SANDY GROUND

In the past decade, the experience of shield tunneling in sand has been generalized, the problems of the interaction between models of shields and sandy soils have been investigated [1], and many design suggestions have been made which were based on the two well-known, fundamentally different methods of retaining the face—forced and natural.

In the first method the face is retained by a mechanical device, e.g., a flat or helical faceplate. A shield with a diameter of 5.7 m with a flat faceplate was installed in 1988 at the face of Aptian sand on the Frunzenskii radius, but it was hardly moved from place, since the power of the drive of the mechanical device was inadequate [2].

In the second method stability of the face is ensured by the friction forces of the earth mounts on the variously designed horizontal platforms in the near-face space of the shield.

A design of platforms in the form of a pointed steel stage is known [3].

Rigid stages do not make it possible to change the magnitude of the friction forces of the mounds along the surface of the stage, which is necessary for increasing the stability of the face, and to facilitate embedding the stages and the entire shield into the ground. Originally such a change was to be achieved by longitudinal and transverse shaking of the entire stage or only its pointed part. It is especially necessary to note the suggestion made in 1946 by engineer V. M. Lenin on vibrating the rings of the extensible stages installed in each compartment of the subway construction shield. Apparently the possibility of dividing the face into decks, in which the formation of rock wastes at the angle of the natural slope is permitted, was taken into account when developing the suggestion [4]. The process of vibration embedding in dry sand of models of a cutting ring and stages of the shield was studied in 1956-1961.
by L. S. Afendikov, who established that the stability of the face is ensured only provided that the rate of embedment coincides with the vibrations \([5]\). In spite of the investigation, specialists cautiously resort to the use of vibration in a sandy face owing to the possibility of disrupting its stability.

In 1960-1961, the Metrogiprotrans, using certain results of the investigations of the Scientific Research Institute of Foundations and Underground Constructions and of the TsNIIS, developed a shield with extensible stages which makes it possible to somewhat change the length and weight of the mound situated on the stage \([6]\). The pointed part of the stages was subjected to transverse vibrations. In 1962 this shield was tested in the construction of a 4.1-m diameter sewer of the Neglinnoi river in Moscow. In 1961, the Scientific Research Institute of Foundations, based on the results of investigations carried out since 1963, made two suggestions which made it possible to widely control the friction forces of the mound along the horizontal platform \([7]\). For this purpose, the angle of inclination of the rotating part of the bulkhead is changed in the shield according to the first suggestion and the type of friction is changed according to the second suggestion. The investigation showed the possibility of reducing by a factor of 1.4-1.7 the force of embedding a shield, made according to the second proposal and adopted in 1961 by the technical council of Metrostroi, in comparison with the shield equipped with rigid platforms.

In spite of the numerous design suggestions for shields with horizontal platforms, the Metrostroi workers used only dam waling when shield tunneling in sand.

The experience of using the shield of Metrogiprotrans with extensible platforms on the sewage conduit of the Neglinnoi river as a whole proved to be unsuccessful. The reason for this was not only in the nonhomogeneity of the face (at the top it was sand, at the bottom compact loam), but in the errors of the scheme of the head part, which include, in particular, the large index of compression (0.42) of the cutting ring and also the arrangement of the platforms within the support ring. These errors led to a marked increase in the force of embedding the shield (more than 1600 t). As a result the builders again came to lose faith in shields with horizontal platforms.

The problems of the stability of an open face of large dimensions and also of the magnitude of the force necessary for embedding the shield into sandy ground remained unresolved.

The experimental studies carried out in 1962 at the Scientific Research Institute of Foundations demonstrated that the stability of an open face in a shield equipped with a very diverse number of the usual rigid platforms, in particular up to 7 platforms, is ensured, and the force of embedding the usual shield with platforms in sand does not exceed the lifting capacity of the jacks of the shield, being in the most unfavorable case 1000-1100 t. In December 1962 these results were reported to the technical council of the construction and assembly administration No. 7 of Metrostroi, which had started work on the construction in homogeneous sand of 5.5-m diameter tunnels between the stations "Kuz’minskaya" and "Ryazanskoe shoose." At the same time, the scheme of the shield with the head part divided into compartments by horizontal platforms was named the best by the technical council. Also proposed was a scheme of a shield with horizontal platforms having a rigid forward pointed part and a rotating part hinged to it; with the horizontal position of the rotating part, the platform becomes the usual rigid platform and with a sloped position it becomes possible to control the face. The technical council, taking into account these qualities of combined platforms, resolved to use them experimentally in the central section of the shield for the right interstation tunnel. The blueprints of the rotating platforms were worked out by members of the Scientific Research Institute of Foundations together with N. A. Semenov of TsNIIPodzemshakhstroi.

Since the accomplishment of this project could be drawn out, the builders, after attaching baffle plate 1 to cutting ring 2, installed in the central compartment A rigid platform 3 and vertical ribs 4 along the axis of the shield (Fig. 1). This did not permit the builders to intervene in the process of embedment or to control this process by mechanical means. Nevertheless, modernization of the shield even in such a form was very fruitful. The dam waling was removed in the central compartment and the work of the tunnelers now amounted mainly to periodic manual levelling of the mound in the compartment. Because the stability of the face in the central compartment was retained, the builders continued to reconstruct the shield, having placed platform 3 and vertical ribs 4 in upper compartment 8 of the shield (Fig. 2). As a result of this, 45% of the area of the face was freed from dam beams, and the consumption of labor for working the face, which had limited the rate of tunneling, was reduced from 41 to 28%. The construction rate on the right tunnel during reconstruction of the shield was 154 meters in March 1963, 175 m in April, 237 m in May \([8, 9]\). In June, 338 running meters were tunneled.