

PERMANENT FORMWORK SYSTEM FOR FORMING WALL STRUCTURES IN THE TIDAL ZONE AND UNDER WATER

Technical Field

The invention relates to the field of construction, namely to formworks, and represents a permanent beam-and-node formwork for casting reinforced concrete, including under water and in the tidal zone, to manufacture concrete wall enclosing structures, such as retaining walls, as well as bank-protection hydraulic engineering structures.

Background Art

From the prior art, removable and permanent formworks for forming concrete structures of the “wall” type and for various methods of joining such walls to each other (corner, T-junction, cross junction) are known, which are manufactured from steel, plywood, fiber concrete, foam plastics, glued-pressed wood chips, and the like.

For example, a permanent formwork block is known that includes formwork panels connected to a spatial reinforcing lattice frame made of tubular elements. The lattice nodes are formed as spherical elements connected to the formwork panels. The lattice nodes have sockets with internal threads, and the tubes are provided with tips arranged along their longitudinal axis and having threaded cantilever protrusions for placement in the sockets of the spherical elements (RU 2029840 C1, published 27.02.1995).

Also known is a permanent decorative formwork representing spatially arranged flat elements that delimit at least part of the external contour of an object to be manufactured. Said flat elements are fastened together to form a space therebetween for placement of reinforcement and for filling with a flowable material capable of hardening. Said flat elements are made of thin-sheet steel and represent fragments of the external contour of the manufactured object, some of which are made with the possibility of fastening to the reinforcement to form part of the surface of the manufactured object after hardening of the flowable material (RU 138426 U1, published 20.03.2014).

The indicated types of formwork are poorly suited for casting concrete under water due to significant difficulties associated with their installation and dismantling in water or due to rapid destruction of the formwork material in salt water. In addition, the known formworks are not adapted for casting concrete into wet (flooded) formwork and require preliminary water removal

from the casting mold using cofferdams, caissons, temporary dams, and other costly methods. Furthermore, the known formworks are unsuitable for casting concrete under pressure from bottom to top and for forming complex volumetric structures, such as stepped retaining walls or zigzag structures of the “floor-wall-floor-wall” type.

Most known mass formwork systems for “wall” type products are not intended to be moved in assembled form and require installation from elements strictly at the installation site. Such formwork systems are generally unsuitable for assembly on shore followed by installation of an already fully prepared concrete mold into water. Assembly of formwork under water is extremely expensive and hazardous. The overwhelming majority of such formworks cannot be easily removed from a concrete product that has gained strength under water and are abandoned under water, causing significant environmental damage.

Summary

One of the technical problems solved by the proposed invention is the creation of a “wall”-type enclosing structure that is optimal in terms of strength-to-material consumption and strength-to-cost ratios for the underwater portion of bank-protection hydraulic engineering structures, such as moles, quay walls, embankments, dams, wet garages, or transport infrastructure.

To solve the above-stated problem, in contrast to the known permanent formwork systems that use wall panels, the proposed system uses a bundle of horizontally laid pipes fixed in a frame (frames).

The technical result achieved by the claimed system consists in the possibility of constructing wall structures of complex shape for coastal (tidal-zone) and/or underwater structures while ensuring strength and rigidity of the entire structure and stability of the walls in the vertical position.

The above-stated technical result is achieved by a design of a permanent formwork system for forming concrete enclosing wall structures under water and in the tidal zone. The system includes a bundle of horizontally laid pipes held together by elements of a frame. A part of the pipes of the bundle or all pipes of the bundle are connected to a manifold which is a pipe segment having pipe sockets arranged in a row with a fixed pitch and intended for connection of the pipes of the bundle. The frame comprises column-pipes and nodal connecting elements. The nodal connecting elements are made as hollow volumetric bodies with pipe sockets oriented at angles to each other, some of which are plugged while others have the pipes installed therein.

In a particular embodiment of the invention, the frames may be assembled into a structure by connecting them to each other with beam-pipes installed into the pipe sockets of the nodal connecting elements.

In a particular embodiment of the invention, the formwork includes external rods made of metal or composite bars installed in holes of the nodal connecting elements at an angle to the pipes.

In a particular embodiment of the invention, at least one of the pipe sockets of the nodal connecting element is configured to be connected to a concrete pump for partial or complete filling of the formwork with concrete.

In a particular embodiment of the invention, the nodal connecting elements are made of polyethylene or PVC, or polypropylene, or metal, or fiberglass.

In a particular embodiment of the invention, standard water-supply or gas or sewer pipes are used as the pipes.

In a particular embodiment of the invention, the pipes are made of polyethylene or PVC, or polypropylene, or metal, or fiberglass.

In a particular embodiment of the invention, the pipes are fixed in the pipe sockets of the nodal connecting element by welding, or locking connection, or adhesive bonding, or socket connection, or fastening with self-tapping screws, anchors, or rivets.

In a particular embodiment of the invention, at least one pipe of the bundle is made with a window in its wall and passes through the manifold in one continuous length while retaining the ability to be filled with concrete.

In a particular embodiment of the invention, the pipe sockets of the nodal connecting elements are arranged coaxially with the possibility of through placement of frame pipes with or without the window.

In a particular embodiment of the invention, the pipe sockets of the nodal connecting elements are arranged coaxially with the possibility of through placement of the rods.

In a particular embodiment of the invention, the pipes are fixed in the pipe sockets of the manifold by welding, or locking connection, or adhesive bonding, or socket connection, or fastening with self-tapping screws, anchors, or rivets, or the pipes pass through the two coaxial pipe sockets of the manifold.

In a particular embodiment of the invention, one of the pipe sockets of the manifold is configured to be connected to a concrete pump.

In a particular embodiment of the invention, the manifold comprises 1–4 rows of nodes for connection of pipes from bundles.

In a particular embodiment of the invention, a part of the pipe sockets of the manifold are plugged.

In a particular embodiment of the invention, the manifold represents one of the frame columns.

In a particular embodiment of the invention, the manifold is made integrally with the nodal connecting element.

Brief Description of the Drawings

The solution is further explained with reference to the figures and three-dimensional models, which show the following:

Fig. 1 shows a general view of the frame;

Fig. 2 shows a general view of the manifold;

Fig. 3 shows a general view of the nodal connecting element;

Fig. 4 shows a general view of the formwork system;

Fig. 5 shows a terraced embankment system;

Fig. 6 shows a marine garage system;

Fig. 7 shows a nodal connecting element G1 for the wet garage;

Fig. 8 shows a nodal connecting element for the frame;

Figs. 9 and 10 show examples of manifolds for different tasks;

3D Model 1 represents the formwork system;

3D Model 2 represents the frame;

3D Model 3 represents the nodal connecting element;

3D Model 4 represents the manifold;

3D Model 5 represents the terraced embankment system;

3D Model 6 represents the marine garage system;

3D Model 7 represents the nodal connecting element G1 for the marine garage;

3D Model 8 represents the nodal connecting element for the frame;

3D Models 9 and 10 represents the examples of manifolds for different tasks.

Detailed Description

The permanent formwork system for forming concrete enclosing wall structures under water and in the tidal zone comprises a bundle 1 of horizontally laid pipes held together by elements of a frame.

The frame comprises column-pipes 2, nodal connecting elements 3, and beam-pipes 4 when frame structures are used. Placement of frames with a predetermined pitch without fastening them to each other may also be used. The nodal connecting elements are made as hollow volumetric bodies with pipe sockets 8 oriented at angles to each other, some of which are plugged, and the beam-pipes 4 and column-pipes 2 are installed in others. In a particular embodiment, the formwork frame may include external rods 5 made of metal or composite bars installed in holes of the nodal connecting elements at an angle to the column-pipes and the beam-pipes. The column-pipes 2 are used when assembling the frame and represent standard plastic, composite, or metal pipes.

The nodal connecting elements 3 make it possible to form the frame from the beam-pipes and to fix the ends of the aforementioned column-pipes. The beam-pipes and the column-pipes may be connected to the nodal connecting element by means of socket connection, clutch coupling, adhesive bonding, welding, flanged connection, threaded connection, or other connection. The distance between the column-pipes and their mutual arrangement makes it possible to reliably fix a straight or curved bundle of pipes in the above-described frame.

The bundle of pipes is fixed by several separate frames assembled with a certain pitch or by a single frame structure containing several frames connected to each other by tubular beams of the frames, in order to impart greater strength and rigidity to the entire structure and to ensure stability of the wall in the vertical working position.

The nodal connecting elements of the frames have a connector for connection to a concrete pipeline, which is a flange or a grooved coupling or a camlock, for monolithic concreting of the frame.

In different embodiments of the invention, joint concreting of the frames and the bundle of pipes may be carried out, or their separate concreting may be carried out. In the latter case, first the frame structure or individual frames are concreted, which have a relatively small internal concreting volume, and after gaining strength, the bundle of pipes itself is concreted.

The nodal connecting element may have fastenings for several columns forming two, three, or more separate frames, which makes it possible to create corners, T-junctions, or cross junctions in enclosing wall structures. Corners, T-junctions, or cross junctions are formed from bundles of pipes aligned along a common edge or corner.

The pipe sockets of the nodal connecting elements are initially made plugged, wherein for assembly, holes are drilled in the required pipe sockets using a hole saw or milling cutter, which makes it possible to adapt the nodal connecting element to different positions in the frame structure or to different types of bundles of pipes according to the thickness of pipes in the bundle or the bending angle of the bundle when forming a wall enclosing structure of complex shape.

A part of the pipes in the bundle are connected to a manifold 6 which is a pipe segment with pipe sockets 7 for connecting the pipes of the bundle 1, arranged with equal pitch.

The manifold provides formation of a single internal volume of pipes required for simultaneous concreting of the entire bundle and may also plug or join the ends of pipe lengths. In some particular embodiments of the invention, the manifolds may be made integrally with the nodal connecting element.

The predetermined pitch of placement of the pipe sockets of the manifold ensures fastening of either all pipes in the bundle or alternately, for example, every other pipe. In the latter case, one part of pipes is fastened to the manifold on one side and the other part of pipes is fastened to the manifold on the opposite side.

The pipes of the bundle may be connected to the manifold, and the manifold, in turn, to the concrete pipeline by welding, or locking connection, or adhesive bonding, or socket connection, or fastening with self-tapping screws, anchors, or rivets.

The manifold may contain one, two, three, or four rows of pipe sockets for connection of the pipes of the bundle, which makes it possible to assemble corners (elbows), T-junctions, or cross junctions from bundles of pipes. The pipe sockets also make it possible to plug the bundle of pipes and are used in the terminal (end) manifold. Through (coaxial) pipe sockets in the manifold make it possible to extend pipe lengths.

The manifold may replace one of the column-pipes in the frame or be placed outside the frame. Examples of manifolds for different tasks are shown in Figs. 2, 9, and 10, as well as in 3D Models 9 and 10.

Examples of Implementation

Example 1

“Marine wall” structures implemented using fixing concrete frames, manifolds, and bundles of horizontal pipes stacked one above another or vertical HDPE pipes (see Fig. 4, 3D Model 1). The bundles of pipes are tightened with reinforcement and filled with concrete through manifolds, or the pipes are combined into a marine wattle. Thus, the structure comprises nodal connecting elements with frame fastening, manifolds, and standard HDPE pipes forming a bundle, frame columns, and truss beams.

For flexible bundles, pipes with a diameter of 75–90 mm and columns with a diameter of 125 mm are preferably used. For straight (rigid) bundles, pipes with a diameter of 125 mm and columns with a diameter of 160 mm are preferably used.

These wall structures are used mainly for terraced bank protection, construction of moles, breakwaters, and piers made of marine gabions, as well as wet slipways.

The main advantages of the series of wall structures are low weight of the empty formwork, the possibility of assembling relatively large monolithic structures, and “transparency” of the walls for water, which is important for rapid equalization of groundwater levels.

Example 2

Terraced embankment system DUNE U45 designed for strengthening embankments or natural shores with a slope of 45° – 35° , including for use in seawater. The DUNE system is configured to create both horizontal double frames (for vertical driven piles with a diameter of 140 mm) and vertical double frames (for bundles of HDPE pipes with a diameter of 125 mm), as well as orthogonal double frames to form two composite grids at a distance of 400 mm from each other for forming marine gabions. It may be used with a retaining wall step of 100% or 50% in height or with a mixed step, as well as with a frame aspect ratio of 1:1 or 1:2. Separate concreting of the frame and bundles of pipes is possible when using manifolds. It operates with manifolds M12 and M13. Concreting is performed through GL4.5" flanges.

The terraces may be straight (steps), zigzag, or mixed.

The terrace shape makes it possible to reduce the number of fittings and pipes or reduce the volume of moved rubble and pebbles by repeating the natural waterline, to realize an architectural concept or adjust the shape of an artificial dune.

Creation of “gabion” tiers at retaining walls is possible.

Example 3

A particular case of a terraced embankment. A beach pier is created using the described formwork for placement of sun loungers (Fig. 5, 3D Model 5) in the tidal zone, allowing vacationers to be located at different heights in said zone. Arcs made of bundles of pipes retain sand, forming sand steps.

In addition to resort use, such a structure with arched constructions made of bundles of pipes creates a visually attractive wave effect in the form of fish scales during high tide in the coastal zone, which also positively affects the recreational properties of the structure obtained using the described formwork.

Example 4

Marine garage (see Fig. 6, 3D Model 6). The described invention may be used in construction of marine garages (single, double, and collective) located at a distance from the waterline or recessed into a reinforced shore or embankment.

The garage may be recessed, in which case the gates are installed flush with the reinforced shore. The garage may also be semi-recessed, when a part of the garage walls and the gates significantly protrude beyond the reinforced shore. The system comprises nodal connecting elements G1 (see Fig. 7, 3D Model 7), triple T-manifolds M13, and straight manifolds M12 (see Fig. 3, 3D Model 4). The system contains everything necessary for creating the underwater part of the structures and the tidal zone.

The wet garage does not, by default, have a continuous “sealed” floor, as it will be filled to some extent during storms.

The above-water part and garage gates are designed, purchased, and installed separately. Use of vertical columns and braces provided in nodal connecting element G1 is optional.

CLAIMS

1. A permanent formwork system for forming concrete enclosing wall structures under water and in a tidal zone, the permanent formwork system comprising:
 - a frame having a bundle of pipes fixed therein, the frame comprising columns and nodal connecting elements, the nodal connecting elements of the frame being made as hollow volumetric bodies having a set of pipe sockets oriented at angles to each other, the set of pipe sockets comprising a first subset of pipe sockets and a second subset of pipe sockets, the first subset of pipe sockets being plugged, and the second subset of pipe sockets having the columns installed therein; and
 - a manifold made as a pipe segment having pipe sockets arranged with an equal pitch, to which a part or all of pipes from the bundle of pipes are connected;
 - wherein the manifold is made integrally with one of the nodal connecting elements of the frame, or one of the columns is made as the manifold.
2. The permanent formwork system according to claim 1, wherein external rods made of metal or composite bars are installed in holes of the nodal connecting elements at an angle to at least one of: (i) the columns, and (ii) the pipes of the bundle of pipes.
3. The permanent formwork system according to claim 1, wherein the set of pipe sockets of one of the nodal connecting elements comprises at least one pipe socket configured to be connected to a concrete pump for filling the permanent formwork system with concrete.
4. The permanent formwork system according to claim 1, wherein the nodal connecting elements are made of one of polyethylene, PVC, polypropylene, metal, and fiberglass.
5. The permanent formwork system according to claim 1, wherein standard water-supply, gas, or sewer pipes are used as the pipes of the bundle of pipes, the columns, and beam-pipes.
6. The permanent formwork system according to claim 1, wherein the pipes of the bundle of pipes, the columns, and beam-pipes are made of one of polyethylene, PVC, polypropylene, metal, and fiberglass.
7. The permanent formwork system according to claim 1, wherein the columns and beam pipes are fixed in the pipe sockets of each of the nodal connecting elements by one of:
 - welding;

locking connection;
 adhesive bonding;
 socket connection; and
 fastening with self-tapping screws, anchors, or rivets.

8. The permanent formwork system according to claim 1, wherein at least one pipe of the bundle of pipes, at least one of the columns, and/or at least one of beam-pipes has a wall having a window made therein.
9. The permanent formwork system according to claim 2, wherein the pipe sockets of the nodal connecting elements are arranged coaxially to provide through placement of the external rods.
10. The permanent formwork system according to claim 1, wherein the pipes of the bundle of pipes are fixed in the pipe sockets of the manifold by one of:
 - welding;
 - locking connection;
 - adhesive bonding;
 - socket connection; and
 - fastening with self-tapping screws, anchors, or rivets.
11. The permanent formwork system according to claim 1, wherein one of the pipe sockets of the manifold is configured to be connected to a concrete pipeline by one of:
 - welding;
 - locking connection;
 - adhesive bonding;
 - socket connection; and
 - fastening with a clamp or with self-tapping screws, anchors, or rivets.
12. The permanent formwork system according to claim 1, wherein the manifold comprises 1–4 rows of pipe sockets for connection of the pipes of the bundle of pipes.
13. The permanent formwork system according to claim 1, wherein a part of the pipe sockets of the manifold are plugged.