VELOCITY DISTRIBUTIONS IN VEGETATED CHANNELS

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ABSTRACT

Aquatic weeds cause many serious problems in open channels such as velocities reduction, increase in water levels, prevent water from reaching the canal end, and a considerable amount of water losses by evapotranspiration. The phenomenon of directing the flow to the right side has been observed during an experimental study in a trapezoidal channel infested by submerged weeds. It is observed that the flow increases in one side of the stream compared with the other side causing a non-uniform velocity distribution. Therefore, the objective of the present study is to investigate this phenomenon and deduce the velocity distributions in channel infested by submerged weeds. Many experimental runs were carried out and the velocity distributions were measured for several sections. Analysis of the measured data indicated that the velocity distributions in channel infested by submerged weeds on bed were seriously affected and the flow was directed to the right side.

Keywords: Open Channels, Aquatic weeds, Velocity Distributions

INTRODUCTION

Growth of aquatic weeds constitutes one of the major problems affecting channel efficiency and water distribution. Aquatic weeds cause many serious problems such as water velocity reduction, changing the magnitude and direction of current along a channel, decreasing water flow, increasing in water level, and preventing water from reaching the canal end. Presence of aquatic weeds may severely complicate the conveyance system operation. Flow resistance varies with type, maturity, and density of vegetation and consequently affects the performance of the channel (Pitlo [16]). Aquatic weeds have to be controlled to an acceptable level to improve the channels performance.

Many researches have been carried out to study the effect of submerged weeds presence on the hydraulic characteristics of open channels. Kouwen et al. [13] pointed out that the methods which empirically represent the functional relationships between Manning`s roughness coefficient and the relevant flow parameters were unsatisfactory. They deduced a quasi-theoretical formula for the roughness in vegetated channels based on the slip velocity at the tips of the vegetation. Carollo et al. [5] deduced a new flow resistance law for channel with submerged grass vegetation covered the channel bed. This law established that the friction factor can be estimated by the shear Reynolds number, the relative submergence, and the degree of vegetation inflection.

Growing of aquatic plants in channels generally produce large obstructions that offer considerable resistance to water flow, particularly if the vegetation is emergent (Mitchell [14]). Guscio et al. [11] reported that aquatic vegetation might reduce the design flow rate for a watercourse by as much as 97%; even floating plants have reduced the flow up to 80% in small channels. Gwinn and Ree [12] concluded that the presence of bushes and trees in a channel reduced the capacity by 29% and the permissible velocity by 6%. Betram [3] and Eilers [7] deduced also that the discharge in vegetated channels was reduced by 63%. A similar reduction was observed by Felkel in channels with natural vegetation (Rouve [18]). El-Samman et al. [9] concluded that both density and distribution of submerged aquatic weeds had a significant impact on the efficiency and equitability of water distribution. Increasing the density or distribution of submerged weeds reduces the flow and obstructs water to reach downstream end of the canal and consequently the distributaries were subjected to shortage of water.

El Gamal [6] concluded that the maximum velocity and its depth, in channel infested by submerged weeds, increased as roughness element height was increased. It was also concluded that for constant element height all velocity values decreased as roughness density increases. Bakry [2] found that the flow velocity through vegetation parts of grassed Egyptian canals almost equal to zero. Querner [17] also proved that the velocity within the obstructed part was less than 10% of the mean velocity. However, Carollo et al. [4] observed that decreasing the stem concentration of submerged grass vegetation increased the flow velocity inside the vegetation and decreases the velocity above it; the thickness of the free-stream zone decreased and the curvature of the velocity profile, both inside and above the vegetation, were decreased as well.

Kouwen et al. [13] noticed during the experiments that a given instant, a great variation of velocity were existed across the width of channel at a given location. El-Samman [8] also observed that the velocity profiles were not symmetrical distribution in case of weeds distribution symmetrical (weeds on bed and two sides, weeds on bed, and weeds on two sides) on channel infested by submerged weeds and the flow was directed to the right side for different weeds density. While, in case of weeds on two sides (no weeds on bed) the velocity was deviated slightly to left by small value. Therefore, weeds in bed were more effective on flow direction and increase the magnitude of velocity compared to the case of no weeds on the bed channel.

The non-uniformity in the velocity distribution and discharge intensity were also observed downstream the outlet of the hydraulic structures such as spillways and inverted syphons. This flow pattern causing this type of flow was defined by Grishin [10] as a swinging flow. Grishin mentioned that "even with uniform releases along the entire width of the spillway face, some non-uniformity in the distribution of the velocities and discharge intensities over the width of the stream bed was observed in tail water". Osman [15] observed that the presence of weeds upstream the regulator leads to unsymmetrical velocity distribution in the channel water cross section. Abdel-Motalab [1] observed that the flow increasing in one side of the stream than the other during a physical model test for an inverted syphon causing a swinging flow phenomena. This phenomenon caused a non-uniform bed shear stress distribution resulting in more bank mad bed erosion. This is due to the warping of the flow axis in plan.

The main aim of this investigation was to study the unsymatrical velocities distribuation as affacted by pressence of submerged weeds on channel cross section.

EXPERIMENTAL PROCEDURE

The experimental work was conducted in re-circulated flume with trapezoidal cross section with dimension of 0.6 m wide, 0.42 m maximum depth, 16.22 m length, and 1.1 side slope. The artificial branched flexible roughness elements to simulat the submerged weeds were cut out from 2 mm flexible plastic sheets. The dimensions of branched roughness element are 1 cm width, 0.2 cm thickness, and 10 cm height, the height was divided into four branches as shown in Figure (1).

The flexible roughness elements were staggerly and uniformly fastened and distributed on plastic sheets on two weeds distributions. The flexible roughness elements were covered either bed only as distribution B or bed and two sides as distribution B2S for selected tested flume length of 5 m in the middle of the flume length. Three weeds densities (D1, D2 and D3), which their densities were 0.25, 0.0625 and 0.0278 stem/cm^2 respectively, were applied in the experiments. Three discharges were also applied in the experimental work (Q1 = 47.9, Q2 = 37.51 and Q3 = 26.44 L/sec) with relevant water depths 19.26, 18.71 and 17.26 cm respectively as measured at cross section CS: A (as shown in Figure (2)) for case of no weeds on cross section.

For all experimental work, seven vertical sections were selected to measure the velocities; these sections were nominated VS: 1, 2, 3, 4, 5, 6 and 7 as shown in Figure (2). The vertical cross section VS: 4 was selected at center line of the trapezoidal cross section. Along, the verticals the velocities were measured for each 1.0 cm height to indicate the velocity profile by using mini electromagnetic water current meter McBirney model 523. Discharges and water surface level were also measured.

Seven cross sections (CS: A, B, C, D, E, F and G) were selected to measure horizontal velocity profiles as shown in Figure (2). The cross section CS: A was selected just upstream the infested area by weeds, and four cross sections (CS: B, C, D, and E) were selected within the area infested by weeds, which CS: D was located in the middle of the infested area by weeds. Two cross sections were selected outside the weeds zone, the first one (CS: F) was selected just outside the weeds zone and the other section (CS: G) was downstream the end of weeds zone by 2 m.

For case of weeds distribution B2S, density D3, and passing discharge Q1, the horizontal velocity profiles were measured on the seven selected cross sections. For case of weed distributions B2S and B, and passing discharge Q1, the horizontal velocity profiles were measured on the cross section CS: D for the three selected weed densities.

To study the effect of discharge variation on horizontal velocity distributions, the velocities were measured on three cross sections (CS: A, D and F) for case of weeds distribution on bed and density D1 for the three selected discharges.

To study the effect of weeds fastening method on directing the flow, that was possibility, the velocity profiles were measured on cross sections A and D for case of weeds distribution B, density D3 and passing discharge Q1. After that the plastic sheets for the entire length of infested area by weeds were rotated by 180° and the velocity measurements were repeated at cross sections CS: A and CS: D-r (at the same location of section D).

RESULTS AND DISCUSSIONS

Velocity profiles were measured at several vertical and cross sections for different weed densities and weed distributions to study the phenomenon of directing the flow to the right side of vegetated channels. The velocity distributions for case of no weeds on cross section were determined for the selected seven cross sections from CS: A to CS: G and found symmetrical.

The velocity distributions for case of weeds distribution B2S, density D3, and passing discharge Q1 are shown in Figure (3). It can be shown that the average velocity at cross sections VS: 2 and VS: 3 on right side is higher than VS: 5 and VS: 6 on left side. Also, it was found that as the flow moved down stream the flume over the infested area, the flow was increasingly tended to the right direction. However, the average velocity distributions at the beginning cross section of the weeds zone (CS: A) were found symmetrical and velocities at right side were the same as the left side.

The effect of weeds density on this phenomenon was studied by measuring the velocities at the cross section D for weed distributions B2S and B and passing discharge Q1 for the three weeds densities as shown in Figure (4) and Figure (5) respectively. It can be shown from Figures, that the flow is also directed towards the right side, and the velocities at right side recorded increase in case of weed densities D2 and D3 comparing with weeds density D1, which is the highest weeds density.

Velocity distribution for case of weeds distributions B2S and B showed that in the highest weeds density D1 the velocity in the layers under the weeds zone was symmetrically distributed for different discharges. While, for the layer above the weeds zone the velocities distribution were directed to the right side. However, for weed densities D2 and D3 the velocities at bed and above layer tended to the right. This phenomenon happens due to the presence of dense weeds for density D1, which blocked the water way at the channel bed layer.

The effect of the discharge on velocity distributions was also studied for the case of weeds distribution B and weeds density D1 for the three selected discharge. The velocities were measured on three cross sections (CS: A, D, and F) to show the velocities variation at the beginning, middle, and end of the infested length by weeds as show in Figures (6), (7) and (8) respectively. It can be shown that the average velocities at the cross section A are symmetrical. However, for cross sections CS: D and CS: F the velocities are unsymmetrical and the flow is directed to right side and decreasing with decreasing the passing discharges.

Velocities distribution at cross sections CS: A and CS: D for case of weeds on bed only and density D3 with passing discharge Q1 are shown in Figure (9). Velocity measurements are repeated at section D after rotating the plastic sheets for the entire length of infested area by weeds by angle 180°, which was nominated cross section CS: D-r, to show if the velocities were affected by methods used to distribute and fasten the flexible roughness elements. It can be observed that the velocity distributions are completely identical for the two cross sections CS: D and CS: D-r.

4- SUMMARY AND CONCLUOSIONS

The experimental work was conducted in trapezoidal cross section infested by submerged weeds to study the phenomenon of directing the flow to the right side in vegetated channels. Velocities were measured on several vertical and cross sections.

Analyses of the experimental results showed that the velocity profile distribution was not uniformly distributed in channel infested by submerged weeds; and the weeds distribution on bed and weeds density affect the velocity distribution. It can be concluded that the flow was directed to the right side in case of weed distributions B2S and B with different selected weed densities and discharge. It can be deduced that the presence of submerged weeds on channel bed had a great effect on flow direction. Furthermore investigation for studying the phenomenon of directing the flow towards the right side was required.

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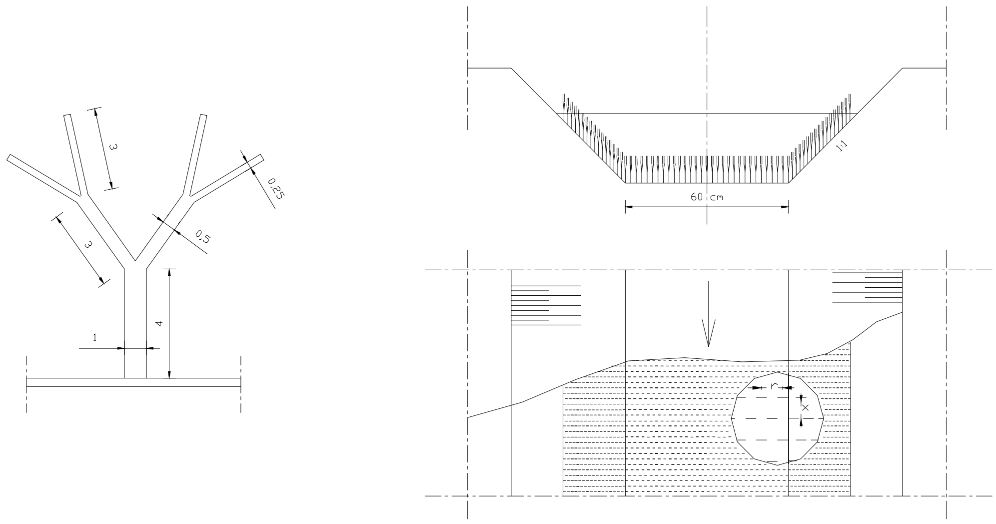
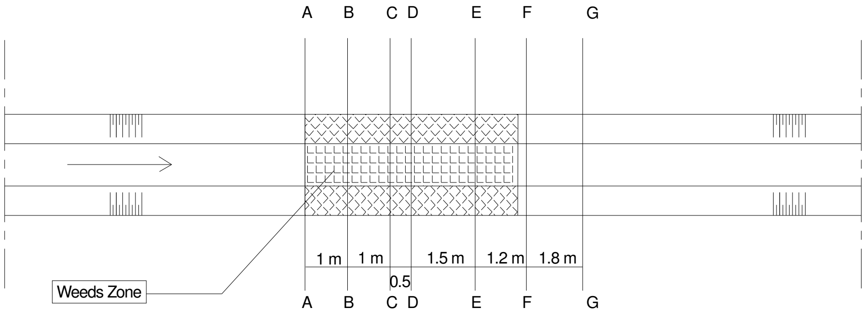
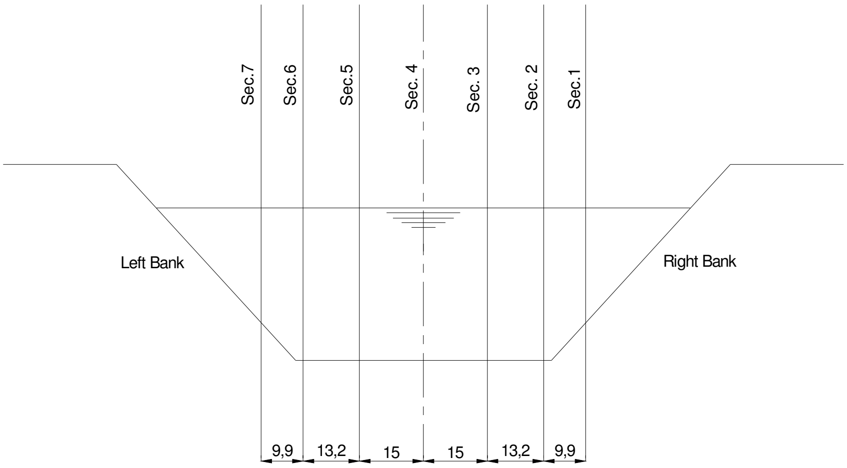


Figure (1): Roughness elements shape and distribution (the dimensions in centimeter).



Cross sections for measured velocity profiles



Vertical sections for measured velocity profiles

Figure (2): Sections of measured velocity profiles.

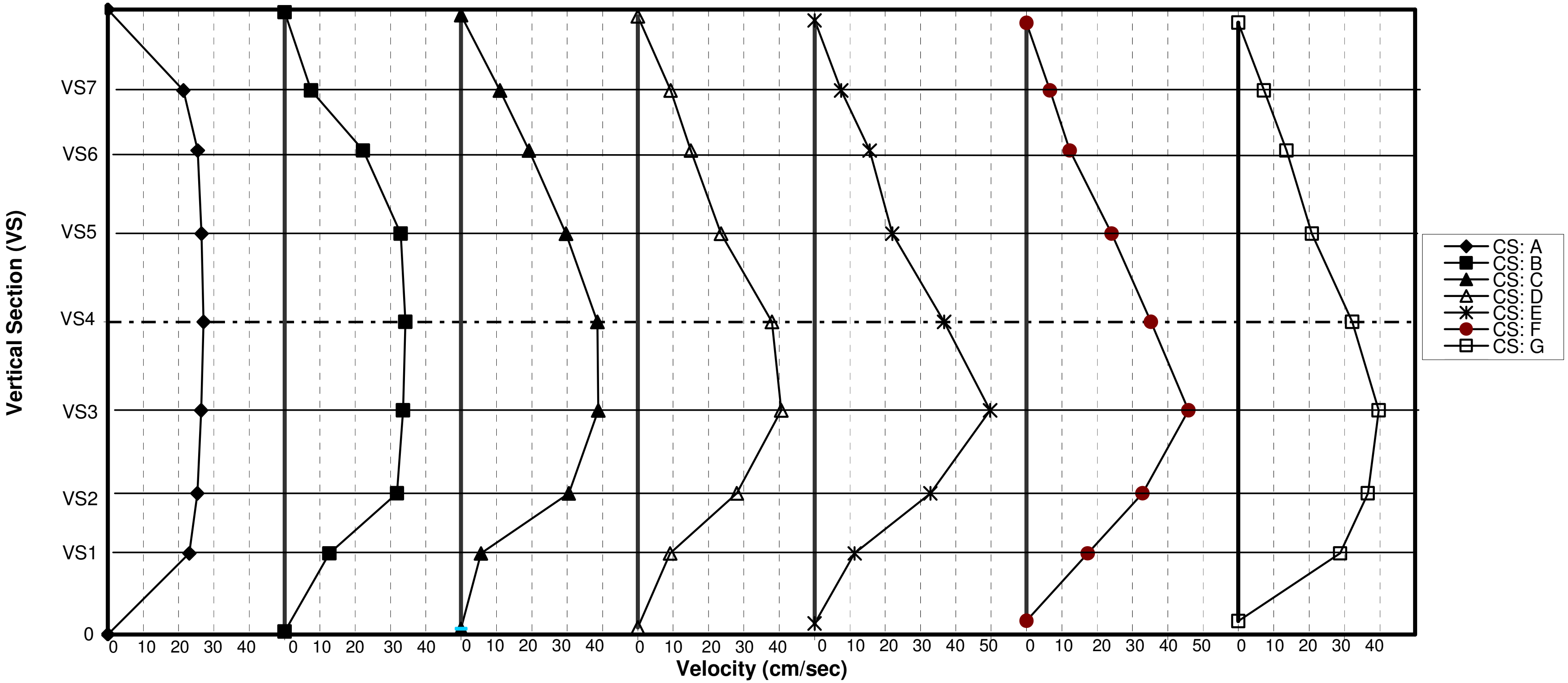


Figure (3): Velocities distribution at seven cross sections in case of weeds on bed and two sides, weed density D3 and passing discharge Q1.

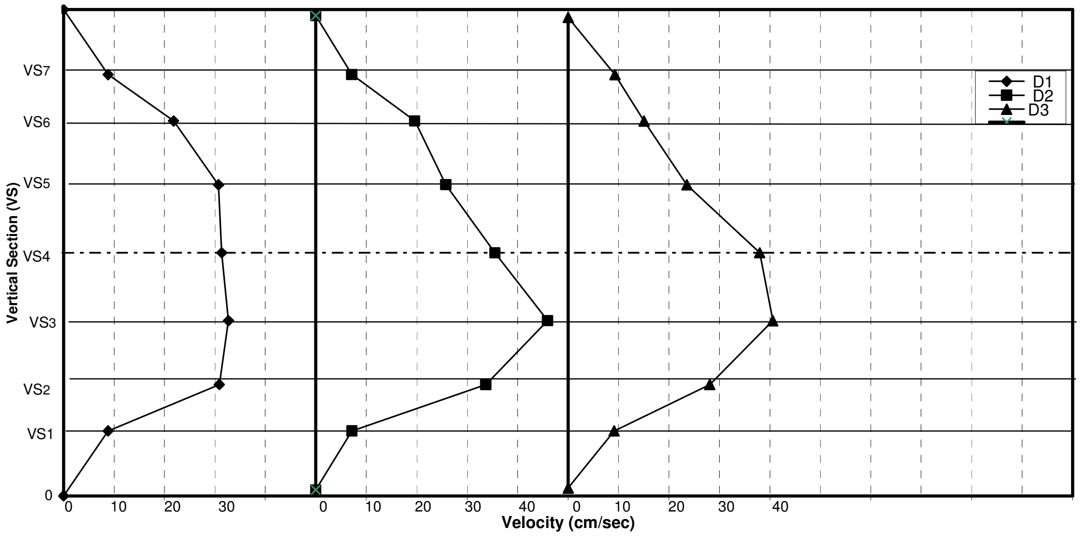


Figure (4): Velocities distribution at cross section CS: D for different weed densities in case of weeds on bed and two sides and passing discharge Q1.

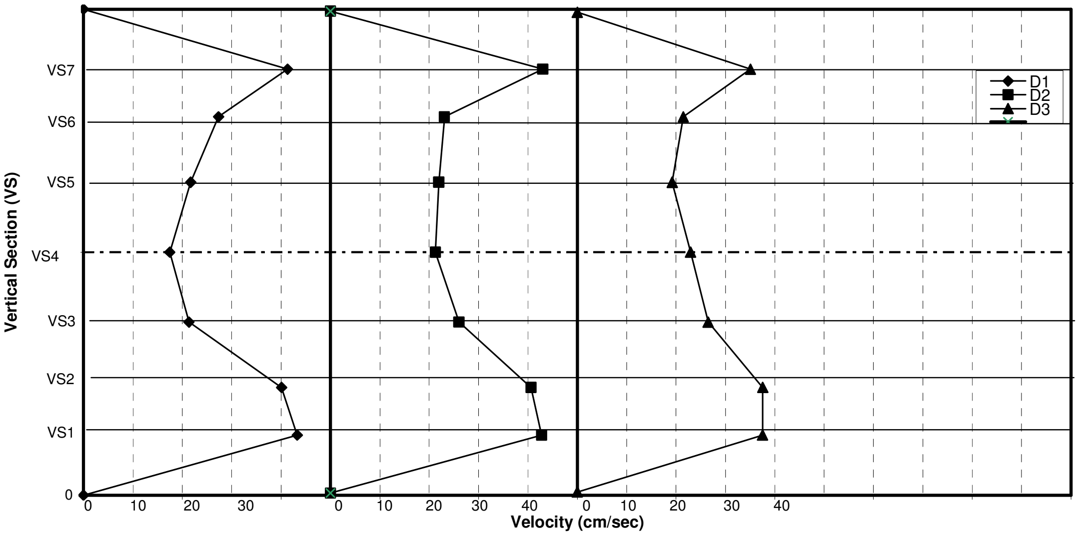


Figure (5): Velocities distribution at cross section CS: D for different weed densities in case of weeds on bed and passing discharge Q1.

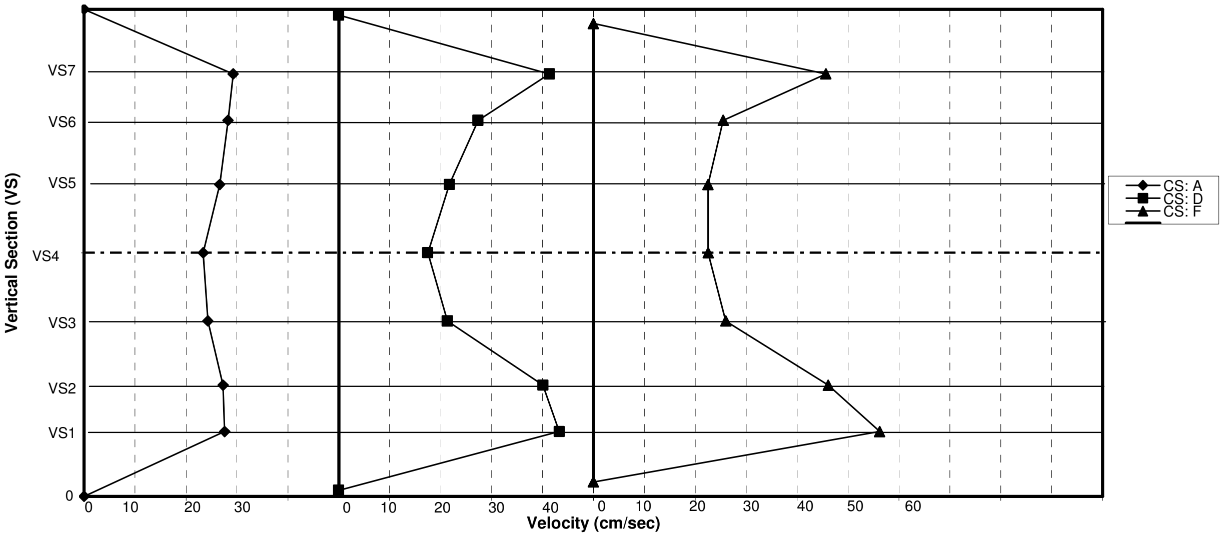


Figure (6): Velocities distribution at three cross sections in case of weeds on bed, density D1 and passing discharge Q1.

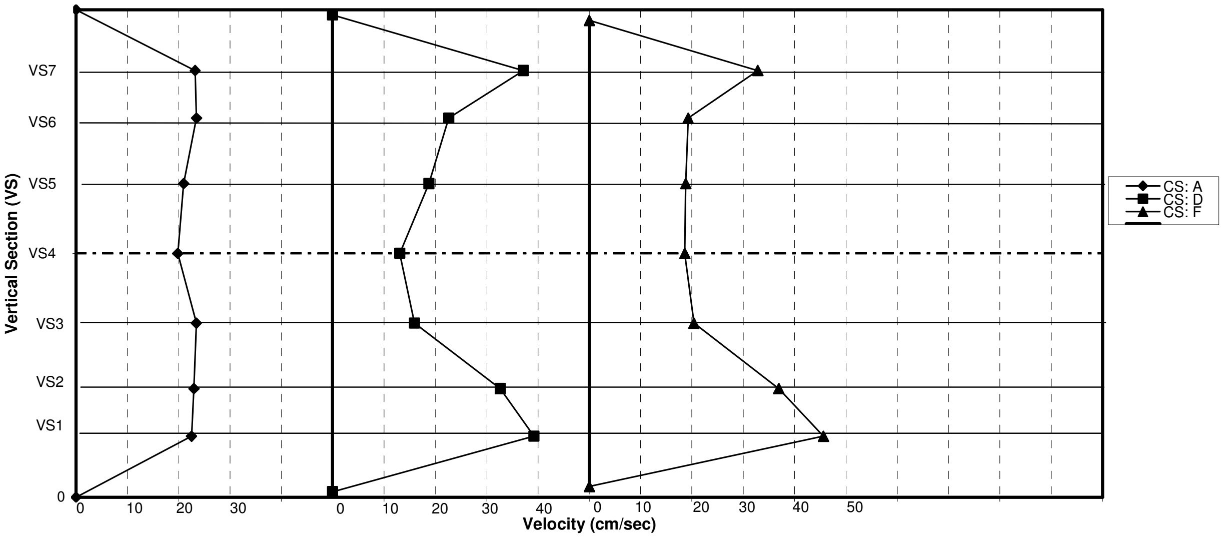


Figure (7): Velocities distribution at three cross sections in case of weeds on bed, density D1 and passing discharge Q2.

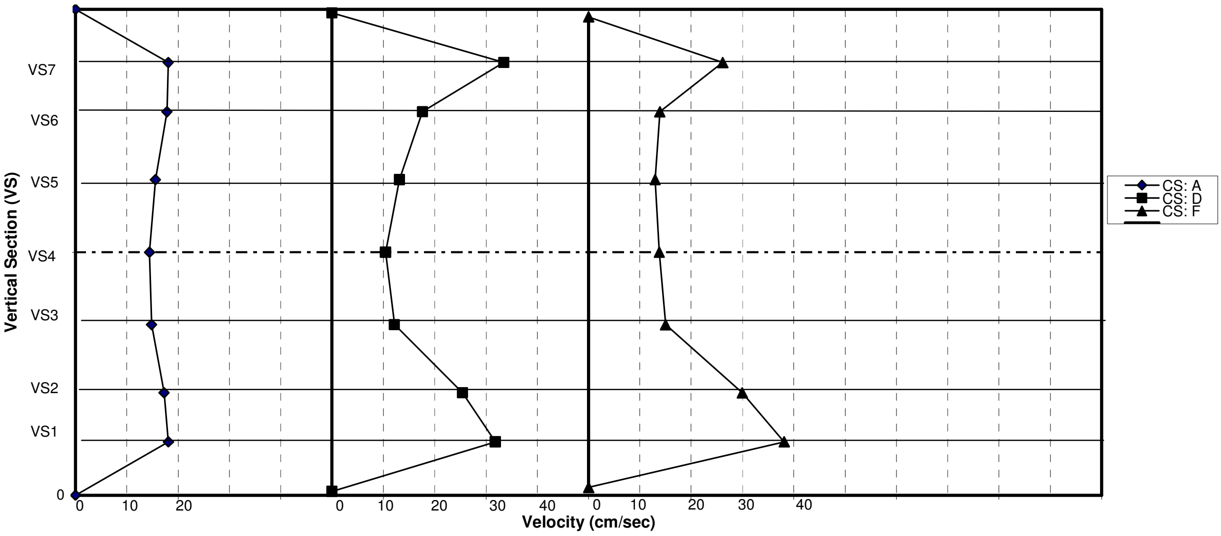


Figure (8): Velocities distribution at three cross sections in case of weeds on bed, density D1 and passing discharge Q3.

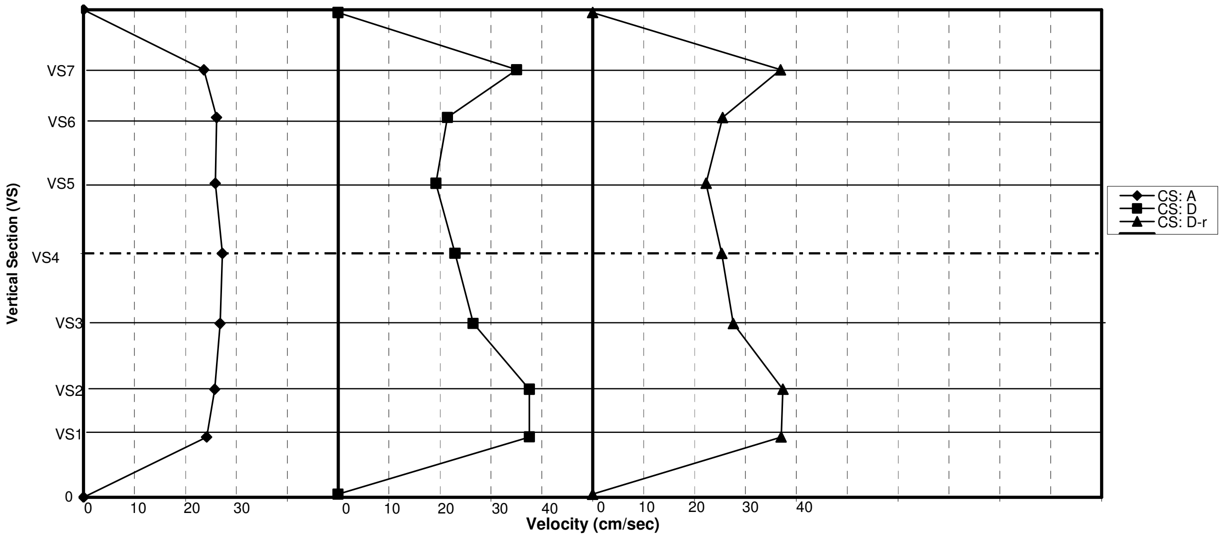


Figure (9): Velocities distribution at cross sections A, D and D-r in case of weeds on bed, density D1 and passing discharge Q1