CONSTRUCTION OF HYDRAULIC TUNNELS IN MEDIUM STRENGTH AND SOFT ROCKS

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Abstract. *Electric power industry of Uzbekistan is a basic industry that determines the development of the country's economy. The need for electricity in the economic sectors and the population of Uzbekistan is determined by the level of current and future economic development, the efficiency of energy use and energy saving.*

The studied Piskent hydroelectric complex is connected to the city of Tashkent by a road of various categories with a length of 120 km. In the construction area, there are proven deposits of local building materials - pebbles, loam, stone and reserves that meet the needs of construction. Local building materials, explored in the construction area, are transported by road.

Keywords: *hydroelectric complex, scope of work, buttress beams, hand-held pneumatic tools*

The technology for constructing the underground complex was adopted taking into account the experience of underground work at other sites in similar engineering and geological conditions and the possibility of using mining equipment. The dimensions of the approach workings are determined in accordance with the use of mining equipment and the transportation of technological metal structures along them [1].

When constructing tunnels of considerable length along their route, rocks may be encountered that have sharply different physical and mechanical properties, as well as having numerous areas with disturbances that are severely fragmented, crushed, and so on.

Under these conditions, due to the very significant rock pressure, the possibility of simultaneous development of the entire tunnel section in one step is excluded. The development of the tunnel face has to be carried out in separate sections with the obligatory use of temporary support, which creates a number of difficulties for the widespread use of mechanized work during the excavation of rock and the construction of the tunnel lining. Excavation of rock under these conditions is usually carried out using hand-held pneumatic tools, and loading of rock using light, small-sized loading devices (mainly material handlers). The construction of the lining in most cases, due to the need for gradual dismantling of temporary support and the limited scope of work, must also be carried out using small means of mechanization.

In the specified mining and geological conditions, the following methods of tunnel construction have been used:

a) with sequential opening of the tunnel profile to its full cross-section;

b) with the opening of the vaulted part of the tunnel section first;

c) with the opening of the tunnel section first along the contour. At the beginning of the tunnel construction work, to prevent possible rock collapse, it is necessary to strengthen the frontal slope, i.e., secure the tie-in. The tie-in is secured by a system of buttress beams 1, which rest with their ends on beams 2, laid perpendicular to the axis of the tunnel. The beams are supported in piles 3, driven to a depth of 2 m. Upper frames 4 are laid on the front slope, each frame is supported by buttress beams 1. The space between the upper frames is tightly tightened with boards, which

are carefully wedged. To prevent slides from the frontal slope, several mounting frames are installed as a continuation of the support of the guide adit.

Construction of a tunnel with its opening to its full cross-section

This method of tunnel construction is characterized by the following work development scheme. First of all, they pass the lower adit 1, intended for transporting rock, delivering material and other purposes. Then the upper adit 2 is installed, which serves to carry out work to expand the vaulted part of the tunnel. Expansion of the vaulted part of the tunnel is usually carried out in two steps: expansion of the small calotte 3 and then the large calotte 4. After developing the vaulted part of the tunnel, they begin to expand its lower part - strosses. This work begins with the development of part of profile 5, called the strotset, which connects the lower and upper adits. Next, the side parts of line 6 are developed, after which they begin the construction of the wall lining, and then the arch of the 7 tunnels. [2]

After completion of the lining construction work, the reverse arch of tunnel 8 is developed and secured. The development of the tunnel along its length with the gradual opening of its profile is carried out in separate rings 4-6 m long.

The main stages of tunnel development are shown in. The lower adit 1 (stage I) is secured with fastening frames made of wood and less often metal and is carried out ahead of four to six rings, i.e. 20-25 m. The upper adit 2 is carried out with the smallest possible cross-section and knocked down every 6-10 m with a lower adit and rising fournel workings 3, which serve to lower rock during the development of the calotte.

The development of a small calotte (stage II) begins with laying beams of logs, called small channels, at a distance of 1.5-2 m perpendicular to the axis of the upper adit on its 1st in grooves about 0.5 m deep. Next, under the upper shafts of the upper adit, the first two longitudinal girders 2, called longarines, are laid, which are supported by pillars 3, resting on small channels. As the small calotte is developed, pillars are installed along the radius, resting on the small channel and supporting the longarines. To ensure the stability of the support, spacers 4 are made between the longarines, and the roof between the longarines is secured with puffs - marchevans. When it is no longer possible to install pillars at the ends of a small channel channel, work on installing a large channel begins (stage III). To do this, between the small channels in the soil of the upper adit, transverse trenches about 0.5 m wide are made, into which the channels of 5 large calottes are laid. The channel of a large calotte is made of thick logs with two edges trimmed and the length is slightly less than the width of the tunnel at the level of its heels. To facilitate the work of delivering and laying the channel, it is made composite. Laying the channel must be strictly horizontal. After laying the large channel, new longer pillars are installed on it under the previously installed longarines. In this case, it is necessary to ensure thorough wedging of them so that all the pressure from the longarine can be transferred to them. After this, the small channel and short pillars are removed.

When the large block has been developed to its full cross-section, the development of the middle part of the line will begin. To do this, first lay beds 1 in the lower adit in one vertical plane using large channels (stage IV). The beds are made from sections of thick logs 1.5-1.7 m long and placed in the lower adit, in niches made in its sides. On the sunbeds there are pillars with 2 strips, which should take pressure from a larger number of channels. The development of the line begins in the middle of the ring on both sides symmetrically. For the correct distribution of forces, the central pillars of the stross must be replaced so that they form a straight line with the pillars of the

large calotte running from the first longarine. When all the line guides are installed, they begin to expand the line to the full profile (stage V). After developing the tunnel to the floor section, they begin to construct the lining in the direction from bottom to top. The lining is erected on both sides of the tunnel at the same time. After erecting the lining, it is necessary to pump: cement mortar behind the support.

The advantages of this method of tunnel construction: monolithic lining along the entire tunnel profile and relatively fast construction of the tunnel due to the excavation of pores and construction of the lining on a wide front. The tunnel construction speed is 1.5–2.5 m/day.

The disadvantages of this method include the large complexity of temporary support, which requires highly qualified workers and significant expenditure of manual labor. In addition, the design of the temporary support does not provide sufficient rigidity and strength. The crepe consists of several supports formed as a result of sequential installation, which ultimately leads to their significant compliance, reaching 20-25 cm. Such compliance of the support excludes the possibility of using this method of constructing tunnels in conditions of urban development.

Construction of a tunnel with opening of the vaulted part of the section first

There are two possible schemes for developing the tunnel face using this method - single-adcut and double-adit. In a single-adit scheme, work begins with the construction of the upper adit 1. Then the calotte 2 is expanded and a permanent lining of the arch 3 is erected. After the concrete lining has hardened, the middle part of the lining 4 is developed, and then its side parts 5, followed by placing the walls of the lining under the heels of the arch oda 6.

With a two-adit scheme, work on the construction of the tunnel b) begins with the construction of the lower adit 1. Then they build the upper adit 2, develop the calotte 3 and build the lining of the vault 4. After the concrete has filled the vault with the appropriate strength, the middle part of the road 5 is developed, and then its side parts 6. After this, the lining walls are brought under the heels of arch 7.[2]

Comparing the above tunnel construction schemes, we can note the following:

a) the advantages of the single-till scheme are lower cost of work, safer and more productive development of the rock, since the work is carried out in an untouched rock massif. The disadvantages of the single-adit scheme include delays in work due to transport along the adit due to the presence of oncoming flows (rock and fastening materials) during simultaneous work on excavating rock and constructing the lining in the tunnel;

b) the two-adit tunnel construction scheme has only one advantage - the independence of transporting rock and materials along the lower adit; the upper adit is used only for work on expanding the tunnel.

The single-drill scheme can be recommended for the construction of short-length tunnels in stable rocks. The two-bar scheme is more universal.

The stages of development of work during the construction of a tunnel according to a two-shaft scheme are shown in Fig. 1, a. Work begins with the lower adit 1. The upper adit 2 is carried out with a lag of about 30 m from the lower adit. After 8-12 m (1-2 rings), the adits are knocked together with furnels, which serve to transfer rock from the upper adit to the lower one (stage I). Next, a calotte is symmetrically developed from the upper adit to both its sides (stage II). The development of the calotte is carried out in a similar way to the previously discussed method.

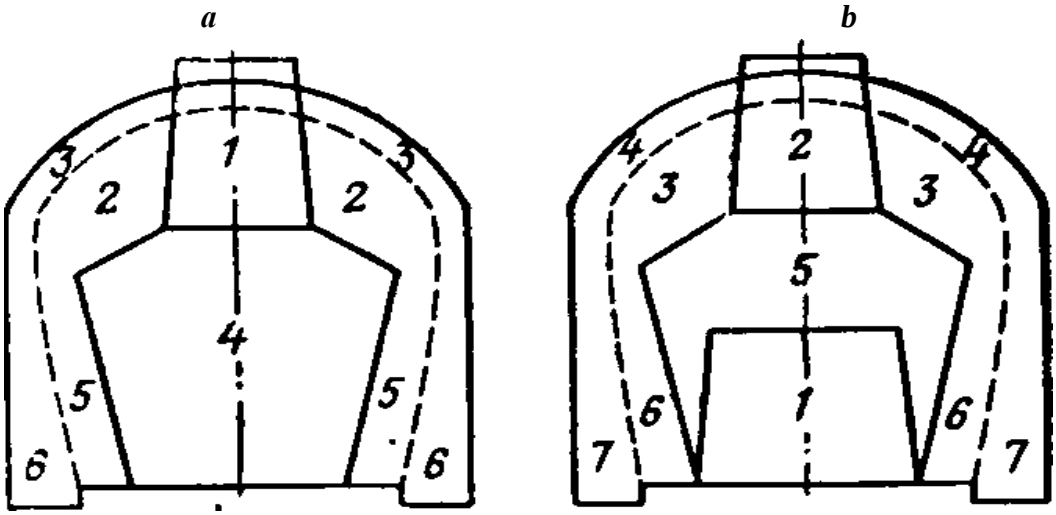

Fig. 1. Schemes for the construction of a tunnel with the opening of the vaulted part of the section first

Temporary support consists of longarines and pillars. The pillars rest directly on the ground through board linings. After developing the calotte to a length of 8-12 m (this work should be carried out as quickly as possible), the construction of the vault lining begins (stage III). To do this, the rock is leveled at the heels of the arch and thick longitudinal boards are laid or a preparation is made of thin concrete 10-15 cm thick. Then circles are installed, which are supported by subcircular posts. For stability, the subcircular pillars are secured to each other with spacers and after this they begin to construct the lining of the vault. As the lining is erected, the longarines and pillars are dismantled, and the marchevans are temporarily supported by short posts installed on the circular ribs (stage IV). After completing the lining of the vault and the concrete reaching a strength of at least 60% of the design strength, i.e., after approximately four to five days, you can begin dismantling the circular ribs and formwork and then begin developing the struss (stage V).

After developing the middle part of the lines, the walls of the lining are lined up under the heels of the arch (stage VI). This operation is very responsible and is carried out in strict order in separate steps. Sequence of work on the construction of the lining for the vault pits. b (the numbers indicate the order of development of the openings). The development of each stope can begin only after the erected wall lining of the previous stope has achieved sufficient strength.

The advantages of this method of tunnel construction: the simplicity of the temporary support design and its sufficient reliability; a short period of time for maintaining the vault on temporary support, which reduces the risk of violating the stability of the roof species.

The disadvantages of this method include:

dismemberment of the tunnel lining between the vaulted part and the walls, as well as in the walls, which sharply reduces its solidity. This disadvantage especially needs to be taken into account when constructing hydraulic tunnels;

Excavation of rock in the highway under the heels of the arch should be carried out in cramped conditions without the use of mechanized means of work. In the presence of fractured rocks this work is very difficult and may exclude the possibility of using this method of tunnel construction;

The speed of tunnel construction is low due to delays associated with the need to maintain the monolithic concrete lining in the vault.

Construction of a tunnel with opening first of all its sections along the contour

The construction of a tunnel with opening, first of all, of its cross-section along the contour begins with the construction of two side adits 1 and a central adit 2, which are connected with each other by transverse workings 3. As adits 1 are developed, lining 1 is erected in them. they are released to the surface through workings 3 and the central adit 2. After developing and securing the first tier of the tunnel, they begin work in the second tier, where adit 4 is moved and lining 4 is erected, etc. By the time the construction of the wall lining is completed, the upper adit 6 is built and developed calotta 7. The rock from the development of the calotte enters through fournel 8 to the lower central adit. After the development of the calottes, the lining of the vault 9 is erected, supporting the heels of the previously erected walls. After the concrete lining of the arch has gained the required strength, you can begin to develop the central pillar of rock 10. The pillar is excavated under the protection of the lining in safe conditions and can be carried out using m powerful tunneling equipment.

The individual stages of work during the construction of the tunnel are shown in Fig. 2, b. Stage I corresponds to the moment when the side adits of the 1st lower tier were driven to a length of 20-30 m and the lining was erected in them; work has begun on construction of adit 2 of the second tier.

b

Fig.2. Stages of work during the construction of a tunnel using a two-shaft scheme with the opening of the vaulted part of the section first

The rock from the adit is dumped through working 3 onto the lower adit, located in the plane of the transverse working 4, and then onto the central adit 5. Stage II corresponds to the moment when the development of the side adits is completed and the lining of the tunnel walls erected, the space between the tunnel walls is filled with rock 1 , which will protect the lining of the walls during the development of the central pillar. The central adit 3 is carried out and from it the development of the calotte 2 begins. The rock from the calotte is dumped through the central fournel 4 to the lower adit 5. Stage III, A - the development of the calotte in the ring is completed, stage III, B - the lining of the vault has been erected. Stage IV corresponds to the moment when the tunnel lining is completely erected and work is underway to develop the central pillar of the rock.

The method of constructing a tunnel with the opening of the section first along the contour has the following advantages: simple and very reliable temporary support, which allows you to easily modify it depending on changes in the physical and mechanical properties of the rocks being crossed; greater work safety; the main mass of the rock (central pillar) is developed in conditions of complete safety under the protection of permanent lining; sedimentation of the rock is excluded.

The disadvantages of this method include the large amount of work associated with the excavation of limited sections (side adits); the tightness of the work, which can cause a decrease in the quality of the lining.

Table 1

Indicators per 1 m of tunnel	Tunnel construction method	
	with full opening	with opening along the section contour
Face development, м3:		
with support	120	69
without support	-	51
Timber consumption, m3:		
round	5,4	3,5
sawn	2,75	2,0
Labor costs, man-days	121,7	80,7
Cost of construction, rub.	1150	880

The method is widely used in the construction of tunnels and chambers of large cross-sections in rocks that have a heterogeneous structure and are not strong enough.

Moving on to a general assessment of the considered methods for constructing tunnels in medium-strength and soft rocks, it can be noted that the most reliable and safe is the method of constructing a tunnel with the opening of the tunnel contour first. This method is especially advisable to use when crossing rocks with frequently changing physical and mechanical properties.

In terms of the consumption of materials for temporary support, labor intensity of work and cost per 1 m of tunnel, the method of constructing a double-track tunnel with opening of the cross-sectional contour first is more effective than the method of constructing a tunnel with opening to its full cross-section.

REFERENCES

1. Feasibility study Construction of the Pskem hydroelectric power station on the Pskem River in the Bostanlyk district of the Tashkent region. Volume 1. Technical part. General explanatory note No. 1921-T1. Tashkent 2020.
2. N. M. Pokrovsky. Technology of construction of underground structures and mines. Part 1. Technology for the construction of horizontal mine workings and tunnels / N. M. Pokrovsky. – 6th ed. – Moscow: Nedra, 1977. – 400 p.
3. Bakiev M.R., Mazhidov Zh., Nosirov B., Khodzhakulov R., Rakhmatov M. “Hydraulic engineering of inshotlari “1-core.” Tashkent, “Yangi asr avlodi”, 2008.
4. L. I. Baron, G. P. Demidyuk, G. D. Lidin and others. Mining. Terminological dictionary. 3rd ed., revised. and additional Moscow: Nedra, 1981. – 479 p.
5. I. E. Erofeev. Increasing the efficiency of drilling and blasting operations in mines. Moscow: Nedra, 1988. – 272 p.
6. G. A. Shetler. Album on drilling and blasting operations / G. A. Shetler, L. M. Feigin, E. M. Zinchenko. – Moscow: Ugletekhizdat, 1953. – 93 p.

7. M.F. Drukovany, L.V. Dubnov, E. O. Mindeli, K. I. Ivanov, V. I. Ilyin. Handbook of drilling and blasting operations. Moscow: Nedra, 1976.
8. B.N. Kutuzov, Yu.K. Valukhin, S. A. Davydov and others. Design of blasting operations. Moscow: Nedra, 1974. – 328 p.
9. P. Ya. Taranov. Drilling and blasting operations. 2nd ed. – Moscow: Nedra, 1964. – 256
10. S. K. Mangush, A. P. Fisup. Handbook on drilling and blasting operations in underground mining. Moscow, 2003. – 344 p.
11. Vokhmin S.A., Kurchin G.S., Kirsanov A.K. The process of rock destruction during the explosion of an explosive charge. Bulletin of ZabSU. No. (126).2015