman-Prandtl attains its maximum value can be treated as the distance affected by the boundary.Using the Micro-ADV, velocities data at different points of each flow depth has been collected and the more reliable boundary shear has been evaluated and discussed in the next chapter.

3.3.7 PRESTON TUBE METHOD

Based on the assumption of an inner law relating the local shear to the velocity distribution near the wall, Preston (1954) developed a simple technique for measuring local shear in a turbulent boundary layer using a pitot tube.The tube is placed in contact with the surface. The method is based on the assumption of an inner law (law of the wall) which relates the boundary shear stress to the velocity distribution near the wall. Assessment of the near wall velocity distribution is empirically inferred from the differential pressure (ΔP) between total and static and static pressure at the wall. The main difficulty of this method is obtaining the most appropriate calibration equation or curve for the given tube diameter. Preston suggested a non-dimensional relationship between ΔP and τ_0 as

$$\frac{\Delta P}{\rho}\frac{d^2}{v^2} = F\left[\frac{d^2\tau_0}{\rho v^2}\right] \qquad (7)$$

Where F needs to be determined. Preston proposed the following calibration equation

$$y' = 0.875x' - 1.396 \qquad (8)$$

for $4.1 \leq x' \leq 6.5$, where $x' \equiv \log10\left((\Delta P d^2)/4\rho v^2)\right)\ )$ and $y' \equiv \log10((\tau_0 d^2)/4\rho v^2))$.

Patel (1965) proposed a relationship for F in <u>equation **(7)**</u> valid in three ranges (y' between 1.5 -3.5).

(i) $y' = 0.5x' + 0.037$ for $y' \leq 1.5$ and $u_* d/2\nu < 5.6$

(ii) $y' = 0.8287x' - 1.3$ for $1.5 < y' \leq 3.5$, and $5.6 < u_* d/2\nu < 55$

(iii) $y' = 0.5x' + 0.037$ for $3.5 < y' \leq 5.3$ and $55 < u_* d/2\nu < 800$

A Preston tube method requires calibration curve or equation and using the above approaches the boundary shear stress is than evaluated

CHAPTER 4

OBSERVATIONS

<u>FCF DATA:</u>Series-1

TABLE- 4.1: Discharge of water = 15.899 ((m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
66	3	0.12163	23	3	1.011473
64	3	0.557881	22	3	1.102168
62	3	0.62807	21	3	1.135681
60	3	0.675526	20	2.5	1.231766
58	3	0.657012	19	2	1.470691
56	3	0.699313	17.999	1.5	1.397221
54	3	0.71607	17	1	1.449364
52	3	0.711265	16	0.5	1.490376
50	3	0.718882	15	0	1.482643
48	3	0.722163	14	0	1.526233
46	3	0.729897	12.999	0	1.650558
44	3	0.696853	11.999	0	1.661924
42	3	0.687244	11	0	1.650558
40	3	0.740091	10	0	1.646691
38	3	0.7115	7.999	0	1.716411
36	3	0.742317	6	0	1.677391
34	3	0.760949	4	0	1.748401
32	3	0.8186	2	0	1.744299
30	3	0.819772	0	0	1.805583
28	3	0.875196			
26	3	0.945151			
25	3	0.958744			
24	3	1.001748			

TABLE- 4.2: Discharge of water = 16.52(m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m^2)	X(cm)	Y(cm)	Tb/To(N/m^2)
100	3.306	26	26	3	0.5618
100	3	25	25	3	0.5718
98	3	24	24	3	0.5513
96	3	23	23	3	0.5566
94	3	22	22	3	0.6669
92	3	21	21	3	0.8848
90	3	20	20	3	0.9977
88	3	18.998	18.998	3	1.1684
86	3	18	18	3	1.4546
84	3	17.118	17.118	2.12	2.0558
82	3	16.42	16.42	1.42	2.5232
80	3	15.698	15.698	0.7	2.8724
76	3	15	15	0	2.2134
72	3	13.98	13.98	0	2.6624
68	3	13	13	0	2.6755
64	3	11.998	11.998	0	2.8278
60	3	11	11	0	2.6335
56	3	10	10	0	2.6597
52	3	8	8	0	3.2505
48	3	6	6	0	3.4264
44	3	3.998	3.998	0	3.4895
40	3	1.98	1.98	0	3.4842
38	3	0	0	0	3.5735
36	3				
34	3				
32	3				
30	3				

TABLE- 4.3: Discharge of water = 17.56 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
100	3.5126	0.6401	30	3	0.7479
100	3	0.3678	28	3	0.7418
98	3	0.6401	26	3	0.7661
96	3	0.6259	25	3	0.7905
94	3	0.6442	24	3	0.8271
92	3	0.6218	23	3	0.8291
90	3	0.6503	22	3	0.9226
88	3	0.6564	21	3	1.064
86	3	0.6544	20	3	1.064
84	3	0.6686	18.998	3	1.134
82	3	0.6218	18	3	1.5282
80	3	0.6279	17.118	2.12	1.7579
76	3	0.5954	16.42	1.42	1.7884
72	3	0.5914	15.698	0.7	2.2132
68	3	0.6503	15	0	1.7559
64	3	0.6361	13.98	0	2.0689
60	3	0.6239	13	0	2.3189
56	3	0.6076	11.998	0	2.3676
52	3	0.6137	11	0	2.2965
48	3	0.6645	10	0	2.2721
44	3	0.6625	8	0	2.6237
40	3	0.6422	6	0	2.8371
38	3	0.6381	3.998	0	2.77
36	3	0.6625	1.98	0	2.88389
34	3	0.693	0	0	2.8432
32	3	0.7174			

TABLE- 4.4: Discharge of water = 18.65 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
100	3.732	0.6823	30	3	0.8316
100	3.4	0.5247	28	3	0.8299
98	3	0.4208	26	3	0.8064
96	3	0.6823	25	3	0.8265
94	3	0.7343	24	3	0.8735
92	3	0.7192	23	3	0.8601
90	3	0.7326	22	3	0.9053
88	3	0.7293	21	3	0.93322
86	3	0.7611	20	3	1.016
84	3	0.7544	18.998	3	1.0948
82	3	0.7628	18	3	1.4972
80	3	0.7175	17.118	2.12	1.4318
76	3	0.7092	16.42	1.42	1.6447
72	3	0.6924	15.698	0.7	1.8124
68	3	0.6824	15	0	1.5575
64	3	0.7494	13.98	0	1.9096
60	3	0.741	13	0	1.9163
56	3	0.7142	11.998	0	2.1075
52	3	0.7092	11	0	2.0879
48	3	0.6907	10	0	2.0689
44	3	0.7393	8	0	2.8524
40	3	0.7695	6	0	2.3774
38	3	0.736	3.998	0	2.2382
36	3	0.746	1.98	0	2.3321
34	3	0.7511	0	0	
32	3	0.7863			

TABLE- 4.5: Discharge of water = 19.88 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)

100	3.976	0.7617	30	3	0.9029
100	3	0.4151	28	3	0.8903
98	3	0.7617	26	3	0.86377
96	3	0.8022	25	3	0.8651
94	3	0.8064	24	3	0.8959
92	3	0.8148	23	3	0.8609
90	3	0.8246	22	3	0.9252
88	3	0.847	21	3	0.9322
86	3	0.819	20	3	0.9937
84	3	0.8176	18.998	3	1.048
82	3	0.798	18	3	1.14
80	3	0.8162	17.118	2.12	1.2215
76	3	0.7813	16.42	1.42	1.4885
72	3	0.7785	15.698	0.7	1.4843
68	3	0.8036	15	0	1.434
64	3	0.8232	13.98	0	1.6353
60	3	0.8148	13	0	1.7569
56	3	0.7715	11.998	0	1.8337
52	3	0.7715	11	0	1.8575
48	3	0.8274	10	0	1.9707
44	3	0.8092	8	0	1.9148
40	3	0.7952	6	0	1.9637
38	3	0.7966	3.998	0	1.9511
36	3	0.8232	1.98	0	2.0126
34	3	0.8525	0	0	2.2307
32	3	0.8623			

TABLE- 4.6: Discharge of water = 21.41 (m^3/ sec)

X(cm)	Y(cm)	Tb/TO(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
100	3	0.27896	30	3	0.97936
98	3	0.75455	28	3	0.99406
96	3	0.7561	26	3	0.99712
94	3	0.8606	25	3	0.96796
92	3	0.91247	24	3	0.997617
90	3	0.90683	23	3	1.02885
88	3	0.90842	22	3	1.05997
86	3	0.89115	21	3	1.05997
84	3	0.91198	20	3	1.06132
82	3	0.87865	18.998	3	1.0407
80	3	0.87682	18	3	1.11853
76	3	0.86995	17.118	2.12	1.0336
72	3	0.86187	16.42	1.42	1.24754
68	3	0.87951	15.698	0.7	1.27376
64	3	0.89311	15	0	1.17942
60	3	0.88968	13.98	0	1.41452
56	3	0.81825	13	0	1.57269
52	3	0.81678	11.998	0	1.5974
48	3	0.87743	11	0	1.6856
44	3	0.90022	10	0	1.69066
40	3	0.87535	8	0	1.65526
38	3	0.87522	6	0	1.7193
36	3	0.93954	3.998	0	1.72019
34	3	0.93746	1.98	0	1.7138
32	3	0.91614	0	0	1.7231

TABLE- 4.7: Discharge of water = 21.44 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
100	3	0.2767	30	3	0.94454
98	3	0.774	28	3	0.97706
96	3	0.8129	26	3	0.97172
94	3	0.8919	25	3	0.9929
92	3	0.9096	24	3	1.0281
90	3	0.8849	23	3	1.00957
88	3	0.9132	22	3	0.98103
86	3	0.9281	21	3	1.02708
84	3	0.8863	20	3	1.0118
82	3	0.9017	18.998	3	1.0241
80	3	0.8899	18	3	1.1474
76	3	0.90631	17.118	2.12	1.1356
72	3	0.88794	16.42	1.42	1.2565
68	3	0.8936	15.698	0.7	1.42065
64	3	0.87205	15	0	1.1289
60	3	0.88446	13.98	0	1.4067
56	3	0.831	13	0	1.5249
52	3	0.78715	11.998	0	1.5539
48	3	0.8754	11	0	1.66629
44	3	0.88533	10	0	1.6976
40	3	0.8597	8	0	1.6824
38	3	0.86547	6	0	1.6659
36	3	0.88265	3.998	0	1.64059
34	3	0.92157	1.98	0	1.79239
32	3	0.95099	0	0	1.66008

TABLE- 4.8: Discharge of water = 25.012 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
100	3	0.30327	30	3	1.03514
98	3	0.68009	28	3	1.09889
96	3	0.89442	26	3	1.0709
94	3	0.8985	25	3	1.10003
92	3	0.900378	24	3	1.0925
90	3	0.9678	23	3	1.13134
88	3	0.95785	22	3	1.05381
86	3	0.9828	21	3	1.11601
84	3	0.97252	20	3	1.085552
82	3	0.93021	18.998	3	1.04313
80	3	0.96054	18	3	1.1024
76	3	0.96127	17.118	2.12	0.94391
72	3	0.936087	16.42	1.42	1.05739
68	3	0.96706	15.698	0.7	1.12147
64	3	0.94236	15	0	1.0725
60	3	0.95899	13.98	0	1.24352
56	3	0.93119	13	0	1.3111
52	3	0.9514	11.998	0	1.3111
48	3	0.93796	11	0	1.36972
44	3	0.95671	10	0	1.36972
40	3	0.94277	8	0	1.38562
38	3	0.94432	6	0	1.35097
36	3	0.96918	3.998	0	1.40168
34	3	0.96299	1.98	0	1.48125
32	3	1.02364	0	0	1.31722

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TABLE- 4.9: Discharge of water = 21.335 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
63.64	3.64	0.355538	26	3	0.866982
63	3	0.379399	25	3	0.848628
62	3	0.624378	24	3	0.888684
61	3	0.588965	23	3	0.892571
60	3	0.651802	22	3	0.95638
59	3	0.683437	21	3	0.996004
58	3	0.683869	20	3	0.956488
57	3	0.673396	19	3	1.06154
56	3	0.696177	18	3	1.172423
54	3	0.711292	17.12	2.12	1.157092
52	3	0.73483	16.42	1.42	1.271106
50	3	0.74066	15.7	0.7	1.328329
48	3	0.814834	15	0	1.249081
46	3	0.769811	14	0	1.542753
44	3	0.805225	13	0	1.53919
42	3	0.766032	12	0	1.600732
40	3	0.786546	11	0	1.622973
38	3	0.771215	10	0	1.596953
36	3	0.825954	8	0	1.596953
34	3	0.828114	6	0	1.676094
32	3	0.85327	4	0	1.719065
30	3	0.882314	2	0	1.695528
28	3	0.872273	0	0	1.707296

TABLE- 4.10 Discharge of water = 24.885 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
64.42	4.42	0.372235	26	3	0.952156
63.7	3.7	0.513748	25	3	0.963172
63	3	0.489944	24	3	1.024955
62	3	0.721975	23	3	1.017867
61	3	0.734069	22	3	1.020255
60	3	0.714733	21	3	1.036818
59	3	0.715735	20	3	1.063395
58	3	0.736611	19	3	1.105842
57	3	0.754252	18	3	1.206989
56	3	0.767503	17.12	2.12	1.174095
54	3	0.775822	16.42	1.42	1.229406
52	3	0.850161	15.7	0.7	1.232256
50	3	0.80887	15	0	1.171399
48	3	0.857788	14	0	1.290341
46	3	0.865723	13	0	1.354203
44	3	0.864413	12	0	1.471297
42	3	0.897538	11	0	1.373077
40	3	0.891684	10	0	1.451037
38	3	0.88814	8	0	1.411518
36	3	0.929508	6	0	1.454426
34	3	0.960938	4	0	1.427849
32	3	0.972108	2	0	1.392182
30	3	0.983356	0	0	1.332556
28	3	0.941217			

TABLE- 4.11: Discharge of water = 15.649 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
63	3	0.2054	26	3	0.27246
62	3	0.3019	25	3	0.28635
61	3	0.2969	24	3	0.31124
60	3	0.27702	23	3	0.33197
59	3	0.26935	22	3	0.3863
58	3	0.26	21	3	0.496617
57	3	0.25774	20	3	0.53788
56	3	0.28096	19	3	0.73486
54	3	0.26354	18	3	1.150204
52	3	0.28158	17.12	2.12	1.74863
50	3	0.2965	16.42	0.7	1.97714
48	3	0.299	15.7	0	2.115444
46	3	0.30025	15	0	1.827014
44	3	0.3075	14	0	2.1363
42	3	0.30087	13	0	2.2303
40	3	0.30626	12	0	2.3837
38	3	0.2934	11	0	2.56209
36	3	0.29175	10	0	2.70433
34	3	0.31352	8	0	2.9044
32	3	0.30813	6	0	3.17005
30	3	0.32285	4	0	3.0978
28	3	0.3	2	0	3.19203
			0	0	3.10494

TABLE- 4.12: Discharge of water = 16.873 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
63.2	3.2	2.9365	26	3	0.54969
63	3	0.22078	25	3	0.54387
62	3	0.29365	24	3	0.65872
61	3	0.3438	23	3	0.70996
60	3	0.36325	22	3	0.73068
	3	0.36797	21	3	0.92457
59	3	0.36143	20	3	1.06031
58	3	0.368703	19	3	1.24458
57	3	0.35289	18	3	1.51206
56	3	0.36761	17.12	2.12	1.65089
54	3	0.382332	16.42	1.42	2.13335
52	3	0.391236	15.7	0.7	2.31253
50	3	0.39759	15	0	1.6916
48	3	0.4234	14	0	2.00924
46	3	0.398869	13	0	2.08429
44	3	0.38305	11	0	2.08429
42	3	0.385058	12	0	1.9938
40	3	0.388148	10	0	2.1382
38	3	0.4134	8	0	2.34469
36	3	0.47155	6	0	2.5296
34	3	0.45465	4	0	2.5649
32	3	0.48373	2	0	2.59455
30	3	0.522254	0	0	2.46644
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TABLE- 4.13 Discharge of water = 16.99 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
63.398	3.398	0.311	26	3	0.50413
63	3	0.1884	25	3	0.56967
62	3	0.311	24	3	0.65361
61	3	0.3685	23	3	0.64291
60	3	0.3877	22	3	0.74608
59	3	0.3854	21	3	0.80878
58	3	0.37186	20	3	0.99488
57	3	0.3675	19	3	1.0736
56	3	0.3737	18	3	1.37411
54	3	0.37571	17.12	2.12	1.50353
52	3	0.37387	16.42	1.42	1.66639
50	3	0.41868	15.7	0.7	1.75634
48	3	0.39444	15	0	1.588807
46	3	0.421196	14	0	1.87038
44	3	0.39578	13	0	1.92272
42	3	0.37738	11	0	1.9232
40	3	0.3717	12	0	1.93007
38	3	0.4242	10	0	1.968369
36	3	0.44945	8	0	2.1246
34	3	0.45748	6	0	2.3302
32	3	0.43557	4	0	2.40728
30	3	0.50797	2	0	2.4521
28	3	0.48256	0	0	2.40177

TABLE- 4.14: Discharge of water = 17.784 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
63.54	3.54	0.40827	26	3	0.64633
63	3	0.33703	25	3	0.64477
62	3	0.40824	24	3	0.736554
61	3	0.477895	23	3	0.701651
60	3	0.494879	22	3	0.819761
59	3	0.502203	21	3	0.85419
58	3	0.47558	20	3	1.01827
57	3	0.46574	19	3	1.1278
56	3	0.488179	18	3	1.41685
54	3	0.51357	17.12	2.12	1.45067
52	3	0.491296	16.42	1.42	1.70387
50	3	0.511708	15.7	0.7	1.79986
48	3	0.52168	15	0	1.52546
46	3	0.52744	14	0	1.8618
44	3	0.50625	13	0	1.90566
42	3	0.495814	12	0	1.9591
40	3	0.48786	11	0	1.8735
38	3	0.544118	10	0	2.0295
36	3	0.52931	8	0	2.20997
34	3	0.567802	6	0	2.2615
32	3	0.55253	4	0	2.2564
30	3	0.609094	2	0	2.2666
28	3	0.59631	0	0	2.3572

TABLE- 4.15 Discharge of water = 18.676 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
63.6	3.6	0.440367	26	3	0.700064
63	3	0.253618	25	3	0.749826
62	3	0.440367	24	3	0.772728
61	3	0.489281	23	3	0.809767
60	3	0.535509	22	3	0.808777
59	3	0.555442	21	3	0.877342
58	3	0.560249	20	3	1.036241
57	3	0.544274	19	3	1.126718
56	3	0.558977	18	3	1.277418
54	3	0.567176	17.12	2.12	1.341459
52	3	0.587392	16.42	1.42	1.550686
50	3	0.591633	15.7	0.7	1.597763
48	3	0.619907	15	0	1.458372
46	3	0.630934	14	0	1.671275
44	3	0.61199	13	0	1.888136
42	3	0.608597	12	0	1.870889
40	3	0.616373	11	0	1.910049
38	3	0.62019	10	0	1.896901
36	3	0.640688	8	0	1.879513
34	3	0.668538	6	0	2.023144
32	3	0.686916	4	0	2.051277
30	3	0.728479	2	0	2.094254
28	3	0.719855	0	0	2.041947

TABLE- 4.16: Discharge of water = 19.766 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
63.5	3.5	0.319159	26	3	0.738587
63	3	0.38851	25	3	0.755956
62	3	0.518095	24	3	0.762238
61	3	0.538913	23	3	0.768151
60	3	0.607154	22	3	0.772585
59	3	0.614052	21	3	0.834298
58	3	0.649405	20	3	0.963268
57	3	0.637826	19	3	1.016851
56	3	0.654579	18	3	1.236727
54	3	0.66197	17.12	2.12	1.216033
52	3	0.688576	16.42	1.42	1.365327
50	3	0.730334	15.7	0.7	1.459067
48	3	0.715799	15	0	1.401542
46	3	0.732305	14	0	1.646424
44	3	0.685374	13	0	1.627578
42	3	0.686236	12	0	1.743983
40	3	0.697322	11	0	1.780567
38	3	0.700648	10	0	1.760119
36	3	0.709024	8	0	1.805326
34	3	0.722697	6	0	1.916681
32	3	0.746471	4	0	1.947846
30	3	0.788599	2	0	1.970388
28	3	0.754478	0	0	1.890321

TABLE- 4.17 Discharge of water = 18.695 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
64.72	3.72	0.442587	26	3	0.68825
63	3	0.224831	25	3	0.642786
62	3	0.442587	24	3	0.732142
61	3	0.452806	23	3	0.718909
60	3	0.515565	22	3	0.790839
59	3	0.537053	21	3	0.764897
58	3	0.546879	20	3	0.921073
57	3	0.542293	19	3	1.007547
56	3	0.543341	18	3	1.250196
54	3	0.551858	17.12	2.12	1.303521
52	3	0.546355	16.42	1.42	1.533331
50	3	0.578979	15.7	0.7	1.500969
48	3	0.591426	15	0	1.302342
46	3	0.58933	14	0	1.69881
44	3	0.583434	13	0	1.674178
42	3	0.55985	12	0	1.791179
40	3	0.558933	11	0	1.726324
38	3	0.567187	10	0	1.795241
36	3	0.592867	8	0	1.85826
34	3	0.60348	6	0	1.888527
32	3	0.62916	4	0	1.941459
30	3	0.66637	2	0	1.959409
28	3	0.654709	0	0	1.96845

TABLE- 4.18: Discharge of water = 28.795 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
65.12	5.12	0.534546	26	3	1.016712
64.42	4.42	0.629683	25	3	1.012063
63.7	3.7	0.681933	24	3	1.072039
63	3	0.622219	23	3	1.102093
62	3	0.671588	22	3	1.067128
61	3	0.766004	21	3	1.12514
60	3	0.792915	20	3	1.102093
59	3	0.813212	19	3	1.109688
58	3	0.762468	18	3	1.107134
57	3	0.76954	17.12	2.12	1.143408
56	3	0.802081	16.42	1.42	1.256616
54	3	0.859438	15.7	0.7	1.159319
52	3	0.857474	15	0	1.05973
50	3	0.908284	14	0	1.20836
48	3	0.94017	13	0	1.282937
46	3	0.951039	12	0	1.294788
44	3	0.87142	11	0	1.285884
42	3	0.879474	10	0	1.197295
40	3	0.916664	8	0	1.285884
38	3	0.973236	6	0	1.300747
36	3	0.975462	4	0	1.285884
34	3	1.012063	2	0	1.294788
32	3	1.035634	0	0	1.202795
30	3	1.084414			
28	3	1.057307			

Series-10

TABLE- 4.19: Discharge of water = 20.033 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
66	3	0.12163	25	3	0.958744
64	3	0.557881	24	3	1.001748
62	3	0.62807	23	3	1.011473
60	3	0.675526	22	3	1.102168
58	3	0.657012	21	3	1.135681
56	3	0.699313	20	2.5	1.231766
54	3	0.71607	19	2	1.470691
52	3	0.711265	17.999	1.5	1.397221
50	3	0.718882	17	1	1.449364
48	3	0.722163	16	0.5	1.490376
46	3	0.729897	15	0	1.482643
44	3	0.696853	14	0	1.526233
42	3	0.687244	12.999	0	1.650558
40	3	0.740091	11.999	0	1.661924
38	3	0.7115	11	0	1.650558
36	3	0.742317	10	0	1.646691
34	3	0.760949	7.999	0	1.716411
32	3	0.8186	6	0	1.677391
30	3	0.819772	4	0	1.748401
28	3	0.875196	2	0	1.744299
26	3	0.945151	0	0	1.805583

TABLE- 4.20: Discharge of water = 0.522 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
66	3	0.340436	25	3	1.007963
64	3	0.690883	24	3	1.014029
62	3	0.713733	23	3	1.064685
60	3	0.745179	22	3	1.094614
58	3	0.756402	21	3	1.180153
56	3	0.788049	20	2.5	1.222619
54	3	0.804631	19	2	1.279341
52	3	0.814742	17.999	1.5	1.339299
50	3	0.778949	17	1	1.278735
48	3	0.818483	16	0.5	1.351736
46	3	0.796441	15	0	1.278128
44	3	0.773287	14	0	1.399156
42	3	0.794722	12.999	0	1.448397
40	3	0.768029	11.999	0	1.492379
38	3	0.810394	11	0	1.468517
36	3	0.831627	10	0	1.461743
34	3	0.853467	7.999	0	1.548394
32	3	0.88653	6	0	1.541215
30	3	0.917166	4	0	1.562651
28	3	0.975001	2	0	1.569931
26	3	0.985617	0	0	1.621294

TABLE- 4.21 Discharge of water = 0.522 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
66	3	0.0564	25	3	0.43475
64	3	0.189599	24	3	0.472589
62	3	0.187385	23	3	0.502579
60	3	0.18819	22	3	0.636627
58	3	0.184568	21	3	0.876343
56	3	0.190002	20	2.5	1.087278
54	3	0.202078	19	2	1.557452
52	3	0.215362	18	1.5	1.930441
50	3	0.235288	17	1	1.994214
48	3	0.265882	16	0.5	2.165699
46	3	0.231062	15	0	2.193072
44	3	0.231062	14	0	2.433795
42	3	0.225627	13	0	2.45513
40	3	0.206909	12	0	2.570661
38	3	0.21818	11	0	2.681361
36	3	0.224017	10	0	2.855865
34	3	0.263467	8	0	3.124162
32	3	0.290437	6	0	3.109871
30	3	0.288022	4	0	3.138654
28	3	0.321635	2	0	3.131407
26	3	0.360883	0	0	3.109871

TABLE- 4.22: Discharge of water = 0.2627 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
66	3	0.157057	25	3	0.707005
64	3	0.333312	24	3	0.796374
62	3	0.348538	23	3	0.769398
60	3	0.350524	22	3	0.773039
58	3	0.341256	21	3	1.077223
56	3	0.3209	20	2.5	1.231466
54	3	0.346717	19	2	1.708596
52	3	0.332484	18	1.5	1.767016
50	3	0.342414	17	1	2.013773
48	3	0.36277	16	0.5	2.169341
46	3	0.365915	15	0	2.023868
44	3	0.355489	14	0	2.211377
42	3	0.344731	13	0	2.173313
40	3	0.347214	12	0	2.212701
38	3	0.352841	11	0	2.258047
36	3	0.392064	10	0	2.284196
34	3	0.418543	8	0	2.447707
32	3	0.475309	6	0	2.453334
30	3	0.538198	4	0	2.568851
28	3	0.635841	2	0	2.628762
26	3	0.692938	0	0	2.622638

TABLE- 4.23 Discharge of water = 0.3006 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
66	3	0.146773	25	3	0.898239
64	3	0.437717	24	3	0.889515
62	3	0.463123	23	3	0.948133
60	3	0.468327	22	3	1.023432
58	3	0.445064	21	3	1.168675
56	3	0.456542	20	2.5	1.353098
54	3	0.448737	19	2	1.585731
52	3	0.446135	17.999	1.5	1.612208
50	3	0.497712	17	1	1.777041
48	3	0.490672	16	0.5	1.746584
46	3	0.480877	15	0	1.653837
44	3	0.479806	14	0	1.785765
42	3	0.459756	12.999	0	1.871165
40	3	0.468021	11.999	0	1.942333
38	3	0.468021	11	0	2.012582
36	3	0.498937	10	0	2.026203
34	3	0.55082	7.999	0	2.141754
32	3	0.593367	6	0	2.253173
30	3	0.661168	4	0	2.353879
28	3	0.773658	2	0	2.348522
26	3	0.836561	0	0	2.258377

TABLE- 4.24: Discharge of water = 0.3514 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
66	3	0.131826	25	3	0.976793
64	3	0.484605	24	3	1.019493
62	3	0.579052	23	3	1.035323
60	3	0.576791	22	3	1.04224
58	3	0.550452	21	3	1.234992
56	3	0.557236	20	2.5	1.292458
54	3	0.557502	19	2	1.344337
52	3	0.568011	18	1.5	1.470443
50	3	0.596345	17	1	1.65947
48	3	0.611643	16	0.5	1.606793
46	3	0.604193	15	0	1.517933
44	3	0.595281	14	0	1.767751
42	3	0.599538	13	0	1.767751
40	3	0.579717	12	0	1.842511
38	3	0.595946	11	0	1.868184
36	3	0.631197	10	0	1.846768
34	3	0.650619	8	0	1.933765
32	3	0.706755	6	0	1.965292
30	3	0.723383	4	0	2.00174
28	3	0.815834	2	0	2.034331
26	3	0.885938	0	0	2.006396

TABLE- 4.25: Discharge of water = 0.8071 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
66	3	0.232727	25	3	1.101735
64	3	0.78028	24	3	1.094103
62	3	0.782053	23	3	1.114455
60	3	0.810961	22	3	1.104279
58	3	0.826224	21	3	1.153615
56	3	0.832237	20	2.5	1.150994
54	3	0.873787	19	2	1.145675
52	3	0.866464	18	1.5	1.185992
50	3	0.879877	17	1	1.166951
48	3	0.957813	16	0.5	1.17782
46	3	0.923509	15	0	1.161632
44	3	0.920194	14	0	1.306402
42	3	0.902001	13	0	1.321512
40	3	0.950875	12	0	1.327601
38	3	1.044922	11	0	1.282505
36	3	0.989418	10	0	1.327601
34	3	1.061881	8	0	1.321512
32	3	1.052168	6	0	1.324518
30	3	1.066737	4	0	1.276647
28	3	1.074138	2	0	1.318428
26	3	1.094103	0	0	1.358513

TABLE- 4.26: Discharge of water = 1.0939 (m^3/ sec)

X(cm)	Y(cm)	Tb/To(N/m²)	X(cm)	Y(cm)	Tb/To(N/m²)
66	3	0.466624	25	3	1.10316
64	3	0.878299	24	3	1.115947
62	3	0.90704	23	3	1.16311
60	3	0.911281	22	3	1.16311
58	3	0.915459	21	3	1.184761
56	3	0.930336	20	2.5	1.155134
54	3	0.949834	19	2	1.100628
52	3	0.978702	18	1.5	1.160451
50	3	0.990033	17	1	1.147157
48	3	1.015419	16	0.5	1.126266
46	3	1.017761	15	0	1.100628
44	3	0.999149	14	0	1.157792
42	3	0.969712	13	0	1.215147
40	3	1.008392	12	0	1.190205
38	3	1.008392	11	0	1.209576
36	3	1.020103	10	0	1.184761
34	3	1.031878	8	0	1.190205
32	3	1.043843	6	0	1.220781
30	3	1.060808	4	0	1.234898
28	3	1.085498	2	0	1.204005
26	3	1.136648	0	0	1.184761

Calculation of error in f.c.f data

Series 01 :

SL. NO	1	2	3	4	5	6	7	8	9
DEPTH	0.28795	0.21335	0.24855	0.15649	0.1699	0.17784	0.19796	0.18695	0.18676
Q	1.1142	0.48	0.763	0.2123	0.2492	0.2821	0.3832	0.32382	0.3737
A	0.55823	0.323303	0.434183	0.144193	0.186435	0.211446	0.274824	0.240143	0.239554
ρgAS	5.618357	3.25391	4.369878	1.451245	1.876394	2.128119	2.765994	2.416938	2.411019
τ	3.148321	4.224256	1.389058	1.935824	1.816623	1.98794	2.825592	1.396557	2.351739
%τ	6.009703	3.245	3.33241	4.2851	3.18542	6.587	-2.1547	1.257	2.4587

Series 02 :

SL.NO	1	2	3	4	5	6	7	8
DEPTH	0.15899	0.16519	0.17563	0.18656	0.19881	0.21411	0.21443	0.25012
Q	0.2082	0.2337	0.2852	0.3535	0.4511	0.6001	0.6046	1.0145
A	0.1687	0.19997	0.2519	0.30655	0.3678	0.4443	0.4459	0.62435
ρgAS	1.692493	2.006211	2.525398	3.087507	3.689976	4.454285	4.470326	6.263829
τ	1.607835	1.872986	2.34715	2.90154	3.446836	4.23633	4.241446	6.07516
%τ	5.002203	6.640638	7.058224	6.023207	6.589201	4.893158	5.119982	3.012047

SERIES 8:

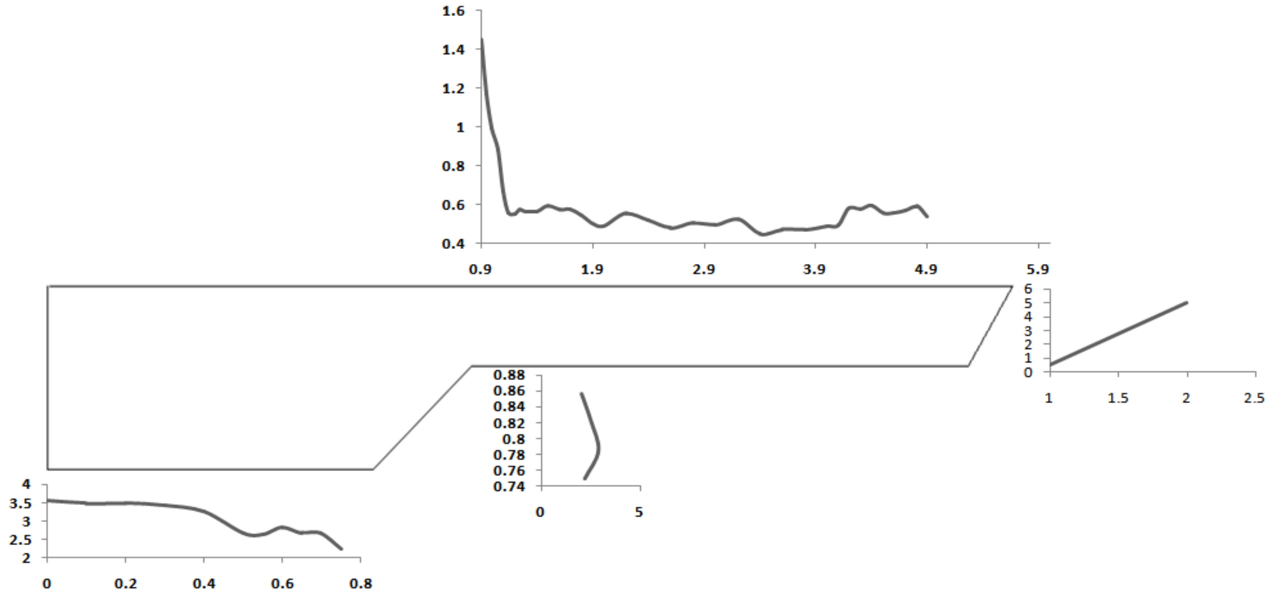
SL.NO	1	2	3	4	5	6	7	8
DEPTH	15.796	16.700000	17.653	18.757	20.008	21.483	25.022	29.973
Q	0.1858	0.2064	0.23815	0.28406	0.34398	0.42726	0.69018	1.1034
A	0.27276	0.327	0.38418	0.45042	0.52548	0.63198	0.82638	0.11233
ρgAS	2.748022	3.294482	3.870564	4.537923	5.294143	6.367116	8.325671	1.13171
τ	2.6895	3.15023	3.68756	4.0356	5.0256	6.32	8.29456	1.08564
%τ	2.129588	4.378608	4.728086	11.06945	5.072449	0.739995	0.373676	4.070843

SERIES 10:

SL.NO	1	2	3	4	5	6	7	8
DEPTH	0.15803	0.1666	0.17654	0.18701	0.20033	0.2493	0.21477	0.2729
Q	0.2368	0.2627	0.3006	0.3514	0.429	0.8071	0.522	1.0939
A	0.161499	0.18978	0.222582	0.257133	0.301089	0.46269	0.348807	0.56301
ρgAS	1.625423	1.91006	2.240199	2.587941	3.03034	4.65679	3.510603	5.66647
τ	1.604949	1.836016	2.088215	2.426676	2.872338	4.446657	3.362603	5.544199
%τ	1.2596	3.8765	6.7844	6.2314	5.214	4.5124	4.2158	2.1578

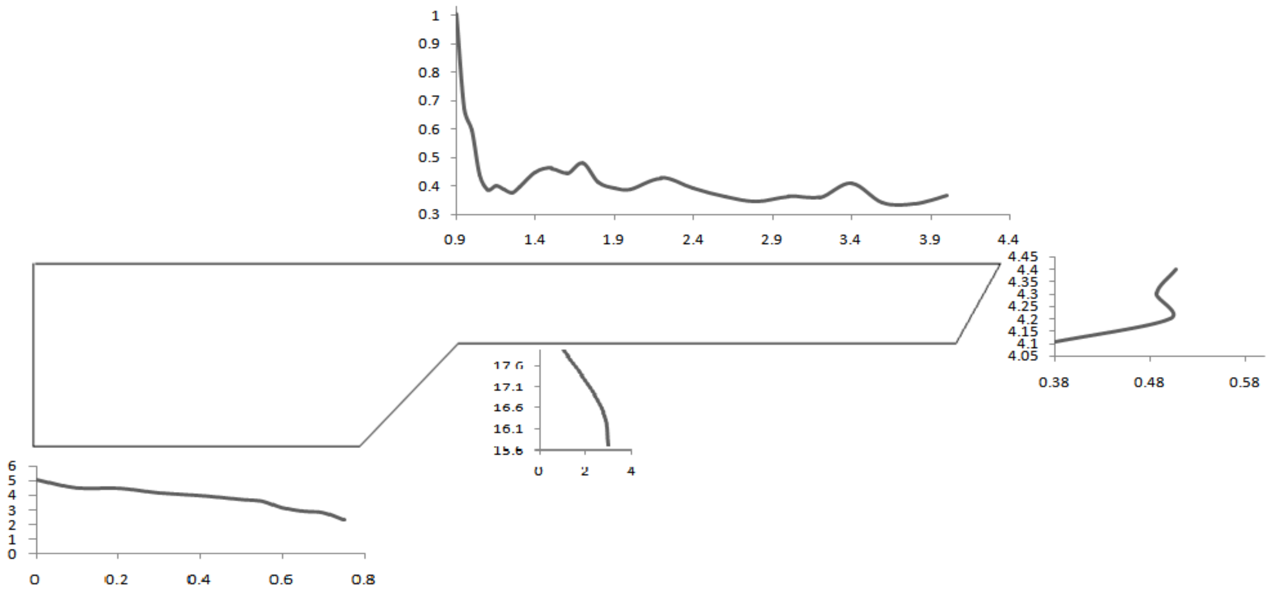
Series 01

(A) For the discharge (Q) = 0.2323 cumecs



(A)

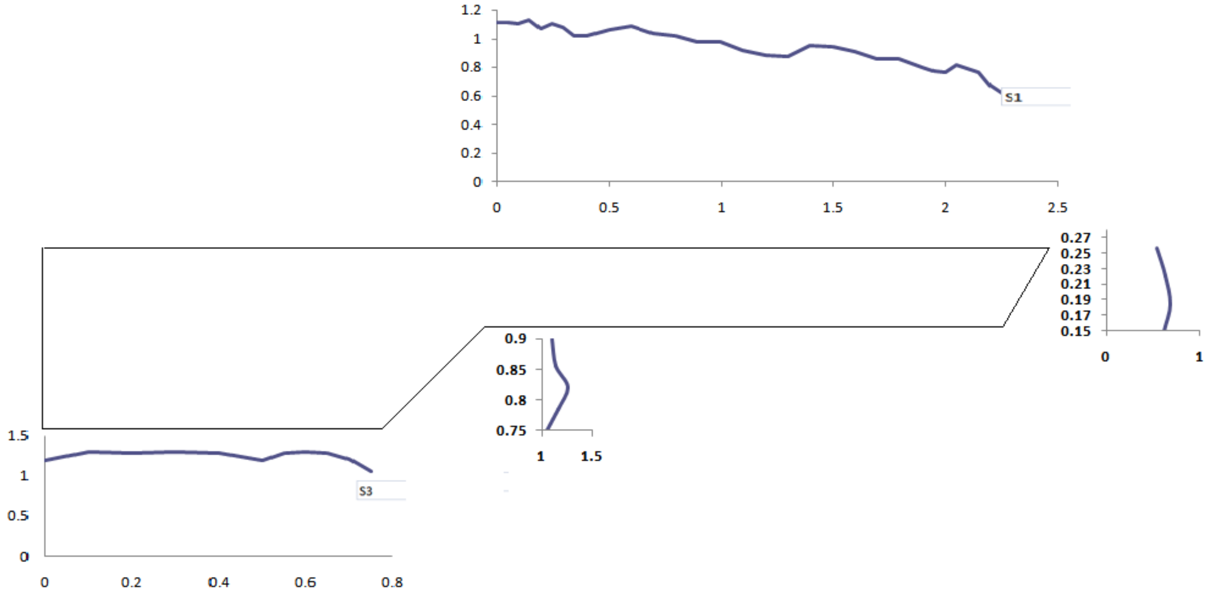
(B) For discharge (Q)= 0.20820 cumecs



(B)

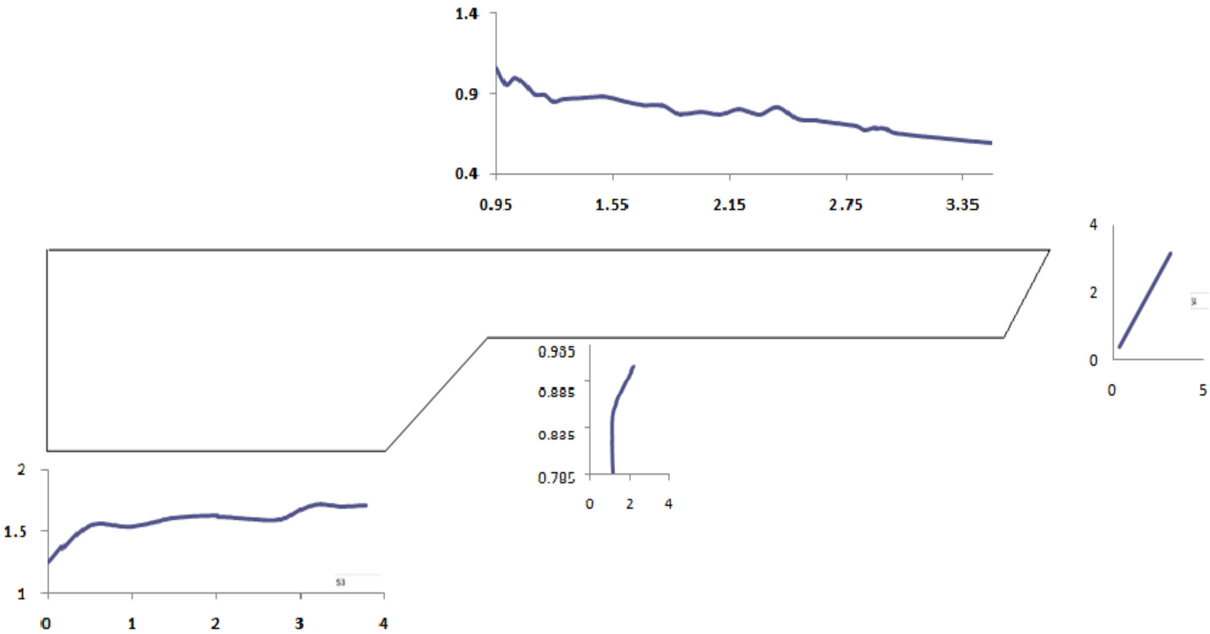
Series-02

(C) For discharge (Q) = 1.1142 cumecs



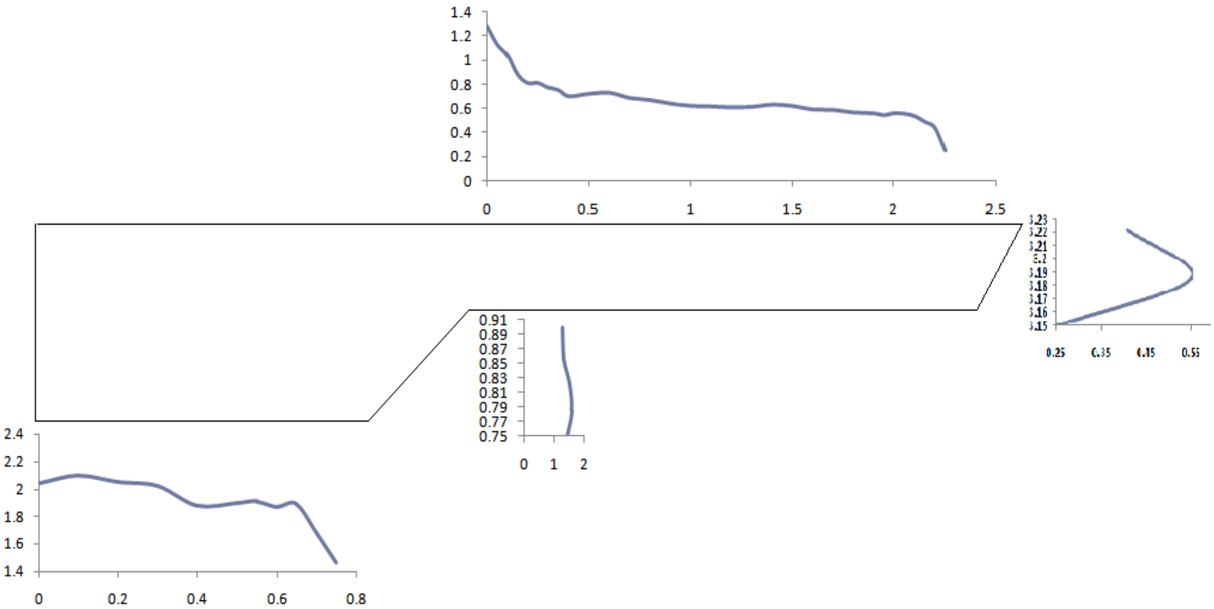
(C)

(D) For discharge (Q)=0.480 cumecs



(E)

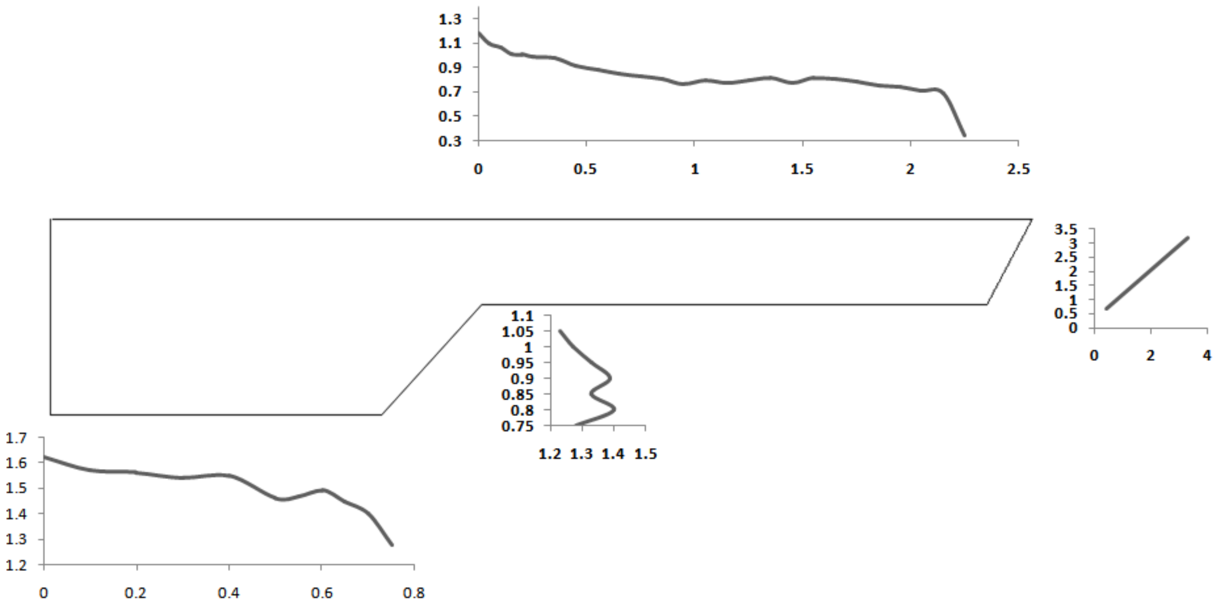
(E) For discharge (Q) = 0.763 cumecs



(F)

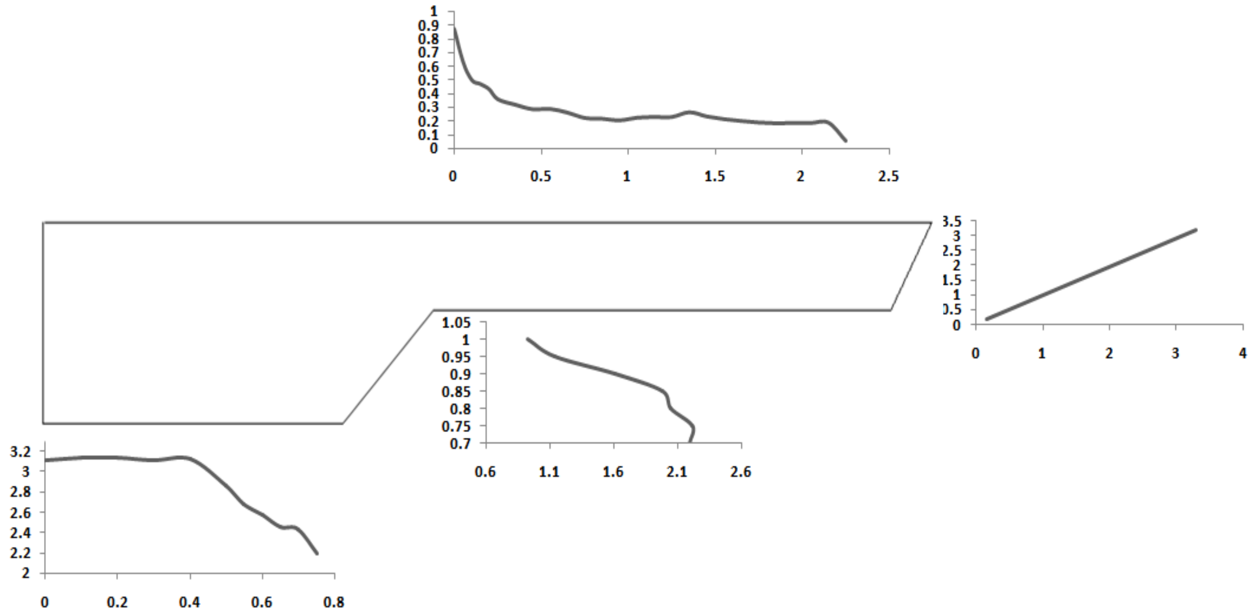
Series-10

(F) For discharge (Q) = 0.522 cumecs



(G)

(G) For discharge(Q)=0.2368 cumec



cross sections of straight compound channel with shear stress distribution (A, B, C, D, E, F, G) is shown by graphs .

4.2 Contours
4.2.1 3D Field

Using very popular software called **3DField** all the velocity contours are plotted in it. It is very user-friendly and has a wide application in engineering areas.

3DField reads:

- scattered data points (X, Y, Z) and matrix data sets.

3DField creates maps, color and BW contours, color cells, color points, Direchlet tessellations, Delauney triangles, color and monotone relief, slices and circle values.

Features of this software are:

- 5 gridding methods.
- Automatic or user-defined contour intervals and ranges.
- Control over contour label format, font, frequency and spacing.
- Automatic or user-defined color for contour lines.
- Color fill between contours, either user-specified or as an automatic spectrum of your choice.
- Base map
- Regression 2D data.
- View and zoom BMP, GIF, PNG and JPG images
- Automatically and manually digitize image
- Import and export lines.
- OpenGL view with full screen rotating.
- Convert a simple contour bitmap to a 3D view
- Output maps as EMF, WMF, BMP, JPG, PNG file formats
- Insert maps (as EMF or bitmap) in any document Microsoft Office
- Multipage scale print
- Multilingual interface

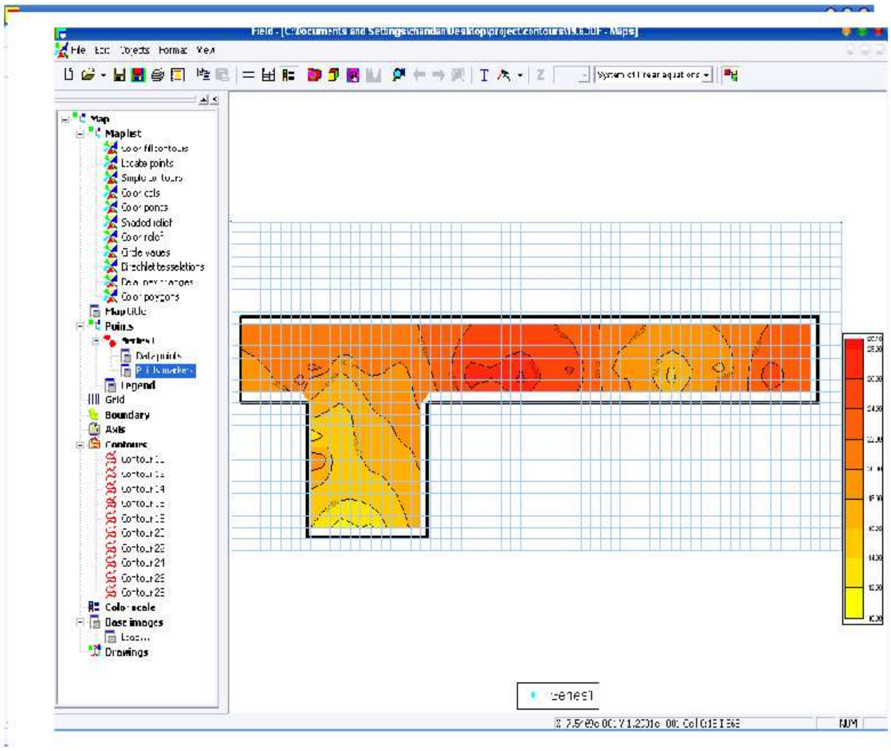


Fig 4.1 A 3DField software layout

CHAPTER 5

ANALYSIS OF EXISTING DATA

EXPERIMENTAL DATA:

Calculation of Boundary shear stress by Preston tube method.

For depth of water = 16 cm

H (m)	v	d	α	$d^2/(4\rho\nu^2)$	A_{mc}	$\rho g A_{mc} S_w$	Actual τ_{fp}	A_{fp}	$\rho g A_{fp} S_w$	τ_{fp} bed	τ_{fp} wall	τ_{mc} wall
0.16	8.77E-07	0.00477	21.4477	4222.149	0.06368	0.641372	1.107897	0.44803	4.512464	4.5065	5.771337	5.771337

Distance	channe	P	Static	Dynami	Δp'	Δp	P*	$\tau_b^*<1.5$	$1.5<\tau_b^*<3.5$	$5<\tau_b^*<$	P*1	τ_b	Average τ_b
0.02	**FPlain**	0.02	54.2	62.2	0.08	286.9	6.083227	3.078614	3.9556361	3.9388	6.0811	0.283844	
0.05	**FPlain**	0.05	54	61.8	0.078	279.7	6.072232	3.073116	3.9452593	3.9293	6.0703	0.280274	
0.08	**FPlain**	0.06	54	61.7	0.077	276.1	6.066628	3.070314	3.9399739	3.9245	6.0648	0.278471	
0.11	**FPlain**	0.09	53.9	61.6	0.077	276.1	6.066628	3.070314	3.9399739	3.9245	6.0648	0.278471	
0.14	**FPlain**	0.14	53.9	61.6	0.077	276.1	6.066628	3.070314	3.9399739	3.9245	6.0648	0.278471	3.981171
0.17	**corner**	0.15	53.9	61.5	0.076	272.5	6.060951	3.067476	3.9346216	3.9196	6.0592	0.276657	
0.2	**corner**	0.18	54.2	61.5	0.073	261.8	6.04346	3.05873	3.9181457	3.9046	6.042	0.271142	5.70432
0.24	**mc wall**	0.19	53.9	61.5	0.076	272.5	6.060951	3.067476	3.9346216	3.9196	6.0592	0.276657	
0.26	**mc wall**	0.18	54.2	61.6	0.074	265.4	6.049369	3.061685	3.9237094	3.9097	6.0478	0.272993	5.771337
0.28	**corner**	0.26	53.8	61.5	0.077	276.1	6.066628	3.070314	3.9399739	3.9245	6.0648	0.278471	
0.32	**corner**	0.18	53.7	61.7	0.08	286.9	6.083227	3.078614	3.9556361	3.9388	6.0811	0.283844	6.171263
0.35	**FPlain**	0.18	53.7	61.7	0.08	286.9	6.083227	3.078614	3.9556361	3.9388	6.0811	0.283844	
0.38	**FPlain**	0.18	**53.7**	**61.7**	**0.08**	286.9	6.083227	3.078614	3.9556361	3.9388	6.0811	0.283844	
0.41	**FPlain**	0.17	53.8	61.7	0.079	283.3	6.077765	3.075882	3.9504795	3.9341	6.0757	0.282065	
0.44	**FPlain**	0.18	53.8	61.6	0.078	279.7	6.072232	3.073116	3.9452593	3.9293	6.0703	0.280274	
0.47	**FPlain**	0.19	53.7	61.6	0.079	283.3	6.077765	3.075882	3.9504795	3.9341	6.0757	0.282065	
0.5	**FPlain**	0.18	53.9	61.6	0.077	276.1	6.066628	3.070314	3.9399739	3.9245	6.0648	0.278471	
0.53	**FPlain**	0.18	53.8	61.5	0.077	276.1	6.066628	3.070314	3.9399739	3.9245	6.0648	0.278471	
0.56	**FPlain**	0.18	53.8	61.5	0.077	276.1	6.066628	3.070314	3.9399739	3.9245	6.0648	0.278471	
0.59	**FPlain**	0.18	53.8	61.5	0.077	276.1	6.066628	3.070314	3.9399739	3.9245	6.0648	0.278471	
0.62	**FPlain**	0.18	53.8	61.5	0.077	276.1	6.066628	3.070314	3.9399739	3.9245	6.0648	0.278471	
0.65	**FPlain**	0.18	53.7	61.5	0.078	279.7	6.072232	3.073116	3.9452593	3.9293	6.0703	0.280274	
0.68	**FPlain**	0.18	53.6	61.6	0.08	286.9	6.083227	3.078614	3.9556361	3.9388	6.0811	0.283844	
0.72	**FPlain**	0.19	53.6	61.4	0.078	279.7	6.072232	3.073116	3.9452593	3.9293	6.0703	0.280274	5.031965

For water depth=20

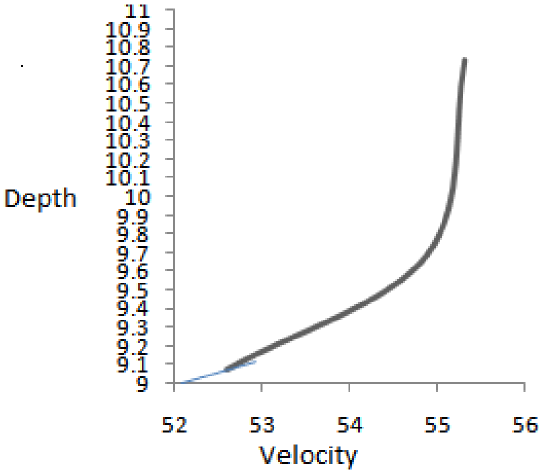
H (m)	v	α	$d^2/(4\rho v^2)$	$\rho g A_{mc} S_w$	Actual τ_{fp}	A_{fp}	$\rho g A_{fp} S_w$	τ_{fp} bed	τ_{fp} wall	τ_{mc} wall
0.2	8.77E-07	21.4477	4222.149	0.801714	1.510768	0.61095	6.153359	6.49072	5.685111	4.605107

Distance	channel section	P	Static	Dynamic	Δp'	Δp	P*	τ_b*<1.5	1.5<τ_b*<3.3	3.5<τ_b*<5.3	P*1	τ_b	Average τ_b
0.02	F.PLAIN	0.03	47.3	55.5	0.082	294.0477	6.093951281	3.0839756	3.965765	3.948013	6.091676	0.28737	
0.05	F.PLAIN	0.03	47.2	55.6	0.084	301.2196	6.104416714	3.0892084	3.975657	3.957023	6.101979	0.290854	
0.08	F.PLAIN	0.03	47.3	55.7	0.084	301.2196	6.104416714	3.0892084	3.975657	3.957023	6.101979	0.290854	
0.11	F.PLAIN	0.06	47.3	56	0.087	311.9774	6.119656681	3.0968283	3.990075	3.970153	6.116988	0.296002	0.29127
0.17	CORNER	0.03	47.4	55.4	0.08	286.8758	6.083227415	3.0786137	3.955636	3.938786	6.081124	0.283844	
0.2	CORNER	0.03	47.5	53.9	0.064	229.5006	5.986317402	3.0301587	3.864468	3.855645	5.985946	0.253878	0.268861
0.23	M C WALL	0.03	47.4	55.4	0.08	286.8758	6.083227415	3.0786137	3.955636	3.938786	6.081124	0.283844	0.268861
0.26	M C WALL	0.03	47.5	53.9	0.064	229.5006	5.986317402	3.0301587	3.864468	3.855645	5.985946	0.253878	
0.29	CORNER	0.03	47.5	53.4	0.059	211.5709	5.95098944	3.0124947	3.8314	3.825446	5.951333	0.243759	
0.32	CORNER	0.03	47.4	53.8	0.064	229.5006	5.986317402	3.0301587	3.864468	3.855645	5.985946	0.253878	0.248819
0.35	F.PLAIN	0.03	47.3	53.7	0.064	229.5006	5.986317402	3.0301587	3.864468	3.855645	5.985946	0.253878	
0.38	F.PLAIN	0.03	47.3	54.4	0.071	254.6022	6.031395777	3.0526979	3.906794	3.894264	6.030177	0.267402	
0.41	F.PLAIN	0.03	47.2	54.7	0.075	268.946	6.055198692	3.0645993	3.929201	3.914695	6.053561	0.274831	
0.44	F.PLAIN	0.03	47.3	55.2	0.079	283.2898	6.07776452	3.0758823	3.95048	3.934088	6.075749	0.282065	
0.47	F.PLAIN	0.03	47.3	55.5	0.082	294.0477	6.093951281	3.0839756	3.965765	3.948013	6.091676	0.28737	
0.5	F.PLAIN	0.03	47.4	55.6	0.082	294.0477	6.093951281	3.0839756	3.965765	3.948013	6.091676	0.28737	
0.53	F.PLAIN	0.03	47.3	55.4	0.081	290.4617	6.088622447	3.0813112	3.960731	3.943428	6.086432	0.285613	
0.56	F.PLAIN	0.03	47.4	55.3	0.079	283.2898	6.07776452	3.0758823	3.95048	3.934088	6.075749	0.282065	
0.59	F.PLAIN	0.03	47.4	55.2	0.078	279.7039	6.072232031	3.073116	3.945259	3.929331	6.070308	0.280274	
0.62	F.PLAIN	0.03	47.3	55.2	0.079	283.2898	6.07776452	3.0758823	3.95048	3.934088	6.075749	0.282065	
0.65	F.PLAIN	0.03	47.2	55	0.078	279.7039	6.072232031	3.073116	3.945259	3.929331	6.070308	0.280274	
0.68	F.PLAIN	0.04	47.3	54.6	0.073	261.7741	6.043460288	3.0587301	3.918146	3.904616	6.042027	0.271142	
0.72	F.PLAIN	0.06	47.3	54.6	0.073	261.7741	6.043460288	3.0587301	3.918146	3.904616	6.042027	0.271142	
0.78	F.PLAIN	0.06	47.3	54.5	0.072	258.1882	6.037469925	3.055735	3.912508	3.899475	6.036142	0.269278	
0.84	F.PLAIN	0.02	47.3	54.3	0.07	251.0163	6.025235468	3.0496177	3.901001	3.888981	6.024128	0.265512	
0.86	F.PLAIN	0.02	47.3	54.2	0.069	247.4303	6.018986519	3.0464933	3.895128	3.883624	6.017994	0.263609	0.275243

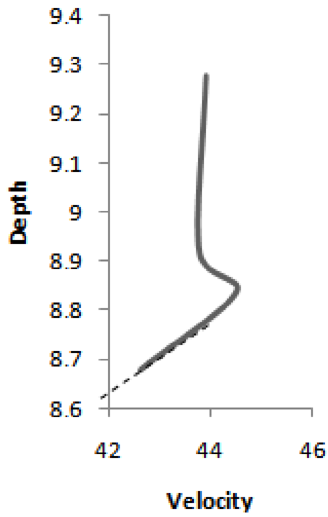
CALCULATION OF SHEAR STRESS BY VELOCITY PROFILE METHOD:

For depth of water = 16 cm

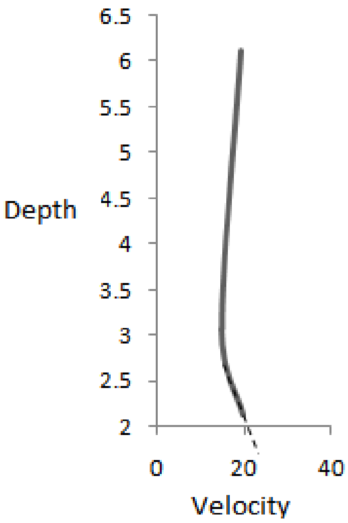
X(cm)	Y(cm)	VELOCITY(cm/s)	X(cm)	Y(cm)	VELOCITY(CM/S)
0.31	13.6	-1.23	33.5	8.83	42.236
0.31	12.5	-1.594	33.5	6.56	45.591
6	9.94	42.047	33.5	4.43	47.312
6	8.93	41.18	33.5	2.43	50.415
6	8.68	36.632	33.5	2.41	30.544
6	11.04	44.567	45.5	10.73	55.314
12.5	8.15	37.285	45.5	9.69	54.881
12.5	10.3	34.055	45.5	9.07	52.606
12.5	9.1	31.102	55.5	9.28	43.91
12.5	8.75	0.051	55.5	8.92	43.775
13	8.1	3.992	55.5	8.84	44.514
14.6	5.9	-1.23	55.5	8.68	42.617
15	5.98	-1.594	65.5	10.7	37.265
17	6	21.217	65.5	9.7	36.899
16.5	5.8	21.141	65.5	8.87	35.526
16.5	5.1	21.26	65.5	8.74	35.418
20.5	6.12	18.998	65.5	8.65	32.313
20.5	3.08	14.771	75.5	9.95	47.751
20.5	2.13	19.8	75.5	9.05	45.552
23.5	0.39	26.131	75.5	8.9	44.217
23.5	10.58	30.962	75.5	8.79	44.661
23.5	8.53	27.893	39.5	9	48.709
23.5	6.48	23.232	39.5	8.8	53.559
23.5	4.58	21.861	39.5	8.5	55.596
23.5	2.48	27.942	41.5	8.4	6.35
33.5	0.54	32.056			



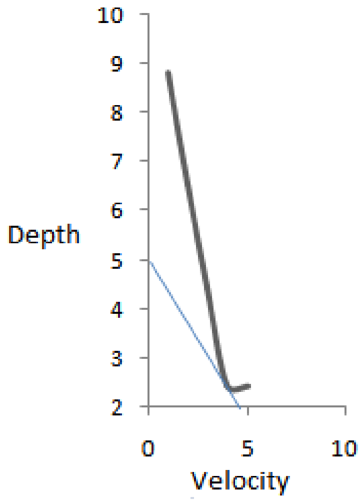
(A)



(B)



(C)



(D)

5.1 Graph plotted between velocity and depth for calculation of boundary shear stress

CHAPTER 6

CONCLUSION

CONCLUSION

A positive value indicates transfer of momentum from the main channel to the floodplain at the assumed plane indicating the floodplain flow retarding the main channel flow. This apparent shear stress is higher than the bed-shear stress at low floodplain depths and reduces gradually as b increases. For the diagonal and horizontal interface planes it is observed that the apparent shear force is positive at low depths and changes sign as depth increases indicating that at higher depths over floodplain there is transfer of momentum from the floodplain to the main channel. The velocity distribution in the channels differs as the depth of flow changes.The variation of bed shear stress with discharge is studied and it is found that bed shear stress increases with the increase in discharge.Functional relationships between shear stress at the walls and at the bed have been analysed as a function of mean shear stress In our investigation, it can be seen that the relationships vary from those of the previous investigationsIt gives a very good result for the aspect ratio ranging from 1 to 5.The following conclusions are further drawn:In over bank flow it has been observed that Main channel shear decreases and flood plain shear increases magnificently.The distribution of boundary shear along the perimeter of straight and meandering compound channels is examined and an empirical relationship to predict boundary shear distribution for the types of geometry is proposed.The variation of computed percentage of shear force of floodplain wetted perimeter with the observed value of the straight compound channels and for meandering compound channels is plotted in Fig. which shows that the present model gives less error as compared to the previous models. The model needs to be validated to more data of a and b with more sinus channel before its reliability application to field.We have fabricated different channels for its validation.

It is recommended that further investigation be focused on extending the present analysis to the compound channel of different cross sections such as trapezoidal cross sections.

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PUBLICATION IN JOURNALS/INTERNATIONAL CONFERENCES
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1. **“***Boundary shear stress distribution in compound channel flow”* The Paper is accepted for publication in the Journal of **ISH**, 2007.
2. *“Discharge Assessment in Two Stage Straight Compound Channels*” Review is complete and sent for publication in the Journal of Hydraulic Engineering, Journal of International Association of Hydraulic Research (**IAHR**) 2007.
3. “*One dimensional solution for Predicting Discharge in Two Stage Meandering Compound Channels”* Review is complete and sent for publication in the Journal of Hydraulic Engineering, American Society of Civil Engineers (**ASCE**), 2007
4. “*Energy loss in two stage meandering and straight compound channels*” Presented and Published in December.2005,**Hydro-2005,**at Tumkur, Karnataka,
5. *“Selection of Interface Plane in the Assessment of Discharge in Two Stage Meandering and Straight Compound Channels”* The Paper is published in the International Conference on Fluvial Hydraulics **(IAHR)** *September 6-8, 2006*-**(River Flow-2006),** Lisbon,
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9. *“Roughness characteristics in two stage meandering and straight compound channels” ”* The Paper is published in the Conference proceeding on CEAC-2007, 9-11, march,2007, M.M. Engineering College Mullana, Ambala
10. *“Flow simulations in two stage meandering and straight compound channels”* The Paper is published in the Conference proceeding on **CEAC-2007**, march,2007, M.M. Engineering College Mullana, Ambala

PAPERS UNDER COMMUNICATION

Sl No.	***Name of Auths. in order***	***Title of the Paper* (*Vol. No., Issue No.*)**	***Name of the Journal***
1.	Khatua K. K and Patra, K.C	*Momentum Transfer in Two Stage Compound Channels.* The Paper is submitted in to the Journal Journal of Indian Society of Hydraulics.	Journal of Indian Society of Hydraulics (ISH, Journal), India
2.	Khatua K. K and Patra, K.C	*Development of a new method for flow prediction in Two Stage Compound Channels.* The Paper is submitted Journal of Institution of Engineering(India), Civil Engineers Division	Journal of Institution of Engineering(India), Civil Engineers Division
3.	Khatua K. K and Patra, K.C	***Flow distribution in meandering compound channel flow.*** The Paper is accepted	International Conference on Water, Environment, Energy & Society (18-21 December, 2007)