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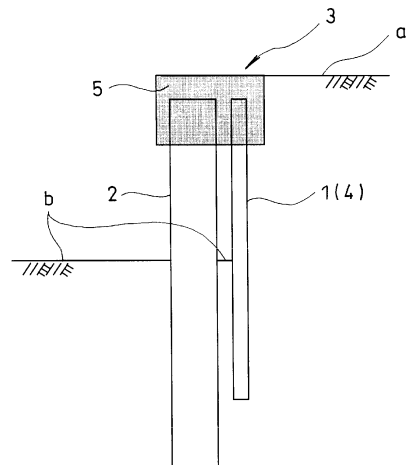
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(54) **STEEL WALL**

(57) To provide an easily constructible steel wall having a wall body in which steel sheet piles capable of easily providing a high water stopping performance are coupled, and reinforced by a steel pipe or an H-shaped steel.

The wall body 4 is provided by coupling the plurality of hat-shaped steel sheet piles 1 by a joint. The steel pipe 2, which reinforces the wall body 4, is provided being arranged along a longitudinal direction of the wall body 4. A space is provided between the wall body 4 and the steel pipe 2. The wall body 4 is formed into a corrugated shape in which a projection and a recess are repeated in a longitudinal direction as a steel sheet pile wall. The steel pipe 2 is disposed such that a part thereof is being entered into a recessed portion of the wall body 4. A head portion of the wall body 4 is coupled to a head portion of the steel pipe 2. The wall body 4 and the steel pipe 2 are coupled by concrete. Load transmission is performed between the wall body 4 and the steel pipe 2. Accordingly, the steel wall 3 may have a structure in which an acting earth pressure and water pressure are received and shared by the wall body 4 and the steel pipe 2.

[Fig. 3]



Description

Technical Field

[0001] The present invention relates to a steel wall used in earth retaining works, cofferdam, bank protection, land reclamation, embankment, and the like.

Background Art

[0002] Conventionally, a steel sheet pile and a steel pipe sheet pile have been used in various construction works such as earth retaining works, cofferdam, bank protection, land reclamation, and embankment. The steel sheet pile and the steel pipe sheet pile are used differently according to required rigidity. In general, the steel sheet pile is used in a situation where the rigidity may be low, and the steel pipe sheet pile is used in a situation where the high rigidity is required.

[0003] Here, the steel pipe sheet pile has a larger amount of joint margin than the steel sheet pile. Therefore, in a case where water stopping performance is required when constructing the cofferdam, the bank protection, and the like, in general, a method in which a joint space is filled with packed cement mortar is used. In this method, in a case where a bag in which the mortar is packed is broken when used in a waterfront environment such as a river and a harbor, there is a possibility that the mortar may flow out. Since a space between the bags may become a water channel, it is not necessarily suitable for a use where the strict water stopping performance is required.

[0004] Therefore, the following has been proposed as a measure in a case where leakage prevention of water inside a disposal site is strictly required such as in a case of water shielding bank protection of a sea surface waste disposal site and the like. That is, there has been proposed a structure in which the leakage prevention measure is implemented to the joint space of the steel pipe sheet pile, and the joint space is directly filled with a filler such as the mortar (see Patent Literature 1, for example). In a case where the mortar is filled in this way, there is a need to perform work of driving the steel pipe sheet pile into the ground, removing earth and sand inside the joint by a water jet and the like, and filling the joint with the packed mortar and mortar. Therefore, it is disadvantageous in that effort and time are required for work at a steel pipe sheet pile site.

[0005] In contrast, the steel sheet pile has low rigidity compared to that of the steel pipe sheet pile but an excellent water stopping performance and a small expansion space of the joint. Even in a state where no measure is implemented, the water stopping performance thereof is high compared to that of the steel pipe sheet pile. By coating the joint with a swelling water stopping material in advance, it is possible to further enhance the water stopping performance of the steel sheet pile. By this method, it is possible to provide the water stopping per-

formance equal to or greater than the steel pipe sheet pile, to which the above-described measure has been implemented, as well as to save the effort in the work at the site.

[0006] As a technique of enhancing the rigidity of the steel sheet pile, a tie rod type steel sheet pile wall such as a tie rod type steel sheet pile bank protection which couples a steel sheet pile wall to be a bank protection and a shoring provided on a land side than the bank protection by a tie rod.

[0007] In the tie rod type steel sheet pile wall, a large construction space is necessary for coupling the steel sheet pile wall to the shoring by a long tie rod.

[0008] Similarly, in the tie rod type steel sheet pile wall, since the steel sheet pile wall is coupled to the shoring through the long tie rod, the tie rod is capable of transmitting a tensile force but not a compression force.

[0009] Furthermore, as a technique of enhancing the rigidity of the steel sheet pile, there has been proposed a technique of using a combination steel sheet pile in which a U-shaped (hat-shaped) steel sheet pile constituting a wall body is integrally stiffened with an H-shaped steel (see Patent

[0010] Literature 2, for example). The combination steel sheet pile having this structure has a large sectional area, and resistance at the time of driving becomes large, whereby a construction method thereof is limited. In particular, construction becomes difficult in a hard ground.

[0011] Therefore, application of a construction method using an earth auger (drilling device) for drilling the ground may be considered for constructing in the hard ground. However, a sectional shape of the combination steel sheet pile extends over a wide range, whereby it is necessary to use ingenuity. As an example of the ingenuity, there has been proposed to use a construction method as below in a case where a combination steel sheet pile having a structure similar to that of the combination steel sheet pile of Patent Literature 2 is built up (see Patent Literature 3, for example). That is, there has been proposed a construction method in which the combination steel sheet pile is driven so as to extend over a range drilled by an earth auger at the time of driving the combination steel sheet pile and a range drilled by an earth auger at the time of driving the combination steel sheet pile that has been driven before this combination steel sheet pile.

Citation List

[0012] Patent Literature

Patent Literature 1: JP 3756755 B1
Patent Literature 2: JP 2002-212943 A
Patent Literature 3: JP 4074241 B1

Summary of Invention

Technical Problem

[0013] As described above, rigidity as a steel wall is higher in a steel pipe sheet pile wall than in a steel sheet pile wall. On the other hand, water stopping performance in a joint can be enhanced more easily in the steel sheet pile wall than the steel pipe sheet pile wall.

[0014] Therefore, as described in Patent Literature 2, by combining a shape steel with the steel sheet pile wall with which the water stopping performance can be easily enhanced, it is possible to construct a steel wall having both the rigidity and the high water stopping performance.

[0015] However, by combining the shape steel with the steel sheet pile, a sectional area thereof becomes large. Therefore, as described above, a construction method that can be used is limited.

[0016] Here, it has been considered to reinforce the steel sheet pile wall (wall body) constituted of the steel sheet pile with the shape steel, in which the steel sheet pile and a reinforcement material such as the shape steel are not joined and integrated, and the steel sheet pile is in a state of being in contact with the shape steel. In this case, it is possible to construct each of them separately. However, in a case where the steel sheet pile and the reinforcement material are constructed separately, relative to a member that is constructed first, a member to be constructed second is driven in a state where it is in contact with the member that is constructed first, whereby the following problem is caused. That is, due to sliding resistance between the steel sheet pile and the reinforcement material, a large force is needed at the time of driving, or there is a fear that noise and vibration may be generated. Depending on construction accuracy, there is also a possibility that deformation may occur to any of the steel sheet pile and the reinforcement material. Since the member to be constructed second is driven in a state of being in contact with the member that is constructed first, a construction method is limited for the member to be driven second. For example, it becomes difficult to rotary press in a steel pipe as a reinforcement material and to use a vibratory type construction method in which a member is driven by being vibrated.

[0017] The present invention has been made in view of the above-described circumstances and has an objective to provide an easily constructible steel wall having a structure in which a wall body, which is constituted of steel sheet piles to which it is possible to easily provide high water stopping performance are coupled with each other, and which is reinforced by a steel pipe or a H-shaped steel.

Solution to Problem

[0018] In order to solve the problem, a steel wall according to the present invention includes a corrugated-shaped wall body in which a plurality of steel sheet piles

is coupled by a joint and in which a projection and a recess are repeated in a longitudinal direction, and a plurality of reinforcement materials constituted of a steel pipe or an H-shaped steel that reinforces the wall body and is arranged in a longitudinal direction of the wall body at a space with the wall body. A part of the reinforcement material is in a state of being entered into a recessed portion of the wall body. The wall body is coupled to the reinforcement material at head portions thereof.

[0019] In the present invention, the wall body and the reinforcement material are apart, whereby there is little restriction on the construction method, and it is possible to select and use from various construction methods that are capable of driving a steel pipe and an H-shaped steel as a reinforcement material into the ground according to a situation.

[0020] That is, since the wall body and the reinforcement material are apart, it is possible to separately perform construction for driving steel sheet piles into the ground while coupling them with each other to construct a wall body, and construction for driving a reinforcement material into the ground. In addition, the construction is easier since the wall body and the reinforcement material are not in contact with each other. For example, by providing a space between the wall body and the reinforcement material, construction by the vibratory hammer construction method becomes possible. In a case where the reinforcement material is a steel pipe, it is also possible to construct by the rotary press in construction method. Needless to say, it is also possible to use the static press-in construction method such as the hydraulic press in construction method. Since there is little restriction on the construction method in this way, it is possible to select and use from various construction methods that are capable of driving a steel pipe and a H-shaped steel into the ground according to a situation.

[0021] A high water stopping performance as with the conventional steel sheet pile wall can be obtained.

[0022] Furthermore, a large construction space such in a case of a tie rod type wall body structure is not necessary. In particular, by the reinforcement material entering into a recessed portion side of the wall body, it is possible to make a wall width smaller than an addition of a steel sheet pile height and a steel pipe diameter, whereby it is possible to construct the steel wall by saving space of a construction space.

[0023] By the reinforcement material entering into the recessed portion side of the wall body, a distance between the reinforcement material and the wall body is short, whereby unlike a tie rod type steel sheet pile wall, in a case where the reinforcement material and the wall body are coupled by a head portion thereof, it is possible to make a structure capable of transmitting both a tensile force and a compression force.

[0024] That is, in a case where an earth pressure and a water pressure act on the steel wall, load transmission is performed between the wall body and the reinforcement material since the head portion of the wall body and

the head portion of the reinforcement material are coupled with each other. Accordingly, the steel wall may be configured to have a structure in which the acting earth pressure and the acting water pressure may be shared and carried by the wall body and the reinforcement material. By coupling and fixing the head portion of the wall body to the head portion of the reinforcement material, it is possible to regulate misalignment in a vertical direction between the wall body and the reinforcement material, and to transmit a shear force.

[0025] In a tie rod type steel sheet pile structure, a waling material is necessary in order to distribute the acting force among tie rods discretely disposed in an extension direction of the wall body and to cause the wall body to behave uniformly. However, in the present invention, the reinforcement material enters into the recessed portion side, and the force is transmitted through a short distance, whereby the waling material is not necessary.

[0026] In particular, in a case where the reinforcement material is disposed to every other steel sheet pile or every two or more steel sheet piles, if there is a space between the reinforcement material and the steel sheet pile, an effect of the reinforcement material becomes partial, whereby a member for distributing the force in the extension direction of the waling material becomes necessary. However, by the reinforcement material entering into the recessed portion of the wall body, the reinforcement material is capable of exerting an effect thereof to the steel sheet pile not installed with the reinforcement material, whereby the waling material and the like are not necessary.

[0027] Note that there has been performed an indoor test for checking behavior of the wall body by, in the middle of a rigid soil tank having a width of 1957 mm, a height of 1000 mm, and a depth of 940 mm, a corrugated acrylic imitating the steel sheet pile wall and an acrylic pipe imitating the steel pipe are fixed at lower ends thereof by an adhesive, and in a state where silica sand number 5 (dry sand) is installed by air pluviation method to the right and left of the corrugated shape, the sand is dug down to the lower end thereof on one side. Through this experiment, it has been confirmed that, when a pitch of the steel pipe is 4/7 or below of the wall height, by disposing the reinforcement material so as to enter into the recessed portion of the wall body and by coupling the head portions thereof, there is an effect of the reinforcement material on skipped portions as well. Therefore, it is preferred that a pitch L and a wall height H of the reinforcement material satisfy $L \leq 4H / 7$.

[0028] In the above-described configuration of the present invention, it is preferred that the wall body and the reinforcement material be coupled at the head portions thereof by a concrete, which has been driven across head portions thereof.

[0029] According to this configuration, it is configured to have a structure in which the head portion of the reinforcement material is coupled with the head portion of the wall body by the concrete, which has been driven

across them, whereby it is possible to make a structure in which the head portions (upper end portions) of the steel pipe and the steel sheet pile are not exposed but covered with the concrete. Accordingly, it is possible to enhance aesthetics of the steel wall. Since the concrete is driven so as to extend across the reinforcement material and the wall body, there is little danger of a top end between the steel pipe and the wall body being collapsed, and the like.

[0030] In the above-described configuration of the present invention, it is preferred that the wall body and the reinforcement material are coupled at head portions thereof being joined by welding them to a steel sheet installed between them.

[0031] According to this configuration, the coupling between the steel sheet and the reinforcement material at the head portion thereof is performed by welding the steel sheet to the reinforcement material and the wall body, whereby it is easy to construct and requires little construction effort. For example, unlike in a case of the tie rod type, in which an effort to make a hole in the steel sheet pile and the steel pipe sheet pile through which the tie rod is passed and an effort of inserting the tie rod through the hole are necessary, is not necessary. Furthermore, compared to a case where the above-described concrete is driven, a curing period of the concrete is not necessary, whereby it is possible to reduce a construction period.

[0032] In the above-described configuration of the present invention, the wall body and the reinforcement material are coupled by being joined by welding to a steel sheet, which is installed between them, at the head portions thereof, and the wall body and the reinforcement material may also be coupled at the head portions thereof by the concrete, which is driven so as to extend across the head portions thereof.

[0033] According to this configuration, coupling by welding the steel sheet and coupling by the concrete are combined, whereby it is possible to mutually complement the aesthetics and strength. For example, the concrete is excellent in transmitting a compression force at a coupled portion while the welded steel sheet is excellent in transmitting the tensile force at the coupled portion, whereby the strength may be mutually complemented. Improvement of transmission of the tensile force by the steel sheet and landscaping and safety measure (for example, prevention of collapse of the top end) by the concrete (maintenance of scenery) may be mutually complemented.

[0034] In the above configuration of the present invention, it is preferred that the reinforcement material be the steel pipe.

[0035] According to this configuration, by using the steel pipe as the reinforcement material, it becomes possible to obtain high rigidity as well as to use the rotary press in construction method and the inner excavation construction method, whereby construction in which the noise and the vibration are suppressed becomes easier.

[0036] In the above-described configuration of the present invention, it is preferred that a space be set between the wall body and the reinforcement material such that the steel sheet pile in the wall body and the reinforcement material are not in contact with each other during construction.

[0037] According to this configuration, when the wall body and the reinforcement material are constructed, the steel sheet pile of the wall body does not come in contact with the reinforcement material during the construction, whereby it is possible to prevent a problem caused by contact between the above-described wall body and the reinforcement material during the construction.

[0038] In the above-described configuration of the present invention, the reinforcement material may be provided on a side of the wall body where a relatively large pressure is received.

[0039] According to this configuration, since the reinforcement material is provided on the side of a surface where the relatively large pressure (earth pressure and water pressure) is received, the wall body and the reinforcement material are to receive the pressure. In this case, a load acts on the wall body in a direction away from the reinforcement material. Here, the head portion of the wall body is coupled to the head portion of the reinforcement material, and since it has a structure in which load transmission (tensile force transmission) is performed between the wall body and the reinforcement material, it is possible to share and receive the load between the wall body and the reinforcement material. Therefore, even if the reinforcement material is disposed on the side of the wall body where the relatively large pressure is received, it is possible to sufficiently improve the strength by combining the reinforcement material with the wall body. In a case where the steel wall is used as, for example, bank protection, an earth-retaining wall, and the like, the reinforcement material is disposed on a back surface side. Therefore, on a side where a top portion of the steel wall is exposed, only a side surface of the wall body is exposed while the reinforcement material is in a hidden state, whereby it has an external appearance that is not complicated and aesthetically excellent.

[0040] In the above-described configuration of the present invention, the reinforcement material may be provided on an opposite side of a side where the relatively large pressure is received of the wall body.

[0041] According to this configuration, the reinforcement material is provided on the opposite side of the side where the relatively large pressure is received of the wall body, whereby the earth pressure and the water pressure act on the wall body. In this case, at the coupled portion of the wall body and the reinforcement material, the load is transmitted from the wall body to the reinforcement material (compression force transmission), whereby the earth pressure and the water pressure may be shared and received by the wall body and the reinforcement material. In a case where it is used as the bank protection, earth-retaining wall, and the like, the reinforcement ma-

terial is disposed on a front surface side, or a side where the top portion is exposed, of the wall body. Therefore, for example, drilling for exposing the head portion of the reinforcement material during the construction is not necessary, and repairs are easily made on the reinforcement material in an exposed state or on the coupled portion of the reinforcement material and the wall body.

Advantageous Effects of Invention

[0042] According to the present invention, it is possible to obtain high water stopping performance similar to a conventional steel sheet pile wall, and to decrease a bending moment that occurs to the wall body due to the load being transmitted to the reinforcement material. It has a structure in which the steel sheet pile and the steel pipe or the H-shaped steel are combined; however, it is possible to construct them separately, whereby construction may be made easier.

Brief Description of Drawings

[0043]

Fig. 1 is a schematic plan view illustrating a steel wall according to a first embodiment of the present invention.

Fig. 2 is a schematic plan view illustrating a principal part of the steel wall according to the first embodiment.

Fig. 3 is a schematic sectional view illustrating the steel wall according to the first embodiment in the ground.

Fig. 4 is a schematic plan view of a steel wall according to a modification of the first embodiment of the present invention.

Fig. 5 is a schematic plan view illustrating a principal part of a steel wall according to a second embodiment of the present invention.

Fig. 6 is a schematic sectional view illustrating the steel wall according to the second embodiment in the ground.

Fig. 7 is a schematic plan view illustrating a principal part of a steel wall according to a third embodiment of the present invention.

Fig. 8 is a schematic sectional view illustrating the steel wall according to the third embodiment in the ground.

Fig. 9 is a schematic plan view illustrating a principal part of a steel wall according to a fourth embodiment of the present invention.

Fig. 10 is a schematic plan view illustrating a principal part of a steel wall according to a fifth embodiment of the present invention.

Fig. 11 is a schematic plan view illustrating a steel wall according to a modification of the fifth embodiment of the present invention.

Fig. 12 is a schematic plan view illustrating a principal

part of a steel wall according to another modification of the fifth embodiment of the present invention.

Description of Embodiments

[0044] Hereinafter, an embodiment of the present invention is described with reference to the drawings.

[0045] As illustrated in Figs. 1 to 3, a steel wall 3 according to a first embodiment of the present invention is configured to combine a hat-shaped steel sheet pile 1 as a steel sheet pile and a steel pipe (reinforcement material) 2. The plurality of steel pipes 2 is disposed at a space from each other and arranged in a line along a longitudinal direction of a wall body (steel sheet pile wall) 4, in which the plurality of hat-shaped steel sheet piles 1 is coupled.

[0046] The hat-shaped steel sheet pile 1 includes: a web 1a; a pair of flanges 1b each diagonally extending from each of both side rims of the web 1a so as to spread out from each other; a pair of arms 1c extending to the right and left to be parallel to the web 1a from a tip of the right and left flanges 1b; and a joint 1d provided at a tip of the arm 1c.

[0047] The hat-shaped steel sheet pile 1 is not in contact with the steel pipe 2, and there is a space between the hat-shaped steel sheet pile 1 and the steel pipe 2. A diameter of the steel pipe 2 is narrower than a width (effective width) of the hat-shaped steel sheet pile 1. A part of this steel pipe 2 is in a state of being entered into a recessed portion, which is a valley portion on one of side surfaces of the wall body constituted of the hat-shaped steel sheet piles 1.

[0048] The plurality of hat-shaped steel sheet piles 1 is arranged in a line by coupling the joints 1d thereof with each other to constitute the above-described wall body 4 as the steel sheet pile wall. The hat-shaped steel sheet pile 1 and the steel pipe 2 are driven into the ground.

[0049] In this steel wall 3, as illustrated in Figs. 2 and 3, a head portion of the wall body 4 constituted of the hat-shaped steel sheet piles 1 is coupled to a head portion of the steel pipe 2 by a coping 5. That is, the coping 5 is provided by the concrete, which is driven by involving the head portion of the wall body 4 and the head portion of the steel pipe 2. The head portion of the wall body 4 and the head portion of the steel pipe 2 enter into the concrete to be the coping 5, whereby the head portion of the wall body 4 and the head portion of the steel pipe 2 are coupled and fixed.

[0050] An upper end opening portion of the steel pipe 2 is blocked by the concrete of the coping 5. The coping 5 is provided along the wall body 4 in a length direction, and by the coping 5 having the same length as the length of one wall body 4, all of the steel pipes 2 are coupled to the wall body 4.

[0051] Relative to the wall body 4, the steel pipe 2 is disposed on an opposite side of a side where the earth pressure is applied, or a front surface side, which is to be the side where the earth pressure is not applied.

[0052] The steel wall 3 in this example is, for example, the bank protection, and relative to a high side ground surface a, a low side ground surface b is a waterside such as sea, lake, and river. Note that the steel wall 3 is not limited to the bank protection. It may be also used in earth retaining work, cofferdam, a land reclamation, embankment, and the like.

[0053] Between the wall body 4 constituted of the hat-shaped steel sheet piles 1 and the steel pipe 2, there is provided a space so that the wall body 4 (hat-shaped steel sheet pile 1) and the steel pipe 2 do not come in contact with each other when they are constructed separately. That is, to the wall body 4 or to the steel pipe 2 that is constructed first, the space is set such that the wall body 4 or the steel pipe 2 that is constructed second does not come in contact with each other during the construction. Specifically, it is preferred that the space at the narrowest part between the wall body 4 and the steel pipe 2 be set to 50 mm or more during the construction. Note that the space may also be 60 mm or more, 70 mm or more, or 80 mm or more. Considering a cost required for coupling the head portion of the wall body 4 and the head portion of the steel pipe 2, a thickness of the steel wall body as a whole, and the like, however, it is configured such that at least a part of the steel pipe 2 is being entered into the recessed portion on the valley side of the corrugated-shaped sheet pile wall, in which a projection and a recess (a mountain and a valley) are repeated, as the wall body 4.

[0054] By configuring such that the steel pipe enters into the recessed portion of the wall body, it is possible to perform hydraulic press in or rotary press in of the steel pipe 2 by grasping the steel sheet pile 4 of the already constructed steel sheet pile wall and an already driven steel pipe. In a case where the hydraulic press in and the rotary press in are performed by receiving a reaction force by the already constructed steel sheet pile wall and the steel pipe, in order to construct stably, it is preferred that the steel pipe be disposed as close as possible to the already constructed steel sheet pile wall and the steel pipe.

[0055] In this case, for example, depending on a type and the like of the hat-shaped steel sheet pile 1, a depth of the recessed portion (a distance between the web 1a and the arm 1c along a direction orthogonal thereto) is different. For example, in a case of the hat-shaped steel sheet pile having a width of 900 mm, the depth of the recessed portion is about 200 mm to 300 mm, whereby it is preferred that the space between the steel pipe 2 and the web 1a of the hat-shaped steel sheet pile 1 of the wall body 4 be not greater than it.

[0056] Next, a method of constructing the steel wall 3 is described herein.

[0057] In constructing the steel wall 3, the hat-shaped steel sheet pile 1 constituting the wall body 4 and the steel pipe 2 to be the reinforcement material are driven separately into the ground.

[0058] At the time, it is possible to drive the hat-shaped

steel sheet pile 1 first into the ground, or to drive the steel pipe 2 first into the ground. The wall body 4 may be an already established steel sheet pile wall, and the steel pipe may be driven for a purpose of reinforcing it and the like.

[0059] It is possible to perform in parallel a process of driving the hat-shaped steel sheet pile 1 in order by coupling it to the hat-shaped steel sheet pile 1 driven in advance, and a process in which the steel pipe 2 is arranged into a line and driven in order.

[0060] Furthermore, in driving the hat-shaped steel sheet pile 1, it is possible to use the hydraulic press in construction method in which the hat-shaped steel sheet pile 1 is pressed in by receiving the reaction force by the hat-shaped steel sheet pile 1 driven first, to use the vibratory hammer construction method, or to perform drilling by an earth auger for driving.

[0061] It is possible to use a construction method similar to that of the hat-shaped steel sheet pile 1 for pressing in the steel pipe 2 as well. In the case of the steel pipe 2, it is possible to use the rotary press in construction method and the inner excavation construction method in which the ground is drilled from inside the steel pipe 2 to press in the steel pipe 2.

[0062] Furthermore, it is also possible to hydraulic press in or rotary press in the steel pipe 2 by grasping the steel sheet pile 1 of the already constructed steel sheet pile wall or an already driven steel pipe. At that time, by the steel pipe being entered into the recessed portion of the wall body, positions of the steel sheet pile wall or the steel pipe, by which the reaction force is received, and the steel pipe to be constructed become close to each other, whereby it is possible to stably construct.

[0063] In this steel wall 3, the wall body 4, which is a steel sheet pile wall, and the steel pipe 2, which is the reinforcement material, are driven into the ground at a space of, for example, 50 mm or more so as not to be in contact with each other during the construction, whereby it is possible to suppress the wall body 4 and the steel pipe 2 from sliding such that vibration, noise, and deformation are not caused during the construction.

[0064] In a case where the wall body 4 and the steel pipe 2 are in contact during the construction, for example, when a vibratory type construction method in which a member to be driven is vibrated during driving or the rotary press in construction method is adopted, a possibility of causing the above-described noise, vibration, and deformation may become higher. A usable construction method may be limited, accordingly. In contrast, in this embodiment, the wall body 4 and the steel pipe 2 are apart during the construction, whereby there are many choices in the construction method.

[0065] In a case where the steel sheet pile and the reinforcement material are joined and integrated, a sectional area of a member to be driven in to the ground becomes large, whereby it becomes difficult to be driven. In contrast, in the steel wall 3 of this embodiment, the

wall body 4 and the steel pipe 2 are separately driven, whereby it becomes easy to construct. Furthermore, since the wall body 4 and the steel pipe 2 are apart so as to avoid being contact with each other during the construction, it becomes much easier to construct than in a case where the wall body 4 and the steel pipe 2 are in contact, as described above.

[0066] After the steel sheet pile 1 (wall body 4) and the steel pipe 2 are driven, the concrete to be the coping 5 is driven across the wall body 4 and the steel pipe 2. Accordingly, the head portion of the wall body 4 is coupled with the head portion of the steel pipe 2.

[0067] In this steel wall 3, the head portion of the wall body 4 is coupled to the head portion of the steel pipe 2, whereby the load transmission is possible between the wall body 4 and the steel pipe 2 by the coupled portion. Therefore, the earth pressure and the water pressure received by the steel wall 3 are shared and received by the wall body 4 and the steel pipe 2. The head portion of the wall body 4 is coupled to the head portion of the steel pipe 2, whereby it is possible to prevent a positional misalignment in the vertical direction between the steel pipe 2 and the wall body 4. As above, in the steel wall 3, it is possible to decrease the bending moment, which occurs to the wall body 4 reinforced by the steel pipe 2, from the independent steel sheet pile wall. It is possible to make the water stopping performance of the steel wall 3 the same level as the steel sheet pile wall, whereby even if filling and the like of the mortar are not performed to the joint 1d, it is possible to obtain the same level of the water stopping performance as the steel pipe sheet pile wall having a joint portion filled with the mortar.

[0068] In this embodiment, as illustrated in Fig. 3, in the steel wall 3, the steel pipe 2 is disposed to an opposite side of a side where the earth pressure is applied of the wall body 4, or on the front surface side where the earth pressure is not applied. Therefore, in a case where an objective is to reinforce the already established steel sheet pile wall, even if there is an obstacle in an above-ground portion or an under-ground portion on a back surface side, it is possible to install a steel pipe for reinforcement on the front surface side. Furthermore, even in a case where the reinforcement is performed with the steel pipe of the same length, compared to a case where it is installed to the back, the length to be driven into the soil becomes short, whereby it is possible to reduce the construction effort and the cost.

[0069] In this embodiment, the steel wall 3 is used as the bank protection, and the head portion of the steel pipe 2 is coupled to the head portion of the wall body 4 by the coping 5. Therefore, the coping 5 is a coupling material of the head portion of the steel pipe 2 and the head portion of the wall body 4, while it also has a function to block an opening portion of the steel pipe 2. In this embodiment, a specialized coupling member such as a tie rod is not necessarily required, whereby it is possible to decrease the cost.

[0070] In the steel wall 3 according to this embodiment,

a length of the steel pipe 2 is made longer than a vertical length of the wall body 4 (a length of the hat-shaped steel sheet pile 1). By making the length of the steel pipe 2 having relatively high rigidity longer, a free design becomes possible such as to allow receiving of the earth pressure by the steel pipe 2 and to allow the wall body 4 to play the role of preventing outflow of the earth and sand. Accordingly, it becomes possible to decrease a steel weight and the construction cost. For example, it is possible to make the steel pipe 2 longer than the wall body 4 and to allow only the steel pipe 2 to be embedded into a support layer.

[0071] Note that as described later, the length of the steel pipe 2 may be shorter than the vertical length of the wall body 4, or the length of the steel pipe 2 may be the same as the vertical length of the wall body 4. The length of the steel pipe 2 is determined from a viewpoint of the rigidity and a ground condition. In a case where boiling, heaving, and an arc sliding are concerned when the length of the steel pipe 2 is the same as the vertical length of the wall body 4, the vertical length of the wall body 4 may be made longer than the steel pipe 2. Furthermore, the wall body 4 may be made longer than the steel pipe 2 in order to cut off ground water.

[0072] In this embodiment, as illustrated in Fig. 1, the steel pipe 2 is disposed to each of the hat-shaped steel sheet piles 1 of the wall body 4 (for each recessed portion of the wall body 4). However, depending on the required yield strength, it is not necessary to dispose the steel pipe 2 to all of the hat-shaped steel sheet piles 1. For example, as illustrated in Fig. 4, it is possible to dispose the steel pipe 2 to every other hat-shaped steel sheet pile 1 (every other recessed portion), while it is also possible to dispose it to every two hat-shaped steel sheet piles 1 (every two recessed portions). Since the reinforcement material is being entered into the recessed portion of the wall body, it is possible to exert an effect of the reinforcement material to an adjacent steel sheet pile without disposing the steel pipe to all of the hat-shaped steel sheet piles 1. It is preferred, however, that the steel pipe 2 be disposed substantially equal in a state where the steel pipe 2 is aligned in the longitudinal direction of the wall body 4.

[0073] The steel sheet pile constituting the wall body 4 is not limited to the hat-shaped steel sheet pile 1; various steel sheet piles such as a U-shaped steel sheet pile, a Z-shaped steel sheet pile, and the like may be used.

[0074] Next, a second embodiment of the present invention is described.

[0075] As illustrated in Figs. 5 and 6, in a steel wall 31 of the second embodiment, the head portion of the steel pipe 2, the head portion of the wall body 4, and the coping 5 are coupled by a steel pillow material (for example, a steel sheet or a shape steel cut into a predetermined length) 6 as a coupling member. The steel pipe 2 and the wall body 4 have the same vertical length. Besides, a configuration thereof is the same as that of the steel

wall 3 of the first embodiment. Therefore, a constituent element that is the same as that of the first embodiment is denoted with the same reference numeral, and a description thereof is omitted.

[0076] In the second embodiment, the steel pillow material 6 (steel material), as the coupling member, is provided in a state of being sandwiched between the head portion of the steel pipe 2 and the head portion of the wall body 4. This pillow material 6 is fixed to the steel pipe 2 and the wall body 4 by, for example, welding, a bolt, a drill screw, and the like. Accordingly, the head portion of the steel pipe 2 is coupled to the head portion of the wall body 4 in a state where the steel pipe 2 and the wall body 4 are apart.

[0077] In the second embodiment, as described above, the length of the steel pipe 2 and the vertical length (length of the hat-shaped steel sheet pile 1) of the wall body 4 are substantially the same.

[0078] A method of constructing the steel wall 31 according to the second embodiment is as follows.

[0079] First, the steel sheet pile 1 and the steel pipe 2 are driven in the same way as in the first embodiment. Next, a steel material to be the pillow material 6 is installed between the steel sheet pile 1 (wall body 4) and the steel pipe 2 and is fixed by welding, a bolt, a drill screw, and the like to the steel sheet pile 1 (wall body 4) and to the steel pipe 2, respectively. Subsequently, in the same way as the first embodiment, the coping is driven across the wall body 4 and the steel pipe 2.

[0080] In the steel wall 31 of the second embodiment, the head portion of the steel pipe 2 is coupled to the head portion of the wall body 4 through both the coping 5 and the pillow material 6. Accordingly, it is possible to more securely transmit the load received by the wall body 4 to the steel pipe 2. Except for this point and an effect based on that the steel pipe 2 and the hat-shaped steel sheet pile 1 have the same length, it is possible to obtain the same act and effect as the steel wall 3 of the first embodiment.

[0081] Next, a third embodiment of the present invention is described.

[0082] As illustrated in Figs. 7 and 8, in a steel wall 32 according to the third embodiment, the head portion of the steel pipe 2 is coupled to the head portion of the wall body 4 not only by the coping 5 but also by a pair of plate materials 7 as coupling members. Furthermore, a vertical length of the wall body 4 is made longer than the length of the steel pipe 2. The steel pipe 2 is disposed on a back surface side of the wall body 4 where an earth pressure is applied. Besides, it has the same configuration as the steel wall 3 of the first embodiment. Therefore, a constituent element that is the same as that of the first embodiment is denoted with the same reference numeral, and a description thereof is omitted.

[0083] In the third embodiment, the steel plate materials 7 are provided in a state of being sandwiched between the head portion of the steel pipe 2 and the head portion of the wall body 4. The plate materials 7 are fixed to the

steel pipe 2 and the wall body 4 by welding, a bolt, and the like, respectively. The head portion of the steel pipe 2 is coupled to the head portion of the wall body 4 in a state where the steel pipe 2 and the wall body 4 are apart. Furthermore, by providing the coping 5 by involving with concrete across the head portion of the steel pipe 2 and the head portion of the wall body 4, which are coupled by the plate material 7, the head portion of the steel pipe 2 is coupled to the head portion of the wall body 4 by the coping 5 as well.

[0084] In the third embodiment, as described above, the vertical length (length of the hat-shaped steel sheet pile 1) of the wall body 4 is made longer than the length of the steel pipe 2. Accordingly, it is possible to prevent the boiling, heaving, and arc sliding as well as to cut off the ground water. By performing coupling by the plate material 7 in addition to coupling by the coping 5, it is possible to enhance strength of the coupled portion of the head portion of the steel pipe 2 and the head portion of the wall body 4. In particular, in this structure, a tensile load acts between the wall body 4 and the steel pipe 2, the coupling by the steel plate material 7 becomes further effective.

[0085] By providing the steel pipe 2 on the back surface side of the wall body 4, it is possible to hide the steel pipe 2 without exposing it on a front side of the wall body 4, whereby it is possible to enhance aesthetics of the steel wall 32.

[0086] In the steel wall 32 of the third embodiment, it is possible to obtain the same act and effect as the first embodiment except for the structure of the coupled portion, the length of the steel pipe 2 and the wall body 4, and the act and effect based on the disposition of the steel pipe 2 relative to the wall body 4.

[0087] Next, a fourth embodiment of the present invention is described.

[0088] As illustrated in Fig. 9, a steel wall 33 according to the fourth embodiment has an H-shaped steel 9 as a reinforcement material in place of a steel pipe 2; any other configuration is the same as the configuration of the steel wall 3 of the first embodiment. Therefore, a constituent element that is the same as that of the first embodiment is denoted with the same reference numeral, and a description thereof is omitted.

[0089] The steel wall 33 of the fourth embodiment uses the H-shaped steel 9 as the reinforcement material. The H-shaped steel 9 is disposed along a longitudinal direction of the wall body 4, to which the hat-shaped steel sheet pile 1 is connected, being arranged in a line at a space in the same way as the steel pipe 2 of the first embodiment. In the same way as the steel pipe 2 of the first embodiment, the space is provided between the H-shaped steel 9 and the wall body 4.

[0090] A part of the H-shaped steel 9 is in a state of being entered into a recessed portion, which is a valley portion on one of side surfaces of a wall body constituted of the hat-shaped steel sheet pile 1. The H-shaped steel 9 is disposed such that a web 9a is orthogonal to the

longitudinal direction of the wall body 4. Therefore, a flange 9b is parallel to the longitudinal direction of the wall body 4.

[0091] The head portion of the wall body 4 is coupled to a head portion of the H-shaped steel 9. The same method as the first to third embodiments may be used as a method of coupling the steel wall 33 to the H-shaped steel 9 as the reinforcement material. That is, the wall body 4 is coupled to the H-shaped steel 9 by the coping 5. Note that the wall body 4 and the H-shaped steel 9 may be coupled by welding through a steel material or by fastening with a bolt. The head portion of the wall body 4 may be coupled to the head portion of the H-shaped steel 9 by combining these methods of coupling.

[0092] Except that the reinforcement material is changed from the steel pipe 2 to the H-shaped steel 9, any other configuration, such as a relationship between the length of the wall body 4 and the length of the H-shaped steel 9 and disposition of the H-shaped steel 9 relative to the wall body 4 (including a space between the wall body 4 and the H-shaped steel 9), may be the same as that of the first to third embodiments.

[0093] The method of constructing the steel wall 33 may be the same as the method of constructing the steel wall of the first to third embodiments except that it is not possible to construct the H-shaped steel 9 by the inner excavation construction method or by the rotary press in construction method.

[0094] With the steel wall 33 of the fourth embodiment, it is possible to obtain the same act and effect as the steel wall 3 of the first to third embodiments except for the act and effect by the steel pipe 2.

[0095] Next, a fifth embodiment of the present invention is described.

[0096] As illustrated in Fig. 10, in a steel wall 34 of the fifth embodiment, coupling of the head portion of the steel pipe 2 and the head portion of the wall body 4 are performed by welding of a steel sheet 8 in each of the above-described embodiments. Concrete is not used for coupling the head portion of the steel pipe 2 and the head portion of the wall body 4. The configuration thereof is the same as the steel wall 3 of the first embodiment, except for this structure of coupling the head portion of the steel pipe 2 and the head portion of the wall body 4. Therefore, the same constituent element is denoted with the same reference numeral, and a description thereof is omitted.

[0097] In the steel wall 34 of the fifth embodiment, in the same way as that of the first embodiment, the plurality of steel pipes 2 is disposed at a space from each other and arranged in a line along the longitudinal direction of the wall body (sheet pile wall) 4, in which the plurality of hat-shaped steel sheet piles 1 is coupled. It is disposed in a state where a part of the steel pipe 2 is being entered into a recessed portion of the corrugated steel sheet pile 1 in which a recess and a projection are repeated.

[0098] The steel sheet 8 is disposed between the hat-shaped steel sheet pile 1 of the wall body 4 and the steel

pipe 2. In this embodiment, the steel sheet 8 is disposed between an arm 1c of the hat-shaped steel sheet pile 1 and an outer circumference of the steel pipe 2. In correspondence to the right and left arms 1c, for one hat-shaped steel sheet pile 1 and one steel pipe 2, a pair of the steel sheets 8 is provided in the right and left.

[0099] One of edges of the steel sheet 8 is welded to the arm 1c of the hat-shaped steel sheet pile 1 and the other edge thereof is welded to the outer circumference of the steel pipe 2.

[0100] In constructing the steel wall 34, construction of the wall body 4 and driving of the steel pipe 2 are performed in the same way as those in the first embodiment. After the construction of the wall body 4 and the driving of the steel pipe 2 are completed, the steel sheet 8 is welded to the hat-shaped steel sheet pile 1 of the wall body 4 and the steel pipe 2.

[0101] In the steel wall 34 of the fifth embodiment, coupling between the head portions of the wall body 4 and the steel pipe 2 is performed by welding of the steel sheet 8, whereby it becomes easy to construct. A cure time is not necessary unlike in a case where the concrete is used for coupling, whereby the construction period becomes short.

[0102] Note that in this embodiment, as illustrated in Fig. 11, the steel sheet 8 may be disposed between the web 1a of the hat-shaped steel sheet pile 1 and the outer peripheral surface of the steel pipe 2, or it may be disposed between a flange 1b and the outer peripheral surface of the steel pipe 2.

[0103] Relative to the hat-shaped steel sheet pile 1, it is also possible to skip a pitch of the steel pipe 2 (for example, to dispose the steel pipe 2 to every other hat-shaped steel sheet pile 1 or every two or more hat-shaped steel sheet piles 1) and to use the steel pipe 2 having a diameter larger than an effective width of the hat-shaped steel sheet pile 1.

[0104] It is also possible to dispose the steel pipe 2 on a side of the wall body 4 where a relatively large pressure is received or to dispose it on an opposite side thereof.

[0105] As a steel wall 34A illustrated in Fig. 12, in addition to the coupling by welding of the steel sheet 8, in the same way as the first embodiment, it is also possible to provide a coping 5 by concrete that is driven by involving the head portion of the wall body 4 and the head portion of the steel pipe 2. In this case, the concrete is to be driven after the welding of the steel sheet 8.

[0106] The wall body 4 and the steel pipe 2 are coupled by the concrete in addition to the welding of the steel sheet 8.

[0107] In this case, it is possible to realize a complementary structure in which, for example, transmission of a compression force between the wall body 4 and the steel pipe 2 is performed mainly by the concrete, and transmission of a tensile force is performed mainly by the steel sheet 8. It is also possible to attain blockage of an upper end opening portion of the steel pipe 2 by the above-described concrete, prevention of collapse of the

top end, and the like.

[0108] The steel walls 3, 31, 32, 33, 34, and 34A may also be constructed by setting an already established steel sheet pile wall as the wall body 4 and by driving the steel pipe 2 or the H-shaped steel 9 relative to this wall body 4.

Reference Signs List

10 **[0109]**

- 1 hat-shaped steel sheet pile (steel sheet pile)
- 1d joint
- 2 steel pipe (reinforcement material)
- 15 3 steel wall
- 5 coping
- 8 steel sheet
- 9 H-shaped steel (reinforcement material)
- 31 steel wall
- 20 32 steel wall
- 33 steel wall
- 34 steel wall
- 34A steel wall
- 25

Claims

1. A steel wall, comprising:

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a corrugated-shaped wall body in which a plurality of steel sheet piles is coupled by a joint and in which a projection and a recess are repeated in a longitudinal direction; and
 35 a plurality of reinforcement materials constituted of a steel pipe or an H-shaped steel that reinforces the wall body and is arranged in a longitudinal direction of the wall body at a space with the wall body, wherein
 40 a part of the reinforcement material is in a state of being entered into a recessed portion of the wall body, and
 the wall body is coupled to the reinforcement material at head portions thereof.

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2. The steel wall according to claim 1, wherein the reinforcement material is installed to every other steel sheet pile or every two or more steel sheet piles.

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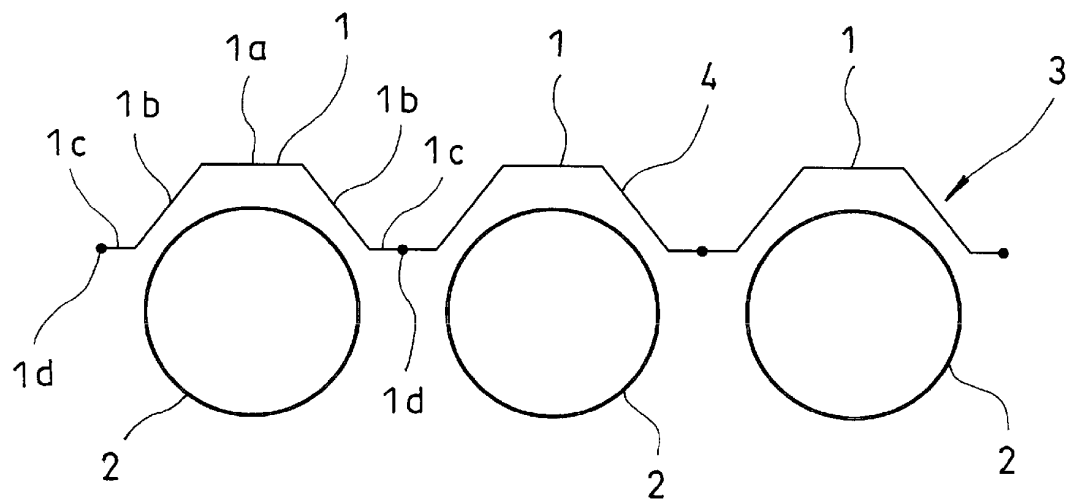
3. The steel wall according to claim 1, wherein the wall body is coupled to the reinforcement material at head portions thereof by concrete, which is driven across the head portion thereof.

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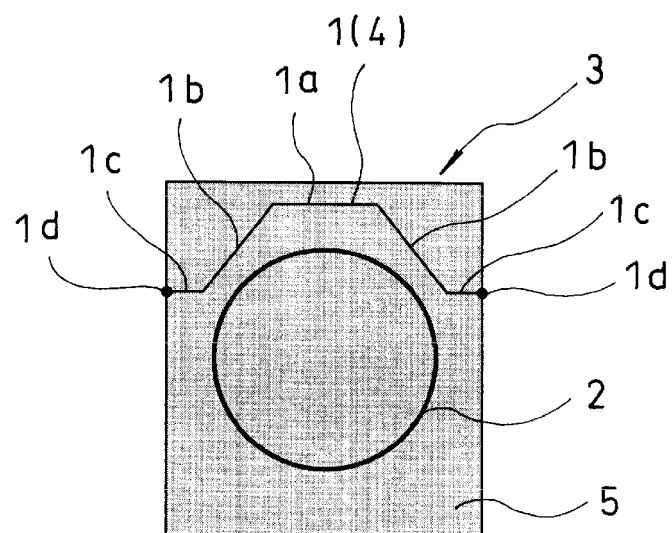
4. The steel wall according to claim 1, wherein the wall body and the reinforcement material are coupled at head portions thereof by each being joined to a steel sheet installed therebetween by welding.

5. The steel wall according to claim 4, wherein the wall body and the reinforcement material are coupled at head portions thereof by concrete driven across the head portions thereof.
- 5
6. The steel wall according to any one of claims 1 to 5, wherein the reinforcement material is the steel pipe.
7. The steel wall according to any one of claims 1 to 5, wherein there is set a space between the wall body and the reinforcement material such that the steel sheet pile of the wall body and the reinforcement material do not contact each other during construction.
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- 15
8. The steel wall according to any one of claims 1 to 5, wherein the reinforcement material is provided on a side of the wall body where a relatively large pressure is received.
- 20
9. The steel wall according to any one of claims 1 to 5, wherein the reinforcement material is provided on an opposite side of the side of the wall body where the relatively large pressure is received.
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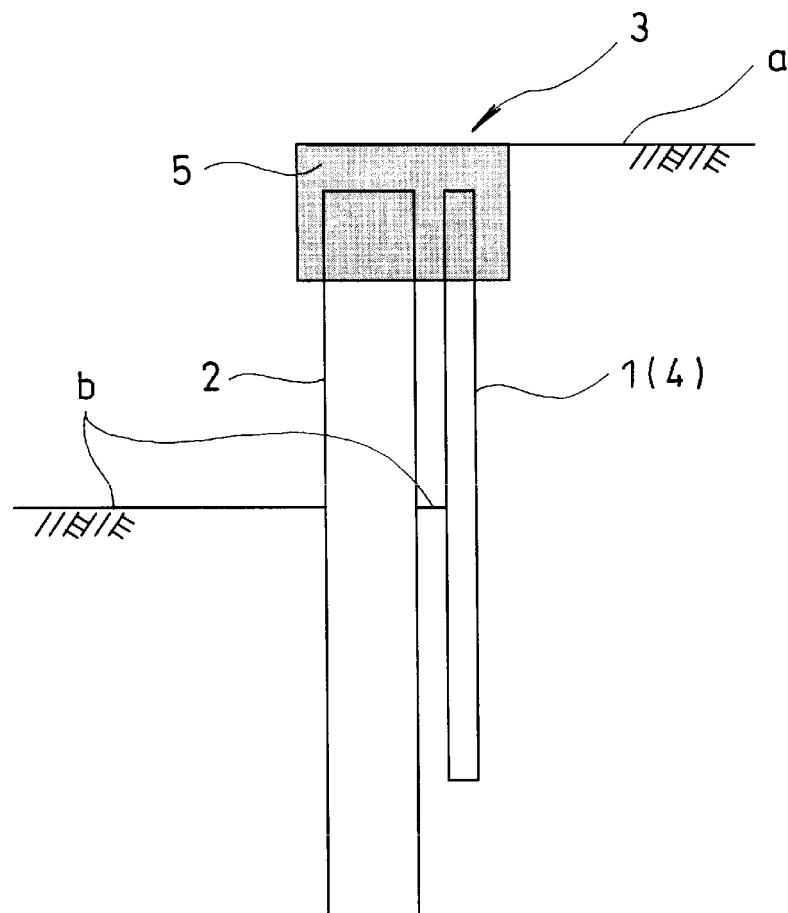
[Fig. 1]



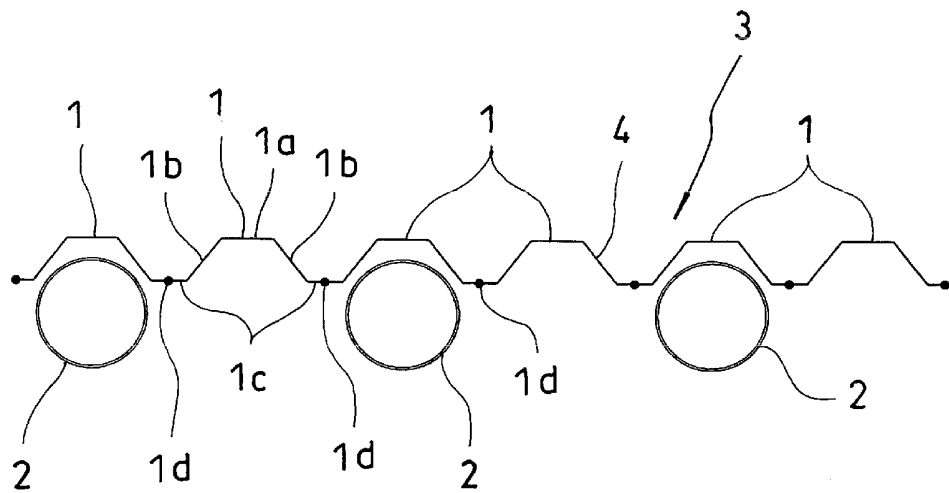
[Fig. 2]



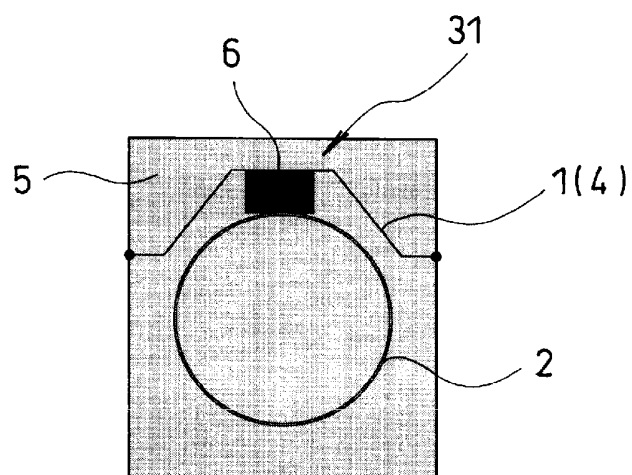
[Fig. 3]



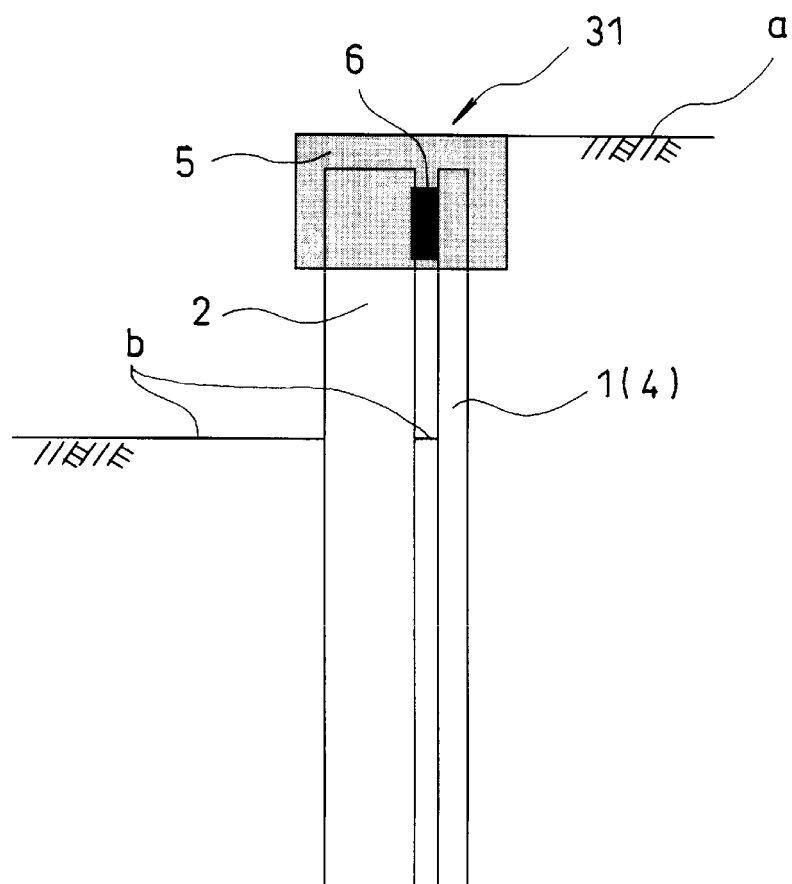
[Fig. 4]



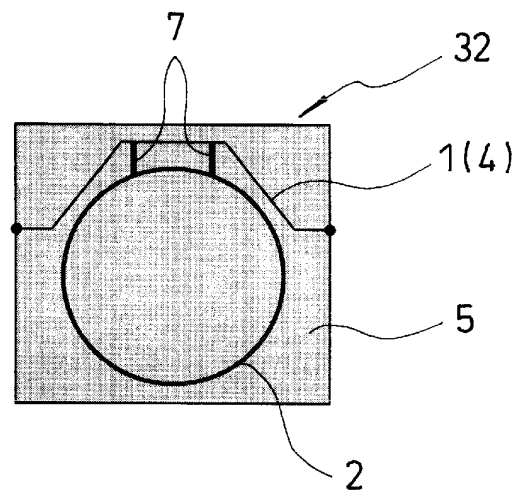
[Fig. 5]



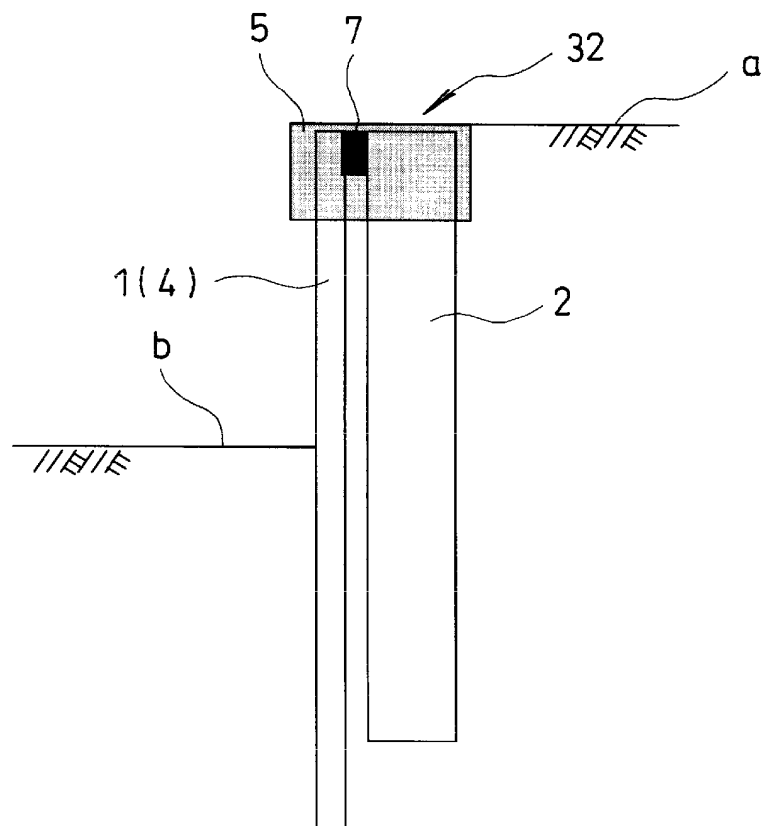
[Fig. 6]



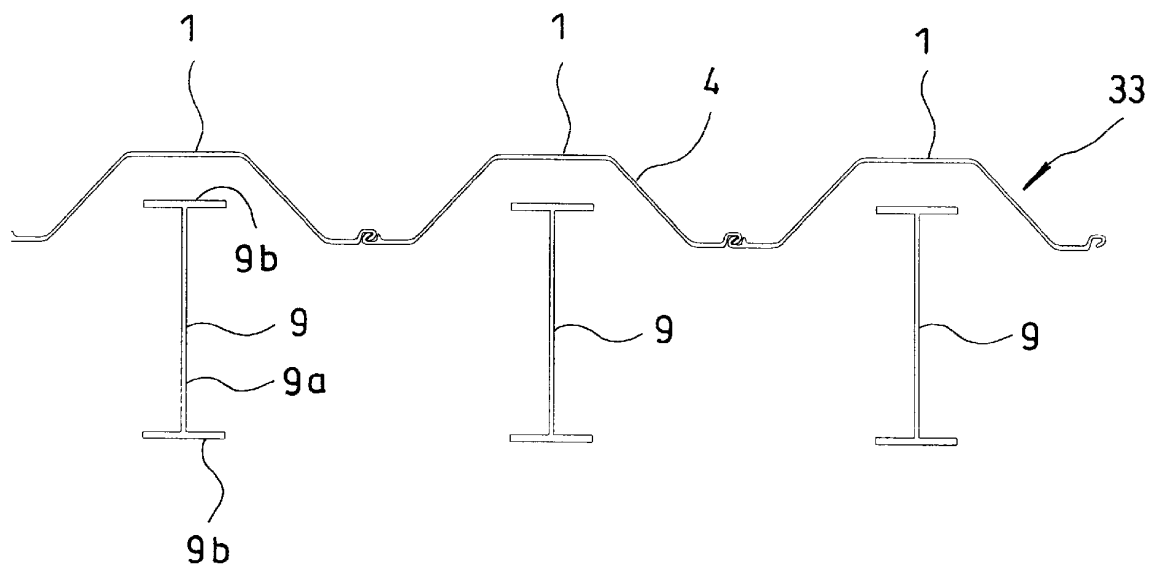
[Fig. 7]



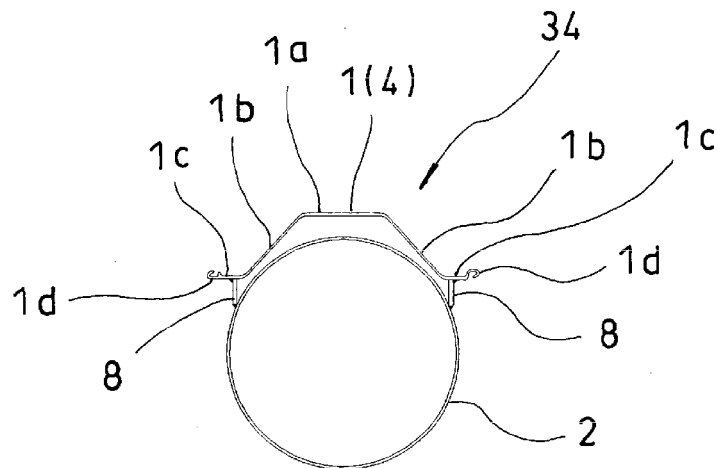
[Fig. 8]



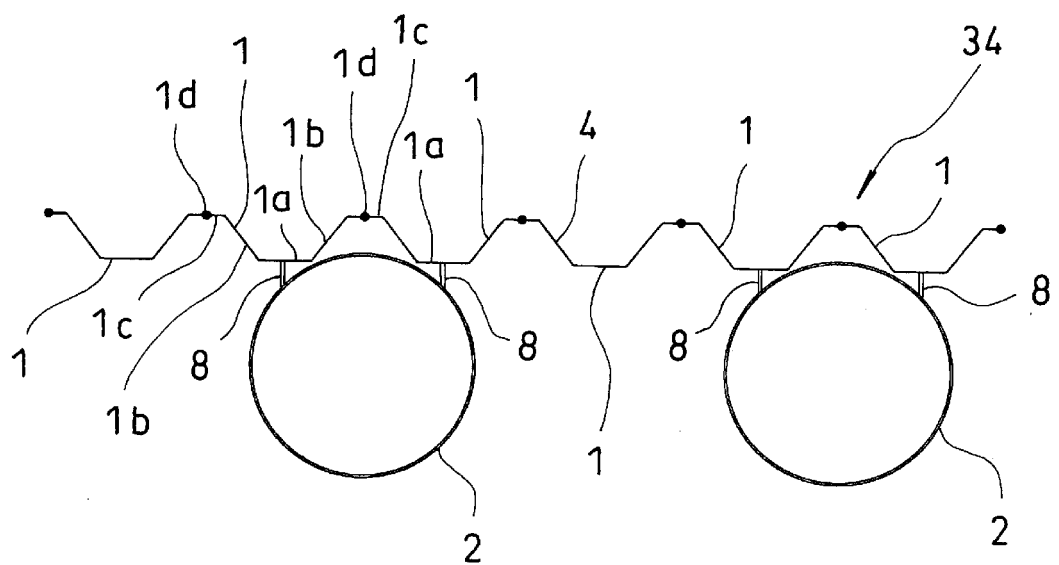
[Fig. 9]



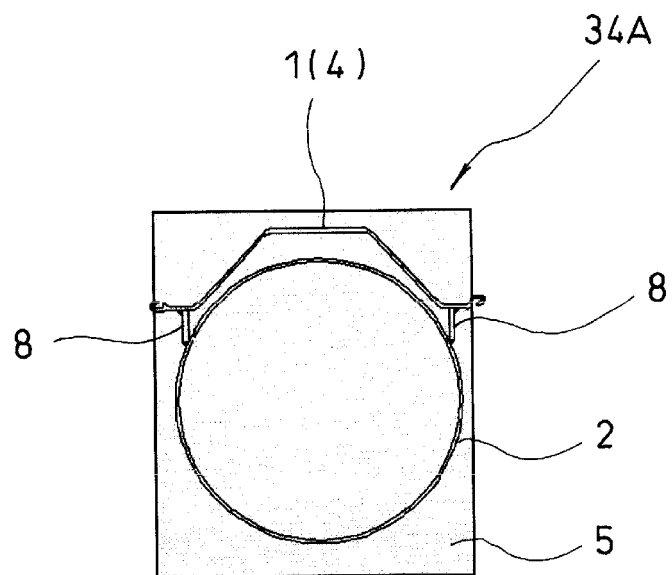
[Fig. 10]



[Fig. 11]



[Fig. 12]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/061574

A. CLASSIFICATION OF SUBJECT MATTER

E02D5/04 (2006.01) i, E02B3/06 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E02D5/04, E02B3/06, E02D5/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2012

Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2005-299202 A (Nippon Steel Corp.),	1-2, 6-9
Y	27 October 2005 (27.10.2005), paragraphs [0018], [0019], [0023], [0024]; fig. 1 (c) (Family: none)	3-5
Y	JP 2009-249959 A (Nippon Steel Corp.), 29 October 2009 (29.10.2009), paragraphs [0045], [0052]; fig. 1 (Family: none)	3-5

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

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"&" document member of the same patent family

Date of the actual completion of the international search

25 May, 2012 (25.05.12)

Date of mailing of the international search report

05 June, 2012 (05.06.12)

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Patent documents cited in the description

- JP 3756755 B [0012]
- JP 2002212943 A [0012]
- JP 4074241 B [0012]