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Evaluating how to control the Sediments to be entered the Intake Channels in a 180-degree arc by the Submerged Plates

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Abstract

A method that is very helpful for controlling and reducing the sediments entering the intake is to use submerged plates. They are small walls made of metal, wood, etc., installed at a well-defined angle to the orientation of the water flow, creating a rotational flow surrounding themselves and removing the sediments from the intake opening, causing the ones entering the intake to be reduced. Among other benefits of these plates are their low cost and easy structure, which has converted the method to one of the top ones in different uses. In the current study, it has been tried the effect of variables such as the angle and rate of the plate distance by building an experiment model (180 °) to be investigated by a twisted radius of 3 and the intake location of 115 ° with an intake angle of 45 ° under various hydraulic conditions. The rate of the sediment entered into the intake increases with increasing the discharge ratio of intake, also regarding the best placement angle of plates, the angle of 15 ° used to install the plates has a higher reduction rate of the sediment entered to the intake due to not avoiding passing the flow lines forward the intake and hitting less with them relative to other angles; also, the least sediment entered to the intake was observed in the distance rate of 0.2 (the rate of the transverse distance to the longitudinal distance of plates) due to the eddies producing, it can have the larger reduction ratio.

1. Introduction

At first, the basics and design of submerged plates were expressed by some scientists in the U.S.A, known as Iowa plates. The main specificity of submerged plates is that the second flow is created backward due to the pressure difference on both sides of the plate, which transfers the bed sediments to the river and creates an erosion slot in front of the intake opening. As a result, it is prevented from entering the bed sediments to the intake channel. These plates create a rotation in the downstream flow whose spread produces transverse shear stress in the bed river where the bed sediment exists. The existing eddies on the bottom edge of the plate have been transferred through the flow to the downstream and form the larger ones. These eventually create a twisted movement and cause the shear stress of the bed and topography of the river bed to be changed. They are known as Iowa plates as well because of their origin and,

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likewise, their short-term history. They could have the effective role of removing the sediments of the bed load from the intake opening and controlling those entered into them (Barkdoll et al., 1995). For other benefits of these plates, we can refer to the low building cost and simple structure, which have converted the use of submerged plates to the best method in different usages.

Literature review showed that sedimentation of intake structure is of the main problems in river engineering, and many researchers focused on to control it (Emamgholizadeh et al. 2005, Emamgholizadeh & Torabi 2008, Aminian et al. 2019)

Nazari & Shafaie Bejestan (1998) have proposed the angle of 60° due to creating the maximum discharge ratio of intake with the minimum amount of the sediment by doing 34 experiments on discharge ratio of intake of the 90-degree arc flume in a position of 60° with 5 different discharge ratio of intake angles (15°, 30°, 45°, 60°, and 70°) along with a moving bed. Abolghasemi (2015), the required sediments were granulated in the soil mechanics laboratory mechanically. The granularity results indicated that the average diameter of sediments is equal to 0.5 mm, their density 2.65, and their uniformity coefficient 1.25 ($\sigma = \sqrt{\frac{d_{84}}{d_{16}}} = 1.25$). So, Abolghasemi (2015) investigated the change of the threshold height in the amount of sediment entering into the lateral intake in a constant situation by doing lab studies on a physical model of the Meander waterway.

Barkdoll et al. (1995) used the submerged plates to control the sediment on the intake opening of the plant. In this way, 70-80% of sediments entered into the intake have been reduced. The low distance of plates has caused the performance of plates for controlling the sediments entering into the intake to be reduced. Wang et al. (1996) created the numerical model of the flow solution along with the submerged plates and examined the results by measuring the prototype. The result of this model has well matched with the prototype measurements, and sedimentation of the opening inlet has been reduced. Michell et al. (2006) used the composition of the separating wall and the submerged plates in front of the opening input of the intake utilized in this study to solve the problem of sediments entering into the thermal plant of the Muskingum River, and the angle of plates was selected to be equal to 22° and their length 3 times the height of the plates. Abdel Azim & Fahmy Salah (2010) indicated that when using a row of submerged plates. The best place for installing these vanes has been diverted to half of the channel width.

Abul Qasimi (2015) performed studies in order to investigate the effect of the longitudinal distance of submerged plates and control the sediment entered into the lateral intake straightforwardly. They investigated the zigzag arrangement effect of plates as well. This researcher proposes the longitudinal distance of $4H$ (four times the plate height) in the longitudinal distance direction of the plates. He also states that the impact of submerged plates with a regular arrangement is more than a zigzag one Yonesi et al (2008) have studied the optimization of the submerged plate system in order to control the sediment that enters into the intake of rivers. The results show the fact that first, the arrangement and submerged plate system is optimized to design the used one to prevent sediments entering into the intake opening for the best results because of specific parameters of the flow and river sediment. In research, Sajdi & Habibi (2002) showed that the plate arrangement for the longitudinal distance of 4, 3, 6 times the plate height causes the amount of sedimentation to be reduced in the intake opening, respectively. Hasanpour (2006) studied the use of submerged plates composed of floor plates and surface ones. In a study,

In order to reduce the sediment entering the lateral intakes, they can be placed at the external arc of rivers. So, the use of submerged plates can be considered as one of the other methods for controlling sediment intake. Therefore, it is well-defined that many studies can be performed regarding the use of these plates in the arc to divert the sediments entering the intake. In this research, based on the presented recommendation by Yonesi et al. (2008), the intake place was chosen at the position of 115° from the external arc, and the intake angle was equal to 45°

2. Material and Methods

Many rivers have angles of more than 90°. They are sinusoidal, and due to extending the second flow, the way of their flow formation is specific. So, in the current study, a flume with an angle of 180°, fixed curvature radius, and a rectangular section were built. The experimental flume was designed and implemented in the sediment lab of the Khuzestan Water and Power Organization, where its different dimensions have been given in Table 1.

Table 1. The specifications of the lab flume.

Total length of the flume (m)	The length of the input channel (m)	The length of the output channel (m)	Curvature radius (m)	The length of the output arc (m)	The length of the input arc (m)	The width of the channel (m)	The ratio of the curvature radius of the arc width	The height of the channel (m)	The arc angles
18	6	4	1.8	6.6	4.7	0.6	3	0.6	180

The wall of the lab flume is made of transparent glass with a thickness of 6 mm till its wall roughness effect is reduced, and the hydraulic phenomena can be observed in the flume. Also, the floor of the flume is made of a metal sheet (3 mm). Figure 1 shows the body of the lab flume in the current study.

Figure 1. The body of the lab flume.

The lateral intake was installed at an angle 45° in the position of 115° from the external arc of the lab flume. The length of the intake channel is equal to 2 m, and the floor slope is 0. The intake width has also been selected based on the recommendation of researchers. Sajdi and Habibi (2002) showed that when the ratio of the intake width to the width of the main channel is between 0.12 and 0.5, the change of this ratio has no effect on the amount of the diverted sediment ratio. So, in this research, the value of 0.34 was used for the ratio of the intake channel width to the length of the main one; therefore, the width of the intake channel was considered 20 cm. A triangular overflow of 90° was placed at the beginning of the flume to measure the flow rate.

The metal inlet was designed experimentally based on the force induced by the water flow to be able to set the desired height of the flow easily (Figure 2).

Figure 2. The sliding inlet for setting up the flow height.

To supply the volume of the required water of the lab, the open square tank ($0.7m \times 3m \times 4m$) with a capacity of 9600 $litr$ was designed, built, and implemented. To transfer the water from the intake to the pumping place and create the water supply cycle, an open rectangular channel ($0.6m \times 1m \times 10m$) with a capacity of 6000 $litr$ was built. To gather the flow and output sediments from the lateral intake as well as measure the flow, another square ($0.6m \times 2m \times 2m$) was built at the front of the transferring channel of the tank, which transfers the flow passing from the overflow to the rectangular channel. It is noted that the tanks are made of building materials (blocks and cement.

To create a flow cycle in the lab flume, a sludge pump (floor pump) with a power of 11 kW was used, and the diameter of its suction/discharge pipe was 6 inches.

The required sediments were granulated in the soil mechanics lab mechanically. The result of the granularity indicated that the average diameter of sediments is equal to 0.5 mm, their density 2.65, and their uniformity coefficient 1.25 ($\sigma = \sqrt{\frac{d_{84}}{d_{16}}} = 1.25$). So, the sediments used in this study are in the range of uniform materials.

Based on the limited facilities as well as many follow-ups regarding the use of a sediment injection system with a fixed leaving rate of sediments, unfortunately, such a system didn't exist in practice; thus, the researcher decided to design and build a sediment injection system to solve this problem. The first way is to inject the dry sediment due to the fact that, after using the sediment, it requires a long time to dry. This option was not possible, so we examined the sediment injection solutions in a wet or completely saturated form and eventually designed and built a device mixed up of a rectangular cube (above), a cone (below), and an embedded valve (1 inch) for setting the output sediments in this regard.

In order to investigate the correct function of the sediment discharge device, several experiments were performed. In these experiments, the amount of sediment leaving the device in the range of different times was evaluated per different heights of sediment. The results show that the amount of device injection in the range of different times varies in a linear form that indicates the uniformity rate of sediments leaving the device. It is noted that the discharge value of the sediment injection is equal to 1521 cm^3 equivalent to $4kg/min$. In this study, metal sheets with a thickness of 3mm were used for building the submerged plates. The submerged plates with a length of 6 cm and a fixed height were cut. The tests are carried out until the sediments settle completely

2.1. Dimensional analysis

As the current model is qualitative and considering the fixed parameters, the impact of other ones on the amount of sediment entering the intake will be examined. So, as the first step, it should be specified the variables affecting the amount of sediment entering the intake channel and then, using Buckingham's π method, the dimensionless parameters are determined. In this way, the variables affecting the amount of sediment entering the intake are given in equation 1:

$f(Q_m, Q_d, V_m, V_d, Y_m, g, \mu, \upsilon, \rho, \rho_s, D_{50}, G_m, S_m, S_d, B_m, B_d, n_m, n_d, \alpha, \varphi, \delta_n, \delta_s, \delta_b, \alpha_v, n, H, L) = 0$ (1)

In equation 1, Q_m is the flow rate of the main channel, Q_d that of the intake, V_m the flow speed on the main channel, V_d the flow speed at the intake, Y_m the flow depth at the main channel, g the acceleration of gravity, μ the dynamic viscosity, υ the kinetic viscosity, ρ the fluid density, ρ_s the sediment density(gs=1.68), D_{50} the average diameter of sediments, G_m the discharge of the sediment entering the main channel, S_m the slope of the main channel, S_d the slope of the intake channel, B_m the width of the main channel, B_d the width of the intake channel, n_m the roughness of the main channel, n_d the roughness of the intake channel, α the angle of the intake relative to the flow extension, φ the angle of the intake placement in the arc, δ_n the effect of the transverse distance (row) of submerged plates, δ_s the longitudinal distance (in the middle) of submerged plates, δ_b the placement distance of submerged plated from the intake or beach, α_v the angle of submerged plate placement, n the number of the plate rows, H the height of submerged plates, and L the height of submerged plates.

To perform the dimensional analysis, the parameters of Q, ρ, and H were utilized as the repetitive variables, so the dimensionless parameters are given in Table 2.

Table 2. The fixed and varied dimensionless parameters of this study.

No	Parameter	No	Parameter	No	Parameter
1	$\frac{Q_d}{Q_m}$	9	$\frac{D_{50}}{H}$	17	S_m
2	$\frac{V_m \times H^2}{Q_m}$	10	$\frac{G_m}{Q_m}$	18	S_d
3	$\frac{V_d \times H^2}{Q_m}$	11	$\frac{B_m}{H}$	19	n_m
4	$\frac{Y_m}{H}$	12	$\frac{B_d}{H}$	20	n_d
5	$\frac{g \times H^5}{{Q_m}^2}$	13	$\frac{\delta_n}{H}$	21	α
6	$\frac{\mu \times H}{\rho \times Q_m} = R_e$	14	$\frac{\delta_s}{H}$	22	φ
7	$\frac{\upsilon H}{Q_m}$	15	$\frac{\delta_b}{H}$	23	α_v
8	$\frac{\rho_s}{\rho}$	16	$\frac{L}{H}$	24	n

So, the dimensionless parameters $(\pi_{11} . \pi_{12} . \pi_{17} . \pi_{18} . \pi_{19} . \pi_{20})$ are removed from the dimensionless variables. The parameters of depth and speed are also constant in the main channel due to its fixed flow rate. Also, due to the fixed flow properties, including Gravitational acceleration and kinematic viscosity, the dimensionless parameters $(\pi_2 . \pi_4 . \pi_5 . \pi_7)$ are removed from the dimensionless variables. The discharge of the sediment in the main channel is constant, and the sediments with uniform granularity and fixed kind are utilized in the experiments, so the dimensionless parameters $(\pi_8 . \pi_9 . \pi_{10})$ are removed from the dimensionless variables. As the Reynolds number of the flow or the same dimensionless parameter (π_6) is in the range of turbulent flows ($R_e = 26315$), so it can be ignored from the viscosity effects versus inertia; therefore, the dimensionless parameter (R_e) is left among the dimensionless variables. The position of the intake and the diverted angle of that in this research have been considered constant based on the research done by Dehghani et al. (2006). So, the dimensionless parameters $(\pi_{21} . \pi_{22})$ are removed from the dimensionless variables. The dimensionless parameters $(\pi_{15} . \pi_{16} . \pi_{24})$ are removed from the dimensionless variables because of the fixed dimensionless parameters of submerged plates, such as the distance of the plate placement from the intake or beach, the length of plates, and the number of their rows. There is another dimensionless parameter due to a combination of the dimensionless parameters $(\pi_{13} . \pi_{14})$ that this parameter is considered a variable in the experiments and shown as a dimensionless parameter ($\frac{\delta_n}{\delta_s}$).

Based on the dimensionless parameters ($\pi_1 . \pi_3$) dependent on each other, the second parameter is also used automatically, considering one of these two dimensionless ones. So, the dimensionless parameter (π_3) is removed from the dimensionless variables. Eventually, the dimensionless numbers below are considered to investigate the effects of variables on the sediment entering the intake:

$$G_r=f\left(\frac{Q_d}{Q_m},\frac{\delta_n}{\delta_s},\alpha_v\right) \quad (3)$$

In the above equation (G_r) is the ratio of the diverted sediment (the diverted sediment discharge to that entering from the upstream) and ($q_r = \frac{Q_d}{Q_m}$) is the discharge ratio of intake (the discharge of the intake channel to that of the main one).

2.2 Selecting the range of changes in the studied parameters of the submerged plate investigation

The geometry of plates is specified by two dimensionless parameters, i.e. (H/L) and (H/Y) that the height of plates is H, their length L, and the water depth Y. Other design parameters of submerged plates include the length and width distances of plates ($\delta_n.\delta_s$), the distance of the first row of intake or beach plates (δ_b), and the angle of plates relative to the flow (a_v), (Figure 3). In this study, the parameters include the placement angle of submerged plates with angles of 15°, 20°, and 25° and distance ratios (the transverse distance to the length distance of plates) with values of 0.1, 0.15, and 0.2, and the discharge ratio of intake of 0.3, 0.35, 0.4, and 0.47 are investigated, and based on the limitations such as time, space, and lab. facilities, the range of changes in the flow parameters was chosen. In this study, 4 submerged plates in 2 rows and a fixed column were considered. It was always tried the placement position of the first plate to be 109.5° and that of the second one in the middle of the intake 115°.

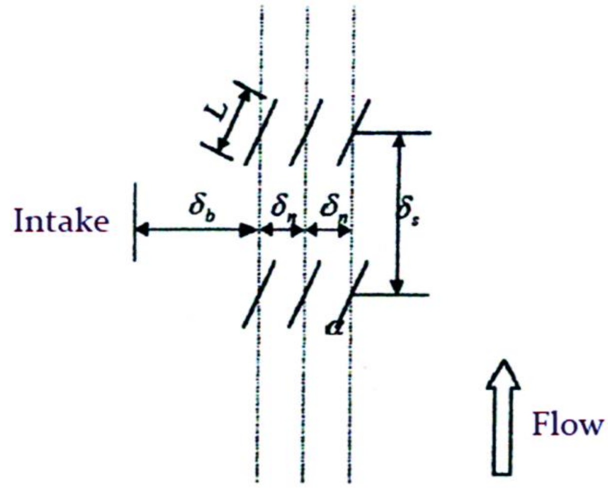

Figure 3. The parameters of submerged plates.

In this research, considering $Y = 8cm$, the value of the plate height for a two-row arrangement is constant and equal to 2cm so that in each row, there are two plates in the middle of the intake and two plates upstream of the intake. According to Edgard's recommendation, who has introduced the proper value of the plate length ($L/H_v = 2 - 3$), the L value is fixed and equal to $H_{v3} = 6cm$.

In this study, the distance of the submerged plates from the targeted intake opening (δ_b) is fixed and equal to 6cm. The row distance of plates from each other is expressed based on the ratio of ($\frac{\delta_n}{H_v}$); and based on Montasery's recommendation, it is equal to 1, 1.5, and 2, which, eventually, δ_n is equal to 2, 3, and 4.

In order to investigate the effect of the parameter, i.e., the angle effect of the submerged plate placement (α_v), and according to the past studies, the range of the optimized changes in the angle is defined as equal to 15° and 35°, so in this research, the angles of 15°, 20°, and 25° were considered as variables.

The parameter value of the diverted discharge ratio based on past studies varies, and in this research, the range of the change in the diverted discharge ratio was selected from 30 to 47% of the flowrate on the main channel, i.e., 30%, 35%, 40%, and 47%. The way change in the diverted discharge ratio is also such that at the end of the intake channels and the main channel, the inlets have been designed and implemented, that the amount of the flow diverted into the lateral intake was set by concurrent setting of two inlets.

2.3. How to do the experiments

After removing the excess flow from the baffle, the flow passes slightly over the 90-degree triangular overflow and is directed into the flume. After passing through the direct path of the flume with a length of 6m, it enters the arc. The water flow after arriving at the lateral intake placed on the second half of the external arc is divided into 2 parts. The part where the flow is diverted into the intake and another that is transferred to the downstream channel after passing the 180° arc, and its direct downstream channel, with a length of 4m, enter into the downstream tank. At the end of the main channel, there is a sliding inlet in order to control the water level, and after passing the flow under the inlet, it enters into the downstream tank of the flume, and then it can pass slightly over the standard triangular overflow. In this way, the depth of the overflow can be read, and the flow rate can be obtained from the stage-discharge relationship. After passing the flow over the overflow, the flow is redirected to the ground tank and is placed in the water supply cycle.

The flow diverted into the intake is entered into a relatively small sedimentation tank, and there are embedded bags to trap the sediment grains in that tank. The water flow after passing the sedimentation tank is directed towards the ground tank by the transferring channel. A schema of the tank and the channel that transfers the flow to the ground tank has been given in Figure 5.

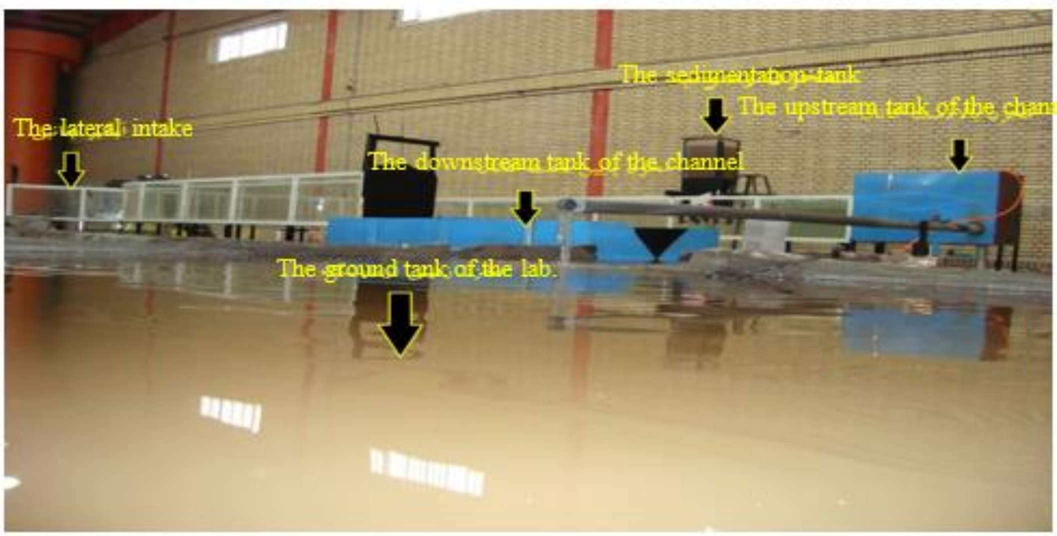

Figure 4. Schema of the laboratory flume and related equipment.

Figure 5. Schema of the sedimentation tank downstream to the lateral intake and transferring channel.

The experiments were planned such that they could be performed by 4 ratios of discharge ratios, q_r, 3 ratios of distance (the transverse distance to the longitudinal distance of plates), $\frac{\delta_n}{\delta_s} L_r$, and 3 placement angles of submerged plates, a_v, and eventually, 36 experiments were done. Meanwhile, due to expressing the summary of experiments, the parameters have been shown by a defined symbol, and the way of doing so has been given in Table 3.

Table 3. How to do the experiments.

No.	L_r (0.2, 0.15, 0.1)	α_v (25, 20, 15)	q_r (0.3, 0.35, 0.4, 0.47)
1	0.1	15	0.3
2	0.1	15	0.35
3	0.1	15	0.4
4	0.1	15	0.47
5	0.1	20	0.3
6	0.1	20	0.35
7	0.1	20	0.4
8	0.1	20	0.47
9	0.1	25	0.3
10	0.1	25	0.35
11	0.1	25	0.4
12	0.1	25	0.47
13	0.15	15	0.3
14	0.15	15	0.35
15	0.15	15	0.4
16	0.15	15	0.47
17	0.15	20	0.3
18	0.15	20	0.35
19	0.15	20	0.4
20	0.15	20	0.47

3. Results and Discussion

3.1 Investigating the discharge ratio of intake without using the submerged plates

In four control experiments, the amount of sediment diverted into the intake channel was investigated without using the submerged plate. In these experiments, which were performed for the discharge ratio of intake of 0.3, 0.35, 0.4, and 0.47, the amount of diverted sediment, as well as the volume of the remaining one, was measured for 60 minutes after starting the experiment. We reach the sediment rate entered into the intake by measuring the volume of the sediment passing the discharge ratio of intake (existing in the output channel) and the amount of sediment entered into the intake channel. In this way, the volume of the sediment diverted into the intake channel was divided into the sediments existing in the output channel to make the amount of dimensionless. The obtained value shows the rate of sediment before diverting into the intake. So, according to the information mentioned above, it is observed that the sediments diverted into the intake increase with the rising discharge ratio of intake (Figure 6).

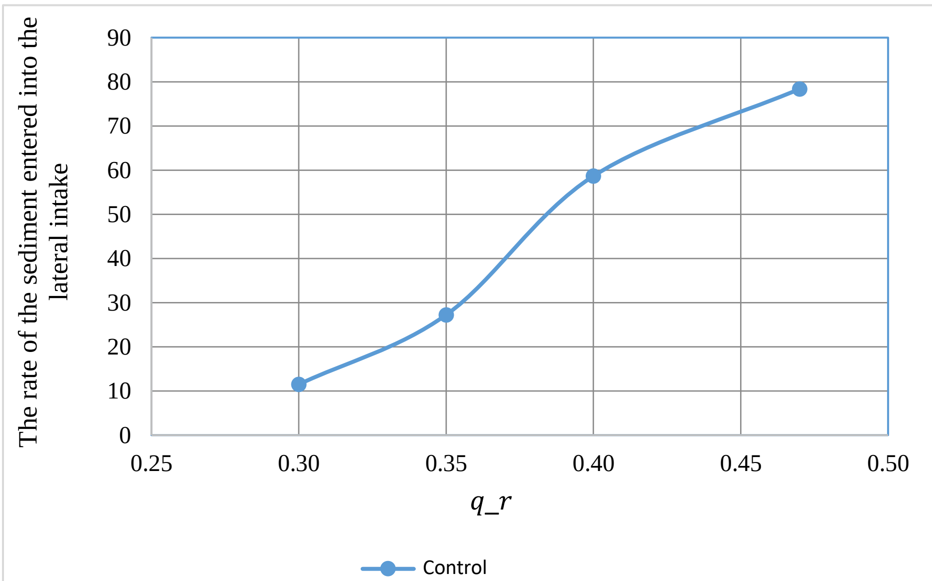

Figure 6. Changes in the sediment rate diverted into the intake against the discharge ratio of intake.

3.2 Investigating the discharge ratio of intake using the submerged plates

To investigate the effect of the submerged plates on preventing sediments from entering the intake, experiments have been done with an external arc of 180° in the discharge ratio of intake state of the channel. In these experiments, performed for each of the series of plates and discharge ratio of intake of 0.3, 0.35, 0.4, and 0.45, the amount of the diverted sediment, as well as the volume of the sediment entered 60 minutes after starting the experiment, was measured in a different state of the plate placement.

3.3 Investigating the effect of the discharge ratio of intake

The amount of sediment entered into the intake increases with the rising discharge ratio of intake (Q_d/Q_m) in all distance ratios of 0.1, 0.15, and 0.2 (the transverse distance to the longitudinal one of plates) as well. Also, this chart shows that the amount of sediment entered into the intake decreases by reducing the distance ratio of plates and installing the plates at the angle of 15°. So, according to this chart, the best distance ratio is 0.2, which is rational based on the previous reasons mentioned above.

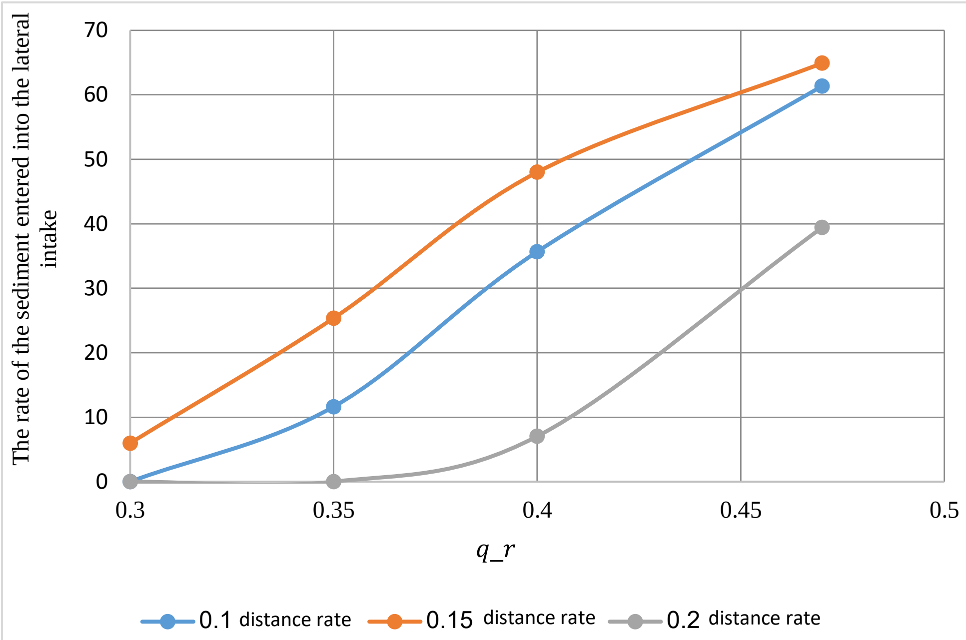

Figure 7. Cumulative diagram for plate angle of 15° based on the variable distance rates.

As you see in Figure 7, the amount of sediment entered into the intake increases with the rising discharge ratio of intake (Q_d/Q_m) in all distance ratios of 0.1, 0.15, and 0.2 (the transverse distance to the longitudinal one of the plates). Also, this chart shows the amount of sediment entered into the intake decreases by reducing the distance ratio of plates and installing the plates at the angle of 20°.

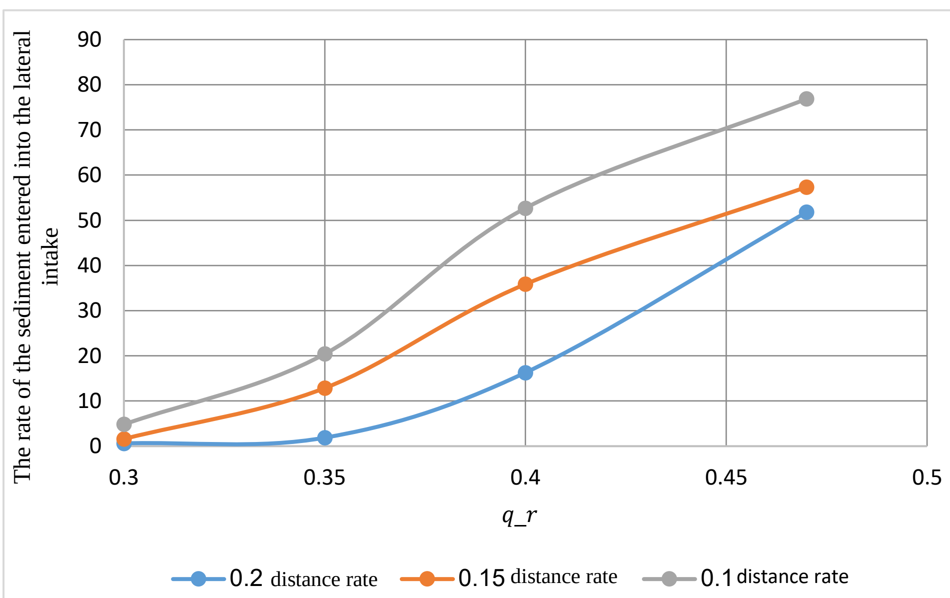

Figure 8. Cumulative diagram for plate angle of 20° based on the variable distance rates.

As you see in Figure 8, the amount of sediment entered into the intake increases with the rising discharge ratio of intake (Q_d/Q_m) in all distance ratios of 0.2, 0.15, and 0.1 (the transverse distance to the longitudinal one of the plates). Also, this chart shows the amount of sediment entered into the intake decreases by reducing the distance ratio of plates and installing the plates at the angle of 25°.

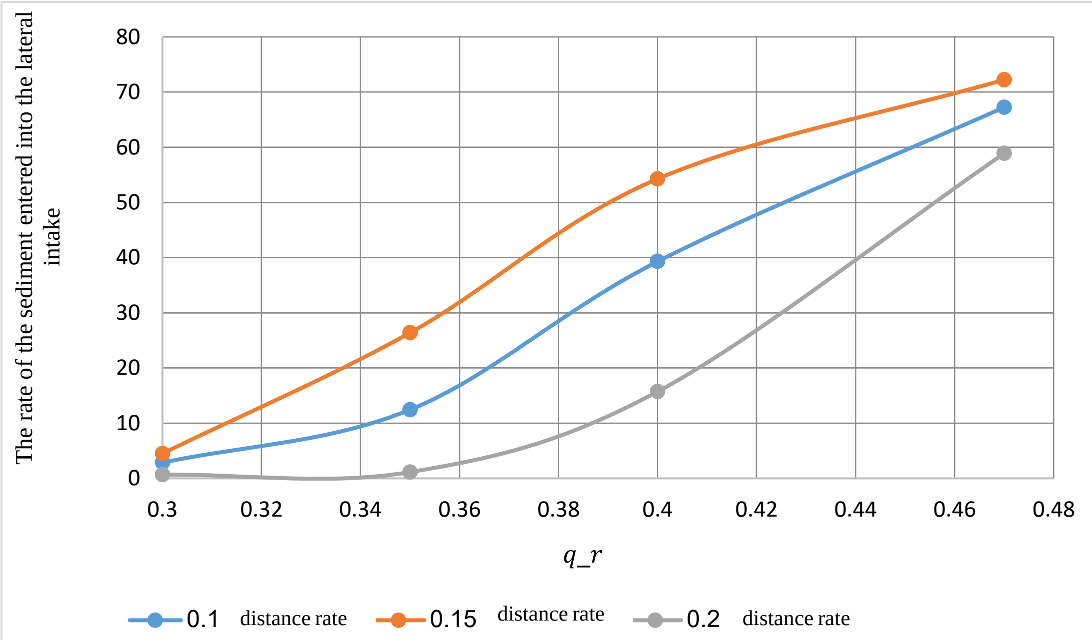

Figure 9. Cumulative diagram for plate angle of 25° based on the variable distance rates.

3.4 Investigating the effect of the distance ratio (the transverse distance to the longitudinal one of plates)

As you see in Figure 9, the amount of the sediment entering into the intake first increases with the rising distance rate of plates in all intake ratios of 0.3, 0.35, 0.4, and 0.47, with a distance ratio of 0.15, and then decreases with the distance ratio of 0.2. Also, this chart shows the number of sediments entered into the intake increases as well with rising the intake ratio and installing the plates at the angle of 15°.

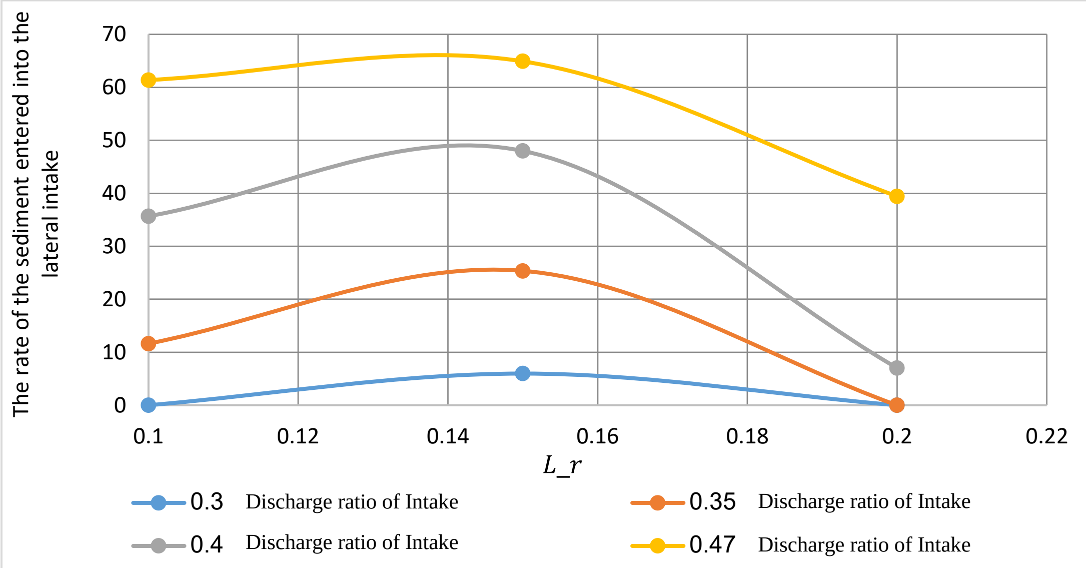

Figure 10. Cumulative diagram for plate angle of 15° and discharge ratio of intake.

As you see in Figure 10, the amount of sediment entering into the intake first increases with the rising distance rate of plates in all intake ratios of 0.3, 0.35, 0.4, and 0.47, and then decreases. Also, this chart shows the amount of sediment entered into the intake increases as well with rising the intake ratio and installing the plates at the angle of 20°.

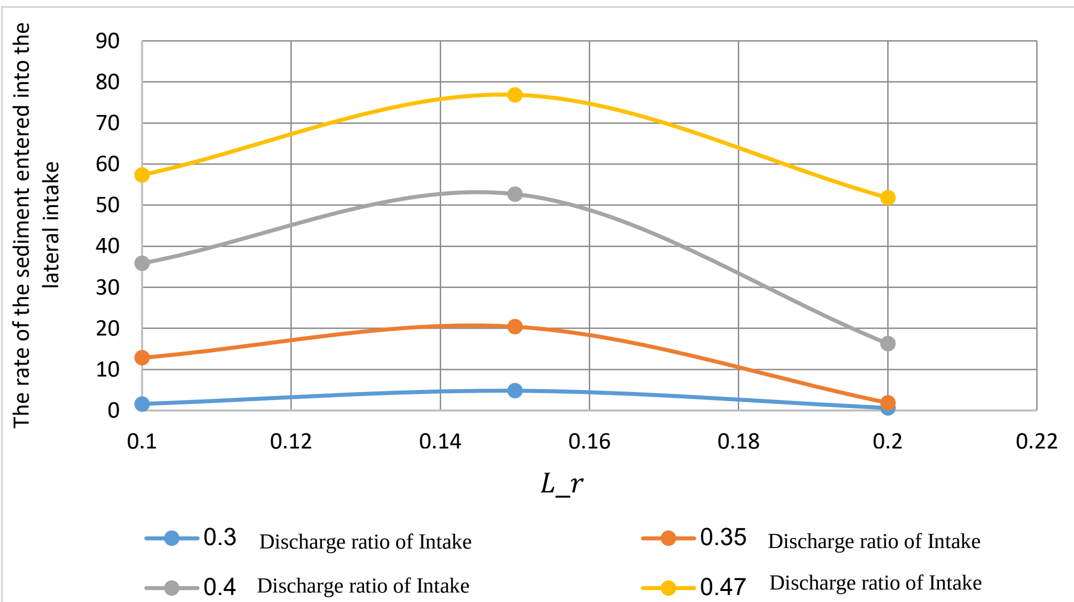

Figure 11. Cumulative diagram for plate angle of 20° and discharge ratio of intake.

The amount of sediment entered into the intake first increases with the rising distance rate of plates in all intake ratios of 0.3, 0.35, 0.4, and 0.47, with a distance ratio of 0.15, and then decreases with the distance ratio of 0.2. Also, this chart shows the amount of sediment entered into the intake increases as well with rising the intake ratio and installing the plates at the angle of 25°.

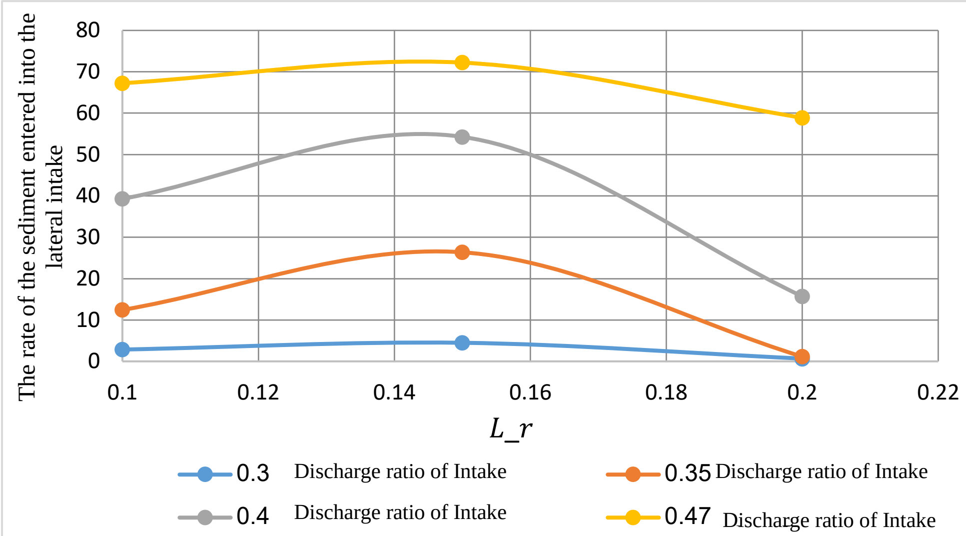

Figure 12. Cumulative diagram for plate angle of 25° and discharge ratio of intake.

3.5 Investigating the angle effect of the plate placement

Some researchers have known the angle producing the maximum power of the second flow is the best angle for the plates in research; the angle of the plate placement can have these properties that create a lower obstruction against the flow lines.

As you see in Figure 13, the rate of sediments entered into the intake is raised by increasing the intake rate (the discharge of the intake channel to that of the main one) throughout the whole state. Also, the process of the sediment entered into the intake is such that the largest sediments are entered into the intake at an angle 20° and the lowest at an angle 15°.

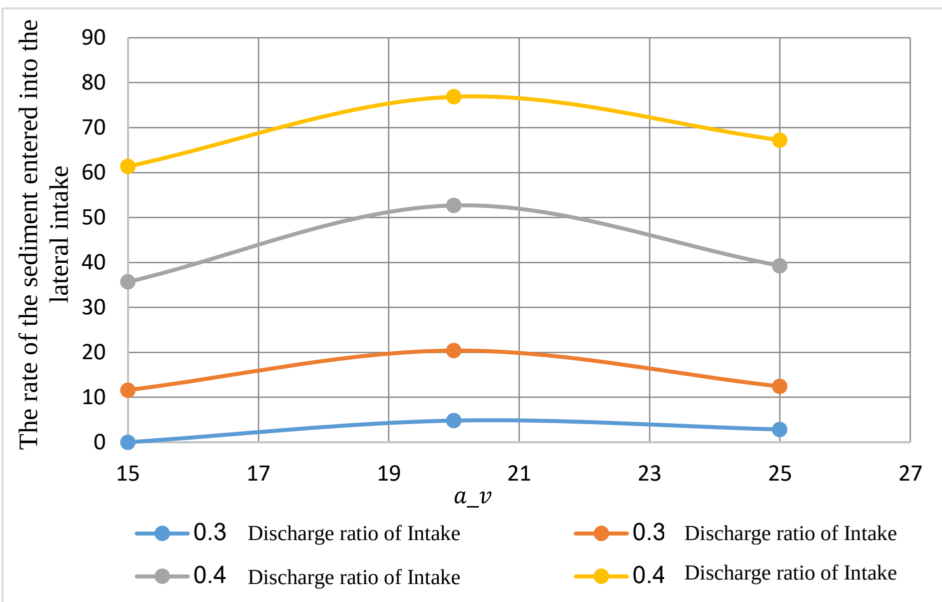

Figure 13. Cumulative diagram for the rate of distance 0.1 and discharge ratio of intake.

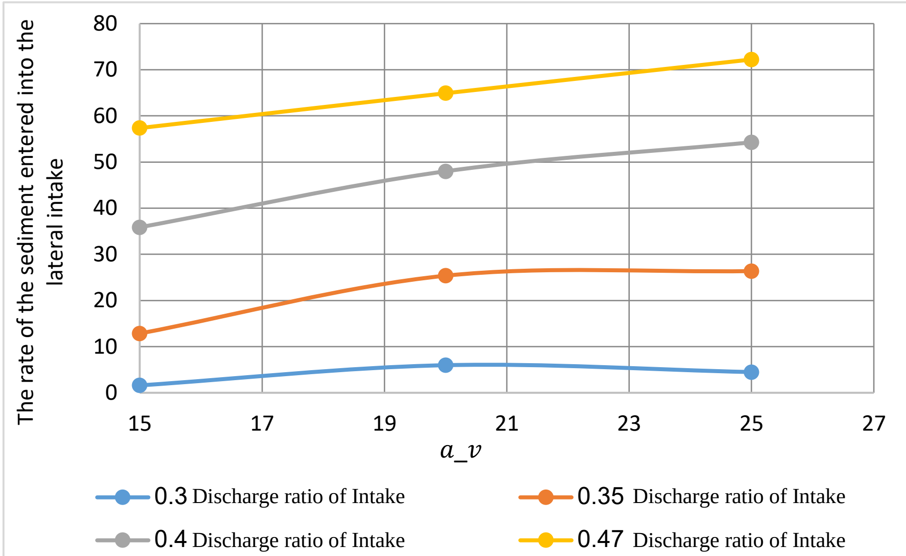

Figure 14. Cumulative diagram for the rate of distance 0.15 and discharge ratio of intake.

If the discharge ratio of intake increases same as all experiments and positions, the amount of sediment entered into the intake increases. While according to the distance rate of 0.15 (the transverse distance to the longitudinal one of the plates), the least amount of sediment entered into the intake is observed at the angle of 15°. Opposing the mentioned angle in this chart, the highest amount of sediment entered into the intake is observed at the angle of 25°.

In this case, we observe the minimum entered sediment, i.e., the rate of distance (the transverse distance to the longitudinal one of plates). In this way, the worst case is 20° due to the position and type of the eddy flow induced by the plates.

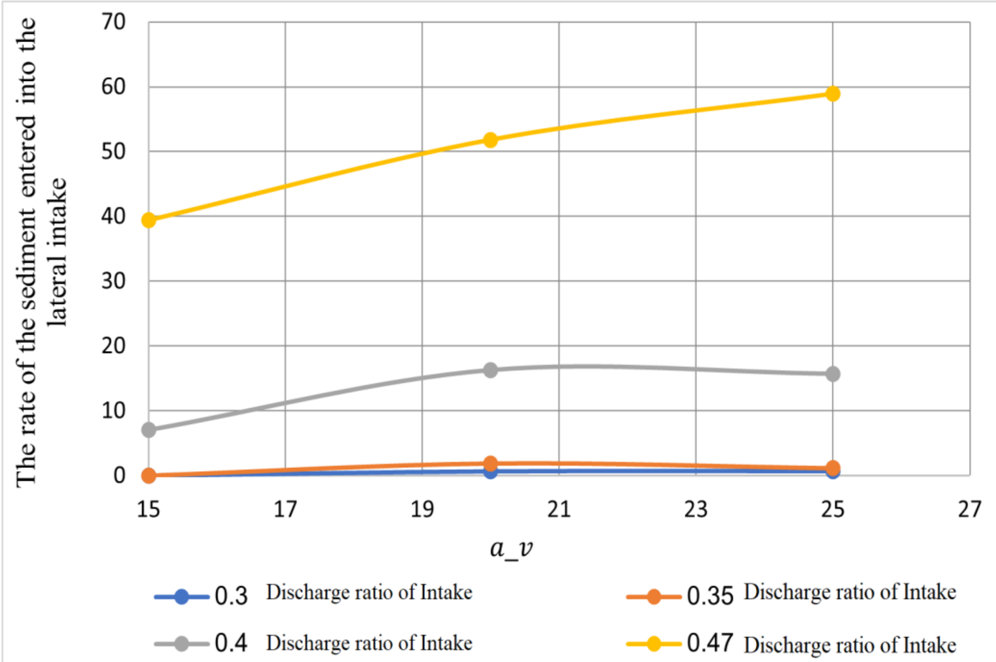

Figure 15. Cumulative diagram for the rate of distance 0.2 and discharge ratio of intake.

4. Conclusions

At higher intake rates, the intake channel creates a negative or suction pressure that the second flow passes forward the intake guided into the intake channel; hence the second ones that have the sediment load drain it away from the intake channel. In brief, the higher the discharge ratio of intake is, the higher the suction created by the intake is, and the larger sediments are entered into the intake as well. But at low discharge ratio of intake, because of the low intake suction as well as the suction power, the lower sediment is entered into the intake; of course, the second flow passing the intake forward has enough power to transfer sediments to the downstream of the intake.

The best angle of the plate placement is the placement angle of 15° relative to the flow direction that has the least sediment entered into the intake. Increasing the angle of the plate placement increases the amount of sediment entering the intake. When the angle of the plate placement is high, the plates are like a blocker versus passing the flow lines toward the intake. This causes the sediments to accumulate behind the plates, and when the discharge ratio of intake increases due to the suction power created by the intake, they are entered into it, but this problem (entered sediments) is lower than the rate of low discharge ratio of intake. However, when the angle of the plate placement is low, there is little sediment in front of the intake because the angle does not prevent the flow lines from passing the intake forward, and they pass easily so that eventually, the sediment is entered into the intake at a higher discharge ratio of intake. In other words, it can be said that the lower the angle of the plate placement in front of the intake is, the lower the sediments are entered into it, and vice versa, and this depends on the discharge ratio of intake to some extent.

Also, the best ratio of the plate distance that includes the least entered sediment of the intake is 0.2. This is because each of the plates creates eddies that can overlap each other, while the created ones avoid passing the sediments between the plates, and so they are able to prevent sediments from entering into the intake to direct towards the downstream. Thus, the amount of sediment entering into the intake decreases as well.

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Conflicts of Interest

The author declares no conflict of interest.

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