

Description

**Title of Invention: ONE COLUMN-ONE PILE FOUNDATION
STRUCTURE**

Technical Field

The present invention relates to a one column-one pile foundation structure used for a foundation of a building and the like.

Background Art

Known examples of the one column-one pile foundation structure used for a foundation of a building and the like include one which comprises a pile buried in (or driven into) the ground and a steel pipe (joint) placed vertically on top of the pile.

Among others, in Patent Literature 1, the present inventors proposed an undermentioned construction method for the one column-one pile foundation structure. That is, a pile, a column base, and a joint adapted to couple the pile and column base together are carried separately into a construction site. Then, after the pile is buried in place in the ground, the joint is put on a head of the pile, a center of the pile and center of the joint are brought into coincidence, and then the pile and the joint are integrated together. Subsequently, a tip of the column base is inserted into an inner space of the joint

through an open end of the joint, vertical and horizontal positions of the column base are adjusted, and then concrete is filled into the joint and solidified, thereby joining together the pile and column base via the concrete.

Since the pile, joint, and column base are carried into the construction site as separate members, the construction method described above can simplify a carry-in operation. Also, since the pile, joint, and column base are carried into the construction site as separate members and assembled by adjusting the vertical and horizontal positions of the column base with the center of the pile and center of the joint brought into coincidence, even if the pile is pressed into (buried in) a location displaced from a predetermined position, any pile-driving error can be absorbed by position adjustments of the column base, making it possible to always install the column at the predetermined position without compromising the strength of the joint.

Citation List

Patent Literature

Patent Literature 1: Japanese Patent Laid-Open No. 2007-63854

Summary of Invention

Technical Problem

The one column-one pile foundation structure transmits loads from the column base to the pile via concrete, but when an excessive pull-out force acts on the column base as a result of an earthquake or the like, the concrete gets fractured and falls out conically, resulting in a significant reduction in the resistance force of the concrete and thereby losing the function of the one column-one pile foundation structure. However, Patent Literature 1 does not give due consideration from this point of view.

Thus, an object of the present invention is to provide a one column-one pile foundation structure capable of maintaining its functions without a significant reduction in the resistance force of concrete even if an excessive pull-out force acts.

Solution to Problem

A one column-one pile foundation structure according to the present invention comprises a pile, a joint, and a column base.

The pile is buried in the ground.

The joint is a tubular part disposed on a pile head of the pile and provided with a cavity to be filled with concrete.

The column base is provided with a base plate at a lower end and joined to the pile via the concrete, with a

joining area including the base plate being inserted into the cavity of the joint.

The one column-one pile foundation structure according to the present invention includes a shear connector. The shear connector is installed at a predetermined position in a height direction of the joint, protruding inward. Also, the shear connector is installed above a position T at which a virtual straight line L intersects an inner wall of the joint, extending at an elevation angle of 45° from an end of the base plate in a horizontal direction (requirement 1).

Furthermore, if concrete bearing strength of the shear connector is denoted by P_n and fracture strength of the entire concrete filling the cavity (hereinafter sometimes referred to as infilled concrete) against a conical fracture is denoted by P_s , the one column-one pile foundation structure according to the present invention is configured to satisfy $P_n > P_s$ (requirement 2).

When tension acts on the concrete, the concrete is most prone to fracture along directions at an angle of 45° from a direction of action of the tension. With the one column-one pile foundation structure according to the present invention, in compliance with requirement 1, the shear connector acts against upward (vertical) forces exerted on a portion on the inner side of the virtual straight line L and thereby prevents the portion from

being displaced upward. Thus, the present invention can prevent conical fractures which are liable to occur in the infilled concrete along 45-degree directions.

Besides, even if fractures along the 45-degree directions can be avoided, a conical fracture could occur at an elevation angle larger than 45° from the end of the base plate in the horizontal direction. However, with the one column-one pile foundation structure according to the present invention, since requirement 2 is satisfied, priority is given to causing a bearing portion to be fractured by the shear connector rather than allowing a conical fracture to occur, and consequently significant reductions in the resistance force can be avoided.

Here, P_n and P_s are found, for example, as follows, and determining factors for P_n and P_s can be adjusted so as to satisfy $P_n > P_s$.

$$P_n = A_n \times f_n \times N \quad \text{Expression (1)}$$

A_n : area per stage of shear connector,

f_n : maximum bearing stress of concrete

N : the number of stages of shear connectors

installed above position T

$$P_s = A_s \times f_s \quad \text{Expression (2)}$$

A_s : surface area of a conical fracture surface

f_s : fracture strength of concrete on the conical fracture surface

Regarding P_n and P_s , there can be other calculation formulae, such as empirical formulae.

In the one column-one pile foundation structure according to the present invention, preferably a bottom plate is fixed to a lower end portion of the joint.

When excessive shaking occurs as a result of an earthquake or the like, horizontal forces are exerted on the one column-one pile foundation structure in addition to vertical forces. Against the horizontal forces, the bottom plate prevents the lower end portion of the joint from deforming elliptically (hereinafter referred to as oval deformation).

The bottom plate may be solid, but preferably the bottom plate has a hollow portion.

Residual stresses are produced when the bottom plate is fixed to the lower end portion of the joint by welding, but the hollow portion, when provided, relieves the residual stresses.

In the one column-one pile foundation structure according to the present invention, preferably a flange is fixed to an upper end portion of the joint, protruding outward. The flange prevents oval deformation from occurring on the upper end portion of the joint.

The flange, when installed on the uppermost end of the joint, can most effectively prevent oval deformation of the upper end portion of the joint.

When the flange is installed on the uppermost end of the joint, if the flange protrudes inward, the protruding portion can be caused to function as a shear connector.

In that case, a single member can combine the functions of both displacement prevention and elliptical-deformation prevention.

Advantageous Effects of Invention

With the one column-one pile foundation structure according to the present invention, since the shear connector restrains upward forces exerted on a portion on the inner side of the virtual straight line L, it is possible to prevent a conical fracture from occurring in the infilled concrete along an elevation angle of 45°. Also, since priority is given to causing the bearing portion to be fractured by the shear connector rather than allowing a conical fracture to occur, it is possible to avoid significant reductions in the resistance force.

Brief Description of Drawings

[FIGS. 1A to 1C] FIGS. 1A to 1C show a first embodiment of a one column-one pile foundation structure according to the present invention, where FIG. 1A is a sectional side view, FIG. 1B is a sectional arrow view taken in the direction of line 1b-1b in FIG. 1A, and FIG. 1C is a sectional view of a portion corresponding to the sectional arrow view taken in the direction of line 1b-1b in FIG. 1A.

[FIGS. 2A to 2D] FIGS. 2A to 2D are diagrams for explaining a construction process of the one column-one

pile foundation structure according to the first embodiment.

[FIGS. 3A and 3B] FIGS. 3A and 3B are diagrams for explaining requirement 2 of the one column-one pile foundation structure according to the first embodiment.

[FIG. 4] FIG. 4 is a diagram showing a modification of the one column-one pile foundation structure according to the first embodiment.

[FIG. 5] FIG. 5 is a sectional side view showing a second embodiment of the one column-one pile foundation structure according to the present invention.

[FIGS. 6A to 6C] FIGS. 6A to 6C are diagrams for explaining an effect of the one column-one pile foundation structure according to the second embodiment.

[FIGS. 7A and 7B] FIGS. 7A and 7B are diagrams showing a modification of the one column-one pile foundation structure according to the second embodiment.

[FIGS. 8A and 8B] FIGS. 8A and 8B are sectional side views showing a third embodiment of the one column-one pile foundation structure according to the present invention.

[FIG. 9] FIG. 9 is a diagram showing a modification of the one column-one pile foundation structure according to the third embodiment.

[FIG. 10] FIG. 10 is a diagram showing another modification of the one column-one pile foundation structure according to the third embodiment.

Description of Embodiments

<First Embodiment>

A first embodiment of a one column-one pile foundation structure according to the present invention will be described below with reference to FIGS. 1A to 3B.

Major components making up a one column-one pile foundation structure 10 according to the present embodiment include a pile 11 buried in or driven into the ground G (FIGS. 2A to 2D), a joining unit (joint) 12 placed vertically above the pile 11, and a column base 13 joined to the pile 11 via infilled concrete 14 in the joining unit 12. Terms such as "above"/"below" ("on"/"under," "upper"/"lower") and "vertical"/"horizontal" describing positional relationship are used with reference to the one column-one pile foundation structure 10 installed state.

A pile made, for example, of steel or concrete may be used as the pile 11. For example, a steel pile provided with a wing (not shown) at a tip (a lower end portion in FIG. 1A) is driven into the ground G by rotary press-in using a press-in pile driver or the like until the tip reaches a supporting layer (not shown).

The joining unit 12 includes a unit body 121 (e.g., steel pipe) which has a hollow cylindrical shape substantially equal in outside diameter to the pile 11 and both of the upper end and lower end of the unit body

121 are open. A shear connector 122 is installed on an inner wall 12X of the unit body 121, protruding inward. The shear connector 122 is shaped in the form of a ring and produced by punching, for example, a steel plate. The shear connector 122 has an inner peripheral edge 122X and outer peripheral edge 122Y. The shear connector 122 is fixed to the unit body 121 as the outer peripheral edge 122Y is welded to the inner wall 12X of the joining unit 12. The present embodiment is distinguished for the position at which the shear connector 122 is installed on the unit body 121, but this will be described later.

The pile 11 and joining unit 12, made of steel pipes, are fixed to each other by welding. However, this is not restrictive, and the two may be fixed to each other via a splice plate and bolts and nuts. Alternatively, if the pile 11 is made of concrete, reinforcing bars may be buried in the pile 11 with upper ends exposed from a pile head and the joining unit 12 may be fixed to the pile 11 via the reinforcing bars and the infilled concrete 14 described later.

A tip (a lower end portion in FIG. 1A) of the column base 13, for example, rectangular in cross section is inserted into a cavity C, which is an inner space of the joining unit 12, and the joining unit 12 and column base 13 are joined together via the infilled concrete 14 filling the cavity C of the joining unit 12. A base plate 131 is installed at the lowermost end of the column

base 13. The base plate 131 is placed along the horizontal direction.

The base plate 131 serves as a reference for an installation location of the shear connector 122. That is, as shown in FIG. 1A, a straight line (virtual straight line L) is drawn upward by being led out from an end of the base plate 131 at an angle of 45° (elevation angle of 45°) in the horizontal direction and the point at which the virtual straight line L intersects the inner wall of the joining unit 12 is designated as position T. Then, the shear connector 122 is installed above the position T. Incidentally, if the column base 13 is rectangular, the virtual straight line L in a plane direction is led out in a perpendicular direction from a midpoint of a side thereof.

Next, a construction method for the one column-one pile foundation structure 10 according to the present embodiment will be described with reference to FIGS. 2A to 2D.

First, a hole 15 is dug in the ground G at a predetermined position where the pile 11 will be buried, the pile 11 is set up in the hole 15, and then the pile 11 is driven into the ground G by rotary press-in using a press-in pile driver or the like (not shown) until the tip of the pile 11 reaches a supporting layer (FIG. 2A).

Next, the joining unit 12 is put on the pile head of the pile 11, the center of the pile 11 and center of the

joining unit 12 are brought into coincidence, and then the pile 11 and joining unit 12 are fixed to each other by welding. Once the pile 11 and joining unit 12 are fixed to each other, the hole 15 is backfilled and only an open end of the joining unit 12 is exposed from a surface of the ground G (FIG. 2B). Incidentally, the hole 15 may be backfilled after completion of a series of operations up to fixing of the column base.

Then, the tip of the column base 13 is inserted into the cavity C of the joining unit 12 through the open end of the joining unit 12, and the center of the joining unit 12 and center of the column base 13 are brought into coincidence using a positioning device or the like (see FIG. 2C).

In this state, the joining unit 12 and column base 13 are joined together by filling the infilled concrete 14 into the inner space of the joining unit 12, thereby completing the construction (see FIG. 2D and FIGS. 1A and 1B).

As described above, the one column-one pile foundation structure 10 thus constructed is characterized in that the shear connector 122 is installed above the position T (requirement 1).

Also, in the one column-one pile foundation structure 10, area A_n of the shear connector 122 is set so as to satisfy the following expression (requirement 2).

$$P_n > P_s$$

Pn: concrete bearing strength of the shear connector
122

Ps: fracture strength of the entire infilled
concrete 14 against conical fracture
<Requirement 1>

When an upward vertical force (pull-out force) acts on the column base 13, a shearing force acts on the infilled concrete 14 surrounding the column base 13, and consequently the infilled concrete 14 tends to rupture at the end of the base plate 131 in an orientation corresponding to the 45-degree elevation angle. The virtual straight line L represents the orientation of the 45-degree elevation angle.

If the shear connector 122 were installed below the position T at which the virtual straight line L and the inner wall 12X of the joining unit 12 intersected with each other, the shear connector 122 could not restrain upward forces exerted on the portion on the inner side of the virtual straight line L. Thus, in that case, the concrete would be fractured easily in such a way as to fall out conically.

In contrast, if the shear connector 122 is installed above the position T, the shear connector 122 can restrain upward forces exerted on the portion on the inner side of the virtual straight line L. This prevents the infilled concrete 14 from being fractured in such a

way as to fall out conically along the virtual straight line L.

<Requirement 2>

When the shear connector 122 is installed above the position T, it is possible to prevent the concrete from being fractured in such a way as to fall out conically along the virtual straight line L. However, the infilled concrete 14 can get fractured along a fracture line DL shown in FIG. 3A by avoiding the shear connector 122. FIG. 3A additionally shows a stress-strain curve of the infilled concrete 14 subjected to a conical fracture, which is a brittle fracture leading to a significant reduction in the resistance force of the infilled concrete 14.

Thus, the present embodiment gives priority to causing the bearing portion to be fractured by the shear connector 122 rather than allowing a fracture to occur along the fracture line DL. For that, factors such as the area A_n of the shear connector 122 are adjusted so as to satisfy the following expression.

$$P_n > P_s$$

P_n : concrete bearing strength of the shear connector 122

P_s : fracture strength of the entire infilled concrete 14 against conical fracture

P_n and P_s can be defined as follows.

P_n (Concrete bearing strength of the shear connector 122)

$$P_n = A_n \times f_n \times N$$

A_n : area per stage of the shear connector 122
(surface area of one of front and back surfaces of the shear connector 122)

f_n : maximum bearing stress of concrete

N : the number of stages of shear connectors 122 installed above position T (one stage, according to the first embodiment)

For example, f_n can be found as follows.

$$f_n = (A_c/A_0)^{1/2} \times F_c$$

A_c : cross sectional area of the infilled concrete 14 (opening area of the joining unit 12, according to the first embodiment)

A_0 : area of the concrete bearing portion ($A_n \times 1 = A_n$, according to the first embodiment)

F_c : design reference strength of the infilled concrete 14 (material strength of concrete)

P_s (fracture strength of the entire infilled concrete against conical fracture)

$$P_s = A_s \times f_s$$

A_s : area of a conical fracture surface (area of a sloped lateral surface of a truncated cone formed by rupture, excluding top and bottom surfaces)

f_s : fracture strength of concrete on the conical fracture surface

Since the one column-one pile foundation structure 10 according to the present embodiment satisfies the relationship $P_n > P_s$, as shown in FIG. 3B, priority is given to causing the bearing portion Z, i.e., that part of the infilled concrete 14 which is located below the shear connector 122, to be fractured by the shear connector 122 rather than allowing a fracture to occur along the fracture line DL. Consequently, as additionally shown in FIG. 3A, the stress-strain curve of the infilled concrete 14 of the one column-one pile foundation structure 10 does not indicate significant reductions in the resistance force because the infilled concrete 14 located below the shear connector 122 is fractured gradually by bearing pressure. Thus, it can be said that the one column-one pile foundation structure 10 is a tough structure.

The first embodiment of the present invention has been described so far.

Although the one column-one pile foundation structure 10 has only a single shear connector 122, the present invention allows multiple stages of shear connectors 122 to be installed. When multiple stages of shear connectors 122 are installed, it is necessary to install all the shear connectors 122 above the position T in order to prevent conical fracture. However, as long as at least one shear connector 122 is installed above the position T, some shear connectors 122 may be

installed below the position T without departing from the scope of the present invention.

The ring-shaped form of the shear connector 122 shown in FIGS. 1A and 1B is strictly exemplary, and any form may be used as long as it suits the purposes. For example, a semilunar shear connector 122 may be used as shown in FIG. 1C.

Furthermore, the shear connector 122 may be cut off partially in a circumferential direction. The shear connector 122, whose diameter can be adjusted by cutting it off partially, can be inserted into the joining unit 12 flexibly.

Also, in the one column-one pile foundation structure 10, as shown in FIG. 4A, if a step S is provided on the inner wall 12X of the joining unit 12, a peripheral edge of the shear connector 122 can be placed on and supported by the step S. The step S can be formed at any position above the position T.

The above configuration allows the shear connector 122 to be positioned easily. Also, since the shear connector 122 is supported in a height direction, the workload of welding the shear connector 122 to the inner wall 12X can be reduced.

<Second Embodiment>

A second embodiment of the one column-one pile foundation structure according to the present invention will be described with reference to FIGS. 5 to 7B.

A one column-one pile foundation structure 20 according to the second embodiment differs from that of the first embodiment described above in that a joining unit 22 is provided instead of the joining unit 12. Other components are the same as the first embodiment, and thus description thereof will be omitted herein. Incidentally, the same components as those in the first embodiment described above are denoted by the same reference numerals as the corresponding components in the first embodiment.

As shown in FIG. 6, in the one column-one pile foundation structure 20, a bottom plate 123 made of steel is fixed to the lower end of the unit body 121, closing an opening of the unit body 121. The bottom plate 123 is a disk-shaped member. The bottom plate 123 is inserted inside the unit body 121 in such a way as to be flush with a lower open end of the unit body 121. In this state, the bottom plate 123 is fixed to the unit body 121 by welding.

Operation and effects of the bottom plate 123 will be described.

When excessive shaking occurs as a result of an earthquake or the like, horizontal forces are exerted on the one column-one pile foundation structure 10 in addition to vertical forces. Consequently, forces are exerted on the joining unit 22 in a radial direction, which can produce horizontal strain in the joining unit

22. When the joining unit 22 is circular, the horizontal strain appears as oval deformation of the joining unit 22. The bottom plate 123 is provided as a stiffening member adapted to prevent oval deformation at a lower end of the joining unit 22.

In an ultimate state caused by a major earthquake or the like (a state in which a structure is damaged while stopping short of the collapse of the building), it is likely that the infilled concrete 14 in the joining unit 22 is damaged. In that case, the bottom plate 123 functions as a stiffening member adapted to prevent the unit body 121 of the joining unit 22 from deforming elliptically and prevents significant reductions in the resistance force even in the ultimate state. This is shown in FIGS. 6A to 6C, where FIG. 6A shows a design value, FIG. 6B shows a value according to the second embodiment, and FIG. 6C shows a value obtained when the bottom plate 123 is not installed.

Since the bottom plate 123 prevents oval deformation of the joining unit 22 as shown in FIG. 5, the design value is satisfied without a fall in the resistance force at the given portion. In contrast, when the bottom plate 123 is not installed, if the concrete in the joining unit is damaged, the joining unit deforms elliptically, resulting in a significant reduction in the resistance force.

Although the bottom plate 123 of the joining unit 22 described above is a solid disk-shaped member, the present invention is not limited to this as long as a function to prevent oval deformation of the unit body 121 is provided. For example, a ring-shaped bottom plate 124 such as shown in FIGS. 7A and 7B is preferable. As in the case described above, the bottom plate 124 is fixed to the unit body 121 by welding. Residual stresses (thermal stresses) are produced in the unit body 121 and bottom plate 124 after welding. The thermal stresses also act in a radial direction of the unit body 121 and bottom plate 124. However, thermal stresses are released through a hollow portion E provided in the ring-shaped bottom plate 124. Therefore, the joining unit 22 shown in FIGS. 7A and 7B can reduce deformation resulting from the thermal stresses.

When the ring-shaped bottom plate 124 is used, the infilled concrete 14 can possibly leak to the outside through a vacant space in the center. Thus, in the present embodiment, preferably a disk-shaped lid 125 is put on the bottom plate 124 so as to cover the vacant space.

Also, although the ring-shaped bottom plate 124 with a circular vacant space has been shown here, the hollow portion E is not limited to a circular shape. Triangular, rectangular, or other polygonal vacant space can also release thermal stresses.

<Third Embodiment>

A third embodiment of the one column-one pile foundation structure according to the present invention will be described with reference to FIGS. 8A, 8B and 9.

A one column-one pile foundation structure 30 according to the third embodiment differs from that of the first embodiment described above in that a joining unit 32 is provided instead of the joining unit 12. Other components are the same as the first embodiment, and thus description thereof will be omitted herein. Incidentally, the same components as those in the first embodiment described above are denoted by the same reference numerals as the corresponding components in the first embodiment.

In the one column-one pile foundation structure 30, as shown in FIG. 8A, a ring-shaped member 126 is fixed to an upper open end of the unit body 121, for example, by welding.

The ring-shaped member 126 is larger in outside diameter than the unit body 121. This part makes up a flange 127. Thus, the one column-one pile foundation structure 30 can function as a stiffening member which prevents oval deformation in an upper end portion of the joining unit body 121. Also, the ring-shaped member 126 is smaller in inside diameter than the unit body 121. This part functions as the shear connector 122.

In this way, in the one column-one pile foundation structure 30, by making the ring-shaped member 126 smaller in inside diameter and larger in outside diameter than the unit body 121, the single member can combine two functions: the function of preventing the displacement of the infilled concrete 14 and the function as a stiffening member which prevents oval deformation of the unit body 121.

In the third embodiment, as shown in FIG. 9, to prevent deformation into an elliptical shape in a lower end portion of the joining unit body 121, a bottom plate 129 can be fixed to the lower end of the unit body 121 by welding. This prevents deformation into an elliptical shape extending from the upper end to the lower end of the unit body 121.

Incidentally, although in FIGS. 8A and 9, the flange 127 and shear connector 122 have an integral structure, the shear connector 122 may be provided separately as shown in FIG. 10. In this case, the installation location of the shear connector 122 is not limited to the upper open end of the unit body 121, and may be any location that satisfies requirement 1 described above.

Embodiments of the present invention have been described above, but the present invention is not limited to the embodiments described above. For example, the pile 11 used in the present invention is not limited to the steel pile (steel pipe pile) described so far, and

may be a pile made of reinforced concrete (RC), i.e., a cast-in-place concrete pile.

Furthermore, the joining unit 12 may be configured to be rectangular (e.g., oblong) in cross-sectional shape. If the joining unit 12 is configured to be rectangular in cross-sectional shape, i.e., equal in cross-sectional shape to the column base 13, the cross sectional area of the joining unit 12 can be minimized.

Furthermore, the one column-one pile foundation structure which includes the pile 11, the joining unit 12 integrated with the pile head of the pile 11, and the column base 13 joined to the pile 11 via the joining unit 12 has been described in the above embodiment. However, the present invention is also applicable to a one column-one pile foundation structure of a form in which a portion corresponding to the joining unit 12 is incorporated, as a pile head, in the pile 11.

Reference Signs List

- 10, 20, 30 One column-one pile foundation structure
- 11 Pile
- 12, 22, 32 Joining unit
- 121 Unit body
- 122 Shear connector
- 123, 124 Bottom plate
- 126 Ring-shaped member
- 127 Flange

129 Bottom plate
13 Column base
131 Base plate
14 Infilled concrete
C Cavity
L Virtual straight line
DL Fracture line
G Ground
T Position

Claims

[Claim 1]

A one column-one pile foundation structure comprising:

a pile buried in the ground;

a joint configured to be tubular in shape, disposed on a pile head of the pile, and provided with a cavity adapted to contain infilled concrete;

a column base provided with a base plate at a lower end and joined to the pile via the infilled concrete, with a joining area including the base plate being inserted into the cavity of the joint; and

a shear connector installed at a predetermined position in a height direction of the joint, protruding inward,

wherein the shear connector is installed above a position T at which a virtual straight line L extending at an elevation angle of 45° from an end of the base plate in a horizontal direction intersects an inner wall of the joint, and

if concrete bearing strength of the shear connector is denoted by P_n and fracture strength of the entire infilled concrete against a conical fracture is denoted by P_s , the shear connector is formed so as to satisfy $P_n > P_s$.

[Claim 2]

The one column-one pile foundation structure according to claim 1, further comprising a bottom plate fixed to a lower end portion of the joint.

[Claim 3]

The one column-one pile foundation structure according to claim 2, wherein the bottom plate has a hollow portion.

[Claim 4]

The one column-one pile foundation structure according to any one of claims 1 to 3, wherein a flange is fixed to an upper end portion of the joint, protruding outward.

[Claim 5]

The one column-one pile foundation structure according to claim 4, wherein the flange is installed on an uppermost end of the joint.

[Claim 6]

The one column-one pile foundation structure according to claim 5, wherein the flange also protrudes inward of the joint.