

DESCRIPTION

TITLE

OSCILLATION MITIGATION DEVICE AND FLOATING BODY PROVIDED WITH SAME

FIELD

[0001]

The present invention relates to an oscillation reducing device to be attached to a floating structure and to a floating structure equipped with the oscillation reducing device.

BACKGROUND

[0002]

Floating structures have been extensively used as floating facilities to be installed on oceans, lakes and reservoirs, and rivers in recent years. Examples of such floating structures include various working ships, drill boats, oil platforms, floating piers, floating warehouses, and floating parking places. The floating structures, which have no pole extending from the bottom of water, on one hand, have an advantage of simple constructions, and on the other hand have disadvantage of susceptible to rolling caused by waves impacting the floating structures. Thus, the rolling of the floating structures should be reduced.

[0003]

Rolling of the floating structure is induced by wave exciting force moment generated by waves. Since common floating structures do not have sufficient damping to the rolling movement, they have large rolling amplitudes at a wave period at and near their own natural periods. A variety of techniques have been proposed for reducing rolling of floating structures (for example, Patent Literatures 1 to 4).

[0004]

Patent Literature 1 discloses a floating structure provided with a plate suspended from a floating structure to a depth within a distance from the bottom of the sea so that hydrodynamic force acting to the plate increases additional

mass and viscous damping force of the plate and thus reduces the oscillation of the floating structure.

Patent Literature 2 discloses a floating structure provided with a tilted plate against the propagating direction of waves on the wave-incident side of the floating structure. The tilted plate extends from the waterline nearly to the bottom to reduce the oscillation of the floating structure.

[0005]

Patent Literature 3 discloses a floating structure provided with movable vertical plates extending downward from the bottom of the wave-incident side of the floating structure. The vertical plates are spaced at intervals so that water can flow through the spaces. Sloshing of the vertical plates can reduce the oscillation of the floating structure.

Patent Literature 4 discloses a box floating structure having a given ratio of the length to the width and another given ratio of the width to the draft. These ratios are controlled to lessen the impact of the wave force and thus to reduce the oscillation of the floating structure.

[Citation List]

[Patent Literature]

[0006]

[Patent Literature 1] Japanese Patent No. 4798573

[Patent Literature 2] Japanese Patent No. 4022973

[Patent Literature 3] Japanese Patent No. 3697091

[Patent Literature 4] Japanese Patent No. 3198698

SUMMARY

TECHNICAL PROBLEMS

[0007]

Unfortunately, the floating structure disclosed in Patent Literature 1 involves a difficulty in the installation of the oscillation reducing device on the ocean. The floating structure disclosed in Patent Literature 2 has a bottom side protruding from the waterline of the floating structure. The protrusion may hamper berthing of the floating structure at and near the waterline. The vertical plates of the floating

structure disclosed in Patent Literature 3 may work as a resistive mass to towing of the floating structure. The floating structures disclosed in Patent Literatures 1 to 3 inevitably require an oscillation reducing device having increased dimensions. The floating structure disclosed in Patent Literature 4 has a reduced degree of freedom on the shape.

[0008]

An object of the present invention, which has been made to solve such problems, is to provide an oscillation reducing device and a floating structure equipped with the oscillation reducing device. The oscillation reducing device has a simple structure without increases in dimensions, can certainly reduce the oscillation of the floating structure, and can reduce the resistance to the towing of the floating structure to facilitate berthing of the floating structure.

SOLUTION TO PROBLEMS

[0009]

(1) For achieving the object, an oscillation reducing device of the present invention comprises a plate disposed at a bottom corner between a side face and a bottom face of a floating structure, the plate having a base end being separated from the bottom corner to define a gap, the plate having a tip portion protruding outward from the side face of the floating structure; and a support fixed to the floating structure and supporting the plate; wherein the upward face of the plate functions as a guide face to converge water streams generated by spilling waves and propagating toward the side face and to guide the streams to the gap; the downward face of the plate functions as a resisting face that blocks water streams generated by an undertow component of waves and propagating away from the bottom face; and the support includes an arm to which the plate is fixed and a drive mechanism that moves the arm to move the plate between an operational position below a water surface and a raised position above the water surface.

[0010]

(2) The support should preferably have a retention

mechanism that holds the plate at one of the operational position and the raised position.

[0011]

(3) It is preferred that the plate is fixed to a lower end of the arm disposed vertically; and the drive mechanism includes a rack disposed on the arm along an axial direction, a drive pinion supported on an upper portion of the floating structure and engaging with the rack, and a guide member for shifting the arm in the vertical direction, and a motor for rotating the drive pinion.

[0012]

(4) It is preferred that the arm has a first arm segment and a second arm segment that are stretchably fixed, and a telescopic mechanism that expands or shrinks between the first arm segment and the second arm segment; the plate is fixed to the lower end of the second arm segment, and the first arm segment has a rack; and in the case of shifting the plate to the operational position, the telescopic mechanism is operated until the second arm segment is downward expanded from the first arm segment, and the motor is activated to lower the first arm segment.

[0013]

(5) It is preferred that the plate is fixed to a distal end of the arm; the proximal end of the arm is pivoted to an upper portion of the floating structure; and the drive mechanism has an actuator that pivots the arm, to unbend the arm in the vertical direction until the plate reaches the operational position or to bend the arm until the plate reaches the raised position on the floating structure.

[0014]

(6) It is preferred that the arm has a rock mechanism has a first arm segment and a second arm segment fixed to each other at a joint in a bendable manner, and a rock mechanism for keeping the stretched state of the first arm segment and the second arm segment, the plate is fixed to the distal end of the second arm segment, and the actuator is disposed at the proximal

end of the first arm segment and in the case of shifting the plate to the operational position, the actuator is operated until the distal end of the first arm segment is vertically unbent at the joint, and the rock mechanism is activated to fix the stretched state of the first arm segment and the second arm segment.

[0015]

(7) The gap between the base end of the plate and the bottom corner should preferably have a small size such that the water stream flowing along the upward face of the plate, through the gap, and beneath the bottom face forms a high-speed laminar flow in the vicinity of the bottom corner of the bottom face.

[0016]

(8) The plate should preferably have a sloping segment that extends from a neighboring region of the bottom corner to an obliquely downward region remote from the side face of the floating structure, at the operational position.

[0017]

(9) The plate should preferably have a drooping segment that extends vertically downward from a bend at the lower end of the sloping segment at the operational position.

[0018]

(10) The plate should preferably extend along the entire longitudinal side of the floating structure.

[0019]

(11) A floating structure of the present invention has a bottom corner between a side face and a bottom face; wherein the bottom corner is equipped with at least one oscillation reducing device described above.

[0020]

(12) The at least one oscillation reducing device comprises two oscillation reducing devices disposed on the two side faces, respectively, of the floating structure.

ADVANTAGEOUS EFFECTS

[0021]

According to the oscillation reducing device of the

present invention, the plate has an upward face that functions as a guide face to converge water streams generated by spilling waves and propagating toward the side face of the floating structure and to guide the streams to the gap the base end of the plate and the bottom corner. The water streams, as shown with normal arrows, are concentrated and accelerated to the gap and propagate through the gap and beneath the bottom face. The water streams moves at a high speed along the bottom face. A negative pressure is thereby generated below the bottom face in the vicinity of the bottom corner, and the downward force impinges on the bottom face of the bottom corner of the floating structure. Although spilling waves act to raise the side face of the floating structure, the negative pressure acts to offset the effect, resulting in a reduction in rolling of the floating structure due to spilling waves.

[0022]

The downward face of the plate functions as a resisting face that blocks the water streams that are generated by the undertow of the waves and propagate from the bottom face to the outside region; hence, the water streams urge the resisting face, so that an upward force impinges on the bottom face of the floating structure. The region below the bottom face in the vicinity of the bottom corner is pressurized. The urging force by the water streams offsets the force pressurizing the resisting face, resulting in a reduction in rolling of the floating structure due to undertow.

[0023]

The drive mechanism facilitates the installation of the plate at the operational position and the shift of the plate from the operational position to the raised position on the water surface. Since the fin does not act as a resistive mass during towing the floating structure, the floating structure can be smoothly towed without an increase in fuel consumption. Although the fin at the operational position protrudes away from the side face, the fin 20 can be moved above the water surface before berthing. The floating structure can thereby berth

without trouble.

BRIEF DESCRIPTION OF DRAWINGS

[0024]

Figure 1 is a perspective view illustrating an oscillation reducing device attached to a floating structure according to an embodiment of the present invention.

Figures 2A to 2D are cross-sectional views of floating structures illustrating the principle of operation of the oscillation reducing device according to embodiments of the present invention; Figure 2A illustrates the rolling of a floating structure not equipped with the apparatus; and Figures 2B to 2D illustrate the principle of operation of the apparatus.

Figures 3A to 3C illustrate the configuration of the oscillation reducing device according to a first embodiment of the present invention; Figure 3A is a cross-sectional view of the floating structure provided with a fin (plate) at a raised position; Figure 3B is a cross-sectional view of the floating structure with the fin at an operational position; and Figure 3C is an enlarged view illustrating the mechanism of the movement of the fin.

Figures 4A to 4C illustrate the configuration of the oscillation reducing device according to a second embodiment of the present invention; Figure 4A is a cross-sectional view of the floating structure provided with fins (plates) at a raised position; Figures 4B and 4C are cross-sectional views of the floating structures with one of the fins at an operational position; and Figure 4D is an enlarged view illustrating the mechanism of the movement of the fin.

Figures 5A to 5C illustrates the configuration of the oscillation reducing device according to a third embodiment of the present invention; Figure 5A is a cross-sectional view of the floating structure provided with a fin (plate) at an operational position; Figure 5B is a cross-sectional view of the floating structure with the moving fin on the way to the raised position; and Figure 5C is a cross-sectional view of the floating structure with the fin at the raised position.

Figure 6 is a cross-sectional view illustrating a shape of the fin (plate) according to embodiments of the present invention.

Figure 7 is a cross-sectional view illustrating a variation of a moving mechanism according to the first and second embodiments.

DESCRIPTION OF EMBODIMENTS

[0025]

Embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

In the following description, vertically upward is referred to as above upward; vertically downward is referred to as below or downward; the direction toward the center in the width direction of the side face of the floating structure is referred to as inside, inner, or inward; the opposite direction away from the center is referred to as outside, outer, or outward.

[0026]

The following embodiments are merely for illustrative purposes, and thus should not be construed to exclude various modifications or variations and application of techniques not described in the embodiments. The following individual configurations may be varied within the scope of the gist of the invention, may be selected as need arises, and may be combined appropriately.

[0027]

[Overview of oscillation reducing device]

With reference to Figure 1 and Figure 2 (Figures 2A to 2D), the oscillation reducing device according to embodiments will now be overviewed.

Figure 1 is a perspective view a floating structure equipped with the oscillation reducing device according to embodiments of the present invention. As shown in Figure 1, the floating structure 1 has a box shape (substantially cuboid) having a top or upper face 2, a bottom or lower face 3, two side

faces 4,4, and front and back faces 5,5. The side faces 4,4 are each provided with an oscillation reducing device 10 in the drawing. Alternatively, one of the side faces 4,4 may be provided with the oscillation reducing device 10. Alternatively, either or both the front and back faces 5,5 may be provided with one or two additional rolling apparatuses 10, in combination with one or more rolling apparatuses on the side face(s) 4.

[0028]

As shown Figure 1 and Figures 2A to 2D, the oscillation reducing device 10 is provided with a fin (plate) 20. The fin 20 is fixed with supports (not depicted in Figure 1) connected to the floating structure 1. The fin 20 has a base end(an upper end) 21 that is disposed at a bottom corner 6 between a side face 4 and a bottom face 3 of the floating structure 1 and is separated from the bottom corner 6 to define a gap 7. The tip portion protrudes outward from the side face of the floating structure 1.

[0029]

In embodiments, the fin 20 has a sloping segment 22 extending from a neighboring region of the bottom corner 6 to an obliquely downward region remote from the side face 4 and a drooping segment 23 extending vertically from a bend at the tip end of the sloping segment 22 at an operational position.

[0030]

The fin 20 has an upward face 22a (in detail, an upper outward face of the sloping segment 22) that functions as a guide face to converge water streams generated by spilling waves and propagating toward the side face 4 and to guide the streams to the gap 7.

[0031]

The gap 7 should preferably have a small size such that the water stream flowing along the upward face 22a of the fin 20, through the gap 7, and beneath the bottom face 3 forms a high-speed laminar flow in the vicinity of the bottom corner 6 of the bottom face 3.

[0032]

The fin 20 has a downward face 22b (in detail, a lower inward face of the sloping segment 22) and an inward face 23b of the drooping segment 23. The faces 22b and 23b function as resisting faces that block water streams generated by the undertow component of waves and propagating away from the bottom face 3.

[0033]

In Figure 2A, for example, when spilling waves attack the side face 4 from the left, the clockwise wave exciting force moment M_1 , shown with a white arrow in Figure 2A, is applied to the floating structure 1. If the oscillation reducing device 10 is not provided, the floating structure 1 would roll or vibrate laterally.

[0034]

In contrast, at the floating structure 1 equipped with the oscillation reducing device 10 as shown Figure 2B, the guide face 22a of the fin 20 concentrates the water streams generated by spilling waves and propagating toward the side face 4 to guide the water streams toward the gap 7 between the base end 21 of the fin 20 and the bottom corner 6, as shown in Figure 2D. The water streams, as shown with normal arrows, are concentrated and accelerated to the gap 7 and propagate through the gap 7 and beneath the bottom face 3; hence, the water streams moves in the form of a high-speed laminar flow along the bottom face 3. A negative pressure is thereby generated below the bottom face 3 in the vicinity of the bottom corner 6, and the downward force F_1 impinges on the bottom face of the bottom corner 6 of the floating structure 1. The force F_1 offsets the wave exciting force moment M_1 , resulting in a reduction in rolling of the floating structure 1 due to spilling waves.

[0035]

With reference to Figure 2C, the resisting faces 22b, 23b of the fin 20 blocks the water streams that are generated by the undertow of the waves and propagate from the bottom face 3 to the outside region; hence, the water streams urge the

resisting faces 22b, 23b, as shown with normal arrows, so that the region below the bottom face 3 in the vicinity of the bottom corner 6 (see Figure 2D) is pressurized. An upward force F_2 impinges on the bottom face 3 of the floating structure 1. Although the undertow generates a counterclockwise wave exciting force moment M_2 in the floating structure 1, the force F_2 offsets the wave exciting force moment M_2 , resulting in a reduction in rolling of the floating structure 1 due to undertow.

[0036]

In detail, as shown in Figure 2D, the oscillation reducing device 10 concentrates the water streams WF_1 caused by spilling waves and propagating toward the side face 4 at the guide face 22a of the fin 20, and guides the streams WF_1 through the gap 7 to a region beneath the bottom face 3 and blocks the water streams WF_2 through the gap 7 from the region beneath the bottom face 3 due to the undertow of waves at the resisting face 22b, 23b of the fin 20.

[0037]

As described above, the force F_1 and the force F_2 generated by spilling waves and undertow, respectively, of the water streams offset the wave exciting force moments M_1 and M_2 of the to reduce rolling of the floating structure 1.

The embodiments described below are characterized in that the floating structure 1 is equipped with an oscillation reducing device having a fin 20 for reducing rolling and that the fin 20 is movable between the operational position below the water surface and the raised position above the water surface.

[0038]

[First embodiment]

The oscillation reducing device 10A according to a first embodiment of the present invention will now be described. As shown in Figures 3A and 3B, a single oscillation reducing device 10A is disposed on one side face 4 of the floating structure 1 and has a fin 20 and supports 30A that are fixed to the floating

structure 1 and support the fin 20. It should be noted that the one side face 4 of the mooring floating structure 1 receives waves propagating from outer sea and is provided with the oscillation reducing device 10A.

[0039]

As described above, the fin 20 has a sloping segment 22 that extends from a neighboring region of the bottom corner 6 to an obliquely downward region remote from the side face 4 of the floating structure 1 and a drooping segment 23 that extends vertically from a bend at the tip end of the sloping segment 22 at an operational position.

[0040]

The upward face 22a of the sloping segment 22 of the fin 20 functions as a guide face that concentrates water streams generated by spilling waves and propagating toward the side face 4 from a remote region of the side face 4 and directs toward the gap 7 (see Figure 1) while the downward face 22b of the sloping segment 22 and the inward face 23b of the drooping segment 23 of the fin 20 function as resisting faces that block water streams generated by the undertow component of waves and propagating away from the bottom face 3.

[0041]

The fin 20 extends along the longitudinal side (along the bottom corner 6) and has a length over the substantially entire longitudinal side of the floating structure 1. The fin 20 is supported with supports 30A at several positions in the longitudinal direction, for example, at three points, i.e., two end portions and an intermediate portion, or at several points, i.e., two end portions and two or more intermediate portions. In this embodiment, the fin 20 is composed of a single component along the entire or substantially entire length of the floating structure 1. Alternatively, the fin 20 may be composed of several separate components along the longitudinal directions and each component may be supported with one or more supports 30A.

[0042]

Each support 30A has an arm 31A to which the fin 20 is fixed and a drive mechanism 32A to move the arm 31A and thus to move the fin 20 between the operational position below the water surface and the raised position above the water surface. In this embodiment, the arm 31A is a single component having a length substantially the same as the height of the floating structure 1, is vertically disposed, has a lower end to which the fin 20 is fixed, and is vertically moved with the drive mechanism 32A.

[0043]

With reference to Figure 3C, the drive mechanism 32A includes racks (linear trains of gears) 33 along the axis of the arm 31A, a drive pinion 34 supported at an upper portion of the floating structure 1 (upper portion of the side face 4 in this embodiment) and engaging with the racks 33, guide pinions or members 35, and a motor 36 for rotating the drive pinion 34. The drive pinion 34 and the guide pinions 35 are supported with brackets 37 at the upper portion of the side face 4. The motor 36 may be an electric motor or hydraulic motor.

[0044]

In this embodiment, the two racks 33 are disposed in parallel and back to back outside and inside the arm 31A. The drive pinion 34 and one of the guide pinion 35 are vertically disposed and engage with one (inner one in this embodiment) of the racks 33, whereas the other two guide pinions 35,35 are vertically disposed so as to face the drive pinion 34 and the inner guide pinion 35, respectively, and engage with the other (outer one in this embodiment) rack 33.

[0045]

When the motor 36 is activated to rotate the drive pinion 34, the rack 33 vertically moves to vertically shift the arm 31A. At the same time, the guide pinion 35 rotates in response to the movement of the rack 33, and shifts the arm 31A in the vertical direction with retention of the figure of the arm 31A. The motor 36 has a brake to restrict its rotation and the brake functions as a retention mechanism to keep vertical position

of the arm 31A and the fin 20.

[0046]

The oscillation reducing device 10A according to the first embodiment of the present invention has the configuration described above. In use of the oscillation reducing device 10A, as shown in Figure 3B, the drive mechanism 32A is activated to vertically shift the arm 31A until the fin 20 reaches a predetermined operational position below the water surface, and then the brake of the motor 36 is driven to fix the arm 31A. Such a configuration facilitates the installation of the oscillation reducing device 10A at the operational position to attenuate the rolling of the floating structure 1 with the oscillation reducing device 10A, as described above.

[0047]

During towing and berthing of the floating structure 1, as shown in Figure 3A, the drive mechanism 32A is activated to upward move the arm 31A until the fin 20 reaches a raised position above the water surface, and then the motor 36 is driven to fix the arm 31A.

Since the fin 20 does not act as a resistive mass during towing the floating structure 1, the floating structure 1 can be smoothly towed without an increase in fuel consumption.

[0048]

Although the fin 20 at the operational position protrudes away from the side face 4, the fin 20 can be moved above the water surface before berthing. The floating structure can thereby berth without trouble. It should be appreciated that the raised position of the fin 20 is set at a height above the level of the pier in view of berthing.

[0049]

In this embodiment, the floating structure 1 is equipped with a single oscillation reducing device 10A on one side face 4; hence, the installation cost of the oscillation reducing device 10A can be reduced. It should be noted that the floating structure 1 may be provided with two oscillation reducing devices 10A on two side faces 4 and any one of the side faces

4 may be directed to an offing.

[0050]

In this embodiment, one of four pinions (two pairs of pinions) 34,35 acts as the driving pinion. Alternatively, the two or more pinions may act as driving pinions. With the guide pinion 35, a roller may be disposed on a face not provided with the rack 33 of the arm 31A so that the arm 31A can be vertically moved. The retention mechanism keeping the fin 20 at the operational and raised positions may be replaced with any other mechanical stopper.

[0051]

[Second embodiment]

A rolling apparatus 10B according to a second embodiment of the present invention will now be described. The oscillation reducing device 10B has substantially the same configuration as that in the first embodiment, except that a support 30B of this embodiment has a configuration partially different from that in the first embodiment. Similar components to those in the first embodiment are denoted with similar reference signs to those in the first embodiment without redundant description, and the following description will be focused on the difference from the first embodiment.

[0052]

With reference to Figures 4A to 4C, two rolling apparatuses 10B according to the second embodiment of the present invention are provided with respective fins 20. These fins 20 are fixed to the respective side faces 4 of the floating structure 1. Each apparatus is provided with a support 30B bonded to the floating structure 1.

Each fin 20 has a sloping segment 22 extending from a neighboring region of the bottom corner 6 to an obliquely downward region remote from the side face 4 and a drooping segment 23 extending vertically from a bent at the tip end of the sloping segment 22 at an operational position.

[0053]

Each support 30B has an arm 31B to which the fin 20 is

fixed and a drive mechanism 32B to move the arm 31B and thus to move the fin 20 between the operational position below the water surface and the raised position above the water surface. The arm 31B and the drive mechanism 32B differ from those in the first embodiment.

[0054]

The arm 31B of this embodiment has a first arm segment 31a and a second arm segment 31b that are stretchably fixed, and a telescopic mechanism 38 that expands or shrinks between the first arm segment 31a and the second arm segment 31b. The first arm segment 31a and the second arm segment 31b after expansion has a length substantially the same as the height of the floating structure, like the arm 31A in the first embodiment.

[0055]

The first arm segment 31a has an inner hollow portion that can receive the second arm segment 31b. The inner periphery of the lower end of the hollow portion of the first arm segment 31a is tapered whereas the outer periphery of the upper end of the second arm segment 31b is flared. When the second arm segment 31b moves relative to the first arm segment 31a in an expanding manner, the taper and the flare as a retention mechanism are fit to each other to fix the second arm segment 31b at an expanded state.

[0056]

With reference to Figure 4D, the drive mechanism 32B includes racks (linear trains of gears) 33a along the axis of a first arm 31a; racks (linear trains of gears) 33b along the axis of a second arm 31b; a drive pinion 34a and a guide pinion (guide member) 35 supported at an upper portion of the floating structure 1 (upper portion of the side face 4) and engaging with the racks 33a; a motor 36a for rotating the drive pinion 34a; a drive pinion 34b and a guide pinion 35 engaging with the racks 33b; and a motor 36b for rotating the drive pinion 34b.

[0057]

In addition to these guide pinions 35, a pair of facing guide pinions 35 may further be disposed. While the motor 36a

is deactivated to fix the first arm segment 31a, the motor 36b is activated to shift the second arm segment 31b. The telescopic mechanism 38 includes rack and pinion mechanisms and respective motors 36a, 36b.

[0058]

The drive pinions 34a, 34b and the guide pinions 35 are fixed to the upper portion of the side face 4 with brackets (not shown in the drawing). The drive pinion 34b and the opposing guide pinion 35 that engage with the racks 33b, respectively, of the second arm segment 31b are detachably supported to the second arm segment 31b with a detaching mechanism (not shown in the drawing) as shown with transverse arrows in Figure 4D. These drive pinion 34b and guide pinion 35 are appropriately detached from the second arm segment 31b.

[0059]

When the motors 36a, 36b are activated, the drive pinions 34a, 34b rotate, the racks 33a, 33b vertically shift, and thus the arm 31B rises or falls. For example, the motor 36a is fixed with a brake while the motor 36b is activated to lower the arm 31B from the raised position, as shown in Figure 4D. The second arm segment 31b is moved relative to the first arm segment 31a in an expansion manner and then the taper and the flare are fit to keep the second arm segment 31b at the expanded state.

[0060]

In the next stage, the drive pinion 34b and the guide pinion 35 engaging with the racks 33b are detached from the second arm segment 31b and the motor 36a is then activated to lower the first arm segment 31a. The first arm segment 31a and the second arm segment 31b, which are mutually fixed in the expanded state, are lowered until the fin 20 drops to a predetermined operational position, and then the motor 36a is braked to fix the arm 31B.

[0061]

In a stage of raising the arm 31B from the lowered position, the drive pinion 34b and the guide pinion 35 engaging with the racks 33b is detached from the second arm segment 31b, and then

the motor 36a is activated to raise the first arm segment 31a. The first arm segment 31a and the second arm segment 31b, which are mutually fixed in the expanded state, are raised until the tops of the racks 33b of the second arm segment 31b rise to the position engageable with the drive pinion 34b and the guide pinion 35. After the drive pinion 34b and guide pinion 35 engage with the racks 33b, the motor 36a is fixed with the brake and the motor 36b is operated to raise the second arm segment 31b. The fit state between the taper and the flare is released by the torque of the motor 36b and the second arm segment 31b shifts relative to the first arm segment 31a in a shrinking manner. When the fin 20 reaches the raised position above the water surface, the brake of the motor 36b is activated to fix the arm 31B.

[0062]

The oscillation reducing device 10B according to the second embodiment of the present invention has the configuration described above. As shown in Figures 4B and 4C, the fin 20 of required one of the side faces 4 can be readily settled at an operational position below the water surface, resulting in a reduction in rolling of the floating structure by the effect of the fin 20 of the oscillation reducing device 10B, like the first embodiment.

[0063]

In the case that the floating structure 1 is towed or berthed, as shown in Figure 4A, the drive mechanism 32B is operated to shift the arm 31B in the vertically upward direction until the fin 20 reaches the raised position above the water surface, and then the brake of the motors 36a, 36b is activated to fix the arm 31B. Such an operation facilitates smooth towing of the floating structure 1 without an increase in fuel consumption and t berthing of the floating structure 1 without trouble.

[0064]

In this embodiment, two oscillation reducing devices 10B are disposed on the respective side faces 4, 4 of the floating

structure 1. Alternatively, a single oscillation reducing device 10B may be disposed on one of the side faces 4 of the floating structure 1.

[0065]

[Third embodiment]

A rolling apparatus 10C according to a third embodiment of the present invention will now be described. The oscillation reducing device 10C has substantially the same configuration as that in the first embodiment, except that a support 130 of this embodiment has a configuration different from that in the first embodiment. Similar components to those in the first embodiment are denoted with similar reference signs to those in the first embodiment without redundant description, and the following description will be focused on the difference from the first embodiment.

[0066]

With reference to Figures 5A to 5C, a single rolling apparatus 10C according to the third embodiment of the present invention is provided with a fin 20. The fin 20 is fixed to one of the side faces 4 of the floating structure 1. The apparatus is provided with a support 130 bonded to the floating structure 1.

The fin 20 has a sloping segment 22 extending from a neighboring region of the bottom corner 6 to an obliquely downward region remote from the side face 4 and a drooping segment 23 extending vertically from a bent at the tip end of the sloping segment 22 at an operational position.

[0067]

The arm 131 has a proximal end and a distal end. The proximal end is pivoted to an upper portion of the floating structure 1 and the distal end is fixed to fin 20. A drive mechanism 132 is also equipped to pivot the arm 131. The drive mechanism 132 has an actuator 136 that pivots to unbend the arm 131 in the vertical direction until the fin 20 reaches the operational position or to bend the arm 131 until the fin 20 reaches the raised position on the floating structure 1.

[0068]

The arm 131 in this embodiment includes a first arm segment 131a and a second arm segment 131b fixed to each other at a joint 131c in a bendable manner. With reference to Figure 5A, a rock mechanism (not shown in the drawing) is disposed to keep the stretched state of the first arm segment 131a and the second arm segment 131b. The fin 20 is fixed to the distal end (remote from the joint 131c) of the second arm segment 131b, and the actuator 136 is disposed at a proximal end 131d of the first arm segment 131a. The actuator 136 may be a hydraulic or electric actuator.

[0069]

With reference to Figure 5A, to shift the fin 20 to the operational position, the actuator 136 is operated until the distal end of the first arm segment 131a is vertically unbent at the joint 131c, and the rock mechanism is activated to fix the stretched state of the first arm segment 131a and the second arm segment 131b. The actuator 136 is then inactivated.

[0070]

To return the fin 20 from the operational position to the raised position, rock mechanism is released, so that the first arm segment 131a and the second arm segment 131b are bendable. With reference to Figure 5B, the actuator 136 is operated as follows: The distal end (at the joint 131c) of the first arm segment 131a is raised, the first arm segment 131a is further turned above the floating structure 1 and fixed on the top face 2 of the floating structure 1, and the actuator 136 is deactivated.

[0071]

The oscillation reducing device 10C according to the third embodiment of the present invention has the configuration described above. As shown in Figure 5A, the fin 20 can be readily settled at an operational position below the water surface, resulting in a reduction in rolling of the floating structure 1 by the effect of the fin 20 of the oscillation reducing device 10C, like the first embodiment.

[0072]

In the case that the floating structure 1 is towed or berthed, as shown in Figure 5C, the drive mechanism 132 is operated to shift the arm 131 with the actuator 136 in the vertically upward direction until the fin 20 reaches the raised position above the water surface, and then the actuator 136 is deactivated. Such an operation facilitates smooth towing of the floating structure 1 without an increase in fuel consumption and to berthing of the floating structure 1 without trouble.

[0073]

In this embodiment, a single oscillation reducing device 10C is disposed on one of the side face 4 of the floating structure 1. Alternatively, two single oscillation reducing devices 10C may be disposed on the respective side faces 4,4 of the floating structure 1.

[0074]

[Shape and geometry of fin]

The shape and geometry of the fin will now be described.

Figure 6 is a transverse cross-sectional view of the fin 20 in use according to the embodiments.

As described above, the fin 20 has a sloping segment 22 that extends from a neighboring region of the bottom corner 6 to an obliquely downward region remote from the side face 4 of the floating structure 1 and a drooping segment 23 extending vertically from a bend at the lower end of the sloping segment 22 at an operational position.

[0075]

It has been confirmed that the cross-sectional structure having the sloping segment 22 and the drooping segment 23 exhibits the highest reduction in oscillation through simulation tests. In addition, optimum values of dimensions and other parameters of individual components were investigated by simulation tests.

[0076]

Define "d" as the depth from the water surface of the bottom face 3 of the floating structure 1; "s" as the vertical

position of the base end 21 of the fin 20 to the floating structure 1, where the value is positive if the position lies below the bottom face 3 of the floating structure 1; "x0" as the horizontal position of the base end 21 of the fin 20 to the floating structure 1, where the value is positive if the position lies at an inner position remote from the side face 4 of the floating structure 1; "b" as the length of the sloping segment 22; "θ" as the inclination angle of the sloping segment 22 from the vertical line; and "h" as the length of the drooping segment 23.

Simulation tests were carried out while these parameters were being modified in a variety of ranges. The following parameters are effective for a reduction in oscillation.

[0077]

[Table 1]

Control parameters			Numerical range
Geometrical parameters	Width of drooping segment	h/b	$0 < h/b \leq 1$
	Width of sloping segment	b/d	$0.05 \leq b/d \leq 0.5$
	Inclination of sloping segment	θ	$0^\circ \leq \theta \leq 90^\circ$
Configurational parameters	Gap width	s/d	$0.01 \leq s/d \leq 0.2$
	Horizontal position	x_0	$0 \leq x_0 \leq b \times \sin \theta$

[0078]

The shapes and geometries shown in Table 1 are preferred.

Since the fin 20 is vertically moved in the first and second embodiments, the parameter "x0" should be less than zero to avoid interference of the fin 20 with the side face 4. In order to achieve a maximum state in the first and second embodiments, a mechanism is provided which shifts the fin 20 or the supports 30A,30B toward the center of the floating structure and to an operational position, as shown by two-dot chain lines in Figure 7, in addition to a mechanism that vertically shifts the fin 20.

[0079]

[Further information]

The embodiments described above may be appropriately

modified or combined with each other within the scope of the present invention.

For example, the fin 20 has specific cross-sectional shapes and geometries in these embodiments; however, the fin 20 may have any other cross-sectional shape and geometry.

[0080]

At least the base end of the fin is disposed at a bottom corner and is separated from the bottom corner to define a gap and the tip portion protrudes outward from the side face of the floating structure. The upward face of the fin functions as a guide face that converges water streams generated by spilling waves and propagating toward the side face and guides the streams to the gap. The downward face of the fin functions as a resisting face that blocks water streams generated by the undertow component of waves and propagating away from the bottom face.

REFERENCE SIGNS LIST

[0081]

- 1 floating structure
- 2 top face (upper face)
- 3 bottom face (lower face)
- 4 side face
- 5 front or back face
- 10, 10A, 10B, 10C oscillation reducing device
- 20 fin (plate)
- 21 base end of fin 20
- 22 sloping segment
- 22a upward face (guide face) of sloping segment 22
- 22b downward face (resisting face) of sloping segment 22
- 23 drooping segment
- 23b inward face (resisting face) of drooping segment 23
- 30A, 30B, 130 support
- 31A, 31B arm
- 31a, 131a first arm segment
- 31b, 131B second arm segment
- 32A, 32B, 132 drive mechanism

33, 3a, 33b rack
34, 34a, 34b drive pinion
35 guide pinion (guide member)
36, 36a, 36b motor
37 bracket
38 telescopic mechanism
136 actuator

CLAIMS

1. An oscillation reducing device comprising:
 - a plate disposed at a bottom corner between a side face and a bottom face of a floating structure, the plate having a base end being separated from the bottom corner to define a gap, the plate having a tip portion protruding outward from the side face of the floating structure; and
 - a support fixed to the floating structure and supporting the plate; wherein
 - an upward face of the plate functions as a guide face to converge water streams generated by spilling waves and propagating toward the side face and to guide the streams to the gap;
 - a downward face of the plate functions as a resisting face that blocks water streams generated by an undertow component of waves and propagating away from the bottom face; and
 - the support includes an arm to which the plate is fixed and a drive mechanism that moves the arm to move the plate between an operational position below a water surface and a raised position above the water surface.
2. The oscillation reducing device of claim 1, wherein the support has a retention mechanism that holds the plate at one of the operational position and the raised position.
3. The oscillation reducing device of Claim 1 or 2, wherein the plate is fixed to a lower end of the arm disposed vertically; and
 - the drive mechanism includes a rack disposed on the arm along an axial direction, a drive pinion supported on an upper portion of the floating structure and engaging with the rack, and a guide member for shifting the arm in the vertical direction, and a motor for rotating the drive pinion.
4. The oscillation reducing device of Claim 3, wherein the arm has a first arm segment and a second arm segment

that are stretchably fixed, and a telescopic mechanism that expands or shrinks between the first arm segment and the second arm segment;

the plate is fixed to the lower end of the second arm segment, and the first arm segment has a rack; and

in the case of shifting the plate to the operational position, the telescopic mechanism is operated until the second arm segment is downward expanded from the first arm segment, and the motor is activated to lower the first arm segment.

5. The oscillation reducing device of Claim 1 or 2, wherein the plate is fixed to a distal end of the arm;

a proximal end of the arm is pivoted to an upper portion of the floating structure; and

the drive mechanism has an actuator that pivots the arm, to unbend the arm in the vertical direction until the plate reaches the operational position or to bend the arm until the plate reaches the raised position on the floating structure.

6. The oscillation reducing device of Claim 5, wherein

the arm has a rock mechanism has a first arm segment and a second arm segment fixed to each other at a joint in a bendable manner, and a rock mechanism for keeping the stretched state of the first arm segment and the second arm segment,

the plate is fixed to a distal end of the second arm segment, and the actuator is disposed at a proximal end of the first arm segment; and

in the case of shifting the plate to the operational position, the actuator is operated until the distal end of the first arm segment is vertically unbent at the joint, and the rock mechanism is activated to fix the stretched state of the first arm segment and the second arm segment.

7. The oscillation reducing device of any one of Claims 1 to 6, wherein

the gap between the upper end of the plate and the bottom

corner has a small size such that the water stream flowing along the upward face of the plate, through the gap, and beneath the bottom face forms a high-speed laminar flow in the vicinity of the bottom corner of the bottom face.

8. The oscillation reducing device of any one of Claims 1 to 7, wherein

the plate has a sloping segment that extends from a neighboring region of the bottom corner to an obliquely downward region remote from the side face of the floating structure, at the operational position.

9. The oscillation reducing device of any one of Claim 8, wherein

the plate has a drooping segment that extends vertically downward from a bend at the lower end of the sloping segment at the operational position.

10. The oscillation reducing device of any one of Claims 1 to 9, wherein

the plate extends along the entire longitudinal side of the floating structure.

11. A floating structure having a bottom corner between a side face and a bottom face; wherein

The bottom corner is equipped with at least one oscillation reducing device of any one of Claims 1 to 10.

12. The floating structure of Claim 11, wherein

the at least one oscillation reducing device comprises two oscillation reducing devices disposed on the two side faces, respectively, of the floating structure.