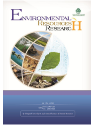

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Numerical simulation of flow and environmental considerations to investigate possibility of fishway use in Mazandaran province

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Abstract

Pool and weir is a type of fishway that provides a route for fish to migrate to dam upstream. The effective parameters for fish swimming include velocity, water depth and turbulence. Several rubber dams have been under construction in Mazandaran Province, but the necessary structures have not been built around them yet. When constructing these rubber dams, numerical models can be used to evaluate flow velocity and currently in Iran there is also the possibility of comparing the results with field measurements at Karkhe-Hamidieh dam of Khuzestan Province. In this paper, the three-dimensional equations governing shallow water in the weir and orifice fishway were solved using the suitable models of turbulence, and the flow pattern and turbulence were calculated. The results of flow simulation and field measurements using Micromollineh were also compared. The final result showed that the velocity lines in submerged and non-submerged modes with constant velocity were similar to those estimated by Micromollineh - about 0.469 mps. We suggest it is not necessary to reduce the flow rate in a submerged state using devices such as baffles. The small Cyprinidae fishes are able to cross the fishway due to the slow flow of non-submerged state. In case of non-submerged state, there is a need to reduce the flow rate.

Keywords: Pool and weir fishway, Fish migration, Energy depreciation, Turbulence models

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Introduction

Fishway is a hydraulic structure that makes it possible for fishes to migrate over natural barriers and dams. The pool and weir is a type of fishway (Fig. 1) that facilitates migration of fishes to dam upstream. Fish jump from a pool to another when water flows through the pools. The pools are separated when the water is not overflowed. This kind of fishway is known as pool and weir fishway and is usually constructed by dividing a rectangular duct into a series of pools using transverse walls known as baffles. Sometimes water may not pass over the weir, but through the opening under the baffle. One hydraulic condition when designing this kind of fishway is the maximum flow rate control. The maximum flow rate should not be more than the rate of fish explosive's speed. A quick burst of speed should be so high that the fish could continue its swimming in less than fifteen seconds. Quick burst of speed's value for adult fish is considered 2.5 mps (Katopodis, 1981). The critical levels of velocity for the fishway include (Bell, 1984):

1. Constant velocity: the velocity that could be fixed for a long period, 2. Fixed velocity: The velocity that could be fixed for a few minutes and 3. Explosive velocity: that is generated in a single effort and not over time. Constant and explosive velocities are caused by aerobic and anaerobic fish muscles, respectively (Beach, 1984). These two critical velocities are added to arrive at the required measurements (Pavlov, 1989).

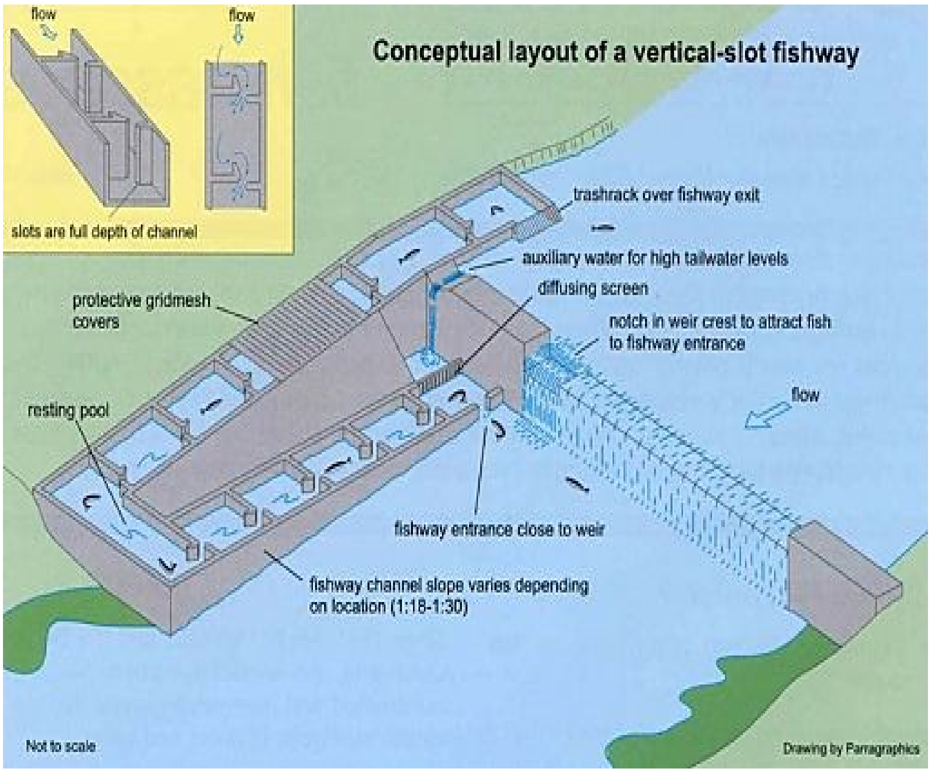

Figure 1: Fishway near a dam
(Duncan *et al.*, 2016)

In the west coast of North America and the Pacific coast, the pool and weir type of fishway are used with orifices in the baffles at dams. On the Columbia River and in many large dams along this river, these fishways are constructed with 30cm level difference with the top of every baffle. On Ice – Harbor and on Snake River near its confluence with the Columbia River, the pool and weir type of fishway with orifices among the baffles are used. The pool and weir type of fishway has been operated on a dam on the Yukon River near Whitehorse in 1959 (Clay, 1959). In 1985, Orsborn reported that a new type of baffle was tested for pool and weir type of fishway in which number of baffles was reduced, but their height increased (Orsborn, 1985). The result of this plan which was applied for Pacific salmon still remains unclear. In the central part of Canada and the United States, a number of pool and weir type fishways are established at diversion dams. These fishways successfully pass Pike and Walleye fish. Various fishways were tested, but they had a weak performance due to the conditions of their input stream affected by large fluctuations. In Canada, 35 pool and weir type fishways have been reported in the provinces of Alberta, Saskatchewan, and Manitoba (Washburn and Gillis Assoc, 1985). In Western Europe, different forms of pool and weir type fishways have been used. McGrath (1960), studied the fishways overflow on the Shannon River, Liffey River, Erne River and Clady River in Donegal County. He demonstrated that annually more than 6,000 Atlantic salmon fish pass through the submerged orifice on pool and weir type fishway on Erne River and fewer through other facilities. By reports in England, the type of pool and weir and Denil fishways has had extensive usage (Beach, 1984). Pools and submerged orifice type fishway is not as common as other types of fishway. In Scotland, pools and submerged orifice type fishway and pool and weir fishway without openings and Borland fishway have been used successfully to pass Atlantic salmon. Zarnecki (1960) noticed the ability of Sea trout for passing through the fishway. Pool and weir fishway for passing salmon is used in two dams on Vistula River in Poland, one of them with 10 meters height and other one with 32 meters height. Other publications by Sakowicz and Zarnecki (1962), reported that the type of pool and weir fishway was suitable for salmon in west and east Europe. In Japan, approximately 1,400 fishways are of the pool and weir type.

The factors that affect fish swimming include velocity, flow depth and turbulence. Additional turbulence could block the path of fishway. Clay (1995), suggested a way to identify high turbulence locations in fishway and to determine their impact on fish behavior in fishway (Clay, 1995).

Numerical methods can be applied to solve such problems. The overflow of a dam could be simulated using computational fluid dynamics (CFD) and the Flow3D model. The results of a study were compared with experimental data and indicated that the CFD as well as pressure and flow rate can be predicted in such structures (Savage *et al*., 2001).

Stair overflows were simulated using the volume of fluid (VOF), the K-ε turbulence model, and meshing without organizing the boundaries. By comparing the results of the model with experimental, the numerical simulation of turbulence was found to be effective to simulate stair overflows (Chen *et al*., 2001).

Weir and pool type of fishway was simulated using the volume of fluid (VOF) and the K-ε turbulence model with combined meshing of organized and unorganized grids, and then compared with the physical model (Carrica *et al*., 2005). Cea *et al*., (2007) modeled the vertical slot type of fishway by mixing the length model, the K-ε and the algebraic stress. In the present paper, the numerical simulation of flow over the weir and orifice type of fishway in the diversion dam of Karkheh – Hamidieh in Iran have been attempted.

Figure 2. Fishway at Karkheh Hamidieh Diversion Dam in Iran (Filli *et al*., 2007)

Weir and pool type of fishway was designed and installed for the first time in Khuzestan- Karkheh Hamidieh diversion dam in Iran. This weir and pool type of fishway is a combination of eleven pools. There is a baffle as an overflow located between every two pools. The weir heights from the upper and lower floor are 75 cm and 100 cm, respectively. Under the baffle, an orifice was considered to pass fish (Filli *et al*., 2007). The 4, 5 and 7th pools were selected to assess the velocity's distribution in this fishway (Filli *et al*., 2007).

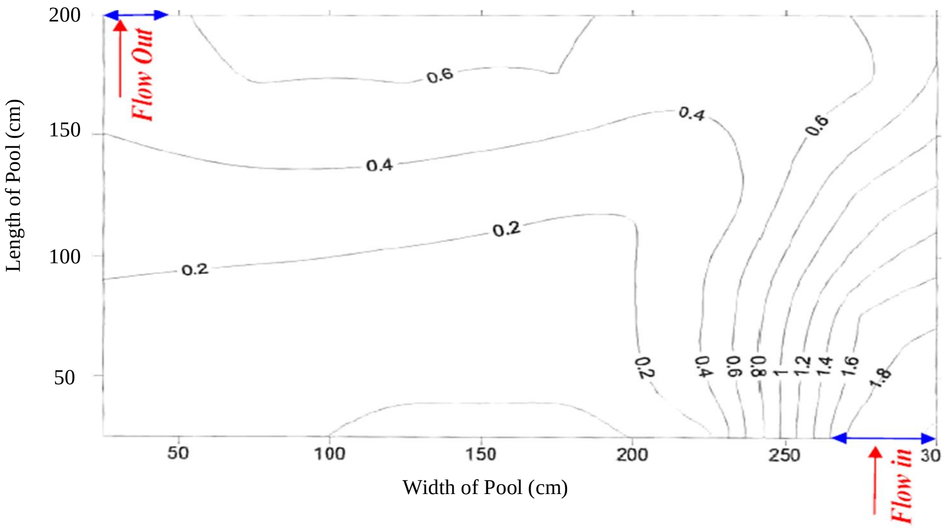

Figure 3. Measured velocity of 4th pool, at half-filling and non-submerged state, depth of flow for the basin: 24 cm, velocity measurement depth: 12 cm from the bottom of the pool, average velocity in the pool: 0.469 mps (Filli *et al.*, 2007)

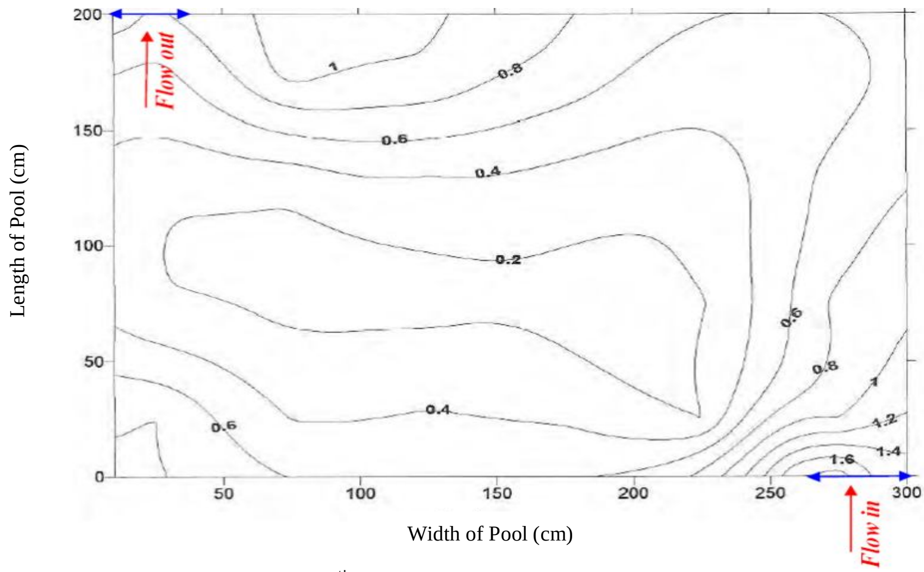

Figure 4. Measured velocity lines of 4th pool at submerged state, depth of flow for the basin: 80 cm, velocity measurement depth: 60 cm from the bottom of the pool, average velocity in the pool: 0.54 mps (Filli *et al.*, 2007)

Velocity, water depth and turbulence are the effective parameters of fish swimming and the main objectives of the present study. In this paper, the three-dimensional equations governing shallow water in weir and orifice fishway are solved using suitable models of turbulence that could calculate flow pattern and turbulence. The flow simulation results were compared with those of field study by Micromollineh.

Material and Methods

This research has been carried out at the Islamic Azad University of Ramsar Branch in Iran. The turbulence model equations includes two equation for k-ε (Standard) (Willcox, 1988) that have been averaged at depth (Rastogi and Reddy, 1978). Surprisingly the k-ε model includes a correction term dependent on the strain with the constant c13, in the ε equation of the RNG model (Yakhot *et al.*, 1992).

Problem definition and formulations

In this study, flow is steady with two-dimensional turbulence form. Velocity and pressure are a function of time and space. To model the velocity and pressure fluctuations, an integrated form of the Navier Stokes equation at time was applied. Integration of Navier Stokes equations at time is also known as Reynolds equations (Reynolds, 1984).

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0 \tag{1}$$

$$\frac{\partial \rho u}{\partial t} + \frac{\partial \rho uu}{\partial x} + \frac{\partial \rho uv}{\partial y} + \frac{\partial \rho uw}{\partial z} - \rho f_c v = -\frac{\partial P}{\partial x} + \frac{\partial \tau_{xx}}{\partial x} + \frac{\partial \tau_{xy}}{\partial y} + \frac{\partial \tau_{xz}}{\partial z} \tag{2}$$

$$\frac{\partial \rho v}{\partial t} + \frac{\partial \rho uv}{\partial x} + \frac{\partial \rho vv}{\partial y} + \frac{\partial \rho vw}{\partial z} + \rho f_c u = -\frac{\partial P}{\partial y} + \frac{\partial \tau_{yx}}{\partial x} + \frac{\partial \tau_{yy}}{\partial y} + \frac{\partial \tau_{yz}}{\partial z} \tag{3}$$

$$\frac{\partial \rho w}{\partial t} + \frac{\partial \rho uw}{\partial x} + \frac{\partial \rho vw}{\partial y} + \frac{\partial \rho ww}{\partial z} = -\frac{\partial P}{\partial z} + \frac{\partial \tau_{zx}}{\partial x} + \frac{\partial \tau_{zy}}{\partial y} + \frac{\partial \tau_{zz}}{\partial z} - \rho g \tag{4}$$

Reynolds equations

Turbulence model equation

The two-equation model of k-ε (Standard) are presented to average for depth as follows: (Rastjy and Reddy, 1978).

(5)

$$\frac{\partial hk}{\partial t}+\frac{\partial U_j hk}{\partial x_j}=\frac{\partial}{\partial x_j}[(\nu+\frac{\nu_t}{\sigma_k})h\frac{\partial k}{\partial x}]+hP_k+hP_{kv}-h\varepsilon$$

(6)

$$\frac{\partial h\varepsilon}{\partial t}+\frac{\partial U_j h\varepsilon}{\partial x_j}=\frac{\partial}{\partial x_j}[(\nu+\frac{\nu_t}{\sigma\varepsilon})h\frac{\partial \varepsilon}{\partial x}]+$$

$$hc_{1\varepsilon}\frac{\varepsilon}{k}P_k+hP_{\varepsilon v}-hc_{2\varepsilon}\frac{\varepsilon^2}{k}$$

(7)

$$\nu_t=c_\mu\frac{k^2}{\varepsilon},P_k=2\nu_t S_{ij}.S_{ij}$$

$$P_{kv}=c_k\frac{k^2}{\varepsilon},c_k=\frac{1}{c_f^{1/2}},P_{\varepsilon v}=c_\varepsilon\frac{u_f^4}{h^2},$$

$$c_\varepsilon=\frac{1}{\sqrt{e_*\sigma_t}}\frac{c_{2\varepsilon}c_\mu^{1/2}}{c_f^{3/4}},$$

$$c_f=\frac{u_f^2}{u^2+v^2+w^2}=\frac{n^2 g}{h^{1/3}}$$

(8)

$$c_\mu=0.09,c_{\varepsilon 1}=1.44,c_{\varepsilon 2}=1.92,\sigma_k=1.0,\sigma_\varepsilon=1.31$$

Where P_{kv} and P_{kv} are production terms as a result of the non-uniform distribution's velocity in the depth that is stronger near-bed. P_k is a production term of the turbulent kinetic energy that was averaged in depth as a result of velocity gradients in the plan. ν_t is the vortex viscosity. The turbulence model is used to calculate the lateral flow into one channel that achieved much better results than ν_t for the fixed parameters of rotational flow (McGurik and Rodi, 1978). c_f is the bed friction coefficient. σ_t is the Schmidt number that shows the relationship between the turbulence viscosity and the turbulent diffusion's coefficient according to the following equation:

$$\varepsilon_d=\frac{\nu_t}{\sigma_t} \qquad (9)$$

The value of σ_t is 0.5 (Keller and Rodi, 1988). However, the values of σ_t are varied from 0.5 to 2 for variable references (Gibson and launder, 1978). e_* is the turbulence diffusion's coefficient in depth given by the following equation (Keller and Rodi, 1988).

$$\varepsilon_d=e_* h u_f \qquad (10)$$

Direct measurement of color broadcasting in the fixed-width channels offers 0.15 for e_*. On one hand, Keller and Rodi achieved better solutions for the velocity and stress within the composite channels (Keller and Rodi, 1988).

On the other hand, to get a better answer within the composite channel, Biglari and Sturm assumed e_* equal to 0.3 (Biglari and Sturm, 1998). McGurik and Rodi have considered $\frac{1}{\sqrt{e_*\sigma_t}}$ equal to 3.6 (McGurik and Rodi, 1978). The ε equation of the RNG model includes a correction term $c_{\varepsilon 1}$ that is constant strain-dependent (Yakhot *et al.*, 1992). For the k-ε (RNG), we have:

$$\frac{\partial h\varepsilon}{\partial t}+\frac{\partial U_j h\varepsilon}{\partial x_j}=\frac{\partial}{\partial x_j}[(\nu+\frac{\nu_t}{\sigma\varepsilon})h\frac{\partial \varepsilon}{\partial x}]+hc_{1\varepsilon}^*\frac{\varepsilon}{k}P_k+hP_{\varepsilon v}-hc_{2\varepsilon}\frac{\varepsilon^2}{k} \qquad (11)$$

$$c_\mu=0.0845,c_{1\varepsilon}^*=c_{1\varepsilon}-\frac{\eta(1-\frac{\eta}{\eta_0})}{1+\beta\eta^3},c_{1\varepsilon}=1.68,\sigma_k=1.39,\beta=0.012,c_{1\varepsilon}=1.42,$$

$$\eta=(2E_{ij}.E_{ij})^{1/2}\frac{k}{\varepsilon},\eta_0=4.377$$

(12)

Only constant β is adjustable, high levels of the turbulent data are obtained near-wall. All other constants are calculated explicitly as part of the RNG process.

$$\frac{\partial hk}{\partial t}+\frac{\partial U_j hk}{\partial x_j}=\frac{\partial}{\partial x_j}[(\nu+\frac{\nu_t}{\sigma_k})h\frac{\partial k}{\partial x}]+P_k+P_b-h\varepsilon \tag{13}$$

$$\frac{\partial h\varepsilon}{\partial t}+\frac{\partial U_j h\varepsilon}{\partial x_j}=\frac{\partial}{\partial x_j}[(\nu+\frac{\nu_t}{\sigma\varepsilon})h\frac{\partial \varepsilon}{\partial x}]+hc_{1\varepsilon}\frac{\varepsilon}{k}P_k+hc_1S_\varepsilon-hc_2\frac{\varepsilon^2}{k+\sqrt{\nu\varepsilon}}+S_\varepsilon \tag{14}$$

$$\begin{gathered}c_1=Max[0.43,\frac{\eta}{\eta+s}],\eta=s\frac{k}{\varepsilon},s=\sqrt{2s_{ij}s_{ij}},\mu_t=hc_\mu\frac{k^2}{\varepsilon},P_k=-\rho\overline{u_i'u_j'}\frac{\partial u_j}{\partial x_i'},\\ P_k=\mu_t s^2,P_b=\beta g_i\frac{\mu_t}{\Pr_t}\frac{\partial T}{\partial x_i},\mu_t=\rho c_\mu\frac{k^2}{\varepsilon},c_\mu=\frac{1}{A_0+A_s\frac{KU^*}{\varepsilon}},U^*=\sqrt{s_{ij}s_{ij}+\overline{\Omega_{ij}}\overline{\Omega_{ij}}},\\ \overline{\Omega_{ij}}=\Omega_{ij}-\varepsilon_{ijk}\omega_k,A_0=4.04,A_s=\sqrt{6}\cos\Phi,\Phi=\frac{1}{3}\cos^{-1}(\sqrt{6}\omega),\omega=\frac{s_{ij}s_{jk}s_{ki}}{\tilde{s}^3},\tilde{s}=\sqrt{s_{ij}s_{ij}},\\ s_{ij}=\frac{1}{2}(\frac{\partial u_j}{\partial x_i}+\frac{\partial u_i}{\partial x_j}),c_{1\varepsilon}=1.44,c_2=1.9,\sigma_k=1,\sigma_\varepsilon=1.2,\beta=-\frac{1}{\rho}(\frac{\partial P}{\partial T})p,\Pr_t=0.85\end{gathered} \tag{15}$$

Willcox, provided the equation of turbulence model k-ω (standard) as follows (Willcox, 1988):

$$\frac{\partial k}{\partial t}+U_j\frac{\partial k}{\partial x_j}=\tau_{ij}\frac{\partial U_i}{\partial x_j}-\beta^*k\omega+\frac{\partial}{\partial x_j}[(\nu+\sigma^*\nu_T)\frac{\partial k}{\partial x_j}] \tag{16}$$

$$\begin{gathered}\frac{\partial \omega}{\partial t}+U_j\frac{\partial \omega}{\partial x_j}=\alpha\frac{\omega}{k}\tau_{ij}\frac{\partial U_i}{\partial x_j}-\beta\omega^2k\omega+\frac{\partial}{\partial x_j}[(\nu+\sigma\nu_T)\frac{\partial \omega}{\partial x_j}]\\ \nu_t=\frac{k}{\omega},\alpha=\frac{5}{9},\beta=\frac{3}{40},\beta^*=\frac{9}{100},\sigma=\frac{1}{2},\varepsilon=\beta^*\omega k\end{gathered} \tag{17}$$

Numerical Model and boundary conditions

The values of water physical properties including density, viscosity, heat capacity and thermal conductivity were 998.2, 0.001003, 4182 and 0.6, respectively. For all the governing equations variables are correctly assigned to the boundary nodes. The steady state problems only required the boundary condition while the unsteady state problems required the initial conditions of all nodes in the network. The common boundary conditions in hydraulic issues is shown in Figure 6 (Soltani and Rahimi Asl, 2003):

A- Inlet boundary condition: the numerical models could fit the model by means of various boundary conditions such as velocity, mass flow, etc. For example, the velocity of inlet could be used as an input of boundary condition in modeling of flow inside a closed or open channel.

B- The outlet boundary condition: here the pressure of the outlet equals the atmospheric pressure. If the output is chosen at a far distance from geometric constraints without any changes in direction of flow, then the flow state is fully developed. This model produces the output surface perpendicular to the flow in which its gradient equals zero in the perpendicular direction of the output surface (Soltani and Rahimi Asl, 2003).

C - Wall boundary condition: the wall boundary condition is used to limit the medial area between the fluid and the solid. The model is ready for simulation by the solutions that set and define the model.

The following steps show the simulation process (Versteeg and Malalasekera, 2007): Selecting the discretization equation methods: The first order upstream differentiation method is used for discretization of the equations of momentum, k, ε, and ω and the standard method is used to find the pressure. Selecting the velocity – pressure methods: The velocity - pressure coupling is used in the SIMPLE method. Determination of the discount factors: The discount factor values are used to control the calculated variables for each iteration. In this paper, the default values 0.3, 1, 0.7, 0.8, 0.8 and 1 are used for the pressure, density, momentum, k, ε and turbulent viscosity, respectively. The initial values of the relative pressure is considered zero and the initial values of velocity components were close to the average values present in the input stream. By completing the steps of the numerical model, we can start the problem solving in a repetitive process. The frequency of reporting the results could be introduced before computing the numerical model. During the solution process, the convergence of solution is observable using residues, integral of surface, statistics and values of the force. When the solution has finished, computation of the unknown quantities and the results could be conducted at any point of the field and could be displayed by vector form of contour and profile views (Versteeg and Malalasekera, 2007).

The solution of flow is usually an initial number with 1000 repeats and reporting in every step of the calculation. The conditions for convergence of the unknown parameters were satisfied after 300 to 350 iterations.

Meshing model

The Gambit software, version 2.3.16. is used to generate the channel geometry and mesh. The network model used is the Quad element, types of Map and Pave for pages and Hex elements and types of the Cooper Map for volumes are as shown in Figures 5 and 7. The Inlet, outlet, wall boundary conditions, and symmetry were introduced in the software as shown in Figure 6. Water inlet's velocity is considered 1.9 mps in non-submerged state and 1.6 mps in submerged state.

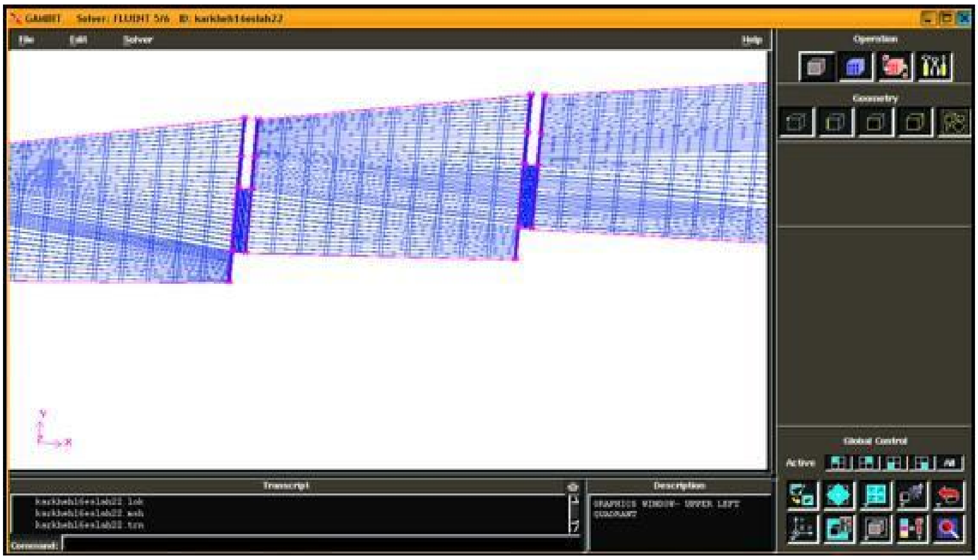

Figure 5. Meshing of Karkhe - Hamidieh fishway in non-submerged state with below orifice

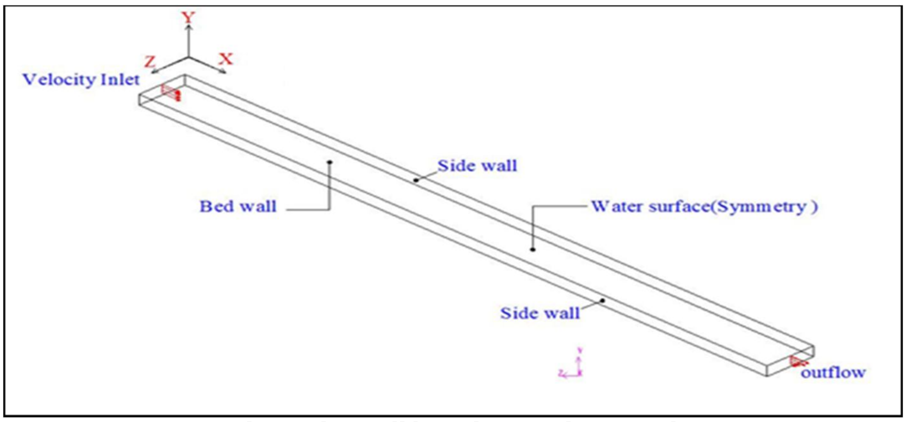

Figure 6. Inlet, outlet, wall boundary conditions and symmetry

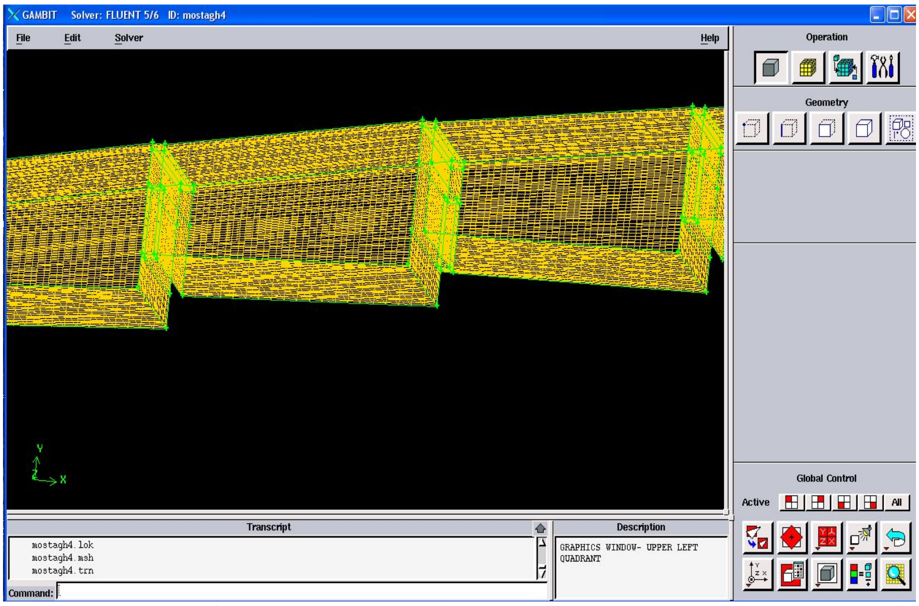

Figure 7. Meshing of Karkhe - Hamidieh fishway in submerged state with below orifice

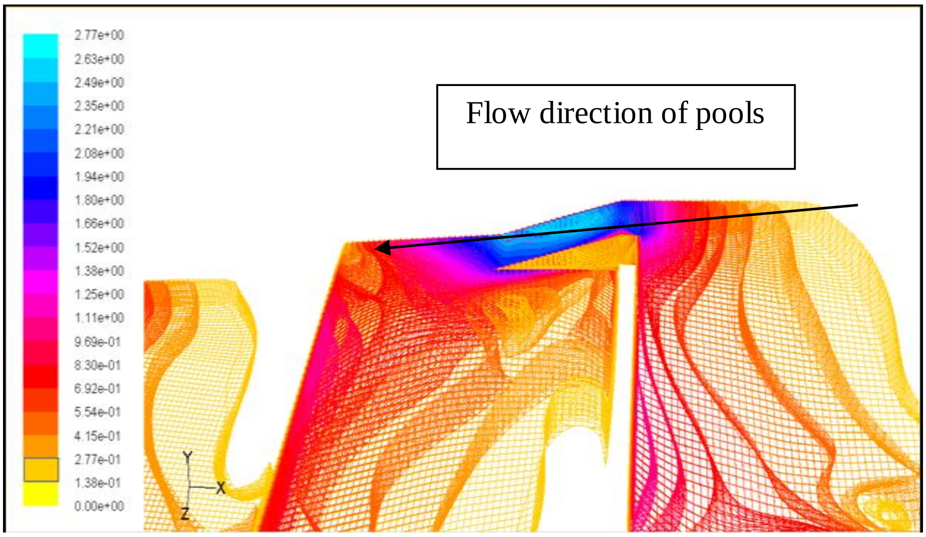

Figure 8. The velocity lines in the pool (4) of fishway at non-submerged mode

The Cyprinidae and *Vimba vimba persa* fishes are found in Mazandaran Rivers. This paper investigated the ability of these fishes climbing dams in submerged and non-submerged states.

The smallest freshwater fish we find here belongs to Cyprinidae fishes. The length ranges of large specimens are between 2 to 3 m, but mostly their length are smaller than 5 cm (Aquatic Science Engineering Research Site, 2009).

To design the fishway we should consider the weakest swimmer fish capable to climb. The carp has 5 cm length, so it is the smallest fish in the river with 10 gr weight. The maximum capacity of a fish in the fishway could be calculated as follows:

In which the flow velocity (v) is assumed to be 2.5 m/s, and R is the water flow index of the water inside the pool that its value is 80 cm. The drag force coefficient includes:

$$N_R = \frac{VR}{v} = \frac{2.5 \times 0.8}{1.007 \times 10^{-6}} = 1986097.319 \quad (18)$$

The drag force, D, is calculated as follows:

(19)

$$C_d = \frac{3.3}{NR^{0.417}} = \frac{3.3}{1986097.319^{0.417}} = 0.0078$$

(20)

$$A = L^2 = 0.0025\,m^2$$

(21)

$$D = C_d \rho A \frac{V^2}{2} = 0.0078 \times 1000 \times 0.0025 \times \frac{2.5^2}{2} = 0.0609N$$

force exerted to fishes

(22)

$$P = D + W \sin\theta$$

(23)

$$S = 20\% \Rightarrow \theta = 11.3^{\circ} \Rightarrow P = 0.0609 + 0.005 * 9.81 Sin 11.3 = 0.0705$$

$$PW_f = P.V = 0.0705 \times 2.5 \Rightarrow PW_f = 0.176$$

The force that the fishes exert is calculated as follows:

The power is calculated in watt. The volume unit of the water capacity in the pool for the first mode is:

$$V = 0.54 m/\sec$$

$PW = \gamma VS = 9810 \times 0.54 \times 0.2 = 1059.44$ watt

(24)

The withstand capacity of the fish in water is calculated, when the volume of fish is considered as follow:

$$L^3 = 0.05^3 = 0.000125\ m^3$$

The energy of water in one pool is 1059.44 watt, so, the minimum power that the fish is required to dominate that power equals:

1059.44×0.000125= 0.132 watt

The Cyprinidae fish have the maximum energy of 0.176 watt and have the ability to overcome 0.132 watt of energy; so, they are able to climb in a submerged state with the water height of 80 cm. In fact, there is no need to reduce the flow rate in a submerged state using devices such as baffles. The Small Cyprinidae fish are also able to cross the fishway due to the slow flow of non-submerged state.

The average length value of *Vimba vimba* fish is between 20-30 cm and its weight is between 90-250 gr. These fish rarely reach 50 cm in length and 1 kilo in weight. This fish is able to climb in a non-submerged state with a water height of 24 cm. In fact, there is a need to reduce the flow rate in a non-volatile state by devices such as pockets used in pools or other fish structures which required further investigation.

Results

The governing equations in three dimensional shallow water of fishway were solved using appropriate turbulence model and the flow pattern and turbulence were calculated. Hydraulic conditions were set at the maximum design of flow rate through the orifice to facilitate fish migration. Burst of speed should be compatible with fish swimming's velocity. The critical velocity rate is 2.5 mps for the adult Salmon. The results of the numerical model were compared with those acquired through Micromolineh using Karkheh-Hamidieh fishway data. The results are shown in Figures 8 to 10.

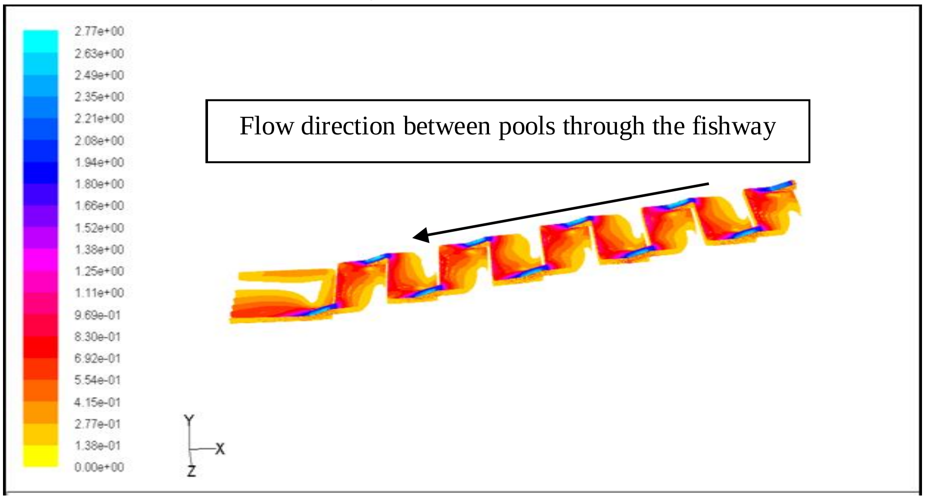

Figure 9. The velocity lines in x- direction in the pool (4) of fishway at non-submerged mode with the k- ω turbulence model

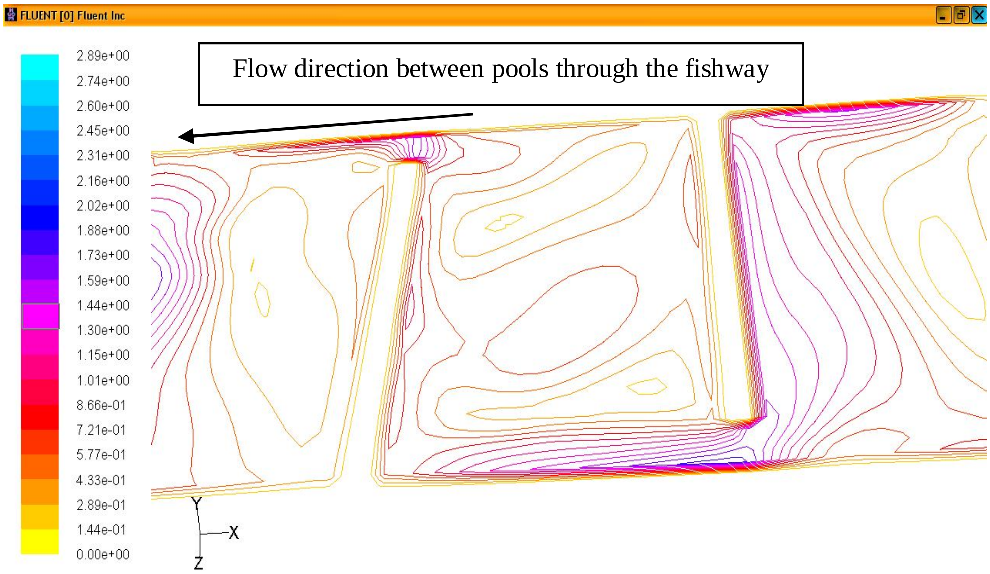

Figure 10. The velocity lines in the pools of fishway at submerged mode using the k- ε standard turbulence model

Discussion and Conclusion

Several rubber dams have been under construction in Mazandaran Province, and several items have been considered for them, but the structures relating to fish have not been built around them. In order to construct this structure that interacts with the environment of the rubber dams in Mazandaran Province, numerical models have been presented that could evaluate the results of measuring flow velocity in the instruments constructed in Karkhe-Hamidieh dam of Khouzestan and provide a means of comparing the results with those of field assessments. Finally, the conditions of using this structure along the rubber dams in interaction with the environment were discussed. The three-dimensional equations governing shallow water in weir and orifice fishway were solved using suitable turbulence models and then the flow pattern and turbulence were calculated. The results of flow simulation were compared with those acquired in the field by Micromollineh. The value of quick burst of speed is considered 2.5 mps for the adult fish. As we know, the Cyprinidae fish have the maximum power of 0.176 watt as well as the ability to overcome the 0.132 watt of energy; so they are able to climb a submerged state with a water height of 80 cm. In fact, there is no need to reduce the flow rate in a submerged state using devices such as baffles. The small Cyprinidae fish are also able to cross the fishway due to the slow flow of non-submerged state.

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