EFFECTS OF VEGETATION ON OPEN CHANNEL FLOW REGIME WITH THE USE OF ANSYS

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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Submitted by

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I, Kirti Deo, Roll No. 2K19/HFE/20 of M.Tech Hydraulics and Water Resources Engineering, hereby declare that the project Dissertation titled "Effects of vegetation on open channel flow regime with the use of ANSYS" which is submitted by me to the Department of Civil Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title pr recognition.

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CERTIFICATE

I hereby certify that the Project Dissertation titled "**Effects of Vegetation on Open Channel Flow Regime with the use of ANSYS**" which is submitted by **Kirti Deo**, Roll no **2K19/HFE/20** of Hydraulics and Water Resource Engineering, Department of Civil Engineering, Delhi Technological University, Delhi in the requirement for the award of the degree of Master of Technology, is a record of the project carried out by the student under my supervision. To my best of the knowledge this work has not been submitted in part or fully for any Degree or Diploma to this University or elsewhere.

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Kirti Deo (2K19/HFE/20)

ABSTRACT

Vegetation is an important part of our ecosystem. Although they can have stabling effects such as protecting the banks but they can also affect negativity towards the flow regime of the river. As such causing or increasing the roughness of the banks which can affect flood diversion capacity of the river. Historically, hydraulic engineers considered vegetation in streams and rivers to be a source of flow resistance and thus their usual goal used to be to eliminate them so that water conveyance can be improved.

So, in this project the effects of these vegetation are studied using ANSYS. Three different velocities are used i.e., 0.4m/s, 0.3m/s and 0.2m/s. in the model to study the velocity variation in the model. The total of three sections are taken from inlet. The section taken are 1.29m from inlet, 2.79m from inlet and 4.29m from inlet.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Open channel flow is the flow in which free surface is open to the atmosphere. In open channel flow the flow regime is basically the flow pattern of the liquid. It gives the description of the flow structure.

Floodplains is an area or land adjacent to any river which experience floods during the time when there is high discharge in the river. In recent years, vegetated floodplains and wet-lands have been regarded as constituents of the ecosystem where significant transport processes take place during floods. Various types of vegetations grow on floodplains. It is seen that they significantly influence the movement of water flow and they also protect the slopes of river or stream.

Vegetation plays a vital role in environment. In the river ecosystems, since vegetation have stabilizing effect on riverbeds hence the influence of vegetation cannot be neglected. Defending dikes and protecting ecological environment are this stabilizing effect and also at the same time, because of vegetation there is an increase in the roughness of banks and change the flow regime, hence affecting the flood diversion capacity of the river.

Lodging refers to the plant bending over of the stems near ground level. It may be due to combined effects of rain, wind and stem strength, etc. Among the all vegetation growing around the river or stream Aquatic vegetation is most prone to lodging under the flow of water. It is due to many factors that induce this lodging of vegetation. Intrinsic factors such as the flexibility and structure of the aquatic vegetation, and also slope is some of the most important factors that affects the lodging of vegetation.

Vegetation in open channel can be classified into rigid vegetation and flexible vegetation. Vegetation can also be classified into natural and artificial. Natural vegetation is found naturally on the banks of the rivers or riverbed. Whereas artificial vegetations are planted along sides of the canals and rivers which served some purpose. Methods for artificial vegetation are cutting and grafting.

1.2 BACKGROUND

Historically, hydraulic engineers considered vegetation in streams and rivers to be a source of flow resistance and thus their usual goal used to be to eliminate them so that water conveyance can be improved. This is the reason why earlier research interests were primarily focused on the estimation of resistance laws, mean velocity distributions, and the determination of approximate rules for the partition of the total action of gravity between friction drag due to bed roughness and form drag due to plants. In recent years, however, plants in aquatic environments have reached a different status, and vegetation is no longer regarded merely as an obstruction to the movement of water, but rather as a means of providing stabilization of banks and channels and habitat and food for animals, as well as pleasing landscapes for recreational use (Haslam and Wolseley 1981).

The preservation of vegetation in rivers is considered of great relevance for the ecology of rivers. Vegetation in the open channels can be of advantage or a disadvantage. In recent years vegetated floodplains and wetlands have been regarded as constituents where significant transport processes take place during floods.

But on the other hand, vegetation can be disadvantageous as if it is as grass or weed on the sides of the channel or on the bed then it can act as a rigid body offering resistance to the low velocities of flow thus having loss in the efficiency of the channel although this vegetation only has low resistance to flow. But if the flow velocity is high then there would not be any much of the loss. Vegetation also affects the Manning's Coefficient if the vegetation is small then the Manning's Coefficient is also small but if the vegetation is dense and high then Manning's Coefficient is also greater.

1.3 VEGETATION AND ITS CLASSIFICATION

Vegetation can be described as the collection of plant gathering, acting as the covering for the ground or the surface. As this might naturally grow on the banks of the river, it can move to river beds as well.

Vegetation can also be classified into natural and artificial. Natural vegetation is found naturally on the banks of the rivers or riverbed. Whereas artificial vegetations are planted along sides of the canals and rivers which served some purpose. Methods for artificial vegetation are cutting and grafting.

1.4 PROS AND CONS OF VEGETATION

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1.5 ANSYS FLUENT

The software used in the thesis is ANSYS FLUENT (R19.2) which is a finite element analysis tool. It is a software commonly used by many engineering branches. ANSYS has a lot of tools that helps analyze electrical, fluid, thermal and structural specific problems. In this project ANSYS R19.2 version is used. This version has widened the CAD tools by adding not only previously added Design-Modeler but also Space Claim that gives more scope for defined boundary conditions.

Ansys provides all the required tools from a single place. Not only you can access the pre-processor, solver and pre-processing tools but you can also maintain the control of your workflow through Ansys Workbench. There are 5 steps in the ANSYS to solve a problem.

1) Geometry - Geometry is made using ANSYS Design-Modeler Software.

2) Mesh - Meshing is the most important step in this process because Simulation results depends upon the quality of meshing. High quality of Mesh gives good and accurate Simulation results and this a good chance the is convergence but a poor quality of Mesh does not give good Simulation results.

3) Setup - It gives input for solution accuracy, boundary conditions, methods to solve, material type, and properties etc.

4) Solutions

5) Results

1.6 OBJECTIVE OF STUDY

The overall objective of the work is to investigate the effect of vegetation on open channel flow regime. 3 different velocities at 3 different depths of water are taken to see how the vegetation affects the flow in the flume. Firstly, the depth of water is less than vegetation height then in second case it is as same as the vegetation height then in third case then depth of flow is more than the vegetation height. In this project the results obtained from the model are then verified using the experimental results on which the model is based on.

The objective is to verify the results obtained from the experiment which were done in a rectangular flume with rigid vegetation with the model made in Ansys Fluent.

1.7 CONCLUSION

This thesis comprises of 5 chapters where, chapter 1 contains the general introduction of the vegetation and the software used in the modelling. Chapter 2 contains the review of literature available. Chapter 3 consists of methodology and the procedure adopted while chapter 4 and chapter 5 contains Results and discussion and Summary and Conclusion respectively.

CHAPTER 2

LITERATURE REVIEW

2.1 General

This chapter provides the brief overview of the current and the previous research available related to the effects of vegetation on the open channel flow regime. This chapter concludes with the discussion of the said researches.

2.2 Literature Review

- **H. M. Nepf (2004),** This paper talks about how the canopy/vegetation affects the flow structure as well as material transport. It discusses about the mean velocity profile with both emergent and submerged canopies well as the nature of turbulence in theses canopies. It also discusses the characterization of drag coefficient Cd. It derives the conclusion that the new internal flow scales which were not present in open water gets introduced such as the stem scales d & ΔS, and canopy characteristics (La). At these scales' advection is complex often unsteady flow around individual stems and dispersion arises only from molecular and small-scale turbulent diffusion. Also, turbulent may be enhanced at these scales by production in stem wakes.
- **F. G. Carollo, et al (2002),** In this flow over flexible bottom vegetation is experimentally studied. The flow velocity is measured using velocimeter for different discharge and different vegetation concentration. It is observed how does the vegetation concentration and depth height ratio of vegetation influence the velocity profile is analysed. Experiment was carried out using a flume with sloping bed,14 m long, 0.6 m wide and 0.6 m deep turf layer is of thickness 5 cm. glass bed is of 3 different mixtures of grass. The local flow velocities were measured by a 2D, side looking probe, acoustic-doppler velocimeter (ADV). 16 runs were carried out to analyse the depth/vegetation height ratio h/kv and the stem concentration on velocity profiles.

  The velocity profiles were measured in 5 vertical of a cross section in middle and 4 different concentrations were used & 3 zones were taken. In this paper it is observed that in zone 1 the concavity of the velocity profile is turned toward bottom whereas in zone 3 it is turned towards free surface and in zone 2 there is an inflection point.

  It shows that for logarithm zone location is influenced is depth height ratio but not by stem concentration. But the stem concentration affects the velocity profile.

- **Vedrana Kutija, et al (1996),** In this a numerical model is introduced which is used for analysing the influence of the factors that contribute to resistance of flow induced by flexible vegetation. Two cases are taken: the case of rigid vegetation and the case of flexible vegetation. In case of rigid vegetation, properties such as the height, diameter and density of the vegetation is taken into account where as in case of flexible vegetation height is taken over by the effective height. It is observed that in case of flexible vegetation there is additional flow resistance is a result of more complex interactions. Also, there is the parameter p used, which is defined as the portion of the vegetation layer in which the turbulent structure is modelled by an eddy-viscosity approximation, and this plays a very important role as one of parameter used as calibration parameters when comparing.
- **N. Kouwen (1992),** In this paper it is shown that n-VR can successfully be produced by relative roughness resistance equation. The velocity is calculated using Darcy-Weisbach friction factor. Mathematical model, resistance model & parameter values derived from model tests with artificial plastic roughness in lab & field test on natural vegetation is used for producing the n-VR curves.
- **Lopez and Garcia (2001),** In this the turbulence models are used to compute the mean flow & turbulence structure in open channel which is having a non-emergent & rigid vegetation. These models are based on two equations i.e., K-E & K-W formulations. These models are further used for estimating vegetation induced flow resistance. It is observed that both model (K-E &K-W) accurately predicted value up to second order statistics also no significant difference was found between these 2 models' some threshold plant density, the flow resistance measured is close to the non-vegetated channels.
- **Lopez and Garcia (1998),** In this 2-equation turbulence model based on K-E closure scheme was used to determine mean flow and turbulence structure through simulated vegetation. It provides information to estimate suspended sediment transport processes. It was found that when comparing the two channels (vegetated & non vegetated) at similar flow rates there is a decrease in suspended sediment transport capacity of vegetated channel. It is dependent on the reduced ability of vegetation covered bed to entrain sediments into suspension from bottom channel.
- **H. M. Nepf (1999),** In this paper a model is developed to describe the drag, turbulence & diffusion for flow through emergent vegetation. It is based on that the energy transfer from kinetic energy to turbulent kinetic energy by the aquatic plants affects the vegetative drag and turbulence intensity. This model is confirmed by experimental result. This model is

confirmed by experimental result. It shows that the turbulence intensity depends upon the vegetative drag and is negligible for vegetative density ~1%. The model also predicts that due to the sparse vegetation the turbulence intensity increases but then decreasing when this density vegetation increases as it decreases the mean flow velocity.

- **Stone and Shen (2002),** The flume was used 12 m long &.4 m wide 0.61 m deep. The setup has circular cylindrical roughness which was due to wooden circular dowels used to simulate vegetation stem. It shows that the flow resistance due to vegetation depends upon the area concentration of stem, flow depth, stem diameter & length. The average CD found is 1.05 regardless size & density of stem based on the average velocity.
- **Fu-Chun Wu, et al (1999),** In this paper the variation of vegetation roughness coefficient is analysed with depth of flow. The experiment was conducted in a flume where horsehair mattress was used to stimulate a vegetation on watercourses. For submerged condition, the mean velocity increases with the flow and the roughness coefficient decreases. As the submergence starts to occur this roughness coefficient either remains constant or rise.
- **Bakry et al., (1992),** investigated an extensive field study over earthen irrigation canal infested with weeds. They calculated the manning coefficient based on 280 measurements at selected cross section in 23 canals with emergent ditch bank vegetation. The mean monthly value of the n is estimated to be 0.017-0.062 and also if dependence on flow regime such as hydraulic depth and product of hydraulic radius and average velocity is explored. The temporal mean of monthly values of vegetation density was also calculated & analysed.
- **Chiew and Tan (1992**) performed an experimental study to measure the frictional resistance of a tropical turf in the tropics. In the experiment the natural turfed slope has a gradient of 14% and consist of cow grass. To stimulate overland flow on the slope,7m long, 0.17 m wide and 0.16m high channel was constructed. In this it was o served that the flow is affected by the stems as they act as solid blocks. They generate huge turbulence by deflecting flow around them. It shows that resistance to flow is influenced by the density of turf. It also shows that the value of f decreases for increasing flow Reynold number through the glass stems.
- **Ikeda and Kanazawaz (1996),** In this the flow over flexible bottom vegetation is experimentally studied. It is seen that due to vegetation, below the top there is inflection in temporally averaged velocity profile. In this a tilting straight open channel, 15m long & 40 cm length&0.25mm diameter. An argon Doppler velocimeter (TSI system) was used. It was observed that the velocity profile induced by the presence of water plants has an

inflection near the top of the plant layer & the flow becomes unstable and rolling up to discrete vertices. The turbulence intensities are strongest near the top of the plant layer & they are transported upward from this level by ejections & downwards by sweeps.

- **Fathi-Maghadam Kouwen (1997),** In this paper, individual pine and cedar tree saplings and branches were used to model the resistance to flow in a water flume for non-submerged and nonrigid vegetation to determine how the amount of decrease in streamlining affects the drag coefficient and how it reduces the momentum absorbing area.

  In the experiment the drag force on a single tree resulting from non-submerged streamflow through cedar and pine tree models were measured. A force-balance apparatus holding a model of a tree was mounted in the floor of a flume. The experiments were conducted in a 13 m long, 600 mm wide Perspex flume, supported by a set of wedges mounted on a fixed frame. In this paper to supported results of experiment for floodplains and vegetative zones of natural waterways a dimensional analysis is also done to developed a relationship between roughness conditions such as density and flexural rigidity and flow conditions such as velocity and depth. Experimental drag force with is measured confirms that there is a strong effect of vegetation flexibility in the deflection of the foliage area and reduction of the drag coefficient as the mean velocity increases. The Manning's n value increases proportionally to the square root of flow and inversely proportional to the mean velocity for non-submerged conditions.
- **Kadlec (1990),** In this paper Robert H Kadlec talks about the emergent wetland vegetation that plays part in the resistance to flow of water. In this paper it is concluded that since stems are spaced typically only diameter apart so the fluid friction to be calculated from drag only on single object like stems and not from channel or bed equations. It is seen that complications only arises because of vertical variations of vegetation density and also from non-oriental spatial variation of soil elevations. And also, the manning's equation does not apply in this case as the flows are in transition region. Also, for the overland flow in wetlands, slopes and depths that generates velocities is not large hence the velocities generated are also not enough hence, it doesn't meet turbulence criteria. This would mean that manning's coefficient is not constant but will depend on depth and vegetation density.
- **Kothyari, et al (2009),** In this paper, the experiments were conducted for various stem densities, channel slopes and sediment sizes to study the sediment transport by channel flows when tall rigid stems are presented. The flume used was 12.0m long and 0.30m deep. Two channel widths of 0.15m and 0.20 m, respectively, were used also two types of model

tree arrangements were used. The rates of sediment transport in the presence of simulated vegetated surfaces were observed to be significantly smaller than those without the vegetation. Stainless-steel cylinders were installed on the channel bed in multiple rows over a length of about 9m. Observations of sediment transport under uniform flow on steep slopes were taken for the test duration, 1 minute for supercritical to 4 minutes for subcritical flows. The process of soil erosion in upland catchment areas is represented in this experiment also it indicates that growing tall vegetation may an effective way in controlling sediment transport.

- **Nadeesha Dharmasiri (2012),** This study proposes a new friction factor function based on the roughness density it is done by drawing analogies between skin friction and form drag. Set of governing equations are established for vegetated flow field using Modified Navier-Stokes Equations. Further a relationship between flow resistance and vegetation density is established. Using this new approach, the vegetation density at which the flow resistance would be maximum is predicted.
- **Masterman and Thome (1992),** In this the channel capacity is predicted by 2 ways, i) Variation with width/depth ratio where width is varied to simulate a comparison between channels with different with-depth ratio, ii) Variation with seasonal growth, the effect of seasonal variation growth represented by increased stiffness is simulated for trapezoidal channels with constant side-slope ratio. This method is based on theory and it can be used for predicting changes in bank vegetation may have on the discharge capacity of a channel and to make comparisons of bank vegetation effects between channels. It also shows the possibility to relate these effects of bank vegetation to the width-depth ratio of channels.
- **Kobayashi, et al (1993),** The vertically two-dimensional problem of small-amplitude waves propagating over submerged vegetation without lateral boundaries has been formulated using the continuity and linearized momentum equations for the regions above and within the vegetation. The effects of the vegetation are seen in terms of the drag force that is acting of the vegetation in flow field. An analytical solution has been obtained for the small-amplitude monochromatic wave whose height decays exponentially in the direction of wave propagation by introducing an unknown damping coefficient and linearizing the drag force. The standard simple approach based on the conservation equation of energy and linear wave theory is acceptable in predicting the decay of the local wave height for most practical applications.

- **Shields Jr., et al (2017),** "Representation of Vegetation in Two-Dimensional Hydrodynamic Models", Journal of Hydraulic Engineering, ASCE. In this flow resistance coefficients for vegetated floodplains are determined for use in two-dimensional hydrodynamic model simulations. First of all, analytical approaches are taken for finding resistance coefficients for vegetative roughness which can be subdivided into four categories based on whether the vegetation is fully submerged or emergent and whether it is rigid or flexible. And then, two-dimensional hydrodynamic models are constructed. Then the comparison is done based on the methods to Estimate the Hydraulic Roughness of Vegetation.

CHAPTER 3

METHODOLOGY

3.1. GENERAL

The main aim for conducting this experiment is to understand the concept of variation in velocity distribution. In order to understand the experimental setup as well as the numerical model is described in detailed summary. It also explains about the procedure followed in both experimental as well as numerical modelling.

3.2.EXPERIMENTAL ARRANGEMENTS

- The experimental arrangement used in the procedure consists of a rectangular flume which has cross section of the dimension 6.18m×0.3m×0.4m.
- To represent the rigid vegetation, iron rods are used which have the height of 10cm and the diameter of 6mm. They are placed with the spacing of 9cm and are in the span of 3m.
- Velocities at 3 sections are noted. These sections are at x= 1.29m, 2.79m and 4.29m.
- The 3 velocities which are taken are 0.4m/s, 0.3m/s and 0.2m/s.

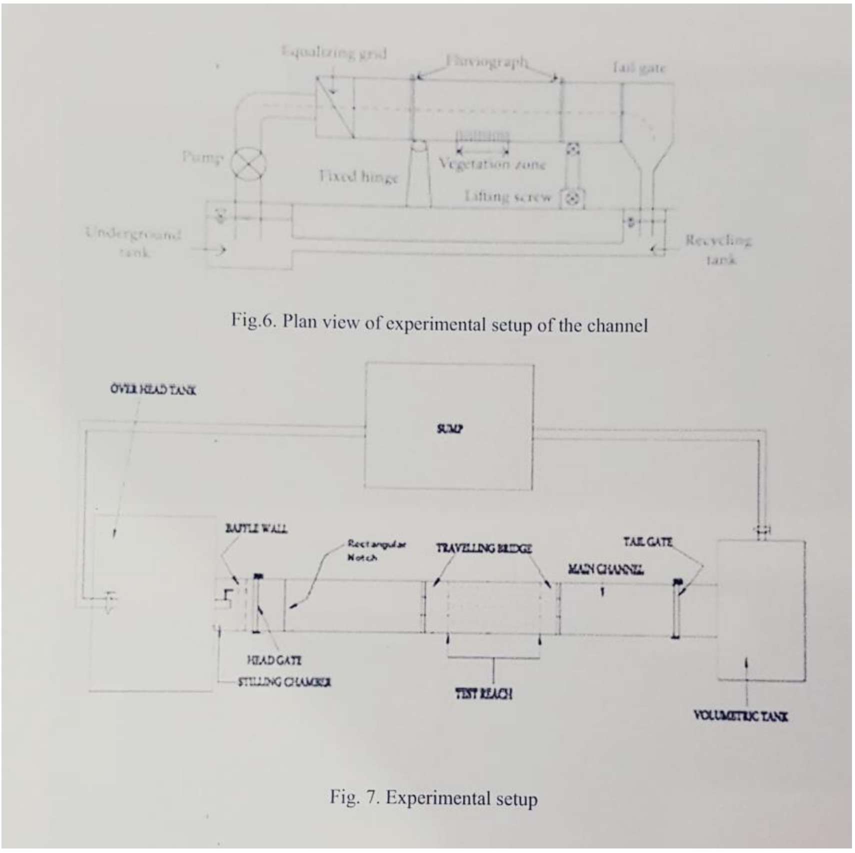

Fig 3.1: experimental setup

3.3.NUMERICAL MODELLING

There are 5 steps in ANSYS to make a model and get results. These are Geometry, Mesh, Setup, Solution and Results as shown in the figure below.

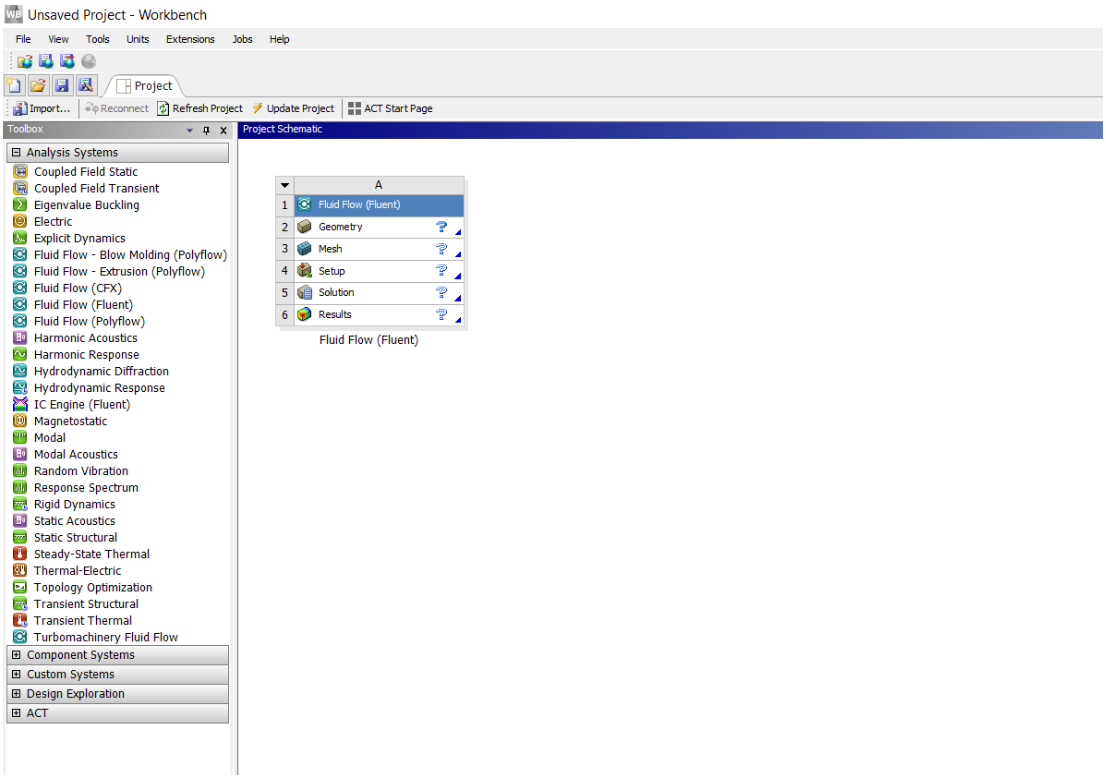

Fig 3.2: ANSYS window.

3.3.1. Geometry:

In geometry we make the required model with the help of DesignModeler.

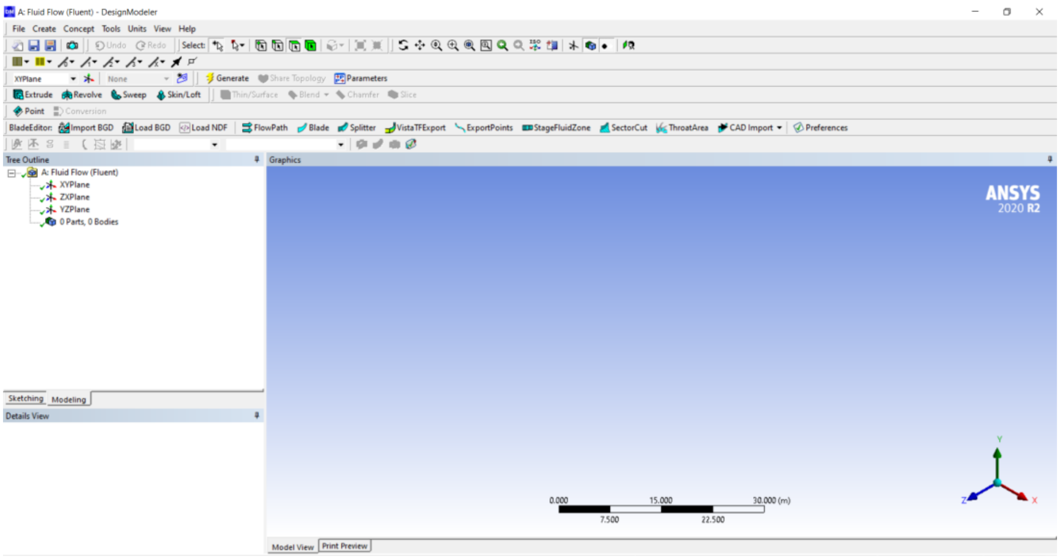

Fig 3.3: Editing the Geometry in DesignModeler.

- The model made in ANSYS is also of the same dimensions of the experimental apparatus i.e., 6.18m×0.3m×0.4m.

- To represent the rigid vegetation, cylinders are used which have the height of 10cm and the diameter of 6mm. They are placed with the spacing of 9cm and are in the span of 3m.

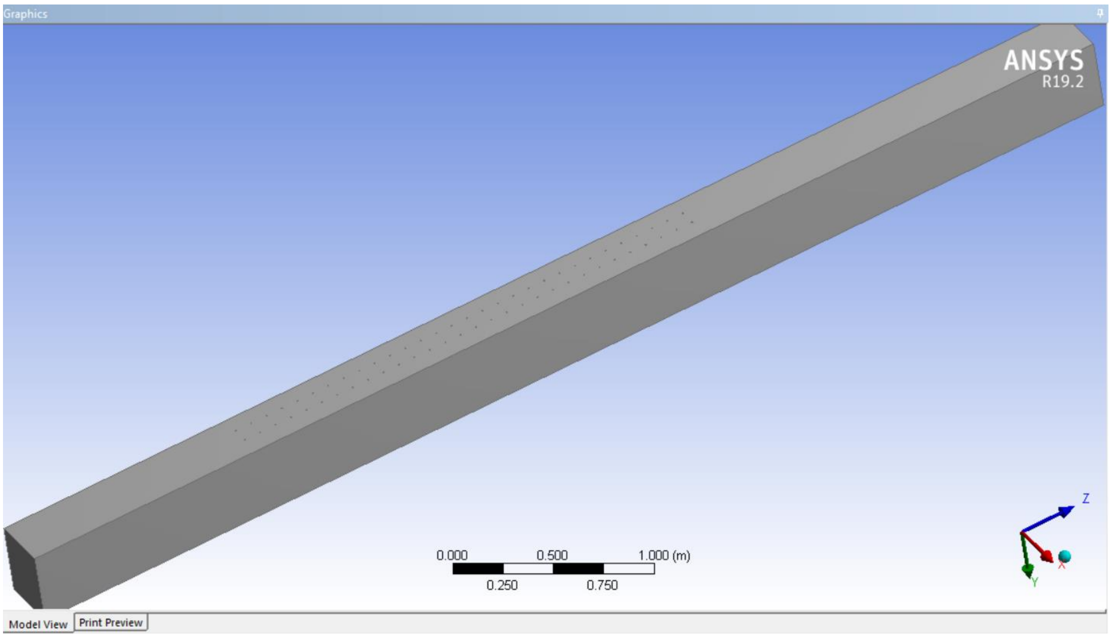

Fig 3.4: placement of vegetation(cylinders) on the bed

3.3.2. Mesh:

- Meshing is the process in which object (geometry) is broken down in thousands or more shapes to define the shape of the object with accuracy. The meshing influences many things such as speed accuracy and convergence of the solution. For a mesh an element size matters the most. The smaller is the element size the results will be more accurate.
- For this project the element size is taken to be 0.3m. Although there are many methods of meshing such as sweep method and multizone method but the mesh is generated using the default meshing by simple clicking the generate mesh after putting the element size to be 0.3m.
- Next Inflation is inserted in the walls and the bed of model and then we again generate mesh.
- After generating mesh, name selection is created where the parts of the model are named i.e., inlet, outlet, open and walls.
- Also, in solid where Fluid/Solid is there changing it to fluid.
- So, for this model the nodes are 303823 and Elements are 1476581.

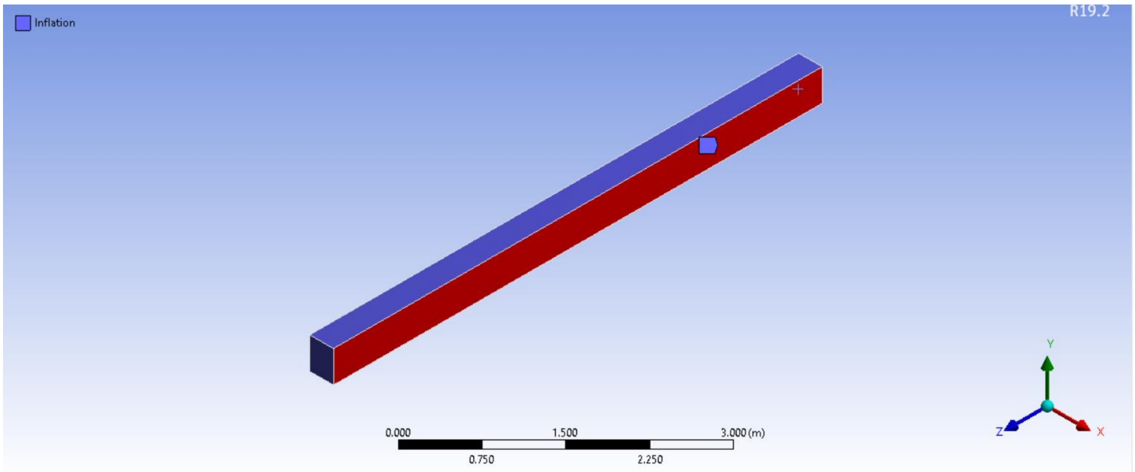

Fig 3.5: inserting inflation

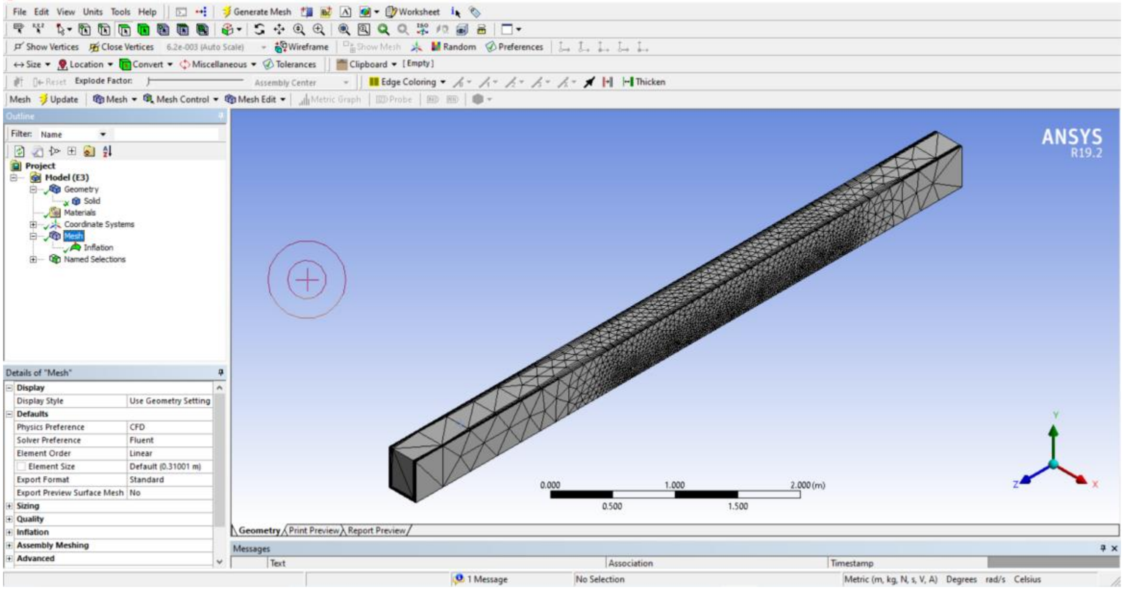

Fig 3.6: mesh window

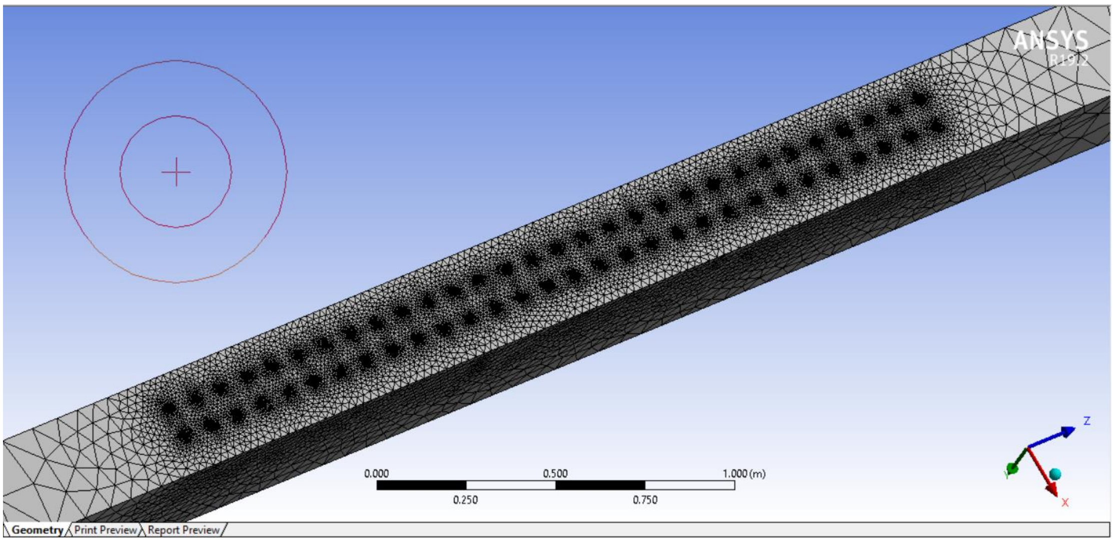

Fig 3.7: meshing of bottom

3.3.3. Setup:

- When we open the Setup, first thing we do is check mesh then select steady in time then we select gravity. In this -9.81 is put in the y direction blank.
- In Model on the left side the Multiphase is enabled the open channel is clicked. Here, Implicit Body Force is also clicked. Then we shift to the Phases. Since only one phase is there i.e., air so we add another phase i.e., water.
- Now editing Viscous. Here, we select k-epsilon model, standard.
- The we move to Materials and change the Primary phase to air and secondary phase to liquid i.e., water.
- Then we click on the Phase Interaction. Here, we change surface tension to be constant and by putting the value to be 0.073.
- The next we select Boundary Conditions select inlet to be pressure inlet type and further editing it to enable open channel in multiphase and also mentioning the free surface depth which are to be chosen as 0.2m, 0.1m and 0.05m same goes with outlet and open. Here, we have selected it to be pressure outlet and then selecting gauge in the multiphase.
- For the inlet 3 different velocities are taken i.e., 0.4m/s, 0.3m/s and 0.2m/s.
- Now we move onto cell zone condition. Here select fluid and edit. Then go to multiphase and then click Numerical Beach. Here, selects compute from inlet boundary to be inlet and also change free surface level. Here z-direction is the direction of fluid flow hence all the values are in that direction by default.
- Now in solution section we select the methods.
- Here we select Pressure-velocity Coupling scheme to be Coupled. Now we select Initialization. Here we take the Hybrid Initialization and selecting compute from inlet. Then click on the bottom Initialize.
- Below the Solution we then go to Run Calculation. Here, we take time step size and number of time step. Then press calculate. A residual graph is obtained.

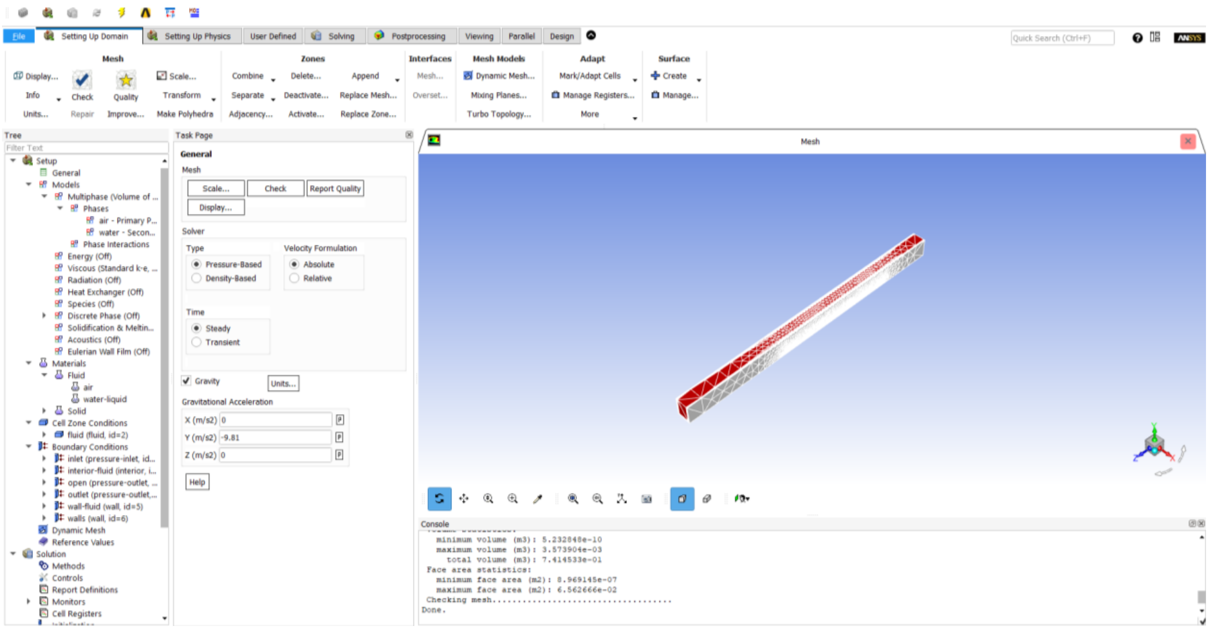

Fig 3.8: setup window

3.3.4. Solution:

It can either be edited in separate window or can be done in Setup only. As mentioned in the Setup; Method, Initialization and Run Calculation comes under this category. Contours, x-y plots are obtained thought this window.

3.3.5. Results:

Here post processing work is done. The process involves displaying of results after the whole process, after all the calculations. Here results are shown in the form of charts, x-y plots, streamlines, etc.

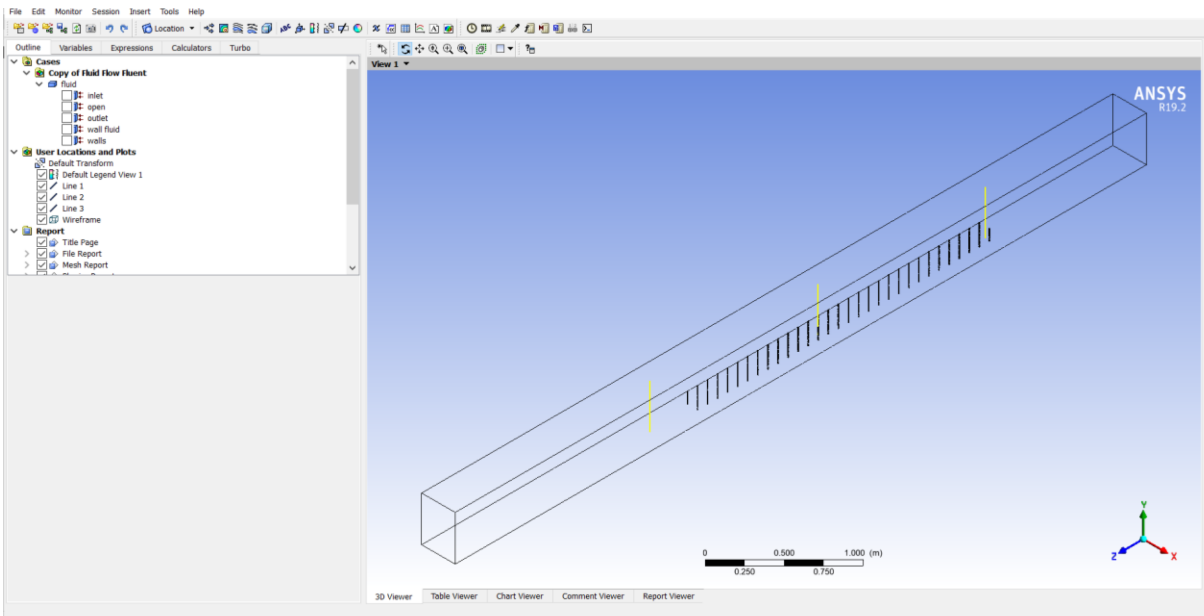

Fig 3.9: Result (post processing window)

CHAPTER 4

RESULTS AND DISCUSSION

4.1. GENERAL

The experimental results of velocities are presented in this chapter. Analysis is done at 3 velocities i.e., 0.4m/s, 0.3m/s and 0.2m/s. The section taken are shown in figure.

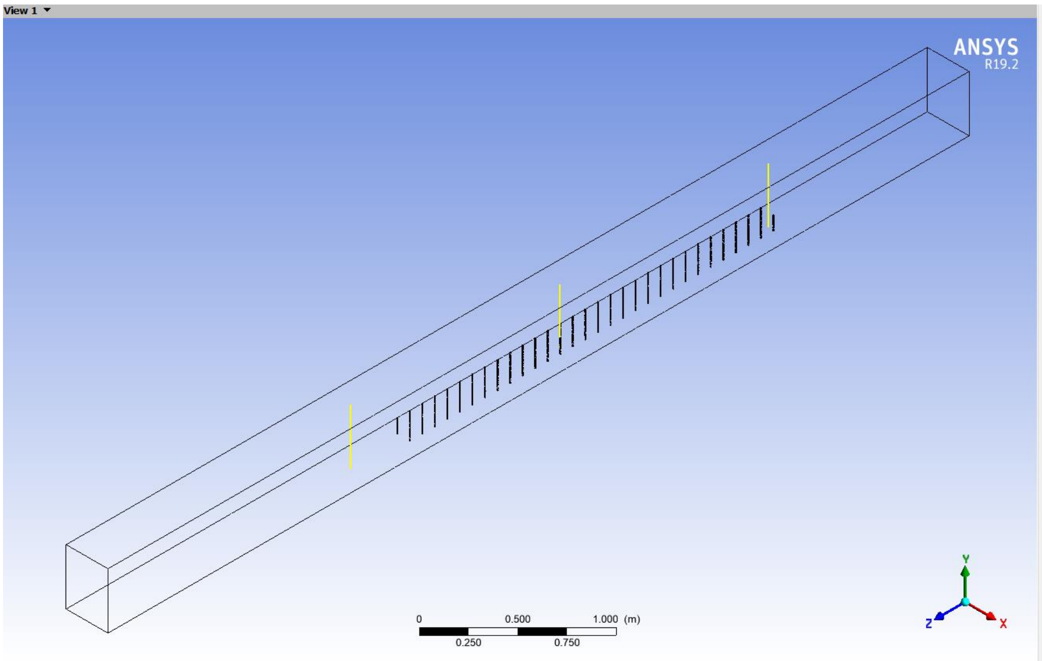

Fig 4.1: sections taken to measure the velocity (yellow lines)

The total of three sections are taken from inlet. The section taken are 1.29m (section1) from inlet, 2.79m (section2) from inlet and 4.29m (section3) from inlet. The velocities which are obtained are then compared with the experimental values.

4.2. Graphs Obtained

Graphs obtained from the analysis of velocities at different sections and different inlet height of the water.

4.2.1: For velocity v=0.4m/s

- Here in the following graphs, we can see 3 water heights i.e., water at inlet at y=0.2m, 0.1m and 0.05m. These heights shows that the vegetation is submerged in the water in case of y=0.2m and vegetation is at the same level as water depth in y=0.1m and the water level is below the vegetation in y=0.05m.
- In case water level is more than vegetation i.e., vegetation submerged the following graphs are obtained. When water level is greater than the vegetation

it is observed that at section 1 the velocity remains nearly as that of inlet but at section 2 velocity decreases and at further section 3 it decreases more in Fig4.2(a).

- In case when water level is at the same level of the vegetation then at section 1 the velocity is that nearly same as that of inlet velocity and at section 2 it decreases but then again at section 3 it increases in Fig4.2(b).
- In case of water level below the vegetation same happens as that when water level is at same level of vegetation i.e., velocity is nearly same as that of inlet velocity at section 1 and at section 2 it decreases but then again at section 3 it increases in Fig4.2(c).
-

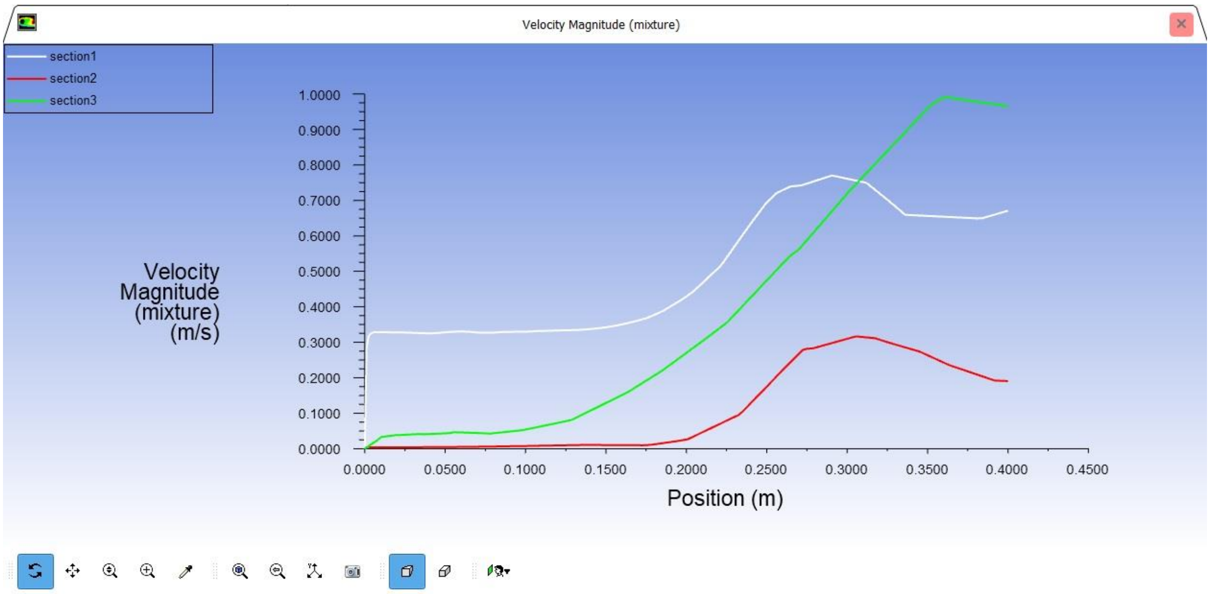

Fig 4.2(a): velocity 0.4m/s at section 1,2&3 at y = 0.2m

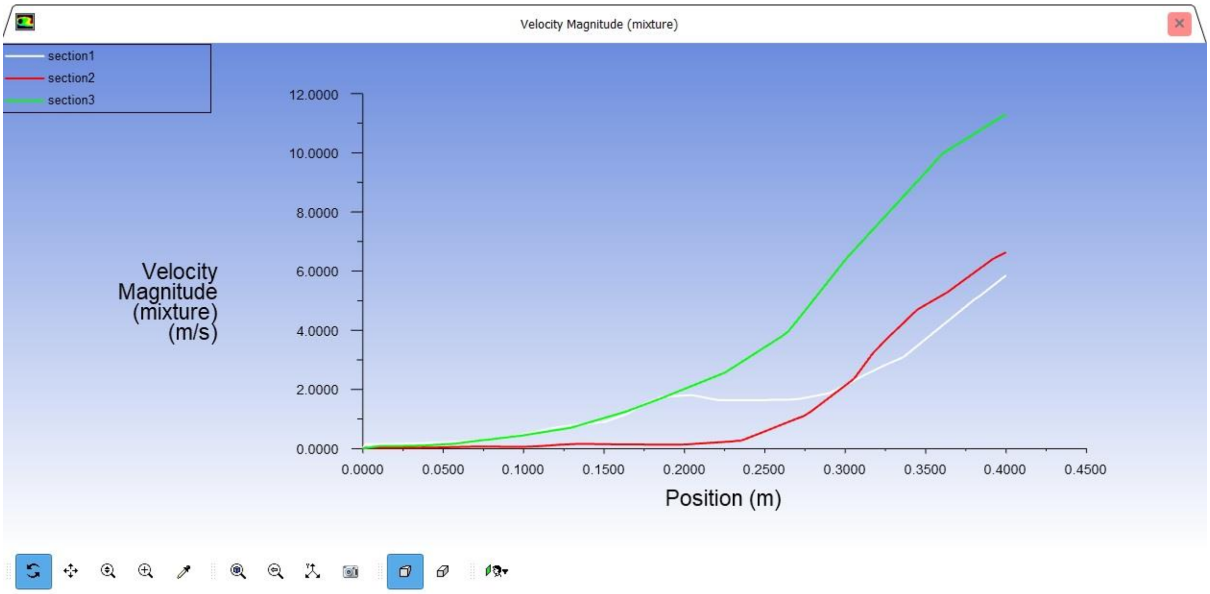

Fig 4.2(b): velocity 0.4m/s at section 1,2&3 at y = 0.1m

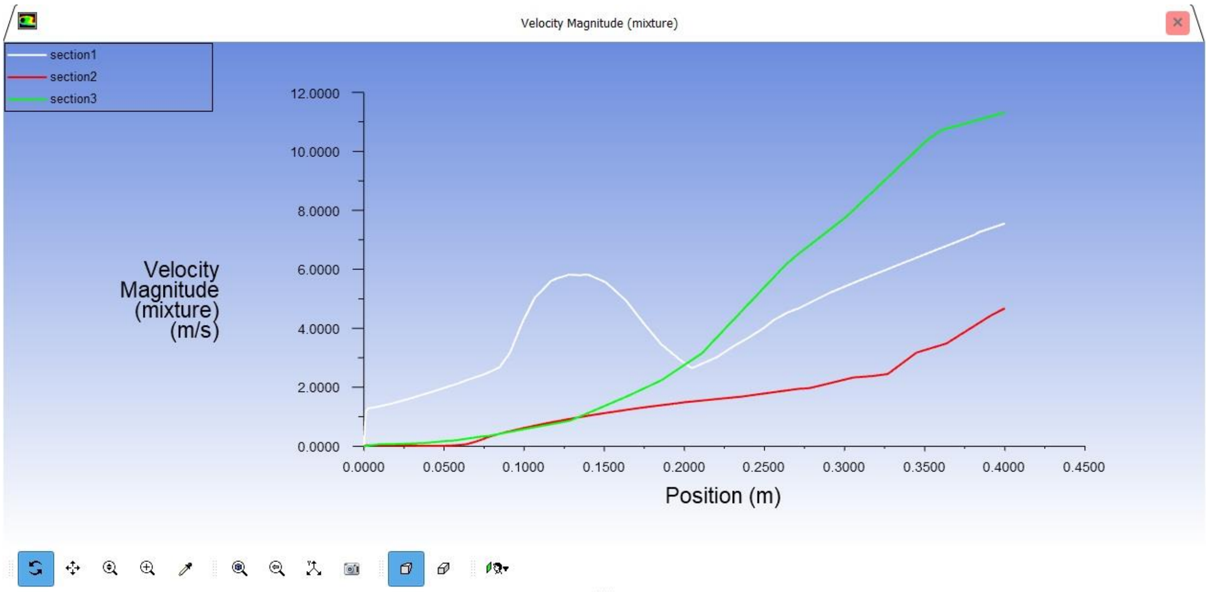

Fig 4.2(c): velocity 0.4m/s at section 1,2&3 at y = 0.05m

Following are the more graphs related to the velocity v = 0.4m/s but at separate section and also separate water level.

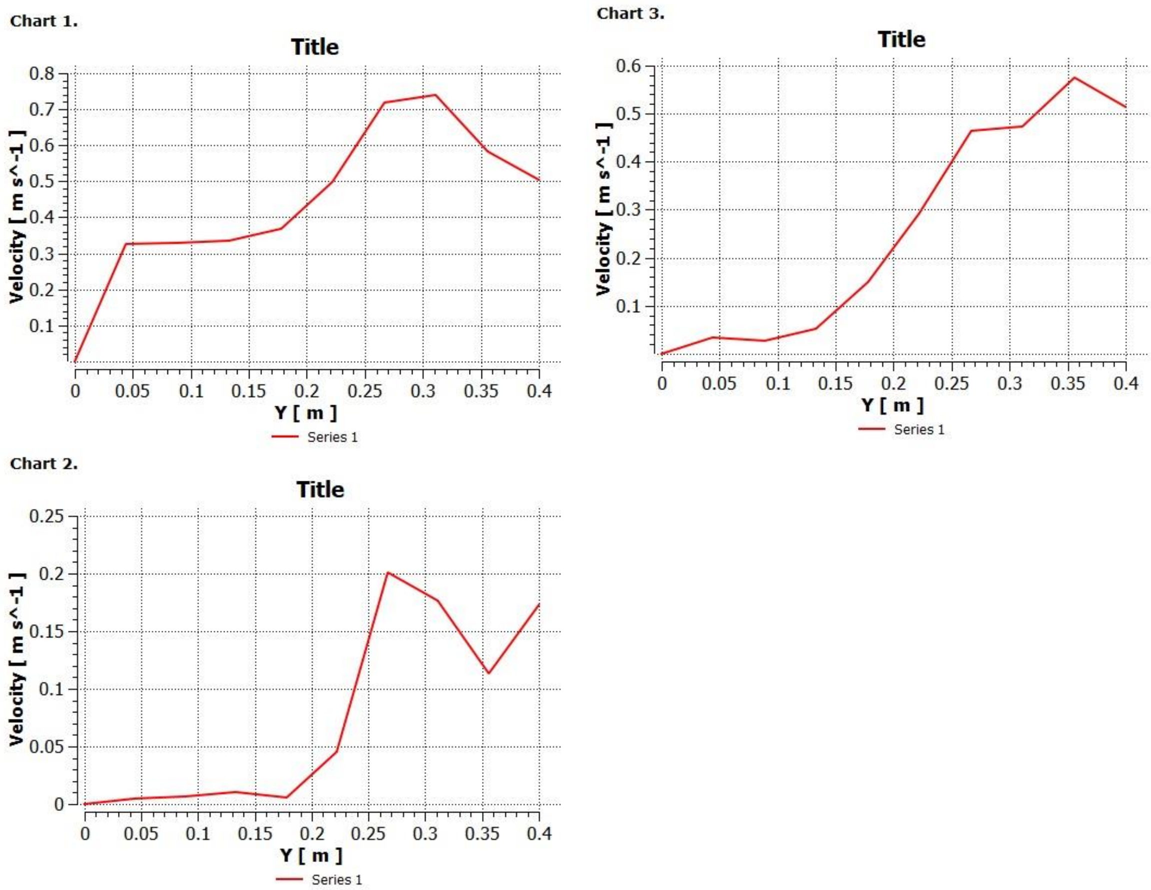

Fig 4.2(d): velocity 0.4m/s at section 1,2&3 at y = 0.2m

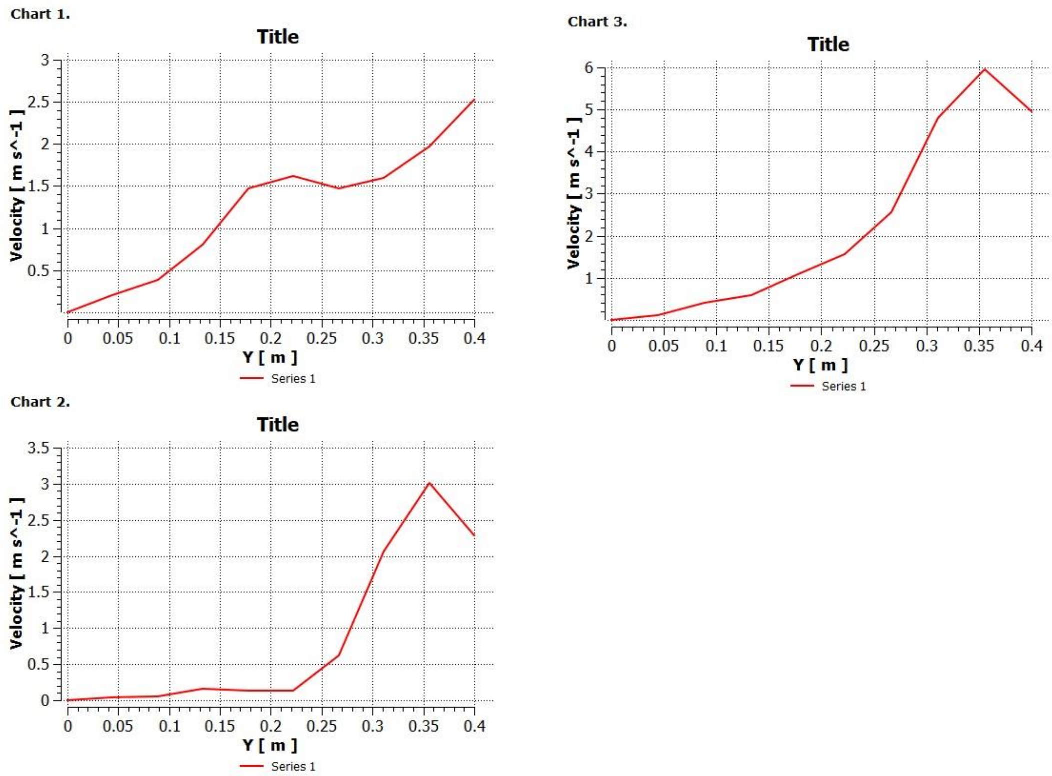

Fig 4.2(e): velocity 0.4m/s at section 1,2&3 at y = 0.1m

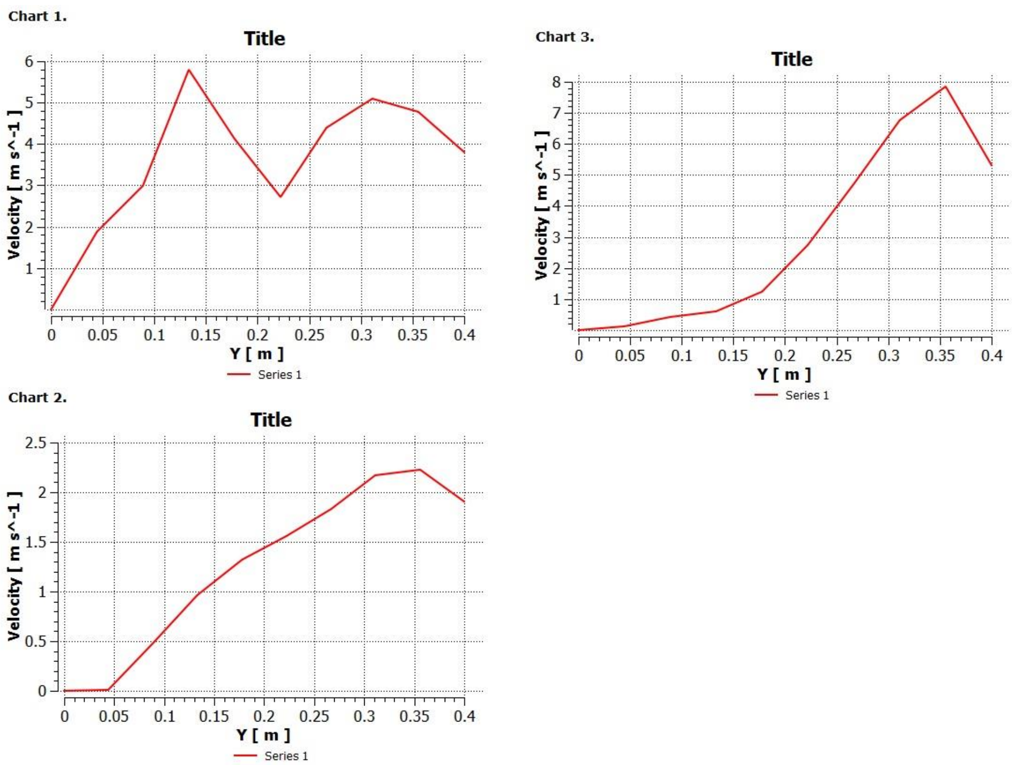

Fig 4.2(f): velocity 0.4m/s at section 1,2&3 at y = 0.05m

4.2.2: For velocity v=0.3m/s

- Here in the following graphs, we can see 3 water heights i.e., water at inlet at y=0.2m, 0.1m and 0.05m. These heights shows that the vegetation is submerged in the water in case of y=0.2m and vegetation is at the same level as water depth in y=0.1m and the water level is below the vegetation in y=0.05m.
- In case water level is more than vegetation i.e., vegetation submerged the following graphs are obtained. When water level is greater than the vegetation it is observed that at section 1 the velocity remains nearly as that of inlet but at section 2 velocity decreases and at further section 3 it decreases more in Fig4.3(a).
- In case when water level is at the same level of the vegetation then at section 1 the velocity is that nearly same as that of inlet velocity and at section 2 it decreases but then again at section 3 it increases in Fig4.3(b).
- In case of water level below the vegetation same happens as that when water level is at same level of vegetation i.e., velocity is nearly same as that of inlet velocity at section 1 and at section 2 it decreases but then again at section 3 it increases in Fig4.3(c).

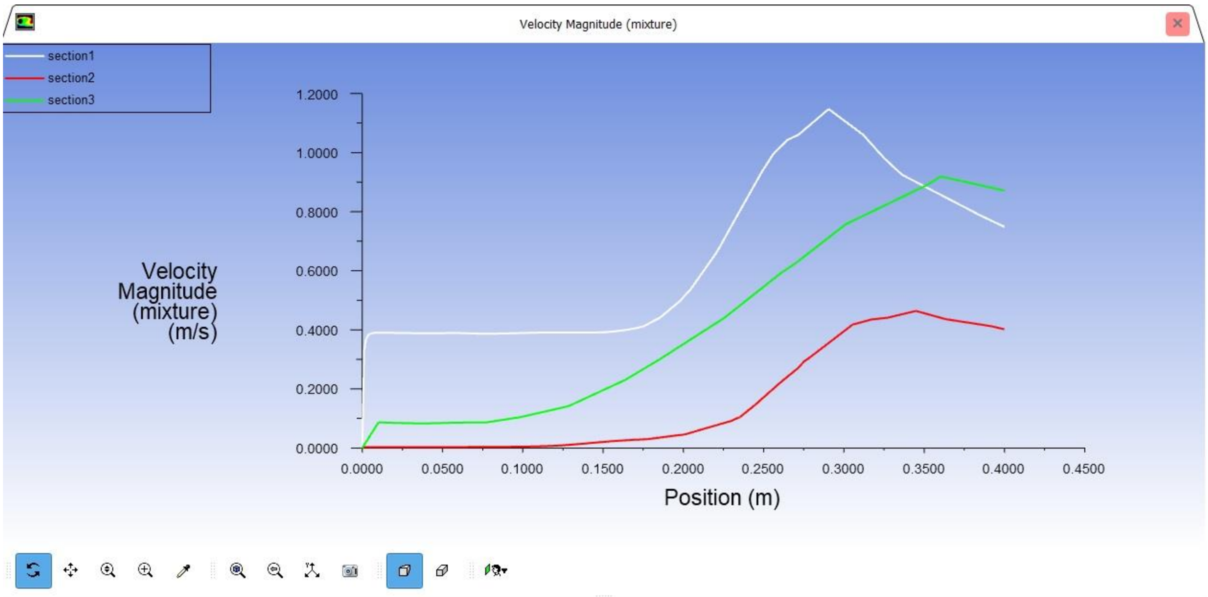

Fig 4.3(a): velocity 0.3m/s at section 1,2&3 at y = 0.2m

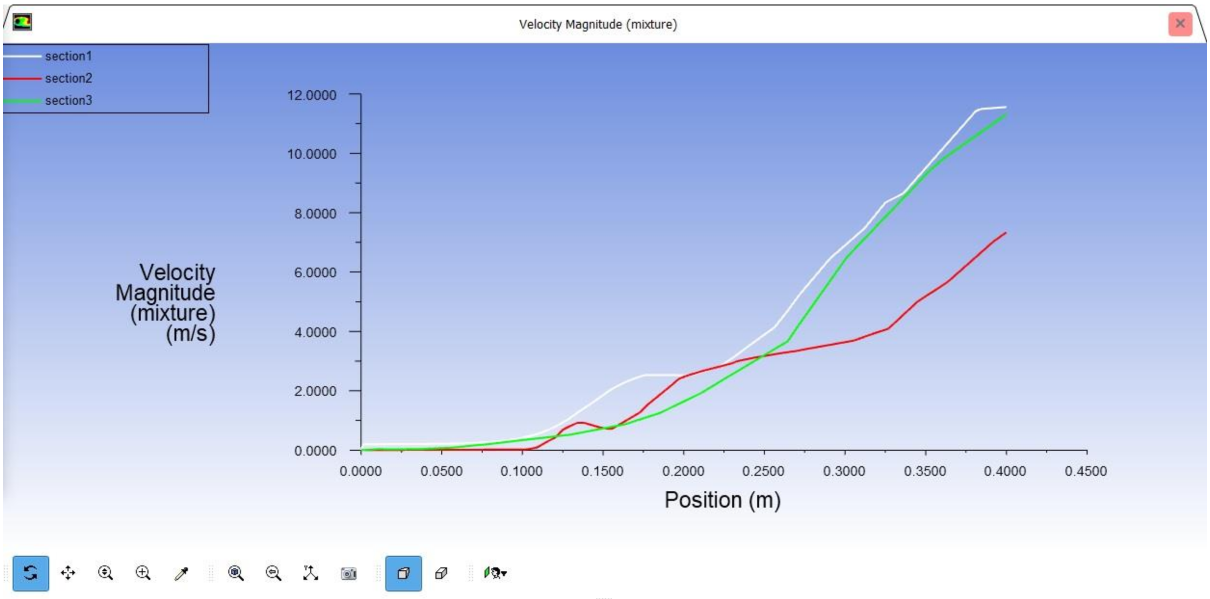

Fig 4.3(b): velocity 0.3m/s at section 1,2&3 at y = 0.1m

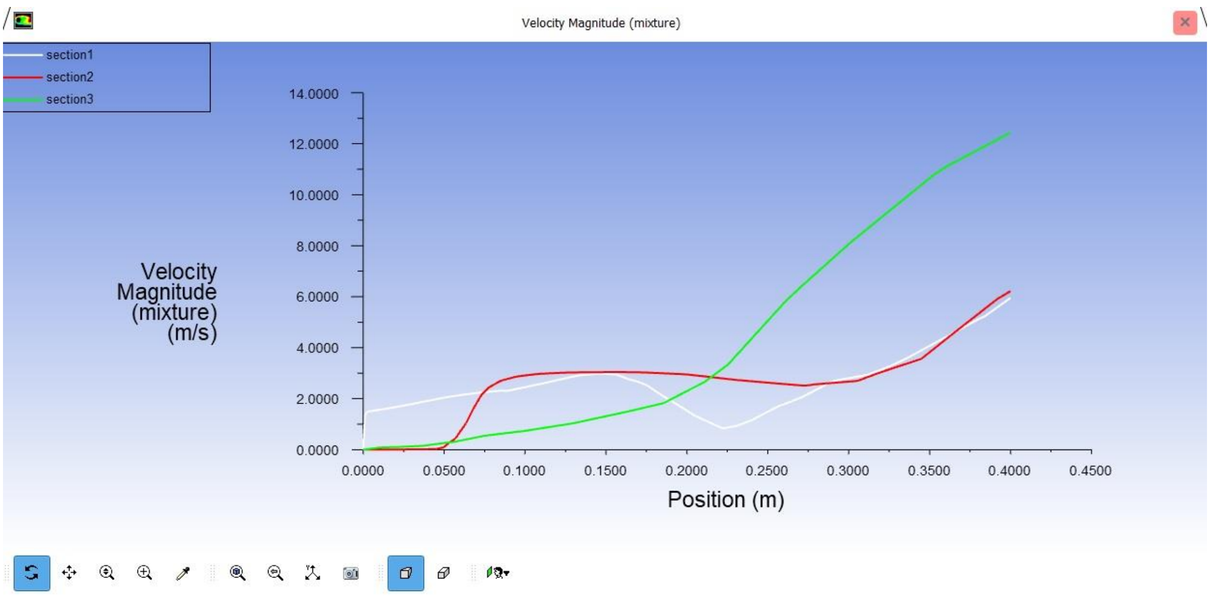

Fig 4.3(c): velocity 0.3m/s at section 1,2&3 at y = 0.05m

Following are the more graphs related to the velocity v = 0.4m/s but at separate section and also separate water level.

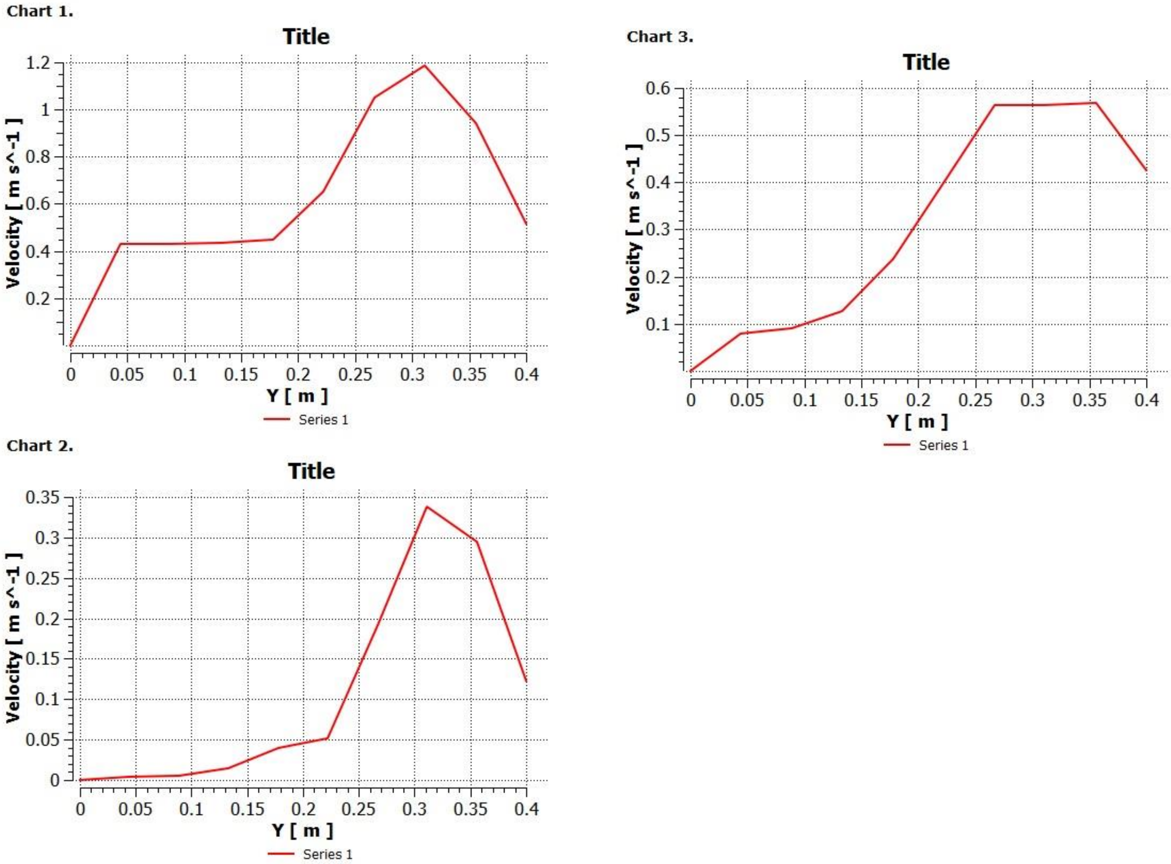

Fig 4.3(d): velocity 0.3m/s at section 1,2&3 at y = 0.2m

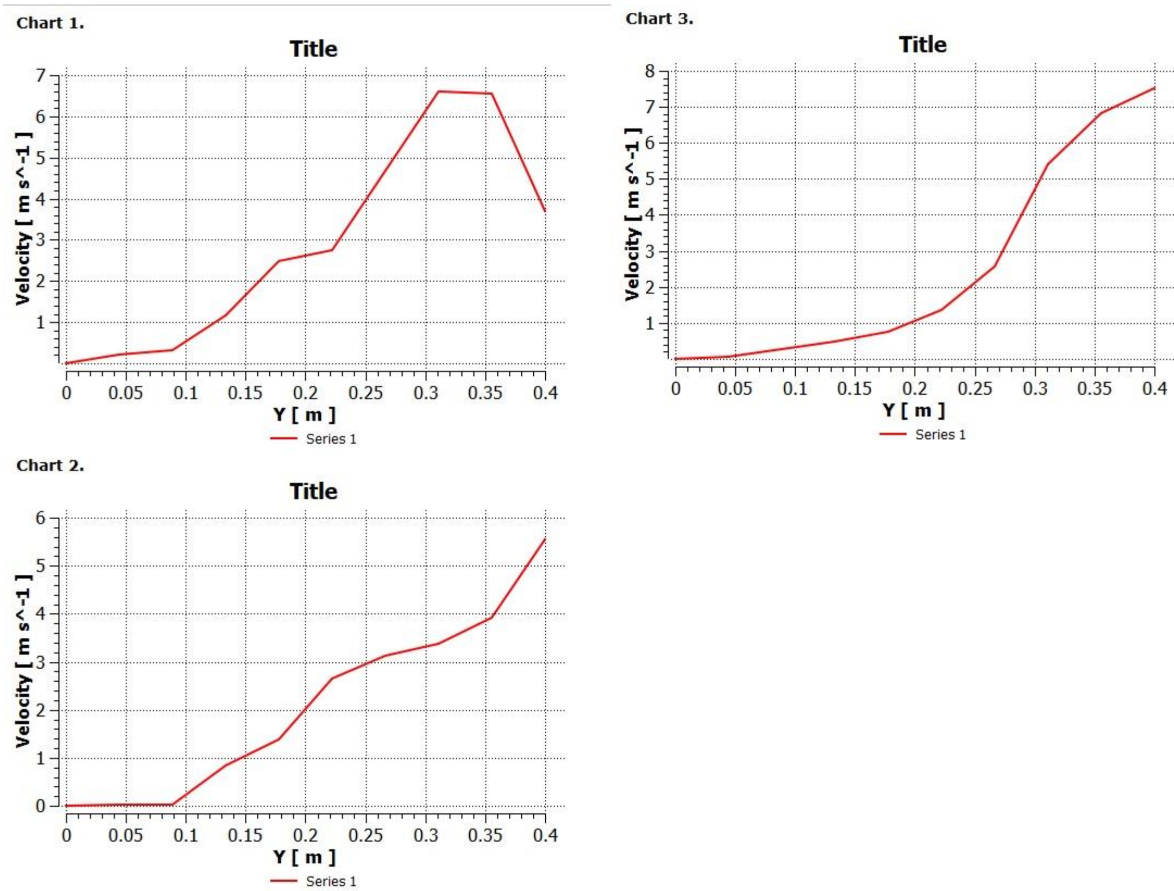

Fig 4.3(e): velocity 0.3m/s at section 1,2&3 at y = 0.1m

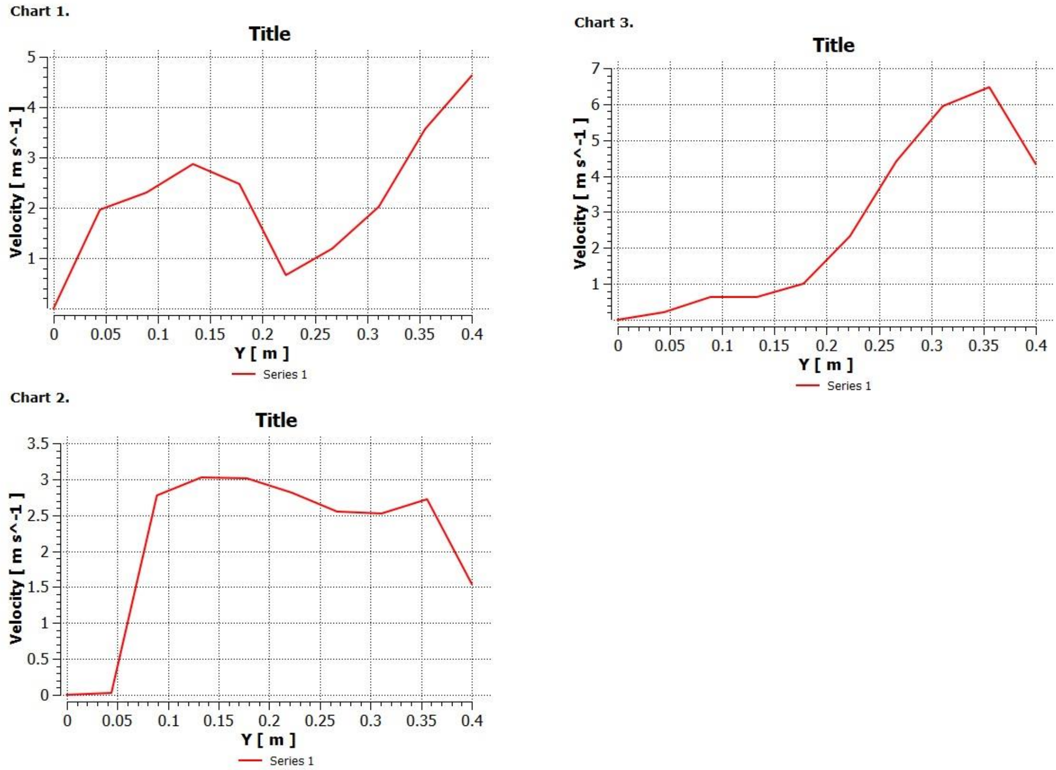

Fig 4.3(f): velocity 0.3m/s at section 1,2&3 at y = 0.05m

4.2.3: For velocity v=0.4m/s

- Here in the following graphs, we can see 3 water heights i.e., water at inlet at y=0.2m, 0.1m and 0.05m. These heights shows that the vegetation is submerged in the water in case of y=0.2m and vegetation is at the same level as water depth in y=0.1m and the water level is below the vegetation in y=0.05m.
- In case water level is more than vegetation i.e., vegetation submerged the following graphs are obtained. When water level is greater than the vegetation it is observed that at section 1 the velocity remains nearly as that of inlet but at section 2 velocity decreases and at further section 3 it decreases more in Fig4.4(a).
- In case when water level is at the same level of the vegetation then at section 1 the velocity is that nearly same as that of inlet velocity and at section 2 it decreases but then again at section 3 it increases in Fig4.4(b).
- In case of water level below the vegetation same happens as that when water level is at same level of vegetation i.e., velocity is nearly same as that of inlet velocity at section 1 and at section 2 it decreases but then again at section 3 it increases in Fig4.4(c).

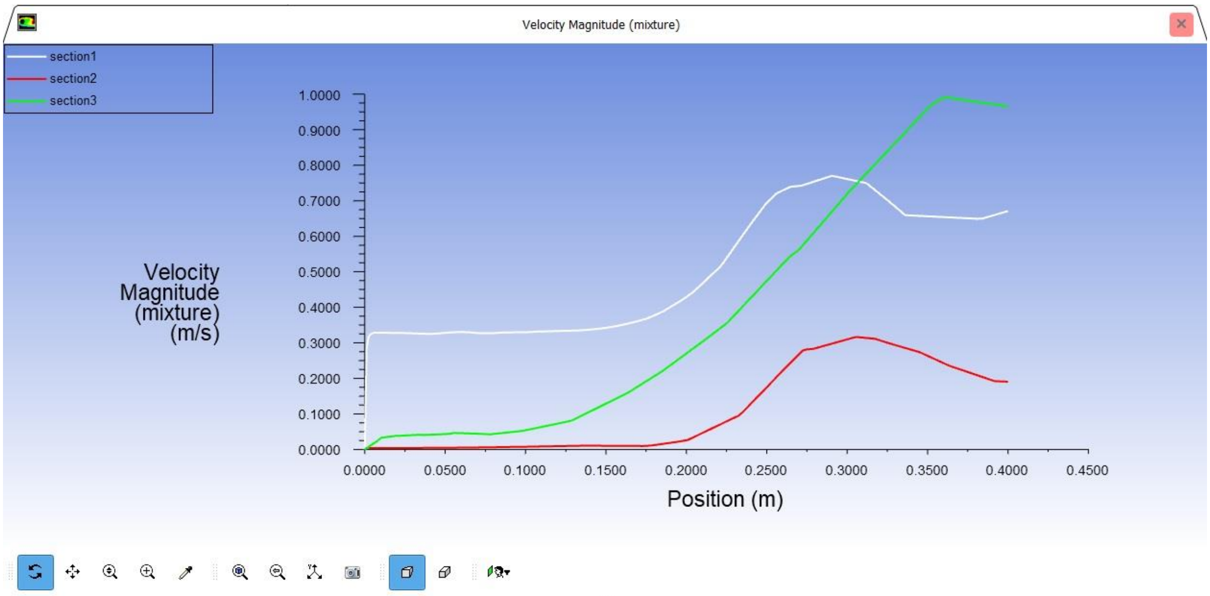

Fig 4.4(a): velocity 0.2m/s at section 1,2&3 at y = 0.2m

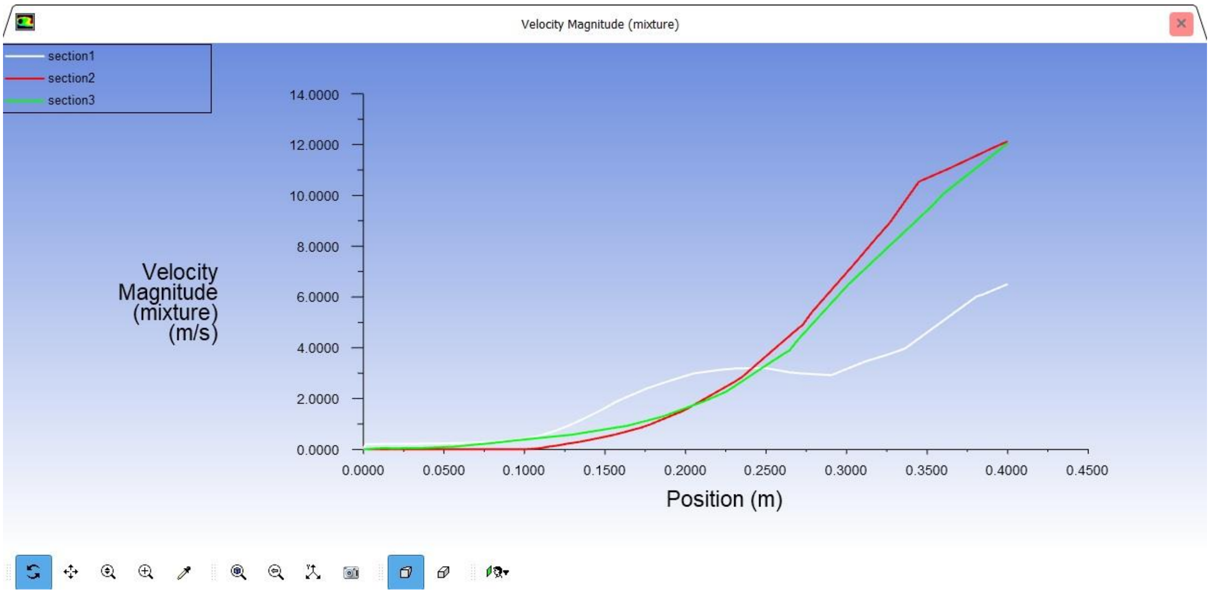

Fig 4.4(b): velocity 0.2m/s at section 1,2&3 at y = 0.1m

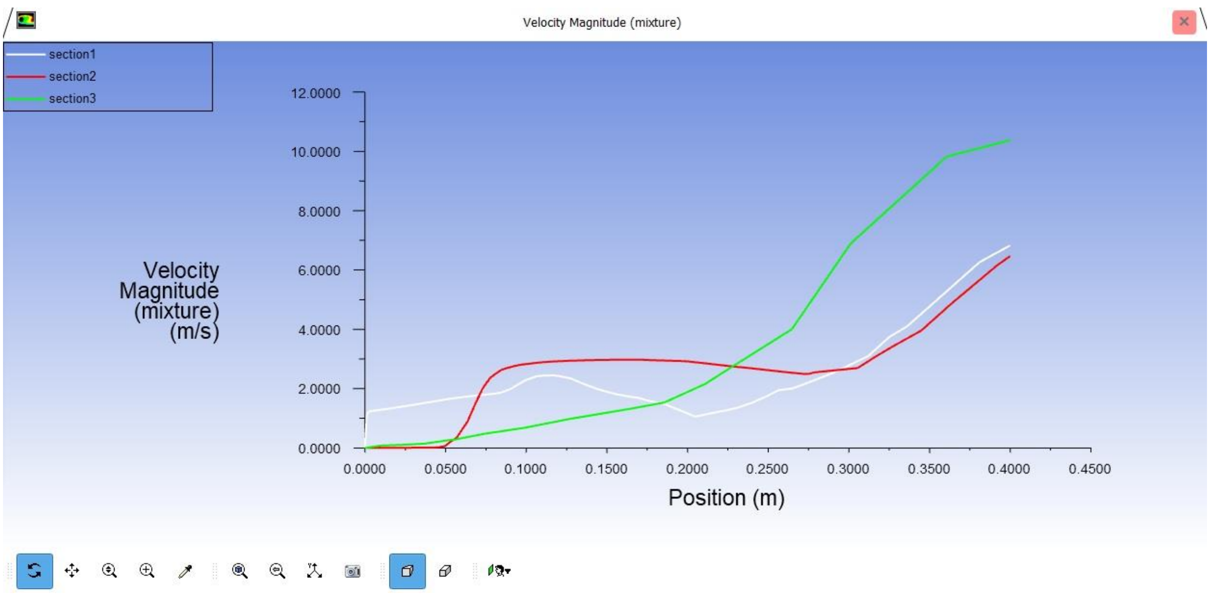

Fig 4.4(c): velocity 0.2m/s at section 1,2&3 at y = 0.05m

Following are the more graphs related to the velocity v = 0.4m/s but at separate section and also separate water level.

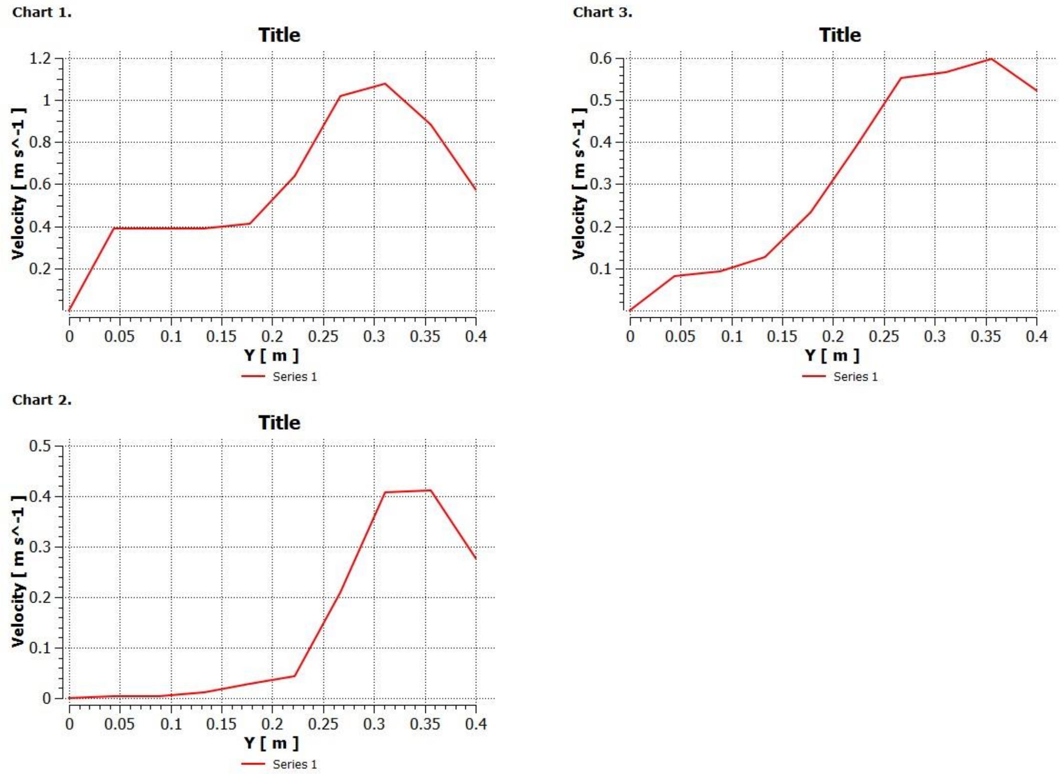

Fig 4.4(d): velocity 0.2m/s at section 1,2&3 at y = 0.2m

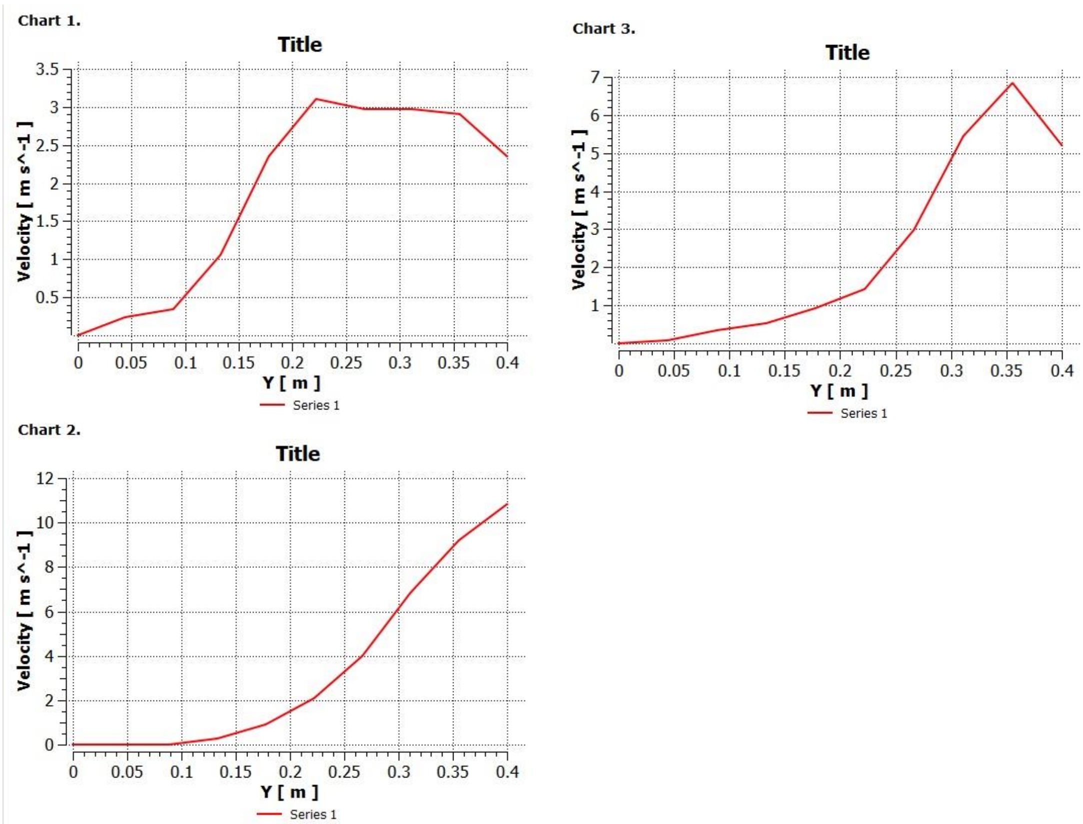

Fig 4.4(e): velocity 0.2m/s at section 1,2&3 at y = 0.1m

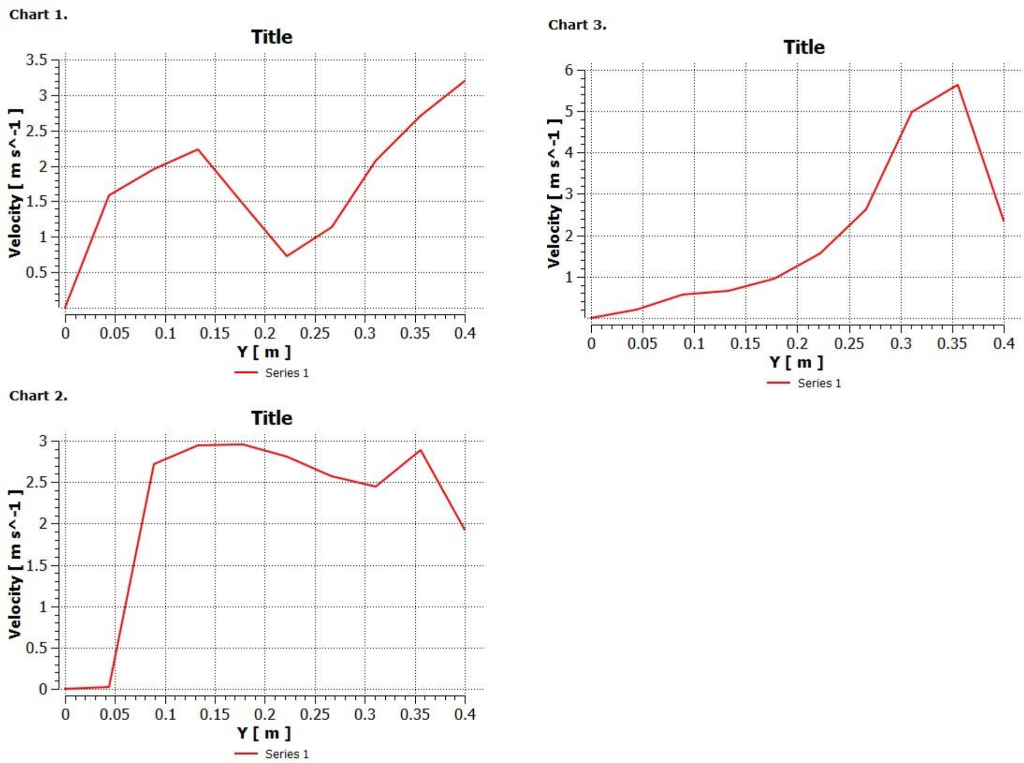

Fig 4.4(f): velocity 0.2m/s at section 1,2&3 at y = 0.05m

CHAPTER 5

CONCLUSION

Vegetation in open channel can be classified into rigid vegetation and flexible vegetation. Vegetation if it is as grass or weed on the sides of the channel or on the bed then it can act as a rigid body offering resistance to the low velocities of flow thus having loss in the efficiency of the channel although this vegetation only has low resistance to flow. But if the flow velocity is high then there would not be any much of the loss.

So, in this project the effects of these vegetation are studied using ANSYS. Three different velocities are used i.e., 0.4m/s, 0.3m/s and 0.2m/s. in the model to study the velocity variation in the model.

The total of three sections are taken from inlet. The section taken are 1.29m from inlet (section1), 2.79m from inlet (section2) and 4.29m from inlet(section3).

Three different water depths are also taken i.e., when water level is less than vegetation, when water level is equal to the vegetation height and when water level is greater then the vegetation depth.

In case water level is more than vegetation i.e., vegetation submerged the following graphs are obtained. When water level is greater than the vegetation it is observed that at section 1 the velocity remains nearly as that of inlet but at section 2 velocity decreases and at further section 3 it decreases more.

In case when water level is at the same level of the vegetation then at section 1 tge velocity is that nearly same as that of inlet velocity and at section 2 it decreases but then again at section 3 it increases.

In case of water level below the vegetation same happens as that when water level is at same level of vegetation i.e., velocity is nearly same as that of inlet velocity at section 1 and at section 2 it decreases but then again at section 3 it increases.

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