CONSTRUCTION OF UNDERGROUND STRUCTURES IN UNSTABLE AND RUNNING GROUND BY THE METHOD OF SINKING TIMBERING IN A THIXOTROPIC JACKET

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UDC 624.157.6

The construction of underground structures in unstable and especially quick ground presents considerable difficulty. Under these conditions it is usually necessary to use special methods of operation aimed at stabilizing the ground (freezing, chemical stabilization, etc.), the use of which increases the time and cost of works considerably.

In recent years the method of sinking drop shafts in a thixotropic jacket has been used increasingly more widely in the USSR and abroad. This method was first proposed in the USSR by N. V. Ozerov as long ago as 1945, but was developed thoroughly and brought to practical introduction at the Scientific-Research Institute of Bases and Underground Structure (NII Osnovani) in the 1960s.

The use of a thixotropic jacket and a number of other technological designs permitted a radical improvement of the method of sinking drop shafts and its use in the construction of mine shafts, having provided the necessary reliability (elimination of emergency situations), considerable economy of means and materials, reduction of time spent on the construction of shafts in the zone of unstable and quick ground and of manpower on the operations, and an increase of the productivity and improvement of the working conditions of the tunnelers.

Sinking of timbering in a thixotropic jacket was accomplished for the first time in Soviet practice on the construction of the Moscow subway in 1969 during construction of shaft No. 832 of the Zhnanovsko-Krasnopresneneskii diameter. At present seven shafts with a depth to 32 m have been constructed by this technology in Moscow under complex hydrogeological conditions (Fig. 1). This method began to be used also in the construction of the Kiev subway, where in 1972 three shafts were constructed. In 1971 the experience of the Moscow Subway Construction Trust (Mosmetrostrroi) was used in constructing the pit mouth of the Chelyuskintsev mine in the Donbas, where timbering of monolithic reinforced concrete was sunk to a depth of 31 m.

In principle, the construction of shafts in the zone of unstable and quick ground is based on the underwater excavation of the face, which provides a hydraulic surcharge preventing the release of the quick ground. A thixotropic jacket of bentonite clays filling the gap between the timbering and ground practically reduces to a minimum the frictional force of the timbering on the ground. This permits in the zone of unstable and quick ground embedding the cutting curb of the drop shaft (timbering) at the contact with the confining bed by an amount which assures that the quick ground or water-bearing sands will not break through into the face during the period of pumping the water from the constructed part of the shaft.

In connection with the successful introduction of the new method into practice, the use of the method of preliminary freezing of the ground has been practically eliminated in the designs of shaft structures in the construction of subways.
Fig. 1. Diagram of the construction of shafts by the method of sinking timbering in a thixotropic jacket. a) Shaft No. 734 of Mosmetrostroj; b) pit mouth of the Chelyuskintsev mine, Donbas: I) clay; II) sand; III) sandstone; IV) loamy sand; V) water-logged sand; zone of timbering with underwater excavation of face.

The cycle of operations on the construction of mine shafts by the method of sinking timbering in a thixotropic jacket consists of the following technological procedures: excavation of the face with removal of the ground and simultaneous sinking of the timbering; delivery of the thixotropic fluid behind the outside surface of the shaft; assembly of the next tubbing ring of the lining of the mine shaft with simultaneous caulking of the joints.

The following equipment (Fig. 1a) was used in subway construction for performing these operations: a self-propelled crane 1 with a lifting capacity of 15-25 tonf, single-line clamshell grab 2 with a capacity of 0.8 m³, jack system 3 with an oil plant, suspended working platform 4, clay mixer and pump for delivering the thixotropic fluid behind the tubbing ring 5 with the curb part 6. Pneumatic stirrers and caulking hammers were among the small mechanization means used.

In the construction of Shaft No. 734, where the timbering was sunk to a depth of 32 m, a gantry crane, designed by the mechanical plant of the Chief Administration of Tunnel and Subway Construction (Glavtonmetrostroj), with a telpher having a lifting capacity of 5 tonf was used in addition to the self-propelled crane for assembling the tubbings.

Four variants of beam constructions for suspending and supporting the hydraulic jacks were used in constructing shafts on the Moscow and Kiev subways. The most rational was the jack system (Fig. 2) which included three beam packs 1 of H-beams. The beam pack consists of two No. 55 beams bolted to anchor beams sealed in the concrete of the support collar.

The beam packs form an open equilateral triangle permitting the uniform distribution of six jacks about the circumference of the shaft timbering.