

JOINT STRUCTURE OF COLUMN AND STEEL PIPE PILE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a joint structure of a column and a steel pipe pile in a steel frame structure.

2. Description of the Related Art

Conventionally, in order to construct foundation beams for a steel frame structure, piles (steel pipe piles) are generally installed into pits (hereinafter referred to as "foundation pits") bored in the ground. Then, between the adjacent foundation pits, a channel (hereinafter referred to as "a foundation beam channel") which leads to the both foundation pits is excavated. In the foundation beam channel, a wooden formwork and rebar are arranged to pour concrete thereinto and thereby the foundation beams are provided (related art 1).

In addition, for example, Japanese Laid-open Patent Publication No. 3-51428 discloses an invention related to a construction method for column pile joint portion. Therein, a spacer is provided in advance on the inner surface entire circumference of a predetermined section of a steel pipe pile erected in the ground, the predetermined section being set from the top end of the steel pipe pile. A filling

concrete is poured into the steel pipe pile. After the filling concrete is cured, the concrete and the spacer are removed from the predetermined section. Then, after a steel column is inserted to the inside of the steel pipe pile, concrete is filled into a gap of the joint portion between the steel pipe pile and the steel column (related art 2).

In the construction method of the above described related art 1, in order to construct the foundation beam, a large foundation beam channel has to be excavated to secure a space, which allows workers to work therein, around the periphery of the outer shape of the wooden formwork. The concrete casting cannot be carried out until most of the large amount of soil excavated is transported outward for disposal. Thus, there are problems in that a lot of man-hours and considerable costs are required and a construction period is prolonged, resulting in inferior workability. Additionally, because the foundation and foundation beams are of concrete and a superstructure joined thereto is a steel pipe column (steel column), design concepts are not unified.

The construction method of the above described related art 2 utilizes a steel pipe pile for the foundation work so that the problems related to an excavation work for the foundation pit, an arrangement work of wooden formworks,

inconsistent design concepts and the like, do not arise compared with the above described related art 1. However, in the method of the above described related art 2, after casting and curing of the concrete in the steel pipe pile, the concrete and spacer need to be removed from the portion to which the steel column is inserted. In addition, the steel column is directly inserted into the steel pipe pile to be joined. Accordingly, a position adjustment work in the vertical direction and horizontal direction of the steel column is extremely cumbersome. A lot of man-hours and costs are required and a prolonged construction period cannot be avoided. In the case where the foundation beam is provided between the adjacent steel pipe piles, similar problems arise as in the case of the related art 1.

The present invention has been made in consideration of the problems of the above described related art and an object of the present invention is to provide a joint structure of a column and a steel pipe pile with an excellent workability which does not need concrete casting for a foundation beam, has a high accuracy in column joining position, and thereby man-hours and construction costs can be reduced to shorten the construction period.

SUMMARY OF THE INVENTION

A joint structure of a column and a steel pipe pile

according to the present invention includes: a column of a superstructure; a steel pipe pile having a rib on an inner wall surface, being erected in the ground, and an interior thereof being filled with concrete; and a connection member that includes a strut having a leg portion, which is inserted into the steel pipe pile and fixed by concrete, and a joint portion to be joined with the column, and at least two cross beams attached to the strut in a horizontal direction.

The above configuration includes the column of the superstructure, the steel pipe pile having the rib on the inner wall surface, being erected in the ground, and the interior thereof being filled with the concrete, and the connection member that includes the strut having the leg portion, which is inserted into the steel pipe pile and fixed by the concrete, and the joint portion joined with the column, and at least the two cross beams attached to the strut in the horizontal direction. Thus, it does not require an excavation work of a large pit, transportation and disposal of soil, an arrangement work of wooden formworks and rebar, a concrete casting work for foundation beam or removal work for cured concrete, or the like. Accordingly, the construction man-hours and costs can be significantly saved and the construction period can be consequently shortened. In addition, by using the steel

pipe pile having the rib on the inner wall surface, the adhesion of concrete filling the inside the steel pipe pile can be increased and the filling volume of the concrete can be suppressed to a minimum. For example, the concrete may be poured only to a portion corresponding to the leg portion of the connection member in the inner space of the steel pipe pile. The rib may be formed only on that portion.

If the configuration further includes positioning means provided between the connection member and an upper portion of the steel pipe pile, for regulating a position of the connection member in a vertical direction and adjusting the position in the vertical and horizontal directions, in a placement work of the connection member, the positioning thereof becomes extremely easy and the location of the joint portion can be adjusted with high accuracy.

If the configuration further includes a coupling beam coupling between the cross beams of adjacent connection members, it is not necessary to arrange wooden formworks and rebar in a coupling beam channel and to cast concrete, and thus the placement work of the coupling beam can be made extremely easily. In addition, by coupling between the adjacent connection members with the coupling beam using welding or the like, both of the substructure and

superstructure become steel structures, and thus the stress flow becomes obvious. Furthermore, because the coupling beam yields first, the entire structure becomes beam collapsing type, and thus the deformation performance is improved. Accordingly, a structure excellent in earthquake resistance can be obtained.

If the adjacent connection members are coupled to each other by the coupling beam in advance to form a framework, the coupling work of the adjacent connection members does not need to be carried out on a construction site. Therefore, the construction cost can be saved by eliminating welding work, which has a large variation factor in construction unit price depending on the season or the region for constructing the joint structure, and bolt fastening work which requires on-site work.

The coupling beam and cross beam provided on the connection member can be joined by bolting or by bolting and by welding. In that case, the welding work, which has a large variation factor in construction unit price depending on the season or the region for constructing the joint structure, can be eliminated or carried out at a minimum level, and thus the construction cost can be reduced.

According to the present invention, works such as an excavation work for a large pit, the consequent

transporting/disposal of soil, an arrangement work of wooden formworks and rebar, and a concrete casting work for foundation beams or a removal work for cured concrete are not required. Therefore, the construction man-hours and construction costs can be significantly saved, thereby shortening the construction period.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an explanatory diagram of a structure to which a joint structure of a column and a steel pipe pile according to an embodiment of the present invention is applied.

Fig. 2 is a cross-sectional view taken along the line II-II in Fig. 1.

Fig. 3 is a longitudinal sectional view schematically illustrating an example of a substructure.

Fig. 4 is a plan view of the substructure illustrated in Fig. 3.

Fig. 5 is a diagram illustrating a connection member, Fig. 5(A) is a perspective view of the connection member, Fig. 5(B) is a side view of the connection member, and Fig. 5(C) is a plan view of the connection member.

Fig. 6 is a diagram illustrating a connection member according to a first modification example, Fig. 6(A) is a perspective view of the connection member, Fig. 6(B) is a

side view of the connection member, and Fig. 6(C) is a plan view of the connection member.

Fig. 7 is a diagram illustrating a connection member according to a second modification example, Fig. 7(A) is a perspective view of the connection member, and Fig. 7(B) is a plan view of the connection member.

Fig. 8 is an exploded perspective view of the connection member illustrated in Fig.7.

Fig. 9 is a diagram illustrating a connection member according to a third modification example, Fig. 9(A) is a perspective view of the connection member, and Fig. 9(B) is a plan view of the connection member.

Fig. 10 is a perspective view illustrating a connection member according to a fourth modification example.

Fig. 11 is a perspective view illustrating a connection member according to a fifth modification example.

Fig. 12 is a perspective view illustrating a connection member according to a sixth modification example.

Fig. 13 is a perspective view illustrating a connection member according to a seventh modification example.

Fig. 14 is a perspective view illustrating a connection member according to an eighth modification example.

Fig. 15 is a diagram illustrating a rib provided on an inner wall surface of a steel pipe pile, Fig. 15(A) is an enlarged sectional view of a main section of the steel pipe pile, a spiral rib being provided thereon, Fig. 15(B) is a cross-sectional view illustrating the whole body of the steel pipe pile illustrated in Fig. 15(A), and Fig. 15(C) is an enlarged sectional view of a main section of the steel pipe pile, ring shaped protrusions being provided thereon, according to a modification example of the rib illustrated in Fig. 15(A).

Fig. 16 is a diagram illustrating protrusions provided on a leg portion of a connection member, Fig. 16(A) is an enlarged view of a main section of the leg portion where a spiral protrusion is provided, Fig. 16(B) is an enlarged view of a main section of the leg portion where a ring shaped protrusions are provided which are ribs according to a modification example of the protrusion illustrated in Fig. 16(A), and Fig. 16(C) is an enlarged view of a main section of the leg portion where striped projections which are ribs according to another modification example of the protrusion illustrated in Fig. 16(A).

Fig. 17 is an explanatory diagram of positioning means.

Fig. 18 is an enlarged view of a main portion of the positioning means illustrated in Fig. 17.

Fig. 19 is a sectional side view of positioning means

according to a first modification example.

Fig. 20 is a perspective view of a supporting member of the positioning means illustrated in Fig. 19.

Fig. 21 is an explanatory diagram illustrating an installation state of a connection member into a pile.

Fig. 22 is a diagram illustrating positioning means according to a second modification example, Fig. 22(A) is a side view of the positioning means, and Fig. 22(B) is a plan view of the positioning means, partially omitted.

Fig. 23 is a perspective view of components of the positioning means illustrated in Fig. 22, Fig. 23(A) is a perspective view of a supporting member, and Fig. 23(B) is a perspective view of a fixing plate.

Fig. 24 is a diagram illustrating positioning means according to a third modification example.

Fig. 25 is a perspective view of components of the positioning means illustrated in Fig. 24, Fig. 25(A) is a perspective view of a supporting member, and Fig. 25(B) is a perspective view of a fixing plate.

Fig. 26 is a perspective view illustrating a modification example of an attachment structure in which a supporting member is attached to a steel pipe pile.

Fig. 27 is an explanatory view illustrating a process in the first half of a first example of a construction method for joint structure of a column and a steel pipe

pile according to an embodiment of the present invention, Fig. 27(A) is a diagram illustrating a state of boring a pit, Fig. 27(B) is a diagram illustrating a state in which a steel pipe pile is inserted and erected in the pit, and Fig. 27(C) is a diagram illustrating a state in which concrete is filled in the steel pipe pile.

Fig. 28 is an explanatory view illustrating a process in the second half of the first example of a construction method illustrated in Fig. 27, Fig. 28(A) is a diagram illustrating a state in which a leg portion of a connection member is installed into the concrete of the steel pipe pile, Fig. 28(B) is a diagram illustrating a state in which the pit having the steel pipe pile and the connection member installed and the circumference thereof is backfilled, and Fig. 28(C) is a diagram illustrating a state in which the column of a superstructure is joined to a joint portion of the connection member exposed from the ground surface.

Fig. 29 is a diagram illustrating an example of a joint method of a coupling beam and cross beams of connection members, Fig. 29(A) is a plan view, and Fig. 29(B) is a side view.

Fig. 30 is an explanatory diagram illustrating a configuration example having a reduced filling volume of concrete in a steel pipe pile, Fig. 30(A) is a diagram

illustrating a state in which a steel pipe pile is inserted and erected in a pit, Fig. 30(B) is a diagram illustrating a state in which a connection member is placed on an upper section of the steel pipe pile, and Fig. 30(C) is a diagram illustrating a state in which concrete is filled inside the steel pipe pile and a leg portion of the connection member.

Fig. 31 is an explanatory view illustrating a process in the second half of a second example of a construction method for a joint structure of a column and a steel pipe pile according to an embodiment of the present invention, Fig. 31(A) is a diagram illustrating a state in which concrete is filled in a lower portion inside the steel pipe pile, Fig. 31(B) is a diagram illustrating a state in which a leg portion of a connection member is inserted into the steel pipe pile, and Fig. 31(C) is a diagram illustrating a state in which concrete is filled until reaching an upper end portion inside the steel pipe pile.

Fig. 32 is a side view of a configuration example formed as a framework in which adjacent connection members are mutually connected in advance by a cross beam.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, a joint structure of a column and a steel pipe pile according to the present invention is exemplified with preferable embodiments and described with reference to

the attached drawings.

Fig. 1 is an explanatory diagram of a structure to which a joint structure A of a column and a steel pipe pile according to an embodiment of the present invention is applied, Fig. 2 is a cross-sectional view taken along the line II-II in Fig. 1. The structure illustrated in Fig. 1 is configured by a substructure 1 provided in the ground and a superstructure 2 constructed on the substructure 1.

Fig. 3 is a longitudinal cross-sectional view schematically illustrating an example of the substructure 1, and Fig. 4 is a plan view of the substructure 1 illustrated in Fig. 3. As illustrated in FIGS. 1 to 4, the substructure 1 includes a circular steel pipe pile (pile) 5 erected inside a pit 3, which is bored using an auger or the like, and a connection member 10 which is erected and fixed in the steel pipe pile 5 in order to join a steel pipe column, a square steel pipe column and the like of the superstructure 2 (hereinafter referred to as "a column"). Incidentally, for the steel pipe pile 5, a square steel pipe pile may be alternatively used.

For example, as illustrated in Fig. 5, the connection member 10 is configured by a strut 11 formed of a steel pipe and four cross beams 14a, 14b, 14c, and 14d formed of H-shaped steel beams which are attached horizontally to the strut 11 by welding via a diaphragm 16 at an outer

circumference of the upper portion of the strut 11. The strut 11 has a joint portion 12 for the column at the upper portion and a leg portion 13 at the lower portion. The cross beams 14a to 14d are attached to the lower portion of the joint portion 12, the upper portion of the leg portion 13, or between them. In Fig. 5, a reference number 15 represents weld access holes formed in webs of the cross beams 14a to 14d for receiving the diaphragm 16. Incidentally, the length of the cross beams 14a to 14d from the center of the strut 11 is preferably longer than the radius of the steel pipe pile 5.

Fig. 6 is a diagram illustrating a connection member 10a according to a first modification example of the connection member 10, Fig. 6(A) is a perspective view of the connection member 10a, Fig. 6(B) is a side view of the connection member 10a, and Fig. 6(C) is a plan view of the connection member 10a. As illustrated in FIGS. 6(A) to 6(C), the connection member 10a is configured such that the cross beams 14a to 14d formed of H-shaped steel beams are attached, via the diaphragm 16 attached to the strut 11, to the strut 11 formed of a square steel pipe. Incidentally, reference number 16a in Fig. 6(C) represents an inner diaphragm attached to the inside of the strut 11 opposing the diaphragm 16.

Fig. 7 is a diagram illustrating a connection member

10b according to a second modification example of the connection member 10, Fig. 7(A) is a perspective view of the connection member 10b, and Fig. 7(B) is a plan view of the connection member 10b. In addition, Fig. 8 is an exploded perspective view of the connection member 10b. As illustrated in Fig. 7(A), Fig. 7(B) and Fig. 8, the connection member 10b is configured such that the cross beams 14a and 14c are attached by welding to flanges of the strut 11 formed of an H-shaped steel beam, and the cross beams 14b and 14d are attached by welding, via diaphragms 16b and 16c, to the lateral side of the flange of the strut 11. In the connection member 10b, when attaching the cross beams 14b and 14d to the strut 11, first, welding is performed at a predetermined position in the height direction of the strut 11 such that a diaphragm 16b is adjusted to webs between both of the flanges along the vertical direction. Next, the diaphragms 16c abut the upper side and the lower side of the diaphragm 16b, and the diaphragms 16c are welded to the web of the strut 11, the inner surfaces of the flanges and the upper and lower surfaces of the diaphragm 16b, and thereby the diaphragms 16b and 16c form an approximately H-shape. Then, the end surface of the cross beams 14b and 14d are welded to the diaphragms 16b, 16c and the lateral side of the flange of the strut 11.

Fig. 9 is a diagram illustrating a connection member 10c according to a third modification example of the connection member 10, Fig. 9(A) is a perspective view of the connection member 10c, and Fig. 9(B) is a plan view of the connection member 10c. As illustrated in Fig. 9(A) and Fig. 9(B), in the connection member 10c, a cross-shaped (in a plan view) strut 11 is formed by an H-shaped steel beam 11a and T-shaped steel beams 17a and 17b having respective webs welded to the web of the H-shaped steel beam. Respective cross beams 14a to 14d are attached, by welding, to the flanges of the H-shaped steel beam 11a and the T-shaped steel beams 17a and 17b. Moreover, the connection member 10c is configured such that in order to correspond to the position of the flanges of the cross beams 14a to 14d, diaphragms 16d are attached, by welding, respectively between the webs of the H-shaped steel beam 11a and the T-shaped steel beams 17a and 17b.

Fig. 10 is a perspective view illustrating a connection member 10d according to a fourth modification example of the connection member 10. As illustrated in Fig. 10, the connection member 10d is configured such that the cross beams 14a to 14d are attached, by welding, to the strut 11 formed of the steel pipe.

Fig. 11 is a perspective view illustrating a connection member 10e according to a fifth modification

example of the connection member 10. As illustrated in Fig. 11, the connection member 10e is configured such that the cross beams 14a to 14d formed of the square steel pipe are attached to the strut 11 formed of the square steel pipe crosswise.

Fig. 12 is a perspective view illustrating a connection member 10f according to a sixth modification example of the connection member 10. As illustrated in Fig. 12, the connection member 10f has a configuration of the strut 11 in which the leg portion 13 formed of the steel pipe is joined to the joint portion 12 formed of the square steel pipe, a C-shaped steel beam is attached to the three position of the strut 11 to form the cross beams 14a, 14b and 14c being arranged in a T-shape.

Fig. 13 is a perspective view illustrating a connection member 10g according to a seventh modification example of the connection member 10. As illustrated in Fig. 13, the connection member 10g is configured such that an I-shaped steel beam is attached to the upper portion of the strut 11 formed of the steel pipe, in an L-shape, so as to form the cross beams 14a and 14b. The upper portion of the cross beams 14a and 14b becomes the joint portion 12, and the lower portion becomes the leg portion 13. Incidentally, in the case of the connection member 10g, it is necessary to provided supporting portions (not shown) at positions

opposing the joint portions of the cross beams 14a and 14b of the strut 11 so that the lower surfaces thereof are on the same plane as the lower surfaces of the cross beams 14a and 14b.

Fig. 14 is a perspective view illustrating a connection member 10h according to an eighth modification example of the connection member 10. As illustrated in Fig. 14, the connection member 10h has a configuration of the strut 11 in which the leg portion 13 formed of the H-shaped steel beam is joined to the joint portion 12 formed of the square steel pipe, then two cross beams 14a and 14b formed of the H-shaped steel beams are linearly attached.

Incidentally, respective connection members 10 and 10a to 10h indicate an example of a configuration applicable to the joint structure A. For example, the strut 11 may be configured by an appropriate combination of steel materials having a round, square, H-shaped cross-section or the like. In addition, the cross beams 14a to 14d may be configured by an appropriate combination of steel materials having an H, U, I-shaped cross-section or the like. Thereby, a desired connection member can be configured by optionally attaching the cross beams 14a to 14d, to two, three or four positions.

As illustrated in Fig. 15(A) and Fig. 15(B), the inner circumferential surface (inner wall surface) of the steel

pipe pile 5 has a rib (protrusion) 6. In Fig. 15(A) and Fig. 15(B), illustrated is a single or a plurality of spiral ribs 6 provided along the inner circumferential surface of the steel pipe pile 5. By providing the rib 6, the adhesion of concrete filling inside the steel pipe pile 5 can be enhanced. The rib 6 may be provided over the entire length of the steel pipe pile 5 (refer to a distance L1 in Fig. 15(B)). Alternatively, the rib 6 may be provided only in the range corresponding to the leg portion 13 of the connection member 10 (10a to 10h), in other words, only in the range necessary for filling concrete (refer to a distance L2 in Fig. 15(B)).

By forming the steel pipe pile 5 into a rib-attached steel pipe provided with the rib 6 as described above, through the improved adhesion action of concrete due to the rib 6, the vertical load from the connection member 10 (10a to 10h) is reliably transmitted to the steel pipe pile 5. For this reason, for example, a filling range of concrete into the steel pipe pile 5 may be limited only to a portion corresponding to the leg portion 13 of the connection member 10 (10a to 10h), for example, only to the upper portion of the distance L2 of the steel pipe pile 5, which has the rib 6. Thus, the volume of concrete used can be reduced and the works can be reduced. That is, it is sufficient if the rib 6 is formed at least in a range to be

filled with concrete (range having concrete).

Incidentally, it may be considered that the rib 6 is formed on a construction site of the joint structure A. However, if formed into the steel pipe pile 5 in advance prior to the stage of transportation to the construction site, welding efforts or the like at the site are not required, and thus effects including streamlining in works can be obtained. For example, if the rib 6 is formed by rolling when producing the steel pipe pile 5 in advance at a factory, a concrete adhesion mechanism having a stable quality can be realized. The rib 6 may have forms other than spiral, of course. For example, a single, a plurality of ring shaped protrusions (rib) 6a (refer to Fig. 15(C)) or multiple projections may be used. Even in this case, it is preferable to form the protrusion or the projection through rolling, welding or the like at the factory in advance. When using the spiral rib 6 (ring shaped protrusion 6a) as the rib 6 as illustrated in Fig. 15(A), the shape of the rib 6 is, for example, set to be approximately equal to or higher than 2.5 mm in height h , approximately 4 to 20 mm in width w , and approximately 30 to 40 mm in pitch p . In addition, the angle in the extending direction of the rib 6 (ring shaped protrusion 6a) is preferably set to be equal to or less than 45° , where the angle of the horizontal direction is 0° , so as to

have a structure capable of regulating the relative movement of the concrete and the steel pipe pile 5 in the axial direction of the steel pipe pile 5.

In order to further enhance the adhesion of the concrete, also on the outer circumferential surface of the leg portion 13 of the connection member 10, a spiral protrusion 18a (refer to Fig. 16(A)), a single or a plurality of ring shaped protrusions 18b (refer to Fig. 16(B)), or a projection such as multiple striped projections 18c (refer to Fig. 16(C)) may be arranged.

As illustrated in Fig. 3 and Fig. 4, pits 3 adjacent to each other may be connected by the coupling beam channel (foundation beam channel) 4. In the coupling beam channel 4, when necessary, the coupling beam (foundation beam) 7 formed from steel material joined to the cross beams 14a to 14d of the connection members 10 (10a to 10h) is placed.

As illustrated in Fig. 3, the connection members 10 (10a to 10h) are positioned at the upper portion of the steel pipe pile 5 using the positioning means (position adjustment means) 20. An example of the positioning means 20 is illustrated in Fig. 17 and Fig. 18.

As illustrated in Fig. 17 and Fig. 18, the positioning means 20 of the connection member 10 has a supporting member 21 and a fixing member 23. The supporting member 21 is attached, by welding, screw clamp or the like, to

positions of the steel pipe pile 5 corresponding to the cross beams 14a to 14d of the connection member 10. The upper end of the supporting member 21 protrudes from the upper end of the steel pipe pile 5 and is held at a predetermined height position. The protruded portion has a slotted hole 22 in the vertical direction. The fixing member 23, being attached to the lower surface of the cross beams 14a to 14d of the connection member 10, has a slotted hole 24.

With such positioning means 20, as illustrated in Fig. 17, when placing the connection member 10 on the steel pipe pile 5, the cross beams 14a to 14d are placed on the supporting member 21. As illustrated in Fig. 18, a bolt 25 is inserted through the slotted hole 22 formed in the supporting member 21 and the slotted hole 24 formed in the fixing member 23, and then the connection member is fastened using a nut to fix the connection member 10 on the steel pipe pile 5. Thus, the joint portion 12 of the connection member 10 can be held at a predetermined position.

The position in the vertical direction of the connection member 10 is regulated by the positioning means 20 as described above. If the position of the joint portion 12 is lower than the predetermined position or the position in the horizontal direction is inconsistent with

the predetermined position, the position adjustment may be performed by using the slotted holes 22, 24 and the bolt 25 to move the connection member 10 upward or in the horizontal direction.

Fig. 19 is a side sectional view of positioning means (position adjustment means) 20a according to a first modification example of the positioning means 20, and Fig. 20 is a perspective view of the supporting member 21 of the positioning means 20a illustrated in Fig. 19. As illustrated in Fig. 19 and Fig. 20, the positioning means 20a is configured such that an adjustment plate 26 having a screw hole 27 and being perpendicular to the supporting member 21 is arranged in the horizontal direction, the slotted hole 22 is formed at a position not interfering with the adjustment plate 26, and a bolt 28 is screwed into the screw hole 27. The supporting member 21 thus configured is attached to the steel pipe pile 5 such that the upper end portion thereof is adjusted to the lower position than the predetermined height position. Then, the bolt 28 is adjusted such that the tip end thereof is located at the predetermined height position. Then, the cross beams 14a to 14d of the connection member 10 are placed on the bolt 28. Thereafter, if the position of the upper end portion of the joint portion 12 of the connection member 10 in the horizontal direction or in the vertical

direction is inconsistent with the predetermined position, the connection member 10 is moved, by using the bolts 25 and 28, in the horizontal direction or in the vertical direction, to adjust the position.

Incidentally, when installing the steel pipe pile 5, there are cases where the center thereof does not match the predetermined center of the column of the superstructure 2. In this case, as illustrated in Fig. 21, it is necessary to install the connection members 10 (10a to 10h) at the position where the joint portion 12 is consistent with the column, for example, at an eccentric position of the steel pipe pile 5. Furthermore, even if the connection member 10 is installed at the eccentric position of the steel pipe pile 5, there are many cases where adjustment of the connection member 10 in the vertical direction, horizontal direction or rotating direction is required.

Therefore, positioning means (position adjustment means) 20b which is an example of positioning effectively usable in this case are illustrated in Fig. 22 and Fig. 23. As illustrated in Fig. 22 and Fig. 23, the positioning means 20b is suitable for regulating the position of the connection members 10 (10a to 10h) in the vertical direction, horizontal direction and rotating direction. In other words, the positioning means 20b includes a screw hole 30 at the upper portion of a supporting member 21

attached to the steel pipe pile 5, a receiving plate 31 arranged at the position not interfering with the screw hole 30 of one side of the supporting member 21 along the vertical direction and being perpendicular to the supporting member 21, and an adjustment plate 32 having a single or a plurality of screw holes 33, arranged at the lower portion of one side of a fixing member 23 (opposite side to the receiving plate 31) along the vertical direction and being perpendicular to the fixing member 23, and attached to the cross beams 14a to 14b of the connection member 10.

The supporting member 21 forming the positioning means 20b is attached to the steel pipe pile 5 such that the upper end portion thereof is located at the predetermined position. Then, the connection member 10 is placed on the supporting member 21 such that the joint portion 12 thereof is consistent with the position of the column of the superstructure 2. Respective bolts 29a and 29b are screwed into the screw hole 30 of the supporting member 21 and the screw hole 33 of the fixing member 23. The tip end portions thereof are brought into contact with the fixing member 23 and the receiving plate 31. At this time, the supporting member 21 regulates the position of the connection member 10 in the vertical direction.

When adjusting the position in the horizontal

direction of the connection member 10, by loosening the bolt 29a of one side of the positioning means 20b and by screwing the bolt 29a of the other side of the positioning means 20b opposing thereto, the connection member 10 can be moved in the horizontal direction. In addition, when rotating the connection member 10 in an arrow direction $\theta 1$, the bolts 29b of the positioning means 20b other than the remaining one bolt 29b are loosened, and the remaining one bolt 29b of the positioning means 20b is screwed. When moving the member in an arrow direction $\theta 2$, by loosening all the bolts 29b of the positioning member 20b and retracting so as to form a predetermined gap with the adjustment plate 32, the connection member 10 can be rotated in the arrow direction $\theta 2$ manually or by other means. In this case, at least one of the positioning means 20b is arranged in the opposite direction to the other positioning means 20b, the bolt 29b of the other positioning means 20b is loosened, and the bolt 29b of the other positioning means 20b is screwed. Then, the connection member 10 can be rotated in the arrow direction $\theta 2$.

In Fig. 24 and Fig. 25, illustrated are positioning means (position adjustment means) 20c capable of adjusting the connection member 10 in all the direction including the

vertical direction, horizontal direction and rotating direction. The positioning means 20c as illustrated in Fig.24 and 25 are configured such that at the lower portion the receiving plate 31 of the supporting member 21 forming the positioning means 20b illustrated in Fig. 22A and 22B and Fig. 23, an adjustment plate 34 is arranged, which has a screw hole 35 and extends in the horizontal direction perpendicular to the supporting member 21. The other configuration is the same as the positioning means 20b illustrated in Fig. 22 and Fig. 23.

The supporting member 21 forming the positioning means 20c is attached to the steel pipe pile 5, a bolt 28 is screwed into the screw hole 35 of the adjustment plate 34 while the tip end portion thereof is held at the predetermined height position, and the cross beams 14a to 14c of the connection member 10 are placed on the bolt 28. Then, when necessary, the height position of the connection member 10 can be adjusted using the bolt 28. Furthermore, in the positioning means 20c, the position adjustment of the connection member 10 in the horizontal direction and rotating direction is the same as that of the positioning means 20b illustrated in Fig. 22 and Fig. 23.

The above description indicates examples in which the supporting member 21 is directly attached to the steel pipe pile 5. For example, as illustrated in Fig. 26, a

plurality of supplementary members 37 may be attached, by welding or the like, to the outer side surface of the supporting member 21, the supporting member 21 may be mounted on the upper end portion of the steel pipe pile 5, and the supplementary members 37 may be attached to the steel pipe pile 5 by welding, bolting or the like. In addition, the positioning means 20 (20a to 20c) illustrated are examples in which the fixing member 23 is attached to the lower surface of the cross beams 14a to 14d of the connection member 10, but the fixing member 23 may be attached to the strut 11. Incidentally, the above described various positioning means 20 and 20a to 20c indicate examples thereof and may be appropriately modified by, for example combining each positioning means 20 and 20a to 20c.

Next, described is a first example of a construction method for a joint structure A of a column and a steel pipe pile according to the embodiment having the above described steel pipe pile 5 and the connection member 10 (10a to 10h).

First, in factories or the like, the steel pipe pile 5 and the connection member 10 are produced and transported to the construction site. At this time, the rib 6 (refer to Fig. 15) is formed on the inner circumferential surface of the steel pipe pile 5. In addition, the supporting member 21 of the positioning means 20 (20a to 20c) is

attached at the predetermined position of the outer periphery in the upper portion of the steel pipe pile 5. The fixing member 23 is attached to the lower surface or the like of the cross beams 14a to 14d of the connection member 10. Incidentally, the supporting member 21 and the fixing member 23 may be attached after being transported to the construction site.

At the construction site, as illustrated in Fig. 27(A), the pit 3 having a predetermined depth with slightly larger inner diameter than the outer diameter of the steel pipe pile 5 is bored, by using the auger or the like, at the predetermined position. Furthermore, on the upper portion of the pit 3, a horizontal hollow is excavated where the cross beams 14a to 14d of the connection member 10 are placed. In this case, the upper portion of the pit 3 may be largely excavated. Without excavating the horizontal hollow, the cross beams 14a to 14d may be placed on the ground E. Furthermore, when arranging the coupling beam 7, the coupling beam channel 4 is excavated at the space between the adjacent horizontal hollows.

Next, as illustrated in Fig. 27(B), the steel pipe pile 5 is inserted and erected inside the pit 3. In this case, after erecting the steel pipe pile 5, on the upper portion of the steel pile 5, the supporting member 21 of the positioning means 20 may be attached, by welding or the

like, such that the tip end portion thereof is located at the predetermined position.

Next, as illustrated in Fig. 27(C), the concrete 35 is filled until reaching the vicinity of the upper end portion inside the steel pipe pile 5.

Then, prior to the curing of the concrete 35 filled into the steel pipe pile 5, the joint portion 12 of the connection member 10 is mated to the predetermined position of the column of the superstructure 2. As illustrated in Fig. 28(A), the leg portion 13 thereof is placed into the concrete 35 of the steel pipe pile 5 and the cross beams 14a to 14d are placed on the supporting member 21 of the positioning means 20. At this time, the concrete 35 is also filled inside the leg portion 13 of the connection member 10. Incidentally, the concrete may be filled inside the leg portion 13 in advance. In this case, as for the concrete filling into the leg portion 13, the concrete of different composition from the concrete 35 filling into the steel pipe pile 5 may be used. In addition, it is preferable that the concrete filled inside the leg portion 13 is designed to be as high as the diameter of the leg portion 13 from the upper surface of the concrete 35 filled into the steel pipe pile 5 when the upper surface thereof is placed above the steel pipe pile 5.

In this state, when necessary, using the positioning

means 20, the position of the connection member 10 in the vertical direction, horizontal direction or rotating direction may be adjusted. The positioning means 20 are removed after the concrete 35 is cured. In addition, the positioning means 20 may be left totally or partially.

In addition, when necessary, between the cross beams 14a to 14d of the adjacent connection member 10, the coupling beam 7 is joined by welding, bolting or the like. For example, in the join of the coupling beam 7 and the cross beams 14a and 14c, as illustrated in Fig. 29(A) and Fig. 29(B), each web lateral surface of the coupling beam 7 and the cross beams 14a and 14c may be fastened using the bolt 39 via a plate 38. Each upper surface of the flange and each lower surface of the flange may be joined by welding W. Incidentally, if each upper and lower surfaces of the flange of the coupling beam 7 and the cross beams 14a and 14c are joined using the plate and the bolt, without using any welding, joint works only by the bolt may be performed. Accordingly, it is possible to eliminate or minimize welding works which have a large variation factor in construction unit price depending on the season or the region for the construction of the joint structure A, to reduce the construction cost.

As illustrated in Fig. 28(B), the pit 3 having the steel pipe pile 5 and the connection member 10 and the

surrounding (including the coupling beam channel 4 in case of arranging the coupling beam 7) are backfilled or cast by the concrete. Incidentally, without backfilling or concrete casting, they may be also left. At this time, the upper portion of the joint portion 12 of the connection member 10 is exposed from the ground surface E or from the cast concrete.

As illustrated in Fig. 28(C), to the joint portion 12 of the connection member 10 exposed from the ground surface E, the column 40 of the superstructure 2 is joined.

Incidentally, as illustrated in Fig. 15(B), the present embodiment has a rib 6 formed throughout the distance L1 or L2 on the inner peripheral surface of the steel pipe pile 5. Accordingly, since the adhesion between the concrete 35 filled inside the steel pipe pile 5 and the steel pipe pile 5 is high, it is not necessary to fill the concrete 35 over the entire length of the steel pipe pile 5. For example, as illustrated in Fig. 30(A) and Fig. 30(B), in the case where the rib 6 is formed in the distance L2 (alternatively, the distance L1 over the entire length of the steel pipe pile 5) corresponding the leg portion 13 of the connection member 10, if the concrete 36 is filled at least in the distance L2 as illustrated in Fig. 30(C), a sufficient adhesion strength secured to pour the concrete and thereby the superstructure 2 can be supported stably.

Next, described is a second example of a construction method for a joint structure A of a column and a steel pipe pile.

In the construction method, the process until the steel pipe pile 5 having the rib 6 and transported to the construction site is inserted and erected into the pit 3 is substantially the same as the case of the above described construction method illustrated in Fig. 27(A) to Fig. 27(C) and Fig. 30(A).

Next, inside the steel pipe pile 5 erected into the pit 3, as illustrated in Fig. 31(A), up to the position slightly downward from the lower end portion of the leg portion 13 of the connection member 10 placed on the supporting member 21 of the steel pipe pile 5, the concrete 35 is filled. In addition, the concrete 35 may be filled in the factories or the like in advance.

After the concrete 35 filled in the steel pipe pile 5 is cured, the joint portion 12 of the connection member 10 is mated to the predetermined position of the column of the superstructure 2. As illustrated in Fig. 31(B), the leg portion 13 thereof is inserted into the steel pipe pile 5 and the cross beams 14a to 14d are placed on the supporting member 21 of the positioning means 20. In this case, a plate may be attached to the leg portion 13. In this state, when necessary, using the positioning means 20, the

position of the connection member 10 is adjusted in the vertical direction, the perpendicular direction or rotating direction.

Subsequently, as illustrated in Fig. 31(C), the concrete 36 is filled until reaching the upper end portion of the steel pipe pile 5. In addition, at this time, the concrete 36 is also filled into the leg portion 13 of the connection member 10. However, the concrete may be filled into the leg portion 13 in the factories or the like in advance as the above description. Incidentally, the subsequent process is substantially the same as the case of the above described construction method illustrated in Fig. 28(A) to 28(C), Fig. 30(B) and Fig. 30(C). Works such as removal works of the positioning means 20, joint works of the coupling beams 7, backfilling or concrete casting works for the pit 3 and the surrounding thereof, and further joint works of the column 40 of the superstructure 2 are carried out.

Incidentally, the above described embodiment has exemplified a configuration where the respective connection members 10 (10a to 10b) are arranged on the upper portions of the respective steel pipe piles 5, and when necessary, each cross beam 14a to 14d of the connection members 10 (10a to 10h) are connected to each other by the coupling beam 7. However, as illustrated in Fig. 32, such a

configuration that each adjacent connection member 10 (10a to 10h) is interconnected mutually using the cross beam 41 in the factories or the like in advance to form a framework may be adapted. This may eliminate the need to carry out the joint work of the cross beams 14a to 14d of the connection member 10 (10a to 10h) and the coupling beam 7 as illustrated in Fig. 29(A) and 29(B) at the construction site. Accordingly, welding works having a large variation factor in the construction unit price depending on the seasons or regions for constructing the joint structure A, or bolt fastening works to be carried out at the site can be eliminated to save the construction cost.

As is obvious from the description hitherto, the joint structure A according to the embodiment includes: the column 40 of the superstructure 2; the steel pipe pile 5 having the rib 6 (ring shaped protrusion 6a) on the inner wall surface, being erected in the ground and the interior thereof being filled with concrete 35 (36); and the connection member 10 (10a to 10h) that includes the strut 11 having the leg portion 13, which is inserted into the steel pipe pile 5 and fixed by the concrete 35 (36), and the joint portion 12 to be joined with the column 40, and the at least two cross beams 14a to 14d attached to the strut 11 in the horizontal direction. Therefore, works such as excavation works for large pits, transportation and

disposal of soil, arrangement works of wooden formworks and rebar, concrete casting works for coupling beams (foundation beams), or removal works of cured concrete, are not required. In addition, position adjustments of the joint portions for the columns can be easily carried out. Therefore, the joint structure of a column and a steel pipe pile having excellent workability and capable of significantly reducing the construction man-hours and costs and shortening the construction period can be obtained.

Moreover, using the steel pipe pile 5 formed with the rib 6 (ring shaped protrusion 6a) on the inner wall surface, the adhesion of the concrete 35 (36) to be filled inside the steel pipe pile 5 can be enhanced. Because the rib 6 (ring shaped protrusion 6a) enables concrete 35 (36) to have a high adhesion, it is no longer necessary to fill the concrete 35 (36) over the entire length of inside the steel pipe pile 5 and the filling volume of the concrete 35 (36) can be suppressed to a minimum. For example, the concrete 35 (36) may be cast only to a portion corresponding to the leg portion 13 of the connection member 10 in the inner space of the steel pipe pile 5. The rib may be formed only at that portion. In other words, if the rib 6 is arranged so as to correspond to the range of the filled concrete 35 (36) in the interior of the steel pipe pile 5, enables the concrete 35 (36) to have a sufficiently improved adhesion

function.

In addition, the present invention is not limited to the above described embodiments and of course may be modified in a range without departing from the gist of the present invention.

What is claimed is:

1. A joint structure of a column and a steel pipe pile, comprising:

a column of a superstructure;

a steel pipe pile having a rib on an inner wall surface, being erected in the ground, and an interior thereof being filled with concrete; and

a connection member that includes

a strut having a leg portion, which is inserted into the steel pipe pile and fixed by concrete, and a joint portion to be joined with the column, and

at least two cross beams attached to the strut in a horizontal direction.

2. The joint structure of a column and a steel pipe pile according to claim 1, further comprising:

positioning means provided between the connection member and an upper portion of the steel pipe pile, for regulating a position of the connection member in a vertical direction and adjusting the position in the vertical and horizontal directions.

3. The joint structure of a column and a steel pipe pile according to claim 1, further comprising:

a coupling beam coupling between the cross beams of

the adjacent connection members.

4. The joint structure of a column and a steel pipe pile according to claim 1,

wherein the adjacent connection members are coupled to each other by a coupling beam in advance to form a framework.

5. The joint structure of a column and a steel pipe pile according to claim 3,

wherein the coupling beam and the cross beam provided on the connection member are joined by bolting or joined by the bolting and by welding.

6. The joint structure of a column and a steel pipe pile according to claim 1,

wherein the rib is arranged so as to correspond at least to a range where the concrete is filled in the interior of the steel pipe pile.