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CALCULATION OF GROUNDWATER TRANSPORT OF WATER FLOW IN CHANNELS

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Abstract: *Based on the Ackers-White dependencies for determining sediment flow in stationary flows, a method for calculating sediment with an unsteady flow is proposed, taking into account the division of sediment into bottom and suspended, which relates to the calculation of sediment transport itself.*

Key words: *sediment, bottom and suspended sediment, unsteady flow, wave, dimensionless parameters, passing flow.*

The following approaches are used to determine the movement of underground fluids: deterministic, probabilistic and the concept of riffle movement of fluids.

In the deterministic approach, the motion of a homogeneous large lumped particle at the bottom of a plane flow is considered in the regime of quadratic resistances. the subsoil stress is assumed to be the basis for the discharge from the bottom of the bed. This parameter is direct or current in calculation formulas$u_* = \sqrt{T_0/\rho_в}$ is entered through the magnitude of the dynamic speed. As a quantitative indicator of the driving force, the difference between these stress values at the beginning of the movement of the particle and the underlying effort stress is taken. In some cases, the difference in the test voltages is replaced by the difference in the vertical mean and flow velocities $(u_0 - u_н)$. In this case, the differences are the speed of subsurface particles,$\left(u_0/\sqrt{gd_{ўр}}\right)$ and size represents the number of particles involved in the movement. In other cases, the difference or dynamic speed and its ratio to the critical speed are considered.

Also, underground discharge is one of the calculation methods, and the channel in the form of underground wave movement is a method of determining the amount of underground discharge. The movement of the underground formation in such a situation is considered to be smoothly variable, that is, all the static characteristics of the underground relief, in particular, its average height and the average length of the riffle, do not depend on time.

Considering the subsurface wave motion to be straight, we write the complete differential of the height of any point of the subsurface line at an instant:

$$\partial z_0 = \frac{\partial z_0}{\partial x}dx + \frac{\partial z_0}{\partial t}dt \quad (1)$$

Marking the height and moving along the bottom about this point, $dz_0 = 0$ we will have:

$$\frac{\partial z_0}{\partial x}\frac{dx}{dt} + \frac{\partial z_0}{\partial t} = 0. \quad (2)$$

z_0 from the differential equation of the deformation written for the point, we have the following:

$$\frac{\partial z_0}{\partial t} = -(1-\varepsilon)\left(\frac{\partial q_{туб}}{\partial x}\right)z_0, \quad (3)$$

where is $\varepsilon$the soil porosity coefficient.

Substituting (3.30) into (3.29) and calling $z_0$the point motion the velocity $dx/dt = C_{Z_0}$, we get:

$$\left(\frac{\partial q_{туб}}{\partial x}\right) = (1-\varepsilon)C_{Z_0}\frac{\partial z_0}{\partial x}. \quad (4)$$

Integrating (3.31), we get:

$$q_{туб} = (1-\varepsilon)C_{Z_0}Z_0F(t) \quad . \quad (5)$$

$F(t) = 0, C_{Z_0} = C_{гр} = const,$ assuming that we get the following:

$$q_{туб} = (1-\varepsilon)C_{гр}Z_0. \quad (6)$$

Integrating the equation (3.33), we get the equation that determines the average flow rate along the grid length:

$$q_{туб} = (1-\varepsilon)C_{гр}Z_0 \quad (7)$$

here $C_{гр}, h_{гр}$- the speed and height of the movement of gradations, respectively; $\sigma = \omega_{гр}/h_{гр}h_{ср}$- coefficient that takes into account the completeness of the wave profile.

In many cases $(1-\varepsilon)\sigma \approx 0{,}5$it is accepted that. Taking this into account, we write (3.33) in the following form:

$$q_{туб} = 0{,}5\rho_н C_{гр}h_{гр} \quad (8)$$

Therefore, it is necessary to determine the height of underground streams and their movement speeds when calculating the specific consumption of groundwater.

In the first chapter, we touched upon the existing calculation methods for determining the transport of groundwater. Based on the analysis of these methods, we have shown the advantages of the Van-Ryn method over other proposed methods. For this reason, this method was chosen in the improvement of the method of calculating the transport of sediments in large soil channels. According to this method, underground fluids move along the subsurface in a vibrational and saltatory manner. The specific flow of groundwater is determined by the following equation:

$$q_{туб} = u_b C_b \delta_g \quad (9)$$

here u_b is the speed of particles of underground fluid; δ_g-saltation movement height; C_b- volume concentration of the particle.

$u_b C_b \delta_g$ Expressions for discrete particles above a flat surface representing the balance force acting on the moving particle are obtained based on the numerical solution of the equation of motion: resistance and gravity forces, particle acceleration and lifting forces. The connection obtained as a result of the numerical solution is presented as follows:

$$\{u_b C_b \delta_g\} = fct\{D_* T\} \quad (10)$$

The main principles of the method are reflected in the following forms:

$$D_* = d_{ўр}\left[\frac{(S-1)g}{\nu^2}\right]^{1/3} \quad (11)$$

$$T = \frac{(u_*')^2 - (u_{*кр}')^2}{(u_{*кр}')^2} \quad (12)$$

where ν -fluid kinematic viscosity coefficient; U_*'-Unbound dynamic speed; $U_{*кр}'$- The dynamic speed of the start of fluid movement, determined from the Shields curve.

In order to facilitate the determination of the dynamic speed of the onset of the movement of the primary fluid, Shields approximates his proposed curve graph in the following form:

$$(u_*')^2 = \theta_{кр}(S-1)gd_{ўр} \quad (13)$$

where the θ – Shields parameter is defined as follows:

$$\left.\begin{array}{l} D_* \leq 4 бўлганда \theta_{кр} = 0{,}24(D_*)^{-1}; \\ 4 < D_* \leq 10 бўлганда \theta_{кр} = 0{,}14(D^*_i)^{-0.66}; \\ 10 < D_* \leq 20 бўлганда \theta_{кр} = 0{,}04(D^*_i)^{-0.1}; \\ 20 < D_* \leq 150 бўлганда \theta_{кр} = 0{,}013(D^*_i)^{0.29}; \\ D_* > 150 бўлганда \theta_{кр} = 0{,}055. \end{array}\right\} \quad (14)$$

Based on the numerical solution, the author proposed the following connections for determining the relative flow rate:

$$\delta_b = 0{,}3 d_{ўр} D_*^{0{,}7} T^{0{,}5} \quad (15)$$

$$u_b = 1{,}5\left[(S-1)gd_{ўр}\right]^{0{,}5}T^{0{,}6} \quad (16)$$

$$C_b = 0{,}117T/D_* \quad (17)$$

$$q_{туб} = 0{,}053[(S-1)g]^{0{,}5}d_{ўр}^{1{,}5}T^{2{,}1}/D_*^{0{,}3}. \quad (18)$$

Van - Reyn based on the results of experimental research with Engelund Hansen, Ackers - White and Meyer - Peter - Muller methods are included in table **3.6** .

The following parameter was adopted as a quantity representing the degree of compatibility of accounting data:

$$R = \left(q_{туб}\right)_{хис}/\left(q_{туб}\right)_{хак}. \quad (19)$$

Table 1 defines the following methods with Roman numerals:

I- Van Rijn; II- Engelund Hansen; III- Akers-White; IV- Meyer-Peter-Muller.

Table 1

Engelund Hansen, results of comparison with Ackers-White, Meyer-Peter-Muller methods

Number of tests	Change range				$0{,}75 \le r \le 1.5$				$0{,}5 \le r \le 2$				$0{,}33 \le r \le 3$			
					I	II	III	IV	I	II	III	IV	I	II	III	IV
	m/s	m	mm	^{0}S	%											
580	0.3-1.29	1-10	0.32-1.5	8-34	42	43	48	23	77	76	77	58	93	90	92	76

The purpose of this study was to investigate the movement and transport of groundwater in trapezoidal channels. As we explained above, in the development of the trapezoidal channel groundwater calculation method, the goal was to improve the Van-Reyn calculation method, which, in our opinion, has more priority aspects than other calculation methods. This method was developed by the author on the basis of the data of his experimental studies in very wide valleys. And we use this method in trapezoidal channels with ground.

For this purpose, laboratory studies were conducted in the laboratory of the Karshi Institute of Engineering and Economics. The procedures and methods of conducting laboratory experiments are described in detail.

Side slopes constructed of sand (average diameter) in a metal tray in the laboratory$d = 0{,}25mm$ $m = 2{,}0; 2{,}5; 3{,}0; 3{,}5$. 4 series of experiments were conducted on the trapezoid channel model. The duration of the experiments was 5-6 hours. At the end of the experiment, the weight of the effluent washed from the channel model and collected in the pool $G$was measured using a weight measuring device. In addition, the cross-sectional profile of the channel was measured. In the course of the experiments, it was shown that the movement of groundwater, like the researches on washing of the stream, first begins at the intersections with the bottom and side slopes of the channel. As a result of this, the channel's side slopes were slowly destroyed and the intensive flow of water began.

the experimental data of the laboratory experiments conducted on the study of the base discharges with the values calculated according to the formula of Van-Reyn, it is seen that the data values obtained in the laboratory conditions are slightly larger The existence of this difference may depend on the trapezoidal shape of the section, the friction along the perimeter of the wetting, the slopes of the side of the channel and other factors.

χ/B we believe that the ratio of the wetting perimeter to the width of the upper surface of the stream has a significant impact on the process of underground and suspended solids transport. Based on this (18), χ/Bwe introduce the coupling ratio, and the coupling takes the following form for trapezoidal channels:

$$q_{myб} = 0{,}053\chi/B[(S-1)g]^{0,5} d_{ўр}^{1,5} T^{2,1}/D_*^{0,3} \quad (20)$$

Thisχ/B the ratio directly involves the coefficients of the side slopes of the trapezoidal channel.

The obtained experimental data were advanced by us during statistical processingχ/B the correctness of the hypothesis that the ratio of the wetting perimeter to the width of the upper surface of the stream has a significant effect on the process of transport of underground and suspended solids has been proved.

(20) for the complete consumption of groundwater in the conditions of trapezoidal channels takes the following form:

$$Q_{myб} = 0{,}053\chi[(S-1)g]^{0,5} d_{ўр}^{1,5} T^{2,1}/D_*^{0,3} \quad (21)$$

Also , when the values calculated according to the formula (20) were compared with the values calculated according to the formulas of Van-Reyn, Hansen and Akers - White, it was seen that they are closely related.

Therefore, taking into account the above-mentioned characteristics of groundwater flow in trapezoidal channels with unbound soil, the recommended connections can be used to predict flow transport in channels.

Table 2

Comparison of experimental data with values calculated by the Van-Ryn formula

The slope of the side slope *is t=2*

No	$h, м$	$Q, м^3/c$	$\vartheta, м/c$	$d, м$	$Q\, m^2/s$	C'	D_*	θ_{kp}	U'_{*kp}	U'_*	T	$q_t\, m^2/s$ Van Rijn
1					0	53.7696662	6.3	0.04	0.000161865	5.72846*10 $^{-5}$	-0.646096264	-
2	0.07	0.003045	0.15	0.00025	0	54.97670146	6.3	0.04	0.000161865	7.29544*10 $^{-5}$	-0.549288869	-
3	0.08	0.004712	0.19	0.00025	0	56.02228296	6.3	0.04	0.000161865	0.000112723	-0.303600067	-
4	0.1	0.0077	0.22	0.00025	0	57.76954826	6.3	0.04	0.000161865	0.000142126	-0.121947381	-
5	0.08	0.010582	0.26	0.00025	0.446547*10 $^{-7}$	56.02228296	6.3	0.04	0.000161865	0.000211082	0.304061924	0.398273*10 $^{-7}$
6	0.08	0.013104	0.28	0.00025	1.31336*10 $^{-7}$	56.02228296	6.3	0.04	0.000161865	0.000244805	0.512403178	1.19164*10 $^{-7}$
7	0.09	0.0138	0.29	0.00025	1.60784*10 $^{-7}$	56.94455121	6.3	0.04	0.000161865	0.000254166	0.570235425	1.49167*10 $^{-7}$
8	0.09	0.0142	0.29	0.00025	1.69935*10 $^{-7}$	56.94455121	6.3	0.04	0.000161865	0.000254166	0.570235425	1.49167*10 $^{-7}$
9	0.1	0.0158	0.3	0.00025	1.96969*10 $^{-7}$	57.76954826	6.3	0.04	0.000161865	0.000264284	0.632742474	1.85582*10 $^{-7}$

The slope of the side slope *t=2.5*

No	$h, м$	$Q, м^3/c$	$\vartheta, м/c$	$d, м$	$Q\, m^2/s$	C'	D_*	θ_{kp}	U'_{*kp}	U'_*	T	$q_t\, m^2/s$ Van Rijn
1	0.06	0.0027	0.15	0.00025	0	53.7696662	6.3	0.04	0.000161865	7.62665*10 $^{-5}$	-0.528826386	-
2	0.07	0.003453	0.17	0.00025	0	54.97670146	6.3	0.04	0.000161865	9.37058*10 $^{-5}$	-0.421086591	-
3	0.08	0.00675	0.2	0.00025	0	56.02228296	6.3	0.04	0.000161865	0.000124901	-0.228365725	-
4	0.09	0.01122	0.24	0.00025	0.0385802*10 $^{-7}$	56.94455121	6.3	0.04	0.000161865	0.000174078	0.075452562	0.0213342*10 $^{-7}$
5	0.09	0.01404	0.26	0.00025	0.57716*10 $^{-7}$	56.94455121	6.3	0.04	0.000161865	0.0002043	0.262163076	0.291716*10 $^{-7}$
6	0.1	0.013525	0.27	0.00025	0.851282*10 $^{-7}$	57.76954826	6.3	0.04	0.000161865	0.00021407	0.322521404	0.450747*10 $^{-7}$
7	0.1	0.0138	0.29	0.00025	2.37385*10 $^{-7}$	57.76954826	6.3	0.04	0.000161865	0.000246959	0.525707134	1.25754*10 $^{-7}$
8	0.11	0.0147	0.31	0.00025	4.38096*10 $^{-7}$	58.51584888	6.3	0.04	0.000161865	0.000275044	0.699219536	2.28902*10 $^{-7}$

2 continued

The slope of the side slope *is t=3*

No	$h, м$	$Q, м^3/c$	$\vartheta, м/c$	$d, м$	$Q\, m^2/s$	C'	D_*	θ_{kp}	U'_{*kp}	U'_*	T	$q_t\, m^2/s$ Van Rijn
1	0.06	0.00297	0.15	0.00025	0	53.7696662	6.3	0.04	0.000161865	7.63443*10 $^{-5}$	-0.528345597	-
2	0.07	0.004284	0.17	0.00025	0	54.97670146	6.3	0.04	0.000161865	9.38014*10 $^{-5}$	-0.420495863	-
3	0.09	0.00756	0.2	0.00025	0	56.94455121	6.3	0.04	0.000161865	0.000121011	-0.252395859	-
4	0.08	0.012672	0.25	0.00025	0.205757*10 $^{-7}$	56.02228296	6.3	0.04	0.000161865	0.000195356	0.206908838	0.177458*10 $^{-7}$
5	0.09	0.015912	0.27	0.00025	0.603865*10 $^{-7}$	56.94455121	6.3	0.04	0.000161865	0.000220542	0.362508546	0.576141*10 $^{-7}$
6	0.09	0.02106	0.28	0.00025	1.02899*10 $^{-7}$	56.94455121	6.3	0.04	0.000161865	0.000237181	0.465304116	0.973212*10 $^{-7}$
7	0.11	0.0358	0.3	0.00025	1.6842*10 $^{-7}$	58.51584888	6.3	0.04	0.000161865	0.000257848	0.592984485	1.61939*10 $^{-7}$
8	0.12	0.042	0.33	0.00025	3.90805*10 $^{-7}$	59,19716797	6.3	0.04	0.000161865	0.000304856	0.88339787	3.74015*10 $^{-7}$

The slope of the side slope *is t=3.5*

No	$h, м$	$Q, м^3/c$	$\vartheta, м/c$	$d, м$	$q_t, m^2/s$	C'	D_*	θ_{kp}	U'_{*kp}	U'_*	T	$q_t, m^2/s$ Van Rijn
1	0.11	0.003328	0.18	0.00025	0	58.51584888	6.3	0.04	0.000161865	$9.28254*10^{-5}$	-0.426525585	-
2	0.09	0.0181	0.24	0.00025	$0.245331*10^{-7}$	56.94455121	6.3	0.04	0.000161865	0.000174256	0.076549963	$0.021991*10^{-7}$
3	0.09	0.0233	0.28	0.00025	$1.02564*10^{-7}$	56.94455121	6.3	0.04	0.000161865	0.000237181	0.465304116	$0.973212*10^{-7}$
4	0.1	0.0298	0.3	0.00025	$1.92471*10^{-7}$	57.76954826	6.3	0.04	0.000161865	0.000264554	0.634408537	$1.8661*10^{-7}$
5	0.12	0.0373	0.33	0.00025	$4.41751*10^{-7}$	59,19716797	6.3	0.04	0.000161865	0.000304856	0.88339787	$3.74015*10^{-7}$
6	0.13	0.0401	0.34	0.00025	$4.66038*10^{-7}$	59.82392077	6.3	0.04	0.000161865	0.000316867	0.957600849	$4.43045*10^{-7}$

Table 3

(3.46) comparison of the values calculated according to the formula with the values calculated according to the formulas of other authors

The slope of the side slope *is m=2*

No	$h, м$	$Q, м^3/c$	$\vartheta, м/c$	$d, м$	$q_t, m^2/s$			
					Van Rijn	**Engelund-Hansen**	**Akers-White**	**(20) formula**
5	0.08	0.010582	0.26	0.00025	$0.398273*10^{-7}$	$1.25364*10^{-7}$	$0.351666*10^{-7}$	$0.43006*10^{-7}$
6	0.08	0.013104	0.28	0.00025	$1.19164*10^{-7}$	$2.10604*10^{-7}$	$0.502455*10^{-7}$	$1.28675*10^{-7}$
7	0.09	0.0138	0.29	0.00025	$1.49167*10^{-7}$	$2.20565*10^{-7}$	$0.762209*10^{-7}$	$1.61513*10^{-7}$
8	0.09	0.0142	0.29	0.00025	$1.49167*10^{-7}$	$2.20565*10^{-7}$	$0.762209*10^{-7}$	$1.61513*10^{-7}$
9	0.1	0.0158	0.3	0.00025	$1.85582*10^{-7}$	$2.34211*10^{-7}$	$1.09168*10^{-7}$	$2.01411*10^{-7}$

The slope of the side slope *is m=2.5*

No	$h, м$	$Q, м^3/c$	$\vartheta, м/c$	$d, м$	$q_t, m^2/s$			
					Van Rijn	**Engelund-Hansen**	**Akers-White**	**(20) formula**
4	0.09	0.01122	0.24	0.00025	$0.0213342*10^{-7}$	$0.586448*10^{-7}$	$0.183637*10^{-7}$	$0.0225552*10^{-7}$
5	0.09	0.01404	0.26	0.00025	$0.291716*10^{-7}$	$1.02698*10^{-7}$	$0.281132*10^{-7}$	$0.308413*10^{-7}$
6	0.1	0.013525	0.27	0.00025	$0.450747*10^{-7}$	$1.12023*10^{-7}$	$0.434503*10^{-7}$	$0.477213*10^{-7}$
7	0.1	0.0138	0.29	0.00025	$1.25754*10^{-7}$	$1.84733*10^{-7}$	$0.606479*10^{-7}$	$1.33138*10^{-7}$
8	0.11	0.0147	0.31	0.00025	$2.28902*10^{-7}$	$2.51203*10^{-7}$	$0.9876*10^{-7}$	$2.42632*10^{-7}$

3 continued

The slope of the side slope *is m=3*

No	$h, м$	$Q, м^3/c$	$\vartheta, м/c$	$d, м$	$q_{t.}$ m^2/s			
					Van Rijn	**Engelund-Hansen**	**Akers-White**	**(20) formula**
4	0.08	0.012672	0.25	0.00025	0.177458*10^{-7}	0.952664*10^{-7}	0.09589*10^{-7}	0.184678*10^{-7}
5	0.09	0.015912	0.27	0.00025	0.576141*10^{-7}	1.33751*10^{-7}	0.208411*10^{-7}	0.600224*10^{-7}
6	0.09	0.02106	0.28	0.00025	0.973212*10^{-7}	1.72527*10^{-7}	0.253708*10^{-7}	1.01389*10^{-7}
7	0.11	0.0358	0.3	0.00025	1.61939*10^{-7}	1.99684*10^{-7}	0.564464*10^{-7}	1.6899*10^{-7}
8	0.12	0.042	0.33	0.00025	3.74015*10^{-7}	3.3664*10^{-7}	1.02744*10^{-7}	3.90559*10^{-7}

The slope of the side slope *is m=3.5*

No	$h, м$	$Q, м^3/c$	$\vartheta, м/c$	$d, м$	$q_{t.}$ m^2/s			
					Van Rijn	**Engelund-Hansen**	**Akers-White**	**(20) formula**
2	0.09	0.0181	0.24	0.00025	0.021991*10^{-7}	0.586448*10^{-7}	0.0590201*10^{-7}	0.0226902*10^{-7}
3	0.09	0.0233	0.28	0.00025	0.973212*10^{-7}	1.72527*10^{-7}	0.157181*10^{-7}	1.00415*10^{-7}
4	0.1	0.0298	0.3	0.00025	1.8661*10^{-7}	2.34211*10^{-7}	0.29921*10^{-7}	1.92661*10^{-7}
5	0.12	0.0373	0.33	0.00025	3.74015*10^{-7}	3.3664*10^{-7}	0.707721*10^{-7}	3.86516*10^{-7}
6	0.13	0.0401	0.34	0.00025	4.43045*10^{-7}	3.63319*10^{-7}	0.947251*10^{-7}	4.58031*10^{-7}

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