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Reviewing trap rate of current density in the sinusoidal channels with regard to obstacle and using FLUENT software

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ABSTRACT

Current density refers to currents that main factor of their movement be attributed to the difference in density between two or more fluid. Density Flow include large group of currents in nature, the density difference may be due to difference of temperature, soluble salts and fine Suspended particles. In this study, we tried to evaluate the behavior and properties of Density Flow in the sinusoidal shape channels with respect to the effect of dam along to pathway using software of Computational Fluid Dynamics (Fluent). In this research, studies of Hosseini (2013) that based on model results of Imran et al (2004) used, which validated on the basis of tests conducted by Li and Yu (1997), has been used. The model is one sinusoidal channel limited of 8.3 m in length, 0.3 in Width and 1 m in Height that simulated in 20 different states by changing the concentration, bottom slope, Froude number and barrier height. according to the results of numerical modeling demonstrated that average concentration of density flow decreased after the obstacle or In other words trap efficiency is also increased, at the same time, the amount of Sediment Trap increased directly proportional by increasing obstacle height and deceased inversely by increasing Froude number of density flow, as well as With increasing distance obstacle from the valve demonstrated that trapping efficiency increased.

KEY WORDS: current density, obstacl, limited sinusoidal channels, FLUENT software.

1. INTRODUCTION

One of the main problems that affects in reducing of useful life obstacl, is deposition and accumulation of sediments into Reservoirs behind dams that this phenomenon has caused loss of national and capital massive resources of a country.in Iran, This problem is also More critical due to drought and climatic conditions. input and output amount of River sediments in an interval of river is approximately Equal and balanced, but problem begins when Human intervention in nature and construction of artifacts and human components in river bed(dams and barrages) is causing the collapse of the equilibrium balance, as noted, deposition and accumulation of sediments into Reservoirs behind obstacles decreases useful volume of the reservoir Over Tim and increases to dead and unused volume of reservoir and volume as well as sediment influence on water quality causing many problems in facilities part and valves of obstacle. At the same time, during flood, annealing increases in upstream of river. One of the most effective approaches to reduce the accumulation of sediments near the obstacl bodies, is establishing submerged obstacles in the flow path upstream into river bed.It should be noted that the density flow is current that its main factor of movement is the difference in density between Two or more fluid. There is a group of dense flow which it carries a fine-grained suspended sediment and is known to muddy flow. Regarding to gradient and material of bed river, volume and speed of muddy flow may be increased during pathway or may be stop the movement. By making obstacles along the way, one can control sediment behind the barrier and consequently with reduction of slope (by accumulation of sediments in the behind barrier to upstream, slope of flow is More gentle than before dam), flow velocity is decreased and destructive power of dense flow is also decreased and flow becomes to sedimentary state, and even eventually dense flow may dissolve by Sedimentation in bed river.

2. Background of Studies and Research

So far, Extensive research has conducted on density flows in laboratory, field, and study of software that can be mentioned following. The first investigations of density follows containing fine grained material(muddy flows) conducted by Farrell on Lake Geneva, Switzerland, in the late nineteenth century pentin and parker in the eighty century, quotes Ghomeshi and omidi (2009) done Researches in relation to power, speed, concentration and Sedimentation or erosion by dense flow, they together provide relationships that studied changes the flow velocity and concentration of dense flow In time. Altinakar and colleagues (1990) studied the effect of slope bed and sediment grain size on forehead height and speed of the muddy flows and they compared the results to salt water flow in the same conditions. The experimental results showed that the in the same slope, growth rate in the forehead height in muddy flows moved faster than flow of salt water.

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Garcia (1992) provide a model for the dense flow with fine particle size, by conducting evaluation a series of experiments to test Several assumptions about development model and the underlying data related to such flows and sedimentation resulting from their study. Garcia also found that the dense flows with high-speed has High erosion power. These flows must be provide its acceleration of momentum, while maintained of its stability.

Imran and kassem (2004) with simulating the density flows in sinusoidal channels, evaluated characteristics and the behavior of this flow including velocity and density under different hydraulic condition in canal curvature. Validation based on study results of Li Wei (1997). Hosseini(1392) studied characteristics of dense flow in limited and unlimited sinusoidal channels, as well as Curved channel 180º using a numerical model. according to their results, model of RNG was the best turbulence model. Also, they Determined that in height of the bed, when concentration increases, the density of dense flow increases and its flow velocity decreases and density, and velocity of dense flow and thickness of flow increased by increasing Froude number at the curved sites, also appears that Lang (1954,1970) was first researcher on establishing obstacle along flow pathway which he studied characteristics of muddy flow along flow pathway with establishing obstacle, it should be noted that Span and Viang(1974) assessment density flow in Collision with Obstacle in different angles.

Woods et al (1998) studied Different flow regimes gray and Volcanic when Collision with Obstacle obstacles using the theory and experimental approaches. The results show that the barrier will block the upstream flow As well as reduce the speed of flow, Subsequently sedimentation occurs behind barrier.

Oehy, Ch., and Schleiss (2007) with making a barrier along the path of dense flow, concluded that in the subcritical condition, 90% of density flow Will stay behind of dense and in supercritical conditions, this amount reach 20 to 50 percent, so they advised that establishing obstacle will be effective Just in subcritical, also barrier should be twice the height of the dense flow.

Asghari pari et al (1388) studied effect concentration of dense flow in collision with an obstacle. making in vitro model, they made Density flow at different concentrations and gradients and without obstacle, measured input conditions of flow velocity and height Body During flume and flow measurement and appropriation to the input conditions and according to the results of previous research theories, they determined range the required height to block of flow. Then, with construction of a barrier along the channel with different height, they studied behavior of dense flows similar to obstacle. This study attempted to Seek assistance of the conducted research and studies in this area by doing method, Numerical and Computational (software Gambit and Fluent) to make upstream dams in the path of the sinusoidal channels in different sites And by changing the height of the barrier, calculate the maximum efficiency of trapping sediments and the results will provide in the block diagrams and Tables compiled, as well as to the accuracy of the survey results, total loss research results Hosseini(92) be used.

GOALS HAIR

The overall objectives:

Reviewing trap rate of current density in the sinusoidal channels with regard to obstacl and using FLUENT software

Equations

- Dense flow equations

continuity equation and nervier-Stokes averaged equations for an incompressible flow as well as diffusion equation is obtained as follows, respectively.

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

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

T is time, μ Fluid Dynamics viscosity, ρ dense fluid density,U1 and U_2 Components of the mean velocity vector – Reynolds of dense flow in Cartesian coordinates and xi, xj and Pi mean pressure -Reynolds in Cartesian coordinates xi, and g is the reduced gravity acceleration, and Ui U j are Reynolds stresses.

$$\frac{\partial(p\emptyset)}{\partial t} + div(\rho\emptyset v) = div(\Gamma grad\emptyset) + S\emptyset \quad (3)$$

in this formula, V velocity vector, ρ fluid density, Γ dispersion coefficient, sø spring semester and ø is Public variable. For determination the flow regime is used from two parameters, densiometeric Froude number and *Richardson* Number in following relations. Fr, Froude number of Primary dense flow, u inlet flow velocity, h the height of dense flow, g ' the reduced gravity acceleration, Re Reynolds number of inlet flow, Ri, is Richardson number of inlet flow Where ρ and ρa are dense fluid density and density of Environmental water, respectively.

Reduced gravity acceleration (g ') and initial *Richardson* Number (Ri_0) are as follows:

$$g' = \frac{\rho_{-}\rho_a}{\rho_a} g \quad (4)$$

$$R_i = \frac{g'.h.\cos\theta}{u^2} = \frac{1}{f_r'^2} \quad (5)$$

For determination of trap efficiency (Te) and sediment amounts behind obstacle, also is used following formula, where c_1 and c_2 are flow concentration Before and After obstacle, Respectively.

$$Te = 1 - \frac{C_2}{C_1} \quad (6$$

3. MATERIALS AND METHOD

There is no specific laboratory model of sinusoidal channels, so as mentioned previously in this study Research of Mr. Hosseini (2013) that used results based on model of Imran et al (2004), so it is the basis for the validation Based on tests conducted by Li and Yu (1997). In vitro, the kaolin is used as suspended solid (thick material) with 2/56 its density and 0/0068 mm particle size and the rate of flow and concentration of sediment are $64/1\ cm^2/s$ and $0/00667$ respectively.

4. REVIEWING TRAP RATE OF CURRENT DENSITY

The water density and dense flow density and velocity are and , respectively. Also Froude number of flow is 1/22 and bottom slope is 0/00139. Flow in a limited sinusoidal shape channel with curved radius of 0/684 m is placed at an angle of 40 °. At the junction with the canal curvature, channel length at upstream and downstream of flow, is 1/5 m. The total length of the channel 8/3 m, its width in all situations 30 cm, and the depth of the channel is 1m. obstacle has 3 heights, 5/4,13/5 and 25 cm which, respectively Equivalent to one, one and a half, two and a half, Almost is five times longer than inlet density flow and is placed 2/825 m distance from valve . It should be noted that this model is simulated with 4 different Longitudinal slopes 0/002, 0/005, 0/008and 0/02 and also is used from 3 different concentrations of 0/00,667, and 0/01 and 3 different Froude number 3/2, 3 and 5.

Also according to the numerical results Hosseini(1392),the best model for sinusoidal channel has been turbulence model k-ε from RNG type of the meshed model with a number of divisions 45 *15* 105 which from left indicating directions of x, y and z,respectively. For this reason, The use of other variety of turbulence and meshed models is avoided. Meanwhile, the triangular barrier is same both the shape and width as the channel. For modeling, theses number 1,3,15 and 20 (Hosseini 1392) is used, Table 1 is numbered sequentially from 1 to 20. in Figure 1 is given an example of modeling, in Figure 2 is displayed the mesh style and boundary conditions in the software Gambit, Figures 3 and 4 is depicted contour lines of the density flow 15 seconds and 235 seconds after the entrance in Fluent software.

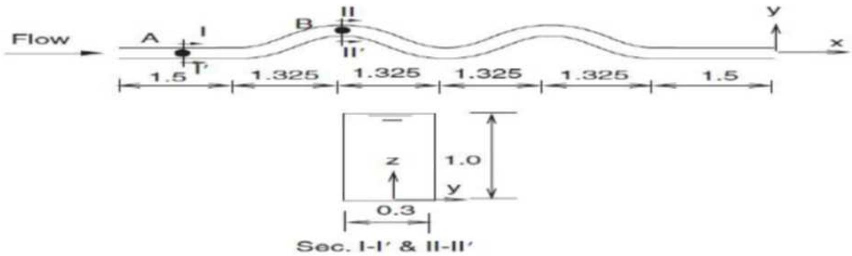


Figure 1. Plan and cross-section of model.

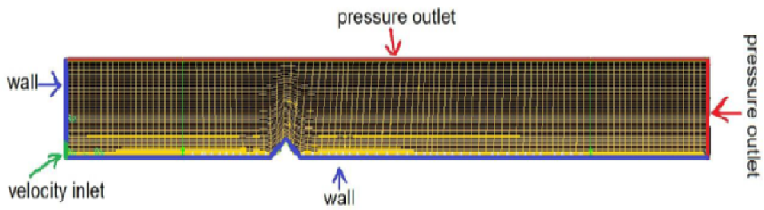
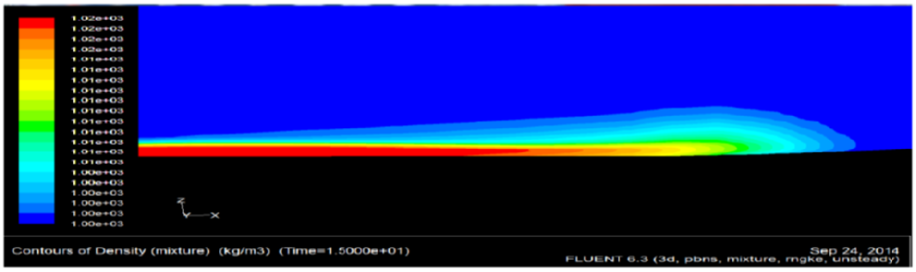


Figure 2. The mesh style and imposing boundary conditions

Table 1 - Initial conditions for the numerical simulation

شماره مدل	slop	C_0 (gr/cm^3)	Fr_0	h (cm) مانع	h (cm) دریچه	U_0 (cm/s)
1	0.002	0.00667	1.22	5.4	5.4	9.3152841
2	0.008	0.00667	5	5.4	5.4	38.177394
3	0.005	0.00859	3	5.4	5.4	25.995082
4	0.008	0.01	5	5.4	5.4	46.745882
5	0.02	0.00859	1.22	5.4	5.4	10.571333
6	0.002	0.00667	1.22	8.1	5.4	9.3152841
7	0.008	0.00667	5	8.1	5.4	38.177394
8	0.005	0.00859	3	8.1	5.4	25.995082
9	0.008	0.01	5	8.1	5.4	46.745882
10	0.02	0.00859	1.22	8.1	5.4	10.571333
11	0.002	0.00667	1.22	13.5	5.4	9.3152841
12	0.008	0.00667	5	13.5	5.4	38.177394
13	0.005	0.00859	3	13.5	5.4	25.995082
14	0.008	0.01	5	13.5	5.4	46.745882
15	0.02	0.00859	1.22	13.5	5.4	10.571333
16	0.002	0.00667	1.22	25	5.4	9.3152841
17	0.008	0.00667	5	25	5.4	38.177394
18	0.005	0.00859	3	25	5.4	25.995082
19	0.008	0.01	5	25	5.4	46.745882
20	0.02	0.00859	1.22	25	5.4	10.571333

In Table 1, C0 initial concentration, Fr0 Froude number for Initial dense flow, U0 velocity of Input flow, h0 flow, height valves of Input dense flow, g0' reduced gravity acceleration and Re0 is Reynolds number of flow.



3- contour lines of dense flow 15 seconds after movement from the inlet valve in the FLUENT program

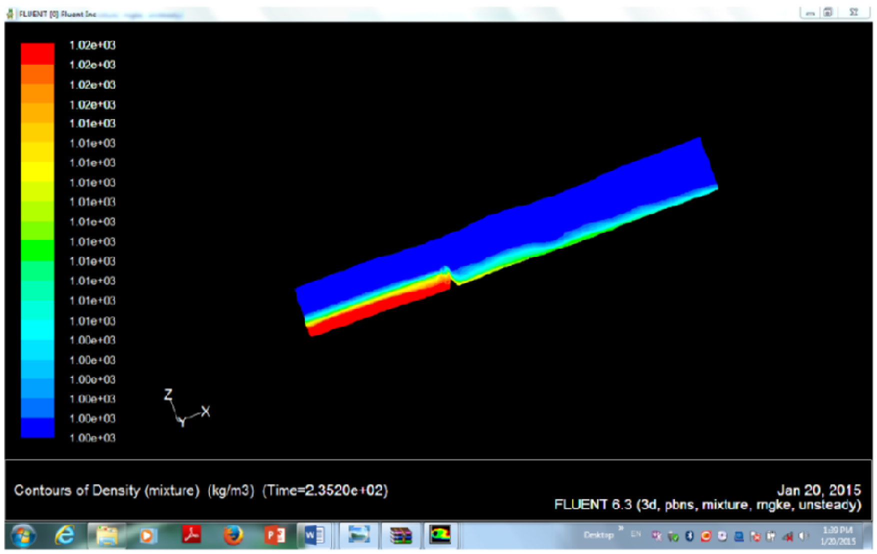


Figure 4. The density contour lines at 235 seconds after entering the dense flow

PARAMETERS OF AVERAGE DEPTH OF THE DENSE FLOW (VELOCITY, HEIGHT AND CONCENTRATION):

in this part of study, the calculated variables of average depth of the dense flow through the 20 cases presented in Table has been tested. parameters of average depth of the dense flow (h), average speed (u), average concentration(C) are Computable Using profiles of vertical velocity and concentration. The following, relationships of average depth is presented (Parker et al. 1986). It should be noted that in all cases, velosity contour profile, concentration, etc. at position 17/5 cm before and after obstacle (Beginning and end obstacle) will be examined.

In these relations, cz and uz are values of Local concentration and Longitudinal velocity in vertical distance from the base level respectively.ht is vertical distance from the baseline to To the place where local velocity is zero again,i= 1 is the first point that it consider close to zero. r also is number of data measured on the vertical profiles. Meanwhile, r wil be Calculated to hr.

In Tables 2 and 3, with respect to 20 different states, software models have been separated in terms of different conditions, and in program, values of average depth of the dense flow have been calculated and compared with base model. Measured index in this section, is Comparison Richardson number in Hosseini model (92) with other models.

Table 2. parameters of average depth of the dense flow before obstacle considering the 20 cases

before obstacle
Average speed deep of dense flow
Average height deep of dense flow
Average concentration deep of dense flow
initial *Richardson* Number
Richardson Number of Fluent Average depth
Richardson Percent error

قبل از مانع	سرعت متوسط عمقی جریان چگال	ارتفاع متوسط عمقی جریان چگال	غلظت متوسط عمقی جریان چگال	عدد ریچادرسون اولیه	عدد ریچاردسون متوسط عمقی فلونت	درصد خطا ریچاردسون
شماره مدل	u (m/s)	h (m)	$c\ (gr/cm^3)$	Ri0	Ri	
1	0.041267	0.296676	0.003607	0.253532	3.838646	14.14065
2	0.086183	0.419115	0.004641	0.015094	0.206084	12.65344
3	0.070448	0.38474	0.005622	0.041928	0.373607	7.910637
4	0.092254	0.471438	0.006992	0.015094	0.27094	16.95029
5	0.03978	0.349435	0.004517	0.253505	0.94145	2.713735
6	0.042658	0.203607	0.004229	0.253532	0.766477	2.023192
7	0.072286	0.358203	0.005594	0.015094	0.353122	22.395
8	0.061326	0.314007	0.006234	0.041928	0.546636	12.03743
9	0.077226	0.4049	0.008422	0.015094	0.465779	29.85873
10	0.044509	0.207447	0.00546	0.253505	0.909082	2.586055
11	0.026228	0.373429	0.003678	0.253532	1.76335	5.955125
12	0.060626	0.502315	0.005361	0.015094	0.481122	30.87521
13	0.048741	0.471034	0.006458	0.041928	0.896656	20.3855
14	0.068323	0.534393	0.008081	0.015094	0.571015	36.83084
15	0.025639	0.496275	0.005423	0.253505	2.721067	9.733787
16	0.018728	0.375565	0.004559	0.253533	4.287274	15.91012
17	0.030375	0.587535	0.004347	0.015094	1.5539	101.9459
18	0.024761	0.367961	0.005058	0.041929	2.720905	63.89358
19	0.039574	0.609548	0.006739	0.015094	1.419243	93.02483
20	0.018728	0.375565	0.004559	0.253533	4.287274	15.91012
بیشترین مقدار	0.092254	0.609548	0.008422			101.9459
کمترین مقدار	0.018728	0.203607	0.003607			2.023192

Table 3. parameters of average depth of the dense flow after obstacle considering the 20 cases
Maximum value
Minimum value

بعد از مانع	سرعت متوسط عمقی جریان چگال	ارتفاع متوسط عمقی جریان چگال	غلظت متوسط عمقی جریان چگال	عدد ریچادرسون اولیه	عدد ریچاردسون متوسط عمقی فلونت	درصد خطا ریچاردسون
شماره مدل	u (m/s)	h (m)	$c\ (gr/cm^3)$	Ri0	Ri	
1	0.063653	0.195499	0.003436	0.253532	1.012753	2.994568
2	0.084108	0.442779	0.004502	0.015094	0.209928	12.90815
3	0.076789	0.361031	0.005522	0.041928	0.308877	6.36681
4	0.088218	0.499828	0.006815	0.015094	0.288791	18.13296
5	0.062298	0.252052	0.004431	0.253505	0.376542	0.485343
6	0.060119	0.179133	0.003407	0.253532	0.310924	0.226367
7	0.074993	0.371277	0.005369	0.015094	0.314899	19.86265
8	0.072695	0.270823	0.005954	0.041928	0.371569	7.862034
9	0.077109	0.439888	0.008046	0.015094	0.446365	28.57249
10	0.06309	0.177292	0.004288	0.253505	0.355368	0.40182
11	0.040653	0.169097	0.00264	0.253532	0.526822	1.077928
12	0.07696	0.450611	0.004989	0.015094	0.277848	17.40793
13	0.068657	0.357142	0.006177	0.041928	0.432252	9.309337
14	0.082199	0.493917	0.007544	0.015094	0.368268	23.39844
15	0.04783	0.270489	0.004814	0.253505	0.694091	1.737979
16	0.036897	0.222006	0.002107	0.253533	0.510363	1.013002
17	0.051378	0.429038	0.002312	0.015094	0.288823	18.13455
18	0.04033	0.306221	0.002033	0.041929	0.412213	8.831271
19	0.058268	0.478427	0.003968	0.015094	0.385531	24.54142
20	0.036897	0.222006	0.002107	0.253533	0.510363	1.013002
بیشترین مقدار	0.088218	0.499828	0.008046			28.57249
کمترین مقدار	0.036897	0.169097	0.002033			0.226367

ASSESMENT OF NUMERICAL MODEL IN TERMS OF DEPOSITION BEHIND BARRIER:

In this part of the study, sedimentation rate is determined on effect Obstacle using of calculated variables for Average speed deep of dense flow of the 20 states that have been tested and using of laboratory results, Trap efficiency is calculated. For trapping measurment, From equation (6) has been used. Due to the thickness and density before and after the barrier, the most optimal Is calculated. Table 4 shows the trapping rate for vigesimalIs models.

Model Number
Average concentration deep of dense flow before obstacle
Average concentration deep of dense flow after obstacle
Trapping percentage of fluent model

Table 4. Evaluation of the results of the trapping by taking 20 states

شماره مدل	غلظت متوسط عمقی جریان چگال قبل از مانع c1 (gr/cm³)	غلظت متوسط عمقی جریان چگال بعد از مانع c2 (gr/cm³)	درصد تله اندازی مدل فلوئنت Te(%)
1	0.003607	0.003436	4.744763
2	0.004641	0.004502	2.981048
3	0.005622	0.005522	1.770648
4	0.006992	0.006815	2.533638
5	0.004517	0.004431	1.907616
6	0.004229	0.003407	19.42698
7	0.005594	0.005369	4.019334
8	0.006234	0.005954	4.487572
9	0.008422	0.008046	4.456833
10	0.00546	0.004288	21.45934
11	0.003678	0.00264	28.22353
12	0.005361	0.004989	6.938547
13	0.006458	0.006177	4.349668
14	0.008081	0.007544	6.649791
15	0.005423	0.004814	11.22506
16	0.004559	0.002107	53.79595
17	0.004347	0.002312	46.82132
18	0.005058	0.002033	59.80903
19	0.006739	0.003968	41.11068
20	0.004559	0.002107	53.79595
بیشترین	0.008422	0.008046	59.80903
کمترین	0.003607	0.002033	1.770648

EVALUATION OF TRAPPING RATE AT DIFFERENT DISTANCES FROM THE MODEL **(6)**

Based on the results of Tables 1 and 2 and to finding the most appropriate numerical model, in terms of the difference in the minimum average depth of Richardson number with the base model that In both tables before and after obstacle of model No.6 are 2.023 and 0. 226 respectively, sediment trap efficiency of this model is evaluated. the obstacles in three regions of the distances 2.825, 4.15 and 5.475 from valve is created, as shown in Table 5,with Away obstacle from valve, trap efficiency Increases up.

Table 5: Comparison of concentration the dencity flow and trapping rate in the barrier height 8/1 cm
in model No.6

		c			Te(%)
مدل	فاصله مانع از دریچه(m)	داده اولیه	مدل فلوئنت قبل از مانع	مدل فلوئنت بعد از مانع	درصد میزان تله اندازی
6	2.825	0.00667	0.004229	0.00341	19.42698
6	4.15	0.00667	0.005568	0.0036	35.42516
6	5.475	0.00667	0.006286	0.00328	47.83661
max Te(%)				47.83661379	

5. DISCUSSION AND CONCLUSION

Regarding to survey results, tables, diagrams, following results is obtained:

In this study, by using a simple Gambit networking software that it is simple and Useful, as well as useful and powerful software for network analysis and modeling Fluent model and numerical simulation of dense flow behavior, is used and evaluated.

2. With regard to the evidence of the numerical model from Mr. Hosseini (92) in terms of networking and type of tolerance, he used network optimization with dimensions

45 *15* 105 which from left indicating directions of x, y and z, respectively, and optimal model of turbulence is model k-ε from RNG type. We refused from choosing of mesh and turbulence types that increases computing time.

3. Dense flow behavior after obstacle is almost similar to dense flow behavior without obstacle except that the concentration and speed power of Material is reduced.

4- In height near bottom, whatever the concentration increases, velocity of dense flow decreases and dense flow density increases.

5- according to Tables 2 and 3 Concerned with average depth parameters in terms of minimum difference between Richardson number and Richardson number of base model (Hosseini 2013) In either case before and after obstacle of model no. 6, minimum difference and most ideal state be conceded. Barrier model, the primary difference is Tryn

Accordingly, by changing place of obstacle in 3 distance in the model no.6, highest level trapping is Within 5.475 meters from the valve (Farthest distance) and is 47.83 % (Table 5). The reason is also more volume of sediment accumulated with respect to its distance to valve.

6- According to Table 4 and Comparison of 20Model, the most trapping rate in all twenty models, Model No.18 with a maximum value of trapping 59.8 is best and Model No.3 with 1.77 percent is Worst Model. however, in review and analysis results of all the models, the slope values, the concentration, Froude number and the barrier height have been Constantly impressive, but one can note to Constantly effectiveness of the barrier height and more gentle slope at higher trapping rate in model no. 18 than other models And also Reducing the barrier height in Froude decreased number trapping in Model 3.

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