EXPERIENCE WITH THE DESIGN AND OPERATION
OF A 10-m$^3$/sec MARINE FILTER IntAKE

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Filter intakes are widely used in the northern rivers. Engineers have had the opportunity to read about experience with the design and operation of only one marine filter intake, of 1-m$^3$/sec capacity, in the city of Novorossiisk. For this reason description of experience with the design and operation of relatively large marine filter intake, of 10-m$^3$/sec capacity, is of unquestionable interest.

The region where this intake was built is characterized by the absence of transitory ocean currents; only drift currents, which change their direction according to the direction of the wind, are observed. The surface currents generally have the same direction as the wind and as a rule the compensating currents have the opposite direction or are inclined at a certain angle, depending on the configuration of the sea bottom.

The surface water velocity may be determined from the well-known relation $V_{\text{water}} = (0.02-0.03) V_{\text{wind}}$. According to our observations, the velocity of the water within the boundaries of the compensating currents varies from 0 to 0.3 m/sec. The characteristics of the wave formation depend on the bank profile and the bottom configuration. The sea bottom is characterized by the presence of a ledge at a depth of 5-6 m and at a distance of about 1 km from the beach, with a surface which rises gently toward the beach. Under great storms, the first surfs are observed at a distance of 1 km. Under lesser wind forces, the first surfs develop closer to the beach. Observations conducted during a four-year period have shown that in a zone where the depth reaches 4-5 m storm waves have a height of 3-3.2 m, which agrees with the norm SN 92-60. The wave parameters at the intake head, as adopted as design quantities, $h = 3.1-3.2$ m, $L = 40$ m. The region is characterized by the presence of dense clays and marls, a large number of submerged stones, and minor amounts of sand in a layer of up to 1 m thick. On the stones and the rock base grow the sea grasses Zestera and Clodophora, which during storms are transported by the currents and accumulate in large quantities. Under a wave action of 3-units force, the zone of disturbance extends through a width of 200-300 m from the beach, and under a wave action of 5-units force it extends through a width of more than 1000 m. Under a 4-units wave force the water turbidity usually does not exceed 100 g/m$^3$, and under a wave action of more than 5-units force it does not exceed 250 g/m$^3$. On calm days, the water in the region of the intake is sufficiently clear. The concentration of algae in the water amounts to 5-10 g/m$^3$, beyond the limits of massive accumulation. The absence of permanent currents attends the lack of conditions for the creation of a transitory flow of bottom sediments. Our investigations also permitted establishing the abnormally low temperatures of the water during the summer period, which are associated with the presence of seaward winds at this time of the year, as well as recording the short-duration negative temperatures during the winter period in the shallow zone near the beach. Furthermore, these investigations permitted establishing the presence of thin ice at the beach and the occurrence of sludge and snow cover during certain intervals when the air temperature decreased sharply. The accumulation of sludge takes place basically in the beach zone. However, when the winds are seaward the sludge may be carried toward the sea.

In the region where the intake is located, submerged structures become covered mainly with shore clams and barnacles. In connection with the considerable development of sea shipping and the possibility of the water-temperature increasing in a zone where industrial wastes are discharged, the accumulation of such matter on the surface of hydraulic structures may constitute a hazard.

For a water consumption of up to 10 m$^3$/sec, the most popular solution is the construction of a pipe intake with the inlet located at a depth of 5-6 m. However, in connection with the presence of dense sands and marls, construction work in open water presents considerable difficulties. For this reason an alternative consisting of a siphon intake with pipes resting on piles was proposed. This alternative is undoubtedly the most economical.

solution; it arouses some concern, however, because of the necessity to install the pipes above the wave crest and the possibility of these pipes becoming covered with sea fauna. It is suspected also that the existence of a seaport in the zone of the intake may be conducive to damage of the pipes in case of emergency overcrowding of vessels. In this connection, it was decided to construct an intake consisting of a sea canal flanked by wave-protecting levees.

When this alternative was being developed it became clear that for a water consumption of 10 m$^3$/sec it was possible to use the filter intake scheme, since the planned length of the levees permitted collecting the required amount of water without constructing an open inlet. The most rational solution for the canal intake is the construction of levees parallel to the canal axis and located at a distance from each other permitting the excavation work to be carried out without the use of floating installations. The cross-section of the headrace canal for a filter intake is determined on the basis of the conditions governing nonscouring velocities and ice formation. Let us note that the slope of the bottom of the canal must be considered to be equal to zero, with possible elevation differences within the limits of the dredging clearance. The levees must be constructed by using local rockfill, with a protection consisting of concrete cubes placed at those locations where wave action originates. In view of the lack of local stones meeting the SNiP norm, it was considered acceptable to use local limestone. Such a solution considerably lowers the capital investment and fully agrees with the nature of the levees, since they may undergo even large deformations without presenting any hazard. The location for the intake head was selected on the basis of the same considerations applying to the design of canal harbor entrances. When the water level reaches its lower limit, the inlet is at a depth of approximately 3 m. We consider that a reduction of the depth down to 3 m for a filter intake under the local conditions does not present any hazards.

This filter intake using levees constructed by placing only rockfill gave rise to apprehensions concerning the possibility of the formation of significant drops, as it occurs in river intakes of the same type. In this connection it was considered convenient to use levees consisting of concrete cubes for the intake head portion (see Fig. 1).

The following procedure was adopted for construction of the rock fill. A special bed was not used for the rock fill, the foundation was of dense clays, and furthermore, the deformations of the structure do not affect its operation. A rock material satisfying the following requirements was accepted: crushing strength $> 50$ kg/cm$^2$; percentage of fines $< 15\%$; coefficient of softening $> 0.85$. Use was made of 3-8 ton concrete cubes to strengthen the rock fill. For the intake head portion, only 8-ton concrete cubes were used.

The headrace canal had 1:3 lateral slopes. The difference in elevation between the crest of the levees at the beach and at the intake head is due to the variation of the wave height as a result of the variation of the depth along the levees. The crest elevations of the levees were established on the basis of the conditions governing construction work under a wave action of not more than 2-3 units force, and also by taking into consideration the admissibility of water flowing over the levees in the case of pronounced wave action during the period of construction. Let us note that in order for the operating conditions of the filter intake to be fulfilled also during large storms, it would be necessary to increase considerably capital investments, a measure which was not considered convenient.

During the four years of operation of the intake, entrance of large fish into the canal has not been observed. Only a small number of fish has been noted in the canal since the time when the levees were closed; this proves that the concrete cubes constitute a reliable protection against the penetration of fish.

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**Fig. 1.** Marine filter intake of 10-m$^3$/sec capacity. 
(a) Arrangement of the structures: 1) Sea canal; 2) pumping station; b) Levees; 1) Concrete cubes weighing 8 tons; 2) fill consisting of 8-ton concrete cubes; 3) fill consisting of 300-kg stones; 4) unassorted rock fill; 5) 4-ton concrete cubes; 6) fill consisting of 1-ton concrete cubes.