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(54) **STRENGTH TEST METHOD FOR ANCHOR INSTALLED UNDERWATER AND FLOATING BODY**

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(57) **ABSTRACT**

A simplified structure allows inspection of the installation strength of an anchor installed underwater. A method includes applying, to an anchor, a lifting force from above a floating body floating on a water surface to submerge the floating body into water, and setting a volume of submergence by which the floating body is submerged to a value to produce a lifting force corresponding to a predetermined installation strength and determining whether the anchor is immovable. The volume of submergence by which the floating body is submerged to produce the lifting force corresponding to the predetermined installation strength is calculated based on the buoyancy acting on the floating body.

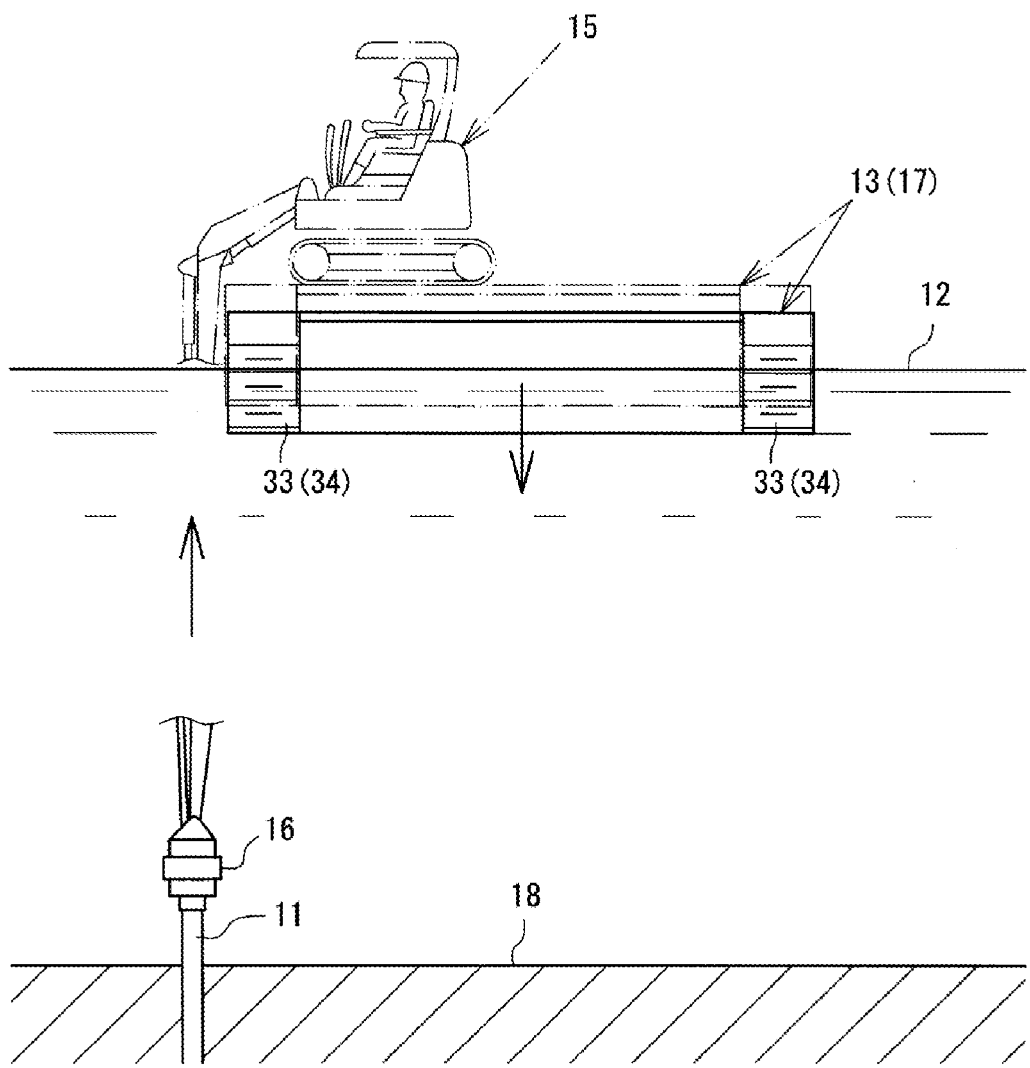


FIG. 1

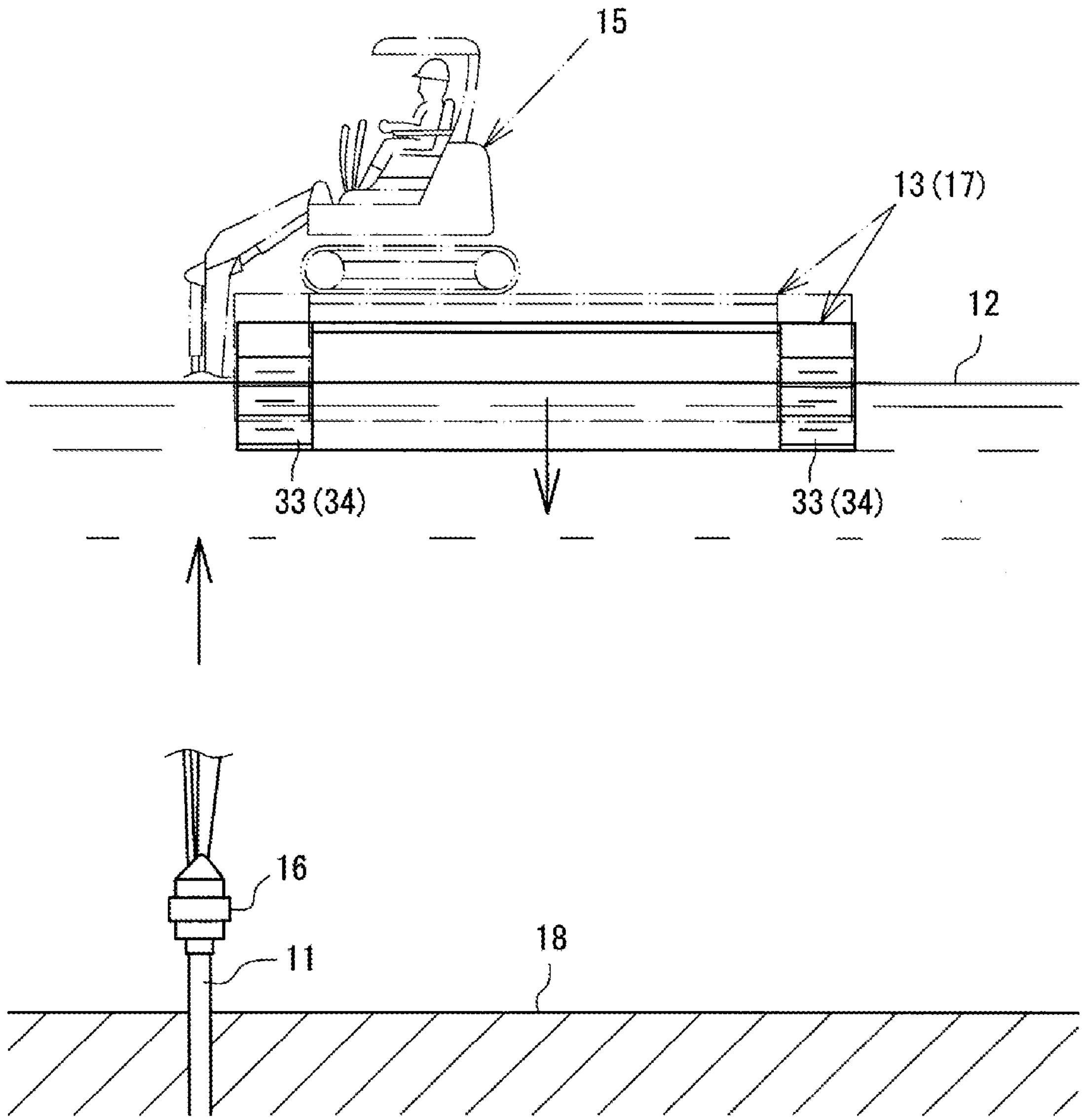


FIG. 2

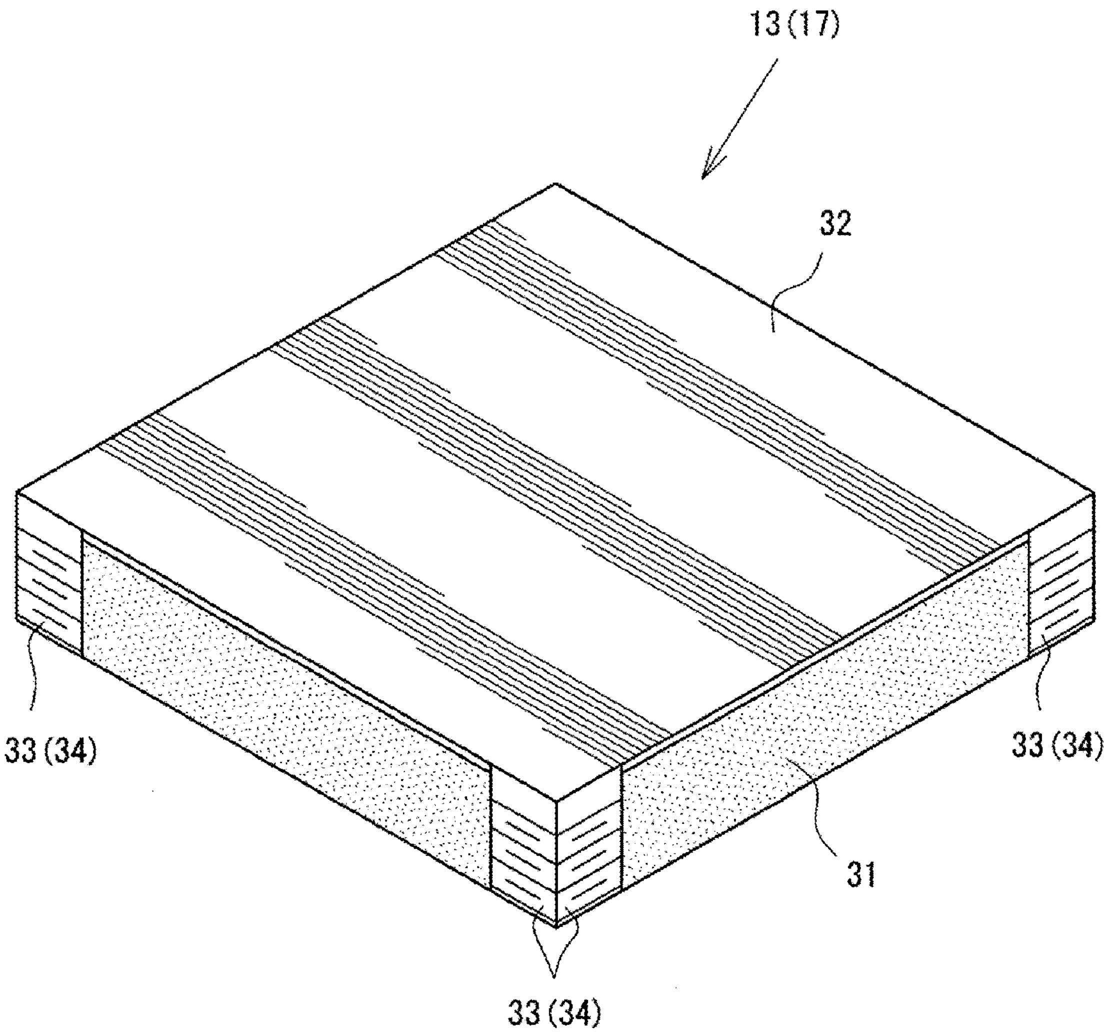


FIG. 3

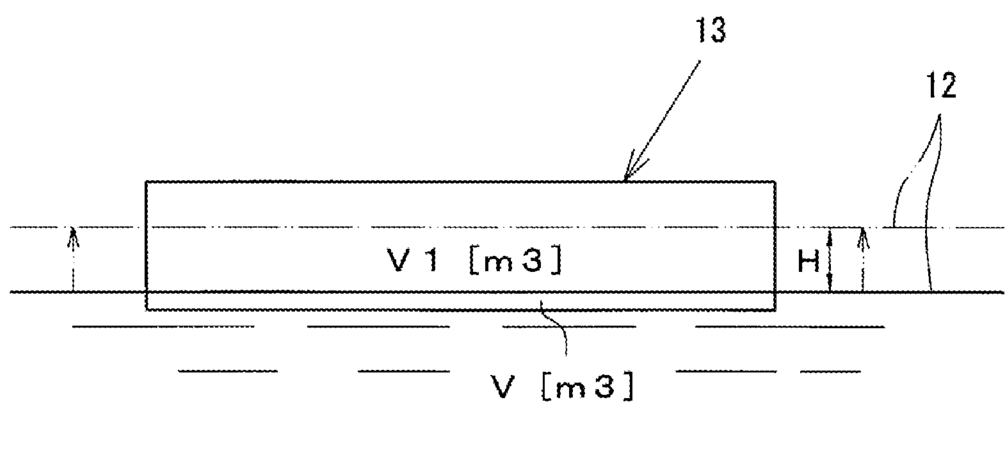
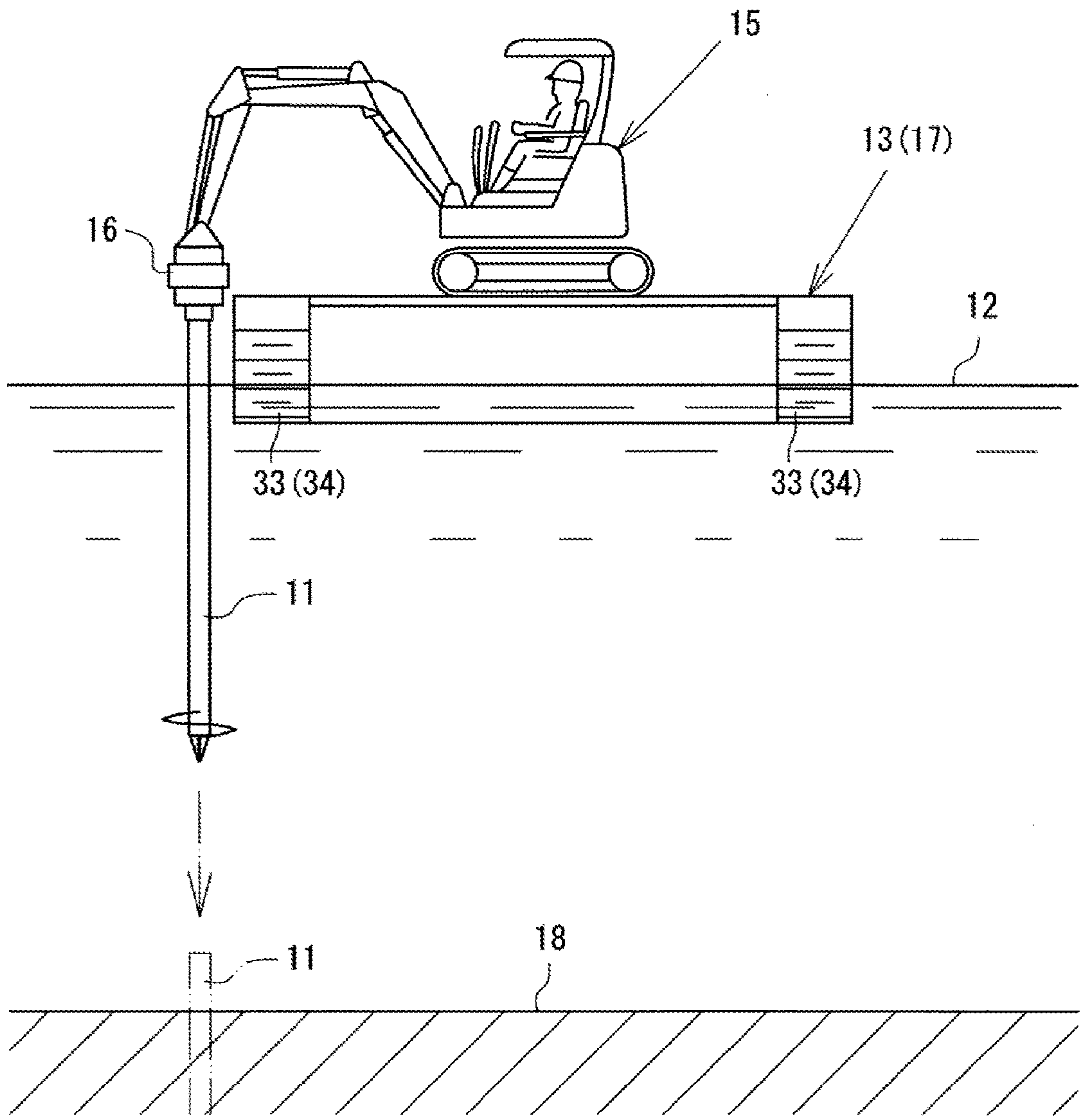


FIG. 4



STRENGTH TEST METHOD FOR ANCHOR INSTALLED UNDERWATER AND FLOATING BODY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation application of International Patent Application No. PCT/JP2018/016556 filed on Apr. 24, 2018, the entire content of which is incorporated by reference.

BACKGROUND OF INVENTION

Field of the Invention

[0002] The present invention relates to a strength test method for an anchor installed underwater for testing whether an anchor for various mooring targets, such as floating photovoltaic power systems, aquaculture cages, floating piers, and water sports facilities, has an intended tensile strength.

Background Art

[0003] A method for inspecting the installation state of an anchor is described in Patent Literature 1.

[0004] This inspection method includes lifting a rod of an installed anchor with a hollow hydraulic jack and determining whether a load indicated by a hydraulic gauge reaches an intended resistance against pulling. The hydraulic jack is included in a lifting structure placed at the water bottom under a floating platform.

[0005] The method uses large equipment for inspection, including the lifting structure placed at the water bottom, in addition to the floating platform, and further a holder for the hollow hydraulic jack in the lifting structure.

CITATION LIST

Patent Literature

[0006] Patent Literature 1: Japanese Patent No. 6252882

SUMMARY OF INVENTION

Technical Problem

[0007] One or more aspects of the present invention are directed to a simplified structure for inspecting an anchor.

Solution to Problem

[0008] A strength test method for an anchor installed underwater includes applying, to an anchor installed underwater, a lifting force from above a floating body floating on a water surface to submerge the floating body into water, and setting a volume of submergence by which the floating body is submerged to a value to produce a lifting force corresponding to a predetermined installation strength and determining whether the anchor is immovable.

[0009] The volume by which the floating body is submerged to produce the lifting force corresponding to the predetermined installation strength is calculated based on the buoyancy acting on the floating body.

[0010] In the structure, the anchor is pulled from above the floating body to submerge a portion of the floating body exposed above the water surface into the water and to apply the lifting force corresponding to the predetermined installation strength to the anchor. When the anchor remains installed, the anchor is determined to have the installation strength. When the anchor fails to remain installed, the anchor is determined to lack the strength. The anchor lacking the strength is pulled up, thus readily moving the floating body and revealing insufficient installation of the anchor.

Advantageous Effects

[0011] The method according to the above aspect of the present invention enables the inspection with a simple operation of pulling the installed anchor from above the floating body to submerge the floating body by a predetermined volume into the water. The structure simply includes at least the floating body and a device for determining the volume by which the floating body is submerged.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. **1** is a diagram describing a strength test method for an anchor installed underwater.

[0013] FIG. **2** is a perspective view of a floating body.

[0014] FIG. **3** is a diagram describing a depth of submergence and a volume of submergence.

[0015] FIG. **4** is a diagram describing a method for installing an anchor.

DETAILED DESCRIPTION

[0016] One embodiment of the present invention will now be described with reference to the drawings.

[0017] FIG. **1** is a diagram describing a strength test method for an anchor installed underwater. The test method includes applying, to an anchor **11** installed underwater by embedding or driving, a lifting force or a vertically upward force from above a floating body **13** floating on a water surface **12** to submerge the floating body **13** into the water. The amount or the volume of submergence is set to a value to produce a lifting force corresponding to an intended installation strength. The method then determines whether the anchor **11** is immovable. When immovable, the anchor **11** passes the test. When moved in the pulling direction, the anchor **11** fails the test.

[0018] The test method uses the floating body **13**. The floating body **13** floats on the water. More specifically, the floating body **13** has a bottom surface submerged in the water and an upper portion including the upper surface exposed above the water surface. When the predetermined pulling force described above is applied to the anchor **11** from above, the floating body **13** with buoyancy does not entirely become submerged in the water.

[0019] FIG. **2** is a perspective view of an example of the floating body **13**. The floating body **13** is a thick polystyrene board that is square in a plan view. The floating body **13** includes a polystyrene floating board **31** and a hard protective metal plate **32** on the upper surface of the floating board **31**. The floating board **31** is solid and includes thick polystyrene boards combined together.

[0020] The floating body **13** includes gauges **33** to indicate the depth or the volume by which the floating body **13** is submerged in the water. The gauges **33** indicating the depth of submergence can be simpler.

[0021] The gauges **33** shown in FIG. **2** are scale plates **34** including scale marks indicating the length (height) of the floating body **13** in the vertical direction, or more specifically, in the thickness direction. The scale plates **34** may be fixed at appropriate positions or, for example, at the four corners. The scale plates **34** at such positions are easily viewable and can protect the corners of the floating body **13** when formed from a hard material.

[0022] Referring now to FIG. **3**, the volume by which the floating body **13** is submerged to produce a lifting force corresponding to an intended installation strength will now be described.

[0023] The buoyancy acting on the floating body **13** is ρVg (N), where g (m/s^2) is a gravitational acceleration, ρ (kg/m^3) is the density of water, and V (m^3) is the volume of a portion of the floating body **13** submerged below the water surface **12**.

[0024] The floating body **13** having a mass m (kg) is also under a gravitational force with a magnitude mg (N), which is balanced with the buoyancy (ρVg=mg). Thus, the volume V of the portion submerged in the water is

$$V=m/\rho,$$

indicating that the floating body **13** is submerged in the water by m/ρ (m^3).

[0025] Buoyancy is proportional to the volume of a submerged portion in the water. Thus, a volume V**1** (m^3) by which the floating body **13** is to be submerged to produce a lifting force corresponding to an intended installation strength is obtained. With this volume of submergence and the dimensions of the floating body **13**, a depth H of submergence for the floating body **13** is obtained as, for example, 10 cm for producing a lifting force of 2 t (ton).

[0026] For the floating body **13**, a machine is used to pull the anchor **11** installed underwater. As indicated by the imaginary lines in FIG. **1**, the anchor **11** is pulled by a construction machine **15**, such as a hydraulic excavator. The construction machine **15** in use has a piling attachment **16** attached to the distal end of the arm.

[0027] As shown in FIG. **4**, the construction machine **15** with the piling attachment **16** is also used to drive or embed the anchor **11**. The floating body **13** is used as a working platform **17** for placing the construction machine **15** on the water. In other words, the floating body **13** used for the strength test also serves as the working platform **17** for installing the anchor **11**.

[0028] The installation strength test for the anchor **11** using the floating body **13** and the construction machine **15** is performed consecutively to the installation of the anchor **11**.

[0029] More specifically, the construction machine **15** is placed on the floating body **13** used as the working platform **17**, and the floating body **13** is towed to a site on the water under which the anchor is to be installed. At the site, the construction machine **15** holds the upper end of the anchor **11** and drives the anchor **11** into a water bottom **18** as shown in FIG. **4**. This completes the installation of the anchor **11**.

[0030] While holding the upper end of the anchor **11**, the construction machine **15** subsequently pulls the anchor **11**. The anchor **11** driven into the water bottom **18** is not easily pulled out. As indicated by the solid lines in FIG. **1**, the portion of the floating body **13** exposed above the water surface **12** is submerged into the water.

[0031] The volume to be submerged by pulling is set to a value for producing the predetermined lifting force described above. The volume by which the floating body **13** is submerged is determined with the gauges **33** included in the floating body **13**.

[0032] More specifically, the position of the water surface **12** before the submergence is determined with the scale plates **34** serving as the gauges **33**. For example, when a depth of submergence of 10 cm produces a lifting force of 2 t, which corresponds to the intended installation strength, a lifting force is applied to the anchor **11** until the floating body **13** is submerged 10 cm deeper from the yet submerged water surface **12**. The scale plates **34** may be checked from above the floating body **13** or may be checked by a diver entering the water for installing the anchor **11**.

[0033] Although the floating body **13** may be inclined by a lifting force applied to the anchor **11**, the scale plates **34**, having the scale marks at the four corners indicating the depth of submergence, allow determination of the submergence depth at each corner. This allows easy calculation of the predetermined volume of submergence.

[0034] After the depth of submergence reaches a predetermined depth, the floating body **13** retains the state for a predetermined duration. In other words, the floating body **13** retains the state of being submerged by the predetermined volume. The duration is determined as appropriate in accordance with, for example, the use of the anchor **11**, an intended installation strength, and an underwater environment. The duration is not excessively long and may be several to ten and several minutes, or more specifically about five minutes, to demonstrate the intended installation strength.

[0035] When the anchor **11** remains immovable after being pulled for the duration, the anchor **11** passes the test. When the anchor **11** is lifted, the anchor **11** fails the test and is reinstalled immediately. The anchor **11** installed improperly is lifted, allowing the diver working underwater to notice the movement. The operator operating the construction machine **15** also readily senses the movement, rather than with the digital numbers indicated on the machine.

[0036] As described above, the inspection includes the simple operation of pulling the anchor **11** from above the floating body **13** to submerge the floating body **13** in the water by a predetermined volume. The volume by which the floating body **13** is submerged is determined with the gauges **33** included in the floating body **13**. The operation includes simply pulling the anchor **11** while checking the gauges **33**, and is easy.

[0037] The operation uses the floating body **13** including the gauges **33**. The anchor **11** is pulled with the construction machine **15** as described above. The floating body **13** eliminates a fixed, dedicated machine (not shown) for pulling the anchor **11**. The floating body **13** can thus have a simpler structure, simplifying the entire equipment for the test.

[0038] In particular, the floating body **13** also serves as the working platform **17** for installing the anchor **11**, further simplifying the entire equipment.

[0039] The installation of the anchor **11** and the test on the installation strength are performed consecutively. This increases the operation efficiency, and provides higher reliability in determining the installation strength than in the inspection performed a predetermined time after the installation.

[0040] The reliability is further increased by retaining the submerged state of the floating body **13** for a duration in the installation strength test, after simply submerging the floating body **13** by the predetermined volume.

[0041] The structure described above is one example for implementing the present invention. The present invention is not limited to the structure described above and may include other structures.

[0042] The gauges **33** may include, rather than scale marks for indicating the depth of submergence as described above, other components including a float on the water surface **12** to allow determination of the depth of the actual submergence with a sense rather than with scale marks. The gauges **33** may also include a member that indicates the portion submerged in the water by changing its appearance.

REFERENCE SIGNS LIST

[0043] **11** anchor

[0044] **12** water surface

[0045] **13** floating body

[0046] **17** working platform

[0047] **33** gauge

1. A strength test method for an anchor installed underwater, the method comprising:

applying, to an anchor installed underwater, a lifting force from above a floating body floating on a water surface to submerge the floating body into water; and

setting a volume of submergence by which the floating body is submerged to a value to produce a lifting force corresponding to a predetermined installation strength and determining whether the anchor is immovable.

2. The strength test method according to claim **1**, further comprising:

retaining the floating body being submerged by the volume of submergence having the set value.

3. The strength test method according to claim **1**, further comprising:

determining the volume of submergence by which the floating body is submerged with a gauge included in the floating body.

4. The strength test method according to claim **1**, wherein

the floating body includes a working platform used to install the anchor.

5. A floating body configured to float on a water surface to conduct an installation strength test for an anchor installed underwater, the floating body comprising:

a gauge configured to indicate a depth or a volume by which the floating body is submerged in water.

6. The floating body according to claim **5**, wherein

the floating body comprises polystyrene.

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