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Determination of Dynamic Forces Affecting Floating Structure in Pump Station Water Supply Channel

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Abstract. Improving the performance of the pump station Development of new technologies in pumping stations, including taking into account the laws of advanced hydrodynamic motion, using the stratified nature of the flow and analyzing the laws based on theoretical data to create new floating structures and their application in open water intake facilities.

It enters the canal from the river in the form of nanos (sediments) moving from the bottom of the river, floating in the water with the water and flowing from the river. These sediments are cleaned using a strainer. Due to the smaller flow depth of the canal than the river and the slower flow of water, burial with sediments occurs in the canal.

At small distances from the barrier, the greatest hydrodynamic characteristics are achieved for a semi-elliptical wing. The data obtained show that by choosing the shape of the wing, it is possible to reduce its coefficient of resistance. It is recommended that the obtained experimental materials be widely used in the construction practice of all floating traps.

INTRODUCTION

Today, the main purpose of creating a new design in the pumping station water supply channels is to increase its performance, that is, to improve the floating and participating elements of several parameters affecting the flow [1-3].

Figure 1 shows the top view of the water source. Described water intake structure and floating structure; Figure 2 shows the A-A shear.

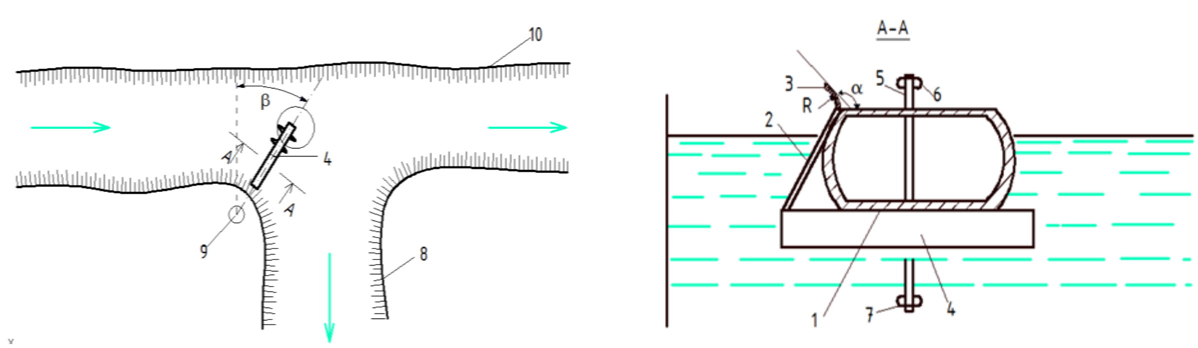

FIGURE 1. For the case where the floating structure is with an open-flow water intake structure.

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The floating structure consists of several floating elements for an open-flow water intake facility. 1 is located at the top of the structure with a floating element, 2 guide holes and 3 limiting elements, 4 vertical underwater wing, and 5 propeller blade of the shaft 6 are located at the top of the structure, and 7 turbine wheels are located at the bottom of the structure. 3 The limiting element is made in the form of a plate, which serves as a continuation of the front part of the guide hole. Its curvature is R = 0.5 H_{border}. H_{border} is the height of the limiting element. The outlet angle α of the flow (the angle of rotation of the water flow at the surface relative to the limiting horizon) is $\alpha = 130^0$-140^0 from the end of the structure. The structure itself is located at an acute angle β= 45-75^0 with respect to the flow; this angle is considered for the plan relative to the drainage channel itself. With respect to 8 structures, our construction is also firmly attached to the shore by means of 9 hinged supports. The wings are attached to the shoreline wall 10 concerning the water intake structure on the opposite side with the convex side [4-9].

The floating structure works in the following order. Filter and floating sediments enter the mud moving from the surface of the water source, where they fall into 8 water supply channels. In 8 water supply channels 1 encounters floating elements. At the same time, the filter element is actuated by means of guide bearings 2. On the other hand, the sediments move under the influence of the rotating wheel 7 under the hydrodynamic pressure of the flow according to the indications of the wheel 7 and the wind pressure flyer 6. The hydrodynamic pressure causes the pumps to move from the top of the filter to the water supply channel 8 by the water intake structure, which causes the pumps to move in the row 1 of the floating element. 4 The speed of movement of the pumps that appear under the wings of the underwater feathers is accelerated.

Under the influence of the compressive force generated by the impact on the water flow and the guide element of the strainer, it does not appear flat at the same time and has different values in length. This amount is significant for the 3 limiting element.

This factor does not adversely affect the change in the kinematic structure of the flow in general.

The function of the proposed model is characterized by the fact that at the same time, we accept the part of the pumps moving along the surface of the water source into the water supply channel (e.g. Pumping stations or Hydroelectric power stations, etc.). Water waves in the application of the limiting element also help. In this case, the 2-element guide device starts operating on the water surface.

This element prevents the rise of water and ensures that the floating device 1 of the floating element operates stably. In addition, the flow of water from the tail of the structure is eliminated by hitting the limiting element.

This pressure flow is applied to the top of the structure as an additional compressive force. This compressive force acts as a pulling force on the 2 guide elements. This situation can sometimes have negative consequences in practice. Such cases have been observed in many cases in the practice of floating traps. Optimal outlet angles of water flow were obtained based on experiments around 130-140^0. These experiments report that large surfaces on the water's surface in front of the 2 collector device elements indicate a force effect. Under the influence of water flow, the front of the element formed by the 2 guide devices is formed by the force of impact between the resistance force and the water flow. The hydrodynamic force is generated by the winged fins under water. A 9-hinged base located on the shore serves to control the resulting force. Its working angle is by moving the element at an acute angle. The axis of the 8 water supply channels relative to the water flow axis was considered to be for the optimal kinematic flow condition in the water supply channel. We also consider it for the transport capacity of the canal. What we have said can be considered to apply to all floating structural elements.

For floating structures proposed for all cases of change of hydrodynamic characteristics, as shown by theoretical studies of these devices and their practical applications, and so on, the optimal device mode automatically falls to the desired modes, the sharp angle of water flow is necessary for the projections of the surface velocities takes directions [10-17].

For the first time, a floating structure is used in a complex way in effective practice. Its filter elements were successfully protected. With the help of this design, the transportation of pumps in production was organized. At the water intake facility, the pumps stuck in the filter were washed, and measures were taken to get rid of the pumps stuck in the guide device using a limiting element.

With the help of 7 deep-set wheel blades and 6 flywheels (in which the device's swimming resistance was controlled, for 1 floating element), the device design is sometimes possible to use even wind energy. The renewable energy of the waves and the wind-generated energy in this way also can hold. For example, it allows the pumps to temporarily exchange electricity.

It is used to wash the pumps stuck in the floating structure from the guide element and the pumps stuck at the edges of the floating structure. Floating structures are exposed to many natural forces by water flow during operation. One of these forces is the force that arises from its own weight. This is the pressure force on the water. Sediment are also forces that arise from gravity and other effects.

There is a need to analyze all the circumstances to take into account the impact of these forces. Therefore, we analyze all the construction conditions and determine its dimensions.

The dimensions of the grounded structure ensure the rigidity of the floating structure. The forces acting on floating structures can take different forms depending on their type. Their exposure times also vary [3].

According to the form of formation, the forces acting on them can be divided into the following groups:

1) The weight of the structure itself is contained within the floating structure;
2) The three different forces of water flow are under the influence of static pressure, dynamic pressure, and even the compressive forces of the wave;
3) The effect of ice on the strainer is static and dynamic;
4) Compressive strength due to wind;
5) Compressive force created when snow accumulates;
6) Deformation forces generated by volumetric forces;
7) Forces occurring during an earthquake;
8) Other forces, forces that appear temporarily.

From these forces, the compressive forces acting on the installed elements for all structures and devices are determined by calculation methods known from wind, snow.

METHODS

Improvement of the conditions of hydraulic structures can be achieved only by introducing new technological structures in practice and introducing new hydrodynamic laws in multi-phase flows.

The stream of water carries with it moving nanos and floating objects. It also carries a large number of sediment with it as it crosses the river to the canal. There is a need to protect the filter device from this large amount of sediment.

Devices that passively affect the flow of water work against the undesirable behavior of floating objects.
These devices do not change the flow content, parameters (floating valves).

RESEARCH RESULTS AND ANALYSIS

Loads are divided into static and dynamic loads according to the nature of the impact on the structure. In these cases, when the power value of the dynamic load cannot be determined by the correct means, it is determined by a coefficient that considers the static load value. This coefficient is called the dynamic coefficient, whose value is $k = 1.1 \div 1.5$. The value of this coefficient is found concerning the load behavior in the structure.

Depending on the scope of these forces (duration, repetition, etc.), the forces are divided as follows:

-basic forces, forces in constant motion, or forces acting continuously. They are distinguished by their constant participation in the process of exploitation. (E.g., the constant pressure force of the water flow, the water level is usually maintained by the same water horizon, etc.);

-additional, transient forces are likely to occur in rare cases. It is more likely to occur in high or low horizon waters. These include pressure forces, sometimes under the influence of large volumes of pumps that accumulate in the device, and sometimes pressure forces that occur on construction devices or during repairs.

-Separate forces occur in rare cases, including forces caused by seismic forces or forces caused by catastrophic demolition processes.

Depending on the duration or repetition of the forces, the following are considered in the calculations. That is, rigidity and strength are used to calculate reserve coefficients for different structures.

In the design processes of these structures, different layout options of load and forces are adopted in construction operations in computational work.

The most unfavorable location cases of these forces are also considered.

The hydrostatic pressure value of water is determined as follows, found using known hydraulic methods. The value of hydrodynamic pressure, on the other hand, is determined by the value of the velocity of the flow of water to a given surface and depends on the lines of motion of the flow of water flowing through the body. This pressure value is also found based on hydraulic formulas.

In the water basin, the waves that appear on the water's surface hit the walls of the structure with a shock wave. In this case, the structure walls are subjected to an additional load on the hydrostatic pressure. This compressive strength is called wave compressive strength.

The value of the compressive strength of the wave against the wall is in the vertical position or slope in the ratio 1: 1 for the structure, and the wave size takes the form of the edge wall of the structure in front of the water wall with a depth of 2L and $2h_b$.

Wave pressure "W" is determined by the following formula:

$$W_b = \gamma \frac{(h + 2h_b + h_0)(h + \alpha)}{2} - \gamma \frac{h^2}{2} \tag{1}$$

In formula (1), h_0 represents the increase in average density.
This distance is taken concerning the quiescent state of the water and is equal to:

$$h_0 = \frac{\pi (2h_b)^2}{2L} cth \frac{\pi h}{L} \tag{2}$$

The compressive force H generated by the a-wave intensity is for the water depth:

$$h_0 = \frac{2h_b}{ch \frac{\pi h}{L}}. \tag{3}$$

The position of the force "W_b" (its shoulder) is determined in the form of a moment:

$$W_b = \gamma \frac{(h + 2h_b + h_0)^2 (h + \alpha)}{6} - \gamma \frac{h^2}{6} \tag{4}$$

If h L then (4). we can get approximate:

$$h_0 = \frac{\pi (2h_b)^2}{2L} \text{ and } a=0 \tag{5}$$

The pressure depends on the slope of the wall (for the slope of the flow 1:1 position) and the slope of the edge formed during the ascent of the wave; its value to the vertical wall will be smaller.

The maximum height value of the wave is determined by the following expression for the wall slope. This formula was created by N.N Jukovsky:

$$H_b = 3.2k(2h_b)tg\alpha, \tag{6}$$

In this case, α is the angle of inclination of the wall relative to the water horizon;k is the coefficient of roughness of the plane, assuming k = 1.0 for flat surfaces.

(6) It is recommended to apply the formula in practice when the slope angles are 140 to 450. These recommendations are recommended for the transmission barriers of floating traps. [16,17,18]

For the strainer elements, in the general case, the width of the structure is b, and for the length L, and for the thickness δ (dimensions are, of course, in meters), 0.6-0.8 m is acceptable.

$$W_{l.d} = k\upsilon\delta\sqrt{lb}m, \tag{7}$$

In this case, the υ is filter speed, in m / sec.

Assume that the k-ice melting coefficient is 2.5-3.0.

When the wind speed is υ m / s when the wind is blowing, or the floating structure is affected by the wind current, its impact width is equal to V, and its length is equal to the dynamic pressure value L m in the direction of movement:

For L <1200 m

$$W_{l.d} = (0.3 + \frac{L}{1000})\alpha \upsilon^2 \mathrm{B} m \tag{8}$$

For river conditions, we do not assume a value of L greater than 3 m in width.

We introduce the following concepts to the effects of seismic vibrations. These include the forces of inertia, the forces of inertia increase in proportion to the mass.

For structures, $\frac{G}{g}$ is determined by the seismic acceleration

$$\mathrm{P}_c = \frac{G}{g} \cdot \frac{\tau}{1000} = k_c G, \tag{9}$$

G is structure gravity; g is free fall acceleration m/s^2; τ is seismic acceleration mm/s^2;
k_c is coefficient of seismic stress:

$$k_c = \frac{\tau}{1000g} \approx 0.0001\tau. \tag{10}$$

Seismic velocity and coefficient are determined based on seismic score. The earth is found to be bound by an earthquake.

Calculations are made depending on the seismic area where the facility is located.

The specific pressure of the water flow is determined for the case of water depth h <50 m.

This formula is written as follows:

$$W_c = 0.55 k_c \gamma h^2 \tag{11}$$

k_c is seismic coefficient.

If the seismic period T and the oscillation period of the structure coincide, then the specific period of the structure "T_o", in which the structure undergoes a resonance phenomenon. In this case, the inertial seismic forces may increase by tens of degrees more than usual. If this happens, the structure will collapse, i.e. the structure will collapse. Assuming a period of seismic oscillations T $\approx$ 1 s., And calculating the structure as seismic, T_0> 2 s. The compressive force generated in the wave pulse is not generated simultaneously by the reference barrier (Fig. 2). This period is short. [5, 9, 10]

This effect is affected by the length of the structure. At some individual points on the barrier, it affects over time on its surface.

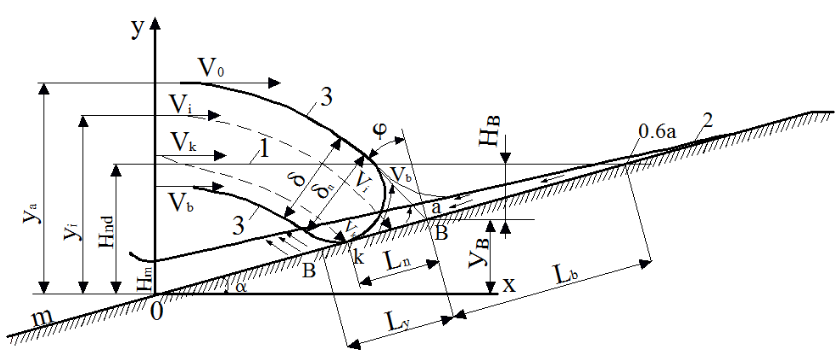

FIGURE 2. Kinematic scheme of the impact generated by the reference barrier:
1 is the calm level of the water table; 2 is surface view of the water for the time when the wave pulse falls; 3 is the appearance of the surface on which the wave strikes the barrier.

Pressure changes q_b, q_k, q_v are the values of the pressure of a separate point "B" for the section under consideration at time t and determined by the following formula:

$$q_{b.k.v}^{(t)} = q_{b.k.v} \frac{a+bt}{c+t} = q_{(3.5)} \beta_{b.k.v} \frac{a+bt}{c+t}, \tag{12}$$

q_{bkv} is initial pressure B, k, for a point barrier, q_b (3. 5) is initial pressure h = 1 m, K_h = 2, 70, h = 4 m we determine the coefficient h by a linear selection K_h;

$q_{b.k.v}^{(t)}$ is the value of pressure sought at point b K for the part under consideration, for a given time t; The duration of exposure to t-pressure. τ is wave period.

In addition to the wave effect of water flow, there are other forces acting on multi-phase liquids. For example, these are pressure forces exerted by weeds collected from accumulating plants that occur in a water supply channel.

At point B.

$$T = t_b = t_e\,; \tag{13}$$

At point K

$$t = t_k = \Delta t_b + t_c = \mathrm{K}_i \frac{h}{\upsilon_b} + t_c \tag{14}$$

At point K

$$t = t_b = \Delta t_b + \Delta t_v + t_c = \frac{h(K_b - K_\varphi) - a}{\upsilon_b} + \mathrm{K}_i \frac{h}{\upsilon_b} + t_c \tag{15}$$

for negative values of Δt b

$\Delta t_v < \Delta t_b; \Delta t_v$ and Δt_v are pieces of time, in the formulas (12) - (16), we accept the values of the point B for the times when the pressure does not appear at the same time, and for the points K relative to the pressure forces that appear relative at the points v: $\Delta t_K = 0$.

The time of propagation of the wave effect on the whole surface corresponds to t_s, the value of the amount of torque generated when hitting a barrier or the maximum deflection of a floating structure

$$t_c = \left(\frac{1}{128} \div \frac{1}{32}\right)\tau = t - t_K\,, \tag{16}$$

If$|t_k| > |t_в|$, or $t_c = t - t_в$,

If$|t_v| > |t_к|$.

The thickness of the water in the barrier is determined by the values of the settling velocities of the υ b and υ b are particles at the time of the wave shock. *B*, k_i, k_v and k_φ are found for water points.

The slope coefficient m of the barrier is given in Table (1):

		TABLE 1.		
m	k_t	k_B	$k\varphi$	k_y
2.0	0.128	0.35	0.11	0.52
3.0	0.118	0.34	0.19	0.49
4.0	0.101	0.33	0.21	0.45
5.0	-	-	-	0.37

	TABLE 2.		
m	β_b	β_k	β_v
2	0.96	0.94	0.85
3	1.02	1.00	1.00
3.5	1.00	1.00	1.00
5	0.98	1.00	1.00

β_b, β_k transition coefficients β_v pressure $q_{b(3,5)}$ on a slope $m=3.5$ q_b compressive strength q_k, q_v on a slope $m=2\div5$ Taken from Table 2;

a, b, c are the transformation coefficients at the beginning of t pressure over time q_b, q_k, q_v at point *B*, at point *K*, and at point *V*, Table 3.

TABLE 3.

Coefficient	Q_b	Q_k	Q_v
a	0.02τ	0.0154τ	0.0138τ
b	0.04	0.054	0.048
c	0.02τ	0.02τ	0.02τ

The proposed method is used in the design and calculation of a floating valve device as a way to determine the dynamic pressure. This method was applied in the operation of the water supply channel ABMK PS.

The strength of the canal banks was applied in the project based on the specified method. We can design this method to be used in other constructions.

The impact of the water wave on the shores occurs through the impact.

Inadequate protective barrier height can cause an emergency for a floating device. To avoid this situation, the barrier height is taken with the reserve [4, 6, 7].

Ensures that the wave passes through the structure, using the desired construction of the boundary barrier. Dimensions to reduce the structure's height are given in Figure 3 for a limiting interpretation.

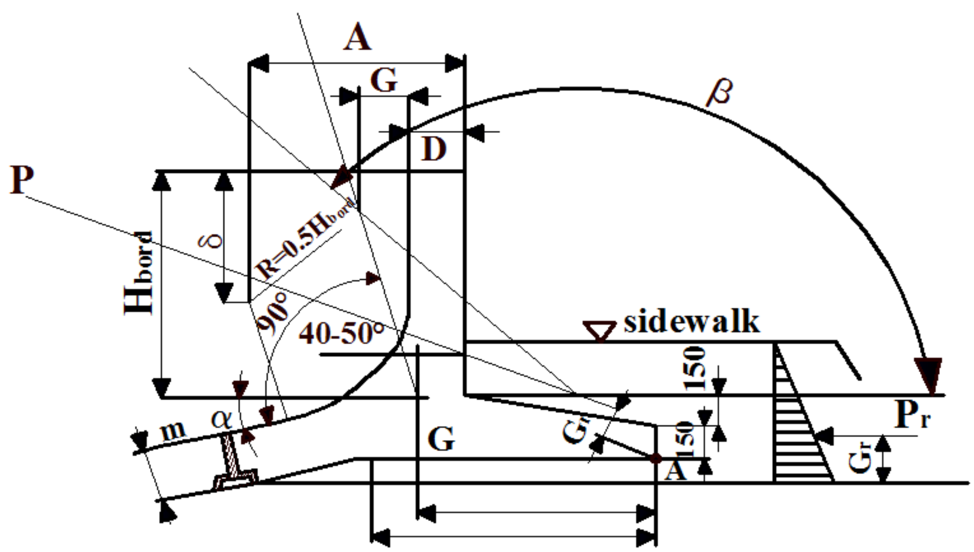

FIGURE 3. Schematic diagram of the wave height limiter used

Boundary wall height H_{border} is selected based on technical and economic indicators. Its recommended value is 0.5-2.0 m.The washable edge of the wall has a curved shape along the radius R =1/2 $H_{border,}$ and the inlet angle is the angle of the flow-limiting command β^0 = (130 ° 140 °)- α^0 .

α^0 - the angle of inclination of the slope surface relative to the horizontal plane. The jumping wave hits the wall, jumps to a height along the slope, and hits the wall. The limiting barrier is affected by R pressure with dynamic force. We determine the value of the dynamic force R by the following formula:

$$P = 2\frac{\gamma}{g}\cdot\frac{1}{k^2}[(0.9V_b k\ ) - 2gl_{bord}\sin\alpha]\frac{k(k_n h\sqrt{m^2+1} - l_{bord})}{k_n\sqrt{m^2+1}} = 2\frac{\gamma}{g}V_{bord}^2\delta_{bord}m\frac{\beta}{2}, \tag{17}$$

Here is the γ is volumetric weight of the water; g is acceleration of free fall; l_{bord} is the distance (length) from the shock wave to the boundary point to point *B*; δ_{bord} is for the position where the thickness of the barrier is mounted on the boundary wall:

$$\delta_{bord} = \frac{k(k_n h\sqrt{m^2+1} - l_{bord})}{k_n\sqrt{m^2+1}}; \tag{18}$$

k and k_n are the transmission coefficients of the wave pulse both for the wave rising position and for the slope (assuming according to Table 4).

We assume the value of kn in the range of 1 m to 4 m of wave height.

TABLE 4.

m	*K*	K_n *h=1m*	*H=4 m*
2	0.34	2.15	3.00
3	0.32	0.61	1.75
4	0.29	1.40	1.50
5	0.26	1.20	1.25

The value of the wave velocity to the boundary wall V_{bord} is found by the following formula:

$$V_{bord} = \frac{1}{k}\sqrt{(0\text{ю}9V_B k\ )^2 - 2gl_{bord}\sin\alpha}\ ; \tag{19}$$

k is the coefficient of the roughness of the protective layer; k = 0.9; V_b is the velocity of the water particles at the shore wave (point *B* in Figure 4)

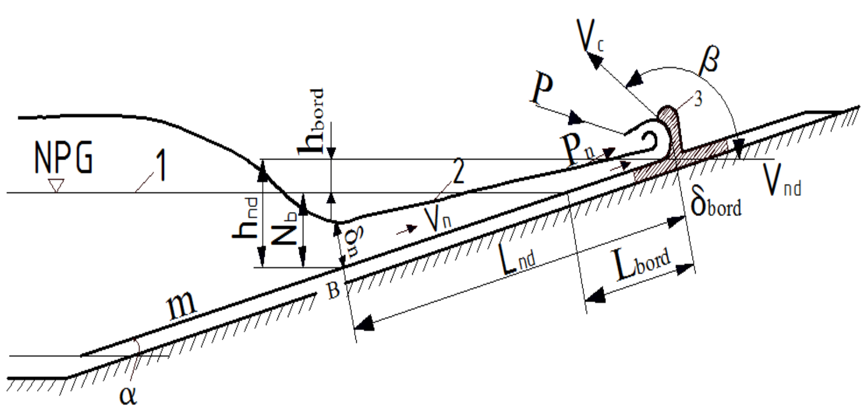

FIGURE 4. Diagram of the dynamic forces of water flow to the wall

The value of V_b can also be determined using Table 5.
α is slope angle of the slope surface relative to the horizontal plane.

TABLE 5.

h, m	***V_b***		
	m=2	***m=3***	***m=4***
1.0	5.86	6.40	6.44
2.0	8.15	9.0	9.02
3.0	9.95	10.7	10.8
4.0	11.3	12.2	12.5

The strength of the limiter under the influence of dynamic forces P is fulfilled under the following condition:

$$K_r = \frac{M_{ud}}{M_{opr}} \leq K_{dop} \quad (20)$$

Here is the K_r is the reserve factor; M_{ud} and M_{opr} are the holding torque forces G. P_g and the breaking P relative to point A; K_{dop} - with a limit coefficient reserve; G is the weight of the limiting barrier; The load force coming from the front of the Pg-limiter. We determine the normal component of the dynamic force P using studies $P_n = 2 \frac{\gamma}{g} V_{bord}^2 \delta_{bord} \sin\beta$ and are taken into account in the calculations; we apply it in the calculation of the boundary wall in rigidity calculations.

The largest value found is calculated for the pontoon point of the floating structure. [11, 12, 13, 14].

$$\nabla H_{bord} = \nabla (NPG;\ FPG;\ KPG) + \nabla h + h_{bord} + h_z .$$

Here the NPG; FPG; KPG are water burial horizons - for the calculated horizon. for normal conditions. ∇ h is the altitude for driving time in the wind; h_{bord} is included in calculations. when $h_{bord} > h_n$. when;

The h_z is construction stock (found in Table 6) depending on the construction class.

TABLE 6. Constructive stock of the boundary barrier

Operating conditions	**The calculated level of the wave exceeds the class of floating structure, *m***				
	1	11	111	1V	V
Exceptions	1.0	0.7	0.5	0.5	-
	0.7	0.5	0.4	0.3	-

The values of Δ h and h_{bord} are taken into account in determining the FPG. NPG mark.

If the wind speed is taken into account and the construction class is also taken into account.

We give a methodology for calculating new floating constructions using graphs and representational formulas.

In a water intake facility: $\alpha_b = 90^0$ and $K_b = 0.337$ if

$$\frac{\Delta h}{h_{sh}} = (8.54\alpha^2 + 4.7\alpha)\frac{1}{10^6} + 0.264;$$

$$\frac{q_b}{q_p} = (1.26\alpha - 0.0114\alpha^2)\frac{1}{10^3} + 0.294;$$

In a water intake facility: $\alpha_b = 60^0$ and $K_b = 0.340$ if

$$\frac{\Delta h}{h_{sh}} = (2.091\alpha - 0.021\alpha^2)\frac{1}{10^2} - 0.04838;$$

$$\frac{q_b}{q_p} = (4.45\alpha - 0.0208\alpha^2)\frac{1}{10^4} + 0.3176;$$

This Δh is the difference between the water horizon. the water level in front of the floating structure and the horizon after it. q_b /q_b is coefficient of water intake; α is the angle of position of the floating structure relative to the water flow. Similar links are 0.21; 0.29; 0.24 was also obtained for water intake coefficients.

CONCLUSIONS AND RECOMMENDATIONS

1. The pressure exerted by a stream on an object in a water source is determined experimentally. At the same time. changes were obtained that represent the change in the water flow velocity relative to the body.
2. Model laboratory research The new floating structure serves for open sources of water intake facilities to the position of the wings in the water flow for the floating device zapan.

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