FLOATING OR SUBMERGED MARINE VESSEL FOR STORAGE, SUPPORT OR TRANSPORT

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ABSTRACT
A marine structure for storage, support or transport operations, said structure comprising a plurality of vertically extending cylindrical walls formed from concrete or the like and intertangentially connected to each other to define a plurality of compartments and being connected to top and bottom hull walls such that the cylindrical walls serve as vertical shear walls strengthening the structure to withstand stresses caused by wave action and the like in both longitudinal and transverse directions.

11 Claims, 8 Drawing Figures
FLOATING OR SUBMERGED MARINE VESSEL FOR STORAGE, SUPPORT OR TRANSPORT

The present invention is generally related to marine vessels and, more particularly, to marine structures which may be fabricated from concrete or similar hardenable material and capable of withstanding stresses caused by wave action and the like. In the past, a variety of concrete type marine vessels have been proposed. However, such constructions, for the most part, have proven unsatisfactory since they did not meet the necessary strength and weight requirements capable of withstanding stresses due to wave action and the like. While a few concrete marine vessels, such as the prestressed types, have proven satisfactory from a structural standpoint, they have been too costly to manufacture and market on a competitive basis with conventional marine vessels.

It is an object of the present invention to provide a novel marine vessel construction which is fabricated from hardenable, moldable materials such as concrete and which is structurally capable of withstanding stresses normally caused by longitudinal wave actions, yet is relatively inexpensive to manufacture.

Another object of the present invention is to provide a unique marine vessel or structure comprising a plurality of intertangentially connected cylindrical walls extending between top and bottom exterior walls to define a plurality of compartments and also provide vertical shear support walls interacting with top and bottom hull slabs thus enhancing the strength of the structure.

It is a further object of the present invention to provide a versatile marine vessel or structure which may be fabricated from concrete or other hardenable, moldable materials by vertical slip form or conventional forming techniques, and which is durable, strong, long-lasting and relatively inexpensive to manufacture.

Still another object of the present invention is to provide a unique marine structure formed from concrete or similar materials and which may be utilized for storage or transportation of liquid or dry cargo, such as a barge or tanker, or as a support vessel for heavy equipment or the landing of aircraft.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout and in which:

FIG. 1 is a perspective view of the marine structure of the present invention with sections removed.

FIG. 2 is a plan sectional view of the structure of the present invention illustrated in FIG. 1.

FIG. 3 is a sectional view taken along section 3—3 of FIG. 2.

FIG. 4 is a sectional view taken along section 4—4 of FIG. 2.

FIG. 5 is a plan sectional view of a second embodiment of the structure of the present invention.

FIG. 6 is a sectional view taken along section 6—6 of FIG. 5.

FIG. 7 is a sectional view taken along section 7—7 of FIG. 6.

FIG. 8 is a partial perspective view illustrating vertical slip form equipment and the method which may be utilized for fabricating the marine structure of the present invention.

Referring now, more particularly, to FIG. 1 of the drawings, a typical marine vessel associated with the construction of the present invention is generally indicated by the numeral 10 and includes a plurality of cargo compartments 12 which are independent of each other and which extend vertically between top and bottom walls 14 and 16, respectively. These compartments may be utilized for the storage or transportation of liquid or dry cargo, such as a barge or tanker, or as a support vessel for heavy equipment or the landing of aircraft.

It should also be noted that the construction of the present invention is not limited to the exact shape and structure illustrated in FIG. 1. In plan, the structure may take the form of a circle, regular or random shape required for the functional purpose. Furthermore, the structures of the present invention may be utilized for both submerged and floating operations. For example, the structure illustrated in FIG. 1 may be used for submerged, underwater storage of petroleum products, the structure being located beneath the water in such a manner that it does not obstruct the passage of sea-going vessels and is less affected by the forces of surface wave action.

It will also be appreciated that the construction associated with the present invention may be utilized to provide floating runway structures where land may not be available or where it is desirable to provide a runway facility remote from an urban area. Larger runway areas may be provided by coupling the floating structures together in alignment with each other to utilize the combined top surface areas for runway purposes.

Referring now, more particularly, to FIG. 2, the structure of the present invention may be seen in more detail. Preferably, the structure is fabricated particularly from concrete which may be prestressed or reinforced by conventional means, not illustrated. A plurality of side walls 22 surround the structure and, preferably, are integral with top and bottom walls 14 and 16 which extend substantially the entire length of the structure. The enclosed area between side walls 22 and top and bottom walls 14 and 16 is provided with a plurality of annular walls 24, preferably, but not necessarily, cylindrical in shape, each of which is tangentially connected at 25 and integral with the cylindrical walls immediately adjacent to it. In addition, the outermost cylindrical walls are tangentially integral at 27 with side walls 22, with support webs 29 providing additional strength. The cylindrical walls together define a continuous honeycomb-like network extending throughout the enclosure which provides a plurality of storage compartments, and also greatly enhances the overall strength of the structure.

Each annular wall serves as a vertical shear wall between top and bottom walls 14 and 16. Furthermore, the interconnection between the adjacent compartments provides a unique structure which is capable of handling large liquid or grain loads which normally exert pressure forces extending outwardly in a radial direction. Since the wall of one compartment is integral with the adjacent compartments, the effect of these radial forces is substantially neutralized. These radial
forces are further neutralized by utilizing the generally diamond-shaped compartments at 30, defined between each group of annular walls, for storage purposes. By filling all compartments within the marine structure, the load capacity is approximately the same or greater than that of conventional barge or tanker of the same size, yet, the strength is greatly increased due to the vertical sheave wall structure.

It will be appreciated that the annular walls serve as baffles which attenuate undesirable liquid flow within the structure. Since each annular wall defines a separate and independent compartment, different liquids or dry loads may be carried in each compartment while still providing the above mentioned neutralizing effect of the radial pressures exerted upon the walls of the adjacent compartments.

Referring now, more particularly, to FIGS. 5-7, a second embodiment of the marine structure of the present invention is illustrated and is generally indicated by the numeral 34 and includes a plurality of side walls 36, similar to those illustrated in FIG. 2. It should be noted, that the second embodiment, as well as the first embodiment, may take several forms, such as rectangles, circles, squares, or the like. Basically the second embodiment utilizes the same concepts as the first, however, a substantial cost savings is realized by interconnecting the annular, or cylindrical, walls indicated at 38 with radial walls 40 which lie along a line between the axes of the adjacent cylinders and which extends between the top and bottom walls 42 and 44, respectively. Thus, the radial load forces exerted outwards upon each cylindrical wall is transmitted to the adjacent cylindrical compartment by way of the radial walls, rather than a direct intertangential connection as utilized with the first embodiment. By utilizing the radial walls of the second embodiment, a significant reduction in the volume of concrete per unit of volume of storage space may be realized. This is readily apparent from the volume equation for each embodiment. For example, the volume of concrete for a single cylindrical wall of the first embodiment may be expressed as follows:

\[ V_1 = \pi h \left( R_1^2 - R_2^2 \right) = 2\pi R_1 h. \]

Where \( R_0 \) = mean radius, \( h \) = height, and \( t \) = wall thickness.

The volume of concrete required to produce substantially the same storage area with the structure of the second embodiment may be expressed as follows:

\[ V_2 = \pi h \left( r_1^2 - r_2^2 \right) + 2 l h t = 2\pi r_m h + 2 l h t. \]

Where \( r_0 \) = mean radius, \( t \) = wall thickness, \( h \) = height of the cylinder, and \( l \) = radial wall length.

Since the cylinder wall volume increases by a factor of \( \pi \) as the radius increases, it is apparent that the total wall volume is less when the radial walls are utilized and a significant cost savings may be realized.

It will be appreciated that the vertical shear walls of both the first and second embodiments resist shear in the longitudinal and transverse directions. The top and bottom hull walls, in turn, act as flanges which resist bending moment in both the longitudinal and transverse directions.

Referring to FIG. 8, the preferred method of fabrication is illustrated. It has been found that the structure of the present invention may be most economically produced by the method of vertical slip forming a concrete structure. This is done by providing vertically movable forms including an outer form 26 to shape exterior walls 22 and a plurality of cylindrical forms 28 which are jacked or otherwise moved upwardly in unison as the lower layers of concrete reach a hardened condition. The forms are continuously filled with concrete supplied by way of a crane assembly 32.

Several techniques and methods of vertical slip forming and the drying procedures related thereto are well known and, of themselves, do not form a part of the present invention. It should be noted that, if desired, the structure of the present invention may be fabricated by the use of more conventional techniques and materials such as structural steel. It will be appreciated, however, that due to the unique shear wall construction associated with the present invention, the structure may be economically fabricated by vertical slip techniques, while conventional marine structures of comparable strength had to be fabricated from steel or similar materials requiring high material and labor costs. Minor changes in the relative positions or number of vertical shear walls or the hull configuration are deemed to fall within the scope of the present invention.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

What is claimed as new is as follows:

1. A marine vessel for storage, support or transportation operation, said vessel comprising a hull including a plurality of rigid exterior side walls and rigid top and bottom walls connected to said side walls and extending therebetween to define a vessel enclosure together with said side walls, a plurality of rigid annular walls connected to and extending axially upward from said bottom wall, each of said annular walls being connected to the immediately adjacent annular walls to provide a continuous interconnected support structure between said side walls, said annular walls defining a plurality of compartments separate from each other, said interconnected annular walls, said side walls, and said top and bottom walls being fabricated particularly of concrete to provide a rigid vessel structure, said annular walls being connected to each other by intermediate walls extending between said top and bottom walls, said intermediate walls and annular walls serving as vertical sheave walls between said top and bottom walls.

2. The structure set forth in claim 1 wherein the outermost ones of said connected annular walls are connected directly to the immediate adjacent side walls.

3. The structure set forth in claim 1 wherein said side walls, annular walls, and bottom walls are integral with each other.

4. A marine structure for storage, support or transportation operations, said structure comprising a hull including a plurality of continuous rigid exterior side-walls and a continuous rigid bottom wall connected to and extending between the lower portions of said side walls to define a structure enclosure, a plurality of rigid cylindrical walls connected to and extending axially upward from said bottom wall to define a plurality of
compartments separate from each other, and a continuous rigid top wall connected to the tops of said cylindrical walls, said rigid cylindrical walls, side walls, top and bottom walls being integral cementitious construction with the cylindrical walls being rigidly connected with each other and the top, bottom and side walls.

5. A marine structure for storage, support or transportation operations, said structure comprising a hull including a plurality of rigid exterior side walls and a rigid bottom wall connected to and extending between the lower portions of said side walls to define a structure enclosure, a plurality of rigid annular walls connected to and extending axially upward from said bottom wall to define a plurality of compartments separate from each other, and a rigid top wall connected to the tops of said annular walls, said annular walls serving as vertical shear walls between said top and bottom walls to define a rigid structure capable of resisting longitudinal wave actions in shear and bending moments, each of said rigid annular walls is connected to the immediately adjacent annular walls to provide a honeycomb-like network defining a plurality of compartments within said marine structure enclosure, said annular walls being connected together by substantially radial walls extending between said top and bottom walls.

6. The structure set forth in claim 5 wherein said radial walls are integral with said annular walls.

7. The structure set forth in claim 6 wherein outer ones of said rigid annular walls are connected to the immediate adjacent side walls.

8. The structure set forth in claim 7 wherein said rigid top wall is connected to upper portions of said rigid side walls.

9. The structure set forth in claim 8 wherein said top wall, bottom wall, annular walls and side walls are fabricated of hardenable, moldable material and are integral with each other to provide a rigid marine structure.

10. The structure set forth in claim 9 wherein said hardenable, moldable wall material includes cementitious material.

11. The structure set in claim 10 wherein said hardenable, moldable wall material is particularly high strength concrete.