

[DESCRIPTION]

[Invention Title]

LIGHTWEIGHT STRUCTURAL MEMBER BASED ON COMPOSITE MATERIAL, AND CONTAINER SHIP CELL GUIDE STRUCTURE COMPRISING SAME

[Technical Field]

[0001] The present disclosure relates to a composite material-based lightweight structural member and a cell guide structure of a container ship including the same, and more specifically, to a composite material-based lightweight structural member and a cell guide structure of a container ship including the same, in which metal and polymer are used as main materials and a plate reinforcement for structural reinforcement is integrally formed therewith, so that the problem of thermal deformation due to welding does not occur, the weight is significantly reduced compared to the existing structure while implementing equivalent structural performance, and a longitudinal strength member can also be integrally manufactured together.

[Background Art]

[0002] In general, a steel plate structural member made of a single metal material is mainly used as a structural member of a ship. The structure of a conventional steel plate structural member is illustrated in FIG. 1 and FIG. 2.

[0003] Referring to FIG. 1, the conventional steel plate structural member is manufactured in a form in which a plate reinforcement 20 made of metal is welded to a lower surface of an upper plate 10 made of metal to reinforce the structure.

[0004] In addition, referring to FIG. 2, the conventional steel plate structural member may also be manufactured in a form in which an upper plate 10 and a lower plate 30 made of metal are disposed to face each other with a predetermined interval therebetween, and

a plate reinforcement 20 made of metal is connected therebetween through welding to reinforce the structure. The structure illustrated in FIG. 2 is referred to as a box type structure in that a hexahedral-shaped empty space is formed therein.

[0005] The conventional steel plate structural member as described above is manufactured by first joining metal plates serving as the upper plate 10 and then welding plate reinforcements 20 for longitudinal strength reinforcement thereon at frame intervals of 500 to 900 mm (in the case of FIG. 1), or by joining metal plates serving as the upper plate 10 and the lower plate 30 and then welding plate reinforcements 20 for longitudinal strength reinforcement therebetween at frame intervals of 500 to 900 mm (in the case of FIG. 2).

[0006] However, the method of welding and coupling the plate reinforcements 20 at close intervals as in the related art has the following problems.

[0007] (1) Problem of Thermal Deformation Due to Welding

[0008] The most fatal problem is thermal deformation caused by welding. When welding the plate reinforcement 20, the welding area is heated to approximately 1,000 to 1,500°C, and considerable stress and deformation occur during the cooling process of the heated steel plate. As a result, after welding the plate reinforcement 20, bending is inevitably formed throughout the plate with a deviation of several tens of millimeters (mm) per meter (m), and therefore, a huge amount of time and cost occur in the subsequent correction work.

[0009] In particular, in the case of a structural member used for a car deck of a pure car carrier (PCC) or a wall of a ship accommodation, a thin plate having an upper plate thickness of approximately 6 to 10 mm is required, and in cases where the structure is formed with such a thin thickness, problems due to welding deformation, such as the upper plate itself being torn by welding deformation or being severely warped to the

extent that it cannot be corrected at all by the subsequent correction process, occur to a much greater extent.

[0010] Currently, in order to prevent the above problems from occurring, an upper plate that is much thicker than the structurally required thickness is simply used, or a huge amount of time and cost is spent to correct the thermal deformation in a subsequent process. Therefore, a more fundamental solution is needed.

[0011] Meanwhile, laser welding is a welding method known to have much less thermal deformation than arc welding or gas welding, which are commonly used in the shipbuilding field. The laser welding is a method of performing joining by concentrating light energy emitted from a laser source on a workpiece to melt a parent material. However, the laser welding has a limitation in generating sufficient power to melt the parent material, and has a disadvantage in that the welding speed and the weldable thickness are affected by the thermal conductivity of the metal and the vaporization of the metal at the surface, and thus, the welding efficiency is greatly reduced when applied to a thick parent material.

[0012] It is generally known that laser welding is possible even at a thickness of 6 mm or more, but in reality, the speed of laser welding decreases significantly when the thickness is only 4 mm or more, and thus, laser welding is generally applied mainly when the thickness of the parent material is 3 mm or less. Accordingly, it is not easy to apply laser welding to a 6 mm steel plate, which is generally known as the thinnest structure in shipbuilding. In addition, a considerable amount of energy is required to melt a 6 mm thick steel plate, and even in this case, since the welding area, which is formed quite widely, cools down and the same welding deformation occurs, there is no great merit.

[0013] (2) Difficulty in Manufacturing Box Type Structure

[0014] The box-type plate reinforcing structure illustrated in FIG. 2 is a structure in

which vertical reinforcement members are connected to each other between two main plates, and since the load is evenly distributed by the two wide main plates, it is a very effective structure capable of withstanding the same load with a weight that is 10 to 30% less than that of a general plate reinforcing structure. In addition, since the plate reinforcement is not exposed to the outside and is finished with a flat main plate, it is a structure capable of greatly increasing the ratio of automatic welding when welding longitudinal strength members, transverse strength members, and the like, which are attached thereafter.

[0015] However, despite having several advantages, this box-type structure is not well applied except for special structures due to its difficult manufacturability.

[0016] For example, when a general plate reinforcing structure (FIG. 1) having an interval of approximately 600 to 900 mm and a height of 100 to 400 mm is changed to a box-type plate reinforcing structure (FIG. 2), the plate reinforcement 20 can be manufactured to have a lower height due to structural optimality.

[0017] In this case, as illustrated in FIG. 3, a primary main plate, to which the plate reinforcement 20 is coupled first among the upper plate 10 and the lower plate 20, may be welded in the same manner as in a general plate reinforcing structure, but in the case of a secondary main plate that is coupled later, it is very difficult to perform welding work because it is difficult to secure a working space.

[0018] That is, it is almost impossible for a person or an automated machine to be put into a space having a height of only 100 to 400 mm to perform welding in a general manner along the length of a long main plate. Accordingly, inconvenience occurs, such as a very special welding machine being put into use, or the secondary main plate having to be finely divided at intervals where the plate reinforcements 20 are located and welded to the plate reinforcements 20, respectively.

[0019] When the secondary main plate is finely divided and welded to the plate reinforcements 20, respectively, fillet welding is not possible, and thus the working time becomes very long. In addition, as the working time becomes longer, a large amount of welding heat is input, which has the disadvantage that the problem of welding thermal deformation described above may occur more severely. In order to straighten the deformed plate again, an additional straightening operation may be required.

[0020] (3) Weight Problem

[0021] Another disadvantage of conventional steel plate structural members is that they are excessively heavy. Of course, the steel plate structural members mainly used in ships are much lighter than reinforced concrete for construction, but in terms of the growing importance of eco-friendly ships, cost reduction, and labor cost reduction, "weight reduction of a ship" is one of the biggest topics in the shipbuilding and shipping industries worldwide. When the weight of a ship is reduced, the energy required for ship propulsion is reduced, so that carbon emissions can also be reduced.

[0022] In addition, the weight reduction of a ship is also very important in terms of securing the stability of the ship. For example, a pure car carrier (PCC) having a plurality of decks has a problem in that the stability of the ship is greatly impaired as the center of gravity of the ship moves upward due to the weight of the deck itself, and therefore, it can be said that it is a structure that requires achieving weight reduction of the ship by reducing the weight of the deck as the most important matter.

[0023] (4) Problem of Low Usability as Building Structural Member

[0024] Although the conventional steel plate structural members described above can implement equivalent structural performance with a much lighter weight and a thinner thickness than reinforced concrete, they are not widely used in the construction field. The biggest reason is the noise transmission characteristics of the steel plate and the flatness

problem caused by welding thermal deformation. Since the steel plate structural member is constituted by a single high-density metal as a whole, it has superior noise transmission capability compared to any other structural member made of other materials when subjected to an impact, and therefore is rarely used as a building material (particularly, a building flooring material where prevention of inter-floor noise is important). In addition, the steel plate structural member is disadvantageous in terms of the flatness of the structure due to the thermal deformation problem occurring during welding of the plate reinforcement.

[0025] In addition, the steel plate structural member is not suitable as a building material where insulation is important because its thermal conductivity is excessively high. The thermal conductivity of reinforced concrete is 1.6 to 2.0 W/mK, whereas that of steel plate is very high at 83 W/mK. Having a high thermal conductivity means that external heat is transferred to the inside very quickly and easily, making it very vulnerable in terms of insulation.

[Disclosure]

[Technical Problem]

[0026] An object of the present disclosure is to provide a high-performance/multi-functional composite material-based lightweight structural member which can overcome the technical limitations described above and thus be effectively applied to a thin plate structure of a ship, and can also be universally applied to other fields such as building structural members and a wall member of a pressure vessel.

[0027] More specifically, the present disclosure aims to dramatically improve the existing problem of thermal deformation due to welding by dramatically reducing the amount of arc welding or gas welding, which causes a lot of thermal deformation when assembling the plate reinforcement in the conventional steel plate structural member, or

by making it possible to replace the welding process with a bending process.

[0028] In addition, a technical problem of the present disclosure is to provide a composite material-based lightweight structural member capable of achieving dramatic weight reduction compared to representative structural members for heavy industries, such as conventional steel plate structural members or reinforced concrete structural members, and easily applicable not only to ship structural members but also to other fields including construction.

[0029] In addition, the present disclosure aims to provide a composite material-based lightweight structural member, which can implement equivalent structural performance without significantly increasing the thickness as compared to a general steel plate structural member made of a single metal material, can be easily utilized as various ship structural members because the shape and assembly method are also implemented similarly, and can be preferably used to construct curved structures such as a deck or vertical wall structure of a ship, a wind deflector of a container ship, and a pressure vessel.

[0030] In addition, an important technical problem of the present disclosure is to overcome the disadvantage that it is very difficult to manufacture a general steel plate structural member made of a single metal material into a box-type structure. The present disclosure aims to provide a composite material-based lightweight structural member, which can be easily manufactured into a box-type structure to easily implement the advantages of the corresponding structure, and can secure sufficient load-bearing capacity even with a light weight as compared to a general steel plate structural member, so that it can be preferably used for a wall member of a pressure vessel requiring an explosion-proof design.

[0031] Furthermore, the present disclosure aims to provide a composite material-based lightweight structural member which can be manufactured by integrating even the

function of a longitudinal strength member installed long along a longitudinal direction of the structural member. Here, the longitudinal strength refers to a strength that resists a longitudinal load that attempts to deform a hull in the longitudinal direction, and the longitudinal strength member refers to a member, among members constituting a ship, that contributes to the longitudinal strength.

[0032] The technical problems of the present disclosure are not limited to the technical problems mentioned above, and other technical problems not mentioned will be clearly understood by those skilled in the art from the description below.

[Technical Solution]

[0033] According to one aspect of the present disclosure for achieving the above object, there may be provided a composite material-based lightweight structural member, including: a first main plate; a second main plate disposed at a predetermined interval from the first main plate; a plurality of reinforcement plates disposed between the first main plate and the second main plate and having one or more bent portions; and a core layer formed in a space between the first main plate and the reinforcement plate, a space between the second main plate and the reinforcement plate, and a space between the adjacent reinforcement plates, wherein a plurality of column portions formed by the adjacent bent portions and the core layer formed therebetween are formed at a predetermined interval to function as a plate reinforcement.

[0034] The first main plate, the second main plate, and the reinforcement plate may be made of a metal or fiber-reinforced plastic material, and the core layer may be made of a non-metallic material.

[0035] The core layer may be formed by injecting a non-foaming polymer raw liquid in a liquid state and curing the same.

[0036] The composite material-based lightweight structural member according to one

aspect of the present disclosure may have a plate reinforcing structure formed including a vertical reinforcing portion formed of the column portion, and a horizontal reinforcing portion formed of the second plate, the reinforcement plate, and the core layer formed therebetween.

[0037] At least some of the plurality of reinforcement plates may be provided in a tubular shape in which an empty space is formed therein.

[0038] The reinforcement plate may have a polygonal or circular cross-sectional shape.

[0039] The composite material-based lightweight structural member according to one aspect of the present disclosure may have a multiple shielding structure formed of a composite material of metal and non-metal by the first main plate, the second main plate, the reinforcement plate, and the core layer.

[0040] The plurality of reinforcement plates may be disposed in at least two or more rows or at least two or more layers between the first main plate and the second main plate.

[0041] An insulating material or a fireproof material may be inserted and disposed in an inner space of the reinforcement plate.

[0042] At least one of an insulating material, a fireproof material, a pipe, and a metal reinforcing material may be inserted and disposed inside the core layer.

[0043] The composite material-based lightweight structural member according to one aspect of the present disclosure may further include a finishing member that finishes at least one of an edge portion between the first main plate and the reinforcement plate and an edge portion between the second main plate and the reinforcement plate.

[0044] The first main plate may be provided as a curved plate having a curvature.

[0045] The second main plate may be provided as a curved plate having a curvature.

[0046] End portions of the first main plate and the second main plate may be coupled to each other to have a streamlined shape that generates lift.

[0047] According to another aspect of the present disclosure for achieving the above object, there may be provided a cell guide structure of a container ship including a composite material-based lightweight structural member, including: a metallic first main plate; a metallic second main plate disposed at a predetermined interval from the first main plate; and a non-metallic core layer formed between the first main plate and the second main plate, wherein the core layer includes an extension portion that is formed thicker than other portions and protrudes toward one side, and the second main plate includes at least two or more bent portions so as to surround the extension portion.

[Advantageous Effects]

[0048] The composite material-based lightweight structural member according to the present disclosure can be effectively applied to a thin plate structure of a ship, and can also be universally applied to other fields such as building structural members and a wall member of a pressure vessel, and specifically has the following effects.

[0049] (1) In the welding and joining process of the plate reinforcement required in the conventional steel plate structural member, it is possible to dramatically reduce the amount of arc welding or gas welding, which causes a lot of thermal deformation, or to replace the welding process with a bending process, thereby dramatically improving the problem of thermal deformation due to conventional welding.

[0050] (2) The composite material-based lightweight structural member according to the present disclosure is very light in weight compared to representative structural members for heavy industries, such as conventional steel plate structural members or reinforced concrete structural members, and thus it is possible to achieve structural lightweighting. Accordingly, when used as a structural member for a ship or a building, it has the effect of lowering the overall weight of the structure.

[0051] (3) The composite material-based lightweight structural member according to the

present disclosure can be manufactured with a thickness similar to that of a general steel plate structural member made of a single metal material while being based on a composite material, and since the shape and assembly method can also be implemented similarly, it can be easily used as a ship structural member. In particular, the composite material-based lightweight structural member according to the present disclosure is expected to have excellent usability when used in manufacturing a deck of a pure car carrier (PCC) where weight reduction of a ship is required most importantly.

[0052] (4) The composite material-based lightweight structural member according to the present disclosure has a great competitive advantage in that it can be easily manufactured into a box-type structure in particular. The lightweight structural member according to the present disclosure is manufactured not by a method of welding a plate reinforcement to a main plate, but by a method of disposing box-structured reinforcement plates at predetermined intervals between the facing main plates (upper plate and lower plate) and filling a polymer in an inner space, and thus, it is possible to fundamentally solve the conventional manufacturability problem.

[0053] (5) Since the structural strength of the composite material-based lightweight structural member according to the present disclosure increases in proportion to the 2nd to 3rd power of the thickness increase due to the characteristics of the composite material, it is possible to implement superior structural performance compared to a general steel plate structural member of similar thickness while being lightweight.

[0054] Accordingly, the lightweight structural member according to the present disclosure can be preferably used to manufacture a structure such as an accommodation installed on a ship or a wind deflector installed at a bow portion of a container ship to block wind and waves, and is also expected to be usefully applied as a structural member constituting an explosion-proof container or a high-pressure pressure vessel that must

withstand a strong impact load.

[0055] (6) Since the composite material-based lightweight structural member according to the present disclosure is manufactured with a composite material of metal and polymer, it can basically have insulation performance in addition to noise and vibration reduction performance, and thus has the advantage of being usable not only in the shipbuilding field but also as a construction structural member.

[0056] (7) In particular, the composite material-based lightweight structural member according to the present disclosure can implement remarkably superior insulation performance. Since the thermal conductivity of the polymer constituting the inner core of the lightweight structural member according to the present disclosure is formed at a level of 0.2 to 0.4 W/mK, it is advantageous in terms of insulation by several tens of times as compared to a general steel plate structural member having a thermal conductivity of approximately 83 W/mK.

[0057] In addition, in the lightweight structural member according to the present disclosure, the web portion (vertical column portion) of the plate reinforcement, which is the most vulnerable in terms of thermal bridge, is filled with a polymer, and the reinforcement plate, which has a rectangular cross-section to form a plate reinforcing structure and is disposed inside the structural member, is separated from the upper/lower plates that are the main plates, so that the metal material penetrating the entire structure can be removed, thereby enabling the implementation of a box-type structure that is remarkably superior in terms of insulation.

[0058] (8) The composite material-based lightweight structural member according to the present disclosure basically implements weight reduction by using a method of replacing the inside of a thick steel plate of a general steel plate structure with a light polymer material. Accordingly, the amount of steel plate used can be reduced by 40 to 50% or

more compared to a general steel plate structure, and thus it has a very great competitive advantage in terms of cost reduction as well. Although the unit cost per ton of the polymer may be more expensive than that of a general steel structure, since the specific gravity of the polymer is light, at a level of 1/7 to 1/10 of that of a steel plate, the material cost of the polymer used in the lightweight structural member according to the present disclosure can be lower than the unit cost of the steel structure that the polymer replaces.

[0059] In addition, since the composite material-based lightweight structural member according to the present disclosure implements the performance of the entire structural member through adjustment of the thickness of the upper plate and the reinforcement plate made of a metal material and the core layer made of a non-metallic material, the type and thickness of the metal plate can be relatively freely selected and applied, so that the design flexibility is very excellent, and it has a great advantage in terms of supply and operation of materials.

[0060] (9) In addition, since the composite material-based lightweight structural member according to the present disclosure uses a relatively thin metal plate compared to a general steel plate structure, there is an advantage in that curved processing is possible even with equipment of relatively low output when performing curved surface bending processing.

[0061] (10) The composite material-based lightweight structural member according to one embodiment of the present disclosure can simply but effectively have the function of a longitudinal strength member by lengthening or extending a length of a part of the configuration.

[0062] (11) Furthermore, the weight reduction method of the structure according to the present disclosure is also very effective in terms of reducing carbon emissions that cause global warming. Embodied CO₂, which refers to the carbon emissions accompanying the structural manufacturing process, can be generally expressed as CO₂ emissions per ton

of each material. In the case of typical concrete, approximately 1 ton of CO₂ similar thereto is emitted when manufacturing 1 ton, and in the case of a steel plate, approximately 2.3 tons of CO₂ may be emitted when manufacturing 1 ton. When the weight reduction method of the present disclosure is applied, it is possible to suppress CO₂ generation by approximately 30 to 50% compared to a general steel structure and approximately 40 to 60% compared to general reinforced concrete.

[0063] The effects of the present disclosure are not limited to the effects mentioned above, and other effects not mentioned will be clearly understood by those skilled in the art from the description below.

[Description of Drawings]

[0064] FIG. 1 is a view illustrating a conventional steel plate structural member for ships.

[0065] FIG. 2 is a view illustrating another example of a conventional steel plate structural member for ships.

[0066] FIG. 3 is a view for explaining the reason why it is difficult to manufacture a conventional steel plate structural member into a box type.

[0067] FIGS. 4 to 16 are views illustrating first to thirteenth embodiments of the lightweight structural member according to the present disclosure.

[0068] FIG. 17 is a view illustrating a stress dispersion structure formed at a connection portion between a flat plate part and a vertical column portion of the lightweight structural member according to the present disclosure.

[0069] FIG. 18 is a view illustrating a structure in which the insulation performance of the lightweight structural member according to the present disclosure is reinforced.

[0070] FIG. 19 is a view illustrating a structure in which the lightweight structural member according to the present disclosure is reinforced with a metal material.

[0071] FIG. 20 is a view for explaining a structure in which the reinforcement plate of

the lightweight structural member according to the present disclosure is additionally divided.

[0072] FIGS. 21 to 23 are views illustrating first to third side end finishing and connection structures of the lightweight structural member according to the present disclosure.

[0073] FIG. 24 is a view for explaining a manufacturing method of the lightweight structural member according to the present disclosure.

[0074] FIG. 25 is a view for explaining an additional method that may be applied when manufacturing the lightweight structural member according to the present disclosure.

[0075] FIGS. 26 to 29 are views illustrating constituent materials required for manufacturing the lightweight structural member according to the present disclosure.

[0076] FIGS. 30 to 37 are views illustrating a specific manufacturing method of the lightweight structural member according to the present disclosure according to a sequential process.

[0077] FIG. 38 is a view illustrating a transverse connection structure of the lightweight structural member according to the present disclosure.

[0078] FIG. 39 is a view illustrating a longitudinal connection structure of the lightweight structural member according to the present disclosure.

[0079] FIG. 40 is an enlarged view illustrating a portion indicated by 'D' in FIG. 39.

[0080] FIG. 41 is a view illustrating a connection portion with a hull when the lightweight structural member according to the present disclosure is utilized as a cofferdam structure of a ship.

[0081] FIG. 42 is a view illustrating a lower end structure of the lightweight structural member according to the present disclosure for being utilized as a cofferdam structure.

[0082] FIG. 43 is a view for explaining a manufacturing problem of a rudder of a

conventional ship.

[0083] FIG. 44 is a view illustrating an exemplary embodiment in which the lightweight structural member according to the present disclosure is utilized as a rudder structure of a ship.

[0084] FIG. 45 is a view illustrating a cross-section taken along line A-B of the rudder structure illustrated in FIG. 44.

[Best Mode]

[0085] The purpose and technical configuration of the present disclosure and the detailed operation and effect thereof will be more clearly understood by the detailed description based on the drawings attached to the specification of the present disclosure.

[0086] The terminology used herein is only used to describe specific exemplary embodiments and is not intended to limit the present disclosure. For example, terms such as "consisting of" or "including" used herein should not be construed as necessarily including all of the various components or various steps described in the disclosure, but should be construed as not including some of the components or some of the steps, or may further include additional components or steps. In addition, the singular expressions used herein include plural expressions unless the context clearly indicates otherwise.

[0087] Hereinafter, the present disclosure will be described in detail by describing preferred exemplary embodiments of the present disclosure with reference to the attached drawings. The exemplary embodiments described below are provided so that those skilled in the art can easily understand the technical idea of the present disclosure, and should not be construed as limiting the present disclosure thereby, and it is obvious that the exemplary embodiments of the present disclosure can have various applications to those skilled in the art.

[0088] I. Structural Features of Lightweight Structural Member According to the Present

Disclosure

[0089] The lightweight structural member 100 according to the present disclosure is basically constituted by a composite material of metal and non-metal, including a metallic upper plate 110, a reinforcement plate 120, a lower plate 130, and a non-metallic core layer 140, and is characterized in that a column portion formed by a downwardly bent portion of the reinforcement plate 120 and the core layer 140 formed along a downward direction between the reinforcement plates 120 functions as a plate reinforcement.

[0090] The lightweight structural member 100 according to the present disclosure may have various exemplary embodiments depending on a shape in which the reinforcement plate 120 is disposed therein or whether reinforcement is provided, and hereinafter, with reference to FIGS. 4 to 14, possible preferred embodiments of the lightweight structural member 100 according to the present disclosure will be described.

[0091] (1) First Embodiment (Basic Structure)

[0092] Referring to FIGS. 4A and 4B, a first embodiment of the lightweight structural member 100 according to the present disclosure may be configured to include: a metallic upper plate 110; a metallic lower plate 130 disposed parallel to the upper plate 110 at a position spaced apart from the upper plate 110 at a predetermined interval below the upper plate 110; a plurality of reinforcement plates 120 disposed between the upper plate 110 and the lower plate 130; and a non-metallic core layer 140 formed in a space between the upper plate 110 and the reinforcement plate 120, a space between the lower plate 130 and the reinforcement plate 120, and a space between the adjacent reinforcement plates 120, such that the core layer 140 between the adjacent reinforcement plates 120 and the structure of the lower plate 130 are interlocked to implement the functions of a web and a flange of a plate reinforcing structure (a portion indicated by a circle).

[0093] That is, in the lightweight structural member 100 according to the present

disclosure, a plate reinforcing structure including a vertical reinforcing portion and a horizontal reinforcing portion may be formed. Here, the vertical reinforcing portion may include the adjacent reinforcement plates 120 and the core layer 140 formed in the space therebetween, and the horizontal reinforcing portion may include the lower plate 130 and the core layer 140 formed in the space between the lower plate 130 and the reinforcement plate 120. The plate reinforcing structure may be located inside the space between the upper plate 110 and the lower plate 130.

[0094] The upper plate 110 and the lower plate 130 may have a predetermined thickness and may be flat plates, or may be curved plates having a curvature. For example, the upper plate 110 may be a square plate.

[0095] The lower plate 130 may be shaped to correspond to the upper plate 110. The lower plate 130 may be disposed such that an end of the lower plate 130 and an end of the upper plate 110 are vertically aligned (that is, overlapped when viewed from above).

[0096] The reinforcement plate 120 may be spaced apart from the upper plate 110 at a predetermined interval so that a space can be formed therebetween, and may likewise be spaced apart from the lower plate 130.

[0097] The reinforcement plate 120 may be manufactured separately into a plurality of components, and may include a structure bent downward from the upper plate 110 so as to perform the function of a plate reinforcement. Specifically, in FIG. 4A, the reinforcement plate 120 may include a first reinforcement plate 120c having a "U"-shaped cross-section and a tubular second reinforcement plate 120d in which a space is formed therein. Although the second reinforcement plate 120d is illustrated in the attached drawing as having a rectangular cross-section, the second reinforcement plate 120d may also be provided in a tubular shape having a polygonal or circular cross-section.

[0098] The first reinforcement plates 120c may be disposed at both ends along a width

direction of the lightweight structural member 100, and at least one second reinforcement plate 120d may be repeatedly disposed therebetween. The gaps between the first reinforcement plate 120c and the second reinforcement plate 120d and between the adjacent second reinforcement plates 120d may be formed to be the same. The reinforcement plate 120 may be bent through bending so as to have a "U"-shaped or rectangular cross-section.

[0099] A similar manner is repeated in FIG. 4B. The reinforcement plate 120 may include a fourth reinforcement plate 120e having an overall "L"-shaped cross-section, a second reinforcement plate 120d having a rectangular cross-section, and a sixth reinforcement plate 120f having a sideways "U"-shaped cross-section. The second reinforcement plate 120d is in a tubular shape in which a space is formed therein, and may have a polygonal or circular cross-section.

[00100] The fourth reinforcement plate 120e and the lower plate 130 and/or the sixth reinforcement plate 120f and the lower plate 130 may be bent integrally, or may be separately processed and coupled through welding (preferably, laser welding).

[00101] The core layer 140 may be formed in a space between the upper plate 110 and the reinforcement plate 120 and the lower plate 130, and in a space between the adjacent reinforcement plates 120. The core layer 140 may be formed of a non-foaming polymer. More preferably, the core layer 140 may be formed of a non-foaming polyurethane having a density of 700 kg/m³ or more and a compressive strength of 3 N/mm² or more, as a material having suitable elasticity and structural strength. As will be described later, the core layer 140 may be formed by curing a non-foaming polymer raw liquid filled in the space.

[00102] In the lightweight structural member 100 according to the present disclosure, an upper flat plate part formed in a horizontal direction by the upper plate 110,

the reinforcement plate 120, and the core layer 140 filled therebetween, and a lower flat plate part formed in a horizontal direction by the lower plate 130, the reinforcement plate 120, and the core layer 140 filled therebetween serve as structural members that bear a load.

[00103] In addition, vertical column portions composed of the reinforcement plates 120 facing each other at a predetermined interval and the core layer 140 therebetween are repeatedly formed at a regular interval, and function as a plate reinforcement that enhances the structural performance of the flat plate part and prevents buckling.

[00104] Accordingly, the lightweight structural member 100 according to the present disclosure can implement a 'box-type structure' in which a plurality of plate reinforcing structures (vertical column portions) are repeatedly formed between the upper plate 110 and the lower plate 130, which are main plates facing each other (FIG. 4A).

[00105] In this case, the present disclosure is not a structure in which the upper plate 110, the lower plate 130, and the reinforcement plate 120 for forming a plate reinforcing structure are coupled to each other by welding, but is manufactured by a method of filling a polymer in an internal space while being disposed at a distance from each other, and thus has the advantage of being able to easily implement a box-type structure without the conventional manufacturability problem (described with reference to FIG. 3).

[00106] In addition, in the lightweight structural member 100 according to the present disclosure, since the flat plate part formed in the horizontal direction and the vertical column portion formed in the vertical direction have a continuous shape without being separated, it is possible to implement a structure that is strong and free from concerns about thermal deformation or cracks due to welding.

[00107] In the lightweight structural member 100 according to the present disclosure having such a strong structure, the reinforcement plate 120 disposed in the middle may be made of a metal material like the upper plate 110 or the lower plate 130, but sufficient structural strength may also be implemented even when the reinforcement plate 120 is made of a composite material such as fiber reinforced plastics (FRP).

[00108] (2) Second and Third Embodiments (Multi-Stage Deck Structure)

[00109] The lightweight structural member 100 according to the present disclosure has another advantage in that it can easily implement a multi-stage deck structure.

[00110] For example, referring to FIGS. 5 and 6, a multi-stage deck structure can be implemented by disposing the second reinforcement plates 120d, in which a hexahedral-shaped space is formed therein, inside the core layer 140 so as to form a plurality of rows and layers.

[00111] In this case, as illustrated in FIGS. 5B and 6B, the cross-section of the first reinforcement plate 120c disposed at both ends of the lightweight structural member 100 may be configured to have a simple straight line shape instead of a "U" shape so as to connect between the upper plate 110 and the lower plate 130, and such a structure may be utilized as a container for transporting heavy goods having a multi-stage deck. That is, an inner space of the plurality of second reinforcement plates 120c disposed inside the core layer 140 may be used as a storage space for transporting heavy goods.

[00112] In order to manufacture a multi-stage deck-type container, a rack structure, or the like in a general manner, a process of welding each deck to an existing skeleton structure is inevitably required, and each deck must be manufactured with a sufficiently strong and thick structure so that heavy goods can be safely stored. For example, a deck of a container having a multi-layer structure is manufactured by welding

a thick angle or channel to a skeleton and then combining a thick plywood or the like to maintain structural rigidity.

[00113] However, the problem is that the work becomes very difficult or impossible as the height between decks decreases. When the height between decks is approximately 1,600 mm or less, in which a person cannot typically work while standing, the work must be performed with the worker's body bent, which takes at least twice as much time as working while standing. If the height between decks is 400 to 600 mm or less, it becomes difficult for a person to work even while lying down, so welding work or robust structural fastening work becomes nearly impossible.

[00114] In addition, a general multi-stage deck structure also has a disadvantage in that plywood disposed between the angles or channels, which are spaced apart from each other, is structurally vulnerable and thus disadvantageous in terms of durability. In addition, since this structure has the angle or channel separated from the deck floor, a minute gap may occur, through which water may pass, which also causes a problem in terms of waterproofing. This is not good for use as a container for transporting dangerous goods or moisture-sensitive goods.

[00115] However, by using the box-type manufacturing method of the present disclosure, it is possible to easily implement a multi-stage deck structure for transporting heavy goods, which was very cumbersome or impossible to manufacture using the conventional method as described above.

[00116] Specifically, the manufacturing may be performed by pre-manufacturing a box-type structure with the upper plate 110, the lower plate 130, and the reinforcement plate 120, fixing the positions of the upper plate 110, the lower plate 130, and the reinforcement plate 120 through a working jig or the like, and then injecting a liquid-state polymer raw liquid into a space formed inside the box-type structure. A multi-stage deck

structure may be formed by disposing a plurality of reinforcement plates 120 adjacent to each other in the horizontal direction and the vertical direction.

[00117] According to the method of the present disclosure as described above, since the injected polymer raw liquid can easily fill an empty space by itself and does not require welding work in a narrow space as in the related art, a multi-stage deck structure can be conveniently manufactured.

[00118] When the lightweight structural member 100 according to the present disclosure is used as a multi-stage deck-type container, the height of the second reinforcement plate 120d disposed therein can be adjusted as desired, and thus it has the advantage of being able to ultimately implement the height between decks as desired.

[00119] In addition, since the entire structure including the wall and the deck is constituted by a uniform composite structure made of a polymer and a metal plate, rather than a structure in which a deck is laid on an angle or channel as in the conventional method, there is no structurally weak portion in any part.

[00120] In addition, since the connection portion between the wall and the deck has a continuous shape without being separated, the multi-stage deck-type container using the lightweight structural member 100 according to the present disclosure enables perfect watertightness/airtightness between the decks.

[00121] Meanwhile, in the process of manufacturing the lightweight structural member 100 according to the present disclosure as a multi-stage deck-type container, various fillers may be inserted in advance into a space in which the core layer 140 is to be formed prior to injection of the polymer, so that a desired function can be easily added. For example, a fireproof material for a fireproofing function or an insulating material for an insulating function may be additionally disposed in the space, or a cooling/heating pipe or a hydraulic line may be disposed in advance.

[00122] In the multi-stage deck-type container using the lightweight structural member 100 according to the present disclosure, the partition wall between the decks is constituted by a multiple composite structure including metal-polymer-metal, and since the thermal conductivity of the polymer is approximately 0.2 to 0.4 W/mK and has a heat transfer blocking performance several hundred times higher than that of metal, it has remarkably superior performance in terms of insulation as compared to a general multi-stage deck structure made of a single metal material.

[00123] (3) Fourth and Fifth Embodiments

[00124] The fourth and fifth embodiments of the lightweight structural member 100 according to the present disclosure illustrated in FIGS. 7 and 8 differ from the first embodiment illustrated in FIG. 4 in that a cross-sectional shape of a space formed by the reinforcement plate 120 is a polygonal or circular shape instead of a rectangular shape. A description of the same configuration as the first embodiment will be omitted.

[00125] As illustrated in FIG. 7, when the cross-sectional shape of the space formed by the reinforcement plate 120 is triangular, there is an advantage in that the proportion of the metal structure increases, thereby being resistant to compressive load or buckling.

[00126] As illustrated in FIG. 8, when the cross-sectional shape of the space formed by the reinforcement plate 120 is formed in a trapezoidal shape, it may be more advantageous in terms of compressive load or buckling, as compared to the case of having a rectangular cross-section as illustrated in FIG. 4.

[00127] The lightweight structural member 100 of the present disclosure may have various cross-sectional shapes such as a circular shape, in addition to the triangular and trapezoidal shapes illustrated in FIGS. 7 and 8.

[00128] (4) Sixth Embodiment

[00129] The sixth embodiment of the lightweight structural member 100 according to the present disclosure illustrated in FIG. 9 differs from the first embodiment illustrated in FIG. 4 in that it includes an extension portion 330 formed to be longer than other vertical column portions. A description of the same configuration as the first embodiment will be omitted.

[00130] The reinforcement plate 120 of the lightweight structural member 100 of the present embodiment includes a third reinforcement plate 120h. The third reinforcement plate 120h has a rectangular cross-section like the second reinforcement plate 120d, but is formed to be longer in the vertical direction than the second reinforcement plate 120d.

[00131] The lower plate 130 of the lightweight structural member 100 of the present embodiment is bent downward at a portion where the third reinforcement plate 120h is disposed.

[00132] The lightweight structural member 100 of the present embodiment can itself have the function of a longitudinal strength member by including the extension portion 330.

[00133] (5) Seventh Embodiment

[00134] The seventh embodiment of the lightweight structural member 100 according to the present disclosure illustrated in FIG. 10 differs from the sixth embodiment illustrated in FIG. 9 in that it further includes one or more additional reinforcement plates 170. A description of the same configuration as the sixth embodiment will be omitted.

[00135] When the lightweight structural member 100 of the present disclosure is configured to also include the function of a longitudinal strength member, a load may be concentrated on the extension portion 330, and buckling or breakage may occur in the

extension portion 330 due to shear force or the like. Accordingly, the present embodiment may be designed such that the extension portion 330 has higher strength than the other vertical column portions to prevent buckling and breakage of the extension portion 330.

[00136] In order to increase the strength of the extension portion 330, the thickness of the extension portion 330 may be formed to be thick, but in order to form only the thickness of the extension portion 330 to be thick, the process becomes complicated and inefficient, and if the entire reinforcement plate 120 is formed to be thick, the portions other than the extension portion become over-designed, which may increase the overall weight and increase the manufacturing cost.

[00137] The lightweight structural member 100 of the present embodiment may increase the strength of the extension portion 330 by disposing one or more additional reinforcement plates 170 inside the core layer 140. When the additional reinforcement plate 170 is disposed in place and the polymer raw liquid is injected and cured, the additional reinforcement plate 170 may be integrated within the core layer 140. It is preferable that the additional reinforcement plate 170 is vertically disposed within the core layer 140 formed in the extension portion 330, and two additional reinforcement plates 170 may be disposed on both sides, respectively.

[00138] (6) Eighth Embodiment

[00139] The eighth embodiment of the lightweight structural member 100 according to the present disclosure illustrated in FIG. 11 differs from the sixth embodiment illustrated in FIG. 9 in that the extension portion 330 includes a plurality of reinforcement plates 120. A description of the same configuration as the sixth embodiment will be omitted.

[00140] For example, as illustrated in FIG. 11, the extension portion 330 of the present embodiment may include two reinforcement plates 120i and 120j disposed up and

down. The present disclosure is not limited thereto, and the extension portion 330 may be configured to include more reinforcement plates 120, if necessary.

[00141] (7) Ninth Embodiment

[00142] The ninth embodiment of the lightweight structural member 100 according to the present disclosure illustrated in FIG. 12 differs from the sixth embodiment illustrated in FIG. 9 in that the extension portion 330 does not include the reinforcement plate 120. A description of the same configuration as the sixth embodiment will be omitted.

[00143] In the extension portion 330 of the present embodiment, the reinforcement plate 120 is not disposed therein, and the interior thereof is constituted only by the core layer 140.

[00144] As illustrated in FIGS. 12B and 12C, the extension portion 330 of the present embodiment may further include reinforcing members 157 and 158 for reinforcing strength. The reinforcing members 157 and 158 are preferably made of a material harder than the core layer 140 (for example, a metal material).

[00145] The reinforcing members 157 and 158 may be disposed at a lower end of the extension portion 330 as illustrated in FIG. 12B, or may be formed to have an "I"-shaped cross-section and vertically disposed at a central portion of the extension portion 330 as illustrated in FIG. 12C.

[00146] (8) Tenth Embodiment

[00147] The tenth embodiment of the lightweight structural member 100 according to the present disclosure illustrated in FIG. 13 differs from the ninth embodiment illustrated in FIG. 12 in that a lower end of the extension portion 330 is formed to have an "L"-shaped cross-section. A description of the same configuration as the ninth embodiment will be omitted.

[00148] As illustrated in FIG. 13B, a reinforcing member 154 having an "L"-shaped cross-section corresponding to the shape of the lower end of the extension portion 330 may be disposed at the lower end of the extension portion 330 of the present embodiment.

[00149] (9) Eleventh Embodiment

[00150] The eleventh embodiment of the lightweight structural member 100 according to the present disclosure illustrated in FIG. 14 differs from the ninth embodiment illustrated in FIG. 12 in that a lower end of the extension portion 330 is formed to have a "T"-shaped cross-section. A description of the same configuration as the ninth embodiment will be omitted.

[00151] As illustrated in FIG. 14B, a reinforcing member 155 having a "T"-shaped cross-section corresponding to the shape of the lower end of the extension portion 330 may be disposed at the lower end of the extension portion 330 of the present embodiment.

[00152] (10) Twelfth Embodiment

[00153] The twelfth embodiment of the lightweight structural member 100 according to the present disclosure illustrated in FIG. 15 is characterized by including one or more pipes 180. FIG. 15A illustrates a case in which the length of the vertical column portion is constant as illustrated in FIG. 4, and FIGS. 15B to 15D illustrate a case in which the extension portion 330 is included as illustrated in FIG. 9. Although not separately illustrated, the pipe 180 may also be applied to other embodiments, such as a case in which the extension portion 330 includes a plurality of reinforcement plates 120 (FIG. 11), a case in which the reinforcement plate 120 is not included (FIG. 12), a case in which the lower end shape of the extension portion 330 is configured to have an "L" shape (FIG. 13), or a case in which it is configured to have a "T" shape (FIG. 14).

[00154] The pipe 180 is disposed in an 'upper flat plate part' formed in a horizontal direction below the upper plate 110, and a plurality of pipes 180 may be disposed side by side along the upper flat plate part. The plurality of pipes 180 may be disposed at a regular interval, or there may be sections disposed at different intervals as needed.

[00155] As illustrated in FIG. 15A, the pipe 180 may be disposed closer to the upper plate 110, or as illustrated in FIG. 15B, the pipe 180 may be disposed at approximately a midpoint between the upper plate 110 and the reinforcement plate 120. Alternatively, as illustrated in FIG. 15C, a plurality of pipes 180 may be disposed vertically. Although FIG. 15C illustrates two rows of pipes 180 disposed vertically, three or more rows may be disposed as needed, and the pipes may also be disposed offset from each other rather than aligned in rows and columns.

[00156] The pipe 180 may be disposed inside the core layer 140. When the pipe 180 is disposed between the upper plate 110 and the reinforcement plate 120 and a raw liquid for forming the core layer 140 is then filled and cured, a high-density sealed structure may be formed around the pipe 180. In this case, even if a crack occurs in the pipe 180, since the outside of the pipe 180 is sealed by the high-density structure, leakage of the pipe 180 does not occur, and the overall structure of the lightweight structural member 100 is not affected.

[00157] The pipe 180 may perform a cooling/heating function. In order to enable rapid heat circulation, the pipe 180 is preferably made of a metal material, but the present disclosure is not limited thereto.

[00158] Referring to FIG. 15D, the lightweight structural member 100 of the present embodiment may further include a pipe installation member 185. The pipe installation member 185 is for facilitating the installation of the pipe 180, and the pipe

installation member 185 may be installed first, and then the pipe 180 may be installed thereon.

[00159] The pipe installation member 185 preferably has a structure capable of withstanding the weight of the pipe 180 while not significantly increasing the weight of the lightweight structural member 100 of the present disclosure, and may be, for example, a thin mesh structure. In addition, a fixed pin, a spacer, or the like may also be used.

[00160] Buildings and ships often require cooling and heating facilities, and in particular, a considerable amount of heat is generated in a data center, and if the generated heat is not properly removed and the indoor temperature increases, the performance of a data storage device or the like may deteriorate.

[00161] Looking at the conventional pipe installation work, it is difficult to install pipes during concrete structure construction, and it is common to perform pipe installation work (typically referred to as "floor leveling work") after the concrete structure construction is completed. This is because, since high-pressure and heavy-weight ready-mixed concrete is applied during concrete pouring, if the pipe is installed in advance and then the ready-mixed concrete is applied, there is a high possibility that pipe breakage and/or a change in the position of the pipe may occur, and even if the pipe is properly installed, if a crack occurs in the pipe later, a fluid inside the pipe may penetrate into the concrete structure, thereby reducing structural performance and possibly even leading to collapse.

[00162] The pipe installation work (floor leveling work) is performed by installing pipes on a concrete structure and then constructing mortar or the like thereon, and such pipe installation work is generally performed on a floor surface, and performing the floor leveling work on a ceiling or a wall surface is very cumbersome in terms of construction method.

[00163] However, according to the lightweight structural member 100 of the present embodiment, since a separate pipe installation work is not required simply by disposing the lightweight structural member 100, the work efficiency is improved. When the lightweight structural member 100 of the present embodiment is utilized as a floor structure, floor cooling and heating (ondol type) is possible by the pipe 180. In addition, the lightweight structural member 100 of the present embodiment can be applied not only to a floor structure but also to a wall surface and ceiling structure, and in this case, pipes can also be easily installed on the wall surface and ceiling. In addition, when the lightweight structural member 100 of the present embodiment is applied to a floor structure of multiple floors, respectively, the heat source of the ceiling of the lower floor and the floor of the upper floor can be simultaneously controlled by the pipe 180.

[00164] (11) Thirteenth Embodiment

[00165] The thirteenth embodiment of the lightweight structural member 100 according to the present disclosure illustrated in FIG. 16 is characterized by further including an edge bar 175 and a protruding member 177.

[00166] An edge bar 175 may be installed at an edge between the upper plate 110 and the reinforcement plate 120 and an edge between the lower plate 130 and the reinforcement plate 120 of the lightweight structural member 100 to assist in coupling such as bolting connection or welding. In this case, as illustrated in FIG. 16A, there is a problem in that the edge bar 175 may be separated due to a load applied to the lightweight structural member 100.

[00167] In order to prevent this problem, referring to FIGS. 16B and 16C, one or more protruding members 177 may be installed on an inner surface of the edge bar 175. When the edge bar 175 with the protruding member 177 installed is disposed in place and the polymer raw liquid is injected and cured, the protruding member 177 may form a

wedge structure embedded in the core layer 140, thereby preventing the edge bar 175 from being separated.

[00168] (12) Additional Supplementary Embodiment

[00169] A. Stress Dispersion Structure

[00170] The lightweight structural member 100 according to the present disclosure can additionally easily implement a structure for alleviating stress concentration at a bent portion extending from the flat plate part to the vertical column portion.

[00171] In the conventional steel plate structural member illustrated in FIG. 2, a structure that is sharply bent at 90° inevitably occurs at a portion where the upper plate 10 and the lower plate 30 are welded to the plate reinforcement 20. Such a structure has a disadvantage in that, in addition to stress concentration at the corresponding portion, a coating film for corrosion prevention is easily peeled off.

[00172] In order to improve this problem, as illustrated in FIG. 17A, a method of adding a triangular-shaped metal reinforcement 21 to a portion where the upper plate 10 and the lower plate 30 meet the plate reinforcement 20 in a conventional steel plate structural member may be considered, but this is rarely applied because not only is the welding of the triangular-shaped metal reinforcement 21 itself not easy, but a structurally weak welding portion also occurs, and there is also a disadvantage in that the overall weight of the structural member significantly increases.

[00173] However, since the lightweight structural member 100 proposed in the present disclosure does not have a structure in which the flat plate part and the vertical column portion functioning as the plate reinforcement are separated from each other, it is very easy to implement a gentle slope at the connection portion between the flat plate part and the vertical column portion by a method such as additionally bending the

reinforcement plate 120 as illustrated in FIG. 17B. That is, four corner portions of the reinforcement plate 120 having a rectangular cross-section may be manufactured to have a chamfer structure that is obliquely inclined.

[00174] In addition, although not illustrated in the drawing, it is also possible to configure the connection portion between the flat plate part and the vertical column portion to have a round shape. Since the reinforcement plate 120 of the lightweight structural member 100 according to the present disclosure is provided as a thin plate, it is not difficult to implement the connection portion in a round shape.

[00175] In addition, in the lightweight structural member 100 according to the present disclosure, since the specific gravity of the inner core layer 140 is only 1/7 to 1/8 of that of metal, the increase in weight is also at a negligible level. Accordingly, it is possible to effectively alleviate the phenomenon of stress concentration at the connection portion between the flat plate part and the vertical column portion of the lightweight structural member 100 according to the present disclosure, and to significantly increase the durability and service life of the coating film.

[00176] B. Reinforcement of Insulation Performance

[00177] A structure for reinforcing the insulation performance of the lightweight structural member 100 according to the present disclosure is presented as follows.

[00178] First, as illustrated in FIG. 18A, when configuring the core layer 140 of the lightweight structural member 100, a high-performance insulating material having already implemented structural performance may be additionally used. That is, a high-performance insulating material 141 having a low thermal conductivity may be additionally disposed between the upper plate 110 and the reinforcement plate 120 and/or between the lower plate 130 and the reinforcement plate 120, and in this case, it is possible to have more excellent performance in terms of insulation and structure.

[00179] More specifically, the core layer 140 may be formed by disposing a high-performance insulating material 141 having a thermal conductivity lower than 0.02 W/mK together with a non-foaming polymer between the upper plate 110 and the reinforcement plate 120 and/or between the lower plate 130 and the reinforcement plate 120. For example, when the core layer 140 is formed to include a vacuum insulation panel (VIP) having a thermal conductivity of approximately 0.004 W/mK, the overall thickness of the lightweight structural member 100 will increase somewhat, but in terms of insulation, it becomes possible to implement insulation performance that is about 6 to 10 times better than that of a general expanded polystyrene (EPS) insulating material. In addition, since the structural strength increases in proportion to the 2nd to 3rd power of the thickness increase due to the characteristics of the composite material, it is possible to realize lightweight but superior structural performance.

[00180] In addition, when the vacuum insulation panel is included within the non-foaming polymer, the vacuum insulation panel can be more effectively protected from external impact, and the gas inflow and outflow into the vacuum insulation panel is completely blocked by the airtight structure of the non-foaming polymer, so that the lifespan of the vacuum insulation panel can be extended almost permanently.

[00181] When the core layer 140 is composed only of a non-foaming polymer, there is an advantage in that the thickness of the lightweight structural member 100 can be optimized and manufactured to a very thin thickness. On the other hand, when a high-performance insulating material 141 such as a vacuum insulation panel is additionally included together with the non-foaming polymer, there is an advantage in that it is simpler in terms of manufacturing the lightweight structural member 100 (since the non-foaming polymer raw liquid may be applied to the surface of the high-performance insulating material 141 and used as an adhesive) and excellent insulation performance can be

obtained. Accordingly, when forming the core layer 140 of the lightweight structural member 100 according to the present disclosure, whether to use the non-foaming polymer alone or to use the non-foaming polymer together with the high-performance insulating material 141 may be selected and applied in consideration of the advantages of each method.

[00182] For reference, when the core layer 140 is composed only of the high-performance insulating material 141, the coupling force with the upper plate 110 and the reinforcement plate 120 is weak, making it difficult to secure sufficient structural performance. The lightweight structural member 100 of the present disclosure can obtain satisfactory structural performance only when the non-foaming polymer surrounding the high-performance insulating material 141 maintains a form firmly fixed by adhesion between the upper plate 110 and the reinforcement plate 120.

[00183] Meanwhile, referring to FIG. 18B, in the lightweight structural member 100 according to the present disclosure having a box-type structure, the insulation performance of the entire structure can be easily increased simply by inserting and disposing a general insulating material (I), such as polyurethane foam or civil engineering EPS, in a box space formed therein. In addition, it would also be possible to additionally implement fire resistance performance by disposing a fireproof material within the box space.

[00184] Since the insulating material I inserted into the inner space of the reinforcement plate 120 is shielded and protected by the robust composite structure of the lightweight structural member 100, there is no need to separately perform finishing work for protecting the insulating material, and an effect of increasing the durability service life of the insulating material I can also be expected.

[00185] The above-described structure is expected to have excellent usability

when used in the manufacture of a ship storage tank or the like where insulation is importantly required.

[00186] C. Additional Arrangement of Metal Reinforcing Material

[00187] Meanwhile, in the lightweight structural member 100 according to the present disclosure, the upper plate 110, the lower plate 130, and the reinforcement plate 120 constituting an outer plate are configured using a metal plate having a much thinner thickness than that used in a conventional steel plate structural member of equivalent performance. Accordingly, when an additional member (for example, a longitudinal/transverse girder, or the like) needs to be welded to the outer plate of the lightweight structural member 100 according to the present disclosure, a problem in which the inner core is burned by welding heat may occur. In order to prevent this problem, a metal material may be additionally disposed in a region where the additional member is to be welded, prior to injecting a polymer to form the core layer 140.

[00188] In addition, a metal material may also be additionally disposed in any region for the purpose of local reinforcement of the upper plate 110, the lower plate 130, or the reinforcement plate 120 of the lightweight structural member 100.

[00189] For example, referring to FIG. 19, the metal reinforcing material 142 may be freely disposed at a position requiring reinforcement in the space between the upper plate 110 or the lower plate 130 and the reinforcement plate 120. Although not illustrated, the metal reinforcing material 142 may be disposed at any position requiring reinforcement, such as a space between the vertically positioned reinforcement plates 120 facing each other, or an outer surface of the upper plate 110, the lower plate 130, or the reinforcement plate 120. When the metal reinforcing material 142 is disposed in the middle of the core layer 140, it may be disposed with a thickness corresponding to the entire core layer 140, but is not necessarily limited thereto, and may also be disposed in

a form attached to one side surface of the upper plate 110, the lower plate 130, or the reinforcement plate 120 at a position requiring reinforcement.

[00190] In the lightweight structural member 100 according to the present disclosure, since the polymer forming the inner core firmly attaches all members, an integrated structural behavior is possible. Accordingly, even without using a strong joining method such as welding, the metal reinforcing material 142 can be firmly fixed within the core layer 140 through interaction with the polymer and behave stably.

[00191] D. Additional Division of Reinforcement Plate

[00192] As described above, in order to implement the lightweight structural member 100 with an integrated plate reinforcement proposed by the present disclosure, the reinforcement plate 120 is bent at least once to several times and used in various shapes.

[00193] Meanwhile, in the case of a ship structural member, it is advantageous for the length to be sufficiently long in order to increase manufacturability within a shipyard, and a structural member of approximately 5 to 10 m is commonly used. The reinforcement plate 120 constituting the lightweight structural member 100 according to the present disclosure has the advantage of being able to easily implement a shape through bending, but due to the performance limitations of bending equipment, a method of dividing the reinforcement plate 120 into several pieces and joining them may be required.

[00194] In addition, as described above, the reinforcement plate 120 of the lightweight structural member 100 constituting one unit may be manufactured separately into a plurality of pieces, and in this case, the interval between the adjacent reinforcement plates 120 may be reduced or increased due to a manufacturing/installation error. If approximately 4 to 10 reinforcement plates 120 are continuously disposed in one lightweight structural member 100, the above-described manufacturing/installation errors

may accumulate, resulting in a concern that defective products may occur, such as a misalignment of a step at an end portion of the lightweight structural member 100 or an uneven thickness of the vertical column portion that performs the function of a web of the plate reinforcement. In particular, since the thickness of the core (polymer) of the vertical column portion of the lightweight structural member 100 proposed in the present disclosure is formed to be thin, at approximately 4 to 5 mm, even an error of only about 1 to 2 mm can have a significant effect on the overall structural performance.

[00195] In addition, since the load stress requirement may differ for each element of the reinforcement plate 120 constituting the vertical column portion of the lightweight structural member 100, there may be cases in which metal plates of different thicknesses need to be used, respectively.

[00196] For this reason, a method of dividing the reinforcement plate 120 constituting the lightweight structural member 100 of the present disclosure into smaller units and joining them through welding may be used. For example, in order to implement the box-type lightweight structural member 100 with an integrated plate reinforcement proposed by the present disclosure, the reinforcement plate 120 having a rectangular cross-section as illustrated in FIG. 20 may be used, and in this case, as illustrated at the bottom of the drawing, the reinforcement plate 120 may be additionally divided into two unit bodies manufactured separately and then connected through welding.

[00197] II. Advantages and Structural Dimensions of Lightweight Structural Member According to the Present Disclosure

[00198] In the lightweight structural member 100 according to the present disclosure described above, the vertical column portion formed in the vertical direction, that is, the portion formed in the shape of a vertical column by the reinforcement plates 120 facing each other and the core layer 140 formed therebetween, functions to increase

the section modulus of the entire structure. The section modulus may be determined by the height or shape of the vertical column portion that functions as a plate reinforcing structure.

[00199] In the conventional steel plate structural member (refer to FIGS. 1 and 2) composed only of metal, which is mainly applied to a ship structure, a plate reinforcement 20 is joined through welding to a lower surface of the upper plate 10 or between the upper plate 10 and the lower plate 30 for structural reinforcement, and it has been explained in the background art that this conventional method has a problem in that significant thermal deformation occurs when the plate reinforcement 20 is connected by welding.

[00200] However, unlike the conventional steel plate structural member in which the upper plate 10 and the lower plate 30, which function as structural members, and the plate reinforcement 20 are each separately manufactured and then joined by welding, the lightweight structural member 100 according to the present disclosure is configured in a form in which the flat plate part and the vertical column portion are manufactured integrally and the plate reinforcing structure is already included therein, and thus there is no concern of the thermal deformation problem due to welding as in the conventional case.

[00201] In addition, even when assuming a case where the plate reinforcement 20 is bolted together without welding in manufacturing the conventional steel plate structural member, additional hole construction or local structural reinforcement work is required for bolting connection between the upper plate 10 or the lower plate 130 and the plate reinforcement 20. In contrast, the lightweight structural member 100 according to the present disclosure, in which the plate reinforcing structure is integrally formed, does not require any of the above-mentioned additional processes, and thus may have structurally stable performance.

[00202] In addition, since the lightweight structural member 100 according to the present disclosure is in a form in which the plate reinforcing structure by the vertical column portion is already included in itself, it is possible to manufacture an optimized composite structure by forming the upper plate 110, the lower plate 130, and the reinforcement plate 120 to have a much thinner structure, as compared to a case in which welding connection of the plate reinforcing structure is required.

[00203] In particular, the lightweight structural member 100 according to the present disclosure is characterized in that not only the flat plate part but also the vertical column portion functioning as the plate reinforcement is composed of a composite material (metal + polymer) rather than a single metal material. According to this structure of the present disclosure, there is an advantage in that structural weight reduction of about 40 to 50% can be achieved compared to when a plate reinforcement made only of metal is used.

[00204] The thicknesses of the upper plate 110, the lower plate 130, and the reinforcement plate 120 constituting an outer plate, and the core layer 140 constituting an inner core, of the lightweight structural member 100 according to the present disclosure may be designed to a degree that allows the lightweight structural member 100 according to the present disclosure to implement structural performance equivalent to the structural strength of a general steel plate structural member.

[00205] Specifically, the thickness of each of the upper plate 110, the lower plate 130, and the reinforcement plate 120 of the lightweight structural member 100 according to the present disclosure may be 0.4 to 20 mm. In this case, as will be described later, since there are cases in which a welding operation should be performed when it is desired to couple the lightweight structural member 100 according to the present disclosure to individual modules or to connect the lightweight structural member 100 to another

structure, it is preferable that the thickness of each of the upper plate 110, the lower plate 130, and the reinforcement plate 120 constituting the outer plate is formed to be 0.4 mm or more, which facilitates laser welding. In addition, in order to achieve the structural lightweighting of the lightweight structural member 100 according to the present disclosure, it is preferable that the thickness of the upper plate 110, the lower plate 130, and the reinforcement plate 120 is formed to be 10 mm or less, and therefore, the present disclosure suggests 0.4 to 10 mm as a more preferable thickness of the metal plate constituting the upper plate 110, the lower plate 130, and the reinforcement plate 120.

[00206] The thickness of the core layer 140 of the lightweight structural member 100 according to the present disclosure may be variously configured from 3 to 40 mm. In this case, the core layer 140 may be formed to have different thicknesses in a portion formed in the horizontal direction and a portion formed in the vertical direction.

[00207] That is, in the lightweight structural member 100 according to the present disclosure, the thickness of the core layer 140 in the flat plate part and the thickness of the core layer 140 in the vertical column portion may be formed to be the same, but may also be adjusted to be different. In the case where it is desired to form the thicknesses to be different, it is preferable that the thickness of the core layer 140 in the vertical column portion, which functions as the plate reinforcement, is formed to be thinner than the thickness of the core layer 140 in the flat plate part.

[00208] Meanwhile, there is something that should not be confused by the names of the members above. For example, it should be understood to mean that the upper plate 110 of the lightweight structural member 100 according to the present disclosure does not have to have, by itself, structural performance equivalent to that of the upper plate 10 of a general steel plate structural member, but rather that, in the lightweight structural member 100 according to the present disclosure, the upper flat plate part, which is formed

in the horizontal direction and directly in contact with the design load, including the upper plate 110, the reinforcement plate 120, and the core layer 140 formed therebetween, may be designed to have structural performance equivalent to that of the upper plate 10 of a general steel plate structural member. This also applies to determining the thicknesses of the reinforcement plate 120 constituting the plate reinforcing structure and the core layer 140 formed therebetween.

[00209] That is, in the lightweight structural member 100 according to the present disclosure, the structural strength should be considered by corresponding the entire upper flat plate part, including the upper plate 110, the reinforcement plate 120, and the core layer 140 formed therebetween, to the upper plate 10 of a general steel plate structural member. Therefore, in the lightweight structural member 100 according to the present disclosure, which is designed to have structural performance equivalent to that of a general steel plate structural member, the thickness of the upper plate 110 will be much thinner than that of the corresponding upper plate 10 of the general steel plate structural member. For example, the lightweight structural member 100 according to the present disclosure, which is equivalent to a 6 mm thick upper plate 10 of a general steel plate structural member, may have a composite structure formed of a 1 mm thick upper plate 110, a 5 mm thick core layer 140, and a 1 mm thick reinforcement plate 120.

[00210] In addition, in the lightweight structural member 100 according to the present disclosure, an interval between vertical column portions performing the web function of the plate reinforcement may be formed within a range of 200 to 3,000 mm. More preferably, the interval between vertical column portions of the lightweight structural member 100 according to the present disclosure may be formed at approximately 600 to 900 mm, which is similar to that of a general steel plate structural member, and if the thin thickness of the lightweight structural member 100 is sacrificed

(for example, in a case in which the thickness is increased by disposing a high-performance insulating material 141 inside the core layer 140 as will be described later), the interval between the vertical column portions may be increased up to 1,500 to 3,000 mm. Here, the interval between the vertical column portions may be determined by a transverse length of the reinforcement plate 120.

[00211] The width of the lightweight structural member 100 according to the present disclosure may be changed according to the number of vertical column portions formed. For example, when the interval between the vertical column portions is uniformly 700 mm, in a structure having 3 to 5 vertical column portions, the width of the entire plate may be formed to be approximately 2,100 to 3,500 mm.

[00212] The height of the vertical column portion formed in the vertical direction in the lightweight structural member 100 may be formed at a level having structural performance equivalent to that of a general steel plate structural member by comparing the section modulus of the entire structure, and may be manufactured to be similar to or lower than that of an existing plate reinforcement made only of metal. For example, if the height of the plate reinforcement of an existing steel plate structural member intended to implement equivalent performance is 100 mm, the height of the vertical column portion of the lightweight structural member 100 according to the present disclosure may also be formed at a similar level. Here, the height of the vertical column portion may mean the entire height of the reinforcement plate 120.

[00213] For reference, in order to implement structural performance equivalent to that of a general steel plate structural member using only a structure in which a non-foaming polymer is simply filled between a flat upper plate and a flat lower plate, without utilizing the structural features of the lightweight structural member 100 with an integrated plate reinforcement proposed by the present disclosure, a very thick and heavy

structure would be required.

[00214] For example, assuming that a hull structure capable of withstanding a load of approximately 20 tons in a 3.2 m width is required, if a general steel plate structural member (refer to FIG. 1) is used, a plate reinforcement 20 having a height of approximately 300 mm and a thickness of 10 mm or more would need to be welded to an upper plate 10 of approximately 15 mm. However, if it is desired to implement equivalent performance using only a simple laminated structure in which a polymer is filled between an upper plate and a lower plate, the thickness of the steel plates constituting the upper plate and the lower plate alone would need to be 6 to 7 mm, and the thickness of the polymer filled therebetween would be tens to hundreds of millimeters, resulting in a very thick and heavy structure. Thickness and weight are problems, but if the thickness of the inner core becomes approximately 50 mm or more, cracking or collapse may occur in the middle of the core due to heat and pressure generated during the curing process of the polymer, and in order to prevent this, it may be necessary to dispose a metal mesh or reinforcing bars inside the core.

[00215] However, the lightweight structural member 100 with an integrated plate reinforcement proposed by the present disclosure not only includes the plate reinforcing structure itself, but also forms the interval between the vertical column portions functioning as a plate reinforcement to be substantially the same as the interval of the plate reinforcement 20 provided in a conventional general steel plate structural member, thereby enabling implementation of an optimized structure using a thin thickness of polymer and steel plate.

[00216] When the thickness, width, height, and the like of each configuration are designed within the range presented above, the lightweight structural member 100 according to the present disclosure can be manufactured into a long-span structure

ranging from a length of approximately 3 m to a maximum length of as much as 14 m. The reason why the lightweight structural member 100 according to the present disclosure can be manufactured into a long-span structure of up to 14 m as described above is that the core layer 140, which has a specific gravity of 0.8 to 1.8 and is composed of a non-foaming polymer that is very lightweight compared to metal, is firmly bonded between the upper plate 110, the lower plate 130, and the reinforcement plate 120 to provide basic structural performance, and at the same time, the vertical column portion formed in the vertical direction in the lightweight structural member 100 serves as a plate reinforcement.

[00217] Another point to note here is that the lightweight structural member 100 according to the present disclosure, which is manufactured with a long-span structure, has excellent structural performance because it is composed of a composite material of metal and polymer. Accordingly, it is possible to exhibit structural performance equal to or greater than that of a general steel plate structural member for ships or reinforced concrete for construction, while remarkably reducing the number of transverse reinforcing materials that must be installed to reinforce the transverse structure of the structural member. That is, the conventional general steel plate structural member had to be configured to essentially include a transverse girder that reinforces the transverse structure, separately from the plate reinforcement 20 that reinforces the longitudinal structure, whereas the lightweight structural member 100 according to the present disclosure does not significantly require such a transverse reinforcing structure.

[00218] The lightweight structural member 100 according to the present disclosure may be manufactured to satisfy a predetermined deflection amount standard, and this deflection amount standard may be satisfied by forming the section modulus of the entire structure to a predetermined level or higher through adjustment/selection of the height and shape of the vertical column portion that functions as the plate reinforcement,

as described above.

[00219] For example, when the total length of the lightweight structural member 100 according to the present disclosure is 6 m, the thickness of each of the upper plate 110, the lower plate 130, and the reinforcement plate 120 is formed to be 1 mm, and the core layer 140 is formed as a thin core of 5 mm, if it is desired to satisfy the L/480 deflection amount standard while forming an interval of 600 mm between the vertical column portions under conditions of a live load of 200 kgf/m² and both ends fixed, the height of the vertical column portion may be calculated to be approximately 65 mm.

[00220] In the deflection amount standard, 'L' refers to the length (span) of the lightweight structural member 100, and in order to satisfy the L/480 deflection amount standard, a central portion of the lightweight structural member 100 should not sag more than 1/480 of the total length of the lightweight structural member 100. As in the example given above, when the lightweight structural member 100 according to the present disclosure is manufactured to have a length (span) of 6 m and both ends are fixed, the L/480 deflection amount standard is satisfied only when the maximum deflection amount is $6,000/480 = 12.5$ (mm) or less.

[00221] That is, the structural performance of the lightweight structural member 100 to satisfy the deflection amount standard may be implemented by adjusting the height or shape of the vertical column portion.

[00222] In addition, by providing an adhesive strength of a certain level or higher between the metal plates constituting the upper plate 110, the lower plate 130, and the reinforcement plate 120 and the core layer 140, it is possible to further help implement the structural performance of the lightweight structural member 100 as described above.

[00223] The non-foaming polymer constituting the core layer 140 has adhesive strength on its own, and as will be described later, during the process in which the liquid

non-foaming polymer raw liquid is cured, the surfaces in contact with the upper plate 110, the lower plate 130, and the reinforcement plate 120 are airtightly bonded. In this case, the present disclosure may impart an adhesive strength of 1 to 10 MPa, more preferably 6 MPa, between the metal plates constituting the upper plate 110, the lower plate 130, and the reinforcement plate 120 and the core layer 140.

[00224] As will be described later, the lightweight structural member 100 according to the present disclosure may have its side end or lower end portion finished with a non-metallic or metallic finishing member for structural connection with other modules in the future, or for the purpose of optimizing the structural strength required by the module itself or reinforcing fatigue strength. In this case as well, it is preferable that a bonding strength of at least 1 MPa (more preferably 6 MPa or more) is provided between the non-foaming polymer, which is the inner core, and the finishing member.

[00225] As described above, the lightweight structural member 100 according to the present disclosure has the advantage of being able to implement ultra-light weight and remarkably excellent structural performance due to the material characteristics of being composed of a composite material of a metal material and a non-metallic material (non-foaming polymer), together with the structural characteristics of being manufactured to include a plate reinforcing structure on its own.

[00226] Specifically, the composite material-based lightweight structural member 100 according to the present disclosure can implement equivalent structural performance with a weight of approximately 50 to 60% as compared to a general steel plate structural member mainly used in the shipbuilding field, and can implement equivalent structural performance with a weight of approximately 15 to 25% as compared to reinforced concrete mainly used in the construction field.

[00227] In addition, according to a general standard carbon emission table, steel

plates and non-foaming polymers are known to generate 2 to 3 kg of CO₂ per kilogram (kg). However, since the specific gravity of the non-foaming polymer is at a level of 0.8 to 1.8, which is much lower than the specific gravity of steel plate, 7.85, the carbon emissions generated during the structural manufacturing process are greatly reduced, and carbon emissions can be reduced by about 50% compared to existing structures.

[00228] III. Finishing and Connection Structure of Lightweight Structural Member According to the Present Disclosure

[00229] Hereinafter, the finishing and connection structure of the lightweight structural member 100 according to the present disclosure will be described with reference to FIGS. 21 to 23.

[00230] (1) First Side End Finishing and Connection Structure

[00231] Referring to FIG. 21, a first side end finishing member 151 made of a metal or non-metallic material may be inserted and disposed between the upper plate 110 and the reinforcement plate 120 and between the lower plate 130 and the reinforcement plate 120 at both end portions formed in the horizontal direction in the lightweight structural member 100 according to the present disclosure. Here, when the first side end finishing member 151 is made of a non-metallic material, it is preferable that the first side end finishing member is made of a material capable of producing a bonding strength of at least 1 MPa (more preferably 6 MPa or more) with the non-foaming polymer, which is the inner core.

[00232] In addition, in the adjacent lightweight structural members 100, the upper plates 110 disposed in contact with each other, the lower plates 130 disposed in contact with each other, and the reinforcement plates 120 disposed in contact with each other may be coupled to each other through laser welding. As described above, laser welding has the advantage of less thermal deformation, but there is a problem in that it is

not easy to apply to a general steel plate structural member of 6 mm or more due to the problem that efficiency decreases as the thickness increases. However, the present disclosure has the advantage of being favorable for the application of laser welding because it is possible to use a metal plate having a thickness thinner than 6 mm (for example, 0.4 to 5 mm) as the upper plate 110, the lower plate 130, and the reinforcement plate 120.

[00233] In addition, in the present exemplary embodiment, the first side end finishing member 151 may be disposed by being pushed inward by a predetermined distance into the lightweight structural member 100. According to this, when the adjacent lightweight structural members 100 are disposed in contact with each other to connect two or more lightweight structural members 100 to each other, a space S is formed between the first side end finishing members 151 arranged on each lightweight structural member 100 facing each other, and by injecting and curing a non-foaming polymer raw liquid (more preferably, a non-foaming polyurethane raw liquid) into the space S, the connection portion of the adjacent lightweight structural members 100 can be airtightly finished.

[00234] In this case, after the adjacent lightweight structural members 100 are connected by welding, a process of injecting and curing the non-foaming polymer raw liquid into the space S may be performed, and an additional effect of providing additional coupling force between the lightweight structural members 100 due to the self-adhesive force of the non-foaming polymer may also be achieved.

[00235] Meanwhile, the first side end finishing member 151 may be deleted and the non-foaming polymer, which is the core layer 140, may be left exposed as is. However, even in this case, it is of course possible to apply the same method of forming a predetermined space S in the portion where the lightweight structural members 100 are

connected and injecting the non-foaming polymer raw liquid into the space S to airtightly finish the connection.

[00236] (2) Second Side End Finishing and Connection Structure

[00237] Referring to FIG. 22, a second side end finishing member 152 made of a metal material may be inserted and disposed at both end portions formed in the horizontal direction in the lightweight structural member 100 according to the present disclosure.

[00238] In the present exemplary embodiment, the second side end finishing member 152 may be provided as a metal plate having a straight-line-shaped cross-section and a thickness corresponding to the core layer 140. Although the drawing illustrates a form in which one end of the second side end finishing member 152 is inserted into the interior of the lightweight structural member 100 and the other end protrudes to the outside, the second side end finishing member 152 does not necessarily need to protrude to the outside, and may also be configured such that the end of the second side end finishing member 152 coincides with the ends of the upper plate 110, the lower plate 130, and the reinforcement plate 120.

[00239] The second side end finishing member 152 may be structurally coupled to the second side end finishing member 152 provided on the side of an adjacent other lightweight structural member 100 through welding or bolting, or the like.

[00240] When the second side end finishing member 152 protrudes to the outside, the second side end finishing members 152 facing each other may be coupled by welding or bolting, and when the second side end finishing member 152 does not protrude to the outside, the entire end portions of the adjacent lightweight structural members 100 may be coupled through welding or bolting.

[00241] In the case where the side end portion of the lightweight structural

member 100 is finished with a metal material having a predetermined thickness as in the present exemplary embodiment, universal welding such as CO2 welding can be applied, and in addition to welding, a mechanical joining method using bolts, or the like, can also be applied, which has the advantage of excellent design flexibility.

[00242] (3) Third Side End Finishing and Connection Structure

[00243] Referring to FIG. 23, a third side end finishing member 153 made of a metal material may be inserted and disposed at both end portions formed in the horizontal direction in the lightweight structural member 100 according to the present disclosure.

[00244] The third side end finishing and connection structure of the lightweight structural member 100 according to the present disclosure is similar to the second side end finishing and connection structure described just before. However, unlike the second side end finishing member 152 described above, which is provided in a simple straight line shape, the third side end finishing member 153 differs in that it is provided in an angle shape having a "U"-shaped cross-section.

[00245] In addition, although the drawing illustrates a form in which the upper surface of the third side end finishing member 153 is exposed, it may also be configured such that the end of the third side end finishing member 153 coincides with the ends of the upper plate 110 and the lower plate 130, that is, such that the upper plate 110 and the lower plate 130 each cover both the upper surface and the lower surface of the third side end finishing member 153.

[00246] The third side end finishing member 153 may be structurally coupled to the third side end finishing member 153 provided on the side of an adjacent other lightweight structural member 100 in a state of being in contact with each other, through welding or bolting, or the like (it is also possible to apply welding and bolting connection together). If the upper plate 110 and the lower plate 130 are configured to both cover the

third side end finishing member 153, the upper plates 110 of the adjacent lightweight structural members 100, and the lower plates 130 thereof, may also be welded to each other.

[00247] The finishing structure of the lightweight structural member 100 according to the present disclosure described above may have an additional function, such as sealing the space between the upper plate 110 and the lower plate 130 and the reinforcement plate 120 during the manufacturing process of the lightweight structural member 100, in addition to the function of assisting the coupling and connection between two or more lightweight structural members 100.

[00248] In addition, the above-described finishing members 151 to 153 may be inserted between the upper plate 110, the lower plate 130, and the reinforcement plate 120 so that contacting surfaces are bonded by an adhesive, and the surfaces in contact with the core layer 140 may also be bonded by the self-adhesive force of the non-foaming polymer forming the core layer 140. Even when the finishing members 151 to 153 are made of metal, sufficient strength can be obtained simply by inserting and bonding without necessarily welding. However, in order to prevent peeling of the bonded surfaces, an adhesive strength of 1 to 10 MPa, more preferably 6 MPa, may be provided between the metal plates constituting the upper plate 110, the lower plate 130, and the reinforcement plate 120 and the finishing members 151 to 153.

[00249] In the lightweight structural member 100 according to the present disclosure, since the upper plate 110, the lower plate 130, and the reinforcement plate 120 are formed to have a very thin thickness, thermal deformation can be minimized through the application of laser welding. In particular, since the core layer 140 is formed by curing after the filling of the non-foaming polymer, laser welding can be performed after structural rigidity is achieved, so that welding deformation can be minimized.

[00250] In addition, in the lightweight structural member 100 according to the present disclosure, since the reinforcement plate 120 made of a metal material constituting the vertical column portion is bonded to the inner core layer 140 with an adhesive strength of 1 MPa or more (more preferably 6 MPa or more), it is possible to sufficiently perform the function of the plate reinforcement without separate welding or with only minimal tag welding.

[00251] IV. Manufacturing Method of Lightweight Structural Member
According to the Present Disclosure

[00252] Hereinafter, the manufacturing method of the lightweight structural member 100 according to the present disclosure will be described with reference to FIGS. 24 and 25.

[00253] In general, the thickness of a plate reinforcement used in ships varies from 6 to 30 mm, but a thin thickness of approximately 6 to 15 mm is usually used. When this is replaced with the composite material structure of the non-foaming polymer and metal proposed in the present disclosure, a metal thin plate having a thickness of approximately 1 to 3 mm may be used for the upper plate 110, the lower plate 130, and the reinforcement plate 120, and the thickness of the non-foaming polymer constituting the core layer 140 may be formed into a very thin structure of approximately 5 to 15 mm.

[00254] However, it is not realistically easy to form a non-foaming polymer structure with such a thin thickness as described above. This is because the raw liquid of the non-foaming polymer has a viscosity higher than that of a lubricant before being cured, so if the space to be filled is too narrow, it is difficult to inject due to frictional resistance, and it is difficult to spread evenly within the space.

[00255] According to a certain classification society regulation that specifies the basic performance and structural requirements of ships, when manufacturing a panel

made of a composite material of metal and non-foaming polymer, it is recommended that the thickness of the metal plate be at least 3 mm and that the core composed of non-foaming polymer be formed to a thickness of 15 mm or more, and separate approval must be obtained if this is not followed.

[00256] The manufacturing methods described below are proposed to solve the above-mentioned manufacturing difficulty, that is, the difficulty in forming the core layer 140 composed of a non-foaming polymer with a thin thickness, in forming the core layer 140 of the lightweight structural member 100 according to the present disclosure with a non-foaming polymer. More preferably, a method is proposed that makes it possible to obtain a uniform core layer 140 by evenly filling the space with the non-foaming polymer while forming the core layer 140 to a thickness of 15 mm or less.

[00257] Referring to FIG. 24, in manufacturing the lightweight structural member 100 according to the present disclosure, a method may be used in which the space between the upper plate 110, the reinforcement plate 120, and the lower plate 130 is formed into a sealed space, and the non-foaming polymer raw liquid is injected into the sealed space using an injection tube. In this case, in order to smoothly and evenly inject the non-foaming polymer raw liquid, the injection tube may be divided into a plurality of small tubes.

[00258] Generally, in a non-foaming polymer, a chemical reaction occurs while two liquids of organic compounds such as ISO and polyol are mixed, and curing begins from this point on. Since the chemical reaction takes only a few minutes, the injection of the non-foaming polymer raw liquid must also be completed within a few minutes. However, since the non-foaming polymer raw liquid is viscous on its own, it may be difficult to spread the raw liquid evenly within a few minutes.

[00259] This manufacturing method is intended to solve the above-mentioned

process difficulties, and by dividing the injection tube for injecting the non-foaming polymer raw liquid into several small tubes and arranging them within the space, the non-foaming polymer raw liquid can be quickly and evenly injected into the sealed space between the upper plate 110, the reinforcement plate 120, and the lower plate 130.

[00260] In applying this manufacturing method, if there is an unblocked portion between the plates, a temporary dam may be used to form a sealed space, and if there is a portion finished with a separate finishing member, the corresponding portion may be sealed by the finishing member.

[00261] In addition, when injecting the non-foaming polymer raw liquid into the space between the upper plate 110, the reinforcement plate 120, and the lower plate 130, the injection may be performed while removing air from the sealed space using a vacuum pump. Specifically, after the space between the upper plate 110, the reinforcement plate 120, and the lower plate 130 is formed into a sealed space, the non-foaming polymer raw liquid may be injected through an injection tube on one side, while air within the sealed space may be sucked using a vacuum pump on the other side.

[00262] When the vacuum pump is used as described above, it is possible to inject the non-foaming polymer raw liquid in a thin thickness while overcoming frictional resistance due to the pressure difference between the inside and outside of the sealed space between the upper plate 110, the reinforcement plate 120, and the lower plate 130. In addition, there is an advantage in that rapid injection is possible due to the suction power of the vacuum pump. The use of a vacuum pump also makes it possible to bundle several injection tubes into an integrated configuration, which may help to simplify the structure for injecting the non-foaming polymer.

[00263] Meanwhile, the upper plate 110, the reinforcement plate 120, and the lower plate 130 used in the manufacturing of the lightweight structural member 100

according to the present disclosure use a metal plate that is much thinner than the steel plate used as a general ship structural member, which causes a construction-related inconvenience. That is, since the thickness of the metal plate is too thin, it is difficult to maintain the shape and manage the flatness of the plate before or during the process of filling the core (non-foaming polymer).

[00264] The present disclosure may use a spacer to maintain the shape and gap in the process of filling the core between the upper plate 110, the reinforcement plate 120, and the lower plate 130. In addition, since the non-foaming polymer forming the core layer 140 has a characteristic of swelling slightly during the curing process, the upper plate (the plate that comes on top during the manufacturing process) may also be pressed with a considerable load. However, in the lightweight structural member 100 according to the present disclosure, since the thickness of the metal plate constituting the upper plate 110, the reinforcement plate 120, and the lower plate 130 is formed to be very thin below a certain level, it may be difficult to maintain the shape and flatness of the plate only by using a spacer or pressing with a predetermined load as described above.

[00265] In addition, a sagging phenomenon of the plate due to the weight of the upper plate also occurs. If the thickness of the core is formed thick enough, the strength of the chemical reaction is also strong, so the sagging upper plate can be pushed up again using the swelling force of the core. However, in the lightweight structural member 100 according to the present disclosure, since the core layer 140 is formed with a thin thickness, the swelling force of the core is weak, and thus may be insufficient to restore the sagging of the upper plate due to its own weight during the manufacturing process.

[00266] In addition, the lightweight structural member 100 according to the present disclosure includes a structure in which the reinforcement plate 120 is bent from the horizontal direction to the vertical direction, and in this case, it is also very difficult

to maintain a constant bending angle due to the characteristic of the reinforcement plate 120 being composed of a thin plate.

[00267] In order to solve such manufacturing difficulties, the present disclosure may use a magnet or a vacuum suction device in the manufacturing process of the lightweight structural member 100. That is, the content described below relates to a method for maintaining the overall shape and flatness of the structural member during the injection and curing process of the non-foaming polymer.

[00268] Specifically, as illustrated in FIG. 25, when a magnet M is disposed on the upper surface of the upper plate 110 disposed at the top in a state in which the space between the upper plate 110, the reinforcement plate 120, and the lower plate 130 is filled with the non-foaming polymer raw liquid, the upper surface of the upper plate 110 can be kept in a flat state by closely contacting the magnet M due to the magnetic field generated by the magnet M.

[00269] For reference, in the exemplary embodiment illustrated in FIG. 25, since the process is performed in a state in which the lower plate 130, the reinforcement plate 120, and the upper plate 110 are sequentially stacked on a surface plate in this order, the magnet M is disposed on top of the upper plate 110. If the manufacturing process of the lightweight structural member 100 is performed with the upper/lower positions reversed, the magnet M may be disposed on the lower plate 130, which is relatively positioned on the upper side.

[00270] Here, the magnet M can be understood as a concept that includes all magnetic materials capable of generating a force that attracts metal, including an electromagnet. The magnet M does not need to be configured to have a size corresponding to the entire area of the plate for which flatness is to be maintained, and even when disposed while occupying only a portion of the area, the effect of flattening the entire

plate can be achieved. In addition, a plurality of magnets M may be disposed on the plate, and when only one magnet M is used, it is preferable that the magnet is disposed at a central portion of the plate.

[00271] In addition, the magnet M may also be disposed on a side surface of the reinforcement plate 120 standing in the vertical direction according to the same principle to maintain flatness and obtain a desired bending angle. In this case, the magnet M may be configured to be included in a working jig or a surface plate that fixes the position of the reinforcement plate 120. Although only the magnet M that applies a tensile force to the reinforcement plate 120 is configured within the surface plate in the drawing, it is of course possible that the magnet M that applies a tensile force to the upper plate 110 may also be configured within a separate jig or surface plate (not illustrated) for fixing the upper plate 110.

[00272] It is also possible to use a vacuum suction device instead of the magnet M. Specifically, the shape of the structural member can be maintained and the flatness can be maintained by suctioning a specific portion of the plate, for which flatness should be maintained, with a vacuum suction device and applying a tensile force thereto. As in the case of using the magnet M, the vacuum suction device can perform the function of maintaining flatness even when providing suction force only to a partial area, not the entire area of the plate, and it is preferable to suction the central portion of the plate, for which flatness is to be maintained. In addition, it is also possible to apply a plurality of vacuum suction devices to one plate.

[00273] The lightweight structural member 100 of the present disclosure manufactured through this process can have a flat surface and maintain the same thickness overall, thereby realizing uniform structural performance. In addition, since the flatness problem is solved during the manufacturing process, the amount of spacers disposed

between the upper plate 110, the reinforcement plate 120, and the lower plate 130 can be greatly reduced, which also has the effect of reducing manufacturing labor and costs.

[00274] Meanwhile, in the process of manufacturing the lightweight structural member 100 according to the present disclosure, a spacer may be disposed between the upper plate 110, the lower plate 130, and the reinforcement plate 120, and between the facing reinforcement plates 120, that is, between the metal plate components, in order to keep the gap between the two plates constant, and in this case, the spacer may be made of a material capable of providing an adhesive strength of 3 MPa or more with the polymer constituting the core layer 140.

[00275] In addition, since a thin non-foaming polymer has a smaller absolute capacity for chemical reaction than a thick non-foaming polymer, it takes more time to cure, and in particular, in periods of low temperature such as winter, the rate of chemical reaction between molecules for curing also decreases, so that the curing time may take longer, or in extreme cases, curing may not occur. In order to prevent this, a heating wire or heating pipe facility capable of raising the temperature on the surface of the working jig or surface plate may be additionally provided.

[00276] V. Specific Manufacturing Method

[00277] Hereinafter, a specific example of a method of manufacturing the lightweight structural member 100 according to the present disclosure will be described. The manufacturing example described below relates to a case in which the 'second side end finishing structure' described with reference to FIG. 22 is applied.

[00278] First, in order to manufacture the lightweight structural member 100, the configurations illustrated in FIGS. 26 to 29 are prepared as materials. FIG. 26 illustrates the upper plate 110 and the lower plate 130, and FIG. 27 illustrates a plurality of first reinforcement plates 120c and second reinforcement plates 120d constituting the

reinforcement plate 120. FIGS. 28 and 29 illustrate elements constituting a perimeter bar 160 that functions as a finishing member to finish a space between the lower plate 130 and the reinforcement plate 120, a space between adjacent reinforcement plates 120, and a space between the upper plate 110 and the reinforcement plate 120 in the lightweight structural member 100.

[00279] Referring to FIG. 26, the upper plate 110 and the lower plate 130 are provided in the form of a flat square plate. In the present embodiment, the lower plate 130 has a simple rectangular shape, whereas the upper plate 110 may be configured to include protruding portions at the front/rear edges along the longitudinal direction, which artificially forms a space so that welding from the lower side is also possible when connecting two manufactured lightweight structural members 100 to each other in the longitudinal direction.

[00280] That is, although it may be viewed as forming a protrusion at the front/rear edge of the upper plate 110, it may also be viewed as forming a rectangular-shaped groove recessed inward at the front/rear edge of the upper plate 110, and when two manufactured lightweight structural members 100 are connected to each other in the longitudinal direction, the grooves provided in each member face each other to form a space into which welding equipment can be inserted. This will be examined in more detail later with reference to FIGS. 39 and 40.

[00281] The upper plate 110 may be provided such that the total length thereof, including the protruding portions, corresponds to the length of the lower plate 130. Since the above-described protruding structure is not required in the transverse direction of the upper plate 110, the width of the upper plate 110 may be provided to be the same as the width of the lower plate 130.

[00282] Referring to FIG. 27, the reinforcement plate 120 may be composed of a

first reinforcement plate 120c having a "U"-shaped cross-section and a second reinforcement plate 120d having a rectangular cross-section. The first reinforcement plate 120c has a shape in which one edge of a plate formed in the horizontal direction is bent in the vertical direction and then re-bent in the horizontal direction again through two bending processes. The second reinforcement plate 120d is in the form of a substantially hollow square pipe with both front and rear ends open along the longitudinal direction, and a hexahedral-shaped empty space may be formed therein.

[00283] In the present exemplary embodiment, two first reinforcement plates 120c are provided so as to be disposed at both ends along the width direction of the lightweight structural member 100, respectively, and the number of second reinforcement plates 120d disposed therebetween may vary depending on how many plate reinforcing structures (vertical column portions) are formed. In the present exemplary embodiment, five plate reinforcing structures (vertical column portions) are formed in one unit of the lightweight structural member 100, and four second reinforcement plates 120d are used for this purpose.

[00284] The perimeter bar 160, which is installed at the edge between the upper plate 110 and the lower plate 130 and functions as a finishing member, may be configured to include a lower edge bar 161 and a vertical bar 162 illustrated in FIG. 28, and an upper edge bar 163 illustrated in FIG. 29. In the present exemplary embodiment, the upper edge bar 163 is separately illustrated from the other components, but since the elements 161 to 163 constituting the perimeter bar 160 are all coupled through welding, the three components 161 to 163 may also be manufactured as an integral structure.

[00285] The lower edge bar 161 is disposed at the edge portion between the lower plate 130 and the reinforcement plate 120 and performs the role of the second side end finishing member 152 (refer to FIG. 22) described above.

[00286] The vertical bar 162 is installed in the vertical direction at a predetermined point on the lower edge bar 161, and performs the role of finishing the vertical reinforcing portion (vertical column portion) formed by the reinforcement plate 120.

[00287] The vertical bar 162 may be installed at the position where the vertical column portion functioning as the plate reinforcement is formed in the lightweight structural member 100. Since the present exemplary embodiment relates to a structure in which five vertical column portions are formed in one unit of the lightweight structural member 100, vertical bars 162 may be installed at five points along the width direction, respectively. In addition, in the present exemplary embodiment, since the lower edge bar 161 has a rectangular frame shape in which a pair of elongated metal plates are installed side by side along the longitudinal direction and the width direction, vertical bars 162 may be installed at a total of ten points, five each at the front and rear along the longitudinal direction.

[00288] The upper edge bar 163 is disposed at the edge portion between the upper plate 110 and the reinforcement plate 120 and performs the role of the second side end finishing member 152 (refer to FIG. 22) described above. The upper edge bar 163 may include portions protruding in a rectangular shape at the front/rear along the longitudinal direction so as to correspond to the shape of the upper plate 110.

[00289] Each of the elements 161 to 163 constituting the perimeter bar 160 may be provided as a metal plate having a predetermined thickness.

[00290] Hereinafter, a method of manufacturing the lightweight structural member 100 according to the present disclosure using the materials prepared as described above will be described according to a sequential process.

[00291] Referring to FIG. 30, first, the lower edge bar 161 is placed on the lower

plate 130 and fixed. At this time, the lower edge bar 161, provided in a rectangular frame shape, is disposed at the edge along the rectangular perimeter of the lower plate 130. In the present exemplary embodiment, the end of the lower edge bar 161 is aligned with the edge of the lower plate 130, but the end of the lower edge bar 161 may also be disposed to protrude slightly further than the edge of the lower plate 130.

[00292] The lower edge bar 161 may be coupled to the lower plate 130 through laser welding. Since the lower edge bar 161 can subsequently be provided with coupling force by the self-adhesive force of the non-foaming polymer forming the core layer 140, it may be simply fixed to the lower plate 130 using a steel plate adhesive tape or the like instead of laser welding at this stage. However, a fixing force sufficient to withstand the pressure of the rising non-foaming polymer raw liquid and the expansion pressure during curing must be provided. This also applies similarly to the coupling between the reinforcement plate 120 and the vertical bar 162 and the coupling between the upper plate 110 and the upper edge bar 163, which are described below.

[00293] Next, the upper edge bar 163 is disposed and fixed on top of the lower edge bar 161 and the vertical bar 162. The upper edge bar 163 is provided in a rectangular frame shape similar to the lower edge bar 161, but has protruding portions at the front/rear along the longitudinal direction. In this case, the protruding portions may be welded to the upper end of the vertical bar 162 to be coupled.

[00294] Next, referring to FIG. 31, a plurality of reinforcement plates 120, including the first reinforcement plate 120c and the second reinforcement plate 120d, are disposed on the lower plate 130. In this case, the reinforcement plate 120 may be disposed in a form fitted into the structure formed by the perimeter bar 160. Since the thickness of each of the components 161 to 163 constituting the perimeter bar 160 corresponds to the thickness at which the core layer 140 is to be formed, the reinforcement plate 120 may

simply be disposed in contact with the perimeter bar 160.

[00295] Although not illustrated in the drawing, a plurality of spacers (not illustrated) may be disposed between the lower plate 130 and the reinforcement plate 120 and between the facing adjacent reinforcement plates 120 for the purpose of maintaining a gap.

[00296] Referring to FIG. 32, the state in which the arrangement of the reinforcement plates 120 (120c, 120d) is completed can be confirmed. FIGS. 33A and 33B are enlarged views of the portions indicated by 'A' and 'B' in FIG. 32, respectively. After assembling the plurality of reinforcement plates 120 in a sliding manner, the end portions where the reinforcement plate 120 and the perimeter bar 160 are in contact may be joined by laser welding.

[00297] Next, referring to FIG. 34, an operation of disposing the metal reinforcing material 142 in necessary portions on the space where the reinforcement plates 120 are disposed may be additionally performed. For example, in the present exemplary embodiment, the metal reinforcing material 142 is disposed in a cross shape corresponding to the positions where a longitudinal girder and a transverse girder are to be welded to the outer surface of the lightweight structural member 100 after its manufacturing is completed. The metal reinforcing material 142 disposed here enables robust welding of the longitudinal and transverse girders to be welded in the future, and serves to prevent the internal polymer from burning during welding.

[00298] The remaining space, excluding the area where the metal reinforcing material 142 is disposed, is subsequently filled with the non-foaming polymer to form the core layer 140, and after the manufacturing is completed, the metal reinforcing material 142 may be firmly fixed by the self-adhesive force of the polymer forming the core layer 140. Accordingly, in the step of disposing the metal reinforcing material 142, it is not

necessary to firmly fix the metal reinforcing material 142 to the reinforcement plate 120 or the perimeter bar 160 by welding, and it is sufficient to temporarily fix it using a steel plate adhesive tape or the like.

[00299] Thereafter, as illustrated in FIG. 35, the upper plate 110 is covered, and the portion where the upper plate 110 and the upper edge bar 163 are in contact is fixed through laser welding. A plurality of spacers (not illustrated) may also be disposed between the upper plate 110 and the reinforcement plate 120 for the purpose of maintaining a constant gap between the two plates.

[00300] When the arrangement and coupling between the components of the upper plate 110, the reinforcement plate 120, the lower plate 130, and the perimeter bar 160 are completed as described above, an operation of injecting and curing the non-foaming polymer raw liquid into the space formed therebetween is performed.

[00301] More specifically, the lower plate 130 and the reinforcement plate 120 are spaced apart by an amount corresponding to the thickness of the lower edge bar 161, and a space is formed therebetween. In addition, the plurality of reinforcement plates 120 are spaced apart from each other by an amount corresponding to the thickness of the vertical bar 162, and a space is formed therebetween. In addition, the upper plate 110 and the reinforcement plate 120 are spaced apart by an amount corresponding to the thickness of the upper edge bar 163, and a space is formed therebetween. These spaces form a sealed space by the perimeter bar 160, and the core layer 140 is formed by injecting and curing the non-foaming polymer raw liquid into the space.

[00302] In the manufacturing process of the lightweight structural member 100 according to the present disclosure, the upper plate 110, the lower plate 130, the reinforcement plate 120, and the perimeter bar 160 are preferably coupled to each other through laser welding, but if the positions can be mechanically fixed using a working jig

or a surface plate, it is sufficient to couple the above-described components with only a weak force using an adhesive tape (for example, 3M VHB tape) or other adhesives.

[00303] In order to inject the non-foaming polymer raw liquid into the space formed by the upper plate 110, the reinforcement plate 120, the lower plate 130, and the perimeter bar 160, an injection hole communicating with the inner space and a vent hole for venting air present in the corresponding space may be formed at predetermined positions. In addition, a plurality of injection tubes as illustrated in FIG. 24 may be disposed within the space to inject the non-foaming polymer raw liquid, and a vacuum pump may be used to induce faster and more effective injection of the non-foaming polymer raw liquid.

[00304] In addition, in order to prevent the plate from swelling or warping due to expansion pressure when the non-foaming polymer raw liquid is cured, a method such as pressing the upper plate during the manufacturing process or disposing a magnet M on the upper surface of the plate as described with reference to FIG. 25 may be used.

[00305] As the non-foaming polymer raw liquid is cured, the formation of the core layer 140 is completed.

[00306] The structure of the lightweight structural member 100 manufactured through the above process is illustrated in FIG. 36. FIG. 37 is an enlarged view illustrating the portion indicated by 'C' in FIG. 36. The present exemplary embodiment presents a structure in which five vertical column portions are formed in one unit of the lightweight structural member 100, but as described above, the number of vertical column portions formed can be changed depending on the structural performance required for the lightweight structural member 100.

[00307] FIGS. 38 and 39 are views illustrating a transverse connection structure and a longitudinal connection structure of the lightweight structural member 100

according to the present disclosure, respectively.

[00308] Referring to FIG. 38, in the case of transverse coupling, the adjacent lightweight structural members 100 may be coupled by performing straight-line welding (more preferably, laser welding) on the upper end and the lower end, respectively, in a state in which they are abutted against each other.

[00309] Referring to FIGS. 39 and 40, in the case of longitudinal coupling, when the adjacent lightweight structural members 100 are abutted against each other, the lower end portion is exposed by the rectangular-shaped groove formed at the edge of the upper plate 110, and welding equipment may be inserted through this exposed space to perform welding between the lower end portions of the lightweight structural members 100. In addition, the portion where the protruding portions formed on the facing upper plates 110 abut each other is welded to connect them.

[00310] VI. Application Examples of Lightweight Structural Member According to the Present Disclosure

[00311] The lightweight structural member 100 according to the present disclosure may be utilized to form a ship structure or a floor, ceiling, and wall structure of a building.

[00312] Preferably, the lightweight structural member 100 according to the present disclosure may be used as a deck structure of a ship. In addition, the lightweight structural member 100 according to the present disclosure may be installed on the upper or lower portion of a concrete slab that divides the upper and lower floors in a building and used as a floor or ceiling structure, and of course, may also be applied to a wall structure of a building as needed.

[00313] Hereinafter, specific application examples of the lightweight structural member 100 according to the present disclosure and the resulting operational effects

thereof will be examined in more detail.

[00314] (1) Shipbuilding Field

[00315] The lightweight structural member 100 according to the present disclosure can be usefully utilized in constructing structures installed on a ship. The lightweight structural member 100 according to the present disclosure is expected to be particularly highly useful in the shipbuilding field when used to manufacture a car deck of a pure car carrier (PCC). In addition, it can also be very effectively used in constructing structures such as a wind deflector installed to block wind and waves on a container ship, or a ship accommodation, or the like.

[00316] In addition, the lightweight structural member 100 according to the present disclosure can be utilized to implement a cofferdam or rudder of a ship and a cell guide structure for a container ship, and these three application examples will be examined in detail below for each exemplary embodiment.

[00317] A. Utilization as a Cofferdam Structure

[00318] A cofferdam refers to a buffer space installed using a double bulkhead to prevent gas, oil, liquids, or the like from directly penetrating from one compartment to another. According to related regulations, a cofferdam is specified to be configured with a double bulkhead having a minimum spacing of 600 mm, considering regular inspection and maintenance, but in actual practice, it occupies a space of up to 800 to 900 mm due to difficulties in workability during manufacturing.

[00319] By implementing a cofferdam structure of a ship using the lightweight structural member 100 of the present disclosure, it is possible to solve the above-described conventional problem, that is, the problem in terms of space utilization, while also having the effect of excellent manufacturability and installability.

[00320] As an example, the installation of the cofferdam structure can be

performed very easily simply by standing the manufactured lightweight structural member 100 illustrated in FIG. 36 upright in a vertical direction inside the hull and coupling the upper/lower end portions thereof to the hull structure.

[00321] When the lightweight structural member 100 according to the present disclosure is used as a cofferdam structure, the 'upper flat plate part' and the 'lower flat plate part', which function as structural members as described above, each perform the role of a bulkhead. That is, the lightweight structural member 100 of the present disclosure may perform the role of a double bulkhead by including a plate reinforcing structure and a multiple shielding structure between the upper plate 110 and the lower plate 130.

[00322] As described above, the lightweight structural member 100 according to the present disclosure is manufactured by injecting a liquid-state polymer between metal plates and curing it, and in this case, as the temperature rises during the curing process of the polymer, considerable expansion pressure is generated in the inner core space. The pressure at this time is strong enough to cause the polymer to spurt out even if there is a very fine hole in the outer metal plate. Accordingly, the metal-polymer-metal composite structure forming the lightweight structural member 100 according to the present disclosure can be implemented as a perfect triple shielding structure, and since international classification societies are trending toward recognizing such a multiple shielding structure as having the same shielding performance as a conventional cofferdam, it is expected that classification society rules can also be sufficiently satisfied.

[00323] More specifically, in the lightweight structural member 100 according to the present disclosure, the upper flat plate part and the lower flat plate part each include a triple shielding structure, so that the overall structure has a total of six layers of shielding.

[00324] In addition, since the reinforcement plate 120 disposed inside the

lightweight structural member 100 according to the present disclosure includes a space portion, the inner space (void) required for a cofferdam can be seen as automatically formed, and thus it has the advantage of excellent installability.

[00325] Using the conventional method, a double bulkhead must be manufactured to install a cofferdam, and in this case, workability is very poor due to working in a narrow space, and safety problems may also occur due to welding in an enclosed space.

[00326] However, when applying the present disclosure, since the box-type lightweight structural member 100 is separately manufactured at the factory, and only the welding of the connection portion with the hull needs to be performed in the field, an effect of incomparably improved workability can be enjoyed compared to the conventional method.

[00327] Meanwhile, the double bulkhead forming the cofferdam is required to have a spacing of 600 mm or more therebetween, but typically occupies a space of approximately 800 to 900 mm considering the working environment. However, since the lightweight structural member 100 according to the present disclosure has a six-layer shielding structure, there is a high possibility that more relaxed regulatory standards may be applied compared to the above. Since the lightweight structural member 100 according to the present disclosure is typically manufactured as a single panel having a thickness of 100 to 200 mm, an effect of securing an additional space of approximately a minimum of 400 mm to a maximum of 800 mm is expected.

[00328] In addition, all of the effects of the lightweight structural member 100 according to the present disclosure can be implemented as they are. For example, a weight reduction effect of approximately 30 to 40% can be expected, and as the overall weight is reduced, the amount of steel plate used is reduced by 40% or more, and since a

relatively small weight of polymer is used, the overall amount of carbon generation can be reduced by approximately 40 to 50%.

[00329] Meanwhile, when installing the lightweight structural member 100 according to the present disclosure as a cofferdam structure, a method capable of easily doubling the sealing performance of the connection portion with the hull may be presented, as illustrated in FIG. 41.

[00330] Referring to FIG. 41, the lower end portion of the upper plate 110 and the lower end portion of the lower plate 130 are welded to the hull deck, and it is possible to additionally increase the sealing performance at the connection portion by injecting a polymer on-site (that is, injecting it during installation on the hull) into the sealed space formed at the lower end portion between the reinforcement plates 120 and curing it. However, the core layer 140a formed in the space between the upper plate 110 and the reinforcement plate 120 and in the space between the lower plate 130 and the reinforcement plate 120 may be formed in advance during manufacturing at the factory, and only the core layer 140b formed at the portion in contact with the hull deck may be formed by the on-site injection method. This can be similarly applied to the upper end portion connected to another part of the hull as well.

[00331] A welding structure inevitably also occurs at the upper/lower end portions of a conventional cofferdam structure, and the corresponding portion is structurally vulnerable to liquid-tightness/airtightness. However, the present disclosure has the advantage of being able to easily compensate for this conventional vulnerability by increasing the sealing performance at the connection portion as described above. The above-described structure for increasing the sealing performance at the connection portion is not an essential matter and is an optional matter that can be applied.

[00332] Meanwhile, in order to perform inspection of the space formed inside the

cofferdam, it may be required that the internal space is not disconnected and is connected as a single space. To this end, when the lightweight structural member 100 according to the present disclosure is used as a cofferdam structure, the structure may be manufactured such that the spaces respectively formed in the plurality of reinforcement plates 120 communicate with each other, as illustrated in FIG. 42.

[00333] Referring to FIG. 42, the lightweight structural member 100 of the present disclosure may further include a separation plate 164 that is disposed vertically with respect to the plurality of reinforcement plates 120 and forms an inner space (void) together with the reinforcement plates 120. In addition, two holes H1 and H2 may be formed in the plurality of reinforcement plates 120. The first hole H1 and the second hole H2 are formed on opposite sides with respect to the separation plate 164, the second hole H2 is formed on the side of the inner space (void) of the reinforcement plate 120, and the first hole H1 may be formed on the opposite side, the protruding portion 165. The polymer may be injected on-site through the first hole H1, and the inner spaces of the reinforcement plates 120 may communicate with each other through the second hole H2.

[00334] B. Utilization as a Rudder Structure

[00335] By utilizing the lightweight structural member 100 of the present disclosure, a structure formed in a streamlined shape to generate lift, such as a rudder of a ship or a wing of an aircraft, can be manufactured more robustly and conveniently.

[00336] FIG. 43A illustrates butt welding, FIG. 43B illustrates slot welding, and FIG. 43C illustrates a rudder structure of a conventional ship.

[00337] Referring to FIG. 43C, a rudder of a conventional ship typically has a structure in which a first side plate 51 and a second side plate 52 form a body, and a plurality of horizontal reinforcing materials 53 and vertical reinforcing materials 54 are installed therein to support the structure when subjected to a load.

[00338] When manufacturing such a conventional rudder structure, if the first side plate 51 is welded first and then the second side plate 52 is subsequently joined by welding, since welding for the first side plate 51 is performed in a state in which the opposite surface is open, a sufficient working space is secured, enabling robust butt welding (FIG. 43A), whereas in the case of the second side plate 52, robust welding becomes difficult because it is difficult to secure a working space. Accordingly, it is common to work by adopting a slot welding method (FIG. 43B) for the second side plate 52, which is joined later, in which a hole is partially drilled in the plate and a weld bead is then formed in the hole to weld it to the internal horizontal and vertical reinforcing materials 53 and 54.

[00339] However, this slot welding method has a weaker bonding strength than butt welding, so cracks may occur due to vibration or load, and a fluid such as water may enter the unwelded portions, which may cause corrosion.

[00340] In addition, since a flange must be additionally welded for slot welding, the weight increases and the working time also increases. In addition, deformation may occur in the skin plate of the second side plate 52 constituting the body of the rudder due to welding heat generated in the process of welding the horizontal and vertical reinforcing materials 53 and 54, and this can be particularly problematic in structures such as a rudder of a ship or a wing of an aircraft, where a streamlined shape is very important for generating lift and reducing cavitation.

[00341] In contrast, the lightweight structural member 100 according to the present disclosure does not require welding of a plate reinforcing structure and is easy to perform curved processing due to the characteristic of being manufactured with a thin metal plate, and thus it is possible to easily implement a curved structure such as a rudder of a ship or a wing of an aircraft.

[00342] FIG. 44 is a view illustrating an exemplary embodiment in which the lightweight structural member according to the present disclosure is utilized as a rudder structure of a ship, and FIG. 45 is a view illustrating a cross-section taken along line A-B of the rudder structure illustrated in FIG. 44.

[00343] Referring to FIGS. 44 and 45, the rudder structure can be manufactured by applying the same manufacturing method as that of the lightweight structural member 100 according to the present disclosure. Specifically, a plurality of box-shaped reinforcement plates 120 having a polygonal cross-sectional structure therein are disposed at a predetermined interval (which may be disposed in two or more rows and two or more layers), and the upper plate 110 and the lower plate 130 are disposed and coupled as skin plates on both sides, and then a non-foaming polymer in a liquid state is injected into the space between the upper plate 110, the lower plate 130, and the reinforcement plate 120 and cured, thereby enabling manufacturing of a rudder structure having a robust internal reinforcing structure.

[00344] The upper plate 110 and the lower plate 130 may be provided as curved plates having a curvature, and may have a streamlined shape in which the end portions thereof are coupled to each other to generate lift. In this case, the end portions of the upper plate 110 and the lower plate 130 may be directly coupled by abutting each other, but may also be coupled via another plate.

[00345] When manufacturing is performed in the above-described manner, welding coupling is performed only at the edge portions of the upper plate 110 and the lower plate 130 forming both side surfaces of the structure, and thus there is no problem with workability at all. In addition, since the upper plate 110 and the lower plate 130 are coupled with sufficient bonding strength by the core layer 140 formed by injecting and curing a non-foaming polymer therein, there is no need at all to weld to internal

reinforcing materials as in the conventional case, so that the overall workability can rather be remarkably improved.

[00346] That is, the lightweight structural member 100 according to the present disclosure can easily implement the vertical and horizontal skeleton structure formed inside the rudder through an operation of injecting and curing a non-foaming polymer into the space between the upper plate 110, the lower plate 130, and the reinforcement plate 120.

[00347] In addition, structures such as a rudder of a ship or a wing of an aircraft are importantly required to be manufactured with a sealed structure in order to form lift, and when a rudder structure is implemented using the lightweight structural member 100 according to the present disclosure as described above, it is easy to form a sealed structure by the core layer 140 injected and cured in the inner space.

[00348] C. Utilization as a Cell Guide Structure for Container Ships

[00349] The lightweight structural member 100 according to the present disclosure may also be manufactured in a form in which a single protrusion protruding in a direction orthogonal to the flat plate part is formed, and the lightweight structural member 100 of this form may be very usefully utilized as a cell guide structure of a container ship.

[00350] A cell guide is provided for efficient container loading on a container ship, and is installed at regular intervals on a transverse bulkhead or web frame of a cargo hold of the container ship to guide the loading of containers.

[00351] A conventional cell guide has a structure in which two "L"-shaped metal angles having a thickness of approximately 10 to 15 mm are arranged to abut each other and an intermediate reinforcing material made of a metal material is welded therebetween to form a basic shape. This basic-shaped cell guide is transferred to an installation site

within a shipyard and then installed on the deck of a container ship at intervals of approximately 3 to 5 m in the height direction.

[00352] However, the conventional method has the inconvenience of having to weld thousands of intermediate reinforcing materials per container ship. The intermediate reinforcing materials must be disposed at intervals of approximately 1 m to form the basic shape of the angle, and as container ships have recently been gradually becoming larger, the size of the cargo hold has also increased, and as a result, an enormous amount of intermediate reinforcing materials must be welded.

[00353] Since automatic welding is nearly impossible for welding thousands of intermediate reinforcing materials, manual welding using manpower is mainly used, and thus there is a disadvantage in that an enormous amount of labor time is required. In addition, welding deformation phenomena, such as warping of the entire cell guide structure, frequently occur due to welding heat generated while welding thousands of intermediate reinforcing materials, and thus additional work is also required to correct this.

[00354] As such, the conventional cell guide structure has a fatal problem of poor accuracy. Since a cell guide is a structure that positions a container loaded onto a container ship, dimensional and shape accuracy control is very important. Even if there is an error of only a few millimeters, the container cannot smoothly slide down the cell guide, and damage to the container or the cell guide may occur during the descent, or the container may even become stuck midway, and noise may also be generated. In addition, since the conventional cell guide has a structure with no particular reinforcement other than the intermediate reinforcing material between the angle structures, a phenomenon of bending due to impact occurring during loading of the container frequently occurs.

[00355] However, when the lightweight structural member 100 according to the

present disclosure is used as a cell guide structure of a container ship, the following effects can be achieved.

[00356] The cell guide using the lightweight structural member 100 of the present disclosure is manufactured as a single composite structure, rather than a method in which an angle and an intermediate reinforcing material are separately manufactured, and thus there is no thousands of intermediate reinforcing materials that conventional cell guides included, and accordingly, the welding work resulting therefrom can be significantly reduced, saving enormous labor time and cost.

[00357] In addition, the weight can be greatly reduced. While general conventional cell guides use a metal angle having a thickness of 10 to 15 mm, when the lightweight structural member 100 according to the present disclosure is used, since the outer plate is composed of a thin plate of 2 to 5 mm with a light polymer injected therein, the overall weight of the cell guide structure can be reduced by approximately 30% or more compared to the conventional structure.

[00358] In particular, when the lightweight structural member 100 according to the present disclosure is used as a cell guide structure, welding deformation that occurs during conventional welding of intermediate reinforcing materials does not occur, and thus it has an excellent effect in terms of accuracy control during the manufacturing of the cell guide.

[00359] In addition, since the lightweight structural member 100 according to the present disclosure has a structure in which a polymer is uniformly injected throughout the entire structure, there is no structural vulnerability between the angle structures as in a conventional cell guide, and thus durability is also excellent.

[00360] As described above, when the lightweight structural member 100 according to the present disclosure is utilized as a ship structural member, the effect of

solving the existing welding thermal deformation problem can be achieved.

[00361] Conventionally, a general steel plate structural member of the type illustrated in FIG. 1 was mainly used to construct the deck of a ship, and as described in the background art, it was unavoidable that serious thermal deformation occurred as the plate reinforcement 20 was welded under the upper plate 10, which functions as a structural member. In addition, considering only the structural performance as a typical ship deck, the upper plate 10 of the steel plate structural member can simply be formed to a thickness of approximately 6 mm, but considering the thermal deformation due to welding of the plate reinforcement 20, the thickness of the upper plate 10 is frequently increased to approximately 10 mm from the beginning during manufacturing. However, even when the thickness of the upper plate 10 is increased, the problem of thermal deformation due to welding of the plate reinforcement 20 still persists, and thus, in most cases, a considerable amount of time is invested in corrective work through heat processing after welding the plate reinforcement 20.

[00362] However, the lightweight structural member 100 according to the present disclosure is in a form in which the vertical column portion functioning as a plate reinforcement is already included in the structure, and thus does not require welding for attachment of the plate reinforcement, thereby greatly reducing the amount of welding required for the entire process and the resulting thermal deformation. Accordingly, it is possible to fundamentally solve the problem of thermal deformation due to welding of steel plate structural members, which are still mainly used in the shipbuilding industry.

[00363] In addition, even when connecting adjacent lightweight structural members 100 according to the present disclosure to each other, since metallic finishing members are welded to each other, or lightweight structural members 100 whose rigidity is already secured by the core layer 140 formed therein are welded to each other, the

amount of thermal deformation of the entire plate can be greatly reduced.

[00364] In addition, since the lightweight structural member 100 according to the present disclosure, which is composed of a composite material, can implement equivalent structural performance with a weight that is approximately 40 to 50% lighter than that of conventional steel plate, it can also greatly contribute to the weight reduction of a ship.

[00365] (2) Construction Field

[00366] Since the inner space of the lightweight structural member 100 according to the present disclosure is mostly filled with a non-foaming polymer, it has a thermal conductivity at a level of 0.2 to 0.4 W/mK, similar to high-density wood. This means that it has an incomparably superior insulation performance compared to a general steel plate structural member ($k = 83$ W/mK) mainly used for ships, and also has superior insulation performance compared to reinforced concrete ($k = 1.6$ W/mK) used for construction. In addition, since the lightweight structural member 100 according to the present disclosure also has excellent performance in terms of vibration/noise reduction due to the role of the elastic non-foaming polymer, it can be sufficiently used not only as a structural member for ships but also as a floor or wall structure for land.

[00367] Representatively, both ends along the longitudinal direction of the lightweight structural member 100 according to the present disclosure may be structurally connected to a wall to form a floor or ceiling structure of a building.

[00368] Specifically, the lightweight structural member 100 according to the present disclosure may be used in a floor structure of a building, and in particular, since it can be manufactured as a long-span structure, it can be very usefully utilized in forming a double floor structure of a building. The composite material-based lightweight structural members may be overlappingly disposed at a predetermined interval to form a double floor structure.

[00369] In general, in a multi-story building such as an apartment, a house, an officetel, or a building, the portion between the upper and lower levels is divided by a concrete slab, and the concrete slab is used as the floor on the upper level and as the ceiling on the lower level. That is, a general multi-story building has a structure in which the floor structure of the upper level forms the ceiling structure of the lower level, and since one concrete slab is shared between two levels, it is fundamentally vulnerable to noise transmission through this.

[00370] The double floor structure is the most widely used method to solve this inter-floor noise problem, and the generally known conventional double floor structure is a structure in which an additional lightweight floor is installed on a concrete slab, that is, a method of forming two floors and disposing an air layer therebetween to block sound transmission.

[00371] However, since the structural strength of the lightweight floor is not as strong as that of a concrete floor in this conventional double floor structure, tens to hundreds of supports are required to be installed to support between the lightweight floor and the concrete slab, and thus, noise/vibration transmission through the numerous supports cannot be ignored. In addition, there are also problems such as increased installation labor and cost due to the requirement for installing a large number of supports.

[00372] However, since the lightweight structural member 100 according to the present disclosure can be manufactured as a long-span structure, sufficient structural performance can be secured simply by fixing only both ends along the longitudinal direction to the building wall, and thus, a sturdy and perfect double floor structure can be implemented without a separate lower support structure.

[00373] That is, when implementing a double floor structure of a building by forming an upper floor with the lightweight structural member 100 according to the

present disclosure, there is no need to install a separate support for supporting the lightweight structural member 100 on the concrete slab, and thus, the upper floor and the concrete slab are structurally completely separated, thereby enabling the implementation of a double floor structure that is very effective in reducing inter-floor noise.

[00374] The composite material-based lightweight structural member and a concrete or wooden structure may be disposed at a predetermined interval to form a double floor structure.

[00375] Meanwhile, the lightweight structural member 100 according to the present disclosure may also be installed under a concrete slab and utilized as a ceiling structure of a lower level. In this case, since the ceiling finishing material of the lower level can be directly attached to the lower surface of the lightweight structural member 100, separate support construction and carpentry work for attaching the ceiling finishing material is not required, and thus the effect of simplifying the ceiling construction can be achieved. In addition, since various pipes and fittings (for example, a ceiling-type air conditioner) to be installed on the ceiling can be easily attached to the lightweight structural member 100 according to the present disclosure, application of a modular construction method is also possible through prior fitting.

[00376] When the lightweight structural member 100 according to the present disclosure is utilized as a building structural member, the following operational effects can be expected.

[00377] First, it is possible to implement an ultra-lightweight long-span dry structure with remarkably superior structural performance, and when using this, the overall efficiency of construction work can be greatly increased.

[00378] Among construction works, reinforced concrete floor construction is the most cumbersome basic framework construction that takes up a large portion of the

construction period. In particular, since it is manufactured using a wet construction method that is greatly affected by environmental factors and has poor on-site conditions, it is considered one of the most important construction works in terms of construction management and performance implementation. Recently, there have also been cases where forcibly pushing forward with wet concrete slab construction to shorten the construction period has led to major accidents.

[00379] The lightweight structural member 100 presented in the present disclosure weighs only approximately 30 to 40% of general concrete, but it is possible to implement a much longer long-span structure compared to a conventional reinforced concrete floor structure. Above all, since construction can be performed by a dry method, it is hardly affected by environmental factors, and has the advantage of being able to dramatically reduce the cumbersome and poor on-site process. In addition, unlike a wet method, since structural performance is implemented immediately upon installation, the overall construction period can be significantly shortened.

[00380] In addition, by using the lightweight structural member 100 according to the present disclosure, it is possible to implement a sturdy double floor structure that does not require a support, and thus the inter-floor noise problem, which has become a major social issue, can be very remarkably reduced.

[00381] In addition, when the lightweight structural member 100 according to the present disclosure is used as a floor structure of a building, the floor leveling work for ondol can be simplified. Since the lightweight structural member 100 according to the present disclosure has remarkably superior structural performance, there is no need to construct ondol construction (heating construction) on a lightweight floor to increase structural strength as in a conventional double floor structure. Therefore, when the lightweight structural member 100 according to the present disclosure is installed on an

existing concrete slab, the work of hot water pipes or heating/cooling pipes required for ondol construction can be conveniently performed on the existing concrete, and there is an advantage in that there is no need to perform separate floor leveling mortar work.

[00382] In the conventional floor leveling work for ondol, since hot water pipes are disposed after installing an insulating material on a concrete slab, finishing flooring construction was possible only by performing floor mortar work or additionally installing a separate dry ondol panel in order to form a flat floor that can be walked on thereon.

[00383] However, since the lightweight structural member 100 according to the present disclosure performs a sufficient function as a structural member by itself, the separate floor mortar work or dry ondol panel installation work conventionally performed is not necessary, and since finishing flooring can be constructed directly on the lightweight structural member 100, the floor leveling work for ondol can be made much simpler.

[00384] Step construction can also be simplified. Generally, the floor of a bathroom or an entrance is designed to have a step of approximately tens of millimeters (mm) lower than other floor slabs, and in conventional construction methods, separate formwork or floor leveling work was required to form such a step. However, according to the present disclosure, since all floor slabs on the same level can be manufactured flat and step construction is performed only on the lightweight structural member 100, there is an advantage in that step construction is simplified, and the manufacturing of a step structure for the floor slab of a bathroom or an entrance also becomes very convenient.

[00385] In addition, when the lightweight structural member 100 according to the present disclosure is used as a ceiling structure of a building, the ceiling construction can be simplified as it becomes possible to directly attach the ceiling finishing material of the lower level to the lower surface of the lightweight structural member 100, and application

of a modular construction method also becomes possible through prior fitting in which various pipes and fittings to be installed on the ceiling are attached to the lightweight structural member 100 in advance.

[00386] (3) Other Fields

[00387] Since the lightweight structural member 100 according to the present disclosure is light yet has very excellent structural performance, it is expected to be usefully applied also as a structural member constituting an explosion-proof container or a high-pressure pressure vessel, or the like, which must withstand strong impact loads caused by an explosion.

[00388] The lightweight structural member 100 according to the present disclosure may be formed into a multi-stage deck structure (FIGS. 5 and 6) and used as a multi-stage deck-type container for storing and transporting heavy goods in an inner space. In particular, since the lightweight structural member 100 according to the present disclosure has excellent structural performance sufficient to withstand a strong impact load caused by an explosion, it may be usefully utilized as a waste battery container for the storage and transportation of waste batteries, the demand for which is rapidly increasing along with the rapid growth of the electric vehicle market.

[00389] Generally, explosion-proof containers or pressure vessels are manufactured in a spherical or cylindrical shape in order to withstand internal pressure well. However, the lightweight structural member 100 according to the present disclosure is structurally very robust due to the characteristic of being composed of a composite material, and since the plate reinforcing structure formed in the wall and the interior (which is utilized as a deck when used as a container) is configured in a continuous shape, remarkably superior structural performance can be implemented. Accordingly, by using the lightweight structural member 100 according to the present disclosure, the shape of

the explosion-proof container or pressure vessel is not limited to a spherical or cylindrical shape, and it becomes possible to manufacture it in an angular shape, including a hexahedral shape.

[00390] The present disclosure is not limited to the described exemplary embodiments, and it is obvious to those skilled in the art that various modifications and variations can be made without departing from the spirit and scope of the present disclosure. Accordingly, such modifications or variations should fall within the scope of the claims of the present disclosure.

[CLAIMS]

[Claim 1]

A first main plate;
a second main plate disposed at a predetermined interval from the first main plate;
a plurality of reinforcement plates disposed between the first main plate and the second main plate and having one or more bent portions; and
a core layer formed in a space between the first main plate and the reinforcement plate, a space between the second main plate and the reinforcement plate, and a space between the adjacent reinforcement plates,
wherein a plurality of column portions formed by the adjacent bent portions and the core layer formed therebetween are formed at a predetermined interval and function as a plate reinforcement,
a composite material-based lightweight structural member.

[Claim 2]

The composite material-based lightweight structural member of claim 1, wherein the first main plate, the second main plate, and the reinforcement plate are made of a metal or fiber-reinforced plastic material, and
the core layer is made of a non-metallic material.

[Claim 3]

The composite material-based lightweight structural member of claim 2, wherein the core layer is formed by injecting a non-foaming polymer raw liquid in a liquid state and curing the non-foaming polymer raw liquid.

[Claim 4]

The composite material-based lightweight structural member of claim 1, wherein a plate reinforcing structure is formed including a vertical reinforcing portion formed of

the column portion, and a horizontal reinforcing portion formed of the second plate, the reinforcement plate, and the core layer formed therebetween.

[Claim 5]

The composite material-based lightweight structural member of claim 1, wherein at least some of the plurality of reinforcement plates are provided in a tubular shape in which an empty space is formed therein.

[Claim 6]

The composite material-based lightweight structural member of claim 5, wherein the reinforcement plate has a polygonal or circular cross-sectional shape.

[Claim 7]

The composite material-based lightweight structural member of claim 5, having a multiple shielding structure formed of a composite material of metal and non-metal by the first main plate, the second main plate, the reinforcement plate, and the core layer.

[Claim 8]

The composite material-based lightweight structural member of claim 5, wherein the plurality of reinforcement plates are disposed in at least two or more rows or at least two or more layers between the first main plate and the second main plate.

[Claim 9]

The composite material-based lightweight structural member of claim 5, wherein an insulating material or a fireproof material is inserted and disposed in an inner space of the reinforcement plate.

[Claim 10]

The composite material-based lightweight structural member of claim 1, wherein at least one of an insulating material, a fireproof material, a pipe, and a metal reinforcing material is inserted and disposed inside the core layer.

[Claim 11]

The composite material-based lightweight structural member of claim 1, further comprising a finishing member that finishes at least one of an edge portion between the first main plate and the reinforcement plate and an edge portion between the second main plate and the reinforcement plate.

[Claim 12]

The composite material-based lightweight structural member of claim 1, wherein the first main plate is provided as a curved plate having a curvature.

[Claim 13]

The composite material-based lightweight structural member of claim 12, wherein the second main plate is provided as a curved plate having a curvature.

[Claim 14]

The composite material-based lightweight structural member of claim 13, wherein end portions of the first main plate and the second main plate are coupled to each other to have a streamlined shape that generates lift.

[Claim 15]

A cell guide structure of a container ship including a composite material-based lightweight structural member, comprising:

- a metallic first main plate;

- a metallic second main plate disposed at a predetermined interval from the first main plate; and

- a non-metallic core layer formed between the first main plate and the second main plate,

- wherein the core layer includes an extension portion that is formed thicker than other portions and protrudes toward one side, and

the second main plate includes at least two or more bent portions so as to surround the extension portion.