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(54) A RETAINING WALL STRUCTURE AND A METHOD OF MAKING OR REINFORCING A RETAINING WALL STRUCTURE

(57) A retaining wall structure, such as a quay structure, comprises an upwardly directed longitudinal wall of which at least a lower portion is in a bottom. The height of the bottom at a front side of the longitudinal wall is lower than at a back side of the longitudinal wall which is located opposite to the front side. Furthermore, the retaining wall structure comprises a series of upwardly directed transverse walls which are located at a distance from each other in horizontal longitudinal direction of the longitudinal wall and extend at the back side of the longitudinal wall by an angle with respect to the longitudinal wall and of which at least lower portions are located in the bottom. The thickness of the longitudinal wall is smaller than the thickness of each of the transverse walls.

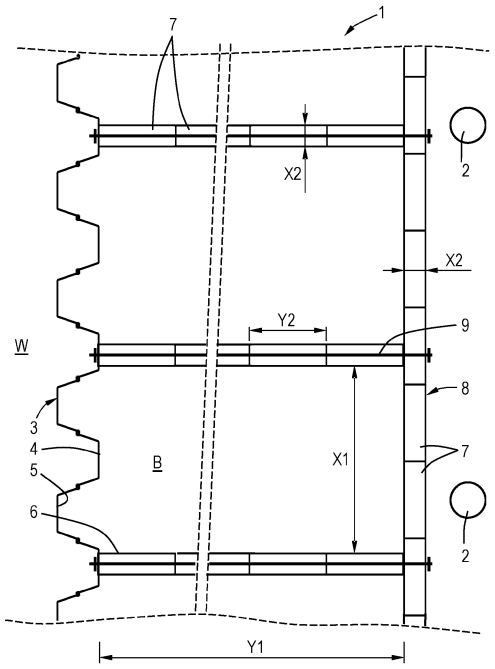

Fig. 1

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Description

[0001] The present invention is related to a retaining wall structure, such as a quay structure.

[0002] Several types of retaining wall structures, such as quay structures, are known in the prior art. For example, in respect of a quay structure it is possible to sink a caisson, wherein one side of the sunk caisson forms the water side where a ship can moor, whereas the opposite side retains the soil behind it. The soil pressure in horizontal direction may be transferred via the lower side of the caisson to the bottom. Disadvantages of such a retaining wall structure are that the bottom must be prepared for sinking the caisson and that the caisson must be transported from a location where this is manufactured to the location where it must be sunk. This leads to high costs.

[0003] An object of the invention is to provide an advantageous retaining wall structure.

[0004] This object is achieved with the retaining wall structure according to the invention, which comprises an upwardly directed longitudinal wall of which at least a lower portion is in a bottom, wherein the height of the bottom at a front side of the longitudinal wall is lower than at a back side of the longitudinal wall which is located opposite to the front side, and a series of upwardly directed transverse walls which are located at a distance from each other in horizontal longitudinal direction of the longitudinal wall and extend at the back side of the longitudinal wall by an angle with respect to the longitudinal wall and of which at least lower portions are located in the bottom, wherein the thickness of the longitudinal wall is smaller than the thickness of each of the transverse walls.

[0005] The relatively large thicknesses of the transverse walls create a large support capacity in vertical direction. Furthermore, relatively large forces in horizontal direction can be transferred to the bottom via lower sides of the transverse walls, such that the horizontal pressure of the soil behind the retaining wall structure onto the back side of the longitudinal wall is relatively low. Furthermore, the horizontal pressure of portions of the soil which are located between each pair of neighbouring transverse walls are at least partially absorbed by the transverse walls. The latter effect may be influenced by the selection of the distance between each pair of neighbouring transverse walls. The retaining wall structure according to the invention provides the possibility of applying a relatively light longitudinal wall. In fact the transverse walls cause a block of reinforced soil, which behaves like an assembled foundation element or a mass wall. Another advantage of the retaining wall structure is that it may be built on site, such that no big parts such as a caisson for making a quay structure have to be supplied.

[0006] The transverse walls may be directly adjacent to the longitudinal wall, but it is also possible that a thin layer of the soil is located between the longitudinal wall and head sides of the transverse walls.

Preferably, lower sides of the transverse walls lie at a lower level than the height of the bottom at the front side of the longitudinal wall, such that the horizontal forces onto the transverse walls can be transferred appropriately to the bottom at the front side of the longitudinal wall.

[0007] Lower sides of the transverse walls can lie on a lower level than a lower side of the longitudinal wall. Consequently, the transverse walls can transfer horizontal forces in the direction of the back side to the front side of the longitudinal wall directly to the bottom, for example via head sides of the transverse walls.

[0008] Each transverse wall may comprise a continuous rigid material in its horizontal direction.

[0009] In an embodiment each transverse wall comprises a plurality of rigid panels, which are located behind each other in horizontal longitudinal direction of the transverse wall.

[0010] In an alternative embodiment each transverse wall has at least two rigid parts in its horizontal longitudinal direction, between which a portion of the bottom is located. As a consequence, the transverse wall forms a discontinuous rigid wall in horizontal longitudinal direction thereof. In practice, the soil material between the rigid parts may also behave like rigid material for transferring horizontal forces onto the transverse walls in the direction of the longitudinal wall, depending on the soil structure. For example, the distance between the rigid parts may be smaller than the length of each of the rigid parts in the horizontal longitudinal direction of the transverse walls.

[0011] The rigid parts may comprise rigid panels, respectively.

[0012] In case of rigid panels they preferably comprise soilmix panels, respectively. These are well-known panels which are made on site by means of cutter soilmixing technique. Existing soil material is mixed with a suspension, for example cement mixture, by means of a cutter head which comprises two cutter wheels. In this way a homogeneously mixed mass is created, in which the cutter head can sink by its own weight. Eventually this leads to a mixed result with the soil material as being a part thereof and after curing a rigid panel will arise. No or a little soil must be removed for creating the transverse walls. If necessary, reinforcement elements, such as vertical steel beams may be applied into the soilmix panels when they are still not cured.

[0013] It is possible that some rigid panels of a transverse wall are deeper in the bottom than others. If the panels of a transverse wall are alternatingly deeper and less deeper in the bottom, for example, the lower side of the transverse wall has a sort of reversed battlement structure, which may have a beneficial effect on transferring horizontal forces of the transverse wall to the bottom.

[0014] The transverse walls may be perpendicular to the longitudinal wall, whereas the longitudinal wall and/or the transverse walls may be vertical.

[0015] The longitudinal wall may be made of metal, preferably steel.

[0016] The longitudinal wall may have a sheet pile profile, for example.

[0017] In a particular embodiment an upwardly directed anchor wall is located behind the transverse walls, as seen from the longitudinal wall, wherein an anchor element connects the longitudinal wall and the anchor wall to each other. Consequently, an additional reinforcement of the longitudinal wall is created in order to avoid bending outwardly to the front side thereof. The anchor element may be mounted in an upper portion of the sheet pile profile. The anchor wall may be placed directly behind the transverse walls, but it is also conceivable that it is placed at a distance thereof. The anchor wall may also comprise soilmix panels.

[0018] The anchor element may comprises an anchor rod.

[0019] Upper portions of the transverse walls may support a rigid platform. This may be a sand layer with a hardened upper layer. Due to the presence of the transverse walls a relatively large supporting force is provided, which allows high ground level loads.

[0020] In a specific embodiment the retaining wall structure comprises a quay structure, wherein the bottom at the front side of the longitudinal wall is formed by a water bottom above which a layer of water is located. The quay structure according to the invention is an advantageous structure for absorbing varying horizontal forces onto the longitudinal wall as a consequence of changing water levels, in particular for resisting the bottom forces in case of a low water level.

[0021] The invention is also related to a method of making a retaining wall structure, such as a quay structure, comprising the following steps: inserting an upwardly directed longitudinal wall into a bottom at a longitudinal wall line, making a series of upwardly directed transverse walls in the bottom at a distance from each other in longitudinal direction of the longitudinal wall line at one side of the longitudinal wall line by an angle with respect to the longitudinal wall by means of cutter soilmixing technique.

[0022] In a practical embodiment first the longitudinal wall is inserted into the bottom, after which the transverse walls are made.

[0023] The invention is also related to a method of reinforcing a retaining wall structure, such as a quay structure, wherein the retaining wall structure is provided with an upwardly directed longitudinal wall of which at least a lower portion is in a bottom, wherein the height of the bottom at a front side of the longitudinal wall is lower than at a back side of the longitudinal wall which is located opposite to the front side, wherein a series of upwardly directed transverse walls are made in the bottom at a distance from each other in longitudinal direction of the longitudinal wall at the back side of the longitudinal wall by an angle with respect to the longitudinal wall by means of cutter soilmixing technique. For example, this method can be applied at existing quay structures, which must be reinforced because of increasing ground level loads, for example, whereas the existing longitudinal wall may remain in tact. This is a relatively simple operation which requires little supply of new materials. For example, the method also provides the possibility to deepen the water bottom at an existing quay structure.

[0024] Hereinafter the invention will be further elaborated by means of drawings, which show an embodiment of the invention very schematically.

Fig. 1 is a plan view of a horizontal section of an embodiment of a retaining wall structure according to the invention.

Fig. 2 is a cross-section of the retaining wall structure according to Fig. 1.

Figs. 1 and 2 show an embodiment of a retaining wall structure 1 according to the invention. In this case the retaining wall structure 1 comprises a quay structure against which a ship can moor. As an example, Fig. 1 shows two bollards 2 to which hawsers of a ship can be fixed.

[0025] The retaining wall structure 1 has an upwardly directed longitudinal wall in the form of a vertical sheet pile wall 3 of which a lower portion is located in a bottom B. The sheet pile wall 3 may be made of steel and can be inserted into the bottom B in a well-known manner, for example by means of vibrating. The sheet pile wall 3 has a front side 4 which contacts water W above the bottom B and a back side 5 which is directed away from the water W. The height of the bottom B at the front side 4 of the sheet pile wall 3 is lower than at the back side 5 thereof.

[0026] At the back side 5 of the sheet pile wall 3 there is a series of parallel vertical transverse walls 6, which are located at a distance X1 from each other, for example a few meters. In the embodiment as shown the transverse walls 6 are entirely located in the bottom B. Lower sides of the transverse walls 6 are located at a lower level than the water bottom, which means below the level of the bottom B at the front side 4 of the sheet pile wall 3. In this case the lower sides of the transverse walls 6 are also located at a lower level than a lower side of the sheet pile wall 3. Each transverse wall 6 may have a length Y1 of 15 meters, for example, and a height of 20 meters, for example.

[0027] The thickness of the sheet pile wall 3, which means of the plate material of the sheet pile wall 3, is smaller than a thickness X2 of each of the transverse walls 6. Consequently, the transverse walls 6 can transfer relatively large forces of the bottom B at the back side 5 of the sheet pile wall 3 in horizontal direction to the bottom B at the lower portions of the transverse walls 6 and in vertical direction to the bottom B below the transverse walls 6. The thickness of the sheet pile wall 3 is a few centimeters, for example 2 cm, whereas the thickness X2 of a transverse wall 6 is a few tens of centimeters, for

example 50 cm.

[0028] A portion of the bottom B, or a compartment which is filled with bottom material, is located between each pair of neighbouring transverse walls 6. Due to the presence of the transverse walls 6 pressure of the bottom material in the direction of the sheet pile wall 3 is at least partly absorbed by the transverse walls 6, such that the bottom material in the mentioned compartments applies a relatively small force onto the sheet pile wall 3. Vertical ground level forces are transferred to the underlying bottom B by the transverse walls 6, such that a possible resulting pressure of the bottom material in the compartments in horizontal direction onto the sheet pile wall 3 is minimized.

[0029] Each transverse wall 6 is built-up of separate soilmix panels 7. A soilmix panel 7 can be created on site by mixing existing bottom material and cement mortar in a well-known manner by means of a cutter head which comprises cutter wheels. A soilmix panel 7 has a width Y2 of about 2 meters, for example. In order to make a continuous transverse wall 6 at first soilmix panels 7 can be made in the bottom at a distance from each other in horizontal longitudinal direction of the intended transverse wall 6, after which between the soilmix panels 6, which are already created and at least partly cured, intermediate soilmix panels 7 are formed. As a consequence, a transverse wall 6 arises which comprises continuous rigid material in horizontal longitudinal direction of the transverse wall 6. In the direction perpendicular to the plane of the sheet pile wall 3 each transverse wall 6 can absorb a relatively large bending moment.

[0030] The embodiment according to Figs. 1 and 2 is also provided with an anchor wall 8, which extends parallel to the plane of the sheet pile wall 3. The transverse walls 6 extend between the sheet pile wall 3 and the anchor wall 8. In this case the anchor wall 8 is also formed as a continuous series of soilmix panels 7. Anchor rods 9 are applied between the sheet pile wall 3 and the anchor wall 8 in order to transfer pressure of the bottom material between the transverse walls 6, which is applied onto the sheet pile wall 3, to the anchor wall 8. As indicated above, this pressure is relatively low, such that the anchor wall 8 and the anchor rods 9 may be omitted in some cases, for example in case of a rigid bottom structure. It can be seen in the figures that the anchor rods 9 extend across upper sides of the respective transverse walls 6, but in an alternative embodiment they can also be applied at other locations. Although the anchor wall 8 lies directly behind the transverse walls 6 in the figures, as seen from the sheet pile wall 3, it is also conceivable to place the anchor wall 8 at a distance from the transverse walls 6. Optionally, the sheet pile wall 3 can also be anchored with grout anchors.

[0031] Fig. 2 shows that above the transverse walls 6 a layer of sand 10 is applied, on top of which a hardened platform 11 is applied. In addition to that or instead thereof a pressure distributing material, such as geotextile, may be applied in order to transfer load to the transverse walls 6 appropriately.

[0032] The retaining wall structure 1 can be built-up by firstly inserting the sheet pile wall 3 into the bottom B, for example by means of vibrating, after which the soilmix panels 7 are made perpendicularly to the plane of the sheet pile wall 3.

[0033] In an alternative embodiment (not shown) the soilmix panels of each transverse wall are placed at a distance from each other in horizontal longitudinal direction thereof. This means that a portion of the bottom is located between two soilmix panels. Depending on the bottom structure the intermediate bottom material may also behave as a rigid material.

[0034] The invention is not limited to the embodiment as shown in the drawings and described above, which can be varied in different manners within the scope of the invention. For example, it is possible that the retaining wall structure is not applied as a quay structure, but as a retaining wall structure for retaining soil for creating a building site or a quay for transport vehicles.

Claims

1. A retaining wall structure (1), such as a quay structure, comprising an upwardly directed longitudinal wall (3) of which at least a lower portion is in a bottom (B), wherein the height of the bottom (B) at a front side (4) of the longitudinal wall (3) is lower than at a back side (5) of the longitudinal wall (3) which is located opposite to the front side (4), and a series of upwardly directed transverse walls (6) which are located at a distance from each other in horizontal longitudinal direction of the longitudinal wall (3) and extend at the back side (5) of the longitudinal wall (3) by an angle with respect to the longitudinal wall (3) and of which at least lower portions are located in the bottom (B), wherein the thickness of the longitudinal wall (3) is smaller than the thickness of each of the transverse walls (6).

2. A retaining wall structure (1) according to claim 1, wherein lower sides of the transverse walls (6) are located at a lower level than the height of the bottom (B) at the front side (4) of the longitudinal wall (3).

3. A retaining wall structure (1) according to claim 1 or 2, wherein lower sides of the transverse walls (6) are located at a lower level than a lower side of the longitudinal wall (3).

4. A retaining wall structure (1) according to any one of the preceding claims, wherein each transverse wall (6) comprises a continuous rigid material in its horizontal longitudinal direction.

5. A retaining wall structure (1) according to claim 4, wherein each transverse wall (6) comprises a plu-

rality of rigid panels (7), which are located behind each other in horizontal longitudinal direction of the transverse wall (6).

6. A retaining wall structure (1) according to any one of the claims 1-3, wherein each transverse wall (6) has at least two rigid parts (7) in its horizontal longitudinal direction, between which a portion of the bottom (B) is located.

7. A retaining wall structure (1) according to claim 6, wherein the rigid parts comprise rigid panels (7), respectively.

8. A retaining wall structure (1) according to claim 5 or 7, wherein the rigid panels comprise soilmix panels (7), respectively.

9. A retaining wall structure (1) according to any one of the preceding claims, wherein the longitudinal wall (3) is made of metal, preferably steel, wherein the longitudinal wall (3) may have a sheet pile profile.

10. A retaining wall structure (1) according to any one of the preceding claims, wherein an upwardly directed anchor wall (8) is located behind the transverse walls (6), as seen from the longitudinal wall (3), wherein an anchor element (9) connects the longitudinal wall (3) and the anchor wall (8) to each other, wherein the anchor element may comprise an anchor rod (9).

11. A retaining wall structure (1) according to any one of the preceding claims, wherein upper portions of the transverse walls (6) support a rigid platform (11).

12. A retaining wall structure (1) according to any one of the preceding claims, wherein the retaining wall structure comprises a quay structure (1), wherein the bottom (B) at the front side (4) of the longitudinal wall (3) is formed by a water bottom above which a layer of water (W) is located.

13. A method of making a retaining wall structure (1), such as a quay structure, comprising the following steps:
inserting an upwardly directed longitudinal wall (3) into a bottom (B) at a longitudinal wall line, making a series of upwardly directed transverse walls (6) in the bottom (B) at a distance from each other in longitudinal direction of the longitudinal wall line at one side of the longitudinal wall line by an angle with respect to the longitudinal wall (3) by means of cutter soilmixing technique.

14. A method according to claim 13, wherein first the longitudinal wall (3) is inserted into the bottom (B), after which the transverse walls (6) are made.

15. A method of reinforcing a retaining wall structure (1), such as a quay structure, wherein the retaining wall structure (1) is provided with an upwardly directed longitudinal wall (3) of which at least a lower portion is in a bottom (B), wherein the height of the bottom (B) at a front side (4) of the longitudinal wall (3) is lower than at a back side (5) of the longitudinal wall (3) which is located opposite to the front side (4), wherein a series of upwardly directed transverse walls (6) are made in the bottom (B) at a distance from each other in longitudinal direction of the longitudinal wall (3) at the back side (5) of the longitudinal wall (3) by an angle with respect to the longitudinal wall (3) by means of cutter soilmixing technique.

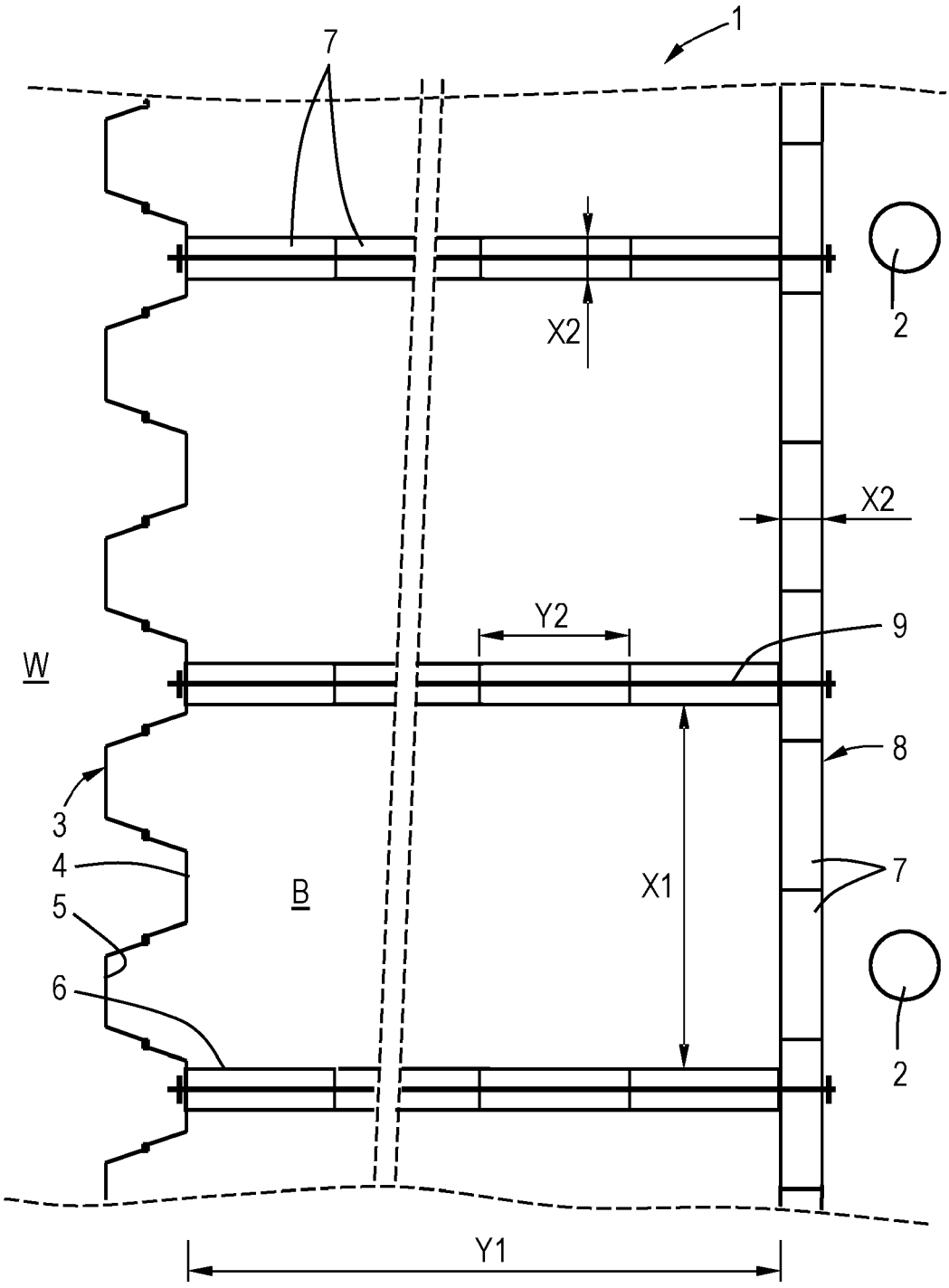

Fig. 1

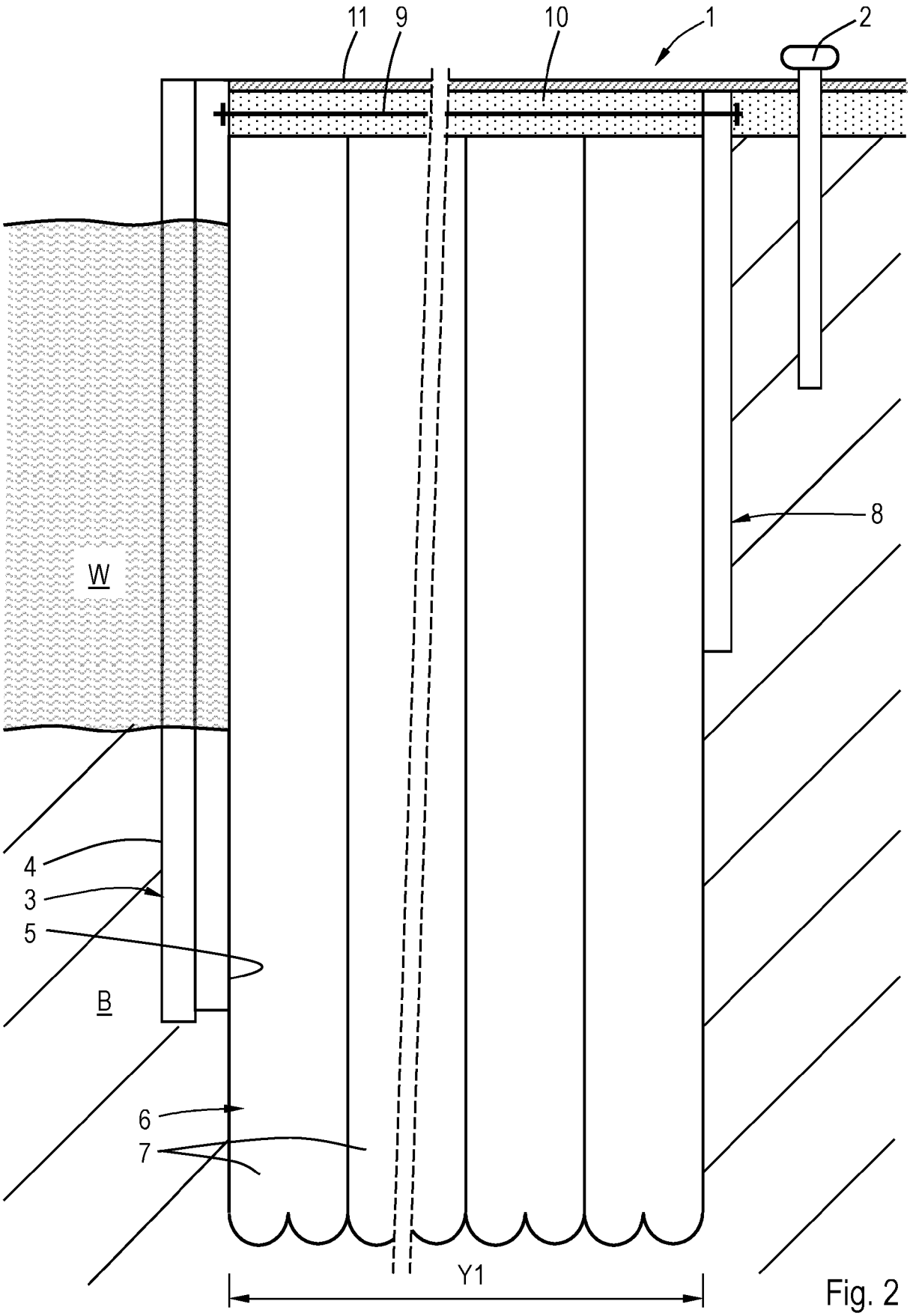

Fig. 2