

# LONGITUDINAL JOINT STRUCTURE FOR HAT-TYPE STEEL SHEET PILES, LONGITUDINAL JOINT HAT-TYPE STEEL SHEET PILE UNIT, AND STEEL WALL

## [Technical Field of the Invention]

[0001]

The present invention relates to a longitudinal joint structure for hat-type steel sheet piles, in which a plurality of hat-type steel sheet piles are coupled to each other in the member axis direction, a longitudinal joint hat-type steel sheet pile unit having the longitudinal joint structure, and a constituent wall in which the longitudinal joint hat-type steel sheet pile units are continuously connected to each other in the wall width direction.

Priority is claimed on Japanese Patent Application No. 2015-168456, filed on August 28, 2015, and Japanese Patent Application No. 2016-004004, filed on January 13, 2016, the contents of which are incorporated herein by reference.

## [Related Art]

[0002]

In the related art, Patent Document 1 discloses a longitudinal joint structure for hat-type steel sheet piles proposed as an example in which water-stopping properties, rigidity, and proof stress of a longitudinal joint section are ensured and which can be constructed inexpensively and simply so that a construction period and costs can be reduced.

[0003]

Patent Document 1 discloses a longitudinal joint structure for coupling upper and lower hat-type steel sheet piles individually having at least one or more webs and

flanges each and is formed in a bent shape in a cross section. This longitudinal joint structure includes lower joint members, upper joint members, and fixing units.

The lower joint members protrude out of front surfaces of the web and the flange in at least two different locations of the webs and the flanges in an upper end portion of the lower hat-type steel sheet pile, thereby being fixed thereto. The upper joint members protrude out of front surfaces of the web and the flange in at least two different locations of the webs and the flanges in a lower end portion of the upper hat-type steel sheet pile corresponding to the lower joint members, thereby being fixed thereto. The fixing units respectively fix the lower joint members and the upper joint members to each other in a state where an upper end edge of the lower hat-type steel sheet pile and a lower end edge of the upper hat-type steel sheet pile abut each other.

[Prior Art Document]

[Patent Document]

[0004]

[Patent Document 1] Japanese Unexamined Patent Application, First Publication No. 2011-38288

[Disclosure of the Invention]

[Problems to be Solved by the Invention]

[0005]

However, in a longitudinal joint structure for hat-type steel sheet piles disclosed in Patent Document 1, since cross-sectional performance of steel plates serving as a lower joint member and an upper joint member falls behind the cross-sectional performance of the hat-type steel sheet piles coupled to each other above and below, bending rigidity of a longitudinal joint section in which only the lower joint

member and the upper joint member are disposed becomes low. Therefore, there is a possibility that the longitudinal joint section will become a structural weak point in a case where a bending load equal to or greater than expected acts thereon.

[0006]

In addition, there is a method in which a plurality of hat-type steel sheet piles are coupled to each other by performing welding at a construction site. However, recently, hat-type steel sheet piles tend to be increased in cross section, so that the significant cross-sectional area per hat-type steel sheet pile results in an increase of a welding amount. Therefore, it takes a long period of time to perform welding for one longitudinal joint section. Particularly, a construction period is lengthened in a case where there are many longitudinal joint sections.

Even in a method in which a plurality of hat-type steel sheet piles are coupled to each other by performing high strength bolted friction bonding, since shearing proof stress per one high-strength bolt is not much high, many high-strength bolts are required to ensure connection strength to the same extent as the cross-sectional performance of the hat-type steel sheet pile. Therefore, splice plates increase in size, processing costs rise, and it takes time to carry out construction due to many high strength bolts to be fastened, and thus the construction period is lengthened.

These problems are noticeably present particularly in hat-type steel sheet piles having a significant dimension in the wall width direction compared to steel members such as an H-steel and a steel pipe.

[0007]

The present invention has been made in consideration of the foregoing problems, and an object thereof is to provide a longitudinal joint structure for hat-type steel sheet piles, a longitudinal joint hat-type steel sheet pile unit, and a steel wall in

which sufficient bending rigidity can be ensured at locations where a plurality of hat-type steel sheet piles are coupled to each other in the member axis direction and coupling cost can be limited.

[Means for Solving the Problem]

[0008]

The overview of the present invention is as follows.

[0009]

(1) According to a first aspect of the present invention, there is provided a longitudinal joint structure for hat-type steel sheet piles, in which a first hat-type steel sheet pile and a second hat-type steel sheet pile are coupled by causing end surfaces thereof in a member axis direction to butt each other. The longitudinal joint structure includes a first engagement target portion that protrudes outward from a side surface of the first hat-type steel sheet pile, and an installation portion that is provided on a side surface of the second hat-type steel sheet pile and locks the first engagement target portion of the first hat-type steel sheet pile in the member axis direction.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect, the installation portion provided on the side surface of the second hat-type steel sheet pile locks the first engagement target portion that protrudes outward from the side surface of the first hat-type steel sheet pile. Therefore, it is possible to cope with bending stress acting on a longitudinal joint location in the hat-type steel sheet pile due to the installation portion, and it is possible to enhance bending rigidity. In addition, when longitudinal joint construction is carried out, the first hat-type steel sheet pile and the second hat-type steel sheet pile can be easily and reliably coupled to each other by causing the installation portion provided in the second hat-type steel sheet pile to lock the first engagement target portion of the first hat-type steel sheet pile.

Therefore, the longitudinal joint construction can be carried out without essentially performing welding work requiring labor and costs.

[0010]

(2) The longitudinal joint structure for hat-type steel sheet piles according to (1) may employ a configuration which further includes a second engagement target portion that protrudes outward from the side surface of the second hat-type steel sheet pile and in which the installation portion also locks the second engagement target portion in addition to the first engagement target portion.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect, when longitudinal joint construction is carried out, the first hat-type steel sheet pile and the second hat-type steel sheet pile can be more easily and reliably coupled to each other by causing the installation portion to lock the second engagement target portion of the second hat-type steel sheet pile. Therefore, the longitudinal joint construction can be carried out without essentially performing welding work requiring labor and costs.

[0011]

(3) The longitudinal joint structure for hat-type steel sheet piles according to (2) may employ a configuration in which the end surface of the first hat-type steel sheet pile and an end surface of the first engagement target portion are flush with each other, and the end surface of the second hat-type steel sheet pile and an end surface of the second engagement target portion are flush with each other.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect, not only the end surfaces of the first hat-type steel sheet pile and the second hat-type steel sheet pile but also both end surfaces of the first engagement target portion and the second engagement target portion can butt each other. Therefore, a

compressive force acting in a direction in which the first hat-type steel sheet pile and the second hat-type steel sheet pile approach each other in the member axis direction can be received not only by the end surfaces of steel plates but also by the side surfaces of the engagement target portions. Thus, it is possible to cope with a greater bending load.

[0012]

(4) The longitudinal joint structure for hat-type steel sheet piles according to any one of (1) to (3) may employ a configuration in which the first engagement target portion has an extension projection which extends in the member axis direction on a front end side of the extension projection, and the installation portion has a recess which extends in a wall width direction perpendicular to the member axis direction and a through-thickness direction of the first hat-type steel sheet pile and locks the extension projection.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect, the first engagement target portion and the installation portion lock each other by causing the extension projection of the first engagement target portion to slide in the wall width direction with respect to the recess of the installation portion.

Therefore, coupling work can be easily performed. Moreover, the installation portion can be prevented from falling off from the first engagement target portion. Therefore, the first hat-type steel sheet pile and the second hat-type steel sheet pile can be more reliably coupled to each other.

[0013]

(5) The longitudinal joint structure for hat-type steel sheet piles according to (4) may employ a configuration which further includes a slide prevention portion that restricts relative movement between the installation portion and the first engagement

target portion in the wall width direction.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect, the slide prevention portion can prevent a locking state between the installation portion and the first engagement target portion from being released due to a relative movement therebetween.

[0014]

(6) The longitudinal joint structure for hat-type steel sheet piles according to any one of (1) to (5) may employ a configuration in which a plurality of the first engagement target portions are provided while being separated from each other along the member axis direction.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect, bending stress received by one first engagement target portion can be reduced. Therefore, breakage of the first engagement target portion can be prevented.

[0015]

(7) The longitudinal joint structure for hat-type steel sheet piles according to (6) may employ a configuration in which the plurality of first engagement target portions are provided integrally with a common substrate.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect, it is possible to uniformly retain a separation distance between the plurality of first engagement target portions separated from each other in the member axis direction. Therefore, when the plurality of first engagement target portions are attached to the first hat-type steel sheet pile, all the first engagement target portions can be precisely attached in one process in which the substrate is fixed to the first hat-type steel sheet pile.

[0016]

(8) The longitudinal joint structure for hat-type steel sheet piles according to any one of (1) to (7) may employ a configuration in which a cross-sectional area in a case where a part of the installation portion excluding a locking region with respect to the first engagement target portion is seen in a cross section perpendicular to the member axis direction is maximized at a butting position between the first hat-type steel sheet pile and the second hat-type steel sheet pile.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect, the cross-sectional area at a location in which bending rigidity is required the most in the installation portion is increased. Therefore, it is possible to compatibly reduce the weight and ensure the bending rigidity of the installation portion.

[0017]

(9) According to a second aspect of the present invention, there is provided a longitudinal joint hat-type steel sheet pile unit including the longitudinal joint structure for hat-type steel sheet piles according to any one of (1) to (8).

According to the hat-type steel sheet pile of the aspect, longitudinal joint construction can be carried out without essentially performing welding work requiring labor and costs.

[0018]

(10) According to a third aspect of the present invention, there is provided a steel wall in which a plurality of the longitudinal joint hat-type steel sheet pile units according to (9) are continuously installed in the wall width direction perpendicular to the member axis direction and the through-thickness direction of the first hat-type steel sheet pile. The installation portions of the longitudinal joint hat-type steel sheet pile units adjacent to each other in the wall width direction are disposed at different positions in the member axis direction.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect, it is possible to avoid coupling locations, which may become structural weak points, being continuously arranged in the wall width direction. Therefore, it is possible to ensure high bending rigidity of a wall body in its entirety.

[Effects of the Invention]

[0019]

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect disclosed in (1), bending rigidity can be ensured due to the installation portion, and reliable longitudinal joint construction can be carried out without essentially performing welding work as in the structures in the related art. Therefore, sufficient bending rigidity can be ensured while construction costs when a plurality of hat-type steel sheet piles are longitudinally joined to each other in the member axis direction are kept low.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect disclosed in (2), construction costs when a plurality of hat-type steel sheet piles are longitudinally joined to each other in the member axis direction can be kept lower.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect disclosed in (3), more sufficient bending rigidity can be ensured.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect disclosed in (4), construction costs for longitudinal joint construction can be kept lower.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect disclosed in (5), a locking state between the installation portion and the first engagement target portion is prevented from being released. Therefore, the

coupling state therebetween can be reliable and sound.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect disclosed in (6), breakage of the first engagement target portion can be prevented. Therefore, bending rigidity at the longitudinal joint location between the first hat-type steel sheet pile and the second hat-type steel sheet pile can be further enhanced.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect disclosed in (7), all the first engagement target portions can be precisely attached in one process. Therefore, the construction costs can be kept lower.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect disclosed in (8), a light-weight installation portion having high bending rigidity can be used. Therefore, longitudinal joint construction can be carried out more easily.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect disclosed in (9), reliable longitudinal joint construction can be carried out without essentially performing welding work as in the structures in the related art. Therefore, it is possible to ensure sufficient bending rigidity while construction costs when a plurality of hat-type steel sheet piles are longitudinally joined to each other in the member axis direction are kept low.

According to the longitudinal joint structure for hat-type steel sheet piles of the aspect disclosed in (10), it is possible to ensure high bending rigidity of a wall body in its entirety.

[Brief Description of the Drawings]

[0020]

FIG. 1 is a perspective view showing a steel wall in which longitudinal joint

structures for hat-type steel sheet piles are applied.

FIG. 2 is a front view of the longitudinal joint structure for hat-type steel sheet piles.

FIG. 3 is a plan view of the longitudinal joint structure shown in FIG. 2.

FIG. 4 is a plan view of the longitudinal joint structures in a case where installation portions are also provided in web portions of the hat-type steel sheet piles.

FIG. 5 is a plan view of the longitudinal joint structures in a case where the installation portions are provided on both surfaces of the hat-type steel sheet piles.

FIG. 6A is a rear view of the installation portion.

FIG. 6B is a side view of the installation portion.

FIG. 7A is a front view of the longitudinal joint structure, of which a part is shown in a cross-sectional view.

FIG. 7B is a longitudinal cross-sectional view of the longitudinal joint structure.

FIG. 8A is a longitudinal cross-sectional view of the longitudinal joint structure in which engagement target portions are provided in both end portions of a first hat-type steel sheet pile and a second hat-type steel sheet pile.

FIG. 8B is a longitudinal cross-sectional view of the longitudinal joint structure in which the engagement target portion is provided in only the end portion of the first hat-type steel sheet pile.

FIG. 8C is a longitudinal cross-sectional view of the longitudinal joint structure in which the engagement target portions are provided in both surfaces of the hat-type steel sheet piles.

FIG. 9A is a longitudinal cross-sectional view of the longitudinal joint structure in which bolts are screwed to welding nuts.

FIG. 9B is a longitudinal cross-sectional view of the longitudinal joint structure in which the bolts are screwed to female screw portions formed on side surfaces of the hat-type steel sheet piles.

FIG. 10 is a side view of the longitudinal joint structure in which installation portion-side projections and the engagement target portions are each formed in a substantially rectangular shape in cross section.

FIG. 11 is a side view of the longitudinal joint structure in which the installation portion-side projections and the engagement target portions are each formed in a substantially trapezoidal shape in a cross section.

FIG. 12 is a side view of the longitudinal joint structure in which the installation portion-side projections and the engagement target portions are each formed in a substantially T-shape in a cross section.

FIG. 13 is a side view of the longitudinal joint structure in which the installation portion-side projections and the engagement target portions are formed through welding of flat steels.

FIG. 14A is a longitudinal cross-sectional view of the longitudinal joint structure in which the installation portion-side projections and the engagement target portions are formed in substantially parallel to each other.

FIG. 14B is a partially enlarged view of the longitudinal joint structure shown in FIG. 14A.

FIG. 14C is a modification example of the longitudinal joint structure shown in FIG. 14A.

FIG. 14D is another modification example of the longitudinal joint structure shown in FIG. 14A.

FIG. 15A is a longitudinal cross-sectional view of the longitudinal joint

structure in which gaps between the installation portion-side projections and the engagement target portions on front end sides are formed to be smaller than gaps therebetween on base end sides.

FIG. 15B is a partially enlarged view of the longitudinal joint structure shown in FIG. 15A.

FIG. 16A is a longitudinal cross-sectional view of the longitudinal joint structure in which one end surface of the installation portion-side projection and one end surface on a side opposite to an abutting surface of the engagement target portion may be formed to be a substantially right angle.

FIG. 16B is a partially enlarged view of the longitudinal joint structure shown in FIG. 16B.

FIG. 17A is a longitudinal cross-sectional view showing a compressive force acting on the hat-type steel sheet piles.

FIG. 17B is a longitudinal cross-sectional view showing a tensile force acting on the hat-type steel sheet piles.

FIG. 17C is a longitudinal cross-sectional view showing warp deformation occurring in the installation portion.

FIG. 18A is a longitudinal cross-sectional view of the longitudinal joint structure in which the installation portion-side projections mesh with the engagement target portions.

FIG. 18B is a longitudinal cross-sectional view showing a case where eccentric bending acts on the installation portion in the longitudinal joint structure shown in FIG. 18A.

FIG. 18C is a longitudinal cross-sectional view of the longitudinal joint structure in which the installation portion-side projections and the engagement target

portions at positions farthest from a butting surface between the first hat-type steel sheet pile and the second hat-type steel sheet pile are each formed in a tapered shape, and the diagram shows a case where eccentric bending has acted on the installation portion.

FIG. 19A is a longitudinal cross-sectional view of the longitudinal joint structure in which the plate thickness dimension on a center side of a flat plate portion is formed to be greater than the plate thickness dimensions on the end portion sides of the flat plate portion in the installation portion.

FIG. 19B is a longitudinal cross-sectional view of the longitudinal joint structure in which the plate thickness dimension on the center side of the flat plate portion is formed to be greater than the plate thickness dimensions on the end portion sides of the flat plate portion in the installation portion.

FIG. 19C is a longitudinal cross-sectional view of the longitudinal joint structure in which the plate thickness dimension on the center side of the flat plate portion is formed to be greater than the plate thickness dimensions on the end portion sides of the flat plate portion in the installation portion.

FIG. 20 is a perspective view showing a state where the installation portions of the longitudinal joint structures according to the same embodiment move in the through-thickness direction X.

FIG. 21 is a perspective view showing a state where the installation portion in which the installation portion-side projections each having a substantially trapezoidal shape or a substantially T-shape in a cross section are formed moves in the wall width direction Z.

FIG. 22 is a perspective view showing a state where the installation portion in which wedge-type installation portion-side projections and the engagement target

portions are formed moves in the wall width direction Z.

FIG. 23A is a front view showing the plate member subjected to cutting.

FIG. 23B is a front view showing the installation portion subjected to cutting.

FIG. 23C is a front view showing the installation portion-side projections and the engagement target portion inclined in the wall width direction Z.

FIG. 24A is a front view showing a state of positioning the plate member having a protrusion portion formed therein and the plate member having a recess portion formed therein.

FIG. 24B is a front view showing a state where the protrusion portion is fitted in the recess portion.

FIG. 25A is a perspective view showing the installation portion making a slide movement.

FIG. 25B is a perspective view showing a frame member attached to the installation portion.

FIG. 25C is a perspective view showing a state of being interposed between both side portions of the frame member.

FIG. 26A is a front view showing the installation portion in which the bolt penetrating the installation portion in the member axis direction Y, and the like are provided.

FIG. 26B is a longitudinal cross-sectional view of the installation portion shown in FIG. 26A.

FIG. 27A is a perspective view showing the installation portion making a slide movement.

FIG. 27B is a perspective view showing a bar member being attached to the installation portion.

FIG. 27C is a perspective view showing the bar member fitted in a notch groove.

FIG. 28 is a plan view showing the hat-type steel sheet piles on which a bending load is acting.

[Embodiment of the Invention]

[0021]

Hereinafter, a longitudinal joint structure 1 for hat-type steel sheet piles (hereinafter, will be simply referred to as the longitudinal joint structure 1) according to an embodiment of the present invention will be described in detail with reference to the drawings.

[0022]

As shown in FIG. 1, for example, the longitudinal joint structure 1 is used for a plurality of hat-type steel sheet piles 2 (first hat-type steel sheet pile 2A and second hat-type steel sheet pile 2B) which are embedded below and above in a ground 8 and are coupled to each other in the member axis direction Y at a construction site such as a narrow ground where long hat-type steel sheet piles cannot be constructed.

[0023]

A long longitudinal joint hat-type steel sheet pile unit 70 is formed by coupling the plurality of hat-type steel sheet piles 2 to each other in the member axis direction Y. Then, a steel wall 7 is built in the ground 8 or the like by continuously installing a plurality of longitudinal joint hat-type steel sheet pile units 70 in the wall width direction Z.

[0024]

As shown in FIG. 2, the hat-type steel sheet piles 2 to be coupled to each other in the member axis direction Y are coupled by means of an installation portion 5 in a

state where end surfaces 3a of end portions 3 thereof butt each other in the member axis direction Y.

[0025]

For example, the installation portion 5 is made of steel and is installed across side surfaces 3b and 3b of the end portions 3 in the member axis direction Y of the hat-type steel sheet piles 2 facing each other in the member axis direction Y.

[0026]

As shown in FIG. 3, the hat-type steel sheet pile 2 has a flange portion 2a, a pair of web portions 2b, a pair of arm portions 2c, and a pair of joint portions 2d. When the joint portions 2d of the hat-type steel sheet piles 2 adjacent to each other in the wall width direction Z are fitted together, the plurality of hat-type steel sheet piles 2 can be continuously installed in the wall width direction Z.

[0027]

In the hat-type steel sheet pile 2, the flange portion 2a extending in the wall width direction Z is formed, and the web portions 2b respectively inclined from both ends of the flange portion 2a in the wall width direction Z are formed, thereby forming a groove portion S. In the hat-type steel sheet pile 2, each arm portion 2c is formed from one end of each web portion 2b, and each joint portion 2d is formed in a front end of each arm portion 2c.

[0028]

In the hat-type steel sheet pile 2, the flange portion 2a, the web portions 2b, and the arm portions 2c each have a flat surface 20 which is formed in a substantially flat shape.

[0029]

The installation portion 5 may be installed on only the flat surface 20 of the

flange portion 2a as shown in FIG. 3, may be installed on the flat surfaces 20 of the flange portion 2a and the pair of web portions 2b as shown in FIG. 4, and may be installed on the flat surfaces 20 of the flange portion 2a and the pair of arm portions 2c as shown in FIG. 5. Particularly, as shown in FIG. 5, the installation portion 5 may be installed not only on one surface of the flat surface 20 but also on both surfaces thereof.

In the example shown in FIG. 4, three installation portions 5 are installed on the flat surfaces 20 of the flange portion 2a and the pair of web portions 2b. However, a plurality of installation portions 5 may be integrally installed in a hat-type steel sheet pile.

[0030]

As shown in FIGS. 6A and 6B, the installation portion 5 has a flat plate portion 51 made by using a steel plate or the like, and installation portion-side projections 50 protruding in the through-thickness direction X from the flat plate portion 51.

The installation portion-side projections 50 extend straight continuously in the wall width direction Z and are integrally formed with the flat plate portion 51 through rolling such as hot rolling and cold rolling.

[0031]

The installation portion-side projections 50 may be integrally formed with the flat plate portion 51 through cutting of a steel plate, or the like. In addition, the installation portion 5 may be obtained by using a steel plate as the flat plate portion 51 and performing weld-bonding of the installation portion-side projections 50 on a side surface thereof.

[0032]

In the installation portion 5, for example, a plate thickness dimension  $t$  of the

flat plate portion 51 ranges approximately from 9 mm to 25 mm, a width dimension B ranges approximately from 50 mm to 125 mm or approximately from 200 mm to 400 mm, and a height dimension H ranges approximately from 200 mm to 400 mm. In addition, in the installation portion 5, a length L of each of the installation portion-side projections 50 in the member axis direction Y ranges approximately from 10 mm to 38 mm, a height h in the through-thickness direction X ranges approximately from 4.5 mm to 25 mm, and a distance D at which the installation portion-side projections 50 are separated from each other ranges approximately from 60 mm to 100 mm.

[0033]

As shown in FIGS. 7A and 7B, the installation portion 5 is provided such that the flat plate portion 51 is continuously laid across the side surfaces 3b of the upper and lower hat-type steel sheet piles 2 in the member axis direction Y, and the installation portion-side projections 50 protrude from the flat plate portion 51 toward the side surface 3b. The installation portion 5 is provided along the flat surfaces 20 formed in the end portions 3 of the hat-type steel sheet piles 2.

[0034]

For example, as shown in FIG. 7A, the flat plate portion 51 is formed in a substantially rectangular shape. As shown in FIG. 7B, in the flat plate portion 51, bolt insertion holes 40 penetrating the flat plate portion 51 in the through-thickness direction X are formed in each of an upper side and a lower side in the member axis direction Y. In the flat plate portion 51, a plurality of installation portion-side projections 50 are provided while being separated from each other along the member axis direction on the side surface facing the flat surfaces 20 of the end portions 3 of the hat-type steel sheet piles 2. In this case, bending stress received by one installation portion-side projection 50 can be reduced. Therefore, breakage of the installation

portion-side projections 50 can be prevented. However, there is no need to provide the plurality of installation portion-side projections 50, and only one thereof may be provided.

[0035]

As shown in FIGS. 7A and 7B, the installation portion-side projections 50 lock engagement target portions 60 (first engagement target portions) protruding outward from the side surface 3b of the end portion 3 of the first hat-type steel sheet pile 2A, and engagement target portions 60 (second engagement target portions) protruding outward from the side surface 3b of the end portion 3 of the second hat-type steel sheet pile 2B, in the member axis direction Y. Accordingly, relative movement between the first hat-type steel sheet pile 2A and the second hat-type steel sheet pile 2B in the member axis direction Y is restricted.

In this manner, the installation portion-side projections 50 are formed on each of the upper side and the lower side in the member axis direction Y in the flat plate portion 51 and lock the engagement target portions 60 provided on the side surface 3b of the end portion 3 of the first hat-type steel sheet pile 2A. Therefore, it is possible to cope with bending stress acting on longitudinal joint locations in the hat-type steel sheet piles 2 due to the installation portion 5, and it is possible to enhance bending rigidity. In addition, the plurality of hat-type steel sheet piles 2 can be easily and reliably coupled to each other by means of the installation portion 5. Therefore, longitudinal joint construction can be carried out without essentially performing welding work requiring labor and costs.

[0036]

In the longitudinal joint structure 1 shown in FIGS. 7A and 7B, a plurality of engagement target portions 60 are provided while extending straight continuously in

the wall width direction Z and being separated from each other in the member axis direction Y. In addition, the engagement target portions 60 are integrally formed with a plate member 6 (substrate), and the plate members 6 are attached to the side surfaces 3b of the end portions 3 of the hat-type steel sheet piles 2. In the plate member 6, the engagement target portions 60 extending straight continuously in the wall width direction Z are integrally formed with the plate member 6 through rolling such as hot rolling and cold rolling.

[0037]

In the longitudinal joint structure 1 shown in FIGS. 7A and 7B, the end surface 3a of the first hat-type steel sheet pile 2A and an end surface of the plate member 6 of the engagement target portions 60 in the member axis direction Y are configured to be flush with each other, and the end surface 3a of the second hat-type steel sheet pile 2B and the end surface of the plate member 6 of the engagement target portions 60 in the member axis direction Y are configured to be flush with each other.

According to this configuration, not only the first hat-type steel sheet pile 2A and the end surface 3a of the second hat-type steel sheet pile 2B but also the end surfaces of the engagement target portions 60 can also butt each other. Therefore, a compressive force acting in a direction in which the first hat-type steel sheet pile 2A and the second hat-type steel sheet pile 2B approach each other in the member axis direction can be received not only by the end surfaces of the steel plates but also by the side surfaces of the engagement target portions. Thus, it is possible to cope with a greater bending load.

In the longitudinal joint structure 1 shown in FIGS. 7A and 7B, the end surfaces of the plate members 6 butt each other. However, even in a case of having no plate member 6, when the end surfaces of the engagement target portions 60 in the

member axis direction Y are configured to butt each other, it is possible to achieve a similar effect.

[0038]

The engagement target portions 60 may be integrally formed with the plate member 6 through cutting of a steel plate, or the like. In addition, the engagement target portions 60 may be obtained by using a steel plate as the plate member 6 and performing weld-bonding of flat steels onto the side surface thereof.

[0039]

In the longitudinal joint structure 1 shown in FIGS. 7A and 7B, the plurality of engagement target portions 60 are provided on the side surface thereof while being separated from each other along the member axis direction Y. Accordingly, bending stress received by one engagement target portion 60 can be reduced. Therefore, breakage of the engagement target portions 60 can be prevented. However, only one engagement target portion 60 may be provided.

[0040]

Moreover, in the longitudinal joint structure 1 shown in FIGS. 7A and 7B, the plurality of engagement target portions 60 provided while being separated from each other along the member axis direction Y are integrally formed with a single plate member 6 serving as a common substrate. Therefore, it is possible to uniformly retain a separation distance between the plurality of engagement target portions 60 separated from each other in the member axis direction. Therefore, when the plurality of engagement target portions 60 are attached to the hat-type steel sheet pile 2, all the engagement target portions 60 can be precisely attached in one process in which the plate members 6 (substrates) are fixed to the hat-type steel sheet pile 2.

However, as shown in FIG. 8A, the engagement target portions 60 may be

provided by attaching flat steels or the like to the side surface 3b of the end portion 3 of the hat-type steel sheet pile 2 through direct welding or the like.

[0041]

Moreover, in the longitudinal joint structure 1 shown in FIGS. 7A and 7B, the installation portion 5 locks the engagement target portions 60 of the first hat-type steel sheet pile 2A and the second hat-type steel sheet pile 2B. However, as shown in FIG. 8B, the installation portion 5 may lock only the engagement target portions 60 of the first hat-type steel sheet pile 2A. In this case, the installation portion-side projections 50 are not formed in the flat plate portion 51 of the installation portion 5, and the side surface 3b of the end portion 3 of the second hat-type steel sheet pile 2B and the flat plate portion 51 are attached to each other through direct welding or the like.

Moreover, as shown in FIG. 8C, the installation portion 5 may be attached to both surfaces of the hat-type steel sheet piles 2.

[0042]

As shown in FIGS. 7A and 7B, the installation portion 5 is subjected to bolt-bonding on the side surfaces 3b of the end portions 3 of the hat-type steel sheet piles 2 using bolts 4 penetrating the longitudinal joint structure 1 from the flat plate portion 51 to the end portions 3 of the hat-type steel sheet piles 2 in the through-thickness direction X. When fastening nuts 41 are screwed to the bolts 4 on rear surfaces of the end portions 3 of the hat-type steel sheet piles 2, the installation portion 5 is fixed to the end portions 3 of the hat-type steel sheet piles 2.

[0043]

The installation portion 5 may be fixed not only by using the fastening nuts 41 fastening the bolts 4 in the through-thickness direction X but also as shown in FIGS. 9A and 9B, for example, by using welding nuts 42 or female screw portions 43

provided on the flat surfaces 20 of the end portions 3 of the hat-type steel sheet piles 2. In this case, the installation portion 5 is fixed when the bolts 4 are screwed to the welding nuts 42 or the female screw portions 43. Even in this case, the installation portion 5 may also be attached to both surfaces of the hat-type steel sheet piles 2.

[0044]

The bolts 4 are inserted through the bolt insertion holes 40 formed in the flat plate portion 51 of the installation portion 5, the plate members 6, and the end portions 3 of the hat-type steel sheet piles 2. As shown in FIG. 9A, the bolts 4 are screwed to the welding nuts 42 attached to the end portions 3 of the hat-type steel sheet piles 2 through welding, or as shown in FIG. 9B, the bolts 4 are screwed to the female screw portions 43 formed in the end portions 3 of the hat-type steel sheet piles 2 through female-screwing.

[0045]

As shown in FIG. 10, the installation portion-side projections 50 and the engagement target portions 60 are each formed in a substantially rectangular shape in a cross section. Particularly, in a case where the installation portion-side projections 50 and the engagement target portions 60 are formed through rolling such as hot rolling and cold rolling, as shown in FIG. 11, the installation portion-side projections 50 and the engagement target portions 60 may be each formed in a substantially trapezoidal shape in a cross section. In addition, as shown in FIG. 12, the installation portion-side projections 50 and the engagement target portions 60 may be each formed in a substantially T-shape in a cross section.

[0046]

As shown in FIGS. 10 to 12, when the installation portion-side projections 50 and the engagement target portions 60 receive a tensile force  $T$  in a direction in which

the plurality of hat-type steel sheet piles 2 are separated from each other in the member axis direction Y, one end surface of each of the installation portion-side projections 50 in the member axis direction Y and one end surface of each of the engagement target portions 60 in the member axis direction Y abut each other.

[0047]

The one end surfaces of the installation portion-side projections 50 and the engagement target portions 60 facing each other in the member axis direction Y abut each other, thereby forming abutting surfaces 30. When the one end surfaces of the installation portion-side projections 50 and the engagement target portions 60 knock each other in the member axis direction Y on the abutting surfaces 30, the one end surfaces thereof resist against the tensile force T. Therefore, the plurality of hat-type steel sheet piles 2 are restricted so as not to be separated from each other in the member axis direction Y.

[0048]

As shown in FIG. 10, when the installation portion-side projections 50 and the engagement target portions 60 are each formed in a substantially rectangular shape in a cross section, the abutting surfaces 30 of the installation portion-side projections 50 are formed while being substantially orthogonal to the side surface of the flat plate portion 51 of the installation portion 5, and the abutting surfaces 30 of the engagement target portions 60 are formed while being substantially orthogonal to the flat surfaces 20 of the end portions 3 of the hat-type steel sheet piles 2 or the side surfaces of the plate members 6.

[0049]

As shown in FIG. 11, when the installation portion-side projections 50 and the engagement target portions 60 are each formed in a substantially trapezoidal shape in a

cross section, the installation portion-side projections 50 inclined in a tapered shape in the through-thickness direction X toward the end portions 3 of the hat-type steel sheet piles 2 are formed, and the engagement target portions 60 inclined in a tapered shape in the through-thickness direction X toward the flat plate portion 51 of the installation portion 5 are formed.

[0050]

As shown in FIG. 11, the installation portion-side projection 50 is inclined in a tapered shape such that a front end side 50a protruding toward the side surface 3b of the end portion 3 of the hat-type steel sheet pile 2 is further increased in width in the member axis direction Y than a base end side 50b connected to the flat plate portion 51 of the installation portion 5. In addition, the engagement target portion 60 is inclined in a tapered shape such that a front end side 60a protruding toward the flat plate portion 51 of the installation portion 5 is further increased in width in the member axis direction Y than a base end side 60b connected to the flat surface 20 of the end portion 3 of the hat-type steel sheet pile 2 or the plate member 6.

[0051]

As shown in FIG. 11, when the one end surfaces thereof are formed to be substantially parallel to each other, the installation portion-side projections 50 and the engagement target portions 60 abut each other on the abutting surfaces 30 inclined in a tapered shape in the through-thickness direction X. The installation portion-side projections 50 and the engagement target portions 60 lock each other on the abutting surfaces 30 so as not to be separated from each other in the through-thickness direction X, when the front end sides 50a of the installation portion-side projections 50 are inclined in a tapered shape so as to be increased in width, and when the front end sides 60a of the engagement target portions 60 are inclined in a tapered shape so as to be

increased in width.

[0052]

As shown in FIG. 12, when the installation portion-side projections 50 and the engagement target portions 60 are each formed in a substantially T-shape in a cross section, installation portion-side extension portions 52 extending in the member axis direction Y on the front end side 50a of the installation portion-side projections 50 are formed, and engagement target portion-side extension portions 62 extending in the member axis direction Y on the front end side 60a of the engagement target portions 60 are formed.

[0053]

The installation portion-side projections 50 and the engagement target portions 60 abut each other on the abutting surfaces 30 while the base end sides 50b of the installation portion-side projections 50 and the engagement target portion-side extension portions 62 of the engagement target portions 60 are formed to be substantially parallel to each other. The installation portion-side projections 50 and the engagement target portions 60 abut each other on the abutting surfaces 30 while the installation portion-side extension portions 52 of the installation portion-side projections 50 and the base end sides 60b of the engagement target portions 60 are formed to be substantially parallel to each other.

[0054]

The installation portion-side projections 50 and the engagement target portions 60 lock each other so as not to be separated from each other in the through-thickness direction X, when the installation portion-side extension portions 52 on the front end sides 50a of the installation portion-side projections 50 and the engagement target portion-side extension portions 62 on the front end sides 60a of the engagement

target portions 60 are formed to extend in the member axis direction Y.

[0055]

In the installation portion-side projections 50 and the engagement target portions 60, the installation portion-side projections 50 inclined in a tapered shape may be formed, the engagement target portions 60 inclined in a tapered shape may be formed, and the installation portion-side extension portions 52 on the front end sides 50a of the installation portion-side projections 50 and the engagement target portion-side extension portions 62 on the front end sides 60a of the engagement target portions 60 may be formed.

[0056]

As shown in FIG. 13, in a case where the distance D at which the installation portion-side projections 50 and the engagement target portions 60 are separated from each other is greater than the length L thereof in the member axis direction Y, the installation portion-side projections 50 may be welded on the side surface of the flat plate portion 51 of the installation portion 5 on the one end surfaces disposed on a side opposite to the abutting surfaces 30, and the engagement target portions 60 may be welded on the flat surfaces 20 of the end portions 3 of the hat-type steel sheet piles 2 or the side surface of the plate member 6.

[0057]

In the longitudinal joint structure 1, it is desirable that the plurality of installation portion-side projections 50 locking the plurality of engagement target portions 60 are formed, and as shown in FIGS. 14A, 14B, 14C, 14D, 15A, 15B, 16A, and 16B, particularly, the installation portion-side projections 50 and the engagement target portions 60 are formed to be inclined in a tapered shape. In the longitudinal joint structure 1, R-portions 30a are formed on the front end side 50a and the base end

side 50b of the installation portion-side projection 50 on one end surface 53 of the installation portion-side projection 50 in the member axis direction Y, and the R-portions 30a are formed on the front end side 60a and the base end side 60b of the engagement target portion 60 on one end surface 63 of the engagement target portion 60 in the member axis direction Y, thereby leading to easy extruding and improving the workability.

[0058]

In the longitudinal joint structure 1, as shown in FIGS. 14A and 14B, particularly in parts other than the R-portions 30a, it is preferable that the one end surfaces 53 of the installation portion-side projections 50 facing each other in the member axis direction Y are each formed in a tapered shape so as to be substantially parallel to each other and the one end surfaces 63 of the engagement target portions 60 facing each other in the member axis direction Y are each formed in a tapered shape so as to be substantially parallel to each other. In this case, in a state where the installation portion-side projections 50 lock the engagement target portions 60, the one end surfaces 53 of the installation portion-side projections 50 and the one end surfaces 63 of the engagement target portions 60 facing each other in the member axis direction Y are formed so as to be substantially parallel to each other. Accordingly, the workability can be further improved.

[0059]

In this case, in the longitudinal joint structure 1, a gap W1 between the front end sides 50a at which the plurality of installation portion-side projections 50 are separated from each other in the member axis direction Y is substantially the same in size as a gap W2 between the base end sides 50b at which the plurality of installation portion-side projections 50 are separated from each other in the member axis direction

Y. Accordingly, an inclination angle  $\theta_1$  (inclination angle on the side surface far from the end portion 3) of the abutting surface 30 of the installation portion-side projection 50 resisting against the tensile force T and an inclination angle  $\theta_2$  (inclination angle on the side surface close to the end portion 3) of the one end surface 53 on a side opposite to the abutting surface 30 become substantially the same in size as each other at each position.

[0060]

In addition, in the longitudinal joint structure 1, the gap W1 between the front end sides 60a at which the plurality of engagement target portions 60 are separated from each other in the member axis direction Y is substantially the same in size as the gap W2 between the base end sides 60b at which the plurality of engagement target portions 60 are separated from each other in the member axis direction Y.

Accordingly, the inclination angle  $\theta_1$  of the abutting surface 30 of the engagement target portion 60 resisting against the tensile force T and the inclination angle  $\theta_2$  of the one end surface 63 on a side opposite to the abutting surface 30 become substantially the same in size as each other at each position.

[0061]

In the longitudinal joint structure 1, for example, the radius of curvature of the R-portion 30a can be set to approximately 5 mm, and the inclination angle  $\theta_1$  can be set to approximately 45°. In the longitudinal joint structure 1, for example, when the gap W1 is set to approximately 30 mm and the difference in size between the gap W1 and the gap W2 is minimized, it is advantageous in improving the workability of extruding.

[0062]

In the example shown in FIG. 14B, the inclination angle  $\theta_1$  is set to be less

than  $90^\circ$ , and the inclination angle  $\theta_2$  is set to be greater than  $90^\circ$ . However, as in a modification example shown in FIG. 14C, the inclination angle  $\theta_1$  may be set to be greater than  $90^\circ$ , and the inclination angle  $\theta_2$  may be set to be less than  $90^\circ$ .

In addition, in the example shown in FIG. 14B, both side surfaces of the projection 50 are parallel to each other. However, as in another modification example shown in FIG. 14D, the projection 50 may have a shape tapered toward the front end side.

[0063]

In addition, in the longitudinal joint structure 1, in a case where the installation portion-side projections 50 and the engagement target portions 60 are each formed in a substantially trapezoidal shape in a cross section, as shown in FIGS. 15A and 15B, the gap W1 between the front end sides 50a of the plurality of installation portion-side projections 50 is formed to be smaller than the gap W2 between the base end sides 50b of the plurality of installation portion-side projections 50, and the gap W1 between the front end sides 60a of the plurality of engagement target portions 60 is formed to be smaller than the gap W2 between the base end sides 60b of the plurality of engagement target portions 60. In this case, in the longitudinal joint structure 1, as necessary, as shown in FIGS. 16A and 16B, the inclination angle of the one end surface 53 of the installation portion-side projection 50 on a side opposite to the abutting surface 30 and the inclination angle (inclination angle  $\theta_2$ ) of the one end surface 63 of the engagement target portion 60 may be formed to be a substantially right angle.

[0064]

Here, in the longitudinal joint structure 1, a compressive force P acting in a direction in which the plurality of hat-type steel sheet piles 2 approach each other in the member axis direction Y as shown in FIG. 17A or the tensile force T acting in a

direction in which the plurality of hat-type steel sheet piles 2 are separated from each other in the member axis direction Y as shown in FIG. 17B is generated. In the longitudinal joint structure 1, when the tensile force T acts on the plurality of hat-type steel sheet piles 2, due to the distance from the abutting surfaces 30 of the installation portion-side projections 50 to the center of gravity in the flat plate portion 51 in the through-thickness direction X, eccentric bending acts on the installation portion 5. Therefore, as shown in FIG. 17C, there is a possibility that warp deformation will occur in the installation portion 5 and the installation portion-side projections 50 will be uncoupled.

[0065]

Therefore, as shown in FIGS. 18A to 18C, in the longitudinal joint structure 1, it is desirable that the installation portion-side projections 50 formed farthest on end portion sides G in the member axis direction Y are meshed with two engagement target portions 60 in a state of being separated or abutting both sides in the member axis direction Y. In this case, in the longitudinal joint structure 1, the engagement target portion 60 is provided above the installation portion-side projection 50 on an upper end side of the installation portion 5 in the member axis direction Y, and the engagement target portion 60 is provided below the installation portion-side projection 50 on a lower end side of the installation portion 5 in the member axis direction Y.

[0066]

Accordingly, in the longitudinal joint structure 1, when the installation portion-side projections 50 farthest on the end portion sides G in the member axis direction Y are meshed with the plurality of engagement target portions 60 from both sides in the member axis direction Y, as shown in FIG. 18B, even in a case where eccentric bending acts on the installation portion 5, the installation portion-side

projections 50 respectively lock the engagement target portions 60 above and below thereof. Therefore, warp deformation of the installation portion 5 is suppressed, and the installation portion-side projections 50 can be prevented from being uncoupled.

In the longitudinal joint structure 1, when the one end surface 53 of the installation portion-side projection 50 on a side opposite to the abutting surface 30 and the one end surface 63 of the engagement target portion 60 are formed to be a substantially right angle, and as shown in FIG. 18C, when the one end surface 53 thereof and the one end surface 63 thereof are inclined in a tapered shape and lock each other, the installation portion-side projections 50 are more reliably prevented from being uncoupled, which is preferable.

[0067]

In addition, as shown in FIGS. 19A to 19C, in the longitudinal joint structure 1, it is preferable that a plate thickness dimension  $t_1$  of the flat plate portion 51 on a center side F in the member axis direction Y is greater than plate thickness dimensions  $t_2$  of the flat plate portion 51 of the installation portion 5 on the end portion sides G in the member axis direction Y.

In this manner, when the cross-sectional area in a case where parts of the installation portion 5 excluding locking regions with respect to the engagement target portions 60 are seen in a cross section perpendicular to the member axis direction Y is maximized at a butting position between the hat-type steel sheet piles 2, it is possible to increase the cross-sectional area at a location in which bending rigidity is required the most in the installation portion 5. Therefore, it is possible to compatibly reduce the weight and ensure bending rigidity of the installation portion 5.

[0068]

In the longitudinal joint structure 1 shown in FIG. 19A, the installation portion

5 is formed in a tapered shape in which an outer surface 51a of the flat plate portion 51 protrudes further on the center side F than on the end portion sides G, so that the plate thickness dimension t1 is greater than the plate thickness dimensions t2.

In the longitudinal joint structure 1 shown in FIGS. 19B and 19C, an inner surface 51b of the flat plate portion 51 is formed to protrude further on the center side F than the end portion sides G, so that the plate thickness dimension t1 is greater than the plate thickness dimensions t2. Specifically, as shown in FIG. 19B, the thickness of the flat plate portion 51 may be continuously and gradually reduced while being separated from the end portions 3, or as shown in FIG. 19C, the thickness of the flat plate portion 51 may be gradually reduced in a stepped manner while being separated from the end portions 3, so that the plate thickness dimension t1 is greater than the plate thickness dimensions t2.

[0069]

Accordingly, in the longitudinal joint structure 1, the rigidity of the installation portion 5 on the center side F in the member axis direction Y is improved by causing the plate thickness dimension t1 of the flat plate portion 51 on the center side F to be greater than the plate thickness dimensions t2 of the flat plate portion 51 of the installation portion 5 on the end portion sides G. Therefore, even in a case where eccentric bending acts on the installation portion 5, warp deformation in the installation portion 5 is suppressed, and the installation portion-side projections 50 can be prevented from being uncoupled.

As shown in FIGS. 18A to 18C, in the longitudinal joint structure 1, while the installation portion-side projections 50 on the farthest end portion sides G are meshed with the plurality of engagement target portions 60 from both sides in the member axis direction Y, as shown in FIGS. 19A to 19C, the plate thickness dimension t1 of the flat

plate portion 51 on the center side F in the member axis direction Y can be increased.

[0070]

As described above, in the longitudinal joint structure 1 shown in FIGS. 11, 12, 14A to 19C, and the like, the engagement target portion 60 has an extension projection (part of the engagement target portion 60 inclined in a tapered shape, or the engagement target portion-side extension portions 62) extending in the member axis direction Y on its front end side. The extension projection locks a recess of the installation portion 5 formed to extend in the wall width direction Z.

Accordingly, coupling work can be easily performed, and the installation portion 5 can be reliably prevented from being uncoupled.

[0071]

In the longitudinal joint structure 1, in a case where the installation portion-side projections 50 and the engagement target portions 60 are each formed in a substantially rectangular shape in a cross section, as shown in FIG. 20, the installation portion 5 moves in the through-thickness direction X from the outside of the groove portions S of the hat-type steel sheet piles 2. In this case, the installation portion 5 is attached to the hat-type steel sheet piles 2 from the outside of the groove portions S and is fixed using the bolts 4 or the like. The installation portion 5 may move from the inside of the groove portions S of the hat-type steel sheet piles 2 so as to be attached to the hat-type steel sheet piles 2 from the inside of the groove portions S.

[0072]

In the longitudinal joint structure 1, in a case where the installation portion-side projections 50 and the engagement target portions 60 are each formed in a substantially trapezoidal shape in a cross section or in a substantially T-shape in a cross section, as shown in FIG. 21, the installation portion 5 makes a slide movement in the

wall width direction Z. In this case, in the installation portion 5, the installation portion-side projections 50 are inserted between the plurality of engagement target portions 60 in a sliding manner, and the engagement target portions 60 are inserted between the plurality of installation portion-side projections 50 in a sliding manner, thereby being fixed so as not to be separated from each other in the through-thickness direction X.

[0073]

In the longitudinal joint structure 1, as shown in FIG. 22, the engagement target portions 60 and the installation portion-side projections 50 may be each formed in a wedge shape. In this case, construction characteristics when the engagement target portions 60 are inserted between the plurality of installation portion-side projections 50 in a sliding manner are improved and uncoupling of the installation portion 5 can be prevented due to a frictional force between the installation portion-side projections 50 and the engagement target portions 60. Moreover, looseness between the projections is reduced, so that it is possible to reduce slip deformation at the time of deformation.

[0074]

In the longitudinal joint structure 1, as shown in FIGS. 23A and 23B, the plate member 6 in which the engagement target portions 60 are formed, and the installation portion 5 may be manufactured through cutting or the like performed along a cutting-plane line E inclined in the member axis direction Y or the like. In this case, as shown in FIG. 23C, in the longitudinal joint structure 1, the engagement target portions 60 and the installation portion-side projections 50 are formed to be inclined in the wall width direction Z, and the installation portion 5 makes a sliding movement in the wall width direction Z, the plurality of installation portion-side projections 50 are inserted

between the plurality of engagement target portions 60 in a sliding manner.

[0075]

In the longitudinal joint structure 1, as necessary, a stopper member 33 is provided on one side end in the wall width direction Z. Therefore, when the installation portion 5 makes a slide movement in the wall width direction Z, the installation portion 5 abuts the stopper member 33. In this case, in the longitudinal joint structure 1, since the engagement target portions 60 and the installation portion-side projections 50 are inclined, the installation portion 5 can easily make a slide movement, and since the installation portion 5 abuts the stopper member 33, the installation portion 5 is prevented from making a slide movement more than necessary, and the installation portion 5 can be prevented from falling off.

[0076]

In the longitudinal joint structure 1, as necessary, as shown in FIGS. 24A and 24B, the plate member 6 in which the engagement target portions 60 are formed may be attached to both the side surface 3b of the end portions 3 of the first hat-type steel sheet pile 2A and the second hat-type steel sheet pile 2B. In this case, in the longitudinal joint structure 1, for example, a protrusion portion 65 protruding in the member axis direction Y may be formed in the plate member 6 on the first hat-type steel sheet pile 2A side, and a recess portion 66 depressed in the member axis direction Y may be formed in the plate member 6 on the second hat-type steel sheet pile 2B side.

[0077]

In the longitudinal joint structure 1 shown in FIG. 24A, FIG. 24B, when the first hat-type steel sheet pile 2A and the second hat-type steel sheet pile 2B are coupled to each other in the member axis direction Y, the protrusion portion 65 formed in the plate member 6 on the first hat-type steel sheet pile 2A side is fitted in the recess

portion 66 formed in the plate member 6 on the second hat-type steel sheet pile 2B side. Accordingly, in the longitudinal joint structure 1, when the protrusion portion 65 is fitted in the recess portion 66, the plurality of end portions 3 of the hat-type steel sheet piles 2 can be easily positioned in the wall width direction Z. Furthermore, in the longitudinal joint structure 1, particularly, since the protrusion portion 65 and the recess portion 66 are formed to be inclined in the wall width direction Z, inclination surfaces of the protrusion portion 65 and the recess portion 66 serve as guides to each other, so that fitting of the protrusion portion 65 and the recess portion 66 can be easily executed.

[0078]

In the longitudinal joint structure 1, as shown in FIGS. 25A to 25C, in a state where the plurality of installation portion-side projections 50 are inserted between the plurality of engagement target portions 60 in a sliding manner, a frame member 55 surrounding the installation portion-side projections 50 and the engagement target portions 60 engaging with each other in the member axis direction Y may be formed in the installation portion 5. In this case, in the longitudinal joint structure 1, the installation portion-side projections 50 and the engagement target portions 60 are interposed between both side portions 55a of the frame member 55, so that the installation portion 5 can be prevented from making a slide movement more than necessary. Moreover, in the longitudinal joint structure 1, as necessary, a groove 54 is formed on an upper end surface 5b of the installation portion 5, and an upper end portion 55b of the frame member 55 is fitted into the groove 54. Accordingly, movement of the frame member 55 in the through-thickness direction X is restricted, so that the frame member 55 can be prevented from falling off.

[0079]

In the longitudinal joint structure 1, as shown in FIGS. 26A and 26B, a lower end surface 5a of the installation portion 5 may be formed to be inclined to the end portion 3 side of the hat-type steel sheet pile 2 downward from above in the member axis direction Y. In the longitudinal joint structure 1, the lower end surface 5a of the installation portion 5 is inclined to the end portion 3 side of the hat-type steel sheet pile 2. Accordingly, when the hat-type steel sheet piles 2 (longitudinal joint hat-type steel sheet pile unit 70) in a state of being coupled by the installation portion 5 are embedded, it is possible to reduce installation resist received by the lower end surface 5a of the installation portion 5.

[0080]

Here, in the longitudinal joint structure 1, the upper end surface 5b of the installation portion 5 or the outer surface 51a of the flat plate portion 51, shaft members 56 such as the bolts 4 and screws penetrating the installation portion 5 continuously to the engagement target portion 60 or the plate member 6 may be provided. In addition, in the longitudinal joint structure 1, a plate 44 which is a flat steel or the like installed continuously from the installation portion 5 to the engagement target portions 60 or the plate member 6 may be provided, and the plate 44 may be fixed using fastening screws or the like.

[0081]

Furthermore, in the longitudinal joint structure 1, as shown in FIGS. 27A to 27C, a notch groove 57a may be formed in the installation portion-side projections 50 and the engagement target portions 60 by partially notching the installation portion-side projections 50 and the engagement target portions 60 in the wall width direction Z. In this case, in the longitudinal joint structure 1, a bar member 57 having a substantially polygonal shape or the like and extending continuously in the member

axis direction Y is fitted in the notch groove 57a formed by partially notching the installation portion-side projections 50 and the engagement target portions 60.

From the viewpoint of construction characteristics, it is preferable that the notch groove 57a and the bar member 57 each have a triangle shape in which the width dimension is gradually reduced toward a front end section side, instead of a substantially polygonal shape.

[0082]

In this manner, in the longitudinal joint structure 1, only one of the frame member 55 shown in FIGS. 25A to 25C, the shaft members 56 and the plate 44 shown in FIGS. 26A and 26B, and the bar member 57 shown in FIGS. 27A to 27C may be provided as a slide prevention portion. As necessary, these may be suitably combined and provided. Accordingly, in the longitudinal joint structure 1, movement of the installation portion 5 in the wall width direction Z is restricted due to the slide prevention portion, so that the installation portion 5 can be prevented from falling off.

[0083]

In the longitudinal joint structure 1, in a case where the installation portion-side projections 50 and the engagement target portions 60 are each formed in a substantially trapezoidal shape in a cross section, in a substantially T-shape in a cross section, or the like, the installation portion 5 is fixed so as not to be separated in the through-thickness direction X, movement of the installation portion 5 in the wall width direction Z is restricted by means of the frame member 55 or the like, and the installation portion-side projections 50 and the engagement target portions 60 lock each other in the member axis direction Y. In this case, in the longitudinal joint structure 1, the installation portion 5 is prevented from falling off without using the bolts 4 penetrating the end portions 3 of the hat-type steel sheet piles 2 in the through-

thickness direction X, and no open holes are formed in the end portions 3 of the hat-type steel sheet piles 2. Accordingly, water-stopping performance of the hat-type steel sheet piles 2 can be improved.

[0084]

In the longitudinal joint structure 1, particularly as shown in FIG. 28, when the plurality of hat-type steel sheet piles 2 coupled to each other by means of the installation portion 5 are embedded in the ground 8, or in a state where the plurality of hat-type steel sheet piles 2 have been embedded in the ground 8, a bending load M acts on the location where the plurality of hat-type steel sheet piles 2 are coupled to each other.

[0085]

In the longitudinal joint structure 1, in order to be able to sufficiently resist against the bending load M at the location where the plurality of hat-type steel sheet piles 2 are coupled to each other, it is desirable that bending rigidity and bending proof stress of the installation portion 5 are approximately the same as those of a single hat-type steel sheet pile 2. In this case, in the longitudinal joint structure 1, for example, the installation portions 5 are installed in the flange portion 2a and the arm portions 2c, so that distances  $e_1$  and  $e_2$  from a neutral axis C of the bending load M to the center of gravity of the installation portions 5 become substantially the same as the separation distance from the neutral axis C to the flange portion 2a and the arm portions 2c of the hat-type steel sheet piles 2.

[0086]

In the longitudinal joint structure 1, it is preferable that the dimension of the installation portion 5 in the through-thickness direction X is smaller than the dimension of the installation portion 5 in the wall width direction Z. In this case, since the

distances  $e_1$  and  $e_2$  from the neutral axis C of the bending load M to the center of gravity of the installation portion 5 become substantially the same as the flange portion 2a and the arm portions 2c of the hat-type steel sheet piles 2, the installation portion 5 having approximately the same cross-sectional area as that of the hat-type steel sheet piles 2 is installed. Accordingly, the bending rigidity and bending proof stress of the installation portion 5 can be approximately the same as those of a single hat-type steel sheet pile 2. In the longitudinal joint structure 1, even an installation portion 5 having a plate thickness approximately as thin as those of the hat-type steel sheet piles 2 can sufficiently resist against the bending load M at the location where the plurality of hat-type steel sheet piles 2 are coupled to each other. Therefore, the installation portion 5 can be reduced in weight and can be compact.

[0087]

In the longitudinal joint structure 1, particularly, when the installation portion 5 is installed at a position separated from the neutral axis C of the bending load M and the second moment of area of the installation portion 5 increases, even if the plate thickness of the installation portion 5 becomes thinner, the installation portion 5 can sufficiently resist against the bending load M at the location where the plurality of hat-type steel sheet piles 2 are coupled to each other. Accordingly, in the longitudinal joint structure 1, sufficient bending rigidity can be ensured at the location where the plurality of hat-type steel sheet piles 2 are coupled to each other, and at the same time, the installation portion 5 can be reduced in weight and can be compact. Therefore, it is possible to limit the coupling cost for the plurality of hat-type steel sheet piles.

[0088]

In the longitudinal joint structure 1, since sufficient bending rigidity can be ensured at the location where the plurality of hat-type steel sheet piles 2 are coupled to

each other, the location where the plurality of hat-type steel sheet piles 2 are coupled to each other does not become a structural weak point. Therefore, it is possible to avoid deterioration of bending performance of the entire longitudinal joint hat-type steel sheet pile in which the plurality of hat-type steel sheet piles are coupled to each other in the member axis direction Y.

[0089]

In the longitudinal joint structure 1, in a case where an acting direction of the bending load M is specified, as shown in FIG. 3, the usage amount of steel for the installation portion 5 can be limited by installing the installation portion 5 only on the flat surface 20 of the flange portion 2a which is a tensile side.

[0090]

In the longitudinal joint structure 1, as shown in FIGS. 10 to 12, the plurality of hat-type steel sheet piles 2 coupled to each other in the member axis direction Y lock each other in the member axis direction Y on the abutting surfaces 30, thereby resisting against the tensile force T. Generally, since the bearing strength of the installation portion-side projections 50 and the engagement target portions 60 required to resist against the tensile force T is higher than the tensile strength by approximately 1.5 times, when the heights h of the installation portion-side projections 50 and the engagement target portions 60 in the through-thickness direction X are reduced to approximately 70% ( $h=1/1.5 \times t'$ ) of a plate thickness dimension  $t'$  of the hat-type steel sheet piles 2, the installation portion 5 can be further reduced in weight and can be more compact.

[0091]

As shown in FIG. 1, the steel wall 7 includes the installation portion 5 which is installed on the side surfaces 3b of the end portions 3 of the plurality of hat-type

steel sheet piles 2 coupled to each other in the member axis direction Y, and the plurality of longitudinal joint hat-type steel sheet pile units 70 in which the plurality of hat-type steel sheet piles are coupled to each other in the member axis direction Y by means of the installation portion 5. The steel wall 7 is built to extend in the wall width direction Z in the ground 8 or the like by continuously installing the plurality of longitudinal joint hat-type steel sheet pile units 70 in the wall width direction Z.

[0092]

In the steel wall 7, particularly in the plurality of longitudinal joint hat-type steel sheet pile units 70 which are continuously installed adjacent to each other in the wall width direction Z, the installation portions 5 of the longitudinal joint hat-type steel sheet pile units 70 are disposed at different positions in the member axis direction Y. In this case, in the steel wall 7, since the locations where the plurality of hat-type steel sheet piles 2 are coupled to each other are disposed in a substantially zig-zag state or the like in the wall width direction Z, it is possible to avoid coupling locations, which may become structural weak points of the longitudinal joint hat-type steel sheet pile units 70, being disposed substantially at the same positions in the member axis direction Y and being continuously arranged in the wall width direction Z.

[0093]

Hereinabove, examples of the embodiment of the present invention have been described in detail. However, all the embodiment described above are merely examples specified for executing the present invention, and the technical scope of the present invention is not to be interpreted as limited by the examples.

[Industrial Applicability]

[0094]

According to the present invention, it is possible to provide a longitudinal

joint structure for hat-type steel sheet piles, in which sufficient bending rigidity can be ensured at locations where a plurality of hat-type steel sheet piles are coupled to each other in the member axis direction Y and coupling cost can be limited, a longitudinal joint hat-type steel sheet pile unit, and a steel wall.

[Brief Description of the Reference Symbols]

[0095]

1: LONGITUDINAL JOINT STRUCTURE OF HAT-TYPE STEEL SHEET PILE

2: HAT-TYPE STEEL SHEET PILE

2A: FIRST HAT-TYPE STEEL SHEET PILE

2B: SECOND HAT-TYPE STEEL SHEET PILE

2a: FLANGE PORTION

2b: WEB PORTION

2c: ARM PORTION

2d: JOINT PORTION

20: FLAT SURFACE

3: END PORTION

3a: END SURFACE

3b: SIDE SURFACE

30: ABUTTING SURFACE

30a: R-PORION

31: ONE END PORTION

32: OTHER END PORTION

33: STOPPER MEMBER

4: BOLT

- 40: BOLT INSERTION HOLE
- 41: FASTENING NUT
- 42: WELDING NUT
- 43: FEMALE SCREW PORTION
- 44: PLATE
- 5: INSTALLATION PORTION
- 5a: LOWER END SURFACE
- 5b: UPPER END SURFACE
- 50: INSTALLATION PORTION-SIDE PROJECTION
- 50a: FRONT END SIDE OF INSTALLATION PORTION-SIDE

#### PROJECTION

- 50b: BASE END SIDE OF INSTALLATION PORTION-SIDE

#### PROJECTION

- 51: FLAT PLATE PORTION
- 51a: OUTER SURFACE
- 51b: INNER SURFACE
- 52: INSTALLATION PORTION-SIDE EXTENSION PORTION
- 53: ONE END SURFACE OF INSTALLATION PORTION-SIDE

#### EXTENSION PORTION

- 54: GROOVE
- 55: FRAME MEMBER
- 55a: BOTH SIDE PORTIONS OF FRAME MEMBER
- 55b: UPPER END PORTION OF FRAME MEMBER
- 56: SHAFT MEMBER
- 57: BAR MEMBER

57a: NOTCH GROOVE

6: PLATE MEMBER

60: ENGAGEMENT TARGET PORTION

60a: FRONT END SIDE OF ENGAGEMENT TARGET PORTION

60b: BASE END SIDE OF ENGAGEMENT TARGET PORTION

62: ENGAGEMENT TARGET PORTION-SIDE EXTENSION

PORTION

63: ONE END SURFACE OF ENGAGEMENT TARGET PORTION

65: PROTRUSION PORTION

66: RECESS PORTION

7: STEEL WALL

70: LONGITUDINAL JOINT HAT-TYPE STEEL SHEET PILE UNIT

8: IN GROUND

X: THROUGH-THICKNESS DIRECTION

Y: MEMBER AXIS DIRECTION

Z: WALL WIDTH DIRECTION

## CLAIMS

What is claimed is:

1. A longitudinal joint structure for hat-type steel sheet piles, in which a first hat-type steel sheet pile and a second hat-type steel sheet pile are coupled by causing end surfaces thereof in a member axis direction to butt each other, the longitudinal joint structure comprising:

a first engagement target portion that protrudes outward from a side surface of the first hat-type steel sheet pile; and

an installation portion that is provided on a side surface of the second hat-type steel sheet pile and locks the first engagement target portion of the first hat-type steel sheet pile in the member axis direction.

2. The longitudinal joint structure for hat-type steel sheet piles according to Claim 1, further comprising:

a second engagement target portion that protrudes outward from the side surface of the second hat-type steel sheet pile,

wherein the installation portion also locks the second engagement target portion in addition to the first engagement target portion.

3. The longitudinal joint structure for hat-type steel sheet piles according to Claim 2,

wherein the end surface of the first hat-type steel sheet pile and an end surface of the first engagement target portion are flush with each other, and

wherein the end surface of the second hat-type steel sheet pile and an end surface of the second engagement target portion are flush with each other.

4. The longitudinal joint structure for hat-type steel sheet piles according to any one of Claims 1 to 3,

wherein the first engagement target portion has an extension projection which extends in the member axis direction on a front end side of the extension projection, and

wherein the installation portion has a recess which extends in a wall width direction perpendicular to the member axis direction and a through-thickness direction of the first hat-type steel sheet pile and locks the extension projection.

5. The longitudinal joint structure for hat-type steel sheet piles according to Claim 4, further comprising:

a slide prevention portion that restricts relative movement between the installation portion and the first engagement target portion in the wall width direction.

6. The longitudinal joint structure for hat-type steel sheet piles according to any one of Claims 1 to 5,

wherein a plurality of the first engagement target portions are provided while being separated from each other along the member axis direction.

7. The longitudinal joint structure for hat-type steel sheet piles according to Claim 6,

wherein the plurality of first engagement target portions are provided integrally with a common substrate.

8. The longitudinal joint structure for hat-type steel sheet piles according to any one of Claims 1 to 7,

wherein a cross-sectional area in a case where a part of the installation portion excluding a locking region with respect to the first engagement target portion is seen in a cross section perpendicular to the member axis direction is maximized at a butting position between the first hat-type steel sheet pile and the second hat-type steel sheet pile.

9. A longitudinal joint hat-type steel sheet pile unit comprising:

the longitudinal joint structure for hat-type steel sheet piles according to any one of Claims 1 to 8.

10. A steel wall in which a plurality of the longitudinal joint hat-type steel sheet pile units according to Claim 9 are continuously installed in the wall width direction perpendicular to the member axis direction and the through-thickness direction of the first hat-type steel sheet pile,

wherein the installation portions of the longitudinal joint hat-type steel sheet pile units adjacent to each other in the wall width direction are disposed at different positions in the member axis direction.