

# STUDY THE FACTORS INFLUENCING THE LACK OF APPROPRIATE FUNCTIONING OF FISH WAY STRUCTURE AND PROVIDING IMPROVEMENT STRATEGIES

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**ABSTRACT:** Fish ways are structures that allow the fish to pass to the dam upstream and provide the fish access to their intended habitats, which can reduce the negative effects of dam construction on the environment. However, most of the fish ways built in the world lack the required efficiency. The problem can be also seen in Iran even despite the low number of the structures. In this study, the factors affecting the lack of proper performance of fish way were studied in the design and implementation phases. The results indicated the most common causes of inefficiency of fish ways as neglect of the characteristics of the target fish and conditions of flow and flow rate at the site of structures implementation at designing time.

**Keywords:** Fish way, Dam, Environment, Ecosystem, Inefficiency

## INTRODUCTION

If there is a barrier in the upward migration path of the fish (inside the river), the fish are not deterred from moving forward and continue the effort to either succeed in cross the barrier and move upward or die. Since the small and large dams constructed on the rivers paths occupy the width of the rivers, they will impede the fish passage and lead to death of fish behind the dams and extinction of many fish species

[1]. Construction of fish ways is one way to reduce the damaging effects of dam construction and prevent the extinction of fish species, which is a solution for fish passing through the dam cross section. Some tips should be followed in designing different types of fish ways so that the structures could function properly, and the fish can overcome the height difference of the river at the dam site and pass through it. Alipour and Nohani [2] simulated the hydraulic behavior of the flow by applying different geometric and hydraulic conditions. The results showed that when fish passes the orifice, the safest route is the inner edge of the orifice that lower speed occurs in the non-submerged orifice. Also in the middle of pool the minimum speed has occurred. Kim *et al.* [3] attempted to simulate the flow in the fish way to be well consistent with the reality. They proved that having this information associated with analysis of the simulated flow and the flow characteristics according to the type of fish, the flow can be adjusted so that the fish can easily through it. Calluud *et al.* [4] proposed the installation of barrier opposite the outlet orifice of fishway with a vertical gap to modify the performance of the structure. Alvarez *et al.* [5] to obtain the fish reaction when approaching a barrier and the specification of its swimming installed a sensor in fish body or installed a camera.

## MATERIALS & METHODS

Designing of fish ways is an expert and sensitive work. The first phase of designing is to obtain information related to the dam where the fish way is to be constructed. Then, considering the factors, including upstream and downstream water levels, size of the structure, passing flow rate, pools and the slope, the structure will be designed. Then, the flow conditions in the structure must be specified. Subsequently, if necessary, the size and the slope of the fish way are sufficiently changed to achieve the optimal circumstances of flow in the structure for fish passage, which is the most important part of the fish way designing process. Numerical

calculations and computational hydraulics are as forecasting tools of flow in the fish way pools. The most important part of the structure is the water entrance from one pool to another, in which the speed control appears to be very important. The required velocity or flow rate to have the optimal rate can be obtained from the following formula:

$$Q = 0.7 \times h_2 \times b_2 \times \sqrt{2g \times (h_1 - h_2)} \quad (1)$$

Where,  $d_1$  and  $d_2$  are the water heights above and bottom of each pool wall and  $b_2$  is the groove width connecting the pools. Study and review of constructed fish ways throughout the world as well as review of papers written on unsuccessful fish ways can help the designer in providing a successful project and avoiding the repeat of those mistakes. This raises the success rate of the structure. In this research, the problems and defects causing the failure of the fish way malfunctioning were grouped and given in an applied form. Also, the proper suggestions and solutions to overcome the defects and improve the efficiency of the structure were presented.

## Discussion

The problems and defects may lead to inefficiency of fish way during the design and implementation of the fish may are numerous, some of which remain still unknown even for the experts in the field. However, the most common ones are discussed below.

1. The designer's lack of sufficient knowledge about the aquatic or fish of the target river and non-consideration of their characteristics in the design:

Usually while designing the fish ways in the world, the designers use the design guidance books and manuals, but unfortunately, they do not determine the aquatic and fish at the river construction site those have to use the structures to continue to live and for the survival of their generations, and would not consider their characteristics at the design stage. It should be noted here that there are other aquatic animals other than fish that may need to move in the river path, which need to move up through the fish way, including crabs and shrimps. These animals usually use the fish way walls to climb, which are usually neglected by the designers. A fish way designer, before the start of the design phase and at study phase, needs to specify the target aquatic and extract the information from the documented sources about them, including the reasons for migration, migration seasons, migration distance and other useful and applied information.

Since usually the fish use these structures mostly compared to other aquatic and climb through the structures by swimming or jumping, a set of complete information about the characteristics of the target fish such as swimming speed, swimming burst speed, migration seasons, migration distance as well as other information need to be derived from documented sources. Even if necessary, such information should be collected through field or laboratory research. In some cases, to obtain the reaction of fish at the time of reaching to the barrier and its swim characteristics, the method of installation sensor in the body of the fish or cameras are used that the results of such research are provided by Keffer et al. At first, it may seem expensive and uneconomical; however, its cost is not unreasonable compared to the manufacture of an unsuccessful fish way. Also, sufficient data should be collected on the fish population passing through the fish way section at any time period to design a structure with proper size.

2. Lack of sufficient information on the characteristics of the river flow at the site of the fish way construction:  
Lack sufficient knowledge of the designer regarding the flow rate and situation of the river at place of the structure construction may lead to changes the water level at the upstream of the fish way, and thereby, the input flow rate to the fish way would be changed. In rivers with unavailable flow rate statistics in different years, the flow rate should be obtained in different states and situation depending on the catchment area of the river and rainfall statistics. The fish was should be designed in such a way that provides the necessary efficiency and functioning in different flow rates, particularly in flow rates of seasons that the fish need to migrate. According to Phili et al. studies, the terminal ponds of the fish way constructed in the Karkheh diversion dam are not submerged during low water seasons, and the fish way do not have the required functioning. However, as can be seen in Figure 1, the structure downstream erosion at the junction to the river also aggravates the problem.



**Figure 1: The downstream conditions of the fish way constructed on Karkheh dam**



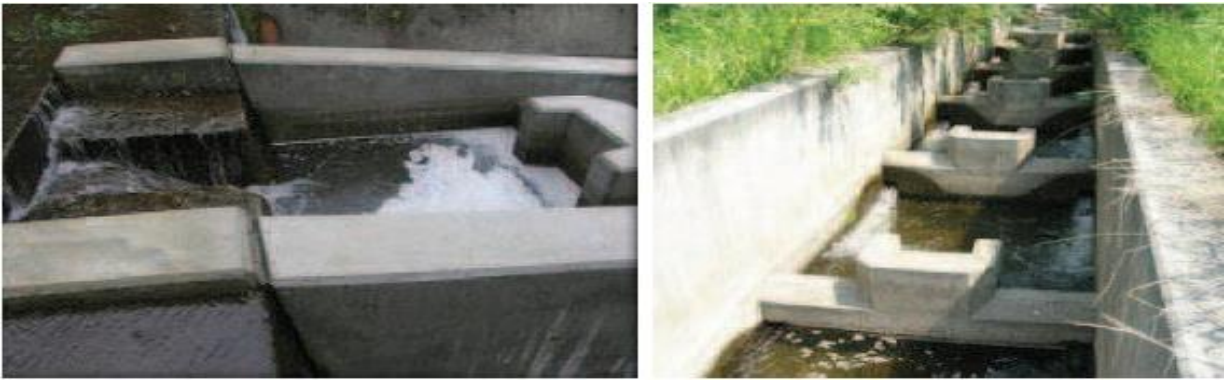
**Figure 2: Improper flow conditions in small floods at the upstream of the fish way (type of Pool-weir)**

Figure 3: Improper flow conditions in low water condition at the downstream of the fish way



### 3. Inappropriate size selection for the fish way:

In general, the size of the fish way should be determined based on the flow rate and the number of fish passing through the fish way that at any time period; since the large structures would be non-economic, and small structures will cause fish swarm at the downstream and their death. The flow hydraulics in the



**Figure 4: Inattention in determining the size of the fish way according to the flow rate leads to inefficiency of the structure**

Also, according to studies conducted by Ahwazi et al., the fish way constructed on Ask diversion dam has the same problem, and practically during the low-water seasons, the pools at the structure terminal are left out of the water over one meter and the fish connection to the structure is being cut. Thus, it must be concluded that if a designer fails to predict the river flow rate in different conditions and the flow characteristics in the flood stages, it would be impossible to design a proper fish way for fish migration to the upstream. Figure 2 shows the improper flow conditions at the time of discharge increase, while Figure 3 shows the improper flow conditions due to reduced flow rate.

fish way needs to be designed based on the flow rate and normal estimates (due to the migration season). Some engineers design the dimensions of the fish way structure regardless of the flow rate in different conditions, which leads to adverse hydraulic conditions that is not appropriate for the moving direction of fish and other aquatic animals (Figure 4).

#### **4. Not selecting the right type of the fish way:**

Choosing the wrong type of the fish way according to the target fish and the river's condition would cause the structure poor performance. For example, the pool-type fish way is not suitable for the fish unable to jump. Instead, the fish way with vertical openings can be used, or in the case of using the pool type, an opening can be imbedded below the walls for passage of fish unable to jump. It should be noted to select the fish way to be proper for most of the fish species and aquatic animals living in the river. When it becomes impossible due to the diversity of fish species, given the need for upstream moving, the fish species should be prioritized for their generation survival.

#### **5. Inappropriate location or inaccuracy in the implementation of the fish way different components:**

One of the causes of poor performance of the fish way includes inaccuracies in the location, input and output functioning and the rest parts of the structure. In brief, the structure input should be placed in a part of the river where the fish use to pass naturally through at the time of migration. Due to the fact that the flow rate is low at coastal sides, the fish ways should usually be constructed at these locations. It should be noted that given the dam spillway condition and its position, the input must be in place to the stilling basin where the hydraulic jumping range is finished and the flow is

normal. Also, some measures should be taken to prevent the destruction and changes in the riverbed, since changes made at the entrance of the fish way can cause change in the flow conditions and malfunctions. The fish way outlet should also be set in a way that the fish can easily get out from the structure and enter the water without being thrown into the water. The distance between the output and the spillway should be such that the flow conditions in the area would not lead the fish towards the spillway after leaving the structure, which may cause the falling of the fish into the downstream. It is better to embed a valve or take other measures at the

structure output to regulate the discharge in order to set the appropriate flow for the fish moving by controlling the flow in the fish way in different situations. Also according to the conditions, it is better to predict a system for screening the waste material at the water inlet to control wood and other additional materials submerged in the water. However, it is important that the holes of the trash screen would be proper to exit the passing largest fish and aquatic animals. The walls of the pools should be appropriately high so that the fish would not be fallen when jumping and moving in the structure's pools.

#### **6. Failure to manage the fish way:**

One factor leading to the insufficient efficiency of the fish way even with correct designing is lack of appropriate management. For example, if the inlet flow rate into the structures is not controlled, the flow in the structure may be different from what was considered when designing, and the fish cannot use the help climb the structure. The flow conditions in the fish ways ponds must be such that the target fish can easily and quickly climb out the structure; also, the flow rate at the pools outlet should be less than the burst speed of the target fish so that they can swim contrary to the water direction. In the pools, the flow should be designed in such a way that in some points the water velocity becomes so low that the fish can rest in them and prepare themselves for the next moves. The high flow rate also causes a lot of damage to structure's downstream. Flow management of the fish way greatly affects the sediment management as well. Figure 5 shows the entry of sand and stone into the fish way, which leads to inefficiency of the fish way.



Figure 5: Entry of sediment causes the inefficiency of the fish way



Figure 6: The moving path and place of crabs and shrimps in the body of the fish way

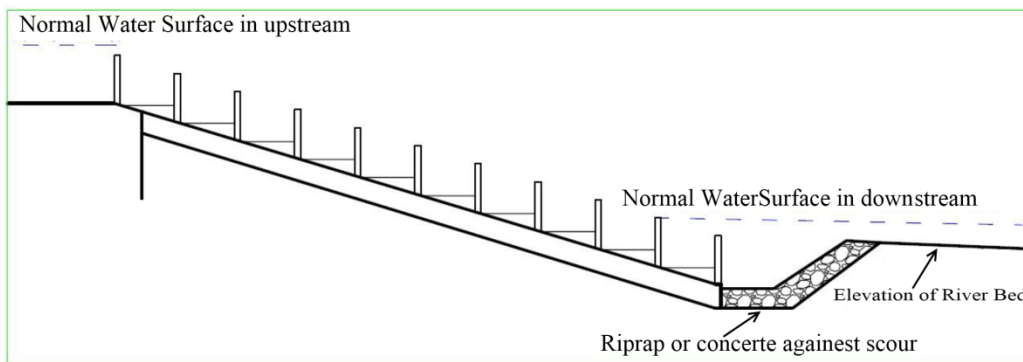


Figure 7: The correct way to run downstream to improve the structure's function at times that the flow rate of the river changes compared to the designed flow rate

It should be noted that the movement of pebbles, stones, sand and large waste and trash and throwing them in the fish way downstream will prevent the movement of aquatic and fish and cause the damage and losses of them. This problem is more critical for animals such as crabs that use the lower part of the body to move, and these aquatic animals will not be able to climb in the fish way in absence of controlling large suspended solids in the structure.

By modeling the flow at 1/10 scale in the laboratory, Yasuda et al. showed that the flow in the fish way should be adjusted in a way that the particles larger than 2 cm can only move in the structures at flood time so that the flow would be proper for passage of aquatic using the pool wall to move upward, such as shrimps and crabs. Figure 6 shows the movement pattern and place of shrimps and crabs in the fish way.

However, in certain situations such as floods, additional materials may enter into the structure and deposit. Thus, some measures need to be taken to change the flow conditions and increase its speed for washing the pools. Alternatively, a path can be considered for entering the pools for hand or machine discharge of the sediments.

### CONCLUSION

Basic studies on the location condition and the target fish and aquatic are very important in the design of the fish way, and it cannot be designed only for the normal conditions. Some measures should be considered that the flow rate changes through different seasons would not make any change in the efficiency of the fish way, and the structure can function properly. It is to be noted that the flow rate changes have a direct effect on the flow conditions at the downstream of the structure. Since not finding the structure opening by the

aquatic is one of the most important factors in the failure of the constructed fish ways, the ponds at the beginning of these structures are considered as the most important parts. Continual of the structure pools to a depth greater than normal level of the rivers leads to the submergence of the structure's beginning in all conditions. Also, the stone or concrete coverage of the section can prevent the destruction or changes in the level of the river downstream (Figure 7).

### REFERENCES

1. Silva, A.T., M.T. Ferreira, A.N. Pinheiro, C. Katopodis, 2010. Effects of water velocity and turbulence on the behaviour of Iberian barbel (*Luciobarbus bocagei*, Steindachner 1864) in an experimental pool-type fishway. *River Research and Applications*, 27: 360-373.
2. Alipour, R. and Nohani, N. 2014. Flow Simulation in the Orifice and Weir Fishways (Case Study: Diversion Dam of Karkhe). *Adv. Environ. Biol.*, 8(25), 370-374.
3. S.Kim, K.Yu, B.Yoon, and Y.Lim. 2011. A Numerical Study on Hydraulic Characteristics in the Ice Harbor-type Fishway , *KSCE Journal of Civil Engineering*, 16(2) 265-272.
4. D. Callaud, R.W. Wang, G. Pineau, M. Larinier, A. Texier, L. David. 2010. Experimental study of 2D instationary flow in vertical slot fishways ans with and without cylinders.
5. L.J. Alvarez-Vázquez , A.Martinez , M.E. Vázquez-Méndez and M.A.Vilar.2011. The importance of design in river fishways , *Procedia Environmental Sciences* (9) 6 – 10.