Advanced drainage of the sides of a coal mine by horizontal wells with a camouflage cavity

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Abstract. The article presents the results of experiments on models made of equivalent materials of the operability of wells with a camouflage cavity and comparison with the output of groundwater by a natural aquifer. In the experiment, the geometric, physical similarity of materials in the nature of the model was observed. The results obtained showed that when using wells with a camouflage cavity, not only increases the inflow of groundwater, but also decreases the peak loads of depression stresses on the array, as well as the moistening of rocks around the aquifer, in addition, a graph is shown of the rate of water outflow in time on which with the distribution of water inflow without peaks at the time of the formation of washouts. The conducted experiments have shown good performance of wells with camouflage cavities providing effective drainage of the instrument array.

1 Introduction

Currently, the most economical and least labor-intensive is the method of advanced drainage of the side of the quarry (section) using slightly inclined wells with water extraction without the use of pumps.

However, this method has certain disadvantages, such as a large amount of drilling, silting, collapse of the walls of wells and an increase in water leakage between wells.

A new design of charges for the formation of a camouflage cavity is proposed, which makes it possible to significantly improve the water flow through a horizontal well, reducing silting and increasing the catchment area.

The operability of the proposed horizontal structure was tested on an advanced drainage well with a camouflage cavity based on models made of equivalent materials, which made it possible to compare the natural output of groundwater along the aquifer and the interception of water by wells with camouflage cavities.

To observe the similarity and approximation of the properties of the sample material to the properties of the model material, samples were cut directly from the layers of the model and also subjected to testing. The tests showed a fairly close similarity of the physical and mechanical properties of the material of the main model with the full-scale indicators6

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different compositions of equivalent material were tested. For each composition, 3 series of tests were carried out and the composition was determined, which, according to its physical and mechanical parameters, reproduces the properties of the rocks of the Angrensky section, for the conditions of which the modeling task was set.

The components of equivalent materials are: the upper layer of kaolin, as an aquifer (Suzak sands) klinets with river sand filling in a ratio of 30% to 70%, the lower horizon is gray (burnt kaolin and sandstone with clay cement) [1-42].

2 Materials and methods

The model is a three-wall box with a pallet (Fig. 1), with a size of 2000 mm * 1000 mm * 1000 mm.

The bottom of the box was filled with serozem to a height of 200 mm, at half the height of this layer there is a ledge with a slope angle of 600 (Fig. 2). The water-resistant layer had a slope of about 8 degrees for water flow through the aquifer.

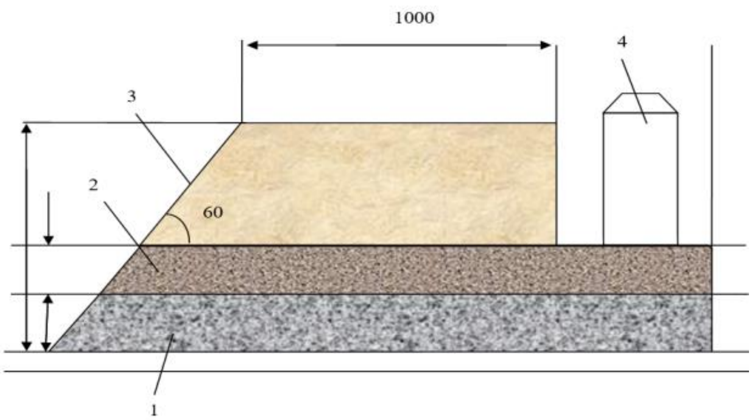

Fig. 1. The design of the model in the section without a camouflage cavity: 1 – a water–resistant horizon, 2 – an aquifer, 3 – the upper platform of the slope, 4 - a storage tank.

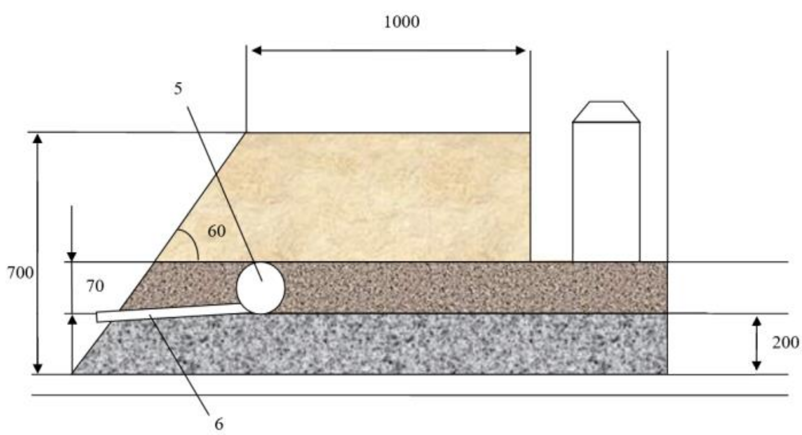

Fig. 2. The design of the model in the section with a camouflage cavity: 5 – camouflage cavity, 6 – slightly inclined well.

Kaolin slopes with a height of 650 mm were built along the edges with a width of 150 mm. This was necessary to prevent the effects of side effects. On this slope, at a height of 100 mm, protrusions with a width of 5 mm were made, to the entire depth of the model. The space between these slopes was filled with an aquifer of a mixture of clinza and sand – 2 to a height of 105 mm. Before filling the aquifer, the mixture was moistened. The space above the aquifer of the upper slope area was filled with kaolin – 3.At the same time, the aquifer was compacted by about 5 mm. In accordance with the lower horizon made of gray earth at an angle of 60 degrees, a slope was cut to a height of 700 mm. A storage tank – 4 for water with a capacity of 10 liters with a perforated bottom was installed in the rear. There was a filling hole in the upper part of the tank. The space from the tank to the upper edge of the slope was – 1100mm.

After finishing the work, the model dried within 24 hours. The simulation began with the fact that the aquifer was moistened until signs of moisture appeared on the slope surface. Then 10 liters of water were poured into the tank. Within 58 minutes, the water from the tank completely flowed out. Several water outlets formed on the surface of the aquifer (Fig. 3), which graduallyaccumulated in the sump. In total, 5.4 liters accumulated in the sump. Areas with collapsed rocks were found in places where water came to the surface (Fig. 4), which in full-scale conditions can lead to deformation of the entire side.

Fig. 3. Model of opening of the aquifer and groundwater outlet to the surface by gravity, the process of water outflow to the surface with the formation of primary deformations.

Fig. 4. The model of the opening of the aquifer and the release of groundwater to the surface by gravity, the end of the outflow of water, the frosting in the aquifer of the washout.

Despite the fact that there was already a small amount of water in the aquifer, the yield was slightly more than 54%. Thus, it can be said that water has accumulated around small particles inside the aquifer, and despite the fact that in the future the flow of moisture has stopped, there is still a sufficiently large amount of water in the aquifer that can moisten both the upper and lower rocks, thereby contributing to the formation of deformations in the contour array.

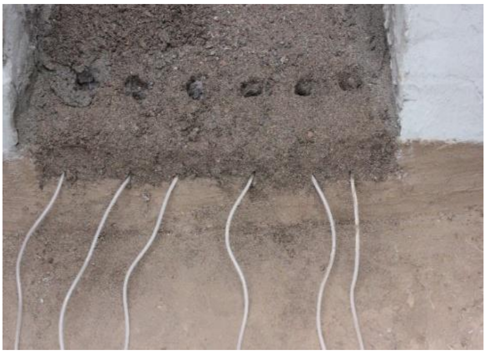

Fig. 5. Laying wells with a camouflage cavity.

Fig. 6. The moment of the appearance of "groundwater".

Fig. 7. Water collection tank.

The second experiment was carried out on the same model under the same conditions, only before the experiment the upper kaolin layer was carefully removed without touching the aquifer. The destroyed sections of the aquifer were restored at an angle of 60 degrees.

Then the model was dried for 24 hours. After that, camouflage cavities were made at a distance of 180 mm/ in the depth of the aquifer.

Using a metal ball connected to the handle by a pin (a device for making artificial flowers). From the camouflage cavities to the surface with the help of a metal tube, “wells” were formed (Fig. 5 and 6), into which polyethylene tubes were inserted, then the upper kaolin layer was restored. 10 liters of water were poured into the water tank. After a while, water began to come out of the tubes, from that moment on, after 42 minutes, the water stopped coming out of the “wells”, while the volume of water released was 7.2 liters. As can be seen in the figures, no washouts were formed during the water outlet. The slope below the water-resistant layer remained absolutely dry. The water was collected in a catchment basin (Fig. 7).

When using camouflage cavities, the water output from the aquifer increased to 72%, which is 14% more than in the absence of wells. We believe that the increase in the time of water release in the first experiment is due to the moistening of rocks around the aquifer, therefore, the amount of water coming out of the aquifer decreases, and the stability of the sides of quarries decreases.

3 Results and discussion

Thus, it can be said with full confidence that camouflage cavities, accumulating water on themselves, at the same time reduce the depression curve, creating conditions for the complete withdrawal of water from the aquifer. In addition, with a decrease in water inflow, a “void” is formed in the camouflage cavity, which creates the effect of water suction in the camouflage cavity. Due to the increase in the rate of water outflow from the aquifer, the water around it does not have time to fully moisten the array, which increases the stability of the side of the quarry, the section.

After the end of the experiment, after 1.5 hours, small puddles were noticed under the tubes, which indicated that the process of water release continued even after the tubes were practically dry. Consequently, even after the water supply to the aquifer was stopped, water continued to accumulate in the camouflage cavities, which in the form of drops came out of the wells. Based on the conducted experiment, it can be concluded that the use of slightly inclined wells with camouflage cavities makes it possible to extract water from the aquifer as much as possible and transport it in any direction by means of pipes, significantly reduce the moisture content of the rocks of the contour array, and, consequently, increase the stability of the side, reduce the possibility of its deformation and transfer clean ground water to the surface (Fig. 8).

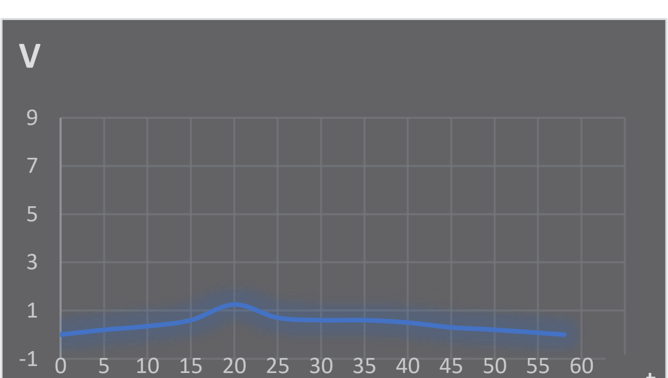

Fig. 8. The graph of the dependence of the change in water flow over time.

The graph (Fig.9) shows the dependence of the change in water inflow over time, over the aquifer. Which shows that for the first 10 minutes there is a uniform increase in water inflow associated with the flooding of the aquifer. At 20 minutes, there is a sharp jump in the output of water from the aquifer. At this moment, the aquifer is washed in several places, that is, the formation of aquifers inside the aquifer. Then, the water flow drops and stabilizes. Starting from the 40th minute, the water output gradually decreases and at the 58th minute the water flow practically stops.

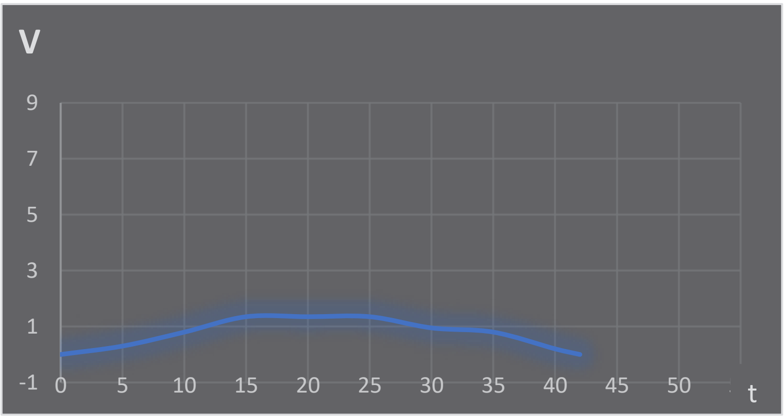

Fig. 9. A graph of the dependence of the change in water flow over time using the proposed design.

The graph shows the results of an experiment using horizontal wells with a camouflage cavity, which clearly shows that the water flow increases smoothly for the first 15 minutes, starting from 14 minutes and up to 26 minutes, the water flow is stable. Then, there is a gradual decrease in water flow to 28 minutes. From 28 to 36 minutes, the water flow stabilizes. We believe that this is due to the suction of water into the cumulative cavities due to the formation of a void inside the upper part of this cavity. Starting from 36 minutes, there is a smooth decrease in water flow to 42 minutes. From this moment on, the water flow practically stops.

4 Conclusion

Therefore, it can be said that the interception of water with the help of wells with a camouflage cavity creates a stable water flow, without dangerous sudden releases of water due to the formation of gullies and the collapse of the aquifer.

The presence of a camouflage cavity significantly increases the output of groundwater even after feeding it with an external source. As a result, the moisture content of rocks around the aquifer decreases and the stability of the side itself increases.

With constant water supply of the aquifer, the use of wells with a camouflage cavity allows you to obtain a stable amount of water inflow into the drainage system and completely drain the instrument array.

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