USE OF THE DIAPHRAGM WALL METHOD
IN HYDROTECHNICAL CONSTRUCTION

E. M. Perlei and V. F. Rayuk

Construction of ports and other hydraulic structures by the diaphragm wall method belongs to the group of "dry" construction methods.

It is expedient to use the diaphragm wall method during construction in basins being created at the expense of the nearshore territory or on territories being created by filling a water area, when constructing barrier and unloading structures, as well as supports of crane tracks and technological equipment at structures being reconstructed. Unique mooring and other hydraulic structures have been constructed by this method abroad (England, France, Italy, Romania, etc.).

In our practice the diaphragm wall method began to be used for constructing watertight curtains [1] and then in industrial and civil construction for constructing load-bearing enclosing walls of embedded structures and deep supports of trench foundations when performing the works under confined urban conditions and reconstructing operating enterprises.

In domestic hydrotechnical construction the diaphragm wall method was used for constructing anchored bulkheads and coastal-protection walls, and "Recommendations on the Design of Mooring Structures Constructed by the Diaphragm Wall Method" were developed [3]. On the basis of investigations they give recommendations on the designs of mooring structures, their construction, calculation of unanchored and anchored bulkheads, and gravity and semiburied cellular-type structures for depths at the upper edge face of 20-25 m. The characteristics of construction by the diaphragm wall method are reflected rather completely in the section of the recommendations on constructing structures.

Design and technological data are presented in greater detail in the "Album of Design and Technological Solutions of the Construction of Mooring Structures by the Diaphragm Wall Method" developed by the All-Union Research Institute of Hydraulicking, Sanitary Engineering, and Special Works (VNIIGS).

Let us examine examples of hydrotechnical construction by the diaphragm wall method abroad, which are of interest for domestic construction practice.

The wharf in the Redcar port in England (Fig. 1) consists of a row of cells made of monolithic reinforced concrete, the front and back walls of which are curved. The soils are hydraulic-fill sand, below which, to a depth of 24-30 m, are alluvial deposits, loams, and silts with interlayers of gravel, soft clays, and marl with a thickness of 1-2 m and deeper are strong limestones, into which were embedded the walls. The longitudinal walls have thickness of 0.8 m and the transverse 1 m.

The length of the sections when excavating the trench under bentonite mud was from 3.75 to 6.2 m. The joint between the sections of the longitudinal walls was made by steel pipes with a diameter equal to the width of the trench. In soft ground the trench was excavated by a grab and in rock by a drilling rig. Excavation of the soil of one section took up to 30 h. Before concreting, the trench bottom was cleaned of slurry by a grab and airlift. The trench was concreted by the tremie method, and the sections were joined together in the transverse walls by flat sheet piles. A steel sheet welded to a U-shaped sheet pile was the limiter of the section.

A characteristic design feature of the enclosing wall of the dry dock at Dunkirk (France) is the combination of steel sheet piling and diaphragm wall of monolithic reinforced concrete (Fig. 2). At first the trench was excavated with deepening 1-1.5 m into the aquiclude, which was filled to the top with cement—bentonite mud. Then packets made up of sheet piling, the inner side of which was preliminarily bonded with a waterproof material, were dropped into the unhardened mud. Since submergence of the packets of sheet piling occurred under the effect of their own weight, the continuity of the waterproofing was not disturbed.

This ensured impermeability of the enclosing wall. Such a design and technological procedure, including driving sheet piles, provides its integrity, high accuracy of positioning the wall, and its reliability and long life.

Fig. 1. Mooring wall in Redcar port made of closed sections — curved cells: 1) front wall of cell; 2) grillage; 3 and 4) connecting the joints of the sections of transverse walls of the cells by steel sheet piles; 5) steel reinforcement; 1) sand; II) loam or silt with gravel interlayer; III) soft clay; IV) marl; V) limestone.

Wall stability was provided by two rows of embedded anchors fastened to an anchor wall before excavating the soil from the foundation pit.

In the region of Bristol port (England), a part of the wharves and wall of the lock are made by the diaphragm wall method from monolithic reinforced concrete. At the construction site is fill, alluvial clay, sand, and gravel, and lower, marl. These soils made it possible to dig the trench by a Bashi grab suspended on a flexible suspension from a crane. The T-shaped enclosing walls have a thickness of 0.8 m and depth of 20-30 m, depending on the occurrence of marl. General stability of the wall is provided by installing every 17.5 m buttresses in the form of closed rectangular wells, the rear wall of which was secured by vertical permanent ground anchors, the working part of which was embedded in marl (Fig. 3). Steel pipes were used as limiters of the sections.

The use of a T-section made it possible to increase the allowable bending moment on the enclosing wall and to bring it to 1·10^4 kN·m and more. A competing design of the T-section is the "Passive" type wall, which in plan has a U-shaped profile with a small or large indent (Fig. 4). Each section of the enclosing wall is separated from another by a steel pipe. Such walls successfully passed tests under on-site conditions.

In recent years VNIIGIS and other organizations carried out considerable research and development, the results of which can be used in constructing hydraulic structures by the diaphragm wall method.

Bentonite clay mud, which, having given properties and thixotropy, plugs the soil and forms a thin contact layer on the trench walls, is used in constructing diaphragm walls. This layer, performing also the role of a membrane, creates favorable conditions for providing stability of the trench walls.

At the same time, investigations showed that the clay film is less strong compared with the plugged soil layer and substantially reduces friction on the side surface of the trench foundation. Holding the trench under the mud for a time determined by the plugging threshold [4] increases the shear strength by 1.3 times, and "overholding" of the trench reduces it by 2.6 times. Furthermore, slurry, as a rule, forms on the bottom of the trench, which should be removed before placing the concrete.