DETERMINATION OF THE HEIGHT OF THE OVERFLOW WALL OF A TWO-SECTION STORMWATER DETENTION TANKS

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Nowadays, issues related to the introduction of advanced world technologies for stormwater management into the engineering practice of the sewage system of Ukraine are quite relevant. One of the main ways to regulate stormwater runoff is to install stormwater detention tanks (SWDT) on the city’s drainage networks [1, 2, 3]. One of the important engineering tasks is to determine the optimal design parameters of SWDT, for the possibility of their most efficient use [4, 5]. The purpose of the work is to determine the height of the overflow wall of a two-section SWDT, which is one of the most important design features of a two-section tank.

The simplest multi-section structures include a two-section flow-through tank (Fig. 1) with a relatively small overflow chamber and a large storage chamber [4, 5].

Fig. 1. Scheme of a two-section stormwater detention tank:
1 – overflow chamber; 2 – storage chamber; 3 – inflow channel;
4 – outlet channel; 5 – overflow wall; 6 – flow regulator (flap valve).

The advantage of this design is that even at low rainfall intensity, the outlet channel quickly begins to work in pressure mode, which prevents its siltation. The filling of the storage chamber begins only after the stormwater in the overflow
chamber rises to the level of the top of the overflow wall. Thus, the filling of the storage chamber, the volume of which is the main part of the working volume of the entire structure, occurs at a high rate of flow discharge \( Q_c \), which reduces the required regulating volume of the tank.

An important technological task is the device of an overflow wall of such a height that, at the calculated regulating volume, the tank works with its full volume. That is, the height in the storage \( h_z \) and the overflow chamber \( h_l \) must be equal to the height of the overflow wall \( h_w \) (\( h_l = h_z = h_w \)).

The dimensionless height of the wall \( h'_w = h_w/h_c \) (\( h_c \) – difference between the elevation marks of the outlet channel) with a known value of the regulating volume is determined by the formula:

\[
h'_w = K_{reg} \cdot b
\]

The regulating volume coefficient \( K_{reg} \) is a complex function that depends on the values of the initial regulating coefficient \( \alpha_o \), the dimensionless rain duration \( X_d \) and the coefficient of change in the discharge pressure head \( b \) [5]. It is a difficult task to take into account all the parameters that would describe the parameters of the runoff basin, design parameters of the SWDT and patterns of changes in rain intensity at the same time. Therefore, a computer program was used to determine the regulating volume coefficient, taking into account all these parameters for single-section and two-section SWDT. The numerical experiment was performed for a linear runoff basin with rain intensity varying according to a linear law and the variable value of the coefficient of change in the discharge pressure head \( b \). Dimensionless characteristics were taken constant and equal: the initial control coefficient \( \alpha_o = 0.3 \), the dimensionless duration of rain \( X_d = 3 \).

According to the results of the numerical experiment, graphical dependences of the height of the wall of the overflow chamber \( h'_w \) on the regulating volume coefficient \( K_{reg} \) were obtained.

Fig. 2. Dependences of the height of the overflow chamber wall on the regulating volume coefficient: 1 – \( b = 0.1 \); 2 – \( b = 1 \); 3 – \( b = 3 \); 4 – \( b = 5 \); 5 – \( b = 7 \)
The results of the numerical experiment were approximated. The mathematical processing of the results allowed to obtain a formula for determining the dimensionless height of the wall:

\[ h' = A'K_{\text{reg}} + B' \]  

(2)

where:

\( A' \) and \( B' \) are empirical coefficients that depend on the coefficient of change in the discharge pressure head \( b \).

Empirical coefficients \( A' \) and \( B' \) can be described by the following dependences:

\[ A' = 0.936 \cdot b^{0.03} \]  

(3)

\[ B' = 0.02 \cdot b^2 - 0.096 \cdot b + 0.06 \]  

(4)

Using the formulas (2) - (4) can greatly simplify the determination of the height of the wall of the overflow chamber at different values of dimensionless characteristics such as: the coefficient of change in the discharge pressure head \( b \) and the regulating volume coefficient \( K_{\text{reg}} \).

References:

[1] Жук, В.М. (2011). Сучасні системи управління дощовим стоком на забудованих територіях. Проблеми водопостачання, водовідвідування та гідраліки, (17), 38-46.

[2] Todeschini, S., Papiri, S., Ciaponi, C. (2012). Performance of stormwater detention tanks for urban drainage systems in northern Italy. Journal of Environmental Management, (101), 33-45. https://doi.org/10.1016/j.jenvman.2012.02.003

[3] Попадюк, І. Ю. (2015) Регулювання поверхневого стоку за допомогою багатосекційних резервуарів дощових стічних вод. Науковий вісник НЛТУ України, (25 №8), 149-154. https://doi.org/10.15421/40250825.

[4] Starzec, M., Dziopak, J., Slyś, D., Pochwat, K., Kordana, S. (2018). Dimensioning of required volumes of interconnected detention tanks taking into account the direction and speed of rain movement. Water (Switzerland), (10(12)), 1826. https://doi.org/10.3390/w10121826.

[5] Zhuk, V., Vovk, L., Popadyuk, I. (2009). Storage volume of two-sectional stormwater storage tanks for the linear catchments for the rains with constant intensity. Zeszyty Naukowe Politechniki Rzeszowskiej. Budownictwo i Inżynieria Środowiska, (54 [266]), 139-142.