

JOINT STRUCTURE FOR STEEL PIPE PILE

Technical Field

[0001]

The present invention relates to a joint structure for a steel pipe pile for coupling a first steel pipe pile and a second steel pipe pile in an axial center direction.

Priority is claimed on Japanese Patent Application No. 2013-252957, filed December 6, 2013, the content of which is incorporated herein by reference.

Related Art

[0002]

In the related art, a welded joint and a mechanical joint are used as joint structures that couple a first steel pipe pile and a second steel pipe pile in an axial center direction.

The welded joint is obtained by butt-welding the first steel pipe pile and the second steel pipe pile to each other at end sections. However, a joint structure based on the welded joint has difficulty in workability, and the quality and working hours of welded parts are greatly influenced by field circumstances or a worker's level of skill.

[0003]

Thus, joint structures for a steel pipe pile based on the mechanical joint as disclosed in Patent Document 1 and Patent Document 2 are suggested as joint structures for a steel pipe pile having excellent workability.

[0004]

In the joint structure for a steel pipe pile disclosed in Patent Document 1, a pair of an outer fitting end section and an inner fitting end section that are fittable to each other are separately formed in the first pile and the second pile adjacent to each other in

an axial center direction. An engaging section and an engaged section, which are engaged with each other by rotating the inner fitting end section relative to the outer fitting end section around an axial center in a state where the inner fitting end section is inserted into the outer fitting end section, are formed in the outer fitting end section and the inner fitting end section.

In the joint structure for a steel pipe pile disclosed in this Patent Document 1, separation preventing means for preventing the engaging section and the engaged section from being separated from each other in a radial direction of the first pile or the second pile is provided in the engaging section and the engaged section.

[0005]

In the joint structure for a steel pipe pile disclosed in Patent Document 2, a pair of an outer fitting end section and an inner fitting end section that are fittable to each other are separately formed in the first pile and the second pile adjacent to each other in an axial center direction. A plurality of engaging protrusions and a plurality of engaged protrusions, which are engaged with each other by rotating the inner fitting end section around an axial center in a state where the inner fitting end section is inserted into the outer fitting end section, are formed in the axial center direction in the outer fitting end section and the inner fitting end section.

In the joint structure for a steel pipe pile disclosed in Patent Document 2, the outer fitting end section is formed so as to have a larger diameter in formation places of the engaging protrusions provided on a tip side than in formation places of the engaging protrusions provided on a base end side, and the inner fitting end section is formed so as to have a smaller diameter in formation places of the engaged protrusions provided on the tip side than in formation places of the engaged protrusions provided on the base end side.

Prior Art Document

Patent Document

[0006]

Patent Document 1: Japanese Unexamined Patent Application, First

Publication No. H11-43937

Patent Document 2: Japanese Unexamined Patent Application, First

Publication No. H11-43936

Disclosure of the Invention

Problems to be Solved by the Invention

[0007]

In the joint structure for a steel pipe pile, tensile forces transmitted from the engaging section and the engaging protrusions to the engaged section and the engaged protrusions decrease from the base end side of the outer fitting end section and the inner fitting end section toward the tip side thereof.

[0008]

However, in the joint structure for a steel pipe pile disclosed in Patent Document 1, the plate thickness of the engaged section is made the same in the axial center direction irrespective of decreases in tensile forces transmitted from the base end sides of the outer fitting end section and the inner fitting end section to the engaged section toward the tip side. For this reason, the joint structure for a steel pipe pile disclosed in Patent Document 1 has problems in that useless portions increase in the plate thickness of the outer fitting end section and the inner fitting end section on the tip side, and the plate thickness increases more than needed and causes a rise in cost.

[0009]

Meanwhile, in the joint structure for a steel pipe pile disclosed in Patent Document 2, as tensile forces transmitted from the base end sides of the outer fitting end section and the inner fitting end section to the engaged protrusions toward the tip side decrease, the plate thickness of the engaged protrusions is made gradually smaller from the base end side toward the tip side. However, in the joint structure for a steel pipe pile disclosed in this Patent Document 2, the compression yield strength of the engaged protrusions decreases on the tip sides of the outer fitting end section and the inner fitting end section. Thus, there are problems in that the plate thickness of the engaged protrusions becomes small on the tip sides of the outer fitting end section and the inner fitting end section and the engaged protrusions are buckled and deformed.

[0010]

The invention has been developed in view of the above-described problems, and an object thereof is to provide a joint structure for a steel pipe pile that can make the plate thicknesses of an outer fitting end section and an inner fitting end section on the tip side small, thereby suppressing an increase in material cost and simultaneously preventing buckling deformation of the thinnest part on a tip side.

Means for Solving the Problem

[0011]

An aspect of the invention is as follows.

(1) A first aspect of the invention is a joint structure for a steel pipe pile that coaxially couples a first steel pipe pile and a second steel pipe pile. The joint structure for a steel pipe pile includes an outer fitting end section that is provided in the first steel pipe pile and has a plurality of outer fitting stepped sections formed along an extending

direction of a first axial center of the first steel pipe pile; and an inner fitting end section that is provided in the second steel pipe pile and has a plurality of inner fitting stepped sections formed along an extending direction of a second axial center of the second steel pipe pile. Each of a plurality of outer fitting stepped sections includes a plurality of outer fitting peak sections that protrudes in a direction approaching the first axial center and are formed in a circumferential direction with the first axial center as a center; outer fitting groove sections that are formed between the outer fitting peak sections adjacent to each other; and an outer fitting valley section that is adjacent to the outer fitting peak sections and is formed on a base end side near the first steel pipe pile. Each of the plurality of inner fitting stepped sections includes a plurality of inner fitting peak sections that protrude in a direction separated from the second axial center and are formed in a circumferential direction with the second axial center as a center; inner fitting groove sections that are formed between the inner fitting peak sections adjacent to each other; and an inner fitting valley section that is adjacent to the inner fitting peak sections and is formed on the base end side close to the second steel pipe pile. In the plurality of outer fitting stepped sections, the outer fitting valley section is formed so that the plate thickness thereof increases the closer an outer fitting stepped section is to the first steel pipe pile. In the plurality of inner fitting stepped sections, the inner fitting valley section is formed so that the plate thickness thereof increases the closer an inner fitting stepped section is to the second steel pipe pile. In a state where the inner fitting end section is inserted into the outer fitting end section, rotated relative to the outer fitting end section, and fitted thereto, an inner fitting tip surface on a tip side of the inner fitting end section and a surface that faces the inner fitting tip surface are separated from each other by a predetermined separation distance D . The total area of tension-side abutting surfaces that are made to bear tensile forces among abutting

surfaces that abut against each other between the plurality of outer fitting stepped sections and the plurality of inner fitting stepped sections is equal to or smaller than the summed area of the area of an outer fitting tip surface on a tip side of the outer fitting end section that bears compressive forces and the total area of compression-side abutting surfaces that bear compressive forces.

(2) In the joint structure for a steel pipe pile described in the above (1), the total area of the tension-side abutting surfaces may be equal to or smaller than the total area of the compression-side abutting surfaces.

(3) In the joint structure for a steel pipe pile described in the above (1) or (2), in the inner fitting peak sections of the inner fitting stepped section closest to the tip side of the inner fitting end section, when a protruding height in a direction approaching the second axial center is defined as h and a length in an extending direction of the second axial center is defined as l , the predetermined separation distance D may be set so as to satisfy the following Expression (A).

$$D \geq (h^2 + l^2)^{0.5} - l \quad \text{Expression (A)}$$

(4) In the joint structure for a steel pipe pile described in any one of the above (1) to (3), either the protruding heights of the inner fitting peak sections in the plurality of inner fitting stepped sections or the protruding heights of the outer fitting peak sections in the plurality of outer fitting stepped sections may be approximately equal to each other.

(5) In the joint structure for a steel pipe pile described in any one of the above (1) to (4), the facing surface of the inner fitting tip surface may be an outer fitting base end surface on the base end side of the outer fitting end section.

(6) In the joint structure for a steel pipe pile described in any one of the above (1) to (4), the facing surface of the inner fitting tip surface may be an end surface

of the first steel pipe pile.

Effects of the Invention

[0012]

According to the joint structure for a steel pipe pile described in the above (1), there is provided a configuration in which, in the plurality of outer fitting stepped sections, the outer fitting valley section is formed so that the plate thickness thereof increases the closer an outer fitting stepped section is to the first steel pipe pile, and in the plurality of inner fitting stepped sections, the inner fitting valley section is formed so that the plate thickness thereof increases the closer an inner fitting stepped section is to the second steel pipe pile. Therefore, since the plate thickness in a region on the tip side with a smaller tensile force and a smaller compressive force to be transmitted compared to those on the base end side is rationally made small, an increase in material cost can be suppressed, and simultaneously, buckling deformation of an outer fitting thinnest section and an inner fitting thinnest section can be prevented.

Moreover, according to the joint structure for a steel pipe pile according to the above (1), in a state where the inner fitting end section is inserted into the outer fitting end section, coaxially rotated relative to the outer fitting end section, and fitted thereto, the inner fitting tip surface on the tip side of the inner fitting end section and the surface that faces the inner fitting tip surface are separated from each other by a predetermined separation distance D . Therefore, since the compressive forces from the facing surface can be prevented from being transmitted to the inner fitting tip surface, the buckling deformation of the inner fitting thinnest section that is apt to be deformed at the time of the action of the compressive forces can be prevented.

Moreover, according to the joint structure for a steel pipe pile described in the

above (1), the total area of the tension-side abutting surfaces that are made to bear tensile forces among the abutting surfaces that abut against each other between the plurality of outer fitting stepped sections and the plurality of inner fitting stepped sections is equal to or smaller than the summed area of the area of the outer fitting tip surface on the tip side of the outer fitting end section that bears the compressive forces and the total area of the compression-side abutting surfaces that bear the compressive forces. Therefore, even in a case where the outer fitting thinnest section is buckled and deformed and the compressive forces capable of being borne by the outer fitting tip surface become small, the compressive forces can be resisted by the compression-side abutting surfaces of the remaining stepped sections. For this reason, it is possible to maintain a predetermined compression yield strength in the entire outer fitting end section and the entire inner fitting end section.

According to the joint structure for a steel pipe pile described in the above (2), the total area of the tension-side abutting surfaces is equal to or smaller than the total area of the compression-side abutting surfaces.

Therefore, even in a case where the outer fitting thinnest section is buckled and deformed and the compressive forces cannot be borne by the outer fitting tip surface, the compressive forces can be resisted by the compression-side abutting surfaces of the remaining stepped sections. For this reason, it is possible to more reliably maintain the predetermined compression yield strength in the entire outer fitting end section and the entire inner fitting end section.

According to the joint structure for a steel pipe pile described in the above (3), the predetermined separation distance D is set so as to satisfy the following Expression (A). Therefore, even in a case where the joint structure for a steel pipe pile is bent and deformed, the compressive forces from the facing surface can be prevented from being

transmitted to the inner fitting tip surface. Therefore, the buckling deformation of the inner fitting thinnest section that is apt to deform at the time of the action of the compressive forces can be more reliably prevented.

According to the joint structure for a steel pipe pile described in the above (4), either the protruding heights of the inner fitting peak sections in the plurality of inner fitting stepped sections or the protruding heights of the outer fitting peak sections in the plurality of outer fitting stepped sections are approximately equal to each other. Therefore, the cutting workability of the inner fitting stepped sections and/or the outer fitting stepped sections is improved.

According to the joint structure for a steel pipe pile described in the above (5) or (6), a structural design can be adopted in which the facing surface of the inner fitting tip surface is the outer fitting base end surface on the base end side of the outer fitting end section or the end surface of the first steel pipe pile.

Brief Description of the Drawings

[0013]

FIG. 1 is a perspective view illustrating a joint structure of a steel pipe pile related to an embodiment of the invention.

FIG. 2 is a view illustrating an outer fitting end section of the joint structure, and is a sectional view as seen in a section including an axial center.

FIG. 3 is a view illustrating the outer fitting end section of the joint structure, and is a sectional perspective view of main parts.

FIG. 4 is a front view illustrating an inner fitting end section of the joint structure.

FIG. 5 is a view illustrating the inner fitting end section of the joint structure,

and is a sectional perspective view of main parts.

FIG. 6 is a perspective view illustrating a state where the inner fitting end section is inserted into the outer fitting end section of the joint structure.

FIG. 7 is a view illustrating a state after the inner fitting end section is inserted into the outer fitting end section of the joint structure and is relatively rotated, and is a perspective view in which a part is seen in a sectional view.

FIG. 8 is a partially sectional view illustrating the main parts of the joint structure.

FIG. 9 is a partially sectional view illustrating a first modification example of the joint structure.

FIG. 10 is a partially sectional view for illustrating a preferable lower limit of a separation distance D of the joint structure.

FIG. 11 is a partially sectional view illustrating a second modification example of the joint structure.

FIG. 12A is a bottom plan view illustrating the outer fitting end section of the joint structure.

FIG. 12B is a plan view illustrating the inner fitting end section of the joint structure.

FIG. 13A is a plan view illustrating the outer fitting end section of the joint structure.

FIG. 13B is a bottom plan view illustrating the inner fitting end section of the joint structure.

FIG. 14 is a sectional view of main parts illustrating tensile forces that act on the outer fitting end section of the joint structure.

FIG. 15 is a sectional view of main parts illustrating compressive forces that act

on the outer fitting end section of the joint structure.

FIG. 16 is a sectional view of main parts illustrating tensile forces that act on the inner fitting end section of the joint structure.

FIG. 17 is a sectional view of main parts illustrating compressive forces that act on the inner fitting end section of the joint structure.

FIG. 18A is a sectional view of main parts illustrating a third modification example of the joint structure.

FIG. 18B is a sectional view of main parts illustrating a fourth modification example of the joint structure.

FIG. 19 is a sectional view of main parts illustrating abutting surfaces of the outer fitting end section of the joint structure.

FIG. 20 is a sectional view of main parts illustrating abutting surfaces of the inner fitting end section of the joint structure.

Embodiments of the Invention

[0014]

Hereinafter, a joint structure 7 (hereinafter may be referred to as the joint structure 7 related to the present embodiment or simply as the joint structure 7) of a steel pipe pile related to an embodiment of the invention will be described in detail referring to the drawings.

In addition, in the following description, an axial center extending direction of the steel pipe pile may be referred to as an axial center direction Y, a direction orthogonal to the axial center direction Y may be referred to as an axial center orthogonal direction X, and a direction around the axial center of the steel pipe pile may be referred to as a circumferential direction W.

[0015]

In a foundation pile of a structure constructed on the ground or the like, the joint structure 7 related to the present embodiment, as illustrated in FIG. 1, is provided as a mechanical joint that couples a first steel pipe pile 1 having a first axial center and having a substantially circular section, and a second steel pipe pile 2 having a second axial center and having a substantially circular section coaxially (axial center direction Y).

[0016]

An outer fitting end section 3 in which a plurality of outer fitting stepped sections 4 are formed along the axial center direction Y is joined to an upper end section of the first steel pipe pile 1 by welding or the like. An inner fitting end section 5 in which a plurality of inner fitting stepped sections 6 are formed along the axial center direction Y is joined to a lower end section of the second steel pipe pile 2 by welding or the like. The outer fitting end section 3 and the inner fitting end section 5 have a mutually fittable structure.

[0017]

Each of the plurality of outer fitting stepped sections 4 formed in the outer fitting end section 3 has a plurality of outer fitting peak sections 31 that protrude in a direction approaching the axial center and are formed in the circumferential direction W, outer fitting groove sections 32 that are formed between the outer fitting peak sections 31 adjacent to each other in the circumferential direction W, and an outer fitting valley section 33 that is adjacent to the outer fitting peak sections 31 and is formed on a base end side close to the first steel pipe pile.

In each outer fitting stepped section 4, as illustrated in FIG. 1, it is preferable that the outer fitting groove sections 32 and the outer fitting valley section 33 are

formed with the same plate thickness so as to become flush with each other, from viewpoints of fittability and workability.

In the joint structure 7 related to the present embodiment, as illustrated in FIG. 1, four outer fitting peak sections 31 are formed at predetermined intervals in the circumferential direction W with respect to each of the plurality of outer fitting stepped sections 4. However, the invention is not limited to this structure only.

[0018]

Each of the plurality of inner fitting stepped sections 6 formed in the inner fitting end section 5 has a plurality of inner fitting peak sections 51 that protrude in a direction separated from the axial center and are formed in the circumferential direction W, inner fitting groove sections 52 that are formed between the inner fitting peak sections 51 adjacent to each other in the circumferential direction W, and an inner fitting valley section 53 that is adjacent to the inner fitting peak sections 51 and is formed on a base end side close to the second steel pipe pile.

In each inner fitting stepped section 6, as illustrated in FIG. 1, it is preferable that the inner fitting groove sections 52 and the inner fitting valley section 53 are formed with the same plate thickness so as to become flush with each other, from viewpoints of fittability and workability.

In the joint structure 7 related to the present embodiment, as illustrated in FIG. 1, four inner fitting peak sections 51 are formed at predetermined intervals in the circumferential direction W with respect to each of the plurality of inner fitting stepped sections 6. However, the invention is not limited to this structure only.

[0019]

Additionally, in the joint structure 7 related to the present embodiment, as illustrated in FIG. 1, four key grooves P for allowing rotation restraint keys for

restraining the relative rotation after fitting between the outer fitting end section 3 and the inner fitting end section 5 to be inserted therethrough are formed in the circumferential direction W. However, the key grooves may not be formed.

[0020]

In the joint structure 7 related to the present embodiment, as illustrated in FIG. 2, four-stage outer fitting stepped sections 4 are formed in the axial center direction Y of the outer fitting end section 3. That is, the outer fitting end section 3 has a first outer fitting stepped section 41, a second outer fitting stepped section 42, a third outer fitting stepped section 43, and a fourth outer fitting stepped section 44 in order from a tip side to a base end side in the axial center direction Y of the outer fitting end section 3.

[0021]

In each outer fitting stepped section 4, the plate thickness of the outer fitting groove sections 32 is made smaller than the plate thickness of the outer fitting peak sections 31, and the outer fitting peak section 31 and the outer fitting groove section 32 are alternately formed in the circumferential direction W. The outer fitting peak sections 31 of the plurality of outer fitting stepped sections 4 are arranged substantially in one row in the axial center direction Y.

Similarly, in the outer fitting stepped sections 4, the plate thickness of the outer fitting valley section 33 is made smaller than the plate thickness of the outer fitting peak sections 31, and the outer fitting peak sections 31 and the outer fitting valley sections 33 are alternately formed in the axial center direction Y.

[0022]

As illustrated in FIG. 3, the outer fitting valley section 33 is formed so that the plate thickness thereof increases the closer the outer fitting stepped sections 4 are to the base end side of the outer fitting end section 3.

That is, the plate thickness of the outer fitting valley section 33 of the first outer fitting stepped section 41 is smaller than the plate thickness of the outer fitting valley section 33 of the second outer fitting stepped section 42, the plate thickness of the outer fitting valley section 33 of the second outer fitting stepped section 42 is smaller than the plate thickness of the outer fitting valley section 33 of the third outer fitting stepped section 43, and the plate thickness of the outer fitting valley section 33 of the third outer fitting stepped section 43 is smaller than the plate thickness of the outer fitting valley section 33 of the fourth outer fitting stepped section 44.

[0023]

The outer fitting valley section 33 of the first outer fitting stepped section 41 is formed as an outer fitting thinnest section 30 with the smallest plate thickness in the outer fitting end section 3, and an outer fitting tip surface 34 is formed in a substantially planar shape on a tip side of an outer fitting peak section 31 of the first outer fitting stepped section 41 in the axial center direction Y.

Additionally, an outer fitting extra length section 45 is formed on a base end side of the outer fitting valley section 33 of the fourth outer fitting stepped section 44 in the axial center direction Y. An outer fitting base end surface 35 is formed on a tip side of the outer fitting extra length section 45 over its whole circumference.

[0024]

In the joint structure 7 related to the present embodiment, as illustrated in FIG. 4, four-stage inner fitting stepped sections 6 are formed in the axial center direction Y of the inner fitting end section 5. That is, the inner fitting end section 5 has a first inner fitting stepped section 61, a second inner fitting stepped section 62, a third inner fitting stepped section 63, and a fourth inner fitting stepped section 64 in order from the tip side to the base end side in the axial center direction Y of the inner fitting end section 5.

[0025]

In each inner fitting stepped section 6, the plate thickness of the inner fitting groove sections 52 is made smaller than the plate thickness of the inner fitting peak sections 51, and the inner fitting peak sections 51 and the inner fitting groove sections 52 are alternately formed in the circumferential direction W. The inner fitting peak sections 51 of the plurality of inner fitting stepped sections 6 are substantially arranged in one row in the axial center direction Y.

Similarly, in the inner fitting stepped sections 6, the plate thickness of the inner fitting valley section 53 is made smaller than the plate thickness of the inner fitting peak sections 51, and the inner fitting peak sections 51 and the inner fitting valley sections 53 are alternately formed in the axial center direction Y.

[0026]

As illustrated in FIG. 5, the inner fitting valley section 53 is formed so that the plate thickness thereof increases the closer the inner fitting stepped sections are to the base end side of the inner fitting end section 5.

That is, the plate thickness of the inner fitting valley section 53 of the first inner fitting stepped section 61 is smaller than the plate thickness of the inner fitting valley section 53 of the second inner fitting stepped section 62, the plate thickness of the inner fitting valley section 53 of the second inner fitting stepped section 62 is smaller than the plate thickness of the inner fitting valley section 53 of the third inner fitting stepped section 63, and the plate thickness of the inner fitting valley section 53 of the third inner fitting stepped section 63 is smaller than the plate thickness of the inner fitting valley section 53 of the fourth inner fitting stepped section 64.

[0027]

The inner fitting valley section 53 of the first inner fitting stepped section 61 is

formed as an inner fitting thinnest section 50 with a smallest plate thickness in the inner fitting end sections 5, and an inner fitting tip surface 54 is formed in a substantially planar shape on a tip side of the inner fitting peak section 51 of the first inner fitting stepped section 61 in the axial center direction Y.

Additionally, an inner fitting extra length section 65 is formed on a base end side of the inner fitting valley section 53 of the fourth inner fitting stepped section 64 in the axial center direction Y. An inner fitting base end surface 55 is formed on a tip side of the inner fitting extra length section 65 over its whole circumference.

[0028]

In the joint structure 7 related to the present embodiment, in order to coaxially couple the first steel pipe pile 1 and the second steel pipe pile 2, as illustrated in FIGS. 6 and 7, the outer fitting end section 3 and the inner fitting end section 5 are made to fit to each other. In addition, FIG. 7 is a perspective view illustrating a state where a portion of the outer fitting end section 3 is cut.

[0029]

Specifically, first, as illustrated in FIG. 6, the inner fitting end section 5 attached to the second steel pipe pile 2 is inserted into the outer fitting end section 3 attached to the first steel pipe pile 1. In each inner fitting stepped section 6, the height of the inner fitting peak sections 51 in the axial center orthogonal direction X is set to be equal to or smaller than the depth of the corresponding outer fitting groove sections 32 in the axial center orthogonal direction X at the time of fitting. This provides a structure in which the inner fitting peak sections 51 are capable of passing through the outer fitting groove sections 32.

[0030]

Next, as illustrated in FIG. 7, the first steel pipe pile 1 and the second steel pipe

pile 2 are rotated relative to each other in the circumferential direction W around the axial center in a state where the inner fitting end section 5 is inserted into the outer fitting end section 3. In each inner fitting stepped section 6, the depth of the inner fitting valley section 53 in the axial center orthogonal direction X is designed to be equal to or larger than the height of the corresponding outer fitting peak sections 31 in the axial center orthogonal direction X at the time of fitting. This provides a structure in which the outer fitting peak sections 31 are fittable to the inner fitting valley section 53.

[0031]

FIG. 8 is a schematic sectional view in a state where the inner fitting end section 5 of the joint structure 7 related to the present embodiment is inserted into the outer fitting end section 3 and is relatively rotated. As illustrated in FIG. 8, the joint structure 7 has an outer fitting facing section 36 in which the outer fitting tip surface 34 on the tip side of the outer fitting end section 3 and an inner fitting base end surface 55 on the base end side of the inner fitting end section 5 face each other, and an inner fitting facing section 56 in which the inner fitting tip surface 54 on the tip side of the inner fitting end section 5 and the outer fitting base end surface 35 on the base end side of the outer fitting end section 3 face each other.

[0032]

As illustrated in FIG. 8, in the outer fitting stepped sections 4 (the first outer fitting stepped section 41, the second outer fitting stepped section 42, and the third outer fitting stepped section 43) excluding the fourth outer fitting stepped section 44 and the inner fitting stepped sections 6 (the fourth inner fitting stepped section 64, the third inner fitting stepped section 63, and the second inner fitting stepped section 62) excluding the first inner fitting stepped section 61, the length of the inner fitting peak

sections 51 in the axial center direction Y is designed to be approximately equal to the length of the corresponding outer fitting valley section 33 in the axial center direction Y at the time of fitting, and the length of the outer fitting peak sections 31 in the axial center direction Y is designed to be approximately equal with the length of the corresponding inner fitting valley section 53 in the axial center direction Y at the time of fitting. Accordingly, it is possible to engage the outer fitting peak sections 31 and the inner fitting peak sections 51 with each other in the axial center direction Y.

[0033]

Meanwhile, in the fourth outer fitting stepped section 44 and the first inner fitting stepped section 61, as illustrated in FIG. 8, the length of the inner fitting peak sections 51 in the axial center direction Y is designed to be smaller than the length of the outer fitting valley section 33 in the axial center direction Y. Accordingly, the inner fitting tip surface 54 and the outer fitting base end surface 35 that is a facing surface of the inner fitting tip surface 54 are separated from each other by a predetermined separation distance D (mm) in the inner fitting facing section 56, and an inner fitting gap 57 is formed in the inner fitting facing section 56.

[0034]

FIG. 9 is a schematic sectional view illustrating a joint structure 107 of a steel pipe pile related to a first modification example of the invention. In the joint structure 107, the plate thickness of the outer fitting extra length section 45 is set so as to become equal to the plate thickness of the outer fitting valley section 33 of the fourth outer fitting stepped section 44. According to this structure, it is possible to reduce the material cost of the outer fitting end section 3, and it is possible to improve the cutting workability of the outer fitting valley section 33 to reduce the manufacturing cost of the outer fitting end section 3.

In the case of the joint structure 107, the facing surface of the inner fitting tip surface 54 is an end surface of the first steel pipe pile 1. Therefore, an inner fitting gap 157 is formed in the inner fitting facing section 56 by separating the inner fitting tip surface 54, and the end surface of the first steel pipe pile 1, which is a facing surface of the inner fitting facing section, by the predetermined separation distance D (mm) in the inner fitting facing section 56.

[0035]

By forming the inner fitting gaps 57 and 157, it is possible to avoid that compressive forces in the axial center direction Y are transmitted to the inner fitting tip surface 54. Therefore, it is possible to prevent buckling deformation of the inner fitting thinnest section 50.

[0036]

The separation distance D (mm) of the inner fitting gaps 57 and 157 may be more than 0 mm. However, in order to avoid that the compressive forces in the axial center direction Y are transmitted to the inner fitting tip surface 54 even in a case where a steel pipe pile is bent and deformed, it is preferable to set the separation distance D (mm) so as to satisfy the following Expression (1).

[0037]

$$D \geq (h^2 + l^2)^{0.5} - l \quad \text{Expression (1)}$$

h (mm): Protruding height, in direction approaching axial center, of inner fitting peak section in inner fitting stepped section closest to tip side of inner fitting end section

l (mm): Length, in extending direction of axial center, of inner fitting peak section in inner fitting stepped section closest to tip side of inner fitting end section

[0038]

The above Expression (1), as illustrated in FIG. 10, is an expression derived by supposing bending deformation having a connection point between the inner fitting thinnest section 50 and the inner fitting peak section 51 having a bending center point C. That is, by setting the separation distance D (mm) so as to satisfy the above Expression (1), even in a case where a steel pipe pile is bent and deformed, it is possible to reliably avoid that the inner fitting tip surface 54 contacts the facing surface thereof.

[0039]

FIG. 11 is a sectional view of main parts illustrating a joint structure 207 related to a second modification example of the invention. In the joint structure 207, similar to the inner fitting facing section 56, the outer fitting gap 37 is also formed in the outer fitting facing section 36. According to this structure, it is possible to avoid that the compressive forces in the axial center direction Y are transmitted to the outer fitting tip surface 34, and it is possible to prevent buckling deformation of the outer fitting thinnest section 30. Although illustration is omitted, the plate thickness of the inner fitting extra length section 65 may be set so as to become equal to the plate thickness of the inner fitting valley section 53 of the fourth inner fitting stepped section 64. In that case, the facing surface of the outer fitting tip surface 34 is an end surface of the second steel pipe pile 2. Additionally, the separation distance D' (mm) of the outer fitting gap 37 may be more than 0 mm, and may be set so as to satisfy the following Expression (2).

[0040]

$$D' \geq (h'^2 + l'^2)^{0.5} - l' \quad \text{Expression (2)}$$

h' (mm): Protruding height, in direction approaching axial center, of outer fitting peak section in outer fitting stepped section closest to tip side of outer fitting end section

l' (mm): Length, in extending direction of axial center, of outer fitting peak section in outer fitting stepped section closest to tip side of outer fitting end section

[0041]

However, buckling deformation more easily occurs on the inner fitting facing section 56 side than on the outer fitting facing section 36 side due to the eccentricity from a steel-pipe part at the time of the action of the compressive forces. Therefore, a buckling deformation prevention effect obtained by providing the outer fitting gap 37 is smaller than a buckling deformation prevention effect obtained by providing the inner fitting gap 57.

[0042]

Next, abutting surfaces 8 of the joint structure 7 related to the present embodiment will be described.

In the joint structure 7 related to the present embodiment, the abutting surfaces 8 on which the outer fitting peak sections 31 and the inner fitting peak sections 51 abut each other in the axial center direction Y are formed in the outer fitting stepped sections 4 and the inner fitting stepped sections 6 by inserting the inner fitting end section 5 into the outer fitting end section 3 and rotating the inner fitting end section 5 relative to the outer fitting end section 3.

[0043]

When tensile forces and compressive forces act on the outer fitting end section 3 and the inner fitting end section 5 in the axial center direction Y from the first steel pipe pile 1 and the second steel pipe pile 2, in a state where the first steel pipe pile 1 and the second steel pipe pile 2 are coupled together, the outer fitting peak sections 31 and the inner fitting peak sections 51 resist the tensile forces and the compressive forces that act in the axial center direction Y, on the abutting surfaces 8 in the axial center direction

Y.

[0044]

In the joint structure 7 related to the present embodiment, as illustrated in FIGS. 12A and 12B, the base end side of the outer fitting end section 3 and the base end side of the inner fitting end section 5 among the abutting surfaces 8 on which the outer fitting peak sections 31 and the inner fitting peak sections 51 abut each other in the outer fitting stepped sections 4 and the inner fitting stepped sections 6 are tension-side abutting surfaces 81 that are made to bear the tensile forces.

[0045]

As illustrated in FIG. 12A and FIG. 12B, the outer fitting peak sections 31 of the first outer fitting stepped section 41 and the inner fitting peak sections 51 of the fourth inner fitting stepped section 64 have tension area At1 on the tension-side abutting surfaces 81, the outer fitting peak sections 31 of the second outer fitting stepped section 42 and the inner fitting peak sections 51 of the third inner fitting stepped section 63 have tension area At2 on the tension-side abutting surfaces 81, the outer fitting peak sections 31 of the third outer fitting stepped section 43 and the inner fitting peak sections 51 of the second inner fitting stepped section 62 have tension area At3 on the tension-side abutting surfaces 81, and the outer fitting peak sections 31 of the fourth outer fitting stepped section 44 and the inner fitting peak sections 51 of the first inner fitting stepped section 61 have tension area At4 on the tension-side abutting surfaces 81.

[0046]

Additionally, in the joint structure 7 related to the present embodiment, as illustrated in FIGS. 13A and 13B, the tip side of the outer fitting end section 3 and the tip side of the inner fitting end section 5 among the abutting surfaces 8 on which the outer fitting peak sections 31 and the inner fitting peak sections 51 abut each other in the outer fitting

stepped sections 4 and the inner fitting stepped sections 6 are compression-side abutting surfaces 86 that are made to bear the compressive forces.

[0047]

As illustrated in FIGS. 13A and 13B, the outer fitting peak sections 31 of the second outer fitting stepped section 42 and the inner fitting peak sections 51 of the fourth inner fitting stepped section 64 have compression area Ac1 on the compression-side abutting surfaces 86, the outer fitting peak sections 31 of the third outer fitting stepped section 43 and the inner fitting peak sections 51 of the third inner fitting stepped section 63 have compression area Ac2 on the compression-side abutting surfaces 86, and the outer fitting peak sections 31 of the fourth outer fitting stepped section 44 and the inner fitting peak sections 51 of the second inner fitting stepped section 62 have compression area Ac3 on the compression-side abutting surfaces 86.

[0048]

In the joint structure 7 related to the present embodiment, there is provided a structure in which the outer fitting tip surface 34 and the inner fitting base end surface 55 abut each other in the outer fitting facing section 36, and the inner fitting tip surface 54 and the outer fitting base end surface 35 do not abut against each other in the inner fitting facing section 56.

Therefore, in the joint structure 7 related to the present embodiment,

(A) the tensile forces that act in the axial center direction Y are resisted by only four tension-side abutting surfaces 81 on which the outer fitting peak sections 31 and the inner fitting peak sections 51 abut each other, and

(B) the compressive forces that act in the axial center direction Y is resisted by only the outer fitting tip surface 34 on the tip side of the outer fitting end section 3 and three compression-side abutting surfaces 86 on which the outer fitting peak sections 31

and the inner fitting peak sections 51 abut against each other.

[0049]

In addition, as in the joint structure 207 (FIG. 11) related to the above-described second modification example, when there is provided a structure in which the outer fitting gap 37 is also formed in the outer fitting facing section 36, similar to the inner fitting facing section 56, in the joint structure 207,

(A') the tensile forces that act in the axial center direction Y is resisted by only four tension-side abutting surfaces 81 on which the outer fitting peak sections 31 and the inner fitting peak sections 51 abut each other, and

(B') the compressive forces that act in the axial center direction Y is resisted by only three compression-side abutting surfaces 86 on which the outer fitting peak sections 31 and the inner fitting peak sections 51 abut each other.

[0050]

The total area ($At1 + At2 + At3 + At4$) of the tension-side abutting surfaces 81 that are made to bear the tensile forces among the abutting surfaces 8 on which the outer fitting stepped sections 4 and the inner fitting stepped sections 6 abut each other is made to be equal to or smaller than the summed area of the area (0 in the case of the joint structure 207 related to the second modification example) of the outer fitting tip surface 34 that are made to bear the compressive forces, and the total area ($Ac1 + Ac2 + Ac3$) of the compression-side abutting surfaces 86 that are made to bear the compressive forces.

[0051]

Additionally, it is preferable that the total area ($At1 + At2 + At3 + At4$) of the tension-side abutting surfaces 81 that are made to bear the tensile forces among the abutting surfaces 8 on which the outer fitting stepped sections 4 and the inner fitting stepped sections 6 abut each other is made to be equal to or smaller than the total area

($A_{c1} + A_{c2} + A_{c3}$) of the compression-side abutting surfaces 86 that are made to bear the compressive forces.

[0052]

In this way, in the joint structure 7 related to the present embodiment, irrespective of the number of stages in which the compression-side abutting surfaces 86 are formed being made to be smaller than the number of stages in which the tension-side abutting surfaces 81 are formed, the abutting surfaces 8 on which the outer fitting peak sections 31 and the inner fitting peak sections 51 abut against each other are formed so that the total area of the tension-side abutting surfaces 81 is equal to or smaller than the summed area of the area of the outer fitting tip surface 34 that is made to bear the compressive forces, and the total area of the compression-side abutting surfaces 86.

[0053]

In addition, when the key grooves P for allowing the rotation restraint keys for restraining the relative rotation of the outer fitting end section 3 and the inner fitting end section 5 after fitting to be inserted therein are formed in the outer fitting tip surface 34, the "area of the outer fitting tip surface 34 that are made to bear the compressive forces" does not include the area of places where the key grooves are formed. This is because the rotation restraint keys do not bear the compressive forces basically.

[0054]

In the joint structure 7 related to the present embodiment, by setting the summed area of the area of the outer fitting tip surface 34 that is made to bear the compressive forces and the total area of the compression-side abutting surfaces 86 to be equal to or more than the total area of the tension-side abutting surfaces 81, the compressive forces that act with magnitudes equal to or more than the tensile forces in

the axial center direction Y can be resisted by only the outer fitting tip surface and the compression-side abutting surfaces 86 of the outer fitting peak sections 31 and the inner fitting peak sections 51. Additionally, when the total area of the compression-side abutting surfaces 86 is set to be equal to or more than the total area of the tension-side abutting surfaces 81, the compressive forces that act with magnitudes equal to or more than the tensile forces in the axial center direction Y can be resisted by only the compression-side abutting surfaces 86 of the outer fitting peak sections 31 and the inner fitting peak sections 51.

[0055]

In the joint structure 7 related to the present embodiment, even if the outer fitting tip surface 34 and the inner fitting base end surface 55 abut against each other in the outer fitting facing section 36, the compressive forces substantially do not act on the outer fitting peak sections 31 of the first outer fitting stepped section 41, it is not necessary to take into consideration the compressive forces that act on the outer fitting peak sections 31 of the first outer fitting stepped section 41 in terms of design.

[0056]

Tensile forces transmitted to the outer fitting end section 3 of the joint structure 7 related to the present embodiment are illustrated in FIG. 14.

A tensile force that acts on the outer fitting peak sections 31 of the first outer fitting stepped section 41 is transmitted to the outer fitting valley section 33 of the first outer fitting stepped section 41. Tensile forces that act on the outer fitting peak sections 31 of the first outer fitting stepped section 41 and the second outer fitting stepped section 42 are put together and transmitted to the outer fitting valley section 33 of the second outer fitting stepped section 42. Tensile forces that act on the outer fitting peak sections 31 of the first outer fitting stepped section 41, the second outer

fitting stepped section 42, and the third outer fitting stepped section 43 are put together and transmitted to the outer fitting valley section 33 of the third outer fitting stepped section 43. Tensile forces that act on the outer fitting peak sections 31 of the first outer fitting stepped section 41, the second outer fitting stepped section 42, the third outer fitting stepped section 43, and the fourth outer fitting stepped section 44 are put together and transmitted to the outer fitting valley section 33 of the fourth outer fitting stepped section 44.

[0057]

Similarly, compressive forces transmitted in the outer fitting end section 3 of the joint structure 7 related to the present embodiment is illustrated in FIG. 15.

A compressive force that acts on the outer fitting peak sections 31 of the second outer fitting stepped section 42 is transmitted to the outer fitting valley section 33 of the second outer fitting stepped section 42. Compressive forces that act on the outer fitting peak sections 31 of the second outer fitting stepped section 42 and the third outer fitting stepped section 43 are put together and transmitted to the outer fitting valley section 33 of the third outer fitting stepped section 43. Compressive forces that act on the outer fitting peak sections 31 of the second outer fitting stepped section 42, the third outer fitting stepped section 43, and the fourth outer fitting stepped section 44 are put together and transmitted to the outer fitting valley section 33 of the fourth outer fitting stepped section 44.

[0058]

In this way, in the joint structure 7 related to the present embodiment, the tensile forces and the compressive forces that are transmitted from the outer fitting peak sections 31 to the outer fitting valley sections 33 decrease from the base end side of the outer fitting end section 3 toward the tip side thereof. Therefore, even if the plate

thickness of the outer fitting valley section 33 is made small on the tip side of the outer fitting end section 3, the tensile forces and the compressive forces can be resisted.

Accordingly, by making the plate thickness of the outer fitting valley section 33 small from the base end side of the outer fitting end section 3 toward the tip side thereof to suppress an increase in the plate thickness of the entire outer fitting end section 3, it is possible to suppress an increase in material cost.

[0059]

In the joint structure 7 related to the present embodiment, by making the plate thickness of the outer fitting valley section 33 small in the first outer fitting stepped section 41 on the tip side of the outer fitting end section 3 to suppress an increase in material cost of the outer fitting end section 3, and simultaneously preventing the compressive force from acting on the outer fitting peak sections 31 of the first outer fitting stepped section 41 as much as possible, the compressive force is not substantially transmitted to the outer fitting valley section 33 in the first outer fitting stepped section 41. As a result, it is possible to prevent the buckling deformation of the outer fitting thinnest section 30.

[0060]

Additionally, in the joint structure 7 related to the present embodiment, even if the compressive force acts on the outer fitting peak sections 31 of the first outer fitting stepped section 41, compression yield strength is not expected from the outer fitting valley section 33 of the first outer fitting stepped section 41. For this reason, in the joint structure 7, even if the outer fitting thinnest section 30 is buckled and deformed due to the compressive force transmitted to the outer fitting valley section 33 of the first outer fitting stepped section 41, the compressive force can be resisted by the outer fitting valley sections 33 of the second outer fitting stepped section 42, the third outer

fitting stepped section 43, and the fourth outer fitting stepped section 44. Therefore, it is possible to maintain predetermined compression yield strength in the whole outer fitting end section 3.

[0061]

Tensile forces transmitted to the inner fitting end section 5 of the joint structure 7 related to the present embodiment are illustrated in FIG. 16.

A tensile force that acts on the inner fitting peak sections 51 of the first inner fitting stepped section 61 is transmitted to the inner fitting valley section 53 of the first inner fitting stepped section 61. Tensile forces that act on the inner fitting peak sections 51 of the first inner fitting stepped section 61 and the second inner fitting stepped section 62 are put together and transmitted to the inner fitting valley section 53 of the second inner fitting stepped section 62. Tensile forces that act on the inner fitting peak sections 51 of the first inner fitting stepped section 61, the second inner fitting stepped section 62, and the third inner fitting stepped section 63 are put together and transmitted to the inner fitting valley section 53 of the third inner fitting stepped section 63. Tensile forces that act on the inner fitting peak sections 51 of the first inner fitting stepped section 61, the second inner fitting stepped section 62, the third inner fitting stepped section 63, and the fourth inner fitting stepped section 64 are put together and transmitted to the inner fitting valley section 53 of the fourth inner fitting stepped section 64.

[0062]

Similarly, compressive forces transmitted in the inner fitting end section 5 of the joint structure 7 related to the present embodiment is illustrated in FIG. 17.

A compressive force that acts on the inner fitting peak sections 51 of the second inner fitting stepped section 62 is transmitted to the inner fitting valley section

53 of the second inner fitting stepped section 62. Compressive forces that act on the inner fitting peak section 51 of the second inner fitting stepped section 62 and the third inner fitting stepped section 63 are put together and transmitted to the inner fitting valley section 53 of the third inner fitting stepped section 63. Compressive forces that act on the inner fitting peak sections 51 of the second inner fitting stepped section 62, the third inner fitting stepped section 63, and the fourth inner fitting stepped section 64 are put together and transmitted to the inner fitting valley section 53 of the fourth inner fitting stepped section 64.

[0063]

In this way, in the joint structure 7 related to the present embodiment, the tensile forces and the compressive forces that are transmitted from the inner fitting peak sections 51 to the inner fitting valley section 53 decrease from the base end side of the inner fitting end section 5 toward the tip side thereof. Thus, even if the plate thickness of the inner fitting valley section 53 is made small on the tip side of the inner fitting end section 5, the tensile forces and the compressive forces can be resisted. Accordingly, in the joint structure 7, by making the plate thickness of the inner fitting valley section 53 small from the base end side of the inner fitting end section 5 toward the tip side thereof to suppress an increase in the plate thickness of the entire inner fitting end section 5, it is possible to suppress an increase in material cost.

[0064]

In the joint structure 7, by making the plate thickness of the inner fitting valley section 53 small in the first inner fitting stepped section 61 on the tip side of the inner fitting end section 5 to suppress an increase in material cost of the inner fitting end section 5, and simultaneously, preventing the compressive force from acting on the inner fitting peak sections 51 of the first inner fitting stepped section 61, using the inner

fitting gap 57, the compressive force is not transmitted to the inner fitting valley section 53 in the first inner fitting stepped section 61. As a result, it is possible to prevent the buckling deformation of the inner fitting thinnest section 50.

[0065]

FIG. 18A illustrates a joint structure 307 related to a third modification example of the invention. As in the joint structure 307, tapers may be provided on side surfaces, in the axial center orthogonal direction X, of the outer fitting valley sections 33 and the inner fitting peak sections 51 in all or some of the plurality of outer fitting stepped sections 4 and inner fitting stepped sections 6.

[0066]

FIG. 18B illustrates a joint structure 407 related to a fourth modification example of the invention. As in the joint structure 407, tapers may be provided on side surfaces, in the axial center orthogonal direction X, of the inner fitting valley sections 53 and the outer fitting peak sections 31 in all or some of the plurality of outer fitting stepped sections 4 and inner fitting stepped sections 6.

[0067]

In the joint structure 7 related to the present embodiment, as illustrated in FIG. 19, the outer fitting peak sections 31 of each outer fitting stepped section 4 is arranged on the inside in the axial center orthogonal direction X from the tip side of the outer fitting end section 3 toward the base end side thereof.

In the joint structure 7 related to the present embodiment, when a radius from the central axis to the outer fitting peak sections 31 of the first outer fitting stepped section 41 is defined as r_{41} , a radius from the central axis to the outer fitting peak sections 31 of the second outer fitting stepped section 42 is defined as r_{42} , a radius from the central axis to the outer fitting peak sections 31 of the third outer fitting stepped

section 43 is defined as r_{43} , and a radius from the central axis to the outer fitting peak sections 31 of the fourth outer fitting stepped section 44 is defined as r_{44} , the relationship, $r_{41} > r_{42} > r_{43} > r_{44}$, is satisfied.

[0068]

Moreover, in the joint structure 7 related to the present embodiment, as illustrated in FIG. 19, when a height on the base end side of the outer fitting end section 3 in the outer fitting peak sections 31 of the first outer fitting stepped section 41 is defined as ht_1 , a height on the base end side of the outer fitting end section 3 in the outer fitting peak sections 31 of the second outer fitting stepped section 42 is defined as ht_2 , a height on the base end side of the outer fitting end section 3 in the outer fitting peak sections 31 of the third outer fitting stepped section 43 is defined as ht_3 , and a height on the base end side of the outer fitting end section 3 in the outer fitting peak sections 31 of the fourth outer fitting stepped section 44 is defined as ht_4 , the relationship, $ht_1 \leq ht_2 \leq ht_3 \leq ht_4$, is satisfied.

[0069]

Here, the heights of the outer fitting peak sections 31 may be set to be approximately equal to each other so that the relationship, $ht_1 = ht_2 = ht_3 = ht_4$, is satisfied.

This case is preferable from the viewpoint of the cutting workability of the outer fitting peak sections 31.

[0070]

Additionally, by setting the heights of the outer fitting peak sections 31 so that the relationship, $ht_1 < ht_2 < ht_3 < ht_4$, is satisfied so as to follow the relationship, $r_{41} > r_{42} > r_{43} > r_{44}$, in the outer fitting peak sections 31 of the outer fitting stepped sections 4, tension area At_1 , tension area At_2 , tension area At_3 , and tension area At_4 may be

made approximately equal to each other.

[0071]

Similarly, in the joint structure 7 related to the present embodiment, as illustrated in FIG. 19, when a height on the tip side of the outer fitting end section 3 in the outer fitting peak sections 31 of the second outer fitting stepped section 42 is defined as $hc1$, a height on the base end side of the outer fitting end section 3 in the outer fitting peak sections 31 of the third outer fitting stepped section 43 is defined as $hc2$, and a height on the base end side of the outer fitting end section 3 in the outer fitting peak sections 31 of the fourth outer fitting stepped section 44 is defined as $hc3$, the relationship, $hc1 \leq hc2 \leq hc3$, is satisfied.

[0072]

Here, the heights of the outer fitting peak sections 31 may be set to be approximately equal to each other so that the relationship, $hc1 = hc2 = hc3$, is satisfied.

This case is preferable from the viewpoint of the cutting workability of the outer fitting peak sections 31.

[0073]

Additionally, by setting the heights of the outer fitting peak sections 31 so that the relationship, $hc1 < hc2 < hc3$, is satisfied so as to follow the relationship, $r41 > r42 > r43 > r44$, in the outer fitting peak sections 31 of the outer fitting stepped sections 4, compression area $Ac1$, compression area $Ac2$, and compression area $Ac3$ may be made approximately equal to each other.

[0074]

In the joint structure 7 related to the present embodiment, as illustrated in FIG. 20, the inner fitting peak sections 51 of each inner fitting stepped section 6 is arranged on the outside in the axial center orthogonal direction X from the tip side of the inner

fitting end section 5 toward the base end side thereof.

In the joint structure 7 related to the present embodiment, when a radius from the central axis to the inner fitting peak sections 51 of the first inner fitting stepped section 61 is defined as $r61$, a radius from the central axis to the inner fitting peak sections 51 of the second inner fitting stepped section 62 is defined as $r62$, a radius from the central axis to the inner fitting peak sections 51 of the third inner fitting stepped section 63 is defined as $r63$, and a radius from the central axis to the inner fitting peak sections 51 of the fourth inner fitting stepped section 64 is defined as $r64$, the relationship, $r61 < r62 < r63 < r64$, is satisfied.

[0075]

Moreover, in the joint structure 7 related to the present embodiment, as illustrated in FIG. 20, when a height on the base end side of the inner fitting end section 5 in the inner fitting peak sections 51 of the fourth inner fitting stepped section 64 is defined as $ht1$, a height on the base end side of the inner fitting end section 5 in the inner fitting peak sections 51 of the third inner fitting stepped section 63 is defined as $ht2$, a height on the base end side of the inner fitting end section 5 in the inner fitting peak sections 51 of the second inner fitting stepped section 62 is defined as $ht3$, and a height on the base end side of the inner fitting end section 5 in the inner fitting peak sections 51 of the first inner fitting stepped section 61 is defined as $ht4$, the relationship, $ht1 \geq ht2 \geq ht3 \geq ht4$, is satisfied.

[0076]

Here, the heights of the inner fitting peak sections 51 may be set to be approximately equal to each other so that the relationship, $ht1 = ht2 = ht3 = ht4$, is satisfied. This case is preferable from the viewpoint of the cutting workability of the inner fitting peak sections 51.

[0077]

Additionally, by setting the heights of the inner fitting peak sections 51 so that the relationship, $ht1 < ht2 < ht3 < ht4$, is satisfied so as to follow the relationship, $r61 < r62 < r63 < r64$, in the inner fitting peak sections 51 of the inner fitting stepped sections 6, the tension area At1, the tension area At2, the tension area At3, and the tension area At4 may be made approximately equal to each other.

[0078]

Similarly, in the joint structure 7 related to the present embodiment, as illustrated in FIG. 20, when a height on the tip side of the inner fitting end section 5 in the inner fitting peak sections 51 of the fourth inner fitting stepped section 64 is defined as $hc1$, a height on the base end side of the inner fitting end section 5 in the inner fitting peak sections 51 of the third inner fitting stepped section 63 is defined as $hc2$, and a height on the base end side of the inner fitting end section 5 in the inner fitting peak sections 51 of the second inner fitting stepped section 62 is defined as $hc3$, the relationship, $hc1 \geq hc2 \geq hc3$, is satisfied.

[0079]

Here, the heights of the inner fitting peak sections 51 may be set to be approximately equal to each other so that the relationship, $hc1 = hc2 = hc3$, is satisfied. This case is preferable from the viewpoint of the cutting workability of the inner fitting peak sections 51.

[0080]

Additionally, by setting the heights of the inner fitting peak section 51 so that the relationship, $hc1 < hc2 < hc3$, is satisfied so as to follow the relationship, $r61 < r62 < r63 < r64$, in the inner fitting peak sections 51 of each inner fitting stepped section 6, the compression area Ac1, the compression area Ac2, and the compression area Ac3

may be made approximately equal to each other.

[0081]

In addition, when the tension area $At1$, the tension area $At2$, the tension area $At3$, and the tension area $At4$ are set to be approximately equal to each other, the tensile forces that act in the axial center direction Y can be substantially equally resisted in the outer fitting peak sections 31 and the inner fitting peak sections 51 of each outer fitting stepped section 4 and each inner fitting stepped section 6.

Additionally, since the compression area $Ac1$, the compression area $Ac2$, and the compression area $Ac3$ are set to be approximately equal to each other, the compressive forces that act in the axial center direction Y can be substantially equally resisted in the outer fitting peak sections 31 and the inner fitting peak sections 51 of each outer fitting stepped section 4 and each inner fitting stepped section 6.

Accordingly, in the joint structure 7, the tensile forces and the compressive forces that act in the axial center direction Y can be approximately equally resisted in the outer fitting peak sections 31 and the inner fitting peak sections 51 of each outer fitting stepped section 4 and each inner fitting stepped section 6. Therefore, it is possible to reduce the futility of the outer fitting end section 3 and the inner fitting end section 5 in terms of structural resistance to facilitate structural calculation on the tensile forces and the compressive forces.

[0082]

In the joint structure 7 related to the present invention, as described above, either the protruding heights of the inner fitting peak sections in the plurality of inner fitting stepped sections or the protruding heights of the outer fitting peak sections in the plurality of outer fitting stepped sections may be approximately equal to each other.

The "approximately equal" in the present invention allows manufacturing

errors or the like of about 20%, and even if these manufacturing errors or the like have occurred in the outer fitting peak sections 31 and the inner fitting peak sections 51, the areas shall be set to be approximately equal to each other.

[0083]

Although the embodiments of the invention have been described above in detail, all of the above-described embodiments merely illustrate examples of embodiment in carrying out the invention, and the technical scope of the invention should not be interpreted in a limited way by these embodiments.

[0084]

For example, the inner fitting end section 5 may be attached to the first steel pipe pile 1, and the outer fitting end section 3 may be attached to the second steel pipe pile 2.

Additionally, the outer fitting stepped sections 4 and the inner fitting stepped sections 6 may be formed in an arbitrary number of stages in the axial center direction Y of the outer fitting end section 3 and the inner fitting end section 5.

Additionally, in the outer fitting stepped sections 4 and the inner fitting stepped sections 6, the outer fitting peak sections 31 and the inner fitting peak sections 51 may be substantially alternately arranged such that the positions thereof in the axial center direction Y are shifted from each other.

Additionally, by cutting the end section of the first steel pipe pile 1 or the second steel pipe pile 2, the outer fitting end section 3 or the inner fitting end section 5 may be provided in the first steel pipe pile 1 or the second steel pipe pile 2 itself.

Industrial Applicability

[0085]

According to the invention, it is possible to provide the joint structure for a steel pipe pile that can make the plate thicknesses of the outer fitting end section and the inner fitting end section on the tip side made, thereby suppressing an increase in material cost and simultaneously preventing the buckling deformation of the thinnest part on the tip side.

Brief Description of the Reference Symbols

[0086]

- 1: FIRST STEEL PIPE PILE
- 2: SECOND STEEL PIPE PILE
- 3: OUTER FITTING END SECTION
- 30: OUTER FITTING THINNEST SECTION
- 31: OUTER FITTING PEAK SECTION
- 32: OUTER FITTING GROOVE SECTION
- 33: OUTER FITTING VALLEY SECTION
- 34: OUTER FITTING TIP SURFACE
- 35: OUTER FITTING BASE END SURFACE
- 36: OUTER FITTING FACING SECTION
- 37: OUTER FITTING GAP
- 4: OUTER FITTING STEPPED SECTION
- 41: FIRST OUTER FITTING STEPPED SECTION
- 42: SECOND OUTER FITTING STEPPED SECTION
- 43: THIRD OUTER FITTING STEPPED SECTION
- 44: FOURTH OUTER FITTING STEPPED SECTION
- 45: OUTER FITTING EXTRA LENGTH SECTION

- 5: INNER FITTING END SECTION
- 50: INNER FITTING THINNEST SECTION
- 51: INNER FITTING PEAK SECTION
- 52: INNER FITTING GROOVE SECTION
- 53: INNER FITTING VALLEY SECTION
- 54: INNER FITTING TIP SURFACE
- 55: INNER FITTING BASE END SURFACE
- 56: INNER FITTING FACING SECTION
- 57, 157: INNER FITTING GAP
- 6: INNER FITTING STEPPED SECTION
- 61: FIRST INNER FITTING STEPPED SECTION
- 62: SECOND INNER FITTING STEPPED SECTION
- 63: THIRD INNER FITTING STEPPED SECTION
- 64: FOURTH INNER FITTING STEPPED SECTION
- 65: INNER FITTING EXTRA LENGTH SECTION
- 7, 107, 207, 307, 407: JOINT STRUCTURE FOR STEEL PIPE PILE
- 8: ABUTTING SURFACE
- 81: TENSION-SIDE ABUTTING SURFACE
- 86: COMPRESSION-SIDE ABUTTING SURFACE
- P: KEY GROOVE
- W: CIRCUMFERENTIAL DIRECTION
- X: AXIAL CENTER ORTHOGONAL DIRECTION
- Y: AXIAL CENTER DIRECTION

CLAIMS

1. A joint structure for a steel pipe pile that coaxially couples a first steel pipe pile and a second steel pipe pile, the joint structure for a steel pipe pile comprising:

an outer fitting end section that is provided in the first steel pipe pile and has a plurality of outer fitting stepped sections formed along an extending direction of a first axial center of the first steel pipe pile; and

an inner fitting end section that is provided in the second steel pipe pile and has a plurality of inner fitting stepped sections formed along an extending direction of a second axial center of the second steel pipe pile,

wherein each of a plurality of outer fitting stepped sections includes:

a plurality of outer fitting peak sections that protrudes in a direction approaching the first axial center and is formed in a circumferential direction with the first axial center as a center;

outer fitting groove sections that are formed between the outer fitting peak sections adjacent to each other; and

an outer fitting valley section that is adjacent to the outer fitting peak sections and is formed on a base end side near the first steel pipe pile,

wherein each of the plurality of inner fitting stepped sections includes:

a plurality of inner fitting peak sections that protrudes in a direction separated from the second axial center and is formed in a circumferential direction with the second axial center as a center;

inner fitting groove sections that are formed between the inner fitting peak sections adjacent to each other; and

an inner fitting valley section that is adjacent to the inner fitting peak sections

and is formed on the base end side close to the second steel pipe pile,

wherein in the plurality of outer fitting stepped sections, the outer fitting valley section is formed so that the plate thickness thereof increases the closer an outer fitting stepped section is to the first steel pipe pile,

wherein in the plurality of inner fitting stepped sections, the inner fitting valley section is formed so that the plate thickness thereof increases the closer an inner fitting stepped section is to the second steel pipe pile,

wherein in a state where the inner fitting end section is inserted into the outer fitting end section, rotated relative to the outer fitting end section, and fitted thereto, an inner fitting tip surface on a tip side of the inner fitting end section and a surface that faces the inner fitting tip surface are separated from each other by a predetermined separation distance D,

wherein the total area of tension-side abutting surfaces that are made to bear tensile forces among abutting surfaces that abut against each other between the plurality of outer fitting stepped sections and the plurality of inner fitting stepped sections is equal to or smaller than the summed area of the area of an outer fitting tip surface on a tip side of the outer fitting end section that bears compressive forces and the total area of compression-side abutting surfaces that bear compressive forces, and

wherein in the inner fitting peak sections of the inner fitting stepped section closest to the tip side of the inner fitting end section, when a protruding height in a direction approaching the second axial center is defined as h (mm) and a length in an extending direction of the second axial center is defined as l (mm), the predetermined separation distance D (mm) is set so as to satisfy the following Expression (1).

$$D \geq (h^2 + l^2)^{0.5} - 1 \quad \text{Expression (1)}$$

2. The joint structure for a steel pipe pile according to Claim 1,
wherein the total area of the tension-side abutting surfaces is equal to or smaller than the total area of the compression-side abutting surfaces.
3. The joint structure for a steel pipe pile according to Claim 1,
wherein either the protruding heights of the inner fitting peak sections in the plurality of inner fitting stepped sections or the protruding heights of the outer fitting peak sections in the plurality of outer fitting stepped sections are approximately equal to each other.
4. The joint structure for a steel pipe pile according to any one of Claims 1 to 3,
wherein the facing surface of the inner fitting tip surface is an outer fitting base end surface on the base end side of the outer fitting end section.
5. The joint structure for a steel pipe pile according to any one of Claims 1 to 3,
wherein the facing surface of the inner fitting tip surface is an end surface of the first steel pipe pile.