A STUDY ON NUMERICAL SIMULATION OF OPENING HEIGHT OF DENSE FLOW INLET ON DENSE FLOW CHARACTERISTIC PARAMETERS

Nader Berahmand

Department of Civil Engineering Larestan Branch ,Islamic Azad University, Iran

Arash Jaael

Department of Civil Engineering Larestan Branch, Islamic Azad University, Iran

Mohammad Janparvar

Department of Civil Engineering, Islamic Azad University of Larestan, Iran

ABSTRACT

Thick currents are produced where density differences exist between the fluid and the fluid layers. This density difference may be appeared by various mechanisms, such as temperature, salinity and flow of sediment-laden river in case of flooding into the aquatic environment. Such flows make up one of mechanism of sediment transport mechanisms in reservoirs, lakes, seas and oceans. In this study, the effect of valve size (the size of current input density) are examined on the dense flow characteristics. For this purpose, laboratory studies of Hosseini (2006) was used for calibration of fluent numerical model. In this research, a section located at a distance of 5 meters from the sluice gate was used in order to calculate and consider the effect of the valve on dense flow characteristics. The results showed that in a fixed gate opening height increased initial velocity, flow rate and thickness of the dense flow is reduced. Meanwhile, in an amount fixed initial velocity, by increasing the amount of valve opening, discharges and thick dense flow increases.

Keywords: *dense flow, numerical simulation, Fluent, the thickness of the flow of dense, dense flow rate*

INTRODUCTION

The most important factors of sedimentation in reservoirs, streams are thick or dense. Basically, the flow of a fluid density can be input has turned into a mass density of the fluid with a different density, gravity due to the difference in specific gravity defined. Variations in density may be due to suspended solids, dissolved solids, temperature, or combination. Figure 1 how the formation and flow in the reservoir shows dense opaque. The maximum concentration of these flows occur during floods, which resulted in the creation of a muddy lake near the dam structures have been deposited and this has impairs the performance of intake and output floor. (Sloff 1999)

Figure 1 and the formation of dense muddy dam reservoirs (Sloff 1999)

Ellison and Turner (1959) for the first time on the analytical and experimental studies conducted within the dense mixture flow. Ellison and Turner with salt water solution for two-dimensional experiments for the first time to verify the theories governing this process began and could relation to the mixing of flow at the intersection of Richardson provide dense in terms of number. Further, the Alavian (1986) conducted experiments on water-salt solution for three-dimensional viscous flow of payments. Garcia (1994), studies the effect of slope on the flow behavior of dense turbulent did. He indicated that turbidity currents and salt water having the same initial conditions, almost before and after internal hydraulic jump are the same structure. Firoozabadi et al (2001) experiments with brine and stream containing kaolin and limestone were used in different concentrations.

Also, kernel (1997) and Hussain (2006) test three dimensional turbidity currents and slopes and discharges were different. For the first time Felix (2004) using numerical methods showed that the mean flow velocity density almost equal to half the maximum velocity at any point during the same period. Choi in 1998, an average model layer two-dimensional finite element numerical solution developed turbidity currents. Imran and colleagues in 1998 averaged just two-dimensional equations for turbidity currents in deep solved. Rafat et al (2014) investigated the effects of density, scour the pipeline and offer several models to estimate and compare them with each scour the pipeline, respectively. Dense flows, the performance of the reservoirs Sefidrood, Dez, Minab and Latian in Iran is disrupted. Due to the dense flows threatened reservoirs and reduce the quantity and quality of water reservoirs and dams dysfunction, study and understanding of hydrodynamic behavior and the factors affecting these flows is necessary. Therefore, in this study that investigated the effect of density altitude gate opening on the flow characteristics.

METHOD

A) The equations governing the flow field

The average - Reynolds equations conservation of mass and momentum for a non-permanent dense flow is as follows:

$$\frac{\partial \rho}{\partial t} + \frac{\partial (\rho U_i)}{\partial x_i} = 0 \quad (1)$$

$$\frac{\partial (\rho U_i)}{\partial t} + \frac{\partial (\rho U_i U_j)}{\partial x_j} = -\frac{\partial P_i}{\partial x_i} + \rho g'_i + \frac{\partial}{\partial x_j} \left(\mu \frac{\partial U_i}{\partial x_j} - \rho \overline{U'_i U'_j} \right) \quad (2)$$

That U_i and U_j average velocity vector components-Reynolds dense Cartesian directions x_i and x_j , t times, P_i medium-to Cartesian Reynolds x_i , ρ and μ viscosity fluid dynamics are thickening fluid density. Reynolds stress also reduced gravity $-\rho U_i' U_j'$ and are calculated as follows g_i' respectively. It should be noted that Reynolds stress using Boussinesq theory are obtained as follows.

$$-\rho U_i' U_j' = \mu_T \left(\frac{\partial U_i}{\partial x_j} + \mu \frac{\partial U_j}{\partial x_i} \right) - \frac{2}{3} \left(\rho K + \mu_T \frac{\partial U_i}{\partial x_i} \right) \delta_{ij} \quad (3)$$

$$g_i' = g_i \frac{\rho - \rho_a}{\rho_a} \quad (4)$$

That ρ_a environmental fluid density (water here is clean) δ_{ij} Kronecker delta and K is confusion kinetic energy. In addition acceleration of gravity is g_i and for $i=1,2,3$ is equal to $(g \sin \theta, -g \cos \theta, 0)$. θ , the slope of the channel bed. In addition eddy viscosity is μ_T at a model $K - \varepsilon$ of about $\mu_T = \rho C_\mu \frac{K^2}{\varepsilon}$ results that turbulent kinetic energy dissipation rate ε and C_μ proved the equation.

It should be noted that in addition to the above-mentioned equations, mass conservation equations deposits (or soluble material) in a non-permanent dense flow is as follows:

$$\frac{\partial(\rho C)}{\partial t} + \frac{\partial[(\rho U_j - v_s \delta_{j2}) C]}{\partial x_j} = \frac{\partial \left[\left(\rho \lambda + \frac{\mu_T}{Sc} \right) \frac{\partial C}{\partial x_j} \right]}{\partial x_j} \quad (5)$$

That λ fluid diffusion coefficient, v_s sediment fall velocity (the soluble amount is zero) and δ_{j2} component in the opposite direction of gravity is the Kronecker delta. Also turbulent Schmidt number is Sc . This number affected as Prandtl number of floats. But often times the amount it flows thick unit considered.

In addition $C = \frac{\rho - \rho_a}{\rho_s - \rho_a}$ - average-Reynolds concentration of salt sediment or suspended sediment density current density is ρ_s . (Or salt)

It should be noted that the pressure in the momentum equation P , at a distance y of the substrate obtained from the following relationship:

$$\frac{P}{\rho_a} = \frac{P_0}{\rho_a} - g'(H - h) + \rho g \frac{(H - y)}{\rho_a} \quad (6)$$

That P_0 free fluid pressure at a depth of H environmental and fluid environment, taking into account the thickness h is dense.

Finally, it should be mentioned that turbulence models are of great diversity.

Some of these models can be zero-equation model (such as Prandtl mixing length model, the model of Baldwin and Lomax and mixing length mixing length model that ABC and Smith) standard two-equation models $k - \varepsilon$, $k - \varepsilon$ models of type RNG, Model $k - \varepsilon$ achieved ADJ modified model $k - \varepsilon$, model $k - \varepsilon$ for low Reynolds numbers, model $k - \omega$, model $v^2 - f$, model Reynolds stress equation RSM, algebraic stress model ASM, RNG model and scale model large eddy simulation LES cited.

But in this study, only the standard $k - \varepsilon$ models available in the fluent software is used for simulation.

B) Modeling

The present study was performed using the fluent software. In addition tests Hosseini (2006) for computational fluid dynamics software fluent numerical model calibration were used. Laboratory channel geometry Hosseini (2006) using Gambit 2.4.6 software were drawn. In addition Quad quadrilateral mesh using the volume controls and the type carried Map. This type of mesh is structured meshing.

Free surface of fluid to the environment and the current output, the output pressure boundary condition Pressure outlet, at the gate at the border of the channel bed and the wall Wall and under slide valve in the inlet velocity boundary condition was considered Inlet velocity. Velocity, volume concentration and thickness of the dense flow at the inlet (in the slide valve) the data and the information it Hosseini (2006) were used.

Results and Discussion

A) Calibration of the numerical model fluent

It should be noted that on the on laboratory studies Hosseini (2006) numerical studies have been done, which results in this section for model calibration results Shabani Sabzeh Meidani (2012) is used.

Shabani Sabzeh Meidani (2012) for calibration of being independent of the type of mesh, 5 types of mesh was used. Finally, given that speed and volume concentration vertical profiles, policies with dimensions of 48 x 1200 (1200 divided by 48 divided in the direction of the channel length in the vertical direction) was chosen as the optimum mesh the mesh will be used in the present study.

In addition results of numerical Shabani Sabzeh Meidani (2012) Numerical results obtained showed that $k - \varepsilon$ of the RNG model with experimental data showed that the best compatibility. Therefore, in the present thesis was tried with this type of mesh and the turbulence models used for numerical modeling.

B) The effect on the flow characteristics gate opening height of dense

In this study, two experiments 5 and 6 Hosseini (2006) was used. Both of these tests are cm with a height of valve opening. In addition of heights cm thick slide valve opening (valve lower altitudes) 2, 3, 4, 5 and 6 cm were used. In addition to the initial speeds of 16.67 and 25 cm from the initial velocity of centimeters per second 12.5 was used.

In other words, gate opening height of six different values for three different values of numerical modeling was done quickly, A total of 18 numerical model in this regard were prepared that results of the models listed below.

The effect of these parameters on the flow rate measured in cross section (section placed at a distance of 5 meters from gate) in table (1) is shown.

As can be seen computational flow rates (measured in cubic centimeters per second) in the fourth column of the table above is shown. Since the models I and II represent numerical experiments are 6 and 5 Hosseini. (2006) for fluent model performance testing, laboratory values of these two models listed in the fifth column of the above table.

As can be seen, the calculated values are close to experimental data, So that errors are about 2 percent with a minus sign. In other words the amount of error is negligible. In addition calculated flow rates

less than those of his lab are low density. Therefore, we can trust the results of the numerical modeling.

It should be noted that since the other numerical (16 numerical model residual) value of no laboratory. Therefore, for these 16 columns lab value and percent error-free data model and information.

Q calculated values show that the first gate opening fixed at a height h_0 increased initial velocity u_0 , dense flow rate increases. The reason could also increase the supercritical Froude number and therefore more dense flow. It should be noted that the flow of supercritical density is more dense flow mixing with clean water increases your high that the increasing discharges at initial speeds higher causes. This gate opening at all levels of up to six cm.

In addition initial velocity u_0 in an amount fixed by increasing h_0 , dense flow rate Q increases.

Also in seventh column of the above table values %d- h_0 is shown. This parameter represents the percentage difference between the amount Q calculated at constant u_0 Initial rates, but with different h_0 by the amount of Q calculated in h_0 equal to one centimeter. In other words, gate opening height reference value was assumed equal to one centimeter and the effect of opening height on the Q calculation for this parameter is shown.

In other words, this parameter values in the model between 4640 and 2380 (4) the percentage of error that finally 48.71 percent is obtained. In other words, the initial velocity of 25 centimeters per second by increasing the gate opening from one to two centimeters, dense flow rate measured at the level of the amount of 48.71 per cent.

As can be seen from column % d- h_0 increase generally less dense flow does not change by changing the initial velocity U_0 , but by increasing the flow rate of the high-density gate opening is h_0 percent. So the gate opening height of one to six centimeters value of this parameter increases to approximately 80%.

Table 1. Effect of the lake as well as high initial velocity on flow rate Q measured density level

Explanation	%d- h_0	Percent of error	Q (cm ³ /S) Laboratory	Q (cm ³ /S) Computational	u_0 (cm/s)	h_0 (cm)	Number of model
Experiment 6 of Hosseini (2006)	0	-2.11	2431.42	2380.00	25	1	1
Experiment 5 of Hosseini (2006)	0	-1.83	1334.62	1310.26	16.67	1	2
	0			835.00	12.5	1	3
	48.71			4640.00	25	2	4
	48.29			2533.84	16.67	2	5
	48.77			1630.00	12.5	2	6
	64.10			6630.00	25	3	7
	64.69			3710.74	16.67	3	8
	65.10			2392.50	12.5	3	9
	72.58			8680.00	25	4	10
	73.23			4894.31	16.67	4	11
	73.15			3110.00	12.5	4	12
	77.91			10775.00	25	5	13
	78.11			5984.53	16.67	5	14
	77.88			3775.00	12.5	5	15
	81.42			12810.00	25	6	16
	81.29			7001.40	16.67	6	17
	81.07			4410.00	12.5	6	18
Minimum	0.00			835.00	12.5	1	

Maximum	81.42	12810.00	25	6
Middle	57.57	4861.25	18.06	3.5

Also effect of these parameters on the amount of thickness h dense flow at the point of measurement (section located at a distance of 5 meters from gate) in Table 2 is shown.

As can be seen, the calculated values are close to experimental data so that errors are less than 3% with a negative sign. In other words the amount of error is negligible. In addition numerical values of h dense flow is less than laboratory values. Therefore, we can trust the results of the numerical modeling.

Values of h calculated shows at a fixed gate opening height h_0 increased initial velocity u_0 , h the dense flow is reduced. This gate opening at all levels of up to six cm.

In addition initial velocity u_0 in an amount fixed by increasing h_0 , h increases the thickness of the dense flow.

Also in seventh column of the above table values% $d-h_0$ is shown. This parameter represents the percentage difference between the value of h Initial rates computational constant u_0 , but with different h_0 calculated by the amount h in h_0 equal to one centimeter. In other words, gate opening height reference value was assumed equal to one centimeter and the effect of increasing on opening height h value calculated for this parameter is shown.

In other words, the value of this parameter in the model (4) the percentage of error between 12.28 and 10.86 is values that ultimately 15.29 percent is obtained. In other words, the initial velocity of 25 centimeters per second by increasing the gate opening from one to two centimeters, h value measured dense flow in schools has increased the amount of 15.29 percent.

As can be seen from column% $d-h_0$ except on opening height equal to two centimeters, percentage changes are generally h dense flow does not change by changing the initial velocity U_0 , but by increasing flow high-density gate opening h_0 h is the percentage change. So that the gate opening height of one to six centimeters value of this parameter increases to approximately 55 percent.

Table 2. Effect of the lake as well as high initial velocity measurement of on thickness of flow dense point h

Explanation	%d- h0	Percent of error	Q (cm ³ /S) Laboratory	Q (cm ³ /S) Computational	u_0 (cm/s)	h_0 (cm)	Number of model
Experiment 6 of Hosseini (2006)	0	-1.72	11.05	10.86	25	1	1
Experiment 5 of Hosseini (2006)	0	-2.78	11.89	11.56	16.67	1	2
	0			12.85	12.5	1	3
	15.29			12.82	25	2	4
	11.69			13.09	16.67	2	5
	7.89			13.95	12.5	2	6
	27.79			15.04	25	3	7
	28.73			16.22	16.67	3	8
	26.78			17.55	12.5	3	9
	40.36			18.21	25	4	10
	43.66			20.52	16.67	4	11
	40.59			21.63	12.5	4	12
	46.95			20.47	25	5	13
	47.14			21.87	16.67	5	14
	45.71			23.67	12.5	5	15
	55.87			24.61	25	6	16
	56.26			26.43	16.67	6	17
	54.14			28.02	12.5	6	18

Minimum	0.00	10.86	12.5	1
Maximum	56.26	28.02	25	6
Middle	30.49	18.30	18.06	3.5

CONCLUSION

Experiments No 5 and 6 of the studies Hosseini (1385) to evaluate the effect of density was used valve flow characteristics. These experiments with a slope of 2%, the initial concentration of the input 0.055 grams per cubic centimeter, 20 and 30 liters per minute flow of raw, gate opening height h_0 1 cm, U_0 16.67 and 25 centimeters per second of raw speed and Froude number Fr accepted early 9.525 and 14.286. The results of numerical modeling with Fluent showed that for two experiments 5 and 6 Hosseini (2006) numerical results is close with experimental results. Debbie Shows calculated values at a fixed gate opening height h_0 increased initial velocity u_0 , dense flow rate increases. In addition initial velocity u_0 in an amount fixed by increasing h_0 , dense flow rate Q increases. Generally percent less dense flow does not change by changing the initial velocity U_0 , but by increasing the flow rate of the high-density gate opening is h_0 percent. So that the gate opening height of one to six centimeters value of this parameter increases to approximately 80%. Values of h dense flow calculation shows that the thickness at a fixed gate opening height h_0 increased initial velocity u_0 , h value dense flow is reduced. The initial velocity u_0 in an amount fixed by increasing h_0 , h increases the thickness of the dense flow. Except for the opening of two cm height, generally less dense flow by changing the initial velocity U_0 h percentage does not change, but by increasing flow high-density gate opening h_0 h is the percentage change.

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