Experimental investigation of impact of length and height of parallel skimming walls on controlling inlet sediment to lateral intake

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ABSTRACT

Parallel skimming walls are regarded as one of most applicable methods for gaining a decline in the amount of sediment entering a lateral intake. The parallel skimming walls are installed on the main channel, in front of the intake span, creating a rotational flow and diverting sediments from the intake span, and as a result a reduction in the amount of sediment entry into the intake can be realized. The present paper aims at experimentally studying the impact of length (*L*) and height (*H*) of parallel skimming walls, as well as the effect of discharge shifts associated with the main channel on controlling the inlet sediment into the intake. First, the impact of parallel skimming walls incorporating three lengths ($L = 60$ cm, 75 cm, 90 cm) in front of the intake is investigated, then the impact of skimming walls incorporating three heights ($H = 2$ cm, 4 cm, 6 cm) is scrutinized. After each test, the sediment volume entry (*V*) into the intake was measured. By performing dimensional analysis, dimensionless ratios were obtained and the relation between the variables was determined. The results demonstrated that in the case of parallel skimming walls, the increase in *L* and *H* leads to mitigation in the amount of inlet sediment into the intake. Moreover, there is a proper agreement between the procedure of this study and the previous ones.

Key words | dimensionless analysis, lateral intake, sediment control, skimming walls

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INTRODUCTION

The intake from channels is an important feature in the field of hydraulic engineering. The transportation and accumulation of sediments in the intake channel are problems associated with the use of lateral intake. As the main flow approaches toward the intake channel, stream separation occurs, and the flow is divided into two parts, in such a way that one part enters the intake and the other part flows into the downstream within the main channel.

Parallel skimming walls are used in the main channel located in the intake channel span for reducing the sediment volume entry into the lateral intakes. The skimming wall is a structure consisting of two plates; one of the plates is obliquely attached to the shore with a certain angle, while the other plate parallel to the main stream direction is installed in the main channel, in front of the lateral intake. This structure leads to formation of rotational flow at the downstream and causes a transverse shear stress within the riverbed, where there is maximum sediment concentration (Barkdoll *et al.* 1999). The developed vortices, at the down section of the walls, not only rotate, but also move toward the downstream and lead to greater vortices. The vortices formation location is close to the ending edge head (Odgaard & Wang 1991). Finally, a relative and continuous deep

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groove is formed along the main channel, in front of the intake span, and it drives the sediments toward the downstream. This phenomenon provides the grounds for mitigation of sediment entry into the intake.

Ho *et al.* (2004) developed a physical model for determining the best installation location of the submerged plates to hinder sediment entry into the intake structure located in Rio Grande. The obtained results demonstrated the proper ratios of various factors, which are as follows: ratio of outside-bed height of the plates to follow depth: $\frac{H}{d} = 0.2 - 0.3$, ratio of plate length to outside-bed height of the plates: $\frac{L}{H} = 3$, transverse distance between the plates: $\delta_n = 3H$, longitudinal distance between the plates: $\delta_s = 30H$, distance of the plates from intake shore: $\delta_b = 3H$ and angle of plates with flow: $\alpha = 20^\circ$. Hassanpour (2007) focused on the role of the submerged plates in reducing sediment entry into the lateral intake with an angle of 90°. He studied the control of the inlet sediment into the intake span for various intake ratios and in the case of using the submerged plates with an arranged array with three heights. The results indicated that the submerged plates exhibit a desirable performance in controlling the inlet sediment into the intake, and for an intake ratio of 8%, they can fully prevent the entry of the sediment into the intake span. Esmaeiliveraki (2009) performed experiments to assess the impact of the intake angle on the amount of sediment entering the intake span in a diversion dam. They reported that an increase in the intake angle from 90 degrees to 100 degrees leads to reduction in the inlet sediment of up to 25.1%.

Nazari (2010) experimentally studied the impact of the deviation angle and sill height of the intakes on the control over the sediment amount. Thirty-four experiments were performed on the intake from a curved-plane channel with an angle of 90 degrees in the intake state of 70 degrees with five various angles (15, 30, 45, 60 and 70 degrees) and a movable bed. The obtained results verified that the angle of 60 degrees gives the least amount of inlet sediment into the intake. Seyedian & Shafai Bajestan (2010) studied the impact of the wall slope of the main channel on sediment entry into the lateral intake. The results indicated that the shift in the wall slope of the main channel leads to modification in the flow pattern, so that the sediment entry into the intake is reduced. Moreover, the amount of the suspended inlet sediment into the intake is the least for a Froude number of 0.37.

Abbasi *et al.* (2015) experimentally examined the impact of the intake angle on controlling sediment entry into the intake considering the presence of submerged plates. They reported that the inlet sediment into the intake, with the presence of the submerged plates, depends on the parameters, including Froude number of flow intake angle and the discharge ratio of intake, among which the discharge ratio of the intake is more effective, compared with other factors. The ratio of sediment entry into the intake reaches its minimum and maximum values at intake angles of 90 and 45 degrees, respectively.

Tabrizi *et al.* (2017) surveyed the impact of the spillway structure on regulating the deviated flow pattern into the intakes located at the curve. The results showed that the ratio of sediment deviation is affected by the intake ratio and there is a direct relation between them. The presence of a spillway at the intake reduces the amount of sediment deviation ratio by modifying the flow pattern in the intake entrance. Moradinejad *et al.* (2017) experimentally studied sediment control via skimming walls and installing a spillway at the entrance of the lateral intake. They conducted two groups of experiments. The first group aimed at determining the impact of the positioning, spillway angle and skimming wall, while the latter were accomplished to survey the effect of the skimming wall, in combination with the spillway, on flow deviation and sediment entry into the lateral intake. The results showed that the presence of the skimming walls along with the spillway leads to a reduction in the amount of sediment entry into the intake on average by up to 81%, 78% and 76%, respectively for walls with angles of 10°, 14° and 18°.

Golej *et al.* (2019) experimentally studied the role of structures, including sill, dike and skimming walls, in controlling the sediment for three various intake ratios of 0.17, 0.21 and 0.26. They reported that the combination of the aforementioned structures (sill, dike and skimming wall) possesses the highest control over the sediment in various percentages and there was up to 92% reduction in the inlet sediment, relative to the experiments without a sediment control structure.

Moreover, the studies accomplished by Nakato *et al.* (1990) with a focus on the array and the angle of the submerged plates, by Barkdoll *et al.* (1997) on the combination of the submerged plates with skimming walls, by Nakato & Odgen (1998) on the combination of the submerged plates with sill, and Barkdoll *et al.* (1999) on the array of the submerged plates, the combination of the plates with skimming wall and modification of the intake span are all among the typical research on the same topic. The literature available on the intake is mainly concerned with submerged plates, sill, spillway or a combination of these systems.

Hence, further studies are required in the field, particularly in the case that the parallel skimming walls are installed in front of the intake. In addition, for revealing the impact of the length of the parallel skimming wall and height of the same structure on the amount of the inlet sediment into the intake, the use of two parallel skimming walls is recommended, and a comparison can be made between the cases with and without the structure. Therefore, the main objective of the present research is to use two parallel skimming walls for controlling the sediment entering a lateral intake with an angle of 60° from the rectangular channel. Figure 1 shows the general schema of the research.

The main objectives of the present research include the impact of height and length of skimming walls, intake ratio (Q_R) and Froude number (Fr) on the amount of inlet sediment into the lateral intake. It is worth noting that the available literature on the topic has mostly focused on the submerged vanes, dike and sill, so using the parallel skimming walls should be considered as the novelty of the research.

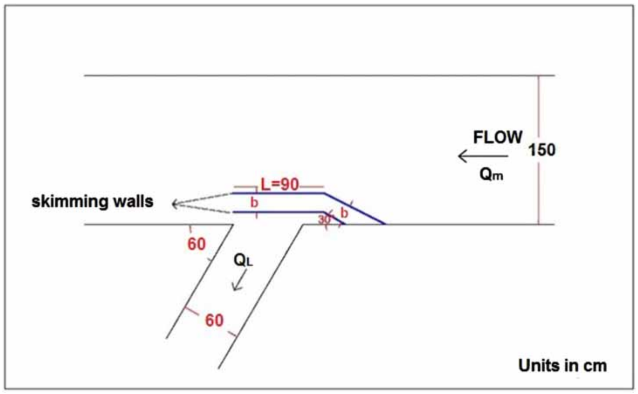

Figure 1 | General schematic of experimental flume and placement of parallel skimming walls.

MATERIALS AND METHODS

As the number of the parameters effective on the entry of the bed load sediment into the intake span is high, so the impact of the parameters is assessed using dimensionless figures. To this end, the dimensional analysis method devised by Buckingham is adopted for developing a series of dimensionless groups. There are numerous parameters which can affect the sediment flow into the intake. These parameters are as below.

Discharge of a stream of the main channel (Q_m), discharge of a stream for the intake channel (Q_l), stream depth in main channel (D), velocity of stream in main channel (V_m), velocity of stream in intake channel (V_L), width of main channel (B_m), width of intake channel (B_L), slope of main channel (S_m), gravitational acceleration (g), flow density (ρ), kinematic viscosity (υ), angle of intake channel with main channel (γ), angle of skimming-wall structure with shore (β), height of skimming-wall plates (H), length of oblique branch of skimming walls (L_0), length of direct branch of skimming walls (L), experiment duration (t), average diameter of sediments (d_{50}), sediment density (ρ_s), bed roughness (K_s), wall distance (b) and volume of sediment entry into intake (V).

The values for γ, B_L, B_m, β, d_{50}, ρ_s, ρ, t, υ, S_m, K_s, L_0, and b are constant, the parameters effective on the phenomenon are determined by applying dimensional analysis and the dimensionless ratios are determined. The ultimate dimensionless relation can be expressed by Equation (1):

$$f\left(\frac{Q_l}{Q_m}, \mathrm{Fr}, \frac{V}{D^3}, \frac{L}{b}, \frac{H}{b}\right) = 0 \tag{1}$$

where, $Q_R = \frac{Q_l}{Q_m}$ denotes the ratio of intake channel discharge to the main channel discharge (intake ratio), Fr refers to the Froude number of the upstream of the intake, $C_s = \frac{V}{D^3}$ is the volume of sediment entry into the intake, divided by the stream depth to the power of 3 (ratio of deviated sediment volume), $\frac{L}{b}$ represents the length of the direct branch of the skimming walls divided by the distance between two skimming walls and $\frac{H}{b}$ is the outside-bed height of the skimming walls divided by the distance between two skimming walls.

The associated experiments were accomplished at the Soil Conservation and Watershed Management Research Institute (SCRI) of Tehran, in a flume 12 m in length, 1.5 m in width and 0.9 m in height incorporating a water circulation system. The intake was realized through a lateral channel with width, length and angle of 0.6 m, 2.5 m and 60°, respectively, relative to the stream direction within the main channel. The main channel with a slope of 0.002, horizontal intake, was aligned with the sedimentary bed of the main channel. The intake channel was located at a distance of 9 m from the upstream stilling pool and a distance of 3 m from the adjustment valve/gate for surface water within the end section of the flume. A closed water circulation system was used for the flume, which provided the required water from the linked ground storages embedded beneath the flume. The discharge entering the main channel was controlled at the pumping station using adjustable control valves. The stream depth was adjusted via valves located at the end of each main channel and intake. For measuring the flow of the main and intake channels, sharp-edged rectangular and triangular weirs (overflows) were adopted, while for measuring the water depth, a point gage was used.

The skimming-wall structure consisted of two branches, and the oblique branches with lengths of 30 cm and 70 cm were attached to the wall of the main channel. One side of these branches of angle 30° with the shore was attached to the intake side, and the other side was attached to the direct branch of the skimming wall. The direct branch with length L and outside-bed height of H was parallel to the direction of the main stream. Figure 2 shows the flume use during the experiments and the placement of the parallel skimming walls.

The sediments used during the experiments were selected in such a way that they had not experienced any suspension and had been transported in the form of bed load. So, sand with an average diameter of 1 mm, specific density of $2.65\frac{\text{gr}}{\text{cm}^3}$, standard deviation of 1.47 and uniformity coefficient of 2.2 was used. The gradation properties associated with the sediment of the channel bottom (base) are presented in Table 1.

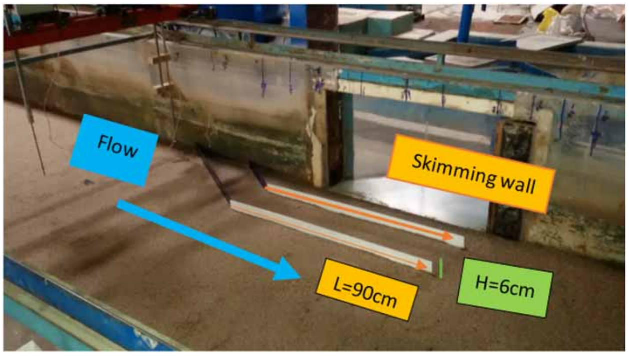

Figure 2 | View of parallel skimming walls installed in front of the intake span, 90 cm in length and 6 cm in height.

Table 1 | Gradation properties of sediments within channel base

D_{10}(mm)	D_{16}(mm)	D_{50}(mm)	D_{60}(mm)	D_{84}(mm)	C_u	σ_g
0.50	0.56	1.00	1.10	1.22	2.20	1.47

The experiments were performed for determining the impact of the direct branch length (L) of the skimming walls and the height of the skimming walls on controlling the sediment entering the intake. The lengths were supposed to be equal to $L = 60$ cm, 75 cm and 90 cm, and the heights were assumed to be equal to $H = 2$ cm, 4 cm and 6 cm. For each situation, experiments with four discharge rates of $30\frac{\text{lit}}{\text{sec}}, 40\frac{\text{lit}}{\text{sec}}, 50\frac{\text{lit}}{\text{sec}}, 60\frac{\text{lit}}{\text{sec}}$ were carried out. After each experiment, the volume of the sediment entering the intake (V) was measured. Table 2 presents the information and shift range for each variable.

RESULTS

The obtained relations and equations are validated using the determination coefficient (R^2) and root mean square error (RMSE). R^2 shows the statistical measurement of the data

Table 2 | Variable values in experiments

Parameters	$Q_m\left(\frac{\text{lit}}{\text{sec}}\right)$	$Q_L\left(\frac{\text{lit}}{\text{sec}}\right)$	D(cm)	Fr	Q_R
Case #1	30	4.8	7.7	0.30	0.16
Case #2	40	11.2	8.1	0.37	0.28
Case #3	50	17.5	8.2	0.45	0.35
Case #4	60	25.8	8	0.56	0.43

closeness to the fitted regression line, which is declared as below:

$$RMSE = \left[\frac{1}{n}\sum_{i=1}^{n}(C_{\mathrm{cal}} - C_{\mathrm{obs}})^2\right]^{0.5} \tag{2}$$

where C_{cal} is the calculated value, C_{obs} represents the value observed for the variable expected from validation data and n denotes the number of available data. The value for the above-mentioned index in the best case should be low and close to zero.

Variation in deviated sediment volume (C_s) with changes of intake ratio (Q_R) for various lengths of skimming wall

In this section, the pattern and amount of impressionability of C_s by various lengths of the skimming wall and intake ratio are studied, and the associated relation with intake ratio is expressed for different lengths. For this purpose, the relation of C_s with Q_R for lengths $L = 60$ cm, $L = 75$ cm, $L = 90$ cm considering a constant distance between L skimming walls ($b = 20$ cm) and constant heights of the skimming wall ($H = 4$ cm) was investigated. The obtained results are shown in Figure 3 and Table 3.

Analyzing the results presented in Figure 3 and Table 3 revealed the following:

(1) For a constant length, an increase in Q_R leads to an increase in $C_{S,}$ that is, there is a direct relation between C_S and Q_R. The slope of the curve for intake ratio less than 0.3, is low, while for the intake ratio greater than 0.3, there is a significant increase in the curve slope.

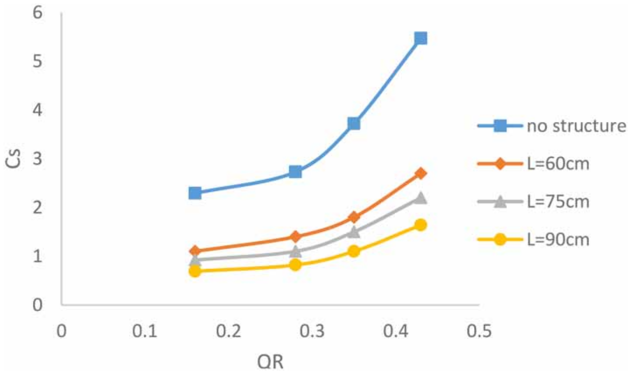

Figure 3 | Variation of C_s with Q_R for various lengths of skimming walls.

Table 3 | Variation statistical information for C_s with Q_R for various lengths of skimming walls

Row	Length of skimming walls (cm)	Relation	R^2	RMSE
1	No structure	$C_S = 9.35Q_R^{0.82}$	0.83	0.5094
2	60	$C_S = 4.72Q_R^{0.84}$	0.87	0.2356
3	75	$C_S = 3.77Q_R^{0.82}$	0.84	0.2031
4	90	$C_S = 2.76Q_R^{0.81}$	0.83	0.1568

(2) For a constant Q_R, an increase in wall length leads to a reduction in C_S, which is mainly due to the full coverage of the intake span by the walls.

(3) The parallel skimming walls with lengths of 60 cm, 75 cm and 90 cm lead to mitigation in the sediment entering the intake up to 51%, 60% and 70%, respectively. That is, the walls of 90 cm in length outperformed in reducing the sediment entering the intake, compared with the other alternatives.

(4) For low intake ratio, the skimming walls make a great contribution to the control of the sediment, while for the high intake ratio these structures have a low impact, which is mainly due to the results obtained for the separation width of the stream. Indeed, the parallel skimming walls reduce the entry of the bed load sediments of the main channel into the intake, while the collision with the stream close to the bottom leads to the increase in the turbulence around the walls for higher intake ratios, which results in the sediments being lifted from the bottom and entering the intake.

Variation in deviated sediment volume ratio (C_S) with variation in intake ratio (Q_R) for various heights of skimming wall

In this section, the pattern and impressionability of C_S by different heights of the skimming walls and intake ratios are studied, and its relation with the intake ratio for various heights is expressed. To this end, the relation of C_S with Q_R heights of $H = 2$ cm, $H = 4$ cm and $H = 6$ cm was investigated considering a constant length of skimming walls

($L = 90$ cm) and constant distance between skimming walls ($b = 20$ cm).

Analyzing results presented in Figure 4 and Table 4 indicates that:

(1) For a constant height, an increase in Q_R leads to an increase in C_S, implying that there is a direct relation between C_S and Q_R.
(2) For a constant Q_R, an increase in the wall height leads to a reduction in C_S, while a decrease in C_S will not be so considerable. With regard to Figure 4, it can be inferred that the heights greater than 2 cm have a low impact on controlling the sediments entering the intake.
(3) The parallel skimming walls of heights equal to 2 cm, 4 cm and 6 cm lead to a reduction in the sediment entering the intake up to 65%, 70% and 74%, respectively.

Variation in deviated sediment volume (C_S) by changes in dimensionless Froude number $\left(\frac{L}{b}\right)$ for various Froude numbers

In this section, the pattern and impressionability rate for C_S by $\frac{L}{b}$ as the dimensionless number and Froude number are studied, and its relation with $\frac{L}{b}$ is presented considering various Froude numbers. For this purpose, the relation of C_S with $\frac{L}{b}$ for Froude numbers of 0.30, 0.37, 0.45 and 0.56, is investigated considering a constant height of skimming walls ($H = 4$ cm). Figure 5 and Table 5 present the associated results.

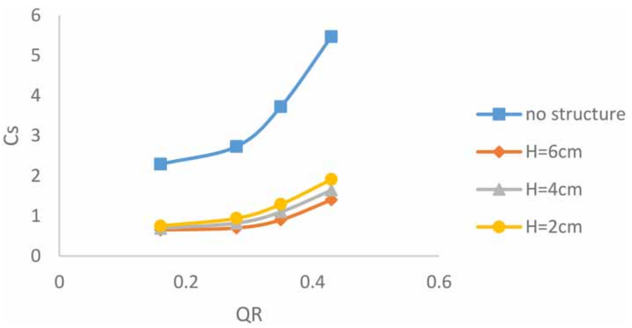

Figure 4 | Variation of C_S with Q_R for various heights of skimming walls.

Table 4 | Variation statistical information for C_S with Q_R for various heights of skimming walls

Row	Walls height (cm)	Relation	R^2	RMSE
1	No structure	$C_S = 9.35Q_R^{0.82}$	0.83	0.5094
2	2	$C_S = 3.47Q_R^{0.88}$	0.86	0.1694
3	4	$C_S = 2.76Q_R^{0.81}$	0.83	0.1568
4	6	$C_S = 2.06Q_R^{0.69}$	0.72	0.1587

The analysis of the presented results by Figure 5 and Table 5 demonstrates that:

(1) For a constant Froude number, an increase in $\frac{L}{b}$ leads to a reduction in value of C_S, that is, there is a reverse relation between C_S and $\frac{L}{b}$.
(2) For a constant $\frac{L}{b}$, an increase in the Froude number increases the value of C_S.

Variation in deviated sediment volume ratio (C_S) with $\frac{H}{b}$ dimensionless number for various intake ratios

In this section, the pattern and impressionability rate of C_S by $\frac{H}{b}$ dimensionless number and intake ratios are studied,

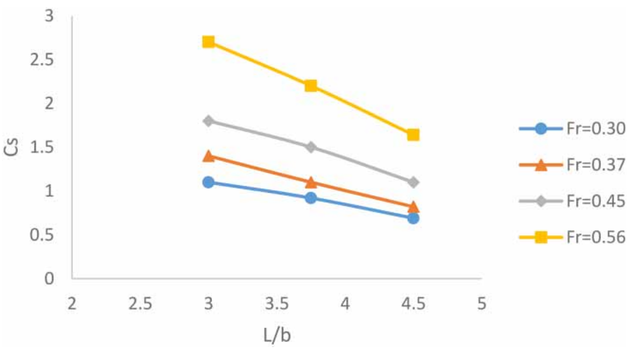

Figure 5 | Variation in C_S by $\frac{L}{b}$ for various Froude numbers.

Table 5 | Statistical information for C_S with $\frac{L}{b}$ for various Froude numbers

Row	Froude number (Fr)	Relation	R^2	RMSE
1	0.30	$C_S = 3.93\left(\frac{L}{b}\right)^{-1.41}$	0.96	0.3083
2	0.37	$C_S = 6\left(\frac{L}{b}\right)^{-1.31}$	0.99	0.4269
3	0.45	$C_S = 6.91\left(\frac{L}{b}\right)^{-1.20}$	0.96	0.5296
4	0.56	$C_S = 10.51\left(\frac{L}{b}\right)^{-1.22}$	0.97	0.7901

and its relation with $\frac{H}{b}$ for various intake ratios is assessed. For this purpose, the relation of C_S with $\frac{H}{b}$ for intake ratios 0.16, 0.28, 0.35 and 0.43 is studied considering a constant length for skimming walls ($L = 90$ cm). Figure 6 and Table 6 present the results.

The analysis of the results presented in Figure 6 and Table 6 reveals the following:

(1) For a constant intake ratio, an increase in $\frac{H}{b}$ leads to a reduction in the value of C_S, that is, there is a reverse relation between C_S and $\frac{H}{b}$.
(2) For a constant $\frac{H}{b}$, an increase in the intake ratio leads to an increase in the value of C_S.

DISCUSSION

The results of the present research were compared with that of the previous studies of Davoodi & Shafai Bajestan (2012), Karami Moghaddam *et al.* (2011) and Moradinejad *et al.* (2017). Figure 7 illustrates the relation between intake ratio (Q_R) and ratio of deviated sediment to intake (G_R) in the case of the absence of a sediment control structure. All available literature reported that an increase in the intake ratio (Q_R) leads to an increase in the ratio of deviated sediment into the intake (G_R). Various studies have been carried out considering various Froude numbers under different geometrical conditions for the main and secondary channels. With regard to the results of Davoodi & Shafai Bajestan (2012), an increase in the quantitative value of Q_R leads to a significant increase in the G_R and the slope of the curve.

In the experiment performed by Karami Moghaddam *et al.* (2011), it was observed that a slight increase in the curve slope leads to an increase in Q_R. That is, an increase in the intake ratio leads to a considerable surge in the deviated sediment entering the intake. In the research conducted by Moradinejad *et al.* (2017), they assumed that the size of Q_R is variable between 0.1 to 0.2, and it was observed that an increase in the value of Q_R leads to an increase in the deviated sediment ratio entering the intake. In the present study, it was observed that an increase in the intake ratio (Q_R) leads to an increase in the ratio of the deviated sediment entry into the intake (G_R). The $G_R = \frac{V_{\text{Intakes}}}{V_{\text{Canal}}}$ relation is used for calculating G_R, where V_{canal} refers to the sediment volume trapped in the end of the main channel and V_{intakes} refers to the sediment volume accumulated in the lateral intake. After measuring these volumes, the required calculations are accomplished and the associated curve is plotted. As was seen, the results of the present paper are

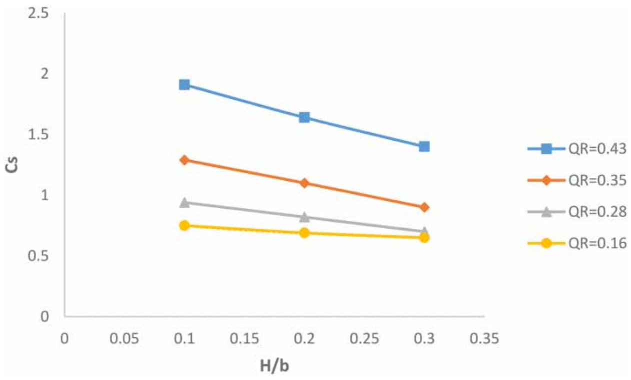

Figure 6 | Variation of C_S by $\frac{H}{b}$ for various intake ratios.

Table 6 | Statistical information on the relation of C_S with $\frac{H}{b}$ for various intake ratios

Row	Intake ratio (Q_R)	Relation	R^2	RMSE
1	0.43	$C_S = 1.022\left(\frac{H}{b}\right)^{-0.28}$	0.97	0.0351
2	0.35	$C_S = 0.631\left(\frac{H}{b}\right)^{-0.32}$	0.95	0.0341
3	0.28	$C_S = 0.522\left(\frac{H}{b}\right)^{-0.26}$	0.96	0.0183
4	0.16	$C_S = 0.558\left(\frac{H}{b}\right)^{-0.13}$	0.99	0.0024

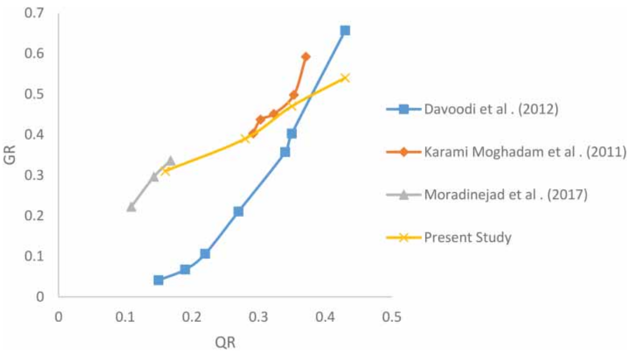

Figure 7 | Comparison between the results of the present study and preceding research obtained for a ratio of deviated sediment into intake (G_R) and intake ratio (Q_R) without a sediment control structure.

Table 7 | Statistical information on relation of G_R with Q_R for various studies

Row	Scholar	Relation	R^2	RMSE
1	Davoodi & Shafai Bajestan (2012)	$G_R = 2.19Q_R - 0.35$	0.96	0.0403
2	Karami Moghaddam *et al.* (2011)	$G_R = 2.09Q_R - 0.21$	0.91	0.0199
3	Moradinejad *et al.* (2017)	$G_R = 1.95Q_R - 0.012$	0.99	0.0240
4	Present study	$G_R = 0.86Q_R + 0.16$	0.98	0.0107

in line with those of the previous studies. Table 7 summarizes the governing equations of the previous studies.

Using the experimental data of the present study and the equations governing the curves presented by other scholars, the validation of the data and comparison with previous studies were accomplished. The associated results are presented in Figure 8.

With regard to Figure 7, RMSE for the G_R relation based on the equation of Davoodi & Shafai Bajestan (2012) is equal to 0.0403, RMSE for the G_R relation based on the equation of Karami Moghaddam *et al.*(2011) is equal to 0.0199, while RMSE for the G_R relation based on the equation of Moradinejad *et al.* (2017) is equal to 0.0240. The relation of the present study is close to the other relations, since the ratio of the lines' slopes in Figure 8 is 1 to 1.

CONCLUSION

As the previous studies focused on submerged vanes, dike and sill, so the use of parallel skimming walls is a novel attempt in the field. Of course, it should be noted that the implementation method of the parallel skimming walls relative to the previous structures follows an easy procedure among hydraulic projects. In addition, this structure is capable of hindering the entry of sediments into the intakes. Therefore, in this paper the changes in the length and height of the parallel skimming walls and their role in controlling the inlet sediment into the lateral intake were the main agenda and the obtained results revealed that an increase in Q_R leads to an increase in the amount of inlet sediment into the intake, as any increase in the intake ratio demands a transverse increase in momentum value, and as a result this problem leads to transportation of higher sediment into the intake.

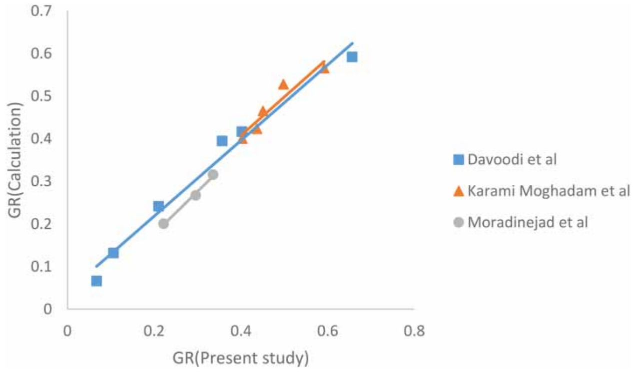

Figure 8 | Relation of computational G_R using the governing equations of other scholars and observational G_R of the present study.

An increase in the Froude number of the flow within the main channel leads to a surge in the amount of sediment entering the intake, since any increase in Froude number causes higher inertia, and as a result an increase in Froude number can be another factor beside the intake ratio contributing to an increase in the inlet sediment into the intake. Furthermore, it was observed that in the case of parallel skimming walls with $\frac{L}{b} = 3$, $\frac{L}{b} = 3.75$ and $\frac{L}{b} = 4.5$ there was a reduction in the amount of sediment entry into the intake up to 51%, 60% and 71%, respectively.

The main reason lies in the fact that the higher the amount of L increases, the greater the overlap with the span intake that exists and this reduces the entry of sediment into the intake. The investigations indicate that the presence of skimming wall incorporating $\frac{L}{b} = 4.5$ exhibits 15% efficiency compared with the wall with $\frac{L}{b} = 3.75$. Moreover, in the presence of a skimming wall with $\frac{L}{b} = 4.5$, 28% better efficiency relative to $\frac{L}{b} = 3$ was observed. Thus, using parallel skimming walls with $\frac{L}{b} = 4.5$ leads to more proper results in terms of controlling the volume of sediment entry into the intakes, in such a way that an increase in $\frac{L}{b}$ leads to a reduction in the inlet sediment into the intake.

With regard to the results, it can be inferred that in the presence of parallel skimming walls with $\frac{H}{b} = 0.1$, $\frac{H}{b} = 0.2$ and $\frac{H}{b} = 0.3$ the amount of sediment entering the intake is on average 65%, 70%, and 74%, respectively.

This is mainly due to the fact that any increase in H leads to formation of greater height in front of the intake span, and can lessen the sediment inlet into the intake, so in the presence of parallel skimming walls with $\frac{H}{b} = 0.3$, 5% higher efficiency was observed, compared with $\frac{H}{b} = 0.2$, while in the presence of skimming walls with $\frac{H}{b} = 0.3$, 12% higher efficiency was noticed relative to $\frac{H}{b} = 0.1$. To wrap it up, the parallel skimming walls incorporating $\frac{H}{b} = 0.3$ outperform other alternatives in controlling the sediment entry into the intake, while changes in the height of this structure do not play a significant role during control of inlet sediment.

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