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Flow Transition Due to Width Contraction

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Abstract:

This study analyses an open channel flow's transition due to contraction of width. The flow is initially subcritical (i.e. Fr < 1). Comparison between theoretical and experimental study is done to analyse the minimum contracted width such that if the width of the downstream section is more than this minimum contracted width flow can take place without any change in upstream specific energy. The abbreviated term suggests that the width of the open channel decreases and that leads to changes in the flow values of the differentiation from the others produced above. The dimensions of many water streams, which satisfy proper hydraulic conditions, may not be compatible with the designed dimensions of an irrigation work that needs to be constructed in some locations. The design requirements of such irrigation works may involve a contraction in the channel width in the required location. Then 2 models are prepared on ANSYS fluent one having width 0.190m which is more than the minimum contracted width and other having width of 0.1m which is less than minimum contracted width. Then the results are presented in the form of contours of volume fraction on the wall of model which validates the theoretical changes in upstream and downstream depths of flow in each case.

Keywords: Froude's number, Ansys fluent, Flow transition, upstream, downstream

1. Introduction

In order to achieve a simple and effective transition from one flow to another, changes are presented in open channels that are accompanied by practical considerations. Here, we will discuss the basic principles under different types of open channel change; and the impact of change in conditions of flow both upstream and the downstream itself. In this paper, flow transition due to contraction of width is studied theoretically and experimentally to determine the minimum possible contracted width for a particular upstream cross-sectional width so that there is no change in upstream energy of flow. Abbreviation of the watercourses has encouraged many researchers to present statistics in order to quantify its features and limitations through experimentation and theory. Some have found that direct access is better than equivalent lengths in hydraulic operation and cost. Henderson (1966) argued that the limitation rate could be calculated by using the force balance between the ascending and critical access points, or by using the pressure balance between the critical access points and downstream; received statistics on two cases that will be reviewed later. The angle of change has also been read by many authors. Alsamman (1989) investigated the effect of the change angle and concluded that the coefficient of contraction decreased by increasing the inlet angle of rotation from 30 ° to 90 °, while the output angle of change has an insignificant effect on the coefficient of conflict. to pull. Furthermore, the associated transition length, (L / b), has no significant effect on the coefficient of coefficient when (L / b) is greater than five. They found that the length of the related protection increases with the decrease of the relative contract width range. Wu and Molinas (2005) re-established the theory of theory to predict the concise limitations from energy conservation and sustainability goals. Scour is one of the main factors affecting the depth of the canal.[1] Day and Raikar (2005) learned the scour in a long summary. It was found that the depth of the scour increases by increasing the size of the rock soil and decreasing the width of the channel contract. Decrease by increasing the Froude number of large proportions of related contract width.[2] Devadson (2007) noted that the depth of the flow and the geometry of the suction phase significantly affected the final depth of scour in the soil compacted with deep flow and severe friction leading to an increase in scour depth.[3] Xiong et al. (2013) concluded that shorter lengths had only a small effect on the depth of the scour and equilibrium bed morphologies.[4] Zidan et al. (2015) examined composite changes in open channels and concluded that power values and pressure coefficients depend on output, measure of contract-related width, and hump size. Mohamed et al. (2013) investigated the effect of different contractual scales on the scourge of a local scour, where 90% of the maximum scour depth was reached within two hours.

From technical research to previous research on canal width shortcuts it was concluded that the width of the canals significantly affects different hydraulic parameters as well as the depth and length of the scour. However, studying the impact of the contractual scope of the related contract, the change angle before and after the contractual phase, and the scour depth and length is the most comprehensive task in just one investigation; further research is needed, from which the significance of current research is derived.[5] Attia & Ibrahim (2000), studied the effect of channel shrinkage on disturbances using Laser Doppler velocimetry. They found that the turbulence escalating just above the curve was higher at the shorter sums than the larger ones and during the transition, the turbulence increased with the narrowing rate and greater in the lower reaches of the river for smaller gaps.

In (2001) Negm studied flow characteristics at asymmetric sudden contraction and concluded that lower contraction ratios produce more backed up depth ratio as well as more loss of energy and higher contraction ratios produce larger discharge coefficients[6] Negm et al. (2003) and Mahmoud Abdullah, studied the Protected length downstream of compound transitions and concluded that the protected length (L) increases with the decrease of the contraction ratio.[7] Wu & Molinas (2005) studied short-term loss of power, lateral attenuation of the flow of the lower open channel. Obtained theoretical statistics to predict the rate of limited summaries from energy savings and continuity principals.[1] Akers and Bokhove (2008) examined the probability of shallow water flow in a contracted canal. The researchers used a laboratory channel with a b_O width and in the access area, the width was b_C.[8] During the experiment, it was observed that the steady flow upstream of the river and the moving bores would produce a sloping wave in the contracted zone. Experimental work has shown that when the (^{bc}) ratio decreases, a complex hydraulic jump occurs. b_O In (2010) Defina and viero studied flow through linear contraction in an open channel.[9] The main focus of their study was on flow configuration with a two dimensional jump in zone of contraction and a two dimensional simple quasi model was proposed to determine equilibrium and stability conditions.

The results showed stability of flow is affected by bed slope and bed friction. Ladopoulos (2014) The free-surface profile of a potential flow in transition is described by the singular integral equations. This method is commonly used in numerical analysis to study the flow.[10] In (2014) I. Datta • K. Debnath studied effect of Channel contraction on fluent using three different contraction ratios (0.77, 0.61, 0.44) and found out that within the contracted region, the longitudinal mean velocity as well as the turbulent intensity increased with decrease in contraction ratio.[11] The authors also found out that turbulent kinetic energy and dissipation rate also increased with decrease in contraction ratio, especially near contracted zone and channel bottom which are the regions of turbulence production and dissipation. Goel et al. (2015) presented a study to develop a device for measuring discharge from laboratory and irrigation stations. All tests were performed with flow meters on sharp edges with four values of 26.5º, 33.7º, 45º and 90º in the flow area and all devices were tested under free flow and underwater flow conditions. Each device was tested with eight output volumes ranging from 2 l / s to 30 l / s with a total tracking time of up to 500 times. The 33.7º inclination tool was the most efficient to allow for the most critical water immersion.[12] Mohamed et al. (2016) in their study investigated the effect of erodible beds on backwater rise after bridge piers were constructed. They found that the increasing contraction ratio decreases the backwater rise values. Although the flow patterns of the oblique hydraulic jump showed significant differences in the area of the abridged channel, the single dimensional analysis of the viscid flow away from the water-driven jumps was positive.[13]

2. Methodologies:

2.1 Analysis on ANSYS FLUENT

In this project the minimum contracted width is first calculated for a particular open channel flume having width 0.315m and 0.5m deep having a discharge of 0.0545$m3$/, using the theoretical formula. For the numerical study, a 0.315m wide rectangular open channel flume having depth 0.8 m is analyzed for a certain discharge such that the resulting flow at upstream is subcritical. Two models were prepared one having a width of contraction more than the theoretical minimum width of contraction and other having width of contraction less than the theoretical minimum width of contraction.

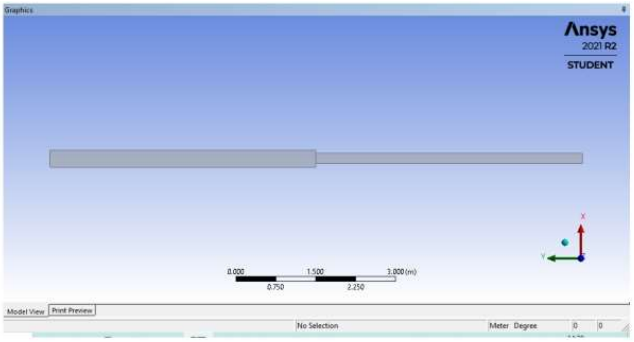

Fig.1 Three-Dimensional Geometry of the channels

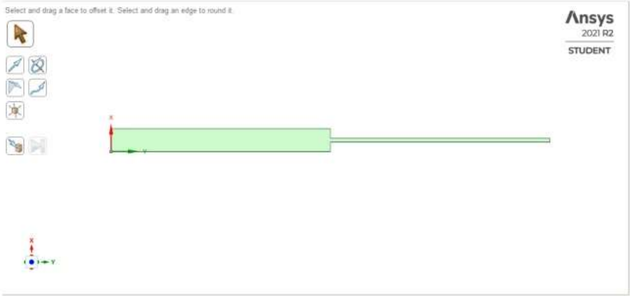
Select and drag a face to offset it. Select and drag an edge to round it.

Fig.2 Three-Dimensional Geometry of the channels

2.2 Geometry and mesh of present models

Figure 3 and 4 shows the 3-d models of the channels which were built in ANSYS with the help of space claim. and figure 5 and 6 shows the meshed models of the respective geometries.

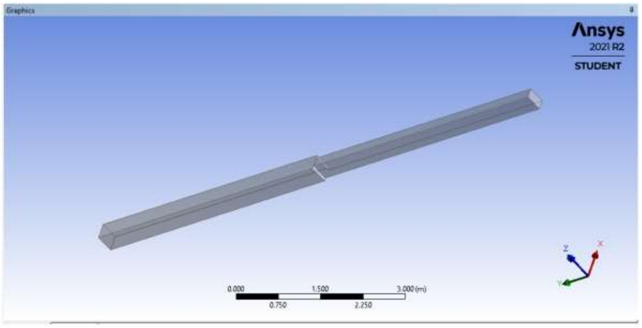

Figure-3 Three-Dimensional models of the channels

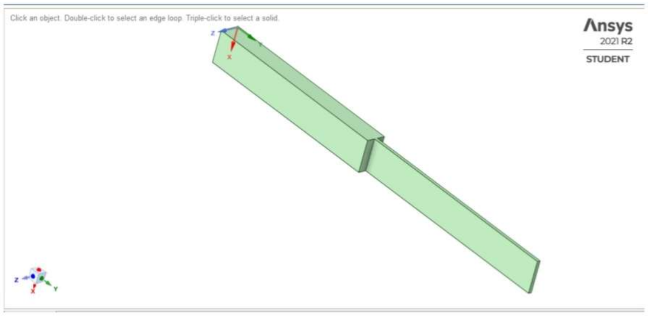

Figure-4 Three-Dimensional models of the channels

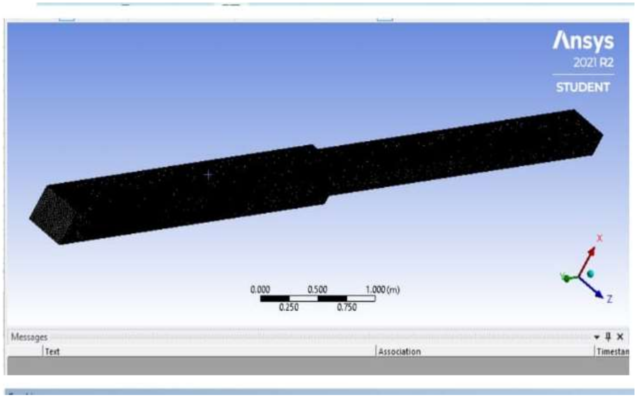

Fig.5 Meshing of the proposed models

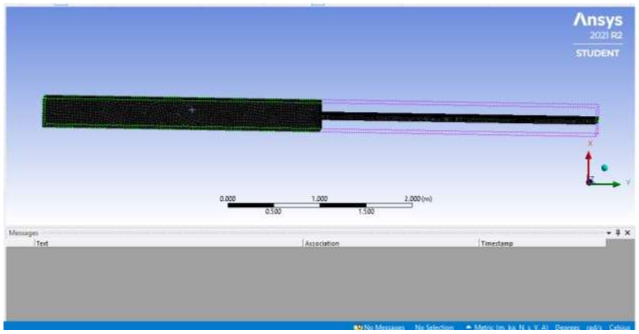

Fig.6 Meshing of the proposed models

3. Results and Discussions:

For the analysis, width at section at upstream taken is 0.315 m, depth of flow taken is 0.4 m and a discharge of 0.0545$\frac{m^3}{s}$ is considered. For the above data the minimum contracted width for the section can be determined theoretically as –

- Check nature of flow

$$fr^2 = \frac{q^2}{gy^3} \qquad (\,where\ q = \frac{Q}{B})$$

Fr = 0.0476 < 1 i.e. **subcritical flow.**

- Calculation of theoretical minimum width of contraction

Energy at upstream = $y + \frac{Q^2}{2gb^2y^2}$ = 0.409m

- If the width is contracted to 0.190m, depth of flow at contracted section can be calculated using specific energy equation (neglecting the losses). $y2$=0.380m.

- If the width is contracted to 0.1m, depth of flow at upstream changes to $y1$`=0.46m and depth of flow at contracted section changes to 0.311m.

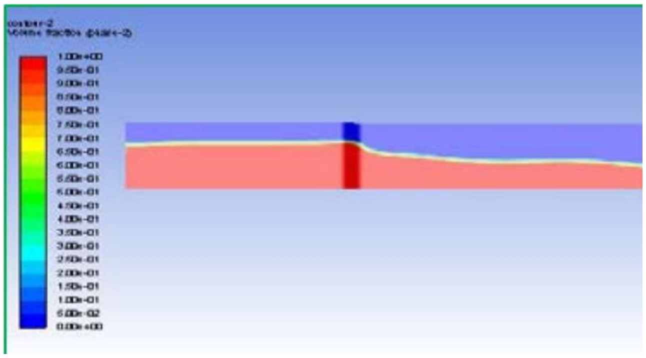

Fig.7 Simulated upstream flow for Model 1

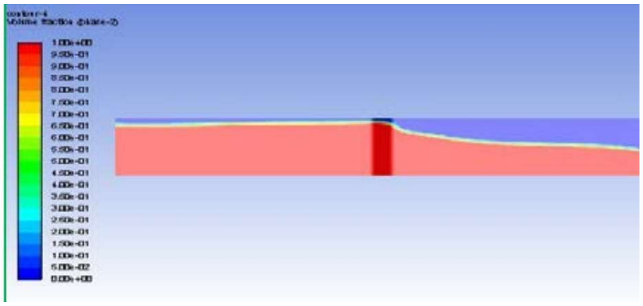

Fig.8 Simulated upstream flow for Model 2

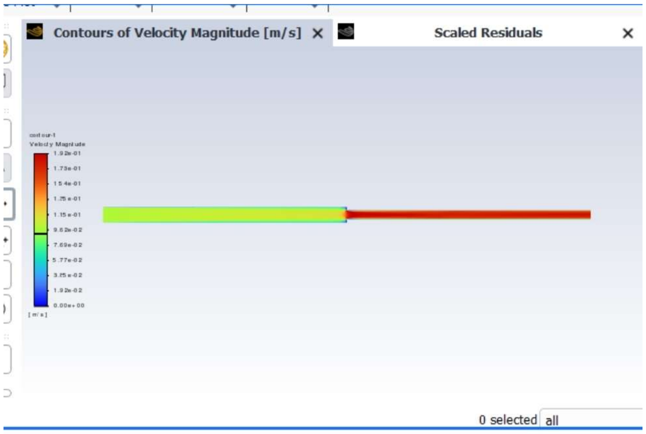

Fig.9 Simulated downstream flow for Model 1

4. Conclusions:

- From results it can be seen that for model 1, contracted width has no effect on depth of flow at upstream section and thus there is no change in the specific energy of the section. But there is a decrease in depth of flow in the contracted section as the flow is sub critical. This validates the theoretical results.
- From model 2 results it can be seen that depth of flow at upstream section has increased which validates the theoretical result that when contracted width is kept lesser than the Bmin, the depth of flow at upstream increases to y` = 0.460m and at contracted section the flow remains critical but the critical depth of flow changes to yc = 0.311m .
- Also, the area of cross section is lesser in the contracted section but discharge is kept same so the velocity head of flow increases in the contracted section.

Declarations:

The authors declare no conflict of interest.

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