A floating prestressed concrete wharf and a method of manufacturing the same are disclosed. The wharf includes pretensioned strands in critical disposition, may include transverse pretensioned cables in its uppermost slab, has wire reinforcing mesh in the concrete and a core of buoyant material.

7 Claims, 9 Drawing Figures
FLOATING PRESTRESSED CONCRETE WHARF

FIELD OF THE INVENTION

This invention relates to the art of prestressed concrete structures, and more particularly to floating prestressed concrete wharves which comprise cables pretensioned before the concrete is poured into the form for the wharf; and to the methods of making such wharves. After the wharf is removed from the form, the cables tend to hold the concrete in compression, thereby permitting the wharf to withstand both tension and compression loadings, hence increasing its flexibility in service.

DESCRIPTION OF THE PRIOR ART

Prestressed and reinforced concrete wharf structures of the floating and stationary types have been in use for many years. Similarly, the methods for making such structures have received considerable attention. U.S. Pat. No. 2,153,741 to Cobi discloses a process for making prestressed hollow slabs; however, no teaching is found of the unique apparatus of the applicant's invention wherein both longitudinal and transverse pretensioning may be accomplished. U.S. Pat. No. 2,518,091, to Stopkeryc, shows means for interconnecting pontoon assemblies; however, no suggestion is made of the applicant's connecting apparatus which provides either a flexible or rigid joint between wharf sections and a support for an optional protective deck plate over the joint. U.S. Pat. No. Re. 24,837 to Usab shows a reinforced concrete wharf structure made up of hollow, waterproof floats, but no disclosure is made of the applicant's structure having pretensioned cables located critically in the overall structure. U.S. Pat. No. 3,022,759 to McCa1 shows a concrete floating wharf in which a longitudinally prestressed deck slab rests on hollow reinforced concrete floats. Applicant's integral, prestressed structure having both longitudinal and transverse prestressed cables is neither shown nor suggested.

U.S. Pat. No. 3,073,271 to Brill discloses another means for interconnecting float assemblies; but, as discussed above, no provision is made for installation of a protective deck plate over the joint. U.S. Pat. No. 3,091,203 to Usab shows a concrete floating wharf structure having extensive wire mesh reinforcements and an elaborate post-tensioning cable system. No suggestion of the applicant's longitudinal pretensioning system is made. U.S. Pat. No. 3,128,737 to Usab shows a reinforced concrete float having transverse cross-rods for attachment of tie rails, but no mention is made of applicant's unique transverse pretensioned cables or wires which help retain threaded inserts used for attachment of side rails.

U.S. Pat. No. 3,207,829 to Nieber, et al. describes means and a method for pretensioning wires such as might be useful in practicing the inventive method disclosed herein; however, no teaching is found of applicant's method of making a longitudinally and transversely prestressed wharf structure. U.S. Pat. No. 3,276,209 to Mosdell discloses the use of reinforcing rods in a floating wharf structure; but once again, no mention is made of the applicant's structure wherein the float is prestressed as claimed herein. U.S. Pat. No. 3,323,479 to Filak shows a float structure having a buoyant core of lightweight material; however, no prestressed float structure is used.

U.S. Pat. No. 3,448,709 to Hardwick shows a float construction comprising lightweight floats and a reinforced deck slab. No suggestion is found of a unitary, prestressed structure as now disclosed. U.S. Pat. No. 3,580,202 to Thompson shows a wharf structure having reinforcing bars and wire mesh, and further including a lightweight core; but no prestressed structure is mentioned. U.S. Pat. No. 3,616,774 to Thompson shows yet another floating dock structure which does not comprise prestressed concrete in the manner of this invention.

SUMMARY OF THE INVENTION

The apparatus and method of this invention provide concrete floating wharf structure capable of being used in greater overall length per unit than the known prior art devices, while providing a wharf that is resilient and flexible under in-service conditions. The increased wharf length permits the use of fewer units in assembling a wharf, thereby minimizing the number of connections to be made between units and minimizing costs.

These advantages are embodied in the invention by providing a block of lightweight buoyant material such as expanded polystyrene, encased in wire reinforcing mesh, which acts as a temperature and shrinkage reinforcement for the concrete. The enclosed block is placed in a form of similar configuration having pretensioned cables strung along the longitudinal corners thereof or as otherwise disposed. Preferably lightweight concrete is poured around the block in the form so as to encase the block, mesh and cables in an integral float or wharf unit. When the concrete has set, the cables are cut at the form and the form removed, leaving a prestressed wharf unit, compressed under the action of the cables or wires. If desired for greater flexibility, transverse pretensioned cables may be provided within the top surface of the float unit so as to provide prestressing in all directions in the upper portion of the unit, thereby increasing its resiliency and flexibility. Means are provided for joining one float unit to another and for attaching bumper rails along the longitudinal edges of the float units.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a perspective view of a wharf unit according to the invention, partially cut away to reveal the orientation of its components;
FIG. 2 shows an exploded perspective view of the components used to manufacture the invention, exclusive of the concrete;
FIG. 3 shows a partial section through a longitudinal corner of the invention, particularly the lightweight core, the pretensioned longitudinal cable and the threaded inserts for the bumper rails;
FIG. 4 shows a side elevation in section taken along line 4-4 of FIG. 1;
FIG. 5 shows an elevation view of the means for connecting neighboring float units;
FIG. 6 shows a plan view of the means for connecting neighboring float units;
FIG. 7 shows a plan view of the joint between neighboring float units, an optional cover plate being in place;
FIGS. 8 and 9 show alternate configurations for connecting the inventive float units.
DESCRIPTION OF THE PREFERRED EMBODIMENTS

There follows a detailed description of the preferred embodiments of the invention, reference being had to the FIGURES in which like numerals identify like elements of structure.

FIG. 1 shows a perspective view of a floating wharf unit, partially cut away to reveal the interior structure of the unit. Unit 10 comprises one or more cores 12 of lightweight (density less than water) material such as expanded polystyrene, which provide the necessary buoyancy for the unit when it is in place in the water as indicated by phantom water line 14. If desired hollow watertight enclosed volumes of similar configuration may be used as cores. When two or more cores 12 are used, they are spaced so as to provide a membrane 16 of concrete therebetween, which provides lateral stability in the overall structure and prevents one core from transmitting water to the next in the event that leakage into the wharf unit should occur. The cores are preferably surrounded on all sides by a blanket 18 of lightweight concrete, which forms end wall membranes 16 at either end. Embedded in the concrete adjacent to and surrounding each core is a layer 20 of wire screening or mesh which provides reinforcement to strengthen the concrete against normal loading, temperature effects and shrinkage. Whereas lightweight concrete is specified, standard concrete may be applied as the blanket 18.

The cores 12 are preferably but not necessarily bevelled along their longitudinal corners 22 and 24, as shown, and further include a cutaway portion 26 in the longitudinal sides near the ends 28 and 30 of the wharf unit. See also FIG. 2. These bevilled portions provide a longitudinal space 32 within the concrete blanket 18 in which are located pretensioned cables 34, extending the entire length of the wharf unit. The size and number of the cables varies, depending on the length of the wharf unit. Attached to cables 34 along the upper longitudinal edges 36 and 38, are threaded inserts 40 which extend flush to the outer side surfaces of the unit. Bumpers 42 and 44, of wood, rubber or other resilient material, are attached to the unit along edges 36 and 38 using suitable bolt fasteners 46 threaded into inserts 40. See also FIG. 3. The threaded inserts may also be installed flush to the upper surface to provide attachment points for hand rails, and so forth. Where desired to provide additional strength and flexibility in the upper portion of blanket 18, transverse pretensioned wires or cables 48 may be included which may be attached to each threaded insert as shown or may be stretched between the longitudinal pretensioned cables 34. The size of the wires varies depending on the width of the wharf unit.

Affixed to each end of the wharf unit 10 are combined end plates 50 and 52, and connectors 54 and 56. These plates, which may be of galvanized steel, include on one side pairs of hooked anchor bars 58 and 60 which extend into the concrete which fills cutaway portions 26 of the ends of cores 12, thereby securely holding the end plates to the wharf unit. The cut ends 62 of cables 34 extend through apertures in the corners of the end plates. If desired, the end plates 50 and 52 may be secured by attaching pretension means to the ends of cables 34, in which case anchor bars 58 and 60 may be omitted; however, the use of anchor bars is preferred. Attached to the end plates 50 and 52 are vertically disposed pairs of connector lugs 54 and 56 which are used to join individual wharf units in use. The upper and lower edges of end plates 50 and 52 include outwardly projecting flanges 64 and 66. The top surface of the wharf unit 10 may be textured as desired to provide a safe walking surface as shown at 68.

FIG. 2 shows an exploded perspective view of the components used to manufacture the wharf unit 10 in accordance with the method of the invention. A form having inner dimensions of the size desired for the wharf units is assembled from a bottom plate 70, side plates 72 and 74 and end plates 76 and 78. If desired, the side and end plates may be hinged to bottom plate 70 so as to facilitate their set up and removal during manufacture. Any suitable means for securing the form together prior to insertion of the components of the wharf unit may be used, for example, the side and end plates may be prewelded together.

End plates 50 and 52 are inserted into the form with anchor bars 58 and 60 facing into the form. If desired, apertures 80 and 82 may be provided in end plates 76 and 78 to accommodate connectors 54 and 56; or connectors 54 and 56 may be attached to end plates 50 and 52 after the wharf unit has been removed from the form. In any event, end plates 50 and 52 must be secured in the form to prevent movement during pouring of the concrete. The cables 34 are then threaded through end plates 76 and 78 and end plates 50 and 52, usually first at the bottom of the form, and then at the top. As the cables 34 are threaded through the top of the form, threaded fasteners 40 are strung thereon, one for each attachment point desired for bumpers 42 and 44. At this point cores 12 may be inserted into the forms after having been wrapped with layer 20 of wire mesh. Cables 34 remain slack until this time, to facilitate insertion of cores 12. Cables 34 are then pretensioned or stretched using hydraulic or mechanical tensioning means as are well known in the art. Cable chucks 84 or similar gripping means are affixed over the ends of cables 34 prior to tensioning and serve to hold the cables in the stretched position when the tensioning means (not shown) are removed. Threaded inserts 40 are pulled against the form side plates 72 and 74 using bolts 86, which may be identical to fasteners 46.

If it is desired to provide transverse pretensioned cables or wires 48 in the upper portion of blanket 18, these may now be threaded between the threaded inserts 40 and pretensioned using any suitable means. The combined effects of the cables 34 and wire or cables 48 attached to threaded insert 40 is thus to ensure that insert 40 cannot pull out of the wharf unit in service. Also at this time, it may be desirable to install sleeves through which lateral connecting rods 88 are passed. Rods 88 are threaded on each end in the upper and lower portions of the membranes 16, and are located in the spaces between the cores 12, under the cables 48, and in similar locations in the end walls, to provide attachment points for wharf units attached side by side or end to end. See also FIGS. 8 and 9.

After the above preparations have been completed, the preferred lightweight concrete is poured into the form. This concrete is of such consistency that it will flow under the cores 12 and raise them until the lower portion of blanket 18 has flowed into place. To prevent further upward movement of the cores 12 and to main-
tain them in their proper position in the mold, it is sometimes necessary to fix the cores in place by any suitable means, especially if the transverse pretensioned wires or cables 48 are not being used in the particular wharf unit. If the wires 48 are being used, they restrain the cores 12 from excessive upward movement and thereby acquire some added pretensioning. The form is filled carefully to avoid the inclusion of any void spaces in blanket 18, after which the top surface may be finished or textured as desired depending on the intended use. The concrete is then permitted to set, the pretensioning cables are cut outboard of end plates 50 and 52 and the form walls may be removed. The completed wharf unit is then ready for attachment of bumper rails 42 and 44 and other connection fittings prior to being placed in the water.

FIG. 3 shows a partial section through a longitudinal corner of the wharf unit. Concrete blanket 18 provides an essentially uniform coating all around core 12. The upward force applied to transverse cable or wire 48 has deformed it slightly as shown. The relationship of transverse wire 48 and longitudinal cables 34 to the integral eye 90 of threaded insert 40 is clearly shown.

FIG. 4 shows a side elevation in section taken along lines 4–4 of FIG. 1. The spaces between the cores 12 form membranes 16. Lateral connecting sleeve and rod elements 88, if used, extend through the upper portion of membrane 16 approximately on a level with threaded inserts 40, and through the lower portion of membrane 16.

FIG. 5 shows an elevation view of the means for connecting neighboring floats end-to-end. Connector lugs 54 and 56 are joined using long bolt 92, threaded at either end, and fasteners 94. Both the top and bottom pairs of lugs may be so joined, or only one, depending on the amount of flexure desired in the joint. To provide a suitable walkway over the joint between wharf units 10, a cover plate 96, suitably textured for safe walking, may be attached to flanges 64 and 66. FIG. 6 shows a plan view of the connecting means without cover plate 96 and FIG. 7 shows the optional cover plate in place.

FIGS. 8 and 9 suggest alternate means of joining one wharf unit to another. In FIG. 8, lateral connecting rods 88 have been installed through sleeves, not shown, in the membranes 16 of a first wharf unit so as to extend from one side only thereof. See also FIG. 2. Affixed to the extending end of the connecting rods is a connecting plate identical to end plates 50 and 52 except for the anchor bars, having connecting lugs similar to lugs 56 for connection to lugs 54 of a second adjacent wharf unit to form a “T” structure. In FIG. 9, two wharf units similar to the first unit in FIG. 8 are joined side by side in like manner. These modes of joining one wharf unit to another are merely exemplary, and other configurations will occur to one of ordinary skill in the art without departing from the spirit of this invention.

In practice, it has been found feasible to manufacture wharf units up to 24 feet long, 4 feet wide and from 2 to 3 feet in depth. This compares favorably with prior art, non-prestressed units which typically are available in 8 foot lengths. The increased length made possible by this invention reduces the number of connections required for a given installation, simplifies manufacture and reduces expense.

Having described my invention in such detail as to enable one skilled in the art to make and use it, I claim:

1. A floating wharf unit of a rectangular parallelepiped configuration comprising:
   A. at least one core of light weight material
   B. a layer of concrete substantially surrounding the at least one core to define a volume having top, bottom and sidewall surfaces; and
   C. a first plurality of pretensioned strands of resilient material, a first portion of the first plurality being located within the layer of concrete above the bottom surface of the unit and a second portion of the first plurality being located within the layer of concrete below the upper surface of the unit, thereby maintaining the concrete layer in compression.

2. The wharf unit of claim 1 further comprising:
   D. a layer of reinforcing wire mesh located in the concrete layer and substantially surrounding the at least one core.

3. The wharf unit of claim 1 further comprising:
   D. a second plurality of pretensioned strands of resilient material within the layer of concrete below the upper surface of the unit and transverse to the second portion of the first plurality of pretensioned strands, thereby maintaining the portion of the wharf unit below the upper surface in bilateral compression.

4. The wharf unit of claim 3 further comprising:
   D. means attached to the second portion of the first plurality of pretensioned strands below the top wall surface and extending to the side wall surface for attaching a bumper rail;
   E. bumper rails extending along the longitudinal sides of the unit; and
   F. means coacting with the attaching means for securing the bumper rail to the wharf unit.

5. The wharf unit of claim 4 wherein the means for attaching a bumper rail comprises a plurality of threaded inserts each having an eye integral therewith, at least one of the second portion of the first plurality of pretensioned strands being threaded through the eye of each of the plurality of threaded inserts and the second plurality of pretensioned strands of resilient material being stretched between the eyes of the plurality of inserts on opposite sides of the unit.

6. A floating wharf unit comprising:
   A. at least one core of light weight material including longitudinal sides having cutaway portions at either end of the core,
   B. a layer of concrete substantially surrounding the at least one core to define a volume having top, bottom and sidewall surfaces; and
   C. a first plurality of pretensioned strands of resilient material, a first portion of the first plurality being located within the layer of concrete above the bottom surface of the unit and a second portion of the first plurality being located within the layer of concrete below the upper surface of the unit, thereby maintaining the concrete layer in compression,
   D. means for joining one float to another comprising an end plate having on one side a plurality of hook-shaped anchor bars extending into the concrete located in the cutaway portions and on the other side...
a plurality of spaced connector lugs for joining one float to another.
7. The wharf unit of claim 6 wherein there are a plurality of cores of lightweight material separated by membranes of concrete and wherein the means for joining one float to another further comprises hollow sleeves extending through the concrete membranes to the walls of the unit, the sleeves surrounding threaded connecting rods.

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