

## SPECIFICATION

## COMBINED STEEL SHEET PILE, CONTINUOUS WALL USING COMBINED STEEL SHEET PILE, AND PRESS-IN METHOD OF COMBINED STEEL SHEET PILE

## TECHNICAL FIELD

[0001]

The present invention relates to a combined steel sheet pile, a continuous wall using the combined steel sheet pile, and a press-in method of the combined steel sheet pile. The combined steel sheet pile of the invention is used as an earth-retaining wall in the fields of civil engineering and construction, a fundamental structure, and a structural member used as bank protection, a quay wall, and a water stop wall of a port and a river. In particular, the invention relates to a combined steel sheet pile that reliably exhibits a high vertical bearing force and is suited for implanting a versatile press-in machine, a continuous wall using the combined steel sheet pile, and a press-in method of the combined steel sheet pile.

## BACKGROUND ART

[0002]

In a steel sheet pile used as an earth-retaining wall in the fields of civil engineering and construction, a fundamental structure, and a structural member used as bank protection, a quay wall, and a water stop wall of a port and a river, joints are provided at both ends thereof in the width direction. A wall surface is formed by implanting a plurality of steel sheet piles into the ground so that the joints of the adjacent steel sheet piles are fitted to each other.

[0003]

In recent years, as a technique for improving the vertical bearing force of the steel sheet pile, for example, the Patent Document 1 and the Patent Document 2 propose steel sheet piles as below.

[0004]

In the technique disclosed in the Patent Document 1, for example, as shown in FIG. 12, a closing cross-section is formed by a steel sheet pile 102 and a closing steel sheet 103 by bonding the closing steel sheet 103 to the front end of the steel sheet pile 102. For this reason, when the combined steel sheet pile 101 is implanted into the ground, clods inserted into the closing cross-section are compacted, so that the front end of the steel sheet pile 101 is blocked. Therefore, a high vertical bearing force (a high end bearing force) may be obtained. The end bearing force may be improved as the closing cross-section becomes larger.

[0005]

Incidentally, when the steel sheet pile penetrates the ground, a vibro-hammer method has been frequently used which facilitates the penetration of the steel sheet pile in a manner such that a vibration is applied to the ground through the steel sheet pile and a fluidizing phenomenon or a sensitization phenomenon is generated in the ground. In the technique disclosed in the Patent Document 1, the steel sheet pile 101 may be made to penetrate the ground by the vibro-hammer method.

[0006]

However, when the combined steel sheet pile 101 is implanted into the ground by a press-in method (a method of gripping the combined steel sheet pile 101 to be pressed-in by a chuck (jaws) of the press-in machine and applying a static load using a cylinder on the combined steel sheet pile 101 to be pressed into the ground), the combined steel sheet pile 101 cannot be gripped by the chuck if the closing steel sheet 103 increases in size. Therefore, in order to grip the combined steel sheet pile 101, a special dedicated press-in machine needs to be provided.

[0007]

Further, according to the technique disclosed in the Patent Document 2, a hat-shaped steel sheet pile attached with H-shaped steel may be gripped by the chuck of the versatile press-in machine used in the construction of the hat-shaped steel sheet pile. Specifically, the steel sheet pile of the technique disclosed in the Patent Document 2 has a

cross-section included in a circle having a center set to the middle point of the line (the fitting axis) connecting joints provided at the front ends of the pair of arms and a diameter set to be equivalent to the entire width of the hat-shaped steel sheet pile.

[0008]

However, according to the technique disclosed in the Patent Document 2, the steel sheet pile may be reliably implanted into the ground on the basis of the press-in method, but the closing cross-section may not be formed. As a result, a high vertical bearing force, obtained by compacting clods inserted into the closing cross-section, may not be ensured.

#### RELATED ART DOCUMENTS

##### PATENT DOCUMENTS

[0009]

[Patent Document 1] Japanese Unexamined Patent Application, First Publication No. 2008-248503

[Patent Document 2] Japanese Unexamined Patent Application, First Publication No. 2008-175029

#### DISCLOSURE OF THE INVENTION

##### PROBLEMS TO BE SOLVED BY THE INVENTION

[0010]

The invention is made in view of the above-described problems. An object of the invention is to provide a combined steel sheet pile that reliably exhibits a high vertical bearing force and may be gripped by a chuck of a press-in machine used in a versatile press-in method used in a construction of a hat-shaped steel sheet pile, a continuous wall using the combined steel sheet pile, and a method of pressing-in the combined steel sheet pile.

##### MEANS FOR SOLVING THE PROBLEMS

[0011]

The invention adopts the following configuration in order to solve the above-described problem.

(1) A first aspect of the invention provides a combined steel sheet pile including: a first hat-shaped steel sheet pile which includes a web, a pair of flanges provided at both ends of the web, a pair of arms respectively provided at the ends of the pair of flanges, and a pair of joints respectively provided at the ends of the pair of arms; and a closing member which is attached to at least a part of the first hat-shaped steel sheet pile along the longitudinal direction of the first hat-shaped steel sheet pile. The shape of a closing cross-section formed by the first hat-shaped steel sheet pile and the closing member is included in a circle having a diameter set to a line connecting the pair of joints.

(2) In the combined steel sheet pile according to (1), a side portion of the closing member may be attached to the arm or the flange of the first hat-shaped steel sheet pile.

(3) In the combined steel sheet pile according to (1) or (2), the closing member may be a second hat-shaped steel sheet pile.

(4) In the combined steel sheet pile according to (1) or (2), the closing member may be a U-shaped steel sheet pile.

(5) In the combined steel sheet pile according to (1) or (2), the closing member may be a joint cut steel sheet pile.

(6) In the combined steel sheet pile according to (1) or (2), the closing member may be a steel sheet.

(7) In the combined steel sheet pile according to (1) or (2), the closing member may be a folded steel sheet which is bent at one or more positions.

(8) In the combined steel sheet pile according to (1) or (2), the closing member may be a curved steel sheet which is bent in a curve shape.

(9) In the combined steel sheet pile according to (8), the curved steel sheet may be curved along the circle.

(10) In the combined steel sheet pile according to (1) or (2), the side portion of the closing member may be attached to the first combined steel sheet pile by any one of

welding, adhering, bolting, riveting, attaching with screws, and attaching with tacks.

[0012]

(11) A second aspect of the invention provides a continuous wall including: at least two combined steel sheet piles according to (1) or (2). The joints of at least two combined steel sheet piles are connected to each other, and the lower end of the continuous wall penetrates a support layer.

[0013]

(12) A third aspect of the invention provides the combined steel sheet pile according to (1) or (2). The joint of the first hat-shaped steel sheet pile is connected to a joint of a third hat-shaped steel sheet pile, and at least the lower end of the combined steel sheet pile penetrates a support layer.

[0014]

(13) A fourth aspect of the invention provides a press-in method of the combined steel sheet pile according to (1) or (2), the method including: gripping the pair of arms by a chuck of a press-in machine; and pressing-in the lower end of the combined steel sheet pile to a support layer of the ground.

## EFFECTS OF THE INVENTION

[0015]

In the invention with the above-described configuration, the size of the closing member is adjusted so that the cross-section of the combined steel sheet pile is included in the circle. As a result, the combined steel sheet pile may be gripped by the chuck of the press-in machine that is frequently used in the press-in method. That is, in the present invention, the combined steel sheet pile having a closing cross-section may be pressed-in based on the press-in method by using the existing press-in machine. Therefore, since the existing equipment and device may be directly used and no special investment in facilities is needed, an increase in construction costs may be suppressed.

[0016]

Further, in the combined steel sheet pile according to the invention, the closing

cross-section formed by the first hat-shaped steel sheet pile and the closing member is included in the circle having a center set to the middle point of the fitting axis connecting the pair of joints and a diameter set to be equivalent to the entire width of the first hat-shaped steel sheet pile. As a result, when the combined steel sheet pile is pressed in into the ground, clods may be inserted into the closing cross-section. Furthermore, since the clods inserted into the closing cross-section are compacted, the inside of the combined steel sheet pile may be blocked. Particularly, when the lower end of the combined steel sheet pile is made to penetrate the support layer as described above, clods of the support layer may be inserted into the closing cross-section especially located at the lower end of the combined steel sheet pile. As a result, since the lower end of the combined steel sheet pile 1 may be compacted by the clods of the support layer inserted therein, a high vertical bearing force may be obtained.

[0017]

In this manner, the combined steel sheet pile according to the invention may reliably exhibit a high vertical bearing force and be gripped by the chuck of the press-in machine used in the versatile press-in method used in the construction of the hat-shaped steel sheet pile.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

FIG. 1 is a cross-sectional view illustrating a combined steel sheet pile according to a first embodiment of the invention.

FIG. 2 is a perspective view illustrating the combined steel sheet pile.

FIG. 3 is a plan view illustrating a continuous wall according to a second embodiment of the invention.

FIG. 4 is a perspective view illustrating a continuous wall.

FIG. 5 is a perspective view illustrating a continuous wall according to a third embodiment of the invention.

FIG. 6A is a diagram illustrating a press-in machine which is an example used in a

press-in method.

FIG. 6B is a plan view illustrating the press-in machine.

FIG. 7A is a diagram illustrating a modified example of the combined steel sheet pile according to the first embodiment of the invention, and is a diagram illustrating a case where a U-shaped steel sheet pile is used as a closing member.

FIG. 7B is a diagram illustrating a modified example of the combined steel sheet pile according to the first embodiment of the invention, and is a diagram illustrating a case where a U-shaped steel sheet pile is used as a closing member.

FIG. 8 is a diagram illustrating a modified example of the combined steel sheet pile according to the first embodiment of the invention, and is a diagram illustrating a case where a hat-shaped steel sheet pile is used as a closing member.

FIG. 9A is a diagram illustrating a modified example of the combined steel sheet pile according to the first embodiment of the invention, and is a diagram illustrating a case where a folded steel sheet with four folded portions are used as the closing member.

FIG. 9B is a diagram illustrating a modified example of the combined steel sheet pile according to the first embodiment of the invention, and is a diagram illustrating a case where a folded steel sheet with two folded portions are used as the closing member.

FIG. 10A is a diagram illustrating a modified example of the combined steel sheet pile according to the first embodiment of the invention, and is a diagram illustrating a case where a curved steel sheet bent in a curve shape is used as the closing member.

FIG. 10B is a diagram illustrating a modified example of the combined steel sheet pile according to the first embodiment of the invention, and is a diagram illustrating a case where a curved steel sheet bent in a curve shape is used as the closing member.

FIG. 11 is a diagram illustrating a modified example of the combined steel sheet pile according to the first embodiment of the invention, and is a diagram illustrating a case where one steel sheet is used as the closing member.

FIG. 12 is a diagram illustrating a related art.

## EMBODIMENTS OF THE INVENTION

[0019]

The inventors have found that a closing member needs to be fixed to a hat-shaped steel sheet pile and the cross-section thereof needs to be formed to have a shape and a size included in a circle obtained based on a shape of a chuck of a press-in machine in order to reliably exhibit a high vertical bearing force and allow the steel sheet pile to be gripped by the chuck of the press-in machine used in a versatile press-in method of the construction of the hat-shaped steel sheet pile. Therefore, the inventors have contrived a combined steel sheet pile in which a closing member is attached thereto to close the inner opening cross-section of a first hat-shaped steel sheet pile with a hat-shaped cross-section and the closing member is formed in a shape which is included in a circle having a center set to the middle point of the fitting axis connecting the pair of joints respectively provided at the front ends of the arms and a diameter set to be equivalent to the entire width of the first hat-shaped steel sheet pile.

[0020]

Hereinafter, a combined steel sheet pile according to preferred embodiments of the invention, used as an earth-retaining wall in the civil engineering and construction field, a fundamental structure, and a structural member used as bank protection, a quay wall, and a water stop wall of a port and a river, and a continuous wall using the combined steel sheet pile will be described in detail by referring to the drawings.

[0021]

First, a first embodiment of the invention will be described by referring to FIGS. 1 and 2. FIG. 1 is a cross-sectional view illustrating a combined steel sheet pile 1 according to the embodiment, and FIG. 2 is a perspective view thereof. In the drawings, "a" indicates the longitudinal direction (the press-in direction of the combined steel sheet pile 1) of the combined steel sheet pile 1, "b" indicates the width direction of the combined steel sheet pile 1, and "c" indicates the thickness direction of the combined steel sheet pile 1. Further, in the invention, as shown in the drawings, the side with a concave cross-section of the hat-shaped steel sheet pile or the closing member is referred to as the inside (I) and the side with a convex cross-section thereof is referred to as the outside (O).

[0022]

The combined steel sheet pile 1 includes a first hat-shaped steel sheet pile 10 and a closing member 20.

[0023]

The first hat-shaped steel sheet pile 10 includes a web 11, a pair of flanges 12, a pair of arms 13, and a pair of joints 14, where these constituents are integrally formed with each other. The pair of flanges 12 obliquely extends from both sides of the web 11. Further, the pair of arms 13 extends from the front ends of the flanges 12 to be parallel to the web 11. The pair of joints 14 is formed at the front ends of the arms 13. In the pair of joints 14, one joint 14 and the other joint 14 have cross-sectional shapes which are point-symmetric to each other. The joint 14 has a shape fittable to another joint 14 in the adjacent another combined steel sheet pile 1, and has high fitting strength so that the joints 14 are not separated from each other especially when they are fitted to each other.

[0024]

Further, the first hat-shaped steel sheet pile 10 used in the embodiment is rolled steel manufactured by hot-rolling, where the joint 14 is formed to have a complicated shape and the strength of the joint 14 is improved. As for the first hat-shaped steel sheet pile 10, the bending rigidity of the entire steel sheet pile including the joint is improved as a whole compared to an existing steel sheet pile manufactured by cold-bending one steel sheet.

[0025]

The closing member 20 of the embodiment includes a web 21, a pair of flanges 22 which obliquely extends from both sides of the web toward the inside (I) in the drawing, and arms 23 which respectively extend from the front ends of the pair of flanges 22 to be parallel to the web 21. The closing member 20 may be formed by cutting the front end of an arm of a second hat-shaped steel sheet pile (not shown) (a joint cut steel sheet pile). The closing member 20 is attached to the first hat-shaped steel sheet pile 10 to close the inner opening cross-section. The closing member 20 is attached to the first hat-shaped steel sheet pile 10 so that the inner surface of the closing member faces the

inner surface of the first hat-shaped steel sheet pile. As a result, a closing cross-section 31 which is swollen at the center is formed. Further, the arm 23 corresponding to the end of the closing member 20 is attached to the arm 13 in the first hat-shaped steel sheet pile 10 while the bottom surface thereof comes into plane-contact therewith. Furthermore, the arm 23 corresponding to the end of the closing member 20 may be attached to the flange 12 instead of the arm 13 in the first hat-shaped steel sheet pile 10. Further, one end of the closing member 20 may be attached to the arm 13, and the other end thereof may be attached to the flange 12. Further, as shown in FIG. 2, the closing member 20 may be attached to the first hat-shaped steel sheet pile 10 throughout the entire length thereof, and may be attached to only a part of the first hat-shaped steel sheet pile 10 in the longitudinal direction.

[0026]

In addition, the connection of the closing member 20 with respect to the first hat-shaped steel sheet pile 10 may be performed by, for example, any one of welding, adhering, bolting, riveting, attaching with screws, attaching with tacks, and the like. Further, the connection between the first hat-shaped steel sheet pile 10 and the closing member 20 may be performed at a factory or a construction site before or during implanting.

[0027]

As for the cross-sectional shape of the closing member 20, it is essential that the shape is included in a circle 47 having a center set to a middle point 52 of a fitting axis connecting the pair of joints 14 respectively provided at the front ends of the arms 13 and having a diameter equivalent to the entire width T of the first hat-shaped steel sheet pile 10.

[0028]

Furthermore, the closing member 20 may be formed as a folded steel sheet which is bent to have the web 21, the flange 22, and the arm 23 described above.

[0029]

Next, a second embodiment of the invention will be described by referring to

FIGS. 3 and 4. FIGS. 3 and 4 illustrate a continuous wall 5 which is formed by connecting the combined steel sheet piles 1 with the above-described configuration to each other. In the embodiment, the continuous wall 5 is formed to be pressed-in into an intermediate layer 75, and forms one wall by connecting the combined steel sheet piles 1 to each other through the joints 14 thereof. Further, the continuous wall 5 is formed by continuously disposing the same combined steel sheet piles 1. Then, all lower ends of the combined steel sheet piles 1 penetrate a support layer 76 which is present below the intermediate layer 75. Further, the closing member 20 may be attached to the first hat-shaped steel sheet pile 10 throughout the entire length thereof as shown in FIG. 4, and may be attached to only part of the hat-shaped steel sheet pile 10 in the longitudinal direction.

[0030]

Next, a third embodiment of the invention will be described by referring to FIG. 5. FIG. 5 illustrates a continuous wall 6 which is formed by the combined steel sheet pile 1 with the above-described configuration in the above-described first embodiment and a third hat-shaped steel sheet pile 143. In the embodiment, the continuous wall 6 is formed to be pressed-in into the intermediate layer 75 of the ground. Further, the combined steel sheet pile 1 and the hat-shaped steel sheet pile 143 are alternately connected to each other through the joints 14 to form one wall. In the continuous wall 6, only the combined steel sheet pile 1 penetrates the support layer 76 of the ground, and the third hat-shaped steel sheet pile 143 is formed to not reach the support layer 76. Further, the closing member 20 may be attached to the first hat-shaped steel sheet pile 10 throughout the entire length thereof as shown in FIG. 5, and may be attached to only part (only a portion implanted into the support layer 76) thereof in the longitudinal direction of the steel sheet pile.

[0031]

Next, a press-in method of the combined steel sheet pile 1 with the above-described configuration into the ground will be described.

[0032]

FIGS. 6A and 6B illustrate an example of a press-in machine which is used to

press-in the combined steel sheet pile of the invention.

[0033]

A press-in machine 4 includes a clamp 41, a saddle 42, a main cylinder 43, a mast 44, and a chuck 45. The clamp 41 is a mechanism for clamping the head of the combined steel sheet pile 1 which is implanted into the ground, and has a function of freely running on the combined steel sheet piles 1. The saddle 42 is provided with a mechanism for moving the mast 44 in the longitudinal direction, and is equipped with a power source for executing various operations of the press-in machine 4 in many cases. The main cylinder 43 is configured to be freely driven in the vertical direction of the drawing and press-in the combined steel sheet pile 1 gripped by the chuck 45 into the ground. That is, the chuck 45 is moved down on the basis of the power of the main cylinder 43, so that the combined steel sheet pile 1 is pressed-in into the ground.

[0034]

The press-in machine 4 with such a configuration presses-in the subsequent combined steel sheet pile 1 into the ground by using a hydraulic pressure and a drawing resistance of the combined steel sheet pile 1 which is implanted into the ground.

[0035]

FIG. 6B is a diagram illustrating the press-in machine 4 when seen from above. The chuck 45 grips the combined steel sheet pile 1 in a manner of pressing the pair of arms 13 of the first hat-shaped steel sheet pile 10 in the direction depicted by the arrow D3. Then, an opening 46 is provided inside the chuck 45. Generally, the opening 46 is set to have an allowance that prevents contact with the web or the flange of the general steel sheet pile. However, the opening 46 is set assuming a general steel sheet pile. Regarding the size of the opening 46, it is desirable to consider, for example, the circle 47 shown in FIG. 6B. The circle 47 is obtained based on the shape of the chuck 45 in the press-in machine 1. Specifically, the circle 47 is obtained in consideration of the position of the arm 13 gripped in the direction depicted by the arrow D3, the position of the joint 14, and the position of the peripheral side wall 48 forming the opening 46.

[0036]

In the invention, the combined steel sheet pile 1 may be gripped by using the chuck 45 having a size according to the circle 47. In particular, the combined steel sheet pile 1 is formed in a shape in which all the constituents thereof are included in the circle 47 as described above. As shown in FIG. 1, the circle 47 is formed such that the center is set to the middle point 52 of the fitting axis 51 connecting the pair of joints 14 provided at the front ends of the arms 13 and the diameter is set to be equal to the entire width T of the hat-shaped steel sheet pile 10. In other words, the circle 47 is an imaginary circle that has a diameter set to the line connecting the pair of joints of the hat-shaped steel sheet pile 10.

[0037]

In the combined steel sheet pile 1 according to the invention, the closing member is attached to the hat-shaped steel sheet pile 10 so that the inner surface of the hat-shaped steel sheet pile 10 faces the inner surface of the closing member 20. Then, the cross-sectional shape of the attached closing member 20 is designed to be included in the circle 47. Further, in the invention, it is designed so that the combined steel sheet pile 1 is included in the circle 47, and particularly, the size of the closing member 20 is adjusted in advance. As a result, the combined steel sheet pile 1 may be gripped by the chuck 45 of the press-in machine 4 that is frequently used in a press-in method. That is, in the invention, the combined steel sheet pile 1 may be pressed-in based on the press-in method by using the existing press-in machine 4. Therefore, since the existing equipment and device may be directly used and no special investment in facilities is needed, an increase in construction costs may be suppressed.

[0038]

Further, the closing cross-section 31 formed by the first hat-shaped steel sheet pile 10 and the closing member 20 is formed inside the combined steel sheet pile 1 according to the present invention. As a result, when the combined steel sheet pile 1 is pressed-in into the ground, clods may be inserted into the closing cross-section 31. Further, since the clods inserted into the closing cross-section 31 are compacted, the inside of the combined steel sheet pile 1 may be blocked. Particularly, when the lower end of

the combined steel sheet pile 1 is made to penetrate the support layer 76 as described above, clods of the support layer 76 may be inserted into the closing cross-section 31 especially located at the lower end of the combined steel sheet pile 1. As a result, since the lower end of the combined steel sheet pile 1 may be compacted by the clods of the support layer 76 inserted therein, the high vertical bearing force may be obtained.

[0039]

In this manner, the combined steel sheet pile 1 according to the invention may reliably exhibit a high vertical bearing force and be gripped by the chuck of the press-in machine used in the versatile press-in method used in the construction of the hat-shaped steel sheet pile.

[0040]

Furthermore, the combined steel sheet pile 1 according to the invention is not limited to the above-described embodiment, and for example, the modified examples to be described below are also included in the invention.

[0041]

For example, as shown in FIGS. 7A and 7B, the combined steel sheet pile 1 may be formed by using a U-shaped steel sheet pile 80 having a U-shaped cross-section as the closing member 20. The U-shaped steel sheet pile 80 includes a web 81, flanges 82 which are integrally formed with both sides of the web 81 inclined inward in the drawing, and a joint 83 which is formed at the front end of the flange 82. FIG. 7A illustrates an example in which the joint 83 of the end of the U-shaped steel sheet pile 80 is attached to the flange 12 of the hat-shaped steel sheet pile 10, and FIG. 7B illustrates an example in which the joint 83 of the end of the U-shaped steel sheet pile 80 is attached to the arm 13 of the hat-shaped steel sheet pile 10. Even in these examples, the closing cross-section 31 may be made by the first hat-shaped steel sheet pile 10 and the closing member 20, and the high vertical bearing force may be obtained by compacting the clods of the support layer 76. Further, even in the examples of FIGS. 7A and 7B, since the cross-section of the combined steel sheet pile 1 is adjusted to be included in the circle 47, the combined steel sheet pile 1 may be gripped by the press-in machine 4 having the chuck 45 with a

size according to the circle 47 and be pressed-in into the ground.

[0042]

Furthermore, the side end of the closing member 20 may be attached to either the arm 13 or the flange 12 of the first hat-shaped steel sheet pile 10, one end may be attached to the arm, and the other end may be attached to the flange.

[0043]

Further, for example, as shown in FIG. 8, the combined steel sheet pile 1 may be formed by using a second hat-shaped steel sheet pile 85 as the closing member 20. In FIG. 8, regarding the same constituents as those of FIG. 1, the description thereof will be omitted by referring to the description of FIG. 1. In the second hat-shaped steel sheet pile 85 as the closing member 20, the flanges 22 are integrally formed with both sides of the web 21 inclined inward in the drawing, the arm 23 is provided from the front end of the flange 22 to be parallel to the web 21, and a joint 24 is provided at the front end of the arm. Then, the joint 24 corresponding to the end of the closing member 20 is attached to the arm 13 in the first hat-shaped steel sheet pile 10. Even in the embodiment, the cross-sectional shape of the combined steel sheet pile 1 is designed to be included in the circle 47. Furthermore, when the curved steel sheet bent along the circle 47 is used as the closing member, the maximum closing area may be obtained within the range where the combined steel sheet may be gripped by the chuck 45, so that the high vertical bearing force may be exhibited.

[0044]

Further, for example, as shown in FIG. 9A, a folded steel sheet 86 may be used as the closing member 20. As shown in FIG. 9B, a folded steel sheet 87 may be used as the closing member 20. The folded steel sheet 86 has a shape which is bent at four positions, so that surfaces 91, 92, 93, 97, and 98 are respectively formed. Then, the side end of the folded steel sheet 86 is attached to the arm 13 of the first hat-shaped steel sheet pile 10. The folded steel sheet 87 has a shape which is bent at two positions, so that surfaces 94 and 95 are formed. Then, the end of the folded steel sheet 87 is attached to the arm 13 of the first hat-shaped steel sheet pile 10. Of course, the ends of the folded steel sheets 86

and 87 may be attached to the flange 12. Even in the embodiment, the cross-sectional shape of the combined steel sheet pile 1 is included in the circle 47.

[0045]

Furthermore, as shown in FIGS. 10A and 10B, curved steel sheets 131 and 132 each having a curved cross-section may be used as the closing member 20. In the example of FIG. 10A, the end of the curved steel sheet 131 is attached to the arm 13. Further, in the example of FIG. 10B, the end of the curved steel sheet 131 is attached to the flange 12. Even in the embodiment, the cross-section of the combined steel sheet pile 1 is included in the circle 47. To compare FIG. 9A with FIG. 9B, the folded steel sheet 86 is formed to be more similar to the shape of the circle 47 than the folded steel sheet 87. For this reason, since the shape of the combined steel sheet pile shown in FIG. 9A has the larger closing cross-section, the combined steel sheet pile shown in FIG. 9A can exhibit excellent vertical bearing force.

[0046]

Furthermore, as shown in FIG. 11, one steel sheet 136 may be used as the closing member 20. The end of the steel sheet 136 is attached to the bottom surface of the arm 13. Even in the embodiment, the cross-section of the combined steel sheet pile 1 is included in the circle 47.

Furthermore, since the curved steel sheet 131 is formed in a shape similar to the shape of the circle 47 as shown in FIGS. 10A and 10B, the larger closing cross-section may be obtained within the range where the combined steel sheet pile may be gripped by the chuck 45. For this reason, the high vertical bearing force may be exhibited.

[0047]

While preferred embodiments of the present invention have been described and illustrated above, it should be understood that these are examples of the invention and are not to be considered as limiting, and the invention includes various modifications of the above-described embodiment. That is, the specific configuration or the like in the above-described embodiment is merely an example, and may be appropriately modified.

## INDUSTRIAL APPLICABILITY

[0048]

According to the combined steel sheet pile, the continuous wall using the combined steel sheet pile, and the press-in method of the combined steel sheet pile, since the high vertical bearing force may be reliably exhibited and the combined steel sheet pile may be gripped by the chuck of the press-in machine used in the versatile press-in method used in the construction of the hat-shaped steel sheet pile, the industrial applicability of the invention is high.

## EXPLANATION OF REFERENCE NUMERALS

[0049]

- 1: COMBINED STEEL SHEET PILE
- 4: PRESS-IN MACHINE
- 5, 6: CONTINUOUS WALL
- 10: FIRST HAT-SHAPED STEEL SHEET PILE
- 11: WEB
- 12: FLANGE
- 13: ARM
- 14: JOINT
- 20: CLOSING MEMBER
- 21: WEB
- 22: FLANGE
- 23: ARM
- 31: CLOSING CROSS-SECTION
- 41: CLAMP
- 42: SADDLE
- 43: MAIN CYLINDER
- 44: MAST
- 45: CHUCK

46: OPENING

47: CIRCLE

52: MIDDLE POINT

75: INTERMEDIATE LAYER

76: SUPPORT LAYER

## CLAIMS

1. A combined steel sheet pile comprising:  
a first hat-shaped steel sheet pile which includes a web, a pair of flanges provided at both ends of the web, a pair of arms respectively provided at ends of the pair of flanges, and a pair of joints respectively provided at ends of the pair of arms; and  
a closing member which is attached to at least a part of the first hat-shaped steel sheet pile along the longitudinal direction of the first hat-shaped steel sheet pile,  
wherein a shape of a closing cross-section formed by the first hat-shaped steel sheet pile and the closing member is included in a circle having a diameter set to a line connecting the pair of joints.
2. The combined steel sheet pile according to claim 1,  
wherein a side portion of the closing member is attached to the arm or the flange of the first hat-shaped steel sheet pile.
3. The combined steel sheet pile according to claim 1 or 2,  
wherein the closing member is a second hat-shaped steel sheet pile.
4. The combined steel sheet pile according to claim 1 or 2,  
wherein the closing member is a U-shaped steel sheet pile.
5. The combined steel sheet pile according to claim 1 or 2,  
wherein the closing member is a joint cut steel sheet pile.
6. The combined steel sheet pile according to claim 1 or 2,  
wherein the closing member is a steel sheet.
7. The combined steel sheet pile according to claim 1 or 2,

wherein the closing member is a folded steel sheet which is bent at one or more positions.

8. The combined steel sheet pile according to claim 1 or 2,  
wherein the closing member is a curved steel sheet which is bent in a curved shape.
9. The combined steel sheet pile according to claim 8,  
wherein the curved steel sheet is curved along the circle.
10. The combined steel sheet pile according to claim 1 or 2,  
wherein a side portion of the closing member is attached to the first combined steel sheet pile by any one of welding, adhering, bolting, riveting, attaching with screws, and attaching with tacks.
11. A continuous wall which uses at least two of the combined steel sheet piles according to claim 1 or 2, wherein  
the joints of the at least two of the combined steel sheet piles are connected to each other, and  
a lower end of the continuous wall penetrates a support layer.
12. A continuous wall which uses the combined steel sheet pile according to claim 1 or 2, wherein  
the joint of the first hat-shaped steel sheet pile is connected to a joint of a third hat-shaped steel sheet pile, and  
at least a lower end of the combined steel sheet pile penetrates a support layer.
13. A press-in method of the combined steel sheet pile according to claim 1 or 2, the method comprising:

gripping the pair of arms by a chuck of a press-in machine; and  
pressing-in the lower end of the combined steel sheet pile to a support layer of a  
ground.