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A Review on the Impact of Vertical Slotted Fish Passages on Fish Populations in River Basins

Feng Xuan[1], Cao Yanmin[2]
Hunan City University, Water Resources and Hydropower Engineering major, Yiyang, Hunan, China

Abstract: ***The interruption of fish migration routes has a negative impact on the health of aquatic populations and ecosystems. To address this issue, vertical seam fishways are designed to assist fish in crossing dams and embankments. This article integrates the concept and design ideas of vertical seam fishways, the impact assessment of vertical seam fishway construction on fish in the watershed, as well as the problems and challenges encountered, by searching and reading relevant materials. The aim is to provide reference for ecological restoration and fish protection in hydraulic engineering.***
Keywords: vertical seam fishway, fish migration, ecological protection, migration demand, fishway construction.

I. INTRODUCTION

With the rapid development of water conservancy engineering, many rivers have built dams and hydropower stations. Although these facilities have effectively promoted the economic development of human society, they have also had a serious impact on the river ecosystem, especially the natural migration behavior of fish. As a new type of ecological channel design, the vertical seam fishway aims to solve this problem by simulating the natural migration environment of fish and providing a path for fish to cross dams, thereby protecting fish diversity and maintaining river ecological balance.

II. THE CONCEPT AND DESIGN IDEAS OF VERTICAL SEAM FISHWAY

A. The concept and Development History of Vertical Seam Fishway

Vertical seam fishway is an artificial structure used to assist fish migration, which is widely used in hydraulic engineering due to its simple structure and good fish passage effect[1]. It provides a pathway for fish to pass through by constructing vertically arranged slits on rivers or dams, which can alleviate the impact of blocking natural swimming channels for fish caused by river blocking projects[2]. The development of vertical seam fishways can be traced back to the late 19th and early 20th centuries. Early fishway designs mainly included sloping or stepped structures to assist fish in crossing vertical obstacles such as dams or weirs. However, these designs have many issues, such as excessive flow velocity, large water flow disturbances, and limited adaptability to different types of fish[3]. Due to the development needs of the times, China's development of hydropower resources has gradually deepened[4]. At the same time, people are paying more attention to the protection of the ecological environment, and the construction and development of fishways have been given renewed attention. At the same time, relevant departments have also formulated design specifications for fishway construction[5]. Thus, the design of fishways has become one of the indicators for evaluating the feasibility of hydraulic engineering design.

B. Design Concept of Vertical Seam Fishway

The construction of vertical seam fishways aims to help fish migrate smoothly in rivers, and its design concept mainly involves the basic principles of water dynamics[6] and fish behavior[7]. In the research of Zhang Yanyan et al., it was found that by designing appropriate cross-sectional structures, fishways can have better water flow patterns and meet the requirements of different fish species for water flow velocity, making it easier for fish to pass through fishways and reducing the impact on fish migration[8]. The goal of vertical slit fishway design is to simulate natural flow conditions, such as rapids, mudflat or waterfalls in rivers. By setting slits of different sizes and shapes in the fishway, water flow disturbances, eddies, and bubbles can be generated, creating hydrodynamic conditions similar to natural environments[9]. The design of the vertical seam fishway takes into account the migration behavior of different fish species. The size and shape of the slit can affect the behavioral choices of fish. In the study of the hydrodynamic characteristics of migratory fish by Ma Weizhong and others, it was pointed out that different migratory fish have different preferences for migratory flow velocity and swimming ability[10].

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This means that the design and construction of fishways must allow multiple migratory fish species in the watershed to pass through the fishways smoothly without excluding them. In addition, Sun Shuangke et al. pointed out in their research that specific colors, textures, or natural river sand and stone decorations may be used in fishway design to achieve a natural channel like design, in order to attract fish to enter and pass through the fishway[11]. At the same time, the design of vertical seam fishways should also pursue good passability and safety. The spacing and width of the slits should ensure that fish can pass smoothly, and the water flow conditions in the fishway should allow fish to swim easily and provide shelter or resting areas[12].

In the intricate design process of vertical seam fishways, an aspect of utmost significance and criticality lies in adapting to local conditions. One must not, under any circumstances, blindly copy the design data of others. When embarking on the design of fishways for water conservancy projects, it is of paramount importance to initially conduct a thorough investigation into the species of fish and the aquatic environment within the entire watershed. Only by doing so can one lay a solid foundation for a well-informed design. Subsequently, it is necessary to combine the extensive research of a large number of scholars. This collaborative effort brings together diverse perspectives and expertise, enhancing the quality and effectiveness of the design. Once the design is completed, it is imperative to conduct feasibility studies or experiments. These steps are crucial in ensuring the feasibility of the fishway. Only after confirming its viability can the construction process proceed with confidence and assurance.

III. ASSESSMENT OF THE IMPACT OF VERTICAL SEAM FISHWAY CONSTRUCTION ON FISH SPECIES IN THE WATERSHED

A. Vertical seam fish passage effect

Vertical seam fishway is an innovative and effective engineering design that plays an important role in protecting and promoting fish migration[13]. The vertical seam fishway has shown increasingly better fish passage effects in past practices. The vertical seam fishway provides a relatively natural passage for fish, allowing them to smoothly cross obstacles such as dams. This channel structure simulates the environment of natural rivers and is more in line with the behavior and migration needs of fish. According to monitoring data from Cai Yueping and others in the Angu vertical seam fishway and downstream river channel of Dadu River in Sichuan Province, it was found that 70.59% of the fish species entering the fishway accounted for the downstream species, while 79.17% of the fish species entering the fishway through the fishway[14]. This indicates that most fish can cross water conservancy structures through fishways, reducing the impact of water conservancy structures on blocking rivers. The design of vertical seam fishways usually takes into account the size, morphological characteristics, and migration habits of different types of fish. By adjusting parameters such as width, height, and length of the channel, it is possible to meet the passage needs of various fish species, allowing different types of fish to benefit from this fishway. The construction of vertical fishways can help restore or improve river ecosystems affected by human activities such as dams. Fish are an important component of the aquatic food chain, and their migration plays a crucial role in maintaining ecological balance. By helping fish migrate smoothly, vertical fishways can promote the restoration and healthy development of river ecosystems. Overall, vertical seam fishways have demonstrated good fish passage effects by providing effective channels, adapting to various fish species, improving ecosystems, and reducing fish mortality rates[15]. The construction of such fishways is of great significance for protecting fish resources, maintaining ecological balance, and promoting harmonious coexistence between humans and nature.

B. Assessment of the Ecological Impact of Fishway Construction on the Watershed

The construction of fishways is not only a way to protect fish, but also a responsibility to maintain the biodiversity of the entire watershed ecosystem. In the report by Bao Nini and others, it was pointed out that the reduction of fish species in the Oujiang River Basin only improved after the construction of fishways, and the construction of fishways was called "opening up life channels", which further reflects the importance of fishway construction for ecological protection[16]. Evaluate the effect of fishway construction on fish migration and passage, including the impact of factors such as fishway patency, water flow velocity, and water depth on different fish species. This helps determine whether the fishway design meets the biological needs of fish[17]. It is not difficult to see from the comparative experiment conducted by Liu Chao et al. that inappropriate fishway construction not only fails to improve the living environment of fish, but also brings a blow to juvenile fish[18]. The construction of fishways is an extremely important matter, which not only relates to reducing the damage caused by water conservancy projects to the ecological environment of fish, but also is the key to the ecological restoration of the entire watershed. Assess the impact of fishway construction on aquatic vegetation, including vegetation types, coverage, and growth conditions in the fishway. This helps to determine whether fishway construction provides sufficient habitat and food sources. Research has shown that the shrinkage of aquatic habitats will form after water storage, which is unfavorable for the reproduction and habitat of fish in the watershed[19].

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However, corresponding ecological and environmental protection measures should be taken, including the restoration of migration channels, that is, the restoration of fishways, to ensure that the impact is within the acceptable range of the ecological environment system. Assess the impact of fishway construction on hydrological characteristics of the watershed, including changes in water volume, water flow velocity, water level, etc. This helps to determine whether fishway construction has improved the connectivity and stability of aquatic ecosystems. Comprehensively evaluate the impact of fishway construction on the ecosystem functions within the watershed, including ecological connectivity, species diversity, and food chain relationships[20]. This helps to determine whether fishway construction has a positive impact on the ecosystem within the watershed.

The above evaluation content can be investigated and analyzed through on-site inspections, water quality monitoring, biological sampling, and other methods. The evaluation results will provide scientific basis for fishway construction, ensuring its positive role in protecting aquatic ecosystems and maintaining biodiversity.

IV. ISSUES AND CHALLENGES IN THE CONSTRUCTION OF VERTICAL SEAM FISHWAYS

Vertical seam fishway is a common fish migration channel structure used to assist fish in crossing dams or other obstacles. However, the construction of vertical seam fishways involves some technical challenges, and the following are some of the possible problems that may be encountered. The vertical seam fishway needs to ensure that the water flow maintains an appropriate speed and depth within the channel, so that fish can pass through smoothly. Therefore, in the design and construction process, it is necessary to consider how to adjust the flow velocity and flow rate of water to meet the migration needs of fish[21]. The structural design of vertical seam fishways should take into account the size and morphological characteristics of fish. Different types of fish may have different body shapes and sizes, so the width, height, and length of the channel need to be reasonably designed according to the actual situation to ensure that fish can freely pass through. However, structural design is not only limited to this, but also needs to consider the impact of its structure on the water flow structure[22]. Some studies have pointed out that the aspect ratio is the main factor affecting the water flow structure of the pool chamber. Once the aspect ratio changes, it will directly affect the trajectory of the mainstream, which in turn will affect the fish passage efficiency. Vertical seam fishways are usually composed of multiple continuous gaps, and fish need to swim from one gap to another. Therefore, during the construction process, it is necessary to ensure smooth connections between each gap, without any obstacles or uneven areas, to ensure that fish can pass through smoothly. Wang Yongmeng and others conducted systematic experiments to study the swimming ability of two types of split belly fish in the Yalong River, which provided a better understanding of the swimming characteristics of fish and provided strong factual basis for the design and construction of fishways, and can also improve the fish passage ability of fishways[23]. Vertical seam fishways are usually located above dams or other hydraulic structures, which may experience backflow. Therefore, in the design and construction process, corresponding measures need to be taken to prevent backflow from affecting fish migration, such as setting appropriate valves or barriers at the entrance of the fishway.

In the study by Huang Yongzeng et al., three different fishway inlet layout schemes were compared. By constructing numerical models and conducting river section investigations, it was found that the layout scheme of the fishway should be determined by comprehensively considering economic factors, construction factors, engineering factors, etc., and it was recommended to adjust the operation scheme of the gate accordingly to better play its role[24]. In addition, the layout plan of the fishway inlet will directly affect the fish attraction effect and fish passage efficiency of the fishway. The slope design of the fishway is also a major difficulty. When the slope of the fishway is small, fish can better adapt to changes in water level, but the distance of the fishway construction needs to be extended, which will increase the construction cost.

So in the design of fishways, it is necessary to consider both the practicality of the fishway and choose appropriate design schemes to save engineering costs. Vertical seam fishways require regular maintenance and cleaning to ensure that there are no debris or blockages in the passage. This is crucial for the smooth passage of fish, so effective maintenance and cleaning work needs to be considered at the beginning of construction.

The construction of vertical seam fishways involves technical challenges such as water flow control, structural design, channel connectivity, prevention of backflow, and maintenance and cleaning. To solve these problems, it is necessary to comprehensively consider the migration needs of fish and the actual environmental conditions, and take corresponding measures to ensure that fish can pass through the fishway smoothly. The construction of fishways serves fish, so understanding the swimming characteristics of fish also has a great impact on the design of fishways. Fishway design is related to various aspects, which requires designers to consider many factors and comprehensively design various indices when designing fishways, in order to design fishways that are acceptable for both engineering and fish.

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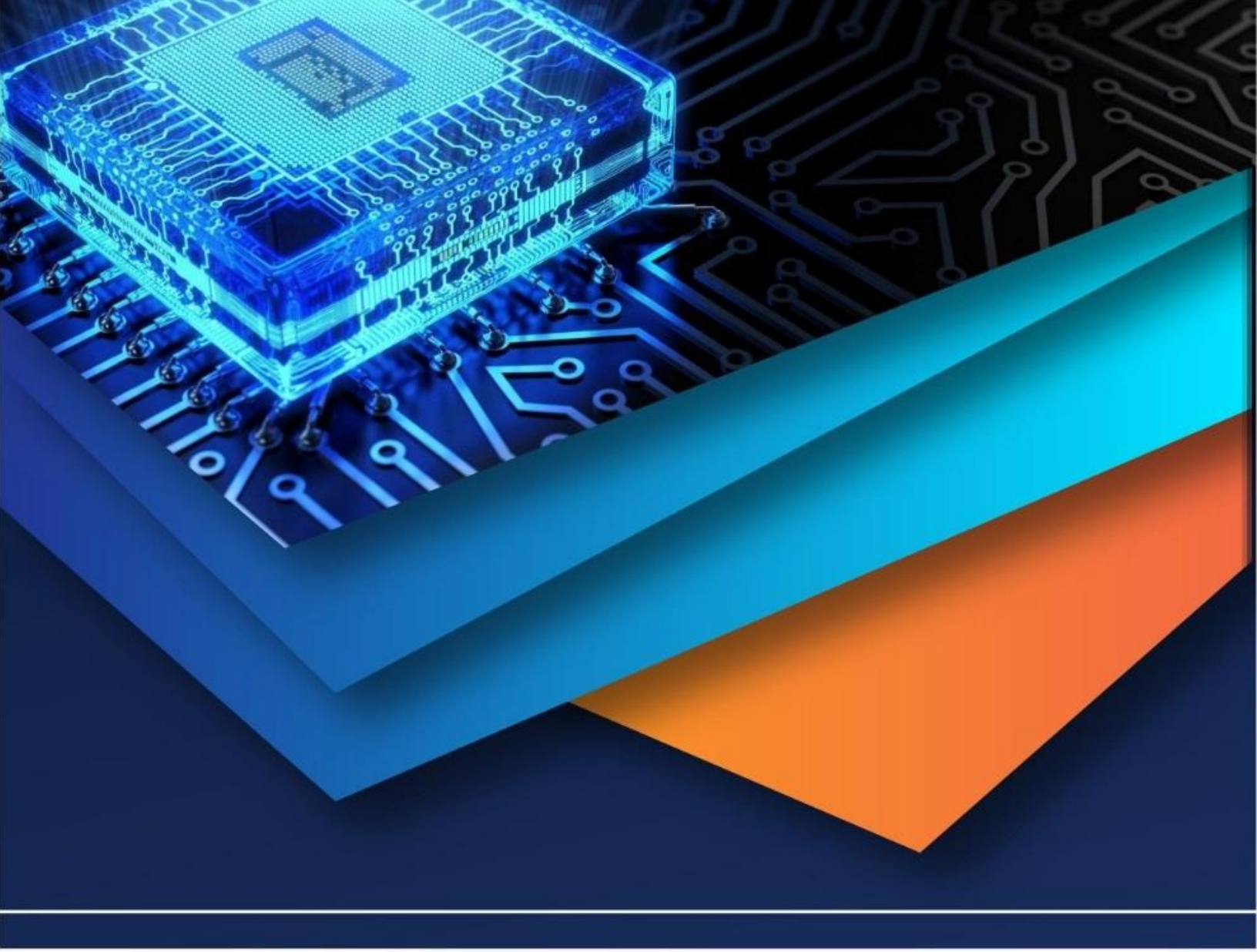
V. SUMMARY AND PROSPECT

Vertical seam fishways play an important role in protecting and promoting fish migration, demonstrating good fish passage effects, allowing most fish to smoothly cross obstacles such as dams, and helping to restore and improve river ecosystems. In addition, the construction of fishways is crucial for maintaining the biodiversity of the entire watershed ecosystem, which has an impact on fish migration and passage, aquatic vegetation, watershed hydrological characteristics, and ecosystem functions, and requires comprehensive assessment[25]. However, the construction of vertical seam fishways also faces some technical challenges, such as water flow control, structural design, channel connectivity, prevention of backflow, and maintenance and cleaning. To solve these problems, it is necessary to comprehensively consider the migration needs of fish and the actual environmental conditions. Overall, the construction of vertical seam fishways is of great significance for protecting fish resources, maintaining ecological balance, and promoting harmonious coexistence between humans and nature.

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