

METHOD AND DEVICE FOR DETERMINING THE MECHANICAL PROPERTIES OF AN UNDERWATER BOTTOM

TECHNICAL FIELD OF THE INVENTION

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The invention relates to a device and method for determining the mechanical properties of an underwater bottom, and particularly of a mass of rocks ('rock mound') lying under water.

BACKGROUND OF THE INVENTION

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For the purpose of carrying out work operations under water it is important to analyse the underwater bottom, and more particularly to know the mechanical properties of this bottom which are relevant to the work. The underwater bottom generally functions as foundation for the work, and insufficient insight into the properties thereof is unacceptable.

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A known method and device for determining the mechanical properties of an underwater bottom consists of driving a cylindrical test probe vertically into the bottom and then expanding the test probe, wherein a horizontal pressure is exerted on the bottom. The stress-strain curve resulting from this pressure gauge test provides insight into the mechanical properties of the bottom.

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Other known methods take a sample of the bottom, which is then subjected to mechanical testing above water.

The known methods and corresponding devices have the drawback that the underwater bottom is disturbed in all cases. Not only can this be disadvantageous for the load-bearing capacity of the bottom, it can moreover result in relatively inaccurate measurement of the mechanical properties. The above stated drawback applies particularly to an underwater bottom comprising a mass of rocks. Inserting the test probe or taking a sample disrupts the coherence between the rocks in the mass, whereby it is not easily possible to collect reliable data. This problem increases further as the layer thickness of the mass of rocks becomes less, for instance less than 2-3 m, and/or when the rocks have relatively large dimensions, for instance greater than 0.2 m on average.

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SUMMARY OF THE INVENTION

35 An object of the present invention is therefore to provide a method and device of the type stated in the preamble, whereby the above stated drawbacks are at least partially avoided.

The invention provides for this purpose a device according to claim 1. A device for determining the mechanical properties of an underwater bottom is particularly provided, comprising a support frame which provides a fixed support relative to the underwater bottom; means for carrying the support frame onto the bottom; a pressure plate accommodated in the support frame; pressing means for pressing the pressure plate against the bottom with a force; means for measuring the displacement of the pressure plate during pressing; and computing means for determining mechanical properties of the underwater bottom from the measured displacement and the force.

- 10 According to the invention, the device is carried under water during use by lifting the support frame with for instance a lifting means and placing it on the underwater bottom such that the bottom for testing can be reached by the pressure plate. Although the pressure plate is pressed against the bottom with force, it is substantially not urged into the bottom. The bottom hereby remains relatively intact and the measured mechanical properties will be representative for the intended uses of the bottom, for instance to function as foundation for a structure to be arranged in the water.

- In an embodiment the support frame has at least one relatively flat side with which the support frame can be placed on the underwater bottom. In this state of the support frame the bottom can be reached by the pressure plate. The pressure plate is pressed against the bottom during use, wherein the engaged part of the bottom can move relatively freely in lateral direction. This is understood to mean that the bottom is preferably not enclosed by a separate structure, which would impede lateral movement of the bottom. During pressing, lateral movement of the bottom is limited only by the bottom itself. The lateral direction is a direction running perpendicularly of the pressing direction.

- The means for carrying the support frame onto the underwater bottom can be embodied in any manner. Such means can thus comprise a lifting crane and a set of lifting eyes which are mounted on the frame and on which a hoisting tackle of the lifting crane can engage, if desired via hoisting lines. It is also possible to carry the support frame under water autonomously, for instance by carrying it from a vessel into the water and providing it with drive means which are able to steer the support frame to the desired position on the bottom.

- The pressure plate is accommodated in the support frame such that the forces exerted on the pressure plate by the bottom can be diverted to the support frame, particularly with interposing of a force measuring means. The support frame is here rigid enough to limit deformation of the support

frame such that it does not influence the displacement measurement, or only does so to very limited extent, whereby the displacement measurement is not influenced, or only to very limited extent.

- 5 The dimensions and geometry of the pressure plate can be chosen within wide limits. It is thus possible to apply pressure plates, the number of corners and/or sides of which varies from zero to almost infinite, for instance three, four, five and more corners and/or sides. The form can be regular or irregular, have symmetry or conversely lack symmetry. The angle between possible sides can be 90° , but can also differ therefrom. In an embodiment the pressure plate is elliptical,
10 more preferably circular. The dimensions can be chosen subject to the bottom properties. It is thus possible to opt for a longest dimension of the pressure plate (in the plane of the pressure plate) of between 0.01 and 10 m, more preferably between 0.1 and 5 m, still more preferably between 0.2 and 2 m, most preferably between 0.4 and 1.5 m. For a circular pressure plate the longest dimension is the diameter, and suitable diameters are for instance 0.5 m, 0.75 m and 1 m. The
15 thickness of the pressure plate can likewise be chosen within wide limits, and the ratio of the thickness and the longest dimension preferably amounts to between 1/50 and 1/5, more preferably between 1/20 and 1/10.

- In some embodiments the pressing means for pressing the pressure plate against the underwater
20 bottom with a force comprise clamping means for the pressure plate and drive means for moving the pressure plate reciprocally in a direction running at an angle other than zero to the bottom. The direction of movement preferably runs perpendicularly of the bottom. The drive means can be mechanical, comprising for instance a chain drive, but can also be hydraulic or pneumatic, comprising for instance hydraulic pressure cylinders (pistons).

- 25 An embodiment of the invention comprises a device wherein the pressing means comprise a hydraulic cylinder.

- The pressure plate can be pressed against the bottom with a force, if desired a constant force. An
30 embodiment of the device further comprises means for measuring the force on the pressure plate during pressing. Such means are per se known and can comprise mechanical, optical, electromagnetic, piezometric and acoustic force sensors, or optionally combinations of such sensors. Because the force measuring means are accommodated in the support frame, they preferably take a watertight form.

A device according to another embodiment of the invention is characterized in that the pressing means engage (directly) on a surface of the pressure plate. In another embodiment of the device the pressure plate comprises a drive rod and the pressing means engage on the drive rod. The drive rod preferably runs in the direction in which the force has to be exerted on the pressure plate, this most preferably being a direction running perpendicularly of the bottom. Although this is not essential, the drive rod preferably engages at a geometrical centre of the pressure plate. In some embodiments the geometrical centre of the pressure plate coincides with the centre of gravity of the pressure plate.

- 10 The connection between the drive rod and the pressure plate can form a rigid connection, although a preferred embodiment comprises a device wherein the pressure plate is connected pivotally to the drive rod, more preferably by means of a ball joint. Such a method of connecting ensures that the pressure plate remains substantially wholly in contact with the bottom, even when the support frame forms an angle other than zero with the bottom. This further improves the quality of the measurement.

It is further advantageous to characterize the device according to an embodiment in that the means for measuring the displacement of the pressure plate during pressing comprise means for determining the depth position of the pressure plate. Such means allow the displacement of the pressure plate to be measured accurately during pressing thereof onto the bottom, and can for instance be based on the determining of the static water pressure at a determined depth position. By determining the depth of the pressure plate, the position of the pressure plate is known for each force acting on the pressure plate. Combining these measurements results in determination of the mechanical properties of the bottom.

25 An embodiment of the invention provides a device wherein the means for measuring the displacement of the pressure plate, more particularly the means for determining the depth position of the pressure plate, comprise a depth wheel or depth encoder.

- 30 In order to further increase the stability of the support frame, according to an embodiment the device can further comprise ballast attached to the support frame.

According to another embodiment of the invention, the device further comprises a programmable logic unit (PLC) which is situated under water during use and which controls the different components of the device on the basis of information obtained via inputs, and which stores the measurement data from the measurements and/or sends these data to a computing unit, which is

situated above water in another embodiment. The manner in which the PLC reads the data is known to the skilled person and depends on, among other factors, the installed interface cards and the fieldbus networks along which the components of the device exchange data with each other.

- 5 Another aspect of the invention relates to a method for determining the mechanical properties of an underwater bottom, particularly a mass of rocks. The method comprises of providing a device according to the invention; carrying the support frame in which the pressure plate is accommodated onto the underwater bottom; pressing the pressure plate against the bottom with a force; measuring the displacement of the pressure plate during pressing; and determining the mechanical properties
10 of the bottom from the measured displacement and the force.

- The support frame provided with the pressure plate and the other components can be carried under water in essentially any manner, wherein the invented method is preferably characterized in that the support frame is connected to a vessel. Using the vessel and the support frame the pressure
15 plate can easily be placed at any desired position, wherein the support frame can provide for an accurate positioning of the pressure plate relative to the bottom, both in the depth and in the two-dimensional plane (length and width).

- In order to obtain a two-dimensional image of the properties of the bottom the measurements
20 (force and displacement of the pressure plate) can be repeated for different positions of the support frame in the two-dimensional plane. According to an embodiment of the method according to the invention, the measurements can be repeated at discrete positions in the two-dimensional plane.

- It will further be apparent that the invention is not limited to the use of one support frame with
25 pressure plate, but that a plurality of support frames with pressure plate can be applied simultaneously as desired, and/or a support frame provided with a plurality of pressure plates.

- The embodiments of the invention described in this patent application can be combined in any possible combination of these embodiments, and each embodiment can individually form the
30 subject-matter of a divisional patent application.

BRIEF DESCRIPTION OF THE FIGURES

- The invention will now be further elucidated with reference to the following figures, without
35 otherwise being limited thereto. In the figures:

- figure 1 shows a schematic side view of an embodiment of a device according to the invention;

- figure 2 shows a schematic perspective view of an embodiment of a pressure plate according to the invention;
- figure 3 shows a schematic perspective view of an embodiment of a pressure plate according to the invention during inspection of an underwater bottom; and
- 5 - figure 4 shows a schematic measuring curve of a force-displacement measurement performed with the invented device.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

- 10 Shown with reference to figure 1 is an embodiment of a device 1 according to the invention. Device 1 is employed to inspect a bottom 3 situated under water 2, more particularly to determine the mechanical properties of the bottom 3. Device 1 comprises a support frame 4 which is constructed in three dimensions from at least 12 steel profiles 40 rigidly connected to each other. Support frame 4 is placed with a bottom surface 5 on the bottom 3 to be inspected, for instance by
- 15 lifting it by lifting eyes 6 with a lifting crane (not shown) and lowering it into the water 2 and onto the bottom 3.

- Support frame 4 provides fixed support relative to the underwater bottom 3 to different components of device 1 which are accommodated in the support frame. Essential components
- 20 connected to support frame 4 comprise a pressure plate 7 accommodated in support frame 4. In the embodiment shown in figure 2 the pressure plate takes the form of a circle with a diameter of 0.5 m, 0.75 m or 1 m, although other diameters are also possible. The plane of pressure plate 7 runs roughly parallel to the bottom 3. This is made possible by connecting pressure plate 7 to a drive rod 8 which runs in a direction 30 which is roughly perpendicular to the bottom (or parallel to an
- 25 upright profile 40), and which is connected to pressure plate 7 by means of a ball joint 70. Such a pivoting connection allows angular rotation of the pressure plate relative to support frame 4, drive rod 8 and/or the bottom 3. Pressure plate 7 thus remains substantially wholly in contact with the bottom 3, even when bottom surface 5 of support frame 4 forms for instance an angle other than zero to the bottom 3.

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- In the shown embodiment drive rod 8 is mounted on support frame 4 by means of a suspension 9 and intermediate means for measuring the displacement of drive rod 8 and so also of pressure plate 7 in a direction running parallel to a longitudinal axis of drive rod 8. These means for determining the depth position of the pressure plate comprise a depth wheel or encoder (10, 17). As shown in
- 35 figure 1, these can be situated in the vicinity of pressure plate 7 (designated in this position with

the number 17) and/or they can be situated at the position of an upper side of drive rod 8 (designated in this position with the number 10).

Device 1 can further also comprise means for determining the depth position of pressure plate 7, such as pressure sensor 18. Such means allow the static water pressure and, with this, the depth position to be determined. This can help to determine the displacement of pressure plate 7 in the direction of the bottom 3.

The embodiment shown in figure 1 further comprises pressing means 11 for pressing the pressure plate 7 against the bottom 3 with force. The pressing means in the form of a hydraulic drive 11 comprise a clamp 12 for engaging drive rod 8, an assembly of two counter-rotating chains (13a, 13b) which engage on drive rod 8 with pressure. Hydraulic cylinders (14a, 14b) running on two guides (15a, 15b) can move clamp 12 (and the drive rod 8 received in clamp 12) upward and downward in the direction 30. Pressure plate 7 is hereby likewise moved upward and downward in direction 30, and can be pressed against the bottom 3 with a force which can be constant if desired, but is generally an increasing force. Pressure plate 7 is here pressed against the bottom 3, wherein the engaged part of bottom 3 can move relatively freely in the lateral direction 31, and is therefore not enclosed. This is not however essential.

Figure 3 shows pressure plate 7 in a position in which it is pressed against the bottom 3, wherein the bottom comprises a mass of rocks 3a (also referred to as rock mound).

Hydraulic drive 11 is driven by means of a hydraulic motor 19 to which a pump 23 and an accumulator 22 for the hydraulic oil are coupled. If desired, a pressure sensor 21 is incorporated in the hydraulic circuit in order to measure the pressure herein.

The force exerted on the bottom 3 (or the reactive force generated by the bottom 3) is measured by means of a for instance piezometric force sensor 16. Force sensor 16, and for that matter also other components, preferably take a watertight form.

The different components of device 1 are controlled in combination with each other by means of a programmable logic unit (PLC) 20 which is situated under water during use and, if desired, is accommodated in support frame 4. The control by PLC 20 takes place on the basis of information of for instance force sensor 16, depth encoder 17, depth gauge 18 and pressure sensor 21, obtained via input cabling 26. Hydraulic motor 19 is controlled through cabling 25. The measured force and

displacement are sent by the PLC to a computing unit 27 which is situated above water in the shown embodiment, but can also be accommodated in support frame 4.

Computing unit 27 is provided with computing means and software for determining mechanical properties of the underwater bottom 3 from the measured displacement 28 and the force 29. A typical measurement result is shown in figure 4. Characteristic properties of the bottom 3 can be determined from such a measurement result.

During use the described device 1 is carried onto the bottom 3 situated under water surface 2 until support frame 4 supports on the bottom or is situated in the vicinity of the bottom 3. Pressure plate 7 is then pressed against the bottom 3 with force 29 and the displacement 28 of pressure plate 7 is measured during pressing. Relevant mechanical properties of the bottom 3 can be determined from the measured displacement 28 and the force 29.

The skilled person will appreciate that the invention is not limited to the above illustrated exemplary embodiment of the method and device according to the invention, but that modifications and variations can be made within the scope of protection defined by the appended claims.

CLAIMS

1. Device for determining the mechanical properties of an underwater bottom, comprising:
 - a support frame which provides a fixed support relative to an underwater bottom;
- 5 - means for carrying the support frame onto the underwater bottom;
- a pressure plate accommodated in the support frame;
- pressing means for pressing the pressure plate against the underwater bottom with a force without urging it into the bottom;
- means for measuring the displacement of the pressure plate during pressing; and
- 10 - computing means for determining mechanical properties of the underwater bottom from the measured displacement and the force.

2. Device according to claim 1, further comprising means for measuring the force on the pressure plate during pressing.
- 15 3. Device according to claim 1 or 2, wherein the pressing means engage on a surface of the pressure plate.

4. Device according to any one of the foregoing claims, wherein the pressure plate comprises
- 20 a drive rod and the pressing means engage on the drive rod.

5. Device according to claim 4, wherein the pressure plate is connected pivotally to the drive rod.

- 25 6. Device according to any one of the foregoing claims, wherein the pressing means comprise a hydraulic cylinder.

7. Device according to any one of the foregoing claims, wherein the means for measuring the displacement of the pressure plate during pressing comprise means for determining the depth position
- 30 of the pressure plate.

8. Device according to claim 7, characterized in that the means for determining the depth position of the pressure plate comprise a depth wheel or depth encoder.

- 35 9. Device according to any one of the foregoing claims, further comprising ballast attached to the support frame.

10. Device according to any one of the foregoing claims, further comprising a programmable logic unit (PLC) which is situated under water during use.

11. Method for determining the mechanical properties of an underwater bottom, comprising
5 of:

- providing a device according to any one of the foregoing claims;
- carrying the support frame in which the pressure plate is accommodated onto the underwater bottom;
- pressing the pressure plate against the underwater bottom with a force without urging it into the
10 bottom;
- measuring the displacement of the pressure plate during pressing; and
- determining the mechanical properties of the underwater bottom from the measured displacement and the force.