

**RESEARCH OF FLOW KINEMATICS IN THE LOCAL EROSION AREA
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**ИССЛЕДОВАНИЕ КИНЕМАТИКИ ПОТОКА В ОБЛАСТИ ЛОКАЛЬНОЙ ЭРОЗИИ
НИЖНЕГО БРЫША СООРУЖЕНИЯ*****Эшев Собир Саматович***

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ABSTRACT

The presented article examines the determination of hydraulic conditions in the junction sections of bays during the design of water discharge hydraulic structures, which has important scientific and practical significance. In these areas, sharp changes in flow regime are observed, during which the flow transitions from a turbulent, i.e., supercritical, state to a calm, or subcritical state. It has been established that such a transition is possible only through the phenomenon of a hydraulic jump, which represents a complex hydrodynamic process. Reducing the excess energy of the flow is carried out by various forms of jumps - bottom or surface type, as well as by the method of free discharge of the jet. The correct choice of energy dissipation method contributes to the effective reduction of the destructive impact of the flow, ensures the long-term operational stability of the hydraulic structure, and increases its reliability and safety in various hydrological conditions.

АННОТАЦИЯ

В представленной статье рассматривается определение гидравлических условий в участках сопряжения бьефов при проектировании водосбросных гидротехнических сооружений, что имеет важное научное и практическое значение. В данных участках наблюдаются резкие изменения режима течения, при которых поток переходит из бурного, то есть суперкритического состояния, в спокойное, или субкритическое. Установлено, что подобный переход возможен исключительно посредством явления гидравлического прыжка, представляющего собой сложный гидродинамический процесс. Снижение избыточной энергии потока осуществляется различными формами прыжков — донного или поверхностного типа, а также методом свободного сброса струи. Правильный выбор способа гашения энергии способствует эффективному снижению разрушительного воздействия потока, обеспечивает долговременную эксплуатационную устойчивость гидротехнического сооружения, повышает его надёжность и безопасность работы в различных гидрологических условиях.

Keywords: erosion, cohesive soil, lower reach, turbulent flow, experiment, flow velocity, aggregate, durability, model.

Ключевые слова. эрозия, сцепленный грунт, нижнее течение, турбулентное течение, эксперимент, скорость течения, агрегат, долговечность, модель.

Introduction. The bottom-mode connection can be installed for all types of spillway structures. The disadvantage of this mode can be attributed to the significant and slow attenuation of bottom velocities along the length of the section, as well as damage to the elements of the spillway structure due to the rotation of solid materials in the circulation zone. The damper at the junction of bottom-hole basins damages the damper plates of the wells when solid materials fall into the wells.

Such a sharp change in the hydraulic regime is characterized by the nature of intensive changes in velocities in the longitudinal and transverse sections due to the compression of the dam's spillway width relative to the channel width at relatively short distances. This situation creates conditions for a sharp increase in flow rate and velocity compared to the rear calm flow regime.

This can be explained as follows: in many cases, due to the uneven flow along the length of the discharge front, the flow structure is disrupted, which subsequently leads to an increase in specific discharge. The boundary medium in which the disturbed stream, falling into the section of the lower reach where wide channel erosion occurs, moves, significantly deforms the flow velocity field and has a significant influence on the stream. Under these conditions, the initial flow velocity diagram changes sharply depending on its values on the flow axis, and a sharp decrease in flow velocities occurs in the area adjacent to the water circulation zone.

Materials and Methods. Disruption of the kinematic structure of such a flow in the lower reach increases local erosion in the deformable channel, disrupts the transportation of sediments and their accumulation

in the designated area of the reach, and stops their entry into the lower reach. Such conditions negatively affect the operating mode of the structure. For example, an increase in hydrodynamic pressure and velocity pulsations in the deformable section after the risberm intensifies the total erosion of the channel, which leads to a decrease in the water level and an increase in the head of the structure. Local erosion, which occurs in this case, creates conditions for the erosion of the structure and requires the development of special additional measures to prevent it.

If the lower reach of the hydraulic structure consists of rapidly eroding soil, then for effective dissipation of the energy of the flowing water, the contact of the lower reach levels should be in the form of bottom or surface hydraulic jumps.

At the junction of the flow from the spillway with the lower reach, where the velocity distribution along the flow depth is uneven, high velocities are observed in the section of the transit flow. To the center of the water circulation zone, the flow velocity sharply decreases to zero and in subsequent cases is replaced by velocities of the opposite direction from a separate transit stream to the water circulation boundary. In the lower reach, at the boundaries of the energy dissipator and the fixed one, the flow velocities gradually equalize along the depth, and during its interaction with various dissipators, a redistribution of flow velocities occurs.

Depending on the length of the risberm in the lower reach, the flow at the end of the risberm can be in

a smoothly changing uniform state of the flow regime or in a rapidly changing uneven state after the risberm in the form of an undamped hydraulic jump in a wave-like state. In the subsequent form of the noted flow, the averaged velocity distribution has a complex shape, exceeding the velocity pulsations of the smooth flow. In the local washing funnel after the risberm, a significant transfer of the velocity field occurs. In this case, the distribution of averaged velocities along the depth of the washing funnel depends on the degree of excess energy dissipation, the shape of the washing funnel, the distribution of specific costs, and other factors.

The movement of water in spillway structures has a flow characteristic. The movement of the flow in expanding channels, in which the water circulation zone arises, has a more complex character compared to the movement of smooth streams in a confined medium. Under these conditions, the flow retains the characteristics of its main jet flow, which in the first approximation can be considered as a turbulent flow with a smooth or rough bottom along the width of the bounded channel.

Results and Discussion. Based on the available data and experimental data, the goal was set to study the kinematic structure of the flow in the erosion funnel in the bound soil section of the lower reach, to establish the necessary relationships between the distribution of flow velocities by depth to determine the maximum depth of erosion and the shape of this erosion funnel.

Table 1.

Laboratory data obtained under the influence of a wave hydraulic jump

№	I_{stv}			II_{stv}			III_{stv}			IV_{stv}			V_{stv}			VI_{stv}		
	h_1	l_1	v_1	h_2	l_2	v_2	h_3	l_3	v_3	h_4	l_4	v_4	h_5	l_5	v_5	h_6	l_6	v_6
1.1	0,045	0,10	0,28	0,05	0,20	0,34	0,065	0,30	0,34	0,06	0,40	0,45	0,04	0,50	0,55	0,035	0,60	0,47
			0,37			0,32			0,32			0,5			0,48			0,35
			0,35			0,25			0,25			0,48			0,4			0,26
			0,25			0,19			0,19			0,35			0,32			0,22
1.2	0,052	0,10	0,6	0,06	0,20	0,55	0,068	0,30	0,55	0,065	0,40	0,69	0,045	0,50	0,43	0,04	0,60	0,39
			0,67			0,64			0,64			0,71			0,47			0,4
			0,63			0,63			0,63			0,69			0,46			0,35
			0,53			0,6			0,6			0,65			0,45			0,28
1.3	0,055	0,10	0,45	0,065	0,20	0,35	0,07	0,30	0,35	0,068	0,40	0,75	0,050	0,50	0,50	0,045	0,60	0,38
			0,81			0,45			0,45			0,68			0,48			0,42
			0,87			0,42			0,42			0,55			0,42			0,45
			0,8			0,35			0,35			0,42			0,35			0,38
1.4	0,062	0,10	0,82	0,07	0,20	0,81	0,076	0,30	0,81	0,073	0,40	0,87	0,055	0,50	0,71	0,05	0,60	0,65
			0,83			0,88			0,88			0,97			0,82			0,72
			0,85			0,93			0,93			0,94			0,79			0,69
			0,80			0,90			0,90			0,85			0,76			0,65
1.5	0,065	0,10	0,86	0,075	0,20	0,84	0,08	0,30	0,84	0,076	0,40	0,88	0,065	0,50	0,81	0,055	0,60	0,78
			0,84			0,88			0,88			0,84			0,79			0,74
			0,78			0,90			0,90			0,80			0,72			0,65
			0,65			0,82			0,82			0,75			0,65			0,60
1.6	0,068	0,10	0,92	0,080	0,20	0,94	0,09	0,30	0,94	0,085	0,40	0,85	0,075	0,50	0,83	0,06	0,60	0,82
			0,95			0,92			0,92			0,96			0,95			0,95
			0,88			0,85			0,85			0,94			0,90			0,88
			0,82			0,79			0,79			0,83			0,83			0,75

We will try to find a solution to the above-mentioned problem. To simplify the calculation, we enter the data into Table 1.

Fig. 1...3 shows the distribution of flow velocities measured in the sections along the washing funnel, occurring at the beginning of the deformable section of the channel after the wave jump (Table 1).

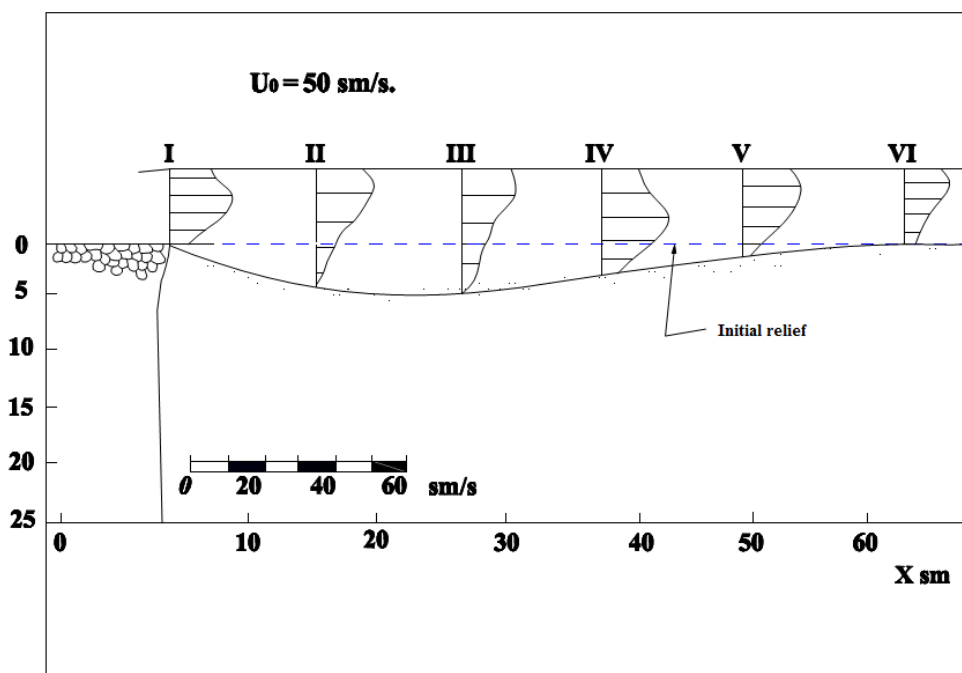


Figure 1. Distribution of flow velocity in the washing funnel

When the water flow flowing from the end of the riserm enters the channel of deformable cohesive soil, a number of features arise in the erosion mechanism when the flow acts on the cohesive soil. At the beginning of the washing period, fine clay particles are washed away under the influence of the flow, and then during the further influence of the flow, the breakage of the aggregates, i.e., the washing process, is observed (Fig. 1). At the beginning of the washing funnel, this situation occurred quickly, and subsequently, the breakdown of large-diameter units began. This situation continued along the slope of the washing funnel entrance (Fig. 1). With the appearance of a washing funnel, the dimensions of the detachable units are significantly reduced. The diameter of the detachable

aggregates, of course, largely depends on the texture and structure of the cohesive soil, but mainly on the scale of turbulence of the flow in the washing funnel. This state continued until the current of the washing funnel reached its maximum depth (Fig. 1). Also, an increase in bottom velocities was observed at the bottom of the washing funnel from the beginning to the end.

In the sections after the maximum washing of the washing funnel, the flow velocity gradually increases, and after the degree of influence of the funnel decreases, the flow velocity equalizes. Correspondingly, the distribution of prime velocities also occurs.

The distribution of flow velocities occurring in the washing funnel showed similarity in other experiments (Fig. 1...3).

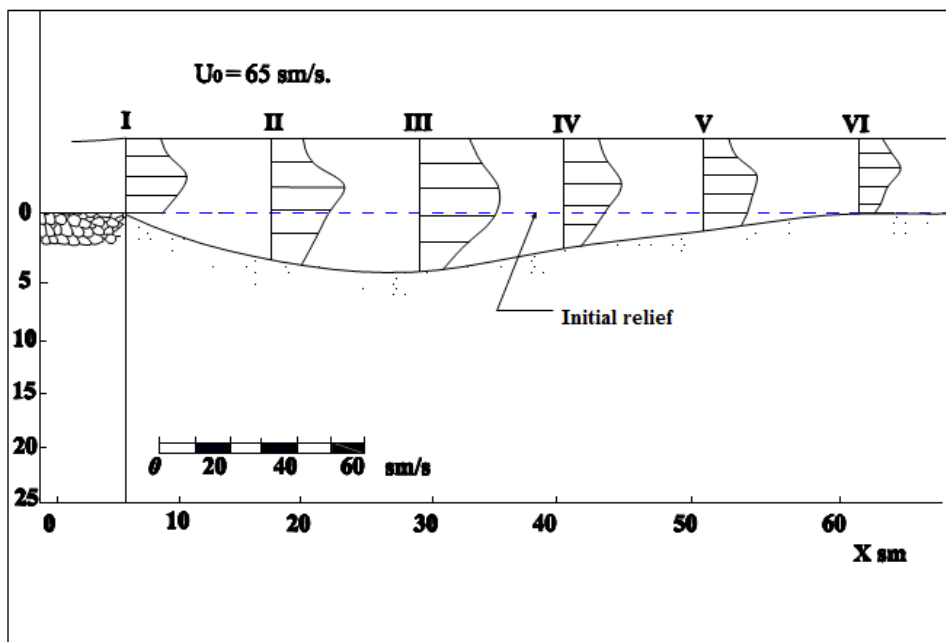


Figure 2. Distribution of flow velocity in the washing funnel

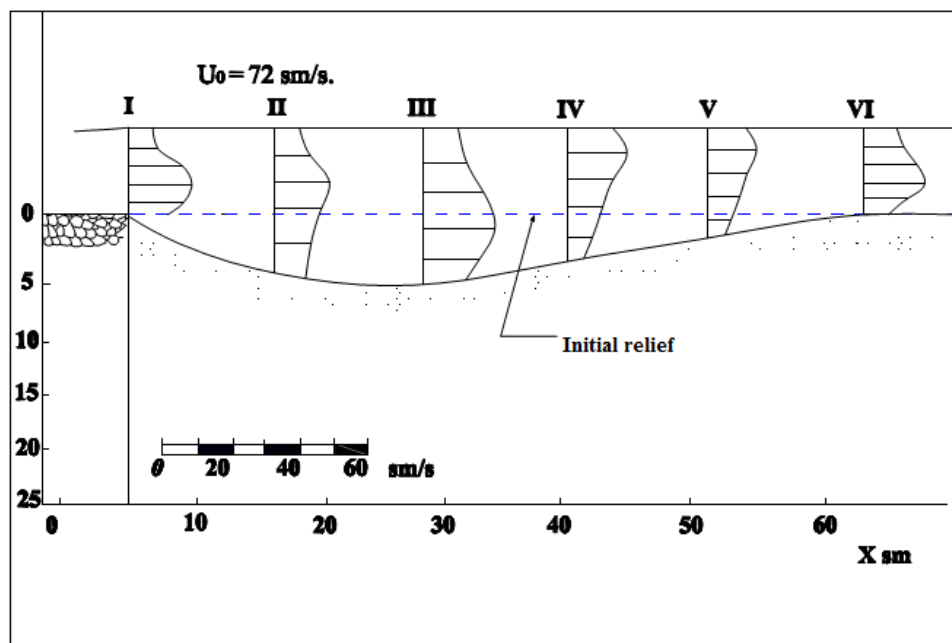


Figure 3. Distribution of flow velocity in the washing funnel

Field studies were conducted on the intersections PK387+75 and PK388+44 of the M-3 canal, located in the Guzar district of the Kashkadarya region.

Under the conditions of the conducted experiment, only a wave hydraulic jump was observed ($h''/h' < 2$).

Here, h', h'' is the contact depth of the hydraulic jump. Fig. 4...6 shows the distribution of measured flow

velocities in the seams of the erosion funnel, occurring in the section after the wave hydraulic jump.

Let us consider the distribution of average non-erosion velocities along the longitudinal profile of the erosion funnel and the distribution of maximum underground erosion velocities in the specified sections. For analysis, we use Table 2 for.

Table 2.

Distribution of average non-erosion velocities and bottom-hole non-erosion maximum velocities along the longitudinal profile of the erosion funnel, velocities in designated sections

№	$Q, m^3/s$	$v_{m/s}$	H_o	I_{stv}			II_{stv}			III_{stv}			IV_{stv}			V_{stv}			VI_{stv}		
				h_1	l_1	v_1	h_2	l_2	v_2	h_3	l_3	v_3	h_4	l_4	v_4	h_5	l_5	v_5	h_6	l_6	v_6
2.1	9.68	0.94	2.062	0.25	15	0.49	0.20	25	0.72	0.23	35	0.49	0.20	45	0.49	0.20	50	0.23	0.20	55	0.15
				0.50		0.66	0.50		0.39	0.49		0.57	0.49		0.29	0.50		0.17	0.46		
				0.70		0.33	0.80		0.75	0.80		0.39	0.8		0.22	0.85		0.48	0.65		
				0.90		0.26	1.17		0.31	1.0		0.21	1.17		0.37	1.11		0.55	0.96		
2.2	9.09	1.050	1.989	0.21	15	0.66	0.57	25	0.33	0.50	35	0.16	0.23	45	0.41	0.21	50	0.46	0.25	55	0.25
				0.49		0.54	0.93		0.18	0.79		0.34	0.57		0.39	0.50		0.84	0.51		
				0.79		0.51	1.16		0.42	1.18		0.45	1.01		0.32	0.71		0.78	0.77		
				0.98		0.32	1.42		0.21	1.50		0.15	1.26		0.45	1.09		0.26	1.01		
2.3	9.216	1.050	1.898	0.51	15	0.55	0.21	25	0.22	0.50	35	0.29	0.51	45	0.40	0.25	50	0.21	0.23	55	0.61
				0.72		0.3	0.60		0.34	0.84		0.48	0.80		0.36	0.51		0.23	0.47		
				0.87		0.46	0.82		0.36	1.14		0.38	1.00		0.29	0.80		0.52	0.69		
				1.05		0.39	1.12		0.32	1.39		0.36	1.30		0.28	1.00		0.60	0.96		
2.4	9.686	0.939	1.843	0.23	15	0.37	0.24	25	0.43	0.23	35	0.74	0.20	45	0.26	0.20	50	0.45	0.21	55	0.55
				0.51		0.40	0.64		0.66	0.51		0.59	0.47		0.50	0.44		0.52	0.41		
				0.76		0.85	0.98		0.43	0.76		0.24	0.79		0.65	0.80		0.30	0.58		
				0.95		0.46	1.18		0.44	1.06		0.39	1.23		0.35	1.05		0.64	0.85		
2.5	9.666	0.865	1.868	0.21	15	0.48	0.25	25	0.52	0.21	35	0.49	0.22	45	0.30	0.24	50	0.50	0.22	55	0.24
				0.49		0.53	0.50		0.78	0.50		0.53	0.48		0.72	0.55		0.69	0.41		
				0.67		0.63	0.80		0.45	0.78		0.61	0.80		0.82	0.92		0.51	0.74		
				0.86		0.38	1.05		0.25	1.03		0.51	0.98		0.45	1.20		0.26	0.92		
2.6	0,098	0,90	0,20	0.44	15	0.42	0.21	25	0.48	0.45	35	0.36	0.25	45	0.45	0.50	50	0.30	0.21	55	0.31
				0.68		0.61	0.54		0.65	0.85		0.62	0.55		0.66	0.76		0.55	0.55		
				0.97		0.30	0.86		0.41	1.10		0.44	0.86		0.43	1.12		0.44	0.77		
				1.20		0.31	1.10		0.25	1.42		0.36	1.01		0.29	1.42		0.12	0.98		

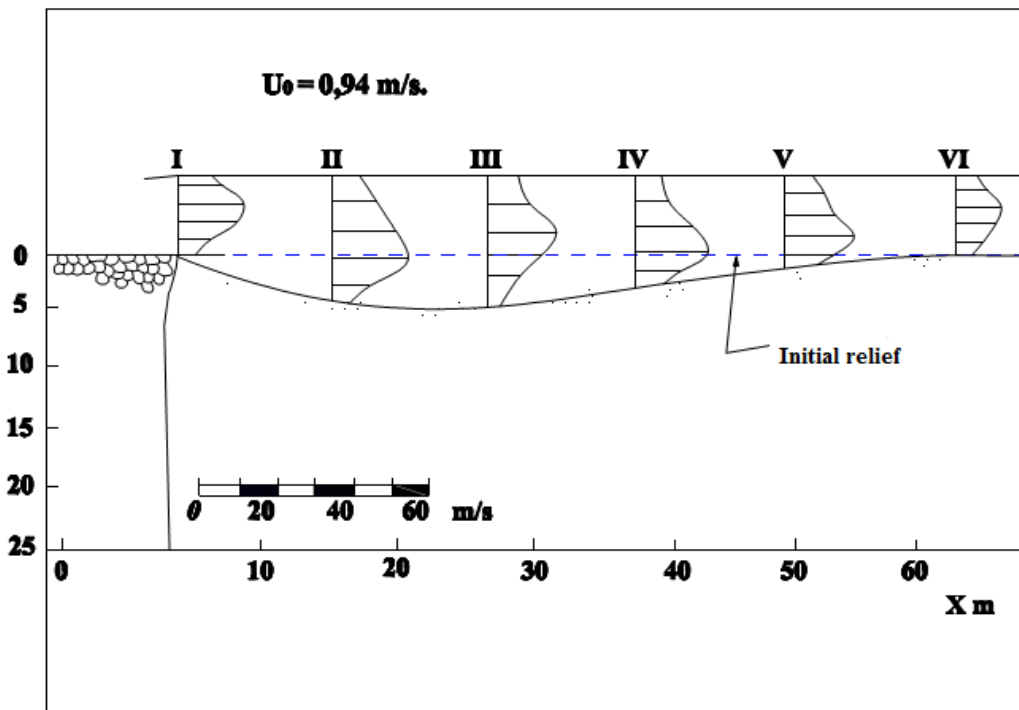


Figure 4. Distribution of flow velocity in a flushing funnel under field conditions

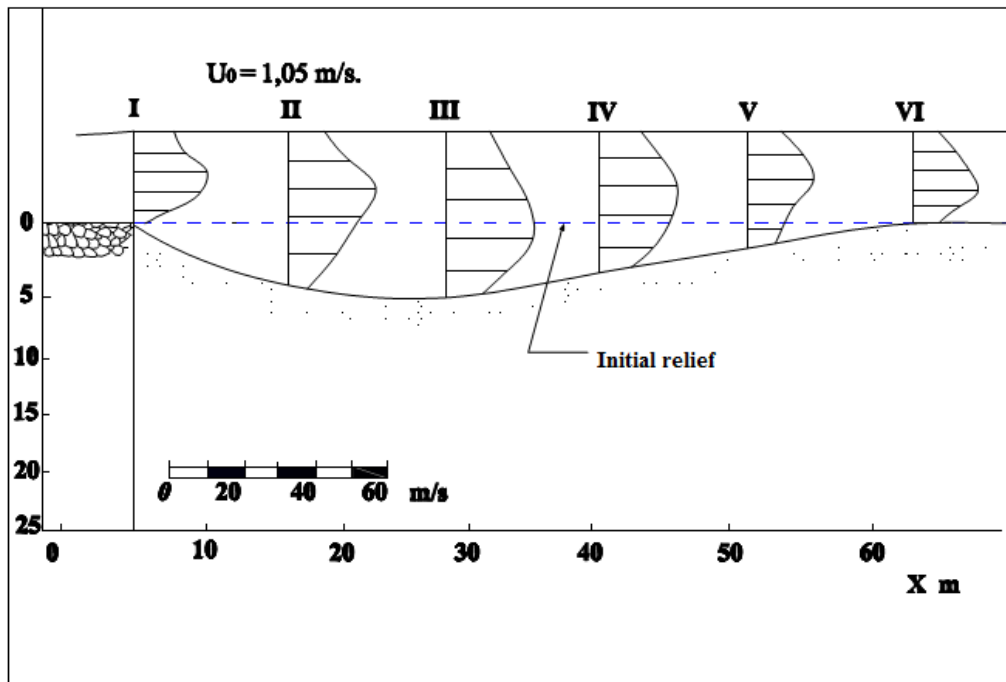


Figure 5. Distribution of flow velocity in a flushing funnel under field conditions

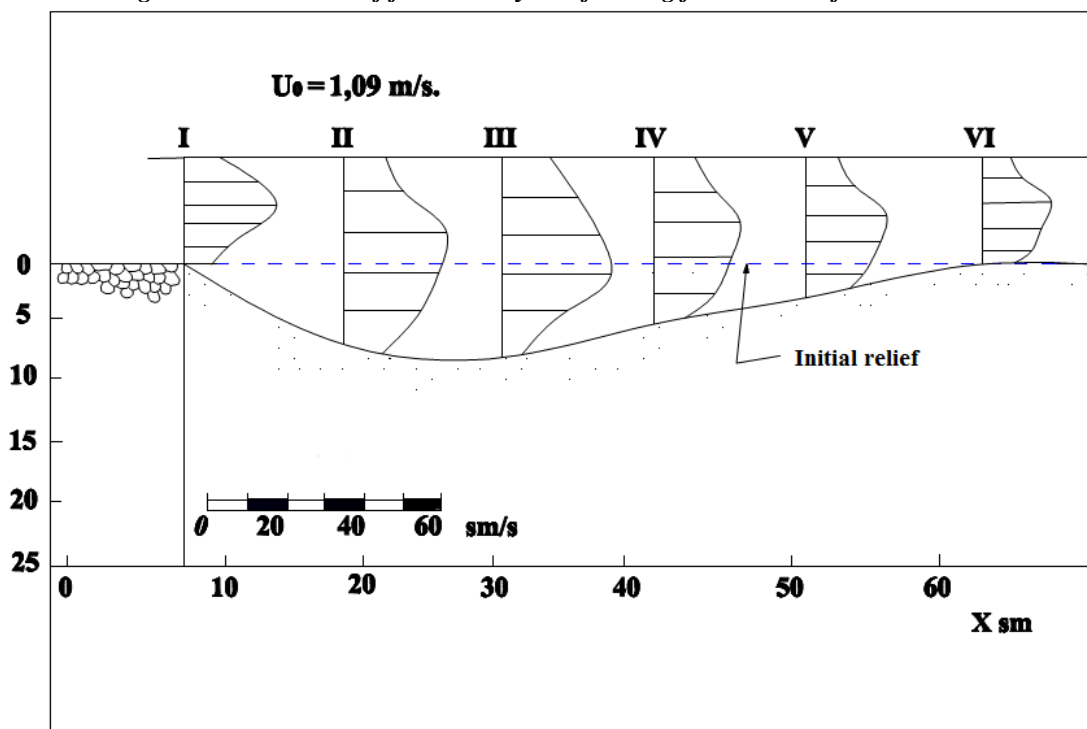


Figure 6. Distribution of flow velocity in a flushing funnel under field conditions

Conclusion. Analysis of the data on the flow velocity distribution in the channel, obtained under field conditions, shows that we also have velocity diagrams corresponding to the velocity distributions obtained under laboratory conditions (Fig. 4...6).

Consequently, studies on the distribution of velocities along the washing funnel, conducted under laboratory and field conditions, show that when the flow

passes from the riserm into the channel bed of the connected soil, at the beginning of the channel, the washing of fine soil particles begins under the influence of the flow velocity, and then, due to the increase in velocities, the detachment of large aggregates from the soil begins, and a washing funnel occurs.

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