5.2.3. Basic points of fish protection structure projecting

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Basing on the accumulated experience in the field of fish protection, analysis of the present FPS constructions, clauses of SanPiN 2.06.07 – 87 [1] and on a method of FPS construction selection [2], the following basic provisions, which can be used by hydraulic engineers at projecting of the modern FPS, can be formulated [7].

1. At designing of hydrosystems and water intakes at rivers, reservoir storages and other basins, which have a fishery value and can be used in fishery purposes, in accordance with the current legislation, it is necessary to foresee the building of fish protecting and other fish conservation structures and constructions, agreed with fishing control authorities and intended for saving the conditions of natural reproduction of water bio sources during hydro technical construction.

2. Fish protection structures are necessary to be foreseen in purposes of preventing from ingress into water intakes, injuring and death of larvae and the young fish and in purposes of taking fish aside in viable condition to a safe place of the fishery basin for natural reproduction.

3. FPSs are necessary to be designed on basis of fish-water and biological grounds with implementation of proper ichthyological researches, during which it should defined the following: specific and length composition of the protected fish, specifying its least size; period of its falling and migration; vertical and horizontal disposition of fish; location of spawning areas and hibernating pits; carrying away current for the young protected fish.

4. Water intakes with FPSs should be placed, considering ecological division of the basins into districts in zones (biotopes) with lower density of fish. Its location is not permitted in regions of spawning areas, hibernating puts, at areas of intensive migration and large concentration of larvae and young fish, in reserves.

5. Fish protection structures should provide protection of fish of any type and parameters. By this, their fish protecting efficiency for fish of 12 mm in size and longer shouldn't be less than 70 %.

6. Fish protection structures are permitted to be set as a block of separate sections in condition of eliminating their mutual negative influence on a process of protection and fish withdrawal.

7. A number of sections to be installed in the block of concentrating constructions is estimated by the following condition:

$$n \geq 0{,}625 Q_{max}/Q_{min},$$

where Q_{max} and Q_{min} —maximum and minimum consumptions of water intake, accordingly.

8. Fish protection construction consists of three basic functional elements: incoming stream forming, working with protective and water-receiving surface and outgoing fish withdrawal. Additionally, the complex of auxiliary elements can be included in construction of FPS.

9. Stream forming element is intended for creation of hydraulic structure of watercourse, flowing into FPS. This course provides fish withdrawal to a transit stream zone, distant from protective and water-receiving surface of the working organ and provides optimal condition for fish falling inside the transit current into fish withdrawal element;

10. Working organ (protective and water-receiving element) is intended for providing the optimal hydraulic conditions of passive young fish, falling inside the transit stream as well as for uniform selection of the working organ inside the water intake by real or imaginable protecting and water-receiving surface with speeds that do not exceed the carrying away speed for the minimum size of the protected fish.

11. Fish withdrawal element is intended for taking away of the protected young fish out of the working organ coverage into a safe place of fish habitable basin. Natural current of watercourse or artificially organized current in the basin or fish withdrawal track can be used as fish withdrawal element.

12. Auxiliary element is intended for raising the protection efficiency, mainly, of grown-up, free-moving fish in the basin. With a help of additional features, it allows more fully and more efficiently using fish protection qualities of basic functional elements as in a complex or separately. One or several auxiliary elements can be included in construction of fish protection structures. As a rule, auxiliary elements exerts on fish physiological influence of different origin. This influence provides an independent active movement of fish from dangerous source to areas of the basin with comfort conditions of habitat.

13. Recommended structure of FPS is shown in Fig. 5.43.

14. Construction of FPS should be designed by a method of combination by a complex of functional basic and auxiliary elements (Fig. 5.44).

Having imagined FPS as a complex of basic functional elements, it is necessary to analyze each of them with regards to conditions of concrete water and hydro technical objects and to detect its constructions, type and principle of action, being more compatible and optimal to solve the present problems. After that, combining the selected constructions of functional elements between each other in limits of trinomial complex and adding them by the needed auxiliary elements; it is necessary to compose optimal constructions of fish protection structure for concrete conditions (characteristics of hydro technical and water objects, fish fauna, etc.).

Principle scheme of FPS, combined from the logically arranged functional elements is shown in Fig. 5.44.

15. Parameters of FPS are necessary to fix basing on a condition of ensuring the supply of the calculated consumption of water to consumer.

16. Parameters of FPS are necessary to be also set basing on a condition of formation of a hydraulic mode in their working organ with the following characteristics:

- speed (longitudinal component of speed) of transit current of water υ_{tr} along protecting and water-receiving surface of the working organ shouldn't be 2,5 times as much as the carrying away speed υ_p for fish of the largest protected size:

$$\upsilon_{tr} \geq 2{,}5\,\upsilon_{p\,max}$$

- speed (transverse component of speed) of working stream overflow into water intake υ_{wf} through the protecting and water-receiving surface of the working organ shouldn't exceed the carrying away speed υ_p for fish of the least protection size:

$$\upsilon_{wf} \leq \upsilon_{p\ min}$$

- speed of stream flowing into headwall of fish withdrawal υ_t should be 1,4 times as much as the speed of the connected current into water intake υ_{ws} :

$$\upsilon_t \geq 1{,}4\,\upsilon_{ws}.$$

17. The carrying away speed υ_p for the falling young fish is permitted to estimate by a length of the fish body l_f and to accept it equal to 10 l_f/s.

18. Protective and water-receiving surface of FPS working organ should be implemented as impermeable for fish, that is, finely perforated (reticulate, filtering, finely perforated), half-impermeable for fish – large-perforated and possibly permeable for fish – not equipped with protective apparatuses, followed by a surface of working stream diffluence into water intake.

19. Application of impermeable for fish protecting and water-receiving surface is permitted at its location in zones of water intake with minimal concentration of the falling young of fish of yearly aged groups and at its compulsory equipment with a system of washing out.

20. Application of half-impermeable for fish protecting and water-receiving surface is permitted only at its washing by transit fish withdrawal current, hydraulic mode of which meets the requirements of it. 16.

21. Application of possible permeable for fish surface is permitted only at occurrence of overconcentration of fish in a zone of transit fish withdrawal current, distant from the present surface.

Table 5.17. **Dependence of diameter of a hole in screens, being impermeable for fish, on length of fish body***

Length of fish body, mm	12	15	20	30	40	50	60	70	90
Diameter of hole in screens, being impermeable for fish, mm	1,5	2	3	4	6	7	8	9	10

* At square holes the sizes correspond to diagonals of the cell.

Table 5.18. **Dependence of protecting and water-receiving surface section length on speed of the working stream overflow**

υ_{wf}, m/s	$0{,}5\upsilon_p$	$1{,}0\upsilon_p$
l_p, m	$1200 l_f$	$600 l_f$

22. Diameters of holes in impermeable for fish protecting and water-receiving surface of FPS working organs should be accepted according to Table 5.17.

23. Length of single section, being impermeable for fish, of protecting and water-receiving surface l_p of working organ should be fixed in dependence on overflow working stream υ_{wf} speed through protecting and water-receiving surface into water intake according to Table 5.18.

24. Area of finely perforated protecting and water-receiving surfaces of FPS should be fixed with the reserve coefficient γ=1,2, which considers a possibility of its obstruction during operation.

25. Half-impermeable for fish protecting and water-receiving surfaces should be implemented from plate-jalousies, between which there are water-throughput chinks. Working edges of plate-jalousies have direct-and-wave character, and toothing and hollows of the following plate-jalousies are located in staggered order over the stream.

26. Louvered protecting and water-receiving surfaces should be implemented as visual impermeable ones. At installation of plate-jalousies normally to the stream, its working edges should be arranged with exceeding of the following edge in comparison with the previous one by 20 mm. At installation of plate-jalousies at a cute angle, which does not exceed 38^0 to axis of the stream, they should be located with excess of not less than 12 mm.

27. It's possible, that the permeable for fish water-receiving surfaces are always imaginable and are the rated border of working stream overflow into water intake. As a rule, they are added also by flat of volumetric surfaces of diffluence that connect stream forming element with the headwall of fish withdrawal.

28. Possible permeable for fish water-receiving surface can be implemented also as the hydraulic screen: symmetrical – at the intake of water from basin or asymmetrical – at the intake of water from watercourse.

29. Symmetrical and asymmetrical hydraulic screen should be formed using the water streams, which flow from nozzles of stream generator that frame water-receiver, accordingly, by sides symmetrically to its axis or only from its superficial part and which are directed at a angle to water intake front.

30. Speed of water stream current υ_s, intended for creation of current inside the fish withdrawal, as well as forming of transit current or hydraulic screen, should not be more than 10 m/s and exceed the current speed in water environment that surrounds the stream υ_{wo}:

$$\upsilon_s \leq \upsilon_{wo} + 10 \text{ m/s}.$$

31. Overflow of working stream is not permitted through the possible permeable for fish surfaces into water intake with creation of high speeds hearths, which exceed the carrying away speed for the protected fish.

32. Speed of stream current in fish withdrawal, directed to a safe place of fish habitable basin, should be accepted, being not less than the carrying-away speed for the protected fish:

$$\upsilon_t \geq \upsilon_{p\ max}.$$

33. Safe place of fish habitable basin is the area of its water territory, from which falling young fish into water intake absent.

A method of selection of optimal and universal FPS construction and also basic provisions of FPS designing are developed in the branch company of "UES Engineering Centre - Hydroproject Institute" (ph. 940-54-51, E-mail: ivanovr-zu@land.ru.).