

DESCRIPTION

STEEL MEMBER VERTICAL JOINT STRUCTURE

Technical Field

[0001] The present disclosure relates to a vertical joint structure for steel members, in which steel members are coupled together in a member-axial direction.

Background Art

[0002] When vertically joining together plural steel sheet piles, such vertical joining is generally performed by welding the steel sheet piles together on-site. In such cases, the amount of welding increases as the cross-sectional area of the steel sheet piles increases, thereby increasing welding time. In particular, in cases in which there are many vertical joints, this tends to increase the duration of the construction project.

[0003] For example, the disclosure of Japanese Patent Application Laid-Open (JP-A) No. 2011-38288 (hereafter referred to as Patent Document 1) proposes a cheap and simple steel sheet pile joint structure capable of reducing the duration of construction projects and cutting costs, while still securing rigidity and load-withstand ability.

[0004] In the steel sheet pile joint structure disclosed in Patent Document 1, steel sheet piles with a bent cross-section profile are coupled together vertically. An upper end portion of a lower steel sheet pile is provided with a lower joint member projecting from front faces of a web and a flange of the steel sheet pile. A lower end portion of an upper steel sheet pile is provided with an upper joint member projecting from front faces of a web and a flange. The lower joint member and the upper joint member are fixed together by a fixing means in a state in which an upper edge of the lower steel sheet pile and a lower edge of the upper steel sheet pile abut each other.

SUMMARY OF INVENTION

Technical Problem

[0005] However, the joint of the steel sheet pile joint structure disclosed in Patent Document 1 has low bending rigidity, as a result of which the joint is liable to become a point of structural weakness.

[0006] In consideration of the above circumstances, an object of the present disclosure is to provide a vertical joint structure for steel members that facilitates an operation to couple together the steel members in a member-axial direction, while being capable of securing adequate initial rigidity and load-withstand ability.

Solution to Problem

[0007] A vertical joint structure for steel members addressing the above issue includes steel member-side projections configured to respectively project from one steel member and another steel member that are coupled together along a member-axial direction so as to project from an end portion side face of the one steel member and from an end portion side face of the other steel member, each of the steel member-side projections being formed with a steel member-side inclined face that is inclined with respect to a projection direction on at least one of a side of the steel member-side projection facing toward a boundary between the two steel members or another side of the steel member-side projection away from the boundary between the two steel members; a coupling member that includes a flat plate configured to be disposed straddling the boundary, coupling-side projections projecting from the flat plate toward end portion side faces of the respective steel members, and a coupling-side inclined face being formed at each of the coupling-side projections so as to oppose the steel member-side inclined faces of the steel member-side projections; and a fixing member that presses each coupling-side inclined face against an opposing steel member-side inclined face in a state in which a gap is formed between the flat plate and the steel member-side projection.

Advantageous Effects

[0008] The steel member vertical joint structure according to the present disclosure facilitates an operation to couple together steel members in a member-axial direction, while being capable of securing adequate initial rigidity and load-withstand ability.

BRIEF DESCRIPTION OF DRAWINGS

[0009] Fig. 1 is a perspective view illustrating a steel wall employing a steel member vertical joint structure applied with the present disclosure.

Fig. 2 is a perspective view illustrating a steel member vertical joint structure applied with the present disclosure.

Fig. 3 is a plan view illustrating a state in which only flanges of hat-shaped steel sheet piles have been coupled using a coupling member in a steel member vertical joint structure applied with the present disclosure.

Fig. 4 is a plan view illustrating a state in which U-shaped steel sheet piles have been coupled together using a steel member vertical joint structure applied with the present disclosure.

Fig. 5 is a plan view illustrating a state in which Z-shaped steel sheet piles have been coupled together using a steel member vertical joint structure applied with the present disclosure.

Fig. 6 is a plan view illustrating a state in which both flanges and arms of hat-shaped

steel sheet piles have been coupled together using a steel member vertical joint structure applied with the present disclosure.

Fig. 7 is a front view illustrating a coupling member of a steel member vertical joint structure applied with the present disclosure.

Fig. 8 is a back view illustrating a coupling member of a steel member vertical joint structure applied with the present disclosure.

Fig. 9 is a side view illustrating a vertical join portion between steel sheet piles in a steel member vertical joint structure according to an exemplary embodiment applied with the present disclosure.

Fig. 10 is a side view illustrating a modified example of a steel member vertical joint structure applied with the present disclosure.

Fig. 11 is an enlarged view illustrating part of Fig. 9.

Fig. 12 is a side view of part of a modified example illustrating coupling-side projections and steel member-side projections with profiles tapered at both faces such that leading end sides of the projections are enlarged in a steel member vertical joint structure applied with the present disclosure.

Fig. 13 is a side view of part of a modified example illustrating coupling-side projections and steel member-side projections with profiles tapered at both faces such that both side faces run substantially parallel to each other in a steel member vertical joint structure applied with the present disclosure.

Fig. 14 is a side view of an exemplary embodiment, illustrating a state prior to moving a coupling member with shaft members that pass through a flat plate of the coupling member in a steel member vertical joint structure applied with the present disclosure.

Fig. 15 is a side view of an exemplary embodiment, illustrating a state after moving a coupling member with shaft members that pass through a flat plate of the coupling member in a steel member vertical joint structure applied with the present disclosure.

Fig. 16 is a side view of a modified example, illustrating shaft members that pass through coupling-side projections of a coupling member and abut end portion side faces of steel sheet piles in a steel member vertical joint structure applied with the present disclosure.

Fig. 17 is a side view of a modified example, illustrating shaft members that pass through coupling-side projections of a coupling member and abut plate shaped members provided at end portion side faces of steel sheet piles in a steel member vertical joint structure applied with the present disclosure.

Fig. 18 is a side view of a modified example, illustrating shaft members that only pass through end portions of steel sheet piles in a steel member vertical joint structure applied

with the present disclosure.

Fig. 19 is a side view of a modified example, illustrating shaft members that pass through end portions of steel sheet piles and plate shaped members in a steel member vertical joint structure applied with the present disclosure.

Fig. 20 is a side view of a modified example, illustrating a state prior to moving a coupling member, with a wedge member interposed between the coupling member and an end portion side face of a steel sheet pile in a steel member vertical joint structure applied with the present disclosure.

Fig. 21 is a side view of a modified example, illustrating a state after moving a coupling member, with a wedge member interposed between the coupling member and an end portion side face of a steel sheet pile in a steel member vertical joint structure applied with the present disclosure.

Fig. 22 is an enlarged view of part of Fig. 14.

Fig. 23 is an enlarged view of part of Fig. 15.

Fig. 24 is a partial side view corresponding to Fig. 13, illustrating a state prior to moving a coupling member.

Fig. 25 is a partial side view corresponding to Fig. 13, illustrating a state after moving a coupling member.

Fig. 26 is a partial side view corresponding to Fig. 12, illustrating a state prior to moving a coupling member.

Fig. 27 is a partial side view corresponding to Fig. 12, illustrating a state in which a coupling member has been moved until an inside face of a coupling-side projection and an outside face of a steel member-side projection approach each other until they abut.

Fig. 28 is a partial side view corresponding to Fig. 12, illustrating a state prior to moving a coupling member.

Fig. 29 is a partial side view corresponding to Fig. 12, illustrating a state in which a coupling member has been moved such that an inside face of a coupling-side projection and an outside face of a steel member-side projection approach each other without abutting.

Fig. 30 is a side view illustrating compression force acting as a result of bending load in a steel member vertical joint structure applied with the present disclosure.

Fig. 31 is a side view illustrating tensile force acting as a result of bending load in a steel member vertical joint structure applied with the present disclosure.

Fig. 32 is a plan view illustrating an example in which H-beam steel is employed as a steel member in a steel member vertical joint structure applied with the present disclosure.

Fig. 33 is a plan view illustrating an example in which a rectangular steel tube is

employed as a steel member in a steel member vertical joint structure applied with the present disclosure.

Fig. 34 is a plan view illustrating an example in which a circular steel tube is employed as a steel member in a steel member vertical joint structure applied with the present disclosure.

Fig. 35 is a plan view illustrating a modified example in which an end portion of a steel sheet pile is coupled so as to be surrounded from both plate thickness direction faces in a steel member vertical joint structure applied with the present disclosure.

Fig. 36 is a perspective view illustrating a state prior to vertically joining together vertical join portions of steel sheet piles in a steel member vertical joint structure according to another exemplary embodiment applied with the present disclosure.

Fig. 37 is a perspective view illustrating a state in which vertical join portions of steel sheet piles have been vertically joined together in a steel member vertical joint structure according to another exemplary embodiment applied with the present disclosure.

Fig. 38 is a perspective view illustrating a modified example of another exemplary embodiment of a steel member vertical joint structure applied with the present disclosure.

Fig. 39 is a partial side view illustrating coupling-side projections and steel member-side projections with profiles tapered at both faces in another exemplary embodiment of a steel member vertical joint structure applied with the present disclosure.

Fig. 40 is a partial side view illustrating a modified example of a steel member vertical joint structure according to another exemplary embodiment applied with the present disclosure.

Fig. 41 is a side view illustrating a state in which a shaft member has been inserted into a hole provided in a coupling-side projection in a modified example of another exemplary embodiment of a steel member vertical joint structure applied with the present disclosure.

Fig. 42 is a side view illustrating a state in which a shaft member inserted into a hole provided in a coupling member passes through a hole provided in an end portion of a steel sheet pile and is screwed together with a nut in a modified example.

Fig. 43 is a perspective view illustrating a state prior to fixing a coupling member using temporary fasteners in a modified example of another exemplary embodiment of a steel member vertical joint structure applied with the present disclosure.

Fig. 44 is a perspective view illustrating a state in which a coupling member has been fixed using temporary fasteners in a modified example of another exemplary embodiment of a steel member vertical joint structure applied with the present disclosure.

Fig. 45 is a partial side view corresponding to Fig. 39, illustrating a state prior to

moving a coupling member.

Fig. 46 is a partial side view corresponding to Fig. 39, illustrating a state after moving a coupling member.

Fig. 47 is a side view illustrating a state in which a projection height of coupling-side projections and a projection height of steel member-side projections are formed so as to be substantially equal in another exemplary embodiment of a steel member vertical joint structure applied with the present disclosure.

Fig. 48 is a partial side view illustrating a state after moving the coupling member in Fig. 47.

Fig. 49 is a partial side view illustrating a case in which an edge of a leading end face of a coupling-side projection has abutted a side face of a steel member-side projection in a modified example of another exemplary embodiment of a steel member vertical joint structure applied with the present disclosure.

Fig. 50 is a partial side view illustrating a case in which an edge of a leading end face of a steel member-side projection has abutted a side face of a coupling-side projection in a modified example of another exemplary embodiment of a steel member vertical joint structure applied with the present disclosure.

Fig. 51 is a side view illustrating vertical joint portions of steel sheet piles vertically joined using a vertical joint structure in which steel member-side projections are formed on a side closer to a boundary between steel members in a modified example of another exemplary embodiment of a steel member vertical joint structure applied with the present disclosure, illustrating a state prior to moving a coupling member with shaft members that pass through a flat plate of the coupling member.

Fig. 52 is a side view illustrating a state after moving the coupling member with the shaft members that pass through the flat plate of the coupling member in Fig. 51.

DESCRIPTION OF EMBODIMENTS

[0010] Detailed explanation follows regarding an exemplary embodiment in which the present disclosure is applied to a steel member vertical joint structure 1, with reference to the drawings.

[0011] As illustrated in Fig. 1, the steel member vertical joint structure 1 is, for example, employed in confined locations where long steel sheet piles 2 cannot be installed, and is used to couple together plural short steel sheet piles 2, serving as plural steel members to be embedded above and below the ground 8, in a member-axial direction Y.

[0012] The steel member vertical joint structures 1 are used to form long coupled steel

members 70 in which plural steel members, for example the steel sheet piles 2, are coupled together in the member-axial direction Y. The steel member vertical joint structures 1 are also employed in construction of a steel wall 7 in which plural coupled steel members 70 are linked together in a wall-lateral direction Z, each of the coupled steel members 70 being configured by plural steel members coupled together along the member-axial direction Y.

[0013] As illustrated in Fig. 2, the steel member vertical joint structure 1 is principally employed with steel sheet piles 2, for example configured by hat-shaped steel sheet piles 21, as the respective steel members. In the steel member vertical joint structure 1, member-axial direction Y end portions 30 of plural steel sheet piles 2 are made to oppose each other in the member-axial direction Y, such that a vertical joint location 3 is formed where the member-axial direction Y end portions 30 of the respective steel sheet piles 2 are coupled together. The vertical joint location 3 configures a boundary between one and another vertically joined steel sheet piles 2.

[0014] The steel member vertical joint structure 1 includes a coupling member 5 that spans across the vertical joint location 3 between plural steel sheet piles 2 in the member-axial direction Y, fixing members 4 employing shaft members 41 or the like attached to the coupling member 5, and steel member-side projections 60 provided at the end portion 30 of each steel sheet pile 2.

[0015] As illustrated in Fig. 3, in cases in which the hat-shaped steel sheet piles 21 are employed, each steel sheet pile 2 includes a flange 2a, a pair of webs 2b, a pair of arms 2c, and a pair of join portions 2d. Steel sheet piles 2 arranged along the wall-lateral direction Z are fitted and coupled to one another at the join portions 2d.

[0016] In each steel sheet pile 2, the flange 2a is formed extending along the wall-lateral direction Z, and a groove S is formed by angling the respective webs 2b with respect to the wall-lateral direction Z from either end of the flange 2a. In each steel sheet pile 2, the respective arms 2c are formed from one end of each web 2b, and the respective join portions 2d are formed at a leading end of each arm 2c.

[0017] In each steel sheet pile 2, side faces of the flange 2a, the webs 2b, and the arms 2c are each formed with substantially flat profiles, thereby forming substantially flat-profiled end portion side faces 31 at the mutually-coupled member-axial direction Y end portions 30.

[0018] The steel sheet piles 2 are not limited to the hat-shaped steel sheet piles 21, and, for example, U-shaped steel sheet piles 22 or Z-shaped steel sheet piles 23 may be employed, as illustrated in the modified examples in Fig. 4 and Fig. 5.

[0019] As illustrated in Fig. 4, in cases in which the U-shaped steel sheet piles 22 are employed, each steel sheet pile 2 includes a flange 2a, a pair of webs 2b, and a pair of join

portions 2d, and side faces of the flange 2a and the webs 2b form the substantially flat-profiled end portion side faces 31 at the member-axial direction Y end portions 30.

[0020] As illustrated in Fig. 5, in cases in which the Z-shaped steel sheet piles 23 are employed, each steel sheet pile 2 includes a web 2b, a pair of arms 2c, and a pair of join portions 2d, and side faces of the web 2b and the pair of arms 2c form the substantially flat-profiled end portion side faces 31 at the member-axial direction Y end portions 30.

[0021] In the steel sheet piles 2, there is no limitation to providing the coupling member 5 to the end portion side face 31 at the flange 2a as illustrated in Fig. 3, and a coupling member 5 may also be provided at the substantially flat-profiled end portion side faces 31 of the webs 2b or the arms 2c. In particular, as illustrated in Fig. 6, in cases in which the hat-shaped steel sheet piles 21 are employed as the steel sheet piles 2, coupling members 5 are preferably provided at the end portion side faces 31 of both the flange 2a and the pair of arms 2c.

[0022] As illustrated in Fig. 7 and Fig. 8, each coupling member 5 includes a flat plate 51 employing a steel plate or the like, and coupling-side projections 50 projecting from the flat plate 51 in a member-axis-orthogonal direction X. Each coupling member 5 is formed with plural of the coupling-side projections 50, and each coupling-side projection 50 extends continuously along the wall-lateral direction Z. The flat plate 51 and each of the coupling-side projections 50 are formed integrally to one another, for example by hot extrusion or by hot or cold rolling.

[0023] The coupling members 5 are not limited thereto, and the flat plate 51 and the coupling-side projections 50 may be integrally formed by machining, for example by cutting a thick steel sheet. Moreover, in the coupling members 5, the flat plate 51 and the coupling-side projections 50 may be integrated together by employing flat steel or the like for the coupling-side projections 50, and welding the flat steel to a side face of a steel plate employed as the flat plate 51.

[0024] The flat plate 51 is, for example, formed in a substantially rectangular shape, and has a width dimension B in the region of from 50 mm to 400 mm, and a height dimension H in the region of from 200 mm to 400 mm. As illustrated in Fig. 9, the flat plate 51 has a plate thickness t in the region of from 9 mm to 25 mm, and is formed continuously in the member-axial direction Y so as to straddle the vertical joint location 3 between mutually coupled steel sheet piles 2, from the end portion 30 of one steel sheet pile 2 to the end portion 30 of another steel sheet pile 2.

[0025] The flat plate 51 includes an upper plate portion 51a configuring a portion disposed at the side of the end portion 30 of the one steel sheet pile 2, and a lower plate portion 51b configuring a portion disposed at the side of the end portion 30 of the other steel sheet pile 2.

The upper plate portion 51a and the lower plate portion 51b of the flat plate 51 are each formed with one or plural of the coupling-side projections 50, and one or plural threaded holes 40 are formed penetrating each of the upper plate portion 51a and the lower plate portion 51b in the member-axis-orthogonal direction X.

[0026] The coupling-side projections 50 project from the flat plate 51 toward the end portion side faces 31 of the steel sheet piles 2 in the member-axis-orthogonal direction X. The coupling member 5 is formed with plural of the coupling-side projections 50 spaced apart from each other in the member-axial direction Y. Moreover, coupling-side grooves 52 are formed in the spaces between the plural coupling-side projections 50 adjacent to each other in the member-axial direction Y. In the present exemplary embodiment, the upper plate portion 51a and the lower plate portion 51b are each formed with plural of the coupling-side projections 50.

[0027] As illustrated in Fig. 11, the coupling-side projections 50 are each formed with a member-axis-orthogonal direction X leading end face 50c at the portion of the coupling-side projection 50 projecting furthest in the member-axis-orthogonal direction X, this being the projection direction, and an inside face 50a and outside face 50b that respectively run continuously from the leading end face 50c to bottom faces of the respective coupling-side grooves 52.

[0028] In each of the coupling-side projections 50, the member-axial direction Y inside face 50a of the coupling-side projection 50 is disposed so as to be closer to the vertical joint location 3 in the member-axial direction Y. The member-axial direction Y outside face 50b of the coupling-side projection 50 is disposed on the direction away from the vertical joint location 3 in the member-axial direction Y. The coupling-side projections 50 are formed with vertical symmetry to each other about the vertical joint location 3.

[0029] As illustrated in Fig. 9, each steel member-side projection 60 projects from the end portion side face 31 of the respective steel sheet pile 2 toward the coupling member 5. One or plural steel member-side projections 60 are formed at each end portion side face 31 of each steel sheet pile 2. The vertical joint location 3 of each steel sheet pile 2 is formed with plural of the steel member-side projections 60 spaced apart from each other in the member-axial direction Y, and steel member-side grooves 62 are formed in the spaces between the plural steel member-side projections 60 that are adjacent to each other in the member-axial direction Y.

[0030] As illustrated in Fig. 9, the respective steel member-side projections 60 are provided at a plate shaped member 6 such as a steel plate. The plate shaped member 6 is attached to the end portion 30 of each steel sheet pile 2 by welding or the like. The steel member-side

projections 60 project from the plate shaped member 6 in the member-axis-orthogonal direction X.

[0031] The plate shaped member 6 is integrally formed with plural of the steel member-side projections 60 extending continuously along the wall-lateral direction Z, for example by hot extrusion or by hot or cold rolling. The steel member-side projections 60 may also be integrally formed at the plate shaped member 6 by cutting, for example by machining a thick steel sheet. Moreover, the steel member-side projections 60 may be integrated to the plate shaped member 6 by employing flat steel or the like for the steel member-side projections 60, and welding the flat steel to a side face of a steel plate configuring the plate shaped member 6.

[0032] The steel member-side projections 60 are not limited to a configuration in which the plate shaped members 6 are attached to the end portions 30 of the respective steel sheet piles 2. As illustrated by the modified example in Fig. 10, the steel member-side projections 60 may be formed by attaching flat steel or the like configuring the steel member-side projections 60 to the end portions 30 of the respective steel sheet piles 2 by welding directly, for example. By configuring the steel member-side projections 60 by providing flat steel or the like configuring the steel member-side projections 60 directly to the end portions 30 of the steel sheet piles 2, the steel member-side projections 60 project from the end portion side faces 31 of the respective steel sheet piles 2 toward the coupling member 5 in the member-axis-orthogonal direction X.

[0033] As illustrated in Fig. 11, the steel member-side projections 60 are each formed with a member-axis-orthogonal direction X leading end face 60c at the portion of the steel member-side projection 60 projecting furthest in the member-axis-orthogonal direction X, and an inside face 60a and outside face 60b that respectively run continuously from the leading end face 60c to the respective steel member-side grooves 62. In each of the steel member-side projections 60, the member-axial direction Y inside face 60a of the steel member-side projection 60 is disposed so as to be closer to the vertical joint location 3 in the member-axial direction Y. The member-axial direction Y outside face 60b of the steel member-side projection 60 is disposed on the direction away from the vertical joint location 3 in the member-axial direction Y.

[0034] As illustrated in Fig. 2, each coupling member 5 is provided spanning across the vertical joint location 3 between plural of the steel sheet piles 2 by sliding the coupling member 5 in the wall-lateral direction Z along the end portion side faces 31 of the steel sheet piles 2 to which the steel member-side projections 60 are provided. When this is performed, as illustrated in Fig. 9 and Fig. 10, the coupling-side projections 50 of the coupling member 5 fit together with the steel member-side grooves 62 in the spaces between the plural steel

member-side projections 60. The steel member-side projections 60 fit together with the coupling-side grooves 52 in the spaces between the plural coupling-side projections 50.

[0035] As illustrated in Fig. 11, the outside face 60b on the side of each steel member-side projection 60 that faces away from the vertical joint location 3 configuring the boundary between joined steel sheet piles 2 is a steel member-side inclined face, being inclined with respect to the member-axis-orthogonal direction X, this being the projection direction.

Moreover, the inside face 60a on the side of each steel member-side projection 60 closer to the vertical joint location 3 extends along the member-axis-orthogonal direction X.

Regarding the steel member-side projections 60, the inside face 60a and the leading end face 60c of each steel member-side projection 60 are substantially orthogonal to each other, such that each steel member-side projection 60 has a profile that is tapered at one face.

[0036] The inside faces 50a on the side of each coupling-side projection 50 closer to the vertical joint location 3 that configures the boundary between joined steel sheet piles 2 is a coupling-side inclined face inclined with respect to the member-axis-orthogonal direction X, this being the projection direction, and opposes the outside face 60b of the corresponding steel member-side projection 60. The outside face 50b on the side of each coupling-side projection 50 on the side facing away from the vertical joint location 3 extends along the member-axis-orthogonal direction X. The outside face 50b and the leading end face 50c of each coupling-side projection 50 are substantially orthogonal to each other, such that each coupling-side projection 50 has a profile that is tapered at one face.

[0037] As illustrated in the modified examples in Fig. 12 and Fig. 13, both member-axial direction Y-side faces 50a, 50b of the coupling-side projections 50, and both member-axial direction Y-side faces 60a, 60b and the steel member-side projections 60 may be inclined, thereby configuring profiles that are tapered on both faces.

[0038] In the coupling-side projections 50 and the steel member-side projections 60 illustrated in the example of Fig. 12, the inside faces 50a and the outside faces 50b of the coupling-side projections 50 are inclined in different directions to each other, and the outside faces 60b and the inside faces 60a of the steel member-side projections 60 are inclined in different directions to each other.

[0039] As illustrated in Fig. 11 and Fig. 12, in the coupling-side projections 50 and the steel member-side projections 60, the leading end face 50c of each coupling-side projections 50 is longer in the member-axial direction Y than the flat plate 51 side of the coupling-side projection 50. Moreover, the leading end face 60c of each steel member-side projection 60 is longer in the member-axial direction Y than the end portion side face 31 side of the steel member-side projection 60. In the examples of Fig. 11 and Fig. 12, the coupling-side

projections 50 and the steel member-side projections 60 are each formed with a profile tapered at one face or a profile tapered at both faces so as to be enlarged on the member-axis-orthogonal direction X leading end side.

[0040] In the coupling-side projections 50 and the steel member-side projections 60 illustrated in the example of Fig. 13, the outside faces 50b and the inside faces 50a of the coupling-side projections 50 are substantially parallel to each other, and the inside faces 60a and the outside faces 60b of the steel member-side projections 60 are also substantially parallel to each other. Although the coupling-side projections 50 and the steel member-side projections 60 are not enlarged on the member-axis-orthogonal direction X leading end side, the coupling-side projections 50 are each formed with a profile that leans toward the vertical joint location 3 side on progression toward the leading end side. This profile is also regarded as a profile that is tapered at both faces.

[0041] For example, the coupling-side projections 50 and the steel member-side projections 60 illustrated in Fig. 11 to Fig. 13 each have a member-axis-orthogonal direction X leading end side projection width w_1 in the region of from 20 mm to 60 mm, and a member-axis-orthogonal direction X projection height h in the region of from 10 mm to 30 mm. The coupling-side projections 50 and the steel member-side projections 60 are formed such that the member-axial direction Y projection width w_1 on the leading end side of each coupling-side projection 50 and the member-axial direction Y projection width w_1 on the leading end side of each steel member-side projection 60 are substantially the same as each other, and such that the member-axis-orthogonal direction X projection heights h are also substantially the same as each other.

[0042] In the coupling-side projections 50 and the steel member-side projections 60, corner portions C between the leading end faces 50c and either the inside faces 50a or the outside faces 50b of the coupling-side projections 50 are applied with, for example, substantially curved or substantially straight bevels during hot extrusion. Note that each corner portion C may be beveled by machining. Likewise, in the coupling-side projections 50 and the steel member-side projections 60, corner portions C between the leading end faces 60c and the inside faces 60a or the outside faces 60b of the steel member-side projections 60 are also applied with substantially curved or substantially straight bevels by hot extrusion, for example.

[0043] A member-axial direction Y opening width c_1 at the leading end sides of the coupling-side grooves 52 of the coupling-side projections 50 and at the leading end sides of the steel member-side grooves 62 of the steel member-side projections 60 is set in the region of from 10 mm to 50 mm. The coupling-side projections 50 and the steel member-side

projections 60 are formed such that the total member-axial direction Y length $l_p (= w_1 + c_1)$ obtained by combining the coupling-side projections 50 and the coupling-side grooves 52 is substantially the same as the total member-axial direction Y length $l_p (= w_1 + c_1)$ obtained by combining the steel member-side projections 60 and the steel member-side grooves 62.

[0044] The coupling-side projections 50 and the steel member-side projections 60 are formed so as to have substantially the same profile and dimensions as each other. As illustrated in Fig. 11 and Fig. 12, in cases in which the coupling-side projections 50 and the steel member-side projections 60 are formed with a profile tapered at one face or a profile tapered at both faces so as to be larger at the member-axis-orthogonal direction X leading end side, a connection width w_2 on a member-axis-orthogonal direction X base end side is smaller than the projection width w_1 on the member-axis-orthogonal direction X leading end side. A member-axial direction Y spacing width c_2 at the bottom of the coupling-side grooves 52 or the steel member-side grooves 62 is greater than an opening width c_1 of the coupling-side grooves 52 or the steel member-side grooves 62. As described above, the coupling member 5 is provided spanning across the vertical joint location 3 of the steel sheet piles 2 by sliding the coupling member 5 in the wall-lateral direction Z along the end portion side faces 31 of the steel sheet piles 2.

[0045] In cases in which the coupling-side projections 50 and the steel member-side projections 60 are enlarged at their member-axis-orthogonal direction X leading end sides, the relationship between the projection width w_1 and the total member-axial direction Y extension length l_p obtained by combining the coupling-side projections 50 and the coupling-side grooves 52 is as defined by Equation (1) below. Moreover, in the coupling-side projections 50 and the steel member-side projections 60, the relationship between the projection width w_1 and the total member-axial direction Y extension length l_p obtained by combining the steel member-side projections 60 and the steel member-side grooves 62 is also as defined by Equation (1) below.

[0046]

$$w_1 > l_p / 2 \quad (1)$$

[0047] The respective projection widths w_1 at the member-axis-orthogonal direction X leading end sides of the coupling-side projections 50 and steel member-side projections 60 are set smaller than the respective spacing widths c_2 of the coupling-side grooves 52 and the steel member-side grooves 62, and the respective connection widths w_2 at the member-axis-orthogonal direction X base end sides are set smaller than the respective opening widths c_1 of the coupling-side grooves 52 and the steel member-side grooves 62. Accordingly, by moving the coupling-side projections 50 and the steel member-side

projections 60 apart from each other in the member-axis-orthogonal direction X, the inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the steel member-side projections 60 adopt a coupled state abutting and pressing against each other.

[0048] As illustrated in Fig. 14, predetermined gaps G are formed between the coupling-side projections 50 and the steel member-side projections 60 by spacing the coupling-side projections 50 and the steel member-side projections 60 apart from each other prior to being moved by the shaft members 41. Thus, in a state in which the coupling-side projections 50 are fitted together with the steel member-side grooves 62, and the steel member-side projections 60 are fitted together with the coupling-side grooves 52, at least the inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the steel member-side projections 60 are spaced apart from each other in the member-axial direction Y.

[0049] As illustrated in Fig. 15, the fixing members 4 move the coupling member 5 in the member-axis-orthogonal direction X, and the inside faces 50a of the coupling member 5 are pressed against the opposing inside faces 60a of the steel member-side projections 60 in a state in which a member-axis-orthogonal direction X gap SP is formed between the flat plate 51 of the coupling member 5 and the steel member-side projections 60.

[0050] The fixing members 4 principally employ the shaft members 41 that pass through the coupling member 5 and abut the steel member-side projections 60 or the end portion side faces 31 of the steel sheet piles 2. The shaft members 41 may employ bolts that are passed through the coupling member 5 and screwed into the threaded holes 40, or as other examples, screws, tacks, or the like may be employed such that leading end portions 41a of the bolts or the like abut the steel member-side projections 60 or the like.

[0051] In cases in which the threaded holes 40 are formed opening into the coupling-side grooves 52 of the coupling member 5, the leading end portions 41a of the bolts or the like configuring the shaft members 41 abut the steel member-side projections 60. As another example of the shaft members 41, as illustrated in Fig. 16, in cases in which the threaded holes 40 are formed through the coupling-side projections 50 of the coupling member 5, and the steel member-side projections 60 are provided directly to the end portions 30 of the steel sheet piles 2, the leading end portions 41a of the bolts or the like may abut the end portion side faces 31 of the steel sheet piles 2.

[0052] Moreover, as illustrated in Fig. 17, as another example of the shaft members 41, in cases in which the threaded holes 40 are formed through the coupling-side projections 50 of the coupling member 5, and the plate shaped member 6 integrally formed with the steel member-side projections 60 is attached to the end portions 30 of the steel sheet piles 2, the leading end portions 41a of the bolts or the like may abut the plate shaped member 6.

[0053] As illustrated in Fig. 18, the fixing members 4 may employ shaft members 41 that pass through the end portions 30 of the steel sheet piles 2 and abut the coupling member 5. The shaft members 41 may employ bolts that are passed through the end portions 30 of the steel sheet piles 2 by being screwed into threaded holes 40, or as other examples, screws, tacks, or the like may be employed such that the leading end portions 41a of the bolts or the like abut the coupling member 5.

[0054] As illustrated in Fig. 18, regarding the shaft members 41, in cases in which the steel member-side projections 60 are provided directly to the end portions 30 of the steel sheet piles 2, the threaded holes 40 are formed in the end portions 30 of the steel sheet piles 2 at portions corresponding to the steel member-side grooves 62. The leading end portions 41a of the bolts or the like screwed into the threaded holes 40 abut the coupling-side projections 50 of the coupling member 5.

[0055] As illustrated in Fig. 19, in cases in which the threaded holes 40 are also formed in the plate shaped member 6 attached to the end portions 30 of the steel sheet piles 2, the shaft members 41 may employ bolts or the like that pass through the end portions 30 of the steel sheet piles 2 and through the plate shaped member 6 in order to abut the coupling member 5.

[0056] As illustrated in Fig. 14, immediately after the coupling-side projections 50 and the steel member-side projections 60 have been fitted together, the leading end portions 41a of the bolts or the like configuring the shaft members 41 adopt a state abutting the steel member-side projections 60 or the like. Namely, the bolts or the like configuring the shaft members 41 screwed into the threaded holes 40 in the coupling member 5 are screwed in as illustrated in Fig. 15.

[0057] When this is performed, a reaction force acts on the shaft members 41 as the bolts or the like, of which the leading end portions 41a abut the steel member-side projections 60 or the like, are twisted in, such that as illustrated in Fig. 15 to Fig. 19, the coupling member 5 is moved in the member-axis-orthogonal direction X, toward a direction away from the end portion side faces 31 of the steel sheet piles 2.

[0058] As illustrated in the modified examples of Fig. 20 and Fig. 21, the fixing members 4 may employ a wedge member 42 that moves the coupling member 5 in the member-axis-orthogonal direction X by being interposed between the coupling member 5 and the end portion side face 31 of a steel sheet pile 2. In the present exemplary embodiment, explanation is given regarding an example in which the wedge member 42 is provided on one side in the member-axis-orthogonal direction X; however, the wedge members 42 may be provided on both sides of the coupling member 5 in the member-axis-orthogonal direction X.

[0059] The wedge member 42 is formed in a substantially wedge shape tapered so as to

increase in plate thickness from a leading portion 42a that is knocked in between the coupling member 5 and the end portion side face 31 of the steel sheet pile 2 first.

[0060] As illustrated in Fig. 20, the wedge member 42 is knocked in between the coupling member 5 and the end portion side face 31 of the steel sheet pile 2 from the leading portion 42a immediately after the coupling-side projections 50 and the steel member-side projections 60 have been fitted together. Then, as illustrated in Fig. 21, the wedge member 42 is knocked in further between the coupling member 5 and the end portion side face 31 of the steel sheet pile 2 so as to move the coupling member 5 in the member-axis-orthogonal direction X toward the direction away from the end portion side face 31 of the steel sheet pile 2.

[0061] Note that the shaft members 41 are employed in isolation as the fixing members 4 in Fig. 14 to Fig. 19, and the wedge member 42 is employed in isolation as the fixing member 4 in Fig. 20 and Fig. 21. However, the shaft members 41 and the wedge member 42 may be employed in combination in order to move the coupling member 5 in the member-axis-orthogonal direction X.

[0062] As illustrated in Fig. 22, in a state prior to the fixing members 4 moving the coupling member 5 toward the direction away from the end portion side faces 31 of the steel sheet piles 2, the inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the steel member-side projections 60 are spaced apart from each other in the member-axial direction Y. Moreover, as illustrated in Fig. 23, the inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the steel member-side projections 60 approach each other in the member-axial direction Y in a state in which the fixing members 4 have moved the coupling member 5 toward the direction away from the end portion side faces 31 of the steel sheet piles 2.

[0063] As illustrated in Fig. 22 and Fig. 23, in cases in which the coupling-side projections 50 and the steel member-side projections 60 are each formed with a profile tapered at one face, the fixing members 4 cause the inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the steel member-side projections 60 to adopt a state in which they approach each other until they abut.

[0064] As illustrated in Fig. 24 and Fig. 25, in cases in which the coupling-side projections 50 and the steel member-side projections 60 are each formed with a substantially parallel profile tapered at both faces, the fixing members 4 cause the inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the steel member-side projections 60 to adopt a state in which they approach each other until they abut.

[0065] As illustrated in Fig. 26 to Fig. 29, in cases in which the coupling-side projections 50

and the steel member-side projections 60 are each formed with a spreading profile tapered at both faces, the fixing members 4 cause the inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the steel member-side projections 60 to adopt a state in which they approach each other.

[0066] In such cases, the gaps G between the inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the steel member-side projections 60 in the state prior to moving the coupling member 5, as illustrated in Fig. 26, for example, are smaller than the gaps G when the outside faces 50b of the coupling-side projections 50 and the inside faces 60a of the steel member-side projections 60 are spaced apart from each other.

[0067] Then, in the state after moving the coupling member 5, as illustrated in Fig. 27, the fixing members 4 cause the inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the steel member-side projections 60 to adopt a state in which they approach each other until they abut.

[0068] As illustrated in Fig. 28, in the state prior to moving the coupling member 5, the gaps G where the inside faces 50a of the coupling-side projections 50 are spaced apart from the outside faces 60b of the steel member-side projections 60 may be larger than the gaps G where the outside faces 50b of the coupling-side projections 50 are spaced apart from the inside faces 60a of the steel member-side projections 60.

[0069] In the state after moving the coupling member 5, as illustrated in Fig. 29, the fixing members 4 cause the inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the steel member-side projections 60 to adopt a state in which they approach each other without abutting.

[0070] Note that in the state prior to moving the coupling member 5, the gaps G where the inside faces 50a of the coupling-side projections 50 are spaced apart from the outside faces 60b of the steel member-side projections 60 and the gaps G where the outside faces 50b of the coupling-side projections 50 are spaced apart from the inside faces 60a of the steel member-side projections 60 may be approximately the same size as each other. In the state after moving the coupling member 5, the fixing members 4 cause both side faces of both the coupling-side projections 50 and the steel member-side projections 60 to adopt a state in which they approach each other until they abut.

[0071] The coupling-side projections 50 of the coupling member 5 are disposed in the steel member-side grooves 62 between the plural steel member-side projections 60 that form a row along the member-axial direction Y, and the steel member-side projections 60 are disposed in the coupling-side grooves 52 between the coupling-side projections 50.

[0072] As illustrated in Fig. 11, for example, the steel member-side projections 60 disposed

on a direction away from the vertical joint location 3 function as stoppers that restrict the respective coupling-side projections 50 disposed in the steel member-side grooves 62 between the steel member-side projections 60 from detaching along the direction away from the vertical joint location 3.

[0073] The steel member-side projections 60 disposed on the direction away from the vertical joint location 3 refer to steel member-side projections 60 disposed on the direction away from the vertical joint location 3 as viewed from the respective steel member-side projection 60 pressed by the inside faces 50a of the coupling-side projections 50.

[0074] The stoppers do not only act as stoppers when the inside faces 60a of the steel member-side projections 60 are in contact with the outside faces 50b of the coupling-side projections 50. For example, even when the inside faces 60a of the steel member-side projections 60 are spaced apart from the outside faces 50b of the coupling-side projections 50, a configuration capable of contacting the coupling-side projections 50 to restrict detachment if the coupling-side projections 50 collapse also configures a stopper.

[0075] Operation

In the steel member vertical joint structure 1, forming the gaps G where the coupling-side projections 50 are spaced apart from the steel member-side projections 60 enables the coupling-side projections 50 and the steel member-side projections 60 to be fitted together smoothly. The steel member vertical joint structure 1 thereby achieves a smooth fitting operation of the coupling-side projections 50 and the steel member-side projections 60, thereby facilitating an operation to couple together the plural steel sheet piles 2 in the member-axial direction Y, and enabling the task to be performed speedily.

[0076] In the steel member vertical joint structure 1, when embedding the plural steel sheet piles 2 in the ground 8 as illustrated in Fig. 1, or in a state in which the plural steel sheet piles 2 have been embedded in the ground 8, a bending load acts on the vertical joint location 3 where the plural steel sheet piles 2 are coupled together.

[0077] Moreover, the steel member vertical joint structure 1 is provided in order to secure adequate bending rigidity similar to that of the steel sheet piles 2 themselves at the vertical joint location 3, right from an initial state in which a load is received when the coupling member 5 is slid along so as to fit the coupling-side projections 50 and the steel member-side projections 60 together, as illustrated in Fig. 2.

[0078] As illustrated in Fig. 30, in the steel member vertical joint structure 1 applied with the present disclosure, a compression force P caused by bending load acts in the directions in which the plural steel sheet piles 2 approach each other in the member-axial direction Y. When this occurs, from the state immediately after the coupling-side projections 50 and the

steel member-side projections 60 are fitted together, end faces 30a of the end portions 30 of the respective steel sheet piles 2 abut each other at the vertical joint location 3, enabling the compression force P to be transmitted between the plural steel sheet piles 2. Note that even if a slight gap is present between the end faces 30a of the respective steel sheet piles 2, when bending load is input, the compression force P can be transmitted between the respective steel sheet piles 2 from the moment the end faces 30a of the steel sheet piles 2 abut each other.

[0079] Moreover, as illustrated in Fig. 31, tensile force T caused by bending load acts in directions to separate the plural steel sheet piles 2 in the member-axial direction Y. In the steel member vertical joint structure 1 applied with the present disclosure, the coupling member 5 is moved by the fixing members 4 such that, as illustrated in Fig. 22 to Fig. 27, the inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the steel member-side projections 60 adopt a state in which they approach each other until they abut.

[0080] Note that the outside faces 60b of the steel member-side projections 60 are inclined with respect to the member-axis-orthogonal direction X, and the inside faces 50a of the coupling-side projections 50 pressing against the outside faces 60b are also inclined with respect to the member-axis-orthogonal direction X.

[0081] In the steel member vertical joint structure 1 applied with the present disclosure, the inside faces 50a of the coupling-side projections 50 abut the outside faces 60b of the steel member-side projections 60, eliminating rattling at the gaps G. Accordingly, as soon as the tensile force T acts, the tensile force T (see Fig. 31) can be transmitted between the plural steel sheet piles 2 through the flat plate 51 of the coupling member 5.

[0082] In this manner, the compression force P and the tensile force T are capable of being transmitted as soon as, or at a comparatively early stage after, the coupling-side projections 50 and the steel member-side projections 60 have been fitted together. This thereby enables the plural steel sheet piles 2 to be firmly coupled together in the member-axial direction Y using the coupling member 5 that includes the flat plate 51, while also achieving a smooth operation when fitting the coupling-side projections 50 and the steel member-side projections 60 together. Namely, a larger load-withstand ability can be achieved when the tensile force acts in the flat plate 51 than in cases in which load-withstand ability is achieved by the shear force of bolts used to join steel sheet piles 2 together vertically, thereby enabling adequate bending rigidity to be secured at the initial stage.

[0083] The steel member vertical joint structure 1 applied with the present disclosure secures adequate bending rigidity at the vertical joint location 3 between the plural steel sheet piles 2 at the initial stage, such that the vertical joint location 3 between the plural steel sheet piles 2 is unlikely to become a structural weak point. Moreover, a reduction in the overall

bending rigidity of the vertically joined steel sheet piles 2 can be avoided, while also avoiding an increase in the duration of the construction project, in comparison to cases in which steel sheet piles 2 are welded together on-site at the vertical joint location 3, or cases in which steel sheet piles 2 are joined together vertically using shear force, and frictional mating force during tightening, of a large number of high-strength bolts.

[0084] In this state, the steel member-side projections 60 disposed on the direction away from the vertical joint location 3 function as stoppers for the coupling-side projections 50 disposed in the steel member-side grooves 62 between the steel member-side projections 60, thereby restricting detachment toward the direction away from the vertical joint location 3.

[0085] Accordingly, even were the tensile force T from the steel member-side projections 60 to act as a force attempting to deform the coupling-side projections 50, the coupling-side projections 50 can be suppressed from collapsing by the steel member-side projections 60 disposed on the direction away from the vertical joint location 3.

[0086] Accordingly, the coupling-side grooves 52 formed between one steel member-side projection 60 and the other steel member-side projection 60 on either side of the vertical joint location 3 can be suppressed from spreading open. Accordingly, load-resistance is improved, and unexpected decoupling of the coupling member 5 can be suppressed in comparison to in cases in which plural of the steel member-side projections 60 are provided alone.

[0087] Moreover, in the steel member vertical joint structure 1 applied with the present disclosure, as illustrated in Fig. 14 to Fig. 19, the shaft members 41 such as bolts are employed as the fixing members 4, and the leading end portions 41a of the bolts or the like screwed into the threaded holes 40 abut the steel member-side projections 60 or the like. When this occurs, since the leading end portions 41a of the shaft members 41 abut the steel member-side projections 60 or the like, lateral slipping of the coupling-side projections 50 and the steel member-side projections 60 is suppressed, enabling unexpected detachment of the coupling member 5 to be prevented.

[0088] As illustrated in the modified examples of Fig. 20 and Fig. 21, employing the wedge member 42 that is knocked in between the coupling member 5 and the end portion side face 31 of the steel sheet pile 2 as the fixing member 4 enables the coupling member 5 to be moved in the member-axis-orthogonal direction X. In such cases, there is no need to perform a drilling operation on the coupling member 5 or a screwing operation using bolts or the like, enabling a structure for moving the coupling member 5 to be realized simply.

[0089] The corner portions C of the coupling-side projections 50 and the steel member-side projections 60 are preferably applied with bevels by hot extrusion as required, as illustrated in Fig. 11 to Fig. 13. The hot extrusion of the corner portions C of the coupling-side

projections 50 and the steel member-side projections 60 can thus be performed easily, enabling ease of processing of the coupling-side projections 50 and the steel member-side projections 60 to be improved.

[0090] In cases in which the coupling-side projections 50 and the steel member-side projections 60 are each formed with substantially the same profiles and dimensions as each other, and each have a profile tapered at one face or a profile tapered at both faces so as to be wider at the leading end side, the total member-axial direction Y extension length l_p , obtained by combining the coupling-side projections 50 and the coupling-side grooves 52, and the projection width w_1 satisfy Equation (1) given previously. In such cases, the coupling-side projections 50 and the steel member-side projections 60 can be suppressed from decoupling from their fitted-together state in the member-axis-orthogonal direction X.

[0091] Note that in the steel member vertical joint structure 1 applied with the present disclosure, plural steel members having a particular cross-section profile are coupled together in the member-axial direction Y; however, there is no limitation thereto. For example, steel sheet piles 2 configured by the hat-shaped steel sheet piles 21 with a substantially hat-shaped cross-section profile illustrated in Fig. 3 to Fig. 5 may be employed as the steel members. Alternatively, H-beam steel 24 with a substantially H-shaped cross-section profile illustrated in Fig. 32, rectangular steel tubes 25 with a substantially rectangular cross-section profile illustrated in Fig. 33, or circular steel tubes 26 with a substantially circular cross-section profile illustrated in Fig. 34 may be employed as the steel members and coupled together along the member-axial direction Y.

[0092] The coupling member 5 includes the flattened flat plate 51, thus achieving simpler manufacture and processing than a circular arc shape, and improving the ease of the vertical joining operation. When joining together circular steel tubes 26 vertically, vertical joining may be performed at plural discrete locations in a circumferential direction. Accordingly, the ease of operation is improved in comparison to cases in which the circular steel tubes 26 have to be vertically joined around their entire circumference using the coupling member 5.

[0093] Instead of providing a single coupling member 5 spanning between the end portions 30 of the steel sheet piles 2 as illustrated in Fig. 6, two of the coupling members 5 may be provided sandwiching the end portions 30 of the steel sheet piles 2 in the member-axis-orthogonal direction X as illustrated in Fig. 35, for example. The positions and numbers of the coupling members 5 provided may be set as desired.

[0094] Next, detailed explanation follows regarding other exemplary embodiments for implementing the steel member vertical joint structure 1 applied with the present disclosure, with reference to the drawings. Configuration elements matching configuration elements

described above are allocated the same reference numerals, and explanation thereof is omitted.

[0095] As illustrated in Fig. 36 and Fig. 37, a steel member vertical joint structure 1 applied with the present disclosure is formed with plural coupling-side projections 50 and steel member-side projections 60 spaced apart from each other in the member-axial direction Y.

[0096] The fixing members 4 achieve at least one of a state in which the steel member-side projections 60 are fitted into the coupling-side grooves 52 between the coupling-side projections 50, or in a state in which the coupling-side projections 50 are fitted into the steel member-side grooves 62 between the steel member-side projections 60.

[0097] In the present exemplary embodiment, the coupling member 5 is moved in a direction approaching the end portion side faces 31 of the steel sheet piles 2 in the member-axis-orthogonal direction X (see the arrows in Fig. 36), such that the respective side faces 50a, 50b of the coupling-side projections 50 abut the respective side faces 60a, 60b of the steel member-side projections 60 (see Fig. 39). When this is performed, a compression force toward the side of the steel sheet piles 2 acts on the coupling-side projections 50 from the coupling member 5 side. The coupling-side projections 50 of the coupling member 5 are thus provided spanning across the vertical joint location 3 between the steel sheet piles 2 in a state anchored by the steel member-side projections 60.

[0098] Note that Fig. 36 and Fig. 37 illustrate a case in which the steel member-side projections 60 are provided at the plate shaped members 6 attached to the end portions 30 of the respective steel sheet piles 2. However, there is no limitation thereto. For example, as illustrated in the modified example of Fig. 38, flat steel or the like configuring the steel member-side projections 60 may be attached directly to the end portions 30 of the respective steel sheet piles 2 by welding or the like.

[0099] As illustrated in Fig. 39 and Fig. 40, the coupling-side projections 50 and the steel member-side projections 60 may be configured such that the respective side faces 50a, 50b of the coupling-side projections 50 and the respective side faces 60a, 60b of the steel member-side projections 60 are each formed with a tapered profile inclined with respect to the member-axis-orthogonal direction X.

[0100] The coupling-side projections 50 each have a profile that is larger along the member-axial direction Y on the flat plate 51 side than on the leading end face 50c side. The steel member-side projections 60 each have a profile that is larger along the member-axial direction Y on the end portion side face 31 side than on the leading end face 60c side. Namely, as viewed along the Z direction, the coupling-side projections 50 and the steel member-side projections 60 have trapezoidal profiles with short edges on the side of their

respective leading end faces 50c, 60c.

[0101] As illustrated in Fig. 39, for example, the respective side faces 50a, 50b, 60a, 60b of the coupling-side projections 50 and the steel member-side projections 60 are respectively formed with profiles that are tapered on both faces so as to be inclined with respect to the member-axis-orthogonal direction X. In the coupling-side projections 50 and the steel member-side projections 60, the inside faces 50a and the outside faces 50b of the coupling-side projections 50 are inclined in different directions to each other, and the inside faces 60a and the outside faces 60b of the steel member-side projections 60 are inclined in different directions to each other.

[0102] Explanation has been given regarding a case in which in the coupling-side projections 50 and the steel member-side projections 60, the inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the steel member-side projections 60 are inclined with respect to the member-axis-orthogonal direction X. However, there is no limitation thereto. For example, as illustrated in the modified example of Fig. 40, a profile tapered at one face may be applied, in which the inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the steel member-side projections 60 are inclined with respect to the member-axis-orthogonal direction X.

[0103] As illustrated in Fig. 39 and Fig. 40, the shaft members 41 that are passed through the holes 5a provided in the coupling member 5 and are inserted into holes 60d provided through the steel member-side projections 60 are employed as the fixing members 4. Moreover, as illustrated in the modified example of Fig. 41, the shaft members 41 may be passed through holes 30b provided in the end portions 30 of the steel sheet piles 2, and also inserted into holes 50d provided in the coupling-side projections 50. Here, "inserted into" refers to a non-penetrating, partially inserted state.

[0104] Bolts or the like are employed as the shaft members 41. As illustrated in the modified example of Fig. 40, the shaft members 41 are screwed into the threaded holes 60d provided through the steel member-side projections 60, or as illustrated in Fig. 41, the shaft members 41 are screwed into the holes 50d provided in the coupling-side projections 50. Whether or not to form threads in the holes 5a provided in the coupling member 5, or in the holes 30b provided in the end portions 30 of the steel sheet piles 2, to be penetrated by bolts or the like is optional.

[0105] As illustrated in the modified example of Fig. 42, for example, the bolts or the like configuring the shaft members 41 may be passed through the holes 5a provided in the coupling member 5 and the holes 30b provided in the end portions 30 of the steel sheet piles 2, and be screwed together with nuts 43 or the like. Whether or not to form threads in the holes

5a provided in the coupling member 5 and the holes 30b provided in the end portions 30 of the steel sheet piles 2 is optional.

[0106] In cases in which the holes 5a provided in the coupling member 5 or the holes 30b provided in the end portions 30 of the steel sheet piles 2 are not threaded, for example, the shaft members 41 may be formed with a larger profile.

[0107] Accordingly, when the shaft members 41 move the coupling member 5, the position of the coupling member 5 in the member-axial direction Y may be adjusted such that the respective side faces 50a, 50b of the coupling-side projections 50 and the respective side faces 60a, 60b of the steel member-side projections 60 abut each other. This enables at least one state out of a state in which the steel member-side projections 60 have been fitted into the coupling-side grooves 52, or a state in which the coupling-side projections 50 have been fitted into the steel member-side grooves 62, to be achieved easily.

[0108] Note that in cases in which the holes 5a provided in the coupling member 5 or the holes 30b provided in the end portions 30 of the steel sheet piles 2 are not threaded, elongated holes may be provided with length in the member-axial direction Y. This enables the range over which the position of the coupling member 5 can be adjusted in the member-axial direction Y to be increased when the shaft members 41 move the coupling member 5. This enables at least one state out of a state in which the steel member-side projections 60 have been fitted into the coupling-side grooves 52, or a state in which the coupling-side projections 50 have been fitted into the steel member-side grooves 62, to be achieved even more easily.

[0109] In the steel member vertical joint structure 1 applied with the present disclosure, as illustrated in the modified example of Fig. 43 and Fig. 44, in a state in which the coupling member 5 has approached the steel member-side projections 60, the coupling member 5 may, for example, be fixed using temporary fasteners 44 or the like, such that part of the coupling member 5 is fixed in a state abutting the steel member-side projections 60.

[0110] For example, a steel member with a Z-shaped profile is employed for each of the temporary fasteners 44. A pair of the temporary fasteners 44 are provided on either side of the steel member-side projections 60 in the member-axial direction Y. One end of each temporary fastener 44 is fixed to the end portion side face 31 of the corresponding steel sheet pile 2 using bolts or the like, such that the one end of the temporary fastener 44 is capable of rotating about the bolt or the like. In a state in which the coupling member 5 has approached the steel member-side projections 60, the temporary fastener 44 is rotated such that the other end of the temporary fastener 44 abuts the coupling member 5 (see the arrows in Fig. 44), and the temporary fastener 44 temporarily fixes the coupling member 5 in the member-axial direction Y.

[0111] After temporarily fixing the coupling member 5 using the temporary fasteners 44, as illustrated in Fig. 45, the shaft members 41 are passed through the holes 5a provided in the coupling member 5 and inserted into the holes 60d provided through the steel member-side projections 60 so as temporarily fasten the coupling member 5. The coupling member 5 is temporarily fastened in a state in which part of each shaft member 41 is, for example, screwed into the corresponding threaded hole 60d provided in the corresponding steel member-side projection 60.

[0112] Note that in the steel member vertical joint structure 1 applied with the present disclosure, for example, the coupling member 5 may be temporarily fastened and fixed using the shaft members 41 in a state in which the coupling member 5 has approached or abutted the steel member-side projections 60, without employing the temporary fasteners 44 or the like.

[0113] Then, as illustrated in Fig. 46, the shaft members 41 are screwed into the holes 60d provided through the steel member-side projections 60. When this is performed, the shaft members 41 move the coupling member 5 in the direction approaching the end portion side faces 31 in the member-axis-orthogonal direction X such that at least one state is adopted out of a state in which the steel member-side projections 60 are fitted into the coupling-side grooves 52, or a state in which the coupling-side projections 50 are fitted into the steel member-side grooves 62. When this is performed, each coupling-side projection 50 adopts a mutually abutting state with the two steel member-side projections 60 adjacent to the coupling-side projection 50.

[0114] When screwing the shaft members 41 into the holes 60d provided through the steel member-side projections 60, sometimes a state arises in which at least one of an inside face 50a of a coupling-side projection 50 and a mutually adjacent outside face 60b of a steel member-side projection 60, or an outside face 50b of a coupling-side projection 50 and a mutually adjacent inside face 60a of a steel member-side projection 60 abut each other.

[0115] When this occurs, the shaft members 41 move the coupling member 5 in the direction approaching the end portion side faces 31 in the member-axis-orthogonal direction X, such that at least one of the contact surface area between the inside face 50a of the coupling-side projection 50 and the mutually adjacent outside face 60b of the steel member-side projection 60, or the contact surface area between the outside face 50b of the coupling-side projection 50 and the mutually adjacent inside face 60a of the steel member-side projection 60, increases.

[0116] After the shaft members 41 have been screwed into the holes 60d provided through the steel member-side projections 60, the shaft members 41 are tightened further. When this is performed, the shaft members 41 apply a compression force to the coupling member 5 in a direction from the coupling member 5 side toward the steel sheet pile 2 side. This causes

frictional force to arise at the abutting portions between each coupling-side projection 50 and the two adjacent steel member-side projections 60, and the coupling-side projections 50 are anchored in the member-axial direction Y by the two adjacent steel member-side projections 60. When this is performed, the leading end faces 50c of the coupling-side projections 50 may be spaced apart from the steel member-side groove 62, and the leading end faces 60c of the steel member-side projections 60 may be spaced apart from the coupling-side groove 52.

[0117] As illustrated in Fig. 47 and Fig. 48, the coupling-side projections 50 and the steel member-side projections 60 may be formed such that a member-axis-orthogonal direction X projection height $h1b$ of the coupling-side projections 50 is substantially equal to a member-axis-orthogonal direction X projection height $h1a$ of the steel member-side projections 60. In such cases, a minimum spacing width $c2a$, this being the minimum groove width of the steel member-side grooves 62, is no greater than a member-axial direction Y projection width $w1b$ of the leading end faces 50c of the coupling-side projections 50. Moreover, a minimum spacing width $c2b$, this being the minimum groove width of the coupling-side grooves 52, is formed so as to be no greater than a member-axial direction Y projection width $w1a$ of the leading end faces 60c of the steel member-side projections 60.

[0118] In such cases, when the fixing members 4 move the coupling member 5, as illustrated as an example in Fig. 49, the respective side faces 50a, 50b of each coupling-side projection 50 and the respective side faces 60a, 60b of the two adjacent steel member-side projections 60 abut each other in a state in which the edges of the leading end faces 50c of the coupling-side projections 50 either abut or are spaced apart from the steel member-side grooves 62 (see Fig. 49).

[0119] Moreover, when the fixing members 4 move the coupling member 5, as illustrated as another example in Fig. 50, the respective side faces 60a, 60b of each steel member-side projection 60 and the respective side faces 50a, 50b of the two adjacent coupling-side projections 50 abut each other in a state in which the edges of the leading end faces 60c of the steel member-side projections 60 either abut or are spaced apart from the coupling-side grooves 52.

[0120] In this manner, in the coupling-side projections 50 and the steel member-side projections 60, when the projection height $h1b$ of the coupling-side projections 50 and the projection height $h1a$ of the steel member-side projections 60 are substantially equal, at least one relationship is satisfied of a relationship in which the minimum spacing width $c2a$ of the steel member-side grooves 62 is no greater than the projection width $w1b$ of the coupling-side projections 50, or a relationship in which the minimum spacing width $c2b$ of the coupling-side grooves 52 is no greater than the projection width $w1a$ of the steel member-side projections

60.

[0121] Accordingly, in the coupling-side projections 50 and the steel member-side projections 60, each coupling-side projection 50 and the two adjacent steel member-side projections 60 reliably abut each other accompanying the movement of the coupling member 5 by the fixing members 4. Accordingly, a state in which each coupling-side projection 50 is anchored in the member-axial direction Y by the two adjacent steel member-side projections 60 can be reliably achieved.

[0122] In particular, in the coupling-side projections 50 and the steel member-side projections 60, in cases in which the projection height $h1b$ of the coupling-side projections 50 and the projection height $h1a$ of the steel member-side projections 60 are substantially equal, the projection width $w1b$ of the leading end faces 50c is substantially equal to the minimum spacing width $c2a$, and the projection width $w1a$ of the leading end faces 60c is substantially equal to the minimum spacing width $c2b$, the volume of a space between the coupling-side projections 50 and the steel member-side projections 60 can be reduced. This thereby enables the contact surface area between the coupling-side projections 50 and the steel member-side projections 60 to be increased, enabling a concentration of stress to be avoided.

[0123] Operation

In the steel member vertical joint structure 1 applied with the present disclosure, as illustrated in Fig. 47 and Fig. 48, for example, at least one of the inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the steel member-side projections 60, or the outside faces 50b of the coupling-side projections 50 and the inside faces 60a of the steel member-side projections 60, run substantially parallel to each other. Accordingly, at least one of the contact surface area between the inside face 50a of a coupling-side projection 50 and the mutually adjacent outside face 60b of the steel member-side projection 60, or the contact surface area between the outside face 50b of a coupling-side projection 50 and the mutually adjacent inside face 60a of the steel member-side projection 60, can be increased. This thereby enables load to be transmitted readily between the coupling-side projections 50 and the steel member-side projections 60.

[0124] As illustrated in Fig. 49 and Fig. 50, for example, sometimes at least one of the inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the steel member-side projections 60, or the outside faces 50b of the coupling-side projections 50 and the inside faces 60a of the steel member-side projections 60, are tapered at different angles to each other. In such cases too, a state in which each coupling-side projection 50 is abutted and anchored by the two adjacent steel member-side projections 60 can be achieved.

[0125] As illustrated in Fig. 49, a state is achieved in which the edges of the leading end

faces 50c of the coupling-side projections 50 (edges of the inside faces 50a and the outside faces 50b) abut the inside faces 60a and the outside faces 60b of the steel member-side projections 60, thereby anchoring the coupling-side projections 50. Alternatively, as illustrated in Fig. 50, a state is achieved in which the edges of the leading end faces 60c of the steel member-side projections 60 (the inside faces 60a and the outside faces 60b) abut the inside faces 50a and the outside faces 50b of the coupling-side projections 50, thereby anchoring the coupling-side projections 50.

[0126] Note that configurations in which the edges of the inside faces 50a and the outside faces 50b of the coupling-side projections 50 abut the inside faces 60a and the outside faces 60b of the steel member-side projections 60 are encompassed in cases in which coupling-side inclined faces of the present disclosure are "pressed against" opposing steel member-side inclined faces. Moreover, configurations in which the edges of the inside faces 60a and the outside faces 60b of the steel member-side projections 60 abut the inside faces 50a and the outside faces 50b of the coupling-side projections 50 are also encompassed in cases in which coupling-side inclined faces of the present disclosure are "pressed against" opposing steel member-side inclined faces.

[0127] Accordingly, the taper angles of the respective side faces 50a, 50b, 60a, 60b of the coupling-side projections 50 and the steel member-side projections 60, the member-axis-orthogonal direction X projection heights, and the member-axial direction Y placement pitch may be set as desired within ranges in which a state in which each coupling-side projection 50 is abutted and anchored by the two adjacent steel member-side projections 60 is capable of being achieved.

[0128] The other exemplary embodiments exhibit similar operation and advantageous effects to the exemplary embodiments previously described. Moreover, the steel member-side projections 60 disposed on the direction away from the vertical joint location 3 function as stoppers that can restrict the coupling-side projections 50 disposed in the steel member-side grooves 62 between the steel member-side projections 60 from detaching toward the direction away from the vertical joint location 3.

[0129] Moreover, adequate bending rigidity at the vertical joint location 3 between the plural steel sheet piles 2 is secured at the initial stage, such that the vertical joint location 3 between the plural steel sheet piles 2 does not become a structural weak point. This thereby enables a reduction in the overall bending rigidity of the steel member configured by the plural coupled steel sheet piles 2 to be avoided, while also avoiding an increase in the duration of the construction project caused by performing welding on-site or friction linking using high-strength bolts at the vertical joint location 3 between the plural steel sheet piles 2.

[0130] The fixing members 4 are employed to move the coupling member 5 in at least one state out of a state in which the steel member-side projections 60 have been fitted into the coupling-side grooves 52, or a state in which the coupling-side projections 50 have been fitted into the steel member-side grooves 62. Accordingly, a compression force toward the side of the steel sheet piles 2 acts on the coupling member 5 from the coupling member 5 side, thereby achieving a state in which the coupling-side projections 50 are anchored by the steel member-side projections 60.

[0131] Accordingly, when external pressure toward the side of the steel sheet piles 2 acts from the coupling member 5 side during installation, the compression force acts in a direction to retain the anchored state of the coupling-side projections 50, enabling the overall bending rigidity of the steel member to be improved.

[0132] The shape of the coupling-side projections 50 and the shape of the steel member-side projections 60 enable the coupling-side projections 50 to be abutted against the two adjacent steel member-side projections 60 easily. Accordingly, a state in which the coupling-side projections 50 are anchored in the member-axial direction Y by the two adjacent steel member-side projections 60 can be achieved easily, enabling slippage as a result of alternating positive and negative bending loads to be suppressed.

[0133] Moreover, due to employing the shaft members 41 configured by bolts or the like as the fixing members 4, the bolts or the like are passed through the holes 5a provided in the coupling member 5, and are screwed into the threaded holes 60d provided through the steel member-side projections 60, or screwed together with the nuts 43. This thereby enables the anchored state of the coupling-side projections 50 to be retained, while also preventing detachment of the coupling member 5.

[0134] When the projection height $h1b$ of the coupling-side projections 50 and the projection height $h1a$ of the steel member-side projections 60 are substantially equal, satisfying at least one relationship out of a relationship in which the minimum spacing width $c2a$ of the steel member-side grooves 62 is no greater than the projection width $w1b$ of the coupling-side projections 50, or a relationship in which the minimum spacing width $c2b$ of the coupling-side grooves 52 is no greater than the projection width $w1a$ of the steel member-side projections 60, enables the coupling-side projections 50 and the steel member-side projections 60 to be made to abut each other reliably.

[0135] This thereby enables a state to be reliably achieved in which the coupling-side projections 50 are anchored in the member-axial direction Y by the two adjacent steel member-side projections 60, enabling slippage as a result of alternating positive and negative bending loads to be further suppressed.

[0136] Moreover, at least one of the inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the steel member-side projections 60, or the outside faces 50b of the coupling-side projections 50 and the inside faces 60a of the steel member-side projections 60, run substantially parallel to each other. Accordingly, the contact surface area between the inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the mutually adjacent steel member-side projections 60, or the contact surface area between the outside faces 50b of the coupling-side projections 50 and the mutually adjacent inside faces 60a of the steel member-side projections 60, can be increased. This thereby enables stress to be easily transferred between the coupling-side projections 50 and the steel member-side projections 60, enabling slippage as a result of alternating positive and negative bending loads to be further suppressed.

[0137] The inside faces 50a of the coupling-side projections 50 and the outside faces 60b of the steel member-side projections 60, or the outside faces 50b of the coupling-side projections 50 and the inside faces 60a of the steel member-side projections 60, run substantially parallel to each other. This thereby enables the volume of a space between the coupling-side projections 50 and the steel member-side projections 60 to be reduced. This thereby enables the contact surface area between the coupling-side projections 50 and the steel member-side projections 60 to be increased, facilitating load transmission.

[0138] Note that in the other exemplary embodiments of the steel member vertical joint structure 1 applied with the present disclosure, similarly to in the exemplary embodiment described earlier, the corner portions C of the coupling-side projections 50 and the steel member-side projections 60 may be applied with bevels by hot extrusion as required, as illustrated in Fig. 11 to Fig. 13, for example. Moreover, in the steel member vertical joint structure 1 applied with the present disclosure, hot extrusion can be performed easily at the corner portions C of the coupling-side projections 50 and the steel member-side projections 60, enabling processing of the coupling-side projections 50 and the steel member-side projections 60 to be made easier.

[0139] For example, the other exemplary embodiments of the steel member vertical joint structure 1 applied with the present disclosure may be employed to couple together plural steel members having a particular cross-section profile in the member-axial direction Y, similarly to in the exemplary embodiment described earlier.

[0140] Moreover, the steel sheet piles 2, such as the hat-shaped steel sheet piles 21 illustrated in Fig. 3 to Fig. 5 that have substantially hat-shaped cross-section profiles, have been employed as the steel members. However, there is no limitation thereto. For example, the H-beam steel 24 with a substantially H-shaped cross-section profile illustrated in Fig. 32,

the rectangular steel tubes 25 with a substantially rectangular cross-section profile illustrated in Fig. 33, or the circular steel tubes 26 with a substantially circular cross-section profile illustrated in Fig. 34 may be employed as the steel members and coupled together along the member-axial direction Y.

[0141] Moreover, instead of providing a single coupling member 5 spanning between the end portions 30 of the steel sheet piles 2 as illustrated in Fig. 6, as illustrated in Fig. 35, for example, two of the coupling members 5 may be provided sandwiching the end portions 30 of the steel sheet piles 2 in the member-axis-orthogonal direction X. The positions and numbers of the coupling members 5 provided may be set as desired.

[0142] The fixing members 4 may be passed through the holes 5a provided through the coupling member 5 and inserted into holes 30b provided through the steel member-side projections 60 or through the steel sheet piles 2 configuring the steel members.

[0143] As illustrated in Fig. 51 and Fig. 52, a vertical joint structure may be configured in which the inside faces 60a configuring the steel member-side inclined faces of the steel member-side projections 60 are formed on the side nearer the vertical joint location 3, this being the boundary between the steel sheet piles 2 configuring the steel members. The coupling member 5 is provided spanning across the vertical joint location 3 between the plural steel sheet piles 2 by sliding the coupling member 5 in the wall-lateral direction Z along the end portion side faces 31 of the steel sheet piles 2 provided with the steel member-side projections 60.

[0144] When this is performed, the coupling-side projections 50 of the coupling member 5 are fitted into the steel member-side grooves 62 formed between the plural steel member-side projections 60. The steel member-side projections 60 of the steel sheet piles 2 are fitted into the coupling-side grooves 52 formed between the plural coupling-side projections 50.

[0145] Detailed explanation has been given regarding examples of exemplary embodiments of the present disclosure. However, the exemplary embodiments described above are merely specific examples of implementation of the present disclosure, and are not to be construed as limiting the technical scope of the present disclosure.

[0146] Reference numerals used herein are as follows.

[0147] 1 steel sheet pile vertical joint structure
2 steel sheet pile
2a flange
2b web
2c arm
2d join portion

21	hat-shaped steel sheet pile
22	U-shaped steel sheet pile
23	Z-shaped steel sheet pile
24	H-beam steel
25	rectangular steel tube
26	circular steel tube
3	vertical joint location
30	end portion
30a	end face
30b	hole provided in end portion
31	end portion side face
4	fixing member
40	threaded hole
41	shaft member
41a	leading end portion
42	wedge member
42a	leading portion
43	nut
44	temporary fastener
5	coupling member
5a	hole provided in coupling member
50	coupling-side projection
50a	inside face of coupling-side projection
50b	outside face of coupling-side projection
50c	leading end face of coupling-side projection
50d	hole provided in coupling-side projection
51	flat plate
51a	upper plate portion
51b	lower plate portion
52	coupling-side groove
6	plate shaped member
60	steel member-side projection
60a	inside face of steel member-side projection
60b	outside face of steel member-side projection
60c	leading end face of steel member-side projection

60d	hole provided in steel member-side projection
62	steel member-side groove
7	steel wall
70	coupled steel member
8	ground
X	member-axis-orthogonal direction
Y	member-axial direction
Z	wall-lateral direction

Supplement

The following aspects may be generalized from the present specification.

A vertical joint structure for steel members of a first aspect includes:

steel member-side projections configured to respectively project from one steel member and another steel member that are coupled together along a member-axial direction so as to project from an end portion side face of the one steel member and from an end portion side face of the other steel member, each of the steel member-side projections being formed with a steel member-side inclined face that is inclined with respect to a projection direction on at least one of a side of the steel member-side projection facing toward a boundary between the two steel members or another side of the steel member-side projection away from the boundary between the two steel members;

a coupling member that includes a flat plate configured to be disposed straddling the boundary, coupling-side projections projecting from the flat plate toward end portion side faces of the respective steel members, and a coupling-side inclined face being formed at each of the coupling-side projections so as to oppose the steel member-side inclined faces of the steel member-side projections; and

a fixing member that presses each coupling-side inclined face against an opposing steel member-side inclined face in a state in which a gap is formed between the flat plate and the steel member-side projection.

A steel member vertical joint structure of a second aspect is the first aspect, wherein: plural of the steel member-side projections are provided at each of the steel members so as to be disposed in a row along the member-axial direction; and

a stopper that restricts detachment, in a direction away from the boundary, of a coupling-side projection that is disposed between respective steel member-side projections, is configured by a steel member-side projection of the steel member-side projections disposed on a side away from the boundary.

A steel member vertical joint structure of a third aspect is the first or the second

aspect, wherein the fixing member presses each of the coupling-side inclined faces against the opposing steel member-side inclined face by applying a load in a direction separating the coupling member from the steel members.

A steel member vertical joint structure of a fourth aspect is the third aspect, wherein the fixing member includes either a shaft member to pass through the coupling member and abut the steel member-side projection or the end portion side face, or a shaft member to pass through the end portion side face of the steel member and abut the coupling member.

A steel member vertical joint structure of a fifth aspect is the fourth aspect, wherein the shaft member includes a bolt that is screwed into a threaded hole penetrating either the coupling member or the steel member.

A steel member vertical joint structure of a sixth aspect is any one of the third to the fifth aspect, wherein the fixing member includes a wedge member interposed between the coupling member and the end portion side face.

A steel member vertical joint structure of a seventh aspect is any one of the third to the sixth aspect, wherein the coupling member includes plural of the coupling-side projections disposed in a row along the member-axial direction, and a coupling-side groove in which to dispose a corresponding steel member-side projection, and which is formed between adjacent coupling-side projections;

a projection width $w1$ in the member-axial direction of a projection direction leading end of each of the coupling-side projections and each of the steel member-side projections is substantially a same dimension; and

a combined dimension lp in the member-axial direction obtained by combining a dimension of a base end side of one of the coupling-side projections with a dimension of the coupling-side groove satisfies a relationship defined by (1) below with respect to the projection width $w1$

$$w1 > lp / 2 \quad \dots (1)$$

A steel member vertical joint structure of an eighth aspect is the first aspect, wherein: plural of the coupling-side projections are provided so as to be disposed in a row along the member-axial direction, and each coupling-side projection has a profile in which the flat plate side of the coupling-side projection is larger in the member-axial direction than a leading end side of the coupling-side projection;

the steel member-side projections include plural of the steel member-side projections disposed in a row along the member-axial direction, and each steel member-side projection has a profile in which a side of the steel member-side projection at a steel member end portion side face is larger in the member-axial direction than a leading end side of the steel

member-side projection;

the fixing member includes a shaft member to pass through a hole provided in the coupling member so as to be inserted into a hole provided in the corresponding steel member-side projection or a hole provided in the corresponding steel member, or includes a shaft member to pass through a hole provided in the corresponding steel member so as to be inserted into a hole provided in the coupling member; and

the fixing member presses the coupling member against the steel member side in at least one of a state in which each of the steel member-side projections is disposed in a coupling-side groove between adjacent coupling-side projections, or a state in which each of the coupling-side projections is disposed in a steel member-side groove between adjacent steel member-side projections.

A steel member vertical joint structure of a ninth aspect is the eighth aspect, wherein:

the shaft member is a bolt to screw into a threaded hole in the corresponding steel member-side projection or a threaded hole in the corresponding coupling-side projection, or is a bolt to pass through the coupling member and the corresponding steel member so as to be screwed together with a nut.

A steel member vertical joint structure of a tenth aspect is the eighth or ninth aspect, wherein at least one relationship is satisfied of a relationship in which a minimum groove width $c2a$ of the steel member-side groove is no greater than a projection width $w1b$ in the member-axial direction of a leading end of each of the coupling-side projections, or a relationship in which a minimum groove width $c2b$ of the coupling-side groove is no greater than a projection width $w1a$ in the member-axial direction of a leading end of each of the steel member-side projections.

A steel member vertical joint structure of an eleventh aspect is any one of the first aspect and the eighth to the tenth aspect, wherein in each of the coupling-side projections and the steel member-side projections, at least a face on the boundary side of the coupling-side projection and a face on the side away from the boundary of the steel member-side projection run substantially parallel to each other, or a face on the side away from the boundary of the coupling-side projection and a face on the boundary side of the steel member-side projection run substantially parallel to each other.

A steel member vertical joint structure of a twelfth aspect is any one of the first to the eleventh aspect, wherein projection direction leading end side corner portions of each of the coupling-side projections and the steel member-side projections are applied with beveled profiles.

Other Aspects

The following other aspects may also be generalized from the present specification.

A vertical joint structure for a steel member of a first aspect is configured to couple together plural steel members with a predetermined cross-section profile in a member-axial direction, the steel member vertical joint structure including:

a coupling member that provided spanning across a vertical joint location where member-axial direction end portions of each steel member are coupled together, a fixing member that moves the coupling member in a member-axis-orthogonal direction, and base member-side projections that project in the member-axis-orthogonal direction from an end portion side face of each steel member toward the coupling member,

the coupling member including a flat plate that straddles continuously across the vertical joint location in the member-axial direction, and coupling-side projections that project in the member-axis-orthogonal direction from the flat plate toward the end portion side faces, and

in each of the coupling-side projections and the base member-side projections, side faces of the coupling-side projections and side faces of the base member-side projections being formed with a tapered profile inclined with respect to the member-axis-orthogonal direction.

A steel member vertical joint structure of a second aspect is the first aspect, wherein:

in the coupling-side projections and the base member-side projections, an inside face of each of the coupling-side projections that is closer to the vertical joint location in the member-axial direction and an outside face of each of the base member-side projections that is on the direction away from the vertical joint structure in the member-axial direction are each formed with a tapered profile inclined with respect to the member-axis-orthogonal direction; and

the fixing member moves the coupling member toward the direction away from the end portion side faces in the member-axis-orthogonal direction, such that the inside face of each of the coupling-side projections and the outside face of each of the base member-side projections transition from a state spaced apart from each other to a state close to each other in the member-axial direction.

A steel member vertical joint structure of a third aspect is the first or second aspect, wherein:

the fixing member employs either a shaft member to pass through the coupling member and abut the corresponding base member-side projection or the end portion side face, or a shaft member to pass through the end portion of the corresponding steel member and abut the coupling member.

A steel member vertical joint structure of a fourth aspect is the third aspect, wherein:
the shaft member employs a bolt that is screwed into a threaded hole penetrating either the coupling member or the end portion of the corresponding steel member.

A steel member vertical joint structure of a fifth aspect is any one of the first to the fourth aspect, wherein:

the fixing member employs a wedge member interposed between the coupling member and the end portion side face.

A steel member vertical joint structure of a sixth aspect is any one of the first to the fifth aspect, wherein:

the coupling member is formed with plural of the coupling-side projections disposed spaced apart from each other along the member-axial direction, and each of the base member-side projections is fitted into a corresponding coupling-side groove at a portion where plural adjacent coupling-side projections in the member-axial direction are spaced apart from each other; and

a projection width $w1$ in the member-axial direction at a member-axis-orthogonal direction leading end side of each of the coupling-side projections and each of the base member-side projections is substantially the same; and a total length lp in the member-axial direction obtained by combining a dimension of one of the coupling-side projections with a dimension of the coupling-side groove satisfies the relationship defined by (1) below with respect to the projection width $w1$.

$$w1 > lp / 2 \quad \dots (1)$$

A steel member vertical joint structure of a seventh aspect is the first aspect, wherein:
plural of the coupling-side projections are formed spaced apart from each other in the member-axial direction, and each coupling-side projection has a profile in which the flat plate side of the coupling-side projection is larger in the member-axial direction than a leading end face side of the coupling-side projection;

plural of the base member-side projections are formed spaced apart from each other in the member-axial direction, and each base member-side projection has a profile in which a side of the steel member-side projection at a steel member end portion side face is larger in the member-axial direction than a leading end side of the steel member-side projection;

the fixing member employs a shaft member to pass through a hole provided in the coupling member so as to be inserted into a hole provided in the corresponding base member-side projection, or employs a shaft member to pass through a hole provided in the end portion of the corresponding steel member so as to be inserted into a hole provided in the corresponding coupling-side projection; and

the fixing member moves the coupling member in a direction toward the corresponding end portion side face in the member-axis-orthogonal direction, so as to achieve at least one state out of a state in which each base member-side projection is fitted into a coupling-side groove at a portion where plural adjacent coupling-side projections in the member-axial direction are spaced apart from each other, or a state in which each coupling-side projection is fitted into a base member-side groove at a portion where plural adjacent base member-side projections in the member-axial direction are spaced apart from each other.

A steel member vertical joint structure of an eighth aspect is the seventh aspect, wherein:

the shaft member employs a bolt to screw into a threaded hole provided in the corresponding base member-side projection or a threaded hole provided in the corresponding coupling-side projection, or is a bolt to pass through the coupling member and the end portion of the corresponding steel member so as to be screwed together with a nut.

A steel member vertical joint structure of a ninth aspect is the seventh or the eighth aspect, wherein:

in each of the coupling-side projections and each of the base member-side projections, when a member-axis-orthogonal direction projection height $h1b$ of the coupling-side projections is substantially equal to a member-axis-orthogonal direction projection height $h1a$ of the base member-side projections,

at least one relationship is satisfied of a relationship in which a minimum groove width $c2a$ of each of the base member-side grooves is no greater than a projection width $w1b$ in the member-axial direction of a leading end face of each of the coupling-side projections, or a relationship in which a minimum groove width $c2b$ of each of the coupling-side grooves is no greater than a projection width $w1a$ in the member-axial direction of a leading end face of each of the base member-side projections.

A steel member vertical joint structure of a tenth aspect is any one of the first aspect or the seventh to the ninth aspect, wherein:

in each of the coupling-side projections and the base member-side projections, at least an inside face of each of the coupling-side projections that is closer to the vertical joint location in the member-axial direction and an outside face of each of the base member-side projections that is on the direction away from the vertical joint location in the member-axial direction run substantially parallel to each other, or an outside face of each of the coupling-side projections that is on the direction away from the vertical joint location in the member-axial direction and an inside face of each of the base member-side projections that is

closer to the vertical joint location in the member-axial direction run substantially parallel to each other

A steel member vertical joint structure of an eleventh aspect is any one of the first to the tenth aspect, wherein:

corner portions between a member-axis-orthogonal direction leading end face and a member-axial direction inside face or a member-axial direction outside face of each of the coupling-side projections and each of the base member-side projections are applied with beveled profiles.

The other aspects exhibit the following operation and advantageous effects.

The first to the eleventh aspects secure adequate initial bending rigidity at the vertical joint location between plural steel sheet piles or the like, and the vertical joint location between the plural steel sheet piles or the like does not become a structural weak point. Accordingly, a reduction in the overall bending rigidity of the mutually coupled steel members can be avoided in the plural steel sheet piles or the like, while also avoiding an increase in the duration of the construction project that arises in cases in which vertical joint locations between plural steel sheet piles or the like are welded together on-site or joined by friction using high-strength bolts.

According to the second aspect to the sixth aspect and the eleventh aspect, gaps are formed where the coupling-side projections and the base member-side projections are spaced apart from each other, such that an operation to fit together the coupling-side projections and the base member-side projections can be performed smoothly, enabling the operation to couple together the plural steel sheet piles or the like in the member-axial direction to be performed quickly and easily.

According to the second aspect to the sixth aspect and the eleventh aspect, tensile force can be transferred either immediately after, or at a comparatively early stage after, the coupling-side projections and the base member-side projections have been fitted together. This thereby enables the plural steel sheet piles or the like to be firmly coupled together in the member-axial direction while enabling an operation to fit the coupling-side projections and the base member-side projections together to be performed smoothly, and enables adequate initial bending rigidity similar to that of the steel sheet piles or the like themselves to be secured.

In particular, in the third aspect, the fourth aspect, and the eleventh aspect, due to employing a shaft member such as a bolt as the fixing member, a leading end portion of the bolt or the like screwed into the threaded hole abuts the corresponding base member-side projection or the like, enabling the coupling-side projections and the base member-side

projections to be suppressed from sliding when in a fitted-together state, and enabling the coupling member to be prevented from detaching.

In particular, according to the fifth aspect and the eleventh aspect, employing the wedge member as the fixing member that is knocked in so as to be interposed between the coupling member and the end portion side face of the corresponding steel sheet piles or the like enables the coupling member to be moved in the member-axis-orthogonal direction, rendering an operation to drill holes in the coupling member and an operation to screw in bolts unnecessary, and thereby enabling the coupling member to be moved with a simple structure.

In particular, according to the sixth aspect and the eleventh aspect, when the coupling-side projections and the base member-side projections are formed with substantially the same profiles and dimensions as each other such that leading end sides of the coupling-side projections and the base member-side projections have a spreading profile tapered at one face or a profile tapered at both faces, the member-axial direction total length l_p obtained by combining the coupling-side projection and the coupling-side groove and the projection width w_1 satisfy the relationship defined by (1) above. This thereby enables the coupling-side projections and the base member-side projections to be reliably prevented from disengaging in the member-axis-orthogonal direction when in a fitted-together state.

In particular, according to the seventh aspect to the eleventh aspect, the fixing member is employed to move the coupling member in order to achieve at least one state out of a fitted-together state of the coupling-side grooves and the base member-side projections, or a fitted-together state of the base member-side grooves and the coupling-side projections. Accordingly, a compression force acts in the coupling member from the coupling member side toward the steel member side, thereby achieving a state in which the coupling-side projections are anchored by the base member-side projections. Accordingly, when an external force acts from the coupling member side toward the steel member side during construction work, the compression force acts in a direction to retain the anchored state of the coupling-side projections, thereby enabling the overall bending rigidity of the coupled steel members to be improved.

In particular, in the seventh aspect to the eleventh aspect, the profile of the coupling-side projections and the profile of the base member-side projections enable each of the coupling-side projections to easily abut the two adjacent base member-side projections. Accordingly, a state in which the coupling-side projections are anchored in the member-axial direction by the two adjacent base member-side projections can be achieved easily, enabling slippage as a result of alternating positive and negative bending loads to be suppressed.

In particular, in the eighth aspect to the eleventh aspect, due to employing a shaft member such as a bolt or the like as the fixing member, the bolt or the like is passed through a hole or the like provided in the coupling member and screwed into a threaded hole or the like provided in the corresponding base member-side projection or screwed together with a nut. This thereby enables the anchored state of the coupling-side projections to be retained, and also enables the coupling member to be prevented from detaching.

In particular, in the ninth aspect to the eleventh aspect, when the projection height $h1b$ of the coupling-side projections is substantially equal to the projection height $h1a$ of the base member-side projections, since at least one relationship is satisfied of the relationship in which the minimum groove width $c2a$ of each of the base member-side grooves is no greater than the projection width $w1b$ of each of the coupling-side projections, or the relationship in which the minimum groove width $c2b$ of each of the coupling-side grooves is no greater than the projection width $w1a$ of each of the base member-side projections, each of the coupling-side projections can be made to reliably abut the two adjacent base member-side projections. Accordingly, the anchored state of each of the coupling-side projections by the two adjacent base member-side projections in the member-axial direction can be reliably achieved, enabling slippage as a result of alternating positive and negative bending loads to be further suppressed.

In particular, in the tenth aspect and the eleventh aspect, at least the inside face of each of the coupling-side projections and the outside face of each of the base member-side projections run substantially parallel to each other, or the outside face of each of the coupling-side projections and the inside face of each of the coupling-side projections run substantially parallel to each other. Accordingly, the contact surface area between the inside face of the coupling-side projection and the outside face of the mutually adjacent base member-side projection, or the contact surface area between the outside face of the coupling-side projection and the inside face of the mutually adjacent base member-side projection can be increased. This thereby enables stress to be transferred easily between the coupling-side projections and the base member-side projections, enabling slippage as a result of alternating positive and negative bending loads to be further suppressed.

In particular, in the tenth aspect and the eleventh aspect, since the inside faces of the coupling-side projections and the outside faces of the base member-side projections run substantially parallel to each other, and the outside faces of the coupling-side projections and the inside faces of the base member-side projections run substantially parallel to each other, the volume of a space between each of the coupling-side projections and each of the base member-side projections can be reduced. This thereby increases the contact surface area

between the coupling-side projections and the base member-side projections, facilitating stress transfer.

In particular, in the eleventh aspect, the corner portions of the coupling-side projections and the base member-side projections are beveled, facilitating hot extrusion of the corner portions of the coupling-side projections and the base member-side projections, and thereby enabling the ease of processing the coupling-side projections and the base member-side projections to be improved.

The disclosure of Japanese Patent Application No. 2016-156002, filed on August 8, 2016, is incorporated in its entirety by reference herein. Moreover, the disclosure of Japanese Patent Application No. 2017-027817, filed on February 17, 2017, is also incorporated in its entirety by reference herein.

All cited documents, patent applications, and technical standards mentioned in the present specification are incorporated by reference in the present specification to the same extent as if each individual cited document, patent application, or technical standard was specifically and individually indicated to be incorporated by reference.

CLAIMS

1. A vertical joint structure for steel members comprising:

steel member-side projections configured to respectively project from one steel member and another steel member that are coupled together along a member-axial direction so as to project from an end portion side face of the one steel member and from an end portion side face of the other steel member, each of the steel member-side projections being formed with a steel member-side inclined face that is inclined with respect to a projection direction on at least one of a side of the steel member-side projection facing toward a boundary between the two steel members or another side of the steel member-side projection away from the boundary between the two steel members;

a coupling member that includes a flat plate configured to be disposed straddling the boundary, coupling-side projections projecting from the flat plate toward end portion side faces of the respective steel members, and a coupling-side inclined face being formed at each of the coupling-side projections so as to oppose the steel member-side inclined faces of the steel member-side projections; and

a fixing member that presses each coupling-side inclined face against an opposing steel member-side inclined face in a state in which a gap is formed between the flat plate and the steel member-side projection.

2. The steel member vertical joint structure of claim 1, wherein:

a plurality of the steel member-side projections are provided at each of the steel members so as to be disposed in a row along the member-axial direction; and

a stopper that restricts detachment, in a direction away from the boundary, of a coupling-side projection that is disposed between respective steel member-side projections, is configured by a steel member-side projection of the steel member-side projections disposed on a side away from the boundary.

3. The steel member vertical joint structure of claim 1 or claim 2, wherein the fixing member presses each of the coupling-side inclined faces against the opposing steel member-side inclined face by applying a load in a direction separating the coupling member from the steel members.

4. The steel member vertical joint structure of claim 3, wherein the fixing member includes either a shaft member to pass through the coupling member and abut the steel member-side

projection or the end portion side face, or a shaft member to pass through the end portion side face of the steel member and abut the coupling member.

5. The steel member vertical joint structure of claim 4, wherein the shaft member includes a bolt that is screwed into a threaded hole penetrating either the coupling member or the steel member.

6. The steel member vertical joint structure of any one of claim 3 to claim 5, wherein the fixing member includes a wedge member interposed between the coupling member and the end portion side face.

7. The steel member vertical joint structure of any one of claim 1 to claim 6, wherein:

the coupling member includes a plurality of the coupling-side projections disposed in a row along the member-axial direction, and a coupling-side groove in which to dispose a corresponding steel member-side projection, and which is formed between adjacent coupling-side projections;

a projection width w_1 in the member-axial direction of a projection direction leading end of each of the coupling-side projections and each of the steel member-side projections is substantially a same dimension; and

a combined dimension l_p in the member-axial direction obtained by combining a dimension of a base end side of one of the coupling-side projections with a dimension of the coupling-side groove satisfies a relationship defined by (1) below with respect to the projection width w_1

$$w_1 > l_p / 2 \quad \dots (1).$$

8. The steel member vertical joint structure of claim 1, wherein:

the coupling-side projections include a plurality of the coupling-side projections disposed in a row along the member-axial direction, and each coupling-side projection has a profile in which the flat plate side of the coupling-side projection is larger in the member-axial direction than a leading end side of the coupling-side projection;

the steel member-side projections include a plurality of the steel member-side projections disposed in a row along the member-axial direction, and each steel member-side projection has a profile in which a side of the steel member-side projection at a steel member end portion side face is larger in the member-axial direction than a leading end side of the steel member-side projection;

the fixing member includes a shaft member to pass through a hole provided in the coupling member so as to be inserted into a hole provided in the corresponding steel member-side projection or a hole provided in the corresponding steel member, or includes a shaft member to pass through a hole provided in the corresponding steel member so as to be inserted into a hole provided in the coupling member; and

the fixing member presses the coupling member against the steel member side in at least one of a state in which each of the steel member-side projections is disposed in a coupling-side groove between adjacent coupling-side projections, or a state in which each of the coupling-side projections is disposed in a steel member-side groove between adjacent steel member-side projections.

9. The steel member vertical joint structure of claim 8, wherein:

the shaft member is a bolt to screw into a threaded hole in the corresponding steel member-side projection or a threaded hole in the corresponding coupling-side projection, or is a bolt to pass through the coupling member and the corresponding steel member so as to be screwed together with a nut.

10. The steel member vertical joint structure of claim 8 or claim 9, wherein at least one relationship is satisfied of a relationship in which a minimum groove width $c2a$ of the steel member-side groove is no greater than a projection width $w1b$ in the member-axial direction of a leading end of each of the coupling-side projections, or a relationship in which a minimum groove width $c2b$ of the coupling-side groove is no greater than a projection width $w1a$ in the member-axial direction of a leading end of each of the steel member-side projections.

11. The steel member vertical joint structure of any one of claim 1 and claim 8 to claim 10, wherein in each of the coupling-side projections and the steel member-side projections, at least a face on the boundary side of the coupling-side projection and a face on the side away from the boundary of the steel member-side projection run substantially parallel to each other, or a face on the side away from the boundary of the coupling-side projection and a face on the boundary side of the steel member-side projection run substantially parallel to each other.

12. The steel member vertical joint structure of any one of claim 1 to claim 11, wherein projection direction leading end side corner portions of each of the coupling-side projections and the steel member-side projections are applied with beveled profiles.